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USER MANUAL OF THE POWER SYSTEM SI48-28

10.09.2020

Warnings

- **Please read this User Manual thoroughly before using the device.**
- **Please don't disassemble device which is energized. Touching the internal components results in high risk of electric shock or skin burning.**
- **During repair or exchange of the device please obey basic rules of handling electrical equipment:**
  - **disconnect mains power and make sure that it couldn't be accidentally switched on;**
  - **disconnect the batteries and make sure that its terminals couldn't be accidentally short-circuited (such event results in risk of fire or explosion)**
  - **make sure that the devices nearby are not powered and accidental touching them does not create risk of electric shock.**
- **Please protect the device from the possibility of any items or fluids entering in – they can cause a risk of electric shock and device damage.**
- **Do not cover ventilation openings – doing so may result in device damage.**
- **Please provide a free space of at least 8 cm at the sides of the device, enabling its proper ventilation.**
- **The device must be supplied from the mains with a protective earthing terminal.**
- **The device may interfere with operation of sensible radio and television equipment located nearby.**
- **The device may be operated only by authorized and trained personnel.**
- **The device may only be serviced by the manufacturer's service department or specialized units authorized by the manufacturer.**

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1. Introduction

This manual is a document addressed to users of the power system SI48-28. It includes data and guidelines on installation, functionality, set-up, operation and maintenance of the device.

The power system is dedicated to power telecommunications equipment, in particular switches. Its construction allows application to access systems of various load currents. The rectifier ZPA-48/7 with power factor correction is the main building block of the system.

A detailed description of the computer application to monitor and control the power system (optional outfit of some versions) is included in a separate manual.

2. Models of the power system SI48-28

Specific models differ by the number of mounted rectifiers (thus maximal output current) and type of optional outfit. The table below summarizes all models the current manual refers to.

Model	Number of rectifiers	Output current	RS-232	RS-485
SI48-28-42	4	28 A	+	-
SI48-28-43	4	28 A	-	+
SI48-28-32	3	21 A	+	-
SI48-28-33	3	21 A	-	+
SI48-28-22	2	14 A	+	-
SI48-28-23	2	14 A	-	+

2.1 Description of the operational environment

Allowable storage temperature	-40°C ÷ +85°C
Recommended storage temperature	+5°C ÷ +40°C
Ambient temperature during operation (loadability of the system shown in Fig. 1)	-33°C ÷ +70°C
Relative humidity (no condensation)	30% ÷ 80%
Atmospheric pressure	84 ÷ 107 kPa
True altitude	up to 1500m
Direct insolation	Inadmissible
Permissible sinusoidal vibrations during operation	0,1g 10 ÷ 150Hz
Vibration and impact during transport	0.5g 10 ÷ 150Hz

REMARK: If the ambient temperature exceeds 40°C and the load of the power system approaches the nominal level, it is recommended to set up a forced circulation of air vertically through the ventilation holes of the power systems and around heat sinks at the rear part.

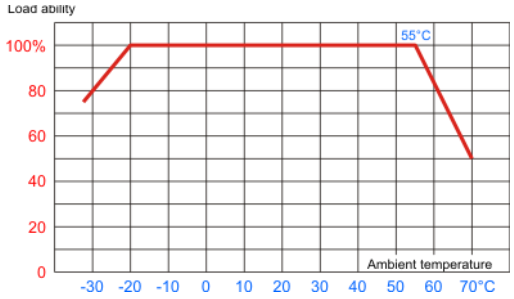
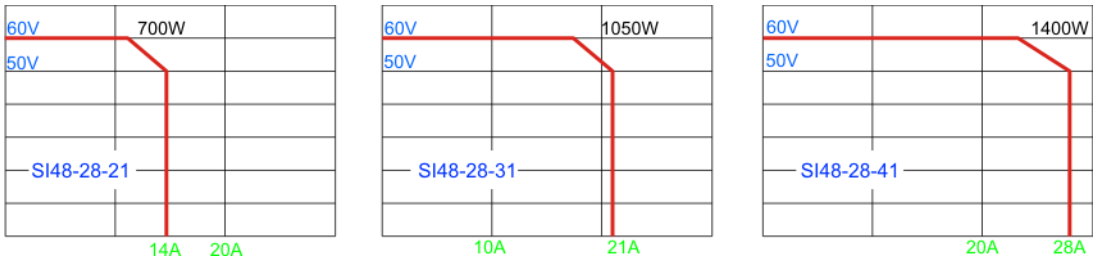


Fig. 1 Load ability of the power system as a function of ambient temperature

2.2 Maximal current and voltage relationships



2.3 Abstract of technical data

Underlined font denotes nominal or factory preset values (default)

Input	**SI48-28-4x**	**SI48-28-3x**	**SI48-28-2x**
Voltage *	184...220...230...253V		
Frequency	47 ÷ 53 Hz		
Tolerance for increased and decreased voltage	176...265V		
Maximal inrush current **	30A/phase		
Leakage current in the PE wire	<6mA	<4.5mA	<3mA
Monitoring of presence of the input voltage	Yes		
Maximal input current at the full configuration **	3A/phase		
Electrical safety	EN 60950-1 + A1 kl. I		
EMC emission	EN 61000-6-3		
EMC immunity	EN 61000-6-2		
Cooperation with a diesel generator	Yes		
Output			
Range of output voltage ▪ operation w/o a battery bank ▪ operation with a battery bank ***	44.0...48.0...59.0V 52.8…54.2…55.2V		
Maximal output current ▪ operation w/o a battery bank **** ▪ operation with a battery bank ****	5..21..28A 5..17..28A	5..14..21A 5..11..21A	5..7..14A 5..5.5..14A

Cooperation with the battery bank			
Floating mode voltage (@ 25°C)	52.8…54.2…55.2V		
Temperature compensation of the floating voltage	0…-96…-144mV/°C		
Equalize mode voltage	55.2…55.7…57.6V		
Criteria to enter the equalize mode: ▪ duration of operation in the battery mode ▪ voltage drop during the battery mode	15 minutes 45.6V		
Criteria to leave the equalize mode: ▪ drop of the charging current ▪ maximal duration of the equalize charging ▪ increase of the battery temperature during the equalize charging	0.3..2.5..5A 18 hours 40°C	0.3..1.8..5A	0.3..0.9..5A
Maximal current of the battery charging (current limit)	1.0..10..15A	1.0..7..15A	1.0..3.5..15A
Admissible difference of currents between banks – indication	0.5..2.0..5A	0.5..1.4..5A	0.5..0.7..5A
Voltage to disconnect the discharged battery bank	36.0…42.0…48.0V		
Mechanical parameters			
Weight	12.5kg	10.7kg	8.9kg
Dimensions (width × height × depth)	483 ×132.5 × 313.5		

*) The presented voltage range refers to voltage of a single phase with respect to the neutral wire. In case of powering by three phases the neutral wire must be connected. In both cases the power supply should be connected via mains breakers (e.g. S300) installed on all wires of the input power.

**) For phase L3 of the power system SI48-28-4x it is 30A and 6A, respectively (this phase powers rectifiers #3 and #4). If the power supply is connected to a single phase one has to sum up currents otherwise distributed over three phases.

