

# Semiconductors

Book S2b

1987

**Thyristors**

**Triacs**

**Accessories**



*page*

<b>Selection guide</b> . . . . .	1
<b>General</b>	
Type designation . . . . .	7
Rating systems . . . . .	9
Letter symbols . . . . .	11
Quality conformance and reliability . . . . .	13
General explanatory notes . . . . .	15
Heatsinks . . . . .	29
<b>Device specifications</b>	
Gate-turn-off thyristors . . . . .	37
Thyristors . . . . .	175
Triacs . . . . .	313
<b>Accessories</b> . . . . .	429
<b>Mounting instructions</b> . . . . .	439
<b>Type number index (alpha-numerical)</b> . . . . .	461
<b>Index of all devices in semiconductor Data Handbooks</b> . . . . .	465



## 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:

- T1**      **Tubes for r.f. heating**
- T2a**     **Transmitting tubes for communications, glass types**
- T2b**     **Transmitting tubes for communications, ceramic types**
- T3**      **Klystrons**
- T4**      **Magnetrons for microwave heating**
- T5**      **Cathode-ray tubes**  
Instrument tubes, monitor and display tubes, C. R. tubes for special applications
- T6**      **Geiger-Müller tubes**
- T8**      **Colour display systems**  
Colour TV picture tubes, colour data graphic display tube assemblies, deflection units
- T9**      **Photo and electron multipliers**
- T10**     **Plumbicon camera tubes and accessories**
- T11**     **Microwave semiconductors and components**
- T12**     **Vidicon and Newvicon camera tubes**
- T13**     **Image intensifiers and infrared detectors**
- T15**     **Dry reed switches**
- T16**     **Monochrome tubes and deflection units**  
Black and white TV picture tubes, monochrome data graphic display tubes, deflection units

## 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:

<b>IC01</b>	<b>Radio, audio and associated systems</b> Bipolar, MOS	new issue 1986 IC01N 1985
<b>IC02a/b</b>	<b>Video and associated systems</b> Bipolar, MOS	new issue 1986 IC02Na/b 1985
<b>IC03</b>	<b>Integrated circuits for telephony</b> Bipolar, MOS	new issue 1987 IC03N 1985
<b>IC04</b>	<b>HE4000B logic family</b> CMOS	new issue 1986 IC4 1983
<b>IC05N</b>	<b>HE4000B logic family — uncased ICs</b> CMOS	published 1984
<b>IC06N</b>	<b>High-speed CMOS; PC74HC/HCT/HCU</b> Logic family	published 1986
<b>IC08</b>	<b>ECL 10K and 100K logic families</b>	New issue 1986 IC08N 1984
<b>IC09N</b>	<b>TTL logic series</b>	published 1986
<b>IC10</b>	<b>Memories</b> MOS, TTL, ECL	new issue 1986 IC7 1982
<b>IC11N</b>	<b>Linear LSI</b>	published 1985
<b>Supplement to IC11N</b>	<b>Linear LSI</b>	published 1986
<b>IC12</b>	<b>I<sup>2</sup>C-bus compatible ICs</b>	not yet issued
<b>IC13</b>	<b>Semi-custom</b> Programmable Logic Devices (PLD)	new issue 1986 IC13N 1985
<b>IC14</b>	<b>Microcontrollers and peripherals</b> Bipolar, MOS	published 1986
<b>IC15</b>	<b>FAST TTL logic series</b>	new issue 1986 IC15N 1985
<b>IC16</b>	<b>CMOS integrated circuits for clocks and watches</b>	first issue 1986
<b>IC17</b>	<b>Integrated Services Digital Networks (ISDN)</b>	not yet issued
<b>IC18</b>	<b>Microprocessors and peripherals</b>	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

# SELECTION GUIDE

## GATE TURN-OFF THYRISTORS

$I_T(\text{AV})_{\text{max.}}$ (A)	$I_{\text{TCRM}}_{\text{max.}}$ (A)	Outline	$V_{\text{DRMmax}}$ (V)							Page
			600	800	850	1000	1200	1300	1500	
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

$I_T(\text{RMS})_{\text{max}}$ (A)	Outline	$V_{\text{RRMmax}}$ (V)								Page
		200	400	500	600	650	800	1000	1200	
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)				Page
			500	600	800	1000	
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)					Page
			500	600	800	1000	1200	
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 ( $R_{th\ j-mb} > 15\ K/W$ )
- D. TRANSISTOR; power, audio frequency ( $R_{th\ j-mb} \leq 15\ K/W$ )
- E. DIODE; tunnel
- F. TRANSISTOR; low power, high frequency ( $R_{th\ j-mb} > 15\ K/W$ )
- G. MULTIPLE OF DISSIMILAR DEVICES – MISCELLANEOUS; e.g. oscillator
- H. DIODE; magnetic sensitive
- L. TRANSISTOR; power, high frequency ( $R_{th\ j-mb} \leq 15\ K/W$ )
- 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 ( $R_{th\ j-mb} > 15\ K/W$ )
- S. TRANSISTOR; low power, switching ( $R_{th\ j-mb} > 15\ K/W$ )
- T. CONTROL AND SWITCHING DEVICE; e.g. thyristor, power ( $R_{th\ j-mb} \leq 15\ K/W$ )
- U. TRANSISTOR; power, switching ( $R_{th\ j-mb} \leq 15\ K/W$ )
- 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.

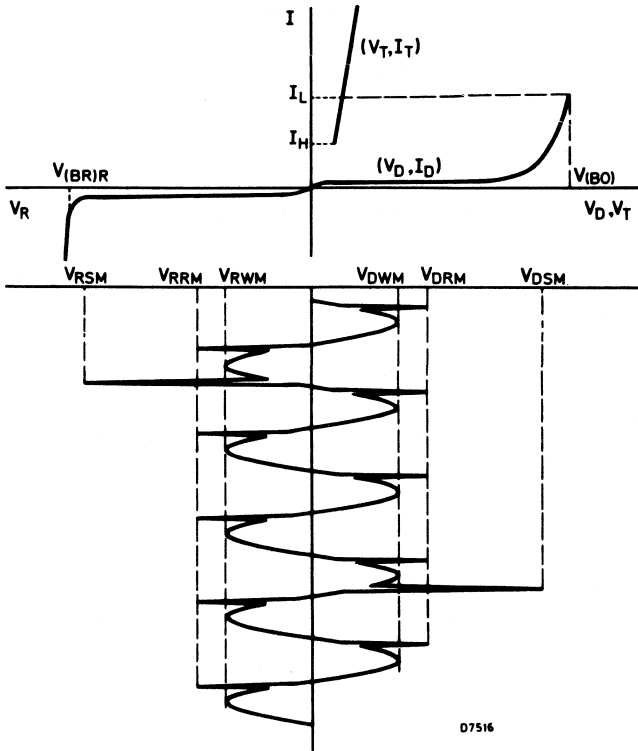
### Subscripts

amb	Ambient
(AV), (av)	Average value
(BO)	Breakover
(BR)	Breakdown
case	Case
C	Controllable
D,d	Forward off-state <sup>1)</sup> , non-triggered (gate voltage or current)
F,f	Forward <sup>1)</sup> , 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 <sup>1)</sup> , 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.

<sup>1)</sup> 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



D7516

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, DEF 131A, 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 initial 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.

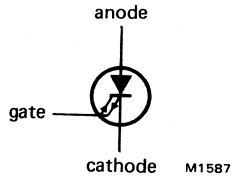


Fig.1 GTO circuit symbol.

### 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)

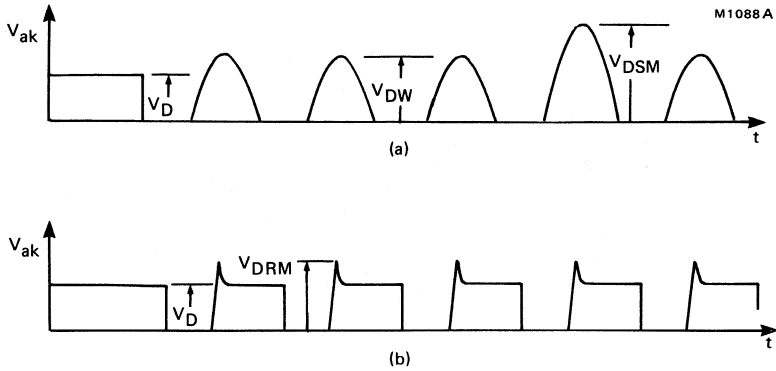


Fig.2

- 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.

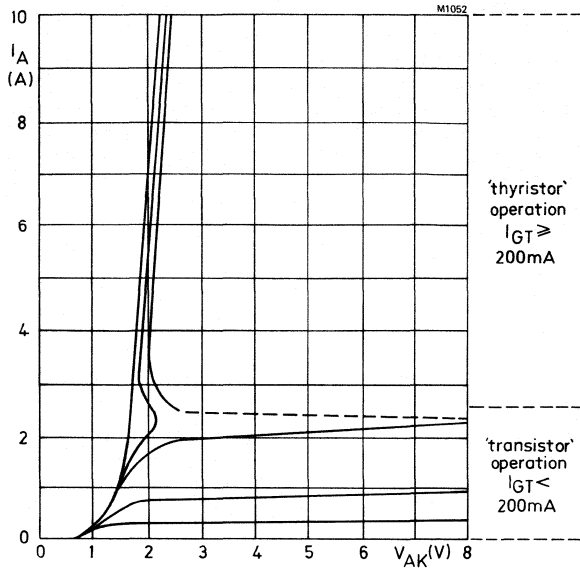
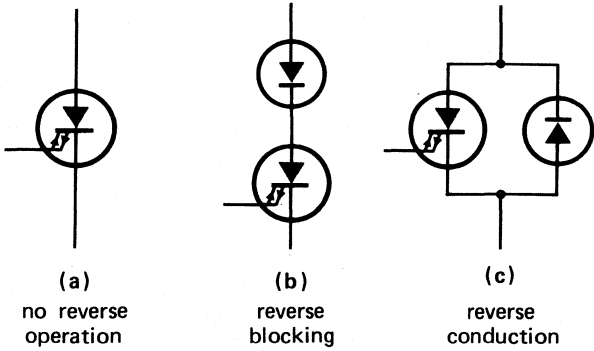


Fig.3 On-state current as a function of the on-state voltage with gate current as a parameter for the BTV59 GTO.

**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.



M 1091

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.

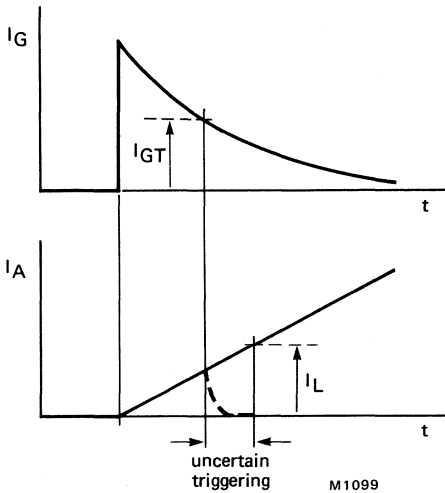


Fig.5a To ensure good triggering the anode current must rise above the latching level before the gate current falls below the minimum level required to ensure triggering.

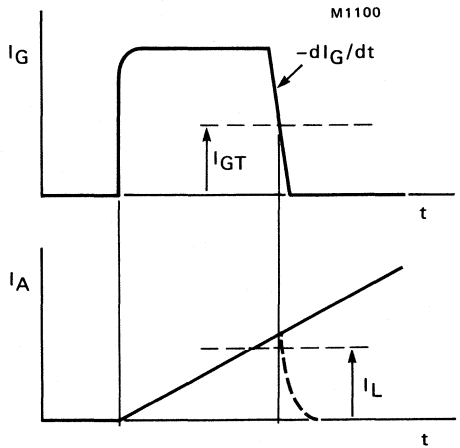


Fig.5b Unlatching can occur if the anode current is only slightly higher than the latching level during a rapid fall in gate current.

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/ $\mu$ s.

**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 analogous 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.

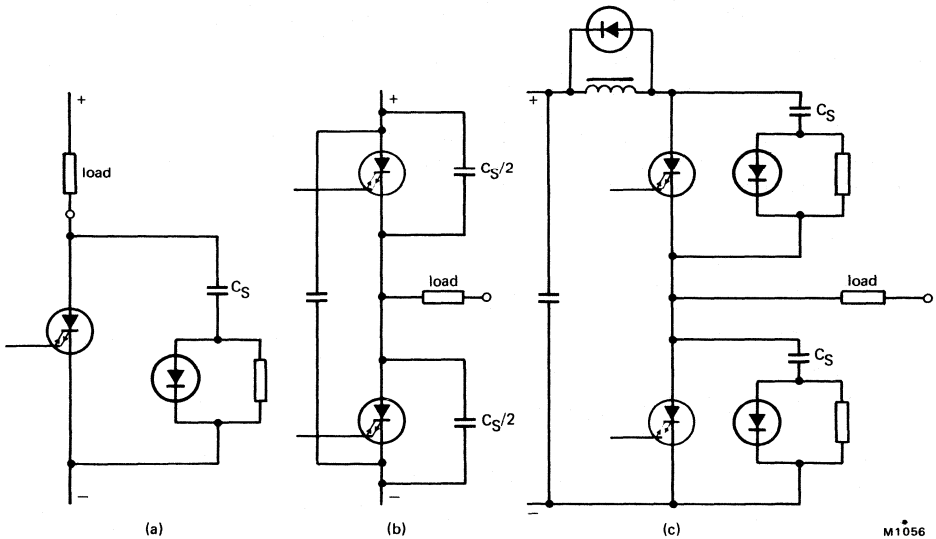


Fig.6 Snubber networks.

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.

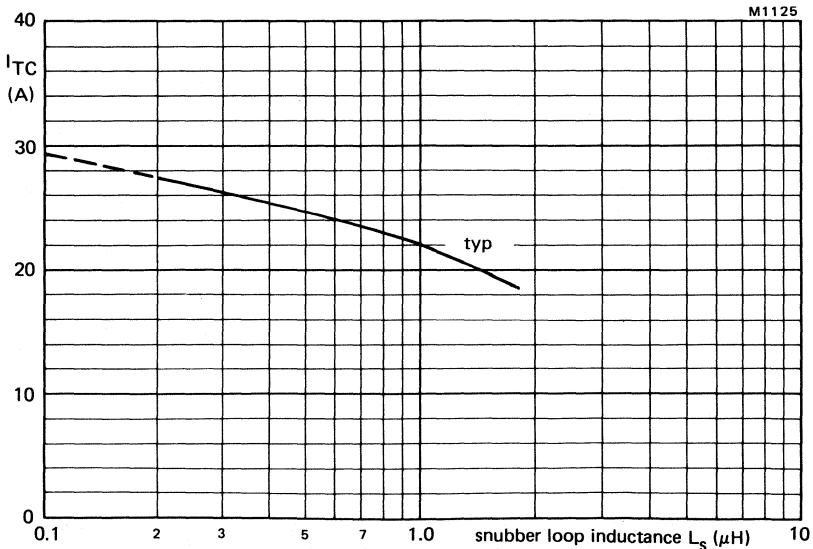


Fig.7 Typical anode current which can be turned off, as a function of snubber loop inductance for the BTV59 ( $C_S = 20$  nF,  $T_{mb} = 25$  °C)

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.

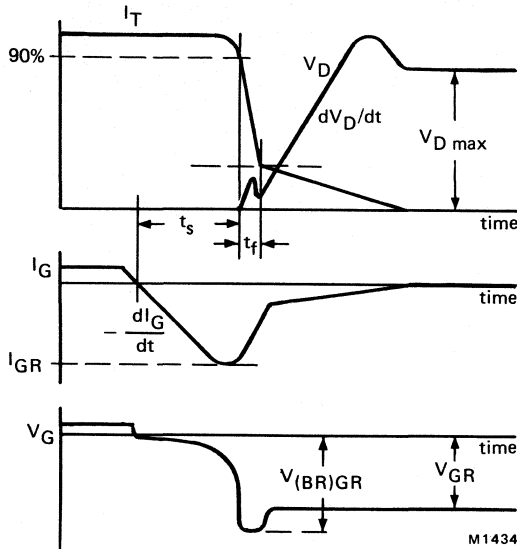


Fig.8 Typical turn-off waveforms.

**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)

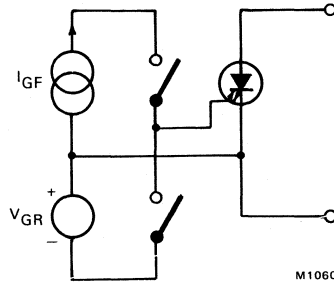


Fig. 9 Idealised gate circuit.

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.

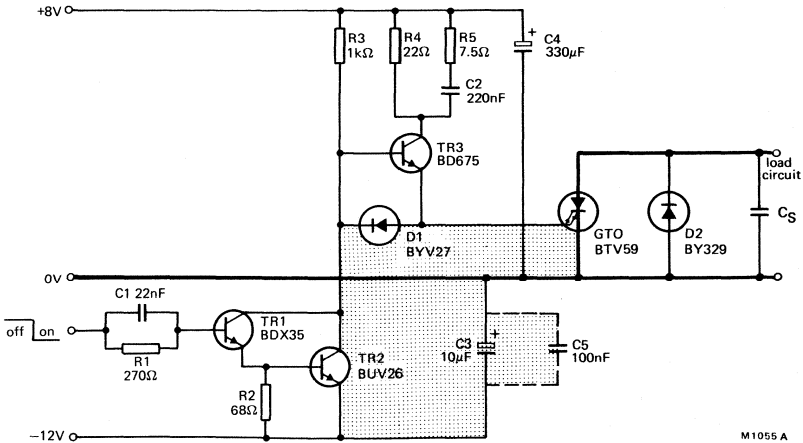


Fig. 10 Practical drive circuit suitable for a BTV59. The turn-off loop (shaded) should have minimum inductance, and the small decoupling capacitor (shown in dashed lines), should be wired as close as possible to the electrolytic capacitor.



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  $-12\text{ V}$  rail, resulting in a negative gate voltage ( $V_{GR}$ ) of approx.  $10\text{ V}$  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.

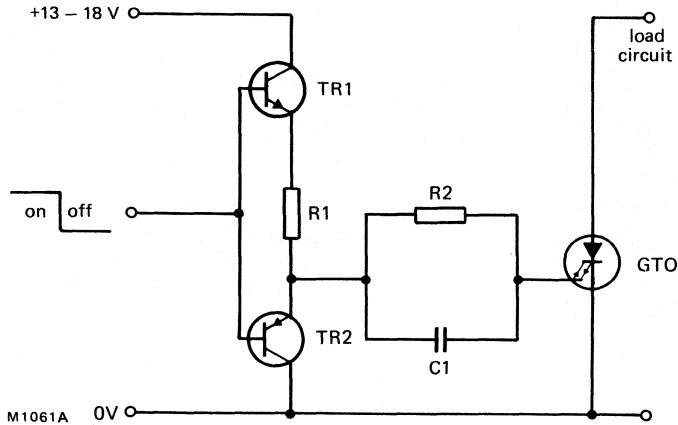


Fig.11 Simple gate circuit

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  $1\text{ V}$ , 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-repetitive 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

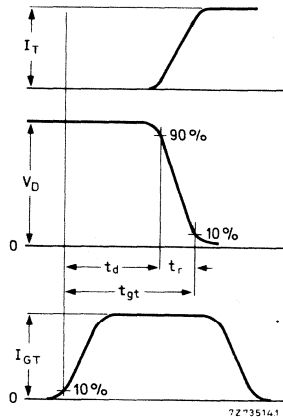
Anode current does not commence flowing at the instant the gate current is applied.

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:

- Off-state voltage ( $V_D$ ).
- On-state current ( $I_T$ ).
- Gate trigger current ( $I_G$ ) – high gate currents reduce turn-on time.
- Rate of rise of gate trigger current ( $dI_G/dt$ ) – high values reduce turn-on time.
- Junction temperature ( $T_j$ ) – high temperatures reduce turn-on time.

The waveforms are shown in the following diagram:



## THYRISTORS

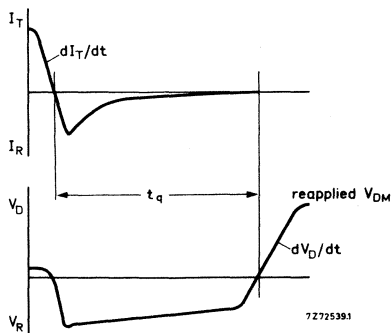
### CIRCUIT-COMMUTATED TURN-OFF TIME

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:

- On-state current ( $I_T$ ) – high peak currents mean longer turn-off times.
- 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.
- Rate of fall of anode current ( $di/dt$ ) – high rates mean shorter turn-off times.
- Rate of rise of reapplied off-state voltage ( $dV_D/dt$ ) – high rates mean longer turn-off times.
- Temperature ( $T_j$  or  $T_{mb}$ ) – high temperatures mean longer turn-off times.
- 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

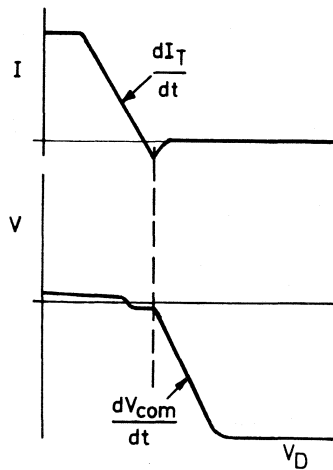
### COMMUTATION $dV_{com}/dt$

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 re-applied  $dV_D/dt$  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:

- R.M.S. current ( $I_T(RMS)$ ) – high currents make commutation harder.
- Re-applied off-state voltage ( $V_D$ ), normally  $V_{DRM}$  max. – high voltage will make commutation harder.
- Temperature ( $T_j$  or  $T_{mb}$ ) – high temperatures make commutation harder.
- $-dI/dt$  – 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 ( $\mu\text{F}$ )	R ( $\Omega$ )	C ( $\mu\text{F}$ )	R ( $\Omega$ )
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  $^{\circ}C/W$ ) analogous to the electric resistance ( $R$  in  $\Omega$ ).

Fig. 1 shows the heat path from junction to ambient as three thermal resistances in series:

- $R_{th\ j-mb}$  The thermal resistance from junction to mounting base. Its value is given in the data sheets of a device.
- $R_{th\ mb-h}$  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.
- $R_{th\ h-a}$  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:  $T_j - T_{amb} = P \times (R_{th\ j-mb} + R_{th\ mb-h} + R_{th\ h-a})$

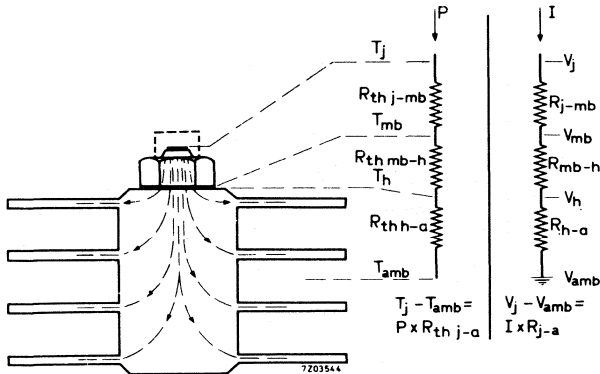


Fig. 1

## 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 and 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  $R_{thh-a}$  to keep the total thermal resistance below the maximum given for  $P$  and  $T_{amb}$ . A larger heatsink may be necessary.

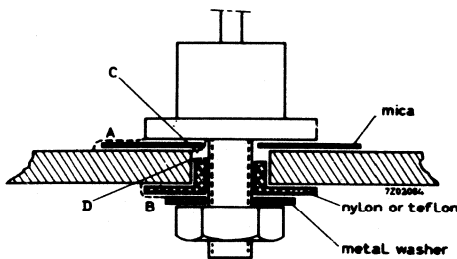


Fig. 2 Creepage distances with an insulated diode

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 heat-sink twice the length needed for a single diode.

Reverse polarity devices are convenient 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.

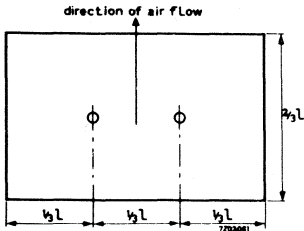


Fig. 3 Plain cooling fin with two diodes

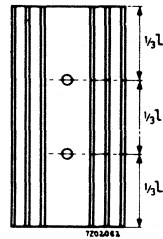


Fig. 4 Extruded aluminium heatsink with two diodes

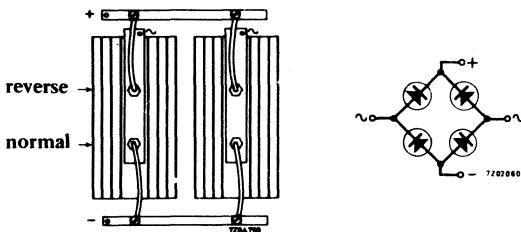


Fig. 5 Single phase full wave rectifier with diodes of different polarity on extruded aluminium heatsinks

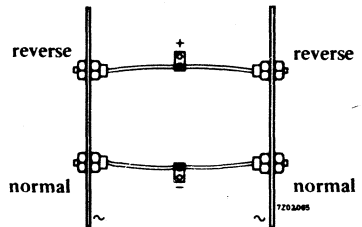


Fig. 6 Single phase full wave rectifier with diodes of different polarity on plain cooling fins (top view)

CONSTRUCTIONS (continued)

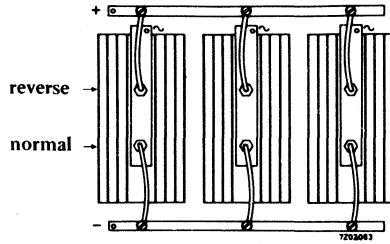


Fig. 7 Three phase full wave rectifier with diodes of different polarity on extruded aluminium heatsinks

EXAMPLES OF HEATSINK CALCULATION

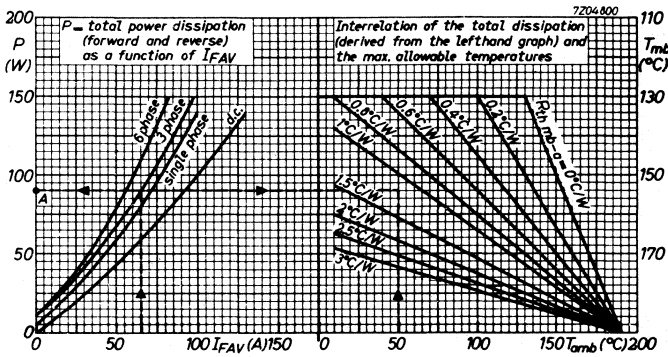
1. Devices without controlled avalanche properties.

Assume that the diode of which the outlines are shown, is used in a three phase 50 Hz rectifier circuit at  $T_{amb} = 50\text{ }^{\circ}\text{C}$ . Further assume: average forward current per diode  $I_{F(AV)} = 65\text{ A}$ ; contact thermal resistance  $R_{th\text{ mb-h}} = 0,1\text{ }^{\circ}\text{C/W}$ .



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

Type	Free convection	Forced cooling
flat, blackened	-	125 cm <sup>2</sup> ; 2 m/s or 300 cm <sup>2</sup> ; 1 m/s
flat, bright	-	175 cm <sup>2</sup> ; 2 m/s
diecast 56280	applicable	
extrusion		
56230 bright	$l = 12\text{ cm}$	$l = 5\text{ cm}^1$ ; 1 m/s
56230 blackened	$l = 8\text{ cm}$	$l = 5\text{ cm}^1$ ; 1 m/s
56231 bright	$l = 7\text{ cm}$	
56231 blackened	$l = 5\text{ cm}^1$	

<sup>1</sup>) Practical minimum length

## EXAMPLES OF HEATSINK CALCULATION (continued)

### 2. Devices with controlled avalanche properties

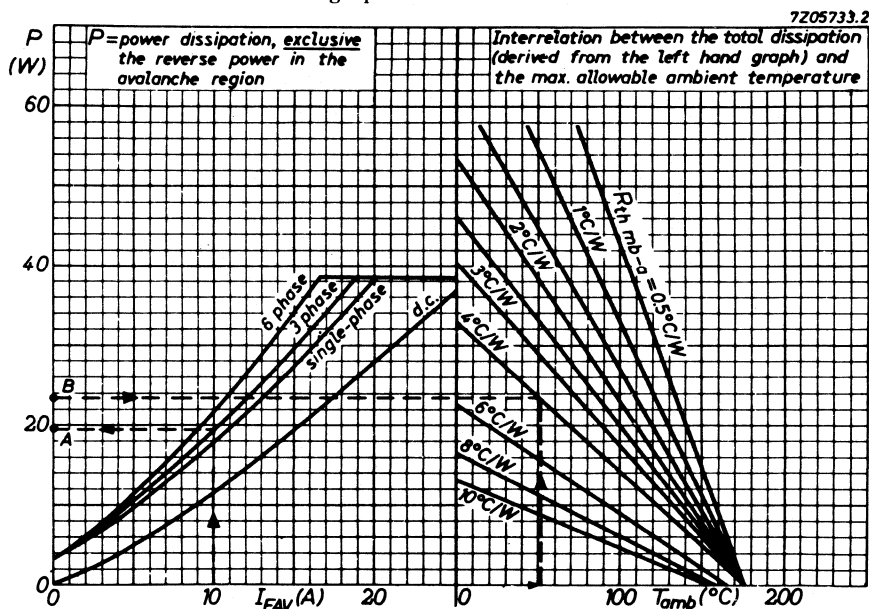
Assume that the diode of which the outlines are shown, is used in a three phase 50 Hz rectifier circuit at  $T_{amb} = 40^{\circ}\text{C}$ . Further assume: average forward current per diode  $I_{F(AV)} = 10\text{ A}$ ; contact thermal resistance:

$R_{th\ mb-h} = 0,5^{\circ}\text{C/W}$ ; repetitive peak reverse power in the avalanche region ( $t = 40\mu\text{s}$ )  $P_{RRM} = 2\text{ kW}$  (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  $P_{tot} = 19,5\text{ W}$  per diode (point A). The average reverse power in the avalanche region, averaged over any cycle, follows from

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

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

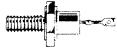
Therefore the total device power dissipation  $P_{tot} = 19,5 + 4 = 23,5\ \text{W}$  (point B). From the righthand graph it follows that  $R_{th\ mb-a} = 4^{\circ}\text{C/W}$ . Hence the heatsink thermal resistance should be:

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

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

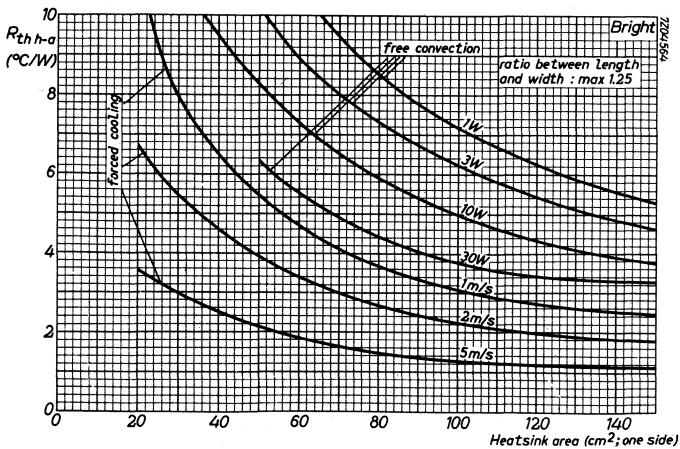
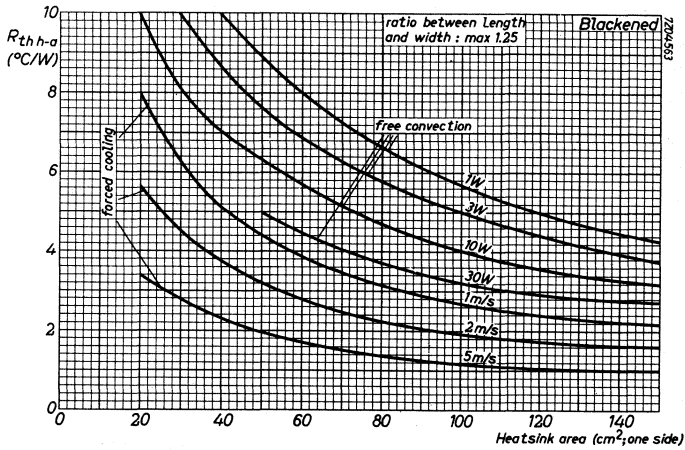
# Flat heatsink

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



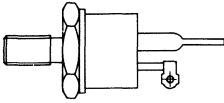
Studs: 10-32UNF

Mounting bases, across the flats: max. 11,0 mm

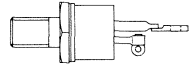


# Flat heatsink

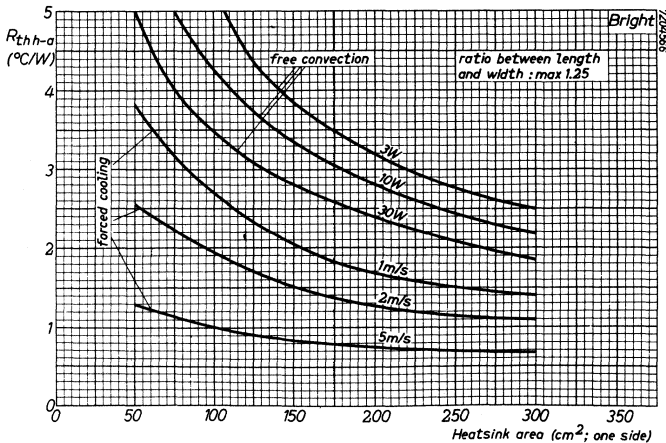
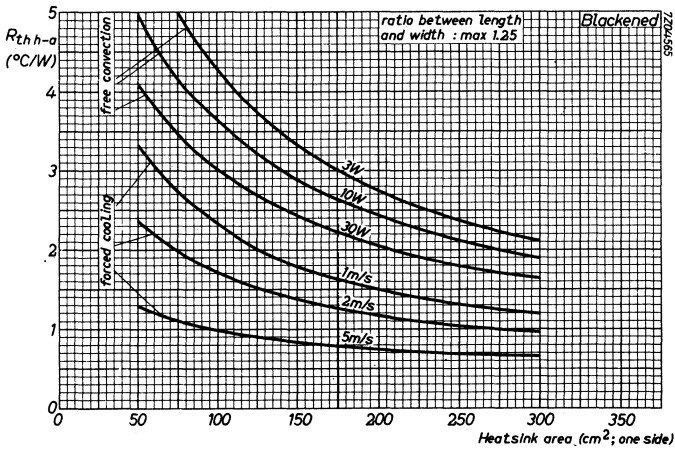
Thermal resistance of flat heatsinks of 2 mm copper or 3 mm aluminium.  
The graphs are valid for the combination of device and heatsink.



Stud: 1/4" x 28 UNF  
Mounting base, across the flats: max. 17 mm



Stud: M6  
Stud: 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.

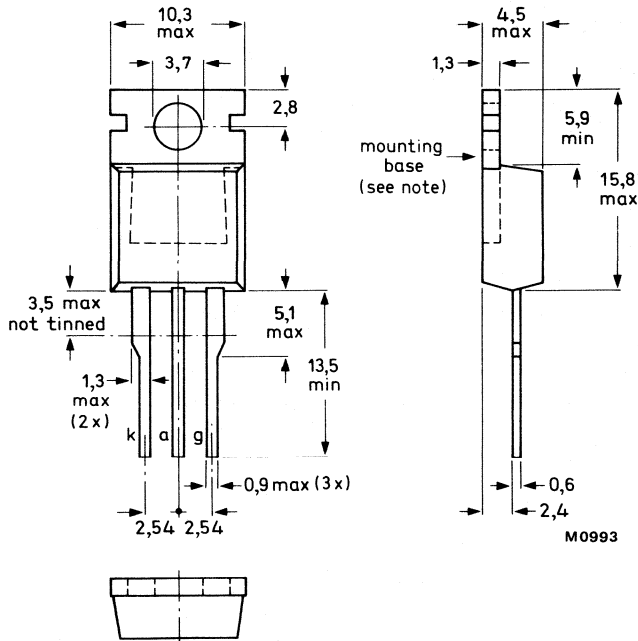
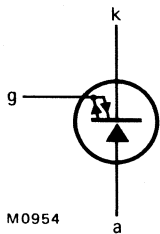
### QUICK REFERENCE DATA

			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)

			BT157-1300R	1500R		
<b>Anode to cathode</b>						
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 $T_{mb} = 80\text{ }^\circ\text{C}$						
	$I_{T(AV)}$	max.		3.2	A	
Controllable anode current						
	$I_{TCRM}$	max.		12	A	
Non-repetitive peak on-state current $t = 10\text{ ms}$ ; half-sinewave; $T_j = 120\text{ }^\circ\text{C}$ prior to surge						
	$I_{TSM}$	max.		20	A	
$I^2 t$ for fusing; $t = 10\text{ ms}$						
	$I^2 t$	max.		2	$\text{A}^2\text{s}$	
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$						
	$P_{tot}$	max.		47.5	W	
<b>Gate to cathode</b>						
Repetitive peak on-state current $T_j = 120\text{ }^\circ\text{C}$ prior to surge						
gate-cathode forward; $t = 1\text{ ms}$ ; half-sinewave						
	$I_{GFM}$	max.		25	A	
gate-cathode reverse; $t = 20\text{ }\mu\text{s}$						
	$I_{GRM}$	max.		15	A	
Average power dissipation (averaged over any 20 ms period)						
	$P_{G(AV)}$	max.		2.5	W	
<b>Temperatures</b>						
Storage temperature						
	$T_{stg}$			-40 to +150	$^\circ\text{C}$	
Operating junction temperature						
	$T_j$	max.		120	$^\circ\text{C}$	
<b>THERMAL RESISTANCE</b>						
From junction to mounting base						
	$R_{th\ j-mb}$	=		2.0	K/W	
From mounting base to heatsink with heatsink compound						
	$R_{th\ mb-h}$	=		0.3	K/W	
with 56367 alumina insulator and heatsink compound (clip-mounted)						
	$R_{th\ mb-h}$	=		0.8	K/W	
From junction to ambient in free air, mounted on a printed circuit board						
	$R_{th\ j-a}$	=		60	K/W	

\* Measured with gate-cathode connected together.

**CHARACTERISTICS**

**Anode to cathode**

On-state voltage $I_T = 2.5 \text{ A}; I_G = 0.2 \text{ A}; T_j = 120 \text{ }^\circ\text{C}$	$V_T$	<	3.4	V*
Rate of rise of off-state voltage that will not trigger any off-state device; exponential method $V_D = 2/3 V_{Dmax}; V_{GR} = 5 \text{ V}; T_j = 120 \text{ }^\circ\text{C}$	$dV_D/dt$	<	10	kV/ $\mu$ s
Rate of rise of off-state voltage that will not trigger any device following conduction; linear method; $I_T = 1.8 \text{ A}; V_D = V_{DRMmax}; V_{GR} = 10 \text{ V}; T_j = 120 \text{ }^\circ\text{C}$	$dV_D/dt$	<	1.5	kV/ $\mu$ s
Off-state current $V_D = V_{Dmax}; T_j = 120 \text{ }^\circ\text{C}$	$I_D$	<	2.0	mA
Latching current; $T_j = 25 \text{ }^\circ\text{C}$	$I_L$	typ.	0.75	A**
<b>Gate to cathode</b>				
Voltage that will trigger all devices $V_D = 12 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$	$V_{GT}$	>	1.5	V
Current that will trigger all devices $V_D = 12 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$	$I_{GT}$	>	200	mA
Minimum reverse breakdown voltage $I_{GRM} = 1.0 \text{ mA}$	$V_{(BR)GR}$	>	10	V

**Switching characteristics (resistive load)**

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

delay time  
rise time

$t_d$	<	0.25	$\mu$ s
$t_r$	<	1.0	$\mu$ s

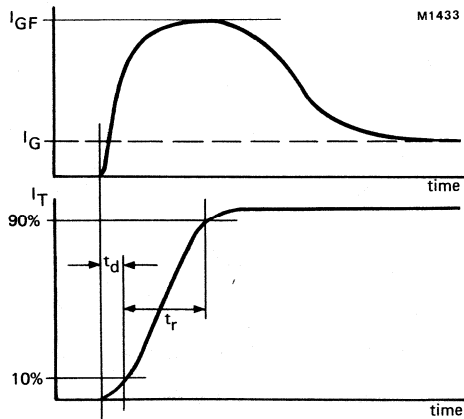


Fig.2 Waveforms

\* 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  $I_T = 2.5 \text{ A}$  to  $V_D = V_{DRM} \text{ max.}$   
 $V_{GR} = 10 \text{ V}$ ;  $L_G \leq 1.5 \mu\text{H}$ ;  $L_S \leq 0.25 \mu\text{H}$ ,  $T_j = 25 \text{ }^\circ\text{C}$

storage time	$t_s$	<	0.5	$\mu\text{s}$
fall time	$t_f$	<	0.20	$\mu\text{s}$
peak reverse gate current	$I_{GR}$	<	2.8	A

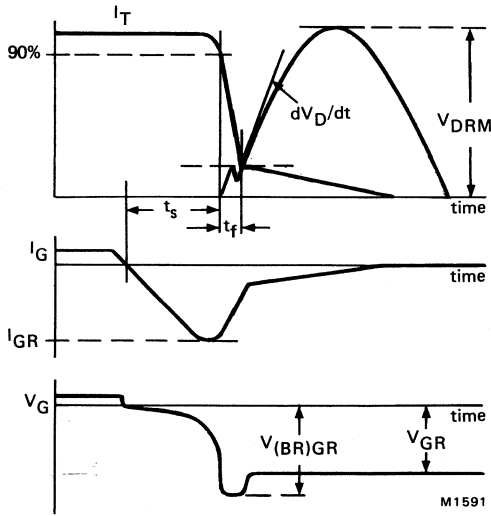


Fig.3 Waveforms

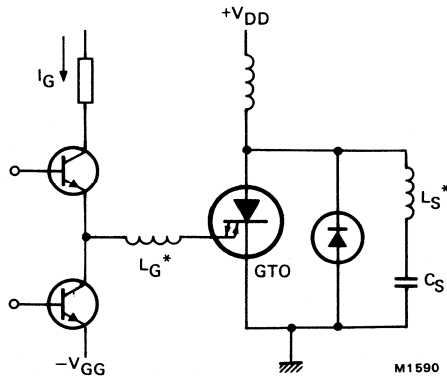


Fig.4 Inductive load test circuit

\* Indicates stray series inductance only.

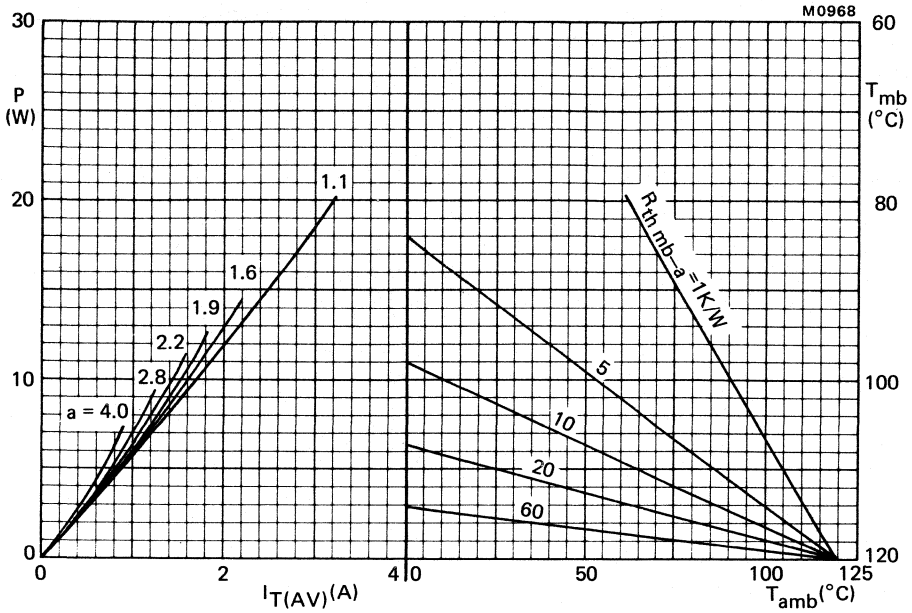


Fig.5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

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

P = Power excluding switching losses

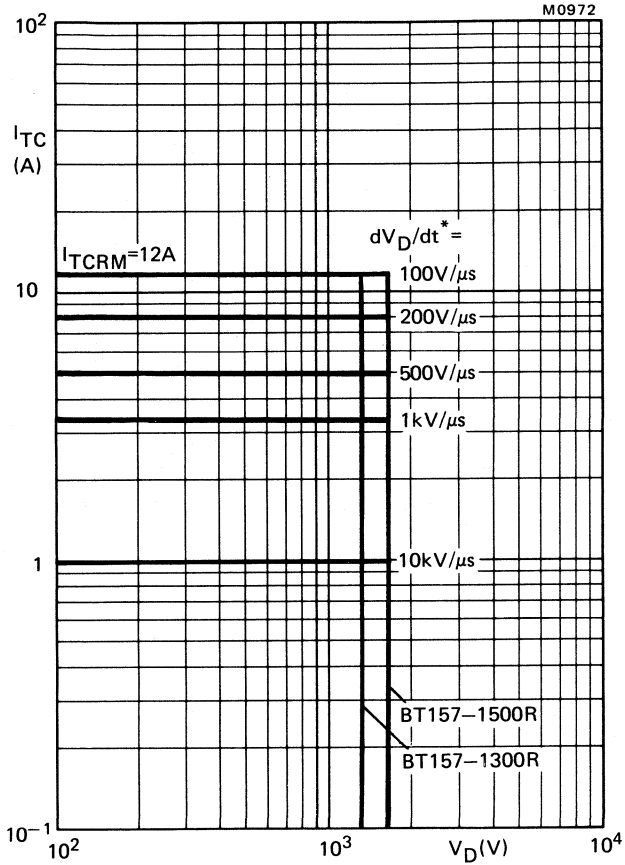


Fig.6 Anode current which can be turned off versus anode voltage;  
 inductive load,  $V_{GR} = 10 V$ ;  $L_G \leq 1.5 \mu H$ ;  $L_S \leq 0.25 \mu H$ ;  $T_j = 85^\circ C$   
 \* $dV_D/dt$  is calculated from  $I_T/C_S$ .

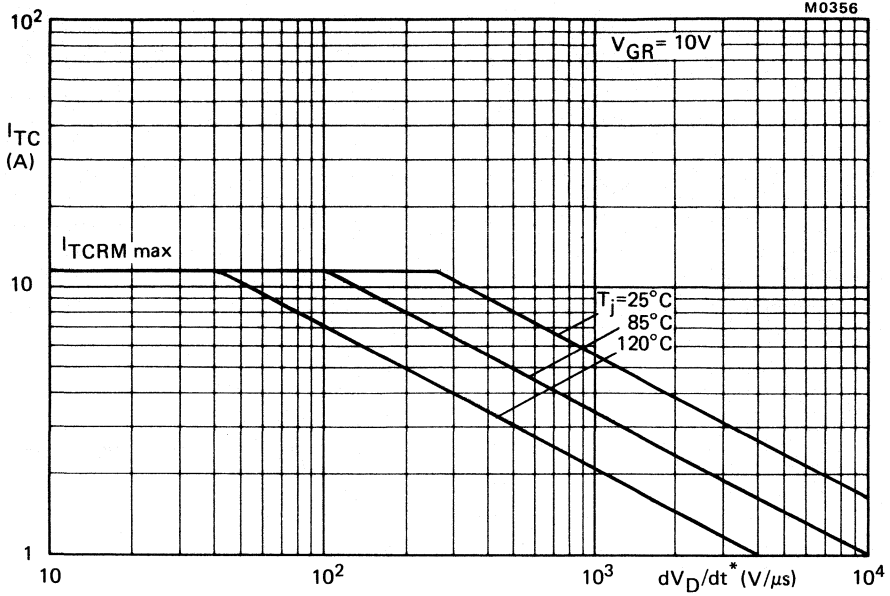


Fig. 7 Anode current which can be turned off versus applied  $dV_D/dt^*$ ; inductive load;  $V_{GR} = 10 \text{ V}$ ;  $L_G \leq 1.5 \mu\text{H}$ ;  $L_S \leq 0.25 \mu\text{H}$ ; \* $dV_D/dt$  is calculated from  $I_T/C_S$ .

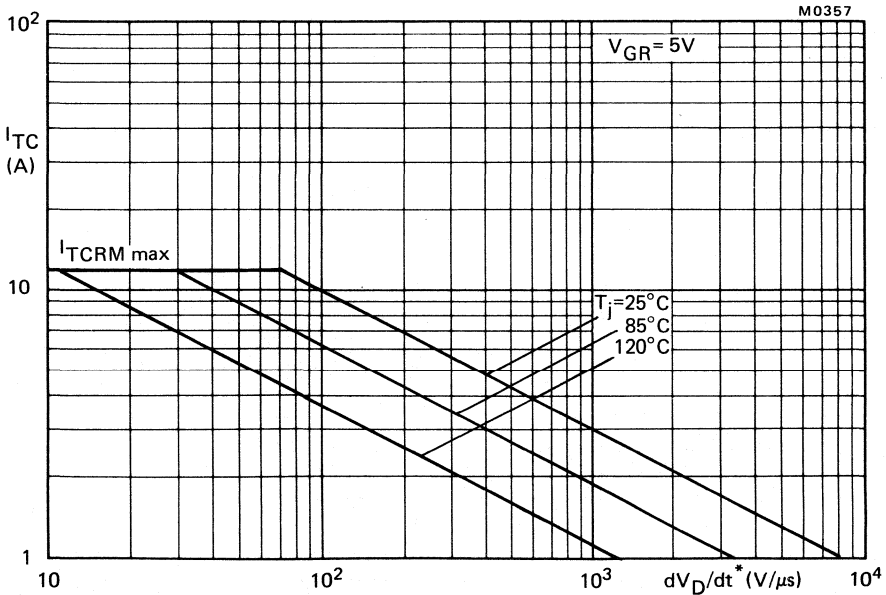


Fig. 8 Anode current which can be turned off versus applied  $dV_D/dt^*$ ; inductive load;  $V_{GR} = 5 \text{ V}$ .  $L_G \leq 1.5 \mu\text{H}$ ;  $L_S \leq 0.25 \mu\text{H}$ ; \* $dV_D/dt$  is calculated from  $I_T/C_S$ .

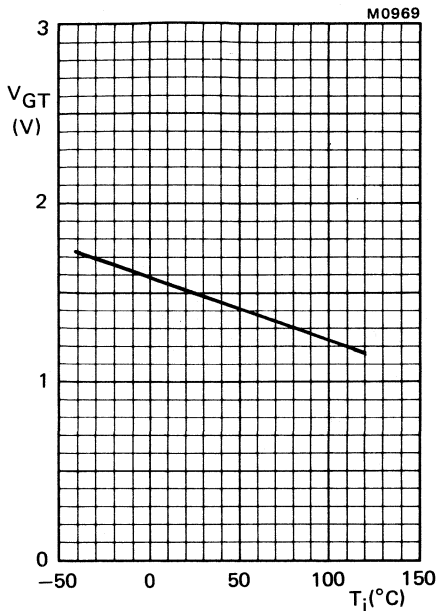


Fig.9 Minimum gate voltage that will trigger all devices as a function of junction temperature;  $V_D = 12$  V.

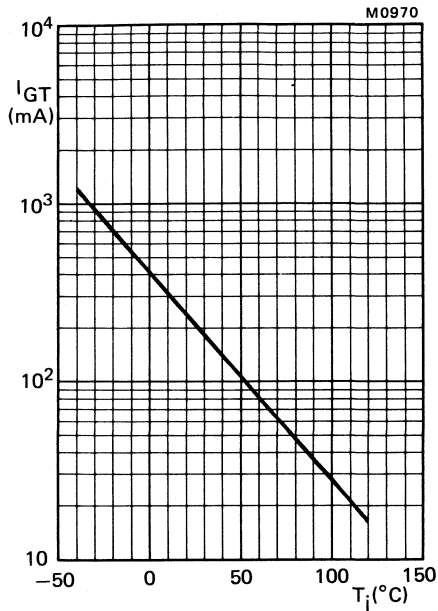


Fig.10 Minimum gate current that will trigger all devices as a function of junction temperature;  $V_D = 12$  V.

