TRANSISTOR IGBT AND MOSFET DRIVER DR2180P–BF1(2)-K
ANALOGUE OF 2SP0320V(S)

USER'S MANUAL

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1 GENERAL DESCRIPTION

A double-channel driver of powerful transistors with field drive (MOSFET or IGBT) (hereinafter – driver) is intended for dependant galvanic isolated controlling of two power transistors with maximum permissible voltage up to 1700 V. The driver is an amplifier – generator of transistor gates control signals with frequency up to 100 kHz. The driver contains built-in galvanic isolated DC/DC-converter, providing requisite levels of unlocking and locking voltages on transistor gate. The driver is an analogue of **2SP0320V(S)** in structure and function.

When supplying the driver has been set for protection operation threshold against overvoltage collector-emitter is equal to 1100 V (jumper J1.1(2)). If there is a necessary to set other values you should change relevant jumpers.

2 DRIVER COMPOSITIONS

2.1 The driver is a printed-circuit board with mounted driver module on it (DM), made in a hermetic plastic housing, necessary tuning element and connectors for connection of controlled transistors and control signals.

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.

3 FUNCTIONAL DRIVER FEATURES

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

1 Saturation voltage control on collector-emitter of controlled transistor, its protective disconnection when saturation state output;
2 Threshold regulation of protective turn-off on saturation voltage;
3 Soft 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 alarm;
6 On/off time regulation of controlled transistor by means of change of resistor resistance in output circuit (Ron, Roff);
7 Block of simultaneous turn-on of upper and lower arm;
8 Switching delay of upper and lower arm;
9 Switching delay regulation of upper and lower arm;
10 Driver supply voltage control (built-in comparators) on DC/DC converter output.

