

FAST HIGH VOLTAGE THYRISTOR SWITCHES

These solid-state switches are designed for high voltage high peak current switching applications such as shock wave generators, flash lamp drivers, crow bar circuits and surge generators.

The switching modules contain a large number of reverse blocking thyristors (SCR) with a special chip architecture for high surge conditions. Several hundred of these SCR's, each with its own low-impedance gate drive, are connected in series and in parallel to ensure the extreme di/dt of upto 24 kA/ μ s. The safe and synchronous control of all SCR's is performed by a special driver circuit which also provides the high galvanic isolation necessary for high-side circuits and safety-relevant applications (e.g. medical equipment).

In contrast to conventional high voltage switches like spark gaps, electron tubes, gas discharge tubes and mechanical switches, thyristor switches of series SCR and SCR/DT show very stable switching characteristics independent of temperature and age. The mean time between failures (MTBF) is by several orders of magnitude higher than that of the classical HV switches.

An interference-proof control circuit provides signal conditioning, auxiliary voltage monitoring, frequency limitation and temperature protection. In case of false operating conditions, the switches are immediately inhibited and a fault signal is generated. Three LED's indicate the operating state. The switches are triggered by a positive going pulse of 3-10 Volts.

The switching behaviour will not be influenced by the trigger rise time or the trigger amplitude. After being triggered the switches remain in on-state until the load current drops below the holding current (typical thyristor behaviour). The turn-off process requires insofar a current commutation, a current limitation or a current bypass.

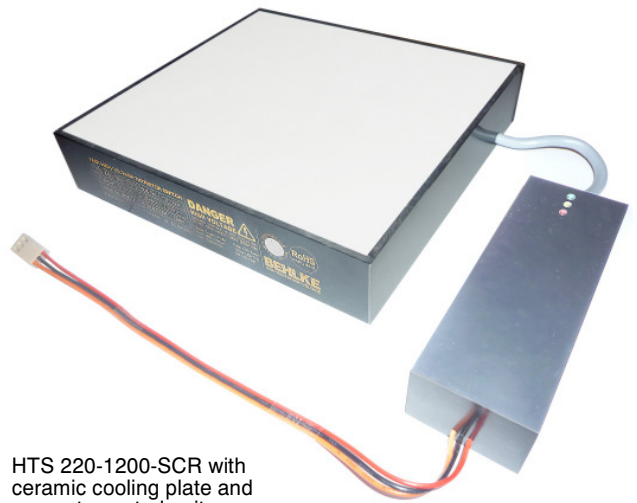
Capacitor discharge applications with charging currents less than the holding current do not require special turn-off measures. In all other cases, the switches can be anyway. turned off by a slight current reversal, which is nevertheless given in most pulsed power applications.

If the current reversal is higher than 10%, and if the periodic duration of the current is shorter than 1 ms, a free-wheeling diode (e.g. Behlke FDA) must be used to avoid hard turn-off, which can damage the switching module under certain circumstances. Please compare also the application note below.

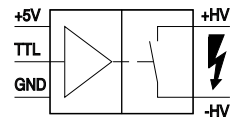
The plastic case is the cost-effective standard package in low frequency applications with low average power. For higher loads, there are additional cooling options such as ceramic cooling surface, non-isolated cooling fins, grounded cooling flange or direct liquid cooling, either for conductive and non-conductive liquids. With these options the Max. Continuous Power Dissipation Pd(max) can be increased from 50 to 30.000 Watts.

For further design recommendations please refer to the general instructions.

