ELTROPLAN-REVCON

Elektrotechnische Anlagen GmbH

Operating instructions

Inverter REVCON® PFU

Power range	7 ... 250 kW
Nominal voltage	400V

V 3.2 Issue 11/12

Contents

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1 Important information

1.1 About these operating instructions

- These present operating instructions are the translation of the original instructions, which were composed in the official EU language German.
- This operating instructions act for working secured on and with the REVCON® PFU system. It contains security advices which must be observed and information which are necessary for an undisturbed operation of the units together with the exploitation of all advantages of the system.
- All persons who work on and with the REVCON® PFU system must have the operating instructions accessible, or the equal chapters of the operating instructions for other with this option equipped REVCON® products available. All persons must follow the relevant notes and designations.
- The operating instructions must be complete and perfectly legible
- The in this operating instructions described device ranges include only the systems for the power supply at a line voltage of 400V.
- The PFU systems for other line voltages, for the configuration of a three- phase stand alone system and the realization of emergency power systems are not described in these operating instructions.

Important information

1.2 Used terms and definitions

PFU system
PFU system is a system that inducts electrical energy of regenerative energy sources into the public mains power supply. This system can consist of one PFU device or of several components (detailed information see chapter 1.5.3)

PFU device
A PFU device includes the components inverter, boost converter, SKS-and interference filter. These components can be in one enclosure and device or comprise of maximum four devices. The assignment of the respective components happens at Eltroplan REVCON and results by the order reference of the device. By this provision is at orders only to specify the type designation e.g. PFU-PD-330/150-400, although the device comprises of four devices.

PFU Module
The PFU module consists of source modules (PQM) and power module (PNM), which can be combined in dependence of the application. A source module consists of a boost converter, a SKS filter and an input reactor. A power module consists of an inverter, a SKS filter and a RF filter. The single devices must not be specified at the order and are an inherent part of the scope of delivery.
These single modules offer a high flexibility by the possibility of parallel connection of power-and source modules.

Device range
A device range includes all PFU systems for same applications, e.g. line voltage U=400V and source voltages of an AC voltage source U_q.

Example 1: PFU-PA-…-400 device range
Example 2: HST-PD-…-400 device range

Series
A series includes all PFU systems with same, constructive configuration.
Example: Type series A includes among other things device types PFU-PA-7-400 and PFU-PD-30-400.

Device types
A device type describes one or several components of a PFU system.

Example 1: A power module, device type inverter with the type designation SVCDS-150-400 inclusive SKS-and interference filter.
Example 2: A PFU device, device type PFU-PA-20-400 A in the tape series A.

AC voltage or -current
AC voltage or -current terms e.g. public mains supply and synchronous generators.

DC voltage or -current
It is a DC voltage or –current e.g. photovoltaic and accumulator.

Inverter
A power electronically system which converts a DC voltage to an AC current (current source), or converts to an ac voltage (voltage source). The inverter at the PFU devices realizes the power supply of the complete system.

Boost converter
Is a power electronically system which enables the power transmission of a lower DC voltage to a higher DC voltage. The boost converter controls (operation with external setpoint setting) or controls (closed operation with MPP tracking) the source current.

SKS Filter
The SKS filter (harmonic line filter) is filtering the line current of the inverter at low frequency range to ca. 2,5KHz and are even named NF filter.

RF Filter
The RF Filter is filtering the line current of the inverter at high frequency range at MHz range and are even named HF filter.

MPP tracking
Controls the current of the source, so that a maximum power of the source (P_q) appears.

Source voltage or –current, U_q, I_q
Root mean square values of voltage and current of the power producer, e.g. generator of a wind turbine.

Stand alone system
The stand alone system is a mains power supply that is e.g. only energized by an inverter and is not connected with the public mains supply. The device range standby generates a three phase AC voltage for a standalone system, if the public mains voltage is failed.

Standby operation
The PFU device type standby offers additional to the network feeder (grid- connected operation) the option, to arrange an autarkic mains power supply (stand alone system) at mains power failure. This device type is described in an own manual.

Grid-connected operation
This operation is available, if a current- carrying inverter inducts electrical energy into an electrical mains power supply, e.g. network supply of PFU devices. At grid-connected operation the PFU devices can not generate voltage.

AC voltage or -current
AC voltage or –current is an alternating voltage or –current e.g. public mains power supplies and synchronous generators.

Important information

ENS device*
Is a redundant built network monitoring device, which is prescribed by several network operators, if energy is inducted into the public mains supply.

*Not included

1.3 SI units and symbols

	Prefix	Symbol			Prefix	Symbol
10^{24}	Yotta	Y		10^{-1}	Dezi	d
10^{21}	Zetta	Z		10^{-2}	Zenti	c
10^{18}	Exa	E		10^{-3}	Milli	m
10^{15}	Peta	P		10^{-6}	Mikro	µ
10^{12}	Tera	T		10^{-9}	Nano	n
10^{9}	Giga	G		10^{-12}	Piko	p
10^{6}	Mega	M		10^{-15}	Femto	f
10^{3}	Kilo	k		10^{-18}	Atto	a
10^{2}	Hekto	h		10^{-21}	Zepto	z
10^{1}	Deka	da		10^{-24}	Yokto	y

Measure	Name
Ampere	A
Speed	n
Farad	F
Frequency	f
Degree Celsius	℃
Gramm	g
Henry	H
Hertz	Hz
Magnetic flux density	T
Meter	m
Minute	min
Newton meter	Nm
Second	s
Thermodynamic temperature	K
Volt	V
Resistor, electrical	Ω
Real power	W
Efficiency factor	η

Measure	Name
Electromagnetic compatibility	EMC
Direct current	DC
Revolutions per minute	r/min
Alternating current	AC
Point of maximum power, Maximum Power Point	MPP

Marking	Short cut
Source	q

Important information

1.4 Unit designation

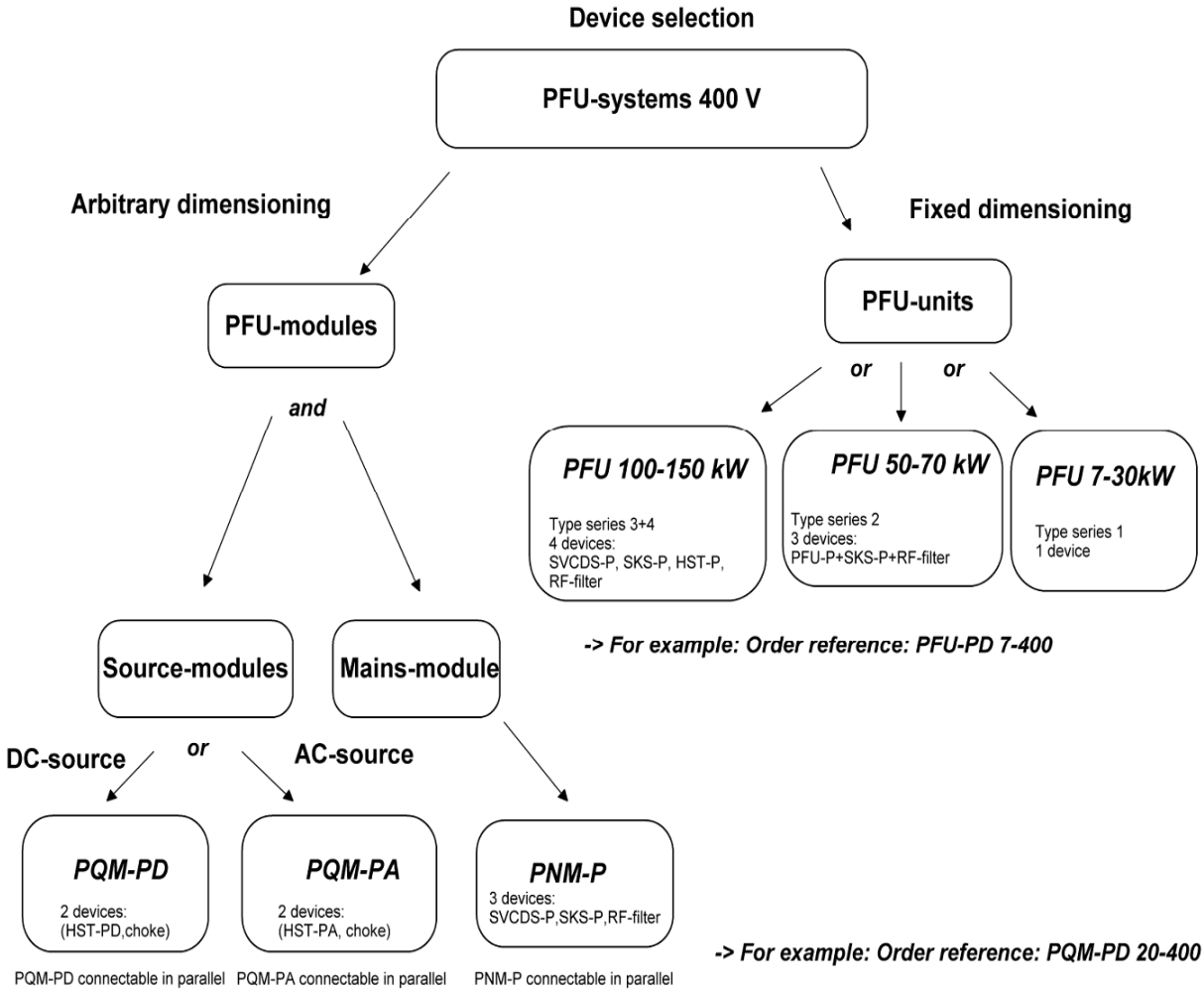


Figure 1: Device select

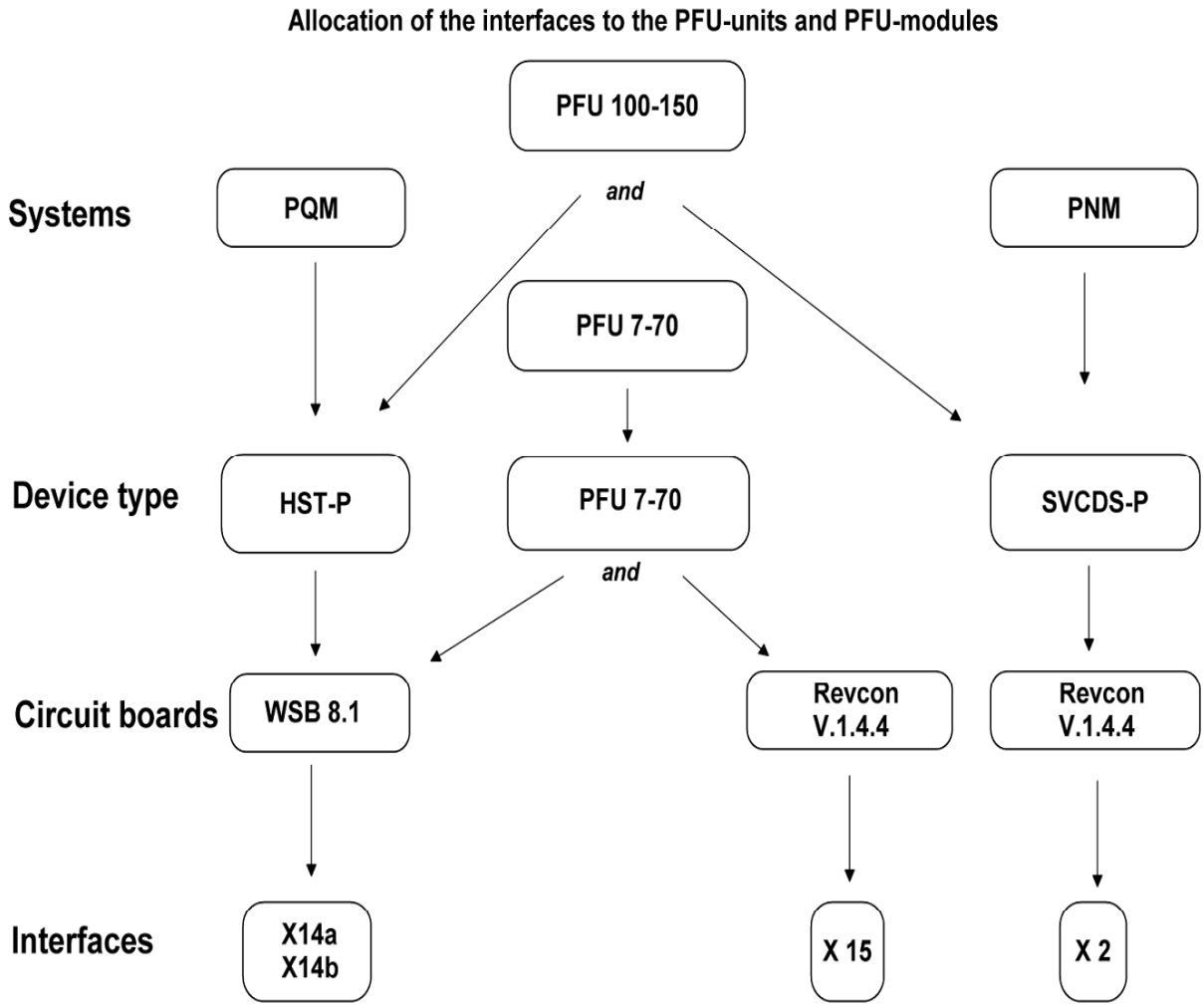


Figure 2: Assignment of the interfaces to the PFU units and PFU modules

Important information

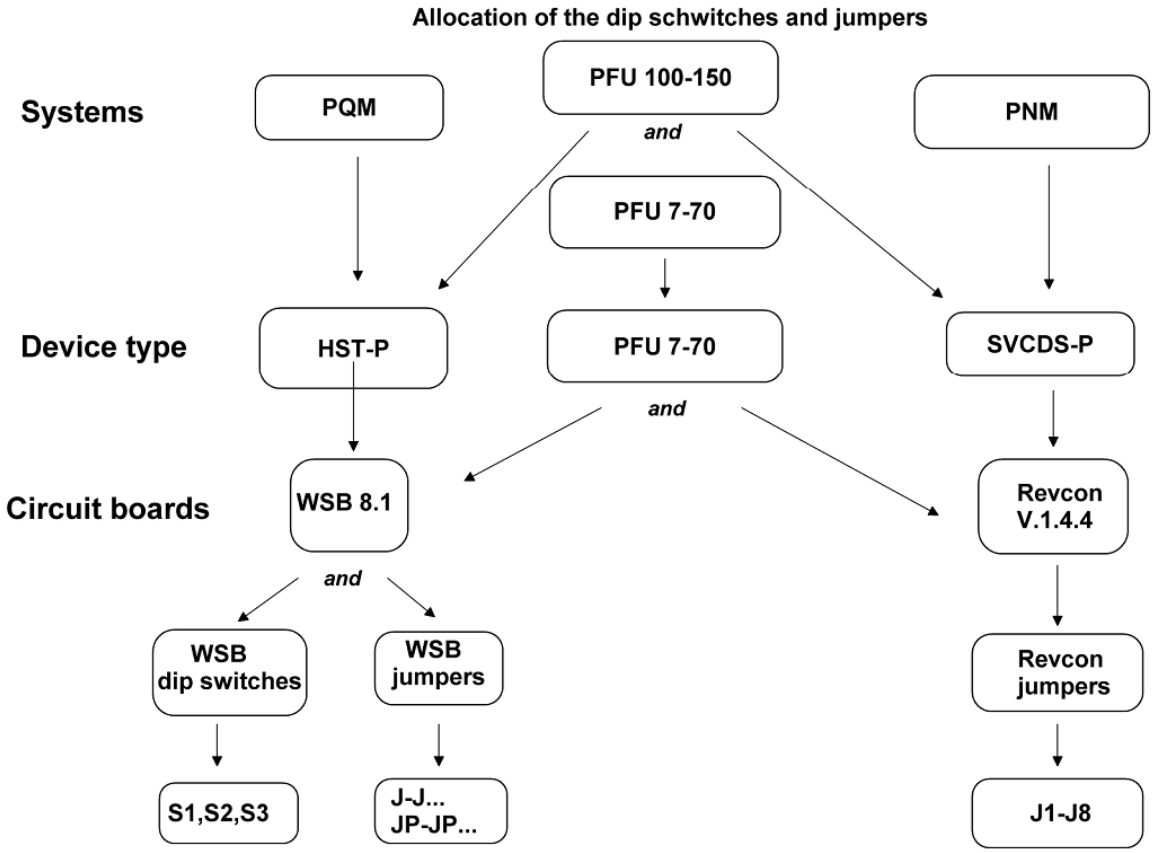
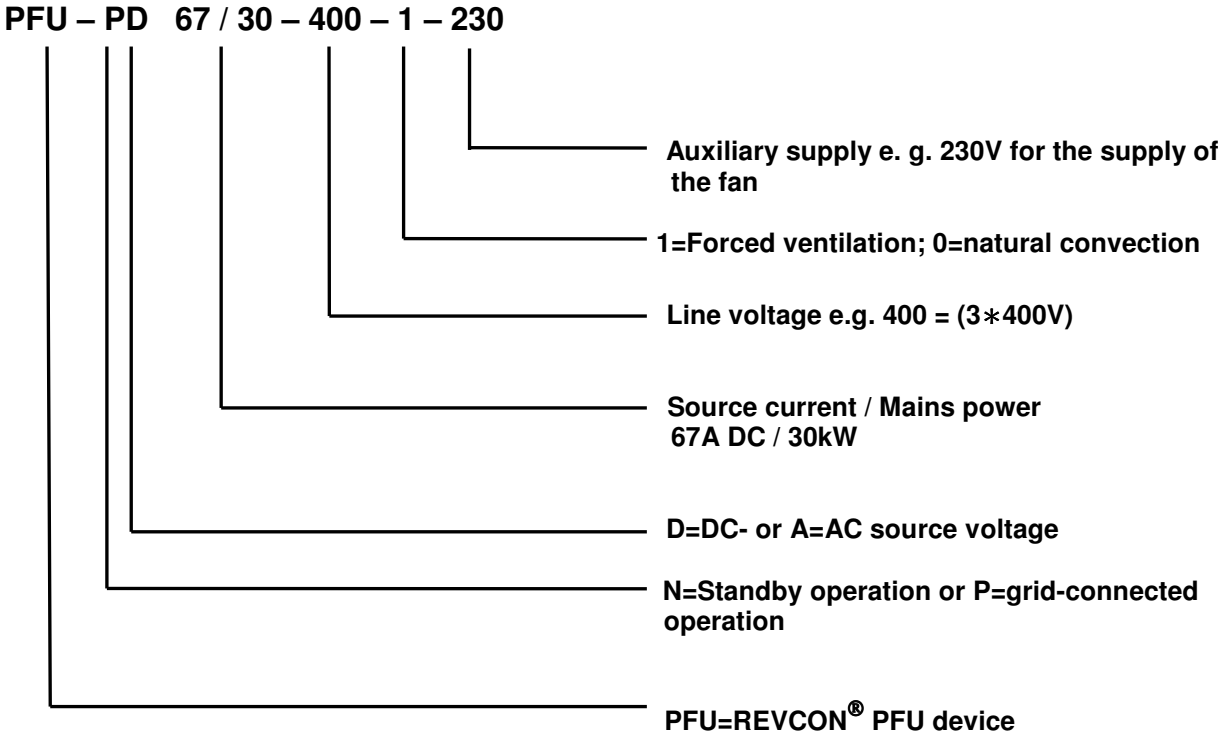


Figure 3: Assignment of the DIP switches and jumper

1.4.1 Ordering code PFU devices

The selection of a PFU device with the type designation PFU-P…equates to the order reference of the device.



- The order references comprise one or several devices.
  This circumstance is in line of order not relevant, because these devices are automatically composed to devices by company Eltroplan REVCON.

- The device types and their type designation are specified in the chapter 1.5.3.

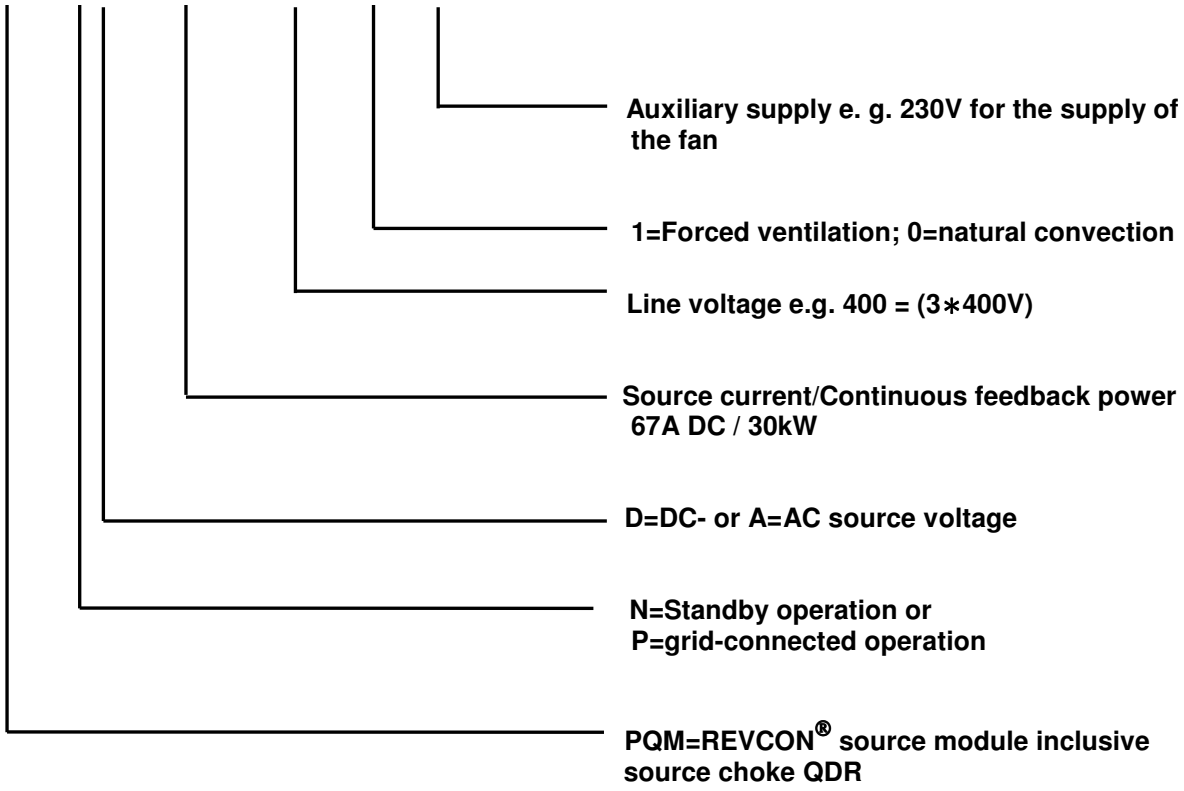
Important information

1.4.2 Ordering code PFU modules

A complete PFU module consists of minimum one source module and one power module.

Ordering code source modules

PQM – PD 67 / 30 – 400 – 1 – 230

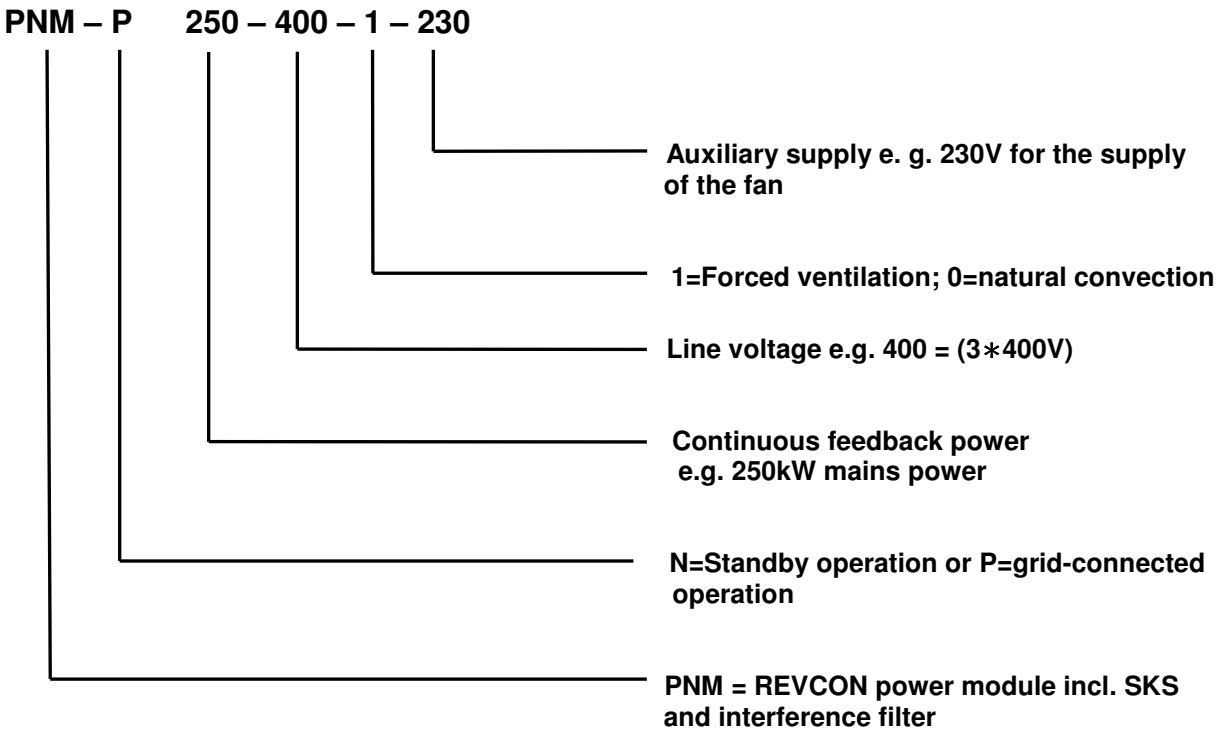


- The order reference of the source modules contain in dependence of the type of the source an AC or a DC choke and a boost- converter. This circumstance is in line of order not relevant, because these devices are automatically composed to source modules by company Eltroplan REVCON.

- The device types and their type designation are specified in the chapter 1.5.3.

1.4.3 Ordering code PFU

Ordering code power modules



- A power module consists of an inverter, a SKS filter and a RF filter. This circumstance is in line of order not relevant, because these devices are automatically composed to a power module by company Eltroplan REVCON.
- The device types and their type designation are specified in the chapter 1.5.3.

Important information

1.5 Applications and basically equipment configuration

The PFU systems provide the opportunity to induct electrical Energy of AC voltage sources (e.g. synchronous generators) or DC- voltage sources (e.g. photovoltaic, direct current generator) into the public mains supply. The complete PFU series is designed for the three phase network supply.

1.5.1 Operation of the device range PFU-PA with 3-phase AC voltage sources

For this operation the following data result for the source voltage, –current and –frequency:

The nominal source voltage rating at this series: $U_{qrated} = 300\,VAC$

The power feedback unit is configured for the operation at a permanent excited generator with the following data:

REVCON® - type	U_{rated} [V] AC	I_{rated} [A] AC	f_{rated}[Hz]
PFU 7-400	≤360	12	≤300
PFU 13-400	≤360	21	≤300
PFU 20-400	≤360	32	≤300
PFU 25-400	≤360	40	≤300
PFU 30-400	≤360	48	≤300
PFU 50-400	≤360	80	≤300
PFU 70-400	≤360	112	≤300
PFU 100-400	≤360	144	≤300
PFU 150-400	≤360	216	≤300
PFU 200-400	≤360	289	≤300
PFU 250-400	≤360	360	≤300

Table 1: Rated voltage and rated current

The maximum source voltage of 360VAC must not be exceeded. An exceedance of this value leads to a restriction of the range of operation of the device. At a source voltage of below 120VAC the device stops automatic and is arranged in standby- operation.

The maximum power of the PFU-PA devices results of:

$$P_q = \sqrt{3} * U_q * I_{qrated} * \cos\varphi \qquad \text{(equ.1)}$$

Example for the dimensioning for a PFU-PA device:

3-phase synchronous generator:

$$U_{rated} = 200\,V,\ I_{rated} = 20\,A\,, U_{Mains} = 400\,V$$

With (equation 1) the power results: $P_q = 6{,}93\,kW$

Right device: PFU-PA-13-400-1-230V

Reason: The dimensioning of the PFU-PA device range tends to the maximum current of the AC voltage source. The PFU PA-7 would be dimensioned too small with a source current of maximum 12A.

1.5.2 Operating data of the device range PFU-PD with a DC current source

The PFU systems can generally be operated with any DC voltage source, if the following limit values for the rate of the source voltage are observed (at 400V line voltage):

- Maximum voltage of 500V (at full adjustment range P=0-100%)
- Minimum voltage of 100V*
- Maximum open circuit voltage 600V

All versions are on request available also for 460, 500 or 690V line voltage. According to line voltage, follow than other valid ranges for the valid source voltages.

*Smaller values on request

Important information

For this operation the following data for the source voltage and – current result:

REVCON® - type	U_{Max} [V] DC	I_{rated} [A] DC
PFU 7-400	≤500	15
PFU 13-400	≤500	26
PFU 20-400	≤500	40
PFU 25-400	≤500	50
PFU 30-400	≤500	60
PFU 50-400	≤500	100
PFU 70-400	≤500	140
PFU 100-400	≤500	200
PFU 150-400	≤500	300
PFU 200-400	≤500	400
PFU 250-400	≤500	500

Table 2: Maximum- and rated values of DC-sources

The maximum source voltage of 500VDC must not be exceeded. An exceedance of this value leads to a restriction of the range of operation of the device. At a source voltage of below 100VDC the device stops automatic and is arranged in standby- operation.

The dimensioning of the PFU-PD devices is made in the same way as in the dimensioning example for PFU-PA devices, see page 14.

For the complete PFU-P- series is at the dimensioning of the source voltage to observe, that the maximum efficiency at the respective nominal voltage is achieved.

