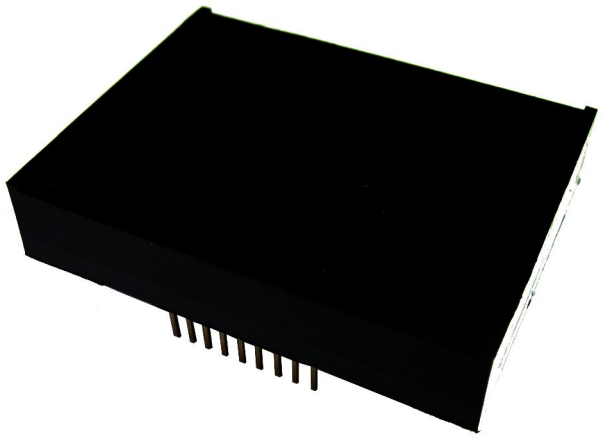
IGBT AND MOSFET TRANSISTORS DRIVER
DM280P–B, DM280P–B1

USER'S MANUAL



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1 OVERVIEW

A two-channel driver of powerful transistors with dependent drive (hereinafter – driver) is intended for galvanic isolated control of two powerful transistors with field drive (MOSFET or IGBT) with maximum permissible voltage up to 1700 V. The driver is an amplifier – generator of transistor gates control signals with frequency up to 50 kHz. The driver contains built-in galvanic isolated DC/DC-converter, providing requisite levels of unlocking and locking voltages on transistor gate.

2 COMPOSITION AND FUNCTIONAL DRIVER FEATURES

2.1 The driver is made in a hermetic plastic housing with compound-filling.

2.2 The driver contains the following functional assemblies:

1 Driver supply voltage stabilizer with protection against false turn-on polarity;
2 Built-in DC-DC converter with stabilization of unlocking and locking voltage levels on gates of controlled transistors;
3 Input logics;
4 Drive circuit of controlled transistor gates;
5 Protection circuit against undervoltage and overvoltage on controlled transistors gate;
6 Protection circuit of controlled transistors against current overload.

2.3 The driver provides the following drive functions, control and protection functions of controlled transistor:

1 Saturation voltage control on collector-emitter of controlled transistor, its protective disconnection when saturation state output;
2 Protective turn-off threshold regulation of on saturation voltage;
3 Smooth driver junction from active state to inactive one when an “emergency” (output of controlled transistor from saturation mode);
4 Control block when an “emergency”;
5 Emergency signaling;
6 Turn-on/off time regulation of controlled transistor by resistors resistance change in output circuit (Ron, Roff);
7 Simultaneous turn-on block of higher and lower arms;
8 Switch delay of top and lower arms;
9 Switch delay regulation of higher and lower arms;
10 Driver supply voltage control (built-in comparators) on output of DC-DC converter.

