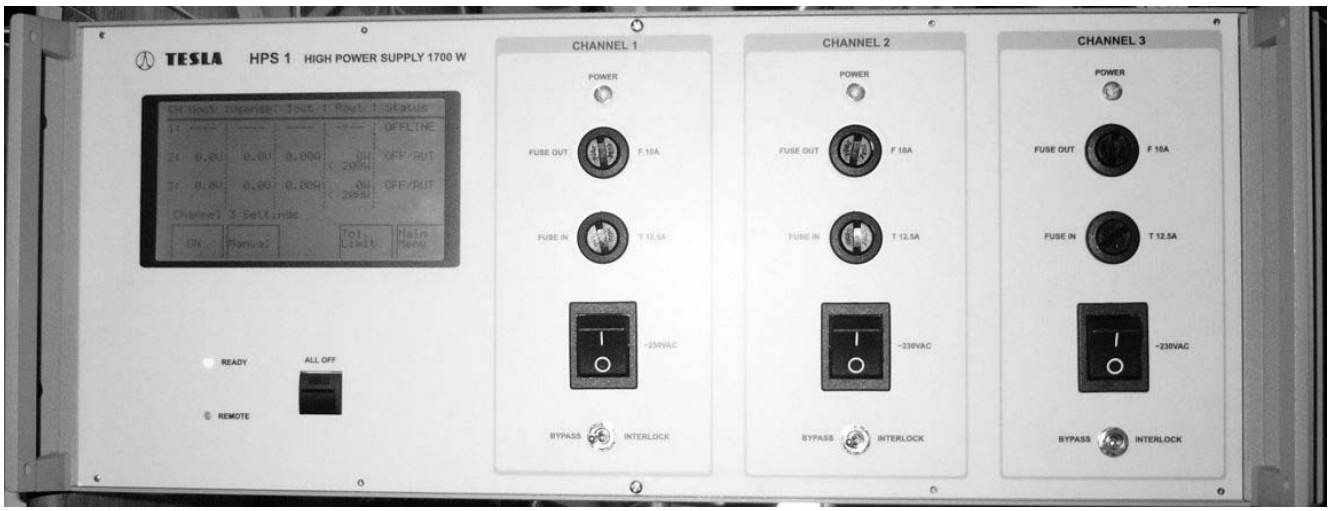
HIGH POWER SUPPLY HPS1

OPERATION MANUAL



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Operation manual

1. Introduction

The unit HPS 1 contains three power supplies (changers) with output power 1.7 kW operating with output voltage from 200 V/8.5 A till 240 V/7.1 A. Each of three outputs of HPS 1 is feeding via as far as 150 m long cable 32 DC/32 DC changers connected in parallel. In the project CERN will be used 22 units HPS 1 that means 66 power supplies with output power 1.7 kW. The number of 64 power supplies will operate in the continuous operation and remaining 2 pcs will be used as the reserve.

Description of Operation

Unload (input voltage of DC/DC changers) is on the end of feeder cable with length 150 m automatically controlled by the help of the return line wires (sense wire) with the accuracy ± 0.1% of nominal value 200V ± 0.2V. The speed of response of Uout up to the step change of load is to the limit 500msecs at the minimal operating power Poutmin = 225W. As for as the return line wires are not used the terminals of „sense“outputs must be connected with terminals of output (+sense=>+200V, -sense=>FGND). The output voltage Uout is possible to adjust manually from the front panel of HPS + within the range from 200V till 240V, automatically by the help of. the return line wires (sense wire), when the voltage +200V on the end of feeder cable or by the remote control in the mode „manually“. There are used 12bitA/D and 10bitD/A converters on the plate of power supply for adjusting value of Uout. At the front panel are situated the following elements: three power supply switches with indication of status for the independent switching on and switching off for all three changers, the connectors of interlock type LEMO, the touch-panel for the manually controlling of HPS1 (incl. individual push button OFF for the central switching off all outputs). The supply of control and communication unit is provided after switching either of three power changers. The LCD unit displays independently information and status all three power changers of HPS 1.

