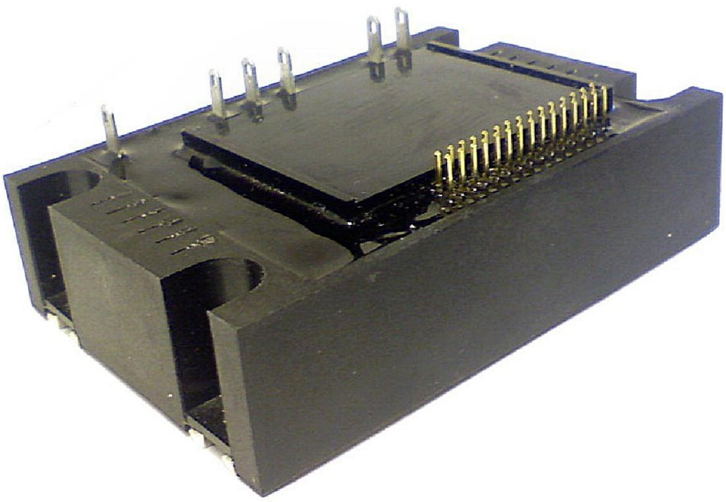
THREE-PHASE AC DRIVE MODULE MODERNIZED – 3PHACDMM

USER'S MANUAL



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CONTENTS

1 DESCRIPTION AND FUNCTIONS

The three-phase AC motor drive modernized (hereinafter - 3PHACDMM or module) is intended for variable-frequency controlling of three-phase electric AC motor. 3PHACDMM 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 technology advances.

3PHACDMM supports the following functions and performances:

- Controllable start/stop engine;
- Reversal of rotation of engine with smooth closedown by sharp reversal of rotation;
- Smooth starting duty and closedown motor mode with controllable acceleration and deceleration;
- Rate control (scalar algorithm U/f);
- Acceleration and deceleration regulation;
- Electric motor protection against current overload and short-circuit;
- Protection against pulse current inrush;
- Current protection pickup adjustment;
- Overheating protection;
- Protection against the simultaneous operation of transistors of the upper and lower inverter arm;
- Emergency external signaling ;
- Internal supply voltage control;
- It allows feeding the external circuits with its own stabilized voltage +5 V and +15 V with current overload protection;
- Module power from the power circuit (for modules of 1,2,6 class);
- AC voltage connection without prior rectification (3PHACDMM with radiator type “1’);
- Smooth charge of filter capacity without additional charge resistor and charge control circuits (3PHACDMM with radiator type “1’).

3PHACDMM provides works and protection of the engines up to 15 KW. 3PHACDMM comes with different control options; it allows using the block both for the solution of common industrial tasks and for solutions of special cases.

2 MODULE TYPES

3PHACDMM is produced with different types of radiators and different control types. The recommended connection circuits of the modules depending on the version are presented in sections 5 and 6.

3PHACDMM are produced at 5, 10, 20, 30, 50, 70, 100 A and for inverter voltages 100, 200, 600, 1200 V. The current in module name indicates the maximum inverter current at which control circuit allows normal operation; the maximum transistor current exceeds the specified one in the product name. At higher current the current protection will be activated and inverter current will be limited. The current specified in the product name is the protection operation current at the average current. Meanwhile 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. 3PHACDMM is available to voltage 100, 200, 600 and 1200 V that corresponds to the values of 1, 2, 6 and 12 in the name of the module. Meanwhile module peak supply voltage is lower than it is indicated in the name (see section 4), that conditioned on security measures when power transistors operation.

Power assembly options:

«4» - only inverter.

«2» - inverter and braking transistor. The brake transistor composed of the module allows connecting the brake resistor directly to the module that is it allows managing without the additional brake blocks. The brake transistor is controlled by means of internal control circuit; the external drive of brake transistors is not provided for.

«1» - inverter, brake transistor and rectifier bridge. There is controllable thyristor-diode rectifier bridge besides brake transistor which allows the module to operate directly from the AC voltage. The control circuit of thyristor rectifier bridge provides smooth (within 300ms) filter capacity charge, that in turn allows managing without current-limiting resistor.

The modules of the sixth group for 5 and 10A are produced with power assemblies types «2» and «1», that is the modules 3PHACDMM-5-1,2,6x2, 3PHACDMM-10-1,2,6x2, 3PHACDMM-5-1,2,6x1, 3PHACDMM-10-1,2,6x1. The other versions of 3PHACDMM are produced with power assembly type «4».

Control options:

"A" – standard. Digital-to-analog control with using all standard module outputs.

"B" – simplified. The control option 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. Single-input control or DAC control or by means of variable resistor appropriately connected. 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. All control options are applicable to all power assembly types regardless of module current and voltage.

Figure 2.1 shows the decoding of the modules name series 3PHACDMM.

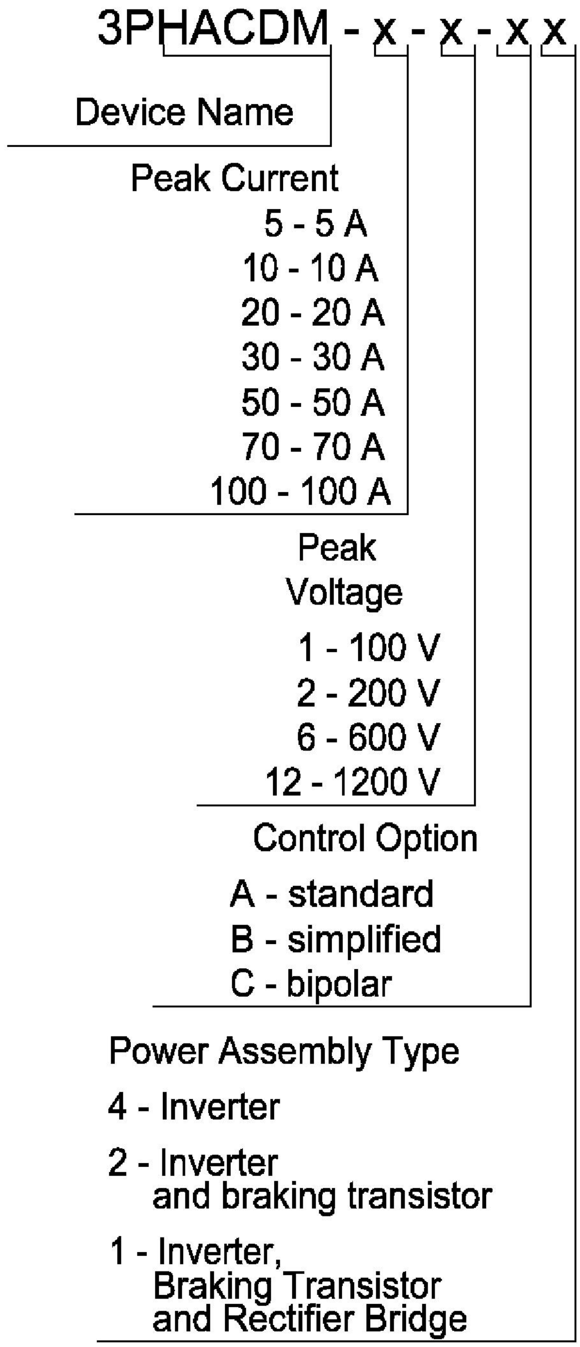


Figure 2.1 – the module name decoding

For instance, the module 3PHACDMM-30-12-B4: AC drive module with maximum inverter current 30 A, peak inverter voltage 1200 V, with control option «C», power assembly – only inverter.

3 GENERAL MODULE DESCRIPTION

The module 3PHACDMM is an assembly of transistor control module M31 and control module 3PHACCM. The structure circuit of 3PHACDMM is shown at Figure 3.1.

