BRUSH DC DRIVE MODULE MODERNIZED - BDCDMM

USER'S MANUAL

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1 DESCRIPTION AND FUNCTIONS

Brush DC drive module modernized (hereinafter - BDCDMM or module) is intended for brush DC motor driving. BDCDMM is performed on the basis of modern power electronics, microelectronics, digital-to-analogue integrated circuits and controllers of digital and analogue signal processing with the integral PWM schemes.

BDCDMM supports the following functions and performances:

- Controllable start/stop engine;
- Motor shaft rotation direction change;
- Rate control;
- Electric motor protection from current overload and short-circuit;
- Pulse current surge protection;
- Current protection pickup setting;
- Overheating protection;
- Protection against simultaneous turn-on of top and lower inverter arm transistors;
- External signaling about an accident;
- Internal voltage control;
- Module power from the power circuit (for modules of 1, 2, 6 class);
- Allows supplying the external circuits with its own stabilized voltage +5 V and +15 V with protection against current overload;
- Connection of AC voltage without rectification (BDCDMM with radiator type “3”);
- Smooth charge of filter capacity without additional charge resistor and charge control circuits (BDCDMM with radiator type “3”)

BDCDMM provides operation and protection of the engines up to 15 kW. BDCDMM produced with different control options which allow using the module as solution to common industrial problems and solutions for special cases.

2 MODULE TYPES

BDCDMM are produced with different radiator types and control options. Sections 5 and 6 give the recommended module connection circuits depending on the version.

BDCDMM are produced at 5, 10, 20, 30, 50, 70 and 100 A. The current in the module name indicates the maximum inverter current control circuit which allows normal operation; the maximum transistor current exceeds the specified one in the product name. The current protection will trigger at higher current and inverter current will be limited. The current specified in the product name is the protection operation current at the average current. Meanwhile the protection current can be regulated but only to the lower side (see section 5).

The peak voltage designed in the module name indicates collector-emitter voltage capability of transistors used in the module. BDCDMM is available for 100, 200, 600 and 1200V that correspond to 1, 2, 6 and 12 in the name of the module. Meanwhile the peak supply voltage is lower for the module than it is indicated in the name (see section 4), that conditioned on security measures when operating of the module's power transistors.

Modules at 100V are produced at 5, 10, 20, 30, 50, 70 and 100 A;

Modules for 200 V are produced at 5, 10, 20, 30, 50 and 70 A;

Modules at 600 V are produced at 5, 10, 20, 30 and 50 A

Modules at 1200 V are produced at 5, 10, 20, 30 and 50 A;

Types of power assembly:

«4» - only inverter.

«3» - inverter and rectifier bridge. This version of the radiator contains a controlled thyristor-diode rectifier bridge which allows the module to operate directly from the alternating voltage. The control circuit of the rectifier bridge thyristors provides a smooth (within 300 ms) filter capacity charge, which, in turn, allows managing without the current-limiting resistor.

With power assembly type "3" the module of 1, 2, 6-th group at currents 5 and 10 A are produced that is BDCDMM-5-1-x3, BDCDMM-10-1-x3, BDCDMM-5-2-x3, BDCDMM-2-x3, BDCDMM-5--6x3, BDCDMM-10-6-x3. All other types of BDCDMM are produced only with power assembly type "4"

Control option:

"A" - standard with the PWM. Digital-to-analog control using all standard control module outputs with integral PWM generator circuit.

"B" – simplified with PWM. The control option with built-in PWM-oscillator scheme which allows choosing operation enable/disable and motor shaft rotation direction with one switch, that is convenient, in particular, using the module in lifting and traction mechanisms.

"C" – bipolar with PWM. Control with built-in PWM-oscillator scheme, is carried out on one input or with DAC or with a variable appropriately connected resistor. Control voltage is over the range -10 … +10 V with the braking range -0.5 … +0.5 V. The rotation speed meanwhile is determined by the voltage amplitude and the rotation direction of its polarity.

"D" – digital with PWM. DAC forms a part of the module. DAC allows carrying out the speed control with help of digital code; meanwhile the module can be controlled by the standard control scheme (type "A"); the control option choice is carried out with availability or deficiency of the jumper (see section 5). The module has an internal PWM-oscillator.

"E" – standard without PWM. The control algorithm is not differed from the type "A", except that the module does not include PWM-oscillator. For module operation it is necessary the external connection of timing chain for PWM-oscillator, feedbacks connection. The module options without internal PWM-oscillator can be convenient for decision of complicated particular problems and for realization of specific speed feedbacks.

"F" – simplified without PWM.

"G" – bipolar without PWM.

"H"- digital without PWM.

All control options are applicable to all types of power assemblies regardless of the module's current and the module's voltage.
Figure 2.1 shows the decoding of the module's series BDCDMM.

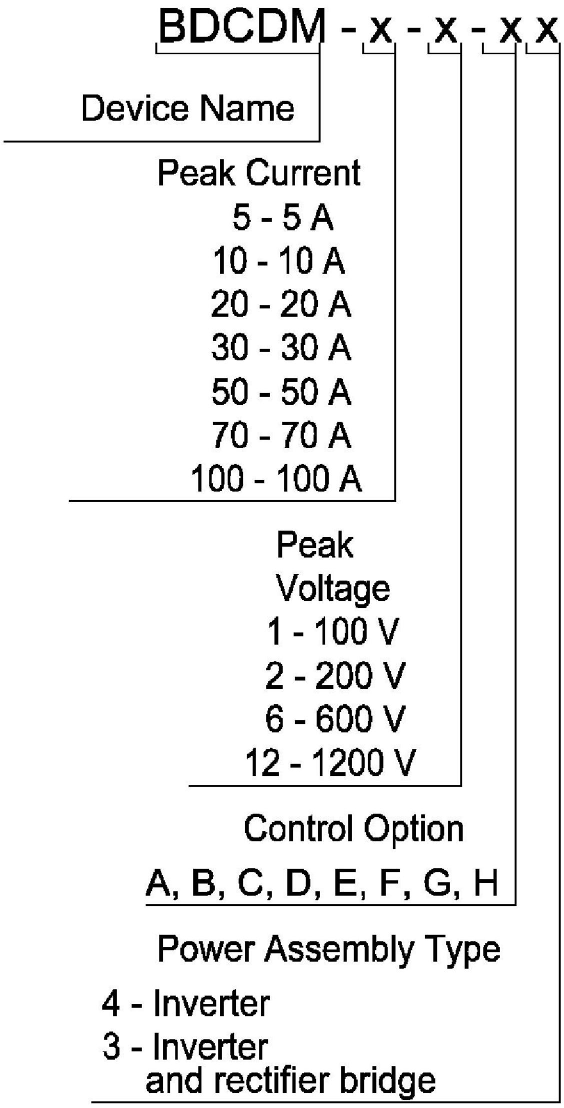

Figure 2.1 – Module name decoding

For instance, the module BDCDMM-30-12-B4: brushless motor control module with maximum inverter current 30 A, peak inverter voltage 1200V, with control option «C», power assembly – only inverter.

3 GENERAL MODULE DESCRIPTIONS

Module BDCDMM is an assembly of control thyristors module M31 and control module BDCCM. The structural circuit of BDCDMM is shown at Figure 3.1.