1.5.3 Constructional installation of the PFU-P series

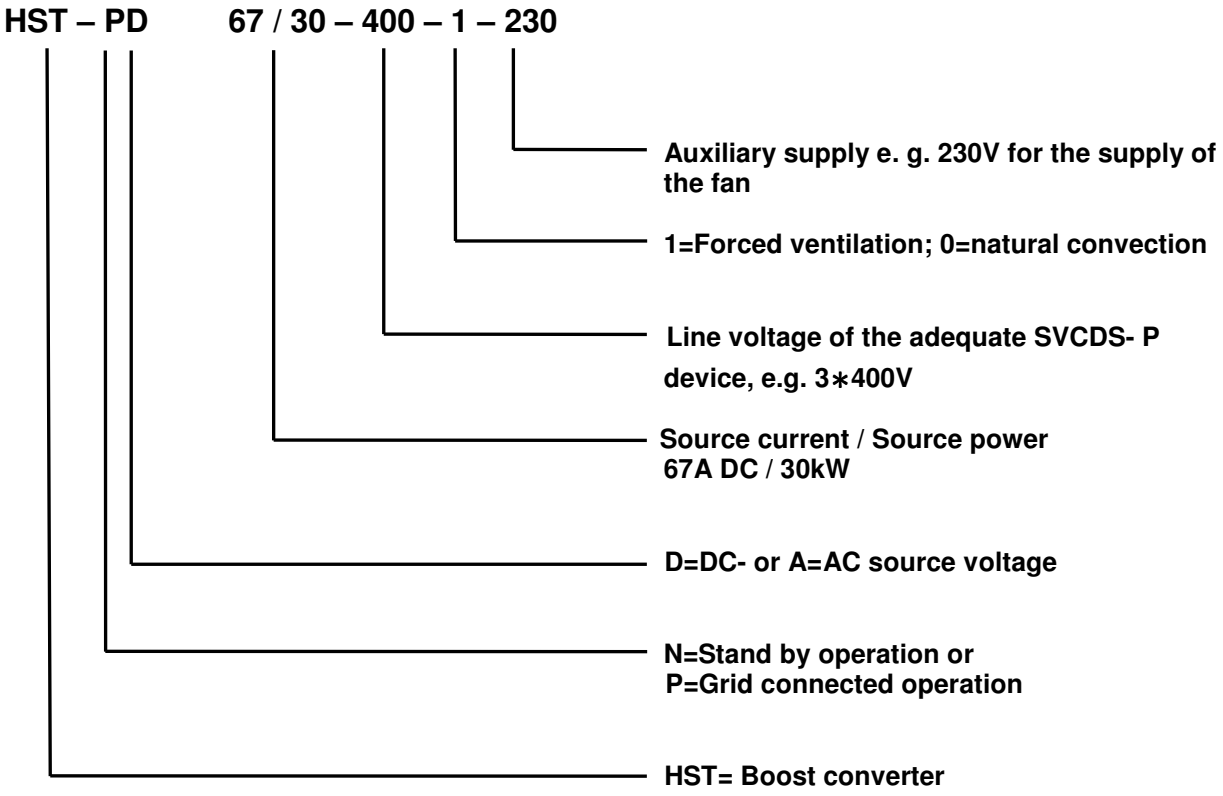
The PFU devices are composed of the following assemblies*:

a) An inverter
b) A boost converter
c) An interference filter (HF Filter)
d) A harmonic line filter (NF Filter)

Subject to the range of performance these assemblies are delivered in one enclosure or in separate enclosures.

*The single assemblies are aerated separate in dependence of the power

Ordering code boost- converter



Note!

Not included in delivery are:

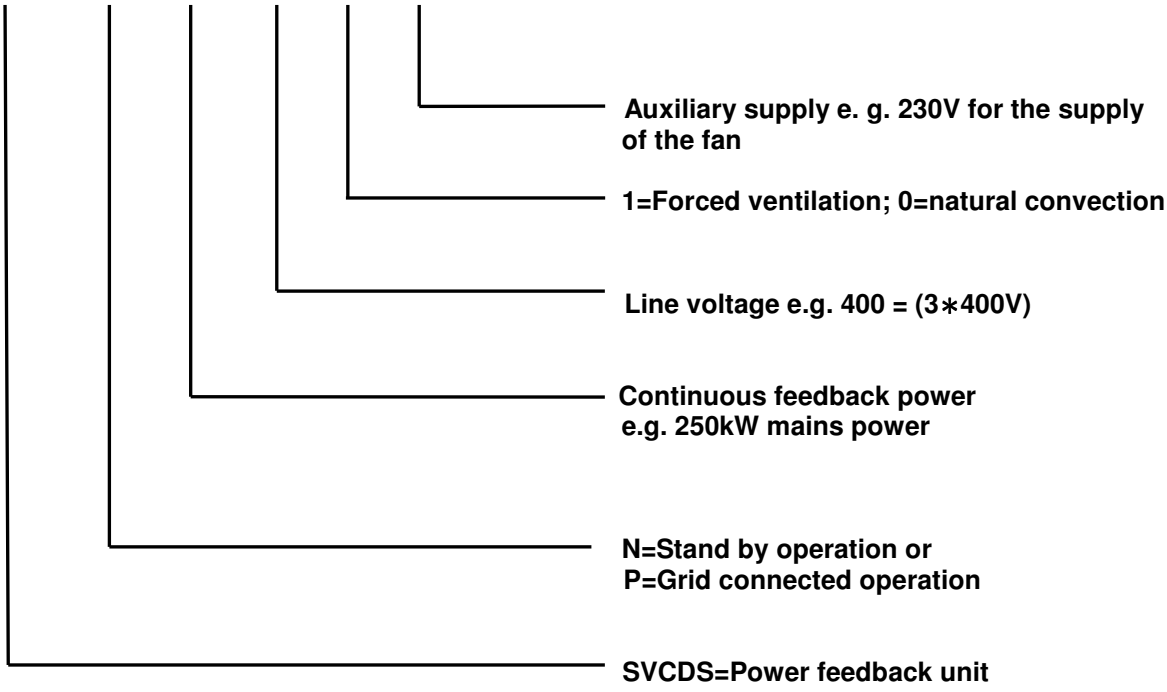
- Automatically disconnection with 3-phase mains monitoring following VDE 0126-1-1:2006-02

These assemblies must be arranged at application of inverters of the series PFU external and on site!

Important information

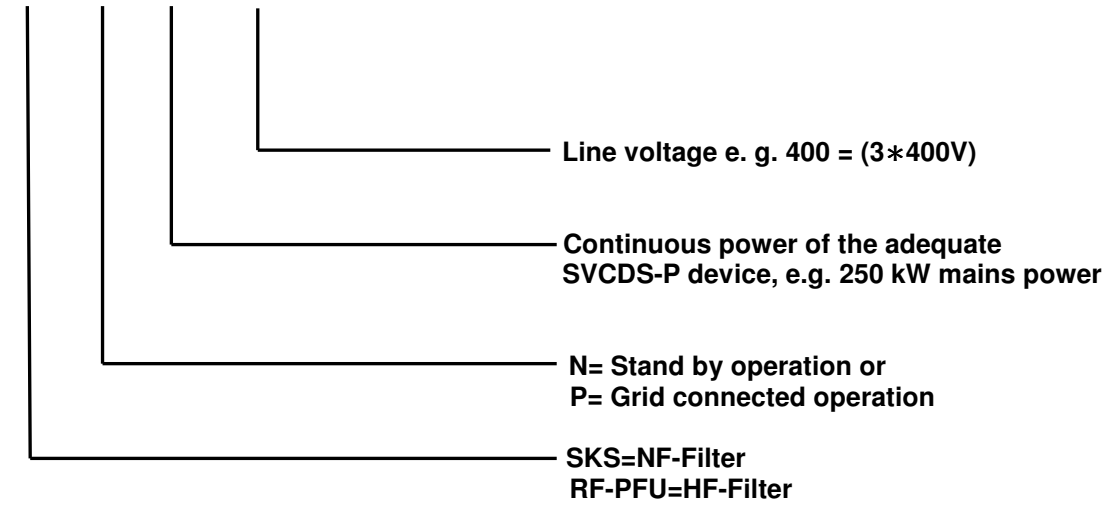
Ordering code inverter

SCVDS – P 250 – 400 – 1 – 230



Ordering code NF-and HF filter

SKS – P 250 – 400



- The designations of the device types must not be specified by the order of PFU devices. The selection of the devices happens automatically at company Eltroplan REVCON The designation of the device types must be specified by the spare parts supply.
- The designation of the device types complies with the name plate of the devices.
- The designations of the device types correspond to the type plate of the devices.

Series A:

The PFU devices up to and including PFU-P-30-400, are delivered in one enclosure:

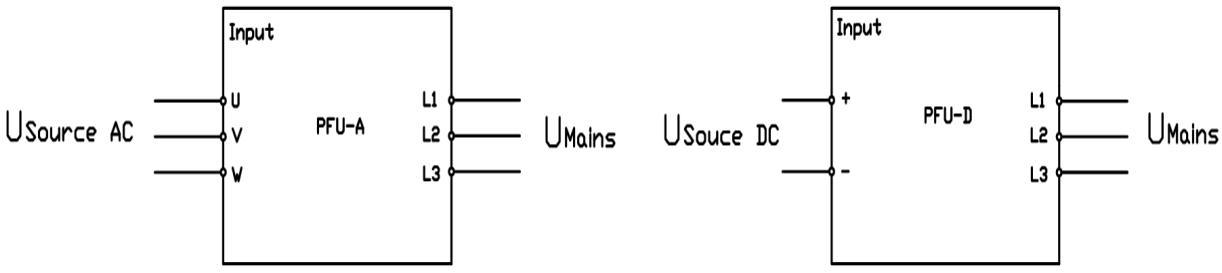


Figure 4: PFU series A

Important information

Series B:

The PFU-P50-400 and PFU-P70-400 systems are assembled of the following assembly, which are built-in in three enclosures and which have the following classification:

a)	and b) inverter and boost converter	type PFU-P…
c)	An interference filter	type RF-PFU
d)	A harmonic line filter	type SKS-P

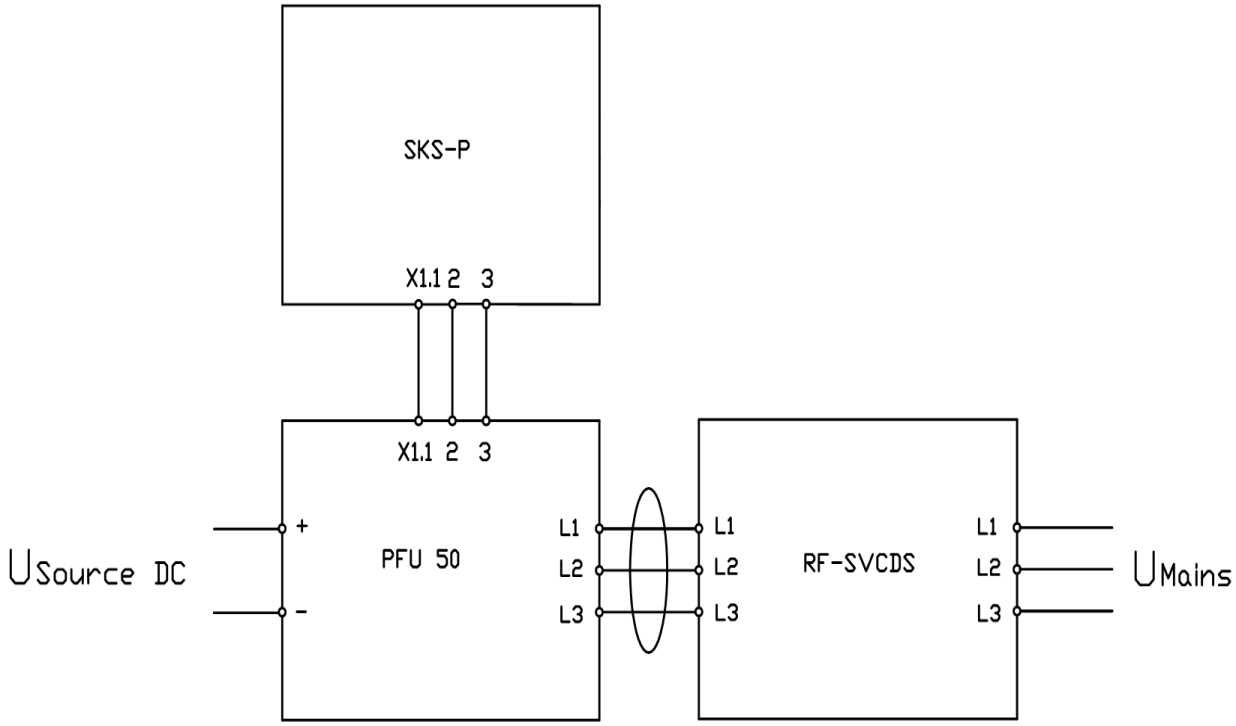


Figure 5: Series B

The PFU systems of the Series B are designated as PFU devices with external filter in the operating instructions.

Series C:

The PFU systems in the range of performance from PFU 70-400 are assembled of the following assembly, which are built-in in four enclosures and which have the following classification:

a) Inverter	type SVCDS-P
b) Boost converter	type HST-P…
c) Interference filter	type RF PFU-P
d) Harmonic line filter	type SKS-P

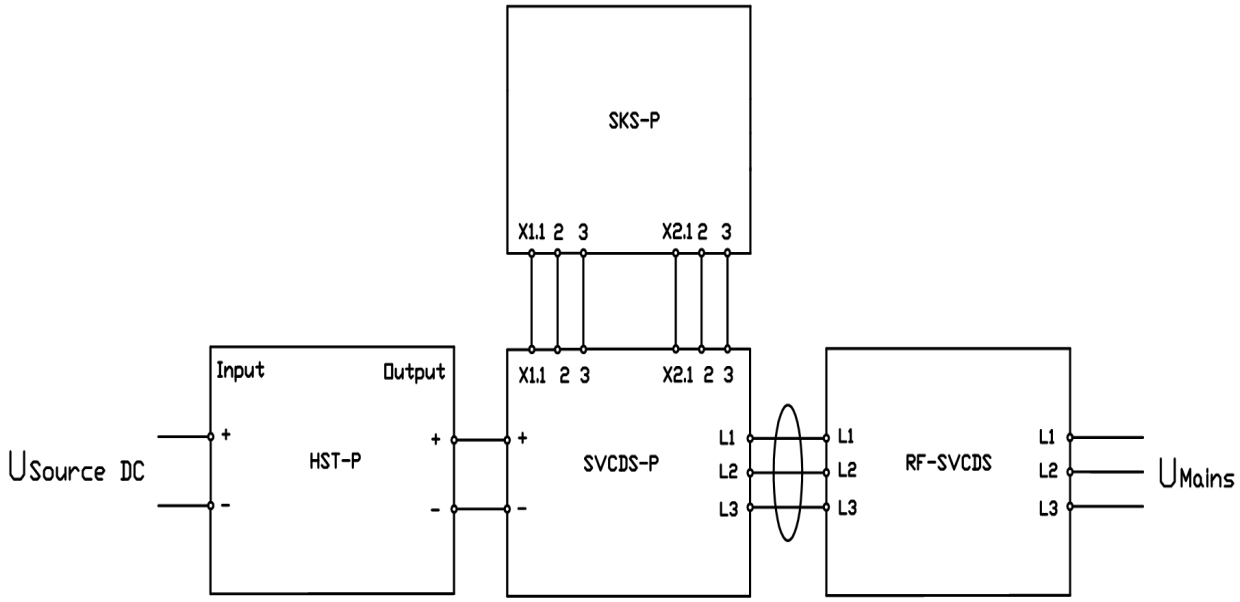


Figure 6: Series C

Important information

Series D:

The PFU systems in the range of performance are assembled of the following assembly, which are built-in in four enclosures and which have the following classification:

a) Inverter	type SVCDS
b) Boost converter	type HST-P…
c) Interference filter	type RF-SVCD PFU100
d) Harmonic line filter	type SKS-P

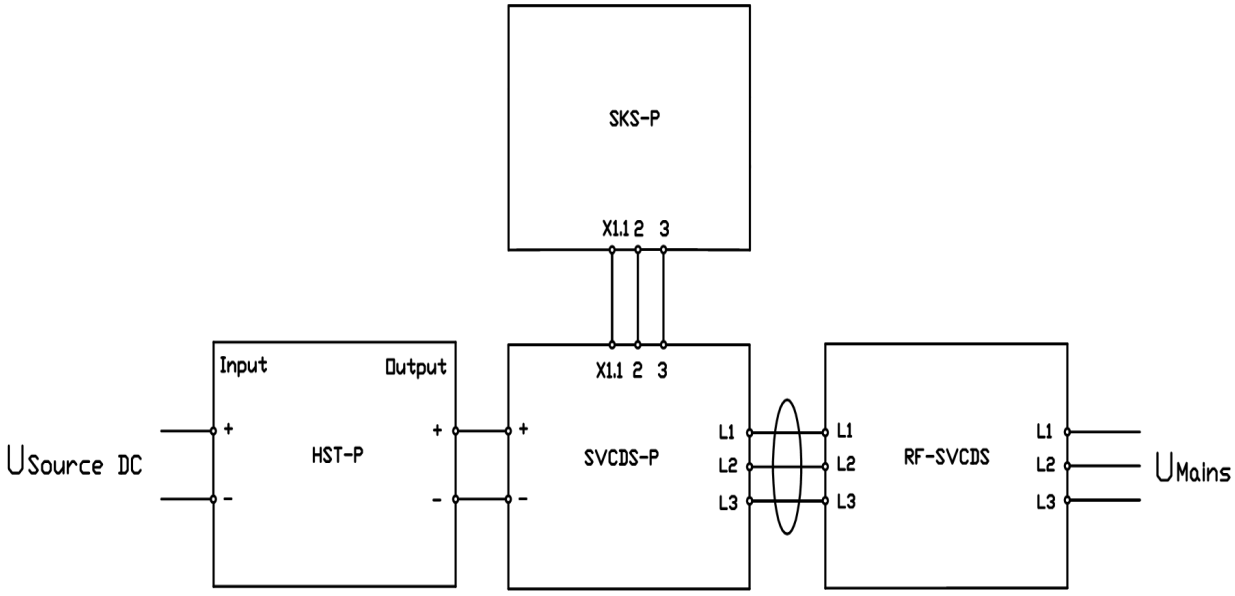


Figure 7: Series D

1.5.4. Constructional configuration of the PFU modules

- The PFU-P modules consist of minimum one source module and one power module.

- A power module PNM-P consists of the following devices:

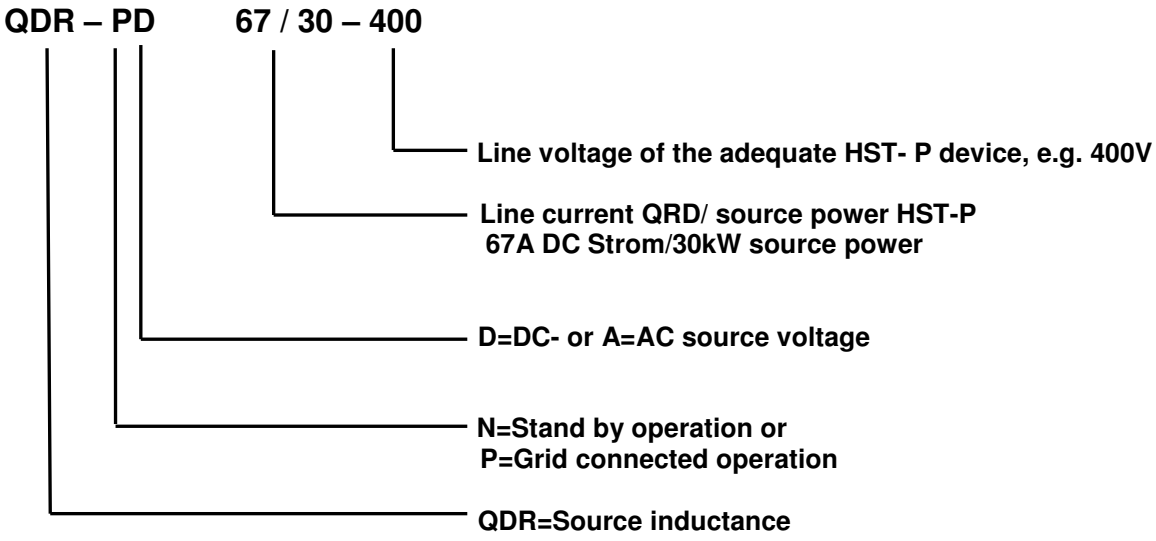
  a) a inverter
  b) a interference filter (HF Filter)
  c) a harmonic line filter (NF Filter)

- A source module PQM-P consists of the following devices:

  a) A boost converter
  b) A source inductance

- All devices excepting the source inductances have the same device classification and ordering code as described in chapter 1.5.3.

Device- order reference source inductances



Important information

The PNM-modules up to and including PNM-P 100-400 are connected as in Fig.8.

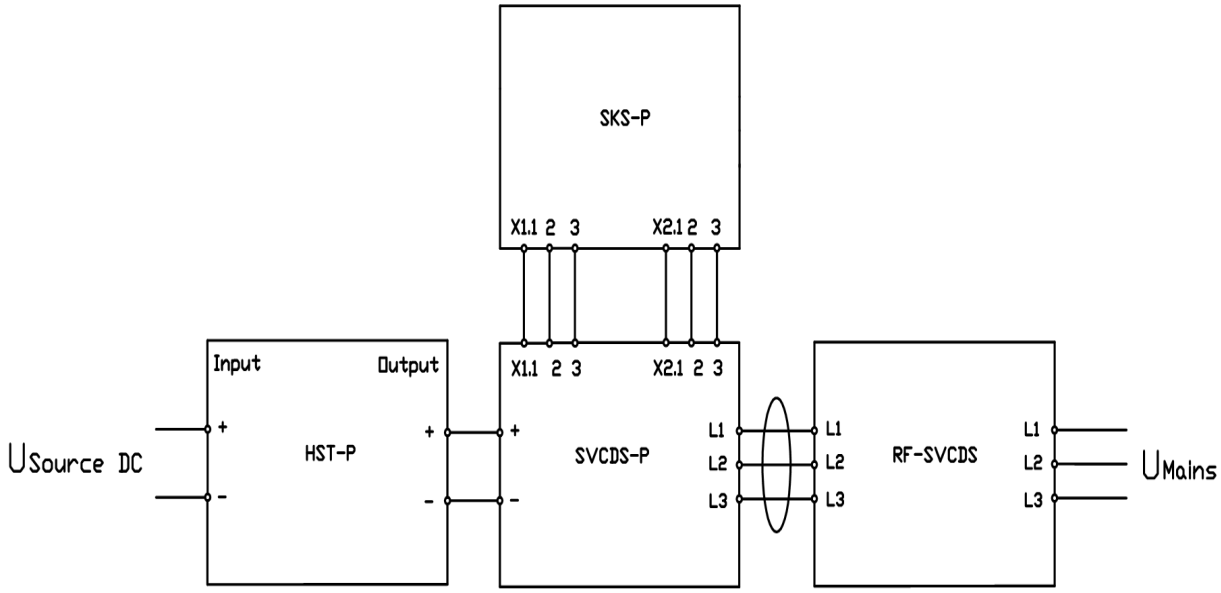


Figure 8: The connection of the module up to and including PNM-P 100-400

1.6 Scope of supply

- One REVCON® PFU device or system (consisting of the above-named components...)

Note!

Not included in delivery are:

- Automatically disconnection with 3-phase mains monitoring following VDE 0126-1-1:2006-02

These assemblies must be arranged at application of inverters of the series PFU external and on site!

- 1 operating instructions
- After receipt of the delivery verify immediately, if the scope of supply correspond to the shipping documents. We make no warranty for later complained defects

– Complain

- visible damages in transit immediately at the deliverer
- visible defects / incompleteness immediately at ELTROPLAN- REVCON

2 Information for the planning of installations

An installation consists of the PFU system, the energy source and the connection to the mains power supply. The clean operation of such an installation assumes that the described parts of this installation are concerted. With this information should the methods engineers and the operators of an installation be given reference notes of special characteristics, directives and standards in reference to the network supply. No demand of completeness will be raised with these reference notes.

2.1 Line side requirements for the clean operation of PFU systems

In this chapter themes are dealt, which affect the grid connection requirements of the PFU systems, the short-circuit power of the mains power supply, the grid connection by transformers and the valid cable lengths.
All PFU systems are built-on without transformer and there is no isolation between the energy source and the low voltage grid.
The planning and setting up of a conforming to standard grid connection of the PFU system has to be ensured by the planner and operator (constructor) of an installation.

Danger!

At a supply into a mains power supply at the connection with the grid of the PFU system there are voltage boost compared to the nominal voltage of the mains. Minimizing the voltage boost calls for e.g. short cable lengths, a low u_k and a sufficient power of the transformer and a high short-circuit power at the connection point of the mains.
The PFU system is responsive to voltage boost which are in the amount of the valid voltage tolerance first to a reduction of the inducted power. In a row over voltage interruptions can happen.
Fast voltage boosts can lead to the destruction of the connected PFU system and of connected loads.

2.1.1 Direct network supply into the low voltage grid

The planning of installations for the supply of electrical energy into the low voltage grid contains the observance of the scope of the mains power supply, to adjust this energy again. The scope to adjust the generated energy is determined by the ratio of short-circuit power at the connection point of the mains and the power of the energy source (generator).
The operator (e.g. RWE) checks at the planning period, if the power of the generator at the respective connection point of the low voltage grid can be supplied.
The „guideline for interconnection and operation of electric generation systems in parallel to the low voltage grid“ (Forum Netztechnik, Berlin), contains the specifications for the planning and the operation of these installations.

If it is not possible to install a planned installation at the low voltage grid, there is the possibility to carry out an installation at the medium voltage grid. In this case is the „guideline for electric generation systems at the medium voltage grid“ (BDEW, Berlin) valid (see chapter 2.1.3.).

At the planning outside the Federal Republic of Germany the respectively valid standards and guidelines must be followed (e.g. Austria: ÖVE/Ö standard E 2750).

2.1.2 Network supply into the low voltage grid with an isolation transformer

The observance of the under 2.1.1.defined planning requirements, guidelines and standards is even valid for installations with isolation transformers.
An electrical isolation can be built-on by the assembly of an isolation transformer between PFU system and low voltage grid.

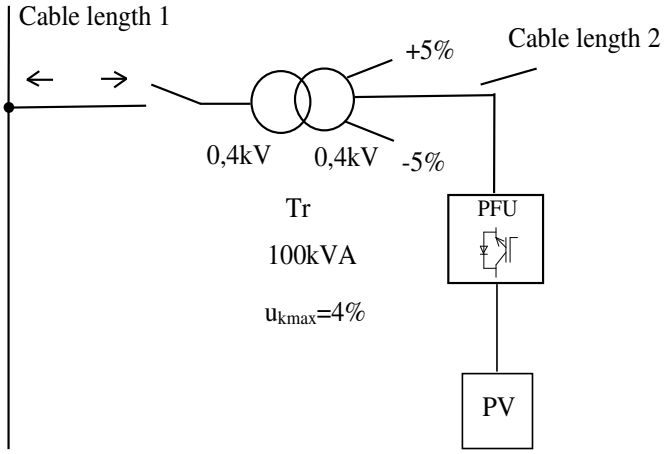


Figure 9: Grid connection with electrical isolation

At the dimensioning of the isolation transformer the following criterion should be considered:

- $U_{k\ max}$=4%
- Dimension the transformer for the inducting operation into the mains power supply, i.e. the secondary open circuit voltage at the PFU sided mains supply averages circa 400V at a primary mains voltage U_{Mains}=400V. This voltage rises at nominal power at the inducting operation e.g. 405V.
- About clearing the impact of lower short circuit power at the connection point of the low voltage grid, long cable lengths (see figure 8 „cable length 1 and 2“) or high mains impedance must a transformer with tap be used (see figure 9)
- At the thermal dimensioning muss the low distortion of the current at the rate of THDI=10% must be considered.

At an observance of all aforementioned criterions for the dimensioning of the transformer can e.g. at a PFU-…-20 a 20kVA transformer be dimensioned.

Information for the planning of installations

2.1.3 Network supply into the medium voltage grid with a transformer

The possibility to adjust the generated energy is determined by the ratio of short-circuit power at the connection point of the mains and the power of the energy source (generator).
At connection of the PFU system at a transformer and supply into the medium voltage grid checks the operator (e.g. RWE) at the planning period the possibility of the supply at the respective connection point.
In this case is the „guideline for electric generation systems at the medium voltage grid“ (BDEW, Berlin) valid.
The planning and setting up of a conforming to standard grid connection of the PFU system has to be ensured by the planner and operator (constructor) of an installation.

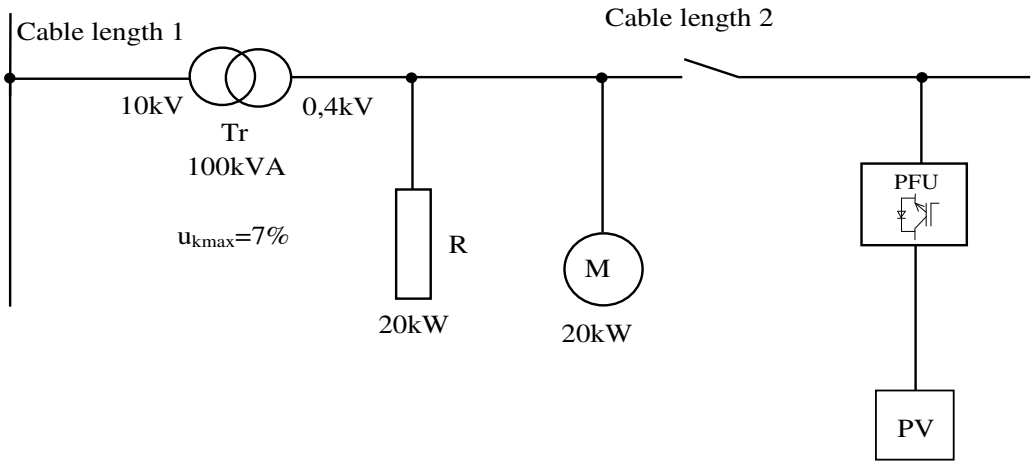


Figure 10: Operation on a transformer

- At the dimensioning of the isolation transformer the under 2.1.1 and 2.1.2 listed criteria are valid.

