FAST HIGH VOLTAGE TRANSISTOR SWITCHES

Features

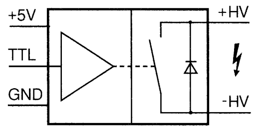
- **Nanoseconds Rise Time**
- **Very Large di/dt**
- **Low Turn-On Jitter**
- **Short Delay Time**
- **High Frequencies**
- **Low Trigger Voltage**
- **Galvanic Isolation**
- **Reliable Switching**

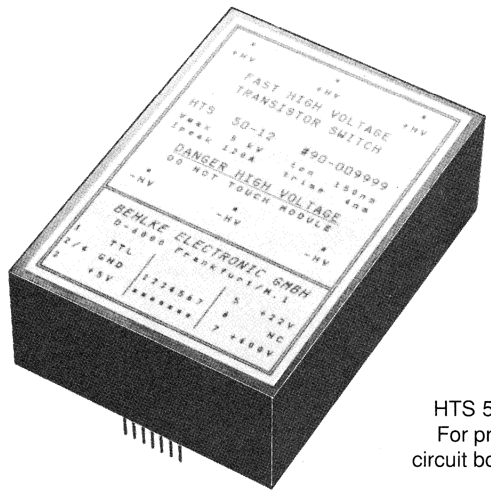
Applications

- **HV Pulse Generators**
- **Pockels Cell Drivers**
- **Power Tube Drivers**
- **Deflection Grid Drivers**
- **Crowbar Switches**
- **EMC Test Equipment**
- **Radar Modulators**
- **Laser Electronics**

HTS 50-12

5000 VOLTS / 120 AMPS
Fixed On-Time





HTS 50-12
For printed
circuit boards

INTRODUCTION

This solid-state switch has been designed for high voltage, high speed switching applications such as pockels cell drivers, deflection grid drivers and nanosecond pulse generators. The HTS 50-12 is used for short-time pulse applications requiring very fast rise times in connection with high peak currents. In contrast to conventional high voltage switches, e.g., with cold cathode tubes, triggered spark gaps or thyratrons, the transistor switch HTS 50-12 has a very short recovery time, a high repetion rate, a very low jitter and the lifetime typical for a semiconductor device. Its semiconductor design allows a stable operation over the full range of rated voltage. Neither trigger transformer nor high auxiliary voltages are required for operation.

The switch is triggered by a positive going pulse of 3 to 20 volts amplitude. The on-time after being triggered is typically 150 nanoseconds. The turn-on rise time depends essentially on the operating voltage, load capacitance, stray capacitance and stray inductance. Rise times of less than 3 nanoseconds are attainable with optimized circuit designs. Due to the galvanic isolation of more than 10 kVDC, positive as well as negative voltages can be switched on or off. The switch can also be floated at a high potential.

LAYOUT DESIGN CONSIDERATIONS

Since HTS-switches can generate extremely rapid rates of voltage and current change, the circuit design should be in accordance with the typical requirements of RF-circuits. That means all leads should be kept as short as possible, part components must be low inductance types (No wirewound resistors!) and power supplies should be decoupled. Ground leads must be connected to a common ground point. If the printed board layout is not made according to the above mentioned RF circuit principles, wild oscillations may occur, which can cause a switch overload, especially in case of loads with low impedances. To keep the risk of oscillations as low as possible, a connection between logic ground and HV-ground is recommended. The ground to ground connection should be kept very short. In a floating set-up, the ground points may be coupled by a capacitor Cc.

CONNECTION AND OPERATION

Some examples of connection are shown in Fig. 2, 3 and 6. The control side is connected by use of the seven outer pins. Pin 1 is the trigger input. Whenever possible, the leads to input should be shielded and terminated properly, e. g. with 50 Ohms. Pin 2 is the ground of the trigger input and pin 4 the ground for the 5 VDC supply. The positive 5 VDC supply is connected to pin 3. A tantalium capacitor of approx. 10 µF between pin 3 and pin 4 is necessary for decoupling. To ensure a stable operation, trigger sources with an output level of more than 3 VDC are recommended. The auxiliary voltage should be well stabilized at 5,00 VDC, higher values than 5,25 VDC or a false polarity can destroy the switch. The current should therefore be limited to less than 1 ADC by the power supply.

