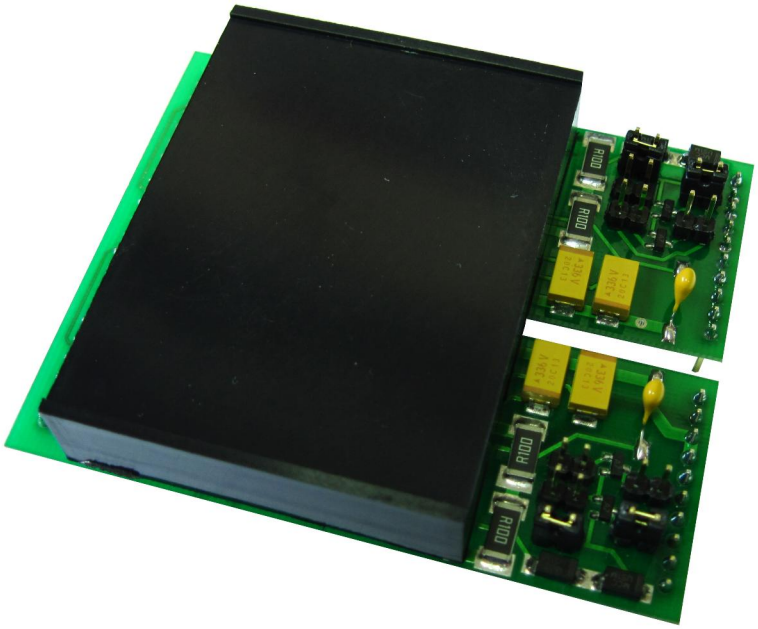
IGBT И MOSFET TRANSISTORS DRIVER DR6180P–B1
Analogue of control board SkiiP 3

USESR'S MANUAL



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1 GENERAL INFORMATION

A six channel driver of power transistor with field control (MOSFET and IGBT) (hereinafter – driver) is intended for independent galvanically isolated controlling of two power transistors with maximum voltage up to 3300V. The driver is a former-amplifier of transistor gates control signals with frequency up to 100 kHz. The driver contains an inbuilt galvanically isolated DC-DC converter that provides necessary levels of open and close voltages at transistor gate. The driver is an analogue of SkiiP3 block.

2 DRIVER COMPOSITIONS

2.1 The driver – PCB with installed 3 driver modules (DM) on it that are performed in a hermetic plastic housing with necessary adjusting elements and connectors for controlled transistors connection and control signals.

2.2 The driver contains the following functional units:

1 Driver supply voltage stabilizer with protection from wrong turn-on polarity;
2 Inbuilt DC-DC converter with level stabilization of open and close voltage at controlled transistors gates;
3 Input logics;
4 Controlled transistors gates control circuit;
5 Protection circuit from heightened and reduced voltage at controlled transistor gate;
6 Controlled transistors protection circuit from current overload;
7 Current control circuit.
8 Voltage control circuit.

3 DRIVER FUNCTIONAL FEATURES

3.1 The driver provides the following control, management and protection functions of controlled transistor:

1 Voltage saturation control on collector of controlled transistor, its protection shutdown at remove from saturation state;
2 Regulation of threshold protection shutdown at saturation;
3 Procuring of smooth junction from active state into inactive one at an emergency mode (control transistor failure from saturation mode);
4 Control blocking at an «emergency»
5 Signaling about emergency presence;
6 Turn-on/ turn-off regulation time of controlled transistor by resistance in input circuit (Ron, Roff);
7 Blocking of simultaneous turn-on of upper and lower arm;
8 Delay regulation at switching of upper and lower arm;
9 Voltage control of driver supply (inbuilt comparators) at output of DC-DC converter;
10 Temperature control by external sensor and forming of analogue voltage independently from temperature;
11 Amplifying current into voltage on each phase.

