INVERTOR MODULE M31

User's Manual

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1 DESCRIPTION AND FUNCTIONS

Module M31 is an assembly of power transistors with control circuits and protection circuits. M31 is designed to control the powerful load, in particular electric motors of various types. M31 is made on the basis of the best domestic and foreign achievements of technologies of power electronics, microelectronics, digital-to-analog integrated circuits.

M31 supports the following features and capabilities:

- Control of any type of load in accordance with control signals;
- Protection against current overloads and short circuits;
- Protection against pulse current surge;
- Current protection pickup threshold adjustment;
- Protection against overheating;
- Protection against the simultaneous operation of transistors of the upper and lower inverter arm;
- External signaling about an accident;
- Internal supply voltage control;
- Power supply module from the power circuit (for modules of 1,2, 6 class);
- Allows external circuits are powered its own stabilized voltage +15 V with protection against current overload;
- Connection of the AC voltage without rectification (type radiator "1" and "3");
- Smooth filter capacity charge without any charging resistor and charge control circuits (type radiator "1" and "3").

M31 provides operation and load protection up to 15 kW. M31 is available with various types of radiators; it allows using the module both for solution of common industrial problems and for solutions of special cases.

2 MODULE TYPES

M31 is produced with different types of radiators. The recommended schemes of module connection depending on the version are presented in section 6.

M31 produced at 5, 10, 20, 30, 50, 70 and 100 A. The current in the module's name indicates the maximum inverter current control circuit which allows normal operation; the maximum current of transistors exceeds the specified in the product name. At higher current the current protection will trigger and the inverter current will be limited. The current specified in the product name is the protection operation current at the average current. This protection current can be regulated but only in the lower side (see section 5).

The maximum voltage that is indicated in the module name, specifies the maximum-allowable collector-emitter voltage used in the transistor module. M31 is available for 100, 200, 600 and 1200 V which corresponds to the values 1, 2, 6 and 12 in the module name. The maximum supply voltage for the module is lower than it is indicated in the name (see Section 4), due to safety measures at the operation of the power transistors of the module.

Modules for 100 V 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 for 600 V are produced at 5, 10, 20, 30 and 50 A;
Modules for 1200 V are produced at 5, 10, 20, 30 and 50 A.

Variation of power assembly:

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

"2" - the inverter and braking transistor. Brake transistor in the module allows you to connect the braking resistor directly to the module, namely allows managing without the additional braking blocks. Brake transistor is controlled by the external circuit of the control input "Brake".

"1" - the inverter, brake transistor and rectifier bridge.

Table 2.1 shows all types of modules M31

Table 2.1 – Produced M31

Type of power assembly	Voltage	Modules
A1	100	M31-5-1A1, M31-10-1-A1
	200	M31-5-2A1, M31-10-2-A1
	600	M31-5-6A1, M31-10-6-A1
A2	100	All currents
	200	All currents, except 70 A
	600	M31-5-2A2, M31-10-2-A2
A3	100	M31-5-1A3, M31-10-1-A3
	200	M31-5-2A3, M31-10-2-A3
	600	M31-5-6A3, M31-10-6-A3
A4	All voltages	All currents
B1	100	M31-5-1A1, M31-10-1-A1
	200	M31-5-2A1, M31-10-2-A1
	600	M31-5-6A1, M31-10-6-A1
B2	All voltages	All currents
B3	100	M31-5-1A3, M31-10-1-A3
	200	M31-5-2A3, M31-10-2-A3
	600	M31-5-6A3, M31-10-6-A3
B4	All voltages	All currents

At Figure 2.1 is shown a decryption of module name version M31.

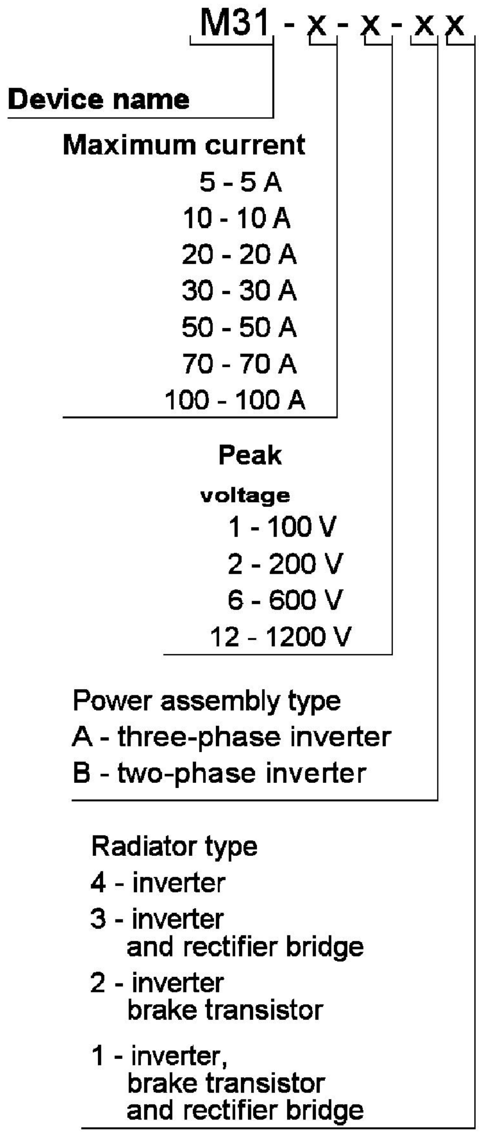

Figure 2.1 – Decryption of module name

For instance, module M31-10-6-A2: module with maximum inverter current 10 A, peak voltage 600 V, with three phase inverter and brake transistor.

3 GENERAL MODULE DESCRIPTIONS

Module M31 is an assembly of transistor control circuits and, in fact, of power transistors. The structural circuit of M31 is shown at Figure 3.1.

