WESTCODE SEMICONDUCTORS

Technical Publication
TR395C
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High Frequency Inverter Grade Capsule Thyristor Type R395C

distributed amplified gate for high di/dt and low switching losses

1050 amperes average: up to 1800 volts V_{RRM}/V_{DRM}

Ratings (Maximum values at 125°C Tj unless stated otherwise)

RATING	CONDITIONS	SYMBOL	
Average on-state current	Half sine wave: 55°C heatsink temperature (double side cooled)	$I_{T(AV)}$	1050 A
	Half sine wave: 85°C heatsink temperature (single side cooled)		393 A
R.M.S. on-state current	25°C heatsink temperature, double side cooled	$I_{T(RMS)}$	2140 A
Continuous on-state current	25°C heatsink temperature, double side cooled	I_T	1720 A
Peak one-cycle surge	10ms duration, 60% V_{RRM} re-applied	$I_{TSM(1)}$	15500 A
(non-repetitive) on state current	10ms duration, $V_R \leq$ 10 volts	$I_{TSM(2)}$	17000 A
Maximum permissible surge energy	10ms duration, $V_R \leq$ 10 volts	$I^2t_{(2)}$	1450000 A^2s
	3ms duration, $V_R \leq$ 10 volts	I^2t	1080000 A^2s
Peak forward gate current	Anode positive with respect to cathode	I_{FGM}	36 A
Peak forward gate voltage	Anode positive with respect to cathode	V_{FGM}	16 V
Peak reverse gate voltage		V_{RGM}	5 V
Average gate power		P_G	2 W
Peak gate power	100μs. pulse width	P_{GM}	120 W
Rate of rise of off-state voltage	To 80% V_{DRM} gate open-circuit	dv/dt	*200V/μs
Rate of rise of on-state current (repetitive)	Gate drive 20 volts, 20 ohms with $t_r \leq 1\mu$s. Anode voltage > 80% V_{DRM}	di/dt (1)	1000A/μs
Rate of rise of on-state current (non-repetitive)	Gate drive 20 volts, 20 ohms with $t_r \leq 1\mu$s. Anode voltage > 80% V_{DRM}	di/dt (2)	1500A/μs
Operating temperature range		T_{hs}	−40 + 125°C
Storage temperature range		T_{stg}	−40 + 150°C

Characteristics (Maximum values at 125°C Tj unless stated otherwise)

CHARACTERISTIC	CONDITIONS	SYMBOL	
Peak on-state voltage	At 2000 A, I_{TM}	V_{TM}	1.90 V
Forward conduction threshold voltage		V_O	1.30 V
Forward conduction slope resistance		r	0.30 mΩ
Repetitive peak off-state current	At V_{DRM}	I_{DRM}	100 mA
Repetitive peak reverse current	At V_{RRM}	I_{RRM}	100 mA
Maximum gate current required to fire all devices	At 25°C, V_A = 10 V, I_A = 2A	I_{GT}	300 mA
Maximum gate voltage required to fire all devices	At 25°C, V_A = 10 V, I_A = 2A	V_{GT}	3 V
Maximum holding current	At 25°C, V_A = 10 V, I_A = 2A	I_H	1 A
Maximum gate voltage which will not trigger any device		V_{GD}	0.25 V
Stored charge	I_{TM} = 1000A, dir/dt 60A/μs, V_{RM} = 50V, 50% chord value	Q_{rr}	420 μC
Circuit commutated turn-off time available down to	I_{TM} = 1000A, dir/dt = 60A/μs, V_{RM} = 50V, 200V/μs to 80% V_{DRM}	tq	65–75 μs
	I_{TM} = 1000A, dir/dt = 60A/μs, V_{RM} = 50V, 20V/μs to 80% V_{DRM}	tq typical	60–70 μs
Thermal resistance, junction to heat sink, for a device with a maximum forward volt drop characteristic	Double side cooled	$R_{th(j-hs)}$	0.032°C/W
	Single side cooled		0.064°C/W

VOLTAGE CODE		H12	H14	H15	H16	H18			
Repetitive peak voltages / Non-repetitive peak off-state voltage	V_{RRM} V_{DRM} V_{DSM}	1200	1400	1500	1600	1800			
Non-repetitive peak reverse blocking voltage	V_{RSM}	1300	1500	1600	1700	1900			

Ordering Information (Please quote device code as explained below — 11 or 12 digits)

R 3 9 5 C	● ● ●	●	●	●	0
Fixed type code	Voltage Code (see ratings)	dv/dt code to 80% V_{DRM}: C = 20V/μs, E = 100V/μs, D = 50V/μs, F = 200V/μs	Turn-off time: E = 75 μs, W = 65 μs	Turn-off time: 2G = 70 μs, 2H = 60 μs	

Typical code: R395CH16FE0 = 1600 V_{RRM} 1600 V_{DRM} 200 V/μs dv/dt to 80% V_{DRM} 75 μs turn-off

*Other values of dv/dt up to 1000 V/μs, and turn-off time may be available.