3 OVERALL DRAWING AND FUNCTIONAL CIRCUIT

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

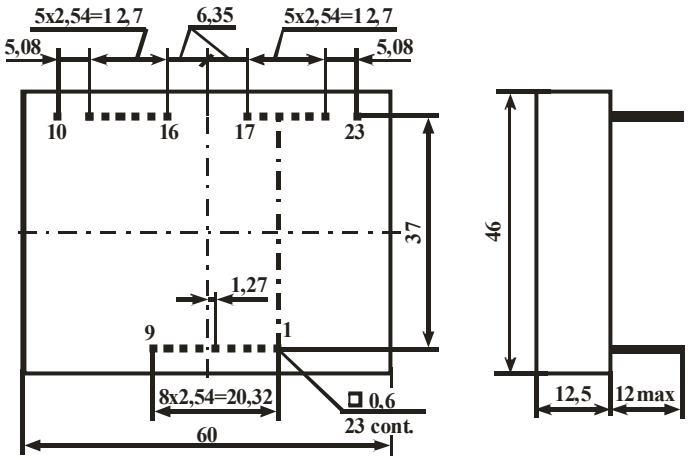


Figure 1 – Driver overall drawing

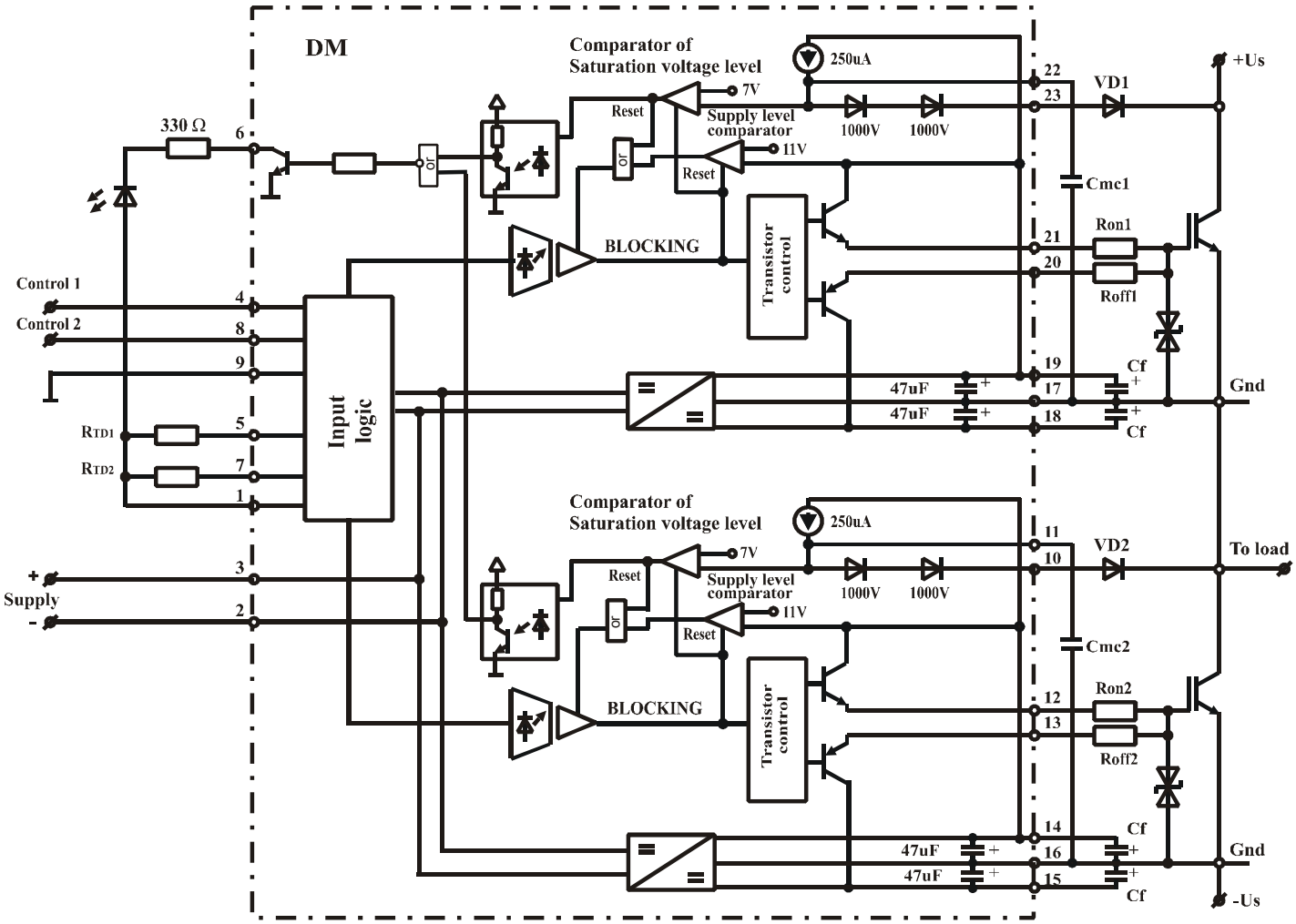


Figure 2– Functional circuit and driver turn-on circuit

3.2 Outputs description is shown in Table 1.

Table 1 – Driver outputs description

Outputs	Outputs description	Symbol
1	Internal supply stabilizer output +5 V	Vc
2	Ground supply	POWER GND
3	Supply input +15 V	Vs
4	Controlling input of channel 1	IN1
5	Output of turn-on delay duration trimming of channel 1	R_{TD1}
6	Error signal output	$\overline{ERROR}$
7	Output of turn-on delay duration trimming of channel 2	R_{TD2}
8	Controlling input of channel 2	IN2
9	Ground signaling output for delivery of controlling signals	Signal GND
10	Measuring collector – saturation voltage control circuit on controlled transistor of channel 2	MC2
11	Output of saturation protection turn-on delay setup of controlled transistor of channel 2	MCR2
12	Connecting driver output of channel 2	OUTon2
13	Disconnecting driver output of channel 2	OUToff2
14	Supply output +18 V of channel 2	Uon2
15	Supply output -7 V of channel 2	Uoff2
16	Ground output of channel 2	OUTGND 2
17	Ground output of channel 1	OUTGND 1
18	Supply output -7 V of channel 1	Uoff1
19	Supply output +18 V of channel 1	Uon1
20	Disconnecting driver output of channel 1	OUToff1
21	Connecting driver output of channel 1	OUTon1
22	Output of saturation protection turn-on delay setup of controlled transistor of channel 1	MCR1
23	Measuring collector – saturation voltage control circuit on controlled transistor of channel 1	MC1

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			200	f = 0 Hz, ref. to Figures 5 and 6
