User documentation for switching power supply system S3000-S1A version 4

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1 INTRODUCTION

This document represents the usage instruction for switching power supply system *C3000 C1A* version 4 and is designed for device users.

The instruction includes all general data, as well as data related to exploitation, control and maintenance of the system and particular assemblies.

Text of the document is classified in sections containing:

- the first section as an introduction to the document,
- the second section with description of system operation,
- the third section introducing description of system assemblies,
- the fourth section with the most relevant engineering data in relation to the system and system assemblies,
- the fifth section addressing precautionary measures to be taken during the operation in the network field and distribution,
- the sixth section providing the system installation instructions,
- the seventh section providing the instruction manual,
- the eighth section containing testing instructions for the regular checks or those prior to installation,
- the ninth section as a maintenance instruction, i.e. diagnostics' procedure and error recovery,
- supplement section provides electrical diagrams and list of components with codes and supplier information.

Traditionally, GVS team is looking forward to all constructive remarks concerning text contents and its organization, in order to derive future instruction versions more precise, better arranged and highly adaptable to large number of users.

2 SYSTEM DESCRIPTION

This section illustrates the switching power supply system *C3000 C1A в4*, describing its purpose, system characteristics and operation.

2.1 Purpose

The switching power supply system *C3000 C1A в4* is intended to power supply telephone exchanges and other TT devices, requiring high performances in relation to interference, noise, and response speed. The system is entirely automatic and provides uninterruptable, independent operation, ensuring its usage in maintenance systems, remote facilities with no personnel and DC supply for all consumers.

Switching supply system *C3000 C1A в4* outlet provides DC voltage nominal value of 48V and 100A nominal current. System is tested for usage within Russian ПТТ system. On a special request, the system is designed for other standard values of DC voltage, 24V, 60V and 110V nominal.

Switching supply system *C3000 C1A в4* is a modern, highly professional system, provided with exceptional electrical features, easy handling and high reliability.

System allows simple enhancements and modifications, not requiring any interruption of the system operation or harming its basic functions in any way.

The system may operate with or without batteries, diesel aggregates or other auxiliary supply source.

Switching supply system *C3000 C1A в4* is stored in the standard cabinet *S1*.

2.2 Operation description

Switching supply system *C3000 C1A в4* is designed to operate in rectifier configurations. System includes:

- rectifiers *И1400Т48В в4*, maximum 4 *C1* rectifiers
- measuring and diagnostics panel *МДП С36 в4* for *C1* cabinet
- distribution *Д100А в4* with:
  - two fuse bases for 125A high-performance battery fuses
  - two fuse bases for 125A high-performance distribution fuses
  - six 16A distribution automatic fuses
  - two 100A (100mV) shunts for measuring battery current and distribution
  - energetic switch for 100A nominal current

- battery voltage protection *ПЗБ2х в4*
- small universal convertor *УМК0102*
- network field *МРП4А10 в4*.

Circuit diagram of the switching supply system *C3000 C1A в4* is illustrated in figure 1.

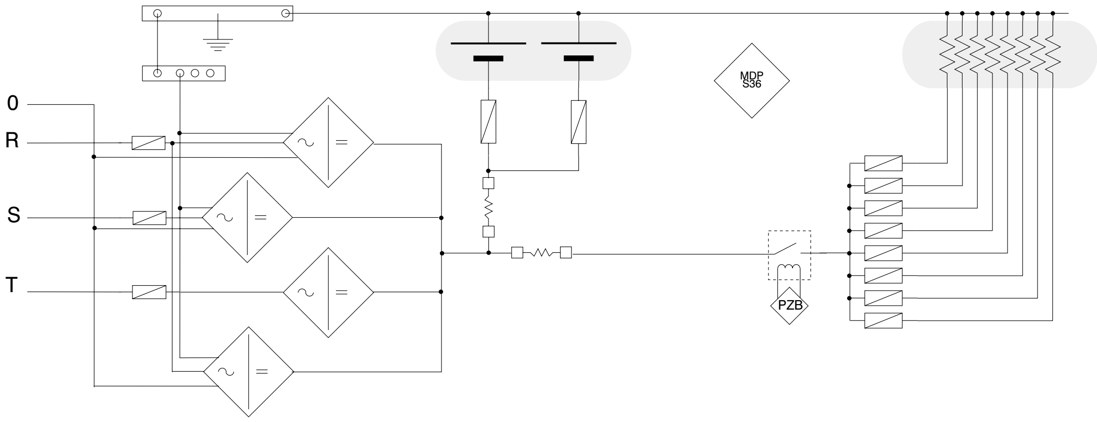


Figure 1: *C1A cabinet circuit diagram*

2.2.1 System operation description

In regular conditions, input to the system is supplied with three-phase (or one-phase) alternating voltage. Network voltage is rectified and stabilized (using DC-DC converter) to preferred direct output voltage value. Batteries are (re)charged, and their relating voltage (Ub) depends on temperature and battery type.

The system provides energy for consumer supply, with maximum load, and the battery maintenance current. Distribution (consumer) voltage, Ud is essentially equal to battery voltage, Ub, differing only for a small voltage drop at the system bus.

Total system load is distributed equally to all regular present rectifiers. For a diminutive rectifier load, the system automatically switches off the certain number of rectifiers (*stand-by* mode), thus obtaining the optimal conditions for the remaining ones. Sudden load changes are compensated from the active rectifier resources, and when exceeding their current capacities, battery load is used, temporarily, until a necessary number of (*stand-by)* rectifiers is switched on.

Rectifier currents synchronize with consumption changes, maintaining stabilized output voltage.

Measuring and diagnostics panel *МДП*, via keyboard and display (*LCD* and *LED*), performs system operation control, checks the alarm origin, battery current/voltage capacity and distribution, network voltage and system parameters, enabling parameter entry.

2.2.2 System operation in the event of network supply termination

In situation of total termination of network supply or unstable network voltage (exceeding the allowed range of 176V - 253V), rectifiers are switched off and the entire consumer supply is battery provided.

Battery voltage drops during the time, thereby consumers supplied in this system configuration must be allowed to operate with a wider input voltage range (40.5V - 57V). On the battery voltage dropped under the allowed value the alarm is generated, and in case of further voltage drop, consumer is eventually switched off.

On network supply recovery, rectifiers are automatically switched on, assuming consumer power supply and battery charging function.

2.2.3 Operation in resource deficiency conditions

It's a complete termination of network supply that most frequently results in failure of network supply or one or two phases. With failure of one or two phases, system maintains the stable output voltage, while the maximum output current goes down to 2/3 or 1/3 nominal output current. Besides the phase failure there may occur a rectifier irregularity. In that case, maximum output current decreases in relation to the number of irregular and regular rectifiers.

Maximum power transmitted to the system by rectifiers in network supply error conditions shall be referred to as Pr. For consumption value less than currently available stream system capacity, system shall function as if in normal operating mode. In the case opposite, system operates with maximum currently available stream capacity, while the rest of energy is battery provided. Such system operating mode is maintained until termination of irregularity condition.

2.2.4 Battery voltage

On network supply interruption, battery shall provide consumer supply. Battery voltage decreases continuously, and in case of persisting network supply interruption exceeding the autonomous battery operation, battery voltage shall drop under the allowed level.

Thereby, for battery protection purposes, sound remote alarm on the measuring and diagnostics panel is switched on. If the battery voltage still declines, battery voltage protection shall serve for switching the consumers off the battery and thus preventing the battery discharge and destruction.

On the activation of voltage protection, system goes down, and consumer supply is interrupted until the network supply recovery, when the system automatically continues the operation.

2.2.5 System operation on network supply recovery

On network supply recovery, rectifiers are switched on successively with 60 second delay to obtain network stability, providing energy for battery charging. Loading current is controlled and limited in relation to battery type and capacity. On battery voltage reaching the voltage protection deactivation point, system disconnects consumers automatically. In that moment, rectifiers obtain current sufficient to cover consumer needs, with concurrent battery charging.

On battery voltage reaching the maintaining voltage value (depending on temperature and battery type), the battery charging is terminated and rectifiers switch to stand-by mode. Duration of battery charging mode is in the range of few to maximum 14 hours.

In case of lead-acid battery used, battery voltage at the moment of transition to stand-by mode is exceeding the rectifier voltage. Consequently, battery is being discharged for some time until voltage is restored to maintaining voltage value thereby having regular system operation mode reestablished.

When dealing with hermetic batteries, charging is realized according to control function realized within measuring and diagnostics panel. Charging voltage is equal to maintaining voltage. In the initial phase of charging process, system maintains constant current defined with battery capacity as $0.3 \cdot C_{10}$. Based on battery temperature, current limit (Io) and charging voltage Uo are formed for battery current. Once reached charging voltage is being maintained further on. Battery charging voltage controls distribution of rectifier currents, total current and system voltage, on each rectifier level. Thereof, Io current overflow is not allowed, that is, Uo voltage is maintained. Meanwhile, current value is descending, while voltage value remains constant. Duration of hermetic battery charging controlled in such a matter is not limited. Charging current is a system parameter function and is set to optimum value to prolong battery lifetime.

3 ASSEMBLY DESCRIPTION

This section brings description of measuring and diagnostics panel *МДП С36 в4*, distribution *Д100А в4*, voltage protection *П3Б2х в4*, network field *МРП4А10 в4* and cabinet *С1*. Description refers to purpose, operating mode, construction etc.

3.1 Measuring and diagnostics panel МДП С36 в4

Detail description in user documentation for МДП С36 в4.

3.1.1 Purpose of МДП С36 в4

Measuring and diagnostics panel is a microprocessor controlled device performing: measuring and displaying of corresponding system parameters' values (voltage, current, storage temperature etc.), detection and informing of the system state, controlling battery charging in relation to the temperature of the room the battery block is stored in, communication with other microprocessor controlled system parts, communication with system periphery (PC, modem), system integration into the independent whole. Single measuring and diagnostics panel controls entire power supply system and is labeled with *МДП С36 в4*.

3.1.2 Description of МДП С36 в4

Measuring and diagnostics device is contained of *МДМ* - measuring and diagnostics module, one *УМК* small universal converter for *МДМ* logic and communication bus supply, slave mechanical devices, cases for device and connecting parts.

- *МДМ* module is a system central module. Its control block is realized over *Intel* microprocessor *80188*, two microcontrollers *HC11* and their slave memory blocks, programmable dual-port memory, *LCD* and *LED* display, user keyboard and alarm elements. *МДП* performs following functions: detection and reporting, signaling, measuring and display, system parameter settings, communication functions, protection functions, battery charge control functions and testing functions. All functions shall be discussed in the following sections.

- *УМК* generates dedicated voltages out of a battery voltage:

  - +5 V for *МДМ* power supply;
  - ±5 Vb for power supply of measuring and diagnostics blocks on the battery side (distribution power supply)
  - +10 VSC for communication bus supply;
  - +5 Vp for external communication supply and primary/secondary protection.

МДП basic functions

Measuring and display functions relating to:

- battery current and voltage;
- distribution current and voltage;
- network voltage;
- storage temperature (from $-15,0°C$ to $99,9°C$).

LCD and *LED* displays used are placed on *МДМ* front panel. Measuring results are expressed with one decimal.

Detection and report functions:

- **General alarm** is a logic signal generated on or preceding to failure of a *C3000* system vital part which may be:

    1. irregular rectifier;
    2. battery voltage below battery undervoltage threshold;
    3. distribution voltage exceeding the allowed level (according to ПТТ standards);
    4. battery or distribution fuse blow;
    5. detected irregularity of network voltage.

    General alarm is sound and remote signalized.

- **Sound alarm**. On the occurrence of a system error, sound alarm is activated. Sound alarm may be deactivated using the switch on the front panel, in any particular case.

- **Remote alarm**. Remote alarm is generated simultaneously with a sound alarm. Sound alarm deactivation shall never effect the remote alarm functioning nor cause its generation. Remote signaling is realized via relay and appropriate signals, *АЛМД*$^+$ and *АЛМД*$^-$, connected to serial terminals of cabinet distribution. 24V, 1A relay output contacts are connected in the alarm state.

Other report functions. Menu *Status/Alarm status* informs user of different failure events or related system events. See section "Menu options" on *LCD* display. Menus such as: *Battery field, Distribution* or *ПЗБ* inform user of specified values for system/battery voltage and current and possible battery/distribution fuse blow.

Protection functions

- **Battery undervoltage protection**. Independently from *ПЗБ* module, *МДП* detects battery undervoltage before *ПЗБ* switching off the contactor (for 0.5V earlier) and informs (alarms) user of the possible system operation failure, ПБ in menu *Alarm status*.
- **Watchdog timer** - automatic device protection in irregular operation events. Due to different external effects (electromagnetic interference, power supply related interference), the device may switch to temporary irregular operation state. *МДМ* module realizes the function which shall, in maximum 200ms time, provide device being brought back to regular operation. The function is software realized via *Watchdog* timer of microcontroller *68HC11*.

Testing functions

Regularity check for indicator and sound and remote alarm is accomplished in *LCD* display menu, option *Display test*. On selecting this option, all *LED* characters and indicators are activated, as well as sound and remote alarm (if found any).

Control functions

- Battery (re)charging

  Battery charging interval depends on system parameters, consumer capacity, rectifier section power, battery state and storage temperature. The entire process shall take at least several hours. *МДП* controls battery charging on the basis of current optimum values of battery current and voltage, battery storing capacity and temperature. Battery capacity value is in 40 Ah to 9995 Ah range.

Communication functions

- Communication functions of measuring and diagnostics panel may be classified to those relating to communication with *C3000* system (dual, RS485, 4800 Bd) and communication with peripheral devices (RS485, 4800 Bd), to provide continuous or temporary screening and updating of system measuring values. Communication reliability are obtained via: message doubling, communication path doubling, *Hand_shaking*, time protection, network collision detection.
- Communication with rectifier - *МДП* is allowed to inspect all relevant rectifier parameters: regularity, current, temperature, serial number, rectifier status, 220 V network regularity.

Master control functions

- Current distribution to rectifiers up to 1% of mean system current value for each. With deviation exceeding 25% the rectifier is considered technically irregular.

- System voltage regulation to battery charging/maintaining value.
- Controlling rectifier activation/deactivation to maintain the active rectifier value between 6A and 12,5A.
- Detection of rectifier irregular operation followed with its deactivation.

3.1.3 МДП С36 в4 construction

МДП is designed with all functions relevant for a user located on the front panel. *МДМ* card is installed on the front cabinet side, while *УМК* and *ПЗБ* card are installed on the narrow cabinet plane.

МДП front panel view is illustrated in figure 2:

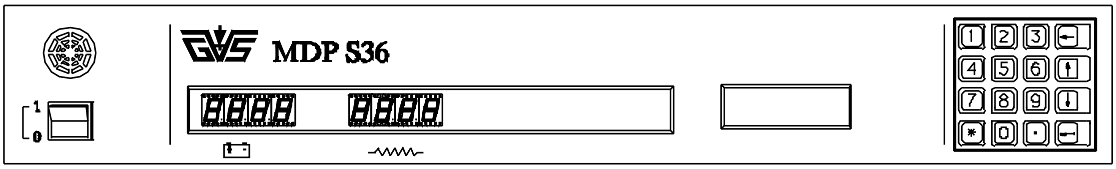


Figure 2: *МДП С36 в4, front view*

3.2 Distribution Д100А в4

3.2.1 Д100А в4 distribution purpose

Д100А distribution is part of *C3000* system performing:

- battery connection to the system *C3000*,
- system *C3000* connection to external consumers.

