SOLID STATE VOLTAGE CONTROL MODERNIZED
SSVCM

USER'S MANUAL

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CONTENTS

1 DESCRIPTION AND FUNCTIONS

Solid state voltage control modernized (hereinafter - module or SSVCM) is intended for commutating and load voltage controlling. SSVCM is intended for using in circuits which require a smooth charge of filtering condensers, voltage surge removal generated by load and, in particular, in motor control circuits of different types.

SSVC performs the following functions:

- power voltage commutation;
- commutation voltage control by turn-on/off of braking and charging transistors;
- transistors turn-on/off threshold regulation;
- regulate the duration of transistor operation delay;
- power from the power circuit.

SSVCM provides the operation and load protection of power to 15 kW. SSVCM is produced with different radiator types that allow using the module as a decision of general industrial problems and also of particular cases.

2 MODULE TYPES

SSVCM is produced with different types of power assemblies and for different controlled voltages. SSVCM are manufactured for currents of 5, 10, 20, 30, 50, 70 and 100 A. Maximum voltage, designated in module name, indicates maximum-permissible collector-emitter voltage used in transistors module. SSVCM is made for voltages of 100, 200, 600 and 1200 V that corresponds to the values 1, 2, 6 and 12 in module name. Meanwhile maximum power voltage for module is lower than it is indicated in the name (ref. to section 4), due to safety measures when power transistor operation.

Modules of voltage 100 V are produced to currents 5, 10, 20, 30, 50, 70 and 100 A;

Modules of voltage 200 V are produced to currents 5, 10, 20, 30, 50 and 70 A;

Modules of voltage 600 V are produced to currents 5, 10, 20, 30 and 50 A

Modules of voltage 1200 V are produced to currents 5, 10, 20, 30 and 50 A;

Power assembly variants:

«A» - without rectifier bridge for module connection to direct voltage source.

«B» - with three-phase rectifier bridge, for connection of the module to single- or-three-phase AC voltage.

Figure 2.1 shows decoding of module name of line SSVCM.

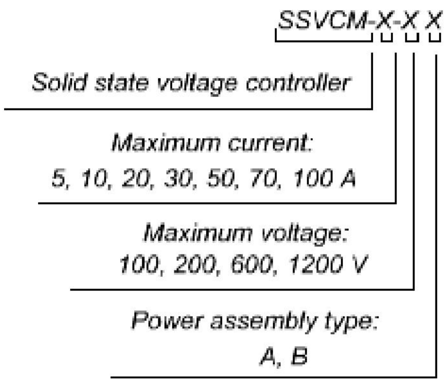

Figure 2.1 – Decoding of module name

For instance, SSVCM-50-12B – SSVCM with maximum load current 50 A, with peak voltage of power circuit 1200 V with rectifier bridge.

3 GENERAL MODULE DESCRIPTION

The module SSVCM is an assembly of transistor control circuit and actually of power transistors, protective reverse diodes and rectifier diodes (for type «B»). The structure scheme of SSVCM is represented at Figure 3.1.

