THYRISTOR POWER REGULATORS
TPR1, TPR3

USER'S MANUAL

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CONTENTS

1. APPLICATION AND FUNCTIONS

Thyristor single-phase power regulator (TPR1) and three-phase (TPR3) is intended to adjust the power of active load and active-inductive one in the AC nets with voltage 220/380V. In the TPR has been used a phase method to adjust the power in load; at this method changing of load power is carried out by changing by duration of pair open state of inverse-parallel thyristors, during a relevant half-period of the net voltage. The TPR TPM is used in the automotive temperature regulation systems and other technological parameters.

The TPR operates as a part of control devices (third party manufacturer) having a DC standard analogue output signal. The value of the power is adjusted by applying the control signal having standard kind (0…5 V, 0…10 V, 4…20 mA, 0…5 mA, 0…20 mA); changing of the signal from minimum to maximum changes the output power value from 0 to 100%. In the TPR is maintained a galvanic isolation of control circuits and power circuits.

The TPR maintains the following functions:

–commutation of alternating voltage;
–changing of output power by phase method;
–smooth start at supplying voltage;
–galvanic insulation of load circuits from signal circuits;
–protection against overload in load circuit;
–forming of status signal «Overload» (output – open collector);
–control of phase loss (for TPR3);
–forming of status signal «Loss» (output – open collector) (for TPR3);
–forming of voltage 24 V of DC (for supplying of controlling device).

The TPR maintains the operation from AC net with linear voltage up to 450V and maintains the control by load voltage with current consumption up to 250 A (rms).

2. PRODUCED TPR

By the control types the modules TPR1 and TPR3 are represented by the following versions:
A – maximum amplitude of control signal corresponds to minimum output power;
B – maximum amplitude of control signal corresponds to maximum output power;
By the control signal type by thyristors conductance angle (signal of input «+Ctrl»):
1 – potential control 0…5 V;
2 – potential control 0…10 V;
3 – current control 4…20 mA;
4 – current control 0…5 mA;
5 – current control 0…20 mA;

Independently from the control type TPR1 are produced with an amount of maximum output rms current 25,40,63,100,160,250 A, with peak voltage 1200 V;

The TPR3 are produced with an amount of maximum output rms current 100,160,250 A (current of each phase), with peak voltage 1200 V.

On Figure 2.1 is shown TPR name explanation.

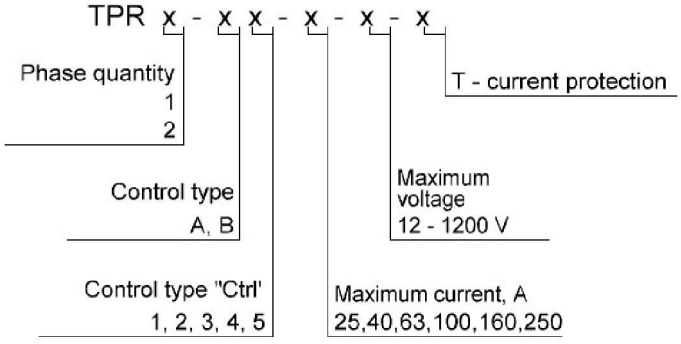

Figure 2.1 – TPR name explanation

For example, , TPR1-B1-100-12-T: thyristor single-phase power regulator with potential control 0…5 V, maximum amplitude of control signal corresponds to maximum load voltage, with maximum rms load current 100 A and peak voltage of power circuit 1200 V.

3. GENERAL DESCRIPTION OF TPR

The TPR is an assembly of power supply, thyristors' control circuit and power thyristors based on modules M25. The structural circuits of TPR1 and TPR3 are represented on Figures 3.1 and 3.2.