3.2 Overall drawing is shown on Figure 1; functional driver circuit is shown on Figure 2.

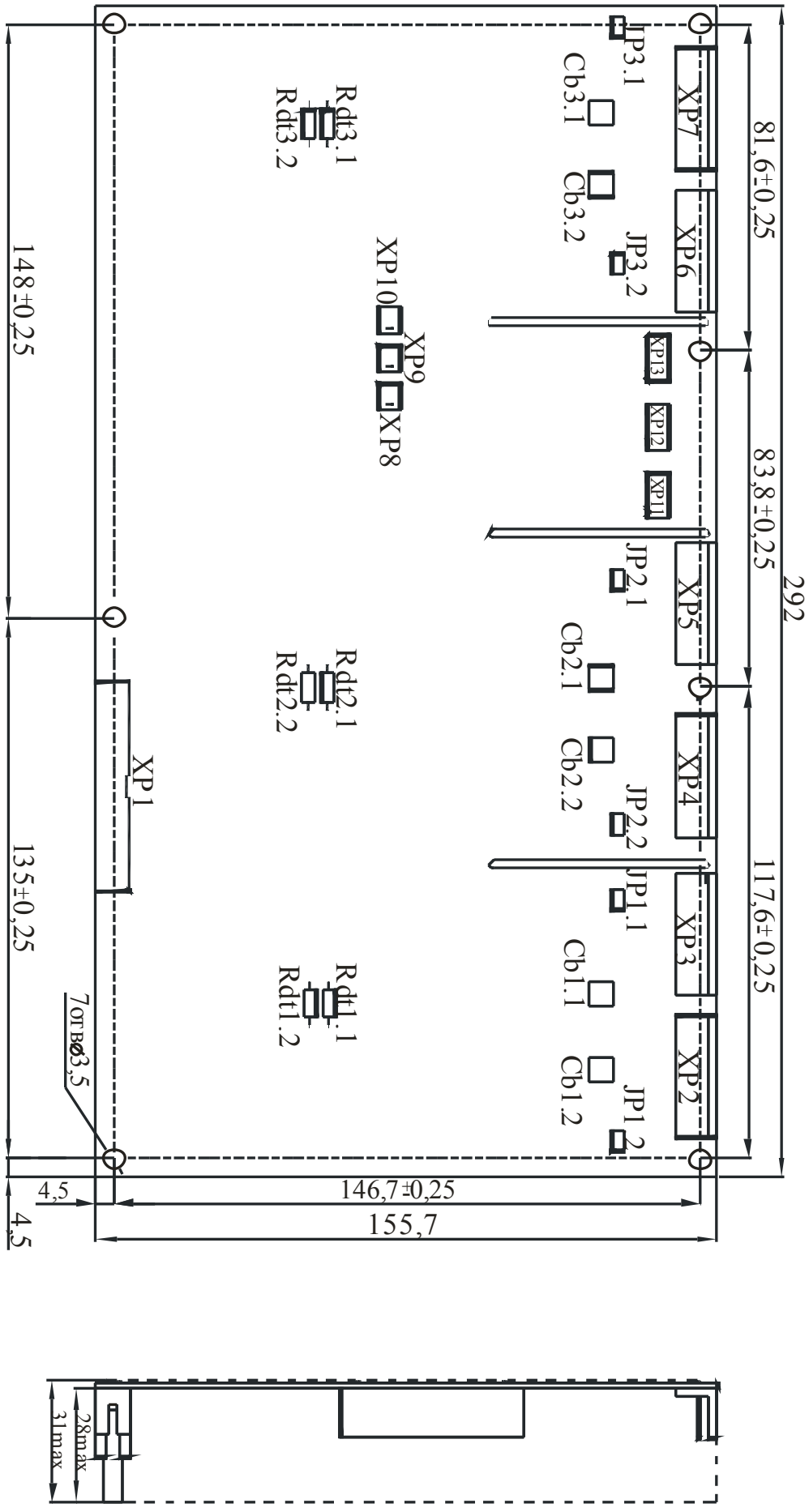


Figure 1 – Driver overall dimensions

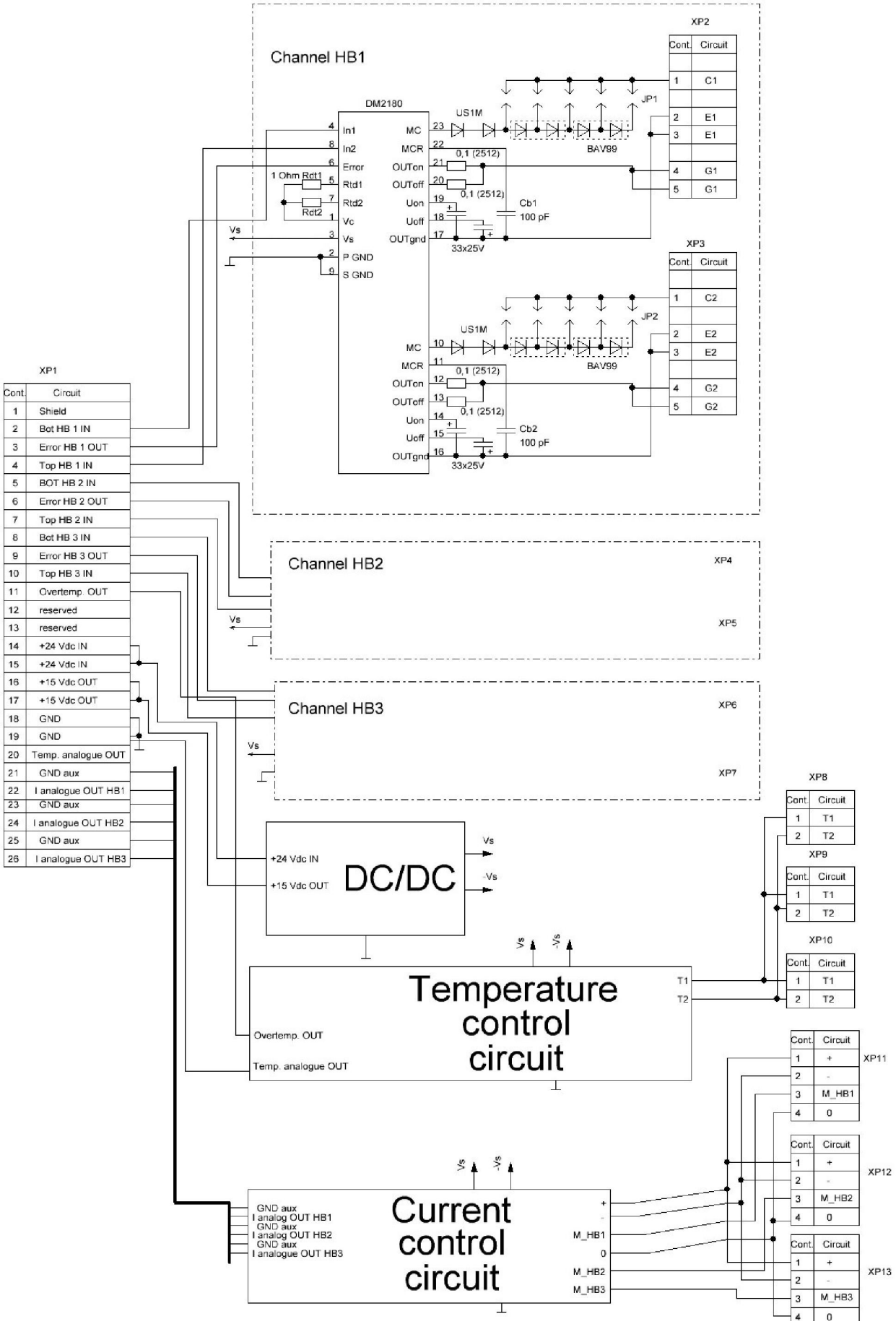


Figure 2– Driver functional circuit

3.3 Outputs application is shown in Table 1.

Table 1 – Driver outputs application

Contact	Output number	Output symbol	Outputs application
XP1	1	shield	
	2	BOT HB 1 IN	Control 15 V CMOS logic; resistance at input 5.9 kΩ
	3	ERROR HB 1 OUT	Channel output mistake HB1, output – open collector, In absence of error at «0» output.
	4	TOP HB 1 IN	Control 15 V CMOS logic; resistance at input 5.9 kΩ
	5	BOT HB 2 IN	Control 15 V CMOS logic; resistance at input 5.9 kΩ
	6	ERROR HB 2 OUT	Channel output mistake HB2, output – open collector, In absence of error at «0» output.
	7	TOP HB 2 IN	Control 15 V CMOS logic; resistance at input 5.9 kΩ
	8	BOT HB 3 IN	Control 15 V CMOS logic; resistance at input 5.9 kΩ
	9	ERROR HB 3 OUT	Channel output mistake HB3, output – open collector, In absence of error at «0» output.
	10	TOP HB 3 IN	Control 15 V CMOS logic; resistance at input 5.9 kΩ
	11	Overtemp. OUT	State signal output of temperature excess, circuit with common collector.
	12	Reserved	
	13	Reserved	
	14	+24Vdc IN	Supply +24 V
	15	+24Vdc IN	Supply +24 V
	16	+15Vdc OUT	Voltage output +15V
	17	+15Vdc OUT	Voltage output +15V
	18	GND	Supply circuits and control ground
	19	GND	Supply circuits and control ground
	20	Temp. Analog OUT	Temperature sensor analogue sensor output
	21	GND aux	Analogue signals circuits ground
	22	I analogue OUT HB 1	Analogue signal output of HB1 Channel current sensor
	23	GND aux	Not in effect
