isle Steuerungstechnik und Leistungselektronik GmbH

Technical Description

BSZ PG 1200

Table of Contents

Introduction 3
1 Basic Operation 4
1.1 Topology of DC-DC-Converter 4
1.2 Operating Modes of The Whole System (Automatic Mode) 4
1.2.1 Standby 4
1.2.2 Power (LED green on) 4
1.2.2.1 Current Charge 4
1.2.2.2 Voltage Charge 4
1.2.2.3 Reloading 5
1.2.3 Shutdown (LED green blinks quickly) 5
1.2.4 Turn on The System 5
2 Handling 6
2.1 Control Elements 6
2.1.1 Control Unit 6
2.1.2 System ON/OFF 6
2.1.3 Nexa ON/OFF 7
2.1.4 LED Functions 7
2.1.5 Showing Nexa Parameters 7
2.1.6 Showing DC/DC Parameters 8
2.1.7 Visualisation Software 8
2.2 Changing Parameters 11
2.2.1 Mode Selection 11
2.2.2 Setting By Software 11
2.2.3 Characteristic Setting by Spreadsheet 11
2.3 Error handling 12
3 Installation 13
4 Specifications 13
5 Pin Assignment 14
5.1 Pin Assignment Power Board 14
5.2 Control Elements On Controller Board 17
5.3 Pin Assignment Display/Control Unit 18

Introduction

The DC-DC-Converter ""BSZ-PG 1200"" was developed especially for the operation on the fuel cell "Nexa" made by the company Ballard.
The whole system consists of fuel cell, the DC-DC-converter ""BSZ-PG 1200"", an accumulator and the load (Figure 5, Page 19; Figure 6, Page 20). The ""BSZ-PG 1200"" has to handle the battery-management and to control the fuel cell.
The DC-DC-converter ""BSZ-PG 1200"" complies following requirements

- High efficiency also at light load
- Protection of battery and fuel cell
- Microprocessor controlled operation for optimum use of battery and fuel cell
- Fully automatic operation
- Manual controlling possibilities by supervisory control system
- Easy installation
- Compact design, lightweight construction
- LCD-Display shows Nexa and "BSZ-PG 1200" parameters
- Integrated galvanic isolated RS232 adapter

The DC-DC-converter ""BSZ-PG 1200"" is available in two variants, for use in 12V- and 24V-systems (*given parameters for 24V-system*).

1 Basic Operation

1.1 Topology of DC-DC-Converter

The DC-DC-converter ""BSZ-PG 1200"" generates a PWM-Signal that controls a MOSFET-half-bridge. This half-bridge acts as a Synchronous-Buck-Converter.
This topology assures the high efficiency of the converter.
The DC-Power input is heavily filtered so that EMI-RFI does not affect to the fuel cell. The output voltage is filtered before going out to the load terminals.
To prevent flowing a current back from battery to fuel cell a return protection, controlled by micro controller, is integrated.

1.2 Operating Modes of the Whole System (Automatic Mode)

1.2.1 Standby

The "BSZ-PG 1200" monitors the battery voltage on terminals SSC5 and SSC6.
If the actual battery voltage is higher than 10.3V (*20.6V*) the galvanic isolated contact on terminals X1-2 and X1-3 will be closed. On these terminals it's possible to connect an external load relay. This load relay prevents over-discharging of the battery. After the relay is opened, the battery voltage has to be 2min over 10.3V (*20.6V*) for closing the contact again. Then the load is connected and the battery can be discharged. If the battery voltage reaches its minimum (V_ch_min), the "BSZ-PG 1200" is activating the fuel cell. The terminals X6-1 and X6-2 get the Nexa supply voltage of 24V by a semiconductor switch.
The fuel cell now is able to initialise itself and 15s after switching supply voltage of 24V it gets the signal "Enable_Nexa". The Nexa is starting its chemical process. If Nexa is able to provide energy it sends the signal "Nexa_OK" to the DC-DC-Converter and the ""BSZ-PG 1200"" switches to mode "Power"

1.2.2 **Power** (LED green on)

1.2.2.1 Current Charge

The first phase in mode "Power" is "Current Charge" (I_Charge). "The "BSZ-PG 1200"" acts as a current source. Beginning at zero, the current rises over a ramp to the value of the charge current (I_ch_Max). The maximum charge current is 110A (*55A*). The output power is limited to 1200W. The external load can take out a current greater then the charge current for a short time. This current depends on capacity and internal resistance of the battery.
If the battery voltage reaches the maximum battery voltage (V_ch_Max) caused by the charge current, the ""BSZ-PG 1200"" changes to the phase "Voltage Charge" (V_Charge).

1.2.2.2 Voltage Charge

During phase "Voltage Charge" (V_Charge) the "BSZ-PG 1200" acts as a voltage source. Its output voltage is the adjusted maximum charge voltage (V_ch_Max) of the battery. The maximum current of this phase is the adjusted charge current (I_ch_Max). The output power of this phase is also limited to 1200W. If the load on the terminals SSC5 and SSC6 needs more than 1200W, the battery will be discharged and the battery voltage drops.
The ""BSZ-PG 1200"" turns to the phase "Reloading", if the charge current falls below the adjusted change current (I_Change).

1.2.2.3 Reloading

During phase "Reloading", the ""BSZ-PG 1200"" continues the voltage charge of the battery with the adjusted parameters. If the reload time (t_reload) is exceeded, the ""BSZ-PG 1200"" changes to next mode. The reload time (t_reload) is reset if the charge current (I_Charge) exceeds the change current (I_Change). The phase "Reload" starts again.
After "Reloading" follows the mode "Shutdown".

1.2.3 Shutdown (LED green blinks quickly)

In mode "Shutdown", the charge current is controlled to zero over a ramp. After that, the shutdown of Nexa starts. The ""BSZ-PG 1200"" resets the signal "Enable_Nexa". The Nexa stops its process. If Nexa sends the signal "Nexa Standby" the Nexa supply voltage of 24V is switched off on terminals X6-1 and X6-2. "The "BSZ-PG 1200"" changes to mode "Standby". If the battery voltage reaches the value of minimum battery voltage (V_ch_Min) during shutdown, the ""BSZ-PG 1200"" immediately changes to mode "Power" and a complete loading of the battery starts again.