Power of built-in supply source of output driver module part	P_{DC-DC}	W	4			To each channel
Voltage monitor characteristics						
Turn-off threshold	U_{UVLO+}	V		11		DC-DC output
Turn-on threshold	U_{UVLO-}	V		12		
Control inputs characteristics						
High level input voltage	U_{IH}	V	3	5	5.6	DM280P-B
			9	15	16.8	DM280P-B1
Low level input voltage	U_{IL}	V	-0.6	0	0.8	DM280P-B
			-0.6	0	2.4	DM280P-B1
Input resistance	R_{IN}	kΩ		2.0		DM280P-B
				5.9		DM280P-B1

Time characteristics						
Signal turn-on delay time between input and output	$t_{d\ on(in-out)}$	µs			0.5	ref. to Figure 13
Signal turn-off delay time between input and output	$t_{d\ off\ (in-out)}$	µs			0.5	ref. to Figure 13
«Dead time» between signal changes on outputs of first and second channels	t_{TD}	µs		2.5		ref. to Figure 4; set by consumer; ref. to section 6 and Figure 12
Maximum operating frequency	f_{max}	kHz			50	No load; ref. to section 6, Figures 6 and 8
Block time of fall voltage control on controlled open state transistor	t_{BLOCK1}	µs		6		Set by consumer; ref. to section 6, Figures 3 and 11
Block time of controlled transistor after “emergency”	t_{BLOCK2}	ms		70		ref. to section 3
Time of smooth emergency shutdown of controlled transistor	t_{off}	µs		6		ref. to section 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 allowable loads
Low level output voltage	U_{OL}	V	-7,5	-6	-4	In all range of allowable loads
Maximum output pulse current	I_{Omax}	A	-8		+8	Set by consumer; ref. to section 6
Mean output current	I_O	mA			160	To each channel
Output signal rise time	t_r	ns			150	No-load, ref. to section 6 and Figures 7, 13
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	At I_{ERR} = 20 mA
Threshold voltage on measure input MC causing emergency turn-off	U_{mc}^{Th}	V		5.8		Without additional elements