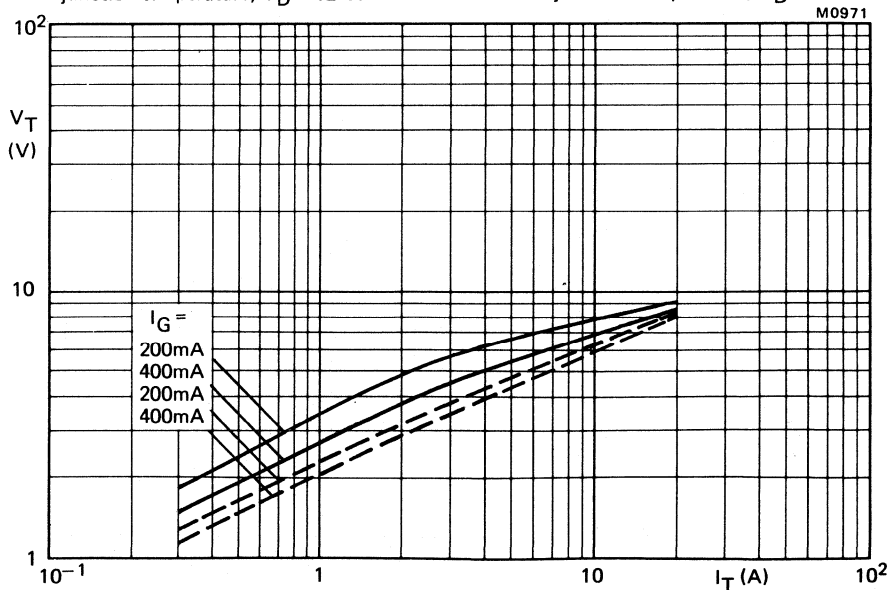


Fig.11 Maximum  $V_T$  versus  $I_T$ ; ———  $T_j = 25$  °C; - - -  $T_j = 120$  °C.



M0973

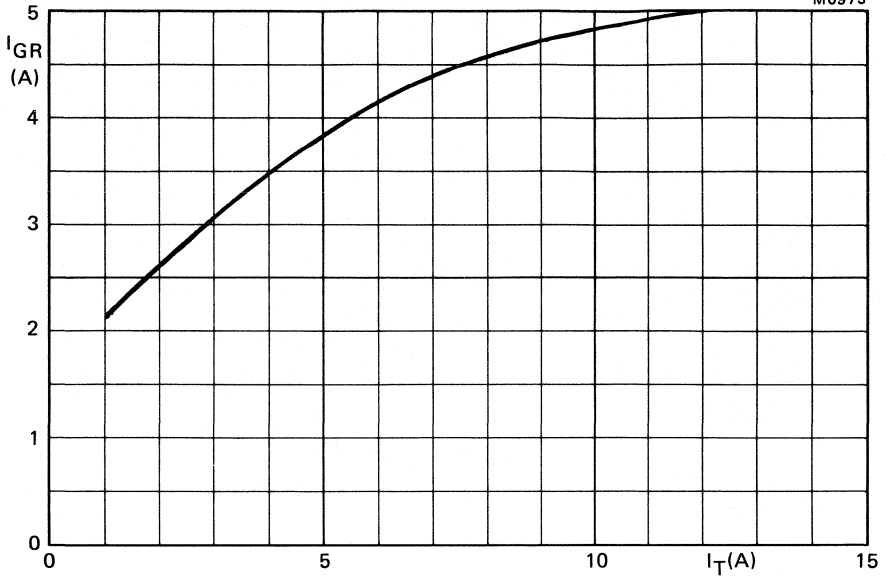


Fig.12 Peak reverse gate current versus anode current at turn-off; inductive load;  $V_{GR} = 10\text{ V}$ ;  $I_G = 0.2\text{ A}$ ;  $L_G = 0.8\text{ }\mu\text{H}$ ;  $T_j = 120\text{ }^\circ\text{C}$ ; maximum values.

M0974

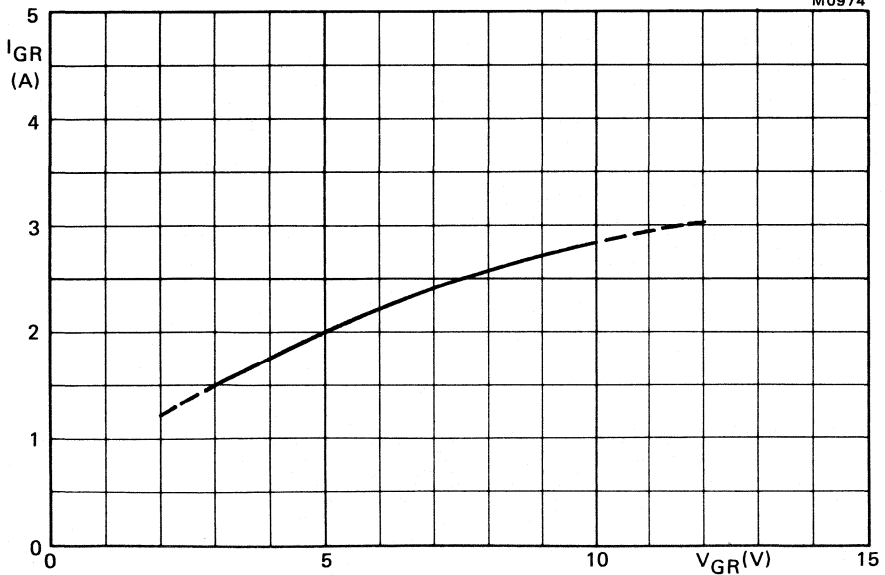


Fig.13 Peak reverse gate current versus applied gate voltage; inductive load;  $I_T = 2.5\text{ A}$ ;  $I_G = 0.2\text{ A}$ ;  $L_G = 0.8\text{ }\mu\text{H}$ ;  $T_j = 120\text{ }^\circ\text{C}$ ; maximum values.

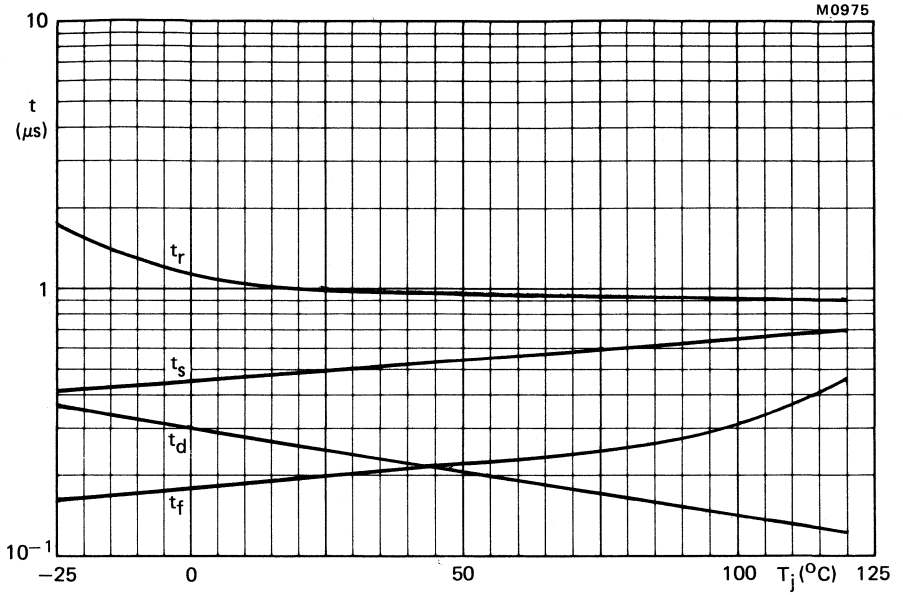


Fig.14 Switching times as a function of junction temperature;  $V_D \geq 250$  V;  $I_T = 2.5$  A;  $I_{GF} = 0.4$  A;  $I_G = 0.2$  A;  $V_{GR} = 10$  V;  $L_G = 0.8 \mu\text{H}$ ; maximum values.

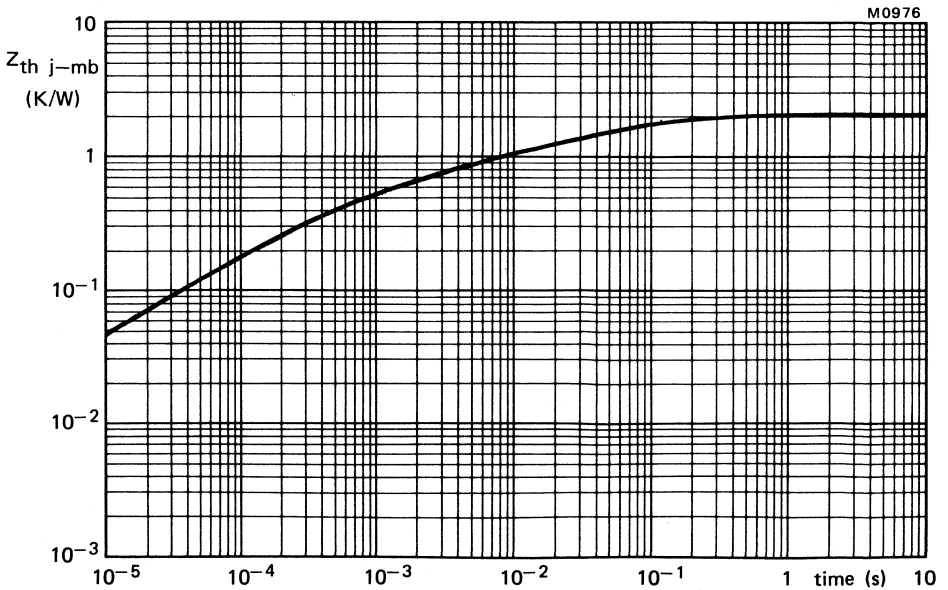


Fig.15 Transient thermal impedance.

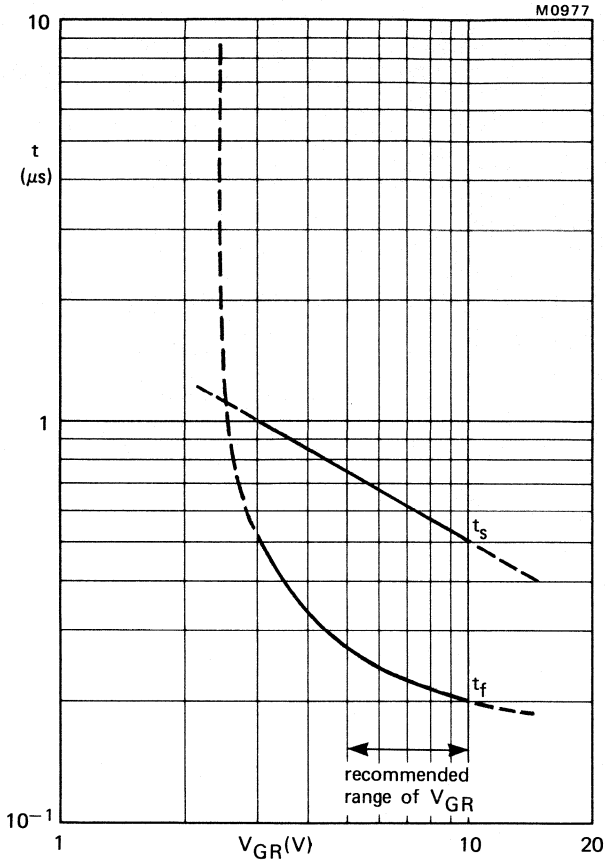


Fig. 16 Storage and fall times versus applied reverse gate voltage; inductive load;  $I_T = 2.5$  A;  $L_G = 0.8 \mu H$ ;  $I_G = 0.2$  A;  $T_j = 25$  °C; maximum values.

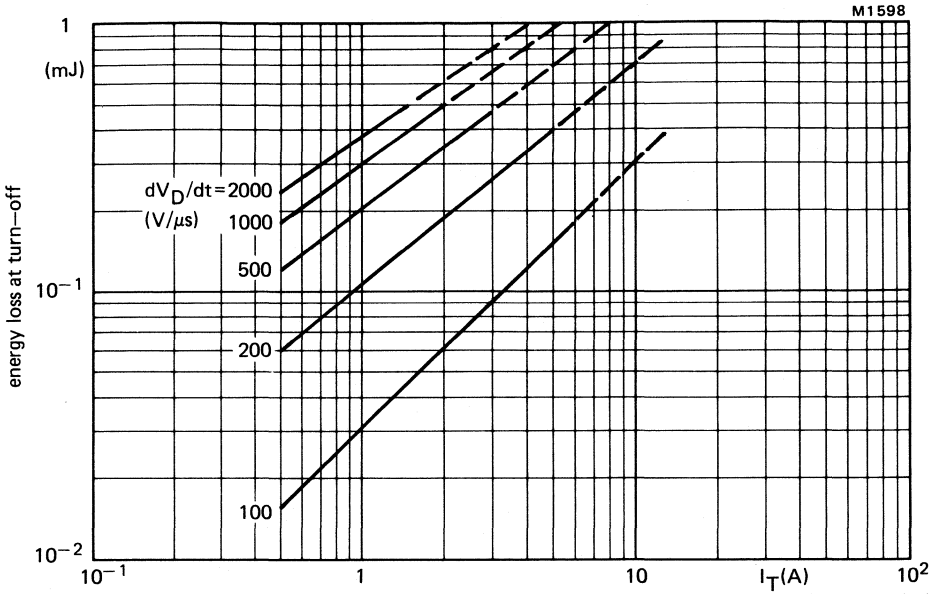


Fig.17 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied  $dV_D/dt$  (calculated from  $I_T/C_S$ ); reapplied voltage sinusoidal up to  $V_{DRM} = 1200$  V;  $V_{GR} = 10$  V;  $I_G = 0.2$  A;  $L_G \leq 1.5 \mu H$ ;  $L_S \leq 0.25 \mu H$ ;  $T_j = 120$  °C.

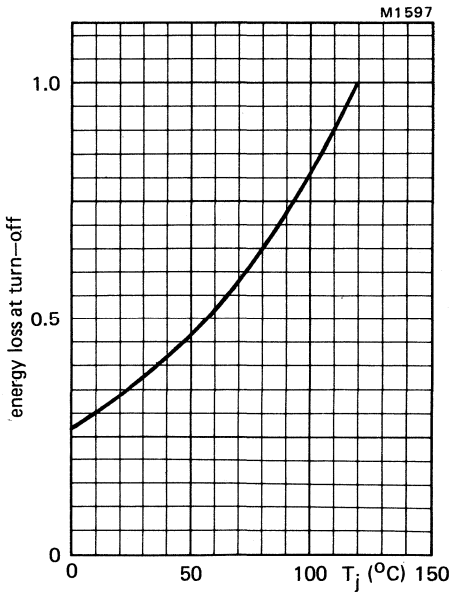


Fig.18 Energy loss at turn off as a function of junction temperature;  $I_G = 0.2$  A;  $V_{GR} = 10$  V. Normalised to  $T_j = 120$  °C.

# DEVELOPMENT DATA

This data sheet contains advance information and specifications are subject to change without notice.

# BTR59 SERIES

## 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.

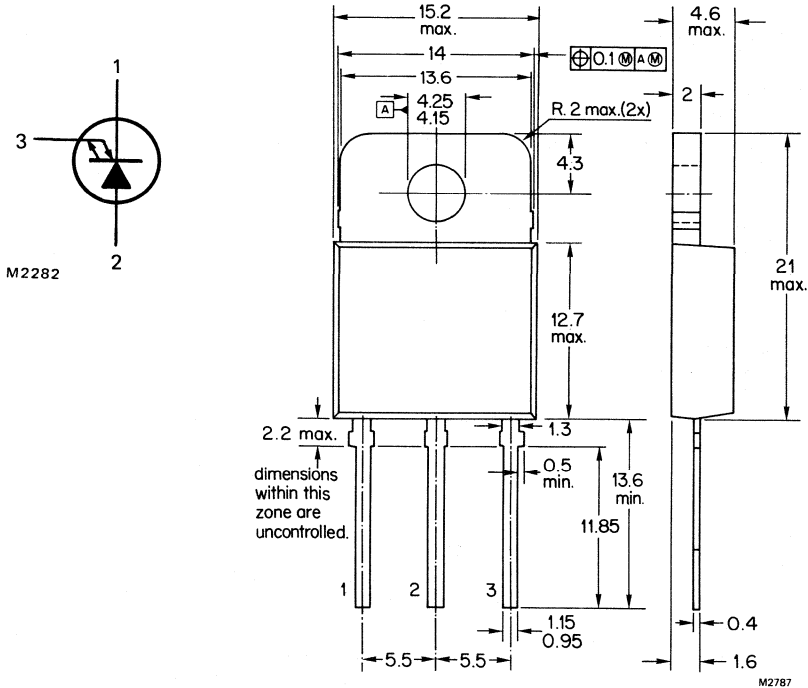
### QUICK REFERENCE DATA

		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		$\mu s$

### 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).

		BTR59-800R		1300R	
<b>Anode to cathode</b>					
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 $T_{mb} = 85\text{ }^\circ\text{C}$	$I_{T(AV)}$	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 $t = 10\text{ ms}$ ; half-sinewave; $T_j = 120\text{ }^\circ\text{C}$ prior to surge	$I_{TSM}$	max.	100		A
$I^2 t$ for fusing; $t = 10\text{ ms}$	$I^2 t$	max.	50		A <sup>2</sup> s
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	105		W
<b>Gate to cathode</b>					
Repetitive peak current $T_j = 120\text{ }^\circ\text{C}$ prior to surge gate-cathode forward; $t = 10\text{ ms}$ ; half-sinewave	$I_{GFM}$	max.	25		A
gate-cathode reverse; $t = 20\text{ }\mu\text{s}$	$I_{GRM}$	max.	25		A
Average power dissipation (averaged over any 20 ms period)	$P_G(AV)$	max.	5.0		W
<b>Temperatures</b>					
Storage temperature	$T_{stg}$		-40 to +125		$^\circ\text{C}$
Operating junction temperature	$T_j$	max.	120		$^\circ\text{C}$
<b>THERMAL RESISTANCE</b>					
From mounting base to heatsink; with heatsink compound	$R_{th\text{ mb-h}}$	=	0.2		K/W
From junction to mounting base	$R_{th\text{ j-mb}}$	=	0.9		K/W

\*Measured with gate-cathode connected together.

**CHARACTERISTICS**

**Anode to cathode**

On-state voltage

$I_T = 10 \text{ A}; I_G = 0.5 \text{ A}; T_j = 120 \text{ }^\circ\text{C}$   $V_T < 3.0 \text{ V}^*$

Rate of rise of off-state voltage that will not trigger any off-state device; exponential method

$V_D = 2/3 V_{Dmax}; V_{GR} = 5 \text{ V}; T_j = 120 \text{ }^\circ\text{C}$   $dV_D/dt < 10 \text{ kV}/\mu\text{s}$

Rate of rise of off-state voltage that will not trigger any device following conduction, linear method

$I_T = 20 \text{ A}; V_D = V_{DRMmax}; V_{GR} = 10 \text{ V}; T_j = 120 \text{ }^\circ\text{C}$   $dV_D/dt < 1.0 \text{ kV}/\mu\text{s}$

Off-state current

$V_D = V_{Dmax}; T_j = 120 \text{ }^\circ\text{C}$   $I_D < 5.0 \text{ mA}$

Latching current;  $T_j = 25 \text{ }^\circ\text{C}$

$I_L \text{ typ. } 1.5 \text{ A}^{**}$

**Gate to cathode**

Voltage that will trigger all devices

$V_D = 12 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$   $V_{GT} > 1.5 \text{ V}$

Current that will trigger all devices

$V_D = 12 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$   $I_{GT} > 500 \text{ mA}$

Minimum reverse breakdown voltage

$I_{GR} = 1.0 \text{ mA}$   $V_{(BR)GR} > 10 \text{ V}$

**Switching characteristics (resistive load)**

Turn-on when switched to  $I_T = 10 \text{ A}$  from  $V_D = 250 \text{ V}$  with  $I_{GF} = 2.5 \text{ A}; T_j = 25 \text{ }^\circ\text{C}$

delay time  $t_d < 0.3 \text{ } \mu\text{s}$

rise time  $t_r < 1.5 \text{ } \mu\text{s}$

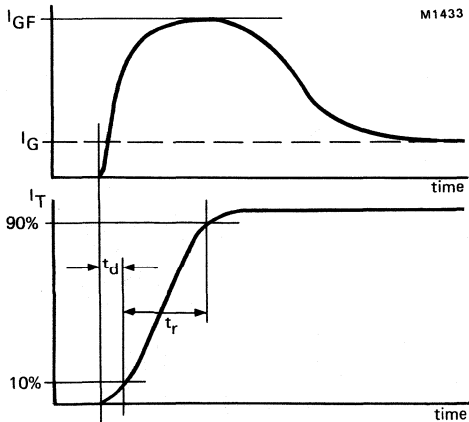


Fig.2 Waveforms.

\*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  $I_T = 10\text{ A}$  to  $V_D = V_{D\text{max}}$ :

$V_{GR} = 10\text{ V}$ ;  $L_G \leq 0.5\ \mu\text{H}$ ;  $L_S \leq 0.25\ \mu\text{H}$ ;  $C_S \geq 20\ \text{nF}$ ;  $T_j = 85\text{ }^\circ\text{C}$

storage time	$t_s$	<	0.60	$\mu\text{s}$
fall time	$t_f$	<	0.25	$\mu\text{s}$
peak reverse gate current	$I_{GR}$	<	10	A

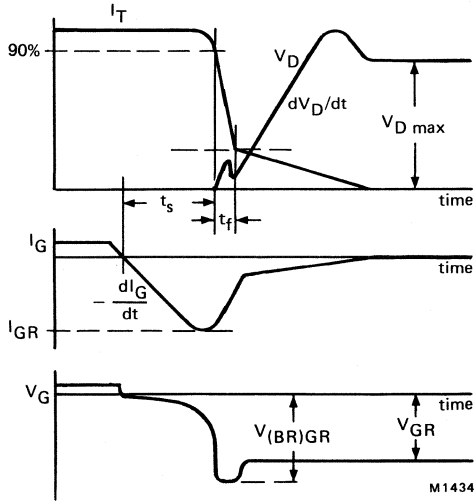


Fig.3 Waveforms.

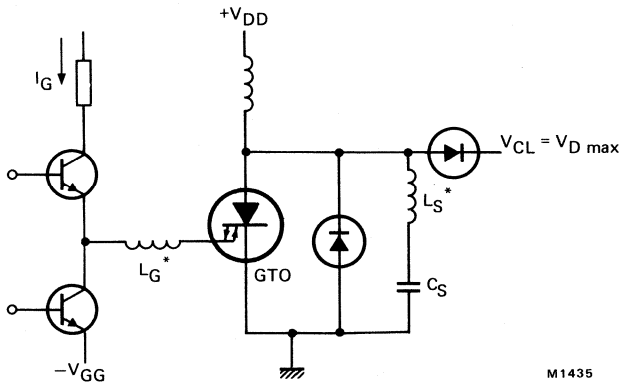


Fig.4 Inductive load test circuit.

\*Indicates stray series inductance only.

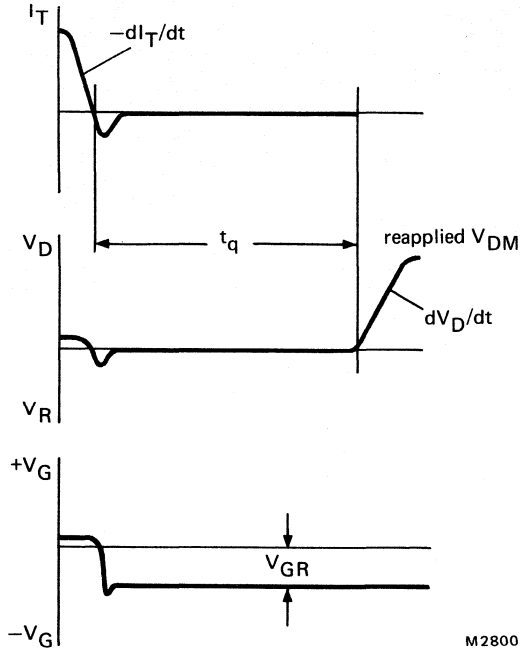


Switching characteristics (circuit-commutated)\*

Turn-off time

$I_T = 50 \text{ A}$ ;  $-di_T/dt = 10 \text{ A}/\mu\text{s}$ ;  $dV_D/dt = 200 \text{ V}/\mu\text{s}$ ;  
 $V_{GR} = 5 \text{ V}$ ;  $T_j = 120 \text{ }^\circ\text{C}$

$t_q < 1.0 \mu\text{s}$



M2800

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

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

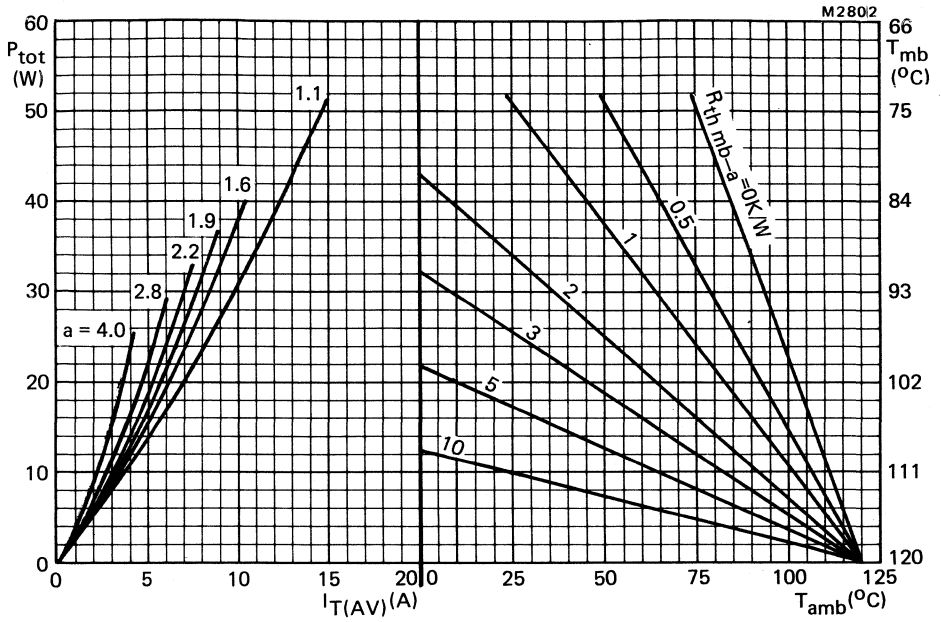


Fig.6 The right hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

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

P = power excluding switching losses.

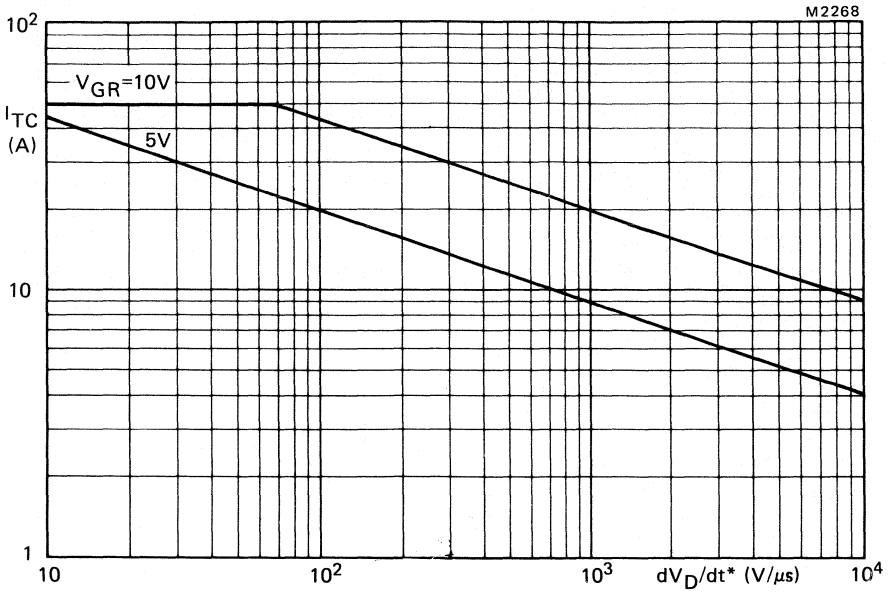


Fig.7 Anode current which can be turned off versus applied  $dV_D/dt^*$ ; inductive load;  $L_G \leq 0.5 \mu H$ ;  $L_S \leq 0.25 \mu H$ ;  $T_j = 120 \text{ }^\circ\text{C}$ .

\* $dV_D/dt$  is calculated from  $I_T/C_S$ .

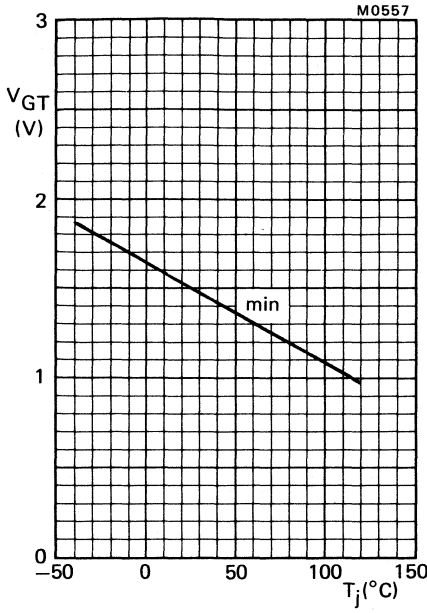


Fig.8 Minimum gate voltage that will trigger all devices as a function of junction temperature;  $V_D = 12$  V.

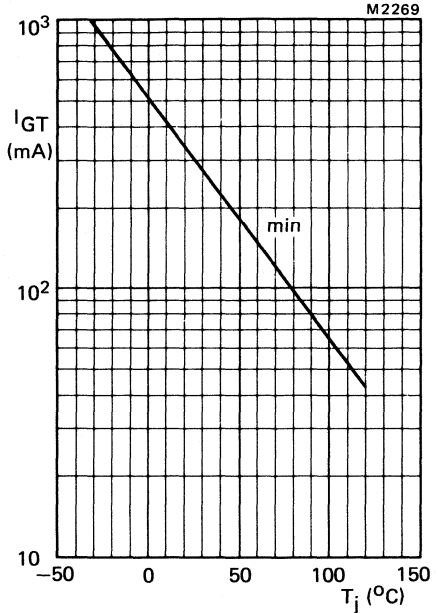


Fig.9 Minimum gate current that will trigger all devices as a function of junction temperature;  $V_D = 12$  V.

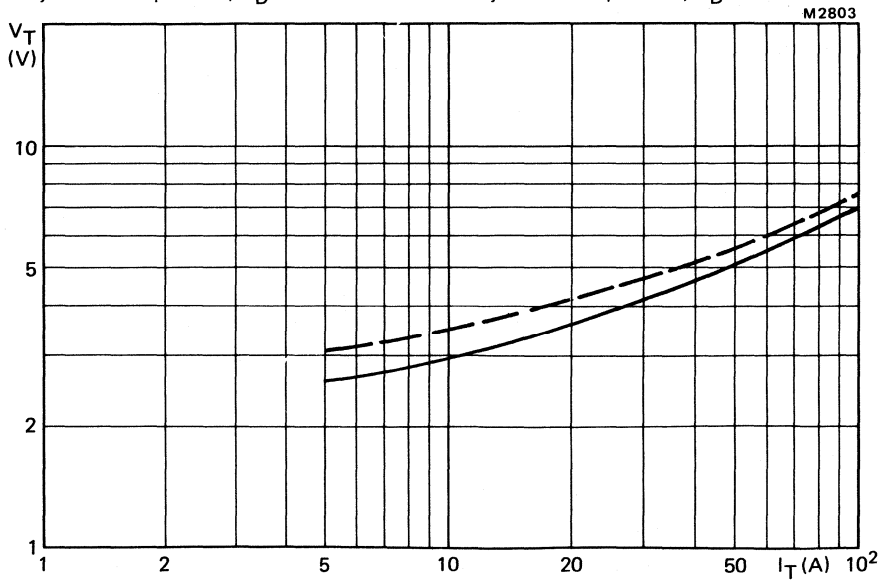


Fig.10 Maximum  $V_T$  versus  $I_T$ ; ---  $T_j = 25$  °C; —  $T_j = 120$  °C;  $I_G = 0.5$  A.

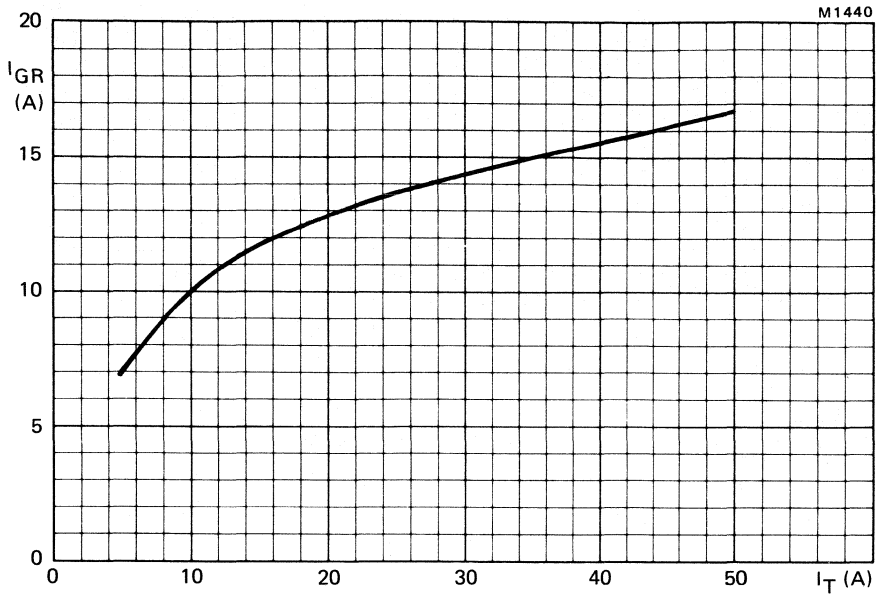


Fig. 11 Peak reverse gate current versus anode current at turn-off; inductive load;  
 $V_{GR} = 10 \text{ V}$ ;  $I_G = 0.5 \text{ A}$ ;  $L_G = 0.4 \mu\text{H}$ ;  $T_j = 120 \text{ }^\circ\text{C}$ ; maximum values.

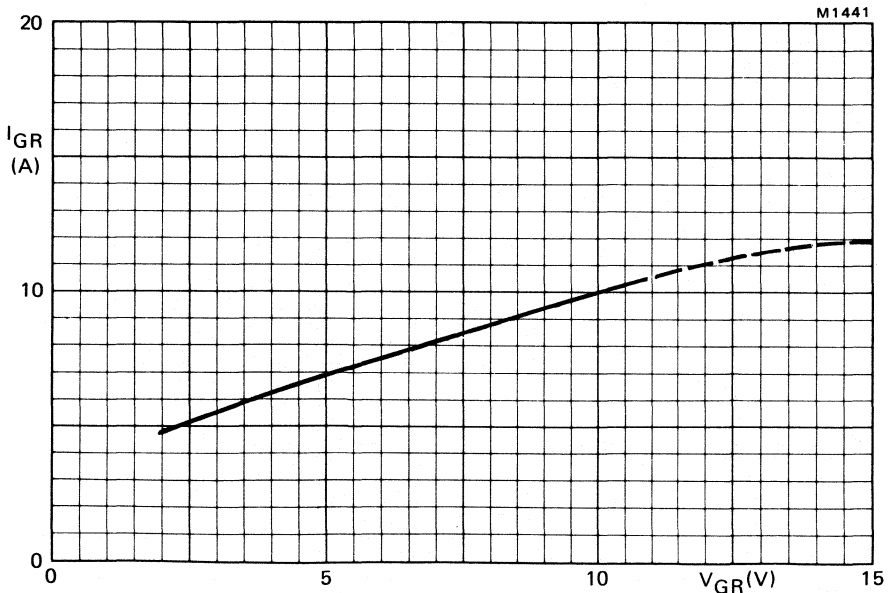


Fig. 12 Peak reverse gate current versus applied reverse gate voltage; inductive load;  
 $I_T = 10 \text{ A}$ ;  $I_G = 0.5 \text{ A}$ ;  $L_G = 0.4 \mu\text{H}$ ;  $T_j = 120 \text{ }^\circ\text{C}$ ; maximum values.

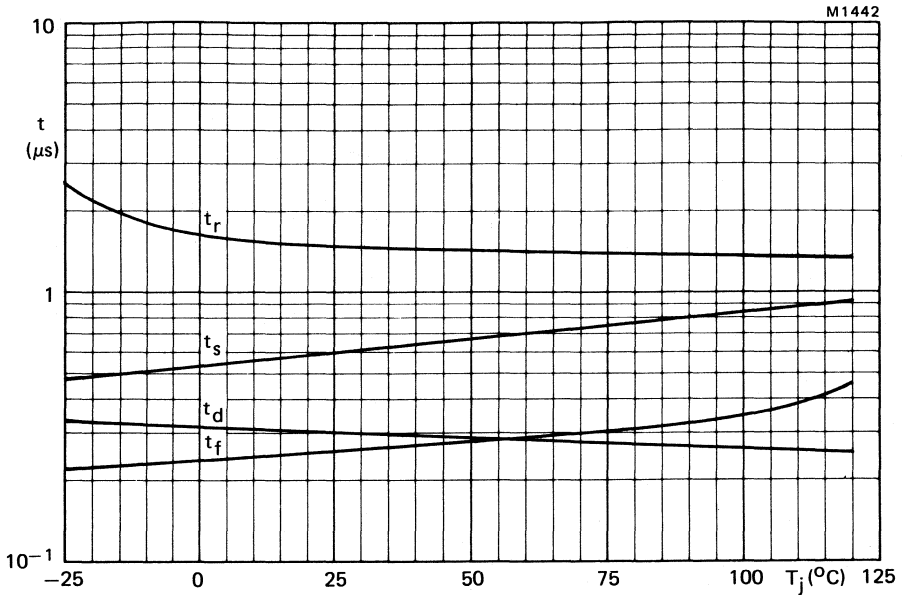


Fig.13 Switching times as a function of junction temperature;  $V_D \geq 250 \text{ V}$ ;  $I_T = 10 \text{ A}$ ;  $I_{GF} = 1.0 \text{ A}$ ;  $V_{GR} = 10 \text{ V}$ ;  $I_G = 0.5 \text{ A}$ ;  $L_G = 0.4 \mu\text{H}$ ; maximum values.

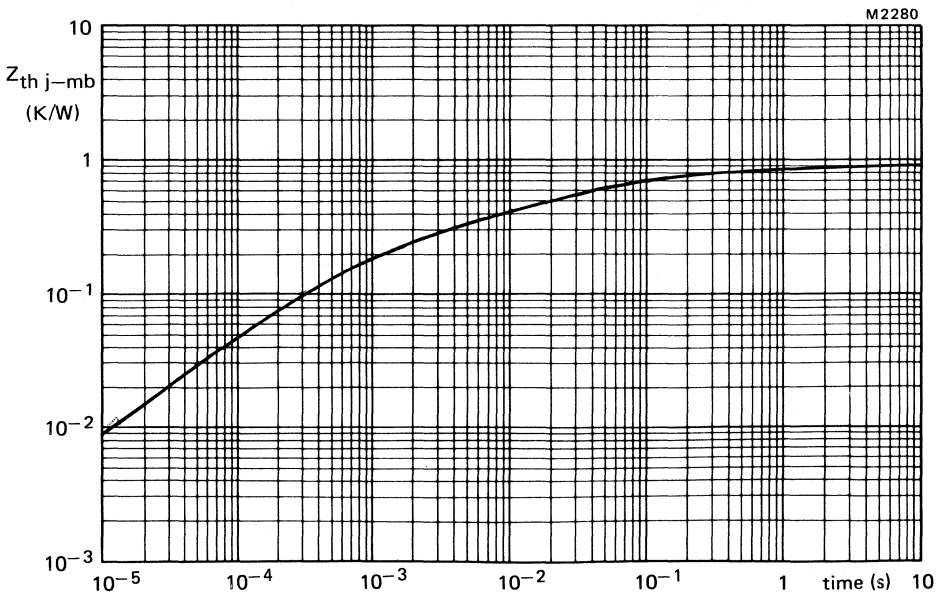


Fig.14 Transient thermal impedance.

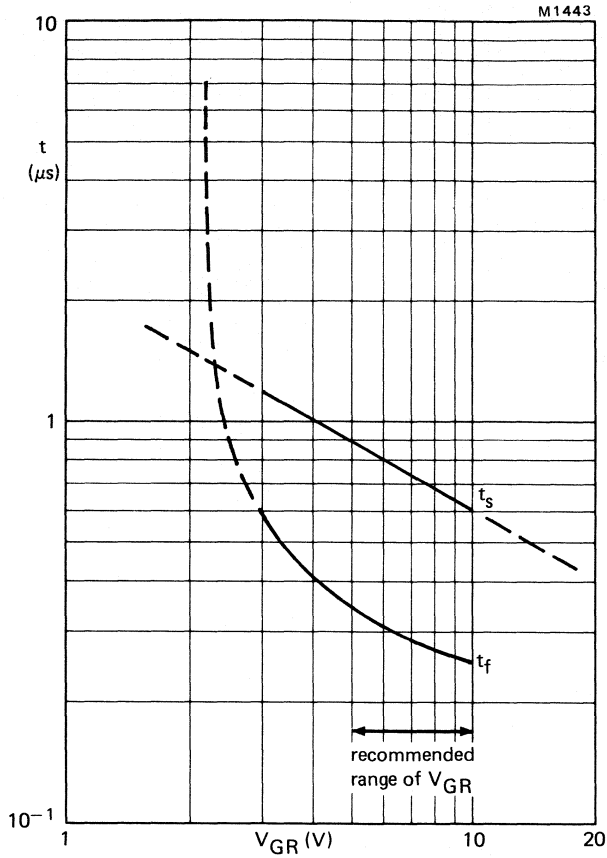


Fig. 15 Storage and fall times versus applied reverse gate voltage; inductive load,  $I_T = 10$  A;  $I_G = 0.5$  A;  $L_G = 0.4$   $\mu H$ ;  $T_j = 25$   $^{\circ}C$ ; maximum values.

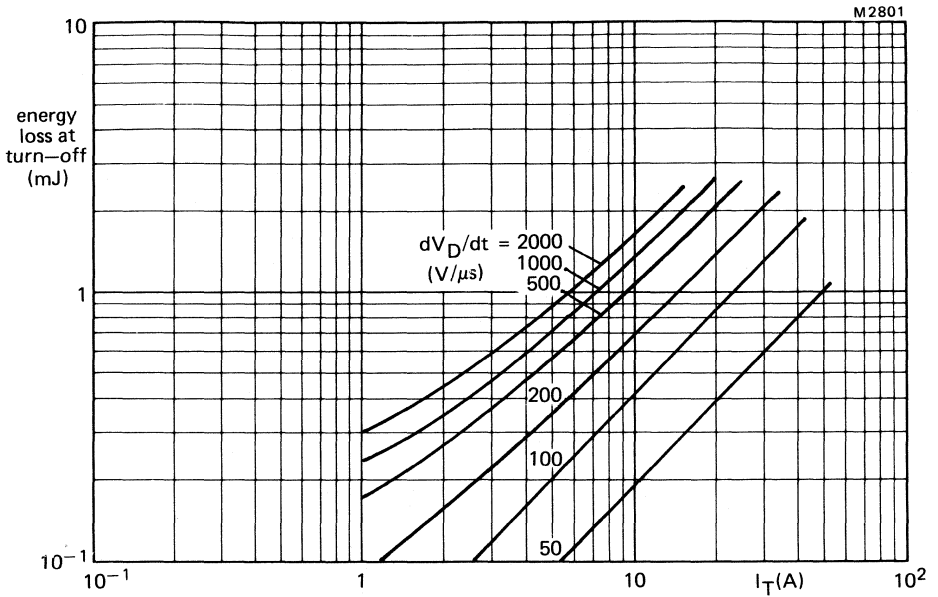


Fig. 16 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied  $dV_D/dt$  (calculated from  $I_T/C_S$ );  $dV_D/dt$  linear up to  $V_D = V_{DWmax}$ ;  $V_{GR} = 10$  V;  $I_G = 0.5$  A;  $L_G < 0.5$   $\mu$ H;  $L_S < 0.25$   $\mu$ H;  $T_j = 120$  °C.

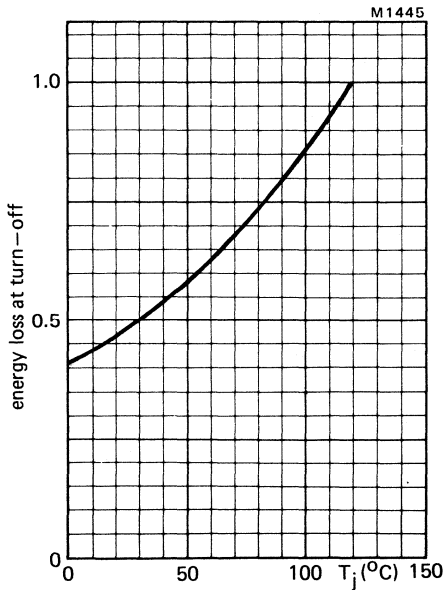


Fig. 17 Energy loss at turn-off as a function of junction temperature;  $I_G = 0.5$  A;  $V_{GR} = 10$  V. Normalised to  $T_j = 120$  °C.



## FAST GATE TURN-OFF THYRISTORS

Thyristors in 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.

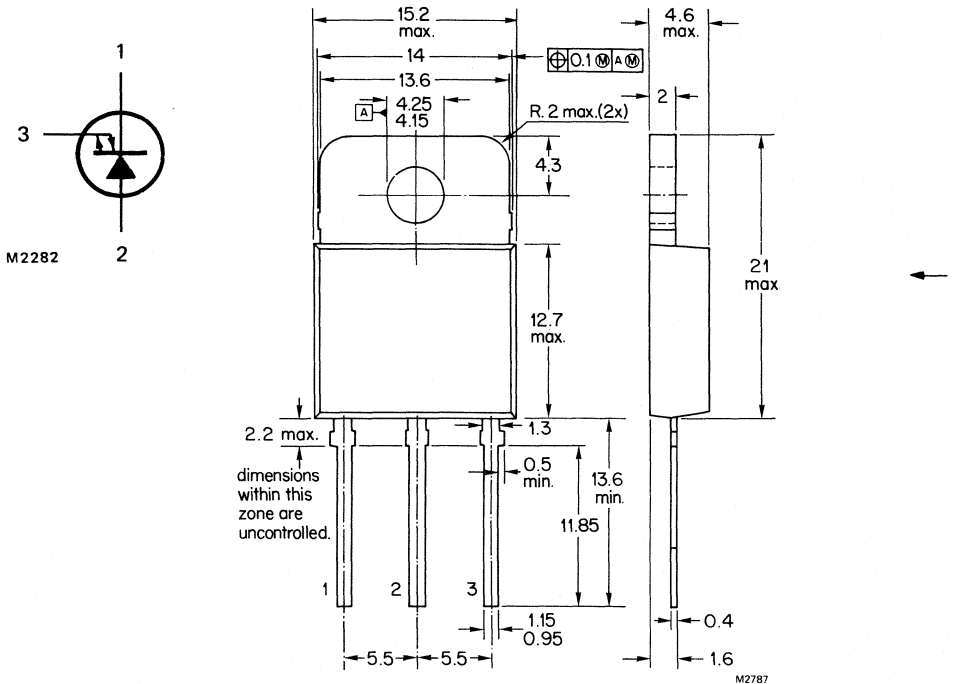
### QUICK REFERENCE DATA

		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 $T_{mb} = 85^\circ\text{C}$					
Controllable anode current	$I_T(AV)$	max.	15		A
Non-repetitive peak on-state current t = 10 ms; half-sinewave; $T_j = 120^\circ\text{C}$ prior to surge	$I_{TCRM}$	max.	50		A
$I^2 t$ for fusing; t = 10 ms	$I_{TSM}$	max.	100		A
Total power dissipation up to $T_{mb} = 25^\circ\text{C}$	$I^2 t$	max.	50		A <sup>2</sup> s
	$P_{tot}$	max.	105		W
<b>Gate to cathode</b>					
Repetitive peak current $T_j = 120^\circ\text{C}$ prior to surge					
gate-cathode forward; t = 10 ms; half-sinewave	$I_{GFM}$	max.	25		A
gate-cathode reverse; t = 20 $\mu\text{s}$	$I_{GRM}$	max.	25		A
Average power dissipation (averaged over any 20 ms period)	$P_G(AV)$	max.	5.0		W
<b>Temperatures</b>					
Storage temperature	$T_{stg}$		-40 to +125		$^\circ\text{C}$
Operating junction temperature	$T_j$	max.	120		$^\circ\text{C}$
<b>THERMAL RESISTANCE</b>					
From mounting base to heatsink; with heatsink compound	$R_{th\ mb-h}$	=	0.2		K/W
From junction to mounting base	$R_{th\ j-mb}$	=	0.9		K/W

\* Measured with gate-cathode connected together.

**CHARACTERISTICS**

**Anode to cathode**

On-state voltage

$I_T = 10 \text{ A}; I_G = 0.5 \text{ A}; T_j = 120 \text{ }^\circ\text{C}$   $V_T < 2.3 \text{ V}^*$

Rate of rise of off-state voltage that will not trigger any off-state device; exponential method

$V_D = 2/3 V_{Dmax}; V_{GR} = 5 \text{ V}; T_j = 120 \text{ }^\circ\text{C}$   $dV_D/dt < 10 \text{ kV}/\mu\text{s}$

Rate of rise of off-state voltage that will not trigger any device following conduction, linear method

$I_T = 20 \text{ A}; V_D = V_{DRMmax}; V_{GR} = 10 \text{ V}; T_j = 120 \text{ }^\circ\text{C}$   $dV_D/dt < 1.0 \text{ kV}/\mu\text{s}$

Off-state current.

$V_D = V_{Dmax}; T_j = 120 \text{ }^\circ\text{C}$   $I_D < 5.0 \text{ mA}$

Latching current;  $T_j = 25 \text{ }^\circ\text{C}$

$I_L \text{ typ. } 1.5 \text{ A}^{**}$

**Gate to cathode**

Voltage that will trigger all devices

$V_D = 12 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$   $V_{GT} > 1.5 \text{ V}$

Current that will trigger all devices

$V_D = 12 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$   $I_{GT} > 300 \text{ mA}$

Minimum reverse breakdown voltage

$I_{GR} = 1.0 \text{ mA}$   $V_{(BR)GR} > 10 \text{ V}$

**Switching characteristics (resistive load)**

Turn-on when switched to  $I_T = 10 \text{ A}$  from  $V_D = 250 \text{ V}$  with  $I_{GF} = 1.5 \text{ A}; T_j = 25 \text{ }^\circ\text{C}$

delay time  $t_d < 0.3 \mu\text{s}$   
 rise time  $t_r < 1.5 \mu\text{s}$

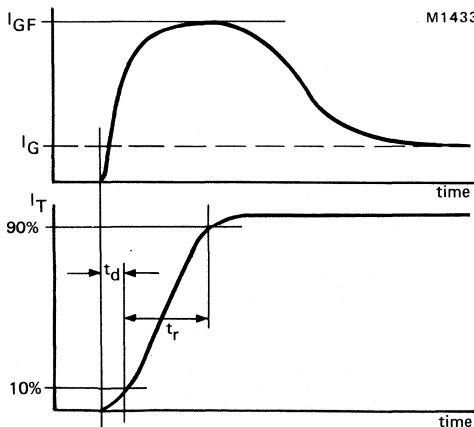


Fig.2 Waveforms

\* 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  $I_T = 10\text{ A}$  to  $V_D = V_{Dmax}$ :

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

storage time	$t_s$	<	0.60	$\mu\text{s}$
fall time	$t_f$	<	0.25	$\mu\text{s}$
peak reverse gate current	$I_{GR}$	<	10	A

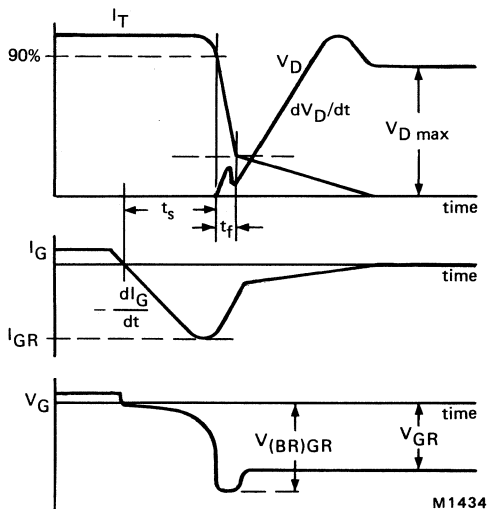


Fig.3 Waveforms.