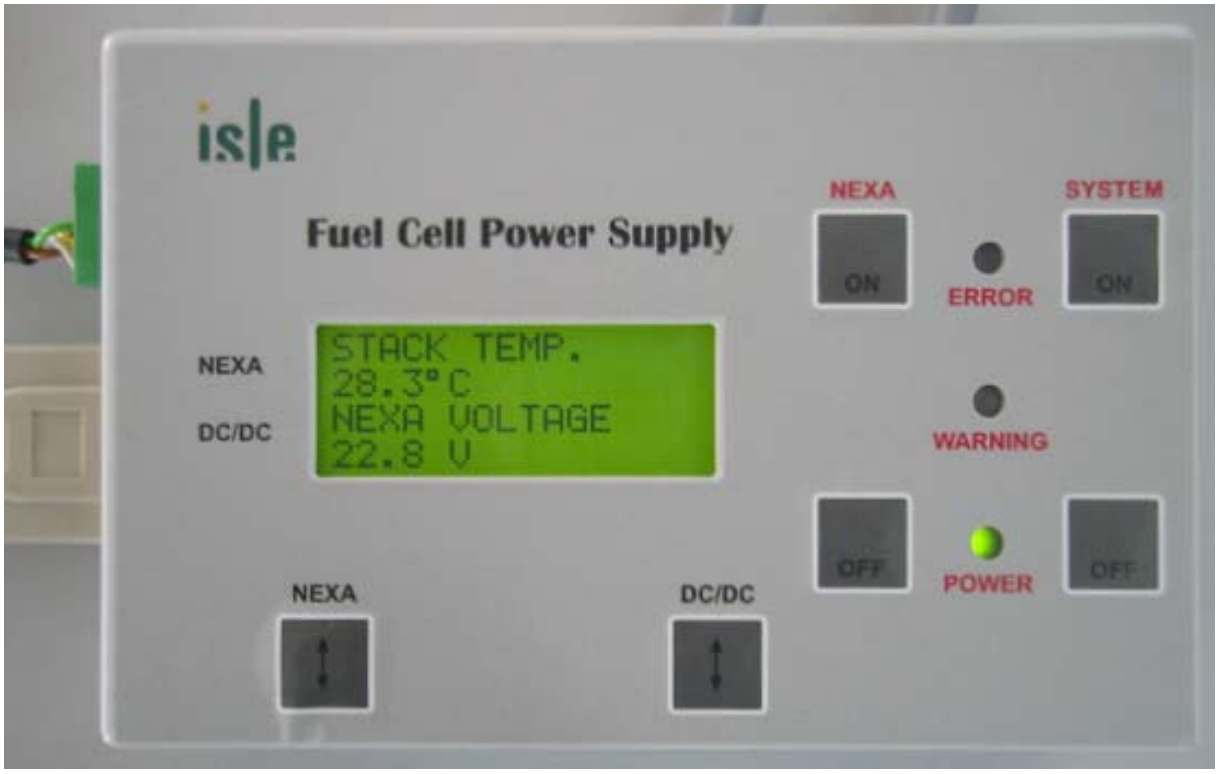
1.2.4 Turn on the System

After turn on the ""BSZ-PG 1200"", independent of charging condition of the battery, a complete charging cycle begins. Thereafter the system goes to mode "Standby".

2 Handling

2.1 Control Elements

2.1.1 Control Unit



The control unit consists of System- and Nexa- On- and Off- buttons, DC/DC- and Nexa-parameter buttons, a 4-line LCD display and 3 LED.

2.1.2 System ON/OFF

To power-up the system, push the button "System_On" on control unit. After switching (min. 200ms) the ""BSZ-PG 1200"" initialises and a self-holding is activated.
To power down the system push the button "System_Off". After switching (min 100ms) the ""BSZ-PG 1200"" changes, independent of charging condition of the battery, to mode "Shutdown" (1.2.3). The galvanic isolated contact on terminals X1-2 and X1-3 (1.2.1) is opened after the charge current reached zero. If Nexa sends the signal "Nexa Standby", the system is switched off. Restart the system during "Shutdown " is possible by pushing the button "Nexa_On".

2.1.3 Nexa ON/OFF

It's possible to turn on and turn off the Nexa fuel cell manual by pushing buttons, independent of charging condition of the battery.
After switching "Nexa_ON" (min 100ms), the ""BSZ-PG 1200"" changes from mode "Standby" to "Power" (1.2.2) and a complete charging cycle begins. If the push-button "Nexa_ON" is replaced by a relay, the Nexa stays activated until opening the contact and finishing the charging cycle.
After switching "Nexa_OFF" (min 100ms), the "BSZ-PG 1200" changes independent of charging condition of the battery to mode "Standby" (1.2.1).

2.1.4 LED Functions

LED	Status	Description	Chapter
Green	On	DC/DC converter in mode "Power"	1.2.2
	Slow blinking	DC/DC converter in mode "Standby"	1.2.1
	Quick blinking	DC/DC converter in mode "Shutdown"	1.2.3
Yellow	On	Nexa Warning	2.1.5
Red	On	Nexa Error or DC/DC Error	2.1.5 / 2.1.6

2.1.5 Showing Nexa Parameters

For scrolling Nexa parameters push button "NEXA↕". Following parameters are displayed in the upper two lines:

- Nexa State
  - Standby
  - Start Up
  - Normal Operation
  - Normal Shutdown
  - Failure Shutdown
  - Warning
  - Non Restartable
- Stack Temperature
- Stack Voltage
- Stack Current
- Fuel Pressure
- Fuel Leak
- Fuel Consumtion
- Oxygen Concentration
- Air Temperature
- Purge Cell Voltage
- Stack Power

If an error or warning occurs, the error code will be displayed immediately.

2.1.6 Showing DC/DC Parameters

For scrolling DC/DC parameters push button "DC/DC↕". Following parameters are displayed in the lower two lines:

- DC/DC Phase
  - Start
  - Standby
  - I-Charge
  - U-Charge
  - t-Charge
  - Shutdown
  - Error
- Nexa Voltage
- Battery Voltage
- Battery Current
- V_Charge_Min
- V_Charge_Max
- I_Charge_Max
- I_Change
- Reload Time
- DC/DC Failure