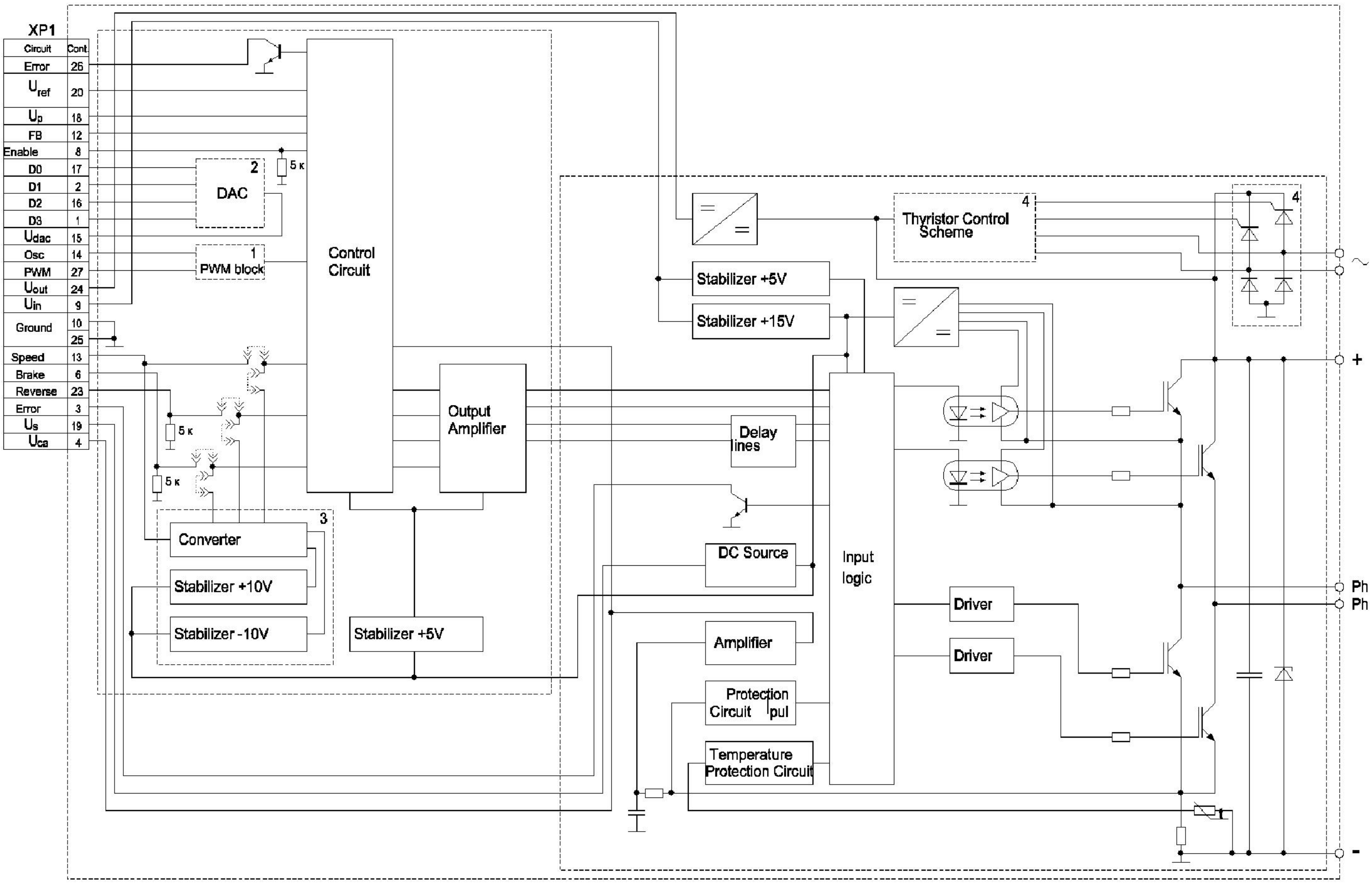

Figure 3.1 – Structural circuit of BDCDMM

«1» - internal PWM generator scheme, installed for control options «A», «B», «C» and «D».

«2» -internal DAC, installed for control options «D», «H»

«3» - conversion circuit for bipolar connection, being a part of BDCDMM for control options «C» и «G».

«4» - rectifier bridge circuit providing smooth filter capacity charge and capability of module operation from AC voltage. The scheme is a part of 3PHBLDCDMM with power assembly type “3”.

Connector XP1 is two rows of contacts PLS-15 with the response part of the type PBS-15. The connector is intended for module controlling. Power contacts or tips (for modules at currents 5 and 10 A), or tread contacts for screw M8 (see overall drawings). Outputs assignment of connectors XR1 and power outputs are represented in Table 3.1. In the column “Control” the sign “+” denotes the output is used for this control type, the sign “-” denotes that the output is not used.

Table 3.1 – Module outputs description

Number	Symbol	Description
1	D2	The second discharge of digital speed control input
2	D0	The null discharge of digital speed control input
3	Error 1	Signaling output of current and temperature overload
4	U_{ca}	Amplifier output of Bypass Current
5		Not involved
6	Brake	Braking Control Input
7		Not involved
8	Enable	Operation Enable/Inhibit Input
9	U_{in}	Internal voltage stabilizer Input
10	Ground	Ground
11		Not involved
12	FB	Speed Feedback Input
13	Speed	Rotation Speed Control Input
14	Osc.	Connection Input of pulse-time frequency elements of PWM Oscillator
15	U_{dac}	Digital Speed Control Input
16	D3	The third discharge of digital speed control input
17	D1	The first discharge of digital speed control input
18	U_p	Protection Operation Current Control Output
19	U_s	DC Source Output +15 V
20	U_{ref}	Reference Voltage Source
21		Not involved
22		Not involved
23	Reverse	Control Input of Motor Shaft Rotation Direction
24	U_{out}	Internal DC/DC – converter Output
25	Ground	Ground
26	Error 2	Signaling Output of Operation Inhibit
27	PWM	Inverting PWM Comparator Input
28		Not involved
29		Not involved
30		Not involved
	+	Power Supply Connection Output «+»
	Ph	Motor Connection Outputs
	-	Power Supply Connection Output «-»
	~	AC Voltage Connection Output (only for modules with rectifier bridge)

For easy connection of control circuits schematic external connectors XP1 of BDCDMM are shown at Figures 3.2.

1									10					15
D3	D1	Error 1	U_{ca}		Brake		Enable	U_{in}	Ground		FB	Speed	Osc.	U_{dac}
D2	D0	U_p	U_s	U_{ref}			Rev	U_{out}	Ground	Error 2	PWM		Protec.	
16									25					30

Figure 3.2.1 – Appearance of connector XP1 with control A.

1									10					15
		Error 1	U_{ca}		Brake		Enable	U_{in}	Ground			Speed		
		U_p	U_s	$U_{\text{оп}}$			Rev	U_{out}	Ground	Error 2				
16									25					30

Figure 3.2.2 – Appearance of connector XP1 with control B.

1									10					15
		Error 1	U_{ca}				Enable	U_{in}	Ground			Speed		
		U_p	U_s	U_{ref}				U_{out}	Ground	Error 2				
16									25					30

Figure 3.2.3 – Appearance of connector XP1 with control C.

1									10					15
D2	D0	Error 1	U_{ca}		Brake		Enable	U_{in}	Ground			Speed		U_{dac}
D3	D1	U_p	U_s	U_{ref}			Rev	U_{out}	Ground	Error 2				
16									25					30

Figure 3.2.4 – Appearance of connector XP1 with control D.

1									10					15
		Error 1	U_{ca}		Brake		Enable	U_{in}	Ground		FB	Speed	Osc.	
		U_p	U_s	U_{ref}			Rev	U_{out}	Ground	Error2	PWM			
16									25					30

Figure 3.2.5 – Appearance of connector XP1 with control E.

1									10					15
		Error 1	U_{ca}		Brake		Enable	U_{in}	Ground		FB	Speed	Osc.	
		U_p	U_s	U_{ref}			Rev	U_{out}	Ground	Error 2	PWM			
16									25					30

Figure 3.2.6 – Appearance of connector XP1 with control F.

1									10					15
		Error 1	U_{ca}				Enable	U_{in}	Ground		FB	Speed	Osc .	
		U_p	U_s	U_{ref}				U_{out}	Ground	Error2	PWM			
16									25					30

Figure 3.2.7 – Appearance of connector XP1 with control G.

1									10					15
D2	D0	Error 1	U_{ca}		Brake		Enable	U_{in}	Ground		FB	Speed	Osc.	U_{dac}
D3	D1	U_p	U_s	U_{ref}			Rev	U_{out}	Ground	Error 2	PWM			
16									25					30

Figure 3.2.8 – Appearance of connector XP1 with control H.

4 BASIC CHARACTERISTICS

Basic electric characteristics and maximum allowable electric characteristics of the modules BDCDMM at 25^0C are represented in Tables 4.1 - 4.5.