Isolation characteristics						
Maximum permissible reverse voltage on output «MC»	$U_{R(MC)}$	V			2000	
Isolation voltage between input and output of DC	$U_{ISO(IN-OUT)}$	V			4000	DC, 1 minute
Isolation voltage between outputs of first and second channels DC	$U_{ISO(OUT1-OUT2)}$	V			4000	DC, 1 minute
Critical rate of voltage change 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	

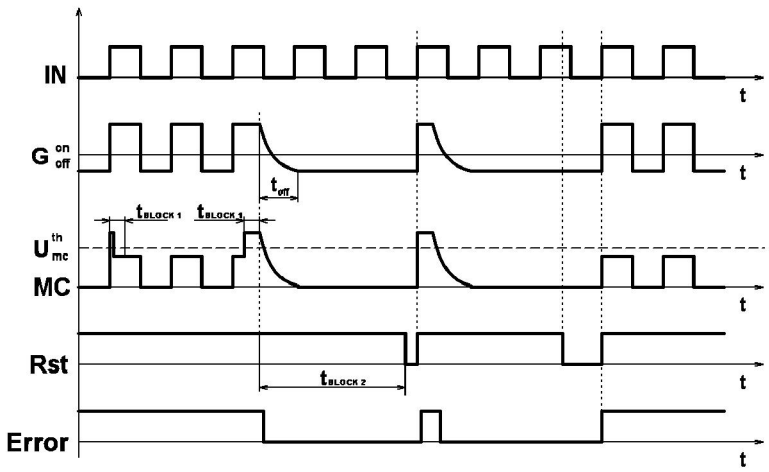
5 DRIVER OPERATION

Delivery of «log.1» on controlling input «IN1» or «IN2» 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 increase (when current overload). When "emergency" the transistor will open that is connected in accordance with the circuit with open collector (output «Error»). 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 recur.

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.

There is no control block by simultaneous delivery of "log. 1" to outputs «IN1» and «IN2» and controlled transistors will be closed, thereby there is no an error signaling on output "Error".

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



R_{st} – Periodic internal reset signal «Emergency»

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

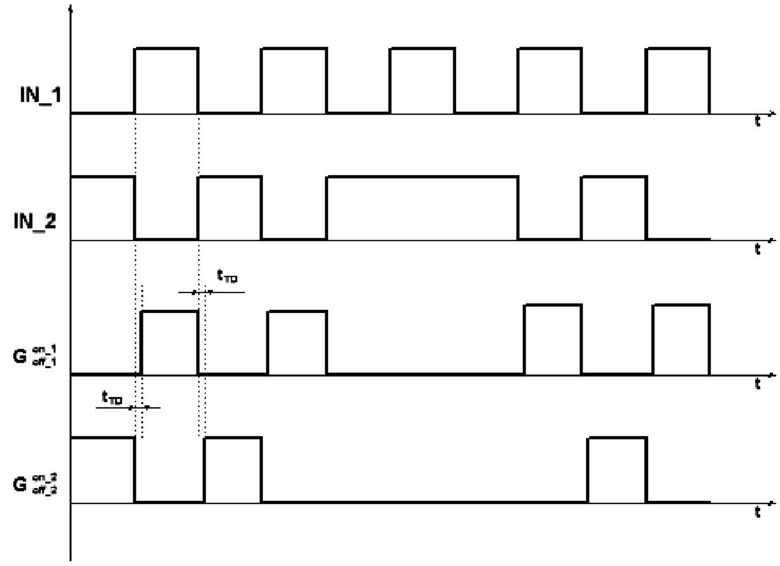


Figure 4 – Functional diagram of driver operation

6 DRIVER CONNECTION RECOMENDATIONS

IN1, IN2 – Controlling inputs. Driver control is described in section “Driver operation”. When delivering of controlling voltage you must note that reverse protective diodes are set on control inputs. If control voltage will exceed supply voltage by more than 0.6 then current consumption on outputs will be increased and to considerable excess of supply voltage the driver can fail.

