PHILIPS Thyristors, Triacs S2b 1987

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Data handbook

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Book S2b 1987

Thyristors

Triacs

Accessories

THYRISTORS AND TRIACS

DATA HANDBOOK SYSTEM

Our Data Handbook System comprises more than 60 books with specifications on electronic components, subassemblies and materials. It is made up of four series of handbooks:

ELECTRON TUBES	BLUE
SEMICONDUCTORS	RED
INTEGRATED CIRCUITS	PURPLE
COMPONENTS AND MATERIALS	GREEN

The contents of each series are listed on pages iv to vii.

The data handbooks contain all pertinent data available at the time of publication, and each is revised and reissued periodically.

When ratings or specifications differ from those published in the preceding edition they are indicated with arrows in the page margin. Where application information is given it is advisory and does not form part of the product specification.

Condensed data on the preferred products of Philips Electronic Components and Materials Division is given in our Preferred Type Range catalogue (issued annually).

Information on current Data Handbooks and on how to obtain a subscription for future issues is available from any of the Organizations listed on the back cover.
Product specialists are at your service and enquiries will be answered promptly.

ELECTRON TUBES (BLUE SERIES)

The blue series of data handbooks comprises:

SEMICONDUCTORS (RED SERIES)

The red series of data handbooks comprises:

S1 **Diodes**
Small-signal silicon diodes, voltage regulator diodes (< 1,5 W), voltage reference diodes, tuner diodes, rectifier diodes

S2a **Power diodes**

S2b **Thyristors and triacs**

S3 **Small-signal transistors**

S4a **Low-frequency power transistors and hybrid modules**

S4b **High-voltage and switching power transistors**

S5 **Field-effect transistors**

S6 **R.F. power transistors and modules**

S7 **Surface mounted semiconductors**

S8a **Light-emitting diodes**

S8b **Devices for optoelectronics**
Optocouplers, photosensitive diodes and transistors, infrared light-emitting diodes and infrared sensitive devices, laser and fibre-optic components

S9 **Power MOS transistors**

S10 **Wideband transistors and wideband hybrid IC modules**

S11 **Microwave transistors**

S12 **Surface acoustic wave devices**

S13 **Semiconductor sensors**

***S14** **Liquid Crystal Displays**

*To be issued shortly.

INTEGRATED CIRCUITS (PURPLE SERIES)

The NEW SERIES of handbooks is now completed. With effect from the publication date of this handbook the "N" in the handbook code number will be deleted.
Handbooks to be replaced during 1986 are shown below.

The purple series of handbooks comprises:

IC01	**Radio, audio and associated systems** Bipolar, MOS	new issue 1986 IC01N 1985
IC02a/b	**Video and associated systems** Bipolar, MOS	new issue 1986 IC02Na/b 1985
IC03	**Integrated circuits for telephony** Bipolar, MOS	new issue 1987 IC03N 1985
IC04	**HE4000B logic family** CMOS	new issue 1986 IC4 1983
IC05N	**HE4000B logic family — uncased ICs** CMOS	published 1984
IC06N	**High-speed CMOS; PC74HC/HCT/HCU** Logic family	published 1986
IC08	**ECL 10K and 100K logic families**	New issue 1986 IC08N 1984
IC09N	**TTL logic series**	published 1986
IC10	**Memories** MOS, TTL, ECL	new issue 1986 IC7 1982
IC11N	**Linear LSI**	published 1985
Supplement to IC11N	**Linear LSI**	published 1986
IC12	**I²C-bus compatible ICs**	not yet issued
IC13	**Semi-custom** Programmable Logic Devices (PLD)	new issue 1986 IC13N 1985
IC14	**Microcontrollers and peripherals** Bipolar, MOS	published 1986
IC15	**FAST TTL logic series**	new issue 1986 IC15N 1985
IC16	**CMOS integrated circuits for clocks and watches**	first issue 1986
IC17	**Integrated Services Digital Networks (ISDN)**	not yet issued
IC18	**Microprocessors and peripherals**	new issue 1986

COMPONENTS AND MATERIALS (GREEN SERIES)

The green series of data handbooks comprises:

C2 Television tuners, coaxial aerial input assemblies, surface acoustic wave filters

C3 Loudspeakers

C4 Ferroxcube potcores, square cores and cross cores

C5 Ferroxcube for power, audio/video and accelerators

C6 Synchronous motors and gearboxes

C7 Variable capacitors

C8 Variable mains transformers

C9 Piezoelectric quartz devices

C11 Varistors, thermistors and sensors

C12 Potentiometers, encoders and switches

C13 Fixed resistors

C14 Electrolytic and solid capacitors

C15 Ceramic capacitors

C16 Permanent magnet materials

C17 Stepping motors and associated electronics

C18 Direct current motors

C19 Piezoelectric ceramics

C20 Wire-wound components for TVs and monitors

C22 Film capacitors

SELECTION GUIDE

GATE TURN-OFF THYRISTORS

$I_{T(AV)}$ max. (A)	I_{TCRM} max. (A)		Outline	V_{DRMmax} (V) 600	800	850	1000	1200	1300	1500	Page
3.2	12	BT157	TO-220AB						●	●	39
6.5	25	BTW58	TO-220AB				●		●	●	163
10	25	BTV58	TO-220AB	●		●	●				75
10	50	BTR59	SOT-93		●				●		51
15	50	BTS59	SOT-93			●	●	●			63
15	50	BTV59	TO-238AA	●		●	●				87
15	50	BTV59D	TO-238AA			●	●	●			99
15	50	BTV70	TO-238AA			●	●	●			137
15	50	BTV70D	TO-238AA			●	●	●			149
25	120	BTV60	TO-238AA			●	●	●			113
25	120	BTV60D	TO-238AA			●	●	●			123

THYRISTORS

General purpose thyristors

$I_{T(RMS)max}$ (A)		Outline	V_{RRMmax} (V) 200	400	500	600	650	800	1000	1200	Page
0.8	BT169	TO-92	●	●		●					237
4	BT150	TO-220AB			●						189
9	BT151F	SOT-186			●		●	●			207
12	BT151	TO-220AB			●		●	●			197
16	BTY79	TO-64		●	●	●		●	●		295
16	BTW38	TO-64				●		●	●		243
16	BTW42	TO-64				●		●	●		257
20	BT152	TO-220AB		●		●		●			217
25	BT145	TO-220AB			●	●		●			179
25	BTW45	TO-48		●		●		●	●	●	261
25	BTY91	TO-48		●	●	●		●			305
32	BTW40	TO-48		●		●		●			251

THYRISTORS (Cont.)

Fast turn-off thyristors

$I_{T(RMS)max}$ (A)		Outline	V_{DRMmax} (V) 500	600	800	1000	Page	
6	BT153	TO-220AB	●				225	
28	BTW62	TO-238AA		●	●	●	267	(ASCR construction)
28	BTW62D	TO-238AA		●	●	●	275	(ASCR construction)
40	BTW63	TO-48		●	●	●	287	(ASCR construction)

TRIACS

$I_{T(RMS)max}$ (A)		Outline	V_{DRMmax} (V) 500	600	800	1000	1200	Page
4	BT136	TO-220AB	●	●	●			315
4	BT136F	SOT-186	●	●	●			327
8	BT137	TO-220AB	●	●	●			339
8	BT137F	SOT-186	●	●	●			351
12	BT138	TO-220AB	●	●	●			363
12	BT138F	SOT-186	●	●	●			375
15	BTW43	TO-64		●	●	●	●	421
16	BT139	TO-220AB	●	●	●			387
16	BT139F	SOT-186	●	●	●			399
25	BTA140	TO-220AB	●	●	●			411

Page

Bi-directional trigger device BR100/03: $V_{(BO)}$ = 28 to 36 V; I_{FRMmax} = 2 A ———— 177

GENERAL SECTION

Type Designation
Rating Systems
Letter Symbols
Quality Conformance and Reliability
General Explanatory Notes
Heatsinks

PRO ELECTRON TYPE DESIGNATION CODE FOR SEMICONDUCTOR DEVICES

This type designation code applies to discrete semiconductor devices – as opposed to integrated circuits –, multiples of such devices and semiconductor chips.

"Although not all type numbers accord with the Pro Electron system, the following explanation is given for the ones that do."

A basic type number consists of:

TWO LETTERS FOLLOWED BY A SERIAL NUMBER

FIRST LETTER

The first letter gives information about the material used for the active part of the devices.

A. GERMANIUM or other material with band gap of 0,6 to 1,0 eV.
B. SILICON or other material with band gap of 1,0 to 1,3 eV.
C. GALLIUM-ARSENIDE or other material with band gap of 1,3 eV or more.
R. COMPOUND MATERIALS (e.g. Cadmium-Sulphide).

SECOND LETTER

The second letter indicates the function for which the device is primarily designed.

A. DIODE; signal, low power
B. DIODE; variable capacitance
C. TRANSISTOR; low power, audio frequency ($R_{th\ j\text{-}mb} > 15$ K/W)
D. TRANSISTOR; power, audio frequency ($R_{th\ j\text{-}mb} \leqslant 15$ K/W)
E. DIODE; tunnel
F. TRANSISTOR; low power, high frequency ($R_{th\ j\text{-}mb} > 15$ K/W)
G. MULTIPLE OF DISSIMILAR DEVICES – MISCELLANEOUS; e.g. oscillator
H. DIODE; magnetic sensitive
L. TRANSISTOR; power, high frequency ($R_{th\ j\text{-}mb} \leqslant 15$ K/W)
N. PHOTO-COUPLER
P. RADIATION DETECTOR; e.g. high sensitivity phototransistor
Q. RADIATION GENERATOR; e.g. light-emitting diode (LED)
R. CONTROL AND SWITCHING DEVICE; e.g. thyristor, low power ($R_{th\ j\text{-}mb} > 15$ K/W)
S. TRANSISTOR; low power, switching ($R_{th\ j\text{-}mb} > 15$ K/W)
T. CONTROL AND SWITCHING DEVICE; e.g. thyristor, power ($R_{th\ j\text{-}mb} \leqslant 15$ K/W)
U. TRANSISTOR; power, switching ($R_{th\ j\text{-}mb} \leqslant 15$ K/W)
X. DIODE: multiplier, e.g. varactor, step recovery
Y. DIODE; rectifying, booster
Z. DIODE; voltage reference or regulator (transient suppressor diode, with third letter W)

The remainder of the type number is a **serial number** indicating a particular design or development and is in one of the following two groups:

(a) **A serial number** consisting of three figures from 100 to 999.

(b) **A serial number** consisting of one letter (Z, Y, X, W, etc.) followed by two figures.

RANGE NUMBERS

Where there is a range of variants of a basic type of rectifier diode, thyristor or voltage regulator diode the type number as defined above is often used to identify the range; further letters and figures are added after a hyphen to identify associated types within the range. These additions are as follows:

RECTIFIER DIODES, THYRISTORS AND TRIACS

A group of figures indicating the rated repetitive peak reverse voltage, V_{RRM}, or the rated repetitive peak off-state voltage, V_{DRM}, whichever value is lower, in volts for each type.

The final letter R is used to denote a reverse polarity version (stud-anode) where applicable. The normal polarity version (stud cathode) has no special final letter.

REGULATOR DIODES

A first letter indicating the nominal percentage tolerance in the operating voltage V_Z.

A. 1% (according to IEC 63: series E96)
B. 2% (according to IEC 63: series E48)
C. 5% (according to IEC 63: series E24)
D. 10% (according to IEC 63: series E12)
E. 20% (according to IEC 63: series E6)

A group of figures indicating the typical operating voltage V_Z for each type at the nominal operating current I_Z rating of the range.

The letter V is used to denote a decimal sign.

The final letter R is used to denote a reverse polarity version (stud anode) where applicable. The normal polarity version (stud cathode) has no special final letter.

Example:

BTW23-800R Silicon thyristor in the BTW23 range with 800 V maximum repetitive peak voltage, reverse polarity, stud connected to anode.

RATING SYSTEMS

The rating systems described are those recommended by the International Electrotechnical Commission (IEC) in its Publication 134.

DEFINITIONS OF TERMS USED

Electronic device. An electronic tube or valve, transistor or other semiconductor device.

Note
This definition excludes inductors, capacitors, resistors and similar components.

Characteristic. A characteristic is an inherent and measurable property of a device. Such a property may be electrical, mechanical, thermal, hydraulic, electro-magnetic, or nuclear, and can be expressed as a value for stated or recognized conditions. A characteristic may also be a set of related values, usually shown in graphical form.

Bogey electronic device. An electronic device whose characteristics have the published nominal values for the type. A bogey electronic device for any particular application can be obtained by considering only those characteristics which are directly related to the application.

Rating. A value which establishes either a limiting capability or a limiting condition for an electronic device. It is determined for specified values of environment and operation, and may be stated in any suitable terms.

Note
Limiting conditions may be either maxima or minima.

Rating system. The set of principles upon which ratings are established and which determine their interpretation.

Note
The rating system indicates the division of responsibility between the device manufacturer and the circuit designer, with the object of ensuring that the working conditions do not exceed the ratings.

ABSOLUTE MAXIMUM RATING SYSTEM (As used throughout this book)

Absolute maximum ratings are limiting values of operating and environmental conditions applicable to any electronic device of a specified type as defined by its published data, which should not be exceeded under the worst probable conditions.

These values are chosen by the device manufacturer to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environmental variations, and the effects of changes in operating conditions due to variations in the characteristics of the device under consideration and of all other electronic devices in the equipment.

The equipment manufacturer should design so that, initially and throughout life, no absolute maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply voltage variation, equipment component variation, equipment control adjustment, load variations, signal variation, environmental conditions, and variations in characteristics of the device under consideration and of all other electronic devices in the equipment.

DESIGN MAXIMUM RATING SYSTEM

Design maximum ratings are limiting values of operating and environmental conditions applicable to a bogey electronic device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

These values are chosen by the device manufacturer to provide acceptable serviceability of the device, taking responsibility for the effects of changes in operating conditions due to variations in the characteristics of the electronic device under consideration.

The equipment manufacturer should design so that, initially and throughout life, no design maximum value for the intended service is exceeded with a bogey device under the worst probable operating conditions with respect to supply voltage variation, equipment component variation, variation in characteristics of all other devices in the equipment, equipment control adjustment, load variation, signal variation and environmental conditions.

DESIGN CENTRE RATING SYSTEM

Design centre ratings are limiting values of operating and environmental conditions applicable to a bogey electronic device of a specified type as defined by its published data, and should not be exceeded under normal conditions.

These values are chosen by the device manufacturer to provide acceptable serviceability of the device in average applications, taking responsibility for normal changes in operating conditions due to rated supply voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in the characteristics of all electronic devices.

The equipment manufacturer should design so that, initially, no design centre value for the intended service is exceeded with a bogey electronic device in equipment operating at the stated normal supply voltage.

LETTER SYMBOLS FOR RECTIFIER DIODES, THYRISTORS, TRIACS AND BREAKOVER DIODES

LETTER SYMBOLS FOR CURRENTS, VOLTAGES AND POWERS

Basic letters: – The basic letters to be used are:

I, i = current V, v = voltage P, p = power

Lower-case basic letters shall be used for the representation of instantaneous values which vary with time. In all other instances upper-case letters shall be used.

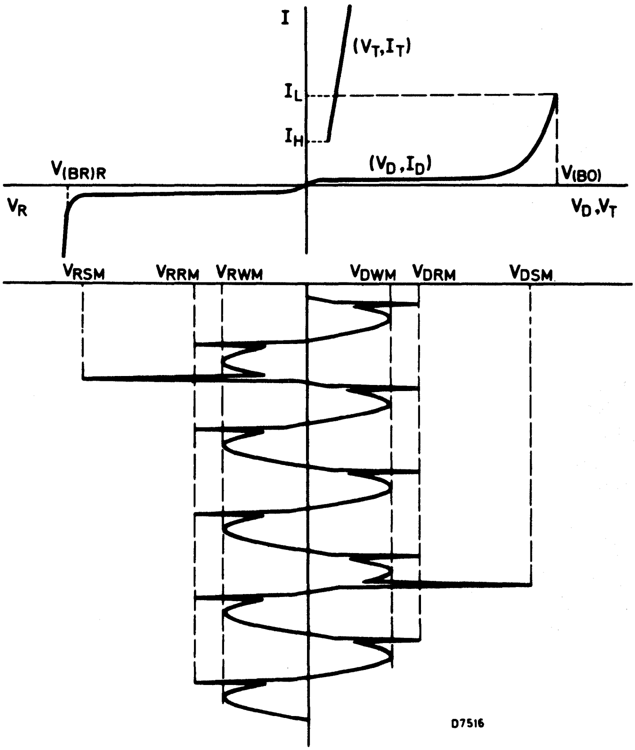
Subscripts

amb	Ambient
(AV), (av)	Average value
(BO)	Breakover
(BR)	Breakdown
case	Case
C	Controllable
D,d	Forward off-state [1]), non-triggered (gate voltage or current)
F,f	Forward [1]), fall
G,g	Gate terminal
H	Holding
I,i	Input
J,j	Junction
L	Latching
M,m	Peak or crest value
min	Minimum
O,o	Output, open circuit
(OV)	Overload
P,p	Pulse
Q,q	Turn-off
R,r	As first subscript: reverse, rise
	As second subscript: repetitive, recovery
(RMS), (rms)	R.M.S. value
S,s	As first subscript: storage, stray, series, source, switching
	As second subscript: non-repetitive
stg	Storage
T,t	Forward on-state [1]), triggered (gate voltage or current)
th	Thermal
(TO)	Threshold
tot	Total
W	Working
Z	Reference or regulator (i.e. zener)

For power rectifier diodes, thyristors and triacs, the terminals are **not** indicated in the subscript, except for the gate-terminal of thyristors and triacs.

[1]) For the anode-cathode voltage of thyristors and triacs, F is replaced either by D or T, to distinguish between 'off-state' (non-triggered) and 'on-state' (triggered).

Example of the use of letter symbols



Simplified thyristor characteristic together with an anode-cathode voltage as a function of time (no gate signal).

QUALITY CONFORMANCE AND RELIABILITY

In addition to 100% testing of all major device parameters in the production department, independently controlled statistical sampling for conformance and reliability takes place using BS6001 'Sampling Procedures and Tables'. BS6001 is consistent with MIL—STD—105D. DEF131A, IS02859, CA—C—115.

The market demand for a continuously improving product quality is being met by the annual updating of formal quality improvement plans.

The 'Defect free' and 'Right first time' concepts are applied regularly as part of an overall quality programme covering all aspects of device quality from initital design to final production. These concepts, together with the quality assurance requirements, embrace all the principles outlined in DEF STAN 05—21, AQAP—1, and BS5750 Pt1.

CONFORMANCE

The Company actively promote a policy of customer cooperation to determine their quality problems and future requirements. This cooperation is often in the form of a 'ppm' activity. The 'ppm' is a measure of conformance of the outgoing product, and is expressed as the number of reject devices found per million of products delivered (e.g. a process average of 0.01% = 100 ppm). Mutually agreed ppm targets are set, and a programme of quality improvement work initiated.

In addition to the above, special inspection and/or test procedures are available, following consultation with the customer and the agreement of a special specification.

RELIABILITY

'Screening', or 'Burn-in' procedures are also available, based on the requirements of CECC 50 000.

CECC 50 000 offers a choice of four screening sequences: 'A', 'B', 'C', 'D'. The Company's standard 'Hi-rel' procedure offers a combination of 'C' and 'D' sequences.

Sequence 'C'

1. High temperature storage — 24 hours minimum.
2. Rapid change of temperature — as detailed in agreed specification.
3. Sealing — fine leak test.
   — gross leak test.
4. Functional electrical characteristics — within group 'A' limits.

Sequence 'D'

1. 'Burn-in' — high-voltage reverse bias, 48 hours duration. Conditions as specified in CECC 50 000.
2. Post 'Burn-in' measurements — functional electrical characteristics, within group 'A' limits.

Other 'Hi-rel', 'Burn-in', or 'Screening' procedures may be available on request.

GATE TURN-OFF THYRISTORS

INTRODUCTION

The gate turn-off thyristor (GTO) is a three-junction bistable semiconductor switch for controlling current flow (the circuit symbol for the GTO is shown in Fig.1). Like a conventional thyristor, it can block a high-level forward voltage while in the off-state, and can pass a peak current far in excess of its rated average current when in the on-state. Unlike an ordinary thyristor, however, it can be turned off by the extraction of reverse current from the gate. In this respect it is similar to a high-voltage transistor, and combines the most desirable properties of both types of device.

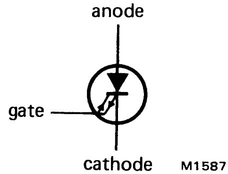


Fig.1 GTO circuit symbol.

FORWARD CHARACTERISTICS

Forward blocking

When the gate is held at or below the potential of the cathode, the GTO is in its forward blocking (off) state, with a low leakage current flowing between anode and cathode.
Four different anode to cathode voltage ratings are given in each GTO data sheet, and are defined as follows:

V_{DSM} the non-repetitive transient voltage.

V_{DRM} the repetitive peak voltage, with a short duty cycle (less than 5%).

V_{DW} the crest working voltage, which is the repetitive peak voltage with a duty cycle of up to 50%.

V_D the continuous d.c. anode to cathode voltage for the required life at maximum junction temperature.

These ratings are interpreted in Fig.2 for two different types of application:

Forward blocking (cont)

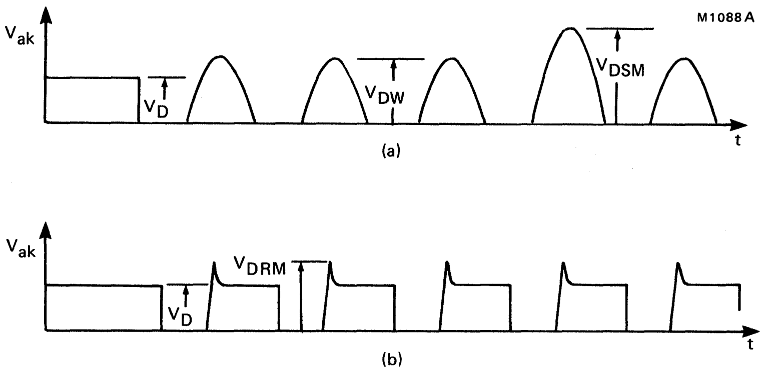


Fig.2

a) A resonant circuit such as a CRT line deflection stage or series resonant power supply.

b) A square wave circuit such as a d.c. chopper or pulse-width modulated a.c. motor control.

Forward conduction

In forward conduction the GTO has two stable states, as indicated in Fig.3. When the anode current is below the latching current I_L, the device behaves as a high-voltage transistor, with a gate-anode current amplification factor I_A/I_G which increases with increasing anode current and with increasing junction temperature. When the anode current is equal to or greater than the latching current (i.e. when the gate current has been increased above the level required to trigger the device), the GTO is in its on-state with a small potential difference between the anode and cathode. Provided the anode current does not fall below the holding level, the device will remain in the on-state even when the gate current is removed, as in a conventional thyristor. Unlike most normal thyristors, however, the on-state voltage drop (V_T) can be reduced to some extent by maintaining a forward gate current and this is indicated in data graphs of V_T versus I_T. Since the latching currents of GTOs can be relatively high (typically 10–20% of the rated average current) it may be desirable in most applications to keep forward gate current flowing at a low level while the GTO is conducting, to prevent spurious unlatching of the device.

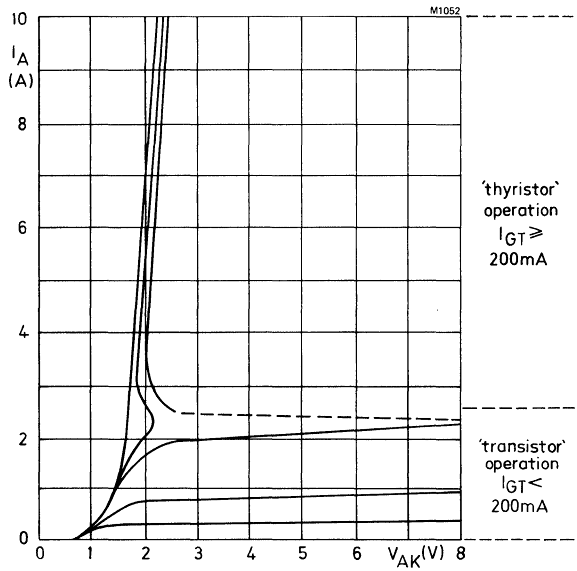


Fig.3 On-state current as a function of the on-state voltage with gate current as a parameter for the BTV59 GTO.

REVERSE CHARACTERISTICS

The reverse characteristic of the GTO is equivalent to that of a resistance which is incapable of blocking voltage or conducting significant current. For d.c. switching, this does not present any problems. However, if reverse voltage blocking is required for a.c. switching, a diode must be connected in series with the GTO as shown in Fig.4. If reverse current must be allowed to flow, a diode must be connected in anti-parallel with the GTO.

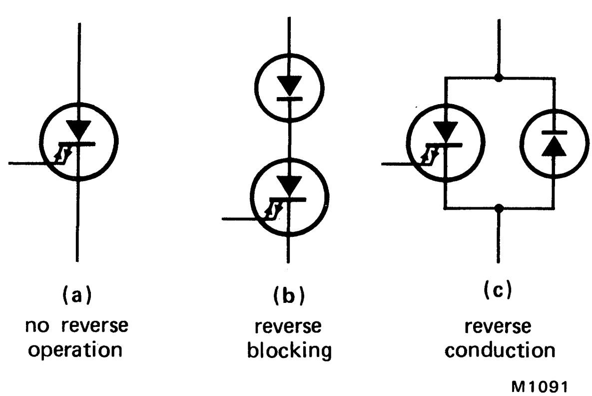


Fig.4 The use of additional diodes to change the reverse characteristic of the GTO circuit.

SWITCHING CHARACTERISTICS

Turn-on

During turn-on, care should be taken to ensure that adequate gate current is available whenever the anode current is likely to be less than the latching level. For example, Fig.5a shows that, if turn-on is achieved by discharging a capacitor into the gate of a GTO with an inductive load, too brief a time constant may cause the gate current to fall below I_{GT} before sufficient time has elapsed for the anode current to rise above the latching level. This could cause uncertain triggering. Also, if the anode current is only slightly higher than the latching level, a steep trailing edge of a positive gate pulse may cause the GTO to unlatch as shown in Fig.5b.

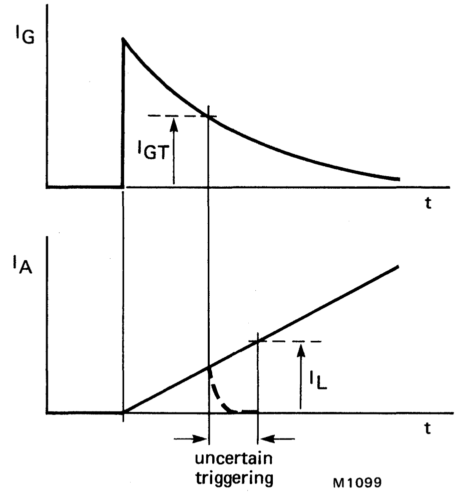


Fig.5a To ensure good triggering the anode current must rise above the latching level before the gate current falls below the minimum level required to ensure triggering.

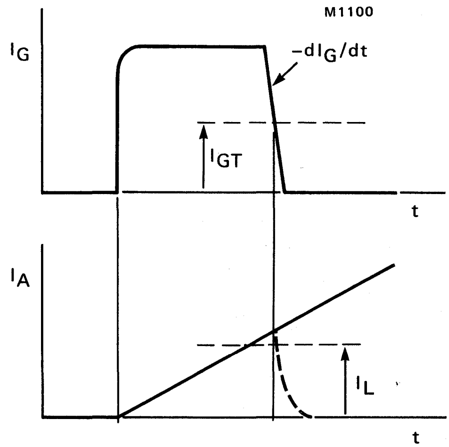


Fig.5b Unlatching can occur if the anode current is only slightly higher than the latching level during a rapid fall in gate current.

Although the value of gate current stated in data for a given junction temperature will always cause a GTO to turn on, the turn-on process may be very slow if the gate current supplied is only just greater than the trigger current of a particular device. Therefore it is usually desirable to apply an initial gate current pulse of 2–5 times the I_{GT} value given in data, to ensure fast turn-on. All turn-on times in data are defined under these conditions.

dI_T/dt limitation

Provided that sufficient gate over-drive is given at turn-on to ensure fast switching, rapid rise of anode current at turn-on (due, for instance, to the discharge of a capacitor or the reverse recovery current of a flywheel diode) will not cause any problems. This is due to the interdigitated gate-cathode structure of the device and to the fact that the rate of rise of current at turn-on is low and self-limiting until a large proportion of the device has come into conduction. The GTO can typically withstand values of turn-on dI_T/dt up to 2000A/μs.

Turn-off

As mentioned above, a major characteristic of the GTO is its ability to be turned off from the conducting state by the reverse biasing of the gate-cathode junction. However, there are several limitations which must be taken into account when designing a GTO circuit:

Controllable Anode Current, Rate of rise of Anode Voltage, and Snubber Network design.

There is a limit to the magnitude of anode current which may be interrupted, and this is dependent on the behaviour of the anode voltage during turn-off (if this current is exceeded a failure occurs which is analagous to reverse-biased second breakdown in bipolar transistors, and may result in the destruction of the device). More particularly, the controllable anode current (I_{TC}) is a function of the rate of rise of reapplied voltage (dV_D/dt). In order to take advantage of the high peak current handling capabilities of the GTO, it is normally necessary to use a form of dV_D/dt limiting network (snubber network) connected across the anode-cathode of the device. This may take the form of a capacitor connected directly across the device, or a polarised (RCD) network. However, it should be noted that the standard RC snubber as used in thyristor or ASCR circuits is not suitable for use with the GTO, because the GTO current is interrupted internally rather than by an external commutating circuit.

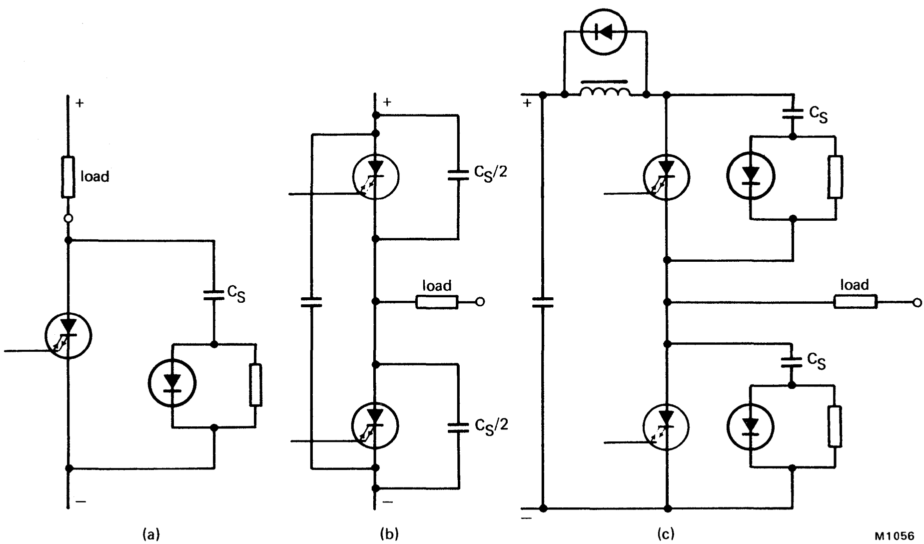


Fig.6 Snubber networks.

Fig.6 shows some examples of snubber networks which may be used in practice:

(a) Polarised (RCD) snubber for a single GTO.

(b) and (c) Simple capacitor and RCD snubbers used in a bridge configuration. Note that when using an RCD network in this circuit it is necessary to decouple the d.c. supply with an inductor to prevent the top snubber capacitor (C_S) from charging up through the bottom GTO, and vice versa.

Turn-off (cont)

In all cases, the applied dV_D/dt is defined by the equation:

$$I_T = C_S \times dV_D/dt$$

and the minimum permissible value of snubber capacitance which may be used in a particular circuit should be determined by consulting the relevant data graph of I_{TC} versus dV_D/dt. In resonant circuits, of course, dV_D/dt may be fixed by other circuit requirements.

If a simple capacitive snubber is used, the largest value of capacitance which may be connected directly across the GTO is limited by the energy dissipated in the GTO and the peak GTO anode current caused by its discharge at turn-on. Suggested maximum values (for a supply voltage equal to V_{Dmax}.) are as follows:

GTO	max. C_S
BT157	25 nF
BTV58, BTW58	50 nF
BTV59, BTW59	100 nF
BTV60	200 nF

If snubber capacitances greater than these values are required, a polarised (RCD) network should be used.

For any snubber network to be effective, the inductance in series with it (including stray inductance) must be minimised. The presence of series inductance in the snubber gives rise to an uncontrolled voltage across the device during the fall time (see the waveforms given in Fig.8). Since this is the equivalent of allowing a higher dV_D/dt, excessive inductance will reduce the value of I_{TC} below that which might be expected from a given value of snubber capacitance. Fig.7 indicates the effect this may have on controllable current for a typical device.

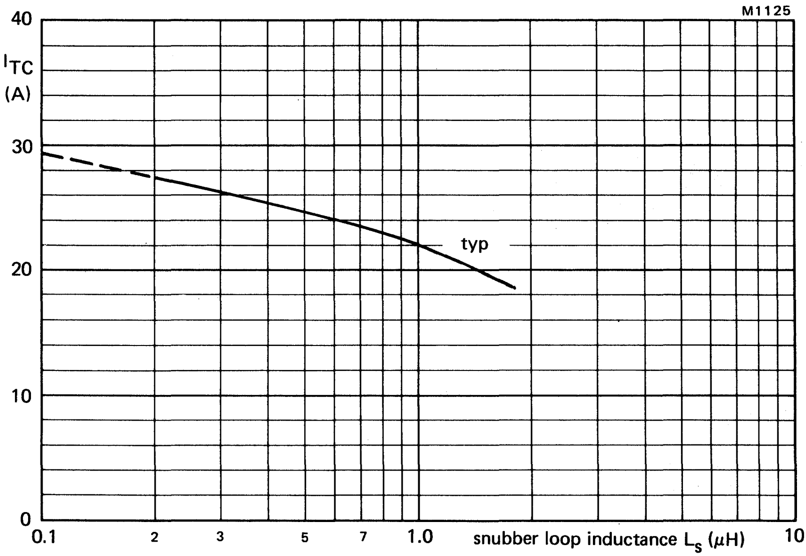


Fig.7 Typical anode current which can be turned off, as a function of snubber loop inductance for the BTV59 (C_S = 20 nF, T_{mb} = 25 °C)

When using an RCD snubber network, in which the current transferred from the GTO to the snubber capacitor must pass through the diode, care should be taken in the selection of the diode used, since (particularly in 'fast-recovery' gold-doped diodes) a high transient forward voltage can appear when the forward current through the diode is increased rapidly from zero. This voltage will have exactly the same effect as that due to stray inductance, and must be minimised. In general, the effect of snubber inductance will increase with increasing anode current and reducing dV_D/dt.
Another factor which should be taken into account when designing an RCD snubber network is the need for the snubber capacitor to be fully discharged before the device is turned off. When the GTO is turned on, the capacitor is, of course, charged up to the d.c. supply voltage, and must discharge through the snubber resistance R_S. For a supply voltage equal to the V_{Dmax} rating of the GTO, a safe period to ensure adequate discharge of the capacitor is given by:

$$t_{on} = 5 \times R_S \times C_S$$

where t_{on} is in microseconds, R_S is in ohms and C_S is in microfarads.

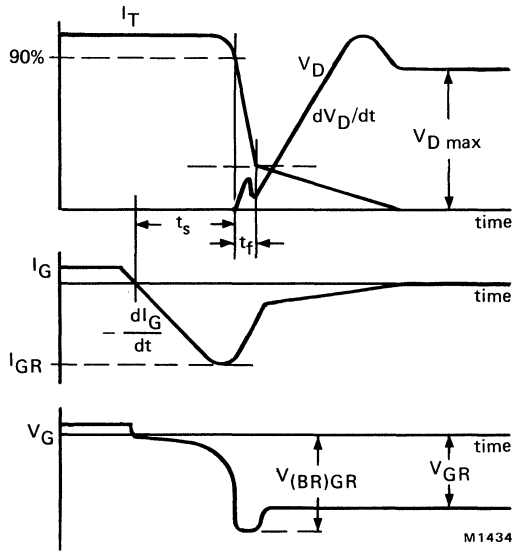


Fig.8 Typical turn-off waveforms.

Gate circuit design

The amount of current a GTO can turn off is dependent on the performance of the gate drive circuit used, as well as the factors mentioned above. Essentially, the gate drive circuit consists of two distinct parts: a forward current source which provides gate current while the device is on, and a negative voltage source which is connected across the gate-cathode through a low impedance at turn-off. An idealised version of this is shown in Fig.9.

Gate circuit design (cont)

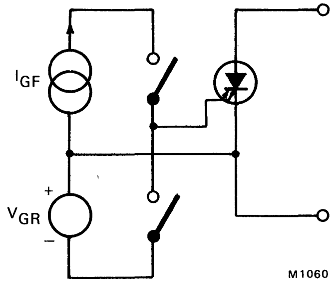


Fig.9 Idealised gate circuit.

The gate-cathode junction of a GTO may be regarded as a zener diode with a reverse breakdown voltage greater than that specified in the data sheet, so that, provided the negative voltage source does not exceed this voltage, no significant current will flow once the turn-off process is completed and the device is in the off state. During turn-off (see Fig.8) however, a current with a peak value of I_{GR} will flow. The ratio I_A/I_{GR} is known as the 'turn-off gain' of the device, and may vary from <1 to 3–4, depending on the current being turned off (each data sheet gives the maximum value of I_{GR} which might be expected, as a function of anode current). The rate at which the negative gate current rises during the storage period of turn-off ($-dI_G/dt$) is controlled by the impedance in the gate circuit. In practice this should be kept to a minimum, but a certain amount of wiring inductance is unavoidable, and is not detrimental to turn-off performance provided it is kept below the maximum limit given in each data sheet. Series resistance in the negative gate current path should be minimised, and this generally implies the use of a low-voltage fast-switching bipolar or power MOS device to switch the gate to a negative voltage. An example of a practical gate drive circuit (for the BTV/BTW59) is shown in Fig.10.

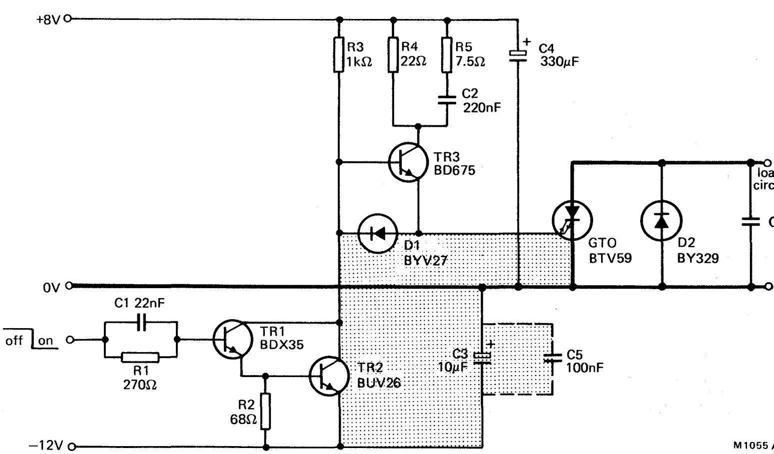


Fig.10 Practical drive circuit suitable for a BTV59. The turn-off loop (shaded) should have minimum inductance, and the small decoupling capacitor (shown in dashed lines), should be wired as close as possible to the electrolytic capacitor.

Forward gate drive is provided by TR3, with an initial gate pulse being supplied via R5/C2. The discrete Darlington pair TR1/TR2 switches the gate to the −12 V rail, resulting in a negative gate voltage (V_{GR}) of approx. 10 V when the V_{CEsat} of TR2 is taken into account.
For smaller devices, such as the BT157 and the BTV/BTW58, a simpler gate circuit (as shown in Fig.11) may be adequate.

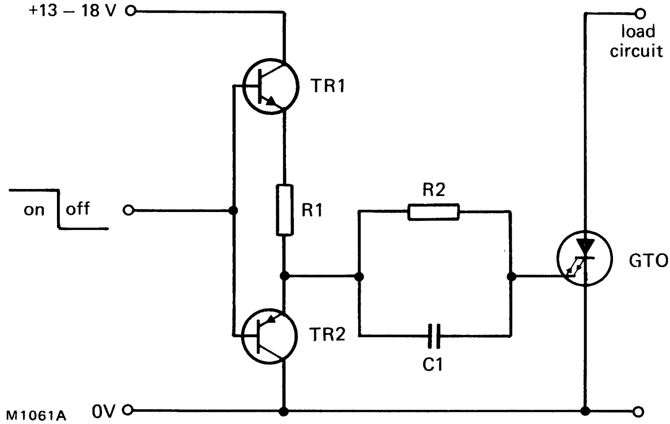


Fig.11 Simple gate circuit

The capacitor C1 is charged during the GTO on-time, and can then be used to supply the negative gate voltage to turn off the GTO. The capacitor must be large enough to ensure that the negative gate current pulse which occurs at turn-off does not discharge the capacitor by more than about 1 V, and must also be charged up adequately the first time the GTO is switched on.
It is recommended that wherever possible, full advantage should be taken of the guaranteed reverse breakdown voltage of the gate-cathode junction so that the maximum possible negative drive voltage is used. However, if this voltage is limited by other considerations to a lower value, due attention should be paid to the relevant data graph to ensure the maximum controllable current is not exceeded, since I_{TC} falls with reducing V_{GR}.
It should be noted that in most practical gate drives the gate-cathode junction is normally driven into reverse avalanche conduction for a short time while the negative gate current falls from its peak value back to zero (see Fig.8). Because of its interdigitated structure, the junction is capable of withstanding high avalanche currents for short periods without sustaining damage, so this does not cause a problem.

SAFE OPERATING AREA (SOAR)

Forward-biased SOAR

Since the GTO is a regenerative device it does not have forward-biased SOAR limitations in the same way as a bipolar transistor. Peak on-state current is limited by the capabilities of the connecting wires and the thermal capacity of the crystal, and is stated in data as a maximum non-repetive surge current limit in the same way as an ordinary thyristor.

Reversed-biased SOAR

For any particular applied dV_D/dt the GTO is capable of turning off the current given by the data graph of I_{TC} versus dV_D/dt up to the full rated V_{DRM} of the device. The RB SOAR curve is therefore a rectangle bounded by I_{TC} and V_{DRM}.

SWITCHING LOSSES

When the GTO is switched from the off- to the on-state and vice versa, there is a loss of energy resulting from the simultaneous presence of high voltage and high current during switching. The average power loss resulting from this may or may not be significant, depending on the frequency of operation. The switching losses are dependent on the operating conditions and must be considered when a circuit is being designed.

Turn-on Losses

The energy loss at turn-on can be estimated from the equation:

$$E_{on} = V_D \times I_T \times t_r \times 1/6$$

→ where E_{on} is in microjoules, V_D is the voltage from which the GTO is being turned on, I_T is the current being turned on to, and t_r is the rise time in microseconds. These losses can clearly be minimised by ensuring fast turn-on with an initial high gate current pulse.

Turn-off Losses

At turn-off, switching losses are almost completely due to the small 'tail current' which flows after the anode voltage has begun to rise (see Fig.8). Turn-off losses are a function of anode current, applied dV_D/dt, and junction temperature. Each data sheet includes graphs which can be used to calculate losses given these conditions.

THYRISTORS AND TRIACS

SWITCHING CHARACTERISTICS

Thyristors and triacs are not perfect switches. They take a finite time to go from the off to the on-state and vice-versa. At frequencies up to about 400 Hz these effects can often be ignored, but in many applications involving fast switching action the departure from the ideal is important.

Gate-controlled turn-on time

Anode current does not commence flowing at the instant the gate current is applied.
There is a period which elapses between the application of gate current and the onset of anode current known as delay time (t_d). The rise time of anode current is known as t_r and is measured as the time taken for the anode voltage to fall from 90% to 10% of its initial value.
The conditions which need to be specified are:

a) Off-state voltage (V_D).

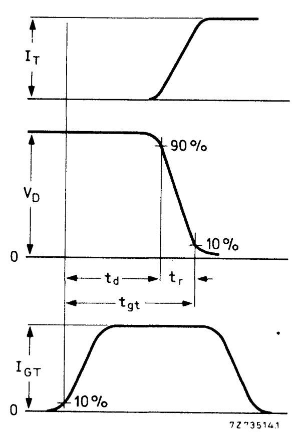
b) On-state current (I_T).

c) Gate trigger current (I_G) – high gate currents reduce turn-on time.

d) Rate of rise of gate trigger current (dI_G/dt) – high values reduce turn-on time.

e) Junction temperature (T_j) – high temperatures reduce turn-on time.

The waveforms are shown in the following diagram:



THYRISTORS

CIRCUIT-COMMUTATED TURN-OFF TIME

When a thyristor has been conducting and is reverse biased it cannot go immediately into the forward blocking state. Thyristors exhibit a stored charge in a similar fashion to rectifiers; it is only after this charge has been recombined or been swept out that the device can block reapplied off-state voltage. The turn-off time (t_q) is measured from the instant the anode current passes through zero to the instant the thyristor is capable of blocking reapplied off-state voltage.

The conditions which need to be specified are:

a) On-state current (I_T) — high peak currents mean longer turn-off times.

b) Reverse voltage (V_R) — low reverse voltages mean longer turn-off times.
An example of this is when the thyristor is in anti-parallel with a diode, limiting the reverse voltage to a volt or so.

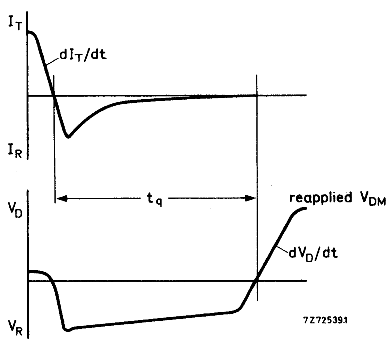
c) Rate of fall of anode current (dI/dt) — high rates mean shorter turn-off times.

d) Rate of rise of reapplied off-state voltage (dV_D/dt) — high rates mean longer turn-off times.

e) Temperature (T_j or T_{mb}) — high temperatures mean longer turn-off times.

f) Gate conditions ($-V_{GG}$, R_{tot}) — the application of a negative gate voltage during reverse recovery can be used to reduce the turn-off time. Care must be taken not to exceed the reverse gate voltage rating (V_{RGMmax}).

The waveforms are shown in the following diagram:



TRIACS

COMMUTATION dV_{com}/dt

When a triac has been conducting current in one direction and is then required to block voltage in the other, it is faced with a difficult task. Reverse recovery current adds to the capacitive current from the reapplied dV_D/dt in such a fashion that the device's ability to withstand high rates of reapplication of voltage is impaired. For this reason the commutation dV_D/dt is invariably worse than the static dV_D/dt.

The conditions which need to be specified are:

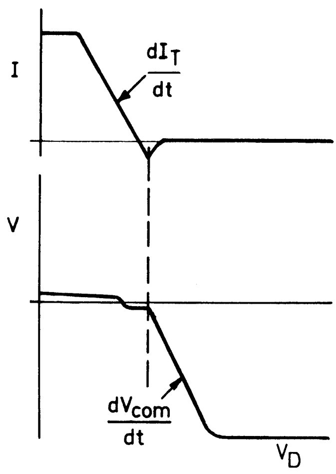
a) R.M.S. current ($I_{T(RMS)}$) – high currents make commutation harder.

b) Re-applied off-state voltage (V_D), normally V_{DRM} max. – high voltage will make commutation harder.

c) Temperature (T_j or T_{mb}) – high temperatures make commutation harder.

d) $-dI/dt$ – high rates of change make commutation harder.

The waveforms are shown in the following diagram:



THYRISTORS

OPERATING NOTES

When there is a possibility that transients, due to the energy stored in the transformer, will exceed the maximum permissible non-repetitive peak reverse voltage, a damping circuit should be connected across the transformer.

Either a series RC circuit or a voltage dependent resistor may be used. Suitable component values for an RC circuit across the transformer primary or secondary may be calculated as follows:

$\frac{V_{RSM}}{V_{RWM}}$	RC across primary of transformer		RC across secondary of transformer	
	C (μF)	R (Ω)	C (μF)	R (Ω)
2.0	$200\frac{I_{mag}}{V_1}$	$\frac{150}{C}$	$225\frac{I_{mag}T^2}{V_1}$	$\frac{200}{C}$
1.5	$400\frac{I_{mag}}{V_1}$	$\frac{225}{C}$	$450\frac{I_{mag}T^2}{V_1}$	$\frac{275}{C}$
1.25	$550\frac{I_{mag}}{V_1}$	$\frac{260}{C}$	$620\frac{I_{mag}T^2}{V_1}$	$\frac{310}{C}$
1.0	$800\frac{I_{mag}}{V_1}$	$\frac{300}{C}$	$900\frac{I_{mag}T^2}{V_1}$	$\frac{350}{C}$

where I_{mag} = magnetising primary r.m.s. current (A)

V_1 = transformer primary r.m.s. voltage (V)

V_2 = transformer secondary r.m.s. voltage (V)

T = V_1/V_2

V_{RSM} = the transient voltage peak produced by the transformer

V_{RWM} = the actually applied crest working reverse voltage

The capacitance values calculated from the above table are minimum values; to allow for circuit variations and component tolerances, larger values should be used.

Heatsinks are used where a semiconductor device is unable of itself to dissipate the heat generated by its internal power losses without the junction temperature exceeding its maximum. The simplest form of heatsink is a flat metal plate, but for economy in weight, size, and cost, more complex shapes are usually used.
Apart from information on heat transfer and the construction of assemblies, this Section shows how to take advantage of reverse polarity types, describes three types of heatsink, and gives calculation examples.

HEAT TRANSFER PATH

In, for example, a silicon rectifier the heat is generated inside the wafer and flows mainly by way of the base, through a heatsink to the ambient air.
The heat flow can be likened to the flow of electric current, with thermal resistance (R_{th} in °C/W) analogous to the electric resistance (R in Ω).
Fig. 1 shows the heat path from junction to ambient as three thermal resistances in series:

$R_{th\,j\text{-}mb}$ — The thermal resistance from junction to mounting base. Its value is given in the data sheets of a device.

$R_{th\,mb\text{-}h}$ — The thermal resistance from mounting base to heatsink (contact thermal resistance). It is caused by the imperfect nature and limited size of the contact between the two. Its value is also given in the data sheets.

$R_{th\,h\text{-}a}$ — The thermal resistance between the contact surface mentioned above and the ambient air.

For thermal balance air warmed by the heatsink must be replaced by cool, i.e., there must be an air flow.
From Fig. 1: $T_j - T_{amb} = P \times (R_{th\,j\text{-}mb} + R_{th\,mb\text{-}h} + R_{th\,h\text{-}a})$

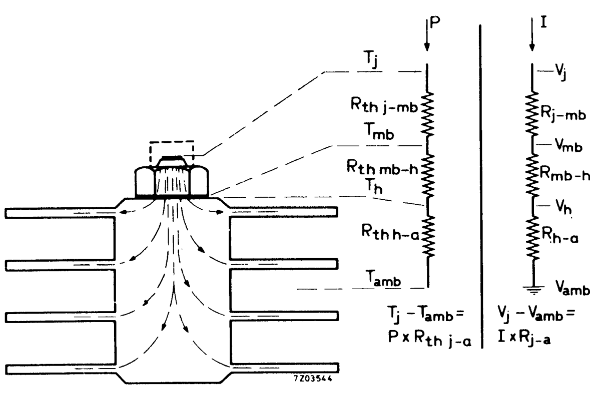


Fig. 1

IMPROVING HEAT TRANSFER

Heat transfer can be improved by reducing the thermal resistance of the contact and the thermal resistance of the heatsink.

Contact thermal resistance

- Make the contact area large
- Make the contact surfaces plane parallel by attention to drilling an punching, and make them burr-free.
- Apply sufficient pressure. Use a torque spanner adjusted to at least the rated minimum torque.
- Use metal oxide-loaded compound to fill air pockets.

Heatsink thermal resistance

- Paint or anodise the surface to improve radiation
- Increase the flow of cooling air
- Use a larger heatsink

The simplest form of air flow is natural convection. Mount the fins vertically, make intake and outlet apertures large, avoid obstructions, create a draught (chimney effect). A blower or fan must be used where free convection is not enough or where a smaller heatsink is wanted.

INSULATED MOUNTING

Where a semiconductor must be insulated from its heatsink (e.g., in bridge rectifiers) by a mica or teflon washer, the contact thermal resistance will be about ten times higher than without insulation. This must be compensated by a reduction in $R_{th\,h\text{-}a}$ to keep the total thermal resistance below the maximum given for P and T_{amb}. A larger heatsink may be necessary.

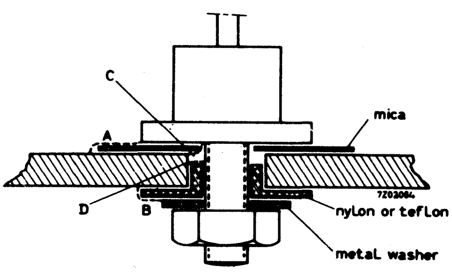


Fig. 2 Creepage distances with an insulated diode

Note: care must be taken that the creepage distances, see Fig. 2, are sufficient for the voltage involved. While A and B can be made large enough, C and D are likely to be the critical ones.

CONSTRUCTIONS

Good thermal coupling is essential to semiconductors connected in parallel to ensure good current sharing in view of the forward characteristics, and semiconductors in series in view of the reverse characteristics.
Mounting the semiconductors on the same heatsink not only saves mounting costs but also provides the needed thermal coupling.
Fig. 3 shows the construction for a plain heatsink, and Fig. 4 the construction for an extruded heatsink. The electrical connection is made with a copper strip at least 1 mm thick. For two diodes a plain heatsink should be twice the area, and an extruded heatsink twice the length needed for a single diode.
Reverse polarity devices are covenient for series connection of two diodes on a common heatsink. Figs. 5, 6 and 7 show how the use of normal polarity and reverse polarity diodes simplifies the construction of single-phase and three-phase bridge rectifiers.

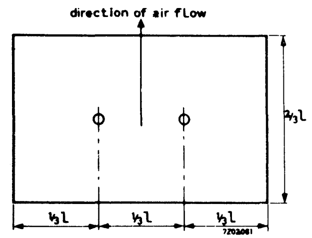


Fig. 3 Plain cooling fin with two diodes

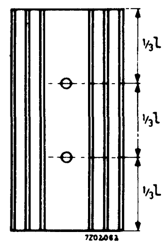


Fig. 4 Extruded aluminium heatsink with two diodes

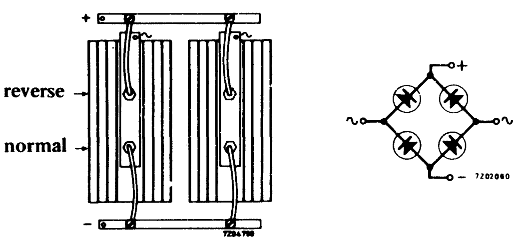


Fig. 5 Single phase full wave rectifier with diodes of different polarity on extruded aluminium heatsinks

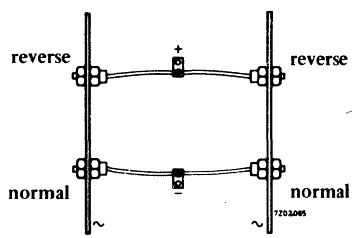


Fig. 6 Single phase full wave rectifier with diodes of different polarity on plain cooling fins (top view)

CONSTRUCTIONS (continued)

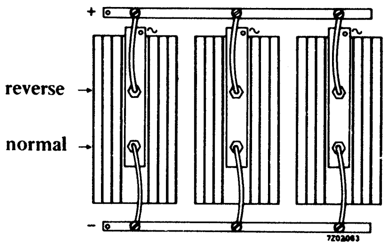


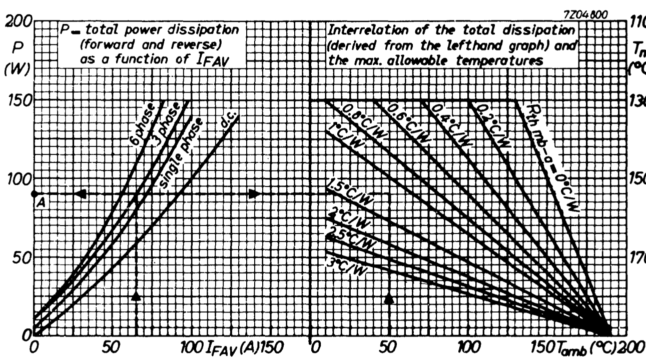
Fig. 7 Three phase full wave rectifier with diodes of different polarity on extruded aluminium heatsinks

EXAMPLES OF HEATSINK CALCULATION

1. Devices without controlled avalanche properties.
   Assume that the diode of which the outlines are shown, is used in a three phase 50 Hz rectifier circuit at T_{amb} = 50 °C. Further assume: average forward current per diode $I_{F(AV)}$ = 65 A; contact thermal resistance $R_{th\ mb\text{-}h}$ = 0,1 °C/W.

Stud: M12
Mounting base, across the flats: max. 27 mm

From the data of the diode the graph to be used is shown below.



From the lefthand graph it follows that P_{tot} = 90 W per diode (point A).
From the righthand graph it follows that $R_{th\ mb\text{-}a} \approx 1,2$ °C/W.
Thus $R_{th\ h\text{-}a} = R_{th\ mb\text{-}a} - R_{th\ mb\text{-}h}$ = (1, 2 − 0, 1) °C/W = 1, 1 °C/W.
This may be achieved by different types of heatsinks as shown below.

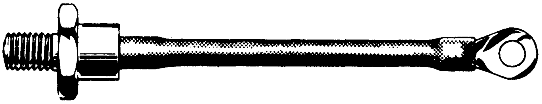
Type	Free convection	Forced cooling
flat, blackened bright	– –	125 cm²; 2 m/s or 300 cm²; 1 m/s 175 cm²; 2 m/s
diecast 56280	applicable	
extrusion		
56230 bright	ℓ = 12 cm	ℓ = 5 cm [1]; 1 m/s
blackened	ℓ = 8 cm	ℓ = 5 cm [1]; 1 m/s
56231 bright	ℓ = 7 cm	
blackened	ℓ = 5 cm [1]	

[1] Practical minimum length

EXAMPLES OF HEATSINK CALCULATION (continued)

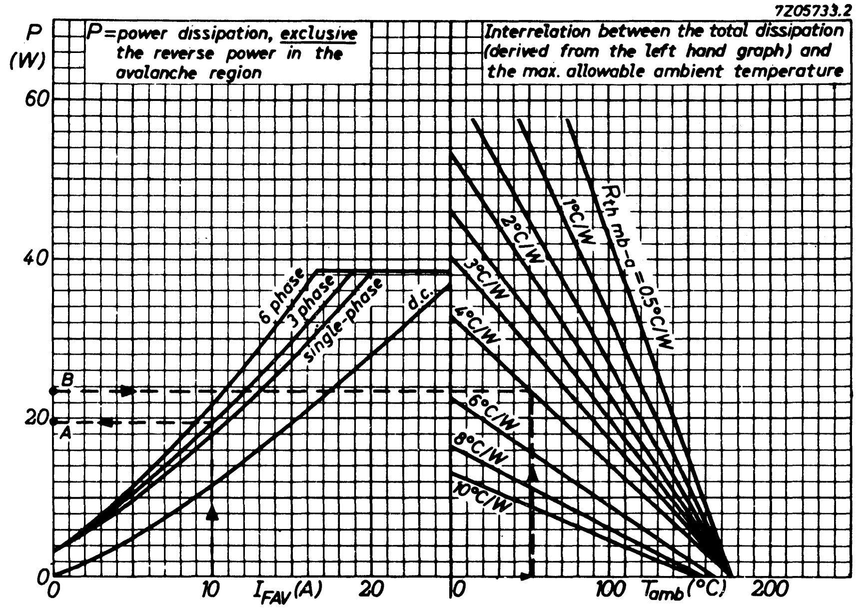
2. Devices with controlled avalanche properties

Assume that the diode of which the outlines are shown, is used in a three phase 50 Hz rectifier circuit at T_{amb} = 40 °C. Further assume: average forward current per diode $I_{F(AV)}$ = 10 A; contact thermal resistance: $R_{th\ mb\text{-}h}$ = 0,5 °C/W; repetitive peak reverse power in the avalanche region (t = 40 μs) P_{RRM} = 2 kW (per diode).



Stud: M12
Mounting base, across the flats: max. 27 mm

From the data of this diode the graph to be used is shown below.



From the lefthand graph it follows that P_{tot} = 19,5 W per diode (point A). The average reverse power in the avalanche region, averaged over any cycle, follows from

$P_{R(AV)} = \delta \times P_{RRM}$, where the duty cycle $\delta = \frac{40\ \mu s}{20\ ms} = 0,002$.

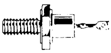
Thus $P_{R(AV)}$ = 0,002 x 2 kW = 4 W.

Therefore the total device power dissipation P_{tot} = 19,5 + 4 = 23,5 W (point B). From the righthand graph it follows that $R_{th\ mb\text{-}a}$ = 4 °C/W. Hence the heatsink thermal resistance should be:

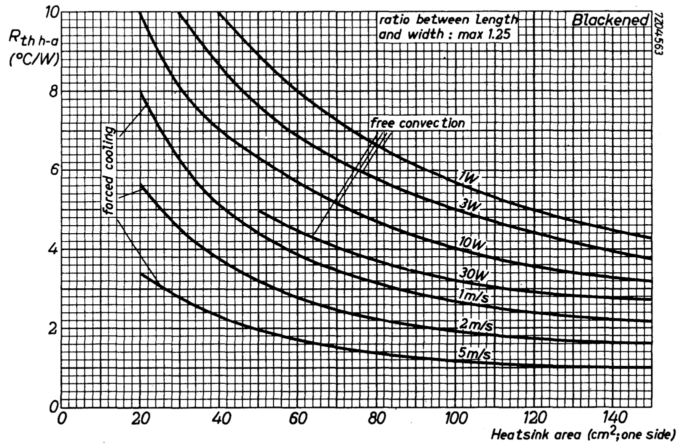
$$R_{th\ h\text{-}a} = R_{th\ mb\text{-}a} - R_{th\ mb\text{-}h} = (4 - 0,5)\ ^{\circ}C/W = 3,5\ ^{\circ}C/W.$$

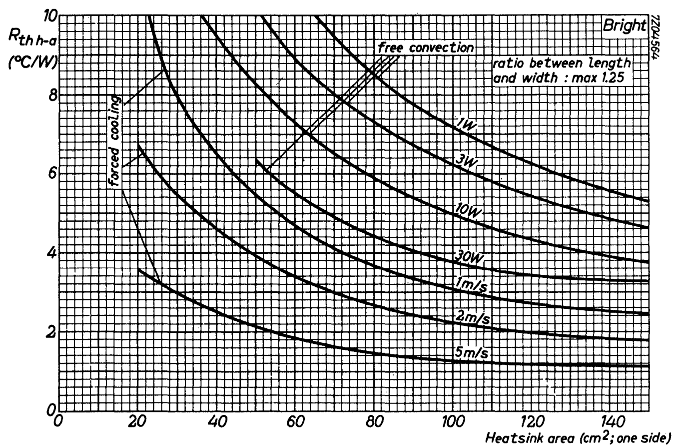
A table of applicable heatsinks, similar to that on the foregoing page, can de derived for this case.

Thermal resistance of flat heatsinks of 2 mm copper or 3 mm aluminium.
The graphs are valid for the combination of device and heatsink.

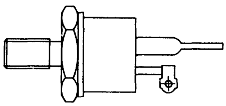


Studs: 10-32UNF
Mounting bases, across the flats: max. 11,0 mm

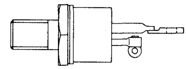




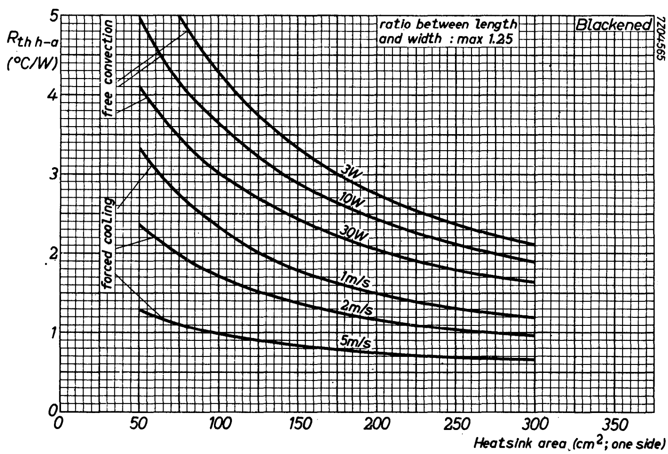
Thermal resistance of flat heatsinks of 2 mm copper or 3 mm aluminium.
The graphs are valid for the combination of device and heatsink.

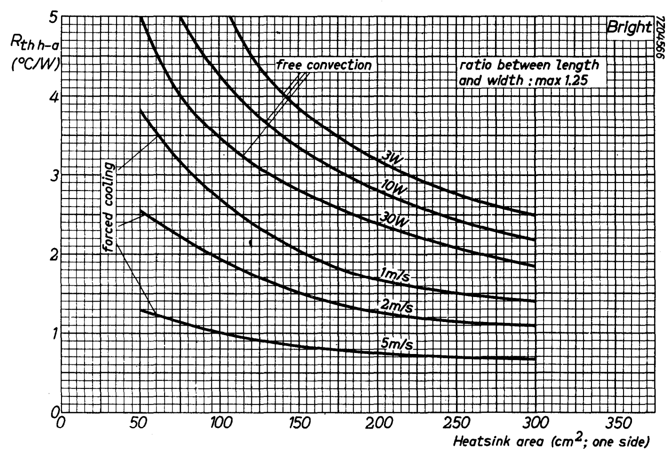


Stud: ¼" x 28 UNF
Mounting base, across the flats: max. 17 mm



Stud: M6
Stud: $\frac{1}{4}$" x 28 UNF
Mounting base, across the flats: max. 14,0 mm





GATE TURN-OFF THYRISTORS

FAST GATE TURN-OFF THYRISTORS

Thyristors in TO-220AB envelopes capable of being turned both on and off via the gate. They are suitable for use in high-frequency inverters, resonant power supplies, horizontal deflection systems etc. The devices have no reverse blocking capability. For reverse blocking operation use with a series diode, for reverse conducting operation use with an anti parallel diode.

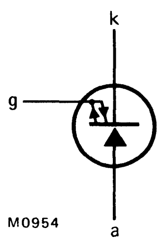
QUICK REFERENCE DATA

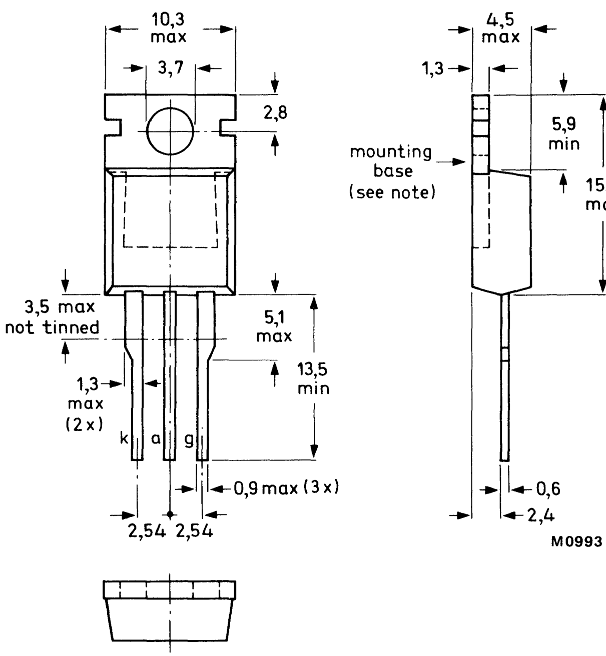
			BT157–1300R	1500R	
Repetitive peak off-state voltage	V_{DRM}	max.	1300	1500	V
Non-repetitive peak on-state current	I_{TSM}	max.	20		A
Controllable anode current	I_{TCRM}	max.	12		A
Average on-state current	$I_{T(AV)}$	max.	3.2		A
Fall time	t_f	max.	200		ns

MECHANICAL DATA

Dimensions in mm

Fig.1 TO-220AB





Net mass: 2 g

Note: The exposed metal mounting base is directly connected to the anode.

Accessories supplied on request: see data sheets Mounting instructions and accessories for TO-220 envelopes.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134)

Anode to cathode

			BT157–1300R	1500R	
Transient off-state voltage	V_{DSM}	max.	1500	1650	V*
Repetitive peak off-state voltage	V_{DRM}	max.	1300	1500	V*
Working off-state voltage	V_{DW}	max.	1200	1300	V*
Continuous off-state voltage	V_D	max.	750	800	V*

Average on-state current (averaged over any 20 ms period) up to T_{mb} = 80 °C	$I_{T(AV)}$	max.	3.2	A
Controllable anode current	I_{TCRM}	max.	12	A
Non-repetitive peak on-state current t = 10 ms; half-sinewave; T_j = 120 °C prior to surge	I_{TSM}	max.	20	A
I^2t for fusing; t = 10 ms	I^2t	max.	2	A^2s
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	47.5	W

Gate to cathode

Repetitive peak on-state current T_j = 120 °C prior to surge gate-cathode forward; t = 1 ms; half-sinewave	I_{GFM}	max.	25	A
gate-cathode reverse; t = 20 μs	I_{GRM}	max.	15	A
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	2.5	W

Temperatures

Storage temperature	T_{stg}		–40 to +150	°C
Operating junction temperature	T_j	max.	120	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2.0	K/W
From mounting base to heatsink with heatsink compound	$R_{th\ mb\text{-}h}$	=	0.3	K/W
with 56367 alumina insulator and heatsink compound (clip-mounted)	$R_{th\ mb\text{-}h}$	=	0.8	K/W
From junction to ambient in free air, mounted on a printed circuit board	$R_{th\ j\text{-}a}$	=	60	K/W

* Measured with gate-cathode connected together.

CHARACTERISTICS

Anode to cathode

On-state voltage I_T = 2.5 A; I_G = 0.2 A; T_j = 120 °C	V_T	<	3.4	V*
Rate of rise of off-state voltage that will not trigger any off-state device; exponential method V_D = 2/3 V_{Dmax}; V_{GR} = 5 V; T_j = 120 °C	dV_D/dt	<	10	kV/μs
Rate of rise of off-state voltage that will not trigger any device following conduction; linear method; I_T = 1.8 A; V_D = V_{DRMmax}; V_{GR} = 10 V; T_j = 120 °C	dV_D/dt	<	1.5	kV/μs
Off-state current V_D = V_{Dmax}; T_j = 120 °C	I_D	<	2.0	mA
Latching current; T_j = 25 °C	I_L	typ.	0.75	A**

Gate to cathode

Voltage that will trigger all devices V_D = 12 V; T_j = 25 °C	V_{GT}	>	1.5	V
Current that will trigger all devices V_D = 12 V; T_j = 25 °C	I_{GT}	>	200	mA
Minimum reverse breakdown voltage I_{GRM} = 1.0 mA	$V_{(BR)GR}$	>	10	V

Switching characteristics (resistive load)

Turn-on when switched to I_T = 2.5 A from V_D = 250 V with I_{GF} = 0.4 A; T_j = 25 °C

delay time	t_d	<	0.25	μs
rise time	t_r	<	1.0	μs

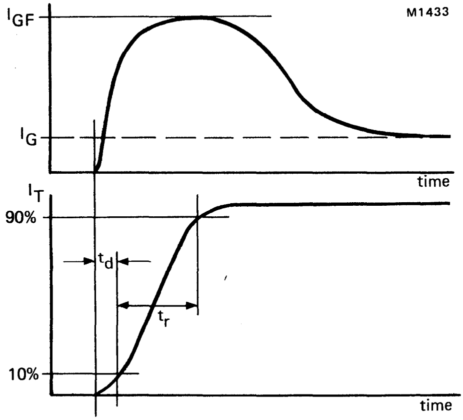


Fig.2 Waveforms

* Measured under pulse conditions to avoid excessive dissipation.
** Below latching level the device behaves like a transistor with a gain dependent on current.

Switching characteristics (inductive load)

Turn-off when switched from I_T = 2.5 A to V_D = V_{DRM} max.
V_{GR} = 10 V; $L_G \leqslant$ 1.5 μH; $L_S \leqslant$ 0.25 μH, T_j = 25 °C

storage time	t_s	<	0.5	μs
fall time	t_f	<	0.20	μs
peak reverse gate current	I_{GR}	<	2.8	A

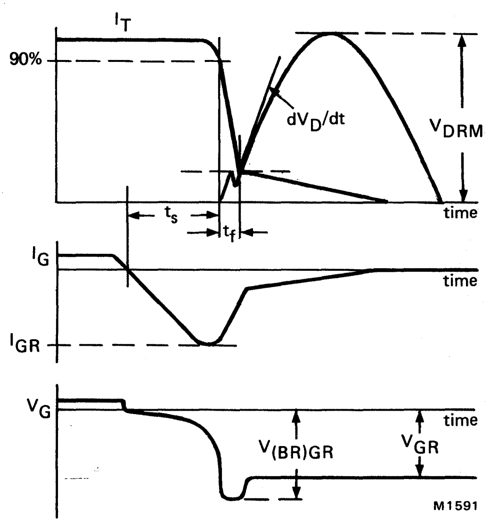


Fig.3 Waveforms

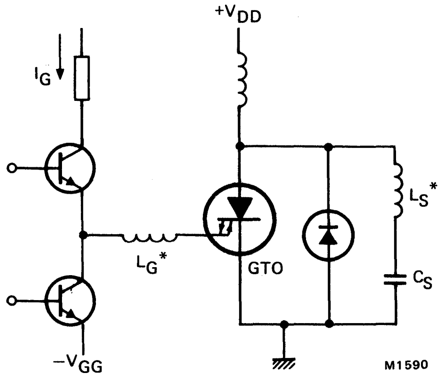


Fig.4 Inductive load test circuit

*Indicates stray series inductance only.

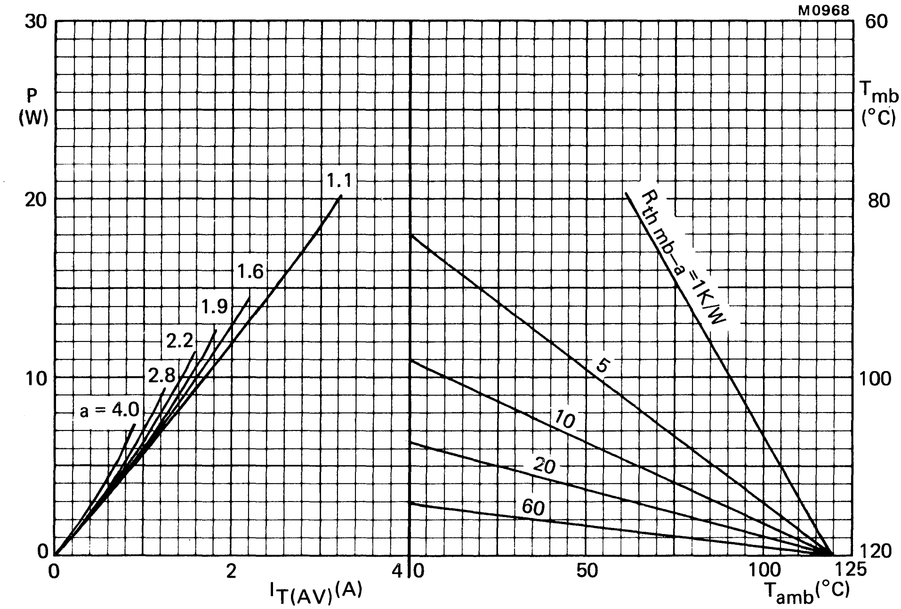


Fig.5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

$$a = \text{form factor} = \frac{I_{T(RMS)}}{I_{T(AV)}}$$

P = Power excluding switching losses

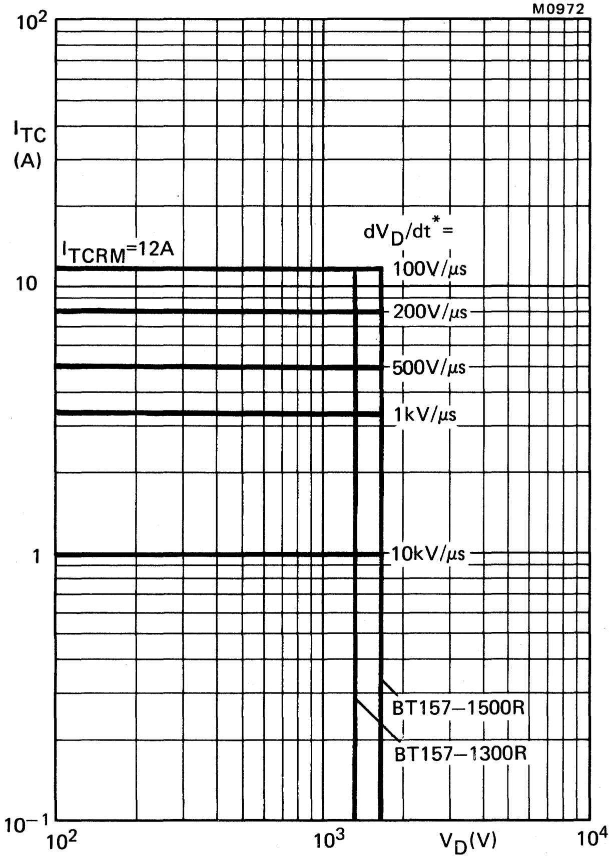


Fig.6 Anode current which can be turned off versus anode voltage; inductive load, V_{GR} = 10 V; $L_G \leqslant 1.5\ \mu H$; $L_S \leqslant 0.25\ \mu H$; T_j = 85 °C
*dV_D/dt is calculated from I_T/C_S.

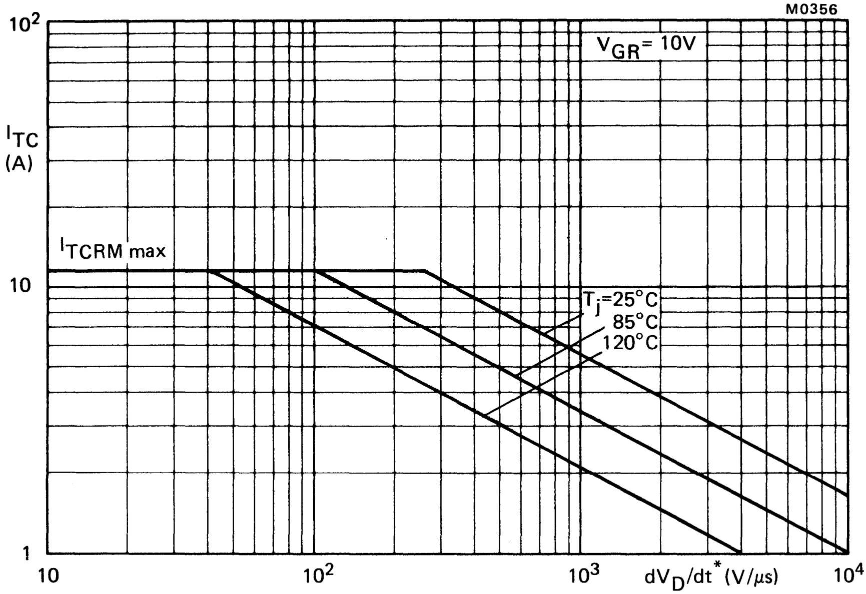


Fig.7 Anode current which can be turned off versus applied dV_D/dt^*; inductive load; V_{GR} = 10 V; $L_G \leqslant 1.5\ \mu H$; $L_S \leqslant 0.25\ \mu H$; $*dV_D/dt$ is calculated from I_T/C_S.

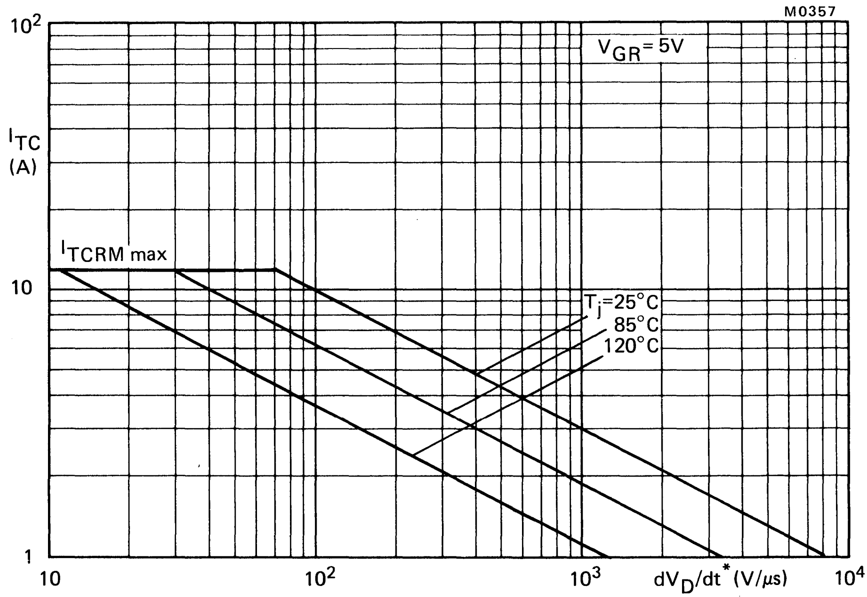


Fig. 8 Anode current which can be turned off versus applied dV_D/dt; inductive load; V_{GR} = 5 V. $L_G \leqslant 1.5\ \mu H$; $L_S \leqslant 0.25\ \mu H$; $*dV_D/dt$ is calculated from I_T/C_S.

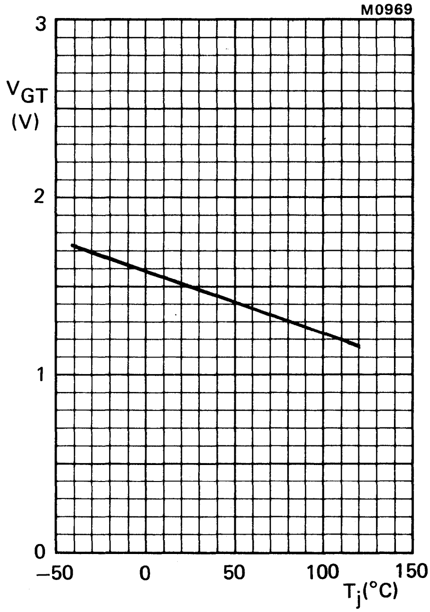


Fig.9 Minimum gate voltage that will trigger all devices as a function of junction temperature; V_D = 12 V.

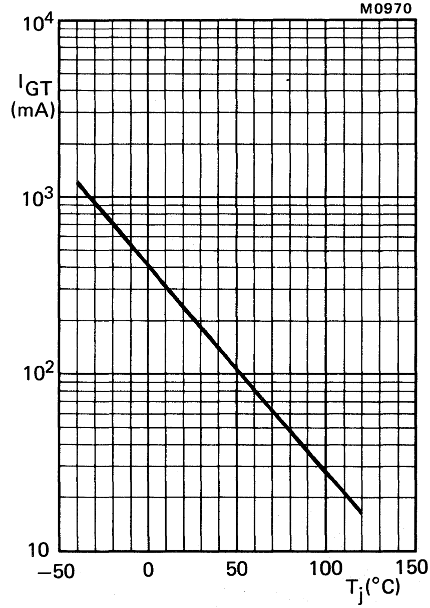


Fig.10 Minimum gate current that will trigger all devices as a function of junction temperature; V_D = 12 V.

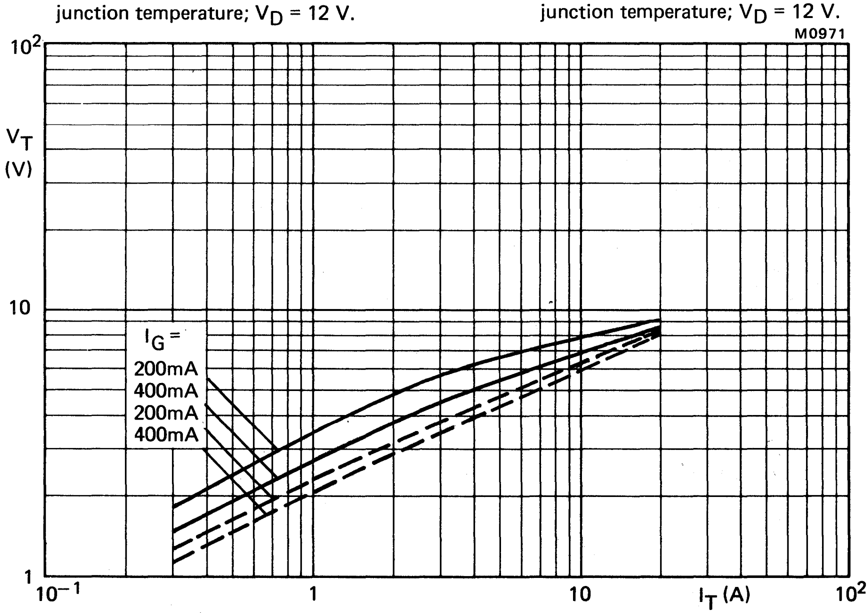


Fig.11 Maximum V_T versus I_T; —— T_j = 25 °C; – – – T_j = 120 °C.

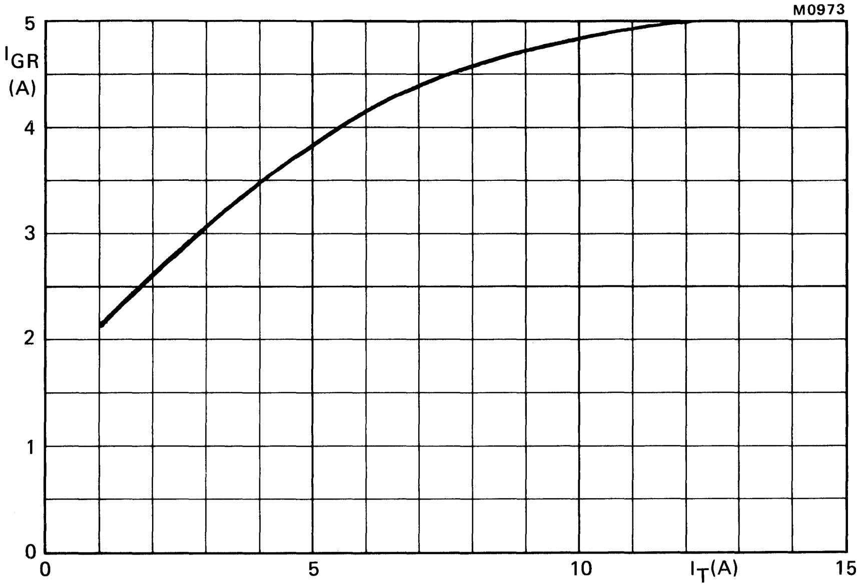


Fig.12 Peak reverse gate current versus anode current at turn-off; inductive load; V_{GR} = 10 V; I_G = 0.2 A; L_G = 0.8 μH; T_j = 120 °C; maximum values.

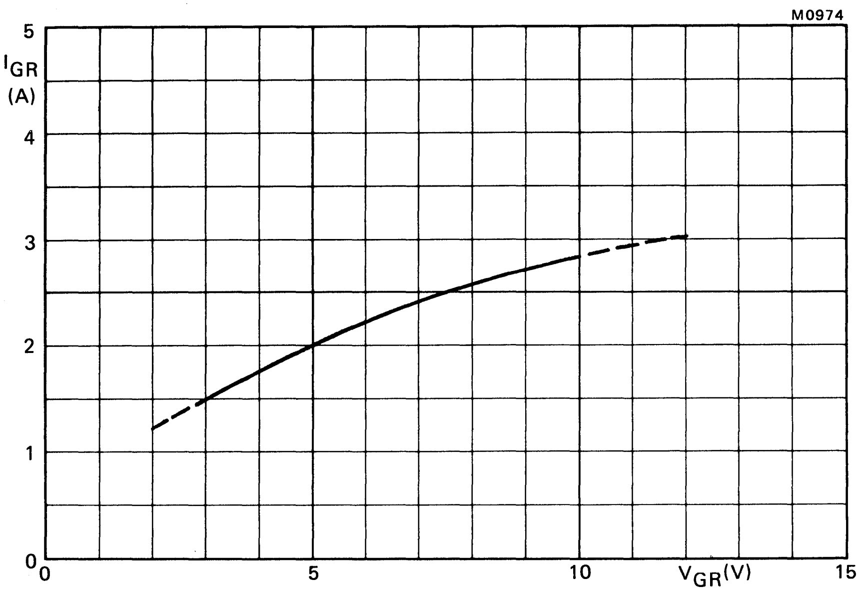


Fig.13 Peak reverse gate current versus applied gate voltage; inductive load; I_T = 2.5 A; I_G = 0.2 A; L_G = 0.8 μH; T_j = 120 °C; maximum values.

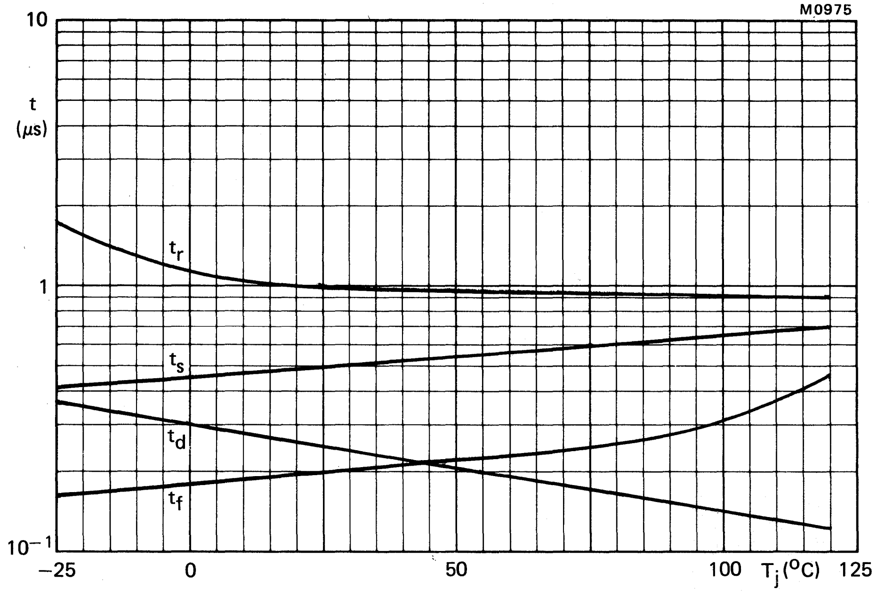


Fig.14 Switching times as a function of junction temperature; $V_D \geq 250$ V; $I_T = 2.5$ A; $I_{GF} = 0.4$ A; $I_G = 0.2$ A; $V_{GR} = 10$ V; $L_G = 0.8$ μH; maximum values.

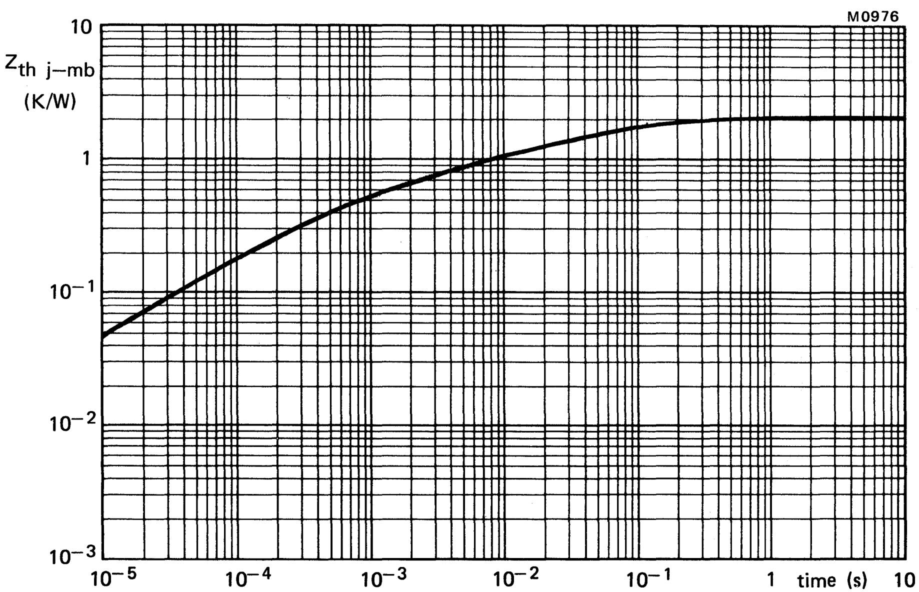


Fig.15 Transient thermal impedance.

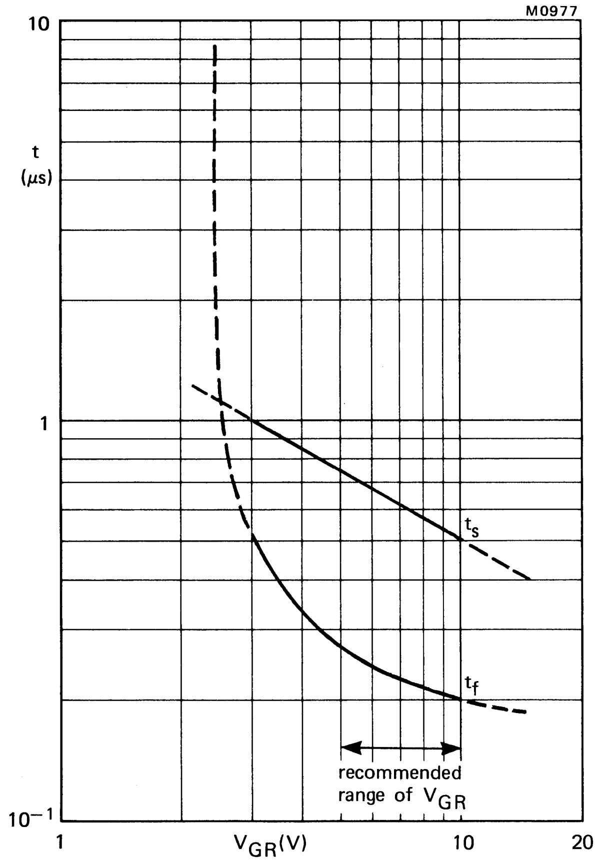


Fig. 16 Storage and fall times versus applied reverse gate voltage; inductive load; I_T = 2.5 A; L_G = 0.8 μH; I_G = 0.2 A; T_j = 25 ^oC; maximum values.

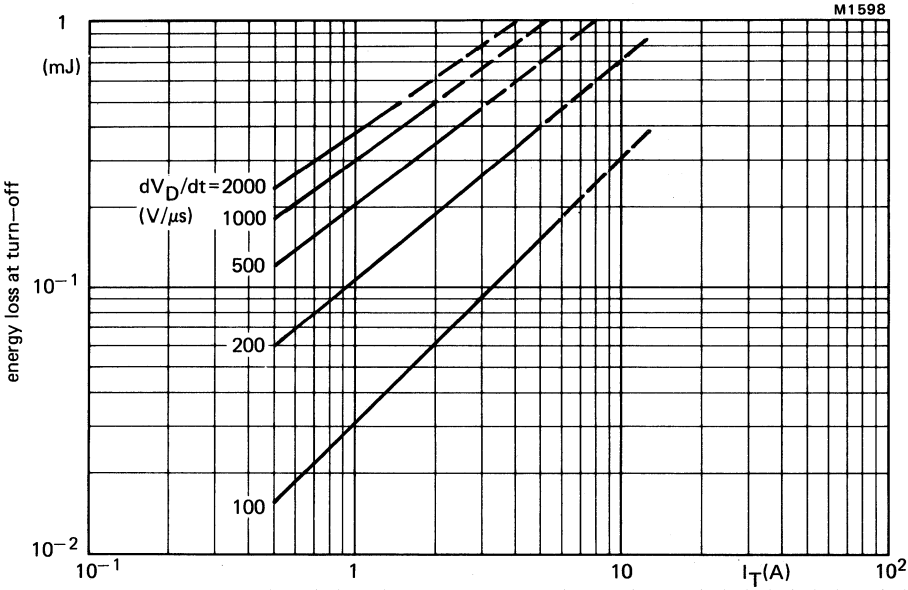


Fig.17 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied dV_D/dt (calculated from I_T/C_S); reapplied voltage sinsusoidal up to V_{DRM} = 1200 V; V_{GR} = 10 V; I_G = 0.2 A; $L_G \leqslant 1.5$ μH; $L_S \leqslant 0.25$ μH; T_j = 120 °C.

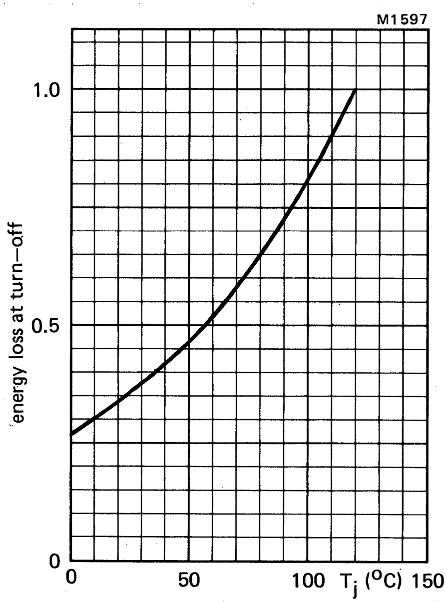


Fig.18 Energy loss at turn off as a function of junction temperature; I_G = 0.2 A; V_{GR} = 10 V. Normalised to T_j = 120 °C.

FAST GATE TURN-OFF THYRISTORS

Thyristors in SOT-93 envelopes which are capable of being turned both on and off via the gate, and may be used with gate-assisted turn-off in anode-commutated circuits. They are suitable for use in resonant power supplies, high-frequency inverters, motor control etc. The devices have no reverse blocking capability; for reverse blocking operation use with a series diode, for reverse conducting operation use with an anti-parallel diode. The anode is connected to the mounting base.

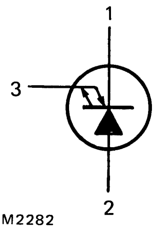
QUICK REFERENCE DATA

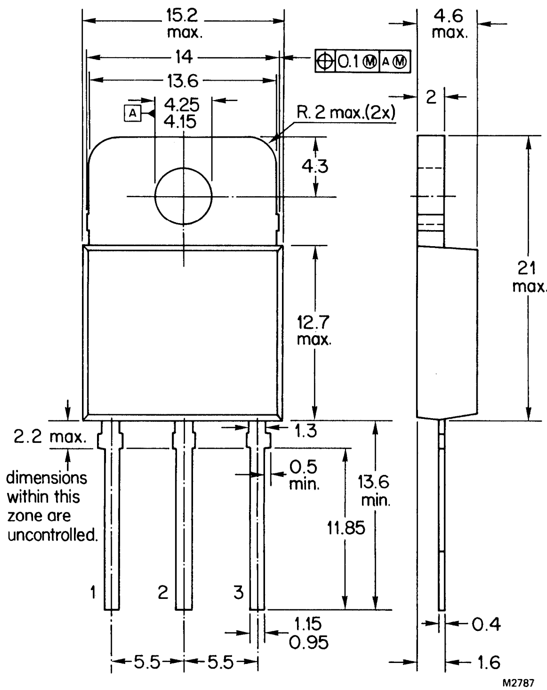
			BTR59–800R	1300R	
Repetitive peak off-state voltage	V_{DRM}	max.	800	1300	V
Controllable anode current	I_{TCRM}	max.	50		A
Average on-state current	$I_{T(AV)}$	max.	10		A
Circuit commutated turn-off time	t_q	<	1.0		μs

MECHANICAL DATA

Dimensions in mm

Fig.1 SOT93; anode connected to mounting base.





Accessories supplied on request; see data sheets Mounting instructions and accessories for SOT-93 envelopes.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134).

Anode to cathode			BTR59–800R	1300R	
Transient off-state voltage	V_{DSM}	max.	800	1300	V*
Repetitive peak off-state voltage	V_{DRM}	max.	800	1300	V*
Working off-state voltage	V_{DW}	max.	600	1000	V*
Continuous off-state voltage	V_D	max.	400	750	V*
Average on-state current (averaged over any 20 ms period) up to T_{mb} = 85 °C	$I_{T(AV)}$	max.	10		A
R.M.S. on-state current	$I_{T(RMS)}$	max.	16.5		A
Controllable anode current	I_{TCRM}	max.	50		A
Non-repetitive peak on-state current t = 10 ms; half-sinewave; T_j = 120 °C prior to surge	I_{TSM}	max.	100		A
I^2t for fusing; t = 10 ms	I^2t	max.	50		A^2s
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	105		W

Gate to cathode

Repetitive peak current T_j = 120 °C prior to surge				
gate-cathode forward; t = 10 ms; half-sinewave	I_{GFM}	max.	25	A
gate-cathode reverse; t = 20 μs	I_{GRM}	max.	25	A
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	5.0	W

Temperatures

Storage temperature	T_{stg}		–40 to +125	°C
Operating junction temperature	T_j	max.	120	°C

THERMAL RESISTANCE

From mounting base to heatsink; with heatsink compound	$R_{th\ mb\text{-}h}$	=	0.2	K/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	0.9	K/W

*Measured with gate-cathode connected together.

DEVELOPMENT DATA

CHARACTERISTICS

Anode to cathode

On-state voltage I_T = 10 A; I_G = 0.5 A; T_j = 120 °C	V_T	<	3.0	V*
Rate of rise of off-state voltage that will not trigger any off-state device; exponential method V_D = 2/3 V_{Dmax}; V_{GR} = 5 V; T_j = 120 °C	dV_D/dt	<	10	kV/μs
Rate of rise of off-state voltage that will not trigger any device following conduction, linear method I_T = 20 A; V_D = V_{DRMmax}; V_{GR} = 10 V; T_j = 120 °C	dV_D/dt	<	1.0	kV/μs
Off-state current V_D = V_{Dmax}; T_j = 120 °C	I_D	<	5.0	mA
Latching current; T_j = 25 °C	I_L	typ.	1.5	A**

Gate to cathode

Voltage that will trigger all devices V_D = 12 V; T_j = 25 °C	V_{GT}	>	1.5	V
Current that will trigger all devices V_D = 12 V; T_j = 25 °C	I_{GT}	>	500	mA
Minimum reverse breakdown voltage I_{GR} = 1.0 mA	$V_{(BR)GR}$	>	10	V

Switching characteristics (resistive load)

Turn-on when switched to I_T = 10 A from V_D = 250 V with I_{GF} = 2.5 A; T_j = 25 °C				
delay time	t_d	<	0.3	μs
rise time	t_r	<	1.5	μs

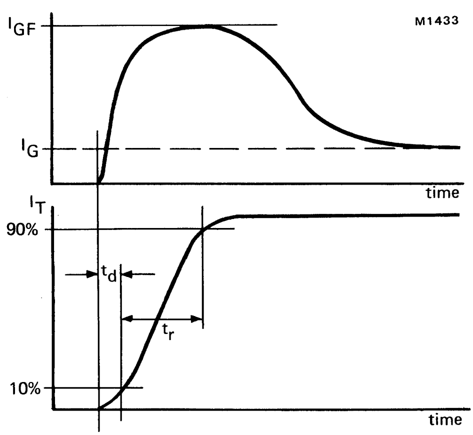


Fig.2 Waveforms.

*Measured under pulse conditions to avoid excessive dissipation.
**Below latching level the device behaves like a transistor with a gain dependent on current.

Switching characteristics (inductive load)

Turn-off when switched from I_T = 10 A to $V_D = V_{Dmax}$;

V_{GR} = 10 V; $L_G \leqslant$ 0.5 μH; $L_S \leqslant$ 0.25 μH; $C_S \geqslant$ 20 nF; T_j = 85 °C

storage time	t_s	<	0.60	μs
fall time	t_f	<	0.25	μs
peak reverse gate current	I_{GR}	<	10	A

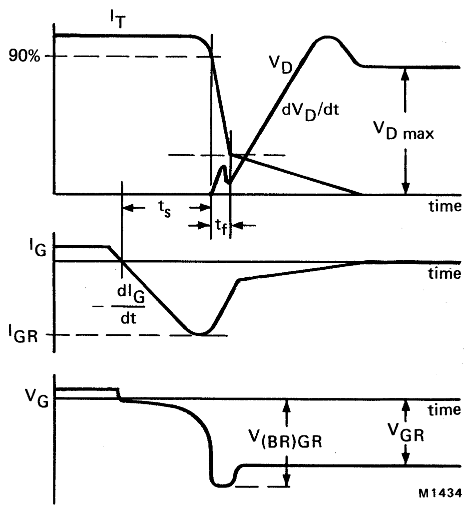


Fig.3 Waveforms.

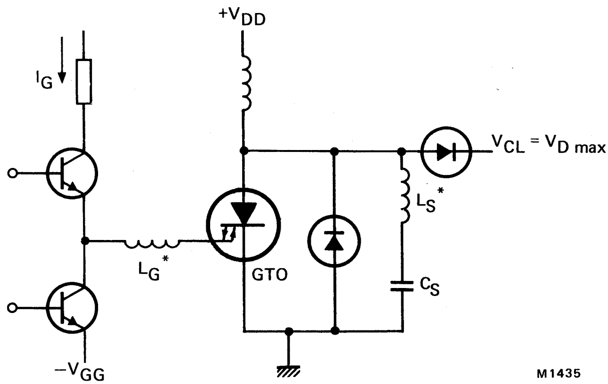


Fig.4 Inductive load test circuit.

*Indicates stray series inductance only.

Switching characteristics (circuit-commutated)*

Turn-off time

I_T = 50 A; $-dI_T/dt$ = 10 A/μs; dV_D/dt = 200 V/μs;
V_{GR} = 5 V; T_j = 120 °C | t_q | < | 1.0 | μs

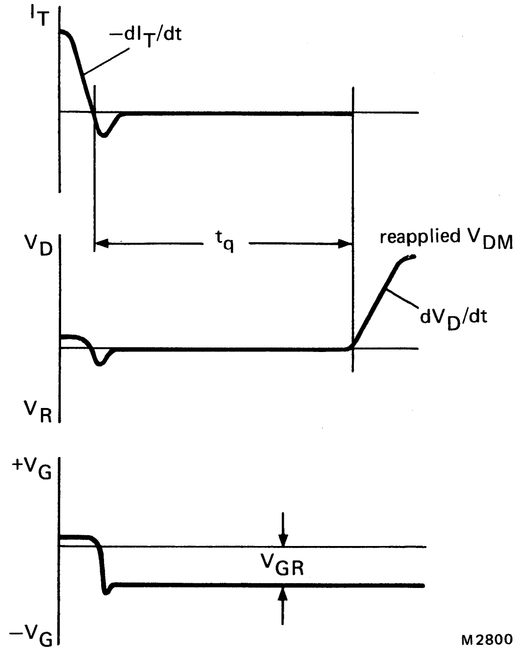


Fig.5 Circuit-commutated turn-off time definition.

*Figs. 7, 11, 12, 13, 15, 16, 17 do not apply to commutated turn-off.

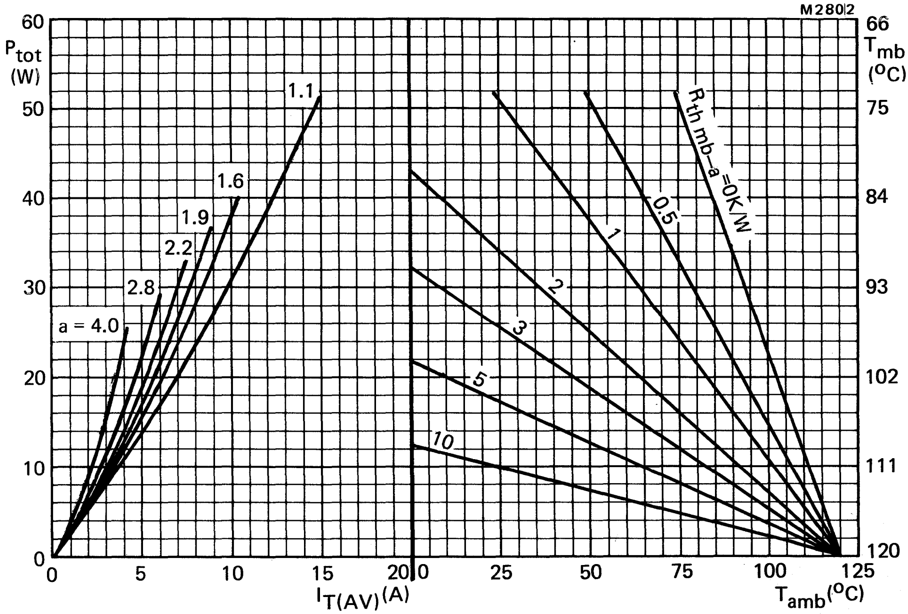


Fig.6 The right hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

$$a = \text{form factor} = \frac{I_{T(RMS)}}{I_{T(AV)}}$$

P = power excluding switching losses.

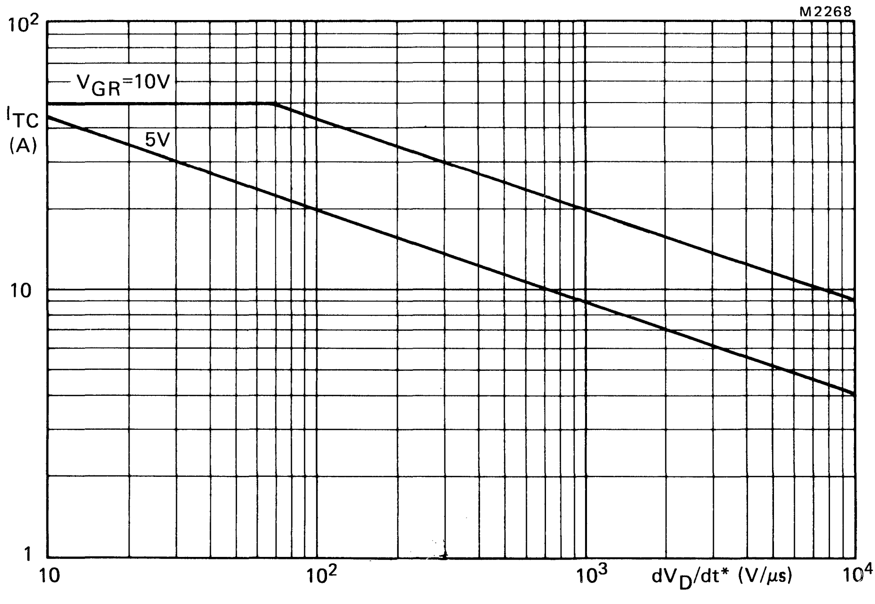


Fig.7 Anode current which can be turned off versus applied dV_D/dt^*; inductive load; $L_G \leqslant 0.5\ \mu H$; $L_S \leqslant 0.25\ \mu H$; T_j = 120 °C.

*dV_D/dt is calculated from I_T/C_S.

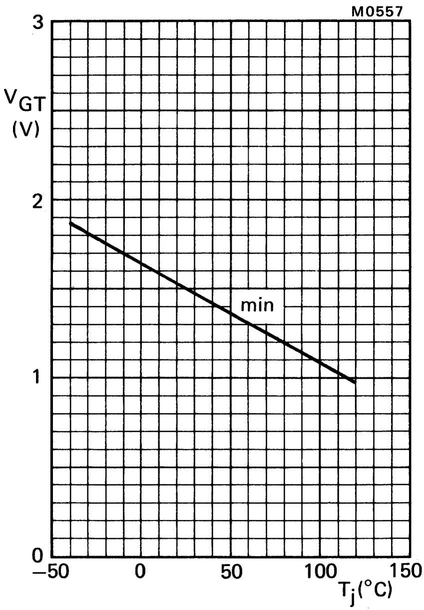


Fig.8 Minimum gate voltage that will trigger all devices as a function of junction temperature; V_D = 12 V.

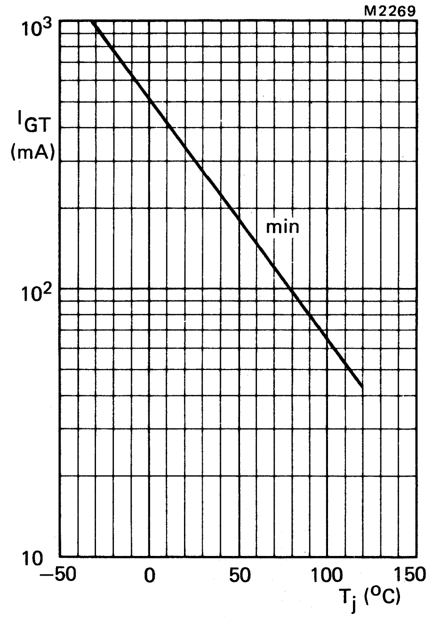


Fig.9 Minimum gate current that will trigger all devices as a function of junction temperature; V_D = 12 V.

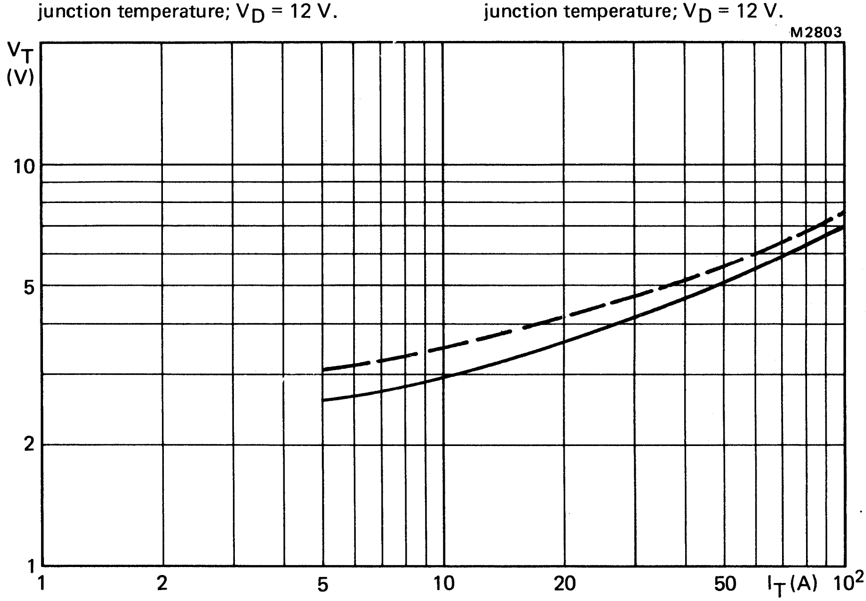


Fig.10 Maximum V_T versus I_T; – – – T_j = 25 °C; —— T_j = 120 °C; I_G = 0.5 A.

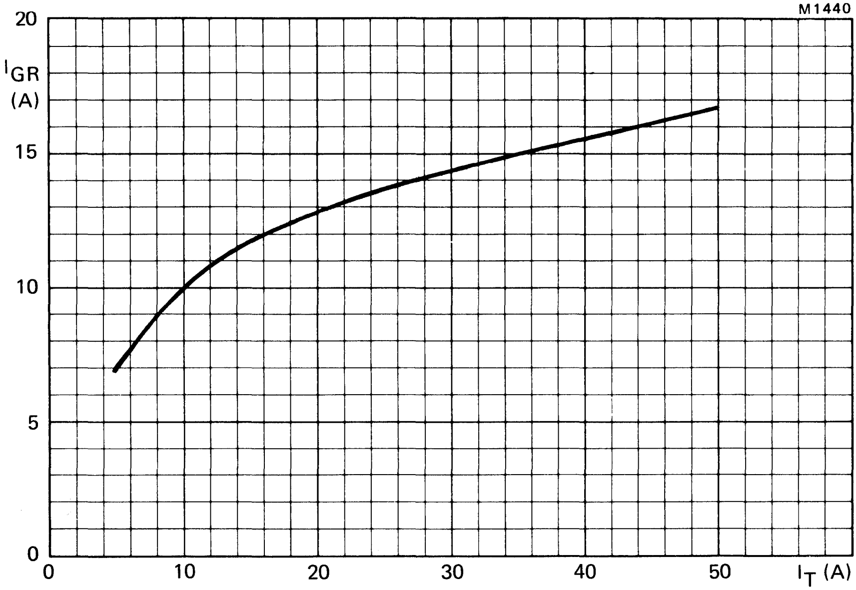


Fig.11 Peak reverse gate current versus anode current at turn-off; inductive load; V_{GR} = 10 V; I_G = 0.5 A; L_G = 0.4 μH; T_j = 120 °C; maximum values.

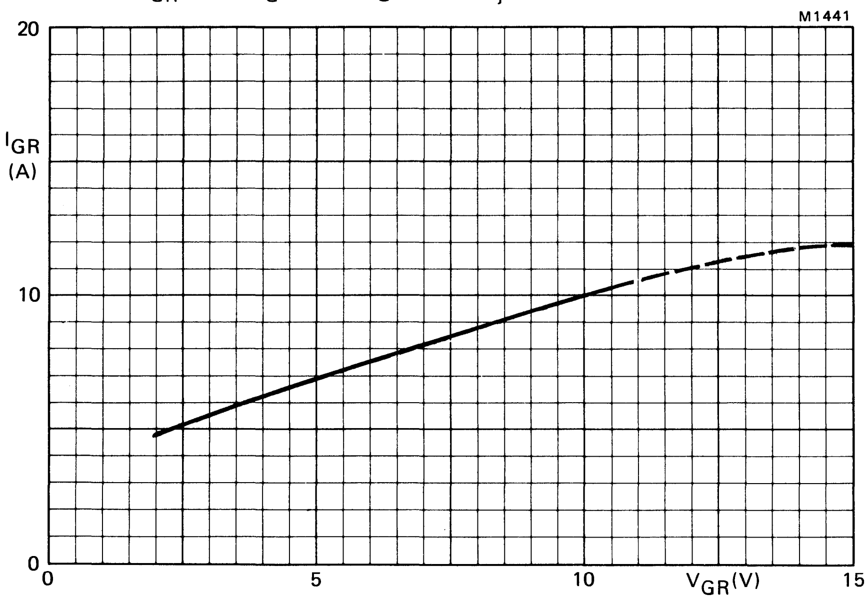


Fig.12 Peak reverse gate current versus applied reverse gate voltage; inductive load; I_T = 10 A; I_G = 0.5 A; L_G = 0.4 μH; T_j = 120 °C; maximum values.

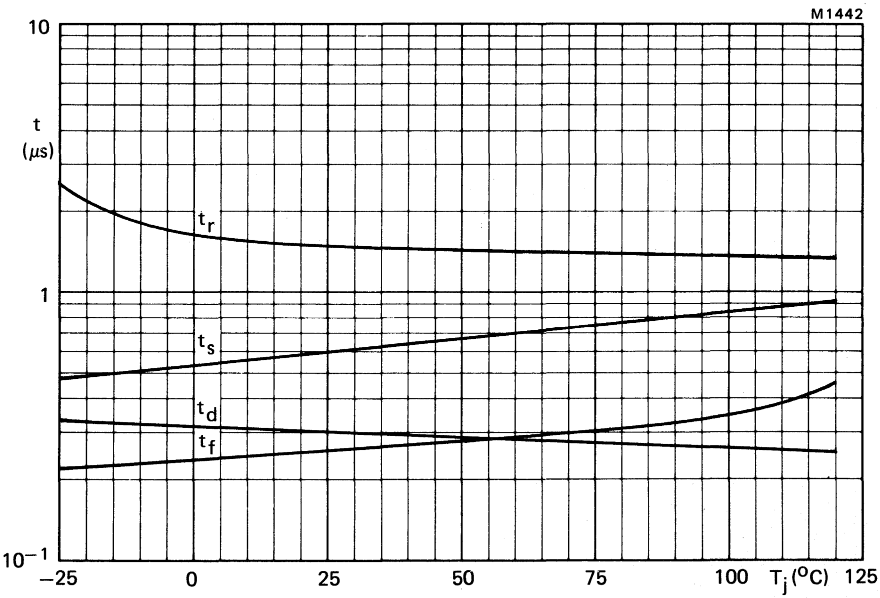


Fig.13 Switching times as a function of junction temperature; $V_D \geqslant 250$ V; $I_T = 10$ A; $I_{GF} = 1.0$ A; $V_{GR} = 10$ V; $I_G = 0.5$ A; $L_G = 0.4$ μH; maximum values.

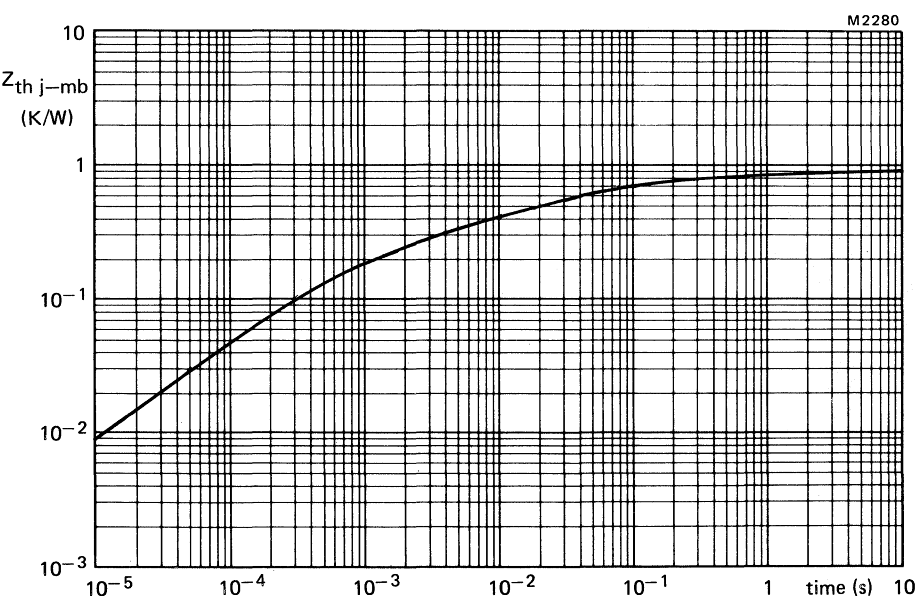


Fig.14 Transient thermal impedance.

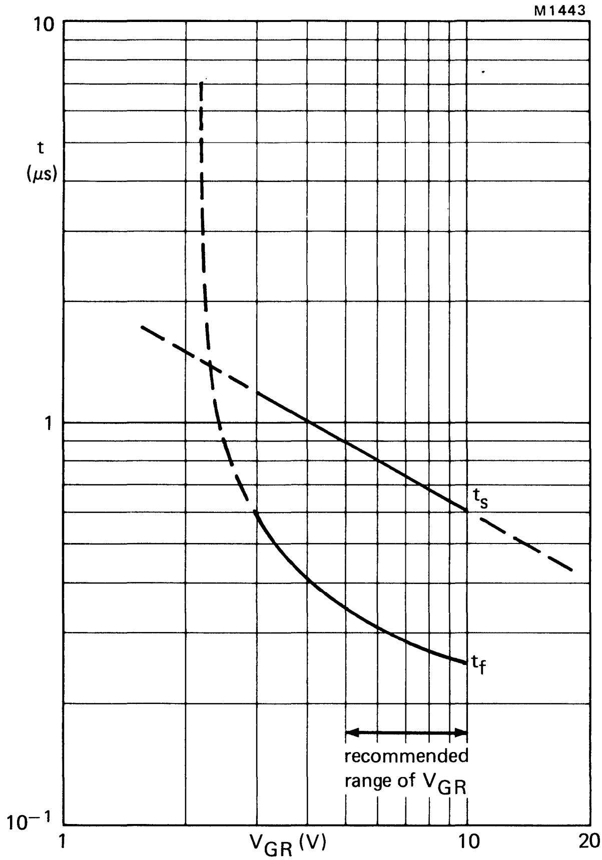


Fig.15 Storage and fall times versus applied reverse gate voltage; inductive load, I_T = 10 A; I_G = 0.5 A; L_G = 0.4 μH; T_j = 25 °C; maximum values.

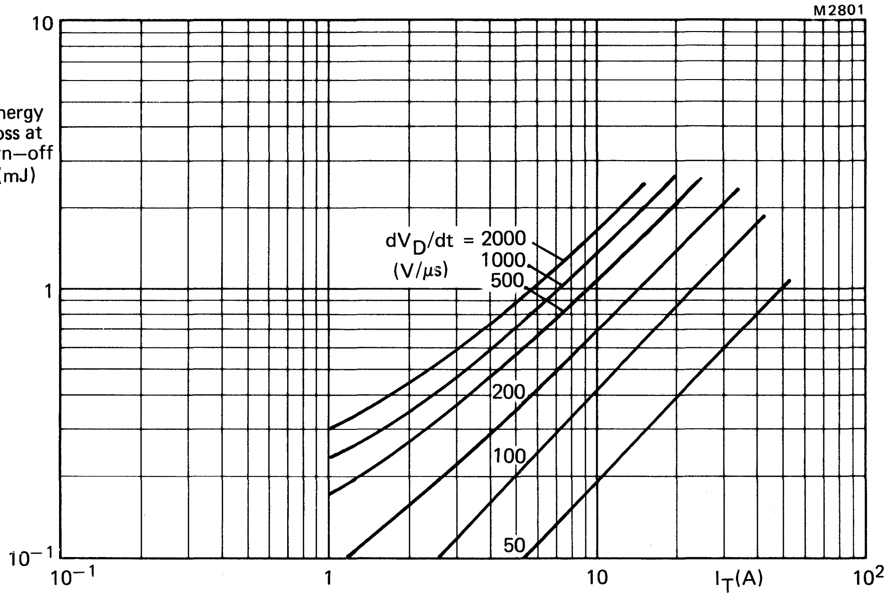


Fig.16 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied dV_D/dt (calculated from I_T/C_S); dV_D/dt linear up to $V_D = V_{DWmax}$; V_{GR} = 10 V; I_G = 0.5 A; L_G < 0.5 μH; L_S < 0.25 μH; T_j = 120 °C.