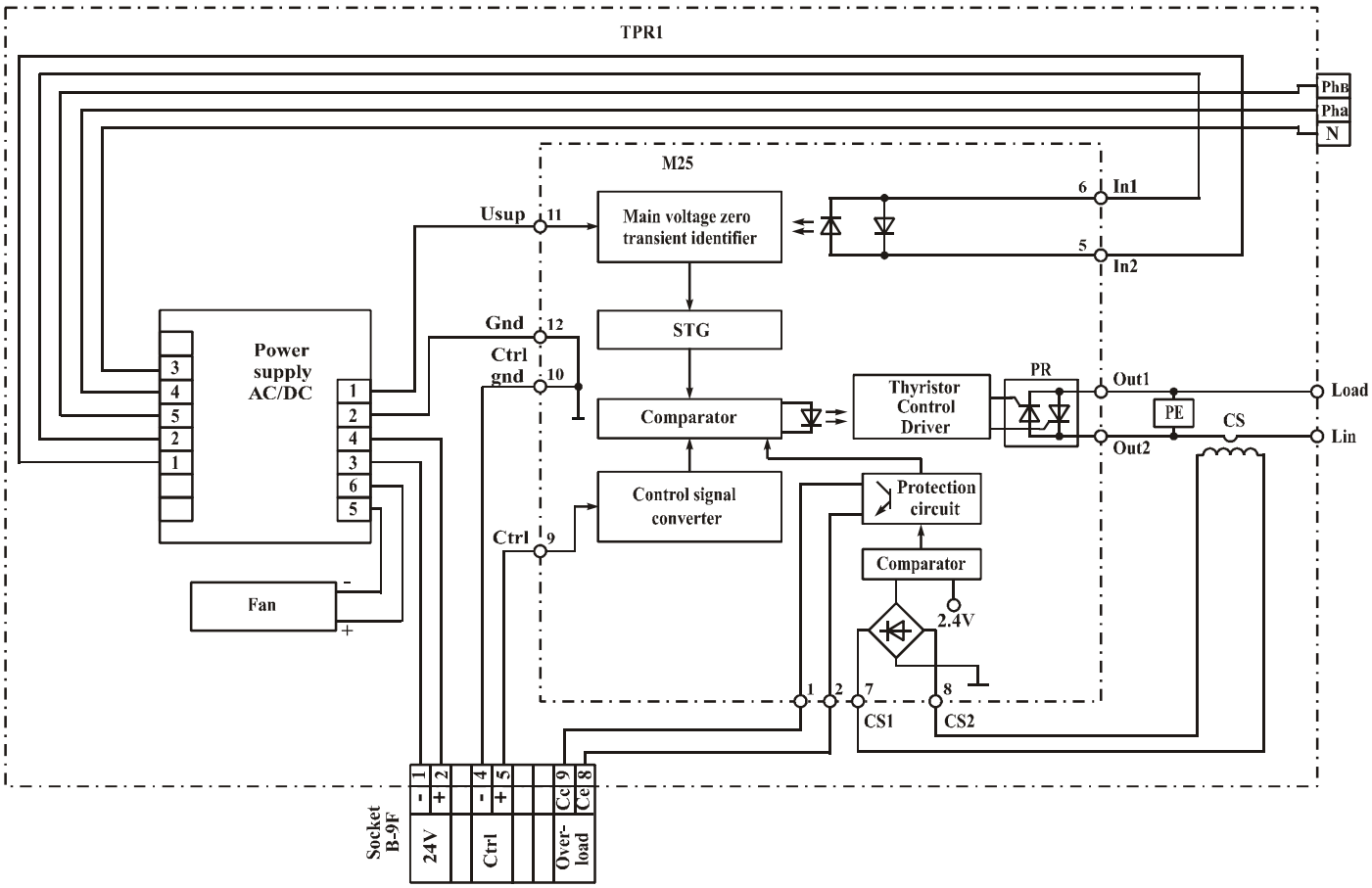

Figure 3.1 – Structural circuit of TPR1

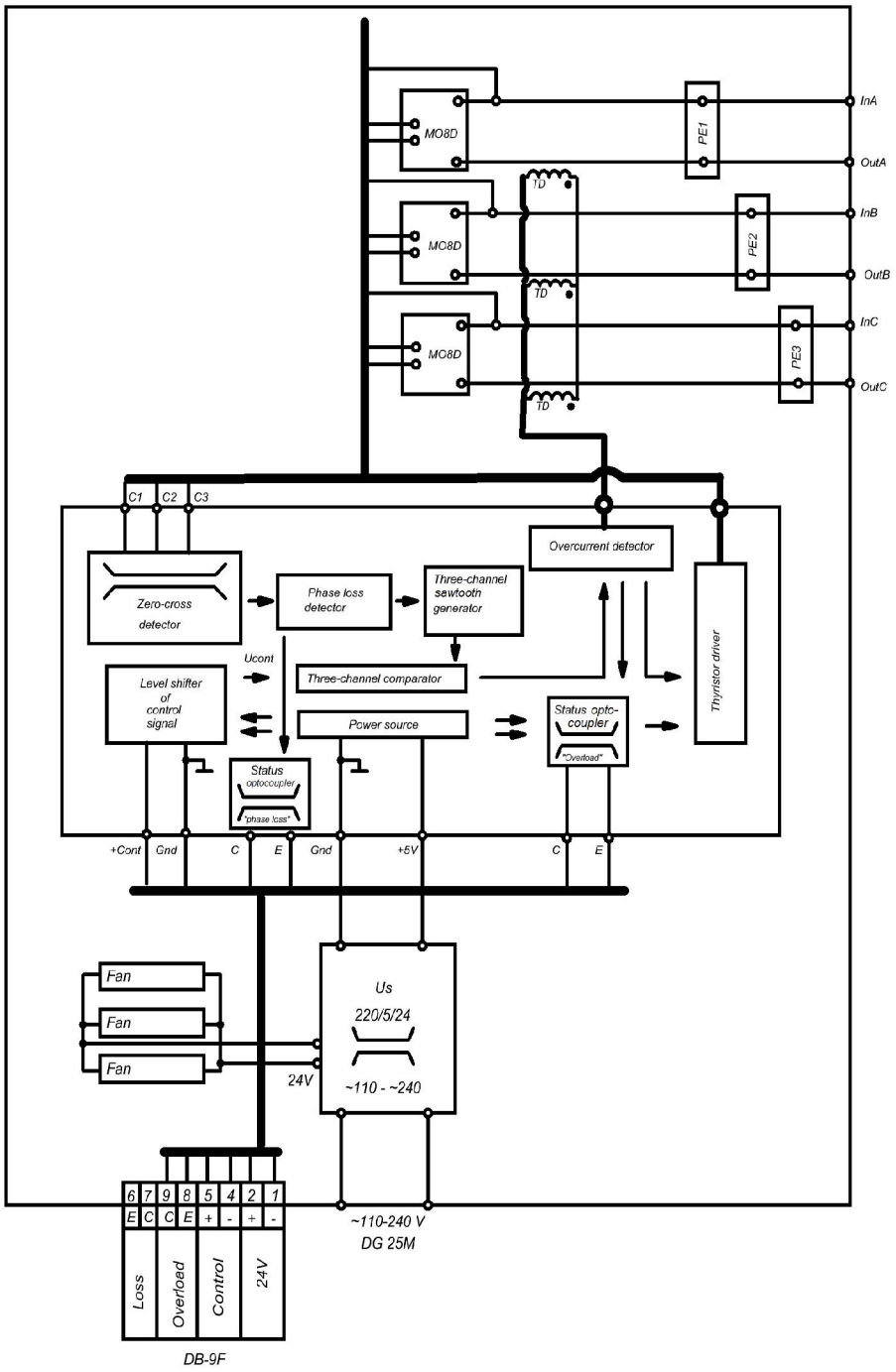

Figure 3.2 – Structural circuit of TPR3

The power terminals of the TPR – for bolts M6, M8 or M10 (see the overall drawings). The control socket - DB-9F with a mate DB-9M (included in the supply package). The supply socket – is a terminal block for screws M5 of kind DG-25. The application of the control socket outputs and power outputs are represented in Table 3.1.

Table 3.1 – Output application of TPR

Socket	Output #	Name	Application
Control (DB-9F)	1	-24 V	Output «common» of voltage source 24 V
	2	+24 V	Output «+» of voltage source 24 V
	3	-	Not used
	4	-Ctrl	Input for connection of «common» control signal
	5	+Ctrl	Input for connection of «+» control signal
	6	Oe	Emitter output of net break indication status transistor (for TPR3)
	7	Oc	Collector output of net break indication status transistor (for TPR3)
	8	Ce	Emitter output of overcurrent indication status transistor
	9	Cc	Collector output of overcurrent indication status transistor
Supply (DG-25)	1	Pha	Supply input of control circuit - phase A
	2	Phв	Supply input of control circuit - phase B
	3	N	Supply input of control circuit - neutral
Power outputs	-	Lin	Power input for net voltage connection (for TPR1)
	-	Load	Power output for load connection (for TPR1)
	-	InA, InB, InC	Power input for net voltage connection of phase «A», «B», «C» (for TPR3)
	-	OutA, OutB, OutC	Power output for load connection of phase «A», «B», «C» (for TPR3)