Table 4.1 – Basic electric characteristics and maximum allowable electric characteristics of BDCDMM

Title	Unit measure	Rate			Note
		min	type	max	
Supply characteristics					
Supply Voltage (power from the power circuit)*	V	40		60	1 group
		40		160	2 group
		40		350	6 group
Current Consumption	mA			40	Supply from power circuit U_s=350 V
Supply Voltage	V	15		20	External Supply
Current Consumption	mA		200	250	External Supply
Input characteristics					
Output Current Consumption	mA			1	
Control Voltage Range	V	-0.3		5.2	
Lower Level Input Voltage	V	-0.3		0.5	For logic inputs
High Level Input Voltage	V	2.4		5.2	For logic inputs
Closedown Voltage	V		1.2		
Maximum Speed Voltage	V		4.5		
PWM oscillator characteristics					
PWM oscillator Frequency	kHz	15		25	
Maximum Peak Tooth Voltage	V	4.2		4.6	
Minimum Peak Tooth Voltage	V	1.0		1.2	
Output characteristics					
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			20	
Voltage on Output «U_s»	V		15	16.5	No load
Maximum Load Current on Output «U_s»	mA			50	
Current Protection Pickup Voltage on Output «U_{ca}»	V		1.0		

* Control circuit of two-phase inverter modules will be powered only from an external source

Protection characteristics					
Protection Operation Current at average Current	A		5		5 A
			10		10 A
			20		20 A
			30		30 A
			50		50 A
			70		70 A
			100		100 A
Current Protection Speed	µs			100	
Protection Operation Current at Pulse Current	A		20		5 A
			40		10 A
			70		20 A
			120		30 A
			200		50 A
			250		70 A
			350		100 A
Protection Speed at Pulse Current	µs			3	
Turn-on Temperature of Temperature Protection	^{0}C	90		100	
Turn-off Temperature of Temperature Protection	^{0}C	50		60	
Temperature Protection Speed	ms			1	
Output Operation Delay «Error»	µs			2	

Table 4.2 – Basic and maximum permissible electric characteristics of power circuits for modules of 1-st class (BDCDMM-xx-1-xx)

Title	Unit	Rate			Note
		min	type	max	
Power switches characteristics					
Drain-Source Maximum Voltage	V			100	
DC Link Peak Voltage	V			60	
Power Transistor Maximum average current at 100^0C	A			12	5 A
				23	10 A
				30	20 A
				40	30 A
				68	50 A
				97	70 A
				107	100 A
Power Transistor Maximum Pulse Current at 25^0C	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	W			5.5	5 A
				11	10 A
				36	20 A
				52	30 A
				75	50 A
				105	70 A
				200	100 A
Power Circuit Closed Transistor Leakage Current	mA			100	
Isolation characteristics					
Isolation Voltage Module Outputs – housing base	V	1000			DC, 1 minute

Table 4.3 – Basic and maximum permissible electric characteristics of power circuits for modules of 2-nd class (BDCDMM-xx-2-xx)

Title	Unit	Rate			Note
		min	type	max	
Power switches characteristics					
Peak Voltage Drain-Source	V			200	
DC Link Peak Voltage	V			160	
Power Transistor Maximum average current at 100^0C	A			11	5 A
				17	10 A
				32	20 A
				44	30 A
				66	50 A
				76	70 A
Power Transistor Maximum Pulse Current at 25^0C	A			70	5 A
				90	10 A
				180	20 A
				260	30 A
				380	50 A
				420	70 A
Loss Power by Maximum Load	W			10	5 A
				25	10 A
				55	20 A
				55	30 A
				125	50 A
				270	70 A
Power Circuit Closed Transistor Leakage	µA			100	

Current					
Isolation characteristics					
Isolation Voltage Module Outputs – housing base	V	2000			DC, 1 minute

Table 4.4 – Basic and maximum permissible electric characteristics of power circuits for modules of 6-th class (BDCDMM-xx-6-xx)

Title	Unit	Rate			Note
		min	type	max	
Power switches characteristics					
Collector-Emitter Peak Voltage	V			600	
DC Link Peak Voltage	V			400	
Power Transistor Maximum Average Current at 100^0C	A			11	5 A
				16	10 A
				30	20 A
				60	30 A
				60	50 A
Power Transistor Maximum Pulse Current at 25^0C	A			35	5 A
				60	10 A
				105	20 A
				240	30 A
				240	50 A
Loss Power at Maximum Load	W			20	5 A
				45	10 A
				80	20 A
				90	30 A
				280	50 A
Power Circuit Closed Transistor Leakage Current	µA			100	
Isolation characteristics					
Isolation Voltage Module Outputs – housing base	V	4000			DC, 1 minute

Table 4.5 – Basic and maximum permissible electric characteristics of power circuits for modules of 12-th class (BDCDMM -xx-12-xx)

Title	Unit measure	Rate			Note
		min	type	max	
Power switches characteristics					
Collector-Emitter Peak Voltage	V			1200	
DC Link Peak Voltage	V			700	
Power Transistor Maximum Average Current at 100^0C	A			10	5 A
				15	10 A
				24	20 A
				60	30 A
				60	50 A
Power Transistor Maximum Pulse Current at 25^0C	A			40	5 A
				60	10 A
				90	20 A
				240	30 A
				240	50 A
Loss Power at Maximum Load	W			25	5 A
				65	10 A
				160	20 A
				90	30 A
				280	50 A
Power Circuit Closed Transistor Leakage Current	µA			100	
Isolation characteristics					
Isolation Voltage Module Outputs – housing base	V	4000			DC, 1 minute

5 MODULE CONTROL

We recommend the following turn-on schemes versus module control type (Figures 5.1 – 5.4).

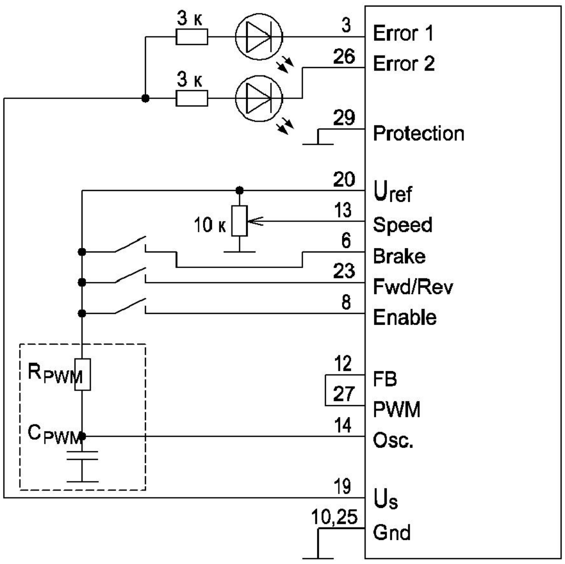

Figure 5.1 – Turn-on schemes of Control Circuits BDCDMM «A» and «E»

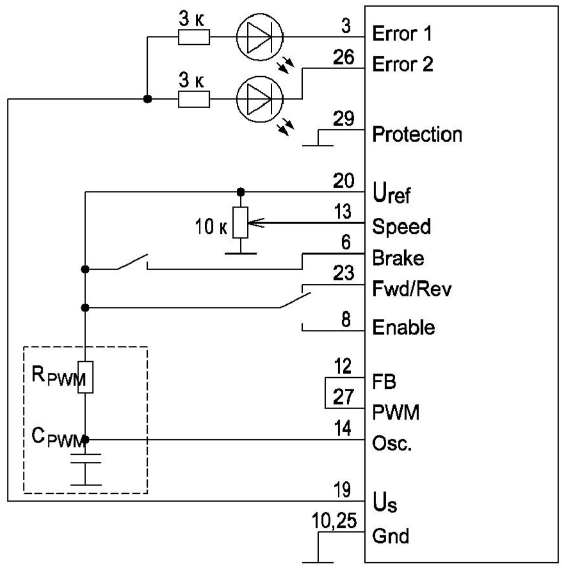

Figure 5.2 – Turn-on schemes of Control Circuits BDCDMM «B» and «F»

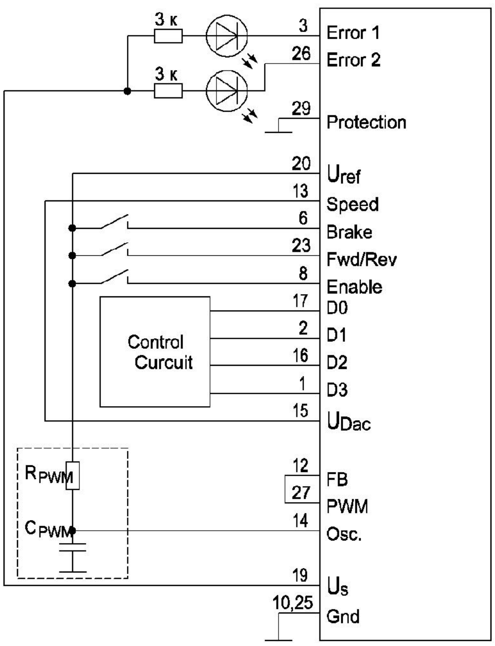

Figure 5.3 – Turn-on schemes of Control Circuits BDCDMM «D» and «H»