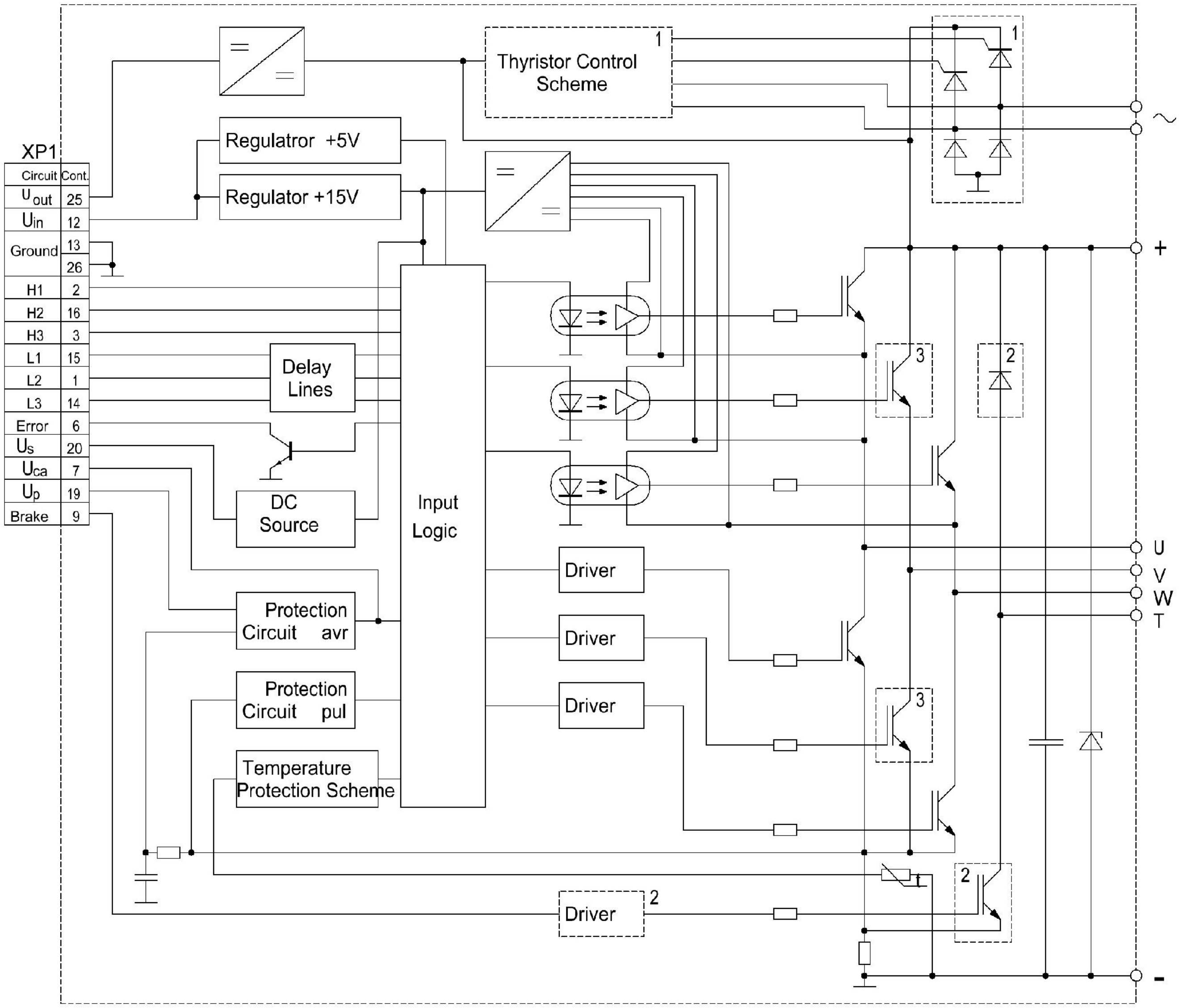

Figure 3.1 – Structural circuit of M31

«1» - rectified bridge circuit, providing smooth filter capacity charge and operation capability of the module by AC voltage. The circuit is included in M31 with radiator types «1» and «3».

«2» - brake transistor circuit included in M31 with power assembly types «1» and «2».

«3» - Transistors which are absent for radiator type «B» (two-phase inverter).

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

Connector XP1 is two levels PLS-13 with a counterpart PBS-13. The connector is designed for module control. Power contacts – or pins (for modules for currents 5 and 10A), or contact screw M8 (see outline drawings). Output assignment of connector XP1 and of power outputs are shown in Table 3.1.

Table 3.1 – Function of module outputs

Number	Sign	Function
1	L2	Back up Switch Phase V Control Input (only for three-phase inverter modules)
2	H1	Top Switch Phase U Control Input
3	H3 (H2 for «B»)	Top Switch Phase W Control Input
4		Not involved
5		Not involved
6	Error	Current and Temperature Overload Signaling Output
7	U_{ca}	Inverter Current Amplifier Output
8		Not involved
9	Brake	Brake Transistor Control Input (only for brake transistor modules)
10		Not involved
11		Not involved
12	$U_{in\ ss}$	Internal Voltage Stabilizer Input
13		Ground
14	L3 (L2 for «B»)	Back up Switch Phase W Control Input
15	L1	Back up Switch Phase U Control Input
16	H2	Top Switch Phase V Control Input (only for three-phase modules)
17		Not involved
18		Not involved
19	U_{ch}	Protection Operation Current Adjustment Output
20	U_s	DC Source Output +15 V
21		Not involved
22		Not involved
23		Not involved
24		Not involved
25	$U_{out\ dc/dc}$	Internal Converter Output DC/DC
26	Ground	Ground
	+	Connection Output «+» of Power Supply
	U (1)	Phase U connection Output
	V	Phase V connection output (only for three phase inverter modules)
	W (2)	Phase W Connection Output
	T	Brake Transistor Connection Output (only for modules with brake transistor)
	-	Connection Output «-» of Power Supply
	~	AC voltage connection Output (only for modules with rectifier bridge)

For easy connection of control circuits it is shown at Figure 3.2 a schematic drawing of connector appearance XP1 of module M31.

1 … 13

L2	H1	H3			Error	U_{ca}		Brake			U_{in}	Ground
L3	L1	H2			U_p	U_s					U_{out}	Ground

14 … 26

Figure 3.2 – Appearance of connector XP1.

4 BASIC CHARACTERISTICS

Basic electric characteristics and maximum permissible electric characteristics of modules M31 at temperature 25 ^{0}C are shown in Table 4.1 – 4.5.