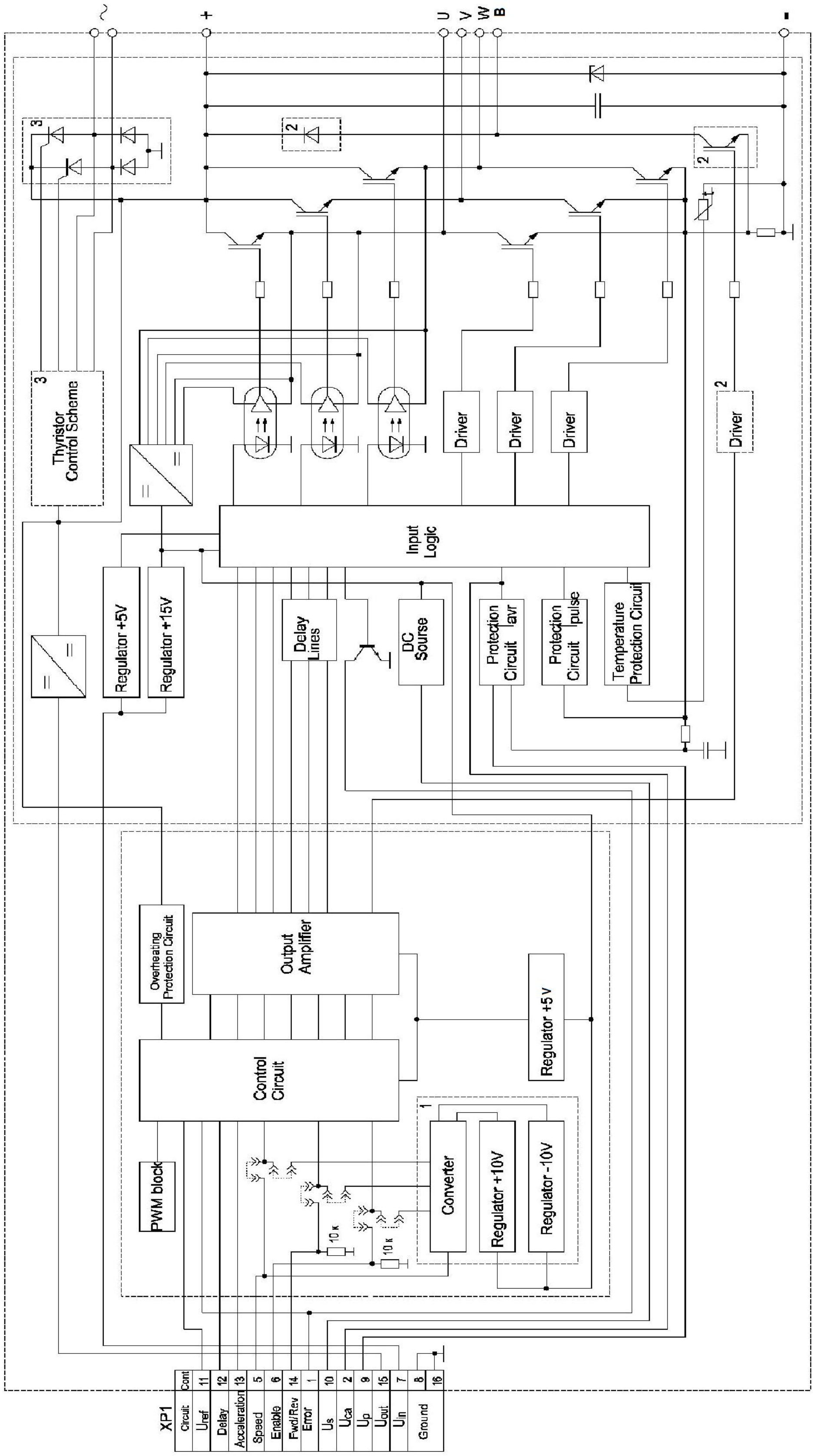


Figure 3.1 – Structure circuit of 3PHACDMM

«1» - control scheme, it's a part of 3PHACDMM for control option «C» (bipolar control). For options «A» и «B» the scheme is absent.

«2» - brake transistor scheme, a part of 3PHACDMM with power assembly types «1» and «2».

«3» - rectifier bridge scheme which provides smooth filter capacity charge and capability of AC voltage module operation. The scheme is a part of 3PHACDMM with power assembly type «1».

DC/DC converter of power supply is installed to circuit supply for modules of 1, 2, 6 class.

Connector XP1 is two rows of contacts PLS-8 with the response part of the type PBS-8. Connector XP2 is intended for module controlling. Power connectors or tips (for modules at currents 5 and 10A), or bolt tread contacts M8 (see overall drawings). Outputs assignment of connectors XP1 and power outputs assignment are represented in Table 3.1.

Table 3.1 – Module outputs function

Contact number	Symbol	Function
1	Error	Signaling Output of Current and Temperature overload
2	U_{ca}	Output of Inverter Current Amplifier
3		Not involved
4		Not involved
5	Speed	Control Input of Motor Shaft Rotation Speed
6	Enable	Input of Enable/Disable Module Operation (not involved for control option «C»)
7	U_{in}	Input of Internal Voltage Regulator
8	Ground	Ground
9	U_p	Output of Protection Operation Current Adjustment
10	U_s	Output of DC Source +15 V
11	U_{ref}	Output of Reference Voltage Source
12		Not involved
13	Acceleration	Control input of Acceleration and Deceleration
14	Fwd/Rev	Control Input of Motor Shaft Rotation (not involved for control option «C»)
15	U_{out}	Output of internal DC/DC - converter
16	Ground	Ground
	+	Connection Output «+» of supply Voltage
	U	Connection Output of Phase U
	V	Connection Output of Phase U V
	W	Connection Output of Phase U W
	B	Connection Output of Brake Resistor (only for modules with brake resistor)
	-	Connection Output «-» of Supply Voltage
	~	AC Voltage Connection Outputs (only for modules with rectifier bridge)

For easy connection of control circuits the schematic external connectors XP1 of the module 3PHACDMM are shown at Figures 3.2.

1							8
Error	U_I			Speed	Enable	U_{in}	Ground
U_p	U_s	U_{ref}		Acceleration	Fwd/Rev	U_{out}	Ground
9							16

Figure 3.2 – Appearance of connector XP1.

4 BASIC CHARACTERISTICS

Basic electric characteristics and maximum allowable electric characteristics of the modules 3PHACDMM at 25 ^{0}C are represented in Tables 4.1

Table 4.1 – Basic electric characteristics and maximum allowable electric characteristics of control circuits

Function	Unit	Rate			Note
		min	type	max	
Supply characteristics					
Supply Voltage (supply from power circuit)	V	40		60	Module of 1 class
		40		160	Module of 2 class
		40		350	Module of 6 class
Current Consumption	mA			40	Power Circuit Supply U_s=350 V
Supply Voltage	V	15		20	External supply
Current Consumption	mA		200	250	No-load external supply
Input characteristics					
Input Current Consumption	mA			1	
Control Voltage Range	V	-0.3		5.2	
Low Level Input Voltage	V	-0.3		0.5	For logic inputs
High Level Input Voltage	V	2.4		5.2	For logic inputs
Voltage, corresponding to maximum speed	V		5		
Voltage, corresponding to maximum acceleration	V		5		
Output characteristics					
Maximum voltage of output «Error»	V			20	
Maximum current of output «Error»	mA			20	
Voltage «Uref»	V	4.75	5	5.25	No-load
Maximum load current of output «U_{ref}»	mA			10	
Voltage of output «U_s»	V		15	16.5	No-load
Maximum load current «Us»	mA			50	
Output frequency	Hz	1		128	
Speedup/Deceleration acceleration	Hz/sec	0.5		128	
PDM frequency	kHz		10		
Voltage on output «U_{ca}» corresponding to current protection operation	V		1		

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
Protection Speed at Average Current	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	
Transistor Turn-Off Delay when Current Overload without an additional capacity on output «Delay»	s	0.5		1	
Latency Time after Protection Operation	c		30		
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	
Operation Delay of Output «Error»	µs			2	

* There is no control circuit supply from power voltage for the modules of 12-th class.

Table 4.2 – Basic electric characteristics and maximum allowable electric characteristics of power circuits of 1-st class (3PHACDMM-xx-1-xx)

Title	Measure Unit	Rate			Note
		min	type	max	
Power Switches Characteristics					
Maximum D-S Voltage	V			100	
Maximum Voltage of DC element	V			60	
Maximum Average Current of Power Transistors at 100 ^{0}C	A			12	5 A
				23	10 A
				30	20 A
				40	0 A
				68	50 A
				97	70 A
				107	100 A
Maximum Pulse Current of Power Transistors at 25 ^{0}C	A			60	5 A
				110	10 A
				140	20 A
				230	30 A
				380	50 A
				550	70 A
				600	100 A
Loss Power with 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
Leakage Current of Power Circuit Closed Transistor	µA			100	
Isolation Characteristics					
Insulation Voltage Module Outputs– Housing Base	V	1000			DC, 1 minute

Table 4.3 – Basic electric characteristics and maximum allowable electric characteristics of power circuits of 2-nd class (3PHACDMM-xx-2 -xx)

Title	Unit measure	Rate			Note
		min	type	max	
Power Switches Characteristics					
Maximum D-S Voltage	V			200	
Maximum Voltage of DC Element	V			160	
Maximum Average Current of Power Transistors at 100 ^{0}C	A			11	5 A
				17	10 A
				32	20 A
				44	30 A
				66	50 A
				76	70 A
Maximum Pulse Current of Power Transistors at 25 ^{0}C	A			70	5 A
				90	10 A
				180	20 A
				260	30 A
				380	50 A
				420	70 A
Loss Power with Maximum Load	W			10	5 A
				25	10 A
				55	20 A
				55	30 A
				125	50 A
				270	70 A
Leakage Current of Power Circuit Closed Transistor	µA			100	
Isolation Characteristics					
Insulation Voltage Module Outputs– Housing Base	V	2000			DC, 1 minute

Table 4.4 – Basic electric characteristics and maximum allowable electric characteristics of power circuits of 6-th class (3PHACDMM-xx-6-xx)

Title	Unit measure	Rate			Note
		min	type	max	
Power Switches Characteristics					
Maximum Collector-Emitter Voltage	V			600	
Maximum Voltage of DC Element	V			400	
Maximum Average Current of Power Transistors at 100 ^{0}C	A			11	5 A
				16	10 A
				30	20 A
				60	30 A
				60	50 A
Maximum Pulse Current of Power Transistors at 25 ^{0}C	A			35	5 A
				60	10 A
				105	20 A
				240	30 A
				240	50 A
Loss Power with Maximum Load	W			20	5 A
				45	10 A
				80	20 A
				90	30 A
				280	50 A
Leakage Current of Power Circuit Closed Transistor	µA			100	
Isolation Characteristics					
Insulation Voltage Module Outputs– Housing Base	V	4000			DC, 1 minute

Table 4.5 – Basic electric characteristics and maximum allowable electric characteristics of power circuits of twelfth class (3PHACDMM-xx-12-xx)

Title	Unit measure	Rate			Note
		min	type	max	
Power Switches Characteristics					
Maximum Collector-Emitter Voltage	V			1200	
Maximum Voltage of DC Element	V			700	
Maximum Average Current of Power Transistors at 100 ^{0}C	A			10	5 A
				15	10 A
				24	20 A
				60	30 A
				60	50 A
Maximum Pulse Current of Power Transistors at 25 ^{0}C	A			40	5 A
				60	10 A
				90	20 A
				240	30 A
				240	50 A
Loss Power with Maximum Load	W			25	5 A
				65	10 A
				160	20 A
				90	30 A
				280	50 A
Leakage Current of Power Circuit Closed Transistor	µA			100	
Isolation Characteristics					
Insulation Voltage Module Outputs– Housing Base	V	4000			DC, 1 minute

5 MODULE CONTROL

We recommend the following turn-on schemes versus module control type (Fig.5.1 – 5.3).