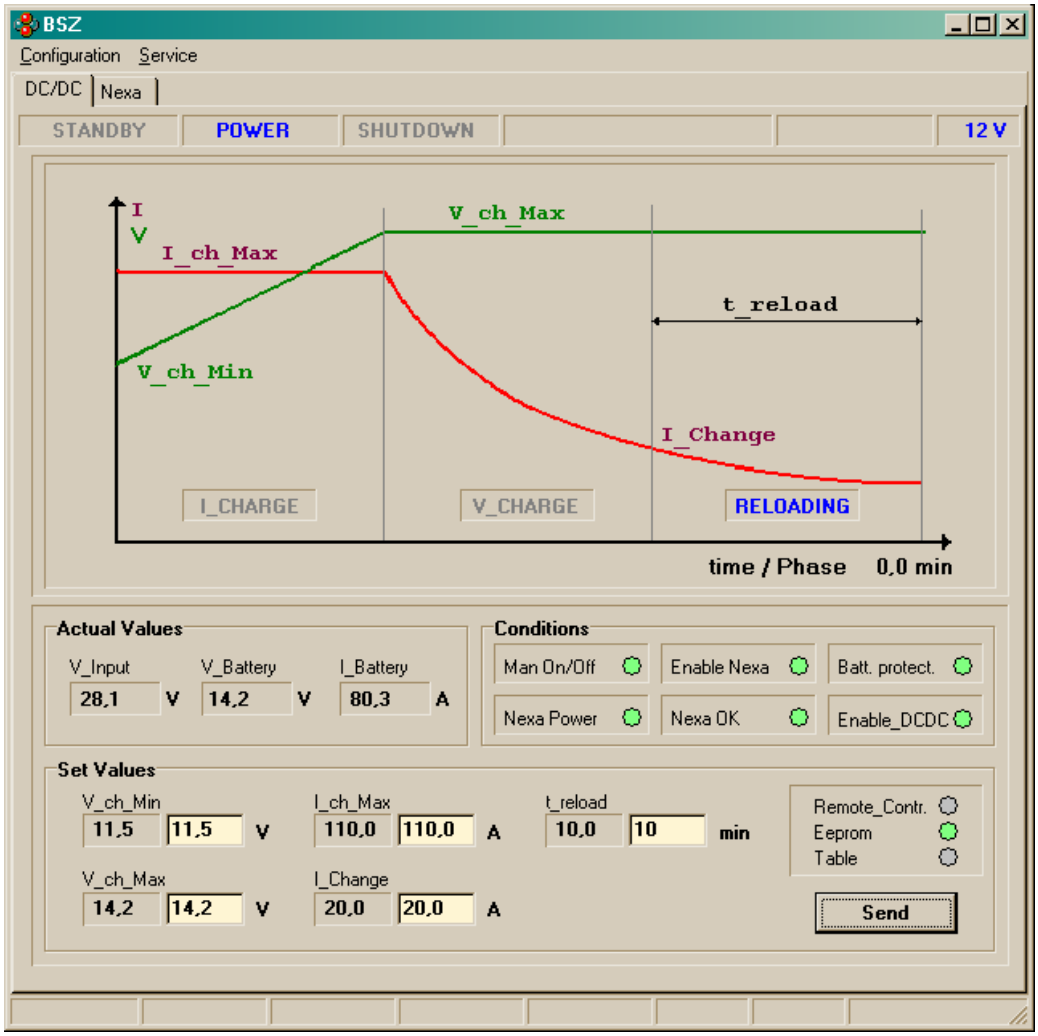
  0x02 TEMP_Error
  0x04 V_Out_MIN_Error
  0x08 V_Out_Max_Error
  0x10 V_Nexa_Min_Error
  0x20 V_Nexa_Max_Error
  0x40 I_Max_Error
  0x80 Nexa-Start_Error

If an error occurs, the error code will be displayed immediately. If two or more errors occur, the sum of single error codes is displayed.

2.1.7 Visualisation Software

For using the visualisation it's necessary to have a Windows-PC with an RS232-Interface. A galvanic isolated RS232 adapter is integrated on control unit of "BSZ-PG-1200" The control unit is being connected to the PC by a Sub-D-Cable (1:1; 9-pole). As soon as turning on the system, the communication is working and parameters and status are transmitted between ""BSZ-PG 1200"" and PC. After starting visualisation software, two register can be choosen.

On the first register one can find the DC/DC settings:



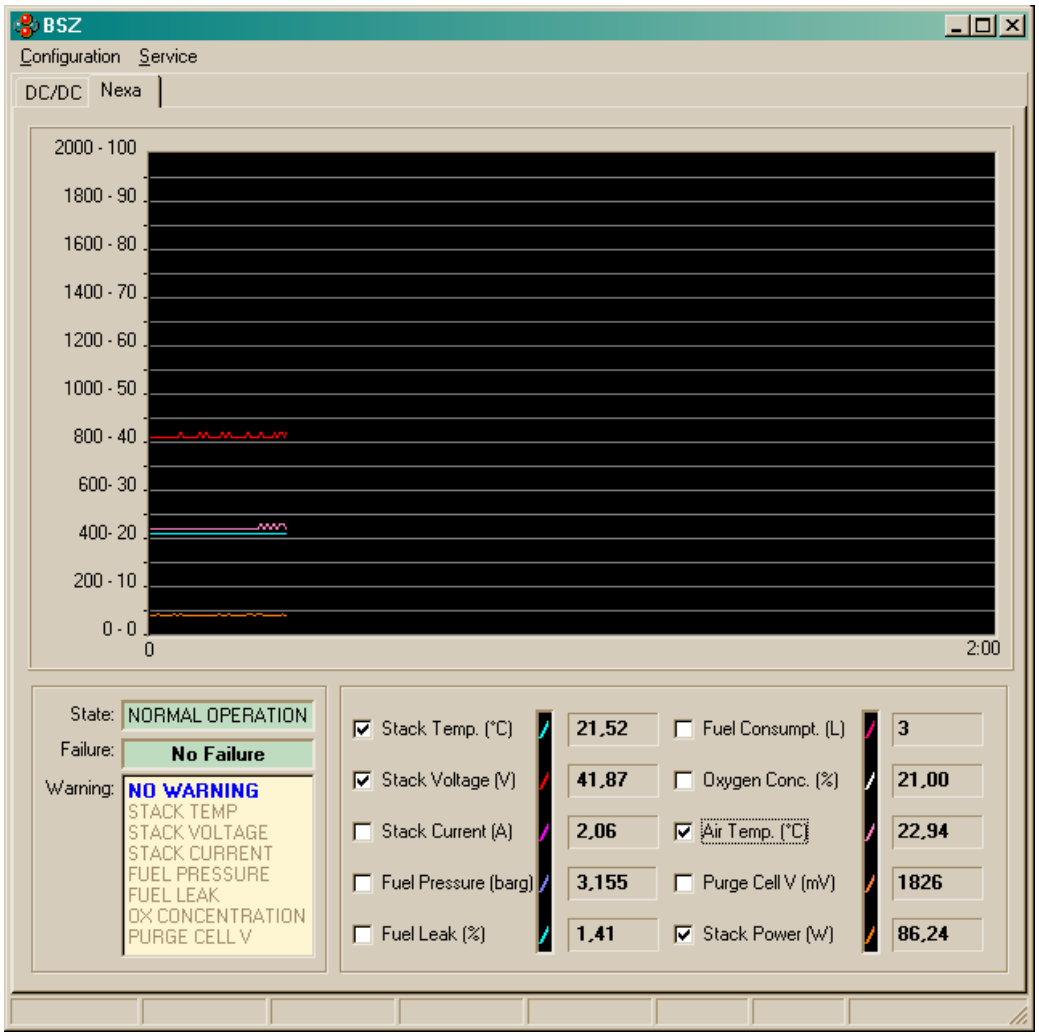
The status of ""BSZ-PG 1200"" (STANDBY, POWER, SHUTDOWN) is shown in blue. The type of system (12V/24V) is displayed right on the same line.
The voltage characteristic line is green; the current characteristic line is red. The adjustable parameters (V_ch_Min, V_ch_Max, I_ch_Max, I_Change, t_reload) are shown near the lines.
The momentary charge phase (I_Charge, V_Charge, Reloading) is displayed in blue.
In the array "Actual Values" the current values (V_Nexa, V_Battery, I_Battery) are visualised.
In the array "Set Values" the reference values (V_ch_Min, V_ch_Max, I_ch_Max, I_Change, t_reload) are shown.
The registered reference values (white arrays) were transmitted to ""BSZ-PG 1200"" by mouse click on "Send"-Button. These values stay active even after turning off the system.
The source of the reference value;[EEPROM (2.2.2); spreadsheet (2.2.3)] is displayed on the array above the "Send"-Button.