3.2 Overall drawing is shown at Figure 1, functional driver scheme is represented at Figure 2

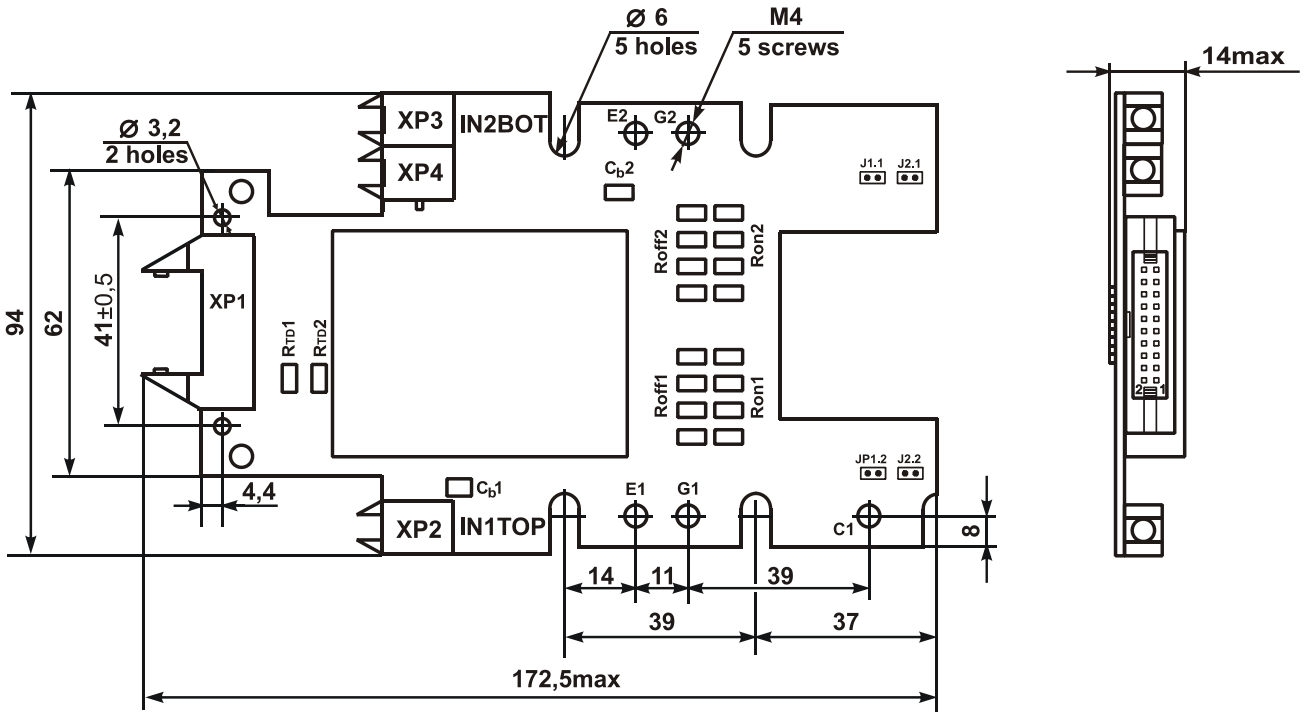


Figure 1.1 – Overall drawing of driver DR2180P-BF1-1

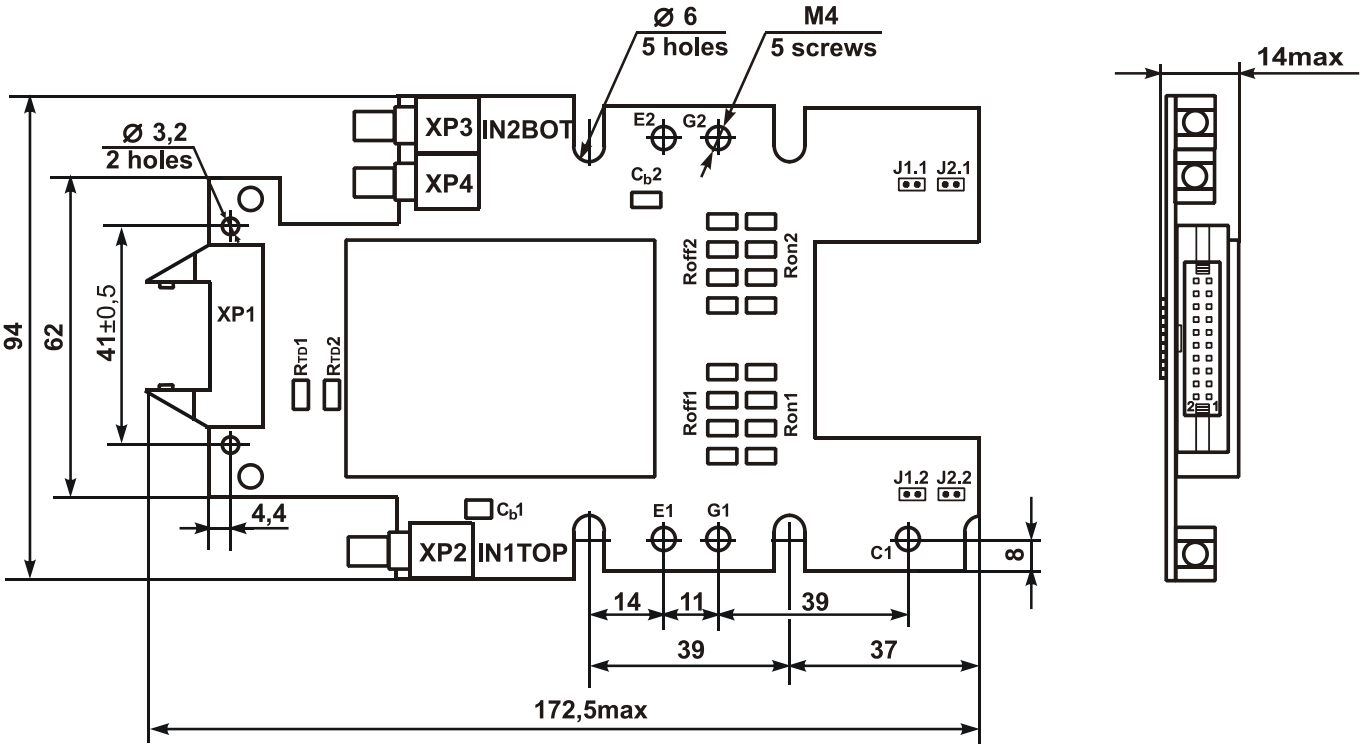


Figure 1.2 – Overall drawing of driver DR2180P-BF1-2