The unit contains a DC-DC converter, which generates two auxiliary voltages for switch driving. Above a continuous frequency of 10 kHz, these voltages must be supplied by an external power supply with 50 mA current limitation. In such case pin 5 is connected to 22 VDC and pin 7 to 380 VDC (±1%). When high frequency bursts (above 10 kHz) are produced, buffer capacitors at pin 5 and pin 7 must be used. The capacitors should have such values, that the voltages at pin 5 and pin 7 can not drop below 90 % of their nominal value at each end of burst. This must be verified by an oscilloscope before high voltage will be applied. For example, if a burst of 1 MHz with 1000 pulses is generated, the capacitor at pin 7 should be at least 10 µF/400VDC and 100 µF/25VDC at pin 5.

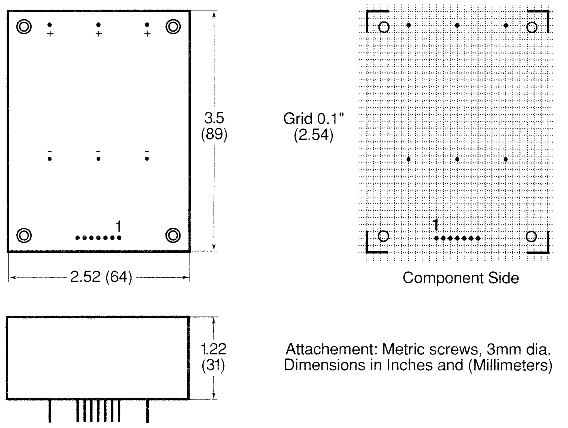


Fig. 1: Case Style

Three pins in the middle of the unit are used as minus pole and the other three pins as plus pole of switch. To achieve shortest turn-on rise times, the stray capacitances and lead inductances must be reduced to a minimum. This is done by keeping the wiring short. The tracks of PCB layout should be kept as wide as possible in order to obtain a low stray inductance. For the same reason, all three pins of each HV-pole should be connected together. If the switch turns off after conducting a large current, self-induced overvoltage transients may appear across long leads and can destroy the switch. If overvoltage transients can not be avoided by a low inductance design or by limiting the load current, a proper clamping device (e. g. a RC-snubber) must be connected, physically as close as possible to the switch terminals.

Because of the fixed on-time of 150 ns, the load capacitance should be not greater than 3 nF. The displacement current of a large load capacitance (>100 pF) should be limited to the specified maximum peak current $I_{P(max)}$ by a series resistor R_S. Its minimum resistance is calculated by

(1) $$R_S = (V_O/I_P)-R_{stat}$$

where V_O is the operating voltage, I_P is the max. peak current and R_{stat} the static on-resistance. If coaxial cables for pulse transmission are used, a series resistor of 25 to 75 Ohm should match the impedance difference between cable and switch.

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The turn-off rise time depends essentially on the switched-off current and the time constant $C_L \cdot R_L$. The minimum value of R_L is determined by the maximum peak current, the operating voltage and the possibly connected load capacitance. Operating voltage, R_L and C_L must be chosen carefully, so that the maximum continuous power dissipation $P_{d(max)}$ will not be exceeded. Due to the fast switching of HTS-switches, switching losses are negligible in most applications. The power disspation P_d for resistive loads can therefore be approximately calculated by

(2)
$$P_d = \frac{R_{stat} \cdot I_L^2 \cdot t_{on}}{T}$$

where I_L is the load current, t_{on} the pulse duration (on-time), T the pulse spacing and R_{stat} the static on-resistance, which depends on the load current (see data table). If a circuitry according to Fig. 2 is used, the power dissipation P_d caused by the additional load capacitance is given approximately by

(3)
$$P_d = \frac{R_{stat} \cdot (V_C/R_S)^2 \cdot R_S \cdot C_L}{T}$$

where V_C is the capacitor voltage, R_S the series resistance (1), C_L the load capacitance and T the pulse spacing. R_L will usually be several orders of magnitude higher than R_S, so that the current I_L trough R_L can be neglected. If lower values of R_L are required, the additional power dissipation caused by R_L (2) must be taken into account.