1. INTRODUCTION

The R395CH12-18 thyristor family incorporates diffused 50 mm silicon slices in cold-weld encapsulations. This series offers extended voltage ratings while maintaining an on-state voltage comparable with that of the R400 series.

2. NOTES ON THE RATINGS

(a) **Rate of rise of on-state current**
The maximum un-primed rate of rise of on-state current must not exceed 1500 A/μs at any time during turn-on on a non-repetitive basis. For repetitive performance the on-state rate of rise of current must not exceed 1000 A/μs at any time during turn-on. Note that these values of current rate of rise apply to the circuit external to the device and its specified snubber network and device current rates of rise will be higher.

(b) **Square wave ratings**
These ratings are given for leading edge linear rates of rise of forward current of 100 and 500 A/μs.

(c) **Duty Cycle Lines**
The 100% duty cycle line appears on all these ratings. These frequency ratings are presented in the form that all duty cycles may be represented by straight parallel lines.

(d) **Maximum operating Frequency**
The maximum operating frequency, f_{max}, is set by the time required for the thyristor to turn off (tq) and for the off-state voltage to reach full value (tv), i.e.

$$f_{max} = \frac{1}{t_{pulse} + tq + tv}$$

(e) **Energy per pulse characteristics**
These curves enable rapid estimation of device dissipation to be obtained for conditions not covered by the frequency ratings.

Let E_p be the Energy per pulse for a given current and pulse width, in joules.

Then $W_{AV} = E_p \times f$.

3. REVERSE RECOVERY LOSS

On account of the number of circuit variables affecting reverse recovery voltage, no allowance for reverse recovery loss has been made in these ratings. The following procedure is recommended for use where it is necessary to include reverse recovery loss.

(a) **Determination by Measurement**
From waveforms of recovery current obtained from a high frequency shunt (see Note 1) and reverse voltage present during recovery, an instantaneous reverse recovery loss waveform must be constructed. Let the area under this waveform be A joules per pulse. A new heat sink temperature can then be evaluated from:

$$T_{SINK}\,(new) = T_{SINK}\,(original) - A\left(\frac{r_t.10^6}{t} + R_{th} \times f\right)$$

where $r_t = 4.11 \times 10^{-5}\sqrt{t}$

t = duration of reverse recovery loss per pulse in microseconds

A = Area under reverse loss waveform per pulse in joules (W.S.)

f = rated frequency at the original heat sink temperature

The total dissipation is now given by

$W_{(TOT)} = W_{(original)} + A \times f$

(b) **Design Method**
In circumstances where it is not possible to measure voltage and current conditions, or for design purposes, the additional losses may be estimated from figure 7. A typical R-C snubber network is connected across the thyristor to control the transient reverse voltage waveform.

Let E be the value of energy per reverse cycle in joules (figure 7).

Let f be the operating frequency in Hz

then T_{SINK} new $= T_{SINK}$ original $- ER_{th} \times f$

where T_{SINK} new is the required maximum heat sink temperature

and T_{SINK} original is the heat sink temperature given with the frequency ratings.

4. GATE DRIVE

The recommended gate drive is 20 V, 20 ohms with a short-circuit current rise time of not more than 1 μs. This gate drive must be applied when using the full di/dt capability of the device.

5. THE DV/DT SUPPRESSION NETWORK

The effect of a conventional resistor-capacitor snubber of 0.25 μF 5 ohms has been included in these ratings and all rating di/dt values apply to the circuit external to the thyristor and its suppression network.

6. NOTE 1

REVERSE RECOVERY LOSS BY MEASUREMENT

This thyristor has a low reverse recovered charge and peak reverse recovery current. When measuring the charge care must be taken to ensure that:

(a) a.c. coupled devices such as current transformers are not affected by prior passage of high amplitude forward current.

(b) The measuring oscilloscope has adequate dynamic range — typically 100 screen heights — to cope with the initial forward current without overload.

