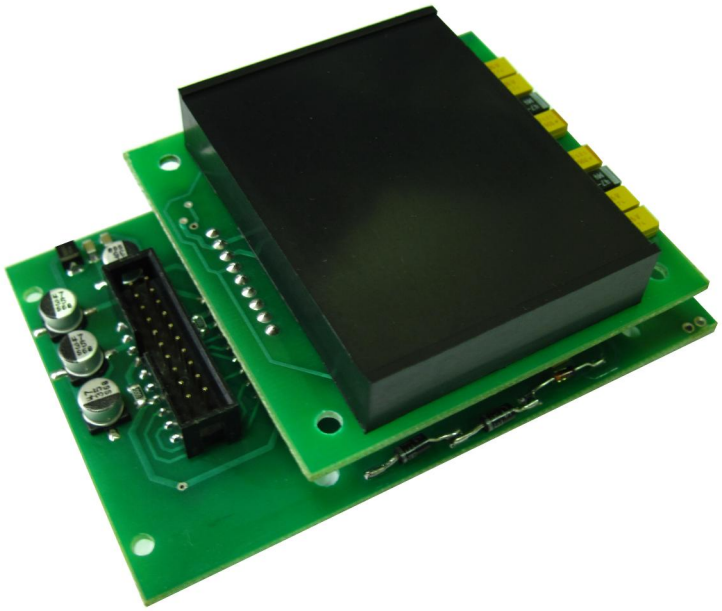
IGBT AND MOSFET TRANSISTORS DRIVER
DR2160P–B1

USER'S MANUAL



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CONTENTS

1 OVERVIEW

Powerful transistors half-bridge driver with field control (MOSFET or IGBT) (hereinafter - driver) is intended for dependent galvanic isolated control of two powerful transistors with maximum permissible voltage up to 1700 V. The driver is meant for half-bridge control type Semix. It is a device identical in design to Board 3S Skyper 32 pro. The driver is an amplifier-former of transistors gate control signals with frequency up to 50 kHz.

2 DRIVER COMPOSITION

2.1 The driver – a circuit plate with installed a driver module (DM), performed in hermetic plastic housing, necessary tuning elements and connectors for connection of controlled transistor and control signals.

Connector type X1- IDC-20MS.

2.2 Driver contains the following functional parts:

1 Supply voltage stabilizer of driver with protection against abnormal turn-on polarity;
2 Build-in DC-DC converter with stabilization of enabling and blocking voltage level on controlled transistors gates;
3 Input logics;
4 Control circuit of controlled transistors gate;
5 Protection circuit against under-voltage of driver supply.
6 Protection circuit against current overload of controlled transistors (voltage drop of open state controlled transistor)
7 Temperature protection circuit

3 FUNCTIONAL DRIVER FEATURES

3.1 The driver provides the following driving, controlling and protecting functions of controlled transistor:

1 Saturation voltage control on controlled transistor collector, its protective turn-off when saturation state output;
2 Threshold regulation of protective turn-off on saturation voltage;
3 Smooth driver junction from active state to inactive one when an “emergency” (controlled transistor output from saturation mode);
4 Control block when an “emergency”
5 Emergency signaling;
6 Driver supply voltage control (built-in comparator) on DC-DC converter output;
7 On time/off time regulation of controlled transistor with resistors resistance change in output circuit (Ron, Roff);
8 Block of simultaneous turn-on the upper and lower arm;
9 Switching delay of upper and lower arm;
10 Temperature protection of controlled modules

