IGBT AND MOSFET TRANSISTORS DRIVER
DR4120P-A-K

USER'S MANUAL

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1 OVERVIEW

A four-channel IGBT and MOSFET transistors driver that is intended for galvanically isolated controlling by four power transistors with field control with maximum permissible current values and voltages 600V/600A, 1200V/400A, 1700V/400A. The driver has inbuilt DC/DC-converters and is sharpener amplifier of gate control signals with frequency up to 25 kHz.

2 FUNCTIONAL DRIVER FEATURES

2.1 The driver provides the following functions of control and protection of controlled transistors:

1 Transistors control in accordance with control signals;
2 Controlled transistors galvanically isolated disabling and barrier voltages forming;
3 Saturation voltage control on the controlled transistors collectors, protection turn-off in out from saturation state;
4 Protection activation adjusting at non-saturation;
5 Providing of smooth driver junction from active state into inactive in an «emergency» case (controlled transistor from saturation state);
6 Control blocking in an «emergency»;
7 Control blocking duration adjustment in an «emergency»;
8 Protection activation delay adjustment at non-saturation;
9 Duration adjustment of controlled transistor smooth emergency turn-off;
10 Signaling about emergency existence;
11 One half-bridge blocking of simultaneous transistors turn-on;
12 “Dead time” forming on switching of half-bridge transistors;
13 “Dead time” duration adjustment.

3 DIMENSIONAL DRAWING AND FUNCTIONAL DIAGRAM

3.1 Dimensional drawing is shown on Figure 1, functional diagram is shown on Figure 2, connection circuit is shown on Figure 3.