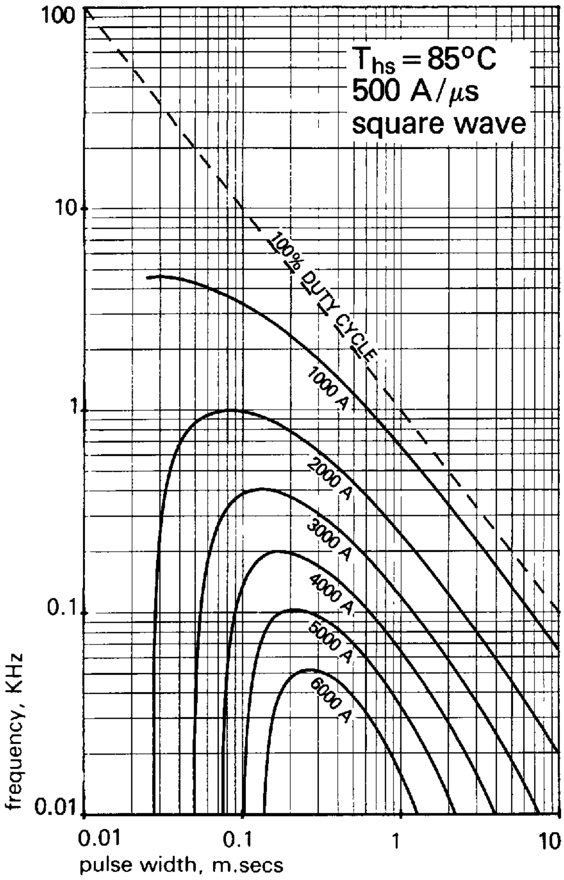


Figure 1 Frequency v. pulse width

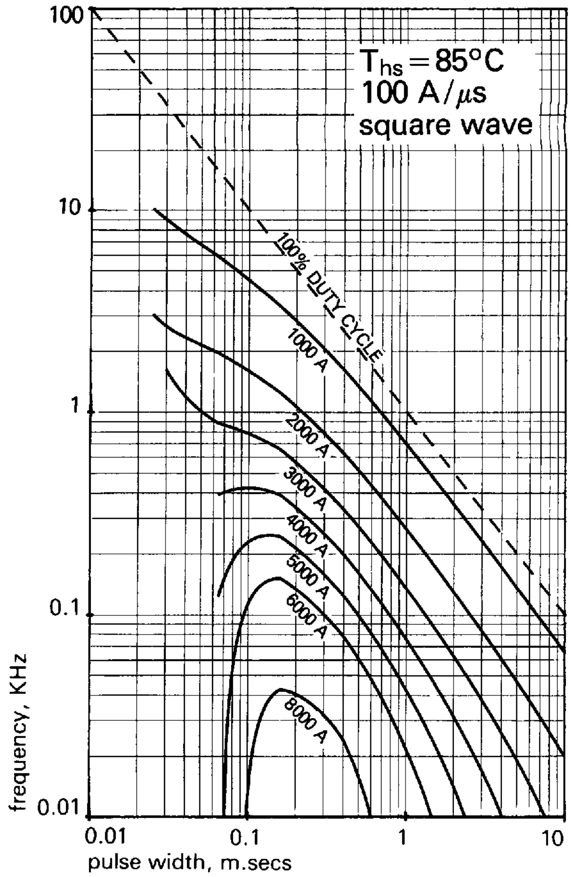


Figure 2 Frequency v. pulse width

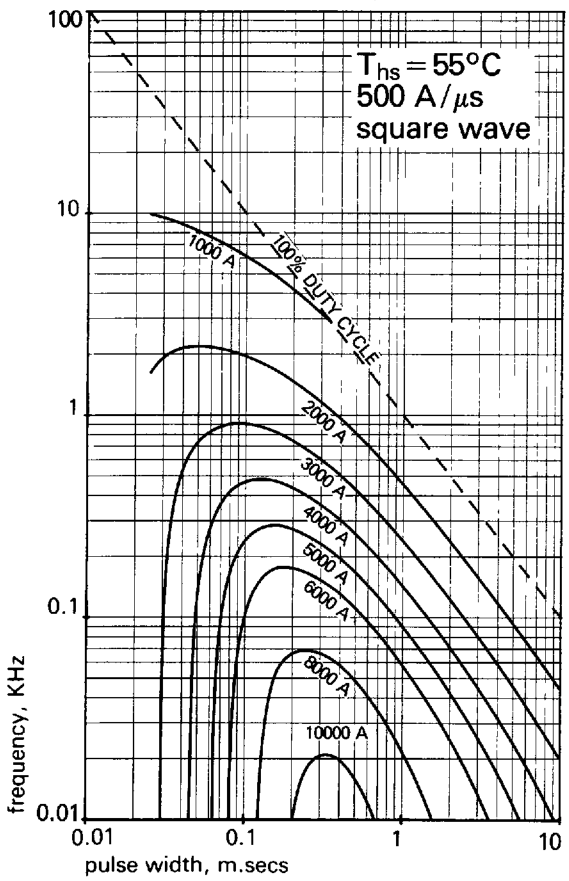