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

Title	Unit	Rate			Note
		min	type	max	
Supply characteristics					
Supply Voltage*	V	40		60	Module of the 1-st class
		40		160	Module of the 2–nd class
		40		350	Module of the 6-th 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
Input/Output Delay of control inputs	μs	1		3	
Output characteristics					
Maximum voltage of output «Error»	V			20	
Maximum current of output «Error»	mA			20	
Voltage «Us»	V		15	16.5	No-load
Maximum load current of output «Us»	mA			20	
Voltage «U_{ca}» corresponding to protection current operation	V		1		

* Control circuit of two-phase inverter modules will be powered only from 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
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	
Temperature Protection On Temperature	^{0}C	90		100	
Temperature Protection Off Temperature	^{0}C	50		60	
Temperature Protection Speed	Ms			1	
Output «Error» Operation Delay	µs			2	

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

Table 4.2 – Basic and maximum permissible electric characteristics of power circuits for modules of 1-st class (M31-xx-1-xx)

Title	Unit	Rate			Note
		min	type	max	
Power switches characteristics					
Peak Voltage Drain-Source	V			100	
DC Link Peak Voltage	V			60	
Power Transistor Maximum average current at 100 ^{0}C	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 ^{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 by 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	μA			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 the 2-nd class (M31-xx-2-xx)

Title	Unit measure	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 ^{0}C	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 ^{0}C	A			70	5 A
				90	10 A
				180	20 A
				260	30 A
				380	50 A
				420	70 A
Loss Power at 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 Current	μA			100	
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 (M31-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 ^{0}C	A			11	5 A
				16	10 A
				30	20 A
				60	30 A
				60	50 A
Power Transistor Maximum Pulse Current at 25 ^{0}C	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 (M31-xx-12-xx)

Title	Unit	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 ^{0}C	A			10	5 A
				15	10 A
				24	20 A
				60	30 A
				60	50 A
Power Transistor Maximum Pulse Current at 25 ^{0}C	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

Control of loading by means of M31 proceeds by using the following outputs:

«L1», «L2», «L3», «H1», «H2», «H3». TTL-level inputs are to control corresponding to the power transistors. The transistor opening corresponds to the "log.1", the closure to "log.0". If you want to control module from 15 V, it is recommended to install on the control input resistive dividers reduce the control voltage to TTL level. If any power transistor is not used, its control input should be connected with the output "Common". The module has no internal delay circuit for switching the upper and lower phase switch. When applying the control signals it is recommended to install the delay on the switching of at least 2.5 microseconds for modules for current of 5, 10 A and not less than 5 microseconds for modules for currents over 10 A, otherwise it may be high current through the upper and lower switches of one inverter arm.

For modules with the radiator option "B" (two phases) the inputs «L1», «L3», «H1», «H3» are the control inputs meanwhile the outputs «L3» and «H3» correspond to upper and lower transistors of phase 2.

The unit has a lock on the simultaneous operation of the upper and lower transistors of one phase, so when applying "log.1" on the control inputs of one phase, all the inverter transistors are closed, while the signal of a nonstandard situation at the output "Error" appears.

«Brake». Input TTL-level of braking transistor control. The opening of the brake transistor corresponds to the "log.1", the closure to "log.0". Input is enabled only for the radiator options "1" and "2".

«U_{ca}». The current shunt amplifier output (motor current). Maximum module current corresponds to 1 V at the amplifier output regardless of the current passport size supported by module. Voltage dependence on the output «U_{ca}» on motor current is linear.

«U_p». Current protection operation threshold set output. When output «U_p» is vacant the protection will be triggered at the maximum allowable current of the module, when connecting the outputs «U_p» and "Ground" the protection will be triggered at 10 ... 20% of the maximum current. To set the protection threshold the resistor must be connected between the output of «U_p» and output «Ground» whose nominal value should be chosen from the following graphic (Figure 5.1).

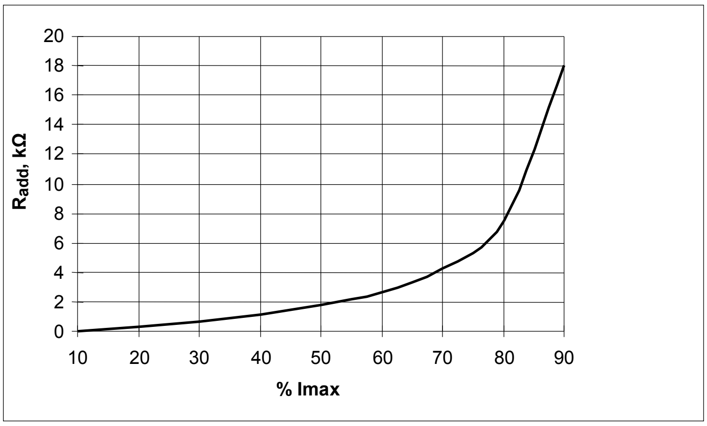

Figure 5.1 – Protection Operation Current versus Protection Resistor Value.

Thus, for instance, if resistor of 2.7 kΩ is connected to M31 of 10A, then the protection will operate at current of 6A. For convenience of calculation refer to Table 5.1 of adjustable protection current percentage against maximum protection current.

Table 5.1 – 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

«Error». Output that signals about an accident which is an open transistor collector of protection schemes. Active level (0) at this output will arise when overloading by the average current, the pulse current and the overheating.

«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…350V in stabilized voltage +18V with load capability up to 250mA. In the event if the module is supplied from the external voltage source that connected to output «U_{in}» then this output must be unactuated.

It is recommended to use the external supply at the running voltage of power circuit no less than 40V (as at a lower voltage DC/DC-converter will not start) and no more than 350V (the converter can fail); that is by power supplying 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 of power voltage with stabilizer setting at 16…20V. If the module supply from the power voltage through the internal DC/DC-converter is provided, than the outputs «U_{in}» and «U_{out}» must be connected.

Features of the module protection operation.

M31 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 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 duration of more than 20 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 duty cycle varies, as reflected in the charge of the motor average current.

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" 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 when the housing temperature is 90 ... 100 ^{0}C and turns on when the temperature is 50 ... 60 ^{0}C, providing a hysteresis of 30 ... 40 ^{0}C. During the temperature protection operation transistor on output "Error" will be open to the module housing temperature reduction to 50 ... 60^{0}C.