Distribution section also provides battery (re)charging of *И1400Т48В в4* rectifier.

In the case of network supply interruption, distribution section enables consumer battery supply completely controlled and undervoltage protected.

Basic distribution function is *C3000* system connecting to battery and consumer thus enabling safe consumer supply. Distribution also provides overload and short-circuit protection for battery, system and consumer. Protection is realized using meltable and automatic fuses, mounted in distribution section.

Battery is additionally undervoltage protected for the case of exceeded discharging.

Two shunts are located in distribution section: battery and distribution shunt. These provide battery and consumer current measuring.

Battery or distribution fuse blow is signalized via measuring and diagnostics panel *МДПС36*.

3.2.2 Distribution operation description

Distribution section is delivered as part of *C1* cabinet, completely wired and ready for connection to the external network (consumers and batteries).

Consumers within *С3000-С1А в4* system are connected to distribution over six automatic and two high-performance fuses (figure 3, position 9 and 10), functioning as the overload and short-circuit protection.

System is connected to batteries using two battery high-performance fuses (figure 3, position 11) installed in distribution section.

Direct current and voltage are conducted from the rectifier outlet *И1400Т48В в4* via B-bus to the distribution shunt (figure 3, position 13). On the distribution shunt output system voltage and current are measured.

To prevent exceeded (deep) battery discharging that might cause permanent damage, battery undervoltage protection is installed. On distribution voltage drop under allowed values, a pulse is sent via electronic subcircuit *ПЗБ2х* (figure 3, position 7) for contactor switching off (figure 3, position 14), introducing own contact and canceling the connection between battery and consumer. On voltage recovery, contactor is automatically switched on.

In regular operating conditions, consumers obtain dc voltage and current from rectifiers over distribution fuses, while battery charging is obtained with battery fuses. In case of network supply termination, consumers are supplied from battery over battery and distribution fuses. Battery voltage and current measuring is performed on battery shunt (figure 3, position 12).

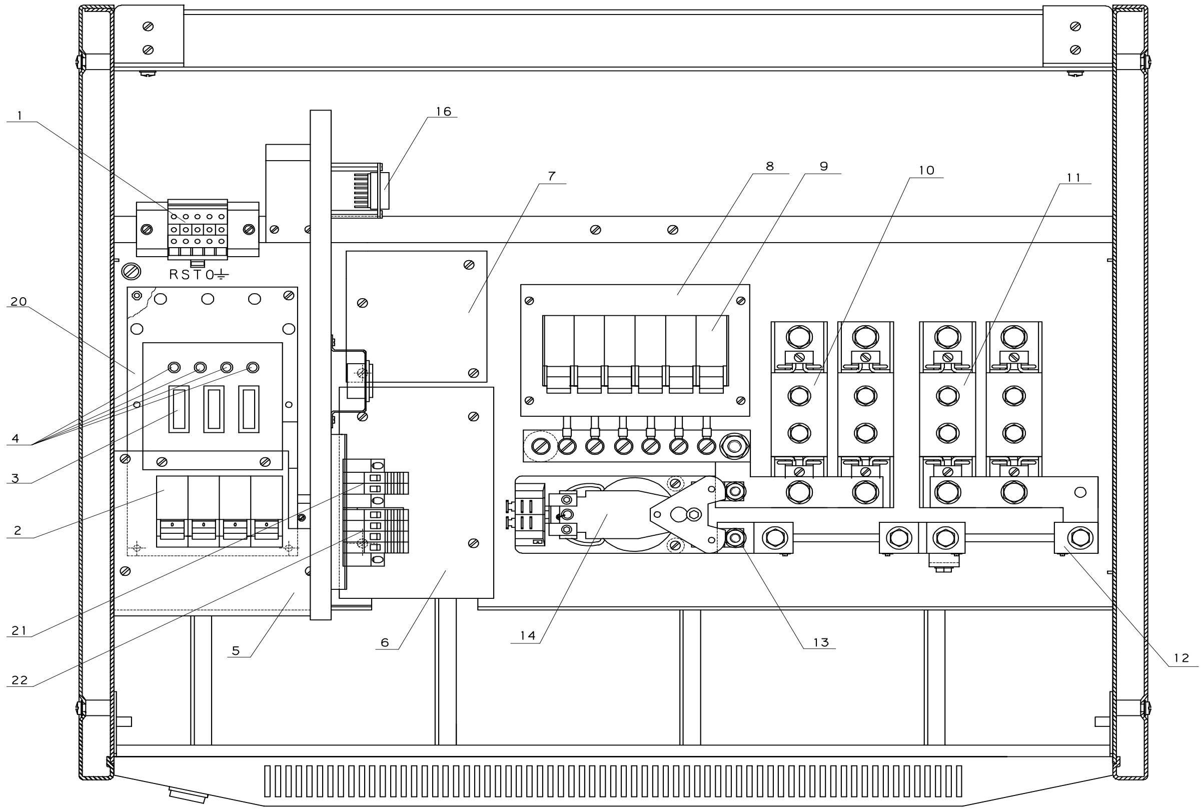
State of distribution elements is detected and forwarded to measuring and diagnostics panel used to signalize distribution and battery fuse failure and perform measuring of system input and output parameters.

3.2.3 Distribution construction

Distribution *Д100А в4* is firmly connected to *C1* cabinet and is considered its structural part. It is stored in upper right cabinet part, above module rack.

Distribution may be accessed from the front and upper side, either by pulling out the front distribution mask or by lifting the upper right cabinet cover, respectively.

Fuse-carriers, contactor and automatic fuses are mounted on the carrier board. Carrier board is stationary and firmly connected to cabinet lateral parts.



1. supply line connecting terminal 2. automatic network fuse 3. control lamp 4. measuring receptacles 5. network fuse carrier board 6. electric subassembly УМК0102 7. electric subassembly ПЗБ2x в4 8. distribution fuse protection board 9. automatic distribution fuses 10. high-performance distribution fusebase 11. high-performance battery fusebase 12. battery shunt 13. distribution shunt 14. contactor 15. electronic subassembly МДП С36 в4 16. external communication connector 17. bus B+ 18. earthing bus 19. printed board PCO 20. electronic subassembly MMH 21. remote alarm operating terminals 22. temperature probe operating terminals

Figure 3: *Network field МРП4А10 в4 and distribution Д100А в4*

3.3 Network field МРП4А10 в4

Network field and distribution mechanically are the unified whole.

3.3.1 Purpose

МРП4А10 в4 network field is part of *C3000-C1A в4* system and provides the energetic system connection to the mains network which supplies the system with alternative current and voltage. It is mounted in *C1* cabinets and delivered thereafter.

All elements required for signaling and alternative supply check are mounted in the network field.

Network field functions are:

- enabling *C3000* system connecting to 220VAC network and its functioning; connection to the network is realized with connecting terminals via supply lines;
- provision of the overload and short-circuit protection, using three automatic fuses;
- provision of phase voltage measuring, using four measuring receptacles;
- phase voltage measuring and sending relative data to *МДП*;
- phase voltage presence signaling.

3.3.2 Network field operation description

МРП4А10 в4 network field is delivered with complete internal wiring, ready for connection to network supply. On supply lines connected, network field may operate.

Setting the switchers to the automatic fuses (figure 3, position 2) the network field and all belonging rectifiers are energized. On switching on, the lamps are enlightened (figure 3, position 3), signalizing the presence of network voltage for each phase.

Input voltage for each rectifier is provided over inlet fuses.

After power-up, network field functions regularly to the moment of possible network irregularity occurred, which shall be discussed in section 8.

Network field deactivation is performed using automatic fuse switchers.

3.3.3 Network field construction

МРП4А10 network field is located in upper left *C1* cabinet part. It is designed as unique compact mechanical module with integrated command, protection and signaling elements and connecting elements for connection to network and rectifiers, located on the carrier board.

Network field also includes *ММН* board for network voltage measuring, all three phases.

Network field elements may be accessed from the front and upper side of the cabinet either by pulling out the front distribution mask or lifting the upper left cabinet cover, respectively.

3.4 Cabinet C1 в4

3.4.1 C1 в4 cabinet purpose

C1 в4 cabinet is designed to store the uninterruptable power supply system, with power up to 6KW. Maximum four rectifiers *И1400Т48В в4*, distribution *Д100А в4*, network field *МРП4А10 в4* and measuring and diagnostics panel *МДП С36 в4* are mounted in the cabinet.

3.4.2 C1 в4 cabinet description

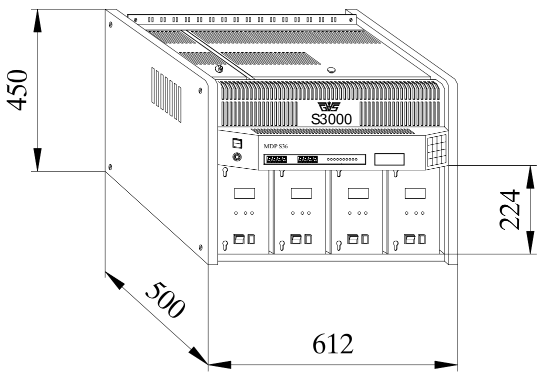


Figure 4: *Cabinet C1 в4*

For small systems, cabinet is mounted to the wall. The cabinet is divided into two vertical sections, as illustrated in figure 4. The upper section is reserved for *Д100А* distribution storing, and the lower one is a four rectifier module rack.

Cabinet is delivered with the frame which is fixed to the wall to carry the cabinet *C1 в4*.

Cabinet is accessed from the front and upper side. Cabinet dimensions are introduced in figure 4.

Figure 5 shows location of the holes at the wall for *C1* cabinet mounting.

C1 cabinet is connected to network voltage via corresponding serial terminal located under left upper cover.

Cabinet is cable connected to users and batteries, via distribution and battery fuses.

Remote signaling is realized over serial terminal located on the barrier board between network field and distribution.

3.4.3 C1 в4 cabinet construction

Carrier board integrates the elements of network field and distribution into a unified whole. Carrier board is divided in two sections - network and distribution.

The section belonging to network field *МРП4А10 в4* includes:

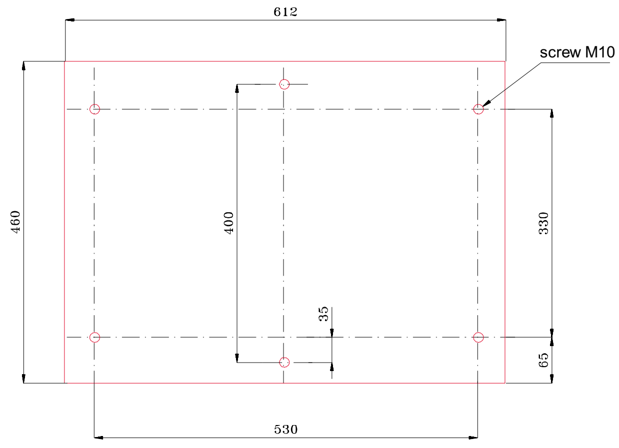


Figure 5: *Hole location on the wall*

- connecting five-pole supply line terminal,
- 4 automatic network fuses, up to 10A nominal current,
- signaling lamps for network voltage presence,
- measuring receptacles,
- *MMH* board for network voltage measuring.

Five-pole connection terminal is used to connect phase, zero and protection supply line conductor to *C3000* system. Maximum allowed supply line cross-section is $16mm^2$.

Four automatic 10A nominal current fuses are mounted on the carrier board (one for each rectifier).

On network voltage connected to network field, phase lamp is enlightened.

System contains four measuring receptacles, three upper ones (figure 3, position 4a) connected to phases, and a lower one (figure 3, position 4б) to zero conductor.

Carrier board section belonging to distribution *Д100А в4* includes:

- electronic subassembly *УМК0102*,
- electronic subassembly *П3Б2х в4*,
- protection plexiglas board preventing contact between energized fuse parts,
- automatic distribution fuses, 10A, 16A, 20A and 36A nominal current (consumer dependant),

- two bases for battery high-performance fuses, 125A nominal current,
- two bases for distribution high-performance fuses, 125A nominal current,
- 100A nominal current contactor,
- one shunt for battery current measuring,
- one shunt for consumer current measuring,
- buses, wire form, isolators etc.

Back cabinet side is illustrated in figure 6.

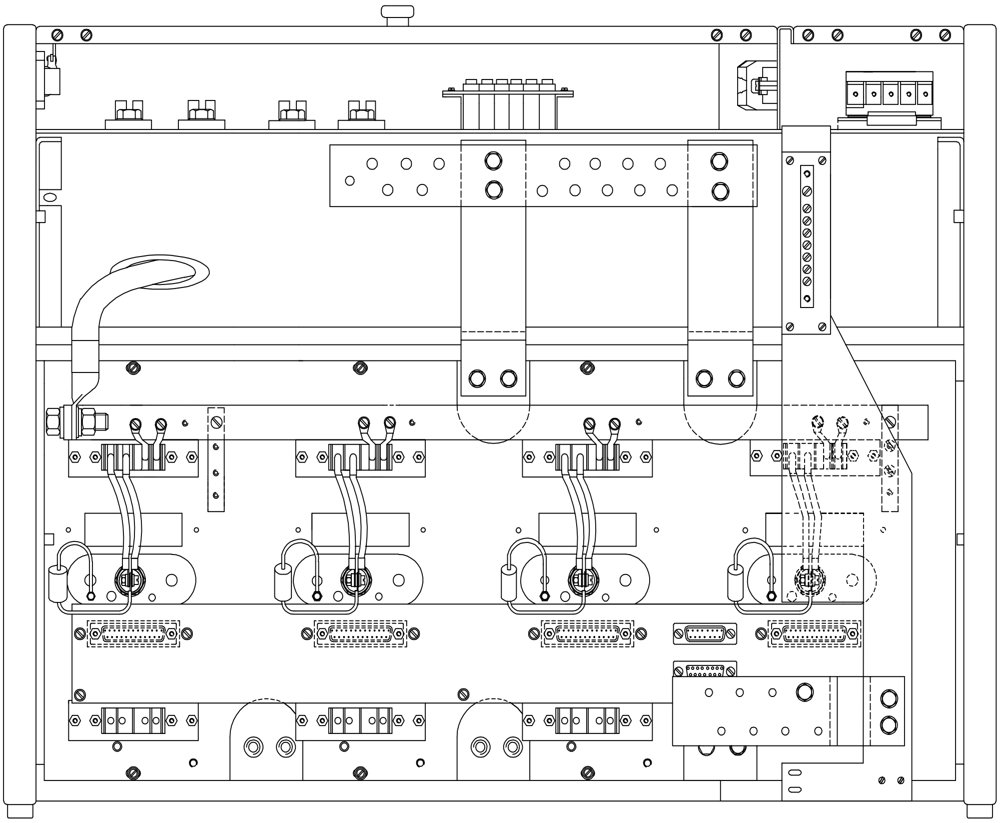


Figure 6: *C1 в4 cabinet back side*

3.5 ПЗБ2х в4 undervoltage protection board

3.5.1 ПЗБ2х в4 purpose

ПЗБ2x module is intended for battery protection from exceeded discharge. This protection is realized by interrupting the line connecting consumer to the battery, using appropriate contactor. *ПЗБ2x* is battery supplied and continuously monitors battery voltage. On battery voltage reaching the upper threshold, *ПЗБ2x* activates the contactor.

