TRANSISTOR MODULES IGBT
M9, M10, M11, M12, M12.1

USER'S MANUAL

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CONTENTS

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1. APPLICATION AND PRODUCED MODULES

IGBT-modules are assemblies of IGBT-transistors and FRDs intended to commutate power loads as a part of converters with maximum peak voltage up to 1200 V and DC up to 400 A. The IGBT-modules are represented with the following versions:

M9 – a single transistor shunted by reverse fast-recovery diode. The module is produced with an amount of maximum DC 50,100,200,300,400 A.

M10 – series-connected IGBT-transistor shunted by reverse fast-recovery diode and series-connected fast-recovery diode (common collector-anode). The module is produced with an amount of maximum DC 50,100,150,200 A.

M11 – series-connected IGBT-transistor shunted by reverse fast-recovery diode and series-connected fast-recovery diode (common emitter-cathode). The module is produced with an amount of DC 50,100,150,200 A.

M12 – two series-connected IGBT-transistors (half-bridge) shunted by reverse fast-recovery diodes. The module is produced with an amount of maximum DC 50,100,150, 200 A.

M12.1 – two back-to-back IGBT-transistors (common emitter) shunted by reverse fast-recovery diodes. The module is produced with an amount of maximum DC 50,100,150,200 A.

The modules have two versions: the first version in the name of the module is not shown, the second version is marked with the digits 01(02) in the end of the module name.

Depending on the current and version the IGBT-modules are produced in the design versions shown in Table 1.1. The modules are produced only in the versions where at crossing the line with the module type and the column is specified the figure of overall drawing corresponding to the version.

Table 1.1 – Produced IGBT-modules and corr. to them overall drawings

Module type	**Current, A**					
	50	**100**	**150**	**200**	**300**	**400**
M9	Fig. 6.12	Fig. 6.12		Fig. 6.2	Fig. 6.2	Fig. 6.2
M9-01	Fig. 6.12	Fig. 6.1		Fig. 6.2	Fig. 6.2	
M10	Fig. 6.12	Fig. 6.12	Fig. 6.5	Fig. 6.5		
M10-01	Fig. 6.3	Fig. 6.3	Fig. 6.4	Fig. 6.4		
M11	Fig. 6.12	Fig. 6.12	Fig. 6.9	Fig. 6.9		
M11-01	Fig. 6.7	Fig. 6.7	Fig. 6.8	Fig. 6.8		
M12	Fig. 6.12	Fig. 6.12	Fig. 6.10	Fig. 6.11		
M12-02	Fig. 6.12	Fig. 6.12	Fig. 6.10	Fig. 6.11		
M12.1-01	Fig. 6.6	Fig. 6.6	Fig. 6.6	Fig. 6.6		

On Figure 1.1 is shown modules' names explanation.

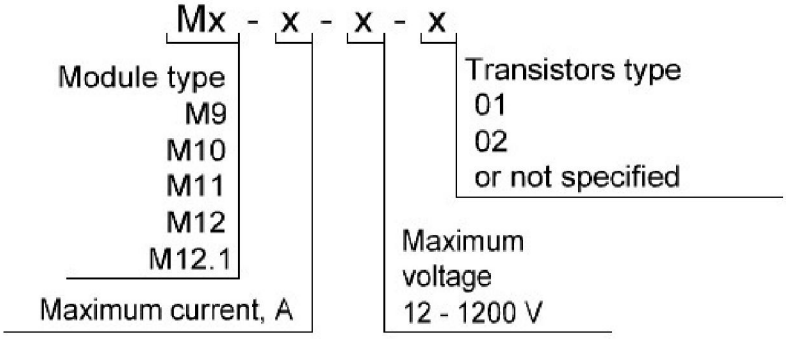

Figure 1.1 – Modules' names explanation

For example, a module M12-100-12-02: half-bridge with maximum permissible collector-emitter voltage 1200 V, with maximum permissible DC 100 A, version 02.

2. GENERAL DESCRIPTION

Depending on the module's type and maximum DC the electric circuits of the modules are different; on Figures 2.1 – 2.13 are represented all possible sorts of the circuits of IGBT-modules.

