TRANSISTOR MODULES MOSFET
M9, M12, M12.1

USER'S MANUAL

5 Naugorskoe shosse, Orel, 302020, Russia Tel. +7(4862) 44-03-44, Fax +7(4862) 47-02-12,
E-mail: mail@electrum-av.com

CONTENTS

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1. APPLICATION AND PRODUCED MODULES

MOSFET-modules are assemblies of MOSFET-transistors intended to commutate power loads as a part of converters with maximum peak voltage up to 250 V and DC up to 500 A. The MOSFET-modules have the following versions (specified maximum permissible values of currents and voltages):

M9 – single transistor with a built-in reverse diode. The module is produced in the following variants:

Peak voltage 40 V with an amount of DC 100,200,300,400,500 A.

Peak voltage 60 V with an amount of DC 150,220,300,360,450 A.

Peak voltage 100 V with an amount of DC 120,160,200,250,300,400 A.

Peak voltage 200 V with an amount of DC 120,160,200,240,320,400 A.

Peak voltage 250 V with an amount of DC 120,150,200,240,300 A.

M12 – two series connected MOSFET-transistors (half-bridge) with built-in reverse diodes. The module is produced in the following variants:

Peak voltage 40 V with an amount of DC 100,200,300,400,500 A.

Peak voltage 60 V with amount of DC 75,150,220,300 A.

Peak voltage 100 V with an amount of DC 120,160,200,250 A.

Peak voltage 200 V with an amount of DC 120,160,200 A.

Peak voltage 250 V with DC 120 A.

M12.1 – two back-to-back MOSFET-transistors (common emitter) with built-in reverse diodes. The module is produced in the following variants:

Peak voltage 40 V with an amount of DC 100,200,300,400,500 A.

Peak voltage 60 V with amount of DC 75,150,220,300 A.

Peak voltage 100 V with an amount of DC 120,160,200,250 A.

Peak voltage 200 V with an amount of DC 120,160,200 A.

Peak voltage 250 V with DC 120 A.

Depending on the current and version the MOSFET-modules are produced in the designs represented in Table 1.1. The modules are produced only in the versions where at crossing the current line and the voltage column is specified the drawing figure of the overall drawing corresponding to the version.

On Figure 1.1 is shown the modules' name explanation.

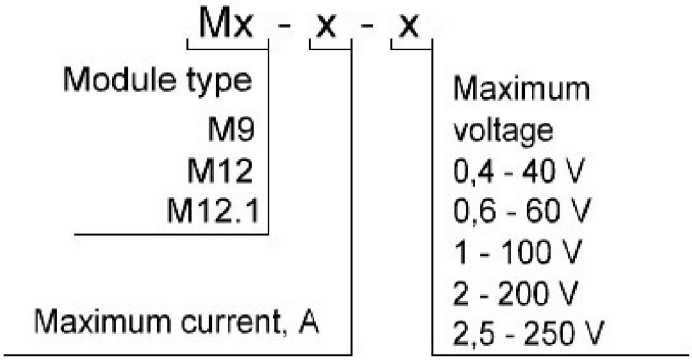

Figure 1.1 – Modules name explanation

For example, module M12-120-2: half-bridge with maximum permissible drain-source voltage 200 V and maximum permissible DC 120 A.

Table 1.1 – Produced MOSFET-modules and overall dimensions corres. to them

Module type	Current, A	Voltage class				
		0,4	0,6	1	2	2,5
M9	100	Fig. 6.5				
	120			Fig. 6.6	Fig. 6.4	Fig. 6.6
	150		Fig. 6.6			Fig. 6.6
	160			Fig. 6.6	Fig. 6.4	
	200	Fig. 6.6		Fig. 6.4	Fig. 6.4	Fig. 6.4
	220		Fig. 6.6			
	240				Fig. 6.4	Fig. 6.4
	250			Fig. 6.4		
	300	Fig. 6.6	Fig. 6.4	Fig. 6.4		Fig. 6.4
	320				Fig. 6.4	
	360		Fig. 6.4			
	400	Fig. 6.4		Fig. 6.4	Fig. 6.4	
	450		Fig. 6.4			
	500	Fig. 6.4				
M12	75		Fig. 6.1			
	100	Fig. 6.1				
	120			Fig. 6.2	Fig. 6.2	Fig. 6.2
	150		Fig. 6.2			
	160			Fig. 6.2	Fig. 6.2	
	200	Fig. 6.2		Fig. 6.2	Fig. 6.2	
	220		Fig. 6.2			
	250			Fig. 6.2		
	300	Fig. 6.2	Fig. 6.2			
	400	Fig. 6.2				
	500	Fig. 6.2				
M12.1	75		Fig. 6.1			
	100	Fig. 6.1				
	120			Fig. 6.3	Fig. 6.3	Fig. 6.3
	150		Fig. 6.3			
	160			Fig. 6.3	Fig. 6.3	
	200	Fig. 6.3		Fig. 6.3	Fig. 6.3	
	220		Fig. 6.3			
	250			Fig. 6.3		
	300	Fig. 6.3	Fig. 6.3			
	400	Fig. 6.3				
	500	Fig. 6.3				

2. GENERAL DESCRIPTION

Depending on the module type and maximum circuit DC the modules electric circuits are different; on Figures 2.1 – 2.7 are shown the different circuits' variants of MOSFET-modules.