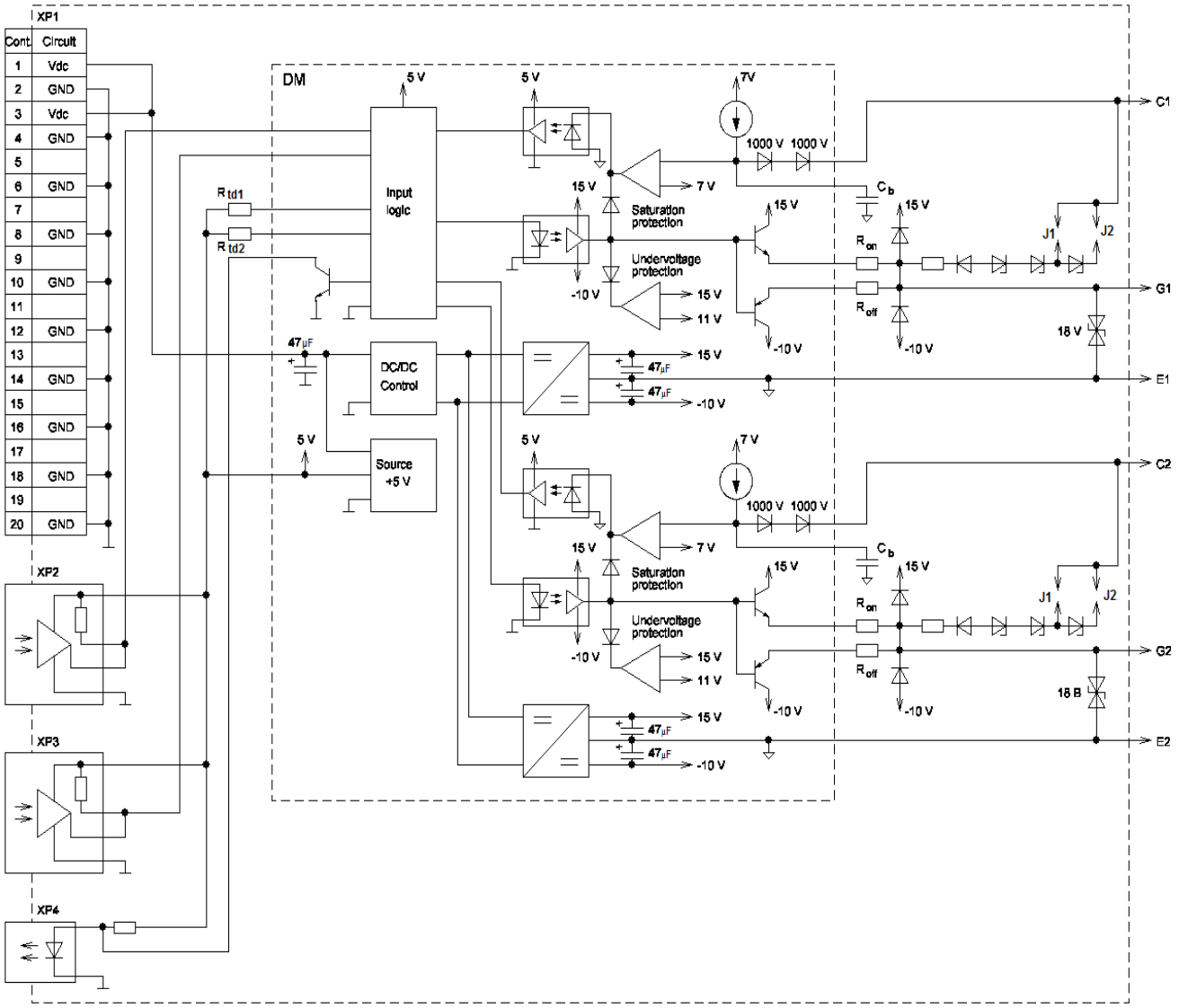


Figure 2– Functional driver circuit and turn-on circuit

XP1 – plug IDCC-20MS; mate - socket IDC-20
XP2, XP3 – signal receiver HFBR-2522 (for DR2180P-BF1-1);
HFBR-2422Z (for DR2180P-BF1-2)
XP4 – signal transmitter HFBR-1522 (for DR2180P-BF1-1); HFBR 1422Z (DR2180P-BF1-2).