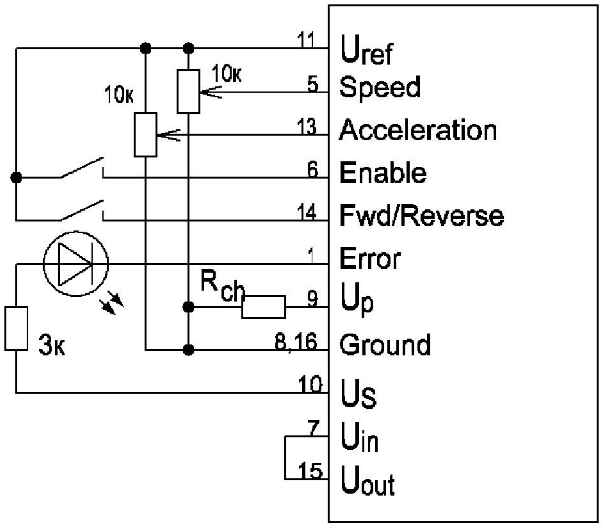


Figure 5.1 – Turn-on schemes of Control Circuits 3PHACDMM «A»

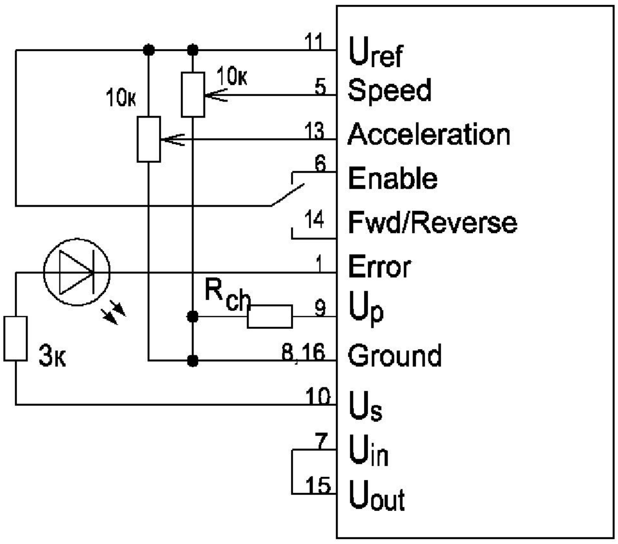


Figure 5.2 – Turn-on schemes of Control Circuits 3PHACDMM «B»

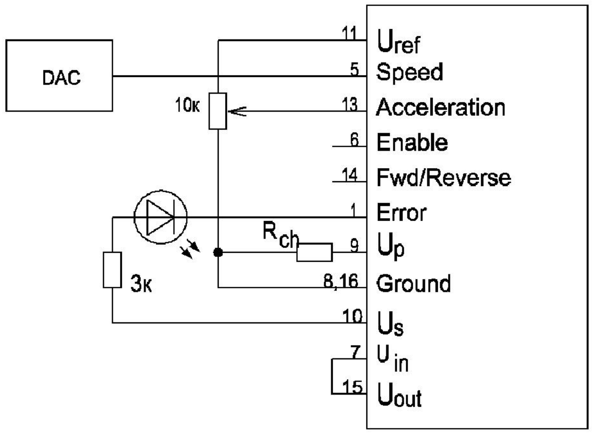


Figure 5.3 – Turn-on schemes of Control Circuits 3PHACDMM «C»

Figure 5.2 gives the turn-on scheme of the module with control option «B» with common switch to "Forward Reverse" and "Enable". In case of switch breaking with both contacts module operation will be inhibited.

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

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

«Enable». Direct digital input. "Log.1" of TTL-level corresponds to enable of 3PHACDMM operation, "log.0" – to inhibit. Meanwhile the launching of 3PHACDMM is carried out on control signal rise. If there is a "log.1" on output "Enable" then with the power supply 3PHACDMM will not be launched; at first, you should remove enable and then turn on the module.

If it is necessary the automatic turn-on the 3PHACDMM after power supply to power circuit, then the following connection circuits of 3PHACDMM are recommended (Figure 5.4).

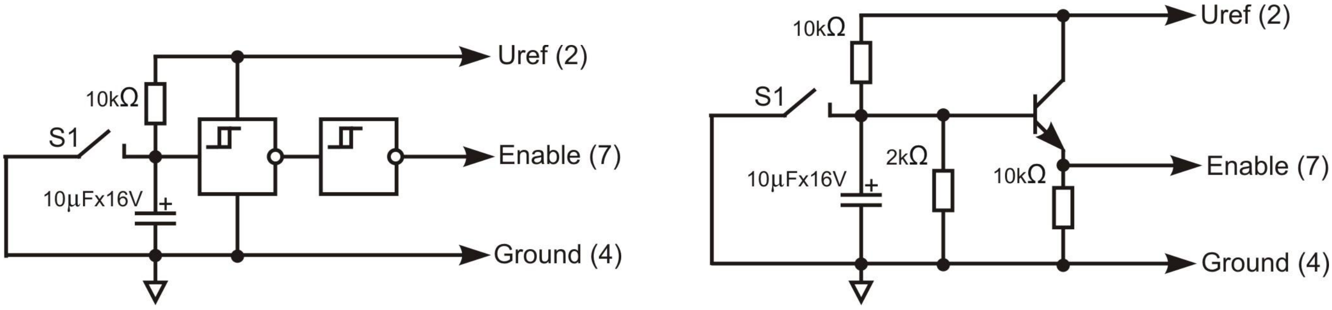


Figure 5.4 – Connection circuits of 3PHACDMM with the automatic launching after power supplying.

The switch S1 is necessary to disconnect 3PHACDMM without the power removal; its installation is recommended, particularly, for security purposes.

«Forward Reverse». TTL-level digital input. The motor shaft rotation direction depends on connection order of its phases. It is allowed the change of motor shaft rotation direction without its previous shutdown, because the internal control scheme provides automatic smooth shutdown (shutdown and acceleration time is regulated by voltage on input "Acceleration") by PWM regulation with change of logic states on output "Forward Reverse"

The diagrams explaining 3PHACDMM and controllable motor operation versus controlling signals on outputs "Enable" and "Forward Reverse" are shown at Fig. 5.5 and 5.6.

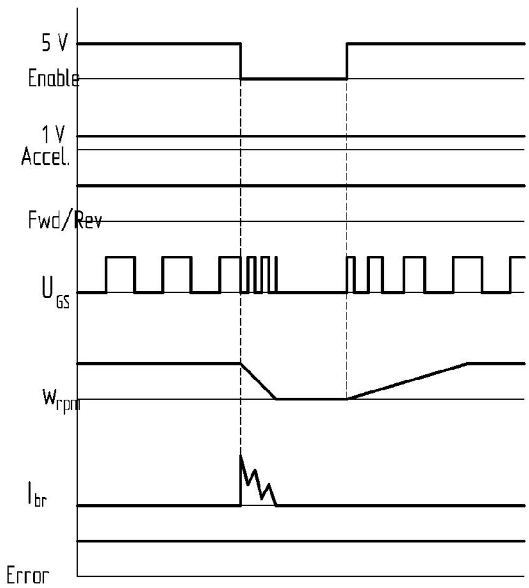


Figure 5.5 – Module control with help of output "Enable"

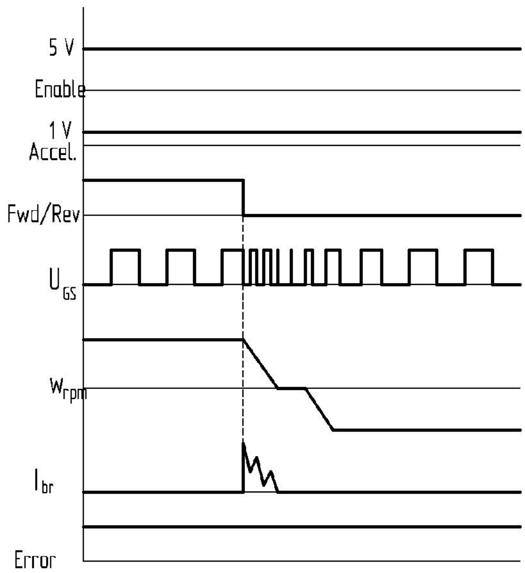


Figure 5.6 – Module control with help of output "Forward Reverse"

Here W_{rpm} – motor shaft rotation frequency, U_{GS} – control signals on power transistors gates, I_{br} – current flowing through the brake resistor.

«Speed». Motor Shaft Rotation Velocity Demand Analog Input. Maximum rotation frequency corresponds to +5 V, shutdown corresponds to 0 V, that is equivalent to 1…128 Hz. We turn your attention to that when voltage is less than 0.5 V the motor shaft cannot rotate, because of too low frequency, which, by virtue of design features, AC motor cannot operate at. The motor shaft rotation speed depending on voltage on input «Speed» is shown at Figure 5.7 and 5.8 (for control option «C»).

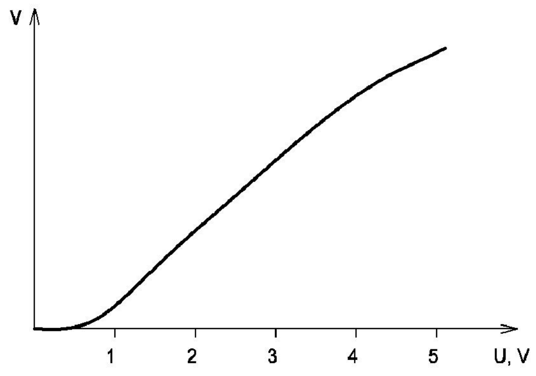


Figure 5.7 – Motor Shaft Rotation Speed versus Output Voltage «Speed»

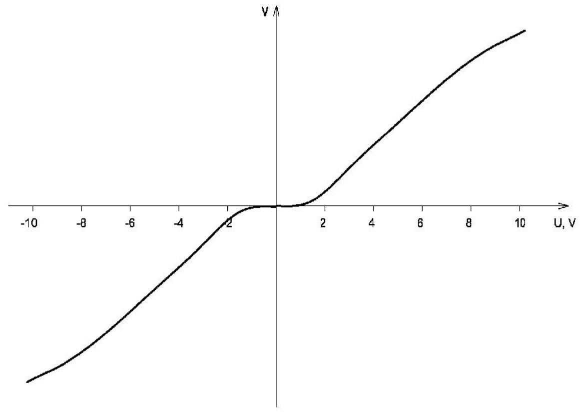


Figure 5.8 – Motor Shaft Rotation Speed versus Output Voltage «Speed» for Control Option "C"

If you need constant motor shaft rotation frequency, it is recommended to connect resistive divider to the output "Speed" relative to «U_{ref}» and «Ground».