3.5.2 ПЗБ2х в4 description

ПЗБ2x undervoltage protection board is realized in the analog technology. Comparator devices detect battery undervoltage, generating the alarm signal. Comparator thresholds are set during manufacturing process by means of trimmer potentiometers with value depending on battery type and number of cells in battery field. Contactor is controlled over switching transistor with maximum 1A output current. *ПЗБ2x* may independently control operation of two contactors. The board is connected to system over three connectors. Operation principle is illustrated in figure 7.

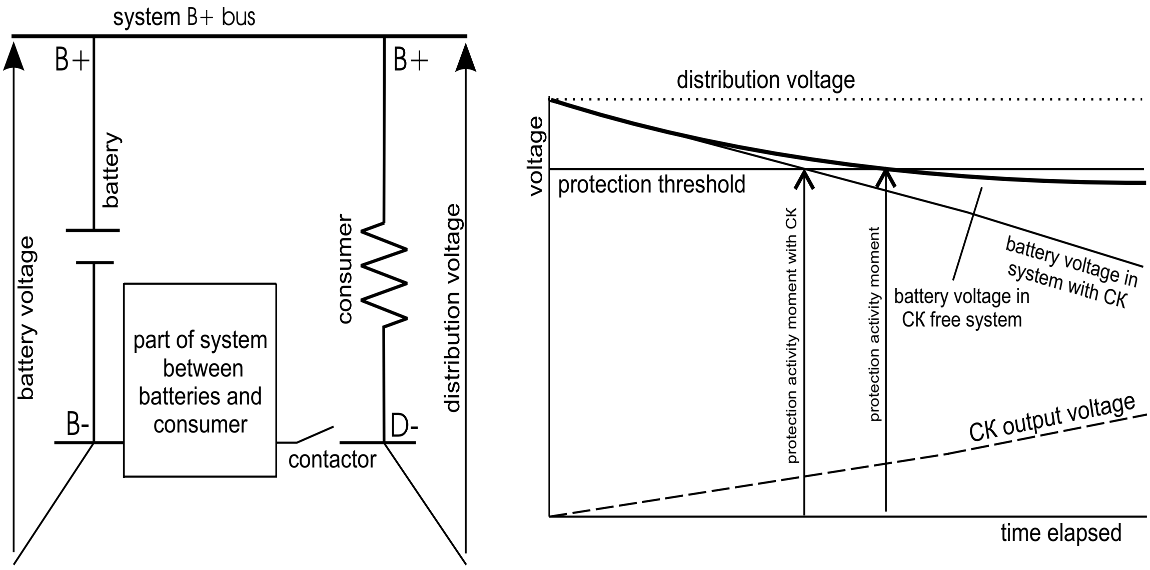


Figure 7: *Block diagram and graphic with description of ПЗБ2x в4 purpose*

Figure proves the contactor interrupts the battery-consumer circuit, disconnecting consumer from the battery and preventing its further discharge. Graphic shows system voltage time diagrams. Protection threshold represents the voltage value resulting in protection activity (consumer disconnected). On protection activated, not only consumer, but all other unnecessary system elements causing battery discharge are disconnected from batteries.

On battery voltage drop below the threshold adjustable by board trimmers, comparator switches off the corresponding FET. On FET being switched off, circuit through contactor coil and distribution lines are interrupted.

The other comparator half is used for battery undervoltage signaling, activated some time before consumer disconnection. The board also contains contactor switch on signaling part. Contactor microswitches are serially connected to realize "AND" function. With deactivation of a switch, the circuit is interrupted thus signalizing protection activity. If there was an undetected contactor in the system, corresponding microswitch is switched over by means of corresponding DIP switch activation.

The board is fully equipped with signaling types selected by user. Further text introduces the list of output pins with description of relative functions.

K1-, K2-: This pins control contactor coil. Contactor is activated in the event of low pin voltage (FET activated). 100V FETs are used (for 110V systems another FET shall be introduced). Contactor coil circuit for standard versions *ПЗБ9305 в4* should not exceed 1A.

УК1+: With УК1+ on mass, all system contactors are switched on. This is regular state (if not so, system exercises certain difficulties).

ПНС: Bringing this signal to mass, battery undervoltage is signalized some time before protection activity. Modern exchanges may use consumer discrimination (deactivation of less important consumers) in the event of battery energy reaching minimum to signalize the system operation interruption approaching on predefined time expiry.

The board provides selection of two thresholds for undervoltage protection activation introducing the external ИК signal, over J1 connector. Bringing this signal to mass, undervoltage protection threshold is getting lower for 0.16 V per cell in relation to set threshold value. This enables the variable undervoltage protection activation threshold in processor controlled systems within range of 1.65 V per cell - 1.81 V per cell. In case of sudden battery discharge, (detected with processor measuring of battery current and time) bringing ИК signal to mass may modify undervoltage protection activation threshold (to 1.65 V per cell). In such circumstances, processor may deactivate the contactor in any moment while the voltage value is between 1.65 V per cell and 1.81V per cell, simply by getting the signal back to higher voltage value. This is how variable threshold of the undervoltage protection activation is achieved within *C3000 в4* system, selected from МДМ keyboard.

3.5.3 ПЗБ2x в4 board construction

ПЗБ2x module is a printed board with dimensions 91.44 x 76.20 x 1.6 mm. This board is fixed onto specified distribution location using four M_3 screws to the board corners. Disposition of components on *ПЗБ2x* board is illustrated in figure 11, section 7.4.

3.6 Network voltage measuring board MMH в4

3.6.1 MMH в4 board purpose

MMH9901 network voltage measuring module provides detection of network voltage state for all three phases. During measuring process, network and control electronics are galvanic isolated. Effective voltage value is measured for all three phases and results are forwarded to *МДП* where the measured values are displayed by means of *LCD*. Measuring accuracy is 1%.

3.6.2 MMH в4 board construction

MMH9901 module is a printed board, dimensions 91.44 x 76.20 x 1.6 mm. The board is fixed onto specified location in the network field using four M_3 screws to the board corners.

4 ENGINEERING DATA

4.1 Engineering data for C1A B4 system

Input data:

Network voltage Vu	220/230 Veff
Network frequency	47-63 Hz
Allowed voltage phase deviation	-15% to +10%
Allowed phase distortion	30%
Input current on full load and nominal input voltage	4 x 7A
Surge current	<(4 x 8A)
Power factor (cos φ)	> 0,98
Input rectifier fuse	10A
Protection	overvoltage, undervoltage, fuse, lightning surge protection

Output data for 48V output voltage system:

Nominal voltage V	48V
Adjustable maintaining voltage	49-56V
Adjustable charging voltage	52-56V
Stability	better than 1%
Nominal current	4 x 25A
Current restriction	4 x 26A
Output power	4 x 1400W
Response duration	1ms
Voltage surge amplitude	less than 2Vp-p
Psophometer value of battery-free noise voltage	less than 1mVeff
Effective noise value within range 10Hz - 450kHz	less than 25mV
Broadband noise	less than 10mVeff/MHz
Rectifier dedicated protection	overvoltage, undervoltage, overcurrent, short-circuit protection

General data:

Processor control	RS485 interface
Module operating frequency	50 kHz
Allowed ambient temperature	0°C to + 40°C
Allowed storage temperature	−10°C to + 70°C
Allowed humidity	up to 90%
Distribution fuses	high-performance meltable
Battery fuses	high-performance meltable
Temperature protection	69°C
Battery undervoltage protection	adjustable
Automatic battery (re)charging	
Indicating instruments	digital 1%
Sound alarm	
Fuse failure signaling	
External dimensions: height	450mm
width	632mm
depth	500mm
Spare part provision	20 years
Warranty	3 years
Assembly	modular
Certification	ЗЈПТТ

4.2 Engineering data for МДП С36 в4

- for *МДМ С36 в4*
Consumption: maximum consumption on +5V is equal to 500mA,
$\pm 5V_b$ at the source: 40mA, on $+5V_p$: 20mA.
Maximum consumption on 48V is equal to 250mA.
Communication
External: RS485, 4800 Bd, bothway
Internal: RS485, 4800 Bd, dual communication channel with maximum consumption of 2A.
Battery (re)charging

- HI batteries: current limit is specified depending on temperature and charging voltage i.e. maintaining voltage
- EG batteries: charging started with 200 mA/Ah in relation to total battery capacity; charging stopped with 20 mA/Ah in relation to total battery capacity.
- USER batteries: user defines thresholds and specified voltages and charging currents.

Maximum number of monitored distribution fuses: 8.
Maximum number of monitored battery fuses: 2.
Remote signaling: dead relay contacts, maximum 24V, 1A, connected in the alarm state.
Display refresh rate: 8kHz.
Sound signaling: buzzer, 5V direct voltage, 80dB.

4.3 Engineering data for Д100А в4:

Д100А в4 distribution output data for 48V output voltage:

Nominal voltage (Vi)	48VDC
Nominal current	100A
Output fuses	
- distribution	2 x 125A - meltable
	6 x 10A - automatic
- battery	2 x 125A - meltable
Protection	fuses, battery undervoltage protection, contactor
Measuring	battery shunt 100A, 100mV
	distribution shunt 100A, 100mV

General data:

Allowed ambient temperature	0°C to + 45°C
Allowed storage temperature	−10°C to + 75°C
Allowed humidity	до 90%
Spare part provision	20 years
Warranty	3 years
Certification	ЗЈПТТ

4.4 Engineering data for МРП4А10 в4:

МРП4А10 в4: network field input data

Network voltage Vu	220/230 VAC
Network frequency	47-63 Hz
Allowed voltage phase deviation	-15% to +10%
Input current on full load and nominal input voltage	4 x 7A

МРП4А10 в4 network field output data:

Nominal voltage Vi	220/230 VAC
Network frequency	47-63 Hz
Allowed voltage phase deviation	-15% to +10%
Output automatic fuses	4 x 10A
Protection	fuse

General data:

Allowed ambient temperature	0°C to + 45°C
Allowed storage temperature	−10°C to + 75°C
Allowed humidity	maximum 90%
Spare part provision	20 years
Warranty	3 years
Certification	ЗЈПТТ

4.5 Engineering data for УМК0102

- Input voltage: 35 - 75V
- Input current: 120mA - 600mA
- Output voltages: +10V, +5V, $\pm 5V_b$, $+5V_p$
- Output current: up to 3A for +10V, up to 1A for +5V, 150mA for other voltages
- Operating frequency: 50kHz.

4.6 Engineering data for ПЗБ2х в4

- Input voltage: 48V or 60V nominal
- Allowed deviation: 24 - 80V
- Input current: 25mA
- Maximum current for contactor coil: 1A (on request, up to 10A)
- Output fuses: 3A each (or more, for larger output current values)
- Dual threshold selection of undervoltage protection activation: 1.8 or 1.65 V/h
- Adjustable protection threshold:
  - 42V - 46V for 48V systems (threshold 1.8 V per cell)

  - 51V - 56V for 60V systems (threshold 1.8 V per cell)
  - 38V - 42V for 48V systems (threshold 1.65 V per cell)
  - 46V - 51V for 60V systems (threshold 1.65 V per cell)

- Two protection activity thresholds
- Signalizing the prospective protection activity

5 PRECAUTIONS

Besides common precautions considered in operation with electrical equipment, specified by corresponding legal regulations, and those related to elements installed in system *C3000-C1A*, network field *МРП4А10* and distribution *Д100А*, described in corresponding instructions, following issues should be applied:

- no installation work, testing, repair and similar activities by an unauthorized and untrained person are allowed;
- device in the active state conducts dangerous voltages and accumulated energy;
- device enclosure and other metallic parts of network field are connected to protection earthing via appropriate supply line conductor;
- when conducting certain activities at the network field, the network automatic fuses and related switch in the distribution cabinet providing *C3000* system supply should be switched off;
- when operating with distribution (fuse replacement, shunt measuring etc., with tool usage) consider avoiding short circuit on the energized elements;
- buses, contactor, shunts, are not isolated, being stored internally in the distribution, thereby requiring strong attention when using appropriate tools and equipment during distribution interventions;
- during fuse replacement consider avoiding its reaching the electronic boards;
- all system and module interventions are forbidden for the warranty duration period (except the fuse replacement); each intervening activity results in complete warranty dismission and user being charged for servicing.

6 INSTALLATION

This section illustrates installation procedure for C1 system and assemblies, demountable by user. Corresponding conditions required for system installation are also introduced. Network field, racks and distribution are delivered in connection with the cabinet and its installation is performed in GVS.

GVS provides complete system installation, unless required different by purchaser. In case of purchaser taking over the system installation, GVS is obliged to deliver the tested and appropriately set system.

6.1 System installation conditions

To enable *C3000* system installation, following conditions should be completed:

- ***System storage conditions***

  C3000 system is intended for storage within rectifier, exchange, operating or other environment. It requires no special air conditions. System storage area should be illuminated and dry, according to corresponding regulations.

- ***Network supply***

  Network supply switchboard should be placed near the system, with a main switch and a number of fuses according to system configuration. Number of fuses is defined within power supply design project, providing three fuses for each rectifier cabinet. Cross-section of supply line from the main switchboard to the network supply switchboard is defined for each system separately, within power supply design project.

- ***Battery supply***

  System battery supply requires supply lines for each battery. Cable cross-section depends on its length and current provided from the battery. Battery cables are specified according to calculation results. GVS conducts battery cables to the corresponding connecting points (fuses, terminal spots or batteries) in maximum 5m length, unless other specified by the contract.

- ***Battery forming***

  Batteries may be formed in accordance with relating manufacturer instructions or investor regulations. GVS company shall not consider battery forming as part of *C3000* system installation.

  However, GVS may perform battery forming, when specified by contract, and according to procedure described in corresponding GVS instructions.

6.2 Cabinet mounting to the wall

Before switching the system on, it is necessary to mount the cabinet to the wall. This is performed in following steps:

- place the carrier frame on the specified place on the wall (see 3.4.2) and fix it to provide carrying capacity equal to multiple *C1* cabinet weight;
- fix the cabinet onto the frame and locate cabinet slides;
- remove B+ bus and set textolyte carriers (delivered with cabinet) on it;
- restore B+ bus to its previous location and fix it.

System is ready for further installation.

Note*If not mounted to the wall, C1 cabinet should not be placed directly to the floor, thus disabling the vertical air flow on the module side, especially through the channel on the back of front panel. The interruption of the air flow prevents module cooling thereby deteriorating output power on high temperatures.*

6.3 МДП С36 в4 - C1 mounting

Measuring and diagnostics panel should also be mounted to *C1* system. Mounting procedure includes:

- remove front distribution mask;
- mount (fix) *МДП С36 - C1* onto four pins on the inside of the cabinet;
- connect wire form and *МДП* over two 64 pole connectors J1 and J2, considering connector labels in order to prevent their substitution; J1 and J2 connectors contain 4 segments each (J1-1 to J1-4 and J2-1 to J2-4) connected to specified locations;
- restore the front distribution mask to its previous location, ensuring *МДП С36-C1* wire form cable pass through specified opening;
- fix the front distribution mask.

6.4 Network supply connection

220V/230V alternating voltage is connected to *МРП4А10* network field using appropriate supply lines.

Supply line is connected in de-energized state, fixing the serial terminal screws.

To execute the installation procedure:

- open left upper cabinet cover;
- make sure that the main output switch for connection to network field is in switched off ("0") position; output terminal is located in user distribution cabinet;
- set automatic fuse switchers (figure 3, position 2) to "0" position, if not already set so;
- pull the endings of supply line phase conductors into P, C, T connecting terminals (figure 3, position 1) and fix them using a screw;
- pull the ending of supply line zero conductor into 0 connecting terminal (figure 3, position 1) and fix using a screw;
- pull the ending of supply line protection conductor into connecting terminal "earthing" (figure 3, position 1) and fix with a screw;
- connect supply line to cabinet terminal providing power supply.