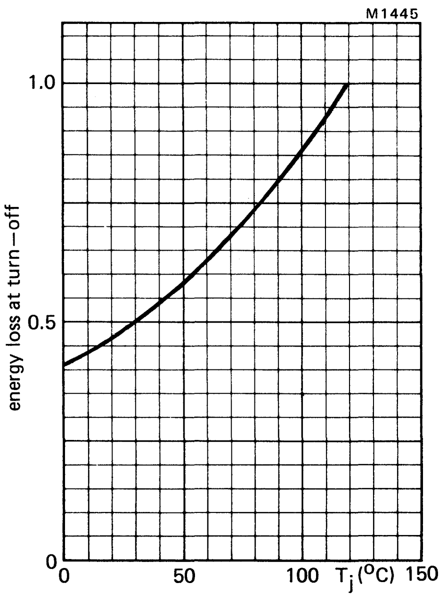


Fig.17 Energy loss at turn-off as a function of junction temperature; I_G = 0.5 A; V_{GR} = 10 V. Normalised to T_j = 120 °C.

FAST GATE TURN-OFF THYRISTORS

Thyristors in SOT-93 envelopes capable of being turned both on and off via the gate. They are suitable for use in high-frequency inverters, power supplies, motor control etc. The devices have no reverse blocking capability; for reverse blocking operation use with a series diode, for reverse conducting operation use with an anti-parallel diode. The anode is connected to the mounting base.

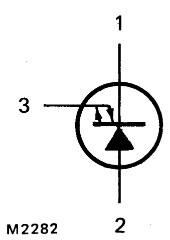
QUICK REFERENCE DATA

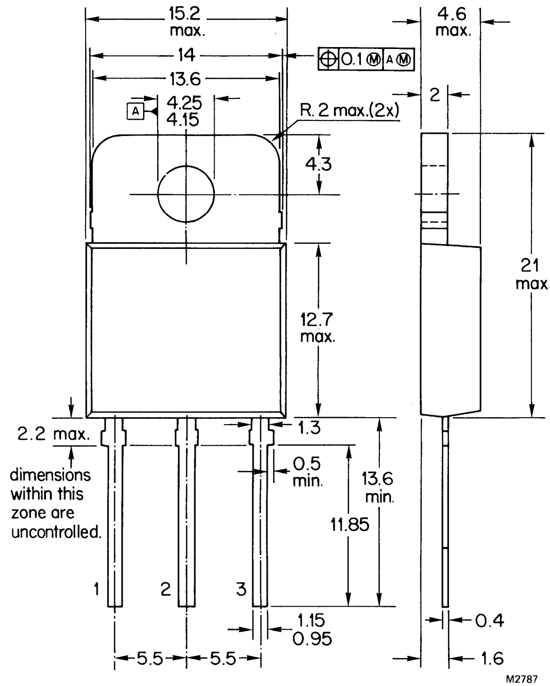
			BTS59-850R	1000R	1200R	
Repetitive peak off-state voltage	V_{DRM}	max.	850	1000	1200	V
Non-repetitive peak on-state current	I_{TSM}	max.		100		A
Controllable anode current	I_{TCRM}	max.		50		A
Average on-state current	$I_{T(AV)}$	max.		15		A
Fall time	t_f	<		250		ns

MECHANICAL DATA

Dimensions in mm

Fig.1 SOT-93; anode connected to mounting base





Accessories supplied on request: see data sheets Mounting instructions and accessories for SOT-93 envelopes.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134)

Anode to cathode			BTS59-850R	1000R	1200R	
Transient off-state voltage	V_{DSM}	max.	1000	1100	1300	V*
Repetitive peak off-state voltage	V_{DRM}	max.	850	1000	1200	V*
Working off-state voltage	V_{DW}	max.	600	800	1000	V*
Continuous off-state voltage	V_D	max.	500	650	750	V*

Average on-state current (averaged over any 20 ms period) up to T_{mb} = 85 °C	$I_{T(AV)}$	max.	15	A
Controllable anode current	I_{TCRM}	max.	50	A
Non-repetitive peak on-state current t = 10 ms; half-sinewave; T_j = 120 °C prior to surge	I_{TSM}	max.	100	A
I^2t for fusing; t = 10 ms	I^2t	max.	50	A^2s
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	105	W

Gate to cathode

Repetitive peak current T_j = 120 °C prior to surge gate-cathode forward; t = 10 ms; half-sinewave	I_{GFM}	max.	25	A
gate-cathode reverse; t = 20 µs	I_{GRM}	max.	25	A
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	5.0	W

Temperatures

Storage temperature	T_{stg}		−40 to +125	°C
Operating junction temperature	T_j	max.	120	°C

THERMAL RESISTANCE

From mounting base to heatsink; with heatsink compound	$R_{th\ mb\text{-}h}$	=	0.2	K/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	0.9	K/W

* Measured with gate-cathode connected together.

CHARACTERISTICS

Anode to cathode

On-state voltage I_T = 10 A; I_G = 0.5 A; T_j = 120 ^oC	V_T	<	2.3	V*
Rate of rise of off-state voltage that will not trigger any off-state device; exponential method V_D = 2/3 V_{Dmax}; V_{GR} = 5 V; T_j = 120 ^oC	dV_D/dt	<	10	kV/µs
Rate of rise of off-state voltage that will not trigger any device following conduction, linear method I_T = 20 A; V_D = V_{DRMmax}; V_{GR} = 10 V; T_j = 120 ^oC	dV_D/dt	<	1.0	kV/µs
Off-state current. V_D = V_{Dmax}; T_j = 120 ^oC	I_D	<	5.0	mA
Latching current; T_j = 25 ^oC	I_L	typ.	1.5	A**

Gate to cathode

Voltage that will trigger all devices V_D = 12 V; T_j = 25 ^oC	V_{GT}	>	1.5	V
Current that will trigger all devices V_D = 12 V, T_j = 25 ^oC	I_{GT}	>	300	mA
Minimum reverse breakdown voltage I_{GR} = 1.0 mA	$V_{(BR)GR}$	>	10	V

Switching characteristics (resistive load)

Turn-on when switched to I_T = 10 A from V_D = 250 V with I_{GF} = 1.5 A; T_j = 25 ^oC				
delay time	t_d	<	0.3	µs
rise time	t_r	<	1.5	µs

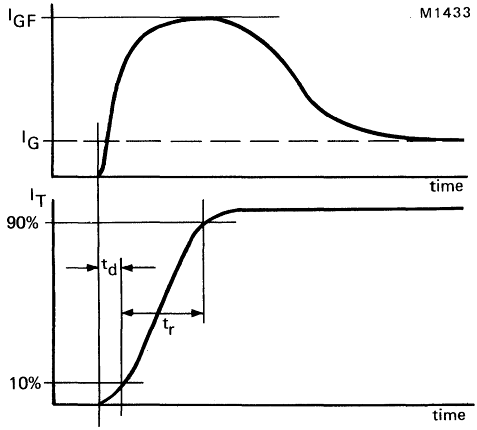


Fig.2 Waveforms

* Measured under pulse conditions to avoid excessive dissipation.

** Below latching level the device behaves like a transistor with a gain dependent on current.

Switching characteristics (inductive load)

Turn-off when switched from I_T = 10 A to $V_D = V_{Dmax}$;

→ V_{GR} = 10 V; $L_G \leq 0.5\ \mu H$; $L_S \leq 0.25\ \mu H$; $C_S \geq 20$ nF; T_j = 25 °C

storage time	t_s	<	0.60	μs
fall time	t_f	<	0.25	μs
peak reverse gate current	I_{GR}	<	10	A

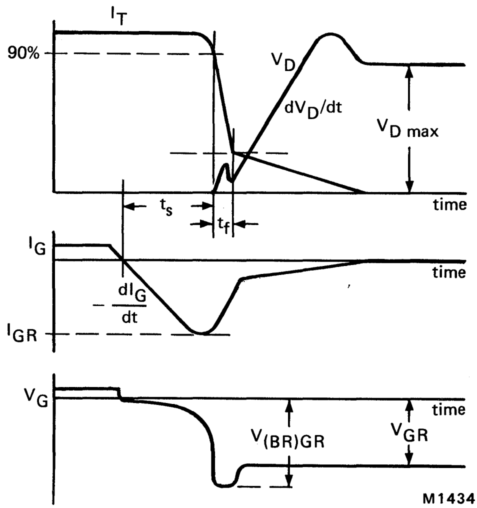


Fig.3 Waveforms.

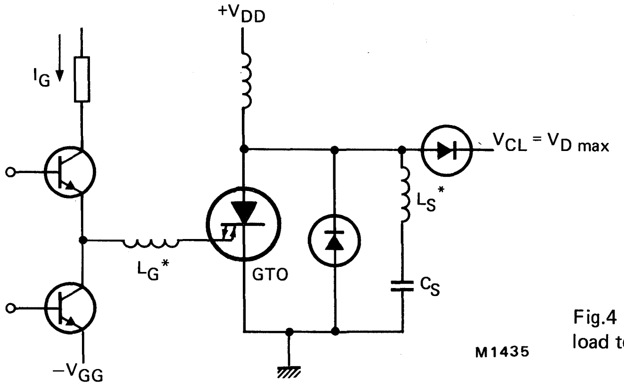


Fig.4 Inductive load test circuit.

*Indicates stray series inductance only

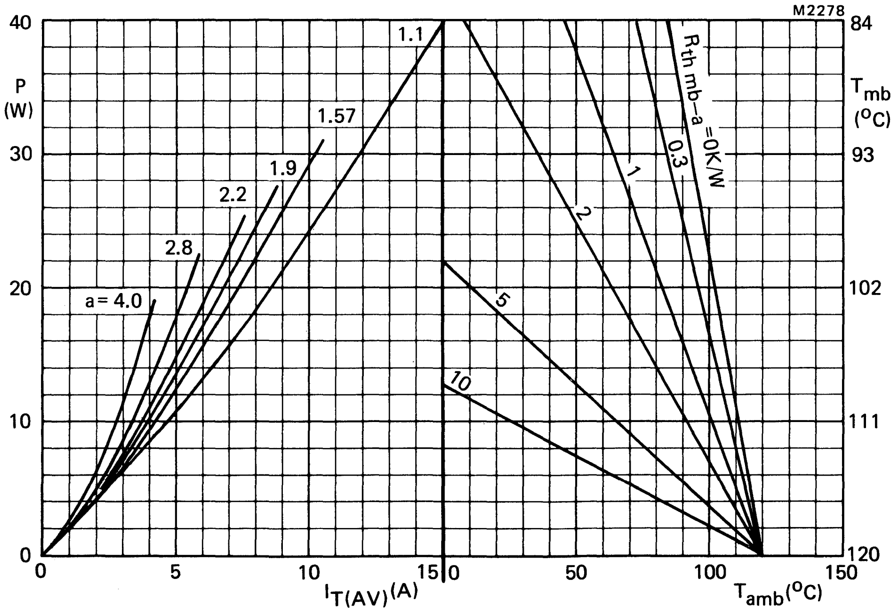


Fig.5 The right hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

$$a = \text{form factor} = \frac{I_{T(RMS)}}{I_{T(AV)}}$$

P = power excluding switching losses.

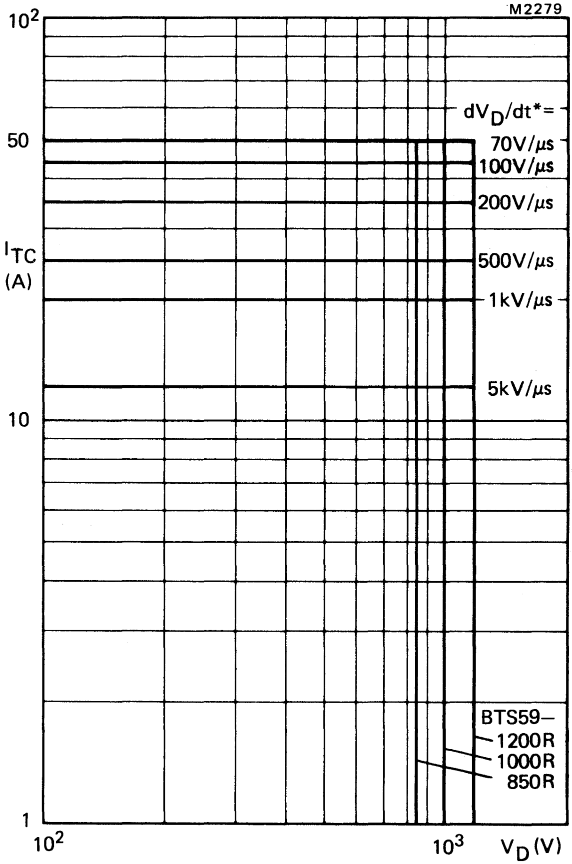


Fig.6 Anode current which can be turned off versus anode voltage; inductive load; V_{GR} = 10 V; $L_G \leqslant 0.5\ \mu H$; $L_S \leqslant 0.25\ \mu H$; T_j = 120 °C.
*dV_D/dt is calculated from I_T/C_S.

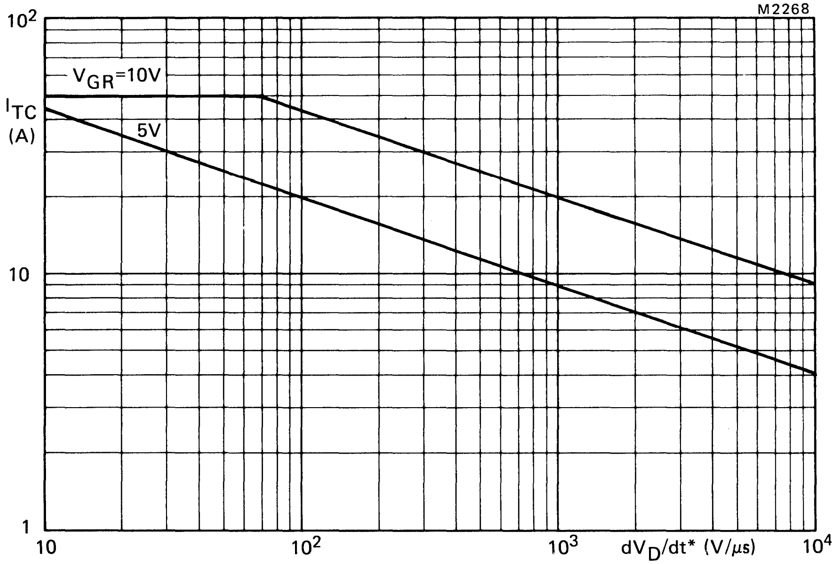


Fig.7 Anode current which can be turned off versus applied dV_D/dt^*; inductive load; $L_G \leqslant 0.5\ \mu H$; $L_S \leqslant 0.25\ \mu H$; $T_j = 120\ ^{o}C$. $^*dV_D/dt$ is calculated from I_T/C_S.

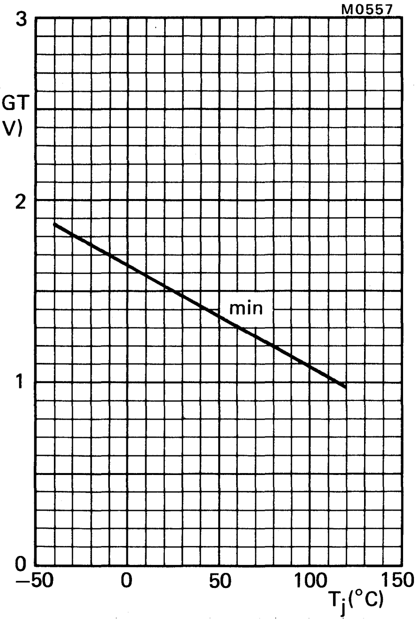


Fig.8 Minimum gate voltage that will trigger all devices as a function of junction temperature; V_D = 12 V.

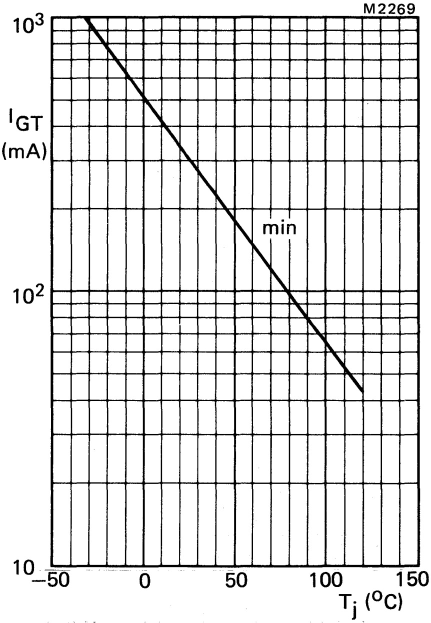


Fig.9 Minimum gate current that will trigger all devices as a function of junction temperature; V_D = 12 V.

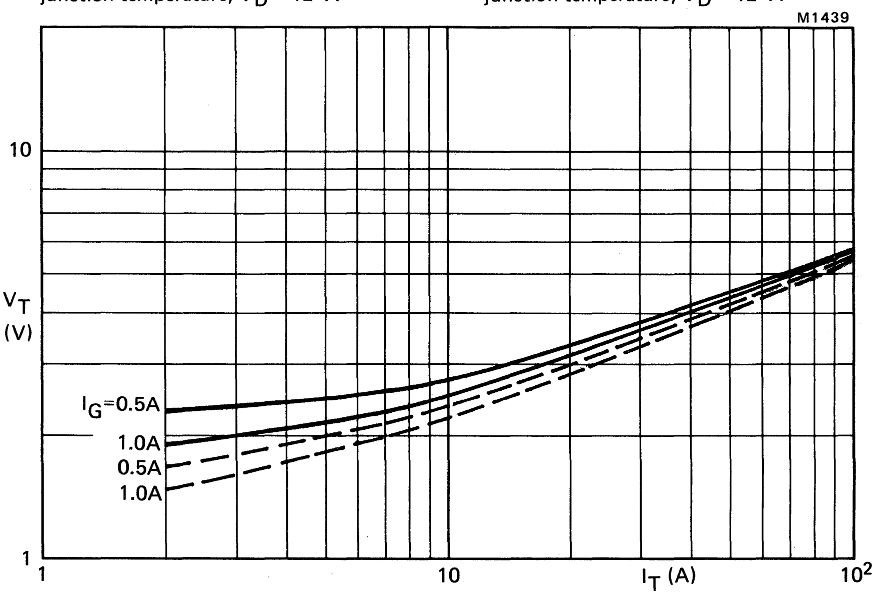


Fig.10 Maximum V_T versus I_T; ——— T_j = 25 °C; – – – – T_j = 120 °C.

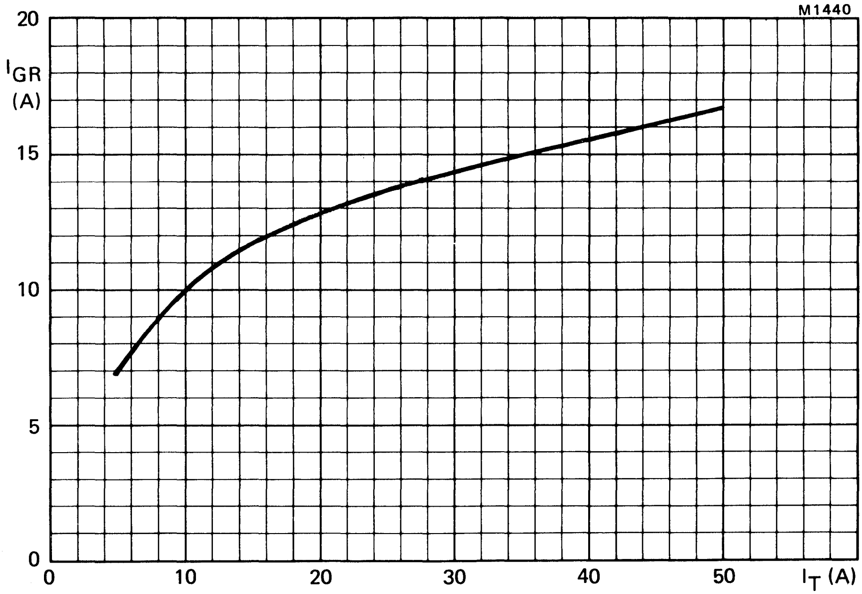


Fig.11 Peak reverse gate current versus anode current at turn-off; inductive load; V_{GR} = 10 V; I_G = 0.5 A; L_G = 0.4 μH; T_j = 120 °C; maximum values.

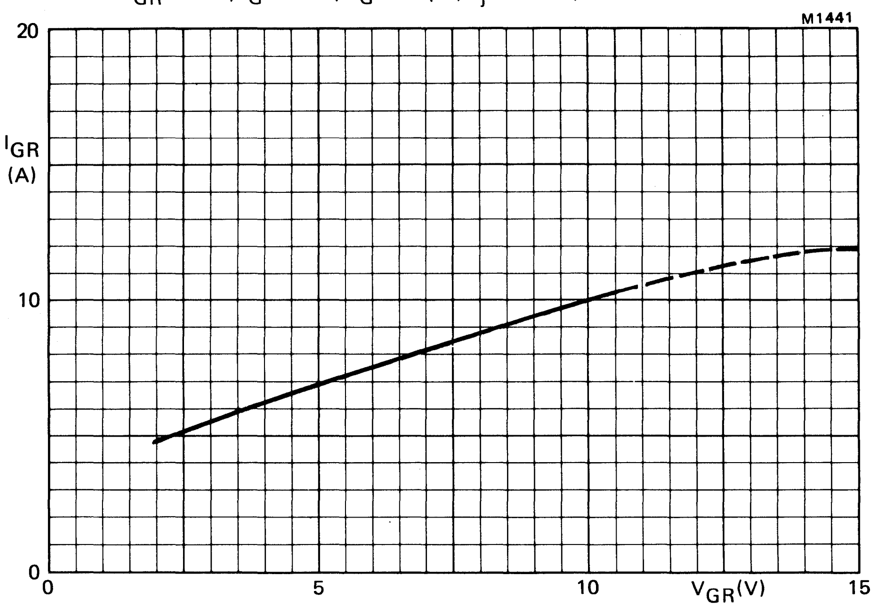


Fig.12 Peak reverse gate current versus applied reverse gate voltage; inductive load; I_T = 10 A; I_G = 0.5 A, L_G = 0.4 μH; T_j = 120 °C; maximum values.

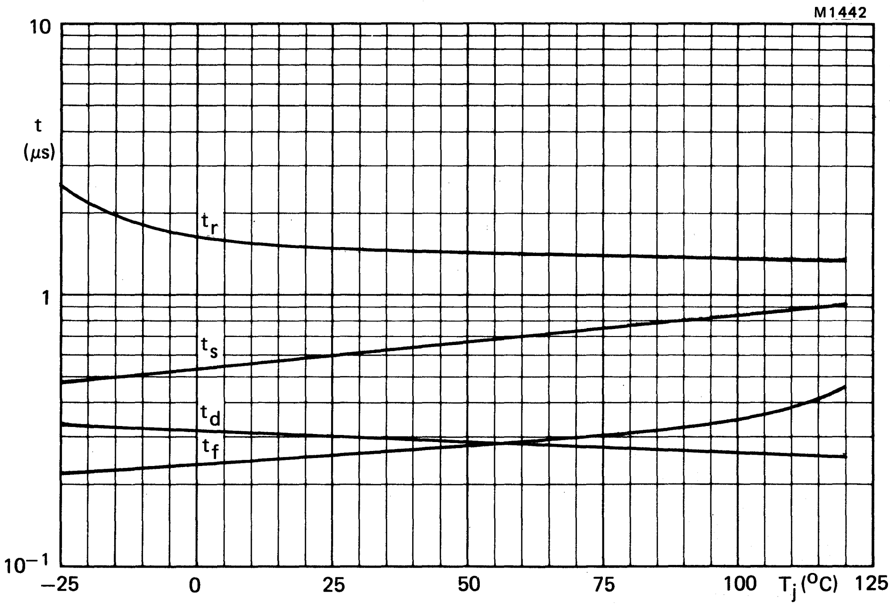


Fig.13 Switching times as a function of junction temperature; $V_D \geqslant 250$ V; $I_T = 10$ A; $I_{GF} = 1.0$ A; $V_{GR} = 10$ V; $I_G = 0.5$ A; $L_G = 0.4$ μH; maximum values.

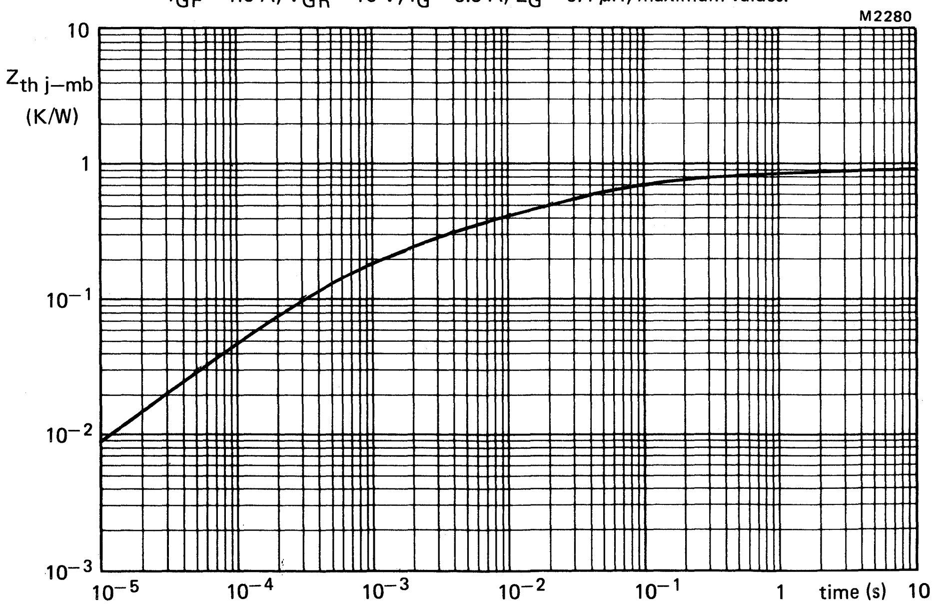


Fig.14 Transient thermal impedance.

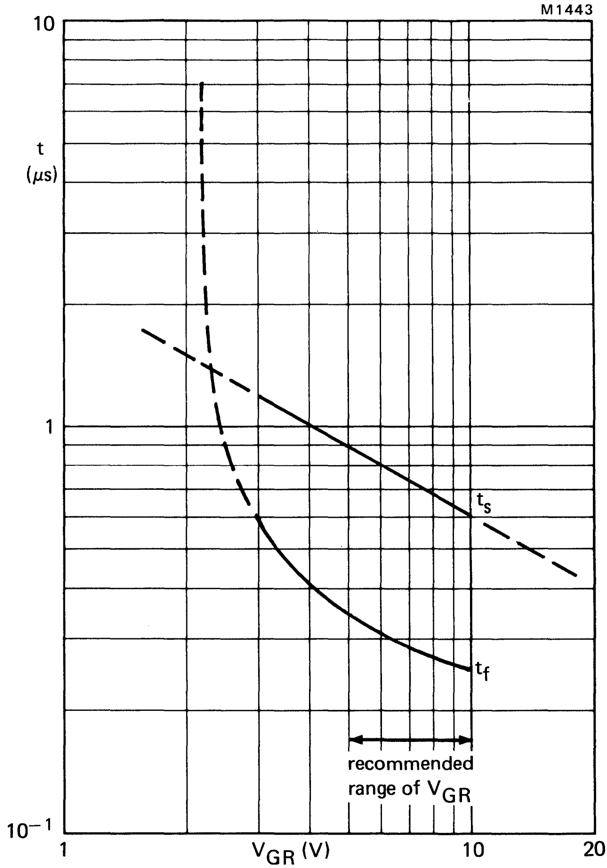


Fig.15 Storage and fall times versus applied reverse gate voltage; inductive load; I_T = 10 A; I_G = 0.5 A; L_G = 0.4 μH; T_j = 25 °C; maximum values.

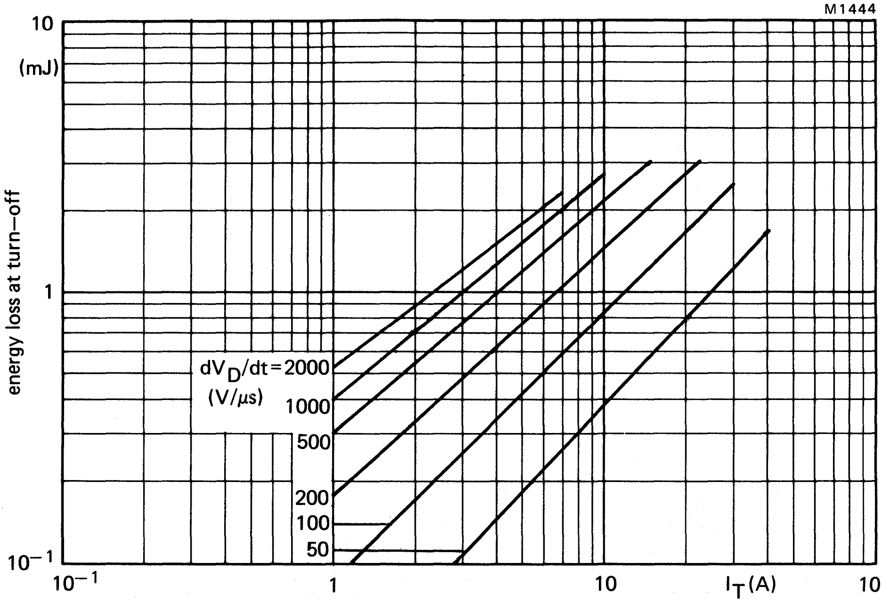


Fig.16 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied dV_D/dt (calculated from I_T/C_S); dV_D/dt linear up to V_{Dmax} = 600 V; V_{GR} = 10 V; I_G = 0.5 A; $L_G \leqslant 0.5\ \mu H$; $L_S \leqslant 0.25\ \mu H$; T_j = 120 °C.

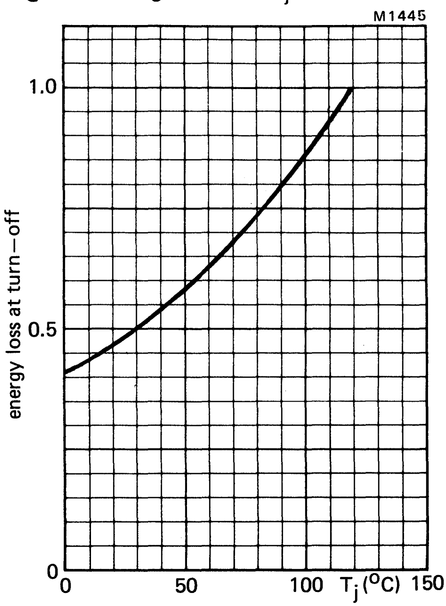


Fig.17 Energy loss at turn off as a function of junction temperature; I_G = 0.5 A; V_{GR} = 10 V. Normalised to T_j = 120 °C.

FAST GATE TURN-OFF THYRISTORS

Thyristors in TO-220AB envelopes capable of being turned both on and off via the gate. They are suitable for use in high-frequency inverters, power supplies, motor control etc. The devices have no reverse blocking capability. For reverse blocking operation use with a series diode, for reverse conducting operation use with an anti parallel diode.

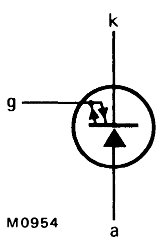
QUICK REFERENCE DATA

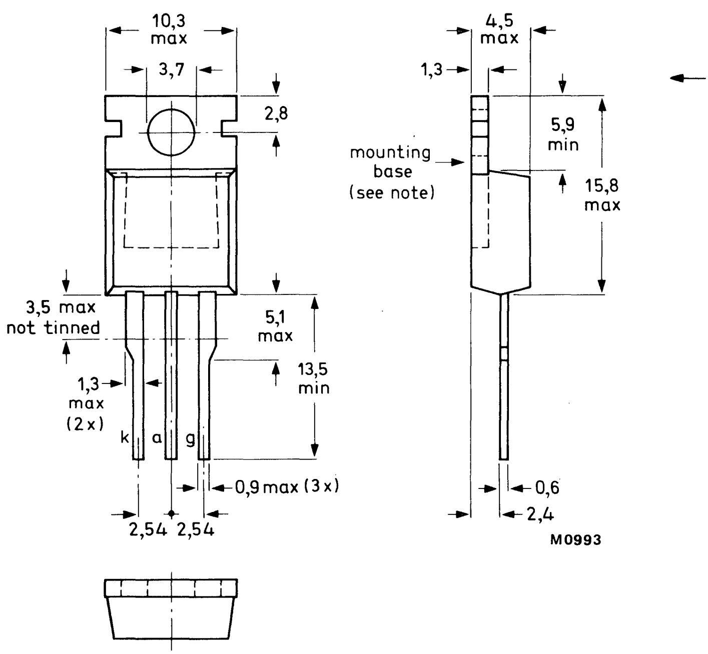
			BTV58–600R	850R	1000R	
Repetitive peak off-state voltage	V_{DRM}	max.	600	850	1000	V
Non-repetitive peak on-state current	I_{TSM}	max.		75		A
Controllable anode current	I_{TCRM}	max.		25		A
Average on-state current	$I_{T(AV)}$	max.		10		A
Fall time	t_f	max.		250		ns

MECHANICAL DATA

Dimensions in mm

Fig.1 TO-220AB.





Net mass: 2 g

Note: The exposed metal mounting base is directly connected to the anode.

Accessories supplied on request: see data sheets Mounting instructions and accessories for TO-220 envelopes.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Anode to cathode

			BTV58-600R	850R	1000R	
Transient off-state voltage*	V_{DSM}	max.	750	1000	1100	V
Repetitive peak off-state voltage*	V_{DRM}	max.	600	850	1000	V
Working off-state voltage*	V_{DW}	max.	400	600	800	V
Continuous off-state voltage*	V_D	max.	400	500	650	V

Average on-state current (averaged over any 20 ms period) up to T_{mb} = 80 °C	$I_{T(AV)}$	max.	10	A
Controllable anode current	I_{TCRM}	max.	25	A
Non-repetitive peak on-state current t = 10 ms; half-sinewave; T_j = 120 °C prior to surge	I_{TSM}	max.	75	A
I^2t for fusing; t = 10 ms	I^2t	max.	28	A^2s
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	65	W

Gate to cathode

Repetitive peak on-state current T_j = 120 °C prior to surge				
gate-cathode forward; t = 10 ms; half-sinewave	I_{GFM}	max.	25	A
gate-cathode reverse; t = 20 μs	I_{GRM}	max.	25	A
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	2,5	W

Temperatures

Storage temperature	T_{stg}		−40 to + 150	°C
Operating junction temperature	T_j	max.	120	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,5	K/W
From mounting base to heatsink with heatsink compound	$R_{th\ mb\text{-}h}$	=	0,3	K/W
with 56367 alumina insulator and heatsink compound (clip-mounted)	$R_{th\ mb\text{-}h}$	=	0,8	K/W

* Measured with gate connected to cathode.

CHARACTERISTICS

Anode to cathode

On-state voltage $I_T = 5$ A; $I_G = 0.2$ A; $T_j = 120$ °C	V_T	<	1.8	V*
Rate of rise of off-state voltage that will not trigger any off-state device; exponential method $V_D = 2/3\ V_{Dmax}$; $V_{GR} = 5$ V; $T_j = 120$ °C	dV_D/dt	<	10	kV/μs
Rate of rise of off-state voltage that will not trigger any device following conduction, linear method $I_T = 5$ A; $V_D = V_{DRMmax}$; $V_{GR} = 10$ V; $T_j = 120$ °C	dV_D/dt	<	1.5	kV/μs
Off-state current $V_D = V_{Dmax}$; $T_j = 120$ °C	I_D	<	3.0	mA
Latching current; $T_j = 25$ °C	I_L	typ.	1.0	A**

Gate to cathode

Voltage that will trigger all devices $V_D = 12$ V; $T_j = 25$ °C	V_{GT}	>	1.5	V
Current that will trigger all devices $V_D = 12$ V; $T_j = 25$ °C	I_{GT}	>	200	mA
Minimum reverse breakdown voltage $I_{GR} = 1.0$ mA	$V_{(BR)GR}$	>	10	V

Switching characteristics (resistive load)

Turn-on when switched to $I_T = 5$ A from $V_D = 250$ V with $I_{GF} = 0.5$ A; $T_j = 25$ °C				
delay time	t_d	<	0.25	μs
rise time	t_r	<	1.0	μs

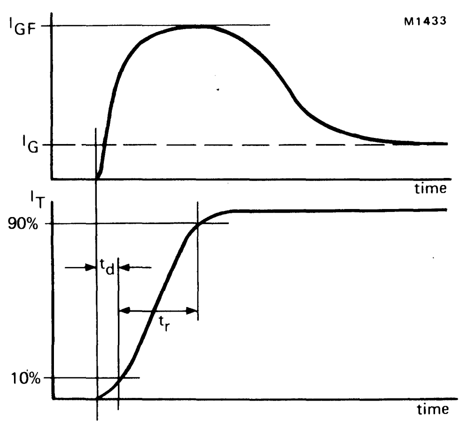


Fig.2 Waveforms

* Measured under pulse conditions to avoid excessive dissipation.
** Below latching level the device behaves like a transistor with a gain dependent on current.

Switching characteristics (inductive load)

Turn-off when switched from I_T = 5 A to V_D = V_{Dmax};

V_{GR} = 10 V; $L_G \leqslant 1.0\ \mu H$; $L_S \leqslant 0.25\ \mu H$; T_j = 25 °C

storage time	t_s	<	0.5	μs
fall time	t_f	<	0.25	μs
peak reverse gate current	I_{GR}	<	6	A

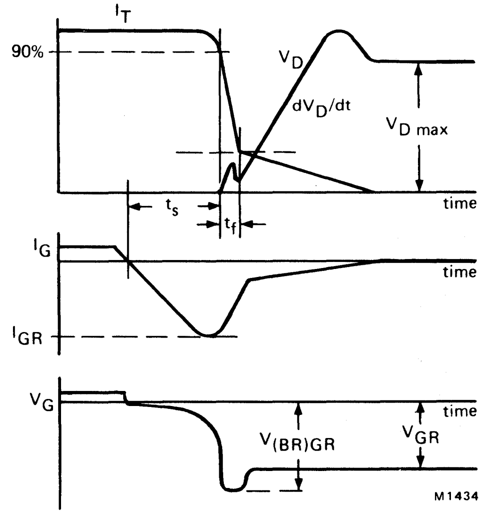


Fig.3 Waveforms.

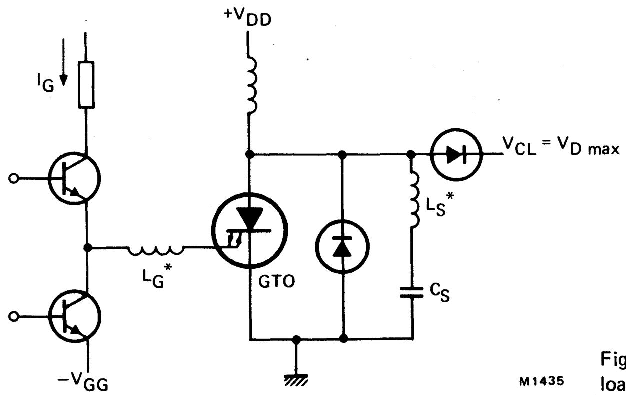


Fig.4 Inductive load test circuit.

*indicates stray series inductance only.

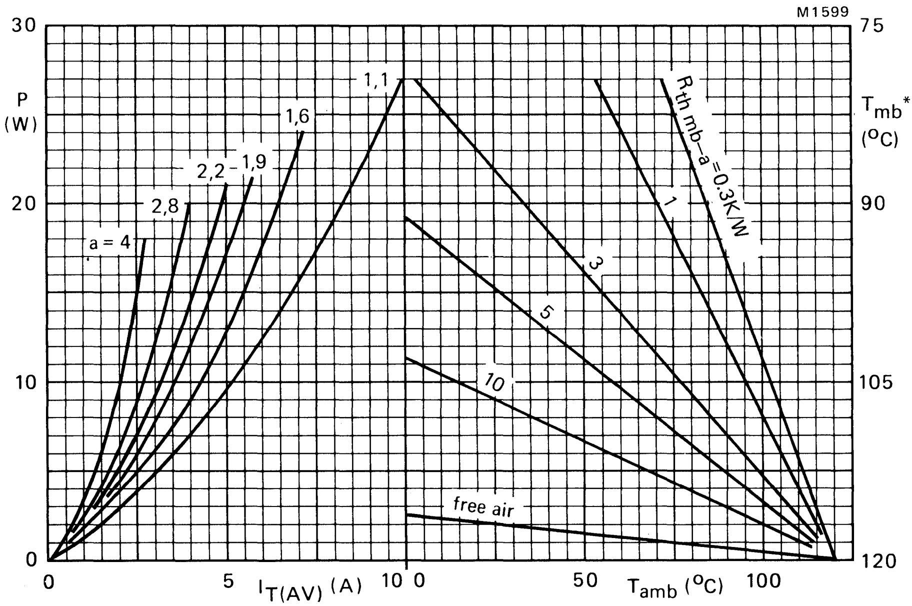


Fig.5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

$$a = \text{form factor} = \frac{I_{T(RMS)}}{I_{T(AV)}}$$

P = power excluding switching losses.

*Mounting-base temperature scale is for comparison purposes and is correct only for $R_{th\ mb\text{-}a} < 9.6$ K/W.

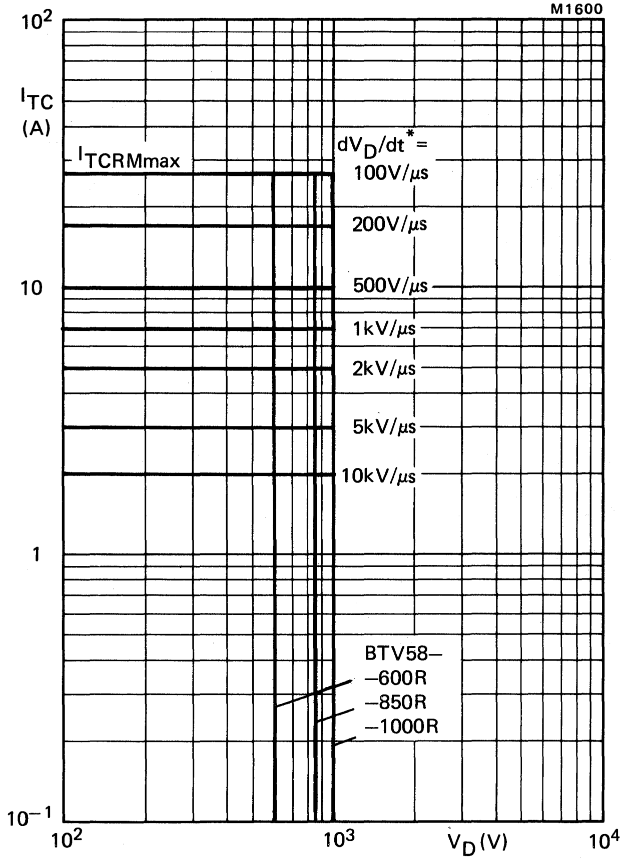


Fig.6 Anode current which can be turned off versus anode voltage; inductive load; V_{GR} = 10 V; $L_G \leqslant 1.0$ μH; $L_S \leqslant 0.25$ μH; T_j = 85 °C.
*dV_D/dt is calculated from I_T/C_S.

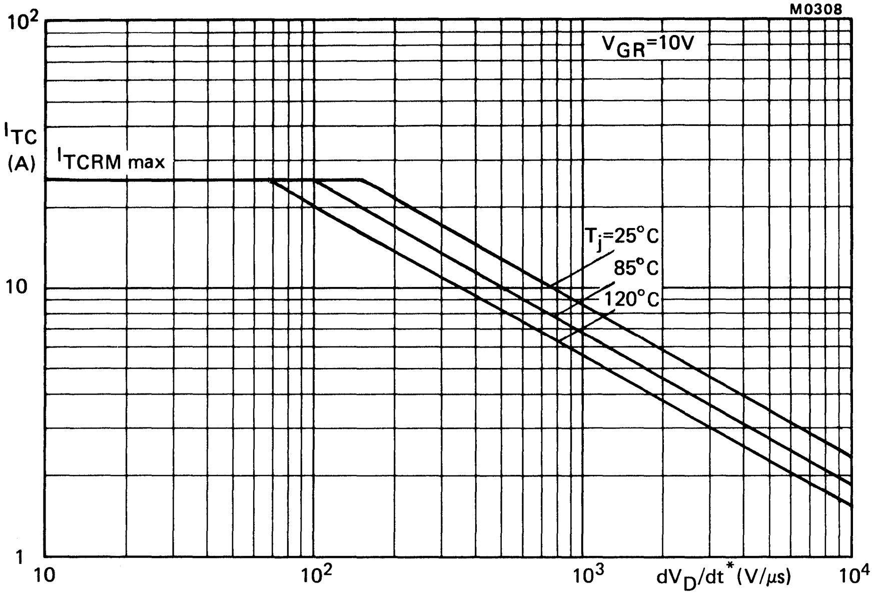


Fig.7 Anode current which can be turned off versus applied dV_D/dt^*; inductive load; V_{GR} = 10 V. $L_G \leqslant 1.0\ \mu H$; $L_S \leqslant 0.25\ \mu H$. $^*dV_D/dt$ is calculated from I_T/C_S.

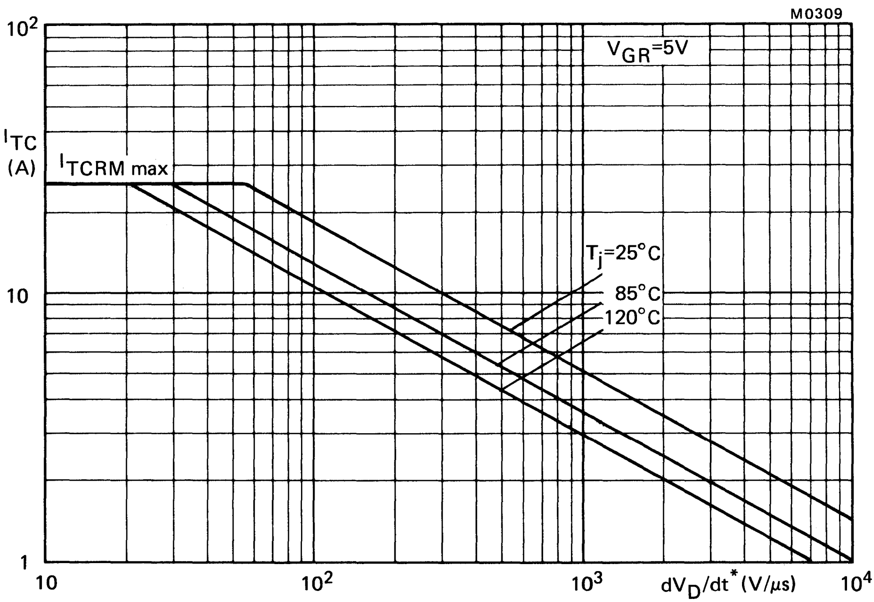


Fig.8 Anode current which can be turned off versus applied dV_D/dt^*; inductive load; V_{GR} = 5 V. $L_G \leqslant 1.0\ \mu H$; $L_S \leqslant 0.25\ \mu H$; $^*dV_D/dt$ is calculated from I_T/C_S.

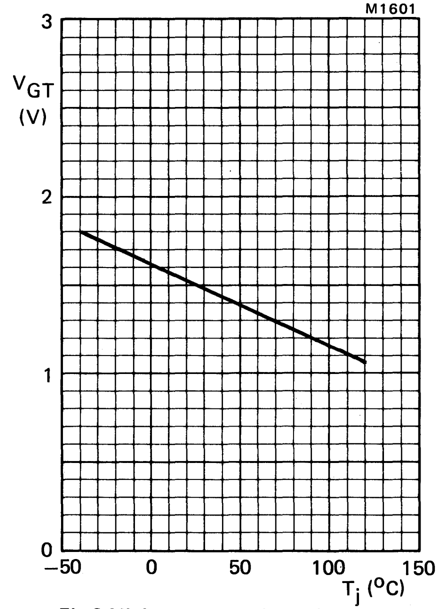


Fig.9 Minimum gate voltage that will trigger all devices as a function of junction temperature; V_D = 12 V.

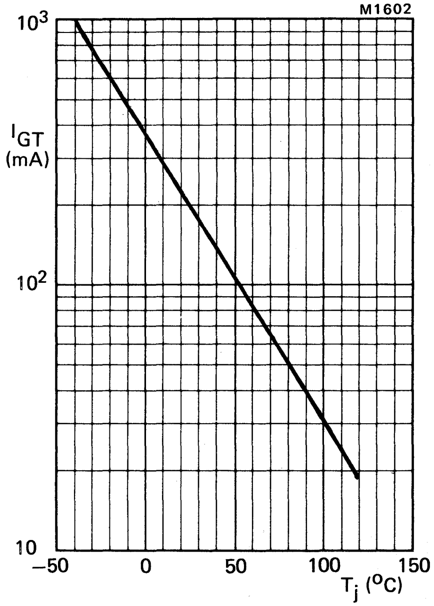


Fig.10 Minimum gate current that will trigger all devices as a function of junction temperature; V_D = 12 V.

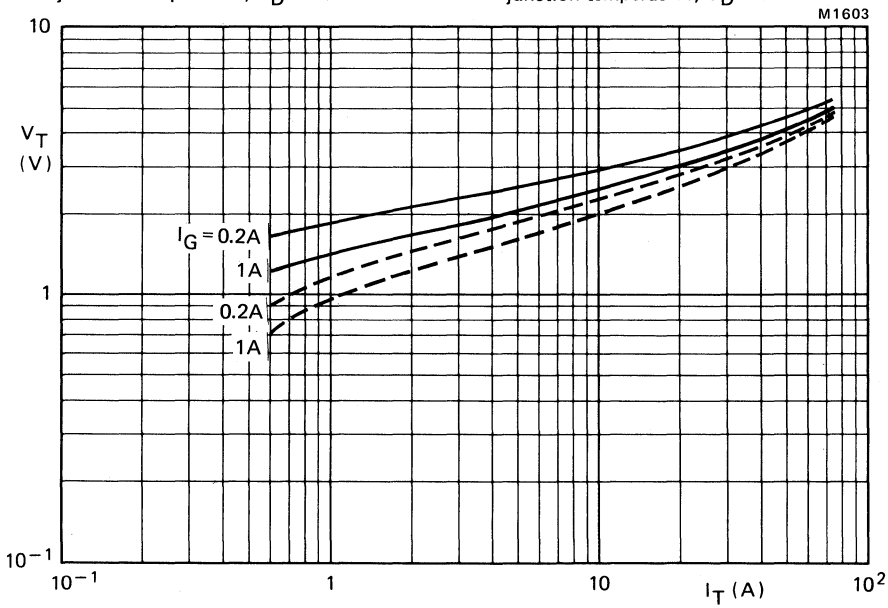


Fig.11 Maximum V_T versus I_T; —— T_j = 25 °C; – – – – T_j = 120 °C.

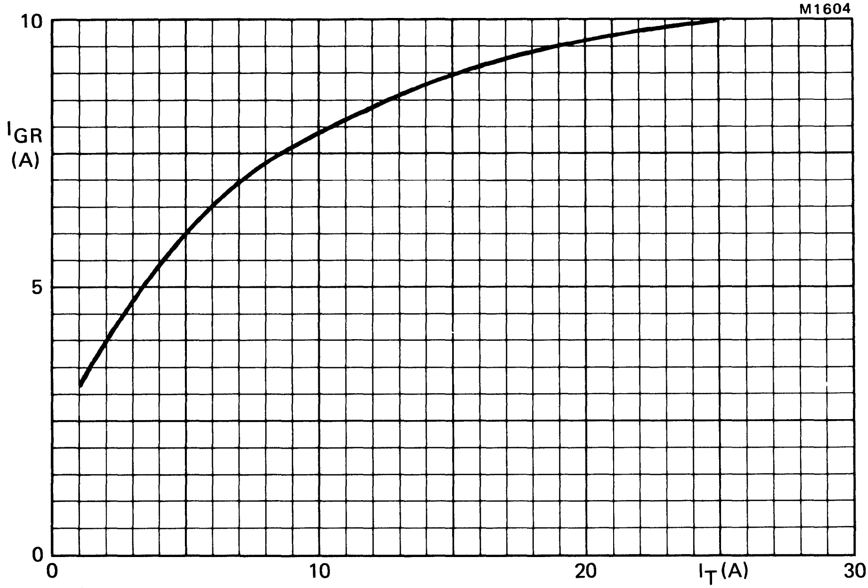


Fig.12 Peak reverse gate current versus anode current at turn-off; inductive load; V_{GR} = 10 V; I_G = 0.2 A; L_G = 0.8 μH; T_j = 120 °C; maximum values.

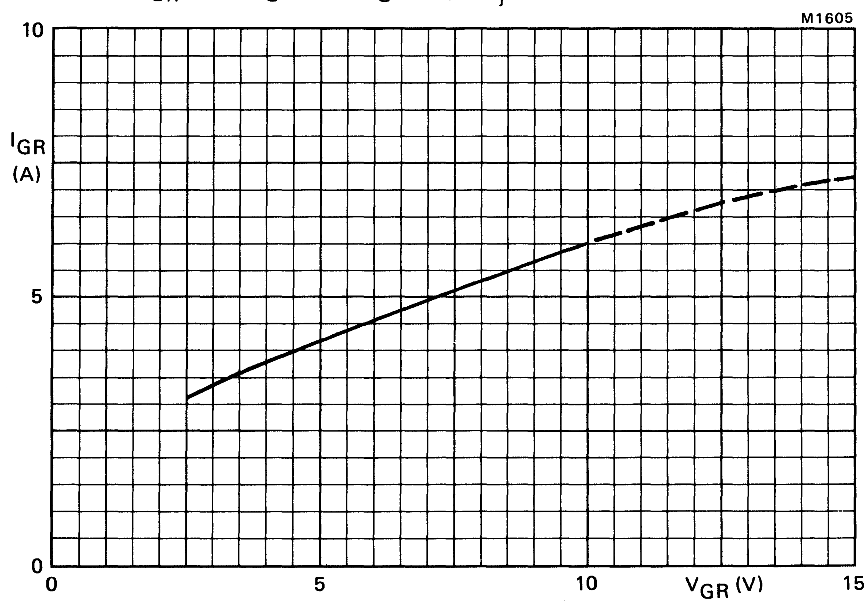


Fig.13 Peak reverse gate current versus applied reverse gate voltage; inductive load; I_T = 5 A; I_G = 0.2 A; L_G = 0.8 μH; T_j = 120 °C; maximum values.

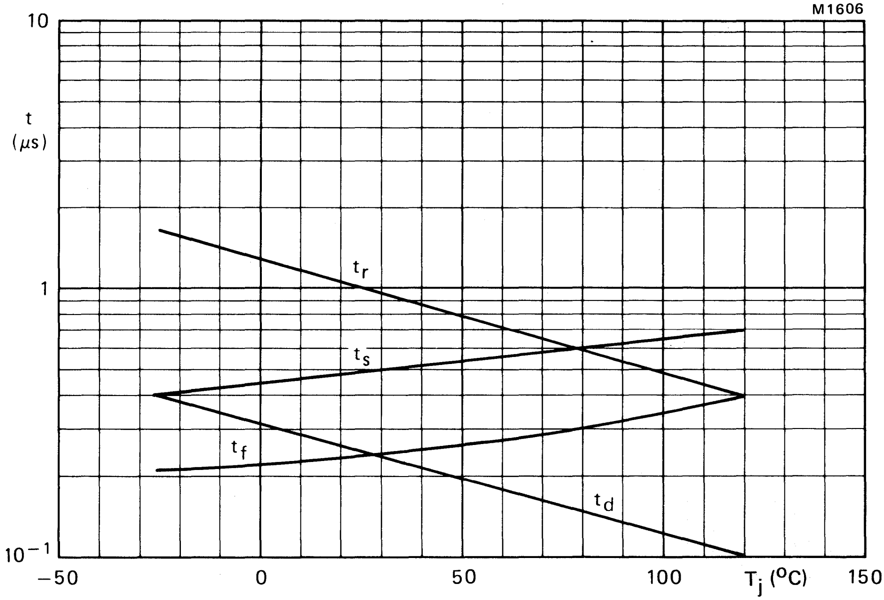


Fig.14 Switching times as a function of junction temperature; $V_D \geqslant 250$ V; $I_T = 5$ A; $I_{GF} = 0.5$ A; $V_{GR} = 10$ V; $I_G = 0.2$ A; $L_G = 0.8$ μH; maximum values.

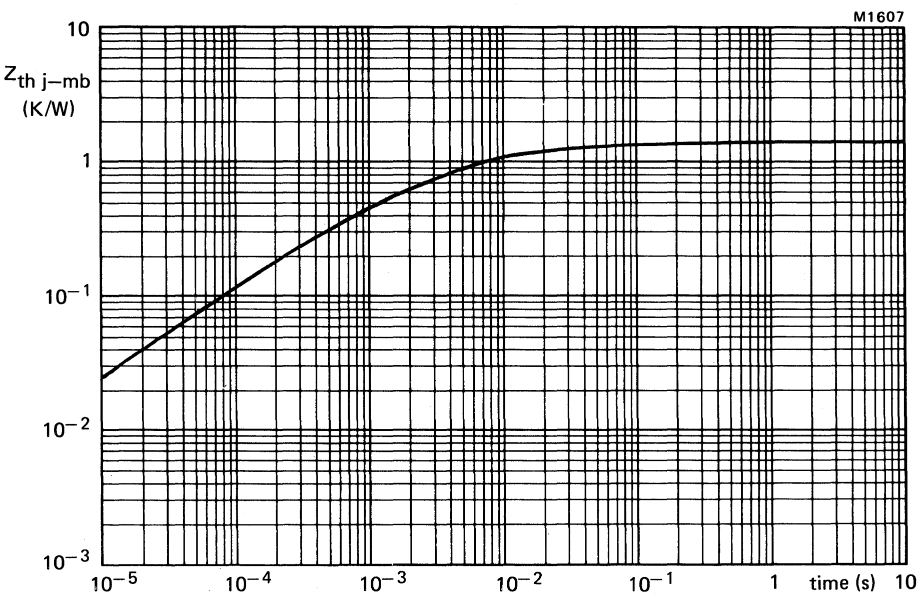


Fig.15 Transient thermal impedance.

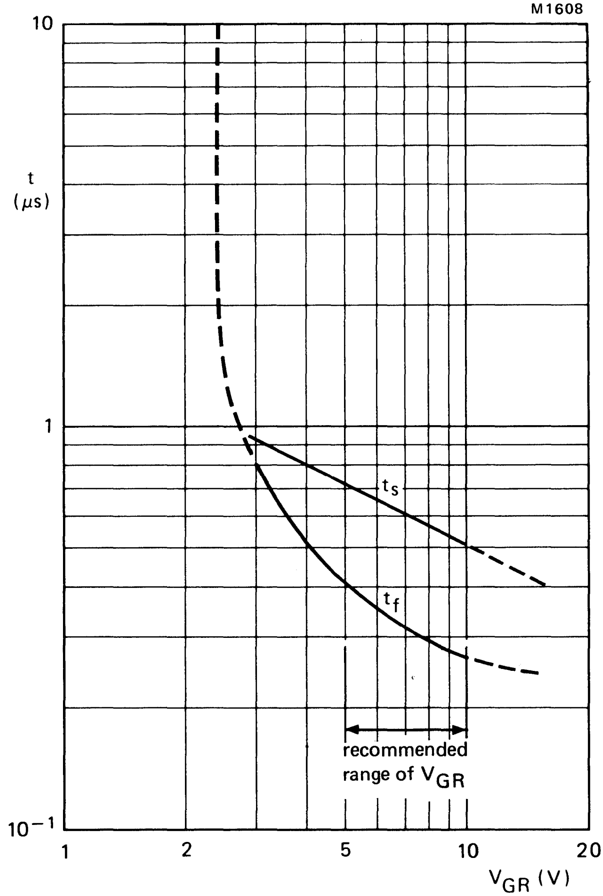


Fig.16 Storage and fall times versus applied reverse gate voltage; inductive load; I_T = 5 A; I_G = 0.2 A; L_G = 0.8 μH; T_j = 25 °C; maximum values.

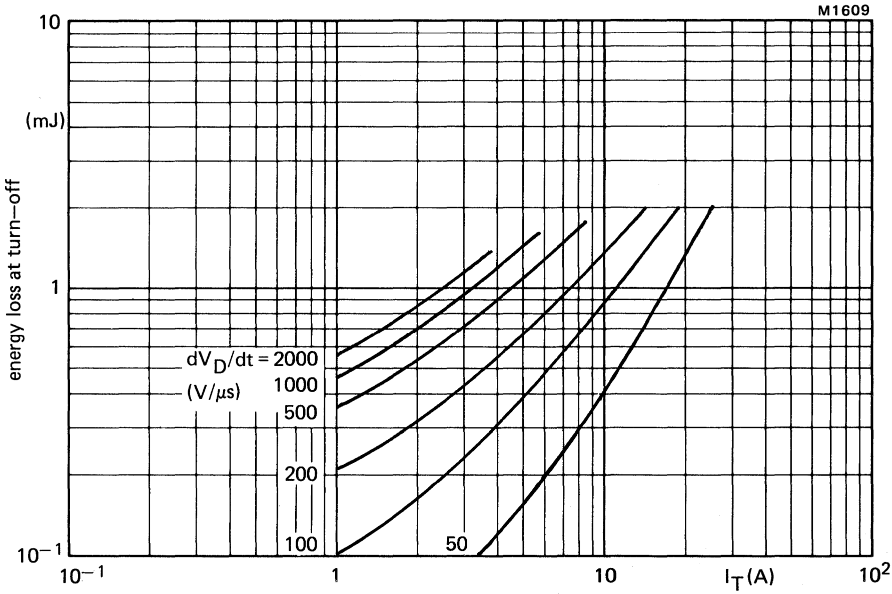


Fig.17 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied dV_D/dt (calculated from I_T/C_S); dV_D/dt linear up to V_{Dmax} = 600 V; V_{GR} = 10 V; I_G = 0.2 A; $L_G \leqslant 1.0\ \mu H$; $L_S \leqslant 0.25\ \mu H$; T_j = 120 °C.

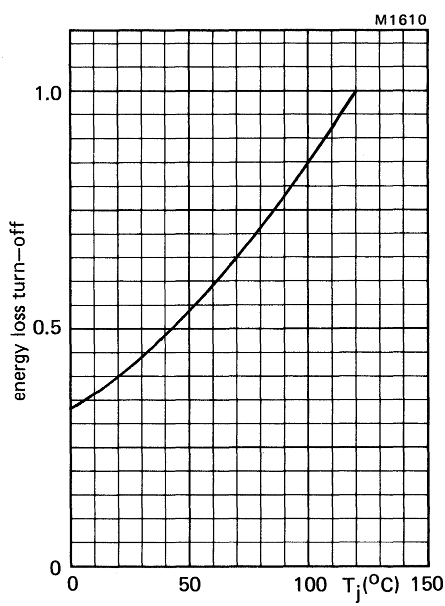


Fig.18 Energy loss at turn off as a function of junction temperature; I_G = 0.2 A; V_{GR} = 10 V. Normalised to T_j = 120 °C.

FAST GATE TURN-OFF THYRISTORS

Thyristors in TO-238AA envelopes with electrically isolated metal baseplates capable of being turned both on and off via the gate. They are suitable for use in high-frequency inverters, power supplies, motor control etc. The devices have no reverse blocking capability. For reverse blocking operation use with a series diode, for reverse conducting operation use with an anti-parallel diode.

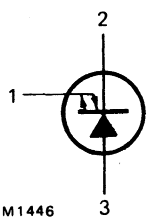
QUICK REFERENCE DATA

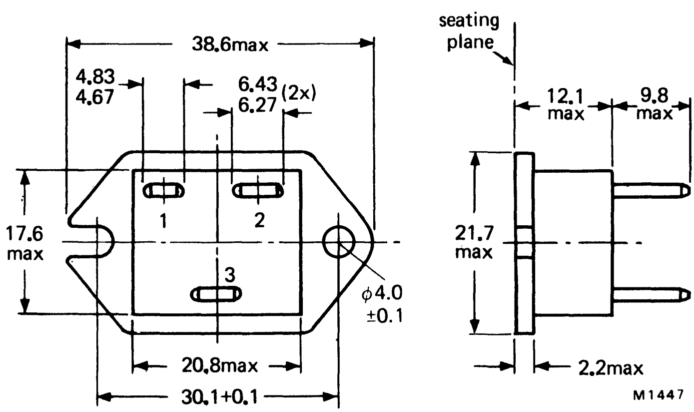
			BTV59-600R	850R	1000R	
Repetitive peak off-state voltage	V_{DRM}	max.	600	850	1000	V
Non-repetitive peak on-state current	I_{TSM}	max.		100		A
Controllable anode current	I_{TCRM}	max.		50		A
Average on-state current	$I_{T(AV)}$	max.		15		A
Fall time	t_f	<		250		ns

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-238AA





Pin 1 = gate (AMP 187 series)
2 = cathode (AMP 250 series)
3 = anode (AMP 250 series)
Baseplate is electrically isolated.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134)

Anode to cathode			BTV59-600R	850R	1000R	
Transient off-state voltage	V_{DSM}	max.	750	1000	1100	V*
Repetitive peak off-state voltage	V_{DRM}	max.	600	850	1000	V*
Working off-state voltage	V_{DW}	max.	400	600	800	V*
Continuous off-state voltage	V_D	max.	400	500	650	V*

Average on-state current (averaged over any 20 ms period) up to T_{mb} = 60 °C	$I_{T(AV)}$	max.	15	A
Controllable anode current	I_{TCRM}	max.	50	A
Non-repetitive peak on-state current t = 10 ms; half-sinewave; T_j = 120 °C prior to surge	I_{TSM}	max.	100	A
I^2t for fusing; t = 10 ms	I^2t	max.	50	A^2s
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	60	W

Gate to cathode

Repetitive peak on-state current T_j = 120 °C prior to surge gate-cathode forward; t = 10 ms; half-sinewave	I_{GFM}	max.	25	A
gate-cathode reverse; t = 20 µs	I_{GRM}	max.	25	A
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	5.0	W

Temperatures

Storage temperature	T_{stg}		−40 to +150	°C
Operating junction temperature	T_j	max.	120	°C

ISOLATION**

R.M.S. isolation voltage	V_{isol}	min.	2500	V

THERMAL RESISTANCE

From mounting base to heatsink; with heatsink compound	$R_{th\ mb\text{-}h}$	=	0.5	K/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1.5	K/W

* Measured with gate-cathode connected together.

** From baseplate to all terminals strapped together.

CHARACTERISTICS

Anode to cathode

On-state voltage I_T = 10 A; I_G = 0.5 A; T_j = 120 °C	V_T	<	2.3	V*
Rate of rise of off-state voltage that will not trigger any off-state device; exponential method V_D = 2/3 V_{Dmax}; V_{GR} = 5 V; T_j = 120 °C	dV_D/dt	<	10	kV/μs
Rate of rise of off-state voltage that will not trigger any device following conduction, linear method I_T = 10 A; V_D = V_{DRMmax}; V_{GR} = 10 V; T_j = 120 °C	dV_D/dt	<	1.0	kV/μs
Off-state current V_D = V_{Dmax}; T_j = 120 °C	I_D	<	5.0	mA
Latching current; T_j = 25 °C	I_L	typ.	1.5	A**

Gate to cathode

Voltage that will trigger all devices V_D = 12 V; T_j = 25 °C	V_{GT}	>	1.5	V
Current that will trigger all devices V_D = 12 V; T_j = 25 °C	I_{GT}	>	200	mA
Minimum reverse breakdown voltage I_{GR} = 1.0 mA	$V_{(BR)GR}$	>	10	V

Switching characteristics (resistive load)

Turn-on when switched to I_T = 10 A from V_D = 250 V with I_{GF} = 1.0 A; T_j = 25 °C				
delay time	t_d	<	0.3	μs
rise time	t_r	<	1.5	μs

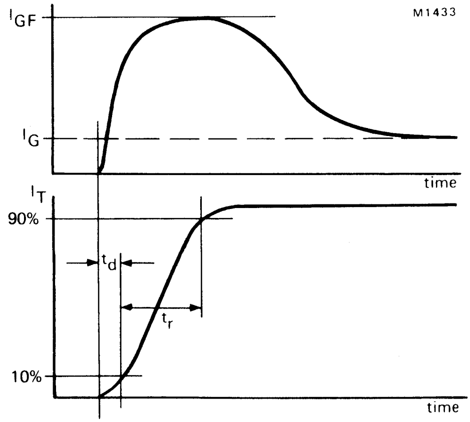


Fig.2 Waveforms

* Measured under pulse conditions to avoid excessive dissipation.
**Below latching level the device behaves like a transistor with a gain dependent on current.

Switching characteristics (inductive load)

Turn-off when switched from I_T = 10 A to V_D = V_{Dmax};
V_{GR} = 10 V; $L_G \leqslant 0.5\ \mu H$; $L_S \leqslant 0.25\ \mu H$; T_j = 25 °C

storage time	t_s	<	0.60	μs
fall time	t_f	<	0.25	μs
peak reverse gate current	I_{GR}	<	10	A

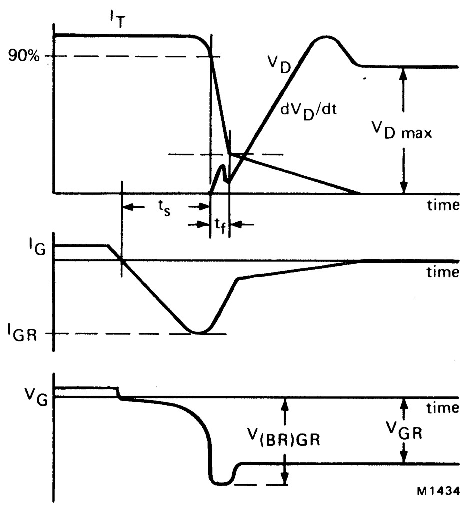


Fig.3 Waveforms.

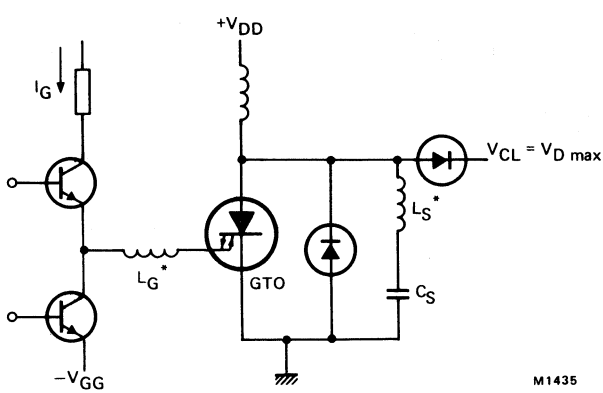


Fig.4 Inductive load test circuit.

*Indicates stray series inductance only.

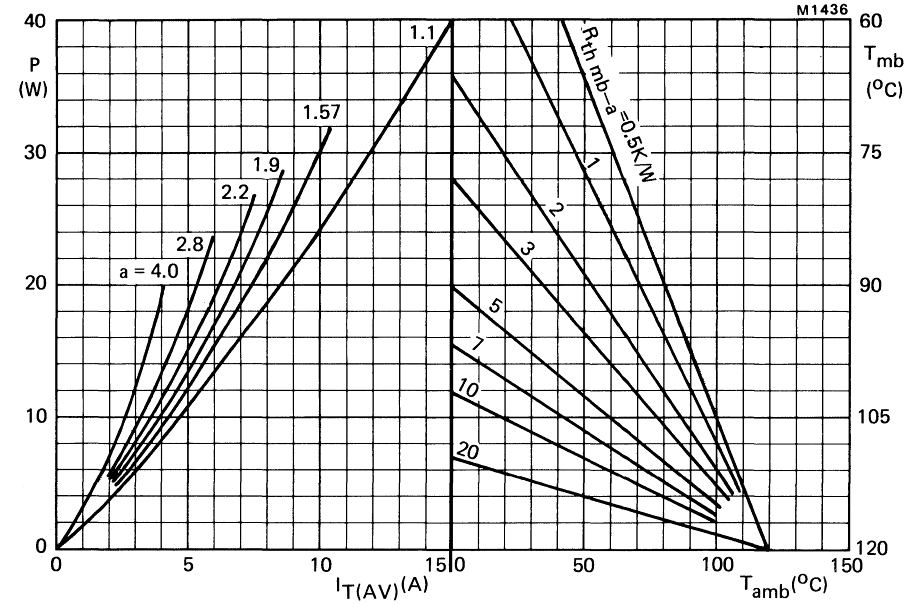


Fig. 5 The right hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

$$a = \text{form factor} = \frac{I_{T(RMS)}}{I_{T(AV)}}$$

P = power excluding switching losses.

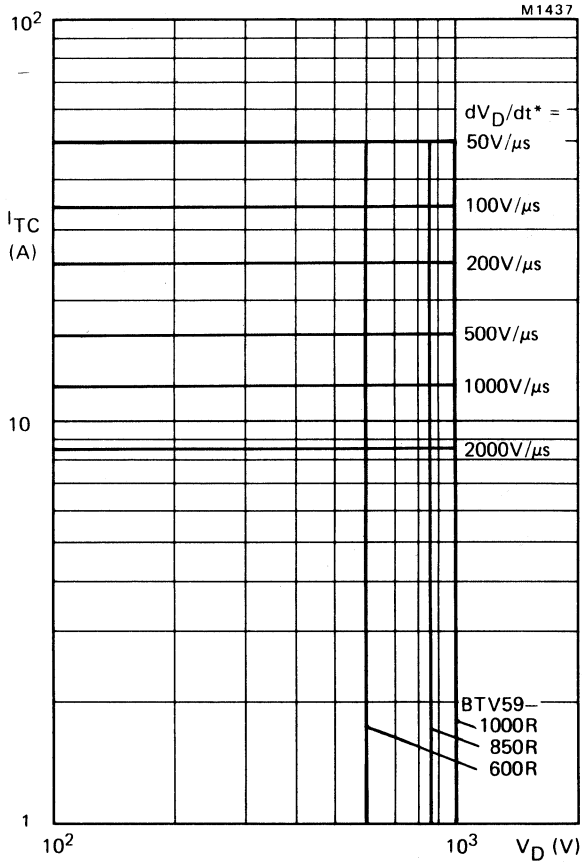


Fig. 6 Anode current which can be turned off versus anode voltage; inductive load; V_{GR} = 10 V; $L_G \leqslant 0.5$ μH; $L_S \leqslant 0.25$ μH; T_j = 85 °C.
*dV_D/dt is calculated from I_T/C_S.

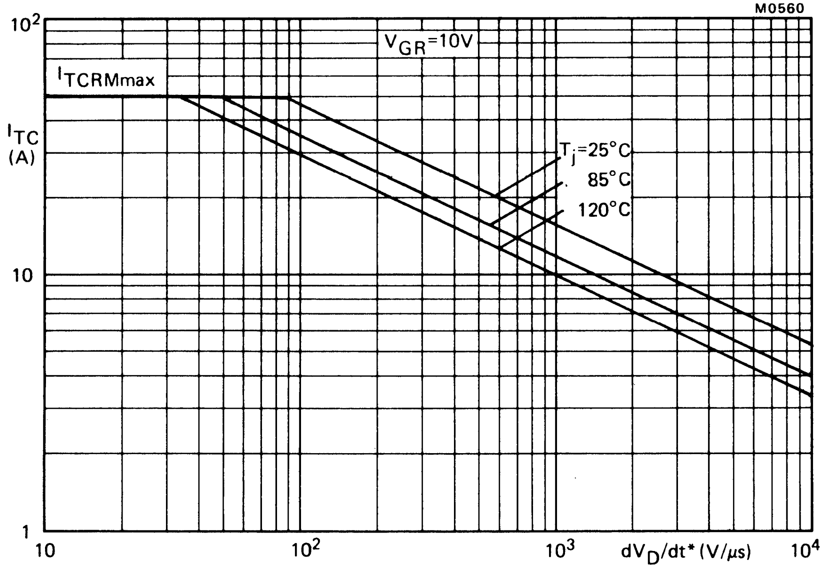


Fig.7 Anode current which can be turned off versus applied dV_D/dt^*; inductive load; V_{GR} = 10 V; $L_G \leqslant 0.5\ \mu H$; $L_S \leqslant 0.25\ \mu H$. *$dV_D/dt$ is calculated from I_T/C_S.

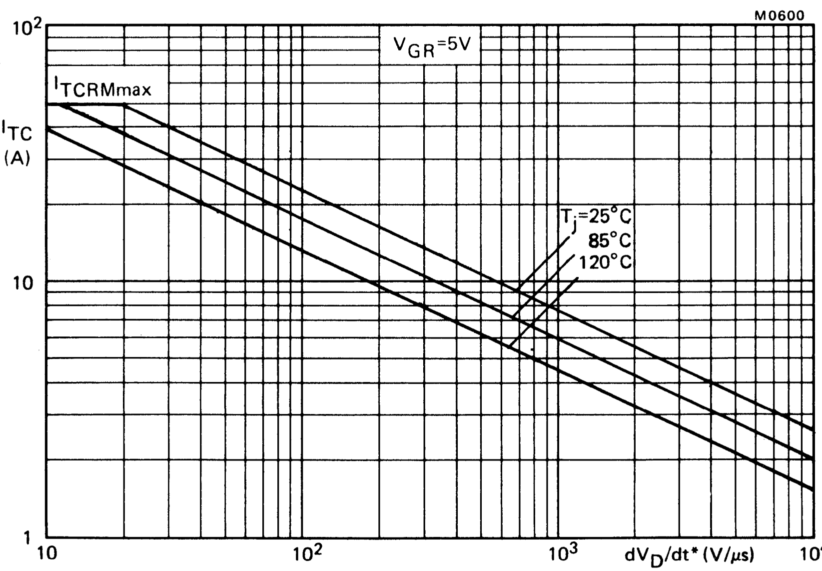


Fig.8 Anode current which can be turned off versus applied dV_D/dt^*; inductive load; V_{GR} = 5 V; $L_G \leqslant 0.5\ \mu H$; $L_S \leqslant 0.25\ \mu H$. *$dV_D/dt$ is calculated from I_T/C_S.

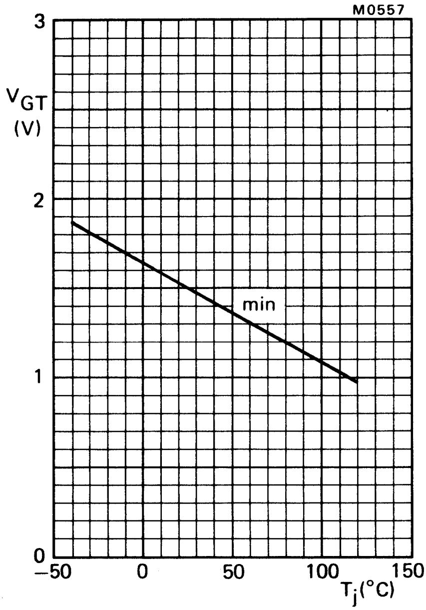


Fig.9 Minimum gate voltage that will trigger all devices as a function of junction temperature; V_D = 12 V.

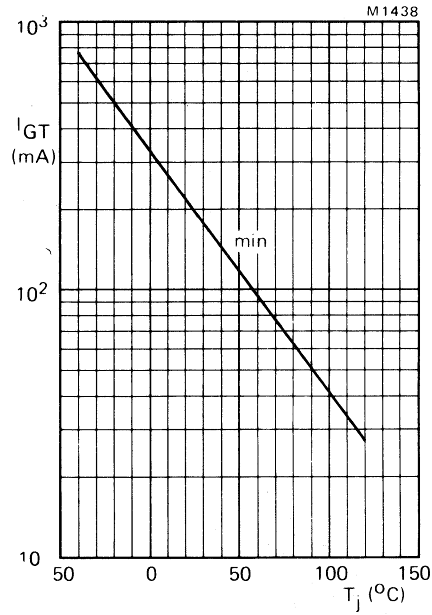


Fig.10 Minimum gate current that will trigger all devices as a function of junction temperature; V_D = 12 V.

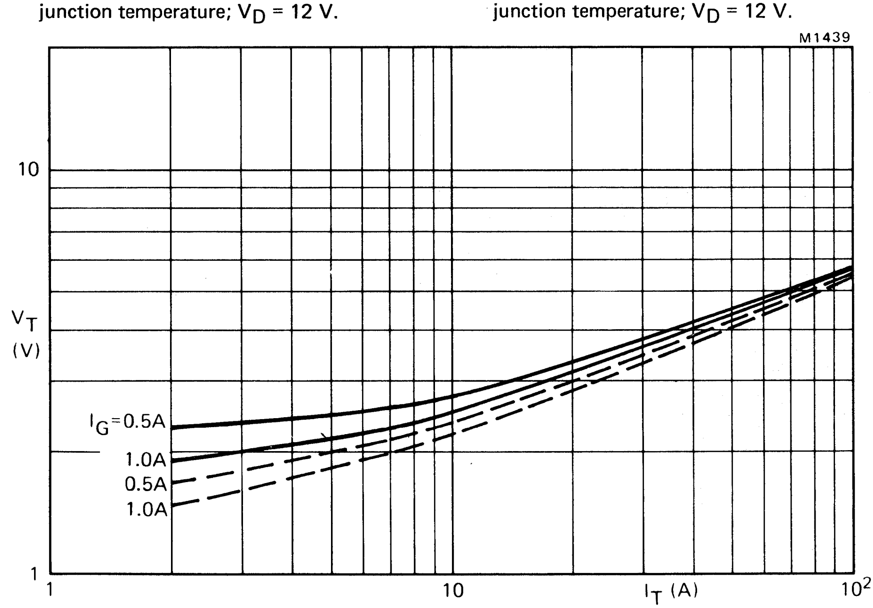


Fig.11 Maximum V_T versus I_T; —— T_j = 25 °C; – – – – T_j = 120 °C.

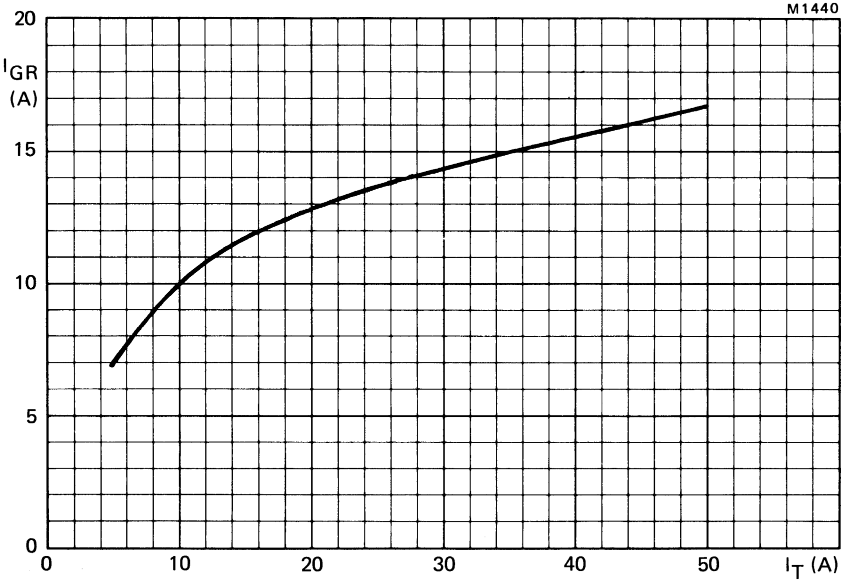


Fig.12 Peak reverse gate current versus anode current at turn-off; inductive load;
V_{GR} = 10 V; I_G = 0.5 A; L_G = 0.4 μH; T_j = 120 ^oC; maximum values.

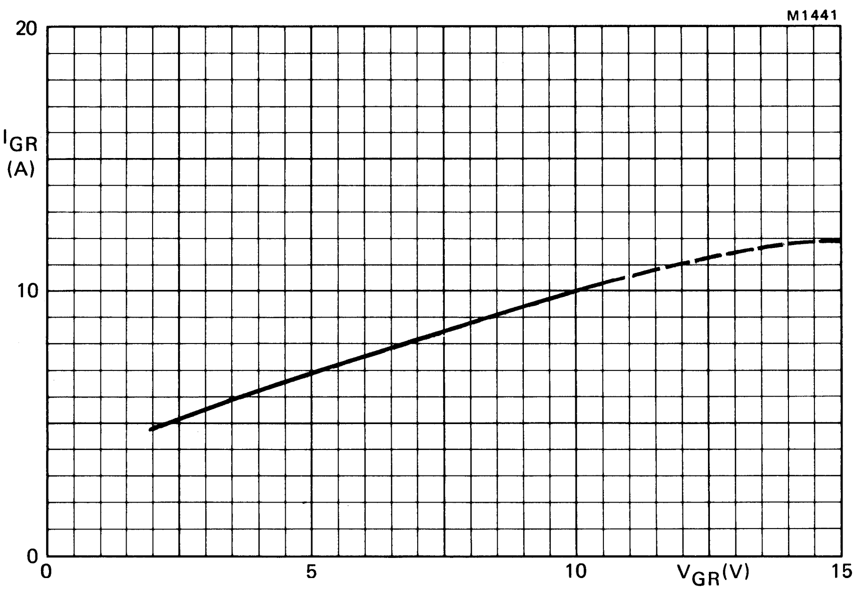


Fig.13 Peak reverse gate current versus applied reverse gate voltage; inductive load; I_T = 10 A;
I_G = 0.5 A; L_G = 0.4 μH; T_j = 120 ^oC; maximum values.

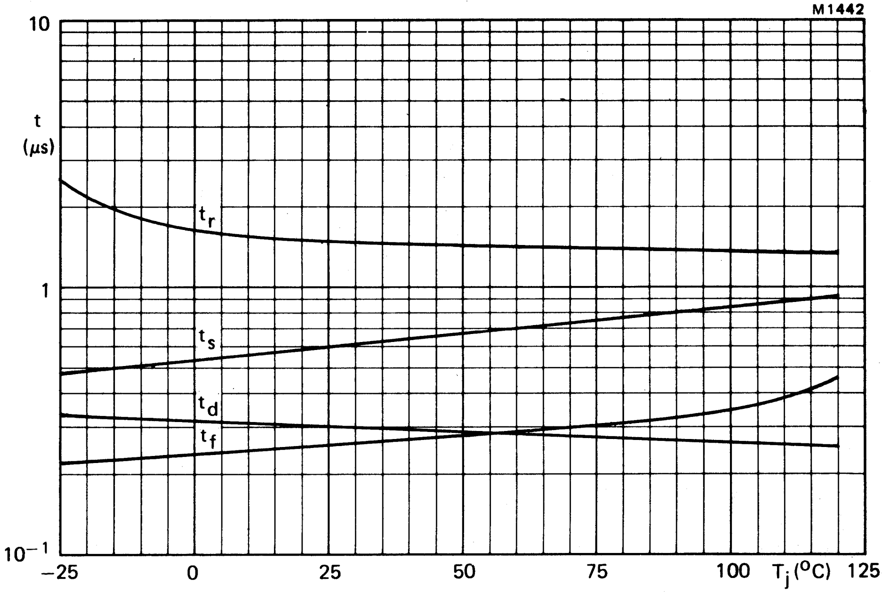


Fig.14 Switching times as a function of junction temperature; $V_D \geqslant 250$ V; $I_T = 10$ A; $I_{GF} = 1.0$ A; $V_{GR} = 10$ V; $I_G = 0.5$ A; $L_G = 0.4$ μH; maximum values.

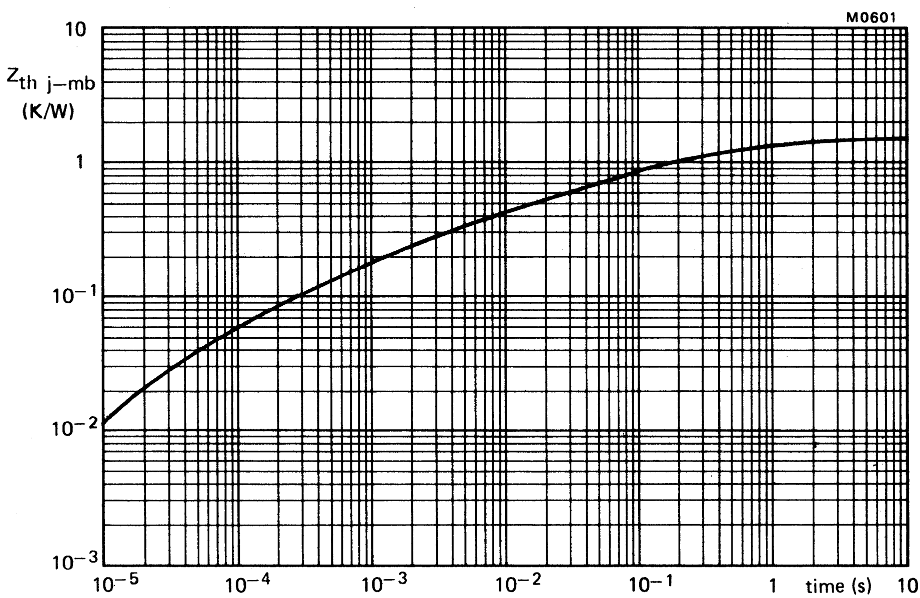


Fig.15 Transient thermal impedance.

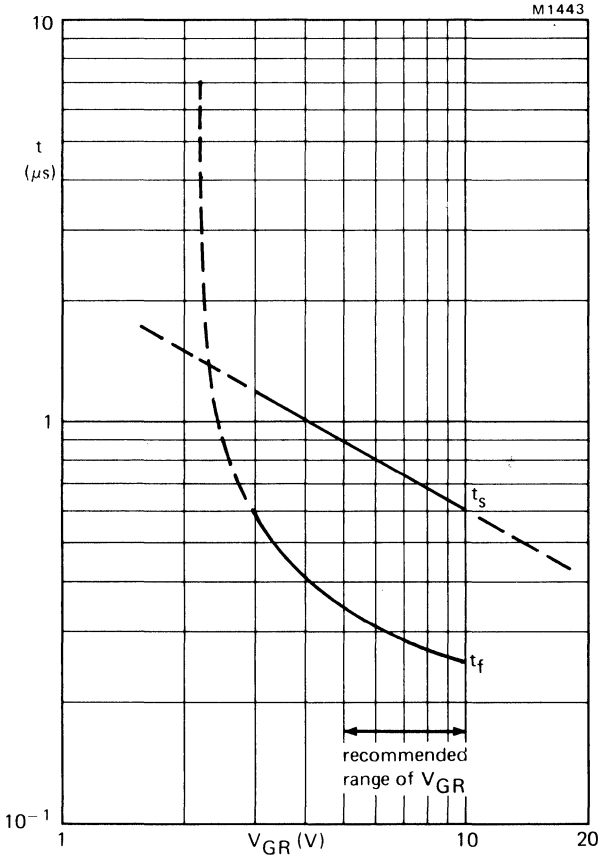


Fig. 16 Storage and fall times versus applied reverse gate voltage; inductive load; I_T = 10 A; I_G = 0.5 A; L_G = 0.4 μH; T_j = 25 °C; maximum values.

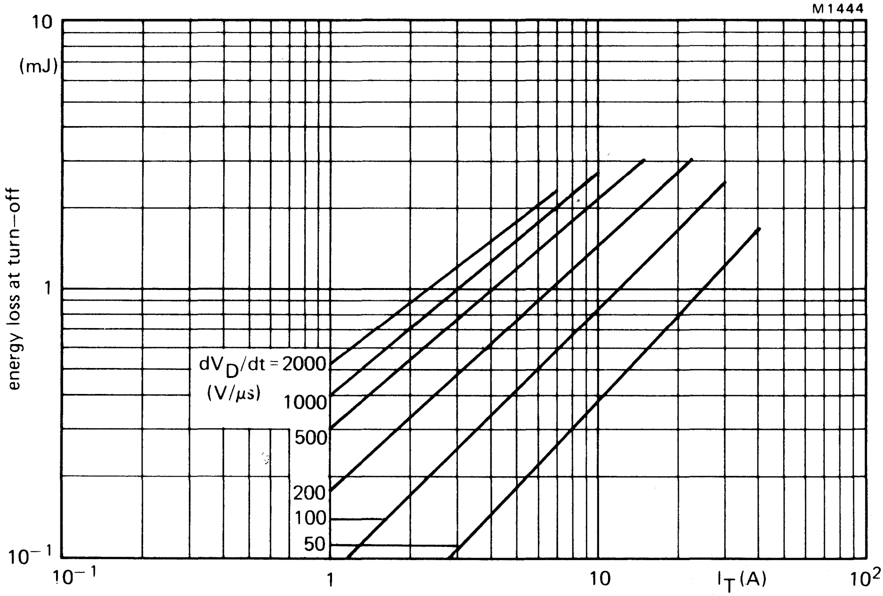


Fig.17 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied dV_D/dt (calculated from I_T/C_S); dV_D/dt linear up to V_{Dmax} = 600 V; V_{GR} = 10 V; I_G = 0.5 A; $L_G \leq 0.5\ \mu H$; $L_S \leq 0.25\ \mu H$; T_j = 120 °C.

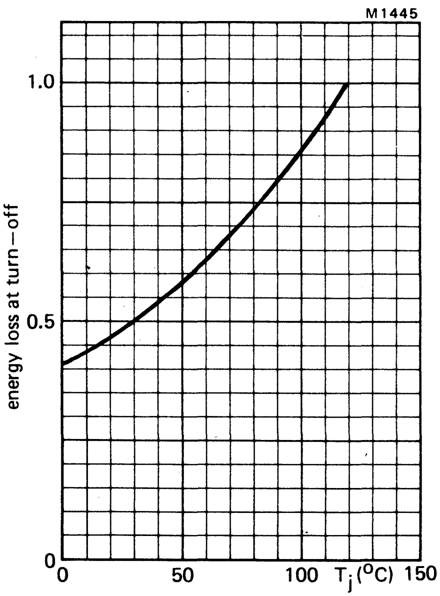


Fig.18 Energy loss at turn off as a function of junction temperature; I_G = 0.5 A; V_{GR} = 10 V. Normalised to T_j = 120 °C.

FAST GATE TURN-OFF THYRISTORS WITH ANTI-PARALLEL DIODE

Fast gate turn-off thyristors with anti-parallel connected fast soft-recovery diodes in TO-238AA. They are suitable for use in high frequency inverters, power supplies and motor control systems requiring a parallel connected flywheel or efficiency diode. The baseplate is electrically isolated.

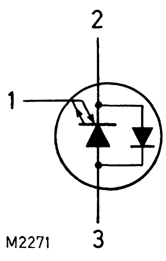
QUICK REFERENCE DATA

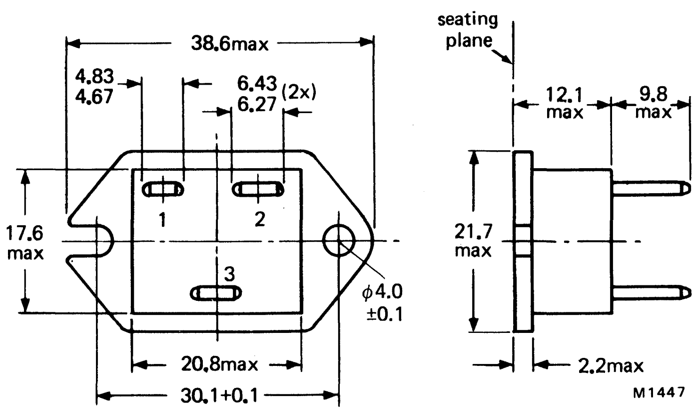
GTO			BTV59D-850R	1000R	1200R	
Repetitive peak off-state voltage	V_{DRM}	max.	850	1000	1200	V
Non-repetitive peak on-state current	I_{TSM}	max.		100		A
Controllable anode current	I_{TCRM}	max.		50		A
Average on-state current	$I_{T(AV)}$	max.		15		A
Fall time	t_f	<		250		ns
Diode						
Average forward current	$I_{F(AV)}$	max.		9.0		A
Non-repetitive peak forward current	I_{FSM}	max.		60		A
Reverse recovery time	t_{rr}	<		600		ns

MECHANICAL DATA

Dimensions in mm

Fig.1 TO-238AA





Pin 1 = gate (AMP 187) series
2 = k(GTO) a(Diode); (AMP 250 series)
3 = a(GTO) k(Diode); (AMP 250 series)
Baseplate is electrically isolated.

For further information see data sheets BTV59 and BY359.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134)

Anode to cathode			BTV59D-850R	1000R	1200R	
Transient off-state voltage	V_{DSM}	max.	1000	1100	1300	V*
Repetitive peak off-state voltage	V_{DRM}	max.	850	1000	1200	V*
Working off-state voltage	V_{DW}	max.	600	800	1000	V*
Continuous off-state voltage	V_D	max.	500	650	750	V*

Average on-state current (averaged over any 20 ms period) up to T_{mb} = 60 °C	$I_{T(AV)}$	max.	15	A
Controllable anode current	I_{TCRM}	max.	50	A
Non-repetitive peak on-state current t = 10 ms; half-sinewave; T_j = 120 °C prior to surge	I_{TSM}	max.	100	A
I^2t for fusing; t = 10 ms	I^2t	max.	50	A^2s
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	60	W
Gate to cathode				
Repetitive peak on-state current T_j = 120 °C prior to surge				
gate-cathode forward; t = 10 ms; half-sinewave	I_{GFM}	max.	25	A
gate-cathode reverse; t = 20 µs	I_{GRM}	max.	25	A
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	5.0	W
Diode				
Average forward current (averaged over any 20 ms period) up to T_{mb} = 70 °C	$I_{F(AV)}$	max.	9.0	A
Non-repetitive peak on-state current t = 10 ms; half-sinewave T_j = 120 °C prior to surge	I_{FSM}	max.	60	A
Temperatures				
Storage temperature	T_{stg}		−40 to +125	°C
Operating junction temperature	T_j	max.	120	°C

ISOLATION**

R.M.S. isolation voltage	V_{isol}	min.	2500	V

* Measured with gate-cathode connected together.
** From baseplate to all terminals strapped together.

THERMAL RESISTANCE

GTO

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1.5	K/W
From mounting base to heatsink with heatsink compound	$R_{th\ mb\text{-}h}$	=	0.3	K/W

Diode

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	3.6	K/W
From mounting base to heatsink with heatsink compound	$R_{th\ mb\text{-}h}$	=	0.3	K/W

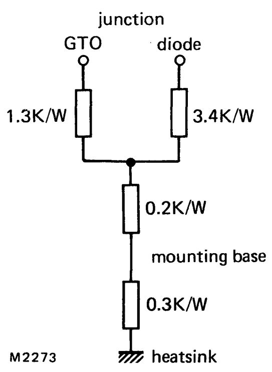


Fig.2 Equivalent thermal network.

GTO CHARACTERISTICS

Anode to cathode

On-state voltage I_T = 10 A; I_G = 0.5 A; T_j = 120 °C	V_T	<	2.3	V*
Rate of rise of off-state voltage that will not trigger any off-state device; exponential method V_D = 2/3 V_{Dmax}; V_{GR} = 5 V; T_j = 120 °C	dV_D/dt	<	10	kV/μs
Rate of rise of off-state voltage that will not trigger any device following conduction, linear method I_T = 10 A; V_D = V_{DRMmax}; V_{GR} = 10 V; T_j = 120 °C	dV_D/dt	<	1.0	kV/μs
Off-state current V_D = V_{Dmax}; T_j = 120 °C	I_D	<	5.0	mA
Latching current; T_j = 25 °C	I_L	typ.	1.5	A**

Gate to cathode

Voltage that will trigger all devices V_D = 12 V; T_j = 25 °C	V_{GT}	>	1.5	V
Current that will trigger all devices V_D = 12 V; T_j = 25 °C	I_{GT}	>	200	mA
Minimum reverse breakdown voltage I_{GR} = 1.0 mA	$V_{(BR)GR}$	>	10	V

Switching characteristics (resistive load)

Turn-on when switched to I_T = 10 A from V_D = 250 V with I_{GF} = 1.0 A; T_j = 25 °C				
delay time	t_d	<	0.3	μs
rise time	t_r	<	1.5	μs

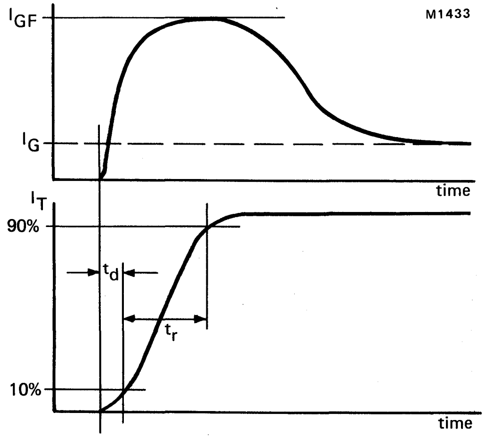


Fig.3 Waveforms.

* Measured under pulse conditions to avoid excessive dissipation.

** Below latching level the device behaves like a transistor with a gain dependent on current.

GTO (cont.)

Switching characteristics (inductive load)

Turn-off when switched from I_T = 10 A to $V_D = V_{Dmax}$;
V_{GR} = 10 V; $L_G \leqslant 0.5\ \mu H$; $L_S \leqslant 0.25\ \mu H$; T_j = 25 °C

storage time	t_s	<	0.60	μs
fall time	t_f	<	0.25	μs
peak reverse gate current	I_{GR}	<	10	A

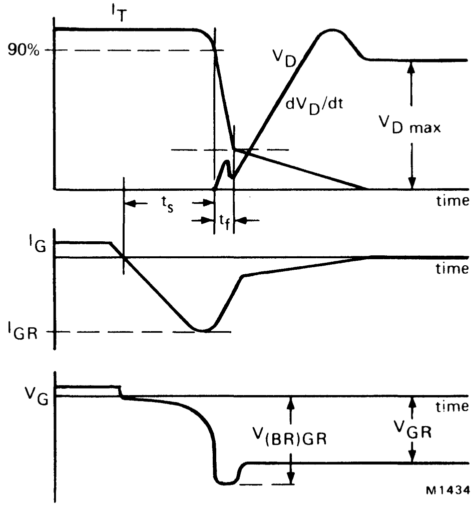


Fig.4 Waveforms.

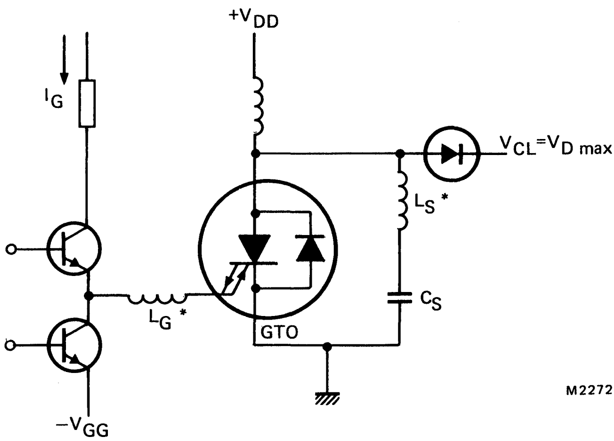


Fig.5 Inductive load test circuit.

*Indicates stray series inductance only

GTO (cont.)

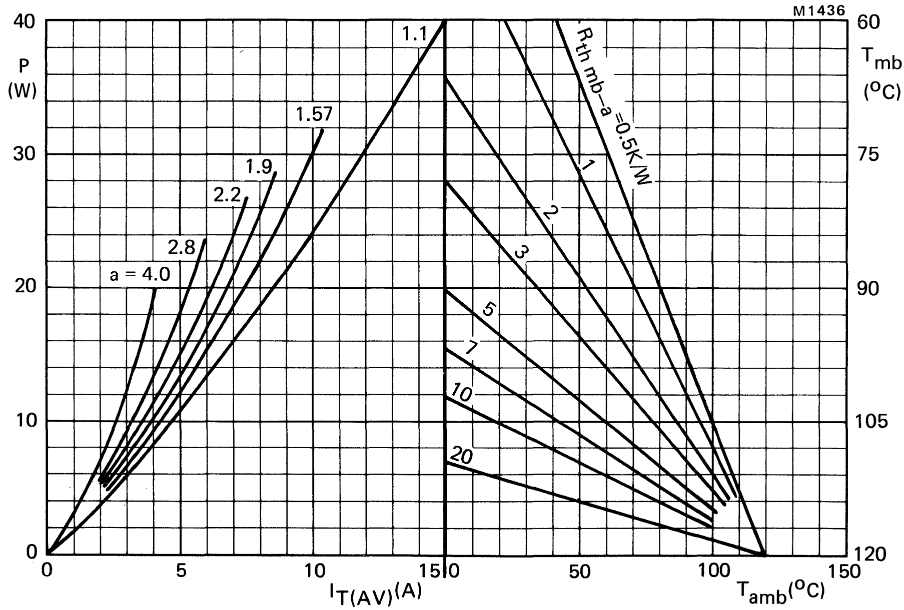


Fig.6 The right hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

a = form factor = $\frac{I_{T(RMS)}}{I_{T(AV)}}$

P = power excluding switching losses.

Values given on the right hand graph assume that the diode is not dissipating significant power.

GTO (cont.)

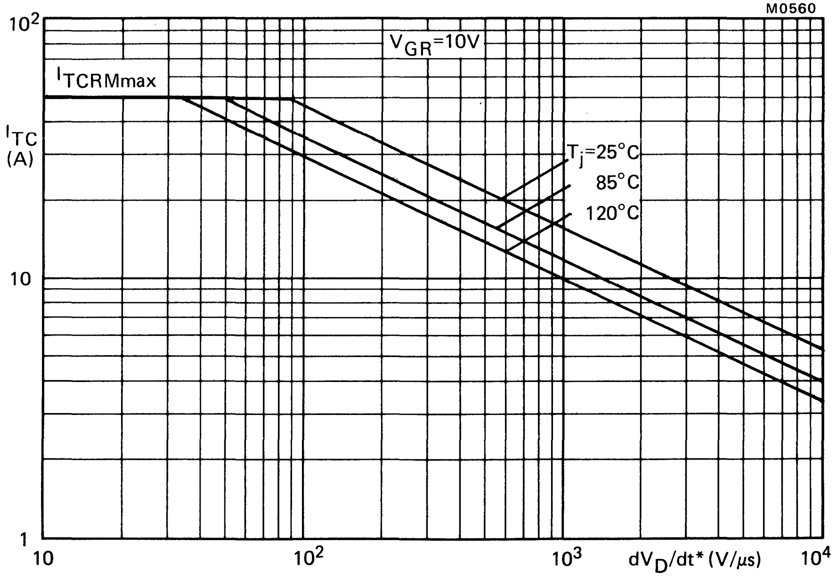


Fig.7 Anode current which can be turned off versus applied dV_D/dt^*; inductive load; V_{GR} = 10 V; $L_G \leqslant 0.5\ \mu H$; $L_S \leqslant 0.25\ \mu H$. $^*dV_D/dt$ is calculated from I_T/C_S.

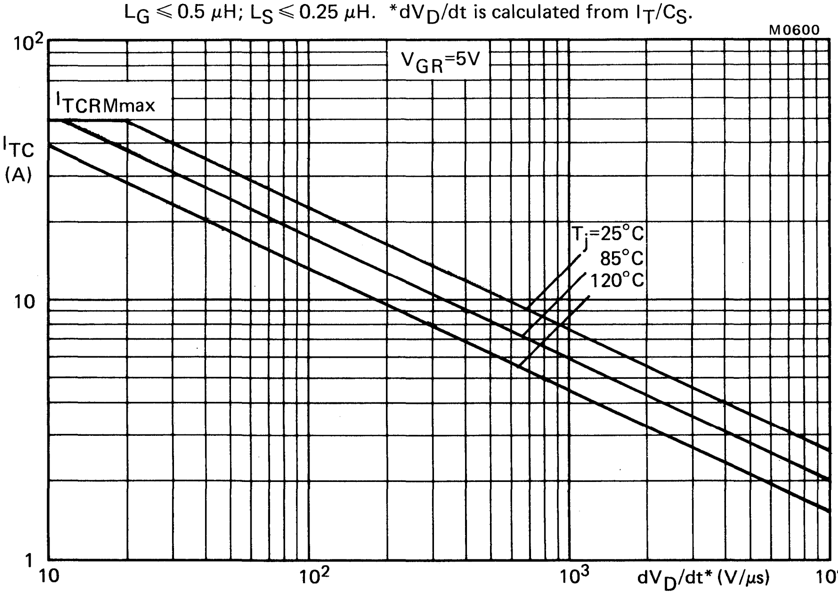


Fig.8 Anode current which can be turned off versus applied dV_D/dt^*; inductive load; V_{GR} = 5 V; $L_G \leqslant 0.5\ \mu H$; $L_S \leqslant 0.25\ \mu H$. $^*dV_D/dt$ is calculated from I_T/C_S.

GTO (cont.)

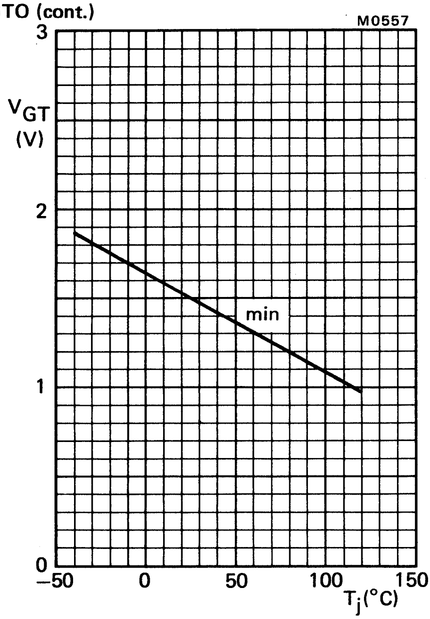


Fig.9 Minimum gate voltage that will trigger all devices as a function of junction temperature; V_D = 12 V.

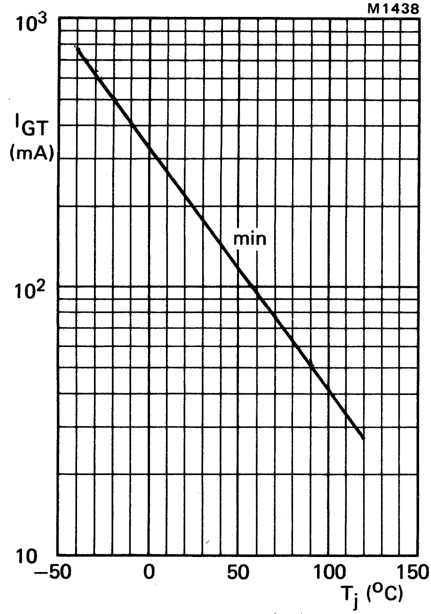


Fig.10 Minimum gate current that will trigger all devices as a function of junction temperature; V_D = 12 V.

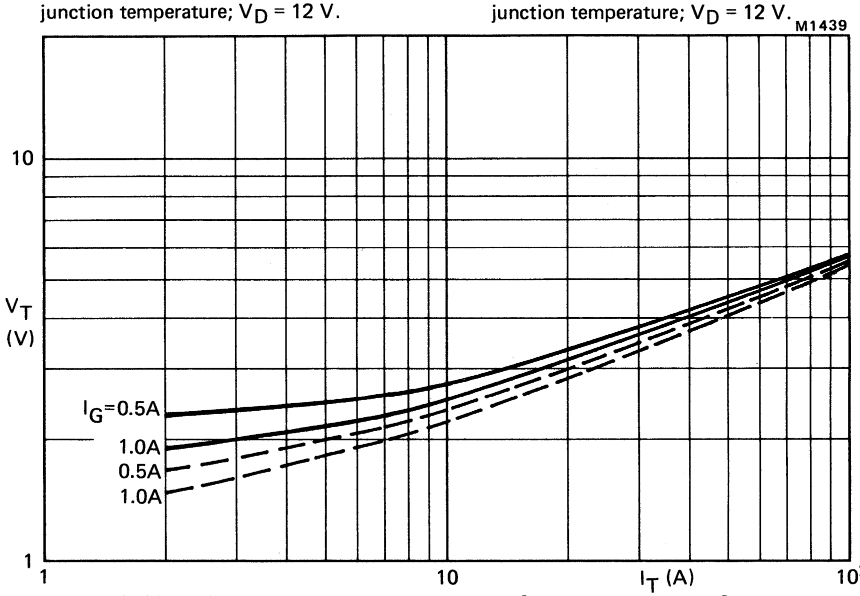


Fig.11 Maximum V_T versus I_T; ——— T_j = 25 °C; – – – – T_j = 120 °C.

GTO (cont.)

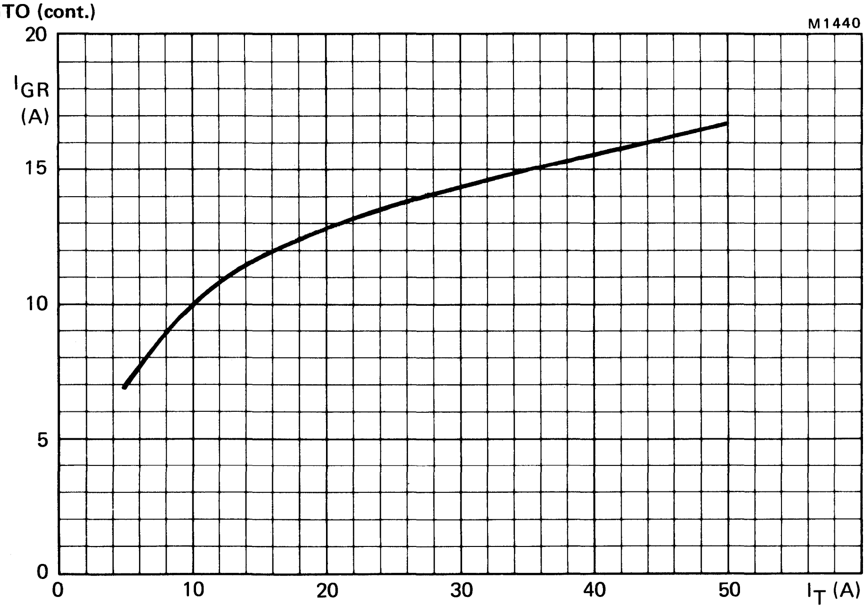


Fig.12 Peak reverse gate current versus anode current at turn-off; inductive load; V_{GR} = 10 V; I_G = 0.5 A; L_G = 0.4 μH; T_j = 120 °C; maximum values.

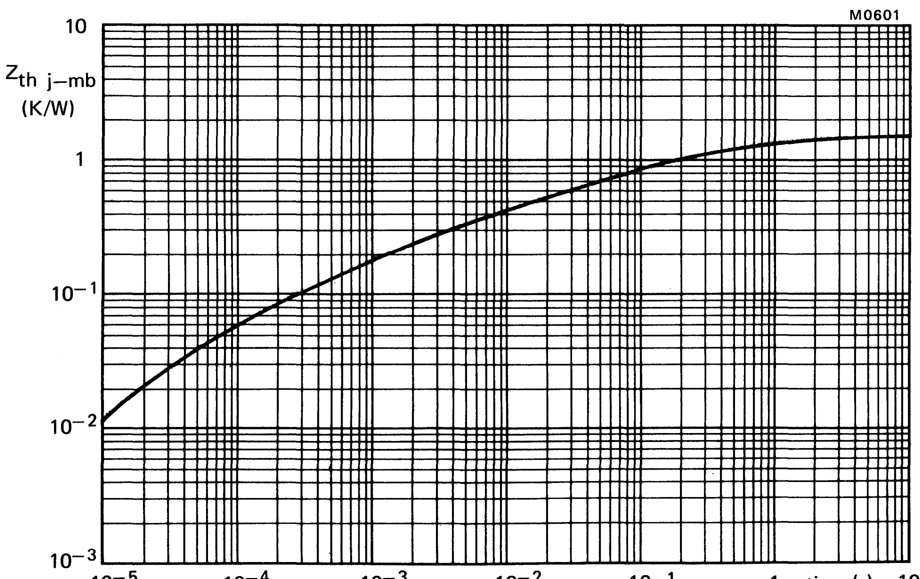


Fig.13 Transient thermal impedance.

GTO (cont.)

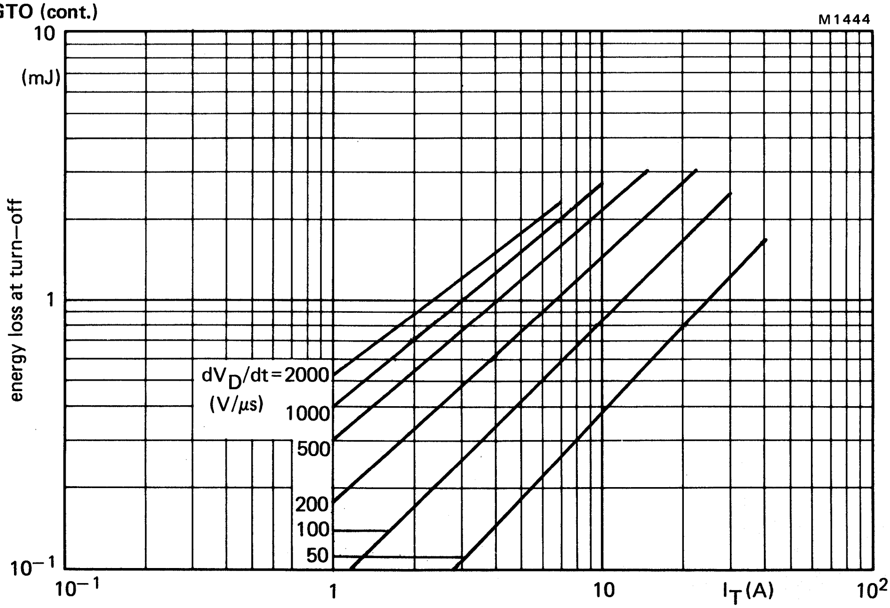


Fig.14 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied dV_D/dt (calculated from I_T/C_S); dV_D/dt linear up to V_{Dmax} = 600 V; V_{GR} = 10 V; I_G = 0.5 A; $L_G \leqslant 0.5\ \mu H$; $L_S \leqslant 0.25\ \mu H$; T_j = 120 °C.

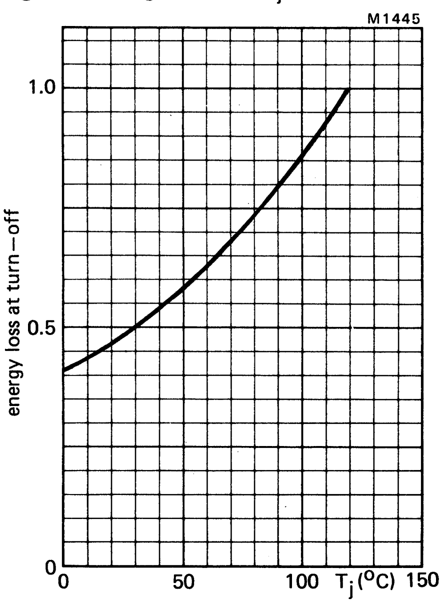


Fig.15 Energy loss at turn off as a function of junction temperature; I_G = 0.5 A; V_{GR} = 10 V. Normalised to T_j = 120 °C.

DIODE CHARACTERISTICS

Forward voltage				
I_F = 10 A; T_j = 25 °C	V_F	<	2.0	V*
Reverse recovery when switched from				
I_F = 2 A to $V_R \geqslant$ 30 V with $-dI_F/dt$ = 20 A/μs; T_j = 25 °C				
recovered charge	Q_s	<	2.0	μC
recovery time	t_{rr}	<	0.6	μs
Forward recovery when switched to				
I_F = 5 A with t_r = 0.1 μs; T_j = 25 °C				
recovery time	t_{fr}	<	1.0	μs

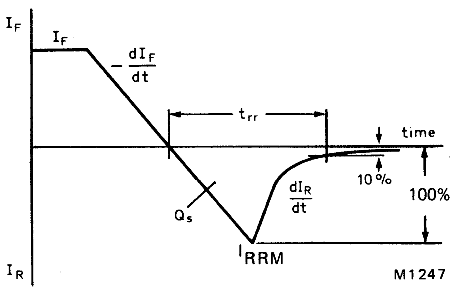


Fig.16 Definition of t_{rr} and Q_s.

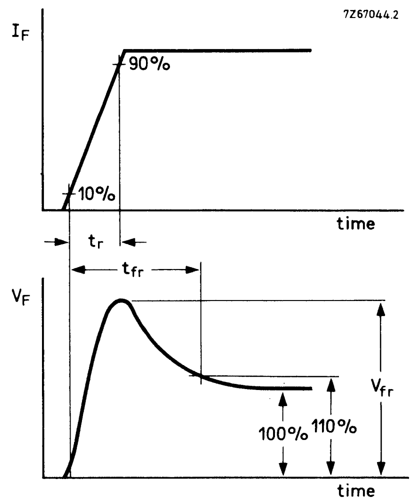


Fig.17 Definition of t_{fr}.

*Measured under pulse conditions to avoid excessive dissipation

DIODE (cont.)

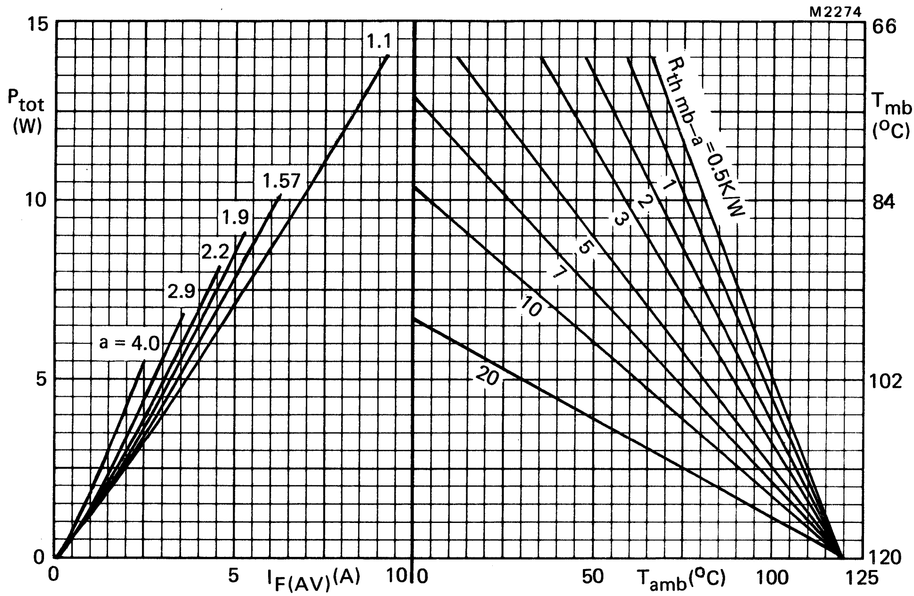


Fig.18 The right hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

$$a = \text{form factor} = \frac{I_{F(RMS)}}{I_{F(AV)}}$$

Values given on the right hand graph assume that the GTO is not dissipating significant power.

DIODE (cont.)

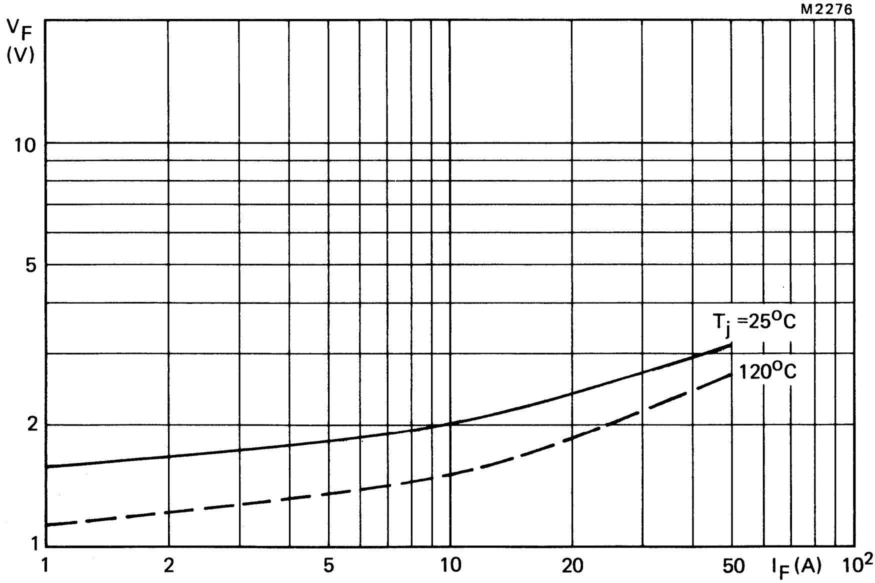


Fig.19 Forward voltage as a function of forward current; maximum values.

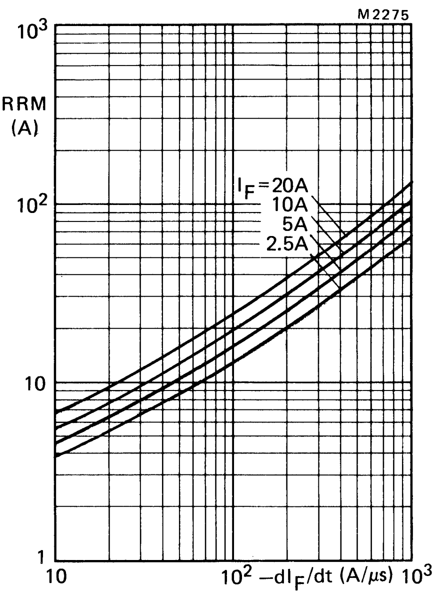


Fig.20 Peak reverse recovery current versus $-dI_F/dt$; T_j = 25 °C; maximum values.