HTS 220-1200-SCR 22kV/12kA

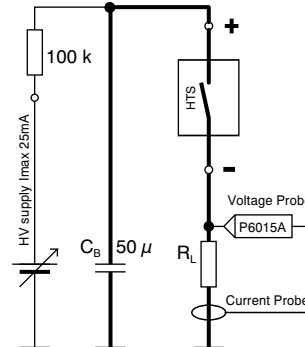


HTS 220-1200-SCR with ceramic cooling plate and separate control unit



Compact Design
Extremely High di/dt
High Surge Current Capability

Test Circuit for $t_{r(on)}$

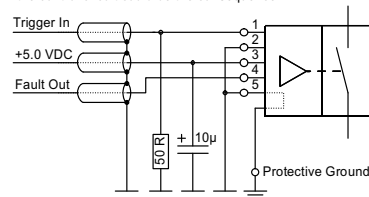


Notes:

- Total wiring inductance < 50 nH
- C_b is a MAXWELL low inductance energy storage capacitor (<10 nH)
- R_L depends on voltage and peak current test conditions. Low inductance mass resistors, CESIWID series 900, washer style, 3 inch disc diameter, $E_{max}=27600$ J/disc.
- Voltage probe: Tektronix P6015A
Current probe: Pearson 4997
Oscilloscope: Tektronix TDS684C

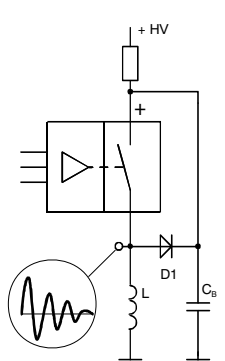
Control Connection

- Use shielded cables or apply optical decoupling at trigger input
- Input should be terminated properly if connected via coaxial line
- Never mix control wiring and load circuit wiring. Heavy magnetic fields of the load circuit can cause dangerous overvoltage spikes on the input wiring. Malfunction or even irreparable damage of the control circuit could be the consequence.



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|-------------------------------|---------------------------------|
| Standard Plug | Option SPT-C (Lemo Plug) |
| 1 - Trigger Input (3-10 V) | 1 - Trigger Input (3-10 V) |
| 2 - GND (Logic Ground) | 2 - GND (Logic Ground) |
| 3 - +5.00 VDC (600 mADC) | 3 - +5.00 VDC (600 mADC) |
| 4 - Fault Signal Output (TTL) | 4 - Fault Signal Output (TTL) |
| 5 - GND (Logic Ground) | Shielding - GND |

Inductive Load



Note: D1 is a fast recovery diode with Kiloamps peak current capability (E.g. Behlke Series FDA)