With all previous performed, *МРП4А10* network field is ready for starting up.

On the installation complete, *МРП4А10* network field operation is started switching the automatic network fuses on.

Note: *Recommended supply line is five-wired PPOO-Y cross-section type in accordance with system installation conditions (main cabinet distance).*

6.5 Direct supply and consumers' switch on

Distribution part is delivered firmly connected to the cabinet so the field installation requires only cable connecting.

Battery and consumer connecting to the distribution part is performed as following:

- open the left upper cabinet cover and set the automatic fuse switchers (figure 3, position 2) to "0" position, if not already set so; also switch off the main switch in user distribution cabinet;
- open the right upper cabinet cover;
- make sure that the *ПЗБ2х* board switch is in position "off";
- set the automatic distribution fuse switchers (figure 3, position 9) to "0" position, if not already set so;
- connect battery cables (- pole) to battery fuses (figure 3, position 11) and fix them using a screw;
- connect battery cables (+ pole) to B+ cabinet bus;

- connect consumer cables (- pole) to distribution fuses (figure 3, position 9 and 10) and fix them with a screw;
- connect distribution cables (+ pole) to B+ cabinet bus;
- place meltable fuse insertions into bearings using isolation handle;
- close the upper cabinet cover.

Distribution part is ready for operation.

Note: Perform cable connecting in de-energized state, either by disconnecting the main cabinet switch or removing the insertion of related fuse. When removing the fuse insertion without switching off the main switch, consider the energized elements and strictly observe precautions supplied in section 4

6.6 Rectifier installation and connecting

Rectifiers are installed as following:

- make sure that the rectifier activation switch is in position "0" (downwards);
- place *И1400Т48В в4* rectifier into rack slides and pull it along to the utmost position (notice the moment connectors reach the back panel);
- turn the rectifier on and set the rectifier activation switch to position "1" (upwards).

6.6.1 Module positioning within C1 cabinet

If not requiring the full configuration installed, thus leaving the empty space in the rack, it is recommended to position it in the middle of the rack. In the case of two empty positions required, make it the second and fourth from the left.

7 INSTRUCTION MANUAL

This section introduces handling procedure for C1A system and related assemblies, as concerning users. In addition, system reactions in particular situations are described.

7.1 C1A в4 system handling

C1A system is totally automatic, monitoring own operation and reporting (using visual, sound and remote alarm) noticed system errors. During system operation, *МДП* makes certain system parameters available for user, on user request. User is also enabled to define system operation selecting system parameters.

7.1.1 System handling in regular operation

In regular operation, the system supplies consumers while batteries remain in stand-by mode. Network supply is detected. All system rectifiers are regular, some being in the active state, and others remaining in stand-by mode, depending on system load. Consumer voltage depends on battery type and ambient (battery) temperature. Values are presented in the following table.

Battery type	Mode	Temperature	Number of cells	Battery voltage range	
HI	maintaining	0°C - 35°C	24	56.4V	53V
EG	charging	0°C - 35°C	24	58.8V	55.2V
EG	maintaining	0°C - 35°C	24	56.4V	52V
USER	charging	0°C - 35°C	24	49.2V	55.2V
USER	maintaining	0°C - 35°C	24	52.8V	57.6V

Total system current (towards battery and consumers) is equally distributed along active rectifiers, with difference between rectifier currents not exceeding ±0.2A.

In case of system load decreased, certain active rectifiers disconnect for ten minute period, while others distribute current according to previously described procedure.

In case of increased system load, certain stand-by rectifiers switch on (for ten minute period) and distribute current according to previously described procedure.

On system detecting the decreased battery capacity or considerable (20% of capacity) battery maintaining current during the operation, system switches to battery charging mode. Battery charging shall last until the batteries are fully charged, but not longer than time (in hours) specified in user menu.

In regular operation, *МДП* provides user the access to different system parameters (battery and distribution current and voltage, temperature, network voltage, battery field parameters etc.) and description of alarms detected in system.

Various alarms detected within system are described in details over *LCD* (see description for *МДП*). System reports the alarms visually (light emitting diodes and *LCD*), using sounds (*МДП* buzzer) and by remote closing the relay contacts connected into the system according to user needs. Sound alarm may be deactivated only during the elimination of whatever caused it.

On the alarm reported, user starts the elimination procedure and the system continues its regular operation.

7.1.2 Manual settings of system parameters

Depending on assigned priority, user may define following system parameters: display light, display accuracy correction of temperature and current voltage values; specification of battery capacity, number of battery cells, upper and lower threshold for switching to battery charging mode, allowed battery charging time, minimum battery voltage and voltage control mode, battery type, maintaining and charging voltage for user battery type, current limit for battery charging. User may save these parameters or restore the default ones.

User may introduce the system into forced battery charging mode with corresponding conditions provided, or restore it to stand-by mode, select one of the available languages (English, Serbian, Russian) and set the system time and date.

- Display light is specified from *МДП* menu, selecting the value for *LED* display, within range 1-15.
- Display accuracy correction. User may perform display zero correction for all five measured values to provide display accuracy. All corrections are conducted from *МДП* menu. Unprofessional usage of this option, that is, incorrect voltage/current measuring may endanger regular system operation.
- Battery capacity may be specified within range of 45Ah - 9995Ah. For total battery field, it is required to gather capacities of all batteries parallel connected. Notice that the current limit and battery charging mode thresholds depend on selected capacity.
- Number of battery cells is specified solely in case of system being required to operate with smaller or bigger voltage value, e.g. 60V. Therewith, it is necessary to provide corresponding rectifiers for the expected distribution voltage.
- Setting the lower and upper battery charging mode threshold. Lower threshold may be set to a value within range 1-199Ah, and the upper to value 10-1999Ah. In case of changed battery capacity, thresholds are set automatically to 1/5 of battery capacity.
- Allowed time for battery charging. This is time defined by user for batteries to remain in charging mode, unless conditions were provided for charging mode termination in relation to current criteria. Minimum is 10 minutes while the maximum specified time is 100 hours.

- Minimum battery voltage. User primary selection may be defined relating to voltage specifying mode in *ПНБ* control menu, selecting permanent (fixed), manual or automatic option. Fixed minimum battery voltage is defined with number of cells and is product of number of battery cells multiplied by 1.80. Note that *МДП* is blocked only by *ПЗБ* reacting on 1.83V per cell so the main battery protection for *МДП* in error conditions is realized by *ПЗБ* board. Manual selection of minimum battery voltage may vary in range of 15V-110V, thus enabling operation within different systems. User should calculate voltage per cell value. Automatic setting for minimum battery voltage is realized with *МДП* monitoring the speed of battery discharge and defining minimum voltage according to following table. For more than 20 hours of charging, minimum battery voltage is defined with 1.80V per cell.

up to 1h	2h	3h	4h	5h	6h	7h	8h	9h	10h
1.65	1.66	1.67	1.68	1.68	1.69	1.70	1.71	1.71	1.72
11h	12h	13h	14h	15h	16h	17h	18h	19h	20h
1.73	1.74	1.75	1.75	1.76	1.77	1.77	1.78	1.79	1.79

Table 1: *Minimum discharge voltage per cell dependance with discharge time function*

- User selects one of battery types: HI, EG or USER (user defined type). More detailed description of battery types is supplied in battery charging section.
- Maintaining and charging battery voltage are defined solely for USER batteries and may be specified in range 2.20-2.40V per cell for maintaining voltage and 2.05-2.30V per cell for battery charging voltage. Notice that these voltages are defined for 20°C temperature conditions and when specified by user, their values depend on 20°C temperature value.
- Current limit is also specified solely for USER batteries, in range 0.05-0.50 of battery capacity.

7.1.3 Battery charging

МДП controls battery charging on basis of present optimum battery current and voltage values, relating capacity and room temperature.

HI leak-proof battery type charging

With network voltage during normal operation, batteries are supplied with small current. On error detected within system (e.g. network voltage loss), battery current drops suddenly and changes direction, after which system is battery supplied (discharging current varies in proportion to consumption). In case such state lasts longer, exceeding default battery autonomous duration, undervoltage shall occur.

On network voltage recovery, current "overwhelms" the battery. *МДП* enters battery charging mode, maintaining the current limit $Io = 0{,}3C_{10}$. C_{10} battery capacity provides ten hour autonomous operation. *МДП* commands repeated rectifier charging mode such as current source, *Io* currents, all until battery voltage reaches *Uo* charging voltage value defined with voltage per cell in function with working temperature.

°C	0	1	2	3	4	5	6	7	8	9	10	11
V/cell	2.350	2.345	2.340	2.335	2.330	2.325	2.320	2.315	2.310	2.305	2.300	2,297
°C	12	13	14	15	16	17	18	19	20	21	22	23
V/cell	2.294	2.291	2.288	2.285	2.282	2.279	2.276	2.273	2.270	2.266	2.262	2.258
°C	24	25	26	27	28	29	30	31	32	33	34	35
V/cell	2.254	2.250	2.246	2.242	2.238	2.234	2.230	2.226	2.222	2.218	2.214	2.210

Table 2: *Charging voltage/cell dependance with working temperature function (HI batteries)*

On battery voltage reaching *Uo* value (charging voltage), current value starts descending and shall retain the value corresponding to stand-by mode. Maintaining voltage of HI batteries is equal to charging voltage.

Figure 8 illustrates HI battery charging process. Top graphic shows battery voltage and the bottom one specifies battery current.

t_1 = time of network voltage loss;

t_2 = time of network voltage recovery;

t_3 = time of maximum rectifier power.

System operates regularly until t_1 moment in time.

t_1 - t_2: system is battery supplied; battery current varies in proportion to consumption; battery voltage persistently drops, possibly leading to battery undervoltage occurrence. In this case, system operation is paused until network voltage recovery.

t_2 - t_3: network voltage is restored, rectifiers switch on and current loads the battery. *Io* current limit is reached and *МДП* keeps this current value constant while rectifiers serve as current sources all until battery voltage reaches *Uo* value defined with number of cells and battery storage temperature.

t_3: batteries are still being charged, with voltage approaching constant value equal to *Uo* and descending current value. For leak-proof HI type batteries, this voltage presents maintaining voltage as well, thereby battery current in further operation conforms to charging/maintaining voltage.

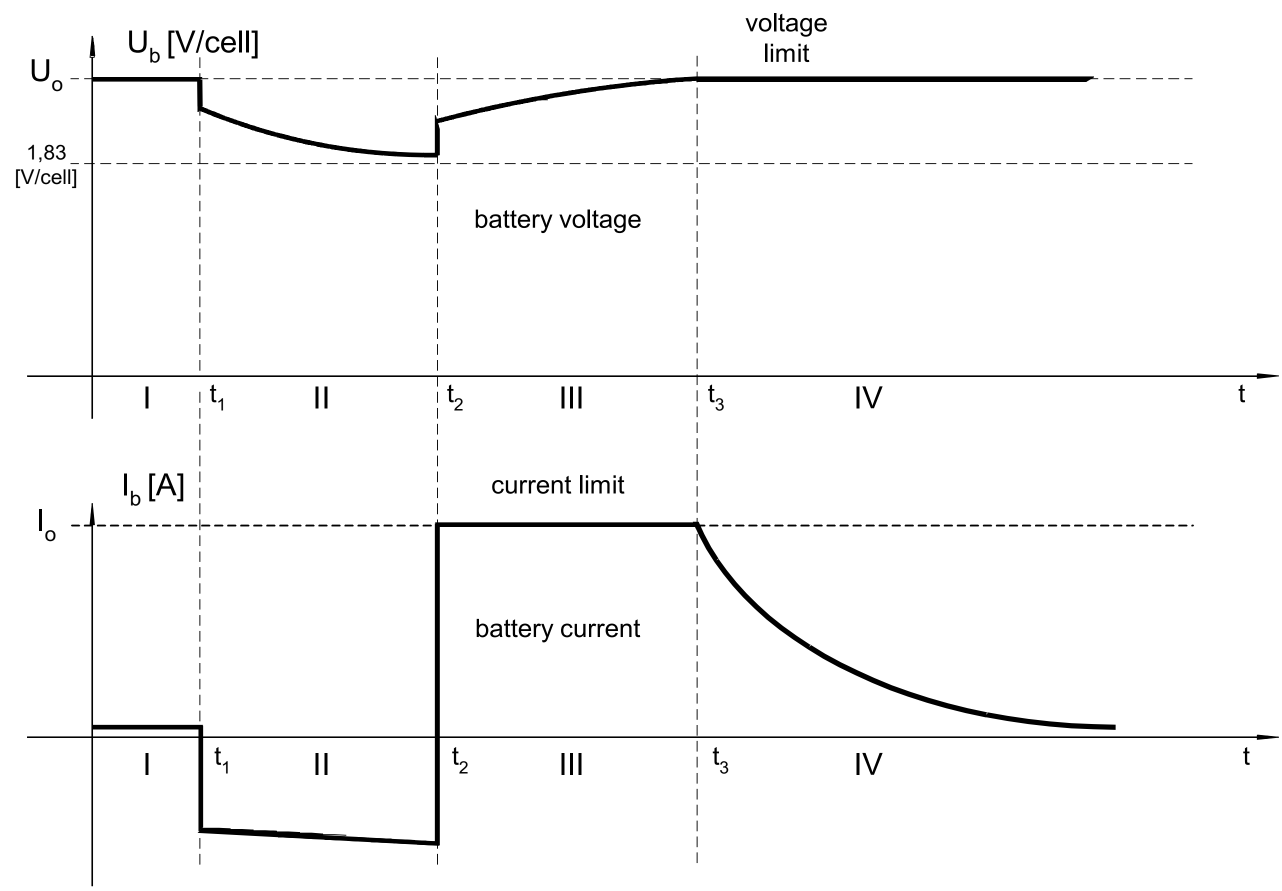


Figure 8: *HI battery charging*

EG battery type charging

EG battery type charging is different than HI battery charging. *EG* battery charging voltage is not equal to maintaining voltage and consequently, system behaves accordingly.

Current limit in charging mode is derived from equation $Io = 0{,}3C_{10}$. Rectifiers act as current sources, *Io*currents, until battery voltage reaches *Uo* charging voltage value defined with voltage per cell in function with working temperature. Charging voltage per cell dependance with temperature is illustrated in table 3.

°C	0	1	2	3	4	5	6	7	8	9	10	11
V/cell	2.450	2.445	2.440	2.435	2.430	2.425	2.420	2.415	2.410	2.405	2.400	2,395
°C	12	13	14	15	16	17	18	19	20	21	22	23
V/cell	2.390	2.385	2.380	2.375	2.370	2.365	2.360	2.355	2.350	2.347	2.344	2.341
°C	24	25	26	27	28	29	30	31	32	33	34	35
V/cell	2.338	2.335	2.332	2.329	2.326	2.323	2.320	2.316	2.312	2.308	2,304	2,300

Table 3: *Charging voltage/cell dependance with battery temperature function (EG batteries)*

On battery voltage reaching *Uo* charging voltage value, current value drops and on reaching lower threshold, 20 mA/Ah of full capacity, *МДП* commands stand-by mode. *Uc*, maintaining voltage, also depends on battery storage temperature. Maintaining voltage per cell dependance with temperature is illustrated in table 4.