DIODE (cont.)

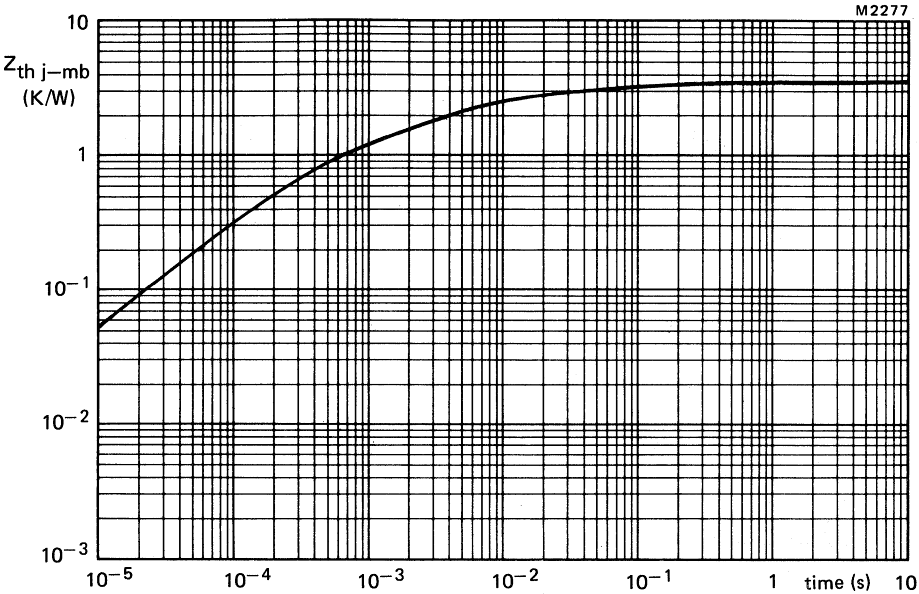


Fig.21 Transient thermal impedance.

FAST GATE TURN–OFF THYRISTORS

Thyristors in TO-238AA envelopes with electrically isolated metal baseplates capable of being turned both on and off via the gate. They are suitable for use in high-frequency inverters, power supplies, motor control etc. The devices have no reverse blocking capability. For reverse blocking operation use with a series diode, for reverse conducting operation use with an anti-parallel diode.

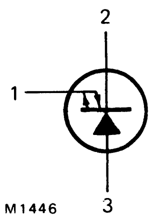
QUICK REFERENCE DATA

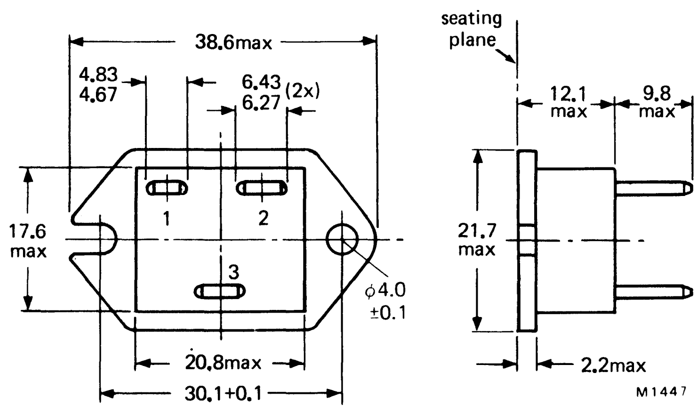
			BTV60–850R	1000R	1200R	
Repetitive peak off-state voltage	V_{DRM}	max.	850	1000	1200	V
Non-repetitive peak on-state current	I_{TSM}	max.		240		A
Controllable anode current	I_{TCRM}	max.		120		A
Average on-state current	$I_{T(AV)}$	max.		25		A
Fall time	t_f	<		300		ns

MECHANICAL DATA

Dimensions in mm

Fig.1 TO-238AA





Pin 1 = gate (AMP 187 series)
2 = cathode (AMP 250 series)
3 = anode (AMP 250 series)
Baseplate is electrically isolated.

RATINGS

Limiting values in accordance with the absolute Maximum System (IEC134)

Anode to cathode

			BTV60–850R	1000R	1200R	
Transient off-state voltage	V_{DSM}	max.	1000	1100	1300	V*
Repetitive peak off-state voltage	V_{DRM}	max.	850	1000	1200	V*
Working off-state voltage	V_{DW}	max.	600	800	1000	V*
Continuous off-state voltage	V_D	max.	500	650	750	V*

Average on-state current (averaged over any 20 ms period) up to T_{mb} = 70 °C	$I_{T(AV)}$	max.	25	A
Controllable anode current	I_{TCRM}	max.	120	A
Non-repetitive peak on-state current t = 10 ms; half-sinewave; T_j = 120 °C prior to surge	I_{TSM}	max.	240	A
I^2t for fusing; t = 10 ms	I^2t	max.	290	A^2s
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	120	W
Maximum rate of rise of anode current at turn-on, $V_D = V_{Dmax}$; I_{GF} = 2.5 A; I_T = 200 A	dI_T/dt	max.	1000	A/μs

Gate to cathode

Repetitive peak on-state current T_j = 120 °C prior to surge gate-cathode forward; t = 10 ms; half-sinewave	I_{GFM}	max.	35	A
gate-cathode reverse; t = 20 μs	I_{GRM}	max.	50	A
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	10	W

Temperatures

Storage temperature	T_{stg}		−40 to +150	°C
Operating junction temperature	T_j	max.	120	°C

ISOLATION**

R.M.S. isolation voltage	V_{isol}	min.	2500	V

THERMAL RESISTANCE

From mounting base to heatsink, with heatsink compound	$R_{th\ mb\text{-}h}$	=	0.3	K/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	0.8	K/W

*Measured with gate-cathode connected together.
**From baseplate to all terminals strapped together.

CHARACTERISTICS

Anode to cathode

On-state voltage				
I_T = 20 A; I_G = 0.5 A; T_j = 120 °C	V_T	<	2.2	V*
Rate of rise of off-state voltage that will not trigger any off-state device; exponential method				
V_D = 2/3 V_{Dmax}; V_{GR} = 5 V; T_j = 120 °C	dV_D/dt	<	10	kV/μs
Rate of rise of off-state voltage that will not trigger any device following conduction, linear method				
I_T = 60 A; V_D = V_{DRMmax}; V_{GR} = 10 V; T_j = 120 °C	dV_D/dt	<	1.0	kV/μs
Off-state current				
V_D = V_{Dmax}; T_j = 120 °C	I_D	<	5.0	mA
Latching current; T_j = 25 °C	I_L	typ.	5.0	A**

Gate to cathode

Voltage that will trigger all devices				
V_D = 12 V; T_j = 25 °C	V_{GT}	>	1.5	V
Current that will trigger all devices				
V_D = 12 V; T_j = 25 °C	I_{GT}	>	500	mA
Minimum reverse breakdown voltage				
I_{GR} = 1.0 mA	$V_{(BR)GR}$	>	10	V

Switching characteristics (resistive load)

Turn-on when switched to I_T = 50 A from V_D = 250 V with I_{GF} = 2.5 A; T_j = 25 °C				
delay time	t_d	<	0.5	μs
rise time	t_r	<	2.0	μs

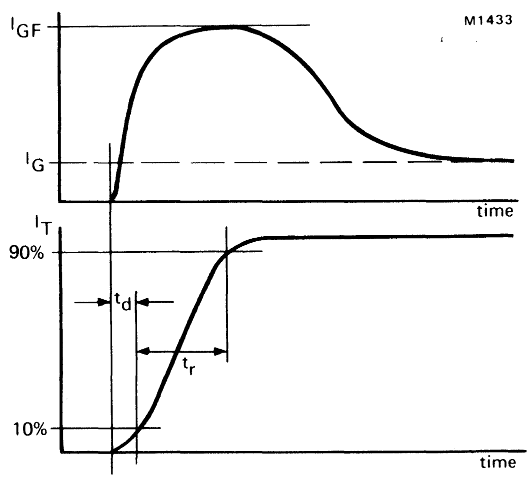


Fig.2 Waveforms.

*Measured under pulse conditions to avoid excessive dissipation.
**Below latching level the device behaves like a transistor with a gain dependent on current.

Switching characteristics (inductive load)

Turn-off when switched from I_T = 50 A to V_D = V_{Dmax};
V_{GR} = 10 V; $L_G \leqslant$ 0.5 μH; $L_S \leqslant$ 0.25 μH; T_j = 25 °C

storage time	t_s	<	1.0	μs
fall time	t_f	<	0.3	μs
peak reverse gate current	I_{GR}	<	25	A

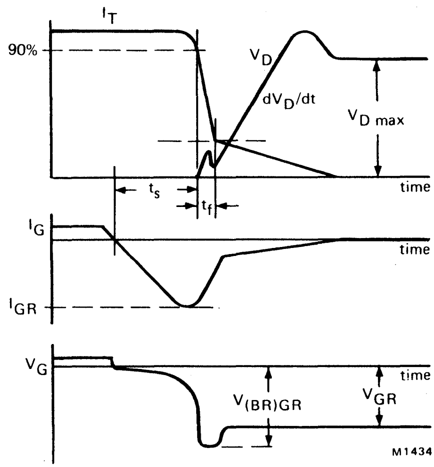


Fig.3 Waveforms.

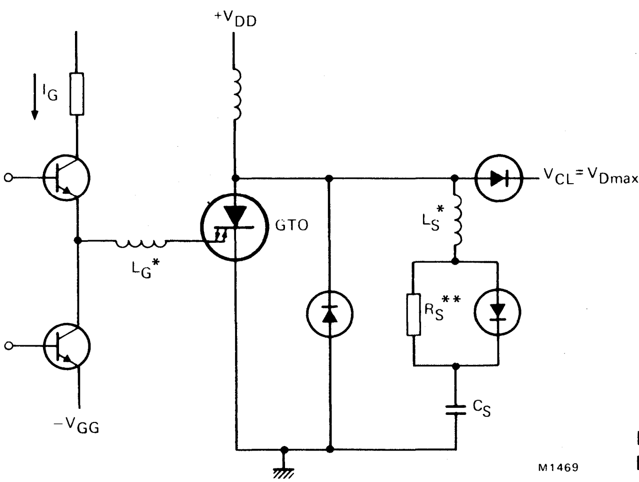


Fig.4 Inductive load test circuit.

*Indicates stray series inductance only.
**Minimum permissible GTO on-time (μs) = R_S (Ω) x C_S (μF) x 5.

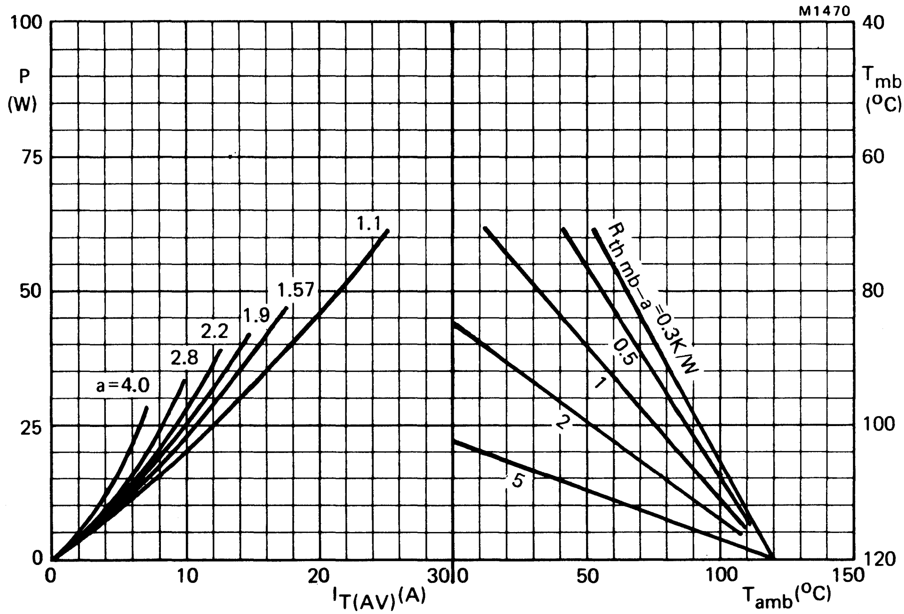


Fig.5 The right hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

$$a = \text{form factor} = \frac{I_{T(RMS)}}{I_{T(AV)}}$$

P = power excluding switching losses.

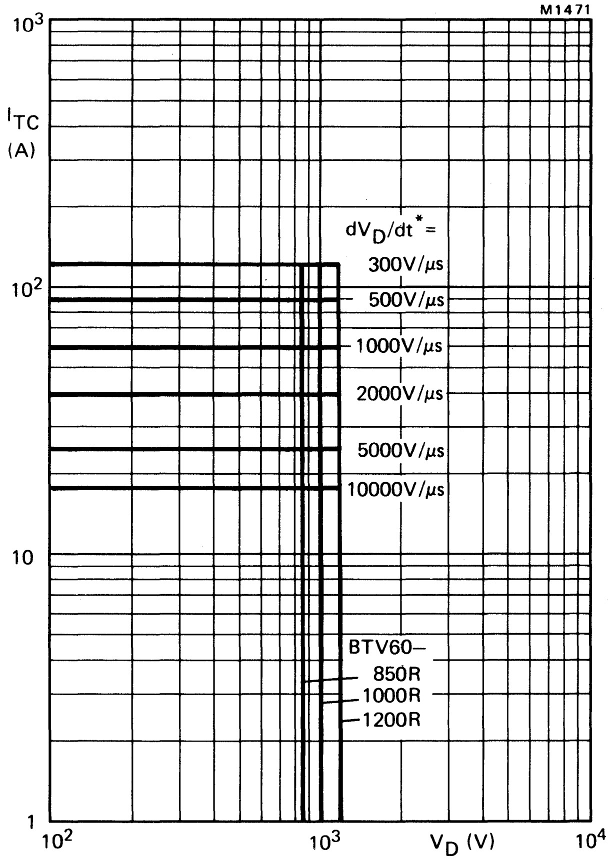


Fig.6 Anode current which can be turned off versus anode voltage; inductive load; V_{GR} = 10 V; $L_G \leqslant 0.5\ \mu H$; $L_S \leqslant 0.25\ \mu H$; T_j = 120 °C.
*dV_D/dt is calculated from I_T/C_S.

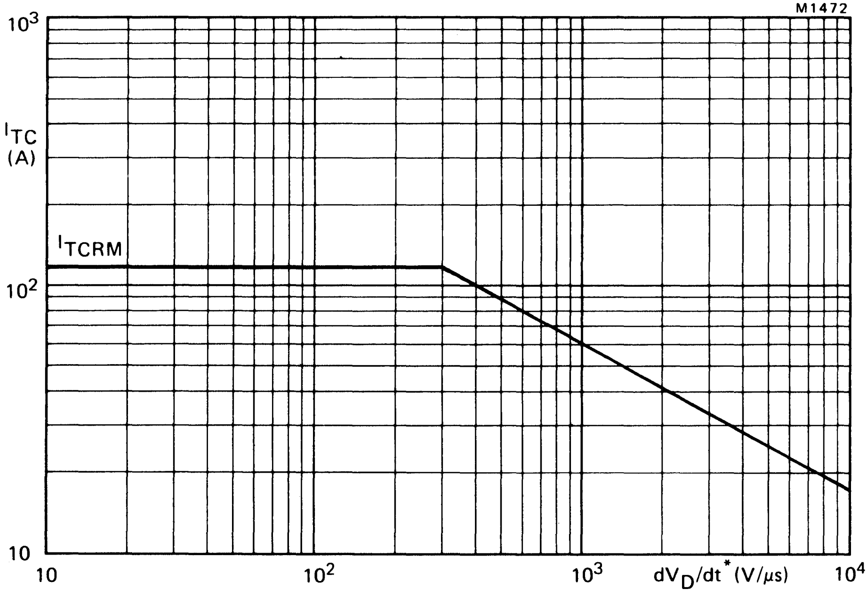


Fig.7 Anode current which can be turned off versus applied dV_D/dt^*; inductive load; V_{GR} = 10 V; $L_G \leqslant 0.5\ \mu H$; $L_S \leqslant 0.25\ \mu H$; T_j = 120 °C. $^*dV_D/dt$ is calculated from I_T/C_S.

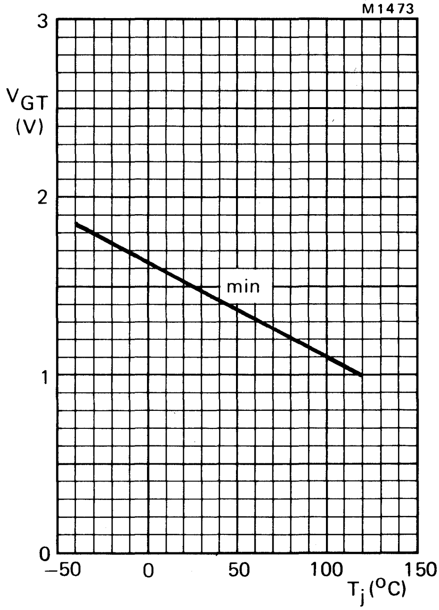


Fig.8 Minimum gate voltage that will trigger all devices as a function of junction temperature; V_D = 12 V.

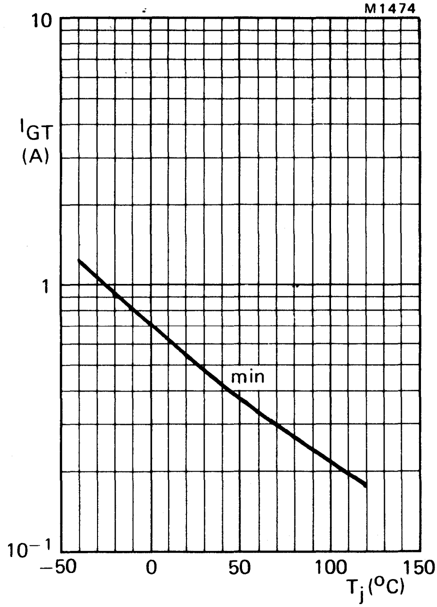


Fig.9 Minimum gate current that will trigger all devices as a function of junction temperature; V_D = 12 V.

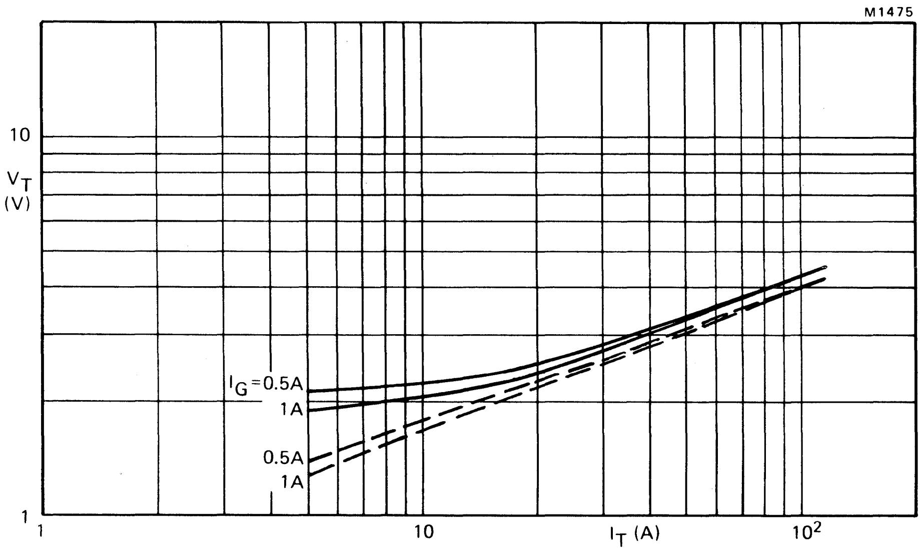


Fig.10 Maximum V_T versus I_T; —— T_j = 25 °C; – – – – T_j = 120 °C.

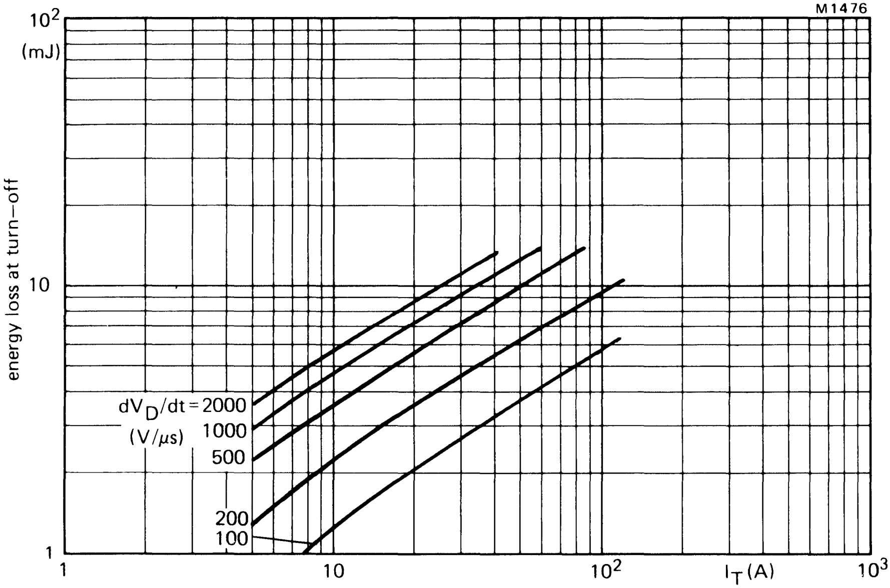


Fig.11 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied dV_D/dt (calculated from I_T/C_S); dV_D/dt linear up to V_{Dmax} = 600 V; V_{GR} = 10 V; I_G = 0.5 A; $L_G \leqslant 0.5\ \mu H$; $L_S \leqslant 0.25\ \mu H$; T_j = 120 °C.

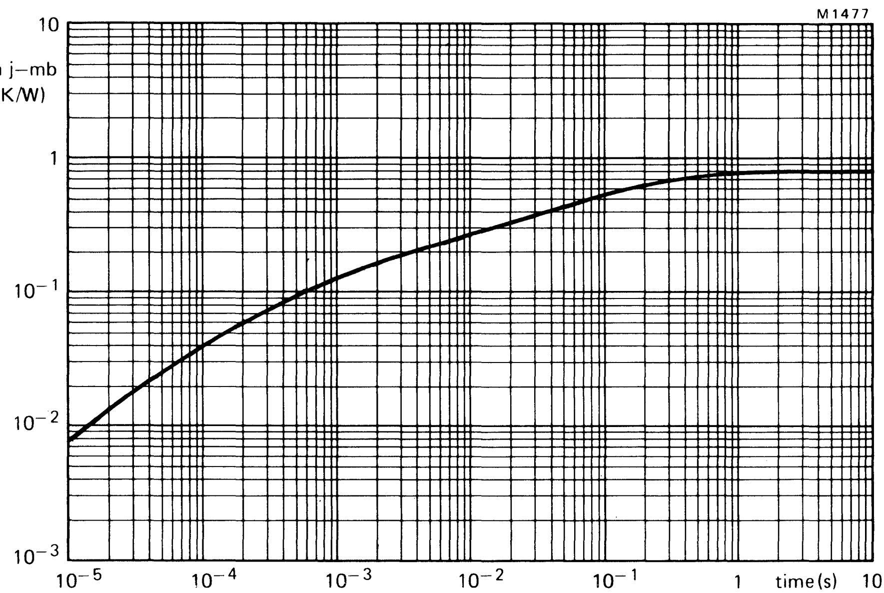


Fig.12 Transient thermal impedance.

FAST GATE TURN-OFF THYRISTORS WITH ANTI-PARALLEL DIODE

Fast gate turn-off thyristors with anti-parallel connected fast soft-recovery diodes in TO-238AA. They are suitable for use in high-frequency inverters, power supplies and motor control systems requiring a parallel-connected flywheel or efficiency diode. The baseplate is electrically isolated.

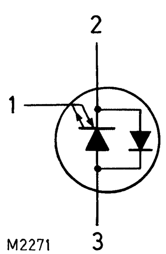
QUICK REFERENCE DATA

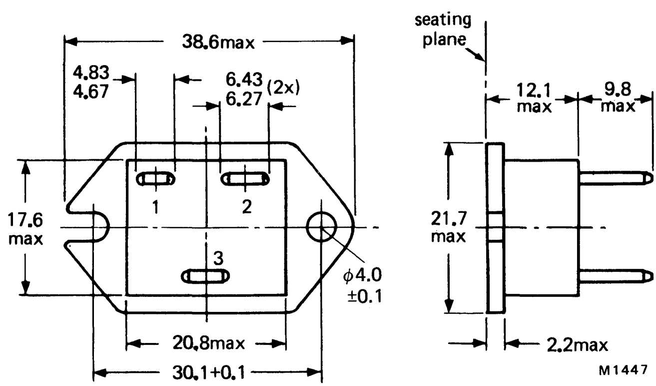
GTO		BTV60D-850R		1000R	1200R	
Repetitive peak off-state voltage	V_{DRM}	max.	850	1000	1200	V
Non-repetitive peak on-state current	I_{TSM}	max.		240		A
Controllable anode current	I_{TCRM}	max.		120		A
Average on-state current	$I_{T(AV)}$	max.		25		A
Fall time	t_f	<		300		ns
Diode						
Average forward current	$I_{F(AV)}$	max.		14		A
Non-repetitive peak forward current	I_{FSM}	max.		100		A
Reverse recovery time	t_{rr}	<		600		ns

MECHANICAL DATA

Dimensions in mm

Fig.1 TO-238AA





Pin 1 = gate (AMP 187) series
2 = k(GTO) a(Diode); (AMP 250 series)
3 = a(GTO) k(Diode); (AMP 250 series)
Baseplate is electrically isolated.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134)

			BTV60D–850R	1000R	1200R	
Anode to cathode						
Transient off-state voltage	V_{DSM}	max.	1000	1100	1300	V*
Repetitive peak off-state voltage	V_{DRM}	max.	850	1000	1200	V*
Working off-state voltage	V_{DW}	max.	600	800	1000	V*
Continuous off-state voltage	V_D	max.	500	650	750	V*
Average on-state current (averaged over any 20 ms period) up to T_{mb} = 70 °C	$I_{T(AV)}$	max.		25		A
Controllable anode current	I_{TCRM}	max.		120		A
Non-repetitive peak on-state current t = 10 ms; half-sinewave; T_j = 120 °C prior to surge	I_{TSM}	max.		240		A
I^2t for fusing; t = 10 ms	I^2t	max.		290		A^2s
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		120		W
Maximum rate of rise of anode current at turn-on, $V_D = V_{Dmax}$; I_{GF} = 2.5 A; I_T = 200 A	dI_T/dt	max.		1000		A/µs
Gate to cathode						
Repetitive peak on-state current gate-cathode forward; t = 1 ms;	I_{GFM}	max.		35		A
gate-cathode reverse; t = 20 µs	I_{GRM}	max.		50		A
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.		10		W
Diode						
Average forward current (averaged over any 20 ms period) up to T_{mb} = 70 °C	$I_{F(AV)}$	max.		14		A
Non-repetitive peak forward current t = 10 ms, half-sinewave T_j = 120 °C prior to surge	I_{FSM}	max.		100		A
Temperatures						
Storage temperature	T_{stg}			−40 to +125		°C
Operating junction temperature	T_j	max.		120		°C
ISOLATION**						
R.M.S. isolation voltage	V_{isol}	min.		2500		V

*Measured with gate-cathode connected together.
**From baseplate to all terminals strapped together.

THERMAL RESISTANCE

GTO

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	0.8	K/W
From mounting base to heatsink with heatsink compound	$R_{th\ mb\text{-}h}$	=	0.2	K/W

Diode

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1.4	K/W
From mounting base to heatsink with heatsink compound	$R_{th\ mb\text{-}h}$	=	0.2	K/W

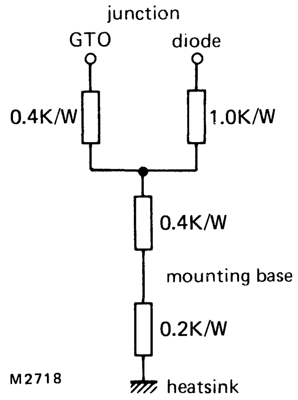


Fig.2 Equivalent thermal network.

GTO CHARACTERISTICS

Anode to cathode

On-state voltage				
I_T = 20 A; I_G = 0.5 A; T_j = 120 °C	V_T	<	2.2	V*
Rate of rise of off-state voltage that will not trigger any off-state device; exponential method				
V_D = 2/3 V_{Dmax}; V_{GR} = 5 V; T_j = 120 °C	dV_D/dt	<	10	kV/µs
Rate of rise of off-state voltage that will not trigger any device following conduction, linear method				
I_T = 60 A; V_D = V_{DRMmax}; V_{GR} = 10 V; T_j = 120 °C	dV_D/dt	<	1.0	kV/µs
Off-state current				
V_D = V_{Dmax}; T_j = 120 °C	I_D	<	5.0	mA
Latching current; T_j = 25 °C	I_L	typ.	5.0	A**

Gate to cathode

Voltage that will trigger all devices				
V_D = 12 V; T_j = 25 °C	V_{GT}	>	1.5	V
Current that will trigger all devices				
V_D = 12 V; T_j = 25 °C	I_{GT}	>	500	mA
Minimum reverse breakdown voltage				
I_{GR} = 1.0 mA	$V_{(BR)GR}$	>	10	V

Switching characteristics (resistive load)

Turn-on when switched to I_T = 50 A from V_D > 250 V with I_{GF} = 2.5 A; T_j = 25 °C				
delay time	t_d	<	0.5	µs
rise time	t_r	<	2.0	µs

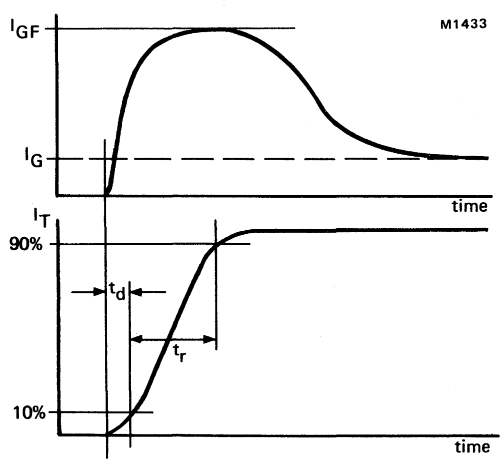


Fig.3 Waveforms.

*Measured under pulse conditions to avoid excessive dissipation.
**Below latching level the device behaves like a transistor with a gain dependent on current.

GTO(cont.)

Switching characteristics (inductive load)

Turn-off when switched from I_T = 50A to $V_D = V_{Dmax}$;

V_{GR} = 10 V; $L_G \leqslant 0.4\mu H$; $L_S \leqslant 0.25\ \mu H$, $C_S \geqslant 50nF$, $T_j = 25^oC$

storage time	t_s	<	1.0	μs
fall time	t_f	<	0.3	μs
peak reverse gate current	I_{GR}	<	25	A

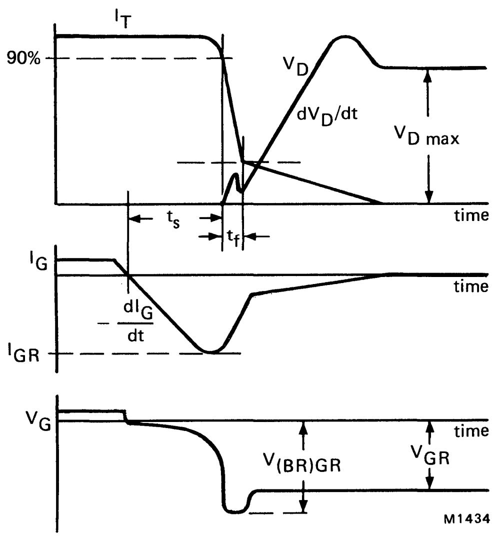


Fig.4 Waveforms.

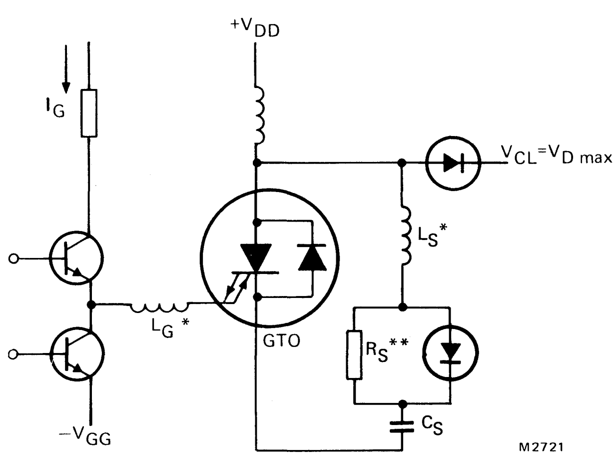


Fig.5 Inductive load test circuit.

* Indicates stray series inductance only.

**Minimum permissible GTO on-time (μs)= $5R_S\ (\Omega) C_S\ (\mu F)$.

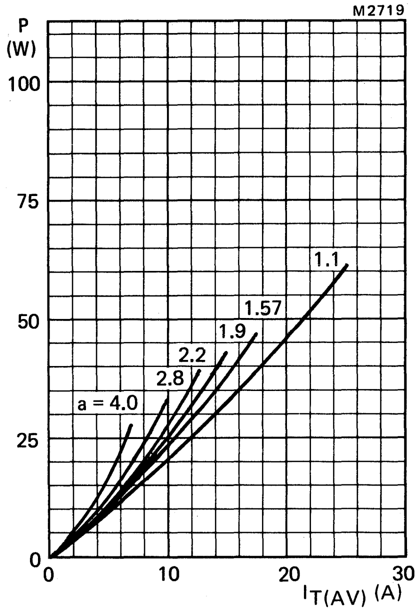


Fig.6 (a,b) Power dissipation as a function of average current (maximum values).

a = form factor = $I_{T(RMS)}/I_{T(AV)}$

P=power excluding switching losses.

Fig.6a GTO

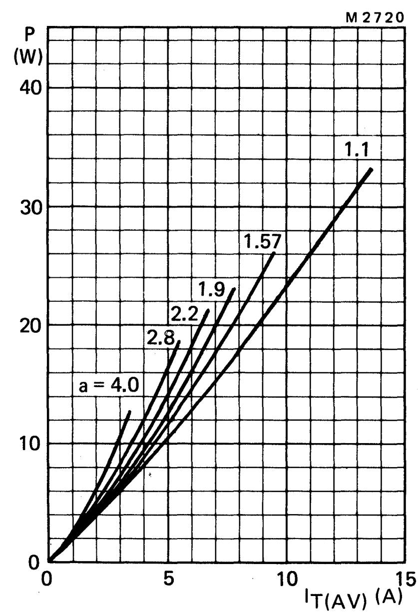


Fig.6b Diode.

GTO

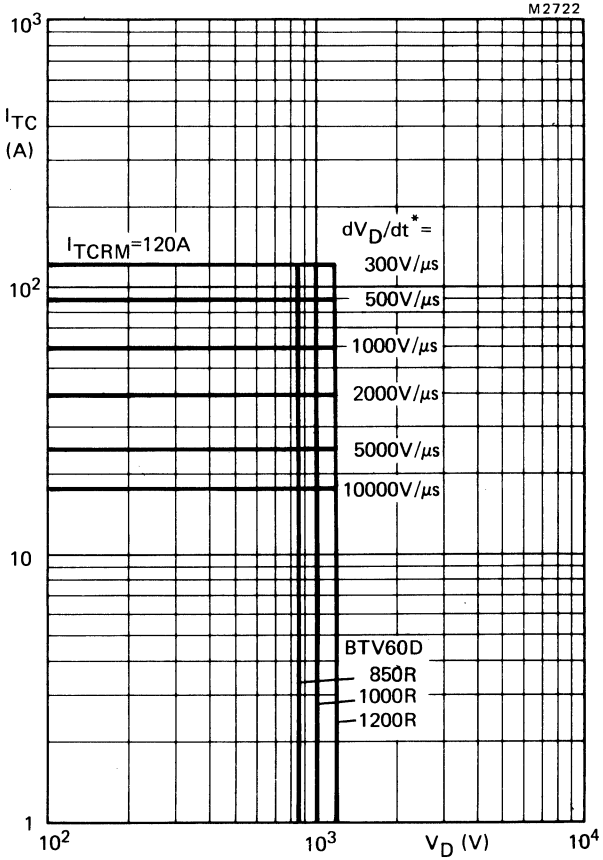


Fig.7 Anode current which can be turned off versus anode voltage; inductive load; V_{GR} = 10 V; $L_G \leqslant 0.5\ \mu H$; $L_S \leqslant 0.25\ \mu H$; T_j = 120°C.
*dV_D/dt is calculated from I_T/C_S.

GTO (cont.)

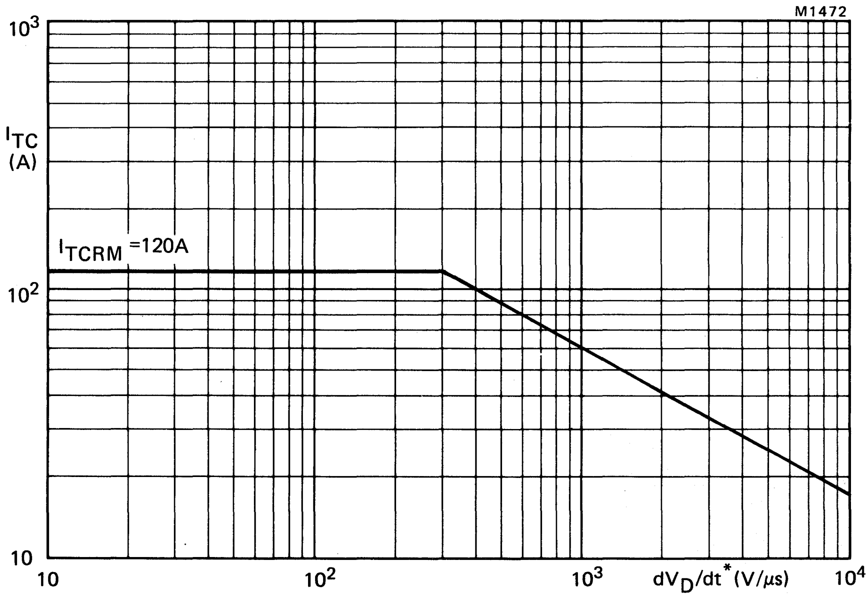


Fig.8 Anode current which can be turned off versus applied dV_D/dt*; inductive load; V_{GR} = 10 V; $L_G \leqslant 0.5\ \mu H$; $L_S \leqslant 0.25\ \mu H$; T_j = 120 °C.
*dV_D/dt is calculated from I_T/C_S.

GTO (cont.)

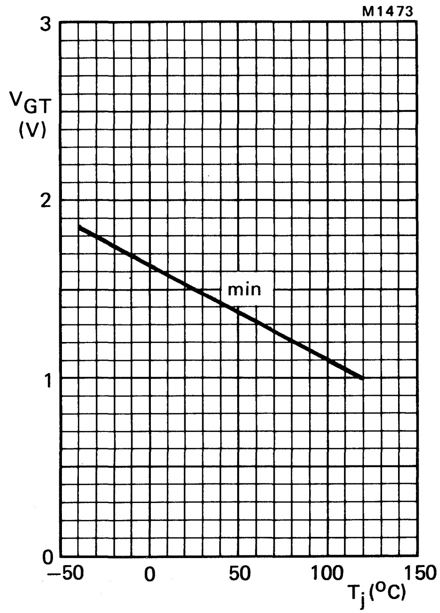


Fig.9 Minimum gate voltage that will trigger all devices as a function of junction temperature; V_D = 12 V.

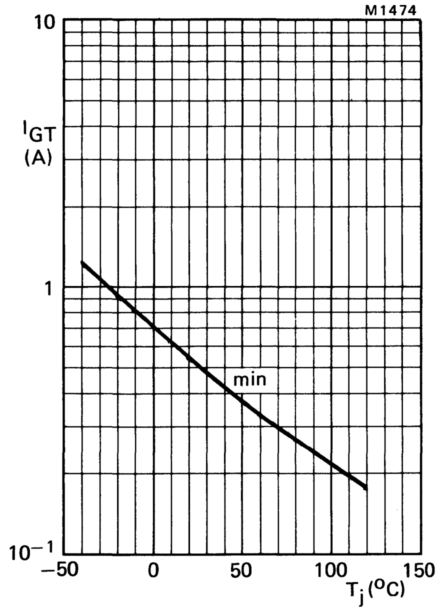


Fig.10 Minimum gate current that will trigger all devices as a function of junction temperature; V_D = 12 V.

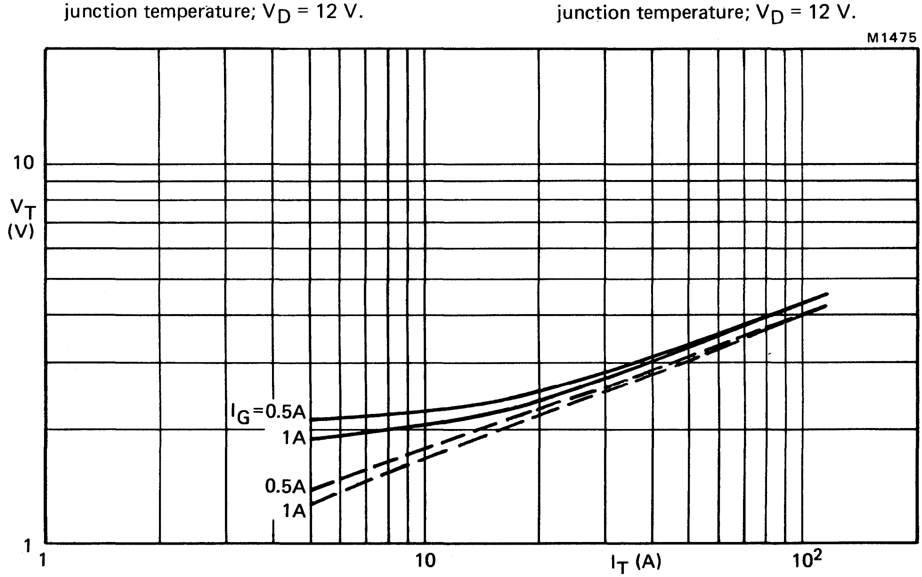


Fig.11 Maximum V_T versus I_T; ——— T_j = 25 °C; – – – – T_j = 120 °C.

GTO (cont.)

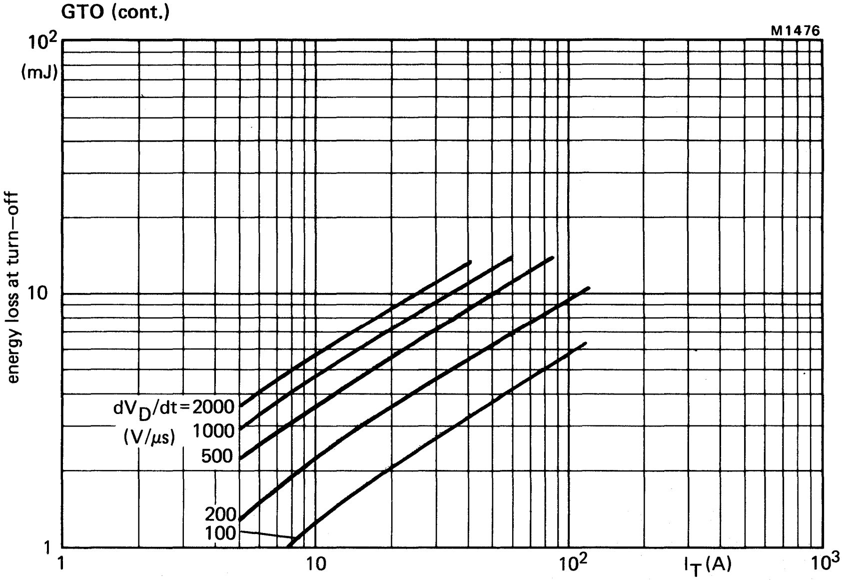


Fig.12 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied dV_D/dt (calculated from I_T/C_S); dV_D/dt linear up to V_{Dmax} = 600 V; V_{GR} = 10 V; I_G = 0.5 A; $L_G \leqslant 0.5\ \mu H$; $L_S \leqslant 0.25\ \mu H$; T_j = 120 °C.

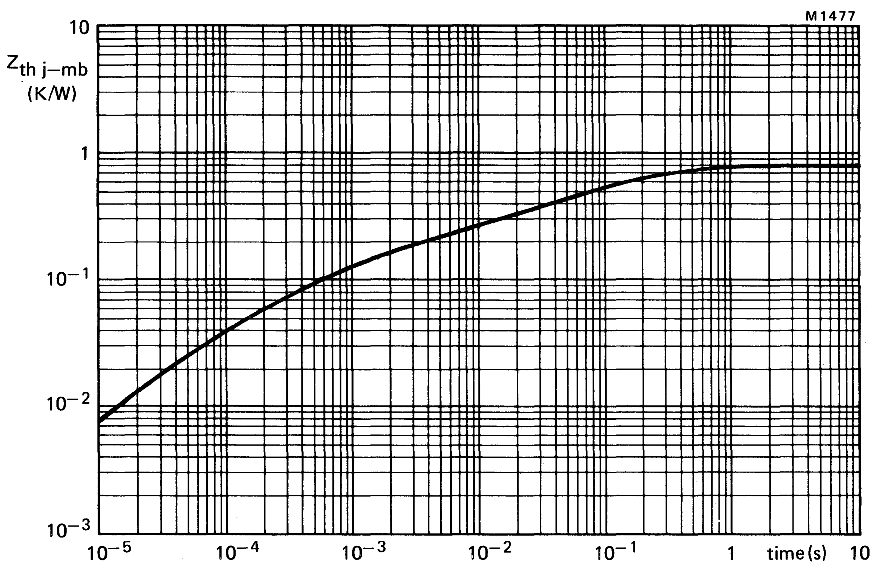


Fig.13 Transient thermal impedance.

DIODE CHARACTERISTICS

Forward voltage				
I_F = 20 A; T_j = 25 °C	V_F	<	2.5	V*
Reverse recovery when switched from				
I_F = 2 A to $V_R \geqslant$ 30 V with $-dI_F/dt$ = 20 A/μs; T_j = 25 °C				
recovered charge	Q_s	<	2.0	μC
recovery time	t_{rr}	<	0.6	μs
Forward recovery when switched to				
I_F = 5 A with t_r = 0.1 μs; T_j = 25 °C				
recovery time	t_{fr}	<	1.0	μs

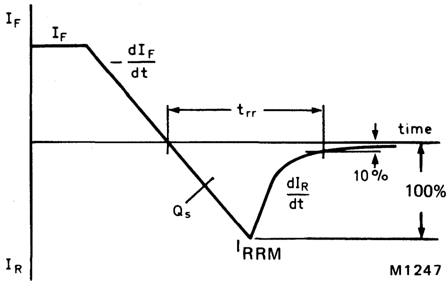


Fig.14 Definition of t_{rr} and Q_s.

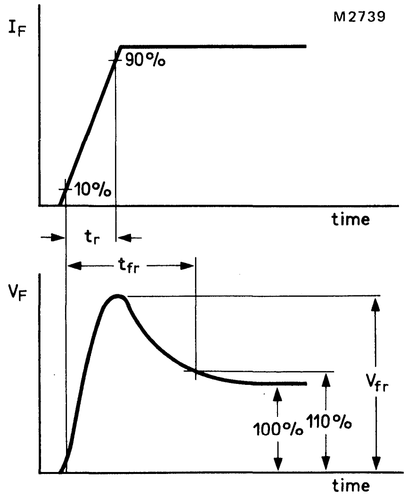


Fig.15 Definition of t_{fr}.

*Measured under pulse conditions to avoid excessive dissipation.

DIODE (cont.)

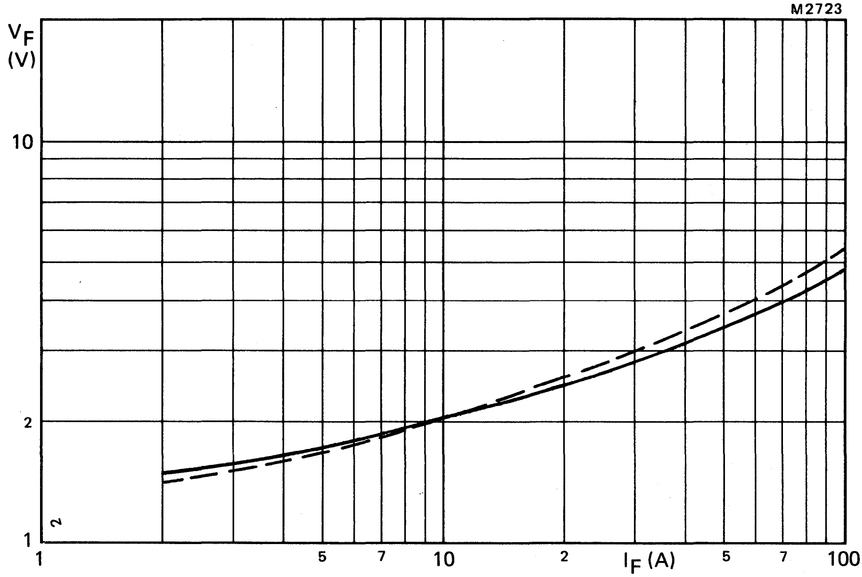


Fig. 16 Forward voltage as a function of forward current; maximum values;
—— T_j = 25 °C; – – – T_j = 120 °C.

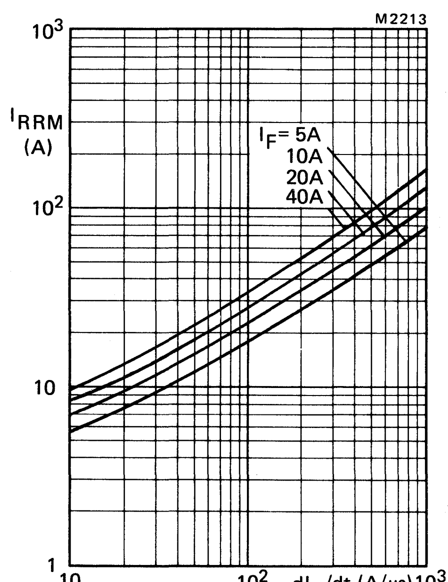


Fig. 17 Peak reverse recovery current versus $-dI_F/dt$; T_j = 25 °C; maximum values.

DIODE (cont.)

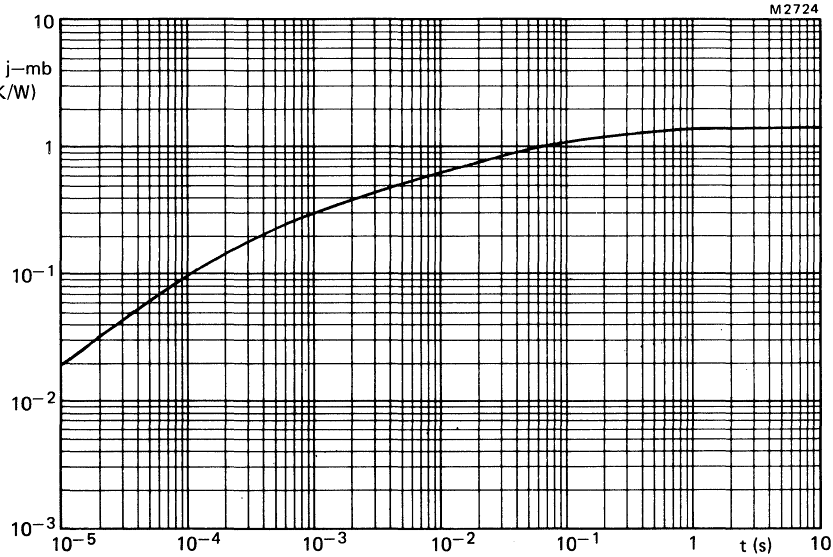


Fig.18 Transient thermal impedance.

FAST GATE TURN-OFF THYRISTORS

Thyristors in TO-238AA envelopes with electrically isolated metal baseplates capable of being turned both on and off via the gate. They are suitable for use in high-frequency inverters, power supplies, motor control etc. The devices have no reverse blocking capability. For reverse blocking operation use with a series diode, for reverse conducting operation use with an anti-parallel diode.

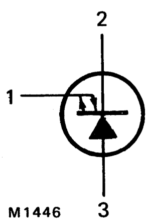
QUICK REFERENCE DATA

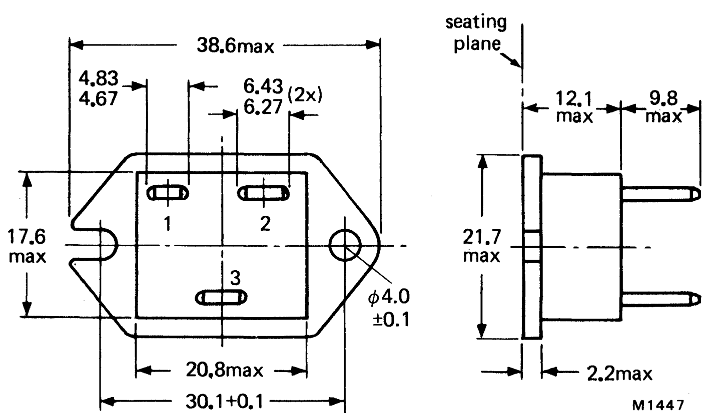
			BTV70-850R	1000R	1200R	
Repetitive peak off-state voltage	V_{DRM}	max.	850	1000	1200	V
Non-repetitive peak on-state current	I_{TSM}	max.		100		A
Controllable anode current	I_{TCRM}	max.		50		A
Average on-state current	$I_{T(AV)}$	max.		15		A
Fall time	t_f	<		250		ns

MECHANICAL DATA

Dimensions in mm

Fig.1 TO-238AA





Pin 1 = gate (AMP 187 series)
2 = cathode (AMP 250 series)
3 = anode (AMP 250 series)
Baseplate is electrically isolated.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134)

Anode to cathode			BTV70-850R	1000R	1200R	
Transient off-state voltage	V_{DSM}	max.	1000	1100	1300	V*
Repetitive peak off-state voltage	V_{DRM}	max.	850	1000	1200	V*
Working off-state voltage	V_{DW}	max.	600	800	1000	V*
Continuous off-state voltage	V_D	max.	500	650	750	V*

Average on-state current (averaged over any 20 ms period) up to T_{mb} = 60 °C	$I_{T(AV)}$	max.	15	A
Controllable anode current	I_{TCRM}	max.	50	A
Non-repetitive peak on-state current t = 10 ms; half-sinewave; T_j = 120 °C prior to surge	I_{TSM}	max.	100	A
I^2t for fusing; t = 10 ms	I^2t	max.	50	A^2s
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	60	W
Gate to cathode				
Repetitive peak current T_j = 120 °C prior to surge gate-cathode forward; t = 10 ms; half-sinewave	I_{GFM}	max.	25	A
gate-cathode reverse; t = 20 µs	I_{GRM}	max.	25	A
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	5.0	W
Temperatures				
Storage temperature	T_{stg}		−40 to +125	°C
Operating junction temperature	T_j	max.	120	°C

ISOLATION**

R.M.S. isolation voltage	V_{isol}	min.	2500	V

THERMAL RESISTANCE

From mounting base to heatsink; with heatsink compound	$R_{th\ mb-h}$	=	0.3	K/W
From junction to mounting base	$R_{th\ j-mb}$	=	1.5	K/W

* Measured with gate-cathode connected together.

** From baseplate to all terminals strapped together.

CHARACTERISTICS

Anode to cathode

On-state voltage $I_T = 10$ A; $I_G = 0.5$ A; $T_j = 120$ °C	V_T	<	2.3	V*
Rate of rise of off-state voltage that will not trigger any off-state device, exponential method $V_D = 2/3\ V_{Dmax}$; $V_{GR} = 5$ V; $T_j = 120$ °C	dV_D/dt	<	10	kV/µs
Rate of rise of off-state voltage that will not trigger any device following conduction, linear method $I_T = 20$ A; $V_D = V_{DRMmax}$; $V_{GR} = 10$ V; T_j 120 °C	dV_D/dt	<	1.0	kV/µs
Off-state current $V_D = V_{Dmax}$; $T_j = 120$ °C	I_D	<	5.0	mA
Latching current; $T_j = 25$ °C	I_L	typ.	1.5	A**

Gate to cathode

Voltage that will trigger all devices $V_D = 12$ V; $T_j = 25$ °C	V_{GT}	>	1.5	V
Current that will trigger all devices $V_D = 12$ V; $T_j = 25$ °C	I_{GT}	>	300	mA
Minimum reverse breakdown voltage $I_{GR} = 1.0$ mA	$V_{(BR)GR}$	>	10	V

Switching characteristics (resistive load)

Turn-on when switched to $I_T = 10$ A from $V_D = 250$ V with $I_{GF} = 1.5$ A; $T_j = 25$ °C				
delay time	t_d	<	0.3	µs
rise time	t_r	<	1.5	µs

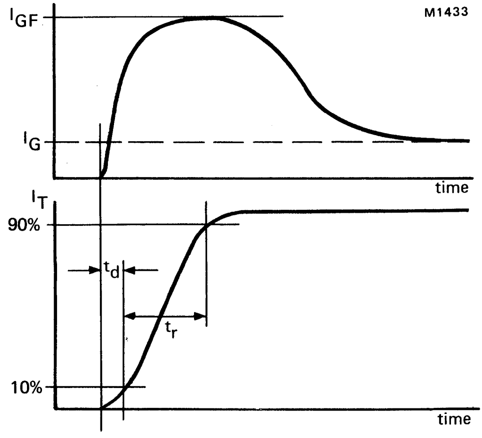


Fig.2 Waveforms.

* Measured under pulse conditions to avoid excessive dissipation.

** Below latching level the device behaves like a transistor with a gain dependent on current.

Switching characteristics (inductive load)

Turn-off when switched from I_T = 10 A to $V_D = V_{Dmax}$;
V_{GR} = 10 V; $L_G \leqslant 0.5\ \mu H$; $L_S \leqslant 0.25\ \mu H$; T_j = 25 °C

storage time	t_s	<	0.60	μs
fall time	t_f	<	0.25	μs
peak reverse gate current	I_{GR}	<	10	A

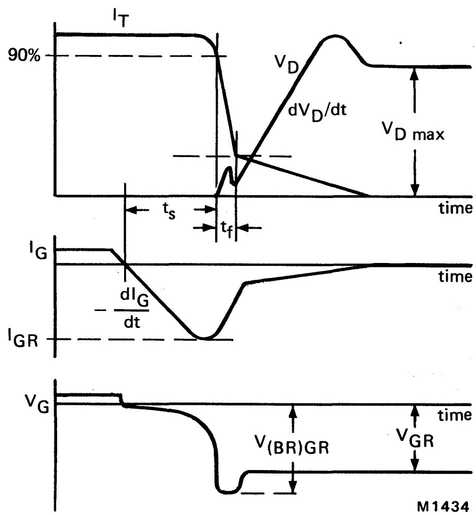


Fig.3 Waveforms.

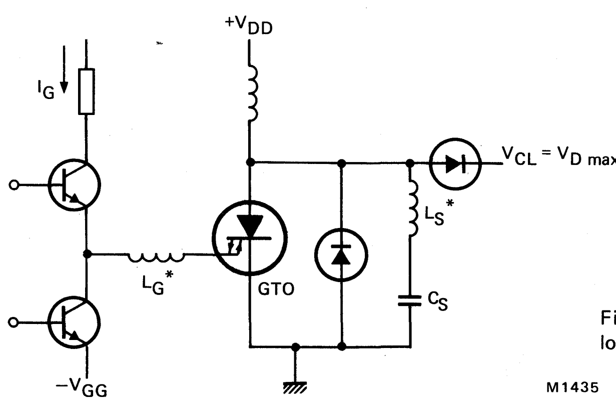


Fig.4 Inductive load test circuit.

* Indicates stray series inductance only

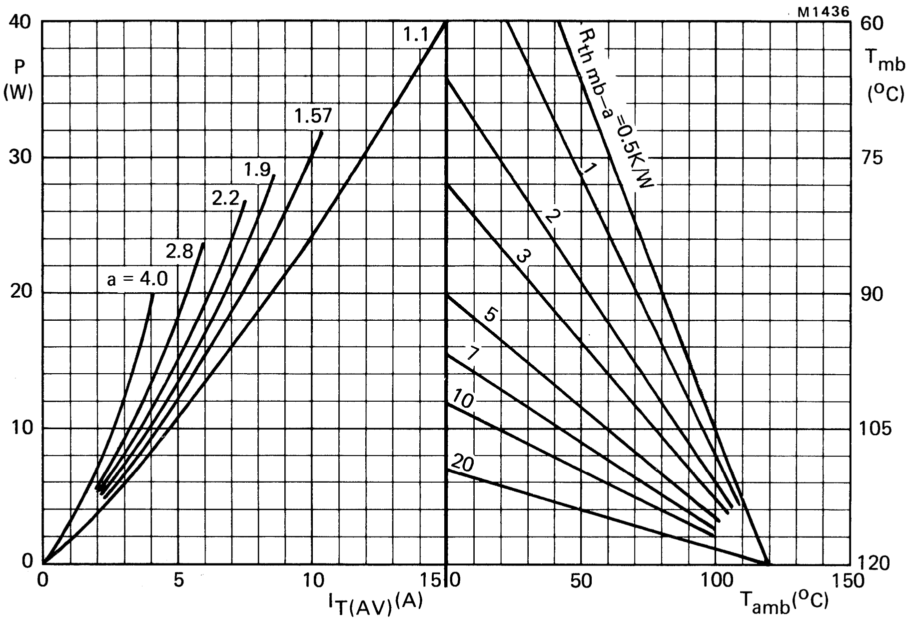


Fig.5 The right hand part shows the interrelationship between the power (derived from the left hand part) and the maximum permissible temperatures.

a = form factor = $\frac{I_{T(RMS)}}{I_{T(AV)}}$

P = power excluding switching losses.

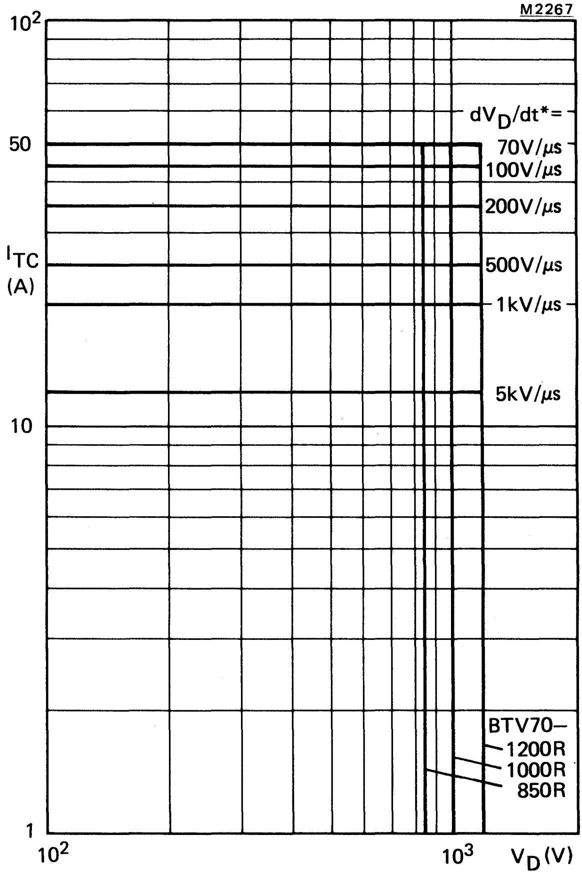


Fig.6 Anode current which can be turned off versus anode voltage; inductive load; V_{GR} = 10 V; $L_G \leqslant 0.5$ μH; $L_S \leqslant 0.25$ μH; T_j = 120 °C.

*dV_D/dt is calculated from I_T/C_S.

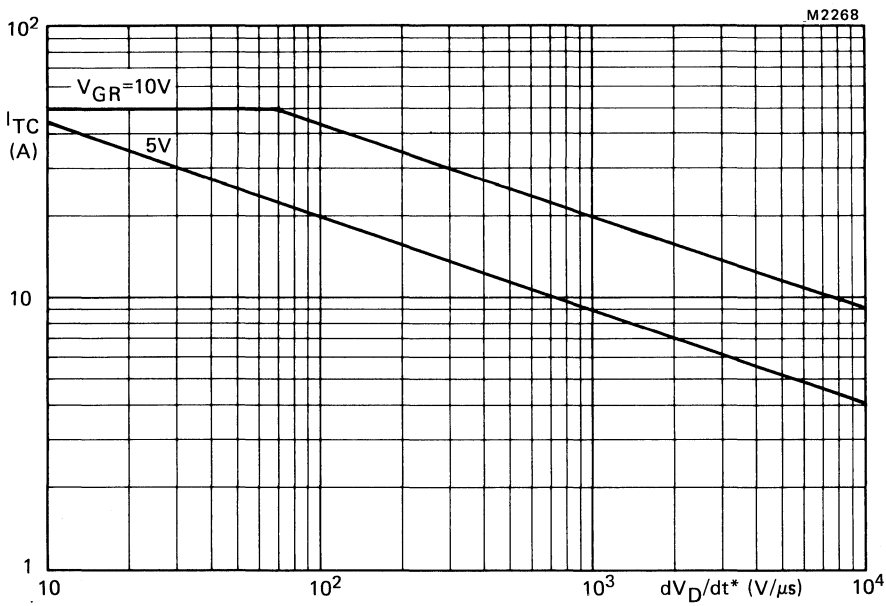


Fig.7 Anode current which can be turned off versus applied dV_D/dt^*; inductive load;
$L_G \leqslant 0.5\ \mu H$, $L_S \leqslant 0.25\ \mu H$, $T_j = 120\ ^oC$;

*dV_D/dt is calculated from I_T/C_S.

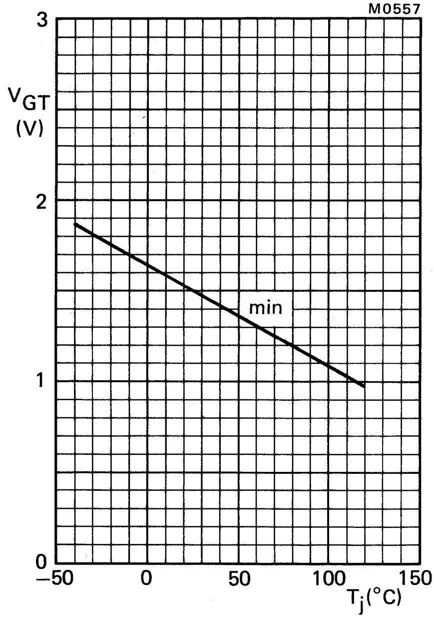


Fig.8 Minimum gate voltage that will trigger all devices as a function of junction temperature; V_D = 12 V.

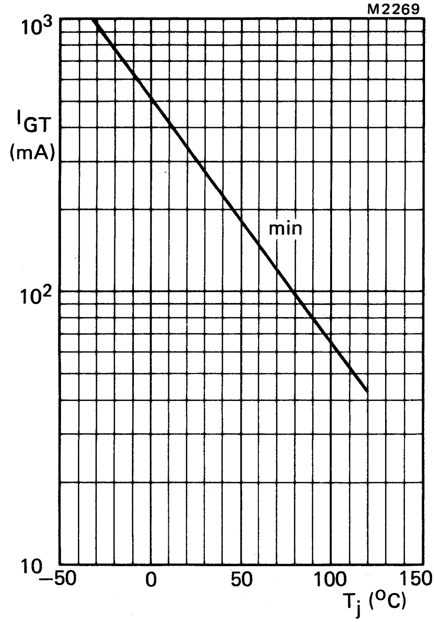


Fig.9 Minimum gate current that will trigger all devices as a function of junction temperature; V_D = 12 V.

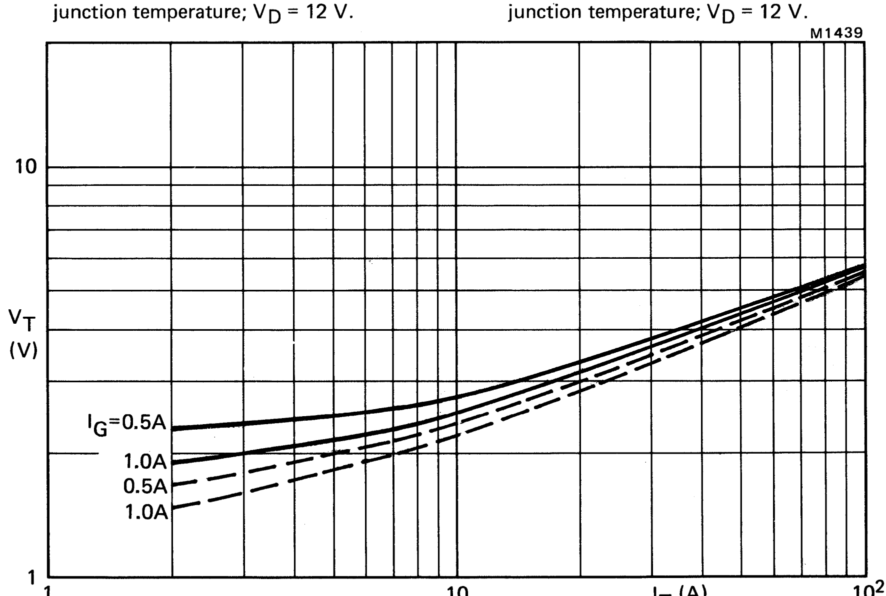


Fig.10 Maximum V_T versus I_T; —— T_j = 25 °C; – – – – T_j = 120 °C.

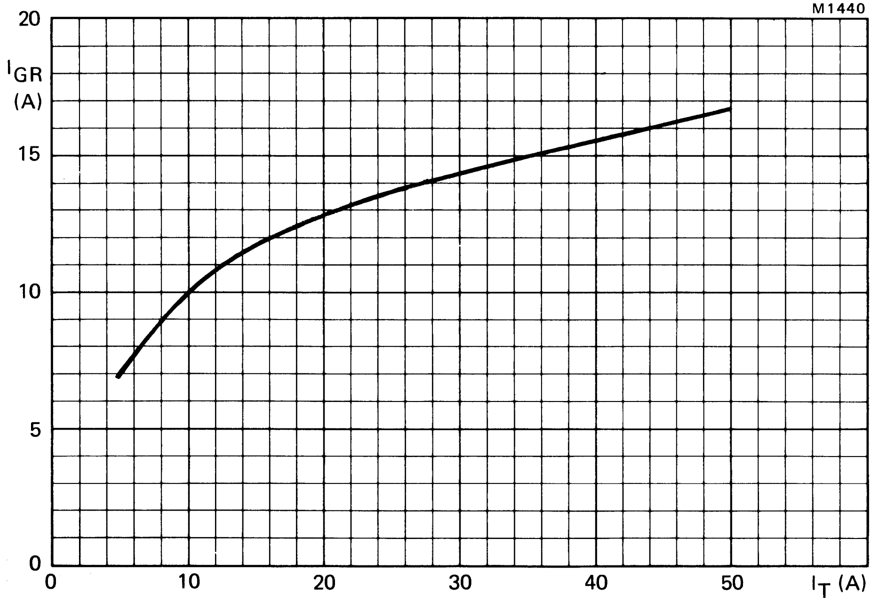


Fig.11 Peak reverse gate current versus anode current at turn-off; inductive load; V_{GR} = 10 V; I_G = 0.5 A; L_G = 0.4 μH; T_j = 120 ^oC; maximum values.

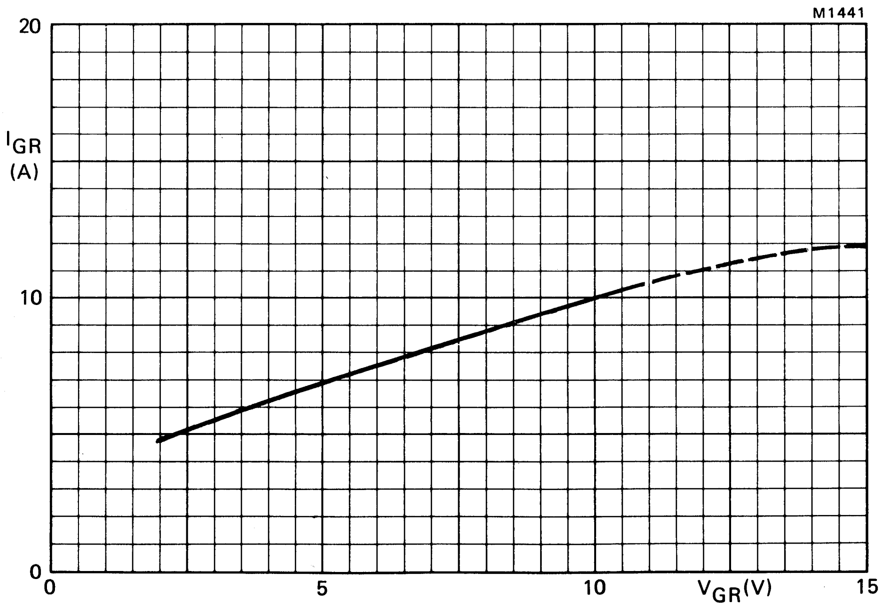


Fig.12 Peak reverse gate current versus applied reverse gate voltage; inductive load; I_T = 10 A; I_G = 0.5 A; L_G = 0.4 μH; T_j = 120 ^oC; maximum values.

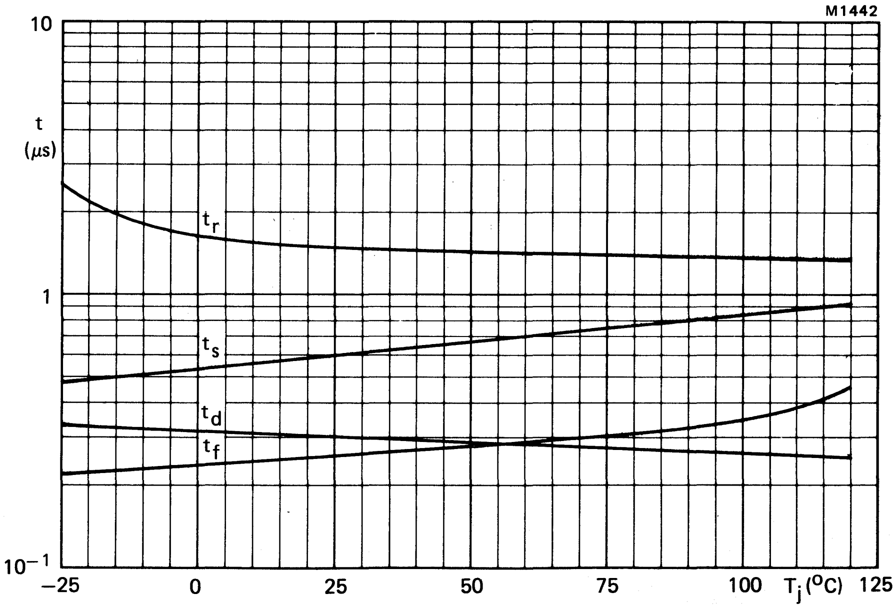


Fig.13 Switching times as a function of junction temperature; $V_D \geqslant 250$ V; $I_T = 10$ A; $I_{GF} = 1.0$ A; $V_{GR} = 10$ V; $I_G = 0.5$ A; $L_G = 0.4$ μH; maximum values.

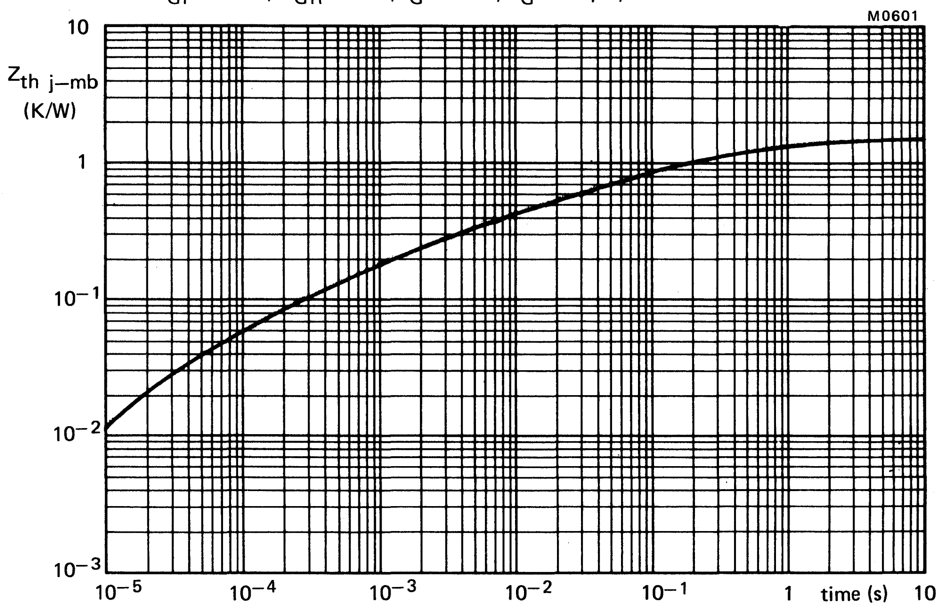


Fig.14 Transient thermal impedance.

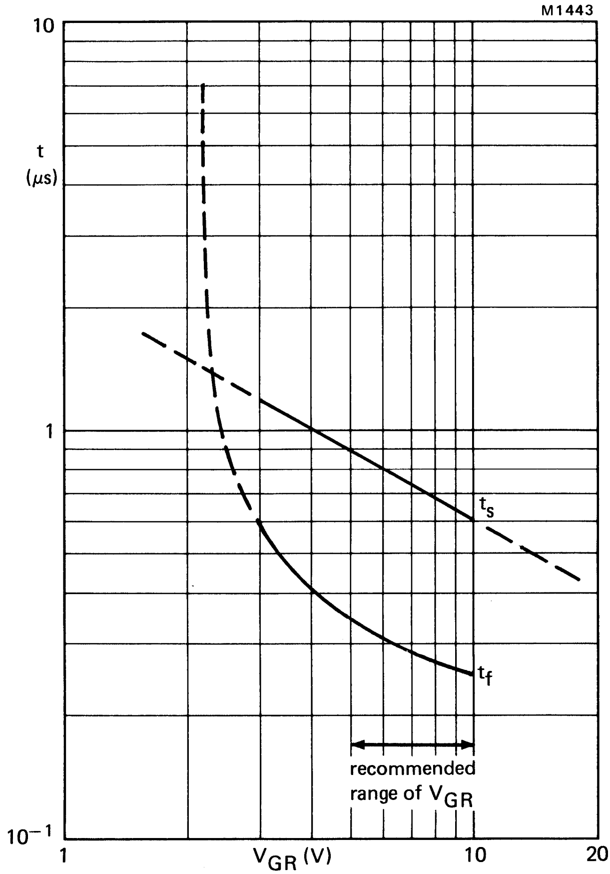


Fig.15 Storage and fall times versus applied reverse gate voltage; inductive load; I_T = 10 A; I_G = 0.5 A; L_G = 0.4 μH; T_j = 25 °C; maximum values.

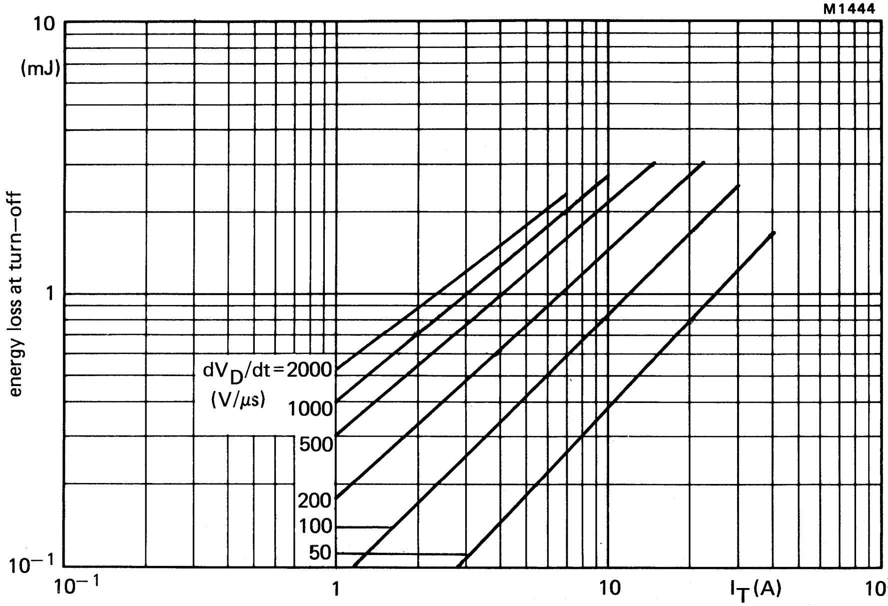


Fig.16 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied dV_D/dt (calculated from I_T/C_S); dV_D/dt linear up to V_{Dmax} = 600 V; V_{GR} = 10 V; I_G = 0.5 A; $L_G \leqslant 0.5$ µH; $L_S \leqslant 0.25$ µH; T_j = 120 °C.

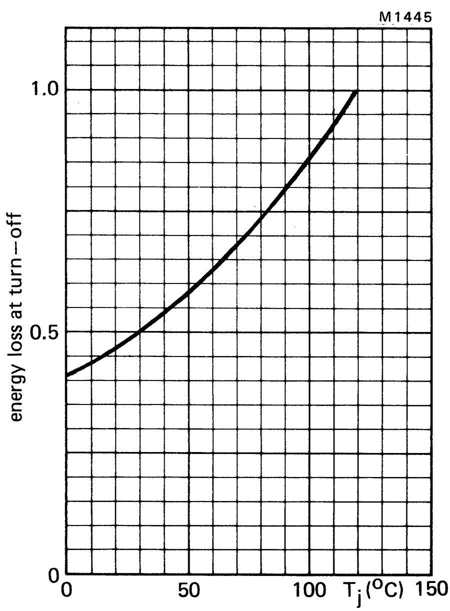


Fig.17 Energy loss at turn-off as a function of junction temperature; I_G = 0.5 A; V_{GR} = 10 V. Normalised to T_j = 120 °C.

FAST GATE TURN-OFF THYRISTORS WITH ANTI-PARALLEL DIODE

Fast gate turn-off thyristors with anti-parallel connected fast soft-recovery diodes in TO-238AA. They are suitable for use in high-frequency inverters, power supplies and motor control systems requiring a parallel connected flywheel or efficiency diode. The baseplate is electrically isolated.

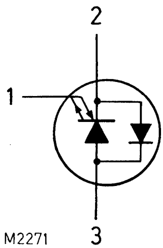
QUICK REFERENCE DATA

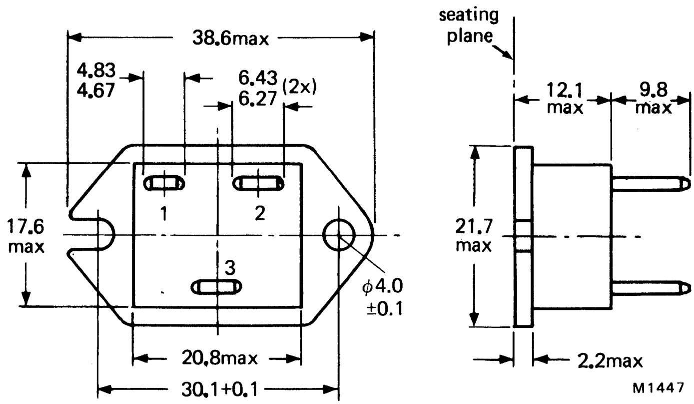
GTO		BTV70D	850R	1000R	1200R	
Repetitive peak off-state voltage	V_{DRM}	max.	850	1000	1200	V
Non-repetitive peak on-state current	I_{TSM}	max.		100		A
Controllable anode current	I_{TCRM}	max.		50		A
Average on-state current	$I_{T(AV)}$	max.		15		A
Fall time	t_f	<		250		ns
Diode						
Average forward current	$I_{F(AV)}$	max.		9.0		A
Non-repetitive peak forward current	I_{FSM}	max.		60		A
Reverse recovery time	t_{rr}	<		600		ns

MECHANICAL DATA

Dimensions in mm

Fig.1 TO-238AA





Pin 1 = gate (AMP 187 series)
2 = k (GTO), a (diode); AMP 250 series
3 = a (GTO), k (diode); AMP 250 series
Baseplate is electrically isolated.

For further information see data sheets BTV70 and BY359.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134)

Anode to cathode		BTV70D	850R	1000R	1200R	
Transient off-state voltage	V_{DSM}	max.	1000	1100	1300	V*
Repetitive peak off-state voltage	V_{DRM}	max.	850	1000	1200	V*
Working off-state voltage	V_{DW}	max.	600	800	1000	V*
Continuous off-state voltage	V_D	max.	500	650	750	V*

Average on-state current (averaged over any 20 ms period) up to T_{mb} = 60 °C	$I_{T(AV)}$	max.	15	A
Controllable anode current	I_{TCRM}	max.	50	A
Non-repetitive peak on-state current t = 10 ms; half-sinewave; T_j = 120 °C prior to surge	I_{TSM}	max.	100	A
I^2t for fusing; t = 10 ms	I^2t	max.	50	A^2s
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	60	W
Gate to cathode				
Repetitive peak on-state current T_j = 120 °C prior to surge gate-cathode forward; t = 10 ms; half-sinewave	I_{GFM}	max.	25	A
gate-cathode reverse; t = 20 µs	I_{GRM}	max.	25	A
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	5.0	W
Diode				
Average forward current (averaged over any 20 ms period) up to T_{mb} = 70 °C	$I_{F(AV)}$	max.	9.0	A
Non-repetitive peak on-state current t = 10 ms; half-sinewave; T_j = 120 °C prior to surge	I_{FSM}	max.	60	A
Temperatures				
Storage temperature	T_{stg}		−40 to +125	°C
Operating junction temperature	T_j	max.	120	°C
ISOLATION**				
R.M.S. isolation voltage	V_{isol}	min.	2500	V

* Measured with gate-cathode connected together.

** From baseplate to all terminals strapped together.

THERMAL RESISTANCE

GTO

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1.5	K/W
From mounting base to heatsink with heatsink compound	$R_{th\ mb\text{-}h}$	=	0.3	K/W

Diode

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	3.6	K/W
From mounting base to heatsink with heatsink compound	$R_{th\ mb\text{-}h}$	=	0.3	K/W

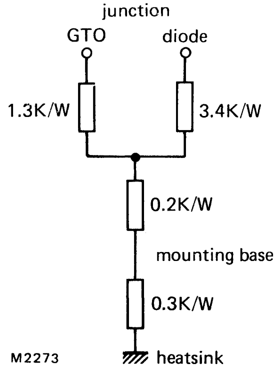


Fig.2 Equivalent thermal network.

GTO CHARACTERISTICS

Anode to cathode

On-state voltage $I_T = 10$ A; $I_G = 0.5$ A; $T_j = 120$ °C	V_T	<	2.3	V*
Rate of rise of off-state voltage that will not trigger any off-state device; exponential method $V_D = 2/3\ V_{Dmax}$; $V_{GR} = 5$ V; $T_j = 120$ °C	dV_D/dt	<	10	kV/μs
Rate of rise of off-state voltage that will not trigger any device following conduction, linear method $I_T = 20$ A; $V_D = V_{DRMmax}$; $V_{GR} = 10$ V; $T_j = 120$ °C	dV_D/dt	<	1.0	kV/μs
Off-state current $V_D = V_{Dmax}$; $T_j = 120$ °C	I_D	<	5.0	mA
Latching current; $T_j = 25$ °C	I_L	typ.	1.5	A**

Gate to cathode

Voltage that will trigger all devices $V_D = 12$ V; $T_j = 25$ °C	V_{GT}	>	1.5	V
Current that will trigger all devices $V_D = 12$ V; $T_j = 25$ °C	I_{GT}	>	300	mA
Minimum reverse breakdown voltage $I_{GR} = 1.0$ mA	$V_{(BR)GR}$	>	10	V

Switching characteristics (resistive load)

Turn-on when switched to $I_T = 10$ A from $V_D = 250$ V with $I_{GF} = 1.5$ A; $T_j = 25$ °C				
delay time	t_d	<	0.3	μs
rise time	t_r	<	1.5	μs

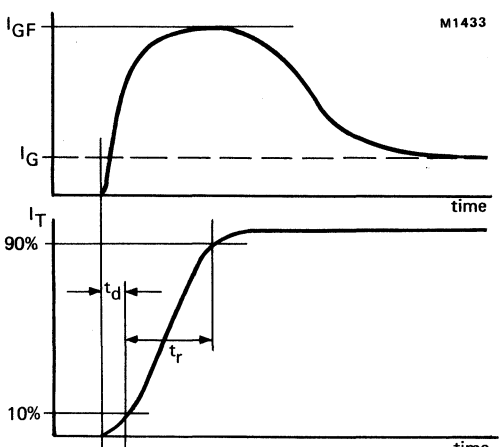


Fig.3 Waveforms.

* Measured under pulse conditions to avoid excessive dissipation.

** Below latching level the device behaves like a transistor with a gain dependent on current.

GTO (cont.)

Switching characteristics (inductive load)

Turn-off when switched from I_T = 10 A to V_D = V_{Dmax};
V_{GR} = 10 V; $L_G \leqslant 0.5\ \mu H$; $L_S \leqslant 0.25\ \mu H$; T_j = 25 °C

storage time	t_s	<	0.60	μs
fall time	t_f	<	0.25	μs
peak reverse gate current	I_{GR}	<	10	A

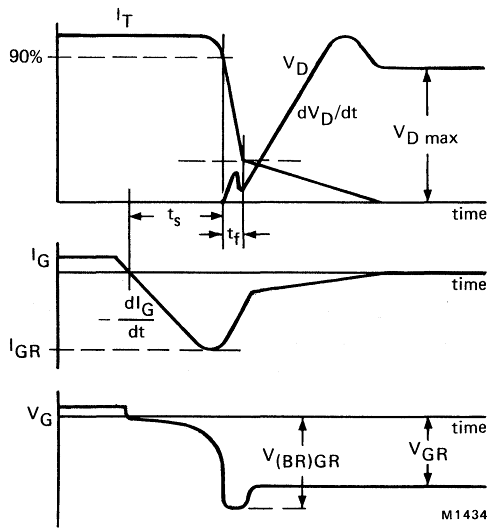


Fig.4 Waveforms.

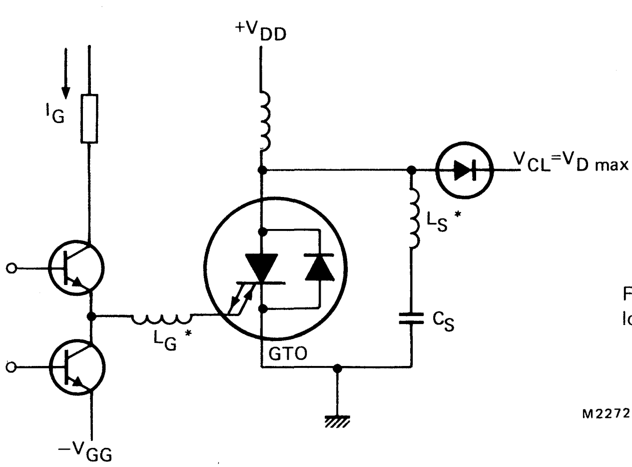


Fig.5 Inductive load test circuit.

*Indicates stray series inductance only

GTO (cont.)

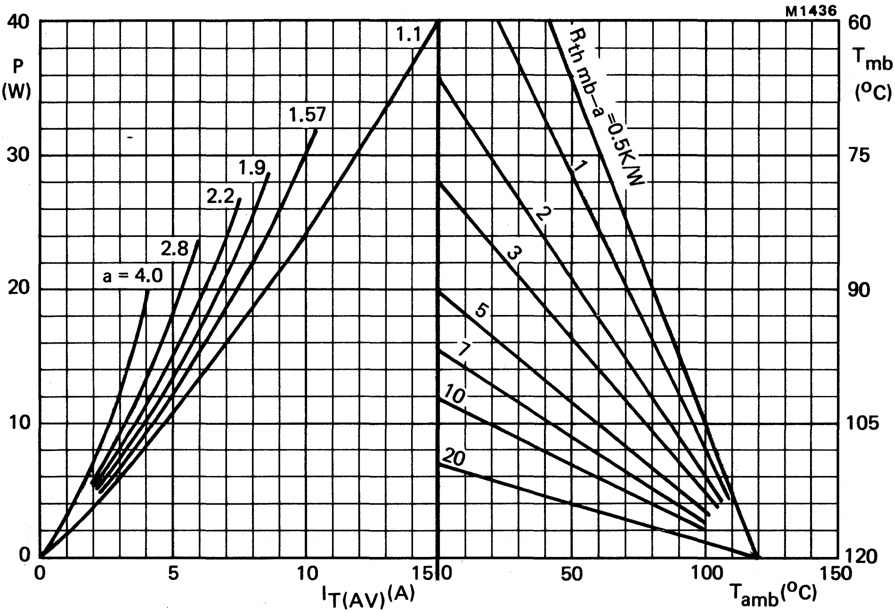


Fig.6 The right hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

$$a = \text{form factor} = \frac{I_{T(RMS)}}{I_{T(AV)}}$$

P = power excluding switching losses.

Values given on the right hand graph assume that the diode is not dissipating significant power.

GTO (cont.)

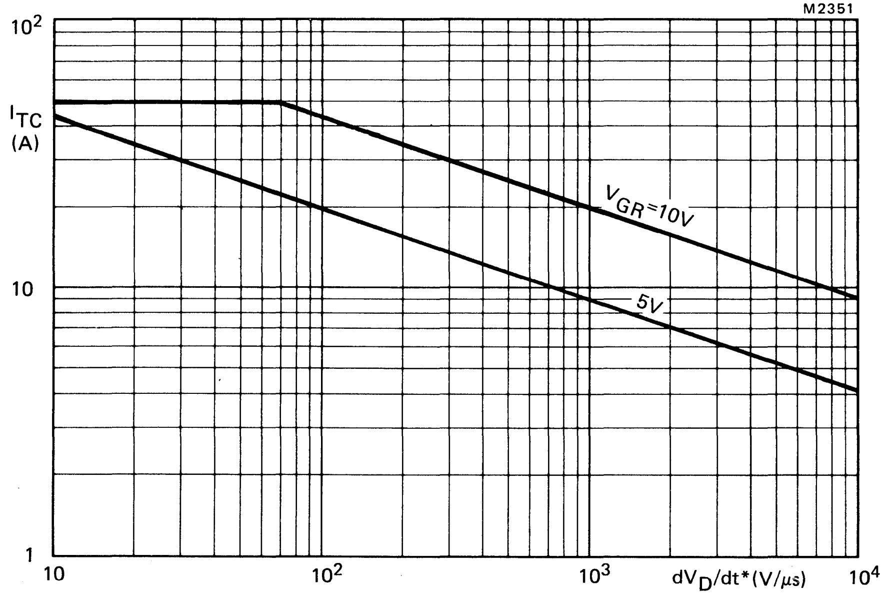


Fig.7 Anode current which can be turned off versus applied dV_D/dt^*; inductive load; $L_G \leqslant 0.5\ \mu H$; $L_S \leqslant 0.25\ \mu H$; $T_j = 120\ ^oC$.

*dV_D/dt is calculated from I_T/C_S.

GTO (cont.)

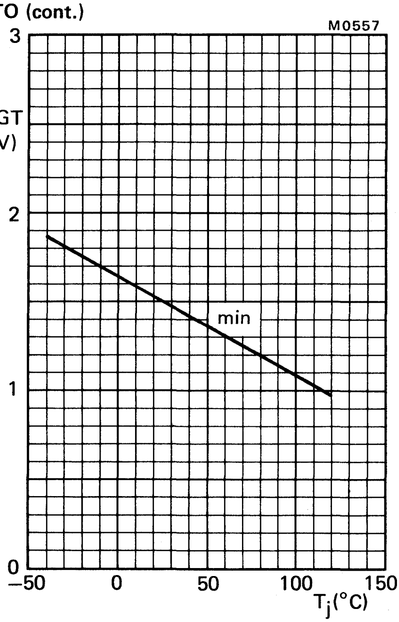


Fig.8 Minimum gate voltage that will trigger all devices as a function of junction temperature; V_D = 12 V.

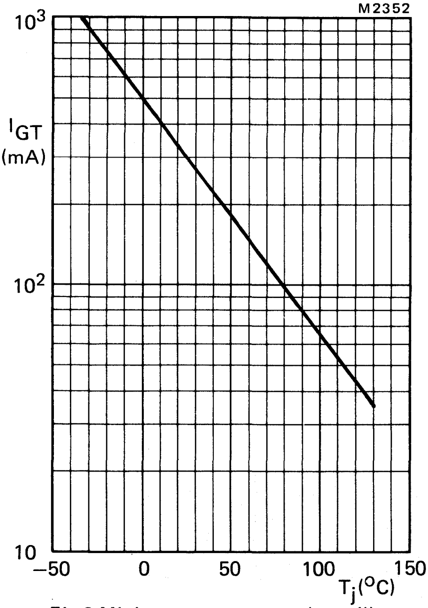


Fig.9 Minimum gate current that will trigger all devices as a function of junction temperature; V_D = 12 V.

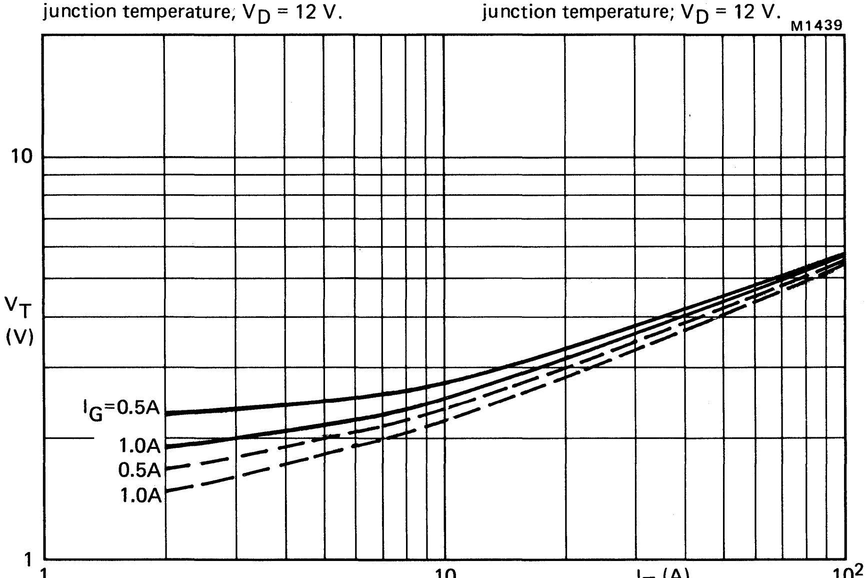


Fig.10 Maximum V_T versus I_T; ——— T_j = 25 °C; – – – – T_j = 120 °C.

GTO (cont.)

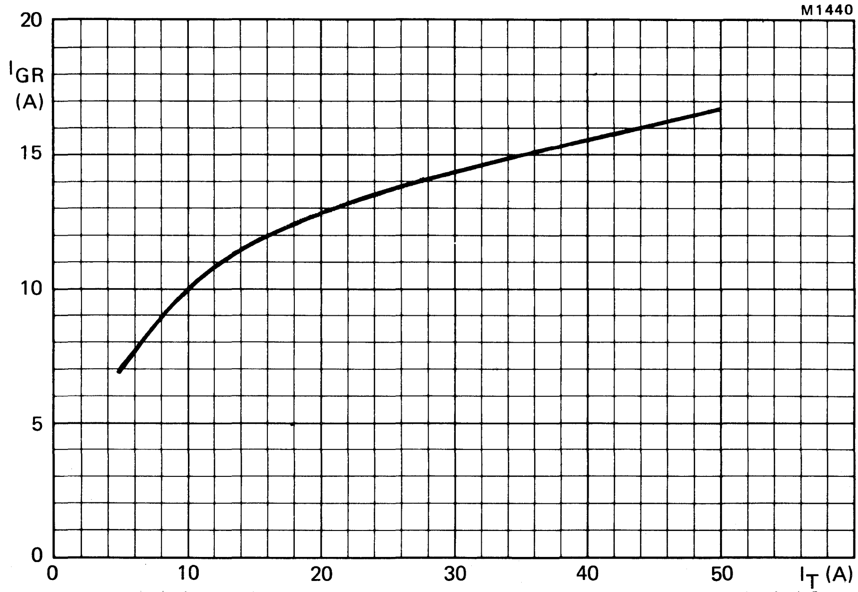


Fig.11 Peak reverse gate current versus anode current at turn-off; inductive load; V_{GR} = 10 V; I_G = 0.5 A; L_G = 0.4 μH; T_j = 120 °C; maximum values.

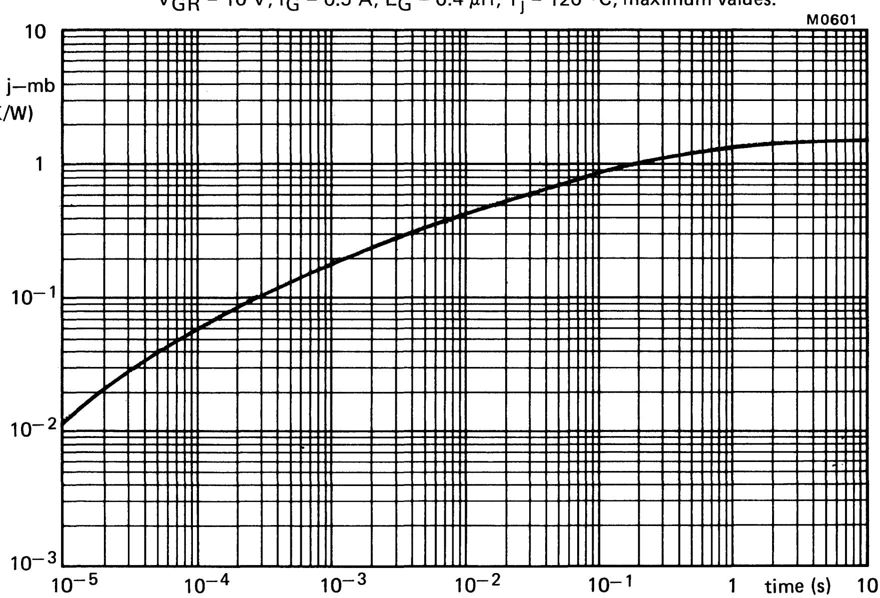


Fig.12 Transient thermal impedance.

GTO (cont.)

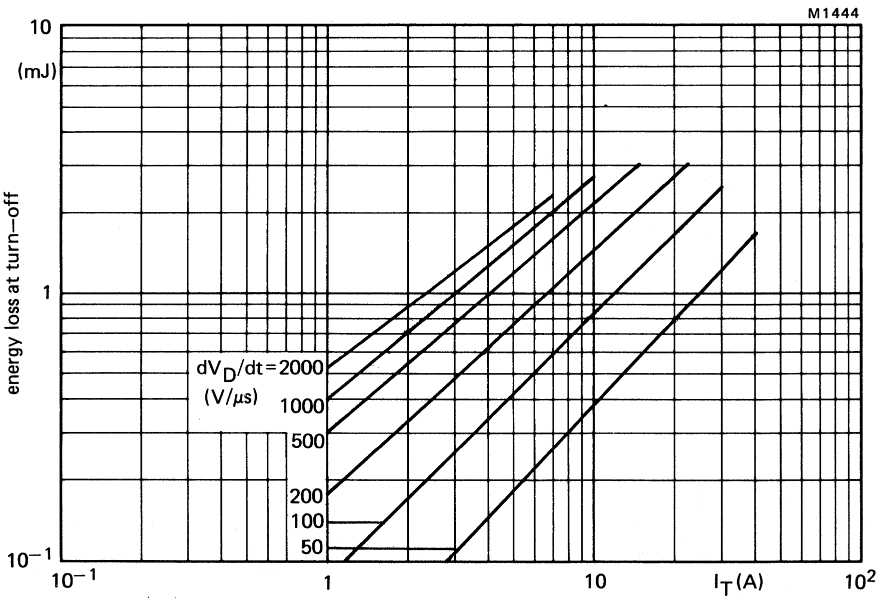


Fig.13 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied dV_D/dt (calculated from I_T/C_S); dV_D/dt linear up to V_{Dmax} = 600 V; V_{GR} = 10 V; I_G = 0.5 A; $L_G \leqslant 0.5$ µH; $L_S \leqslant 0.25$ µH; T_j = 120 °C.

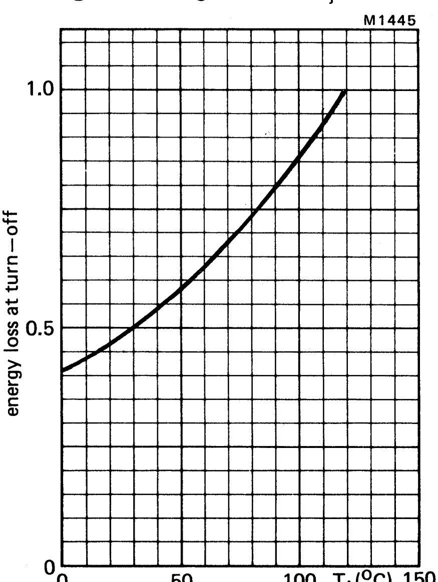


Fig.14 Energy loss at turn off as a function of junction temperature; I_G = 0.5 A; V_{GR} = 10 V. Normalised to T_j = 120 °C.

DIODE CHARACTERISTICS

Forward voltage				
I_F = 10 A; T_j = 25 °C	V_F	<	2.0	V*
Reverse recovery when switched from				
I_F = 2 A to $V_R \geqslant$ 30 V with $-dI_F/dt$ = 20 A/μs; T_j = 25 °C				
recovered charge	Q_s	<	2.0	μC
recovery time	t_{rr}	<	0.6	μs
Forward recovery when switched to				
I_F = 5 A with t_r = 0.1 μs; T_j = 25 °C				
recovery time	t_{fr}	<	1.0	μs

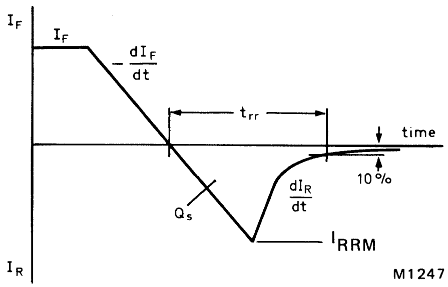


Fig.15 Definition of t_{rr} and Q_s.

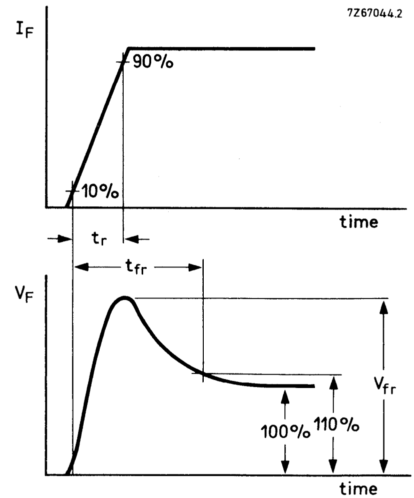


Fig.16 Definition of t_{fr}.

*Measured under pulse conditions to avoid excessive dissipation

DIODE (cont.)

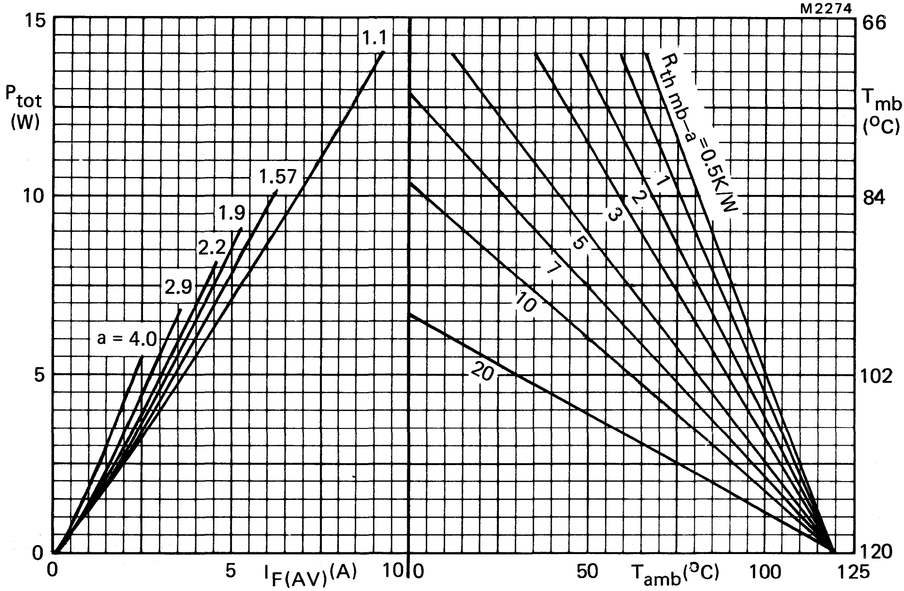


Fig.17 The right hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

$$a = \text{form factor} = \frac{I_{F(RMS)}}{I_{F(AV)}}$$

Values given on the right hand graph assume that the GTO is not dissipating significant power.

DIODE (cont.)

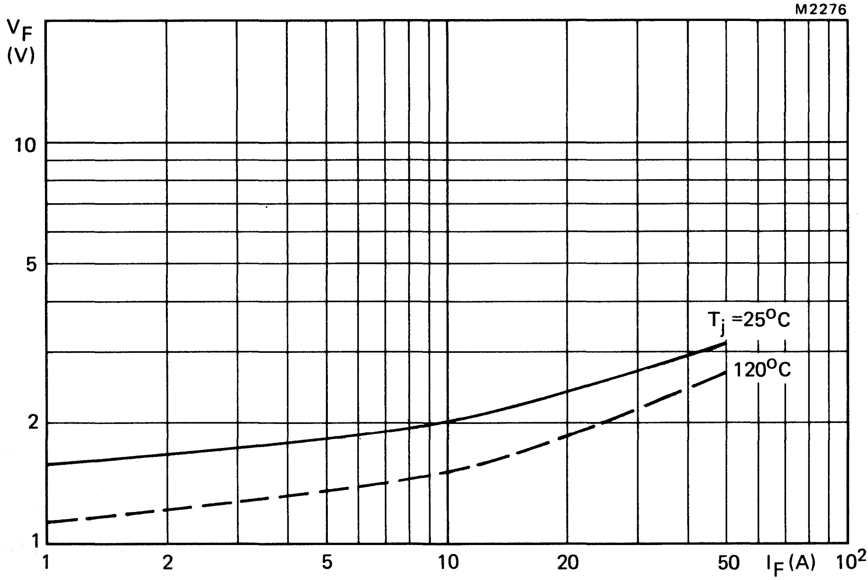


Fig. 18 Forward voltage as a function of foward current; maximum values.

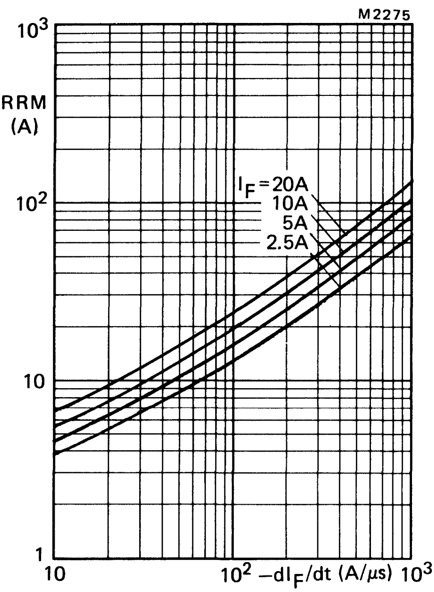


Fig. 19 Peak reverse recovery current versus $-dI_F/dt$; T_j = 25 °C; maximum values.

DIODE (cont.)

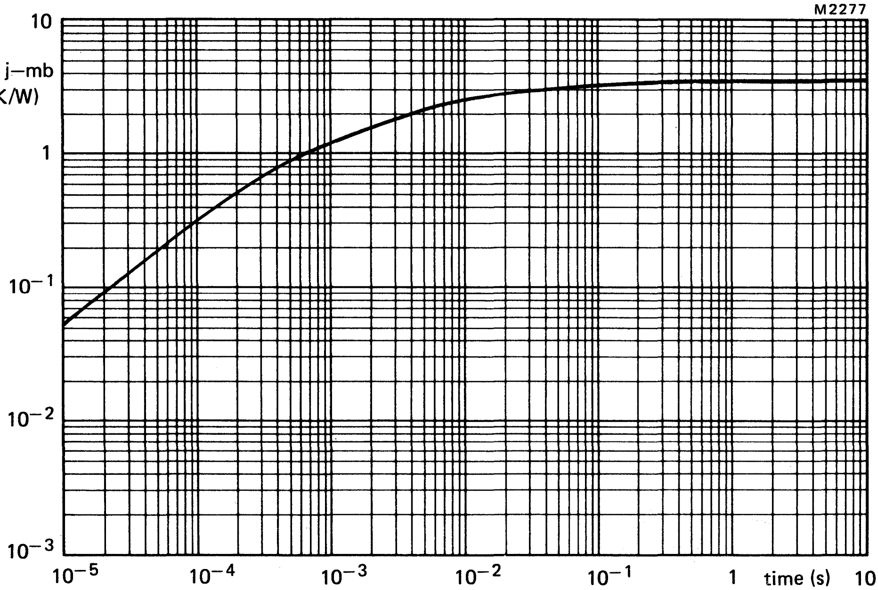


Fig.20 Transient thermal impedance.

FAST GATE TURN-OFF THYRISTORS

Thyristors in TO-220AB envelopes capable of being turned both on and off via the gate. They are suitable for use in high-frequency inverters, resonant power supplies, motor control, horizontal deflection systems etc. The devices have no reverse blocking capability. For reverse blocking operation use with a series diode, for reverse conducting operation use with an anti parallel diode.

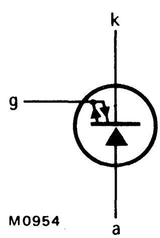
QUICK REFERENCE DATA

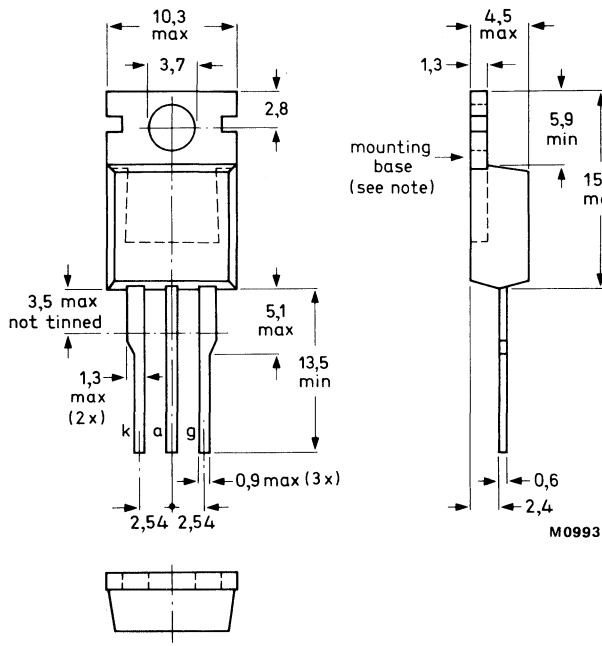
			BTW58–1000R	1300R	1500R	
Repetitive peak off-state voltage	V_{DRM}	max.	1000	1300	1500	V
Non-repetitive peak on-state current	I_{TSM}	max.		50		A
Controllable anode current	I_{TCRM}	max.		25		A
Average on-state current	$I_{T(AV)}$	max.		6.5		A
Fall time	t_f	<		250		ns

MECHANICAL DATA

Dimensions in mm

Fig.1 TO-220AB





Net mass: 2 g

Note: The exposed metal mounting base is directly connected to the cathode.

Accessories supplied on request: see data sheets Mounting instructions and accessories for TO-220 envelopes.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134)

Anode to cathode

			BTW58–1000R	1300R	1500R	
Transient off-state voltage	V_{DSM}	max.	1200	1500	1650	V*
Repetitive peak off-state voltage	V_{DRM}	max.	1000	1300	1500	V*
Working off-state voltage	V_{DW}	max.	650	1200	1300	V*
Continuous off-state voltage	V_D	max.	650	750	800	V*

Average on-state current (averaged over any 20 ms period) up to T_{mb} = 85 °C	$I_{T(AV)}$	max.	6.5	A
Controllable anode current	I_{TCRM}	max.	25	A
Non-repetitive peak on-state current t = 10 ms; half-sinewave; T_j = 120 °C prior to surge	I_{TSM}	max.	50	A
I^2t for fusing; t = 10 ms	I^2t	max.	12.5	A^2s
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	65	W

Gate to cathode

Repetitive peak on-state current T_j = 120 °C prior to surge				
gate-cathode forward; t = 10 ms; half-sinewave	I_{GFM}	max.	25	A
gate-cathode reverse; t = 20 µs	I_{GRM}	max.	25	A
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	2.5	W

Temperatures

Storage temperature	T_{stg}		−40 to +150	°C
Operating junction temperature	T_j	max.	120	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1.5	K/W
From mounting base to heatsink with heatsink compound	$R_{th\ mb\text{-}h}$	=	0.3	K/W
with 56367 alumina insulator and heatsink compound (clip-mounted)	$R_{th\ mb\text{-}h}$	=	0.8	K/W

*Measured with gate-cathode connected together.

CHARACTERISTICS

Anode to cathode

On-state voltage $I_T = 5$ A; $I_G = 0.2$ A; $T_j = 120$ °C	V_T	<	3.0	V*
Rate of rise of off-state voltage that will not trigger any off-state device; exponential method $V_D = 2/3\ V_{Dmax}$; $V_{GR} = 5$ V; $T_j = 120$ °C	dV_D/dt	<	10	kV/µs
Rate of rise of off-state voltage that will not trigger any device following conduction, linear method $I_T = 5$ A; $V_D = V_{DRMmax}$; $V_{GR} = 10$ V; $T_j = 120$ °C	dV_D/dt	<	1.5	kV/µs
Off-state current $V_D = V_{Dmax}$; $T_j = 120$ °C	I_D	<	3.0	mA
Latching current; $T_j = 25$ °C	I_L	typ.	1.0	A**

Gate to cathode

Voltage that will trigger all devices $V_D = 12$ V; $T_j = 25$ °C	V_{GT}	>	1.5	V
Current that will trigger all devices $V_D = 12$ V; $T_j = 25$ °C	I_{GT}	>	200	mA
Minimum reverse breakdown voltage $I_{GR} = 1.0$ mA	$V_{(BR)GR}$	>	10	V

Switching characteristics (resistive load)

Turn-on when switched to $I_T = 5$ A from $V_D = 250$ V with $I_{GF} = 0.5$ A; $T_j = 25$ °C				
delay time	t_d	<	0.25	µs
rise time	t_r	<	1.0	µs

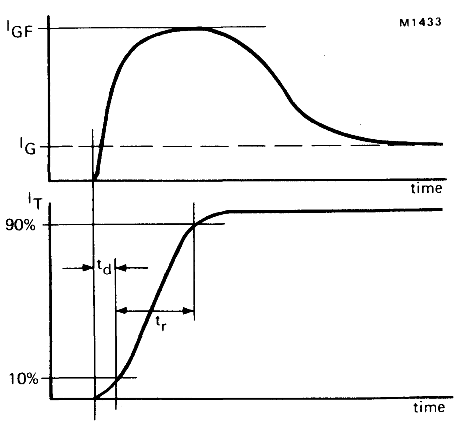


Fig.2 Waveforms

* Measured under pulse conditions to avoid excessive dissipation.
** Below latching level the device behaves like a transistor with a gain dependent on current.

Switching characteristics (inductive load)

Turn-off when switched from I_T = 5 A to $V_D = V_{DRMmax}$.
V_{GR} = 10 V; $L_G \leqslant 1.0\ \mu H$; $L_S \leqslant 0.25\ \mu H$; T_j = 25 °C

storage time	t_s	<	0.5	µs
fall time	t_f	<	0.25	µs
peak reverse gate current	I_{GR}	<	6	A

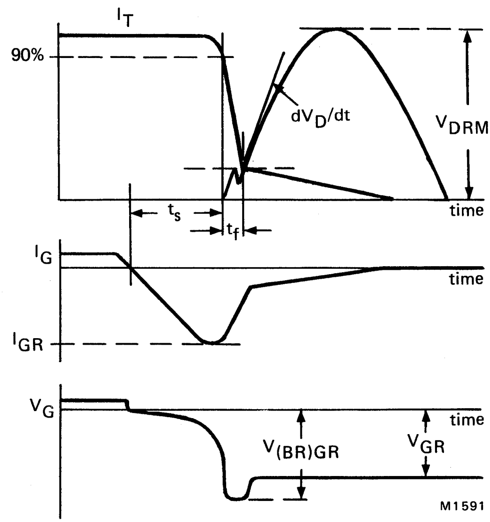


Fig.3 Waveforms.

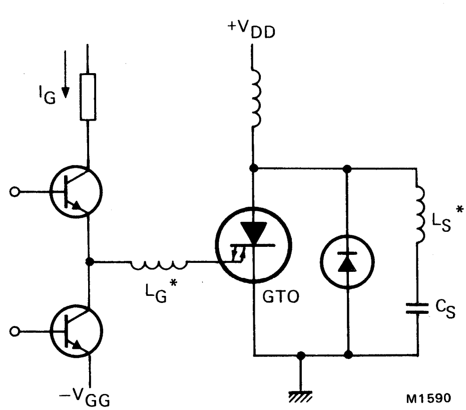


Fig.4 Inductive load test circuit

*Indicates stray series inductance only.

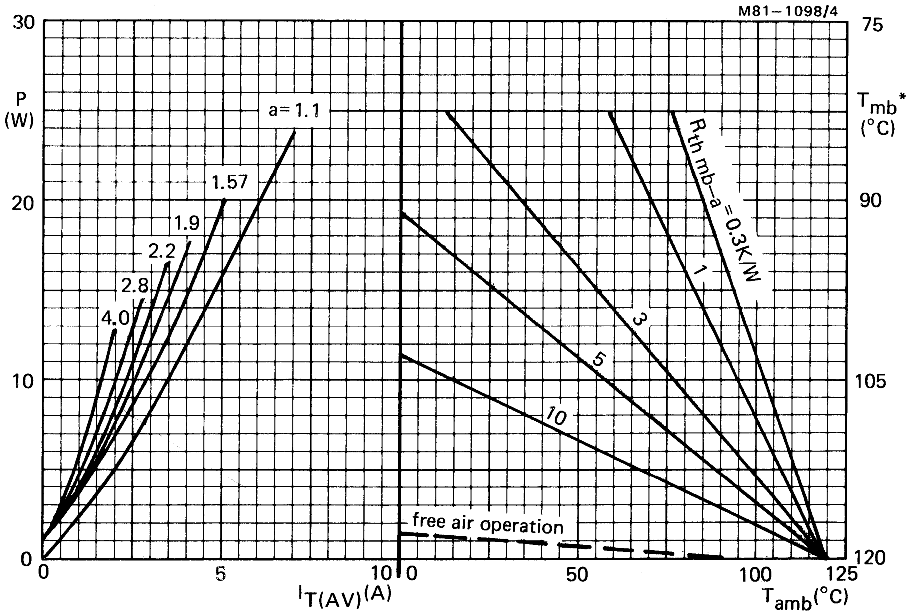


Fig.5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

$$a = \text{form factor} = \frac{I_{T(RMS)}}{I_{T(AV)}}$$

P = power excluding switching losses.

*T_{mb} scale is for comparison purposes and is correct only for $R_{th\ mb\text{-}a} < 9.6$ K/W.

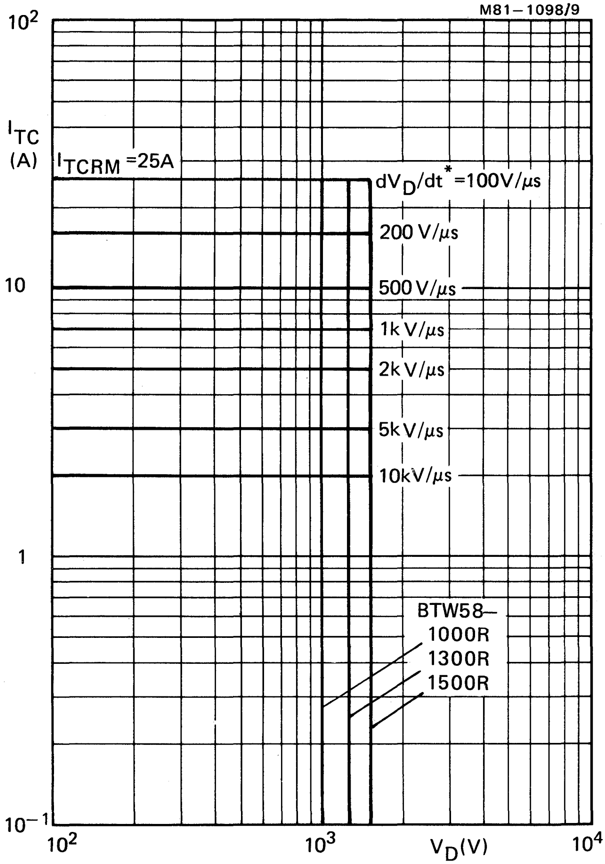


Fig.6 Anode current which can be turned off versus anode voltage; inductive load; V_{GR} = 10 V; $L_G \leqslant 1.0\ \mu H$; $L_S \leqslant 0.25\ \mu H$; T_j = 85 °C.
*dV_D/dt is calculated from I_T/C_S.

