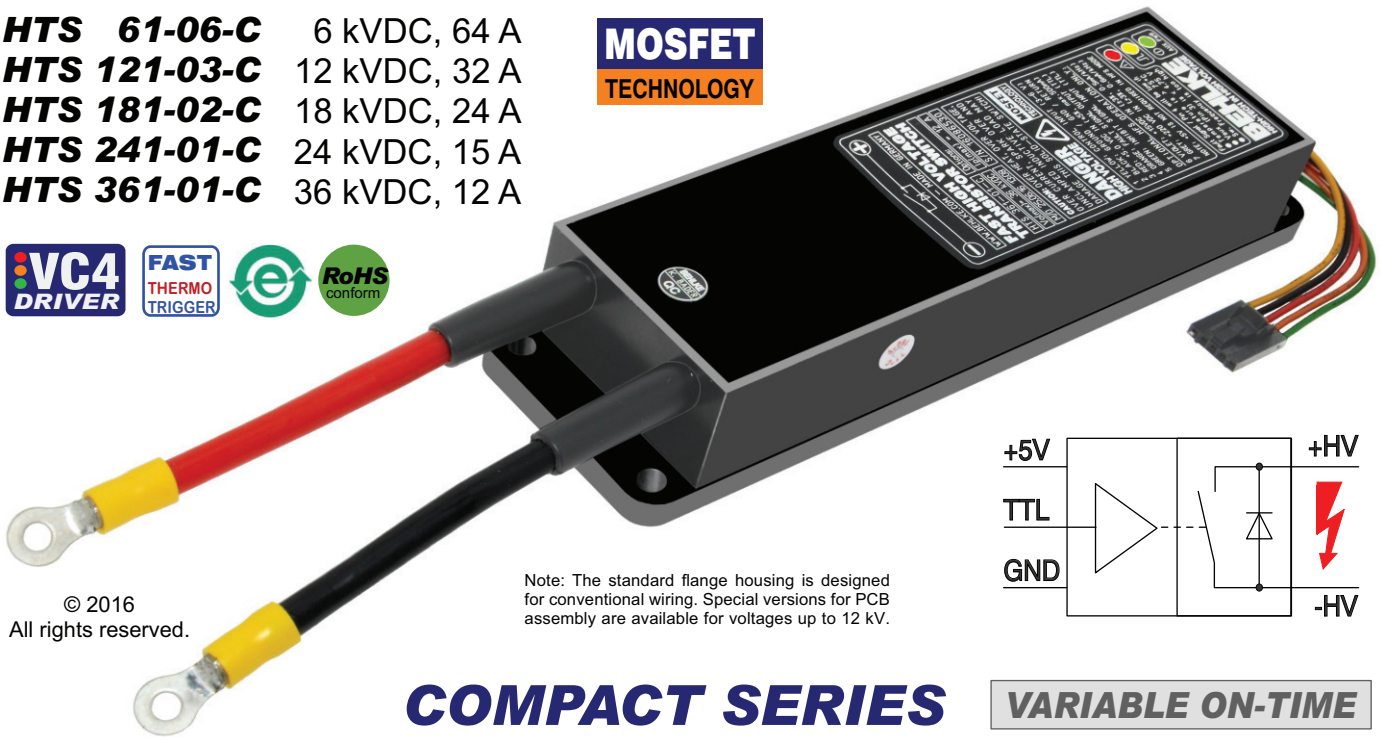
FAST HIGH VOLTAGE TRANSISTOR SWITCHES

HTS 61-06-C	6 kVDC, 64 A
HTS 121-03-C	12 kVDC, 32 A
HTS 181-02-C	18 kVDC, 24 A
HTS 241-01-C	24 kVDC, 15 A
HTS 361-01-C	36 kVDC, 12 A

MOSFET TECHNOLOGY

VC4 DRIVER | FAST THERMO TRIGGER | RoHS conform



Note: The standard flange housing is designed for conventional wiring. Special versions for PCB assembly are available for voltages up to 12 kV.

COMPACT SERIES

VARIABLE ON-TIME

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.

