FAST HIGH VOLTAGE PUSH-PULL SWITCH

The HTS 241-15-SiC-GSM is a universal high-voltage push-pull switching module in a half-bridge configuration. The standard version is suitable for low-frequency, low-power laboratory applications, and with suitable cooling and driver options, it can also be used for industrial high power applications with operating frequencies of up to 500 kHz and even much higher at larger housing dimensions. Operation at higher frequencies requires the DLC liquid cooling option (Direct Dielectric Liquid Cooling), both for the HV switches and their drivers. For this purpose, the driver electronics are integrated into a solid aluminum housing (option LC-AH-DR). The housing is flanged to the HV switching module, whereby a leak-proof connection between the cooling channels of the switching module and its driver unit is maintained.

For certain applications with bipolar pulses, pulse pauses can be controlled so that a zero potential is maintained at the switch output for a freely adjustable time between each polarity reversal. This option, known as PPC (Pulse Pause Control), is available for both the standard and the liquid-cooled power versions.

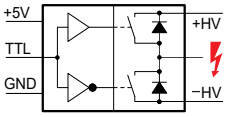
As with all BEHLKE high-voltage switching modules, the control and high-voltage switching sections are galvanically isolated from each other. This allows the switch to be operated with positive and/or negative voltages. By supplying with both polarities, true AC square wave voltage can be generated at the output. Floating operation is possible up to the specified max. isolation voltage. The isolation can be optionally increased to up to 200 kV without impact on other electrical parameters.

The switches are equipped with the control circuit VC4, which provides active input filtering, signal conditioning, auxiliary voltage monitoring, frequency limitation and temperature protection. The input filter allows an unshielded input wiring of at least 25 cm (10") length. Undefined control signals, noise and transients are uncritical to the switch. The high-voltage transistor stack is always safely controlled regardless to the pulse width or waveshape of the control signal. The control inputs are TTL with Z = 100 Ohm as standard. Fiber optic inputs are available as an option. The control circuit has three integrated temperature triggers. One thermotrigger with a response time of <60 seconds protects the high-voltage switches, two further sensors with <10 seconds response time are placed in the critical areas of the driver circuit. An inhibit input 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 (Vcc < 4.5 V, 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 (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 5 VDC supply is sufficient for operating frequencies up to several kHz. For higher operating frequencies, two additional external auxiliary power supplies (+15 VDC and +85 VDC) must be connected to the control unit, as the internal voltage converters can only generate the necessary driver power to a limited extent from the 5 VDC supply. If external auxiliary power supplies are used, the 5 VDC supply can be omitted entirely. 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.

HTS 241-15-SiC-GSM

24 kVDC / 175 A / 500 kHz

Fully integrated half-bridge switching module in Silicon Carbide + LC2 technology for industrial high-frequency switching applications such as cold plasma generators and food sterilizers.



FAST THERMO TRIGGER

RoHS conform

HTS 241-15-SiC-GSM
with optional DLC liquid cooling (5 kW) and removable power driver (Option LC-AH-DR)

- Optional high power driver for up to 500 kHz CW (Option LC-AH-DR)
- Optional DLC liquid cooling for power dissipation up to 10 kW @ 20°C
- Optional pulse pause control (Option PPC) for bipolar pulse generation

www.behlke.com

Available with option PPC:
Pulse Pause Control

SiC TECHNOLOGY

DLC LIQUID COOLING

Note: Design drawings of switching modules in various configurations are available for download as PDF's from our website (online catalog, chapter C8). In case the demanded drawing is not listed on-line or if you need a custom specific module design please consult our support team.

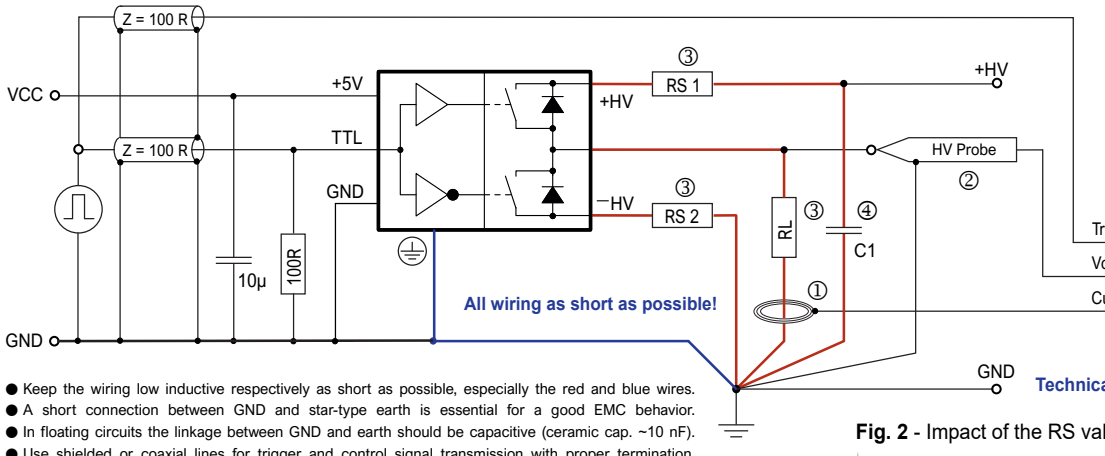


Fig. 1 - Test Circuit

① Pearson model 110 or similar
② Tektronix # P 6015A or similar
③ HVR rod resistors, series 7xx
④ General Atomics # 31158 or similar (1µF / 40 kV / 22 nH)