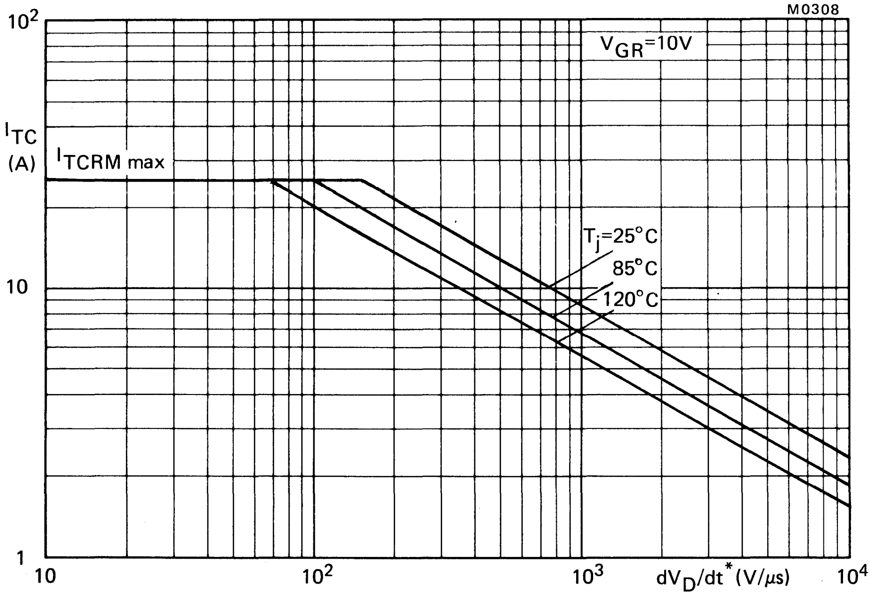


Fig.7 Anode current which can be turned off versus applied dV_D/dt^*; inductive load; V_{GR} = 10 V; $L_G \leqslant 1.0\ \mu H$; $L_S \leqslant 0.25\ \mu H$. *$dV_D/dt$ is calculated from I_T/C_S.

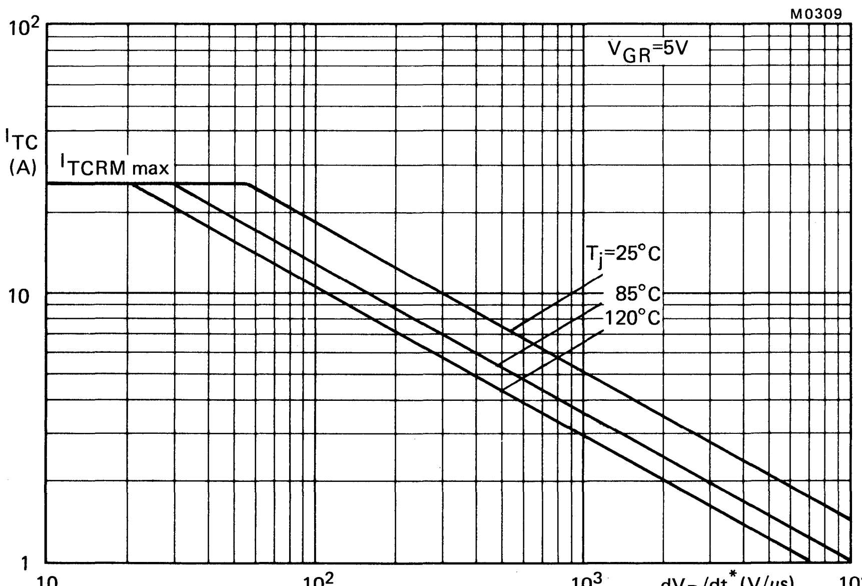


Fig.8 Anode current which can be turned off versus applied dV_D/dt^*; inductive load; V_{GR} = 5 V; $L_G \leqslant 1.0\ \mu H$; $L_S \leqslant 0.25\ \mu H$. *$dV_D/dt$ is calculated from I_T/C_S.

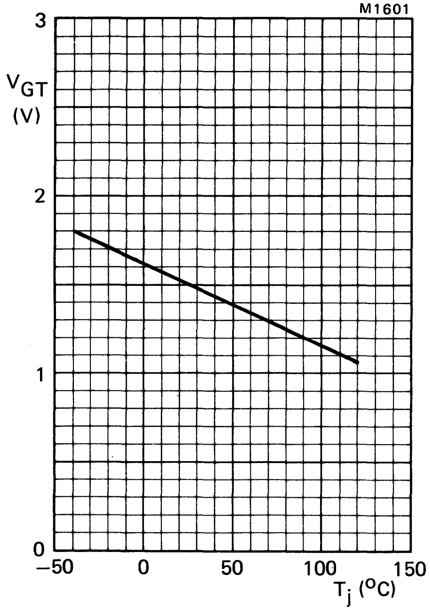


Fig.9 Minimum gate voltage that will trigger all devices as a function of junction temperature; V_D = 12 V.

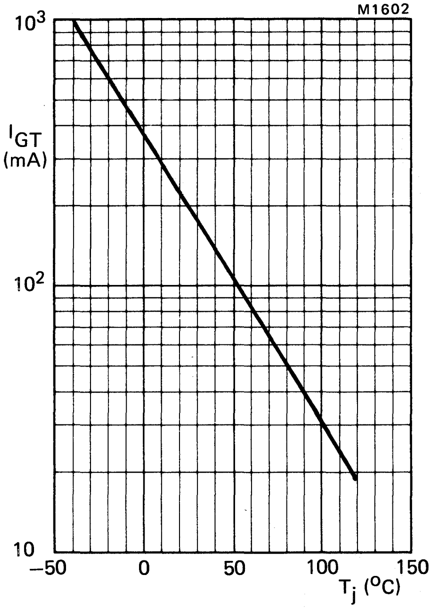


Fig.10 Minimum gate current that will trigger all devices as a function of junction temperature; V_D = 12 V.

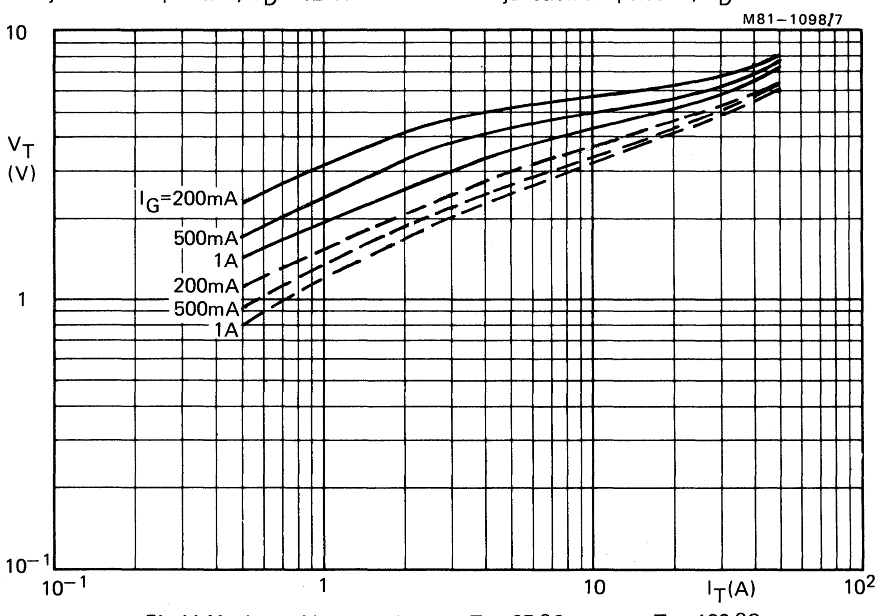


Fig.11 Maximum V_T versus I_T; —— T_j = 25 °C; – – – –T_j = 120 °C.

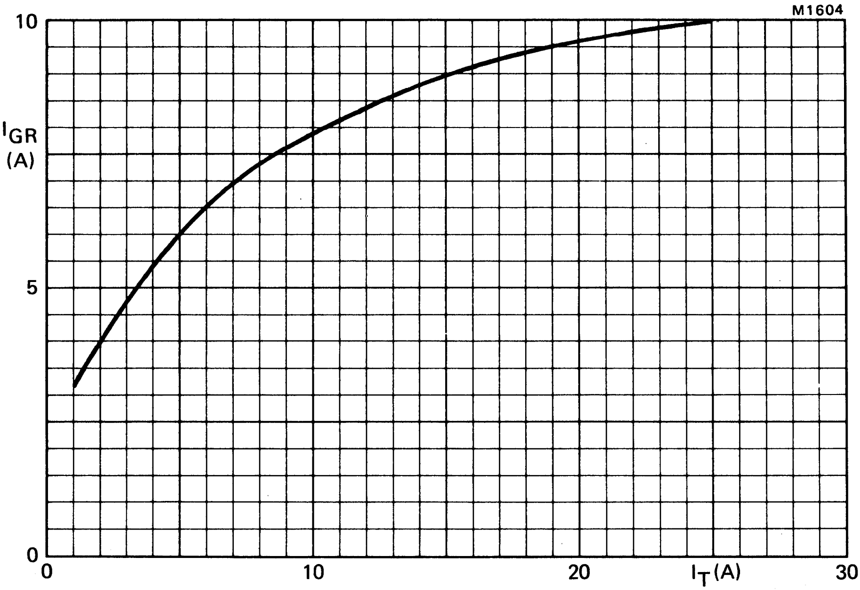


Fig.12 Peak reverse gate current versus anode current at turn-off; inductive load; V_{GR} = 10 V; I_G = 0.2 A; L_G = 0.8 μH; T_j = 120 °C; maximum values.

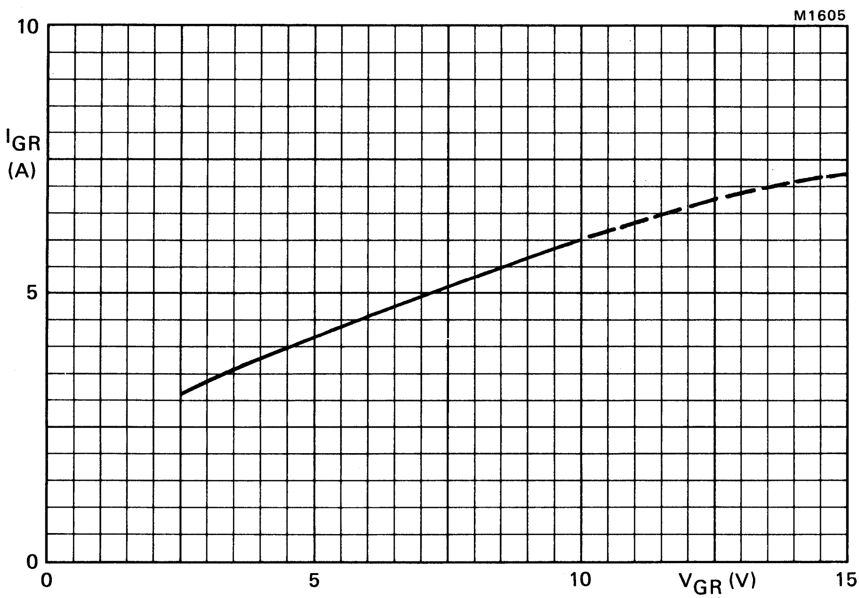


Fig.13 Peak reverse gate current versus applied reverse gate voltage; inductive load; I_T = 5 A; I_G = 0.2 A; L_G = 0.8 μH; T_j = 120 °C; maximum values.

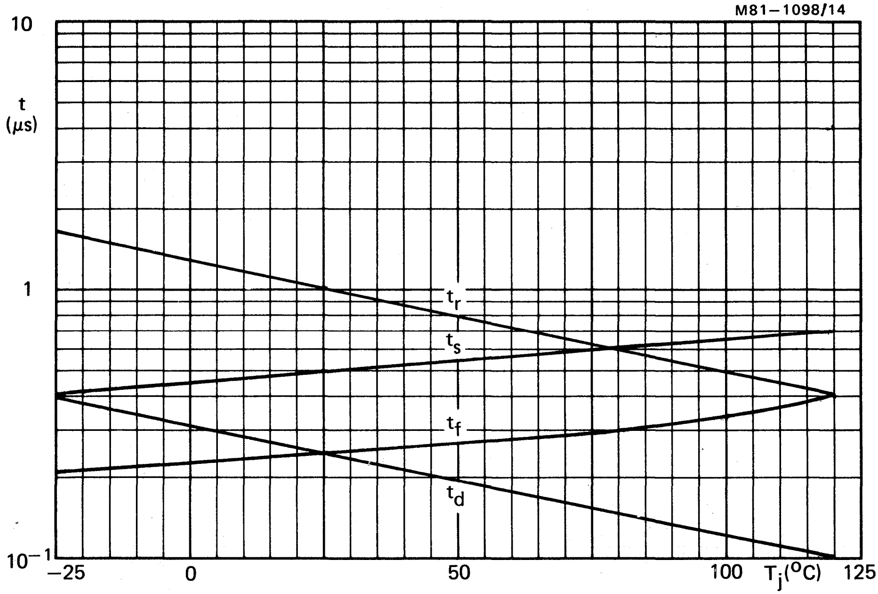


Fig.14 Switching times as a function of junction temperature; $V_D \geqslant 250$ V; $I_T = 5$ A; $I_{GF} = 0.5$ A; $V_{GR} = 10$ V; $I_G = 0.2$ A; $L_G = 0.8$ μH; maximum values.

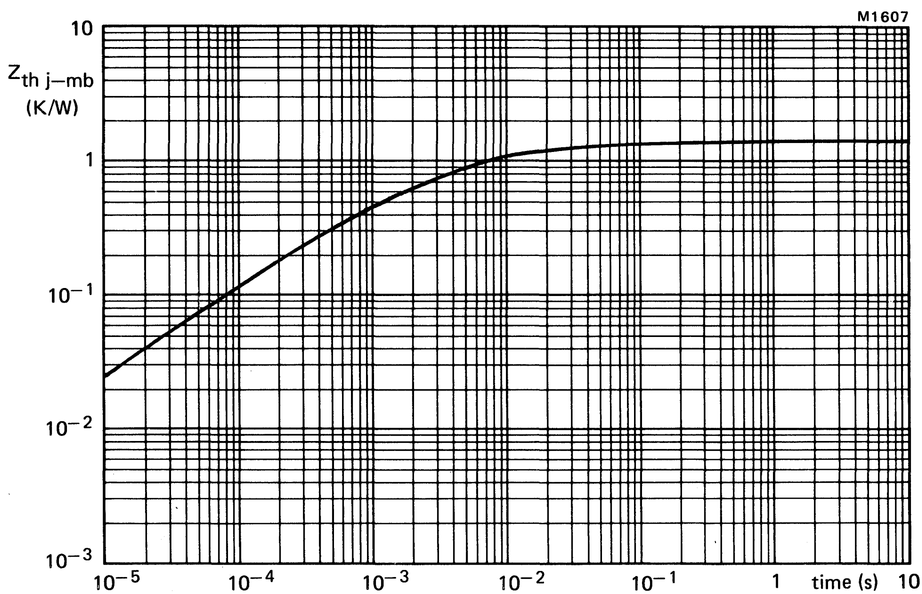


Fig.15 Transient thermal impedance.

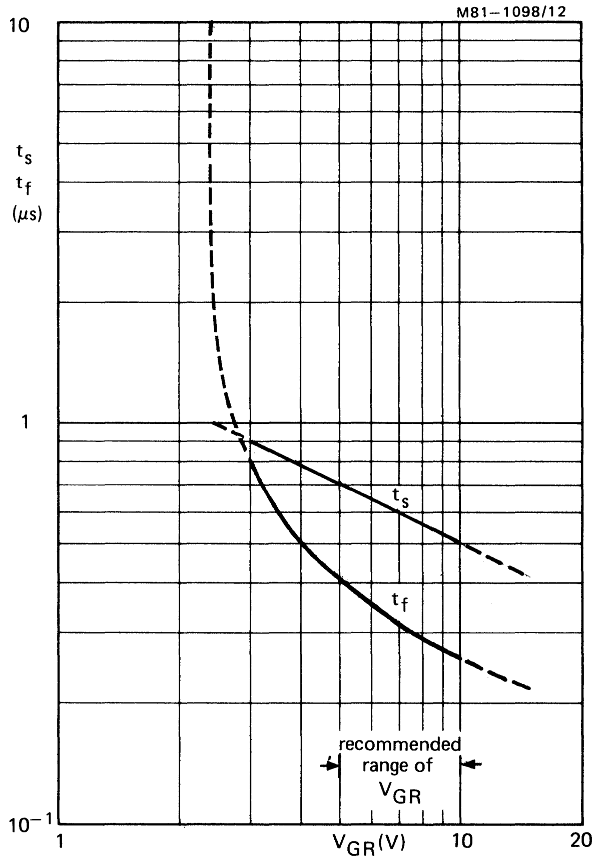


Fig.16 Storage and fall times versus applied reverse gate voltage; inductive load; I_T = 5 A; I_G = 0.2 A; L_G = 0.8 μH; T_j = 25 °C; maximum values.

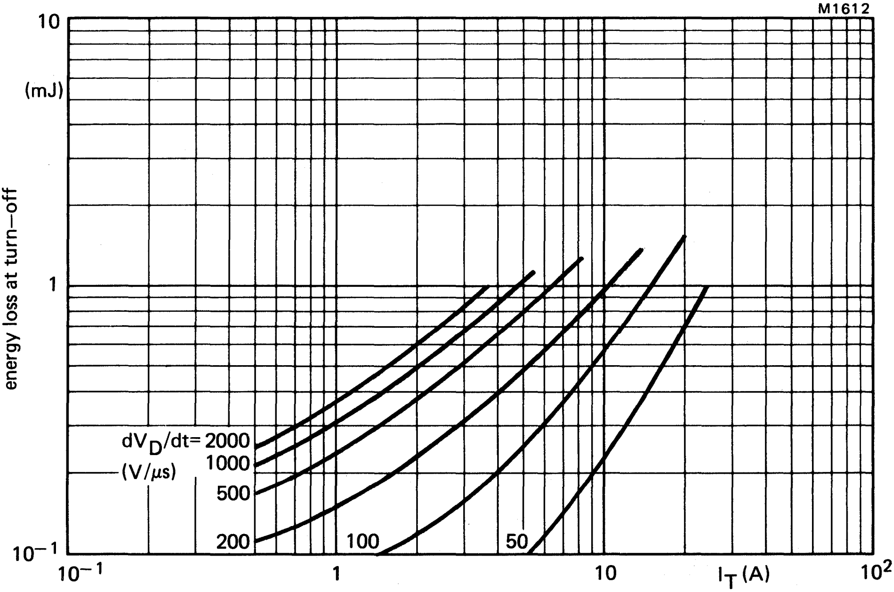


Fig.17 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied dV_D/dt (calculated from I_T/C_S); reapplied voltage sinsusoidal up to V_{DRM} = 1200 V; V_{GR} = 10 V; I_G = 0.2 A; $L_G \leqslant 1.0\ \mu H$; $L_S \leqslant 0.25\ \mu H$; T_j = 120 °C.

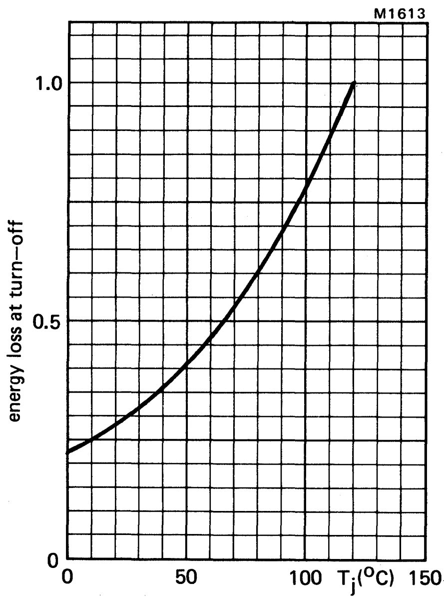


Fig.18 Energy loss at turn off as a function of junction temperature; I_G = 0.2 A; V_{GR} = 10 V. Normalised to T_j = 120 °C.

THYRISTORS

SILICON BI-DIRECTIONAL TRIGGER DEVICE

Silicon bi-directional trigger device intended for use in triac and thyristor trigger circuits.

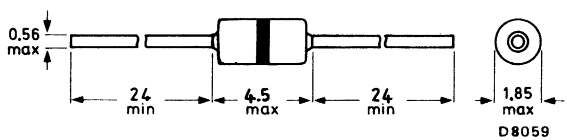
QUICK REFERENCE DATA

Breakover voltage	$V_{(BO)}$		28 to 36	V
Output voltage	V_O	>	5	V
Repetitive peak current	I_{FRM}	max.	2	A

MECHANICAL DATA

Dimensions in mm

Fig. 1



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134)

Total power dissipation up to T_{amb} = 50 °C	P_{tot}	max.	150	mW
Repetitive peak current ($t \leq 20\ \mu s$)	I_{FRM}	max.	2	A
Storage temperature	T_{stg}		−55 to +125	°C
Junction temperature	T_j	max.	100	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.33	K/mW

CHARACTERISTICS

$T_j = 25\ ^oC$

Breakover voltage at $\frac{dV}{dt} = 10$ V/ms	$V_{(BO)}$		28 to 36	V
Breakover voltage symmetry	$\lvert V_{(BO)I} - V_{(BO)III} \rvert$	<	3	V
Output voltage at $\frac{dV}{dt} = 10$ V/ms	V_O	>	5	V
Breakover current at $V = 0.98\ V_{(BO)}$	$I_{(BO)}$	<	100	μA

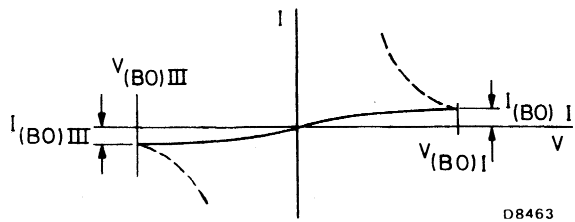


Fig.2

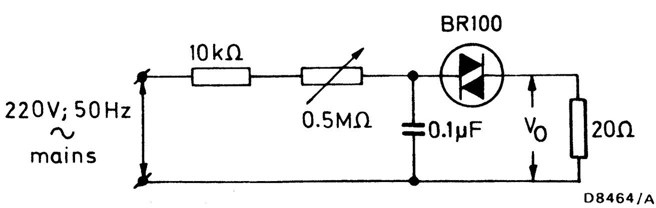


Fig. 3 Test circuit for output voltage

THYRISTORS

Glass-passivated 25 ampere thyristors intended for use in applications involving high fatigue stress due to thermal cycling and repeated switching. These thyristors feature a high surge current capability. Typical applications include motor and heating control, regulators for transfomerless power supply circuits, relay and coil pulsing and power supply crowbar protection circuits.

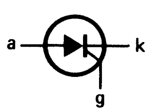
QUICK REFERENCE DATA

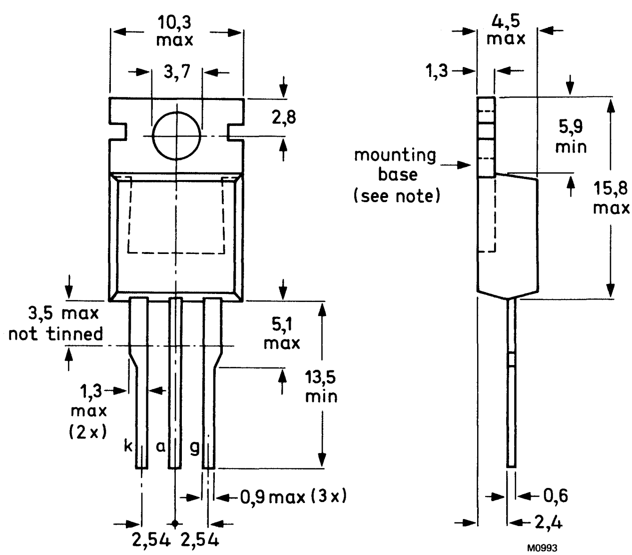
			BT145-500R	600R	800R	
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	500	600	800	V
Average on-state current	$I_{T(AV)}$	max.		16		A
R.M.S. on-state current	$I_{T(RMS)}$	max.		25		A
Non-repetitive peak on-state current	I_{TSM}	max.		300		A

MECHANICAL DATA

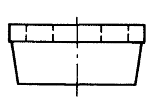
Dimensions in mm

Fig.1 TO–220AB





Net mass: 2 g



Note: The exposed metal mounting base is directly connected to the anode.

Accessories supplied on request: see data sheets Mounting instructions and accessories for TO–220 envelopes.

RATINGS

Limiting values accordance with the Absolute Maximum System (IEC 134)

Anode to cathode

			BT145-500R	600R	800R	
No-repetitive peak voltages	V_{DSM}/V_{RSM}	max.	500	600	800	V
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	500	600	800	V
Crest working voltages	V_{DWM}/V_{RWM}	max.	400	400	400	V

Average on-state current (averaged over any 20 ms period) up to T_{mb} = 93 °C	$I_{T(AV)}$	max.	16	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	25	A
Repetitive peak on-state current	I_{TRM}	max.	300	A
Non-repetitive peak on-state current; t = 10 ms; half sine-wave; T_j = 115 °C prior to surge; with reapplied V_{RWMmax}	I_{TSM}	max.	300	A
I^2t for fusing (t = 10 ms)	I^2t	max.	450	A^2s
Rate of rise of on-state current after triggering with I_G = 160 mA to I_T = 50 A; dI_G/dt = 160 A/ms	dI_T/dt	max.	200	A/µs

Gate to cathode

Reverse peak voltage	V_{RGM}	max.	5	V
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	0.5	W
Peak power dissipation; t ⩽ 10 µs	P_{GM}	max.	20	W

Temperature

Storage temperature	T_{stg}		−40 to + 150	°C
Juction temperature	T_j	max.	110	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1.0	K/W
From mounting base to heatsink with heatsink compound	$R_{th\ mb\text{-}h}$	=	0.3	K/W

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1.0	K/W
Transient thermal impedance; t = 1 ms	$Z_{th\ j\text{-}mb}$	=	0.09	K/W

Influence of mounting method

1. Heatsink-mounted with clip (see mounting instructions)

Thermal resistance from mounting base to heatsink

a. with heatsink compound	$R_{th\ mb\text{-}h}$	=	0.3	K/W
b. with heatsink compound and 0.06 mm maximum mica insulator	$R_{th\ mb\text{-}h}$	=	1.4	K/W
c. with heatsink compound and 0.1 mm maximum mica insulator (56369)	$R_{th\ mb\text{-}h}$	=	2.2	K/W
d. with heatsink compound and 0.25 mm maximum alumina insulator (56367)	$R_{th\ mb\text{-}h}$	=	0.8	K/W
e. without heatsink compound	$R_{th\ mb\text{-}h}$	=	1.4	K/W

2. Free-air operation

The quoted values of $R_{th\ j\text{-}a}$ should be used only when no leads of other dissipating components run to the same tie-point.

Thermal resistance from junction to ambient in free air:
mounted on a printed-circuit board at a = any lead length — $R_{th\ j\text{-}a}$ = 60 K/W

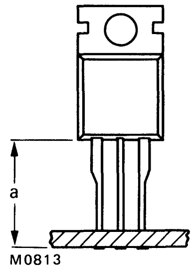


Fig.2.

CHARACTERISTICS

Anode to cathode

On-state voltage (measured under pulse conditions)				
I_T = 30 A; T_j = 25 °C	V_T	<	1.5	V
Rate of rise of off-sate voltage that will not trigger any device				
T_j = 110 °C; R_{GK} = open circuit	dV_D/dt	<	200	V/μs
Reverse current				
$V_R = V_{RWMmax}$; T_j = 110 °C	I_R	<	1.0	mA
Off-state current				
$V_D = V_{DWMmax}$; T_j = 110 °C	I_D	<	1.0	mA
Latching current; T_j = 25 °C	I_L	<	80	mA
Holding current; T_j = 25 °C	I_H	<	60	mA

Gate to cathode

Voltage that will trigger all devices				
V_D = 12 V; T_j = −40 °C	V_{GT}	>	1.5	V
V_D = 12 V; T_j = 25 °C	V_{GT}	>	1.0	V
Voltage that will not trigger any device				
$V_D = V_{DRMmax}$; T_j = 110 °C	V_{GD}	<	0.25	V
Current that will trigger all devices				
V_D = 12V; T_j = −40 °C	I_{GT}	>	55	mA
V_D = 12 V; T_j = 25 °C	I_{GT}	>	35	mA

Switching characteristics

Gate-controlled turn-on time ($t_{gt} = t_d + t_r$) when switched from $V_D = V_{DRMmax}$ to I_T = 40 A; I_{GT} = 100 mA; dI_G/dt = 5 A/μs; T_j = 25 °C	t_{gt}	typ.	2	μs

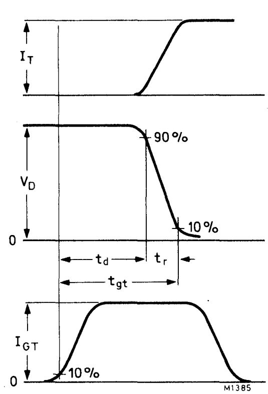


Fig.3 Gate controlled turn-on time definition.

MOUNTING INSTRUCTIONS

1. The device may be soldered directly into the circuit, but the maximum permissible temperature of the soldering iron or bath is 275 °C; it must not be in contact with the joint for more than 5 seconds. Soldered joints must be at least 4.7 mm from the seal.
2. The leads should not be bent less than 2.4 mm from the seal, and should be supported during bending. The leads can be bent, twisted or straightened by 90° maximum. The minimum bending radius is 1 mm.
3. It is recommended that the circuit connection be made to the anode tag, rather than direct to the heatsink.
4. Mounting by means of a spring clip is the best mounting method because it offers:
   a. a good thermal contact under the crystal area and slightly lower $R_{th\ mb\text{-}h}$ values than screw mounting.
   b. safe isolation for mains operation.

   However, if a screw is used, it should be M3 cross-recess pan-head. Care should be taken to avoid damage to the plastic body.
5. For good thermal contact, heatsink compound should be used between mounting base and heatsink. Values of $R_{th\ mb\text{-}h}$ given for mounting with heatsink compound refer to the use of a metallic oxide-loaded compound. Ordinary silicone grease is not recommended.
6. Rivet mounting (only possible for non-insulated mounting).

   Devices may be rivetted to flat heatsinks; such a process **must neither** deform the mounting tab, **nor** enlarge the mounting hole.
7. The heatsink must have a flatness in the mounting area of 0.02 mm maximum per 10 mm. Mounting holes must be deburred.

OPERATING NOTES

Dissipation and heatsink considerations:

a. The various components of junction temperature rise above ambient are illustrated in Fig.4.

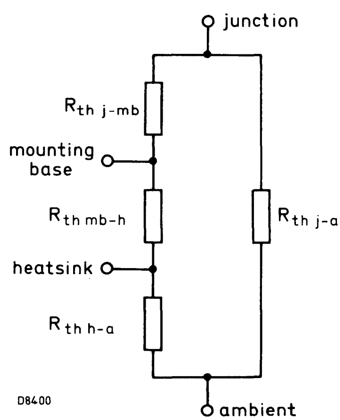


Fig.4

b. The method of using Fig.5 is as follows:
Starting with the required current on the $I_{T(AV)}$ axis, trace upwards to meet the appropriate form factor curve. Trace right horizontally and upwards from the appropriate value on the T_{amb} scale. The intersection determines the $R_{th\ mb\text{-}a}$. The heatsink thermal resistance value ($R_{th\ h\text{-}a}$) can now be calculated from:

$$R_{th\ h\text{-}a} = R_{th\ mb\text{-}a} - R_{th\ mb\text{-}h}.$$

c. Any measurement of heatsink temperature should be made immediately adjacent to the device.

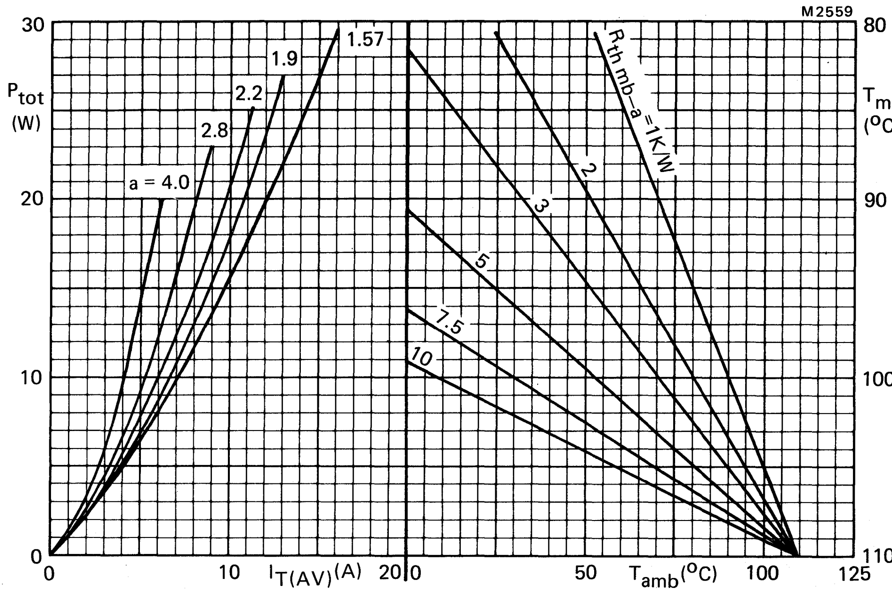
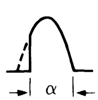


Fig.5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



α = conduction angle per half cycle

$$a = \text{form factor} = \frac{I_{T\,(RMS)}}{I_{T(AV)}}$$

α	a
30°	4
60°	2.8
90°	2.2
120°	1.9
180°	1.57

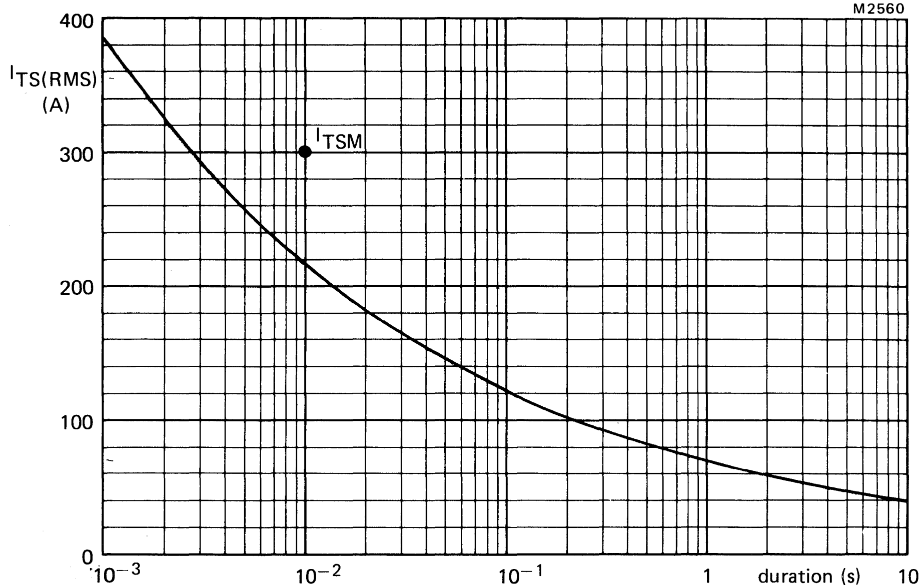
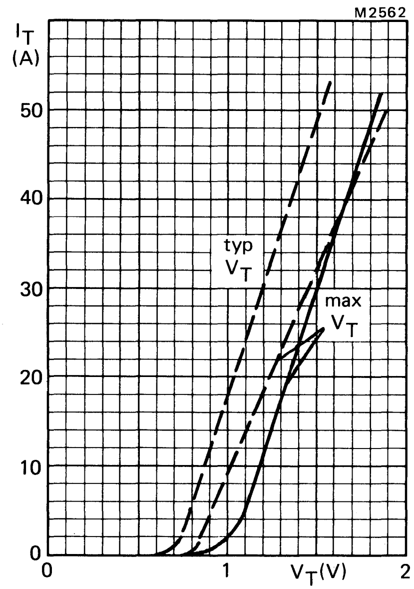


Fig.6 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents (f=50Hz) with re-applied V_{RWMmax}; T_j = 110 °C prior to surge.



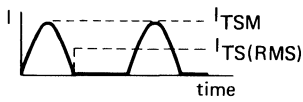


Fig.7 —— T_j = 25 °C; – – – T_j = 110 °C.

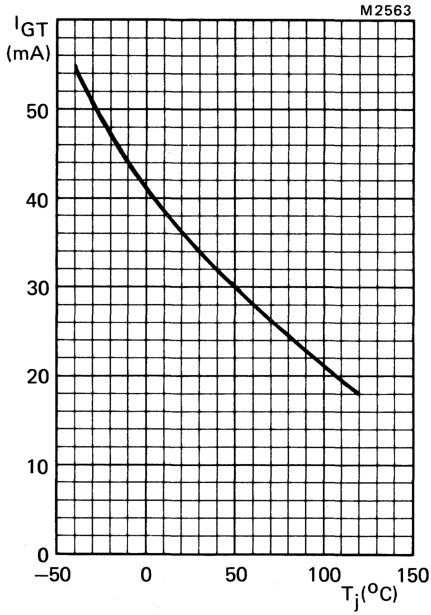


Fig.8 Minimum gate current that will trigger all devices as a function of junction temperature.

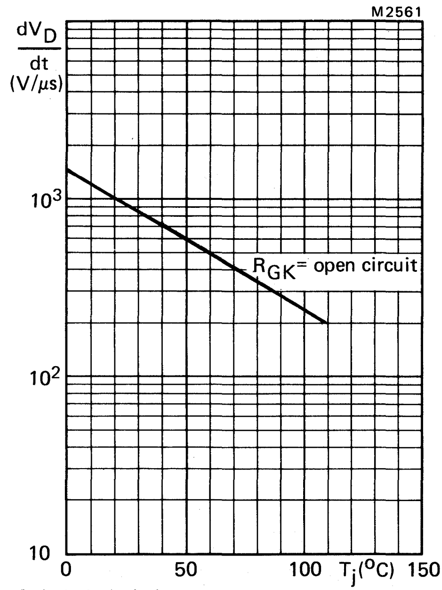


Fig.9 Maximum rate of rise of off-state voltage that will not trigger any device as a function of junction temperature.

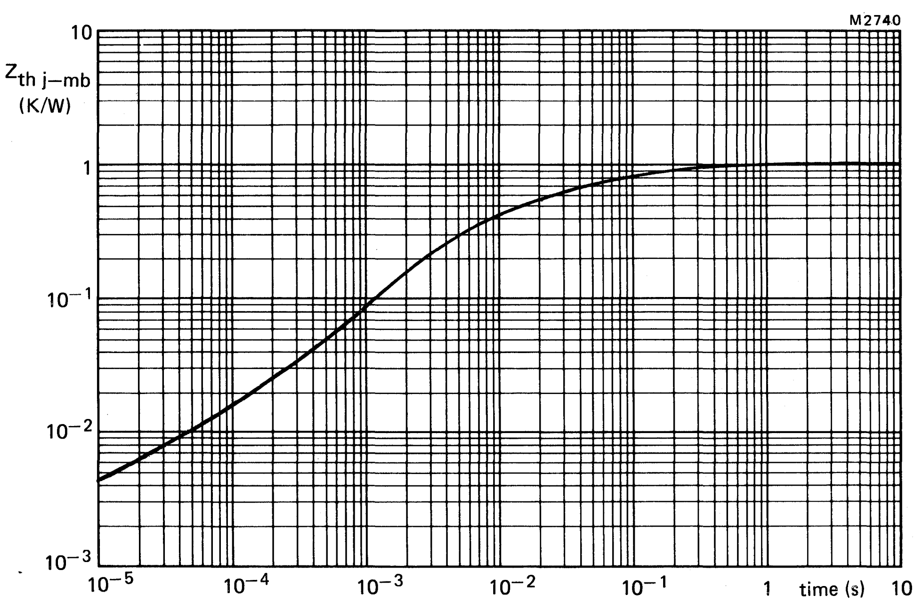


Fig.10 Transient thermal impedance.

THYRISTORS

Fully-diffused thyristors in TO—92 package, with low gate current requirement suitable for driving from IC outputs. Applications include relay and coil pulsing, control of small d.c. motors, small lamps, etc.

QUICK REFERENCE DATA

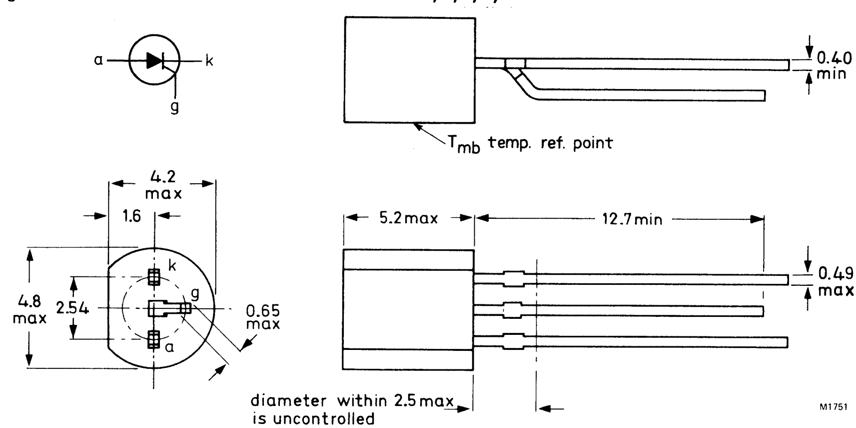
			BT149 — F	A	B	D	E	M	
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	50	100	200	400	500	600	V
Average on-state current	$I_{T(AV)}$	max.	0.5						A
R.M.S. on-state current	$I_{T(RMS)}$	max.	0.8						A
Non-repetitive peak on-state current	I_{TSM}	max.	8						A

MECHANICAL DATA

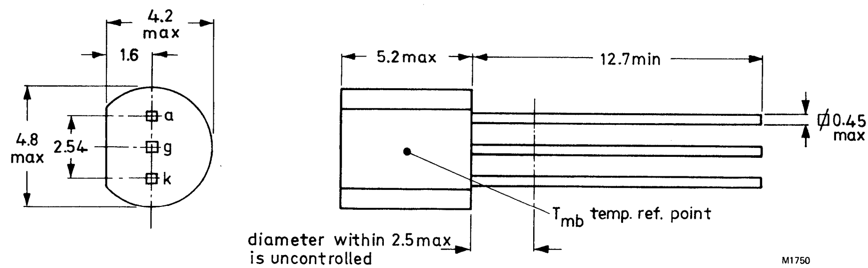
Dimensions in mm

Fig.1 TO—92 variant

BT149—F,A,B,D,E



BT149—M



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Anode to cathode

			BT149 – F	A	B	D	E	M	
Non-repetitive peak voltages ($t \leq 10$ ms)	V_{DSM}/V_{RSM}	max.	50	100	200	400	500	600	V*
Repetitive peak voltages ($\delta \leq 0.01$)	V_{DRM}/V_{RRM}	max.	50	100	200	400	500	600	V

Average on-state current (averaged over any 20 ms period) up to T_{mb} = 55 °C	$I_{T(AV)}$	max.	0.5	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	0.8	A
Repetitive peak on-state current	I_{TRM}	max.	8	A
Non-repetitive peak on-state current; t = 10 ms; half sine-wave; T_j = 125 °C prior to surge; with reapplied V_{RWMmax}	I_{TSM}	max.	8	A
I^2t for fusing (t = 10 ms)	I^2t	max.	0.32	A^2s
Rate of rise of on-state current after triggering with I_G = 1 mA to I_T = 1.8 A; dI_G/dt = 4 mA/µs	dI_T/dt	max.	30	A/µs

Gate to cathode

Peak reverse voltage	V_{RGM}	max.	8	V
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	0.1	W
Peak power dissipation	P_{GM}	max.	2	W

Temperatures

Storage temperature	T_{stg}		−40 to +150	°C
Operating junction temperature	T_j	max.	125	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	100	K/W
From junction to ambient in free air, mounted on a p.c.b. with any lead length	$R_{th\ j\text{-}a}$	=	200	K/W

*R_{GK} = 1 kΩ

THYRISTORS

Glass-passivated thyristor in TO-220AB envelope, featuring sensitive gate triggering as low as 200 μA. Particularly suitable in applications where high fatigue stresses due to thermal cycling and repeated switching are present. Typical applications include temperature and motor control, relay and coil pulsing and power supply crowbar protection circuits and regulators in transformerless power supply systems.

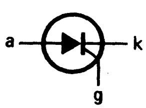
QUICK REFERENCE DATA

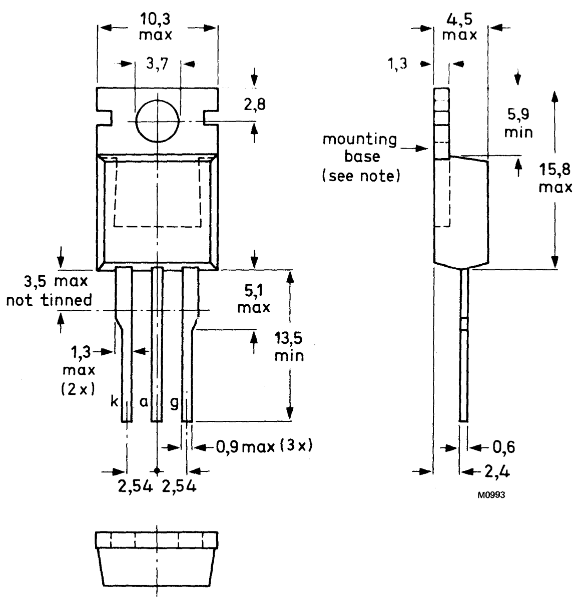
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	500	V
Average on-state current	$I_{T(AV)}$	max.	2.5	A
rms on-state current	$I_{T(RMS)}$	max.	4	A
Non-repetitive on-state current	I_{TSM}	max.	25	A

MECHANICAL DATA

Dimensions in mm

Fig.1 TO-220AB





Net mass: 2 g

Note: The exposed metal mounting base is directly connected to the anode.

Accessories supplied on request, see data sheets Mounting instructions and accessories for TO-220 envelopes.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134).

Anode to cathode

Non-repetitive peak voltages ($t \leq 10$ ms)	V_{DSM}/V_{RSM}	max.	500	V*
Repetitive peak voltage ($\delta \leq 0.01$)	V_{DRM}/V_{RRM}	max.	500	V
Crest working voltages	V_{DWM}/V_{RWM}	max.	400	V
Continuous voltages	V_D/V_R	max.	400	V
Average on-state current (averaged over any 20 ms period) up to $T_{mb} = 98$ °C	$I_{T(AV)}$	max.	2.5	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	4	A
Repetitive peak on-state current	I_{TRM}	max.	25	A
Non-repetitive peak on-state current $t = 10$ ms; half sine-wave; $T_j = 110$ °C prior to surge; with reapplied V_{RWMmax}	I_{TSM}	max.	25	A
I^2t for fusing ($t = 10$ ms)	I^2t	max.	3	A^2s
Rate of rise of on-state current after triggering with $I_G = 50$ mA; to $I_T = 10$ A; $dI_G/dt = 50$ mA/μs	dI_T/dt	max.	50	A/μs

Gate to cathode

Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	0.5	W
Peak power dissipation	P_{GM}	max.	5	W

Temperatures

Storage temperature	T_{stg}		−40 to +125	°C
Junction temperature	T_j	max.	110	°C

*Although not recommended, higher off-state voltages may be applied without damage, but the thyristor may switch into the on-state. The rate of rise of on-state current should not exceed 15 A/μs.

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2.5	K/W
Transient thermal impedance; t = 1 ms	$Z_{th\ j\text{-}mb}$	=	0.2	K/W

Influence of mounting method

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from mounting base to heatsink

a. with heatsink compound	$R_{th\ mb\text{-}h}$	=	0.3	K/W
b. with heatsink compound and 0.06 mm maximum mica insulator	$R_{th\ mb\text{-}h}$	=	1.4	K/W
c. with heatsink compound and 0.1 mm maximum mica insulator (56369)	$R_{th\ mb\text{-}h}$	=	2.2	K/W
d. with heatsink compound and 0.25 mm maximum alumina insulator (56367)	$R_{th\ mb\text{-}h}$	=	0.8	K/W
e. without heatsink compound	$R_{th\ mb\text{-}h}$	=	1.4	K/W

2. Free air operation

The quoted values of $R_{th\ j\text{-}a}$ should be used only when no leads of other dissipating components run to the same tie-point.

Thermal resistance from junction to ambient in free air; mounted on a printed-circuit board at a = any lead length	$R_{th\ j\text{-}a}$	=	60	K/W

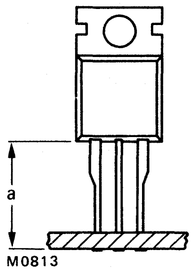


Fig.2

CHARACTERISTICS (T_j = 25 °C unless otherwise stated)

Anode to cathode

On-state voltage I_T = 5 A	V_T	<	1.8	V*
Rate of rise of off-state voltage that will not trigger any device R_{GK} = 100 Ω; T_j = 110 °C	dV_D/dt	typ.	5	V/μs
Reverse current $V_R = V_{RWMmax}$; T_j = 110 °C	I_R	<	0.5	mA
Off-state current $V_D = V_{DWMmax}$; T_j = 110 °C	I_D	<	0.5	mA
Latching curent	I_L	<	10	mA
Holding current	I_H	<	6	mA

Gate to cathode

Voltage that will trigger all devices V_D = 12 V	V_{GT}	>	1.5	V
V_D = 12 V; T_j = –40 °C	V_{GT}	>	2.3	V
Voltage that will not trigger any device V_D = 12 V; T_j = 110 °C	V_{GD}	<	250	mV
Current that will trigger all devices V_D = 12 V	I_{GT}	>	200	μA
V_D = 12 V; T_j = –40 °C	I_{GT}	>	260	μA

Switching characteristics

Gate-controlled turn-on time ($t_{gt} = t_d + t_r$) with switched from $V_D = V_{DWMmax}$ to I_T = 10 A; I_{GT} = 5 mA; dI_G/dt = 0.2 A/μs	t_{gt}	typ.	2	μs

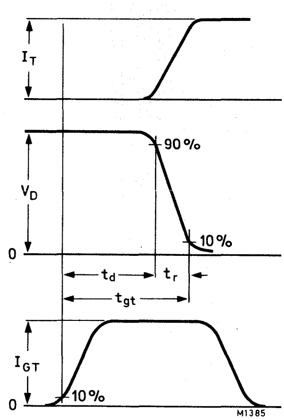


Fig.3 Gate-controlled turn-on time definition.

*Measured under pulse conditions to avoid excessive dissipation.

MOUNTING INSTRUCTIONS

1. The device may be soldered directly into the circuit, but the maximum permissible temperature of the soldering iron or bath is 275 ^{o}C; it must not be in contact with the joint for more than 5 seconds. Soldered joints must be at least 4.7 mm from the seal.
2. The leads should not be bent less than 2.4 mm from the seal, and should be supported during bending. The leads can be bent, twisted or straightened by 90^{o} maximum. The minimum bending radius is 1 mm.
3. It is recommended that the circuit connection be made to the anode tag, rather than direct to the heatsink.
4. Mounting by means of a spring clip is the best mounting method because it offers:
   a. a good thermal contact under the crystal area and slightly lower $R_{th\ mb\text{-}h}$ values than screw mounting.
   b. safe isolation for mains operation.

   However, if a screw is used, it should be M3 cross-recess pan-head. Care should be taken to avoid damage to the plastic body.
5. For good thermal contact, heatsink compound should be used between mounting base and heatsink. Values of $R_{th\ mb\text{-}h}$ given for mounting with heatsink compound refer to the use of a metallic oxide-loaded compound. Ordinary silicone grease is not recommended.
6. Rivet mounting (only possible for non-insulated mounting).

   Devices may be rivetted to flat heatsinks; such a process **must neither** deform the mounting tab, **nor** enlarge the mounting hole.
7. The heatsink must have a flatness in the mounting area of 0.02 mm maximum per 10 mm. Mounting holes must be deburred.

OPERATING NOTES

Dissipation and heatsink considerations:

a. The various components of junction temperature rise above ambient are illustrated in Fig.4.

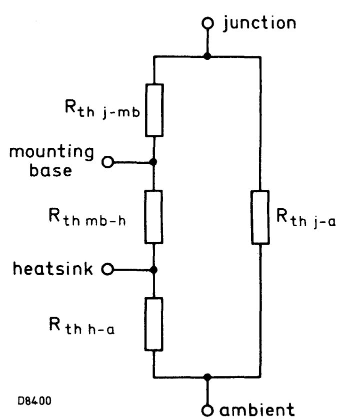


Fig.4

b. The method of using Fig.5 is as follows:
   Starting with the required current on the $I_{T(AV)}$ axis, trace upwards to meet the appropriate form factor curve. Trace right horizontally and upwards from the appropriate value on the T_{amb} scale. The intersection determines the $R_{th\ mb\text{-}a}$. The heatsink thermal resistance value ($R_{th\ h\text{-}a}$) can now be calculated from:

$$R_{th\ h\text{-}a} = R_{th\ mb\text{-}a} - R_{th\ mb\text{-}h}.$$

c. Any measurement of heatsink temperature should be made immediately adjacent to the device.

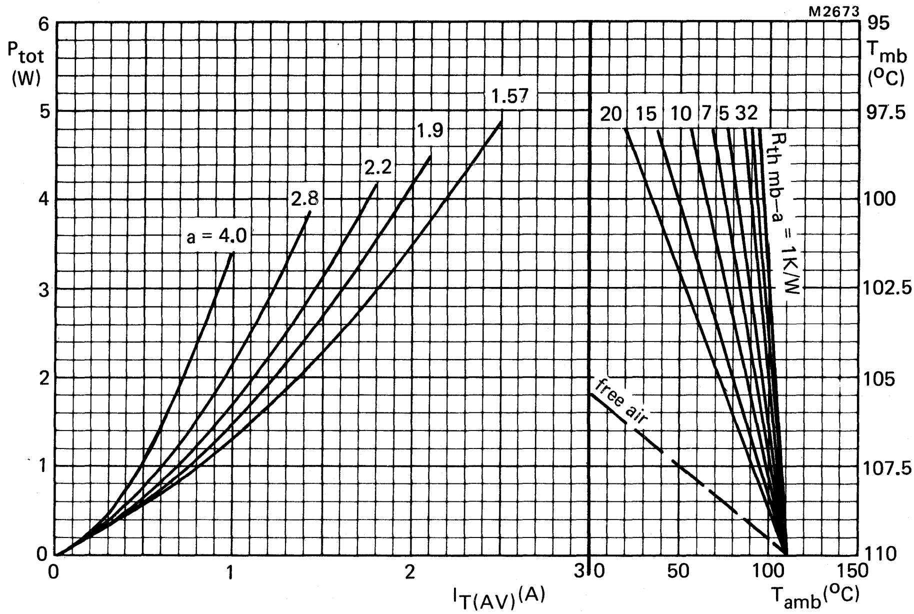
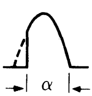


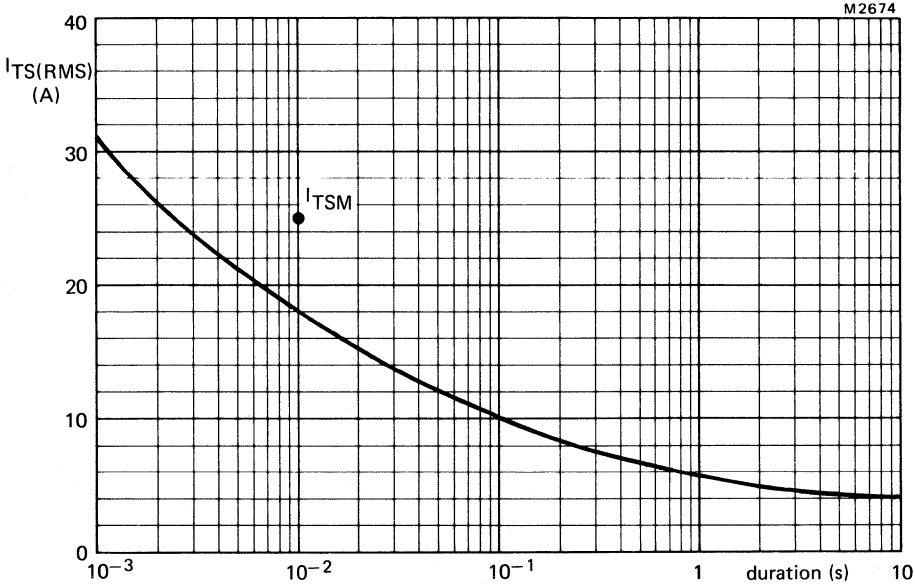
Fig.5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



α = conduction angle per half cycle

$$a = \text{form factor} = \frac{I_{T(RMS)}}{I_{T(AV)}}$$

α	a
30°	4
60°	2.8
90°	2.2
120°	1.9
180°	1.57



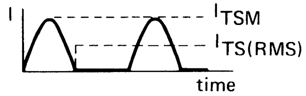


Fig.6 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents (f = 50 Hz) with reapplied V_{RWMmax}. T_j = 110 °C prior to surge.

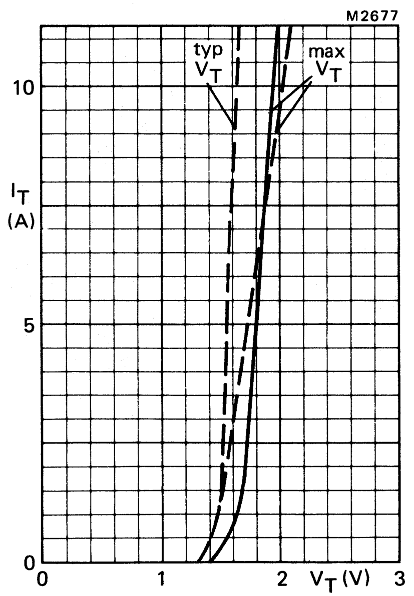


Fig.7 —— T_j = 25 °C; – – – T_j = 110 °C.

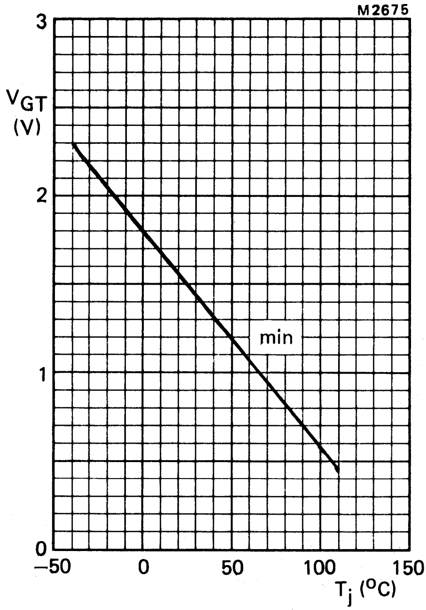


Fig.8 Minimum gate voltage that will trigger all devices as a function of junction temperature.

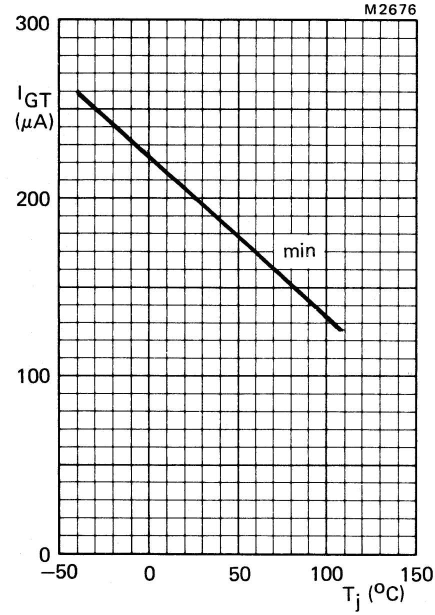


Fig.9 Minimum gate current that will trigger all devices as a function of junction temperature.

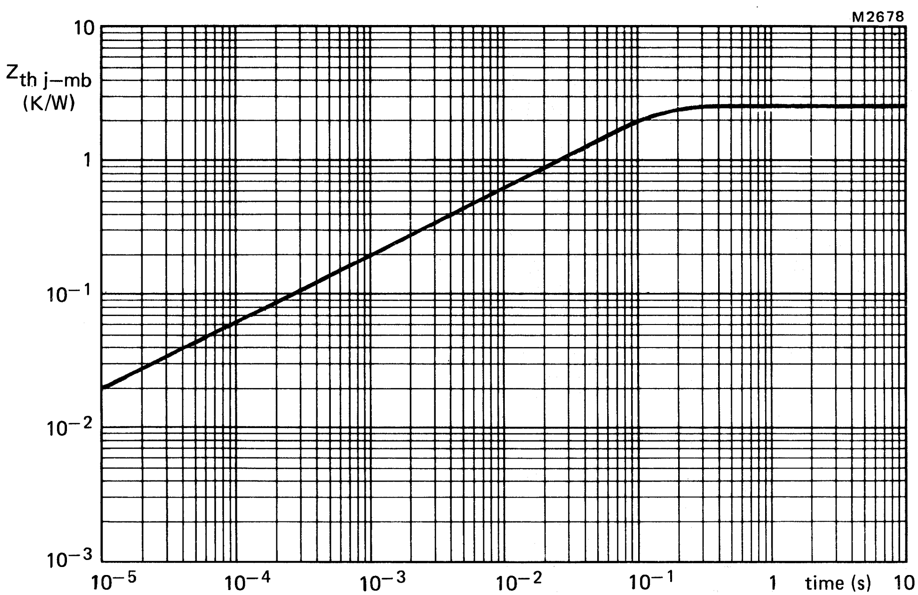


Fig.10 Transient thermal impedance.

THYRISTORS

Glass-passivated thyristors in TO-220AB envelopes, which are particularly suitable in situations creating high fatigue stresses involved in thermal cycling and repeated switching. Applications include temperature control, motor control, regulators in transformerless power supply applications, relay and coil pulsing and power supply crowbar protection circuits.

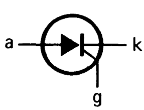
QUICK REFERENCE DATA

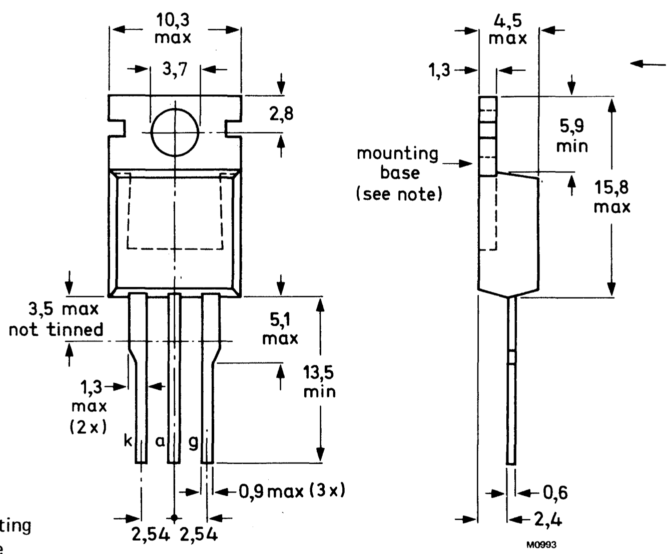
			BT151-500R	650R	800R	
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	500	650	800	V
Average on-state current	$I_{T(AV)}$	max.		7.5		A
R.M.S. on-state current	$I_{T(RMS)}$	max.		12		A
Non-repetitive peak on-state current	I_{TSM}	max.		100		A

MECHANICAL DATA

Fig.1 TO-220AB.

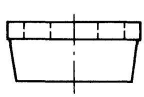
Dimensions in mm





Net mass: 2 g

Note: The exposed metal mounting base is directly connected to the anode.



Accessories supplied on request: see data sheets Mounting instructions and accessories for TO-220 envelopes.

Products approved to CECC 50 011--003 available on request.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Anode to cathode			BT151-500R	650R	800R	
Non-repetitive peak voltages ($t \leqslant 10$ ms)	V_{DSM}/V_{RSM}	max.	500	650	800	V*
Repetitive peak voltages ($\delta \leqslant 0.01$)	V_{DRM}/V_{RRM}	max.	500	650	800	V
Crest working voltages	V_{DWM}/V_{RWM}	max.	400	400	400	V
Continuous voltages	V_D/V_R	max.	400	400	400	V
Average on-state current (averaged over any 20 ms period) up to T_{mb} = 95 °C	$I_{T(AV)}$	max.		7.5		A
R.M.S. on-state current	$I_{T(RMS)}$	max.		12		A
Repetitive peak on-state current	I_{TRM}	max.		65		A
Non-repetitive peak on-state current; t = 10 ms; half sine-wave; T_j = 110 °C prior to surge; with reapplied V_{RWMmax}	I_{TSM}	max.		100		A
I^2t for fusing (t = 10 ms)	I^2t	max.		50		A^2s
Rate of rise of on-state current after triggering with I_G = 50 mA to I_T = 20 A; dI_G/dt = 50 mA/µs	dI_T/dt	max.		50		A/µs
Gate to cathode						
Reverse peak voltage	V_{RGM}	max.		5		V
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.		0.5		W
Peak power dissipation	P_{GM}	max.		5		W
Temperatures						
Storage temperature	T_{stg}			−40 to +125		°C
Operating junction temperature	T_j	max.		110		°C

*Although not recommended, higher off-state voltages may be applied without damage, but the thyristor may switch into the on-state. The rate of rise of on-state current should not exceed 15 A/µs.

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	= 1.3	K/W
Transient thermal impedance; t = 1 ms	$Z_{th\ j\text{-}mb}$	= 0.2	K/W

Influence of mounting method

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from mounting base to heatsink

a. with heatsink compound	$R_{th\ mb\text{-}h}$	= 0.3	K/W
b. with heatsink compound and 0.06 mm maximum mica insulator	$R_{th\ mb\text{-}h}$	= 1.4	K/W
c. with heatsink compound and 0.1 mm maximum mica insulator (56369)	$R_{th\ mb\text{-}h}$	= 2.2	K/W
d. with heatsink compound and 0.25 mm max. alumina insulator (56367)	$R_{th\ mb\text{-}h}$	= 0.8	K/W
e. without heatsink compound	$R_{th\ mb\text{-}h}$	= 1.4	K/W

2. Free-air operation

The quoted values of $R_{th\ j\text{-}a}$ should be used only when no leads of other dissipating components run to the same tie-point.

Thermal resistance from junction to ambient in free air:
mounted on a printed-circuit board at a = any lead length
and with copper laminate — $R_{th\ j\text{-}a}$ = 60 K/W

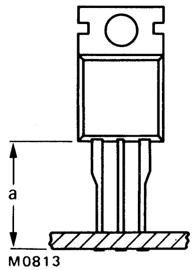


Fig. 2.

CHARACTERISTICS

Anode to cathode

On-state voltage				
I_T = 23 A; T_j = 25 °C	V_T	<	1,75	V*
Rate of rise of off-state voltage that will not trigger any device; T_j = 110 °C; see Fig.10				
R_{GK} = open circuit	dV_D/dt	<	50	V/μs
R_{GK} = 100 Ω	dV_D/dt	<	200	V/μs
Reverse current				
$V_R = V_{RWMmax}$; T_j = 110 °C	I_R	<	0,5	mA
Off-state current				
$V_D = V_{DWMmax}$; T_j = 110 °C	I_D	<	0,5	mA
Latching current; T_j = 25 °C	I_L	<	40	mA
Holding current; T_j = 25 °C	I_H	<	20	mA

Gate to cathode

Voltage that will trigger all devices				
V_D = 6 V; T_j = 25 °C	V_{GT}	>	1,5	V
V_D = 6 V; T_j = −40 °C	V_{GT}	>	2,3	V
Voltage that will not trigger any device				
$V_D = V_{DRMmax}$; T_j = 110 °C	V_{GD}	<	250	mV
Current that will trigger all devices				
V_D = 6 V; T_j = 25 °C	I_{GT}	>	15	mA
V_D = 6 V; T_j = −40 °C	I_{GT}	>	20	mA

Switching characteristics

Gate-controlled turn-on time ($t_{gt} = t_d + t_r$) when switched from $V_D = V_{DRMmax}$ to I_T = 40 A; I_{GT} = 100 mA; dI_G/dt = 5A/μs; T_j = 25 °C	t_{gt}	typ.	2	μs

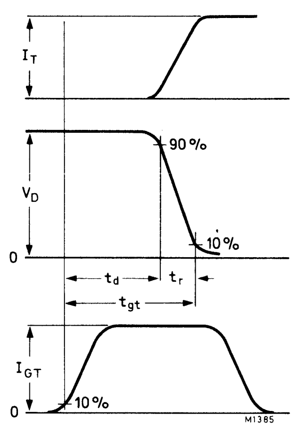


Fig.2a Gate controlled turn-on time definition.

*Measured under pulse conditions to avoid excessive dissipation.

MOUNTING INSTRUCTIONS

1. The device may be soldered directly into the circuit, but the maximum permissible temperature of the soldering iron or bath is 275 ^{o}C; it must not be in contact with the joint for more than 5 seconds. Soldered joints must be at least 4.7 mm from the seal.
2. The leads should not be bent less than 2.4 mm from the seal, and should be supported during bending. The leads can be bent, twisted or straightened by 90^{o} maximum. The minimum bending radius is 1 mm. ←
3. It is recommended that the circuit connection be made to the anode tag, rather than direct to the heatsink.
4. Mounting by means of a spring clip is the best mounting method because it offers:
   a. a good thermal contact under the crystal area and slightly lower $R_{th\ mb\text{-}h}$ values than screw mounting.
   b. safe isolation for mains operation.
   However, if a screw is used, it should be M3 cross-recess pan-head. Care should be taken to avoid damage to the plastic body.
5. For good thermal contact, heatsink compound should be used between mounting base and heatsink. Values of $R_{th\ mb\text{-}h}$ given for mounting with heatsink compound refer to the use of a metallic-oxide loaded compound. Ordinary silicone grease is not recommended.
6. Rivet mounting (only possible for non-insulated mounting)

   Devices may be rivetted to flat heatsinks; such a process **must neither** deform the mounting tab, **nor** enlarge the mounting hole.
7. The heatsink must have a flatness in the mounting area of 0.02 mm maximum per 10 mm. Mounting holes must be deburred. ←

OPERATING NOTES

Dissipation and heatsink considerations:

a. The various components of junction temperature rise above ambient are illustrated in Fig.3.

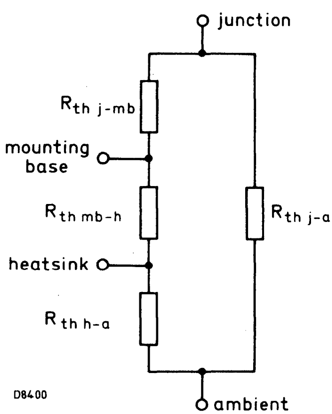


Fig. 3.

b. The method of using Fig.4 is as follows:
   Starting with the required current on the $I_{T(AV)}$ axis, trace upwards to meet the appropriate form factor curve. Trace right horizontally and upwards from the appropriate value on the T_{amb} scale. The intersection determines the $R_{th\ mb\text{-}a}$. The heatsink thermal resistance value ($R_{th\ h\text{-}a}$) can now be calculated from:

$$R_{th\ h\text{-}a} = R_{th\ mb\text{-}a} - R_{th\ mb\text{-}h}.$$

c. Any measurement of heatsink temperature should be made immediately adjacent to the device.

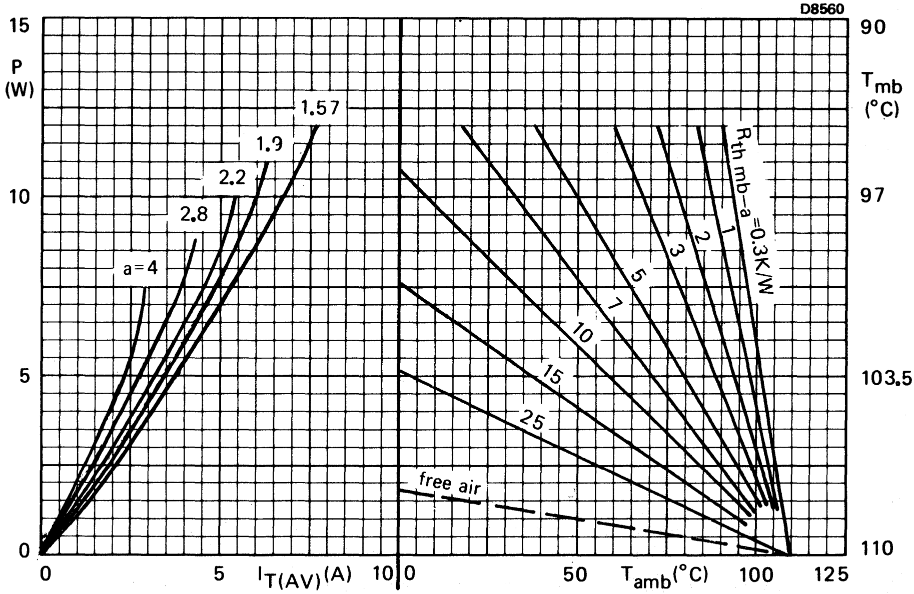
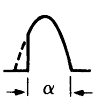


Fig.4 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



α = conduction angle per half cycle

$$a = \text{form factor} = \frac{I_{T(RMS)}}{I_{T(AV)}}$$

α	a
30°	4
60°	2,8
90°	2,2
120°	1,9
180°	1,57

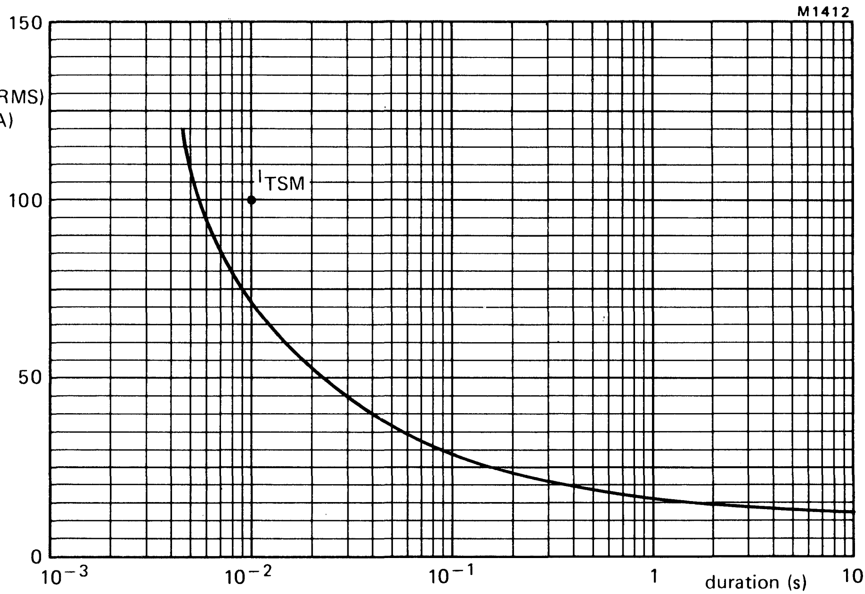
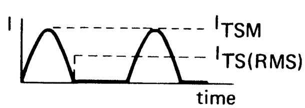


Fig.5 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents (f = 50 Hz); T_j = 110 °C prior to surge; with reapplied V_{RWMmax}.



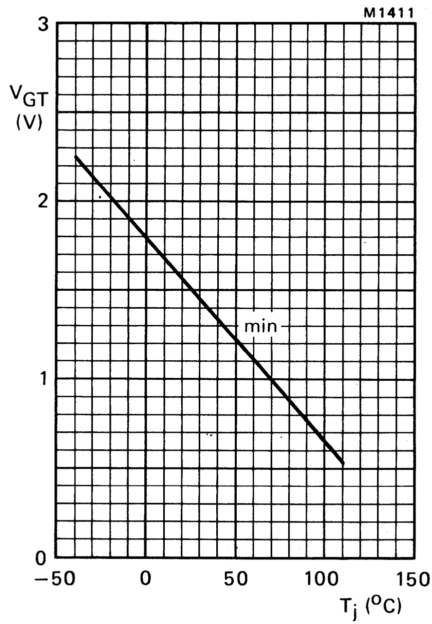


Fig.6 Minimum gate voltage that will trigger all devices as a function of junction temperature.

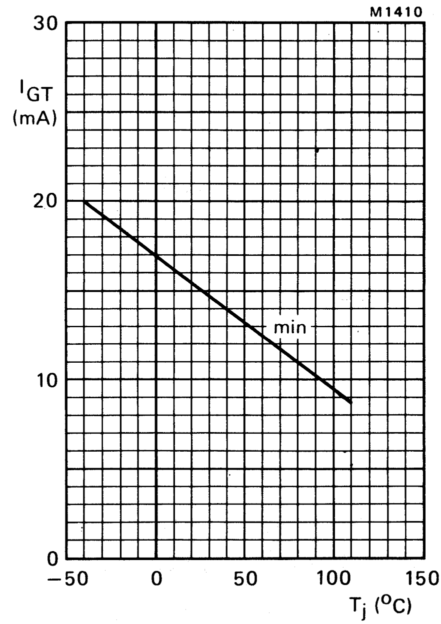


Fig.7 Minimum gate current that will trigger all devices as a function of junction temperature.

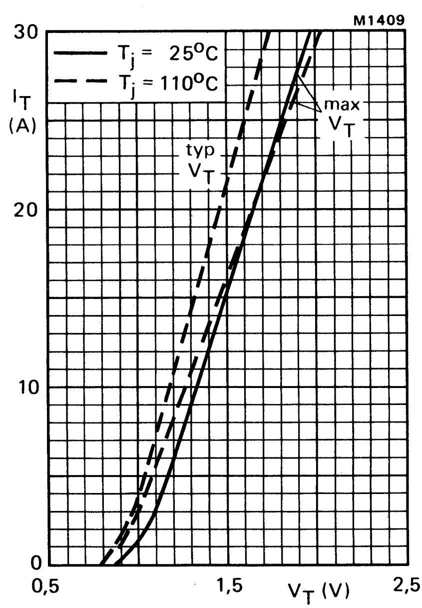


Fig.8.

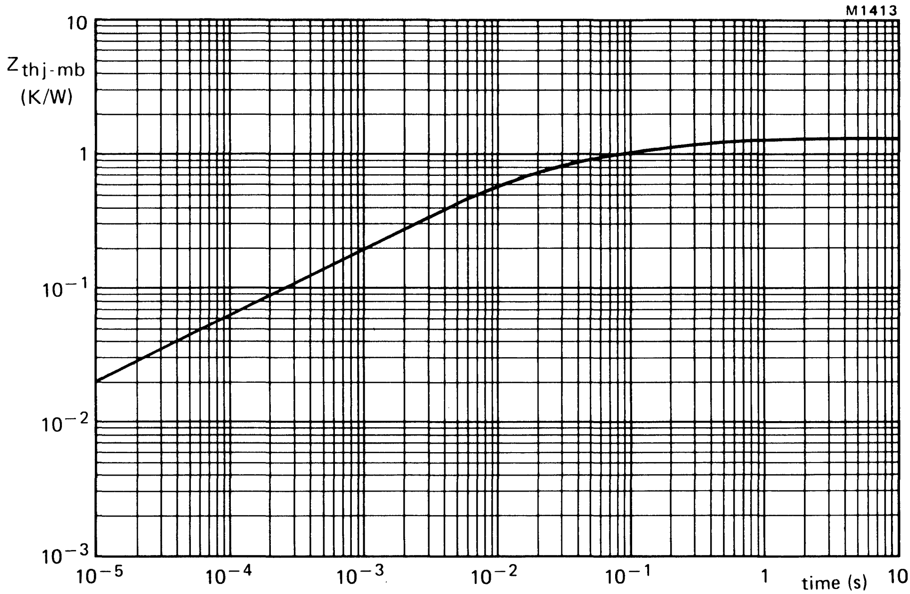


Fig.9

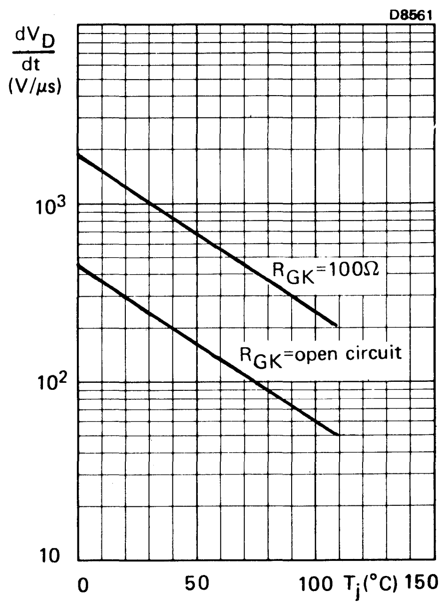


Fig.10 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of junction temperature.

FULL-PACK THYRISTORS

Glass-passivated thyristors in SOT-186 envelopes, incorporating electrical isolation between the seating plane and all three terminals. Applications include temperature control, motor control, regulators in transformerless power supply applications, relay and coil pulsing and power supply crowbar protection circuits.

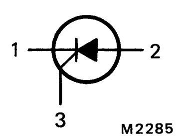
QUICK REFERENCE DATA

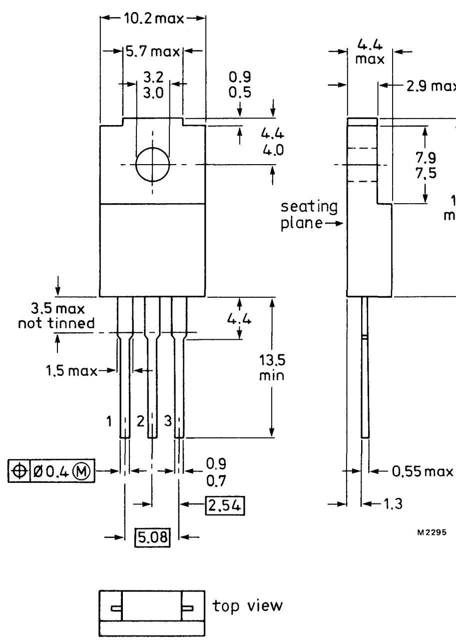
			BT151F-500	650	800	
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	500	650	800	V
Average on-state current	$I_{T(AV)}$	max.		5.7		A
R.M.S. on-state current	$I_{T(RMS)}$	max.		9		A
Non-repetitive peak on-state current	I_{TSM}	max.		100		A

MECHANICAL DATA

Dimensions in mm

Fig.1 SOT-186





Net mass 2 g.

The seating plane is electrically isolated from all three terminals.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Anode to cathode			BT151F-500	650	800	
Non-repetitive peak voltages ($t \leq 10$ ms)	V_{DSM}/V_{RSM}	max.	500	650	800	V*
Repetitive peak voltages ($\delta \leq 0.01$)	V_{DRM}/V_{RRM}	max.	500	650	800	V
Crest working voltages	V_{DWM}/V_{RWM}	max.	400	400	400	V
Continuous voltages	V_D/V_R	max.	400	400	400	V
Average on-state current (averaged over any 20 ms period) up to $T_h = 74$ °C	$I_{T(AV)}$	max.		5.7		A
R.M.S. on-state current	$I_{T(RMS)}$	max.		9		A
Repetitive peak on-state current	I_{TRM}	max.		65		A
Non-repetitive peak on-state current $t = 10$ ms; half-sinewave; $T_j = 110$ °C prior to surge; with reapplied V_{RWMmax}	I_{TSM}	max.		100		A
I^2t for fusing ($t = 10$ ms)	I^2t	max.		50		A^2s
Rate of rise of on-state current after triggering with $I_G = 50$ mA to $I_T = 20$ A; $dI_G/dt = 50$ mA/µs	dI_T/dt	max.		50		A/µs
Gate to cathode						
Reverse peak voltage	V_{RGM}	max.		5		V
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.		0.5		W
Peak power dissipation	P_{GM}	max.		5		W
Temperatures						
Storage temperature	T_{stg}			−40 to +125		°C
Operating junction temperature	T_j	max.		110		°C

ISOLATION

From all three terminals to external heatsink (peak)	V_{isol}	min.	1000	V
Capacitance from anode to external heatsink	C_{isol}	typ.	12	pF

*Although not recommended, higher off-state voltages may be applied without damage, but the thyristor may switch into the on-state. The rate of rise of on-state current should not exceed 15 A/µs.

THERMAL RESISTANCE

1. Heatsink-mounted with clip (see mounting instructions)

   Thermal resistance from junction to external heatsink

With heatsink compound	$R_{th\ j\text{-}h}$	=	4.5	K/W
Without heatsink compound	$R_{th\ j\text{-}h}$	=	6.5	K/W

2. Free-air operation

   The quoted values of $R_{th\ j\text{-}a}$ should be used only when no leads of other dissipating components run to the same tie-point.

   Thermal resistance from junction to ambient in free air; mounted on a printed-circuit board at a = any lead length and with copper laminate $R_{th\ j\text{-}a}$ = 55 K/W

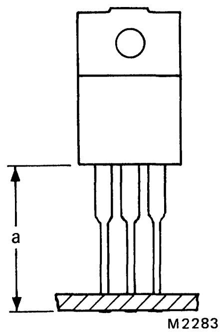


Fig.2.

CHARACTERISTICS

Anode to cathode

On-state voltage				
I_T = 23 A; T_j = 25 °C	V_T	<	1.75	V*
Rate of rise of off-state voltage that will not trigger any device; T_j = 110 °C; see Fig.10				
R_{GK} = open circuit	dV_D/dt	<	50	V/μs
R_{GK} = 100 Ω	dV_D/dt	<	200	V/μs
Reverse current				
$V_R = V_{RWMmax}$; T_j = 110 °C	I_R	<	0.5	mA
Off-state current				
$V_D = V_{DWMmax}$; T_j = 110 °C	I_D	<	0.5	mA
Latching current; T_j = 25 °C	I_L	<	40	mA
Holding current; T_j = 25 °C	I_H	<	20	mA

Gate to cathode

Voltage that will trigger all devices				
V_D = 6 V; T_j = 25 °C	V_{GT}	>	1.5	V
V_D = 6 V; T_j = −40 °C	V_{GT}	>	2.3	V
Voltage that will not trigger any device				
$V_D = V_{DRMmax}$; T_j = 110 °C	V_{GD}	<	250	mV
Current that will trigger all devices				
V_D = 6 V; T_j = 25 °C	I_{GT}	>	15	mA
V_D = 6 V; T_j = −40 °C	I_{GT}	>	20	mA

Switching characteristics

Gate-controlled turn-on time ($t_{gt} = t_d + t_r$) when switched from $V_D = V_{DRMmax}$ to I_T = 40 A; I_{GT} = 100 mA; dI_G/dt = 5 A/μs; T_j = 25 °C	t_{gt}	typ.	2	μs

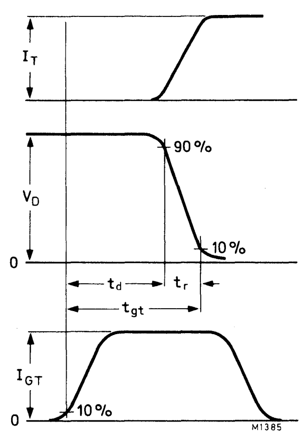


Fig.3 Gate controlled turn-on time definition.

*Measured under pulse conditions to avoid excessive dissipation.

MOUNTING INSTRUCTIONS

1. The device may be soldered directly into the circuit, but the maximum permissible temperature of the soldering iron or bath is 275 °C; it must not be in contact with the joint for more than 5 seconds. Soldered joints must be at least 4.7 mm from the seal.
2. The leads should not be bent less than 2.4 mm from the seal, and should be supported during bending.
3. Mounting by means of a spring clip is the best mounting method because it offers good thermal contact under the crystal and slightly lower $R_{th\ j\text{-}h}$ values than screw mounting. It is recommended that the force exerted on the top of the device by the clip should be at least 2 kgf (20 N).
4. However, if a screw is used it should be M3 cross-recess pan-head. Care should be taken to avoid damage to the plastic body.

   For good thermal contact heatsink compound should be used between seating plane and heatsink. Values of $R_{th\ j\text{-}h}$ given for mounting with heatsink compound refer to the use of a metallic-oxide loaded compound. Ordinary silicone grease is not recommended.
5. Rivet mounting is not recommended.

OPERATING NOTES

Dissipation and heatsink considerations:

a. The various components of junction temperature rise above ambient are illustrated in Fig.4.

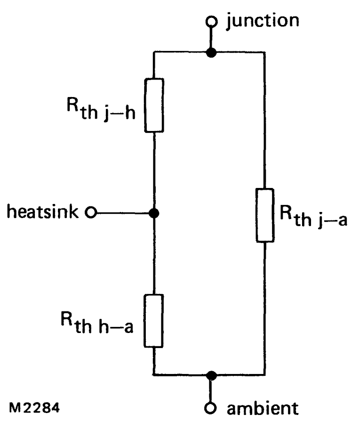


Fig.4.

b. The method of using Fig.5 is as follows:

Starting with the required current on the $I_{T(AV)}$ axis of Fig.5a, trace upwards to meet the appropriate form factor curve and read off the power P on the left hand scale. Using this value of P, on either Fig.5b or c, trace right horizontally and upwards from the appropriate value on the T_{amb} scale. The intersection determines $R_{th\ h\text{-}a}$, the required heatsink thermal resistance value.

c. Any measurement of heatsink temperature should be made immediately adjacent to the device.

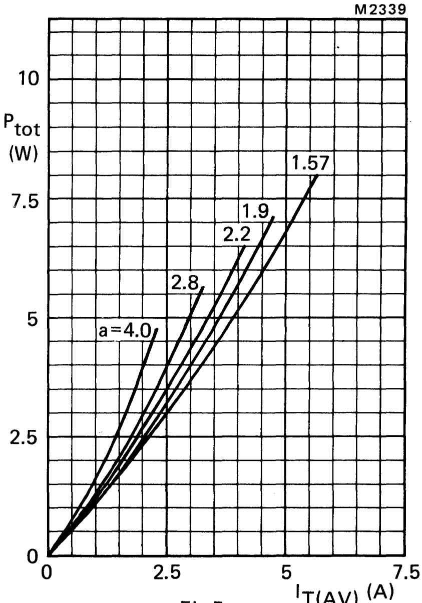
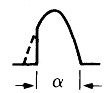


Fig.5a.

∝ = conduction angle per half cycle

$$a = \text{form factor} = \frac{I_{T(RMS)}}{I_{T(AV)}}$$



α	a
30°	4
60°	2.8
90°	2.2
120°	1.9
180°	1.57

Figs. 5a,b,c Interrelationship between power (derived from Fig.5a) and maximum permissible temperatures.

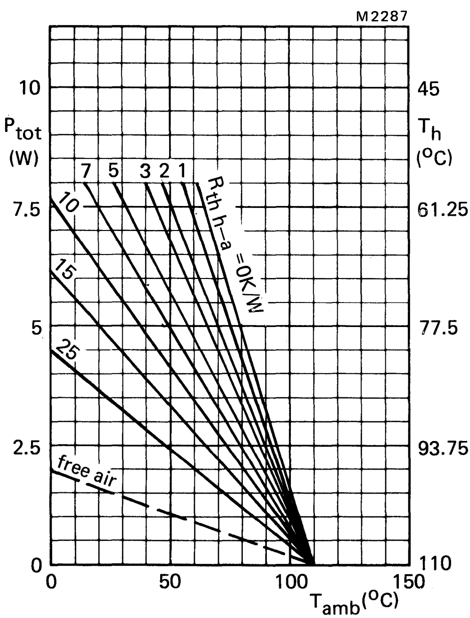


Fig.5b Without heatsink compound.

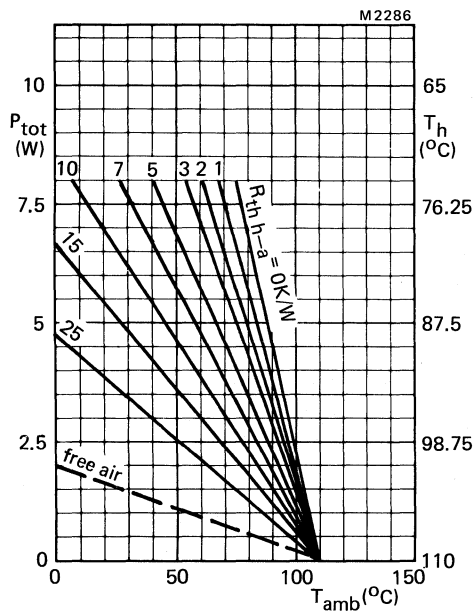


Fig.5c With heatsink compound.

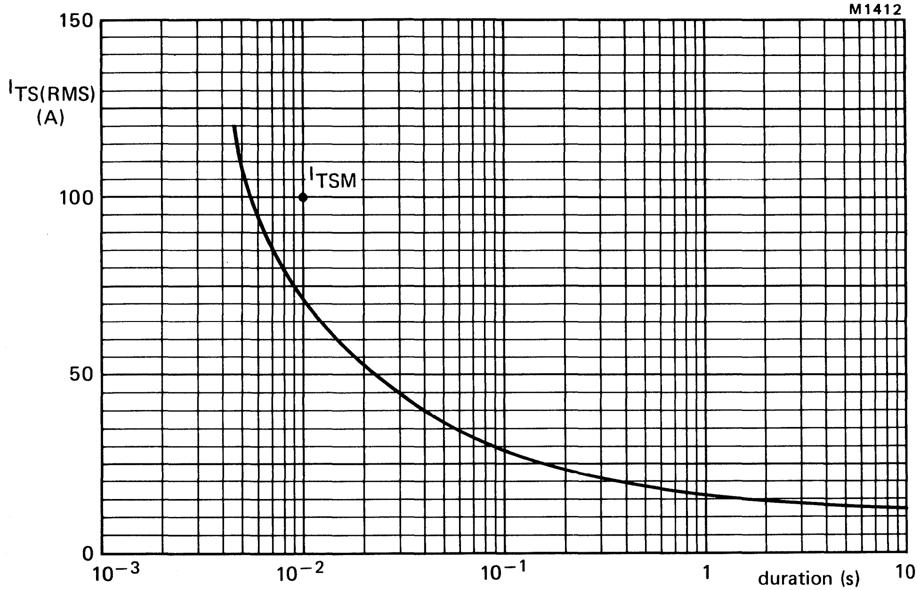
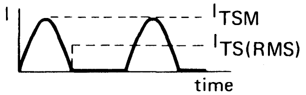


Fig.6 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents (f = 50 Hz); T_j = 110 °C prior to surge; with reapplied V_{RWMmax}.



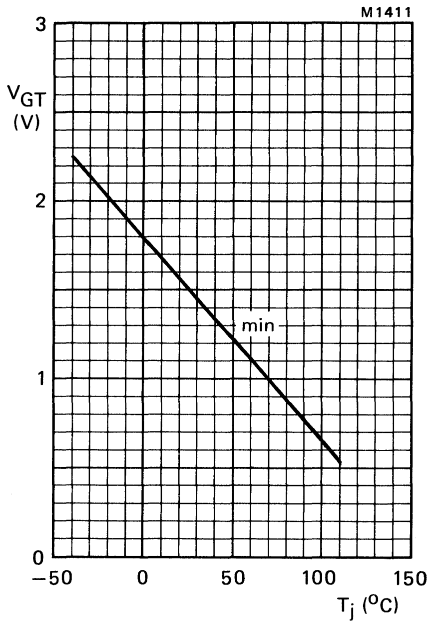


Fig.7 Minimum gate voltage that will trigger all devices as a function of junction temperature.

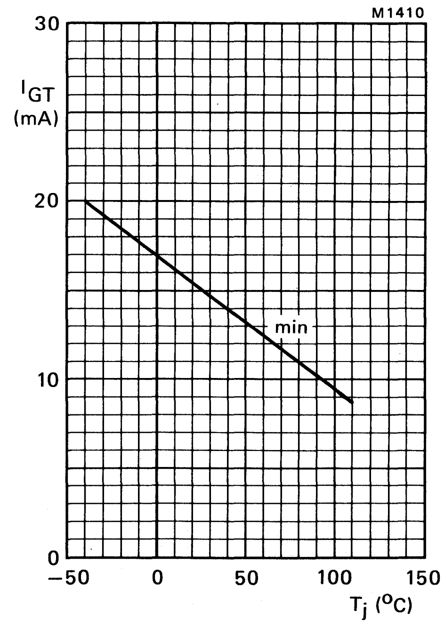


Fig.8 Minimum gate current that will trigger all devices as a function of junction temperature.

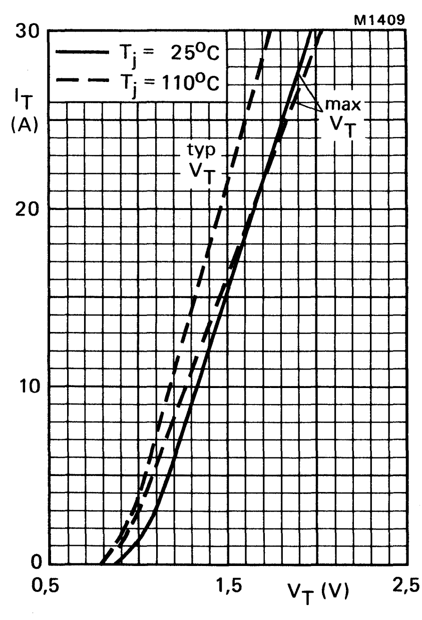


Fig.9.

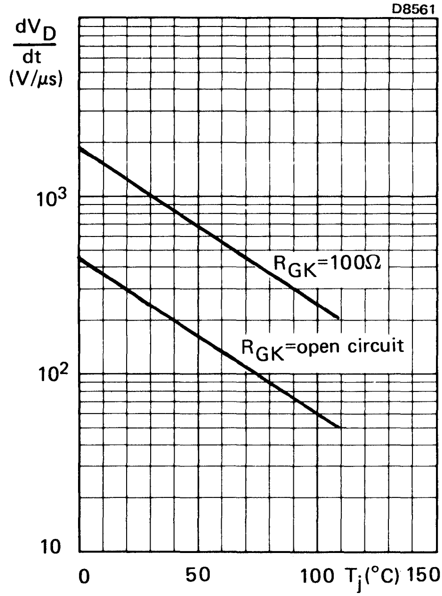


Fig.10 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of junction temperature.

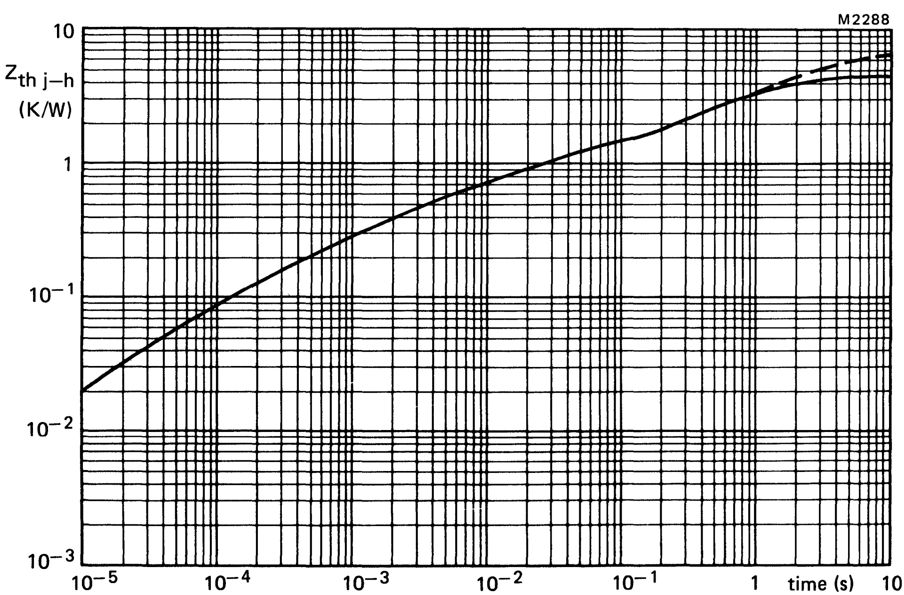


Fig.11 Transient thermal impedance; ——— with heatsink compound; – – – without heatsink compound.

THYRISTORS

Glass-passivated thyristors in TO–220AB envelopes, which are particularly suitable in situations creating high fatigue stresses involved in thermal cycling and repeated switching. Applications include temperature control, motor control, regulators in transformerless power supply applications, relay and coil pulsing and power supply crowbar protection circuits.

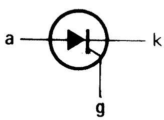
QUICK REFERENCE DATA

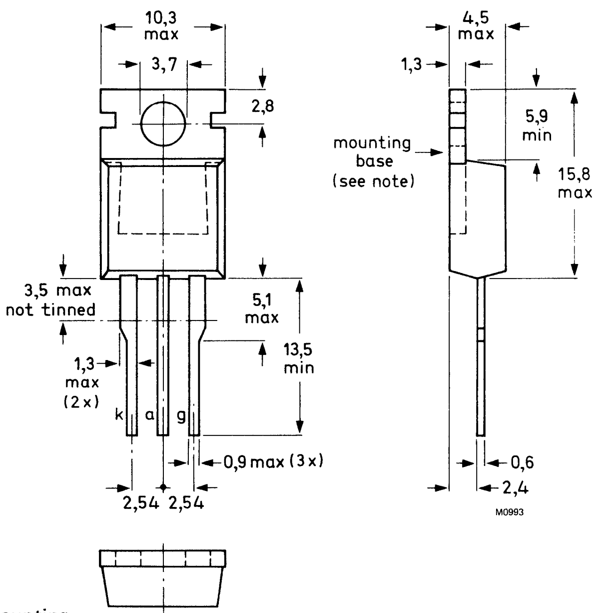
			BT152–400R	600R	800R	
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	400	600	800	V
Average on-state current	$I_{T(AV)}$	max.		13		A
R.M.S. on-state current	$I_{T(RMS)}$	max.		20		A
Non-repetitive peak on-state current	I_{TSM}	max.		200		A

MECHANICAL DATA

Dimensions in mm

Fig.1 TO–220AB





Net mass: 2 g

Note: The exposed metal mounting base is directly connected to the anode

Accessories supplied on request: see data sheets Mounting instructions and accessories for TO–220 envelopes.

Products approved to CECC 50 011-011 available on request.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Anode to cathode

			BT152–400R	600R	800R	
Non-repetitive peak voltages	V_{DSM}/V_{RSM}	max.	450	650	850	V
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	400	600	800	V
Crest working voltages	V_{DWM}/V_{RWM}	max.	400	400	400	V

Average on-state current (averaged over any 20 ms period) up to T_{mb} = 93 °C	$I_{T(AV)}$	max.	13	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	20	A
Repetitive peak on-state current	I_{TRM}	max.	200	A
Non-repetitive peak on-state current; t = 10 ms; half sine-wave; T_j = 115 °C prior to surge; with reapplied V_{RWMmax}	I_{TSM}	max.	200	A
I^2t for fusing (t = 10 ms)	I^2t	max.	200	A^2s
Rate of rise of on-state current after triggering with I_G = 160 mA to I_T = 50 A; dI_G/dt = 160 A/ms	dI_T/dt	max.	200	A/µs

Gate to cathode

Reverse peak voltage	V_{RGM}	max.	5	V
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	0.5	W
Peak power dissipation; t ≤ 10 µs	P_{GM}	max.	20	W

Temperature

Storage temperature	T_{stg}		–40 to +150	°C
Junction temperature	T_j	max.	115	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	= 1.1	K/W
Transient thermal impedance; t = 1 ms	$Z_{th\ j\text{-}mb}$	= 0.12	K/W

Influence of mounting method

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from mounting base to heatsink

a. with heatsink compound	$R_{th\ mb\text{-}h}$	= 0.3	K/W
b. with heatsink compound and 0.06 mm maximum mica insulator	$R_{th\ mb\text{-}h}$	= 1.4	K/W
c. with heatsink compound and 0.1 mm maximum mica insulator (56369)	$R_{th\ mb\text{-}h}$	= 2.2	K/W
d. with heatsink compound and 0.25 mm max. alumina insulator (56367)	$R_{th\ mb\text{-}h}$	= 0.8	K/W
e. without heatsink compound	$R_{th\ mb\text{-}h}$	= 1.4	K/W

2. Free-air operation

The quoted values of $R_{th\ j\text{-}a}$ should be used only when no leads of other dissipating components run to the same tie-point.

Thermal resistance from junction to ambient in free air:
mounted on a printed-circuit board at a = any lead length
and with copper laminate — $R_{th\ j\text{-}a}$ = 60 K/W

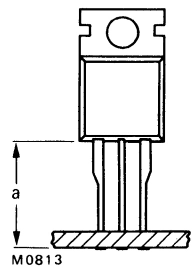


Fig. 2.

CHARACTERISTICS

Anode to cathode

On-state voltage (measured under pulse conditions)				
I_T = 40 A; T_j = 25 °C	V_T	<	1.75	V
Rate of rise of off-state voltage that will not trigger any device				
T_j = 115 °C; R_{GK} = open circuit	dV_D/dt	<	200	V/µs
Reverse current				
$V_R = V_{RWMmax}$; T_j = 115 °C	I_R	<	1.0	mA
Off-state current				
$V_D = V_{DWMmax}$; T_j = 115 °C	I_D	<	1.0	mA
Latching current; T_j = 25 °C	I_L	<	80	mA
Holding current; T_j = 25 °C	I_H	<	60	mA

Gate to cathode

Voltage that will trigger all devices				
V_D = 12 V; T_j = −40 °C	V_{GT}	>	1.5	V
V_D = 12 V; T_j = 25 °C	V_{GT}	>	1.0	V
Voltage that will not trigger any device				
$V_D = V_{DRMmax}$; T_j = 115 °C	V_{GD}	<	0.25	V
Current that will trigger all devices				
V_D = 12 V; T_j = −40 °C	I_{GT}	>	50	mA
V_D = 12 V; T_j = 25 °C	I_{GT}	>	32	mA

Switching characteristics

Gate-controlled turn-on time ($t_{gt} = t_d + t_r$) when switched from $V_D = V_{DRMmax}$ to I_T = 40 A; I_{GT} = 100 mA; dI_G/dt = 5 A/µs; T_j = 25 °C	t_{gt}	typ.	2	µs
Circuit-commutated turn-off time when switched from I_T = 40 A to V_R > 50 V with $-dI_T/dt$ = 10 A/µs; dV_D/dt = 50 V/µs; T_j = 115 °C	t_q	typ.	35	µs

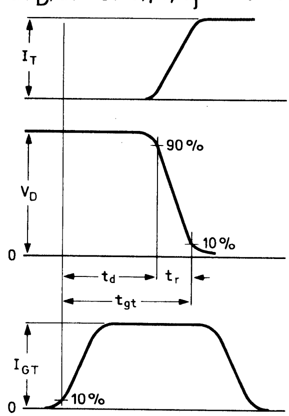


Fig.3a Gate-controlled turn-on time definition.

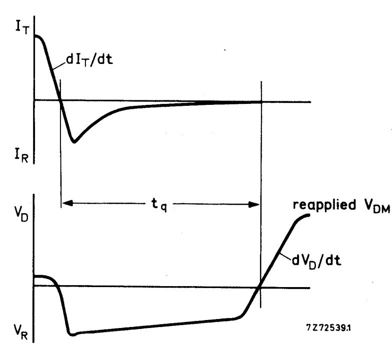


Fig.3b Circuit-commutated turn-off time definition.

MOUNTING INSTRUCTIONS

1. The device may be soldered directly into the circuit, but the maximum permissible temperature of the soldering iron or bath is 275 °C; it must not be in contact with the joint for more than 5 seconds. Soldered joints must be at least 4.7 mm from the seal.
2. The leads should not be bent less than 2.4 mm from the seal, and should be supported during bending. The leads can be bent, twisted or straightened by 90° maximum. The minimum bending radius is 1 mm.
3. It is recommended that the circuit connection be made to the anode tag, rather than direct to the heatsink.
4. Mounting by means of a spring clip is the best mounting method because it offers:
   a. a good thermal contact under the crystal area and slightly lower $R_{th\ mb\text{-}h}$ values than screw mounting.
   b. safe isolation for mains operation.
   However, if a screw is used, it should be M3 cross-recess pan-head. Care should be taken to avoid damage to the plastic body.
5. For good thermal contact, heatsink compound should be used between mounting base and heatsink. Values of $R_{th\ mb\text{-}h}$ given for mounting with heatsink compound refer to the use of a metallic-oxide loaded compound. Ordinary silicone grease is not recommended.
6. Rivet mounting (only possible for non-insulated mounting)
   Devices may be rivetted to flat heatsinks; such a process **must neither** deform the mounting tab, **nor** enlarge the mounting hole.
7. The heatsink must have a flatness in the mounting area of 0.02 mm maximum per 10 mm. Mounting holes must be deburred.

OPERATING NOTES

Dissipation and heatsink considerations:

a. The various components of junction temperature rise above ambient are illustrated in Fig.4.

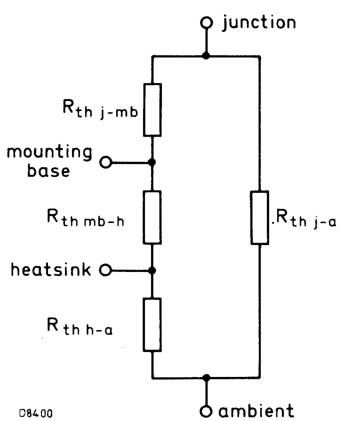


Fig.4

b. The method of using Fig.5 is as follows:
Starting with the required current on the $I_{T(AV)}$ axis, trace upwards to meet the appropriate form factor curve. Trace right horizontally and upwards from the appropriate value on the T_{amb} scale. The intersection determines the $R_{th\ mb\text{-}a}$. The heatsink thermal resistance value ($R_{th\ h\text{-}a}$) can now be calculated from:

$$R_{th\ h\text{-}a} = R_{th\ mb\text{-}a} - R_{th\ mb\text{-}h}.$$

c. Any measurement of heatsink temperature should be made immediately adjacent to the device.

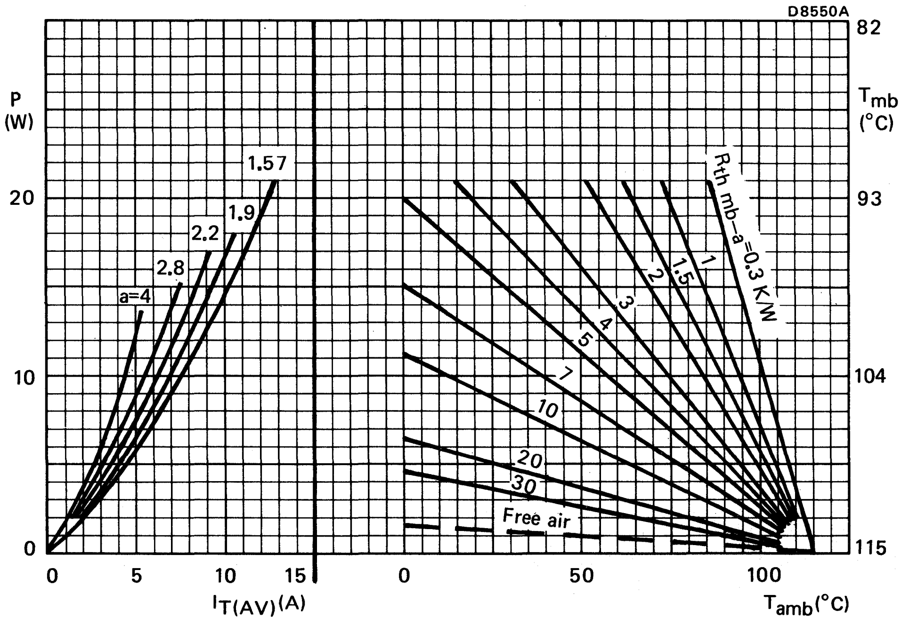
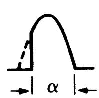


Fig.5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



α = conduction angle per half cycle

$$a = \text{form factor} = \frac{I_{T\,(RMS)}}{I_{T(AV)}}$$

α	a
30°	4
60°	2.8
90°	2.2
120°	1.9
180°	1.57

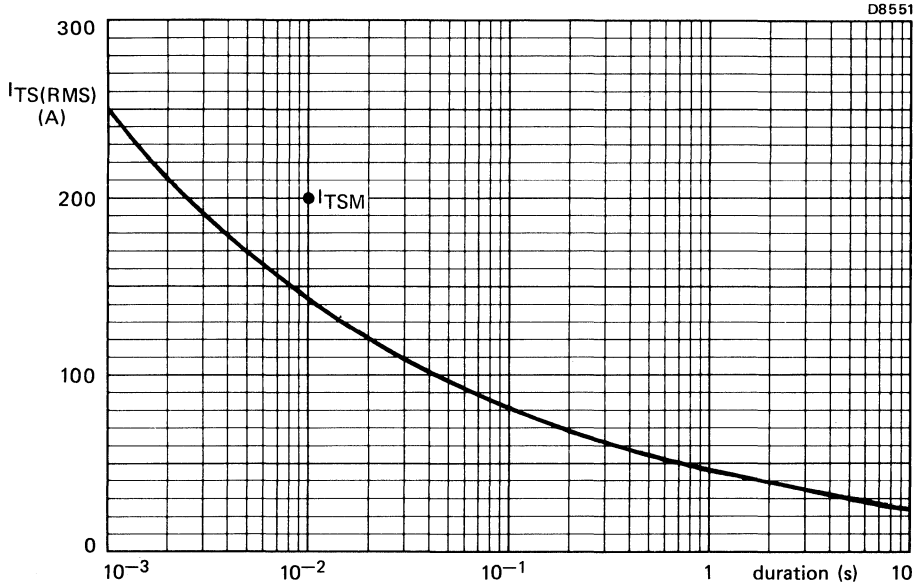
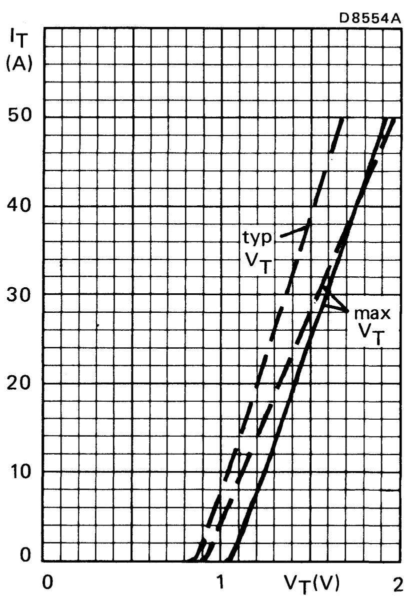


Fig.6 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents (f = 50 Hz); T_j = 115 °C prior to surge; with reapplied V_{RWMmax}.



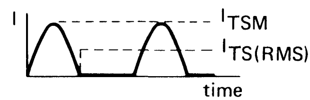


Fig.7 —— T_j = 25 °C; – – – T_j = 115 °C

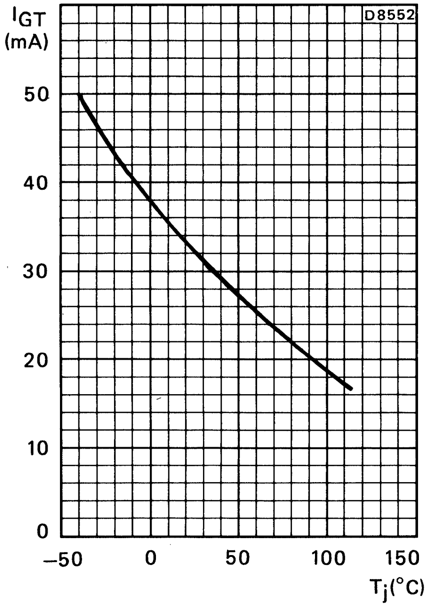


Fig. 8 Minimum gate current that will trigger all devices as a function of junction temperature.

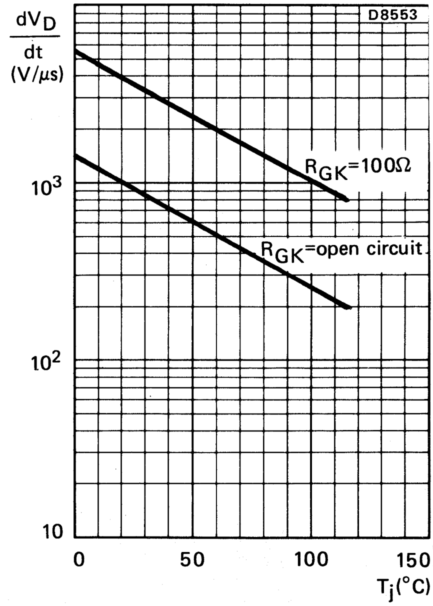


Fig. 9 Maximum rate of rise of off-state voltage that will not trigger any device as a function of junction temperature.

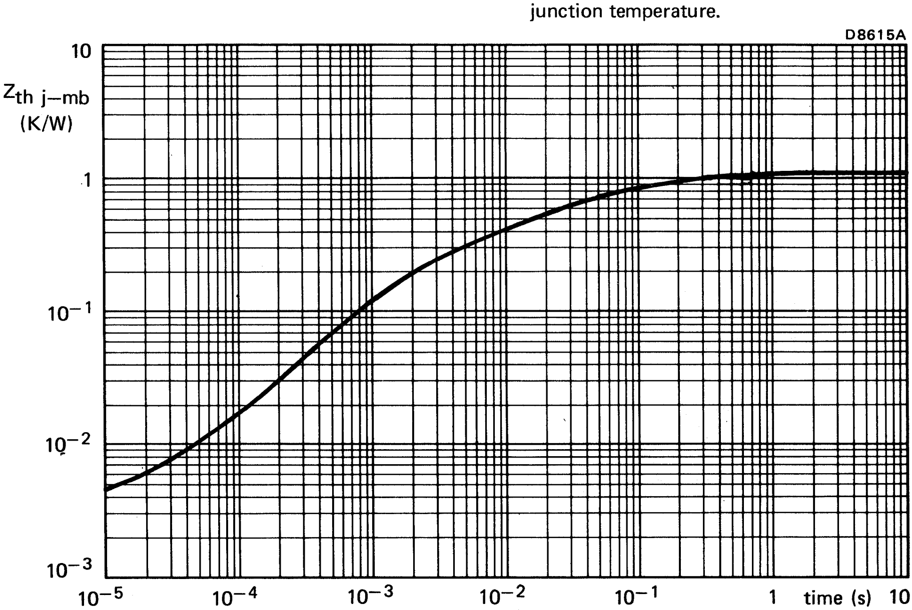


Fig. 10

FAST TURN-OFF THYRISTOR

Glass-passivated fast-turn-off thyristor in a TO-220AB envelope, intended for use in inverter, pulse and switching applications. Its characteristics make the device extremely suitable for use in regulator, vertical deflection, and east/west correction circuits of colour television receivers.

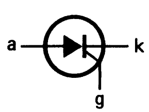
QUICK REFERENCE DATA

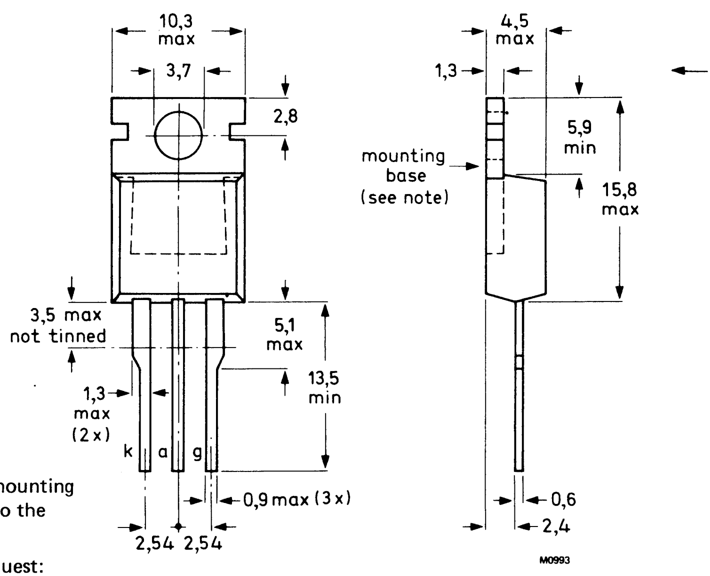
Repetitive peak off-state voltage	V_{DRM}	max.	500	V
Average on-state current	$I_{T(AV)}$	max.	4	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	6	A
Repetitive peak on-state current	I_{TRM}	max.	30	A
Circuit-commutated turn-off time	t_q	<	20	μs

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

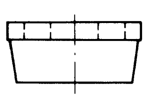




Net mass: 2 g

Note: The exposed metal mounting base is directly connected to the anode.

Accessories supplied on request: see data sheets Mounting instructions and accessories for TO-220 envelopes.



RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Anode to cathode

Non-repetitive peak voltages ($t \leq 10$ ms)	V_{DSM}/V_{RSM}	max.	550	V
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	500	V
Working voltages	V_{DW}/V_{RW}	max.	400	V *
Average on-state current (averaged over any 20 ms period) up to T_{mb} = 95 °C	$I_{T(AV)}$	max.	4	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	6	A
Working peak on-state current	I_{TWM}	max.	10	A
Repetitive peak on-state current	I_{TRM}	max.	30	A
Non-repetitive peak on-state current; t = 10 ms; half sine-wave; T_j = 110 °C prior to surge; with reapplied V_{RWMmax}	I_{TSM}	max.	40	A
I^2t for fusing; t = 10 ms; T_j = 25 °C	I^2t	max.	10	A^2s
Rate of rise of on-state current after triggering up to f = 20 kHz; V_{DM} = 300 V to I_{TM} = 6 A	dI_T/dt	max.	200	A/μs

Gate to cathode

Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	1	W
Peak power dissipation; t = 10 μs	P_{GM}	max.	25	W

Temperatures

Storage temperature	T_{stg}	−40 to + 125		°C
Operating junction temperature	T_j	max.	110	°C

* Voltage shapes as occurring in the intended application.

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	= 1,5 °C/W
Transient thermal impedance; t = 1 ms	$Z_{th\ j\text{-}mb}$	= 0,2 °C/W

Influence of mounting method

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from mounting base to heatsink

a. with heatsink compound	$R_{th\ mb\text{-}h}$	= 0,3 °C/W
b. with heatsink compound and 0,06 mm maximum mica insulator	$R_{th\ mb\text{-}h}$	= 1,4 °C/W
c. with heatsink compound and 0,1 mm maximum mica insulator (56369)	$R_{th\ mb\text{-}h}$	= 2,2 °C/W
d. with heatsink compound and 0,25 mm max. alumina insulator (56367)	$R_{th\ mb\text{-}h}$	= 0,8 °C/W
e. without heatsink compound	$R_{th\ mb\text{-}h}$	= 1,4 °C/W

2. Free-air operation

The quoted values of $R_{th\ j\text{-}a}$ should be used only when no leads of other dissipating components run to the same tie-point.

Thermal resistance from junction to ambient in free air:
mounted on a printed-circuit board at a = any lead length
and with copper laminate $R_{th\ j\text{-}a}$ = 60 °C/W

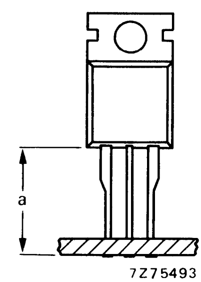


Fig. 2.

CHARACTERISTICS

Anode to cathode

On-state voltage $I_T = 10$ A; $T_j = 25$ °C	V_T	<	2,5 V *
Rate of rise of off-state voltage that will not trigger any device; $T_j \leqslant 110$ °C	dV_D/dt	<	200 V/μs
Off-state current $V_D = V_{DRMmax}$; $T_j = 110$ °C	I_D	<	1,5 mA
Holding current; $T_j = 25$ °C	I_H	<	100 mA

Gate to cathode

Voltage that will trigger all devices $V_D = 6$ V; $T_j = 25$ °C; $t_p \geqslant 5$ μs	V_{GT}	>	2,5 V
Current that will trigger all devices $V_D = 6$ V; $T_j = 25$ °C; $t_p \geqslant 5$ μs	I_{GT}	>	40 mA

Switching characteristics

Circuit-commutated turn-off time (in regulating circuits) when switched from $I_T = 10$ A to $V_R \geqslant 50$ V with $-dI_T/dt = 10$ A/μs; $dV_D/dt = 200$ V/μs; $V_{DM} = 500$ V; $R_{GK} = 68\ \Omega$; $T_{mb} = 80$ °C; $t_p \leqslant 50$ μs	t_q	<	20 μs

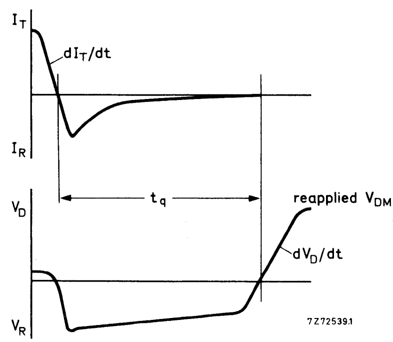


Fig. 3 Circuit-commutated turn-off time definition.

* Measured under pulse conditions to avoid excessive dissipation.

MOUNTING INSTRUCTIONS

1. The device may be soldered directly into the circuit, but the maximum permissible temperature of the soldering iron or bath is 275 °C; it must not be in contact with the joint for more than 5 seconds. Soldered joints must be at least 4.7 mm from the seal.
2. The leads should not be bent less than 2.4 mm from the seal, and should be supported during bending. The leads can be bent, twisted or straightened by 90° maximum. The minimum bending radius is 1 mm.
3. It is recommended that the circuit connection be made to the anode tag, rather than direct to the heatsink.
4. Mounting by means of a spring clip is the best mounting method because it offers:
   a. a good thermal contact under the crystal area and slightly lower $R_{th\ mb\text{-}h}$ values than screw mounting.
   b. safe isolation for mains operation.
   However, if a screw is used, it should be M3 cross-recess pan-head. Care should be taken to avoid damage to the plastic body.
5. For good thermal contact, heatsink compound should be used between mounting base and heatsink. Values of $R_{th\ mb\text{-}h}$ given for mounting with heatsink compound refer to the use of a metallic-oxide loaded compound. Ordinary silicone grease is not recommended.
6. Rivet mounting (only possible for non-insulated mounting)
   Devices may be rivetted to flat heatsinks; such a process **must neither** deform the mounting tab, **nor** enlarge the mounting hole.
7. The heatsink must have a flatness in the mounting area of 0.02 mm maximum per 10 mm. Mounting holes must be deburred.

