DRIVER OF IGBT AND MOSFET TRANSISTORS
DR7120P-A-K

USER'S MANUAL

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1 GENERAL INFORMATION

A seven-channel IGBT and MOSFET transistors driver that is intended for galvanically isolated control of six 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 a 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;
"Dead time" duration adjustment.

3 OVERALL DRAWING AND FUNCTIONAL CIRCUIT

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

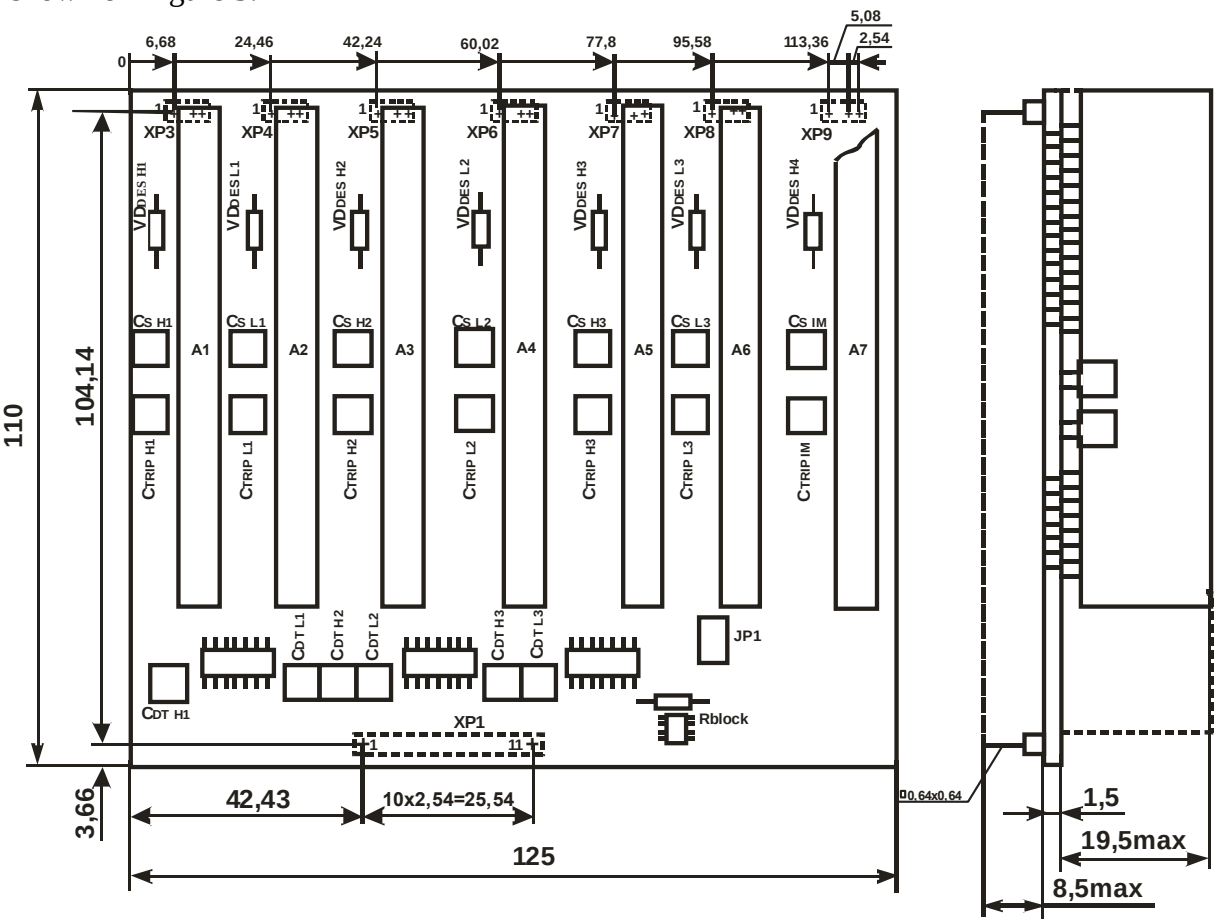

Figure 1 – Overall drawing of driver

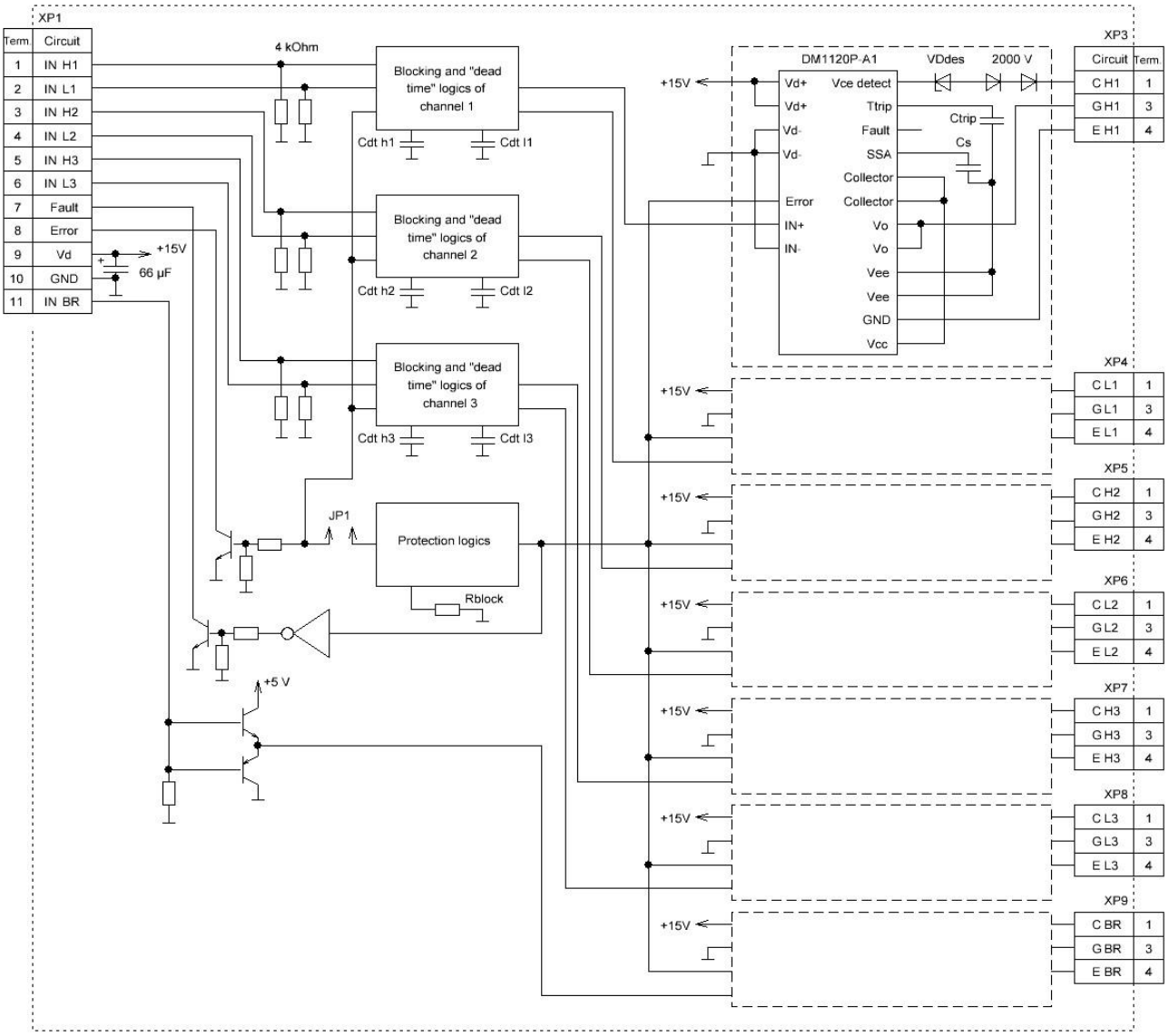