3.3 Output function is given in Table 1.

Table 1 – Output function of XP1

Output No.	Function	Symbol
1	Vdc	Supply +15 V
2	GND	Ground of power circuits and control circuits
3	Vdc	Supply +15 V
4	GND	Ground of power circuits and control circuits
5	-	Not involved
6	GND	Ground of power circuits and control circuits
7	-	Not involved
8	GND	Ground of power circuits and control circuits
9	-	Not involved
10	GND	Ground of power circuits and control circuits

11	-	Not involved
12	GND	Ground of power circuits and control circuits
13	-	Not involved
14	GND	Ground of power circuits and control circuits
15	-	Not involved
16	GND	Ground of power circuits and control circuits
17	-	Not involved
18	GND	Ground of power circuits and control circuits
19	-	Not involved
20	GND	Ground of power circuits and control circuits

4 BASIC AND MAXIMUM PERMISSIBLE PARAMETERS

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

Parameter	Symbol	Unit	Value			Note
			min	type	max	
DC/DC block characteristic						
Supply voltage	U_S	V	13.5	15	16.5	
Off-load current consumption	I_S	mA		180	200	F_{cont} = 0 Hz
Maximum current consumption	$I_{S\ max}$	mA			550	Under load Ref. to Figures 5 and 6
Power of built-in power supply of output part	P_{DC-DC}	W	3			For each channel
Voltage monitor characteristics						
Protection turn-on threshold	U_{UVLO-}	V		11		DC-DC output
Protection turn-off threshold	U_{UVLO+}	V		12		
Control input characteristics						
Wave length used when signal transmission and signal receiving	λ	nm		660		
Time characteristics						
Turn-on/off delay time input-output	$t_{d\ (in-out)}$	μs			0.5	ref. to Figure 11
«Dead time» between signal changes of the first and second output channel	t_{TD}	μs	2			Set by consumer; ref. to Figure 10
Maximum operating frequency	f_{max}	kHz			100	No-load; ref. to Figure 5 and 6
Non-saturation protection operation delay time	t_{BLOCK1}	μs	2			Set by consumer; ref. to Figure 9
Lock time of controlled transistor after “Emergency”	t_{BLOCK2}	ms		70		
Soft emergency shutdown time of controlled transistor	t_{off}	μs		1.5		
Emergency turn-on delay time	$t_{d(on-err)}$	μs			2	
Output characteristics						
High level output voltage	U_{OH}	V	+12	+15	+18	In all range of permissible loads
Low level output voltage	U_{OL}	V	-8	-10	-12	
Maximum output pulse on current	$I_{Omax\ on}$	A	+18	20		Set by consumer; ref. to Figure 8
Maximum output pulse off current	$I_{Omax\ off}$	A		-22	-18	
Average output current	I_O	mA			130	To each channel
Rise and fall time of output signal	$t_{r\ (f)}$	ns			150	ref. to Figure 11
Maximum current of “Emergency” output	$I_{ERR\ max}$	mA			20	

Maximum voltage of “Emergency” output	$U_{ERR\ max}$	V			20	
Residual voltage of “Emergency” output	$U_{O\ ERR}$	V		0.3	0.7	at I_{ERR} = 20 mA
Saturation voltage that corresponds to non-saturation protection operation	U_{mc}^{Th}	V			5.8	
Insulation characteristics						
Maximum permissible reverse collector voltage	U_C	V			2000	
Insulation voltage between input and output	$U_{ISO(IN-OUT)}$	V			4000	DC, 1 minute
Insulation voltage between output of the first and second channel	$U_{ISO(OUT1-OUT2)}$	V			2000	DC, 1 minute
Critical rate of output voltage change	$(dU/dt)_{cr}$	kV/ μs			20	
Protection characteristics against overvoltage						
Protection operation voltage against collector-emitter overvoltage of controlled transistor (ref. to Figure 12)	U_{AC}	V		1100		J1.1(2) installed
				1600		J2.1(2) installed
Characteristics of controlled transistor						
Maximum permissible voltage of controlled transistor	U_{CE} (U_{DS})	V			1700	
Service and storage characteristics						
Operating temperature range	T_A	°C	-45		+85	
Storing temperature	Ts	°C	-60		+100	