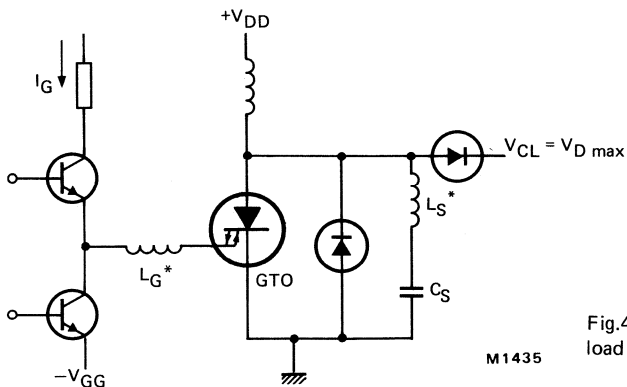


Fig.4 Inductive load test circuit.

\*Indicates stray series inductance only

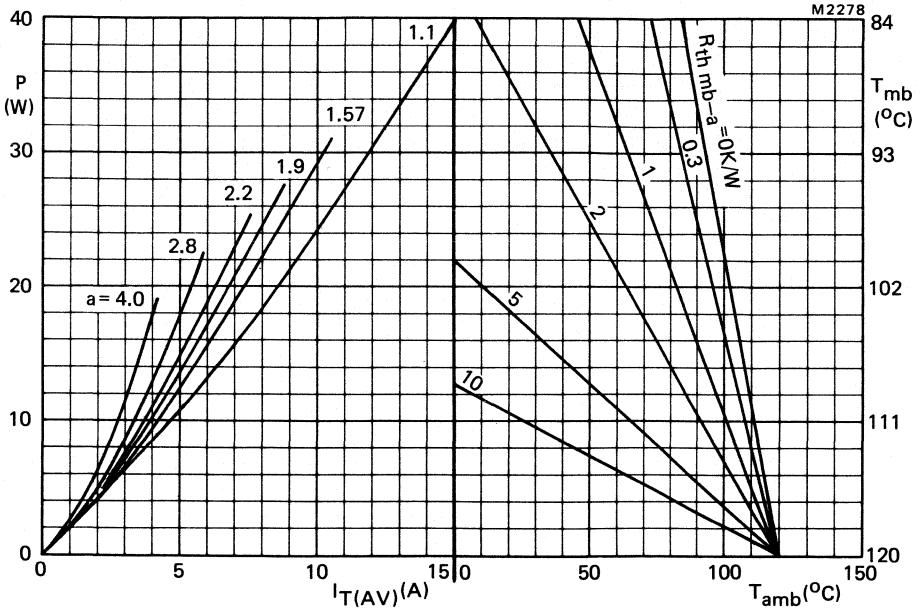


Fig.5 The right hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

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

P = power excluding switching losses.

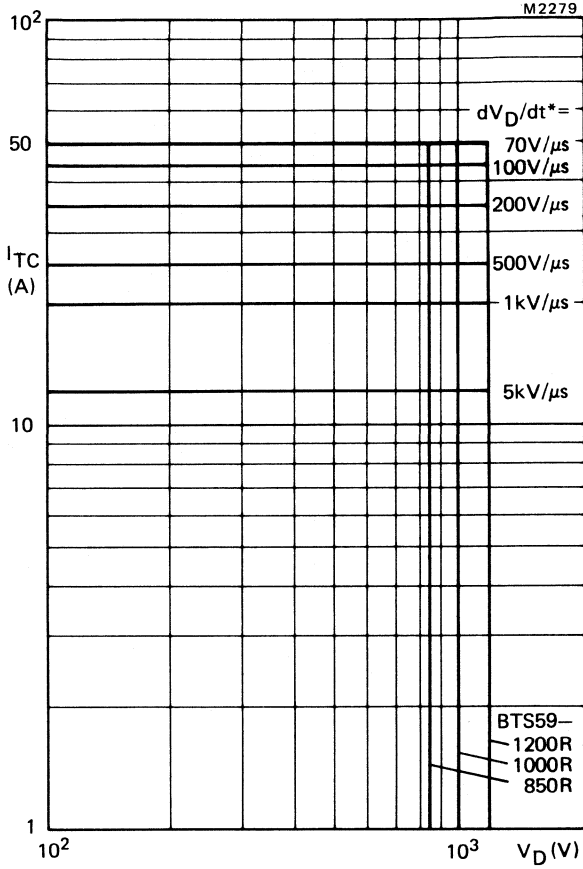


Fig.6 Anode current which can be turned off versus anode voltage; inductive load;  $V_{GR} = 10$  V;  $L_G \leq 0.5 \mu$ H;  $L_S \leq 0.25 \mu$ H;  $T_j = 120$  °C.  
 \* $dV_D/dt$  is calculated from  $I_T/C_S$ .

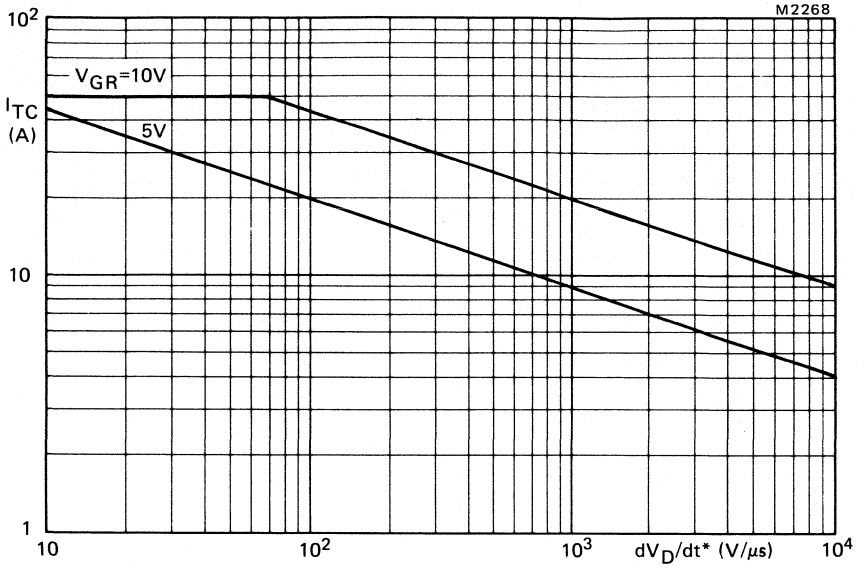


Fig.7 Anode current which can be turned off versus applied  $dV_D/dt^*$ ; inductive load;  
 $L_G \leq 0.5 \mu H$ ;  $L_S \leq 0.25 \mu H$ ;  $T_j = 120^\circ C$ . \* $dV_D/dt$  is calculated from  $I_T/C_S$ .

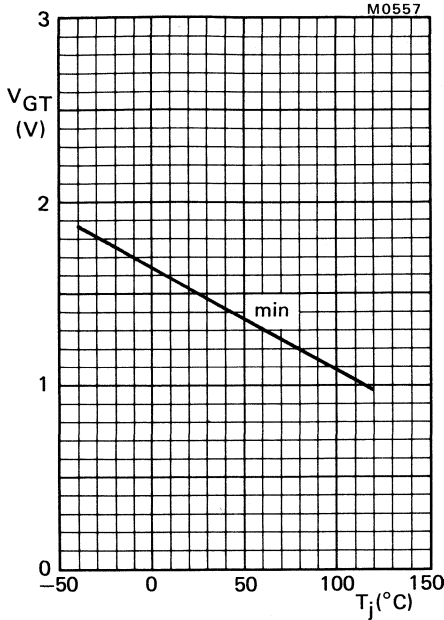


Fig.8 Minimum gate voltage that will trigger all devices as a function of junction temperature;  $V_D = 12 \text{ V}$ .

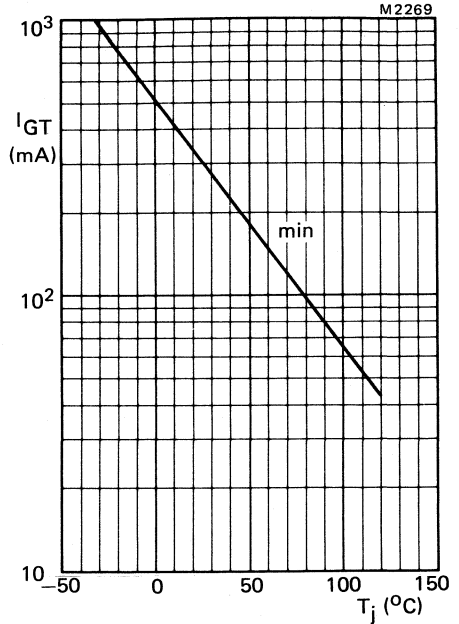


Fig.9 Minimum gate current that will trigger all devices as a function of junction temperature;  $V_D = 12 \text{ V}$ .

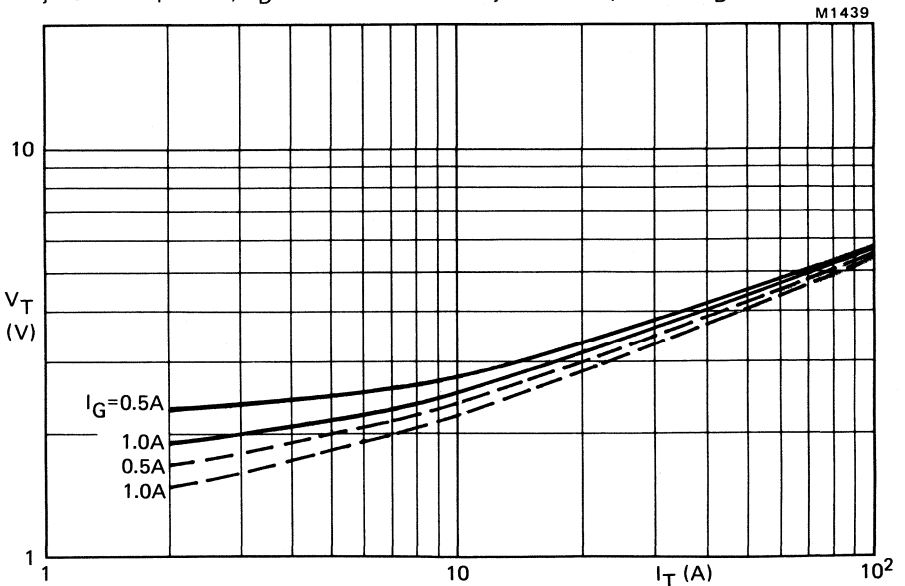


Fig.10 Maximum  $V_T$  versus  $I_T$ ; —  $T_j = 25^{\circ}\text{C}$ ; - - -  $T_j = 120^{\circ}\text{C}$ .



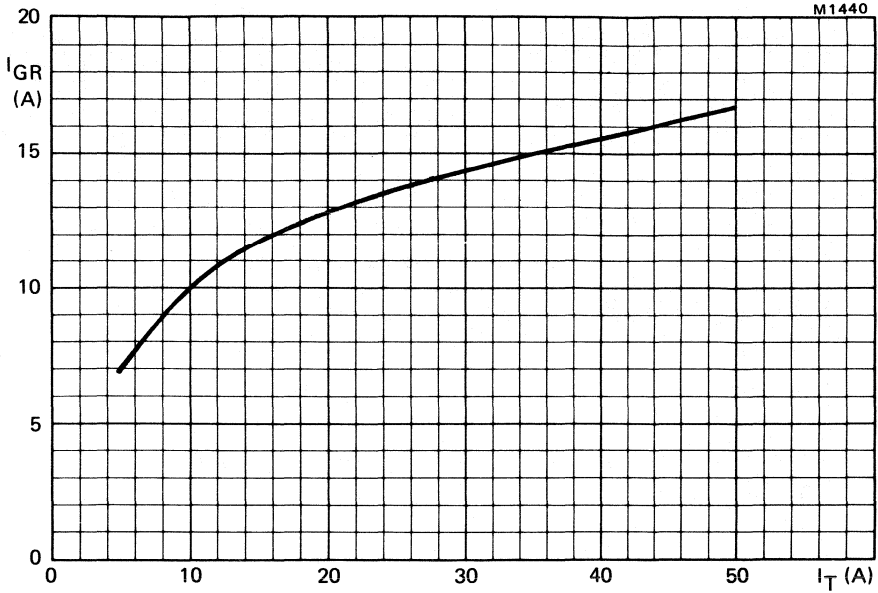


Fig.11 Peak reverse gate current versus anode current at turn-off; inductive load;  $V_{GR} = 10$  V;  $I_G = 0.5$  A;  $L_G = 0.4$   $\mu$ H;  $T_j = 120$   $^{\circ}$ C; maximum values.

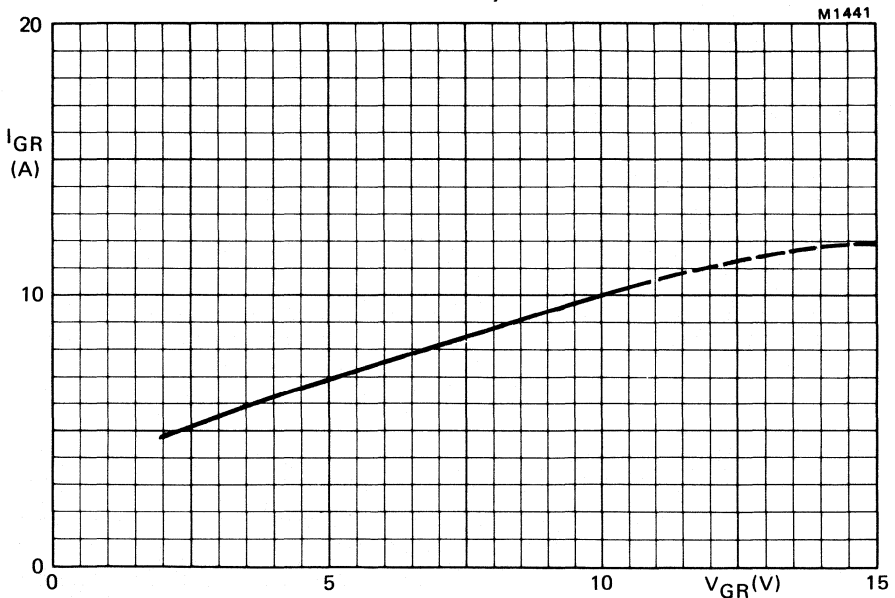


Fig.12 Peak reverse gate current versus applied reverse gate voltage; inductive load;  $I_T = 10$  A;  $I_G = 0.5$  A,  $L_G = 0.4$   $\mu$ H;  $T_j = 120$   $^{\circ}$ C; maximum values.

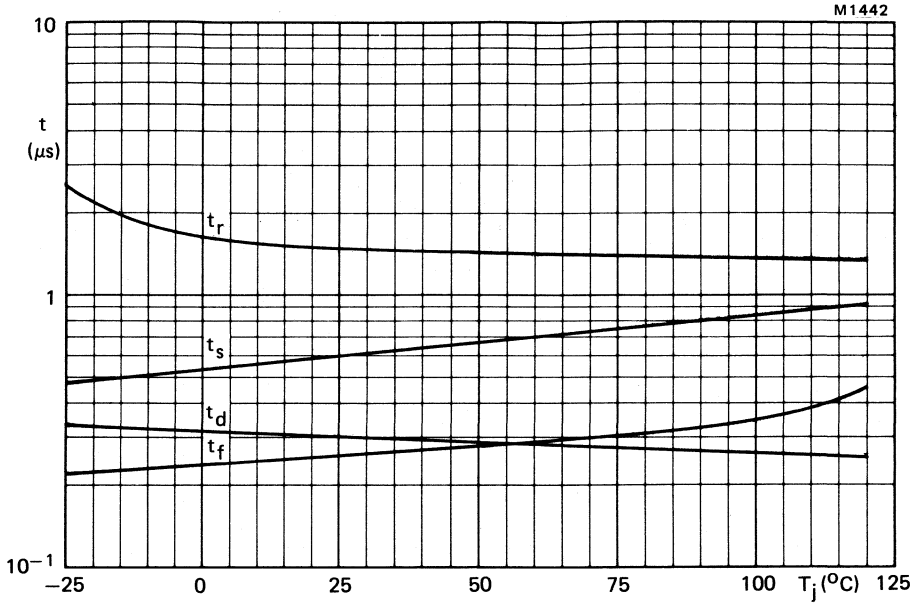


Fig.13 Switching times as a function of junction temperature;  $V_D \geq 250$  V;  $I_T = 10$  A;  $I_{GF} = 1.0$  A;  $V_{GR} = 10$  V;  $I_G = 0.5$  A;  $L_G = 0.4$   $\mu\text{H}$ ; maximum values.

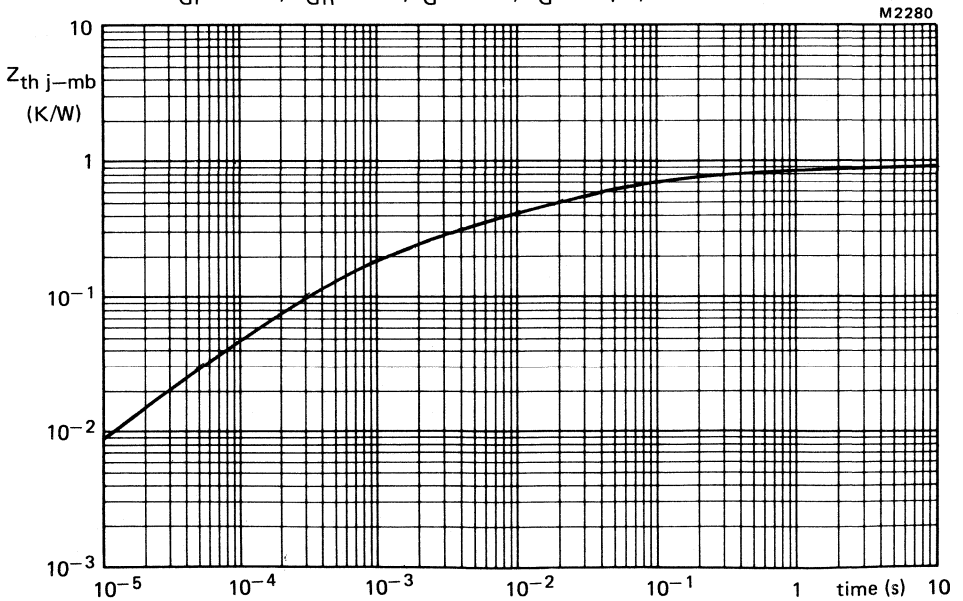


Fig.14 Transient thermal impedance.

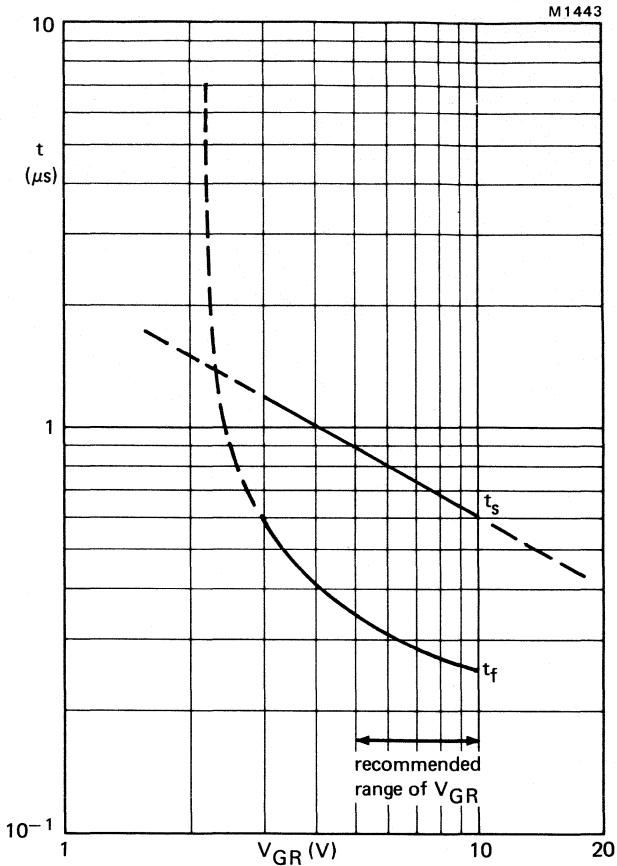


Fig.15 Storage and fall times versus applied reverse gate voltage; inductive load;  $I_T = 10$  A;  $I_G = 0.5$  A;  $L_G = 0.4 \mu H$ ;  $T_j = 25$  °C; maximum values.

M1444

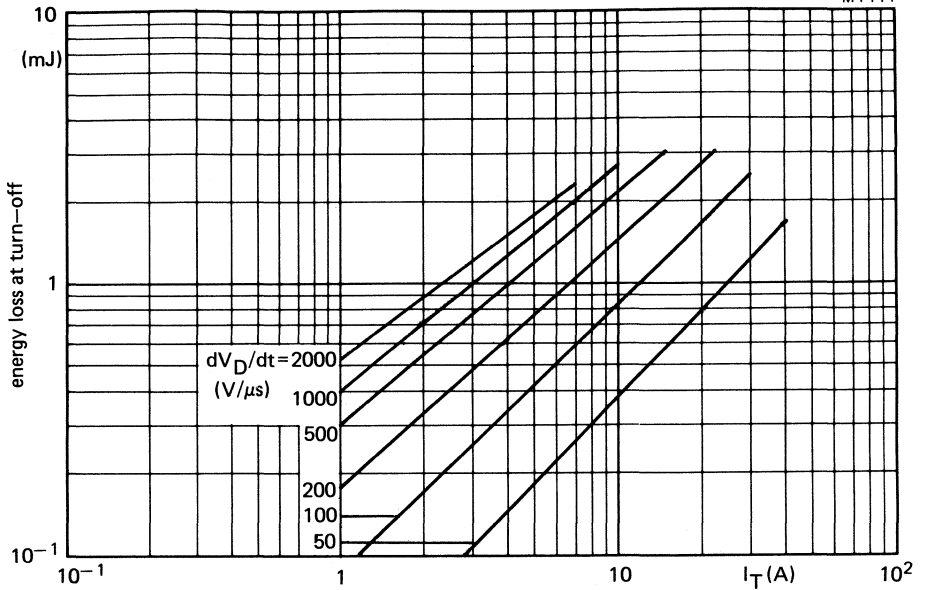


Fig.16 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied  $dV_D/dt$  (calculated from  $I_T/C_S$ );  $dV_D/dt$  linear up to  $V_{Dmax} = 600$  V;  $V_{GR} = 10$  V;  $I_G = 0.5$  A;  $L_G \leq 0.5 \mu$ H;  $L_S \leq 0.25 \mu$ H;  $T_j = 120^\circ$ C.

M1445

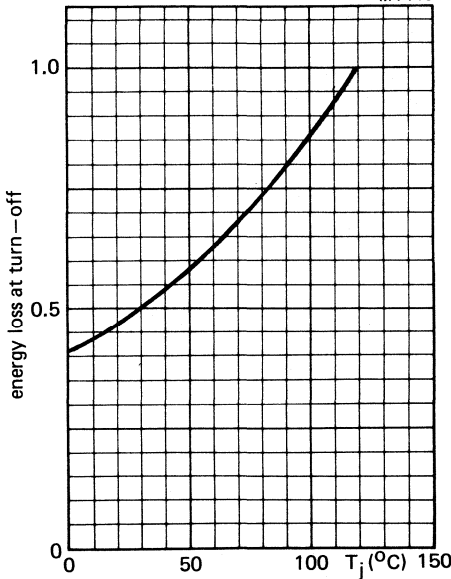


Fig.17 Energy loss at turn off as a function of junction temperature;  $I_G = 0.5$  A;  $V_{GR} = 10$  V. Normalised to  $T_j = 120^\circ$ C.

## 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.

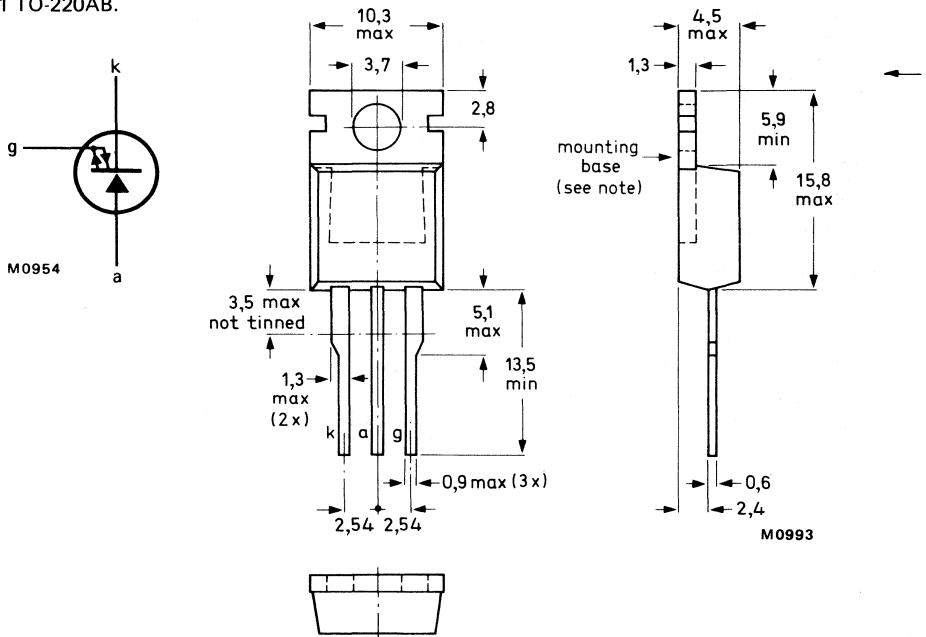
### QUICK REFERENCE DATA

		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 $T_{mb} = 80\text{ }^\circ\text{C}$	$I_{T(AV)}$	max.	10	A
Controllable anode current	$I_{TCRM}$	max.	25	A
Non-repetitive peak on-state current $t = 10\text{ ms}$ ; half-sinewave; $T_j = 120\text{ }^\circ\text{C}$ prior to surge	$I_{TSM}$	max.	75	A
$I^2 t$ for fusing; $t = 10\text{ ms}$	$I^2 t$	max.	28	$\text{A}^2\text{s}$
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	65	W
<b>Gate to cathode</b>				
Repetitive peak on-state current $T_j = 120\text{ }^\circ\text{C}$ prior to surge gate-cathode forward; $t = 10\text{ ms}$ ; half-sinewave gate-cathode reverse; $t = 20\text{ }\mu\text{s}$	$I_{GFM}$ $I_{GRM}$	max. max.	25 25	A A
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	2,5	W
<b>Temperatures</b>				
Storage temperature	$T_{stg}$		-40 to +150	$^\circ\text{C}$
Operating junction temperature	$T_j$	max.	120	$^\circ\text{C}$
<b>THERMAL RESISTANCE</b>				
From junction to mounting base	$R_{th\ j-mb} =$		1,5	K/W
From mounting base to heatsink with heatsink compound	$R_{th\ mb-h} =$		0,3	K/W
with 56367 alumina insulator and heatsink compound (clip-mounted)	$R_{th\ mb-h} =$		0,8	K/W

\* Measured with gate connected to cathode.

**CHARACTERISTICS**

**Anode to cathode**

On-state voltage

$I_T = 5 \text{ A}; I_G = 0.2 \text{ A}; T_j = 120 \text{ }^\circ\text{C}$   $V_T < 1.8 \text{ V}^*$

Rate of rise of off-state voltage that will not trigger any off-state device; exponential method

$V_D = 2/3 V_{Dmax}; V_{GR} = 5 \text{ V}; T_j = 120 \text{ }^\circ\text{C}$   $dV_D/dt < 10 \text{ kV}/\mu\text{s}$

Rate of rise of off-state voltage that will not trigger any device following conduction, linear method

$I_T = 5 \text{ A}; V_D = V_{DRMmax}; V_{GR} = 10 \text{ V}; T_j = 120 \text{ }^\circ\text{C}$   $dV_D/dt < 1.5 \text{ kV}/\mu\text{s}$

Off-state current

$V_D = V_{Dmax}; T_j = 120 \text{ }^\circ\text{C}$   $I_D < 3.0 \text{ mA}$

Latching current;  $T_j = 25 \text{ }^\circ\text{C}$

$I_L$  typ. 1.0 A\*\*

**Gate to cathode**

Voltage that will trigger all devices

$V_D = 12 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$   $V_{GT} > 1.5 \text{ V}$

Current that will trigger all devices

$V_D = 12 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$   $I_{GT} > 200 \text{ mA}$

Minimum reverse breakdown voltage

$I_{GR} = 1.0 \text{ mA}$   $V_{(BR)GR} > 10 \text{ V}$

**Switching characteristics (resistive load)**

Turn-on when switched to  $I_T = 5 \text{ A}$  from  $V_D = 250 \text{ V}$  with  $I_{GF} = 0.5 \text{ A}; T_j = 25 \text{ }^\circ\text{C}$

delay time  $t_d < 0.25 \mu\text{s}$   
 rise time  $t_r < 1.0 \mu\text{s}$

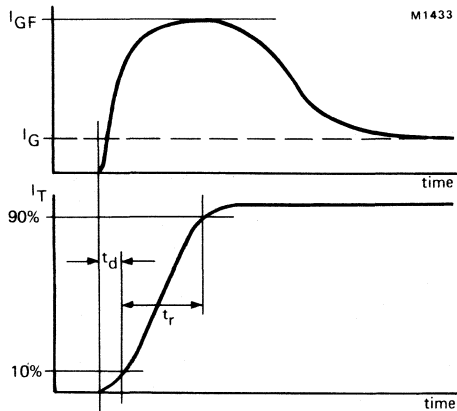


Fig.2 Waveforms

\* 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  $I_T = 5\text{ A}$  to  $V_D = V_{Dmax}$ ;

$V_{GR} = 10\text{ V}$ ;  $L_G \leq 1.0\ \mu\text{H}$ ;  $L_S \leq 0.25\ \mu\text{H}$ ;  $T_j = 25\text{ }^\circ\text{C}$

storage time

$t_s < 0.5\ \mu\text{s}$

fall time

$t_f < 0.25\ \mu\text{s}$

peak reverse gate current

$I_{GR} < 6\text{ A}$

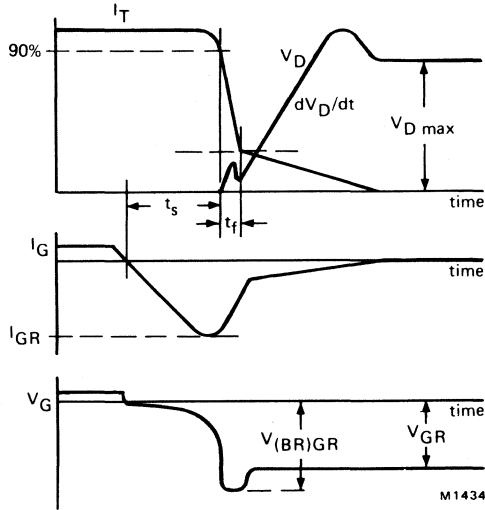


Fig.3 Waveforms.

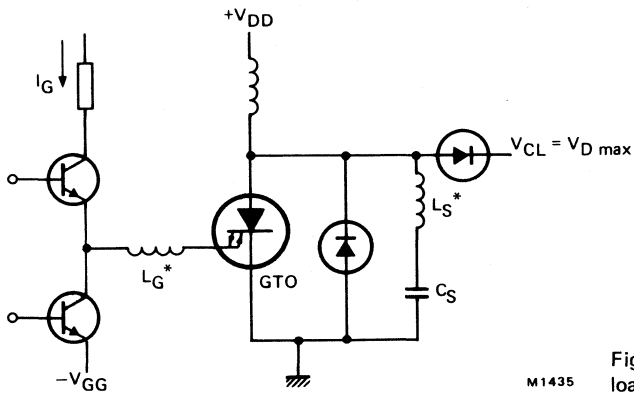


Fig.4 Inductive load test circuit.

\*indicates stray series inductance only.



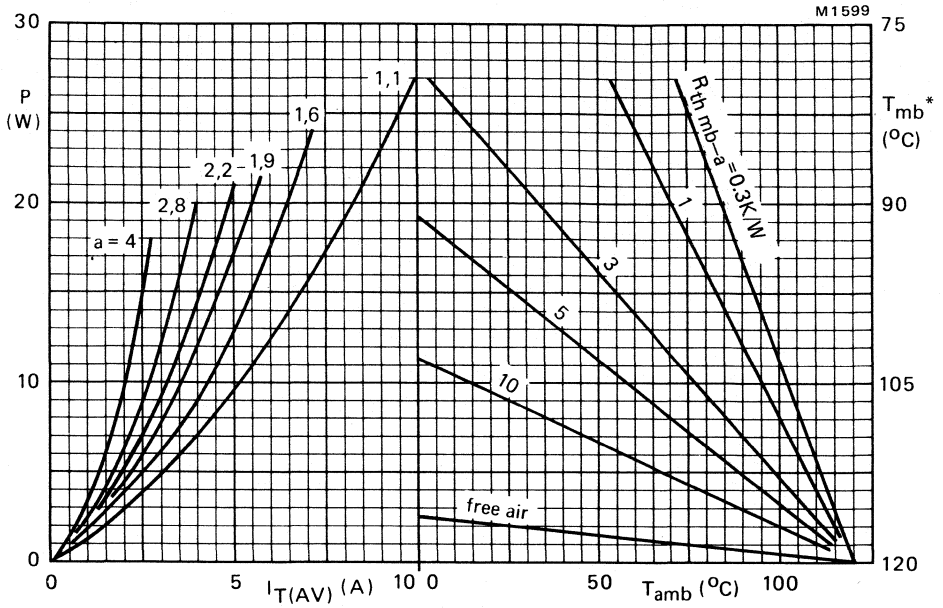


Fig.5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

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

P = power excluding switching losses.

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

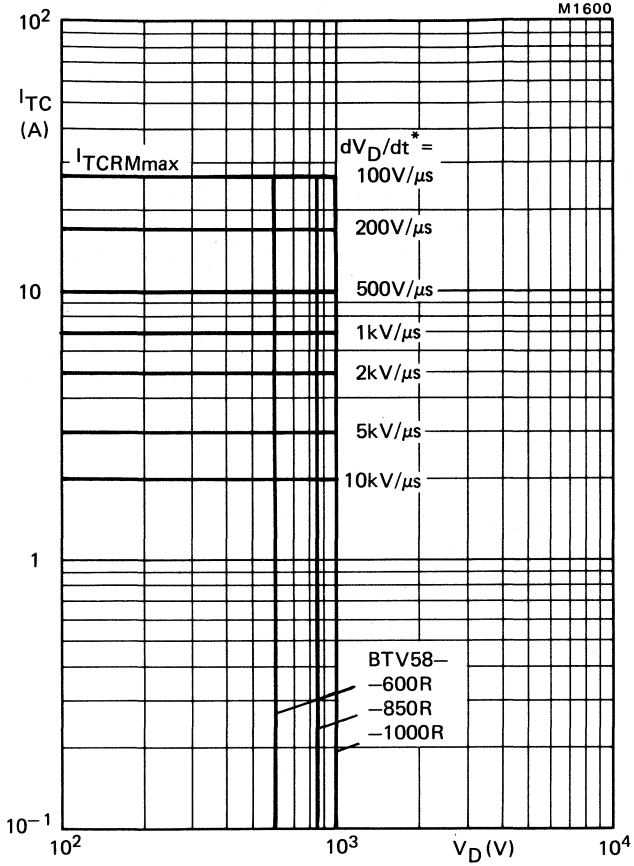


Fig.6 Anode current which can be turned off versus anode voltage; inductive load;  $V_{GR} = 10$  V;  $L_G \leq 1.0 \mu H$ ;  $L_S \leq 0.25 \mu H$ ;  $T_j = 85^\circ C$ .  
 \* $dV_D/dt$  is calculated from  $I_T/C_S$ .

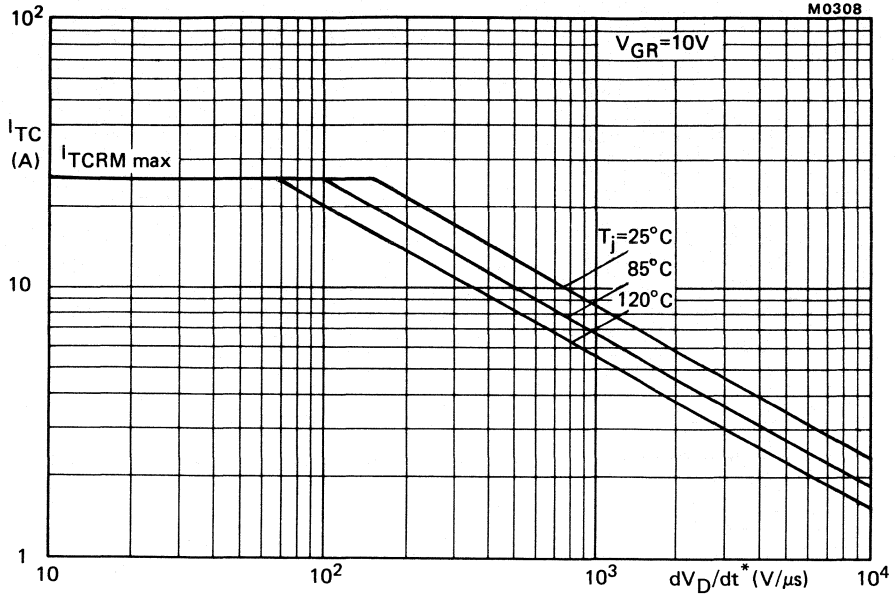


Fig.7 Anode current which can be turned off versus applied  $dV_D/dt^*$ ; inductive load;  $V_{GR} = 10\ V$ .  $L_G \leq 1.0\ \mu H$ ;  $L_S \leq 0.25\ \mu H$ . \* $dV_D/dt$  is calculated from  $I_T/C_S$ .

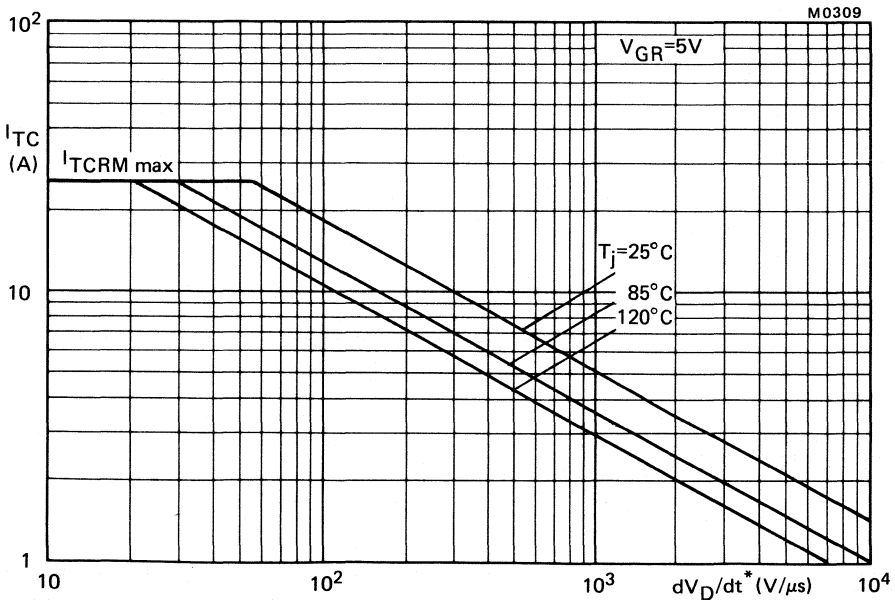


Fig.8 Anode current which can be turned off versus applied  $dV_D/dt^*$ ; inductive load;  $V_{GR} = 5\ V$ .  $L_G \leq 1.0\ \mu H$ ;  $L_S \leq 0.25\ \mu H$ ; \* $dV_D/dt$  is calculated from  $I_T/C_S$ .

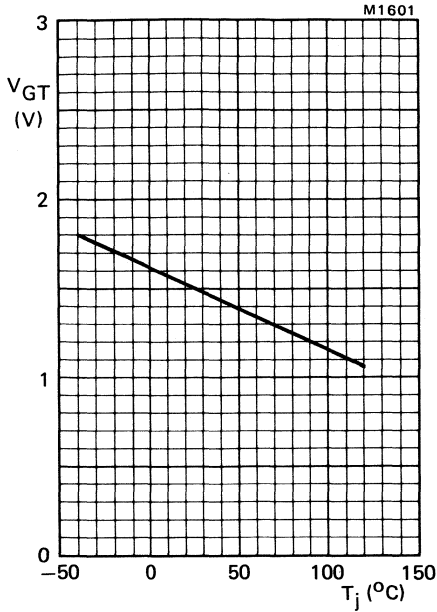


Fig.9 Minimum gate voltage that will trigger all devices as a function of junction temperature;  $V_D = 12$  V.

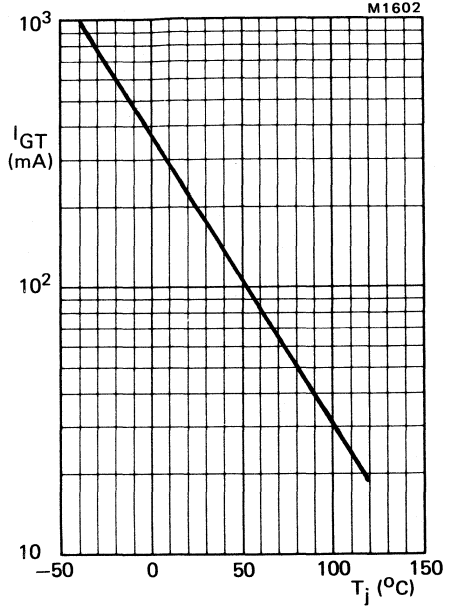


Fig.10 Minimum gate current that will trigger all devices as a function of junction temperature;  $V_D = 12$  V.

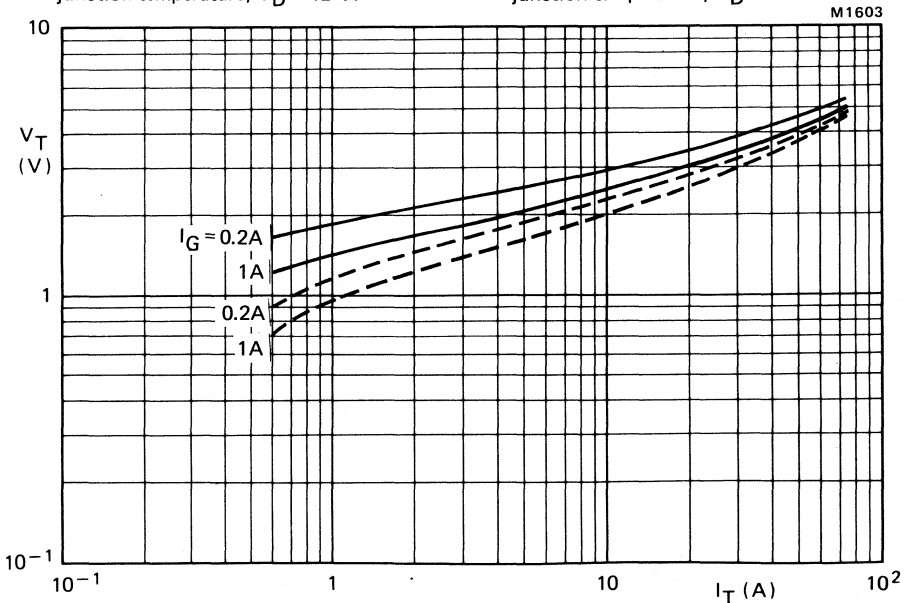


Fig.11 Maximum  $V_T$  versus  $I_T$ ; ———  $T_j = 25^{\circ}\text{C}$ ; - - - -  $T_j = 120^{\circ}\text{C}$ .

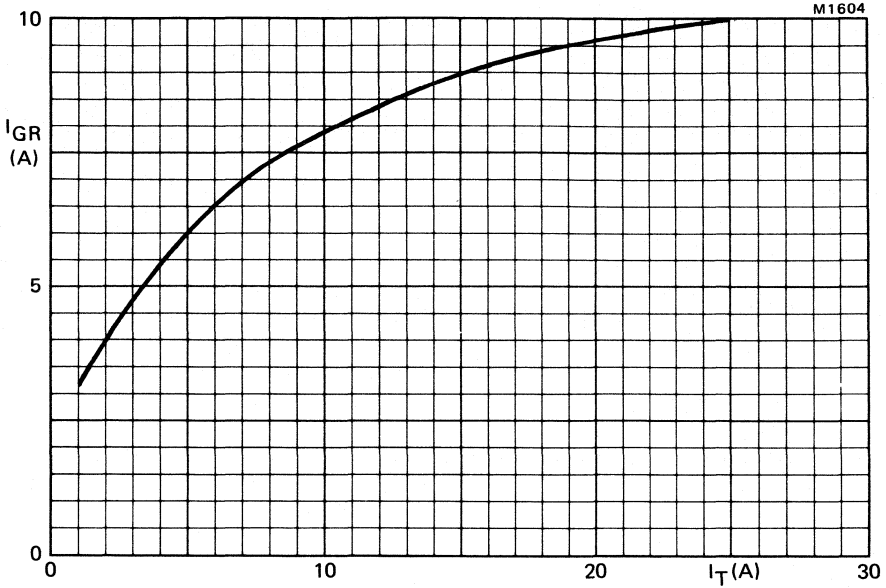


Fig.12 Peak reverse gate current versus anode current at turn-off; inductive load;  $V_{GR} = 10\text{ V}$ ;  $I_G = 0.2\text{ A}$ ;  $L_G = 0.8\text{ }\mu\text{H}$ ;  $T_j = 120\text{ }^\circ\text{C}$ ; maximum values.

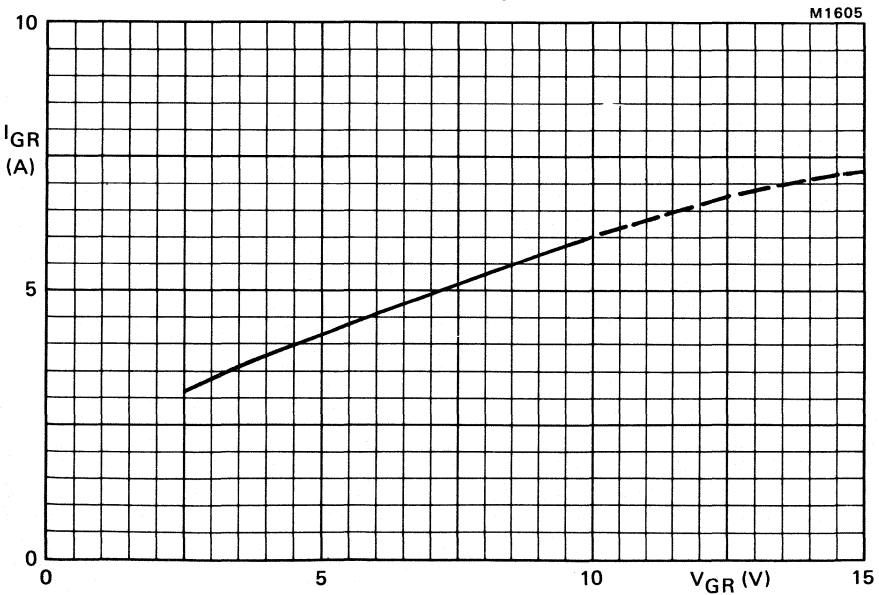


Fig.13 Peak reverse gate current versus applied reverse gate voltage; inductive load;  $I_T = 5\text{ A}$ ;  $I_G = 0.2\text{ A}$ ;  $L_G = 0.8\text{ }\mu\text{H}$ ;  $T_j = 120\text{ }^\circ\text{C}$ ; maximum values.

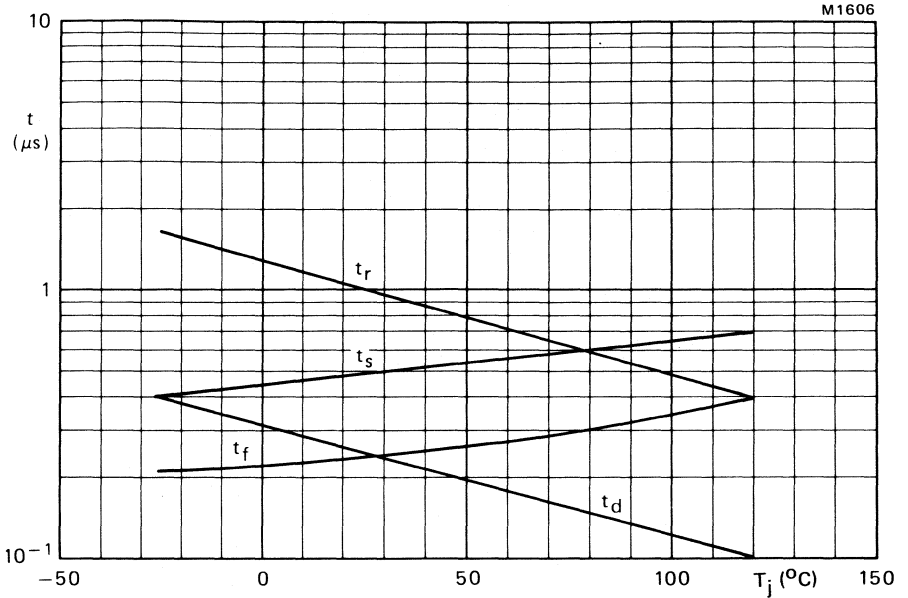


Fig.14 Switching times as a function of junction temperature;  $V_D \geq 250 \text{ V}$ ;  $I_T = 5 \text{ A}$ ;  $I_{GF} = 0.5 \text{ A}$ ;  $V_{GR} = 10 \text{ V}$ ;  $I_G = 0.2 \text{ A}$ ;  $L_G = 0.8 \mu\text{H}$ ; maximum values.

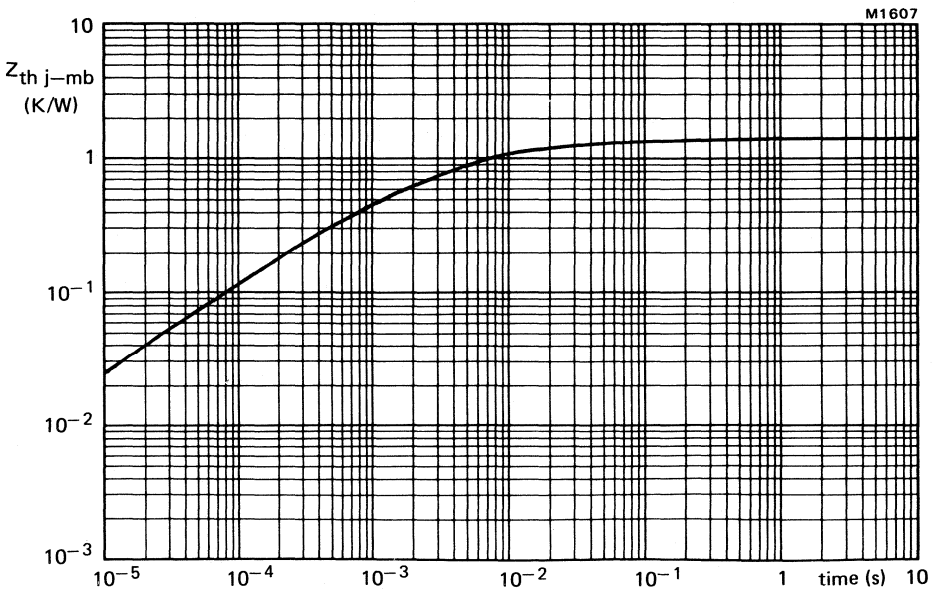


Fig.15 Transient thermal impedance.

