

# FAST HIGH VOLTAGE TRANSISTOR SWITCHES

This new generation of BEHLKE high voltage switching modules utilize an advanced MOSFET technology with very low on-resistance, the so called Trench FET technology. The switching speed of those modern FET is slightly slower than that of a classical power FET, but is still much faster than that of any IGBT, which is preferably used to achieve low turn-on losses. The new MOSFET switches of series HTS-B combine very low dynamic switching losses with moderate turn-on losses and are a serious alternative to IGBT switches. Another important advantage compared to the fault sensitive IGBT is the positive temperature coefficient of the on-resistance, which makes the switch short circuit proof within the thermal limits. Furthermore overvoltage transients as well as voltage reversal respectively current reversal is less dangerous to MOSFET's than to IGBT's. Insofar these switching modules are well suitable for applications with high demands on operational safety even under worst conditions.

The switching modules incorporate all features of the well known HTS switch family: Easy handling, high reliability, low jitter and reproducible switching behaviour.

The switch is turned on by a positive going signal of 3 to 6 volts amplitude, provided the auxiliary power supply is permanently connected to the +5.00 VDC input. The on-time may simply be varied between 250 ns and infinity by the input control pulse width. An interference-proof driver circuit provides signal conditioning, auxiliary voltage monitoring, frequency limitation and temperature protection. In case of any false operating condition the switches turn off immediately and a fault signal is generated (TTL level). The high frequency burst operation (>10 pulses/100µs) requires the option HFB (connection of external buffer capacitors at the driver). For operation at higher frequencies than specified under  $f_{(max)}$  the option HFS must be used. In that case an internal DC/DC converter must be supported by an external supply of +250 VDC to +350 VDC ( $\pm 5\%$ , approx. 2-10 Watts depending on switching frequency and type of switching module).

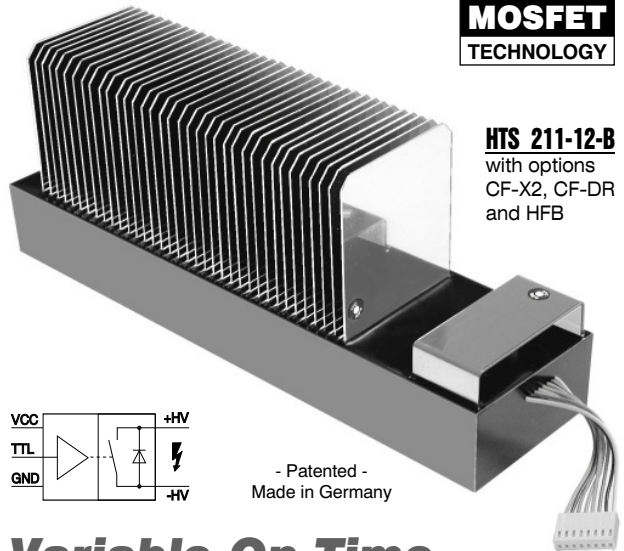
Due to the high galvanic isolation the switches may simply be operated also in floating set-up's or in high-side circuits. Several housing options are available to meet individual constructional and power requirements. The standard plastic housing is used in low frequency applications with low average power dissipation. The plastic modules can additionally be fitted with non-isolated cooling fins (available as options CF, CF-X2 and CF-X3), which improves the max. Continuous Power Dissipation  $P_{d(max)}$  by approx. factor 10 with forced air (>4m/s) or by factor 50, if the switching modules are immersed in isolating cooling liquids (e.g. GALDEN HT135, flow rate >0.1m/s, standard cooling fins). Another cooling method is given by the use of the grounded cooling flange (option GCF and GCF-X2). In conjunction with an optional water cooling plate or any other high performance heatsink, maximum power dissipations in the range of 2 to 6 kW are possible, with larger customized cooling flanges even up to 10 kW.