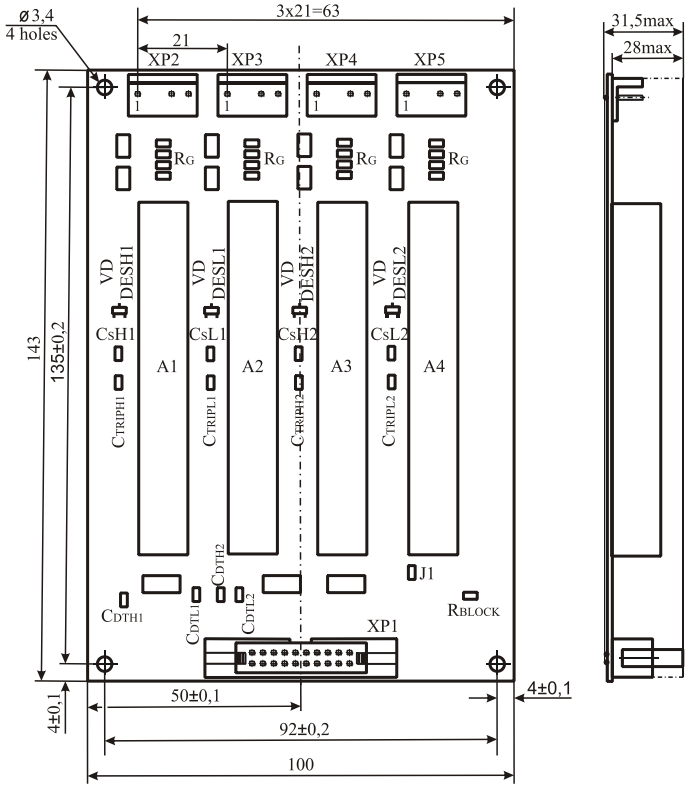

Figure 1 – Driver dimensional drawing

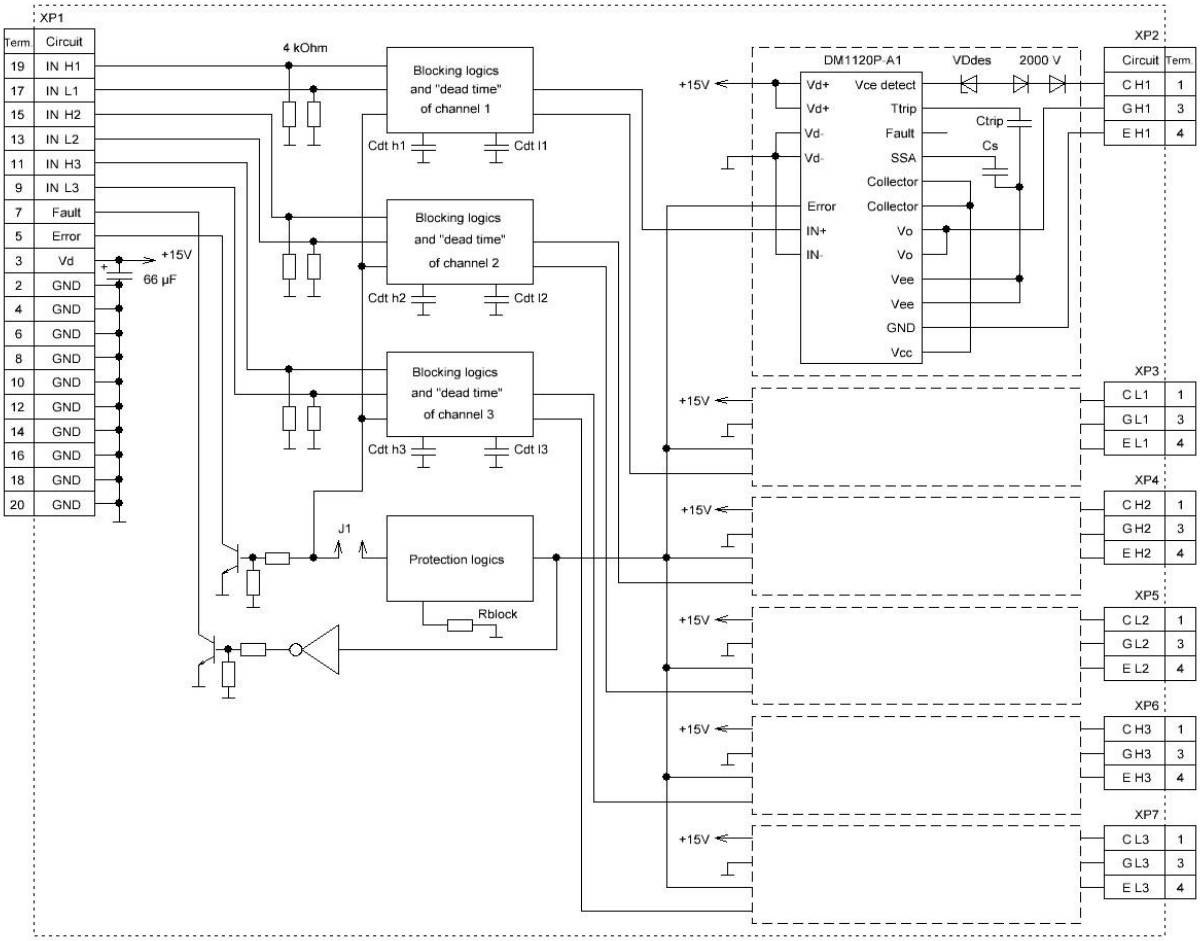

Figure 2 – Driver functional diagram

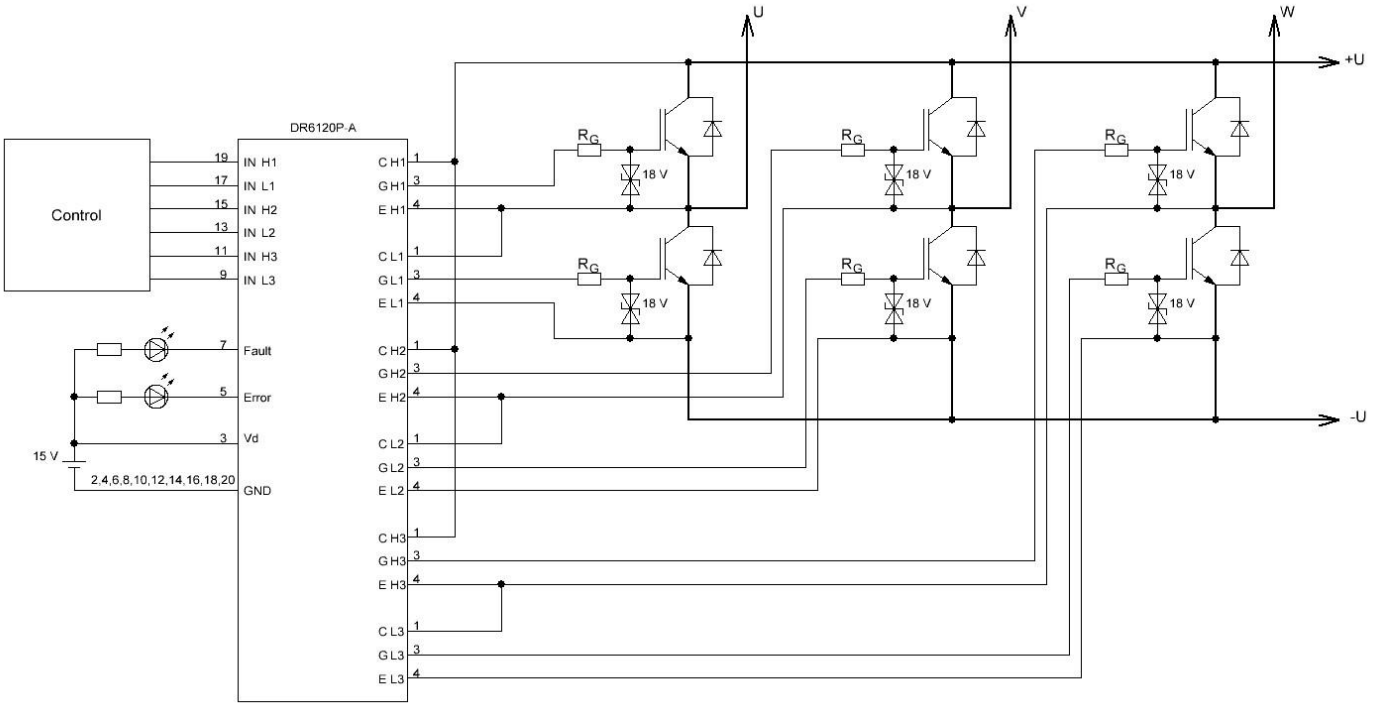

Figure 3 – Driver connection circuit

3.2 Driver outputs application is shown in Table 1, driver trimming elements application is shown in Table 2.

Table 1 – Application of driver outputs

Output	Symbol	Application
XP1.1	-	
XP1.2	GND	Connection output «-» of logic supply and DC/DC-converters; control circuits ground output
XP1.3	Vd	Connection output «+» of logic supply and DC/DC-converters
XP1.4	GND	Connection output «-» of logic supply and DC/DC-converters; control circuits ground output
XP1.5	Error	Output for error signal (open collector); output of blocking circuit
XP1.6	GND	Connection output «-» of logic supply and DC/DC-converters; control circuits ground output
XP1.7	Fault	Output for error signal (open collector); outputs of drivers
XP1.8	GND	Connection output «-» of logic supply and DC/DC-converters; control circuits ground output
XP1.9	-	
XP1.10	GND	Connection output «-» of logic supply and DC/DC-converters; control circuits ground output
XP1.11	-	
XP1.12	GND	Connection output «-» of logic supply and DC/DC-converters; control circuits ground output
XP1.13	IN L2	V phase low switch control input
XP1.14	GND	Connection output «-» of logic supply and DC/DC-converters; control circuits ground output
XP1.15	IN H2	V phase high switch control input
XP1.16	GND	Connection output «-» of logic supply and DC/DC-converters; control circuits ground output
XP1.17	IN L1	U phase low switch control input
XP1.18	GND	Connection output «-» of logic supply and DC/DC-converters; control circuits ground output
XP1.19	IN H1	U phase high switch control input
XP1.20	GND	Connection output «-» of logic supply and DC/DC-converters; control circuits ground output
XP2(3,4,5).1	C	Measuring collector, voltage saturation control output
XP2(3,4,5).2	-	
XP2(3,4,5).3	G	Controlled transistor gate connection output
XP2(3,4,5).4	E	Ground output of output circuits; emitter (source) connection output