After switching on at least one channel of power the LCD unit shows the version of programme and the set up address of power supply, the power outputs are turned off. The restoring of last status of outputs is realizing by command **Restore Last State** from the main menu before switching off.

The control of power supply realized by the help of menu displayed on the touch-panel. The menu is created with maximally five virtual buttons in the bottom part of display, their functions are changing pursuant to actual occasion. From the all sub-menu you can return to the main menu via the button „Main Menu“.

Immediate switching off all channels / SHUTDOWN takes trought push button ALL OFF.

The LED diode **Ready** signalling the equipment is ready for operation
The LED diode **Remote** signalling the permit for remote control. If the equipment is changed-over via serial line to mode Remote the virtual buttons of menu disappear and it is impossible to control them locally. Only the command **Local** enables the local control again.

If the message **„Warning! CMOS error-Load default values“** appears on the display the fault of CMOS RAM has arisen and the original values setting of particular channels, the tolerance field 195 V – 205 V,

the line address „0“, the combination CRLF to CR will be restored. It is necessary to check 3V CMOS battery and eventually to change it.

The outputs of particular channels is possible switching on only with the closed interlock loop or if it is selected the function **Bypass**.

2. Structure of menu

2.1. Main Menu

- **2.1.1 Select Channel**
- **2.1.2 Restore Last State**
- **2.1.3 Bus Set up**
- **2.1.4 Common Setting**

2.2. Select Channel Menu - selection of channel

- **2.2.1 CH-1** - selects channel 1 and shows its menu
- **2.2.2 CH-2** - selects channel 2 and shows its menu
- **2.2.3 CH-3** - selects channel 3 and shows its menu

2.3. Channel Menu - adjusting parameters of the selected channel

- **2.3.1 ON** - turn on output of channel
- **2.3.2 OFF** - turn off output of channel
- **2.3.3 Aut.** - selects automatic mode for relevant channel (200V)
- **2.3.4 Manual** - selects manual mode for relevant channel
- **2.3.5 Output Voltage** - adjusting of output voltage for relevant channel, only in manual
- **2.3.6 Tol. Limit** - shows Tolerance limit menu

2.4. Bus Set up Menu **- setting of communication**

- **2.4.1 Bus Address** - shows menu Bus Address
- **2.4.2 CRLF Set up** - shows menu CRLF Set up menu
- **2.4.3 Remote Enable** - permits remote control via RS422
- **2.4.4 Remote Disable** - forbids remote control via RS422

2.5. CRLF Set up Menu **- setting of combination CR LF**

2.5.1 CR
2.5.2 LF
2.5.3 CRLF
2.5.4 LFCR

2.6. Tolerance Limit Menu - **setting of tolerance limits for relevant channel in manual mode**

2.6.1 Low UP - increases lower limit within 0.1V
2.6.2 Low DOWN - decreases lower limit within 0.1V
2.6.3 High UP - increases upper limit within 0.1V
2.6.4 High DOWN - decreases upper limit within 0.1V

2.7 Common Settings menu **- setting of tolerance limits in automatic mode (200 V) common for all channels**

2.7.1 Low UP - increases lower limit within 0.1V
2.7.2 Low DOWN - decreases lower limit within 0.1V
2.7.3 High UP - increases upper limit within 0.1V
2.7.4 High DOWN - decreases upper limit within 0.1V

2.8. Bus Address - setting of the unit address for the serial communication in the range 0 - 255

2.8.1 UP - increases number of address within 1
2.8.2 DOWN - decreases number of address within 1

3.0 Visual display
The information for all channels are stated in the table.

CH	Vout	Vsense	Iout	Pout	Status
1					
2					
3					

Vout - the voltage measured on the output terminals [V].

Vsense - the voltage measured on the Sense terminals [V].
< Tol indicates the voltage less than required tolerance
> Tol indicates the voltage over than required tolerance

Iout - output current [A].