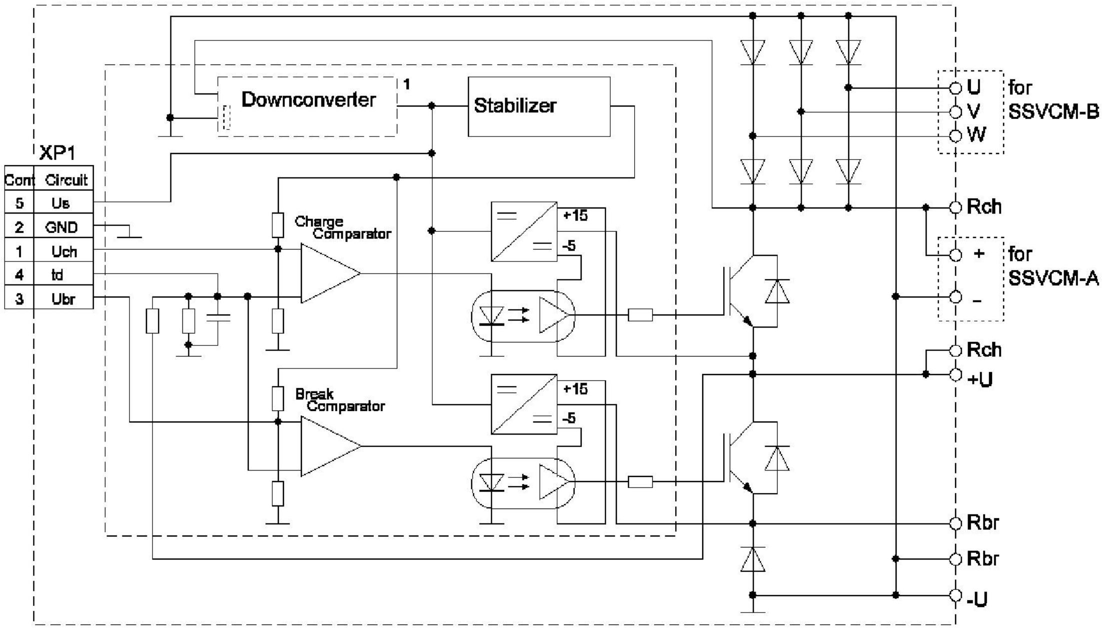

Figure 3.1 – Structure scheme of SSVCM

Connector XP1 is a number of contacts PLS-4 with a counter part of type PBS-4. The connector is intended for module drive setting. Power contacts – are terminal contacts to screw M5 (ref. to overall drawings). Outputs purpose of connector XP1 and power outputs purpose are shown in Table 3.1.

Table 3.1 – Outputs function of SSVCM

Output	Symbol	Function
XP1:1	Up	Setup output of charging transistor operation threshold
XP1:2	GND	Ground output of power and drive circuits
XP1:3	U_{br}	Setup output of braking transistor operation threshold
XP1:4	td	Setup output of transistor operation delay duration
XP1:5	Us	Supply voltage of control circuit (for modules of 12-th class)
Power outputs	+, -	Connection outputs of DC voltage power source (for SSVCM-A)
	U, V, W	Connection outputs of single- or three-phase AC voltage (for type SSVC-B)
	+U, -U	Load connection outputs
	R_{br}	Braking resistor connection outputs
	R_{ch}	Charging resistor connection outputs

4 BASIC AND MAXIMUM PERMISSIBLE CHARACTERISTICS

Basic electrical characteristics and maximum permissible electrical parameters of the modules at 25 ^{0}C are shown in Tables 4.1 - 4.6.

Table 4.1 – Basic and maximum permissible characteristics of control circuits and common parameters of power circuits

Parameter	Symbol	Unit	Value			Note
			min	type	max	
Control circuit characteristics						
Supply voltage from power circuit	U_{PS}	V	21		400	For modules of 1,2,6 class
Supply voltage from external source	Uss	V	13.5		20	For modules of 12 class
Current consumption from power circuit	I_c	mA		30	50	U_{ps} = 350 V
Current consumption from external source	I_{cs}	mA		70	120	U_{cs} = 15 V
Transistors operation delay	T_{dt}	µs		7	10	Set by consumer
Controlled voltage range	U_c	V	21		1000	SSVCM-x-1,2,6
Braking transistor operation voltage (set by consumer)	U_b	V		70		SSVCM-x-1
				150		SSVCM-x-2
				400		SSVCM-x-6
				700		SSVCM-x-12
Charging transistor operation voltage (set by consumer)	U_{ch}	V		25		SSVCM-x-1
				55		SSVCM-x-2
				150		SSVCM-x-6
				270		SSVCM-x-12
Hysteresis of transistor operation	γ	%	5	8		
Power circuit characteristics						
Capacitance of power circuit load	C_c	µF			200	SSVCM-5-x
					500	SSVCM-10-x
					800	SSVCM-20-x
					1200	SSVCM-30-x
					2000	SSVCM-50-x
					2500	SSVCM-70-x
					3000	SSVCM-100-x
Housing insulation voltage of power circuits (DC, 1 minute)	U_{isol}	V	1000			SSVCM-x-1(2)
			3500			SSVCM-x-6(12)

Table 4.2 – Basic and maximum permissible characteristics of rectifier bridge diodes

Characteristic	Symbol	Unit	Value			Note
			min	type	max	
Peak repetitive reverse voltage	V_{RRM}	V			1200	
Direct voltage fall	V_F	V			1.65	
Direct diode current	I_F	A			155	
Pulse diode current t_{pul}=10 ms	I_{FM}	A			1350	
Reverse current	I_{RRM}	mA			1	

Table 4.3 – Basic and maximum permissible electric characteristics of power switches for modules of the 1-st class (SSVCM-x-1x)

Parameter	Symbol	Unit	Value			Note
			min	type	max	
Drain-source voltage	V_{DSS}	V			100	
Direct voltage of power circuit	V_{DC}	V			70	
Drain DC at Ta=100 °C	I_D	A			12	5 A
					23	10 A
					30	20 A
					40	30 A
					68	50 A
					97	70 A
					107	100 A
Pulse drain current at t_{pul}=1 ms	I_{DM}	A			60	5 A
					110	10 A
					140	20 A
					230	30 A
					380	50 A
					550	70 A
					600	100 A
Loss power at maximum load	P_D	W			5.5	5 A
					11	10 A
					36	20 A
					52	30 A
					75	50 A
					105	70 A
					200	100 A
Closed transistor leakage current of power circuit	I_{DSS}	µA			100	