Figure 2 – Functional circuit of driver

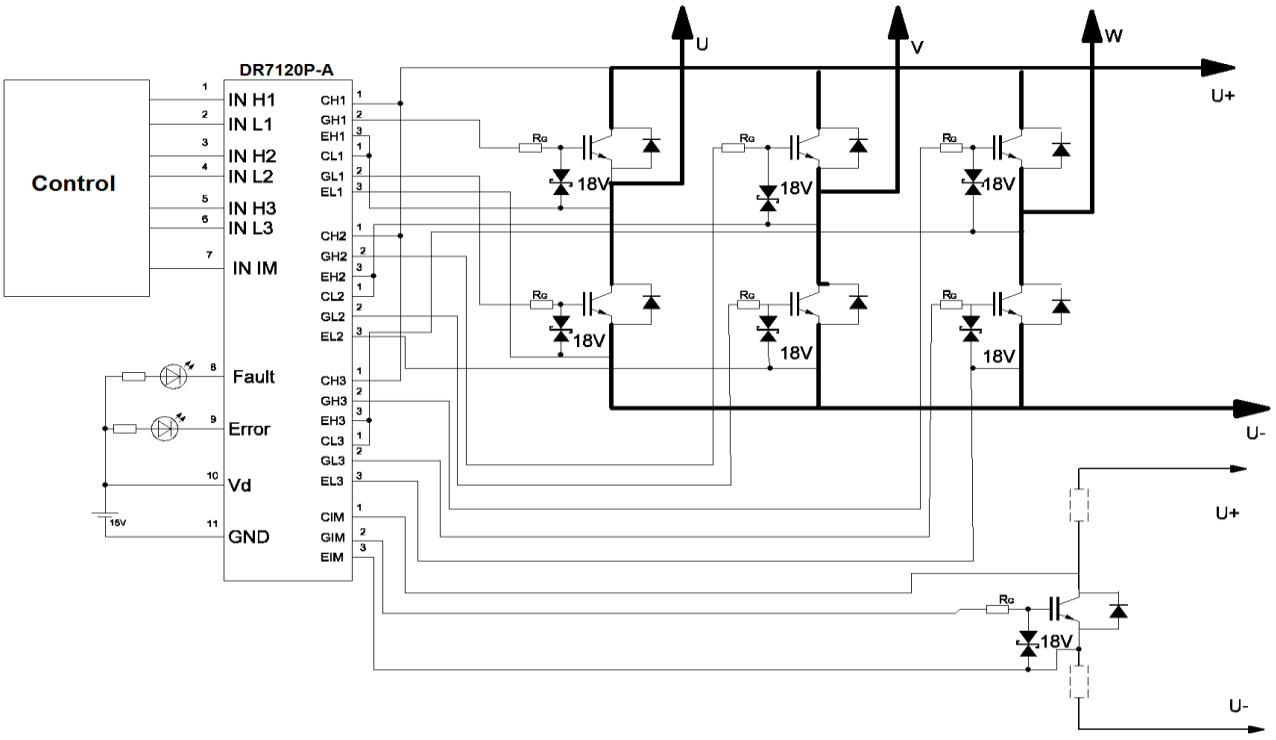

Figure 3 – Driver connection circuit

Note: a channel ChIM (channel with independent control) can operate not only a low switch but also an upper one.

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	IN H1	U phase high switch control input
XP1.2	IN L1	U phase low switch control input
XP1.3	IN H2	V phase high switch control input
XP1.4	IN L2	V phase low switch control input
XP1.5	IN H3	W phase high switch control input
XP1.6	IN L3	W phase low switch control input
XP1.7	IN IM	Input for control of additional switch
XP1.8	Fault	Control signal output (open collector); drivers output
XP1.9	Error	Control signal output (open collector); blocking system output
XP1.10	Vd	Connection output «+» of logic supply and DC/DC-converters
XP1.11	GND	Connection output «-» of logic supply and DC/DC-converters; general output of control circuit
XP3(4,5,6,7,8,9).1	C	Measuring collector, voltage saturation control output
XP3(4,5,6,7,8,9).2	-	
XP3(4,5,6,7,8,9).3	G	Controlled transistor gate connection output
XP3(4,5,6,7,8,9).4	E	Common output of output circuits; emitter (source) connection output