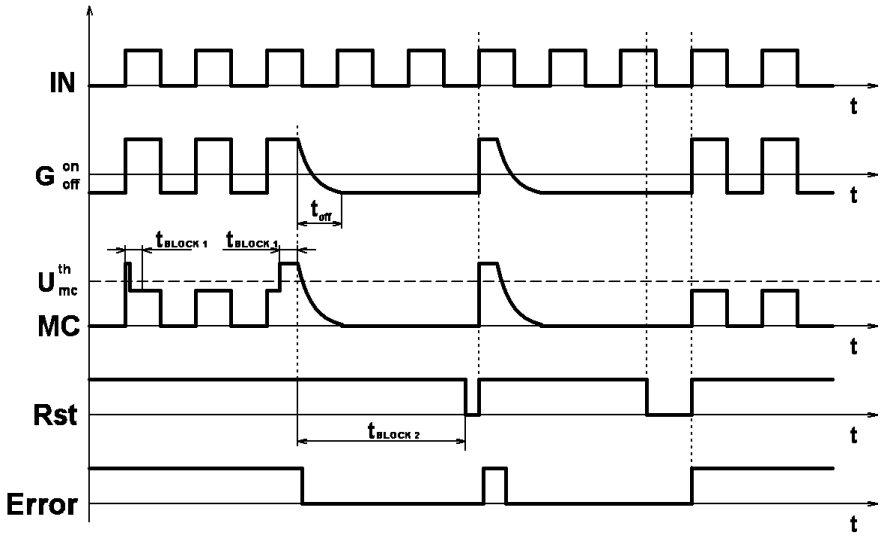
5 DRIVER OPERATION

Delivery of light pulse to receiver of controlled signal XP2 and XP3 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 transmitter LED of XP4 will not light anymore. 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 transmitter XP4 output when protection operation against supply undervoltage.

The simultaneous delivery of light pulses receivers of controlled signal XP2 and XP3 will lead to control block and controlled transistors will be closed (block of simultaneous turn-on), thereby error signaling does not arise.

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



R_{st} – Periodical internal signal of "emergency" reset

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

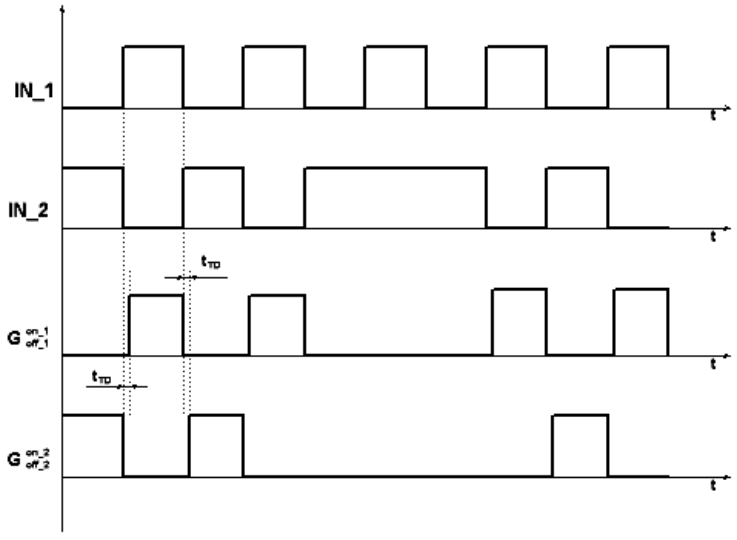


Figure 4 – Functional diagram of driver operation

6 DRIVER CONNECTION RECOMENDATIONS

XP2, XP3 receiver of controlled signal. It is a converter microcircuit of light pulses into logic control signals. The wave length that is used when signal's transmission and reception is 660 ns.

XP4 status transmitter. It is microchip of light signal about driver operation mode. In case of normal driver operation there is a light signal on transmitter output. The transmitter is disconnected only when emergency caused by current overload of power transistor; if driver supply voltage is decreased to «U_{uvlo-}» then the transistors will be closed regardless of input control signals (the signals will be recovered when supply level reaching corresponding to «U_{uvlo+}») but there will not be an error signaling in this case.

Vdc – driver supply connector. You should note that when driver supply voltage decreases, the output voltage of DC/DC – converter will be also decreased. Therewith if the supply is lower than the permissible level the input circuit can operate regularly but the voltage on gates of controlled transistor can drop to level «Uuvlo-» and transistor control will be false.