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

Protection against the simultaneous operation of the upper and lower arm of one phase eliminates the failure of the module on the through currents. Including, because of the control circuit failure the power transistors will not go down. Note that while simultaneous supplying «log.1» on the control inputs of one phase all phases of the module will block, thus, error signaling will not occur.

6 POWER OUTPUTS

Depending on the type of module power assembly it is recommended the following diagrams for power circuits' connection (Figure 6.1 – 6.5).

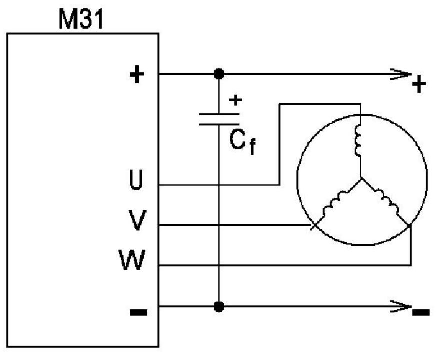

Figure 6.1 – Connection circuit of M31 with power assembly type «4»

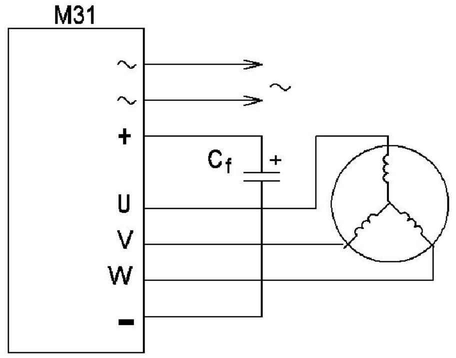

Figure 6.2 – Connection circuit of M31 with power assembly type «3»

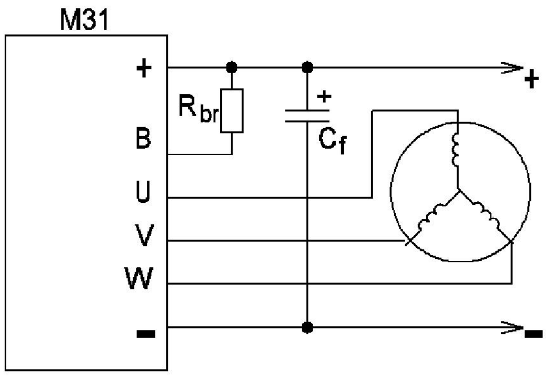

Figure 6.3 – Connection circuit of M31 with power assembly type «2»

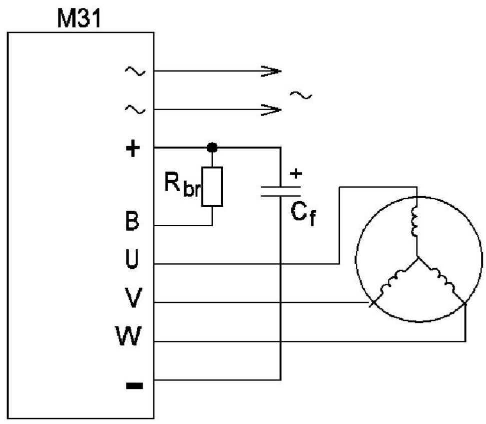

Figure 6.4 – Connection circuit of M31 with power assembly type «1»

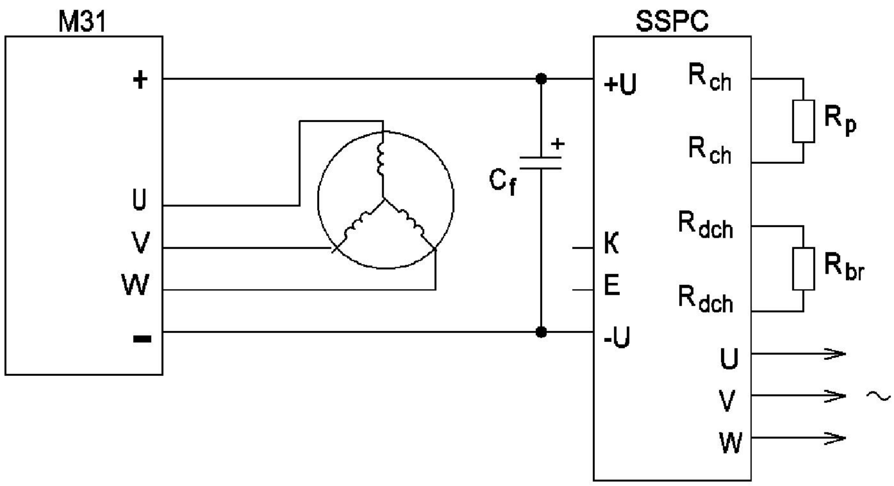

Figure 6.5 – Connection circuit of M31 with power assembly type «4» with SSPC

Figure 6.1 – 6.5 gives connection circuits M31 with three-phase inverter (power assembly type «A»). For power assembly type «B» (two-phase inverter) connection circuit is not changed, except for the connection to motor phases.

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 M31 for all M31 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.

«U», «V», «W» (**«1»** and**«2»** for «B»). Motor phase connection outputs. Below is Tables 6.2 and 6.3, in which the maximum powers of motors are indicated, supported by modules M31 with three-phase (“A”) and two-phase (“B”) inverter.

Table 6.2 – Maximum allowable module current with radiator type «A» and motor voltage for windings connected in triangle and star

Device, M31	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, triangle windings connection*				
M31-5-1	0.077	0.06	0.21	0.18
M31-10-1	0.155	0.12	0.39	0.37
M31-20-1	0.31	0.25	0.55	0.55
M31-30-1	0.47	0.37	0.77	0.75
M31-50-1	0.77	0.75	1.2	1.1
M31-70-1	1.13	1.1	1.8	1.8
M31-100-1	1.55	1.5	1.8	1.8
With mains supply AC 36 V, star windings connection*				
M31-5-1	0.13	0.12	0.37	0.37
M31-10-1	0.27	0.25	0.68	0.55
M31-20-1	0.56	0.55	0.87	0.75
M31-30-1	0.81	0.75	1.2	1.1
M31-50-1	1.35	1.1	2.2	2.2
M31-70-1	1.9	1.8	3.1	3.0
M31-100-1	2.7	2.2	3.1	3.0
With mains supply AC 36 V, triangle windings connection*				
M31-5-2	0.25	0.25	0.65	0.55
M31-10-2	0.47	0.37	1.1	1.1
M31-20-2	0.95	0.75	1.6	1.5
M31-30-2	1.4	1.1	2.4	2.2
M31-50-2	2.4	2.2	3.6	3.0
M31-70-2	3.3	3.0	3.6	3.0