The modules can be installed on a printed circuit board, but if operated under air conditions, the use of option PT-HV (pigtailed for HV connection) is recommended, in order to ensure a sufficient creepage distance according to industrial standards. For detailed design recommendations please refer to the general instructions for use.

**HTS 151-12-B** 15 kV / 125 A  
**HTS 181-12-B** 18 kV / 125 A  
**HTS 211-12-B** 21kV / 125 A

**MOSFET  
TECHNOLOGY**

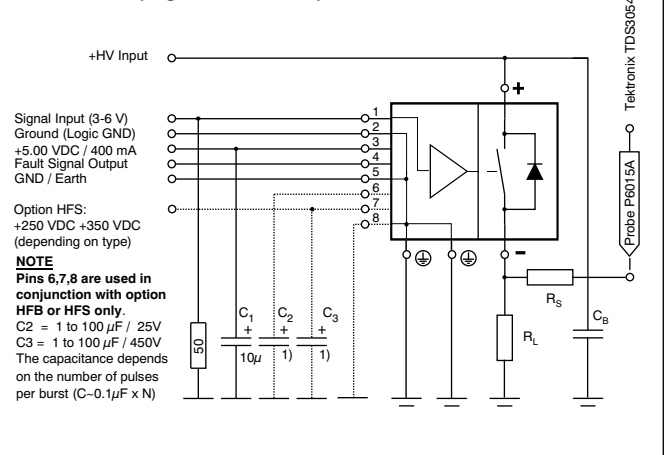
**HTS 211-12-B**  
with options  
CF-X2, CF-DR  
and HFB



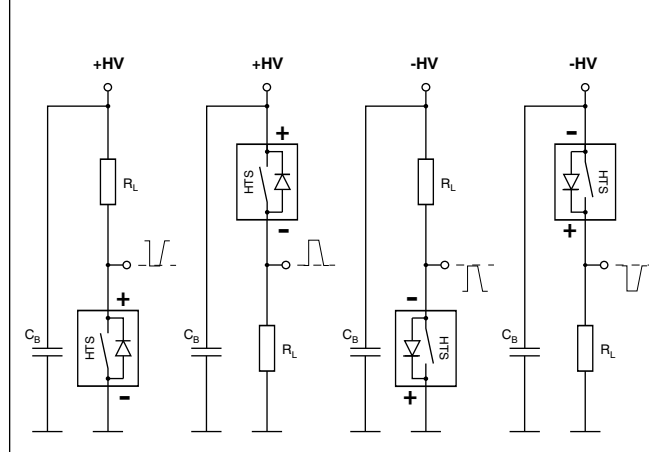
- Patented -  
Made in Germany

**Variable On-Time**  
**Very Low On-Resistance**

## Test Circuit (High-Side Switch)

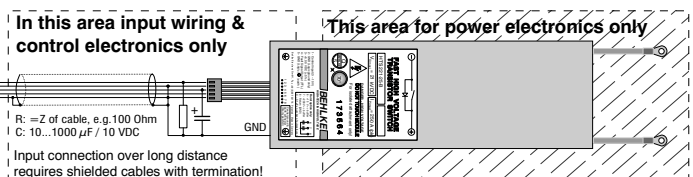


## Basic Circuits



## Important EMC Design Hints

- Keep the wiring as short as possible and avoid large induction loop areas of the peak current carrying lines; the forward and return lines should be installed as closely as possible together. **Control and power circuit must not be mixed. Always keep the transformer principle in mind!**
- Use shielded leads at the control side to minimize noise induction. Low impedance drivers with 5 Volt output swing (into 50 Ohm) are required for driving long pulse transmission lines. Signal transmission lines must be terminated properly (e.g. by 50 Ohm). The auxiliary power supply must be well decoupled by a sufficient buffer capacitor.
- This high speed switching module can generate extreme di/dt's and dv/dt's. Therefore it is not useful to operate the switch and its peripheral components without a shielded housing. Other electronics including power supplies (!) may be disturbed. Please note your local EMC / EMI regulations. Please also see our option offers for possible EMC / EMI relevant modifications.