Table 2 – Application of driver trimming elements

Unit	Symbol	Application
Capacitor	Cdt (H1,H2 ,L1,L2)	Capacity of “dead time” duration adjustment to half-bridge transistors switching
Resistor	R_{block}	Resistance of control circuit blocking duration adjustment in an emergency mode
Jumper	J1	Jumper of control blocking connection in an emergency mode
Capacitor	C_S (H1,H2,L1,L2)	Capacity of smooth emergency turn-off delay adjustment
Capacitor	C_{TRIP} (H1,H2,L1,L2)	Capacity of protection activation delay adjustment
Diode	VD_{DES} (H1,H2,L1,L2)	Diodes (Zener diodes) of protection activation voltage adjusting

4 BASIC AND MAXIMUM PERMISSIBLE CHARACTERISTICS

Table 3 – Basic and maximum permissible characteristics (at T = 25 °C)

Characteristic	Symbol	Unit	Value			Notes
			min	type	max	
Supply characteristics						
Supply voltage	U_S	V	13.5	15	16.5	
No load current consumption	I_S	A		0.6	0.7	f = 0 Hz
Maximum current consumption	$I_{S\ max}$	A			1.8	See Fig. 5
Control input characteristics						
input HIGH voltage	U_{IH}	V	3	5	5.6	
input LOW voltage	U_{IL}	V	-0.6	0	0.8	
Input resistance	R_{IN}	kΩ		4		
Time characteristics						
Turn-on/ turn-off delay time between input and output	$t_{d\ on/off\ (in-out)}$	μs			1	
Maximum operation frequency	f_{max}	kHz			25	See Fig. 5
"Dead time" duration to any half-bridge transistor switching	t_{dt}	μs	2.0	2.5	3.0	Adjusted by customer, see Fig. 9
Non-saturation protection activation delay	t_{trip}	μs	3.0	3.5	4.0	Adjusted by customer, see Fig. 8
Transistor smooth emergency turn-off time	ts	μs	5	10	15	Adjusted by customer, see Fig. 7
Controlled transistor "dead time" after emergency	$t_{block\ 1}$	ms	1	1.6	2	
Control scheme blocking time after emergency	$t_{block\ 2}$	ms	80	100	120	Adjusted by customer, see Fig. 10
«Fault» emergency signal turn-on delay time	$td_{(on-f)}$	μs		0.1	1	
«Error» emergency signal turn-on delay time	$td_{(on-e)}$	μs		25	30	
Output characteristics						
Turn-on pulse current	$I_{Omax\ +}$	A	12			
Turn-off pulse current	$I_{Omax\ -}$	A			-12	
Positive output supply voltage	$U_{out\ +}$	V	15	16	18	In all range of permissible loads
Negative output supply voltage	$U_{out\ -}$	V	-5	10	-15	
Any channel output average current	I_O	mA			130	
Output signal building up period	t_r	ns			100	No load
Output signal fall time	t_f	ns			150	
«Fault» and «Error» state outputs maximum voltage	$I_{F\ max}$	mA			10	
Maximum voltage on «Fault» and «Error» state output	$U_{F\ max}$	V			30	
Residual voltage at «Fault» and «Error» signal output	$U_{O\ F}$	V			1	at I_F = 10 mA
Threshold voltage on «C» measuring input that leads to emergency turn-off	U^{Th}_{ms}	V	9	9.5	11	Adjusted by customer
Isolation characteristics						
Insulation voltage between input and output	$U_{ISO(IN-OUT)}$	V			4000	DC, 1 minute
Voltage isolation between channels outputs	$U_{ISO(OUT-OUT)}$	V			2000	DC, 1 minute
Maximum voltage on «C» measuring inputs	U_C	V			2000	
Output voltage variation at critical speed	dU/dt	kV/μs			20	

Exploitation and storage characteristics						
Operating temperature range	T_A	°C	-40		+85	
Storing temperature	Ts	°C	-45		+100	