- Keep the wiring low inductive respectively as short as possible, especially the red and blue wires.
- A short connection between GND and star-type earth is essential for a good EMC behavior.
- In floating circuits the linkage between GND and earth should be capacitive (ceramic cap. ~10 nF).
- Use shielded or coaxial lines for trigger and control signal transmission with proper termination.
- In the interest of lowest time jitter and good EMC the control pulses should have 4 to 10 V amplitude.
- Use series resistors (RS1, RS2) when ringing occurs and / or input energy (C1) can not be limited.
- Adjust the series resistors RS1, RS2 so that there is no heavy ringing at the edges (see also Fig. 2)
- Series resistors may also have an important current limiting function if a sparking can not be excluded.
- RS1, RS2 must be inductance-free and high-voltage proof! Never use wire-wound resistors!
- Typical values for RS1, RS2 are 1 Ohm to 1 kOhm depending on the application (see also Fig. 2).

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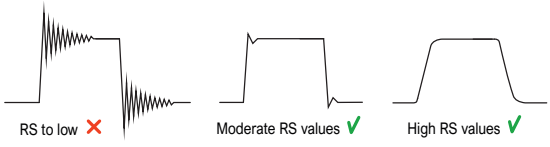
Fig. 2 - Impact of the RS values on the HV pulse shape



	Specification	Symbol	Condition / Comment		241-15-SiC-GSM	Unit
ABSOLUTE MAXIMUM RATINGS	Maximum Operating Voltage	$V_{O(max)}$	I_{off} < 65 µADC, T_{case} = 70°C		24	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		50	kVDC
	Maximum Turn-On Peak Current	$I_{P(max)}$	T_{case} = 25°C	t_p< 200 µs, duty cycle <1% t_p< 1 ms, duty cycle <1% t_p< 10 ms, duty cycle <1% t_p< 100 ms, duty cycle <1%	175 90 29 15	ADC
	Maximum Continuous Load Current	$I_{L(max)}$	T_{case} = 25°C	Standard devices Option CF, cooling fins Devices with option DLC	10 15 50	ADC
	Max. Continuous Power Dissipation	$P_{d(max)}$	T_{case} = 25°C	Standard devices & FC, forced air 4 m/s Devices with option DLC	30 5000	Watt
	Linear Derating		Above 25°C	Standard devices & FC, forced air 4 m/s Devices with option DLC	0.44 50	W/K
	Operating Temperature Range	T_O	Standard devices & options ILC, DLC		-40...70 (60)	°C
	Storage Temperature Range	T_S	Switches with option ILC may require frost protection!		-40...90	°C
	Max. Permissible Magnetic Field	B	Homogeneous steady-field, surrounding the whole switch		25	mT
	Max. Auxilliary Voltage	V_{aux}	Built-in overvoltage limiter (replaceable)		5.5	VDC
ELECTRICAL CHARACTERISTICS	Permissible Operating Voltage Range	V_O	Unipolar operation (one switch pole grounded or floated) Bipolar operation (positive & negative voltage applied)		0... ± 24 0... ± 12	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	± 26	kVDC
	Typical Off-State Current	I_{off}	0.8xV_O, T_{case} =25...70°C, reduced I_{off} on request		65	µADC
	Typical Turn-On Resistance	R_{stat}	Each switching path t_p < 1µs, duty cycle < 1%	0.1 x $I_{P(max)}$, T_{case} =25°C 1.0 x $I_{P(max)}$, T_{case} =25°C 1.0 x $I_{P(max)}$, T_{case} =70°C	0.96 1.4 2.45	Ohm
	Typical Capacitive Power Dissipation of Switch (Natural Power Dissipation)	P_{dc}	Switch capacitances only-without external load and parasitic capacitances!	0.8 x $V_{O(max)}$, f = 10Hz 0.8 x $V_{O(max)}$, f = 100Hz 0.8 x $V_{O(max)}$, f = 10000Hz	3,13 31.3 313	Watt
	Typical Propagation Delay Time	$t_{d(on)}$	Resistive load, 0.1 x $I_{P(max)}$, 0.8 x $V_{O(max)}$, 50-50%		200	ns
	Typical Output Pulse Jitter	t_j	Impedance matched input, V_{aux} / V_{ctrl} = 5.00 VDC		2	ns
	Typical Ouput Transition Time (Rise Time & Fall Time)	t_r, t_f	Resistive load, 10-90%	0.1 x $V_{O(max)}$, I_L = 0.1 x $I_{p(max)}$ 0.8 x $V_{O(max)}$, I_L = 0.1 x $I_{p(max)}$ 0.8 x $V_{O(max)}$, I_L = 1.0 x $I_{p(max)}$	15 20 80	ns
	Maximum Turn-On Time	$t_{on(max)}$	No limitation		∞	ns
	Minimum Turn-On Time	$t_{on(min)}$	can be customized. Please consult factory		280	ns
	Max. 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 Options HFS + LC-AH-DR + DLC	4.5 30 100 500	kHz
	Maximum Burst Frequency	$f_{b(max)}$	Use option HFB for >10 pulses within 20µs or less		1.5	MHz
	Maximum Number of Pulses / Burst	$N_{(max)}$	f_b=500 kHz (1µs spacing). Switch shutdown if $N_{(max)}$ is exceeded.		10 (Use burst option HFB for >10 pulses)	Pulses
	Coupling Capacitance	C_C	Switch against control side		75	pF
	Natural Capacitance	C_N	Between switch poles, @ 0.8 x $V_{O(max)}$		10	pF
	Control Voltage Range	V_{ctrl}	The V_{ctrl} has no impact on the output pulse shape.		3 ... 10	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 1A.	0.01 x $f_{(max)}$ @ specified $f_{(max)}$	200 500	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		85	VDC
	Intrinsic Diode Forward Voltage	V_F	T_{case} = 25°C, I_F = 0.3 x $I_{P(max)}$		20	VDC
	Diode Reverse Recovery Time	t_{rrc}	T_{case} = 25°C, I_F = 0.3 x $I_{P(max)}$, di/dt = 100 A/µs		50	ns
HOUSING	Dimensions	LxWxH	Standard housing, without pigtails Devices with options DLC + LC-AH-DR, without pigtails		250 x 150 x 70 280 x 225 x 95	mm^3
	Weight		Standard housing Devices with options DLC + LC-AH-DR		2560 6800	g

