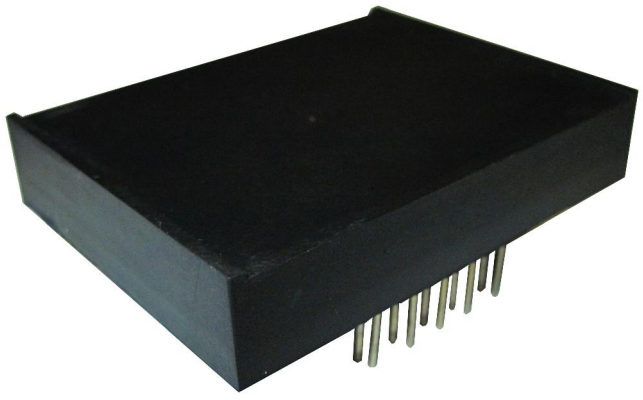
MODULE TO CONTROL BY THREE-PHASE BRUSHLESS DC MOTOR RCM

USER'S MANUAL



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CONTENTS

1. APPLICATION AND FUNCTIONS

The module for control by brushless DC motor (hereinafter - RCM or module) is intended for three-phase electric AC motor controlling on constant magnets with rotor position converter. RCM is performed based on modern achievements of power electronics, microelectronics, digital-to-analogue integrated circuits and controllers of digital and analogue signal processing with the integral PWM circuits.

The RCM maintains the following functions and performances:

- controllable start/stop of motor;
- motor shaft rotation direction change;
- rate control;
- stabilization of rate at changing of motor supply voltage amplitude;
- electric motor protection against current overload and short-circuit;
- protection against simultaneous transistor switching of upper and lower inverter;
- protection against operation when wrong combination signals from rotor positions sensors;
- external alarm about an accident;
- internal voltage control;
- supply of module from power circuit.

The RCM is of control simplicity, small dimensions and it does not require an additional cooling during providing operation and protection of motors with power up to 200 W. The RCM is produced with different control options which allow using the module both for solution of common industrial problems and for solutions of special cases.

2. PRODUCED MODULES

The RCM is produced with different control variants and for different inverter currents. Recommended circuits for modules switching depending on the version you can see in Sections 5 and 6.

The RCMs are produced for currents 0.5, 1, 3 and 5 A. The current in the name of the module specifies the maximum inverter current at which the control circuit enables operation; the maximum permissible transistor current exceeds the specified one in the device name. If the current is larger, then the current protection will operate and the inverter current will be limited. The current specified in the device name is a protection average current operation threshold. At that the protection current can be regulated but only to the lower side (see section 5).

All the variants of the RCM have an inverter transistor for voltage 55 V and maximum supply voltage of power circuit 30 V.

The RCM are produced with the following control types:

«A» - standard with PWM. Digit-analogue control with use of all standard control outputs of the module with an inbuilt PWM-generator circuit.

«B» - bipolar control with PWM. Control with inbuilt circuit of PWM-generator carried out on a single input either using a DAC, or using a connected alternating resistor. The control voltage is in the range -10…+10 V with braking range -0.5…+0.5 V. At that rotation rate determines by voltage amplitude and rotation direction determines by its polarity.

«C» - digital control with PWM. The module includes a DAC that enables you to control the rate using a digital code, at that the module can be controlled also using the standard control circuit (type «A»); The choice of the control variant is carried out using presence or absence of a jumper (see Section 5). The module has an internal PWM-generator.

«D» - standard control without PWM. The control algorithm is same like the type «A», except that the module does not include the PWM-generator. For module operation it is necessary an external connection of time-setting circuit for the PWM-generator, connection of feedbacks. The modules variants without the internal PWM-generator can be convenient to solve complex private tasks and for carrying out specific rate feedbacks.

«E» - bipolar control without PWM.

«F» - digital control without PWM.

All the control variants are applicable to all the RCM regardless of the maximum inverter current.

On Fig. 2.1 is shown the modules name explanation of series RCM.

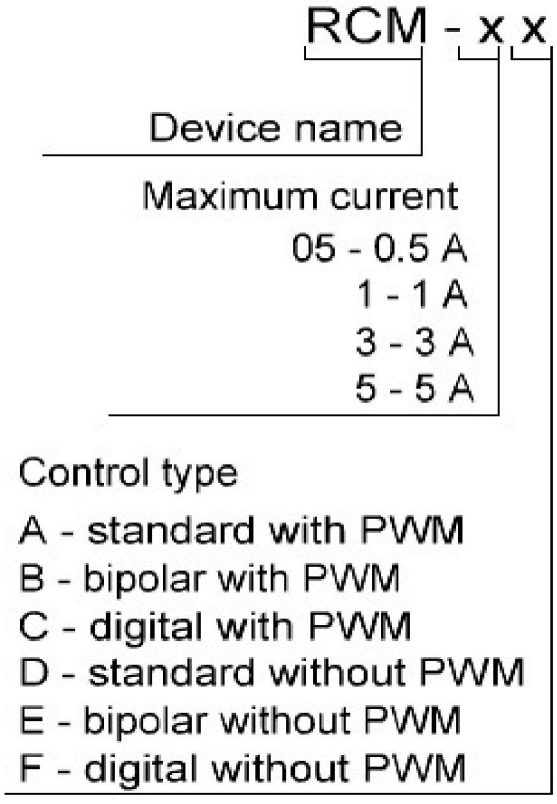

Figure 2.1 – Module name explanation

For example, module RCM-1A: the module for control of brushless DC motor with maximum inverter current 1 A and control type «A».

3. MODULE GENERAL DESCRIPTION

Structural circuit of RCM is shown on Fig. 3.1.

