

# FAST HIGH VOLTAGE TRANSISTOR SWITCHES

The switching modules of the series HTS-GSM consist of two identical MOSFET switching paths that form a so-called half bridge circuit respectively push-pull circuit. Both switching paths are controlled by a common driver, which also provides a logic signal negation for one of the switches. The switches are mutually passively locked, so that a short in the bridge is excluded under all circumstances, including if the control input is disturbed by electromagnetic interferences (due to bad EMC design, for example). Especially in pulse generator applications with capacitive load, the push-pull principle has considerable advantages in comparison with the conventional circuitry using a single-switch with a working resistor. Push-pull circuits do not require large energy storage capacitors for a low pulse drop and, because there are no working resistor power losses, the efficiency of a push-pull pulser is excellent regardless of pulse width, frequency and duty cycle. The pulsers draw only currents for charging the connected load capacitance. Thanks to an extremely precise timing of the switches, there are also almost no cross currents in the bridge, except peak charging currents of the switch natural capacitances.

The switches are controlled by positive going signals of 3 to 10 Volts amplitude. Fault conditions as overfrequency, thermal overload (long-term overload) and incorrect auxiliary supply set the switching path A in off-state and the switching path B in on-state. Faults are indicated as an "L" signal at the fault signal output. Without 5VDC supply, both switching paths (A and B) are in off-state. That implies, without 5VDC the output potential could be undefined if the HV is still applied. To ensure a defined high voltage output potential in such cases, pull-up or pull-down resistors must be connected to the output. For further design recommendations, please refer to the general instructions.

**HTS 111-06-GSM** 2x 11kV / 60A

**HTS 201-03-GSM** 2x 20kV / 30A



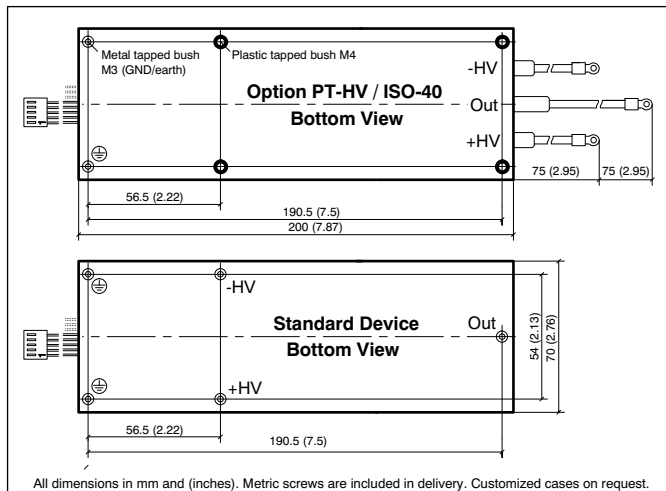
**HTS 201-03-GSM**  
with option CF & HFS

**MOSFET  
TECHNOLOGY**

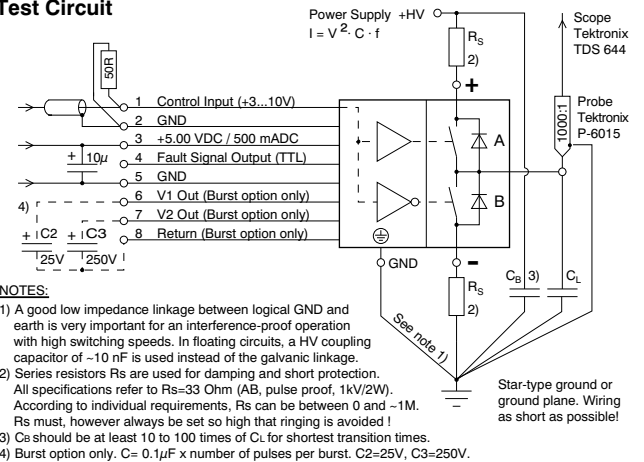
- Highly reliable half-bridge
- Very low crossover current
- Rise time and fall time ~20 ns
- Variable pulse width: 150 ns to infinity
- Excellent pulse top flatness, no ripple
- Various liquid and air cooling options