°C	0	1	2	3	4	5	6	7	8	9	10	11
V/cell	2.350	2.343	2.336	2.329	2.322	2.315	2.308	2.301	2.294	2.287	2.280	2,275
°C	12	13	14	15	16	17	18	19	20	21	22	23
V/cell	2.270	2.265	2.260	2.255	2.250	2.245	2.240	2.235	2.230	2.227	2.224	2.221
°C	24	25	26	27	28	29	30	31	32	33	34	35
V/cell	2.218	2.215	2.212	2.209	2.206	2.203	2.200	2.194	2.188	2.182	2.176	2.170

Table 4: *Uc/cell dependance with temperature function (EG batteries)*

Charging threshold values primarily depend on battery capacity and their values are expressed in relative mA/Ah amounts.

Figure 9 presents charging process for EG type batteries.

t_1 = time of network voltage loss;

t_2 = time of network voltage recovery;

t_3 = time of rectifier maximum power;

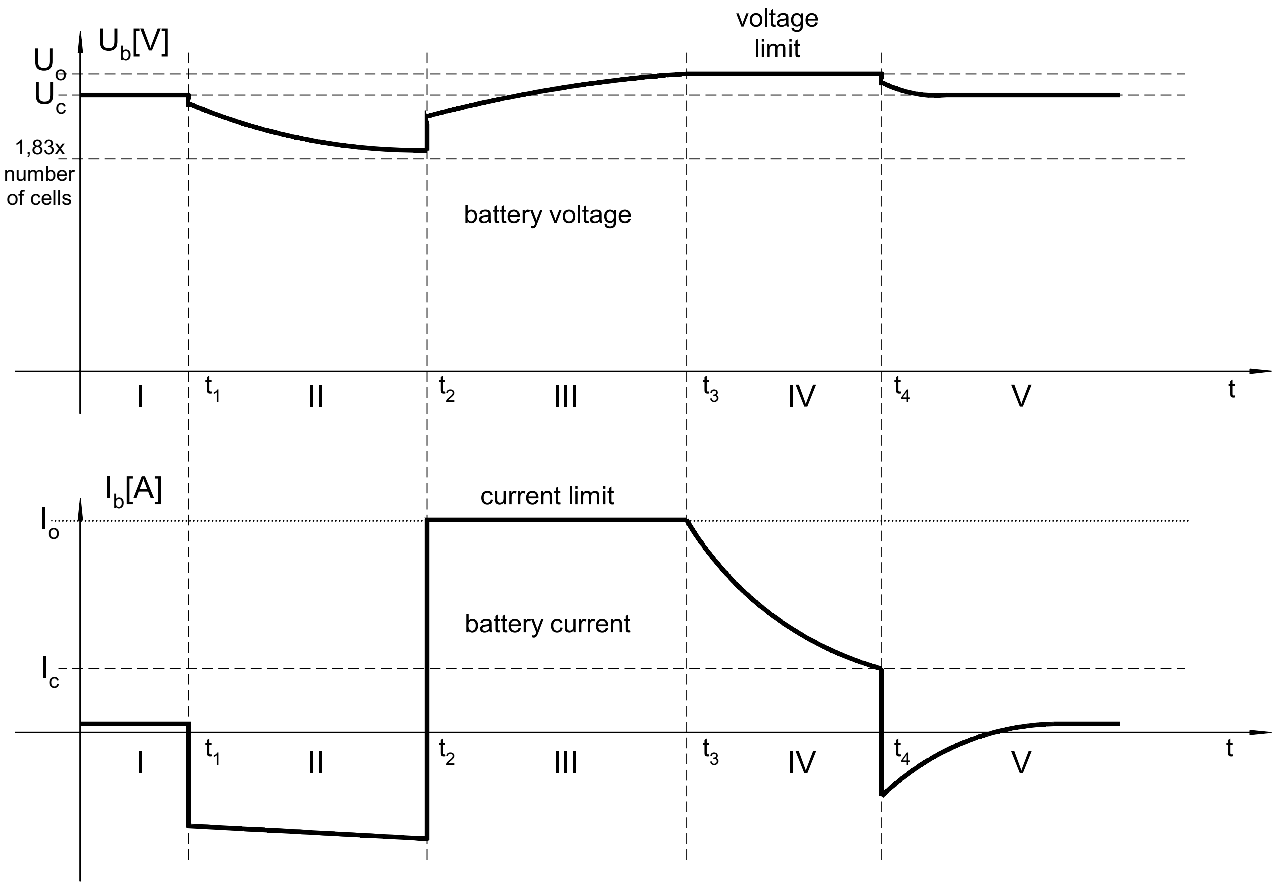


Figure 9: *EG battery charging*

System functions regularly until t_1 moment in time.

t_1 - t_2: system is battery supplied; battery current varies in proportion to consumption; battery voltage value is descending;

t_2 - t_3: network supply is recovered, rectifier switches on and current loads the battery; *Io* current limit is reached and *МДП* keeps this current value constant while rectifiers serve as current sources all until battery voltage reaches *Uo* value;

t_3 - t_4: batteries are still being charged with voltage approaching constant value equal to *Uo* and descending current value; for leak-proof *EG* type batteries, current threshold *Ic* is also defined, below which batteries switch to maintenance mode with maintenance voltage *Uc*.

User defined battery charging

USER battery charging differs from HI or EG battery charging in the way that certain variables are defined by user, such as: charging voltage, maintaining voltage and current limit. Charging is realized similar to EG battery charging only with different parameters specified, temperature dependant. When selecting parameters correspondent to EG batteries, system acts as if containing EG batteries. Also, when selecting parameters correspondent to HI batteries, system considers HI batteries used. Batteries are presented with corresponding graphics.

7.1.4 System handling on network power dump

In case of one or two phase failure (for three-phase network connection), regular phase rectifiers activate and assume load as described above. Network alarm is generated.

In case of network power dump, rectifiers cease the operation and consumers are battery supplied (if possessing any). On network supply recovery, **all** system rectifiers are switched on successively reaching battery voltage and assuming consumer supply, while system enters battery charging mode. 15 minutes later system shall complete current distribution along rectifiers and start deactivation of unloaded rectifiers.

In case battery discharged during network power dump and the undervoltage protection activated (set to 43,2V), all power supply subsystems shall turn off. On network supply recovery (with battery voltage above 41V), rectifiers switch on successively and battery loading is started. Undervoltage protection is activated and consumers are disconnected. Depending on number of rectifiers and battery capacity, this state remains until battery voltage reaches 48V and undervoltage protection deactivates. Consumers are connected to power supply while *МДП* is activated, starting system reinitiation procedure of around 3 minute duration. In this period *МДП* shall receive no requests from user interface. 20 minutes later, system enters the steady state, with current distribution, while battery (and distribution) voltage value persistently increases, with speed corresponding to the battery charging speed.

If battery voltage drops under 40 V during network power dump and no self-starting rectifier is provided, system shall not be able to restart so the batteries should be charged to 41V voltage.

7.1.5 Handling in the alarm event

On system irregularity occurred or detection of a vital system part, the system shall generate the alarm automatically.

User is informed by means of visual, sound or remote alarm (see 3.1.2, МДП C36 description, Detect and inform functions). Alarm cause is presented on *LCD* and seven segment display. Following table shows the alarm indications.

		ALARM DISPLAY			
ALARM CAUSE		*LCD*	*LED*	BUZZER	REM. ALARM
ПБ	- undervoltage protection	+	+	+	+
НД	- distribution voltage, out of range	+	+	+	+
НИ	- irregular rectifier	+	+	+	+
АМ	- network alarm	+	+	+	+
БО	- battery fuse	+	+	+	+
ДО	- distribution fuse	+	+	+	+
ТЕМ	- high temperature	+	+	-	-
ИСЗВ	- deactivated sound alarm	+	+	-	-
УК	- contactor activated	+	-	-	-
РР	- operation mode	+	-	-	-

On the alarm information received user starts repairing of whatever caused the alarm and performs activities according to specified alarm conditions. Meanwhile, sound alarm may be deactivated but after completion of previous activities, it is **necessary** deactivated.

Alarm generating conditions and its recovery are presented in the following table:

ПБ	Undervoltage protection or minimum battery voltage: alarm reported for battery voltage under allowed value (1.83V/cell) possibly implying consumer switching from the battery (on 1.80V/cell, battery may be damaged). Most frequently, these condition is caused by power dump. Depending on activities defined in the internal object instructions, user activates stand-by supply set or allows system "crash" until network supply recovery. If assumed that the alarm appeared for system irregular operation condition, *МДП* and *УМК* should be reset and relating authorized service informed.
НД	Distribution voltage out of range: alarm is reported for distribution voltage out of range 50V - 72V, according to Serbia and Montenegro ПТТ regulations.
НИ	Irregular rectifier: alarm is reported on a rectifier failure and indicated with rectifier light emitting diode and current value. User should replace the irregular rectifier. This signal may also appear in bad network voltage conditions (under 187V or over 253V), having some or all rectifiers failed.
АМ	Network alarm: reported in case of one or several phase failure (indication, network field lamps) or network automatic fuse failure. If there's a missing phase check for error in distribution cabinet (supplying system with network supply); otherwise, wait for network supply recovery. In case of network fuse blow, check rectifier regularity prior to fuse replacement.
БО	Battery fuse: use *LCD* and voltage measuring to detect the burned fuse and replace it.
ДО	Distribution fuse: use *LCD* and test measuring to detect the burned fuse and replace it.
ТЕМ	High temperature: alarm reported for battery ambient temperature out of range 0°C - 35°C. User should obtain ambient working temperature switching the air-condition device on. If temperature probe is disconnected or temporary deactivated, alarm is generated and display shows 20°C. If temperature probe is short circuited, alarm is generated and display shows 19.9°C. User should check and replace the probe, probe cable and terminal.
ИСЗВ	Sound alarm deactivated: alarm is reported on user switching off the sound alarm switch.
УК	Contactor switched on: informing of the undervoltage protection not activated.
РР	Operation mode: informing of the system being in battery charging (stand-by) mode.

If any indicator (*LCD*, *LED*) on *МДП С36* are not operative, reset *МДП* and *УМК*.

Rectifier indication

Each rectifier front side contains three seven segment displays for rectifier current preview and one light emitting diode for rectifier state indication. Display shows following:

Not illuminated	Rectifier switched off, intentionally or resulting from network supply dump.
0A - 0.3A	*УМК* rectifier communication electronics is irregularly supplied. User should replace the rectifier, reset *УМК*, check the connection of wire form with the back panel at the rack back side.
0.5A - 2A	Rectifier operating, rectifier output current presented.
25A - 27A	Rectifier within current limits. Detect system overload cause and cure it.
>27A	Measuring error on display. Replace the rectifier.

Description of light emitting diode indication:

LED	INDICATION
Turned off	Regular operation. Rectifier on A bus under *МДП* control.
Illuminated	Rectifier deactivated, for overheating.
Illuminated for 3s, paused 3s	Rectifier intentionally switched off, small system load.
Blinking once	Network alarm. Rectifier activated 60s after network recovery.
Blinking twice	Rectifier started (after reset), not controlled by *МДП*.
Blinking thrice	No communication between rectifier and *МДП*, either along A bus or B bus.
Blinking four times	Rectifier on B bus.

With combination of the above rectifier indications, user defines its regularity.

7.1.6 Handling in МДП С36 failure conditions

On occurrence of system operation error caused by partial or entire *МДП С36* irregularity, perform *УМК* reset, pulling out and restoring *УМК* supply connectors. After reset, *МДП* starts system initiation with 3 minute maximum duration. If *МДП* still remains irregular, the authorized service should perform replacement of *МДП* and *УМК*. During this replacement, system is not turned off, it operates without *МДП* control, with continuous output voltage and current distribution to rectifiers, depending on their relating characteristics.

7.2 Measuring and diagnostics panel МДП С36 в4 handling

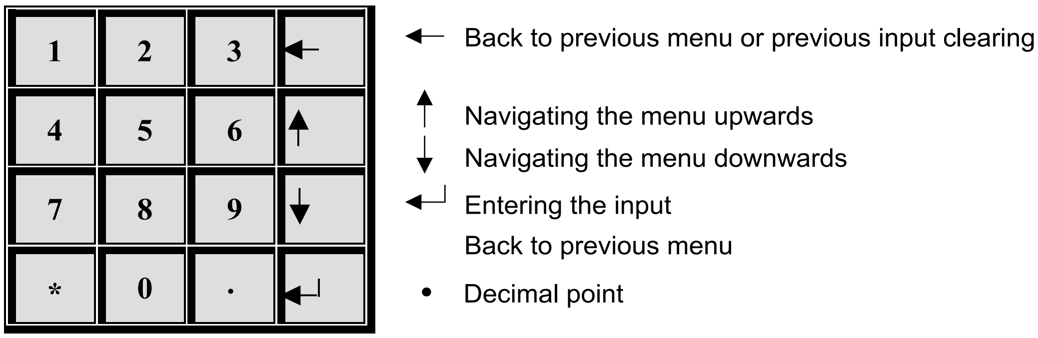
7.2.1 Front panel commands

Front panel contains following parts (figure 10):

- sound alarm switch on/off switch: "0" switch position indicates deactivated sound alarm that won't react in case of system error;
- device display with *LCD* and *LED* sections; *LCD* displays data relating to each system part, while *LED* displays only user most relevant values;
- keyboard for controlling *LED* and *LCD* display and corresponding *МДП* functions.

7.2.2 Keyboard

4 x 4 keyboard with ten digits (0-9) and four menu navigating keys is used. Keyboard with keys' description is illustrated in figure:



All keyboard functions relate to *LCD* display and output contents. To provide required output on *LED* display one should select an option in *МДП* menu, *LED output* submenu on *LCD*. The input of corresponding parameters mainly refers to *МДП* menu and current time and date. Other input contents are factory set, with only informing user of set system parameters or values. Since *LCD* displaying is done using drop-down menus, arrow keys are used to navigate these segments and switch from one to another menu option.

7.2.3 Display

Front side of measuring and diagnostics panel contains two displays, one *LCD* display with 2 x 16 characters and one seven-segment *LED* display with 2 x 4 characters.

LED display is divided into two sections with four D1 and D2 digits each. D1 display is used for description of D2 output value or, if displaying current on D2, D1 is used for voltage value output. Front panel also contains six *LED* indicators signalizing following failure events, in order left to the right:

- irregular rectifier;
- battery voltage below limit or distribution voltage out of range;
- battery or distribution fuse failure;
- network alarm, phase failure or phase voltage out of range;
- temperature out of range or temperature probe disconnected;
- sound alarm deactivated.