Maximum no-load current consumption on supply input is 120 mA. When transistors connection the current consumption will increase by value of gate recharge current and can reach 550 mA equal to the both channels). At higher current consumption DC/DC – converter can fail, or, on short-time current consumption increasing by 550 mA, output voltage of DC/DC – converter will decrease to unallowable level and undervoltage protection will operate, that will lead to faulty transistor drive. If the channel load is assigned irregularly then current consumption by one channel should not exceed 250 mA. Current consumption depends on control signal frequency, gate capacitance and gate resistors values as well as on input gate capacitance (ref. to Figure 6). Thereby, when using the driver you must make a correction for current consumption subject to transistors which the driver will work on. Safe operation area of the driver versus gate capacitance and frequency is shown at Figure 5.

GND – ground of control and supply circuits; thereby control circuit does not have galvanic isolation with DC/DC-converter input.

Resistor Rtd1, **Rtd2** –timing resistor of switching delay setting of the first and second channel. Actually resistors regulate turn-on delay time thereby when you install the resistors with different nominal the rise time switching delay of controlled pulses of the first and second channel will be different. If there is no need to increase of switching delay time then you should install the jumpers instead of resistors. The dependence of delay time on resistor nominal is shown at Figure 10. Initially resistors with nominal 1 Ω are installed that corresponds to min. "dead time" (2 μs).

Capacitors C_{b1}, C_{b2} – timing capacitors of turn-on delay of corresponding controlled transistor at current overload. Protection operation delay is necessary to avoid maloperation of short-time inductive kicks and of transient process when turn-on. Thereby at emergency the delay time will be equal to "rerun pulse" time.

In order to increase protection operation delay it is recommended to install the capacitor with nominal shown at Figure 9. Initially capacitors of 100 pF are installed that corresponds to delay time 5 μs (typ.).

G1, G2 – outputs for gates connection of controlled transistors.

Gate resistors (Ron1, Ron2, Roff1 and Roff2) are necessary for maximum pulse current decrease. Resistor installing with any nominal is allowed, including 0 Ω. Resistor installing with different nominal is also allowed; for instance, in order to increase turn-on time of controlled transistor purposely to decrease voltage amplitude of inductive kicks. Output pulse current versus gate resistor nominal is shown at Figure 8.

Initially the resistors of 0.2 Ω are installed that corresponds to maximum pulse current.

C1, C2 – collector (drain) connection output of controlled transistor. The outputs are intended for voltage fall controlling (saturation protection) on collector-emitter transistor. The maximum value of protection operation threshold is 5.8 V. If there is no need for protection against overload current of controlled transistor then «C» output should be short-circuited to emitter output of the corresponding channel.

E1, E2 – emitter connection outputs of controlled transistor.

J1, J2 – jumpers that connect protection against collector-emitter overvoltage of controlled transistor of channel 1 and 2 accordingly. Thereby operate voltage 1100 V corresponds to position J1.1(2), voltage 1600 V corresponds to position J2.1(2).

7 DRIVER ADJUSTMENT RECOMMENDATIONS

In order to create the driver that is an analogue to the plug-n-play 2SP0320V Driver for the special module it is recommended to adjust the DR2180P-BF1 driver in compliance with driver 2SP0320V. You should adhere to the following technique when driver setting up:

1. Disconnect 2SP0320V driver from the module, connect direct voltage sources between collector and emitter outputs, control gate signal.

2. Signal and measure “dead time” on switching (level 0 V);

3. Measure protection operation voltage by smooth rising of voltage at the sources that imitate transistor saturation voltage.

4. Relative to protection operation threshold you should increase the voltage twice and measure non-saturation protection operation delay.

5. Reset “Emergency” mode, set up the frequency of control signal 0.1…1 kHz, connect RC-chain (resistor to gate) between gate and emitter with nominal 0.1 Ω/ 1μF (non-polar condenser). Connect the driver and measure resistor voltage drop (measurement of pulse driver current).

6. Set up DR2180P-BF1 in compliance with the characteristics of 2SP0320V driver, notably:

- set up “dead time” by Rtd resistors in compliance with the Figure 10;
- set up protection operate delay time by capacitor C_b in compliance with Figure 9;
- set up output pulse current by resistor Rg on(off) in compliance with Figure 8.

7. Measure the received parameter of DR2180P-BF1 similarly to 2SP0320V driver test, be assured in their equivalent.

8. Connect the driver to the power module and be sure that the converter operates by analogy to the variant of 2SP0320V driver.