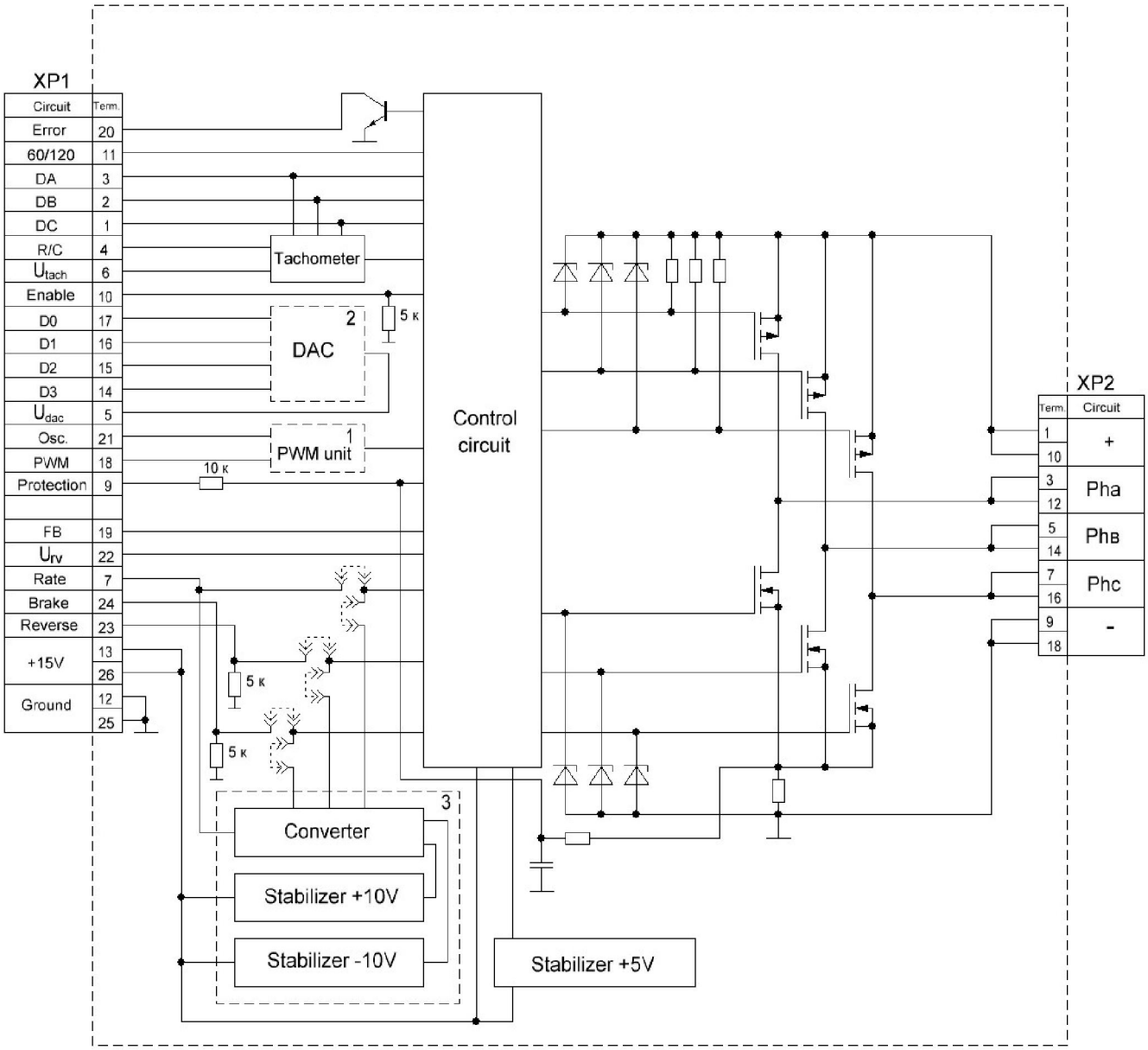

Figure 3.1 – Structural circuit of RCM

«1» - circuit of internal PWM-generator; the circuit is installed for control types «A», «B», «C».

«2» - internal DAC installed for control types «C», «F»

«3» - control circuit that is a part of RCM for control types «B» and «E» (bipolar control).

The socket XP1 is two rows of terminals PLS-13 with the mate of type PBS-13. The socket XP2 – two rows of terminals PLS-9. Outputs assignment of terminals XP1 and XP2 are represented in Table 3.1 and 3.2. In the columns “Control” the sign “+” denotes that the output is used for this control type, the sign “-” denotes that the output is not used.

Table 3.1 – Outputs application of socket XP1

Number	Symbol	Application	Control					
			A	B	C	D	E	F
1	SC	Input to connect sensor of phase C	+	+	+	+	+	+
2	DB	Input to connect sensor of phase B	+	+	+	+	+	+
3	DA	Input to connect sensor of phase A	+	+	+	+	+	+
4	R/C	Output of RC-circuit of tachometer	+	+	+	+	+	+
5	U_{DAC}	Output of rate digital control	-	-	+	-	-	+
6	U_{TACH}	Output of tachometer signal	+	+	+	+	+	+
7	Rate	Input to control rate of motor shaft rotation	+	+	+	+	+	+
8	-	Not used						
9	U_{curr}	Output of inverter current	+	+	+	+	+	+
10	Enable	Input for enable and disable of module operation	+	+	+	+	+	+
11	60/120	Input for control of motor phase correction mode	+	+	+	+	+	+
12	Ground	Ground	+	+	+	+	+	+
13	+15V	Input for supply voltage	+	+	+	+	+	+
14	D3	Input third discharge of digital rate control	-	-	+	-	-	+
15	D2	Input second discharge of digital rate control	-	-	+	-	-	+
16	D1	Input first discharge of digital rate control	-	-	+	-	-	+
17	D0	Input zero discharge of digital rate control	-	-	+	-	-	+
18	PWM	Inverting input of PWM comparator	-	-	-	+	+	+
19	FB	Input for rate feedback	-	-	-	+	+	+
20	Error	Alarming output about sensors failure, overcurrent and disable on input «Enable»	+	+	+	+	+	+
21	Osc.	Input for connection of time-setting elements of frequency of PWM generator	-	-	-	+	+	+
22	U_{ref}	Output of reference voltage source	+	+	+	+	+	+
23	Reverse	Input to control direction of motor shaft rotation	+	-	+	+	-	+
24	Brake	Brake input	+	-	+	+	-	+
25	Ground	Ground	+	+	+	+	+	+
26	+15V	Input of supply voltage	+	+	+	+	+	+

Table 3.2 – Outputs application of socket XP2

Terminal number	Symbol	Application
1	+	Output to connect «+» of power supply
2	Pha	Output for connection of phase A
3	Phв	Output for connection of phase B
4	Phc	Output for connection of phase C
5	-	Output to connect «-» of power supply
6	+	Output to connect «+» of power supply
7	Pha	Output for connection of phase A
8	Phв	Output for connection of phase B
9	Phc	Output for connection of phase C
10	-	Output to connect «-» of power supply

For convenient connection of the power circuits and the control circuits on Fig. 3.2 and Fig. 3.3 are shown the schematic drawings of the external viewings of the sockets XP1 and XP2 of the module RCM.