Figure 3 Frequency v. pulse width

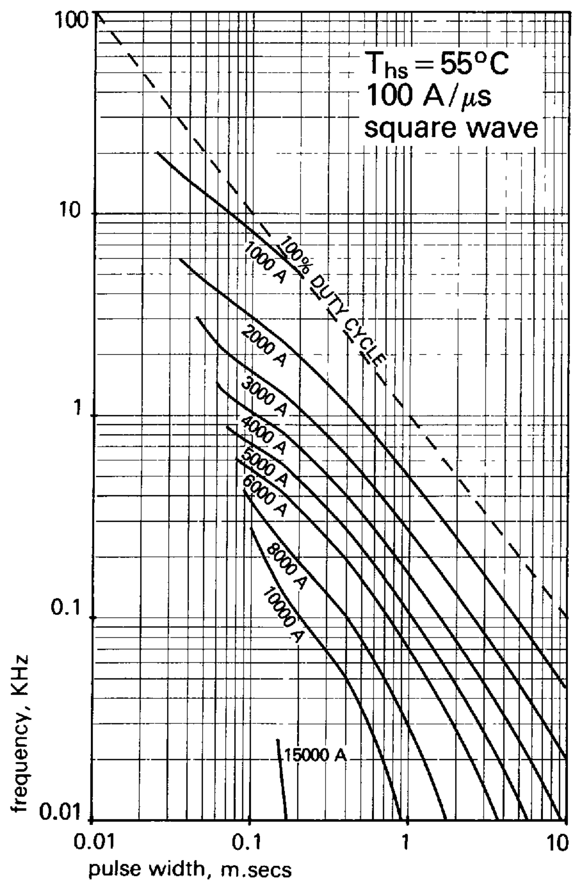


Figure 4 Frequency v. pulse width

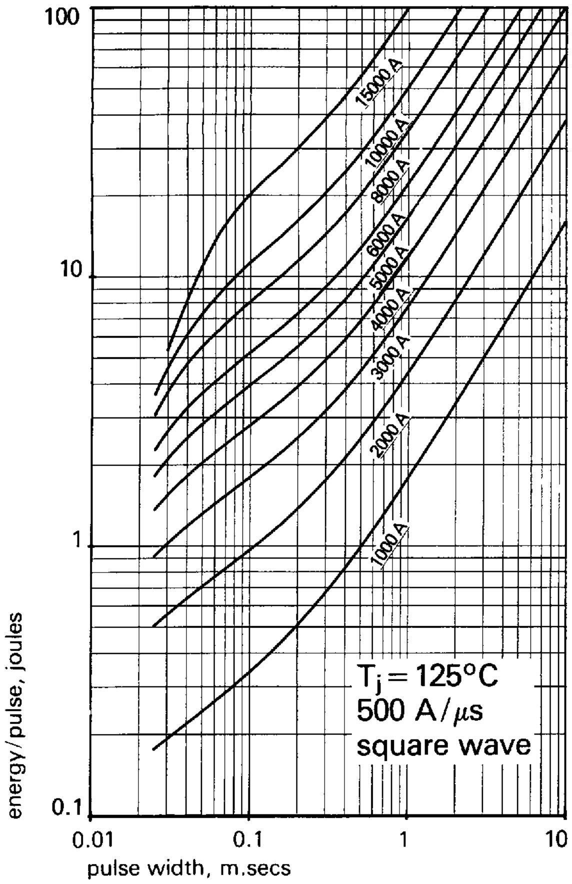


Figure 5 Energy/pulse v. pulse width

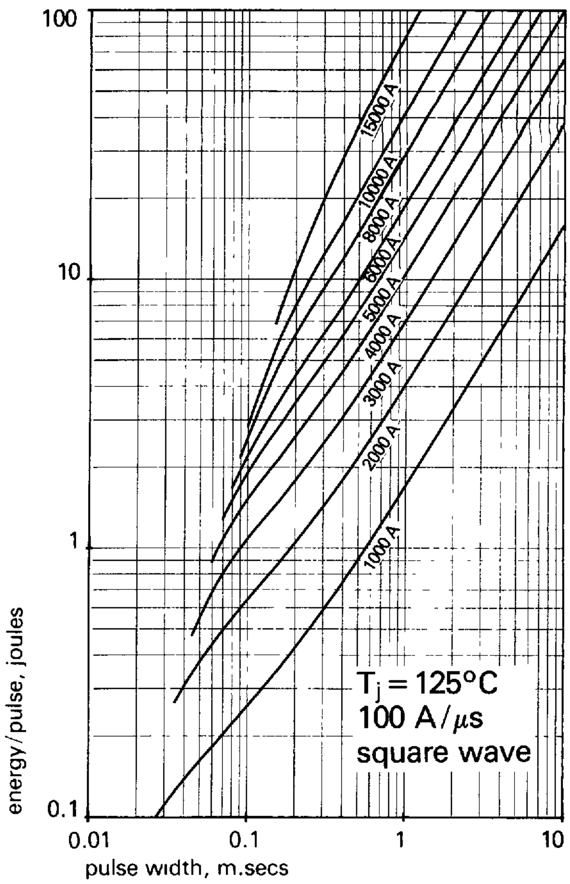