8 GRAPHS EXPLAINING DRIVER OPERATION

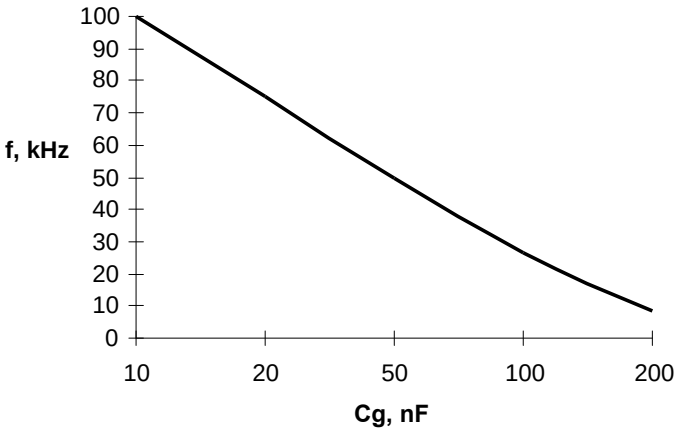


Figure 5 – Safe operation area versus frequency and gate capacitance (with gate resistor 1 Ω)

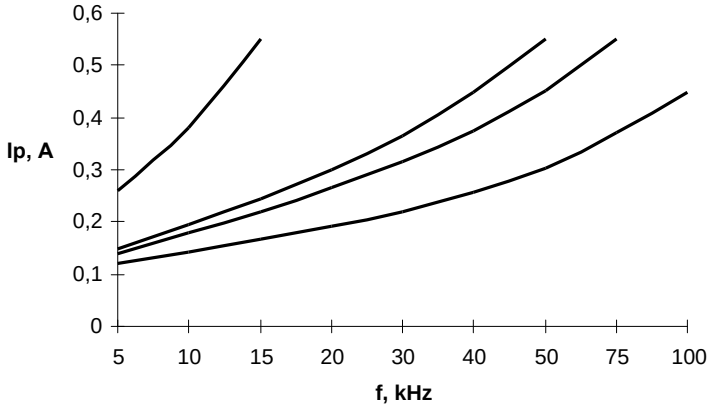


Figure 6 – Current consumption versus signal frequency under load (with gate resistor 1 Ω)
For gate capacitance 10 nF, 25 nF, 50 nF, 100 nF