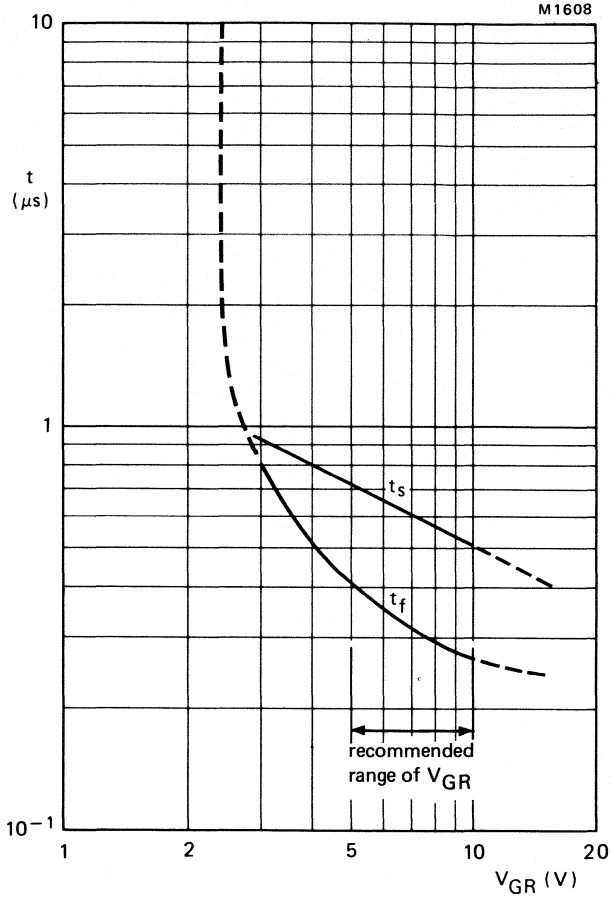


Fig.16 Storage and fall times versus applied reverse gate voltage; inductive load;  $I_T = 5$  A;  $I_G = 0.2$  A;  $L_G = 0.8 \mu H$ ;  $T_j = 25$  °C; maximum values.

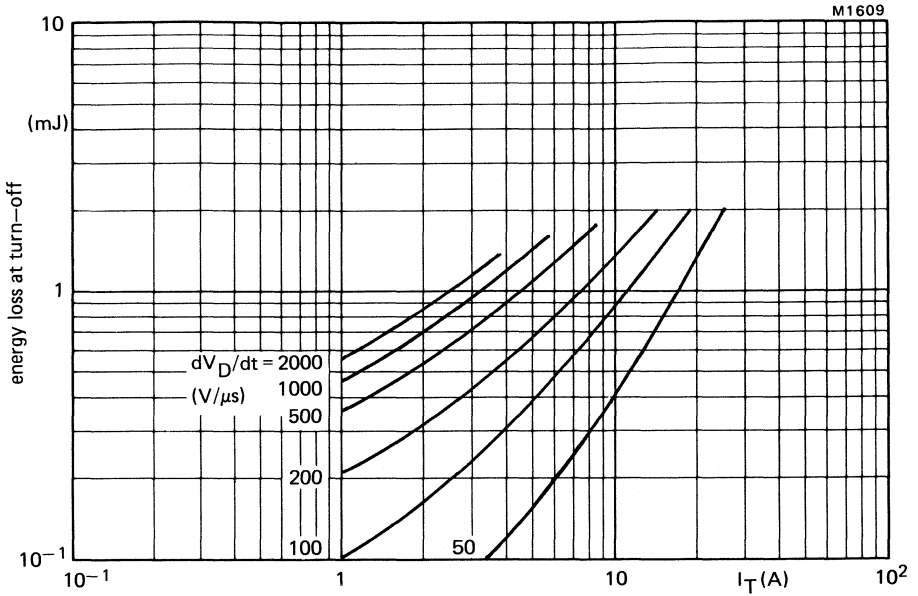


Fig.17 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied  $dV_D/dt$  (calculated from  $I_T/C_S$ );  $dV_D/dt$  linear up to  $V_{Dmax} = 600$  V;  $V_{GR} = 10$  V;  $I_G = 0.2$  A;  $L_G \leq 1.0 \mu H$ ;  $L_S \leq 0.25 \mu H$ ;  $T_j = 120$  °C.

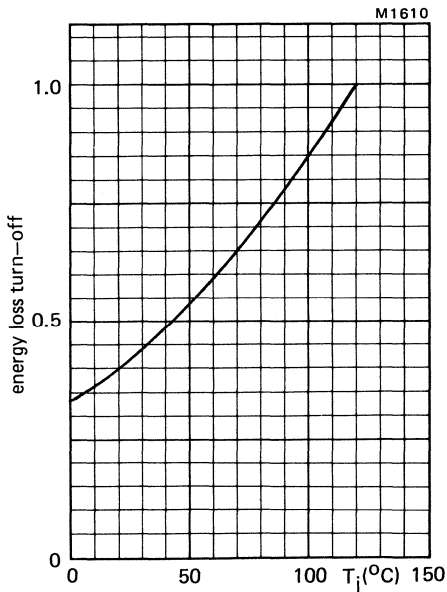


Fig.18 Energy loss at turn off as a function of junction temperature;  $I_G = 0.2$  A;  $V_{GR} = 10$  V. Normalised to  $T_j = 120$  °C.



## 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.

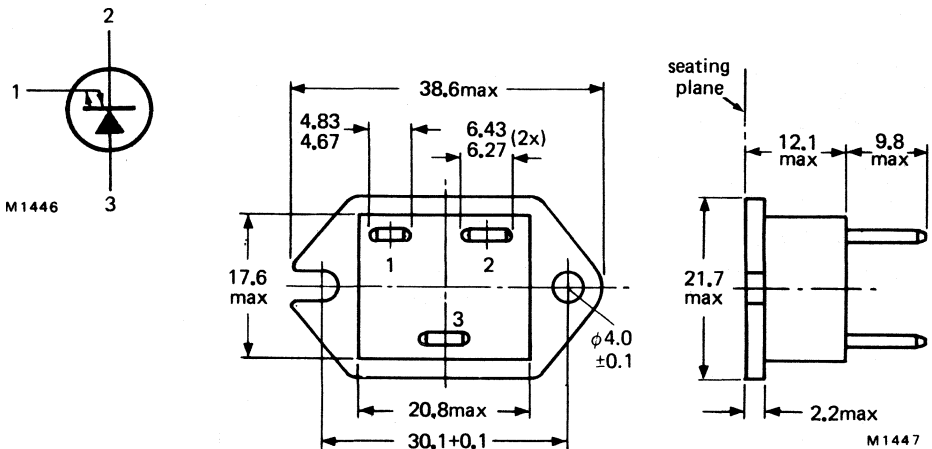
### QUICK REFERENCE DATA

		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)

<b>Anode to cathode</b>		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 $T_{mb} = 60\text{ }^\circ\text{C}$					
	$I_{T(AV)}$	max.	15		A
Controllable anode current	$I_{TCRM}$	max.	50		A
Non-repetitive peak on-state current $t = 10\text{ ms}$ ; half-sinewave; $T_j = 120\text{ }^\circ\text{C}$ prior to surge					
	$I_{TSM}$	max.	100		A
$I^2t$ for fusing; $t = 10\text{ ms}$	$I^2t$	max.	50		A <sup>2</sup> s
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	60		W
<b>Gate to cathode</b>					
Repetitive peak on-state current $T_j = 120\text{ }^\circ\text{C}$ prior to surge gate-cathode forward; $t = 10\text{ ms}$ ; half-sinewave					
	$I_{GFM}$	max.	25		A
gate-cathode reverse; $t = 20\text{ }\mu\text{s}$	$I_{GRM}$	max.	25		A
Average power dissipation (averaged over any 20 ms period)					
	$P_G(AV)$	max.	5.0		W
<b>Temperatures</b>					
Storage temperature	$T_{stg}$		-40 to +150		$^\circ\text{C}$
Operating junction temperature	$T_j$	max.	120		$^\circ\text{C}$
<b>ISOLATION**</b>					
R.M.S. isolation voltage	$V_{isol}$	min.	2500		V
<b>THERMAL RESISTANCE</b>					
From mounting base to heatsink; with heatsink compound					
	$R_{th\text{ mb-h}}$	=	0.5		K/W
From junction to mounting base					
	$R_{th\text{ j-mb}}$	=	1.5		K/W

\* Measured with gate-cathode connected together.

\*\* From baseplate to all terminals strapped together.

**CHARACTERISTICS**

**Anode to cathode**

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

**Gate to cathode**

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

**Switching characteristics (resistive load)**

Turn-on when switched to $I_T = 10 \text{ A}$ from $V_D = 250 \text{ V}$ with $I_{GF} = 1.0 \text{ A}; T_j = 25 \text{ }^\circ\text{C}$				
delay time	$t_d$	<	0.3	$\mu$ s
rise time	$t_r$	<	1.5	$\mu$ s

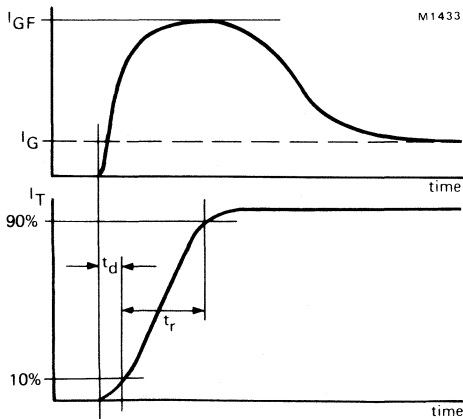


Fig.2 Waveforms

\* 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  $I_T = 10\text{ A}$  to  $V_D = V_{Dmax}$ ;

$V_{GR} = 10\text{ V}$ ;  $L_G \leq 0.5\ \mu\text{H}$ ;  $L_S \leq 0.25\ \mu\text{H}$ ;  $T_j = 25\text{ }^\circ\text{C}$

storage time	$t_s$	<	0.60	$\mu\text{s}$
fall time	$t_f$	<	0.25	$\mu\text{s}$
peak reverse gate current	$I_{GR}$	<	10	A

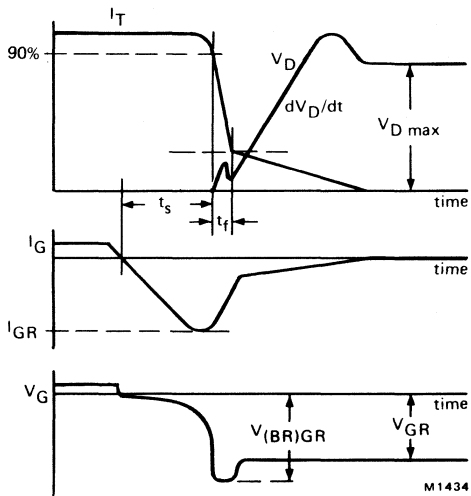


Fig.3 Waveforms.

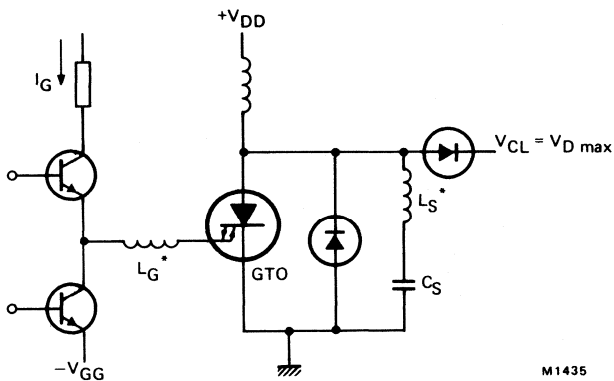


Fig.4 Inductive load test circuit.

\* Indicates stray series inductance only.

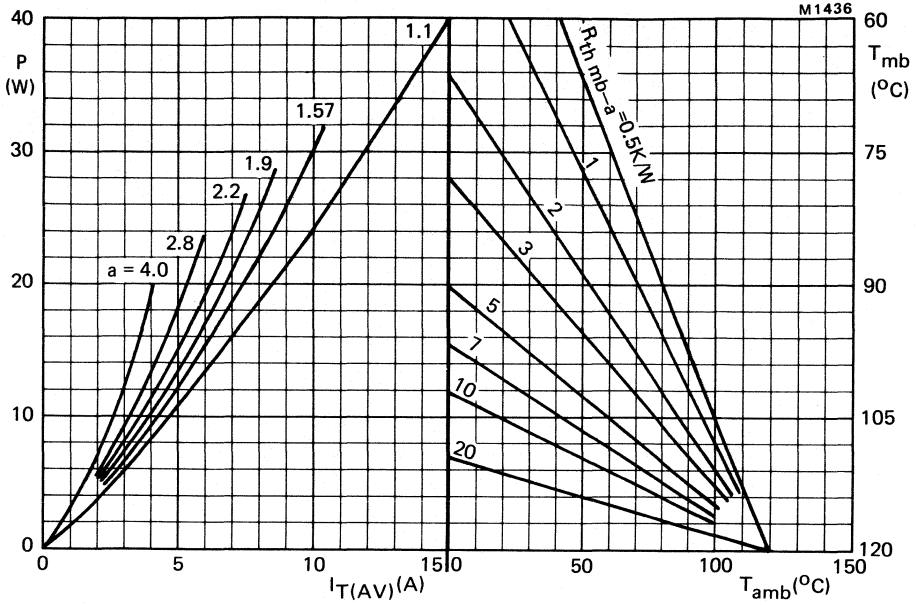


Fig. 5 The right hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

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

P = power excluding switching losses.

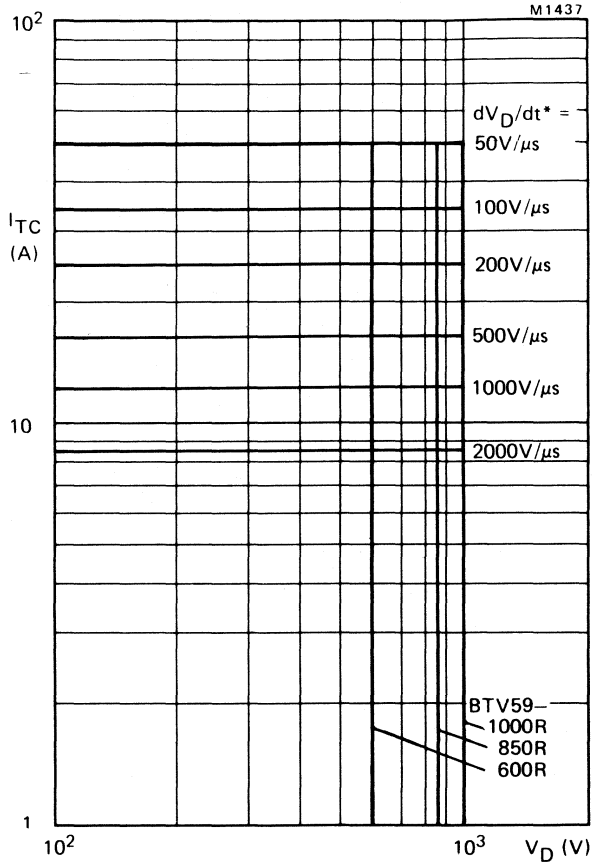


Fig. 6 Anode current which can be turned off versus anode voltage; inductive load;  $V_{GR} = 10$  V;  $L_G \leq 0.5 \mu H$ ;  $L_S \leq 0.25 \mu H$ ;  $T_j = 85^\circ C$ .  
 \* $dV_D/dt$  is calculated from  $I_T/C_S$ .

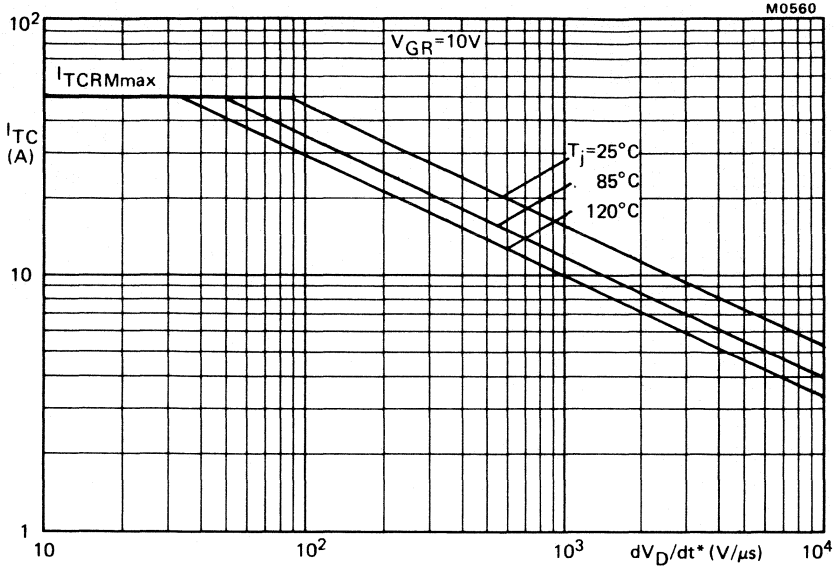


Fig.7 Anode current which can be turned off versus applied  $dV_D/dt^*$ ; inductive load;  $V_{GR} = 10 V$ ;  $L_G \leq 0.5 \mu H$ ;  $L_S \leq 0.25 \mu H$ . \* $dV_D/dt$  is calculated from  $I_T/C_S$ .

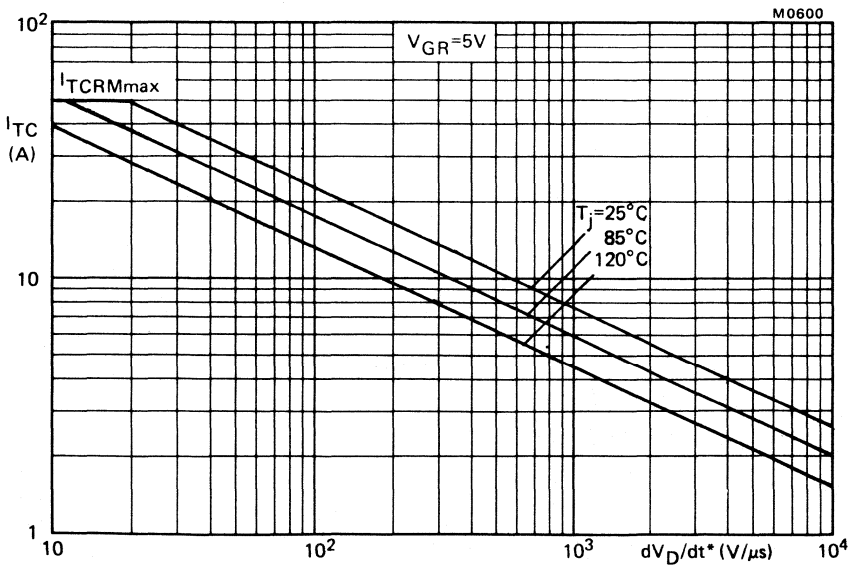


Fig.8 Anode current which can be turned off versus applied  $dV_D/dt^*$ ; inductive load;  $V_{GR} = 5 V$ ;  $L_G \leq 0.5 \mu H$ ;  $L_S \leq 0.25 \mu H$ . \* $dV_D/dt$  is calculated from  $I_T/C_S$ .

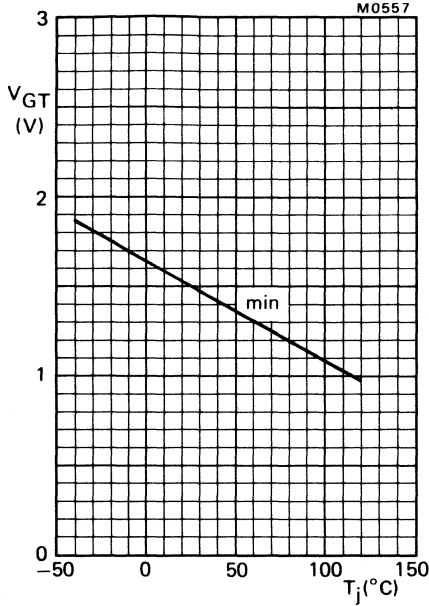


Fig.9 Minimum gate voltage that will trigger all devices as a function of junction temperature;  $V_D = 12$  V.

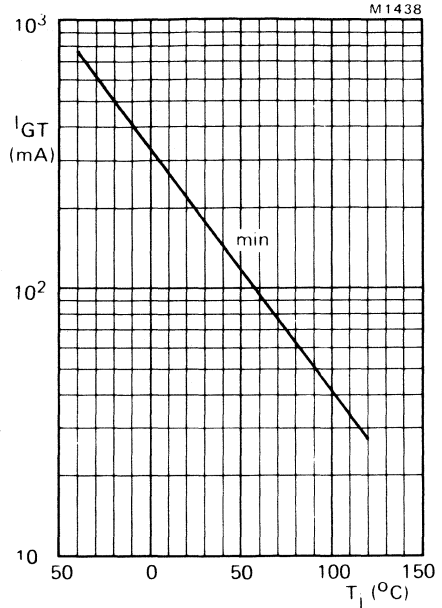


Fig.10 Minimum gate current that will trigger all devices as a function of junction temperature;  $V_D = 12$  V.

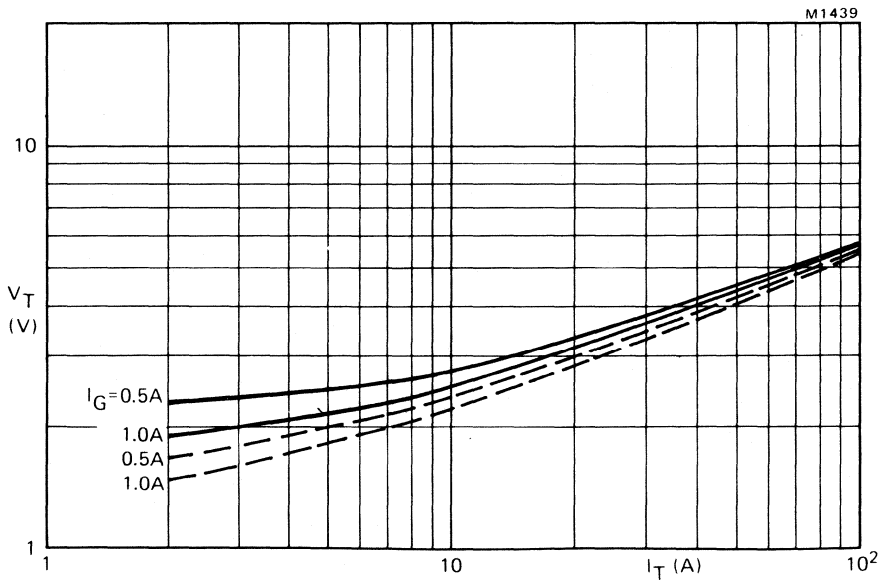


Fig.11 Maximum  $V_T$  versus  $I_T$ ; —  $T_j = 25^{\circ}C$ ; - - -  $T_j = 120^{\circ}C$ .



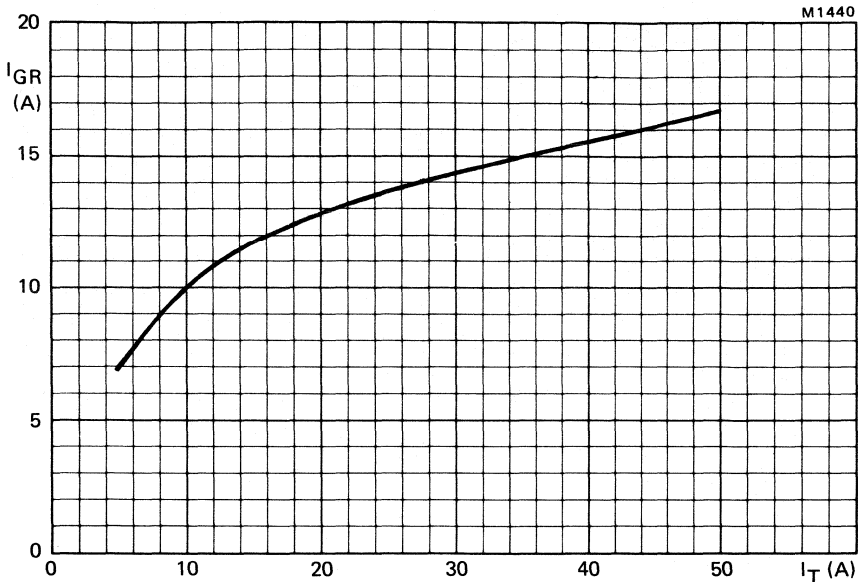


Fig.12 Peak reverse gate current versus anode current at turn-off; inductive load;  $V_{GR} = 10\text{ V}$ ;  $I_G = 0.5\text{ A}$ ;  $L_G = 0.4\ \mu\text{H}$ ;  $T_j = 120\text{ }^\circ\text{C}$ ; maximum values.

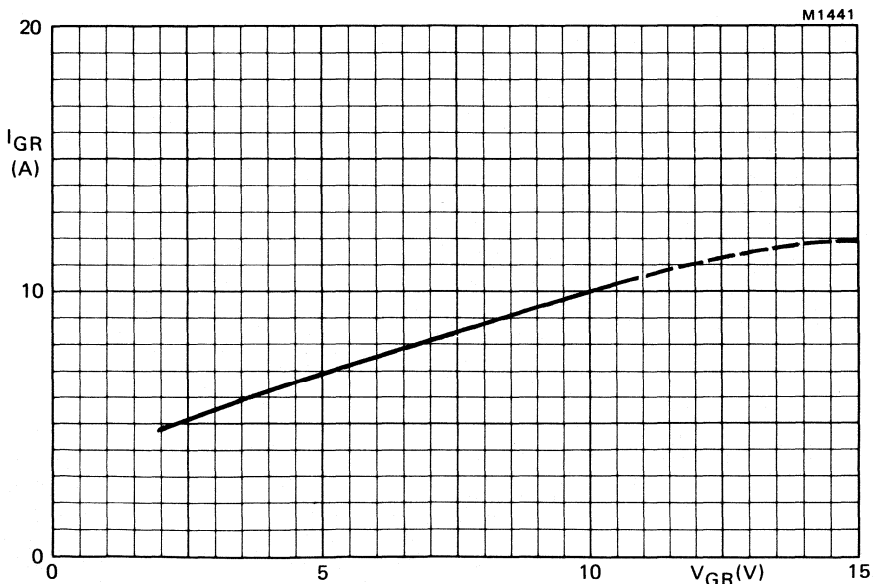


Fig.13 Peak reverse gate current versus applied reverse gate voltage; inductive load;  $I_T = 10\text{ A}$ ;  $I_G = 0.5\text{ A}$ ;  $L_G = 0.4\ \mu\text{H}$ ;  $T_j = 120\text{ }^\circ\text{C}$ ; maximum values.

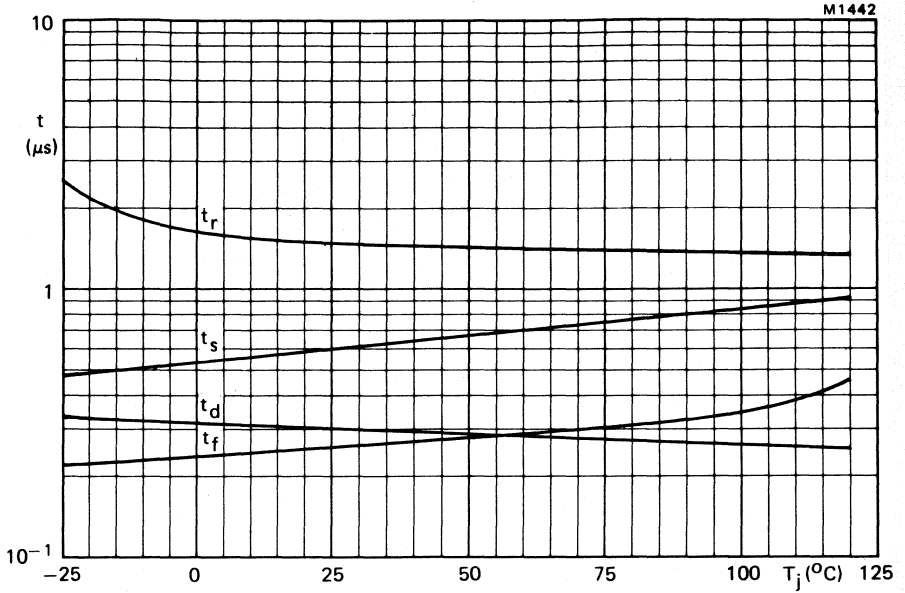


Fig.14 Switching times as a function of junction temperature;  $V_D \geq 250 \text{ V}$ ;  $I_T = 10 \text{ A}$ ;  $I_{GF} = 1.0 \text{ A}$ ;  $V_{GR} = 10 \text{ V}$ ;  $I_G = 0.5 \text{ A}$ ;  $L_G = 0.4 \mu\text{H}$ ; maximum values.

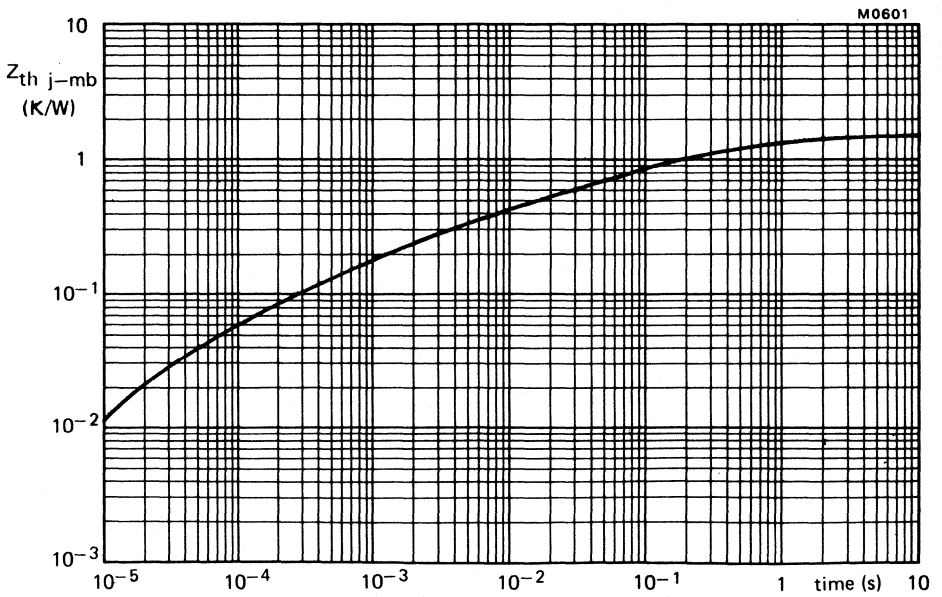


Fig.15 Transient thermal impedance.

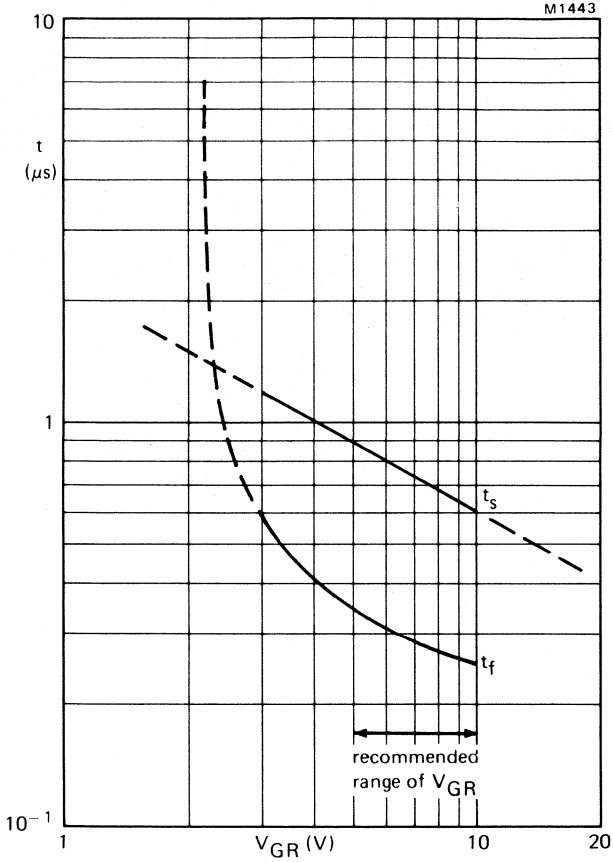


Fig.16 Storage and fall times versus applied reverse gate voltage; inductive load;  $I_T = 10$  A;  $I_G = 0.5$  A;  $L_G = 0.4 \mu H$ ;  $T_j = 25^\circ C$ ; maximum values.

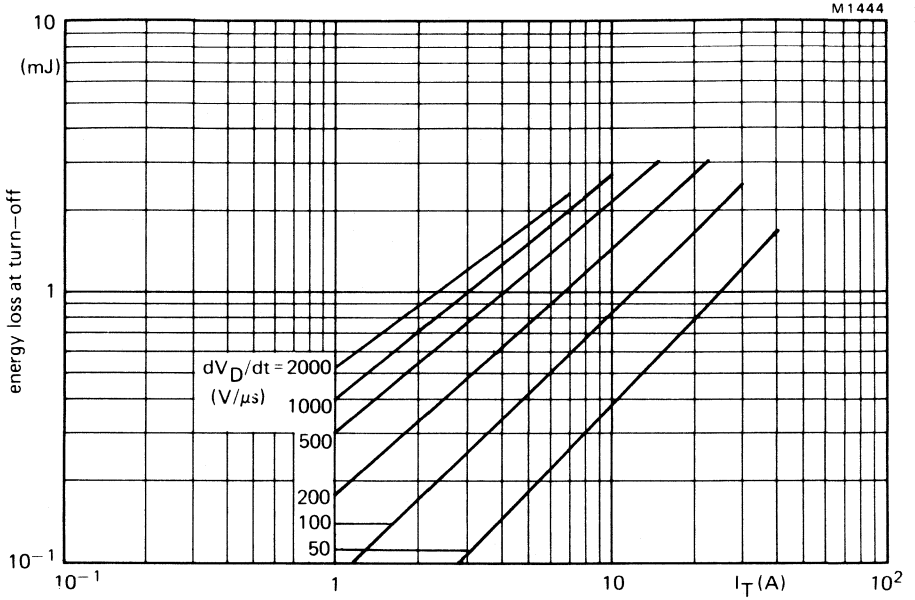


Fig.17 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied  $dV_D/dt$  (calculated from  $I_T/C_S$ );  $dV_D/dt$  linear up to  $V_{Dmax} = 600$  V;  $V_{GR} = 10$  V;  $I_G = 0.5$  A;  $L_G \leq 0.5 \mu H$ ;  $L_S \leq 0.25 \mu H$ ;  $T_j = 120$  °C.

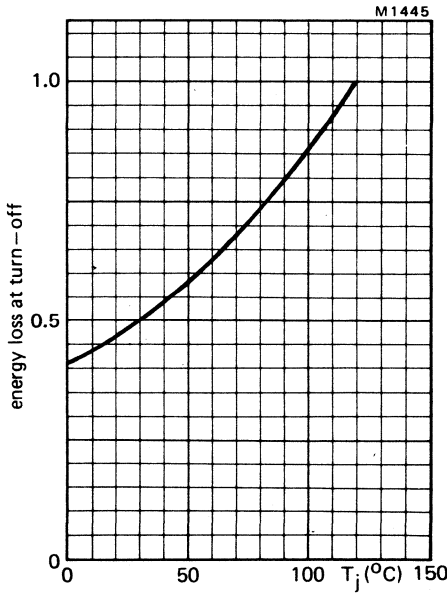


Fig.18 Energy loss at turn off as a function of junction temperature;  $I_G = 0.5$  A;  $V_{GR} = 10$  V. Normalised to  $T_j = 120$  °C.

## 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.

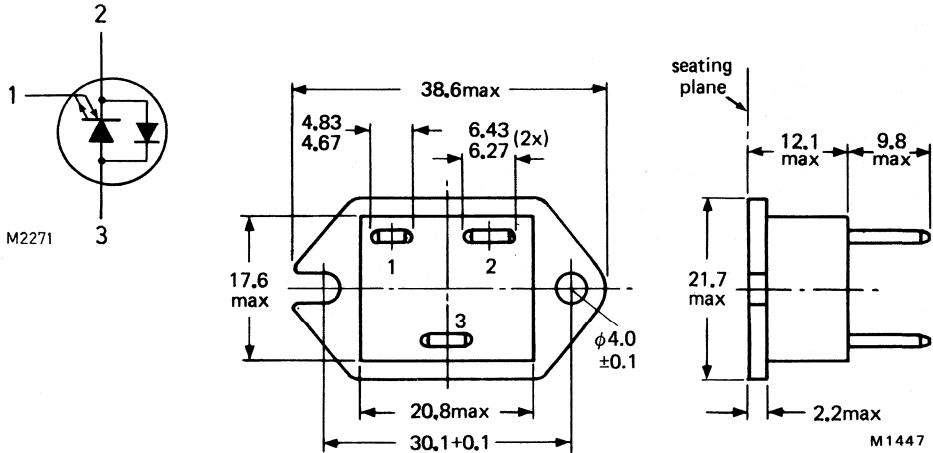
### QUICK REFERENCE DATA

TO		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	
<b>Diode</b>							
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)

<b>Anode to cathode</b>			BTV59D-850R	1000R	1200R	
Transient off-state voltage	$V_{DSM}$	max.	1000	1100	1300	V <sup>*</sup>
Repetitive peak off-state voltage	$V_{DRM}$	max.	850	1000	1200	V <sup>*</sup>
Working off-state voltage	$V_{DW}$	max.	600	800	1000	V <sup>*</sup>
Continuous off-state voltage	$V_D$	max.	500	650	750	V <sup>*</sup>
<b>Average on-state current (averaged over any 20 ms period) up to <math>T_{mb} = 60\text{ }^\circ\text{C}</math></b>						
Average on-state current	$I_{T(AV)}$	max.		15		A
Controllable anode current	$I_{TCRM}$	max.		50		A
<b>Non-repetitive peak on-state current</b>						
t = 10 ms; half-sinewave;						
T <sub>j</sub> = 120 °C prior to surge						
$I^2t$ for fusing; t = 10 ms	$I^2t$	max.		50		A <sup>2</sup>
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P <sub>tot</sub>	max.		60		W
<b>Gate to cathode</b>						
<b>Repetitive peak on-state current</b>						
T <sub>j</sub> = 120 °C prior to surge						
gate-cathode forward; t = 10 ms;						
half-sinewave						
	$I_{GFM}$	max.		25		A
	$I_{GRM}$	max.		25		A
gate-cathode reverse; t = 20 μs						
<b>Average power dissipation (averaged over any 20 ms period)</b>						
	P <sub>G(AV)</sub>	max.		5.0		W
<b>Diode</b>						
<b>Average forward current (averaged over any 20 ms period) up to <math>T_{mb} = 70\text{ }^\circ\text{C}</math></b>						
	$I_F(AV)$	max.		9.0		A
<b>Non-repetitive peak on-state current</b>						
t = 10 ms; half-sinewave						
T <sub>j</sub> = 120 °C prior to surge						
	$I_{FSM}$	max.		60		A
<b>Temperatures</b>						
Storage temperature	T <sub>stg</sub>			-40 to +125		°C
Operating junction temperature	T <sub>j</sub>	max.		120		°C
<b>ISOLATION**</b>						
R.M.S. isolation voltage	V <sub>isol</sub>	min.		2500		V

\* Measured with gate-cathode connected together.

\*\* From baseplate to all terminals strapped together.

**HERMAL RESISTANCE**

**GTO**

From junction to mounting base  $R_{th\ j-mb} = 1.5\ K/W$

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

**Diode**

From junction to mounting base  $R_{th\ j-mb} = 3.6\ K/W$

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

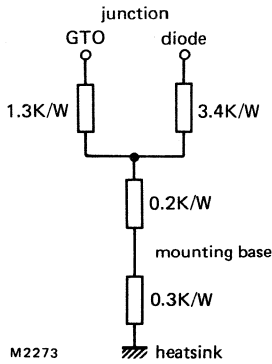


Fig.2 Equivalent thermal network.

## GTO CHARACTERISTICS

### Anode to cathode

On-state voltage

$I_T = 10 \text{ A}; I_G = 0.5 \text{ A}; T_j = 120 \text{ }^\circ\text{C}$   $V_T < 2.3 \text{ V}^*$

Rate of rise of off-state voltage that will not trigger any off-state device; exponential method

$V_D = 2/3 V_{Dmax}; V_{GR} = 5 \text{ V}; T_j = 120 \text{ }^\circ\text{C}$   $dV_D/dt < 10 \text{ kV/}$

Rate of rise of off-state voltage that will not trigger any device following conduction, linear method

$I_T = 10 \text{ A}; V_D = V_{DRMmax}; V_{GR} = 10 \text{ V}; T_j = 120 \text{ }^\circ\text{C}$   $dV_D/dt < 1.0 \text{ kV/}$

Off-state current

$V_D = V_{Dmax}; T_j = 120 \text{ }^\circ\text{C}$   $I_D < 5.0 \text{ mA}$

Latching current;  $T_j = 25 \text{ }^\circ\text{C}$

$I_L \text{ typ. } 1.5 \text{ A}^{**}$

### Gate to cathode

Voltage that will trigger all devices

$V_D = 12 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$   $V_{GT} > 1.5 \text{ V}$

Current that will trigger all devices

$V_D = 12 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$   $I_{GT} > 200 \text{ mA}$

Minimum reverse breakdown voltage

$I_{GR} = 1.0 \text{ mA}$   $V_{(BR)GR} > 10 \text{ V}$

### Switching characteristics (resistive load)

Turn-on when switched to  $I_T = 10 \text{ A}$  from  $V_D = 250 \text{ V}$

with  $I_{GF} = 1.0 \text{ A}; T_j = 25 \text{ }^\circ\text{C}$

delay time

$t_d < 0.3 \text{ } \mu\text{s}$

rise time

$t_r < 1.5 \text{ } \mu\text{s}$

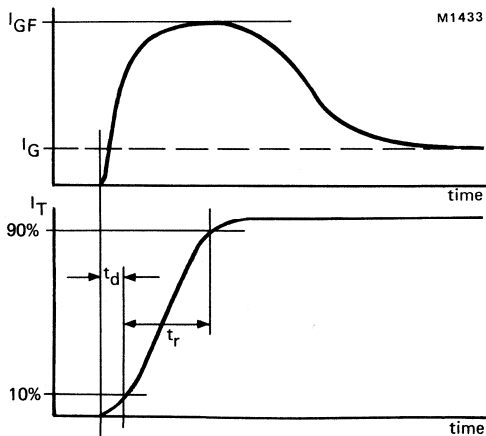


Fig.3 Waveforms.

\* 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  $I_T = 10\text{ A}$  to  $V_D = V_{Dmax}$ ;

$V_{GR} = 10\text{ V}$ ;  $L_G \leq 0.5\ \mu\text{H}$ ;  $L_S \leq 0.25\ \mu\text{H}$ ;  $T_j = 25\text{ }^\circ\text{C}$

storage time

$t_s < 0.60\ \mu\text{s}$

fall time

$t_f < 0.25\ \mu\text{s}$

peak reverse gate current

$I_{GR} < 10\text{ A}$

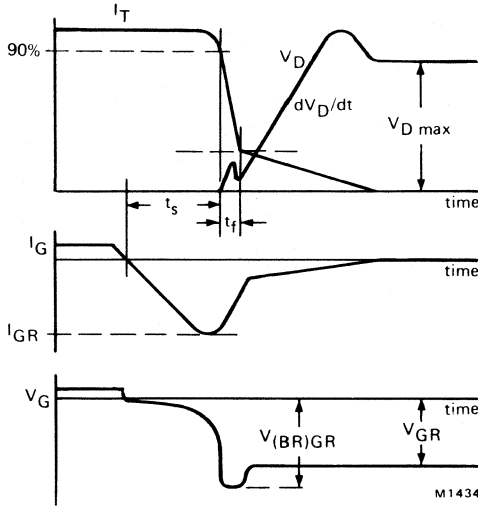


Fig.4 Waveforms.

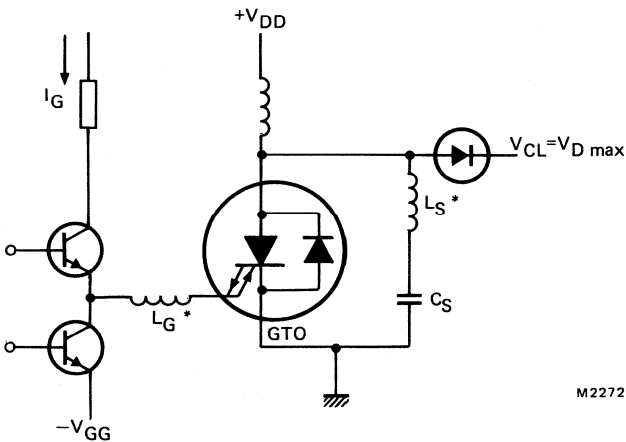


Fig.5 Inductive load test circuit.

\* Indicates stray series inductance only

GTO (cont.)

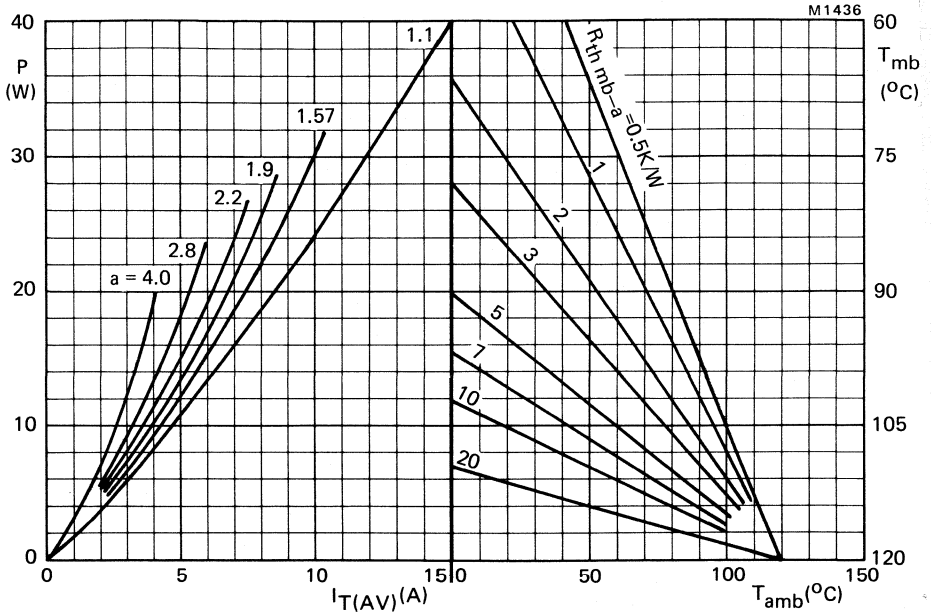


Fig.6 The right hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

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

P = power excluding switching losses.

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

GTO (cont.)

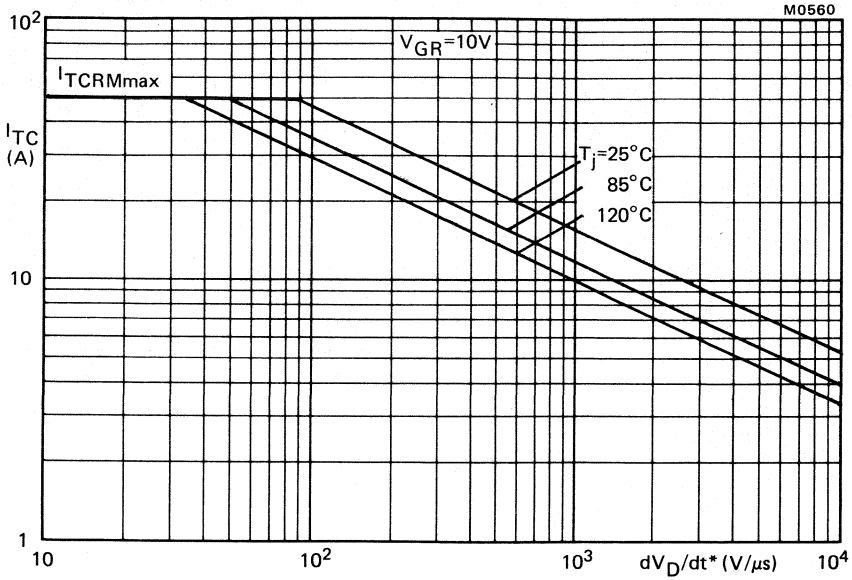


Fig.7 Anode current which can be turned off versus applied  $dV_D/dt^*$ ; inductive load;  $V_{GR} = 10V$ ;  $L_G \leq 0.5 \mu H$ ;  $L_S \leq 0.25 \mu H$ . \* $dV_D/dt$  is calculated from  $I_T/C_S$ .

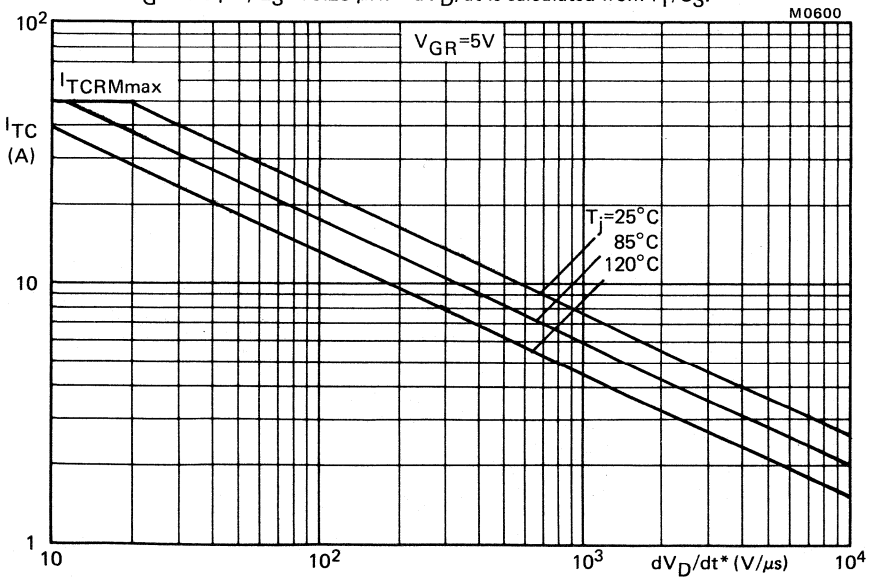


Fig.8 Anode current which can be turned off versus applied  $dV_D/dt^*$ ; inductive load;  $V_{GR} = 5V$ ;  $L_G \leq 0.5 \mu H$ ;  $L_S \leq 0.25 \mu H$ . \* $dV_D/dt$  is calculated from  $I_T/C_S$ .

GTO (cont.)

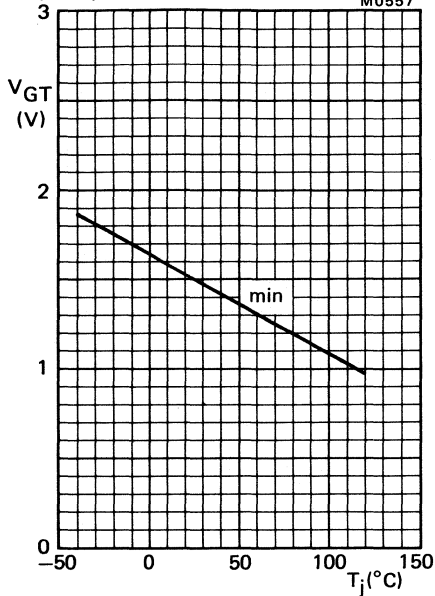


Fig. 9 Minimum gate voltage that will trigger all devices as a function of junction temperature;  $V_D = 12$  V.