Table 4.4 – Basis and maximum permissible electric characteristics of power switches for modules of the 2-nd class (SSVCM-x-2x)

Parameter	Symbol	Unit	Value			Note
			min	type	max	
Drain-source voltage	V_{DSS}	V			200	
Direct voltage of power circuit	V_{DC}	V			150	
Drain DC at Ta=100 °C	I_D	A			11	5 A
					17	10 A
					32	20 A
					44	30 A
					66	50 A
					76	70 A
Pulse drain current at t_{pul}=1 ms	I_{DM}	A			70	5 A
					90	10 A
					180	20 A
					260	30 A
					380	50 A
					420	70 A
Loss power at maximum load	P_D	W			10	5 A
					25	10 A
					55	20 A
					55	30 A
					125	50 A
					270	70 A
Closed transistor leakage current of power circuit	I_{DSS}	µA			100	

Table 4.5 – Basis and maximum permissible electric characteristics of power switches for modules of the 6-th class (SSVCM-x-6x)

Parameter	Symbol	Unit	Value			Note
			min	type	max	
Collector-emitter voltage	V_{CES}	V			600	
Direct voltage of power circuit	V_{DC}	V			400	
Collector DC at Ta=100 °C	I_C	A			11	5 A
					16	10 A
					30	20 A
					60	30 A
					60	50 A
Pulse collector current at t_{pul}=1 ms	I_{DM}	A			35	5 A
					60	10 A
					105	20 A
					240	30 A
					240	50 A
Loss power at maximum load	P_D	W			20	5 A
					45	10 A
					80	20 A
					160	30 A
					280	50 A
Closed transistor leakage current of power circuit	I_{ces}	μA			500	

Table 4.6 – Basic and maximum permissible electric characteristics of power switches for modules of the 12-th class (SSVCM-x-12x)

Parameter	Symbol	Unit	Value			Note
			min	type	max	
Collector-emitter voltage	V_{CES}	V			1200	
Direct voltage of power circuit	U_{DC}	V			700	
Collector DC at Ta=100 °C	I_C	A			10	5 A
					15	10 A
					24	20 A
					60	30 A
					60	50 A
Collector pulse current at t_{pul}=1 ms	I_{CM}	A			40	5 A
					60	10 A
					90	20 A
					240	30 A
					240	50 A
Loss power at maximum load	P_D	W			25	5 A
					65	10 A
					160	20 A
					220	30 A
					280	50 A
Closed transistor leakage current of power circuit	I_{ces}	μA			500	