In the array "Conditions" important system informations are displayed.

- Man On/Off => grey: automatic mode or Nexa-Off pushed
  green: Nexa-On pushed
- Nexa Power => Nexa is getting supply voltage by ""BSZ-PG 1200""
- Enable Nexa => Nexa is getting signal to start by "BSZ-PG 1200"
- Nexa OK => Nexa sends a "ready for work" signal
- Enable_DCDC => "BSZ-PG 1200" is getting started
- Batt Protect => green: battery voltage higher than 10,3V (*20,6V*)
  relay contact on terminals X1-2 and X1-3 is closed
  orange: battery voltage lower than 10,3V (*20,6V*)
  relay contact on terminals X1-2 and X1-3 is opened

Errors are displayed at the lowest line of the visualisation.

On the second register one can find the Nexa parameters:



On this register Nexa informations, failures and warnings are shown.
By activating the checkboxes some important Nexa parameters are visualised as a graphic line.

2.2 Changing Parameters

2.2.1 Mode Selection

There are three ways to change the parameters of the charging characteristic by "BSZ-PG 1200".

- Setting by visualisation software und saving the parameters on EEPROM
- Choosing parameters of the charging characteristic from a spreadsheet

Mode selection is provided by a 16-pole rotary switch (S1) on Controller board BSZ_Con_01.

2.2.2 Setting by Software

For using this operation mode, the rotary switch (S1) has to be on position "E". Following parameters can be adjusted by software and saved on EEPROM:

- V_ch_min (10.5V-12.5V) (*21.0V-25.0V)*
- V_ch_max (12.6V-15.0V) (*25.2V-30.0V)*
- t_reload (5s-85min)
- I_ch_Max (0A-110A) (0*A-55.0A*)
- I_change (0A-110A) (0*A-55.0A*)

In the array "Actual Values" the current values (V_Nexa, V_Battery, I_Battery) are visualised.
In the array "Set Values" the reference values (V_ch_Min, V_ch_Max, I_ch_Max, I_Change, t_reload) are shown.
The registered reference values (white arrays) are transmitted to "BSZ-PG 1200" by mouse click on "Send"-Button. These values stay active even after turning off the system.

2.2.3 Characteristic Setting by Spreadsheet

Some different charging characteristics are integrated in the software of "BSZ-PG 1200". Following positions of rotary switch S1 on controller board BSZ_Con_02 are used to set the charging characteristic.

Position S1	V_ch_Max/V	V_ch_Min/V	t_reload/min	I_ch_Max/A	I_Change/A
0	13.8 *(27.6)*	11.0 *(22.0*)	15	110 *(55.0)*	12 *(6)*
1	13.8 *(27.6)*	11.0 *(22.0*)	45	109 *(54.5)*	12 *(6)*
2	14.4 *(28.8)*	11.0 *(22.0)*	15	109 *(54.5)*	12 *(6)*
3	14.4 *(28.8)*	11.0 *(22.0)*	45	109 *(54.5)*	12 *(6)*
4	13.9 *(27.8)*	11.5 *(23.0)*	15	109 *(54.5)*	6 *(3)*
5	13.9 *(28.8)*	11.5 *(23.0)*	45	109 *(54.5)*	12 *(6)*
6	14.4 *(28.8)*	11.0 *(22.0)*	45	109 *(54.5)*	12 *(6)*
7	14.4 *(28.8)*	11.0 *(22.0)*	45	109 *(54.5)*	12 *(6)*
8	14.4 *(28.8)*	11.0 *(22.0)*	45	109 *(54.5)*	12 *(6)*
9	14.4 *(28.8)*	11.0 *(22.0)*	45	109 *(54.5)*	12 *(6)*
A	14.4 *(28.8)*	11.0 *(22.0)*	45	109 *(54.5)*	12 *(6)*
B	14.4 *(28.8)*	11.0 *(22.0)*	45	109 *(54.5)*	12 *(6)*
C	14.4 *(28.8)*	11.0 *(22.0)*	45	109 *(54.5)*	12 *(6)*
D	14.4 *(28.8)*	11.0 *(22.0)*	45	109 *(54.5)*	12 *(6)*

2.3 Error Handling

Nexa and DC/DC errors are displayed on LCD display as well as in visualisation software. The red LED turns on.

Error	SET-Condition	RESET-Condition
I_bat_Max_Error	I_bat > 120A *(60A)*	After 30s => if I_bat <120A Restart
U_bat_Max_Error	U_Bat > 17.5V *(35V)*	After 30s => if U_Bat <17.0V (*34V)* Restart
U_bat_Min_Error	U_Bat < 9V *(18V)*	After 30s => if U_Bat >9.2V (18.4V) Restart
U_Nexa_Max_Error	U_Nexa > 50V	After 30s => if U_Nexa <50V Restart
U_Nexa_Min_Error	U_Nexa < 26V & Nexa_OK	After 30s => Restart
Nexa_Error	-Nexa_OK isn't set 1min after signal Enable_Nexa -Nexa_OK was reset by Nexa	After 30s => Restart
Temp_Error	Temperature of heat sink > 80°C	Temperature of heat sink < 70°C

The described errors have following error codes on the display:

0x02 TEMP_Error
0x04 V_Out_MIN_Error
0x08 V_Out_Max_Error
0x10 V_Nexa_Min_Error
0x20 V_Nexa_Max_Error
0x40 I_bat_Max_Error
0x80 Nexa-Start_Error

If an error occurs, the error code will be displayed immediately. If two or more errors occur, the sum of single error codes is displayed.
The "BSZ-PG 1200" stops battery charging at all described errors.

When the battery voltage falls below 8.85V *(17.7V)* the sytem turns off itself!

For handling Nexa errors and warnings, please see the according instructions in Nexa manual.

3 Installation

The base plate is intended for mechanical mounting (Figure 7, Page 21). It's possible to mount the "BSZ-PG 1200" both horizontally and vertically. Some hints should be considered for mounting the unit:

- Minimize the cable length between fuel cell and "BSZ-PG 1200"
- Minimize the cable length between "BSZ-PG 1200" and battery
- Ensure a free air convection
- The maximum temperature on base plate can be 80°C (under extreme conditions)
- The maximum torque on terminals SSC1...SSC6 (M6-Screw) is 9,6 Nm

Connect all the wires to Nexa and battery as shown in the schemes at pages 19 and 20.
At first connect the control unit to Nexa and ""BSZ-PG 1200"". Then connect the Nexa power cables to BSZ_PG_1200 (connector SSC1 and SSC2).
Finally connect the battery minus to "BSZ-PG 1200" connector SSC6 and battery plus to connector SSC5.
Prevent battery short circuit!

All the connectors of ""BSZ-PG 1200"" are described in section 5.

The 12V-system needs an external dc-dc-converter 12V=>24V/10A at connector X6 for supplying the fuel cell and the "BSZ-PG 1200" (Figure 6, Page 20).

