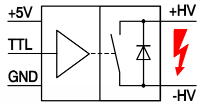
FAST HIGH VOLTAGE TRANSISTOR SWITCHES

HTS 31-06-C 3000 VDC, 64 Amps
HTS 61-03-C 6000 VDC, 32 Amps
HTS 71-02-C 7200 VDC, 25 Amps
HTS 91-02-C 9800 VDC, 20 Amps
HTS 121-01-C 12000 VDC, 15 Amps
HTS 181-01-C 18000 VDC, 12 Amps

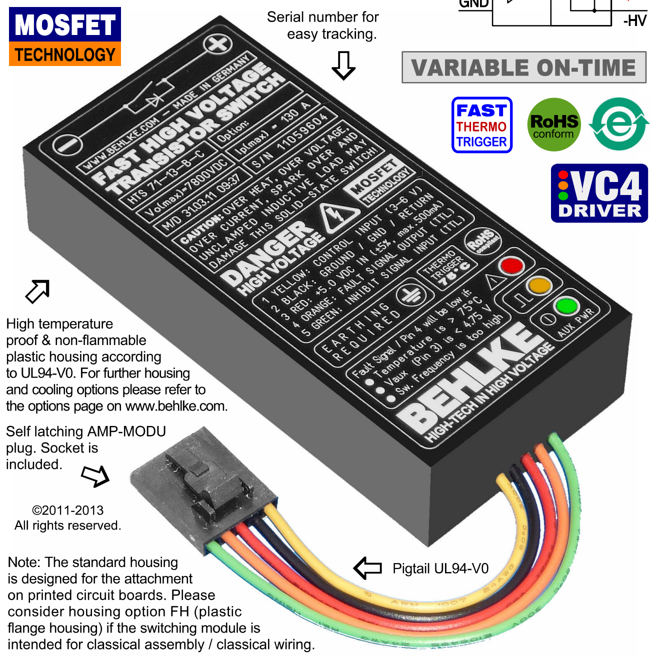
COMPACT SERIES
with low charge MOSFET



MOSFET TECHNOLOGY

VARIABLE ON-TIME

FAST THERMO TRIGGER · RoHS conform · VC4 DRIVER



6 MHz Burst • 3 MHz Rep. Rate
5 ns Rise Time • $t_{(on)}$=50 ns ... ∞

DESCRIPTION

The high-voltage switches of the compact series "HTS-C" have a variable on-time and are comparable with classical solid-state relays; they are turned on as long as a control signal is applied to the control input. BEHLKE solid-state switches are actively controlled devices (no avalanche technique) and show highly reliable and reproducible switching behaviour regardless of temperature, voltage or load condition. Compared to conventional high voltage switching elements, such as gas discharge tubes and spark gaps, BEHLKE solid-state switches do not show aging effects and achieve life times by several orders of magnitude higher than any other classical high voltage switch.

The switches are very easy to handle and only require a simple +5 VDC auxiliary supply (4.5 to 5.5 VDC) and a TTL-compatible control signal. The control signal can be any positive going pulse of at least 25 ns duration and 2 to 10 volts amplitude. Due to the Schmitt-Trigger input characteristics and the very high signal amplification neither the switching behavior nor the turn-on rise time will be influenced by the waveshape of the control pulse. The recovery time after a switching cycle is less than 150 ns, making burst frequencies of up to 6 MHz possible. Burst frequencies of even up to 10 MHz can be achieved by means of the option **HFB**. The maximum continuous switching frequency is primarily limited by the power capability of the internal driver and by the power dissipation of the high-voltage switch. Standard switches without optional cooling and without optional **HFS** supply can reach several 10 kHz, depending on operating voltage and load capacitance. Higher frequencies require an additional auxiliary supply for the internal driver, which is connected by means of the option **HFS**. The switch must also be sufficiently cooled if the frequency depending power dissipation exceeds the specified Pd(max) value. For the individual cooling requirements are various cooling features available, such as option **CCS** (ceramic cooling surface), **CF** (copper cooling fins), **CF-CER** (ceramic cooling fins), **GCF** (grounded cooling flange), **ILC** (indirect liquid cooling) or **DLC** (direct liquid cooling). In connection with option **DLC** the continuous switching frequency can be increased up to 3 MHz. Nevertheless, the switches of the compact series HTS-C are not primarily designed for high frequency operation and high average power dissipation. If these parameters are the main design concern, then the larger switching modules of the HTS standard series are recommended, which offer a significantly lower thermal resistance when combined with the cooling options mentioned above.