Pout - output power, calculation Pout = Vout * Iout [W] .
< 200W indicates output power less than 200W

Status -OFF LINE - it is not possible to control the channel (the mains supply is switched off or the fault of card)

ON	- the output is switched on.
OFF	- the output is switched off
AUT	- selected mode Aut. (200V)
MAN	- selected mode Manual.
PFC Fail	- the fault in the circuit of Power Factor Controler, the channel is not able to switch on
OVERVOLT	- the channel has been switched off automatically the reason was the overvoltage on output
OVERCURR	- the channel has been switched off automatically the reason was the responding of overcurrent protection

FUSE - the fuse on the output of channel has been broken

4. Communication along line RS422

Table 1 Modbus RTU Function Codes Definitions

Function Code	Name	Usage
01	Read Coil Status	Read the State of a Digital Output
02	Read Input Status	Read the State of a Digital Input
03 04	Read Holding Registers / Read Input Registers	Read Data in 16 bit Register Format (high/low).
05	Force Single Coil	Write data to force Digital Output ON/OFF Values of FF 00 forces DO ON Values of 00 00 forces DO OFF Values of FF FF releases the force of the DO All other values are illegal and will not effect the DO.
06	Preset Single Register	Write Data in 16-bit Integer Format (high/low) ONLY.
16 (10h)	Preset Multiple Registers	Write Data in 16-bit Format (high/low). Used to write integer override data.

Table 2 MODBUS Register map

Address (hex)	Coil (decimal)	Parameter Name	Access	Notes
0x0000	0001	Shutdown	R/W	(1=On / 0=Off)
0x0001	0002	Local	R/W	(1=Enabled / 0=Disabled)
0x0002	0003	Remote	R	(1=Enabled / 0=Disabled)
0x0003	0004	Channel 1-ON	R/W	(1=On / 0=Off)
0x0004	0005	Channel 2-ON	R/W	(1=On / 0=Off)
0x0005	0006	Channel 3-ON	R/W	(1=On / 0=Off)
0x0006	0007	Channel 1-Mode	R/W	(Aut.=1 / Man.=0)
0x0007	0008	Channel 2-Mode	R/W	(Aut.=1 / Man.=0)
0x0008	0009	Channel 3-Mode	R/W	(Aut.=1 / Man.=0)

Address (hex)	Input Status (decimal)	Parameter Name	Access	Notes
0x0000	10001	Channel 1-Output	R	(1=on / 0=off)
0x0001	10002	Channel 1-Mode	R	(Aut. = 1 / Man. = 0)
0x0002	10003	Channel 1-ON	R	(On=1/Off=0)
0x0003	10004	Channel 1-Error	R	(1 = HW error)
0x0004	10005	Channel 1-OV	R	(1 = Over voltage)
0x0005	10006	Channel 1-OC	R	(1 = Over current)
0x0006	10007	Channel 1-Fuse	R	(1 = Fuse error)
0x0007	10008	Reserved		
0x0008	10009	Channel 2-Output	R	(1=on / 0=off)
0x0009	10010	Channel 2-Mode	R	(Aut. = 1 / Man. = 0
0x000A	10011	Channel 2-ON	R	(On=1/Off=0)
0x000B	10012	Channel 2-Error	R	(1 = HW error)
0x000C	10013	Channel 2-OV	R	(1 = Over voltage)
0x000D	10014	Channel 2-OC	R	(1 = Over current)
0x000E	10015	Channel 2-Fuse	R	(1 = Fuse error)
0x000F	10016	Reserved		
0x0010	10017	Channel 3-Output	R	(1=on / 0=off)
0x0011	10018	Channel 3-Mode	R	(Aut. = 1 / Man. = 0)
0x0012	10019	Channel 3-ON	R	(On=1/Off=0)
0x0013	10020	Channel 3-Error	R	(1 = HW error)
0x0014	10021	Channel 3-OV	R	(1 = Over voltage)
0x0015	10022	Channel 3-OC	R	(1 = Over current)
0x0016	10023	Channel 3-Fuse	R	(1 = Fuse error)
0x0017	10024	Reserved		
0x0018	10025	Channel 1-Status	R	(1=online / 0=offline)
0x0019	10026	Channel 2-Status	R	(1=online / 0=offline)
0x001A	10027	Channel 3-Status	R	(1=online / 0=offline)
0x001B	10028	Channel 1-Interlock	R	(1 = Close / 0 = Open)
0x001C	10029	Channel 2-Interlock	R	(1 = Close / 0 = Open)
0x001D	10030	Channel 3-Interlock	R	(1 = Close / 0 = Open)
0x001E	10031	Reserved		
0x001F	10032	Reserved		