	24	I analogue OUT HB 2	Analogue signal output of HB1 Channel current sensor
	25	GND aux	Not in effect
	26	I analogue OUT HB 3	Analogue signal output of HB1 Channel current sensor
XP2-XP7	1	C1-C7	Measuring collector
	2,3	E1-E7	Emitter
	4,5	G1-G7	Gate
XP8-XP10	1	T1	External thermal resistor connection
	2	T2	
XP11-XP13	1	+	External current sensor connection
	2	-	
	3	M_HB1-M_HB3	
	4	0	

4 BASIC AND MAXIMUM PERMISSIBLE PARAMETERS

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

Parameter	Symbol	Unit	Value			Notes
			min	type	max	
DC/DC block parameters						
Supply voltage	U_S	V	21	24	27	
Off load current consumption	I_S	mA		200	350	F_{cont} = 0 Hz
Maximum current consumption	$I_{S\,max}$	mA			1500	under load
Inbuilt supply source power of driver module output part	P_{DC-DC}	W	3			for each channel
Voltage control						
Threshold of protection turn on	U_{UVLO-}	V		11		DC-DC input
Threshold of protection turn off	U_{UVLO+}	V		12		
Control input characteristics						
Input high voltage	U_{IH}	V	13	15	15.6	
Input low voltage	U_{IL}	V	-0.6	0	2.4	
Input resistance	R_{IN}	kΩ		5.9		
Time characteristics						
Input-output turn-off and turn-on time	td (in-out)	µs			0.5	see Figure 11
"Dead time" between changes at outputs of first and second channels	t_{TD}	µs	2			adjusted by customer; see Figure 10
Maximum operating frequency	f_{max}	kHz			100	without load; see Figures 5 and 6
Non-saturation protection operation delay time	t_{BLOCK1}	µs	2			adjusted by customer; see Figure 9
Blocking time of controlled transistor after «emergency»	t_{BLOCK2}	ms		70		
Controlled transistor smooth emergency turn off	t_{off}	µs		1.5		
Emergency signal turn on delay time	$td_{(on-err)}$	µs			2	