3.1 Overall drawing is shown at Figure 1, driver functional circuit and turn-on circuit are presented at Figure 2.

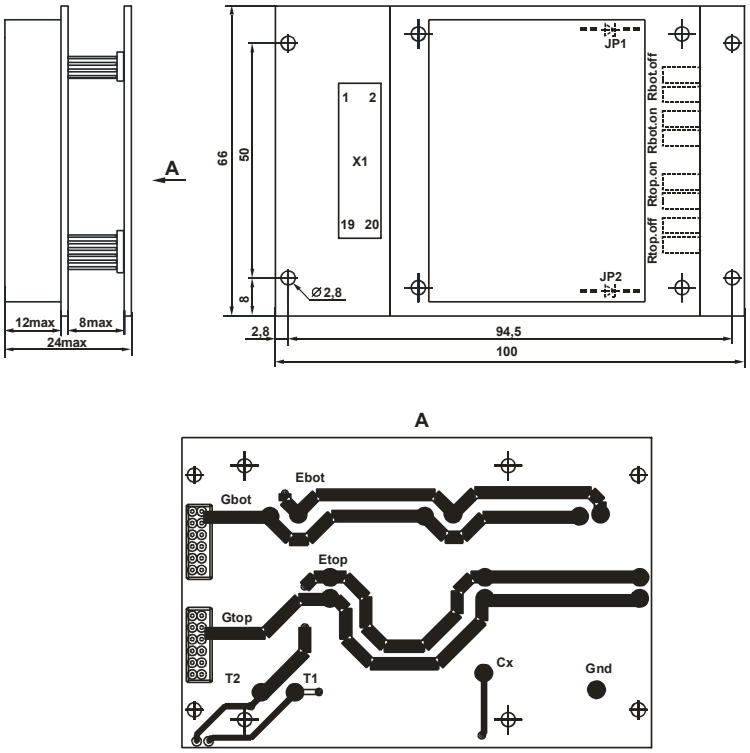


Figure 1 – Overall drawing

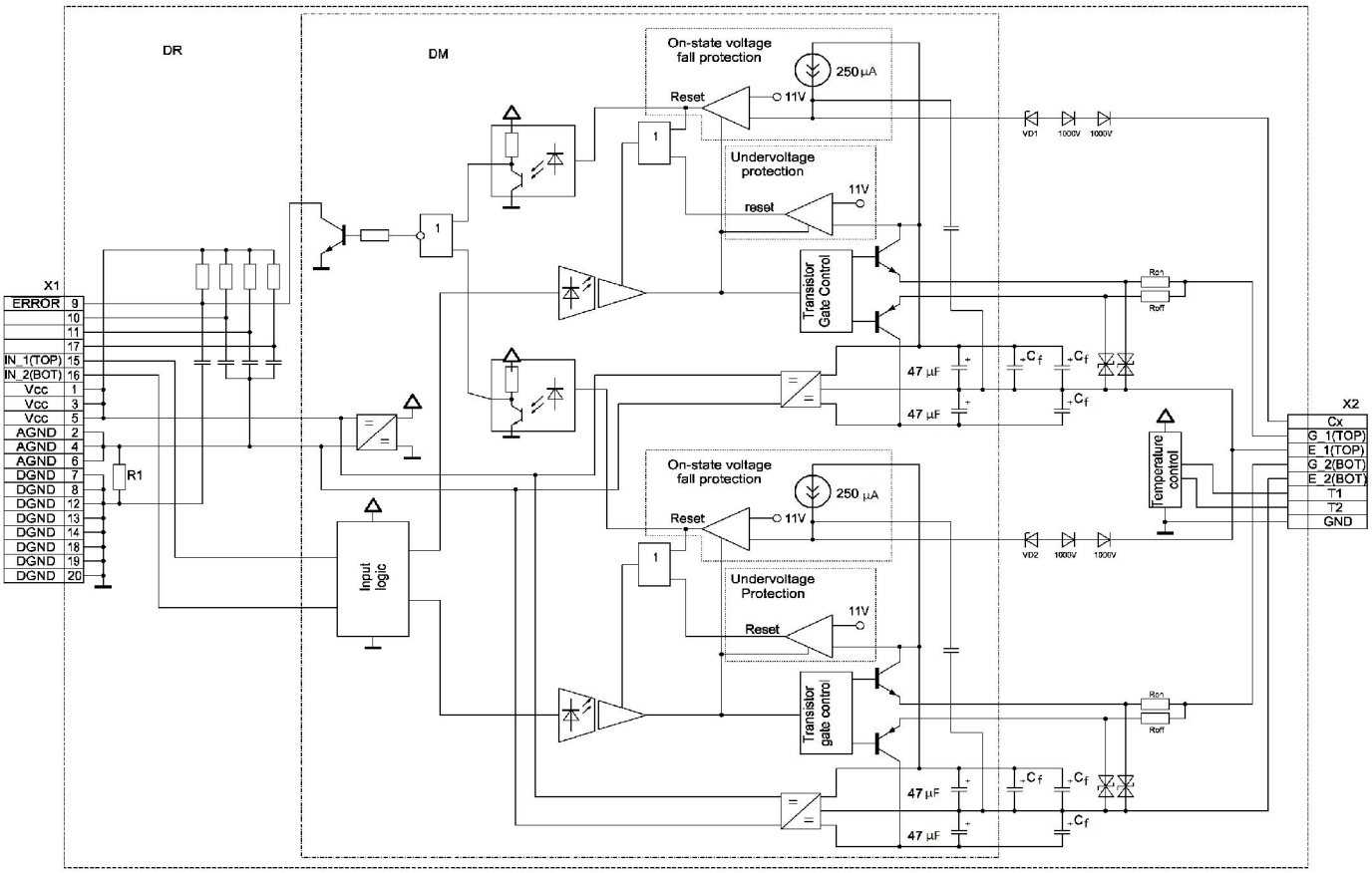


Figure 2– Functional driver circuit

3.3 Outputs description is shown in Table 1.

Table 1 – Driver output description

Outputs	Symbol	Output description
X1.1	V_S	Driver supply
X1.2	AGND	Ground driver supply
X1.3	V_S	Driver supply
X1.4	AGND	Ground driver supply
X1.5	V_S	Driver supply
X1.6	AGND	Ground driver supply
X1.7	DGND	Ground driver control
X1.8	DGND	Ground driver control
X1.9	$\overline{\text{ERROR}}$	Error signal output
X1.10		Not used
X1.11		Not used
X1.12	DGND	Ground driver control
X1.13	DGND	Ground driver control
X1.14	DGND	Ground driver control
X1.15	IN_1(TOP)	Power transistor control input of top arm.
X1.16	IN_2(BOT)	Power transistor control input of lower arm.
X1.17		Not used.
X1.18	DGND	Ground driver control
X1.19	DGND	Ground driver control
X1.20	DGND	Ground driver control
E_1(TOP)	E_1(TOP)	Output for emitter connection of top arm controlled transistor. Output for collector (drain) connection of lower arm controlled transistor.