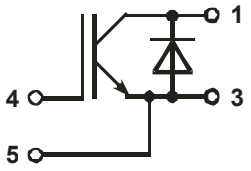

Figure 2.1 – Electric circuit of modules M9-50-12-01 (drawing of Fig.6.12)

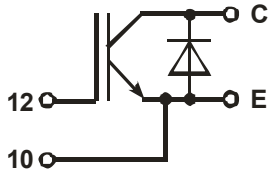

Figure 2.2 – Electric circuit of modules M9-100-12-01 (drawing of Fig.6.1)

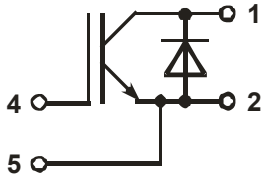

Figure 2.3 – Electric circuit of modules M9-50(100)-12 (drawing of Fig.6.12)

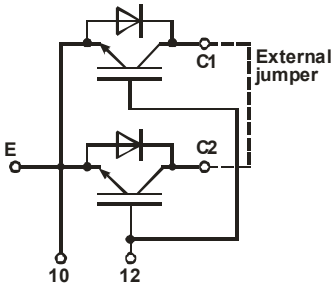

Figure 2.4 – Electric circuit of modules M9-200(300)-12-01; M9-200(300,400)-12 (drawing of Fig.6.2)

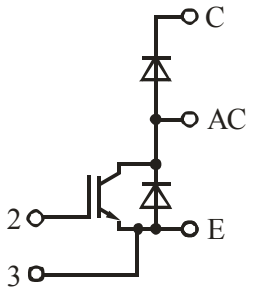

Figure 2.5 – Electric circuit of M10-50(100,150,200)-12-01 (drawing of Fig. 6.3 and Fig.6.4)

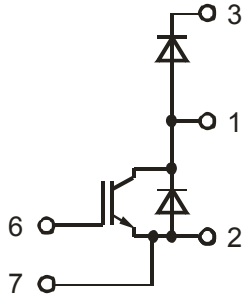

Figure 2.6 – Electric circuit of modules M10-50(100)-12 (drawing of Fig. 6.12)

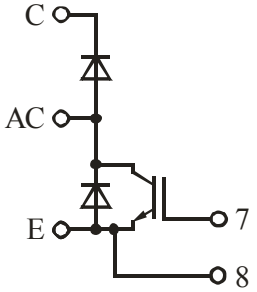

Figure 2.7 – Electric circuit of modules M10-150(200)-12 (drawing of Fig. 6.5)

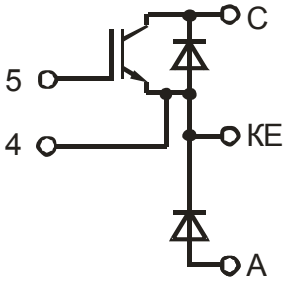

Figure 2.8 – Electric circuit of M11-50(100,150,200)-12-01 (drawing of Fig. 6.7 and Fig. 6.8)

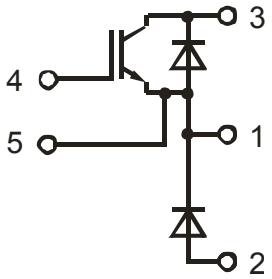

Figure 2.9 – Electric circuit of modules M11-50(100)-12 (drawing of Fig. 6.12)

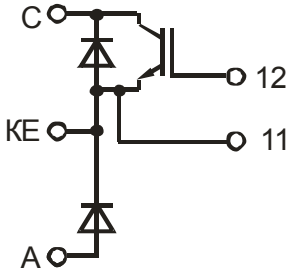

Figure 2.10 – Electric circuit of modules M11-150(200)-12 (drawing of Fig. 6.9)

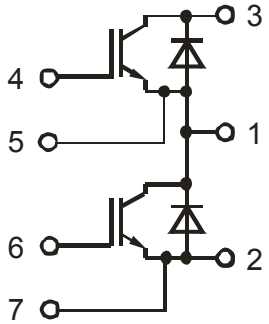

Figure 2.11 – Electric circuit of M12-50(100)-12-02; M12-50(100)-12 (drawing of Fig. 6.12)

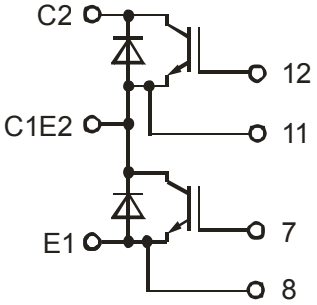

Figure 2.12 – Electric circuit of modules M12-150(200)-12; M12-150(200)-12-02 (drawing of Fig. 6.10 and Fig. 6.11)

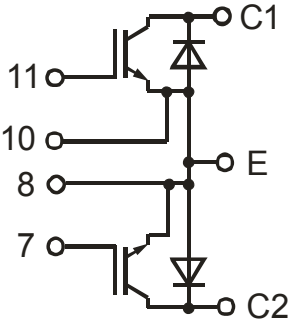

Figure 2.13 – Electric circuit of modules M12.1-50(100,150,200)-12-01 (drawing of Fig. 6.6)

Attention! When transporting the gate and emitter should be short-circuited!

