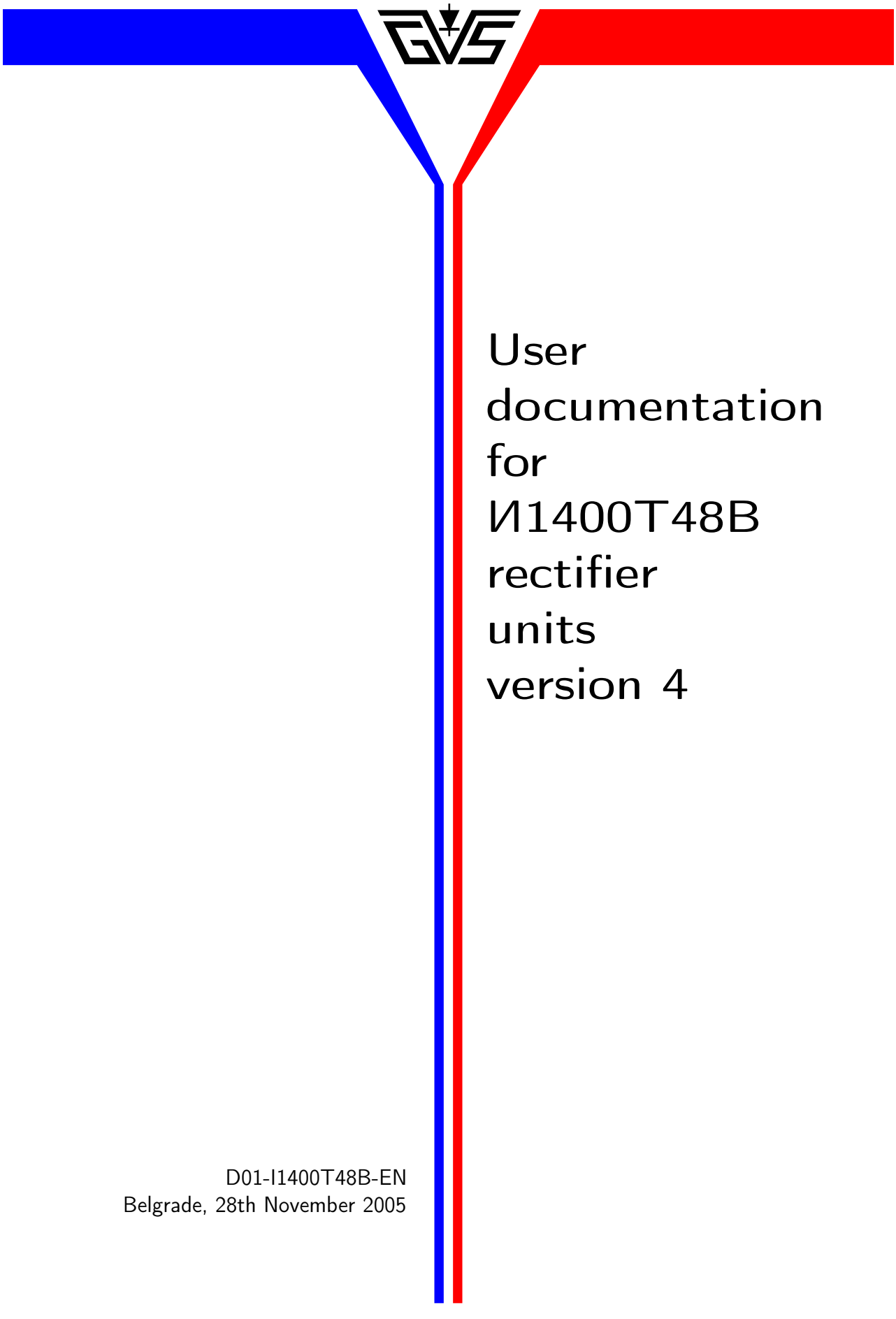

User documentation for И1400T48B rectifier units version 4

D01-I1400T48B-EN
Belgrade, 28th November 2005

Contents

1 INTRODUCTION **4**

2 DESCRIPTION **5**
2.1 Purpose . . . 5
2.2 Functions . . . 5
2.2.1 Energy conversion functions . . . 5
2.2.2 Protection functions . . . 6
2.2.3 Signaling functions . . . 7
2.2.4 Functions in transient modes . . . 8
2.3 Block scheme . . . 9
2.4 Operation description . . . 9
2.4.1 Introduction . . . 9
2.4.2 Power processor . . . 9
2.4.3 Control and handling . . . 15
2.5 Construction . . . 19
2.6 Front board . . . 20
2.7 Back board . . . 21
2.8 Kit contents . . . 23

3 ENGINEERING DATA **24**
3.1 Engineering data . . . 24
3.2 Features . . . 26

4 PRECAUTIONARY MEASURES **31**

5 INSTALLATION **32**
5.1 C3000 system installation . . . 32

6 INSTRUCTION MANUAL **33**
6.1 Handling . . . 33
6.2 Settings . . . 34

7 TESTING INSTRUCTION **35**
7.1 Necessary equipment . . . 35
7.2 Connection of testing equipment . . . 35
7.3 Function testing . . . 36
7.4 Protection testing . . . 36

8 MAINTENANCE INSTRUCTION **38**
8.1 Necessary equipment . . . 38
8.2 Procedures . . . 39
8.3 Rectifier opening . . . 42
8.4 Panelmeter replacement . . . 44
8.5 Transistor check . . . 45
8.6 Board replacement . . . 45

9 SUPPLEMENT LIST **47**
9.1 Material specification for И1400T rectifier . . . 47
9.2 Signal layout on connector pins . . . 47
9.3 Component layout on И1400T rectifier mother board . . . 47
9.4 Electrical schemes of И1400T rectifier . . . 47

List of Figures

1 *Rectifier И1400T48B в4 view* . . . 8
2 *Rectifier И1400T block scheme* . . . 10
3 *Rectifier И1400T circuit diagram* . . . 11
4 *"Forward" topology structure* . . . 11
5 *Main transformer voltage* . . . 13
6 *И1400T rectifier regulator* . . . 17
7 *Current on rectifier start up* . . . 18
8 *И1400T rectifier front board* . . . 20
9 *И1400T rectifier back board* . . . 22
10 *EMI on input terminals* . . . 26
11 *Network voltage "clear factor" dependent on load* . . . 27
12 *Power factor dependent on load* . . . 27
13 *Dynamic characteristic И1400T.. on 15 % load raise* . . . 28
14 *Dynamic characteristic И1400T.. on 15% load drop* . . . 28
15 *0-450kHz noise voltage on rectifier output* . . . 29
16 *Psophometric noise on rectifier output* . . . 29
17 *Rectifier efficiency dependent on load* . . . 30
18 *Testing equipment connection* . . . 36
19 *И1400T rectifier maintenance algorithm* . . . 40
20 *И1400T rectifier opening* . . . 43
21 *И1400T rectifier positions* . . . 46

List of Tables

1 *Input data* 24
2 *Output data for И1400T48* 24
3 *Output data for И1400T60* 25
4 *Basic data* 25

1 INTRODUCTION

This document introduces user documentation for rectifier units of *И1400T..* series (version 4 revision 0).

User documentation for *И1400T..* rectifier series is presented to device users, with basic data and procedures relevant to device exploitation included. Due to the fact of device being developed within switching supply system *C3000*, the instruction is based on this system, but most data apply for other purposes.

User documentation relies on usage instruction performed for previous rectifier version *И1400T..* (version 3 revision 0). Such determination is fully approved for this rectifier version is an upgrade to the previous one. For those users familiar with previous version (в3.0) and relating usage instruction, obtained modifications and enhancements to this version are specially stressed in the text.

Document is organized in sections, forming the unified whole. Section entitled 2 provides the rectifier description. Belonging text illustrates six different issues, featuring with purpose, functions, block scheme, operation description, construction, front and back panel etc. Section 3 includes most relevant engineering data and characteristics. Section 4 introduces precautionary measures required during operation with rectifier *И1400T...* Section 5 presents rectifier installation procedure, in two variants: within *C3000* system and aside of it, as an independent unit. Section 6 includes instruction manual and setting instructions. Testing instructions in regular control or installation is contained in section 7. Section 8 presents rectifier maintenance instruction, with diagnostics procedure and failure recovery.

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 getting familiar with *И1400T..* rectifier.

2 DESCRIPTION

This section describes *И1400T..* rectifier. Subsection 2.1 presents rectifier purpose. In further text, characteristics, lay out, construction, front and back panel elements and set contents delivered with *И1400T...* rectifier are introduced.

2.1 Purpose

Two variants of *И1400T..* rectifier series are designed, with different output characteristics: И1400T48: 48V/25A and И1400T60: 60V/20A. Rectifiers are produced in so-called switch-mode technique and are primarily intended to power supply telephone exchanges within *C3000* system, but may be also used as entirely independent units supplying other devices requiring specified voltages, with power not exceeding 1400W. Rectifier systems are supplied with three-phase or single-phase alternating current sources (local network or aggregate unit), while each individual rectifier unit is mono-phase supplied. Output voltage is strictly regulated within entire range of allowed network and load variations. In order to increase output current and reliability, parallel coupling of several rectifiers is conveyed, with automatic current distribution between rectifiers. For telephone exchanges with small capacity, rectifiers may be used without batteries, while rectifiers in uninterrupted power supply systems (UPS) are also used for 48V/60V battery maintenance, with different capacities. Special devices are dedicated to perform battery diagnostics and load appropriate charging mode (or maintenance mode).

2.2 Functions

2.2.1 Energy conversion functions

- *Energy conversion*

  Energy conversion is the elementary rectifier function. In a particular case, alternating voltage $230V_{eff}$ is converted into direct 48V or 60V voltage. Energy conversion is performed by power processor, profiled to process up to 1400W output power. Power processor is produced in "switching" technology, with transistor as main switching element. Operation frequency is considerably high for this power level and amounts to 50kHz. Such technology enables small device dimensions.

- *Power factor correction*

  Rectifier provides the input current correspondence with input voltage form and phase, so the rectifier within electrical power system functions as linear resistor. This eliminates the possibility of reactive energy occurred in the operation of a facility supplied by rectifier, unrelated to facility type or operation mode.

- *Regulation*

Output voltage is regulated with 1% limit in the entire input voltage range and for all load values 0 - 100%. 1% limit is defined in relation to specified output voltage in both operating modes.

- *Adjustment*

  Unlike previous rectifier versions, with front panel multi-rotary potentiometer for manual setting of output voltage value, this rectifier version is provided with automatic setting controlled by central processor or controller contained in measuring and diagnostics panel. Potentiometer is permanently removed from rectifier with no possibility left for manual setting. Output voltage value may be set manually using measuring and diagnostics panel keyboard. Rectifier output voltage value and therefore, system output voltage value, is automatically modified during operation process, depending on ambient conditions (temperature, duty, etc), under central processor control.