**PUSH-PULL**

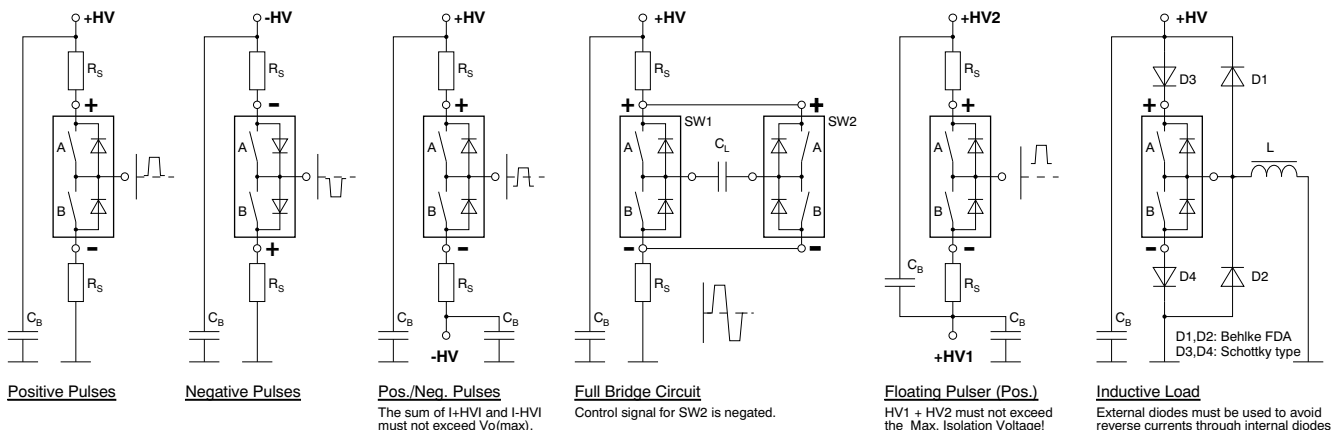
Made in Germany



## Test Circuit



## Basic Circuits



# TECHNICAL DATA

	Specification	Symbol	Condition / Comment	HTS 111-06-GSM	HTS 201-03-GSM	Unit	
<b>ABSOLUTE MAXIMUM RATINGS</b>	Maximum Operating Voltage	$V_{O(max)}$	$I_{off} < 10 \mu ADC$ , full temperature range, both switching paths, one pole grounded	$\pm 11000$	$\pm 20000$	VDC	
	Maximum Galvanic Isolation Voltage	$V_{I(max)}$	Continuously, between control circuit and switching paths HV terminals at bottom (Standard) HV pigtailed at front, Option ISO-40 HV pigtailed at front, Option ISO-80	$\pm 25000$ $\pm 40000$ $\pm 80000$		VDC	
	Maximum Peak Current <sup>5)</sup>	$I_{P(max)}$	$T_{case} = 25^\circ C$	$t_p < 10 \mu s$ , duty cycle $< 1\%$	60	30	ADC
	Maximum Continuous Load Current	$I_{L(max)}$	Each switching path $T_{case} = 25^\circ C$	Standard plastic case, (forced air $> 4m/s$ ) Option CF, cooling fins, (forced air $> 4m/s$ ) <sup>1)</sup> Option DLC or DLC-ISO (1 litre / min) <sup>2)</sup>	0.69 2.67 3.09	0.33 1.29 1.49	ADC
	Maximum Continuous Power Dissipation	$P_{d(max)}$	Both switching paths $T_{case} = 25^\circ C$	Standard plastic case, (forced air $> 4m/s$ ) Option CF, cooling fins, (forced air $> 4m/s$ ) <sup>1)</sup> Option DLC or DLC-ISO (1 litre / min) <sup>2)</sup>	20 300 400		Watts
	Linear Derating		Both switching paths $T_{case} = 25^\circ C$	Standard plastic case, (forced air $> 4m/s$ ) Option CF, cooling fins, (forced air $> 4m/s$ ) <sup>1)</sup> Option DLC or DLC-ISO (1 litre / min) <sup>2)</sup>	0.44 6.66 8.88		W/K
	Maximum Auxilliary Voltage	$V_{aux(max)}$	Built-in overvoltage limiter (replaceable)		5.25		VDC
<b>ELECTRICAL CHARACTERISTICS</b>	Permissible Operating Voltage Range	$V_o$	Unipolar operation (one switch pole grounded or floated on same polarity) Bipolar operation (positive & negative voltages symmetrically applied)	$0... \pm 11000$ $0... \pm 5500$	$0... \pm 20000$ $0... \pm 10000$	VDC	
	Typical Breakdown Voltage	$V_{br}$	$I_{off} > 1 mADC$ , $T_{case} = 70^\circ C$ . Parameter is for quality testing purposes only!		$\pm 13000$	$\pm 25000$	VDC
	Maximum Off-State Current	$I_{off}$	$0.8 \times V_o$ , $T_{case} = 25...70^\circ C$ , reduced $I_{off}$ on request		10		$\mu ADC$
	Typical Static On-Resistance	$R_{stat}$	Each switching path $T_{case} = 25^\circ C$	$0.8 \times I_{P(max)}$ $1.0 \times I_{P(max)}$	10 21	43 90	$\Omega$
	Typical Capacitive Power Dissipation of Switch (Natural Power Dissipation)	$P_{dc}$	Switch capacitances only – without external load and parasitic capacitances! The total capacitive power dissipation is determined by the equation $P_{dc(tot)} = V^2 \times C_{tot} \times f$	$0.8 \times V_{O(max)}$ , $f = 10 Hz$ $0.8 \times V_{O(max)}$ , $f = 100 Hz$ $0.8 \times V_{O(max)}$ , $f = 1000 Hz$ $0.8 \times V_{O(max)}$ , $f = 10000 Hz$	0.046 0.46 4.6 46	0.154 1.54 15.4 154	Watts