It is not allowed to lay the power line and control circuits when mounting in one bundle or common pipe (duct). Avoid loops in connecting wires of control and supply circuits. Connecting wires should be performed by twisted pairs to provide noise immunity.

4. BASIC AND MAXIMUM PERMISSIBLE PARAMETERS

Basic electric parameters and maximum permissible of TPR at temperature 25^0C are represented in Tables 4.1 and 4.2.

Table 4.1 – Basic and maximum permissible parameters of control and supply circuits

Parameter	Unit	Control type									
		A1	**A2**	**A3**	**A4**	**A5**	**B1**	**B2**	**B3**	**B4**	**B5**
Supply voltage	V	~ 110…240									
Consumed power, max	W	15									
DC voltage for supplying of external device	V	22…24									
DC source power for supplying of external device, max	W	4									
Control signal value that corresponds to minimum power	V	5±0.5	10±1	-	-	-	0÷0.5	0÷1	-	-	-
	mA	-	-	20±2	5±0.5	20±2	-	-	4±0.4	0÷0.5	0÷2
Control signal value that corresponds to maximum power	V	0÷0.5	0÷1	-	-	-	5±0.5	10±1	-	-	-
	mA	-	-	4±0.4	0÷0.5	0÷2	-	-	20±2	5±0.5	20±2
Control signal input circuit resistance, max	kΩ	12.5	11.1	0.062	0.2	0.05	12.5	11.1	0.062	0.2	0.05
Voltage on input «Ctrl», max	V	6	12	2	2	2	6	12	2	2	2
Duration of blocking in overcurrent (typical)	ms	300									
Collector current of status outputs (max)	mA	50									
Collector-emitter voltage of status outputs (max)	V	40									
Insulation strength of supply circuits and input circuits relatively to output circuits (AC, 50 Hz)	V	2500									
Insulation strength of status circuits relatively to input circuits (AC, 50 Hz)	V	500									
Isolation resistance of output circuits and supply circuits between each other relatively to housing at normal conditions (min)	MΩ	40									