*****)** The presented range is spanned between voltage of the discharged battery bank (at the end of the battery mode) and voltage of the equalize mode.

****) Default values to trigger indication of exceeded current have been defined taking into consideration redundancy of one rectifier, and for battery mode – also subtracting 40% of the maximal charging current.

2.4 External communication

Operation of the power system is supervised by the microprocessor controller ST-20-1. It is an independent unit mounted inside the power system. It can communicate with the serial communication module RS-232 (RS-485). The connection is made by the socket 6/6 RJ12 available on the rear panel of the power system.

The serial communication modules additionally allow the selection of the MODBUS protocol and the protocol implemented in the SI48-28, so you can use older supervision software for the power system.

2.5 Principle of operation

2.5.1 General characteristics

Characteristic features of the power system:

- powered by three phases or a single chase
- offers redundancy of power supply as required in telecommunications
- ensures precise regulation of voltage of connected battery banks (taking into consideration their type and principle of operation) at the level corresponding to full charge
- allows protection against too deep discharge of batteries
- indicates its state visually and as sound
- triggers alarms
- accepts external alarms

2.5.2 Description of operation

The building blocks of the power system mounted into19” EUROCARD are show in Fig. 2. The specifics elements are:

1. 4, 3 or 2 rectifiers of model ZPA-48/7.
2. Panel of protections of battery banks and outputs.
3. LCD with LEDs indicating the state of operation, as well as a key to select between functions.
4. Terminals to connect AC mains power **L1**, **L2**, **L3**, **N**
5. Protective earth terminal ⏚
6. Socket of temperature probe.
7. Remote indication sockets (relays) **MAINS FAILURE**, **URGENT ALARM**, **NON-URGENT ALARM**
8. DC terminals (outputs and battery banks) **OUT1**, **OUT2**, **BAT1**, **BAT2**
9. Sockets to input external alarms **EXT ALARM1**, **EXT ALARM2**
10. Socket of fixed line digital communication **COM** (RS-232 or RS-485)
11. Additional output of the positive output pole for grounding purposes

3. Functional elements of the power system

The power system is mounted in the cassette EUROCARD 3U/220 devoted to fix into 19” rack.

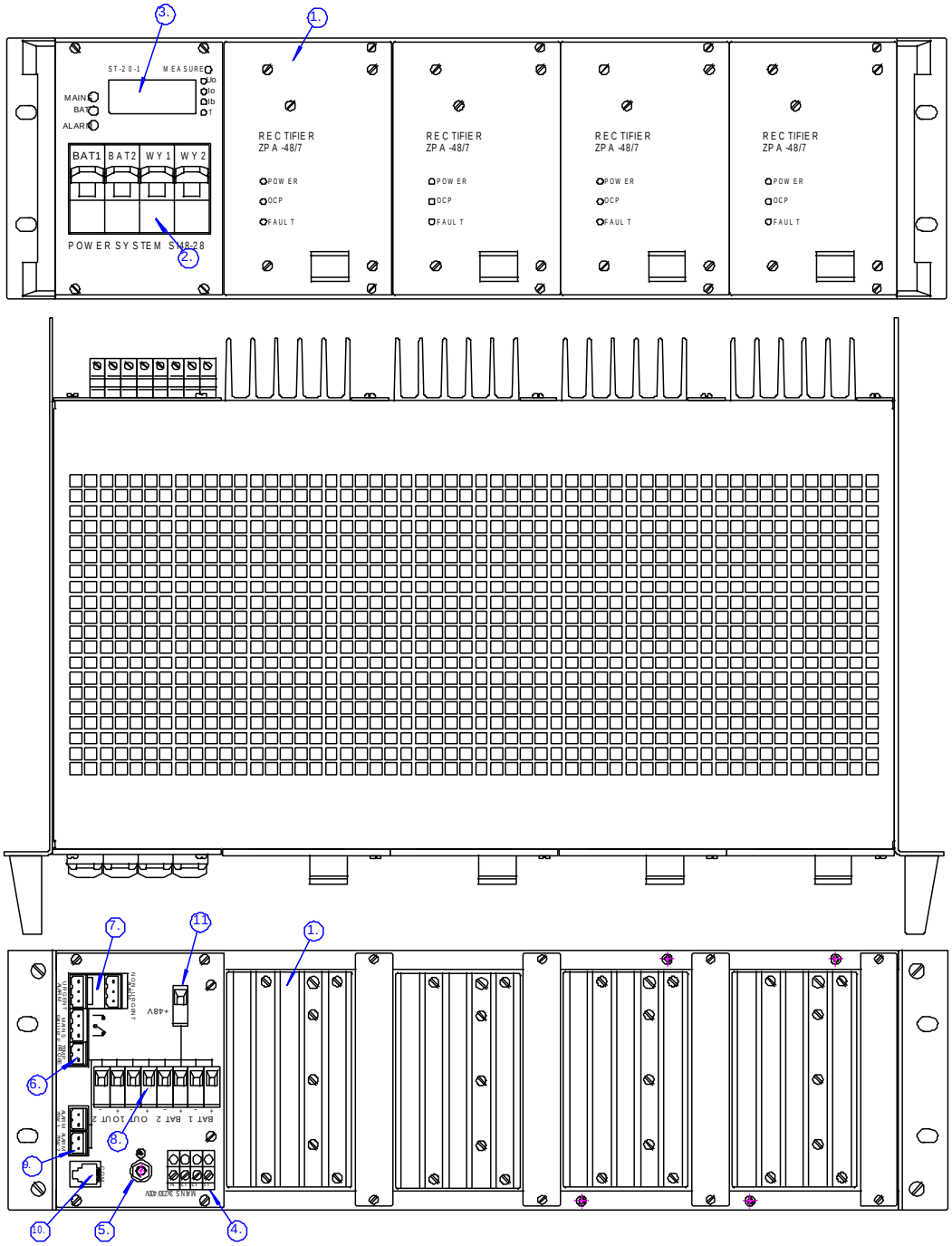


Fig. 2 View of the power system SI48-28-4x (*full configuration – it includes the optional input of the external circuit of monitored charging*)
(Description of shown elements is in the section 2.5.2)

The power system is managed by the microprocessor controller **ST-20-1** built inside the device (not visible on the picture). There is also the relay **LVDD** to disconnect battery banks to protect them against too deep discharge.

The power system operates in direct floating mode (both rectifiers and powered loads are connected in parallel with one or two battery banks). It allows equalize charging of both battery banks. Criteria to enter the equalize mode are shown in the table of parameters and electrical features. Additionally, the equalize mode is triggered when mains returns after an unfinished charging, in spite of not meeting the criteria.

The construction of the power system enables to carry out an automatic test of capacity of the cooperating battery bank and detection of discrepancies between two connected battery banks.

Automatic monitoring of the battery banks complies with requirements defined by telecom operators.

Description of the block diagram of the power system SI48-28-4x

In its basic configuration the power system uses 4 rectifiers **ZPA-48/7** connected to two rails: positive and negative (the positive rail is common for all external signals). Applied rectifiers independently realize I-U characteristics, and in cooperation with the controller **ST-20-1** operate according to I-P-U characteristics at a defined level of voltage and maximal current, as well as at constant maximal power. In the basic configuration the rectifiers work in parallel with uniform current sharing. If a rectifier fails, the load is uniformly distributed among the remaining three rectifiers.