1						7						13
SC	SB	SA	R/C	U_{DAC}	U_{tach}	Rate	$U_{зир}$	U_{curr}	Enable	60/120	Ground	+15V
D3	D2	D1	D0	PWM	FB	Error	Osc.	U_{rv}	Reverse	Brake	Ground	+15V
14						20						26

Figure 3.2 – External view of socket XP1

1	2	3	4	5
+	Pha	Phв	Phc	-
+	Pha	Phв	Phc	-
6	7		9	10

Figure 3.3 – External view of socket XP2

4. BASIC PARAMETERS

Basic electric parameters and maximum permissible electric parameters of the modules RCM at temperature 25 ^{0}C are represented in Table 4.1.

Table 4.1 – Basic and maximum permissible electric parameters of RCM

Name	Unit	Value			Note
		min	typ.	max	
Supply parameters					
Supply voltage of control circuits	V	11		16.5	
Current consumption of control circuits	mA			80	U_{sup}=15 V
Supply voltage of power circuit	V	11		30	
Input parameters					
Current consumption of inputs	mA	0.1		1	
Current consumption for inputs «SA», «SB», «SC»	mA			5	U=15 V
Range of control voltage	V	-0.3		5.2	
Input voltage of low level	V	-0.3		0.5	For logic inputs
Input voltage of high level	V	2.4		5.2	For logic inputs
Voltage corresponding to stop	V		0.5		
Voltage corresponding to maximum rate	V		4.5		
Parameters of generator PWM					
Frequency of generator PWM	kHz	15		25	
Maximum peak sawtooth voltage	V	4.2		4.6	
Minimum peak sawtooth voltage	V	1.0		1.2	
Parameters of electronic tachometer					
Output voltage	V	3.6		4.2	
Duration of positive pulse	ms		0.5		
Instability of pulse duration of output signal	μs			250	
Output parameters					
Maximum voltage on output «Error»	V			20	
Maximum current on output «Error»	mA			20	
Voltage on output «U_{ref}»	V	6.25	6.5	6.75	No load
Maximum load current on output «U_{ref}»	mA			10	

Protection parameters					
Current protection operation current	A		0.5		RCM-0,5
			1		RCM-1
			3		RCM-3
			5		RCM-5
Current protection speed	µs			100	
Delay of signal on output «Error»	µs			2	
Parameters of power switches					
Maximum drain-source voltage	V			55	
Maximum voltage of inverter supply	V			30	
Maximum average current of power transistors at 100 ^{0}C	A			9	
Maximum pulse current of power transistors at 25 ^{0}C	A			56	
Limiting current at double exceeding protection operation current by load current	A		0.25		RCM-0,5
			0.5		RCM-1
			1.5		RCM-3
			2.5*		RCM-5
Protection operation current	A		0.5		RCM-0,5
			1		RCM-1
			3		RCM-3
			5		RCM-5
Loss power at maximum load	W			0.2	RCM-0,5
				0.6	RCM-1
				3	RCM-3
				7	RCM-5
Leakage current of off power transistor	µA			100	

* Average current having duration no longer than 1 minute; average current of the module RCM-5 with duration not longer than 1 minute should not exceed 2.5 A

5. MODULE CONTROL

Depending on the control type of the module is recommended the following switching circuits (Fig.5.1 – 5.4).

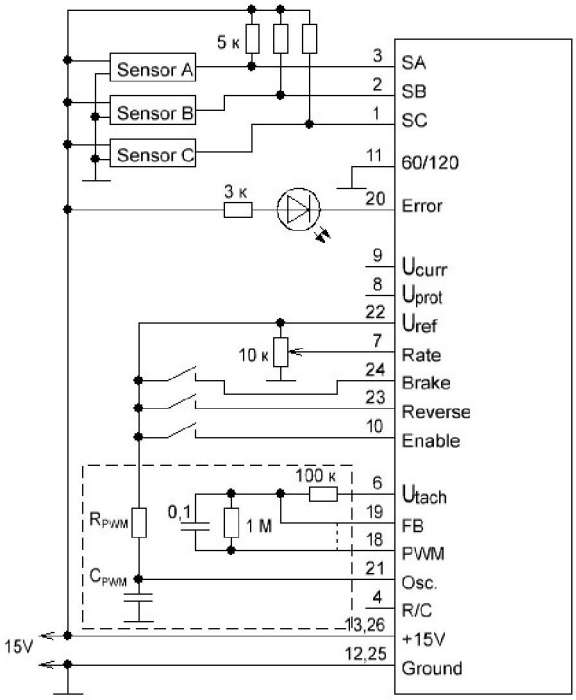

Figure 5.1 – Switching circuit of control circuits RCM «A» and «D»

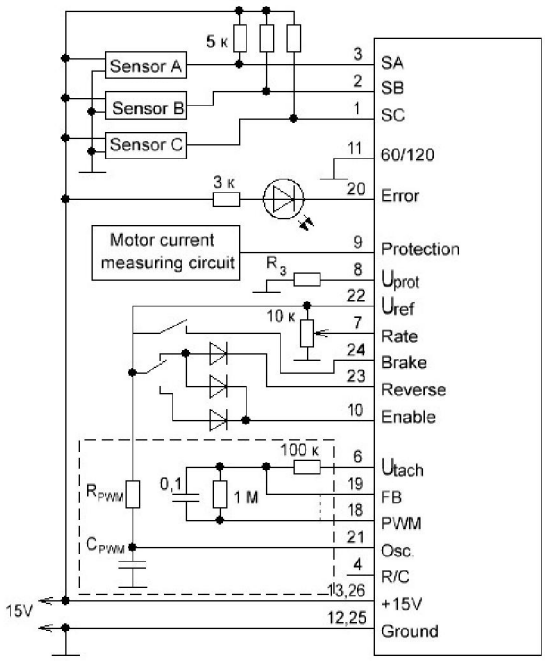

Figure 5.2 – Switching circuit of control circuits RCM «A» and «D» with common switcher