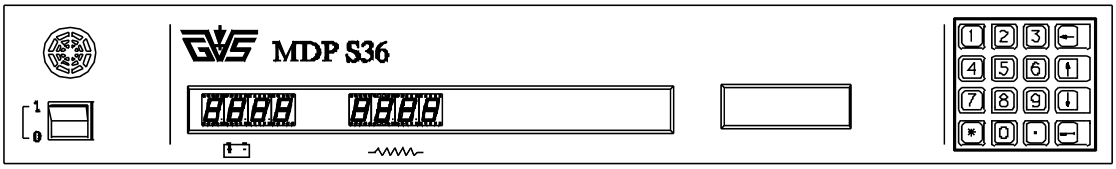


Figure 10: *МДП С36 в4, front view*

7.2.4 LCD display menu options

LCD display menu options are presented in following table:

1. RECTIFIER	**2. SERIAL CONVERTOR**	**3. DISTRIBUTION**
1.1 Present rectifiers	2.1 Present current	3.1 Distribution
1.2 Active rectifiers	2.2 Active serial convertors	3.2 Distribution voltage
		3.3 Fuse condition
		3.4 Shunt current
		3.5 Shunt voltage

4. BATTERY FIELD	**5. МДП**	**6. STATIC SWITCH**
4.1 Battery current	5.1 LED output	6.1 Network Ueff
4.2 Battery voltage	5.2 Display light	6.2 inverter Ueff
4.3 Temperature	5.3 HC11 pair condition	6.3 Consumer Ieff
4.4 Number of cells	5.4 Coupler type	6.4 Power factor
4.5 Battery capacity	5.5 Shunt voltage	6.5 U network frequency
4.6 Battery type	5.6 Shunt current	6. 6 U inverter frequency
4.7 Specified voltage	5.7 Serial convertors	6. 7 Duty
4.8 Specified battery current	5.8 Ub zero correction	6.8 T network testing
4.9 Loading time	5.9 Ub angle correction	6.9 T inverter testing
4.10 Allowed loading time	5.10 Ud zero correction	6.10 Ueff network gauge
4.11 Low current threshold	5.11 Ud angle correction	6.11 Ueff inverter gauge
4.12 High current threshold	5.12 Ib zero correction	6.12 Network gauge
	5.13 Ib angle correction	6.13 U inverter gauge
	5.14 Id zero correction	
	5.15 Id zero correction	
	5.16 Temperature zero correction	
	5.17 Temperature angle correction	
	5.18 Battery capacity	
	5.19 Number of cells	
	5.20 Low current threshold	
	5.21 High current threshold	

	5.22 Allowed loading time	
	5.23 Minimum battery voltage	
	5.24 Battery type	
	5.25 Maintaining voltage	
	5.26 Charging voltage	
	5.27 Current limit	
	5.28 User priority	
	5.29 ПНБ control	
7. SYSTEM	**8. NETWORK FIELD**	**9. STATUS**
7.1 Language	8.1 I phase voltage	9.1 Display test
7.2 Time	8.2 II phase voltage	9.2 Current time
7.3 Date	8.3 III phase voltage	9.3 Control variable
		9.4 Alarm status
		9.5 Static switch
		9.6 Forced loading
		9.7 Parameter saving
		9.8 Restoring factory set parameters

Table 5: *LCD display menu options*

Note: *Since no serial converters are currently used in C1A в4 system, this menu option is reserved for future system versions. "Static switch" option is not used in C1A system either; however, same measuring and diagnostics panel is used in the inverter cabinet so this option is found in the menu, with detail description in the inverter cabinet documentation.*

Submenus are presented in the following table:

LED OUTPUT		LANGUAGE	CONTROL VARIABLE		
Ub Ib	Battery	SERBIAN - LATIN	Uo	Io	Upp
Ud Id	Distribution	ENGLISH	68.1	60	1
Ub	Battery voltage	RUSSIAN			
Ib	Battery current				
Ud	Distribution voltage				
Id	Distribution current				
°C	Battery temperature				
Uo	Specified voltage				
Io	Specified current				

ALARM STATUS					TIME	DATE
УК	ТЕ	ИЗ	НИ	АМ	I: Time	I: Date
БО	ДО	ПБ	НС	РР		
DISTRIBUTION FUSES					**ПНБ CONTROL**	**BATTERY TYPE**
Distribution fuses 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0					ПНБ control fixed (manual, automatic)	HI (EG, USER)

Table 6: *Submenu display options*

- One of nine value may be selected for *LED OUTPUT*. Left of the table contains output type and the calling value's on the right.
- Submenu *LANGUAGE* enables user selection of one of three languages offered. On request, additional language matrix may be delivered.
- *CONTROL VARIABLE* provides monitoring of system module controlling. *Uo* value is for current specified voltage, *Io* value for current limit, and *UPP* is a control variable sent as correction while controlling the system. Its preferable value should be 0.
- *STATUS* indicates failure type or the state or function currently realized in system. Abbreviations on display correspond to certain events: *УК*- contactor activated, *ТЕ*- temperature out of range or temperature probe disconnected, *ИЗ*- sound alarm deactivated, *НИ*- irregular rectifier, *АМ*- network alarm, *БО*- battery fuse blow, *ДО*- distribution

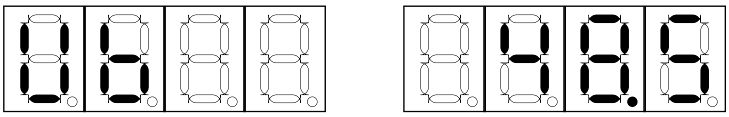
fuse blow, *ПБ*- battery undervoltage, *HC*- irregular serial converter, *PP*- duty function set (only for EG or USER batteries).

- *TIME* is set entering data for hours 0...23, minutes 0..59 and seconds 0...59. These values are separated with decimal point.
- *DATE* is set entering the day 01...31, month 01...12 and year 1000...9999. On *МДП* activation, this value needs to be subsequently entered.
- *DISTRIBUTION FUSES* indicates fuse blow. Sequence number corresponds to fuse position in distribution.
- *ПНБ CONTROL* used for selection of control type (fixed, manual, automatic).
- *BATTERY TYPE* used for selection of battery type (HI, EG or USER).

7.2.5 LED display

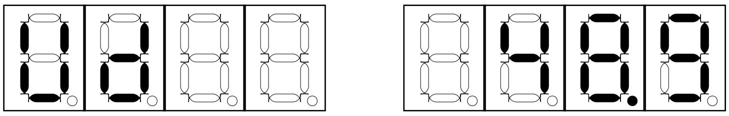
LED display provides representing of battery voltage and current values, distribution voltage and current values, and individually, battery voltage *Ub*, distribution voltage *Ud*, battery current *Ib* or distribution current *Id* value. In addition, current battery temperature °C, specified charging voltage *Uo* or specified current limit during battery charging *Io* may be displayed. To obtain a certain output on *LED* display, one should select corresponding option in *МДП* menu, *LED output* submenu on *LCD*.

A1.Battery voltage display



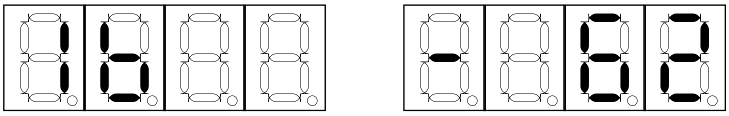
Battery voltage (*Ub*) may value:
48V: 40.5 - 57.0 according to ПТТ standards (35.0 - 75.0 displayed)

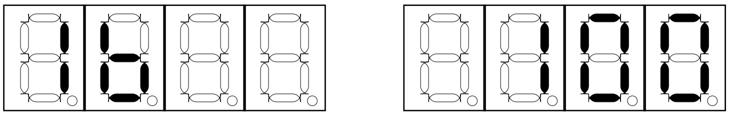
A2.Distribution voltage display



Distribution voltage (*Ud*) may value:
48V: 40.5 - 57.0 following ПТТ standards (35.0 - 75.0 displayed)

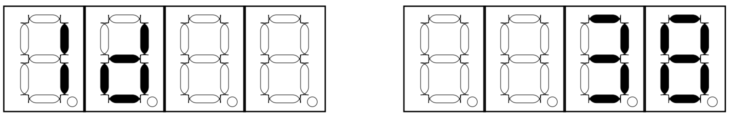
A3.Battery current display





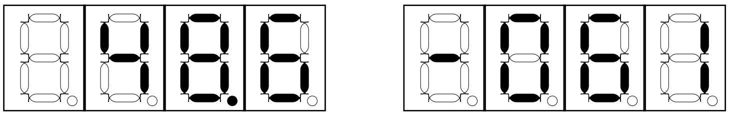
Battery current (*Ib*) may value:
-100A to +100A for *C1* system

A4.Distribution current display

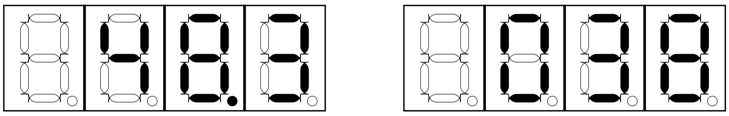


Distribution current (*Id*) may value:
0A to +100A for *C1* system

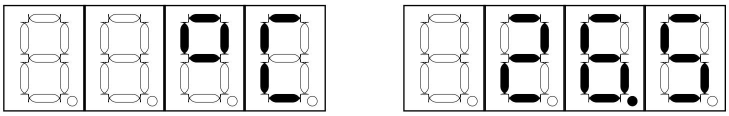
A5. Battery current and voltage display



A6. Distribution current and voltage display

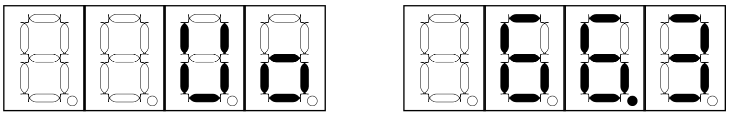


A7. Battery (ambient) temperature



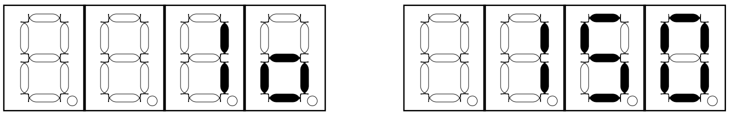
Battery temperature (°C) may value:
−15.0°C - 99.9°C, with disconnected probe value presented is 20.0°C
LED temperature indicator is illuminated

A8. Specified battery charging voltage



Battery charging voltage *Uo* values:
53.1V - 56.4V for *HI* battery type
52.1V - 58.8V for *EG* battery type

A9. Specified current restriction during battery charging



Current restriction values:
12A, for 40Ah batteries, up to 1800A for 6000Ah batteries

7.2.6 МДП С36 в4 settings

All settings are factory performed, in accordance with system characteristics. *GVS* provides factory parameter setting for each system separately, on purchaser request. Provided no special requests were defined by purchaser, parameters are set to standard use values.

7.3 Handling procedure for Д100А в4 distribution and МРП4А10 в4 network field

Network field and distribution device handling includes only switch on and off. Procedures in case of failure shall be also described. These procedures may be performed by personnel trained to operate with energetic equipment based only on the instruction contents. Still, consider the instruction first, before calling the maintenance service, which is to further obey the section "Maintenance instruction".

7.3.1 Switch on/off

Network voltage switch on is realized using network automatic fuses (figure 3, position 2). With all network fuse switchers in position "0" system is switched off; if position is "1", system is switched on and lamps are illuminated indicating network supply presence.

No centralized switch on/off is reserved for *Д100А в4* distribution. With *C3000* system in operation, distribution is energized consequently.

Single switch on/off is enabled for distribution fuses. To switch the consumer off the *C3000* system, use fuse remove handle to remove the fuse link. For consumer switched on via automatic distribution fuse, fuse switcher should be set to position "0". Switch on is performed in reverse order.

7.3.2 Network supply presence control

One control lamp (figure 3, position 3) is dedicated for each phase, to signalize network voltage presence.

On network supply switched on, control lamps are illuminated, indicating the activity of the phase.

On network supply switched off, control lamps are not illuminated.

7.3.3 Input network voltage measuring

Input network voltage measuring is realized on *ММН* module and forwarded to *МДП*, or manually performed with measuring receptacles.

Four measuring receptacles are placed on fuse carrier board (figure 3, position 5). The upper receptacles are connected to phase conductors, L_1, L_2, L_2 (from left to the right).

Lower receptacle is connected to neutral conductor.

To conduct phase voltage measuring, apply the measuring device onto the lower receptacle (figure 3, position 4б) and the one of remaining three (figure 3, position 4a), depending on particular phase voltage measured.

To conduct the interphase voltage measuring, apply the measuring device onto the upper receptacles, depending on particular phase voltage measured.

7.3.4 Direct voltage/current measuring

Battery and distribution direct voltage/current is easily measured.

To conduct battery voltage/current measuring, apply the endings of measuring device onto battery shunt endings (figure 3, position 12). Make sure that the battery is connected to system and the battery fuse link is in its carrier part.

To conduct consumer voltage/current measuring, apply the endings of measuring device onto distribution shunt endings (figure 3, position 13). Make sure the consumer is connected to the system.

7.3.5 Reactions in case of network supply failure

Network field *МРП4A10 в4* is a device with provided long and reliable operation, requiring no interventions.

If network field is not operating (control lamps are not illuminated), check network automatic fuses. If fuses are switched on, check the regularity of relating fuses in the main distribution cabinet supplying the network field. If everything's set correct and system's still not operating well, call maintenance service.

7.3.6 Reactions in case of direct supply failure

Д100A в4 distribution device provides long, reliable operation, with no interventions required.

When БО indicator on measuring and diagnostics panel is illuminated, replace battery fuse link. Replacement procedure is described in section 8.

When ДО indicator on measuring and diagnostic panel is illuminated, replace distribution fuse link or activate the automatic fuse that made a reaction. Replacement procedure is described in section 8.

On irregularity signaling persisting after fuse replacement, call maintenance service.

7.4 Undervoltage protection instruction manual

7.4.1 Handling

Handling includes *ПЗБ2x* card switch turning on and off. Disposition of switches and microswitches on the board is illustrated in figure 11.

SW1 switch enables undervoltage protection circuitry start up. Turning the switch off causes a forced reaction of undervoltage protection, that is, distribution contactor is switched off disconnecting consumer D-line.

Microswitch (U7) provides simulation of another nonexistent contactor (K2S+, K2S-) signaling. For example, for K2 missing contactor, switch ”2” is switched to position ”ON”; for K1 missing contactor, switch ”1” is switched on. Signaling of one or another contactor may be switched, since it might be useful to connect the contactor to J3, and not to J2.

J1 connector is used for connection to *МДП*. J2 and J3 connectors are used for connection to contactors. *C1A* cabinet has only one contactor, connected to one of those two connectors. Microswitch is set to appropriate position. Microswitches ”3” and ”4” are used for factory setting of undervoltage protection activation threshold and no other position is recommended.

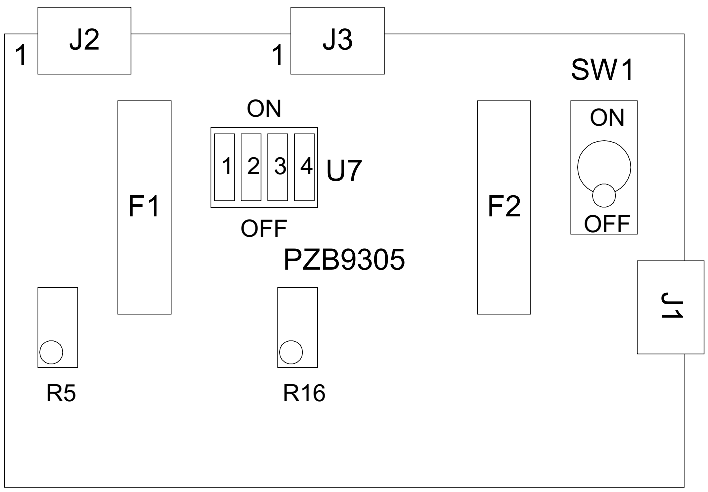


Figure 11: *Component disposition on ПЗБ2x в4 board*

On F1 or F2 fuse blow, replace it with the regular one. Trimmer potentiometers R5 and R16 adjust the undervoltage protection threshold setting and are factory set.

7.4.2 Settings

ПЗБ2x board provides setting facilities for protection activity threshold.