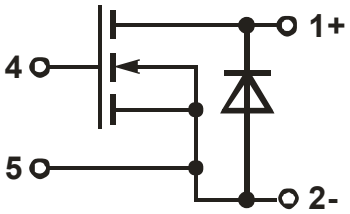

Figure 2.1 – Electric circuit of modules M9 (drawing of Fig. 6.5)

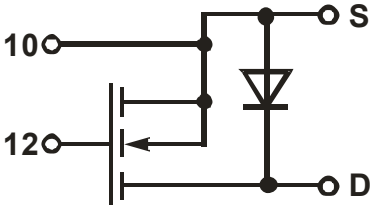

Figure 2.2 – Electric circuit of modules M9 (drawing of Fig. 6.6)

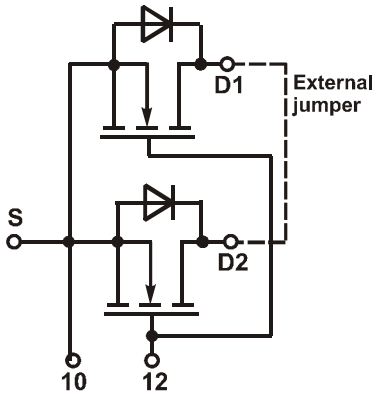

Figure 2.3 – Electric circuit of modules M9 (drawing of Fig. 6.4)

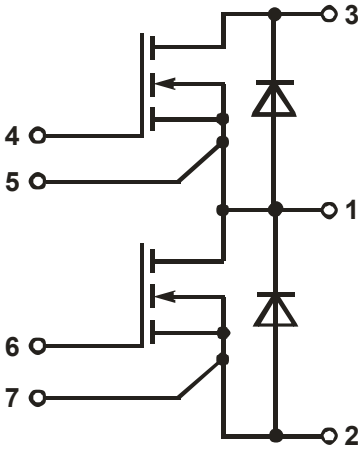

Figure 2.4 – Electric circuit of modules M12 (drawing of Fig. 6.1)

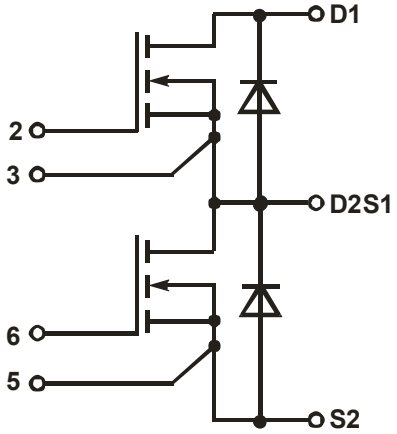

Figure 2.5 – Electric circuit of modules M12 (drawing of Fig. 6.2)

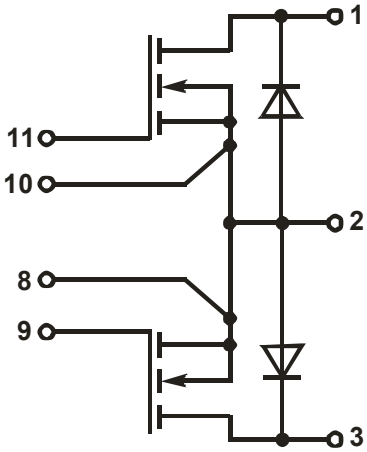

Figure 2.6 – Electric circuit of modules M12.1 (drawing of Fig. 6.1)

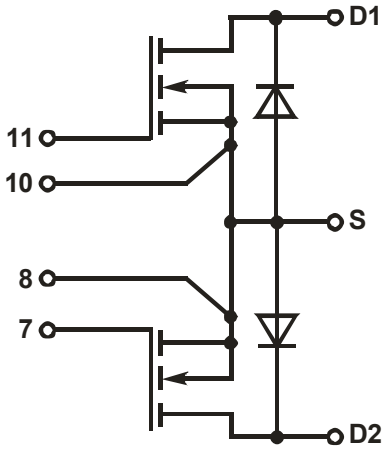

Figure 2.7 – Electric circuit of modules M12.1 (drawing of Fig. 6.3)

Attention! When carrying the gate and source must be circuited!

3. BASIC PARAMETERS

Basic electric parameters and maximum permissible parameters of the modules at temperature 25^0C are represented in Tables 3.1 – 3.6.