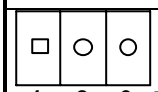
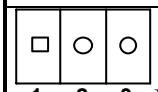
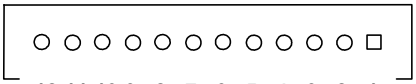
4 Specifications

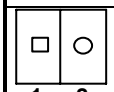
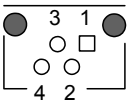
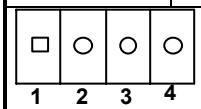
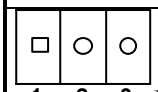
Nominal output voltage.	12V/24V
Output voltage range	11V-15V / 22V-30V
Accuracy of output voltage	2%
Nominal output current	100A/50A
Maximum output current	110A/55A
Maximum output power	1200W
Maximum output current ripple	2%
Operating input voltage range	26VDC-48VDC
Maximum input voltage	50V
Minimum voltage drop input to output	2V
Power consumption standby	2W
Ambient temperature	0°C…40°C
Efficiency	94% (12V) / 96% (24V)
Short-circuit proof	Yes
Thermal protection	Internal 80°C
Mechanical dimensions (HxBxT)	(320 x 14 x 80) mm
Weight	Approx. 1.5 kg

5 Pin Assignment

5.1 Pin Assignment Power Board

All connectors except screw clamps SSC1..SSC6 are located on bottom side of power board!

Connector	Pin	Signal on Pin	In/Out	Description
SSC1		Nexa Plus	I	M6-Screw screw terminal
SSC2		Nexa Minus	I	M6-Screw screw terminal
SSC3		Choke external	O	M6-Screw screw terminal
SSC4		Choke external	O	M6-Screw screw terminal
SSC5		Battery Plus	O	M6-Screw screw terminal
SSC6		Battery Minus	O	M6-Screw screw terminal
X1	X1-1	Relay normally on	I/O	Max. 250VAC/5A
	X1-2	Relay toggle	I/O	Max. 250VAC/5A
	X1-3	Relay normally off	I/O	Max. 250VAC/5A
 Phoenix screw clamp MC1,5/3-ST-3,5				
X2	X2-1	GND		
	X2-2	Vbat_In	I	Battery voltage fused or input of external battery
	X2-3	Vbat	I	Battery voltage unfused
 Phoenix screw clamp MVSTBR2,5/3ST-5,08				
X3	X3-01	GND		
	X3-02	+Vb		+13.5V control unit
	X3-03	SDA	IO	I2C data
	X3-04	SCL	IO	I2C clock
	X3-05	LED_G	O	LED green
	X3-06	TX_232	O	Transmit RS232
	X3-07	RX_232	I	Receive RS232
	X3-08	/Nexa_OFF	I	Manual Stop Nexa (L-active)
	X3-09	/Nexa_ON	I	Manual Start Nexa (L-active)
	X3-10	/System_OFF	I	Sytem Off (L-active)
	X3-11	System_On	O	Battery voltage fused 0.5A
	X3-12	En_Nexa-Vbat_In2	I	Battery voltage switched 0.5A
 Lumberg MSF12 RM 2,5 / front view on cable: Lumberg-plug 3114-12 / Crimp contact 3111-01				

Connector	Pin	Signal on Pin	In/Out	Description
X4	X4-1	GND		
	X4-2	Nexa_P	O	Nexa power supply 24V
 Phoenix screw clamp MVSTBR2,5/2ST-5,08				
X5	X5-1	SDA	I/O	I2C Data
	X5-2	SCL	I/O	I2C Clock
	X5-3	+Vb	O	+13.5V for external components (max 100mA)
	X5-4	GND		
 Lumberg MICS4 RM 1,27 / front view				
X6	X6-1	24V_in	I	24V Power Input
	X6-2	GND		
	X6-3	GND		
	X6-4	V_bat_sw	O	Battery voltage switched 10A
 Phoenix screw clamp MVSTBR2,5/4ST-5,08				
X7	X7-1	AGND		Analog ground
	X7-2	An_in	I	Analog input (0V..5V)
	X7-3	n. c.		Not connected
 Phoenix screw clamp MC1,5/3-ST-3,5				