At most two battery banks cooperating with the system are connected to the rails via breakers **BAT1** and **BAT2**, as well as via low voltage disconnect device **LVDD**.

Output of the power system divides into two circuits (**OUT1** and **OUT2**) outfitted with independent breakers. All overload breakers are located on the front panel of the power system. Each output and battery circuit has own pair of terminals located on the rear panel of the power system. Next to them there are four terminals for mains connection (3 ones for phase wires **L1**, **L2** and **L3** together with the neutral wire terminal **N**). If three phase grid is applied, two rectifiers (**#1** and **#2)** are powered by separate phases, and two remaining (**#3** and **#4)** by the third. If the power system is connected to a single phase, the terminals **L1**, **L2** and **L3** have to be short-circuited by a bridge being added as an outfit. Thus all rectifiers are powered in parallel. In case of three phase connection a mains detector comes up with information about presence or lack of any phase of the mains. A missing single phase can be also recognized by indication of the specific rectifier to be switched off. There is a correspondence: the line **L1** powers the first rectifier (counting from left when looking at the front), the line **L2** – the second, and the line **L3** – the third and fourth rectifier.

Communication of the power system with external devices is carried out via serial communication module **RS-232** (**RS-485**) connected to the **digital communication socket** 6/6 RJ12 on the rear panel.

Processing of measure and control signals, adjustment of their levels, distribution of power to monitoring subsystems and isolation of circuits (where galvanic isolation is required) is conducted by the **adjustment system**. It collects the basic signals on values of voltages, currents and temperatures. In particular, it collects values at the output of the power system $\mathbf{U_{OUT}}$, $\mathbf{I_{OUT}}$ and at battery terminals $\mathbf{U_{B1}}$, $\mathbf{I_{B1}}$, $\mathbf{U_{B2}}$, $\mathbf{I_{B2}}$. The signals after having amplified and normalized to levels appropriate for the controller **ST-20-1** are used by the controller to assess the state of the power system.

Additionally, the adjustment system is fed by information about failure of a phase of the mains power (**mains failure**) and – via a system of diodes connected to each output of the power system – about a **disconnected output**. The state of the disconnected output is detected only when there is any load connected (the output must form a closed circuit with the positive rail of the power system).

The controller, via the adjustment system, controls the output voltage of rectifiers and is fed back by information about the state of their input, internal temperature and possible failure. The controller can also switch off a rectifier and manages visual indication on rectifiers.

Guided by the controller the adjustment system sets on alarm signals:

- **urgent**
- **non-urgent**
- **mains failure** (all phases)

These signals are available as three dry contacts of relays. Cross-referencing of specific events in the power system to the urgent or non-urgent alarm, as well as to sound indication is possible at the production stage or by manufacturer's service. A user can do it independently, if the power system has any link of digital communication.

The controller records also history of events occurring in the power system. It could be read by the **COM** port. Up to 400 events could be stored.

There is a LED on the control panel to read parameters of the power system: output voltage, output current, battery current, temperature and an alarm code (section 4.3.1) in case of its occurrence. The key **measure** switches between types of displayed measurements and the alarm codes. Besides, alarms could be indicated by sound (the sound indication is cancelled by the key **measure** too).

The adjustment system accepts two binary signals of **external alarms** in reference to the positive output rail (the alarm is triggered by a short circuit of the given alarm line with the rail).

There is a socket on the rear panel of the power system to connect a **temperature probe** to measure temperature of batteries. The measured temperature is used by the controller to compensate the floating

voltage of the battery bank and triggers an alarm when limits of the temperature are exceeded. In lack of the probe the power system can't perform the compensation and assumes the temperature to be 25°C.

The controller, via the adjustment system, controls also the relay **LVDD** and can disconnect the battery banks at too low voltage to protect them against too deep discharge.

The power system configures automatically after start-up, i.e. it recognizes:

- number of cooperating battery banks and number of rectifiers mounted in the cassette,
- presence or lack of the temperature probe, and
- type of the communication module (RS-232, RS-485).

To carry out this configuration it is needed to completely disconnect the power system from power, both mains and battery banks by the **physical disconnection**.

The basic, factory preset electrical values have been defined in section 2.3 Abstract of technical data. The default declarations of alarms are shown below.

1. **THE URGENT ALARM**
   (indication by the appropriate relay, by the LED **ALARM** on the panel of the digital display and by sound).
   - 1.1. Inconsistency about presence of the battery bank #1 or #2
   - 1.2. The breaker of a declared bank open
   - 1.3. Battery banks disconnected by LVDD
   - 1.4. Battery test failed
   - 1.5. Max. battery charging current exceeded
   - 1.6. Max. difference of battery currents exceeded
   - 1.7. Output breaker open
   - 1.8. Max. output current exceeded
   - 1.9. Max. output voltage exceeded
   - 1.10. Overload of the power system
   - 1.11. Alarm of two or more rectifiers
   - 1.12. External alarm 1