Output parameters						
Input HIGH voltage	U_{OH}	V	+12	+15	+18	In all range of permissible loads
Input LOW voltage	U_{OL}	V	-8	-10	-12	
Maximum output pulse turn on current	$I_{Omax\,on}$	A	+18	20		adjusted by customer; see Figure 8
Turn off maximum output pulse current	$I_{Omax\,off}$	A		-22	-18	
Average output current	I_O	mA			130	to each channel
Output signal rise and fall time	$t_{r\,(f)}$	ns			150	see Figure 11
Emergency signal maximum current, thermal sensor	$I_{ERR\,max}$	mA			20	
Output emergency signal maximum voltage	$U_{ERR\,max}$	V			20	
Emergency signal output residual voltage	$U_{O\,ERR}$	V		0.3	0.7	at I_{ERR} = 20 mA

Saturation voltage relevant to protection activation at non-saturation	$U_{мс}^{Th}$	V			5.0	adjusted by customer, see Table 3
Additional outputs characteristics						
Temperature when happens emergency signaling			110	115	120	note 1
Voltage value relevant to nominal collector current at 25 °C, at current control output		V		8		note 2
Voltage value relevant to exceeding of nominal current at 25 °C in 1.25 times, at current control output		V		10		note 2
Isolation characteristics						
Maximum permitted reverse voltage at collector	U_C	V			4000	
Voltage isolation between input and output	$U_{ISO(IN-OUT)}$	V			7500	DC, 1 minute
Voltage isolation between outputs of first and second channel	$U_{ISO(OUT1-OUT2)}$	V			4000	DC, 1 minute
Critical change rate of voltage at output	$(dU/dt)_{cr}$	кW/ μs			20	
Controlled transistor characteristics						
Controlled transistor maximum permitted voltage	U_{CE} (U_{DS})	V			3300	
Operating and storing characteristics						
Operating temperature range	T_A	°C	-45		+85	
Storing temperature	Ts	°C	-60		+100	