3. BASIC PARAMETERS

Basic electric parameters and maximum permissible parameters of the modules at temperature 25^0C are shown in Tables 3.1 – 3.3.

Table 3.1 – Basic and maximum permissible parameters of modules M9, M10, M11, M12

Parameter name, unit	Symbol	Maximum module DC, A					
		50	**100**	**150**	**200**	**300**	**400**
Basic characteristics							
Collector-emitter breakdown voltage (min), V	$V_{(BR)CES}$	1200					
Direct voltage of power circuit (max), V	V_{DC}	650					
Power circuit DC (max), A	I_{DC}	50	100	150	200	300	400
Electric insulation strength circuit / housing (DC), V	V_{ISOL}	4000					
Dissipated power (max), W	P_D	400		1000			
Static characteristics							
Gate-emitter threshold voltage, V	$V_{GE\,(th)}$	5…6.5	5…6.5	5…6.5	5…6.5	5…6.5	5…6.5
Gate leakage current (max), nA	I_{GES}	±600	±1200	±1800	±2400	±3600	±2400
Collector-emitter saturation voltage (max), V	$V_{CE(on)}$	2.1	2.1	2.1	2.1	2.1	2.1
Collector leakage current (max), μA	I_{CES}	700	1400	2000	2700	4000	2600
Dynamic characteristics							
Input capacitance (typical), pF	Cies	3600	7200	10800	14400	21600	28800
Output capacitance (typical), pF	Coes	188	375	565	750	1130	1500
Transfer capacitance (typical), pF	Cres	163	325	490	650	980	1300
Switch-on delay time (max), ns	$t_{d(on)}$	90	90	90	90	90	90
Rise time (max), ns	t_r	45	45	45	45	45	45
Switch-off delay time (max), ns	$t_{d(off)}$	520	520	520	520	520	520
Fall time (max), ns	t_f	90	90	90	90	90	90
Common gate charge (typical), nC	Q_G	375	750	1125	1500	2250	3000
Reverse diode characteristics							
Direct voltage fall (typical), V	V_F	2.1	2.1	2.1	2.1	2.1	2.1
Diode DC (max), A	I_F	50	100	150	200	300	400
Diode pulse current at t_{pul}=1 ms (max), A	I_{FM}	100	200	300	400	600	800
Reverse recovery current (typical), A	I_{RR}	50	100	150	200	300	400
Recovery time (typical), ns	t_{RR}	150	150	150	150	150	150
Maximum permissible modes							
Collector-emitter voltage (max), V	V_{CES}	1200	1200	1200	1200	1200	1200
Gate-emitter voltage (max), V	V_{GE}	±20	±20	±20	±20	±20	±20
Collector DC at T_a=25 °C (max), A	I_C	50	100	150	200	300	400
Collector DC at T_a=100 °C (max), A	I_C	30	60	90	120	180	240
Pulse collector current at t_{pul}=1 ms (max), A	I_{CM}	150	300	450	600	900	1200
Junction temperature (max), ºC	Tj	150	150	150	150	150	150

Table 3.2 – Basic and maximum permissible parameters of modules M9-01, M10-01, M11-01, M12-02, M12.1-01