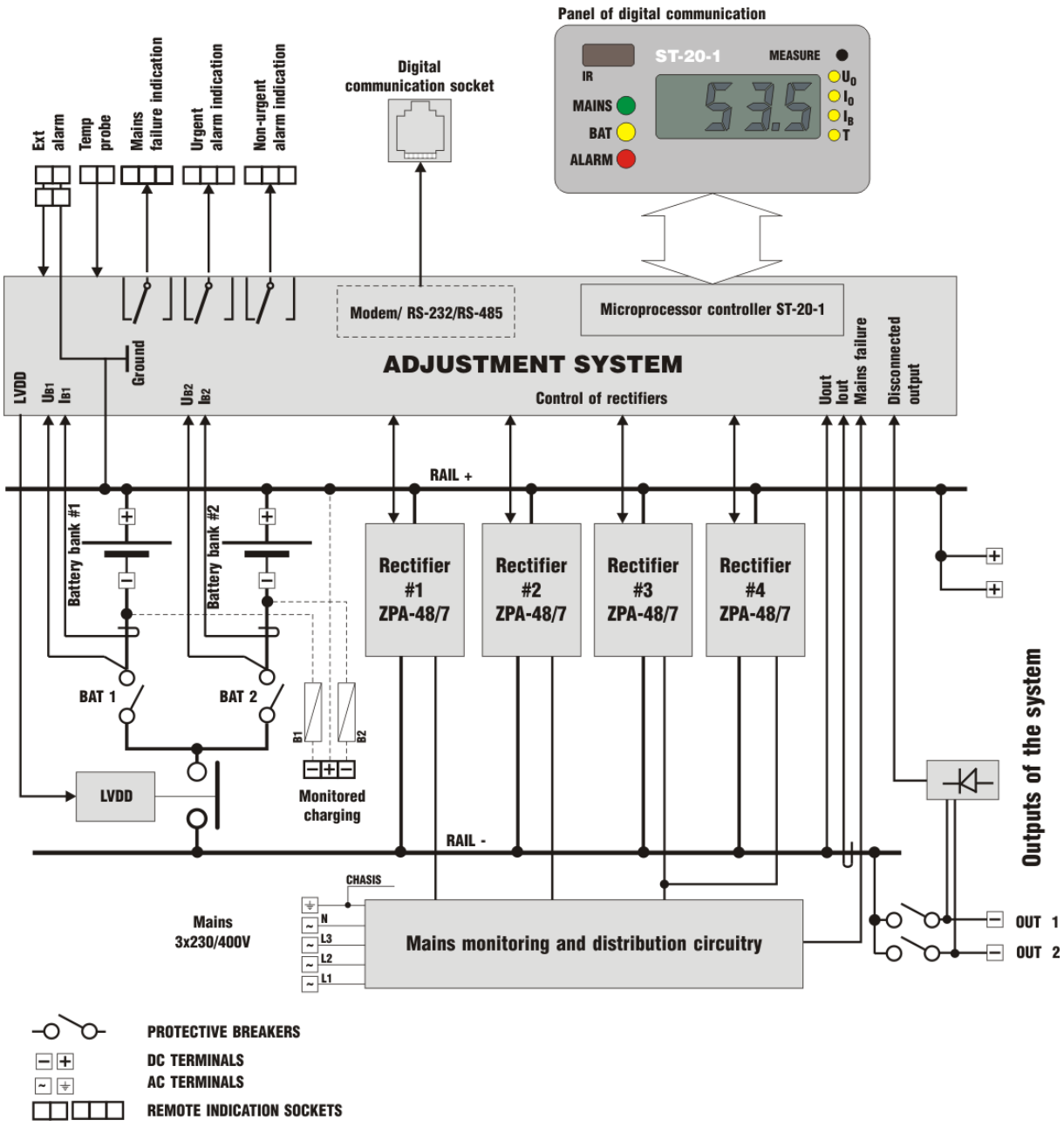


Fig. 3 Block diagram of the power system SI48-28-4x

2. **THE NON-URGENT ALARM**
   (indication by the appropriate relay and by the LED **ALARM** on the panel of the digital display)
   - 2.1. Low battery voltage
   - 2.2. Lack of a single phase of the mains power
   - 2.3. Failure of a single rectifier
   - 2.4. Max. or min. temperature exceeded
   - 2.5. Inconsistency about presence of the temperature probe
   - 2.6. Inconsistency about presence of rectifiers
   - 2.7. Max. temperature during equalize charging exceeded
   - 2.8. External alarm 2
3. An inactive alarm
   (an occurrence of the event does not trigger indication on the front panel and via the optional module of digital communication)
4. Mains failure
   (the power system has a dedicated remote indication – a relay – bound only to the mains failure).

Remark: In case of the mains failure the LED **Mains** on the front panel switches off, and the LED **Bat** switches on to indicate a transfer of the power system to the battery mode.

A user can re-assign the level of urgency to alarms, provided he has a PC with the application supplied by the manufacturer of the power system and the user manual of this application.

3.1 The panel of the digital display

The panel of the digital display is shown in Fig. 4. There are the following elements on the panel:

1. LCD.
2. Set of LEDs to inform what value is displayed.
3. LED indication of the state of the power system:
   - the green diode **MAINS**
   - the yellow one **BAT**
   - the red one **ALARM**
4. A key to select a function and type of measurement.

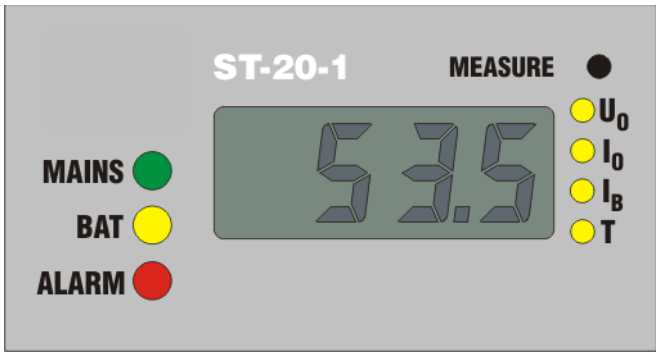


Fig. 4 The panel of the digital display

Consecutive pressing of the key **MEASURE** switches the display to show:

- output voltage (U_0) – shown by default
- output current (I_0)
- battery current (I_B)
- temperature (T)
- a code of an alarm (provided the power system detected a fault in its operation).

The value shown at the given moment (except the alarm code) is indicated by a LED in the row below the key.

4. Set-up

4.1 Conditions of the safe set-up

The power system SI48-28 is devoted to be connected either to a single phase or three phase utility grid with the protective earth wire (class I electrical equipment). **The chassis of the power system must be connected to protective earth.**

The power system is not outfitted with own mains breaker, so a dedicated breaker with overload protection (e.g. of type S302 or S303, see Fig.5) should be applied in the input connection (outside the power system). It is also recommended to apply a dedicated, external battery breaker or detachable contacts to enable full and reliable disconnection of the cooperating battery banks. Such measures ensure safety during mounting and dismounting of the power system, making inadvertent short circuit of battery terminals not feasible. This is important especially in telecommunications installations, where common positive pole is connected to earth, thus connected also directly to the cassette, cabinet or rack where the power system is mounted. During mounting or dismounting of the power system it is enough to disconnect the negative pole of the battery bank, preferably in its direct proximity.

The above mentioned breaker could be used also for easy configuration of the power system (storing the state and number of connected external modules in memory of the microprocessor controller) by a temporal total disconnection from the mains and battery banks.

In the power system, the output circuits, circuits used to connect the battery bank and the temperature probe circuit are separated by reinforced insulation from the input circuit, which is the mains. Reinforced insulation is not shunted by any resistor (group of resistors) or any capacitor (group of capacitors).

The power system is equipped with an additional screw connection available on the rear panel connected to the "plus" output pole, but insulated from the housing. By default, this connector is not connected to the power system's casing.

Depending on the requirements of the telecommunications system, the installer grounds the positive pole of the power plant:

- directly through the yellow-green wire connection of the additional "plus" output screw terminal with the power supply ground terminal;

- indirectly by connecting an additional "plus" output screw terminal with a separate grounded positive rail of a telecommunication DC switchboard by a separate yellow-green wire.

4.2 Mounting of the power system

The power system is devoted to mount into a 19" rack cabinet compatible with cassettes EUROCARD 3U/220. Because there are terminals on the rear panel of the power system, it is recommended to use cabinets offering access to the rear side.

To mount the power system inside a cabinet one has to perform consecutively the following steps:

- attach rails (slides) to the 19" rack to enable sliding the cassette in,
- attach cage nuts in appropriate holes of the rack,
- slide the cassette over the prepared support,
- fasten the power system with four screws with washers,
- check the mounting of the power system.

There is a loss of ca. 50W per each rectifier ZPA-48/7 in the power system with nominal load, so free circulation of air around the heat sink and through perforation in the casing should be enabled.

In case of elevated ambient temperature there should be a forced air circulation, e.g. by means of a panel of fans below the shelf with the power system. There should be free space of ca. 100 mm above the power system to guarantee proper cooling (see also section 2.1 of this manual).

4.3 Connection to the utility grid

The connection of the power system to the power grid should be made (within the 19 "rack) with a 3-core cable with a cross-section of 1.5mm^2.