- *Duty mode*

  Installed microcontroller provides continuous setting of rectifier output voltage, thereby defining duty modes for lead-acid batteries (2.23 and 2.35V/cell) as quanta within a range of possible output voltage settings. C3000 system performs automatic switch-over.

- *On/off switching*

  Rectifier is switched on and off over a switch at the front board. This procedure is the only one required to handle rectifier operation.

- *Open-circuit operation*

  Rectifier functions regularly in open-circuit operation, with automatic activation of internal load. On each output load jump, internal load automatically switches off.

2.2.2 Protection functions

- *Input protection*

  Rectifier is varistor protected from short input disorders (peaks).

  Rectifier is protected from bad network voltage and input irregularities in several ways. Network surveillance is performed and undervoltage and overvoltage values are detected. Aside from that, phase corrector is protected from input undervoltage and output overvoltage, thus protecting input filter capacitors. Input fuses protect from overcurrent. Fast meltable fuse provides phase line protection. The fuse is placed at the back panel and may be replaced without opening specific device. Ultrafast input overvoltage protection is most important of all. This protection system detects overvoltage in the very half-period where network voltage has occurred and stops the rectifier. Any protection, except fuses, is nondestructive and regenerative, therefore enabling automatic rectifier start after the irregularity having caused protection activity has ceased.

Back panel connector provides signaling for rectifier irregularity states and null input voltage.

- *Output protection*

  Rectifier output is multiply protected, More precise, this is protection for consumer supplied by rectifier. Fast electronic overvoltage, undervoltage and overcurrent protection is installed. Rectifier short-circuit protection provides automatic rectifier start-up after short circuit recovery. Polarity-change protection is mechanically conducted within *C3000* system (polarity is impossible to change). When using the rectifier out of *C3000* system, make sure not to provoke polarity change.

- *Temperature protection*

  In case of rectifier superheating under high ambient temperature conditions, rectifier automatically decreases output power (first overheated rectifier is excluded from current distribution). Having reduced the output power and still not restored temperature into required range, rectifier turns off. The rectifier shall continue its operation on temperature reaching the specified range. While rectifier is out of operation under high temperature conditions, red LED diode TEMP on the front board is illuminated.

2.2.3 Signaling functions

- *Measuring and display*

  While operating, rectifier output current value may be read on three-digit 7-segment display on the front board. Output voltage value may be measured on front board test points. On request, rectifier option with a measuring selection switcher may be obtained, providing display of output current value or output voltage value.

- *Light indication*

  Red lamp on the front board indicates input voltage presence, while red LED indicator TEMP indicates device overheating.

- *Remote signaling*

  Remote signaling is performed by a microcontroller installed into device, via asynchronous serial connection. This signaling type is both-way serial communication with environment. Two serial buses are present, providing that, under failure conditions, rectifier automatically continues communication over the other bus.

2.2.4 Functions in transient modes

Time hold on start-up

After front board switch turning to on position, rectifier waits for some time until termination of all transient processes resulting from input voltage connection with power processor. On the time expiry, power processor starts operation.

Figure 1 shows rectifier И1400Т48В в4.

Figure 1: *Rectifier И1400Т48В в4 view*

2.3 Block scheme

Block scheme figure shows power processor on periphery, while control and handling are in the middle (figure 2).

2.4 Operation description

2.4.1 Introduction

Rectifier may be presented as two unified entities performing different activities (figure 3).

The first one is power processor performing current and voltage processing and all other processes in relation to great power values. The second one is "control and handling". Its basic function is to regulate output voltage, keeping it within close, predefined limits. Control logic realizes protection function preventing power processor from reaching destructive states. In addition, control logic maintains connection with other system rectifiers.

2.4.2 Power processor

И1400Т rectifier power processor is based on "Forward" topology (figure 4). Switching transistor operates with 50kHz frequency, allowing minimum gauge to main transformer and other elements in power circuit.

Power processor may be divided into three parts:

- primary part, realizing connection with network voltage
- main transformer, transforming input voltage into output voltage
- secondary part, processing output voltage

2.4.2.1. Primary part

Primary part function includes voltage routing, filtering and producing voltage forms convenient for further processing. Primary part includes:

- rectifier activation block with input overvoltage protection
- input director with filters and protection,
- power factor equalizer
- switching transistor with excitation and protection,
- logic supply part

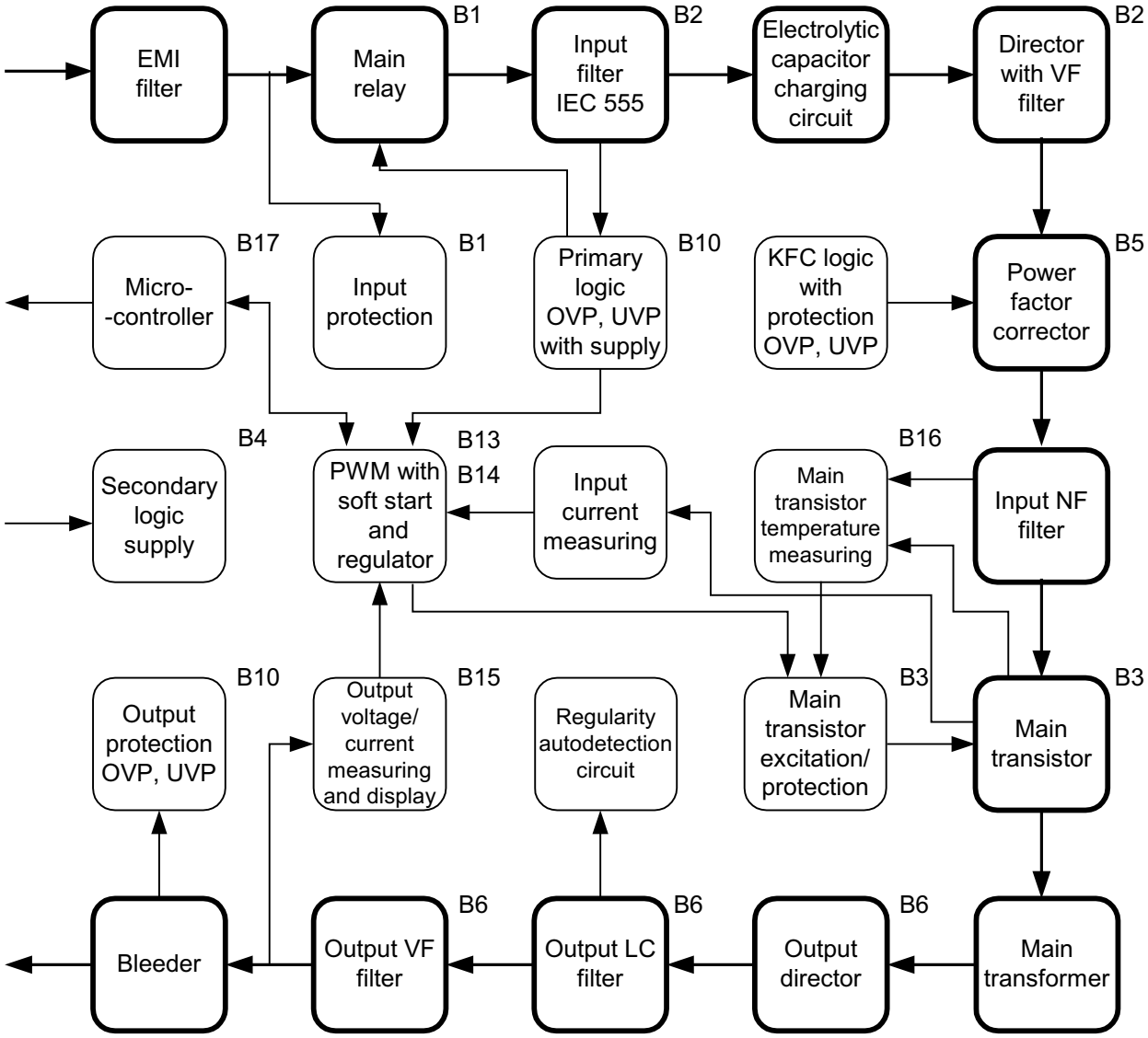

Figure 2: *Rectifier И1400T block scheme*

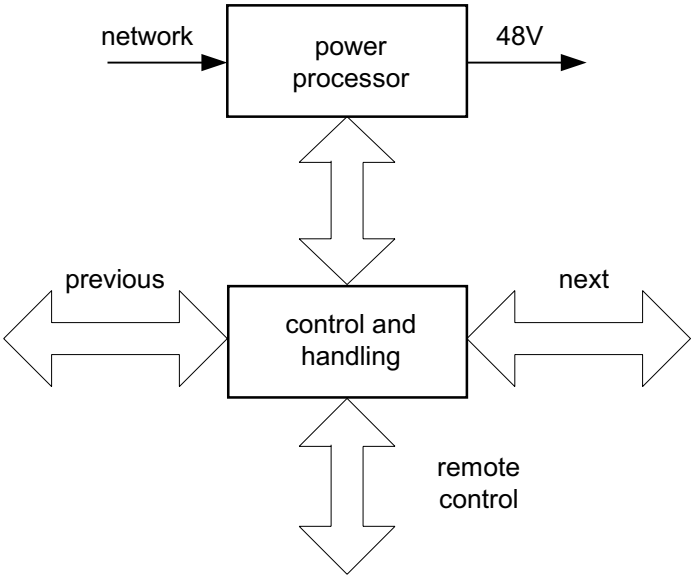

Figure 3: *Rectifier И1400T circuit diagram*

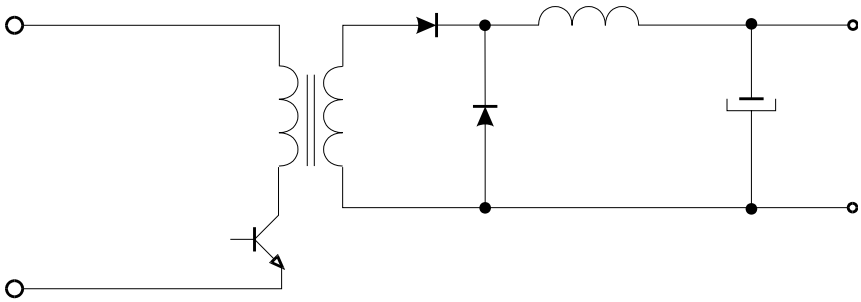

Figure 4: *"Forward" topology structure*

- *Rectifier activation block (B1)*

  This block connects to network voltage. Network voltage may be connected with other power processor parts over relay contacts. Relay is controlled over on/off switch located on the front rectifier board. Protection logic may undertake relay control, in the event of high network voltage. Front board lamp is illuminated when relay contacts are closed.