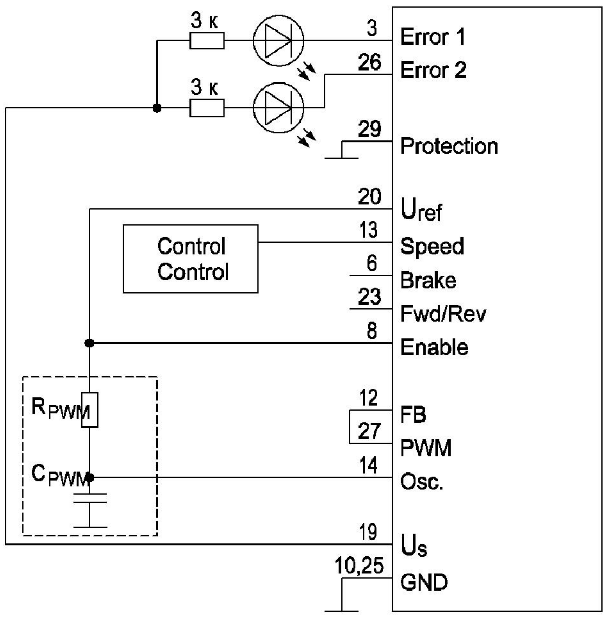

Figure 5.4 – Turn-on schemes of Control Circuits BDCDMM «C» and «G»

Dotted lines represent a part of the scheme that is necessary for turn-on of the modules without internal PWM generator (options «E», «F», «G», «H»). For modules with internal PWM oscillator the indicated outputs should be unactuated.

The turn-on scheme of the module with control option «B» or «F» with common switch to "Forward Reverse" and "Enable" is shown at Figure 5.2. Module operation inhibition will be only in case of switch breaking with both contacts. Control options "B" and "F" can be also controlled on option circuits "A" and "E".

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

The motor control by means of 3PHBLDCDM is carried out with help of following outputs:

«Enable». TTL-level input giving inhibition or enable to control scheme operation. “Log.1” corresponds to enable, “log.0” – to inhibit. When operation inhibition, output transistor “Error 2” will be open (see Table 1).

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

«Forward Reverse». TTL-level input giving motor shaft rotation direction. The rotation change is carried out by switching of module phase top transistors. By rotation direction switching it is recommended first to give braking signal (or to remove the signal “Enable” for motor shutdown with rundown) because when braking with opposite connection the motor can fail.

«Speed». Input of motor shaft rotation velocity demand. Speed control mode is within 1.5…4.5 V. The motor shaft rotation speed versus the input voltage “Speed” is presented at Fig. 5.5 and 5.6 (for control options, “C” and “G”).

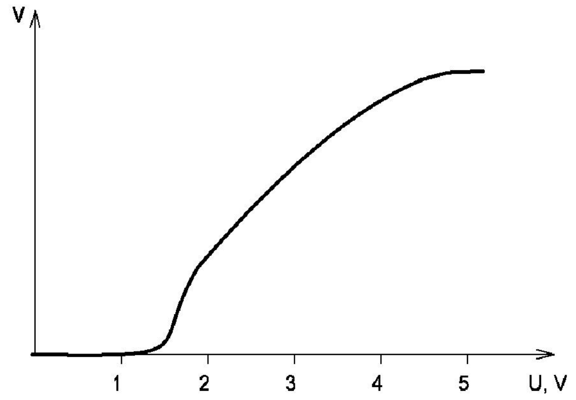

Figure 5.5 – Motor Shaft Rotation Speed versus Output Voltage «Speed»

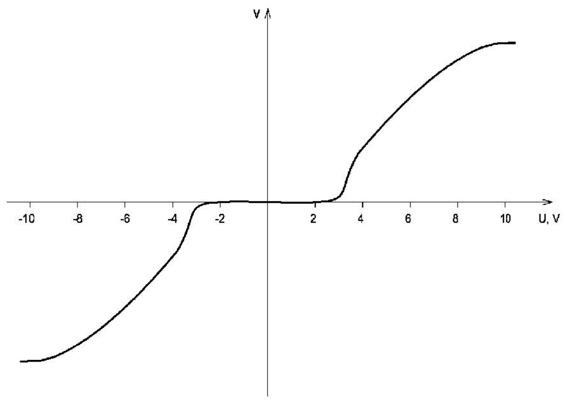

Figure 5.6 – Motor Shaft Rotation Speed versus Output Voltage «Speed» for control options «C» and «G»

For options «C» and «G» the motor control is carried out only on output «Speed»; outputs «Forward Reverse» and «Brake» are unactuated. Output «Enable» can be connected to «U_{ref}», then this output will not affect the module operation, if the output «Enable» to «U_{ref}» through the switch, then the control on this output will be carried out as well as for the other control options.

Motor rotation direction is selected in agreement with signal polarity on output «Speed», the control voltage 0.5…+0.5V corresponds to braking mode (all lower switches are open), the rotation speed is regulated with voltage level (-10…+10 V). The diagram with explaining the module operation with control option «B» and «E» is shown at Figure 5.7.

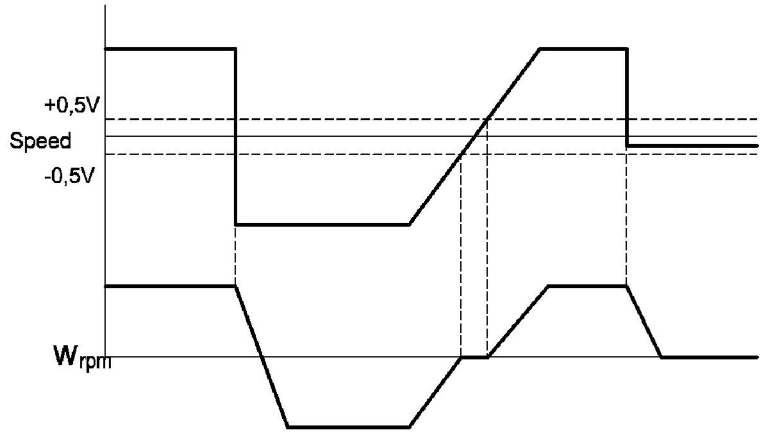

Figure 5.7 – Module control with option «C» and «G»

Below is a table of module statuses when brush DC module control.

Table 5.1 – Options of module statuses when brush DC module control.

Inputs			Protection	Outputs			Note
Fwd/Rev	Enable	Brake		1	2	Error 2	
1	1	0	0	1	0	1	p.1
0	1	0	0	0	1	1	p.1
X	1	1	0	0	0	1	p.2
X	0	1	0	0	0	0	p.3
X	0	0	0	-	-	0	p.4
X	1	0	1	-	-	0	p.5

p.1	On outputs «1», «2» on the high level (1) signifies connection to «+», the low level (0) – connection to «–» (ground minus).
p.2	With the high level (1) on inputs "Enable" and "Brake" – outputs «1», «2» are connected to «-» (ground minus), motor windings outputs are closed between, thus the braking electromagnetic force is generated (dynamic brake).
p.3	If on input «Enable» is a low level (0), and on input «Brake» high level (1) – outputs «1», «2» are in dynamic braking mode; the output "Error" constructed on scheme with open collector has inactive low level (0).
p.4	If on the inputs «Enable» and «Brake» low level (0) – outputs "1" and "2" are disconnected; on output "Error" – low level (0)
p.5	At the current level consumed by the motor from an external source of specified limit above – outputs «1", "2" are disconnected; on output "Error 2" – low level (0).

Where X – any state on input.

«Protection». Enable (Inhibition) input of module operation. The signal «log.1» corresponds to module operation inhibition, the signal «log.0» - enable. In a simple case the input must be connected to the output «Ground».When operation of this protection the output transistor «Error» will be opened.

«U_p». Output of current protection pickup. Protection will operate on maximum current of BDCDMM by unactuated output «U_p»; by connection of outputs «U_p» and «Ground» The protection will operate on the level 10…20% of the maximum current. For protection pickup demand it is necessary to connect the resistor R_{ch} to this output as shown at Figure 5.1 - 5.4. The nominal of this resistor should be chosen proceeding from the following graph (see Figure 5.8).