Danger!

The operation of PFU systems at transformers with a u_k >7% or variable transformers in construction with braked slip ring motor, is only valid in exceptional case and after consultation with the company Eltroplan-REVCON.

- At dimensioning at other than the given values as of the requirements under 2.1.2., e.g. if an existing transformer with a u_k = 6 is used, the requirements of the chapter 2.1 must be followed, to avoid incorrect voltage boosts.
- The mains impedance on the medium voltage level should be kept preferably kept low, to avoid high-frequency harmonics (e.g. by transposition of cables).

2.1.4 Operation on a generator of a isolated network

The operation of a PFU system on an isolated network (e.g. diesel generator of an on board power supply of a ship) is generally possible, but for the rate of the inducted power are close limits valid.

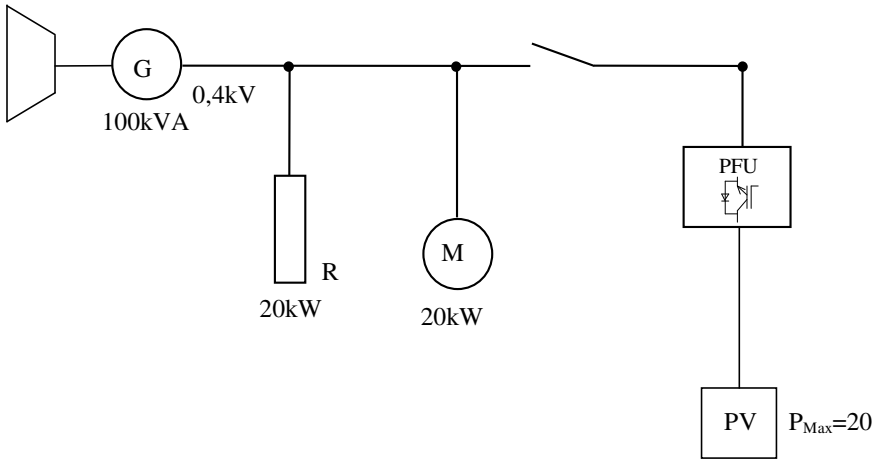


Figure 11: Operation of a PFU system on an isolated network

For a network that is built-on as in figure 10, the power of the generator must only average maximum 1/5 of the nominal power of the main generator. At the isolated network consumer loads must be in operations that have in sum minimum the double power of the PFU system and act as base load.

If these conditions are not observed, at switching operations it can come to step changes in load. They are under circumstances to dynamic for the voltage regulator of the generator, so that the generator reacts with overshoots, what leads in succession in turn to electrical surges in the isolated network.

Danger!

Electrical surges can lead to the destruction of the connected inverter and the remaining loads.

Information for the planning of installations

2.2 Risks and operational disturbance by overvoltage

2.2.1 Commutation inductance

The necessary commutation inductance for the inverter is integrated in the REVCON® PFU system. It is not valid, to connect ahead a further commutation inductance. The connection of the PFU systems must occur direct on the mains. Is this not observed, the inductance prevents the synchronization to the supply grid and the voltage drop at the choke can lead to over voltage at the power input of the PFU system.

Danger!

External inductances can lead to voltage boosts and to destruction of the connected PFU system.

2.2.2 Cable- and contact resistances

The details for the current carrying capacity of the cables deal with the generally used copper conductors. Because of the higher specific resistance for aluminium conductor larger cross sections must be used.

At both conducting materials it must be observed, that the junction of the conductors are performed preferably low impedance, to limit the number to the absolute necessary.
Too much or too high impedance contact points lead to an incorrect line drop in supply operation and leads to an incorrect voltage boost at the power supply terminal of the PFU system.

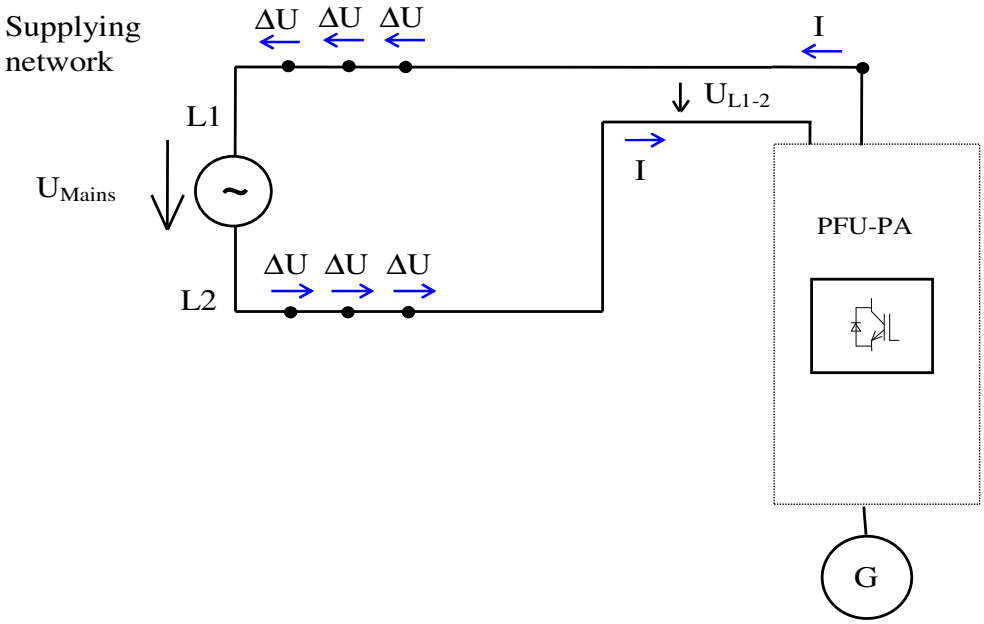


Figure 12: Incorrect voltage drop at supply operation

Assuming a mains voltage of e.g. 400V and a current of 80A, a voltage of 8V drops than on a bad conducted clamping point with R=100mΩ. At seven clamping points at the input terminals of the mains of the PFU systems is an incorrect high voltage of 456V connected. A good conducted clamping point has a contact resistance of ca. 1mΩ.

Danger!

High impedance contact resistances can generate overvoltage and can lead to destruction of the connected PFU system and the remaining loads.

Current carrying capacity of Cu-cables

Table 3 shows the current carrying capacity of Cu-cables*:

Wire cross-section [mm²]	Conductor radius [mm]	Pre fuse [A]	Max. continuous current [A]
16	2,3	63	46
25	2,8	80	59
35	3,3	100	73
50	4,0	125	90
70	4,7	160	106
95	5,5	200	140
120	6,2	250	206
185	7,7	315	250
2x120	2x6,2	400	300
2x150	2x6,9	500	390
2x185	2x7,7	630	485
3x185	3x7,7	800	570
3x240	3x8,7	1000	740
4x240	4x8,7	1250	920

Table 3: The current carrying capacity of Cu-cables

* These parameters are based on a cable length of 100m and a maximum fall of voltage of 5V.

2.2.3 Unchoked compensation plants and resonance danger

Disturbances or damages at compensation plants can affect the rate of the line voltage and cause significant damages by overvoltage.
In practice are today still many compensation plants unchoked in use. The problems, which can occur in connection with a compensation plant without chokes, are varied:

- direct Resonance
- resonance lifting
- switching transients or Impairment of ripple control transmission

The rate of this overcompensation affects the rate of the appearing voltage boost. The previous impact of harmonics at the medium voltage level and the operation of not linear loads on the low voltage level can lead to distortion of the line voltage.
This previous impact of harmonics is transmitted by the transformer to the low voltage level and sums with the distortions on the low voltage level. In dependence of the frequency spectrum of the harmonics overvoltage can appear, which are excited by the resonance with the compensation pant. These phenomena appear especially often in the range of the 5th harmonic.

Example 2:
Calculation of the resonance frequency in dependence on figure 8:

Transformer: $100kVA$, U_k=4 %, f_{Mains}=$50\ Hz$
Compensation: 30kvar

$$S_{kT} = \left(\frac{100kVA}{4\ \%}\right) * 100\ \% = 2{,}5\ \text{MVA}$$

Short circuit power transformer

$$f_r = \left(\frac{2{,}5\ MVA}{30\ kvar}\right) * 50\ Hz = 456\ \text{Hz}$$

Resonance frequency

- The resonance frequency at example 2 is in the range of the 9th harmonic of f_9=450Hz. The PFU system provides as good as no current harmonics at the 9th harmonically harmonic. The harmonics of the PFU system are in the 5´th, 7th, 11th and 13th current harmonic and should be avoided as resonance frequency at the dimensioning of compensation plants.
- If no other loads produce 9th harmonically current harmonics, this dimensioning would be evaluated as uncritical.
- This calculation disregards the short-circuit impedance of the medium voltage level.
- A symmetric loaded grid is assumed.

Additional operating safety affords an in serial to the compensation plant connected choke. These chokes should be so dimensioned, that the resonance frequency of this series resonant circuit is under the 5th harmonic. In practice values of e.g. 189 Hz, 204Hz, and 223Hz have proved.

A compensation power, which exceeds the reactive power of the loads (overcompensation), can lead to voltage boosts and over voltages.
The overcompensation causes at isolated networks massive problems in the form of overvoltage, floating and voltage boosts.

2.2.4 Operating behaviour of the current-leaded PFU system

The inverter of the PFU system is depended of the current structural condition of the line voltage. Commutation notch or voltage fluctuation in the network affect at the supplied current of the device. To feedback the required power, at a short-time notch of the line voltage the current must accordingly increase. If the line voltage falls for a long time, so the maximum power of the PFU system reduces. A phase failure leads to a pulse lock, an error message and the PFU system supplies no current into the network. At a phase failure the over-current release, the under voltage detection or the phase failure supervision can trigger a pulse lock. An anti-islanding unit and its function cannot be realized with these PFU monitoring.

The current-lead PFU system cannot generate an own voltage at power failure.

2.3 Specific information for the planning of installations with PFU systems

Photovoltaic cells have generally a relative low output voltage (12 to 100V per module) at the MPP operating point. To ensure a stable operation with the inverter, so many modules must be connected in series, that a minimum direct voltage of ca. 100V* is generated. At maximum output voltage of the modules, at 400V line voltage, must an input direct voltage of the inverter of 500V not be exceeded, to ensure the full adjustment range (P=0-100%). The open circuit voltage of the module must not exceed a value of 700V (at minimum line voltage).

2.3.1 Introduction into the subject MPP tracking

In order that a solar cell or a solar generator always works at the Maximum Power Point (MMP), a MPP- tracker is used, which regulates the voltage on the required parameter.
The Maximum Power Point is the point of the I-V-curve of a solar cell, where the maximum power can be taken. The MPP is not constant, but depends on the irradiance, the temperature and the type of the solar cell.

- At rising irradiance the current raises approximate proportional, the power considerably increases. The voltage changes low.
- At rising temperature the voltage falls, so that the power falls (typical: 0,4 % / Kelvin), the current changes here insignificant.

This control is taken over by the MPP- Tracker, as the MPP- Tracker controls the boost- and buck converter adequate.
The Maximum Power Point (MPP, Maximum Power Point) follows by the product:

$$P_{max} = U_{pmax} * I_{pmax}$$

These parameters can be taken by the data sheets of the manufacturer.

Figure 13 shows the I-V-curve of a solar cell with the belonging MPP:

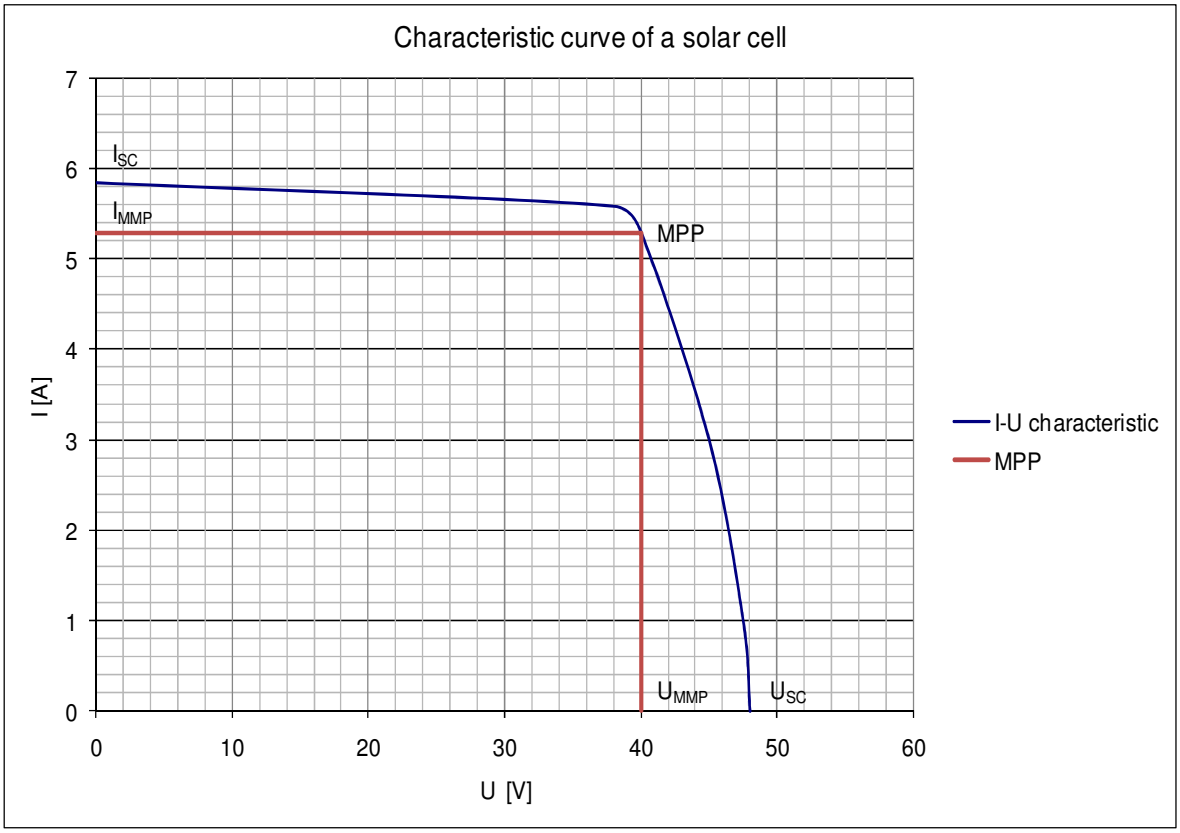


Figure 13: The I-V-curve of a solar cell with the belonging MPP

2.3.2 Selection of the system voltage of photovoltaic systems

Photovoltaic cells have generally a relative low output voltage (12 to 100V per module) at the MPP operating point. The source voltage, which results of the connection in series, is designated as PV system voltage, which adjusts at the MPP operating point.

- To ensure a stable operation with the inverter, so many modules must be connected in series, that a **minimum direct voltage** of ca. 100V is generated.
- The **maximum rate of the MPP-voltage** of the in series connected modules should not exceed the value 500V. This value of 500V ensures the operation of the PFU system inside the whole adjustment range (P=0-100%) of the MPP tracker.
- The **open circuit voltage** of the module must not exceed a value of 700V.

These values are valid at a specification of the installation for the operation at a line voltage of 400V and a tolerance of +/- 10 %.

Information for the planning of installations

In the following diagram are 5 operating ranges defined which result of the rate of the PV system voltage:

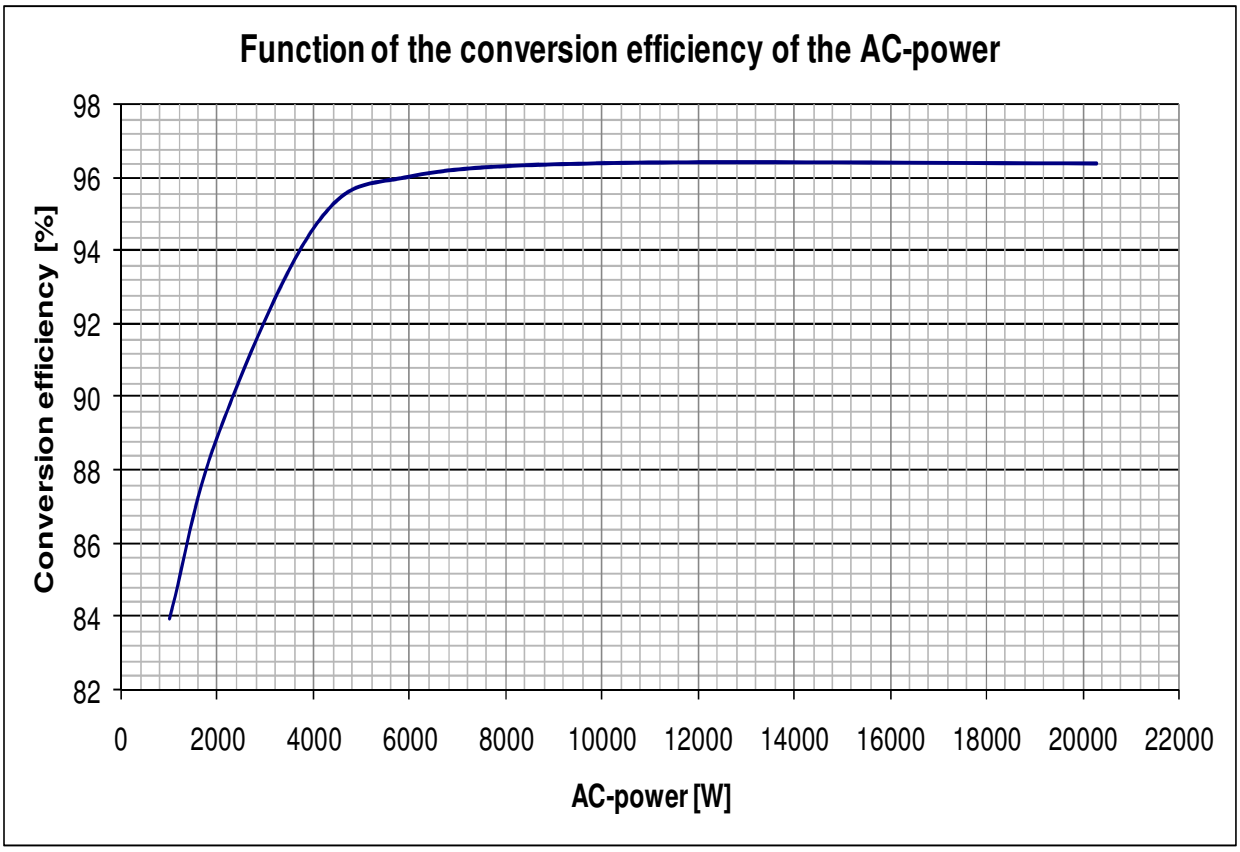


Figure 14: Operating ranges of the PFU-PD …-400V systems

Operating ranges of the PFU-PD …-400V systems subject to the source voltage see figure 14:

A: Pulse lock and source current is zero.
B: MPP-operation to the maximum source current, the resultant, maximum power results of the connected source voltage.
C: MPP-operation to the maximum power, the source current results of the connected source voltage.
D: No MPP-operation possible.
E: Dangerous high source voltage!
Voltages higher than 700V can lead to damages at the PFU system.

The rate of the system voltage affects to the efficiency of the PFU system and is picked out as a central theme in the next chapter 2.3.3.

2.3.3 Conversion- and MPP- efficiency using the example of a PFU-20 series

In this chapter different efficiency are considered:

- MPP efficiency is the value, which represents the deviation of the MPP tracker of the ideal value.
- Conversion efficiency is the value, represents the deviation of the power, which is adjusted by the source to the value which is supplied into the mains.
- The operation of the PFU system with MPP Tracker is:

$$\text{Total efficiency} = \text{Conversion efficiency} * \text{MPP efficiency}$$

- The operation of the PFU system with external setpoint is:

$$\text{Total efficiency} = \text{MPP efficiency}$$

Voltage point	P_{DC} [W]	U_{DC} [V]	I_{DC} [A]	P_{AC} [W]	$\eta_{P\%}$
200	10676,00	207,91	51,60	10097,50	94,57900
300	10580,00	301,26	35,31	10086,80	95,33600
400	10608,00	400,35	26,69	10185,90	96,02100
500	10611,00	500,55	22,05	10263,30	96,72200

Table 4: Measurement of the conversion efficiency in dependence of the rate of the source voltage

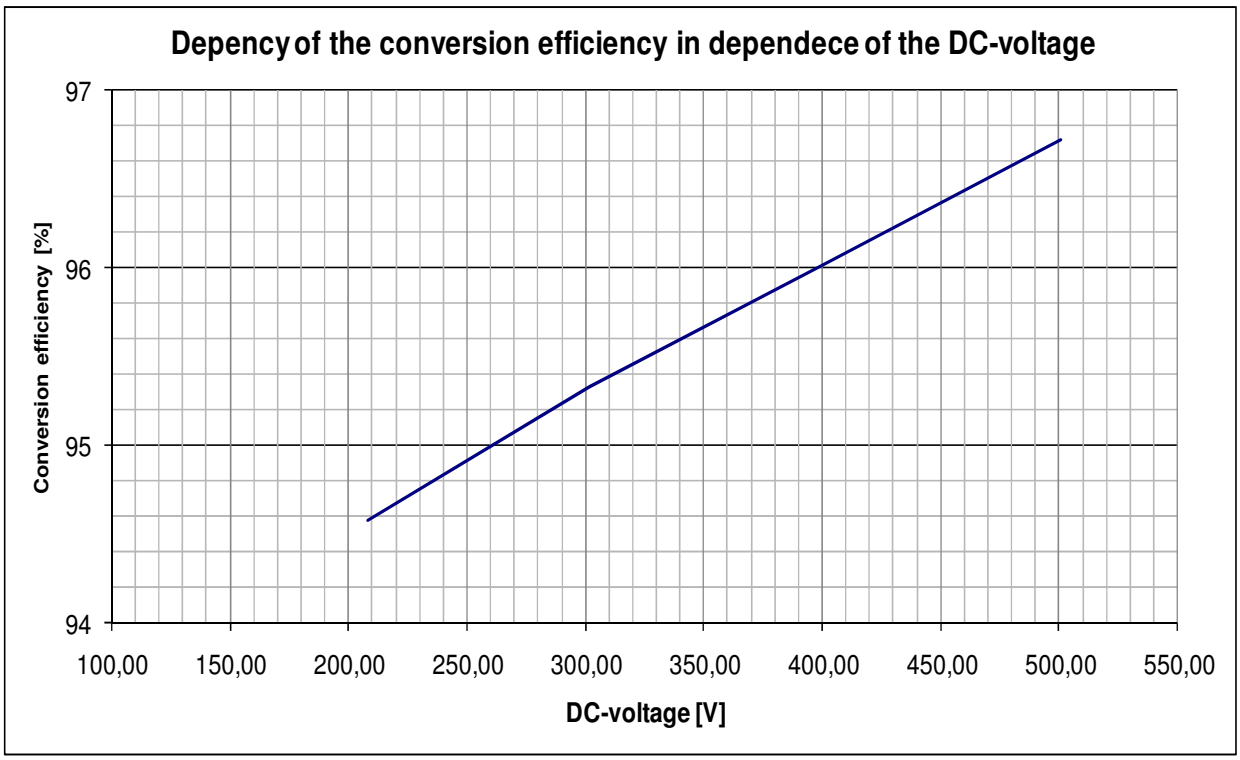


Figure 15: The conversion efficiency of the measurement table 2.3.3

- The conversion efficiency rises at all source power linear with the rate of the source voltage.
- The optimum operating range with regard to the efficiency is arranged in the range C in figure 14

Measurement table 5: Conversion efficiency in dependence of the power:

Power point	P_{DC} [W]	U_{DC} [V]	I_{DC} [A]	P_{AC} [W]	$\eta_{P\%}$
100%	21061,00	446,45	47,50	20300,40	96,39
50%	10651,00	451,01	23,91	10267,70	96,40
30%	6339,00	452,04	14,33	6087,80	96,05
20%	4321,00	452,73	9,74	4095,20	94,77
10%	2258,00	271,74	8,34	2007,50	88,91
5%	1212,00	269,41	4,52	1017,50	83,96

Table 5: Measurement: Conversion efficiency in dependence of the power

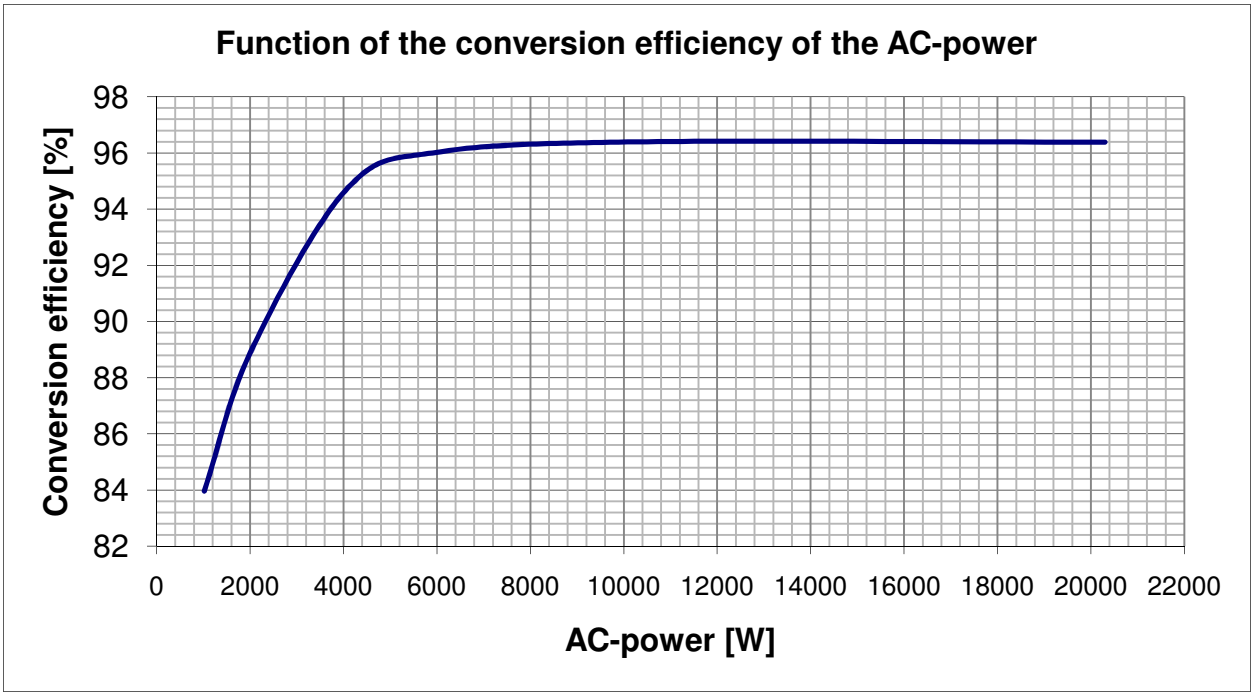


Figure 16: The conversion efficiency of the measurement table 6

- **Note: All MPP efficiencies are based on measurements, which are determined by simulations of voltages sources by laboratory conditions.**
- **The MPP efficiencies can deviate of the indicated values in dependence of the used voltage sources.**

Measurement table 6: MPP efficiency in dependence of the source voltage and the source current.

U_{Mains} [V]	P DC [kW]	U_e [DC]	I_e [DC]	I_{eff} Mains 100% [A]	I_{eff} MPP Mains [A]	$\eta_{MPP\%}$ Overload I_e
405,00	6,27	152,00	38,72	14,44	14,02	97,0914127*
405,00	7,33	176,00	40,20	15,43	14,98	97,0836034*
405,00	9,07	211,00	40,40	17,14	16,94	98,8331389
405,00	10,82	255,00	40,95	19,61	19,41	98,9801122
405,00	12,30	294,00	41,50	21,52	21,23	98,6524164
405,00	14,04	326,00	42,60	23,88	23,49	98,3668342
						98,7081254

Table 6: The measurement of the MPP tracking with a PFU-20

* Input voltage under 200 V, outside of the MPP-range

DC [kW]	U_e [DC]	I_e [DC]	I_{eff} Mains 100% [A]	I_{eff} MPP Mains [A]	$\eta_{MPP\%}$ Overload I_e
8,10	160,00	50,50	16,16	16,00	99,0099010
9,90	189,87	52,14	18,23	18,07	99,1223258
11,77	226,00	51,90	20,56	20,40	99,2217899
14,26	272,66	52,30	23,69	23,46	99,0291262
16,67	324,00	51,40	26,80	26,56	99,1044776
19,19	365,00	52,40	30,14	29,86	99,0710020
				· $\bar{\eta}$	**99,0931038**
				η_{MPP} total%	**98,8895637**

Table 7: The measurement of the MPP tracking with a PFU-20

η_{MPP} total% is the averaged value of the previous two series of measurement.