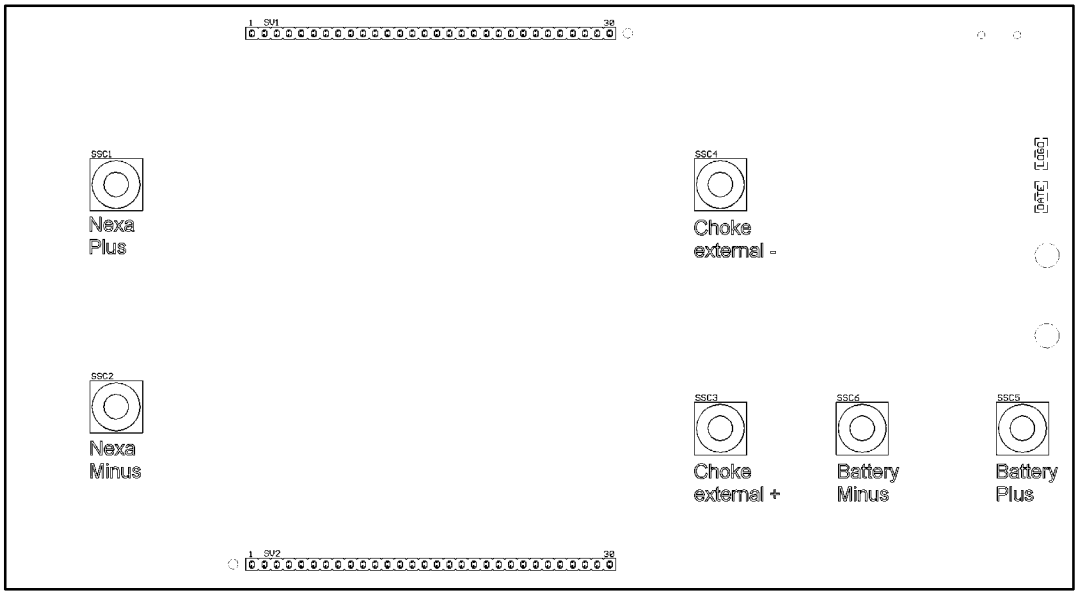


Figure 1 Power board top view

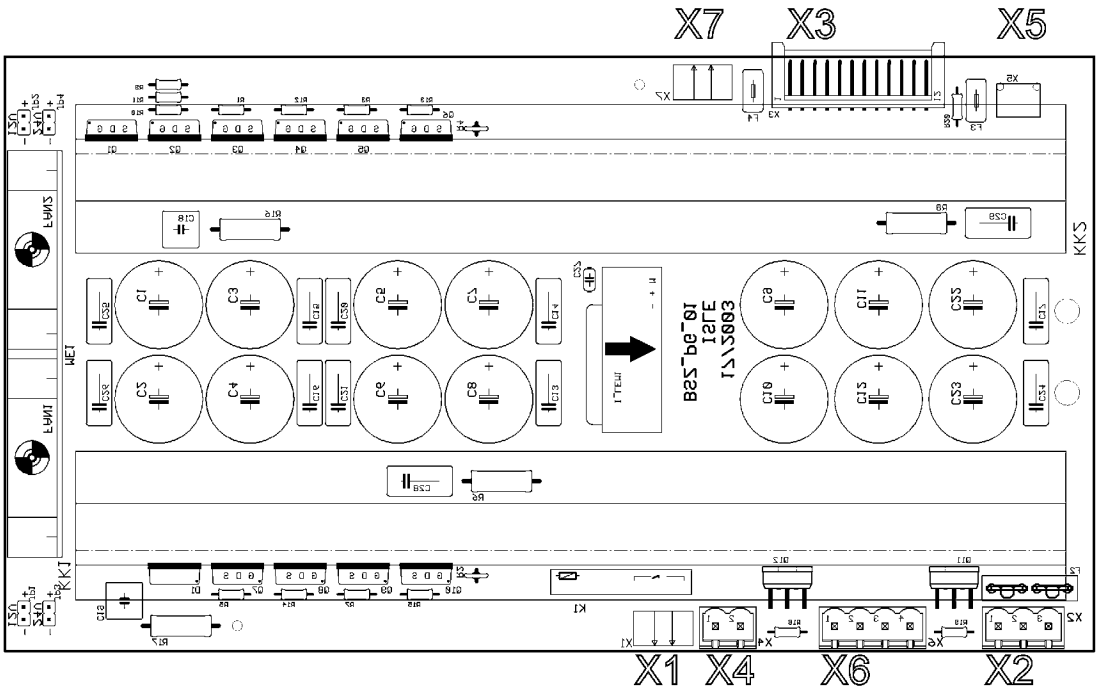


Figure 2 Power board top view with bottom components

5.2 Control Elements on Controller Board

Element	Position	Function
JP1	Open	Normal battery mode
	Closed	Undervoltage protection of battery disabled
JP2	Open	
	Closed	
S1	0..F	Selection of Load Characteristic

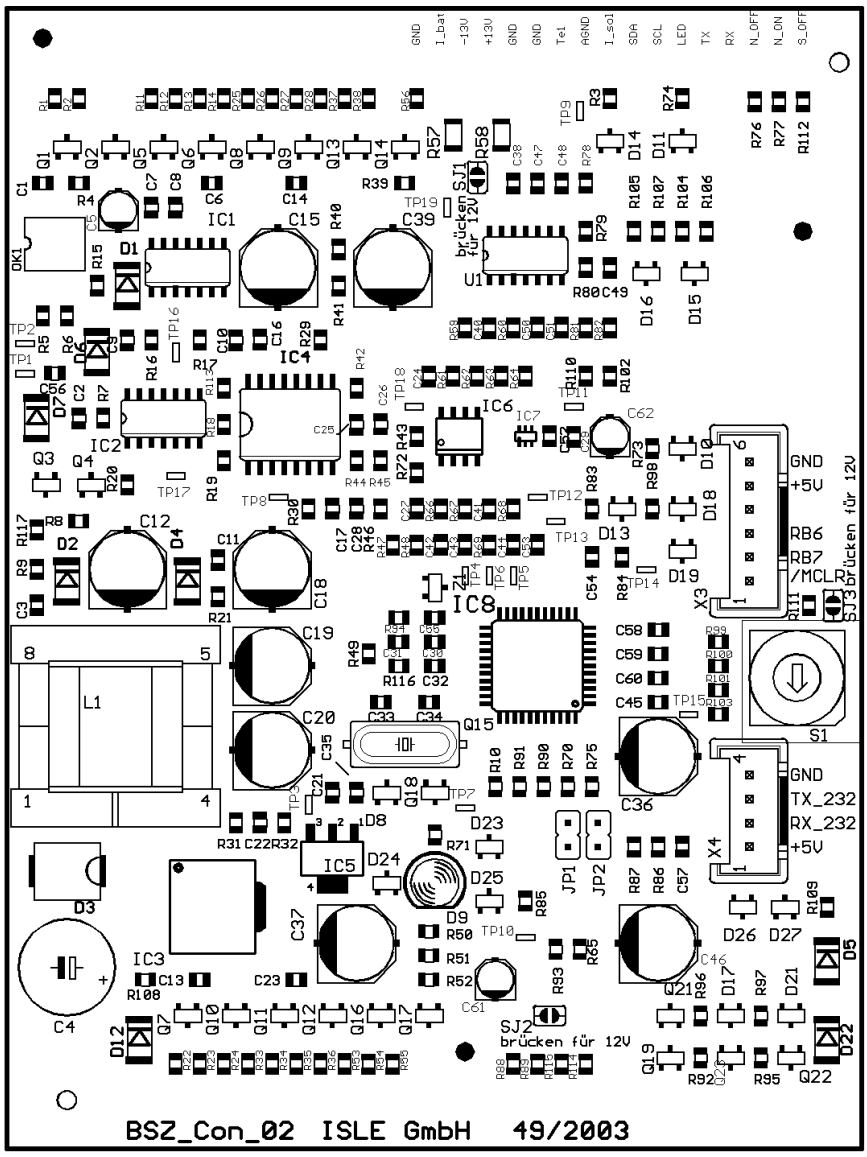
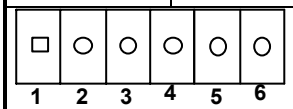
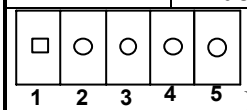


Figure 3 Controller board top view

5.3 Pin Assignment Display/Control Unit

Connector	Pin	Signal on Pin	In/Out	Description
X201	X201-1	GND		
	X201-2	/Nexa_Off	I	Manual Nexa Off (L-active)
	X201-3	/Nexa_On	I	Manual Nexa On (L-active)
	X201-4	/System_Off	I	System Off (L-active)
	X201-5	System_On	O	Battery voltage fused 0.5A
	X201-6	Vbat_In2	I	Battery voltage switched 0.5A
 Phoenix screw clamp MKDS1/6-3,5				
X207	X207-2	TX_Out	I/O	TX_232 galvanic isolated
	X207-3	RX_Out	I/O	RX_232 galvanic isolated
	X207-5	GND_Out	O	GND_232
X208	X208-1	RS485_RX+	I/O	Nexa RS485_RX+
	X208-2	RS485_RX-	I/O	Nexa RS485_RX-
	X208-3	RS485_TX+	I/O	Nexa RS485_TX+
	X208-4	RS485_TX-	I/O	Nexa RS485_TX-
	X208-5	RS485_Com		Nexa RS485_Com
 Phoenix screw clamp MC1,5/5-ST-3,81				