5 DRIVER OPERATION

Sending of control signal that is relevant to «Log 1» of any control input «IN» will lead to opening of relevant controlled transistor. In an signal sending to both control inputs of any half-bridge that are relevant to «Log 1» the controlled transistors will be closed (blocking of half-bridge transistors simultaneous turning-on), herein other channels will operate in standard mode; will be no error signaling in an blocking activation. Voltage drop increasing on any transistor in open state more then on U_{ms}^{Th} at time that exceeds t_{trip} will lead to protection activation at exceeding of voltage drop in open state (at current overload) and transistor will be closed. In an «emergency» the transistor, that is turned-on by circuit with open collector («Fault» output), will open. If jumper J1 is not installed then after 1.5 ms will be done emergency reset and at the next closest after the reset of control signal «IN» leading edge the controlled transistor will be opened (If there is no leading edge on the input, in other words the constant level is «Log 1», there will be no reset), other channels will operate in standard mode; will be no blocking of their control. If jumper J1 is installed, in an protection activation at non-saturation of any transistor the control of all transistors will be blocked, the output transistor «Error» will open and after the time $t_{block\ 2}$ (is adjusted by resistor R_{block}) the blocking will be reset independently from the signals on control inputs and if the overvoltage was not eliminated the cycle will repeat again.

Diagram, explaining the driver operation is shown on Fig. 4.