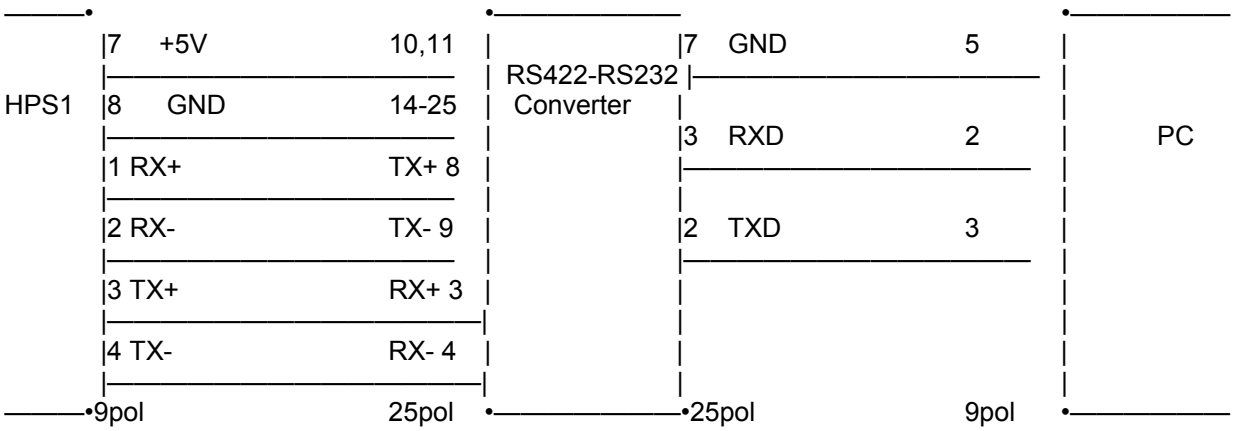
Address (hex)	Input Register (decimal)	Parameter Name	Access	Notes
0x0000	30001	OutVoltage1	R	WORD (1 => 0.1V - 2500 => 250.0V)
0x0001	30002	OutVoltage2	R	WORD (1 => 0.1V - 2500 => 250.0V)
0x0002	30003	OutVoltage3	R	WORD (1 => 0.1V - 2500 => 250.0V)
0x0003	30004	SenseVoltage1	R	WORD (1 => 0.1V - 2500 => 250.0V)
0x0004	30005	SenseVoltage2	R	WORD (1 => 0.1V - 2500 => 250.0V)
0x0005	30006	SenseVoltage3	R	WORD (1 => 0.1V - 2500 => 250.0V)
0x0006	30007	OutCurrent1	R	WORD (1 => 0.01A - 1000 => 10.00A)
0x0007	30008	OutCurrent2	R	WORD (1 => 0.01A - 1000 => 10.00A)
0x0008	30009	OutCurrent3	R	WORD (1 => 0.01A - 1000 => 10.00A)
0x0009	30010	Temp1	R	WORD (1 => 0.1°C - 900 => 90.0°C)
0x000A	30011	Temp2	R	WORD (1 => 0.1°C - 900 => 90.0°C)
0x000B	30012	Temp3	R	WORD (1 => 0.1°C - 900 => 90.0°C)