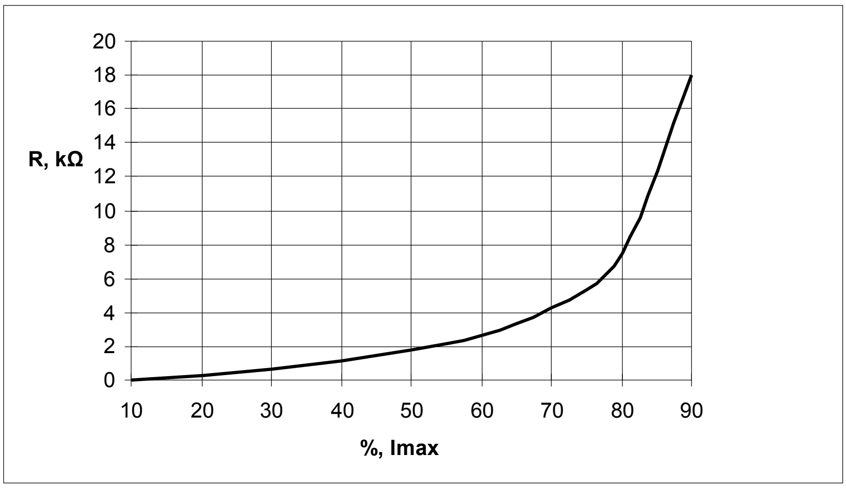

Figure 5.8 - Protection Operation Current versus Protection Resistor Value.

Thus, if, for instance, resistor of 2.7 kΩ will be connected to BDCDMM of 10A, then the protection will operate at current of 6A. For easy calculation refer to Table 5.1 of adjustable protection current percentage against protection over-current.

Table 5.2 - Percentage of probable protection current versus maximum protection current

%	Maximum current specified in product name, A						
	5	10	20	30	50	70	100
20	1	2	4	6	10	15	20
40	2	4	8	12	20	30	40
60	3	6	12	18	30	40	60
80	4	8	16	24	40	55	80
100	5	10	20	30	50	70	100

«U_{ca}». Inverter current amplifier output (motor current). To the maximum module current corresponds 1 V on amplifier output regardless of current nameplate value supported by the module. The dependence of the voltage on output «U_{ca}» on motor current is linear.

«Error 1». Output signals about an incident which is a result of current overload or overheating, being an open transistor collector of protection circuit.

«Error 2». The output signaling about module operation inhibition («log.0» on output «Enable» and "log. 1" on output "Protection"), wrong combination on outputs of rotor position transducers, being an open transistor collector of protection circuit. The explanation of this output operation is shown in Table 5.1.

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

«U_s». Source output of DC voltage +15V with current limiting at level 50 mA. When connecting the external circuits it is recommended to supply them from this output because even in the event of short current or overload the module will not break.

«$U_{in\ ss}$». Internal supply stabilizer +15 and +5V, being necessary for operation of control and protection circuits. For consistent module operation the voltage at this input must be +16…20V; current consumption no more 200 mA without external load.

«U_{out}». Output of internal DC/DC – converter meant for conversion of power circuit voltage 40…600V in stabilized voltage +18V with load capability up to 250mA. In the event if the module is supplied from the external voltage source, connected to output «U_{in}», this output must be unactuated.

It is recommended to use the external supply at the running voltage of power circuit not less than 40V (as at a lower voltage DC/DC-converter will not start) and not more than 350 V (the converter can fail); that is when power supply from three-phase network 380V the module supply should be performed from external source without fail as there is no a DC/DC-converter on the modules of the 12-th class. The delivery priority does not matter.

It is allowed the module supply of power voltage with stabilizer setting at 16…20V. If it is provided for module supply from the power voltage through the internal DC/DC-converter, than the outputs «U_{in}» and «U_{out}» must be connected.

«PWM» and **«FB».** Stabilization inputs of motor shaft rotation speed. The outputs are enabled only for control options «E», «F», «G», «H»; for control options «A», «B» «C» and «D» the feedback is loaded in module circuit and does not require any adjustment. If the feedback is not required, then these outputs should be connected (Fig.5.1 - 5.4). The option of module use in the mode of feedback closed loop is shown at Figure 5.8. The pulse signal which is proportional to speed level (tachometer signal), can be received from any sensor (optical, Hall sensor) with signal level (0…6.5) V.

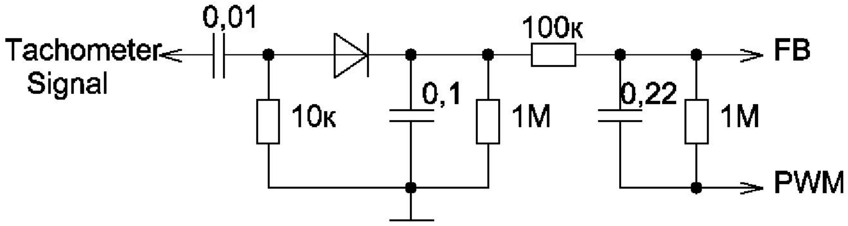

Figure 5.8 – Speed Feedback Control Circuit

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

«Osc.». The input meant for timing chain connection for internal PWM oscillator. The recommended connection scheme of this input is represented at Figure 5.1 – 5.4. The frequency giving by external RC-chain, should be within 15…50 kHz. The frequency versus resistor nominal and capacitor is shown at Figure 5.9.

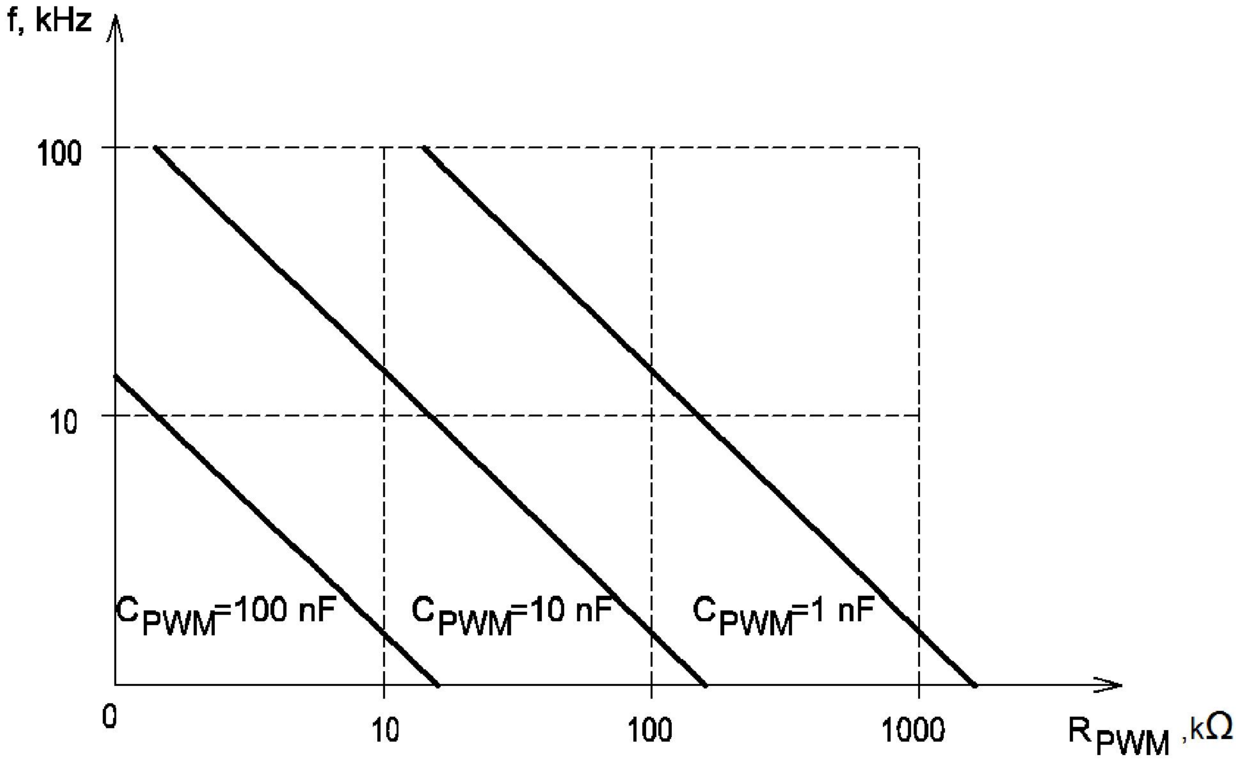

Figure 5.9 – PWM-Frequency versus R_{pwm} and C_{pwm} nominals

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

The output is involved for control options "E", "F", "G", "H" only.