When motor launching you must note that if on the output "Speed" voltage is 0 V then the motor will not start. The motor may be launched with initial maximum velocity demand of motor shaft rotation; in this case it is recommended to regulate the launching speed by "Acceleration" voltage.

For option "C" the motor control is carried out only on outputs "Speed" and "Acceleration", outputs "Forward Reverse" and "Enable" are not involved. Meanwhile motor rotation direction is chosen proceeding from signal polarity on output "Speed", control voltage -0.5…+0.5 V corresponds to inhibition, the rotation speed is regulated by voltage level. Figure 5.9 gives the diagram explaining module operation with control option "C".

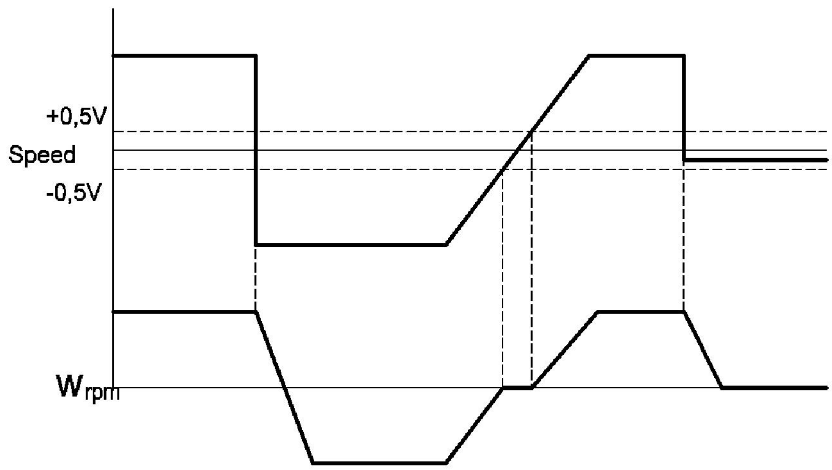


Figure 5.9 – Module Control with option «C»

When module turn-on with control option «C» you must note that for launching of control circuit the input "Speed" bridge from inhibition state (-0.5…+0.5 V) to enable state of any polarity is necessary, otherwise the motor will not launch.

«Acceleration». Launching and Shutdown Velocity Demand Analog Input with master voltage 0…+5 V. Meanwhile motor launching time will always be equal to motor shutdown duration, if the motor shaft load does not influence that.

If the motor will be started up in the same conditions, it is recommended to connect resistance divider to output "Acceleration" relative to «U_{ref}» and «Ground» (and for the output «Speed»).

If there is 0 V on output "Acceleration", the motor will not run.

Choosing motor start duration you must take into account the load condition. It is not recommended to choose high acceleration for cases, when the motor from the start operates at maximum load (or approximate to the maximum) because in this case the motor cannot start (current protection will operate because of high inrush current).

If fast launching with heavy load is necessary, then it is reasonable to connect the condenser of the necessary capacity to the output "Delay" (in detail about the choice below). Thus 3PHACDMM will allow motor operation with overload definitive (preset) time; 3PHACDMM will not shut down (for 30 sec) on brief surges of inrush current.

However you must note that this launching is harder in comparison with the smooth acceleration that can negative influence the nature of motor shaft acceleration and can lead to prohibitive overload of its windings.

The diagrams explaining the motor launching versus voltages values on outputs "Speed" and "Acceleration" are shown at Fig. 5.10 and 5.11.

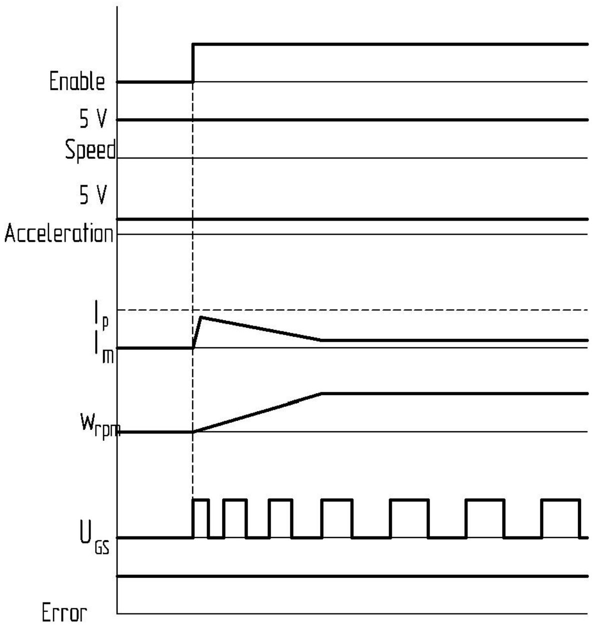


Figure 5.10 – Motor launching with set acceleration

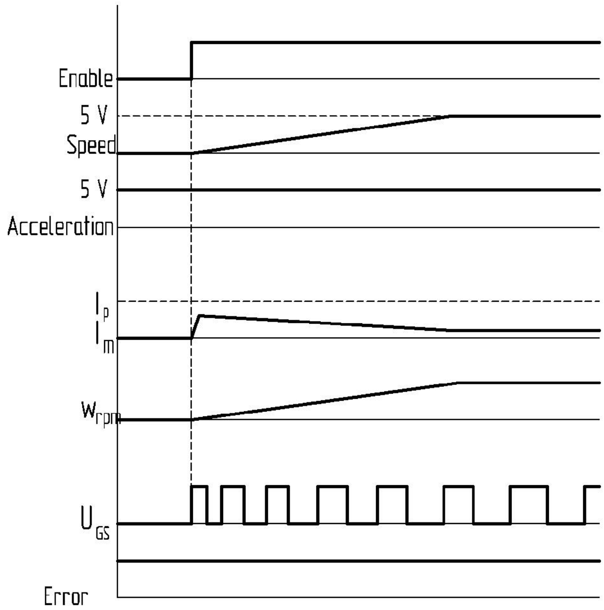


Figure 5.11 – Motor launching with change of motor shaft rotation speed

Here Ip – set current protection pickup, Im – current flowing through the motor windings.

«Delay». Installation output of motor operation enable continuance with current overload. When current protection operation 3PHACDMM operates 0.5…1 s. (initial installation) in motor current restriction mode, after that the control scheme closes power switches for 30 s; then the rerun burst will reset within 1 s. and if the overload is disposed then the motor will launch in standard mode; if the overload is not disposed then the control scheme blocks the switches for 30 s again (see the diagram at Fig. 5.12).

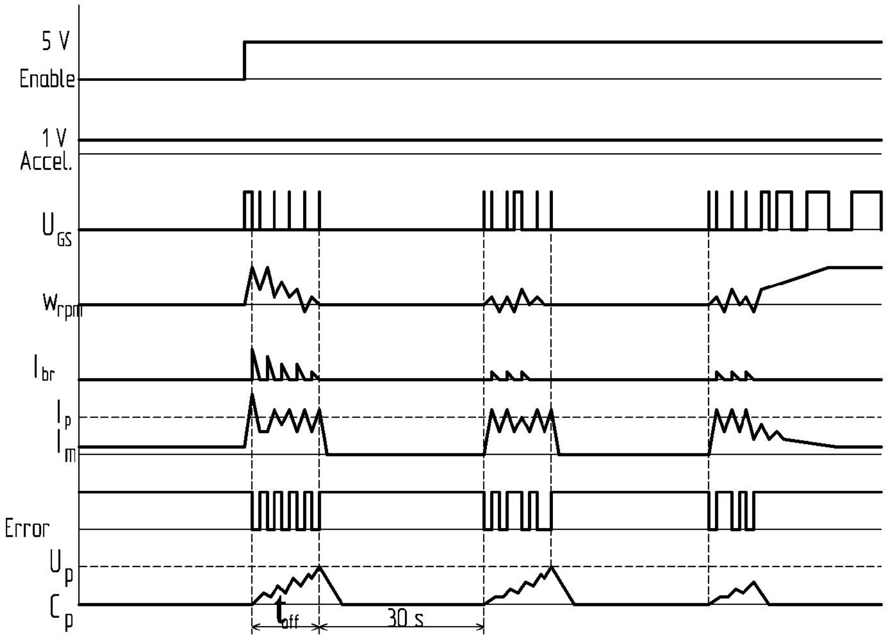


Figure 5.12 – Module operation diagram in current overload mode

By means of condenser connection (with capacity of 1…10 μF, that is equivalent operation enable 1…4 s) to the output «Delay» you can prolong the motor current restriction continuance after current protection operation.

The start-up time should be prolonged in the cases if the fast motor launching on the verge of current protection operation at inrush current is necessary, if the abrupt change of motor load during its operation is supported.

It is not recommended to install the rerun time more than for several seconds, because in this case the faulty launching is virtual, conditioned with constructive features of AC motors. Moreover when constant error arising and its removal the delay adjustment capacity can't be charged up to threshold level and rerun mode can be prolonged indefinitely (see Fig. 5.13).