The switch may be floated at a high potential, if the sum of switching voltage and floating voltage does not exceed the specified isolation voltage.

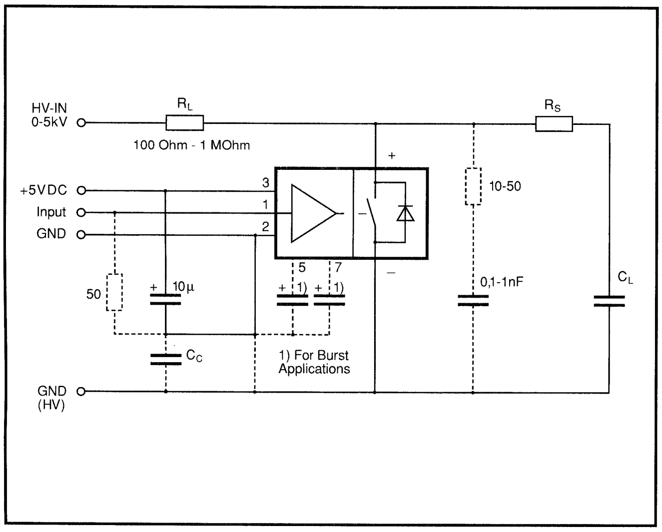

Fig. 2a: Example of Connection

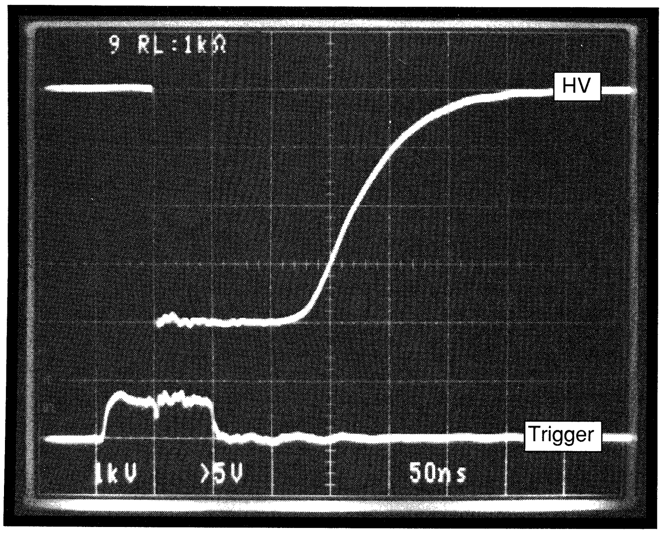

Fig. 2b: Pulse Shape, R_L= 1kOhm; C_L= 30pF; 1kV/div.

ATTACHEMENT

The HTS 50-12 has been designed to mount on printed boards. The module is attached by use of the thread holes at the lower surface. For security reasons, 3 mm plastic screws are recommended. HTS-switches can cause electromagnetic interferences which must be reduced by a shielded housing. The distance between metal housing, metallic parts and switch should not be less than 5 mm, otherwise HV-insulation must be provided.

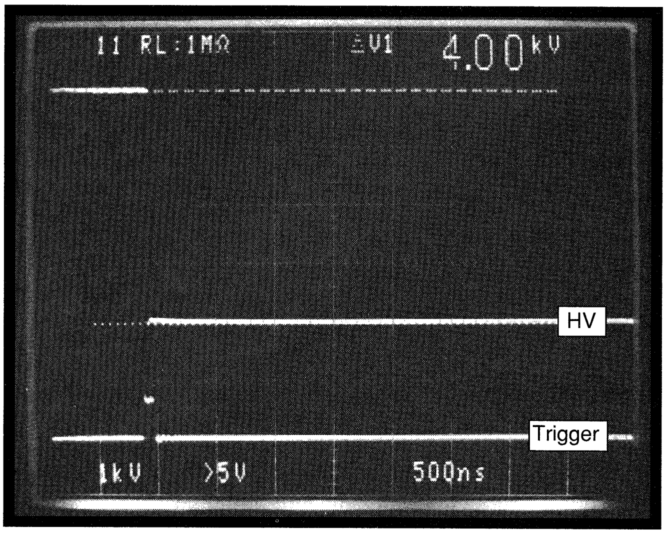

Fig. 2c: Pulse Shape, R_L= 1MOhm; C_L= 30pF; 1kV/div.