  This block also contains a network fuse, functioning as over-current protection. On network fuse blow, red lamp on the front rectifier board is illuminated.

- *Input director with filters and protection (B2)*

  This block contains:

  - both-way director, realized as Gretc connection
  - electromagnetic interference filter
  - routed input voltage LC filter
  - varistor for voltage surge protection
  - circuits for surge current protection on start up

  This block produces output voltage U_{nom}=300V

- *Power factor equalizer (B5)*

  Power factor equalizer is used to correct (reduce) rectifier impedance imaginary part, that is, to increase power factor.

  It is realized as additional high frequency switching converter (100kHz).

- *Switching transistor with excitation and protection (B3)*

  Second generation bipolar switching transistor is used, demonstrating great switching speeds.

  Transistor chops the input filter voltage. A form produced is convenient for further processing and is shown in figure 5.

  Transistor drive circuit is realized to provide base current proportional to collector current. Proportionality coefficient is equal to transistor gain, allowing for maximum switching speeds. Switch on/off command is transferred from control and handling part over drive transformers.

  On transistor current exceeding maximum allowed value, excitation circuit immediately switches the transistor off, on control and handling part command.

  Overvoltage protection is realized using non-dissipation LC snubber and RC voltage clamp.

  Meltable fuse is installed as an additional overvoltage protection.

- *Logic supply part (B4)*

  Small power network transformer provides logic circuit power supply. Transformer output voltage is further routed, filtered and stabilized, as described under 'control and handling part' item.

2.4.2.2. Main transformer

Main transformer is realized on small-gauge ferrite core, 76x69x55mm, 300g. Such small dimensions are due to power processor high frequency (50kHz).

Form and characteristics of transformer primary part voltage are shown in figure 5.

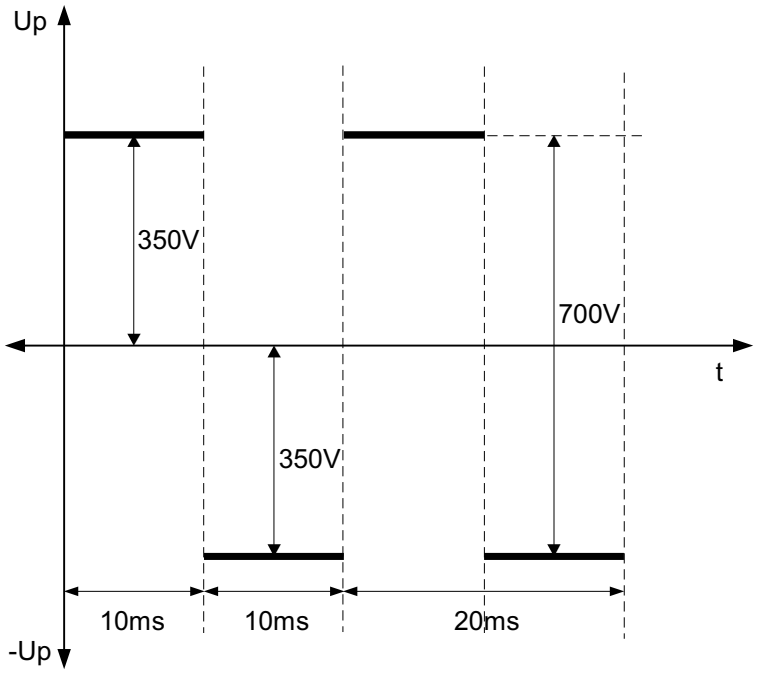

Figure 5: *Main transformer voltage*

Secondary part voltage is of a same form, while the values result from 1:7 transfer ratio.

Electronic shields are mounted on transformer windings to provide interference protection.

2.4.2.3. Secondary part

Secondary part processes output transformer voltage producing constant, stable rectifier output voltage, necessary for exchange supplying.

Secondary part includes:

- output director with filter

- director for parallel operation and polarity change battery protection

Output director with filter (B6)

This block is routing transformer alternative output voltage and then filtering the produced direct voltage to obtain small ripple output voltage.

It is realized, in accordance with "Forward" topology structure, with 2 directors (diodes) and LC filter.

The output voltage supplying the exchange is present at the block outlet.

2.4.2.4. Measuring

Power processors perform measuring of primary voltage and current, transistor temperature and secondary current and voltage in certain points, as shown in figure 2. All measured values are brought to control and handling block.

- *Primary voltage measuring*

  Measuring is performed on B2 block output, using operational amplifier and resistance distribution frame. Measuring is performed to prevent from network overvoltage and undervoltage.

- *Primary current measuring*

  Measuring is performed on main transformer input, using non-contact inductance method (current transformer).

  Measuring is performed to enable current programming method.

- *Transistor temperature measuring*

  Measuring is performed in B3 block, using thermistor. Measuring is done to enable device superheating protection.

- *Secondary current measuring*

  It is realized on main transformer output, using non-contact inductance method (2 current transformers). Measuring is performed to provide pointer data.

  Measured value may be read on rectifier front board display.

- *Output voltage measuring*

  It is performed on B6 block output, using operational amplifier and resistance distribution frame. Measuring is performed to allow for output voltage regulation and provide output overvoltage and undervoltage protection.

  Measured values may be read on rectifier front board.

2.4.3 Control and handling

Control and handling part controls rectifier operation and protect from endangering or destructive states. Block scheme is shown in figure 2.

This part includes three entities: protection logic, control and display.

2.4.3.1. Protection logic (B10)

Protection logic includes:

- input and output overvoltage protection
- input and output undervoltage protection
- thermal protection

Input overvoltage protection is activated on input voltage exceeding 242V$_{eff}$ value. It is realized with one voltage comparator with 1% stability reference provided. Protection activity on rectifier activation block (B1) provides orders for splitting relay contacts. AM network alarm is sent to model front board on measuring and diagnostics panel (rectifier within *C3000* system).

Input undervoltage protection is activated on input voltage value drop under 187V$_{eff}$. It is realized with voltage comparator with 1% stability reference provided. Protection activity on B3 block cancels transistor excitation. AM network alarm is sent to front board of measuring and diagnostics panel (rectifier is part of *C3000* system).

Thermal protection is activated on transistor temperature exceeding 85°C. It is realized over thermistor-operational amplifier-voltage comparator connection, using slave components. Protection activity on B3 block cancels transistor excitation.

Output overvoltage protection is activated on output voltage value exceeding 56V. It is realized over voltage comparator with 1% stability reference provided. Protection activity on B3 block cancels transistor excitation.

Output undervoltage protection is activated on output voltage value drop under 39V. It is realized over voltage comparator with 1% stability reference provided. Protection activity on B3 block cancels transistor excitation.

2.4.3.2. Step activation

Step activation function is realized through microprocessor system control, allowing for central processor an information on rectifier currents within system. In case mean current (note that currents are, under regular conditions, equally distributed to rectifiers) is under specified lower threshold or exceeding specified upper threshold, central processor issues command for rectifier deactivation or activation, respectively. Rectifier has no internal competence as to this function. It is only following central processor commands.

2.4.3.3. Output voltage and current display (B15)

Output voltage/current value may be read out on rectifier front board.

Three-digit display is installed, with "U/I" switcher located close to it.

With switcher in position A, display shows output current value in amperes. To read out output voltage in volts, restore the switcher into position "V".

Analog signal conversion into digital seven-segment code is realized by one integrated circuit at a time (A/D converter).

2.4.3.4. Light indication (B16)

Front rectifier board provides signaling for following states and alarms:

- *Network voltage connected*

  Red lamp illuminated, network voltage within allowed range.

  Lamp is parallel connected to input network voltage.

- *Rectifier superheating*

  Red indicator is illuminated after rectifier switch off, caused by overheating.

2.4.3.5. Control

This block controls rectifier operation, based on signals received from control and measuring block.

Control is performed solely over transistor excitation.

This block contains two parts: regulator and current limit.

- *Current limit B13*

  This block prevents output current from exceeding maximum allowed value.

  It is realized as operational amplifier with postponed action with provided 1% stability reference and a signal from output current measuring circuit.

  On output current exceeding maximum allowed value, this block undertakes control over error signal (see B14), informing that primary current value should be decreased.

- *Current programming (regulator) B14*

  This block regulates output voltage value, maintaining it within range 2.23V/cell ±1% in battery maintenance mode, and 2.3V/cell in battery charging mode.

  It is realized over an integrated circuit, with slave components.

  Output voltage and primary current are measured as described under 2.4.2.4. Measured values are transformed to correspond to integrated circuit operation requirements.

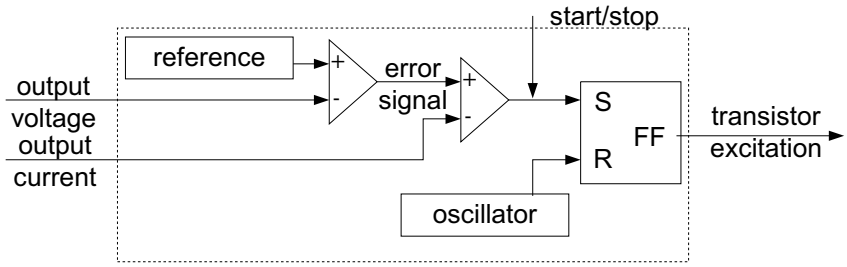

Figure 6: *И1400Т rectifier regulator*

Regulator operates as following (figure 6):

- measured output voltage is compared with reference voltage (error amplifier),
- on load raised, output current value increases, output voltage decreases and operational amplifier generates an error signal (error signal defines primary current threshold, that is, a new, peak primary current value),
- on load drop, output current value decreases, output voltage increases and operational amplifier generates error signal, that is, a new, lower, peak primary current value,
- comparator compares primary current value with error signal. On primary current exceeding value defined by error signal, comparator cancels transistor excitation.

Therefore, regulator provides constant output voltage and current conforming with load changes to a current limit.

Integrated circuit also performs following functions:

- *Start/stop*

  Transistor may be activated or its excitation may be canceled, in any time. This is performed by step activation logic in parallel operation in case of excessive or small output current value (see 2.4.3.2. Step activation).

- *Undervoltage protection*

  Integrated circuit is provided with undervoltage protection. On voltage value drop under 7.7V, circuit operation is suspended: transistor excitation is canceled and rectifier is out of operation.

- *Soft start*

  On rectifier start up, transient modes occur that might be destructive or cause operation errors. In order to avoid such states, integrated circuit controls primary peak current, restricting it to maximum specified value. Primary current is demonstrated in figure 7.