Table 4.2 – Basic and maximum permissible electric parameters of power circuits

Parameter name, Unit	**Symbol**	**Maximum current of TPR, A**					
		25	**40**	**63**	**100**	**160**	**250**
Repetitive pulse voltage: reverse / in off-state (max), V	V_{DRM} /V_{RRM}	±1200					
Minimum switching voltage (rms), (min), V	$V_{O(RMS)\ min}$	~ 200					
Maximum switching voltage (rms), (max), V	$V_{O(RMS)\ max}$	~ 450					
Minimum switching current (rms), (min), A	$I_{O(RMS)\ min}$	0.2	0.2	0.2	0.2	0.5	0.5
Maximum switching current (rms), (max), A	$I_{O(RMS)\ max}$	25	40	63	100	160	250
Surge current in on-state t=10 ms (max), A	I_{TSM}	200	300	750	1250	2000	3200
Protection operation current (typical), A	I_{CP}	35	56	89	141	226	353
Repetitive pulse current: in close state / reverse current (max), mA	I_{DRM} / I_{RRM}	±1					
Pulse voltage in open state at I= $I_{O(RMS)\ max}$ (max), V	V_{TM}	1.65					
Extreme current rise rate in open state (max), A/µs	$(di_T/dt)_{crit}$	160					
Extreme voltage rise rate in open state (max), V/µs	$(du_d/dt)_{crit}$	500					
Insulation strength of supply circuits, output, input circuits relatively to housing (AC, 50 Hz), V	V_{ISOL}	2500					
Isolation resistance of output circuits relatively to housing at normal conditions (min), MΩ	R_{ISOL}	40					

5. OPERATION AND TPR CONTROL

Typical switching circuits of TPR1are represented on Figures 5.1 and 5.2, typical switching circuit of TPR3 is represented on Figure 5.3.

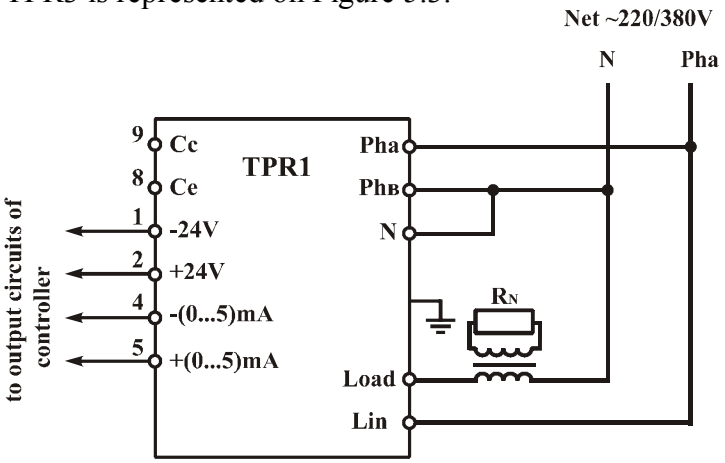

Figure 5.1 – Switching circuit of TPR1 in single-phase mode «Phase – Zero»
(active load or active-inductive one is optimized for phase voltage ~220 V)

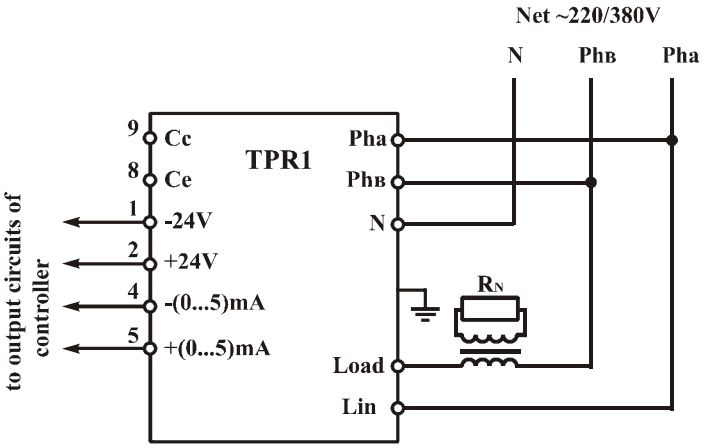

Figure 5.2 – Switching circuit of TPR1 in single-phase mode «Phase – Phase»
(active load or active-inductive one is optimized for linear voltage ~380 V)