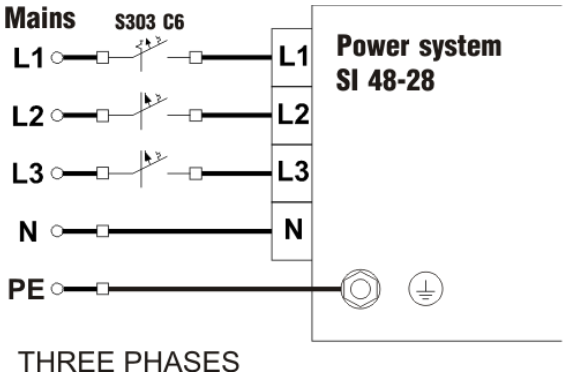
COMMENTS:

1. The power system is not equipped with its own mains breaker, so it is required to use a mains switch with overcurrent and short-circuit protection, e.g. type S301 C10A, in the supply circuits (outside the power system).

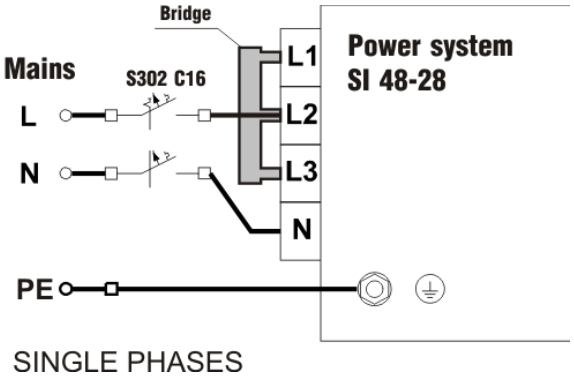
2. The necessary electrical installation should be made in the form of a permanent installation equipped with a surge protection system.

3. The circuit breaker and surge protection system should be installed in the cabinet.

Rectifiers ZPA-48/7 applied in the power system have power factor correction, so the power system could be connected either to a three phase or single phase utility grid.



THREE PHASES



SINGLE PHASES

Fig. 5 Input wiring diagram of the power system SI48-28

The connection to a single phase grid requires a bridge – which is delivered together with the power system – to short-circuit terminals L1, L2 and L3. Together with the bridge the wire L has to be connected to one of terminals. In both cases the input power should be connected via an external maintenance breaker (e.g. of the type S302 or S303), as shown in Fig. 5.

The chassis of the power system must be unconditionally connected to earth. It could be done locally (if available), independently from the PE wire of the mains power, or via the PE wire, as shown on the diagrams above.

4.4 Output and battery circuits

The power system has two output circuits protected by breakers available on the front panel. The controller of the power system, supervising the operation of the system, can check the state of the breaker only when there is a load connected to the given output. If the output remains not connected by a load circuit, then the state of the corresponding breaker is irrelevant, however, it is recommended to keep it open.

To keep correct operation (no alarms) one should neither switch breakers, nor connect, not disconnect loads during the operation of the device – after its successful configuration. If both outputs are used, i.e. loaded, then both breakers on the front panel should be closed. In case only one output is used, the terminals of the second should remain free and the corresponding breaker on the front panel should be open.

Similarly for the battery circuit: the terminals of the unused one should remain free, and the respective breaker on the front panel – open. In case of using both battery inputs, both breakers must be closed. Whatever changes during the operation of the power system (connection or disconnection of a battery bank, switching the breakers on the front panel) will trigger an appropriate alarm.

By its design the power system is devoted to operation with common positive rail. It means that both outputs and both battery circuits (as well as two inputs of external alarms) have the common positive pole. This fact has been depicted on the rear panel in the form of the graphical connection of appropriate contacts by a common thick line.

4.5 Temperature probe

To use the temperature probe (included as the outfit of the power system) on has to plug it into the appropriate socket, and to place its second end with the temperature sensor in the proximity of the battery bank. The metal tip, equipped with a hole, is isolated from the wires, so it could be attached by a screw, e.g. to the frame of the cabinet, or even directly to a terminal of a battery (preferably to a positive pole).

4.6 Relay indication

There are three sockets of the remote indication on the rear panel. Each of them offers three relay contacts, totally isolated from remaining circuits. The three-pole sockets applied in the power system cooperate with two-pole plugs delivered as the outfit of the system. A placement of the plug in the correct socket enables usage of either NC or NO contacts.

The icons next to the sockets of the relay indication show the position of the contacts in the normal, voltage-free state, i.e. when the relays are not activated.

Connecting circuits of remote indication one has to pay attention to electric strength of relays which is 60V/0.5A.

4.7 Inputs of external alarms

The power system SI48-28 has two inputs to process binary signals from outside. For example, they could be used to feed information from a burglary protection system or whatever device a user wants to be monitored by the power system.

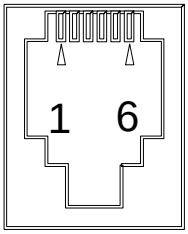
To activate the alarm one has to short-circuit both contacts of the given input.

Remark: Both inputs are galvanically connected with the common positive rail of the power system, depicted on the rear panel by a thick line connecting appropriate contacts of the alarms with positive terminals of outputs and battery circuits.

4.8 The socket of digital communication (option)

Each power system has a socket of the type 6/6 RJ12 for external digital communication. It is located on the rear panel and denoted as **COM**. This socket is active only when the power system is outfitted with an internal communication module: RS232 or RS485.

The table below summarizes signals and shows where they are available in the socket, for each of the offered modes of digital communication.



Pin number	RS-232	RS-485
1	nc	nc
2	GND	GND
3	RxD	A
4	TxD	B
5	GND	GND
6	nc	nc

In case of RS-232 or RS-485 links a special wire is required.

Remote monitoring of the power system or setting of its parameters requires dedicated computer software. This is delivered by the manufacturer on request.

4.9 Circuits of the monitored charging (option)

On customer's request the power system SI48-28 can be prepared to have circuits and terminals for the monitored charging of the selected battery bank from an external voltage source. These terminals can be used also to carry out test discharging of the selected battery bank.

Such a version of the power system has three additional contacts: one common for both battery banks (**+**, the positive rail of the power system) and one (**-**) for each battery bank. Each contact accepts a wire of the cross-section of at most $4mm^{2.}$ Both battery outputs are protected by separate fuses 6.3×32mm15A. It is not allowed to use fuses of higher amperage, because this is the only protection of the battery circuit against an inadvertent short circuit or reversed polarity of the voltage source of the monitored charging.

The monitoring requires separating the chosen battery bank by opening the appropriate breaker on the front panel and to connect either the voltage source (for the monitored charging) or a load (for the monitored discharging) to the above described contacts. In both cases one has to apply external meters of current and voltage of the separated battery bank. These parameters can not be read from the LCD of the power system, because the LCD shows present parameters of the operating power system: output voltage and current of the remained (not being monitored) battery bank. During the monitoring the power system can indicate alarms referring to disconnection of a battery bank and too high difference of currents of both battery banks. One should pay attention to protect the temperature probe from random temperature changes which might be induced if the probe is located too close to the monitored battery bank or to the resistor used to discharge the separated battery bank. The false reading of the temperature will influence the floating voltage of the battery bank remaining in the power system.