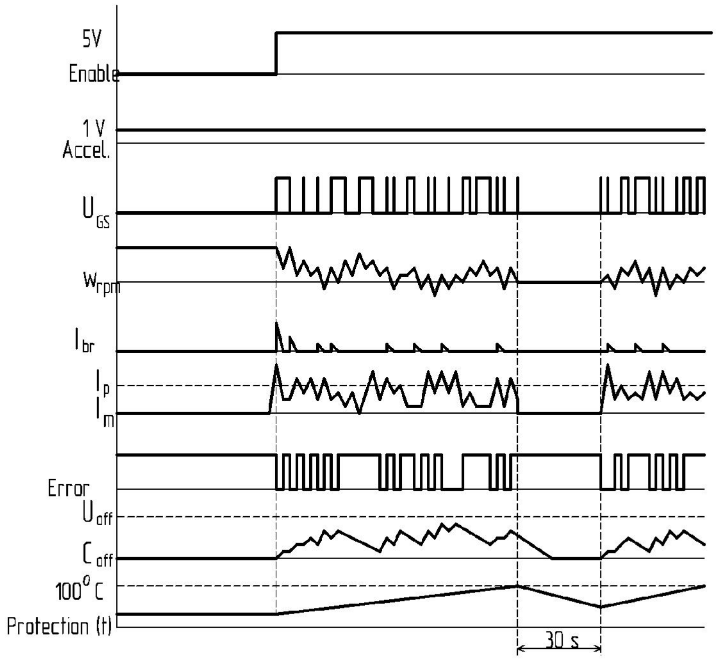


Figure 5.13 – Diagram of 3PHACDMM operation with over capacity on output «Delay»

On connecting the outputs «Delay» and «Ground» the module does not sustain a pause of 30 s when current protection operation and operates in motor current restriction mode to overload removal. However it is recommended to short-circuit the outputs only on using additional protection (particularly against the motor overheating). Figures 5.14 and 5.15 show motor launching without additional capacity and with capacity which is connected to output «Delay». In the same time you must remember that the motor acceleration when rerun is a hard acceleration option and it should be used only in case of emergency.

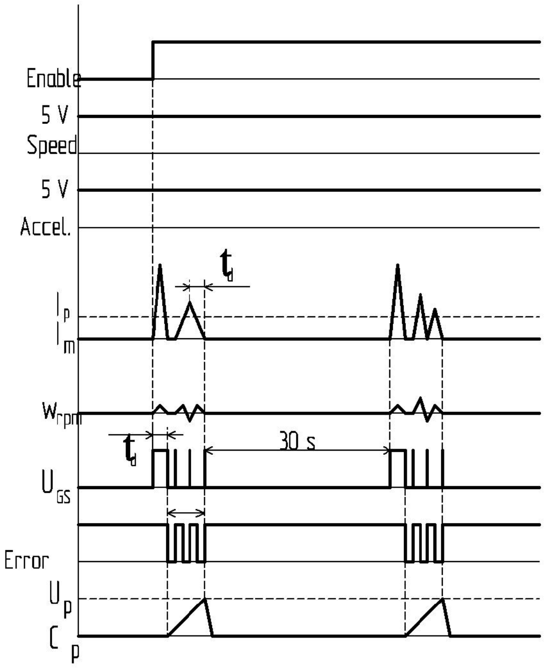


Figure 5.14 – Motor launching without capacity on output «Delay»

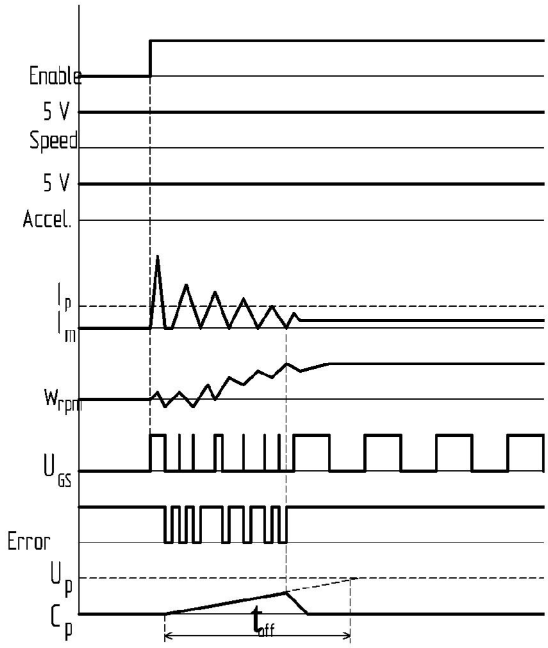


Figure 5.15 – Motor launching with connected capacity on output «Delay»

«U_p». Output of current protection pickup. With untapped output «U_p» the protection will operate on maximum current of the module; with connection of outputs «U_p» and «Ground» the protection will operate on the level 10…20% of the maximum current. For protection pickup specification it is necessary to connect a resistor between the output «U_p» and output «Ground»; which nominal should be chosen based on the diagram (Figure 5.16).

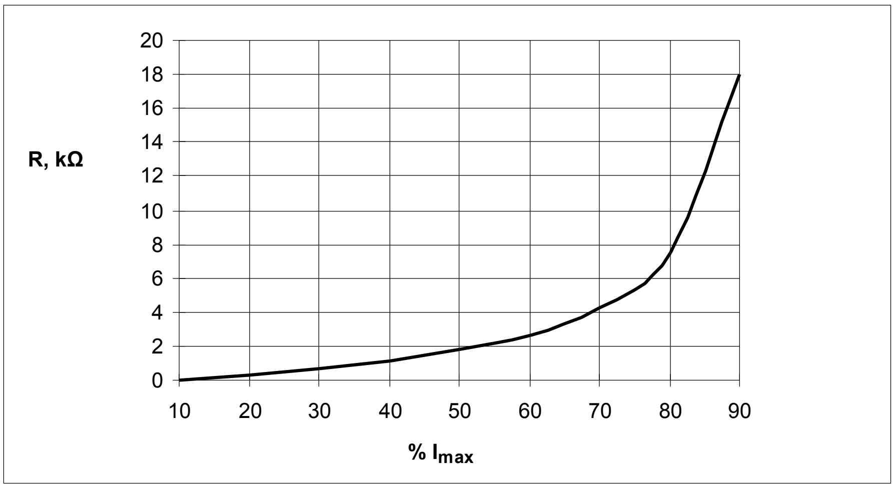


Figure 5.16 – Protection Operation Current versus scale resistor value.

Thus, if, for example, for 3PHACDMM at 10 A the resistor 2.7 kΩ will be connected to the output «U_p», then the protection will operate at current equal to 6A. For easy calculation below there is Table 5.1 of adjustable protection current percentage of maximum protection current.

Table 5.1 – Virtual protection current percentage of the maximum protection current

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

«Error». The output signaling about emergency that is an open transistor collector of protection circuits. The diagram explaining the operation of this output is shown in previous drawings.

«U_{ca}». Amplifier of bypass current (motor current). The maximum module current corresponds to 1 V on amplifier output regardless of ratings of the current supported by the module. Voltage dependence on output «U_{ca}» on current is linear.

«U_s». DC voltage source output +15 V with current limiting at level 50 mA. On 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_{ref}». Reference voltage source output (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.

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

«U_{out}». Output of internal DC/DC – converter meant for conversion of power circuit voltage 40…350V to stabilized voltage +18V with load capability up to 250 mA. In the event that the module is supplied from the external voltage source, connected to output «U_{in}», this output must be untapped.

It is recommended to use the external supply at the running voltage of power circuit not less than 40 V (as at lower voltage DC/DC-converter will not start) and not more than 350V (the converter can fail); that is by power supply from three-phase 380V the module should be supplied from external source as DC/DC converter on the module of 12-th class is not installed. The delivery priority of power and control voltage does not matter.

It is allowed the module supply from 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.

Features of the module protection operation.

3PHACDMM 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.

Average current protection limits the average current flowing through the windings of the motor. Protection speed – is not more than 20 µs. This protection limits the current to the maximum (if a resistor on the output «U_p» is not installed) for the module level. In the name of the module is specified protection operation current at the average current, 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 20 µs. The limitation current is also dependent 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.

Protection at the average current allows the current limiting within 0.5…1 s, with not fixed capacity on output «Delay», after that (if this load is not downfallen) the protection circuit turns out inverter transistors for 30 s, meanwhile the transistor on output «Error» will be closed. The protection for 30 s will be discharged only with removing the power supply and is not discharged with module rerun.

Average current protection operation is explained at Fig. 5.17.

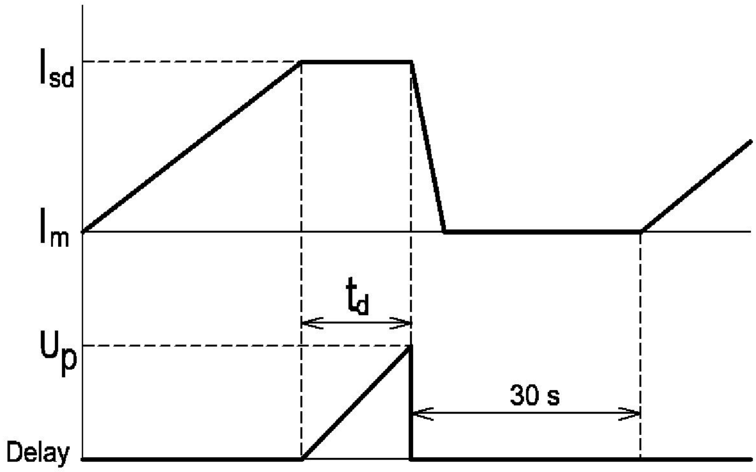


Figure 5.17 – Module operation in current overload mode

If the inspection of average current protection operation is necessary, then it is recommended to connect all three module phases between, to set the maximum speed and connect the outputs "Protection" and "Ground". In this case the current must be limited at the level 70…80% of the module rated current. You must take into account that when testing the module should be installed at a cooler or you should test it not longer than 10 s, or do not boost the current higher than +50% from the start of the restriction.

Pulse current protection turns on the power module transistors at a high motor pulse current. The pulse current protection turns off the module power transistors at high motor pulse current. Protection speed – is not longer than 2 microseconds with operation current exceeding the protection operation current at average current in 3… 4 times. With the standard module operation this protection will operate only when acceleration and braking at high acceleration, limiting inrush and braking currents. As well as in case of the protection at the average current the signal corresponding to operation of this protection will function on output "Error". As opposed to the protection at the average current the protection pickup at the pulse current is not regulated.

Temperature protection turns off the power module transistors when the housing temperature is 90 ... 100 ^{0}C and turns on when the temperature is 50 ... 60 ^{0}C, providing hysteresis of 30 ... 40 ^{0}C. During the temperature protection operation transistor on output "Error" will be opened to the module housing temperature reduction to 50 ... 60 ^{0}C, after that the motor will launch at smooth acceleration in accordance with set acceleration (see Figure 5.18).