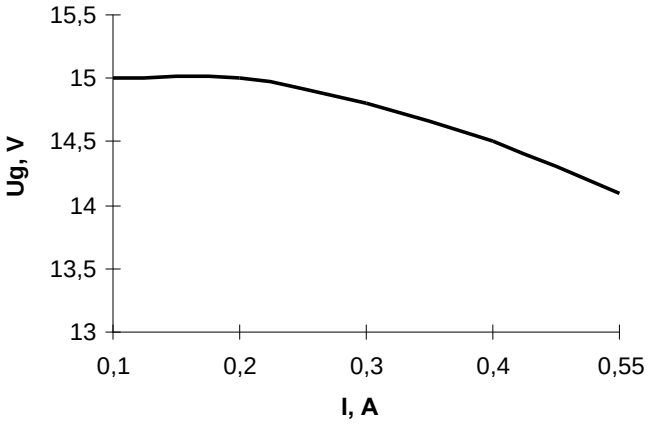


Figure 7 –Transistor gate voltage versus current consumption

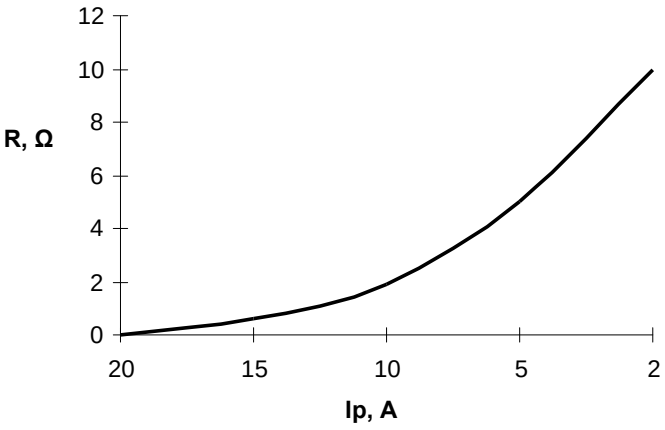


Figure 8 – Output pulse current versus gate resistor nominal

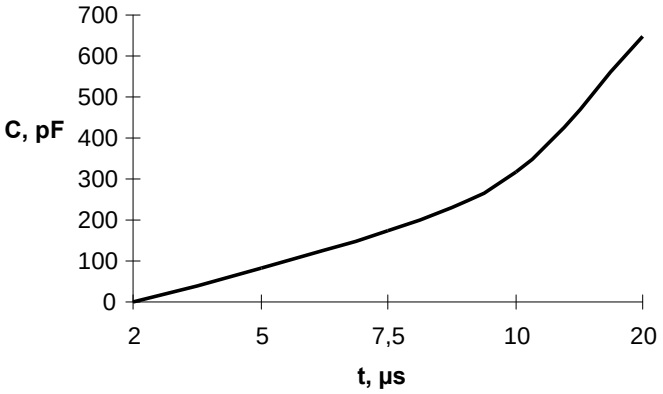


Figure 9 – Turn-on delay time of saturation voltage versus trimming capacitance C_b nominal

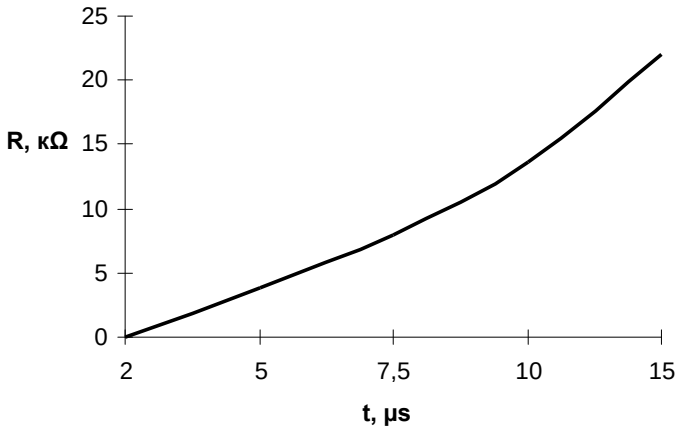


Figure 10 – "Dead time" duration versus trimming resistor R_{TD} nominal

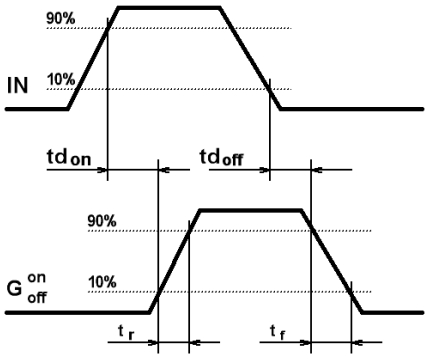


Figure 11 – Diagram explaining timing driver characteristics
where IN – input control signal; G – gate signal of controlled transistor

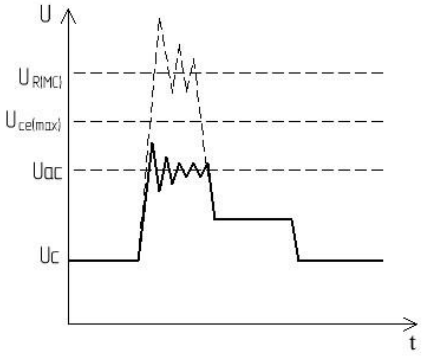


Figure 12 – Driver operation when collector-emitter overvoltage protection operate of controlled transistor
where Uac – protection operate voltage against over-voltage; Uce(max) – max. collector-emitter voltage of power transistor, Ur(mc) – max. reverse voltage on collector output

9 INFORMATION ABOUT PRECIOUS METALS

Precious metals are not contained.

10 SERVICE RECOMMENDATIONS

10.1 Resistance 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 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

10.2 Resistance requirements at climatic impacts

Table 5 - Resistance requirements to climatic impact factors

Climatic factor	Climatic factor value
Lower ambient temperature: - operating, °C; - maximum, °C Higher ambient temperature: - operating, °C; - maximum, °C Relative humidity with temperature 35 °C without moisture condensation, %, max Ambient temperature change, °C	 minus 45 minus 60 +85 +100 98 from minus 60 to +100

11 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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