Parameter name, unit	Symbol	Maximum module DC, A				
		50	**100**	**150**	**200**	**300**
Basic characteristics						
Collector-emitter breakdown voltage (min), V	$V_{(BR)CES}$	1200				
Power circuit direct voltage (max), V	V_{DC}	650				
Power circuit DC(max), A	I_{DC}	50	100	150	200	300
Electrical insulation strength circuit / housing (DC), V	V_{ISOL}	4000				
Dissipated power (max), W	P_D	400	1000			
Static characteristics						
Gate-emitter threshold voltage, V	$V_{GE\ (th)}$	4…6	4…6	4…6	4…6	4…6
Gate leakage current (max), nA	I_{GES}	±100	±200	±300	±400	±600
Collector-emitter saturation voltage (max), V	$V_{CE(on)}$	2.5	2.5	2.5	2.5	2.5
Collector leakage current (max), μA	I_{CES}	500	1000	1500	2000	3000
Dynamic characteristics						
Input capacitance (typical), pF	Cies	4300	8600	12900	17200	25800
Output capacitance (typical), pF	Coes	400	800	1200	1600	2400
Transfer capacitance (typical), pF	Cres	160	320	480	640	960
Switch-on delay time (max), ns	$t_{d(on)}$	94	94	94	94	94
Rise time (max), ns	t_r	45	45	45	45	45
Switch-off delay time (max), ns	$t_{d(off)}$	400	400	400	400	400
Fall time (max), ns	t_f	58	58	58	58	58
Switch-on energy(max), mJ	E_{on}	4900	9800	14700	19600	29400
Switch-off energy(max), mJ	E_{off}	5500	11000	16500	22000	33000
Common gate charge (typical), nC	Q_G	340	680	1020	1360	2040
Reverse diode characteristics						
Direct voltage fall (typical), V	V_F	2.1	2.1	2.1	2.1	2.1
Diode DC (max), A	I_F	120	240	360	480	720
Diode pulse current at t_{pul}=1 ms (max), A	I_{FM}	240	480	720	960	1440
Reverse recovery current (typical), A	I_{RR}	50	100	150	200	300
Recovery time (typical), ns	t_{RR}	180	180	180	180	180
Maximum permissible modes						
Collector-emitter voltage (max), V	V_{CES}	1200	1200	1200	1200	1200
Gate-emitter voltage (max), V	V_{GE}	±20	±20	±20	±20	±20
Collector DC at T_a=25 °C (max), A	I_C	105	210	315	420	630
Collector DC at T_a=100 °C (max), A	I_C	60	120	180	240	360
Pulse collector current at t_{pul}=1 ms (max), A	I_{CM}	240	480	720	960	1440
Junction temperature (max), ºC	Tj	150	150	150	150	150

Table 3.3 – Thermal resistance of transistor modules depending on type and current

Type	Maximum module average current, A					
	50	**100**	**150**	**200**	**300**	**400**
M9	0.55	0.3		0.18	0.13	0.11
M9-01	0.95	0.5		0.27	0.2	
M10(11)	0.55	0.3	0.22	0.18		
M10(11)-01	0.95	0.5	0.35	0.27		
M12	0.3	0.18	0.13	0.11		
M12(12.1)-02	0.5	0.27	0.2	0.16		

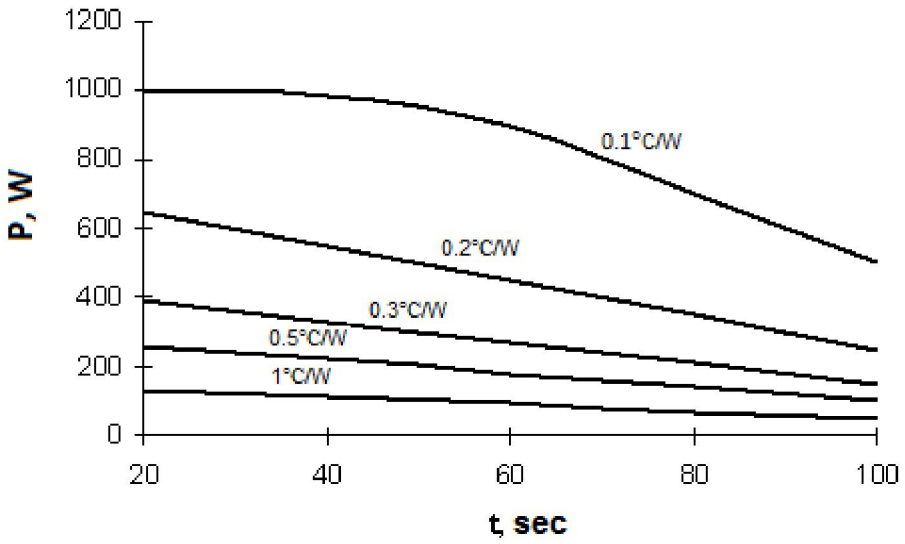

Figure 3.1 – Dependence of permissible power loss versus thermal module resistance and temperature of metal module base