Notes:

1. When you using it together with a thermistor with the following parameters: R_{25}=5 kΩ, R_{100}=495, $B_{T=25/50\ °C}$ = 3375
2. When you using it together with a current sensor of type HAS 50..600-S/SP50

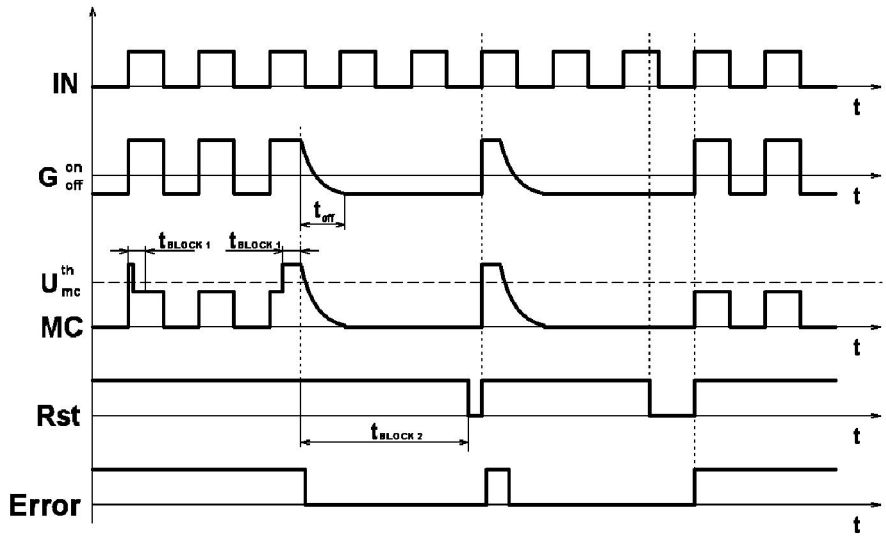
5 DRIVER OPERATION

Sending «log.1» to control input «BOT HB x IN» or «TOP HB x IN» (at any from control channels) will lead to opening of concrete controlled transistor. Voltage fall exceeding in open state more than $U_{мс}^{Th}$ for time, that exceeding t_{BLOCK1} will lead to protection activation at exceeding of voltage fall in open state (non-saturation protection). At appearance of «emergency» will open transistor that turned on by scheme with collector (output «ERROR HB x OUT»). After 70ms will be performed «emergency» reset and at leading edge will be opened controlled transistor. In case if «emergency» reason didn't change the cycle will repeat.

Driver voltage supply driver up to protection activation threshold level from decreased level. Driver voltage decreasing to level of protection activation threshold from decreased voltage of driver supply U_{UVLO-} will lead to close of controlled transistor independently from control input signals. At protection activation from decreased voltage the error signal at « ERROR HB x OUT » outputs doesn't appear.

During the sending to control inputs of one channel simultaneously «log 1» will be blocking of control and controlled transistors will be closed at this time signaling about error existence at outputs «ERROR HB x OUT» will not appear.

Diagrams that explain the driver operation are represented at Figures 3 and 4.



R_{st} – Periodic internal signal of «emergency» reset.