G_ 1(TOP)	G_1(TOP)	Driver output for gate connection of top arm controlled transistor
C_1(TOP)	C_1(TOP)	Output for collector (drain) connection of top arm controlled transistor.
E_2(BOT)	E_2(BOT)	Output for emitter (source) connection of lower arm controlled transistor.
G_2(BOT)	G_2(BOT)	Driver output for gate connection of lower arm controlled transistor
T1	T1	Connection output of temperature sensor
T2	T2	Connection output of temperature sensor
GND	GND	Ground of temperature protection

4 BASIC AND MAXIMUM PERMISSIBLE CHARACTERISTICS

Table 2 – Basic and maximum permissible characteristics (at T = 25 °C)

Characteristic	Symbol	Unit	Value			Note
			min	type	max	
DC/DC block characteristics						
Supply rated voltage	U_S	V	13.5	15	16.5	
Maximum current consumption	I_S	mA		230	250	No-load, see Figures 5 and 6
Power of built-in supply source of output driver module part	P_{DC-DC}	W	4			For each channel
Voltage monitor characteristics						
Turn-off threshold	U_{UVLO+}	V		11		DC-DC output
Turn-on threshold	U_{UVLO-}	V		12		DC-DC output
Control input characteristics						
High level input voltage	U_{IH}	V	9	15	16.8	
Low level input voltage	U_{IL}	V	-0.6	0	2.4	