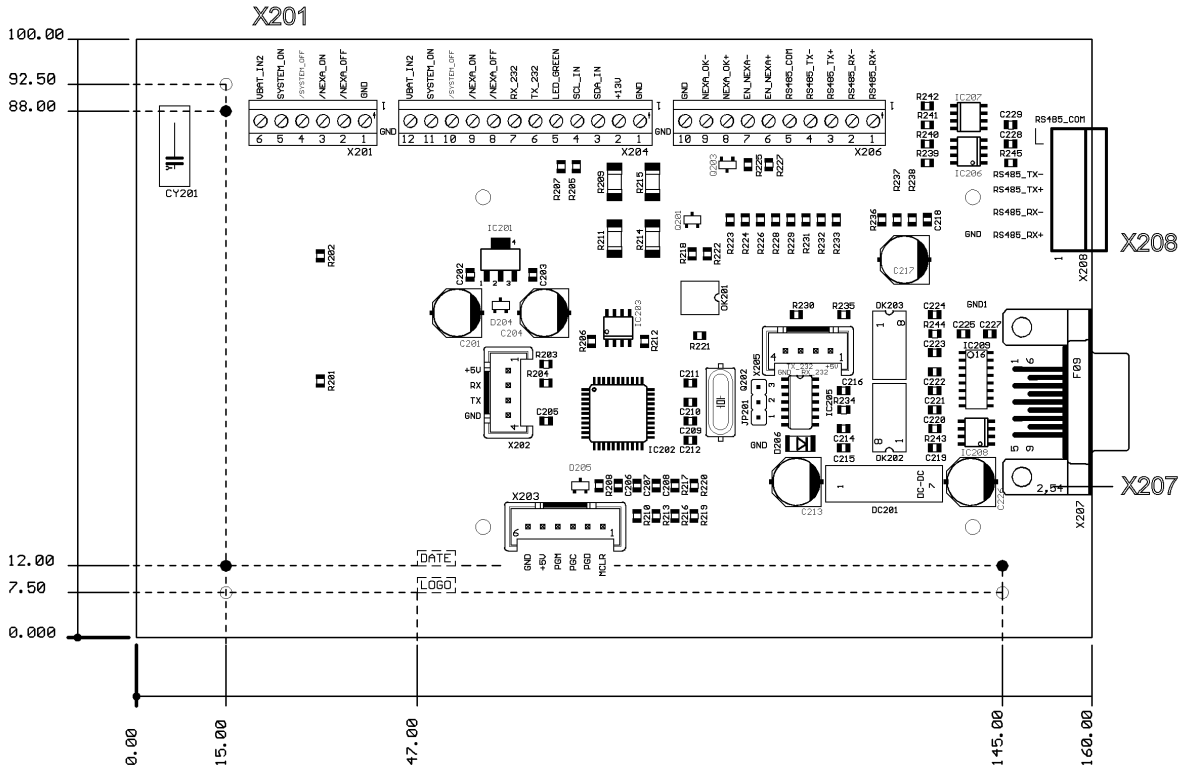


Figure 4 Display/Control unit bottom view

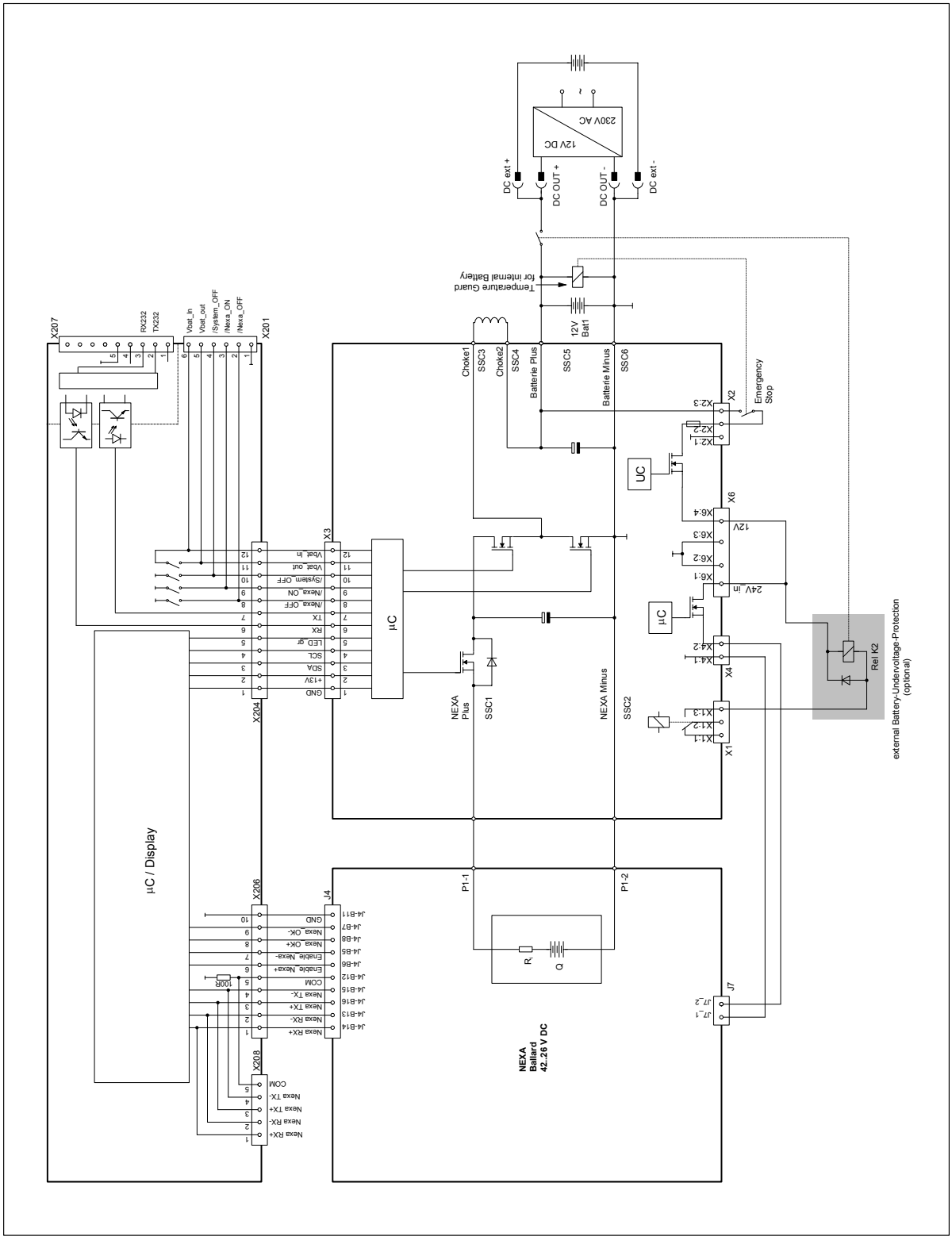


Figure 5 Global scheme 24V-System