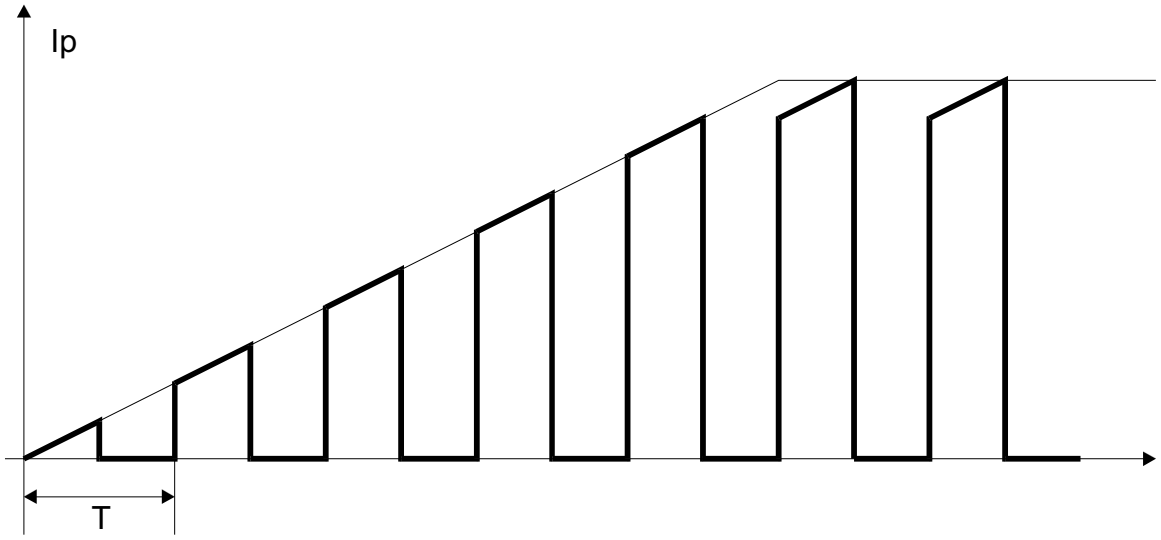

Figure 7: *Current on rectifier start up*

- *Oscillator*

  Integrated circuit is installed an oscillator with slave component adjustable frequency.

- *Reference*

  Voltage reference of 5.1V value and 1% stability is also installed into integrated circuit and is used, over distribution frame, within regulator and other rectifier parts.

2.4.3.6. Microcontroller and communication

For this rectifier version, microcontroller block is installed, performing complicated and sophisticated functions, which is mostly provided due to communication with central processor. This block is based on 8-bit complex microcontroller with integrated multichannel A/D converter and serial communication controller. This block is supplied from a central source, used also for central processor supply. Dual supply is provided within block, as well as a circuit (diode director) enabling block operation with any supply source available of two existing ones.

As mentioned above, microcontroller realizes communication with central processor over dual serial bus, selecting one of two buses in half duplex. At physical level, RS485 standard is applied. Communication is asynchronous and based on central processor polling. Controller located in rectifier receives bus messages and, after recognizing own address, analyses complete message and processes it in accordance with program installed. Finally, controller sends appropriate response or confirmation.

Controller measures following rectifier parameters:

- output current, using current transformers of output circuit,

- main transistor heat sink temperature.

Controller also reads out rectifier logic signals such as: protection activity, internal supply state etc.

Controller performs continuous control over feedback regulator circuit, introducing certain corrections to control voltage value. Circuit hardware provides that, in case of microcontroller irregularity or null supply, control voltage value is automatically set to nominal value.

Controller also manages bleeder operation and is allowed to stop or activate (select) power processor operation within rectifier.

Microcontroller block is entirely galvanic (opto-coupler) isolated from the rest of rectifier and realized on separate printed board.

Microcontroller basic operation concept is not to disturb basic rectifier function, but only correct it and introduce some new functions.

2.5 Construction

И1400Т.. rectifier is realized as compact unique mechanical module containing commands and indicators at the front board and connectors to network, consumers and control *C3000* system modules on the back board. Device case is designed to fit mounting in standard "2H" height, 24in width rack. Construction is firm and rugged. Rectifier may be laid down onto any side except the front board. It is easily transported using a handle fixed to front board openings.

Rectifier is opened and demounted easily, in quite familiar manner to a user having already used similar devices. Left rectifier side is realized as heat sink, used also as basic construction

supporting element. Rectifier is opened removing the right side, also used as an auxiliary heat sink.

Internally, rectifier construction is modular. Module replacement is simplified and independent (see section 8. Maintenance instruction).

2.6 Front board

Front version 4 rectifier board is shown in figure 8. All commands and indicators are located on the front board.

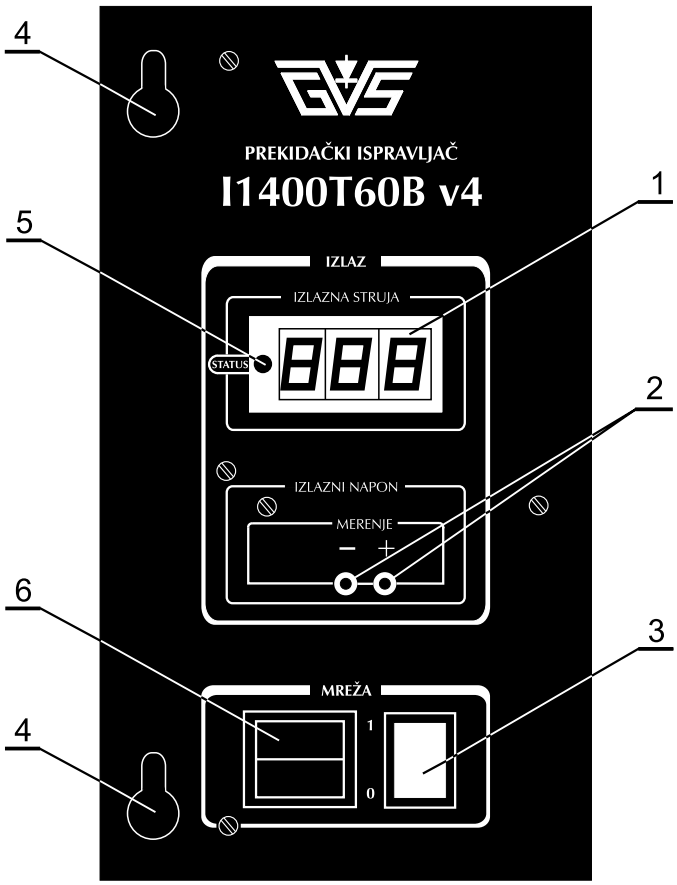

Figure 8: *I1400T rectifier front board*

1. Digit indicator

   Digit indicator is 7-segment LED indicator performing digital output current display. Measuring quantum is 0.1A.

2. Test points for output voltage measuring

   Left point is a negative and right one is a positive output voltage pole. Measuring ratio is 1:1.

3. Network voltage signaling lamp

   This indicator is illuminated during network voltage connection to power processor.

4. Handle openings

   Handle openings are used to fit the handle into for rectifier transport.

5. TEMP indicator

   This indicator is illuminated on rectifier deactivation after superheating.

6. Rectifier on/off switch

   The upper, ON position indicates network voltage presence. Corresponding indicator is illuminated (3).

2.7 Back board

Back rectifier board is shown in figure 9. It includes energetic connectors to network and consumer, signaling connector to control module (*C3000* system control module is measuring and diagnostics panel МДП С36) and a network fuse. Case guide pins enable all contacts set at one time, placing the rectifier into the shelf.

1. Serial number

   Device serial number is engraved in a field at the back board.

2. Side heat sink

   Side heat sink is an aluminum cooling device for unwanted component heat dissipation.

3. Network socket

   Network socket is used to bring 220/230V$_{eff}$, 50Hz network power supply. It is used as five-pole SUB D energetic connector type.

4. Output connector

   Output connector establishes connection between rectifier and consumer, over corresponding distribution cabinet connector. Five-pole SUB D energetic connector type is used. Two left contacts (viewed from back rectifier side) are plus (+B) pole and two right ones are minus (-B) pole.

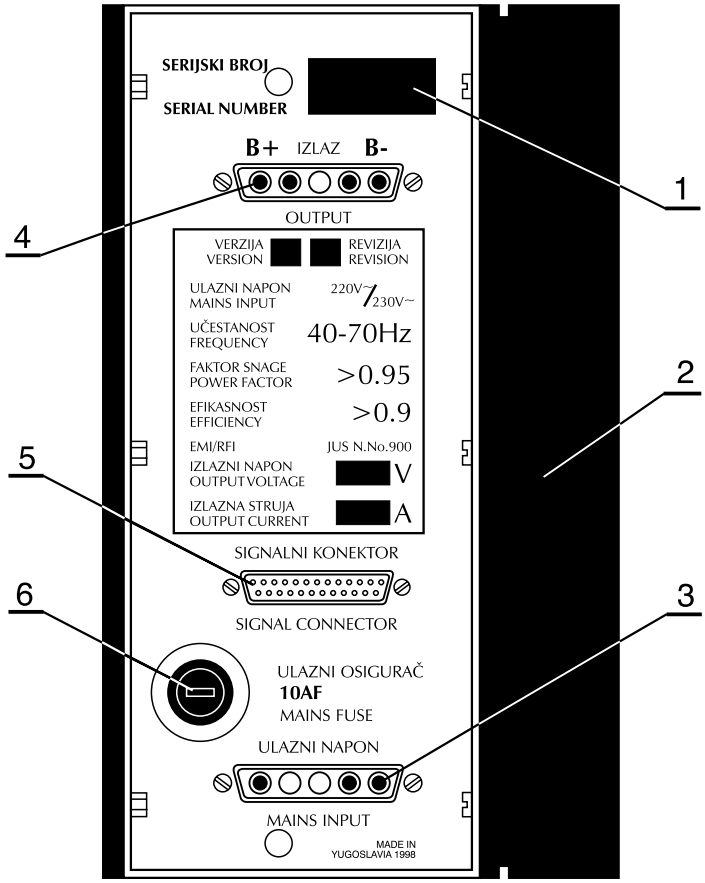

Figure 9: *И1400T rectifier back board*

5. Signaling connector

   Signaling connector is used to connect rectifiers with *C3000* system control module. 25-pole SUB D connector type is used.

6. Network fuse

   Network fuse is provided for network insurance in case of rectifier failure. Fast fuses are used.

2.8 Kit contents

Rectifier *И1400T..* series are delivered in transport suitable package including:

- *И1400T..* rectifier
- User documentation (current document)
- Warranty certificate

All other issues are defined by special contracts.