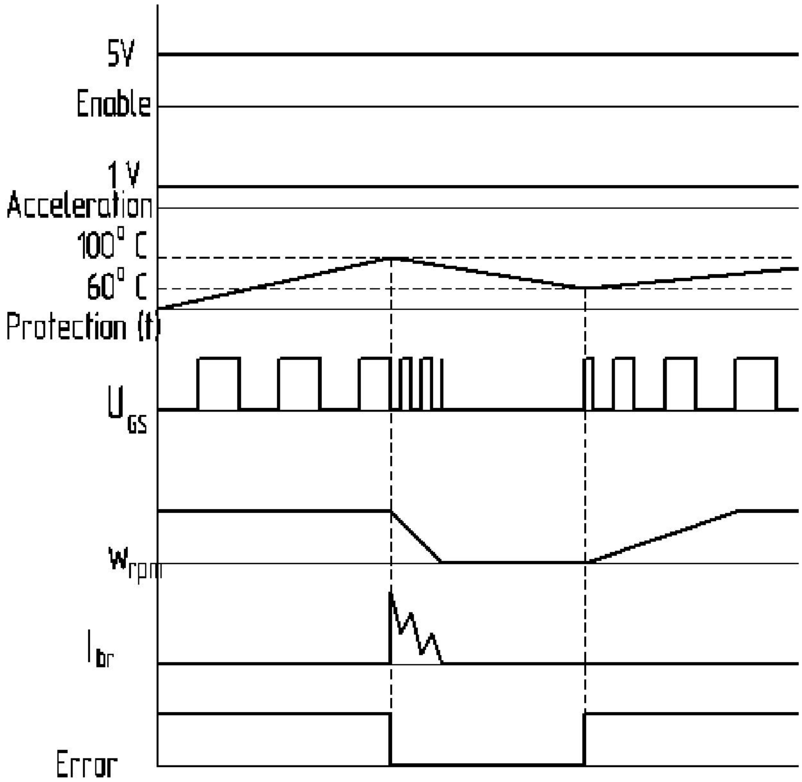


Figure 5.18 – Overheating module operation

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

Protection against simultaneous turn-on of top and lower arm of the same phases with the switching lock during 5µs and 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 of power circuit connection (Fig. 6.1 - 6.4).

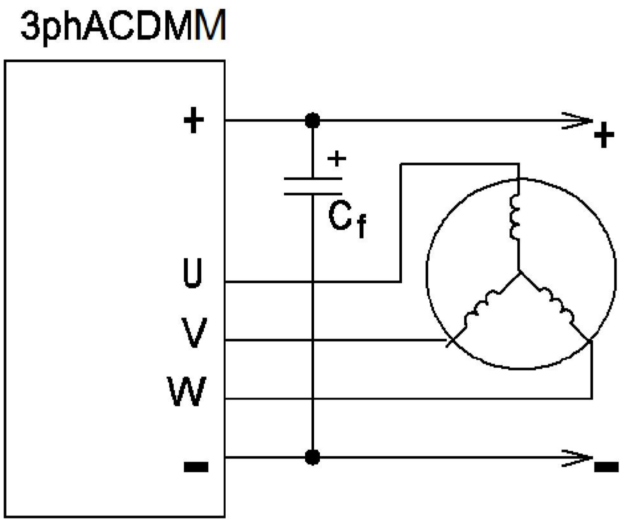
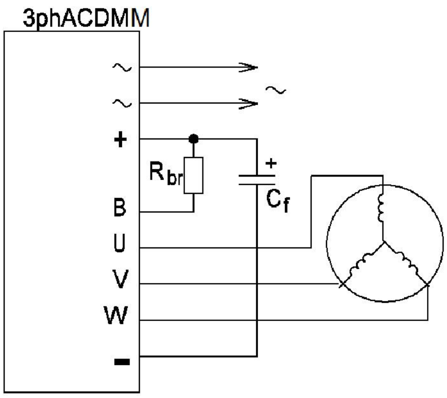


Figure 6.1 – Connection circuit of 3PHACDMM with power assembly type «4»



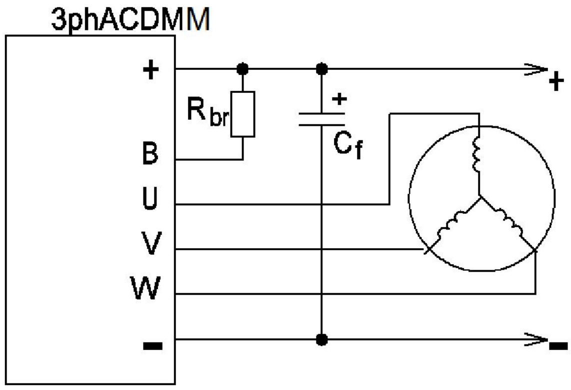


Figure 6.2 – Connection circuit of 3PHACDMM with power assembly type «1»

Figure 6.3 – Connection circuit of 3PHACDMM with power assembly type «2»

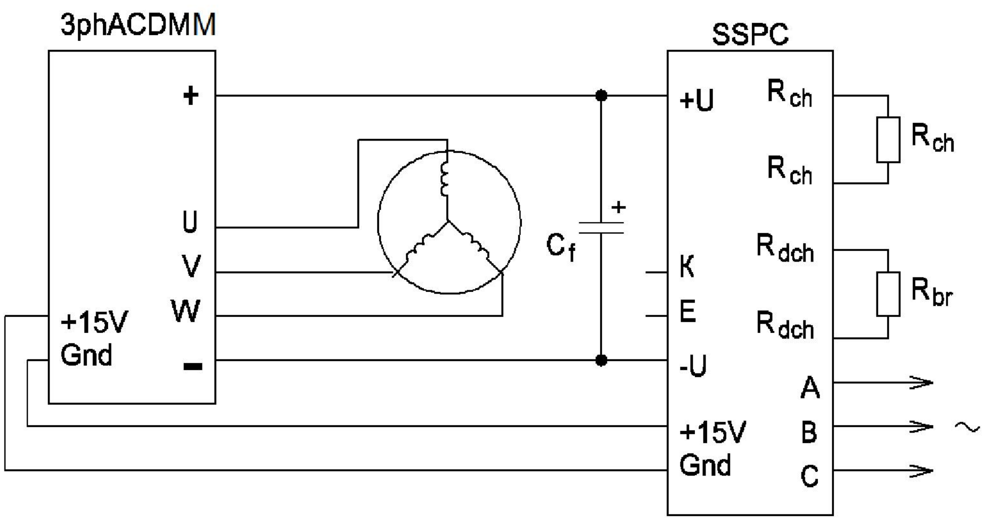


Figure 6.4 – Connection circuit of 3PHACDMM with power assembly type «4» with SSVC

SSVC (solid state voltage controller, see user' s manual SSVC) 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 3PHACDMM for all modules of 3PHACDMM on the power of 380 V and at currents over 20 A.

Filtering capacitor and voltage limiter of 1.5V are turned on between the outputs "+" and "-" of the module. 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 group	Maximum allowable condenser 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 may become unusable.

Below is description of module power outputs.

«U», «V», «W» Motor phase connection outputs. The order of phases' connection does not matter. Below is a Table 6.2 that represents the maximum power of motors supported by modules 3PHACDMM.

Table 6.2 – Maximum allowable module current and AC motor voltage for windings of delta and star connection

Device, 3PHACDMM	Maximum average power supported by module, kW	Maximum motor power on P_{avr}, kW	Maximum launching power supported by module, kW	Maximum motor power on P_l, kW
Rectified 36 V				
-5-1	0.13	0.12	0.37	0.37
-10-1	0.27	0.25	0.68	0.55
-20-1	0.56	0.55	0.87	0.75
-30-1	0.81	0.75	1.2	1.1
-50-1	1.35	1.1	2.2	2.2
-70-1	1.9	1.8	3.1	3.0
-100-1	2.7	2.2	3.1	3.0
Rectified 110 V				
-5-2	0.41	0.37	1.1	1.1
-10-2	0.82	0.75	1.6	1.5
-20-2	16	1.5	2.7	2.2
-30-2	2.5	2.2	4.0	4.0
-50-2	4.1	4.0	6.0	5.5
-70-2	5.8	5.5	6.0	5.5
Rectified 220 V				
-5-6	0.82	0.75	2.2	2.2
-10-6	1.6	1.5	4.1	4.0
-20-6	3.3	3.0	5.6	5.5
-30-6	4.9	4.0	9.6	9
-50-6	8.3	7.5	9.6	9
Rectified 380 V				
-5-12	1.5	1.5	4.1	4.0
-10-12	3.0	3.0	5.8	5.5
-20-12	5.7	5.5	9.2	9.0
-30-12	9.0	9.0	15.2	15
-50-12	15.2	15	15.2	15

M31 of different types can provide the correct operation and the protection of engines with power specified in Table 6.1. In this case, the values specified in column 3 (maximum engine power on P_{avr}) are valid if the engine operates at its full capacity. It is allowed installation of engines with higher wattage, if the motor shaft power will not exceed the maximum average power supported by 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_l).

For example, the engine capacity of 3 kW, powered by a single-phase 220 V, the triangle windings connection. The engine develops the power at the load corresponding to half of the maximum (1.5 kW). Consequently, it is not necessarily to set 3PHACDMM-50-6; it is possible to use the module 3PHACDMM-20-6, as it provides the load 1.5 kW and is able to run engines with a rated capacity up to 3.0 kW. At the same time, if the shaft power (for the same engine at 3 kW) is equal to 0.8 kW, the module 3PHACDMM-10-6 can not be used, although it supports the operation on load of up to 0.95 kW, but when you launch the engine of maximum capacity exceeding 2.2 kW it can fail.

Thus, the choice of the module should depend not only on its rated capacity, and the average operating motor current, but on its starting current; the difference in the module capacities depending on the engines and their operating conditions can be significant.

"+" and "-". The power supply connection outputs; the control scheme operates from the same power, 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 which 3PHACDMM operates at. 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 700 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.

The 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 station condenser when the capacitor is less than 500 μF to 1 kW. The capacity of a nominal value of less than 200 μF to 1 kW should not be installed because the engine will not develop the maximum power, and 3PHACDMM can be switched off by failures in the supply voltage.