Input resistance	R_{IN}	kΩ		5.9		
Threshold resistance of temperature protection sensor	Rt	Ω		520		
Protection Semix temperature	T_M	˚C		105		
Time characteristics						
Signal turn-on delay time between input and output	$t_{d\ on(in-out)}$	µs			3	See Figure 11
Signal turn-off delay time between input and output	$t_{d\ off\ (in-out)}$	µs			0.5	See Figure 11
«Dead time» between signals changes on first and second channels outputs	t_{TD}	µs	1.5	2.0	2.5	
Maximum operating frequency	f_{max}	kHz			50	No-load; See section 6 and Figures 5, 8
Block time of fall voltage control on controlled open state transistor	t_{BLOCK1}	µs		8		
Block time of controlled transistor after “emergency”	t_{BLOCK2}	ms		70		See Figure 3
Transistor smooth emergency shutdown time	t_{off}	µs		2.5		See Figure 3
Turn-on delay time of emergency signal	$t_{d(on-err)}$	µs			2	
Output characteristics						
High level output voltage	U_{OH}	V	+14	+16	+19	In all range of permissible loads
Low level output voltage	U_{OL}	V	-7.5	-6	-4	In all range of permissible loads
Maximum output pulse current	I_{Omax}	A	-16		+16	Set by consumer; see section 6 and Figure 6
Mean output current	I_O	mA			160	For each channel
Output signal rise time	t_r	ns			150	No-load, see section 6 and Figure 7
Output signal fall time	t_f	ns			150	
Maximum current of status output «Error»	$I_{ERR\ max}$	mA			20	
Maximum voltage of status output «Error»	$U_{ERR\ max}$	V			30	
Residual voltage on signal output «Error»	$U_{O\ ERR}$	V	0	0.3	0.7	with I_{ERR} = 20 mA
Threshold voltage on measure inputs C_1(TOP), E_1(TOP) causing emergency turn-off	U_{Mc}^{Th}	V		11		Without additional elements

Isolation characteristics						
Maximum current of status output «Error»	$U_{R(MC)}$	V			2000	
Maximum voltage of status output «Error»	$U_{ISO(IN-OUT)}$	V			4000	DC, 1 minute
Residual voltage on signal output «Error»	$U_{ISO(OUT1-OUT2)}$	V			2000	DC, 1 minute
Critical rate of voltage changing on output	$(dU/dt)_{cr}$	kV/ μs			20	
Service and storage characteristics						
Operating temperature range	T_A	°C	-45		+85	
Storing temperature	Ts	°C	-60		+100	
Controlled transistor characteristics						
Maximum permissible voltage of controlled transistor	U_{CE} (U_{DS})	V			1700	

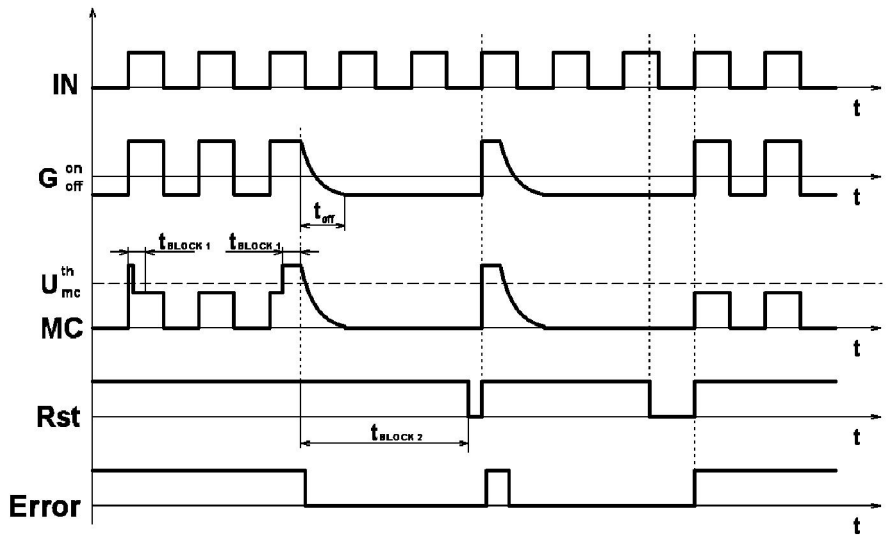
5 DRIVER OPERATION

Delivery of «log.1» on controlling input «IN_1 (TOP)» or «IN_2(BOT)» will lead to opening of controlled transistor. Open state voltage fall increasing by more than U_{ms}^{Th} per time, exceeding t_{BLOCK1}, will lead to protection operation of open state voltage fall increasing (when current overload). When "emergency" the transistor will be opened connected in accordance with the circuit with open collector (output «Error») that is pulled up by means of resistor 5.1 kΩ to internal source +5 V. In 70 ms emergency reset will be performed by internal circuit of emergency reset and on rising edge of control signal «IN» the controlled transistor will be opened. In the event when the emergency cause was not disposed then the protection cycle will be recurred.