Table 2 – Application of driver trimming elements

Element	**Symbol**	**Application**
Capacitor	Cdt (H1,H2,H3,L1,L2,L3)	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	JP1	Jumper of control blocking connection in an emergency mode
Capacitor	C_S (H1,H2,H3,L1,L2,L3,IM)	Capacities of smooth turn-off delay adjustment
Capacitor	C_{TRIP} (H1,H2,H3,L1,L2,L3,IM)	Capacities of protection activation delay adjustment
Diode	VD_{DES} (H1,H2,H3,L1,L2,L3,IM)	Diodes (Zener diodes) of protection activation voltage adjusting

4 BASIC AND MAXIMUM PERMISSIBLE PARAMETERS

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

Parameter	Symbol	Unit	Value			Notes
			min	typ.	max	
Supply parameters						
Supply voltage	U_S	V	1.5	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 Figure 5
Control inputs parameters						
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		

End of Table 3

Parameter	Symbol	Unit	Value			Notes
			min	typ.	max	
Time parameters						
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 Figure 5
"Dead time" duration to any half-bridge transistor switching	t_{trip}	µs	2.0	2.5	3.0	adjusted by consumer, see Figure 9
Non-saturation protection activation delay	t_{trip}	µs	3.0	3.5	4.0	adjusted by consumer, see Figure 8
Transistor smooth emergency turn-off time	ts	µs	5	10	15	adjusted by consumer, see Figure 7
Blocking time of controlled transistor after "emergency"	$t_{block\ 1}$	ms	1	1.6	2	
Blocking time of control circuit after "emergency"	$t_{block\ 2}$	ms	80	100	120	adjusted by consumer, see Figure 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 parameters						
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	
Rise time of output signal	t_r	ns			100	without load
Fall time of output signal	t_f	ns			150	
Maximum current of status outputs «Fault» and «Error»	$I_{F\ max}$	mA			10	
«Fault» and «Error» state outputs maximum voltage	$U_{F\ max}$	V			30	
Residual voltage on «Fault» and «Error» signal output	$U_{O\ F}$	V			1	at I_F = 10 mA
Threshold voltage on measuring input «C» that leads to emergency shutdown	U_{Mc}^{Th}	V	9	9.5	11	adjusted by consumer
Insulation parameters						
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 measuring inputs «C»	U_C	V			2000	
Extreme rate of voltage change on output	dU/dt	kV/µs			20	
Operation and storage parameters						
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 JP1 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 JP1 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 then the protection cycle will be repeated again.

The diagram explaining the driver operation is shown on Figure 4.