Table 3.1 – Basic and maximum permissible parameters of modules of 0,4-th class

Parameter name, unit	Symbol	Maximum module DC, A				
		100	**200**	**300**	**400**	**500**
Basic characteristics						
Breakdown drain-source voltage (min), V	$V_{(BR)DSS}$	40				
Direct voltage of power circuit (max), V	V_{DC}	27				
DC of power circuit (max), A	I_{DC}	100	200	300	400	500
Electric insulation strength circuit/housing (DC), V	V_{ISOL}	1000				
Dissipated power (max), W	P_D	400	1000			
Static characteristics						
Threshold gate-source voltage, V	$V_{GS(th)}$	2…4	2…4	2…4	2…4	2…4
Gate leakage current (max), nA	I_{GSS}	±200	±600	±800	±1200	±1400
Resistance drain-source in on-state (max), mΩ	$R_{DS(on)}$	1.6	0.7	0.8	0.55	0.4
Initial drain current (max), μA	I_{DSS}	20	20	80	120	140
Dynamic characteristics						
Input capacitance (typical), pF	Ciss	6950	19400	14000	21000	28000
Output capacitance (typical), pF	Coss	1750	5100	3500	5250	7000
Transfer capacitance (typical), pF	Crss	970	2500	2000	2900	3850
Switch-on delay time (typical), ns	$t_{d(on)}$	17	13	15	15	15
Rise time (typical), ns	t_r	150	120	135	135	135
Switch-off delay time (typical), ns	$t_{d(off)}$	110	130	120	120	120
Fall time (typical), ns	t_f	105	130	115	115	115
Common gate charge (typical), nC	Q_G	170	420	340	510	680
Reverse diode characteristics						
Direct voltage fall (max), V	V_{SD}	1.3	1.3	1.3	1.3	1.3
Diode DC (max), A	I_S	320	840	640	960	1280
Pulse diode current at t_{pul}=1 ms (max), A	I_{SM}	1360	3240	2720	4080	5440
Reverse recovery current (typical), A	I_{RR}	160	220	320	480	640
Recovery time (max), ns	t_{RR}	65	84	84	84	84
Maximum permissible modes						
Drain-source voltage (max), V	V_{DSS}	40	40	40	40	40
Gate-source voltage (max), V	V_{GS}	±20	±20	±20	±20	±20
Drain DC at Ta=25 °C (max), A	I_D	160	220	320	450	525
Drain DC at Ta=100 °C (max), A	I_D	160	220	320	450	525
Pulse drain current at t_{pul}=1 ms (max), A	I_{DM}	1360	3240	2720	4080	5440
Junction temperature (max), ºC	Tj	175	175	175	175	175

Table 3.2 – Basic and maximum permissible parameters of modules of 0,6-th class

Parameter name, unit	Symbol	Maximum module DC, A					
		75	**150**	**220**	**300**	**360**	**450**
Basic characteristics							
Breakdown drain-source voltage (min), V	$V_{(BR)DSS}$	60					
Direct voltage of power circuit (max), V	V_{DC}	35					
DC of power circuit (max), A	I_{DC}	75	150	220	300	360	450
Electric insulation strength circuit/housing (DC), V	V_{ISOL}	1000					
Dissipated power (max), W	P_D	400	1000				
Static characteristic							
Threshold gate-source voltage, V	$V_{GS(th)}$	2…4	2…4	2…4	2…4	2…4	2…4
Gate leakage current (max), nA	I_{GSS}	±100	±300	±500	±600	±800	±1000
Resistance drain-source in on-state (max), mΩ	$R_{DS(on)}$	3	4	2.4	2	1.5	1.2
Initial drain current (max), μA	I_{DSS}	20	75	125	150	200	250
Dynamic characteristics							
Input capacitance (typical), pF	Ciss	6540	9600	15100	19200	25600	32000
Output capacitance (typical), pF	Coss	720	2070	3450	4150	5500	6900
Transfer capacitance (typical), pF	Crss	360	420	700	840	1120	1400
Switch-on delay time (typical), ns	$t_{d(on)}$	19	17	17	17	17	17
Rise time (typical), ns	t_r	82	80	80	80	80	80
Switch-off delay time (typical), ns	$t_{d(off)}$	55	50	50	50	50	50
Fall time (typical), ns	t_f	83	65	65	65	65	65
Common gate charge (typical), nC	Q_G	120	330	550	660	880	1100
Reverse diode characteristics							
Direct voltage fall (max), V	V_{SD}	1.3	1.3	1.3	1.3	1.3	1.3
Diode DC (max), A	I_S	75	150	225	300	375	450
Pulse diode current at t_{pul}=1 ms (max), A	I_{SM}	840	1000	1650	1980	2650	3300
Reverse recovery current (typical), A	I_{RR}	75	150	225	300	375	450
Recovery time (max), ns	t_{RR}	50	110	110	110	110	110
Maximum permissible modes							
Drain-source voltage (max), V	V_{DSS}	60	60	60	60	60	60
Gate-source voltage (max), V	V_{GS}	±20	±20	±20	±20	±20	±20
Drain DC at Ta=25 °C (max), A	I_D	75	150	225	300	375	450
Drain DC at Ta=100 °C (max), A	I_D	75	150	225	300	375	450
Pulse drain current at t_{pul}=1 ms (max), A	I_{DM}	840	1680	2520	3360	4200	5040
Junction temperature (max), ºC	Tj	175	175	175	175	175	175