# TECHNICAL DATA

Specification	Symb.	Condition / Comment	HTS:	151-12-B	181-12-B	211-12-B	Unit
Maximum Operating Voltage	$V_{O(max)}$	$I_{off} < 60 \mu ADC$		15	18	21.6	kVDC
Minimum Operating Voltage	$V_{O(min)}$	Increased $t_{r(on)}$ and $t_{r(off)}$ below $0.1 \times V_{O(max)}$			0		kVDC
Typical Breakdown Voltage	$V_{br}$	$I_{off} > 1mADC, T_{case} = 75^\circ C$		15.7	18.9	22.7	kVDC
Galvanic Isolation	$V_I$	Continuously Standard housing / PCB attachment Option PT-HV, pigtailed for HV Option PT-HV + Option ISO-80 1)			25 40 80		kVDC
Maximum Peak Current	$I_{P(max)}$	$T_{case} = 25^\circ C$ $T_{fin} = 75^\circ C^*$ *measured at base $t_p < 100 \mu s$ , duty cycle $< 1\%$ $t_p < 1 ms$ , duty cycle $< 10\%$ $t_p < 10 ms$ , duty cycle $< 10\%$			125 67 52		ADC
Maximum Continuous Load Current	$I_L$	$T_{case} = 25^\circ C$ $T_{flange} = 25^\circ C$ $T_{fin} = 75^\circ C^*$ *measured at base Standard plastic case Option CF, fins in air $> 4m/s$ Option CF, in Galden® $> 0.1m/s$ Opt. GCF, grounded cooling flange			3 10 12.9 20.4		ADC
Static On-Resistance	$R_{stat}$	$T_{case} = 25^\circ C$ $0.1 \times I_{P(max)}$ $1.0 \times I_{P(max)}$		2.4 6	3 7.4	3.4 8.6	$\Omega$
Maximum Off-State Current	$I_{off}$	$0.8 \times V_O, T_{case} = 75^\circ C, < 5\mu A$ leakage optionally available			50		$\mu ADC$
Turn-On Delay Time	$t_{d(on)}$	@ $I_{P(max)}$		170	180	200	ns
Typical Turn-On Rise Time	$t_{r(on)}$	$0.1 \times V_O, 0.1 \times I_{P(max)}$ $0.5 \times V_O, 0.1 \times I_{P(max)}$ $0.8 \times V_O, 0.1 \times I_{P(max)}$ $0.8 \times V_O, 1.0 \times I_{P(max)}$		12 15 22 47	13 18 26 51	13 20 31 56	ns
Typical Turn-Off Rise Time	$t_{r(off)}$	$0.8 \times V_O, 0.1 \times I_{P(max)}$ , resistive load, 10-90%			60		ns
Minimum On-Time	$t_{on(min)}$	Lower $t_{on(min)}$ on request			200		ns
Maximum On-Time	$t_{on(max)}$	Please note possible $P_{d(max)}$ limitations			$\infty$		
Switch Recovery Time	$t_{rc}$	$t_{rc}$ = minimum pulse spacing			500		ns
Typical Turn-On Jitter	$t_{j(on)}$	$V_{aux} / V_{tr} = 5.0 VDC$ , fixed switching frequency			500		ps
Max. Switching Frequency	$f_{(max)}$	$T_{case} = 25^\circ C$ Standard, safety turn-off @ $1.5 \times f_{(max)}$ Option HFS, please consult factory		2 max. 80	1.8 max. 80	1.5 max. 80	kHz
Maximum Burst Frequency	$f_{b(max)}$	Use option HFB for $> 5$ pulses within 100 $\mu s$			2		MHz
Maximum Continuous Power Dissipation	$P_{d(max)}$	$T_{case} = 25^\circ C$ $T_{flange} = 25^\circ C$ $T_{fin} = 75^\circ C^*$ *measured at base Standard plastic case incl. option FC Option CF, fins in air $> 4m/s$ Option CF, in Galden® $> 0.1m/s$ Opt. GCF, grounded cooling flange		22 240 1000 2500	26 288 1200 3000	32 346 1440 3600	Watts