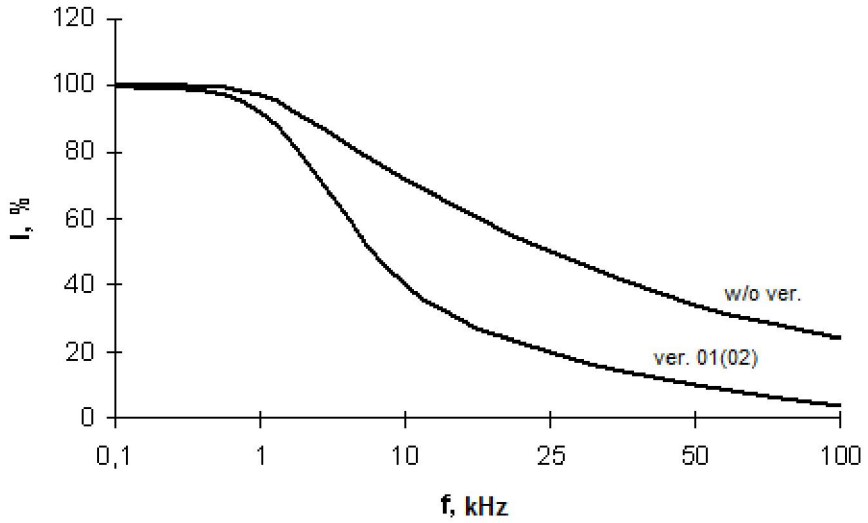

Figure 3.2 – Dependence of permissible average module current (in percent from maximum DC) versus operating frequency

4. INSTRUCTIONS FOR USE

General requirements

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

It is not allowed to operate the module in modes at simultaneous impact of two or more maximum permissible parameters' values.

In an electric circuit of equipment with use of the modules should be provided a fast-speed protection against invalid 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 or having similar heat conducting properties.

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 ease 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