5 MODULE OPERATION AND CONTROL

The recommended connection circuit of SSVCM is shown at Figure 5.1

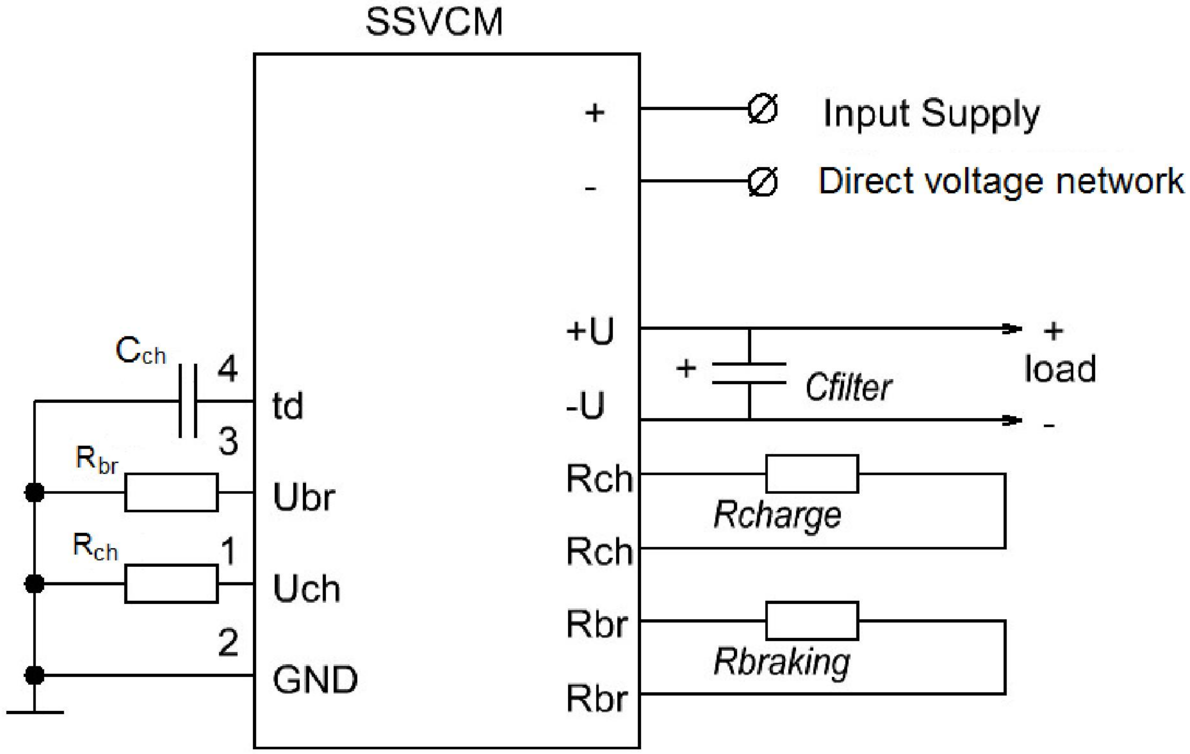

Figure 5.1.1 – Connection circuit of SSVCM-A

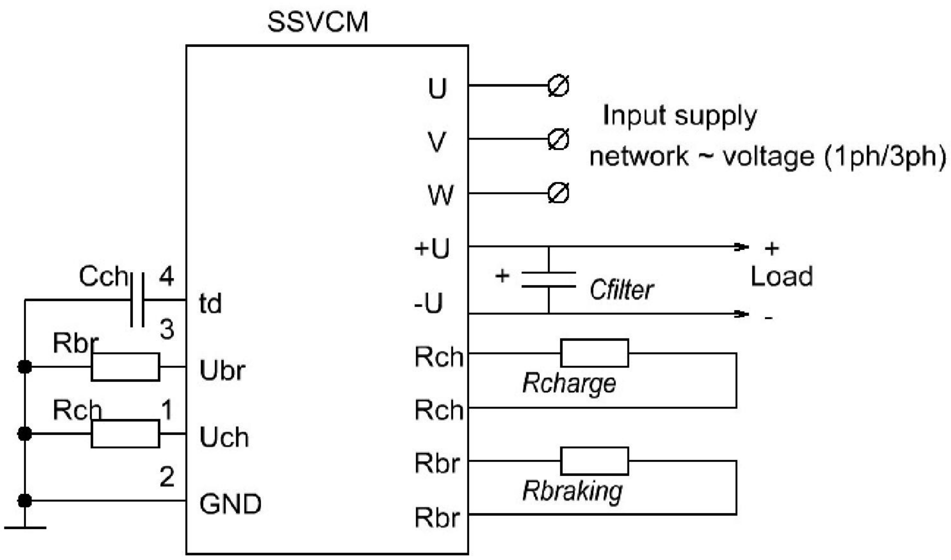

Figure 5.1.2 – Connection Circuit of SSVC-B

The module operates in the following way. After voltage increasing on the filter capacitor C_{filter} to threshold voltage of charging transistor operation (U_{ch}) the charging transistor opens up and shunts the charging resistor R_{charge}, thereby smooth and safe filter capacity charge is carried out. When voltage decreasing lower than U_{ch}, the charging transistor is closed again and load supply is carried out through the charging resistor. When voltage increasing to threshold voltage of braking transistor operation (U_{br}), the braking transistor opens and connects the load through the braking resistor R_{brake} to the ground output of commutation voltage source, thereby relieving load voltage surge. On voltage decreasing to permissible level (lower than U_{br}) the braking transistor will be closed.

Attention! If there is no any supply voltage of control circuit then the SSVCM load will be under voltage (powered by charging resistor), in case of power circuit voltage reduction lower than charging transistor operating threshold the load will be also under voltage (by charging resistor).

«t_{ch}». Condenser connection output setting delay duration of control circuit. It is recommended to increase delay duration if there are voltage surges in power circuit of duration more than 1…2 µs and more or if temporary voltage increase/decrease or switch voltage decrease is possible.

Nominal of trimmer condenser should be over the range 100…2000 pF thereby delay operation of breaking transistor is not rationed as delay time depends substantially on initially voltage at which the surge starts, and on the value dU/dt.

«U_{ch}». Resistor connection output (resistor R_{ch} at Figure 5.1) setting operating transistor threshold (ref. to Figure 5.2). If maximum operation voltage is required (specified in Table 4.1.) then this output should be stopped unused.