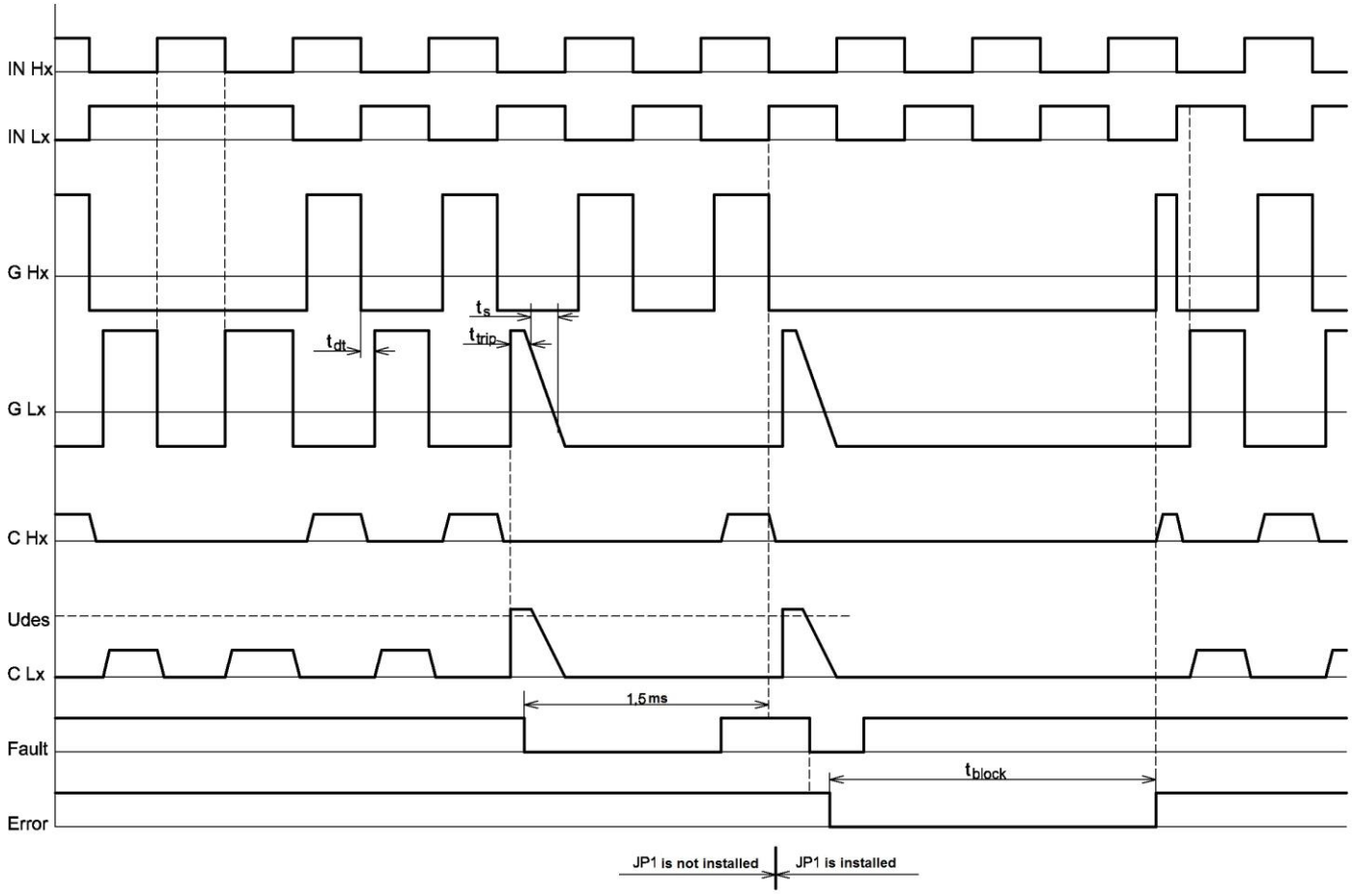

Figure 4 – Functional diagram of driver operation at «emergency»

6 DRIVER CONNECTION RECOMMENDATIONS

IN H1, IN H2, IN H3, IN L1, IN L2, IN L3,IN BR – control inputs by relevant switches. If the driver controlling is necessary with voltage level of 15V, it is recommended installing resistors consequently with control inputs 7.5…10 kΩ. Driver operation is described in «Protection operation» section.

Fault – output signaling about an emergency. The output is a transistor open collector of control driver protection circuit by any switch.

Error – output signaling about an emergency. The output is a transistor open collector of control driver protection circuit in emergency mode. The output works only if the jumper JP1 has installed.

Vd – DC/DC-converters connection supply output and driver input circuit. The current consumption on the input on off-load does not exceed the value 0.7 A and in any driver operation mode must not exceed 1.8 A (in case of similar load at all channels), otherwise the driver can fail. It must be admitted that if not all the channels are loaded then the current consumption by one channel must not lead to exceed of consumption current by more than 0.2 A.

GND – common of driver input circuits (control and DC/DC-converters).

G H1, G H2, G H3, G L1, G L2, G L3,G BR – gates connection outputs of relevant controlled transistors. For decreasing of output driver pulse current (and controlled transistor turn-on/ turn-off time) it is recommended installing a gate resistor in gap of the output and gate; driver turn-on without a gate resistor is possible. For controlled transistor protection from overload on the gate is recommended setting between the gate and emitter (source) a bi-directional limiter on nominal breakdown voltage 18V.

C H1, C H2, C H3, C L1, C L2, C L3, C BR – controlled transistors collector (drain) connection outputs. The outputs are intended for voltage drop control (non-saturation protection) on relevant transistors.

The typical value of threshold protection operation is 9.5 V and is regulated by diodes VDdes: from maximum voltage (9.5 V) extracts voltage drop on Zener diodes and diodes at current 4 mA. For example, if you set the Zener diode with stabilization nominal voltage 5.1 V, then threshold protection operation will be 9.5 – 5.1 = 4.4V. Initially on the driver are installed Zener diodes for nominal stabilization voltage 3.3V and threshold protection operation (initial settings at supply) is 6.3V.