Table 3.3 – Basic and maximum permissible parameters of modules of 1-st class

Parameter name, unit	Symbol	Maximum module DC, A					
		120	**160**	**200**	**250**	**300**	**400**
Basic characteristics							
Breakdown drain-source voltage (min), V	$V_{(BR)DSS}$	100					
Direct voltage of power circuit (max), V	V_{DC}	60					
DC of power circuit (max), A	I_{DC}	120	160	200	250	300	400
Electric insulation strength circuit/housing (DC), V	V_{ISOL}	1000					
Dissipated power (max), W	P_D	1000					
Static characteristics							
Threshold gate-source voltage, V	$V_{GS(th)}$	2…4	2…4	2…4	2…4	2…4	2…4
Gate leakage current (max), nA	I_{GSS}	±300	±400	±500	±700	±800	±1000
Resistance drain-source in on-state (max), mΩ	$R_{DS(on)}$	7.7	5.8	4.6	3.3	2.9	2.3
Initial drain current (max), μA	I_{DSS}	75	100	125	175	200	250
Dynamic characteristics							
Input capacitance (typical), pF	Ciss	9300	12500	15500	21700	25000	31000
Output capacitance (typical), pF	Coss	1230	1640	2050	2870	3280	4100
Transfer capacitance (typical), pF	Crss	210	280	350	490	560	700
Switch-on delay time (typical), ns	$t_{d(on)}$	12	12	12	12	12	12
Rise time (typical), ns	t_r	58	58	58	58	58	58
Switch-off delay time (typical), ns	$t_{d(off)}$	45	45	45	45	45	45
Fall time (typical), ns	t_f	47	47	47	47	47	47
Common gate charge (typical), nC	Q_G	390	520	650	900	1050	1300
Reverse diode characteristics							
Direct voltage fall (max), V	V_{SD}	1.2	1.2	1.2	1.2	1.2	1.2
Diode DC (max), A	I_S	170	228	285	400	456	570
Pulse diode current at t_{pul}=1 ms (max), A	I_{SM}	690	920	1150	1610	1840	2300
Reverse recovery current (typical), A	I_{RR}	84	112	140	196	224	280
Recovery time (max), ns	t_{RR}	220	220	220	220	220	220
Maximum permissible modes							
Drain-source voltage (max), V	V_{DSS}	100	100	100	100	100	100
Gate-source voltage (max), V	V_{GS}	±20	±20	±20	±20	±20	±20
Drain DC at Ta=25 °C (max), A	I_D	170	228	285	400	456	570
Drain DC at Ta=100 °C (max), A	I_D	120	160	200	280	320	400
Pulse drain current at t_{pul}=1 ms (max), A	I_{DM}	540	720	900	1260	1440	1800
Junction temperature (max), ºC	Tj	175	175	175	175	175	175

Table 3.4 – Basic and maximum permissible parameters of modules of 2-nd class

Parameter name, unit	Symbol	Maximum module DC, A					
		120	**160**	**200**	**240**	**320**	**400**
Basic characteristics							
Breakdown drain-source voltage (min), V	$V_{(BR)DSS}$	200					
Direct voltage of power circuit (max), V	V_{DC}	130					
DC of power circuit (max), A	I_{DC}	120	160	200	240	320	400
Electric insulation strength circuit/housing (DC), V	V_{ISOL}	1000					
Dissipated power (max), W	P_D	1000					
Static characteristics							
Threshold gate-source voltage, V	$V_{GS(th)}$	3…5.5	3…5.5	3…5.5	3…5	3…5	3…5
Gate leakage current (max), nA	I_{GSS}	±600	±800	±1000	±600	±800	±1000
Resistance drain-source in on-state (max), mΩ	$R_{DS(on)}$	16.7	12.5	10	4.4	3.3	2.6
Initial drain current (max), μA	I_{DSS}	150	200	250	120	160	200
Dynamic characteristics							
Input capacitance (typical), pF	Ciss	12000	16000	20000	27600	36800	46000
Output capacitance (typical), pF	Coss	1800	2400	3000	2760	3680	4600
Transfer capacitance (typical), pF	Crss	390	520	650	540	720	900
Switch-on delay time (typical), ns	$t_{d(on)}$	14	14	14	14	14	14
Rise time (typical), ns	t_r	32	32	32	32	32	32
Switch-off delay time (typical), ns	$t_{d(off)}$	26	26	26	26	26	26
Fall time (typical), ns	t_f	16	16	16	16	16	16
Common gate charge (typical), nC	Q_G	340	450	570	420	560	700
Reverse diode characteristics							
Direct voltage fall (max), V	V_{SD}	1.3	1.3	1.3	1.3	1.3	1.3
Diode DC (max), A	I_S	144	192	240	372	496	620
Pulse diode current at t_{pul}=1 ms (max), A	I_{SM}	570	770	960	1560	2080	2600
Reverse recovery current (typical), A	I_{RR}	84	112	140	276	368	460
Recovery time (max), ns	t_{RR}	300	300	300	150	150	150
Maximum permissible modes							
Drain-source voltage (max), V	V_{DSS}	200	200	200	200	200	200
Gate-source voltage (max), V	V_{GS}	±30	±30	±30	±30	±30	±30
Drain DC at Ta=25 °C (max), A	I_D	144	192	240	372	496	620
Drain DC at Ta=100 °C (max), A	I_D	100	136	170	264	352	440
Pulse drain current at t_{pul}=1 ms (max), A	I_{DM}	570	770	960	1560	2080	2600
Junction temperature (max), ºC	Tj	175	175	175	175	175	175