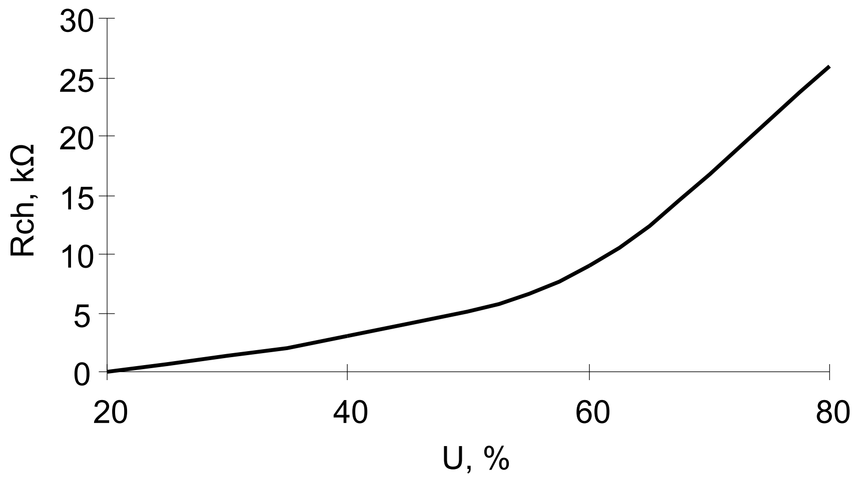

Figure 5.2 – Operation voltage of transistor operating (percentage wise versus maximum value regarding Table 4.1.) versus resistor nominal R_{ch}

«U_{sup}». Output of control circuit supply 12…18 V. It is used for modules of 12-th class (for modules of 1, 2, 6-th class control circuit will be powered from power circuit), as these modules do not have built-in downconverter.

«U_{br}». Resistor connection output (resistor R_{ch} at Figure 5.1) setting operating transistor threshold. Connection output (resistor R_{br} at Figure 5.3). If maximum operation voltage is required (specified in Table 4.1.) then this output should be stopped unused.

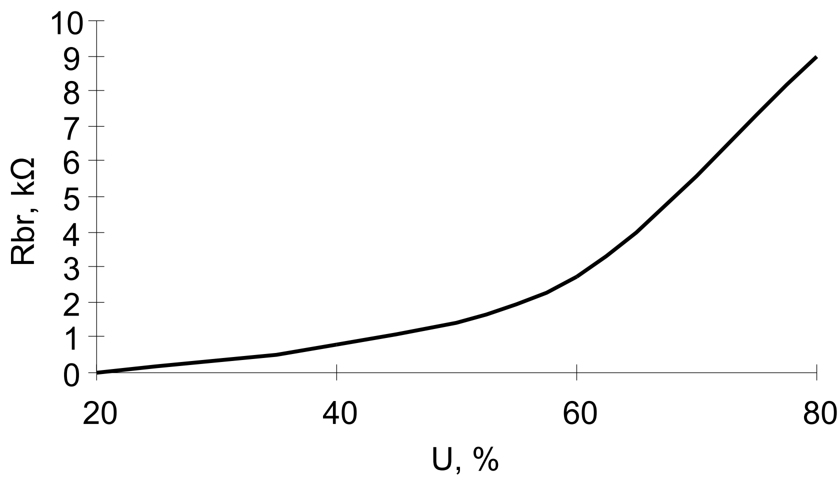

Figure 5.3 – Braking transistor pickup voltage (percentage wise versus maximum value regarding Table 4.1.) versus resistor nominal R_{br}

«GND». Ground output of control circuit. **The output is connected with ground output of power circuit.**

6 POWER OUTPUTS

«+», «-». Connection outputs of power AC voltage SSVCM-x-xA.

«U», «V», «W». Connection outputs of power AC voltage SSVCM-x-xB.

«+U», **«-U»**. Connection outputs of module load; control circuit functions from this power, thus, the module will not be turned on when voltage lower than 35 V for SSVCM-x-1,2,6 and lower than 140 V for SSVCM-x-12. To these outputs the filter capacity C_{filter} will be connected (ref. to Figure 5.1), to be necessary for half-waves smoothing of the rectifier bridge and for kicks filtering arising when motor operation or another type of load. The capacity C_{filter} is recommended to install as close as possible to module outputs. The values of this capacity change in dependence of load power at which SSPCM operates but it should not exceed the maximum permissible values for the module (see Table 4.1). Below there is a table of recommended values C_{filter} for single-phase and three-phase circuits.

Table 6.1 – Capacity choice for different powers.

Load power, kW	Filter capacity, μF
<0.51	200
0.75	200
1.1	200
1.5	300
2.2	400
3.3	700
5.1	1000
7.5	1500
11	2000
15	2000

It is allowed to connect the condensers sequentially, with balancing resistors about 75 kΩ to increase the maximum permissible condenser voltage.