3 ENGINEERING DATA

3.1 Engineering data

network voltage (Vu)	$220/230V_{eff}$
network frequency	47 to 63Hz
tolerances	-15% to +10%
distortion tolerance	30%
input current on full load and nominal input voltage	7A
surge current	less than 15A
fast input fuse	10A
power factor ($\cos \phi$)	over 0.98
protection types	overvoltage, undervoltage, fuse

Table 1: *Input data*

nominal voltage (Vi)	48V
adjustable maintenance voltage	49-56V
adjustable charging voltage	52-58V
stability	better than 1%
nominal current	25A
current limit	26A
output power	1410W
power density	$134W/dm^3$
response time	1ms
voltage surge amplitude	less than 2Vp-p
noise voltage psophometric value with no battery	less then 2mV
noise voltage effective value in range 10Hz to 450kHz	less than 25mV
protection types	overvoltage, undervoltage, overcurrent, short-circuit protection

Table 2: *Output data for I1400T48*

nominal voltage (Vi)	60V
adjustable maintenance voltage	61-69V
adjustable charging voltage	65-73V
stability	better than 1%
nominal current	20A
current limit	21A
output power	1410W
power density	134W/dm^3
response time	1ms
voltage surge amplitude	less than 2Vp-p
noise voltage psophometric value with no battery	less than 2mV
noise voltage effective value in range 10Hz to 450kHz	less than 25mV
protection types	overvoltage, undervoltage, overcurrent, short-circuit protection

Table 3: *Output data for И1400T60*

operation frequency	50kHz
efficiency	more than 0.9
EMI	JVC H.Ho-900
allowed ambient temperature	0°C to +45°C
allowed storage temperature	−10°C to +75°C
allowed humidity	maximum 90%
External dimensions	
height	224mm
width	126mm
depth	373mm
mass	8.5kg
Reliability	
mean time between failures	40 years
provided spare parts and servicing	20 years
warranty expiry	3 years
temperature protection	provided
indicator devices	digital 1%
mounting	modular "plug-in"

Table 4: *Basic data*

- remote control and handling provided,
- direct output connection enables parallel operation.