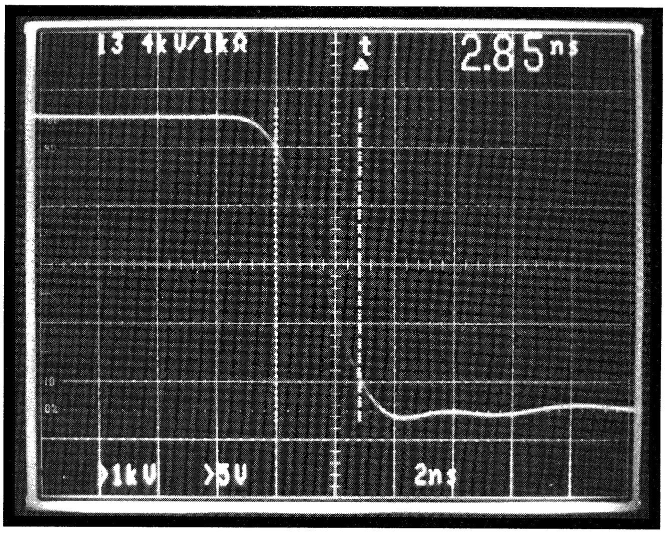

Fig. 2d: Transition Time, R_L=1kOhm; C_L=30pF; V_{in}=4kV, 2 ns/div

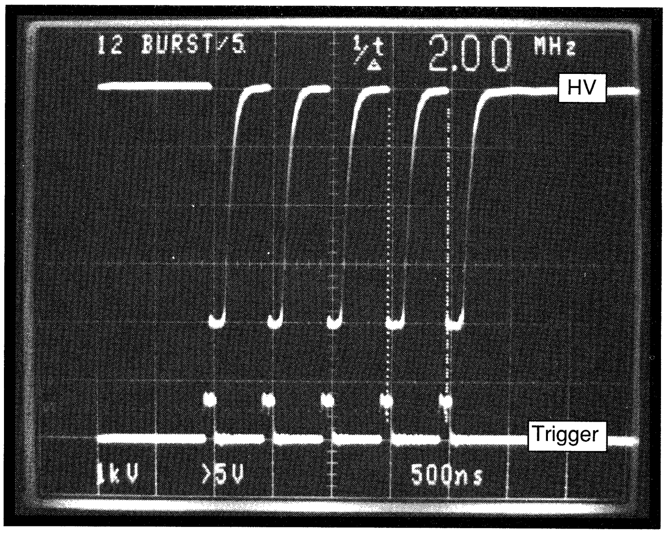

Fig. 2e: 2 MHz-Burst, R_L= 1kOhm; 1kV/div.