--

2.3.4 MPP efficiencies of the PFU-7 series

Table 8: Measurement of the MPP efficiencies at a PFUPA 7:

U_{Mains} [V]	P DC [kW]	f_G [Hz]	U_e [AC]	I_{eff} Mains 100% [A]	I_{eff} MPP Mains [A]	$\eta_{MPP\%}$ Overload I_e
405,00	3009,2634	31,5	135,00	4,29	4,25	99,0675991
405,00	3395,0664	40,3	155,00	4,84	4,80	99,1735537
405,00	4278,9060	50,0	190,00	6,10	6,04	99,0163934
405,00	4706,7966	55,0	207,00	6,71	6,64	98,9567809
405,00	5141,7018	60,0	227,00	7,33	7,25	98,9085948
405,00	6060,6144	70,0	263,00	8,64	8,55	98,9583333
405,00	6909,3810	80,0	300,00	9,85	9,75	98,9847716
					· $\bar{\eta}$	**99,0094324**

Table 8: The measurement of the MPP tracking with a PFU- PA-7

Table 9: Measurement of the MPP efficiencies with a PFUPA 7:

U_{Mains} [V]	P DC [kW]	f_G [Hz]	U_e [AC]	I_{eff} Mains 100% [A]	I_{eff} MPP Mains [A]	$\eta_{MPP\%}$*
405,00	5794,0596	53,0	215,00	8,26	8,06	97,5786920
405,00	7666,9578	70,0	285,00	10,93	10,69	97,8042090
405,00	8768,2500	80,0	324,00	12,50	12,25	98,0000000

*Overload I_e

Table 9: The measurement of the MPP efficiencies with a PFU PA-7

Table 10: Measurement of the MPP efficiencies with a PFUPD-7 device:

U_{Mains} [V]	P DC [kW]	I_{eff} Mains 100% [A]	I_{eff} MPP Mains [A]	$\eta_{MPP\%}$ Overload I_e
405,00	2700,6210	3,85	3,78	98,1818182
405,00	3787,8840	5,40	5,31	98,3333333
405,00	4349,0520	6,20	6,15	99,1935484
405,00	5015,4390	7,15	7,10	99,3006993
405,00	5646,7530	8,05	8,00	99,3788820
			· $\bar{\eta}$	**98,8776562**
			η_{MPP} total%	**98,9435443**

Table 10: The measurement of the MPP efficiency with a PFU PA-7

3 Legal regulations, standards and safety

<table>
<tr><td>Marking</td><td>Name plate</td><td>CE-marking</td><td>Manufacturer</td></tr>
<tr><td></td><td>REVCON® PFU systems are clearly marked by the content of the nameplate</td><td>Conformable to EG directive “low-voltage“</td><td>ELTROPLAN-REVCON
Edisonstraße 3
D-59199 Bönen</td></tr>
<tr><td>Trade mark rights</td><td colspan="3">The essential components of the REVCON® PFU system are protected in the Federal Republic of Germany and in Europe by a utility patent. Patent-Nr.: DE 3938654C1 und Patent-Nr.: 90123584.6-2207.
Violation of this patent text and the verbalized trade mark rights will be prosecuted criminally.</td></tr>
<tr><td>Intended use</td><td colspan="3">REVCON® PFU system
• only to use under the terms of this operating instructions and the required operational conditions
• are components
– to reduce the feedback of the electrical network by specific B6 rectifiers and inverters
– to fit in a machine
– to assembly with other components to a machine together
• are electric equipment to assembly in a electrical enclosure or similar
• locked up operations rooms
• conform to the protection requirements of the EG directive “low-voltage “
• are no machines in terms of the EG directive “machines“
• are no household appliances, but components which are determined only for the further application in commercial use
Drive system with the REVCON® PFU system
• conform to the EG directive “Electromagnetic Compatibility“, if they are installed by the specifications of the CE-typical drive control system
• are applicable
– in the public electrical network and closed electrical networks.
– in the industrial sector and in living areas as well as in business units.
The responsibility for the compliancy of the EG directive with the machine application is one for the user.</td></tr>
<tr><td>Liability</td><td colspan="3">• The indicated information, technical data and notes in this operating instruction were updated at the time of the printing. No demands for changing a delivered filter module can be asserted by the information, figures and descriptions of these operating instructions.
• The represented process engineering notes in this operating instructions and circuit details are suggestions, which transferability on the respective application must be verified. For the suitability of the specified procedures and circuit suggestions accepts the ELTROPLAN-REVCON GmbH no guarantee.
• The data in these operating instructions describe the characteristic of the products without ensuring them.
• No Liability will be taken over for damages and malfunctions which result by:
– disregard of the operating instructions
– optional changes on the PFU system
– operating errors
– improper works on and with the PFU system</td></tr>
<tr><td>Warranty</td><td colspan="3">• Warranty conditions: Look at the sales - and delivery conditions of the ELTROPLAN-REVCON GmbH.
• Immediately announce guarantee claims after the discovery of defects or faults
• The warranty expires in all cases, in which even no liability claims can be asserted.</td></tr>
<tr><td>Disposal</td><td>Material</td><td>Recycling</td><td>Disposal</td></tr>
<tr><td></td><td>Metal</td><td>●</td><td>-</td></tr>
<tr><td></td><td>Plastic</td><td>●</td><td>-</td></tr>
<tr><td></td><td>Assembled printed circuit boards</td><td>-</td><td>●</td></tr>
</table>

Legal regulations, standards and safety

3.1 What is the purpose of EG-directives?

The EG-directives are composed by the European Council and are used as definitions of common technical requirements and certification procedures inside the European Community. At the moment there are 30 EG-directives for different sections. The standards are or will be converted by the respective member states in national laws. An in a member state issued certificate is automatically valid without more testing in all other member states.

The directive- texts restrict on the formulation of the essentially requirement. The technical details are or will be defined in European harmonized standards.

3.2 What is the meaning of the CE- marking?

CE

After an already made Conformity valuation method the accordance with the requirements of the EG- directives will be confirmed by the mounting of a CE-marking. Within the EG consist for a CE-marked product no trade barriers.

Feedback units with CE-marking comply independently, exclusively the low voltage-standard. To the compliance with the EMC-standard recommendations will be pronounced (EMC standard 2004/108/EG).

3.3 EG-directive low voltage

Low voltage-directive	(73/23/EWG)
Changed by:	CE - directive (93/68/EWG)
	CE - directive (2006/95/EG)

General:

- The low voltage-directive is valid for all electrical devices to use at a nominal voltage between 50V and 1000V alternating voltage and between 75V and 1500V direct voltage and at usual environmental condition. Expected is for example the usage of electrical devices in explosive atmosphere and electrical parts of person- and freight elevator.

- Protection target of the low voltage-directive is to put only such electrical devices on the market, which do not endanger the safety of humans or animals and the conservation of material assets.

EG-declaration of conformity

in terms of the EG-directive low voltage (2006/95/EG)

Changed by: CE - directive (93/68/EWG)
CE - directive (2006/95/EG)

The REVCON® PFU systems were developed, designed and manufactured in accordance to the above named EG- directive in exclusive accountability by

**ELTROPLAN-REVCON Elektrotechnische Anlagen GmbH,
Edisonstraße 3, D-59199 Bönen**

Considered standards:

Norm	
EN 61558-1/A1	Safety of power transformers, power supplies, reactors and similar products
EN 60529	International protection rating
DIN EN 61000-6-3:2007 part 6.3 / IEC 61000-6-3:2006	Generic standards – Emission standard for residential, commercial, and light- industrial environments
DIN EN 61000-6-4:2007 part 6.4 / IEC 61000-6-4:2006	Generic standard for industrial environments

Table 11: Considered standards

3.4 EG-directive Electromagnetic compatibility

EMC directive (89/336/EWG)
Replaced by: EMC-directive (2004/108/EG)

General:

The objective target describes article 4 (2004/108/EG), as follows:

The... designated devices must be so manufactured, that

(a) an intended operation of radio- and telecommunication devices and other devices is possible and

(b) the devices have an adequate stability against electromagnetically disturbances, so that an intended operation is possible.

Legal regulations, standards and safety

EG-declaration by the manufacturer

in terms of the EG-standard EMC (2004/108/EG)

The listed REVCON® products are in terms of the EMC no independently recoverable products, this means only after integration in the overall system would they be rateable regarding to EMC. The rating became detected for typical plant constructions, but not for the several products.

**ELTROPLAN-REVCON Elektrotechnische Anlagen GmbH,
Edisonstraße 3, D-59199 Bönen**

3.5 EG-directive on machinery

Machine directive (98/37/EG)
Changed by: Modification directive (2006/42/EG)

General:

Machinery means an assembly, fitted with or intended to be fitted with a drive system other than directly applied human or animal effort, consisting of linked parts or components, at least one of which moves, and which are joined together for a specific application.

EG- declaration by the manufacturer

in terms of the EG-directive machines (2006/42/EG)

The inverter REVCON® PFU were developed, designed and manufactured in accordance to the above named EG- directive in exclusive accountability by

**ELTROPLAN-REVCON Elektrotechnische Anlagen GmbH,
Edisonstraße 3, D-59199 Bönen**

The operation of the filter module REVCON® RHF is prohibited as long as it is determined, that the machine, in which it should be installed, conforms to the regulations of the EG-directive machines.

3.6 Safety instructions

Safety- and application instructions for propulsion converters

(in conformity with low- voltage directive 2006/95/EG)

1. General
During the operation filter modules can own according to their protection class live, blank and if necessary even movable parts, as well as hot surfaces.
The hazard of severe person or property damage exists at not permissible removal of the required coverage, at inadmissible application, at false Installation or operation.
Further information can be learned from the documentation.
All works for transport for installation and commissioning as well as maintenance has to be done by specialized staff (IEC 60364 or CENELEC HD 384 or DIN VDE 0100 und IEC-Report 664 or DIN VDE 0110 and observe national accident prevention regulations).

Specialized staffs in terms of these fundamental safety instructions are persons who are acquainted with installation, assembly, commissioning and operation of the product and who dispose through their work of the corresponding Qualifications.

2. Conventional application
Filter modules are components that are conventional for the installation in electrical systems or machines.
At the installation in machines is the start-up of the filter modules (the start of the conventional operation) prohibited until it is determined that the machine complies with the regulations of the EG directive 2006/42/EG (Machine directive); EN 60204 is to observe.

The start-up (the start of the conventional operation) is only allowed under compliance of the EMC-directive. The filter modules comply with the requirement of the low- voltage directive 2006/95/EG. The technical Data and also the data of the connecting conditions have to be taken from the name-plate and the documentation and they have to be necessarily observed.

3. Transport, storage

The information for Transport, storage and appropriate Handling has to be observed.
The filter module has to be protected of not permissible stress. Particularly at transport und handling no components must have to be bent and / or insulation distances being changed. The touch of electric components and contacts is therefore to avoid. At mechanical defects at electric and other components it is not allowed to commission the device, because a compliance of applied standards is not longer **guaranteed**. Climatic conditions have to be observed accordant to prEN 50178.

4. Assembly
The Assembly and cooling of the devices must occur accordingly the instructions of the respective documentation.
The filter modules have to be protected of not permissible stress. Particularly at transport und handling no components must have to be bent and / or insulation distances being changed. The touch of electric components and contacts is therefore to avoid. Electric components must not be mechanical damaged or destroyed. (Under conditions health hazards!).
At mechanical defects at electric and other components it is not allowed to start up the device, because a compliance of applied standards is not longer guaranteed**.**

5. Electrical connection
At live-line working on filter modules apply national accident prevention regulations (VBG 4) must be observed. Before any installation- and connection works the system must be operated on dead voltage and accordingly must be secured.
The electric installation must be performed according to the respective instructions (e.g. cable cross- section, fuses, connection to the protective conductor). At usage of the filter module with drive system control without a safe disconnect from the supplying circuit (according to VDE 0100) all control cables must be included in additional protective measures (e.g. double insulated or shielded, grounded and insulated).
Notes for the EMV-conform installation – like shielding, grounding, arrangements of filter modules and the installing of conductors – are located in the chapter “Installation of these operating instructions”. These notes must even be observed at CE-marked propulsion converters. The compliance of the required limit values by the EMV- legislation is up to the responsibility of the manufacturer of the system or the machine.

6. Operation
After disconnect of the filter modules of the supply voltage, it is not allowed to touch live-line device parts and line connections because possibly charged capacitors must not be touched immediately.
During the operation all covers and doors must be closed.

7. Service and Maintenance
The operation of the manufacturer must be observed.

These safety instructions have to be kept!

Observe also the product specific safety- and application notes of these operating instructions!

3.7 Layout of the safety instructions

All safety instructions are built uniformly:

- The pictogram marks the type of danger.
- The signal word marks the severity of danger.
- The legend marks the danger and gives notes, how to avoid the danger.

Signal word
Legend

	Used pictograms		Signal words	
Warning of injury to persons		Imminent danger by current	**Danger!**	Warns of an immediately imminent Danger. Consequences by disregard: Death or severe injuries
		Warning of a imminent danger	**Warning!**	Warns of a possible, very danger situation. Possible consequences by disregard: Death or severe injuries
		Dangerous situation	**Caution!**	Warns of a possible, dangerous situation. Possible consequences by disregard: Minor or small injuries
		Warning of hot surface	**Warning!**	Warns of touching a hot surface. Possible consequences by disregard: Burnings
Warning of property damages		Harmful situation	**Stop!**	Warns of possible property damages. Possible consequences by disregard: Damage of the drive system or its surroundings
Useful information and application notes		Information	**Note!**	Marks a generally, useful note, tip. If you follow it, you make the handling of the filter module easier

3.8 General safety guidelines

No demand of completeness will be raised with these safety guidelines.
By questions and problems please confer with a technician of our company.

The inverter complies at the time of the delivery the status of the technical and is valid fundamentally as reliable.

The data of these operation instructions describe the characteristics of the products, without assuring them.

Danger!

Dangers go out from the PFU systems for persons, the inverter itself and for other material assets, when not qualified staff is working on and with PFU system and if the PFU systems are used improperly.

- The PFU systems must be so projected, that they comply their function at proper installation, at intended use and at error-free operation and cause no danger for persons. This is valid even for their interaction with the complete plant.
- The in this operation instructions represented procedural notes and circuit details have to be understood analogously and have to be verified to assignability to the current application.
- The operation of this device is due to causes of personal security to compliance the EMC-instructions and to warranty the accordingly ventilation, only permitted with closed and screwed together cover!
- Operate the drive system only at perfect state.
- Changes or modifications of the inverter are fundamentally prohibited.
  They require in any event the confer with a technician of our company
- The granted guarantee from us expires, if the device is changed or (even partly) dismantled, or if it is deployed in contradiction to our instruction.
- The right selection and arrangement of the electrical equipment is the responsibility of the installer of the plant, the knowledge of technical rules is expected from the installer.
- The operation of the inverter is only permitted on standard conform grids of the electrical energy supply! Disregard can lead to reduction of the filter effect and possibly to destruction of the inverter.

Legal regulations, standards and safety

Stop!

The operation of the PFU systems is only permitted on standard conform grids of the electrical energy supply! Disregard can lead to reduction of the filter effect and possibly to destruction of the filter module.

- According to the corresponding standards and guidelines is the operation even at for a short time overcompensated grids ($\cos\varphi \leq 1$) respectively at compensation plants without chokes not permitted, because the otherwise caused by oscillation recurrent surges can damage all connected loads, particularly electronic equipment for example drive controller and inverter damage.

Stop!

At low- or unstressed generators as well at variable transformers it must not be feed backed in no case without previous consultation with our application department, because this leads to unwanted voltage rises / over voltages! This could lead to the destruction of the inverter and potential connected devices!

- An operation at unearthed electrical network has to be necessarily arranged before with our technicians, because under circumstances devices must be modified for this application. Additional separate security measures (e.g. overvoltage arresters) are necessary, which are subject to arrangement with our technical department. At order are therefore necessarily to specify the network configuration and the designation about the network configuration of the neutral point of the electrical network (earthed or unearthed)!

Stop!

An undisturbed and safe operation of the PFU systems is only to expect under the observance of the following connection instructions.
At deviations of these guidelines in individual case malfunctions and damages could occur.

- Observe the grid- and source voltages.
- Run power- and control lines separated (> 15cm)
- Use shielded / twisted control lines only
- Run the shielding riveted to PE!
- For controlling the logic inputs use only appropriate switching elements, which contacts are appropriate for the corresponding voltages.

- Ground the enclosure of drive, drive control, power feedback unit and the inverter safe. Connect Shielding of power lines riveted and extensive (Remove the lacquer)!

- Ground the electrical enclosure or the plant to main ground star point sigmoid (necessarily avoid ground loops!)
- The inverter is only determined for a solid connection, because particularly at the application of interference filter leakage current of
- 3,5 mA appear. The protective earth conductor must average minimum 10 mm² copper, or one second conductor must be ran electrical parallel to Ground (grounded neutral point sigmoid).

Stop!

At the usage of components, which use no isolated in and outputs, it is necessary, that between the connecting components have the same potential (e.g. by a compensating line). At disregard the components can be destroyed by equalizing currents.

Stop!

At implementation of measuring the insulation according to VDE0100/part 620, the device must be disconnected because of the danger of destruction of the semiconductor, This is allowed according to standard, because all devices are taken to a high voltage test according to VDE 0160 (EN 50178) in line with the final check.

- A standard-ground fault circuit interrupter (pulsed current sensitive) is not allowed as an exclusive protection measure at frequency converter- operation with inverter, because the constant component in the residual current prohibits the activation of a standard-ground fault circuit interrupter. According to VDE 0160 is therefore a protective circuit with standard-ground fault circuit interrupter not allowed as exclusive protection measure. In connection to the available network configuration (TN, IT, TT) more protection measure are necessary according to IEC 60364 and VDE 0100 part 410 and. At TN-networks it is e.g. the protection by over current protection, at IT-network it is the insulating monitoring device with pulse-code measuring method. At all network configurations a safety separated circuit can be used, if the necessary power and line lengths allow this.

  The following measures have to be considered at the selection of the ground fault circuit interrupter:

Legal regulations, standards and safety

- The standard-ground fault circuit interrupter must comply with the new construction according to VDE 0664.
- The release current should average 300 mA or more, to avoid an early release by a leakage current. Dependent of the load, the line length of the generator and the application of an interference filter considerable lager leakage currents could occur.

Note!

Residual current devices with RCD sensitivity have an extensive protection and are valid as exclusive protection measure. The connection instructions of the respective manufacturer have to be observed.

3.9 For the safety responsible persons

Operator

- Operator is every natural or legal person, which uses the drive system or in which order the drive system is used.

  The operator respectively his safety representative must assure:

- That all relevant instructions, notes and laws will be abided
- That only qualified staff works on and with the drive system
- That the staff has the operating instructions at all respective works availably
- That not qualified staff is the work on and with the drive system prohibited.

Qualified staff

Stop!

Qualified staff means persons, that are entitled (by the safety responsible) due to their training, experience, education, their knowledge in relevant norms, directives, accident directives and operation conditions to execute the necessary works and to recognize possible danger and to avoid it. (Definition of qualified staff IEC 364)

Indented use

Danger!

Inverters are components, which are determined for the installation in electrical installations or machines. They serve exclusively for the operation on permanent magnet motors or photovoltaic systems (depending on the construction). The operation on other electrical loads is incorrect and can lead to the destruction of the devices. The connection of the inverter is only on symmetrical grids allowed. Non observance can lead to the destruction of the devices.

Legal regulations, standards and safety

3.10 Remaining danger

Danger!

After switching off the electrical network, the connections for + and – could lead dangerous voltage for some minutes.

Stop!

Cyclic switching on and off of the supply voltage at L1, L2 und L3 can overload the input current limiting: Wait minimum 1 minute between switching on and off.

4 Technical data and dimension diagrams of the PFU-P series

The following data affect the PFU systems for a line voltage of U_{eff}=400V. The series for higher line voltages are considered in a separate operating instruction.

4.1 General Data and Operation conditions

Range	Data
Valid temperature range*	At transport of the device: -25°C...+70°C (following DIN EN 50178) At storage of the device: -25°C...+55°C (following DIN EN 50178) At operation of the device: 5°C...+35°C
Stress of humidity*	Humidity class F without dew (5% - 85% relatively humidity)
Altitude of side h*	h ≤ 1000 m üNN without power reduction 1000 m üNN < h 4000 m üNN with power reduction
Air pressure*	86kPa – 106kPa according to VDE 0875 part 11 und prEN55082
Degree of pollution	Stress of humidity 2 following VDE 0110 part 2
Insulation stability	EN 61000-4-4 Severity level 4 EN 61000-4-2 Severity level 3 EN 50082-2 Criterion A
Package	DIN 55468 for transport package materials
Protection class	IP 20
Approvals	CE: Low- voltage directive

Table 12: General data and operation conditions

*Climatic terms following class 3K3 (EN 50178 part 6.1)

Technical data and dimension diagrams

4.2 Inverter

Device series		PFU 400V
Nominal range of the interlinked electrical network voltage	U_N[V]	400
Tolerance of the line-to-line line voltage	U_N[V]	360 ≤ U_N ≤ 440
Power frequency	f_N[Hz]	50 ± 5 %
Maximum efficiency*	η[%]	96,7 %
Weighted European efficiency	η[%]	95,3 % (typ. PFU-DP 20)
Power factor	cosφ	~ 1
Whole-harmonic ratio Line current	THD-I	~ 10 %
Cooling air requirement**	m³ / h	a) PFU 7-400, 13-400, 20-400, 25-400, 30-400 : 450 b) PFU 50-400, 70-400 : 700 c) PFU 100-250 „Values“
Power reduction	[%/K] [%/m]	40℃ < Ta < 55℃ ⇒ 3%/K 1000m üNN < h ≤4000m üNN ⇒ 5%/1000m

Table 13: Technical data of the PFU systems

* Dependent of the device type and design
** Dependent of the installation size (nominal power of the device)

4.3 PFU devices 7 to 70

4.3.1 Source and rated currents of the PFU devices of the series A and B

PFU-PA and PFU-PD devices	Source AC (PFU-PA) Strom I [A] ED=100% at 360V	Source DC (PFU-PD) Strom I [A] 100% at 450V	AC line current I_{eff} [A] ED=100%	AC line current I_{eff} [A] max.	PFU series
7-400-1-230	12	15	10	12	A
13-400-1-230	22	27	19	23	A
20-400-1-230	34	41	26	31	A
25-400-1-230	42	52	36	44	A
30-400-1-230	51	62	43	51	A
50-400-1-230	85	103	72	86	B
70-400-1-230	119	144	101	120	B

Table 14: Ampacity at rated voltage 400 V

4.3.2 Low frequency filter type SKS-P and Interference filter type RF PFU-P

- For the observation of the EMC-regulations an interference filter of the category B is connected ahead of the PFU systems according to figure 5 and 6. In the table 15 the corresponding interference filter is dedicated to the PFU systems
- The SKS-P filter provide the observance of the THD-I values of the line current, see specification 4.2

Combination filter (RF- und SKS Filter in one enclosure)

Order reference PFU-PD und PFU-PA	Type designation RF Filter and SKS Filter	PFU Series	Combined filter type	Total weight [kg]
PFU-PA 7-400-1-230 PFU-PD 7-400-1-230	RF-SKS-P 7-400	A	1	20
PFU-PA 13-400-1-230 PFU-PD 13-400-1-230	RF-SKS-P 13-400	A	1	22
PFU-PA 20-400-1-230 PFU-PD 20-400-1-230	RF-SKS-P 20-400	A	1	24
PFU-PA 25-400-1-230 PFU-PD 25-400-1-230	RF-SKS-P 25-400	A	1	26
PFU-PA 30-400-1-230 PFU-PD 30-400-1-230	RF-SKS-P 30-400	A	1	28

Table 15: Interference filter

Technical data and dimension diagrams

Total weights:

Order reference PFU-PD and PFU-PA	PFU series	Total weight [kg]
PFU-PA 7-400-1-230 PFU-PD 7-400-1-230	A	58
PFU-PA 13-400-1-230 PFU-PD 13-400-1-230	A	60
PFU-PA 20-400-1-230 PFU-PD 20-400-1-230	A	62
PFU-PA 25-400-1-230 PFU-PD 25-400-1-230	A	64
PFU-PA 30-400-1-230 PFU-PD 30-400-1-230	A	66
PFU-PA 50-400-1-230 PFU-PD 50-400-1-230	A	68
PFU-PA 70-400-1-230 PFU-PD 70-400-1-230	A	70

Table 16: Total weights PFU-PD and PFU-PA

The filter type SKS-P and type RF in separate enclosures

Order reference PFU-PD and PFU-PA	RF type designation	RF construction	SKS type designation	SKS construction
PFU- -50-400-1-230	RF-PFU-P 50-400	2	SKS-P 50-400	C
PFU- -70-400-1-230	RF-PFU-P 70-400	2	SKS-P 70-400	C

Table 17: Filter type SKS-P and type RF in separate enclosures

4.3.3 Dimensions PFU 7-25

- Devices are bolted together with the combined filter, delivery status.

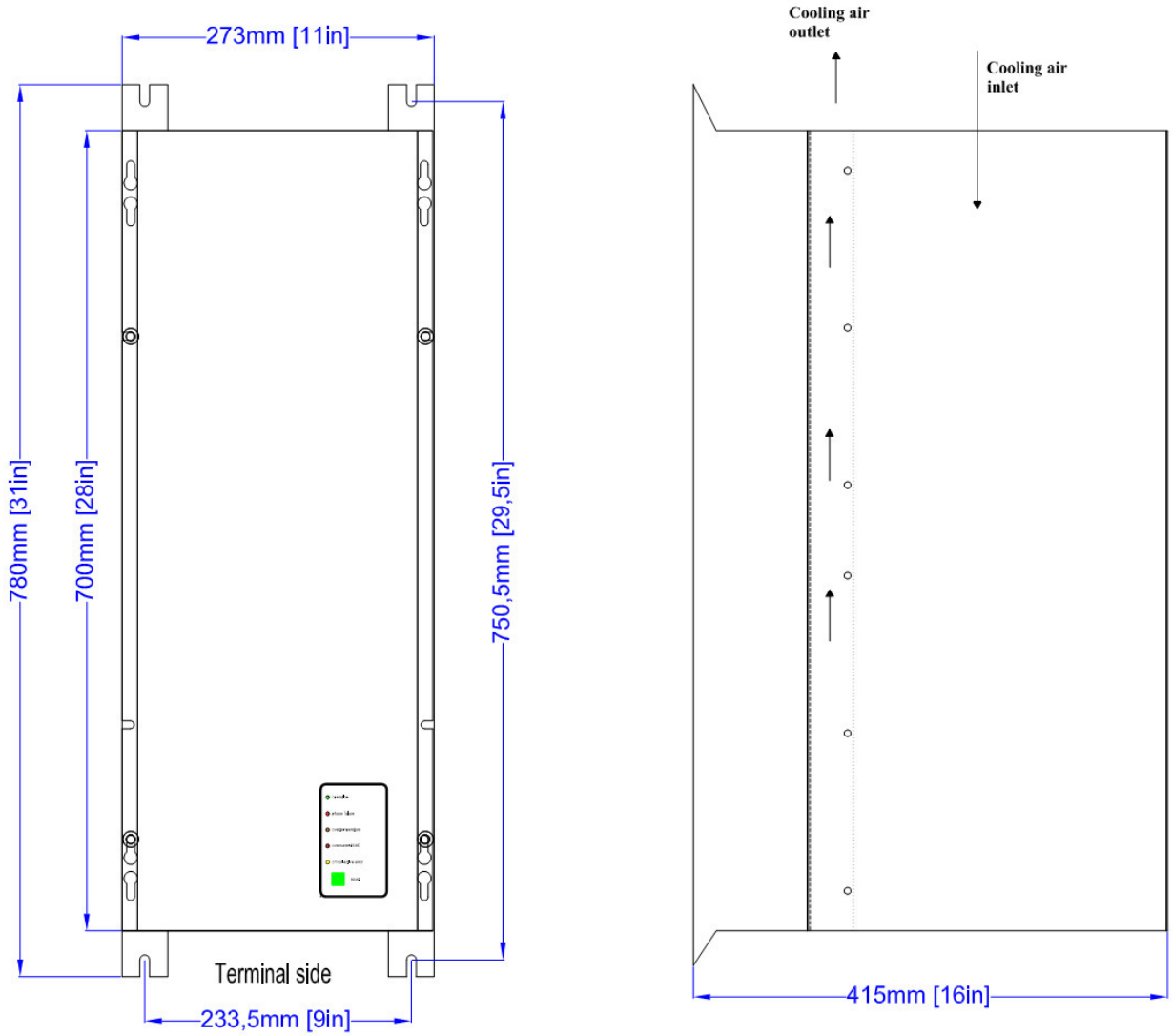


Figure 17: Dimensions PFU 7-25

- **The combined filter and the PFU enclosure are pre-installed ex works and delivered as a packaging unit.**

Technical data and dimension diagrams

4.3.4 Dimensions PFU 30

- Devices are bolted together with the combined filter, delivery status.