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

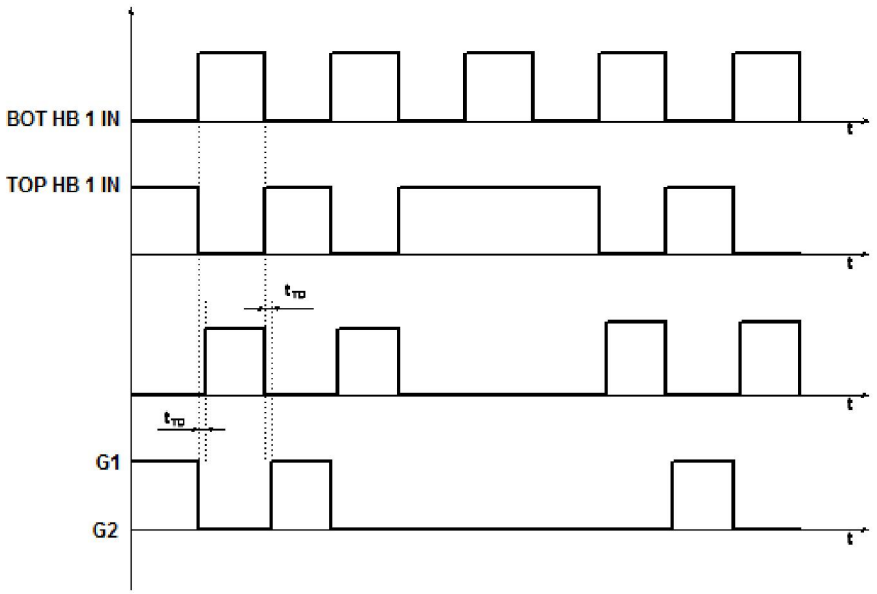


Figure 4 – Functional diagram of driver operation

6 DRIVER CONNECTION RECOMMENDATIONS

BOT HB x IN, TOP HB x IN – controlling inputs. Driver control is described in «Driver operation» paragraph. At control voltage sending should be considered that at control inputs are installed reverse protection diodes and as consequence in the case if control voltage will exceed supply voltage more than 0.6 then will occur increasing of current consumption at inputs and at significant exceeding of supply voltage driver can breakdown.

ERROR HB x OUT – outputs that signal about emergency occur. Outputs represent transistor open collector of protection circuit. At this time transistor will open only at emergency caused by power transistor overload; at decreasing of driver voltage supply up to «U_{uvlo-}» level the transistors will be closed independently from input signals (signals will recuperate at achieving of supply level relevant to «U_{uvlo+}»), however signaling about error in present case will not happen. Also will not occur signaling in case of simultaneous sending to control inputs signals that relevant to « log1», however input transistors will be closed.

It is not recommended sending to the present outputs voltage and current with values higher than maximum permitted, including in a short time.

+24 Vdc IN – driver supply input. Need to consider that at decreasing of driver voltage supply decreases the output voltage of DC/DC converter. Thereby if supply less than permitted level the input circuit can operate right, however, at gates of controlled transistors voltage can fall to «U_{uvlo-}» level and transistor control will be incorrectly.

The current consumption at supply input is maximum 350 mA without load. At connection of transistors the current consumption increases to the value of overcharge current gate and can reach 1500 mA (equal load for both channels). At higher consumption current DC/DC-converter can breakdown or at short term of consumption current exceeding in 1500 mA the output voltage of DC/DC-converter will decrease to impermissible and will activate protection at undervoltage that will lead to incorrect transistor operation. In this case if the load is distributed unequally then the current consumption by one channel must not exceed 250 mA. The current consumption depends on the control signal frequency, on resistance value of gate resistors and on the gate input resistance (see Figure 6). Thereby, at driver operation is necessary to make allowance for current consumption depending on the transistors which driver will operate on. The driver safe operation area depending on gate capability and frequency is represented at Figure 5.

+15 Vdc OUT – output to connect additional circuit supply, maximum current is not higher than 50 mA.

GND – ground of supply and control circuits; thus, control circuit is not galvanically isolated with DC/DC-converter input.

Resistors Rdt1, **Rdt2** – timing resistors of delay adjusting for switching of first and second channels. Resistors regulate turn-on delay time thereby at installation of different nominal resistors the delay for switching at forward fronts of control pulses of first and second channels will be different. In the case if delay time decreasing is not necessary instead of resistors should be installed jumpers. Delay time dependence on the resistors nominal is represented at Figure 10. Initially are installed resistors with nominal 1Ω that is the factor that of minimum "dead time" 2μs.

Capacitors C_{b1} , C_{b2} – timing capacitors turn off delay of relevant controlled transistor at current overload, where x – a serial number of the unit from 1 to 3. Delay for protection activation is necessary to avoid false alarm of short term inductive ejections and at transient processes turn-on. At this time duration of present delay will be equal to duration of "reset impulse" in case of emergency. At protection activation decreasing it is recommended installing capacitors with values that are shown at Figure 9. Initially are installed capacitors with capacity 100 pF that is relevant to duration of 5 μs delay (typ.).

G1-G6 – outputs that are intended for controlled transistor gates connection.