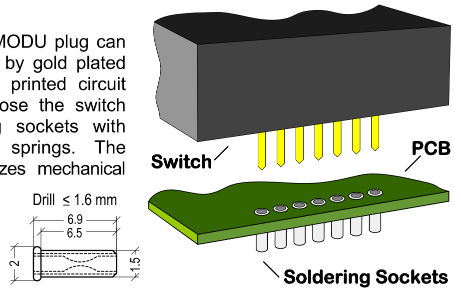
The switches are equipped with the new "intelligent" driving and control circuit VC4, which provides active input filtering, signal conditioning, auxiliary voltage monitoring, frequency limitation and temperature protection. The input filter allows an un-shielded input wiring of at least 25 cm (10") length. Undefined control signals, noise and transients are uncritical to the switch. The high-voltage MOSFET stack is always safely controlled regardless to the pulse width or waveshape of the control signal. The control circuit has 3 integrated temperature triggers. One thermotrigger with a response time of <60 seconds protects the high-voltage switch, two further sensors with <10 seconds response time are placed in the critical areas of the driver circuit. An inhibit input (pin 5, L=Inhibit) allows the connection of external thermotriggers, over current detectors and / or coolant flow detectors from liquid cooling systems. The operating conditions are indicated by three built-in LEDs. In case of a fault (auxiliary voltage < 4.5 VDC, frequency > f(max), case temperature > 75°C and / or Inhibit = Low), the red LED will indicate an error and the switch is inhibited for at least 2 seconds respectively for the duration of the fault condition. At the same time a TTL compatible fault signal occurs at pin 4 (Low = Fault). In case of over temperature the switch can be locked for several minutes, depending on the individual cooling conditions. A green LED indicates "Ready for Operation" and a yellow LED indicates the on-state of the switch as well as short control pulses with a pulse duration down to 30 ns. The design concept of these switching modules offers a large selection of cooling and housing options as well as a very high flexibility regarding the adaption to individual OEM requirements. Please refer to the separate options page for some examples of individual switch solutions.

CIRCUIT DESIGN RECOMMENDATIONS

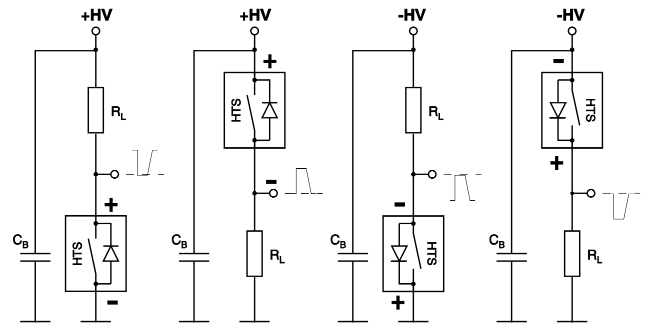
In order to achieve the minimum turn-on rise time and the best HV pulse shape, all leads and circuit paths should be of lowest possible inductance. This can be achieved by means of very wide and short circuit tracks on the printed circuit board, if necessary in several layers (multi layer PCB). Part components such as R_S, C_{BP} and C_B must be "inductance-free" and should only be connected with shortest possible wires / circuit tracks. Ground conducting tracks including the logic ground must be connected to a common ground point (star-type ground). Induction loop areas of dynamically current-carrying circuit paths should always be as small as possible. HV wiring and control circuitry should always be separated by a proper distance. For further design recommendations please refer to the general instructions.