Nominal 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

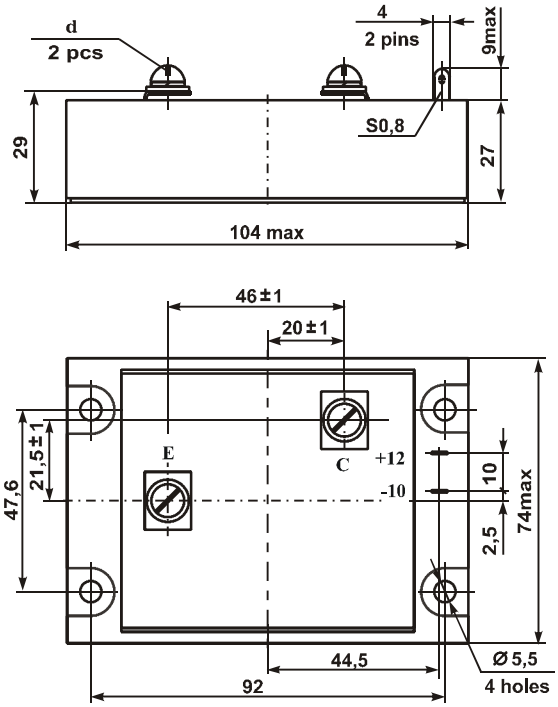

Figure 6.1 – Overall drawing of modules M9-100-12-01

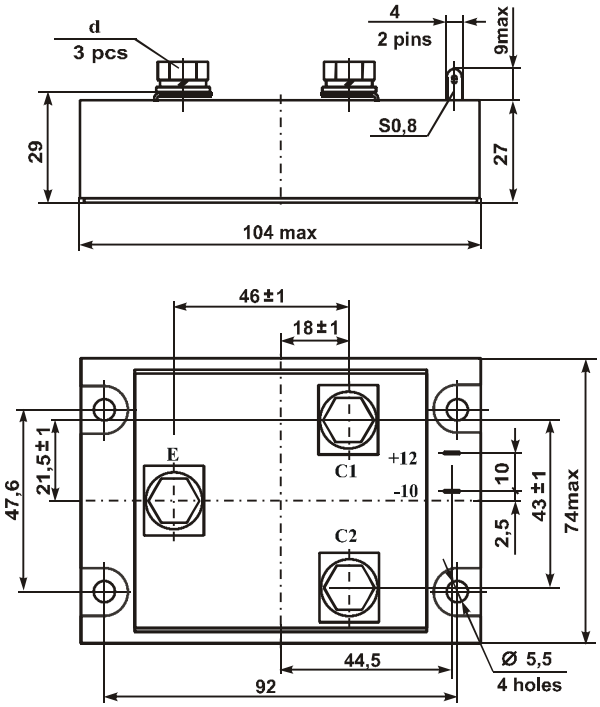

Figure 6.2 – Overall drawing of modules M9-200(300)-12-01; M9-200(300,400)-12

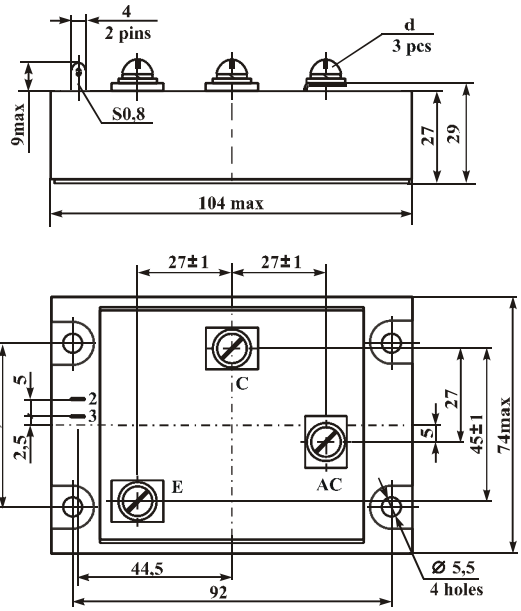

Figure 6.3 – Overall drawing of modules M10-50(100)-12-01

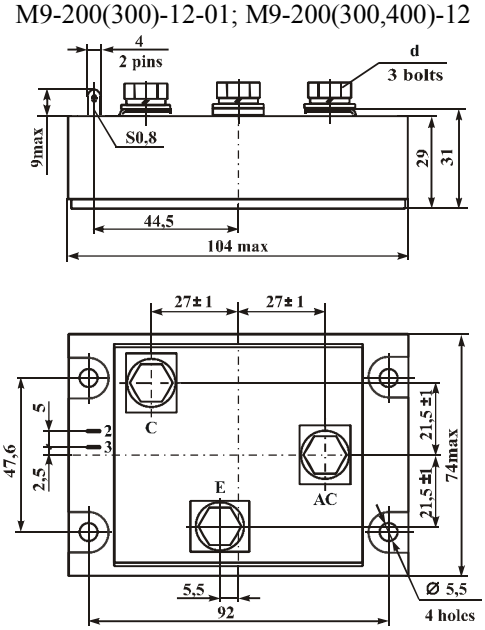

Figure 6.4 – Overall drawing of modules M10-150(200)-12-01

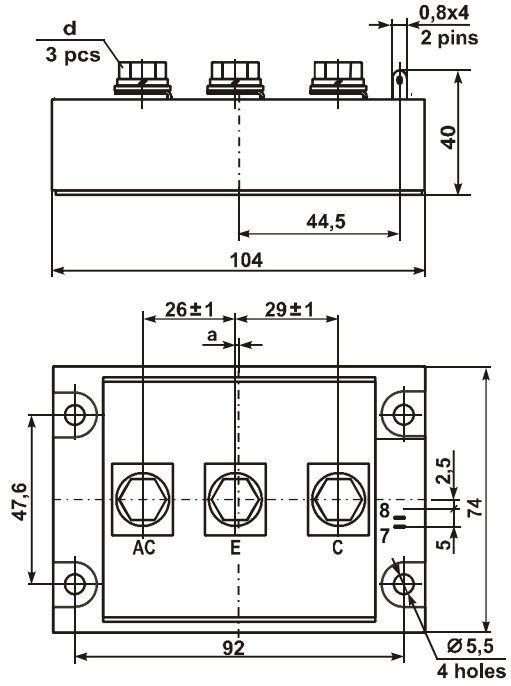

Figure 6.5 – Overall drawing of modules
M10-150(200)-12

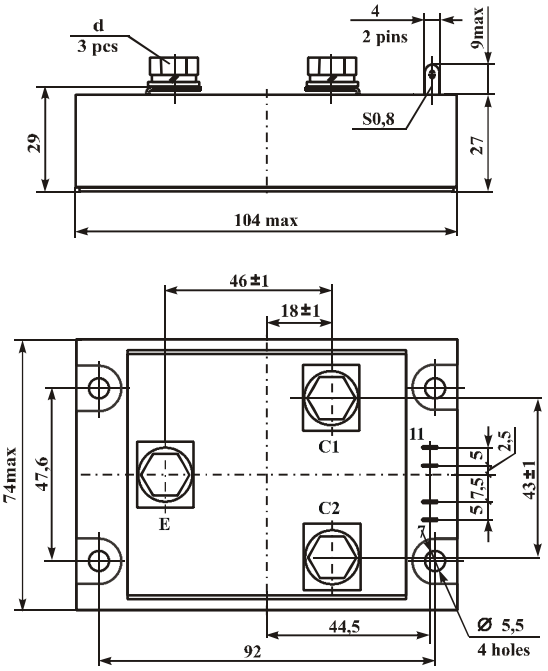