Driver supply voltage decrease to protection operation threshold level against driver supply undervoltage «U_{uvlo-}» will lead to closing of controlled transistor regardless of input control signals. Control signals will recover on protection operation threshold against driver supply undervoltage «U_{uvlo+}». There is not an error signal on output «Error» when protection operation against supply undervoltage.

Simultaneous delivery of "log. 1" to outputs «IN_1(TOP)» and «IN_2(BOT)» will lead to control block and controlled transistors will be closed, thereby error signaling on output «Error» does not arise.

Diagrams explaining driver operation is shown at Figures 3 and 4.



Rst – Periodical internal signal of "emergency" reset

Figure 3 – Functional diagram of driver operation when «emergency»

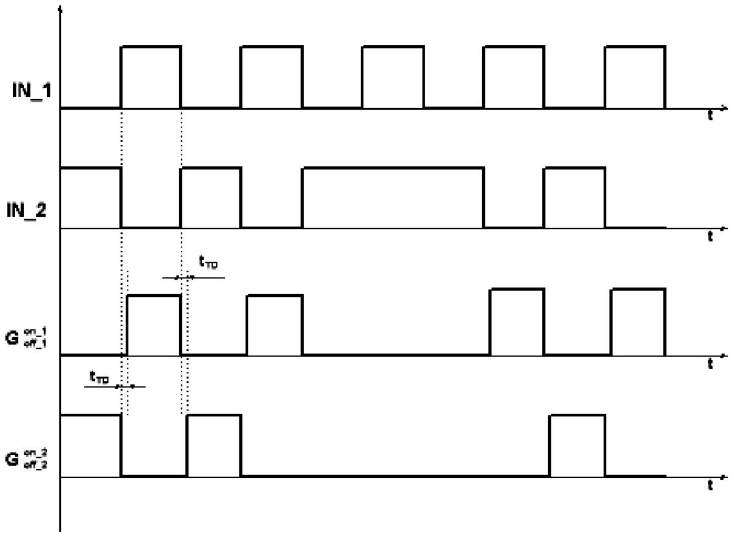


Figure 4 – Functional diagram of driver operation

6 DRIVER CONNECTION RECOMENDATIONS

IN1_1(TOP), IN_2(BOT) – controlling input. Driver control is described in section «Driver operation». When delivering of controlling voltage you must note that the protective reverse diodes are installed on control inputs. As a result if control voltage exceeds supply voltage by more than 0.6 V then current consumption on inputs will be increased and with considerable increase of supply voltage the driver can fail.

Error – inverting output (open collector, that is pulled-up by means of resistor 5.1 kΩ to internal source +5 V), emergency signaling. Meanwhile «log.0» will arise only when emergency caused by current overload of power transistor; when decrease of driver supply voltage to «U_{uvlo-}» level the transistors will be closed regardless of control input signals (signals will be recovered when they reach the supply voltage level corresponding «U_{uvlo+}»), but error signaling in this case will not follow. In the event of simultaneous signal delivery that corresponds to "log. 1" to outputs «IN1» and «IN2» the signaling will not follow too, though output transistors will be closed.

V_S – driver supply output. You must note that on decreasing of driver supply voltage DC/DC – converter output voltage is also decreased. Thereby if supply is less than the allowable level then the input circuit can operate faultlessly, but on gates of controllable transistors the voltage can drop to level «U_{uvlo-}» and transistor control will be faulty.

Maximum no-load current consumption on supply input is not more than 200 mA. When transistors connection the current consumption will increase by amount of gate recharge current and it can reach 750 mA (equal load for both channels). At higher current consumption DC/DC – converter can fail or when short-time exceeding of current consumption by 750 mA, output voltage of DC/DC – converter will decrease to unallowable level and under-voltage protection will operate, that will lead to faulty transistor control. In the event of non-uniformly distributed load the current consumption of one channel should not exceed 300mA (without control circuit consumption). Current consumption depends on controlling pulse ratio, gate input capacity and on gate resistors value (see Figures 4, 5). Thereby when driver service you must make correction for current consumption depending on transistors which the driver will operate on. Driver safe operation zone depending on gate capacity and frequency is shown at Figure 8.