It is recommended installing the gate resistors that are necessary for decreasing of maximum permitted pulse current. Any nominal resistors are permitted also 0 Ω. Different nominal resistors installation is permitted (coherently with diodes), for example, to exceed controlled transistor turn-off duration with aim to decrease voltage amplitude of inductive elections. See dependence of output impulse current versus gate resistor nominals at Figure 8.

C1, C6 – collector connection outputs (drain) of controlled transistor. Outputs are intended for voltage fall controlling (saturation protection) on the transistor. The maximum value of protection activation threshold is 5.0 V. Protection activation thresholds is regulated by the JP1, JP2 jumpers location

In case if there is no a reason in protection against current overload then the output «C» is necessary to short-circuit to the emitter of the relevant channel.

E1-E6 – controlled transistors emitter connection outputs.

Jumpers

JP1, JP2 – jumpers that regulate protection operation threshold at non-saturation of controlled transistors, where x - a serial number of the unit from 1 to 3. Protection operation dependence on the installed jumper is represented in Table 3. If there is no a jumper then the driver will be in an emergency mode. By default, the jumpers are set to the position that corresponds to the threshold of protection that equal to 5V.

Table 3 – Dependence of protection threshold at non-saturation on installed jumper

1 channel jumper	1 channel jumper	Protection threshold, V (typ.)
JP1.1	JP2.1	3.0
JP1.2	JP2.2	3.5
JP1.3	JP2.3	4.0
JP1.4	JP2.4	4.5
JP1.5	JP2.5	5.0

7 GRAPHS THAT EXPLAIN DRIVER OPERATION

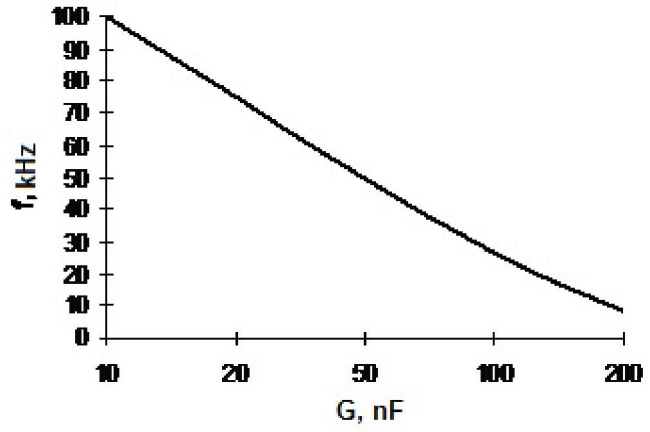


Figure 5 – Graphic of driver safe operation depending on frequency and gate capacity (with gate resistor 1Ω)

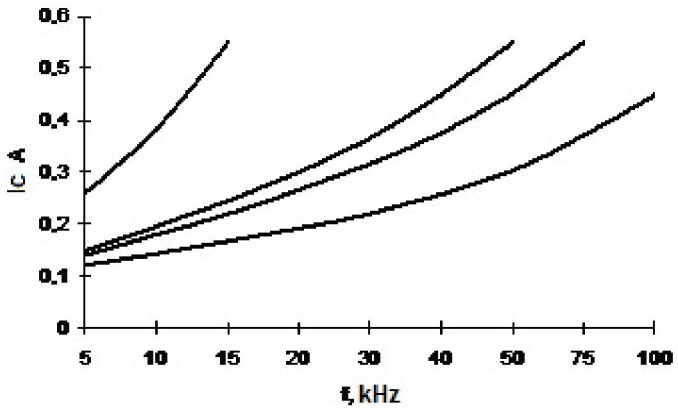


Figure 6 – Dependence graph of current consumption versus signal frequency under load (with gate resistor 1Ω).
for gate capacities 10 nF, 25 nF, 50 nF, 100 nF

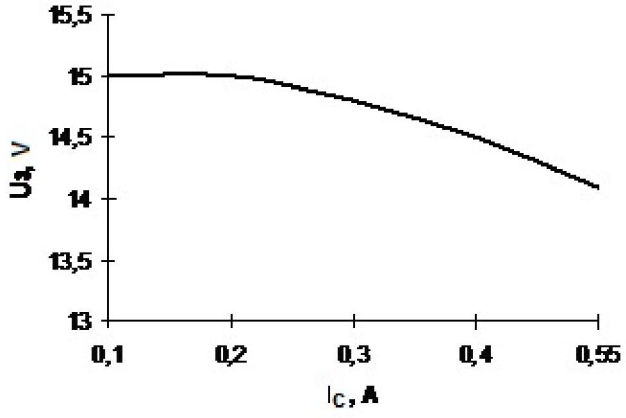


Figure 7 – Graph of dependence of voltage at gate versus current consumption to 1 channel