Protection threshold is the input voltage value for contactor disconnection. This value depends on the number of battery cells and amounts to 1.8V per cell. Protection threshold voltage for 24 cells is equal to 43,2 ±0.1V.

According to battery manufacturer specifications, and considering discharge speed, another threshold values may be set.

Threshold is set using trimmers R5 and R16 on *ПЗБ* board within 0.1% tolerances of threshold voltage presented in the table (this is around 50 mV deviation).

Setting is done switching the potentiometer according to following:

U_b battery voltage is measured. Threshold voltage is designated with U_p. Comparator input voltage should amount to:

$$U = (Ub/Up) \cdot 2,5V \tag{1}$$

Following issue is voltage measuring in the comparator input point and setting the measured value switching the potentiometer. If battery voltage or another supply voltage (in case the board is not battery supplied) changed meanwhile, calculated value shall not be valid and the setting shall be irregular.

This kind of setting is nondestructive and may be applied in particular, previously installed supply system, with no interruption of its operation. However, due to ever present non-linearity of used components, this kind of setting, although quite satisfactory, is not the most precise one. The alternative setting may be the one realized using a testing board (see 8.7).

In this case, setting is realized by modifying the input voltage U_b simulating the battery voltage, with provided variable supply source. On U_b voltage reaching the value of protection threshold for the first or second contactor, *LED* diodes illuminate, D_1 or D_2, respectively. Consequently, settings follow the algorithm below:

а) Set U_b to a large value. D_1 and D_2 are turned off. Further setting relates to first contactor threshold. Same procedure is applied for the second one.

б) Decrease U_b voltage value until *LED* diode D_1 is illuminated.

в) If *LED* illuminates at required threshold voltage value, setting is complete. Otherwise, turn potentiometer in corresponding direction to change the threshold value accordingly.

г) Increase battery voltage until D_1 is turned off.

д) Proceed with item б), to the end of procedure.

This setting principle is much better than the first one, since preciseness depends only on preciseness of instrument performing measuring, plus, for the first case, non-linearity caused error included. GVS recommends the second described setting principle, with appropriate conditions provided.

Each potentiometer has independently adjusted related contactor threshold. This enables the facility of earlier or later (priority) disconnection of power supply for different consumers, with appropriate installations provided.

Also, both contactors may be set to simultaneous disconnection, with parallel fat commands.

8 TESTING INSTRUCTION

8.1 System testing instruction

Switching supply system *C1A* provides factory, acceptance and user system testing. On user level, system monitoring and basic function tests are provided. More detailed tests on acceptance level (requiring consumer disconnection) should be performed in cooperation with manufacturer and only with certain system features being under suspicion.

During user system testing, system should complete following basic functions:

1. Rectifiers are started on public distribution network and rectifier activation.
2. Distribution voltage is stable in load change conditions and corresponds to suggested voltage.
3. System load is equally distributed along rectifier modules.
4. *МДП* receives commands, performs measuring and displays system parameters and alarms.

8.2 Functionality testing procedure

Switch the network supply on using cam switch on tested system.

Set *МДП* to distribution voltage/current measuring mode. Switch all rectifiers on and specify nominal load. Wait until system distributes rectifier current values evenly.

1. Modify load in steps, from current to Inom. Distribution voltage measured on *МДП* is not changed for more than ±0.6V in relation to nominal voltage (real load voltage) and corresponds to specified voltage values.
2. Switch the network voltage off for couple of minutes, in case system is connected to battery field. Consumer is battery supplied, *МДП* measures distribution voltage and current. On network voltage activation (after couple of seconds) all rectifiers are started and *МДП* measures battery charging current. Verify start up switching all rectifiers off, and than switching them on, one by one or pulling them out and back, one by one. Tests should be done for real load.
3. For real load, (wait for 10 min), rectifier currents should equalize to ±0.4A.
4. Make sure that *МДП* receives commands via keyboard, measures and displays battery and distribution voltage/current and that the alarm is reported on switching the rectifier and public distribution network (cam switch) off.

System completed requirements after all above tests passed.

8.3 МДП С36 в4 testing instruction

Do not open *МДП* during its testing.

8.3.1 Testing equipment installation

Depending on tested function following should be provided:

- To check distribution current, connect voltmeter (mV) to distribution shunt. Depending on shunt and *МДП* settings, measured millivolt shunt value corresponds to distribution current in amperes (100 mV shunt), that is, 10 A per millivolt (30 and 60 mV shunt).
- To check battery current, connect voltmeter (mV) to battery shunt. Depending on shunt and *МДП* settings, measured millivolt shunt value corresponds to battery current in amperes (100 mV shunt), that is, 1 A/mV.
- To check communication between *МДП* and rectifiers, connect minimum two rectifiers. Rectifier currents equalized after some time indicate regular communication between *МДП* and rectifier.
- To check battery temperature, connect temperature probe to serial cabinet terminals. After 3-5 minutes, use thermometer to measure battery temperature value in the spot close to temperature probe.
- All other checks are realized via keyboard and display.

8.3.2 Testing procedure

For prior-to-testing preparations, reset *МДП* using switch at the back side. Wait for 3-5 minutes until all modules are initiated. Meanwhile, *LED* displays 00.0 value for *Ub* voltage.

Provided *МДП* device is regular, following shall occur during the activation: *LED* displays battery voltage values while *LCD* displays ”menu, rectifier”. Compare distribution and battery current values with values measured in cabinet measuring points. These value should correspond to each other with 1% of deviation. Compare distribution and battery voltage values with values measured in cabinet measuring points. Allowed deviation is also 1%. Allowed deviation for thermometer measured value is 1 to 2 °C.

To confirm distribution fuse blow, measure the voltage value on fuse endings. In case of a fuse blow, voltage amounts from 20 to 70V and *МДП* registers of it using *LED* indicators, that is, *LCD* display. In case opposite, voltage value is expressed in millivolts. **Do not perform ohm check for fuse blow, voltage check solely**.

In case of battery fuse blow, no failure is detected until fuse voltage reaches 0.7 - 0.9V. Measuring the voltage on fuse endings, it is checked whether *МДП* has properly registered this failure.

To test remote alarm operation, perform an indirect check, provoke any system failure (e.g., switching the rectifier off, *НИ* signal - irregular rectifier - is generated). Use the instrument to detect possible short circuit on remote alarm output terminals (cabinet serial terminals).

In all cases of *МДП* registering something that never really happened inside system, such as considerable measuring error or detection of nonexisting system element failure, or undetected existing system failure, follow the instructions for the case of failure.

Note:

Disposition of connector pins and serial terminals is illustrated in the supplement. Certain pins are reserved for certain purposes and should not be used for any other than that, for it might cause МДП operation irregularities.

8.4 Testing instructions for Д100А в4 distribution

Д100А в4 distribution functional tests are performed to the assembly functionally connected to other configuration assemblies.

8.4.1 Testing in deenergized state

- visually check connection of elements, junctions and links;
- use ohmmeter on switched off device to check characteristic conductive connections linking subassemblies into a functional whole; meltable insertions of battery and distribution fuses should be extracted from its bearings:

  - D^- to mass - no connection
  - B^- to mass - no connection
  - B^- to common shunt point - no connection
  - B^- to mass - short circuit
  - shunts to D^- - no connection, close contactor contacts - short circuit.

8.4.2 Testing in duty mode

Functionality test for *Д100А* distribution assembly is reduced to *ПЗБ2х* subassembly operation test in real operating conditions. Battery undervoltage protection testing shall be described in a separate instruction.

Fuse voltage drop should not exceed 100mV.

8.5 Testing instruction for МРП4А10 в4 network field

Functionality tests for *МРП4А10* network field is realized to the assembly functionally connected to other configuration assemblies.

8.5.1 Testing in deenergized state

- switch off the man distribution cabinet switch, setting the handle into position ”0”;
- check connection of elements, junctions and links;
- use ohmmeter to check characteristic conductive connections linking subassemblies into a functional whole:

- apply black test lead to a lower contact of the first network automatic fuse (phase L_1); apply red test lead to the first and than fourth terminal (from left to the right) on the first serial terminal JP1; proper junction shall be confirmed by appropriate tone;
- apply black test lead to a lower contact of central automatic network fuse (phase L_2); apply red test lead to second terminal of serial terminal JP1;
- apply black test lead to a lower contact of the third network automatic fuse (phase L_3); apply red test lead to third terminal of serial terminal JP1.

8.5.2 Testing in energized state

Perform voltage measuring applying the black test lead into lower receptacle P41 and red test lead into one of remaining three receptacles P11, P21, P31. With 220V measured voltage, power supply is regular.

8.6 Undervoltage protection testing instruction

ПЗБ2х board testing is performed prior to installation, after transporting, in case of system modifications and regular control events, when possible.

8.6.1 Measuring equipment connecting

Connect testing board with *ПЗБ2х в4* board according to figure 12.

8.6.2 Testing procedure

After connecting performed in accordance with figure 12, switch off SW1- SW5 switches and DIP switches on *ПЗБ9305 в4* board (SW1-SW3 switch to position ”0”, SW4 to position ”1” (1.8 V/cell) and SW5 into position ”1” (в4).

Set input voltage to 50V value for 48V systems, or, 65V value for 60V systems. LED diodes D1 and D2 should be illuminated and others turned off.

УК (contactor switched on) signaling check:

Switch on DIP no 1 (to position ”1”). If D5 diode illuminates (УК), there is a short circuit. Restore DIP1 to position ”0”. Repeat same procedure for DIP2.

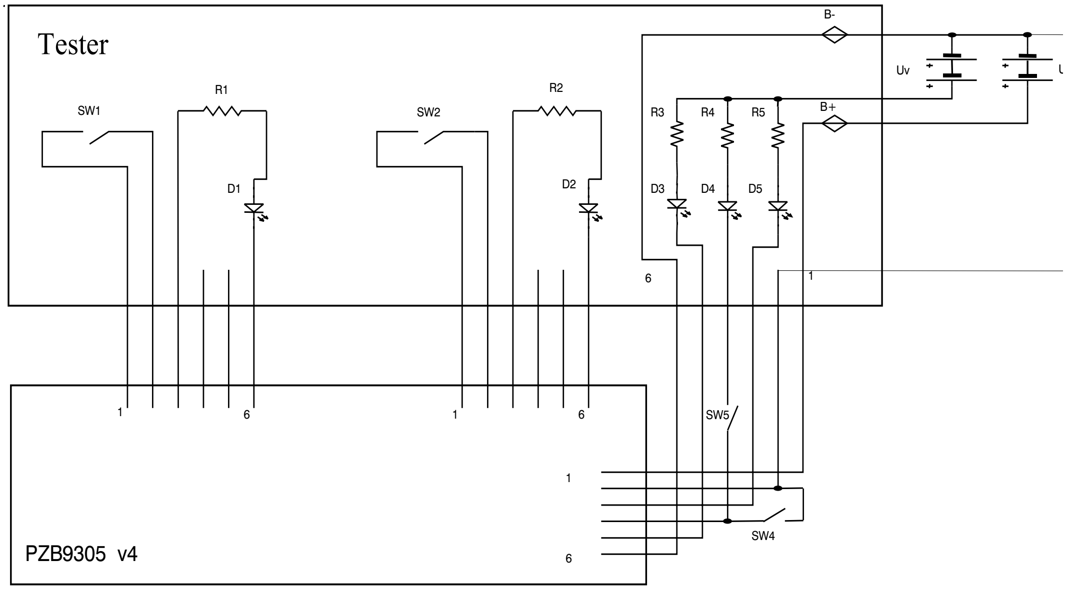


Figure 12: *Scheme for connection of ПЗБ2х в4 testing equipment*

Switch on pair of switches DIP1 and DIP2. LED diode D5 should illuminate (УК).

In the previous three items, SW1-SW2 switches on testing board were switched off. It remains to check whether УК illuminates for following combinations: SW1 and DIP2, SW2 and DIP1, others switched off.

Additional check of protection activation lower threshold:

Bring signal ИК=0 into position "ON" (1.65 V/cell) switching SW4.

Make sure that undervoltage protection activation threshold amounts to 1.65 V/cell and deactivation threshold to 1.9 V/cell.

Switch SW4 into position "OFF".

8.7 Necessary testing equipment

System C1A в4

- multimeter Fluke 75, universal digital measuring instrument (voltmeter measuring direct voltage up to 100V, 1% precision for 5V value);
- ammeter, AC 50A or current probe;
- thermometer (−20°C - 100°C);
- thermal load, continuous 0 - 100A/60V.

МДП С36 в4

- universal digital measuring instrument (voltmeter measuring direct voltage up to 100V, with 1% precision for 5V);
- nominal output voltage 48V rectifier *И1400Т48В в4* with 1% stability or battery with identical characteristics;
- branch feeder set.

МРП4А10 в4 network field and Д100А в4 distribution

- universal digital measuring instrument;
- screwdriver.

ПЗБ2х в4 undervoltage protection board

- testing board, according to scheme in figure 12;
- direct source of variable output voltage 30-80V, 100mA;
- direct source for 5V supply, 100mA;
- universal instrument or voltmeter;
- screwdriver for trimmer setting.

9 MAINTENANCE INSTRUCTION

C1A в4 system and related assemblies do not require special maintenance procedures. Once installed, system and its assemblies function automatically. This section introduces regular maintenance procedures and reactions in case of failure. All activities in relation to maintenance are performed by personnel trained to operate with supply equipment.

9.1 Maintenance and procedures in case of system failure

With *C1A в4* system operation reliability, only maintenance procedures required are periodical surveillance and elimination of system irregularities reported by the alarms.

System failure results in consumer power dump. Individual assembly failure or fuse blow are not considered system failure.

In case of system failure location failure cause. It may be:

- out of system (network supply dump, battery irregularity, high ambient temperature, power installations disconnection etc.); had an external factor caused the failure, wait until it's being recovered, make sure no damage was brought to the system, and than perform start up according to system installation procedure;
- within system - an assembly failure.

System failure is most frequently caused by undervoltage protection failure. Following activities are required:

- make sure the undervoltage protection switch on *ПЗБ2х* board is in position "on";
- check distribution contactor regularity (visually) and coil regularity (ohm check, by disconnection of coil supply);
- check *ПЗБ2х* board regularity:

  if irregular, disconnect all distribution fuses (during *ПЗБ2х* replacement), block the contactor in working position, start the system, connect battery and distribution fuses, respectively. **System now operates without undervoltage protection and requires continuous personnel surveillance, until failure elimination**.
- check regularity of power system installation, distribution, shunts, fuses and rails and replace it when necessary, taking special precautionaries (switching off the network, rectifiers, disconnecting batteries).
- check contacts on power system installations, distribution, shunts, rails and fuses and fix it if necessary, taking special precautionaries (switching off the network, rectifiers, disconnecting batteries).

Failure of single assemblies, *МДП*, netowrk field, rectifiers, control logics and similar results in system performances' degrading, without system operation failure.

In case of an assembly failure, repair the assembly or replace the module. Meanwhile, **system requires continuous personnel surveillance.**

9.2 Maintenance and reactions in case of МДП C36 в4 failure

Measuring and diagnostics panel *МДП C36 в4* requires no regular maintenance. After installation, *МДП C36 в4* automatically functions in all regular conditions. *МДП* maintenance implies regular operation maintenance and procedures in irregularity conditions.

All procedures are performed by trained personnel.

9.2.1 Maintenance in regular МДП operation

Before testing the *МДП* operation regularity, make sure that:

- batteries are fully charged;
- proper values of battery and distribution fuses are set;
- appropriate network voltage is conducted;
- all external parameters values are within allowed range.