«R_{ch}». Connection output of charging resistor. Charging resistor is necessary if the filtering capacitor is not installed in load, because for lack of charging resistor SSVCM will not switched on the charging transistor. The nominal and the power of charging resistor should be chosen proceeding from load capability of power source, filtering condenser capacity and power voltage amplitude. Thus, the charging resistor is chosen proceeding only from concrete conditions of circuit operation.

«R_b». Connection outputs of braking resistor, meant for braking resistor connection (ref. to Figure 5.1), which is necessary for voltage surge during the braking. Resistor resistance should be chosen for each concrete case, proceeding from operation conditions and motor shutdown, but its nominal should be sufficient for that braking current does not exceed the maximum average current of braking transistor SSVCM.

Resistor power is also chosen based on operation conditions and motor shutdown, but here we can give common and correct calculation of braking resistor power.

It is required to calculate load coefficient (ref. to Figure 6.1).

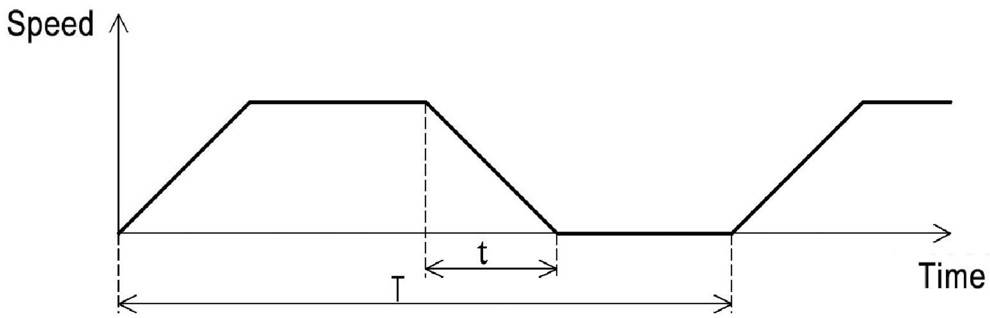

Figure 6.1 – Motor operation diagram.

Where t – braking time, T – cycle time. Then load coefficient (fm) is determined as $f_m = (t/T)$. For instance, it is supposed that the motor will be braking for 10 s one time within 10 minutes. Then load coefficient for this case will be equal f_m=10/600=0.017or 1.7%.

Depending on braking torque and load coefficient the correction factor K1 is determined (ref. to Figure 6.2).

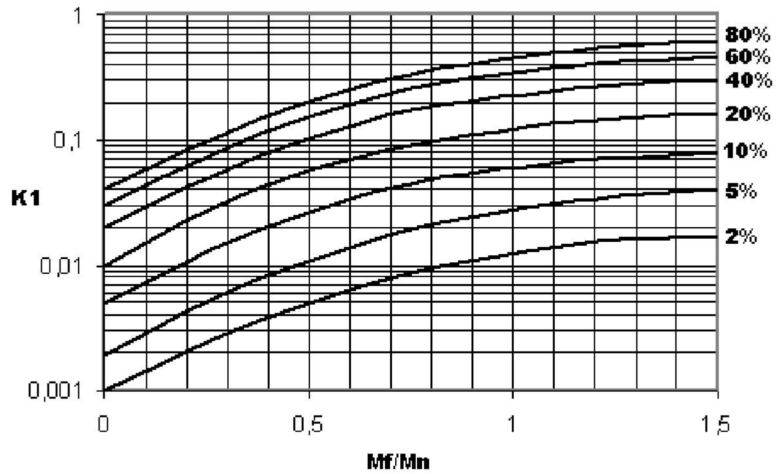

Figure 6.2 – Correcting coefficient detection K1

Where M_n –motor moment, M_f – motor braking torque.

Let's suppose, braking torques ratio is equal to 0.5; then load coefficient is equal to 1.6%. For curve, corresponding to 2% (greater or nearest by value) is a correction factor there K1=0.005.

When load coefficient value considerable lower than 2% is not recommended to complete speculative the curve and choose lesser coefficient K1; the value in this case should be chosen by the curve, corresponding to 2%.

When braking, it is allowed to overload the brake resistor. The permissible overload is determined by coefficient K2, based on Figure 6.3.