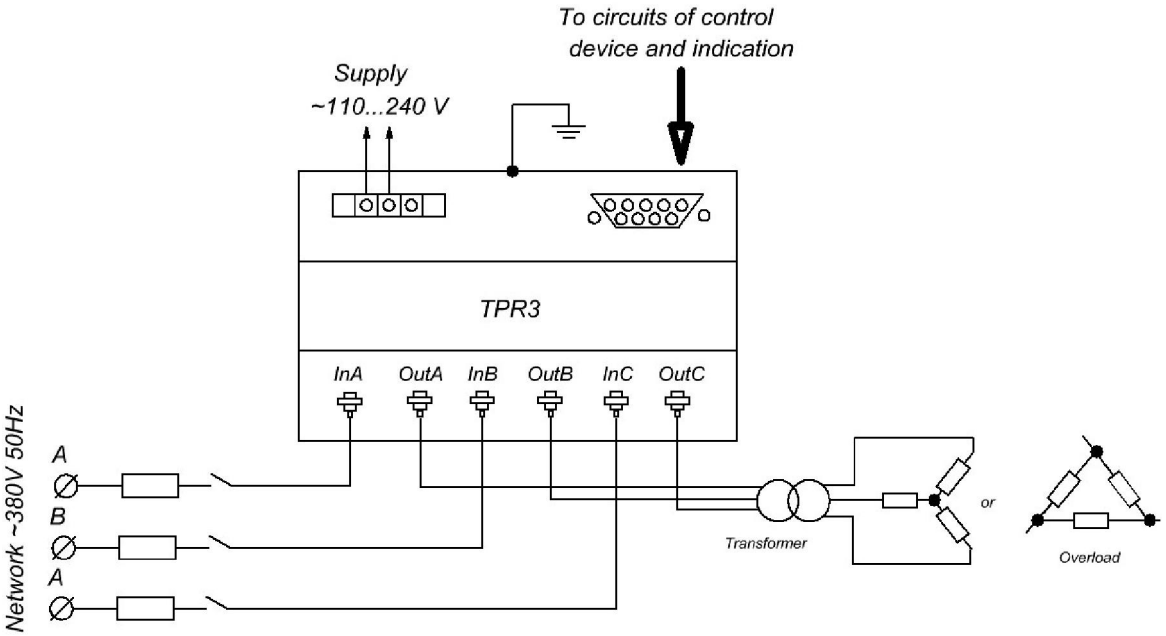

Figure 5.3 – Switching circuit of TPR3

The TPR operates the follows:

A unit for net synchronization forms pulses at the moment of mains voltage zero transient, which synchronize sawtooth generator (STG). In the comparator the STG will be compared to control signal U_{cont} that is received from input signal converter circuit. When the STG reaches the value U_{cont} a pulse will be generated that switches on the power rectifier (thyristor). Changing of control signal value leads to changing of equality moment between STG and U_{cont} and accordingly turn-on phase of PR. Thereby load power regulation will be reached.

The power regulator is provided for smooth launching mode (500 ms, typ.) of supply turn-on that ensures inrush current decrease at operation to active-inductive load (transformer). The TPR is also supplied with overload protection against reaching of instantaneous load current more than 1.41 $I_{com.\ rms}$, the TPR removes load voltage, the status transistor will be open. In 300 ms protection will be removed, status

optocoupler transistor will be closed and there is smooth launch (smooth load voltage rise from null to the value that is determined by control signal value). If an emergency is not eliminated then the above protection cycle will repeat.

Besides of current overload protection the TPR3 has protection that allows controlling voltage at all three phases. Thereby open-phase mode operating is excluded.

If there is a break of one of the phases from the network side then the voltage will be removed from the load and open of status transistor "Break". In the TPR1 the function is absent.

The TPR3 is not sensitive to phase sequence.

The TPR control maintains using the following outputs:

«Pha», «Phв», «N». Output for connection of alternating supply voltage of control circuit. The circuits for supply voltage connection are shown on Figures 5.1 and 5.2. The connection of TPR3 is similar. The consumed power for the inputs is not more than 15 W.

«-Ctrl». Common output for setting of thyristors conductance angle.

«+Ctrl». Output for setting of thyristors conductance angle. Depending on the control type («A» or «B») to maximum value of the control signal corresponds either thyristors' closing (type «A»), or full its opening (type «B»). Depending on the version 1,2,3,4,5 the control signal type is changed (0…5 V; 0…10 V; 0…5 mA; 0…20 mA; 4…20 mA). Dependence of the thyristors' conductance angle (during this time thyristors conduct current) versus relative value of controlling signal for the versions of control "A" and "B" is shown in Figure 5.4.