Address (hex)	Holding Register (decimal)	Parameter Name	Access	Notes
0x0000	40000	LowSenseLimit1	R/W	WORD (1 => 0.1V - 2500 => 250.0V)
0x0001	40001	LowSenseLimit2	R/W	WORD (1 => 0.1V - 2500 => 250.0V)
0x0002	40002	LowSenseLimit3	R/W	WORD (1 => 0.1V - 2500 => 250.0V)
0x0003	40003	HighSenseLimit1	R/W	WORD (1 => 0.1V - 2500 => 250.0V)
0x0004	40004	HighSenseLimit2	R/W	WORD (1 => 0.1V - 2500 => 250.0V)
0x0005	40005	HighSenseLimit3	R/W	WORD (1 => 0.1V - 2500 => 250.0V)
0x0006	40006	Low200	R/W	WORD (1 => 0.1V - 2500 => 250.0V)
0x0007	40007	High200	R/W	WORD (1 => 0.1V - 2500 => 250.0V)
0x0008	40008	SetVolage1	R/W	WORD (1 => 0.1V - 2500 => 250.0V)
0x0009	40009	SetVolage2	R/W	WORD (1 => 0.1V - 2500 => 250.0V)
0x000A	40010	SetVolage3	R/W	WORD (1 => 0.1V - 2500 => 250.0V)
0x000B	40011	SetCurrentLimit1	R/W	WORD (1 => 0.01A - 1000 => 10.00A)
0x000C	40012	SetCurrentLimit2	R/W	WORD (1 => 0.01A - 1000 => 10.00A)
0x000D	40013	SetCurrentLimit3	R/W	WORD (1 => 0.01A - 1000 => 10.00A)

Interconnecting of power supply due to serial data line RS 422 with the computer:

Data signalling rate 9600bd, 8bit,No parity.

1 stop bit
No parity



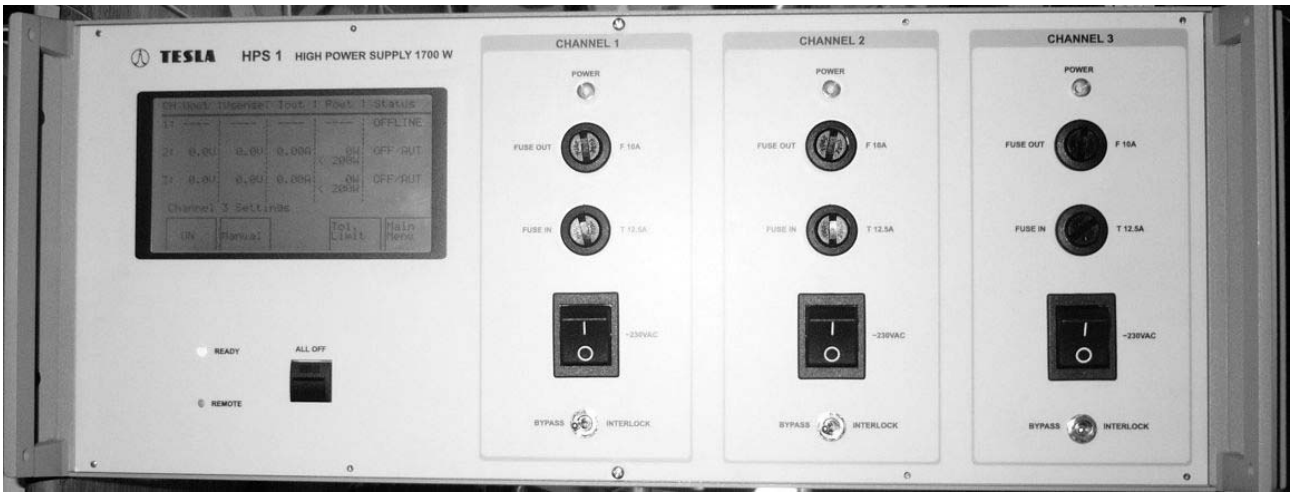
5.0 Technical parameters of HPS 1

Number of power supplies in one crate	3
Maximum output power for one power supply	1700W
Nominal output power for one power supply	900W
Efficiency	90%
Nominal output voltage	200V
Shifting of output voltage due to sensing line wires	+20/-0%
Time response of control	50ms
Inaccuracy of regulation (load from 225W to 1700W or from 13,2% to 100%	max. 0,5%
of nominal output power)	
Short-term stability	max. 0,5%
Long-term stability	max. 0,5%
Ripple + noise	max. 100mVpp
Maximum output current for 200V	max. 8,5A
Maximum output current for 240V	max. 7A
Nominal output power	4,5A
Minimum operational output current	1,125A
Load characteristic	rectangular CV/CC current limit 8,5A
Reaction to unloading 100% > 0%	max. +4V
Reaction to load 0% > 100%	min. -10V
Supply voltage	three-phase, 3 x 230V/50 Hz