Device , M31	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, star windings connection*				
M31-5-2	0.41	0.37	1.1	1.1
M31-10-2	0.82	0.75	1.6	1.5
M31-20-2	16	1.5	2.7	2.2
M31-30-2	2.5	2.2	4.0	4.0
M31-50-2	4.1	4.0	6.0	5.5
M31-70-2	5.8	5.5	6.0	5.5
With mains supply AC 36 V, triangle windings connection*				
M31-5-6	0.47	0.37	1.3	1.1
M31-10-6	0.95	0.75	2.2	2.2
M31-20-6	1.9	1.8	3.3	3.0
M31-30-6	2.8	2.2	5.7	5.5
M31-50-6	4.7	4.0	5.7	5.5
With mains supply AC 36 V, star windings connection*				
M31-5-6	0.82	0.75	2.2	2.2
M31-10-6	1.6	1.5	4.1	4.0
M31-20-6	3.3	3.0	5.6	5.5
M31-30-6	4.9	4.0	9.6	9
M31-50-6	8.3	7.5	9.6	9
With mains supply AC 36 V, star windings connection*				
M31-5-12	1.5	1.5	4.1	4.0
M31-10-12	3.0	3.0	5.8	5.5
M31-20-12	5.7	5.5	9.2	9.0
M31-30-12	9.0	9.0	15.2	15
M31-50-12	15.2	15	15.2	15

* It is necessary an external bridge rectifier.

Table 6.3 – Maximum allowable module current with radiator type «B» and motor voltage

Device, M31	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*				
M31-5-1	0.13	0.12	0.37	0.37
M31-10-1	0.25	0.25	0.68	0.55
M31-20-1	0.55	0.55	0.87	0.75
M31-30-1	0.75	0.75	1.2	1.1
M31-50-1	1.3	1.1	2.2	2.2
M31-70-1	1.8	1.8	3.1	3.0
M31-100-1	2.5	2.2	3.1	3.0
With mains supply AC 110 V*				
M31-5-2	0.38	0.37	1.1	1.1
M31-10-2	0.75	0.75	1.6	1.5
M31-20-2	1.5	1.5	2.7	2.2
M31-30-2	2.3	2.2	4.0	4.0
M31-50-2	3.7	3.3	6.0	5.5
M31-70-2	5.2	4.0	6.0	5.5
With mains supply AC 220 V*				
M31-5-6	0.77	0.75	2.2	2.2
M31-10-6	1.6	1.5	4.1	4.0
M31-20-6	3.1	3.0	5.6	5.5

M31-30-6	4.6	4.0	9.6	9
M31-50-6	7.7	7.5	9.6	9

Device, M31	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 380 V*				
M31-5-12	1.3	1.1	4.1	4.0
M31-10-12	2.6	2.2	5.8	5.5
M31-20-12	5.6	5.5	9.2	9.0
M31-30-12	7.9	7.5	15.2	15
M31-50-12	13.2	11	15.2	15

* It is necessary an external bridge rectifier.

M31 of different types can provide the correct operation and the protection of engines with power specified in Tables 6.1 and 6.2. 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 the module (column 2). However, irrespective of the motor power its rated capacity should not exceed the specified one 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 a half of the maximum (1.5 kW). Consequently, it is not necessarily to install the module up to 50 A; it is possible to use the module at 20 A, 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 at 10 A 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, the choice of the module should focus not only on its rated capacity and the average operating motor current but from 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; 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 - 6.4) 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 changes depending on engine capacity, at which operates M31. The following table shows the minimum and recommended values of C_f.

Table 6.4 – 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 set because the engine will not develop maximum power, and M31 can be turned off by failures in the supply voltage.

In that case, if voltage regulator is set to the module the capacity may be installed less than specified in Table 6.3 (on the order of hundreds μF), but it is not recommended to use M31 without a connected capacity $C_{f.}$

In the modules SSVC and M31 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; M31 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 M31 engine will be run more smoothly but that does not indicate any malfunction of the modules.

If in the M31 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 the 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 6.3 and 6.4) required reducing 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 M31.

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 resistor it is necessary to calculate the load factor (Figure 6.6).

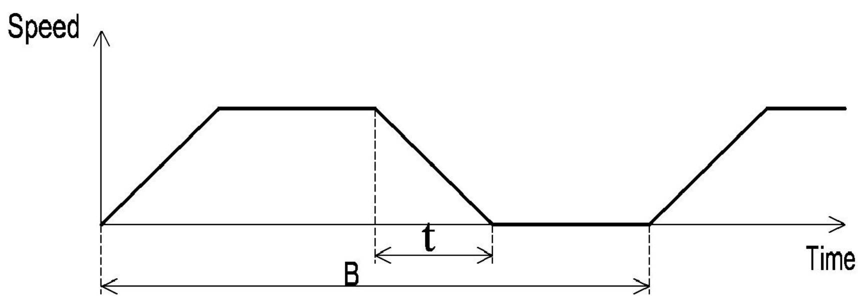

Figure 6.6 – Motor operating diagram.

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

The correction factor K1 is rated in dependence on braking torque and load factor (Figure 6.7).

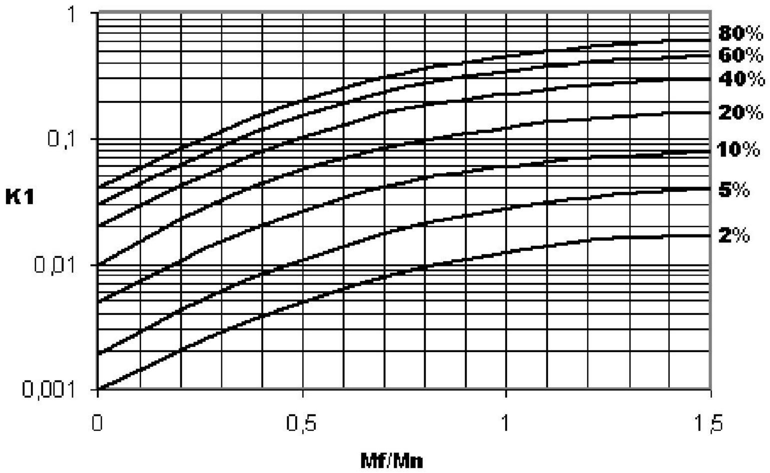

Figure 6.7 – Correction factor rating K1

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%.