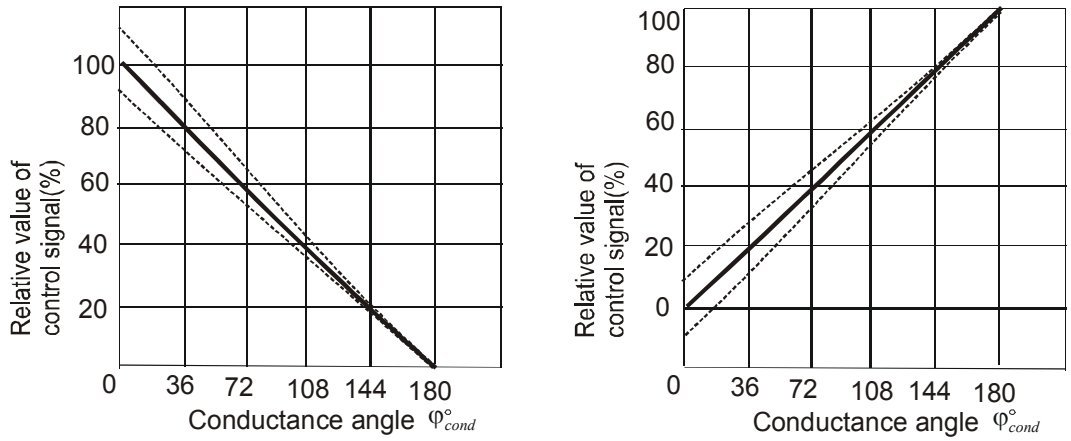

Figure 5.4 – Dependence of the thyristors' conductance angle versus value of controlling signal

«-24 V». Common output of supply voltage 24 V.

«+24 V». Output «+» of internal source of direct voltage 24 V. The voltage source is intended to connect external devices. The voltage source 24 V does not have any built-in protections against overcurrent, not allowed the overload of the source; the load current should not exceed 150 mA.

«Cc», «Ce». Outputs of collector and emitter of status transistor of current protection operation indication. The presence of overcurrent of the power circuit leads to the transistor opening. The voltage between the outputs «CTc» и «CTe» should not exceed 40 V, including pulsation. The load current is not more than 50 mA.

«Oc», «Oe». Output of collector and emitter of phase break indication status transistor. The break of the power circuit leads to the transistor opening. The voltage between the outputs «Oc» and «Oe» should not exceed 40 V, including pulsation. The load current is not more than 50 mA. The outputs are used for TPR3 only.

The status outputs are galvanically isolated from the control circuits by isolation strength not less than 500 V (AC). In the case if the control is carried out with a circuit without insulation of controlling and status circuits then it is recommended uniting the outputs «-Ctrl» and the emitters' outputs of the status transistors.

6. INSTRUCTIONS FOR USE

General requirements

It is recommended operating the TPR when operating value of average current not more than 80% from the specified in the name and the junction temperature not more than (70÷80)% from the maximum one. The TPR operating is not allowed when simultaneous impact of two or more maximum permissible parameters.

In an electric circuit of equipment with use of the TPR should be provided a fast-speed protection against unallowable loads, short circuits and commutating overloads.

Connection to TPR

Electric wires and cables will be connected to power contacts of the TPR by means of screws M6, M8 or M10 with torque (5 ± 0.5) N·m and the washers that are supplied in the package.

The power wires should be connected by means of connectors with corrosion-resistant coat, which are purified of foreign layers. When screws (bolts) are tightened it is recommended fastening the connection with paint. It is recommended tightening screws (bolts) repeatedly in 8 days and in 6 weeks after commencement of the operation. Afterwards the tightening should be controlled at least once a half year.

The controlling TPR outputs are intended for mounting in equipment by means of socket connectors (control socket) or by means screws (supply socket).

When mounting and operating it is necessary to make protection measures of the TPR against static electricity impact; the mounting personnel should use ground bands and grounded low-voltage soldering irons with transformer supply.

Operation requirements

The TPR should be used under climatic loads in accordance with Table 6.1.

Table 6.1 – Climatic loads impacts

Climatic factor	Climatic factor value
Low ambient temperature, °C	- 5
High ambient temperature, °C	+ 65
Relative humidity at temperature 35 °C without moisture condensation, %, max	80

Safety requirements

1. Operation with the TPR should be carried out only by qualified personnel.
2. The TPR housing should be grounded.
3. Do not touch the TPR power outputs when applying the supply voltage.
4. Do not connect or disconnect wires and connectors while on the power circuits are energized.
5. If the TPR is not grounded and energized, do not touch it.
6. Do not touch the TPR housing during the operation because its temperature can be very high.
7. If the TPR is smoking, smelling or abnormal noising, immediately turn off the power; check the correct connection of the TPR.
8. Avoid contacting to the TPR with water and other liquids.

7. RELIABILITY REQUIREMENTS

The manufacturer guarantees the quality of the module all the requirements of the user's manual if the consumer observes terms and conditions of storage, mounting and operation, as well as guidance on the application specified in the user's manual.