In that case, if voltage is set to the module the capacity may be installed less than specified in Table 6.2 (on the order of hundreds μF), but it is not recommended to use 3PHACDMM without the connected capacity $C_{f.}$

In the modules SSVC and 3PHACDMM with a rectifier bridge are used different principles of charge of the capacitor. SSVC operates on the hysteresis loop, limiting the voltage on the upper and lower limit; 3PHACDMM 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 3PHACDMM engine will be run more smoothly but that does not indicate malfunction of the modules.

If the 3PHACDMM that used has not controlled the 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.

«B». Brake transistor output designed for braking resistor connection (see Figure 6.2 and 6.3) is required to reduce surge voltage during braking. Resistor should be chosen for each case based on the operation conditions and engine shutdown conditions, but its value must not be less than 16 Ω for SSVC and not less than 20 Ω for 3PHACDMM.

Resistor power must be also selected based on the operation conditions and engine shutdown conditions but it can be illustrated a general and correct calculation of the braking resistor power.

To determine the resistor power it is necessary to calculate the load factor (Figure 6.5).

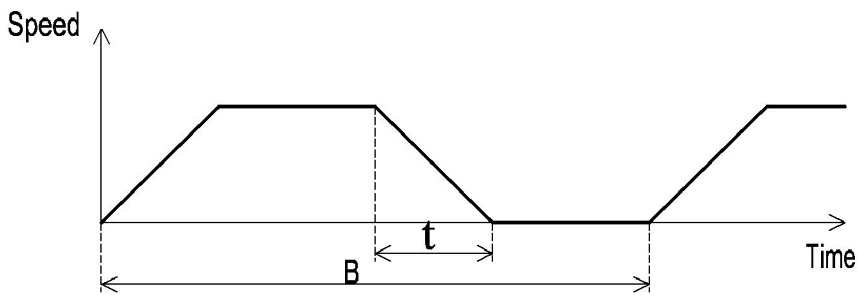


Figure 6.5 – Motor operating diagram.

Where t – braking time, T – cycle time. Then the load factor (fm) is rated as fm = (t/T). For instance, it is assumed that the engine will be braking for 10s once during 10 min. Then the load factor for this case will be equal fm=10/600=0.017 or 1.7%.

The correction factor K1 is rated in dependence of braking torque and load factor (Figure 6.6).

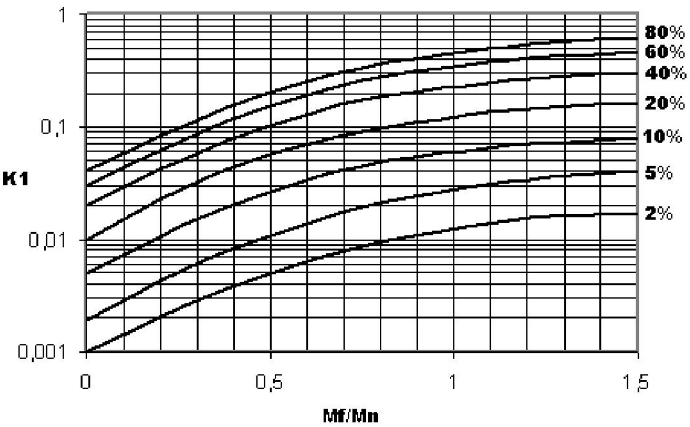


Figure 6.6 – Correction factor rating K1

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

For example, the ratio of braking torques is equal to 0.5; the load factor was defined equal to 1.6%. For the curve corresponding to 2% (higher and the nearer by value) is a correction factor K1 = 0.005.

It is not recommended to complete the curve speculative and choose a lower factor K1 when the values of the load factor is much less than 2%; the value in this case should be selected on a curve corresponding to 2%.

On braking overload of braking resistor is permitted. Overload is determined by factor K2, based on the Figure 6.7.

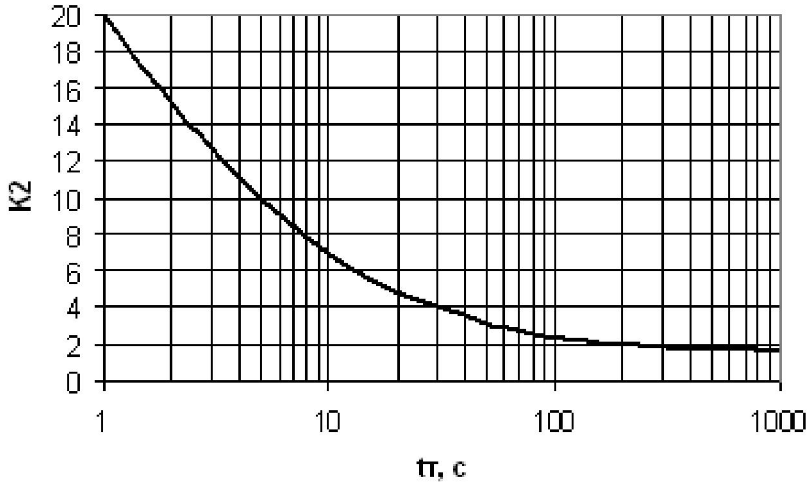


Figure 6.7 – Correction factor K2 rating

Previously, it was suggested that the deceleration time is equal to 10 s, then K2 = 7.

Next, the nominal power braking resistor is determined: $P_{br}=P_m*N_\eta*K1*(1+1/(K2*fm))$, W

Where P_{br} - braking resistor power, Pm - engine power, Nη - motor efficiency factor. For example, engine power is equal to 11 kW, and its efficiency is equal to 0.85. Then for our example P_{br}=11000*0.85*0.005*(1+1/(7*0.017)) = 440 W. Thus, the braking resistor power for this case should be not less than 0.5 kW.

The same calculations applied to the braking resistor of SSVC with ACDCM.

Connection outputs of AC voltage are used only for the power assembly option "1" and "3". When 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 starting the operation. Subsequently, the delay should be monitored at least 1 time per semester.

Thread section of external 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 are designed for installing in equipment by soldering or by means of detachable connectors. The allowable number of module outputs soldering during mounting (assembly) operations is 3. Output soldering must be made at temperature without exceeding 235 ° C. Duration of soldering is no more than 3 s.

When installing and operating you should take measures of module protection against static electricity exposure, during the installation the personnel should use 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 mandatory installation of flat and lock washers. In settings the 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 roughness of the cooler contact surface should be not more than 2.5 µm and the flatness tolerance - less than 30 µm. The cooler surface should not have any rough edges, honeycombs. There should not be foreign particles between the module and the cooler. To improve the thermal balance the module installation on mounting surface or the cooler should be implemented by means of heat-conductive pastes or similar in their heat-conducting properties.

On installation it is necessary to ensure pressing uniformity of module housing to the cooler. To this end, all screws should be tightened evenly in 2 - 4 steps 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 in 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 may 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 3PHACDMM, power loss on it and the necessary cooling area.

Table 7.1 – Necessary cooling area for 3PHACDMM for different types

Device, 3PHACDMM	Loss power on maximum load, max, W	Cooling area without compulsory blow, min, cm^2
-5-1	5	150
-10-1	10	300
-20-1	35	1000
-30-1	50	1500
-50-1	75	2000
-70-1	100	3000
-100-1	200	6000
-5-2	10	300
-10-2	25	750
-20-2	50	1500
-30-2	60	2000
-50-2	130	4000
-70-2	270	8000
-5-6	20	500
-10-6	50	1500
-20-6	80	2500
-30-6	100	3000
-50-6	300	9000
-5-12	25	750
-10-12	70	2000
-20-12	150	4000
-30-12	100	3000
-50-12	300	9000

The small cooling area may be 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 braking transistor (power assembly type "2"), it is recommended to increase the cooling area to 10 ... 20% depending on how often the engine is shut down. If the module includes a rectifier bridge (power assembly type “1”), you need to increase the cooling area to not less than 20% from 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

External exposure factor	External exposure factor value
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 loads

Climatic factor	Climatic factor value
Low temperature of environment: - operating, °C; - maximum, °C	 - 40 - 45
High temperature of environment: - operating, °C; - maximum, °C	 + 85 + 100
Relative humidity at a temperature 35 °C non-condensing %, no more	 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 high.
9. If the module is smoked, smelled or abnormal noises 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!

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 γ = 90 %.

Gamma-percent service life of the modules, subject to cumulative operating time is not more than gamma-percent life, not less than10 years, at γ = 90 %.

Gamma-percent storageability time of the modules, at γ = 90 % and storing – 10 years.

The first launch of the block

1. Connect the unit to the network and to the motor.
2. Be sure in lack of short circuit on outputs «U_{ref}», «U_s», and «+15V».
3. Set the minimum speed and acceleration.
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 inspect the signal on all module phases; be sure in serviceability of the output “Enable’ and “Speed’.
6. Connect the module to the motor in accordance with the recommended turn-on circuit.
7. Set the speed at 30 ... 50% of the maximum, the acceleration at 10 ... 30% of the maximum.
8. Give the power supply and turn on the module; be sure in serviceability of the module in all range of the speed and with forward reverse.

9. Set the required speed and increase the value of the acceleration, run the engine. If the engine starts and stops normally, increase the value of acceleration to necessary one. If the module is switched off on acceleration or braking, reduce the amount of acceleration or (if the lower acceleration is not desirable) set the capacity C_{ch} to the output “Delay” in accordance with foregoing guidelines.
10. After debugging of acceleration try at least four starts and stops of the engine for testing the resistance of the block on this acceleration.