Figure 6 Energy/pulse v. pulse width

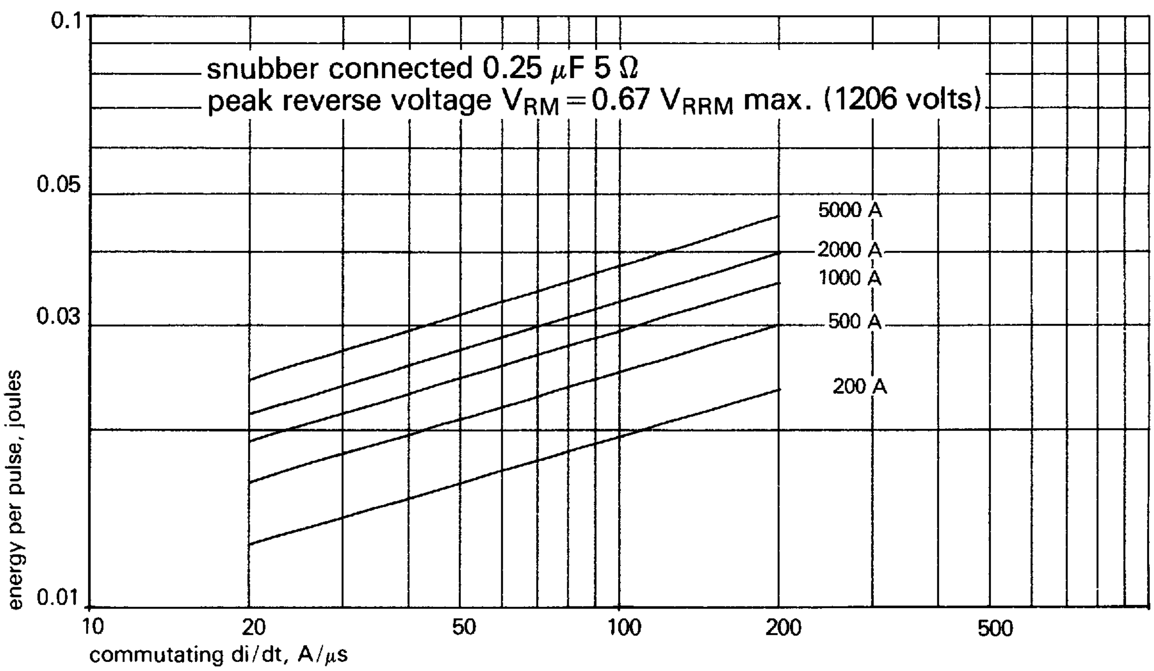


Figure 7 Max. reverse recovery energy loss per pulse at 125°C junction temperature and $V_{RM} = 1206$ volts.