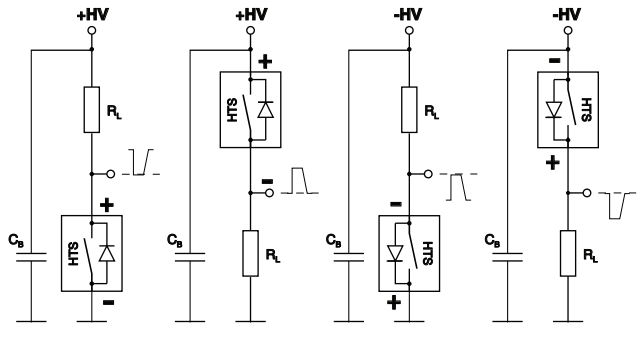
The switches are very easy to handle and only require a simple +5 VDC auxiliary supply (4.5 to 5.5 VDC) and a TTL-compatible control signal. The control signal can be any positive going pulse of at least 25 ns duration and 2 to 10 volts amplitude. Due to the Schmitt-Trigger input characteristics and 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 200 ns, making burst frequencies of up to 5 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.

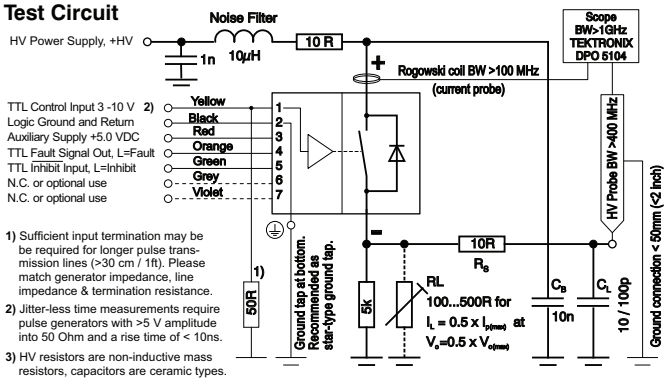
CIRCUIT DESIGN RECOMMENDATIONS

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.