9 OVERALL AND CONNECTING DIMENSIONS

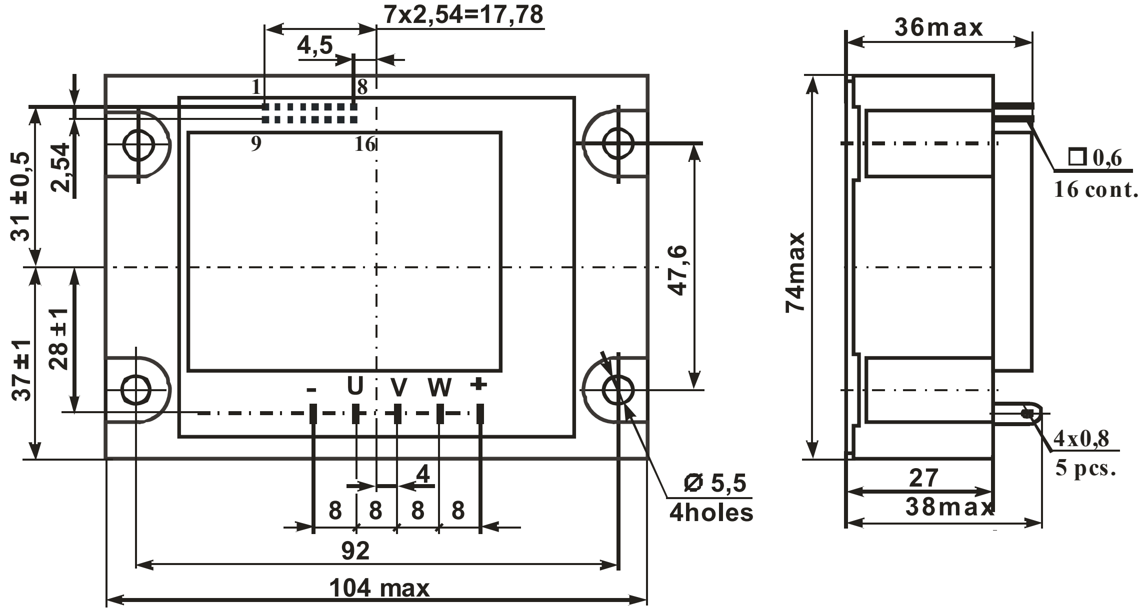


Figure 9.1 – Overall dimensions of 3PHACDMM-5,10-1, 2, 6 radiator type «4»

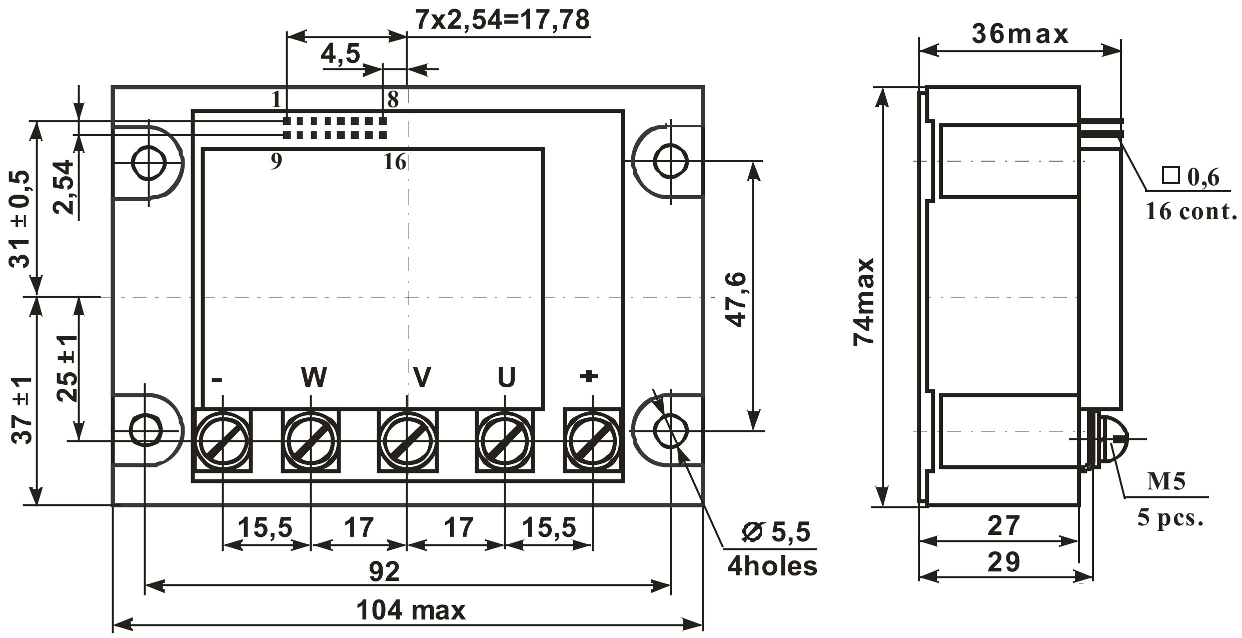


Figure 9.2 – Overall dimensions of 3PHACDMM-20,30,50-1, 2, 6, 3PHACDMM-5,10,20,30,50-12 radiator type «4»

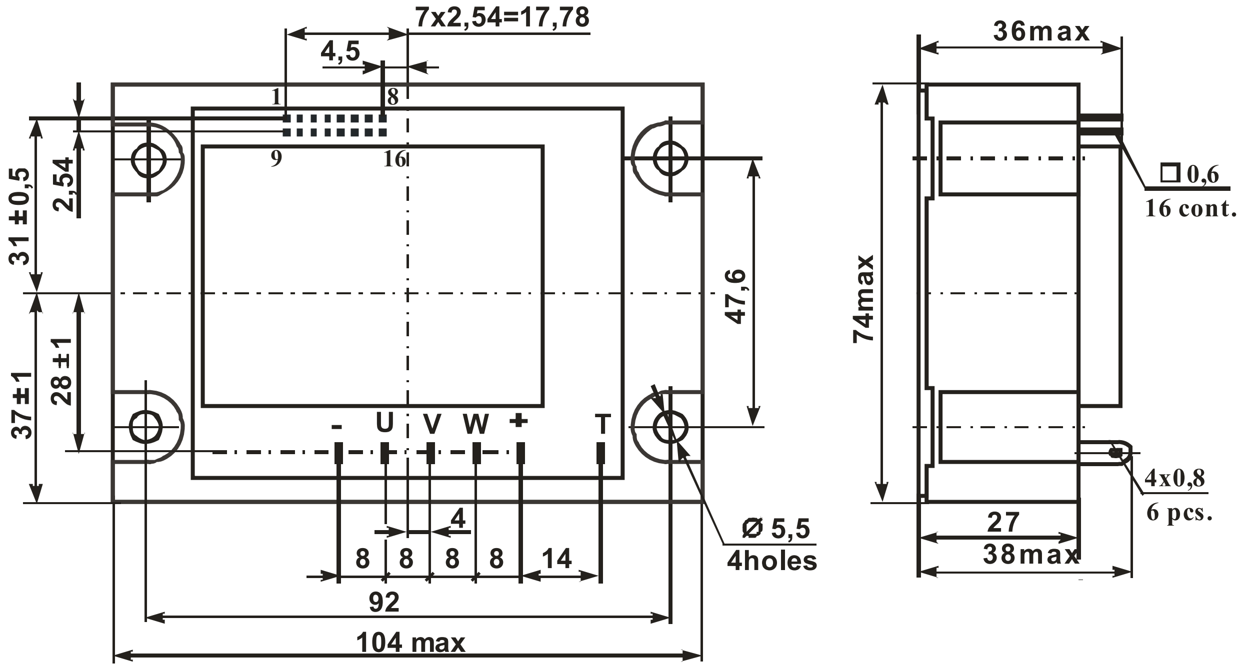


Figure 9.3 – Overall dimensions of 3PHACDMM-5,10-1, 2, 6 radiator type «2»

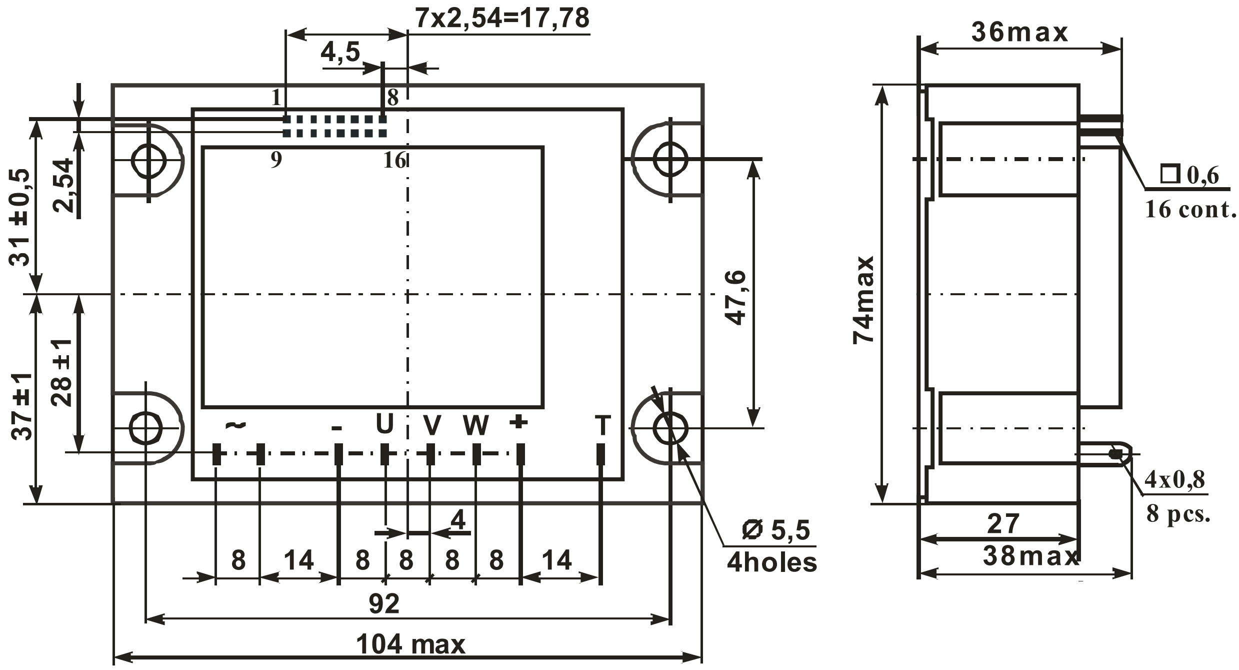


Figure 9.4 – Overall dimensions of 3PHACDMM-5,10-1, 2, 6 radiator type «1»

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

Precious metals are not contained.