«D0», «D1», «D2», «D3». TTL-level inputs of internal DAC. Motor shaft rotation frequency will change from a combination corresponding 1.5 V at the DAC output (the output of «U_{dac}») to a combination corresponding 4.5 V.

The outputs are involved for control options "D" and "H" only.

«U_{dac}». Output of internal DAC. To control connection with DAC you need to connect this output with the output "Speed", as stated in Fig. 5.3. The value changing of the input code from 0000 to 1001 leads to a step changing of the speed level from 0% to 90% approximately on 10%. The values of the input code from 1010 to 1111 correspond to 100% speed level. To provide smother speed regulation it is recommended to install the capacitance integrator 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. Therewith the older the charge the larger range (but and the bigger increment) in which the regulation is carried out: changes 1…1.5 V when signal delivering to output «D3»; changes 0.1…0.2 V when delivering to output «D0».

The outputs are involved only for control options ”D” and ”H”.

Features of the module protection operation.

BDCDMM has four protections: protection at average current, protection at pulse current, temperature protection and protection against the simultaneous turning on of the upper and lower transistor of one phase.

Protection at the average current limits the average current flowing through the windings of the motor. Protection speed – is no more than 100 μs. This protection limits the current to the maximum (if resistor «R_{ch}» is not installed) for the module level. In the name of the module protection operation current at the average current is specified, but limitations current in fact less than the protection operation current that is due to the volatility of current flowing through the windings of the motor; the protection is triggered by bursts of current with a duration of more than 100 μs. The limitation current also depends on the rotation speed of the engine and the nature of the overload (in one phase, two or three). The lower speed and less congested phases, the lower current will limit the module, because with the same amplitude of pulsed current the pulse ratio varies, resulting in a change of the motor average current.

The signaling about protection operation at average current is carried out through the output “Error 1”.

Pulse current protection turns off the power module transistors at high motor pulse current. Protection speed – no more than 2 microseconds with operation current exceeding the protection operation current at average current in 3… 4 times.

During normal engine operation, this protection will be triggered only during acceleration and braking under heavy load, limiting the starting and braking currents.

As in the case of the protection at the average current on the output "Error 1" a signal corresponding to protection operation will appear. In contrast to the average current protection, protection operation threshold on pulsed current is not regulated.

Temperature protection turns off the power module transistors at package temperature 90…100 ^{0}C and turns on at temperature 50…60 ^{0}C, providing the hysteresis 30…40 ^{0}C. During temperature protection operation the transistor on output “Error 1” will be opened to housing temperature decreasing to 50…60 ^{0}C.

When temperature protection operating the power switch does not reset the protection; the module will start only after lowering of the body temperature to acceptable level.

Protection against the simultaneous operation of the upper and lower arm of one phase with the switching lock with continuance of 5 μs eliminates the failure of the module on the cross-currents. Including, because of the control circuit failure the power transistors will not go down.

6 POWER OUTPUTS

Depending on the type of module power assembly it is recommended the following diagrams for power circuits' connection (Figure 6.1 – 6.3).

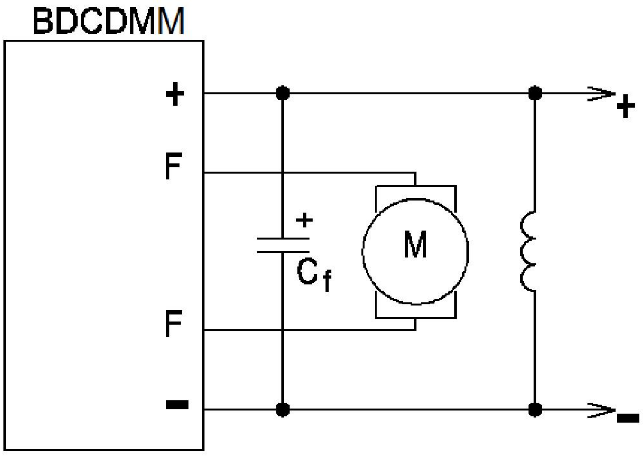

Figure 6.1 – Connection Scheme of BDCDMM with power assembly type "4"

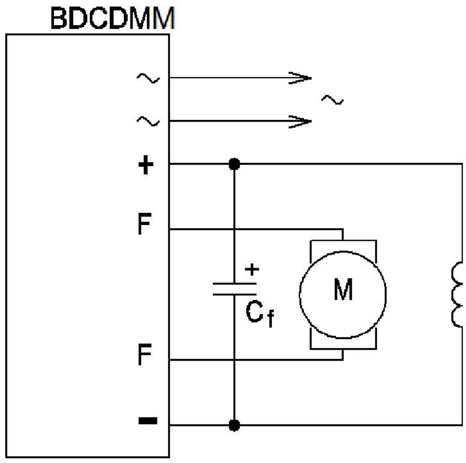

Figure 6.2 – Connection Scheme of BDCDMM with power assembly type "3"

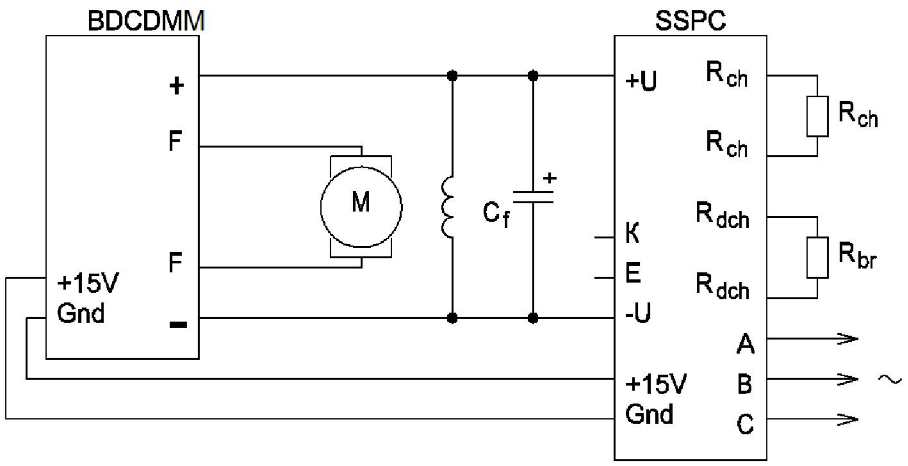

Figure 6.3 – Connection Scheme of BDCDMM with power assembly type "4" with SSVC

SSVC (solid state voltage controller) with rectifier bridge provides smooth capacity charge C_f and provides safe braking, by that allowing to get rid of the additional rectifier bridges, current limit circuits of charge capacity, braking circuits and control voltage schemes. It is recommended to use SSVC with BDCDMM for all BDCDMM modules on the power of 380 V and at currents over 20 A.

Between the outputs "+" and "-" of the module a filtering capacitor and voltage limiter of 1.5V are included. Table 6.1 shows the maximum-allowable capacitor voltage and the limiter breakdown voltage versus the module class.

Table 6.1 – Capacitor and limiter characteristics of power circuit

Module class	Maximum allowable capacitor voltage, V	Limiter breakdown voltage, V
1	250	80
2	250	165
6	700	450
12	700	800

Average voltage of module power circuit must not exceed the lowest value of the specified in the table; otherwise the module can become unusable.

Below is a description of module power outputs.

"1" and "2". Motor phase connection outputs. The phases must be connected to the corresponding outputs. When wrong connecting of phases the motor will operate inconsistent. Below is Table 6.2 in which the maximum powers of motors are indicated that being supported by modules BDCDMM.