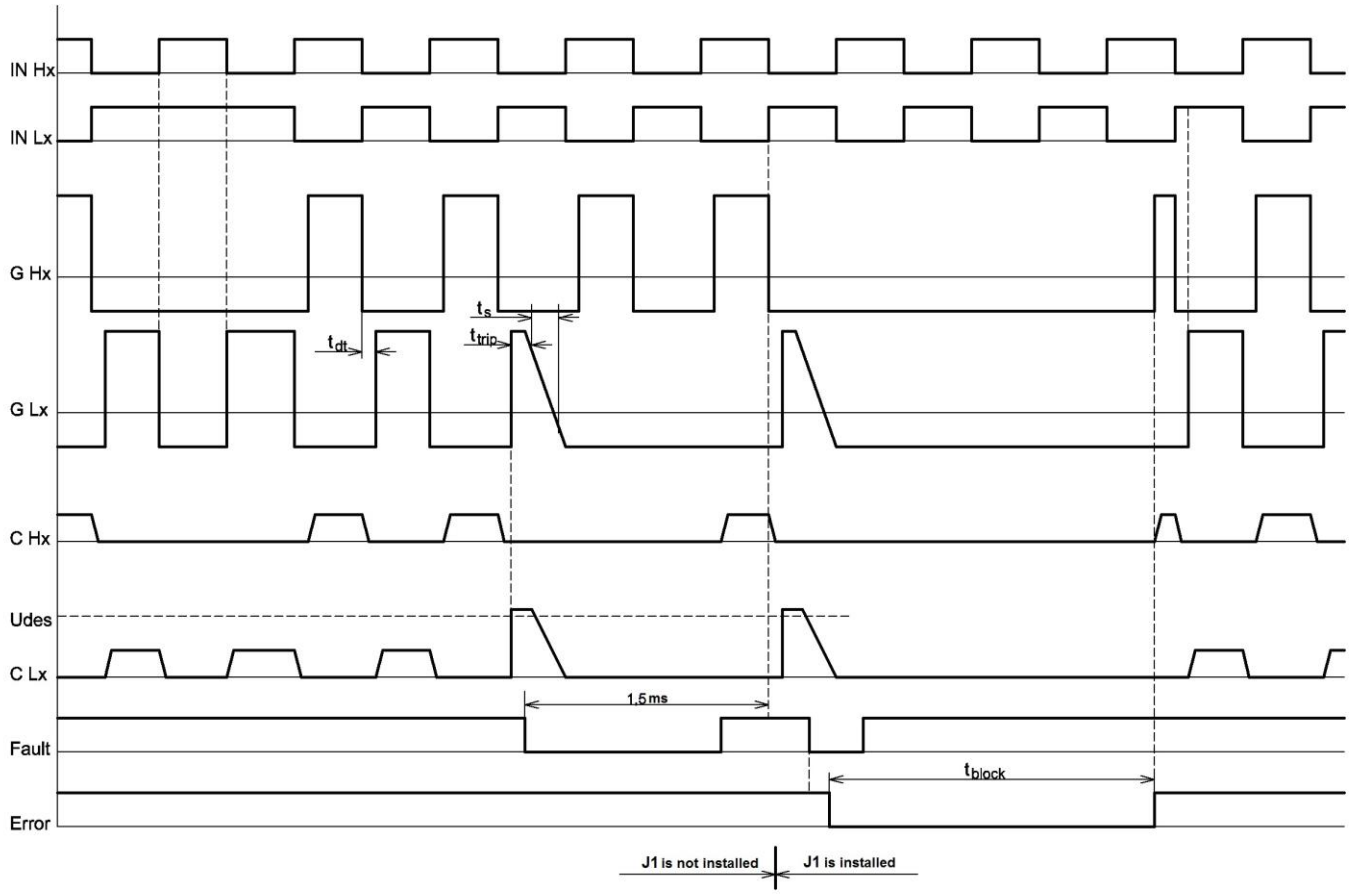

Figure 4 – Functional diagram of driver operation at «emergency»

6 DRIVER CONNECTION RECOMENDATIONS

IN H1, IN H2, IN L1, IN L2 – control inputs by relevant keys. If the driver controlling is necessary with voltage level of 15V, it is recommended to install resistors consequently with control inputs 7.5…10 kΩ. Driver operation is described in «Protection operation» section.

Fault – output, signaling about emergency occurrence. Output represents transistor open collector of control driver protection circuit by any key.

Error – output signaling about emergency occurrence. Output represents transistor open collector of control driver protection circuit in emergency mode. Output works only if jumper J1 is installed.

Vd – DC/DC-converters connection supply output and driver input circuit. Current consumption at input on the no load does not exceed value of 0.7 A and in any driver operation mode must not exceed 1.8 A (in case of similar load at all channels), otherwise driver can broken-down. It must be admitted that If not all channels are loaded then the current consumption by one channel must not lead to exceed of consumption current more then to 0.2 A.

GND – is common of driver output currents (control and DC/DC-converters).

G H1, G H2, G L1, G L2 – gates connection outputs relevant to controlled transistors. For decreasing of output driver pulse current (and controlled transistor turn-on/ turn-off time) it is recommended to install gate resistor in breakage of present output and gate; driver turn-on without gate resistor is possible. For controlled transistor protection from overload is recommended to set voltage bi-directional limiter on to nominal break-down voltage of 18V. Also is recommended to set it between transistor gate and emitter (source).

C H1, C H2, C L1, C L2 – controlled transistors collector (drain) connection outputs. Outputs are intended for voltage drop control (non-saturation protection) at relevant transistors.

Typical value of threshold protection activation is 9.5 V and is regulated by diodes VDdes: from maximum voltage (9.5 V) extracts voltage drop at Zener diodes and diodes at current 4 mA. For example, If you set Zener diode with stabilization nominal voltage of 5.1 V, then threshold protection activation will be 9.5 – 5.1 = 4.4V. Initially on the driver are installed Zener diodes to nominal stabilization voltage of 3.3V and threshold protection activation (tuning presets at supply) is 6.3V.

In the case if controlled transistor current overload protection is not necessary, current must be shorted to «E» output of the relevant channel.

E H1, E H2, E L1, E L2 – emitters (drains) connection outputs relevant to controlled transistors. It is recommended to take from each transistor its own signal emitter even if they are connected by circuits.

J1 – control circuit connection jumper in an emergency. Protection circuits work independently in a missing jumper at non-saturation of each driver.

$VD_{DES\ H1}$, $VD_{DES\ H2}$, $VD_{DES\ L1}$, $VD_{DES\ L2}$ − protection activation voltage adjusting diodes of relevant controlled transistor. Initially (tuning presets at supply) Zener diodes are installed to nominal stabilization voltage of 3.3 V that is relevant to protection activation voltage of 6.3V.

R_{block} – adjustment resistor of circuit duration block in an emergency mode. Block duration is 1 sec in a missing resistor, in an shorted resistor is 10 ms. Initially (tuning presets at supply) the installed resistor is relevant to block duration of 100 ms. Block duration dependence from the nominal of present resistor is shown in Fig. 10.