OPERATING NOTES

Dissipation and heatsink considerations:

a. The various components of junction temperature rise above ambient are illustrated in Fig.4.

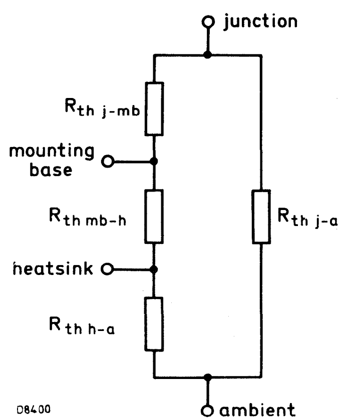


Fig.4

b. The method of using Fig.5 is as follows:
Starting with the required current on the $I_{T(AV)}$ axis, trace upwards to meet the appropriate form factor curve. Trace right horizontally and upwards from the appropriate value on the T_{amb} scale. The intersection determines the $R_{th\ mb\text{-}a}$. The heatsink thermal resistance value ($R_{th\ h\text{-}a}$) can now be calculated from:

$$R_{th\ h\text{-}a} = R_{th\ mb\text{-}a} - R_{th\ mb\text{-}h}.$$

c. Any measurement of heatsink temperature should be made immediately adjacent to the device.

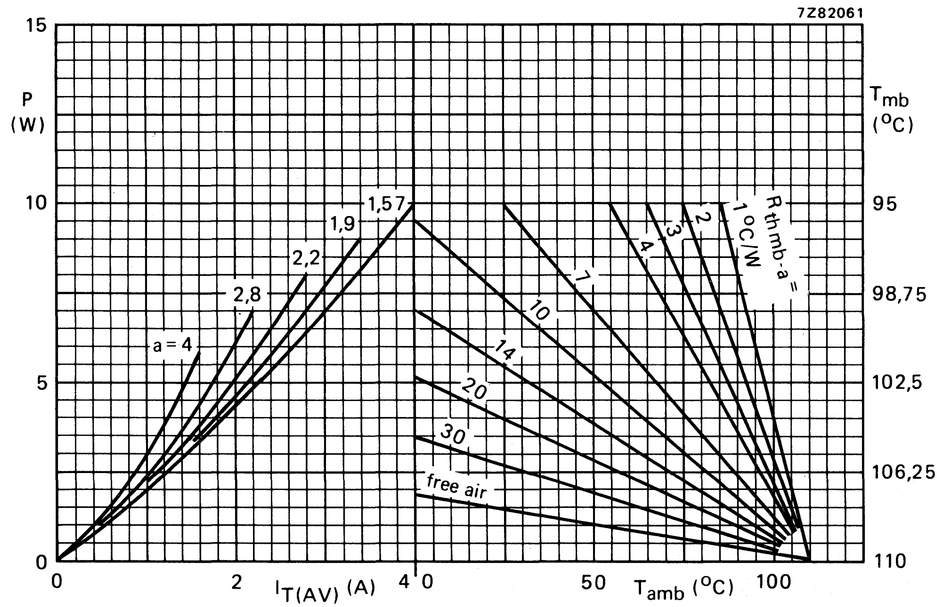
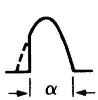


Fig. 5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



α = conduction angle per half cycle

$$a = \text{form factor} = \frac{I_{T(RMS)}}{I_{T(AV)}}$$

α	a
30°	4
60°	2,8
90°	2,2
120°	1,9
180°	1,57

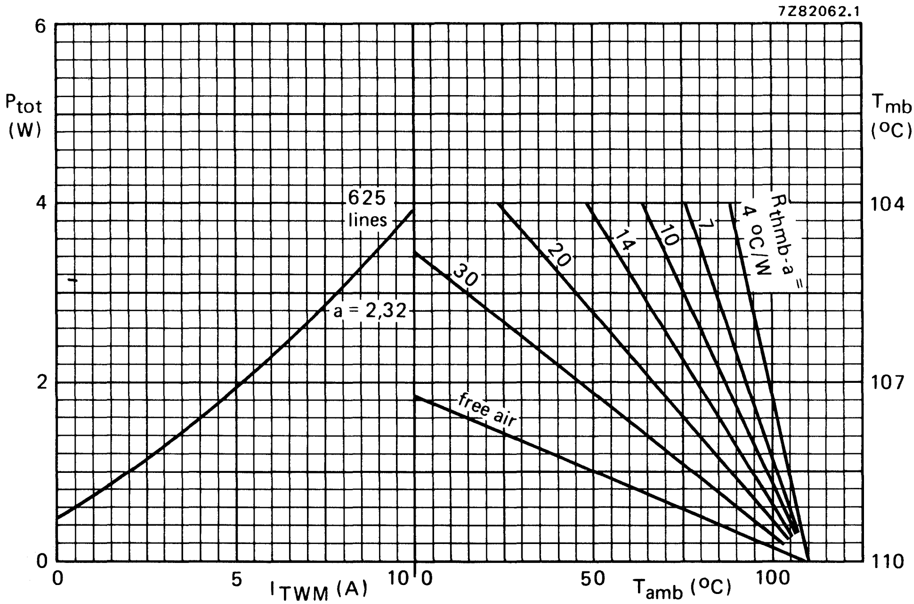


Fig. 6 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.
P_{tot} = maximum power dissipation including gate and switching losses.
I_{TWM} = maximum working peak on-state current.

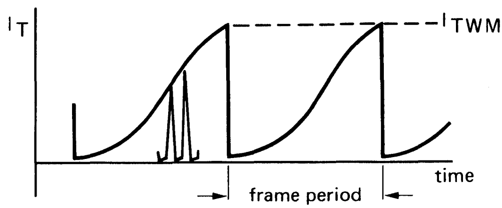


Fig. 7 Waveform defining I_{TWM}.

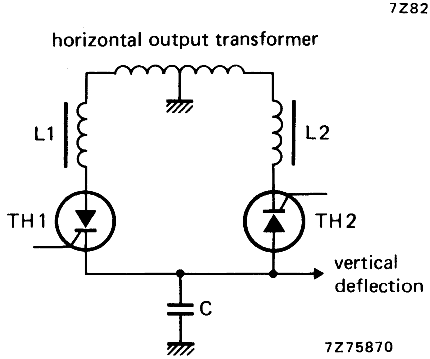


Fig. 8 Basic circuit of a vertical deflection system.

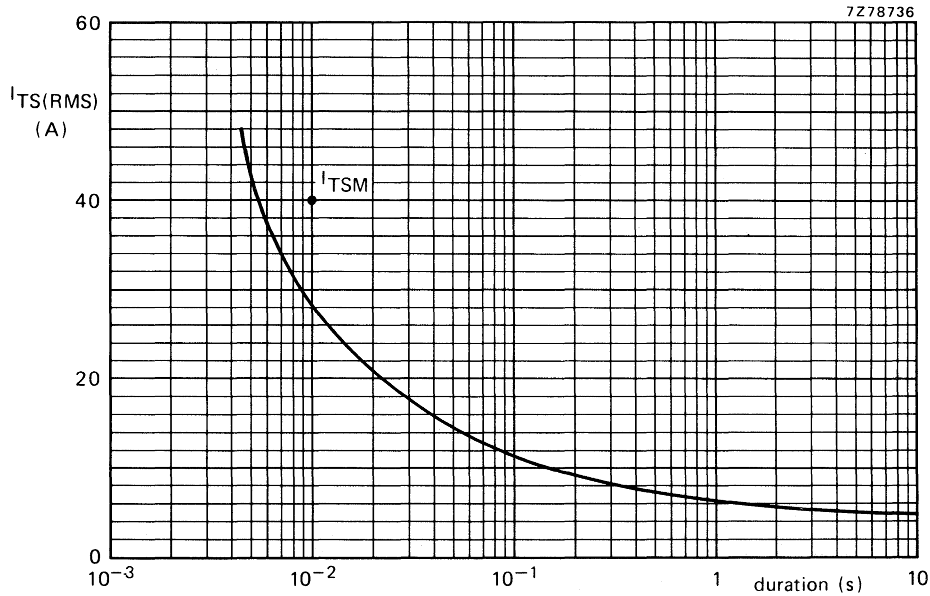
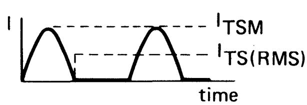


Fig. 9 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents (f = 50 Hz); T_j = 110 °C prior to surge; with reapplied V_{RWMmax}.



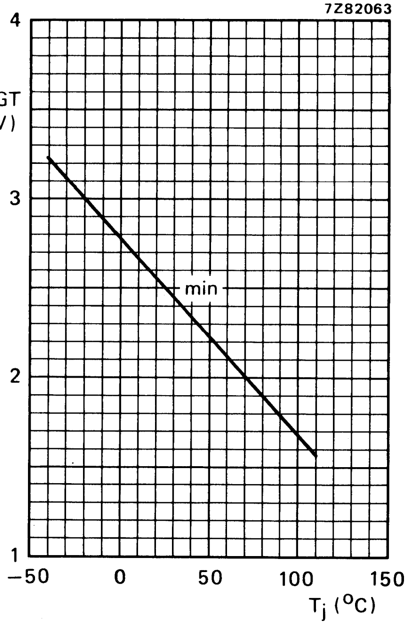


Fig. 10 Minimum gate voltage that will trigger all devices as a function of junction temperature.

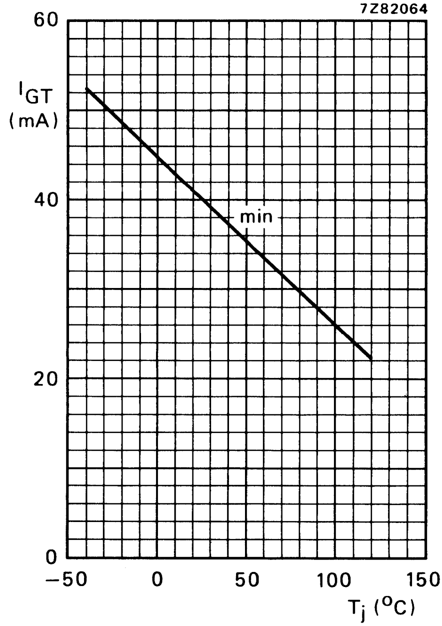


Fig. 11 Minimum gate current that will trigger all devices as a function of junction temperature.

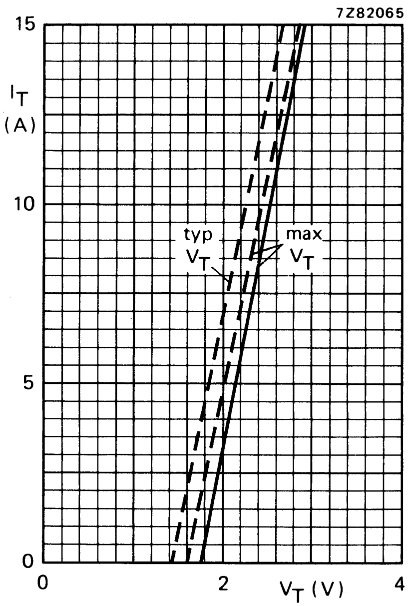


Fig. 12 —— T_j = 25 °C; – – – T_j = 110 °C.

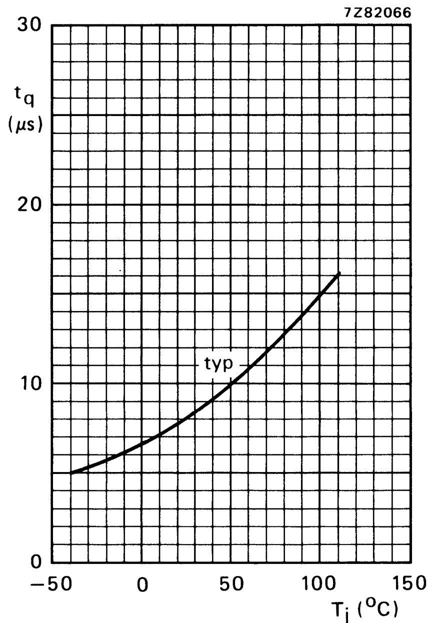


Fig. 13.

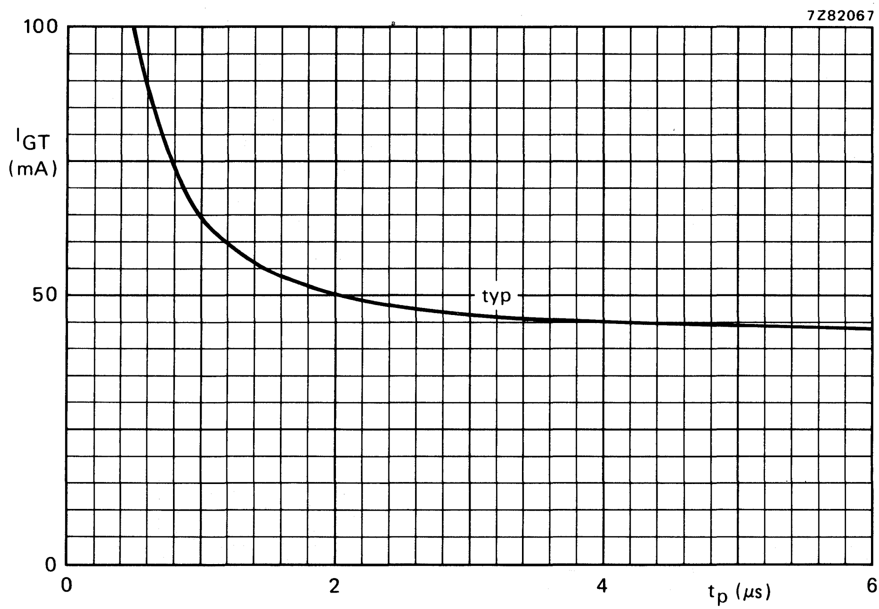
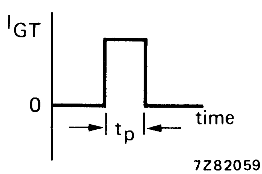


Fig. 14 Gate current that will trigger all devices as a function of rectangular pulse width; T_j = 25 °C.



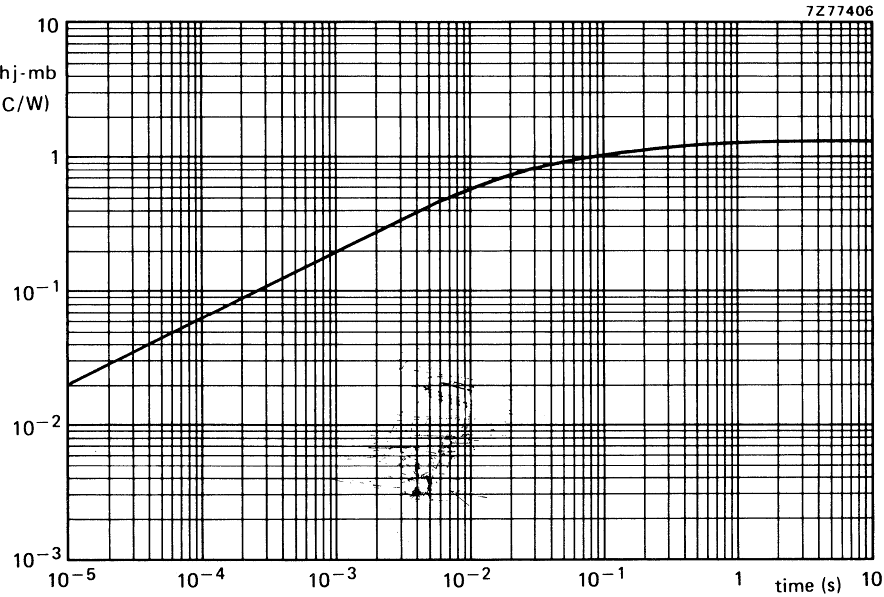

7Z77406
10
$Z_{th\,j\text{-}mb}$
($^oC/W$)
1
10^{-1}
10^{-2}
10^{-3}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
time (s)
10

Fig. 15.

THYRISTORS

Fully-diffused thyristors in TO—92 package, with low gate current requirement suitable for driving from IC outputs. Applications include relay and coil pulsing, control of small d.c. motors, small lamps, etc.

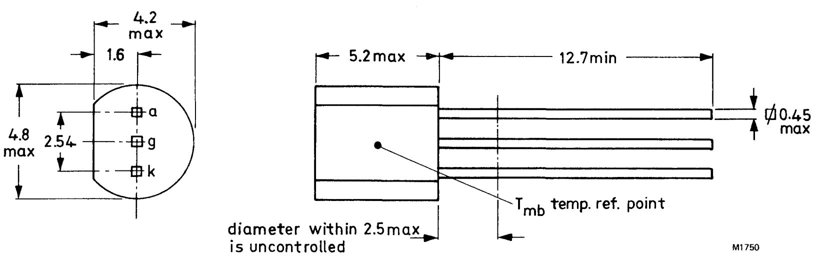
QUICK REFERENCE DATA

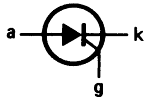
			BT169-B	D	M	
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	200	400	600	V
Average on-state current	$I_{T(AV)}$	max.		0.5		A
R.M.S. on-state current	$I_{T(RMS)}$	max.		0.8		A
Non-repetitive peak on-state current	I_{TSM}	max.		8		A

MECHANICAL DATA

Dimensions in mm

Fig.1 TO—92 variant





RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134).

Anode to cathode			BT169-B	D	M	
Non-repetitive peak voltages (t ⩽ 10 ms)	V_{DSM}/V_{RSM}	max.	200	400	600	V*
Repetitive peak voltages ($\delta \leqslant 0.01$)	V_{DRM}/V_{RRM}	max.	200	400	600	V

Average on-state current (averaged over any 20 ms period) up to T_{mb} = 55 °C	$I_{T(AV)}$	max.	0.5	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	0.8	A
Repetitive peak on-state current	I_{TRM}	max.	8	A
Non-repetitive peak on-state current; t = 10 ms; half sine-wave; T_j = 125 °C prior to surge; with reapplied V_{RWMmax}	I_{TSM}	max.	8	A
I^2t for fusing (t = 10 ms)	I^2t	max.	0.32	A^2s
Rate of rise of on-state current after triggering with I_G = 1 mA to I_T = 1.8 A; dI_G/dt = 4 mA/μs	dI_T/dt	max.	30	A/μs
Gate to cathode				
Peak reverse voltage	V_{RGM}	max.	8	V
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	0.1	W
Peak power dissipation	P_{GM}	max.	2	W
Temperatures				
Storage temperature	T_{stg}		−40 to +150	°C
Operating junction temperature	T_j	max.	125	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	100	K/W
From junction to ambient in free air, mounted on a p.c.b. with any lead length	$R_{th\ j\text{-}a}$	=	200	K/W

*R_{GK} = 1 kΩ.

CHARACTERISTICS

Anode to cathode

On-state voltage I_T = 1 A; T_j = 25 °C	V_T	<	1.35	V*
Rate of rise of off-state voltage that will not trigger any device; exponential method; V_D = 2/3 V_{DRMmax}; R_{GK} = 1 kΩ; T_j = 125 °C	dV_D/dt	<	100	V/μs
Reverse current $V_R = V_{RRMmax}$; R_{GK} = 1 kΩ; T_j = 125 °C	I_R	<	0.1	mA
Off-state current $V_D = V_{DRMmax}$; R_{GK} = 1 kΩ; T_j = 125 °C	I_D	<	0.1	mA
Latching current V_D = 6 V; R_{GK} = 1 kΩ; T_j = 25 °C	I_L	<	6	mA
Holding current V_D = 6 V; R_{GK} = 1 kΩ; T_j = 25 °C	I_H	<	5	mA

Gate to cathode

Voltage that will trigger all devices V_D = 6 V; T_j = 25 °C	V_{GT}	>	0.8	V
Current that will trigger all devices V_D = 6 V; T_j = 25 °C	I_{GT}	>	0.2	mA

Switching characteristics

Gate-controlled delay time when switched from $V_D = V_{DRMmax}$ to I_T = 1.5 A; I_{GT} = 10 mA; dI_G/dt = 0.1 A/μs; T_j = 25 °C	t_d	<	1.0	μs
Circuit-commutated turn-off time when switched from I_T = 0.5 A to V_R > 35 V with $-dI_T/dt$ = 110 A/μs; dV_D/dt = 50 V/μs; T_j = 125 °C	t_q	<	100	μs

*Measured under pulse conditions to avoid excessive dissipation.

THYRISTORS

Silicon thyristors in metal envelopes, intended for general purpose single-phase or three-phase mains operation.
The series consists of reverse polarity types (anode to stud) identified by a suffix R: BTW23-600R to 1600R.

QUICK REFERENCE DATA

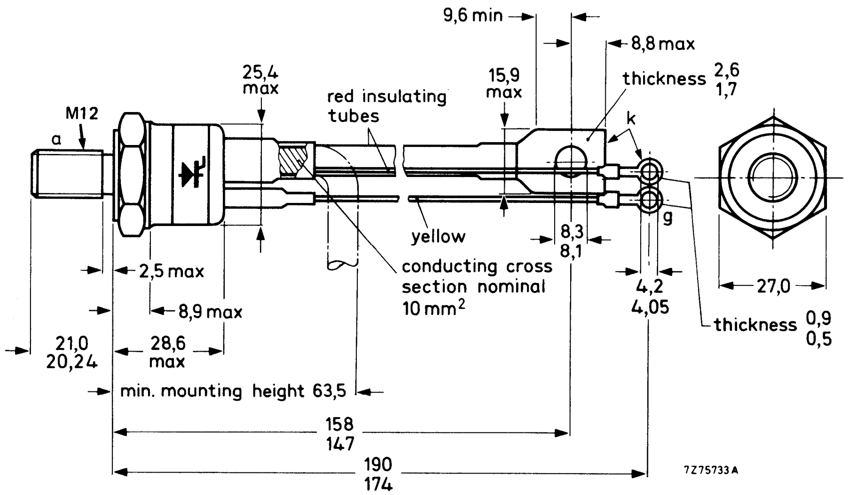
		BTW23-600R	800R	1000R	1200R	1400R	1600R	
Repetitive peak voltages $V_{DRM} = V_{RRM}$	max.	600	800	1000	1200	1400	1600	V

Average on-state current	$I_{T(AV)}$	max.	90	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	140	A
Non-repetitive peak on-state current	I_{TSM}	max.	2000	A
Rate of rise of off-state voltage that will not trigger any device	dV_D/dt	<	200	V/µs
On request (see Ordering Note)	dV_D/dt	<	1000	V/µs

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-94: with metric M12 stud (ϕ 12 mm).
Encapsulation may differ from that shown, but will conform to TO—94 major dimensions.



Net mass: 134 g
Diameter of clearance hole: max. 13,0 mm
Torque on nut: min. 9 Nm (90 kg cm)
max. 17,5 Nm (175 kg cm)

Supplied with device: 1 nut, 1 lock washer
Nut dimensions across the flats: 19 mm.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Anode to cathode

			BTW23-600R	800R	1000R	1200R	1400R	1600R	
Non-repetitive peak voltages ($t \leq 10$ ms)	V_{DSM}/V_{RSM}	max.	600	800	1000	1200	1400	1600	V
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	600	800	1000	1200	1400	1600	V
Crest working voltages	V_{DWM}/V_{RWM}	max.	400	600	700	800	800	800	V*

Average on-state current (averaged over any 20 ms period) up to T_{mb} = 85 °C	$I_{T(AV)}$	max.	90	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	140	A
Repetitive peak on-state current	I_{TRM}	max.	1250	A
Non-repetitive peak on-state current; t = 10 ms; half sine-wave; T_j = 125 °C prior to surge; with reapplied $V_{RWM\,max}$	I_{TSM}	max.	2000	A
I^2t for fusing (t = 10 ms)	I^2t	max.	20 000	A^2s
Rate of rise of on-state current after triggering with I_G = 750 mA to I_T = 300 A; dI_G/dt = 1 A/μs	dI_T/dt	max.	300	A/μs

Gate to cathode

Reverse peak voltage	V_{RGM}	max.	10	V
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	2	W
Peak power dissipation	P_{GM}	max.	10	W

Temperatures

Storage temperature	T_{stg}		−55 to + 125	°C
Junction temperature	T_j	max.	125	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\,j\text{-}mb}$	=	0,3	°C/W
From mounting base to heatsink	$R_{th\,mb\text{-}h}$	=	0,1	°C/W
Transient thermal impedance (t = 1 ms)	$Z_{th\,j\text{-}mb}$	=	0,015	°C/W

* To ensure thermal stability: $R_{th\,j\text{-}a} < 0{,}75$ °C/W (d.c. blocking) or $< 1{,}5$ °C/W (a.c.). For smaller heatsinks $T_{j\,max}$ should be derated.

THYRISTORS

Glass-passivated silicon thyristors in metal envelopes, intended for use in power control circuits (e.g. light and motor control) and power switching systems.
The series consists of reverse polarity types (anode to stud) identified by a suffix R: BTW38–600R to 1000R.

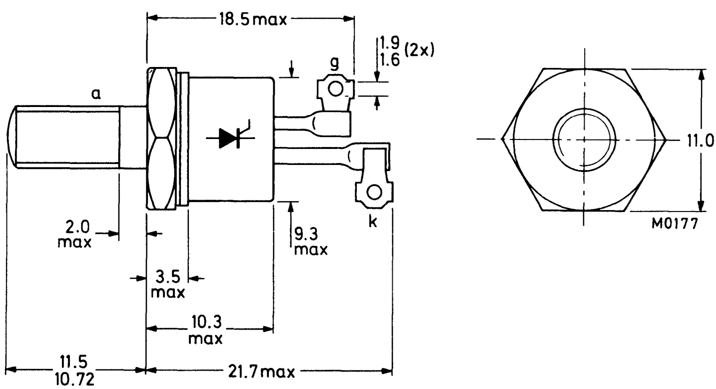
QUICK REFERENCE DATA

			BTW38–600R	800R	1000R	
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	600	800	1000	V
Average on-state current	$I_{T(AV)}$	max.		10		A
R.M.S. on-state current	$I_{T(RMS)}$	max.		16		A
Non-repetitive peak on-state current	I_{TSM}	max.		150		A

MECHANICAL DATA

Dimensions in mm

Fig.1 TO-64: with metric M5 stud (ϕ5 mm); e.g. BTW38–600R.



Net mass: 7 g
Diameter of clearance hole: max. 5.2 mm
Accessories supplied on request:
see ACCESSORIES section

Supplied with device: 1 nut, 1 lock washer
Torque on nut: min. 0.9 Nm (9 kg cm)
max. 1.7 Nm (17 kg cm)
Nut dimensions across the flats: 8.0 mm.

Products approved to CECC 50 011-006 available on request.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Anode to cathode

			BTW38–600R	800R	1000R	
Non-repetitive peak voltages ($t \leq 10$ ms)	V_{DSM}/V_{RSM}	max.	600	800	1000	V
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	600	800	1000	V
Crest working voltages	V_{DWM}/V_{RWM}	max.	400	600	700	V*

Average on-state current (averaged over any 20 ms period) up to T_{mb} = 85 °C	$I_{T(AV)}$	max.	10	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	16	A
Repetitive peak on-state current	I_{TRM}	max.	75	A
Non-repetitive peak on-state current; t = 10 ms; half sine-wave; T_j = 125 °C prior to surge; with reapplied V_{RWMmax}	I_{TSM}	max.	150	A
I^2t for fusing (t = 10 ms)	I^2t	max.	112	A^2s
Rate of rise of on-state current after triggering with I_G = 250 mA to I_T = 25 A; dI_G/dt = 0.25 A/µs	dI_T/dt	max.	50	A/µs

Gate to cathode

Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	0.5	W
Peak power dissipation	P_{GM}	max.	5	W

Temperatures

Storage temperature	T_{stg}		−55 to +125	°C
Junction temperature	T_j	max.	125	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1.8	K/W
From mounting base to heatsink with heatsink compound	$R_{th\ mb\text{-}h}$	=	0.5	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	45	K/W
Transient thermal impedance (t = 1 ms)	$Z_{th\ j\text{-}mb}$	=	0.1	K/W

OPERATING NOTE

The terminals should neither be bent nor twisted; they should be soldered into the circuit so that there is no strain on them.
During soldering the heat conduction to the junction should be kept to a minimum.

*To ensure thermal stability: $R_{th\ j\text{-}a} < 4$ K/W (d.c. blocking) or < 8 K/W (a.c.). For smaller heatsinks $T_{j\ max}$ should be derated. For a.c. see Fig.3.

CHARACTERISTICS

Anode to cathode

On-state voltage (measured under pulse conditions) I_T = 20 A; T_j = 25 °C	V_T	<	2	V
Rate of rise of off-state voltage that will not trigger any device; expontential method; V_D = 2/3 V_{DRMmax}; T_j = 125 °C	dV_D/dt	<	200	V/µs
Reverse current $V_R = V_{RWMmax}$; T_j = 125 °C	I_R	<	3	mA
Off-state current $V_D = V_{DWMmax}$; T_j = 125 °C	I_D	<	3	mA
Latching current; T_j = 25 °C	I_L	<	150	mA
Holding current; T_j = 25 °C	I_H	<	75	mA

Gate to cathode

Voltage that will trigger all devices V_D = 6 V; T_j = 25 °C	V_{GT}	>	1.5	V
Voltage that will not trigger any device $V_D = V_{DRMmax}$; T_j = 125 °C	V_{GD}	<	200	mV
Current that will trigger all devices V_D = 6 V; T_j = 25 °C	I_{GT}	>	50	mA

Switching characteristics

Gate-controlled turn-on time ($t_{gt} = t_d + t_r$) when switched from $V_D = V_{DRMmax}$ to I_T = 40 A; I_{GT} = 100 mA; dI_G/dt = 5 A/µs; T_j = 25 °C	t_{gt}	typ.	2	µs
Circuit-commutated turn-off time when switched from I_T = 40 A to V_R > 50 V with $-dI_T/dt$ = 10A/µs; dV_D/dt = 50 V/µs; T_j = 115 °C	t_q	typ.	35	µs

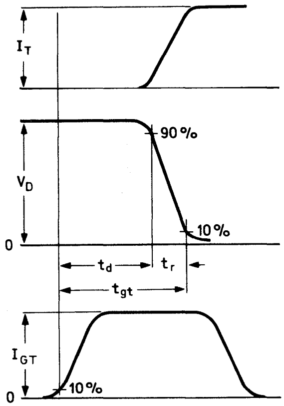


Fig.2a Gate-controlled turn-on time definition.

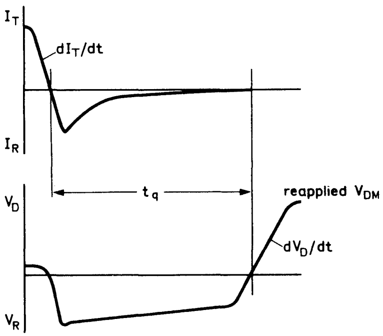


Fig.2b Circuit-commutated turn-off time definition.

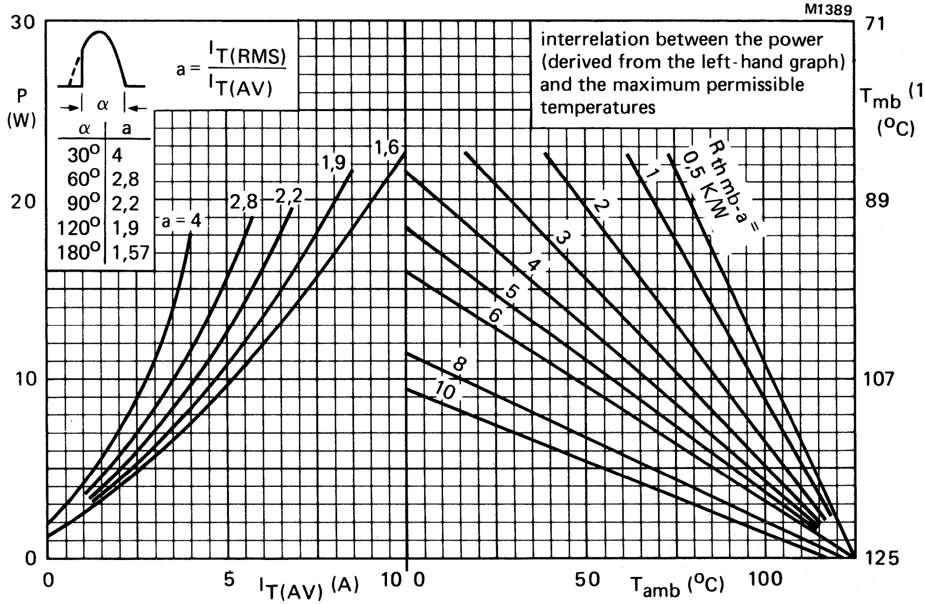


Fig. 3 (1) T_{mb}-scale is for comparison purposes only and is correct only for $R_{th\ mb-a} \leqslant 6$ K/W

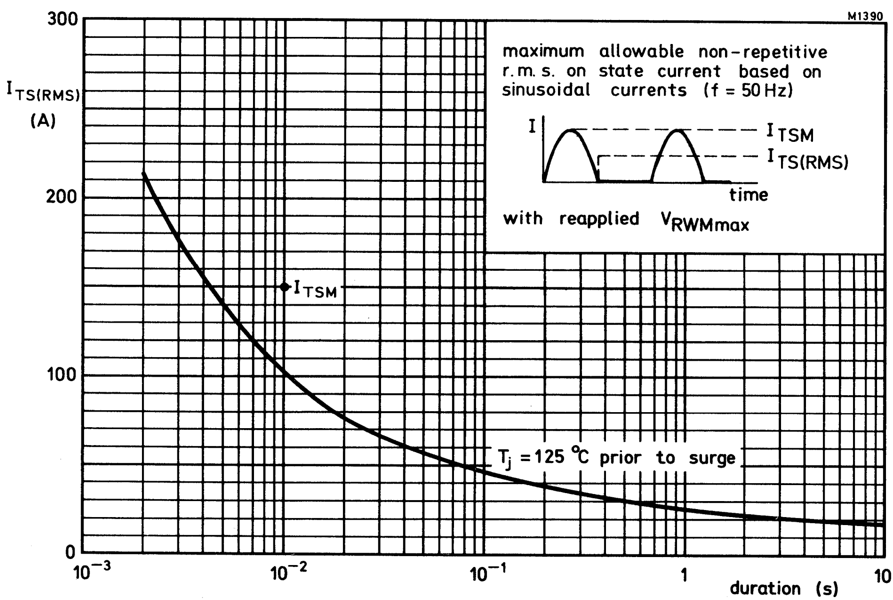


Fig. 4.

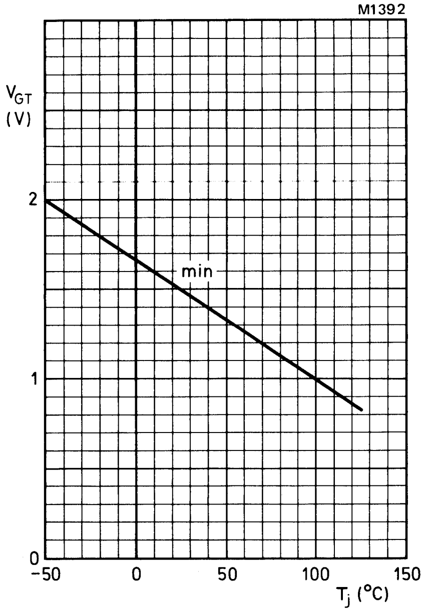


Fig. 5 Minimum gate voltage that will trigger all devices as a function of T_j.

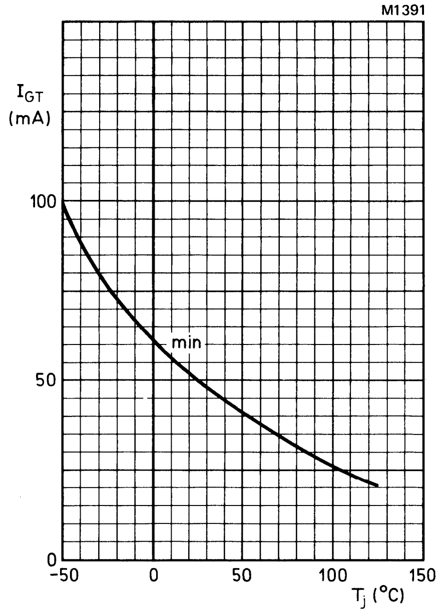


Fig. 6 Minimum gate current that will trigger all devices as a function of T_j.

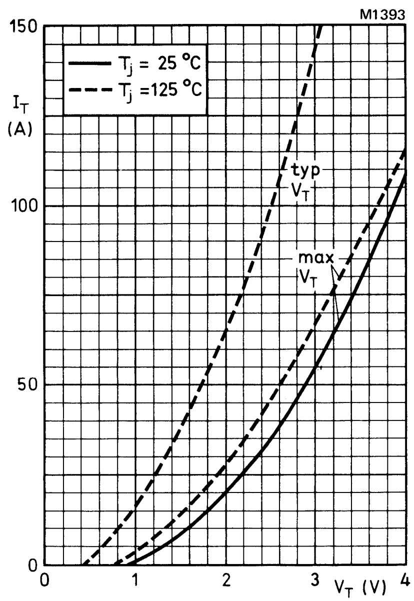


Fig. 7.

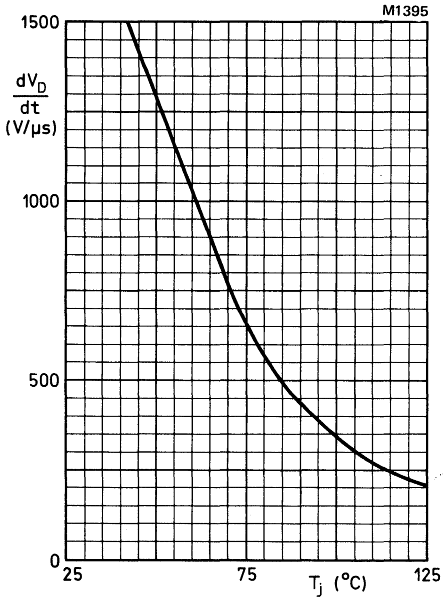


Fig. 8 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of T_j.

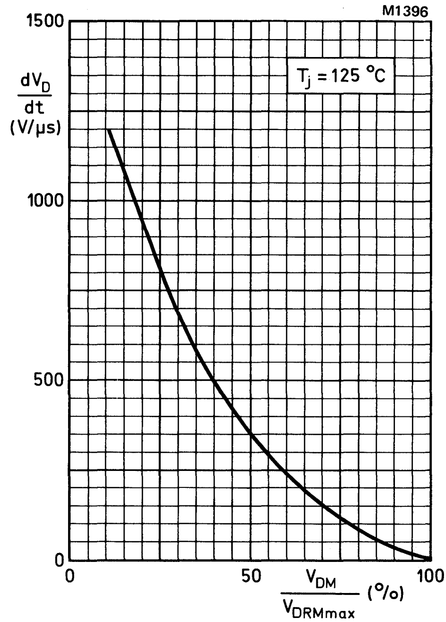
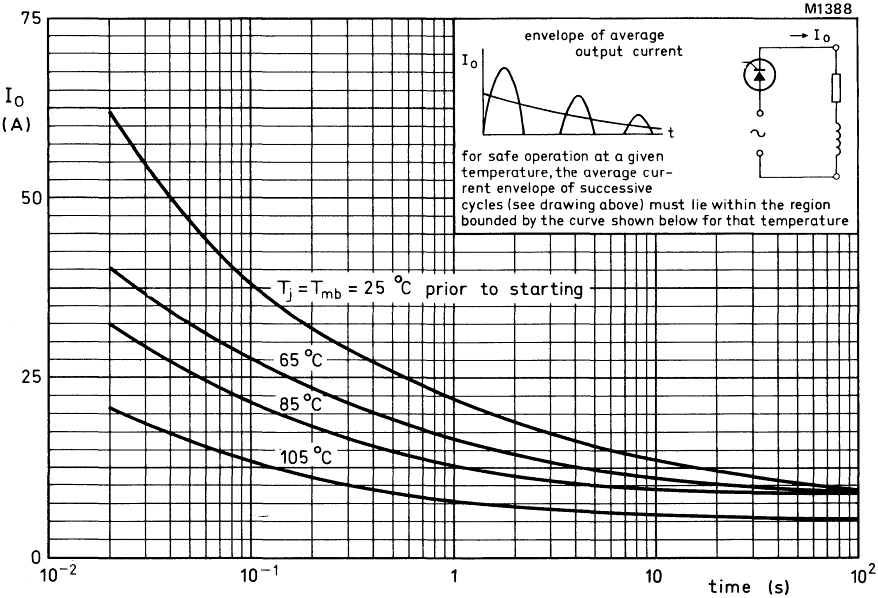


Fig. 9 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of applied voltage.



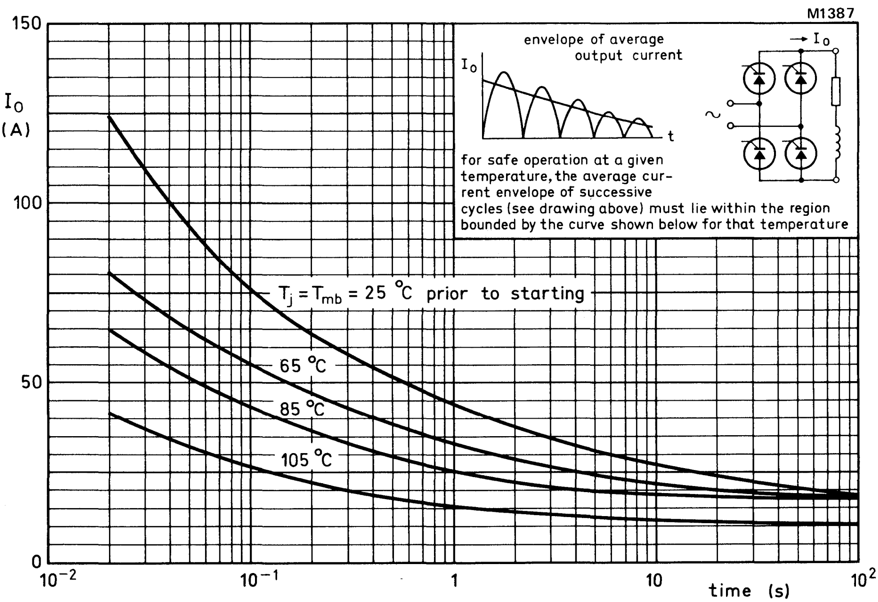


Fig. 10 Limits for starting or inrush currents.

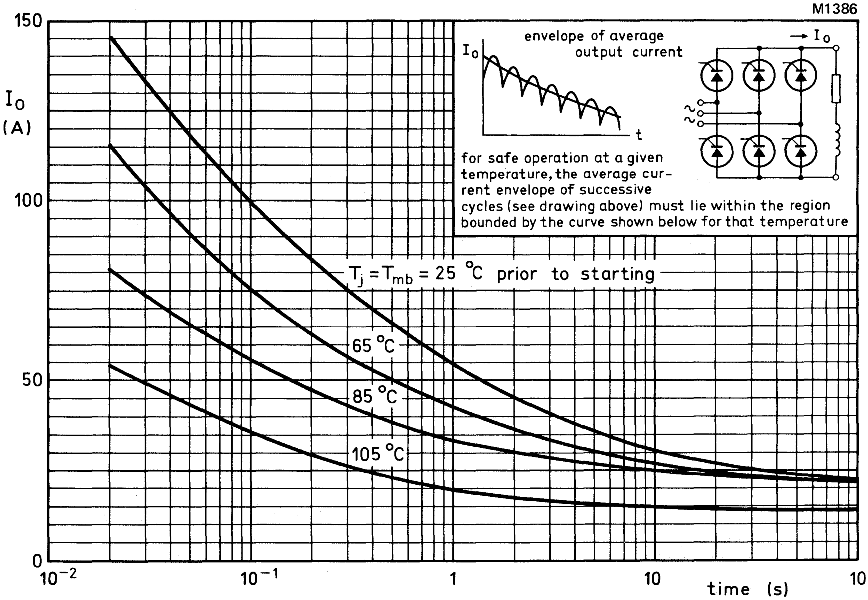


Fig. 11 Limits for starting or inrush currents.

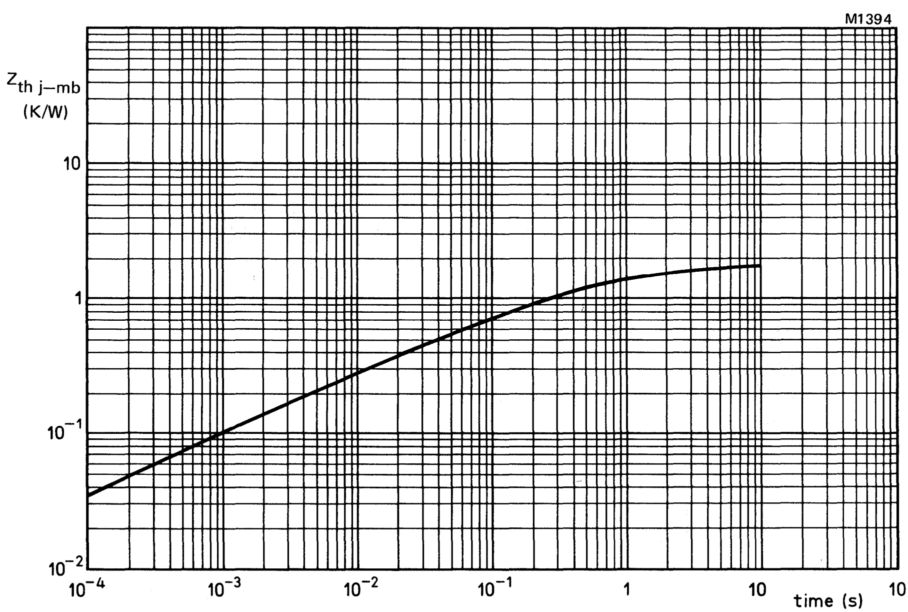


Fig. 12.

THYRISTORS

Also available to BS9341-F083

Glass-passivated silicon thyristors in metal envelopes, intended for use in power control applications in general, and lighting control (in a.c. controller circuit) up to 2,5 kW in particular. A feature of the thyristors is their high surge rating.
The series consistos of reverse polarity types (anode to stud) identified by a suffix R: BTW40-400R to 800R.

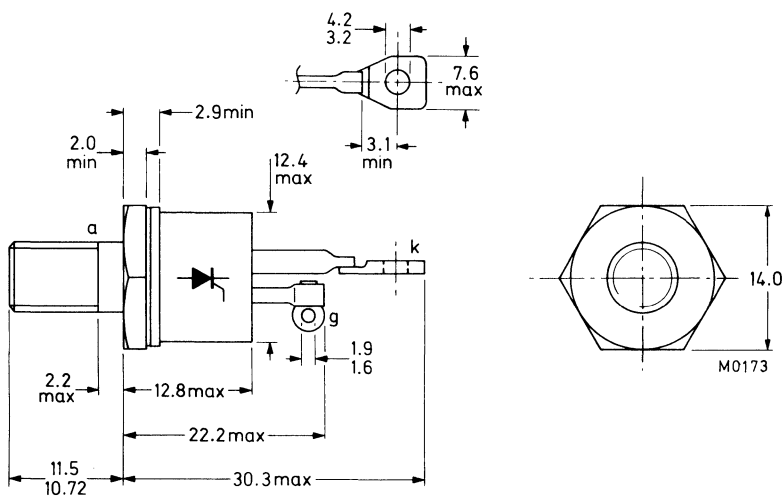
QUICK REFERENCE DATA

			BTW40-400R	600R	800R	
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	400	600	800	V
Average on-state current	$I_{T(AV)}$	max.			20	A
R.M.S. on-state current	$I_{T(RMS)}$	max.			32	A
Non-repetitive peak on-state current	I_{TSM}	max.			400	A

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-48: with metric M6 stud (ϕ 6 mm); e.g. BTW40-400R.
Types with ¼ in x 28 UNF stud (ϕ 6,35 mm) are available on request. These are indicated by the suffix U: e.g. BTW40-400RU.



Net mass: 14 g
Diameter of clearance hole: max. 6,5 mm
Accessories supplied on request:
see ACCESSORIES section

Torque on nut: min. 1,7 Nm (17 kg cm)
max. 3,5 Nm (35 kg cm)
Supplied with the device:
1 nut, 1 lock washer
Nut dimensions across the flats;
M6: 10 mm
¼ in x 28 UNF: 11,1 mm

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Anode to cathode

			BTW40-400R	600R	800R	
Non-repetitive peak voltages ($t \leqslant 10$ ms)	V_{DSM}/V_{RSM}	max.	400	600	800	V
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	400	600	800	V
Crest working voltages	V_{DWM}/V_{RWM}	max.	300	400	600	V *

Average on-state current (averaged over any 20 ms period) up to T_{mb} = 85 °C	$I_{T(AV)}$	max.	20	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	32	A
Repetitive peak on-state current	I_{TRM}	max.	200	A
Non-repetitive peak on-state current; t = 10 ms; half sine-wave; T_j = 125 °C prior to surge; with reapplied V_{RWMmax}	I_{TSM}	max.	400	A
I^2t for fusing (t = 10 ms)	I^2t	max.	800	A^2s
Rate of rise of on-state current after triggering with I_G = 400 mA to I_T = 60 A; dI_G/dt = 0,4 A/µs	dI_T/dt	max.	100	A/µs

Gate to cathode

Reverse peak voltage	V_{RGM}	max.	10	V
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	1	W
Peak power dissipation	P_{GM}	max.	5	W

Temperatures

Storage temperature	T_{stg}		−55 to + 125	°C
Junction temperature	T_j	max.	125	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1	°C/W
From mounting base to heatsink with heatsink compound	$R_{th\ mb\text{-}h}$	=	0,2	°C/W
Transient thermal impedance (t = 1 ms)	$Z_{th\ j\text{-}mb}$	=	0,1	°C/W

OPERATING NOTE

The terminals should neither be bent not twisted; they should be soldered into the circuit so that there is no strain on them.
During soldering the heat conduction to the junction should be kept to a minimum.

* To ensure thermal stability: $R_{th\ j\text{-}a} < 6,5$ °C/W (d.c. blocking) or < 13 °C/W (a.c.). For smaller heatsinks $T_{j\ max}$ should be derated. For a.c. see Fig. 3.

CHARACTERISTICS

Anode to cathode

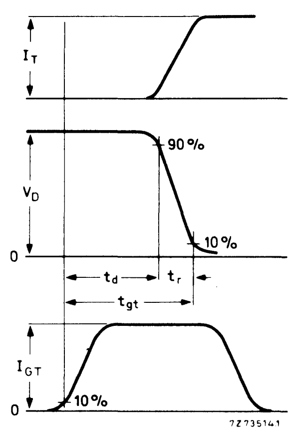
On-state voltage I_T = 50 A; T_j = 25 °C	V_T	<	2,1 V *
Rate of rise of off-state voltage that will not trigger any device; exponential method; V_D = 2/3 V_{DRMmax}; T_j = 125 °C	dV_D/dt	<	100 V/μs
Reverse current V_R = V_{RWMmax}; T_j = 125 °C	I_R	<	3 mA
Off-state current V_D = V_{DWMmax}; T_j = 125 °C	I_D	<	3 mA
Latching current; T_j = 25 °C	I_L	<	150 mA
Holding current; T_j = 25 °C	I_H	<	75 mA

Gate to cathode

Voltage that will trigger all devices V_D = 6 V; T_j = 25 °C	V_{GT}	>	1,5 V
Voltage that will not trigger any device V_D = V_{DRMmax}; T_j = 125 °C	V_{GD}	<	200 mV
Current that will trigger all devices V_D = 6 V; T_j = 25 °C	I_{GT}	>	75 mA

Switching characteristics

Gate-controlled turn-on time (t_{gt} = t_d + t_r) when switched from V_D = V_{DWMmax} to I_T = 100 A; I_{GT} = 400 mA; dI_G/dt = 1 A/μs; T_j = 25 °C	t_{gt} t_r	< <	1 μs 0,5 μs



Gate-controlled turn-on time definition

*Measured under pulse conditions to avoid excessive dissipation.

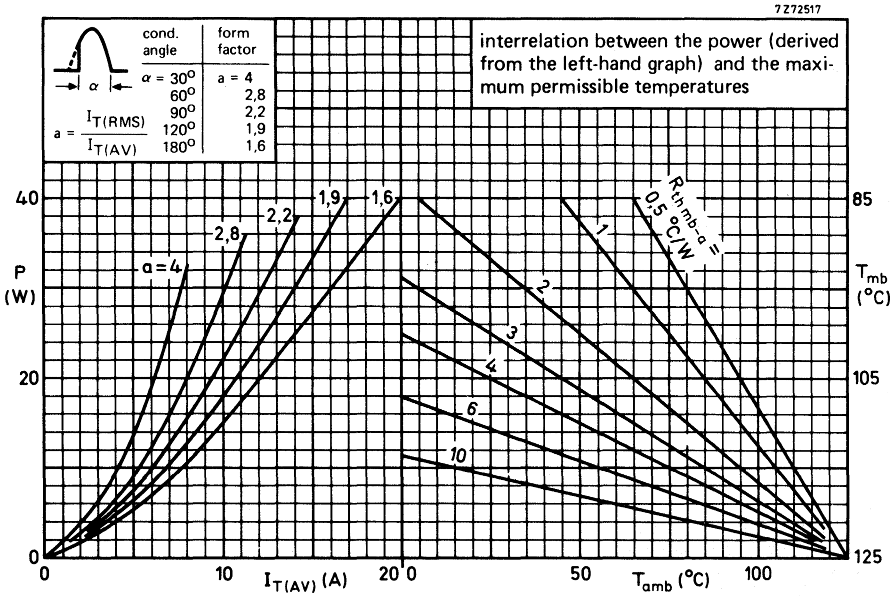

7Z72517
cond. angle
form factor
α = 30° a = 4
60° 2,8
90° 2,2
120° 1,9
180° 1,6
a = I_T(RMS) / I_T(AV)
interrelation between the power (derived from the left-hand graph) and the maximum permissible temperatures
P (W)
I_T(AV) (A)
T_amb (°C)
T_mb (°C)
R_th mb-a = 0,5 °C/W
a=4
2,8
2,2
1,9
1,6
1
2
3
4
6
10

Fig. 2.

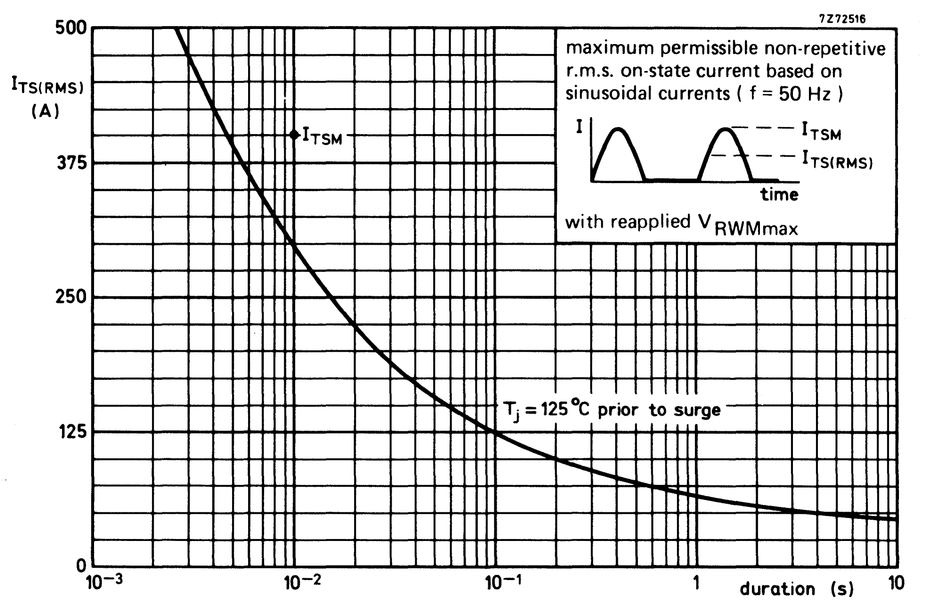

7Z72516
maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents (f = 50 Hz)
I
I_TSM
I_TS(RMS)
time
with reapplied V_RWMmax
I_TS(RMS) (A)
I_TSM
T_j = 125 °C prior to surge
duration (s)

Fig. 3.

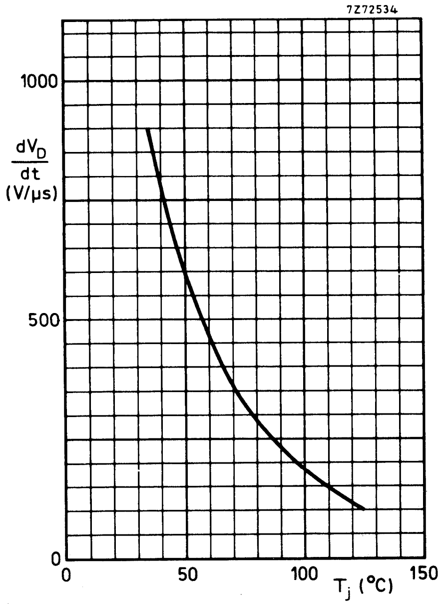


Fig. 4 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of T_j.

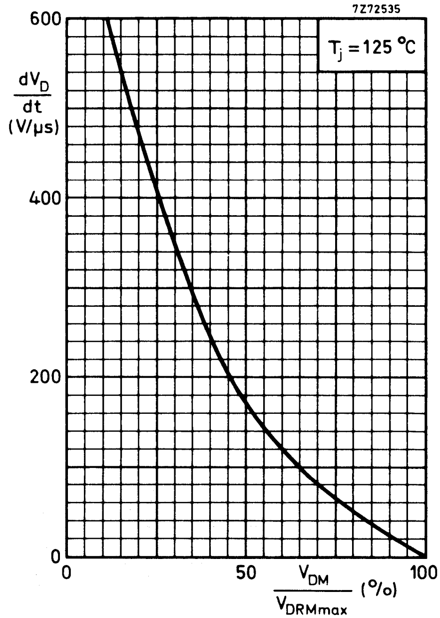


Fig. 5 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of applied voltage.

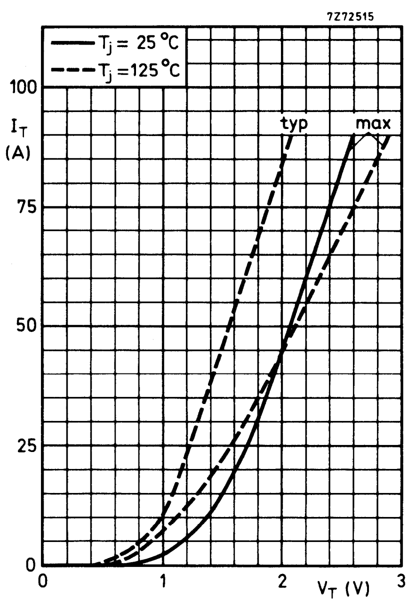


Fig. 6.

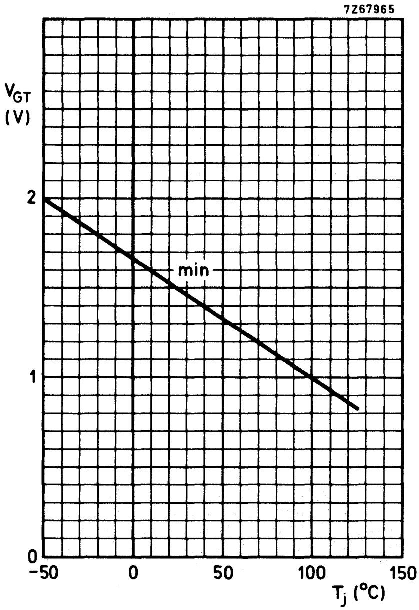


Fig. 7 Minimum gate voltage that will trigger all devices as a function of T_j.

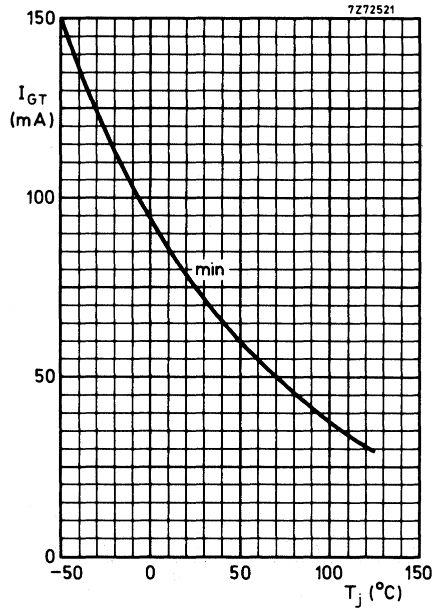


Fig. 8 Minimum gate current that will trigger all devices as a function of T_j.

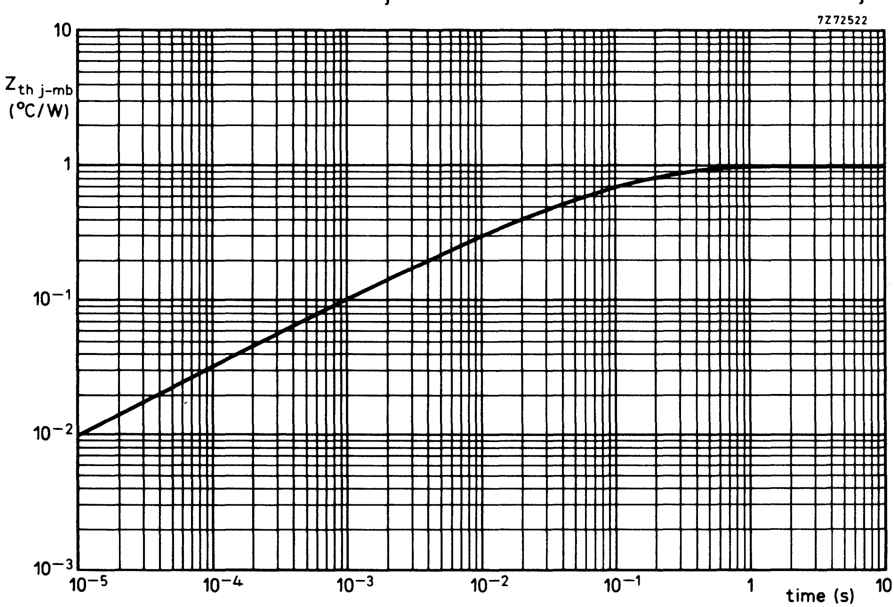


Fig. 9.

THYRISTORS

Glass-passivated silicon thyristors in metal envelopes with high dV_D/dt capabilities. They are intended for use in power control circuits and switching systems where high transients can occur (e.g. phase control in three-phase systems).
The series consists of reverse polarity types (anode to stud) identified by a suffix R: BTW42–600R to 1000R.

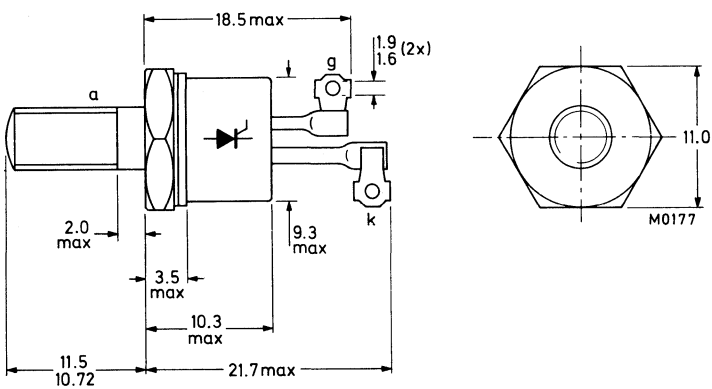
QUICK REFERENCE DATA

			BTW42–600R	800R	1000R	
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	600	800	1000	V
Average on-state current	$I_{T(AV)}$	max.		10		A
R.M.S. on-state current	$I_{T(RMS)}$	max.		16		A
Non-repetitive peak on-state current	I_{TSM}	max.		150		A
Rate of rise of off-state voltage that will not trigger any device	dV_D/dt	<		500		V/µs
On request (see Ordering Note)	dV_D/dt	<		1000		V/µs

MECHANICAL DATA

Dimensions in mm

Fig.1 TO–64: with metric M5 stud (ϕ5 mm); e.g. BTW42–600R.



Net mass: 7 g
Diameter of clearance hole: max. 5.2 mm
Accessories supplied on request:
see ACCESSORIES section

Supplied with device: 1 nut, 1 lock washer.
Torque on nut: min. 0.9 Nm (9 kg cm)
max. 1.7 Nm (17 kg cm)
Nut dimensions across the flats: 8.0 mm.

Products approved to CECC 50 011-006 available on request.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Anode to cathode

			BTW42-600R	800R	1000R	
Non-repetitive peak voltages ($t \leq 10$ ms)	V_{DSM}/V_{RSM}	max.	600	800	1000	V
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	600	800	1000	V
Crest working voltages	V_{DWM}/V_{RWM}	max.	400	600	700	V*

Average on-state current (averaged over any 20 ms period) up to T_{mb} = 85 °C	$I_{T(AV)}$	max.	10	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	16	A
Repetitive peak on-state current	I_{TRM}	max.	75	A
Non-repetitive peak on-state current; t = 10 ms; half sine-wave; T_j = 125 °C prior to surge; with reapplied V_{RWMmax}	I_{TSM}	max.	150	A
I^2t for fusing (t = 10 ms)	I^2t	max.	112	A^2s
Rate of rise of on-state current after triggering with I_G = 250 mA to I_T = 25 A; dI_G/dt = 0,25 A/µs	dI_T/dt	max.	50	A/µs

Gate to cathode

Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	0,5	W
Peak power dissipation	P_{GM}	max.	5	W

Temperatures

Storage temperature	T_{stg}	−55 to + 125		°C
Junction temperature	T_j	max.	125	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,8	K/W
From mounting base to heatsink with heatsink compound	$R_{th\ mb\text{-}h}$	=	0,5	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	45	K/W
Transient thermal impedance (t = 1 ms)	$Z_{th\ j\text{-}mb}$	=	0,1	K/W

OPERATING NOTE

The terminals should neither be bent nor twisted; they should be soldered into the circuit so that there is no strain on them.
During soldering the heat conduction to the junction should be kept to a minimum.

ORDERING NOTE

Types with dV_D/dt of 1000 V/µs are available on request. Add suffix C to the type number when ordering; e.g. BTW42-600RC.

*To ensure thermal stability: $R_{th\ j\text{-}a} < 4$ K/W (d.c. blocking) or < 8 K/W (a.c.). For smaller heatsinks $T_{j\ max}$ should be derated. For a.c. see Fig.3 (BTW38 data).

CHARACTERISTICS

Anode to cathode

On-state voltage (measured under pulse conditions) $I_T = 20$ A; $T_j = 25\ ^oC$	V_T	<	2	V
Rate of rise of off-state voltage that will not trigger any device; expontential method; $V_D = 2/3\ V_{DRMmax}$; $T_j = 125\ ^oC$	dV_D/dt	<	500	V/μs
Reverse current $V_R = V_{RWMmax}$; $T_j = 125\ ^oC$	I_R	<	3	mA
Off-state current $V_D = V_{DWMmax}$; $T_j = 125\ ^oC$	I_D	<	3	mA
Latching current; $T_j = 25\ ^oC$	I_L	<	150	mA
Holding current; $T_j = 25\ ^oC$	I_H	<	75	mA

Gate to cathode

Voltage that will trigger all devices $V_D = 6$ V; $T_j = 25\ ^oC$	V_{GT}	>	1.5	V
Voltage that will not trigger any device $V_D = V_{DRMmax}$; $T_j = 125\ ^oC$	V_{GD}	<	200	mV
Current that will trigger all devices $V_D = 6$ V; $T_j = 25\ ^oC$	I_{GT}	>	50	mA

Switching characteristics

Gate-controlled turn-on time ($t_{gt} = t_d + t_r$) when switched from $V_D = V_{DRMmax}$ to $I_T = 40$ A; $I_{GT} = 100$ mA; $dI_G/dt = 5$ A/μs; $T_j = 25\ ^oC$	t_{gt}	typ.	2	μs
Circuit-commutated turn-off time when switched from $I_T = 40$ A to $V_R > 50$ V with $-dI_T/dt = 10$A/μs; $dV_D/dt = 50$ V/μs; $T_j = 115\ ^oC$	t_q	typ.	35	μs

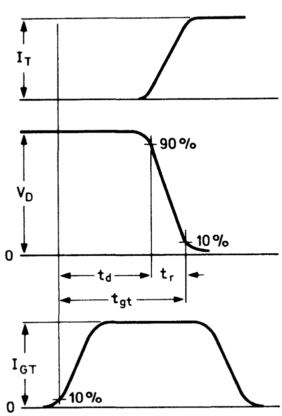


Fig.2a Gate-controlled turn-on time definition.

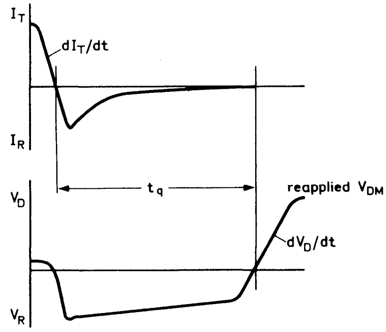


Fig.2b Circuit-commutated turn-off time definition.

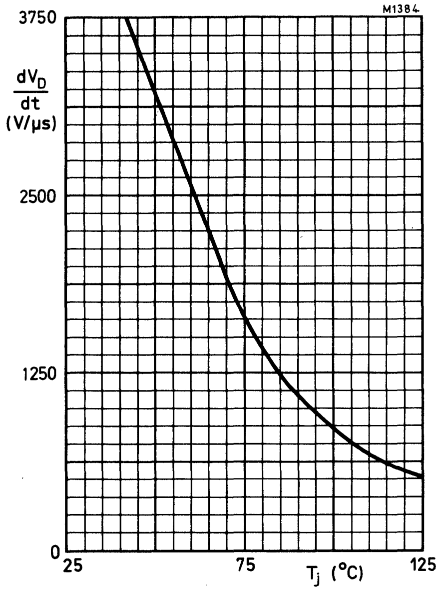


Fig.3 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of T_j.

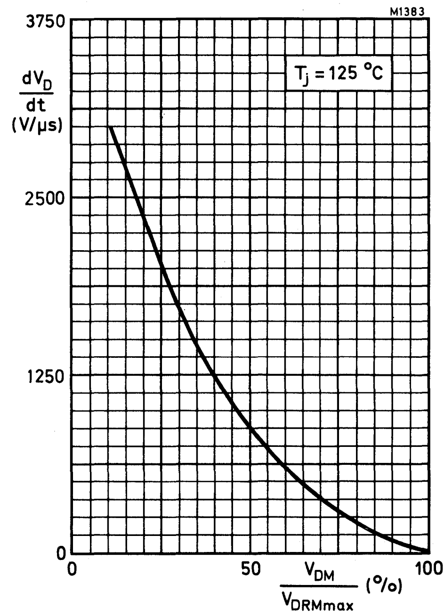


Fig.4 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of applied voltage.

FOR FURTHER DETAILS REFER TO BTW38 DATA.

THYRISTORS

Glass-passivated silicon thyristors in metal envelopes, intended for power control applications.

The series consistos of reverse polarity types (anode to stud) identified by a suffix R: BTW45-400R to 1200R.

QUICK REFERENCE DATA

		BTW45-400R	600R	800R	1000R	1200R	
Repetitive peak voltages $V_{DRM} = V_{RRM}$	max.	400	600	800	1000	1200	V

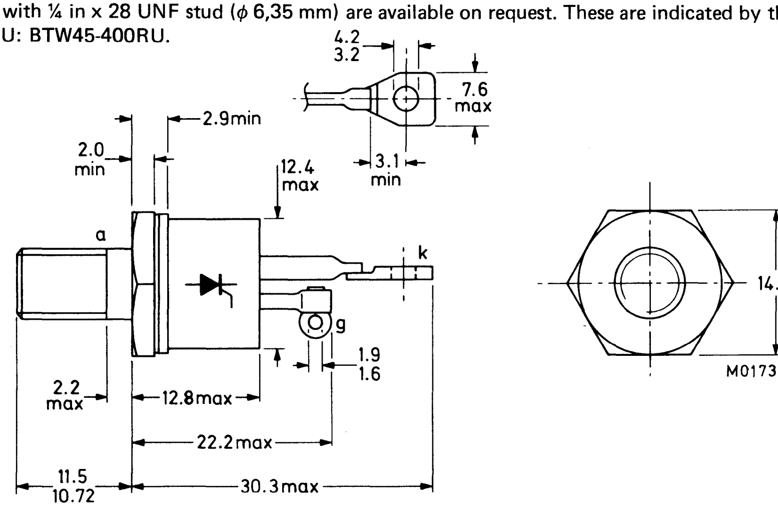
Average on-state current	$I_{T(AV)}$	max.	16	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	25	A
Non-repetitive peak on-state current	I_{TSM}	max.	300	A
Rate of rise of off-state voltage that will not trigger any device	dV_D/dt	$<$	200	V/μs
On request (see Ordering Note)	dV_D/dt	$<$	1000	V/μs

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-48: with metric M6 stud (ϕ 6 mm); e.g. BTW45-400R.

Types with ¼ in x 28 UNF stud (ϕ 6,35 mm) are available on request. These are indicated by the suffix U: BTW45-400RU.



Net mass: 14 g

Diameter of clearance hole: max. 6,5 mm

Accessories supplied on request:
see ACCESSORIES section

Torque on nut: min. 1,7 Nm (17 kg cm)
max. 3,5 Nm (35 kg cm)

Supplied with the device:
1 nut, 1 lock washer

Nut dimensions across the flats;
M6: 10 mm
¼ in x 28 UNF: 11,1 mm

Products approved to CECC 50 011-002, available on request

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Anode to cathode

			BTW45-400R	600R	800R	1000R	1200R	
Non-repetitive peak voltages ($t \leqslant 10$ ms)	V_{DSM}/V_{RSM}	max.	400	600	800	1000	1200	V
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	400	600	800	1000	1200	V
Crest working voltages	V_{DWM}/V_{RWM}	max.	300	400	600	700	800	V*

Average on-state current (averaged over any 20 ms period) up to T_{mb} = 85 °C	$I_{T(AV)}$	max.	16	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	25	A
Repetitive peak on-state current	I_{TRM}	max.	200	A
Non-repetitive peak on-state current; t = 10 ms; half sine-wave; T_j = 125 °C prior to surge; with reapplied $V_{RWM\,max}$	I_{TSM}	max.	300	A
I^2t for fusing (t = 10 ms)	I^2t	max.	450	A^2s
Rate of rise of on-state current after triggering with I_G = 400 mA to I_T = 60 A; dI_G/dt = 0,4 A/µs	dI_T/dt	max.	100	A/µs

Gate to cathode

Reverse peak voltage	V_{RGM}	max.	10	V
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	1	W
Peak power dissipation	P_{GM}	max.	5	W

Temperatures

Storage temperature	T_{stg}	−55 to + 125		°C
Junction temperature	T_j	max.	125	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\,j\text{-}mb}$	=	1,33	°C/W
From mounting base to heatsink; with heatsink compound	$R_{th\,mb\text{-}h}$	=	0,2	°C/W
Transient thermal impedance (t = 1 ms)	$Z_{th\,j\text{-}mb}$	=	0,1	°C/W

OPERATING NOTE

The terminals should neither be bent nor twisted; they should be soldered into the circuit so that there is no strain on them.
During soldering the heat conduction to the junction should be kept to a minimum.

* To ensure thermal stability: $R_{th\,j\text{-}a} < 6,5$ °C/W (d.c. blocking) or < 13 °C/W (a.c.). For smaller heatsinks $T_{j\,max}$ should be derated. For a.c. see Fig. 2.

CHARACTERISTICS

Anode to cathode

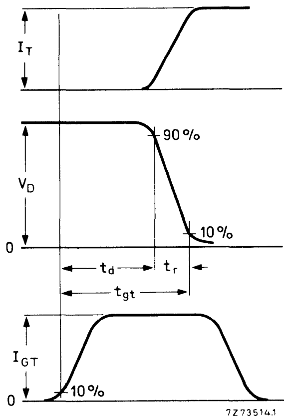
On-state voltage $I_T = 50$ A; $T_j = 25$ °C	V_T	<	2 V*
Rate of rise of off-state voltage that will not trigger any device; exponential method; $V_D = 2/3\ V_{DRM\,max}$; $T_j = 125$ °C	dV_D/dt	<	200 V/μs
Reverse current $V_R = V_{RWM\,max}$; $T_j = 125$ °C	I_R	<	3 mA
Off-state current $V_D = V_{DWM\,max}$; $T_j = 125$ °C	I_D	<	3 mA
Latching current; $T_j = 25$ °C	I_L	<	150 mA
Holding current; $T_j = 25$ °C	I_H	<	75 mA

Gate to cathode

Voltage that will trigger all devices $V_D = 6$ V; $T_j = 25$ °C	V_{GT}	>	1,5 V
Voltage that will not trigger any device $V_D = V_{DRM\,max}$; $T_j = 125$ °C	V_{GD}	<	200 mV
Current that will trigger all devices $V_D = 6$ V; $T_j = 25$ °C	I_{GT}	>	75 mA

Switching characteristics

Gate-controlled turn-on time ($t_{gt} = t_d + t_r$) when switched from $V_D = V_{DWM\,max}$ to $I_T = 100$ A; $I_{GT} = 400$ mA; $dI_G/dt = 1$ A/μs; $T_j = 25$ °C	t_{gt}	<	1 μs
	t_r	<	0,5 μs



Gate-controlled turn-on time definition.

ORDERING NOTE

Types with dV_D/dt of 1000 V/μs are available on request. Add suffix C to the type number when ordering; e.g. BTW45-400RC.

*Measured under pulse conditions to avoid excessive dissipation.

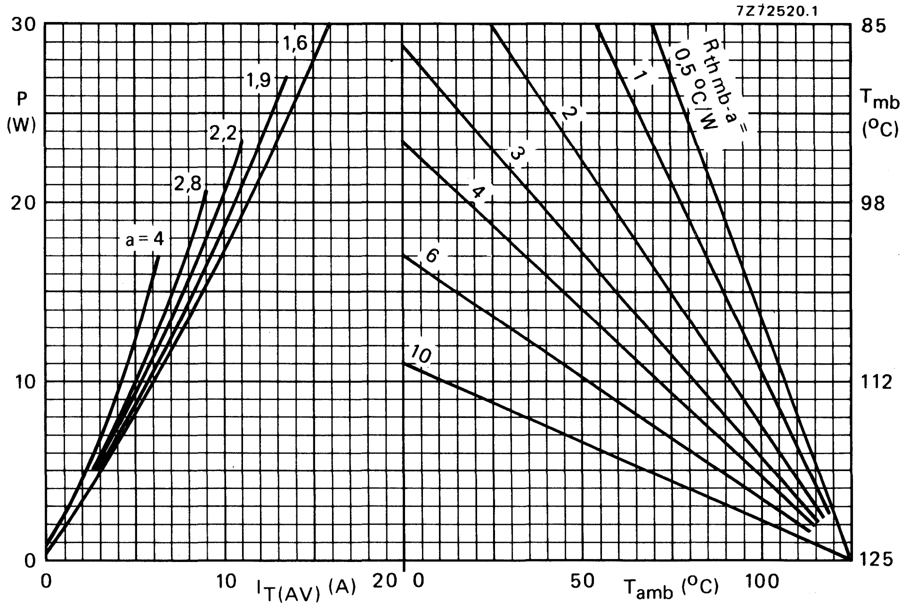

7Z72520.1
P
(W)
30
20
10
0
0
10
$I_{T(AV)}$ (A)
20
a = 4
2,8
2,2
1,9
1,6
0
50
T_{amb} (°C)
100
85
98
112
125
T_{mb}
(°C)
$R_{th\ mb-a}$ =
0,5 °C/W
1
2
3
4
6
10

Fig. 2.

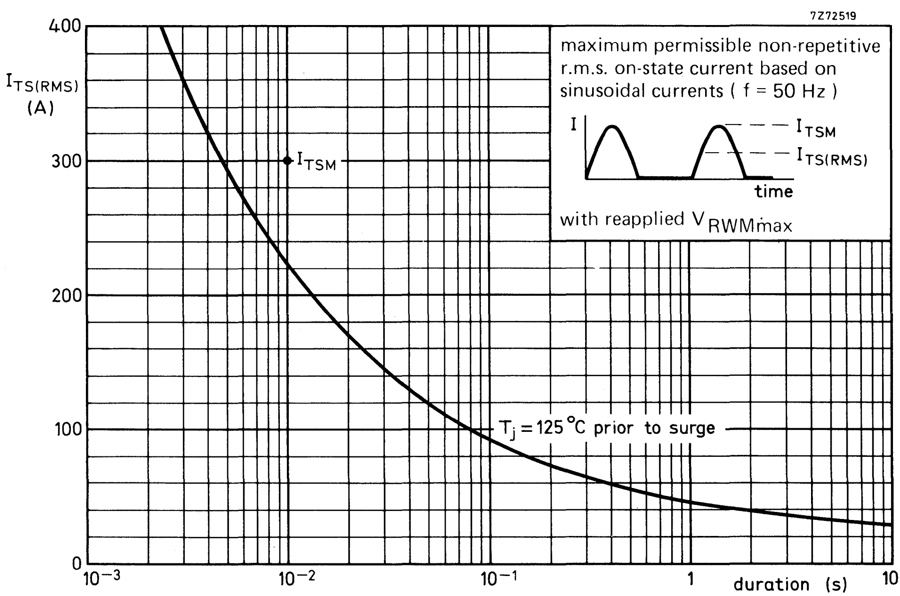

7Z72519
$I_{TS(RMS)}$
(A)
400
300
200
100
0
10^{-3}
10^{-2}
10^{-1}
1
duration (s)
10
I_{TSM}
maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents (f = 50 Hz)
I
I_{TSM}
$I_{TS(RMS)}$
time
with reapplied V_{RWMmax}
T_j = 125 °C prior to surge

Fig. 3.

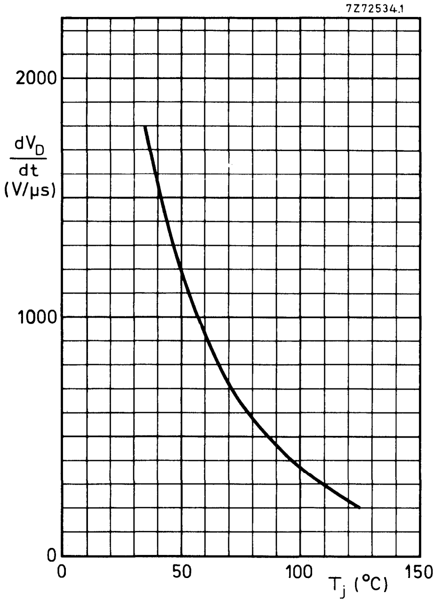


Fig. 4 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of T_j.

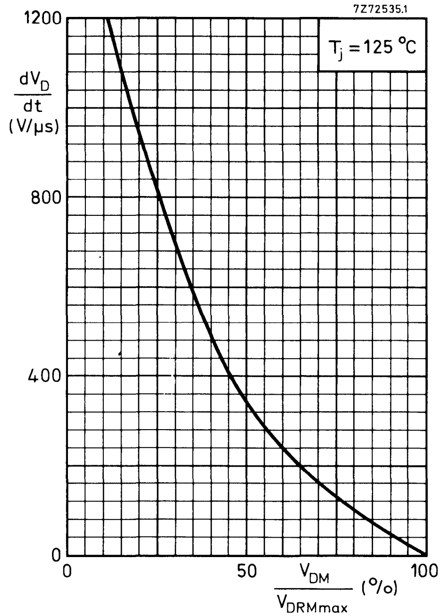


Fig. 5 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of applied voltage.

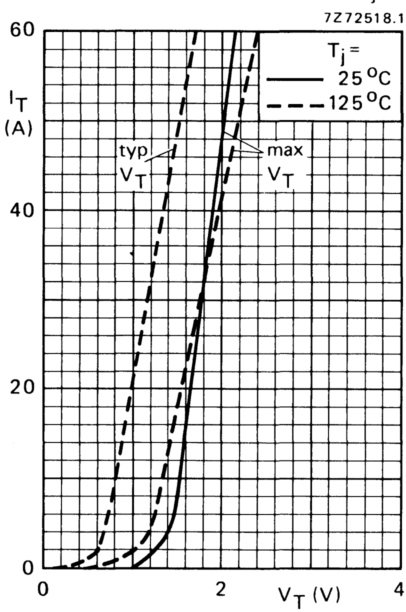


Fig. 6.

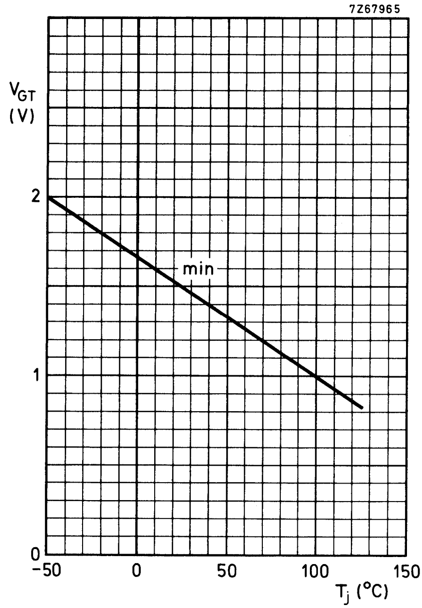


Fig. 7 Minimum gate voltage that will trigger all devices as a function of T_j.

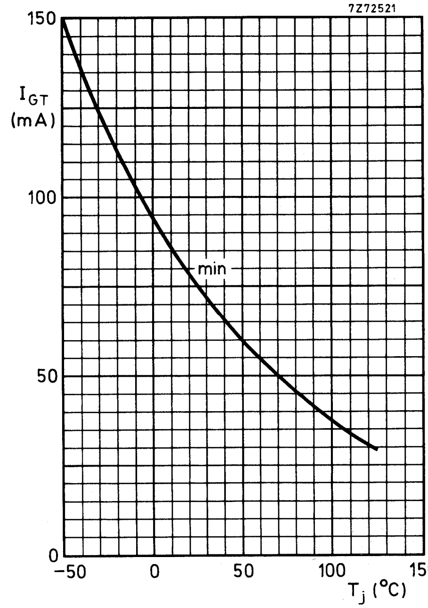


Fig. 8 Minimum gate current that will trigger all devices as a function of T_j.

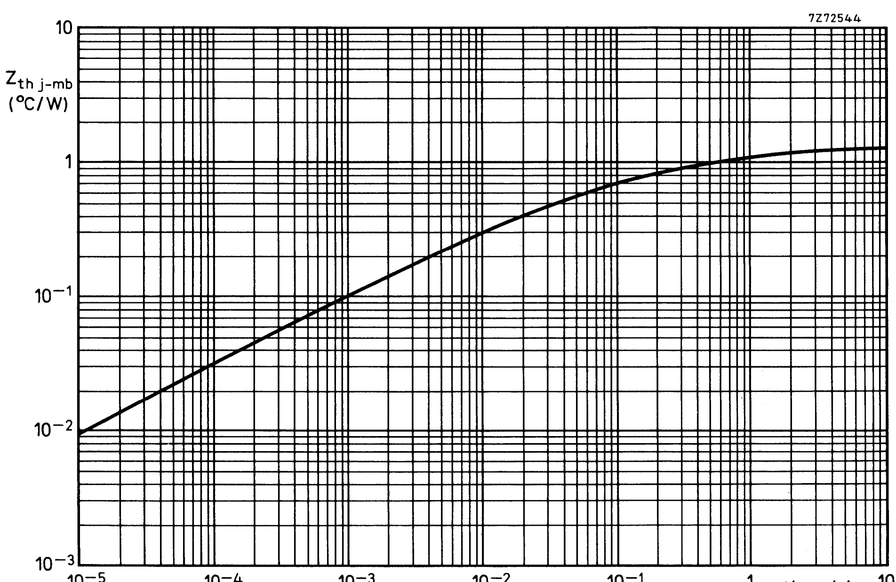


Fig. 9.

FAST TURN-OFF THYRISTORS

Asymmetrical thyristors (ASCR) in TO-238AA envelopes with electrically isolated metal baseplates, suitable for use in high-frequency inverters, power supplies, motor control systems etc. For reverse blocking operation use with a series diode, for reverse conducting operation use with an anti-parallel diode.

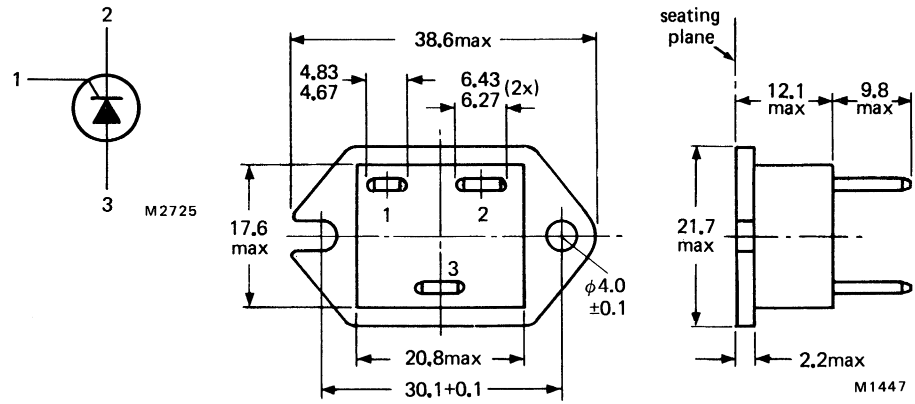
QUICK REFERENCE DATA

			BTW62–600R	800R	1000R	
Repetitive peak off-state voltage	V_{DRM}	max.	600	800	1000	V
Average on-state current	$I_{T(AV)}$	max.		18		A
Repetitive peak on-state current	I_{TRM}	max.		175		A
Circuit-commutated turn-off time						
suffix K	t_q	<		4		μs
suffix N	t_q	<		6		μs

MECHANICAL DATA

Dimensions in mm

Fig.1 TO-238AA



Pin 1 = gate (AMP 187 series)
2 = cathode (AMP 250 series)
3 = anode (AMP 250 series)
Baseplate is electrically isolated.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134).

Anode to cathode			BTW62–600R	800R	1000R	
Transient off-state voltage	V_{DSM}	max.	800	1000	1000	V
Repetitive peak off-state voltage	V_{DRM}	max.	600	800	1000	V
Continuous off-state voltage	V_D	max.	500	650	700	V

Transient reverse voltage; $t_p < 5\ \mu s$	V_{RSM}	max.	15	V
Average on-state current (averaged over any 20 ms period) up to T_{mb} = 85 °C	$I_{T(AV)}$	max.	18	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	28	A
Repetitive peak on-state current; $t_p = 50\ \mu s$; $\delta = 0.05$	I_{TRM}	max.	175	A
Non-repetitive peak on-state current T_j = 125 °C prior to surge; t = 10 ms; half sine-wave	I_{TSM}	max.	200	A
I^2t for fusing; t = 10 ms	I^2t	max.	200	A^2s
Rate of rise of on-state current after triggering with I_G = 1.25 A; I_T = 80 A	dI_T/dt	max.	1000	A/µs
Gate to cathode				
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	1	W
Peak power dissipation; t = 10 µs	P_{GM}	max.	10	W
Temperatures				
Storage temperature	T_{stg}		−40 to +125	°C
Operating junction temperature	T_j	max.	125	°C

ISOLATION*

R.M.S. isolation voltage	V_{isol}	min.	2500	V

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1.1	K/W
From mounting base to heatsink with heatsink compound	$R_{th\ mb\text{-}h}$	=	0.2	K/W

*From baseplate to all three terminals connected together.

CHARACTERISTICS

Anode to cathode

On-state voltage				
I_T = 50 A; T_j = 25 °C	V_T	<	2.6	V*
Off-state current				
$V_D = V_{Dmax}$; T_j = 125 °C	I_D	<	6.0	mA
Holding current; T_j = 25 °C	I_H	<	400	mA

Gate to cathode

Voltage that will trigger all devices				
V_D = 12 V; T_j = 25 °C	V_{GT}	>	2.0	V
Current that will trigger all devices				
V_D = 12 V; T_j = 25 °C	I_{GT}	>	250	mA

Switching characteristics (see Fig.2)

Circuit commutated turn-off time				
dV_D/dt = 500 V/μs (linear to V_{DRMmax});				
R_{GK} = 10 Ω; V_G = 0; T_j = 125 °C;				
when switched from I_T = 100 A; t_p = 150 μs				
$-dI_T/dt$ = 50 A/μs				
suffix K	t_q	<	6	μs
suffix N	t_q	<	9	μs
$-dI_T/dt$ = 10 A/μs				
suffix K	t_q	<	4	μs
suffix N	t_q	<	6	μs

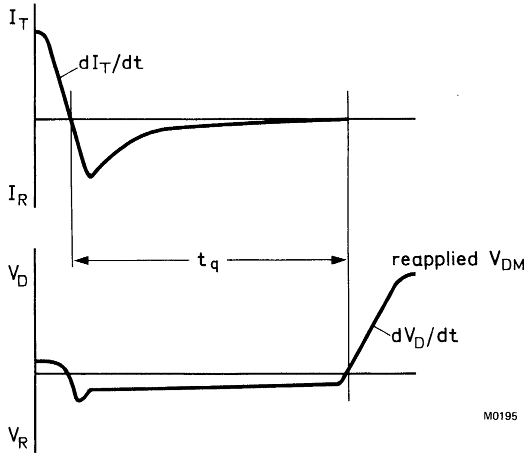


Fig.2 Circuit-commutated turn-off time definition.

*Measured under pulse conditions to avoid excessive dissipation.

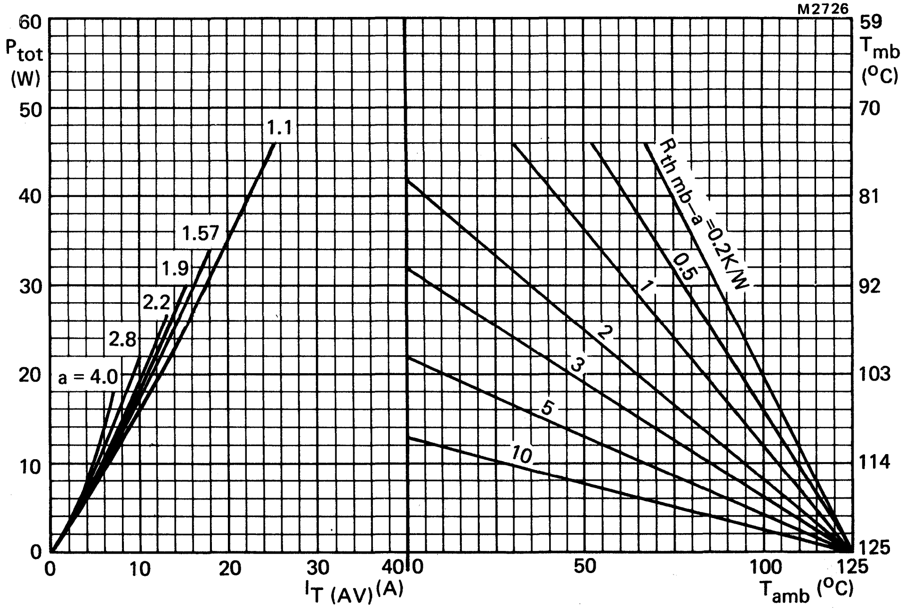


Fig.3 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

$$a = \text{form factor} = \frac{I_{T(RMS)}}{I_{T(AV)}}$$

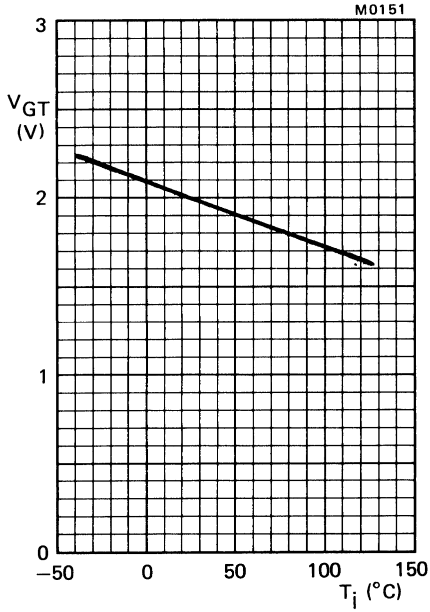


Fig.4 Minimum gate voltage that will trigger all devices plotted against junction temperature.

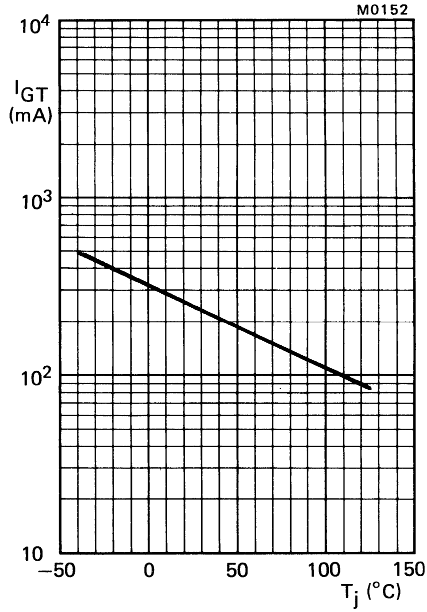


Fig.5 Minimum gate current that will trigger all devices plotted against junction temperature.

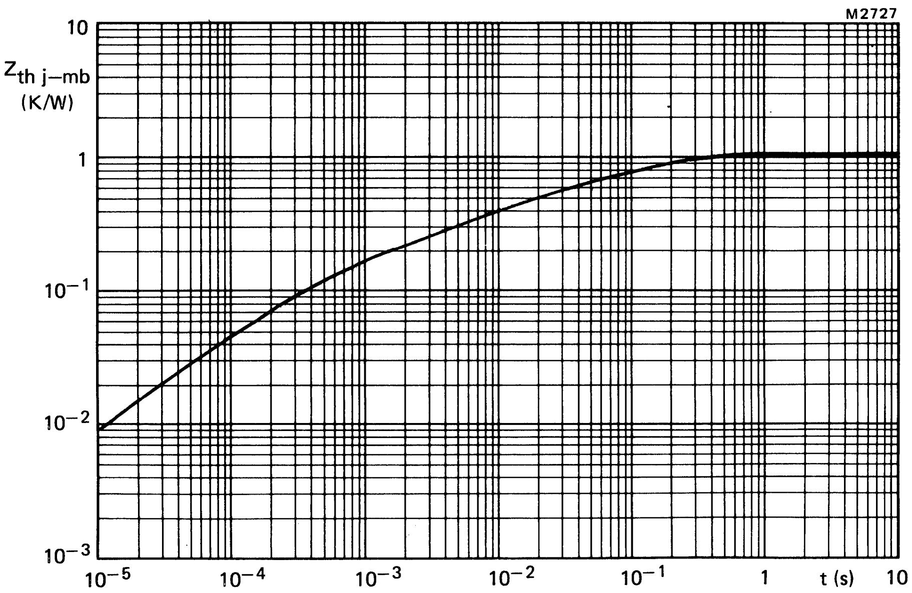


Fig.6 Transient thermal impedance.

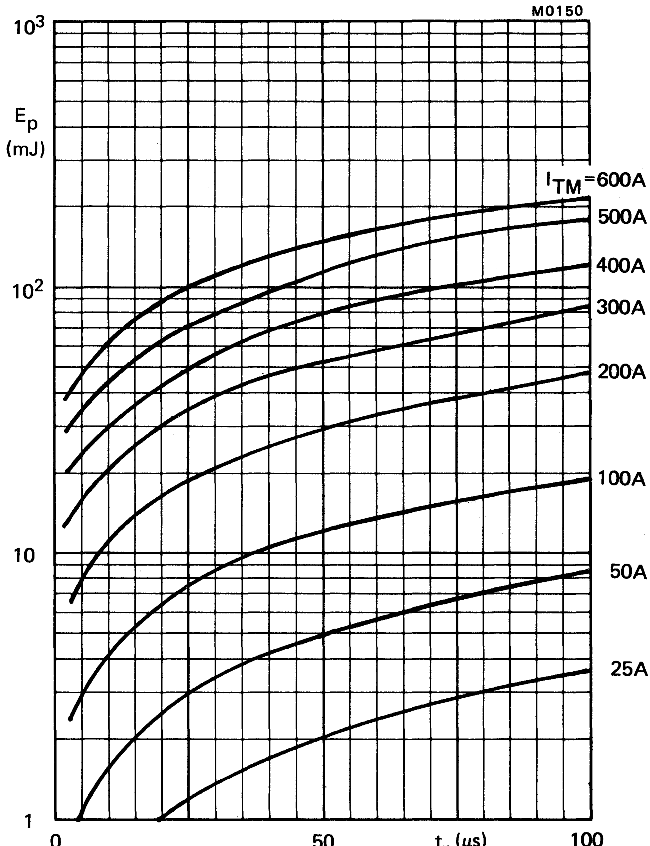


Fig.7 Maximum total energy loss per pulse when switching a half-sinusoidal pulse from 600 V.
Device power (W) = Energy per pulse (J) x No. of pulses per second.
For pulse widths > 100 μs use Fig.3.

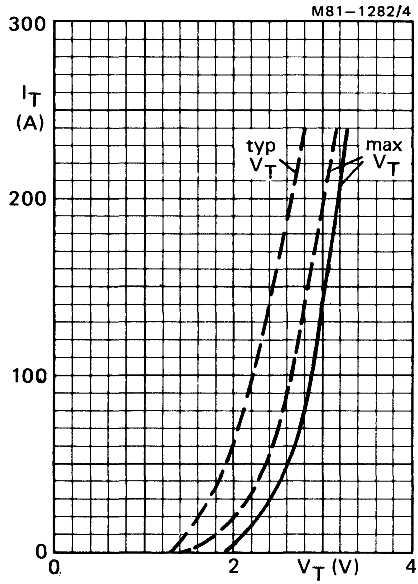


Fig.8 —— T_j = 25 °C; – – – T_j = 125 °C; t_p = 200 μs.

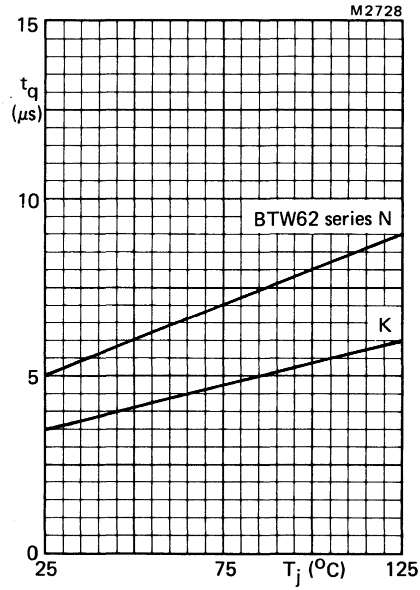


Fig.9 Variation of t_q with T_j; $-dI_T/dt$ = 50 A/μs; dV_D/dt = 500 V/μs (linear to V_{DRMmax}); I_T = 100 A; t_p = 150 μs; R_{GK} = 10 Ω; V_G = 0; maximum values.

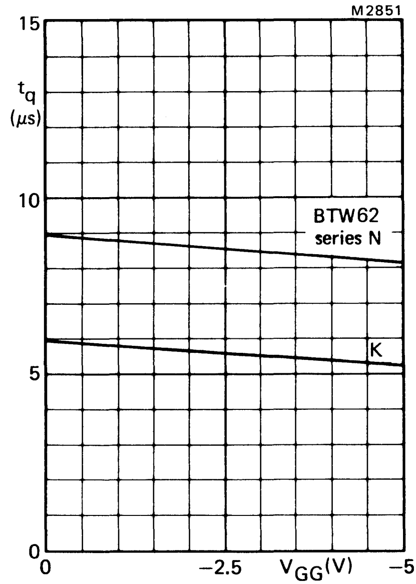


Fig.10 Variation of t_q with negative bias; $-dI_T/dt$ = 50 A/μs; dV_D/dt = 500 V/μs (linear to V_{DRMmax}); I_T = 100 A; t_p = 150 μs; T_j = 125 °C; maximum values.

FAST TURN-OFF THYRISTORS WITH ANTI-PARALLEL DIODES

Asymmetrical fast turn-off thyristors (ASCR) with anti-parallel-connected fast, soft-recovery diodes in TO-238AA envelopes. They are suitable for use in high-frequency inverters, power supplies and motor control systems requiring a parallel-connected flywheel or efficiency diode. The baseplate is electrically isolated.

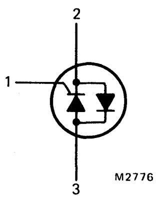
QUICK REFERENCE DATA

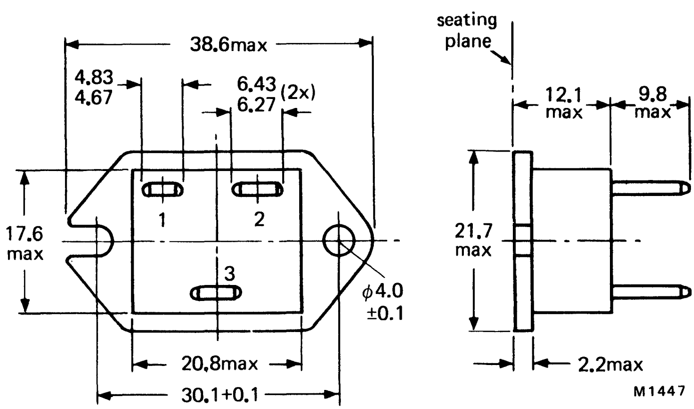
Thyristor			BTW62D–600R	800R	1000R	
Repetitive peak off-state voltage	V_{DRM}	max.	600	800	1000	V
Average on-state current	$I_{T(AV)}$	max.		18		A
Repetitive peak on-state current	I_{TRM}	max.		175		A
Circuit-commutated turn-off time						
suffix K	t_q	<		4		μs
suffix N	t_q	<		6		μs
Diode						
Average forward current	$I_{F(AV)}$	max.		8		A
Reverse recovery time	t_{rr}	<		600		ns

MECHANICAL DATA

Dimensions in mm

Fig.1 TO-238AA





Pin 1 = gate (AMP187 series)

2 = k (thyristor), a(diode) ; (AMP250 series)

3 = a(thyristor), k(diode) ; (AMP250 series)

Baseplate is electrically isolated.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134).

THYRISTOR

Anode to cathode			BTW62D–600R	800R	1000R	
Transient off-state voltage	V_{DSM}	max.	800	1000	1000	V
Repetitive peak off-state voltage	V_{DRM}	max.	600	800	1000	V
Continuous off-state voltage	V_D	max.	500	650	700	V

Average on-state current (averaged over any 20 ms period) up to T_{mb} = 85 °C	$I_{T(AV)}$	max.	18	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	28	A
Repetitive peak on-state current; t_p = 50 µs; δ = 0.05	I_{TRM}	max.	175	A
Non-repetitive peak on-state current T_j = 125 °C prior to surge; t = 10 ms; half sine-wave	I_{TSM}	max.	200	A
I^2t for fusing; t = 10 ms	I^2t	max.	200	A^2s
Rate of rise of on-state current after triggering with I_G = 1.25 A; I_T = 80 A	dI_T/dt	max.	1000	A/µs
Gate to cathode				
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	1	W
Peak power dissipation; t = 10 µs	P_{GM}	max.	10	W
DIODE				
Average forward current (averaged over any 20 ms period) up to T_{mb} = 85 °C	$I_{F(AV)}$	max.	8	A
Non-repetitive peak on-state current t = 10 ms; half sine-wave T_j = 125 °C prior to surge	I_{FSM}	max.	60	A
Temperatures				
Storage temperature	T_{stg}		–40 to +125	°C
Operating junction temperature	T_j	max.	125	°C
ISOLATION*				
R.M.S. isolation voltage	V_{isol}	min.	2500	V

*From baseplate to all three terminals connected together.

THERMAL RESISTANCE

Thyristor

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1.1	K/W
From mounting base to heatsink, with heatsink compound	$R_{th\ mb\text{-}h}$	=	0.2	K/W

Diode

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2.8	K/W
From mounting base to heatsink, with heatsink compound	$R_{th\ mb\text{-}h}$	=	0.2	K/W

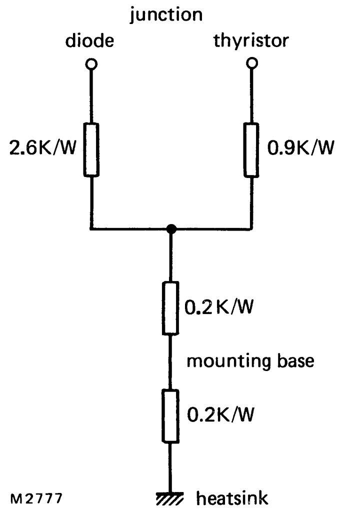


Fig.2 Equivalent thermal network.

THYRISTOR CHARACTERISTICS

Anode to cathode

On-state voltage				
I_T = 50 A; T_j = 25 °C	V_T	<	2.6	V*
Off-state current				
$V_D = V_{Dmax}$; T_j = 125 °C	I_D	<	6.0	mA
Holding current; T_j = 25 °C	I_H	<	400	mA

Gate to cathode

Voltage that will trigger all devices				
V_D = 12 V; T_j = 25 °C	V_{GT}	>	2.0	V
Current that will trigger all devices				
V_D = 12 V; T_j = 25 °C	I_{GT}	>	250	mA

Switching characteristics (see Fig.6)

Circuit-commutated turn-off time				
dV_D/dt = 500 V/µs (linear to V_{DRMmax});				
R_{GK} = 10 Ω; V_G = 0; T_j = 125 °C;				
when switched from I_T = 100 A; t_p = 150 µs				
$-dI_T/dt$ = 50 A/µs				
suffix K	t_q	<	6	µs
suffix N	t_q	<	9	µs
$-dI_T/dt$ = 10 A/µs				
suffix K	t_q	<	4	µs
suffix N	t_q	<	6	µs

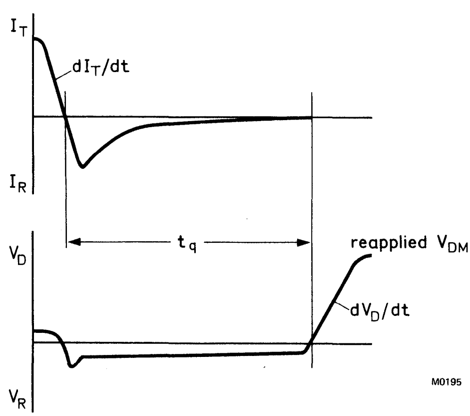


Fig.3 Circuit-commutated turn-off time definition.

*Measured under pulse conditions to avoid excessive dissipation.

THYRISTOR

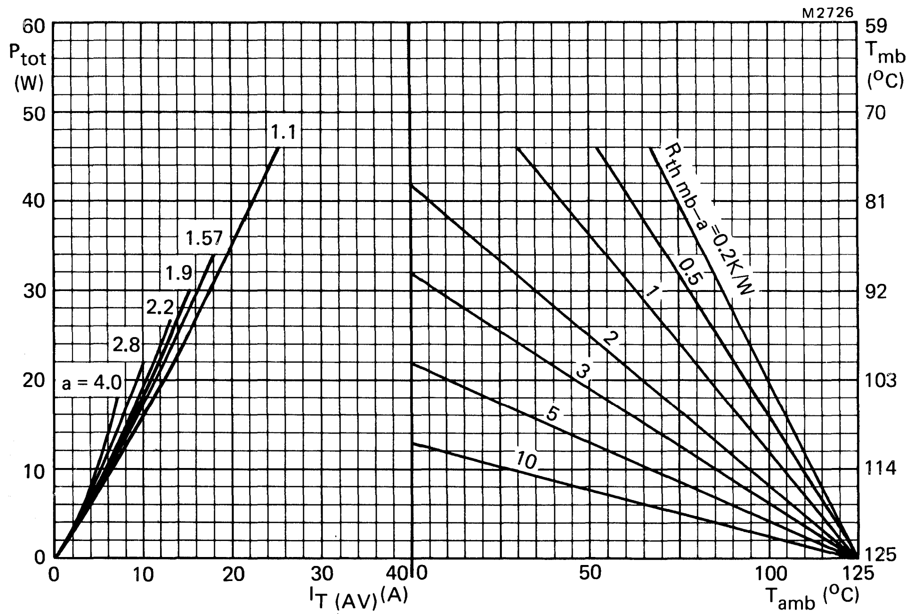


Fig.4 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

$$a = \text{form factor} = \frac{I_{T(RMS)}}{I_{T(AV)}}$$

THYRISTOR

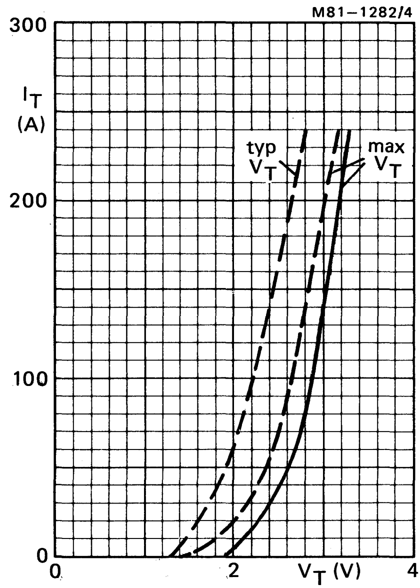


Fig.5 —— T_j = 25 °C; – – – T_j = 125 °C;
t_p = 200 μs.

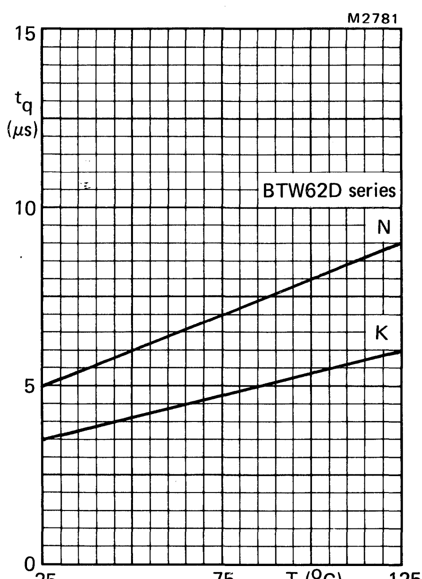


Fig.6a Variation of t_q with T_j;
$-dI_T/dt$ = 50 A/μs; dV_D/dt = 500 V/μs
(linear to V_{DRMmax}); I_T = 100 A; t_p = 150 μs;
R_{GK} = 10 Ω; V_G = 0; maximum values.

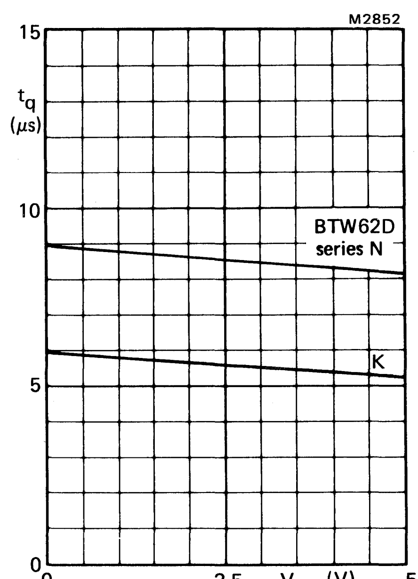


Fig.6b Variation of t_q with negative bias;
$-dI_T/dt$ = 50 A/μs; dV_D/dt = 500 V/μs
(linear to V_{DRMmax}); I_T = 100 A; t_p = 150 μs;
T_j = 125 °C; maximum values.

THYRISTOR

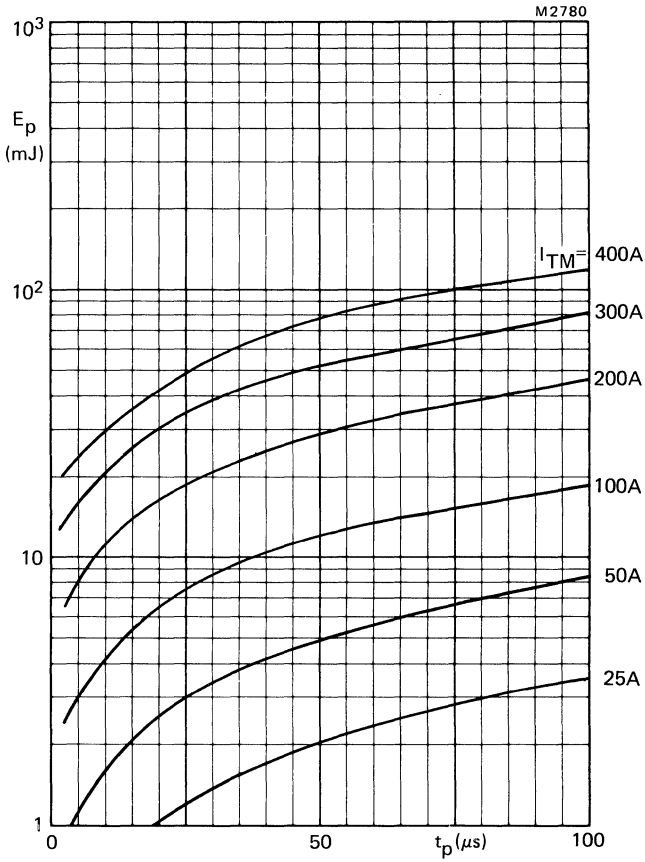


Fig.7 Maximum total energy loss per pulse when switching a half-sinusoidal pulse from 600 V.
Device power (W) = Energy per pulse (J) x No. of pulses per second.
For pulse widths > 100 μs use Fig.4.

THYRISTOR

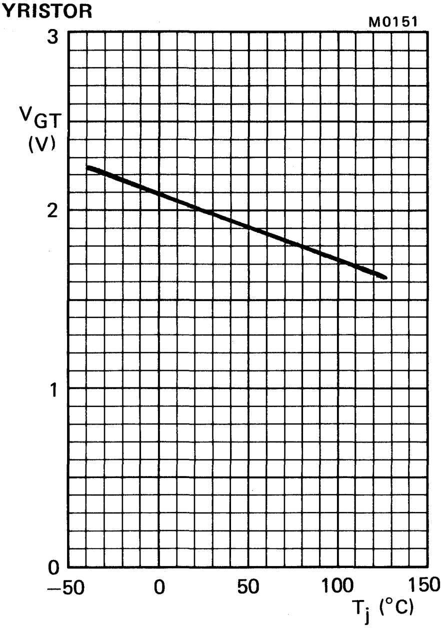


Fig.8 Minimum gate voltage that will trigger all devices plotted against junction temperature.

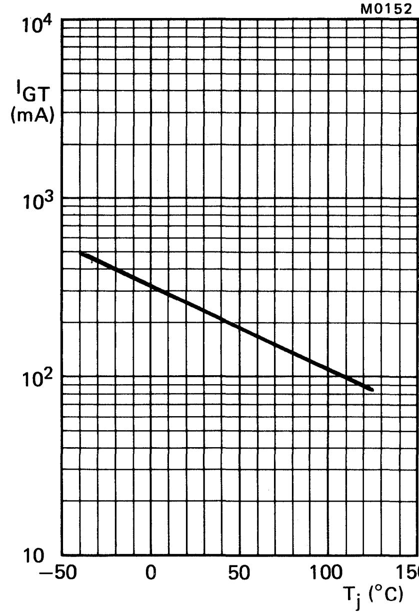


Fig.9 Minimum gate current that will trigger all devices plotted against junction temperature.

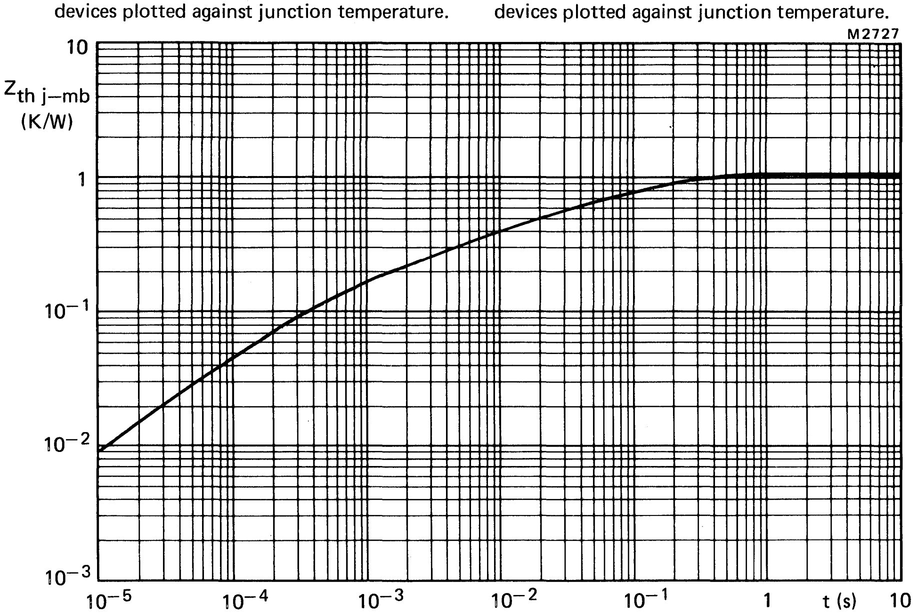


Fig.10 Transient thermal impedance.

DIODE CHARACTERISTICS

Forward voltage				
I_F = 10 A; T_j = 25 °C	V_F	<	2.0	V*
Reverse recovery when switched from				
I_F = 2 A to $V_R \geq$ 30 V with				
$-dI_F/dt$ = 20 A/μs; T_j = 25 °C				
recovered charge	Q_s	<	2.0	μC
recovery time	t_{rr}	<	0.6	μs
Forward recovery when switched to				
I_F = 5 A with t_r = 0.1 μs; T_j = 25 °C				
recovery time	t_{fr}	<	2.0	μs

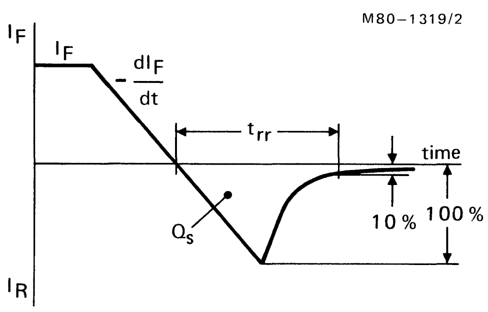


Fig.11 Definition of t_{rr} and Q_s.

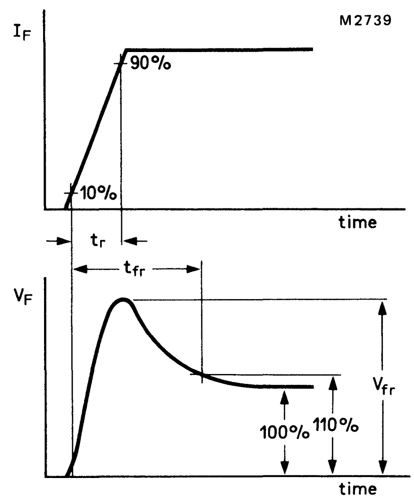


Fig.12 Definition of t_{fr}.

*Measured under pulse conditions to avoid excessive dissipation.

DIODE

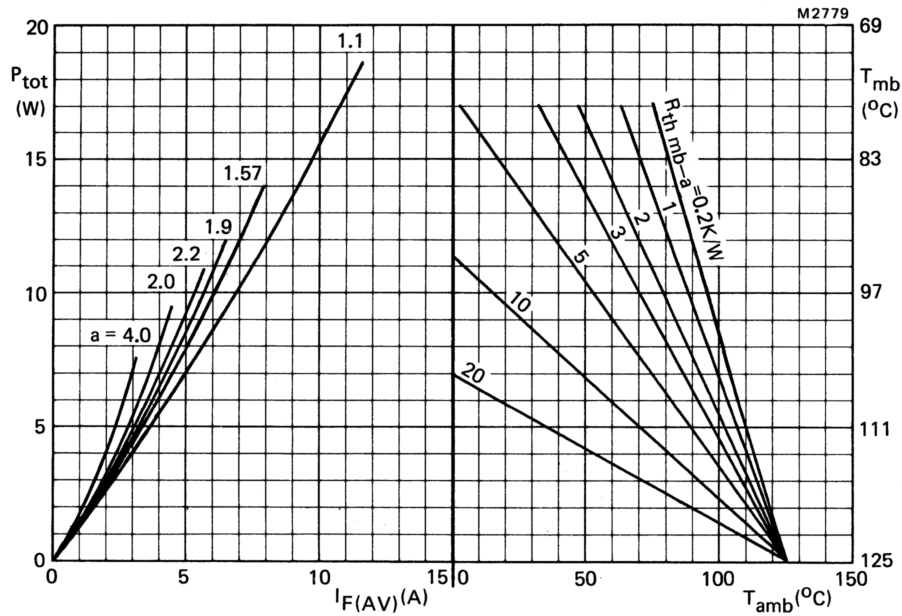


Fig.13 The right hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

$$a = \text{form factor} = \frac{I_{T(RMS)}}{I_{T(AV)}}$$

DIODE

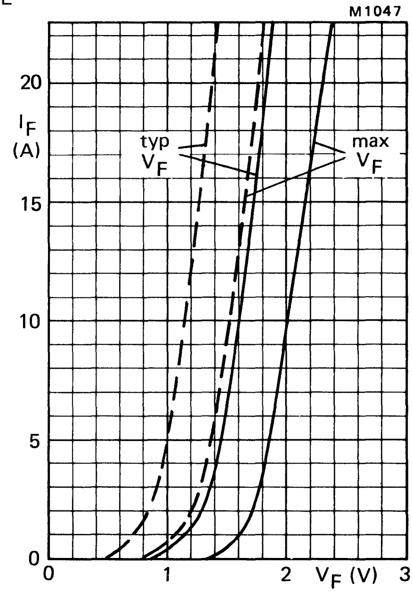


Fig.14 ——— T_j = 25 °C; – – – – T_j = 125 °C.