Table 6.2 – Maximum allowable module current and brushless motor voltage

Device, BDCDMM	Maximum average power supported by module, kW	Maximum motor power on P_{avr}, kW	Maximum starting power, supported by module, kW	Maximum motor power on P_l, kW
With mains supply AC 36 V*				
-5-1	0.13	0.12	0.37	0.37
-10-1	0.25	0.25	0.68	0.55
-20-1	0.55	0.55	0.87	0.75
-30-1	0.75	0.75	1.2	1.1
-50-1	1.3	1.1	2.2	2.2
-70-1	1.8	1.8	3.1	3.0
-100-1	2.5	2.2	3.1	3.0
With mains supply AC 110 V*				
-5-2	0.38	0.37	1.1	1.1
-10-2	0.75	0.75	1.6	1.5
-20-2	1.5	1.5	2.7	2.2
-30-2	2.3	2.2	4.0	4.0
-50-2	3.7	3.3	6.0	5.5
-70-2	5.2	4.0	6.0	5.5
With mains supply AC 220 V*				
-5-6	0.77	0.75	2.2	2.2
-10-2	1.6	1.5	4.1	4.0
-20-2	3.1	3.0	5.6	5.5
-30-2	4.6	4.0	9.6	9
-50-2	7.7	7.5	9.6	9
With mains supply AC 380 V*				
-5-12	1.3	1.1	4.1	4.0
-10-12	2.6	2.2	5.8	5.5
-20-12	5.6	5.5	9.2	9.0
-30-12	7.9	7.5	15.2	15
-50-12	13.2	11	15.2	15

* It is necessary an external bridge rectifier.

BDCDMM of different types can provide the correct operation and the motor protection of power specified in Table 6.1. The values listed in the table (maximum motor power P_{avr}) are valid if the motor is operating at its full capacity. It is allowed motor installation with higher wattage, if the motor shaft power will not exceed the maximum average power supported by the module (column 2). However, irrespective of the motor power its rated capacity should not exceed the specified in column 5, otherwise the module can be easily damaged by the starting current (P_S).

For example, the engine capacity of 3 kW, powered by a single-phase 220 V. The engine develops the power at the load corresponding to a half of the maximum (1.5 kW). Consequently, it is not necessarily to install BDCDMM-30-6; it is possible to use the module at BDCDMM-10-6, as it provides the load 1.5 kW and is able to run engines with a rated capacity up to 4.0 kW. At the same time, if the shaft power (for the same engine at 3 kW) is equal to 0.7 kW, the module at BDCDMM-5-6 can not be used, although it supports the operation on load up to 0.95 kW but when you launch the engine of maximum capacity exceeding 2.2 kW it can fail.

Thus, when choosing the module you should focus not only on its rated capacity and the average operating motor current but on its starting current; at that, the difference in the module capacities depending on the engines and their operating conditions can be significant.

"+" and "-". The power supply connection outputs; from the same power the control scheme operates, so the module will not be turned on at the supply voltage below 40 V. To the same outputs the filter capacitance C_f is connected (see Fig. 6.1 - 6.3) which is necessary to half-waves smoothing from the rectifier bridge and to filter the emissions arising during the engine operation. It is recommended to install the capacity C_f, as close as possible to the module outputs. The values of this capacity change depending on engine capacity, at which operates BDCDMM. The following table shows the minimum and recommended values of C_f.

Table 6.3 – Capacity choice to motors of different power.

Motor power, kW	Minimum capacity, µF	Optimal capacity, µF
<0.51	100	300
0.75	200	500
1.1	200	500
1.5	250	750
2.2	400	1000
3.3	700	1500
5.1	1000	2500
7.5	1500	3500
11	2000	5000
15	3000	7000

Permissible capacitor voltage should be not less than 450 V for single-phase circuit and not less than 750 V for three-phase. For three-phase network it is allowed the value of the filtering condenser capacity on the order below those are indicated. It is allowed to connect capacitors sequentially to increase the maximum allowable voltage with balancing resistance of 75 kΩ of capacity not less than 1 W.

Condenser capacity should be at least 200 µF per 1 kW of engine power, the optimum - 500 µF to 1 kW of power. Capacity of less than 500 µF should be considered only in cases where the engine is running at constant load without the frequent starting and stops. If it is assumed that the load on the engine will change frequently, or the engine will operate in unstable conditions, it is not recommended to install the condenser when the capacitor is less than 500 µF to 1 kW. The capacity of nominal value of less than 200 µF to 1 kW should not be installed because the engine will not develop maximum power, and BDCDMM can be turned off by failures in the supply voltage.

In that case, if voltage regulator is installed before the module the capacity can be installed less than specified in Table 6.2 (on the order of hundreds µF) but it is not recommended to use the BDCDMM without connected capacity C_f.

In the modules SSVC and BDCDMM with a rectifier bridge are used different principles of charge of the capacitor. SSPC operates on the hysteresis loop, limiting the voltage on the upper and lower limit; BDCDMM provides a smooth charge of the capacity for 300 ms (typical). Consequently, during rapid starting engine operation of the low power synchronously with the voltage supply BDCDMM engine will be run more smoothly but that does not indicate any malfunction of the modules.

If in the 3PHBLDCDMM that is used does not contain a controlled rectifier bridge and SSVC is not connected, it is not recommended to install an unmanaged rectifier bridge and directly behind it the filtering capacitor because the bridge and the capacitor can be easily damaged by charge capacity current. In the simplest case, it is recommended to install a current-limiting resistor which nominal should be chosen based on the maximum allowable rectifier bridge current or on a stabilizer (if used). More complex but also more acceptable, is a variant with the control scheme without allowing current overload during capacity charge.

AC voltage connection outputs are used only for power assembly option “3”. By connecting the phasing does not matter.

7 SERVICE INSTRUCTIONS

Connection to the module

The power circuit is attached to the module with pin contacts or soldering (modules at the current of 10 A inclusive) or with screws M5 (modules at the current over 20 A). The screws should be tightened to the torque (5 ± 0.5) Nm, with a mandatory installation of flat and spring washers which are available with.

Power cables connection must be made through the connectors that are corrosion-resistant coating, purified from extraneous accretions. After tightening the screws (bolts) it is recommended to fix the connection with paint. It is recommended to re-tighten the screws (bolts) after 8 days and in 6 weeks after the start of operation. Subsequently, the delay should be monitored at least 1 time per semester.

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

Module controlled outputs designed for installation in equipment by soldering or by means of detachable connectors. The allowable resoldering number of module outputs during mounting (assembly) operations is 3. Output soldering must be made at a temperature not exceeding 235 ° C. Duration of soldering is no more than 3 s.

When installing and operating it is necessary to take measures to protect the module against exposure of static electricity; when mounting it is obligatory to use by personnel the grounding bracelets and grounding soldering irons of low voltage powered through a transformer.

Module installation

The module is mounted in the equipment to the cooler (chassis, frame systems, metal plates, etc.) in any orientation using the M5 or M6 screws with torque (5 ± 0.5) nm, with a mandatory installation of flat and lock washers. In settings module should be positioned in such a way as to protect it against additional heating of the neighboring elements. It is desirable that the planes of cooler ribs are oriented in the direction of air flow.

The contact surface of the cooler should have roughness not more than 2.5 µm and the flatness tolerance - less than 30 µm. The cooler surface should not have any rough edges, honeycombs. No foreign particles should be between the module and the cooler. To improve the thermal balance the module installation on mounting surface or the cooler should be implemented with the help of heat-conductive pastes or similar in their heat-conducting properties.

On installation it is necessary to ensure uniformity of the pressing of the module base to the cooler. To this end, all screws should be tightened evenly in 2 - 4 methods alternately: first, located on one diagonal, then on the other one. During module disassembling the screw spinning should be produced in the reverse order.

Not earlier than three hours after the mounting the screws must wheeled respecting the specified torque, as part of the heat conductive paste under pressure outflow and fastening can weaken.

It is allowed to install for a cooler some modules without additional layers, under the condition that the power between the outputs of the different modules does not exceed the minimum value of puncture potential of each of them at grounded cooler.

Below there is Table 7.1 of conformity BDCDMM, power loss on it and the necessary cooling area.

Table 7.1 – Necessary cooling area for 3PHBLDCDMM of different types

Device, BDCDMM	Loss power on maximum load, max, W	Cooling area without compulsory blow, min, cm^2
-5-1	3	100
-10-1	7	200
-20-1	25	750
-30-1	30	900
-50-1	50	1500
-70-1	75	2000
-100-1	150	3500

-5-2	7	200
-10-2	15	500
-20-2	30	900
-30-2	40	1200
-50-2	100	3000
-70-2	200	6000
-5-6	15	500
-10-2	30	900
-20-2	50	1500
-30-2	70	2000
-50-2	200	6000
-5-12	15	500
-10-12	50	1500
-20-12	100	3000
-30-12	70	2000
-50-12	200	6000

The small cooling area is assumed in the event that the module operates at less than the maximum load, or, if the forced cooling is provided. The table is given for modules with the power assembly type "4" (only the inverter). If the module includes the rectifier bridge (power assembly type "3"), it is necessary to increase the cooling area to not less than 20% of the shown in Table 7.1.