C_1(TOP), E_1(TOP) – collector connection outputs (drain) of controlled transistor. The outputs are intended for voltage fall controlling (saturation protection) on the transistor. Meanwhile the typical value of protection operation threshold is equal to 11 V (if the external elements are not installed). Protection operation threshold is regulated by the external elements (Zener diodes and diodes); voltage fall of Zener diodes and diodes at current 250 μA is deducted from maximum voltage (11 V). For instance, if you install two diodes with fall voltage 0.7 V at current 250 μA, then the protection operation threshold will be equal to 11-2*0.7=9.6 V.

G_1(TOP), G_2(BOT) – meant for gates connection of controlled transistors.

Gate resistors (Ron1, Ron2, Roff1 and Roff2) are necessary for decrease of maximum pulse current. It is not recommended to install resistors with ratings less than 1 Ω. It is allowed to install the resistors with different ratings, for instance, for increase of controlled transistor turn-off continuance to decrease voltage amplitude of inductive kicks.

T1, T2 – thermistor connection outputs. Protection operation threshold is 520 Ω (typ.), hysteresis is not less than 10%. Output "T2" is connected to output $E1_{top;}$ it is not permitted to connect it to general circuits and to "+" of power supply. When protection operation the driver operation block will occur and controlled transistors will be closed to temperature decrease to permissible level. There is low level signal on output «Error» when temperature protection operation. It will be kept to protection turn-off. If thermal protection is not used then the outputs T1 and T2 should be short-circuited between each other.

7 GRAPHICS EXPLAINING DRIVER OPERATION

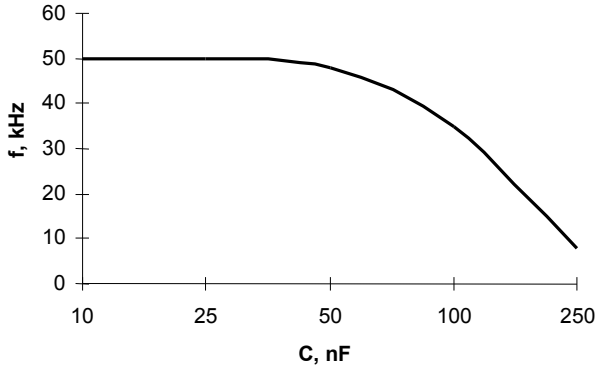


Figure 5 – Graph of driver current consumption versus no-load control signal frequency

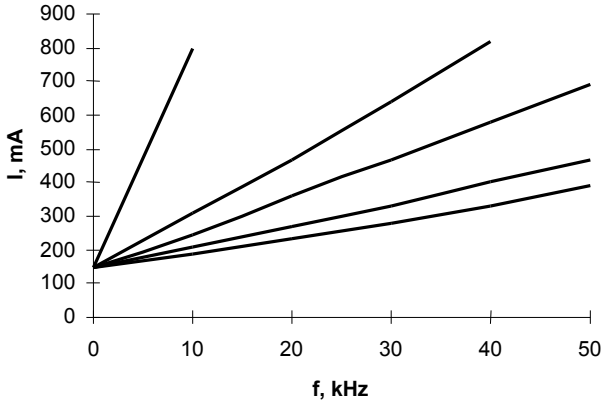


Figure 6 – Graph of current consumption versus signal frequency under load (with gate resistor 5Ω) for gate capacities 10 nF, 25 nF, 50 nF, 100 nF and 250 nF

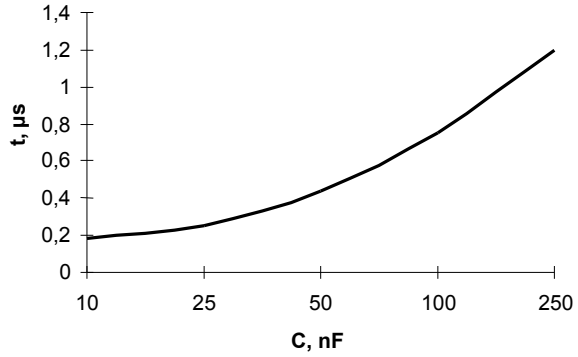


Figure 7 – Graph of rise/fall time versus gate capacity (with gate resistor 5 Ω)