	Typical Output Transition Time (Rise Time & Fall Time)	$t_r, t_f$	Standard device $0.8 \times V_o$ 10-90%	$R_s = 33\Omega$ , $C_L = 10pF$ $R_s = 33\Omega$ , $C_L = 50pF$ $R_s = 33\Omega$ , $C_L = 100pF$ $R_s = 33\Omega$ , $C_L = 200pF$ $R_s = 22\Omega$ , $C_L = 1000pF$ Option S-TT, $R_s = 33\Omega$ , $C_L = 10pF$	7 9 12 19 55 30	14 18 26 45 80 35	ns
	Propagation Delay Time	$t_d$	Resistive load, shorter delay available on request		150		ns
	Minimum Output Pulse Width	$t_{p(min)}$	Reduced minimum output pulse width available on request		150		ns
	Maximum Output Pulse Width	$t_{p(max)}$	No limitation		$\infty$		s
	Minimum Pulse Spacing	$t_{ps(min)}$	(Switch recovery time)		300		ns
	Typical Output Pulse Jitter	$t_j$	$V_{aux} = 5.0 VDC$ $V_{tr} = 5.0 VDC$	Fixed switching frequency, $> 2kHz$ Swept frequency, $< 2kHz$	0.1 2		ns
	Maximum Continuous Switching Frequency <sup>3)</sup>	$f_{(max)}$	$T_{case} = 25^\circ C$ High switching frequencies require sufficient cooling methods!	Standard version Option HFS Options HFS+DLC or CF+CF-DR	5 100 200		kHz
	Maximum Burst Frequency	$f_{b(max)}$	Use option HFB for $> 10$ pulses within $20\mu s$ or less		3.3		MHz
	Operating Temperature Range	$T_o$	Extended temperature range on request		$-40 \dots 70$		$^\circ C$
	Storage Temperature Range	$T_{ST}$			$-50 \dots 100$		$^\circ C$
	Typical Natural Capacitance of Switch	$C_N$	Capacitance of one switch path	$0.1 \times V_{O(max)}$ $0.8 \times V_{O(max)}$	$< 90$ $< 30$		pF
	Typical Coupling Capacitance	$C_C$	Both switches against ground, respectively, control circuit		$< 30$		pF
	Typical Reverse Recovery Time of Intrinsic Diodes	$t_{rrc}$	Repetitive forward current through the diodes (current reversal) may damage the switch. Please refer to note 4)	$I_f = 2A$ $di/dt = 100A/\mu s$	$< 1$		$\mu s$
	Auxiliary Supply Voltage Range	$V_{aux}$	5.00 V $\pm 2\%$ recommended		4.75... 5.25		VDC
	Auxiliary Supply Current	$I_{aux}$	(1000 mA current limitation recommended)	$f < 500 Hz$ $f = 5 kHz$	$< 400$ $< 700$		mADC
Control Signal	$V_{tr}$	$> 3VDC$ recommended for low jitter		3...10		VDC	
Fault Signal Output		Switch will be turned off, if $f > f_{(max)}$ , $V_{aux} < 4.75V$ or $T_{case} > 75^\circ C$ Fault condition is indicated by a logical "L"	Ready = "H" Fault = "L"	$\geq 4.0$ $\leq 0.8$		VDC	
<b>GENERAL</b>	Dimensions	$L \times W \times H$	Standard plastic case (HV terminals at bottom) Option DLC or DLC-ISO (HV terminals on top) Option CF (HV terminals at bottom)	200 x 70 x 28 200 x 70 x 35 200 x 70 x 89		mm <sup>3</sup>	
	Weight		Standard plastic case Option DLC or DLC-ISO Option CF	$< 750g$ $< 900g$ $< 1100g$		g	