Operating warranty is 2 years from the acceptance date, in the case of requalification – from the date of the requalification.

Reliability probability of the driver for 25000 hours must be at least 0.95.

Gamma-percent life must be no less than 50000 hours at $\gamma = 90$ %.

Gamma-percent service life of the modules, subject to cumulative operating time is not more than gamma-percent life, not less than 10 years, at $\gamma = 90$ %.

Gamma-percent storageability time of the modules, at $\gamma = 90$ % and storing – 10 years.

8. OVERALL AND CONNECTING DIMENSIONS

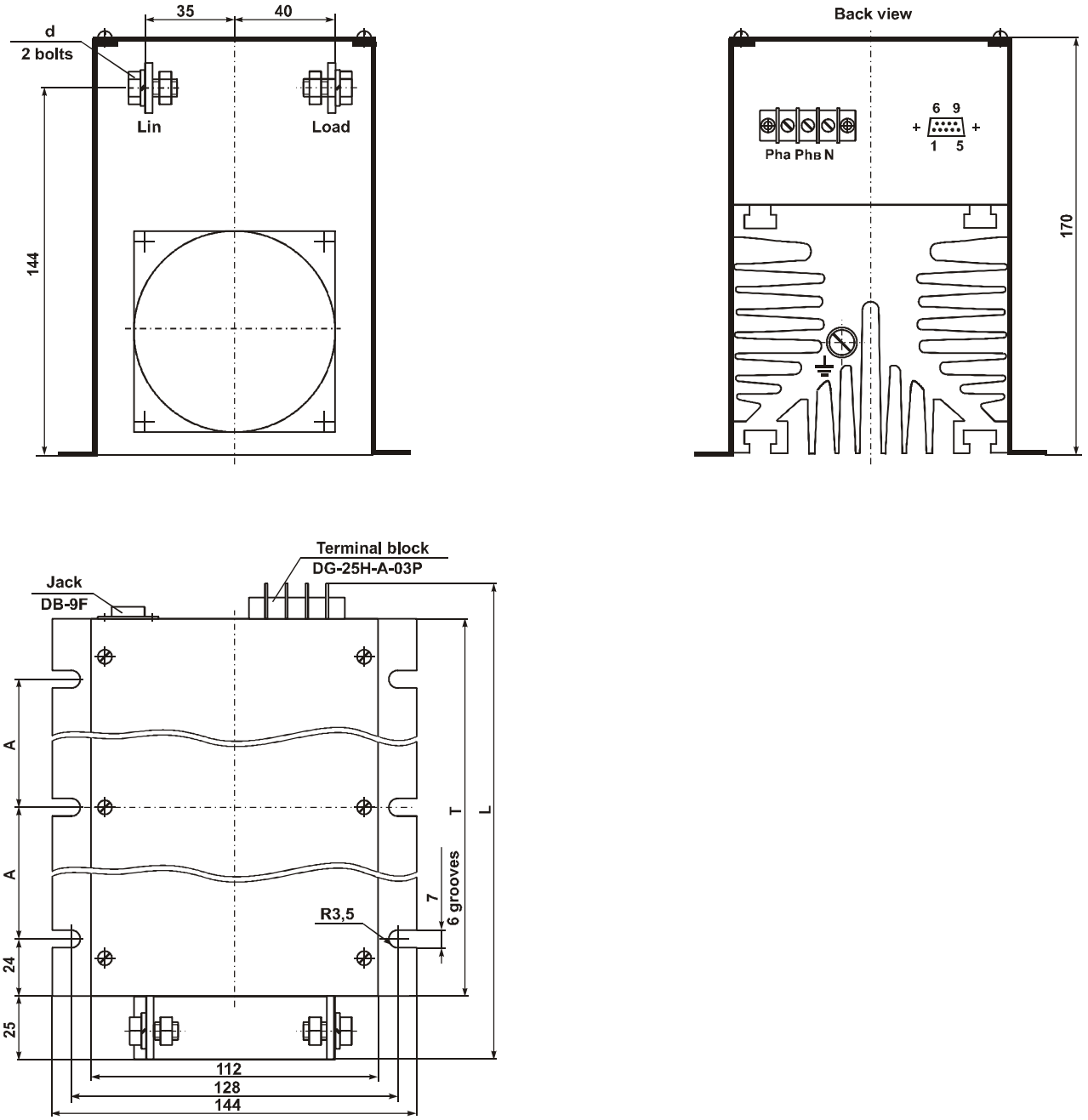

Figure 8.1 – Overall and connecting dimensions of TPR1

Table 8.1 – Table of overall dimensions versions of TPR1

Symbol	L	T	A	d
TPR1- … - 25 - T	310 max	258	105±0.5	Screw M6
TPR1- … - 40 - T				
TPR1- … - 63 - T				
TPR1- … - 100 - T				
TPR1- … - 160 - T	310 max	258	105±0.5	Bolt M8
TPR1- … - 250 - T	410 max	358	155±0.5	Bolt M8