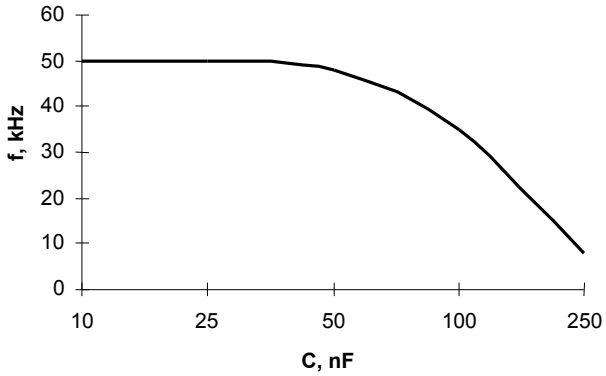


Figure 8 – Graph of driver safe operation zone (with gate resistor 5 Ω)

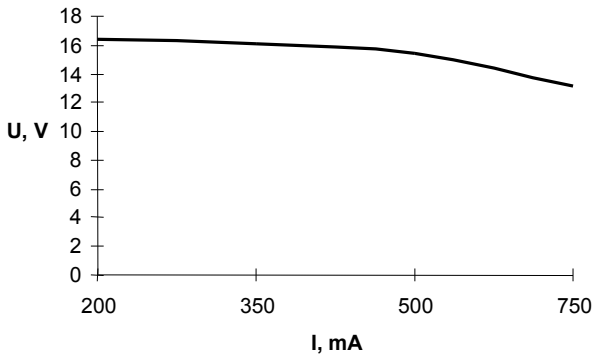


Figure 9 – Graph of transistor gate voltage versus current consumption

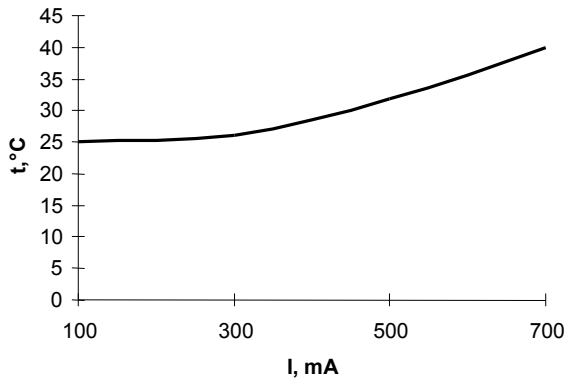


Figure 10 – Graph of driver housing temperature versus current consumption

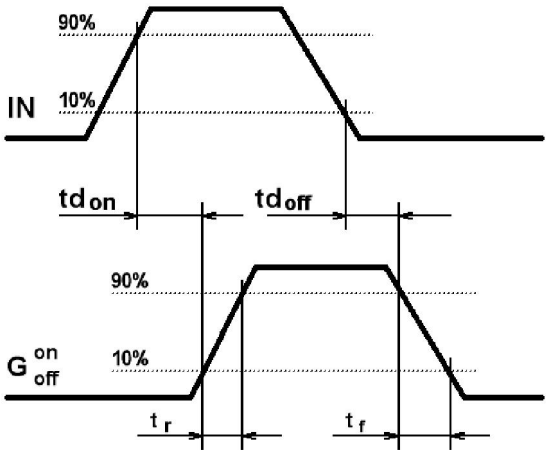


Figure 12 – Diagram explaining driver time characteristics
where IN – input control signal; G – signal on controlled transistor gate

8 INFORMATION ABOUT PRECIOUS METALS

Precious metals are not contained.

9 SERVICE RECOMMENDATIONS

9.1 Tolerance requirements at mechanical impacts.

Mechanical impacts for drivers in accordance with qualifying standards of controlled power transistors are shown in Table 3.

Table 3 – Drivers tolerance requirements to mechanical impact factors

External exposure factor	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

9.2 Tolerance requirements at climatic impacts

Climatic impacts in accordance with qualifying standards of controlled power transistors are shown in Table 4.

Table 4 - Tolerance requirements to climatic impact factors

Climatic factor	Climatic factor value
Lower ambient temperature:	
- operating, °C;	minus 45
- maximum, °C	minus 60
Higher ambient temperature:	
- operating, °C;	+85
- maximum, °C	+100
Relative humidity with temperature 35 °C without moisture condensation, %, max	98
Ambient temperature change, °C	from minus 60 to +100
Lower atmospheric pressure, Pa (mm Hg)	86000 (650)
Higher atmospheric pressure, Pa (mm Hg)	106000 (800)

10 RELIABILITY SPECIFICATIONS

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 event 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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