Error – output, signaling about emergency. Outputs are open transistors collectors of protection circuits. Meanwhile the transistor will open only when emergency, caused by current overload of powerful transistor; when driver supply voltage decrease to level «U_{uvlo-}» transistors will be closed regardless of input control signals (signals will recover when supply level will correspond to «U_{uvlo+}»), but error signaling in this case will not occur. The signaling will not also occur when simultaneous delivery of signals corresponding to “log.1” to inputs “IN1” and “IN2”, though output transistors will be closed.

It is not recommended to deliver on output «Error» voltage and current of values higher than maximum permissible including short-circuited ones.

R_{TD1}, R_{TD2} – connection outputs of timing delay resistors of first and second channels. In fact resistors regulate turn-on delay time, thereby when installed resistors with different nominal the switch delay on leading edges of first and second channel control pulses will be different. If switch delay time increase is not required, then you should install the jumpers instead of resistors. Delay time versus resistors nominal is shown at Figure 12.

V_c – internal supply stabilizer output +5 V. It is allowed to connect the external circuits to this output. The stabilizer has short-time current overload protection, but at the mean the current consumption must not exceed 50 mA, otherwise the driver can fail.

V_S – driver supply output. You must note that on driver supply voltage decreasing DC/DC-converter output voltage is also reduced. Thereby if supply is lower than the permissible level then input circuit can operate properly, but voltage of controlled transistors gates can fall to level «U_{uvlo-}» and transistor control will be faulty.

Maximum no load current consumption of supply input is 200 mA. When transistors connecting the current consumption will increase by value of gate recharge current and it can reach 750 mA. At higher current consumption DC/DC – converter can fail, or, when short-time current consumption increase in 750 mA, DC/DC – converter output voltage will be decreased to unallowable level and under-voltage protection will operate, that will lead to faulty transistor drive. If the channel load is distributed unevenly than current consumption of one channel must not exceed 300 mA (except consumption by control circuit). Current consumption depends on control signal frequency, gate capacitance and gate resistors values (see Figures 5 and 6). Thereby, using the driver you must make a correction for current consumption subject to transistors which the driver will work. Safe operation area of the driver versus gate capacitance and frequency is shown at Figure 8.

MC1, MC2 – collector connection outputs **(**drain) of controlled transistor. Outputs are intended for voltage fall control (saturation protection) on the transistor. Meanwhile maximum protection operation threshold value is equal to 5.8 V (if the external elements are not installed). Protection operation threshold is regulated by external elements installing (Zener diodes and diodes); voltage fall on Zener diodes and diodes at current 250 μA is deducted from the maximum voltage (5.8 V). For instance, if Zener diode with rated Zener voltage 3.3 V and two diodes with voltage fall 0.7 V at current 250 μA are installed sequentially (ref. to recommended connection circuit at Figure 2), then protection operation threshold will be equal to 5.8-3.3-2x0.7=1.1 V.

If current overload protection of controlled transistor is not required then MC output should be short-circuited to source (emitter) of corresponding channel.

MCR1, MCR2 – connection outputs of timing turn-off delay capacitance of corresponding controlled transistor when current overload. Protection operation delay is necessary to avoid malfunction of short-time inductive kicks. Thereby this delay duration will be equal to "rerun pulse" duration when emergency. To increase protection operation delay it is recommended to install the capacitors with nominal showed at Figure 11. If delay increase is not required this output should be disconnected; it is not recommended to connect it to the "ground" output.

OUToff1, OUToff2, OUTon1, OUTon2 – outputs meant for connection of controlled transistors gates. The recommended connection circuit is shown at Figure 2. Voltage limiter should be set with rated breakdown voltage not less than 16 V and not more than maximum-permissible gate voltage. It is recommended the limiter with rated breakdown voltage 18 V. It is allowed to install Zener diodes with corresponding rated Zener breakdown. If the controlled transistor is installed at a remote distance from the driver, then the limiter should be installed direct to transistor.