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

E H1, E H2, E H3, E L1, E L2, E L3,E BR – emitters (drains) connection outputs of relevant controlled transistors. It is recommended taking from each transistor its own signal emitter even if they are connected by the circuit.

JP1 – control circuit blocking connection jumper in an emergency. When the jumper has not installed then non-saturation protection circuits of each driver operate independently.

$VD_{DES\ H1}$, $VD_{DES\ H2}$, $VD_{DES\ H3}$, $VD_{DES\ L1}$, $VD_{DES\ L2}$, $VD_{DES\ L3}$, $VD_{DES\ IM}$ – protection activation voltage adjusting diodes of relevant controlled transistor. Initially (initial settings at supply) Zener diodes are installed to nominal stabilization voltage 3.3 V that corresponds to voltage protection operation 6.3V.

R_{block} – resistor for adjustment of control circuit blocking duration in an emergency mode. Blocking duration is 1 sec at the resistor is not installed, at an shorted resistor is 10 ms. Initially (initial settings at supply) a resistor is installed corresponding to blocking duration 100 ms. Dependence of blocking duration versus the resistor rating is shown on Figure 10.

$C_{DT\ H1}$, $C_{DT\ H2}$, $C_{DT\ H3}$, $C_{DT\ L1}$, $C_{DT\ L2}$, $C_{DT\ L3}$ – capacitors for duration adjustment of switch-on delay of relevant controlled transistor ("dead time" duration for switching). Delay for switching when a capacitor is not installed will be 0 μs and "dead time" for switching will be absent. Initially (initial settings at supply) capacitors are installed corresponding to "dead time" 2.5 μs. The dependence of duration of "dead time" versus the capacitors rating is shown on Figure 9.

$C_{S\ H1}$, $C_{S\ H2}$, $C_{S\ H3}$, $C_{S\ L1}$, $C_{S\ L2}$, $C_{S\ L3}$, Cs_{IM} –capacitors for adjustment of smooth emergency turn-off duration in emergency mode of relevant controlled transistor. Initially (initial settings at supply) capacitors are installed corresponding to smooth turn-off duration 10 μs. Dependence of smooth emergency turn-off duration versus rating of the capacitors is shown on Figure 7.

$C_{TRIP\ H1}$, $C_{TRIP\ H2}$, $C_{TRIP\ H3}$, $C_{TRIP\ L1}$, $C_{TRIP\ L2}$, $C_{TRIP\ L3}$, $C_{TRIP\ IM}$ – capacitors for adjustment of non-saturation protection operation duration delay of relevant controlled transistor. Initially (initial settings at supply) capacitors are installed that correspond to duration delay 3.6 μs. Dependence of non-saturation protection operation delay duration versus rating of the capacitors is shown on Figure 8.

7 DIAGRAMS EXPLAINING DRIVER OPERATION

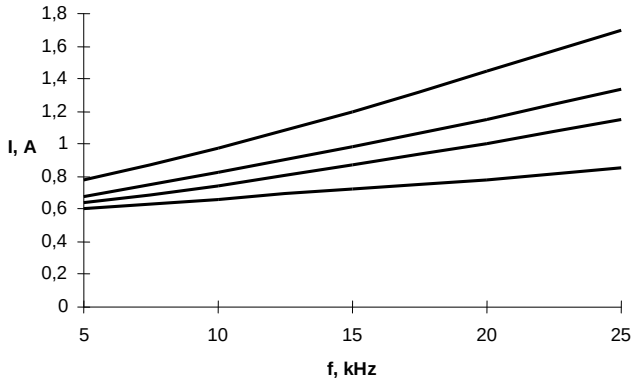

Figure 5 – Dependence of consumption current versus control signal frequency under load
(with gate resistor 1 Ω)
for gate capacitance 10 nF, 25 nF, 50 nF, 100 nF