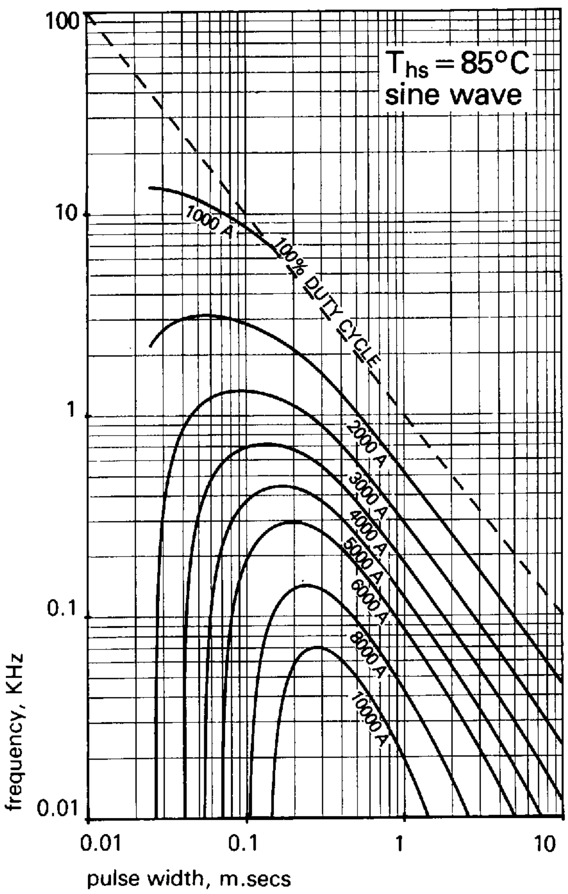


Figure 8 Frequency v. pulse width

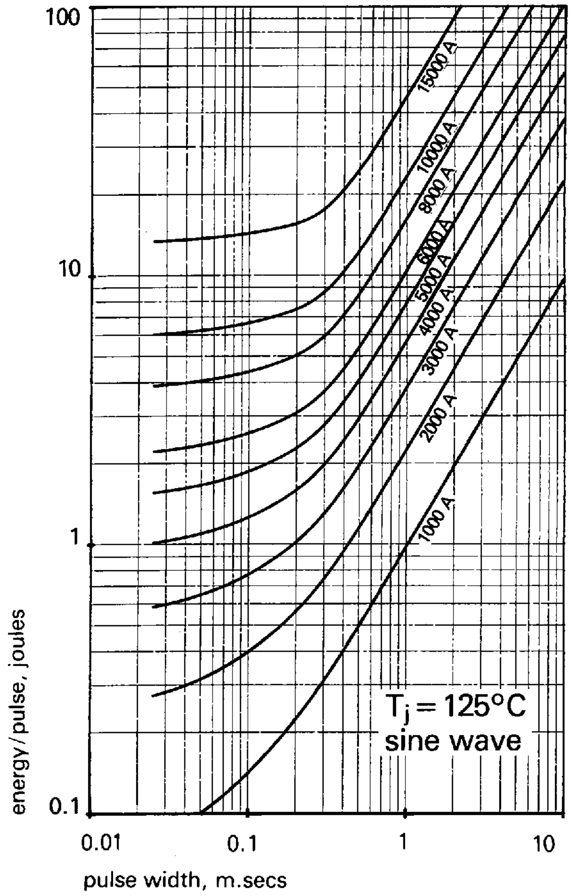


Figure 9 Energy/pulse v. pulse width

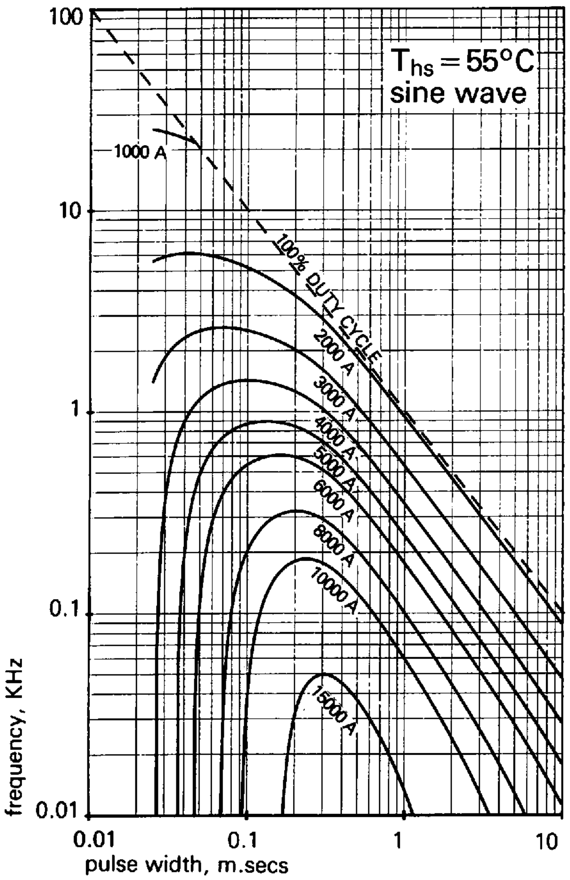


Figure 10 Frequency v. pulse width

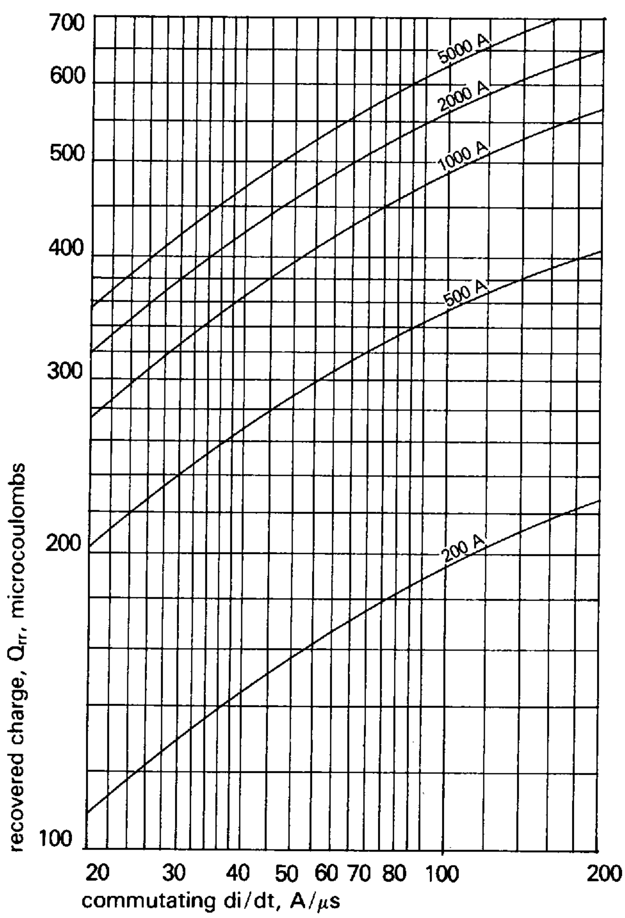