Table 3.5 – Basic and maximum permissible parameters of modules of 2,5 class

Parameter name, unit	Symbol	Maximum module DC, A				
		120	**150**	**200**	**240**	**300**
Basic characteristics						
Breakdown drain-source voltage (min), V	$V_{(BR)DSS}$	250				
Direct voltage of power circuit (max), V	V_{DC}	170				
DC of power circuit (max), A	I_{DC}	120	150	200	240	300
Electric insulation strength circuit/housing (DC), V	V_{ISOL}	1000				
Dissipated power (max), W	P_D	1000				
Static characteristics						
Threshold gate-source voltage, V	$V_{GS(th)}$	3…5	3…5	3…5	3…5	3…5
Gate leakage current (max), nA	I_{GSS}	±400	±500	±700	±800	±1000
Resistance drain-source in on-state (max), mΩ	$R_{DS(on)}$	12	9.6	6.9	6	4.8
Initial drain current (max), μA	I_{DSS}	80	100	140	160	200
Dynamic characteristics						
Input capacitance (typical), pF	Ciss	18200	22800	31900	36500	45600
Output capacitance (typical), pF	Coss	1560	1950	2730	3120	3900
Transfer capacitance (typical), pF	Crss	400	500	700	800	1000
Switch-on delay time (typical), ns	$t_{d(on)}$	18	18	18	18	18
Rise time (typical), ns	t_r	31	31	31	31	31
Switch-off delay time (typical), ns	$t_{d(off)}$	30	30	30	30	30
Fall time (typical), ns	t_f	21	21	21	21	21
Common gate charge (typical), nC	Q_G	290	360	500	580	720
Reverse diode characteristics						
Direct voltage fall (max), V	V_{SD}	1.3	1.3	1.3	1.3	1.3
Diode DC (max), A	I_S	180	225	315	360	450
Pulse diode current at t_{pul}=1 ms (max), A	I_{SM}	720	900	1260	1440	1800
Reverse recovery current (typical), A	I_{RR}	104	130	180	210	260
Recovery time (max), ns	t_{RR}	290	290	290	290	290
Maximum permissible modes						
Drain-source voltage (max), V	V_{DSS}	250	250	250	250	250
Gate-source voltage (max), V	V_{GS}	±30	±30	±30	±30	±30
Drain DC at Ta=25 °C (max), A	I_D	180	225	315	360	450
Drain DC at Ta=100 °C (max), A	I_D	128	160	224	256	320
Pulse drain current at t_{pul}=1 ms (max), A	I_{DM}	720	900	1260	1440	1800
Junction temperature (max), ºC	Tj	175	175	175	175	175

Table 3.6 – Thermal resistance of transistor modules depending on type and current

Type	Class	Maximum module DC, A												
		75 100	120	150	160	200	220	240	250	300	320	360	400	450	500
M9	0,4	1.55				0.55				0.55			0.55		0.43
	0,6			0.8			0.55			0.43		0.35		0.3	
	1		0.35		0.27	0.27			0.23	0.2			0.16		
	2		0.55		0.43	0.35		0.3			0.24		0.2		
	2,5		0.43	0.35		0.27		0.24		0.2					
M12 M12.1	0,4	0.8				0.43				0.43			0.3		0.24
	0,6	0.8		0.43			0.3			0.24					
	1		0.3		0.24	0.24			0.2						
	2		0.3		0.24	0.2									
	2,5		0.24												