Table 8.2 – Weight-size parameters of TPR1

Parameter name		Unit	Value	Note
Weight	max	kg	6.5	25…160 A
			8.2	250 A
Overall dimensions	max	mm	310 × 144 × 170	25…160 A
			410 × 144 × 170	250 A

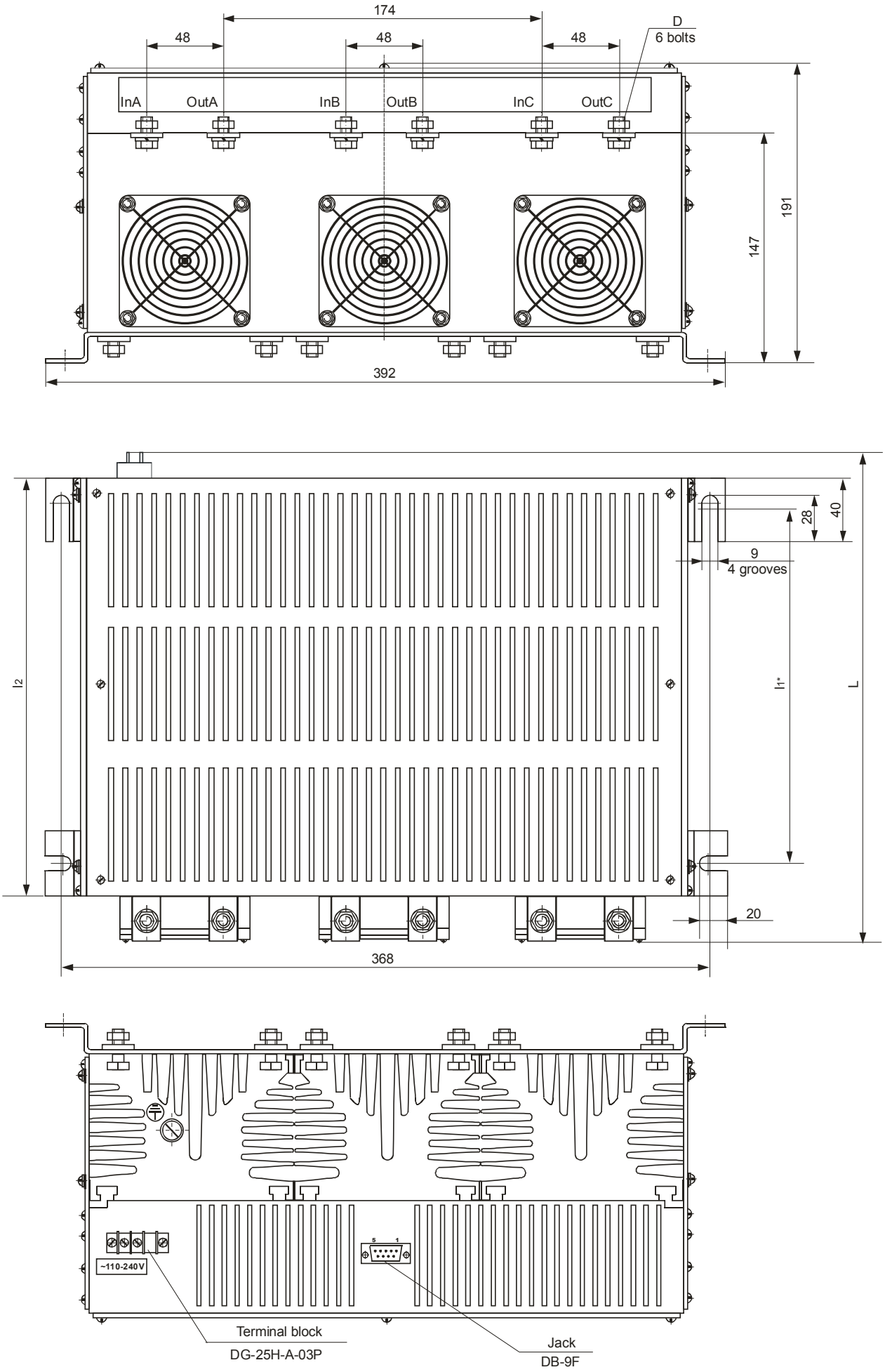

Figure 8.2 – Overall and connecting dimensions of TPR3

Table 8.3 – Table of overall dimensions versions of TPR3

Current, A	**100**	**160**	**250**
D	M8		M10
l_1, mm	218		318
l_2, mm	258		358
L, mm	305		410

Table 8.4 – Weight-size parameters of TPR3

Parameter name		**Unit**	**Value**	**Note**
Weight	max	kg	19	25…160 A
			23	250 A
Overall dimensions	max	mm	368x218x305	25…160 A
			368x248x288	250 A

Precious metals are not contained.

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