Basic Circuits



Test Circuit



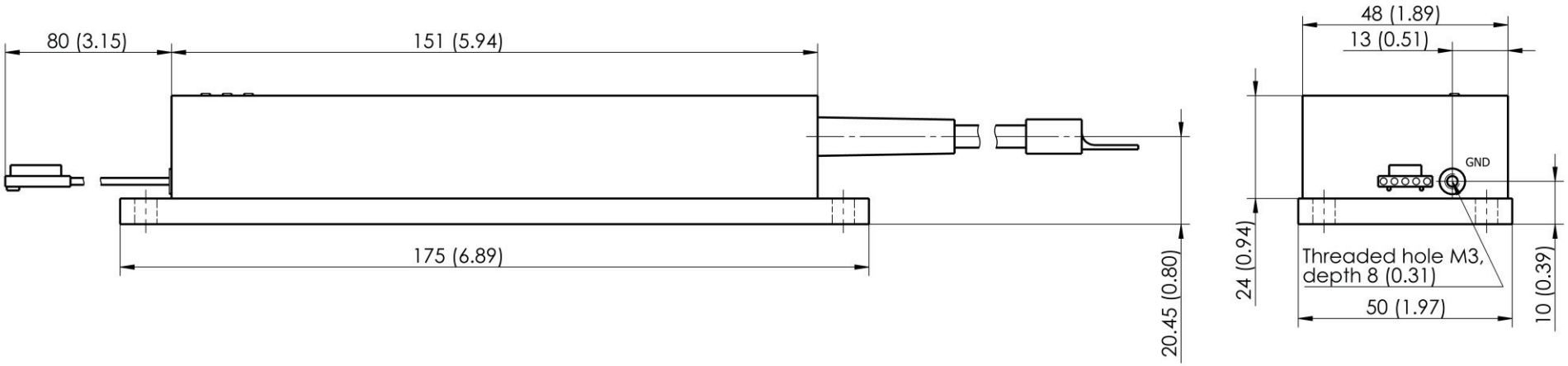
	Specification	Symbol	Condition / Comment		HTS	61-06-C	121-03-C	181-02-C	241-01-C	361-01-C	Unit
ABSOLUTE MAXIMUM RATINGS	Maximum Operating Voltage	$V_{O(max)}$	I_{off} < 50 µADC, T_{case} = 70°C			± 6	± 12	± 18	± 24	± 36	kVDC
	Maximum Isolation Voltage	V_I	Between HV switch and control / GND, continuously					± 40			kVDC
	Max. Housing Insulation Voltage	V_{INS}	Between switch and housing surface, 3 minutes					± 40			kVDC
	Maximum Turn-On Peak Current	$I_{P(max)}$	T_{case} = 25°C	t_p< 200 µs, duty cycle <1%		64	32	24	15	12	ADC
	Maximum Continuous Load Current	I_L	T_{case} = 25°C T_{fin} = 25°C T_{flange} = 25°C T_{inlet} = 25°C	Standard devices, forced air 4 m/s Devices with option CF-LC, air 4 m/s Devices with option GCF, on heat sink. Devices with option ILC, water 0.1 l/min. Devices with option DLC-0.6		1.1 3.11 4.02 4.02 6.96	0.54 1.55 2 2 3.46	0.43 1.22 1.57 1.57 2.72	0.23 0.66 0.86 0.86 1.49	0.21 0.61 0.78 0.78 1.36	ADC
	Max. Continuous Power Dissipation	$P_{d(max)}$	T_{case} = 25°C T_{fin} = 25°C T_{flange} = 25°C T_{inlet} = 25°C	Standard devices, forced air 4 m/s Devices with option CF-LC, air 4 m/s Devices with option GCF on heat sink. Devices with option ILC, water >0.1l/min Devices with option DLC-0.6				15 120 200 200 600			Watt
	Linear Derating		Above 25°C	Standard devices, forced air 4 m/s Devices with option CF-LC, air 4 m/s Devices with option GCF, on heat sink. Devices with option ILC, water 0.1 l/min. Devices with option DLC-0.6				0.333 2.666 4.444 4.444 13.33			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)			0-6	0-12	0-18	0-24	0-36	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		6.3	12.6	18.9	25.2	37.8	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, T_{inlet} = 25°C.	0.1 x $I_{P(max)}$ 1.0 x $I_{P(max)}$		5.2 12.4	21 50	36 81	120 271	144 324	Ohm
	Typical Propagation Delay Time	$t_{d(on)}$	Resistive load, 0.1 x $I_{P(max)}$, 0.8 x $V_{O(max)}$, 50-50%					120			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%	R_L = 5kΩ, 0.2 x $V_{O(max)}$, C_L= 10pF R_L = 5kΩ, 0.8 x $V_{O(max)}$, C_L= 10pF R_L = 5kΩ, 0.8 x $V_{O(max)}$, C_L=100pF V_O= 0.5 x $V_{O(max)}$, I_L = 0.5 x $I_{p(max)}$		6 9 20 <8	10 14 28 <12	12 25 92 <15	19 33 120 <22	20 40 147 <24	ns
	Typical Turn-Off Rise Time	$t_{r(off)}$	10-90%, resistive load @ 1.0 x $I_{p(max)}$					< 12			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 $I_{p(max)}$					75			ns
	Maximum Continuous Switching Frequency	$f_{(max)}$	@ V_{aux}= 5.00 V Sw. shutdown if $f_{(max)}$ is exceeded	Standard devices without HFS option Standard devices with HFS supply Opt. HFS + sufficient cooling option		>15 50 750	>15 50 750	>8 50 750	>12 50 750	>8 50 750	kHz
	Maximum Burst Frequency	$f_{b(max)}$						5			MHz
	Maximum Number of Pulses / Burst	$N_{(max)}$	f_b=1MHz (1µs spacing). Switch shutdown if $N_{(max)}$ is exceeded.					150	Use option HFB for >150 pulses		Pulses
	Coupling Capacitance	C_C	Switch against control side	Standard devices & options CF, DLC Devices with options GCF, ILC				14 50 ... 100			pF
	Natural Capacitance	C_N	Between switch poles, @ 0.5 x $V_{O(max)}$			52	13	20	6	5	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. Active current limitation above 700 mA.	0.01 x $f_{(max)}$ @ specified $f_{(max)}$				120 500			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 <0.9 mA/kHz @ 25°C					180			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 Devices with option CF-LC Devices with option GCF / FH Devices with option ILC & DLC-0.6					175 x 50 x 30 175 x 50 x 42 175 x 50 x 30 175 x 50 x 55			mm^3
	Weight		Standard housing Devices with option CF-LC Devices with option GCF Devices with option ILC & DLC-0.6					250 295 640 430			g