5. The start-up of the power system

Before having the mains power turned on one has to check if the power system is set up property. In particular, one has to pay attention to quality of PE wires and **polarization of connected battery banks.**

Having connected all needed circuits (including the temperature probe, if it is used) and being sure all connections have been made properly one can carry out the start-up of the power system in the following order:

- switch on appropriate battery and output circuits by the breakers on the front panel,
- switch on mains power by an external maintenance breaker.

One has to remember to switch on only these breakers on the front panel which serve actually used circuits, physically connected to terminals **BAT1**, **BAT2**, **OUT1** and **OUT2** (see section 4.4 Output and battery circuits of the manual).

5.1 Auto-configuration

The power system configures automatically during switching-on of power: it recognizes the number of cooperating battery banks, number of rectifiers present in the cassette, presence of lack of the temperature probe as well as the type of the communication module (RS-232, RS-485). This configuration needs an initial, total disconnection of power, both the mains and battery banks, by their physical disconnection.

These conditions are naturally fulfilled during the first start-up of the power system mounted on the site (see section 5).

5.2 Correct operation

The power system which has been properly set up and which works properly at the presence of the mains power can be recognized by continuous light of the green LED denoted as **MAINS**, visible on the panel of the digital display, and by the green LEDs **POWER**, visible on the front panels of the rectifiers ZPA 48-12. All alarm and warning signals, as the LED **ALARM** on the panel of the digital display, the LEDs **OCP** and **FAULT** on the front panels of the rectifiers, and sound indication are not active in this state.

After the first switching-on of the power system it is recommended to carefully check correctness of the set-up and conditions of the operation on the site. One can achieve this using the panel of the digital display of the power system. By pressing the key **MEASURE** one has to read output voltage and current as well as battery current. The values could be used to assess the load of the power system and the state of the battery banks. Reading of temperature and comparing with ambient temperature allows for assessment if this channel operates correctly. Thus one can ensure proper functioning of the temperature compensation of floating voltage.

It is also recommended to check the main function of the power system – its ability to sustain the output voltage in lack of mains power. To do this one has to use the breaker in the input circuit, outside the power system (see section 4.3 Connection to the utility grid of the manual). The power system differentiate between switched off rectifiers and disconnected mains. During this test one can also check the circuit of the remote indication of the mains failure (if used).

To check other indication circuits, it is recommended to induce alarm states by switching off one of the breakers on the front panel, switching off a rectifier or triggering an external alarm (in particular, when inputs of external alarms are used). The detailed description how the power system reacts to alarms can be found in section 6.1.2 of the manual.

6. Regular maintenance of the power system

6.1 LCD

The panel of the digital display allows reading 3 digits of values of characteristic voltages and currents measured by the microprocessor controller. These values are displayed in volts and amperes, respectively with resolution of 0.1 of the unit. Similarly, temperature is measured with resolution of 0.1°C. The same display is used to read codes of alarms.

6.1.1 Measurements of voltages, currents and temperature

The type of the currently shown measurement is indicted by the appropriate LED in the row below the key **MEASURE**. If the power system detects an alarm, it is possible to read – besides the above described measurements – a code of an alarm. When the code of an alarm is shown all LEDs denoting the type of the measurement are off. Repeated pressing of the key **MEASURE** shows consecutive codes of alarms (if there are a few). Finally, the display returns to show the value of the output voltage (Uo) and the cycle restarts. The measurement of the output voltage is the default one – the power system returns to this 30s after the last pressing of the key.

Consecutive pressing of the key **MEASURE** switches the display to show:

- output voltage (U_0),
- output current (I_0),
- battery current (I_B),
- temperature (T),
- a code of an alarm (E01...E64) if the power system has detected any fault in its operations.

If the power system has no connected temperature probe, then the temperature display is skipped (after displaying the output current, an alarm code or value of the output voltage is shown).

6.1.2 Indicated alarms

Detected, faulty states of the operation of the power system are indicated as alarms. Apart from the visual and sound indication also the information about the specific type of the malfunction of the power system is available.

Each alarm has its own code which could be read on the LCD. To display the code of the occurred alarm one has to press the key **MEASURE** until all LEDs below the key turn off. Then the display shows the code of the recognized alarm. If a few alarm events have been recognized, then the next pressing of the key **MEASURE** will show next codes of alarms. Additionally, an urgent alarm is indicated by a blinking letter E preceding the digits of the code. Having reviewed all alarms the next pressing of the key **MEASURE** will switch to the regular display of measurements.

To turn off the indication of the alarm one has to remove its cause and then to press the key **MEASURE** longer than 5s. Pressing the key is effective irrespectively of the current state of the display (the type of measurement), for all detected alarm events.

If the cause of an alarm has not been removed, the alarm will be triggered anew. One has to keep in mind the next triggering of the alarm can happen after some delay needed to detect the alarm. In two cases this delay could be substantial:

- Voltage of the battery test exceeded (E10)
  The alarm could appear during the next battery test (delay up to a few hours);
- Bulk charging overtime (E09)
  The alarm will appear if the system switches again to bulk mode (only after a mains failure) and the allowed duration of the charging is exceeded again.

Alarm code	The name of the alarm	The reason of the alarm occurrence
E01	Max. output current exceeded	Output current has increased above the defined level.
E02	Max. charging current exceeded	Battery charging current has exceeded the maximal allowed value.
E03	Max. battery/output voltage exceeded	Output voltage of the power system (and of the battery bank, if connected) is higher then allowed.
E04	Min. battery/output voltage exceeded	Output voltage of the power system (and of the battery bank, if connected) is lower then allowed.
E05	Low voltage disconnect device open	Battery banks have been disconnected because their voltage has approached the value below which they could be damaged.
E06	Overload of the power system	Current is sourced from the battery bank in spite of presence of mains power.
E07	Min. battery temperature	Battery temperature has reached the minimal value.
E08	Max. battery temperature	Battery temperature has reached the maximal value.
E09	Equalize charging overtime	Duration of equalize charging of the battery bank is longer than allowed. Possibly the battery bank is damaged.
E10	Min. voltage of the battery test exceeded	During the battery test battery voltage is lower then allowed. Possibly the battery bank is damaged.
E11	Max. difference of battery currents exceeded	Difference of battery currents has exceeded the maximal value.
E12	Output breaker open	During operation of the power system an output breaker (**OUT1** or **OUT2**) has been opened.
E13	Breaker of the battery bank #1 open	During operation of the power system the breaker of the battery bank No. 1 has been opened.
E14	Breaker of the battery bank #2 open	During operation of the power system the breaker of the battery bank No. 2 has been opened.
E15	External alarm #1	The external alarm No. 1 has been invoked.
E16	External alarm #2	The external alarm No. 2 has been invoked.
E17	Failure of the phase #1	Failure of one phase of mains power.
E18	Failure of the phase #2	
E19	Failure of the phase #3	
E20	Mains failure	Failure of all phases of mains power.
E21	Max. battery temperature during charging	Temperature during equalize mode has reached the value greater than allowed. Possibly the battery bank is damaged.
E22	Failure of two or more rectifiers	Two or more rectifiers do not function correctly.
E24	Lack of continuity – battery 1	Lack of continuity in battery circuit 1