Linear Derating		$T_{case} = 25^\circ C$ $T_{flange} = 25^\circ C$ $T_{fin} = 75^\circ C^*$ *measured at base Standard plastic case incl. option FC Option CF, fins in air $> 4m/s$ Option CF, in Galden® $> 0.1m/s$ Opt. GCF, grounded cooling flange		0.44 4.8 20 50	0.52 5.76 24 60	0.64 6.92 28.8 72	W/K
Operating Temperature Range	$T_O$	Extended range on request, safety turn-off @ $77^\circ C$			-40...75		$^\circ C$
Storage Temperature Range	$T_{ST}$				-50...90		$^\circ C$
Natural Capacitance	$C_N$	Capacitance between switch poles at $V_{O(max)}$		20	25	30	pF
Coupling Capacitance	$C_C$	HV side to control / GND Standard devices Opt. GCF, grounded cooling flange		39 239	47 287	56 344	pF
Diode Reverse Recovery Time	$t_{rrc}$	$I_F = 10 A, T_{case} = 25^\circ C$ MOSFET parasitic diode			500		ns
Diode Forward Voltage Drop	$V_F$	$I_F = 10 A, T_{case} = 25^\circ C$ MOSFET parasitic diode		27	41	53	VDC
Auxiliary Supply Voltage	$V_{aux}$	Stabilized to $\pm 2\%$ , safety turn-off below 4.75 VDC			5.0		VDC
Auxiliary Supply Current	$I_{aux}$	@ $f_{max}$			600		mADC
Control Signal Voltage	$V_{tr}$	$> 3VDC$ recommended			2-6		VDC
Fault Signal Output		TTL, short circuit proof, L=Fault (=safety turn-off)			H= 4 V, L= 0.5 V		VDC
Dimensions	LxWxH	Standard plastic case Option FC, flat case Option CF, non-isolated cooling fins, standard size Option GCF, grounded cooling flange 2)		212x70x35 212x70x19 212x70x70 252x120x45	263x70x35 263x70x19 263x70x70 312x120x45	263x70x35 263x70x19 263x70x70 312x120x45	mm <sup>3</sup>
Weight		Standard plastic case Option FC, flat case Option CF, non-isolated cooling fins, standard size Option GCF, grounded cooling flange 2)		750 440 1125 2700	1020 590 1560 3420	1050 610 1590 3450	g

Notes: 1) Not available in connection with Option GCF. 2) Also available in other sizes for higher or lower  $P_{d(max)}$ . Please consult factory.

## Ordering Information

**HTS 151-12-B** Transistor switch, 15 kVDC, 125 Amps.

**HTS 181-12-B** Transistor switch, 18 kVDC, 125 Amps.

**HTS 211-12-B** Transistor switch, 21 kVDC, 125 Amps.

**Option HFB** High frequency burst

**Option HFS** High frequency switching (pls. consult factory)

**Option LP** Low pass filter at control input

**Option S-TT** Soft transition time for simplified EMC design

**Option ISO-80** Increased isolation voltage, 80 kVDC isolation

**Option SPT-C** Shielded pigtail for control connection (LEMO miniature plug)

**Option PT-HV** Pigtailed for HV connection (instead of bottom screw terminals)

**Option UL-94** Flame-retardant casting resin according to UL94-V0

**Option FC** Flat plastic case, module height reduced to 19 mm

**Option CF** Non-isolated cooling fins, standard size, 35 mm height

**Option GCF** Grounded cooling flange, direct attachment to heat sink

Further data and mechanical drawings are available on request. All data and specifications subject to change without notice.