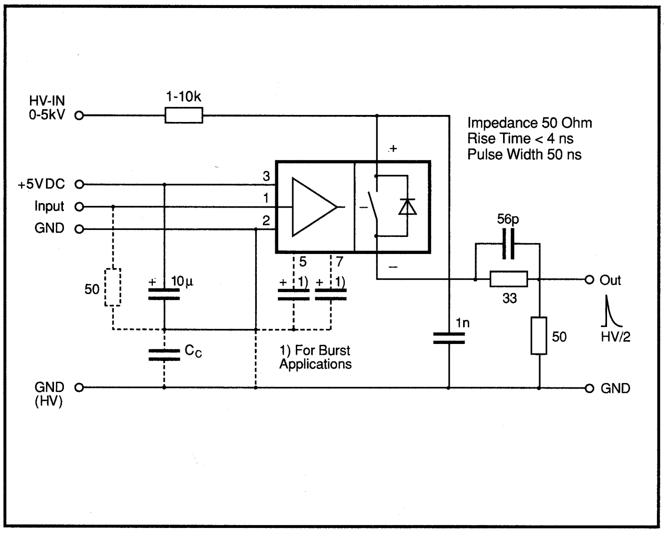

Fig. 3a: Pip Pulse Generator

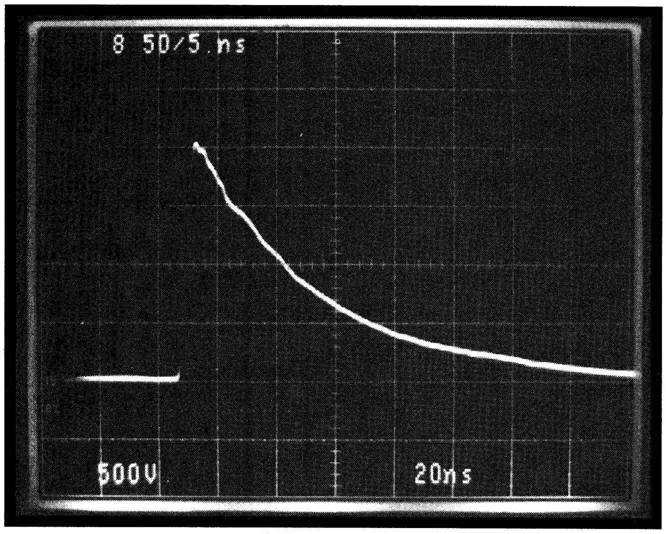

Fig. 3b: Pip Pulse, V_{in}=4kV, 500/div.

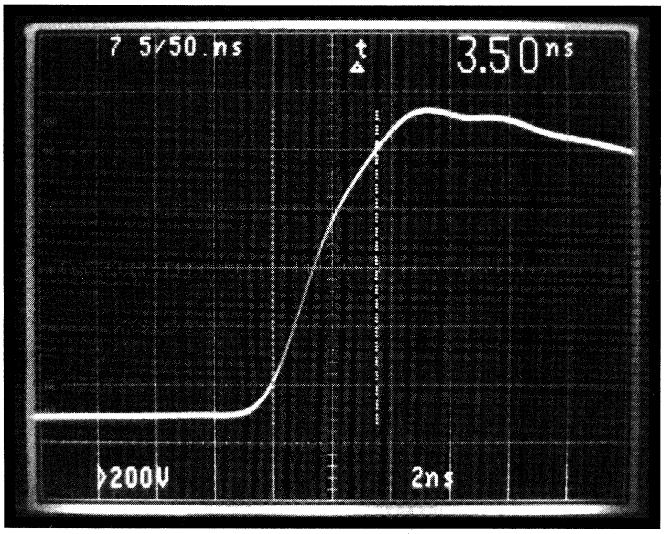

Fig. 3c: Pip Pulse, V_{in}=4kV, 2ns/div.

PRECAUTIONS

- **Do not exceed the max. operating voltage**
- **Do not connect unclamped inductive loads**
- **Avoid oscillations, flyback voltages, ringing, short circuits and spark overs**
- **Check untested circuits first at lower voltages on wild oscillations, ringing and flyback voltages**
- **Verify switch temperature in a untested set-up**
- **Limit the aux. supply current to less than one ampere**
- **Use a shielded housing during operation**
- **Do not use metallic parts for switch attachment**