Option PIN-C

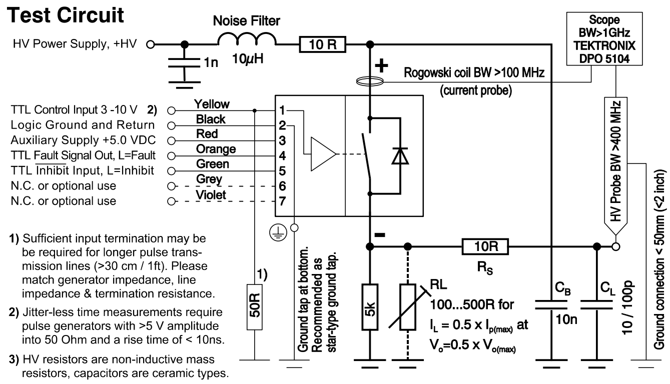
The pigtail with AMP-MODU plug can optionally be replaced by gold plated pins for plugging into printed circuit boards. For that purpose the switch comes with soldering sockets with gold plated contact springs. The plugging solution minimizes mechanical stress at temperature cycling and makes the module exchangeable. The contact pins must not be soldered directly.



Basic Circuits



Test Circuit



1) Sufficient input termination may be required for longer pulse transmission lines (>30 cm / 1ft). Please match generator impedance, line impedance & termination resistance.
2) Jitter-less time measurements require pulse generators with >5 V amplitude into 50 Ohm and a rise time of < 10ns.
3) HV resistors are non-inductive mass resistors, capacitors are ceramic types.