$C_{DT\ H1}$, $C_{DT\ H2}$, $C_{DT\ L1}$, $C_{DT\ L2}$ − adjustment capacitors of relevant controlled transistor turn-on duration delay (“dead time” duration for switching). Delay for switching in a missing capacitor will be 0 μs and “dead time” for switching will absent. Initially installed capacitors are relevant to “dead time” of 2.5 μs (tuning presets at supply). Duration dependence of “dead time” from present capacitors nominal is shown on Fig. 9.

$C_{S\ H1}$, $C_{S\ H2}$, $C_{S\ L1}$, $C_{S\ L2}$ – adjustment capacitors of smooth emergency turn-off duration in emergency mode of relevant controlled transistor. Initially (tuning presets at supply) installed capacitors are relevant to smooth turn-off duration of 10 μs. Duration delay dependence of smooth emergency turn-off from capacitors nominal is shown on Figure 7.

$C_{TRIP\ H1}$, $C_{TRIP\ H2}$, $C_{TRIP\ L1}$, $C_{TRIP\ L2}$ – adjustment capacitors of protection activation duration delay at non-saturation of relevant controlled transistor. When supplying the capacitors are installed corresponding to duration delay 3.6 μs. Duration delay dependence of protection activation at non-saturation from the nominal of present capacitors is shown on Figure 8.

7 DIAGRAMS EXPLAINING DRIVER OPERATION

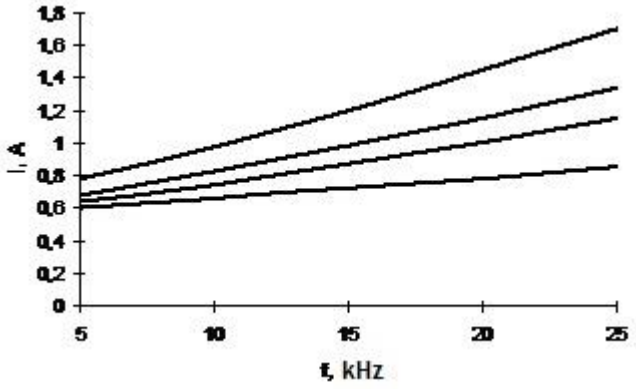

Figure 5 – Graph of consumption current dependence versus control signal frequency under the load (with gate resistor 1 Ω) for gate capacities 10 nF, 25 nF, 50 nF, 100 nF

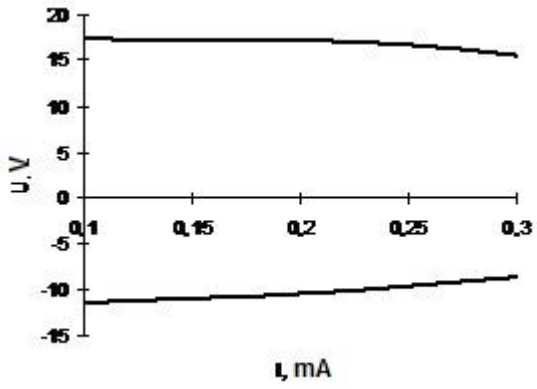

Figure 6 – Graph of voltage amplitude dependence on controlled transistor gate versus driver consumption current

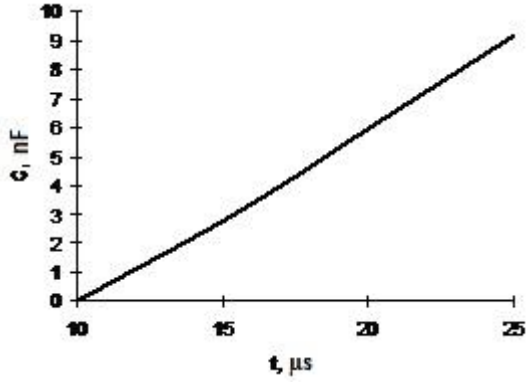

Figure7 – Graph of smooth emergency turn-off dependence versus capacity nominal C_S