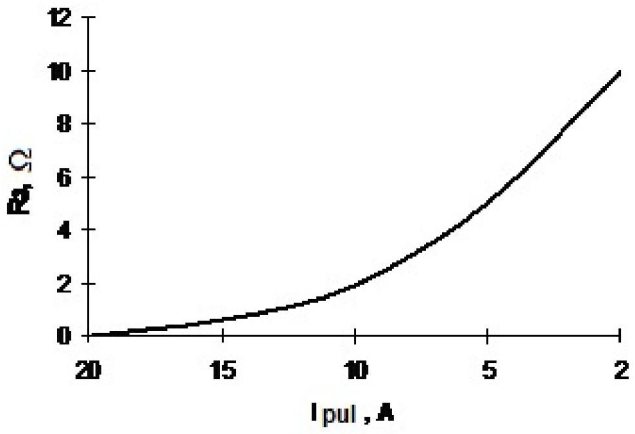


Figure 8 – Graph of dependence of input pulse current versus nominal of gate resistors.

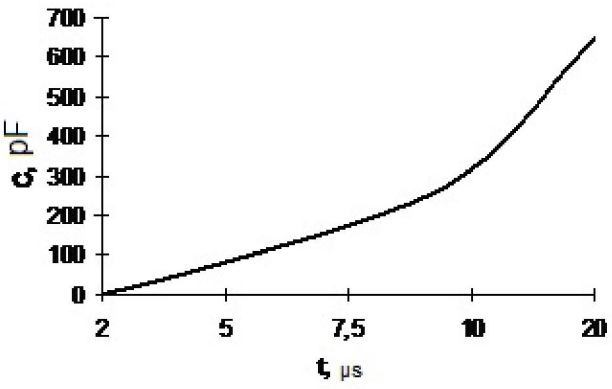


Figure 9 – Dependence graph of turn-on delay duration versus trimmer capacity nominal C_b

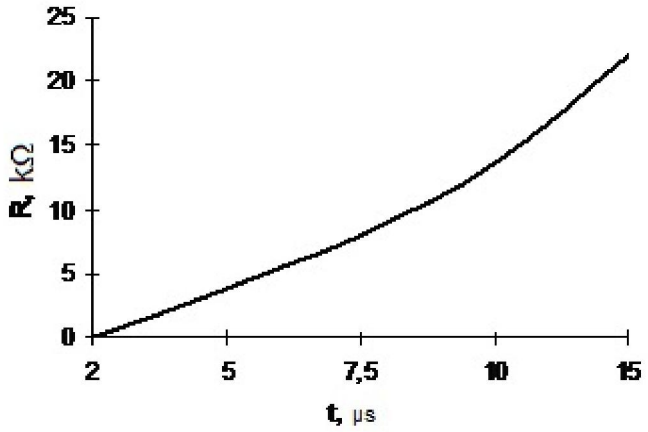


Figure 10 – Dependence graph of "dead time" duration versus nominal of trimmer resistors R_{dt}

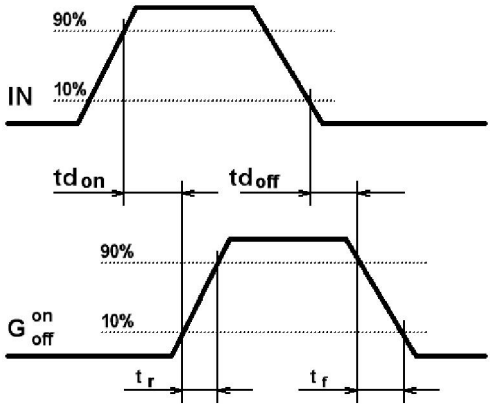


Figure 11 – Diagram explaining driver time parameters
where IN – input control signal; G – controlled transistor gate signal

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 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 specific consumers, the drivers can be produced also for the other service conditions.

9.2 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 moisture condensation, %, maximum	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)

10 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 drivers 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 storageability time of the modules, at $\gamma = 90$ % and storing – 10 years.

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