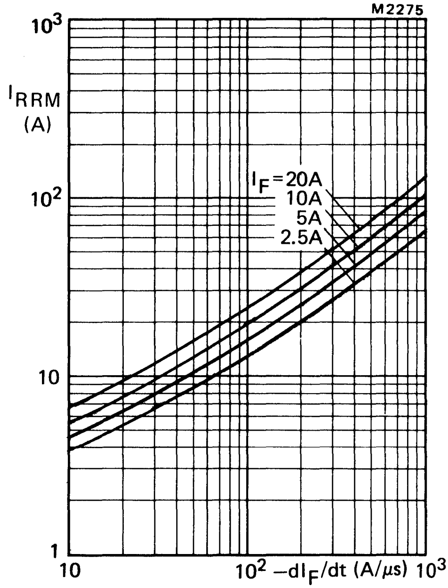


Fig.15 Peak reverse recovery current versus $-dI_F/dt$; T_j = 25 °C; maximum values.

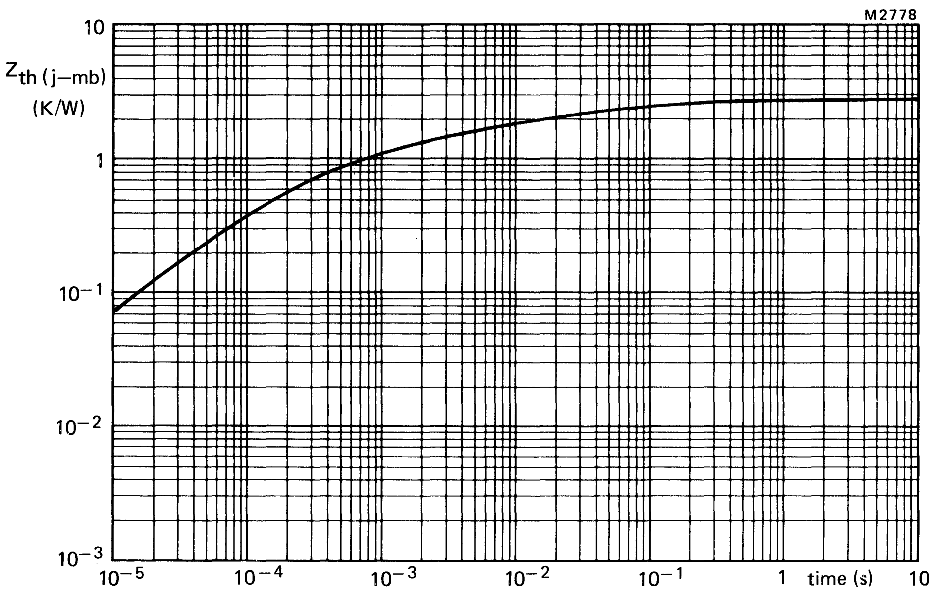


Fig.16 Transient thermal impedance.

FAST TURN-OFF THYRISTORS

Glass-passivated, asymmetrical, fast turn-off, forward blocking thyristors (ASCR) in TO-48 envelopes, suitable for operation in fast power inverters. For reverse-blocking operation use with a series diode, for reverse-conducting operation use with an anti-parallel diode.

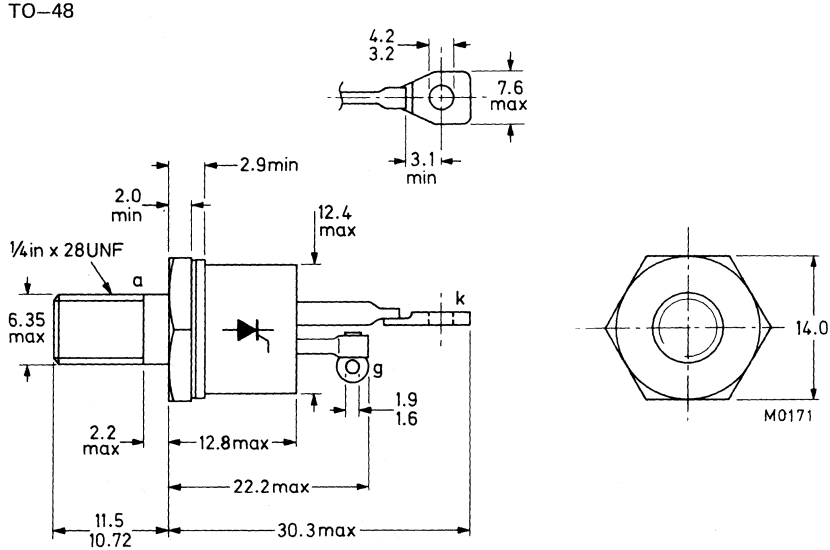
QUICK REFERENCE DATA

			BTW63–600R	800R	1000R	
Repetitive peak off-state voltage	V_{DRM}	max.	600	800	1000	V
Average on-state current	$I_{T(AV)}$	max.		25		A
Repetitive peak on-state current	I_{TRM}	max.		250		A
Circuit-commutated turn-off time						
suffix K	t_q	<		4		μs
suffix N	t_q	<		6		μs

MECHANICAL DATA

Dimensions in mm

Fig.1 TO–48



Net Mass: 14 g
Diameter of clearance hole: max. 6.5 mm
Accessories supplied on request:
56264a (mica washer);
56264b (insulating bush).

Supplied with device: 1 nut, 1 lock washer.
Torque on nut: min. 1.7 Nm (17 kg cm)
max. 3.5 Nm (35 kg cm)
Nut dimensions across the flats: 11.1 mm

Products approved to CECC 50 011-010 available on request.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134)

Anode to cathode			BTW63–600R	800R	1000R	
Transient off-state voltage	V_{DSM}	max.	800	1000	1000	V
Repetitive peak off-state voltage	V_{DRM}	max.	600	800	1000	V
Continuous off-state voltage	V_D	max.	500	650	700	V

Transient reverse voltage ($t_p \leqslant 5\ \mu s$)	V_{RSM}	max.	15	V
Average on-state current averaged over any 20 ms period; → up to $T_{mb} = 85\ ^oC$	$I_{T(AV)}$	max.	25	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	40	A
Repetitive peak on-state current; $t_p = 50\ \mu s$; $\delta = 0.05$	I_{TRM}	max.	250	A
Non-repetitive peak on-state current $T_j = 125\ ^oC$ prior to surge; t = 10 ms; half sine-wave	I_{TSM}	max.	370	A
I^2t for fusing; t = 10 ms	I^2t	max.	700	A^2s
Rate of rise of on-state current after triggering with $I_G = 1.25$ A; $I_T = 80$ A	dI_T/dt	max.	1000	A/μs
Gate to cathode				
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	1	W
Peak power dissipation; t = 10 μs	P_{GM}	max.	10	W
Temperatures				
Storage temperature	T_{stg}		−40 to +125	^oC
Operating junction temperature	T_j	max.	125	^oC

THERMAL RESISTANCE

→ From junction to mounting base	$R_{th\ j\text{-}mb}$	=	0.8	K/W
From mounting base to heatsink with heatsink compound	$R_{th\ mb\text{-}h}$	=	0.2	K/W

OPERATING NOTE

The terminals should be neither bent nor twisted; they should be soldered into the circuit so that there is no strain on them.
During soldering the heat conduction to the junction should be kept to a minimum.

CHARACTERISTICS

Anode to cathode

On-state voltage				
$I_T = 50$ A; $T_j = 25$ °C	V_T	<	2.6	V*
Off-state current				
$V_D = V_{Dmax}$; $T_j = 125$ °C	I_D	<	6.0	mA
Holding current; $T_j = 25$ °C	I_H	<	400	mA

Gate to cathode

Voltage that will trigger all devices				
$V_D = 12$ V; $T_j = 25$ °C	V_{GT}	>	2.0	V
Current that will trigger all devices				
$V_D = 12$ V; $T_j = 25$ °C	I_{GT}	>	250	mA

Switching characteristics (see Fig. 2) ←

Circuit commutated turn-off time

$dV_D/dt = 500$ V/µs (linear to V_{DRMmax});
$R_{GK} = 10\ \Omega$; $V_G = 0$; $T_j = 125$ °C;
when switched from $I_T = 100$ A; $t_p = 150$ µs

$-dI_T/dt = 50$ A/µs				
suffix K	t_q	<	6	µs
suffix N	t_q	<	9	µs
$-dI_T/dt = 10$ A/µs				
suffix K	t_q	<	4	µs
suffix N	t_q	<	6	µs

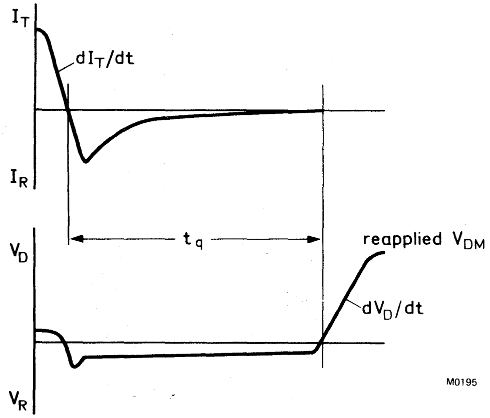


Fig.2 Circuit-commutated turn-off time definition.

*Measured under pulse conditions to avoid excessive dissipation.

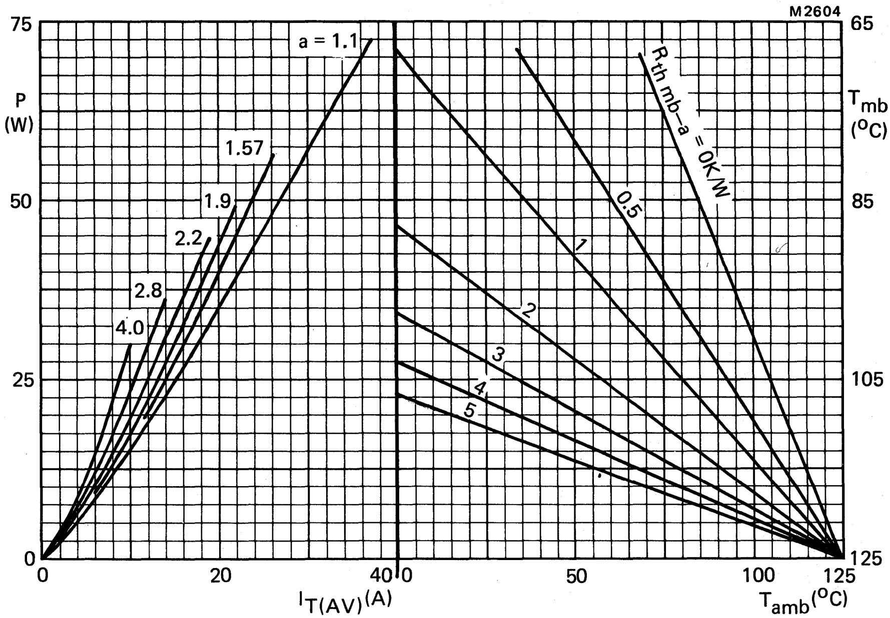


Fig.3 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

$$a = \text{form factor} = \frac{I_{T(RMS)}}{I_{T(AV)}}$$

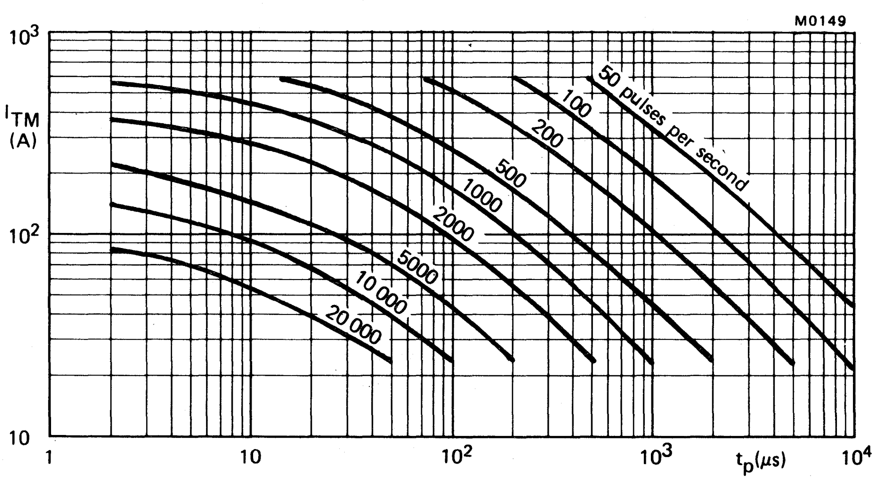


Fig.4 Maximum allowable peak on-state current versus pulse width; T_{mb} = 85 °C.

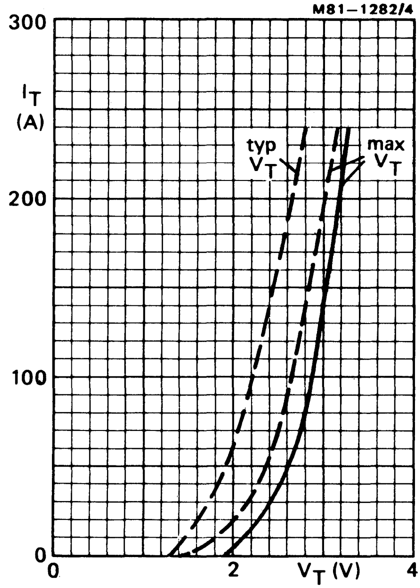


Fig.5 —— T_j = 25 °C; – – – T_j = 125 °C; t_p = 200 μs.

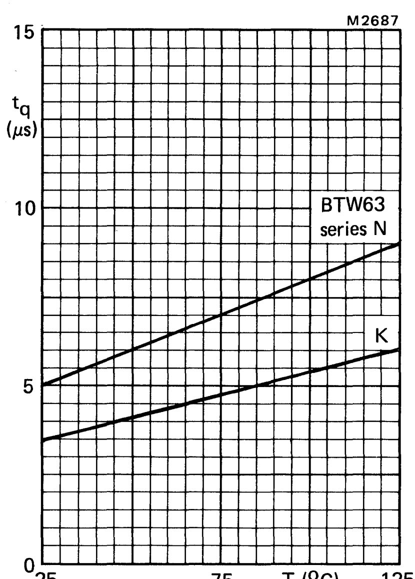


Fig.6a Variation of t_q with T_j;
$-dI_T/dt$ = 50 A/μs; dV_D/dt = 500 V/μs (linear to V_{DRMmax}); I_T = 100 A; t_p = 150 μs; R_{GK} = 10 Ω; V_G = 0; maximum values.

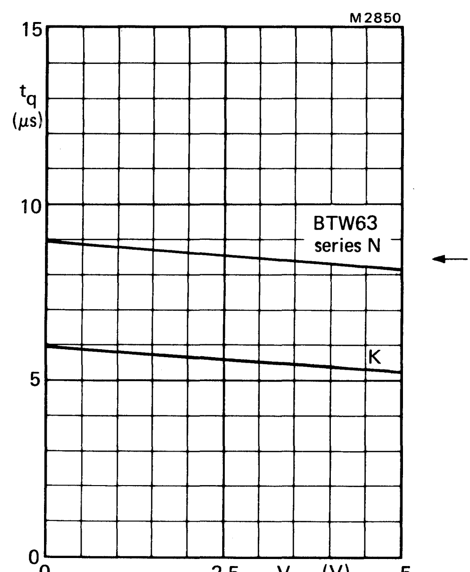


Fig.6b Variation of t_q with negative bias;
$-dI_T/dt$ = 50 A/μs; dV_D/dt = 500 V/μs (linear to V_{DRMmax}); I_T = 100 A; t_p = 150 μs; T_j = 125 °C; maximum values.

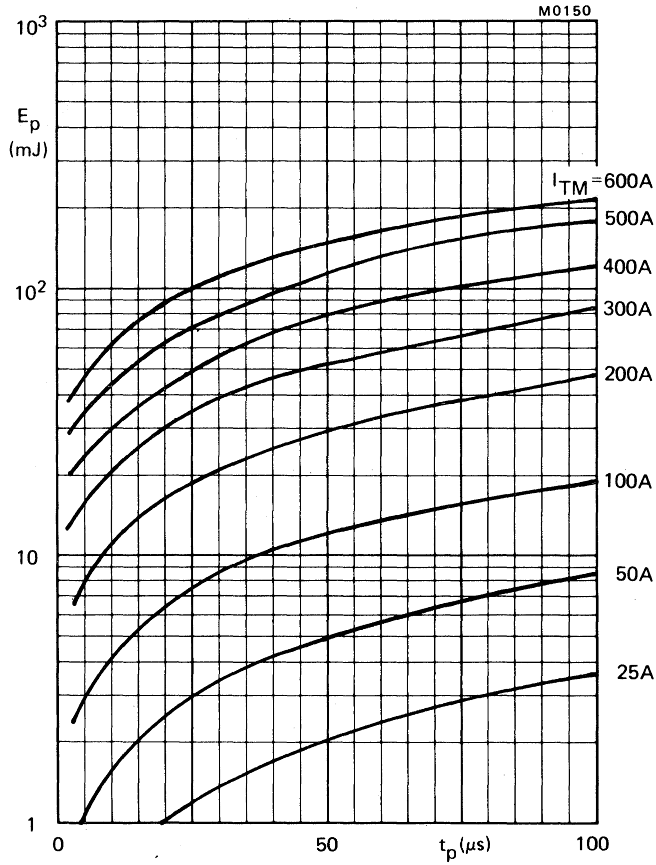


Fig.7 Maximum total energy loss per pulse when switching a half-sinusoidal pulse from 600 V.
Device power (W) = Energy per pulse (J) x No. of pulses per second.
For pulse widths $>$ 100 μs use Fig.3.

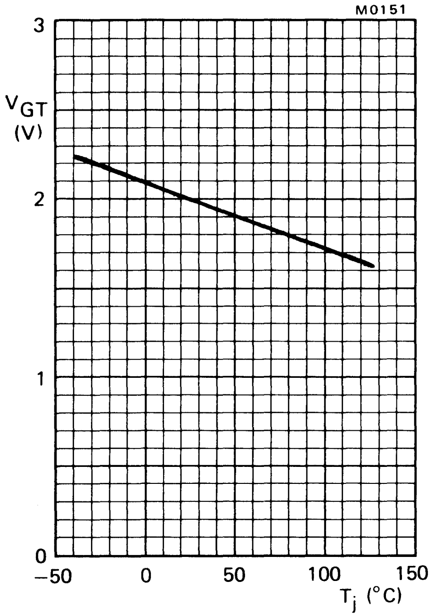


Fig.8 Minimum gate voltage that will trigger all devices plotted against junction temperature.

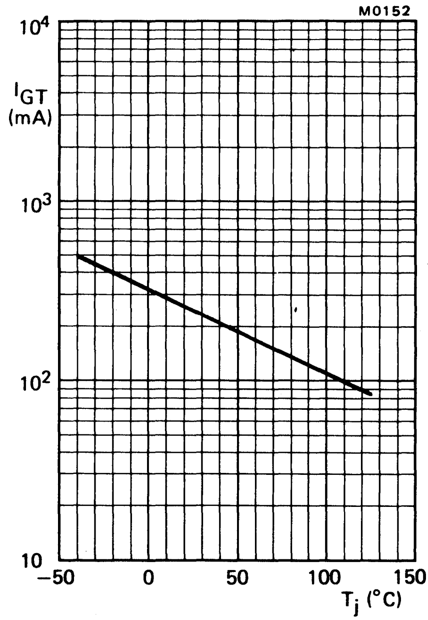


Fig.9 Minimum gate current that will trigger all devices plotted against junction temperature.

THYRISTORS

Glass-passivated silicon thyristors in metal envelopes, intended for use in power control circuits (e.g. light and motor control) and power switching systems.
The series consistos of reverse polarity types (anode to stud) identified by a suffix R: BTY79-400R to 1000R.

QUICK REFERENCE DATA

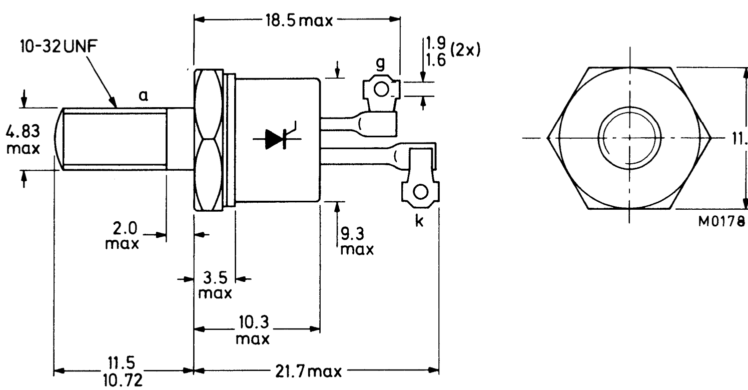
		BTY79-400R	500R	600R	800R	1000R	
Repetitive peak voltages V_{DRM}/V_{RRM}	max.	400	500	600	800	1000	V

Average on-state current	$I_{T(AV)}$	max.	10	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	16	A
Non-repetitive peak on-state current	I_{TSM}	max.	150	A

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-64: with 10-32 UNF stud (ϕ 4,83 mm).



Net mass: 7 g
Diameter of clearance hole: max. 5,2 mm
Accessories supplied on request:
see ACCESSORIES section

Torque on nut: min. 0,9 Nm
(9 kg cm)
max. 1,7 Nm
(17 kg cm)

Supplied with device: 1 nut, 1 lock washer.
Nut dimensions: across the flats: 9,5 mm.
Products approved to CECC 50 011-006 available on request.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Anode to cathode

			BTY79–400R	500R	600R	800R	1000R	
Non-repetitive peak off-state voltage ($t \leq 10$ ms)	V_{DSM}**	max.	500	1100	1100	1100	1100	V
Non-repetitive peak reverse voltage ($t \leq 5$ ms)	V_{RSM}	max.	500	600	720	960	1100	V
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	400	500	600	800	1000	V
Crest working voltages	V_{DWM}/V_{RWM}	max.	400	500	600	800	1000	V*

Average on-state current (averaged over any 20 ms period) up to T_{mb} = 85 °C	$I_{T(AV)}$	max.	10	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	16	A
Repetitive peak on-state current	I_{TRM}	max.	75	A
Non-repetitive peak on-state current; t = 10 ms; half sine-wave; T_j = 125 °C prior to surge; with reapplied V_{RWMmax}	I_{TSM}	max.	150	A
I^2t for fusing (t = 10 ms)	I^2t	max.	112	A^2s
Rate of rise of on-state current after triggering with I_G = 150 mA to I_T = 30 A; dI_G/dt = 0,25 A/μs	dI_T/dt	max.	50	A/μs

Gate to cathode

Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	0,5	W
Peak power dissipation	P_{GM}	max.	5	W

Temperatures

Storage temperature	T_{stg}		−55 to +125	°C
Junction temperature	T_j	max.	125	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\,j\text{-}mb}$	=	1,8	°C/W
From mounting base to heatsink with heatsink compound	$R_{th\,mb\text{-}h}$	=	0,5	°C/W
From junction to ambient in free air	$R_{th\,j\text{-}a}$	=	45	°C/W
Transient thermal impedance (t = 1 ms)	$Z_{th\,j\text{-}mb}$	=	0,1	°C/W

* To ensure thermal stability: $R_{th\,j\text{-}a} < 4$ °C/W (d.c. blocking) or < 8 °C/W (a.c.). For smaller heatsinks $T_{j\,max}$ should be derated. For a.c. see Fig. 3.

** Although not recommended, higher off-state voltages may be applied without damage, but the thyristor may switch into the on-state. The rate of rise of on-state current should not exceed 100 A/μs.

CHARACTERISTICS

Anode to cathode

On-state voltage (measured under pulse conditions) $I_T = 20$ A; $T_j = 25$ °C	V_T	<	2	V
Rate of rise of off-state voltage that will not trigger any device; exponential method; $V_D = 2/3\ V_{DRMmax}$; $T_j = 125$ °C	dV_D/dt	<	200	V/μs
Reverse current $V_R = V_{RWMmax}$; $T_j = 125$ °C	I_R	<	3	mA
Off-state current $V_D = V_{DWMmax}$; $T_j = 125$ °C	I_D	<	3	mA
Latching current; $T_j = 25$ °C	I_L	<	150	mA
Holding current; $T_j = 25$ °C	I_H	<	75	mA

Gate to cathode

Voltage that will trigger all devices $V_D = 6$ V; $T_j = 25$ °C	V_{GT}	>	1.5	V
Voltage that will not trigger any device $V_D = V_{DRMmax}$; $T_j = 125$ °C	V_{GD}	<	200	mV
Current that will trigger all devices $V_D = 6$ V; $T_j = 25$ °C	I_{GT}	>	30	mA
On request (see Ordering Note)	I_{GT}	>	20	mA

Switching characteristics

Gate-controlled turn-on time ($t_{gt} = t_d + t_r$) when switched from $V_D = V_{DRMmax}$ to $I_T = 40$ A; $I_{GT} = 100$ mA; $dI_G/dt = 5$ A/μs; $T_j = 25$ °C	t_{gt}	typ.	2	μs
Circuit-commutated turn-off time when switched from $I_T = 40$ A to $V_R > 50$ V with $-dI_T/dt = 10$ A/μs; $dV_D/dt = 50$ V/μs; $T_j = 115$ °C	t_q	typ.	35	μs

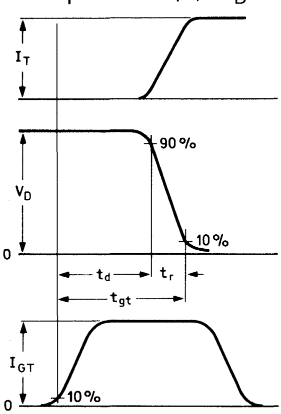


Fig.2a Gate-controlled turn-on time definition.

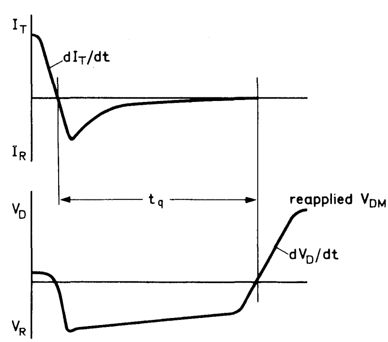


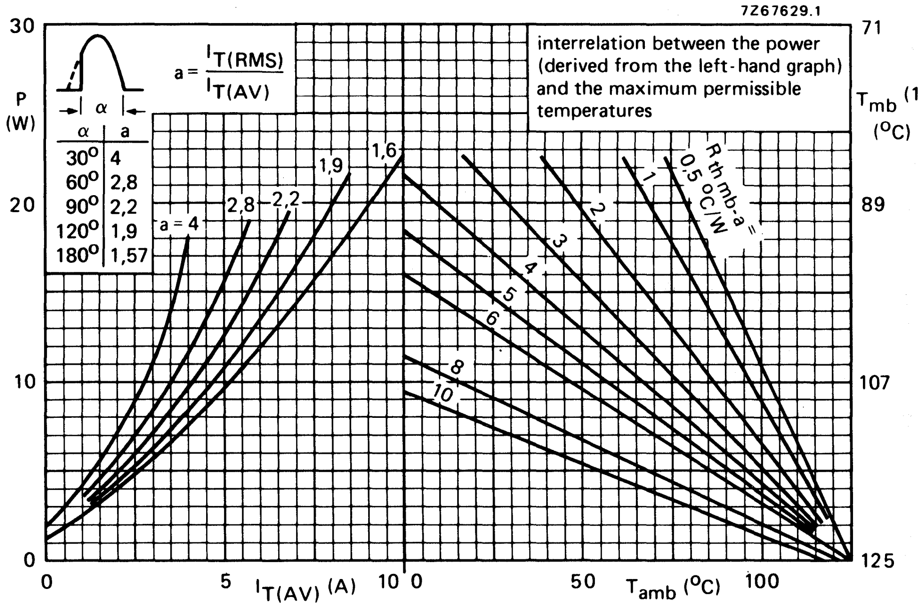
Fig.2b Circuit-commutated turn-off time definition.

OPERATING NOTE

The terminals should neither be bent nor twisted; they should be soldered into the circuit so that there is no strain on them.
During soldering the heat conduction to the junction should be kept to a minimum.

ORDERING NOTE

Types with low gate trigger current, $I_{GT} > 20$ mA, are available on request. Add suffix A to the type number when ordering: e.g. BTY79A-400R.



(1) T_{mb}-scale is for comparison purposes only and is correct only for $R_{th\,mb\text{-}a} \leqslant 6$ °C/W.

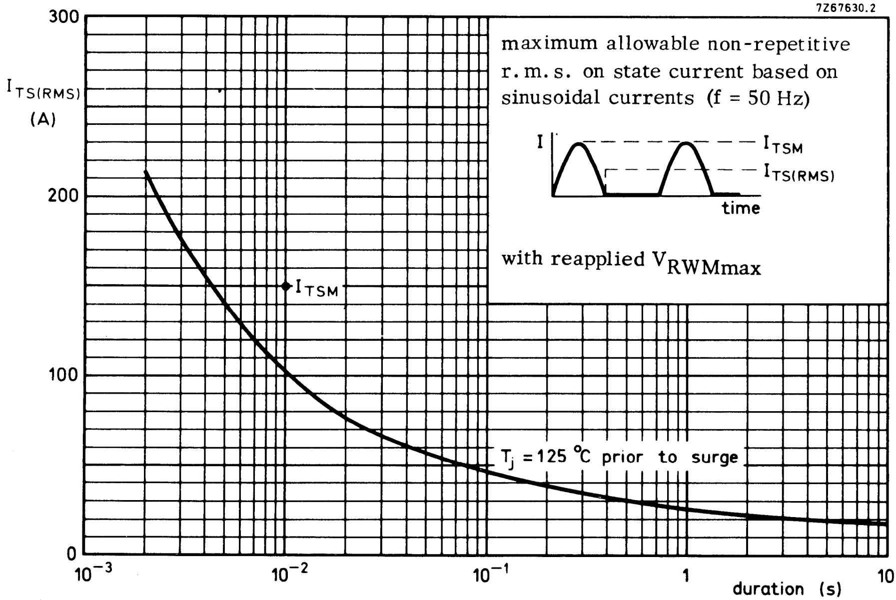

7Z67630.2
300
200
100
0
$I_{TS(RMS)}$
(A)
maximum allowable non-repetitive r.m.s. on state current based on sinusoidal currents (f = 50 Hz)
I
I_{TSM}
$I_{TS(RMS)}$
time
with reapplied V_{RWMmax}
I_{TSM}
T_j = 125 °C prior to surge
10^{-3}
10^{-2}
10^{-1}
1
10
duration (s)

Fig. 4.

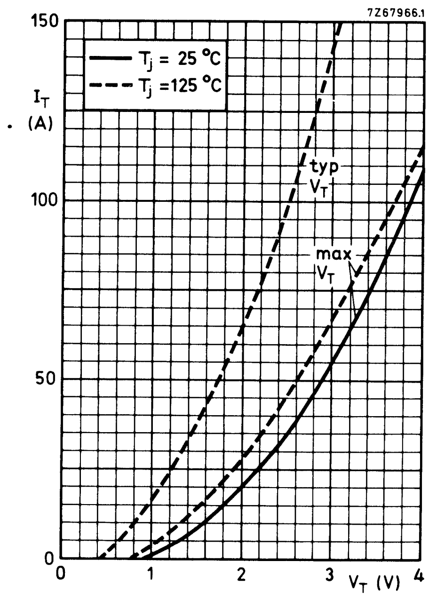

7Z67966.1
150
100
50
0
I_T
(A)
T_j = 25 °C
T_j = 125 °C
typ
V_T
max
V_T
0
1
2
3
4
V_T (V)

Fig. 5.

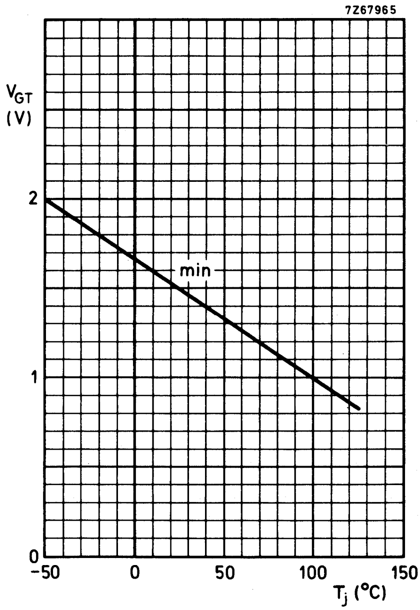


Fig. 6 Minimum gate voltage that will trigger all devices as a function of T_j.

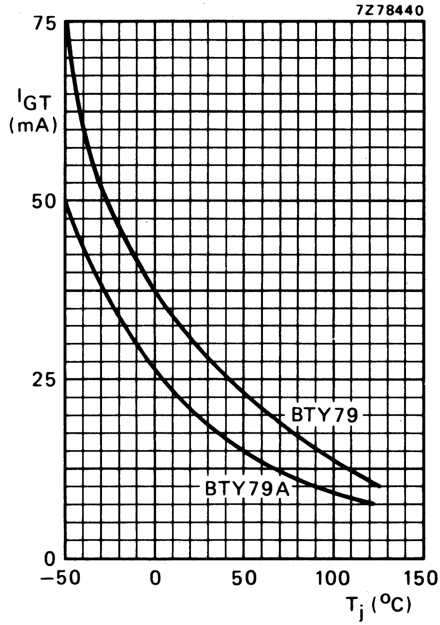


Fig. 7 Minimum gate current that will trigger all devices as a function of T_j.

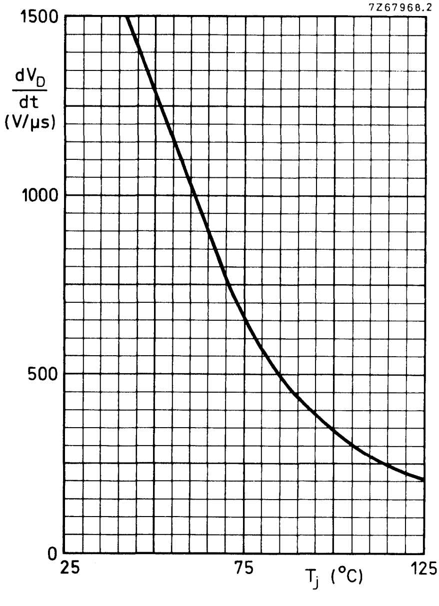


Fig. 8 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of T_j.

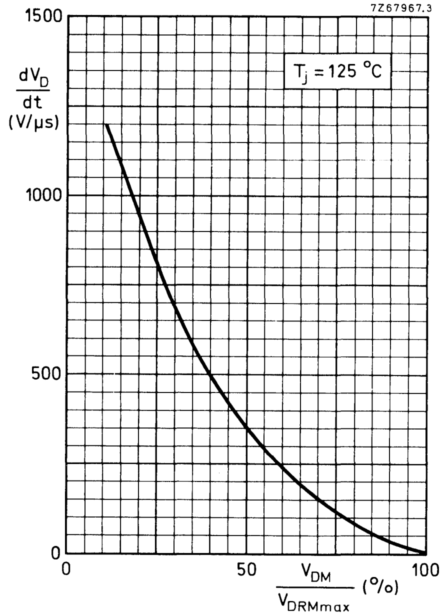
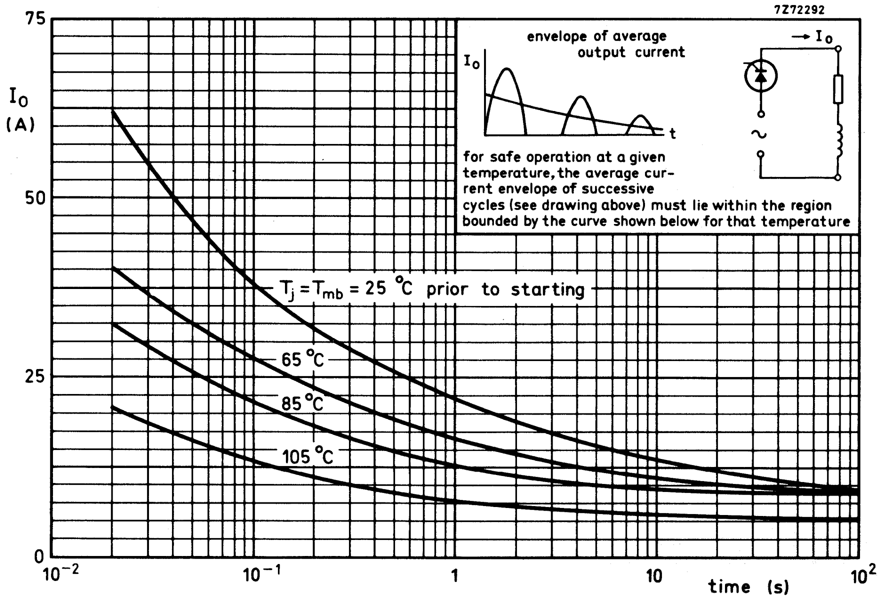


Fig. 9 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of applied voltage.



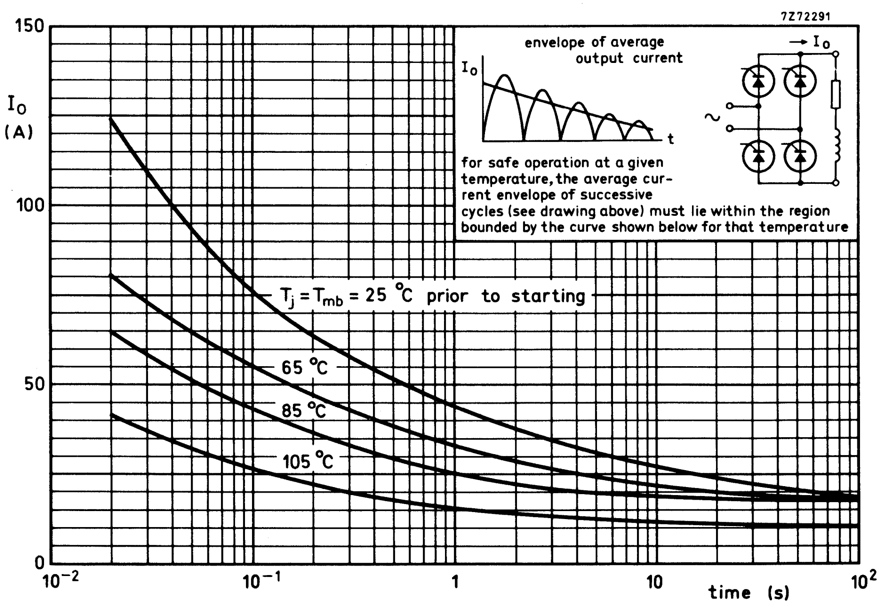


Fig. 10 Limits for starting or inrush currents.

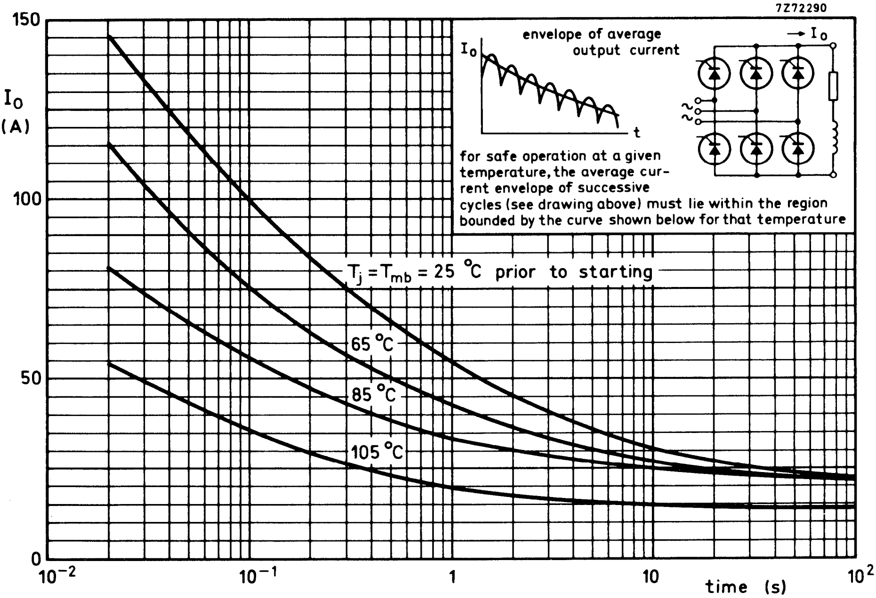


Fig. 11 Limits for starting or inrush currents.

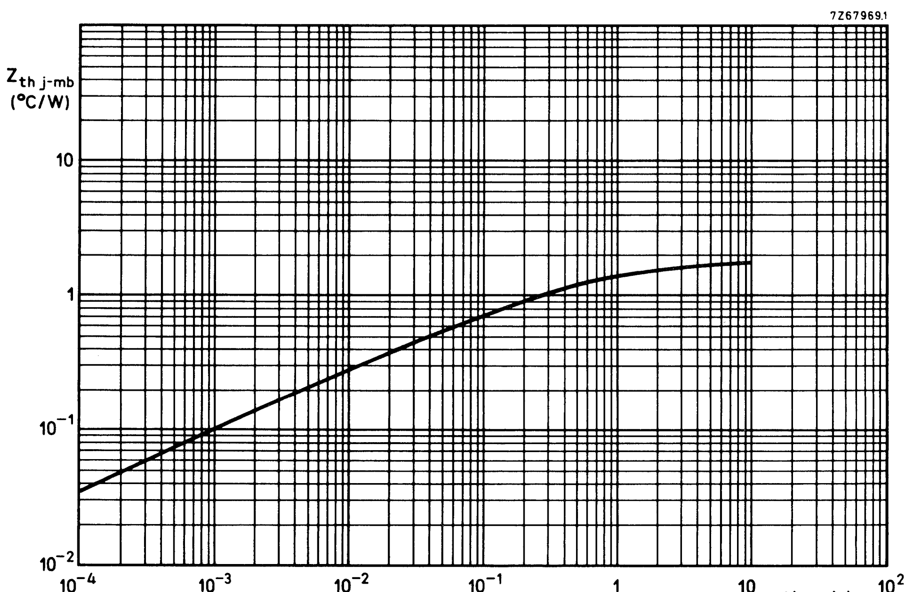


Fig. 12.

THYRISTORS

Glass-passivated silicon thyristors in metal envelopes, intended for power control and power switching applications.
The series consists of reverse polarity types (anode to stud) identified by a suffix R: BTY91-400R to 800R.

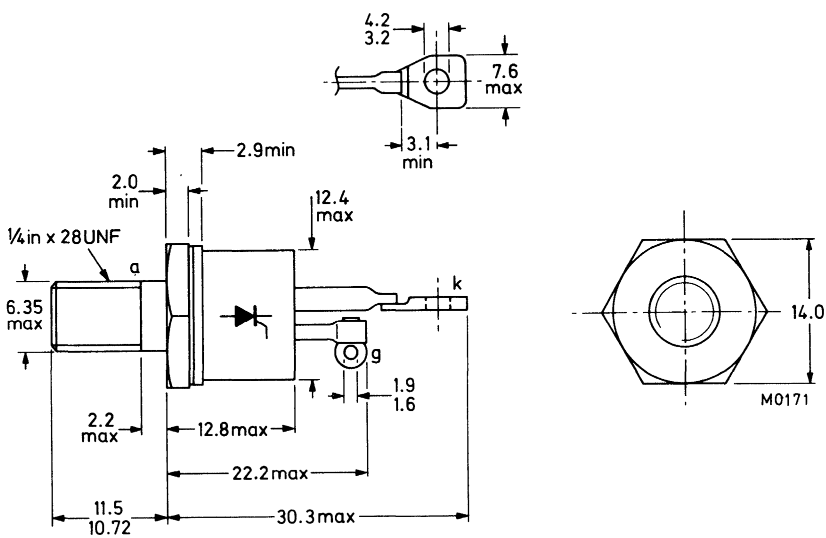
QUICK REFERENCE DATA

			BTY91-400R	500R	600R	800R	
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	400	500	600	800	V
Average on-state current	$I_{T(AV)}$	max.				16	A
R.M.S. on-state current	$I_{T(RMS)}$	max.				25	A
Non-repetitive peak on-state current	I_{TSM}	max.				200	A

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-48: with ¼ in x 28 UNF stud (ϕ 6,35 mm).



Net mass: 14 g
Diameter of clearance hole: max. 6,5 mm
Accessories supplied on request:
see ACCESSORIES section

Torque on nut: min. 1,7 Nm (17 kg cm)
max. 3,5 Nm (35 kg cm)
Supplied with the device:
1 nut, 1 lock washer
Nut dimensions across the flats: 11,1 mm

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Anode to cathode			BTY91-400R	500R	600R	800R	
Non-repetitive peak off-state voltage ($t \leq 10$ ms)	V_{DSM}	max.	500	850	850	850	V
Non-repetitive peak reverse voltage ($t \leq 5$ ms)	V_{RSM}	max.	500	600	720	960	V
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	400	500	600	800	V
Crest working voltages	V_{DWM}/V_{RWM}	max.	400	500	600	800	V *

Average on-state current (averaged over any 20 ms period) up to $T_{mb} = 77$ °C	$I_{T(AV)}$	max.	16	A
at $T_{mb} = 85$ °C	$I_{T(AV)}$	max.	14	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	25	A
Repetitive peak on-state current	I_{TRM}	max.	200	A
Non-repetitive peak on-state current; t = 10 ms; half sine-wave; $T_j = 125$ °C prior to surge; with reapplied V_{RWMmax}	I_{TSM}	max.	200	A
I^2t for fusing (t = 10 ms)	I^2t	max.	200	A^2s
Rate of rise of on-state current after triggering with $I_G = 200$ mA to $I_T = 50$ A	dI_T/dt	max.	20	A/µs

Gate to cathode

Reverse peak voltage	V_{RGM}	max.	5	V
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	0,5	W
Peak power dissipation	P_{GM}	max.	5	W

Temperatures

Storage temperature	T_{stg}		−55 to + 125	°C
Junction temperature	T_j	max.	125	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,6	°C/W
From mounting base to heatsink with heatsink compound	$R_{th\ mb\text{-}h}$	=	0,2	°C/W
Transient thermal impedance (t = 1 ms)	$Z_{th\ j\text{-}mb}$	=	0,09	°C/W

OPERATING NOTE

The terminals should neither be bent nor twisted; they should be soldered into the circuit so that there is no strain on them.
During soldering the heat conduction to the junction should be kept to a minimum.

* To ensure thermal stability: $R_{th\ j\text{-}a} < 4{,}5$ °C/W (d.c. blocking) or < 9 °C/W (a.c.). For smaller heatsinks $T_{j\ max}$ should be derated. For a.c. see Fig. 3.

CHARACTERISTICS

Anode to cathode

On-state voltage I_T = 50 A; T_j = 25 °C	V_T	<	2 V *
Rate of rise of off-state voltage that will not trigger any device; exponential method; V_D = 2/3 V_{DRMmax}; T_j = 125 °C	dV_D/dt	<	200 V/µs
Reverse current V_R = V_{RWMmax}; T_j = 125 °C	I_R	<	3 mA
Off-state current V_D = V_{DWMmax}; T_j = 125 °C	I_D	<	3 mA
Latching current; T_j = 25 °C	I_L	typ.	50 mA
Holding current; T_j = 25 °C	I_H	typ.	25 mA

Gate to cathode

Voltage that will trigger all devices V_D = 6 V; T_j = 25 °C	V_{GT}	>	3 V
Voltage that will not trigger any device V_D = V_{DRMmax}; T_j = 125 °C	V_{GD}	<	200 mV
Current that will trigger all devices V_D = 6 V; T_j = 25 °C	I_{GT}	>	40 mA

Switching characteristics

Gate-controlled turn-on time ($t_{gt} = t_d + t_r$) when switched from V_D = 400 V to I_T = 10 A; I_{GT} = 200 mA; T_j = 25 °C	t_{gt}	typ.	2 µs

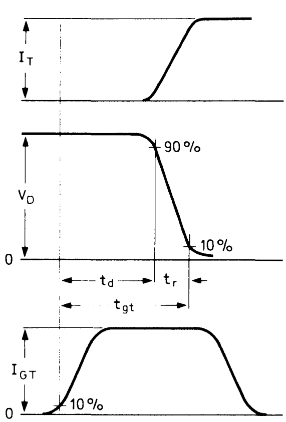


Fig. 2 Gate-controlled turn-on time definitions.

* Measured under pulse conditions to avoid excessive dissipation.

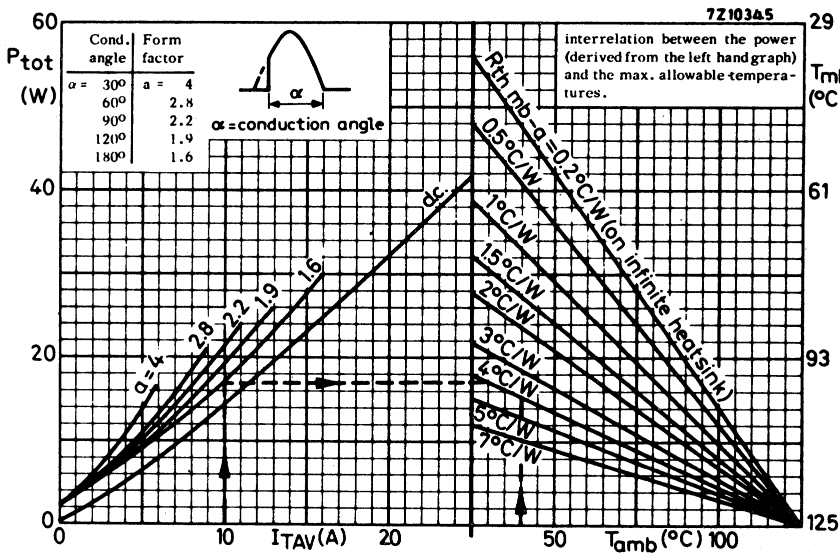

7Z10345
60
40
20
0
Ptot
(W)
Cond. angle | Form factor
α = 30° | a = 4
60° | 2.8
90° | 2.2
120° | 1.9
180° | 1.6
α
α = conduction angle
a=4
2.8
2.2
1.9
1.6
d.c.
0
10
ITAV(A)
20
interrelation between the power (derived from the left hand graph) and the max. allowable temperatures.
Rth mb-a = 0.2°C/W (on infinite heatsink)
0.5°C/W
1°C/W
1.5°C/W
2°C/W
3°C/W
4°C/W
5°C/W
7°C/W
50
Tamb (°C)
100
29
61
93
125
Tmb
(°C)

Fig. 3.

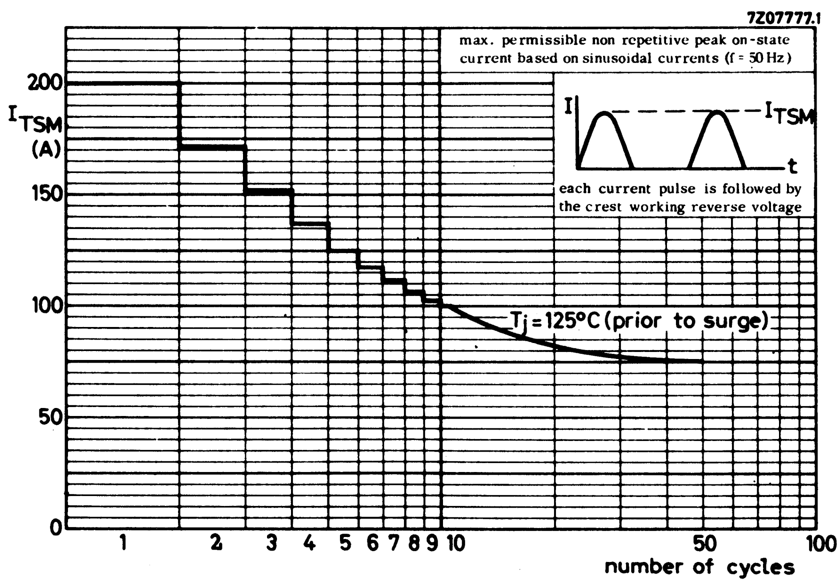

7Z07777.1
200
150
100
50
0
ITSM
(A)
max. permissible non repetitive peak on-state current based on sinusoidal currents (f = 50 Hz)
I
ITSM
t
each current pulse is followed by the crest working reverse voltage
Tj = 125°C (prior to surge)
1
2
3
4
5
6
7
8
9
10
50
100
number of cycles

Fig. 4.

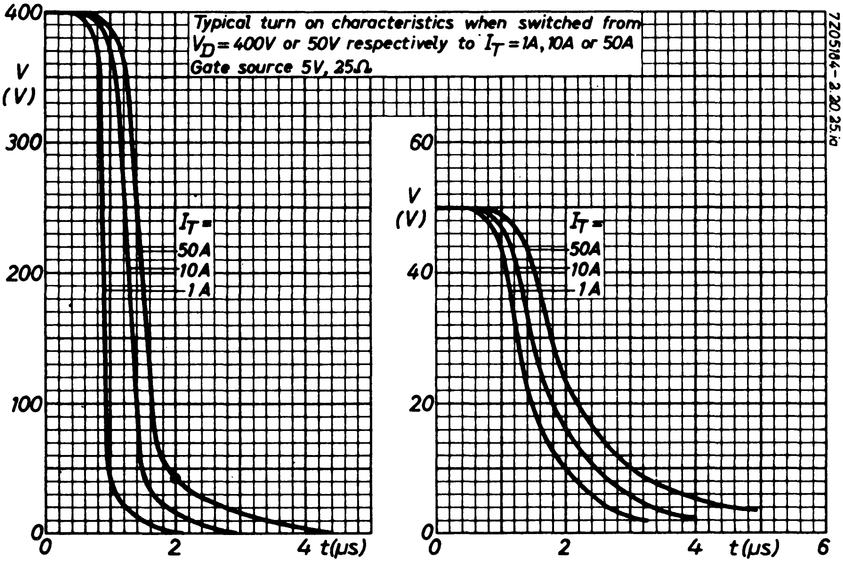

Typical turn on characteristics when switched from
V_D = 400V or 50V respectively to I_T = 1A, 10A or 50A
Gate source 5V, 25Ω
7Z05184-2.20.25.io
400
V
(V)
300
200
100
0
I_T =
50A
10A
1A
0
2
4 t(μs)
60
V
(V)
40
20
0
I_T =
50A
10A
1A
0
2
4
t(μs)
6

Fig. 5.

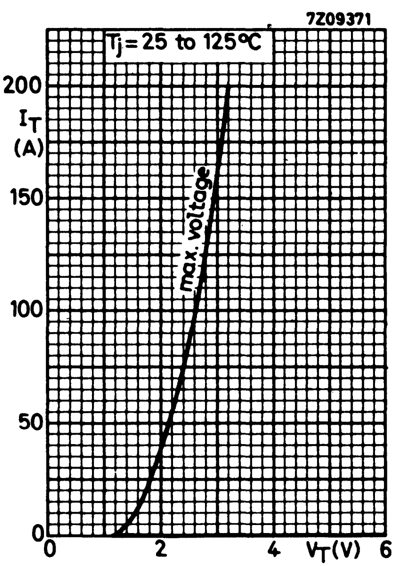

7Z09371
Tj = 25 to 125°C
200
I_T
(A)
150
100
50
0
max. voltage
0
2
4
V_T(V)
6

Fig. 6.

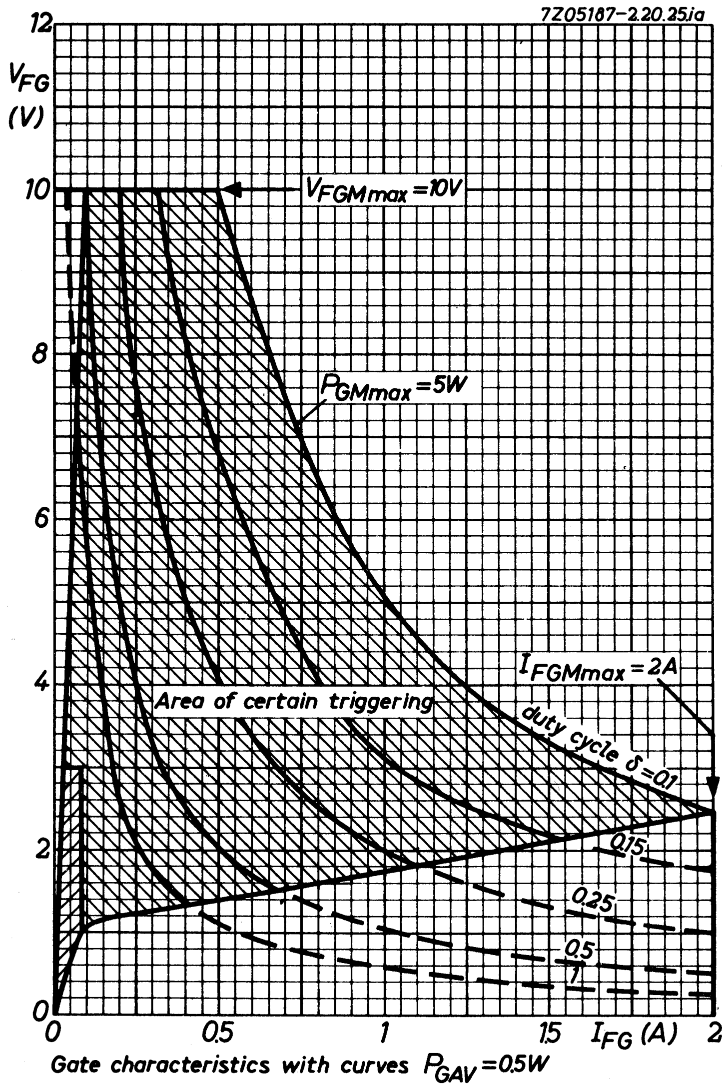

7Z05187-2.20.25.ia
12
V_{FG}
(V)
10
8
6
4
2
0
V_{FGMmax} = 10V
P_{GMmax} = 5W
I_{FGMmax} = 2A
duty cycle δ = 0.1
0.15
0.25
0.5
1
Area of certain triggering
0
0.5
1
1.5
I_{FG} (A)
2
Gate characteristics with curves P_{GAV} = 0.5W

Fig. 7.

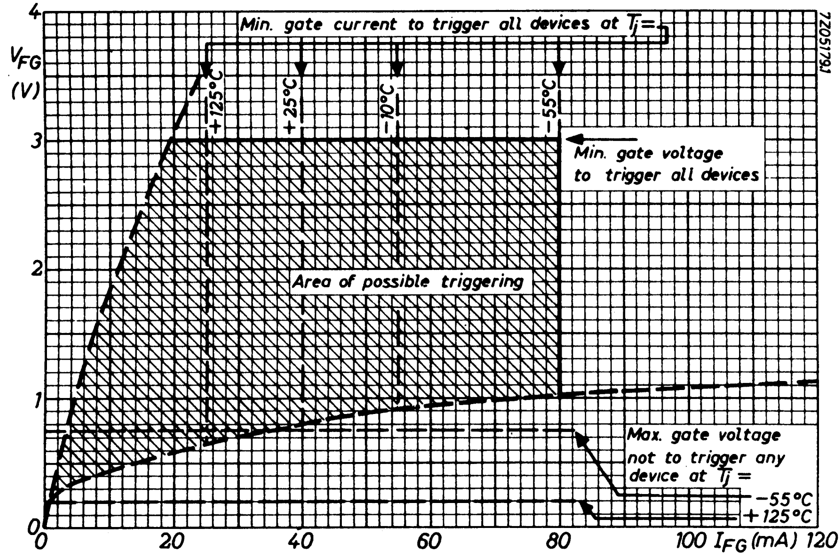

7Z05179.1
Min. gate current to trigger all devices at T_j =
+125°C
+25°C
−10°C
−55°C
Min. gate voltage to trigger all devices
Area of possible triggering
Max. gate voltage not to trigger any device at T_j =
−55°C
+125°C
V_{FG} (V)
I_{FG} (mA)
0
1
2
3
4
20
40
60
80
100
120

Fig. 8.

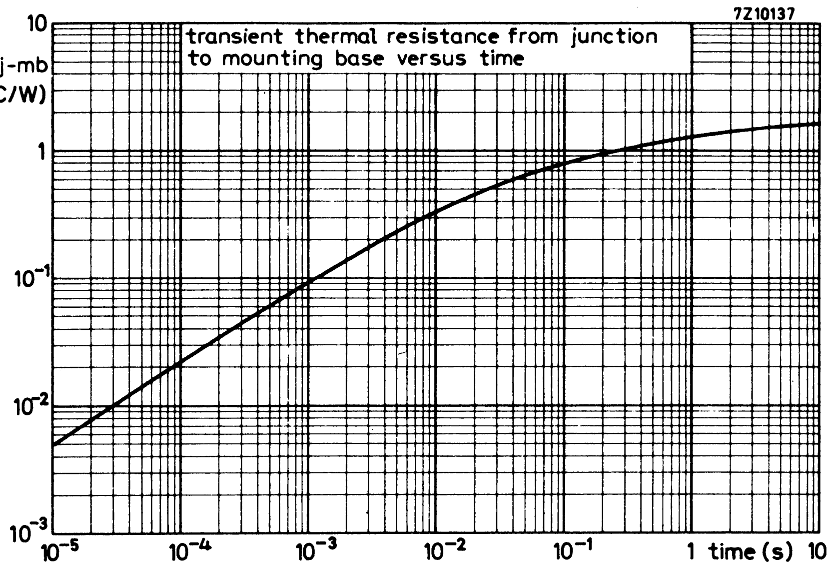

7Z10137
transient thermal resistance from junction to mounting base versus time
$Z_{th\ j\text{-}mb}$ (°C/W)
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
time (s)
10

Fig. 9.

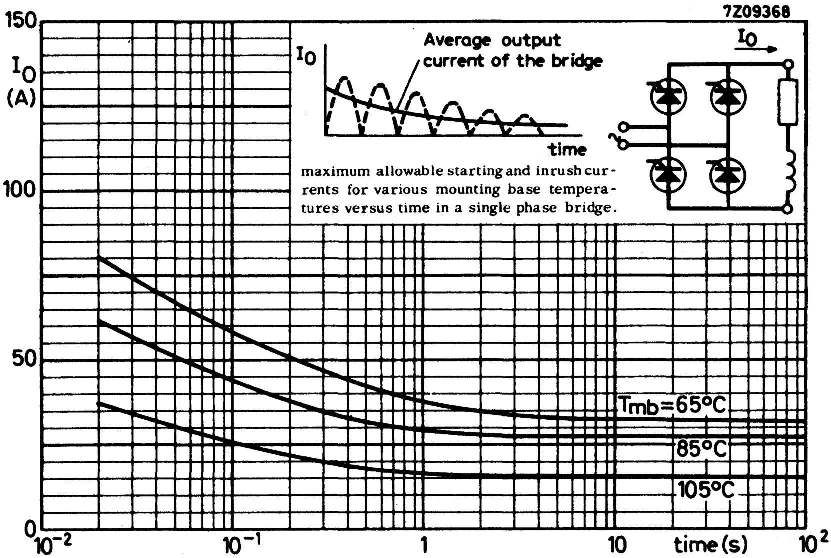

7Z09368
150
I_O
(A)
100
50
0
Average output current of the bridge
I_O
time
maximum allowable starting and inrush currents for various mounting base temperatures versus time in a single phase bridge.
T_{mb}=65°C
85°C
105°C
10^{-2}
10^{-1}
1
10
time (s)
10^2

Fig. 10.

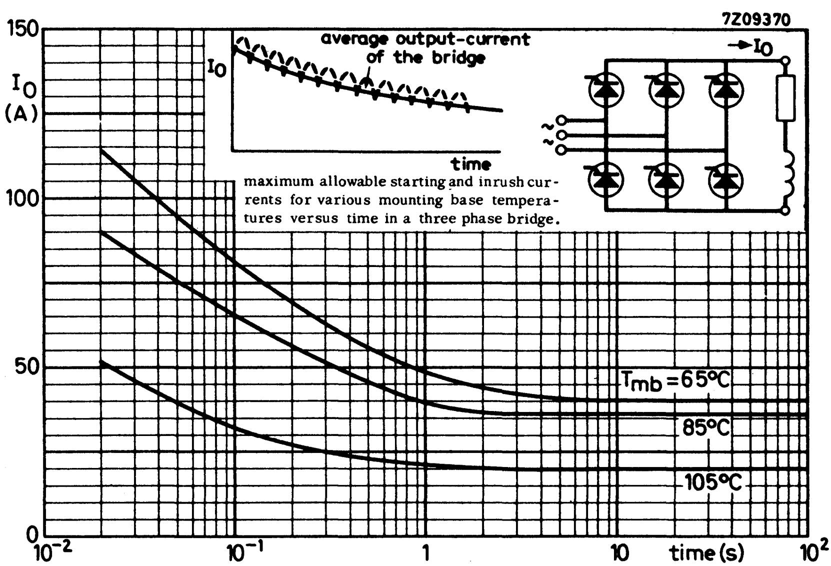

7Z09370
150
I_O
(A)
100
50
0
average output-current of the bridge
I_O
time
maximum allowable starting and inrush currents for various mounting base temperatures versus time in a three phase bridge.
T_{mb}=65°C
85°C
105°C
10^{-2}
10^{-1}
1
10
time (s)
10^2

Fig. 11.

TRIACS

TRIACS

Glass-passivated 4 ampere triacs intended for use in applications requiring high bidirectional transient and blocking voltage capability, and high thermal cycling performance with very low thermal resistances, e.g. a.c. power control applications such as lighting, industrial and domestic heating, motor control and switching systems.

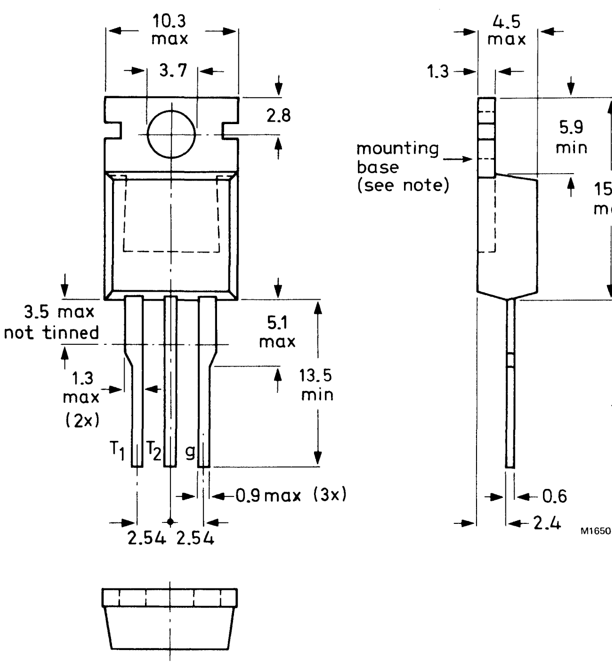
QUICK REFERENCE DATA

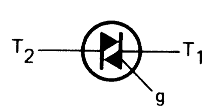
			BT136–500	600	800	
Repetitive peak off-state voltage	V_{DRM}	max.	500	600	800	V
R.M.S. on-state current	$I_{T(RMS)}$	max.		4		A
Non-repetitive peak on-state current	I_{TSM}	max.		25		A

MECHANICAL DATA

Dimensions in mm

Fig.1 TO–220AB





Net mass: 2 g

Note: The exposed metal mounting base is directly connected to terminal T_2.

Supplied on request: accessories (see data sheets Mounting instructions and accessories for TO–220 envelopes).

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

			BT136–500	600	800	
Voltages (in either direction)						
Non-repetitive peak off-state voltage ($t \leqslant 10$ ms)	V_{DSM}	max.	500*	600*	800	V
Repetitive peak off-state voltage ($\delta \leqslant 0.01$)	V_{DRM}	max.	500	600	800	V
Crest working off-state voltage	V_{DWM}	max.	400	400	400	V

Currents (in either direction)				
R.M.S. on-state current (conduction angle 360°) up to T_{mb} = 102 °C	$I_{T(RMS)}$	max.	4	A
Repetitive peak on-state current	I_{TRM}	max.	25	A
Non-repetitive peak on-state current; T_j = 120 °C prior to surge; t = 20 ms; full sine-wave	I_{TSM}	max.	25	A
I^2t for fusing (t = 10 ms)	I^2t	max.	4	A^2s
Rate of rise of on-state current after triggering with I_G = 200 mA to I_T = 6 A; dI_G/dt = 0.2 A/μs	dI_T/dt	max.	10	A/μs

Gate to terminal 1

POWER DISSIPATION

Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	0.5	W
Peak power dissipation	P_{GM}	max.	5	W

Temperatures

Storage temperature	T_{stg}		–40 to +125	°C
Operating junction temperature full-cycle operation	T_j	max.	120	°C
half-cycle operation	T_j	max.	110	°C

*Although not recommended, off-state voltages up to 800 V may be applied without damage, but the triac may switch into the on-state. The rate of rise of on-state current should not exceed 3 A/μs.

THERMAL RESISTANCE

From junction to mounting base				
full-cycle operation	$R_{th\ j\text{-}mb}$	=	3.0	K/W
half-cycle operation	$R_{th\ j\text{-}mb}$	=	3.7	K/W
Transient thermal impedance; t = 1 ms	$Z_{th\ j\text{-}mb}$	=	0.6	K/W

Influence of mounting method

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from mounting base to heatsink

a. with heatsink compound	$R_{th\ mb\text{-}h}$	=	0.3	K/W
b. with heatsink compound and 0.06 mm maximum mica insulator	$R_{th\ mb\text{-}h}$	=	1.4	K/W
c. with heatsink compound and 0.1 mm max. mica insulator (56369)	$R_{th\ mb\text{-}h}$	=	2.2	K/W
d. with heatsink compound and 0.25 mm max. alumina insulator (56367)	$R_{th\ mb\text{-}h}$	=	0.8	K/W
e. without heatsink compound	$R_{th\ mb\text{-}h}$	=	1.4	K/W

2. Free-air operation

The quoted value of $R_{th\ j\text{-}a}$ should be used only when no leads of other dissipating components run to the same tie-point.

Thermal resistance from junction to ambient in free air:
mounted on a printed-circuit board at a = any lead length — $R_{th\ j\text{-}a}$ = 60 K/W

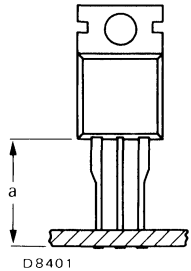


Fig.2.

CHARACTERISTICS (T_j = 25 °C unless otherwise stated)

Polarities, positive or negative, are identified with respect to T_1.

Voltages and currents (in either direction)

On-state voltage (measured under pulse conditions to prevent excessive dissipation)

I_T = 5 A	V_T	<	1.70	V
Rate of rise of off-state voltage that will not trigger any device; T_j = 120 °C; gate open circuit				
BT136 series	dV_D/dt	<	100	V/µs
BT136 series G	dV_D/dt	<	200	V/µs
BT136 series F	dV_D/dt	<	50	V/µs
BT136 series E	dV_D/dt	typ.	50	V/µs
BT136 – 500D	dV_D/dt	typ.	5	V/µs
Rate of change of commutating voltage that will not trigger any device when $-dI_{com}/dt$ = 1.8A/ms; $I_{T(RMS)}$ = 4 A; T_{mb} = 85 °C; gate open circuit; $V_D = V_{DWMmax}$				
BT136 series	dV_{com}/dt	typ.	10	V/µs
BT136 series G	dV_{com}/dt	<	10	V/µs
BT136 series F	dV_{com}/dt	typ.	10	V/µs
Off-state current				
$V_D = V_{DWMmax}$; T_j = 120 °C	I_D	<	0.5	mA
Gate voltage that will trigger all devices	V_{GT}	>	1.5	V
Gate voltage that will not trigger any device				
$V_D = V_{DWMmax}$; T_j = 120 °C; T_2 and G positive or negative	V_{GD}	<	250	mV

Gate current that will trigger all devices (I_{GT}); G to T_1

Holding current (I_H)

Latching current (I_L); V_D = 12 V

			T_2+ G+	T_2+ G–	T_2– G–	T_2– G+	
BT136 series	I_{GT}	>	35	35	35	70	mA
	I_H	<	15	15	15	15	mA
	I_L	<	20	30	20	30	mA
BT136 series G	I_{GT}	>	50	50	50	100	mA
	I_H	<	30	30	30	30	mA
	I_L	<	30	45	30	45	mA
BT136 series F	I_{GT}	>	25	25	25	70	mA
	I_H	<	15	15	15	15	mA
	I_L	<	20	30	20	30	mA
BT136 series E	I_{GT}	>	10	10	10	25	mA
	I_H	<	15	15	15	15	mA
	I_L	<	15	20	15	20	mA
BT136 – 500D	I_{GT}	>	5	5	5	10	mA
	I_H	<	10	10	10	10	mA
	I_L	<	10	15	10	15	mA

MOUNTING INSTRUCTIONS

1. The device may be soldered directly into the circuit, but the maximum permissible temperature of the soldering iron or bath is 275 °C; it must not be in contact with the joint for more than 5 seconds. Soldered joints must be at least 4.7 mm from the seal.
2. The leads should not be bent less than 2.4 mm from the seal, and should be supported during bending. The leads can be bent, twisted or straightened by 90° maximum. The minimum bending radius is 1 mm.
3. It is recommended that the circuit connection be made to tag T_2, rather than direct to the heatsink.
4. Mounting by means of a spring clip is the best mounting method because it offers:
   a. a good thermal contact under the crystal area and slightly lower $R_{th\ mb\text{-}h}$ values than screw mounting.
   b. safe isolation for mains operation.
   However, if a screw is used, it should be M3 cross-recess pan-head. Care should be taken to avoid damage to the plastic body.
5. For good thermal contact, heatsink compound should be used between mounting base and heatsink. Values of $R_{th\ mb\text{-}h}$ given for mounting with heatsink compound refer to the use of a metallic-oxide loaded compound. Ordinary silicone grease is not recommended.
6. Rivet mounting (only possible for non-insulated mounting)

   Devices may be rivetted to flat heatsinks; such a process **must neither** deform the mounting tab, **nor** enlarge the mounting hole.
7. The heatsink must have a flatness in the mounting area of 0.02 mm maximum per 10 mm. Mounting holes must be deburred.

OPERATING NOTES

Dissipation and heatsink considerations:

a. The various components of junction temperature rise above ambient are illustrated in Fig.3.

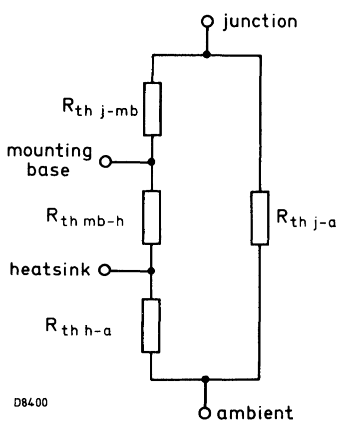


Fig.3.

b. The method of using Fig.4 is as follows:
   Starting with the required current on the $I_{T(RMS)}$ axis, trace upwards to meet the appropriate conduction angle curve. Trace right horizontally and upwards from the appropriate value on the T_{amb} scale. The intersection determines the $R_{th\ mb\text{-}a}$. The heatsink thermal resistance value ($R_{th\ h\text{-}a}$) can now be calculated from:

$$R_{th\ h\text{-}a} = R_{th\ mb\text{-}a} - R_{th\ mb\text{-}h}.$$

c. Any measurement of heatsink temperature should be made immediately adjacent to the device.

FULL-CYCLE OPERATION

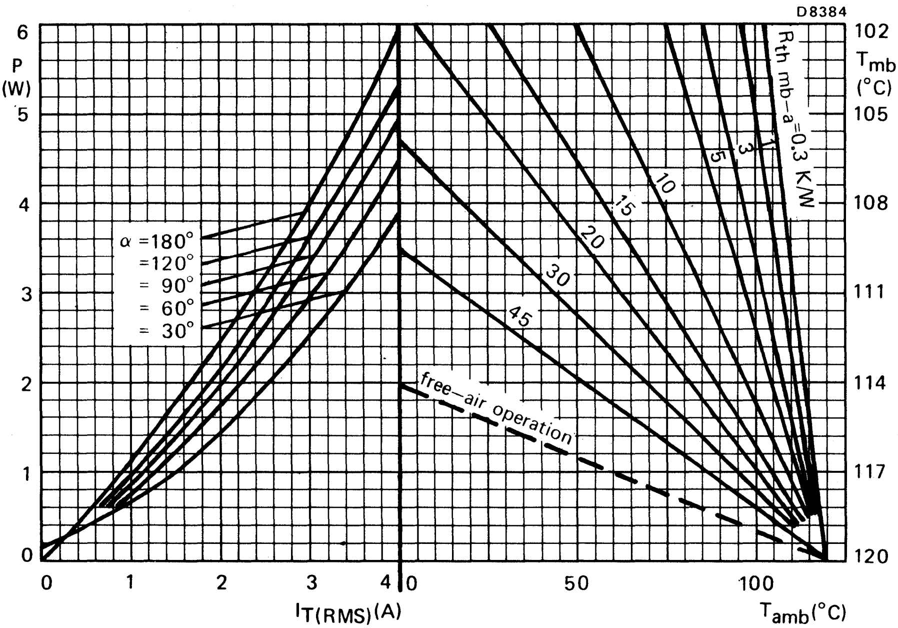
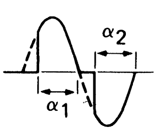


Fig.4 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha = \alpha_1 = \alpha_2$: conduction angle per half cycle

Note: For the type BT136–500D only, any operating point derived from Fig.4 should be derated by a further 10 °C.

OVERLOAD OPERATION

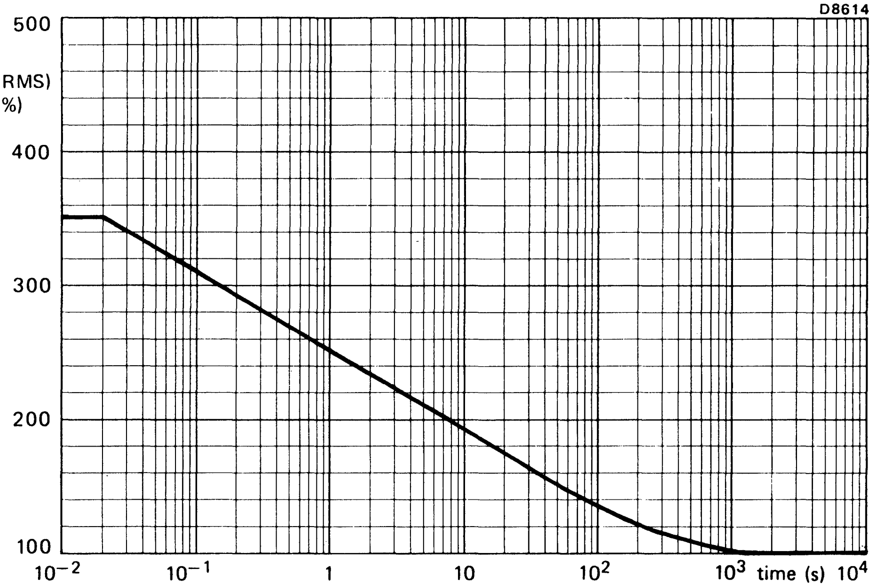


Fig.5 Maximum permissible duration of steady overload (provided that T_{mb} does not exceed 120 °C during and after overload) expressed as a percentage of the steady state r.m.s. rated current. For high r.m.s. overload currents precautions should be taken so that the temperature of the terminals does not exceed 125 °C. During these overload conditions the triac may lose control. Therefore the overload should be terminated by a separate protection device.

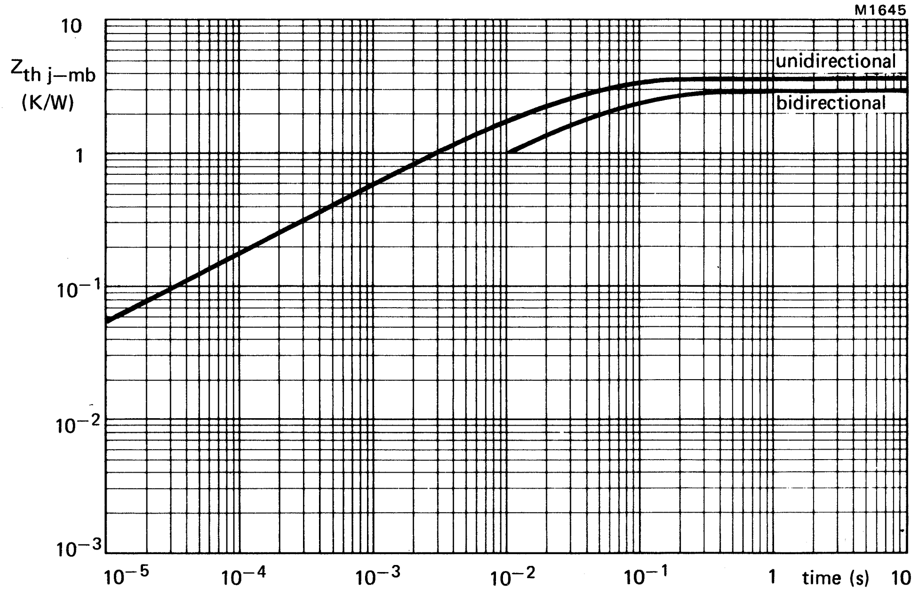

M1645
10
$Z_{th\ j-mb}$
(K/W)
1
10^{-1}
10^{-2}
10^{-3}
unidirectional
bidirectional
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
time (s)
10

Fig. 6

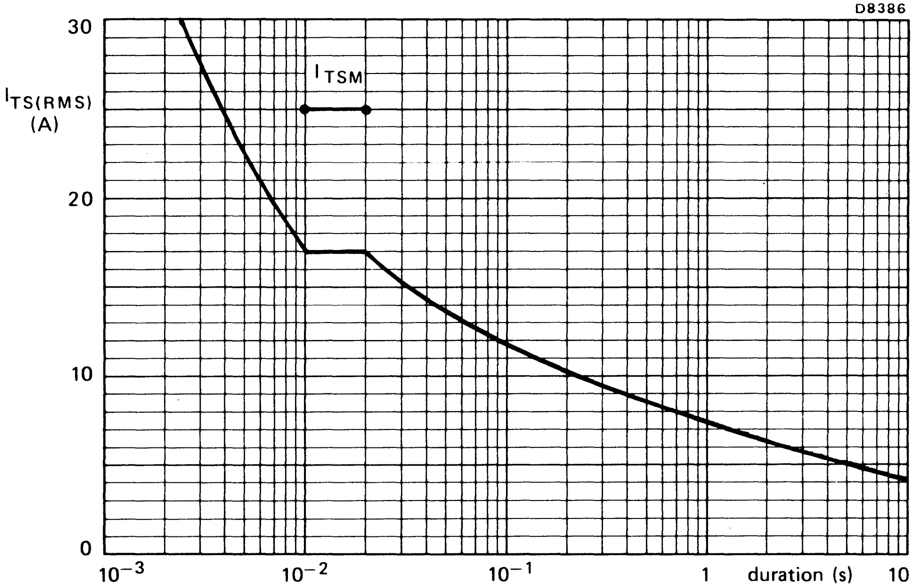
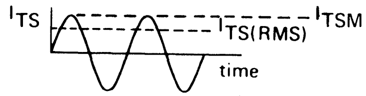


Fig.7 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents (f = 50 Hz); T_j = 120 °C prior to surge. The triac may temporarily lose control following the surge.



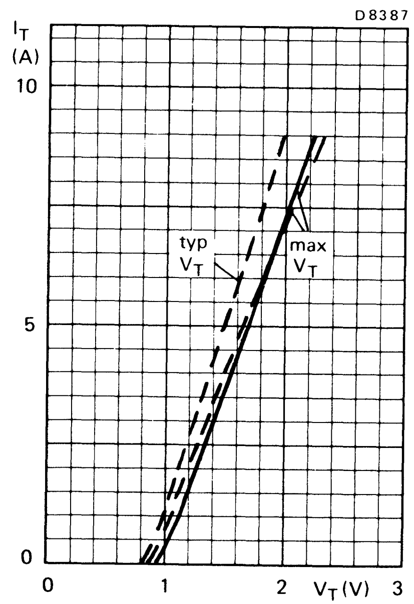


Fig.8 —— T_j = 25 °C; – – – T_j = 120 °C

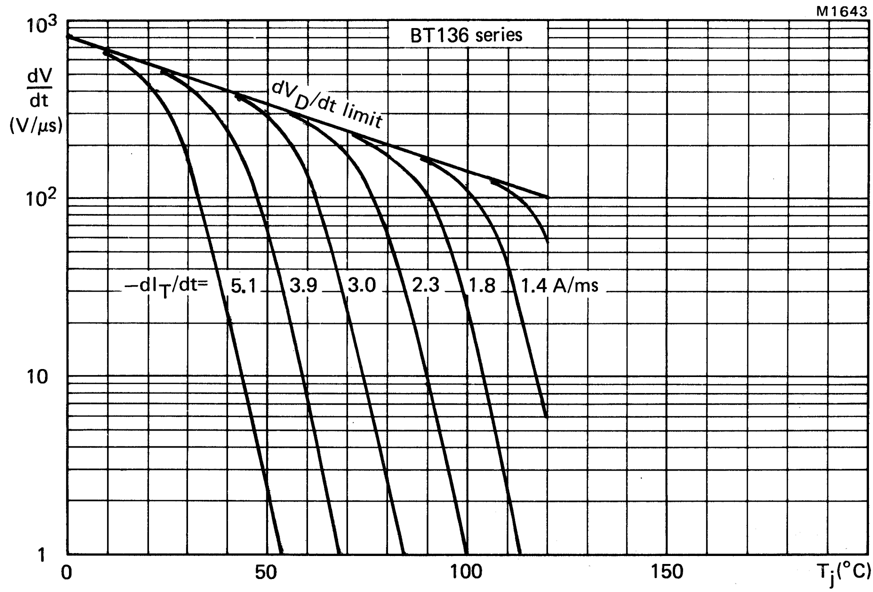


Fig.9 Typical commutation dV/dt for BT136 series versus T_j. The triac should commutate when the dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

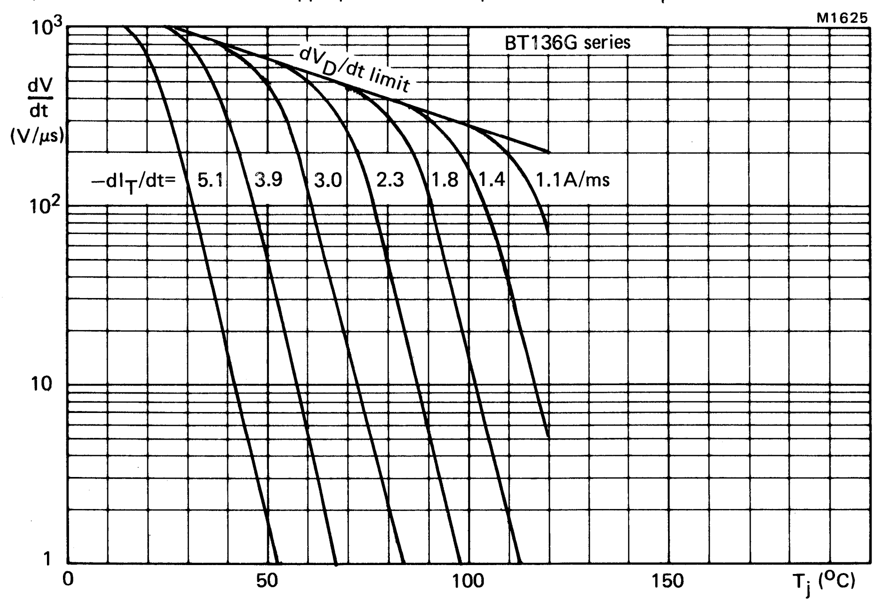


Fig.10 Limit commutation dV/dt for BT136G series versus T_j. The triac should commutate when the dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

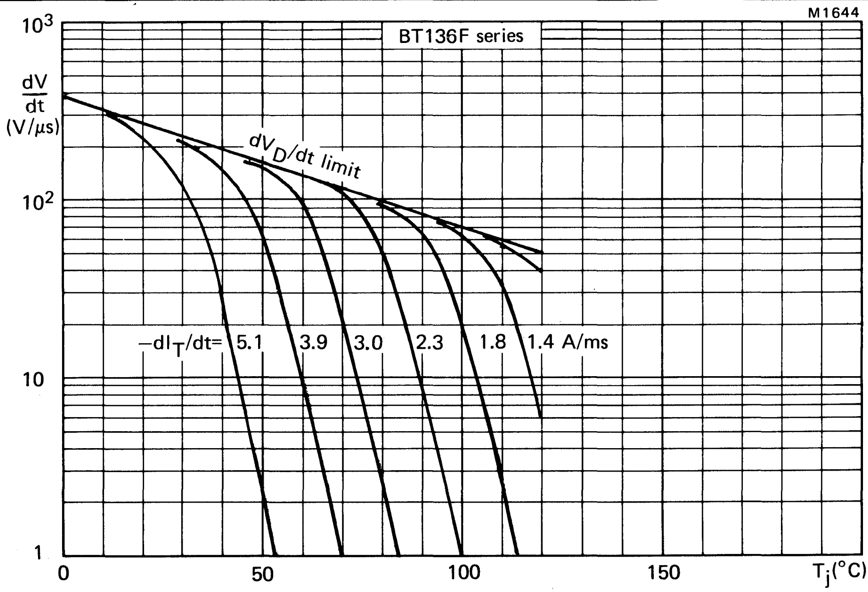


Fig.11 Typical commutation dV/dt for BT136F series versus T_j. The triac should commutate when the dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

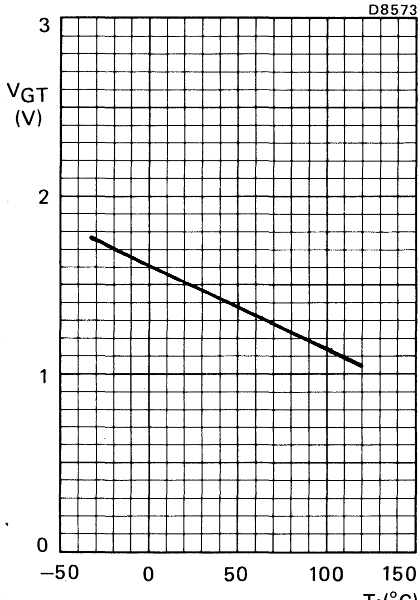


Fig.12 Minimum gate voltage that will trigger all devices; all conditions.

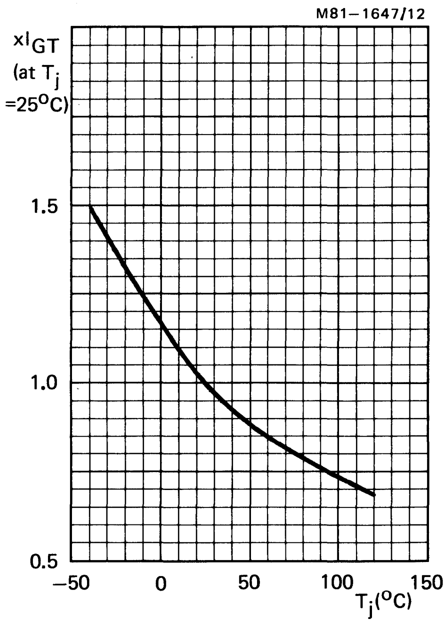


Fig.13 Normalised gate current that will trigger all devices; all conditions.

FULL-PACK TRIACS

Glass-passivated 4 ampere triacs in SOT-186 envelopes, which feature an electrically isolated seating plane. They are intended for use in applications requiring high bidirectional transient and blocking voltage capability. Typical applications include a.c. power control circuits such as lighting, industrial and domestic heating, motor control and switching systems.

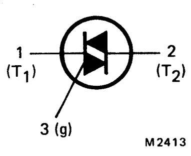
QUICK REFERENCE DATA

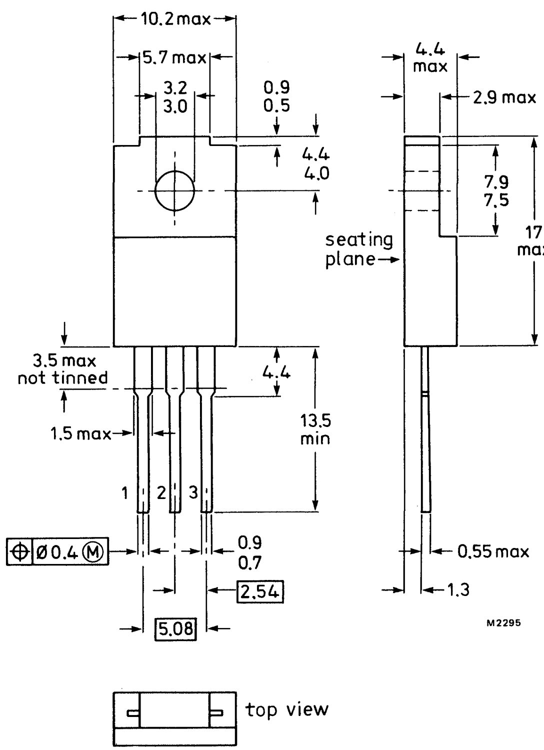
			BT136F–500	600	800	
Repetitive peak off-state voltage	V_{DRM}	max.	500	600	800	V
R.M.S. on-state current	$I_{T(RMS)}$	max.		4		A
Non-repetitive peak on-state current	I_{TSM}	max.		25		A

MECHANICAL DATA

Dimensions in mm

Fig.1 SOT-186





Net mass: 2 g.
The seating plane is electrically isolated from all terminals.
Accessories supplied on request (see data sheets Mounting instructions for F-pack devices and Accessories for SOT-186 envelopes).

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134)

Voltages (in either direction)

			BT136F–500	600	800	
Non-repetitive peak off-state voltage ($t \leq 10$ ms)	V_{DSM}	max.	500*	600*	800	V
Repetitive peak off-state voltage ($\delta \leq 0.01$)	V_{DRM}	max.	500	600	800	V
Crest working off-state voltage	V_{DWM}	max.	400	400	400	V

Currents (in either direction)

R.M.S. on-state current (conduction angle 360°) up to $T_h = 86$ °C	$I_{T(RMS)}$	max.	4	A
Repetitive peak on-state current	I_{TRM}	max.	25	A
Non-repetitive peak on-state current; $T_j = 120$ °C prior to surge; $t = 20$ ms; full sine-wave	I_{TSM}	max.	25	A
I^2t for fusing ($t = 10$ ms)	I^2t	max.	4	A^2s
Rate of rise of on-state current after triggering with $I_G = 200$ mA to $I_T = 6$ A; $dI_G/dt = 0.2$ A/μs	dI_T/dt	max.	10	A/μs

Gate to terminal 1

POWER DISSIPATION

Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	0.5	W
Peak power dissipation	P_{GM}	max.	5	W

Temperatures

Storage temperature	T_{stg}		−40 to +125	°C
Operating junction temperature				
full-cycle operation	T_j	max.	120	°C
half-cycle operation	T_j	max.	110	°C

ISOLATION

From all three terminals to external heatsink (peak)	V_{isol}	min.	1000	V
Capacitance from T_2 to external heatsink	C_{isol}	typ.	12	pF

*Although not recommended, off-state voltages up to 800 V may be applied without damage, but the triac may switch into the on-state. The rate of rise of on-state current should not exceed 3 A/μs.

THERMAL RESISTANCE

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from junction to external heatsink

With heatsink compound	$R_{th\ j\text{-}h}$	=	5.5	K/W
Without heatsink compound	$R_{th\ j\text{-}h}$	=	7.2	K/W

2. Free-air operation

The quoted values of $R_{th\ j\text{-}a}$ should be used only when no leads of other dissipating components run to the same tie-point.

Thermal resistance from junction to ambient in free air: mounted on a printed-circuit board at a = any lead length	$R_{th\ j\text{-}a}$	=	55	K/W

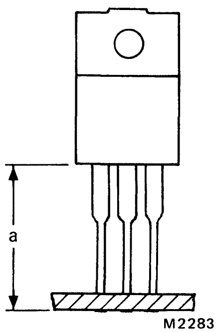


Fig.2.

CHARACTERISTICS (T_j = 25 °C unless otherwise stated)

Polarities, positive or negative, are identified with respect to T_1.

Voltages and currents (in either direction)

On-state voltage (measured under pulse conditions to prevent excessive dissipation)				
$I_T = 5$ A	V_T	<	1.70	V
Rate of rise of off-state voltage that will not trigger any device; T_j = 120 °C; gate open circuit				
BT136F series	dV_D/dt	<	100	V/µs
BT136F series G	dV_D/dt	<	200	V/µs
BT136F series F	dV_D/dt	<	50	V/µs
BT136F series E	dV_D/dt	typ.	50	V/µs
BT136F-500D	dV_D/dt	typ.	5	V/µs
Rate of change of commutating voltage that will not trigger any device when $-dI_{com}/dt$ = 1.8 A/ms; $I_{T(RMS)}$ = 4 A; T_h = 70 °C; gate open circuit; $V_D = V_{DWMmax}$				
BT136F series	dV_{com}/dt	typ.	10	V/µs
BT136F series G	dV_{com}/dt	<	10	V/µs
BT136F series F	dV_{com}/dt	typ.	10	V/µs
Off-state current				
$V_D = V_{DWMmax}$; T_j = 120 °C	I_D	<	0.5	mA
Gate voltage that will trigger all devices	V_{GT}	>	1.5	V
Gate voltage that will not trigger any device $V_D = V_{DWMmax}$; T_j = 120 °C; T_2 and G positive or negative	V_{GD}	<	250	mV

Gate current that will trigger all devices (I_{GT}); G to T_1

Holding current (I_H)

Latching current (I_L); V_D = 12 V

			T_2+ G+	T_2+ G–	T_2– G–	T_2– G+	
BT136F series	I_{GT}	>	35	35	35	70	mA
	I_H	<	15	15	15	15	mA
	I_L	<	20	30	20	30	mA
BT136F series G	I_{GT}	>	50	50	50	100	mA
	I_H	<	30	30	30	30	mA
	I_L	<	30	45	30	45	mA
BT136F series F	I_{GT}	>	25	25	25	70	mA
	I_H	<	15	15	15	15	mA
	I_L	<	20	30	20	30	mA
BT136F series E	I_{GT}	>	10	10	10	25	mA
	I_H	<	15	15	15	15	mA
	I_L	<	15	20	15	20	mA
BT136F-500D	I_{GT}	>	5	5	5	10	mA
	I_H	<	10	10	10	10	mA
	I_L	<	10	15	10	15	mA

MOUNTING INSTRUCTIONS

1. The triac may be soldered directly into the circuit, but the maximum permissible temperature of the soldering iron or bath is 275 ^{o}C; it must not be in contact with the joint for more than 5 seconds. Soldered joints must be at least 4.7 mm from the seal.
2. The leads should not be bent less than 2.4 mm from the seal, and should be supported during bending. The leads can be bent, twisted or straightened by 90^{o} maximum. The minimum bending radius is 1 mm.
3. Mounting by means of a spring clip is the best mounting method because it offers good thermal contact under the crystal area and slightly lower $R_{th\ j\text{-}h}$ values than screw mounting. However, if a screw is used, it should be M3 cross-recess pan-head. Care should be taken to avoid damage to the plastic body. ←
4. For good thermal contact heatsink compound should be used between seating plane and heatsink. Values of $R_{th\ j\text{-}h}$ given for mounting with heatsink compound refer to the use of a metallic-oxide loaded compound. Ordinary silicone grease is not recommended.
5. Rivet mounting is not recommended.
6. The heatsink must have a flatness in the mounting area of 0.02 mm maximum per 10 mm. Mounting holes must be deburred.

OPERATING NOTES

Dissipation and heatsink considerations:

a. The various components of junction temperature rise above ambient are illustrated in Fig.3.

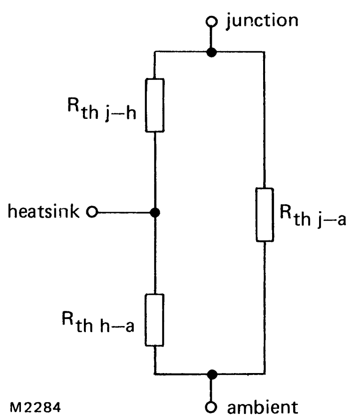


Fig.3.

b. The method of using Figs.4 and 5 is as follows:
Starting with the required current on the $I_{T(RMS)}$ axis (l.h. graph) trace upwards to meet the appropriate conduction angle curve. Trace left from curve to obtain power P. Trace right from curve to obtain T_h (r.h. graph). Trace upwards from T_{amb}, intersect with T_h determines $R_{th\ h\text{-}a}$, required heatsink thermal resistance.

c. Any measurement of heatsink temperature should be made immediately adjacent to the device.

FULL-WAVE CONDUCTION (with heatsink compound)

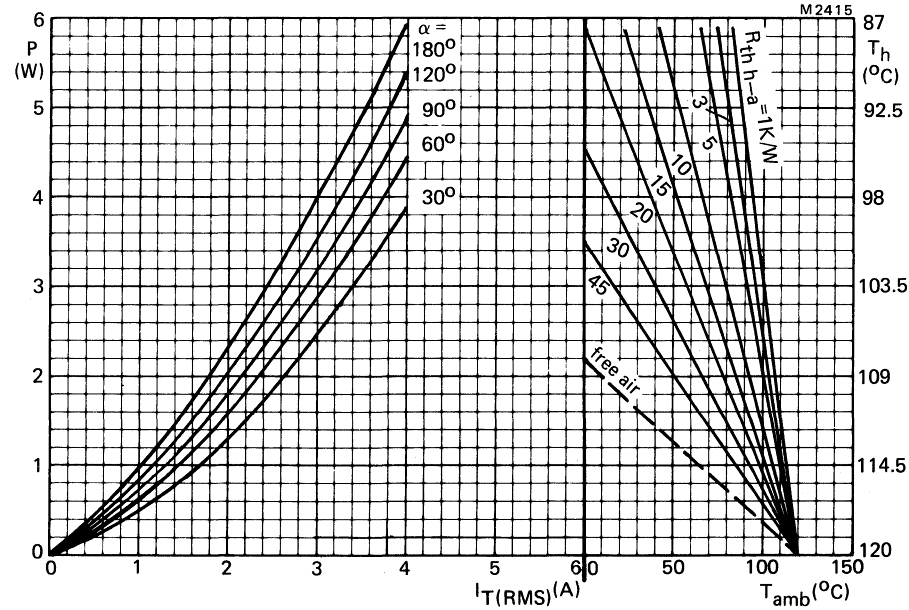
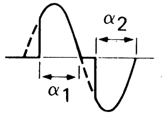


Fig.4 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha = \alpha_1 = \alpha_2$: conduction angle per half cycle

Note: For the type BT136F-500D only, any operating point derived from Fig.4 should be derated by a further 10 °C.

FULL-WAVE CONDUCTION (without heatsink compound)

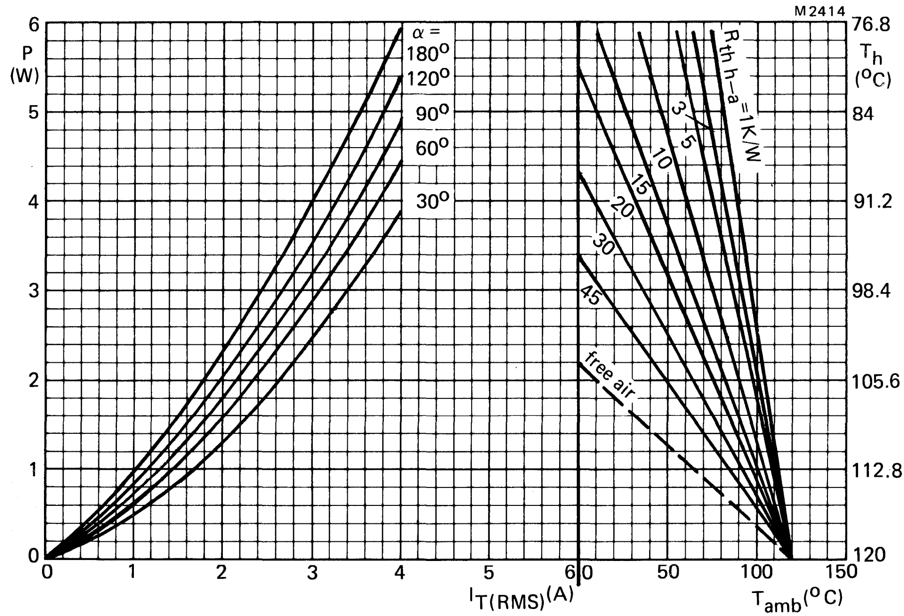
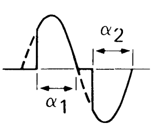


Fig.5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha = \alpha_1 = \alpha_2$: conduction angle per half cycle

Note: For the type BT136F-500D only, any operating point derived from Fig.5 should be derated by a further 10 °C.

OVERLOAD OPERATION

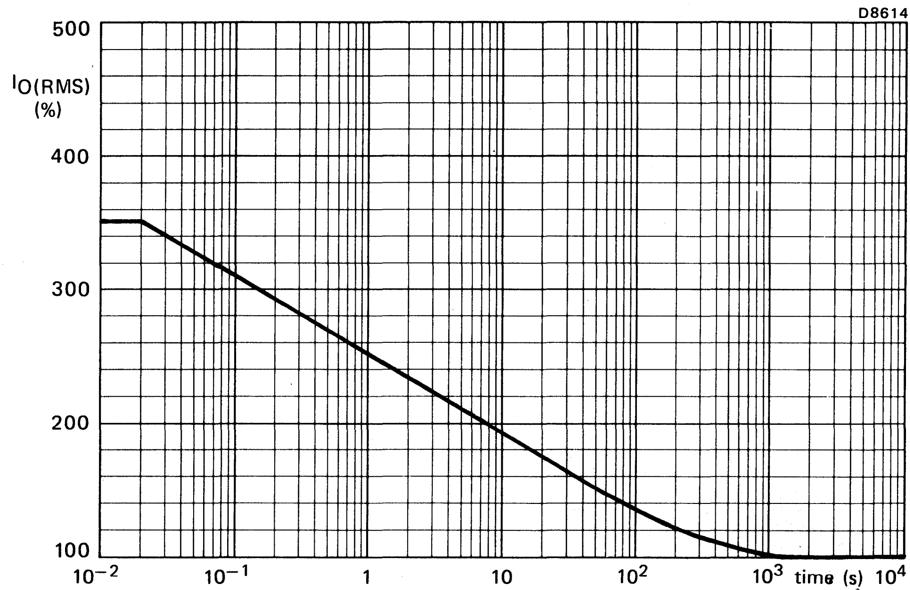


Fig.6 Maximum permissible duration of steady overload (provided that T_h does not exceed 120 °C during and after overload) expressed as a percentage of the steady state r.m.s. rated current. For high r.m.s. overload currents precautions should be taken so that the temperature of the terminals does not exceed 125 °C. During these overload conditions the triac may lose control. Therefore the overload should be terminated by a separate protection device.

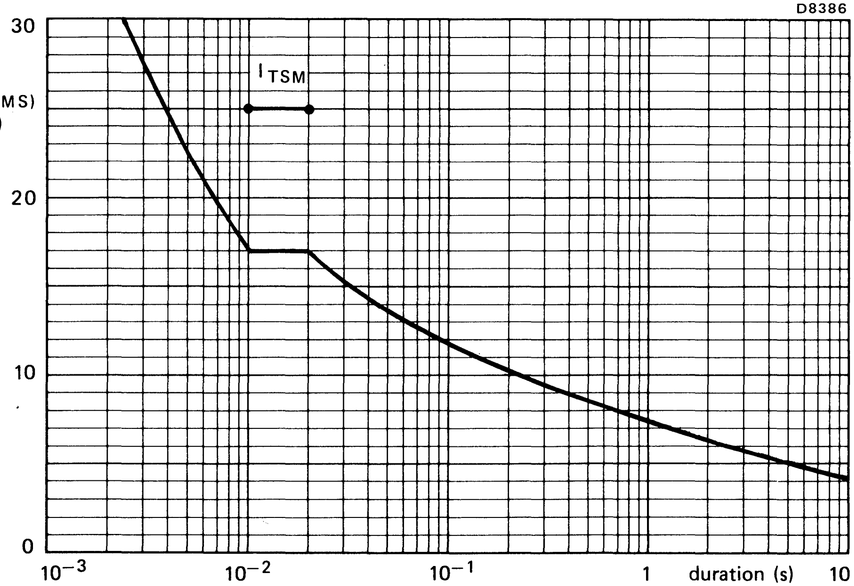
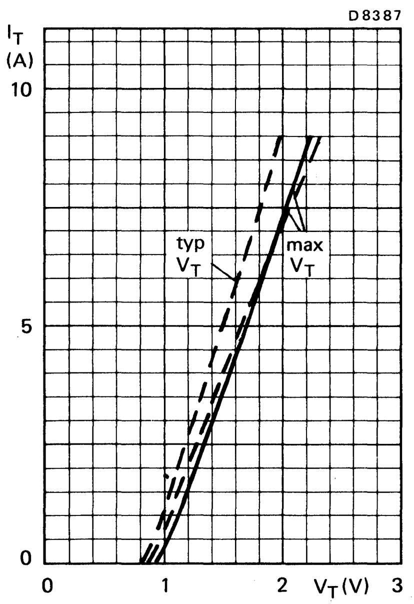


Fig.7 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents (f = 50 Hz); T_j = 120 °C prior to surge. The triac may temporarily lose control following the surge.



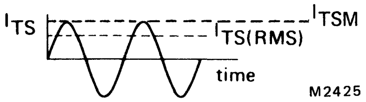


Fig.8 —— T_j = 25 °C; – – – T_j = 120 °C.

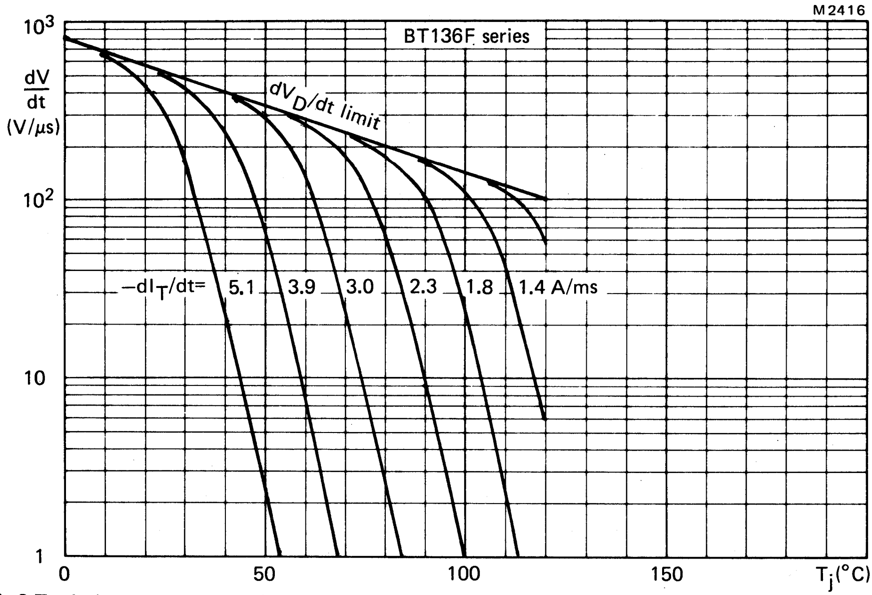


Fig.9 Typical commutation dV/dt for BT136F series versus T_j. The triac should commutate when the dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

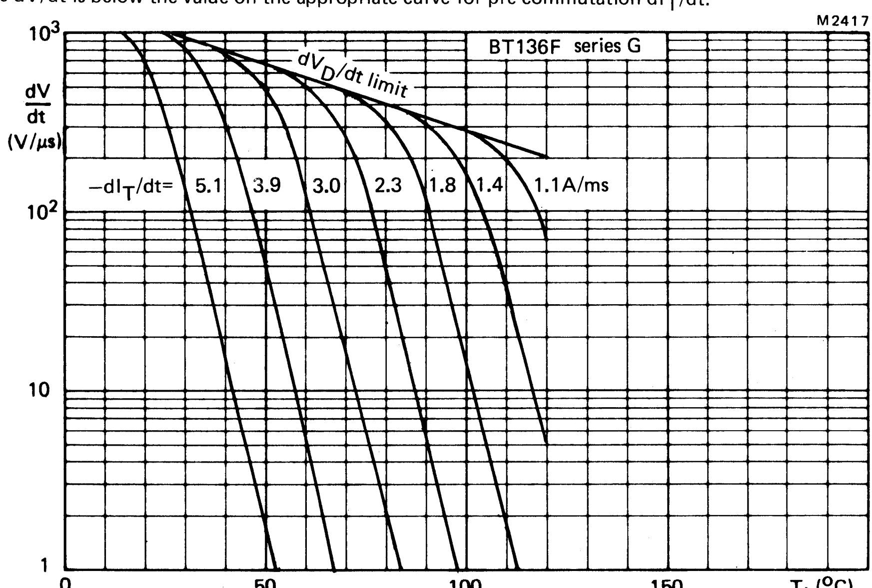


Fig.10 Limit commutation dV/dt for BT136F series G versus T_j. The triac should commutate when the dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

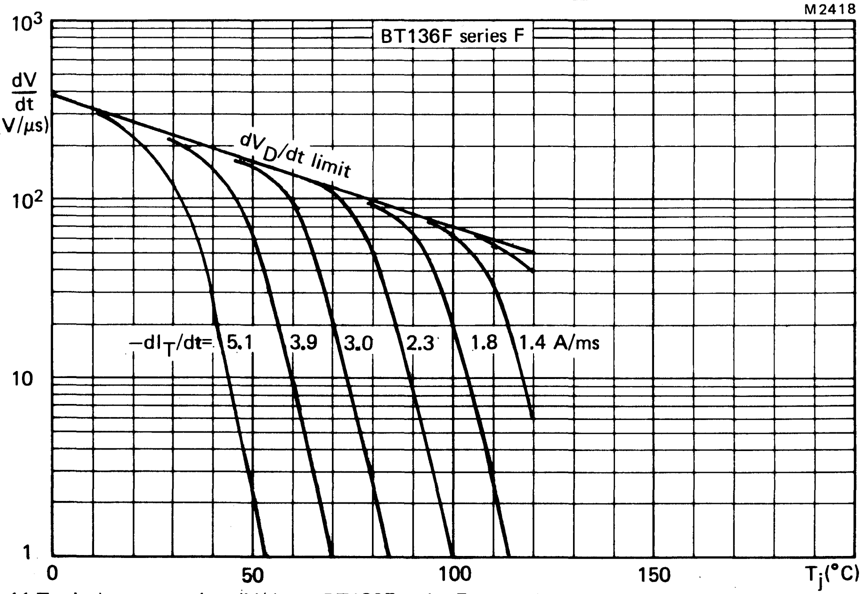


Fig.11 Typical commutation dV/dt for BT136F series F versus T_j. The triac should commutate when the dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

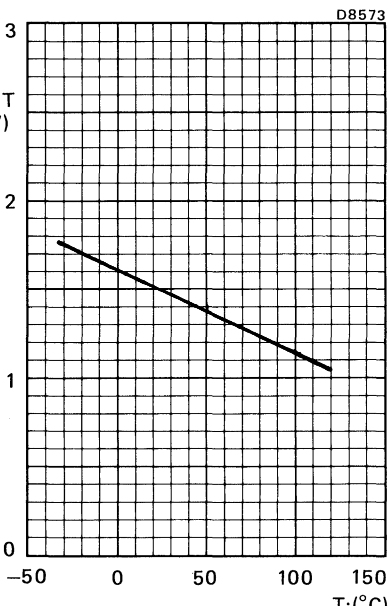


Fig.12 Minimum gate voltage that will trigger all devices; all conditions.

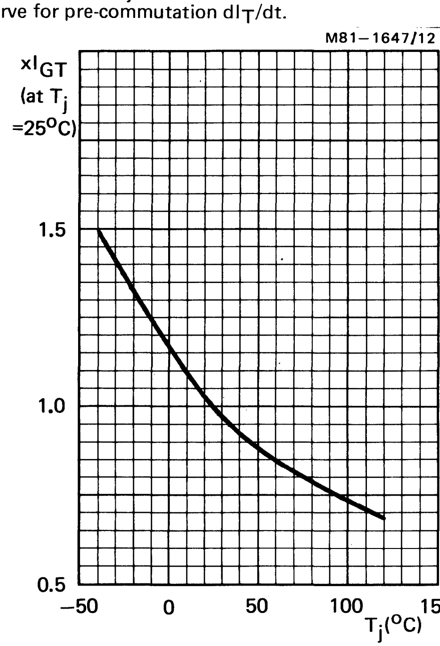


Fig.13 Normalised gate current that will trigger all devices; all conditions.

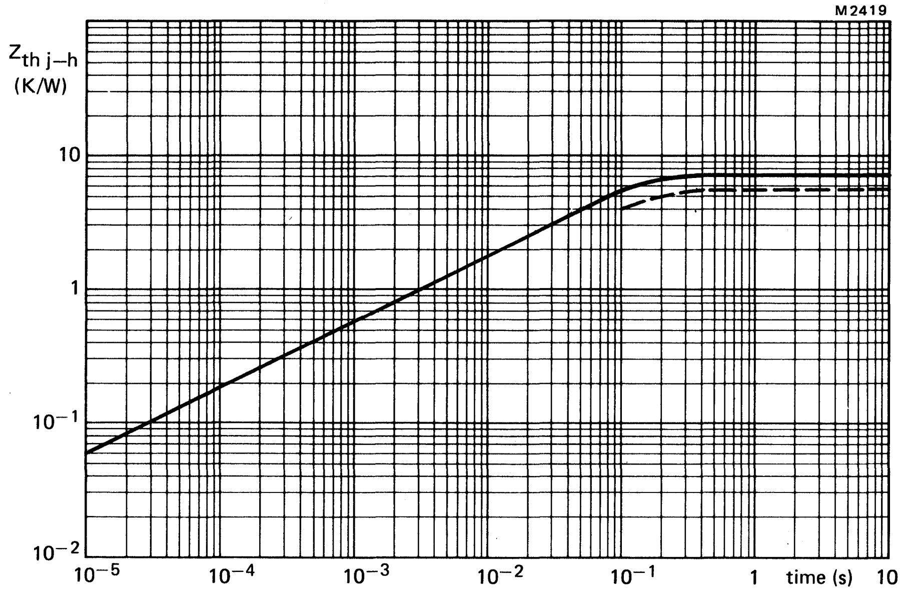


Fig.14 Transient thermal impedance, — — — with heatsink compound; —— without heatsink compound.

TRIACS

Glass-passivated 8 ampere triacs intended for use in applications requiring high bidirectional transient and blocking voltage capability, and high thermal cycling performance with very low thermal resistances, e.g. a.c. power control applications such as lighting, industrial and domestic heating, motor control and switching systems.

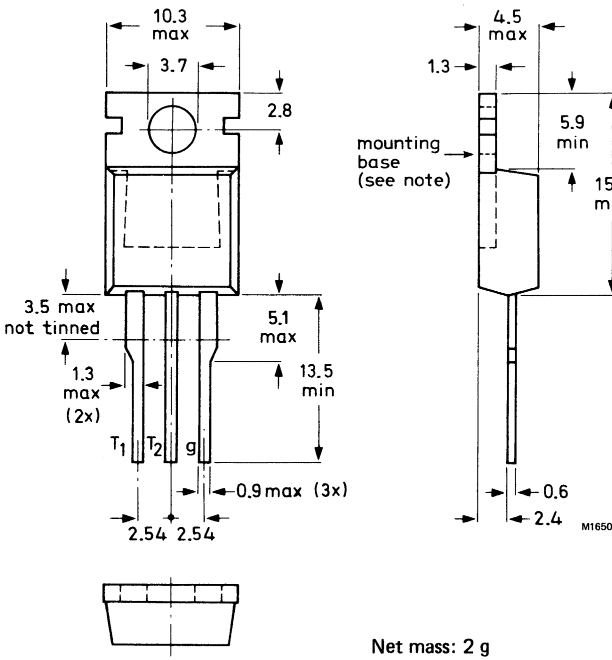
QUICK REFERENCE DATA

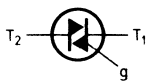
			BT137–500	600	800	
Repetitive peak off-state voltage	V_{DRM}	max.	500	600	800	V
R.M.S. on-state current	$I_{T(RMS)}$	max.		8		A
Non-repetitive peak on-state current	I_{TSM}	max.		55		A

MECHANICAL DATA

Dimensions in mm

Fig.1 TO-220AB.





Net mass: 2 g

Note: The exposed metal mounting base is directly connected to terminal T_2.

Supplied on request: accessories (see data sheets Mounting instructions and accessories for TO-220 envelopes).

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages (in either direction)			BT137–500	600	800	
Non-repetitive peak off-state voltage ($t \leq 10$ ms)	V_{DSM}	max.	500*	600*	800	V
Repetitive peak off-state voltage ($\delta \leq 0.01$)	V_{DRM}	max.	500	600	800	V
Crest working off-state voltage	V_{DWM}	max.	400	400	400	V

Currents (in either direction)				
R.M.S. on-state current (conduction angle 360°) up to T_{mb} = 97 °C	$I_{T(RMS)}$	max.	8	A
→ Repetitive peak on-state current	I_{TRM}	max.	55	A
Non-repetitive peak on-state current; T_j = 120 °C prior to surge; t = 20 ms; full sine-wave	I_{TSM}	max.	55	A
I^2t for fusing (t = 10 ms)	I^2t	max.	15	A^2s
Rate of rise of on-state current after triggering with I_G = 200 mA to I_T = 12 A; dI_G/dt = 0.2 A/μs	dI_T/dt	max.	20	A/μs

Gate to terminal 1

POWER DISSIPATION

Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	0.5	W
Peak power dissipation	P_{GM}	max.	5	W
Temperatures				
Storage temperature	T_{stg}		–40 to +125	°C
Operating junction temperature				
full-cycle operation	T_j	max.	120	°C
half-cycle operation	T_j	max.	110	°C

*Although not recommended, off-state voltages up to 800 V may be applied without damage, but the triac may switch into the on-state. The rate of rise of on-state current should not exceed 6 A/μs.

THERMAL RESISTANCE

From junction to mounting base		
full-cycle operation	$R_{th\ j\text{-}mb}$	= 2.0 K/W
half-cycle operation	$R_{th\ j\text{-}mb}$	= 2.4 K/W
Transient thermal impedance; t = 1 ms	$Z_{th\ j\text{-}mb}$	= 0.3 K/W

Influence of mounting method

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from mounting base to heatsink

a. with heatsink compound	$R_{th\ mb\text{-}h}$	= 0.3 K/W
b. with heatsink compound and 0.06 mm maximum mica insulator	$R_{th\ mb\text{-}h}$	= 1.4 K/W
c. with heatsink compound and 0.1 mm max. mica insulator (56369)	$R_{th\ mb\text{-}h}$	= 2.2 K/W
d. with heatsink compound and 0.25 mm max. alumina insulator (56367)	$R_{th\ mb\text{-}h}$	= 0.8 K/W
e. without heatsink compound	$R_{th\ mb\text{-}h}$	= 1.4 K/W

2. Free-air operation

The quoted values of $R_{th\ j\text{-}a}$ should be used only when no leads of other dissipating components run to the same tie-point.

Thermal resistance from junction to ambient in free air:
mounted on a printed-circuit board at a = any lead length $R_{th\ j\text{-}a}$ = 60 K/W

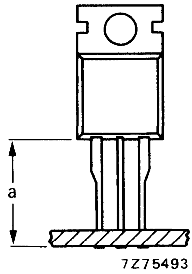


Fig.2

CHARACTERISTICS (T_j = 25 °C unless otherwise stated)

Polarities, positive or negative, are identified with respect to T_1.