When braking it is permitted braking resistor overload. Overload is determined by factor K2, based on Figure 6.8.

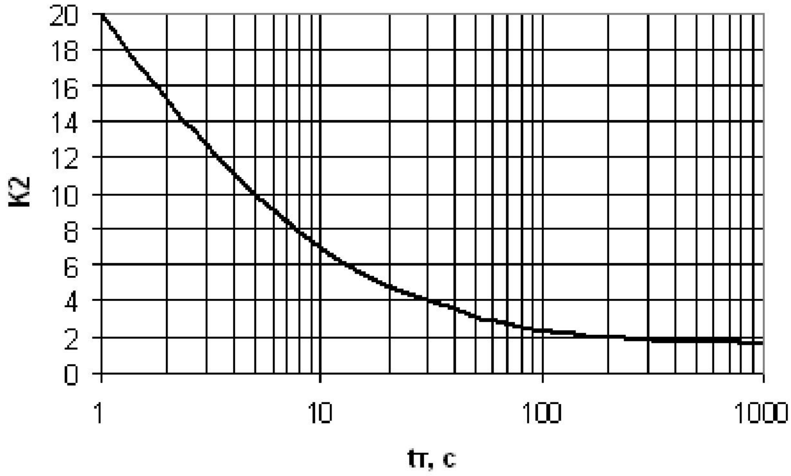

Figure 6.8 – Correction factor K2 rating

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

Next, we need to determine the nominal power braking resistor: $P_p=P_m \cdot N_m \cdot K1 \cdot (1+1/(K2 \cdot f_m))$, W

Where P_{br} - braking resistor power, P_m - motor power, N_η - motor efficiency factor. For example, engine power is equal to 11 kW, and its efficiency is equal to 0.85. Then for our example $P_p=11000 \cdot 0.85 \cdot 0.005$x (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 SSPC with ACDCM.

Connection outputs of AC voltage are used only for the power assembly option "1" and "3". 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 inclusively) or with screws M5 (modules at the current over 20 A). The screws should be tightened to the torque (5 ± 0.5) Nm, with 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 inclusively, 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 soldering number of module outputs when 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 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 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 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. 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.

When installing 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 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 a 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 M31, power loss on it and the necessary cooling area.

Table 7.1 – Necessary cooling area for M31 of different types

Device , M31	Loss power on maximum load, max, W	Cooling area without compulsory blow, min, cm^2
M31-5-1	5	150
M31-10-1	10	300
M31-20-1	35	1000
M31-30-1	50	1500
M31-50-1	75	2000

Device , M31	Loss power on maximum load, max, W	Cooling area without compulsory blow, min, cm^2
M31-70-1	100	3000
M31-100-1	200	6000
M31-5-2	10	300
M31-10-2	25	750
M31-20-2	50	1500
M31-30-2	60	2000
M31-50-2	130	4000
M31-70-2	270	8000
M31-5-6	20	500
M31-10-6	50	1500
M31-20-6	80	2500
M31-30-6	100	3000
M31-50-6	300	9000
M31-5-12	25	750
M31-10-12	70	2000
M31-20-12	150	4000
M31-30-12	100	3000
M31-50-12	300	9000

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 braking transistor (power assembly type "2"), it is recommended to increase the cooling area to 0 ... 20% depending on how often the engine will be 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% of 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/s^2 (g); - frequency, Hz	 100 (10) 1 - 500
Mechanical shock of repeated action : - peak impact acceleration , m/s^2 (g); - duration of impact acceleration, ms	 400 (40) 0.1 – 2.0
Linear acceleration, m/s^2 (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; - maximum, °C	 - 40 - 45
High temperature of environment: - operating, °C; - maximum, °C	 + 85 + 100
Relative humidity at temperature 35 °C non-condensing %, max	 98

Safety Requirements

1. Operation with the module should be carried out only by qualified personnel.
2. Do not touch the module power outputs of the supply voltage applied, 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 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, 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 noises immediately turn off the power and contact 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 $\gamma = 90$ %.