FUNCTIONS	
Control Signal Input	Lemo Pin 1: TTL compatible (LS-C: With 100Ω termination). Schmitt-Trigger characteristics. Control voltage 2-10 V (3-5 V for low jitter).
Logic GND / 5V Return	Lemo Shielding: The logic ground is internally connected with the safety earthing terminal (threaded inserts).
5V Auxiliary Supply	Lemo Pin 4: 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	Lemo Pin 3: TTL output, short circuit proof. Indicating switch & driver over-heat, over-frequency, low auxiliary voltage. L = Fault.
Inhibit Signal Input	Lemo Pin 2: 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 Air Cooling	Standard switches and switches with options FC, CF and GCF: Thermotrigger 75°C, response time < 60 s @ 3xPd(max), ΔT=25K (50 to 75°C).
Temperature Protection DLC Cooling	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 241-15-SiC-GSM

Push-Pull Switch, 24 kV, 175 A

For further ordering options please refer to our on-line catalog, section C8.
https://www.behlke.com/separations/separation_c8.htm

BEHLKE
HIGH-TECH IN HIGH VOLTAGE

Option LP	Low Pass. Input filter for increased noise immunity.	**Option FO-I**	Fibre Optics Input fort the inhibit and PPC signal
Option HFB	High Frequency Burst (improved capability by external	**Option FO-F**	Fibre Optics Output for the fault signal
Option HFS	High Frequency Switching (two auxiliary supply inputs V1 & V2)	**Option UL-94**	Flame retardant casting resin, UL94-V0
Option S-TT	Soft Transition Time decrease the rise and fall time by 20%	**Option I-FWD**	Integrated Free-Wheeling Diode. In connection with inductive load only.
Option Min-On	Individually increased "Min. On-Time" to avoid unwanted	**Option I-FWDN**	Integrated Freewheeling Diode Network. In connection with inductive load.
Option Min-Off	Individually increased "Min. Off-Time" to avoid unwanted	**Option LC-AH-DR**	Removeable Power Driver, DLC cooling, solid aluminum housing
Option PPC	Pulse Pause Control for pauses between pos. and neg. pulses.	**Option SEP-C**	Separated control unit. Control unit with LED indicators in a separate
Option ISO-80	80kV Isolation. Isolation Voltage increased to 80kV.	**Option I-PC**	Integrated part components according to customer specification.
Option ISO-120	120kV Isolation. Isolation Voltage increased to 120kV.	**Option PCC**	Pulser Configuration. Switch combined with custom specific parts.
Option ISO-160	160kV Isolation. Isolation Voltage increased to 160kV.	**Option CF**	Copper Cooling Fins. $P_{d(max)}$ can be increased by the factor 3 to 10
Option ISO-200	200kV Isolation. Isolation Voltage increased to 200kV.	**Option GCF**	Grounded Cooling Flange. $P_{d(max)}$ can be increased by the factor 3 to 15
Option FO-C	Fibre Optics Input for the control input	**Option DLC**	Direct Liquid Cooling. $P_{d(max)}$ can be increased by the factor 100 to 200