DANGER - NEVER TOUCH THE SWITCH UNDER OPERATION

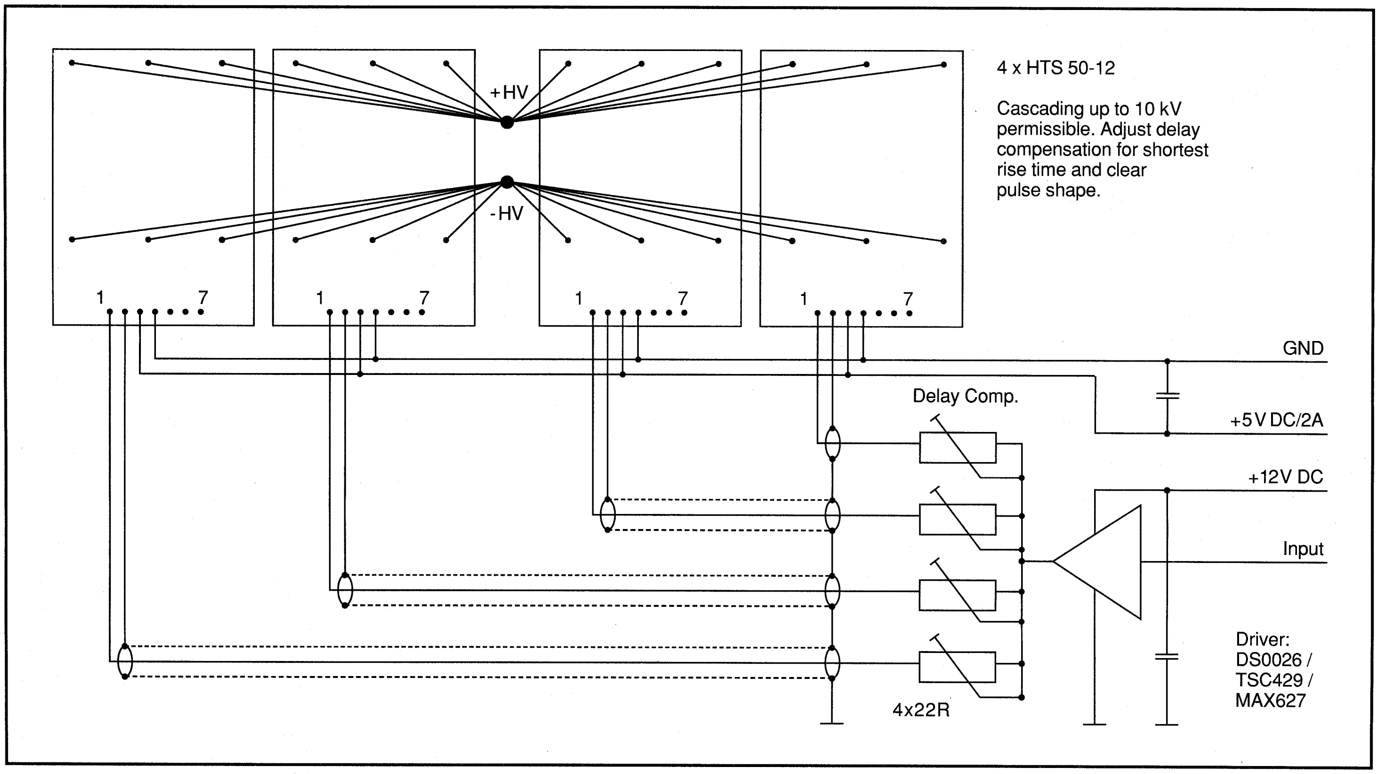

Fig. 4: Paralleling HTS 50-12

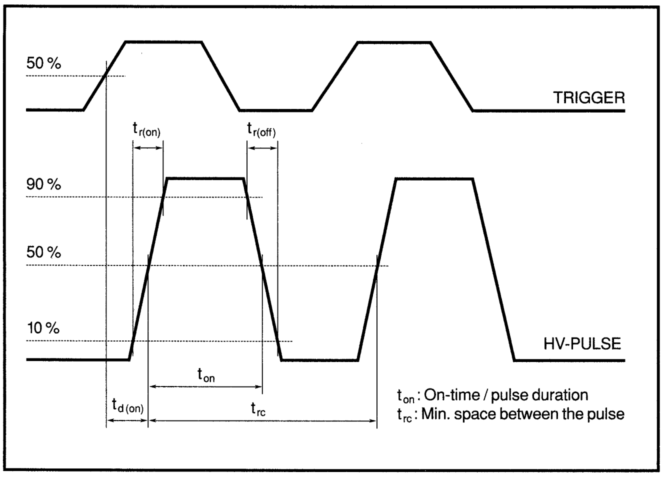

Fig. 5: Definition of pulse parameters

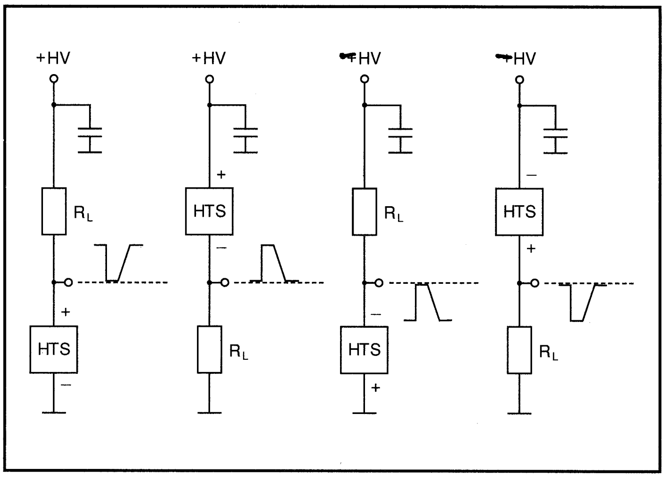

Fig. 6: Basic Circuit Configurations

SPECIFICATION	SYMBOL	TEST CONDITION	VALUE	UNIT
Operating Voltage Range	V_O	$I_{(off)} \le 100\ \mu A$	0-5.000	VDC
Isolation Strength	V_I	Against control side	10.000	VDC
Max. Peak Current	I_P	$t_p = 50$ ns	120	
		Non-repetitive	160	ADC
Current Change Rate	di/dt	Optimized PCB-design	≥ 10	A/ns
Static On-Resistance	R_{stat}	$I_L \le 20$ ADC, $T_{case} = 25\,^{\circ}C$	1.7	
		$I_L = 120$ ADC, $T_{case} = 25\,^{\circ}C$	3.5	Ohm
Off-State Current	$I_{(off)}$	0,8 x V_O	≤ 10	µADC
Turn-On Delay Time	$t_{d(on)}$	$R_L = 100\,\Omega$, $C_L = 30$pF, $V_O = 4$kV	50	ns
Turn-On Rise Time	$t_{r(on)}$	$R_L = 100\,\Omega$, $C_L = 30$pF, $V_O = 4$kV	4	
		$R_L = 2k\Omega$, $C_L = 30$pF, $V_O = 4$kV	2.5	
		$R_L = 2k\Omega$, $C_L = 60$pF, $V_O = 4$kV	5.5	