- 1) Switches with cooling fins can also be immersed in non-conductive cooling liquids (e.g. GALDEN). Depending on the liquid characteristics, flow rate and temperature, a  $P_{d(max)}$  of up to 1200 Watts can be achieved with standard cooling fins.
- 2) The specifications for option DLC and DLC-ISO refer to the standard housing dimensions. Customized liquid cooling options for up to 3000 Watts power dissipation are available in larger housings. Please consult factory.
- 3) The  $f_{(max)}$  parameter specifies the driver capability only. The maximum switching frequency of switch is limited by  $P_{d(max)}$  restrictions, depending on the individual switch configuration & cooling option. Please consult factory.
- 4) The intrinsic diodes must not be used in normal operation. High stray inductances or inductive load requires a fast free-wheeling diode network (series & parallel diode) or sufficient damping resistors in series to the HV inputs.
- 5) Current limiting resistors are not required at moderate capacitive load ( $C_L < 10 nF$ ). Nevertheless, series resistors ( $R_S$ ), in the order of 10 to 100  $\Omega$ , may be required for damping purposes (avoidance of pulse overshoot & undershoot).

## Ordering Information

<b>HTS 111-06-GSM</b>	11kV Push-pull transistor switch	<b>Option CF</b>	Cooling fins, non isolated. Fins must not be shorted or grounded
<b>HTS 201-03-GSM</b>	20kV Push-pull transistor switch	<b>Option GCF</b>	Grounded cooling flange for heat sink assembly. $R_{th} < 0.15 K/W$
<b>Option HFB</b>	High frequency burst	<b>Option DLC</b>	Direct liquid cooling for non-conductive liquids (e.g. GALDEN)
<b>Option HFS</b>	High frequency switching	<b>Option DLC-ISO</b>	Direct liquid cooling for conductive liquids (e.g. mains water)
<b>Option S-TT</b>	Soft Transition Time	<b>Option ISO-40</b>	40kV isolation, HV pigtailed on the front side of housing
<b>Option SPT-C</b>	Shielded input cable with LEMO plug	<b>Option ISO-80</b>	80kV isolation, HV pigtailed on the front side, enlarged housing

For further options, please refer to **survey C8** of catalog. Detailed data and mechanical drawings are available on request. All data and specifications subject to change without notice.