Technical data for HTS 220-1200-SCR, with modification F-0-237

	Specification	Symbol	Condition / Comment	HTS 220-1200-SCR / F-0-237	Unit	
ABSOLUTE MAXIMUM RATINGS	Maximum Operating Voltage	$V_{O(max)}$	$I_{off} < 300 \mu ADC$, $T_{case} = 70^\circ C$	22000	VDC	
	Maximum Isolation Voltage	V_I	Galvanic isolation between HV switch and control input / GND	50000	VDC	
	Maximum Housing Insulation Voltage	V_{INS}	Insulation between internal switch and housing surface, 3 minutes	25000	VDC	
	Maximum Turn-On Peak Current	$I_{P(max)}$	$T_{case} = 25^\circ C$, half sine. Please consult factory for further data.	$t_p < 100 \mu s$, duty cycle <1% $t_p < 500 \mu s$, duty cycle <1% $t_p < 1 ms$, duty cycle <1% $t_p < 10 ms$, duty cycle <1%	12000 6000 4080 2400	ADC
	Max. Non-Repetitive Peak Current	$I_{P(nr)}$	$T_{case} = 25^\circ C$, switch only	Half sine single pulse, $t_p < 200 \mu s$ Half sine single pulse, $t_p < 20 \mu s$	24000 48000	ADC
	Maximum Continuous Load Current	I_L	$T_{case} = 25^\circ C$		3.26	ADC
	Max. Rate-of-Rise of Off-State Voltage	dv/dt	@ $V_{O(max)}$, exponential waveform		150	kV/ μs
	Max. Continuous Power Dissipation	$P_{d(max)}$	Air cooling, $25^\circ C$ ambient temperature, air stream > 4 m / s		75	Watts
	Linear Derating		Above $25^\circ C$ ambient temperature		1.5	W/K
	Operating Temperature Range	T_O			-40...75	$^\circ C$
	Storage Temperature Range	T_S			-40...100	$^\circ C$
	Maximum Auxiliary Supply Voltage	$V_{aux(max)}$			5.25	VDC
	ELECTRICAL CHARACTERISTICS	Permissible Operating Voltage Range	V_O		0 - 22000	VDC
Typical Breakdown Voltage		V_{br}	CAUTION: V_{br} is a test parameter for quality control purposes and not applicable in normal operation. Breakdown tests require special	>26000	VDC	
Typical Off-State Current		I_{off}	$0.8 \times V_O$, $T_{case} = 25^\circ C$	< 400	μADC	
Typical On-State Voltage		V_{sat}	$t_p < 10 \mu s$, duty cycle <1%	$0.001 \times I_{P(max)}$ $0.01 \times I_{P(max)}$ $0.1 \times I_{P(max)}$ $1.0 \times I_{P(max)}$	23 27 43 115	VDC
Typical Holding Current				$T_{case} = 70^\circ C$	35	mADC
Typical Turn-On Delay Time		$t_{d(on)}$	$0.1 I_{P(max)}$, $0.8 \times V_{O(max)}$, resistive load, 50-50%	Standard	0.4	μs
Typical Turn-On Rise Time		$t_{r(on)}$	Resistive load, 10-80 %	$0.1 \times V_{O(max)}$, $0.1 \times I_{P(max)}$ $0.8 \times V_{O(max)}$, $0.1 \times I_{P(max)}$ $0.8 \times V_{O(max)}$, $1.0 \times I_{P(max)}$	550 170 500	ns
Typical Turn-Off Time		t_{off} , t_q	$T_{case} = 25^\circ C$, With internal free- wheeling diode and 5 μH inductive load	$0.01 \times I_{P(max)}$ $0.1 \times I_{P(max)}$ $1.0 \times I_{P(max)}$	10 35 90	μs
Maximum On-Time		$t_{on(max)}$	Depends on holding current only. See product description		unlimited	
Internal Driver Recovery Time		t_c			1000	μs
Typical Turn-On Jitter		$t_{j(on)}$	$V_{aux} / V_{tr} = 5.00$ VDC	Standard	1	ns
Max. Continuous Switching Frequency		$f_{(max)}$	Please note $P_{d(max)}$ limitations, increased $f_{(max)}$ on request		400	Hz
Maximum Burst Frequency		$f_{b(max)}$	With option HFB, $I_{P(max)} < 16$ kA, please consult factory With option HFB, $I_{P(max)} < 3$ kA, please consult factory		1 10	kHz
Coupling Capacitance		C_C	HV side against control side		320	pF
Auxiliary Supply Voltage Range		V_{aux}	5.00 VDC \pm 2% recommended, safety turn-off below 4.70 VDC		4.75 - 5.25 VDC	VDC
Auxiliary Supply Current		I_{aux}	$T_{case} = 25^\circ C$	@ < 10 Hz trigger frequ. @ $f_{(max)}$	350 600	mADC
Trigger Voltage Range		V_{tr}	Switching behaviour is not influenced by trigger quality		3-10	VDC
GENERAL		HV Switch Dimensions			160 x 150 x 32	mm ³
		Control Unit Dimensions			102 x 36 x 26	mm ³
		Total Weight		Including control unit	1600	g
	LED Operating Mode Indication		Green LED: Power good, switch ready for operation Yellow LED: Switch successful triggered / thyristors successful fired Red LED: Fault: Switch temperature over $75^\circ C$ / trigger frequency over limit / V_{aux} below 4.70 VDC			
	High Voltage Connection		Low inductance terminals for printed circuit boards			
	Control Connection		Pigtail with 5 pole MOLEX plug			
	Cooling		Natural or forced air convection.			