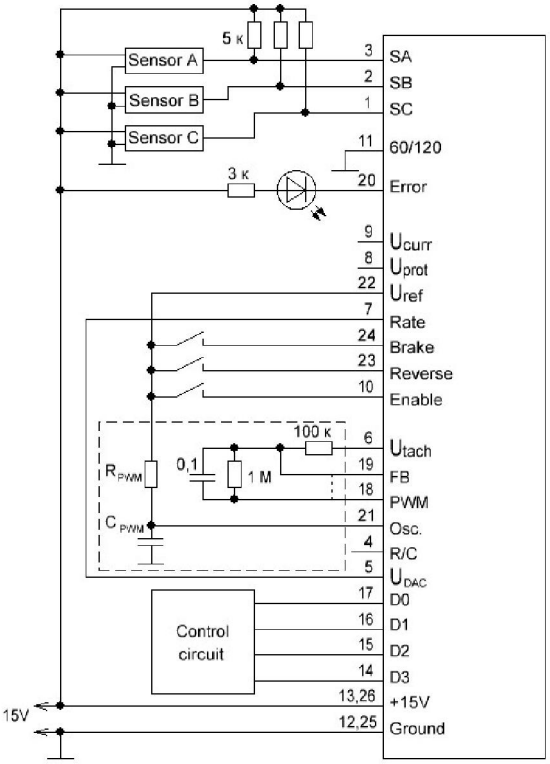

Figure 5.3 – Switching circuit of control circuits RCM «C» and «F»

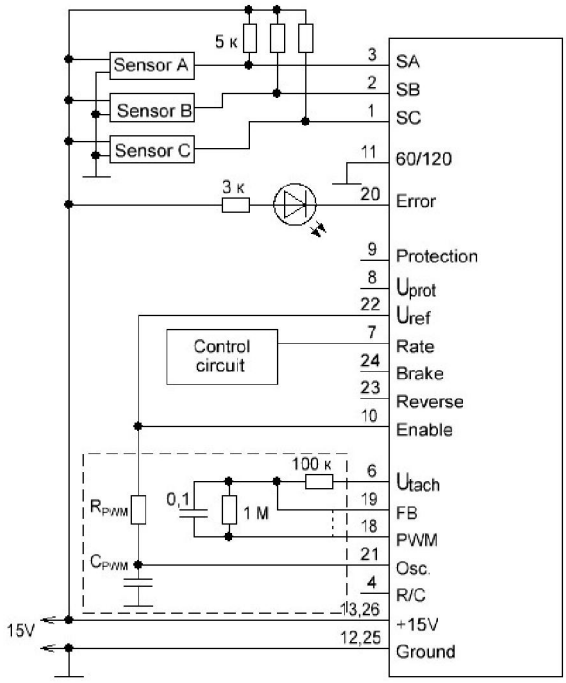

Figure 5.4 – Switching circuit of control circuits RCM «B» and «E»

The dotted lines represent a part of the circuit that is necessary for turn-on of the modules without internal PWM-generator (types «D», «E», «F»). For the modules with internal PWM-generator the indicated outputs should be unactuated.

The turn-on scheme of the module with control option «A» or «D» with a common switch to "Reverse" and "Enable" is shown at Figure 5.2. Module operation inhibition will be only in case of switch breaking with the both terminals.

It is allowed to use the logic TTL-level control instead of the switches.

The motor control by means of RMCM is carried out using the following outputs:

«Enable». TTL-level input giving inhibition or enable for control circuit operation. The "Log.1" corresponds to enable, the "log.0" – to disable. When operation inhibiting the output transistor "Error" will be open (see Table 1).

«Brake». TTL-level input turning on or turning off a braking mode. If there is "log.0" the braking will be absent. When "log.1" is given to this input all the lower inverter transistors will be open, and the motor will switch to a dynamic braking mode (see Table 5.1).

«Reverse». TTL-level input giving motor shaft rotation direction.

«60/120». TTL-level input determining a phase correction mode. The «Log.1» on the input «60/120» sets a phase correction mode in 60 (300) electrical degrees; the «log.0» – phase correction mode in 120 (240) electrical degrees (see Table 5.1).

Algorithms 60° and 300° or 120° and 240° are symmetrical but rotor rotation direction is backward for them. For example, when RPS signals are given on inputs «SA», «SB», «SC» with a phase correction algorithm 60° or 120°, the module gives the current control signals by the motor for forward rotation, and when RPS signals are given with a phase correction algorithm 240° or 300° – for reverse rotation.

The sensors' status depending on the rotor position varies in accordance with the diagram is showed at Figure 5.5.