Voltages and currents (in either direction)

On-state voltage (measured under pulse conditions to prevent excessive dissipation)				
I_T = 10 A	V_T	<	1.65	V
Rate of rise of off-state voltage that will not trigger any device; T_j = 120 °C; gate open circuit				
BT137 series	dV_D/dt	<	100	V/μs
BT137 series G	dV_D/dt	<	200	V/μs
BT137 series F	dV_D/dt	<	50	V/μs
BT137 series E	dV_D/dt	typ.	50	V/μs
BT137 – 500D	dV_D/dt	typ.	5	V/μs
Rate of change of commutating voltage that will not trigger any device when $-dI_{com}/dt$ = 3.6 A/ms; $I_{T(RMS)}$ = 8 A; T_{mb} = 70 °C; gate open circuit ; $V_D = V_{DWMmax}$				
BT137 series	dV_{com}/dt	typ.	10	V/μs
BT137 series G	dV_{com}/dt	<	10	V/μs
BT137 series F	dV_{com}/dt	typ.	10	V/μs
Off-state current				
$V_D = V_{DWMmax}$; T_j = 120 °C	I_D	<	0.5	mA
Gate voltage that will trigger all devices	V_{GT}	>	1.5	V
Gate voltage that will not trigger any device $V_D = V_{DWMmax}$; T_j = 120 °C; T_2 and G positive or negative	V_{GD}	<	250	mV

Gate current that will trigger all devices (I_{GT}); G to T_1

Holding current (I_H)

Latching current (I_L); V_D = 12 V

			T_2+ G+	T_2+ G–	T_2– G–	T_2– G+	
BT137 series	I_{GT}	>	35	35	35	70	mA
	I_H	<	20	20	20	20	mA
	I_L	<	30	45	30	45	mA
BT137 series G	I_{GT}	>	50	50	50	100	mA
	I_H	<	40	40	40	40	mA
	I_L	<	45	60	45	60	mA
BT137 series F	I_{GT}	>	25	25	25	70	mA
	I_H	<	20	20	20	20	mA
	I_L	<	30	45	30	45	mA
BT137 series E	I_{GT}	>	10	10	10	25	mA
	I_H	<	20	20	20	20	mA
	I_L	<	25	35	25	35	mA
BT137 – 500D	I_{GT}	>	5	5	5	10	mA
	I_H	<	15	15	15	15	mA
	I_L	<	15	20	15	20	mA

MOUNTING INSTRUCTIONS

1. The device may be soldered directly into the circuit, but the maximum permissible temperature of the soldering iron or bath is 275 ^{o}C; it must not be in contact with the joint for more than 5 seconds. Soldered joints must be at least 4.7 mm from the seal.
2. The leads should not be bent less than 2.4 mm from the seal, and should be supported during bending. The leads can be bent, twisted or straightened by 90^{o} maximum. The minimum bending radius is 1 mm.
3. It is recommended that the circuit connection be made to tag T_2, rather than direct to the heatsink.
4. Mounting by means of a spring clip is the best mounting method because it offers:
   a. a good thermal contact under the crystal area and slightly lower $R_{th\ mb\text{-}h}$ values than screw mounting.
   b. safe isolation for mains operation.

   However, if a screw is used, it should be M3 cross-recess pan-head. Care should be taken to avoid damage to the plastic body.
5. For good thermal contact, heatsink compound should be used between mounting base and heatsink. Values of $R_{th\ mb\text{-}h}$ given for mounting with heatsink compound refer to the use of a metallic-oxide loaded compound. Ordinary silicone grease is not recommended.
6. Rivet mounting (only possible for non-insulated mounting)

   Devices may be rivetted to flat heatsinks; such a process **must neither** deform the mounting tab, **nor** enlarge the mounting hole.
7. The heatsink must have a flatness in the mounting area of 0.02 mm maximum per 10 mm. Mounting holes must be deburred.

OPERATING NOTES

Dissipation and heatsink considerations:

a. The various components of junction temperature rise above ambient are illustrated in Fig.3.

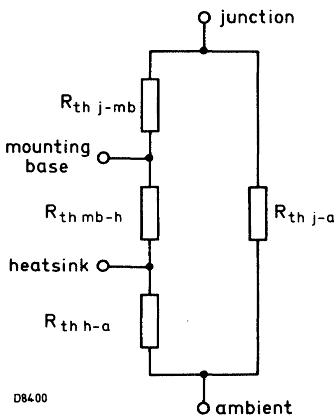


Fig.3.

b. The method of using Fig.4 is as follows:
Starting with the required current on the $I_{T(RMS)}$ axis, trace upwards to meet the appropriate conduction angle curve. Trace right horizontally and upwards from the appropriate value on the T_{amb} scale. The intersection determines the $R_{th\ mb\text{-}a}$. The heatsink thermal resistance value ($R_{th\ h\text{-}a}$) can now be calculated from:

$$R_{th\ h\text{-}a} = R_{th\ mb\text{-}a} - R_{th\ mb\text{-}h}.$$

c. Any measurement of heatsink temperature should be made immediately adjacent to the device.

FULL-CYCLE OPERATION

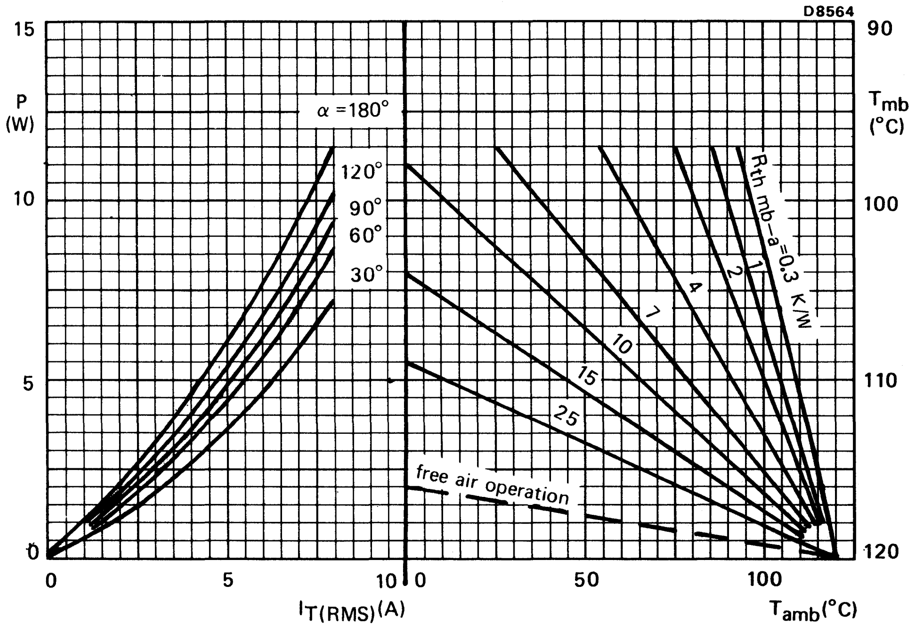
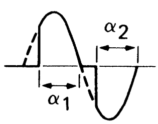


Fig.4 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha = \alpha_1 = \alpha_2$: conduction angle per half cycle

Note: For the type BT137—500D only, any operating point derived from Fig.4 should be derated by a further 10 °C.

OVERLOAD OPERATION

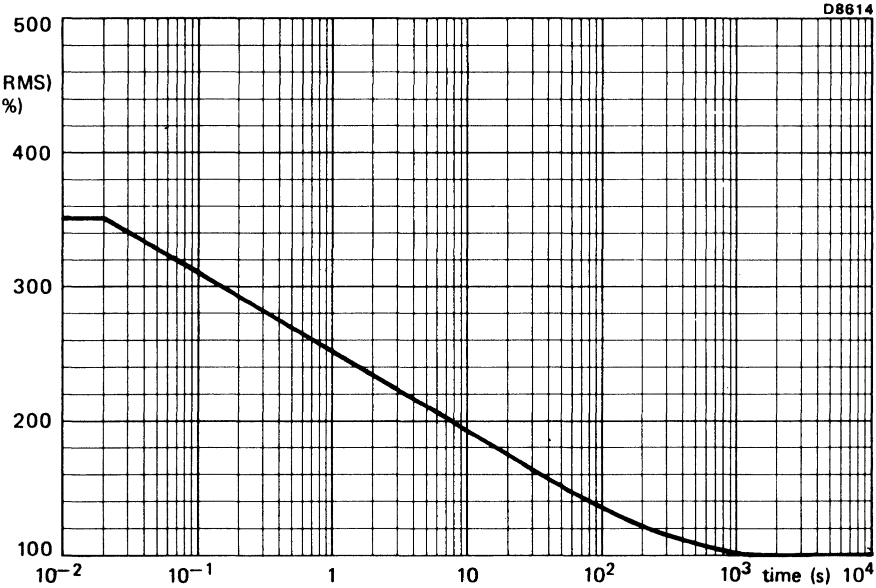


Fig. 5 Maximum permissible duration of steady overload (provided that T_{mb} does not exceed 120 ^{o}C during and after overload) expressed as a percentage of the steady state r.m.s. rated current. For high r.m.s. overload currents precautions should be taken so that the temperature of the terminals does not exceed 125 ^{o}C. During these overload conditions the triac may lose control. Therefore the overload should be terminated by a separate protection device.

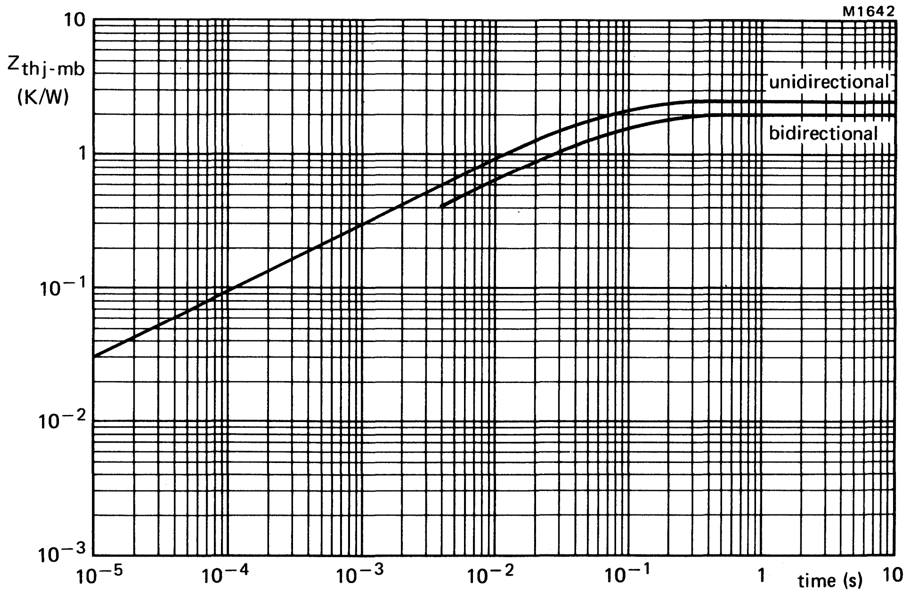

M1642
10
$Z_{thj\text{-}mb}$
(K/W)
1
10^{-1}
10^{-2}
10^{-3}
unidirectional
bidirectional
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
time (s)
10

Fig. 6

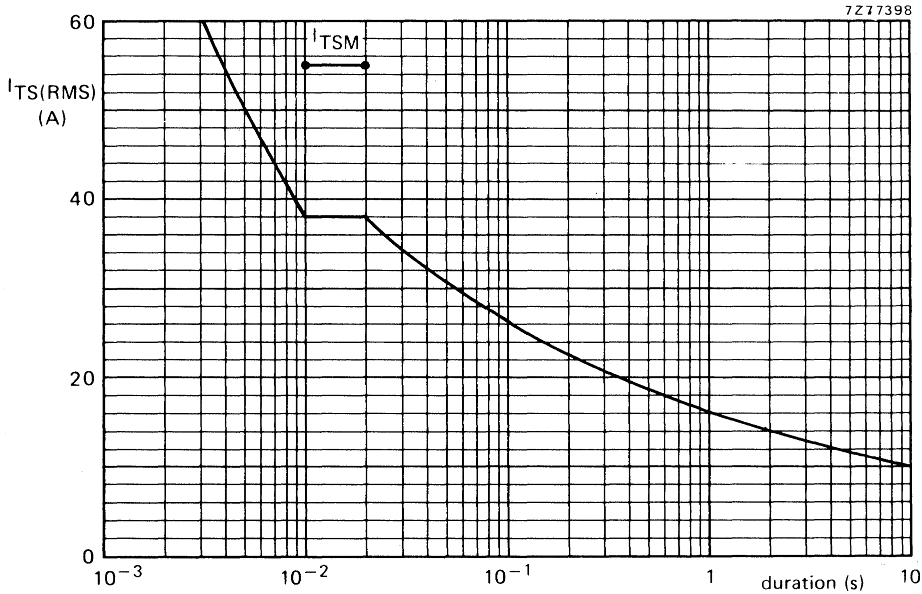
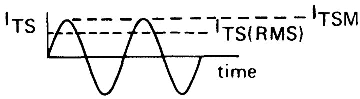


Fig.7 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents (f = 50 Hz); T_j = 120 °C prior to surge. The triac may temporarily lose control following the surge.



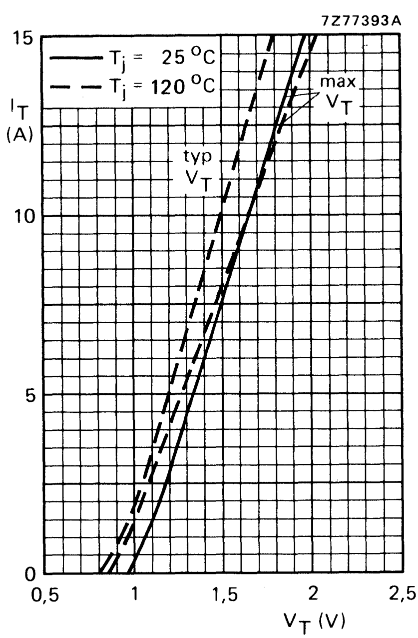


Fig.8

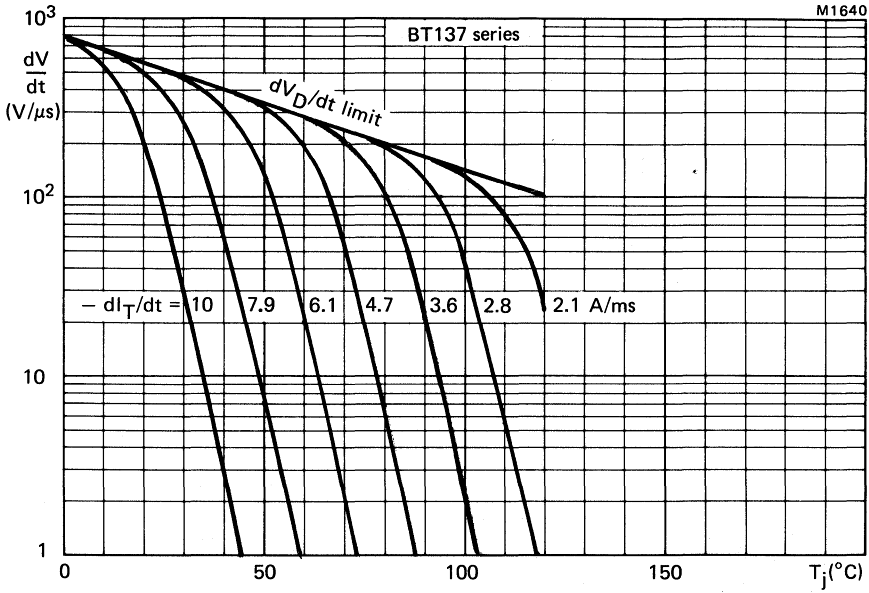


Fig.9 Typical commutation dV/dt for BT137 series versus T_j. The triac should commutate when the dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

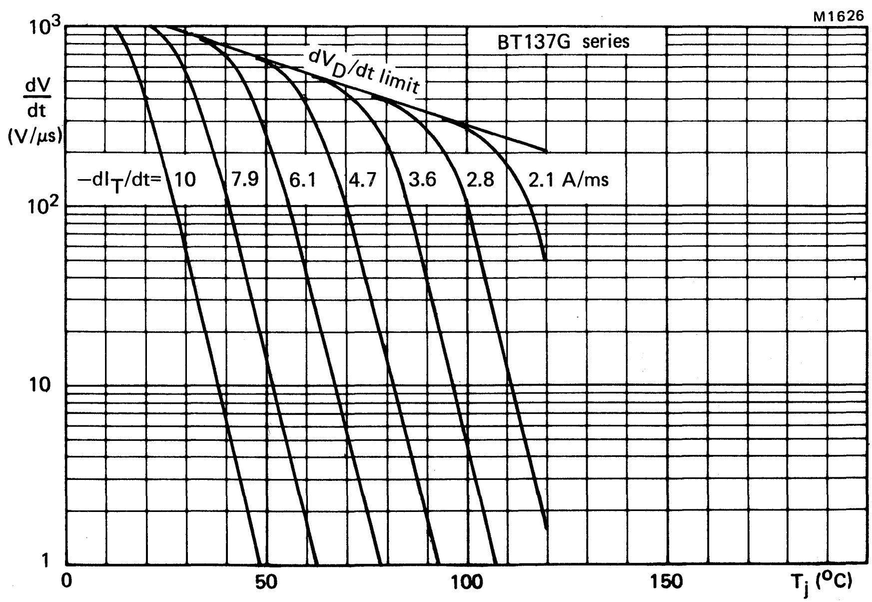


Fig.10 Limit commutation dV/dt for BT137G series versus T_j. The triac should commutate when the dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

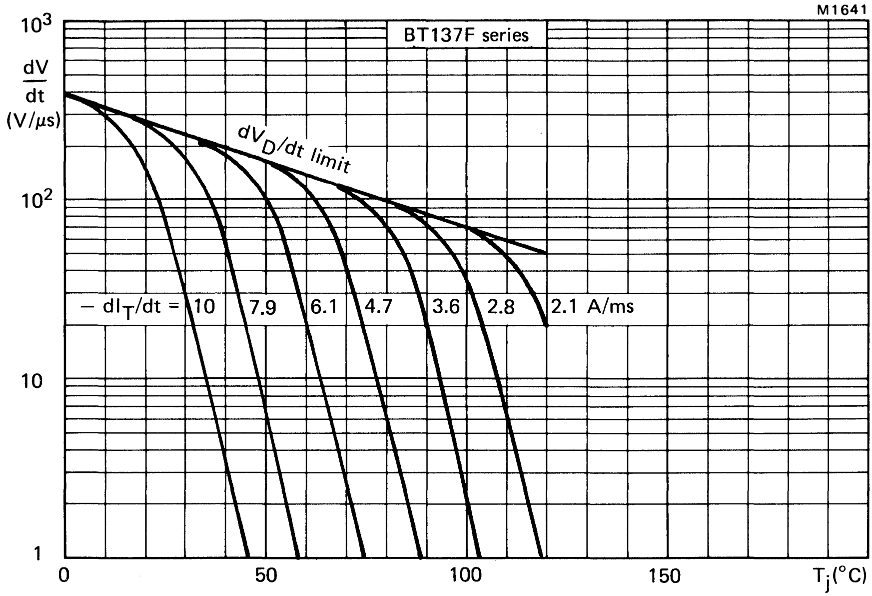


Fig.11 Typical commutation dV/dt for BT137F series versus T_j. The triac should commutate when the dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

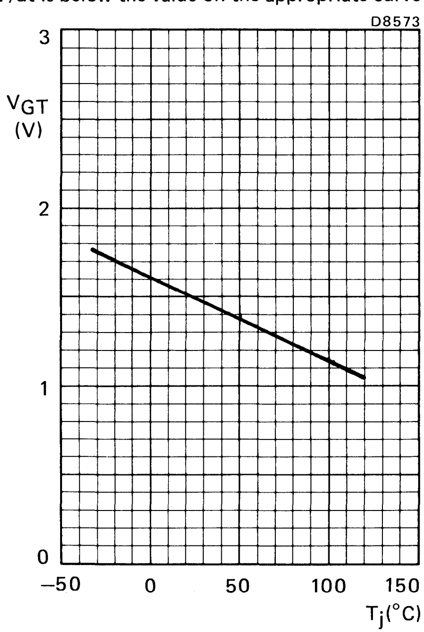


Fig.12 Minimum gate voltage that will trigger all devices; all conditions.

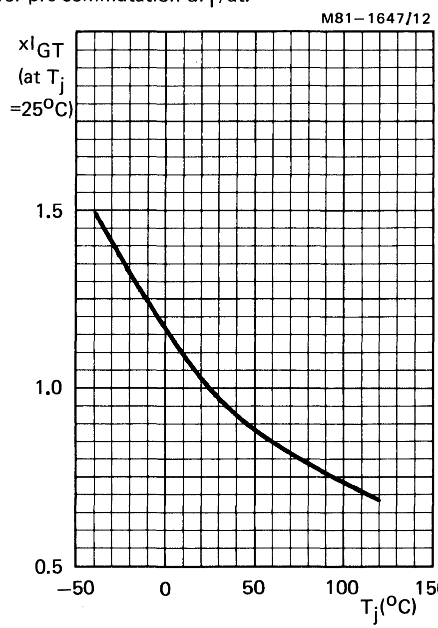


Fig.13 Normalised gate current that will trigger all devices; all conditions.

FULL-PACK TRIACS

Glass-passivated 8 Ampere triacs in SOT-186 envelopes, which feature an electrically isolated seating plan•. They are intended for use in applications requiring high bidirectional transient and blocking voltage capability. Typical applications include a.c. power control circuits such as lighting, industrial and domestic heating, motor control and switching systems.

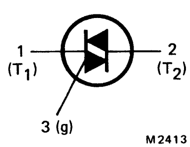
QUICK REFERENCE DATA

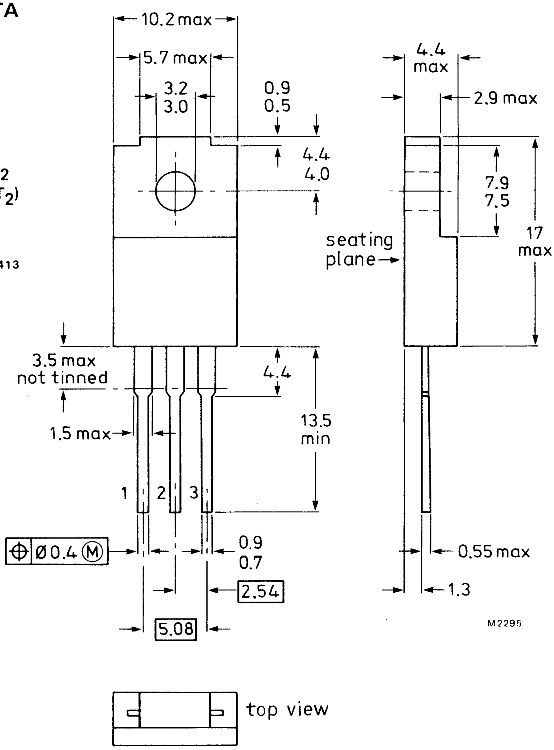
			BT137F–500	600	800	
Repetitive peak off-state voltage	V_{DRM}	max.	500	600	800	V
R.M.S. on-state current	$I_{T(RMS)}$	max.		8		A
Non-repetitive peak on-state current	I_{TSM}	max.		55		A

MECHANICAL DATA

Dimensions in mm

Fig.1 SOT-186





Net mass: 2 g.

The seating plane is electrically isolated from all terminals.

Accessories supplied on request (see data sheets Mounting instructions for F-pack devices and Accessories for SOT-186 envelopes). ←

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134)

Voltages (in either direction)

			BT137F–500	600	800	
Non-repetitive peak off-state voltage ($t \leqslant 10$ ms)	V_{DSM}	max.	500*	600*	800	V
Repetitive peak off-state voltage ($\delta \leqslant 0.01$)	V_{DRM}	max.	500	600	800	V
Crest working off-state voltage	V_{DWM}	max.	400	400	400	V

Currents (in either direction)

R.M.S. on-state current (conduction angle 360°) up to $T_h = 71$ °C	$I_{T(RMS)}$	max.	8	A
Repetitive peak on-state current	I_{TRM}	max.	55	A
Non-repetitive peak on-state current; $T_j = 120$ °C prior to surge; t = 20 ms; full sine-wave	I_{TSM}	max.	55	A
I^2t for fusing (t = 10 ms)	I^2t	max.	15	A^2s
Rate of rise of on-state current after triggering with $I_G = 200$ mA to $I_T = 12$ A; $dI_G/dt = 0.2$ A/μs	dI_T/dt	max.	20	A/μs

Gate to terminal 1

POWER DISSIPATION

Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	0.5	W
Peak power dissipation	P_{GM}	max.	5	W

Temperatures

Storage temperature	T_{stg}		−40 to +125	°C
Operating junction temperature full-cycle operation	T_j	max.	120	°C
half-cycle operation	T_j	max.	110	°C

ISOLATION

From all three terminals to external heatsink (peak)	V_{isol}	min.	1000	V
Capacitance from T_2 to external heatsink	C_{isol}	typ.	12	pF

*Although not recommended, off-state voltages up to 800 V may be applied without damage, but the triac may switch into the on-state. The rate of rise of on-state current should not exceed 6 A/μs.

THERMAL RESISTANCE

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from junction to external heatsink

With heatsink compound	$R_{th\ j\text{-}h}$	=	4.5	K/W
Without heatsink compound	$R_{th\ j\text{-}h}$	=	6.5	K/W

2. Free-air operation

The quoted values of $R_{th\ j\text{-}a}$ should be used only when no leads of other dissipating components run to the same tie-point.

Thermal resistance from junction to ambient in free air:

mounted on a printed-circuit board at a = any lead length	$R_{th\ j\text{-}a}$	=	55	K/W

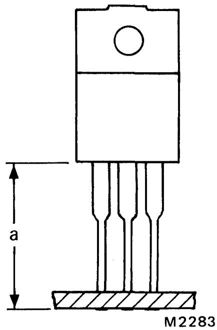


Fig.2.

CHARACTERISTICS (T_j = 25 °C unless otherwise stated)

Polarities, positive or negative, are identified with respect to T_1.

Voltages and currents (in either direction)

On-state voltage (measured under pulse conditions to prevent excessive dissipation)				
I_T = 10 A	V_T	<	1.65	V
Rate of rise of off-state voltage that will not trigger any device; T_j = 120 °C; gate open circuit				
BT137F series	dV_D/dt	<	100	V/µs
BT137F series G	dV_D/dt	<	200	V/µs
BT137F series F	dV_D/dt	<	50	V/µs
BT137F series E	dV_D/dt	typ.	50	V/µs
BT137F-500D	dV_D/dt	typ.	5	V/µs
Rate of change of commutating voltage that will not trigger any device when $-dI_{com}/dt$ = 3.6 A/ms; $I_{T(RMS)}$ = 8 A; T_h = 54 °C; gate open circuit; $V_D = V_{DWMmax}$				
BT137F series	dV_{com}/dt	typ.	10	V/µs
BT137F series G	dV_{com}/dt	<	10	V/µs
BT137F series F	dV_{com}/dt	typ.	10	V/µs
Off-state current				
$V_D = V_{DWMmax}$; T_j = 120 °C	I_D	<	0.5	mA
Gate voltage that will trigger all devices	V_{GT}	>	1.5	V
Gate voltage that will not trigger any device $V_D = V_{DWMmax}$; T_j = 120 °C; T_2 and G positive or negative	V_{GD}	<	250	mV

Gate current that will trigger all devices (I_{GT}); G to T_1

Holding current (I_H)

Latching current (I_L); V_D = 12 V

			T_2+ G+	T_2+ G−	T_2− G−	T_2− G+	
BT137F series	I_{GT}	>	35	35	35	70	mA
	I_H	<	20	20	20	20	mA
	I_L	<	30	45	30	45	mA
BT137F series G	I_{GT}	>	50	50	50	100	mA
	I_H	<	40	40	40	40	mA
	I_L	<	45	60	45	60	mA
BT137F series F	I_{GT}	>	25	25	25	70	mA
	I_H	<	20	20	20	20	mA
	I_L	<	30	45	30	45	mA
BT137F series E	I_{GT}	>	10	10	10	25	mA
	I_H	<	20	20	20	20	mA
	I_L	<	25	35	25	35	mA
BT137F-500D	I_{GT}	>	5	5	5	10	mA
	I_H	<	15	15	15	15	mA
	I_L	<	15	20	15	20	mA

MOUNTING INSTRUCTIONS

1. The triac may be soldered directly into the circuit, but the maximum permissible temperature of the soldering iron or bath is 275 °C; it must not be in contact with the joint for more than 5 seconds. Soldered joints must be at least 4.7 mm from the seal.
2. The leads should not be bent less than 2.4 mm from the seal, and should be supported during bending. The leads can be bent, twisted or straightened by 90° maximum. The minimum bending radius is 1 mm.
3. Mounting by means of a spring clip is the best mounting method because it offers good thermal contact under the crystal area and slightly lower $R_{th\ j\text{-}h}$ values than screw mounting. However, if a screw is used, it should be M3 cross-recess pan-head. Care should be taken to avoid damage to the plastic body. ←
4. For good thermal contact heatsink compound should be used between seating plane and heatsink. Values of $R_{th\ j\text{-}h}$ given for mounting with heatsink compound refer to the use of a metallic-oxide loaded compound. Ordinary silicone grease is not recommended.
5. Rivet mounting is not recommended.
6. The heatsink must have a flatness in the mounting area of 0.02 mm maximum per 10 mm. Mounting holes must be deburred.

OPERATING NOTES

Dissipation and heatsink considerations:

a. The various components of junction temperature rise above ambient are illustrated in Fig.3.

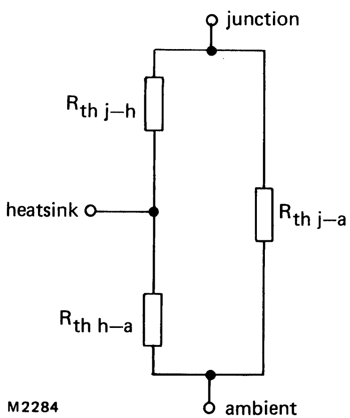


Fig.3.

b. The method of using Figs.4 and 5 is as follows:
Starting with the required current on the $I_{T(RMS)}$ axis (l.h. graph) trace upwards to meet the appropriate conduction angle curve. Trace left from curve to obtain power P. Trace right from curve to obtain T_h (r.h. graph). Trace upwards from T_{amb}, intersect with T_h determines $R_{th\ h\text{-}a}$, required heatsink thermal resistance.

c. Any measurement of heatsink temperature should be made immediately adjacent to the device.

FULL-WAVE CONDUCTION (with heatsink compound)

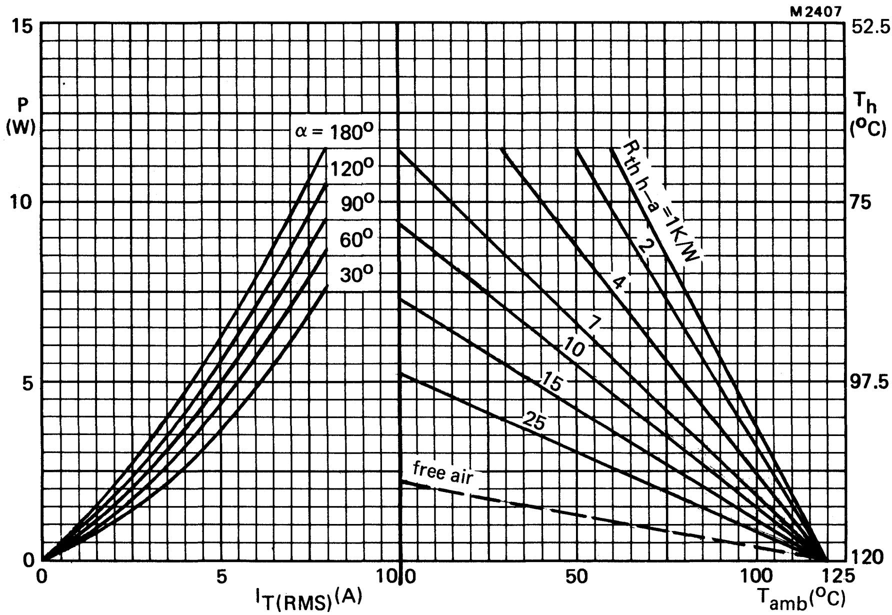
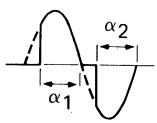


Fig.4 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha = \alpha_1 = \alpha_2$: conduction angle per half cycle

Note: For the type BT137F-500D only, any operating point derived from Fig.4 should be derated by a further 10 °C.

FULL-WAVE CONDUCTION (without heatsink compound)

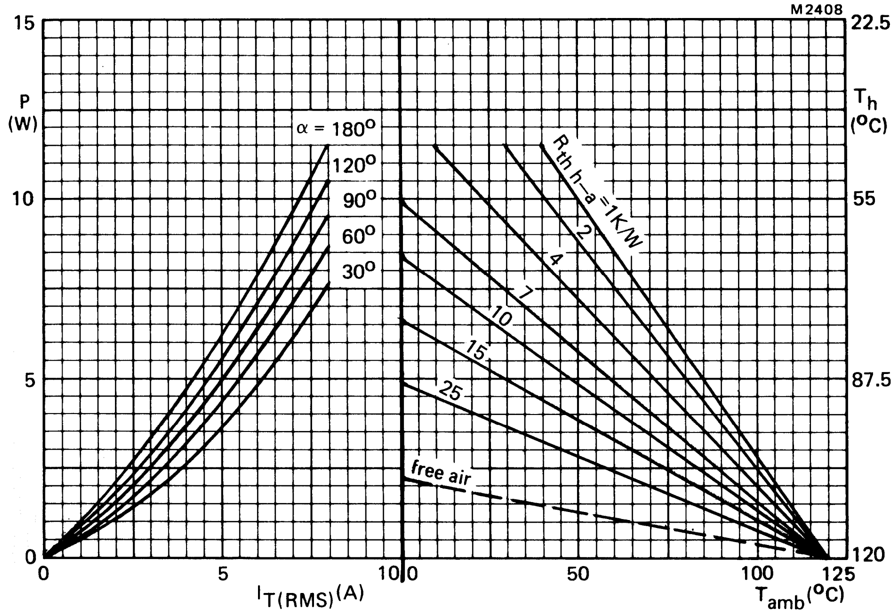
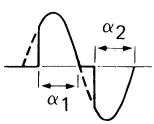


Fig.5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha = \alpha_1 = \alpha_2$: conduction angle per half cycle

Note: For the type BT137F-500D only, any operating point derived from Fig.5 should be derated by a further 10 °C.

OVERLOAD OPERATION

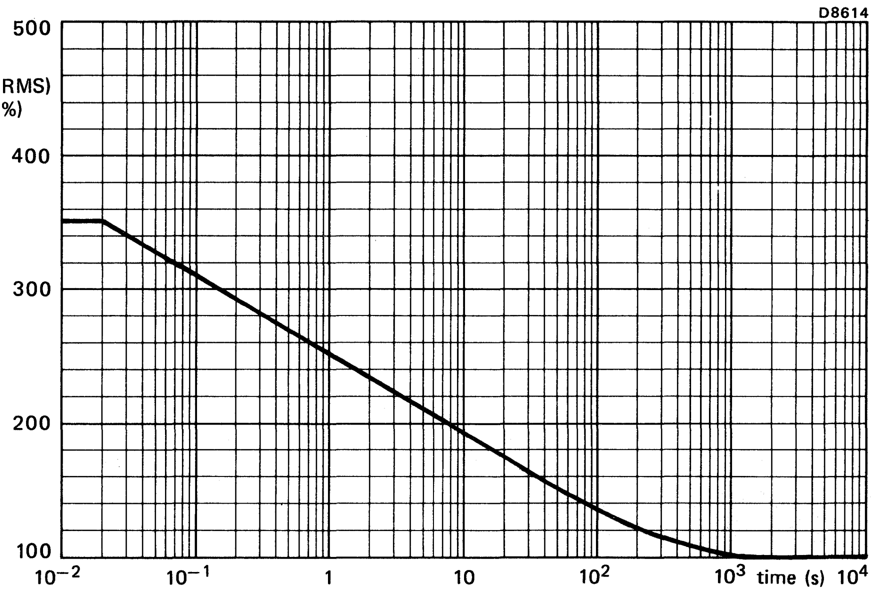


Fig.6 Maximum permissible duration of steady overload (provided that T_h does not exceed 120 °C during and after overload) expressed as a percentage of the steady state r.m.s. rated current. For high r.m.s. overload currents precautions should be taken so that the temperature of the terminals does not exceed 125 °C. During these overload conditions the triac may lose control. Therefore the overload should be terminated by a separate protection device.

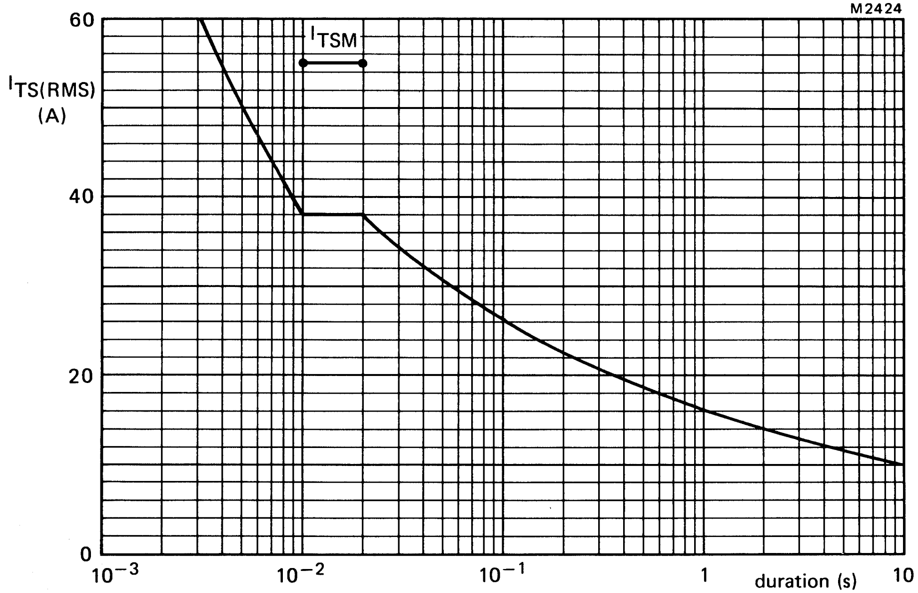
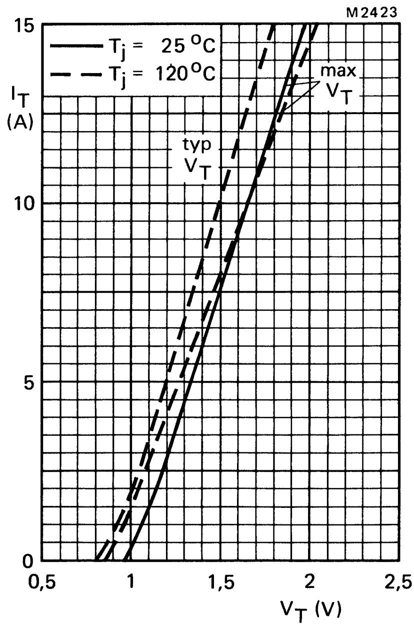


Fig.7 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents (f = 50 Hz); T_j = 120 °C prior to surge. The triac may temporarily lose control following the surge.



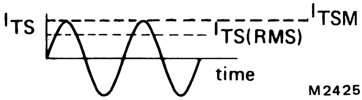


Fig.8.

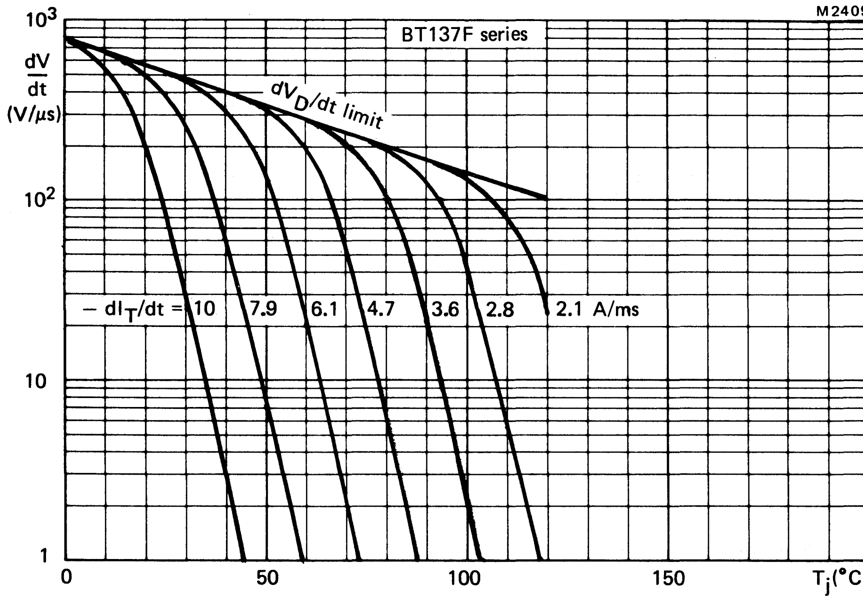


Fig.9 Typical commutation dV/dt for BT137F series versus T_j. The triac should commutate when the dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

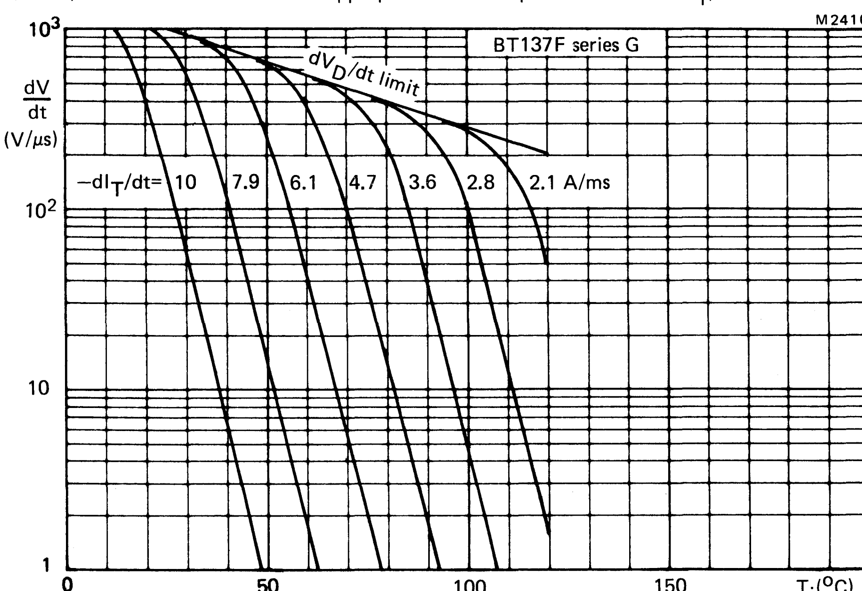


Fig.10 Limit commutation dV/dt for BT137F series G versus T_j. The triac should commutate when the dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

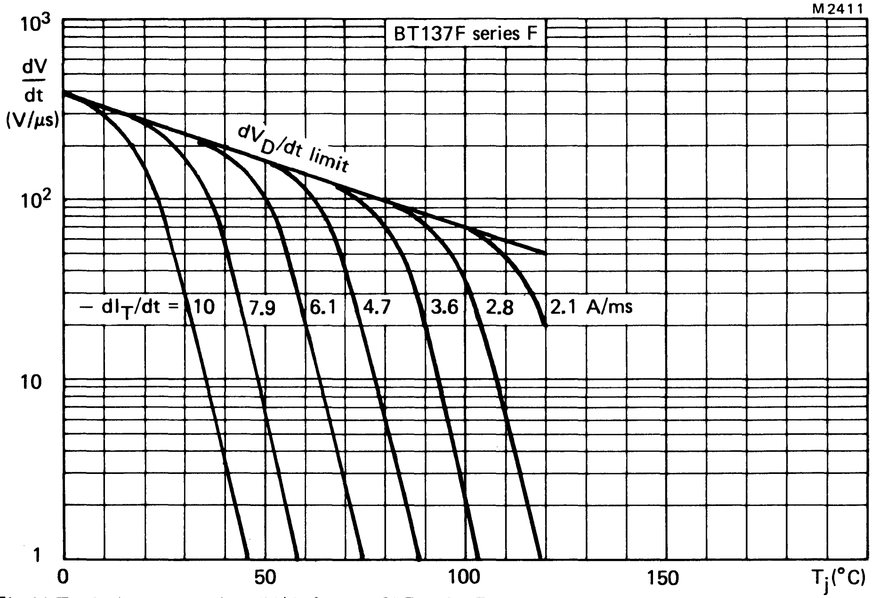


Fig.11 Typical commutation dV/dt for BT137F series F versus T_j. The triac should commutate when the dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

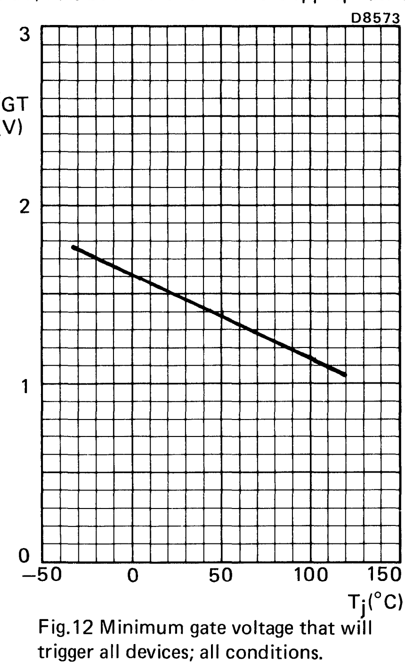


Fig.12 Minimum gate voltage that will trigger all devices; all conditions.

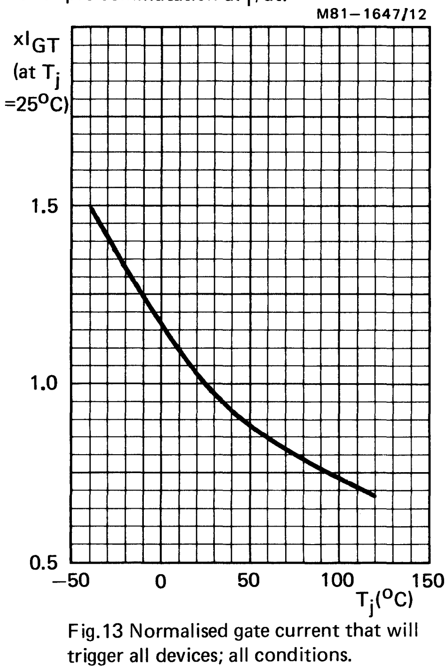


Fig.13 Normalised gate current that will trigger all devices; all conditions.

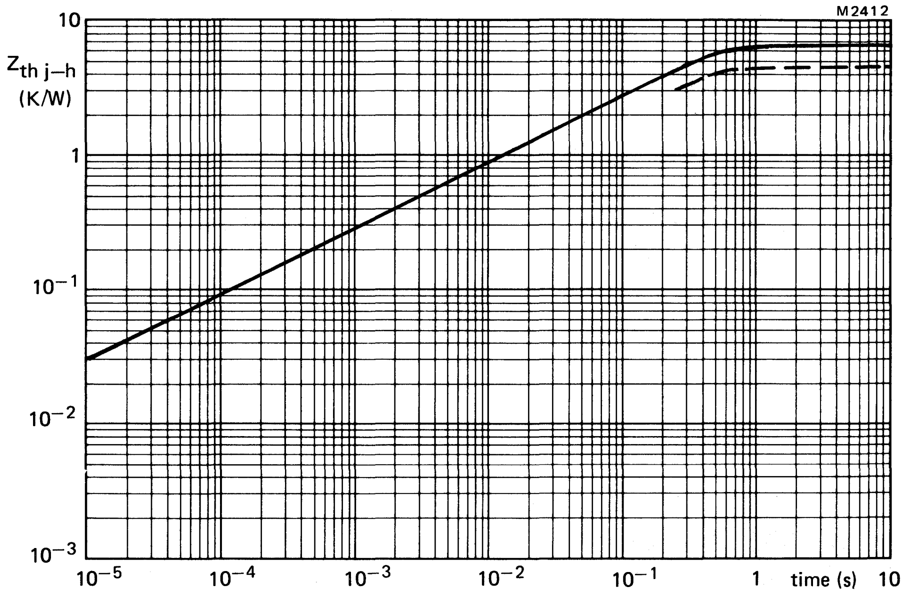


Fig.14 Transient thermal impedance, – – – with heatsink compound; —— without heatsink compound.

TRIACS

Glass-passivated 12 ampere triacs intended for use in applications requiring high bidirectional transient and blocking voltage capability, and high thermal cycling performance with very low thermal resistances, e.g. a.c. power control applications such as motor, industrial lighting, industrial and domestic heating control and static switching systems.

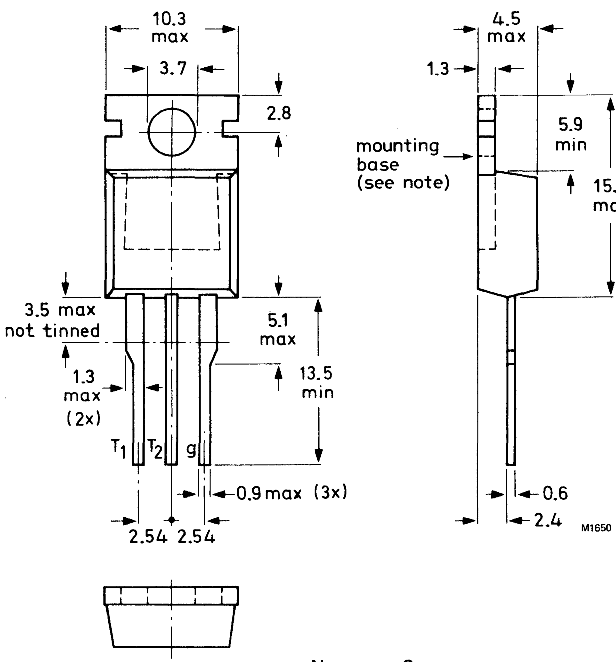
QUICK REFERENCE DATA

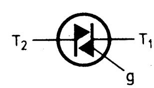
			BT138–500	600	800	
Repetitive peak off-state voltage	V_{DRM}	max.	500	600	800	V
R.M.S. on-state current	$I_{T(RMS)}$	max.		12		A
Non-repetitive peak on-state current	I_{TSM}	max.		90		A

MECHANICAL DATA

Dimensions in mm

Fig.1 TO-220AB





Net mass: 2 g

Note: The exposed metal mounting base is directly connected to terminal T_2.

Accessories supplied on request: see data sheet Mounting instructions and accessories for TO-220 envelopes.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134)

Voltages (in either direction)

			BT138–500	600	800	
Non-repetitive peak off-state voltage ($t \leqslant 10$ ms)	V_{DSM}	max.	500*	600*	800	V
Repetitive peak off-state voltage ($\delta \leqslant 0.01$)	V_{DRM}	max.	500	600	800	V
Crest working off-state voltage	V_{DWM}	max.	400	400	400	V

Currents (in either direction)

R.M.S. on-state current (conduction angle 360°) up to T_{mb} = 95 °C	$I_{T(RMS)}$	max.	12	A
Repetitive peak on-state current	I_{TRM}	max.	90	A
Non-repetitive peak on-state current; T_j = 120 °C prior to surge; t = 20 ms; full sine-wave	I_{TSM}	max.	90	A
I^2t for fusing (t = 10 ms)	I^2t	max.	40	A^2s
Rate of rise of on-state current after triggering with I_G = 200 mA to I_T = 20 A; dI_G/dt = 0.2 A/μs	dI_T/dt	max.	30	A/μs

Gate to terminal 1

Power dissipation

Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	0.5	W
Peak power dissipation	P_{GM}	max.	5.0	W

Temperatures

Storage temperature	T_{stg}		–40 to +125	°C
Operating junction temperature full-cycle operation	T_j	max.	120	°C
half-cycle operation	T_j	max.	110	°C

*Although not recommended, off-state voltages up to 800 V may be applied without damage, but the triac may switch into the on-state. The rate of rise of on-state current should not exceed 15 A/μs.

THERMAL RESISTANCE

From junction to mounting base				
full-cycle operation	$R_{th\ j\text{-}mb}$	=	1.5	K/W
half-cycle operation	$R_{th\ j\text{-}mb}$	=	2.0	K/W
Transient thermal impedance; t = 1 ms	$Z_{th\ j\text{-}mb}$	=	0.1	K/W

Influence of mounting method

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from mounting base to heatsink

a. with heatsink compound	$R_{th\ mb\text{-}h}$	=	0.3	K/W
b. with heatsink compound and 0.06 mm maximum mica insulator	$R_{th\ mb\text{-}h}$	=	1.4	K/W
c. with heatsink compound and 0.1 mm maximum mica insulator (56369)	$R_{th\ mb\text{-}h}$	=	2.2	K/W
d. with heatsink compound and 0.25 mm maximum alumina insulator (56367)	$R_{th\ mb\text{-}h}$	=	0.8	K/W
e. without heatsink compound	$R_{th\ mb\text{-}h}$	=	1.4	K/W

2. Free-air operation

The quoted values of $R_{th\ j\text{-}a}$ should be used only when no leads of other dissipating components run to the same tie-point.

Thermal resistance from junction to ambient in free air: mounted on a printed-circuit board at a = any lead length	$R_{th\ j\text{-}a}$	=	60	K/W

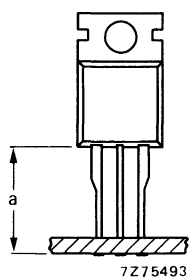


Fig.2

CHARACTERISTICS (T_j = 25 °C unless otherwise stated)

Polarities, positive or negative, are identified with respect to T_1.

Voltages and currents (in either direction)

On-state voltage (measured under pulse conditions to prevent excessive dissipation)

I_T = 15 A	V_T	<	1.65	V

Rate of rise of off-state voltage that will not trigger any device; T_j = 120 °C; gate open circuit

BT138 series	dV_D/dt	<	100	V/μs
BT138 series G	dV_D/dt	<	200	V/μs
BT138 series F	dV_D/dt	<	50	V/μs
BT138 series E	dV_D/dt	typ.	50	V/μs

Rate of change of commutating voltage that will not trigger any device when $-dI_{com}/dt$ = 5.4 A/ms; $I_{T(RMS)}$ = 12 A; T_{mb} = 70 °C; gate open circuit ;$V_D = V_{DWMmax}$

BT138 series	dV_{com}/dt	typ.	10	V/μs
BT138 series G	dV_{com}/dt	<	10	V/μs
BT138 series F	dV_{com}/dt	typ.	10	V/μs

Off-state current

$V_D = V_{DWMmax}$; T_j = 120 °C;	I_D	<	0.5	mA
Gate voltage that will trigger all devices	V_{GT}	>	1.5	V

Gate voltage that will not trigger any device $V_D = V_{DWMmax}$; T_j = 120 °C; T_2 and G positive or negative — V_{GD} < 250 mV

Gate current that will trigger all devices (I_{GT}); G to T_1

Holding current (I_H)

Latching current (I_L); V_D = 12 V

			T_2+ G+	T_2+ G−	T_2− G−	T_2− G+	
BT138 series	I_{GT}	>	35	35	35	70	mA
	I_H	<	30	30	30	30	mA
	I_L	<	40	60	40	60	mA
BT138 series G	I_{GT}	>	50	50	50	100	mA
	I_H	<	60	60	60	60	mA
	I_L	<	60	90	60	90	mA
BT138 series F	I_{GT}	>	25	25	25	70	mA
	I_H	<	30	30	30	30	mA
	I_L	<	40	60	40	60	mA
BT138 series E	I_{GT}	>	10	10	10	25	mA
	I_H	<	30	30	30	30	mA
	I_L	<	30	40	30	40	mA

MOUNTING INSTRUCTIONS

1. The device may be soldered directly into the circuit, but the maximum permissible temperature of the soldering iron or bath is 275 °C; it must not be in contact with the joint for more than 5 seconds. Soldered joints must be at least 4.7 mm from the seal.
2. The leads should not be bent less than 2.4 mm from the seal, and should be supported during bending. The leads can be bent, twisted or straightened by 90° maximum. The minimum bending radius is 1 mm.
3. It is recommended that the circuit connection be made to tag T_2, rather than direct to the heatsink.
4. Mounting by means of a spring clip is the best mounting method because it offers:
   a. a good thermal contact under the crystal area and slightly lower $R_{th\ mb\text{-}h}$ values than screw mounting.
   b. safe isolation for mains operation.
   However, if a screw is used, it should be M3 cross-recess pan-head. Care should be taken to avoid damage to the plastic body.
5. For good thermal contact, heatsink compound should be used between mounting base and heatsink. Values of $R_{th\ mb\text{-}h}$ given for mounting with heatsink compound refer to the use of a metallic-oxide loaded compound. Ordinary silicone grease is not recommended.
6. Rivet mounting (only possible for non-insulated mounting)

   Devices may be rivetted to flat heatsinks; such a process **must neither** deform the mounting tab, **nor** enlarge the mounting hole.
7. The heatsink must have a flatness in the mounting area of 0.02 mm maximum per 10 mm. Mounting holes must be deburred.

OPERATING NOTES

Dissipation and heatsink considerations:

a. The various components of junction temperature rise above ambient are illustrated in Fig.3.

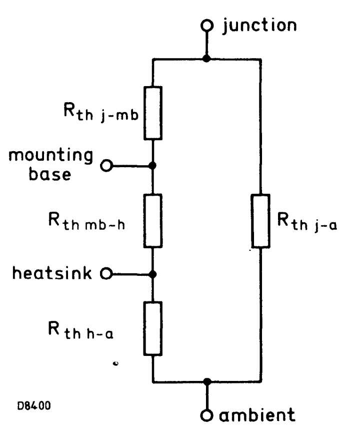


Fig.3.

b. The method of using Fig.4 is as follows:
Starting with the required current on the $I_{T(RMS)}$ axis, trace upwards to meet the appropriate conduction angle curve. Trace right horizontally and upwards from the appropriate value on the T_{amb} scale. The intersection determines the $R_{th\ mb\text{-}a}$. The heatsink thermal resistance value ($R_{th\ h\text{-}a}$) can now be calculated from:

$$R_{th\ h\text{-}a} = R_{th\ mb\text{-}a} - R_{th\ mb\text{-}h}.$$

c. Any measurement of heatsink temperature should be made immediately adjacent to the device.

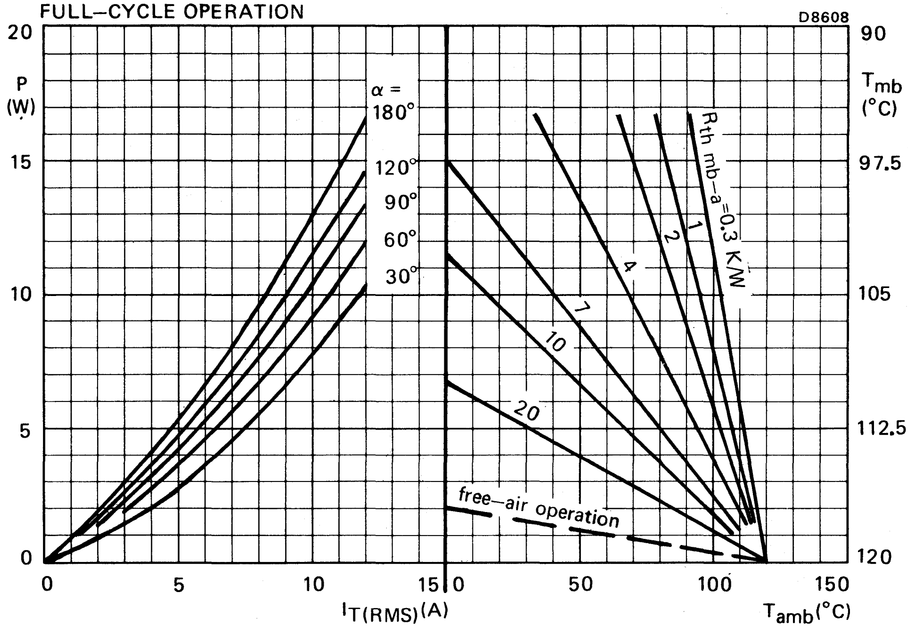
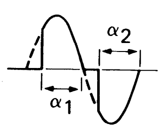


Fig.4 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha = \alpha_1 = \alpha_2$: conduction angle per half cycle

OVERLOAD OPERATION

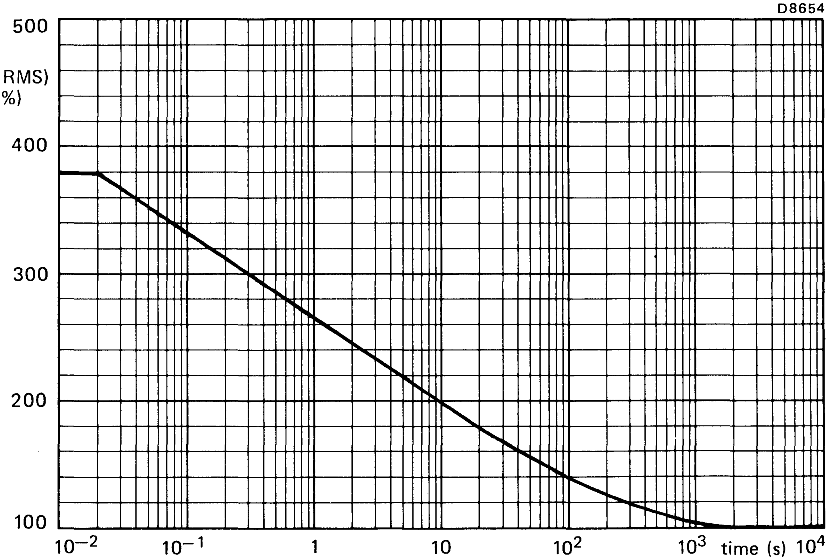


Fig.5 Maximum permissible duration of steady overload (provided that T_{mb} does exceed 120 °C during and after overload) expressed as a percentage of the steady state r.m.s. rated current. For high r.m.s. overload currents precautions should be taken so that the temperature of the terminals does not exceed 125 °C. During these overload conditions the triac may lose control. Therefore the overload should be terminated by a separate protection device.

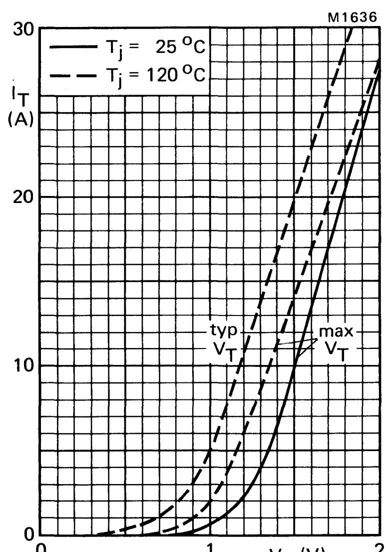


Fig.6

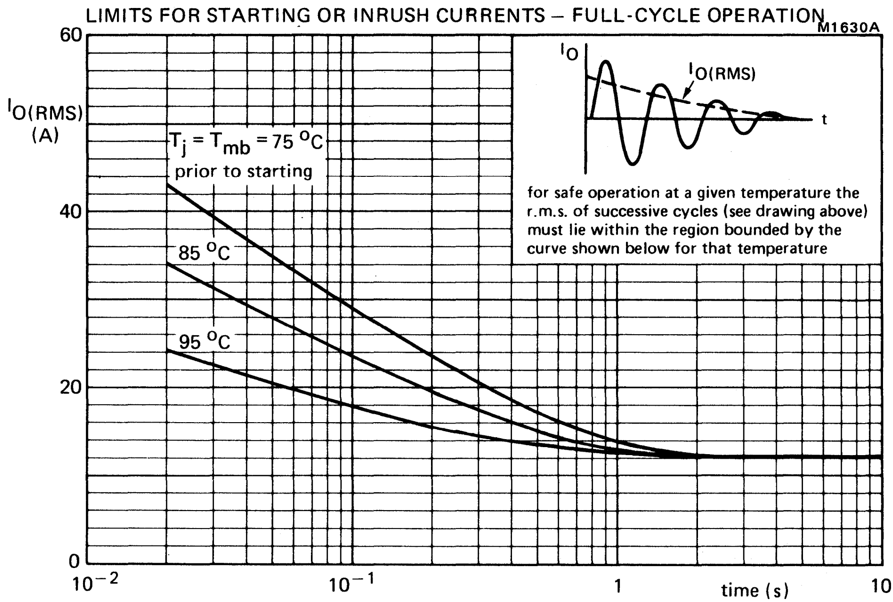

LIMITS FOR STARTING OR INRUSH CURRENTS – FULL-CYCLE OPERATION
M1630A
$I_{O(RMS)}$ (A)
60
40
20
0
$T_j = T_{mb} = 75\ ^oC$ prior to starting
85 ^oC
95 ^oC
I_O
$I_{O(RMS)}$
t
for safe operation at a given temperature the r.m.s. of successive cycles (see drawing above) must lie within the region bounded by the curve shown below for that temperature
10^{-2}
10^{-1}
1
time (s)
10

Fig. 7

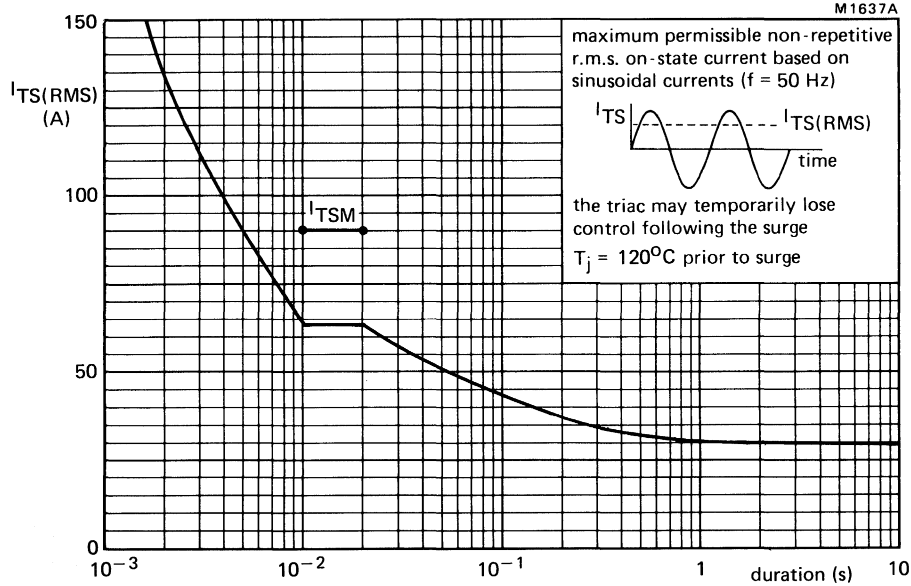

M1637A
150
100
50
0
$I_{TS(RMS)}$ (A)
maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents (f = 50 Hz)
I_{TS}
$I_{TS(RMS)}$
time
the triac may temporarily lose control following the surge
T_j = 120°C prior to surge
I_{TSM}
10^{-3}
10^{-2}
10^{-1}
1
duration (s)
10

Fig.8

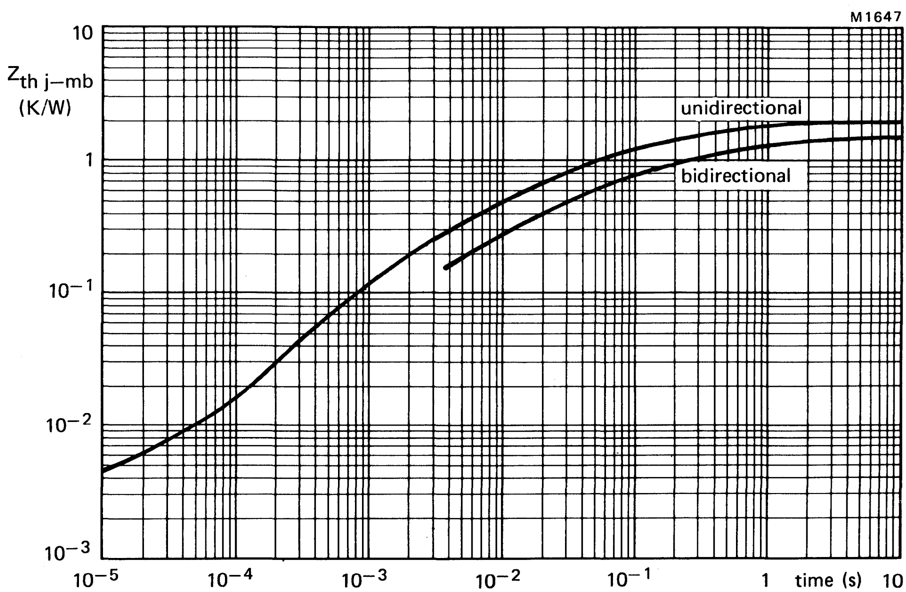

M1647
10
1
10^{-1}
10^{-2}
10^{-3}
$Z_{th\ j-mb}$ (K/W)
unidirectional
bidirectional
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
time (s)
10

Fig.9

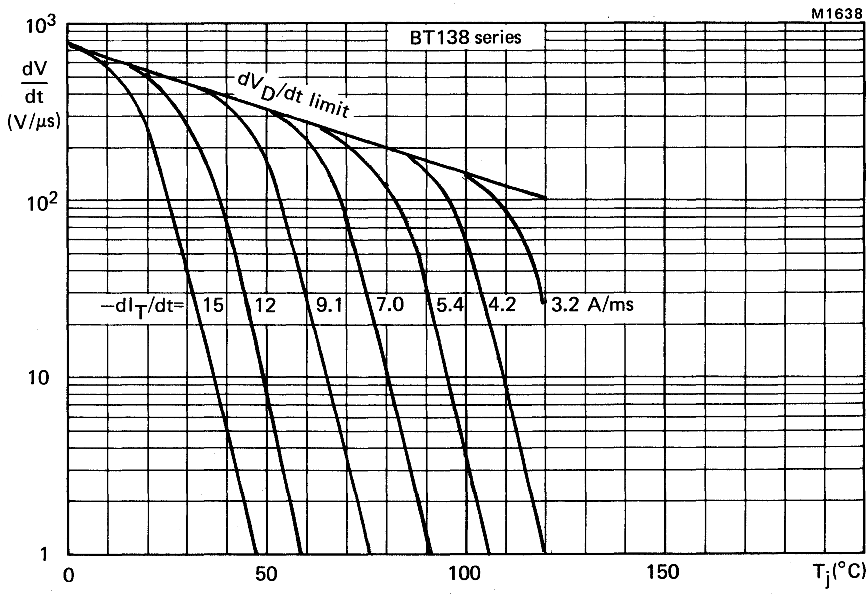


Fig.10 Typical commutation dV/dt for BT138 series versus T_j. The triac should commutate when dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

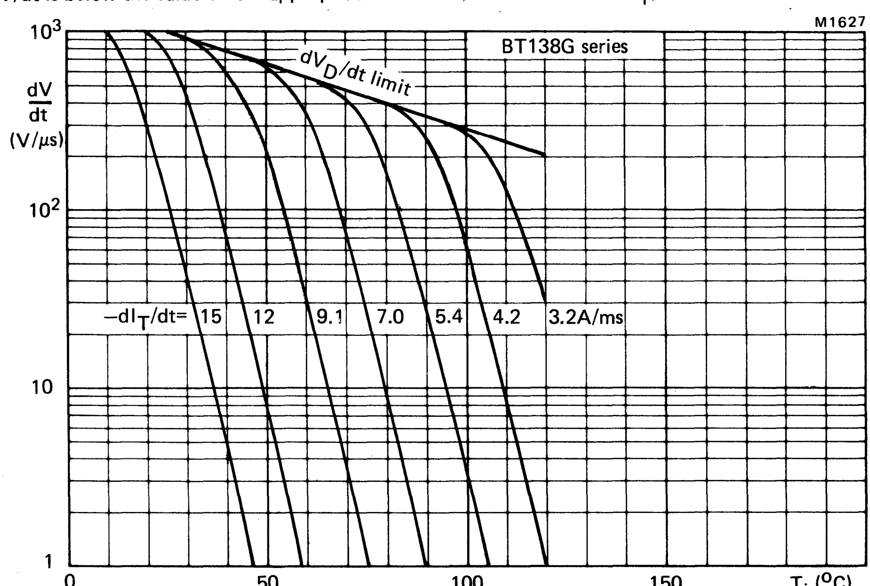


Fig.11 Limit commutation dV/dt for BT138G series versus T_j. The triac should commutate when the dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

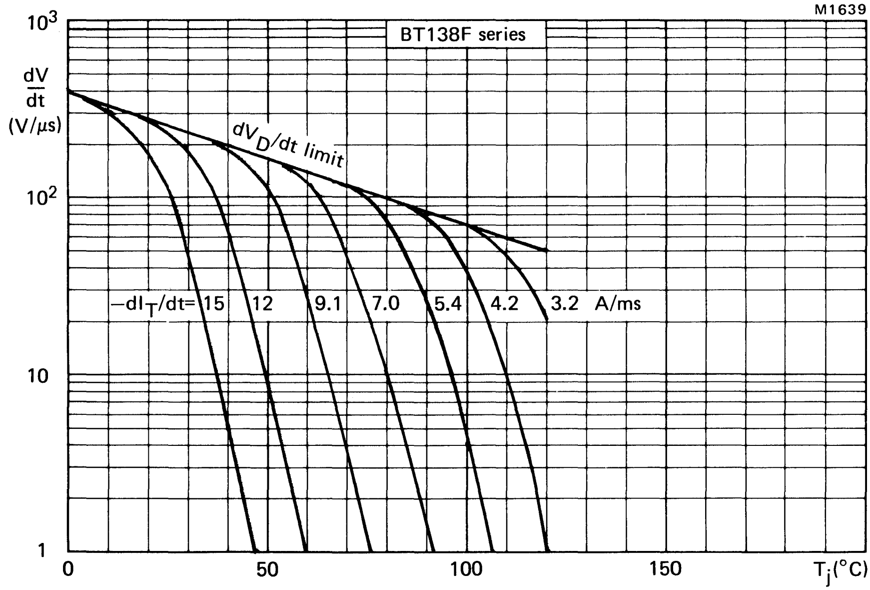


Fig.12 Typical commutation dV/dt for BT138F series versus T_j. The triac should commutate when the dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

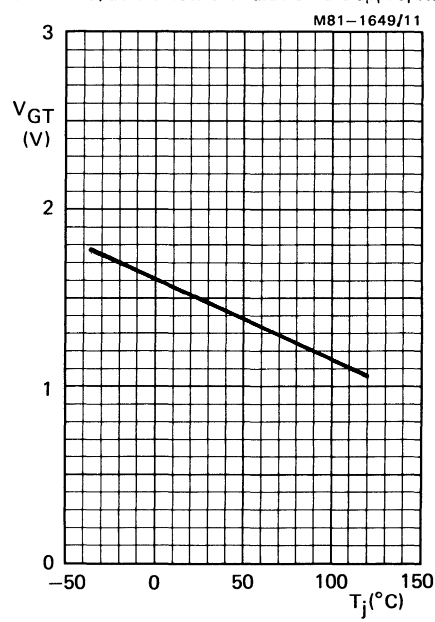


Fig.13 Minimum gate voltage that will trigger all devices; all conditions.

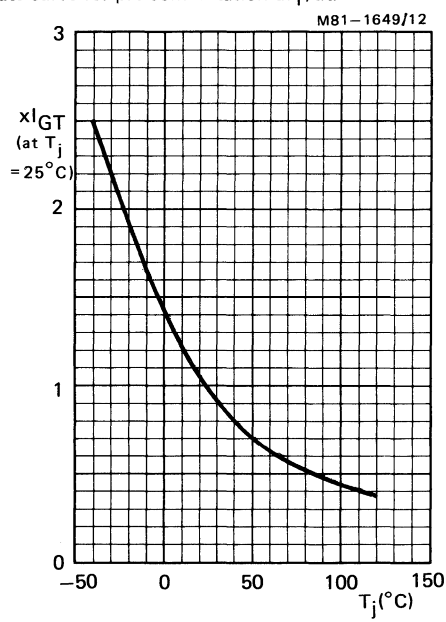


Fig.14 Normalised gate current that will trigger all devices; all conditions.

FULL-PACK TRIACS

Glass-passivated 12 ampere triacs in SOT-186 envelopes, which feature an electrically isolated seating plane. They are intended for use in applications requiring high bidirectional transient and blocking voltage capability. Typical applications include a.c. power control circuits such as lighting, industrial and domestic heating, motor control and switching systems.

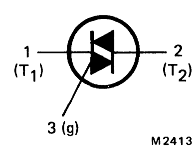
QUICK REFERENCE DATA

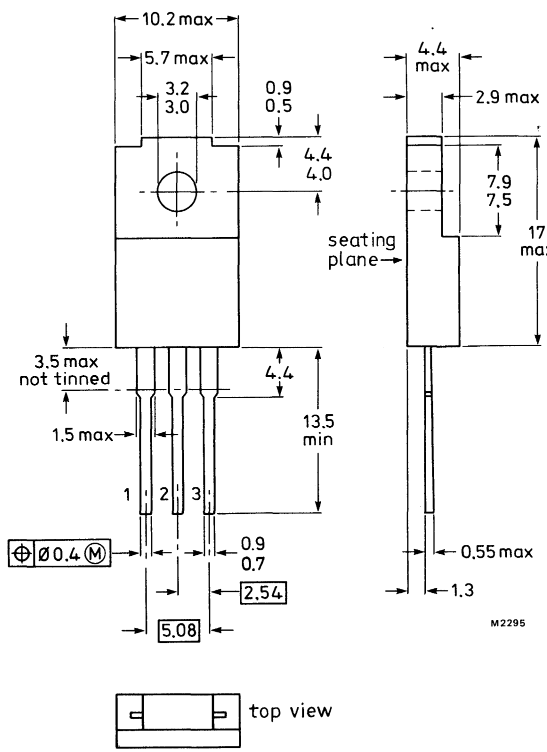
			BT138F–500	600	800	
Repetitive peak off-state voltage	V_{DRM}	max.	500	600	800	V
R.M.S. on-state current	$I_{T(RMS)}$	max.		12		A
Non-repetitive peak on-state current	I_{TSM}	max.		90		A

MECHANICAL DATA

Dimensions in mm

Fig.1 SOT-186





Net mass: 2 g.
The seating plane is electrically isolated from all terminals.
Accessories supplied on request (see data sheets Mounting instructions for F-pack devices and Accessories for SOT-186 envelopes).

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134)

Voltages (in either direction)

			BT138F–500	600	800	
Non-repetitive peak off-state voltage ($t \leqslant 10$ ms)	V_{DSM}	max.	500*	600*	800	V
Repetitive peak off-state voltage ($\delta \leqslant 0.01$)	V_{DRM}	max.	500	600	800	V
Crest working off-state voltage	V_{DWM}	max.	400	400	400	V

Currents (in either direction)

R.M.S. on-state current (conduction angle 360°) up to $T_h = 52$ °C	$I_{T(RMS)}$	max.	12	A
Repetitive peak on-state current	I_{TRM}	max.	90	A
Non-repetitive peak on-state current; $T_j = 120$ °C prior to surge; $t = 20$ ms; full sine-wave	I_{TSM}	max.	90	A
I^2t for fusing ($t = 10$ ms)	I^2t	max.	40	A^2s
Rate of rise of on-state current after triggering with $I_G = 200$ mA to $I_T = 20$ A; $dI_G/dt = 0.2$ A/µs	dI_T/dt	max.	30	A/µs

Gate to terminal 1

Power dissipation

Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	0.5	W
Peak power dissipation	P_{GM}	max.	5.0	W

Temperatures

Storage temperature	T_{stg}		−40 to +125	°C
Operating junction temperature full-cycle operation	T_j	max.	120	°C
half-cycle operation	T_j	max.	110	°C

ISOLATION

From all three terminals to external heatsink (peak)	V_{isol}	min.	1000	V
Capacitance from T_2 to external heatsink	C_{isol}	typ.	12	pF

*Although not recommended, off-state voltages up to 800 V may be applied without damage, but the triac may switch into the on-state. The rate of rise of on-state current should not exceed 15 A/µs.

THERMAL RESISTANCE

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from junction to external heatsink

With heatsink compound	$R_{th\ j\text{-}h}$	=	4.0	K/W
Without heatsink compound	$R_{th\ j\text{-}h}$	=	5.5	K/W

2. Free-air operation

The quoted values of $R_{th\ j\text{-}a}$ should be used only when no leads of other dissipating components run to the same tie-point.

Thermal resistance from junction to ambient in free air: mounted on a printed-circuit board at a = any lead length	$R_{th\ j\text{-}a}$	=	55	K/W

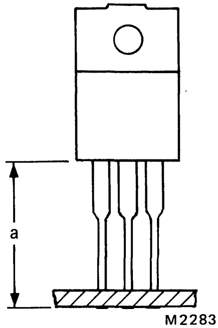


Fig.2.

CHARACTERISTICS (T_j = 25 °C unless otherwise stated)

Polarities, positive or negative, are identified with respect to T_1.

Voltage and currents (in either direction)

On-state voltage (measured under pulse conditions to prevent excessive dissipation)				
I_T = 15 A	V_T	<	1.65	V
Rate of rise of off-state voltage that will not trigger any device; T_j = 120 °C; gate open circuit				
BT138F series	dV_D/dt	<	100	V/μs
BT138F series G	dV_D/dt	<	200	V/μs
BT138F series F	dV_D/dt	<	50	V/μs
BT138F series E	dV_D/dt	typ.	50	V/μs
Rate of change of commutating voltage that will not trigger any device when $-dI_{com}/dt$ = 5.4 A/ms; $I_{T(RMS)}$ = 12 A; T_h = 40 °C; gate open circuit; $V_D = V_{DWMmax}$				
BT138F series	dV_{com}/dt	typ.	10	V/μs
BT138F series G	dV_{com}/dt	<	10	V/μs
BT138F series F	dV_{com}/dt	typ.	10	V/μs
Off-state current				
$V_D = V_{DWMmax}$; T_j = 120 °C;	I_D	<	0.5	mA
Gate voltage that will trigger all devices	V_{GT}	>	1.5	V
Gate voltage that will not trigger any device $V_D = V_{DWMmax}$; T_j = 120 °C; T_2 and G positive or negative	V_{GD}	<	250	mV

Gate current that will trigger all devices (I_{GT}); G to T_1

Holding current (I_H)

Latching current (I_L); V_D = 12 V

			T_2+ G+	T_2+ G−	T_2− G−	T_2− G+	
BT138F series	I_{GT}	>	35	35	35	70	mA
	I_H	<	30	30	30	30	mA
	I_L	<	40	60	40	60	mA
BT138F series G	I_{GT}	>	50	50	50	100	mA
	I_H	<	60	60	60	60	mA
	I_L	<	60	90	60	90	mA
BT138F series F	I_{GT}	>	25	25	25	70	mA
	I_H	<	30	30	30	30	mA
	I_L	<	40	60	40	60	mA
BT138F series E	I_{GT}	>	10	10	10	25	mA
	I_H	<	30	30	30	30	mA
	I_L	<	30	40	30	40	mA

MOUNTING INSTRUCTIONS

1. The triac may be soldered directly into the circuit, but the maximum permissible temperature of the soldering iron or bath is 275 °C; it must not be in contact with the joint for more than 5 seconds. Soldered joints must be at least 4.7 mm from the seal.
2. The leads should not be bent less than 2.4 mm from the seal, and should be supported during bending. The leads can be bent, twisted or straightened by 90° maximum. The minimum bending radius is 1 mm.
3. Mounting by means of a spring clip is the best mounting method because it offers good thermal contact under the crystal area and slightly lower $R_{th\ j\text{-}h}$ values than screw mounting. However, if a screw is used, it should be M3 cross-recess pan-head. Care should be taken to avoid damage to the plastic body. ←
4. For good thermal contact heatsink compound should be used between seating plane and heatsink. Values of $R_{th\ j\text{-}h}$ given for mounting with heatsink compound refer to the use of a metallic-oxide loaded compound. Ordinary silicone grease is not recommended.
5. Rivet mounting is not recommended.
6. The heatsink must have a flatness in the mounting area of 0.02 mm maximum per 10 mm. Mounting holes must be deburred.

OPERATING NOTES

Dissipation and heatsink considerations:

a. The various components of junction temperature rise above ambient are illustrated in Fig.3.

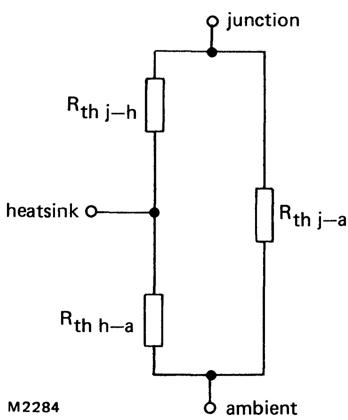


Fig.3.

b. The method of using Figs.4 and 5 is as follows:
Starting with the required current on the $I_{T(RMS)}$ axis (l.h. graph) trace upwards to meet the appropriate conduction angle curve. Trace left from curve to obtain power P. Trace right from curve to obtain T_h (r.h. graph). Trace upwards from T_{amb}, intersect with T_h determines $R_{th\ h\text{-}a}$, required heatsink thermal resistance.

c. Any measurement of heatsink temperature should be made immediately adjacent to the device.

FULL-WAVE CONDUCTION (with heatsink compound)

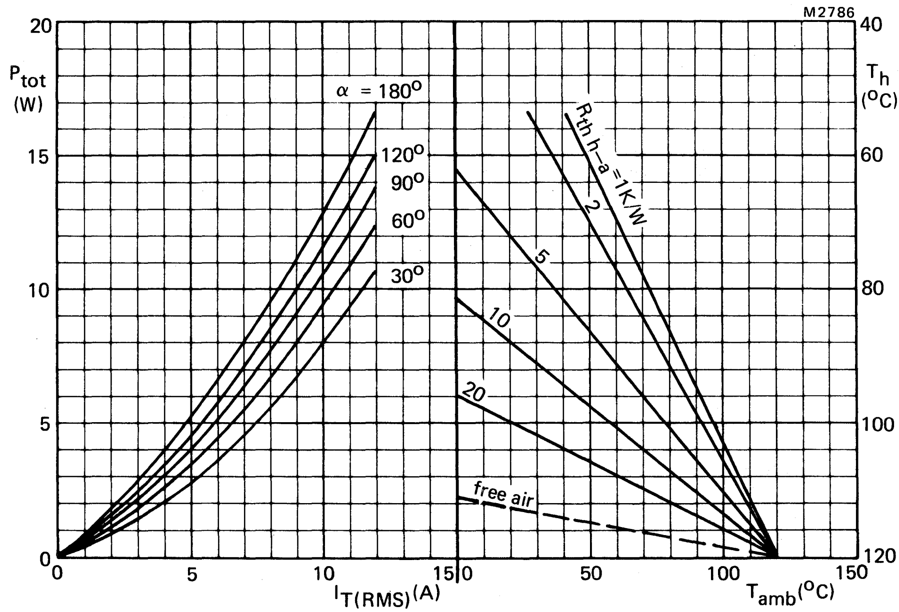
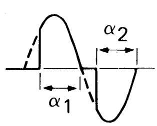


Fig.4 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha = \alpha_1 = \alpha_2$: conduction angle per half cycle

FULL-WAVE CONDUCTION (without heatsink compound)

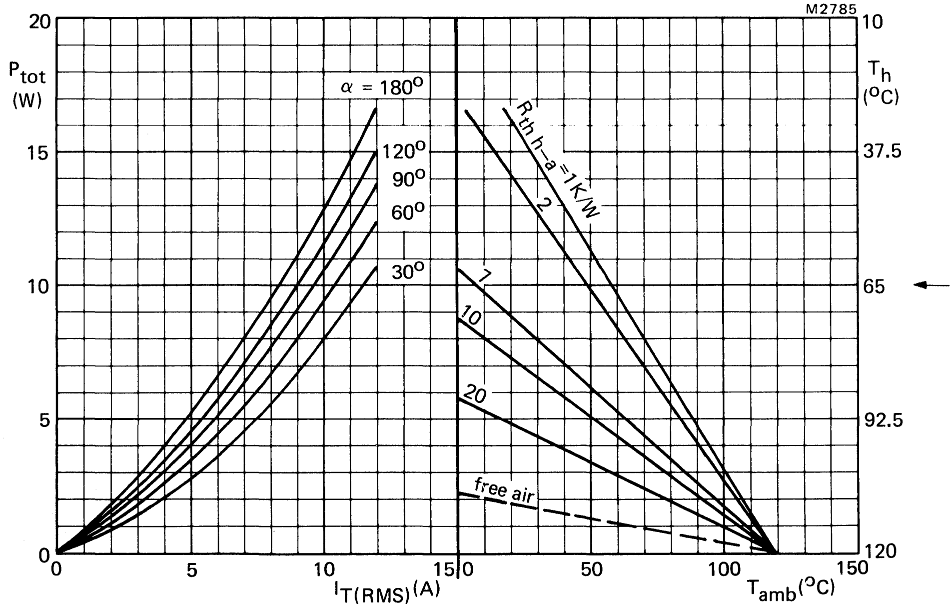
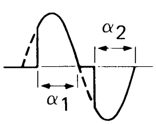


Fig.5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha = \alpha_1 = \alpha_2$: conduction angle per half cycle

OVERLOAD OPERATION

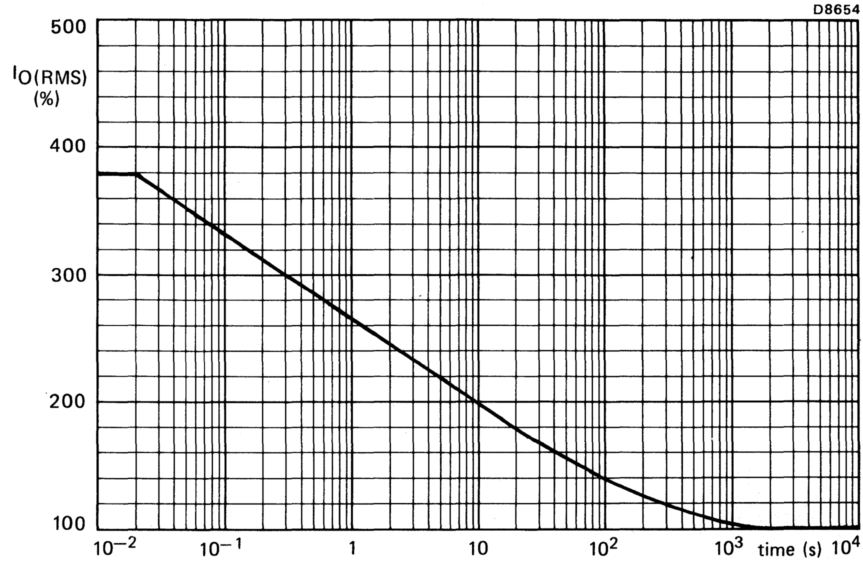


Fig.6 Maximum permissible duration of steady overload (provided that T_h does not exceed 120 °C during and after overload) expressed as a percentage of the steady state r.m.s. rated current. For high r.m.s. overload currents precautions should be taken so that the temperature of the terminals does not exceed 125 °C. During these overload conditions the triac may lose control. Therefore the overload should be terminated by a separate protection device.

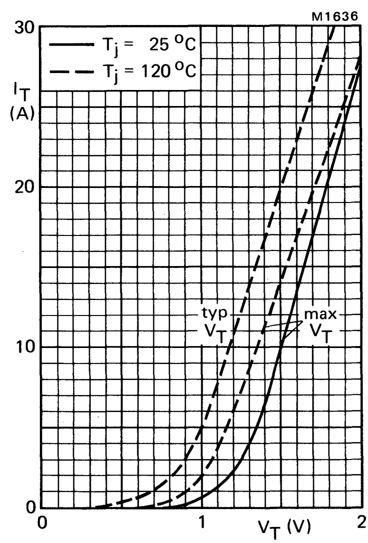


Fig.7.

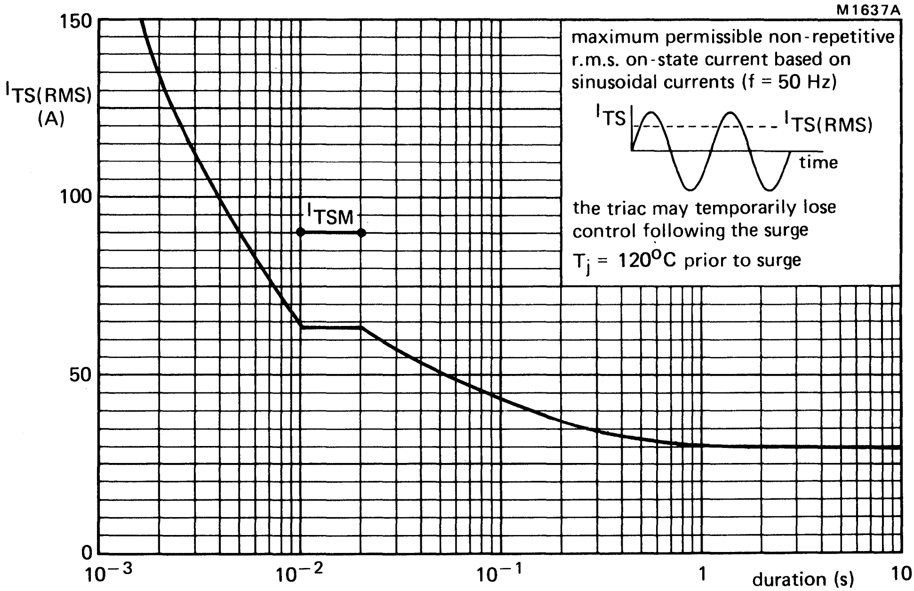


Fig.8.

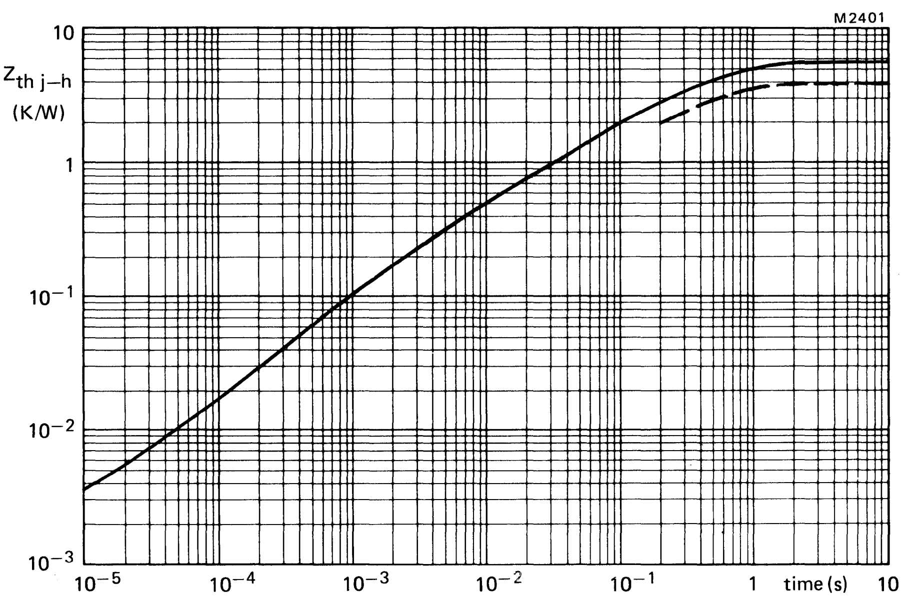


Fig.9 Transient thermal impedance; — — — with heatsink compound; —— without heatsink compound.

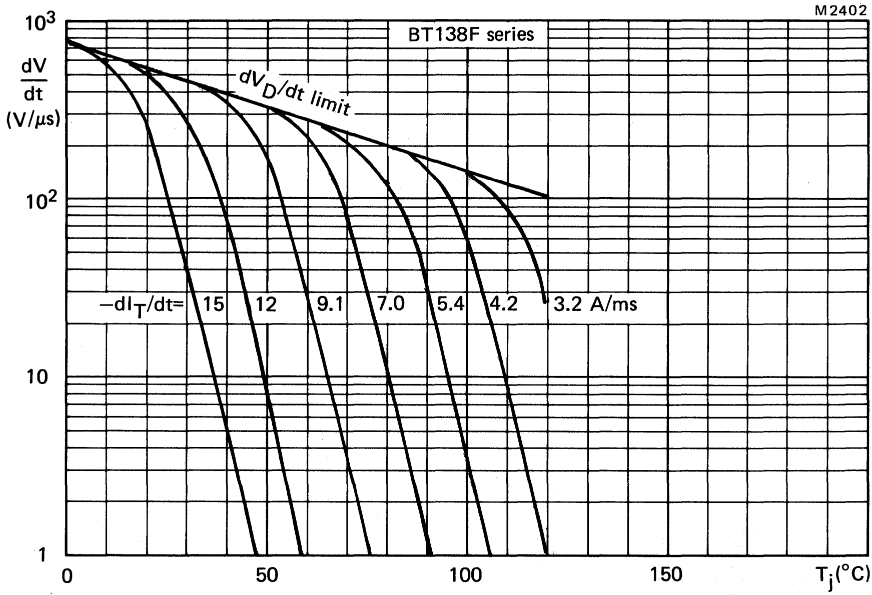


Fig.10 Typical commutation dV/dt for BT138F series versus T_j. The triac should commutate when dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

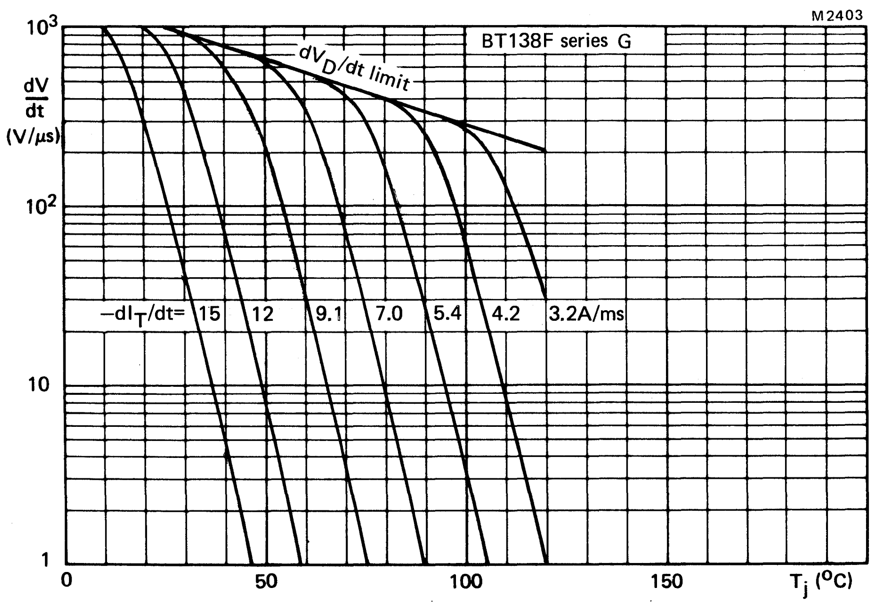


Fig.11 Limit commutation dV/dt for BT138F series G versus T_j. The triac should commutate when the dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

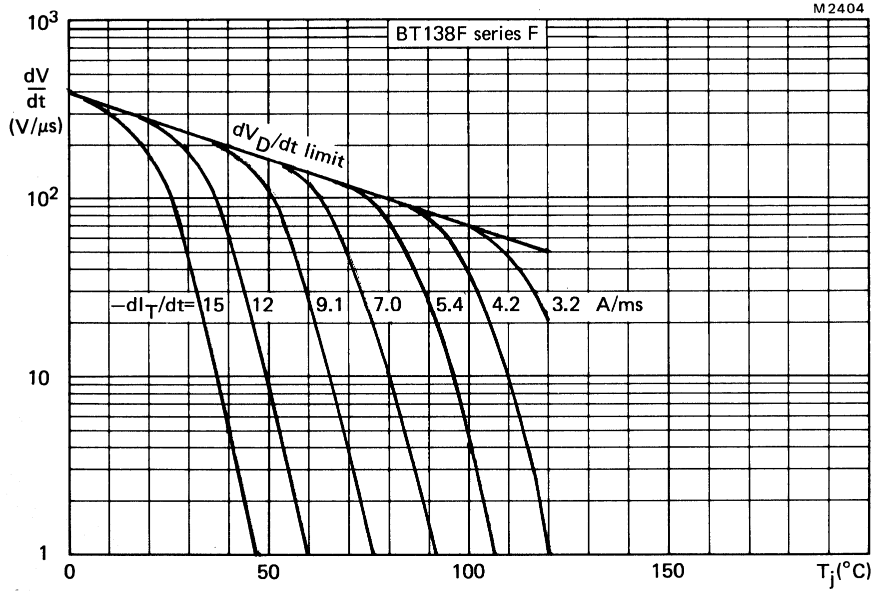


Fig.12 Typical commutation dV/dt for BT138F series F versus T_j. The triac should commutate when the dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

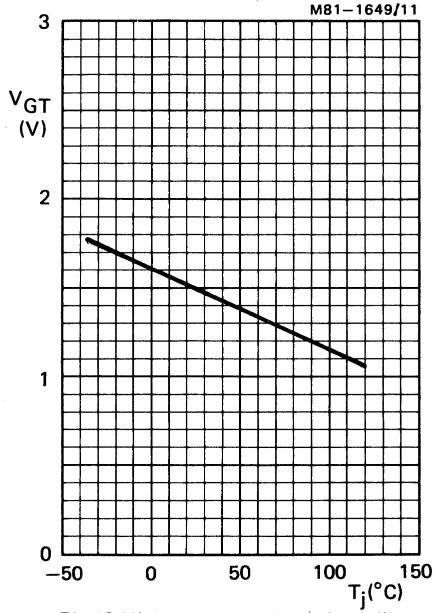


Fig.13 Minimum gate voltage that will trigger all devices; all conditions.

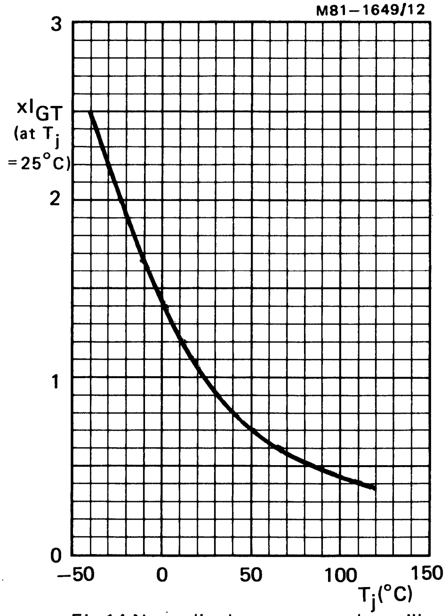


Fig.14 Normalised gate current that will trigger all devices; all conditions.

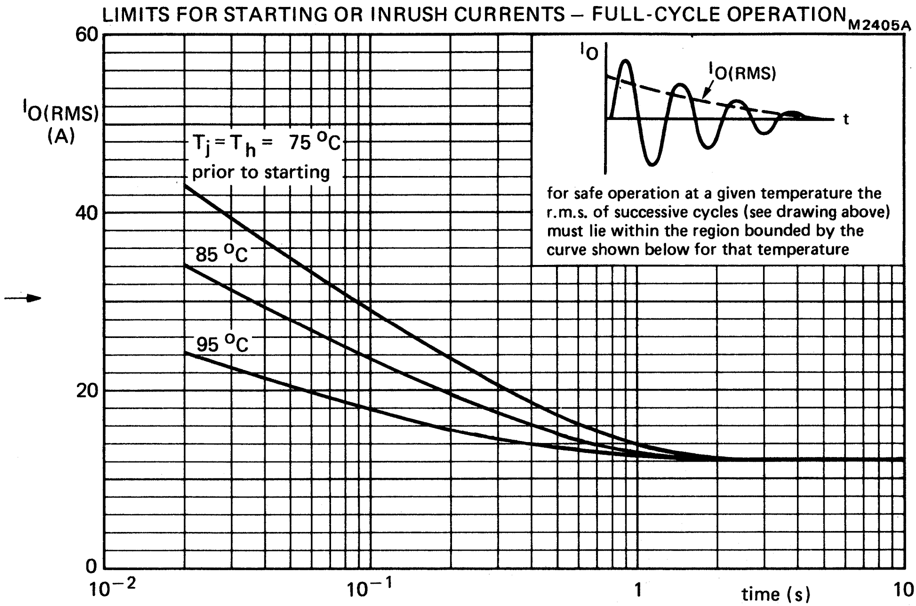

LIMITS FOR STARTING OR INRUSH CURRENTS – FULL-CYCLE OPERATION
M2405A
60
40
20
0
$I_{O(RMS)}$
(A)
$T_j = T_h =$ 75 °C
prior to starting
85 °C
95 °C
I_O
$I_{O(RMS)}$
t
for safe operation at a given temperature the r.m.s. of successive cycles (see drawing above) must lie within the region bounded by the curve shown below for that temperature
10^{-2}
10^{-1}
1
time (s)
10

Fig.15

TRIACS

Glass-passivated 16 ampere triacs intended for use in applications requiring high bidirectional transient and blocking voltage capability, and high thermal cycling performance with very low thermal resistances, e.g. a.c. power control applications such as motor, industrial lighting, industrial and domestic heating control and static switching systems.

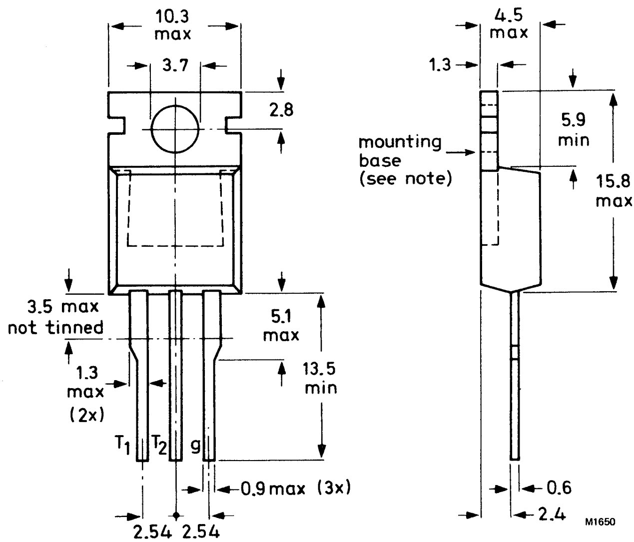
QUICK REFERENCE DATA

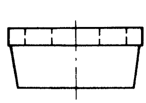
			BT139–500	600	800	
Repetitive peak off-state voltage	V_{DRM}	max.	500	600	800	V
R.M.S. on-state current	$I_{T(RMS)}$	max.		16		A
Non-repetitive peak on-state current	I_{TSM}	max.		140		A

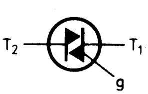
MECHANICAL DATA

Dimensions in mm

Fig.1 TO-220AB







Net mass: 2 g

Note: The exposed metal mounting base is directly connected to terminal T_2.

Accessories supplied on request: see data sheet Mounting instructions and accessories for TO-220 envelopes.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134)

Voltages (in either direction)			BT139–500	600	800	
Non-repetitive peak off-state voltage ($t \leqslant 10$ ms)	V_{DSM}	max.	500*	600*	800	V
Repetitive peak off-state voltage ($\delta \leqslant 0.01$)	V_{DRM}	max.	500	600	800	V
Crest working off-state voltage	V_{DWM}	max.	400	400	400	V

Currents (in either direction)				
R.M.S. on-state current (conduction angle 360°) up to T_{mb} = 93 °C	$I_{T(RMS)}$	max.	16	A
→ Repetitive peak on-state current	I_{TRM}	max.	140	A
→ Non-repetitive peak on-state current; T_j = 120 °C prior to surge; t = 20 ms; full sine-wave	I_{TSM}	max.	140	A
→ I^2t for fusing (t = 10 ms)	I^2t	max.	95	A^2s
Rate of rise of on-state current after triggering with I_G = 200 mA to I_T = 20 A; dI_G/dt = 0.2 A/µs	dI_T/dt	max.	30	A/µs

Gate to terminal 1

Power dissipation				
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	0.5	W
Peak power dissipation	P_{GM}	max.	5	W

Temperatures				
Storage temperature	T_{stg}		–40 to +125	°C
Operating junction temperature full-cycle operation	T_j	max.	120	°C
half-cycle operation	T_j	max.	110	°C

*Although not recommended, off-state voltages up to 800 V may be applied without damage, but the triac may switch into the on-state. The rate of rise of on-state current should not exceed 15 A/µs.

THERMAL RESISTANCE

From junction to mounting base				
full-cycle operation	$R_{th\ j\text{-}mb}$	=	1.2	K/W
half-cycle operation	$R_{th\ j\text{-}mb}$	=	1.7	K/W
Transient thermal impedance; t = 1 ms	$Z_{th\ j\text{-}mb}$	=	0.1	K/W

Influence of mounting method

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from mounting base to heatsink

a. with heatsink compound	$R_{th\ mb\text{-}h}$	=	0.3	K/W
b. with heatsink compound and 0.06 mm maximum mica insulator	$R_{th\ mb\text{-}h}$	=	1.4	K/W
c. with heatsink compound and 0.1 mm maximum mica insulator (56369)	$R_{th\ mb\text{-}h}$	=	2.2	K/W
d. with heatsink compound and 0.25 mm maximum alumina insulator (56367)	$R_{th\ mb\text{-}h}$	=	0.8	K/W
e. without heatsink compound	$R_{th\ mb\text{-}h}$	=	1.4	K/W

2. Free-air operation

The quoted values of $R_{th\ j\text{-}a}$ should be used only when no leads of other dissipating components run to the same tie-point.

Thermal resistance from junction to ambient in free air: mounted on a printed-circuit board at a = any lead length	$R_{th\ j\text{-}a}$	=	60	K/W

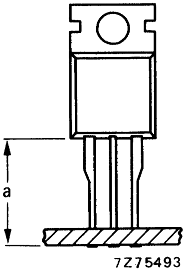


Fig.2

CHARACTERISTICS (T_j = 25 °C unless otherwise stated)

Polarities, positive or negative, are identified with respect to T_1.

Voltages and currents (in either direction)

On-state voltage (measured under pulse conditions to prevent excessive dissipation)

I_T = 20 A	V_T	<	1.6	V

Rate of rise of off-state voltage that will not trigger any device; T_j = 120 °C; gate open circuit

BT139 series	dV_D/dt	<	100	V/μs
BT139 series G	dV_D/dt	<	200	V/μs
BT139 series F	dV_D/dt	<	50	V/μs
BT139 series E	dV_D/dt	typ.	50	V/μs

Rate of change of commutating voltage that will not trigger any device when $-dI_{com}/dt$ = 7.2 A/ms; $I_{T(RMS)}$ = 16 A; T_{mb} = 70 °C; gate open circuit ; $V_D = V_{DWMmax}$

BT139 series	dV_{com}/dt	typ.	10	V/μs
BT139 series G	dV_{com}/dt	<	10	V/μs
BT139 series F	dV_{com}/dt	typ.	10	V/μs

Off-state current

$V_D = V_{DWMmax}$; T_j = 120 °C;	I_D	<	0.5	mA
Gate voltage that will trigger all devices	V_{GT}	>	1.5	V

Gate voltage that will not trigger any device $V_D = V_{DWMmax}$; T_j = 120 °C; T_2 and G positive or negative

	V_{GD}	<	250	mV

Gate current that will trigger all devices (I_{GT}); G to T_1

Holding current (I_H)

Latching current (I_L); V_D = 12 V

			T_2+ G+	T_2+ G−	T_2− G−	T_2− G+	
BT139 series	I_{GT}	>	35	35	35	70	mA
	I_H	<	30	30	30	30	mA
	I_L	<	40	60	40	60	mA
BT139 series G	I_{GT}	>	50	50	50	100	mA
	I_H	<	60	60	60	60	mA
	I_L	<	60	90	60	90	mA
BT139 series F	I_{GT}	>	25	25	25	70	mA
	I_H	<	30	30	30	30	mA
	I_L	<	40	60	40	60	mA
BT139 series E	I_{GT}	>	10	10	10	25	mA
	I_H	<	30	30	30	30	mA
	I_L	<	30	40	30	40	mA

MOUNTING INSTRUCTIONS

1. The device may be soldered directly into the circuit, but the maximum permissible temperature of the soldering iron or bath is 275 °C; it must not be in contact with the joint for more than 5 seconds. Soldered joints must be at least 4.7 mm from the seal.
2. The leads should not be bent less than 2.4 mm from the seal, and should be supported during bending. The leads can be bent, twisted or straightened by 90° maximum. The minimum bending radius is 1 mm.
3. It is recommended that the circuit connection be made to tag T_2, rather than direct to the heatsink.
4. Mounting by means of a spring clip is the best mounting method because it offers:
   a. a good thermal contact under the crystal area and slightly lower $R_{th\ mb\text{-}h}$ values than screw mounting.
   b. safe isolation for mains operation.
   However, if a screw is used, it should be M3 cross-recess pan-head. Care should be taken to avoid damage to the plastic body.
5. For good thermal contact, heatsink compound should be used between mounting base and heatsink. Values of $R_{th\ mb\text{-}h}$ given for mounting with heatsink compound refer to the use of a metallic oxide-loaded compound. Ordinary silicone grease is not recommended.
6. Rivet mounting (only possible for non-insulated mounting)
   Devices may be rivetted to flat heatsinks; such a process **must neither** deform the mounting tab, **nor** enlarge the mounting hole.
7. The heatsink must have a flatness in the mounting area of 0.02 mm maximum per 10 mm. Mounting holes must be deburred.

OPERATING NOTES

Dissipation and heatsink considerations:

a. The various components of junction temperature rise above ambient are illustrated in Fig.3.

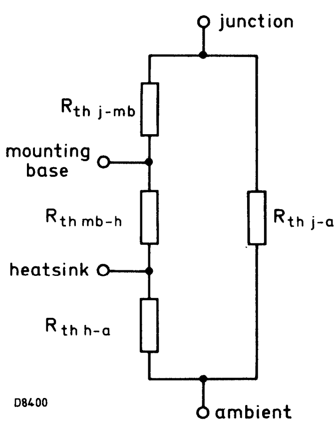


Fig.3.

b. The method of using Fig.4 is as follows:
Starting with the required current on the $I_{T(RMS)}$ axis, trace upwards to meet the appropriate conduction angle curve. Trace right horizontally and upwards from the appropriate value on the T_{amb} scale. The intersection determines the $R_{th\ mb\text{-}a}$. The heatsink thermal resistance value ($R_{th\ h\text{-}a}$) can now be calculated from:

$$R_{th\ h\text{-}a} = R_{th\ mb\text{-}a} - R_{th\ mb\text{-}h}.$$

c. Any measurement of heatsink temperature should be made immediately adjacent to the device.

FULL-CYCLE OPERATION

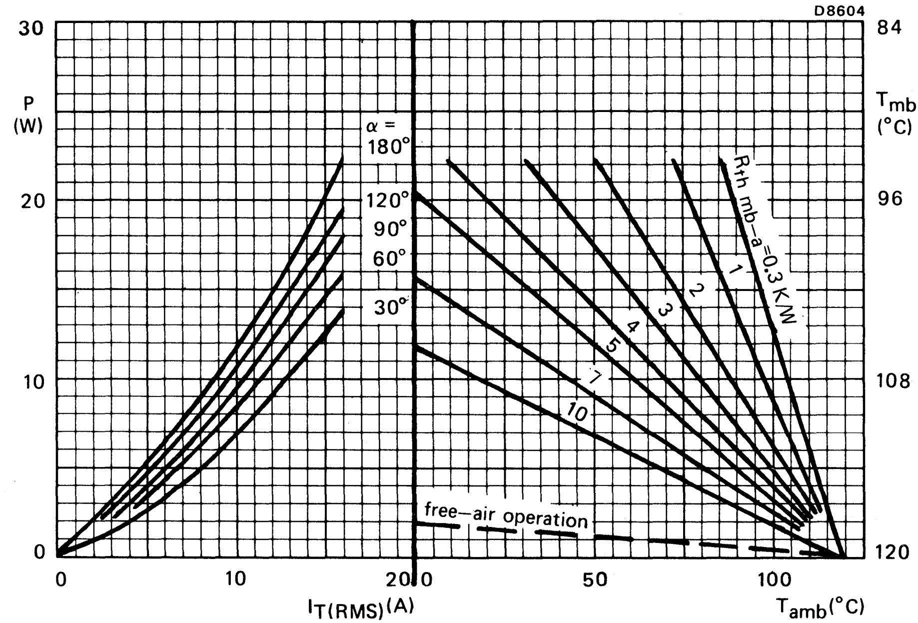
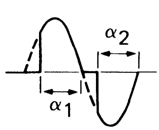


Fig. 4 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha = \alpha_1 = \alpha_2$: conduction angle per half cycle

OVERLOAD OPERATION

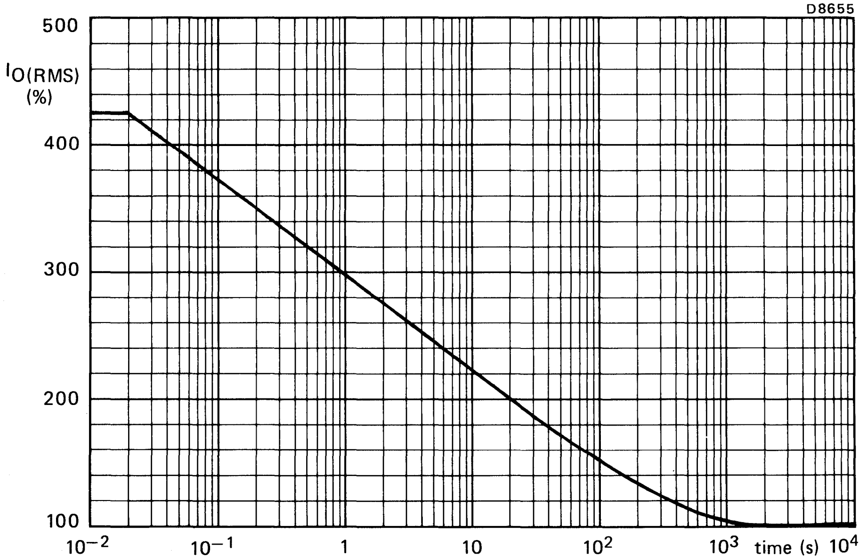


Fig.6 Maximum permissible duration of steady overload (provided that T_{mb} does not exceed 120 °C during and after overload) expressed as a percentage of the steady state r.m.s. rated current. For high r.m.s. overload currents precautions should be taken so that the temperature of the terminals does not exceed 125 °C. During these overload conditions the triac may lose control. Therefore the overload should be terminated by a separate protection device.

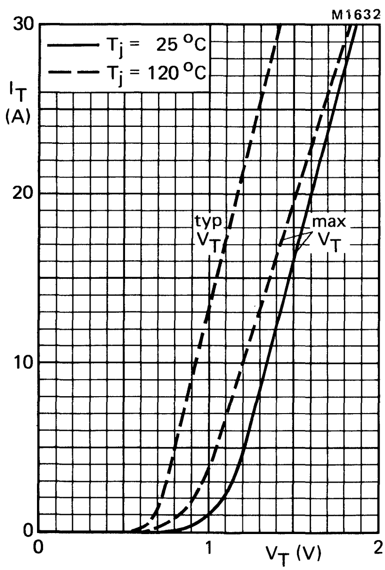


Fig.7

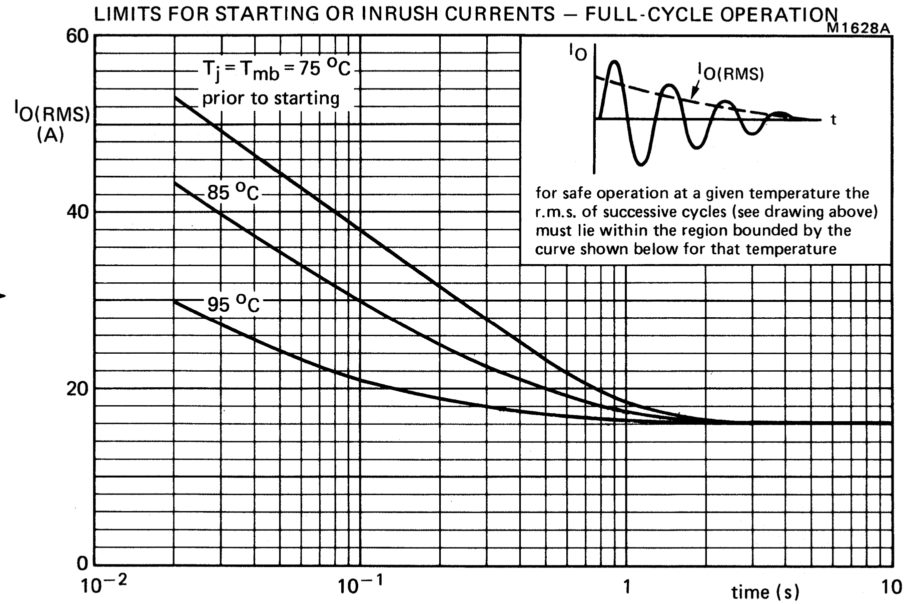

LIMITS FOR STARTING OR INRUSH CURRENTS — FULL-CYCLE OPERATION
M1628A
60
40
20
0
$I_{O(RMS)}$
(A)
$T_j = T_{mb} = 75\ ^oC$
prior to starting
85 °C
95 °C
I_O
$I_{O(RMS)}$
t
for safe operation at a given temperature the r.m.s. of successive cycles (see drawing above) must lie within the region bounded by the curve shown below for that temperature
10^{-2}
10^{-1}
1
time (s)
10

Fig.15

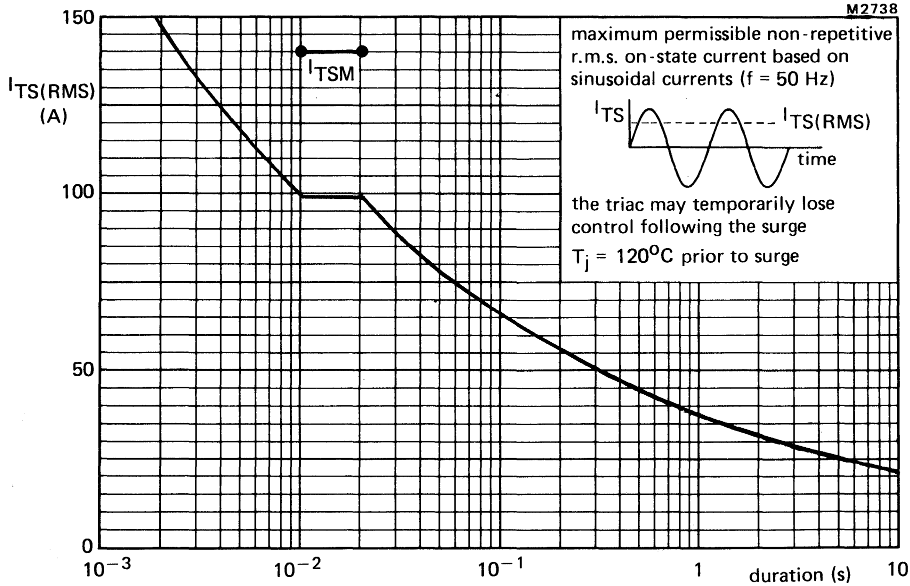

M2738
150
100
50
0
$I_{TS(RMS)}$
(A)
I_{TSM}
maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents (f = 50 Hz)
I_{TS}
$I_{TS(RMS)}$
time
the triac may temporarily lose control following the surge
T_j = 120°C prior to surge
10^{-3}
10^{-2}
10^{-1}
1
duration (s)
10

Fig.8

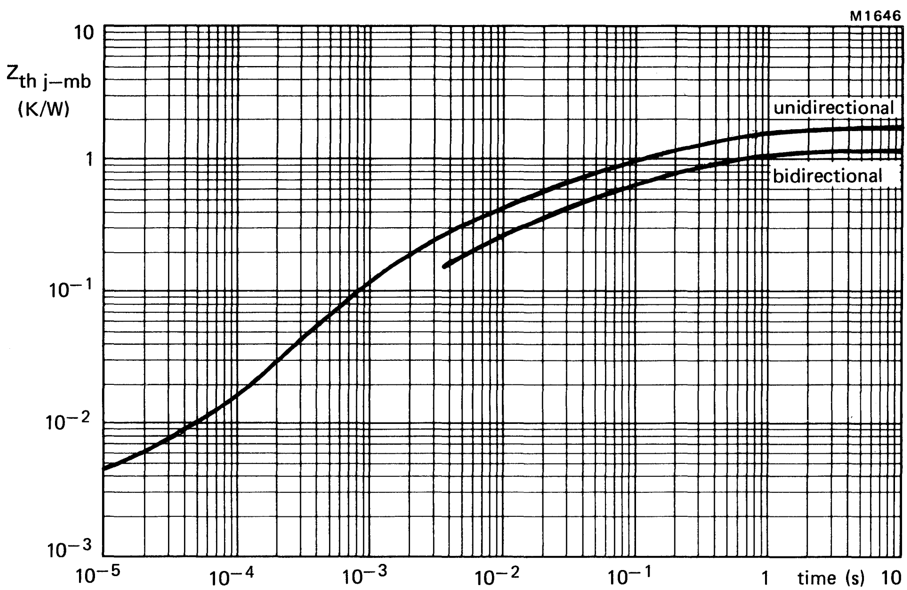

M1646
10
1
10^{-1}
10^{-2}
10^{-3}
$Z_{th\ j\text{-}mb}$
(K/W)
unidirectional
bidirectional
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
time (s)
10

Fig.9

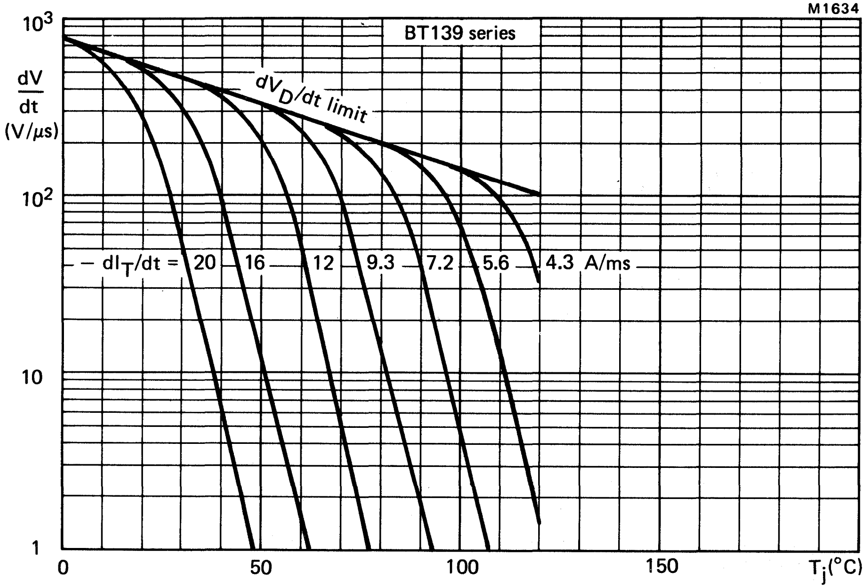


Fig.10 Typical commutation dV/dt for BT139 series versus T_j. The triac should commutate when the dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

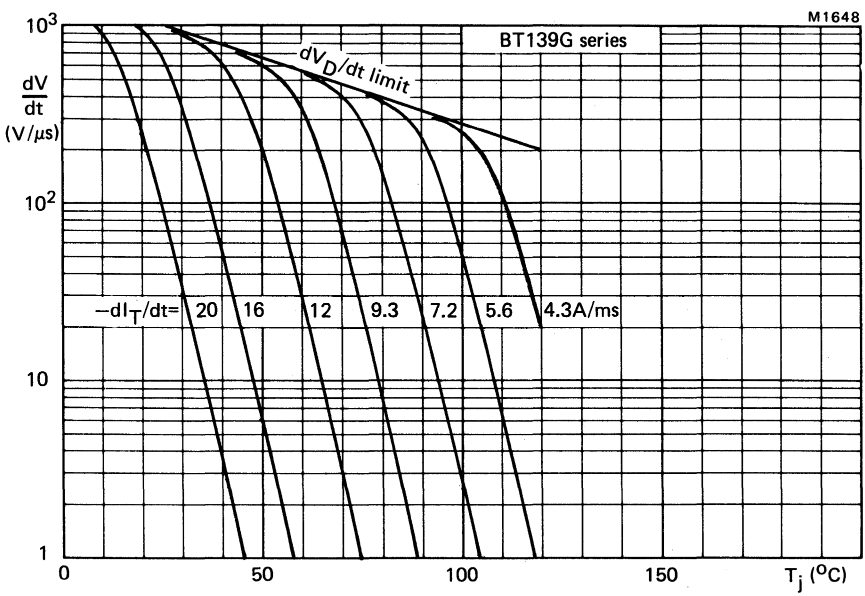


Fig.11 Limit commutation dV/dt for BT139G series versus T_j. The triac should commutate when the dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

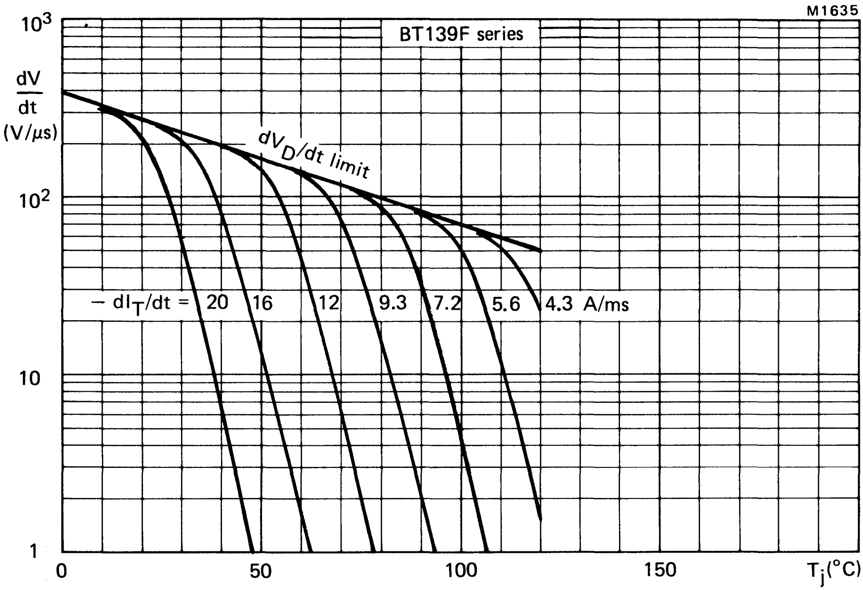


Fig.12 Typical commutation dV/dt for BT139F series versus T_j. The triac should commutate when the dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

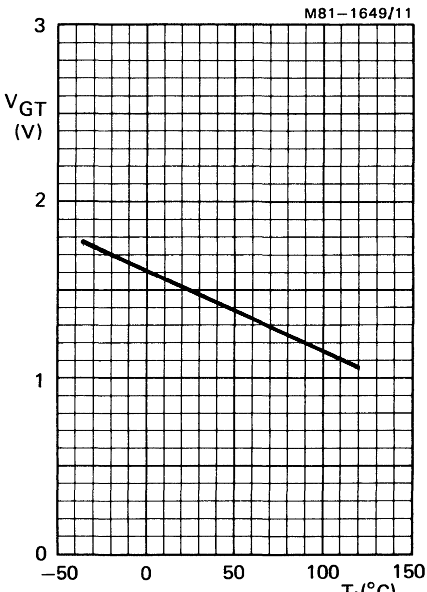


Fig.13 Minimum gate voltage that will trigger all devices; all conditions.