3.2 Features

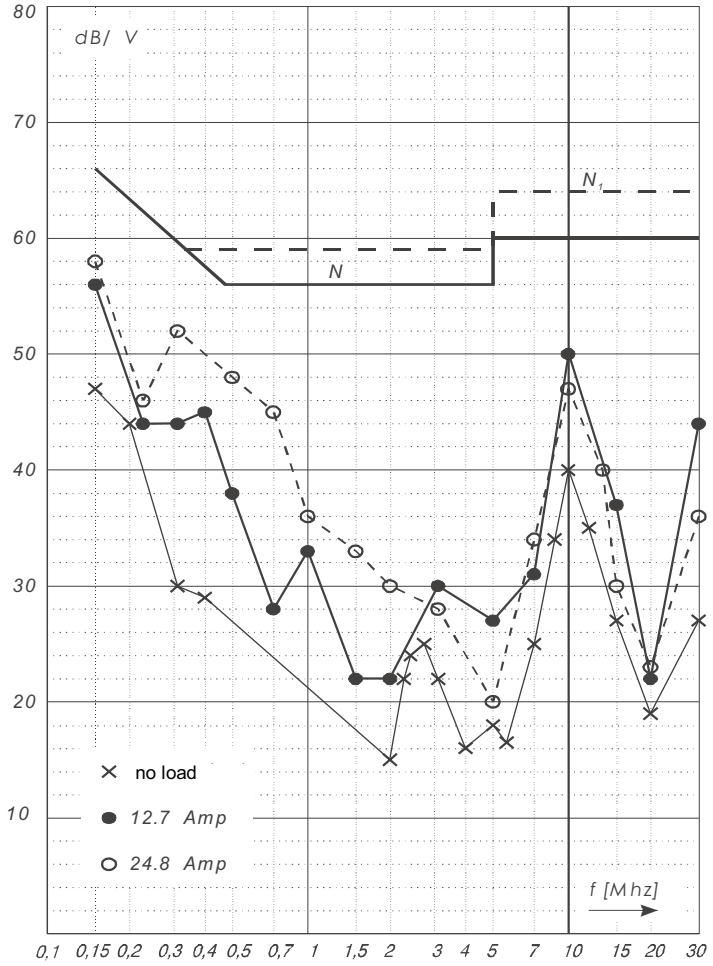

Figure 10: *EMI on input terminals*

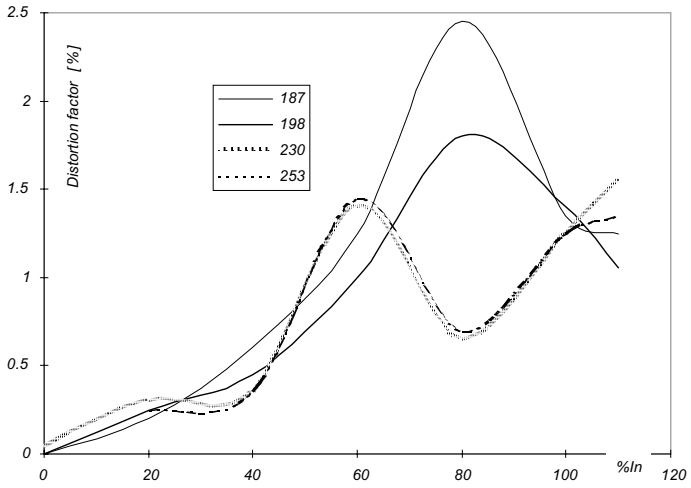

Figure 11: *Network voltage "clear factor" dependent on load*

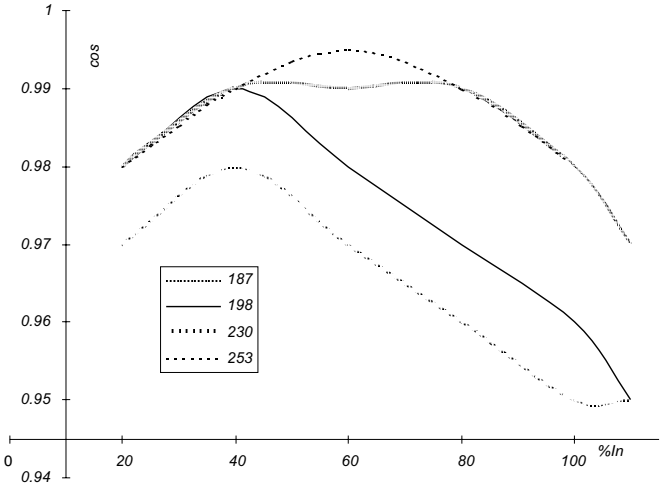

Figure 12: *Power factor dependent on load*

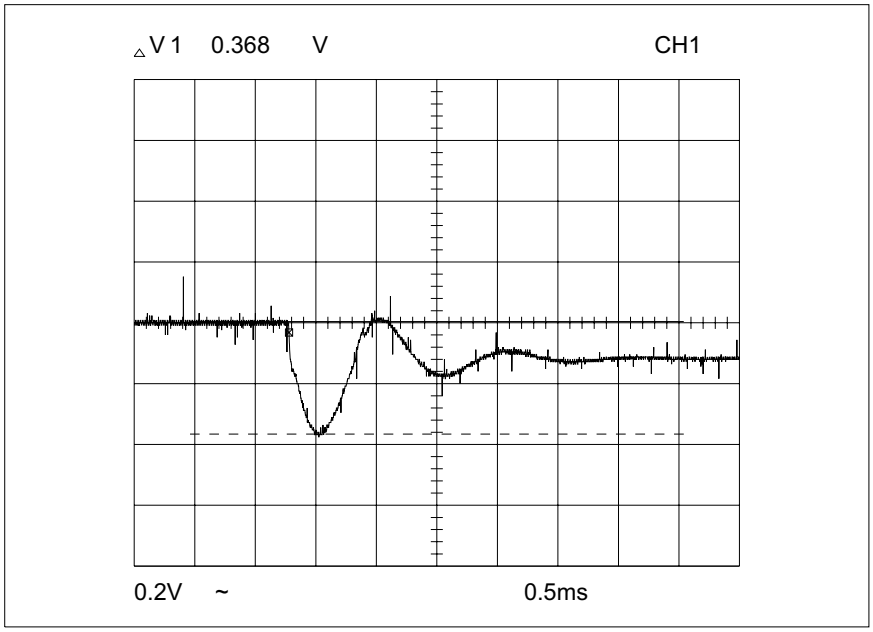

Figure 13: *Dynamic characteristic И1400T.. on 15 % load raise*

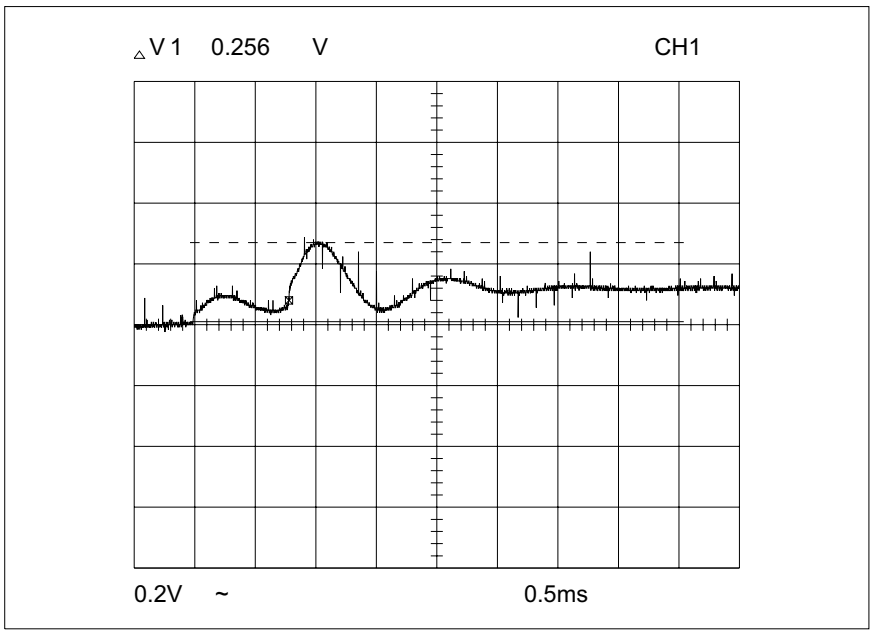

Figure 14: *Dynamic characteristic И1400T.. on 15% load drop*

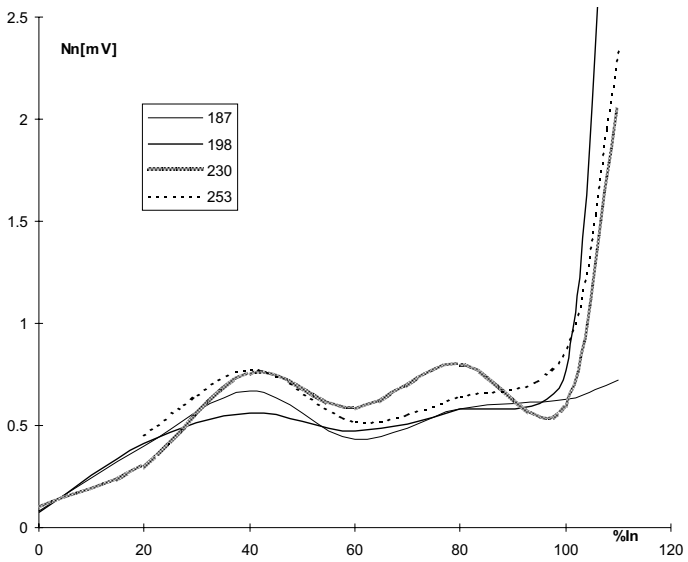

Figure 15: *0-450kHz noise voltage on rectifier output*

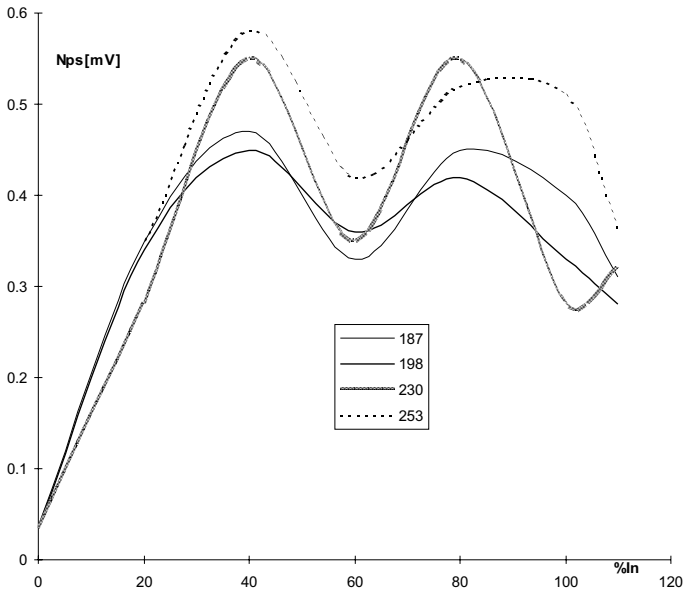

Figure 16: *Psophometric noise on rectifier output*

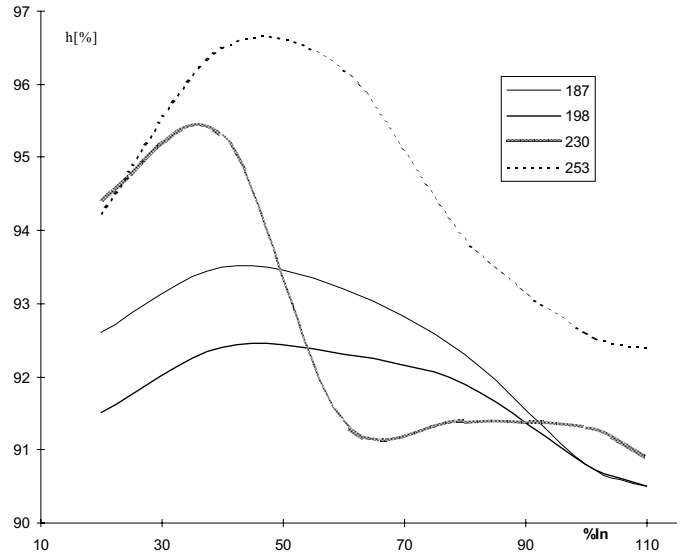

Figure 17: *Rectifier efficiency dependent on load*

4 PRECAUTIONARY MEASURES

Besides common precautionary measures considered in operation with electrical equipment, specified by corresponding legal regulations, 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 rectifier metallic parts are connected to protection Earthing via appropriate supply line conductor;
- do not open the rectifier or perform any interventions when connected to network voltage,
- avoid contact with elements marked as energized and dangerous during rectifier operation, except in case of rectifier being connected to network over isolation transformer,
- use isolated tools to set electrical parameters,
- filter capacitors should not be short circuited; when necessary, use a several hundred ohm resistor to unload them, in duration of 5-10s, with device switched off,
- rectifier opening is strictly forbidden for the warranty duration period; such activities result in complete warranty dismission and user being charged for servicing.

5 INSTALLATION

This section defines principles for proper rectifier installation. System design provides extremely easy and safe installation. Most rectifiers are installed into *C3000* system, but an independent installation of rectifier or a group of rectifiers is also described. Note that *И1400Т..* series are also provided in portable variant, suffixed with letter П. Portable variant is intended for usage out of *C3000* system and its construction is modified to fit easily into the case.

5.1 C3000 system installation

Shelves within *C3000* system are part of cabinets for rectifier installation and are mounted buses connected to relating connectors. Shelves are also provided module (rectifier) guide pins. Cabinet construction enables plug-in rectifier installation. Rectifier is placed onto a shelf and pulled forward.

To perform mounting procedure:

- make sure that rectifier activation switch is in position "0" (downwards),

- place *И1400Т..* rectifier onto guide pins and slowly pull to the end

Installation is complete.

Notes:

When installing the system for the first time, follow the instructions for *C3000* system installation (start with steps defined prior to rectifier installation and than proceed with those coming afterwards).

On installation of new rectifier(s) into the system, there is no need to turn it off completely before performing specified installation procedures.

After procedure is complete, rectifier is started using a front board switch (see section 6. Instruction manual).

6 INSTRUCTION MANUAL

Current section describes *И1400T* rectifier handling. Settings described in subsection 6.2 are also considered 'handling' issues.

И1400T is an entirely automatic device. This implies no interventions after correct installation, except under failure conditions. Rectifier logic controls device operation and external parameters (rectifier environment) and directs device operation. In case of operation irregularity, rectifier operation is suspended and restarted after all irregularities are cleared.

6.1 Handling

И1400T.. automatic device requires certain settings or switching it on/off, when necessary. The text below describes selection of voltage/current measuring and actions specified in case of failure. 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 8. Maintenance instruction.

- *Switch on/off*

  Use front board switch to switch the rectifier on or off (see figure 2). With switch in position "0" (downward position), rectifier is on. In the case opposite, switch in upper position, rectifier is off. On rectifier switched on, power converter inside rectifier is operative. Switching the rectifier on and off has no influence to logic operation, which is constant whenever input network voltage is present.

- *Output voltage measuring*

  Rectifier output voltage in this version may be measured using an external instrument. For this purpose, two test points are dedicated at the front board. Test point designated with - (minus) is connected to output voltage negative end over 10kΩ resistor, while the test point designated with + (plus) is connected to output voltage positive end over 10kΩ resistor. To measure the voltage with 1% precision, use voltmeter with at least 1MΩ input resistance. Test point internal diameter is 2mm, for standard voltmeter and universal measuring instrument probes. Measuring is realized setting the instrument to appropriate measuring range (at least 200V), and applying the probes into the test points.

- *Selection of output voltage/current measuring*

  As already mentioned within current document, front board measuring instrument indicates output current value. Special rectifier variant is offered though, provided with an option existing in the old (2.0) rectifier version, to select output voltage or output current values to be displayed. Selection is performed using the switch on display right side. With the switch in upper, "V" ('volt') position, output voltage value is displayed, and when in

"A" (ampere) position, output current value is displayed. Rectifier variant with output voltage display has no test points.

- *Actions in case of failure*

  И1400Т.. mean time between failures is 40 years, thereby providing long, reliable operation with no interventions required. Still, due to some less probable, unexpected operation conditions, certain logic operation errors might occur, resulting in no destructive failures but only rectifier operation suspension. This is restricted to theory speculations though, since the logic is designed to react correctly under all known operation conditions. Failures might occur for ageing or rectifier component irregularities. On the occurrence of operation errors, try following:.

  When detected the failure visually, either on front or back side, restore the front board switch to position "0" and call the service.

  When out of operation (front board display is not illuminated or zero current is displayed), switch the rectifier off. Wait for some time and switch the rectifier on. If it's still out of function, repeat the procedure.

  If several repeated procedures give no results, call the service.

  Note: In case of ambient high temperature, rectifier might temporarily turn off for cooling. This state is signalized by red indicator on the left side of digit indicator. In such case, rectifier is not irregular and shall be reactivated automatically after some time of cooling. Furthermore, make sure that the network voltage is within range allowed. When out of range, wait for some time to restore, or switch the rectifier to another phase, provided the voltage value is in the range allowed. With rectifier in *C3000* system, bad network voltage is signalized by "AM" indicator on the front board of measuring and diagnostics panel.

6.2 Settings

After rectifier installation into system, central processor performs all necessary settings over serial communication and in accordance with memory stored predefined parameters.

Output voltage setting for entire system or a certain rectifier, may be directed from measuring and diagnostics panel keyboard.

Current distribution is set automatically by system and held within 5% nominal value (in practice, within 1%).

7 TESTING INSTRUCTION

This section provides rectifier testing procedure when assuming its regularity. This makes sense after finished *I1400T* transport bearing risks of mechanical damages or after performing activities described in section 8 or certain system modifications (reconfiguration or relocation). All procedures are conducted by personnel trained to operate with energetic equipment.

7.1 Necessary equipment

Rectifier testing requires following equipment:

- 2 universal digital instruments or
- 1 voltmeter for alternative (network) voltage measuring
- 1 voltmeter for direct voltage measuring up to 200V, 1% precision on 50V (0.5V)
- 1 current probe 60Amp
- 1 60V variable load unit, 0-30A for 48V and 60V rectifiers
- Branch feeders
- Auto-transformer 14A, 220V (no less powered transformer should be used)

7.2 Connection of testing equipment

The equipment listed above is connected to rectifier as following:

1. Make sure the network switch is off.
2. Connect auto-transformer to network voltage via network switch.
3. Make sure the rectifier front board switch is off (position "0").
4. Connect auto-transformer outlet to rectifier inlet.
5. Connect universal measuring instrument (voltmeter), previously set to network voltage measuring range, to rectifier inlet, parallel.
6. Connect variable load unit to rectifier outlet.
7. Connect direct voltage voltmeter, previously set to appropriate range, to rectifier outlet, parallel.
8. Apply current probe to rectifier outlet negative pole cable.