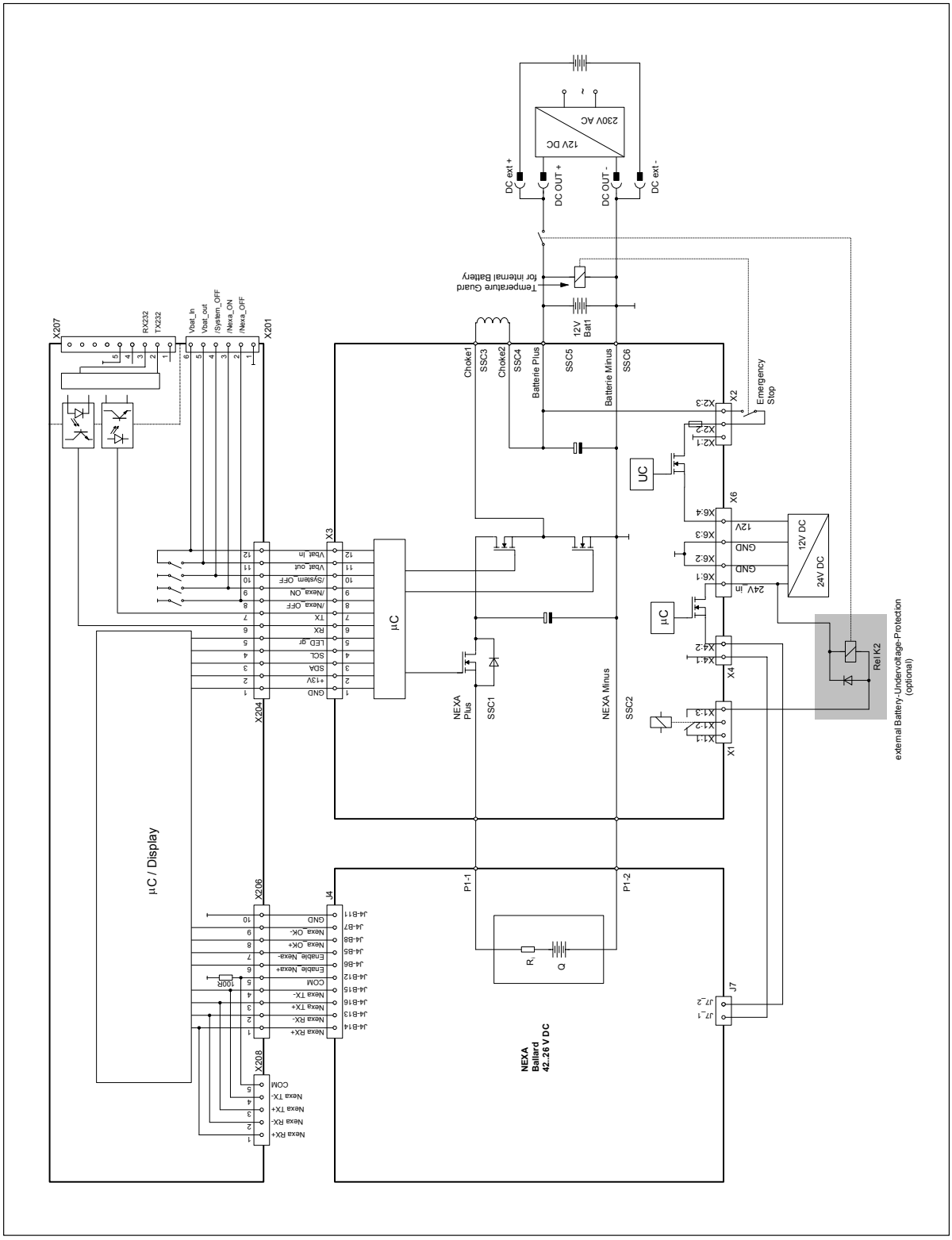


Figure 6 Global scheme 12V-System

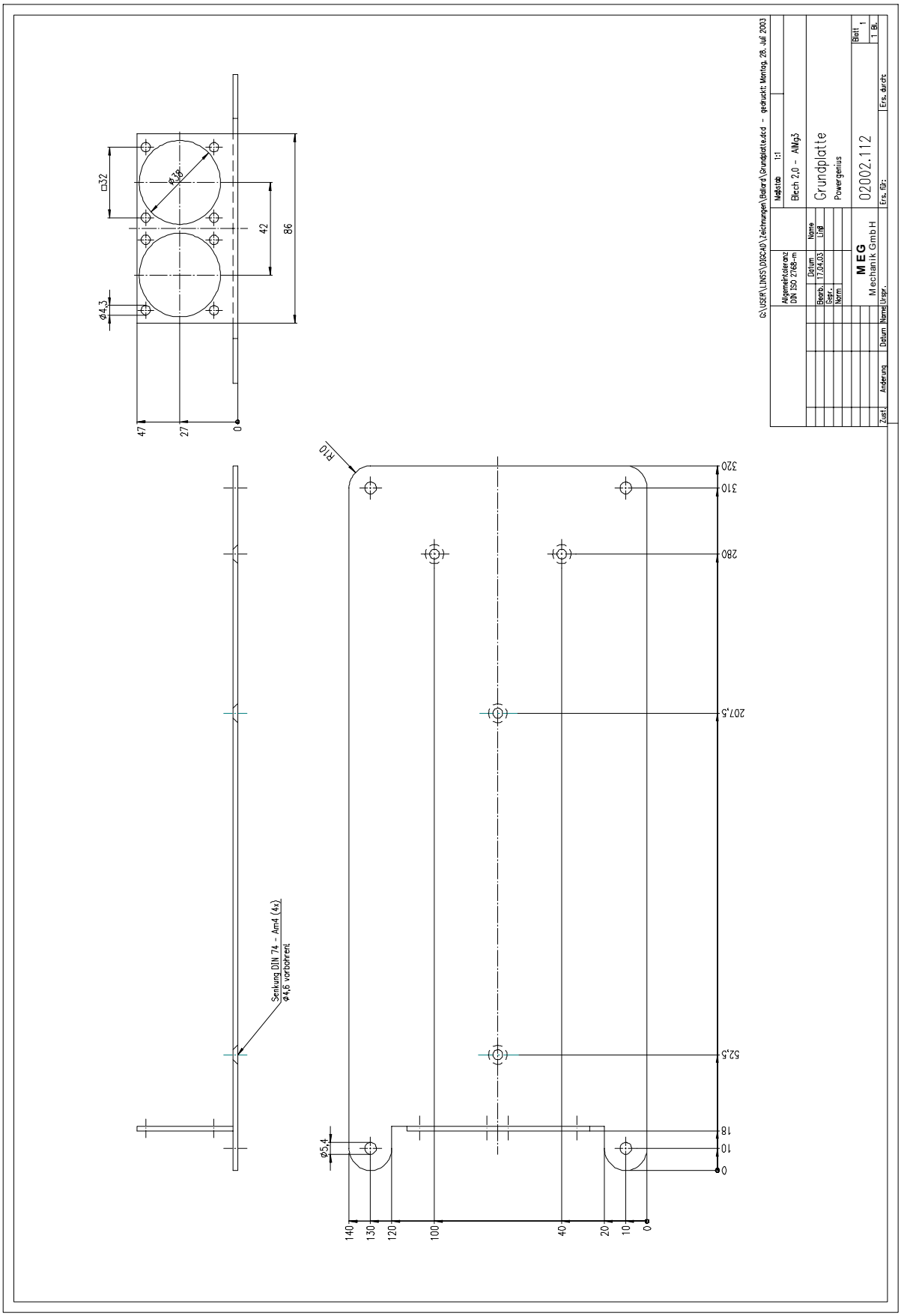


Figure 7 Base plate "BSZ-PG 1200"