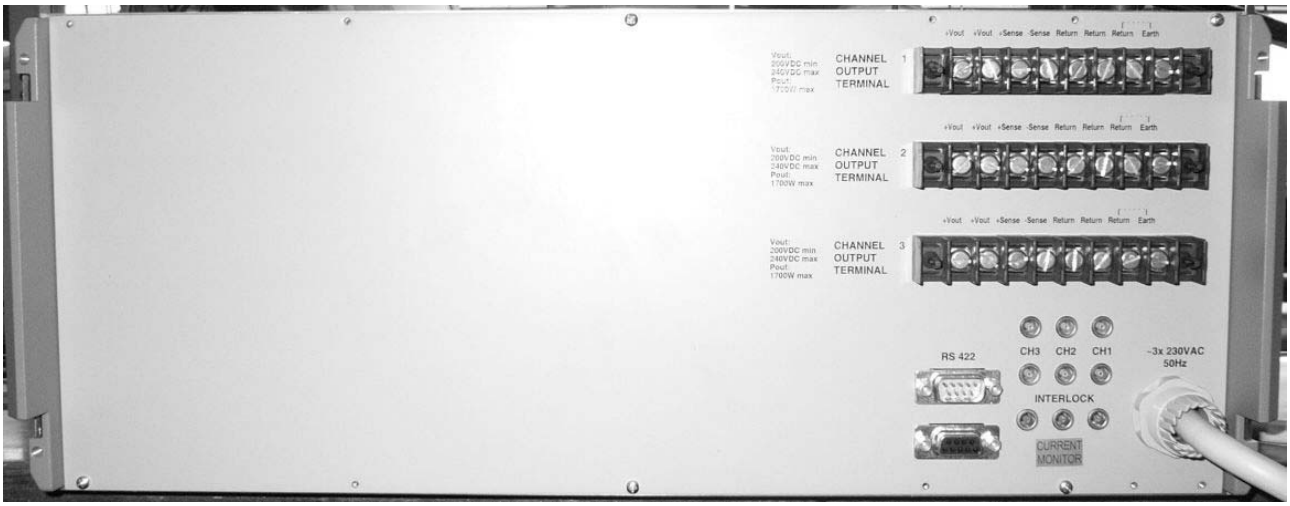
6.0 Description of the electrical circuits. (P1 ÷ P7)