E25	Lack of continuity – battery 2	Lack of continuity in battery circuit 2
E33	Inconsistency about presence of the rectifier #1	A rectifier has been inserted or removed during operation of the power system.
E34	Inconsistency about presence of the rectifier #2	
E35	Inconsistency about presence of the rectifier #3	
E36	Inconsistency about presence of the rectifier #4	
E37	Inconsistency about presence of the battery bank #1	A battery bank has been connected or disconnected during operations of the power system.
E38	Inconsistency about presence of the battery bank #1	
E39	Inconsistency about presence of the temp. probe	Temperature probe has been connected or disconnected (damaged) during operation of the power system.
E49	Rectifier #1 – overheated	A rectifier: ▪ overheated – its temperature is higher than allowed, ▪ failed – there is a fault of the rectifier, ▪ switched off – the input power of the rectifier has been turned off, e.g. by the switch on its front panel,
E50	Rectifier #1 – failed	
E51	Rectifier #1 – switched off	
E53	Rectifier #2 – overheated	
E54	Rectifier #2 – failed	
E55	Rectifier #2 – switched off	
E57	Rectifier #3 – overheated	
E58	Rectifier #3 – failed	
E59	Rectifier #3 – switched off	
E61	Rectifier #4 – overheated	
E62	Rectifier #4 – failed	
E63	Rectifier #4 – switched off	

*) The battery circuit continuity test function is disabled by default. It must be enabled through the software.

6.2 Visual indication

The visual indication of the power system uses LEDs on the panel of the digital display and LEDs of rectifiers ZPA-48/7. The indication informs users about the state of the device.

LED indication of the state of the power system:

- the green diode **MAINS**
- the yellow diode **BAT**
- the red diode **ALARM**

Legend:
1 - continuous light
— - no light
1/3 - blinking light (1s on 3s off)
3/1 - blinking light (3s on 1s off)
1/1 - blinking light (1s on 1s off)

	LEDs on the panel		
	MAINS	**BAT**	**ALARM**
OPERATION			
Operation at presence of mains	**1**	**—**	**—**
Battery mode	**—**	**1**	**—**
Alarm	As below	As below	As below
ALARM			
Mains			
Failure of a single phase	**3/1**	**—**	**1**
Outputs			
An output disconnected	**1/3**	**—**	**1**
Max. output current exceeded	**1/3**	**—**	**1**
Max. output voltage exceeded	**1/3**	**—**	**1**
Min. output voltage exceeded	**1/3**	**—**	**1**
Overload	**1/3**	**—**	**1**
Battery banks			
Charging failure	**—**	**3/1**	**1**
Inconsistency about presence of bank #1 or 2	**—**	**3/1**	**1**
Low battery voltage	**—**	**3/1**	**1**
Battery bank discharged (disconnected)	**—**	**3/1**	**1**
Inconsistency about presence of the probe	**—**	**3/1**	**1**
Max. difference of currents exceeded	**—**	**3/1**	**1**
Min. temperature exceeded	**—**	**3/1**	**1**
Max. temperature exceeded	**—**	**3/1**	**1**

Max. temp. during equalize charging exceeded	**—**	**3/1**	**1**
Lack of continuity – battery 1	**—**	**3/1**	**1**
Lack of continuity – battery 2	**—**	**3/1**	**1**
Rectifier			
Failed	**—**	**—**	**1**
Overheated	**—**	**—**	**1**
Removed	**—**	**—**	**1**
External alarms			
External alarm #1 or 2	**—**	**—**	**1/1**

LED indication of the state of the rectifier:

- the green diode **POWER**
- the yellow diode **OCP**
- the red diode **FAULT**

The indication of the state of the rectifier included in the power system and powered via its output (either by itself, neighboring rectifiers or a battery bank) is summarized in the table below.

Legend: 1 - continuous light — - no light	**LEDs of the rectifier**		
	POWER	**OCP**	**FAULT**
Correct operation	**1**	**—**	**—**
Active over current protection and power limitation	**1**	**1**	**—**
There is a failure	**1**	**—**	**1**
The rectifier has been turned off by the controller	**—**	**—**	**1**
The rectifier has been turned off by the switch on the front panel	**—**	**—**	**—**

6.3 Sound indication

The power system is outfitted with sound indication which is invoked at each occurrence of an urgent alarm (see section 6.4 of the manual). The main goal of the indication is to call maintenance staff. The sound signal can be cancelled by short pressing of the key **MEASURE**, however, it will be turned on again if another urgent alarm is detected.

6.4 Relay indication

Specific events during operation of the power system which trigger the relay indication have been assigned to three channels of the relay indication: the urgent alarm, non-urgent alarm and mains failure. The alarms are indicated on the panel of the digital display by the red LED, and the urgent alarm additionally invokes the sound signal.

The relays of both alarms (**URGENT ALARM** and **NON-URGENT ALARM**) are activated after the controller of the power system triggers an appropriate alarm. The relay to indicate the **MAINS FAILURE** is activated when mains power is present. Thus a fail safe mode of operation of this relay is achieved.

If the power system is powered by three phase utility grid, then a failure of one or two phases is not treated as the mains failure, but triggers an appropriate alarm. The failed phase can be recognized, because the specific phases are unequivocally assigned to consecutive rectifiers ZPA48-12. The line L1 is assigned to the first rectifier (counting from the left when looked at the front), the line L2 to the second, and the line L3 to the third and fourth.

Priorities of alarms are summarized in the table below. Because the mains failure is indicated by a dedicated channel, this event is treated as neither urgent nor non-urgent alarm (shown as inactive). The table presents also the code of the alarm to be read on the digital display (see section 6.1.2).

Event	**Alarm code**	**Alarm priority**		
		Urgent	**Non-urgent**	**Inactive**
Min. battery/output voltage exceeded	E04		√	
Failure of a single phase	E17..E19		√	
Mains failure	E20	√		
Max. output current exceeded	E01	√		
Inconsistency about presence of a rectifier	E33..E36		√	

Inconsistency about presence of a battery bank	E37, E38	√		
Inconsistency about presence of the temp. probe	E39		√	
External alarm #1	E15	√		
External alarm #2	E16		√	
Allowed battery temperature exceeded	E07, E08, E21		√	
Max. battery/output voltage exceeded	E03	√		
Disconnection of a battery bank	E05, E13, E14	√		
Disconnection of output	E12	√		
A problem with a battery bank	E02, E09..E11, E24, E25	√		
A problem with a rectifier	E49..E63		√	
Failure of two or more rectifiers	E22	√		
Overload of the power system	E06	√		

On user's request the manufacturer can change the assigned priorities (or make alarms inactive). It could be achieved using digital communication (see section 2.4).

6.5 Inputs of external alarms

The power system can process two external alarms. An occurrence of such an alarm is indicated on the digital display in a special way – cyclic turning on/off of the red LED. A simultaneous occurrence of an internal alarm of the power system makes the LED to turn on continuously. Each of the external alarm has been assigned different priority of the relay indication (see section 6.4) as well as own code shown on the digital display (see section 6.1.2).

6.6 Temperature probe

The probe measures temperature of the battery banks connected to the power system, both during floating and bulk mode. Exceeding either the defined minimum or maximum value which may damage the bank is indicated as other alarm events of the power system.