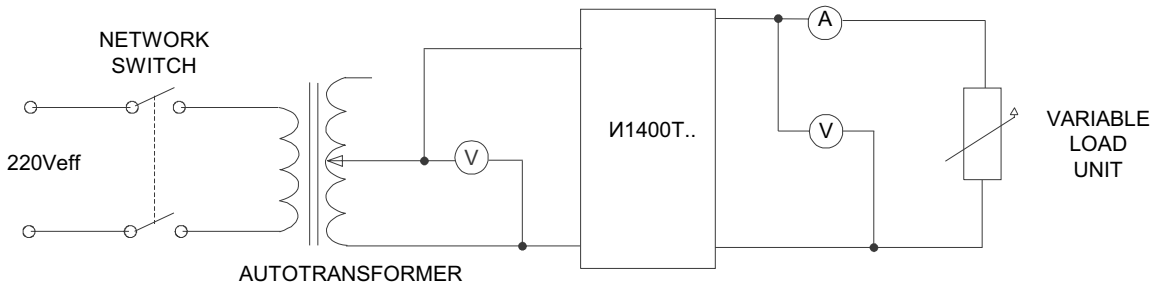

Figure 18: *Testing equipment connection*

Electric scheme of equipment connections is demonstrated in figure 18.

Further text is introduced under assumption of the rectifier being regular and procedures normally conveyed. When results do not match the one described in the text, continue according to section 8. Maintenance instruction.

7.3 Function testing

Procedure:

a1) Network switch is on

a2) Set auto-transformer to display rectifier input voltage value 230V$_{eff}$

a3) Set variable load unit to a small value (20% of nominal one)

a4) Activate rectifier front board switch

Result: Voltmeter shows nominal direct voltage value, within tolerance.

a5) Modify load to the nominal value

Result: Voltmeter shows 1% direct voltage nominal value. Current probe shows current value conforming with load changes.

a6) Modify load to exceed the nominal one

Result: Voltmeter shows the value smaller than voltage nominal value. Current probe shows the value smaller than current limit value.

a7) Set auto-transformer to display the input voltage value in range 187V$_{eff}$ to 253V$_{eff}$

a8) Modify load as under item a5)

Results: Unrelated to input voltage value, voltmeter shows output voltage nominal value and the current probe displays value dependent on load, as under item a5)

a9) Set auto-transformer to display 230V$_{eff}$ rectifier input voltage value.

7.4 Protection testing

Procedure:

b1) Network switch is on

b2) Set auto-transformer to display 230V$_{eff}$ rectifier input voltage value.

b3) Set variable load unit to a small value (20% of nominal one)

b4) Activate rectifier front board switch

Results: Voltmeter shows direct voltage nominal value.

b5) Modify load to exceed the nominal value

Results: Voltmeter shows value smaller than nominal one and current probe displays current value within current limit

b6) Use auto-transformer to gradually increase rectifier input voltage over 253V$_{eff}$ value

Results: Input overvoltage protection activity causes rectifier provision of output voltage suspended.

b7) Deactivate rectifier front board switch

b8) Set auto-transformer to display 230V$_{eff}$ rectifier input voltage value

b9) Activate rectifier front board switch

b10) Decrease gradually rectifier input voltage under 180V$_{eff}$ value

Results: Undervoltage protection activity causes rectifier provision of output voltage suspended.

b11) Deactivate rectifier front board switch

8 MAINTENANCE INSTRUCTION

И1400Т rectifier requires no regular maintenance. After installation, rectifier functions automatically under regular conditions. Naturally, certain states might occur, causing *И1400Т* failure. Failure might also result from rectifier component ageing. Thereby, rectifier maintenance considers maintenance under failure conditions.

Section 6 of the current document, relating to rectifier handling, provides procedures to be performed by personnel on rectifier failure. Personnel requires no training for operation with supply equipment or electric equipment generally. Procedures presented in section 8 are performed by personnel trained to operate with supply equipment. Maintenance procedures are therefore unrelated to those described in handling instruction.

8.1 Necessary equipment

Quantity and type of required equipment depends on failure conditions and the testing level. Relating equipment is introduced under procedure items, and the complete list of total equipment needed in most detailed testing is presented hereafter.

- 2 universal digital instruments or:
  - 1 voltmeter for alternative (network) voltage measuring
  - 1 voltmeter for direct voltage measuring up to 200V, with 1% precision on 50V (0.5V)
- 1 current probe 60Amp
- 1 variable load unit 60V, 0-30A
- Branch feeders
- Auto-transformer 14A, 230V
- Dryer
- Screwdriver
- Oscilloscope
- Spare board kit: PRL, PWN, ILG
- Spare lamp
- Spare network fuses and transistor fuses

8.2 Procedures

Further text provides precise procedure to be followed under rectifier failure conditions.

a) Defining if there is any failed rectifier

"НИ" on measuring and diagnostics panel front board is illuminated and sound alarm is activated.

b) Detecting the failed rectifier

Check all system rectifiers. Network voltage signaling lamp and panelmeter for output current/voltage value display can not be illuminated at one time on failed rectifier. Only one of these two indicators can be illuminated.

c) Activities to follow, depending on indication

On ТЕМП indicator illuminated, wait until it's turned off and repeat procedure. If ТЕМП indicator is not illuminated, there are several possibilities: under item d), panelmeter indicates certain output voltage/current value and lamp is not illuminated; item e), neither lamp nor panelmeter are illuminated; item f), panelmeter is turned off and lamp is illuminated.

d) Lamp is not illuminated

d1) If panelmeter displays correct values of output voltage, lamp is irregular. Switch off the rectifier, remove it from the system, open (see 8.3) and replace the lamp. Lamp is mounted to the front board following "SNAP-IN" mounting method. Brake off two wires connecting the lamp. Extract the lamp through the front board. Mount a new lamp and solder wires onto lamp contacts. Close the rectifier and restore it into system.

d2) Panelmeter is irregular, rectifier should be sent for manufacturer servicing.

e) Neither lamp no panelmeter are illuminated

e1) Switch is off

Make sure that the switch is in position 1 (on), and than go to item e2). If the switch is off, contact the person in charge to check whether rectifier is off for irregularity reasons, or by error, or is only a reserve. In the second and third case, switch it on to check if it's functioning regularly or go back to item c). In the first case, switch the rectifier on and go to item c).

e2) Network voltage out of allowed range

Rectifier might be deactivated in the event of internal overvoltage protection. Within *C3000* system, network voltage value out of tolerances is signalized on the front measuring and diagnostics board, with AM indicator. After overvoltage termination, rectifier is automatically started. If such overvoltage state is uninterruptable, as when caused by

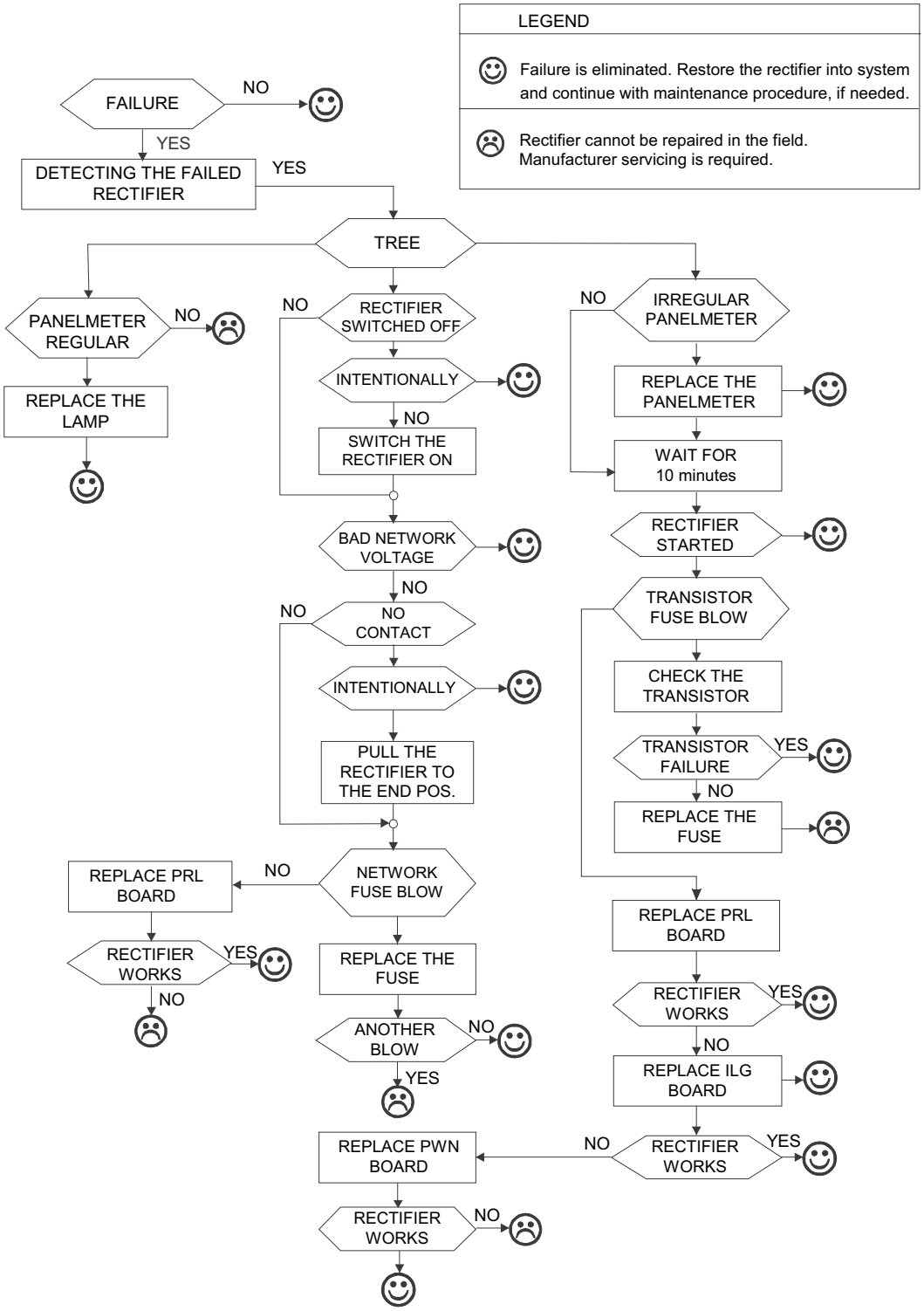

Figure 19: *H1400T rectifier maintenance algorithm*

installation damages, rectifier remains switched off permanently. It is therefore necessary to check network voltage value. On network voltage out of range (over $253V_{eff}$ or under $180V_{eff}$), rectifier is most probably irregular and needs to be tested in accordance to section 7 of the current document. After network voltage error elimination, rectifier is restored to the system.

e3) No contacts released

Check if rectifier is pulled along slides into shelf, to the end position. If not, deactivate the front board switch and pull the rectifier to the end position. Switch on and go to item a).