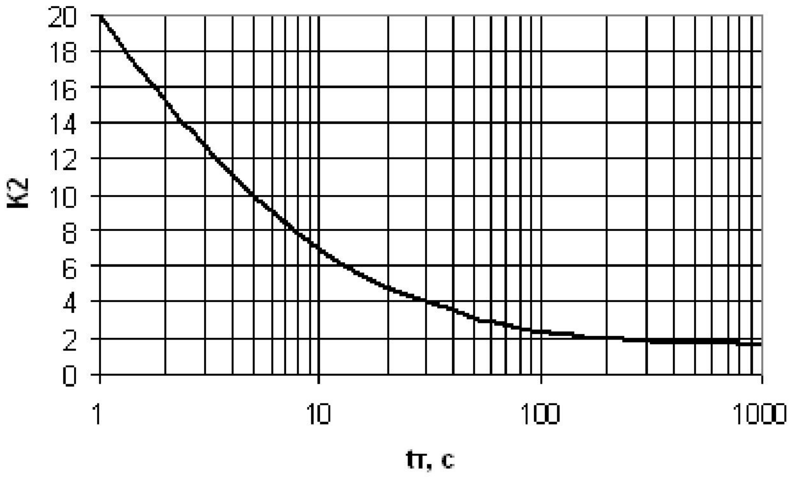

Figure 6.3 – Correction coefficient detection K2

Earlier it was supposed that braking time will be equal to 10 s, then K2=7.

Then, the nominal power of braking resistor is determined: P_r=P_m*N_m*K1*(1+1/(K2*f_m)), W.

Where P_r – braking resistor power, P_m – motor power, N_m – motor efficiency factor. Let's suppose that motor power is equal to 11 kW, and its EF is equal to 0.85. Then for our example Pr=11000*0.85*0.005*(1+1/7*0.017) = 440 W. Thus, braking resistor power for this case should be minimum 0.5 kW.

7 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 installation

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

The contact area of cooler should have roughness not more than 2.5 µm and non-flatness not more than 30 µm. The cooler surface should be without any rough edges, honeycombs. Between the module and the cooler should not be foreign particles. To improve the thermal balance the module installation to the mounting surface or cooler should be accomplished using heat conducting pastes.

When mounting the module foundation should be passed uniformly to the cooler. To that end, all screws should be tightened evenly in two – four steps in turns: first, located on one diagonal, then on the other one. When module dismantling, screws untwisting should be carried out in reverse order.

Not sooner than in three hours after mounting the screws should be turned to the end keeping the given torque because a part of heat conducting paste under pressure outflows and fastening can be eased off.

It is allowed to install several modules to one cooler without additional insulating layers, on conditions that the voltage between outputs of different modules does not exceed the minimum voltage value of isolation breakdown voltage of each of them or when grounded cooler.

Module connection

Power circuit is fastened to the module by screws M5 and M6 with torque (4±0.5) N·m, with obligatory setup of the flat and spring washers, being a part of delivery set.

Power wires connection should be done by connectors, with corrosion-resistant coat, purified from extraneous layers. After screws tightening (bolts) is recommended fastening of connection with paint. It is recommended to re-tighten the screws (pins) in 8 days and in 6 weeks after commencement of operation. Afterwards the tightening should be controlled at least one time in a half year.

Thread section of conductors and cables should be not less than 5 mm^2 for currents to 10 A inclusive and not less than 10 mm^2 for currents over 20 A.

Controlled outputs are intended for mounting in the equipment by soldering or by demountable connector of kind PBS. The permissible number of module outputs soldering during mounting (assembly) operations is 3. Output soldering should be carried out at temperature not more than 235°C. Soldering duration is not more than 3 sec.

When mounting and servicing the module protective measures against static electricity should be taken; when mounting the personnel must use wrist strap and low-voltage soldering irons with power through a transformer.

Service requirements

The module should only be used in exposure to mechanical loads in accordance to Table 7.1.

Table 7.1 – Impact of mechanical loads.

External exposure factor	External exposure factor
Sinusoidal vibration: - acceleration, m/s2 (g); - frequency, Hz	 150 (15) 0.5 - 100
Mechanical shock of repeated action : - peak impact acceleration , m/s2 (g); - duration of impact acceleration, ms	 40 (4) 50
Linear acceleration, m/s2 (g)	5000 (500)

The module should be used under the influence of climate stresses in accordance with Table 7.2.

Table 7.2 – Climatic loads impact

Climatic factor	Value of climatic factor
Low temperature of environment: - operating, °C; - absolute, °C	 - 40 - 45
High temperature of environment: - operating, °C; - absolute, °C	 + 85 + 100
Relative humidity at temperature 35 °C non-condensing %, 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. Do not touch the module radiator.
5. Do not touch the radiator and the module's housing when it is operating because its temperature can be very high.
6. If the module is smoking, smelling or abnormal noising, immediately turn off the power and check whether the module has connected correctly.
7. Avoid contacting to the module with water and other liquids.

The module power circuits are not galvanic isolated from control circuits!
Use caution when operating!

8 RELIABITY SPECIFICATIONS

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 module for 25000 hours must be at least 0.95.

Gamma-percent life must be no less than 50000 hours by γ = 90 %.