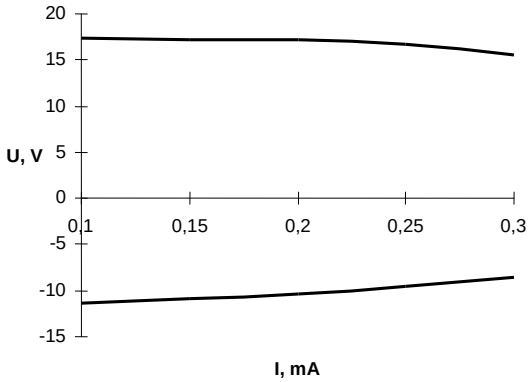

Figure 6 – Dependence of voltage amplitude on control gate versus driver current consumption

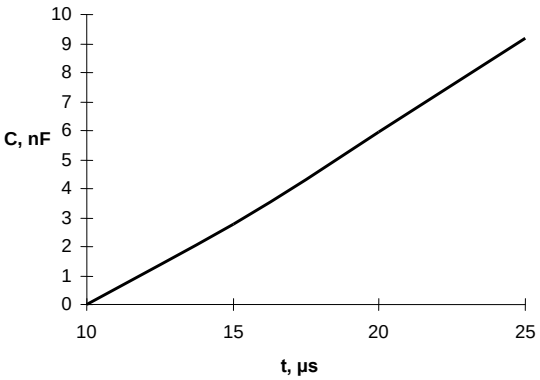

Figure 7 – Dependence of smooth emergency shutdown duration versus capacitance rating Cs

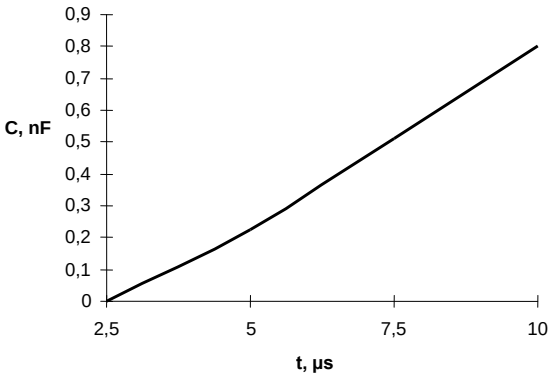

Figure 8 – Dependence of non-saturation protection operation delay duration versus capacitance rating Ctrip

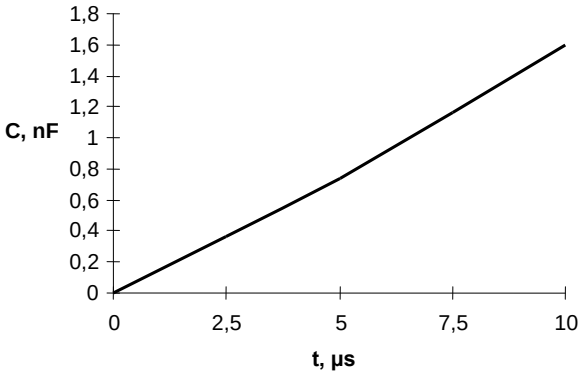

Figure 9 – Dependence of «dead time» duration versus capacitance rating Cdt

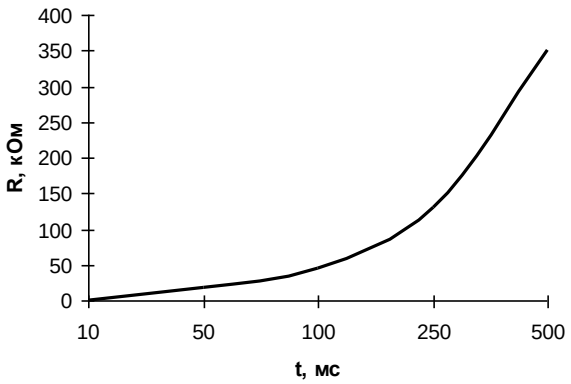

Figure 10 – Dependence of control circuit blocking duration after emergency versus resistance rating R_{block}

8 SERVICE RECOMMENDATIONS

8.1 Resistance requirements when mechanical impacts.

Mechanical impacts for drivers in accordance with qualifying standard or power transistors are shown in Table 4.

Table 4 - Drivers resistance requirements to mechanical impact factors

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

8.2 Resistance requirements when 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 condensation, %, 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

Reliability probability of the drivers 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 drivers, 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 drivers, at $\gamma = 90$ % and storing – 10 years.

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