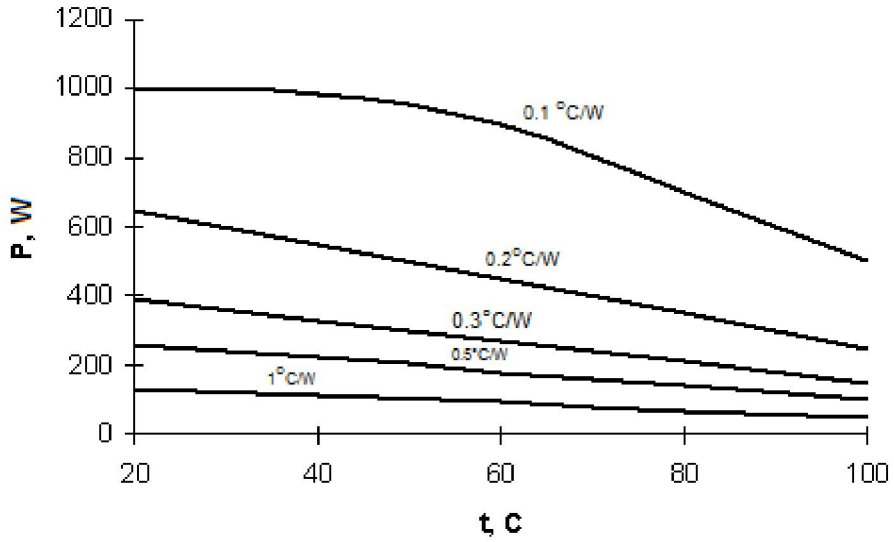

Figure 3.1 – Dependence of allowable loss power versus thermal resistance of module and temperature of metal module base

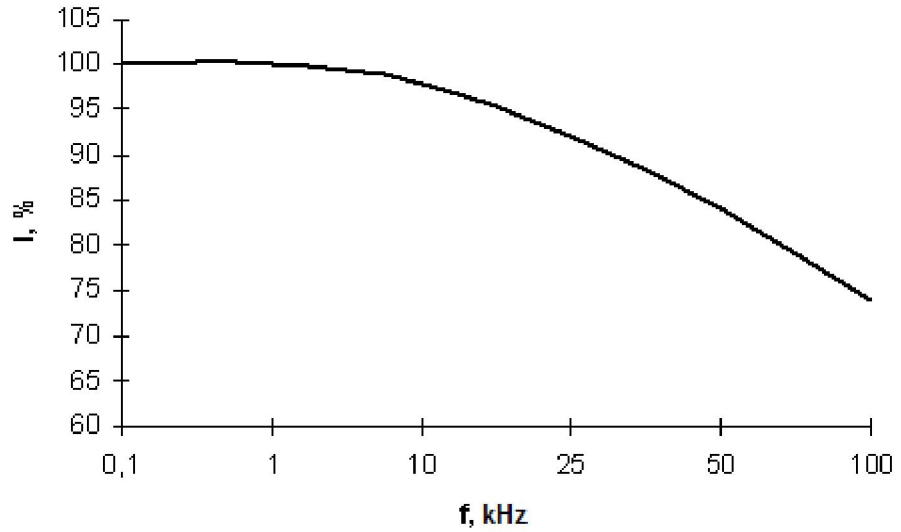

Figure 3.2 – Dependence of allowable module average current (in percent from specified maximum DC) versus operating frequency

4. INSTRUCTIONS FOR USE

General requirements

Module operating is advisable when operating average current value not more than 80% from the specified in the name of the module and junction temperature not more than (70÷80)% from the maximum one.

Module operating is not allowed in modes when simultaneous impact of two or more maximum permissible parameters value.

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

Module mounting

The module is mounted in the equipment on cooler (chassis, application housing, metal plates, etc. providing thermal mode) in any orientation using screws M5 or M6 with a torque (5±0.5) N·m, with obligatory installation of flat and spring washers. The module should be located in such a way to protect it against additional heat from the neighboring elements. The planes of the cooler ribs should be oriented in the direction of air flow.

The contact area of the cooler should have roughness not more than 2.5 μm and flatness tolerance– not more than 30 μm. The cooler surface should not have any rough edges, honeycombs. There should not be extraneous particles between the module and the cooler. To improve the heat balance the module installation to mounting area or cooler should be carried out by instrumentality of heat conducting pastes.

When mounting, you should provide uniform pressure of module housing to cooler. For this purpose you should tighten all the screws uniform in 2 – 4 motions by turns: first, located on one diagonal, then on the other one. Disassembling the module the screw tightening should be done in the reverse order.

Not earlier than in 3 hours after mounting the screws should be rotated to the end, keeping the prescribed torque, because the part of heat conducting paste under pressure will outflow and the fastening can be eased off.

You can install the several modules without additional insulating spacer to one cooler, on condition that voltage between outputs of different modules will not exceed the minimum value of isolation breakdown voltage of each of them or when the cooler is grounded.

Connection to module

Electric wires and cables should be connected to the power contacts of the module by means of screws M5 and M6 with torque (4 ± 0.5) N·m or by means of bolts 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 the screws (bolts) repeatedly in 8 days and in 6 weeks after commencement of operating. Afterwards the tightening should be controlled at least once a half year.

Core section of the external conductors and cables depending on nominal current are represented in Table 4.1.

Table 4.1 – Core section of external conductors and cables depending on current

Rated current, A	**Core section of external wires and cables, mm^2**	
	min	**max**
50	10	25
100	25	50
200	50	120
300	120	-
400	120	-

The controlling module outputs are intended for mounting by means of soldering or split connectors. The permissible number of module outputs' re-soldering during electronic (assembly) edit is three. Outputs soldering should be performed at temperature not higher than (235±5) °C. Soldering duration is not longer than 3 sec.