Specification	Symbol	Condition / Comment	HTS	31-06-C	61-03-C	71-02-C	91-02-C	121-01-C	181-01-C	Unit
ABSOLUTE MAXIMUM RATINGS										
Maximum Operating Voltage	$V_{O(max)}$	I_{off} < 50 µADC, T_{case} = 70°C		± 3.0	± 6.0	± 7.2	± 9.6	± 12.0	± 18.0	kVDC
Maximum Isolation Voltage	V_I	Between HV switch and control / GND, continuously		± 30						kVDC
Max. Housing Insulation Voltage	V_{INS}	Between switch and housing surface, 3 minutes		± 30						kVDC
Maximum Turn-On Peak Current	$I_{P(max)}$	T_{case} = 25°C	t_p< 200 µs, duty cycle <1%	64	32	25	20	15	12	ADC
Maximum Continuous Load Current	I_L	T_{case} = 25°C	Standard devices, forced air 4 m/s	1.25	1.12	0.75	0.51	0.38	0.36	
		T_{fin} = 25°C	Devices with option CF-LC, air 4 m/s	3.2	2.88	1.92	1.32	0.97	0.94	
		T_{flange} = 25°C	Devices with option GCF, on heat sink.	3.92	3.54	2.36	1.62	1.19	1.15	
		T_{inlet} = 25°C	Devices with option ILC, water 0.1 l/min.	3.92	3.54	2.36	1.62	1.19	1.15	
			Devices with option DLC-0.3	4.5	4.0	2.7	1.9	1.4	1.3	ADC
Max. Continuous Power Dissipation	$P_{d(max)}$	T_{case} = 25°C	Standard devices, forced air 4 m/s	10						
		T_{fin} = 25°C	Devices with option CF-LC, air 4 m/s	60						
		T_{flange} = 25°C	Devices with option GCF on heat sink.	100						
		T_{inlet} = 25°C	Devices with option ILC, water >0.1l/min	100						
			Devices with option DLC-0.3	300						Watt
Linear Derating		Above 25°C	Standard devices, forced air 4 m/s	0.22						
			Devices with option CF-LC, air 4 m/s	1.33						
			Devices with option GCF, on heat sink.	2.22						
			Devices with option ILC, water 0.1 l/min.	2.22						
			Devices with option DLC-0.3	8.50						W/K
Operating Temperature Range	T_O	Standard devices & options CF-LC, GCF, ILC (Opt. DLC)		-40...70 (60)						°C
Storage Temperature Range	T_S	Switches with option ILC may require frost protection!		-50...100						°C
Max. Permissible Magnetic Field	B	Homogeneous steady-field, surrounding the whole switch		25						mT
ELECTRICAL CHARACTERISTICS										
Operating Voltage Range	V_O	Positive or negative voltage (depending on connection)		0-3	0-6	0-7.2	0-9.6	0-12	0-18	kVDC
Typical Breakdown Voltage	V_{br}	**NOTE:** V_{br} is a test parameter for quality control purposes only. Not applicable in normal operation!	I_{off} > 0.5 mA	3.2	6.3	7.6	10.1	12.6	18.9	kVDC
Typical Off-State Current	I_{off}	25°C, @ 0.8xV_O. Lower leakage current optionally available.		< 10						µADC
Typical Turn-On Resistance	R_{stat}	T_{case} = 25°C, T_{flange} = 25°C, T_{fin} = 25°C,	0.1 x $I_{P(max)}$	2	8	11	32	38	64	
		T_{inlet} = 25°C.	1.0 x $I_{P(max)}$	5	19	25	72	86	144	Ohm
Typical Propagation Delay Time	$t_{d(on)}$	Resistive load, 0.1 x $I_{P(max)}$, 0.8 x $V_{O(max)}$, 50-50%		100						ns
Typical Output Pulse Jitter	t_j	Impedance matched input, V_{aux} / V_{ctrl} = 5.00 VDC		< 500						ps
Typical Turn-On Rise Time	$t_{r(on)}$	10-90%. t_r can be	R_L = 5kΩ, 0.2 x $V_{O(max)}$, C_L= 10pF	3.0	5.3	5.5	12	12	12	
		customized in	R_L = 5kΩ, 0.8 x $V_{O(max)}$, C_L= 10pF	6.0	7.9	8.1	23	21	25	
		certain limits.	R_L = 5kΩ, 0.8 x $V_{O(max)}$, C_L=100pF	20	18	22	88	75	92	
			V_O= 0.5 x $V_{O(max)}$, I_L = 0.5 x $I_{p(max)}$	<7	<7	<8	<5	<12	<5	ns
Typical Turn-Off Rise Time	$t_{r(off)}$	10-90%, resistive load @ 1.0 x $I_{p(max)}$		< 10						ns
Maximum Turn-On Time	$t_{on(max)}$	No limitation, true on-off switch with relay character		infinite						ns
Minimum Turn-On Time	$t_{on(min)}$	10-90%, resistive load @ 1.0 x $I_{p(max)}$		50	50	50	50	50	50	ns
Max. Continuous Switching Frequency	$f_{(max)}$	@ V_{aux}= 5.00 V	Standard devices without HFS option	>25	>30	>20	>20	>25	>12	
		Sw. shutdown if	Standard devices with HFS supply	100	100	100	100	100	100	
		$f_{(max)}$ is exceeded	Opt. HFS + sufficient cooling option	750	750	750	750	750	750	kHz
Maximum Burst Frequency	$f_{b(max)}$			3	5	5	3	5	5	MHz
Maximum Number of Pulses / Burst	$N_{(max)}$	f_b=1MHz (1µs spacing). Switch shutdown if $N_{(max)}$ is exceeded.		200 Use burst option HFB for >200 pulses						Pulses
Coupling Capacitance	C_C	Switch against	Standard devices & options CF, DLC	8						
		control side	Devices with options GCF, ILC	30 ... 60						pF
Natural Capacitance	C_N	Between switch poles, @ 0.5 x $V_{O(max)}$		10	5	4	6	10	12	pF
Control Voltage Range	V_{ctrl}	The V_{ctrl} has no impact on the output pulse shape.		2 ... 6						VDC
Auxiliary Supply Voltage Range	V_{aux}	The +5 V supply is not required in the HFS mode.		4.5 ... 5.5						VDC
Typical Auxiliary Supply Current	I_{aux}	V_{aux} = 5.00 VDC, T_{case} = 25°C.	0.01 x $f_{(max)}$	100						
		Active current limitation above 700 mA.	@ specified $f_{(max)}$	500						mADC
Opt. HFS, Ext. Supply Voltage V1	$V_{HFS(V1)}$	Stability ±3%, current consumption <0.4 mA/kHz @ 25°C		15						VDC
Opt. HFS, Ext. Supply Voltage V2	$V_{HFS(V2)}$	Stability ±3%, current consumption <0.5 mA/kHz @ 25°C		90						VDC
Intrinsic Diode Forward Voltage	V_F	T_{case} = 25°C, I_F = 0.3 x $I_{P(max)}$		<10						VDC
Diode Reverse Recovery Time	t_{rrc}	T_{case} = 25°C, I_F = 0.3 x $I_{P(max)}$, di/dt = 100 A/µs		<700						ns
HOUSING										
Dimensions		Standard housing		79.5 x 38 x 17						
		Devices with option CF-LC		79.5 x 38 x 28						
		Devices with option GCF / FH		96 x 50 x 28						
		Devices with option ILC & DLC-0.3		89 x 64 x 35						mm^3
Weight		Standard housing		100						
		Devices with option CF-LC		120						
		Devices with option GCF		225						
		Devices with option ILC & DLC-0.3		400						g