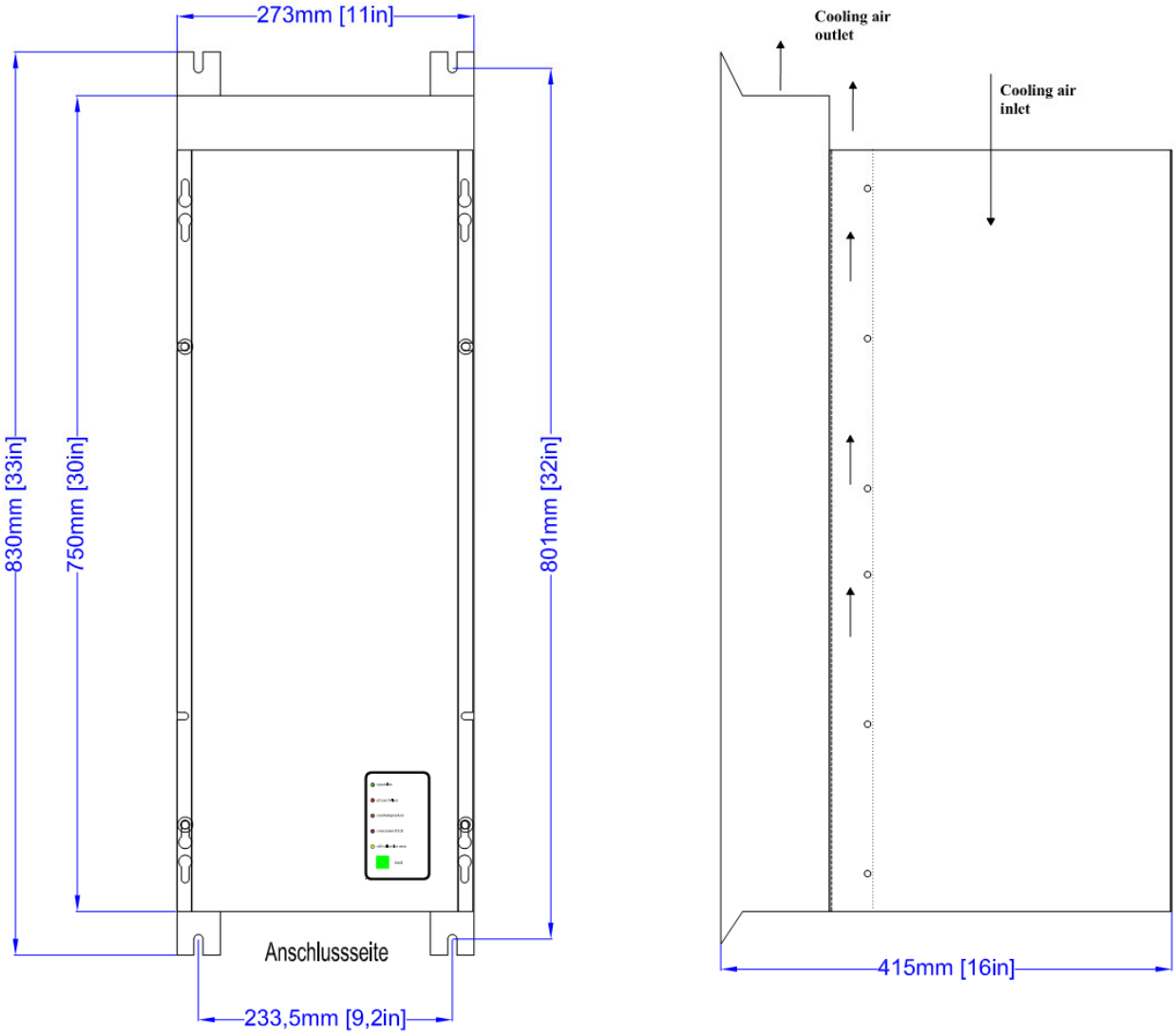


Figure 18: Dimensions PFU 30

- **The combined filter and the PFU enclosure are pre-installed ex works and delivered as a packaging unit.**

Dimensions PFU-P 50 and 70

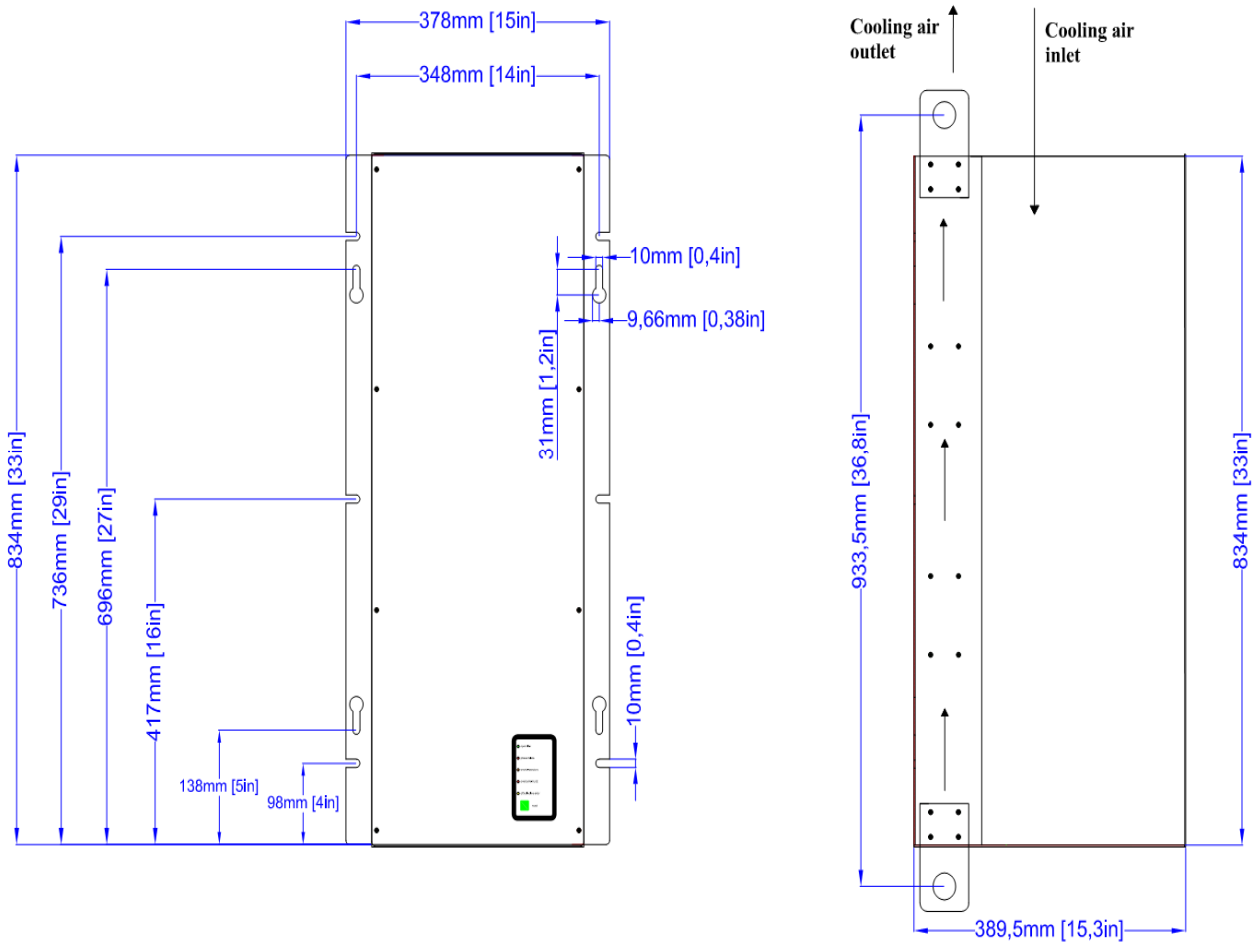


Figure 19: Dimension diagram construction 2: PFU 50 to 70

Technical data and dimension diagrams

Dimensions combination filter RF-PFU 50 and 70, construction 2

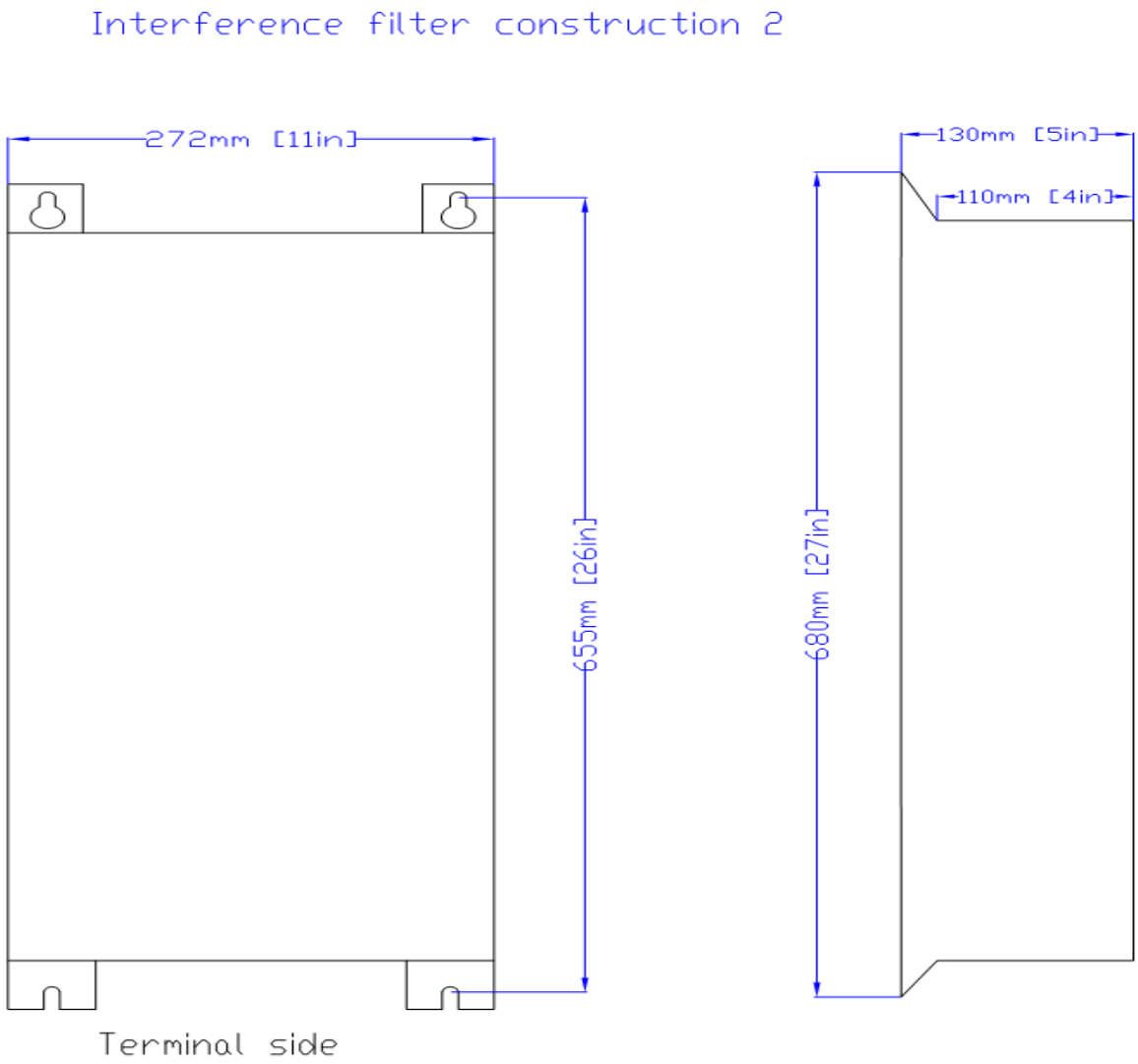


Figure 20: Dimension diagram construction 2: PFU 50 to 70

- **The RF filter can be mounted on the fitting panel of the electrical enclosure.**

Dimensions SKS Filter, PFU 50 and 70, construction C

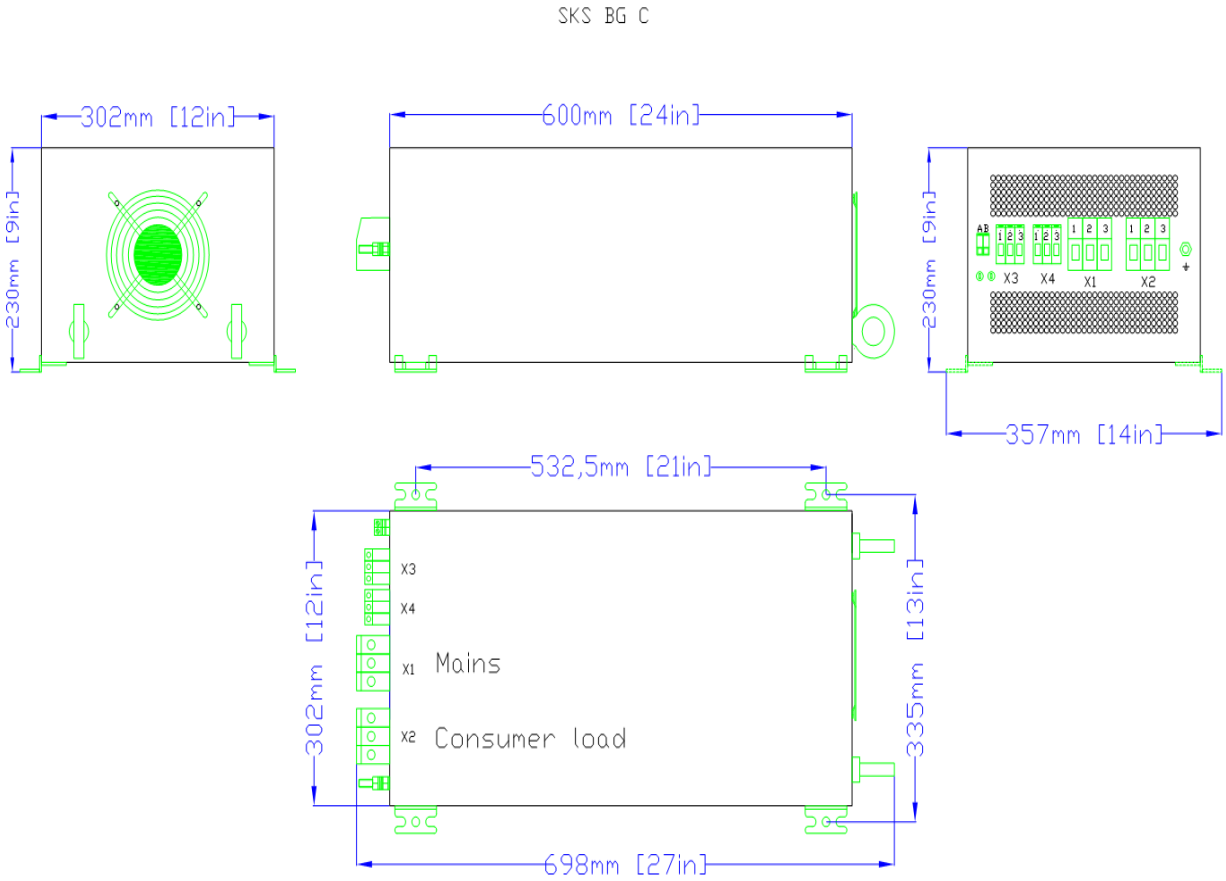


Figure 21: Dimension diagram C SKS filter: PFU-P 50 to 70

Technical data and dimension diagrams

4.4 PFU modules and PFU devices of the series C und D

4.4.1 Source- and line currents of PFU devices of series C and D and the source modules

Order references PFU devices and PFU power modules	Device - type HST-PD or HST-PA	Source AC (HST-PA) Current I_q ED=100% at 340V	Source DC (HST-PD) Current I_q ED=100% at 450V
PQM-P… -50-400-1-230	50-400-1-230	83	100
PQM-P… -70-400-1-230	70-400-1-230	116	140
PFU-P…-100-400-1-230 PQM-P…-100-400-1-230	100-400-1-230	165	200
PFU-P…-150-400-1-230 PQM-P…-150-400-1-230	150-400-1-230	248	300

Table 18: Currents of the HST-P types

Line currents of the PNM power modules and the PFU devices of the series C and D

Order references PFU devices and PNM power modules	Device - types SVCDS-P	Line current [A] ED=100%	Line current [A] max.
PNM-P-50-400-1-230	50-400-1-230	72	86
PNM-P-70-400-1-230	70-400-1-230	101	121
PFU-PA-100-400-1-230 PFU-PD-100-400-1-230 PNM-P-100-400-1-230	100-400-1-230	144	173
PNM-P-125-400-1-230	125-400-1-230	180	216
PFU-PA-150-400-1-230 PFU-PD-150-400-1-230 PNM-P-150-400-1-230	150-400-1-230	216	259
PNM-P-200-400-1-230	200-400-1-230	289	347
PNM-P-250-400-1-230	250-400-1-230	360	432

Table 19: Ampacity at rated voltage 400 V

4.4.2 Assignment of the devices types to the PFU devices and to the PFU modules

Device assignment of the device types HST-P and the types QRD-P

Order references PFU-PA, PFU-PD and PQM-PD, PQM-PA	Type HST-PA	Type HST-PD	Type designation QDR-PA	Type designation QDR-PD
PQM-PA -50-400-1-230	50-400-1-230	-	83/ 50-400-0	-
PQM-PD -50-400-1-230	-	50-400-1-230	-	100/50-400-0
PQM-PA -70-400-1-230	70-400-1-230	-	116/70-400-0	-
PQM-PD-70-400-1-230	-	70-400-1-230	-	140/70-400-0
PQM-PA-100-400-1-230	100-400-1-230	-	165/100-400-0	-
PQM-PD-100-400-1-230	-	100-400-1-230	-	200/100-400-0
PFU-PA-100-400-1-230	100-400-1-230	-	-	-
PFU-PD-100-400-1-230	-	100-400-1-230	-	-
PQM-PA-150-400-1-230	150-400-1-230	-	248/150-400-0	-
PQM-PD-150-400-1-230	-	150-400-1-230	-	300/150-400-0
PFU-PA-150-400-1-230	150-400-1-230	-	-	-
PFU-PD-150-400-1-230	-	150-400-1-230	-	-

Table 20: Device assignment of the device types HST-P and the types QRD-P

Device type HST-PD or HST-PA	Construction HST-P	Construction QDR-PA	Construction QDR-PD
50-400-1-230	B1		
70-400-1-230	B1		
100-400-1-230	B2		
150-400-1-230	B2		

Table 21: Device assignment of the device types HST-P and the types QRD-P

Assignment of the devices SVCDS, SKS and RF

Order references PFU devices and PFU power module PNM	Type designation SVCDS-P-	SVCDS construction	Type designation RF-	RF construction	Type designation SKS-P-	SKS-construction
PNM-P-50-400-1-230	50-400-1-230	B1	PFU-P 50-400	2	50-400	C
PNM-P-70-400-1-230	70-400-1-230	B2	PFU-P 70-400	2	70-400	C
PFU-PA-100-400-1-230 PFU-PD-100-400-1-230 PNM-P-100-400-1-230	100-400-1-230	B2	PFU-P 100-400	3	100-400	C2
PNM-P-125-400-1-230	125-400-1-230	B2	PFU-P 125-400	3	125-400	C2
PFU-PA-150-400-1-230 PFU-PD-150-400-1-230 PNM-P-150-400-1-230	150-400-1-230 150-400-1-230	B2	PFU-P 150-400 PFU-P 150-400	3 3	150-400 150-400	E
PNM-P-200-400-1-230	200-400-1-230	B2	SVCDS-P 200-400	3	200-400	F
PNM-P-250-400-1-230	250-400-1-230	B3	SVCDS-P 250-400	3	250-400	G

Table 22: Assignment of the devices SVCDS, SKS and RF

Technical data and dimension diagrams

4.4.3 Dimensions of the device types SVCDS, HST-P, QRD-P, SKS-P and RF-P

Type HST-P	Mass [kg]
50-400-1-230V	32
70-400-1-230V	40

Table 23: Construction assignment HST-P

Type SVCDS-P	Mass [kg]
50-400-1-230V	40

Table 24: Construction assignment SVCDS-P

Construction B1

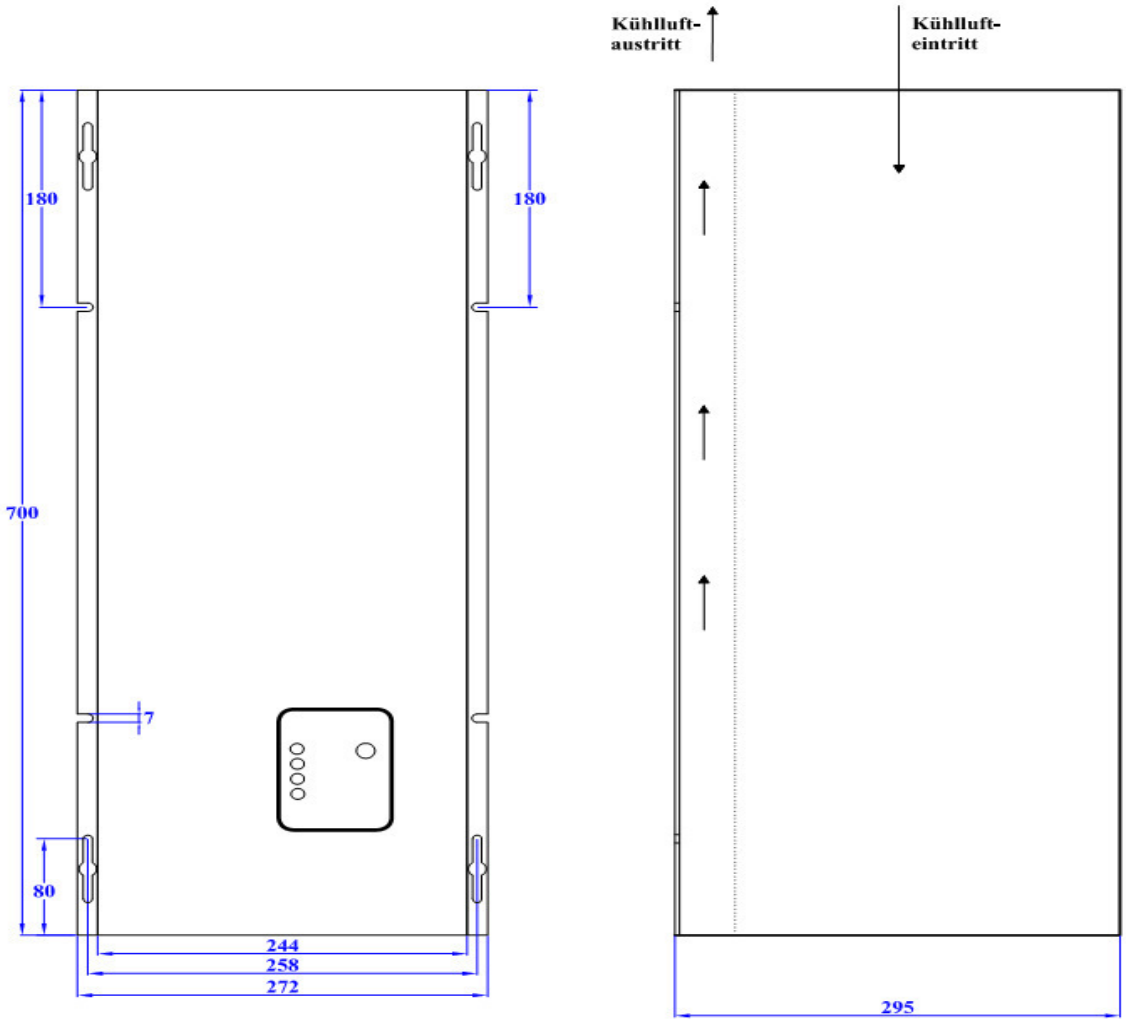


Figure 22: Dimension diagram construction B1

Construction B2

Type HST-P	Mass [kg]
100-400-1-230V	72
150-400-1-230V	74

Table 25: Dimensions boost converter

Type SVCDS-P	Mass [kg]
70-400-1-230V	70
100-400-1-230V	72
125-400-1-230V	74
150-400-1-230V	76
200-400-1-230V	78
250-400-1-230V	80

Table 26: Dimensions inverter

All types are delivered with muff and metal cable screw connection for screened conduction following CE-standard (high + ca. 30 mm) for the cable duct.