One equipment HPS 1 consists of three individual supplies 200V/1700W for the special application in the project CERN. Every supply is fed from one phase of three-phase mains. The power supplies are controlled from the common control unit with the touch-panel. The control unit is connected with the computer by the help of data bus line RS422.
Since equipments supplied by HPS 1 are in long distance so that is necessary to offset the losses on supply leads by increasing of output voltage up to 240 V. Hence the control loop is adapted for sensing of voltage on a long-distance end of lead by the help of inputs SENSE.
The power supply is equipped by the active power factor controling, filtration of input and output, protections against overvoltage and overcurrent, thermal protection and remote control along line RS 422.
In normal operation at power supply on the Power Factor Controler (PFC) and the auxiliary power supply +18V and +12V work constantly, the secondary downward power changer from +420V for +200V up to +240V turns on and off. The diagrams of HPS 1 are shown on annexes P1 ÷ P7.
The input voltage 230V is connected to connector X1.
The current spike is limited by thermistor after switching on that is on starting of auxiliary power supply +18V short-circuited by contact of relay K1. Thereby the thermistor is disabled and the efficiency is growing up.
The current spike rises from the charging of capacitors C46, C47, C48, C49 and C50 through input filter, bridge rectifier V11, booster choke L7 and diode V16. At the same time the PFC is not operating and the transistor V15 is non-conducting.
The rectified voltage before the choke L7 is not filtered and has half-sinusoidal shape. Further this voltage is marked Vin.
Through the diode V14 and the capacitor C38 rectified voltage is used for determination of sufficient input supply voltage and further this voltage is marked Vacin.
The output voltage PFC on the capacitors behind the diode V16 is marked Vpfc.
The auxiliary pulse supply with the integrated cirquit D1 LT1244, transistor BSP300, transformer T1 is blocked by comparator D1A which is watching the value of voltage Vacin. It is fed with voltage Vpfc (approx. +300V)
The variable resistor R39 adjusts the enable start of auxiliary power supply at the input voltage 192 Vef.
After starting of auxiliary power supply are generated the supply voltages needed for the operation of processing control, control loops and communication with bus control.
The output voltage +18V is feeding the circuits of power supply primary part mainly the integrated circuit LT1509.
The output voltage +12V is feeding the circuits of power supply secondary part with the control processor together.
The control cirquit of changer LT1509 is fed by voltage +15V which appears after the starting of auxiliary power supply.
At this moment the cirquit PFC is beginning to work, the transistor V15 is operating and the voltage Vpfc is increasing up to +420V. The value of voltage is adjusted by the divider R51, R52, R53 and R54.
The current spikes are sensing on the parallel combination of resistors R61, R62, R63 and R147. The sensing voltage on the resistors is controlling the current limiting circuit in LT1509.
The reaching of right value of Vpfc is stated by comparators D4D, D4C, D4B and transfered over the separation network to the control processor. The second stage of changer is still blocked by the signal ON/OFF led through second optical separation network H2 to the circuit D5 of changer.
The power stage of power supply is configured as a half-bridge with transistors V26, V22 and diodesV23, V27.
The half-bridge is working to the primary winding of transformer T3. The voltage for the current limiter is sensing on the parallel combination of resistors R74, R75, R76. There is a bimetallic switch S1 on the radiator which interrupts the function of changer on the overheating.
The control voltage from the secondary part of power supply is fed through the resistor R151 to the input of LT1509. The control loop is optical separated by the linear optical network H1.
The secondary part of changer contains the power cirquits supplying the required output power at the voltage 200÷240 V , the protective cirquits making the required rectangular load characteristic and the cirquits protecting against the overvoltage and the overcurrent. The discharging cirquit R119 and V32 warrants the defined reduction of voltage on the output of power supply at its switching off.
The voltage from the transformer T3 is rectified by high speed power diodes V29 and V30 equipped RC protecting circuits. The smoothing filter comprises eight capacitors (total value 800μF), filter choke L8 and capacitors (total value 400 μF). The output voltage is measured on the resistor divider R111, R112, R113, R114 and is marked MOV.
There are used two control loops to safe the stability of control. The analog high-speed loop and the low-speed loop from the long-distance end over the processor.
The analog control of output voltage is realized by the resistor divider R101, R102, R103 and R104 through the signal follower D8A, the amplifier of deviation D8B, the decision cirquit D12A and D12B, the linear optical convertor with D13A, H1 and D14A.

The variety of second reference voltage on the output of AD converter D11 gained by measuring of the voltage MOV on the output of power supply and the voltage SENSE on the long-distance feeding end decides about the absolute value of output voltage.
The value of current is sensing as a voltdrop on the resistors R96 and R144 and after amplification through D6A measured as MOC. The output of D6A is connected through the resistor R91 to the summary point with R94. The second terminal of R94 is connected to the point where is the reference voltage 2.5V at the normal situation.
The increase of voltage on the output of D6A over the adjusted limit causes the drop on the output of D6B and consequently decrease of control voltage and the ouput voltage. That provides the rectangular load characteristic.
The cirquits D7A and D7B are sensing the sample of output voltage and protecting against the overvoltage on the output.
The function of power supply, the limit adjustment of current and voltage are controlled by the processor D18.
The information about the excess of current limits is indicated by closing of the optical coupler OK1.
The communication with the control unit proceeds through the optical couplers H4, H5, H6.



Front Panel HPS1.



Rear panel HPS1.