FUNCTIONS

Control Signal Input	**Pin 1** / Yellow. TTL compatible with Schmitt-Trigger characteristics. Control voltage 2-10 V (3-5 V recommended for low jitter).
Logic GND / 5V Return	**Pin 2** / Black. The ground pin is internally connected with the safety earthing terminal (threaded insert) on bottom side.
5V Auxiliary Supply	**Pin 3** / Red. The 5 V input is used for rep rates up to the specified max. frequency $f_{(max)}$. Higher rep rates require option HFS.
Fault Signal Output	**Pin 4** / Orange. TTL output, short circuit proof. Indicating switch & driver over-heat, over-frequency, low auxiliary voltage. L = Fault.
Inhibit Signal Input	**Pin 5** / Green. TTL compatible, Schmitt-Trigger characteristics for the connection of external safety circuits. L = Switch Inhibited.
LED Indicators	**GREEN**: "Auxiliary power good, switch OFF". **YELLOW**: "Control signal received, switch ON". **RED**: "Fault condition, switch OFF"
Temperature Protection	**A)** Standard switches and switches with option CF, GCF: Thermo trigger 75°C, response time < 60 s @ 3xPd(max), ΔT=25K (50 to 75°C). Separate driver protection. **B)** Switches with option DLC: 65°C, response time < 3 s @ 3xPd(max), ΔT=25K (40 to 65°C), coolant flow > 3l / min. Separate driver protection.

ORDERING

HTS 31-06-C	Fast HV Transistor Switch, 3kV, 64 A	**Option**		**Option CCS**	Ceramic Cooling Surface. $P_{d(max)}$ can be increased by the factor 2 to 3.
HTS 61-03-C	Fast HV Transistor Switch, 6kV, 32 A	**Option**		**Option CF-LC**	Copper Cooling Fins. $P_{d(max)}$ can be increased by the factor 3 to 10.
HTS 71-02-C	Fast HV Transistor Switch, 7kV, 25 A	**Option HFS**	High Frequency Switching (two auxiliary supply inputs V1 & V2)	**Option GCF**	Grounded Cooling Flange (copper). $P_{d(max)}$ can be increased by the factor 3 to 15.
HTS 91-02-C	Fast HV Transistor Switch, 9kV, 20 A	**Option LP**	Low Pass. Input filter for increased noise immunity.	**Option ILC**	Indirect Liquid Cooling (for water). $P_{d(max)}$ can be increased by the factor 3 to 15.
HTS 121-01-C	Fast HV Transistor Switch, 12kV, 15 A	**Option UFTR**	Ultra Fast Thermotrigger. Response time for shut down < 5s.	**Option DLC**	Direct Liquid Cooling (for FPE/PFC). $P_{d(max)}$ can be increased by the factor 10 to 100.
HTS 181-01-C	Fast HV Transistor Switch, 18kV, 12 A	**Option UFTS**	Ultra Fast Thermosensor. Response time < 5s. NTC 10k / ± 1%	**FOR FURTHER PRODUCT OPTIONS PLEASE REFER TO THE OPTIONS PAGE.**	