Gamma-percent service life of the modules, subject to cumulative operating time is no more than gamma-percent life, no less than10 years, when γ = 90 %.

Gamma-percent storage-ability time of the modules, when γ = 90 % and storing – 10 years.

9 OVERALL AND CONNECTING DIMENSIONS

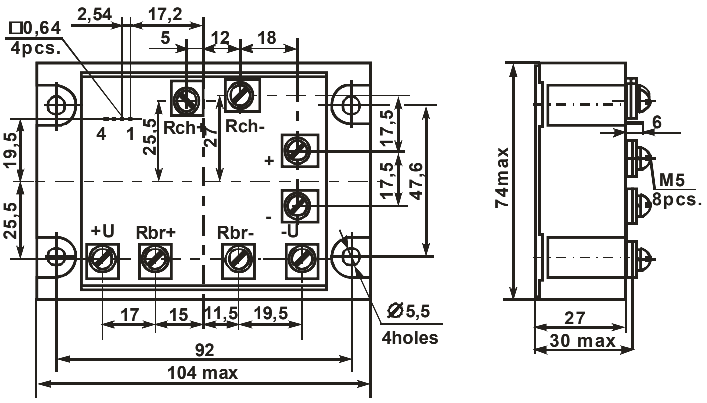

Figure 9.1 – Overall dimensions SSVCM-x-xA for 100, 200, 600 V

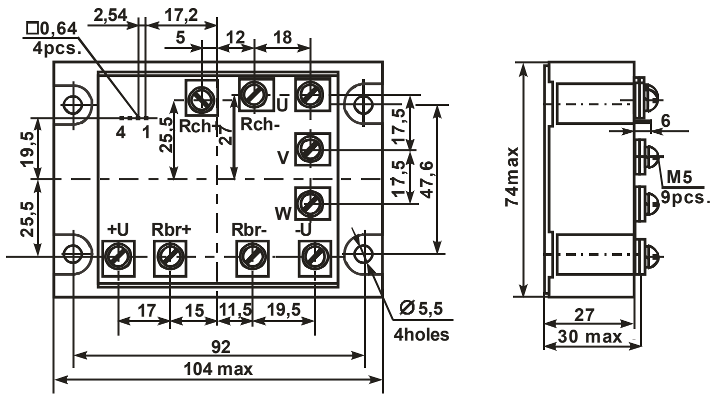

Figure 9.2 – Overall dimensions SSVCM-x-xB for 100, 200, 600 V

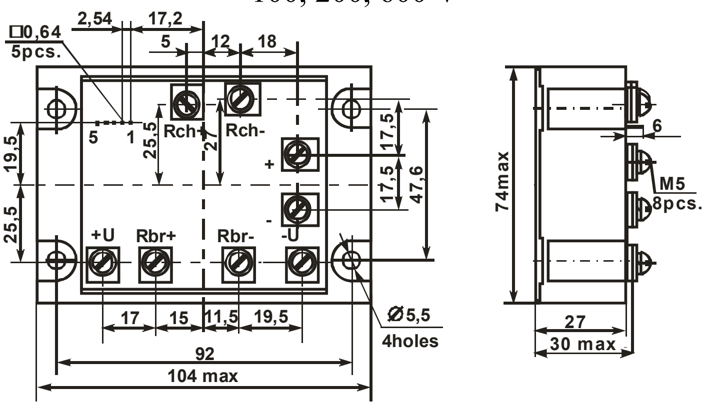

Figure 9.3 – Overall dimensions SSVCM-x-xA for 1200 V

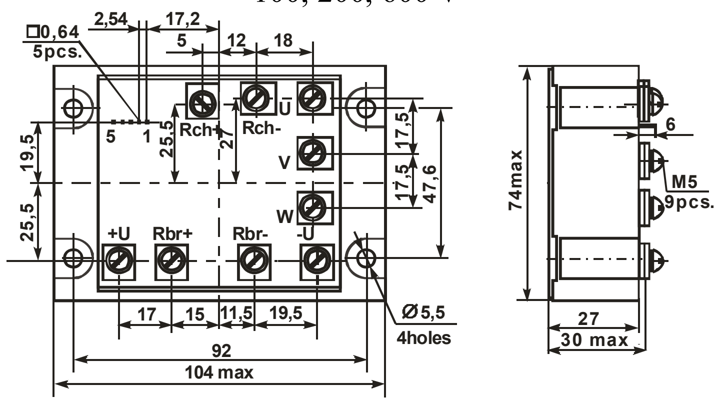

Figure 9.4 – Overall dimensions SSVCM-x-xB for 1200 V

By order of the consumer the delivery of fastening for module installation to DIN-rail is possible. It is recommended to install on DIN-rail the modules with rated current not more than 10A.

Precious metals are not contained.

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