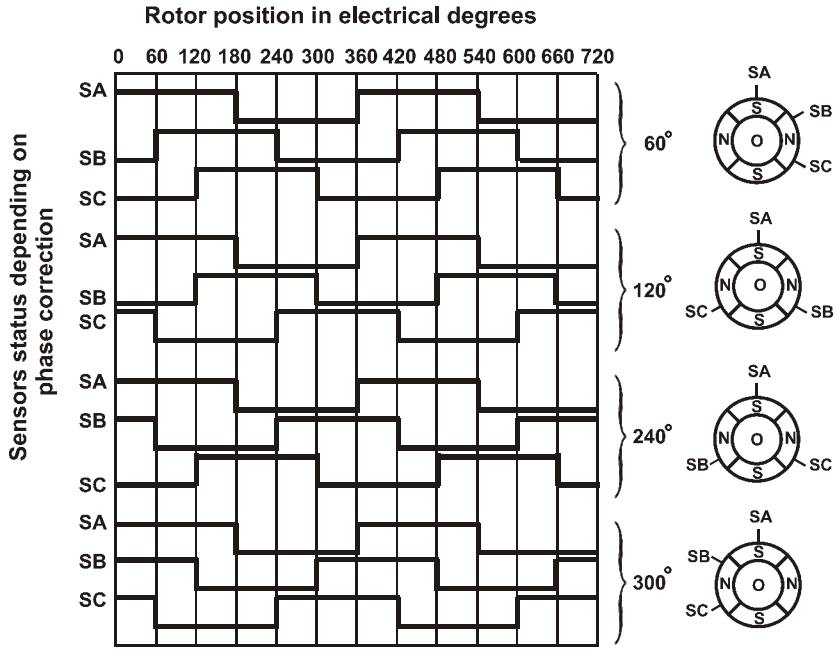

Figure 5.5 – Diagram of position sensors statuses

«Rate». Input for setting of motor shaft rotation speed. The module maintains regulation of motor shaft rotation speed when changing the supply voltage amplitude. If the set rotation speed is less than 50% from the maximum one the speed changes no more than ± 5 % when changing the supply voltage ± 50 %. When the maximum speed is set the regulation is carried out only at increasing the supply voltage amplitude (the speed is changed no more than + 5 %, when amplitude increases no more than + 50 %). The range for speed adjustment is within 0.5…4.5 V for control types «A», «B», «C», and for the other types with adding in an external control circuit of feedback (see Fig. 5.1 - 5.4). If the feedback for the control types "D", "E", "F" is absent (the jumper is installed, as indicated by the dotted line on Fig.5.1 - 5.4), then the speed control range will be in the ranges 1.5 ... 4.5 V. The motor shaft rotation speed versus the input voltage "Speed" is presented at Fig. 5.6 and 5.7 (for control types "B" and "E").

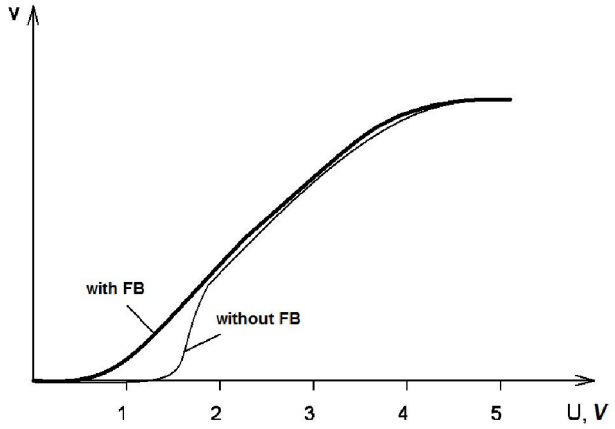

Figure 5.6 – Dependence of motor shaft rotation speed versus voltage on output «Speed» with FB circuit and without it

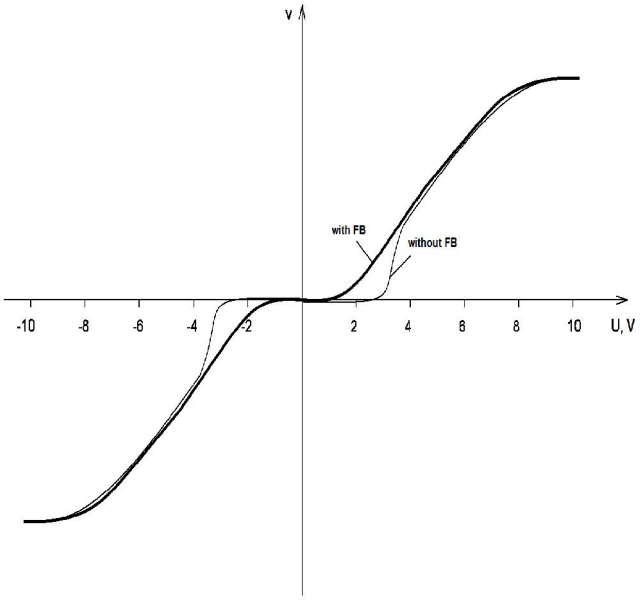

Figure 5.7 – Dependence of motor shaft rotation speed versus voltage on output «Speed» with FB circuit and without it for control types «B» and «E»

For types «B» and «E» the motor control is carried out only on the output «Speed»; the outputs «Reverse» and «Brake» are unactuated. The output «Enable» can be connected to «U_{ref}», then this output will not affected the module operation, if you connect the output «Enable» to «U_{ref}» via the switch, then the control on this output will be carried out same as for the other control types.

The motor rotation direction is selected based on signal polarity on output «Speed», the control voltage -0.5…+0.5 V corresponds to the braking mode (all lower switches are open), the rotation speed is regulated with the voltage level (-10…+10 V). The diagram explaining the module operation with control types «B» and «E» is shown at Figure 5.8.

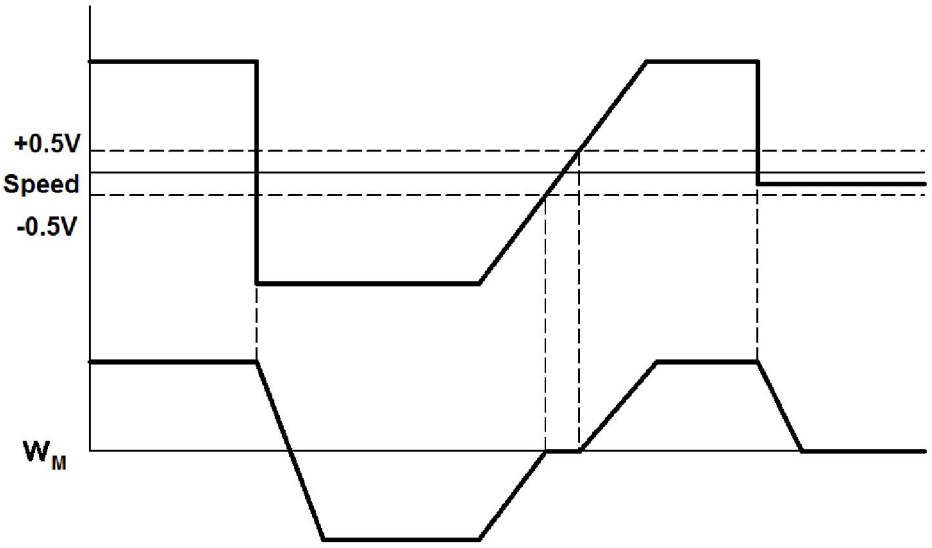

Figure 5.8 – Module control with types «B» and «E»

«SA», «SB», «SC». Inputs of rotor position sensors (RPS). As RPSs can be used sensors of any type with output voltage +5…20 V. When connecting the RPS you must take into account that the outputs «SA», «SB» and «SC» are not connected to supply voltage, therefore, the sensor output is an open collector, then the outputs should be connected to the supply voltage output through resistors as indicated at Fig. 5.1 – 5.4.