Figure 6.6 – Overall drawing of modules
M12.1-50(100,150,200)-12-01

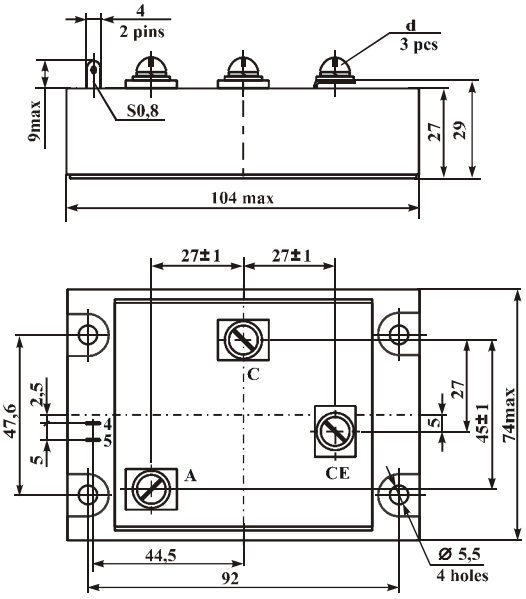

Figure 6.7 – Overall drawing of modules
M11-50(100)-12-01

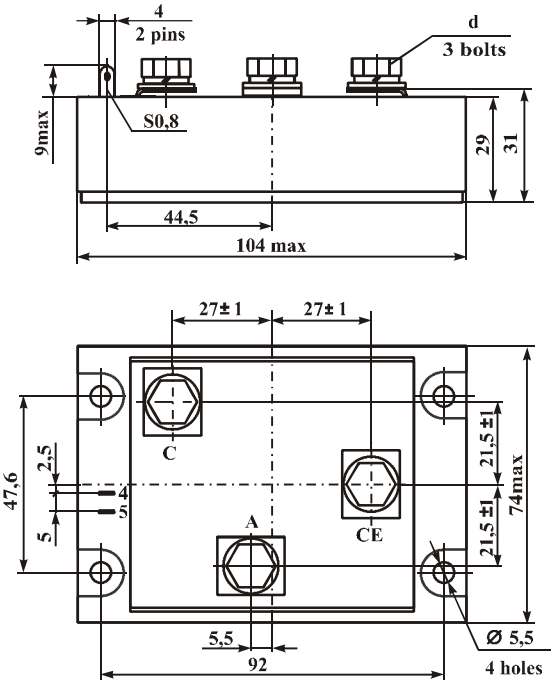

Figure 6.8 – Overall drawing of modules
M11-150(200)-12-01

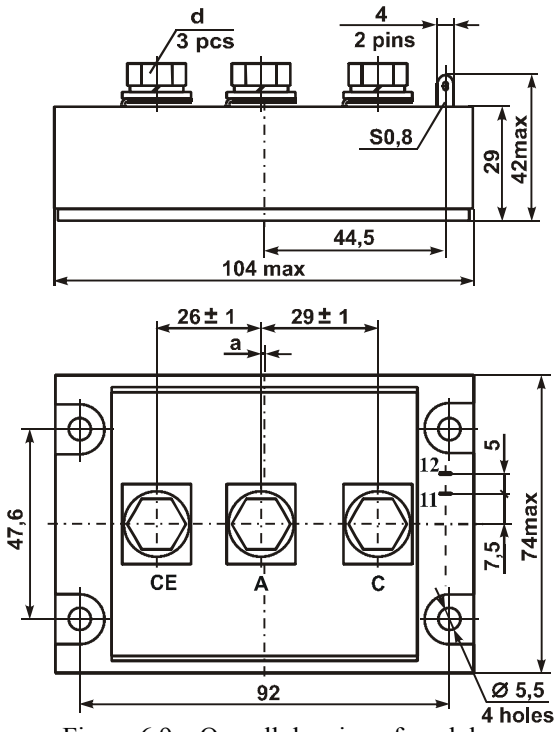

Figure 6.9 – Overall drawing of modules M11-150(200)-12

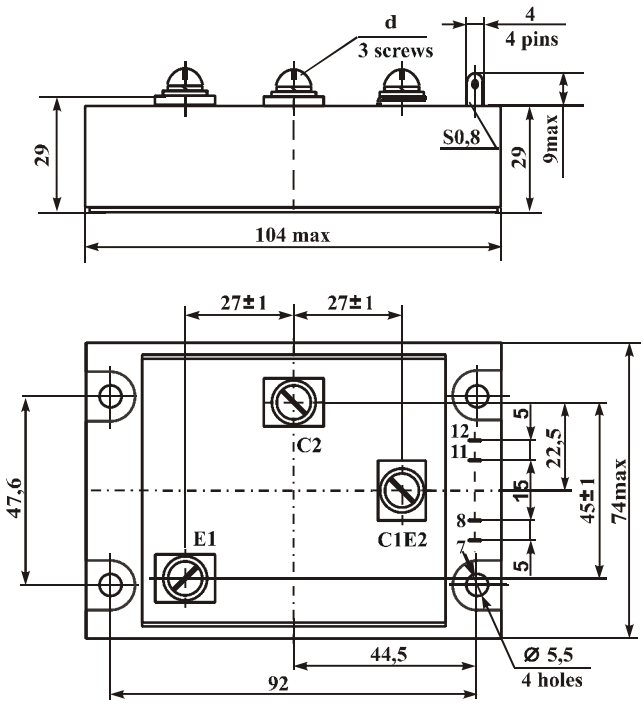

Figure 6.10 – Overall drawing of modules M12-150-12-02; M12-150-12

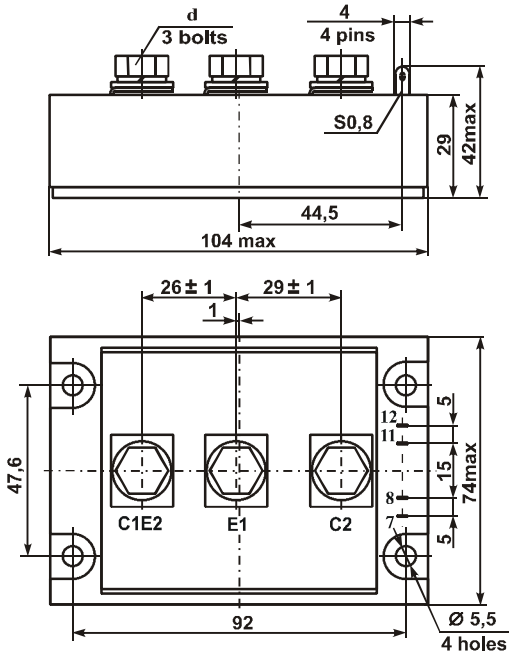

Figure 6.11 – Overall drawing of modules M12-200-12-02; M12-200-12