Figure 11 Maximum recovered charge at 125°C junction temperature

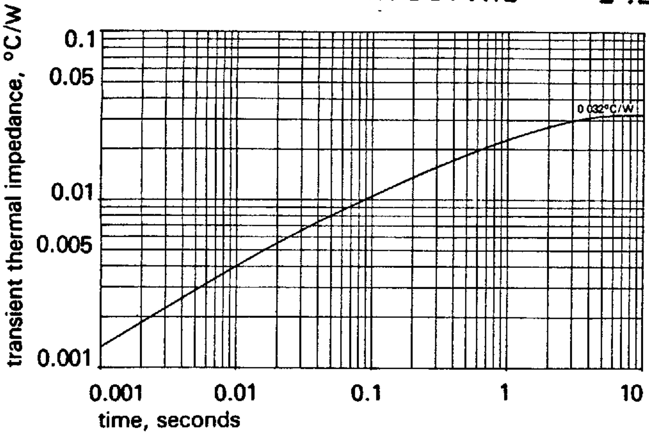


Figure 12 Junction to heatsink transient thermal impedance

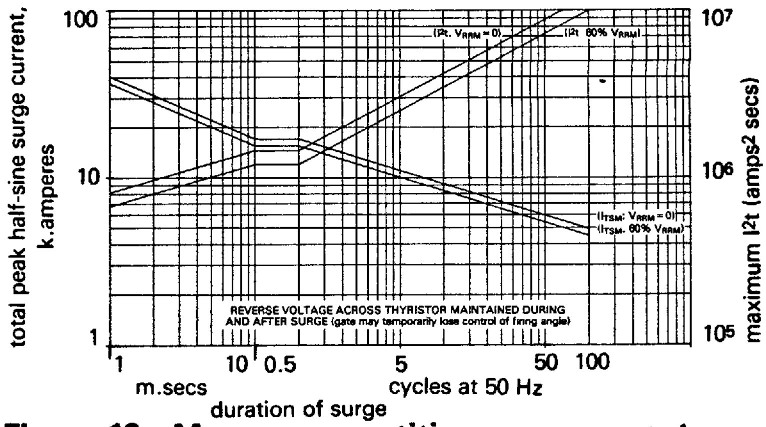


Figure 13 Max. non-repetitive surge current at initial junction temperature 125°C