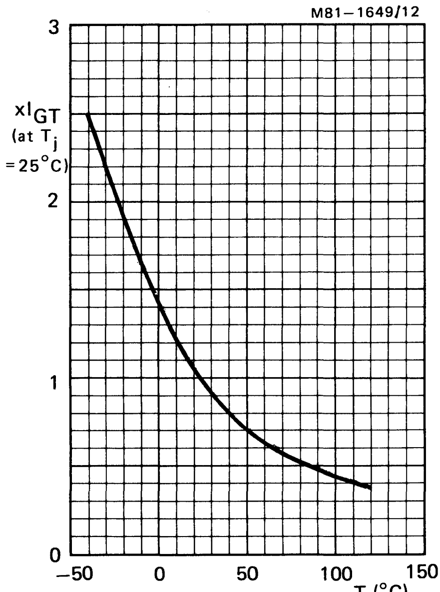


Fig.14 Normalised gate current that will trigger all devices; all conditions.

FULL-PACK TRIACS

Glass-passivated 16 ampere triacs in SOT-186 envelopes, which feature an electrically isolated seating plane. They are intended for use in applications requiring high bidirectional transient and blocking voltage capability. Typical applications include a.c. power control circuits such as lighting, industrial and domestic heating, motor control and switching systems.

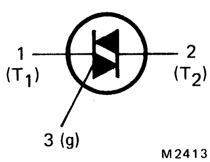
QUICK REFERENCE DATA

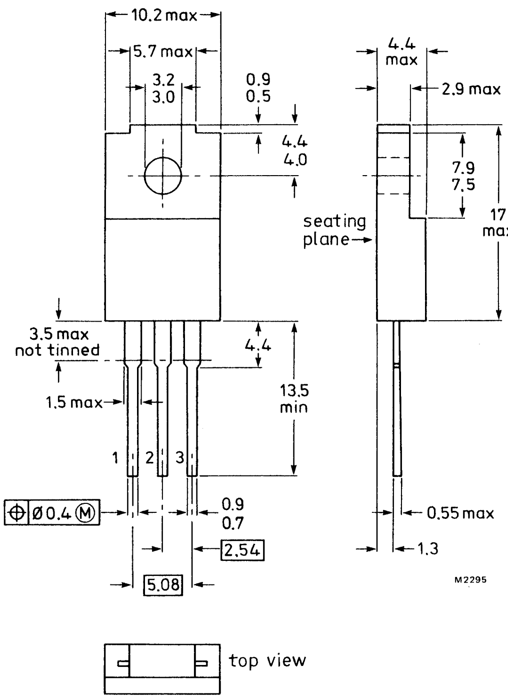
			BT139F–500	600	800	
Repetitive peak off-state voltage	V_{DRM}	max.	500	600	800	V
R.M.S. on-state current	$I_{T(RMS)}$	max.		16		A
Non-repetitive peak on-state current	I_{TSM}	max.		140		A

MECHANICAL DATA

Dimensions in mm

Fig.1 SOT-186





Net mass: 2g

The seating plane is electrically isolated from all terminals.

Accessories supplied on request (see data sheets Mounting instructions for F-pack devices and Accessories for SOT-186 envelopes).

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134).

			BT139F–500	600	800	
Voltages (in either direction)						
Non-repetitive peak off-state voltage ($t \leq 10$ ms)	V_{DSM}	max.	500*	600*	800	V
Repetitive peak off-state voltage ($\delta \leq 0.01$)	V_{DRM}	max.	500	600	800	V
Crest working off-state voltage	V_{DWM}	max.	400	400	400	V
Currents (in either direction)						
R.M.S. on-state current (conduction angle 360 °) up to $T_h = 67$ °C	$I_{T(RMS)}$	max.		16		A
Repetitive peak on-state current	I_{TRM}	max.		140		A
Non-repetitive peak on-state current; $T_j = 120$ °C prior to surge; t = 20 ms; full sine-wave	I_{TSM}	max.		140		A
I^2t for fusing (t = 10 ms)	I^2t	max.		95		A^2s
Rate of rise of on-state current after triggering with $I_G = 200$ mA to $I_T = 20$ A; $dI_G/dt = 0.2$ A/µs	dI_T/dt	max.		30		A/µs
Gate to terminal 1						
Power dissipation						
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.		0.5		W
Peak power dissipation	P_{GM}	max.		5.0		W
Temperatures						
Storage temperature	T_{stg}			−40 to +125		°C
Full-cycle operating temperature	T_j	max.		120		°C

ISOLATION

From all three terminals to external heatsink (peak)	V_{isol}	min.	1000	V
Capacitance from T_2 to external heatsink	C_{isol}	typ.	12	pF

*Although not recommended, off-state voltages up to 800 V may be applied without damage, but the triac may switch into the on-state. The rate of rise of on-state current should not exceed 15 A/µs.

THERMAL RESISTANCE

1. Heatsink-mounted with clip (see mounting instructions)

Thermal resistance from junction to external heatsink

With heatsink compound	$R_{th\ j\text{-}h}$	=	3.5	K/W
Without heatsink compound	$R_{th\ j\text{-}h}$	=	4.5	K/W

2. Free-air operation

The quoted values of $R_{th\ j\text{-}a}$ should be used only when no leads of other dissipating components run to the same tie-point.

Thermal resistance from junction to ambient in free air: mounted on a printed-circuit board at a = any lead length	$R_{th\ j\text{-}a}$	=	55	K/W

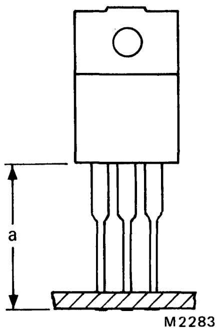


Fig.2

CHARACTERISTICS (T_j = 25 °C unless otherwise stated)

Polarities, positive or negative, are identified with respect to T_1.

Voltages and currents (in either direction)

On-state voltage (measured under pulse conditions to prevent excessive dissipation) I_T = 20 A	V_T	<	1.6	V
Rate of rise of off-state voltage that will not trigger any device; T_j = 120 °C; gate open circuit				
BT139F series	dV_D/dt	<	100	V/µs
BT139F series G	dV_D/dt	<	200	V/µs
BT139F series F	dV_D/dt	<	50	V/µs
BT139F series E	dV_D/dt	typ.	50	V/µs
Rate of change of commutating voltage that will not trigger any device when $-dI_{com}/dt$ = 7.2 A/ms; $I_{T(RMS)}$ = 16 A; T_h = 70 °C; gate open circuit; $V_D = V_{DWMmax}$				
BT139F series	dV_{com}/dt	typ.	10	V/µs
BT139F series G	dV_{com}/dt	<	10	V/µs
BT139F series F	dV_{com}/dt	typ.	10	V/µs
Off-state current $V_D = V_{DWMmax}$; T_j = 120 °C;	I_D	<	0.5	mA
Gate voltage that will trigger all devices	V_{GT}	>	1.5	V
Gate voltage that will not trigger any device $V_D = V_{DWMmax}$; T_j = 120 °C T_2 and G positive or negative	V_{GD}	<	250	mV

Gate current that will trigger all devices (I_{GT}); G to T_1

Holding current (I_H)

Latching current (I_L); V_D = 12 V

			T_2+ G+	T_2+ G−	T_2− G−	T_2− G+	
BT139F series	I_{GT}	>	35	35	35	70	mA
	I_H	<	30	30	30	30	mA
	I_L	<	40	60	40	60	mA
BT139F series G	I_{GT}	>	50	50	50	100	mA
	I_H	<	60	60	60	60	mA
	I_L	<	60	90	60	90	mA
BT139F series F	I_{GT}	>	25	25	25	70	mA
	I_H	<	30	30	30	30	mA
	I_L	<	40	60	40	60	mA
BT139F series E	I_{GT}	>	10	10	10	25	mA
	I_H	<	30	30	30	30	mA
	I_L	<	30	40	30	40	mA

MOUNTING INSTRUCTIONS

1. The triac may be soldered directly into the circuit, but the maximum permissible temperature of the soldering iron or bath is 275 ^oC; it must not be in contact with the joint for more than 5 seconds. Soldered joints must be at least 4.7 mm from the seal.
2. The leads should not be bent less than 2.4 mm from the seal, and should be supported during bending. The leads can be bent, twisted or straightened by 90^o maximum. The minimum bending radius is 1 mm.
3. Mounting by means of a spring clip is the best mounting method because it offers good thermal contact under the crystal area and slightly lower $R_{th\ j\text{-}h}$ values than screw mounting.
However, if a screw is used, it should be M3 cross-recess pan-head. Care should be taken to avoid damage to the plastic body.
4. For good thermal contact heatsink compound should be used between seating plane and heatsink. Values of $R_{th\ j\text{-}h}$ given for mounting with heatsink compound refer to the use of a metallic-oxide loaded compound. Ordinary silicone grease is not recommended.
5. Rivet mounting is not recommended.
6. The heatsink must have a flatness in the mounting area of 0.02 mm maximum per 10 mm. Mounting holes must be deburred.

OPERATING NOTES

Dissipation and heatsink considerations:

a. The various components of junction temperature rise above ambient are illustrated in Fig.3.

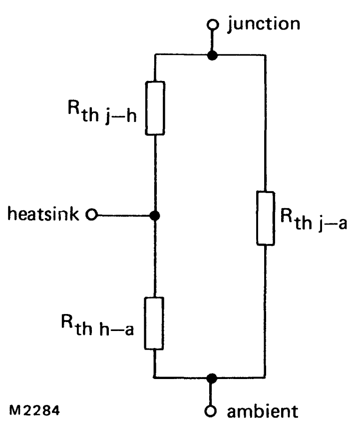


Fig.3.

b. The method of using Figs.4 and 5 is as follows:
Starting with the required current on the $I_{T(RMS)}$ axis (l.h. graph) trace upwards to meet the appropriate conduction angle curve. Trace left from curve to obtain power P. Trace right from curve to obtain T_h (r.h. graph). Trace upwards from T_{amb}, intersect with T_h determines $R_{th\ h\text{-}a}$, required heatsink thermal resistance.

c. Any measurement of heatsink temperature should be made immediately adjacent to the device.

FULL-CYCLE OPERATION (with heatsink compound)

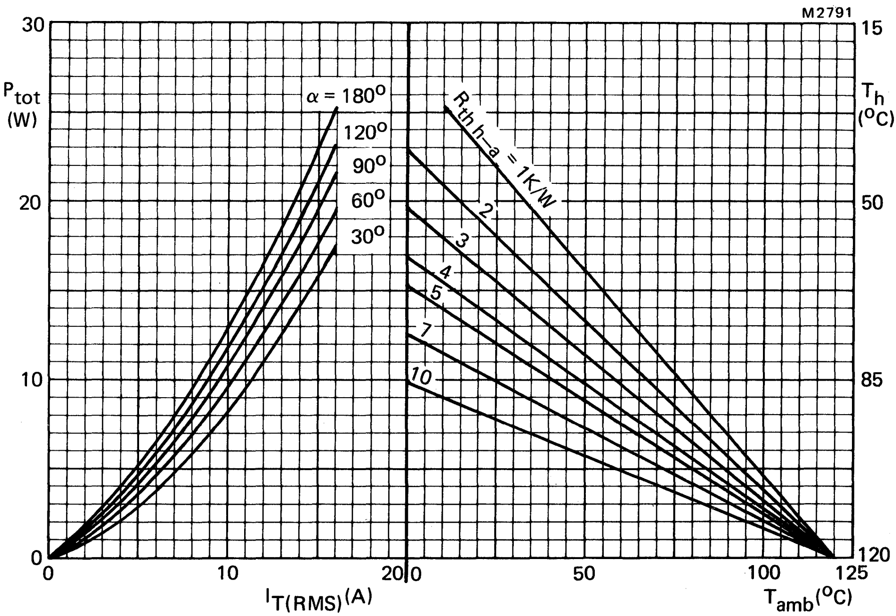
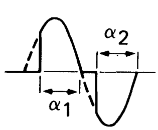


Fig. 4 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha = \alpha_1 = \alpha_2$: conduction angle per half cycle

FULL-WAVE CONDUCTION (without heatsink compound)

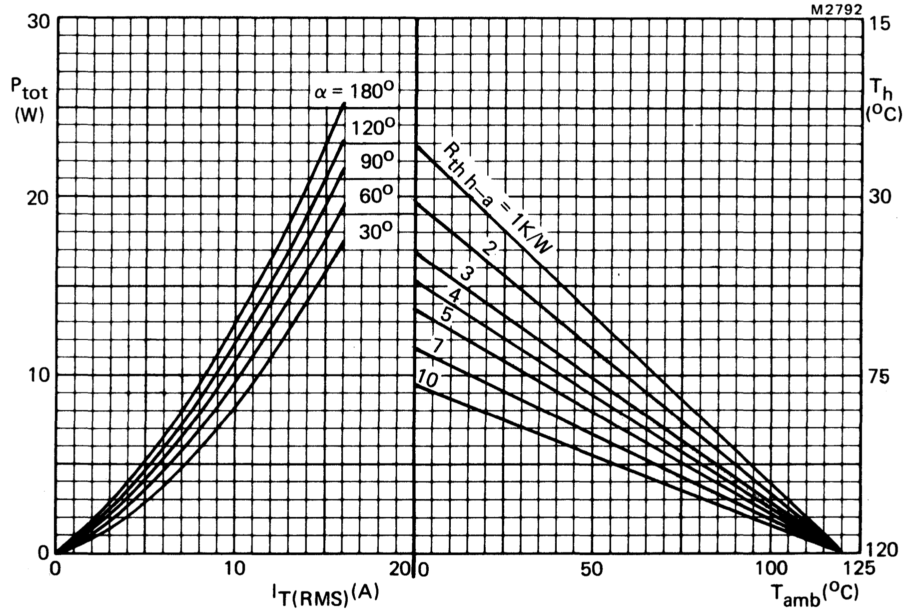
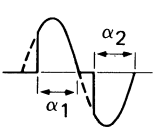


Fig.5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha = \alpha_1 = \alpha_2$: conduction angle per half cycle

OVERLOAD OPERATION

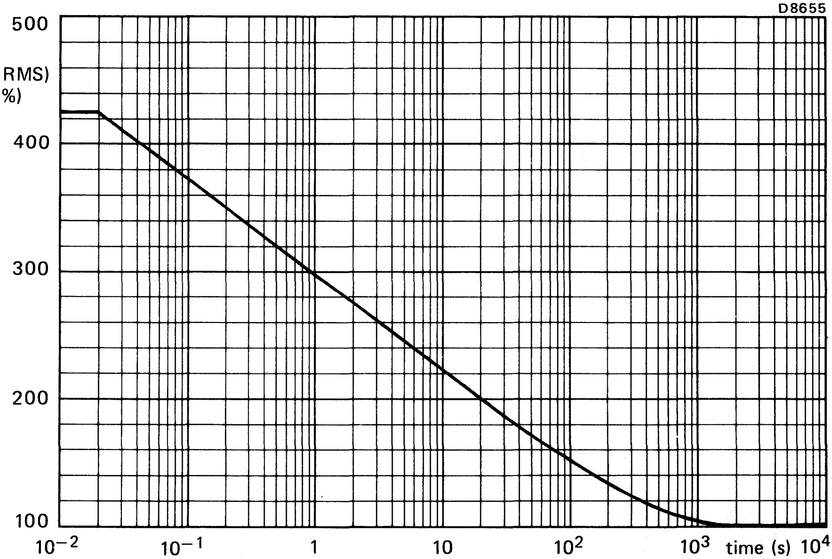


Fig.6 Maximum permissible duration of steady overload (provided that T_{mb} does not exceed 120 °C during and after overload) expressed as a percentage of the steady state r.m.s. rated current. For high r.m.s. overload currents precautions should be taken so that the temperature of the terminals does not exceed 125 °C. During these overload conditions the triac may lose control. Therefore the overload should be terminated by a separate protection device.

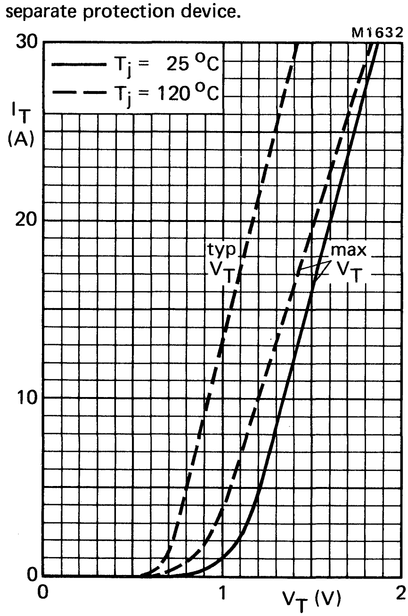


Fig.7

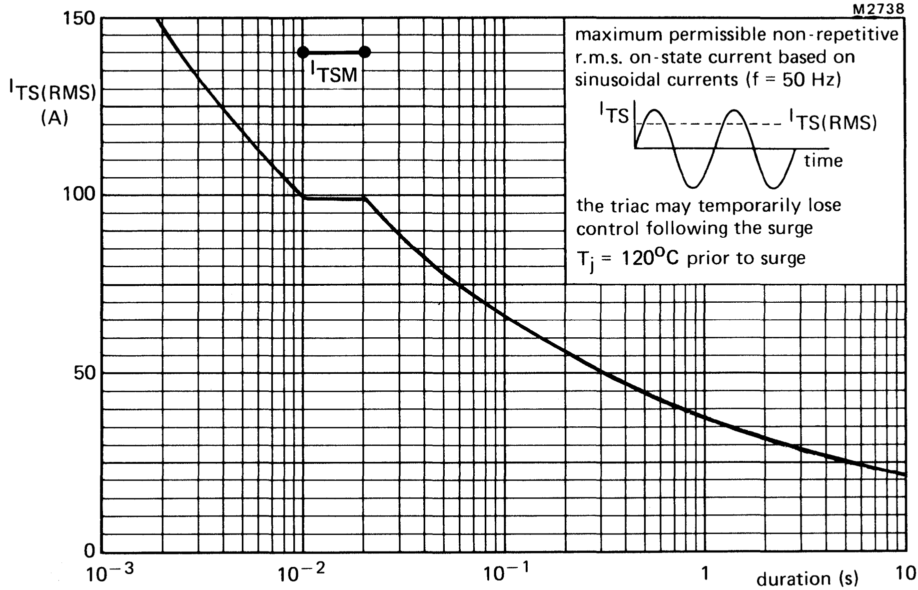


Fig.8

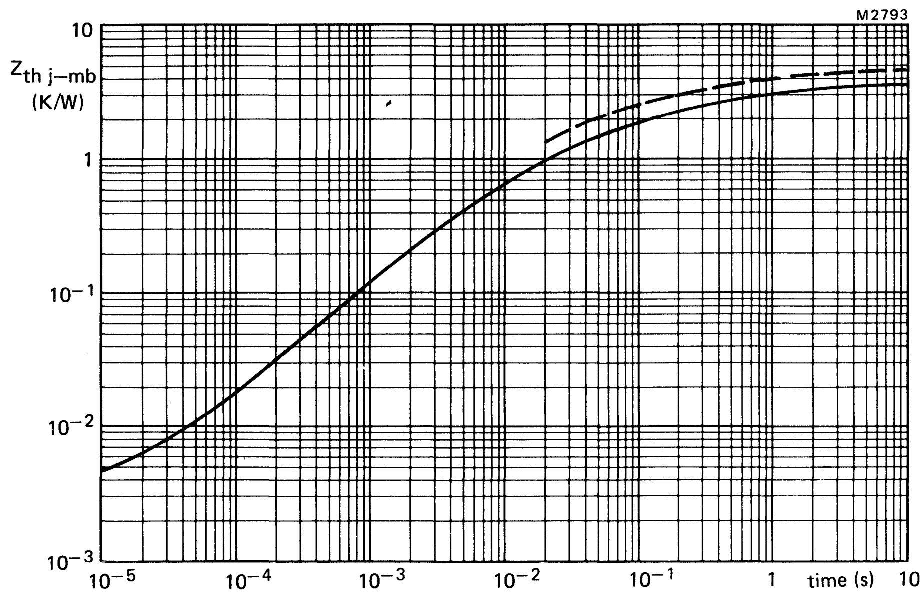


Fig.9 Transient thermal impedance; —— with heatsink compound; – – – without heatsink compound.

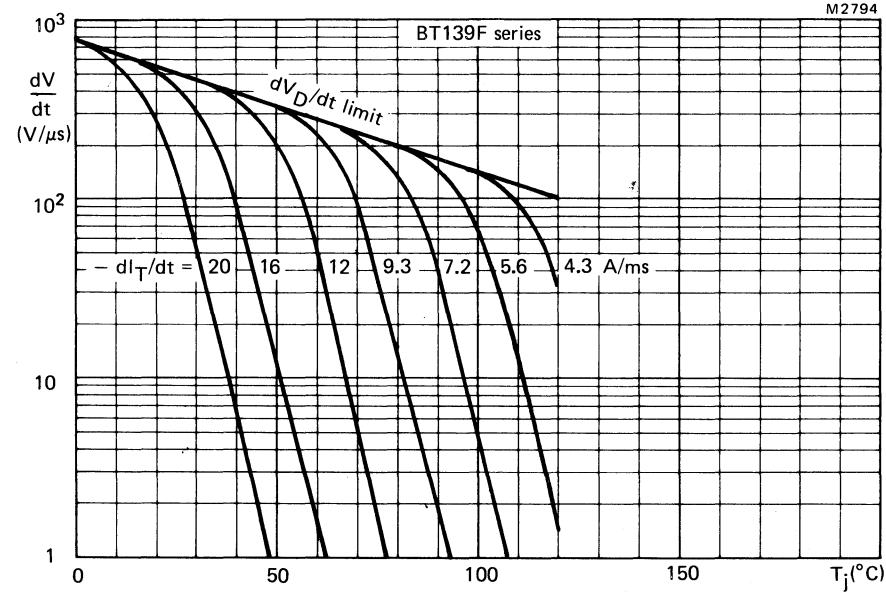


Fig.10 Typical commutation dV/dt for BT139F series versus T_j. The triac should commutate when the dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

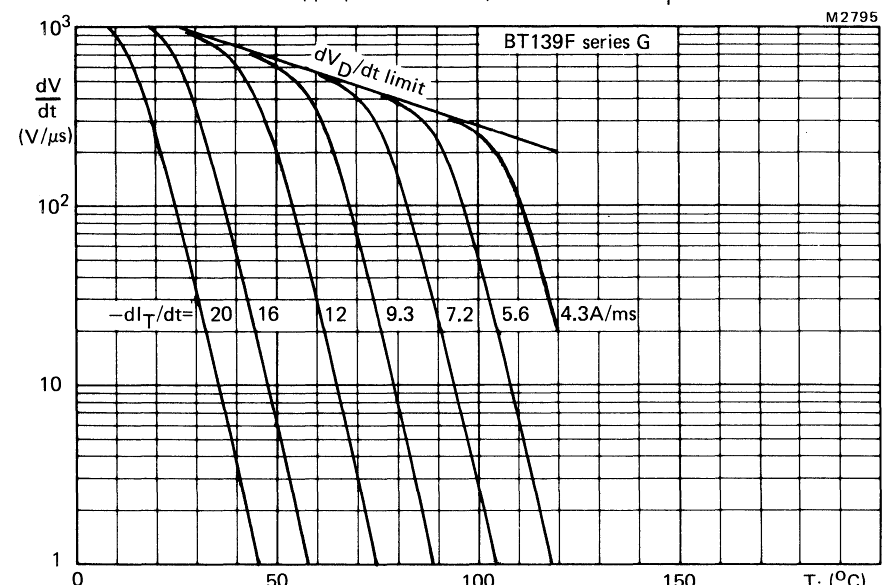


Fig.11 Limit commutation dV/dt for BT139F series G versus T_j. The triac should commutate when the dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

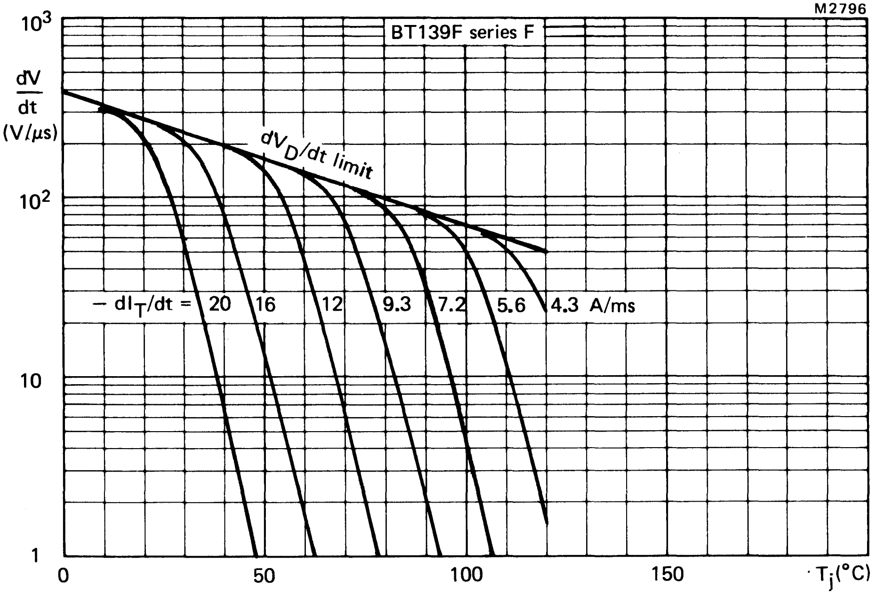


Fig.12 Typical commutation dV/dt for BT139F series F versus T_j. The triac should commutate when the dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

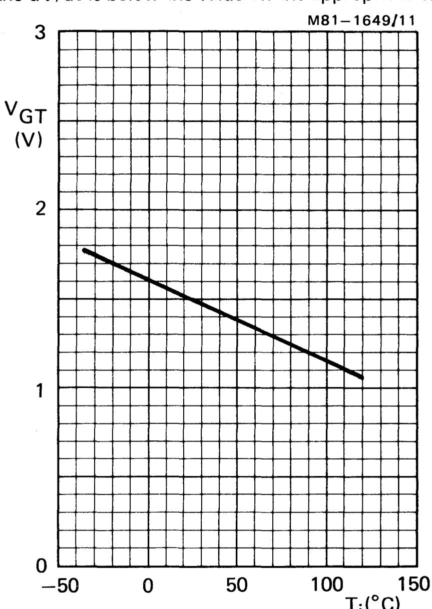


Fig. 13 Minimum gate voltage that will trigger all devices; all conditions.

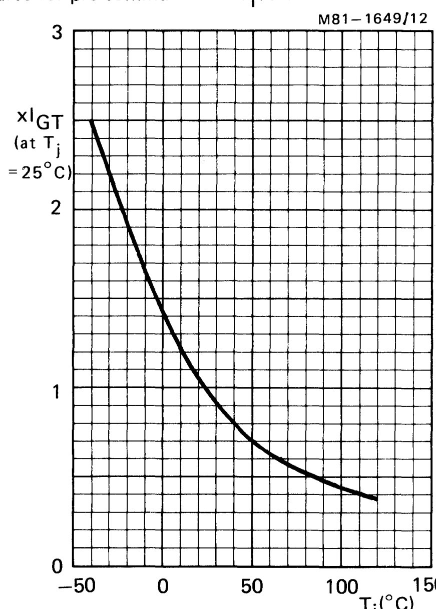


Fig. 14 Normalised gate current that will trigger all devices; all conditions.

LIMITS FOR STARTING OR INRUSH CURRENTS — FULL-CYCLE OPERATION

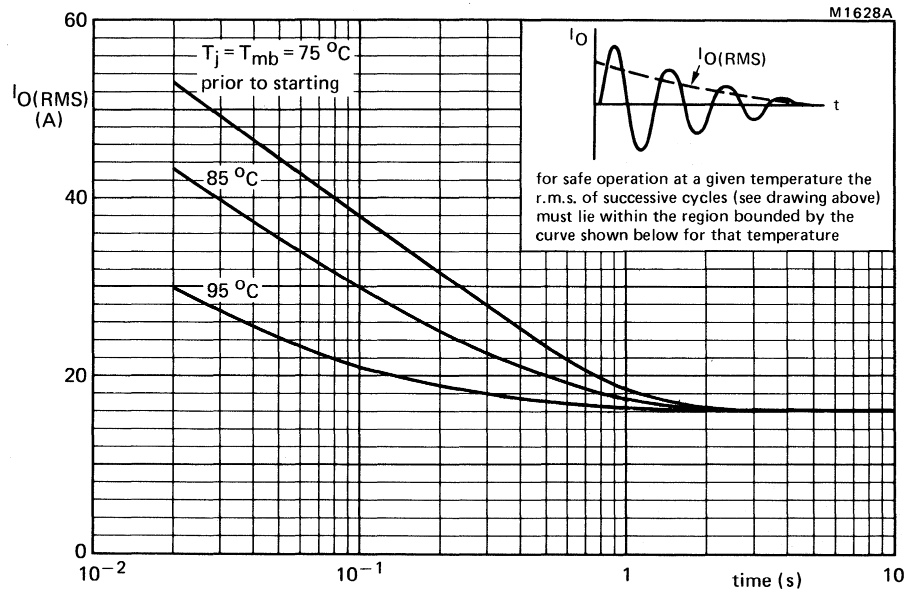


Fig.15.

TRIACS

Glass-passivated 25 ampere triacs intended for use in applications requiring high bidirectional transient and blocking voltage capability and high thermal cycling performance with very low thermal resistances. These triacs feature a high surge current capability. Typical applications include a.c. power control applications such as motor, industrial lighting, industrial and domestic heating control and static switching systems.

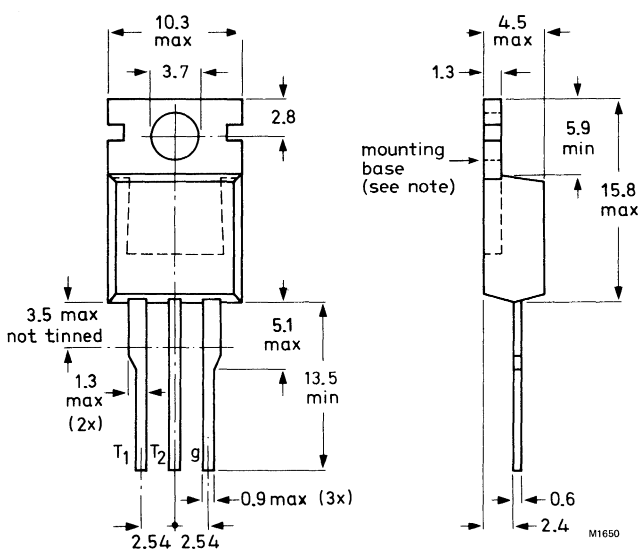
QUICK REFERENCE DATA

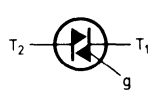
			BTA140-500	600	800	
Repetitive peak off-state voltage	V_{DRM}	max.	500	600	800	V
R.M.S. on-state current	$I_{T(RMS)}$	max.		25		A
Non-repetitive peak on-state current (50Hz)	I_{TSM}	max.		180		A
Non-repetitive peak on-state current (60Hz)	I_{TSM}	max.		200		A

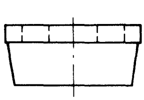
MECHANICAL DATA

Dimensions in mm

Fig.1 TO-220AB







Net mass- 2 g

Note: The exposed metal mounting base is directly connected to terminal T_2.

Accessories supplied on request: see data sheet Mounting instructions and accessories for TO-220 envelopes.

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134).

Voltages (in either direction)

			BTA140 - 500	600	800	
Non-repetitive peak off-state voltage ($t \leq 10$ ms)	V_{DSM}	max.	500*	600*	800	V
Repetitive peak off-state voltage ($\delta \leq 0.01$)	V_{DRM}	max.	500	600	800	V
Crest working off-state voltage	V_{DWM}	max.	400	400	400	V

Currents (in either direction)

R.M.S. on-state current (conduction angle 360°) up to T_{mb} = 89 °C	$I_{T(RMS)}$	max.	25	A
Average on-state current for half-cycle operation (averaged over any 20 ms period) up to T_{mb} = 85 °C	$I_{T(AV)}$	max.	18	A
Repetitive peak on-state current	I_{TRM}	max.	180	A
Non-repetitive peak on-state current; T_j = 120 °C prior to surge; full sine-wave				
t = 20 ms	I_{TSM}	max.	180	A
t = 16.7 ms	I_{TSM}	max.	200	A
I^2t for fusing (t = 10 ms)	I^2t	max.	160	A^2s
Rate of rise of on-state current after triggering with I_G = 200 mA to I_T = 30 A; dI_G/dt = 0.2 A/µs	dI_T/dt	max.	30	A/µs

Gate to terminal 1

Power dissipation

Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	0.5	W
Peak power dissipation	P_{GM}	max.	5	W

Temperatures

Storage temperature	T_{stg}		−40 to +125	°C
Operating junction temperature				
full-cycle operation	T_j	max.	120	°C
half-cycle operation	T_j	max.	110	°C

* Although not recommended, off-state voltages up to 800 V may be applied without damage, but the triac may switch into the on-state. The rate of rise of on-state current should not exceed 15 A/µs.

THERMAL RESISTANCE

From junction to mounting base

full-cycle operation	$R_{th\ j\text{-}mb}$	= 1.0 K/W
half-cycle operation	$R_{th\ j\text{-}mb}$	= 1.4 K/W
Transient thermal impedance; t = 1 ms	$Z_{th\ j\text{-}mb}$	= 0.1 K/W

Influence of mounting method

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from mounting base to heatsink

a. with heatsink compound	$R_{th\ mb\text{-}h}$	= 0.3 K/W
b. with heatsink compound and 0.06 mm maximum mica insulator	$R_{th\ mb\text{-}h}$	= 1.4 K/W
c. with heatsink compound and 0.1 mm maximum mica insulator (56369)	$R_{th\ mb\text{-}h}$	= 2.2 K/W
d. with heatsink compound and 0.25 mm maximum alumina insulator (56367)	$R_{th\ mb\text{-}h}$	= 0.8 K/W
e. without heatsink compound	$R_{th\ mb\text{-}h}$	= 1.4 K/W

2. Free-air operation

The quoted values of $R_{th\ j\text{-}a}$ should be used only when no leads of other dissipating components run to the same tie-point.

Thermal resistance from junction to ambient in free air:

mounted on a printed-circuit board at a = any lead length	$R_{th\ j\text{-}a}$	= 60 K/W

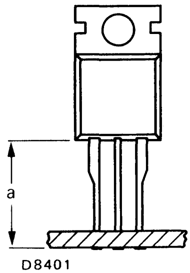


Fig.2

CHARACTERISTICS (T_j = 25 °C unless otherwise stated)

Polarities, positive or negative, are identified with respect to T_1.

Voltages and currents (in either direction)

On-state voltage (measured under pulse conditions to prevent excessive dissipation)				
I_T = 30 A	V_T	<	1.55	V
Rate of rise of off-state voltage that will not trigger any device; T_j = 120 °C; gate open circuit	dV_D/dt	<	100	V/μs
Rate of change of commutating voltage that will not trigger any device when $-dI_{com}/dt$ = 9.0 A/ms $I_{T(RMS)}$ = 25 A; T_{mb} = 75 °C; gate open circuit; $V_D = V_{DWMmax}$	dV_{com}/dt	typ.	10	V/μs
Off-state current				
$V_D = V_{DWMmax}$; T_j = 120 °C	I_D	<	0.5	mA
Gate voltage that will trigger all devices	V_{GT}	>	1.5	V
Gate voltage that will not trigger any device $V_D = V_{DWMmax}$; T_j = 120 °C; T_2 and G positive or negative	V_{GD}	<	250	mV

			T_2+ G+	T_2+ G−	T_2− G−	T_2− G+	
Gate current that will trigger all devices; G to T_1	I_{GT}	>	35	35	35	70	mA
Holding Current	I_H	<	30	30	30	30	mA
Latching current; V_D = 12 V; T_j = 25 °C	I_L	<	40	60	40	60	mA

MOUNTING INSTRUCTIONS

1. The device may be soldered directly into the circuit, but the maximum permissible temperature of the soldering iron or bath is 275 ^{o}C; it must not be in contact with the joint for more than 5 seconds. Soldered joints must be at least 4.7 mm from the seal.
2. The leads should not be bent less than 2.4 mm from the seal, and should be supported during bending. The leads can be bent, twisted or straightened by 90^{o} maximum. The minimum bending radius is 1 mm.
3. It is recommended that the circuit connection be made to tag T_2, rather than direct to the heatsink.
4. Mounting by means of a spring clip is the best mounting method because it offers:
   a. a good thermal contact under the crystal area and slightly lower $R_{th\ mb\text{-}h}$ values than screw mounting.
   b. safe isolation for mains operation.
   However, if a screw is used, it should be M3 cross-recess pan-head. Care should be taken to avoid damage to the plastic body.
5. For good thermal contact, heatsink compound should be used between mounting base and heatsink. Values of $R_{th\ mb\text{-}h}$ given for mounting with heatsink compound refer to the use of a metallic oxide-loaded compound. Ordinary silicone grease is not recommended.
6. Rivet mounting (only possible for non-insulated mounting)

   Devices may be rivetted to flat heatsinks; such a process **must neither** deform the mounting tab, **nor** enlarge the mounting hole.
7. The heatsink must have a flatness in the mounting area of 0.02 mm maximum per 10 mm. Mounting holes must be deburred.

OPERATING NOTES

Dissipation and heatsink considerations:

a. The various components of junction temperature rise above ambient are illustrated in Fig.3.

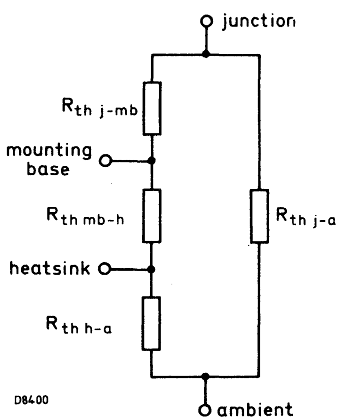


Fig.3.

b. The method of using Fig.4 is as follows:
   Starting with the required current on the $I_{T(RMS)}$ axis, trace upwards to meet the appropriate conduction angle curve. Trace right horizontally and upwards from the appropriate value on the T_{amb} scale. The intersection determines the $R_{th\ mb\text{-}a}$. The heatsink thermal resistance value ($R_{th\ h\text{-}a}$) can now be calculated from:

$$R_{th\ h\text{-}a} = R_{th\ mb\text{-}a} - R_{th\ mb\text{-}h}.$$

c. Any measurement of heatsink temperature should be made immediately adjacent to the device.

FULL-CYCLE OPERATION

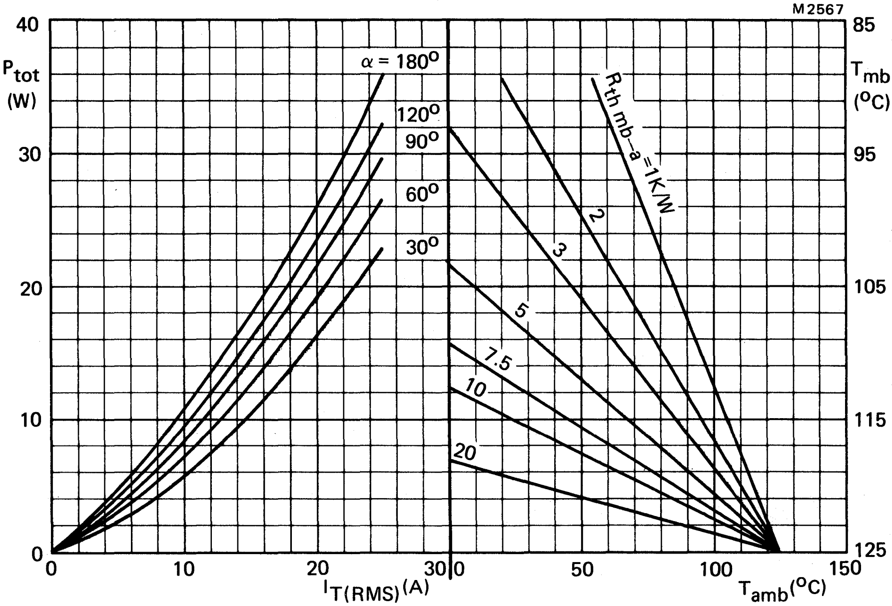
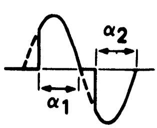


Fig.4 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha = \alpha_1 = \alpha_2$: conduction angle per half cycle

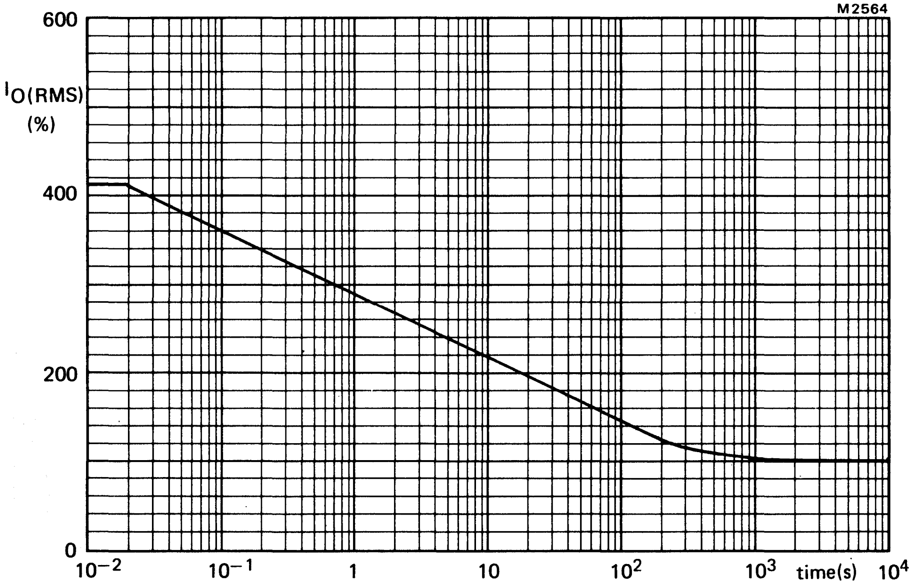


Fig.5 Maximum permissible duration of steady overload (provided that T_{mb} does not exceed 120 °C during and after overload) expressed as a percentage of the steady state r.m.s. rated current. For high r.m.s. overload currents precautions should be taken so that the temperature of the terminals does not exceed 125 °C. During these overload conditions the triac may lose control. Therefore the overload should be terminated by a separate protection device.

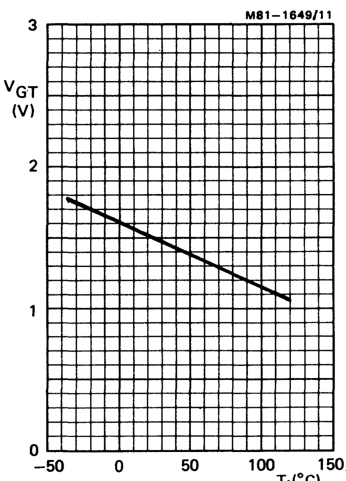


Fig.6 Minimum gate voltage that will trigger all devices; all conditions.

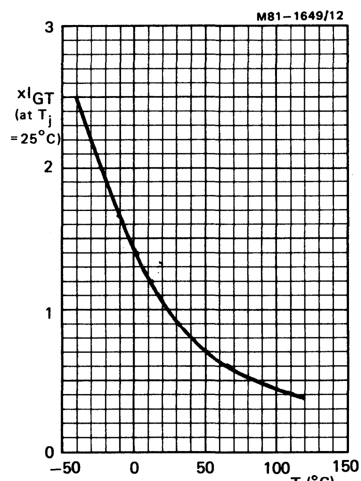


Fig.7 Normalised gate current that will trigger all devices; all conditions.

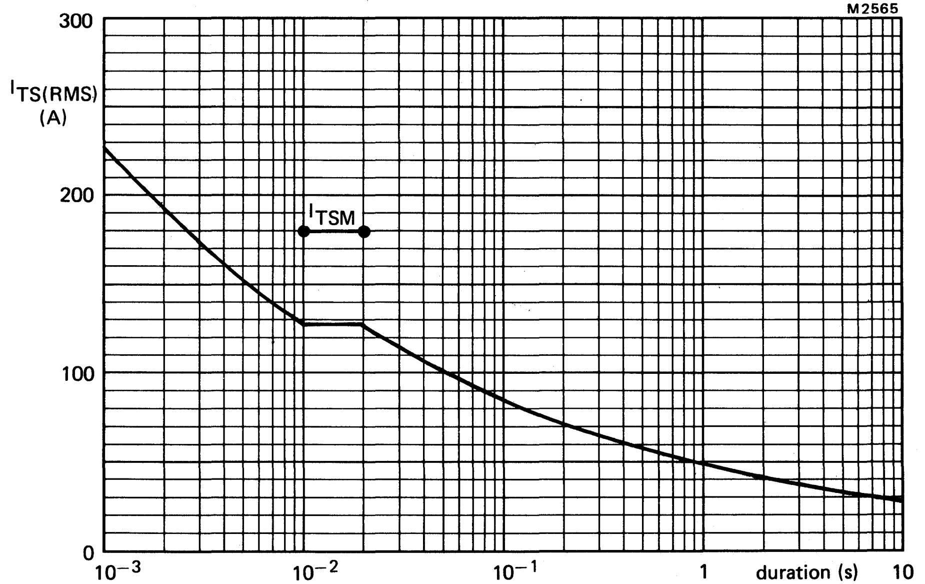
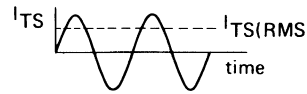


Fig.8 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents (f = 50 Hz); T_j = 120 °C prior to surge. The triac may temporarily lose control following the surge.



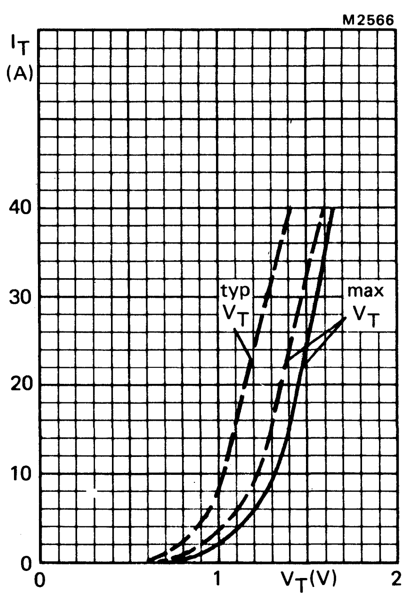


Fig.9 —— T_j = 25 °C; – – – T_j = 120 °C.

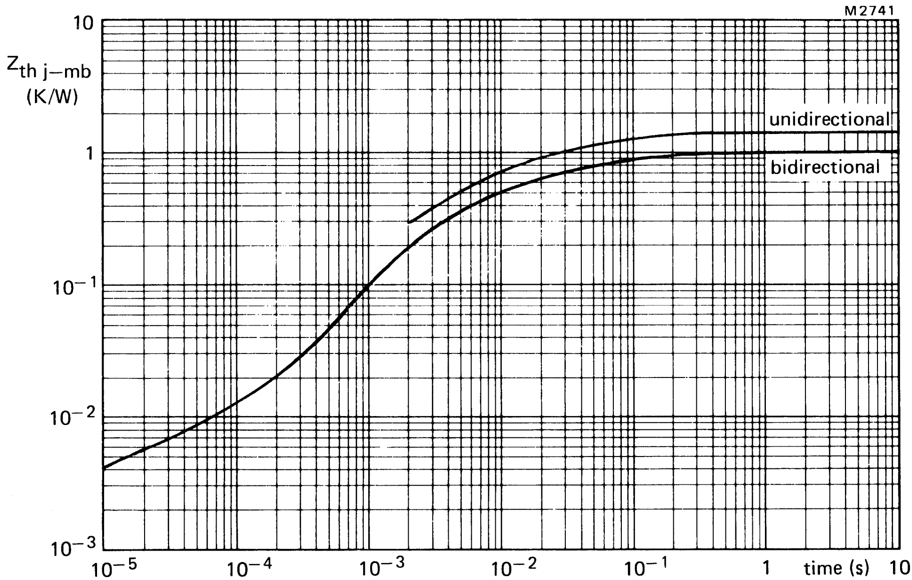


Fig.10 Transient thermal impedance.

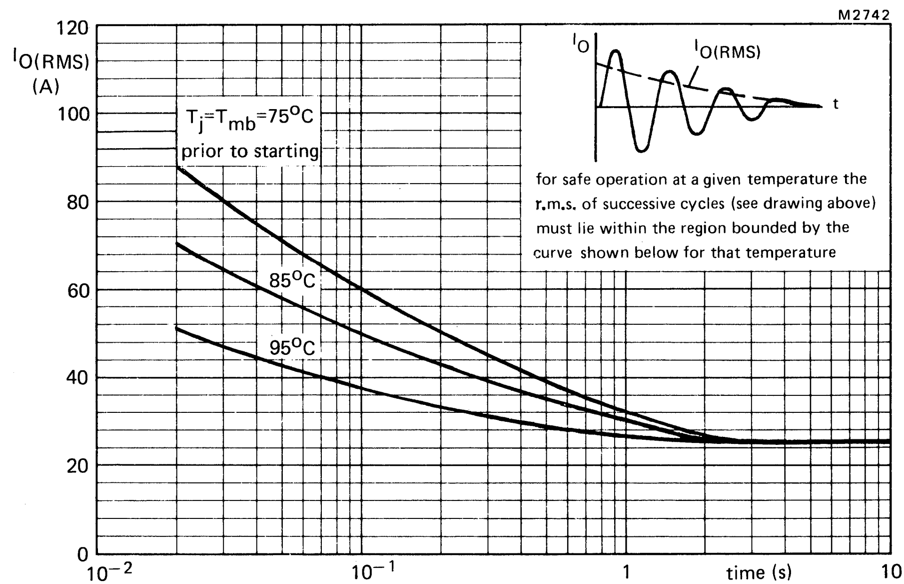


Fig.11 Limits for starting or inrush currents — full-cycle operation

TRIACS

Glass-passivated silicon triacs in metal envelopes, intended for industrial a.c. power control and particularly suitable for static switching of 3-phase induction motors. They may also be used for furnace control, lighting control and other static switching applications up to an r.m.s. on-state current of 15 A.

Two grades of commutation performance are available, 10 V/μs at 5 A/ms (suffix G) and 10 V/μs at 12 A/ms (suffix H).

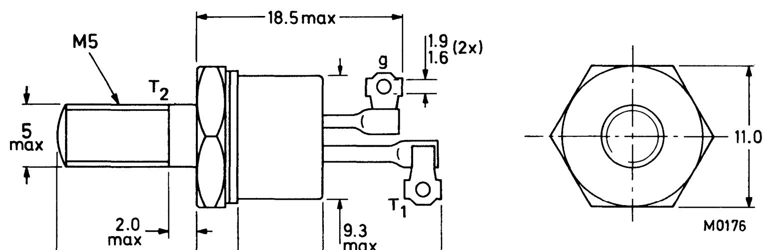
QUICK REFERENCE DATA

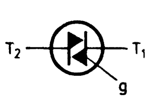
			BTW43–600	800	1000	1200	
Repetitive peak off-state voltage	V_{DRM}	max.	600	800	1000	1200	V
R.M.S. on-state current	$I_{T(RMS)}$	max.				15	A
Non-repetitive peak on-state current	I_{TSM}	max.				120	A
Rate of rise of commutating voltage that will not trigger any device (see Characteristics)	dV_{com}/dt	<				10	V/μs

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-64: with metric M5 stud (ϕ 5 mm).





Net mass: 7 g

Diameter of clearance hole: max. 5,2 mm

Accessories supplied on request: 56295a (mica washer); 56295b (PTFE ring); 56295c (insulating bush).

Torque on nut: min. 0,9 Nm (9 kg cm)
max. 1,7 Nm (17 kg cm)

Supplied with the device: 1 nut, 1 lock washer

Nut dimensions across the flats: 8,0 mm

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages (in either direction)*

			BTW43–600	800	1000	1200	
Non-repetitive peak off-state voltage (t ≤ 10 ms)	V_{DSM}	max.	600	800	1000	1200	V
Repetitive peak off-state voltage	V_{DRM}	max.	600	800	1000	1200	V
Crest working off-state voltage	V_{DWM}	max.	400	600	700	800	V

Currents (in either direction)

R.M.S. on-state current (conduction angle 360°)				
up to T_{mb} = 75 °C	$I_{T(RMS)}$	max.	15	A
at T_{mb} = 85 °C	$I_{T(RMS)}$	max.	12	A
Repetitive peak on-state current	I_{TRM}	max.	50	A
Non-repetitive peak on-state current T_j = 125 °C prior to surge; t = 20 ms; full sine-wave	I_{TSM}	max.	120	A
I^2t for fusing (t = 10 ms)	I^2t	max.	72	A^2s
Rate of rise of on-state current after triggering with I_G = 0,5 A to I_T = 25 A; dI_G/dt = 0,5 A/μs	dI_T/dt	max.	50	A/μs

Gate to terminal 1

Power dissipation

Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	1	W
Peak power dissipation	P_{GM}	max.	10	W

Temperatures

Storage temperature	T_{stg}		− 55 to + 125	°C
Junction temperature	T_j	max.	125	°C

THERMAL RESISTANCE

From junction to mounting base				
full-cycle operation	$R_{th\ j\text{-}mb}$	=	2,0	K/W
half-cycle operation	$R_{th\ j\text{-}mb}$	=	4,0	K/W
From mounting base to heatsink with heatsink compound	$R_{th\ mb\text{-}h}$	=	0,5	K/W
Transient thermal impedance; t = 1 ms	$Z_{th\ j\text{-}mb}$	=	0,2	K/W

* To ensure thermal stability: $R_{th\ j\text{-}a} < 6$ K/W (full-cycle or half-cycle operation). For smalller heat-sinks T_j should be derated (see Fig.2).

CHARACTERISTICS (T_j = 25 °C unless otherwise stated)

Polarities positive or negative, are identified with respect to T_1.

Voltages (in either direction)

On-state voltage I_T = 20 A	V_T	<	2,2 V*
Rate of rise of off-state voltage that will not trigger any device; exponential method; V_D = 2/3 V_{DRMmax}; T_j = 125 °C	dV_D/dt	<	200 V/µs

Rate of rise of commutating voltage that will not trigger any device; $I_{T(RMS)}$ = 12 A; V_D = V_{DWMmax}; T_{mb} = 85 °C

	dV_{com}/dt (V/µs)	$-dI_T/dt$ (A/ms)
BTW43-600G to 1200G	< 10	5
BTW43-600H to 1200H	< 10	12

Currents (in either direction)

Off-state current V_D = V_{DWMmax}; T_j = 125 °C	I_D	<	5 mA

		T_2 pos.	T_2 neg.
Latching current			
G positive	I_L	< 200	200 mA
G negative	I_L	< 200	200 mA
Holding current			
G positive or negative	I_H	< 100	100 mA
Gate to terminal 1			
Voltage and current that will trigger all devices V_D = 12 V			
G positive	V_{GT}	> 2,5	5,0 V
	I_{GT}	> 100	200 mA
G negative	$-V_{GT}$	> 2,5	2,5 V
	$-I_{GT}$	> 100	100 mA
Voltage that will not trigger any device V_D = V_{DRMmax}; T_j = 125 °C; G positive or negative	V_{GD}	< 0,2	0,2 V

* Measured under pulse conditions to avoid excessive dissipation.

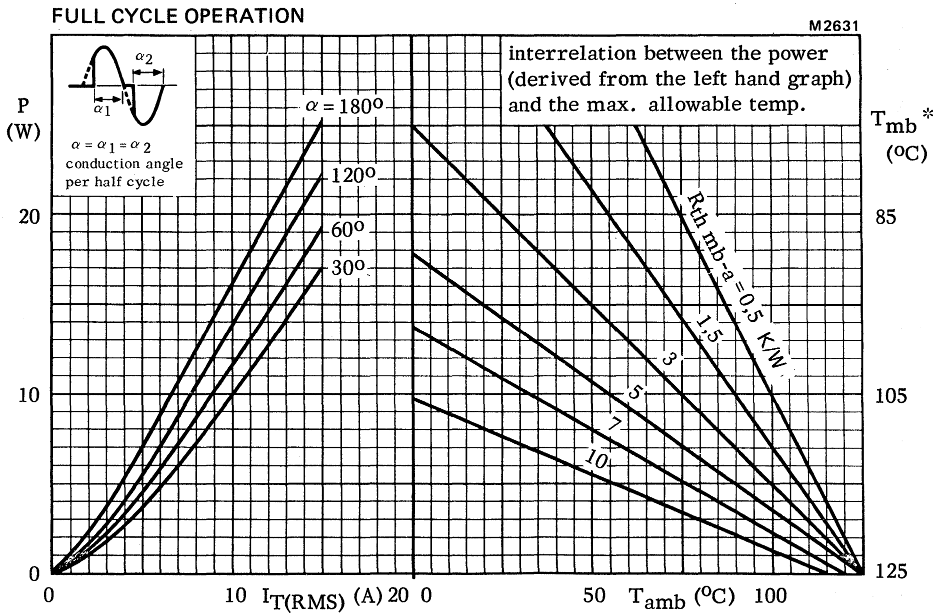


Fig.2 * T_{mb}-scale is for comparison purposes only and is correct only for $R_{th\ mb\text{-}a} \leqslant 4$ K/W.

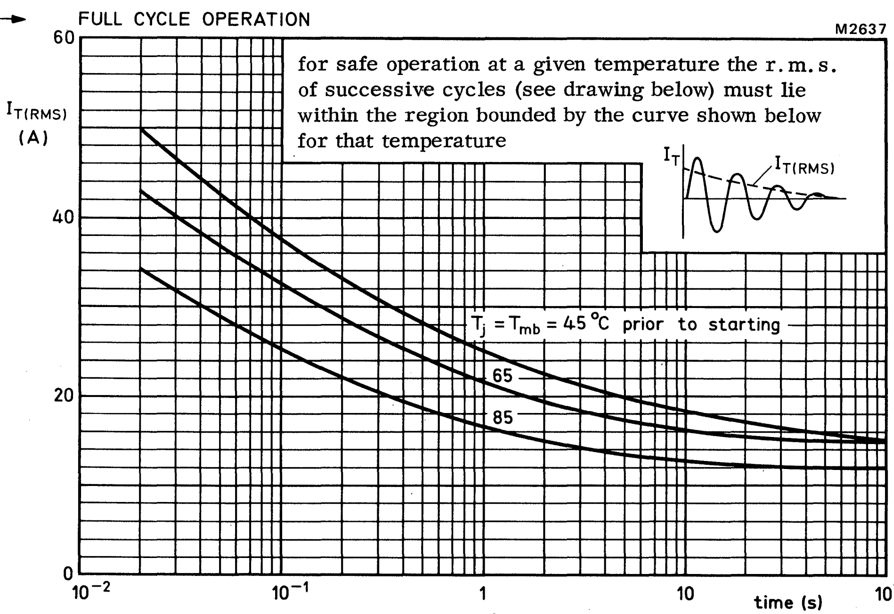


Fig.3

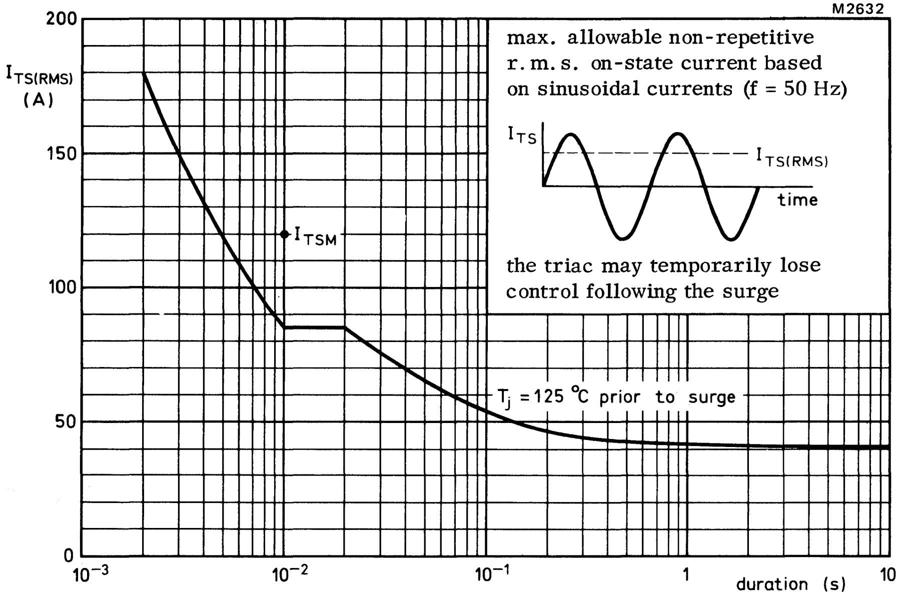

M2632
$I_{TS(RMS)}$ (A)
200
150
100
50
0
10^{-3}
10^{-2}
10^{-1}
1
10
duration (s)
max. allowable non-repetitive r.m.s. on-state current based on sinusoidal currents (f = 50 Hz)
I_{TS}
$I_{TS(RMS)}$
time
the triac may temporarily lose control following the surge
I_{TSM}
T_j = 125 °C prior to surge

Fig. 4.

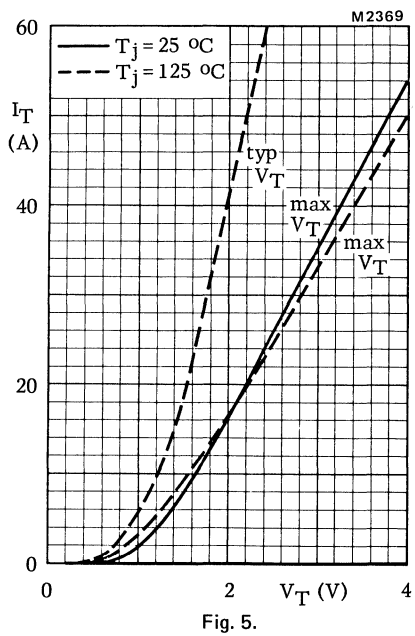

M2369
I_T (A)
60
40
20
0
2
4
V_T (V)
T_j = 25 °C
T_j = 125 °C
typ V_T
max V_T
max V_T

Fig. 5.

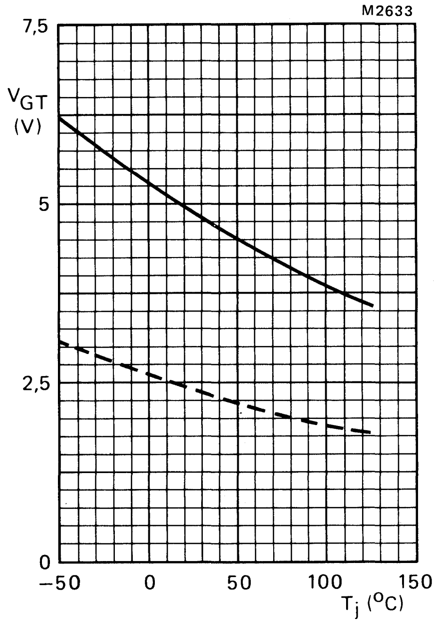


Fig. 6 Minimum gate voltage that will trigger all devices as a function of T_j.

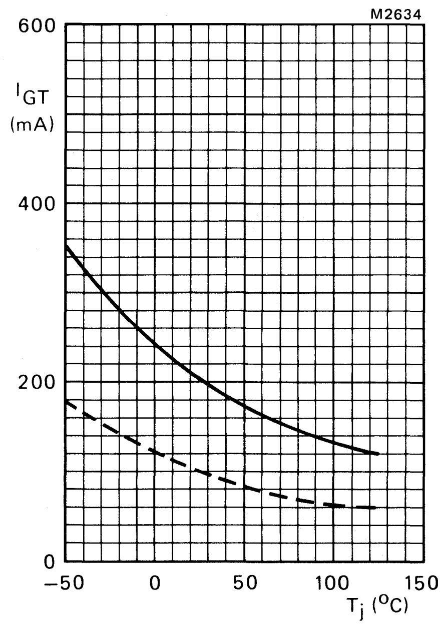


Fig. 7 Minimum gate current that will trigger all devices as a function of T_j.

Conditions for Figs 6 and 7:

——— T_2 negative, gate positive with respect to T_1
– – – – all other conditions

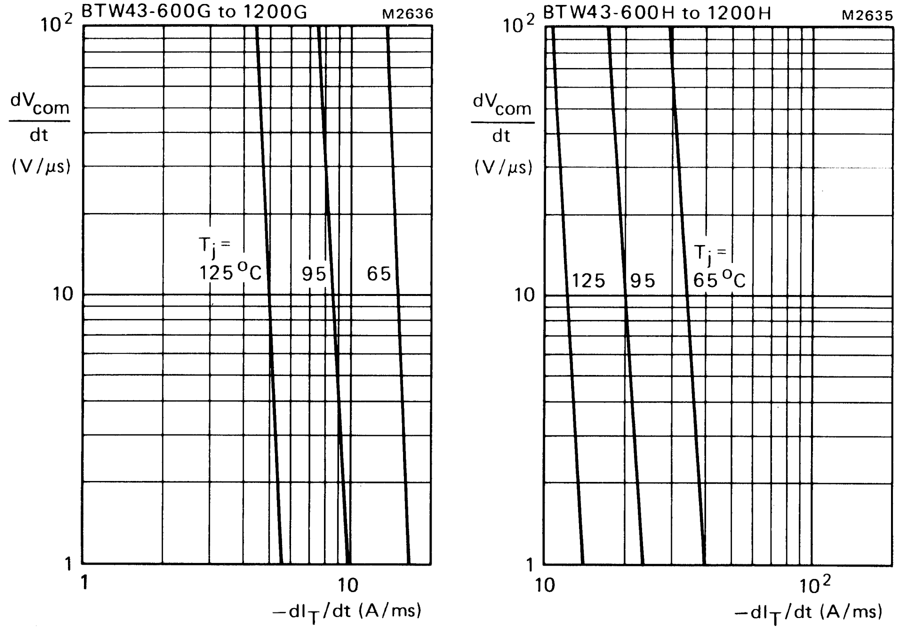


Fig. 8 Maximum rate of rise of commutating voltage that will not trigger any device as a function of rate of fall of on-state current; $I_{T(RMS)}$ = 12 A; $V_D = V_{DWMmax}$.

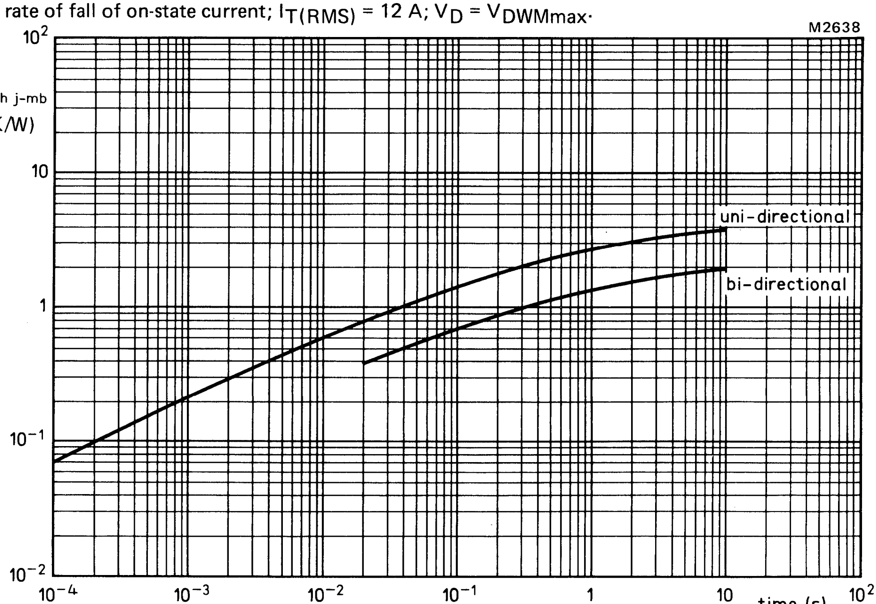


Fig. 9.

ACCESSORIES

TYPE NUMBER SUMMARY

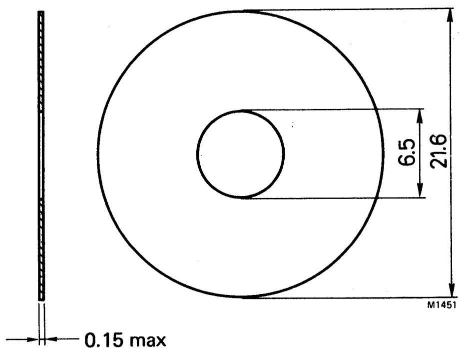
type number	description	envelope
56264a	mica washer (up to 2000 V)	DO-5, TO-48
56264b	insulating bush	DO-5, TO-48
56295a	mica washer (up to 2000 V)	DO-4, TO-64
56295b	PTFE ring	DO-4, TO-64
56295c	insulating bush	DO-4, TO-64
56359b	mica washer (up to 1000 V)	TO-220
56359c	insulating bush (up to 800 V)	TO-220
56359d	rectangular insulating bush (up to 1000 V)	TO-220
56360a	rectangular washer	TO-220
56363	spring clip (direct mounting)	TO-220, SOT-186 ←
56364	spring clip (insulated mounting)	TO-220
56367	alumina insulator (up to 2000 V)	TO-220
56368b	insulating bush (up to 800 V)	SOT-93
56368c	mica insulator (up to 800 V)	SOT-93 ←
56369	mica insulator (up to 2000 V)	TO-220
56378	mica insulator (up to 1500 V)	SOT-93
56379	spring clip	SOT-93, SOT-112

56264a MICA WASHER

Insulator up to 2000 V

MECHANICAL DATA

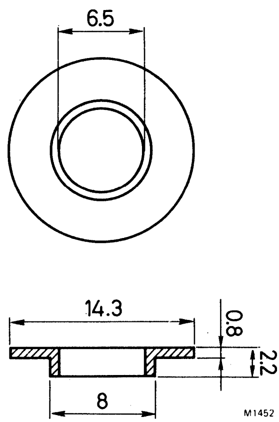
Dimensions in mm



56264b INSULATING BUSH

MECHANICAL DATA

Dimensions in mm



THERMAL RESISTANCE

From mounting base to heatsink

with mica washer, without heatsink compound	$R_{th\ mb\text{-}h}$	=	5	K/W
with mica washer, with heatsink compound	$R_{th\ mb\text{-}h}$	=	2.5	K/W

TEMPERATURE

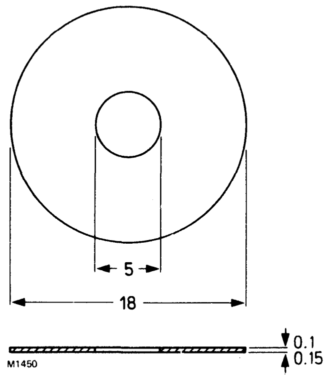
Maximum allowable temperature	T_{max}	=	175	^{o}C

56295a MICA WASHER

Insulator up to 2 kV.

MECHANICAL DATA

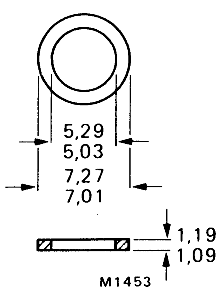
Dimensions in mm



56295b PTFE RING

MECHANICAL DATA

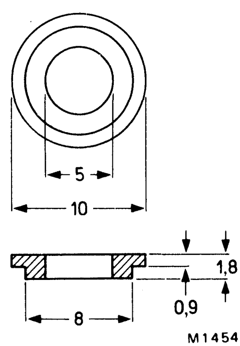
Dimensions in mm



56295c INSULATING BUSH

MECHANICAL DATA

Dimensions in mm



THERMAL RESISTANCE

From mounting base to heatsink				
without heatsink compound	$R_{th\ mb\text{-}h}$	=	5	K/W
with heatsink compound	$R_{th\ mb\text{-}h}$	=	2.5	K/W

TEMPERATURE

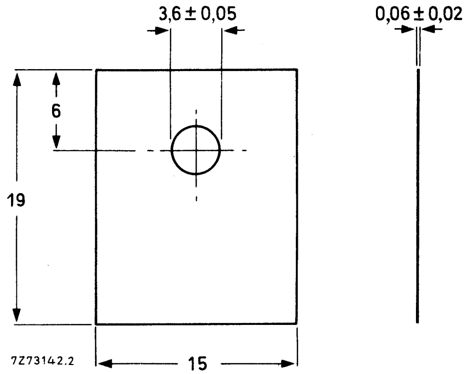
Maximum allowable temperature	T_{max}	=	175	^{o}C

56359b MICA WASHER

Insulator up to 1000 V.

MECHANICAL DATA

Dimensions in mm



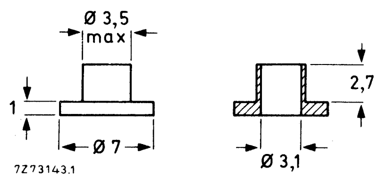
56359c INSULATING BUSH

Insulator up to 800 V.

MECHANICAL DATA

Material: polyester

Dimensions in mm



TEMPERATURE

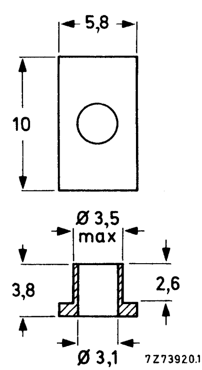
Maximum pemissible temperature T_{max} = 150 °C

56359d RECTANGULAR INSULATING BUSH

Insulator up to 1000 V.

MECHANICAL DATA

Dimensions in mm



TEMPERATURE

Maximum permissible temperature T_{max} = 150 °C

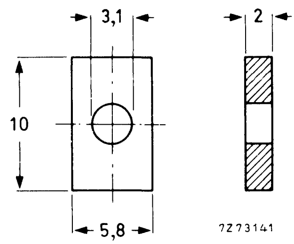
56360a RECTANGULAR WASHER (For TO-220)

For direct and insulated mounting.

MECHANICAL DATA

Dimensions in mm

Material: brass; nickel plated.



56363 SPRING CLIP (For TO-220 and SOT-186)

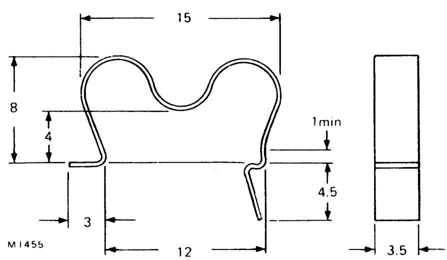
For direct mounting.

MECHANICAL DATA

Dimensions in mm

Material: stainless steel; for mounting on heatsink of 1.0 to 2.0 mm.

Recommended force of clip on device is 20 N (2 kgf).



56364 SPRING CLIP (For TO-220)

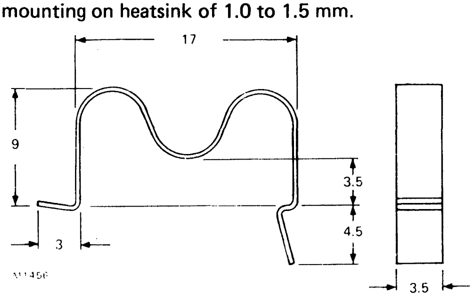
For insulated mounting.

MECHANICAL DATA

Dimensions in mm

Material: stainless steel; for mounting on heatsink of 1.0 to 1.5 mm.

Recommended force of clip on device is 20 N (2 kgf).



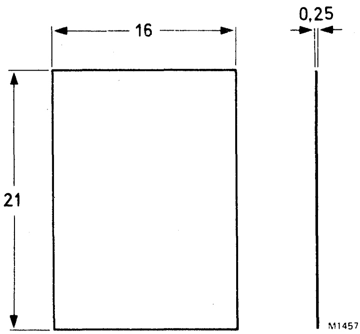
To be used in conjunction with insulators **56367** or **56369**

56367 ALUMINA INSULATOR

For insulated clip mounting up to 2 kV.

MECHANICAL DATA Dimensions in mm

Material: 96-alumina.

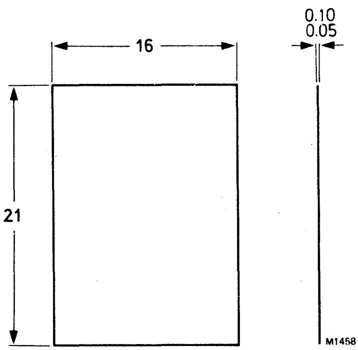


*Because alumina is brittle, extreme care must be taken when mounting devices not to crack the alumina, particularly when used without heatsink compound.

56369 MICA INSULATOR

For insulated clip mounting up to 2 kV.

MECHANICAL DATA Dimensions in mm



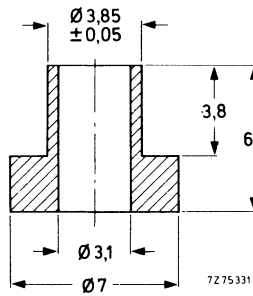
56368b INSULATING BUSH

For insulated screw mounting up to 800 V.

MECHANICAL DATA

Dimensions in mm

Material: polyester



TEMPERATURE

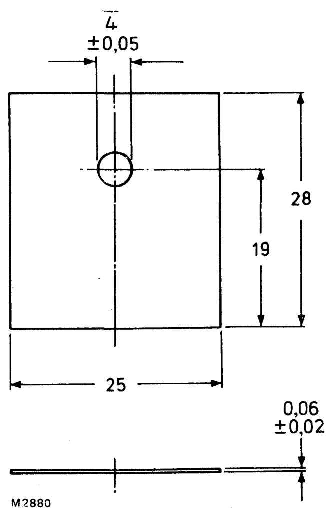
Maximum permissible temperature T_{max} = 150 °C

56368c MICA INSULATOR

For insulated screw mounting up to 800 V.

MECHANICAL DATA

Dimensions in mm



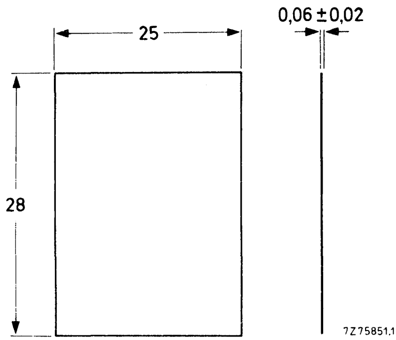
56369: see preceding page.

56378 MICA INSULATOR

For clip mounting up to 1500 V.

MECHANICAL DATA

Dimensions in mm



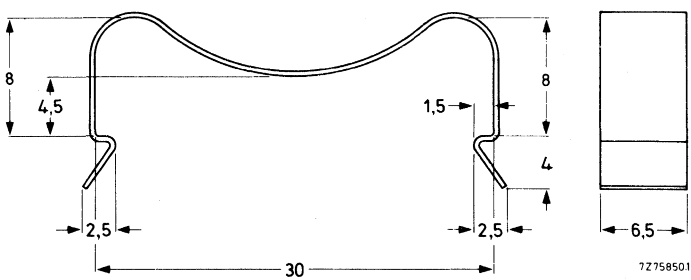
56379 SPRING CLIP

For direct and insulated mounting of SOT-93 and SOT-112 envelopes.

MECHANICAL DATA

Dimensions in mm

Material:
CrNi steel NLN-939;
thickness 0.4 ± 0.04.



MOUNTING INSTRUCTIONS

MOUNTING INSTRUCTIONS FOR TO-220 ENVELOPES

GENERAL DATA AND INSTRUCTIONS

General rules

1. First fasten the device to the heatsink before soldering the leads.
2. Avoid axial stress to the leads.
3. Keep mounting tool (e.g. screwdriver) clear of the plastic body.
4. The rectangular washer may only touch the plastic part of the body; it should not exert any force on that part (screw mounting).

Heatsink requirements

Flatness in the mounting area: 0,02 mm maximum per 10 mm.
Mounting holes must be deburred, see further mounting instructions.

Heatsink compound

Values of the thermal resistance from mounting base to heatsink ($R_{th\ mb\text{-}h}$) given for mounting with heatsink compound refer to the use of a metallic oxide-loaded compound. Ordinary silicone grease is not recommended.

For insulated mounting, the compound should be applied to the bottom of both device and insulator.

Mounting methods for power devices

1. Clip mounting

   Mounting with a spring clip gives:

   a. A good thermal contact under the crystal area, and slightly lower $R_{th\ mb\text{-}h}$ values than screw mounting.
   b. Safe insulation for mains operation.

2. M3 screw mounting

   It is recommended that the rectangular spacing washer is inserted between screw head and mounting tab.

   Mounting torque for screw mounting:

   (For thread-forming screws these are final values. Do not use self-tapping screws.)

Minimum torque (for good heat transfer)	0,55 Nm (5,5 kgcm)
Maximum torque (to avoid damaging the device)	0,80 Nm (8,0 kgcm)

N.B.: When a nut or screw is not driven direct against a curved spring washer or lock washer (not for thread-forming screw), the torques are as follows:

Minimum torque (for good heat transfer)	0,4 Nm (4 kgcm)
Maximum torque (to avoid damaging the device)	0,6 Nm (6 kgcm)

3. Rivet mounting non-insulated

The device should not be pop-rivetted to the heatsink. However, it is permissible to press-rivet providing that eyelet rivets of soft material are used, and the press forces are slowly and carefully controlled so as to avoid shock and deformation of either heatsink or mounting tab.

Thermal data

→ (Typical figures, for exact figures see data for each device type).

			clip mounting	screw mounting	
From mounting base to heatsink					
with heatsink compound, direct mounting	$R_{th\ mb\text{-}h}$	=	0,3	0,5	K/W
without heatsink compound, direct mounting	$R_{th\ mb\text{-}h}$	=	1,4	1,4	K/W
with heatsink compound and 0,1 mm maximum mica washer	$R_{th\ mb\text{-}h}$	=	2,2	–	K/W
with heatsink compound and 0,25 mm maximum alumina insulator	$R_{th\ mb\text{-}h}$	=	0,8	–	K/W
with heatsink compound and 0,05 mm mica washer					
insulated up to 500 V	$R_{th\ mb\text{-}h}$	=	–	1,4	K/W
insulated up to 800 V/1000 V	$R_{th\ mb\text{-}h}$	=	–	1,6	K/W
without heatsink compound and 0,05 mm mica washer					
insulated up to 500 V	$R_{th\ mb\text{-}h}$	=	–	3,0	K/W
insulated up to 800 V/1000 V	$R_{th\ mb\text{-}h}$	=	–	4,5	K/W

Lead bending

Maximum permissible tensile force on the body, for 5 seconds is 20 N (2 kgf).

The leads can be bent through 90^{o} maximum, twisted or straightened. To keep forces within the above-mentioned limits, the leads are generally clamped near the body, using pliers. The leads should neither be bent nor twisted less than 2,4 mm from the body.

Soldering

Lead soldering temperature at > 3 mm from the body; $t_{sld} < 5$ s:

Devices with $T_{j\ max} \leqslant 175\ ^{o}C$, soldering temperature $T_{sld\ max} = 275\ ^{o}C$.
Devices with $T_{j\ max} \leqslant 110\ ^{o}C$, soldering temperature $T_{sld\ max} = 240\ ^{o}C$.

Avoid any force on body and leads during or after soldering: do not correct the position of the device or of its leads after soldering.

It is not permitted to solder the metal tab of the device to a heatsink, otherwise its junction temperature rating will be exceeded.

Mounting base soldering

Recommended metal-alloy of solder paste (85% metal weight)
62 Sm/36 Pb/2 Ag or 60 Sn/40 Pb.
Maximum soldering temperature ⩽ 200 ^{o}C (tab-temperature).
Soldering cycle duration including pre-heating ⩽ 30 sec.

For good soldering and avoiding damage to the encapsulation pre-heating is recommended to a temperature ⩽ 165 ^{o}C at a duration ⩽ 10 s.

INSTRUCTIONS FOR CLIP MOUNTING

Direct mounting with clip 56363

1. Apply heatsink compound to the mounting base, then place the device on the heatsink.
2. Push the short end of the clip into the narrow slot in the heatsink with clip at an angle of 10° to 30° to the vertical (see Figs 1 and 2).
3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body, not on the tab (see Fig.2a).
   Do not insert more than 1 mm beyond final position.

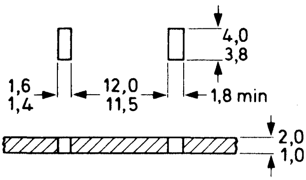


Fig. 1 Heatsink requirements.

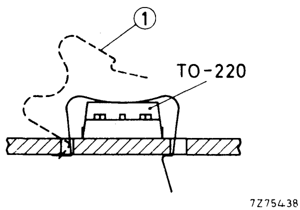


Fig. 2 Mounting.
(1) spring clip 56363.

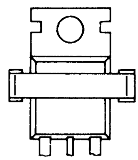


Fig. 2a Position of device (top view).

Insulated mounting with clip 56364

With the insulators 56367 or 56369 insulation up to 2 kV is obtained.

1. Apply heatsink compound to the bottom of both device and insulator, then place the device with the insulator on the heatsink.
2. Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10° to 30° to the vertical (see Figs 3 and 4).
3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body, not on the tab. Ensure that the device is centred on the mica insulator to prevent creepage.
   Do not insert more than 1 mm beyond final position.

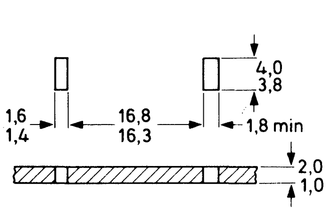


Fig. 3 Heatsink requirements.

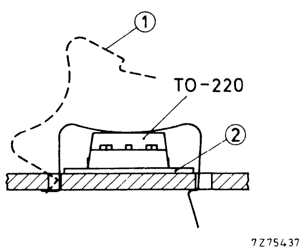


Fig. 4 Mounting.
(1) spring clip 56364.
(2) insulator 56369 or 56367.

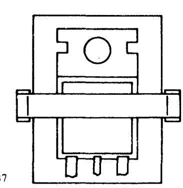


Fig.4a Position of device (top view).

INSTRUCTIONS FOR SCREW MOUNTING

Dimensions in mm

Direct mounting with screw and spacing washer

- *through heatsink with nut*

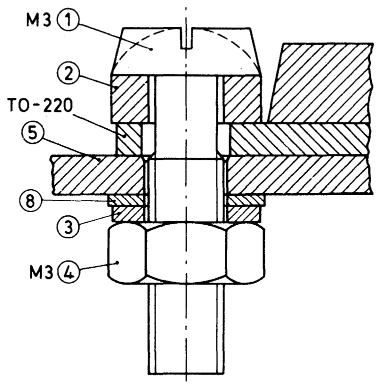


Fig. 5 Assembly.

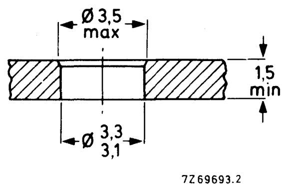


Fig. 6 Heatsink requirements.

(1) M3 screw.
(2) rectangular washer (56360a).
(3) lock washer.
(4) M3 nut.
(5) heatsink.
(8) plain washer.

- *into tapped heatsink*

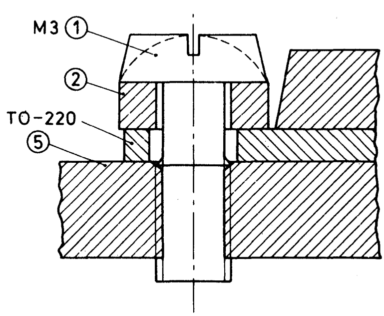


Fig. 7 Assembly.

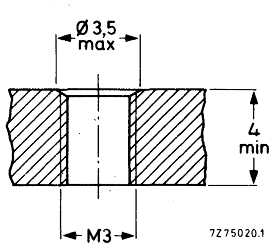


Fig. 8 Heatsink requirements.

(1) M3 screw.
(2) rectangular washer 56360a.
(5) heatsink.

Insulated mounting with screw and spacing washer
(not recommended where mounting tab is on mains voltage)

Dimensions in mm

- *through heatsink with nut*

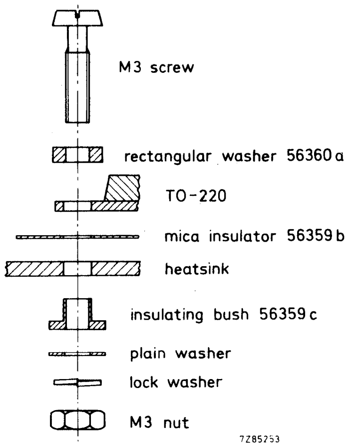


Fig. 9 Insulated screw mounting with rectangular washer. Known as a "bottom mounting".

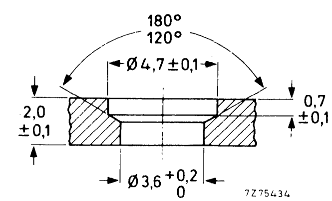


Fig. 10 Heatsink requirements for 500 V insulation.

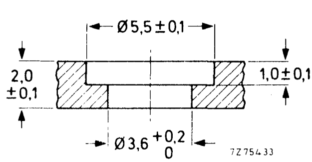


Fig. 11 Heatsink requirements for 800 V insulation.

- *into tapped heatsink*

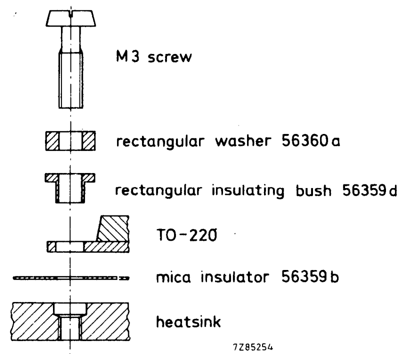


Fig. 12 Insulated screw mounting with rectangular washer into tapped heatsink. Known as a "top mounting".

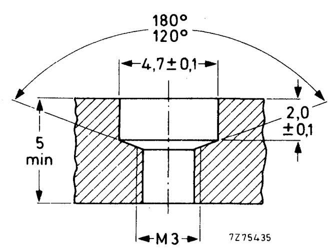


Fig. 13 Heatsink requirements for 500 V insulation.

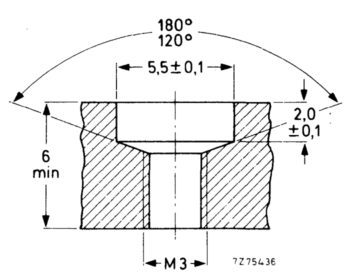


Fig. 14 Heatsink requirements for 1000 V insulation.

MOUNTING INSTRUCTIONS FOR TO-220 FULL-PACK (SOT-186) DEVICES

Use of full-pack (SOT-186 envelope) devices allows an insulated mounting with up to 1kV isolation. These devices require the assembly of less components than TO-220 devices with insulating washers.

GENERAL DATA AND INSTRUCTIONS

General rules

1. Mounting instructions for voltage isolation are given for guidance. Users should aquaint themselves with the relevant statutory and mandatory regulations if the heatsink is earthed or may be touched.
2. Fasten device to heatsink before soldering the leads.
3. Avoid axial stress to the leads.
4. Be careful to avoid damaging plastic with mounting tool (e.g. screwdriver).
5. If a rectangular washer (part no. 56360a) is used in screw mounting it may only touch the main part of the body, it should not exert any force on this part.

Heatsink requirements

Flatness in the mounting area: 0.02mm maximum per 10mm.

Mounting holes must be deburred.

Heatsink compound

Values of thermal resistance given using heatsink compound refer to the use of a metallic oxide-loaded compound. Ordinary silicone grease is not recommended.

Mounting methods for power devices

1. Clip mounting:
   This gives better thermal contact under the crystal area than screw mounting.
   For details of mounting force for spring clip mounting see data sheet "Accesories for TO-220".
2. M3 screw mounting:
   It is recommended that a rectangular spacing washer (part no. 56360a) is inserted between the screw head and plastic mounting tab.

N.B. Data on accessories are given in separate data sheet "Accesories for TO-220".

Mounting torque for screw mounting:

(For thread-forming screws these are final values. Do not use self-tapping screws.)

Minimum torque (for good heat transfer)	0.55 Nm (5.5 kgcm)
Maximum torque (to avoid damaging the device)	0.80 Nm (8.0 kgcm)

N.B. When a nut or screw is not driven against a curved spring washer or lock washer (not for thread-forming screws) the torques are as follows:

Minimum torque (for good heat transfer)	0.40 Nm (4.0 kgcm)
Maximum torque (to avoid damaging device)	0.60 Nm (6.0 kgcm)

3. Rivet mounting:
   This method is **NOT** recommended because it will damage the plastic encapsulation.

Lead bending

(Maximum permissible tensile force on the body, for 5 seconds is 20N (2kgf).

The leads should not be bent less than 2.4mm from the seal, and should be supported during bending.
The leads can be bent, twisted or straightened by 90 ° maximum. The minimum bending radius is 1mm.

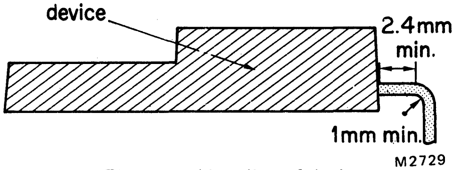


Fig.1 Lead bending of devices.

Soldering

Lead soldering temperature at >3mm from body for t_{sld} <5 seconds:

Devices with T_j max. ≤175 °C, T_{sld} max. = 275 °C.

Devices with T_j max. ≤110 °C, T_{sld} max. = 240 °C.

Avoid any force on body and leads during or after soldering. Do not correct the position of the devices or of its leads after soldering.

INSTRUCTIONS FOR CLIP MOUNTING

1. Apply heatsink compound to the mounting base, then place device on heatsink.
2. Push the short end of clip (part no. 56363) into the narrow slot in the heatsink with the clip at an angle of between 10° to 30° to the vertical (see Figs.2 & 3).
3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear down on the main part of the body, not on the tab (see Fig.3a).

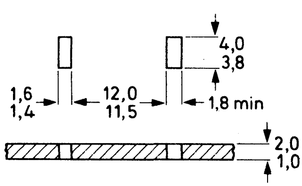


Fig.2 Heatsink requirements

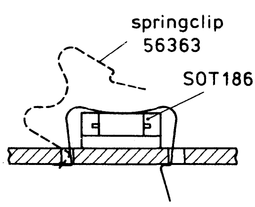


Fig.3 Mounting.

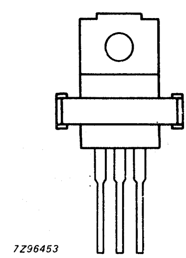


Fig.3a Position of device (top view).

INSTRUCTIONS FOR SCREW MOUNTING

Screw through heatsink with nut

Dimensions in mm

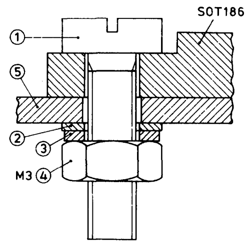


Fig.4 Assembly.

(1) M3 screw
(2) plain washer
(3) lock washer
(4) M3 nut
(5) heatsink

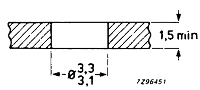


Fig.5 Heatsink requirements.

Into tapped heatsink

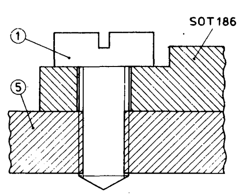


Fig.6 Assembly.

(1) M3 screw
(5) heatsink

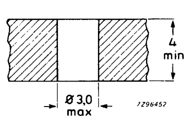


Fig.7 Heatsink requirements.

MOUNTING REQUIREMENTS FOR VOLTAGE ISOLATION

Full-pack devices may be used to maintain voltage isolation between the heatsink and the electrical circuit. However, users must ensure that there is a sufficient creepage distance between the exposed metal of the device (at both the lead and tab ends) and the heatsink. The distance required will vary according to the application and the regulations that may apply.

To increase the creepage distances the heatsink may be formed with slots or holes around the lead and tab ends of the device. The dimensions of the holes will vary according to the creepage distances required. For detail see Fig.8.

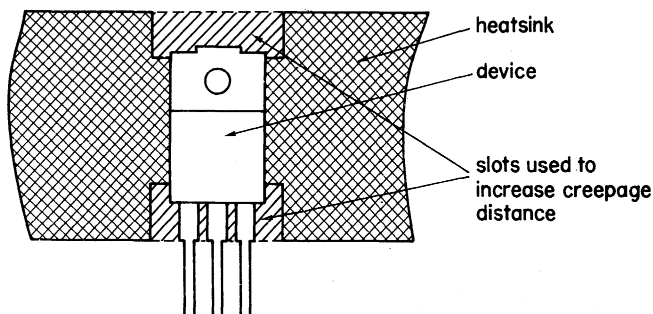


Fig.8 Slots formed in heatsink to increase creepage distance.

MOUNTING INSTRUCTIONS FOR SOT-93 ENVELOPES

GENERAL DATA AND INSTRUCTIONS

General rule

Avoid any sudden forces on leads and body; these forces, such as from falling on a hard surface, are easily underestimated. In the direct screw mounting an M4 screw must be used; an M3 screw in the insulating mounting.

Heatsink requirements

Flatness in the mounting area: 0,02 mm maximum per 10 mm.
The mounting hole must be deburred.

Heatsink compound

The thermal resistance from mounting base to heatsink ($R_{th\ mb\text{-}h}$) can be reduced by applying a metallic-oxide heatsink compound between the contact surfaces. For insulated mounting the compound should be applied to the bottom of both device and insulator.

Maximum play

The bush or the washer may only just touch the plastic part of the body, but should not exert any force on that part. Keep mounting tool (e.g. screwdriver) clear of the plastic body.

Mounting torques

For M3 screw (insulated mounting):	
Minimum torque (for good heat transfer)	0,4 Nm (4 kgcm)
Maximum torque (to avoid damaging the device)	0,6 Nm (6 kgcm)
For M4 screw (direct mounting only):	
Minimum torque (for good heat transfer)	0,4 Nm (4 kgcm)
Maximum torque (to avoid damaging the device)	1,0 Nm (10 kgcm)

Note: The M4 screw head should not touch the plastic part of the envelope.

Lead bending

Maximum permissible tensile force on the body for 5 s — 20 N (2 kgf)

No torsion is permitted at the emergence of the leads.

Bending or twisting is not permitted within a lead length of 0,3 mm from the body of the device. ←

The leads can be bent through 90° maximum, twisted or straightened; to keep forces within the above-mentioned limits, the leads should be clamped near the body. ←

Soldering

Recommendations for devices with a maximum junction temperature rating ⩽ 175 °C:

a. Dip or wave soldering

Maximum permissible solder temperature is 260 °C at a distance from the body of > 5 mm and for a total contact time with soldering bath or waves of < 7 s.

b. Hand soldering

Maximum permissible temperature is 275 °C at a distance from the body of > 3 mm and for a total contact time with the soldering iron of < 5 s.

The body of the device must not touch anything with a temperature > 200 °C.

It is not permitted to solder the metal tab of the device to a heatsink, otherwise the junction temperature rating will be exceeded.

Avoid any force on body and leads during or after soldering; do not correct the position of the device or of its leads after soldering.

Thermal data

(Typical figures, for exact figures see data for each device type).

			clip mounting	screw mounting
Thermal resistance from mounting base to heatsink				
direct mounting				
with heatsink compound	$R_{th\ mb\text{-}h}$	=	0,3	0,3 K/W
without heatsink compound	$R_{th\ mb\text{-}h}$	=	1,5	0,8 K/W
with 0,05 mm mica washer				
with heatsink compound	$R_{th\ mb\text{-}h}$	=	0,8	0,8 K/W
without heatsink compound	$R_{th\ mb\text{-}h}$	=	3,0	2,2 K/W

INSTRUCTIONS FOR CLIP MOUNTING

Direct mounting with clip 56379

1. Place the device on the heatsink, applying heatsink compound to the mounting base.
2. Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10° to 20° to the vertical (see Fig. 1b).
3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body, not on the tab (see Fig. 1(c)).

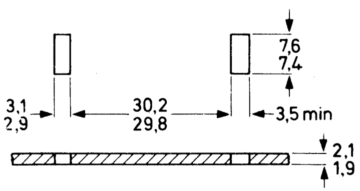


Fig. 1a Heatsink requirements.

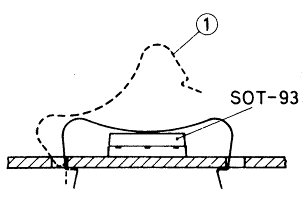


Fig. 1b Mounting.
(1) = spring clip 56379.

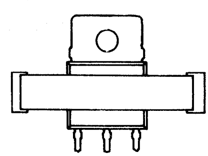


Fig. 1c Position of the device.

Insulated mounting with clip 56379

With the mica 56378 insulation up to 1500 V is obtained.

1. Place the device with the insulator on the heatsink, applying heatsink compound to the bottom of both device and insulator.
2. Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10° to 20° to the vertical (see Figs 2a and 2b).
3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body, not on the tab (see Fig. 2c). There should be minimum 3 mm distance between the device and the edge of the insulator for adequate creepage.

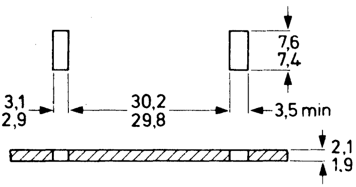


Fig. 2a Heatsink requirements.

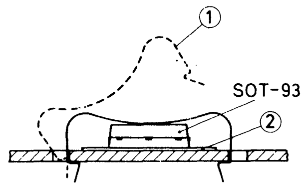


Fig. 2b Mounting.
(1) = spring clip 56379
(2) = insulator 56378

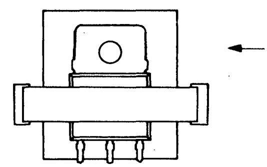


Fig. 2c Position of the device.

INSTRUCTIONS FOR SCREW MOUNTING

Direct mounting

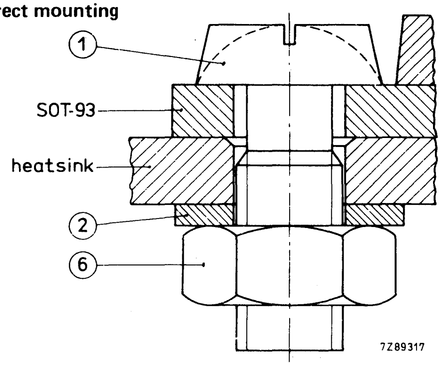


Fig. 3a Assembly through heatsink with nut.

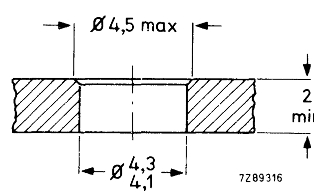


Fig. 3b Heatsink requirements.

When screw mounting the SOT-93 envelope, it is particularly important to apply a thin, even layer of heatsink compound to the mounting base, and to apply torque to the screw slowly so that the compound has time to flow and the mounting base is not deformed. Most SOT-93 envelopes contain a crystal larger than that in the other plastic envelopes, and it is more likely to crack if the mounting base is deformed.

Legend: (1) M4 screw; (2) plain washer; (6) M4 nut.
Where vibrations are to be expected the use of a lock washer or of a curved spring washer is recommended, with a plain washer between aluminium heatsink and spring washer.

Insulated screw mounting with nut; up to 800 V.

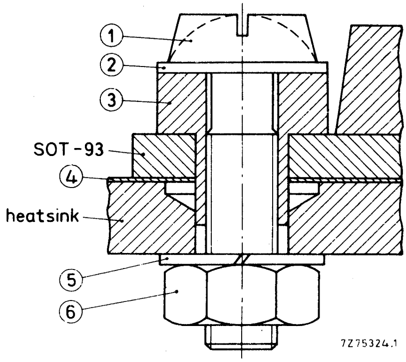


Fig. 4 Assembly.
See also Fig. 9.

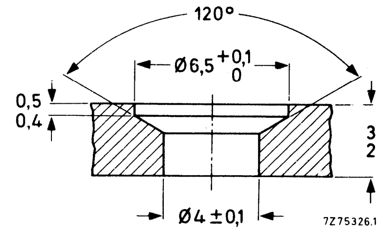


Fig. 5 Heatsink requirements
up to 800 V insulation.

(1) M3 screw
(2) plain washer
(3) insulating bush (56368b)
(4) mica insulator (56368c)
(5) lock washer
(6) M3 nut

Insulated screw mounting with tapped hole; up to 800 V.

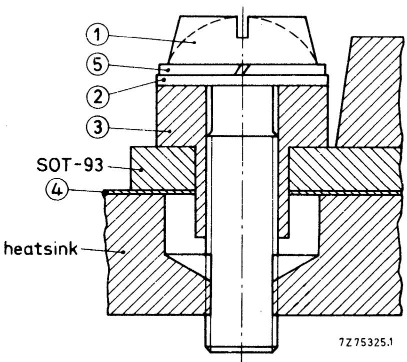


Fig. 6 Assembly.
See also Fig. 9.

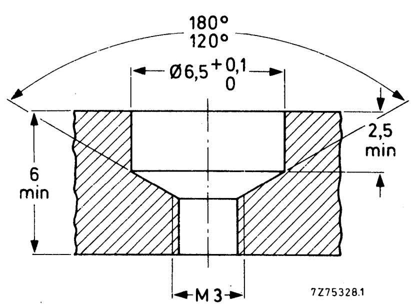


Fig. 7 Heatsink requirements
up to 800 V insulation.

(1) M3 screw
(2) plain washer
(3) insulating bush (56368b)
(4) mica insulator (56368c)
(5) lock washer

Insulated screw mounting with insert nut; up to 500 V

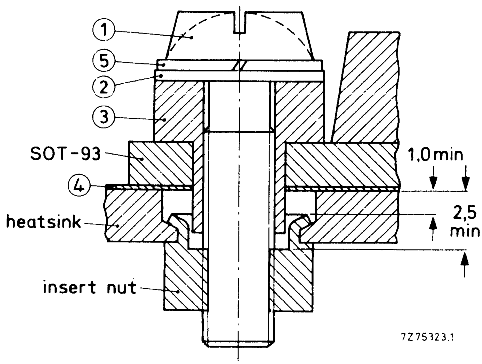


Fig. 8 Assembly and heatsink requirements for 500 V insulation. See also Fig. 3.

(1) M3 screw
(2) plain washer
(3) insulating bush (56368b)
(4) mica insulator (56368c)
(5) lock washer

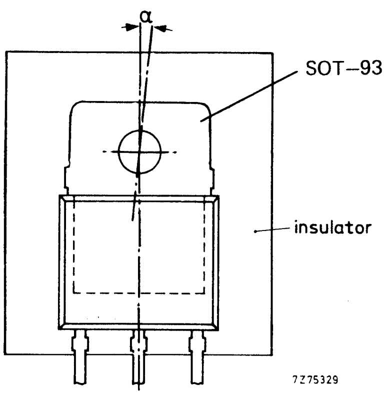
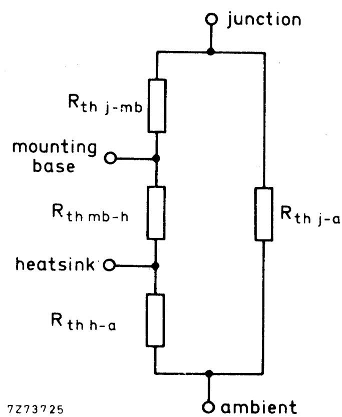


Fig. 9 Mica insulator.

The axial deviation (α) between SOT-93 and mica should not exceed 5°.

MOUNTING CONSIDERATIONS FOR STUD-MOUNTED DEVICES

Losses generated in a silicon device must flow through the case and to a lesser extent the leads.
The greatest proportion of the losses flow out through the case into a heat exchanger which can be either free convection cooled, forced convection or even liquid cooled. For the majority of devices in our range natural convection is generally adequate, however, where other considerations such as space saving must be taken into account then methods such as forced convection etc. can be considered.
The thermal path from junction to ambient may be considered as a number of resistances in series.
The first thermal resistance will be that of junction to mounting base, usually denoted by $R_{th\ j\text{-}mb}$.
The second is the contact thermal resistance $R_{th\ mb\text{-}h}$ and finally there is the thermal resistance of the heatsink $R_{th\ h\text{-}a}$.
In the rating curves, the contact thermal resistance and heatsink thermal resistances are combined as a single figure - $R_{th\ mb\text{-}a}$.
In addition to the steady state thermal conditions of the system, consideration should also be given to the possibility of any transient thermal excursions. These can be caused for example by starting conditions or overloads and in order to calculate the effect on the device, a graph of transient thermal resistance $Z_{th\ j\text{-}mb}$ as a function of time is given in each data sheet.



When mounting the device on the heatsink, care should be taken that the contact surfaces are free from burrs or projections of any kind and must be thoroughly clean.
In the case where an anodised heatsink is used, the anodising should be removed from the contact surface ensuring good electrical and thermal contact.
The contact surfaces should be smeared with a metallic oxide-loaded grease to ensure good heat transfer.
Where the device is mounted in a tapped hole, care should be taken that the hole is perpendicular to the surface of the heatsink. When mounting the device to the heatsink, it is essential that a proper torque wrench is used, applying the correct amount of torque as specified in the published data.
Excessive torque can distort the threads of the device and may even cause mechanical stress on the wafer, leading to the possible failure.
Where isolation of the device from the heatsink is required, it is common practice to use a mica washer between contact surfaces, and where a clearance hole is used, a p.t.f.e. insulating bush is inserted. A metallic oxide-loaded heatsink compound should be smeared on all contact surfaces, including the mica washer, to ensure optimum heat transfer. The use of ordinary silicone grease is not recommended.

MOUNTING INSTRUCTIONS FOR DO-4 AND TO-64 ENVELOPES

GENERAL DATA AND INSTRUCTIONS

Mounting instructions for up to 2000 V insulation using 56295c insulating bush and 56295a mica washer.

Mounting instructions for up to 2000 V insulation using 56295b insulating ring and two 56295a mica washers.

HEATSINK REQUIREMENTS

Mounting holes must be deburred.

MOUNTING TORQUES

Minimum torque (for good heat transfer)	0.9 Nm (9 kg cm)
Maximum torque (to avoid damaging device)	1.7 Nm (17 kg cm)

THERMAL DATA

The thermal resistance from mounting base to heatsink ($R_{th\ mb-h}$) can be reduced by applying a heat conducting compound between device and heatsink. For insulated mounting the compound should be applied to the bottom of both device and insulator.

Thermal resistance from mounting base to heatsink (insulated mounting using 56295a mica washer)

without heatsink compound	$R_{th\ mb-h}$	=	5	K/W
with heatsink compound	$R_{th\ mb-h}$	=	2.5	K/W

MOUNTING INSTRUCTIONS FOR UP TO 2000 V INSULATION

Using 56295c insulating bush and 56295a mica washer.

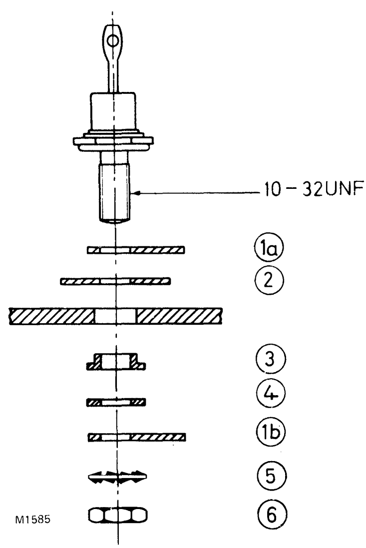


Fig.1

(1a);(1b) tag – alternative positions
(2) mica washer 56295a
(3) insulating bush 56295c
(4) plain washer (may be omitted if tag used in position 1b)
→ (5) toothed lock washer (supplied with device)
(6) 10-32 UNF nut (supplied with device)

MOUNTING INSTRUCTIONS FOR UP TO 2000 V INSULATION

Using insulating ring 56295b and two mica washers 56295a.

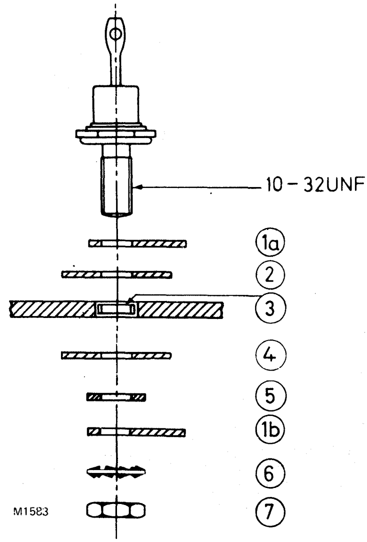


Fig. 2

(1a); (1b) tag – alternative positions
(2) mica washer 56295a
(3) insulating ring 56295b
(4) mica washer 56295a
(5) plain washer (may be omitted if tag used in position 1b)
→ (6) toothed lock washer (supplied with device)
(7) 10-32 nut (supplied with device)

MOUNTING INSTRUCTIONS FOR DO-5 AND TO-48 ENVELOPES

GENERAL DATA AND INSTRUCTIONS

Mounting instructions for up to 2000 V insulation using 56264b insulating bush and 56264a mica washer.

HEATSINK REQUIREMENTS

Mounting holes must be deburred.

MOUNTING TORQUES

Minimum torque (for good heat transfer)	1.7 Nm (17 kg cm)
Maximum torque (to avoid damaging device)	3.5 Nm (35 kg cm)

THERMAL DATA

The thermal resistance from mounting base to heatsink ($R_{th\ mb\text{-}h}$) can be reduced by applying a heat conducting compound between device and heatsink. For insulated mounting the compound should be applied to the bottom of both device and insulator.

Thermal resistance from mounting base to heatsink (insulated mounting using 56264a mica washer)

without heatsink compound	$R_{th\ mb\text{-}h}$	=	5	K/W
with heatsink compound	$R_{th\ mb\text{-}h}$	=	2.5	K/W

MOUNTING INSTRUCTIONS FOR UP TO 2000 V INSULATION

Using insulating bush 56264b and mica washer 56264a.

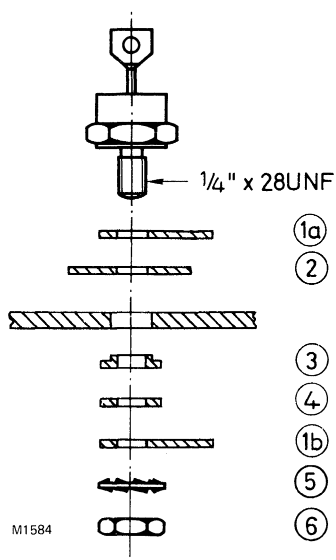


Fig.1

(1a); (1b) tag – alternative positions
(2) mica washer 56264a
(3) insulating bush 56264b
(4) plain washer (may be omitted if tag used in position 1b)
→ (5) toothed lock washer (supplied with device)
(6) ¼" x 28 UNF nut (supplied with device)

INDEX

INDEX OF TYPE NUMBERS

The inclusion of a type number in this publication does not necessarily imply its availability.

Mm = Microminiature semiconductors for hybrid circuits
SD = Small-signal diodes
Sp = Special diodes
T = Tuner diodes
Vrg = Voltage regulator diodes

* = series
FET = Field-effect transistors
Mm = Microminiature semiconductors for hybrid circuits
P = Low-frequency power transistors
Sm = Small-signal transistors
T = Tuner diodes

P = Low-frequency power transistors

P = Low-frequency power transistors

FET = Field-effect transistors
HVP = High-voltage power transistors
Mm = Microminiature semiconductors for hybrid circuits
P = Low-frequency power transistors
Sm = Small-signal transistors
WBT = Wideband transistors

FET = Field-effect transistors
Mm = Microminiature semiconductors for hybrid circuits
RFP = R.F. power transistors and modules
RT = Tripler
Sm = Small-signal transistors
WBM = Wideband hybrid IC modules
WBT = Wideband transistors

* = series
FET = Field-effect transistors
RFP = R.F. power transistors and modules
WMB = Wideband hybrid IC modules

FET = Field-effect transistors
Mm = Microminiature semiconductors for hybrid circuits
PDT = Photodiodes or transistors
RFP = R.F. power transistors and modules
Sm = Small-signal transistors
Th = Thyristors

* = series
FET = Field-effect transistors
Mm = Microminiature semiconductors for hybrid circuits
Sm = Small-signal transistors
SP = Low-frequency switching power transistors
Th = Thyristors
Tri = Triacs

* = series
PM = Power MOS transistors
R = Rectifier diodes
SP = Low-frequency switching power transistors

type no.	book	section	type no.	book	section	type no.	book	section
BYV24*	S2a	R	BYW95A	S1	R	BZX70*	S2a	Vrg
BYV26*	S1/S2a	R	BYW95B	S1	R	BZX75*	S1	Vrg
BYV27*	S1/S2a	R	BYW95C	S1	R	BZX79*	S1	Vrg
BYV28*	S1/S2a	R	BYW96D	S1	R	BZX84*	S7/S1	Mm/Vrg
BYV29*	S2a	R	BYW96E	S1	R	BZY91*	S2a	Vrg
BYV29F*	S2a	R	BYX10G	S1	R	BZY93*	S2a	Vrg
BYV30*	S2a	R	BYX25*	S2a	R	CFX13	S11	M
BYV31*	S2a	R	BYX30*	S2a	R	CFX21	S11	M
BYV32*	S2a	R	BYX32*	S2a	R	CFX30	S11	M
BYV32F*	S2a	R	BYX38*	S2a	R	CFX31	S11	M
BYV33*	S2a	R	BYX39*	S2a	R	CFX32	S11	M
BYV33F*	S2a	R	BYX42*	S2a	R	CFX33	S11	M
BYV34*	S2a	R	BYX46*	S2a	R	CNG35	S8b	PhC
BYV36*	S1	R	BYX50*	S2a	R	CNG36	S8b	PhC
BYV39*	S2a	R	BYX52*	S2a	R	CNR36	S8b	PhC
BYV42*	S2a	R	BYX56*	S2a	R	CNX21	S8b	PhC
BYV43*	S2a	R	BYX90G	S1	R	CNX35	S8b	PhC
BYV43F*	S2a	R	BYX96*	S2a	R	CNX35U	S8b	PhC
BYV44*	S2a	R	BYX97*	S2a	R	CNX36	S8b	PhC
BYV60*	S2a	R	BYX98*	S2a	R	CNX36U	S8b	PhC
BYV72*	S2a	R	BYX99*	S2a	R	CNX38	S8b	PhC
BYV73*	S2a	R	BZD23	S1	Vrg	CNX38U	S8b	PhC
BYV74*	S2a	R	BZD27	S1	Vrg	CNX39	S8b	PhC
BYV79*	S2a	R	BZT03	S1	Vrg	CNX39U	S8b	PhC
BYV92*	S2a	R	BZV10	S1	Vrf	CNX44	S8b	PhC
BYV95A	S1	R	BZV11	S1	Vrf	CNX44A	S8b	PhC
BYV95B	S1	R	BZV12	S1	Vrf	CNX46	S8b	PhC
BYV95C	S1	R	BZV13	S1	Vrf	CNX48	S8b	PhC
BYV96D	S1	R	BZV14	S1	Vrf	CNX48U	S8b	PhC
BYV96E	S1	R	BZV37	S1	Vrf	CNX62	S8b	PhC
BYW25*	S2a	R	BZV46	S1	Vrg	CNX72	S8b	PhC
BYW29*	S2a	R	BZV49*	S1/S7	Vrg/Mm	CNX82	S8b	PhC
BYW29F*	S2a	R	BZV55*	S7	Mm	CNX83	S8b	PhC
BYW30*	S2a	R	BZV80	S1	Vrf	CNX91	S8b	PhC
BYW31*	S2a	R	BZV81	S1	Vrf	CNX92	S8b	PhC
BYW54	S1	R	BZV85*	S1	Vrg	CNY17-1	S8b	PhC
BYW55	S1	R	BZW03*	S1	Vrg	CNY17-2	S8b	PhC
BYW56	S1	R	BZW14	S1	Vrg	CNY17-3	S8b	PhC
BYW92*	S2a	R	BZW86*	S2a	TS	CNY50	S8b	PhC
BYW93*	S2a	R	BZX55*	S1	Vrg	CNY57	S8b	PhC

* = series
M = Microwave transistors
Mm = Microminiature semiconductors for hybrid circuits
PhC = Photocouplers
R = Rectifier diodes
TS = Transient suppressor diodes
Vrf = Voltage reference diodes
Vrg = Voltage regulator diodes

* = series
A = Accessories
I = Infrared devices
LED = Light-emitting diodes
M = Microwave transistors
Ph = Photoconductive devices
PhC = Photocouplers
SEN = Sensors

FET = Field-effect transistors
I = Infrared devices
M = Microwave transistors
Mm = Microminiature semiconductors for hybrid circuits
P = Low-frequency power transistors
PhC = Photocouplers
R = Rectifier diodes
SD = Small-signal diodes
SEN = Sensors
Sm = Small-signal transistors
SP = Low-frequency switching power transistors
St = Rectifier stacks
WBM = Wideband hybrid IC modules

* = series
I = Infrared devices
M = Microwave transistors
P = Low-frequency power transistors
PhC = Photocouplers
R = Rectifier diodes
SD = Small-signal diodes
Vrf = Voltage reference diodes

A = Accessories
FET = Field-effect transistors
Ph = Photoconductive devices
PhC = Photocouplers
R = Rectifier diodes
RFP = R.F. power transistors and modules
SD = Small-signal diodes
Sm = Small-signal transistors
WBT = Wideband transistors

A = Accessories

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