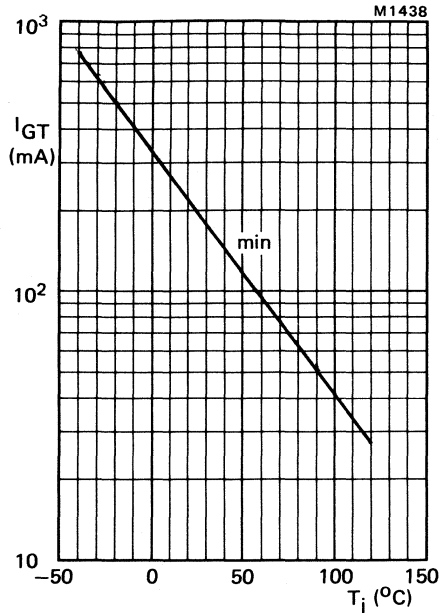


Fig. 10 Minimum gate current that will trigger all devices as a function of junction temperature;  $V_D = 12$  V.

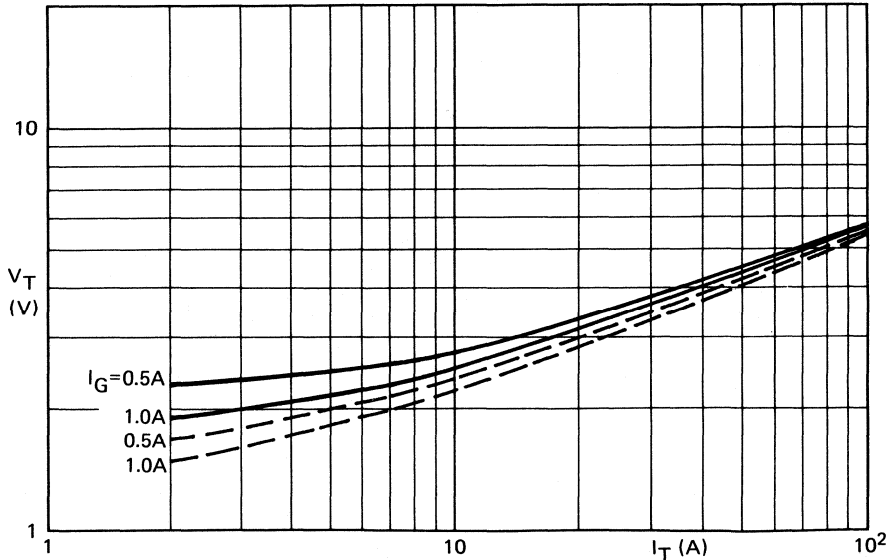


Fig. 11 Maximum  $V_T$  versus  $I_T$ ; —  $T_j = 25$  °C; - - -  $T_j = 120$  °C.

GTO (cont.)

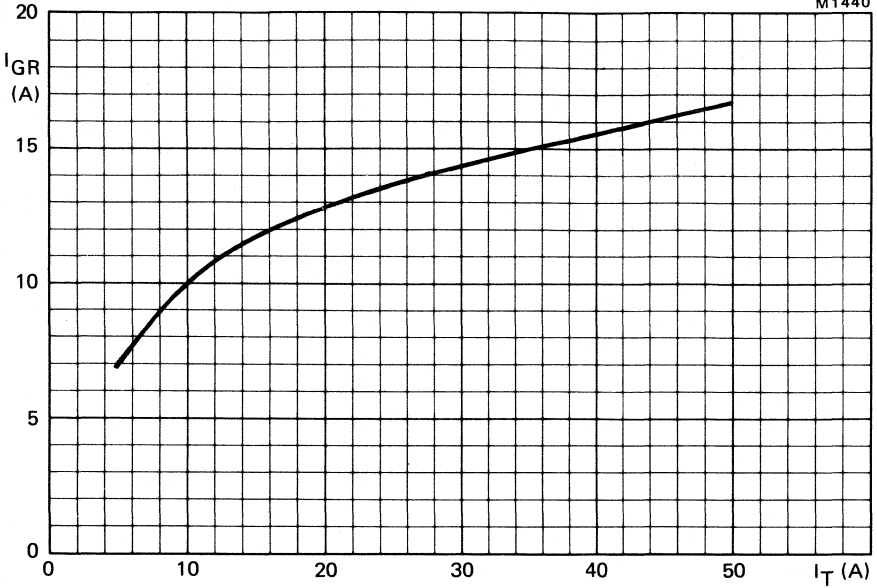


Fig.12 Peak reverse gate current versus anode current at turn-off; inductive load;  $V_{GR} = 10$  V;  $I_G = 0.5$  A;  $L_G = 0.4$   $\mu$ H;  $T_j = 120$   $^{\circ}$ C; maximum values.

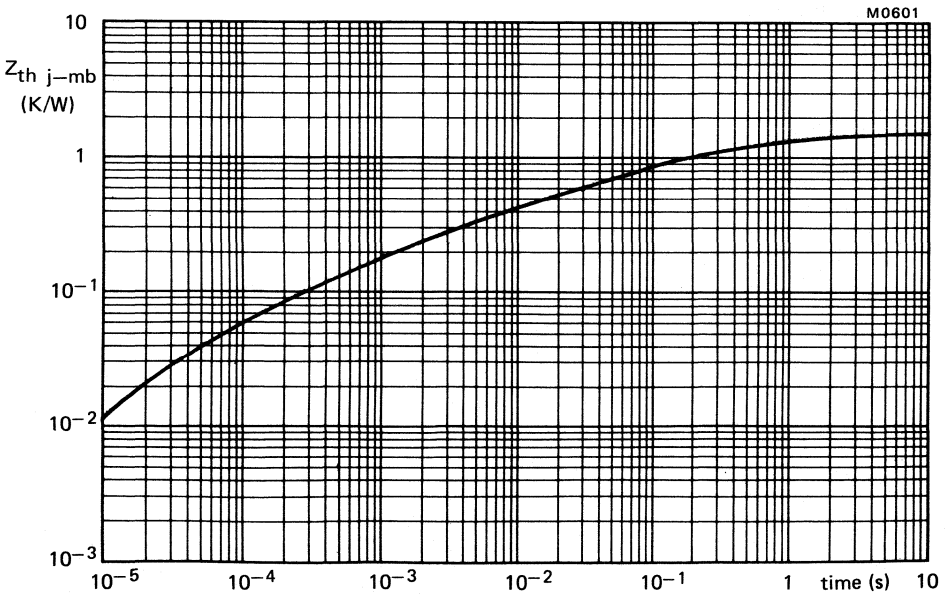


Fig.13 Transient thermal impedance.

GTO (cont.)

M1444

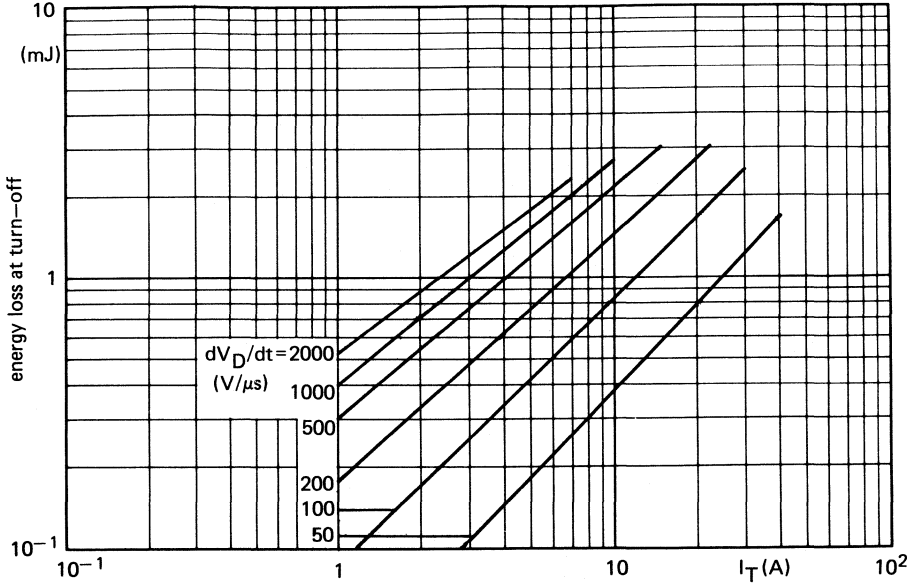


Fig.14 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied  $dV_D/dt$  (calculated from  $I_T/C_S$ );  $dV_D/dt$  linear up to  $V_{Dmax} = 600$  V;  $V_{GR} = 10$  V;  $I_G = 0.5$  A;  $L_G \leq 0.5 \mu H$ ;  $L_S \leq 0.25 \mu H$ ;  $T_j = 120$  °C.

M1445

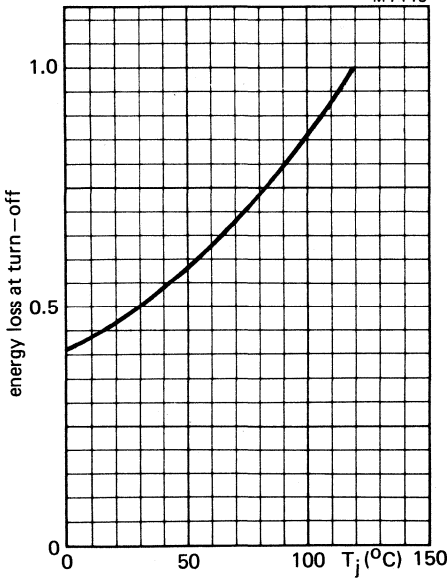


Fig.15 Energy loss at turn off as a function of junction temperature;  $I_G = 0.5$  A;  $V_{GR} = 10$  V. Normalised to  $T_j = 120$  °C.

**DIODE CHARACTERISTICS**

Forward voltage

$I_F = 10 \text{ A}; T_j = 25 \text{ }^\circ\text{C}$

$V_F < 2.0 \text{ V}^*$

Reverse recovery when switched from

$I_F = 2 \text{ A to } V_R \geq 30 \text{ V with } -dI_F/dt = 20 \text{ A}/\mu\text{s}; T_j = 25 \text{ }^\circ\text{C}$

recovered charge

$Q_s < 2.0 \mu\text{C}$

recovery time

$t_{rr} < 0.6 \mu\text{s}$

Forward recovery when switched to

$I_F = 5 \text{ A with } t_r = 0.1 \mu\text{s}; T_j = 25 \text{ }^\circ\text{C}$

recovery time

$t_{fr} < 1.0 \mu\text{s}$

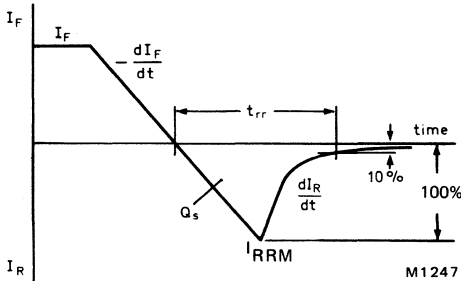


Fig.16 Definition of  $t_{rr}$  and  $Q_s$ .

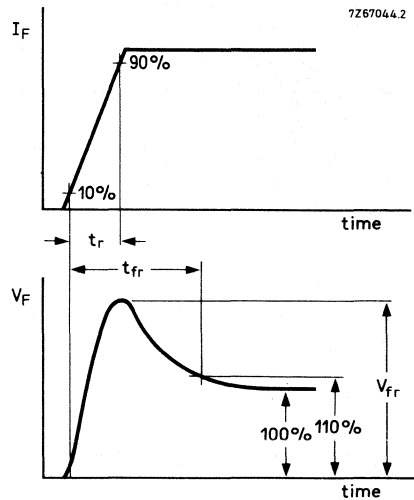


Fig.17 Definition of  $t_{fr}$ .

\*Measured under pulse conditions to avoid excessive dissipation

DIODE (cont.)

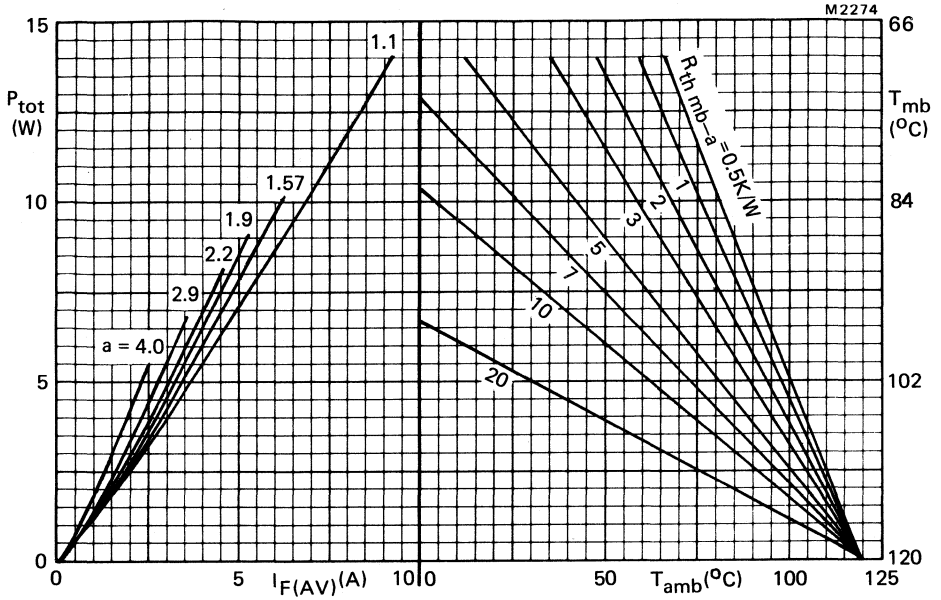


Fig.18 The right hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

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

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



DIODE (cont.)

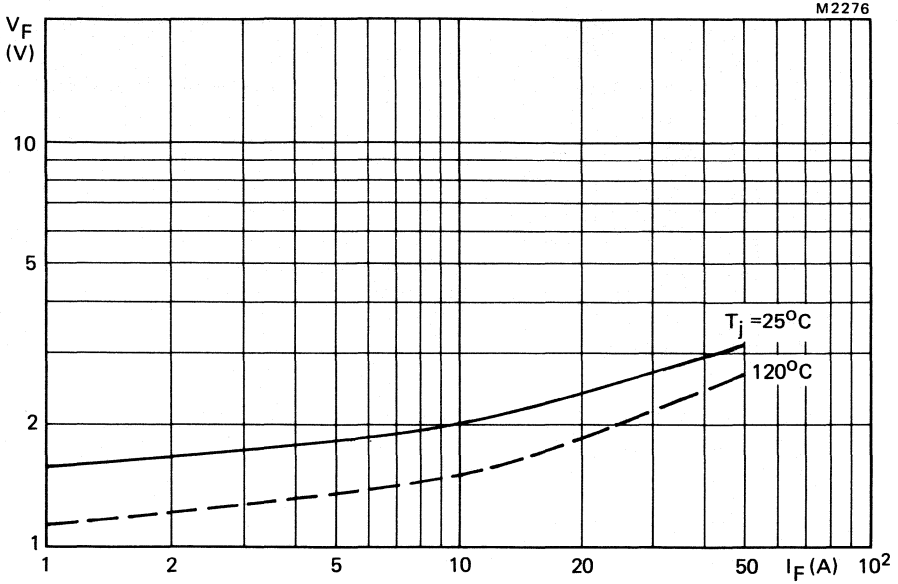


Fig.19 Forward voltage as a function of forward current; maximum values.

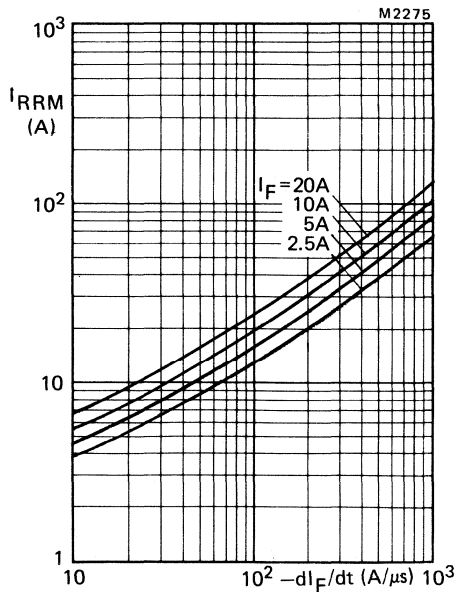


Fig.20 Peak reverse recovery current versus  $-di_F/dt$ ;  $T_j = 25^\circ\text{C}$ ; maximum values.

DIODE (cont.)

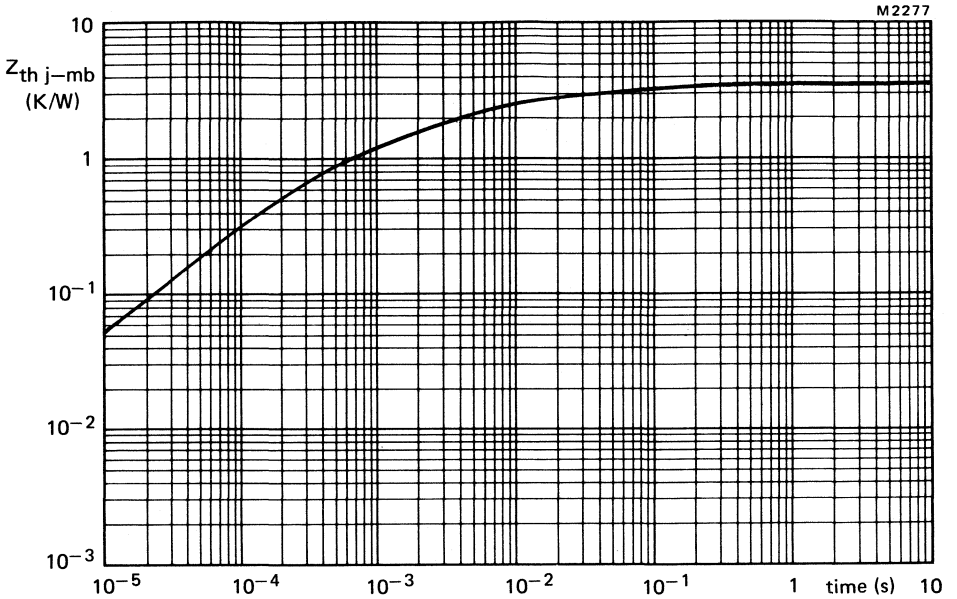


Fig.21 Transient thermal impedance.

## 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.

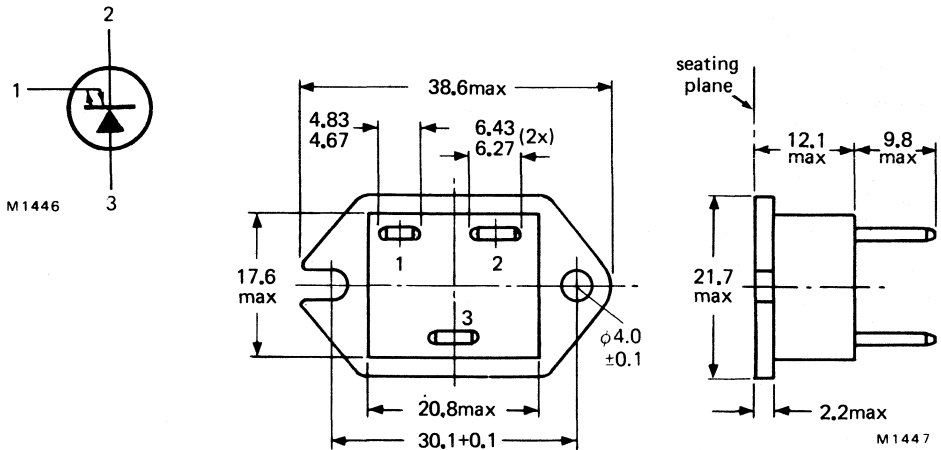
### QUICK REFERENCE DATA

		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)  
 Pin 2 = cathode (AMP 250 series)  
 Pin 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 $T_{mb} = 70\text{ }^\circ\text{C}$					
	$I_T(AV)$	max.	25		A
Controllable anode current					
	$I_{TCRM}$	max.	120		A
Non-repetitive peak on-state current					
t = 10 ms; half-sinewave;					
→ $T_j = 120\text{ }^\circ\text{C}$ prior to surge	$I_{TSM}$	max.	240		A
→ $I^2 t$ for fusing; t = 10 ms	$I^2 t$	max.	290		A <sup>2</sup> s
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$					
	$P_{tot}$	max.	120		W
→ Maximum rate of rise of anode current at turn-on, $V_D = V_{Dmax}$ ; $I_{GF} = 2.5\text{ A}$ ; $I_T = 200\text{ A}$	$di_T/dt$	max.	1000		A/ $\mu$ s
<b>Gate to cathode</b>					
Repetitive peak on-state current					
$T_j = 120\text{ }^\circ\text{C}$ prior to surge					
gate-cathode forward; t = 10 ms;					
	$I_{GFM}$	max.	35		A
	$I_{GRM}$	max.	50		A
gate-cathode reverse; t = 20 $\mu$ s					
Average power dissipation (averaged over any 20 ms period)					
	$P_G(AV)$	max.	10		W
<b>Temperatures</b>					
Storage temperature	$T_{stg}$		-40 to +150		$^\circ\text{C}$
Operating junction temperature	$T_j$	max.	120		$^\circ\text{C}$
<b>ISOLATION**</b>					
R.M.S. isolation voltage	$V_{isol}$	min.	2500		V
<b>THERMAL RESISTANCE</b>					
From mounting base to heatsink, with heatsink compound					
	$R_{th\ mb-h}$	=	0.3		K/W
From junction to mounting base					
	$R_{th\ j-mb}$	=	0.8		K/W

\*Measured with gate-cathode connected together.

\*\*From baseplate to all terminals strapped together.

**CHARACTERISTICS**

**Anode to cathode**

On-state voltage $I_T = 20 \text{ A}; I_G = 0.5 \text{ A}; T_j = 120 \text{ }^\circ\text{C}$	$V_T$	<	2.2	V*
Rate of rise of off-state voltage that will not trigger any off-state device; exponential method $V_D = 2/3 V_{Dmax}; V_{GR} = 5 \text{ V}; T_j = 120 \text{ }^\circ\text{C}$	$dV_D/dt$	<	10	kV/ $\mu$ s
Rate of rise of off-state voltage that will not trigger any device following conduction, linear method $I_T = 60 \text{ A}; V_D = V_{DRMmax}; V_{GR} = 10 \text{ V}; T_j = 120 \text{ }^\circ\text{C}$	$dV_D/dt$	<	1.0	kV/ $\mu$ s
Off-state current $V_D = V_{Dmax}; T_j = 120 \text{ }^\circ\text{C}$	$I_D$	<	5.0	mA
Latching current; $T_j = 25 \text{ }^\circ\text{C}$	$I_L$	typ.	5.0	A**
<b>Gate to cathode</b>				
Voltage that will trigger all devices $V_D = 12 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$	$V_{GT}$	>	1.5	V
Current that will trigger all devices $V_D = 12 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$	$I_{GT}$	>	500	mA
Minimum reverse breakdown voltage $I_{GR} = 1.0 \text{ mA}$	$V_{(BR)GR}$	>	10	V

**Switching characteristics (resistive load)**

Turn-on when switched to $I_T = 50 \text{ A}$ from $V_D = 250 \text{ V}$ with $I_{GF} = 2.5 \text{ A}; T_j = 25 \text{ }^\circ\text{C}$				
delay time	$t_d$	<	0.5	$\mu$ s
rise time	$t_r$	<	2.0	$\mu$ s

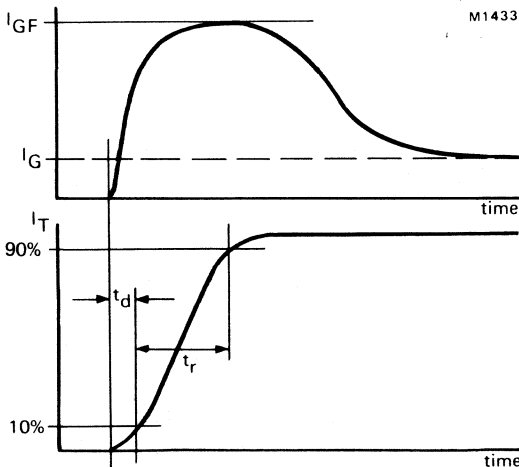


Fig.2 Waveforms.

\* 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;  $L_G \leq 0.5 \mu\text{H}$ ;  $L_S \leq 0.25 \mu\text{H}$ ;  $T_j = 25^\circ\text{C}$

storage time	$t_s$	<	1.0	$\mu\text{s}$
fall time	$t_f$	<	0.3	$\mu\text{s}$
peak reverse gate current	$I_{GR}$	<	25	A

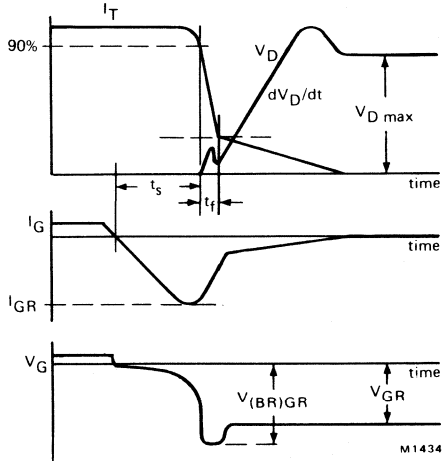


Fig.3 Waveforms.

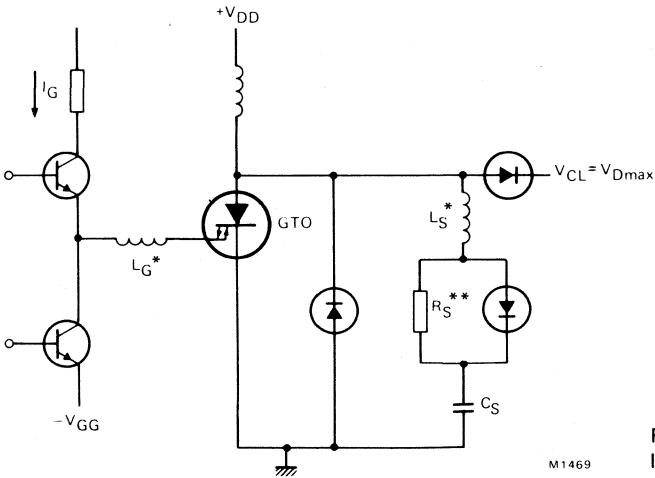


Fig.4 Inductive load test circuit.

\* Indicates stray series inductance only.

\*\* Minimum permissible GTO on-time ( $\mu\text{s}$ ) =  $R_S (\Omega) \times C_S (\mu\text{F}) \times 5$ .

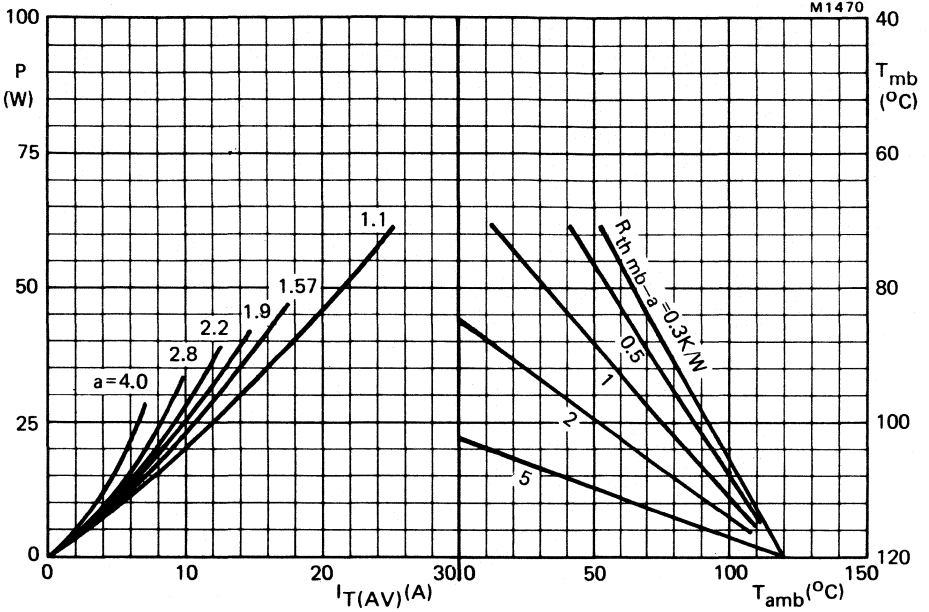


Fig.5 The right hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

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

P = power excluding switching losses.

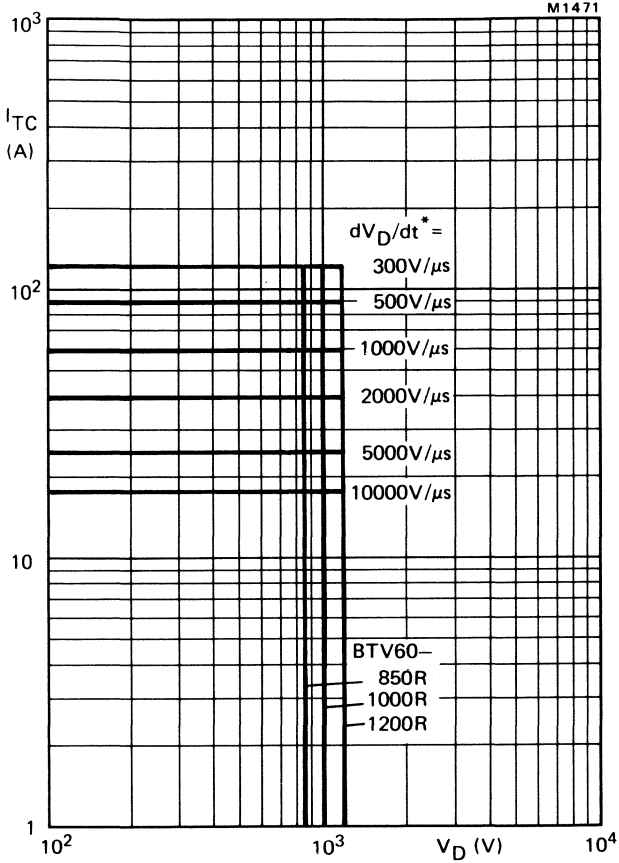


Fig.6 Anode current which can be turned off versus anode voltage; inductive load;  $V_{GR} = 10$  V;  $L_G \leq 0.5 \mu H$ ;  $L_S \leq 0.25 \mu H$ ;  $T_j = 120$  °C.  
 \* $dV_D/dt$  is calculated from  $I_T/C_S$ .



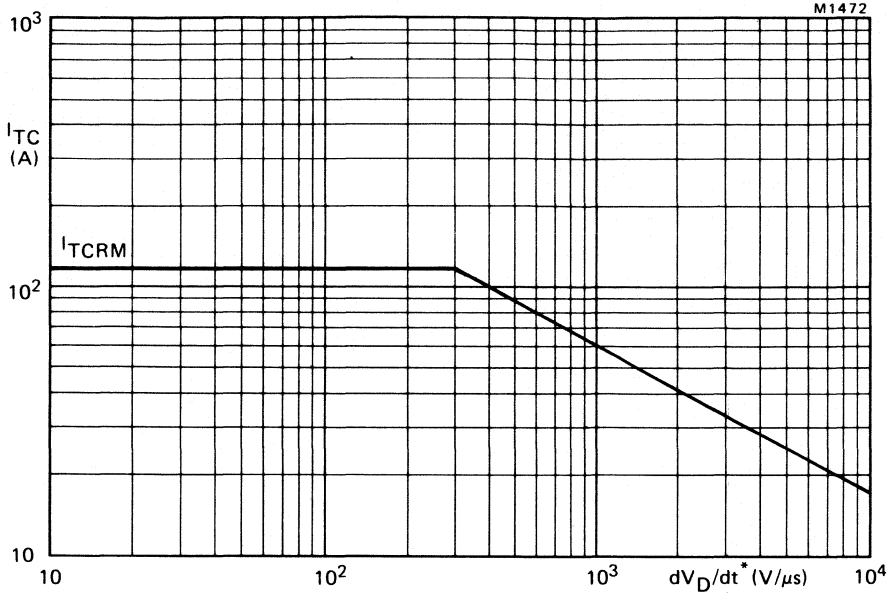


Fig.7 Anode current which can be turned off versus applied  $dV_D/dt^*$ ; inductive load;  $V_{GR} = 10$  V;  $L_G \leq 0.5 \mu H$ ;  $L_S \leq 0.25 \mu H$ ;  $T_j = 120$  °C. \* $dV_D/dt$  is calculated from  $I_T/C_S$ .

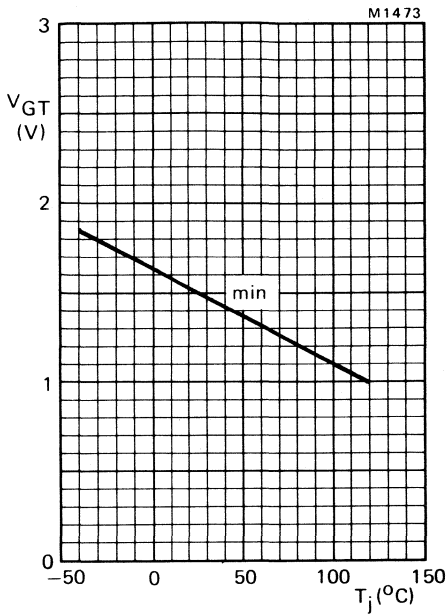


Fig.8 Minimum gate voltage that will trigger all devices as a function of junction temperature;  $V_D = 12$  V.

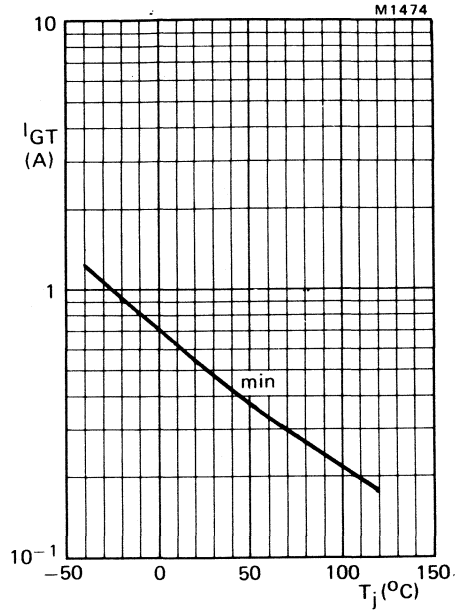


Fig.9 Minimum gate current that will trigger all devices as a function of junction temperature;  $V_D = 12$  V.

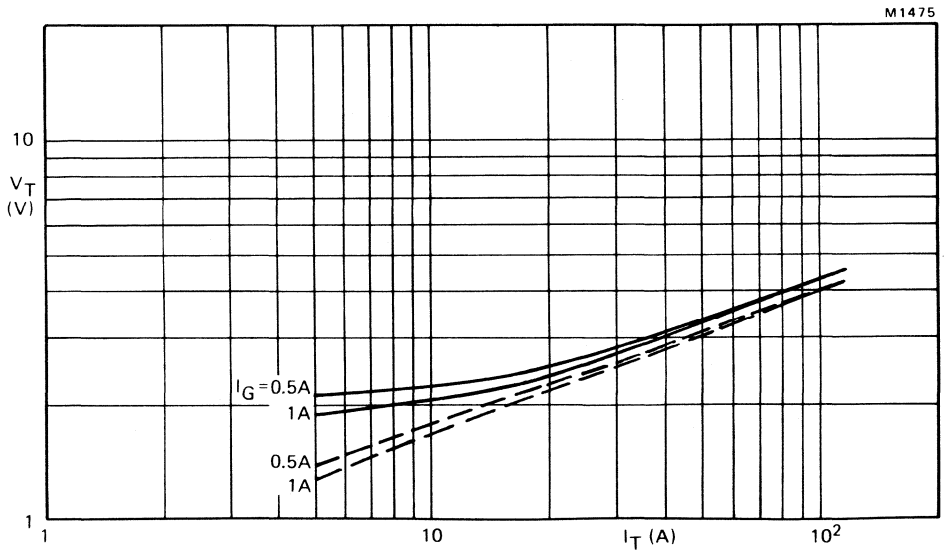


Fig.10 Maximum  $V_T$  versus  $I_T$ ; —  $T_j = 25^{\circ}\text{C}$ ; - - -  $T_j = 120^{\circ}\text{C}$ .

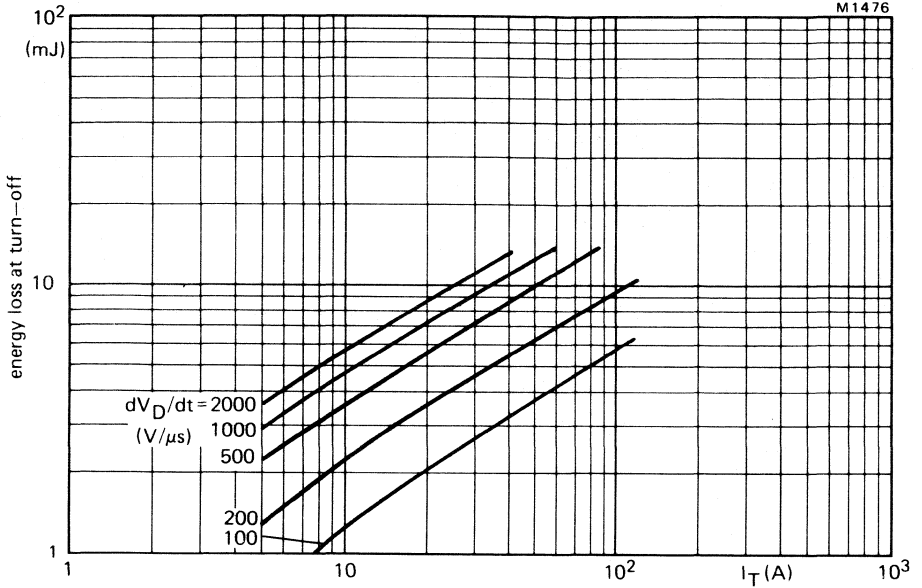


Fig.11 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied  $dV_D/dt$  (calculated from  $I_T/C_S$ );  $dV_D/dt$  linear up to  $V_{Dmax} = 600$  V;  $V_{GR} = 10$  V;  $I_G = 0.5$  A;  $L_G \leq 0.5 \mu H$ ;  $L_S \leq 0.25 \mu H$ ;  $T_j = 120$  °C.

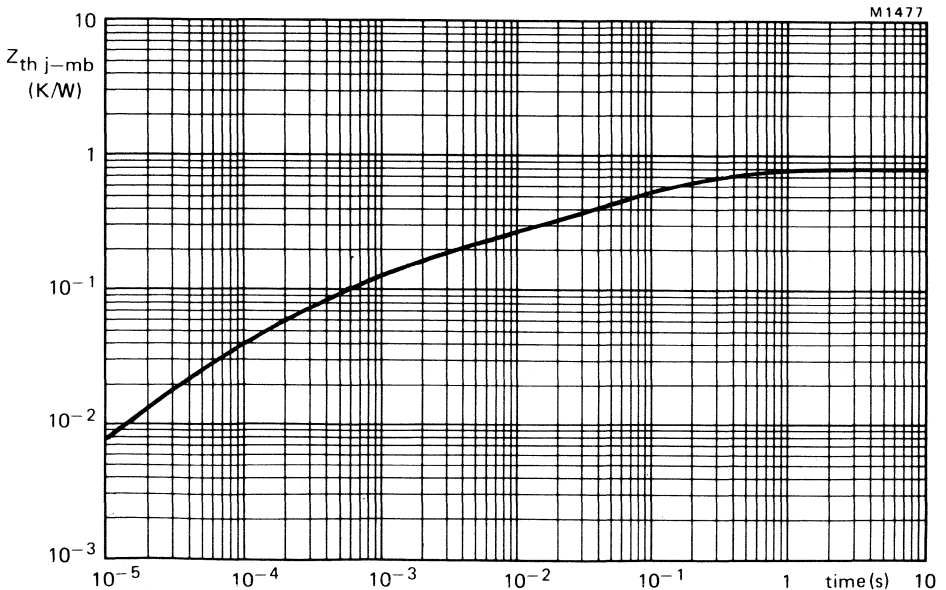


Fig.12 Transient thermal impedance.



## 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.

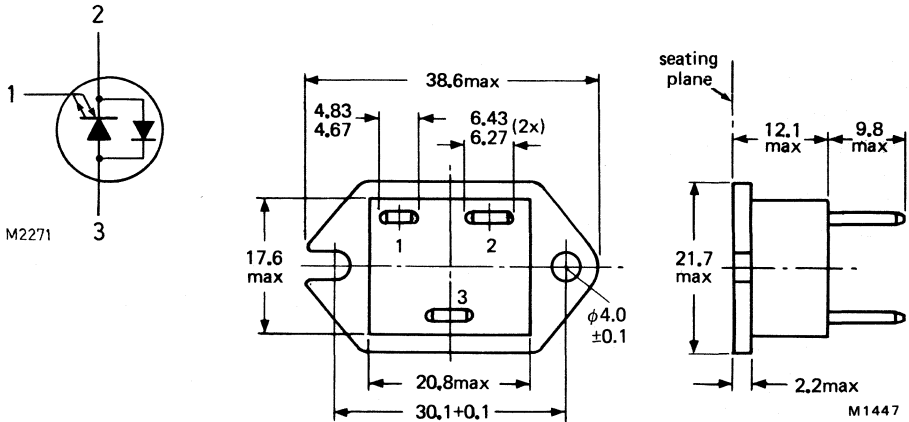
### QUICK REFERENCE DATA

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
<b>Diode</b>					
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)

Anode to cathode		BTV60D-850R			1000R	1200R
			max.	1000	1100	1300
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 $T_{mb} = 70\text{ }^\circ\text{C}$						
	$I_T(AV)$	max.		25		A
Controllable anode current						
	$I_{TCRM}$	max.		120		A
Non-repetitive peak on-state current						
t = 10 ms; half-sinewave;						
$T_j = 120\text{ }^\circ\text{C}$ prior to surge						
	$I_{TSM}$	max.		240		A
$I^2 t$ for fusing; t = 10 ms						
	$I^2 t$	max.		290		A <sup>2</sup> s
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$						
	$P_{tot}$	max.		120		W
Maximum rate of rise of anode current						
at turn-on, $V_D = V_{Dmax}$ ;						
$I_{GF} = 2.5\text{ A}$ ; $I_T = 200\text{ A}$						
	$di_T/dt$	max.		1000		A/ $\mu$ s
<b>Gate to cathode</b>						
Repetitive peak on-state current						
gate-cathode forward; t = 1 ms;						
gate-cathode reverse; t = 20 $\mu$ s						
	$I_{GFM}$	max.		35		A
	$I_{GRM}$	max.		50		A
Average power dissipation (averaged over any 20 ms period)						
	$P_G(AV)$	max.		10		W
<b>Diode</b>						
Average forward current (averaged over any 20 ms period) up to $T_{mb} = 70\text{ }^\circ\text{C}$						
	$I_F(AV)$	max.		14		A
Non-repetitive peak forward current						
t = 10 ms, half-sinewave						
$T_j = 120\text{ }^\circ\text{C}$ prior to surge						
	$I_{FSM}$	max.		100		A
<b>Temperatures</b>						
Storage temperature						
	$T_{stg}$			-40 to +125		$^\circ\text{C}$
Operating junction temperature						
	$T_j$	max.		120		$^\circ\text{C}$
<b>ISOLATION**</b>						
R.M.S. isolation voltage						
	$V_{isol}$	min.		2500		V

\*Measured with gate-cathode connected together.

\*\*From baseplate to all terminals strapped together.

Fast gate turn-off thyristors

THERMAL RESISTANCE

GTO

From junction to mounting base  $R_{th\ j-mb} = 0.8\ K/W$

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

Diode

From junction to mounting base  $R_{th\ j-mb} = 1.4\ K/W$

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

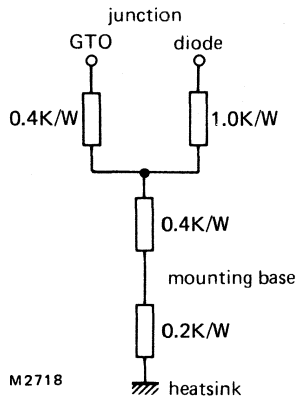


Fig.2 Equivalent thermal network.

## GTO CHARACTERISTICS

### Anode to cathode

On-state voltage

$$I_T = 20 \text{ A}; I_G = 0.5 \text{ A}; T_j = 120 \text{ }^\circ\text{C} \quad V_T < 2.2 \text{ V}^*$$

Rate of rise of off-state voltage that will not trigger any off-state device; exponential method

$$V_D = 2/3 V_{Dmax}; V_{GR} = 5 \text{ V}; T_j = 120 \text{ }^\circ\text{C} \quad dV_D/dt < 10 \text{ kV}/\mu\text{s}$$

Rate of rise of off-state voltage that will not trigger any device following conduction, linear method

$$I_T = 60 \text{ A}; V_D = V_{DRMmax}; V_{GR} = 10 \text{ V}; T_j = 120 \text{ }^\circ\text{C} \quad dV_D/dt < 1.0 \text{ kV}/\mu\text{s}$$

Off-state current

$$V_D = V_{Dmax}; T_j = 120 \text{ }^\circ\text{C} \quad I_D < 5.0 \text{ mA}$$

Latching current;  $T_j = 25 \text{ }^\circ\text{C}$

$$I_L \text{ typ. } 5.0 \text{ A}^{**}$$

### Gate to cathode

Voltage that will trigger all devices

$$V_D = 12 \text{ V}; T_j = 25 \text{ }^\circ\text{C} \quad V_{GT} > 1.5 \text{ V}$$

Current that will trigger all devices

$$V_D = 12 \text{ V}; T_j = 25 \text{ }^\circ\text{C} \quad I_{GT} > 500 \text{ mA}$$

Minimum reverse breakdown voltage

$$I_{GR} = 1.0 \text{ mA} \quad V_{(BR)GR} > 10 \text{ V}$$

### Switching characteristics (resistive load)

Turn-on when switched to  $I_T = 50 \text{ A}$  from  $V_D > 250 \text{ V}$   
with  $I_{GF} = 2.5 \text{ A}; T_j = 25 \text{ }^\circ\text{C}$

$$\text{delay time} \quad t_d < 0.5 \mu\text{s}$$

$$\text{rise time} \quad t_r < 2.0 \mu\text{s}$$

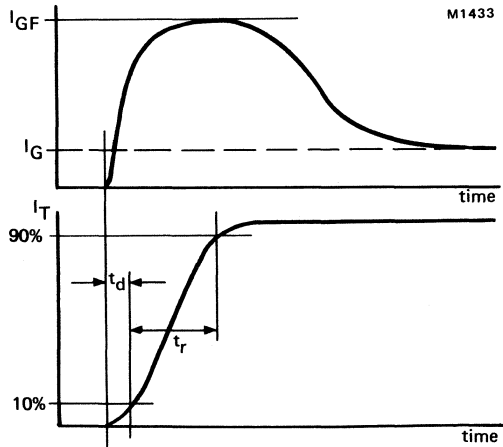


Fig.3 Waveforms.

\*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  $V_D = V_{Dmax}$  ;

$V_{GR} = 10 V$ ;  $L_G \leq 0.4\mu H$ ;  $L_S \leq 0.25 \mu H$ ,  $C_s \geq 50nF$ ,  $T_j = 25^\circ C$

storage time	$t_s$	<	1.0	$\mu s$
fall time	$t_f$	<	0.3	$\mu s$
peak reverse gate current	$I_{GR}$	<	25	A

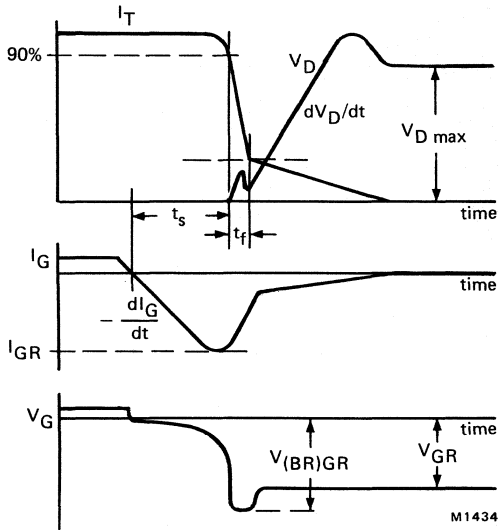


Fig.4 Waveforms.

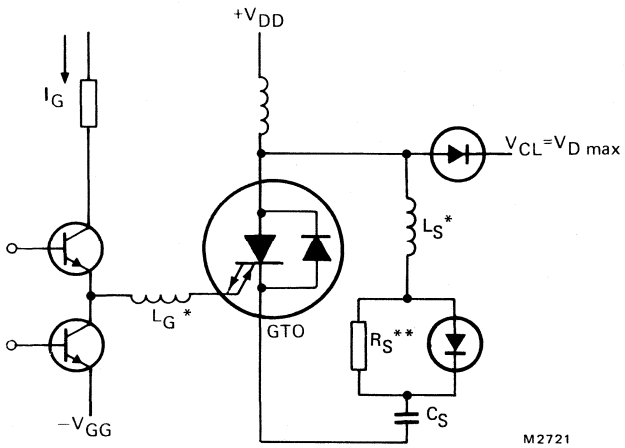


Fig.5 Inductive load test circuit.

\* Indicates stray series inductance only.

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

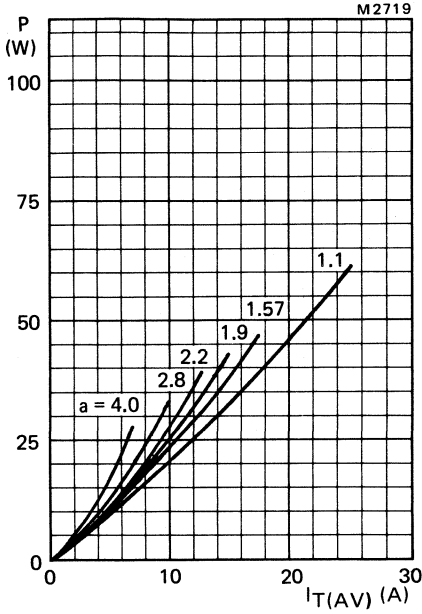


Fig.6 (a,b) Power dissipation as a function of average current (maximum values).

$a = \text{form factor} = I_T(\text{RMS})/I_T(\text{AV})$

P=power excluding switching losses.

Fig.6a GTO

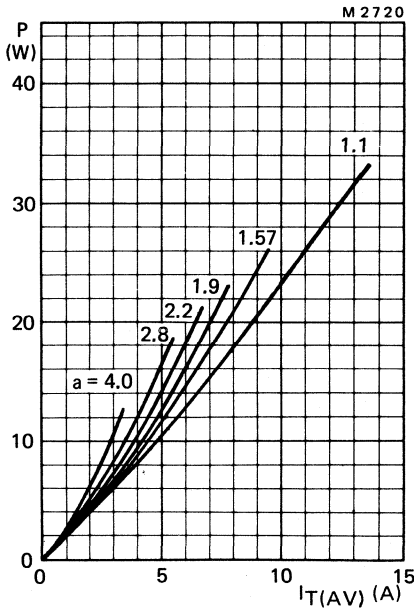


Fig.6b Diode.