Note: This rating must not be interpreted as an intermittent rating

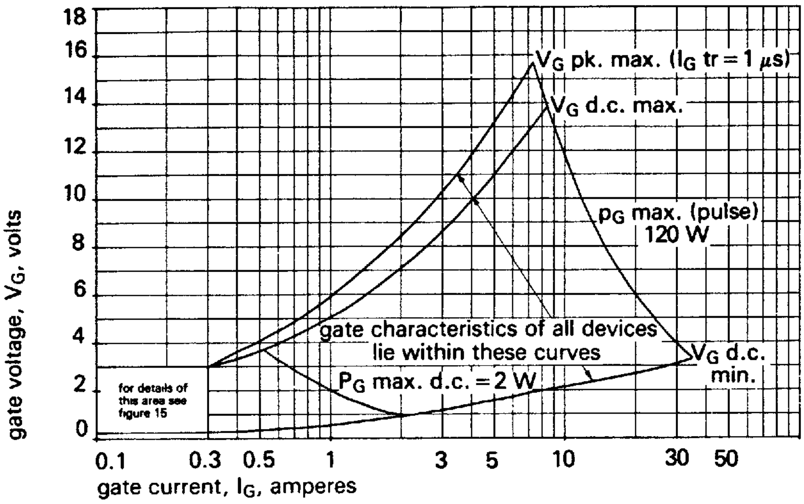


Figure 14 Gate characteristics at 25°C junction temperature

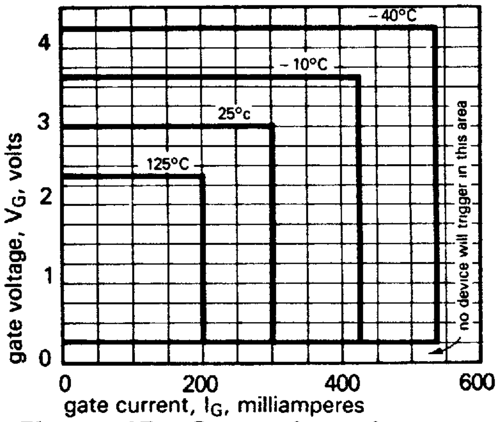


Figure 15 Gate triggering characteristics.

Trigger points of all thyristors lie within the areas shown. Gate drive load line must lie outside appropriate I_G/V_G rectangle

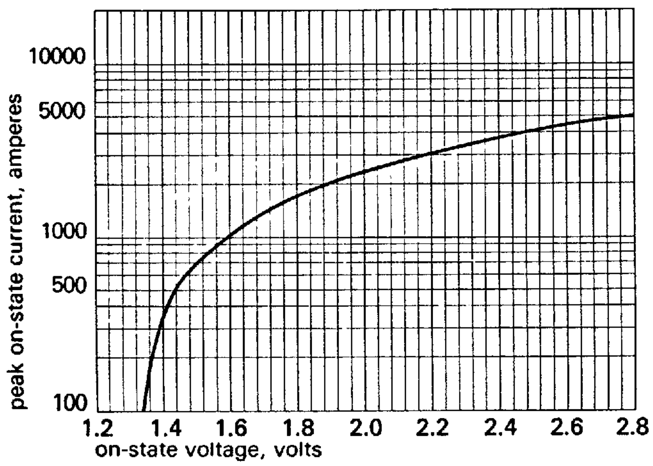
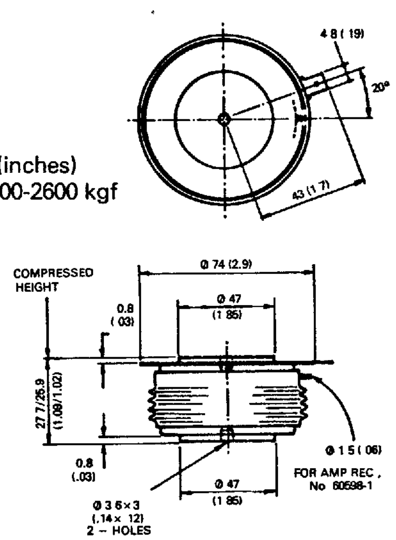


Figure 16 Limit on-state current at 125°C

dimensions in mm (inches)
Mounting force: 1900-2600 kgf
Weight: 510 grams



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In the interest of product improvement, Westcode reserves the right to change specifications at any time without notice.

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