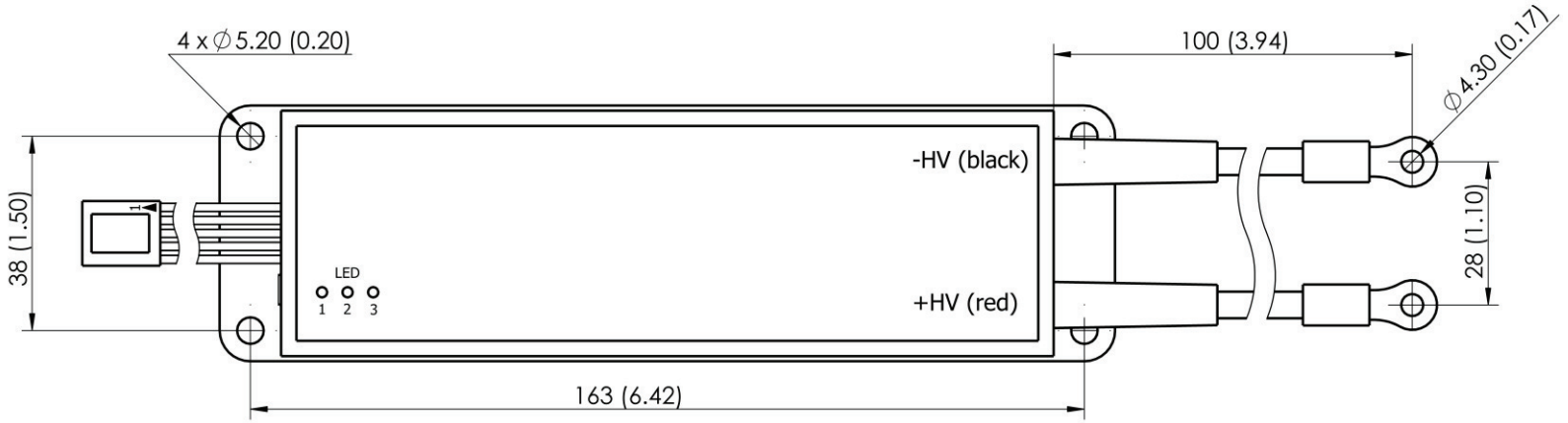
FUNCTIONS	
Control Signal Input	**Pin 1** / Yellow. TTL compatible with Schmitt-Trigger characteristics. Control voltage 2-10 V (3-5 V recommended for low jitter).
Logic GND / 5V Return	**Pin 2** / Black. The ground pin is internally connected with the safety earthing terminal (threaded insert) on bottom 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 61-06-C	Fast HV Transistor Switch, 6 kV, 64 A	**Option LP**	Low Pass. Input filter for increased noise immunity.	**Option CCS**	Ceramic Cooling Surface. $P_{d(max)}$ can be increased by the factor 2 to 3.
HTS 121-03-C	Fast HV Transistor Switch, 12 kV, 32 A	**Option S-TT**	Soft Transition Time. Slower switching speed for simplified EMC.	**Option CF-LC**	Copper Cooling Fins. $P_{d(max)}$ can be increased by the factor 3 to 10.
HTS 181-02-C	Fast HV Transistor Switch, 18 kV, 24 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 241-01-C	Fast HV Transistor Switch, 24 kV, 15 A	**Option UFTR**	Ultra Fast Thermotrigger. Response time for shut down < 5s.	**Option ILC**	Indirect Liquid Cooling (for water). $P_{d(max)}$ can be increased by the factor 3 to 15.
HTS 361-01-C	Fast HV Transistor Switch, 36 kV, 12 A	**Option UFTS**	Ultra Fast Thermosensor. Response time < 5s. NTC 10k / ± 1%	**Option DLC**	Direct Liquid Cooling (for FPE/PFC). $P_{d(max)}$ can be increased by the factor 10 to 100.

FOR FURTHER PRODUCT OPTIONS PLEASE REFER TO THE OPTIONS PAGE.





LED Indicators:

LED 1: Green, Ready/ Power
LED 2: Yellow, Triggered
LED 3: Red, Fault Condition

5- Pole Standard Plug:

1- Yellow, TTL Trigger Input (3-10V)
2- Black, Ground/ GND/ Return
3- Red, +5.00 VDC (±2%, 500mA)
4- Orange, Fault Signal Out, L=Fault
5- Green, TTL Inhibit Input

Drawing (projection) according to DIN standards.
All dimensions in mm and (inches).
All data and dimensions subject to change without notice.

Modification	Date	Name	Drawn	GAL
			Verified	SJ
			Date	08.07.2016

BEHLKE
HIGH-TECH IN HIGH VOLTAGE

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HTS 361-01-C
Options:
Drawing:
Sheet: 1 / 1