Below you can see a table of module statuses when controlling by a three-phase six-step brushless DC motor.

Table 5.1 – Types of module statuses at controlling by three-phase six-step DC motor

Inputs									Защита	Outputs				Note
60º/120º=1			60º/120º=0			Reverse	Enable	Brake		Pha	Phв	Phc	Error	
SA	SB	SC	SA	SB	SC									
1	0	0	1	0	0	1	1	0	0	1	-	0	1	
1	1	0	1	1	0	1	1	0	0	-	1	0	1	
1	1	1	0	1	0	1	1	0	0	0	1	-	1	Reverse=1
0	1	1	0	1	1	1	1	0	0	0	-	1	1	(p.1; p. 2)
0	0	1	0	0	1	1	1	0	0	-	0	1	1	
0	0	0	1	0	1	1	1	0	0	1	0	-	1	
1	0	0	1	0	0	0	1	0	0	0	-	1	1	
1	1	0	1	1	0	0	1	0	0	-	0	1	1	
1	1	1	0	1	0	0	1	0	0	1	0	-	1	Reverse=0
0	1	1	0	1	1	0	1	0	0	1	-	0	1	(p.1; p. 2)
0	0	1	0	0	1	0	1	0	0	-	1	0	1	
0	0	0	1	0	1	0	1	0	0	0	1	-	1	
1	0	1	1	1	1	X	X	0	X	-	-	-	0	p.3
0	1	0	0	0	0	X	X	0	X	-	-	-	0	
1	0	1	1	1	1	X	X	1	X	0	0	0	0	p.4
0	1	0	0	0	0	X	X	1	X	0	0	0	0	
V	V	V	V	V	V	X	1	1	X	0	0	0	1	p.5
V	V	V	V	V	V	X	0	1	X	0	0	0	0	p.6
V	V	V	V	V	V	X	0	0	X	-	-	-	0	p.7
V	V	V	V	V	V	X	1	0	1	-	-	-	0	p.8

p.1	On the outputs «Pha», «Phв», «Phc» the high level (1) indicates connection to «+», low level (0) – connection to «–» (ground minus)
p.2	High level (1) on input «60º/120º» sets a phase correction mode in 60 electrical degrees, low level (0) – phase correction mode in 120 electrical degrees
p.3	At wrong combination on the inputs «SA», «SB», «SC», at low level (0) on input «Brake» - the outputs «Pha», «Phв», «Phc» are disconnected; built according to output with an open collector the «Error» has active low level (0)
p.4	At wrong combination on the inputs «SA», «SB», «SC», at high level (1) on the input «Brake» - the outputs «Pha», «Phв», «Phc» are connected to «-» (ground minus), motor windings are closed between each other, thus, the braking electromagnetic force is generated (dynamic brake); on the output «Error» - low level (0)
p.5	At correct combination on the inputs «SA», «SB», «SC», at high level (1) on the inputs «Enable» and «Brake» - the outputs «Pha», «Phв», «Phc» are in dynamic braking mode; on the output «Error» - high level (1)
p.6	If on the input «Enable» is low level (0), and on the input «Brake» is high level (1) – then the outputs «Pha», «Phв», «Phc» are in dynamic braking mode; on the output «Error» - low level (0)
p.7	If on the inputs «Enable» and «Brake» is low level (0) – then the outputs «Pha», «Phв», «Phc» are disconnected; on the output «Error» - low level (0)
p.8	At the current level consumed by the motor from an external source, higher than the prescribed limit – outputs «Pha», «Phв», «Phc» are disconnected; on the output «Error» - low level (0).

Where X – any state on input, V – any correct state on sensor inputs; the state corresponds to phase correction 60º or 120º.

«U_{curr}». Output of shunt current. To the protection operation voltage always corresponds 100 mV on the output regardless on the maximum module current.

When current protection operating the transistor of the output «Error» will be opened, same as at giving a wrong combination from motor sensors.

«Error». The output alarming about presence of module operation inhibition («log.0» on the output «Enable»), about emergency situation caused by overcurrent or wrong combination on the inputs of rotor position sensors; it is an open transistor collector of the protection circuits. The notification to operation of the output is represented in Table 5.1.

«U_{tach}». TTL-level output of internal module tachometer. When motor shaft rotating then on the output «U_{tach}» there must be the pulses with duration of 0.5 ms with a duty cycle changing depending on the motor shaft rotation speed.

For measuring of the motor speed it is recommended to connect to this output an RC-circuit smoothing the pulses. In this case, at increasing the motor shaft rotation the duty cycle on output «U_{tach}» will be decreased and on the output RC-filter the signal amplitude will be increased. It is rational to use this output either for speed display or speed feedback.

«R/C». Serviceability control input of internal module tachometer. In normal tachometer operation on this output should be the pulses with amplitude of 3 … 5 V and the duty cycle depending on the motor shaft rotation speed; the leading edge should be considerably longer than the rear one.

«PWM» and **«FB».** Stabilization inputs of motor shaft rotation speed. The outputs are used only for the control types «D», «E», «F»; for the control types «A», «B», «C» the feedback has included in the module circuit and does not require any adjustment. If the feedback is not required, then the outputs should be connected (Fig. 5.1 - 5.4), then the speed will be regulated in the control voltage range 1.5…4.5 V. The type of module using in the mode of feedback closed loop is shown at Figure 5.9. Here the pulse signal which is proportional to the speed level (tachometer signal) can be received from any sensor (optical, Hall transducer, etc) with the signal level (0…6.5) V.