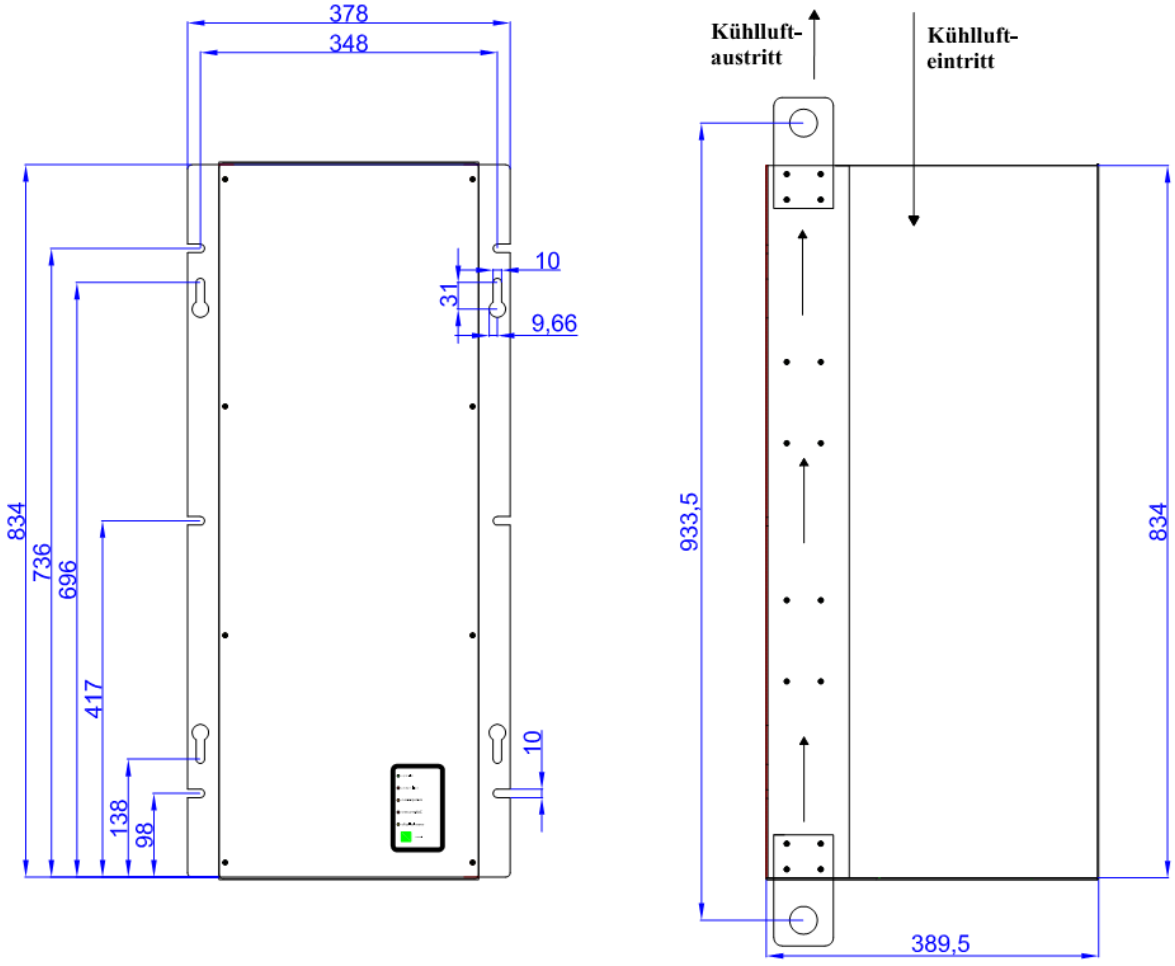


Figure 23: Dimension diagram construction B2

Technical data and dimension diagrams

Construction B3

Type HST-P	Mass [kg]
150-400-1-230V	74

Table 27: Dimensions boost converter

Type SVCDS-P	Mass [kg]
150-400-1-230V	76
200-400-1-230V	78
250-400-1-230V	80

Table 28: Dimensions inverter

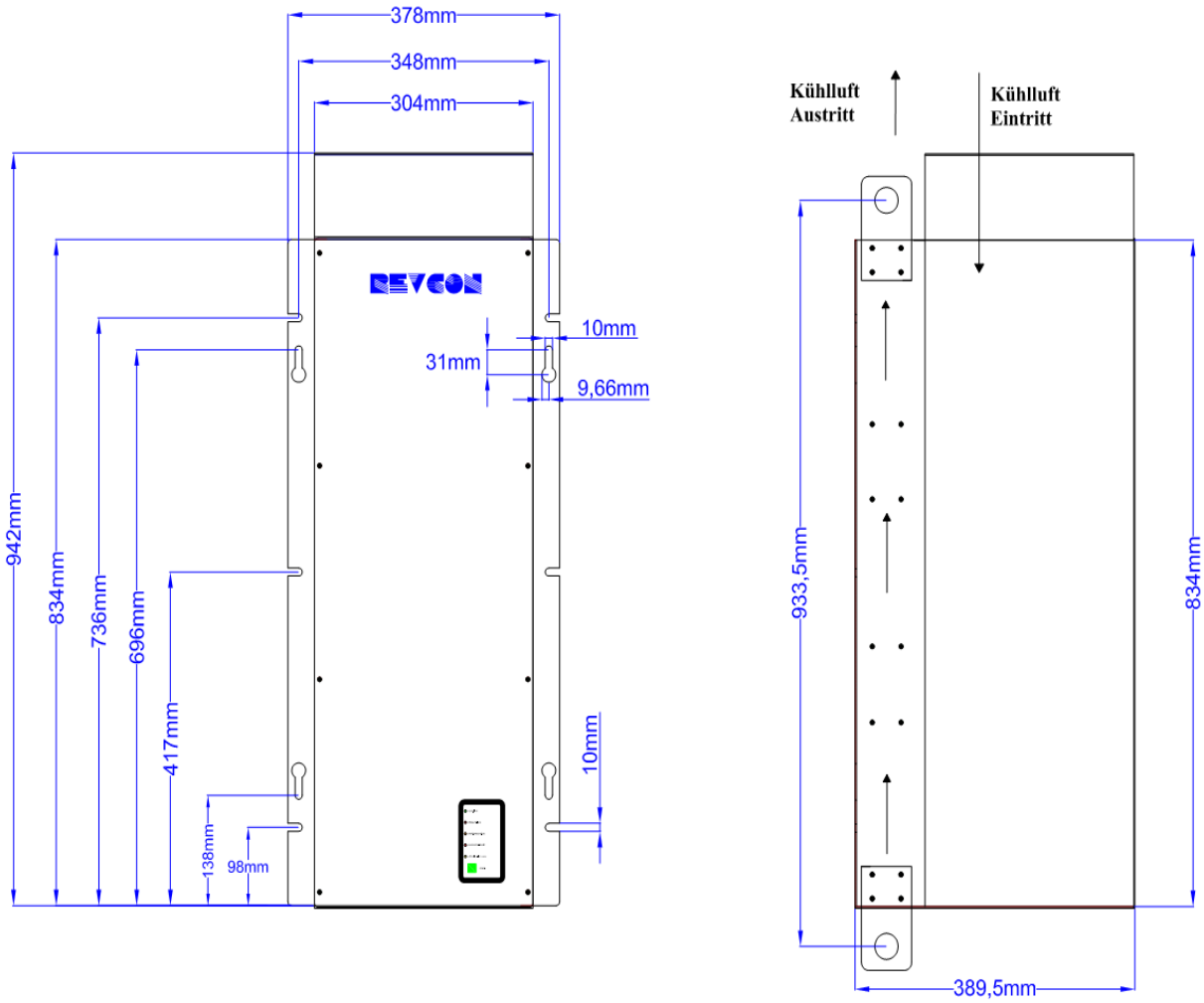


Figure 24: Dimension diagram construction B3

Interference filter type RF-P-

Construction 2

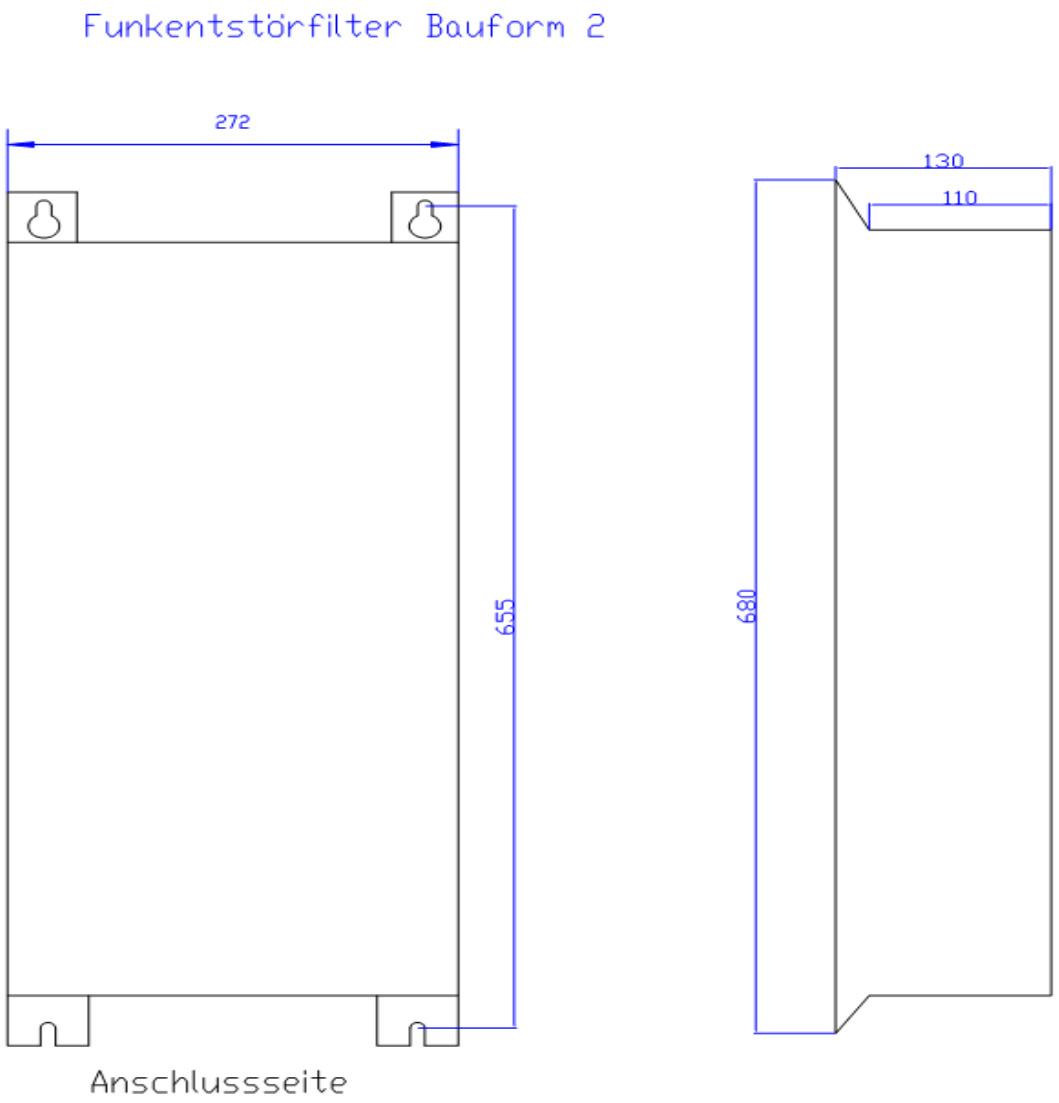


Figure 25: Dimension diagram construction 2

- **The RF filter can be mounted on the fitting panel of the electrical enclosure.**

Technical data and dimension diagrams

SKS-module

The filters of these constructions are situated in enclosures, which are mounted beside the inverter.

Dimension diagram Construction C

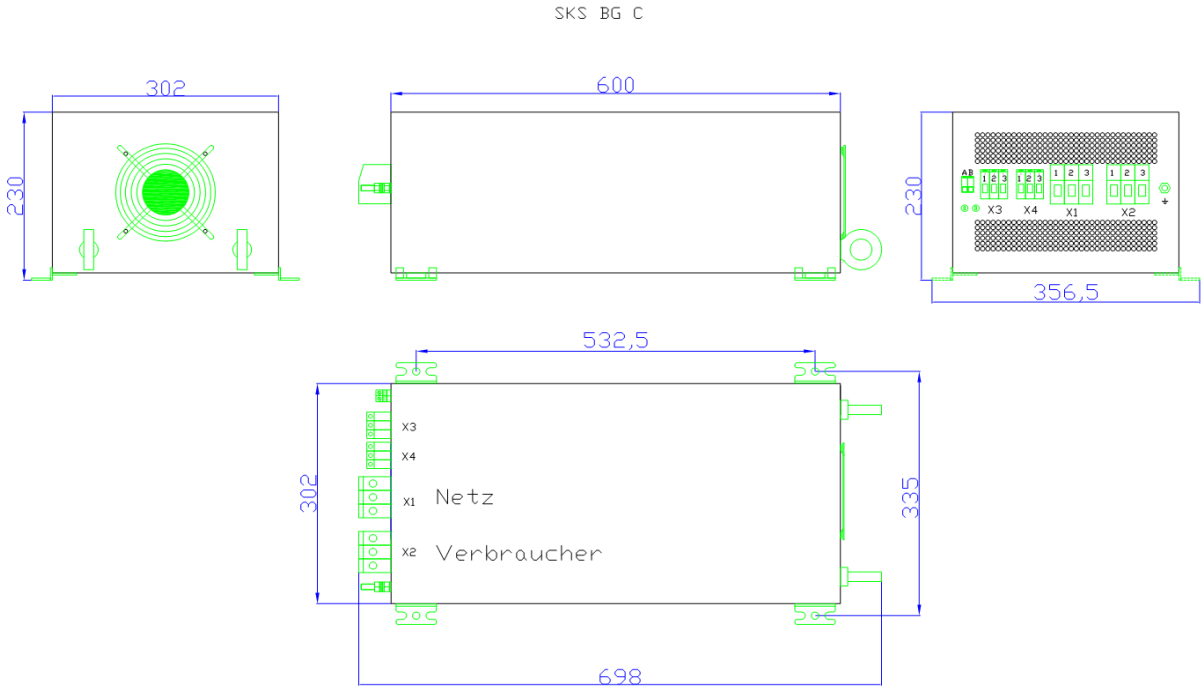


Figure 26: Dimension diagram construction C

Dimension diagram Construction C2

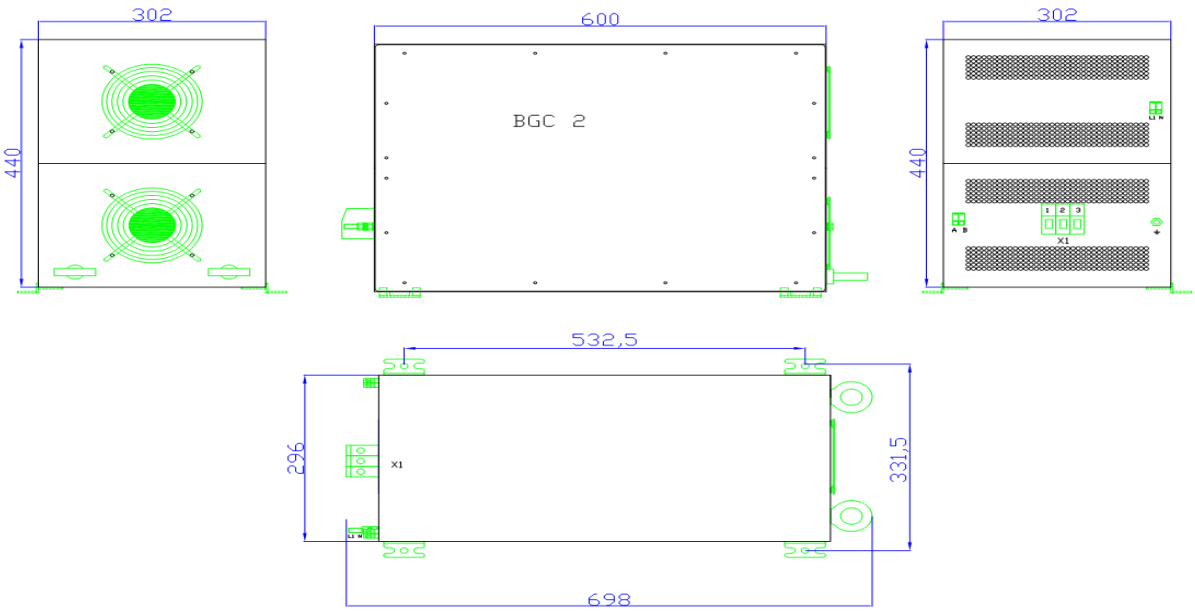


Figure 27: Dimension diagram construction C2

Dimension diagram Construction E

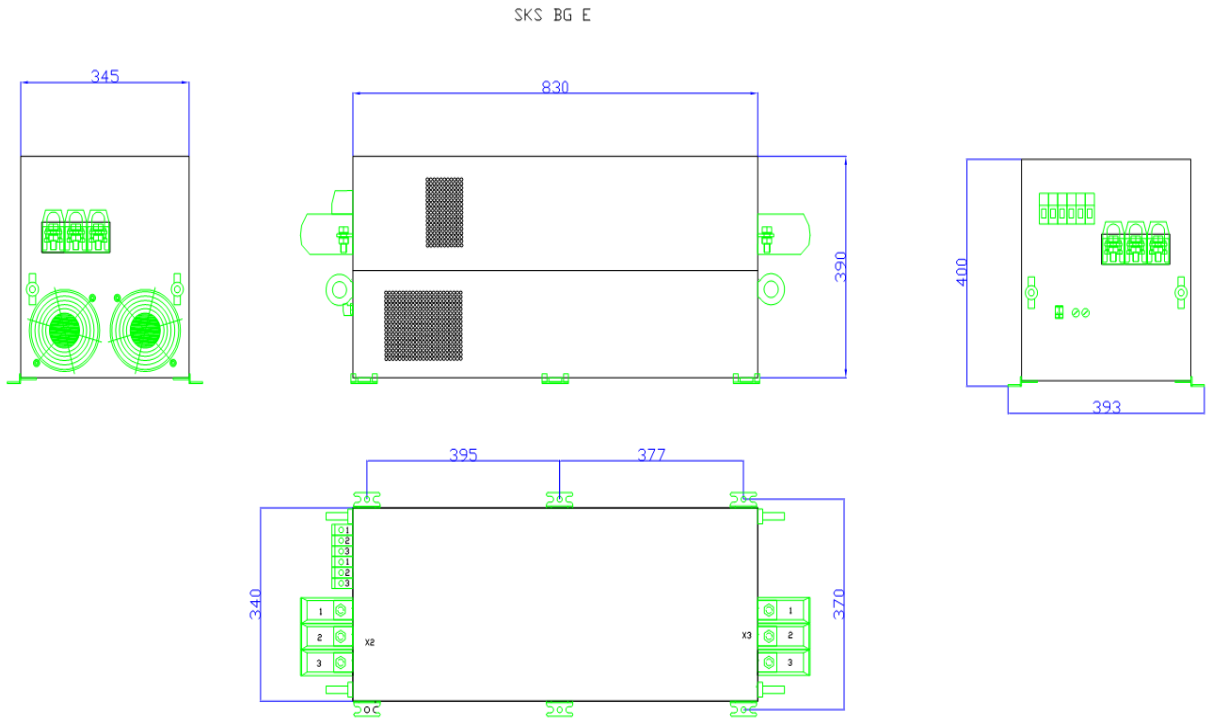


Figure 28: Dimension diagram construction E

Technical data and dimension diagrams

4.4.4 Fuses to connect SVCDS-P VAC

The power port of the PFU system occurs on the terminals L_1-L_3 at the commutation inductance and PE at the heat sink. The mains fuse must be designed appropriate to the current carrying capacity of the valid connecting lead. The in the following table specified semiconductor fuses have to be connected ahead to the inverters (table 28). At the specified manufacturers it is only about a reference, of course also reference types of other manufactures (e.g.: Jean Müller, Ferraz, Bussmann) are adequate.

REVCON® - type SVCDS-P VAC	Maximum series fuse AC	Connection and maximum cable cross-section of the supply line*	
50-400-1-230 VAC	Siba 50 140 06 125A 690 V 2x58mm	AE	25mm²
70-400-1-230 VAC	Siba 20 189 20 200A 660V NH 00	RK M8	95mm²
100-400-1-230 VAC	Siba 20 189 20 250A 660V NH 00	RK M8	95mm²
125-400-1-230 VAC	Siba 20 189 20 315A 660V NH 00	RK M8	95mm²
150-400-1-230 VAC	Siba 20 189 20 350A 660V NH 00	RK M8	95mm²
200-400-1-230 VAC	Siba 20 189 20 400A 660V NH 00	RK M8	95mm²
250-400-1-230 VAC	Siba 20 713 32 500A 1000V NH 1	RK M10	150mm²

Table 29: Fuses to connect

AE ≅ Core end sleeves at multi stranded solid conductors
RK ≅ Tube cable lug with bore for M6 / M8 / M10
* At the copper flags of the power choke.
** At the fuse-holder respectively switch fuse

4.4.5 Fuses to connect PFU-P

The in the following table specified semiconductor fuses have to be connected ahead to the PFU system (table 29). At the specified manufacturers it is only about a reference, of course also reference types of other manufactures (e.g.: Jean Müller, Ferraz, Bussmann) are adequate.

REVCON® - type PFU P	Maximum series fuse AC	Connection and maximum cable cross-section of the supply line*	
7-400-1-230	Siba 50 179 06. 30 A 660 V 10*38mm	RK M5	25 mm²
13-400-1-230	Siba 50 124 06. 40 A 660 V 14*51mm	RK M6	25 mm²
20-400-1-230	Siba 50 140 06. 63 A 660 V 22*58mm	RK M8	25 mm²
25-400-1-230	Siba 50 140 06. 80 A 660 V 22*58mm	RK M8	25 mm²
30-400-1-230	Siba 50 140 06. 100 A 660 V 22*58mm	RK M8	25 mm²
50-400-1-230	Siba 50 193 20. 125 A 660 V 27*60mm	RK M8	25 mm²
70-400-1-230	Siba 50 193 20. 160 A 660 V 27*60mm	RK M8	95mm²
100-400-1-230	Siba 50 193 20. 200 A 660 V 27*60mm	RK M5	25 mm²
150-400-1-230	Siba 50 193 20. 250 A 660 V 27*60mm	RK M6	25 mm²

Table 30: Fuses to connect

AE ≅ Core end sleeves at multi stranded solid conductors
RK ≅ Tube cable lug with bore for M6 / M8 / M10
* At the copper flags of the power choke.
** At the fuse-holder respectively switch fuse

Stop!

At activation of fuses please confer necessarily with a technician of our company, because under circumstances more protection measures in the device have interrupted. At replacement of internal fuses it is necessarily to observe that only the prototypes are applied.

Danger!

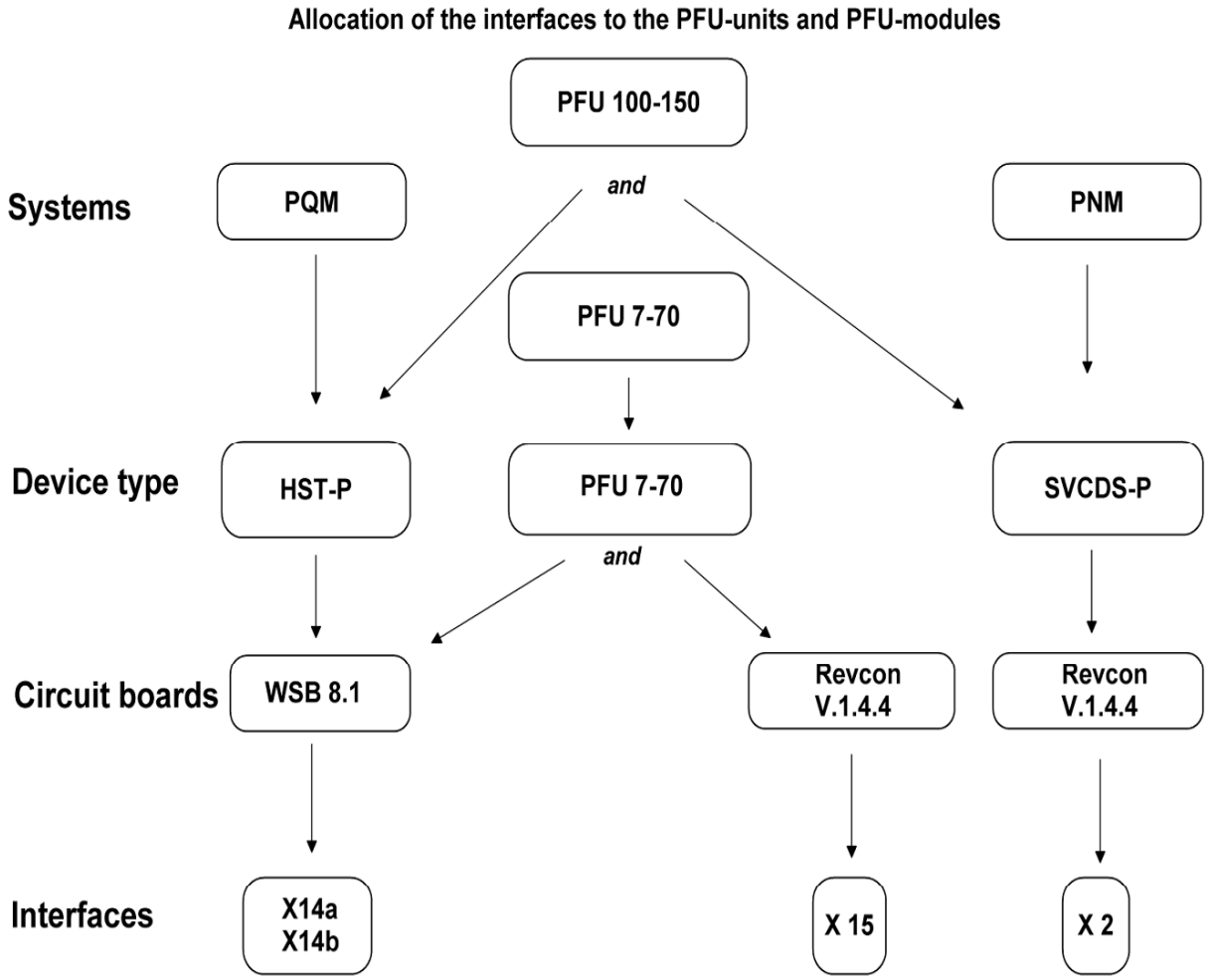
The replacement of the fuses must only occur in dead condition!

5 Projecting

Table 31: Used abbreviations and terms and definitions in the following chapters:

Term	Meaning
EIN.	Input
AUS.	Output
Pulse lock	Disconnection of the power semiconductor, Iq=0A.
Uce>	Overcurrent identified and pulse lock triggered
T>	Temperature of the heat sink too high
WR	Inverter
OE	Open Emitter
OC	Open Collector
IGBT	Type of the used power semiconductor
WSO	Option board WSO

Table 31: Used abbreviations and terms and definitions



5.1 Interfaces of the PFU-P 7-70 devices

Figure 29: Formation of the interfaces at the PFU-P 7 to 30

5.1.1 Pin assignment of the interfaces of the PFU 7-70 devices

Table 32: Assignment and function of the interfaces X14a:1-12:

The specified values are only valid for the factory settings of the coding of the board, see chapter 5.3.

X:14a	1	2	3	4	5	6
Function	External voltage	Reset+Stop	U_{ce}>	U_q<	T>	I_q
Mode	Supply	Digital IN.	OC OUT.	OC OUT.	OC OUT.	Analogue OUT.
Signal	0 V (-)	24 Volt	0 V	0 V	0 V	0-10 V
Value		Reset+Stop	I>>I_{rated}	U_q<100VDC	T>73°C	0-max. I_q
Note	Input Connected internally with X14b:11	Input Stop= Pulse lock	Output 24V= No failure	Output Pulse lock at U_q<100VDC	Output Automatic pulse enable at T<66°	Output Measurement
X:14a	**7**	**8**	**9**	**10**	**11**	**12**
Function	U_q	External nominal value	External voltage	Test Pulse	Common fault	Common fault
Mode	Analogue OUT.	Analogue IN.	Supply	Digital IN.	Relay OUT.	Relay OUT.
Signal	0-10 V	0-10 V	24V(+)	24V(+)	Isolated	Isolated
Value	0-600V	0-100% I_q		Pulse enable inverter	Maximum 230VAC	Maximum 230VAC
Note	Output See table 33	Input See table 33	Input Connected internally with X14b:12	Input 0V= Inverter pulse enable at U_q>100 V	Output	Output

Table 32: Assignment and function of the interfaces X14a:1-12

- All in- and outputs are arranged isolated of the internal power supply.

Projecting

Table 32: Assignment and function of the interfaces X14b:1-12:

The specified values are only valid for the factory settings of the coding of the board, see chapter 5.3.

X:14b	1	2	3	4	5	6
Function	Common fault	Stop 1	Stop 2	Power	Cascade 1	Cascade 2
Mode	Relay OUT.	OE- OUT.	OE- OUT.	Analogue OUT.	Analogue OUT.	Analogue OUT.
Signal	Isolated	24 V	24 V	0-10 V	0-10 V	0-10 V
Value	Maximum 230VAC	I_q>80 % Not used	I_q>75 % Not used	0-max. P_q	Set point Cascade 1	Set point Cascade 2
Note	Output	Output	Output	Output See table 33	Output	Output
X:14b	**7**	**8**	**9**	**10**	**11**	**12**
Function	Failure I>	U_{ce}> Inverter IGBTs	Line voltage < or >	Line voltage	External voltage	External voltage
Mode	OC OUT.	OC OUT.	OC OUT.	Analogue OUT.	Supply option	Supply option
Signal	0 V	0 V	0 V	0-10V	0 V (-)	24V (+)
Value	Failure I>100m		U_{Mains}<360V U_{Mains}>440V	340V-460V		24VDC +/-10%
Note	Output Only with option WSO	Output 24V=No failure	Output Pulse lock at: U_{Mains}<340VAC U_{Mains} >440VAC	Output	Input Connected internally with X14a:1	Input Connected internally with X14a:9

Table 33: Assignment and function of the interfaces X14b:1-12

- All in- and outputs are arranged isolated of the internal power supply of the control logic.

Table 33: Measurements of the source sizes in dependence of the device type

REVCON® - PFU-PD and PFU-PA devices	Source voltage DC Pin6 X14a	Source current DC Pin 7 X14a	Source power DC Pin4 X14b
PFU 7-400-1-230	600V	20A	0-10kW
PFU 13-400-1-230	600V	40A	0-20kW
PFU 20-400-1-230	600V	60A	0-30kW
PFU 25-400-1-230	600V	80A	0-30kW
PFU 30-400-1-230	600V	100A	0-40kW

Table 34: Measurements of the source sizes in dependence of the device type

At the specified values 10 V appear at the analogue outputs.

Feature of the PFU-PA series:

- The measurements for source current and –voltage are measured after the rectifier.
- The alternating quantities are not measured direct.
- For the line voltage of the inverter voltage at rated current is valid:

$$U_{qAC} = \frac{U_{qDC}}{1{,}35}$$

- For the phase current of the AC voltage source is valid:

$$I_{qAC} = \frac{I_{qDC}}{1{,}21}$$

5.1.2 Table of the interface X15

The specified values are only valid for the factory settings of the coding of the board, see chapter 5.3.

X:15	1	2
Function	Common fault	Common fault
Art	Relay off.	Relay off.
Signal	Isolated normally closed	Isolated normally closed
Value	Max. 230VAC	Max. 230VAC
Note	Incorrect rotating field Phase failure Peak value U_{Mains} > 635V	Incorrect rotating field Phase failure Peak value U_{Mains} > 635V

Table 35: Interface X 15

5.1.3 Table of the interface LED display at the control cover:

LED	1	2	3	4	5	Push- button
Function	Supply ok	U_{Mains}> U_{Mains}<	T>	Overcurrent U_{ce}> HST	Common fault	Reset
Colour	Green	Red	Orange	Red	Yellow	No
Failure memory	No	Active	No	Active	Yes	Acknowledgement
Acknowledgement	No	Necessary	No	Necessary	Necessary	After Acknowledgement
Pulse lock	Yes	Yes	Yes	Yes	Yes	After Acknowledgement

Table 36: Interfaces of the LED display at the control cover X 15

Projecting

5.2 Pin assignment of the interfaces of the PFU-P 100 and 150 devices

At these installation sizes are a separate HST-P and a SVCDS-P interface.

5.2.1 HST-P interfaces

Table 37: Assignment and function of the interfaces X14a:1-12:

X:14a	1	2	3	4	5	6
Function	External voltage	Reset+Stop	U_{ce}>	U_q<	T>	I_q
Mode	Supply	Digital IN.	OC OUT.	OC OUT.	OC OUT.	Analogue OUT.
Signal	0 V(-)	24 Volt	0 V	0 V	0 V	0-10 V
Value		Reset+Stop	I>>I_{rated}	U_q<100VDC	T>73°C	0-max. I_q
Note	Input Connected internally with X14b:11	Input Stop= Pulse lock	Output 24V= No failure	Output Pulse lock at U_q<100VDC	Output Automatic pulse enable at T<66°	Output Measurement
X:14a	**7**	**8**	**9**	**10**	**11**	**12**
Function	U_q	External nominal value	External voltage	Test Pulse	Common fault	Common fault
Mode	Analogue OUT.	Analogue IN.	Supply	Digital IN.	Relay OUT.	Relay OUT.
Signal	0-10 V	0-10 V	24V(+)	24V(+)	Isolated	Isolated
Value	0-600V	0-100% I_q		Pulse enable inverter	Maximum 230VAC	Maximum 230VAC
Note	Output See table 38	Input See table 38	Input Connected internally with X14b:12	Input 0V= Inverter pulse enable at U_q>100 V	Output	Output

Table 37: Assignment and function of the interfaces X14b:1-12

- All in- and outputs are arranged isolated of the internal power supply.

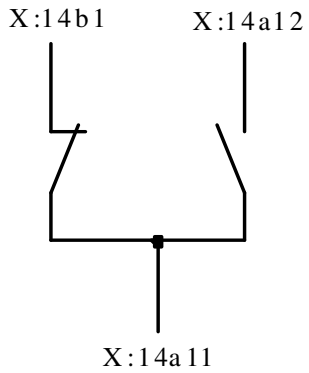
Table 38: Assignment and function of the interfaces X14b:1-12

X:14b	1	2	3	4	5	6
Function	Common fault*	Stop 1	Stop 2	Power	Cascade 1	Cascade 2
Mode	Relay OUT.	OE- OUT.	OE- OUT.	Analogue OUT.	Analogue OUT.	Analogue OUT.
Signal	Isolated	24 V	24 V	0-10 V	0-10 V	0-10 V
Value	Max. 230VAC	I_q>80 % Cascade 1	I_q>75 % Cascade 2	0-max. P_q	Set point Cascade 1	Set point Cascade 2
Note	Output HST disturbance	Output	Output	Output See table 38	Output	Output
X:14b	**7**	**8**	**9**	**10**	**11**	**12**
Function	Failure I>		Line voltage < or >	Line voltage	External voltage	External voltage
Mode	OC OUT.		OC OUT.	Analogue OUT.	Supply option	Supply option
Signal	0 V		0 V	0-10V	0 V(-)	24V(+)
Value	Failure I>100m		U_{Mains}<360V U_{Mains}>440V	340V-460V		24VDC +/- 10%
Note	Output Only with option WSO	Output 24V= No failure	Output Pulse lock at: U_{Mains}<340VAC U_{Mains} >440VAC	Output	Input Connected internally with X14a:1	Input Connected internally with X14a:9

Table 38: Assignment and function of the interfaces X14b:1-12

- All in- and outputs are arranged isolated of the internal power supply of the control logic.

*



Tab. 39: Measurements of the source sizes in dependence of the device type

REVCON® - PFU-PD and PFU-PA devices	Source voltage DC Pin6 X14a	Source current DC Pin 7 X14a	Source power DC Pin4 X14b
HST-P 100-400-1-230	600V	300A	0-150kW
HST-P 150-400-1-230	600V	400A	0-200kW

Table 39: Measurements of the source sizes in dependence of the device type

At the specified values 10 V appear at the analogue outputs.