Requirements for operation

The module should only be used in exposure to mechanical loads in accordance with Table 7.2.

Table 7.2 – Impact of mechanical loads.

Exposure factor	Value of exposure factor
Sinusoidal vibration: - acceleration, m/s2 (g); - frequency, Hz	 100 (10) 1 - 500
Mechanical shock of repeated action : - peak impact acceleration , m/s2 (g); - duration of impact acceleration, ms	 400 (40) 0.1 – 2.0
Linear acceleration, m/s2 (g)	5000 (500)

The module should be used under the influence of climate stresses in accordance with Table 7.3.

Table 7.3 – Impact of climate stresses

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 a 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, even if the engine is stopped.

3. Do not connect or disconnect wires and connectors while on the power circuit is energized.
4. When any operations with the module power outputs after stopping the engine, wait at least 1 minute in order to make sure that the filter capacitor is fully discharged.
5. Connect the oscilloscope probe only after removal of the power voltage and discharge of filter capacity.
6. Do not disassemble or modify the module. If it is necessary, please contact to the manufacturer.
7. If the radiator is not grounded, do not touch it, if the module is filed by force feeding.
8. Do not touch the radiator or discharge resistance because its temperature can be very high.
9. If the module is smoking, smelling or abnormal noising, immediately turn off the power and contact to the manufacturer.
10. Do not spray the module with water and other liquids.

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

The first launch of the block

1. Connect the module to the motor in accordance with the recommended turn-on circuit.
2. Be sure in lack of short circuit on outputs «U_{ref}», «U_s», and «+15V».
3. Set the minimum speed, disconnect the brake and enable.
4. Give to the output «+» the voltage not less than 35V; be sure that the module current consumption does not exceed the maximum.
5. Launch the module and the motor; be sure in serviceability of outputs “Speed”, “Enable”, “Brake” and “Reverse”.
6. Increase the supply voltage to operating and be sure again in serviceability of the module.

8 RELIABILITY SPECIFICATIONS

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 $\gamma = 90$ %.

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

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

9 OVERALL AND CONNECTING DIMENSIONS

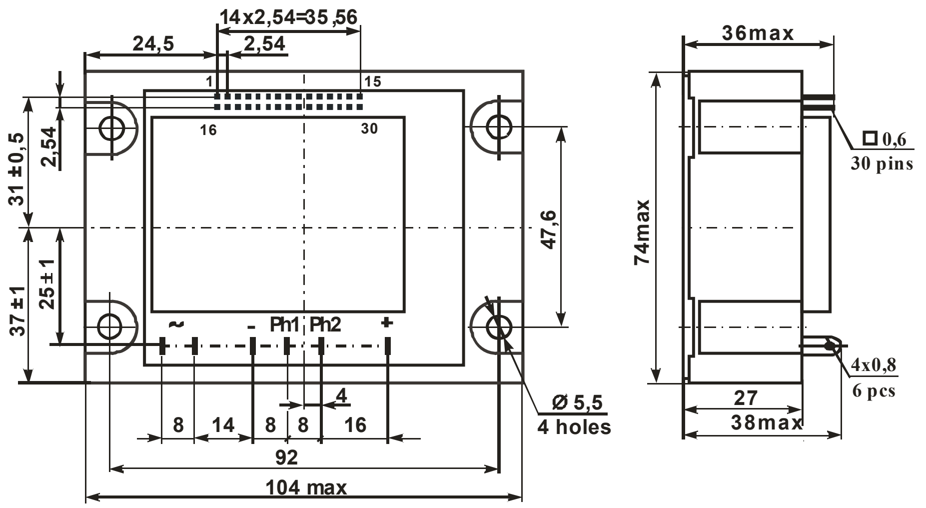

Figure 9.1 – Overall dimensions of BDCDMM-5,10-1,2,6 power assembly type «3»

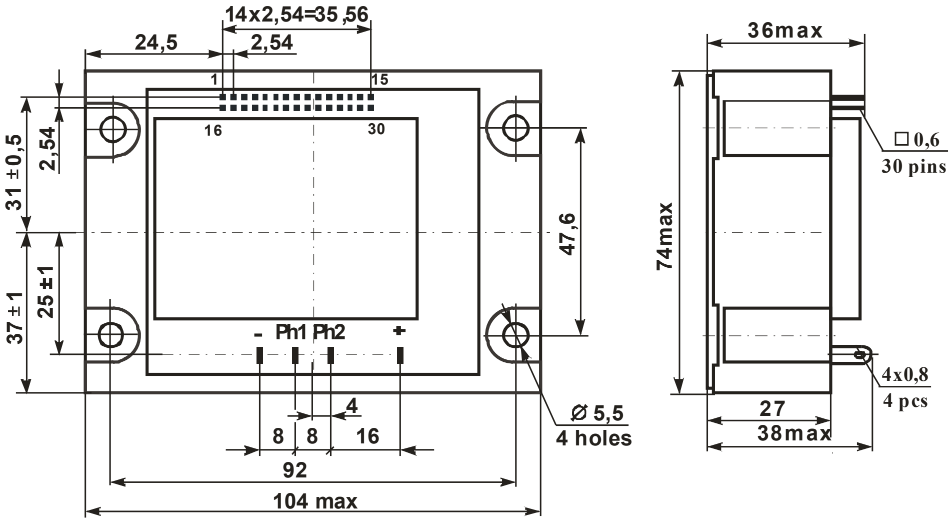

Figure 9.2 – Overall dimensions of BDCDMM-5,10-1,2,6 power assembly type «4»

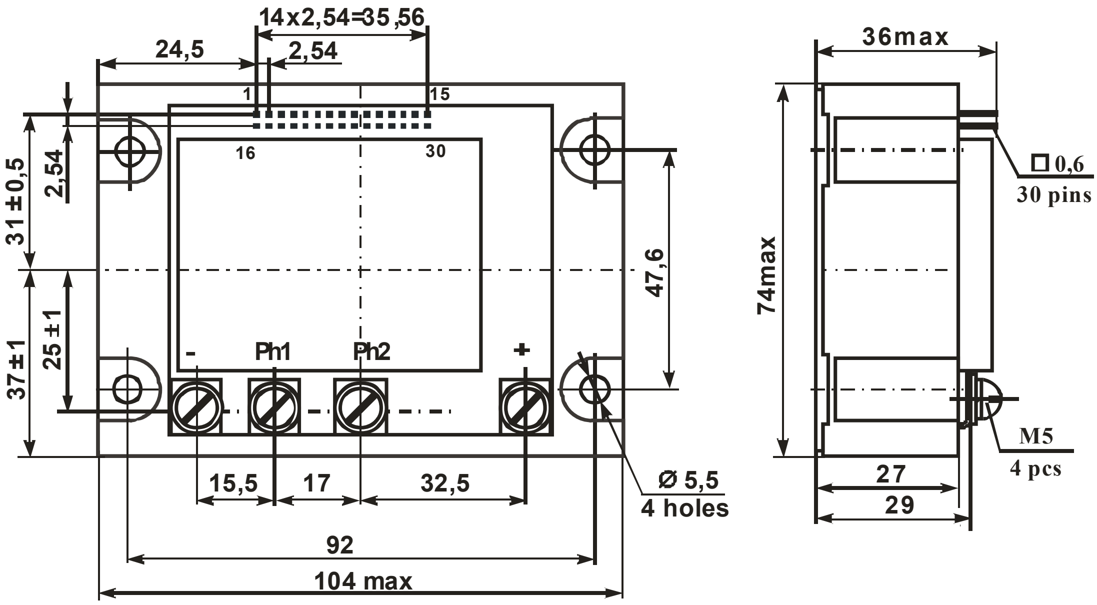

Figure 9.3 – Overall dimensions of BDCDMM -20,30,50,70,100-1,2,6 and BDCDMM-5,10,20,30,50-6,12 power assembly type «4»

At customer's request we can supply brackets for installing the module on a DIN-rail. It is recommended to install on DIN-rail the modules with rated current without exceeding 10 A.

Precious metals are not contained

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