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

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

9 OVERALL AND CONNECTING DIMENSIONS

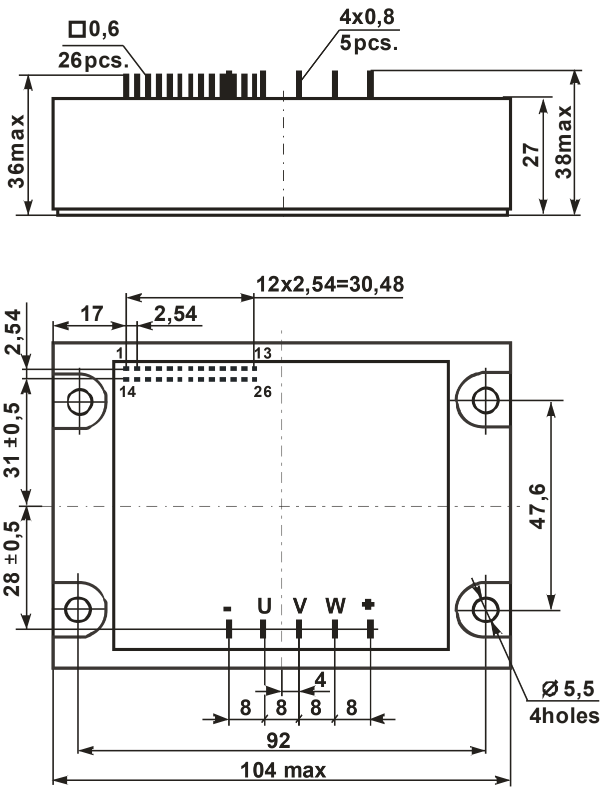

Figure 9.1 – Overall dimensions M31-5,10-1,2,6-A4

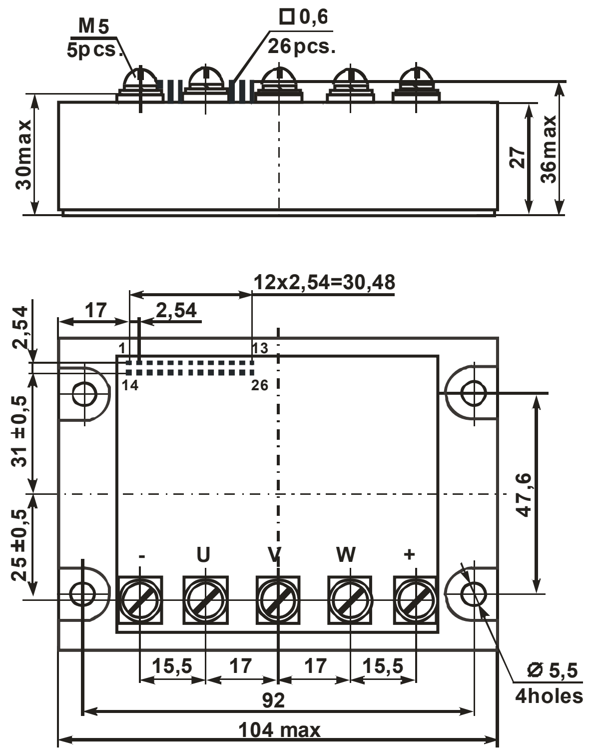

Figure 9.2 – Overall dimensions M31-20,30,50,70,100-1,2,6-A4 and M31-5,10,20,30,50-12-A4