Features of the HST-PA series:

- The measurements for source current and –voltage are measured after the rectifier.
- The alternating quantities are not measured direct.
- For the line voltage of the AV voltage at rated current is valid:

$$U_{qAC} = \frac{U_{qDC}}{1{,}35}$$

- For the phase current of the AC voltage source is valid:

$$I_{qAC} = \frac{I_{qDC}}{1{,}21}$$

5.2.2 SVCDS-P interfaces

X2	1	2	3	4	5	6
Function	Collective error	Collective error	Collective error	Collective error	Temperature supervision	Temperature supervision
Mode	Relay contact	Relay contact	Relay contact	Relay contact	Heatsink	Heatsink
Signal	NCC	NCC	NOC	NOC		
Value	Max. 5 A AC or 3 A DC	Max. 5 A AC or 3 A DC	Max. 5 A AC or 3 A DC	Max. 5 A AC or 3 A DC		
Note	Input	Input	Input	Input	Internally connected	Internally connected
X2	**7**	**8**	**9**	**10**	**11**	**12**
Function	OFF Signal	OFF Signal	Not used	Not used	ON / Acknowledgment	ON / Acknowledgment
Mode	External	External			External voltage	External voltage
Signal	NOC	NOC			DC	DC
Value					24V(+)	24V(-)
Note	Output	Output			Input	Input

Table 40: SVCDS-P interfaces

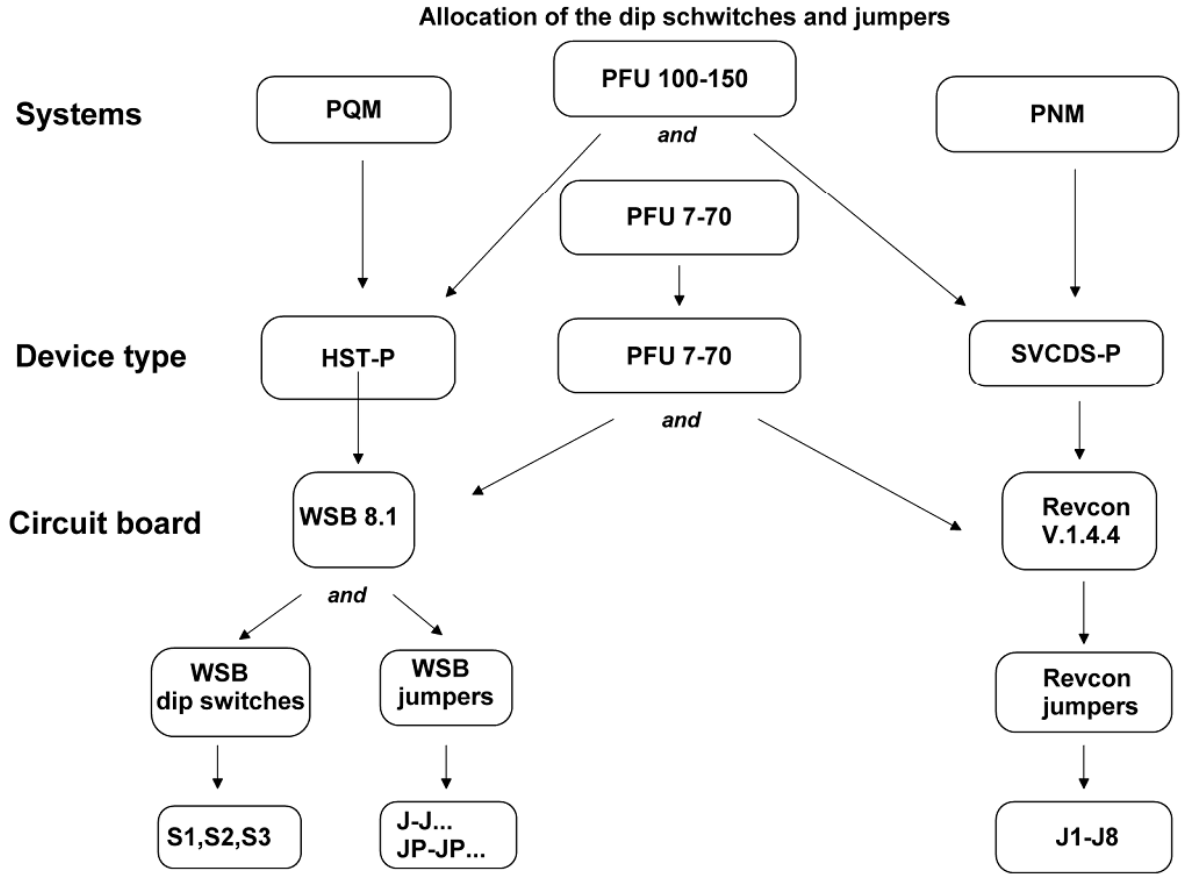
Stop!

STOP

If an external voltage is connected to terminals 5 to 10 unattended actions and damages may occur.

Projecting

5.3 The coding of the PFU-P devices and the PFU modules



The control is provided on the control board WSB and is designated as X14. The terminal block can be attached and is therefore easy to connect (see figure 31).

At the control by a relay can e. g. operation [release]-status messages, respectively the common fault, be connected outside the device and otherwise the control provides the opportunity to complete switching functions linkage with the system control.

5.3.1 Coding of the board WSB 8.1

Stop!

STOP

All modifications at the described DIP switches and jumper must be conducted in dead- voltage condition of the devices.

Stop!

STOP

Jumper and DIP switches which are not described in this chapter must not be modified or only after consultation with company Eltroplan- Revcon.

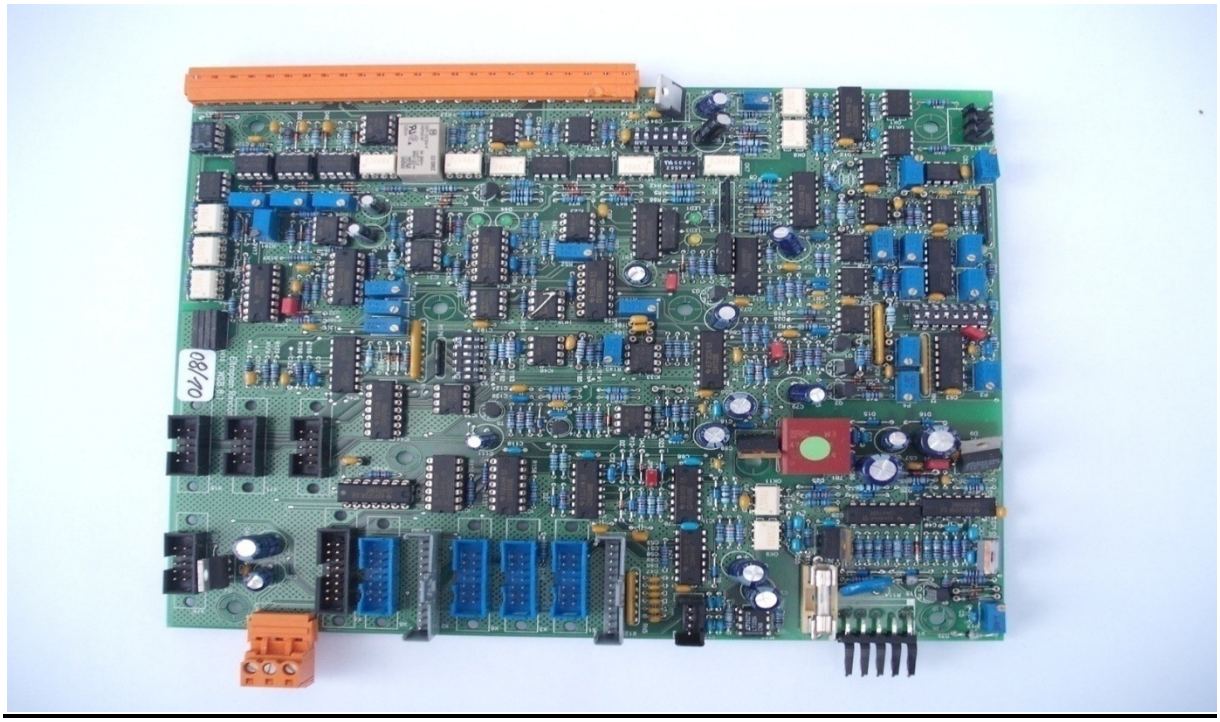


Figure 30: Connection- and component-lay-out of the WSB-board

Table 40 setpoint, coding of the DIP switches S1 and S2:

DIP switch	S1								S2					
Switch	1	2	3	4	5	6	7	8	1	2	3	4	5	Function description
Factory setting	on	off	on	off	on	on	off	on	on	off	off	on	on	Current control by MPP
Selection 1	on	off	on	on	off	on	off	on	on	off	off	on	on	Current control by setpoint setting 0-10V≙100%-0%
Selection 2	on	off	on	on	off	off	on	on	on	off	off	on	on	Current control by setpoint setting 0-10V≙0%-100%

Table 41: The configuration of the DIP switches S1 and S2

Projecting

Table 41 Option 2 Total current measurement, coding of the DIP switch S3:

DIP switch	S3				
Switch	1	2	3	4	Function description
Switch setting					
Selection 1	off	off	off	off	Minimal sensitivity of the total current measurement
Selection 2	on	off	off	off	
Selection 3	on	on	off	off	
Selection 4	on	on	on	off	
Selection 5	on	on	on	on	Maximum sensitivity of the total current measurement

Table 42: The configuration of the DIP switch S3

Coding by jumper, jumper J1-J6 and JP1-JP6:

J	1	2	3	4	5	6
Function	Internal	Start at U_e>120VDC	Internal	Reserve	Reserve	Internal
Open		Start at U_e>120VDC				
Enclosed		Start at Ue=0V				
Factory setting	**open**	**open**	**enclosed**			**open**
Note	Drive voltage		Storage WR U_{ce}>			I_{vcc}
J	1	2	3	4	5	6
Function	Reserve	Reserve	Reserve	Measurement U_q	Internal	Reserve
Open				U_q		
Enclosed				U_a		
Factory setting				**open**	**enclosed**	
Note				S1:1 must be opened before modification	Storage HST U_{ce}>	

Table 43: Coding by Jumper J1-J6 and JP1-JP6

5.4 Option Relay

The option Relay enables the basic changeover switching between setpoint and MPP- operation. Therefore there are the two additional terminals A1 and A2 available (Figure 31). If no voltage is available between the two terminals, the device detects the MPP- operation automatically.

At a connection of 24V at the two additional terminals A1 and A2 the setpoint operation is activated and a setpoint as a 0...10V signal is necessary, which corresponds to a value of 100%-0% I_q (0-10V≙100%-0% source current, page 73 table 32).

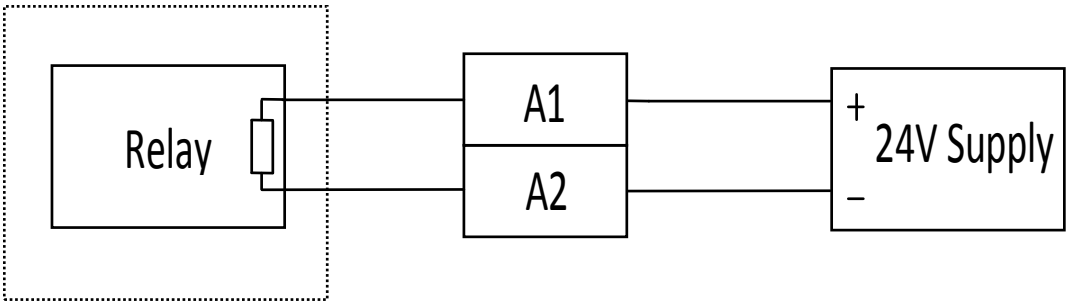


Figure 31: Connection of the option relay

To use the option Relay, the DIP-switches 4 and 5 at S1 must be at position OFF (see table 40).

This pre-adjustment is at a device with the option Relay already applied.

5.5 Coding of the board Revcon V1.4.4

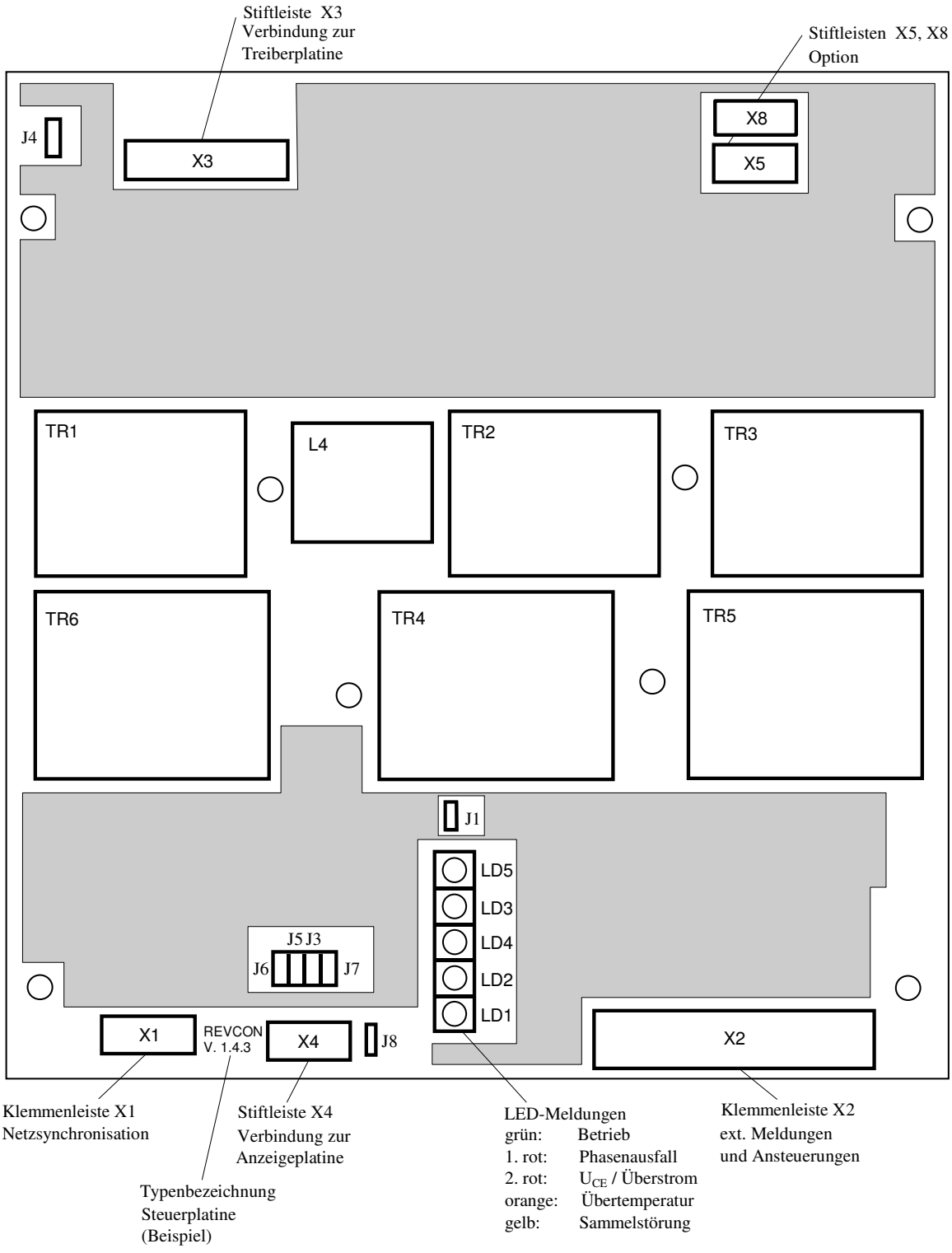


Figure 32: Connection- and component-layout of the SVCD-control board REV 1.4.X

Coding of the line voltage monitoring, jumper, Jumper J3-J8:

J	3	5	6	7	8
Function	Pulse lock Phase failure Incorrect rotating field	Sensitivity of the function of J3	Sensitivity of the function of J3	Internal	Pulse lock U_{Mains}>
Open	Display	Low	Low		No switch-off
Enclosed	Pulse lock and display	High	High		Switch-off
Factory Setting	**Enclosed**	**Enclosed**	**Enclosed**	**Enclosed**	**Enclosed**
Note	Acknowledgement necessary	J5 and J6 must be plugged identical	J5 and J6 must be plugged identical	Function on request	Acknowledgement necessary

Table 44: Coding of the line voltage monitoring, jumper, Jumper J3-J8

Stop!

The opening of J8 can lead to destructions at the PFU systems and other loads.

Factory settings of the internal jumper:

J	1	4
Function	Internal	Internal
Factory Setting	**Enclosed**	**Open**

Table 45: Factory settings of the internal jumper

6 Installation

6.1 Mechanical installation

Important information

Stop!

Use the inverters only as built-in type!

Stop!

Observe the free space of the installation!

Note!

Several inverters in one electrical enclosure can be mounted without clearance side by side.

Stop!

A sidewise clearance to other close-by devices / walls of electrical enclosures of 70mm must not be exceeded, observe 150mm free space above- and below.

Stop!

Observe the unchecked access of the cooling air and the access of the discharged air.

- At polluted convection (dust, fibrous material, fat, aggressive gases), which could affect the function of the filter module:

Stop!

Make adequate retaliatory actions, for example separate airflow, mounting of filter modules, regular cleaning, etc.

Stop!

Do not exceed the admissible range of the operating- ambient temperature.

6.2 Specified mounting position

The inverters are specified for the vertical wall fastening (± 15°). As assembly site must only an even surface be used without the use of distance pieces or similar. At assembling the device within an electrical enclosure must be ensured, that the inverter is bolted direct without the use of distance pieces or similar direct on the mounting plate and that the waste heat in the electrical enclosure is adequate dissipated. This nature of mounting is necessary, to ensure the cooling air guide. A power loss of ca. 2% of the maximum nominal power of the device is expected. The air temperature of 40 °C in direct closeness of the device must not be exceeded. The air entrance- and air outlet on the up- and bottom side of the device (as far as available) must not be buried by installation material as cable ducts or other devices.

Stop!

If these mounting instructions are not observed, this can lead to a thermal overcharge of the inverter.

Danger!

If these mounting instructions and the connection instructions (chapter 6.1) are not observed, this can lead to a thermal overcharge of the inverter and under circumstances to a production of smoke and/or a burning.

Installation

Operator protection

Danger!

At the link terminals of the inverter is also after switching off the supply voltage still a dangerous high voltage for some minutes available! The length of time, until this voltage falls to a not dangerous value, must necessarily be awaited.

Danger!

Change malfunction fuses only in dead condition for the required type (chapter 6.3).

Protection of the inverter

Danger!

The inverter contains electrostatic endangered devices (ESDS).

During the works within the range of the circuit points, the personal must observe the in the international Norm IEC 747-1 chapter 9 defined measures. That needs before beginning the operations the release of electrostatic charges:

Discharge yourself by touching the PE-attachment bolt or another earthed metal surface in the electrical enclosure.

6.3 Network configuration / network conditions

Observe the limitation at the respective network configuration!

Note!

If you want to operate the filter module on electrical networks, which are not mentioned in the following table, please confer with a technician of our company.

VDE conform network configuration	Operation of the inverter	Notes
With direct grounded star point	**Unrestricted allowed**	Observe the rated values of the devices
With insulated star point	**After consultation with the plant and potential modification of the devices possible**	
With earthed live wire	**Allowed after consultation with the plant**	

Table 46: Network configuration / network conditions

6.4 Specification of the used lines

- The used lines must conform to the required specification at the site
- The regulations about the minimum cross- section of PE-conductors must be necessarily observed.
- The efficiency of a shielded line is determined of
  - a right connection to the shield
  - a low shield resistance.
- Only use shields with tin- plated or nickel- plated tinned copper braid!
- The overlap rate of the braid must average minimum 70% to 80% with an overlap angle of 90°
- Protect the supply lines of the inverter with the required circuit breaker.

Installation

6.5 Connection

- All connections have to be manufactured short and induction less as possible.
- To the compliance of the EMC-directives (according to consisting standards as EN 61800-3:2004 / IEC 61800-3:2004) shielded lines have to be applied.
- Connect power lines at the screw clamps L1, L2, L3 (at the power choke) of the inverter. The connection must always occur 3 phase.

Stop!

At the power connection of the power section a defined phase sequence must be followed (clockwise rotating field). The device allots of a phase detector. If the phase detector detects an incorrect rotating field, at the device using LEDs the malfunction message "**rotating field incorrect**" or "**phase failure**" is indicated. In this case the two live wires of the power connection must be replaced.

- Connect the protective conductor of the supply line at the earth bolt at the electrical connection of the devices at the earth bolt.
- The lines for the connection to the generator/photovoltaic system must be connected at the fuse disconnector/ -holder.

Stop!

Do not pass the control lines in parallel to malfunction motor- / generator lines.

6.6 Power connection

Fuse protection (see also chapter 4.4.5)

- By commercial semiconductor protection:

  The nominal voltages of the fuses must be dimensioned accordant to the line voltage on the spot.

- Protection of the inverter on the input (U, V, W):

  The corresponding fuses are integrated in the device:

  The observance of further standards (IEC/EN 60204-1, VDE 0289 and others) is up to the responsibility of the installer of the plant / the operator.

  Figure 32 shows the power connection of the PFU system 50-250 kW:

Danger!

It is in no case allowed to pre-connect not current compensated direct inductances!

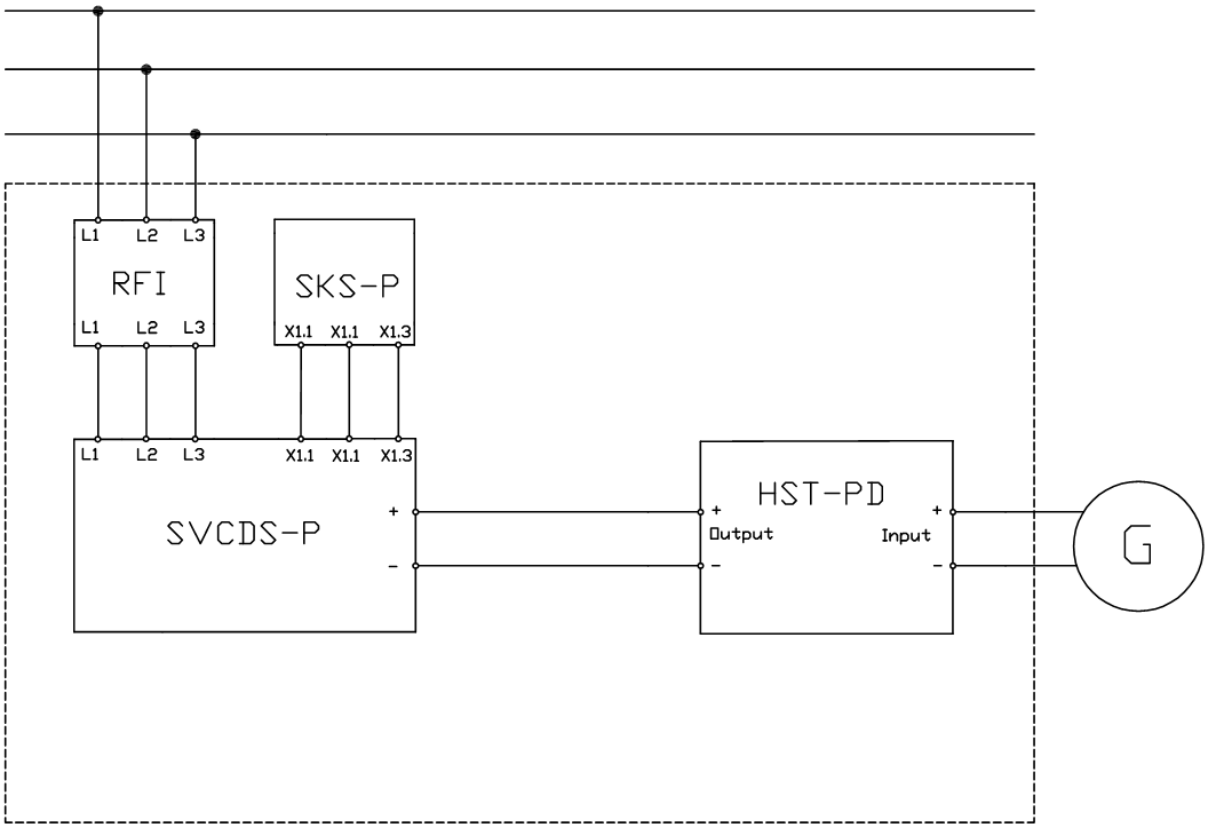


Figure 33: The line connection of the PFU system 50-250 kW

Installation

Figure 34 shows the power connection of the PFU system 7-30 kW:

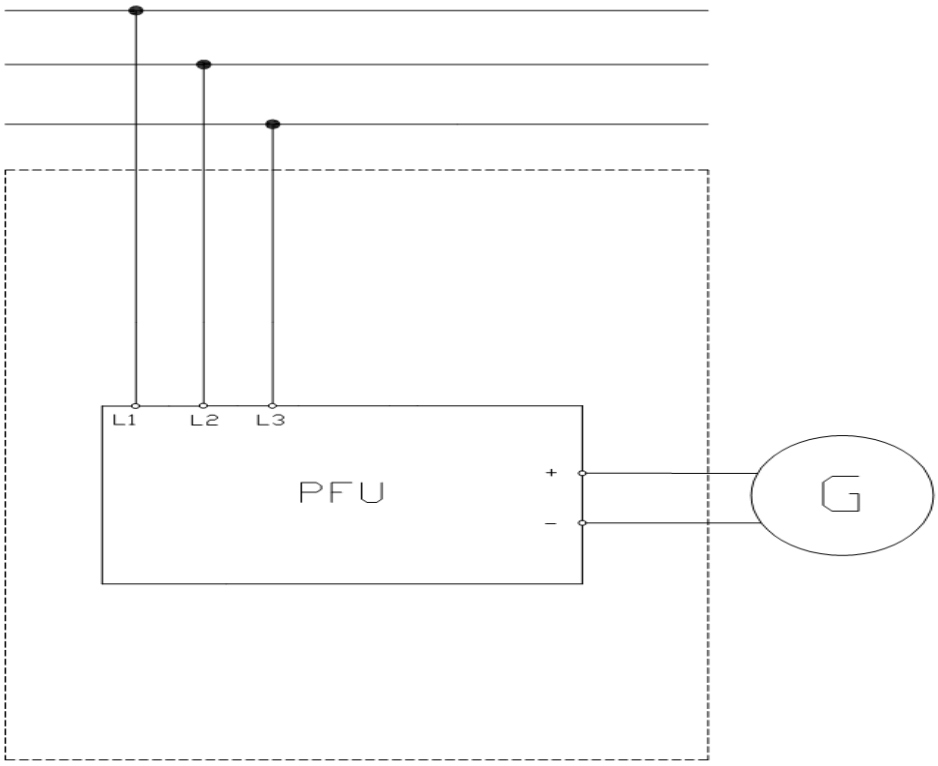


Figure 34: The line connection of the PFU system 7-30 kW

6.7 Control terminal

Note!

It is absolute necessary to connect an external 24V supply at the interface X14a of the circuit board WSB 8.1 for the correct function of the inverter.
(X14a:1 0V(-) und X14a:8 24V(+), see table 32 page 73)

Figure 35 shows the control terminal of the PFU system 7-25 kW:

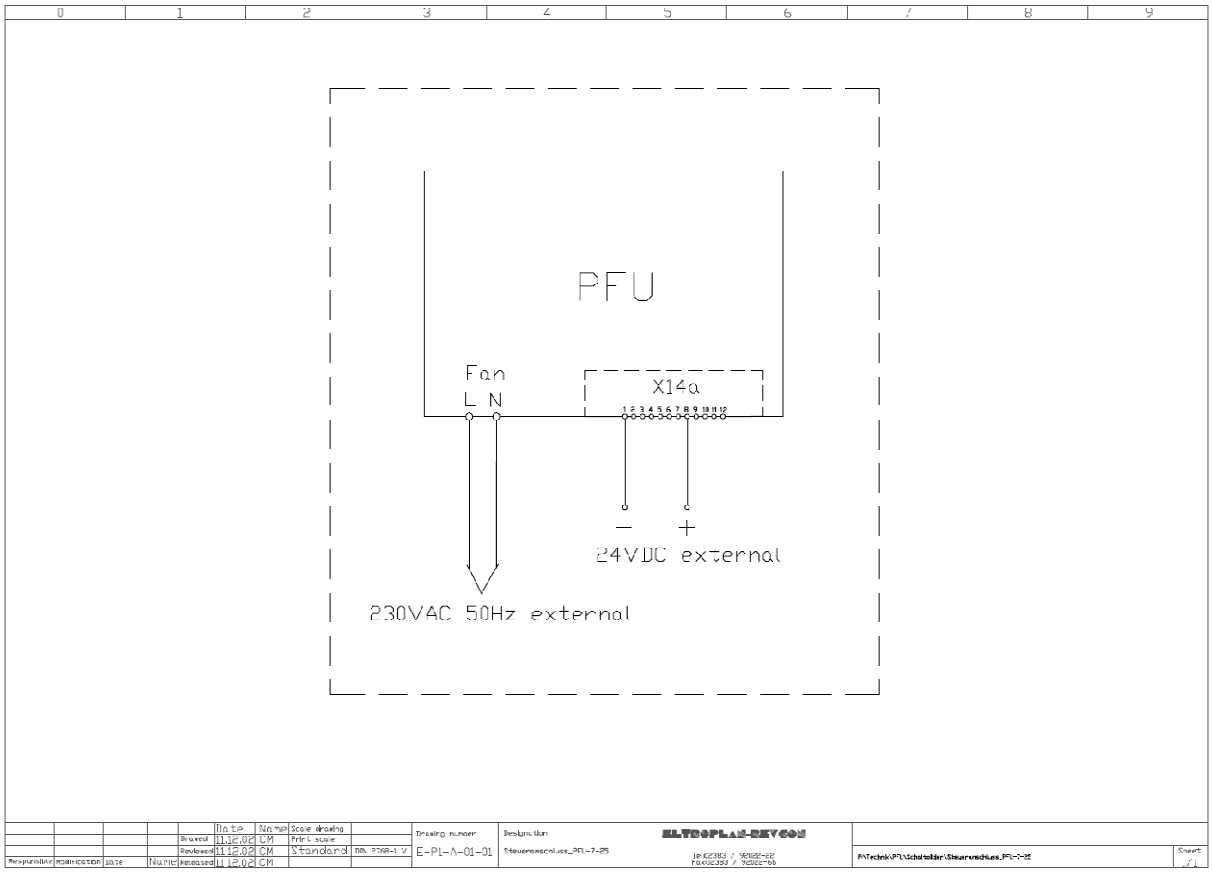


Figure 35: The control terminal of the PFU system 7-25 kW

Further details are located in chapter 5.1 Interfaces of the PFU-P 7-70 devices.