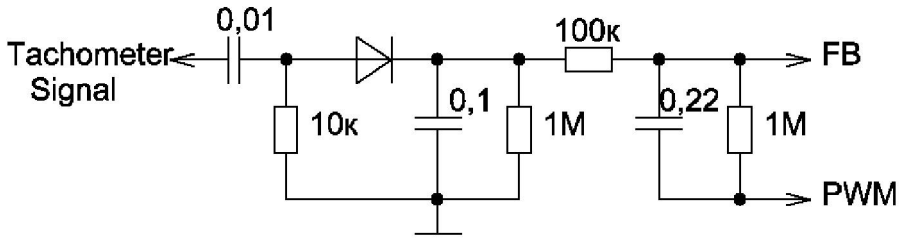

Figure 5.9 – Connection scheme to connect speed feedback

The feedback depth and its operation correctness at different motor shaft rotation speed should be regulated with the capacitor ratio 0.01 μF and resistor 10 kΩ, and capacitor ratio 0.22 μF and resistor 100 kΩ.

«Осц.». The input meant for timing circuit connection for the internal PWM generator. The recommended connection scheme of this input is represented at Figure 5.1 – 5.4. The frequency giving by an external RC-chain, should be within 15…50 kHz. Dependence of frequency versus resistor and condenser nominals is shown at Figure 5.10.

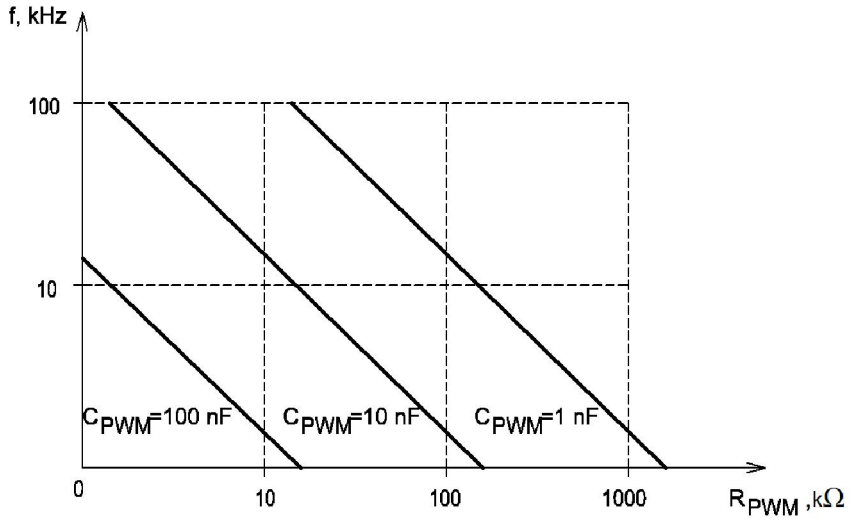

Figure 5.10 – Dependence of frequency PWM versus nominals R_{pwm} and C_{pwm}

For receiving of more linear nature of the motor shaft rotation speed change versus the control voltage, it is recommended to install the current source 0.5 ... 5 mA instead of resistor R_{PWM} depending on the required PWM frequency.

The output is used only for the control types «D», «E», «F».

«D0», «D1», «D2», «D3». TTL-level inputs of internal DAC. The motor shaft rotation frequency will be changed from combination corresponding to 0.5 V at the DAC output (output of «U_{dac}») to combination corresponding to 4.5 V for the types with an internal PWM-generator, or with the used feedback. To control without feedback the speed regulation will be implemented starting with the combination corresponding to 1.5 V.

The outputs are used only for the control types "C" and "F".

«U_{DAC}». Output of internal DAC. To control connection with DAC you need to connect this output with the output "Speed", as specified in Figure 5.3. The value changing of the input code from 0000 to 1001 leads to step changing of the speed level from 0% to 90% approximately upon 10%. The values of the input code from 1010 to 1111 correspond to 100% of speed level. To provide more smooth speed regulation it is recommended to install the integrating RC-circuit 1…10 kΩ / 0.01…0.1 μF between outputs «U_{dac}» and «Speed» and to supply PWM-signal of 1…20 kHz to one of the digital velocity demand input. At that, the older the charge the in larger range (and bigger discreteness) the regulation can be carried out: changes 1…1.5 V when signal delivering to the output «D3»; changes 0.1…0.2 V when delivering to the output «D0».

The output is used only for the control types "C" and "F".

«U_{ref}». A reference voltage source output (6.5V±5%) with maximum output current 10 mA. When connecting this output you should use caution to avoid current overload or short circuit, because in this case the module can fail.

«+15V». Supply input of the module with current consumption 60…100 mA (depending on the control type and ambient temperature) without any external control circuit load. The module supply can carry out both from a separate source and from a power supply with a stabilizer installing (Fig. 6.1 and 6.2). It is not recommended to carry out the supply from a power circuit without a stabilizer even if you use the power supply 12 V, because the control circuit can fail because of commutating surges or voltage's surges in the braking moment.

6. POWER OUTPUTS

To connect the power circuits of RCM recommended the circuits presented in Fig. 6.1 and 6.2.