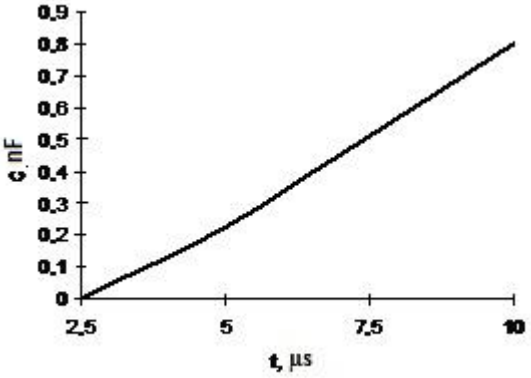

Figure 8 – Graph of protection activation duration delay dependence versus capacity nominal C_{trip}

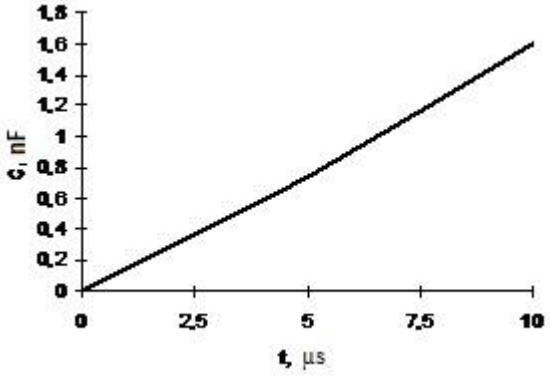

Figure 9 – "Dead time" duration dependence versus nominal capacity C_{TD}

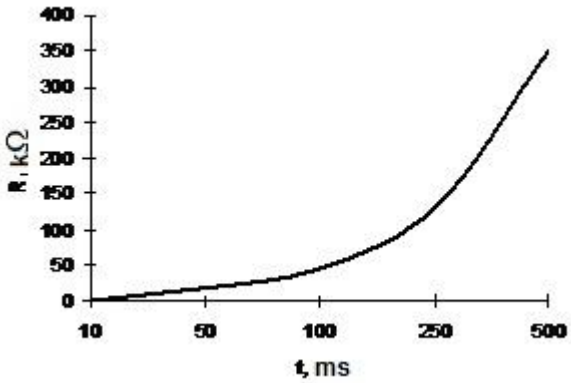

Figure 10 – Control circuit block after emergency duration versus resistance nominal R_{block}

8 SERVICE RECOMMENDATIONS

8.1 Tolerance requirements at mechanical impacts

Mechanical impacts for drivers in accordance with qualifying standards of controlled power transistors are shown in Table 4.

Table 4 - Drivers tolerance requirements to mechanical impact factors

External exposure factors	External exposure factor value
Sinusoidal vibration:	
- frequency range, Hz;	0.5 - 100
- acceleration amplitude, м/s^2 (g)	150 (15)
Mechanical shock of single action:	
- shock acceleration peak value, м/s^2 (g);	40 (4)
- shock acceleration pulse length, мs	50

In technical reasonable cases, on request of concrete consumers, the drivers can be produced also for the other service conditions.

8.2 Tolerance requirements at climatic impacts.

Table 5 - Tolerance requirements to climatic impact factors

Climatic factor	Climatic factor value
Ambient reduced temperature:	
- operating, °C;	minus 40
- maximum, °C	minus 45
Ambient elevated temperature:	
- operating, °C;	+85
- maximum, °C	+100
Relative humidity at 35 °C without humidity, %, max	98
Ambient temperature changing, °C	from minus 45 to +100
Atmospheric decreased pressure, Pa(mm Hg)	86000 (650)
Atmospheric increased pressure, Pa (mm Hg)	106000 (800)

9 RELIABILITY REQUIREMENTS

The manufacturer guarantees the quality of the module all the requirements of the user's manual if the consumer observes terms and conditions of storage, mounting and operation, as well as guidance on the application specified in the user's manual.

Operating warranty is 2 years from the acceptance date, in the case of requalification – from the date of the requalification.

Reliability probability of the driver for 25000 hours must be at least 0.95.

Gamma-percent life must be not 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 storageability time of the modules, at $\gamma = 90$ % and storing – 10 years.

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