Gate resistors (Ron1, Ron2, Roff1 and Roff2) are necessary for maximum pulse current decreasing. It's not recommended to install the resistors with nominal less than 1 Ω. It is allowed to install the resistors with different nominal, for instance, for turn-off duration increasing of controlled transistor to decrease voltage amplitude of inductive surges.

7 GRAPHICS EXPLAINING DRIVER OPERATION

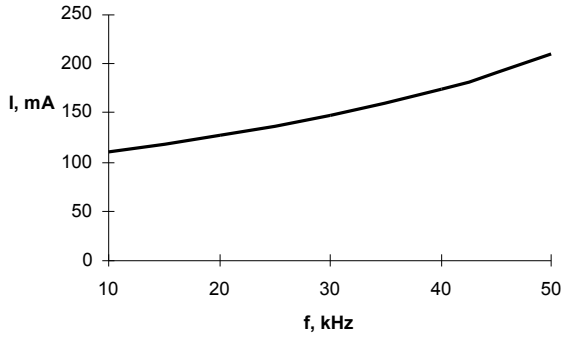


Figure 5 – Graph of current consumption versus no-load control signal frequency

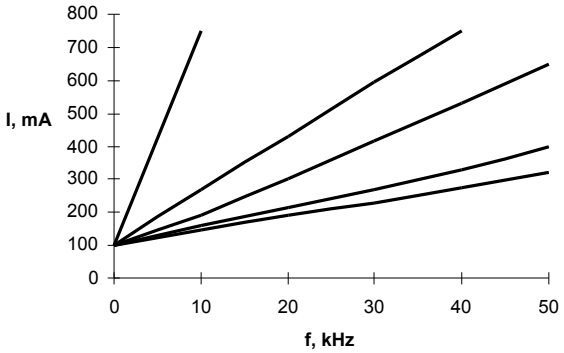


Figure 6 – Graph of current consumption versus signal frequency under load (with gate resistor 5Ω) for gate capacities 10 nF, 25 nF, 50 nF, 100 nF, 250 nF

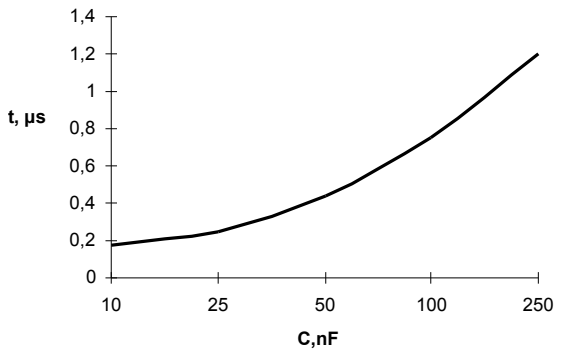


Figure 7 – Graph of acceleration time versus gate capacity (with gate resistor 5 Ω)

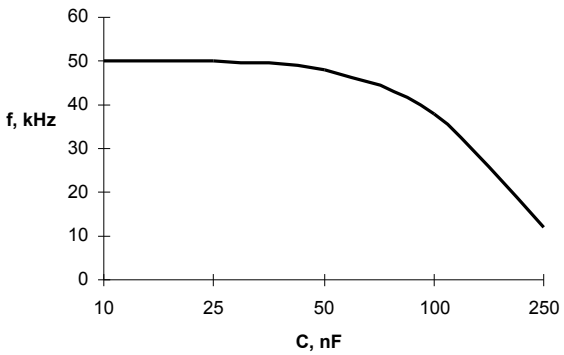


Figure 8 – Graph of driver safe operation area (with gate resistor 5 Ω)