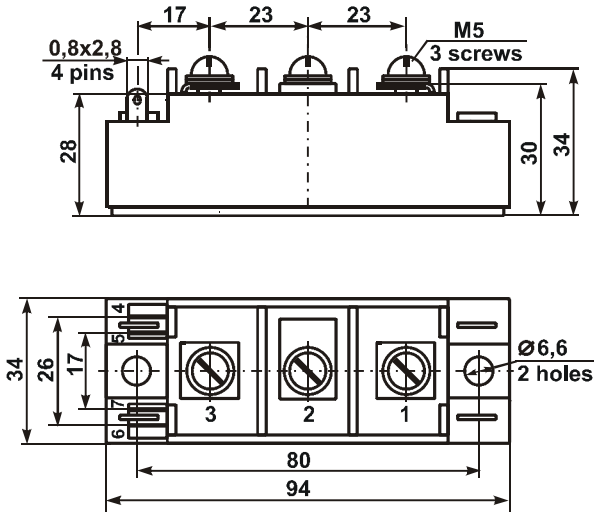

Figure 6.12 – Overall drawing of modulesй M9-50-12-01; M9-50(100)-12; M10-50(100)-12; M11-50(100)-12; M12-50(100)-12-02; M12-50(100)-12

Mounting of the power bus line is carried out using the screws (bolts) depending on the maximum average module current specified in Table 6.1.

Table 6.1 – Mounting of power bus lines depending on module current

Current, A	50	100	150	200	300	400
Mounting of power bus lines (d)	Screw M6 (besides Fig. 6.12)		Bolt M8		Bolt M10	

Precious metals are not contained.

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