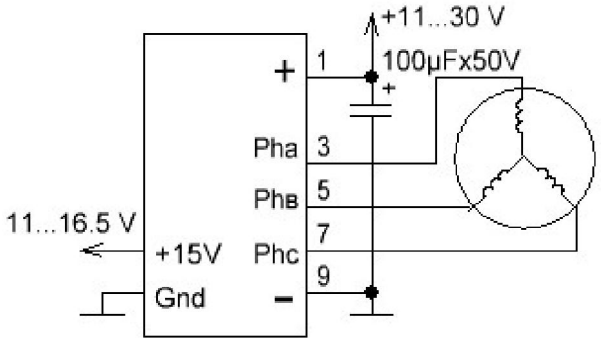

Figure 6.1 – Connection circuit of RCM with separate supply

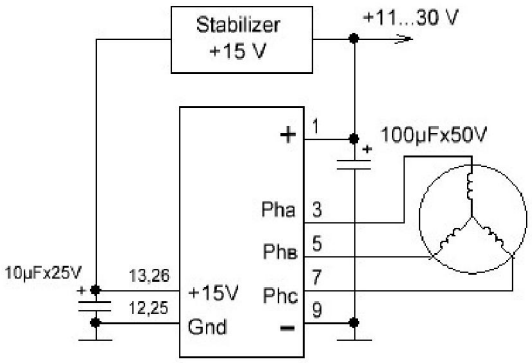

Figure 6.2 – Connection circuit of RCM with supply from power circuit

Feature of use of the module supply from a power supply described in the previous section.

A filtering condenser of the power circuit should install to the module outputs as close as you can. Optimal capacitance of the condenser is 100 µF; not recommended to install a condenser having capacitance less than 10 µF, including at high output capacitance of a voltage stabilizer.

Permissible voltage for power circuit supply is 11…30 V, however, when motor operating can be commutating surges having big amplitude. Permissible amplitude for surges is 36 V. If a motor can give big surges or when braking appear larger voltage surge then it is recommended to connect a voltage limiter with rate breakdown voltage 30…36 V and power not less than 1 W to the outputs of the module «+» and «-».

The phases should be connected to the relevant outputs. When wrong connecting of the phase, the motor will operate incorrectly. При неправильном подключении фаз двигатель будет работать некорректно. Below you can see Table 6.1, in which specified the maximum powers of the motors supporting by the modules RCM.

Table 6.1 – Maximum permissible module current and powers of brushless DC motor

U, V	0.5 A	1 A	3 A	5 A
	P_{max}, W			
15	5	11	33	55
27	10	22	62	110

The RCM of different types can provide correct operation and protection of motor having the power specified in Table 6.1. At that, the values specified in the table (maximum motor power P_{max}) are correct in that case if the motor operates on its full power. It is allowed to install the motors having bigger rate power if the power on the motor shaft will not exceed the maximum average power supported by the module. However, independently on the power providing by the motor its rate power should not exceed 110 W to supply 15 V and 200 W to supply 27 V, otherwise the module can fail because of the starting current.

7. INSTRUCTIONS FOR USE

The module is intended to operate without a cooler.
The module should only be used in exposure to mechanical loads in accordance with Table 7.1.

Table 7.1 – Impact of mechanical loads

External exposure factor	Value of external exposure factor
Sinusoidal vibration: - acceleration, m/s^2 (g); - frequency, Hz	 150 (15) 0.5 - 100
Mechanical shock of repeated action : - peak impact acceleration , m/s^2 (g); - duration of impact acceleration, ms	 40 (4) 50
Linear acceleration, m/s^2 (g)	5000 (500)

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

Таблица 7.2 – Воздействие климатических нагрузок

Climatic factor	Value of climatic factor
Low temperature of environment: - operating, °C; - maximum, °C	 - 40 - 45
High temperature of environment: - operating, °C; - maximum, °C	 + 85 + 100
Relative humidity at temperature 35 °C with non-condensing, %, max	98

The outputs of the module are intended to mount them on PCB using soldering or using bolt connectors. Permissible number of re-solderings of the module outputs when operating mounting (assemble) is 3. The output soldering should be at temperature not higher than 235°C. Duration of the soldering should be not longer than 3 sec.

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

8. RELIABILITY REQUIREMENTS

Manufacturer guarantees quality conformance of modules when compliance by the consumer's storing, mounting and operating conditions, as well as application reference specified in the user's manual.

Operating warranty is two years from the acceptance date, in the event 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 at $\gamma = 90$ %.

Gamma-percent service life of the modules, subject to cumulative operating time is no 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.

9. OVERALL AND CONNECTING DIMENSIONS

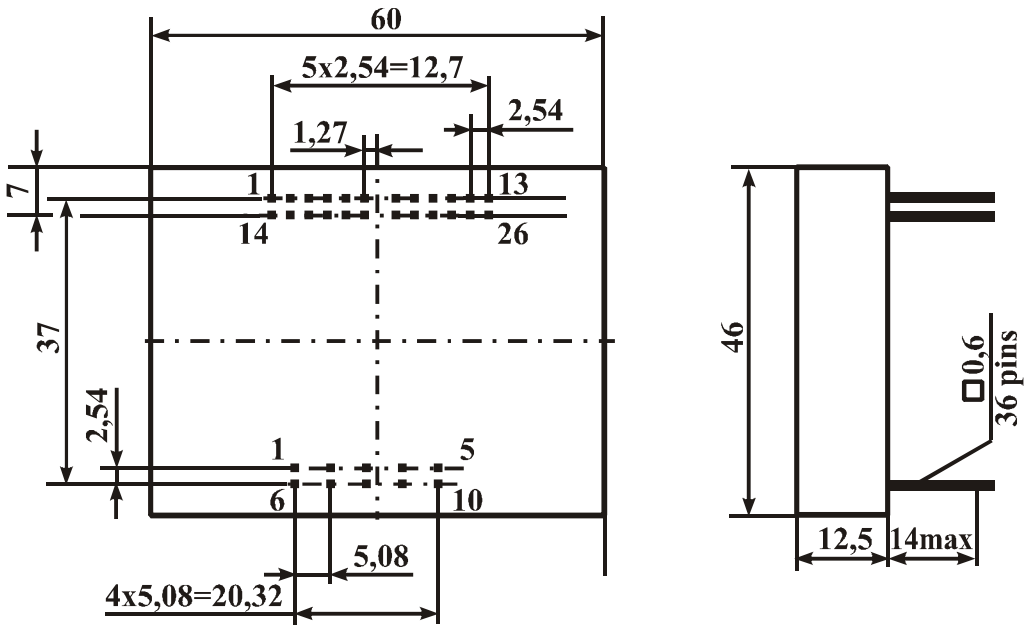

Figure 9.1 – Overall dimensions of RCM

Precious metals are not contained.

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