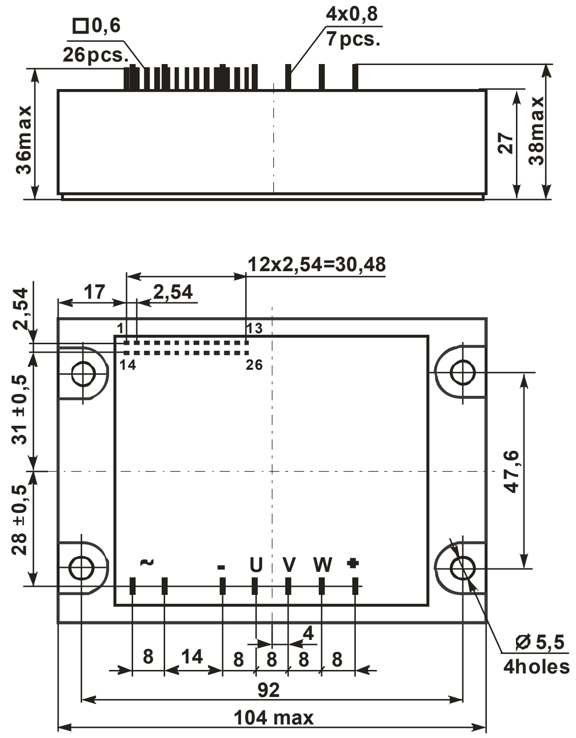

Figure 9.3 – Overall dimensions M31-5,10-1,2,6-A3

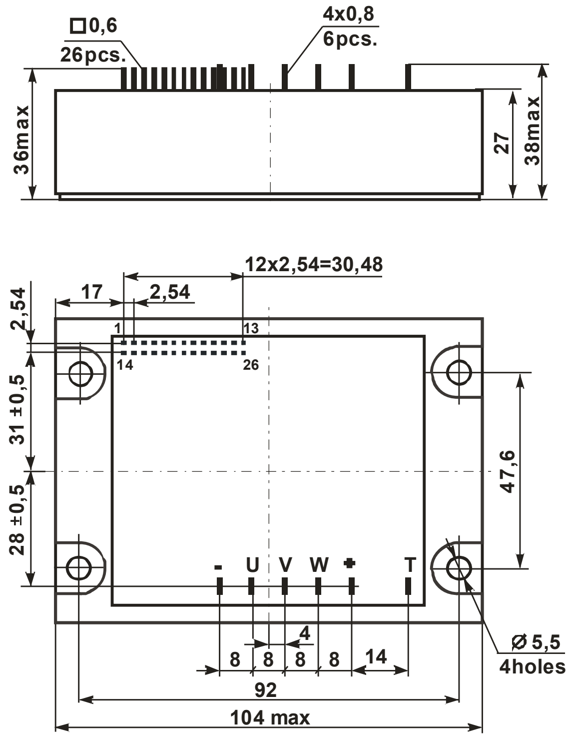

Figure 9.4 – Overall dimensions M31-5,10-1,2,6-A2

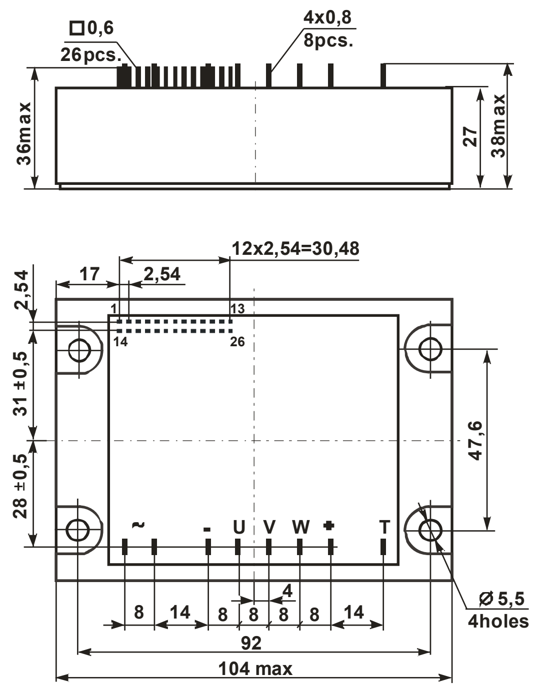

Figure 9.5 – Overall dimensions 1-5,10-1,2,6-A1

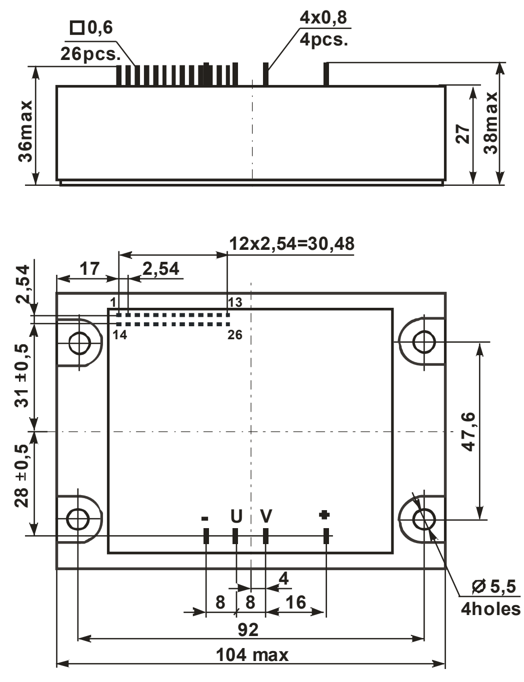

Figure 9.6 – Overall dimensions M31-5,10-1,2,6-B4

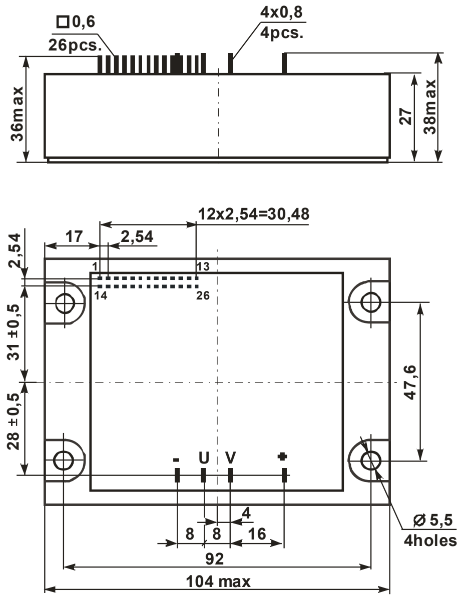

Figure 9.7 – Overall dimensions M31-20,30,50,70,100-1,2,6-B4 and M31-5,10,20,30,50-12-B4

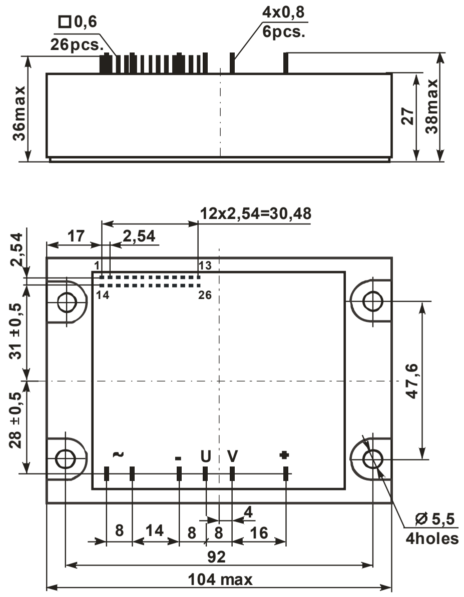

Figure 9.8 – Overall dimensions M31-5,10-1,2,6-B3

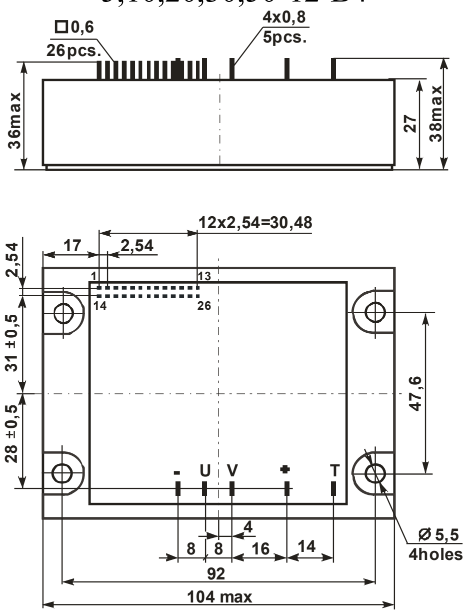

Figure 9.9 – Overall dimensions M31-5,10-1,2,6-B2

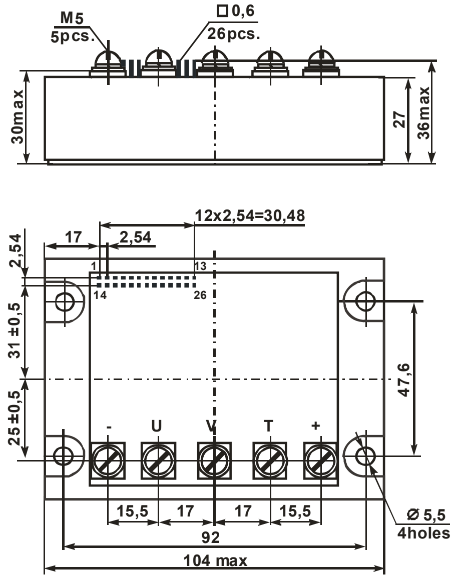

Figure 9.10– Overall dimensions M31-20,30,50,70,100-1,2,6-B2 and M31-5,10,20,30,50-12-B2

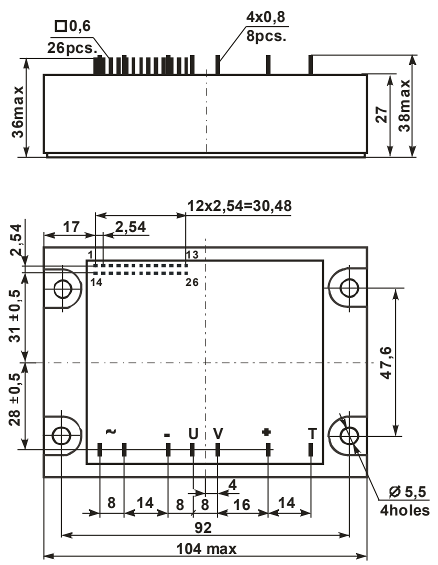

Figure 9.11 – Overall dimensions M31-5,10-1,2,6-B1

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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