Note: rectifier might not be pulled to the end position, in the same line with other rectifiers. This could be done intentionally, when using the rectifier as a reserve only.

e4) Network fuse reacted

Deactivate rectifier front board switch, extract the rectifier from the rack and check the meltable network fuse located on the back rectifier board. If it's regular, continue with item e5), if there was some reaction, replace it and restore rectifier to the system. If the fuse blows out again after switching on, rectifier requires manufacturer servicing. If it doesn't blow go back to item a).

e5) Main relay is not operating

Due to logic operation irregularities, main relay may not connect network voltage to power processor. Therefore, try following: open the rectifier and replace PRL board. PRL board is mounted using mother board connector and slid along two plastic guide pins. Remove the old board pulling it in direction upwards. Insert a new board to the old position pulling it downwards. On board connector reaching mother board pins, gently push the board to the end position. Close the rectifier, restore it into system and activate using front board switch. If the rectifier still won't operate, prepare it for manufacturer servicing.

f) Panelmeter is not illuminated

f1) Irregular panelmeter

Switch other system rectifier panelmeters to output current measuring. Switch off the rectifier with specified panelmeter. If it's regular, other rectifier currents shall increase, due to equally distributed rectifier currents. In such case, switch the rectifier off, remove it from the system and replace the panelmeter as described under item 64). Test the rectifier according to section 7 of the current document, restore into system and switch it on.

In systems with small consumption and great variations, resulting in great number of modules, switching the rectifier off may cause negligible changes of rectifier currents, so the rectifier regularity cannot be precisely determined. A small trick shall do: switch

off several rectifiers so those that remain active provide considerably high currents; this way, the change of current distribution caused by switching the rectifier with irregular panelmeter off shall be clearly visible.

f2) Temperature protection

Due to heat sink high temperature, rectifier is automatically switched off to prevent possible failures. Carefully performed system cooling should prevent most such situations.

Rectifier suspension caused by temperature irregularity is detected as following: carefully touch the rectifier with your hand (but not the palm of the hand); if it's hot, wait for ten minutes, if it starts everything is regular, if not go to item f3); if the rectifier is cold, immediately continue with item f3).

Note: rectifier deactivated by temperature protection has around 60°C temperature value, which is hot to touch. Therefore, be very carefully to avoid skin burn.

f3) Transistor fuse

Extract the rectifier from the system and open it, as described under item 8.3. Check transistor fuse located on DRV board. If not visible, use instrument to check if the fuse blew. If not, follow the item f4) and if the fuse blew, check main transistor, following the item 8.5. If the transistor is regular, replace transistor fuse, close the rectifier, restore it to the system and switch on. Continue procedure starting from item a).

f4) Irregular PRL board

After fuse check performed (item f3), rectifier is already opened. Replace PRL board following item 8.6. Close the rectifier, restore it to the system and switch on. If it reacts the same as before board replacement, go to item f5), if not, item a).

f5) Irregular ILG board

After fuse check (item f3), rectifier is open. Replace ILG board in accordance with item 8.6. Close the rectifier, restore it to the system and switch on. If it reacts the same as before board replacement, go to item f6), if not, item a).

f6) Irregular PWN

After fuse check (item f3), rectifier is open. Replace PWN board in accordance with item 8.6. Close the rectifier, restore it to the system and switch on. If it reacts the same as before board replacement, rectifier requires manufacturer servicing. Otherwise, go to item a).

8.3 Rectifier opening

Extract the rectifier from the system:

- set the rectifier front board switch to off position

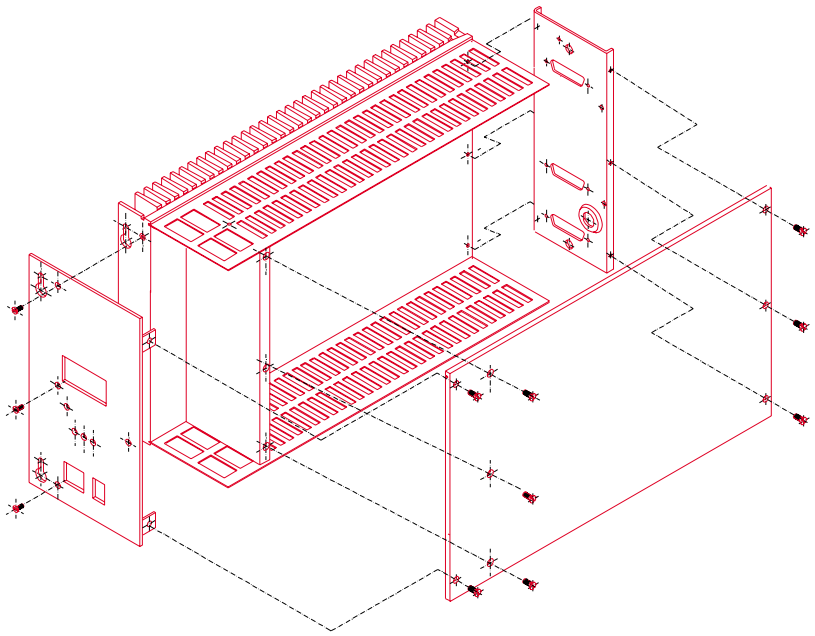

Figure 20: *I1400T rectifier opening*

- fix the handle for rectifier rack extraction (delivered with C3000 system) into appropriate front board openings
- pull the rectifier out until back board connectors detach
- slowly extract the rectifier from the rack

Place the rectifier onto flat horizontal surface with the heat sink side downwards. Viewed from above, 8 screws are found on the rectifier lateral side, 5 close to front side and 3 closer to the back side. Unscrew them all, remove and put aside. Lift the lateral side upwards to make mother board connectors reachable. Disconnect mother board connectors leaving the wires ending with female connectors free on the lateral side. This way, lateral side is removed from the mother board. Put it aside.

Rectifier opening procedure is illustrated in figure 20.

8.4 Panelmeter replacement

After opening the rectifier, panelmeter board with mounted displays is visible in a channel behind the front board. Replacement is performed as following:

- break off two wires connecting potentiometer and panelmeter
- break off two wires connecting panelmeter and test points for panelmeter voltage measuring
- separate the connector using flat cable to connect mother board and panelmeter, leaving the flat cable, ending with connector, in connection with panelmeter board
- unscrew two nuts on spacers carrying panelmeter board and put them aside
- unscrew the front board nut of selection switcher for current/voltage measuring (for rectifier variant with selection switch).

Panelmeter is now released and may be sent for manufacturer servicing. Apply the opposite procedure to instal a new one:

- place the panelmeter into channel to fit onto spacers and pull the switch through the front board
- screw the nut onto switch and two M3 nuts onto spacers
- connect flat cable connector onto mother board
- solder 2 potentiometer wires to panelmeter
- solder 2 test point wires to panelmeter.

8.5 Transistor check

Switch the instrument to resistance measuring. Apply positive (+) instrument end (red test lead) to transistor collector reachable on transistor fuse contact on DRV board. Apply negative (-) instrument end (black test lead) to transistor emitter reachable on board contact of input filter capacitor battery. Touch the contact closest to front rectifier board with DRV board wire reaching. Instrument may detect short circuit between these two spots. Otherwise, transistor is most probably regular.

Figure 8 shows transistor (collector and emitter) control points.

8.6 Board replacement

Replacement procedures for PRL, ILG and PWN boards are practically the same, since all boards are mounted the same way. Extract the old board pulling it in the upward direction. Insert a new board to the old position pulling it to downward direction. On board connector reaching mother board pins, gently push the board to the end position.

Figure 21 shows board positions within rectifier.

1. -panelmeter indicator (PMI) board;
2. -DRW board;
3. -collector;
4. -IF, output filter;
5. -IZF board;
6. -PWN board;
7. -ILG board;
8. -PRL board;
9. -power factor corrector;
10. -input fuse.

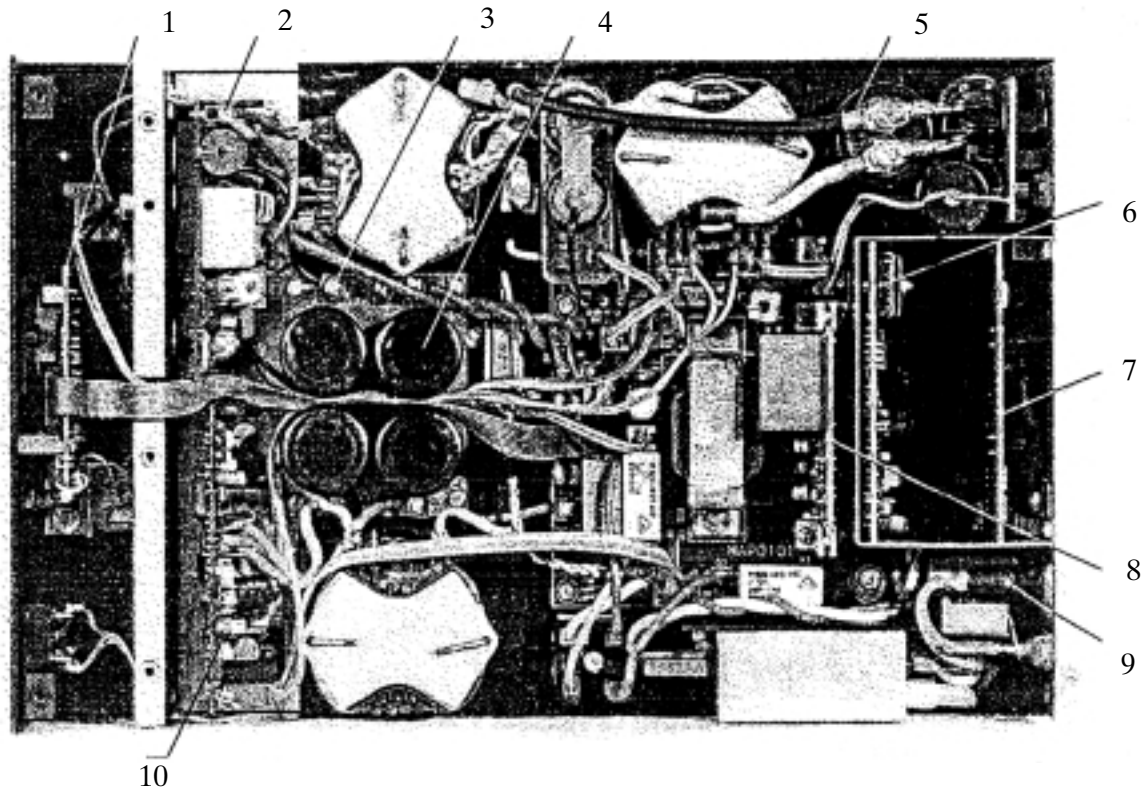

Figure 21: *I1400T rectifier positions*

9 SUPPLEMENT LIST

9.1 Material specification for И1400T rectifier

9.2 Signal layout on connector pins

9.3 Component layout on И1400T rectifier mother board

9.4 Electrical schemes of И1400T rectifier

1. General block scheme
2. Detail scheme of input (network) rectifier part
3. Detail scheme of output rectifier part