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

Operation requirements

The module should be used under mechanical loads in accordance with Table 4.2.

Table 4.2 – Mechanic loads impacts

External exposure factor	External exposure factor value
Sinusoidal vibration: - acceleration, m/s^2 (g); - frequency, Hz	 150 (15) 0.5 - 100
Repeated mechanical shock: - peak shock acceleration, m/s^2 (g); - shock acceleration duration, ms	 40 (4) 50
Linear acceleration, m/s^2 (g)	5000 (500)

The module should be used under climatic loads in accordance with Table 4.3.

Table 4.3 – Climatic loads impacts

Climatic factor	Climatic factor value
Low ambient temperature: - operating, °C; - maximum, °C	 - 40 - 45
High ambient temperature: - operating, °C; - maximum, °C	 + 85 + 100
Relative humidity at temperature 35 °C without moisture condensation, %, max	98

Safety requirements

1. Operation with the module should be carried out only by qualified personnel.
2. Do not touch the module power outputs of the supply voltage applied.
3. Do not connect or disconnect wires and connectors while on the power circuit is energized.
4. If the radiator is not grounded, do not touch it, if the module is filed by force feeding.
5. Do not touch the radiator or discharge resistance because its temperature can be very high.
6. If the module is smoking, smelling or abnormal noising, immediately turn off the power and contact to the manufacturer.
7. Avoid contacting to the module with water and other liquids.

5. 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.

6. OVERALL AND CONNECTING DIMENSIONS

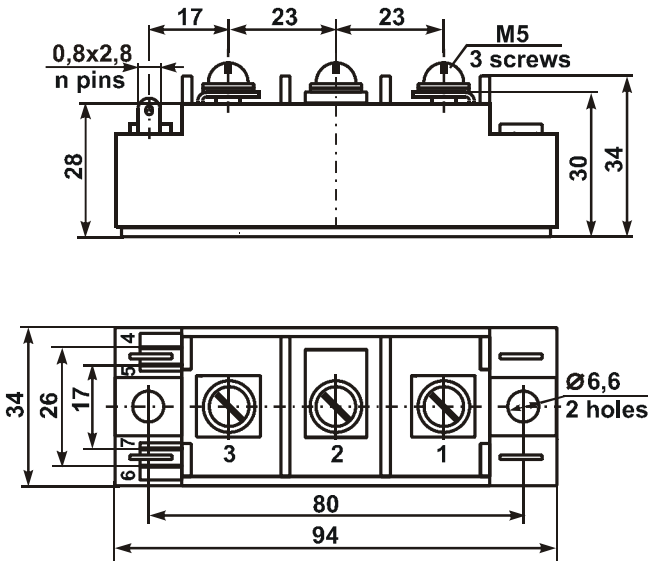

Figure 6.1 – Overall drawing of modules M12-100-0,4; M12-75-0,6; M12.1-100-0,4; M12.1-75-0,6

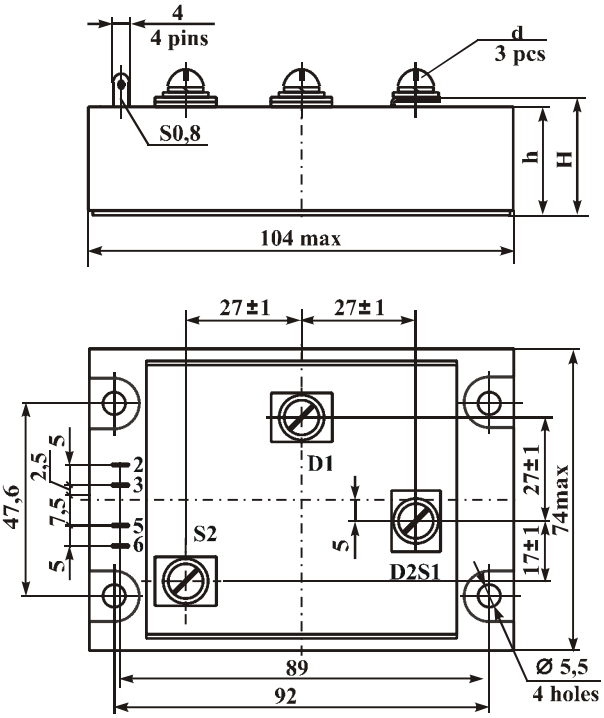

Figure 6.2 – Overall drawing of modules M12-200(300,400,500)-0,4; M12-150(220,300)-0,6; M12-120(160,200,250)-1; M12-120(160,200)-2; M12-120-2,5