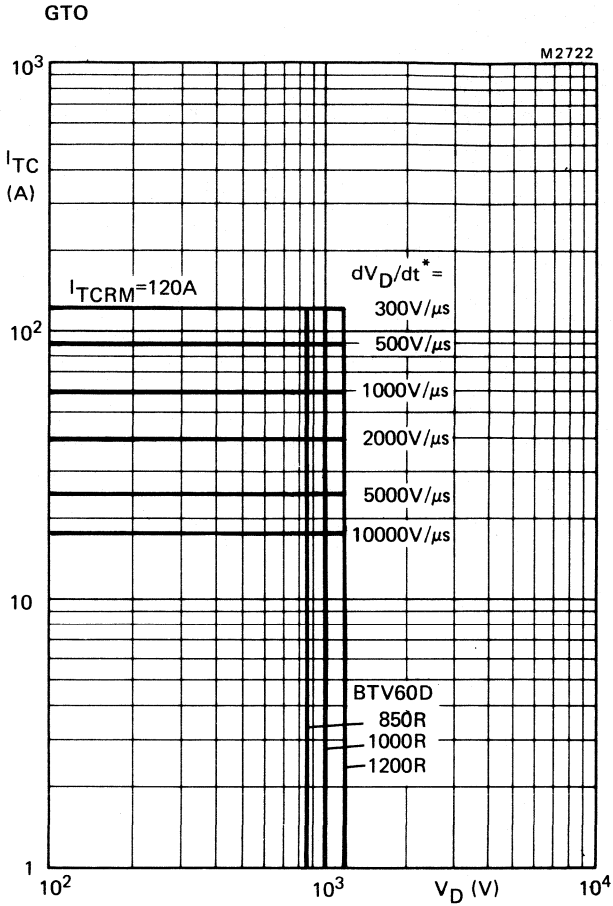


Fig.7 Anode current which can be turned off versus anode voltage; inductive load;  $V_{GR} = 10$  V;  $L_G \leq 0.5 \mu H$ ;  $L_S \leq 0.25 \mu H$ ;  $T_j = 120^\circ C$ .  
 $*dV_D/dt$  is calculated from  $I_T/C_S$ .

GTO (cont.)

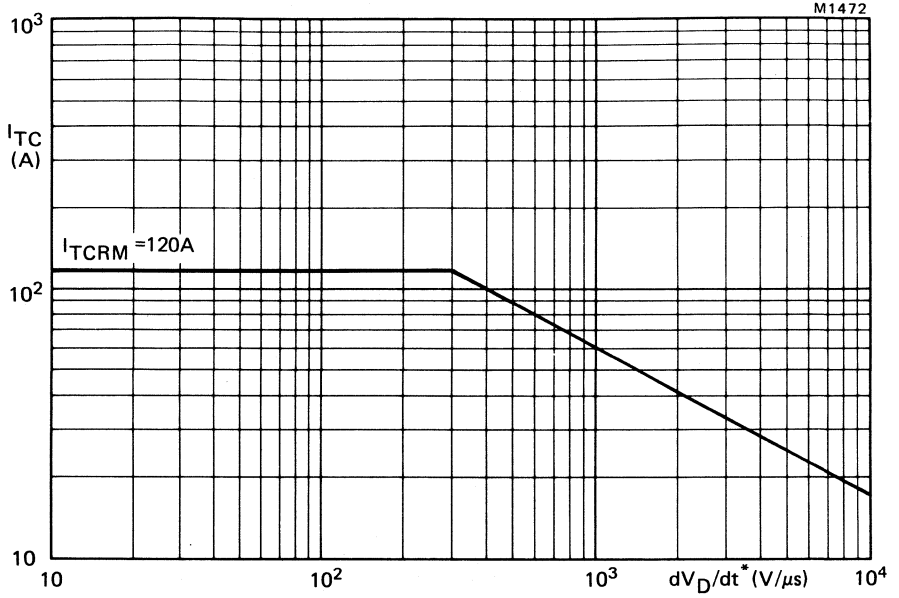


Fig.8 Anode current which can be turned off versus applied  $dV_D/dt^*$ ; inductive load;  $V_{GR} = 10$  V;  
 $L_G \leq 0.5 \mu H$ ;  $L_S \leq 0.25 \mu H$ ;  $T_j = 120$  °C.  
 \* $dV_D/dt$  is calculated from  $I_T/C_S$ .

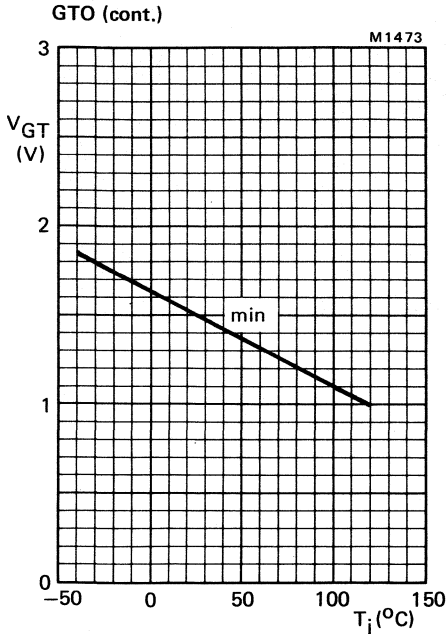


Fig.9 Minimum gate voltage that will trigger all devices as a function of junction temperature;  $V_D = 12\text{ V}$ .

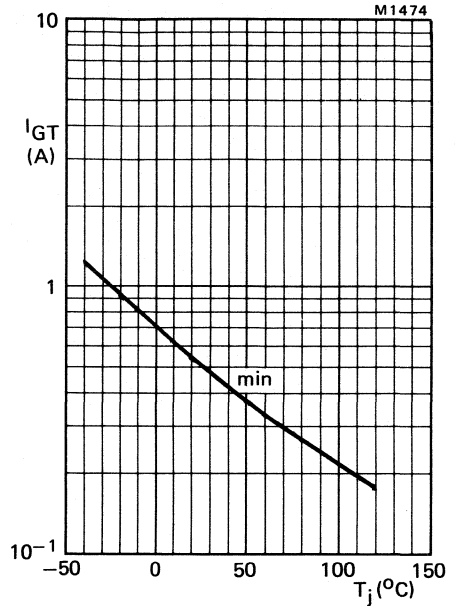


Fig.10 Minimum gate current that will trigger all devices as a function of junction temperature;  $V_D = 12\text{ V}$ .

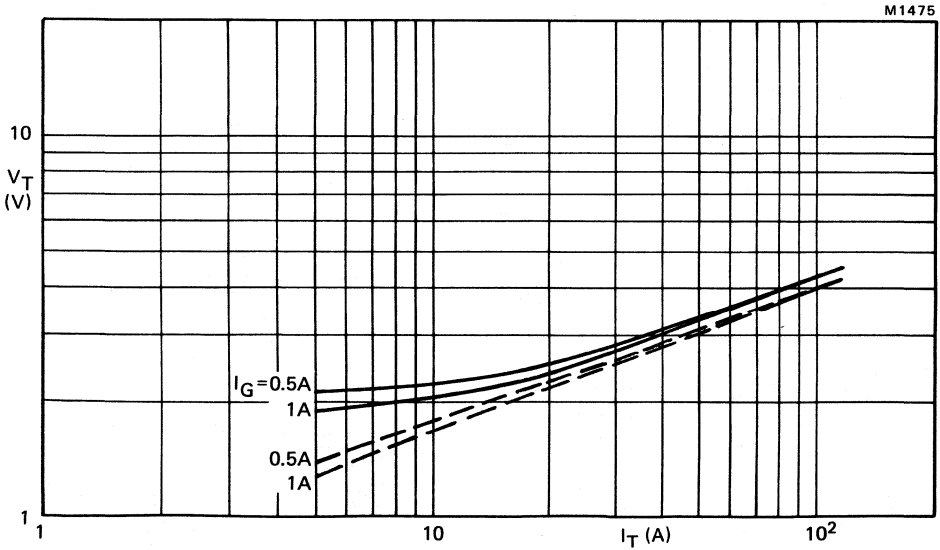


Fig.11 Maximum  $V_T$  versus  $I_T$ ; —  $T_j = 25\text{ °C}$ ; - - -  $T_j = 120\text{ °C}$ .

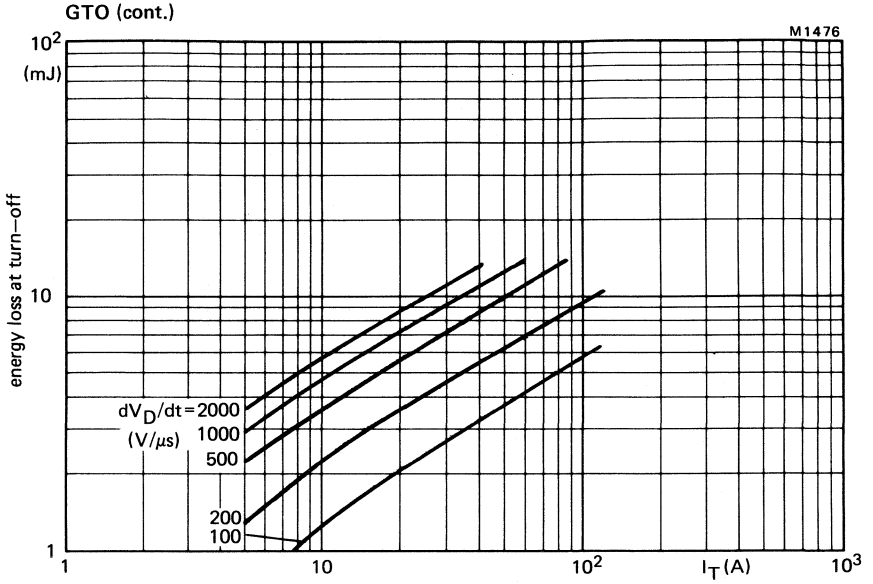


Fig.12 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied  $dV_D/dt$  (calculated from  $I_T/C_S$ );  $dV_D/dt$  linear up to  $V_{Dmax} = 600$  V;  $V_{GR} = 10$  V;  $I_G = 0.5$  A;  $L_G \leq 0.5 \mu H$ ;  $L_S \leq 0.25 \mu H$ ;  $T_j = 120$  °C.

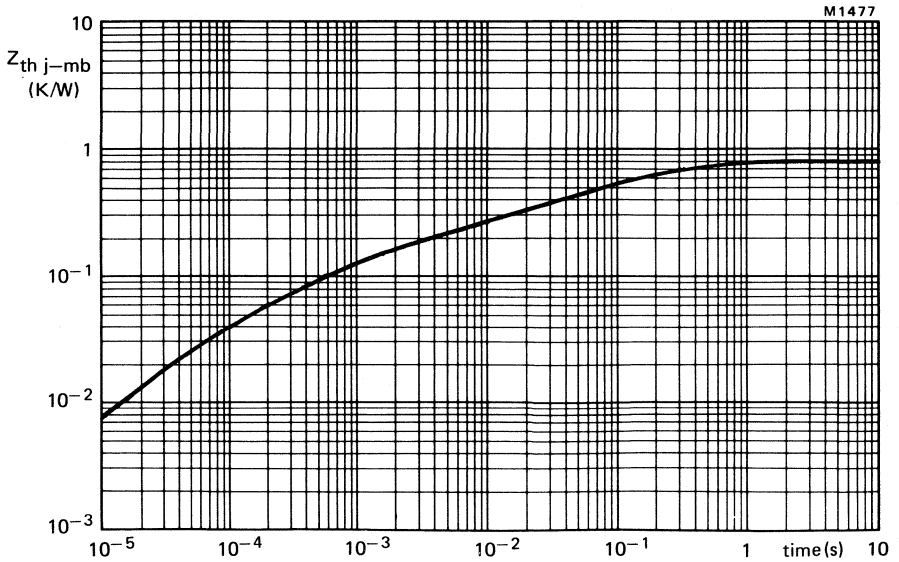


Fig.13 Transient thermal impedance.

**DIODE CHARACTERISTICS**

Forward voltage

$I_F = 20 \text{ A}; T_j = 25 \text{ }^\circ\text{C}$

$V_F < 2.5 \text{ V}^*$

Reverse recovery when switched from

$I_F = 2 \text{ A to } V_R \geq 30 \text{ V with } -dI_F/dt = 20 \text{ A}/\mu\text{s}; T_j = 25 \text{ }^\circ\text{C}$

$Q_s < 2.0 \mu\text{C}$   
 $t_{rr} < 0.6 \mu\text{s}$

recovered charge

recovery time

Forward recovery when switched to

$I_F = 5 \text{ A with } t_r = 0.1 \mu\text{s}; T_j = 25 \text{ }^\circ\text{C}$

recovery time

$t_{fr} < 1.0 \mu\text{s}$

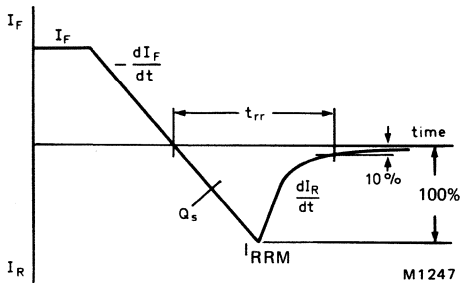


Fig.14 Definition of  $t_{rr}$  and  $Q_s$ .

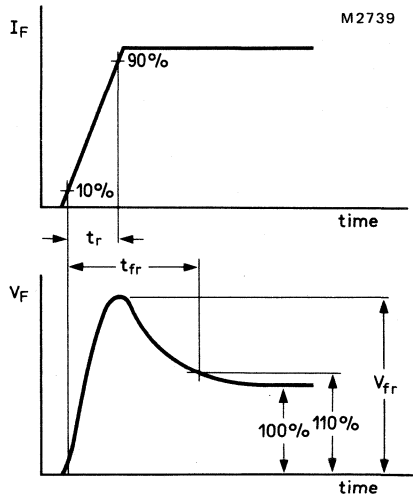


Fig.15 Definition of  $t_{fr}$ .

\*Measured under pulse conditions to avoid excessive dissipation.

DIODE (cont.)

M2723

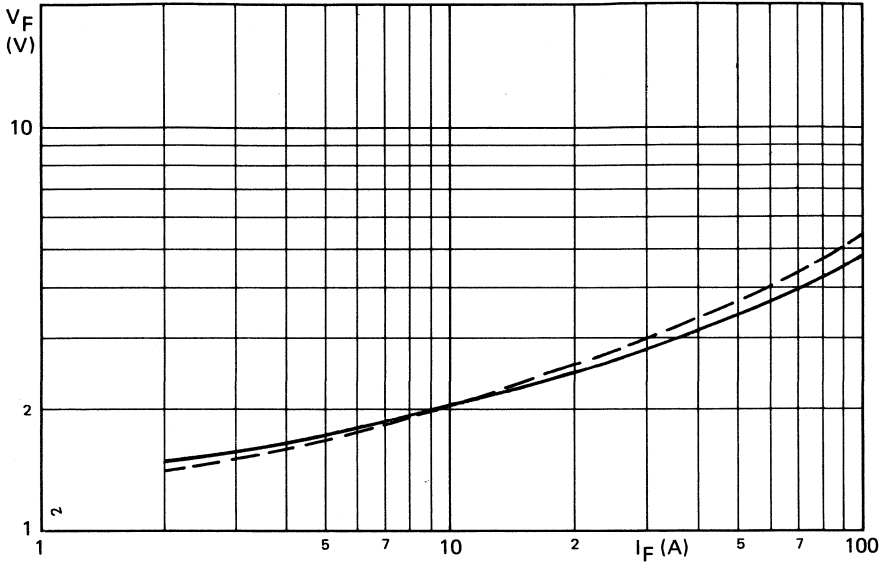


Fig.16 Forward voltage as a function of forward current; maximum values;  
 —  $T_j = 25\text{ }^\circ\text{C}$ ; - - -  $T_j = 120\text{ }^\circ\text{C}$ .

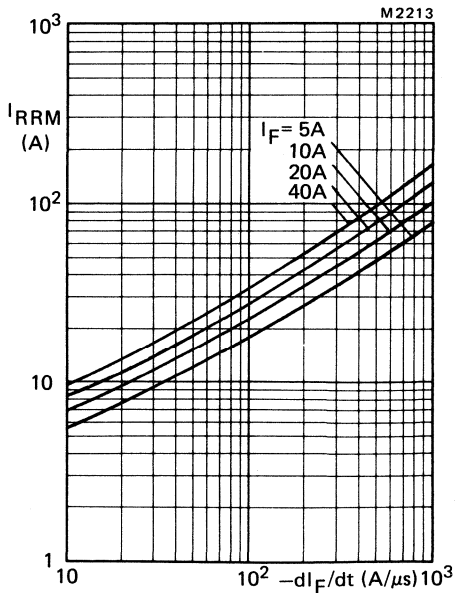


Fig.17 Peak reverse recovery current versus  $-di_F/dt$ ;  $T_j = 25\text{ }^\circ\text{C}$ ; maximum values.



DIODE (cont.)

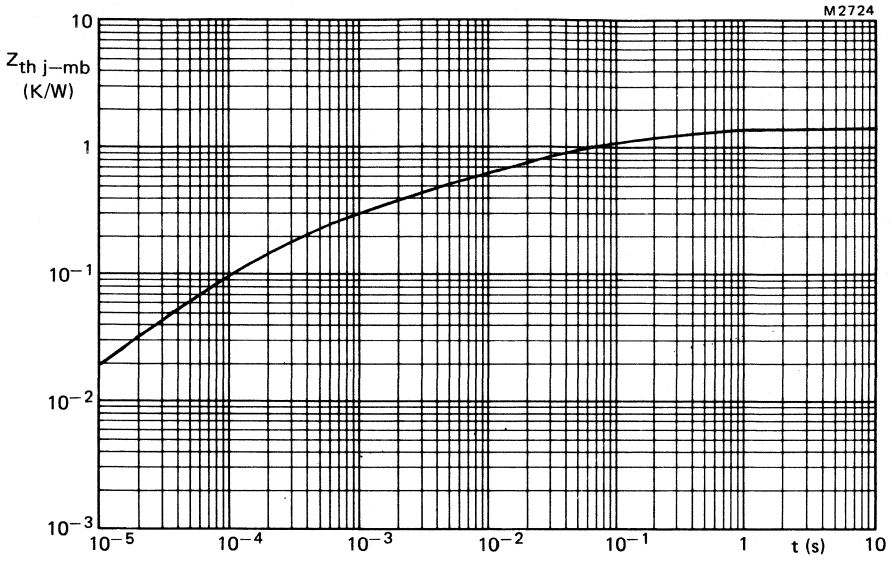


Fig.18 Transient thermal impedance.



## 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.

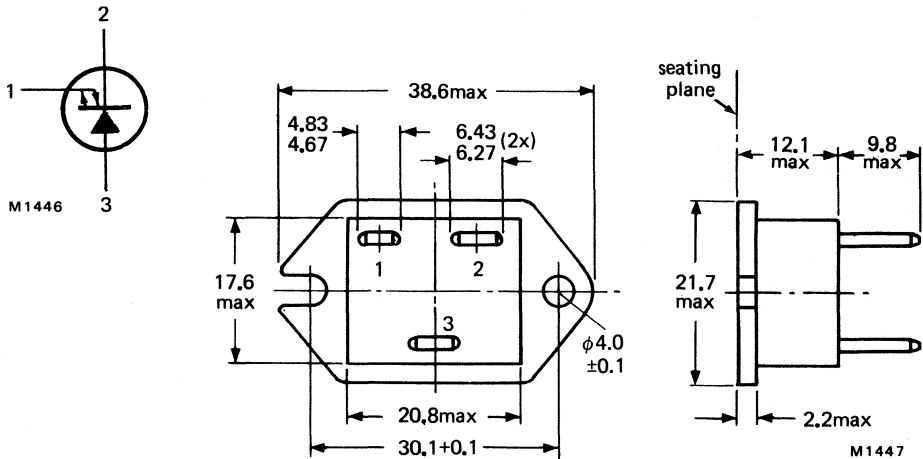
### QUICK REFERENCE DATA

		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)

		BTV70-850R	1000R	1200R		
<b>Anode to cathode</b>						
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 $T_{mb} = 60\text{ }^\circ\text{C}$						
	$I_{T(AV)}$	max.		15		A
Controllable anode current						
	$I_{TCRM}$	max.		50		A
Non-repetitive peak on-state current						
t = 10 ms; half-sinewave;						
$T_j = 120\text{ }^\circ\text{C}$ prior to surge						
	$I_{TSM}$	max.		100		A
$I^2t$ for fusing; t = 10 ms						
	$I^2t$	max.		50		A <sup>2</sup> s
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$						
	$P_{tot}$	max.		60		W
<b>Gate to cathode</b>						
Repetitive peak current						
$T_j = 120\text{ }^\circ\text{C}$ prior to surge						
gate-cathode forward; t = 10 ms;						
half-sinewave						
	$I_{GFM}$	max.		25		A
gate-cathode reverse; t = 20 $\mu$ s						
	$I_{GRM}$	max.		25		A
Average power dissipation (averaged over any 20 ms period)						
	$P_{G(AV)}$	max.		5.0		W
<b>Temperatures</b>						
Storage temperature						
	$T_{stg}$			-40 to +125		$^\circ\text{C}$
Operating junction temperature						
	$T_j$	max.		120		$^\circ\text{C}$
<b>ISOLATION**</b>						
R.M.S. isolation voltage						
	$V_{isol}$	min.		2500		V
<b>THERMAL RESISTANCE</b>						
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 $I_T = 10 \text{ A}; I_G = 0.5 \text{ A}; T_j = 120 \text{ }^\circ\text{C}$	$V_T$	<	2.3	V*
Rate of rise of off-state voltage that will not trigger any off-state device, exponential method $V_D = 2/3 V_{Dmax}; V_{GR} = 5 \text{ V}; T_j = 120 \text{ }^\circ\text{C}$	$dV_D/dt$	<	10	kV/ $\mu$ s
Rate of rise of off-state voltage that will not trigger any device following conduction, linear method $I_T = 20 \text{ A}; V_D = V_{DRMmax}; V_{GR} = 10 \text{ V}; T_j 120 \text{ }^\circ\text{C}$	$dV_D/dt$	<	1.0	kV/ $\mu$ s
Off-state current $V_D = V_{Dmax}; T_j = 120 \text{ }^\circ\text{C}$	$I_D$	<	5.0	mA
Latching current; $T_j = 25 \text{ }^\circ\text{C}$	$I_L$	typ.	1.5	A**

**Gate to cathode**

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

**Switching characteristics (resistive load)**

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

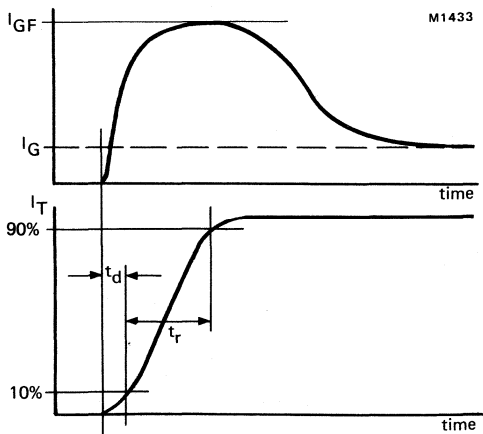


Fig.2 Waveforms.

\* 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  $I_T = 10\text{ A}$  to  $V_D = V_{D\text{max}}$ ;  
 $V_{GR} = 10\text{ V}$ ;  $L_G \leq 0.5\ \mu\text{H}$ ;  $L_S \leq 0.25\ \mu\text{H}$ ;  $T_j = 25\text{ }^\circ\text{C}$

storage time	$t_s$	<	0.60	$\mu\text{s}$
fall time	$t_f$	<	0.25	$\mu\text{s}$
peak reverse gate current	$I_{GR}$	<	10	A

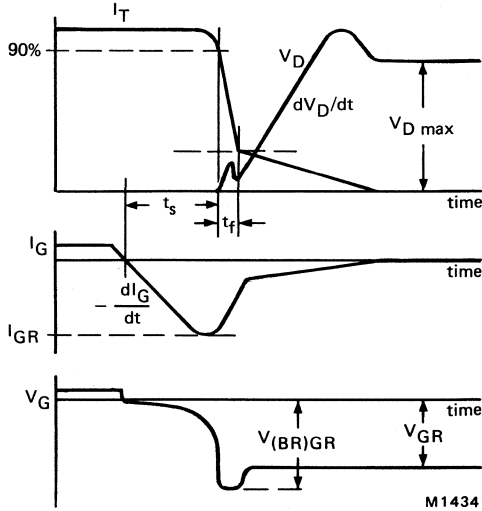


Fig.3 Waveforms.

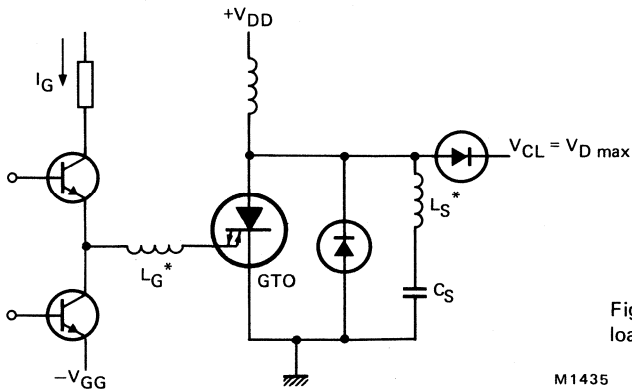


Fig.4 Inductive load test circuit.

M1435

\* Indicates stray series inductance only

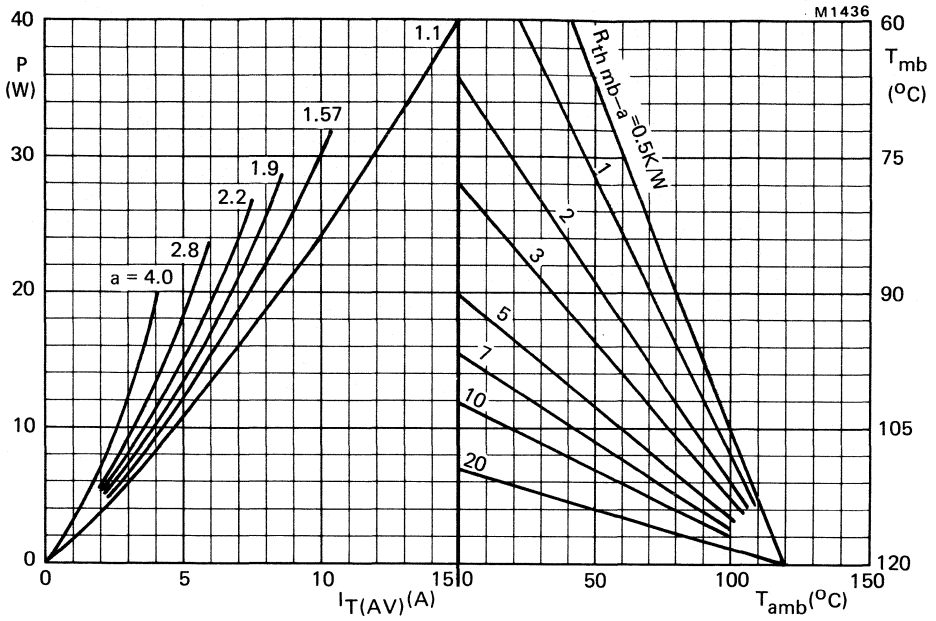


Fig.5 The right hand part shows the interrelationship between the power (derived from the left hand part) and the maximum permissible temperatures.

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

P = power excluding switching losses.

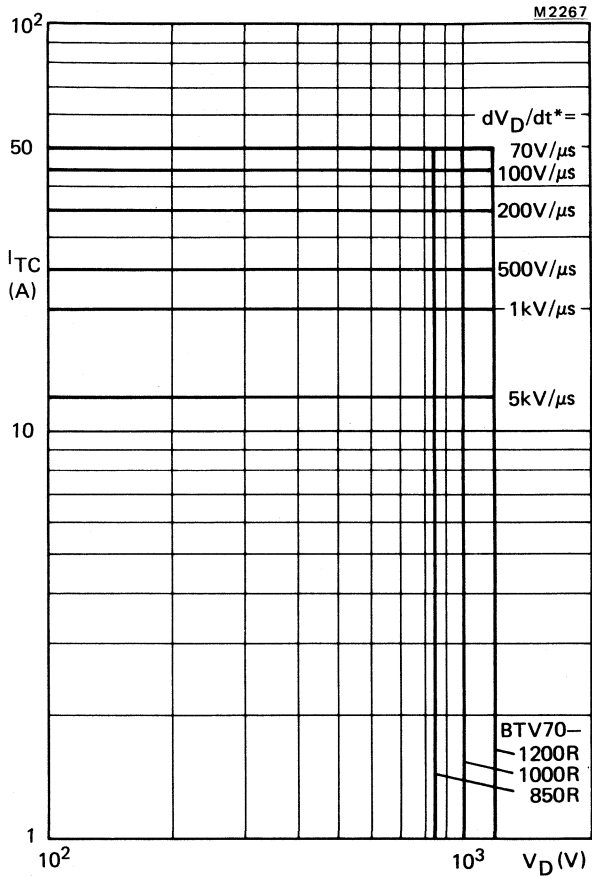


Fig.6 Anode current which can be turned off versus anode voltage; inductive load;  
 $V_{GR} = 10$  V;  $L_G \leq 0.5 \mu$ H;  $L_S \leq 0.25 \mu$ H;  $T_j = 120$  °C.

\* $dV_D/dt$  is calculated from  $I_T/C_S$ .



M2268

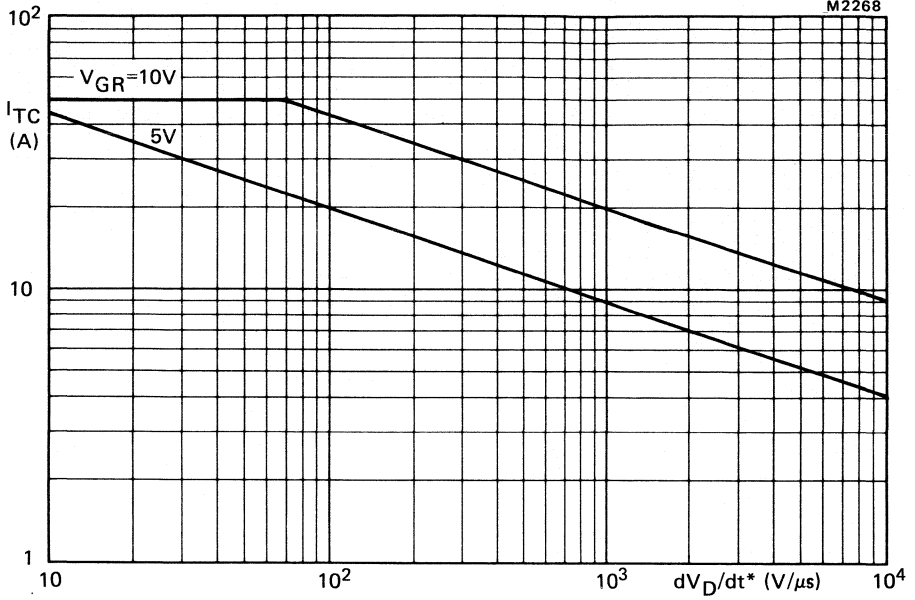


Fig.7 Anode current which can be turned off versus applied  $dV_D/dt^*$ ; inductive load;  
 $L_G \leq 0.5 \mu H$ ,  $L_S \leq 0.25 \mu H$ ,  $T_j = 120^\circ C$ ;

\* $dV_D/dt$  is calculated from  $I_T/C_S$ .

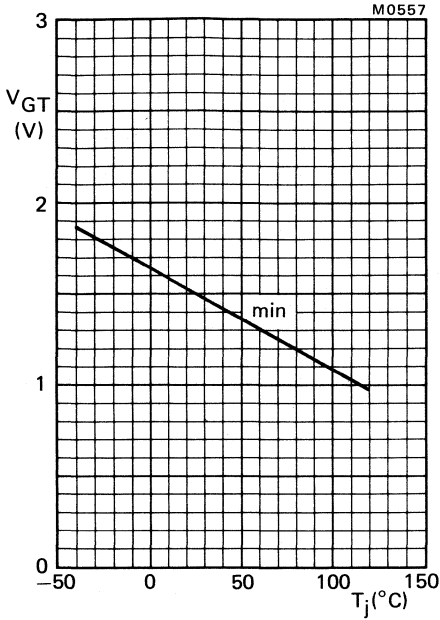


Fig.8 Minimum gate voltage that will trigger all devices as a function of junction temperature;  $V_D = 12$  V.

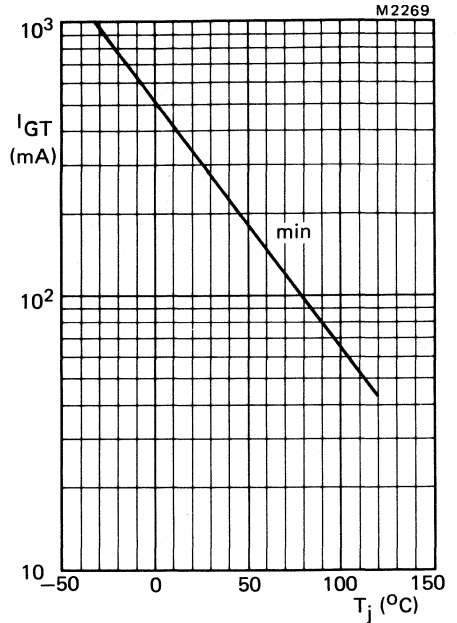


Fig.9 Minimum gate current that will trigger all devices as a function of junction temperature;  $V_D = 12$  V.

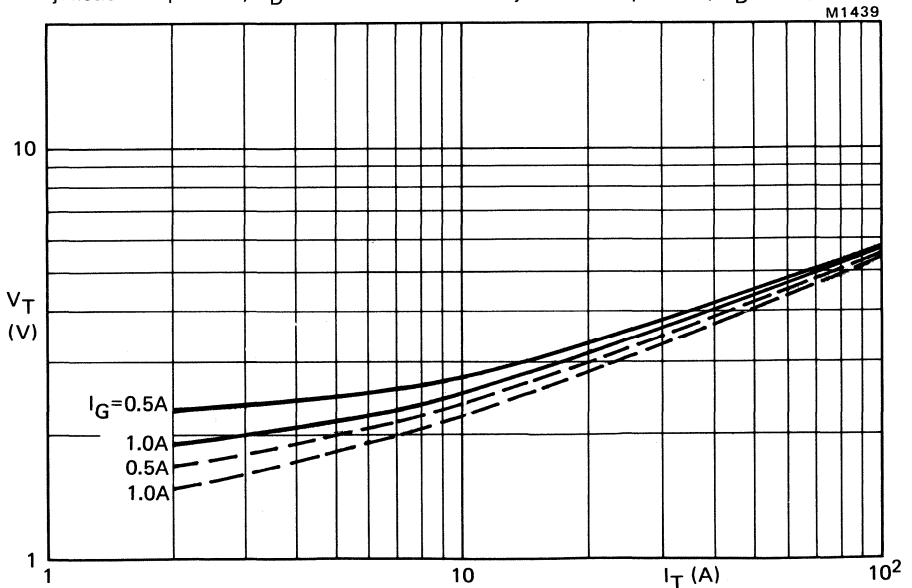


Fig.10 Maximum  $V_T$  versus  $I_T$ ; —  $T_j = 25$   $^{\circ}\text{C}$ ; - - -  $T_j = 120$   $^{\circ}\text{C}$ .

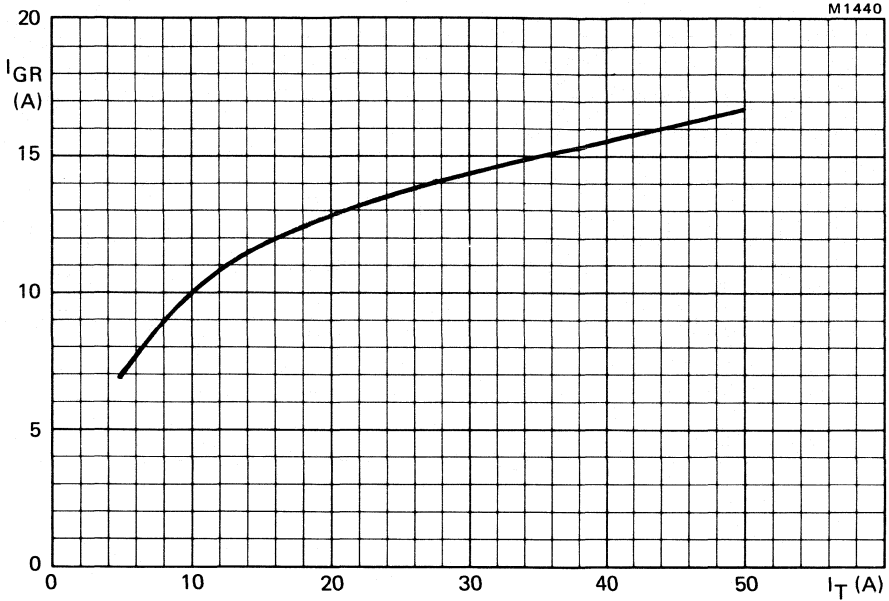


Fig.11 Peak reverse gate current versus anode current at turn-off; inductive load;  $V_{GR} = 10$  V;  $I_G = 0.5$  A;  $L_G = 0.4$   $\mu$ H;  $T_j = 120$   $^{\circ}$ C; maximum values.

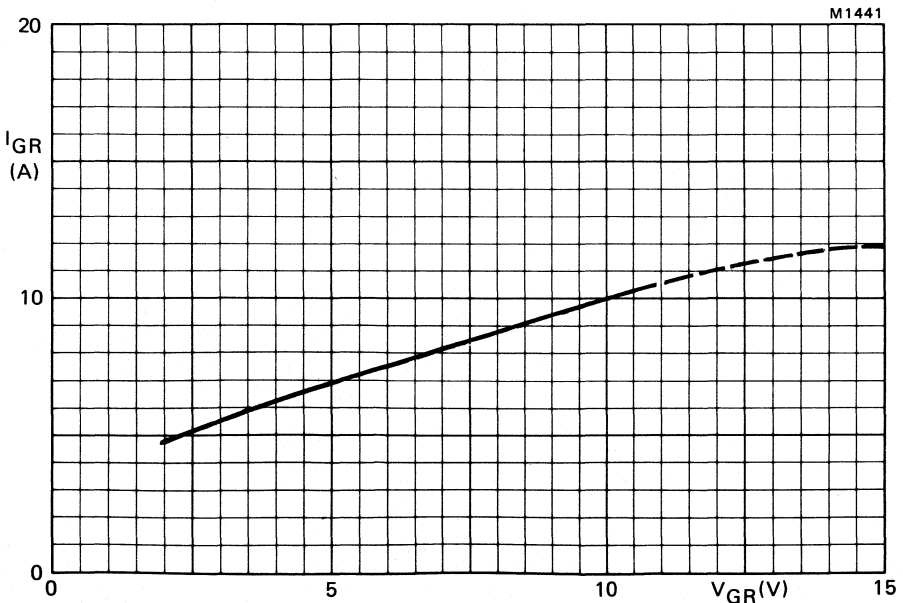


Fig.12 Peak reverse gate current versus applied reverse gate voltage; inductive load;  $I_T = 10$  A;  $I_G = 0.5$  A;  $L_G = 0.4$   $\mu$ H;  $T_j = 120$   $^{\circ}$ C; maximum values.

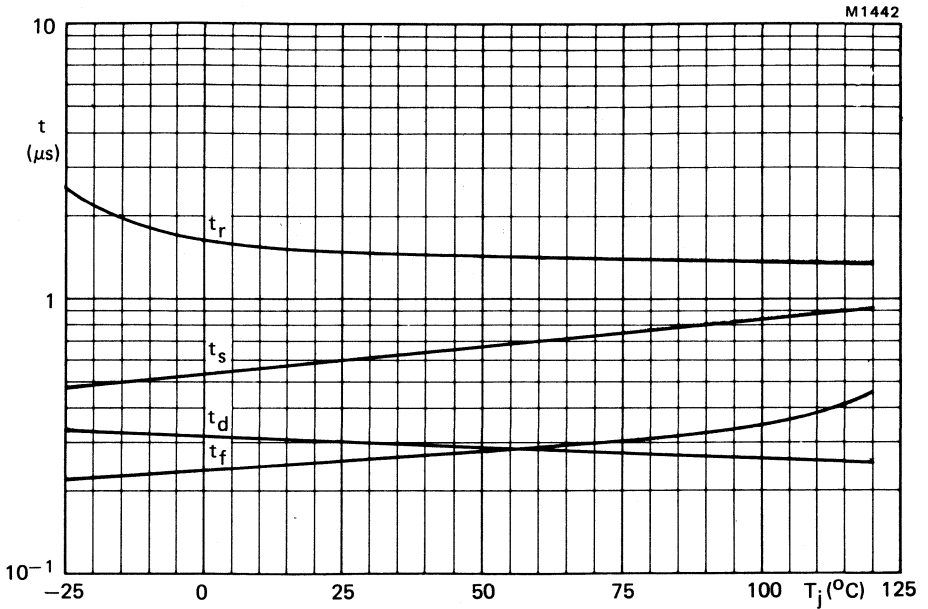


Fig.13 Switching times as a function of junction temperature;  $V_D \geq 250$  V;  $I_T = 10$  A;  $I_{GF} = 1.0$  A;  $V_{GR} = 10$  V;  $I_G = 0.5$  A;  $L_G = 0.4 \mu H$ ; maximum values.

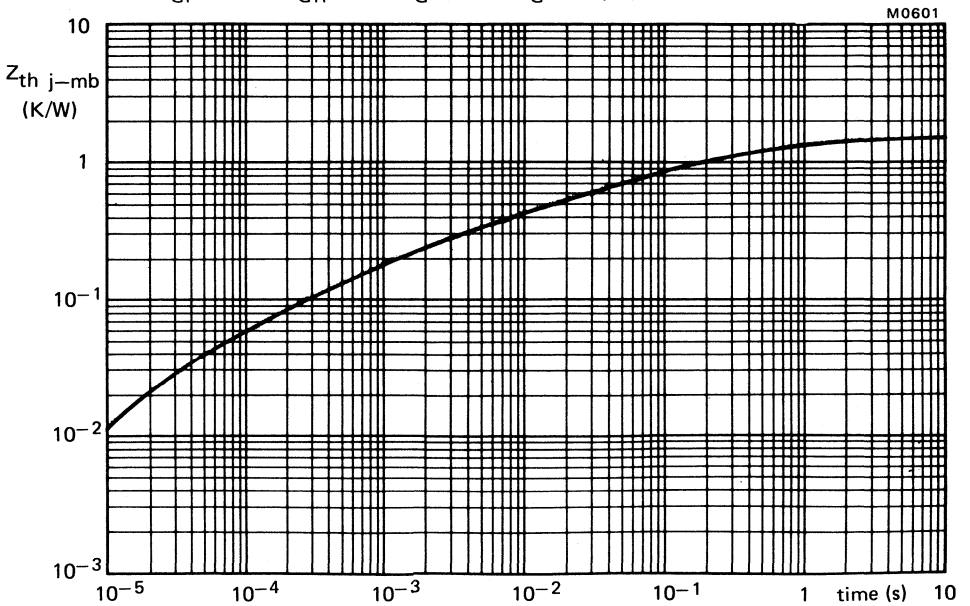


Fig.14 Transient thermal impedance.

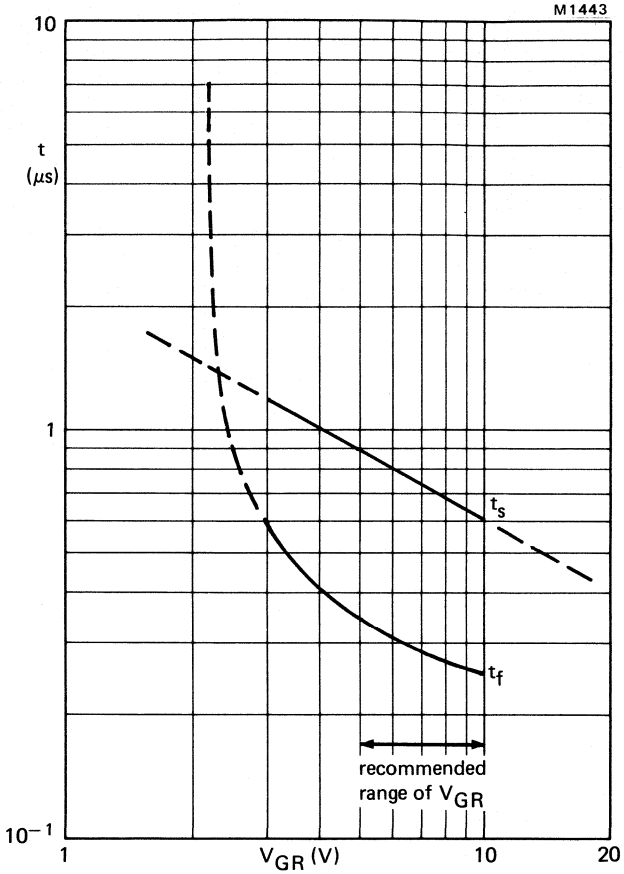


Fig.15 Storage and fall times versus applied reverse gate voltage; inductive load;  $I_T = 10$  A;  $I_G = 0.5$  A;  $L_G = 0.4 \mu H$ ;  $T_j = 25$  °C; maximum values.

M1444

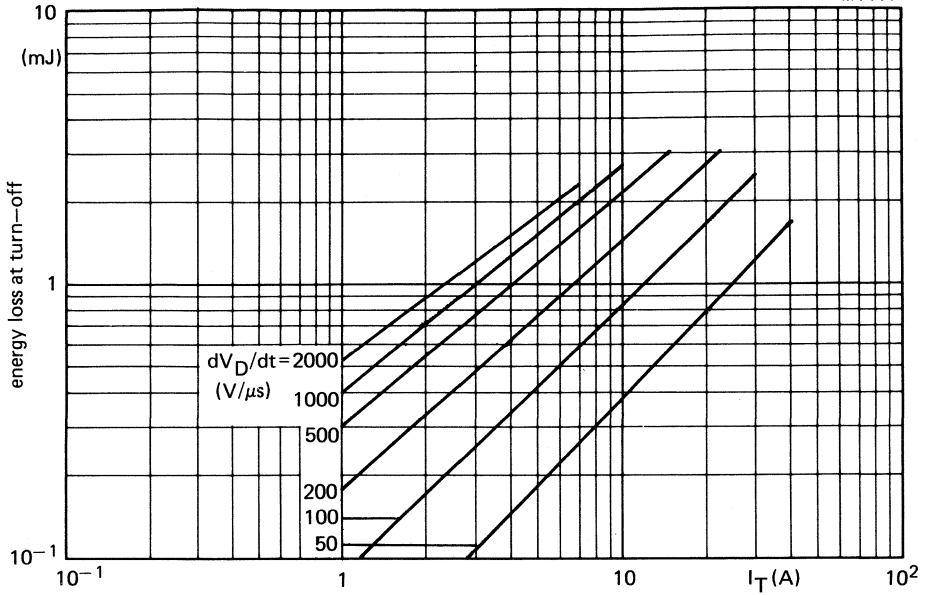


Fig.16 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied  $dV_D/dt$  (calculated from  $I_T/C_S$ );  $dV_D/dt$  linear up to  $V_{Dmax} = 600$  V;  $V_{GR} = 10$  V;  $I_G = 0.5$  A;  $L_G \leq 0.5 \mu H$ ;  $L_S \leq 0.25 \mu H$ ;  $T_j = 120$  °C.

M1445

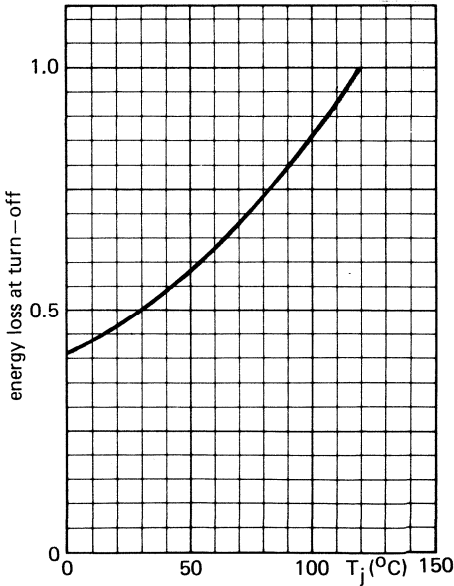


Fig.17 Energy loss at turn-off as a function of junction temperature;  $I_G = 0.5$  A;  $V_{GR} = 10$  V. Normalised to  $T_j = 120$  °C.

## 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.

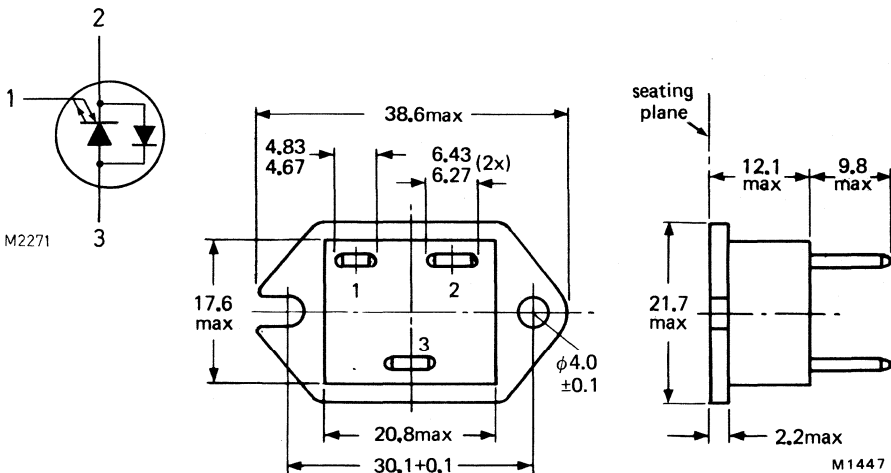
### QUICK REFERENCE DATA

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
<b>Diode</b>						
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)

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

$$R_{th\ j-mb} = 1.5 \quad K/W$$

From mounting base to heatsink  
with heatsink compound

$$R_{th\ mb-h} = 0.3 \quad K/W$$

## Diode

From junction to mounting base

$$R_{th\ j-mb} = 3.6 \quad K/W$$

From mounting base to heatsink  
with heatsink compound

$$R_{th\ mb-h} = 0.3 \quad K/W$$

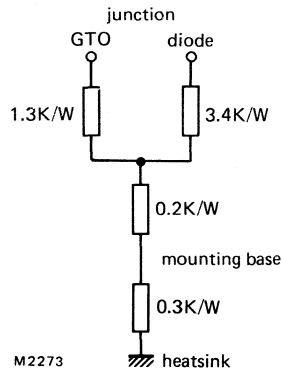


Fig.2 Equivalent thermal network.

## GTO CHARACTERISTICS

### Anode to cathode

On-state voltage

$I_T = 10 \text{ A}; I_G = 0.5 \text{ A}; T_j = 120 \text{ }^\circ\text{C}$   $V_T < 2.3 \text{ V}^*$

Rate of rise of off-state voltage that will not trigger any off-state device; exponential method

$V_D = 2/3 V_{Dmax}; V_{GR} = 5 \text{ V}; T_j = 120 \text{ }^\circ\text{C}$   $dV_D/dt < 10 \text{ kV}/\mu\text{s}$

Rate of rise of off-state voltage that will not trigger any device following conduction, linear method

$I_T = 20 \text{ A}; V_D = V_{DRMmax}; V_{GR} = 10 \text{ V}; T_j = 120 \text{ }^\circ\text{C}$   $dV_D/dt < 1.0 \text{ kV}/\mu\text{s}$

Off-state current

$V_D = V_{Dmax}; T_j = 120 \text{ }^\circ\text{C}$   $I_D < 5.0 \text{ mA}$

Latching current;  $T_j = 25 \text{ }^\circ\text{C}$

$I_L \text{ typ. } 1.5 \text{ A}^{**}$

### Gate to cathode

Voltage that will trigger all devices

$V_D = 12 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$   $V_{GT} > 1.5 \text{ V}$

Current that will trigger all devices

$V_D = 12 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$   $I_{GT} > 300 \text{ mA}$

Minimum reverse breakdown voltage

$I_{GR} = 1.0 \text{ mA}$   $V_{(BR)GR} > 10 \text{ V}$

### Switching characteristics (resistive load)

Turn-on when switched to  $I_T = 10 \text{ A}$  from  $V_D = 250 \text{ V}$  with  $I_{GF} = 1.5 \text{ A}; T_j = 25 \text{ }^\circ\text{C}$

delay time  $t_d < 0.3 \text{ } \mu\text{s}$

rise time  $t_r < 1.5 \text{ } \mu\text{s}$

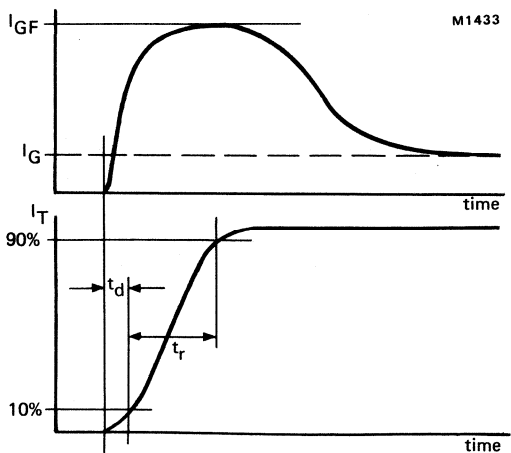


Fig.3 Waveforms.