		$R_L = 2k\Omega$, $C_L = 1$nF, $V_O = 4$kV	30	ns
Turn-Off Rise Time	$t_{r(off)}$	$R_L = 100\,\Omega$, $C_L = 10$pF, $V_O = 4$kV	15	ns
		$R_L = 1M\Omega$, $C_L = 10$pF, $V_O = 4$kV	100	µs
Turn-On Jitter	$t_{j(on)}$	10µF between +5VDC/GND	≤ 100	ps
On-Time	t_{on}	Fixed, ±15%	150	ns
Recovery Time	t_{rc}	Resistive load	500	ns
Max. Continuous Frequency	$f_{c(max)}$	Internal 22/380 VDC supply	15	
		External 22/380 VDC supply	50	kHz
Max. Burst Frequency	$f_{b(max)}$	External puffer capacitors at pin 5 and 7	2	MHz
Max. Continuous Power Dissipation	$P_{d(max)}$	Tcase ≤ 25 °C	25	Watts
Derating		Above 25 °C	0.3	W/°C
Operation Temperature Range	T_O		-10...60	°C
Aux. Supply Voltage Range	V_{aux}		4.75...5.25	VDC
Aux. Supply Current	V_{aux}	At $f_{c(max)}$	0.4	ADC
Trigger Pulse Amplitude	V_t		3...20	VDC
Trigger Pulse Width	t_{tw}		0.2...20	µs
Trigger Pulse Rise Time	t_{tr}		≤ 20	ns
Input Capacitance	C_{in}		100	pF
Dimensions			89 x 63 x 31	mm^3
Weight			400	g

Custom designed devices on request.

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