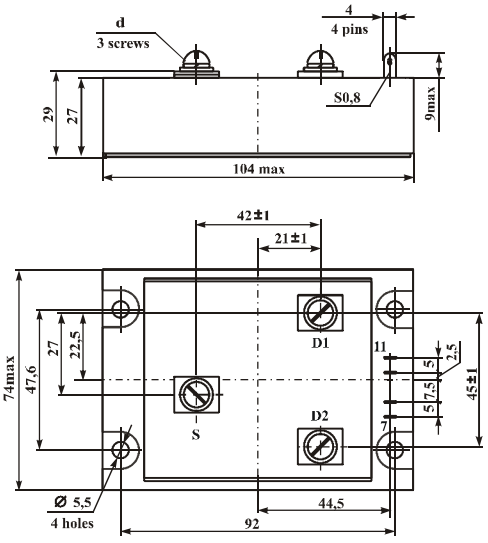

Figure 6.3 – Overall drawing of modules M12.1-200(300,400,500)-0,4; M12.1-150(220,300)-0,6; M12.1-120(160,200,250)-1; M12.1-120(160,200)-2; M12.1-120-2,5; M12.1-120-2,5

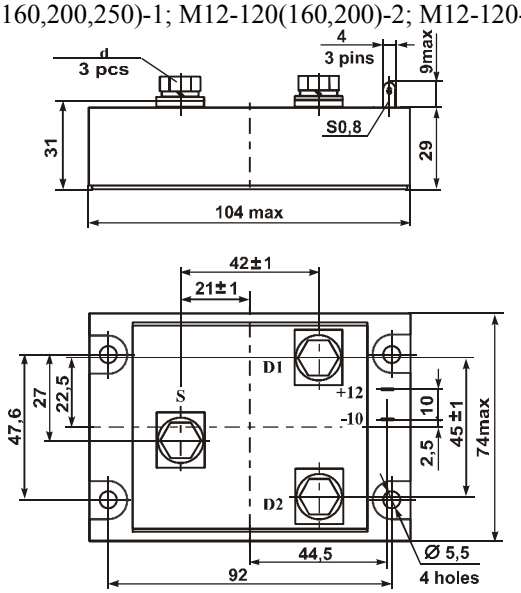

Figure 6.4 – Overall drawing of modules M9-400(500)-0,4; M9-300(360,450)-0,6; M9-200(250,300,400)-1; M9-120(160,200,240,320,400)-2; M9-200(240,300)-2,5

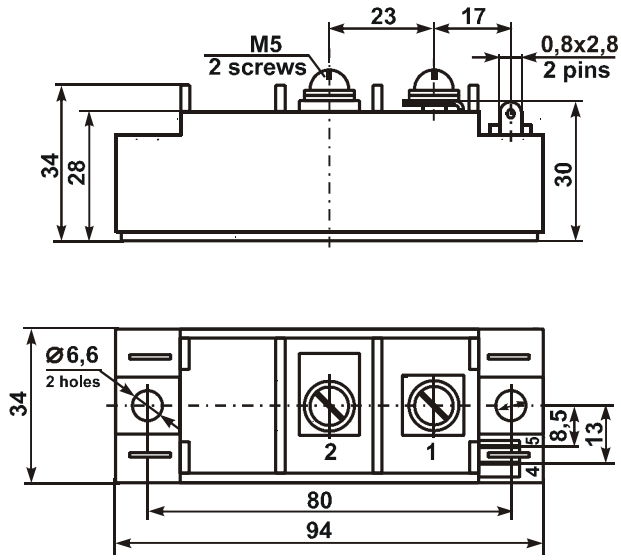

Figure 6.5 – Overall drawing of module M9-100-0,4

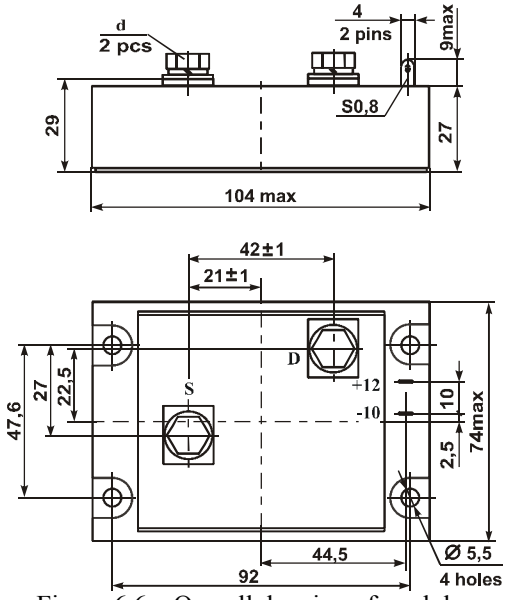

Figure 6.6 – Overall drawing of modules M9-200(300)-0,4; M9-150(220)-0,6; M9-120(160)-1; M9-120(150)-2,5

Depending on the maximum average module current the fastening of the power wires is carried out using the screws (bolts) shown in Table 6.1.

Table 6.1 – Fastening of power wires depending on module current

Current, A	≤160	200…250	≥300
Power wires fastening (d)	Screw M6 (besides Fig. 6.1 and 6.5)	Bolt M8	Bolt M10

Precious metals are not contained.

5 Naugorskoe shosse, Orel, 302020, Russia Tel. +7(4862) 44-03-44, Fax +7(4862) 47-02-12,
E-mail: mail@electrum-av.com