Also:

а) Make sure that *МДП* displays are functioning correctly and *МДП* receives commands from keyboard.

б) Check whether *МДП* measuring results are correct. System parameters should be measured using universal measuring instrument of 1% precision. Values are compared with values shown on *МДП* displays. Measuring results' check considers: (1) battery voltage, (2) battery current, (3) distribution voltage, (4) distribution current, (5) battery ambient temperature.

If there are certain measured values of system parameters that do not correspond to displayed values with 1% precision, try to eliminate the error checking the apporpirate contacts on measuring shunts. If *МДП* operates irregularly, switch to maintenance mode for *МДП* irregular operation conditions.

в) On false alarm occured within system, switch off the sound alarm setting the switch to upper position and check connections between *МДМ* board and fuses, shunts, back panel etc. Also check all connector contacts. If connections from *МДМ* toward other system elements are correct, device should be sent for servicing.

г) If there is no sound alarm after switching *МДП* on (position ”1”) system is functions regularly. On the occurence of alarm indicator, (sound alarm not deactivated), without a sound alarm reported, check connection between buzzer and *МДМ*(2 pin connector).

д) Reported alarm indicates system irregularity and provides information of particular irregular conditions.

On failure indication, check *LCD* display status, (menu, alarm).
Following alarms and failures may occur:

1. *BATTERY UNDERVOLTAGE (ПБ)*

   On battery voltage drop below undervoltage alarm threshold, an alarm is reported warning about possible activation of *ПЗБ* protection on 1.8V/per cell (54V) voltage and automatic consumer disconnection. It is neccesary to establish network voltage (if possible), bring consumption to minimum or supstitute supply source (e.g. switching the aggregate unit on).

2. *IRREGULAR DISTRIBUTION VOLTAGE (НД)*

   Distribution voltage out of range. Possible causes:

   а) Battery voltage (charging mode in accordance with manufacturer notes, current battery storage temperature) is out of range defined by corresponding regulations. Provide appropriate air conditioning.

   б) Frequent network failures or persistent limiting operating conditions of system rectifiers. Temporary jump of distribution voltage might occur.

3. *IRREGULAR RECTIFIER (НИ)*

   а) Make sure all rectifiers are switched on.

   б) Check rectifier connections by pulling out the module and restoring it back to cabinet rack.

   в) If there is a rectifier technically irregular for a considerable period of time, replace corresponding module.

   г) Certain rectifier may be switched off for temperature protection. If such protection type is repeated for one module, replace the module.

   д) Rectifier failure. Replace the module.

4. *BATTERY FUSE (БО)*

   (a) On fuse blow detected, voltage on fuse endings exceeds 1V. Maximum voltage value in operating conditions is 200mV. Replace the fuse.

5. *DISTRIBUTION FUSE (ДО)*

   (a) Do not perform ohm check for distribution fuses, voltage check solely. Regular fuse voltage value is under 200mV, irregular fuse voltage exceeds 20V. Replace the fuse.

6. *IRREGULAR NETWORK VOLTAGE (AM)*

   а) There is a possibility of a network fuse blow within distribution cabinet, with one of three modules out of function or, on two phase failure, one of three modules in function. Besides, one of a network field fuses (rectifier fuse) may blow as well. Replace the fuse. Consult *C3000* system distribution manual.

   б) Network voltage level is out of range defined for safe system operation (187-253V), for any phase. (AM) signal is reported.

7. *TEMPERATURE OUT OF RANGE (TE)*

   а) Displayed value is 20.0°C or 19.9°C, indication exists of something being wrong with the probe or its being disconnected. Switch to maintenance irregular operation mode.

   б) For temperature being out of range, 0.0°C до 35.0°C, provide battery air conditoning.

8. Temporary failure of several modules or a group of modules.

   (a) See item 6.

9.2.2 МДП irregular operation procedure

All procedures for failure elimination should correspond to those described in user documentation for a specified device. Numbers in brackets present numbers of relating procedures listed in text entitled ”Reactions in case of failure”.

1. *МДП* is not operating, no display or *LED* diode is illuminated.

   (a) (3), (2), (6)

2. *LED* or *LCD* display is not functioning or keyboard is not receiving no commands.

   (a) (3), (2), (6)

3. *LED* or *LCD* display incorrect.

   (a) (3), (2), (6)

4. One or more modules operate(s) irregularly.

а) (9)

б) *LED* display of certain modules 0.1V - 0.2V outputs (8), (2), (5).

в) Consult documentation for corresponding module and follow its instructions.

5. Signalling is incorrect or alarm is reported.

   (a) Following failures might have occured: 6, 7, 8, 9, 10, 11, 12 (one or several of them). Also, there is no expected signalling. See other items.

6. *BATTERY UNDERVOLTAGE (ПБ)*

   а) Check (measuring instrument) confirms the irregular signal (2).

   б) State unmodified (6).

7. *IRREGULAR DISTRIBUTION VOLTAGE (НД)*

   (a) *Act as for the case of battery undervoltage.*

8. *IRREGULAR RECTIFIER (НИ)*

   а) (8).

   б) If generated together with AM see signalling 12, otherwise (2).

   в) Consult rectifier documentation and act accordingly; if alarm is still reported, (6).

9. *IRREGULAR SERIAL CONVERTER (НСК)*

   (a) Act as for the case of irrregular rectifier.

10. *BATTERY FUSE (БО)*

    а) If system fuse is regular, check wire form contacts on the fuses and J1 *МДМ* connector.

    б) State unmodified (6).

11. *DISTRIBUTION FUSE (ДО)*

    (a) Act as for the battery fuses.

12. *IRREGULAR NETWORK VOLTAGE (АМ)*

    а) With irregular rectifier signal coming along with this one, (5).

    б) State with no changes or no generation of signal (2), (6).

в) Replace irregular network fuse, if found any, otherwise make sure that network voltage is in the allowed range 187-253V for each phase, or eventually, consult rectifier user documentation.

13. *TEMPERATURE OUT OF RANGE (TE)*

    (a) Displayed temperature value differs from real temeperature value

    - Displayed value is 20.0°C, indication of something being wrong with the probe or its being disconnected (4).
    - No changes to the state, (6)
    - Displayed value is 19.9°C, probe is short-circuited. Try to eliminate the failure at the probe itself or remove the probe when switching the system to automatic maintenance with 20.0°C temperature.
    - No changes to the state (6).
    - Displayed value deviation from the real one more than 5.0°C (6).

14. Wrong output or irregular voltage measuring

    а) Check distribution contacts on B+ and B- rails.

    б) All contacts regular (2), (6).

15. Wrong output or current measuring

    а) Check contacts on measuring shunts

    б) All contacts regular (2), (6).

16. Wrong output or temperature measuring

    а) Check contacts on measuring probe serial terminals

    б) All contacts regular (2),(6).

17. Certain failure or regular state is not registered.

    (a) (2), (6)

18. Remote alarm is not registered

    а) With all conditions provided for remote alarm, perform ohm check on distribution remote alarm terminals.

    б) Relay is not short-circuited (2), (6).

19. Other failures

    (a) (1)...(9).

9.2.3 Procedures related to failure

1 - make sure that *МДП* back switch is in position *ON* (variants *C2* and *C3*).

2 - reset *МДП* by disconnecting and reconnecting the three pin connector on *УМК*.

3 - check connectors J1 and J2 on *МДМ* and J1 and J2 on both *УМК* devices.

4 - check connection of serial terminals for temperature probe.

5 - replace irregular module(s).

6 - *МДП* is sent for manufacturer servicing in case previous checks were realized, and it is still not operating.

7 - check connectors on *ПЗБ* board.

8 - check back panel bus connectors.

9 - check module connection.

9.3 Maintenance and procedures in relation to Д100А в4 distribution failure

Distribution maintenance includes periodical visual check of distribution, signalling wire form, shunts, contactors, fuse bearings and junctions in power circuits.

Possible failure types are:

а) **Battery supply dump**

Red *LED* indicators, FUSE BLOW and ALARM, are illuminated on measuring and diagnostics panel. Measuring the voltage, detect the burned fuse. After replacing the fuse with a regular one, *LED* indicator for fuse blow and alarm are turned off.

б) **Consumer voltage dump** Red *LED* indicators, FUSE BLOW and ALARM, are illuminated on measuring and diagnostics panel. Measuring the voltage on distribution fuses, detect the burned fuse. After replacing the fuse with a regular one, *LED* indicator for fuse blow and alarm are turned off.

в) **Distribution part irregularity**

In case of irregular signalling wire form, shunts, contactors or fuse bearing irregularity, replace it with a regular part. Existing part is demounted and replaced with a regular one. **Do not perform replacement procedure in the energized state** (if not necessary). **Also apply special precautionary measures** to avoid unwanted connections and exchange failure.

9.4 Maintenance and procedure in relation to МРП4А10 в4 network field failure

Network field maintenance includes periodical visual check of wire form, fuse bearings, switch and junctions in power circuits.

Two failure types might occur in *МРП4А10* network field: complete rectifier power dump and partial rectifier power dump.

a) **Network power dump detection**

   On network power dump, control lamps are turned off (figure 1, position 3). AM indicators on measuring and diagnostics panel are illuminated. Make sure that the automatic network fuse switch is in position "1" and network supply is connected to network field correctly. Than proceed with item b).

b) **Network power dump**

   Measure voltage values using universal measuring instrument, via measuring receptacles (figure 1, position 4). If no network voltage is detected, check fuse regularity and switch position in main distribution cabinet supplying MRP4A10 network field. Having all of these devices regular, follow the item c).

c) **Irregular network automatic fuse**

   Network automatic fuse is irregular. Remove it and instal a regular one. De-energized state only.

- release phase conductor used to connect the fuse to connecting terminal (figure 1, position 1);
- release fuse carrier board (figure 1, position 5) loosing the screw;
- lift fuse carrier board and remove the irregular fuse

Installation of a new regular fuse is performed in reverse direction.

9.5 Maintenance and procedures in relation to ПЗБ2х в4 failure

Undervoltage battery protection *ПЗБ2x* requires no regular maintenance. After installation, *ПЗБ2x* functions automatically in all regular conditions. *ПЗБ2x* maintenance is reduced to maintaining procedures in case of failure or threshold synchronization procedures required after certain system changes or eventual ПЗБ setting difficulties.

9.5.1 ПЗБ2x в4 check and detect procedures

In failure conditions, *ПЗБ2x* takes following steps:

a) **Failure detection**

Two failure types are possible:

- *ПЗБ2x* maintains contactors switched on, battery voltage below protection threshold;

- contactors switched off, voltage within allowed range.

First case is less probable since the lowest voltage value having contactors still switched on is the one within protection threshold level, so the contactor shall "loose" although *ПЗБ2x* has failed.

In all other cases, failure is detected only after considerable battery discharge.

Second type of failure is more obvious since consumers are left with no supply, although battery voltage is within allowed range, which is easily detected measuring the battery voltage.

b) **Irregular ПЗБ2x board detection**

In a system with several *ПЗБ2x* boards, each board is connected to two contactors. Consequently, the irregular board is easily detected according to irregular contactor activity the board is connected to.

c) **Indication check**

ПЗБ2x state indication is performed over *LCD* on *МДП*.

If receiving the incorrect indication, check *ПЗБ* board microswitch state. Repositioning the switch during contactors being switched on has no effect since contactors are switched over (make sure not to leave them in a wrong position, causing irregular indication). Set microswitches to regular position, according to instruction manual.

Having set the microswitches correctly, check connections from contactor to *ПЗБ* board; there might be an interruption or short circuit on wires and contacts.

d) **Procedures on undervoltage protection inactivity**

- Check protection threshold value. If not properly set, in accordance with instruction manual, do so.

- Measure gate voltage for corresponding FET. Voltage value should not exceed 0.2V. For all values exceeding this limit, board shall be irregular, requiring replacement. If remaining under 0.2V, FET might be irregular or contactor connection touching B-.

- Separate connector using active contactor. If contactor is still active, replace connector and check connections in distribution signalling wire form. Should contactor switch off, replace the board and let serviced.

e) **Procedures on contactor inactivity**

- Check protection threshold. If it's considerably high, reset it. If necessary, proceed with following option.

- Ohm check the contactor receptacle and its diode regularity. Disconnect contactor off *ПЗБ2x* board and perform checks.

- Check connector contacts on *ПЗБ2x* board.

- Make sure there is no interruption on *ПЗБ* board - contactor connection.

- On fuse activity detected on *ПЗБ* board, disconnect connector from relating contactor on *ПЗБ* board, replace the fuse and check FET and gate voltage on FET (over 1.5V). Had no failure been detected in previous procedures, replace the board.

Note: *During all measuring and/or intervention processes on ПЗБ board IT IS NECESSARY TO BLOCK SWITCHING CONTACTS IN THE OPERATING POSITION, to avoid unexpected power dump and consumer operation suspension (exchange failure).*

9.5.2 ПЗБ2x board replacement

ПЗБ board replacement is a very simple procedure, realized in several steps:

a) Block contactors controlled by the board.

b) Remove connectors from the board.

c) Loosen the screws on the board and remove the board.

d) Install a new board following the procedure described in section 6.

9.6 Necessary equipment

Equipment required for МДП C36 в4 maintenance

- universal measuring instrument for voltage check up to 100V and ohm contact values;
- screwdrivers.

Equipment required for Д100А в4 distribution and МРП4А10 в4 network field maintenance

- screwdrivers;
- spare fuse kit;
- fuse remove handle;

- spare control lamps;
- universal digital measuring instrument.

Equipment required for ПЗБ2х в4 board maintenance

- spare fuse kit;
- thin, flat screwdriver for potentiometer setting;
- spare *ПЗБ2х в4* board.

Equipment required for ММН в4 board maintenance

- flat screwdriver;
- spare *ММН в4* board.

10 ABBREVIATIONS

CYRILLIC ABBREVIATIONS

АЛМД	remote alarm
АМ	network alarm
БО	battery fuse
ДО	distribution fuse
ИК	contactor switched off
ИСЗВ	sound alarm switched off
МДП	measuring and diagnostics panel
МДМ	measuring and diagnostics module
ММН	network voltage measuring
МРП	network field
НД	distribution voltage
НИ	irregular rectifier
НСК (НС)	irregular serial converter
ПБ	battery undervoltage
ПЗБ	undervoltage battery protection
ПНС	undervoltage signal
РР	duty
ТЕ (ТЕМ)	temperature out of range
ЗЈПТТ	Yugoslav post, telephone and telegraph community
УМК	small universal converter
УК	contactor switched on

LATIN ABBREVIATIONS

AC	alternating current
DC	direct current
LCD	liquid crystal display
LED	light-emitting diode
FAS	frame alignment signal
FET	field effect transistor
RS485	recommended standard 485

11 SUPPLEMENT LIST

11.1 MATERIAL SPECIFICATION

1. Material specification for *МРП4А10 в4* network field
2. Material specification for *Д100А в4* distribution

11.2 CONNECTOR PIN POSITIONING

1. *МДП С36 в4* connector pin positioning
2. *ПЗБ2х в4* board connector pin positioning
3. *УМК0102* board connector pin positioning
4. Back panel connector pin positioning

11.3 ELECTRICAL SCHEMES

1. *МРП4А10 в4* network field wiring scheme
2. *Д100А в4* signalling distribution scheme
3. Electrical scheme of network and distribution lines in *C1A* cabinet
4. Back panel electrical scheme
5. Back panel installation scheme