Installation

Figure 36 shows the control terminal of the PFU system 30 kW:

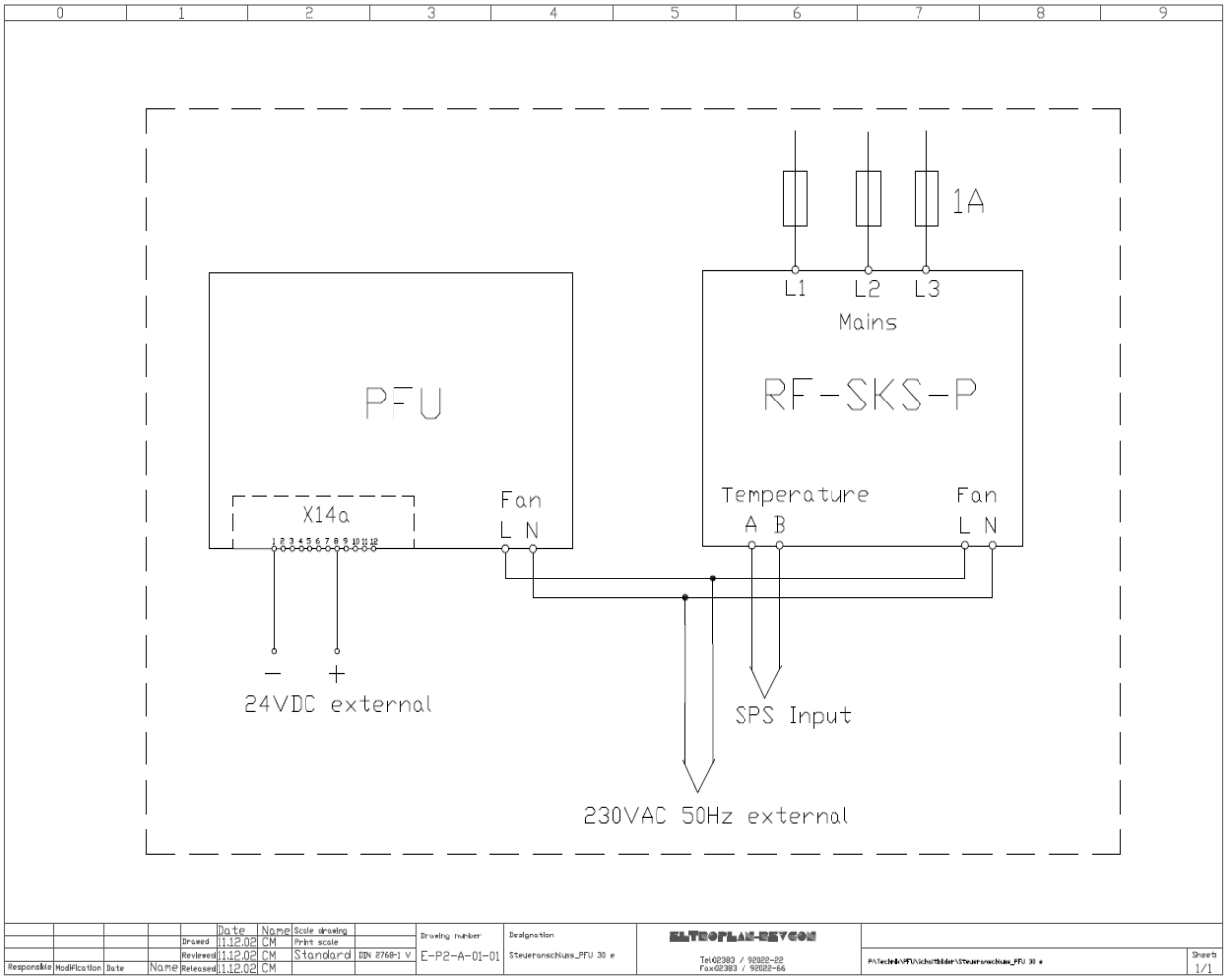


Figure 36: The control terminal of the PFU system 30 kW

Figure 36 shows the control terminal of the PFU system 50-250 kW:

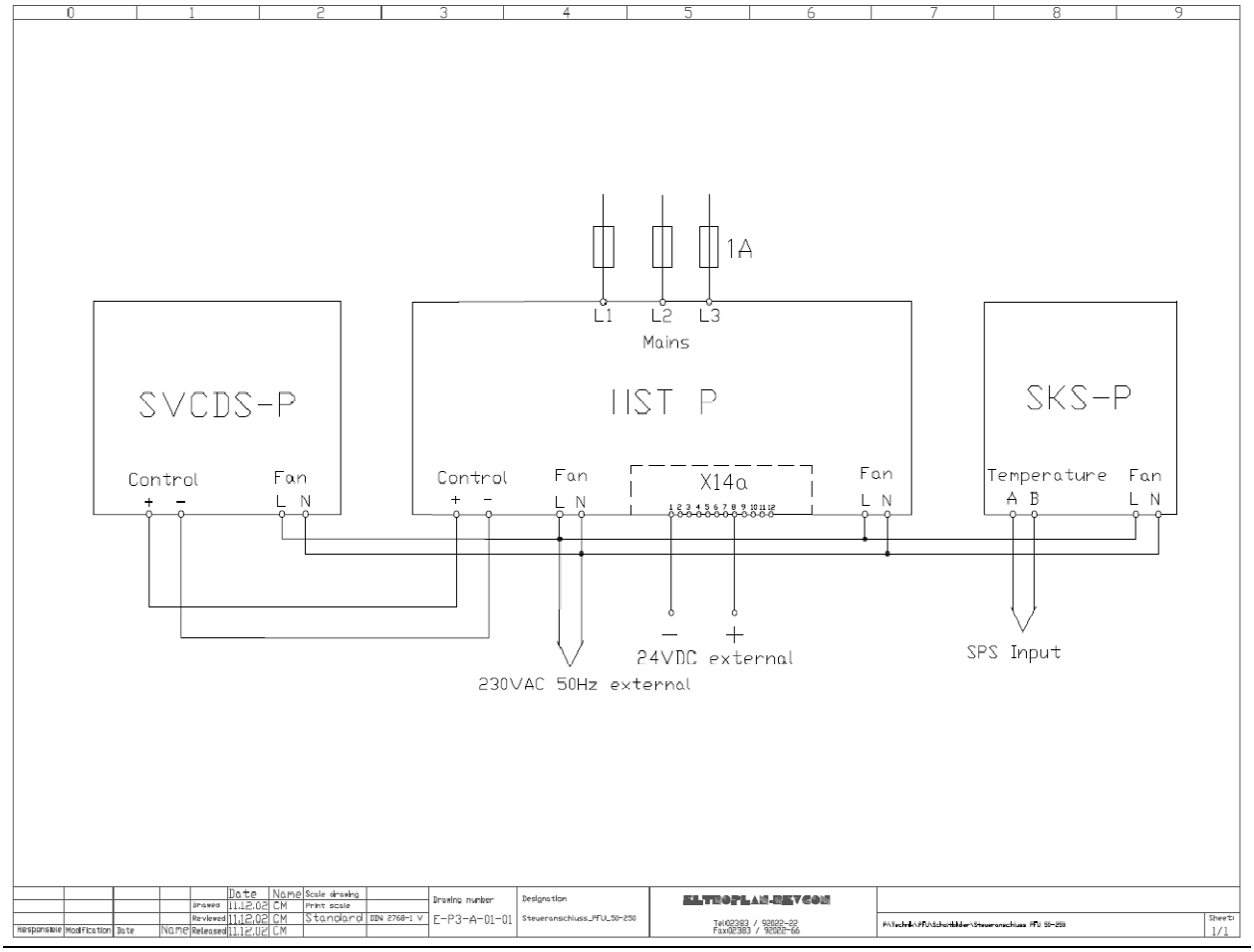


Figure 37: The control terminal of the PFU system 50-250 kW

Further details are located in chapter 5.1 Interfaces of the PFU-P 7-70 devices.

Installation

6.8 Installation in a CE-conform system

General information	• The responsibility for the compliancy of the EG directives with the Machine application is one for the user. If you observe the following measures, you can assume that at the operation of the machine no by the inverter caused EMC-problems occur and that the EG-directives respectively the EMC-directives are complied. – If devices are operated in proximity to the inverter, which do not comply with the CE-standards in terms of the interference immunity of the EN 500082-2, these devices can be affected electromagnetic by the inverter.
Design	• Connect inverter and interference filter extensive to the earthed mounting plate: Mounting plates with electrical conducting surface (zinc coated or stainless steel) allow a durable contacting. – Coated plates are not adequate for a EMC-conform installation • If you use several mounting plates: – Connect mounting plates extensive and conducting to each other (for example with copper band) • At the installing of lines observe the spatial separation of the power lines from the control lines. • Conduits preferably close by reference potential. Levitating lines operate as antenna.
Filtering	• Only use the to the inverter dedicated interference filter. Interference filter reduce incorrect high frequency disturbances to a valid rate.
Shielding	• Metallic cable connections ensure an extensive connection of the shield with the enclosure • At contactors and clamps in the shielded lines: - Interconnect the shields of the there connected lines and also connect extensive with the mounting plate • At power lines among the interference filter and the drive system longer as 300mm: - Shield power lines - Connect the shield of the power lines direct to the drive controller / to the feed back unit, to the interference filter and to the filter module and connect extensive to the mounting plate. • Shield the control lines: - Connect the shield beeline to the shield connections.
Grounding	• Ground all metallic electrically conductive Components (feed back unit, drive controller, interference filter and filter module) by corresponding lines from a central (ground point, PE-bar). • Observe the in den safety regulations defined minimum cable cross section: - But for the EMC is not the cable cross section decisive, but the surface of the line and the 2-dimensional contacting.

Inverters are electrical equipment for the application at industrial and commercial plants. According to EMC-directive 2004/108/EG these devices have no labelling obligation, because they are in terms of the EMC-directive components for the processing by the competent machine- and plant manufacturer and are not independently recoverable. The documented evidence of conformity for the observation of the in the EMC-directive required protection target muss be established by the installer/operator of a machine/plant. Using the by ELTROPLAN-REVCON approved interference filter, as soon as at observation of the following measures and installation guidelines, is the observance of the preset maximum ratings given.

The inverter REVCON® in combination with the respective interference filter is intended for the application in environments of the class „A“ („B“ on request).

Definition according to generic standard:

- EN 61000-6-4:2001 in the range of the electromagnetic interference
- EN 61000-6-2:2005 in the range of the electromagnetic immunity

6.9 Installation

Functional- and proper construction of electrical enclosure or plant

To avoid disturbance decoupling
a) Power-/supply lines
b) Motor lines of converters / servo amplifiers
c) Lay control- and data lines (low voltage level < 48 V) with a clearance of minimum 15 centimetres.

To receive low resistance high frequency connections, groundings and shielding and other metallic connections (for example mounting plate, installed devices) must be applied extensive on metallic blank background. Use rounding- and potential equalization lines with large as possible cross-section (minimum 10mm²) or thick ground strap.

Use shielded lines only with copper- or tinned copper braid, because steel braid is inappropriate in high frequency range. Always lay the shield with clamps or metal bolting on the equalization lines, and accordingly PE-connections. No extending with single conductors!

If external interference filter are used, so they have to be installed with max. 30 centimetre clearance to the disturbance source and have to be installed with very good, extensive contact to the mounting plate.

Inductive switching elements (contactor, relay and so on) always finish with suppressor elements as varistor, RC-elements or protective diodes.

Make all connections short as possible and lead close to reference potential, because levitating lines operate as antenna.

Avoid loops at all connection lines. Lay not accounted stranded wires on both sides at protective earth.

At unshielded lines forward- and return conductor must be twisted, to attenuate symmetric disturbances.

6.10 Connection of a interference filter

Figure 37 shows the mounting and connections of a external interference filter:

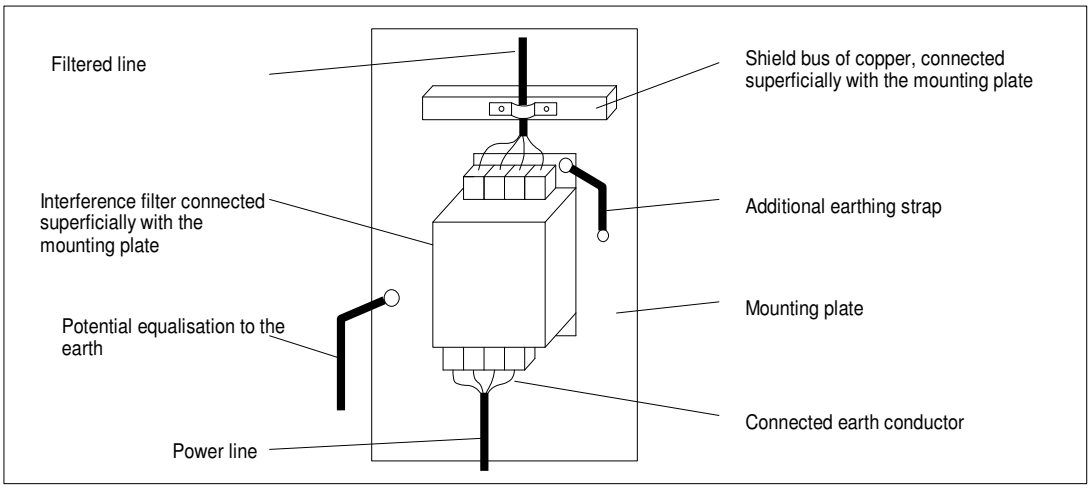


Figure 38: The mounting and connections of an external interference filter

6.11 Installation of a EMC- conform electrical enclosure

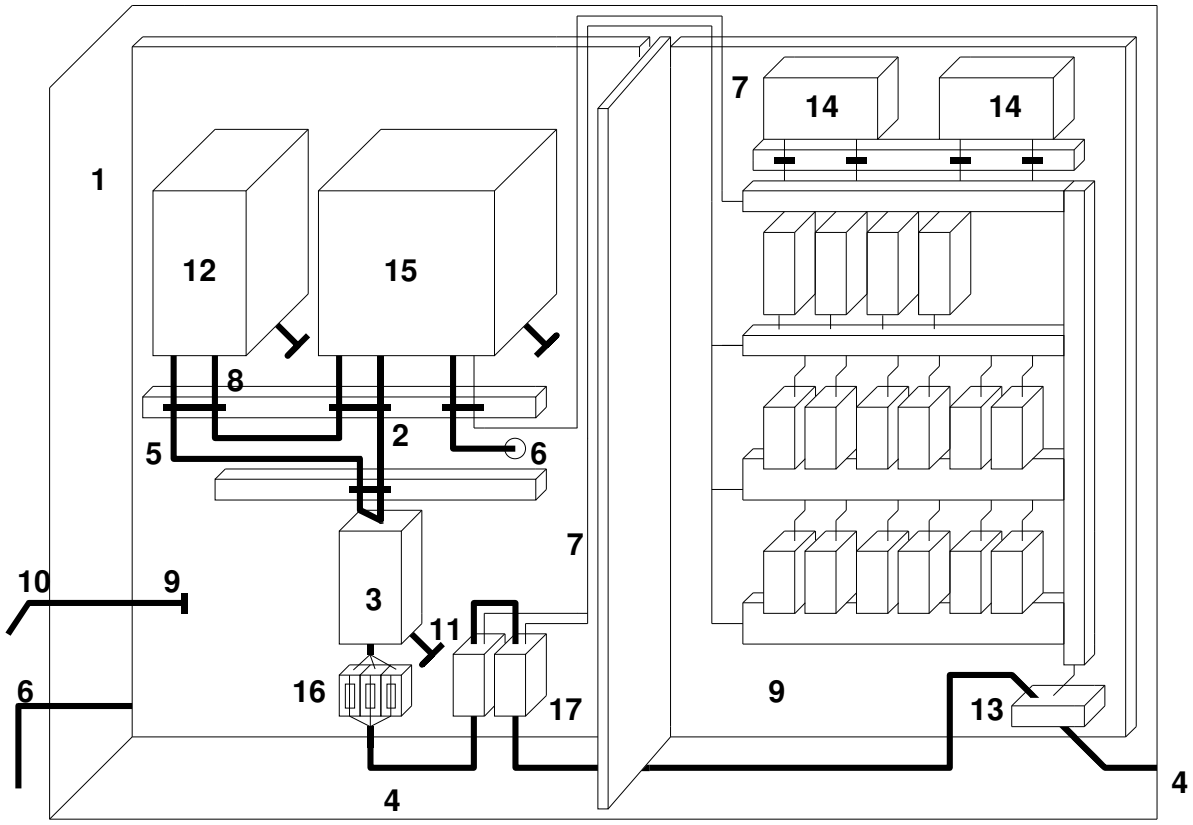


Figure 39: The construction and the connections of an EMC-conform electrical enclosure

1. Electrical enclosure link
2. Line between interference filter and drive control system
3. Interference filter
4. Power line
5. Line between interference filter and inverter cross section: Accordingly supply fuse or passed short-circuit-proof!
6. Supply line of the drive
7. Control cable
8. Connecting cable with inverter (DC)
9. Mounting plate (common neutral point)
10. Potential equalization with the construction ground
11. Additional conductor
12. Inverter
13. Grid connection
14. Control
15. Drive control unit
16. Mains fuse
17. Mains contactor

6.12 Explanation

An electrical enclosure has to be divided fundamentally in power range and control range. It is irrelevant, if the system is installed inside an electrical enclosure or comprises several electrical enclosures. Because of a strong radiation of the power lines the installation of a screening wall is recommended. It must be excellent connected with the frame or the mounting plate (remove the lacquer).

The built-in inverter and a connected upstream interference filter must form a whole, i.e. they must be connected without isolated coat of lacquer extensive over the mounting plate with each other.

The connecting line between interference filter and inverter must be executed as double applied, screened line and should not be longer as 30 cm in normal case.

The mounting plate of the drive control is to regard as neutral point for the total grounding and screening connection in the machine or plant. If the drive or other plant components lead to disturbances, the HF- connection of these components is bad. In that case a potential equalization must be parallel executed.

At the usage of interference filter the leakage current of the devices increases. Because they rate than below the threshold value of 3,5 mA, the following conditions must be met:

- Protective conductor cross-section minimum 10 mm² CU.
- Monitoring of the protective conductor by equipment that disconnects independently at fault.
- Passing of a second conductor electrical in parallel to the protective conductor over separately terminals. This must on its own achieve the requirements to VDE 0100 / part 540.

6.13 Connection of control lines

The shielding of digital signal lines that are not led above the connecting terminal is to pass at access to the enclosure and at closeness to the drive control system to the shield, to reduce the shield impedance.
If digital signal lines are led above the connecting terminals, the shield must passed extensive before and behind the terminals.

If the shield is earthed by single conductor, so the fault leakage declines about ca. 70%.
As shield connection the at the wholesale electrical supply company available metal clamps are suitable

At the usage of not shielded control lines, the control lines should be passed always as twisted pair with forward- and return conductors.

7 Commissioning

Danger!

Control before the first switching-on the wiring for completeness, polarity, short circuit, and ground fault.

Danger!

A disturbance of the drive control unit is at cross connection not in any case to exclude.

7.1 First switching-on

1. Connect the mains:
– The inverter is ready for operation after ca. 1s.
2. Control the readiness for operation of the inverter:
– If only the green LED of the inverter lights:
Inverter is ready for operation.
– If except of the green LED other LEDs light:
A disturbance is present. Before other commissioning, first eliminate the disturbance (see chapter 8.1 "Fault finding und fault clearance).
3. At increasing of the input voltage of 0V to the maximum input voltage the inverter starts automatically at ca. 100V AC, respectively 120V DC.

Commissioning

7.2 Configuration

The coding of the jumper enables different control options and the most different internal functions at defined malfunction message.
Consecutively are the different definitions elucidated, which result at the specific encoding options!

a) „Autostart“
Autostart means, that the device, after the supply voltage was connected, is brought on line automatic with a time lag of ca. 3 s, „automatic starting“.

b) „Switch off“- „starting“
„Switch off“ means that the control of the power semiconductor and the feedback is disconnected and also consequently no braking operation of the drive control system is possible.
„Starting“ is the activation of the control of the power semiconductor.

c) „Storage“
The device has an error memory, which can be dedicated specific errors. Stored error messages must be acknowledged by reset or by disconnecting the supply voltage of the control unit-power supply.
„Storage“ leads at the same time always to a „switch off“ and to the de-energies of the common fault indicator relay.

d) „Acknowledgement“
After storage, after an error is cleared, the error memory must be acknowledged by the ON-acknowledgement button or by 3-phase switch off of the mains supply.

Stop!

STOP

Acknowledgement at too high link voltage, that is while the braking operation is not recommendable. If regardless is acknowledged, the power semiconductor is suspended an increased loading, which can lead to early component aging.

e) „Phase failure“
The phase failure voltage monitoring monitors the line voltage at all 3 phases. At failure of a phase the device stays in mode of operation, but with reduced feedback power.
There are different options, how the device reacts to a phase failure. An option is the „2 phase operation“, the other option is, that the device goes inoperative and indicates the disturbance by the common fault indicator relay.

Table 47 shows the encoding by the jumper:

J3	J5	J6	J7	Phase failure monitoring	
—	0	0	—	Sensitive, error memory "ON"	0 Jumper open
—	—	—	—	Insensitive, error memory "ON"	— Jumper en-closed
0	X	X	—	Deactivated, but error memory "ON"	X Jumper optional
0	X	X	0	Deactivated, error memory "AUS"	

Table 47: Encoding by the jumper

Note!

Jumper J7 is only on version 1.4.2 available. Error memory "ON" means, that the indication of the error "phase failure" by the LED stays so long active, until acknowledgement. Error memory "OFF" in contrast means, that the error "phase failure" is only so long indicated by the LED, until the error also effectively is available.

Stop!

A disconnect of the Jumper J3 is only allowed, if at a disconnection of supply the connected upstream disconnect elements (contactors, main switches etc.) release a pulse lock of the drive control systems or of the inverter, so that the feedback unit is disconnected and a dangerous voltage rise at the disconnected network range at potential present loads is obviated! The Jumper J7 should only be disconnected, if also J3 is disconnected, because otherwise a phase failure at active phase failure monitoring is only so long indicated, as the failure is present (no failure memory).

f) Surge protector

From the version 1.4.3 the devices feature a surge protector for the supply voltage, which disconnects the inverter at a voltage value of ca. factor 1,15 of the device nominal voltage.
The error code 3 is shown as error message (see LED-messages, chapter 14.1).
To differentiate the error messages phase failure and surge, there is the possibility to deactivate the phase failure monitoring by removing the Jumper 3 on the control board. If than a disconnection occurs with the indication by the red and yellow LED (error code 3), so an overvoltage is available as causation of the disconnection.

Commissioning

Table 48 shows the surge protection:

J3	J5	J6	J7	J8	LED status message			Analysis by overvoltage
—	X	X	—	—	Green	1.red	Yellow	Overvoltage and / or phase failure / commutation notch
—	X	X	0	—	Green	—	Yellow	Overvoltage
0	X	X	—	—	Green	1.red	Yellow	Overvoltage and/ or phase failure / commutation notch
0	X	X	0	—	Green	—	Yellow	Overvoltage
0	X	X	0	—	Green	1 red	Yellow	Continuous phase failure

Table 48: Surge protection

Note:
0 Jumper open
— Jumper closed
X Jumper optional

Default setting of the device:
Autostart and no disconnection at phase failure.

8 Operation and service

The inverter is maintenance free, if the required operational conditions are observed (see chapter 4.1).

At polluted ambient air the cooling air opening could clog. Control therefore the inverter regular (depending on the degree of pollution ca. all 4 weeks).

Danger!

Use no sharp or pointed objects as e.g. knives or screwdrivers to clean the cooling air opening.

Exhaust clog cooling air openings with a vacuum cleaner.

8.1 Fault finding and fault clearance

The five LEDs at the cover plate of the inverter indicate the operating condition. For improved checking at service work the same LEDs are at the internal control board. There is unlike to the cover plate a separate orange LED available, which function at the cover plate is taken over by the two coloured (green/orange) LED.

U_{CE}-disconnection:

The inverter disconnects at exceeding the respective for the device specified maximum current by the U_{CE}-protection device. The principle of this protection device determines thereby for less than one millisecond an overload of the IGBTs far over its specification for the normal operation. In particular case this is no problem for the device. If the over current disconnection appears often or actually continuous, so this leads to a strong accelerated deterioration of the power semiconductors and in the end to an early component failure.

For common U_{CE}-disconnections because of over currents can overload, low voltage at the network, a malfunction or oscillating controller, e.g. at the SPS, an oscillating reference variable of the controller or an incorrect dimensioning of the plant be responsible.

8.2 LED-status messages

	LED – display				
LED-display:	**Operation**	**Phase failure**	**U_{CE}**	**Overtemperature**	**Disturbance**
Error code:	**Green**	**Red**	**Red**	**Orange**	**Yellow**
1	X				
2	X				
3	X*			X*	X
4	X				X
5	X				X
6	X				X
7	X	X			X
8	X		X		X
9	X	X	X		X
10	X*	X	X	X*	X
11					
12	X				X
13	X	X			

Table 49: LED status messages

	Status report		Relay status
LED-display **Error code:**	**At commissioning**	**During operation**	
1	Ready to operate (after approx. 1s)	System in operation	Relay in resting position
2	Ready for operation, but no power feedback ⇒ Check the DC-fuses.		Relay in resting position
3		Overtemperature of the heat sink ⇒ Error-message is not resettable as long as the temperature is too high.	Relay dropout
4		Error code 3 ⇒ Heat sink temperature declined to normal and the error is resetable.	Relay dropout
5	System has been switched off, (external OFF) ⇒ Reset necessary	System has been switched off, (external OFF) ⇒ Reset necessary	Relay dropout
6	Overvoltage has been detected (J8 closed) ⇒ After grid voltage has declined to its nominal value, reset necessary		Relay dropout
7	Rotary field orientation incorrect or one phase is missing	Phase failure has been detected ⇒ Reset necessary	Relay dropout
8		Overcurrent has been detected ⇒ Reset necessary	Relay dropout
9	Error code 7 and 8	Overcurrent and phase failure have been detected simultaneously.	Relay dropout
10	Several errors have been detected simultaneously	Several errors have been detected simultaneously	Relay dropout
11	System off, at least two phases lost	System off, at least two phases lost.	Relay dropout
12		With option IFP: I^2t-tripping ⇒ Reset necessary	Relay dropout
13		Voltage breakdown during commutation but without tripping as jumper 3 and 7 are open (chapter 6e) ⇒ Operation possible, mains supply improvement recommended	Relay dropout

Table 50: LED status reports

9 Exhibit

9.1 Accessory

1. **Fuse holder with fuses for line side fuse protection**
   According to table 49 the following fuses with holder are available for the inverter:

REVCON® - type	Order reference	Construction
PFU 7 to PFU 70	SH PFU ZZZ-XXX	A

Table 51: Fuses

*ZZZ ≅ Nominal power of the inverter
*XXX ≅ Nominal voltage of the inverter

2. **Option IL (Insulating lacquer)**
   To protect the electronics of the inverter from pollution of the cooling air, there is the possibility to perform all boards with an insulating lacquer. This option increases the operating safety, but relieves the operator not from his obligation to arrange the observation of the in chapter 4.1 specified operating conditions.

9.2 REVCON® product overview

1. **REVCON® SVC**

Power feedback units for short time operation

(Crane systems, discontinuous centrifugal, etc.)

2. **REVCON® SVCD**

Power feedback units for continuous operation

(Engine test beds, escalators, wind energy plants, elevators etc.)

3. **REVCON® DCV**

Power supply- and feedback unit

For multiple motor applications with dynamic alternation of loads)

4. **REVCON® OSKM**

Harmonics compensation module to reduce the harmonics loading

(In preparation)

5. **REVCON® PFU**

Power feedback units for plants for extraction of regenerative Energy (Wind- / hydraulic power plants etc.). In connection with a durable excited Generator is no drive controller necessary!

6. **REVCON® HSTV**

Boost-converter for the generation of an increased direct current link voltage for the torque increasing in over- synchronous range of speeds

7. **REVCON® EDC**

Power supply module for multiple motor applications (supply of multiple drive controller) without generator- operation

8. **REVCON® SKS**

Filter module for the generation of sinusoidal line currents (THD I 10-16% according to the feed back unit and the load). Can be combined with REVCON SVC, SVCD, DCV, CDCV and PFU and with the most commercial converters!

9. **REVCON® RHF**

Filter module for the generation of sinusoidal line currents (THD I 5-16% according to the frequency converter and the load). Filter module of the newest generation with smaller dimensions and reduced weight and better performance

All products are available for 400V line voltage, the most also for 230V, 400V, 460V, 500V, 600V and 690V! According to the product power from 4 to 440kW can be transmitted, whereby the most products are appropriate for parallel connection, so that power ratings until the megawatt range can be achieved!

10 Contact

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< TECHNICAL CHANGES RESERVED >

11/12

11 Index and directory

Exhibit

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