The power system measures temperature only when it has been configured together with the temperature probe. A change of the configuration, i.e. connection, disconnection or damaging of the probe during operation of the device will trigger an alarm.

A damaged probe is detected by reading extreme resistance. Two extreme values are interpreted by the power system as a damage: they correspond to temperature - 35°C and 75°C.

Resistance characteristic of the temperature probe delivered together with the power system is shown below.

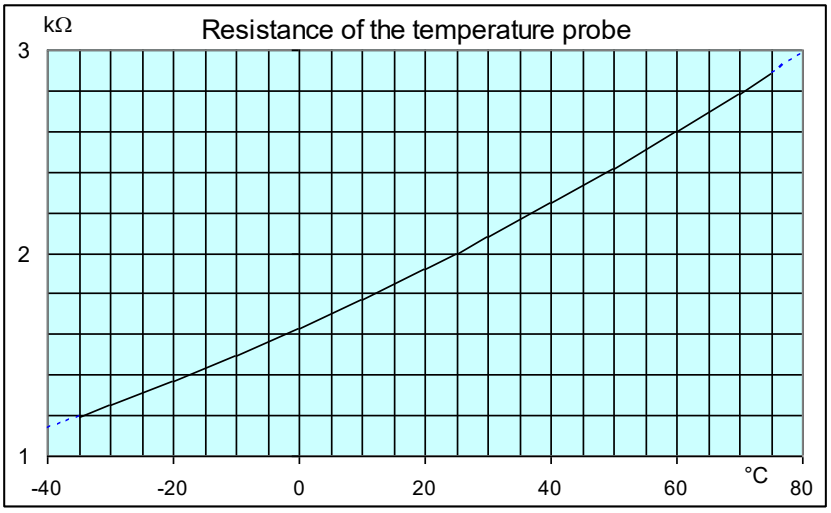


Fig. 6 Characteristic of the temperature probe

6.7 Hidden alarm states

Detected alarm states in operation of the power system are indicated by the red diode **ALARM** and relays. The events declared as inactive (by default this is the mains failure – see section 6.4) do not trigger any indication. Their codes are not displayed even if there are other events triggering the visual indication.

7. Modification of operational parameters of the power system

The power system could be configured by the manufacturer according to a given user's specification or by the user himself, provided he has a communication module and the software handed over by the manufacturer.

Feasible settings for the power system SI48-28 together with standard, default values are shown below.

OPERATION WITHOUT BATTERY BANKS

Status: P -parameter , A -alarm , R -reaction

Parameter	Status	Value			Remarks
		Min	Max	Default	
Output voltage	P	44.0V	59.0V	48.0V	
Maximal output current	A	5A	28A	#	
Maximal temperature	A	40°C	65°C	45°C	
Minimal temperature	A	-35°C	5°C	-10°C	
High output voltage	A	54.0V	59.0V	54.0V	
Low output voltage	A	36.0V	43.0V	43.0V	
Declared number of rectifiers	P	1	4	#	

Values specific for each model of the power system (the table below).

OPERATION WITH A BATTERY BANK

Status: P -parameter , A -alarm , R -reaction

Parameter	Status	Value			Remarks
		Min	Max	Default	
FLOATING MODE					
Battery voltage at temperature of 25°C	P	52.8V	55.2V	54.2V	2.26V/cell
Temperature coefficient ***1)**	P	0mV/°C	-144mV/°C	-96mV/°C	-4mV/°C/ cell
End of the floating mode – battery mode allowed	P	0.3A	8A	#	
Maximal charging current ***2) *6)**	P	1.0A	15A	#	
Period between the battery circuit continuity tests	P/A	10	360	**30**	
CHARGING					
Bulk charging voltage	P	55.2V	57.6V	55.7V	2.3V/ cell
Maximal charging current ***2)**	P	1.0A	15A	#	
Allowed difference of currents between battery banks	A	0.5A	5A	#	
Duration of mains failure to invoke bulk charging	P	5min	60min	15min	
Battery voltage to invoke bulk charging ***3)**	P	40V	48V	45.6V	1.90V/ cell
Current to stop bulk charging	P	0.3A	5A	#	
Temperature to abandon bulk charging ***4)**	R/A	30°C	50°C	40°C	
Maximal duration of bulk charging	R/A	5h	24h	18h	
BATTERY MODE					
Low battery (and output) voltage	A	42.0V	48.0V	43.2V	1.80V/ cell
Voltage to disconnect battery banks	R	38.4V	48.0V	42.0V	1.75V/ cell
Allowed difference of currents between battery banks	A	0.5A	5A	#	
BATTERY TEST					
Minimal allowed battery voltage ***5)**	A	43.0V	48.0V	45.6V	1.90V/ cell
Test period	P	1 day	30 days	2 days	
Test duration	P	5 min	60 min	5 min	
GENERAL					
Maximal output current	A	5A	28A	#	
High battery (and output) voltage	A	58.0V	59.0V	58.8V	2.45V/ cell
Maximal battery temperature	A	40°C	65°C	45°C	
Minimal battery temperature	A	-35°C	5°C	-10°C	
Declared number of rectifiers	P	1	4	#	

Values specific for each model of the power system (the table below).

Remarks

If there are two battery banks connected, the battery voltage is the arithmetical mean of both voltages, and the battery current is the sum of both currents.

***1)** Range when the coefficient is used: +5...35°C (temperature > 70°C interpreted as disconnection of the probe)

***2)** Controlled by changing output voltage of rectifiers.

***3)** The battery voltage at the end of the mains failure.

***4)** If the set level is reached, then an alarm is triggered and the power system transfers from equalize mode to floating mode.
***5)** Rectifiers' voltage is set 1V below the test voltage.
***6)** This parameter is equivalent (and equal) to the current limit during bulk charging mode.

Parameter	SI48-28-2x	SI48-28-3x	SI48-28-4x
Number of rectifiers	2	3	4
Current of a single rectifier	7A	7A	7A
Maximal output current	14A	21A	28A
FLOATING MODE			
End of the floating mode – battery mode allowed	1.4A	2.8A	4A
Maximal charging current ***1)**	3.5A	7A	10A
CHARGING			
Maximal charging current ***1)**	3.5A	7A	10A
Allowed difference of currents between battery banks	0.7A	1.4A	2A
Current to stop bulk charging	0.9A	1.8A	2.5A
BATTERY MODE			
Allowed difference of currents between battery banks	0.7A	1.4A	2A
GENERAL			
Maximal output current	5.5A	11A	17A
OPERATION WITHOUT BATTERIES			
Maximal output current	7A	14A	21A

***1)** This parameter is equivalent (and equal) to the current limit during bulk charging mode.

8. Additional information

8.1 Manufacturer's remarks

The manufacturer reserves the right to introduce changes in the design and technology which shall not impair quality of the product.

8.2 Handling of the package, waste and batteries

Product packaging is made of non-hazardous materials (wood, paper, cardboard, plastics), which can be recycled. Packages which are no longer needed should be passed on to a waste collection station, after they had been sorted.

This marking on the product indicates that the product after that time should not be disposed with household waste, but should be sent to a collection point for electronic waste. Used batteries are a hazardous waste and must be disposed of. This will help to avoid adverse effects on human health and the environment from uncontrolled waste disposal.