\* 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  $I_T = 10\text{ A}$  to  $V_D = V_{Dmax}$ ;

$V_{GR} = 10\text{ V}$ ;  $L_G \leq 0.5\ \mu\text{H}$ ;  $L_S \leq 0.25\ \mu\text{H}$ ;  $T_j = 25\text{ }^\circ\text{C}$

storage time

$t_s < 0.60\ \mu\text{s}$

fall time

$t_f < 0.25\ \mu\text{s}$

peak reverse gate current

$I_{GR} < 10\text{ A}$

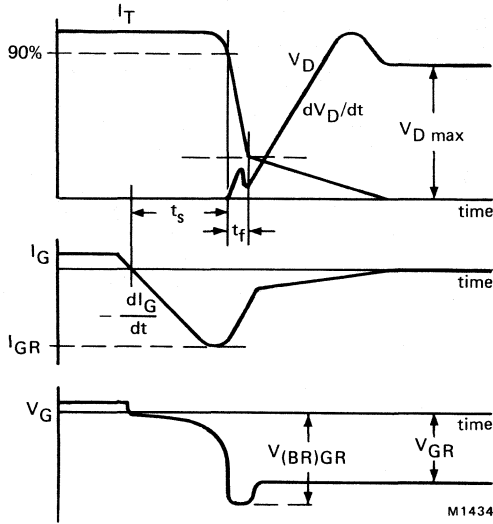


Fig.4 Waveforms.

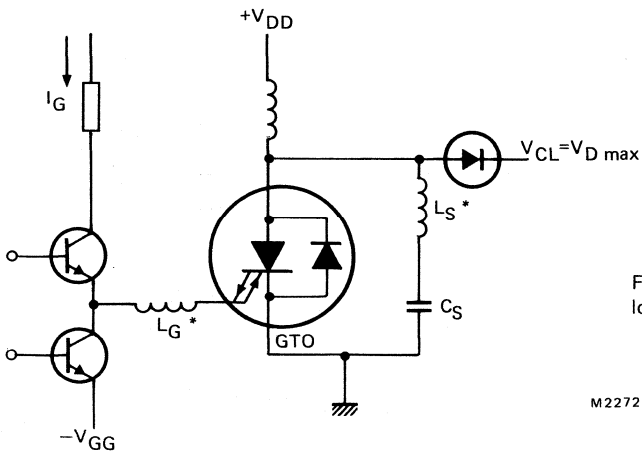


Fig.5 Inductive load test circuit.

M2272

\*Indicates stray series inductance only

GTO (cont.)

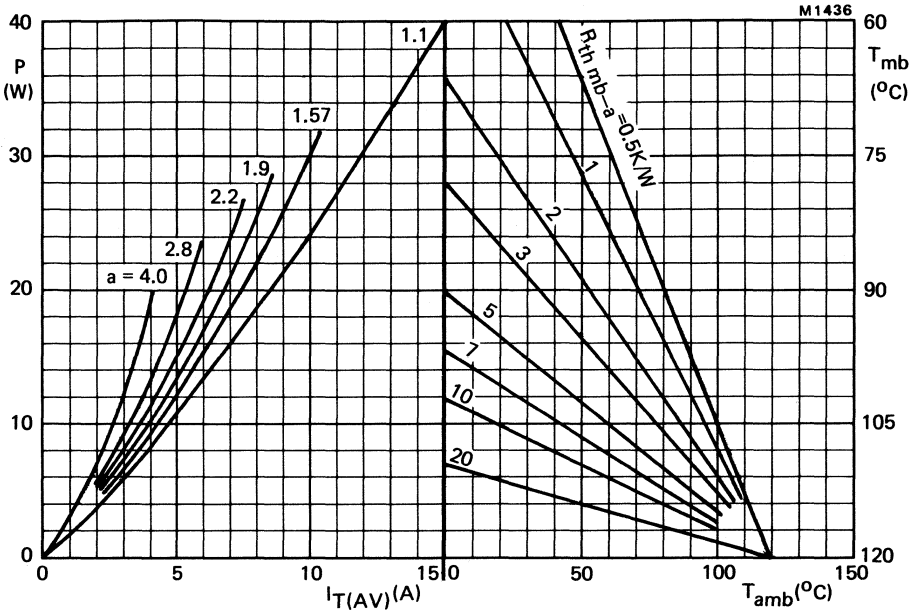


Fig.6 The right hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

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

P = power excluding switching losses.

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

GTO (cont.)

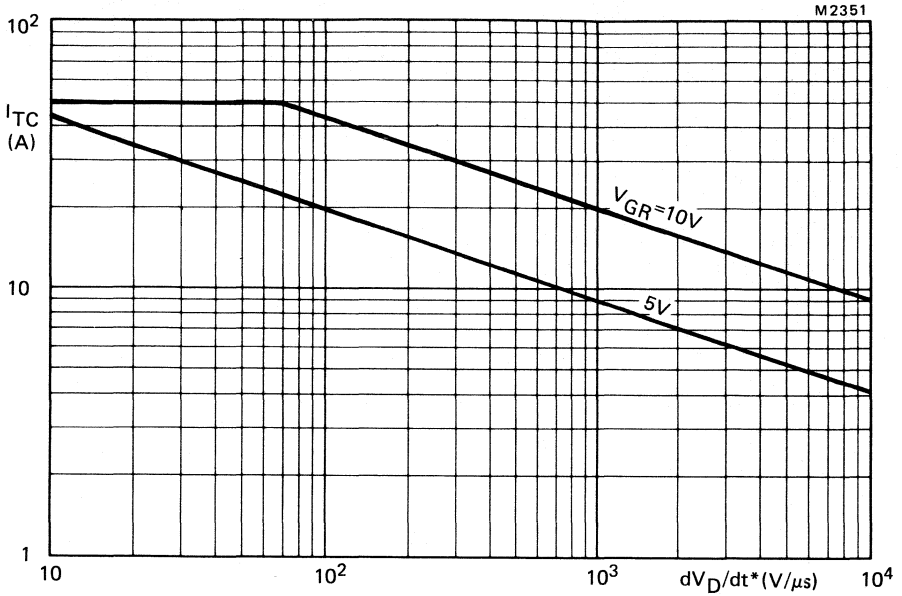


Fig.7 Anode current which can be turned off versus applied  $dV_D/dt^*$ ; inductive load;  
 $L_G \leq 0.5 \mu H$ ;  $L_S \leq 0.25 \mu H$ ;  $T_j = 120 \text{ }^\circ C$ .

\* $dV_D/dt$  is calculated from  $I_T/C_S$ .

GTO (cont.)

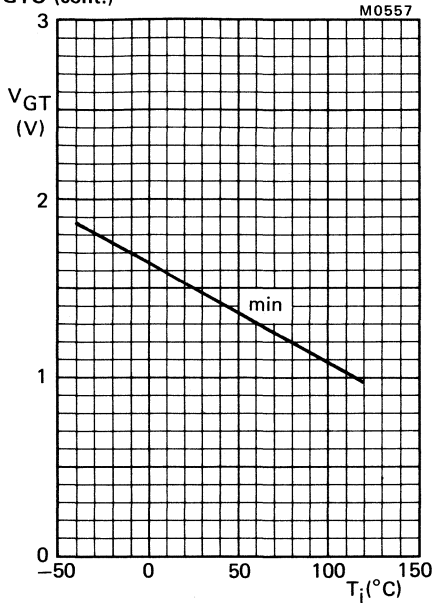


Fig.8 Minimum gate voltage that will trigger all devices as a function of junction temperature,  $V_D = 12$  V.

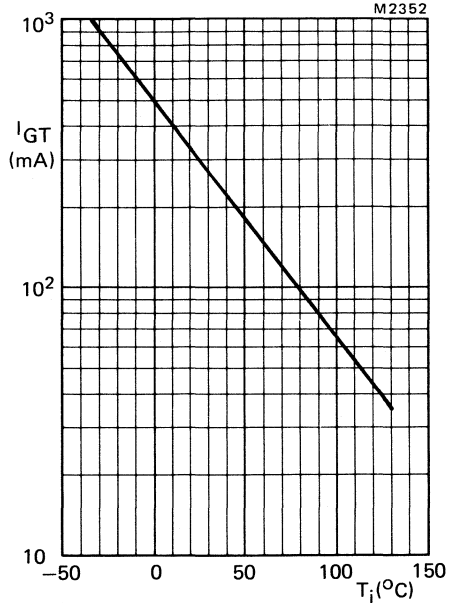


Fig.9 Minimum gate current that will trigger all devices as a function of junction temperature;  $V_D = 12$  V.

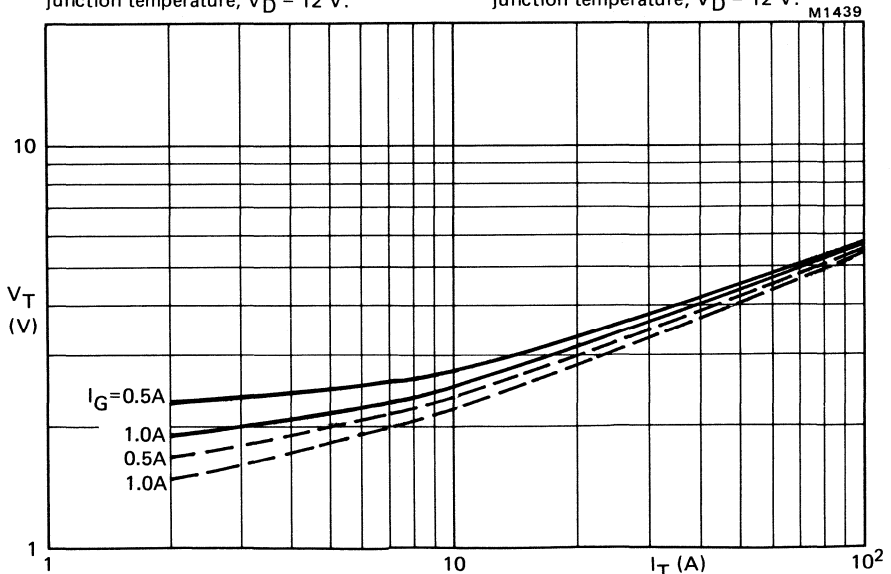


Fig.10 Maximum  $V_T$  versus  $I_T$ ; —  $T_j = 25$  °C; - - -  $T_j = 120$  °C.

GTO (cont.)

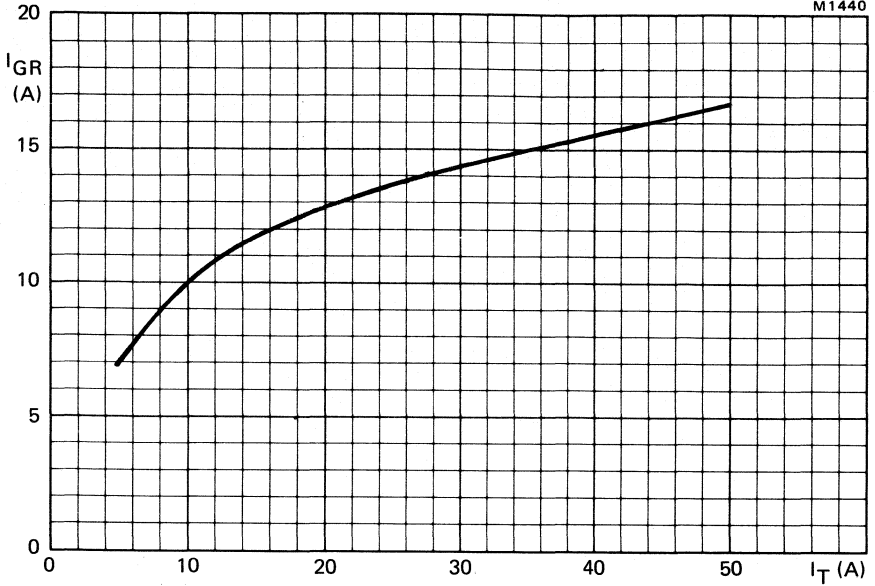


Fig.11 Peak reverse gate current versus anode current at turn-off; inductive load;  
 $V_{GR} = 10 \text{ V}$ ;  $I_G = 0.5 \text{ A}$ ;  $L_G = 0.4 \mu\text{H}$ ;  $T_j = 120 \text{ }^\circ\text{C}$ ; maximum values.

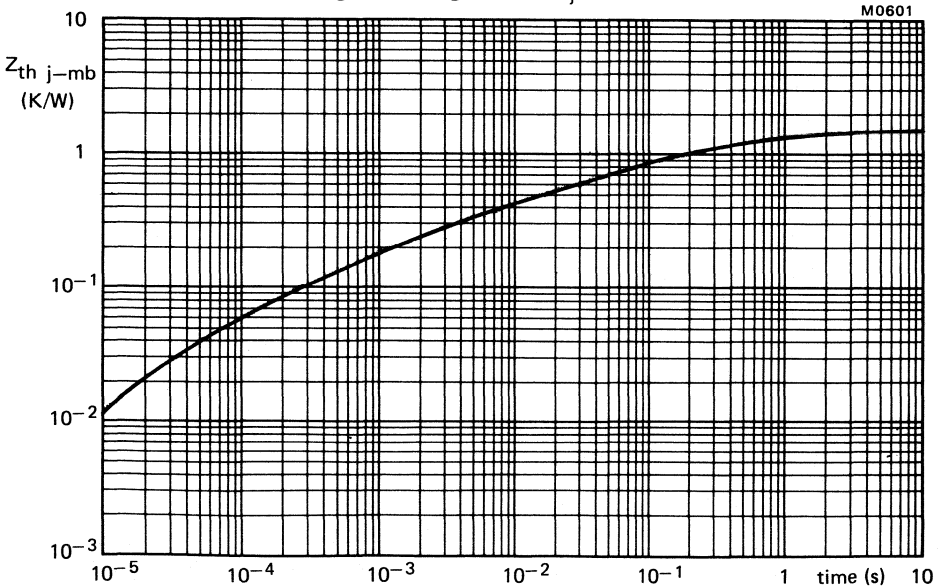


Fig.12 Transient thermal impedance.

GTO (cont.)

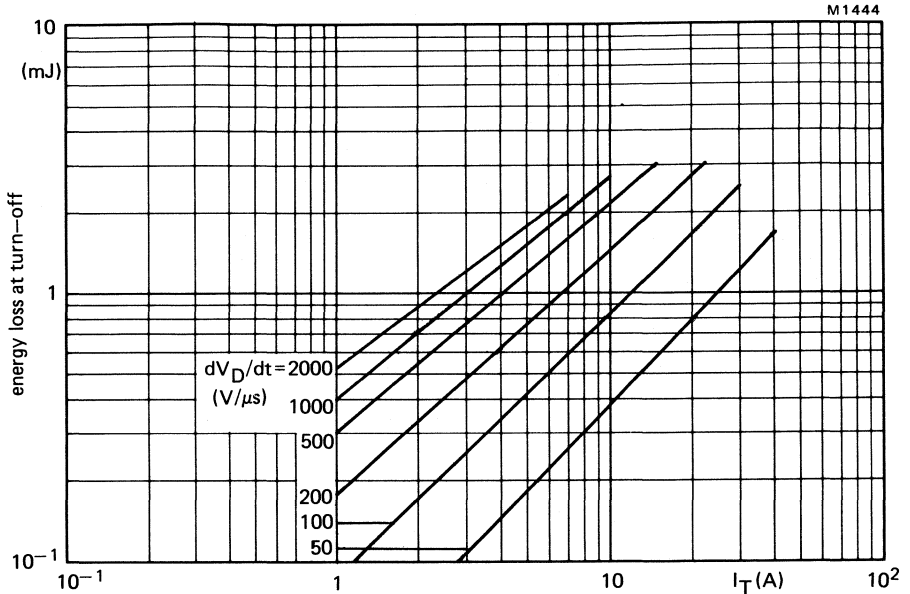


Fig.13 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied  $dV_D/dt$  (calculated from  $I_T/C_S$ );  $dV_D/dt$  linear up to  $V_{Dmax} = 600$  V;  $V_{GR} = 10$  V;  $I_G = 0.5$  A;  $L_G \leq 0.5 \mu H$ ;  $L_S \leq 0.25 \mu H$ ;  $T_j = 120^\circ C$ .

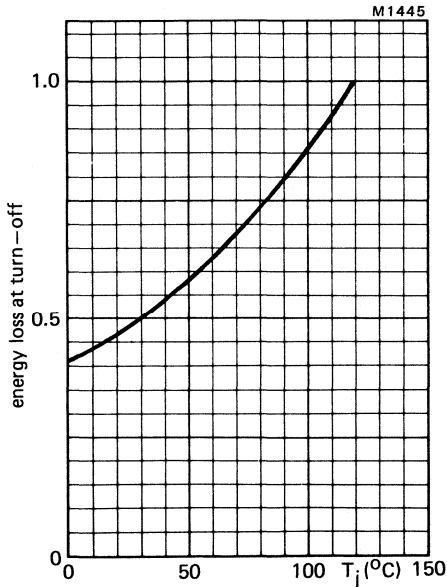


Fig.14 Energy loss at turn off as a function of junction temperature;  $I_G = 0.5$  A;  $V_{GR} = 10$  V. Normalised to  $T_j = 120^\circ C$ .



DIODE CHARACTERISTICS

Forward voltage

$I_F = 10 \text{ A}; T_j = 25 \text{ }^\circ\text{C}$

$V_F < 2.0 \text{ V}^*$

Reverse recovery when switched from

$I_F = 2 \text{ A}$  to  $V_R \geq 30 \text{ V}$  with  $-dI_F/dt = 20 \text{ A}/\mu\text{s}; T_j = 25 \text{ }^\circ\text{C}$

recovered charge

$Q_s < 2.0 \text{ } \mu\text{C}$

recovery time

$t_{rr} < 0.6 \text{ } \mu\text{s}$

Forward recovery when switched to

$I_F = 5 \text{ A}$  with  $t_r = 0.1 \text{ } \mu\text{s}; T_j = 25 \text{ }^\circ\text{C}$

recovery time

$t_{fr} < 1.0 \text{ } \mu\text{s}$

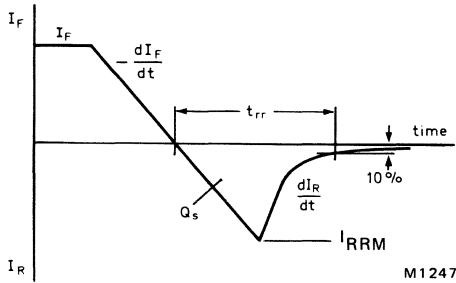


Fig.15 Definition of  $t_{rr}$  and  $Q_s$ .

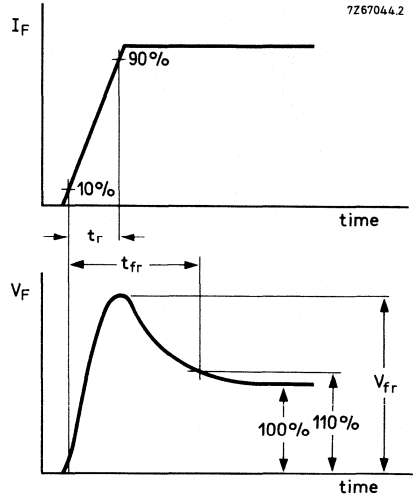


Fig.16 Definition of  $t_{fr}$ .

\*Measured under pulse conditions to avoid excessive dissipation

DIODE (cont.)

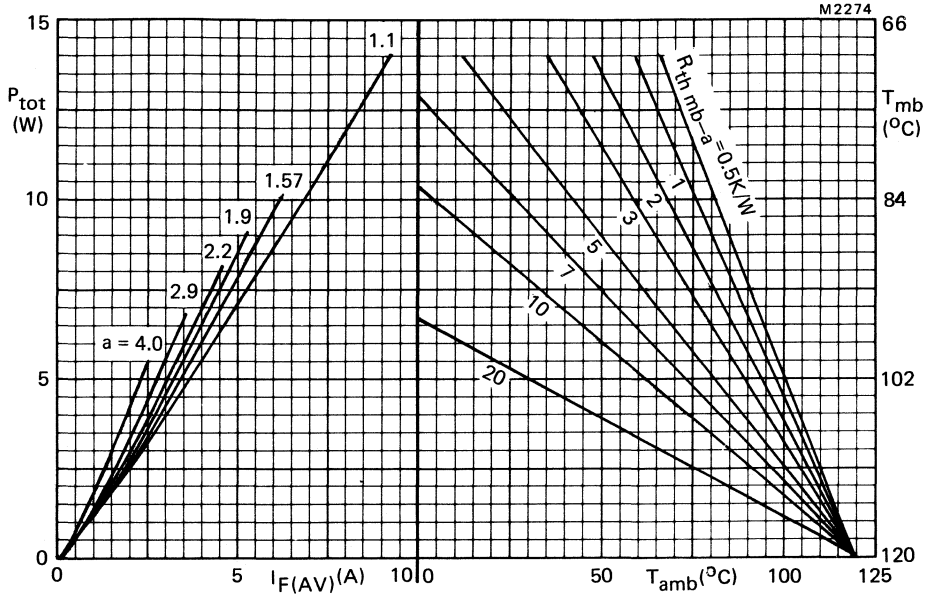


Fig.17 The right hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

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

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

DIODE (cont.)

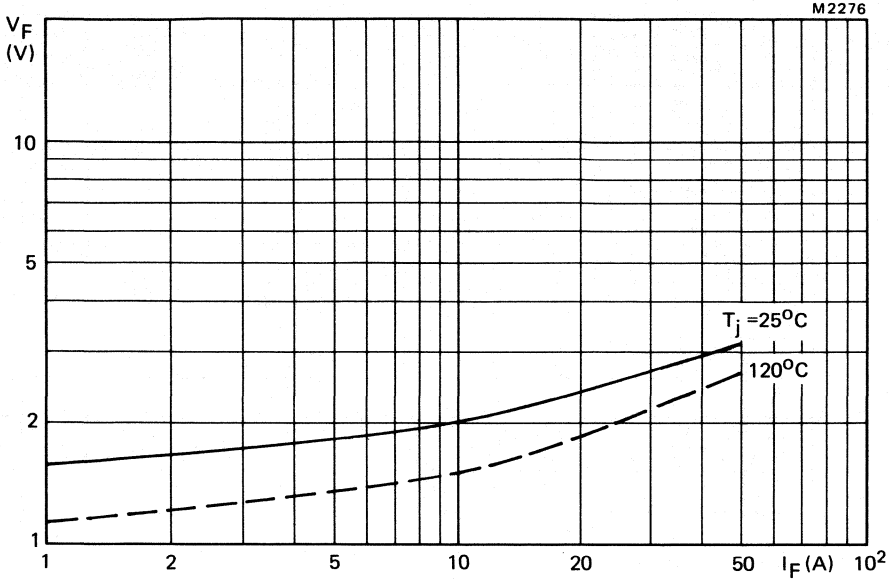


Fig.18 Forward voltage as a function of forward current; maximum values.

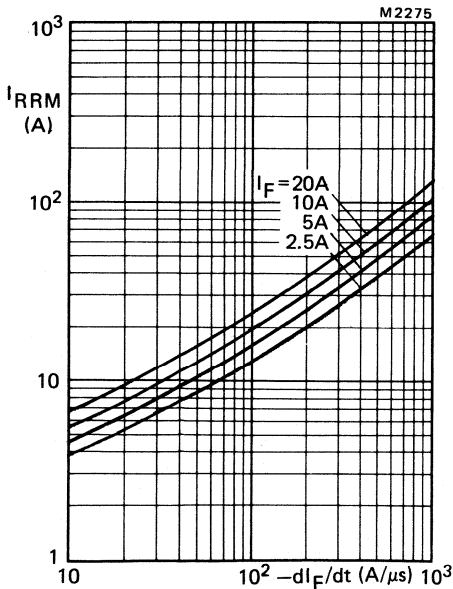


Fig.19 Peak reverse recovery current versus  $-dI_F/dt$ ;  $T_j = 25^\circ\text{C}$ ; maximum values.

DIODE (cont.)

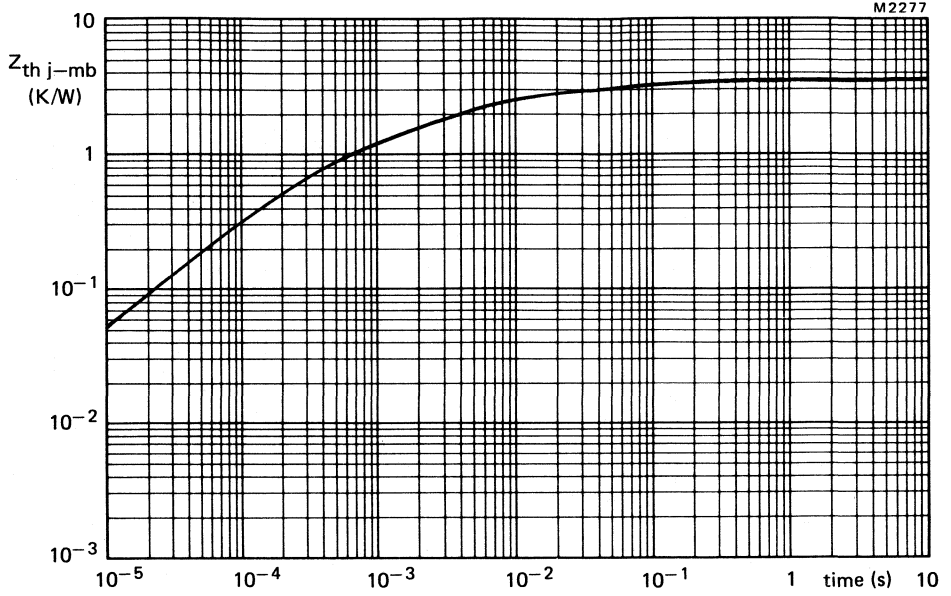


Fig.20 Transient thermal impedance.

## 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.

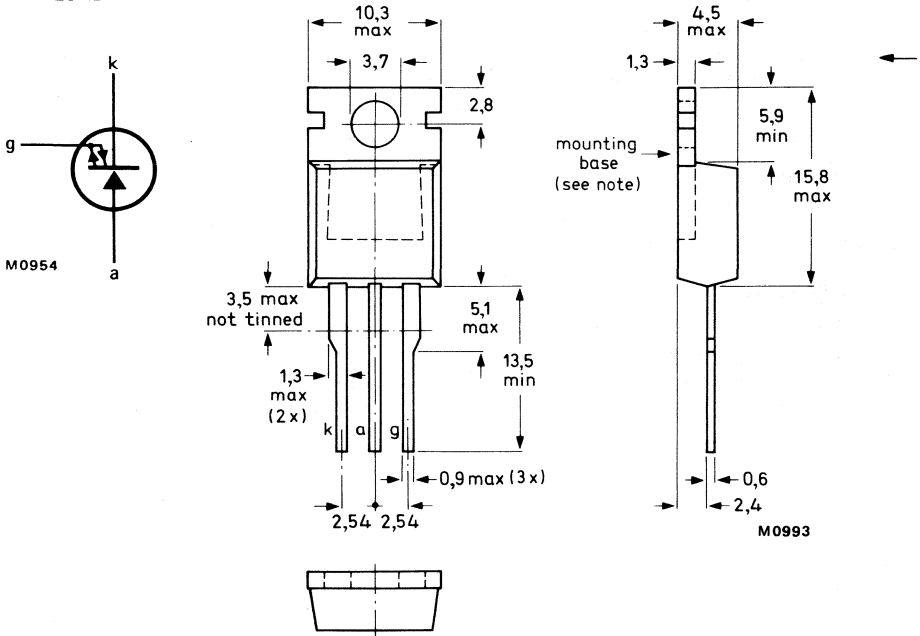
### QUICK REFERENCE DATA

			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

Fig.1 TO-220AB

Dimensions in mm



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

**Gate to cathode**

Repetitive peak on-state current $T_j = 120\text{ }^\circ\text{C}$ prior to surge gate-cathode forward; $t = 10\text{ ms}$ ; half-sinewave gate-cathode reverse; $t = 20\text{ }\mu\text{s}$						
			$I_{GFM}$	max.	25	A
			$I_{GRM}$	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	$^\circ\text{C}$
Operating junction temperature	$T_j$	max.		120	$^\circ\text{C}$

**THERMAL RESISTANCE**

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

\* Measured with gate-cathode connected together.

**CHARACTERISTICS**

**Anode to cathode**

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

**Gate to cathode**

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

**Switching characteristics (resistive load)**

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

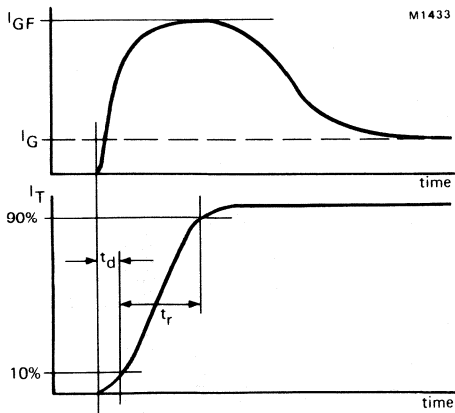


Fig.2 Waveforms

\* 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  $I_T = 5 \text{ A}$  to  $V_D = V_{DRMmax}$ .

$V_{GR} = 10 \text{ V}$ ;  $L_G \leq 1.0 \mu\text{H}$ ;  $L_S \leq 0.25 \mu\text{H}$ ;  $T_j = 25 \text{ }^\circ\text{C}$

storage time

$t_s < 0.5 \mu\text{s}$

fall time

$t_f < 0.25 \mu\text{s}$

peak reverse gate current

$I_{GR} < 6 \text{ A}$

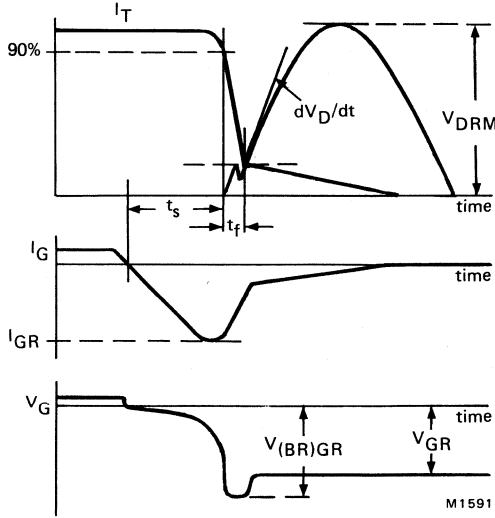


Fig.3 Waveforms.

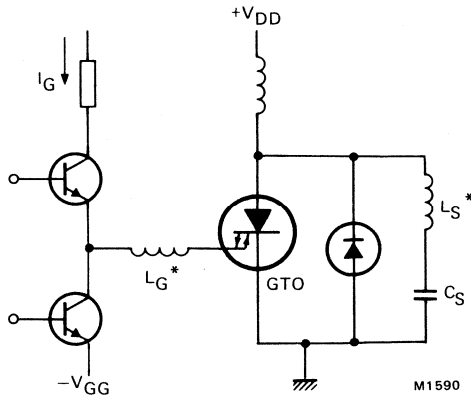


Fig.4 Inductive load test circuit

\* Indicates stray series inductance only.



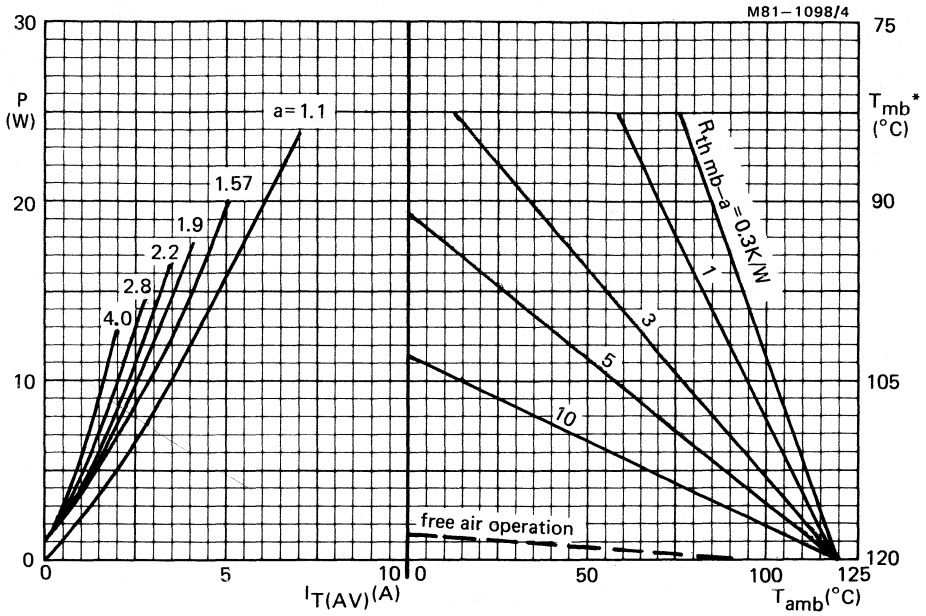


Fig.5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

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

P = power excluding switching losses.

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

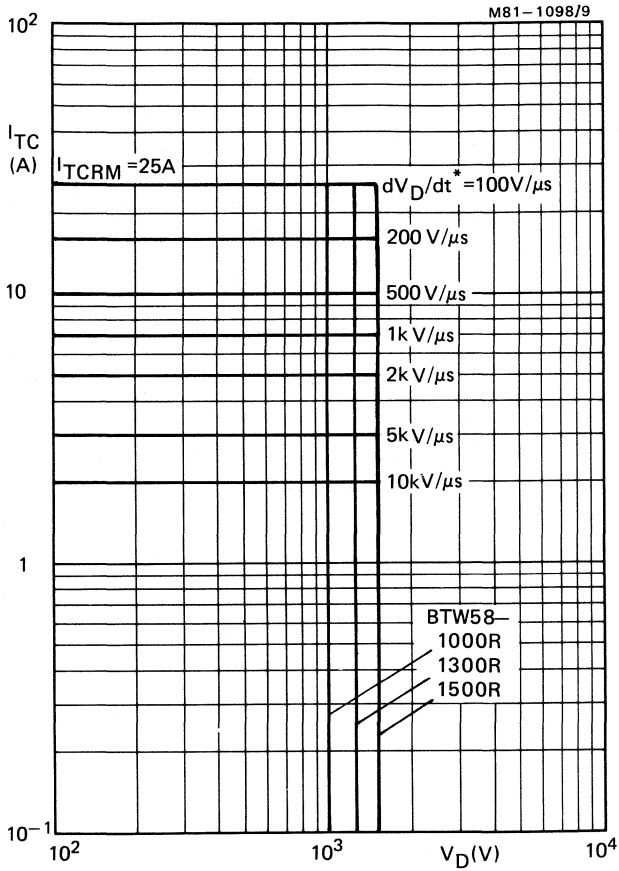


Fig.6 Anode current which can be turned off versus anode voltage; inductive load;  $V_{GR} = 10 V$ ;  $L_G \leq 1.0 \mu H$ ;  $L_S \leq 0.25 \mu H$ ;  $T_j = 85 \text{ }^\circ C$ .  
\* $dV_D/dt$  is calculated from  $I_T/C_S$ .

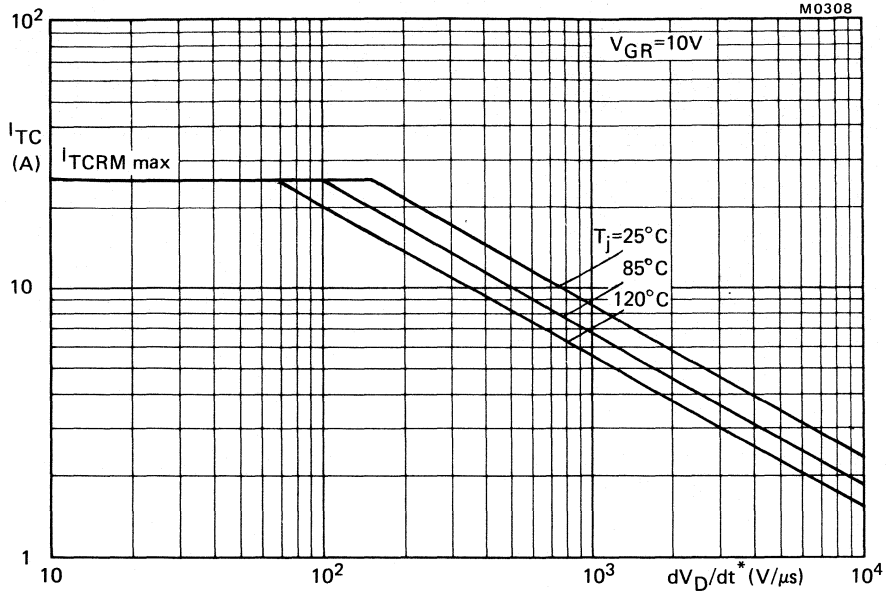


Fig.7 Anode current which can be turned off versus applied  $dV_D/dt^*$ ; inductive load;  $V_{GR} = 10\ V$ ;  $L_G \leq 1.0\ \mu H$ ;  $L_S \leq 0.25\ \mu H$ . \* $dV_D/dt$  is calculated from  $I_T/C_S$ .

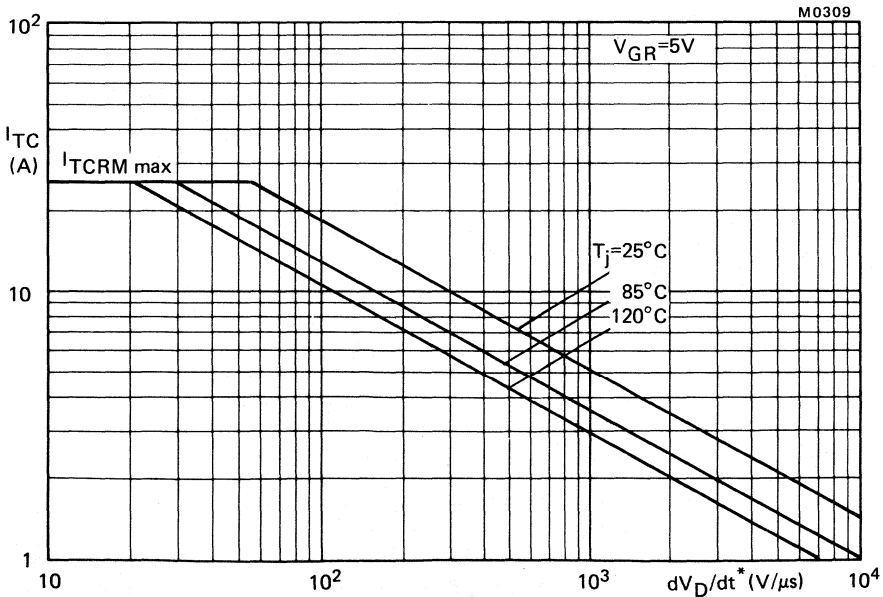


Fig.8 Anode current which can be turned off versus applied  $dV_D/dt^*$ ; inductive load;  $V_{GR} = 5\ V$ ;  $L_G \leq 1.0\ \mu H$ ;  $L_S \leq 0.25\ \mu H$ . \* $dV_D/dt$  is calculated from  $I_T/C_S$ .

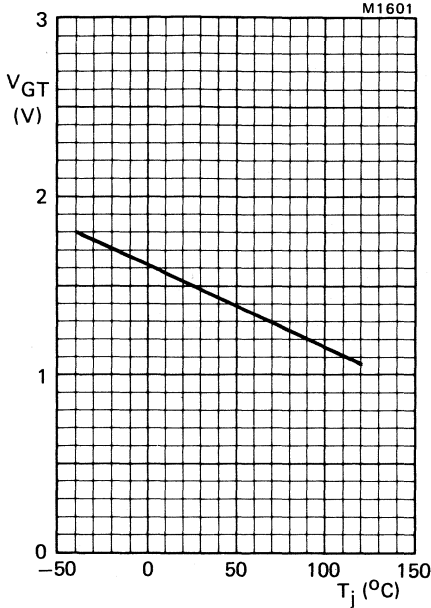


Fig.9 Minimum gate voltage that will trigger all devices as a function of junction temperature;  $V_D = 12$  V.

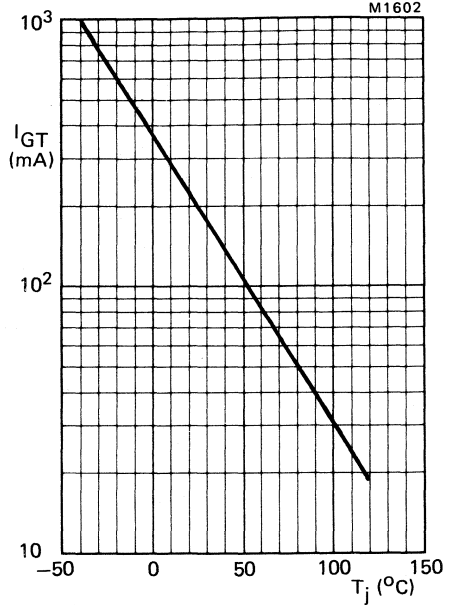


Fig.10 Minimum gate current that will trigger all devices as a function of junction temperature;  $V_D = 12$  V.

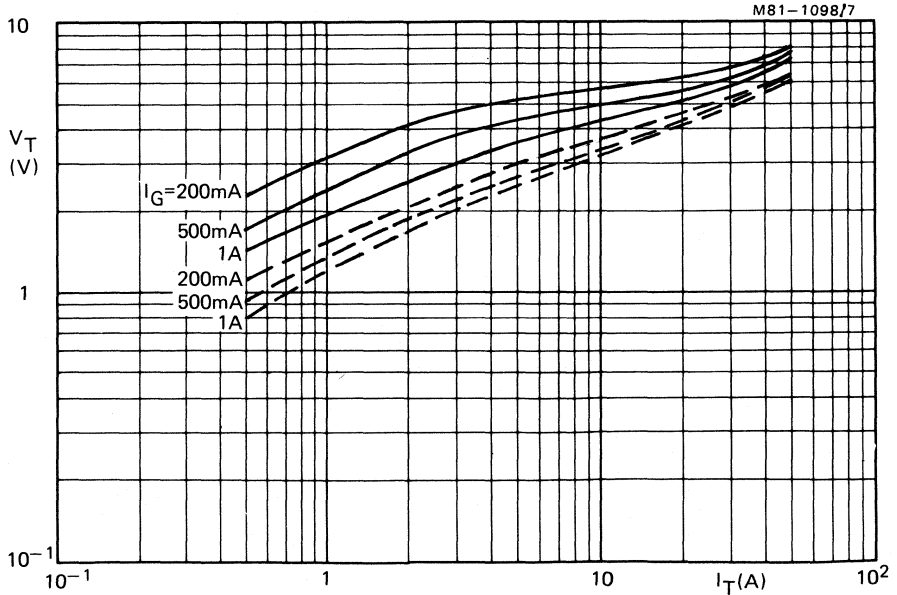


Fig.11 Maximum  $V_T$  versus  $I_T$ ; —  $T_j = 25$  °C; - - -  $T_j = 120$  °C.

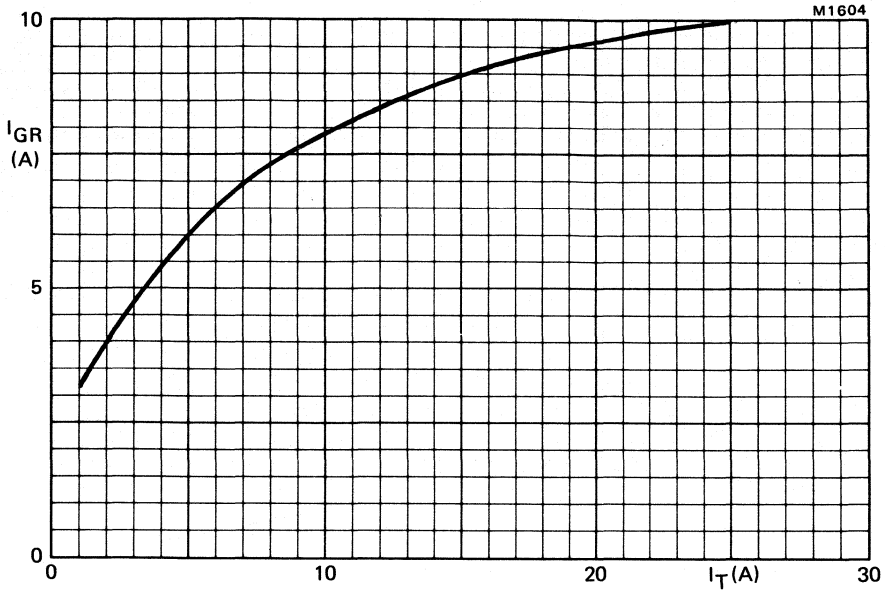


Fig.12 Peak reverse gate current versus anode current at turn-off; inductive load;  $V_{GR} = 10 \text{ V}$ ;  $I_G = 0.2 \text{ A}$ ;  $L_G = 0.8 \mu\text{H}$ ;  $T_j = 120 \text{ }^\circ\text{C}$ ; maximum values.

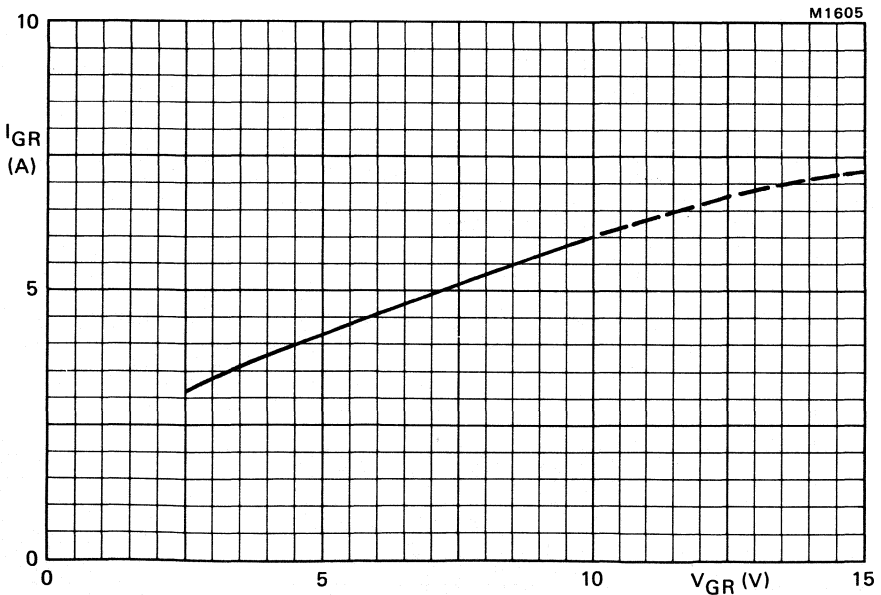


Fig.13 Peak reverse gate current versus applied reverse gate voltage; inductive load;  $I_T = 5 \text{ A}$ ;  $I_G = 0.2 \text{ A}$ ;  $L_G = 0.8 \mu\text{H}$ ;  $T_j = 120 \text{ }^\circ\text{C}$ ; maximum values.

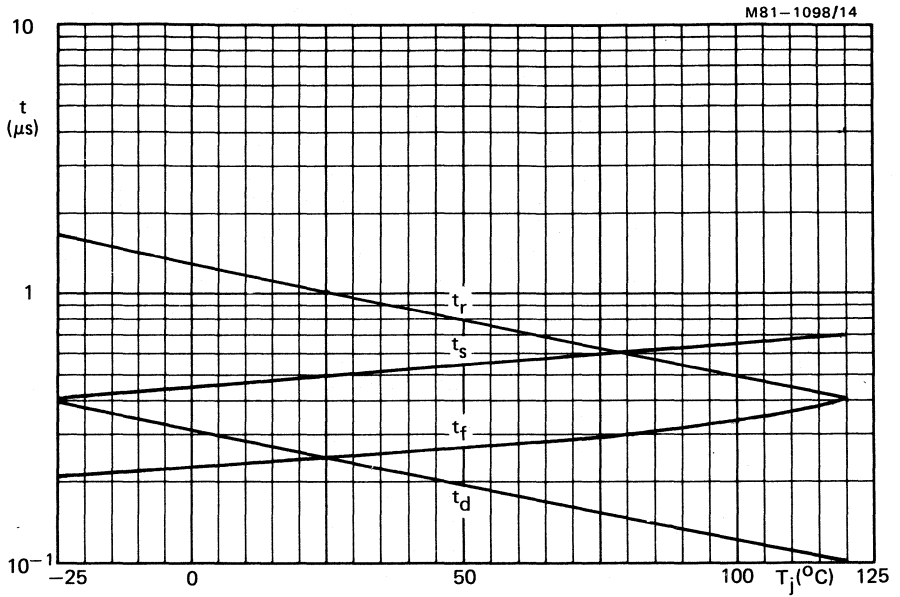


Fig.14 Switching times as a function of junction temperature;  $V_D \geq 250$  V;  $I_T = 5$  A;  $I_{GF} = 0.5$  A;  $V_{GR} = 10$  V;  $I_G = 0.2$  A;  $L_G = 0.8 \mu\text{H}$ ; maximum values.

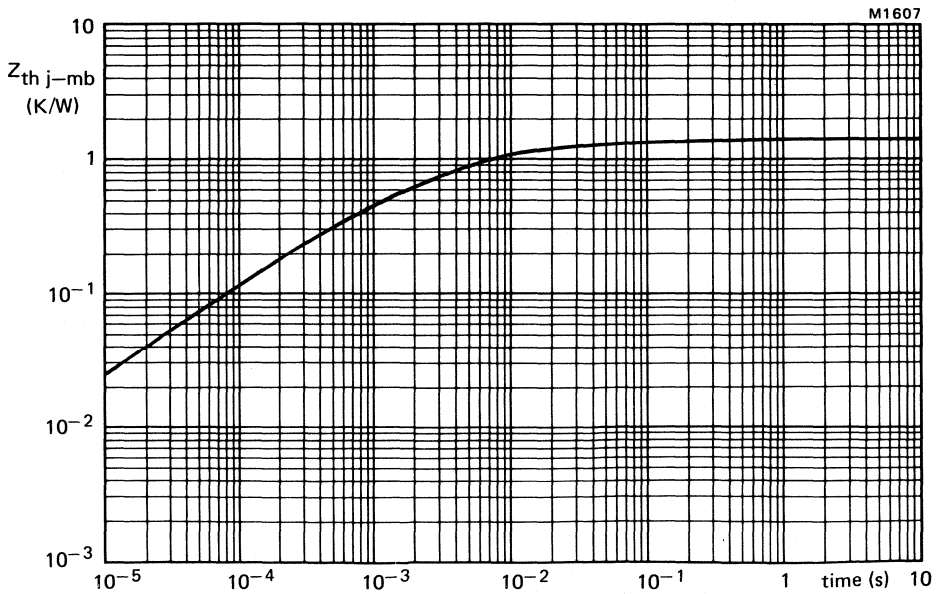


Fig.15 Transient thermal impedance.