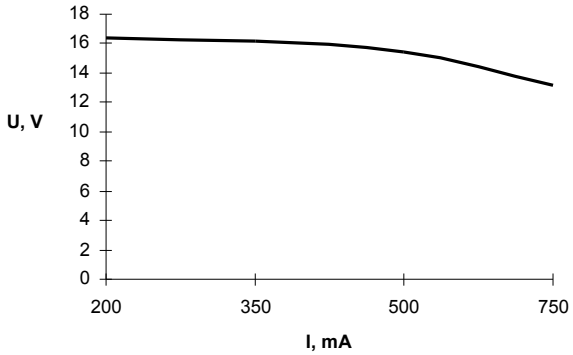


Figure 9 – Graph of transistor gate voltage versus current consumption

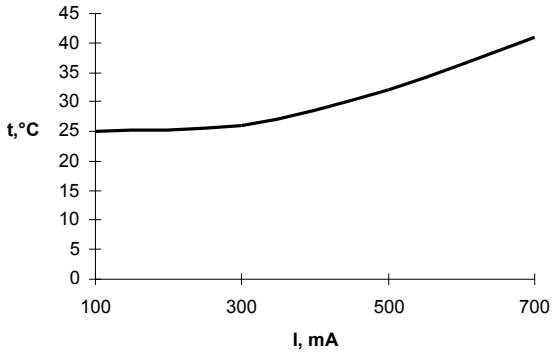


Figure 10 – Graph of driver housing temperature versus current consumption

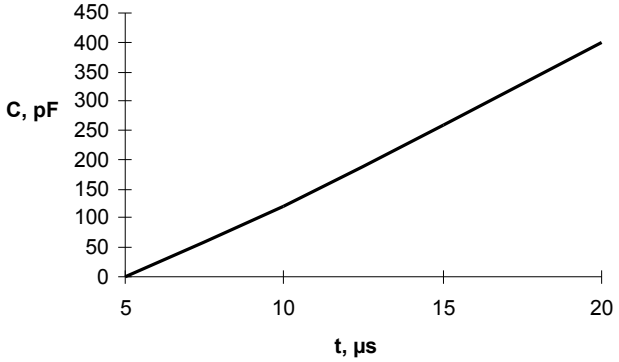


Figure 11 – Saturation protection turn-on delay duration versus trimming capacitance

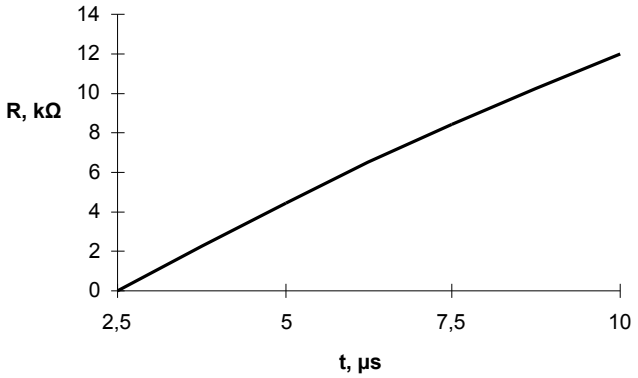


Figure 12 – Switch delay duration versus trimming resistors nominal.

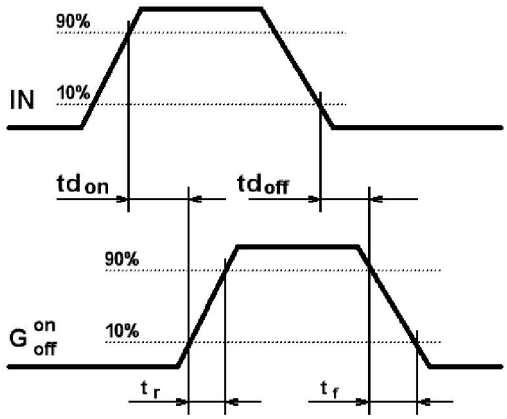


Figure 13 – Diagram explaining driver time characteristics
where IN – input control signal;
G – signal of controlled transistor gate

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 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

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 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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