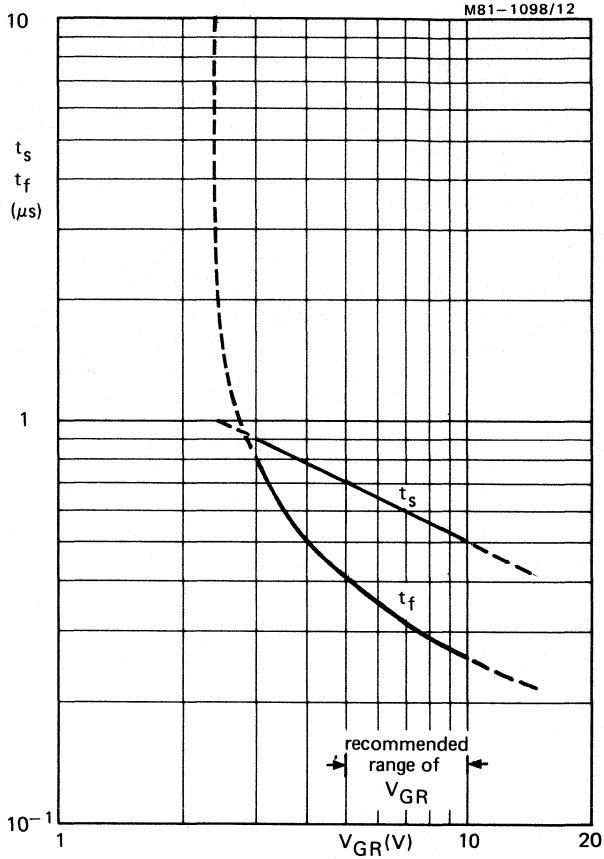


Fig.16 Storage and fall times versus applied reverse gate voltage; inductive load;  $I_T = 5$  A;  $I_G = 0.2$  A;  $L_G = 0.8 \mu H$ ;  $T_j = 25$  °C; maximum values.

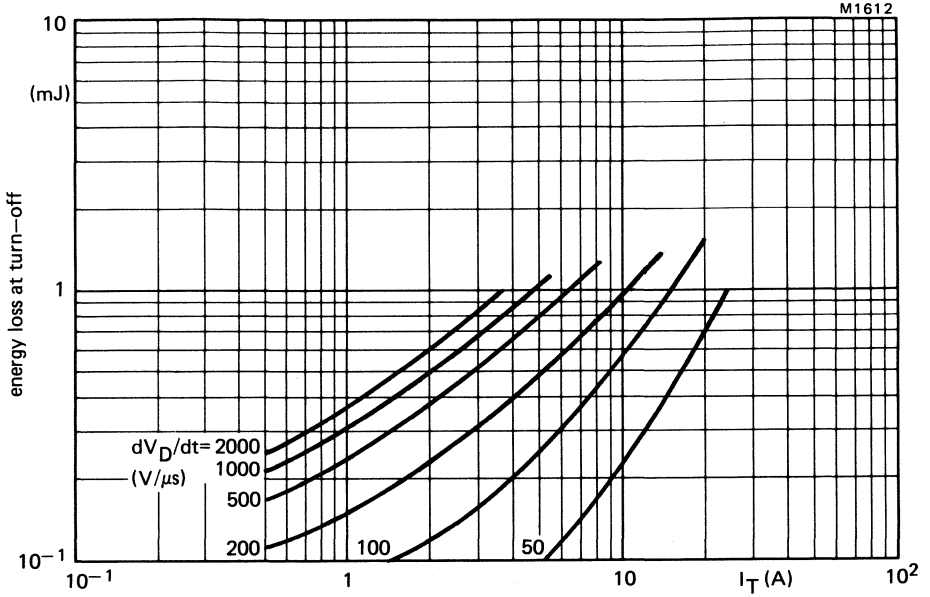


Fig.17 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied  $dV_D/dt$  (calculated from  $I_T/C_S$ ); reapplied voltage sinusoidal up to  $V_{DRM} = 1200$  V;  $V_{GR} = 10$  V;  $I_G = 0.2$  A;  $L_G \leq 1.0 \mu H$ ;  $L_S \leq 0.25 \mu H$ ;  $T_j = 120$  °C.

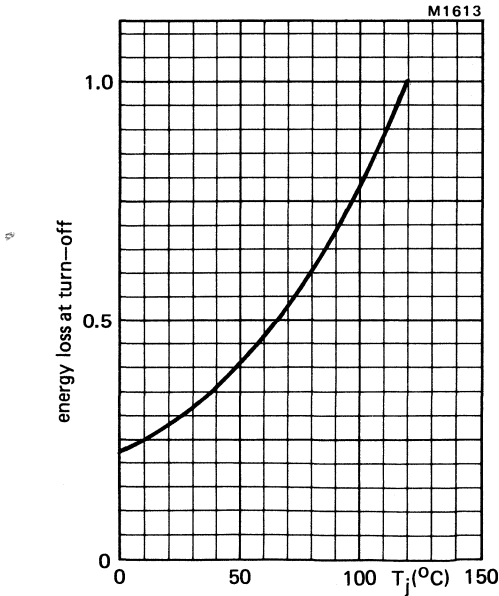


Fig.18 Energy loss at turn off as a function of junction temperature;  $I_G = 0.2$  A;  $V_{GR} = 10$  V. Normalised to  $T_j = 120$  °C.



# THYRISTORS



## SILICON BI-DIRECTIONAL TRIGGER DEVICE

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

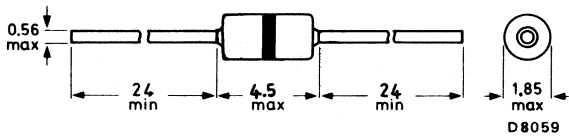
### QUICK REFERENCE DATA

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 $T_{amb} = 50\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	150	mW
Repetitive peak current ( $t \leq 20\text{ }\mu\text{s}$ )	$I_{FRM}$	max.	2	A
Storage temperature	$T_{stg}$		-55 to +125	$^{\circ}\text{C}$
Junction temperature	$T_j$	max.	100	$^{\circ}\text{C}$

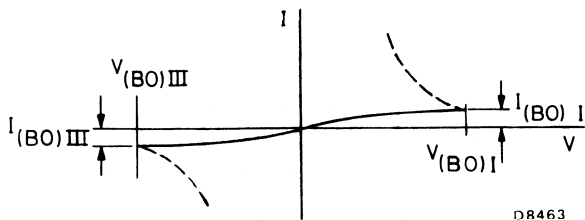
### THERMAL RESISTANCE

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

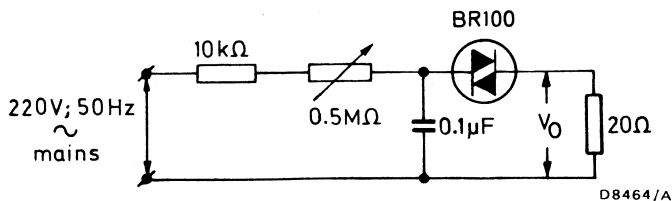
$T_j = 25\text{ }^\circ\text{C}$

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



D8463

Fig.2



D8464/A

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 transformerless power supply circuits, relay and coil pulsing and power supply crowbar protection circuits.

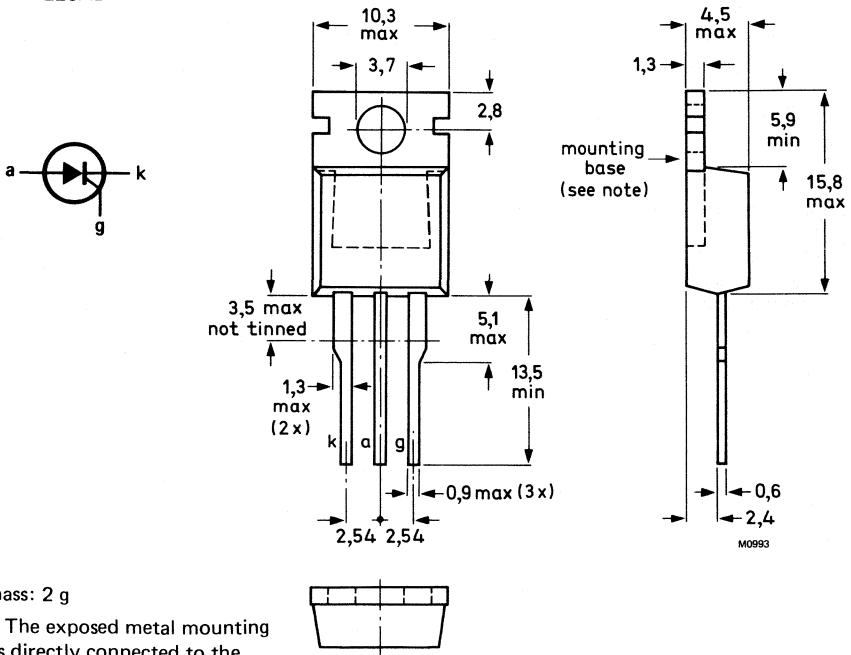
### QUICK REFERENCE DATA

		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)

		BT145-500R			600R	800R	
		max.	500	600	800		
<b>Anode to cathode</b>							
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 $T_{mb} = 93\text{ }^{\circ}\text{C}$		$I_T(AV)$	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; $t = 10\text{ ms}$ ; half sine-wave; $T_j = 115\text{ }^{\circ}\text{C}$ prior to surge; with reapplied $V_{RWMmax}$		$I_{TSM}$	max.		300		A
$I^2 t$ for fusing ( $t = 10\text{ ms}$ )		$I^2 t$	max.		450		$A^2 s$
Rate of rise of on-state current after triggering with $I_G = 160\text{ mA}$ to $I_T = 50\text{ A}$ ; $dI_G/dt = 160\text{ A/ms}$		$dI_T/dt$	max.		200		$A/\mu s$
<b>Gate to cathode</b>							
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; $t \leq 10\text{ }\mu s$		$P_{GM}$	max.		20		W
<b>Temperature</b>							
Storage temperature		$T_{stg}$			-40 to +150		$^{\circ}\text{C}$
Junction temperature		$T_j$	max.		110		$^{\circ}\text{C}$
<b>THERMAL RESISTANCE</b>							
From junction to mounting base		$R_{th\ j-mb}$	=		1.0		K/W
From mounting base to heatsink with heatsink compound		$R_{th\ mb-h}$	=		0.3		K/W

**THERMAL RESISTANCE**

From junction to mounting base

$$R_{th\ j-mb} = 1.0\ K/W$$

Transient thermal impedance;  $t = 1\ ms$

$$Z_{th\ j-mb} = 0.09\ K/W$$

**Influence of mounting method**

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

Thermal resistance from mounting base to heatsink

a. with heatsink compound

$$R_{th\ mb-h} = 0.3\ K/W$$

b. with heatsink compound and 0.06 mm maximum mica insulator

$$R_{th\ mb-h} = 1.4\ K/W$$

c. with heatsink compound and 0.1 mm maximum mica insulator (56369)

$$R_{th\ mb-h} = 2.2\ K/W$$

d. with heatsink compound and 0.25 mm maximum alumina insulator (56367)

$$R_{th\ mb-h} = 0.8\ K/W$$

e. without heatsink compound

$$R_{th\ mb-h} = 1.4\ K/W$$

2. Free-air operation

The quoted values of  $R_{th\ j-a}$  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

$$R_{th\ j-a} = 60\ K/W$$

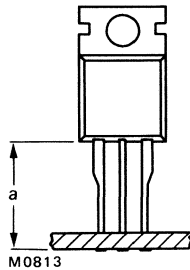


Fig.2.

## CHARACTERISTICS

### Anode to cathode

On-state voltage (measured under pulse conditions)

$$I_T = 30 \text{ A}; T_j = 25 \text{ }^\circ\text{C}$$

$$V_T < 1.5 \text{ V}$$

Rate of rise of off-state voltage that will not trigger any device

$$T_j = 110 \text{ }^\circ\text{C}; R_{GK} = \text{open circuit}$$

$$dV_D/dt < 200 \text{ V}/\mu\text{s}$$

Reverse current

$$V_R = V_{RWMmax}; T_j = 110 \text{ }^\circ\text{C}$$

$$I_R < 1.0 \text{ mA}$$

Off-state current

$$V_D = V_{DWMmax}; T_j = 110 \text{ }^\circ\text{C}$$

$$I_D < 1.0 \text{ mA}$$

Latching current;  $T_j = 25 \text{ }^\circ\text{C}$

$$I_L < 80 \text{ mA}$$

Holding current;  $T_j = 25 \text{ }^\circ\text{C}$

$$I_H < 60 \text{ mA}$$

### Gate to cathode

Voltage that will trigger all devices

$$V_D = 12 \text{ V}; T_j = -40 \text{ }^\circ\text{C}$$

$$V_{GT} > 1.5 \text{ V}$$

$$V_D = 12 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$$

$$V_{GT} > 1.0 \text{ V}$$

Voltage that will not trigger any device

$$V_D = V_{DRMmax}; T_j = 110 \text{ }^\circ\text{C}$$

$$V_{GD} < 0.25 \text{ V}$$

Current that will trigger all devices

$$V_D = 12 \text{ V}; T_j = -40 \text{ }^\circ\text{C}$$

$$I_{GT} > 55 \text{ mA}$$

$$V_D = 12 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$$

$$I_{GT} > 35 \text{ mA}$$

### Switching characteristics

Gate-controlled turn-on time ( $t_{gt} = t_d + t_r$ )

when switched from  $V_D = V_{DRMmax}$  to  $I_T = 40 \text{ A}$ ;

$$I_{GT} = 100 \text{ mA}; dI_G/dt = 5 \text{ A}/\mu\text{s}; T_j = 25 \text{ }^\circ\text{C}$$

$$t_{gt} \text{ typ. } 2 \text{ } \mu\text{s}$$

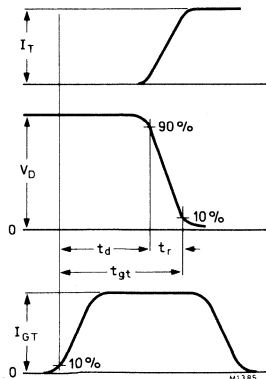


Fig.3 Gate controlled turn-on time definition.



### 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  $R_{th\ mb-h}$  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  $R_{th\ mb-h}$  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.

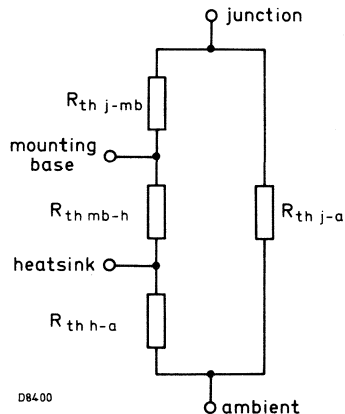


Fig.4

- 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  $R_{th\ mb-a}$ . The heatsink thermal resistance value ( $R_{th\ h-a}$ ) can now be calculated from:

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

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

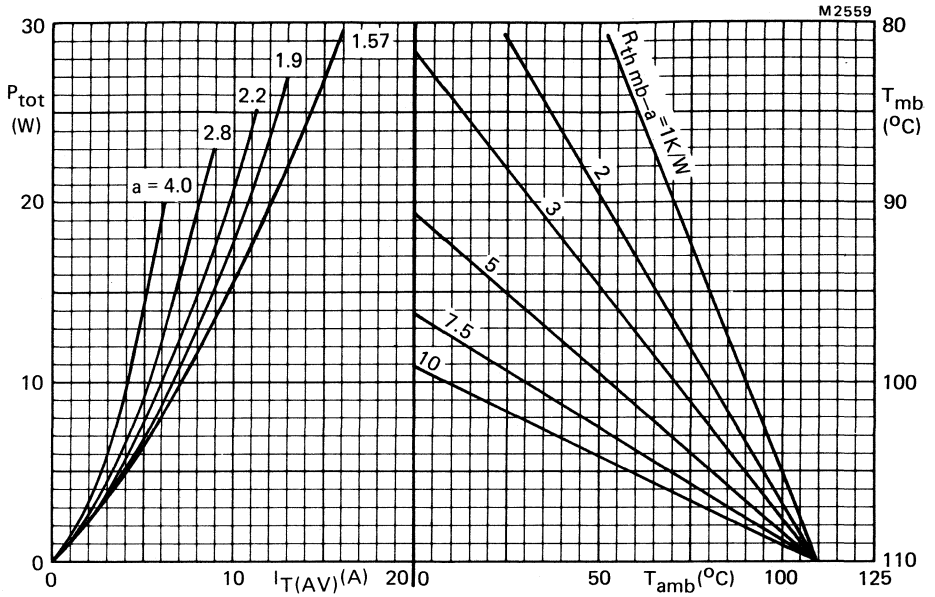


Fig.5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha$  = conduction angle per half cycle

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

$\alpha$	a
30 $^{\circ}$	4
60 $^{\circ}$	2.8
90 $^{\circ}$	2.2
120 $^{\circ}$	1.9
180 $^{\circ}$	1.57

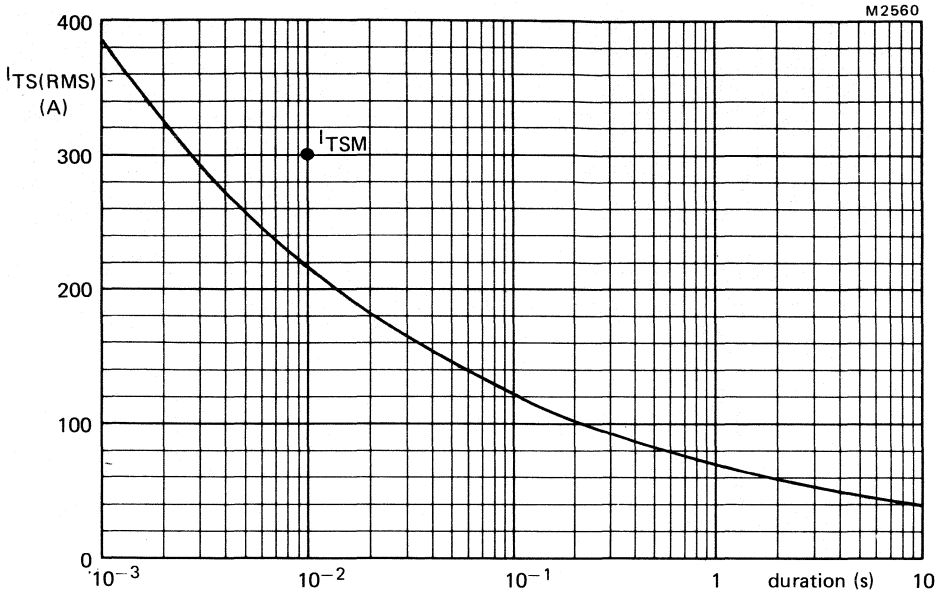


Fig.6 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents ( $f=50\text{Hz}$ ) with re-applied  $V_{RWMmax}$ ;  $T_j = 110\text{ }^\circ\text{C}$  prior to surge.

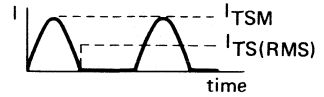
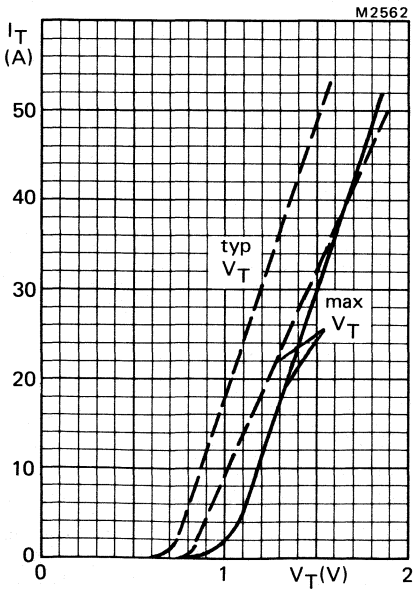


Fig.7 —  $T_j = 25\text{ }^\circ\text{C}$ ; - - -  $T_j = 110\text{ }^\circ\text{C}$ .

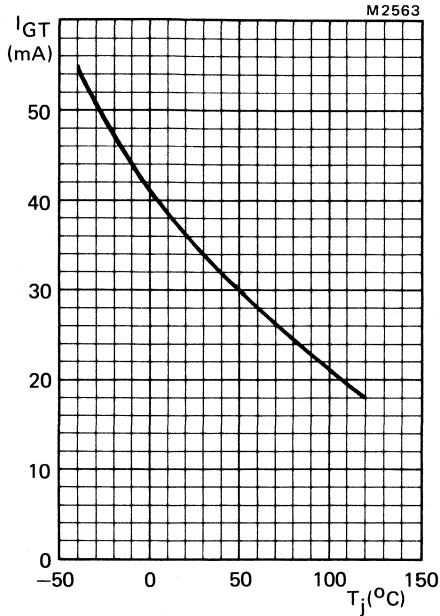


Fig.8 Minimum gate current that will trigger all devices as a function of junction temperature.

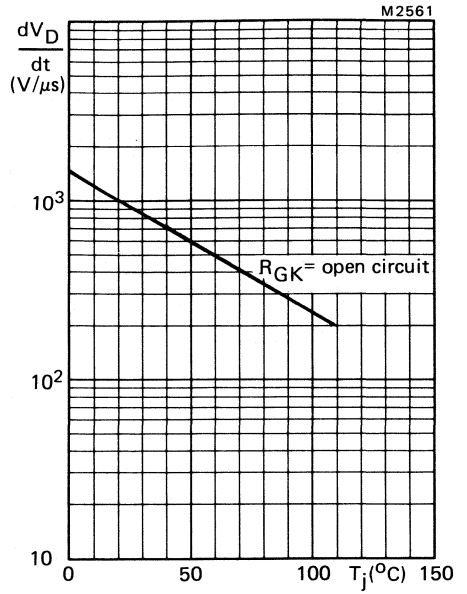


Fig.9 Maximum rate of rise of off-state voltage that will not trigger any device as a function of junction temperature.

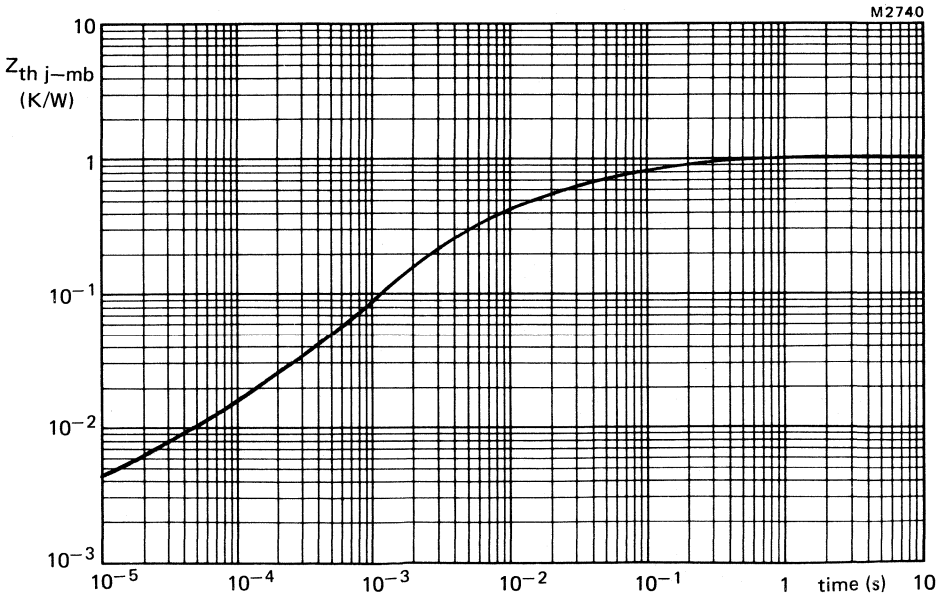


Fig.10 Transient thermal impedance.

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

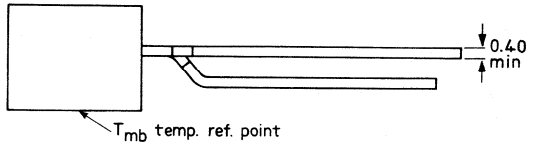
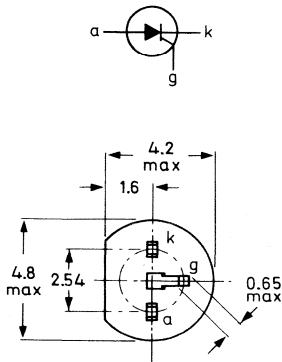
		BT149 - F						
		A	B	D	E	M		
Repetitive peak voltages	$V_{DRM}/V_{RRM}$	max. 50	100	200	400	500	600	V
Average on-state current	$I_T(AV)$	max.			0.5			A
R.M.S. on-state current	$I_T(RMS)$	max.			0.8			A
Non-repetitive peak on-state current	$I_{TSM}$	max.			8			A

MECHANICAL DATA

Dimensions in mm

Fig.1 TO-92 variant

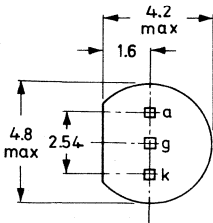
BT149-F,A,B,D,E



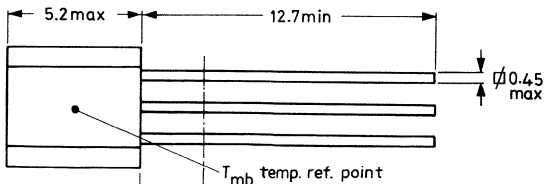
diameter within 2.5max is uncontrolled

M1751

BT149-M



diameter within 2.5max is uncontrolled



M1750

**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
$I^2 t$ for fusing ( $t = 10$ ms)	$I^2 t$					max. 0.32		A <sup>2</sup> s
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/ $\mu$ s	$dI_T/dt$					max. 30		A/ $\mu$ s
<b>Gate to cathode</b>								
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
<b>Temperatures</b>								
Storage temperature	$T_{stg}$					–40 to +150		°C
Operating junction temperature	$T_j$					max. 125		°C
<b>THERMAL RESISTANCE</b>								
From junction to mounting base	$R_{th j-mb}$					= 100		K/W
From junction to ambient in free air, mounted on a p.c.b. with any lead length	$R_{th j-a}$					= 200		K/W

\* $R_{GK} = 1$  k $\Omega$

## THYRISTORS

Glass-passivated thyristor in TO-220AB envelope, featuring sensitive gate triggering as low as 200  $\mu$ A. 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.

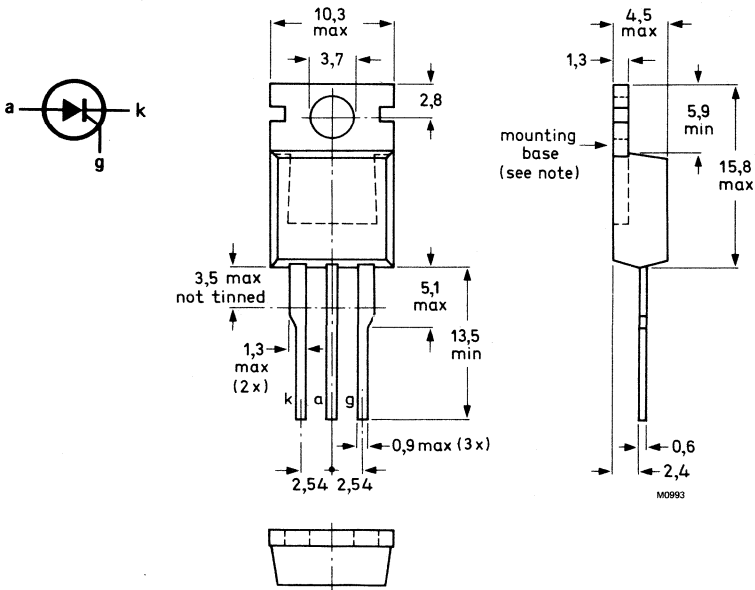
### QUICK REFERENCE DATA

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
$I^2 t$ for fusing (t = 10 ms)	$I^2 t$	max.	3	A <sup>2</sup> s
Rate of rise of on-state current after triggering with $I_G = 50$ mA; to $I_T = 10$ A; $dI_T/dt = 50$ mA/ $\mu$ s	$dI_T/dt$	max.	50	A/ $\mu$ s

**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/ $\mu$ s.



**THERMAL RESISTANCE**

From junction to mounting base

$$R_{th\ j-mb} = 2.5 \text{ K/W}$$

Transient thermal impedance;  $t = 1 \text{ ms}$ 

$$Z_{th\ j-mb} = 0.2 \text{ K/W}$$

**Influence of mounting method**

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from mounting base to heatsink

a. with heatsink compound

$$R_{th\ mb-h} = 0.3 \text{ K/W}$$

b. with heatsink compound and 0.06 mm maximum mica insulator

$$R_{th\ mb-h} = 1.4 \text{ K/W}$$

c. with heatsink compound and 0.1 mm maximum mica insulator (56369)

$$R_{th\ mb-h} = 2.2 \text{ K/W}$$

d. with heatsink compound and 0.25 mm maximum alumina insulator (56367)

$$R_{th\ mb-h} = 0.8 \text{ K/W}$$

e. without heatsink compound

$$R_{th\ mb-h} = 1.4 \text{ K/W}$$

2. Free air operation

The quoted values of  $R_{th\ j-a}$  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

$$R_{th\ j-a} = 60 \text{ K/W}$$

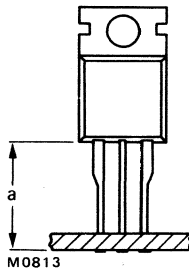


Fig.2

**CHARACTERISTICS** ( $T_j = 25\text{ }^\circ\text{C}$  unless otherwise stated)

**Anode to cathode**

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

**Gate to cathode**

Voltage that will trigger all devices $V_D = 12\text{ V}$	$V_{GT}$	>	1.5	V
$V_D = 12\text{ V}; T_j = -40\text{ }^\circ\text{C}$	$V_{GT}$	>	2.3	V
Voltage that will not trigger any device $V_D = 12\text{ V}; T_j = 110\text{ }^\circ\text{C}$	$V_{GD}$	<	250	mV
Current that will trigger all devices $V_D = 12\text{ V}$	$I_{GT}$	>	200	$\mu\text{A}$
$V_D = 12\text{ V}; T_j = -40\text{ }^\circ\text{C}$	$I_{GT}$	>	260	$\mu\text{A}$

**Switching characteristics**

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

$t_{gt}$	typ.	2	$\mu\text{s}$
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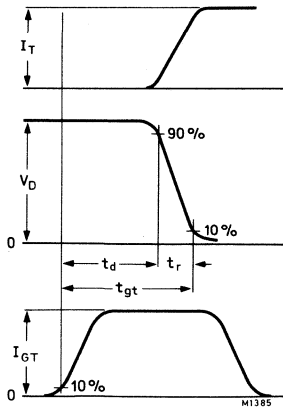


Fig.3 Gate-controlled turn-on time definition.

\*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. 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  $R_{th\ mb-h}$  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  $R_{th\ mb-h}$  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.

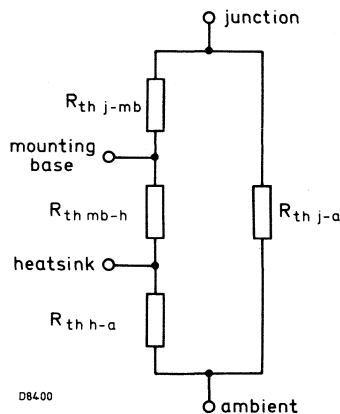


Fig.4

- 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  $R_{th\ mb-a}$ . The heatsink thermal resistance value ( $R_{th\ h-a}$ ) can now be calculated from:

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

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

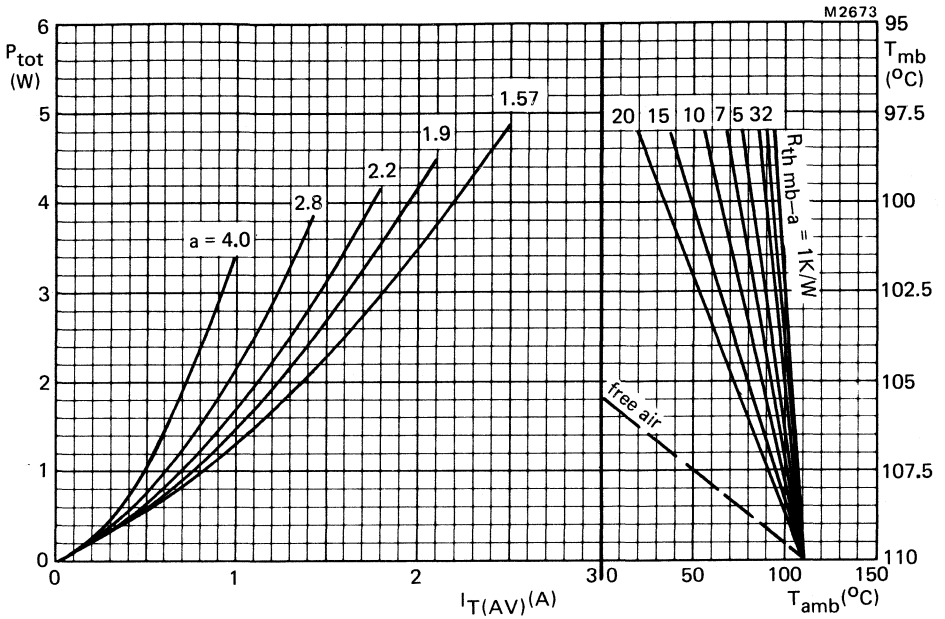


Fig.5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha$  = conduction angle per half cycle

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

$\alpha$	a
30°	4
60°	2.8
90°	2.2
120°	1.9
180°	1.57

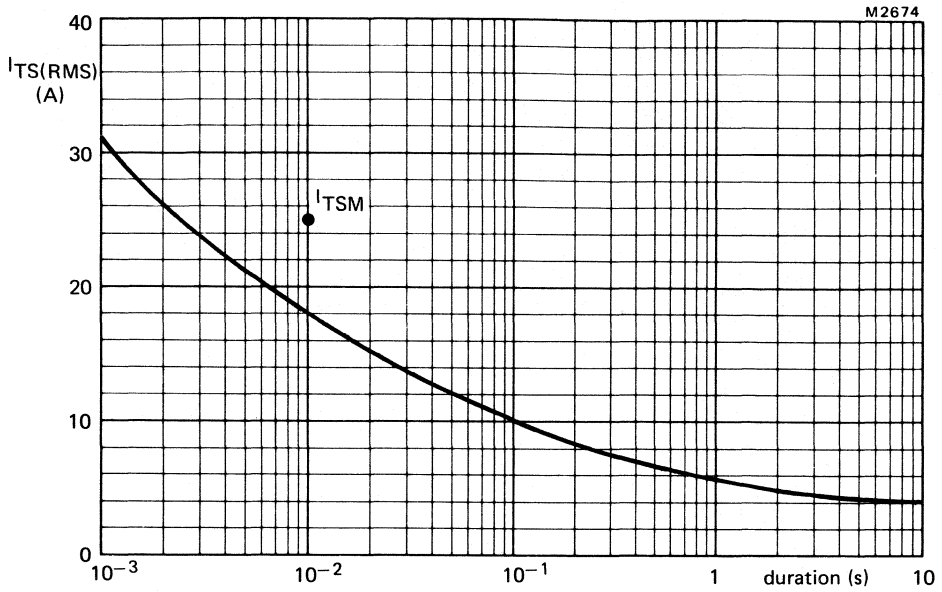


Fig.6 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents ( $f = 50$  Hz) with reapplied  $V_{RWMmax}$ .  $T_j = 110$  °C prior to surge.

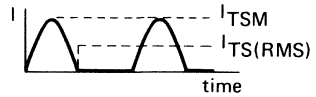
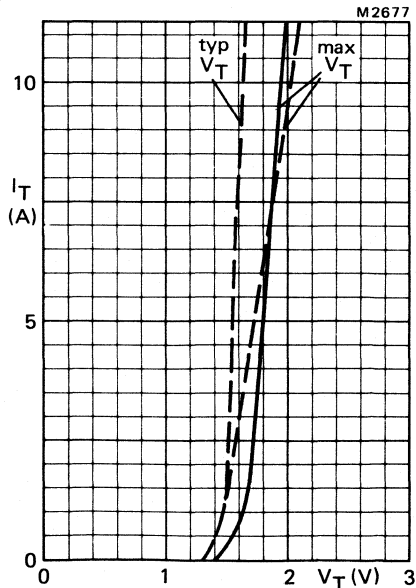


Fig.7 —  $T_j = 25$  °C; - - -  $T_j = 110$  °C.

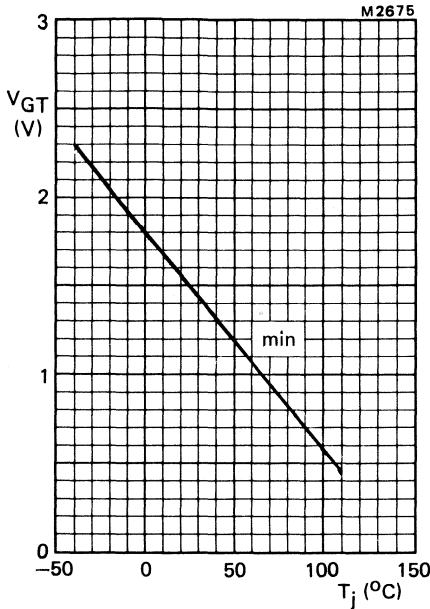


Fig.8 Minimum gate voltage that will trigger all devices as a function of junction temperature.

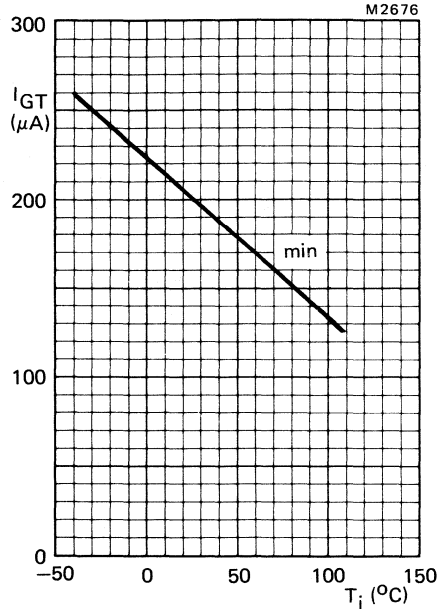


Fig.9 Minimum gate current that will trigger all devices as a function of junction temperature.

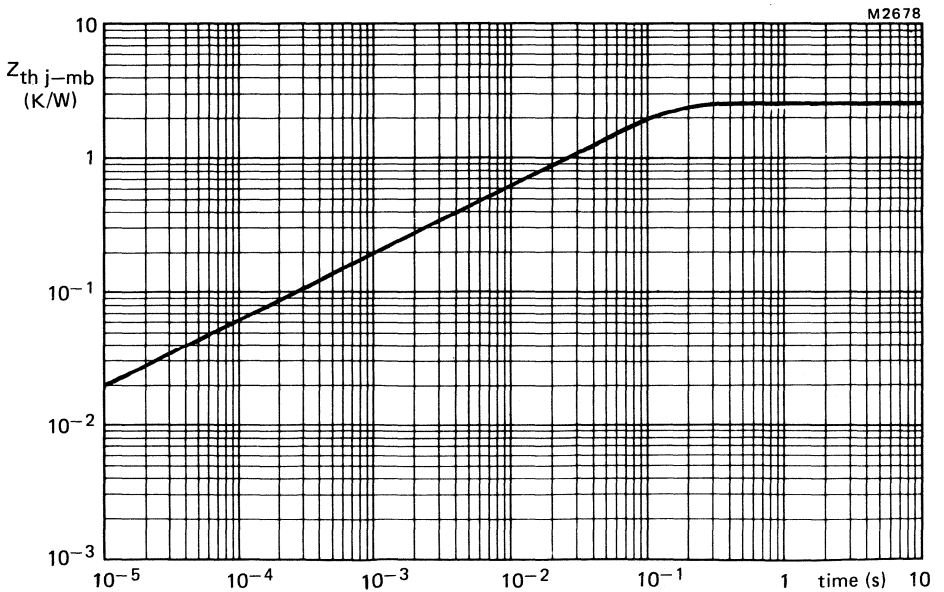


Fig.10 Transient thermal impedance.

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.

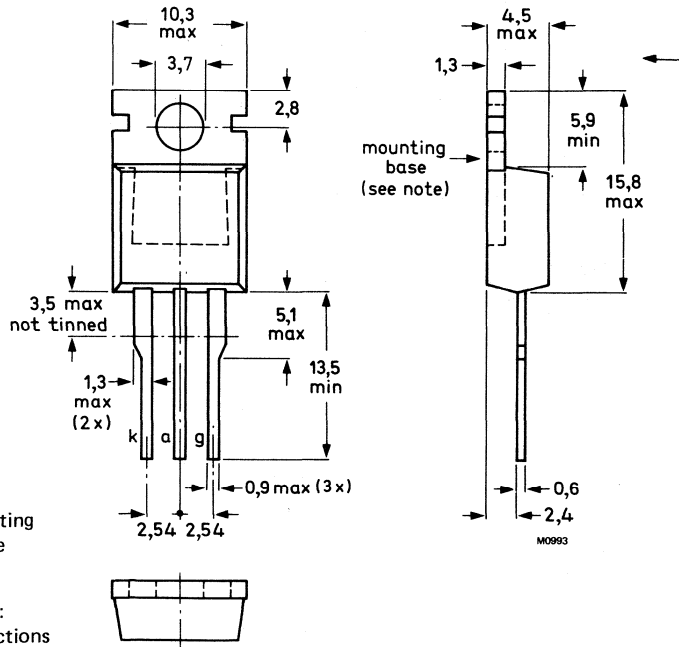
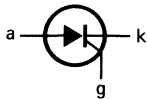
**QUICK REFERENCE DATA**

		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.

**RATINGS**

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

<b>Anode to cathode</b>		BT151-500R	650R	800R	
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 $T_{mb} = 95$ °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
$I^2 t$ for fusing ( $t = 10$ ms)	$I^2 t$	max.	50		A <sup>2</sup> s
Rate of rise of on-state current after triggering with $I_G = 50$ mA to $I_T = 20$ A; $dI_G/dt = 50$ mA/ $\mu$ s	$dI_T/dt$	max.	50		A/ $\mu$ s
<b>Gate to cathode</b>					
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
<b>Temperatures</b>					
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/ $\mu$ s.



**THERMAL RESISTANCE**

From junction to mounting base

$$R_{th\ j-mb} = 1.3\ K/W$$

Transient thermal impedance;  $t = 1\ ms$ 

$$Z_{th\ j-mb} = 0.2\ K/W$$

**Influence of mounting method**

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from mounting base to heatsink

a. with heatsink compound

$$R_{th\ mb-h} = 0.3\ K/W$$

b. with heatsink compound and 0.06 mm maximum mica insulator

$$R_{th\ mb-h} = 1.4\ K/W$$

c. with heatsink compound and 0.1 mm maximum mica insulator (56369)

$$R_{th\ mb-h} = 2.2\ K/W$$

d. with heatsink compound and 0.25 mm max. alumina insulator (56367)

$$R_{th\ mb-h} = 0.8\ K/W$$

e. without heatsink compound

$$R_{th\ mb-h} = 1.4\ K/W$$

2. Free-air operation

The quoted values of  $R_{th\ j-a}$  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

$$R_{th\ j-a} = 60\ K/W$$

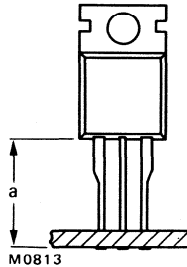


Fig. 2.

**CHARACTERISTICS**

**Anode to cathode**

On-state voltage

$I_T = 23 \text{ A}; T_j = 25 \text{ }^\circ\text{C}$

$V_T < 1,75 \text{ V}^*$

Rate of rise of off-state voltage that will not trigger any device;  $T_j = 110 \text{ }^\circ\text{C}$ ; see Fig.10

$R_{GK} = \text{open circuit}$

$R_{GK} = 100 \text{ } \Omega$

$dV_D/dt < 50 \text{ V}/\mu\text{s}$

$dV_D/dt < 200 \text{ V}/\mu\text{s}$

Reverse current

$V_R = V_{RWMmax}; T_j = 110 \text{ }^\circ\text{C}$

$I_R < 0,5 \text{ mA}$

Off-state current

$V_D = V_{DWMmax}; T_j = 110 \text{ }^\circ\text{C}$

$I_D < 0,5 \text{ mA}$

Latching current;  $T_j = 25 \text{ }^\circ\text{C}$

$I_L < 40 \text{ mA}$

Holding current;  $T_j = 25 \text{ }^\circ\text{C}$

$I_H < 20 \text{ mA}$

**Gate to cathode**

Voltage that will trigger all devices

$V_D = 6 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$

$V_D = 6 \text{ V}; T_j = -40 \text{ }^\circ\text{C}$

$V_{GT} > 1,5 \text{ V}$

$V_{GT} > 2,3 \text{ V}$

Voltage that will not trigger any device

$V_D = V_{DRMmax}; T_j = 110 \text{ }^\circ\text{C}$

$V_{GD} < 250 \text{ mV}$

Current that will trigger all devices

$V_D = 6 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$

$V_D = 6 \text{ V}; T_j = -40 \text{ }^\circ\text{C}$

$I_{GT} > 15 \text{ mA}$

$I_{GT} > 20 \text{ mA}$

**Switching characteristics**

Gate-controlled turn-on time ( $t_{gt} = t_d + t_r$ ) when

switched from  $V_D = V_{DRMmax}$  to  $I_T = 40 \text{ A}$ ;

$I_{GT} = 100 \text{ mA}; dI_G/dt = 5 \text{ A}/\mu\text{s}; T_j = 25 \text{ }^\circ\text{C}$

$t_{gt} \text{ typ. } 2 \text{ } \mu\text{s}$

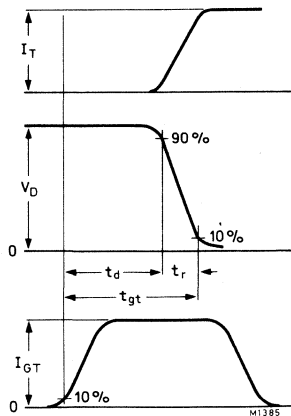


Fig.2a Gate controlled turn-on time definition.

\*Measured under pulse conditions to avoid excessive dissipation.

## MOUNTING INSTRUCTIONS

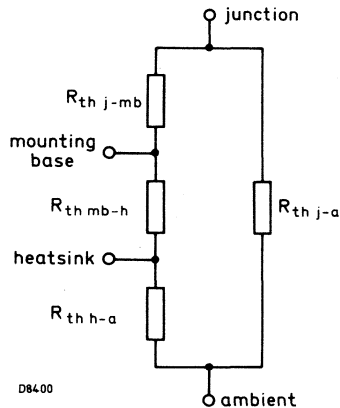
1. The device may be soldered directly into the circuit, but the maximum permissible temperature of the soldering iron or bath is 275 °C; it must not be in contact with the joint for more than 5 seconds. Soldered joints must be at least 4.7 mm from the seal.
2. The leads should not be bent less than 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  $R_{th\ mb-h}$  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  $R_{th\ mb-h}$  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.



- 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  $R_{th\ mb-a}$ . The heatsink thermal resistance value ( $R_{th\ h-a}$ ) can now be calculated from:

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

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

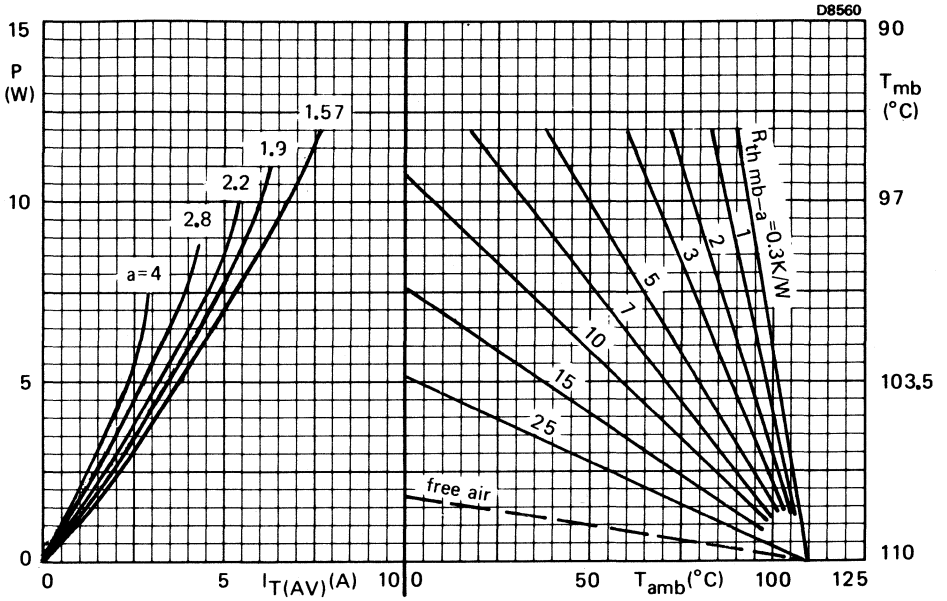
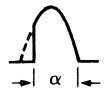


Fig.4 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

$\alpha$  = conduction angle per half cycle



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

$\alpha$	a
30°	4
60°	2,8
90°	2,2
120°	1,9
180°	1,57

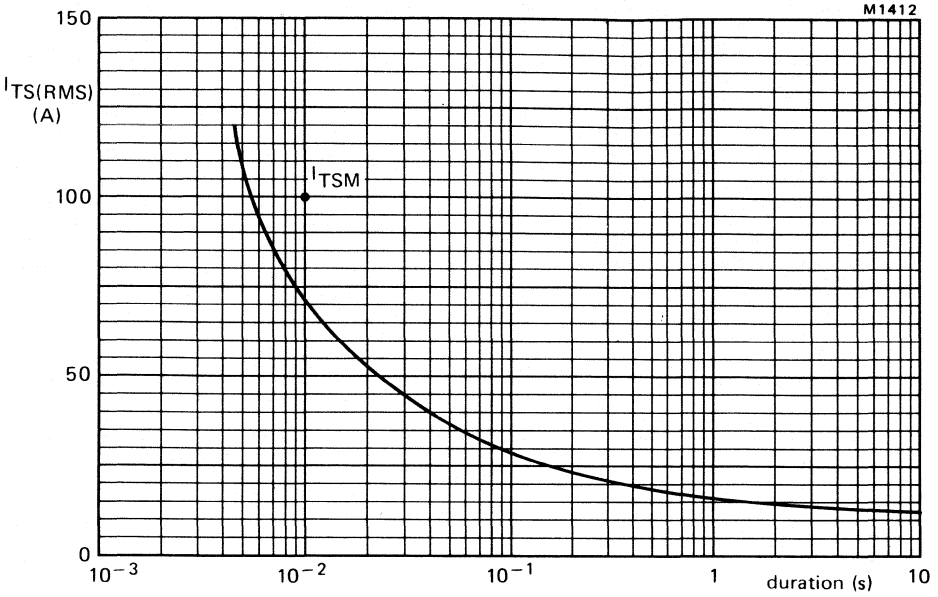
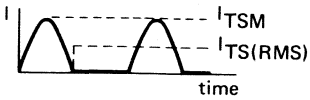


Fig.5 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents ( $f = 50$  Hz);  $T_j = 110$  °C prior to surge; with reapplied  $V_{RWMmax}$ .



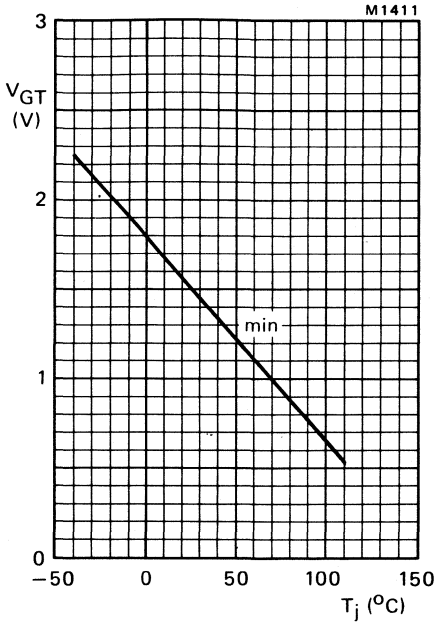


Fig.6 Minimum gate voltage that will trigger all devices as a function of junction temperature.

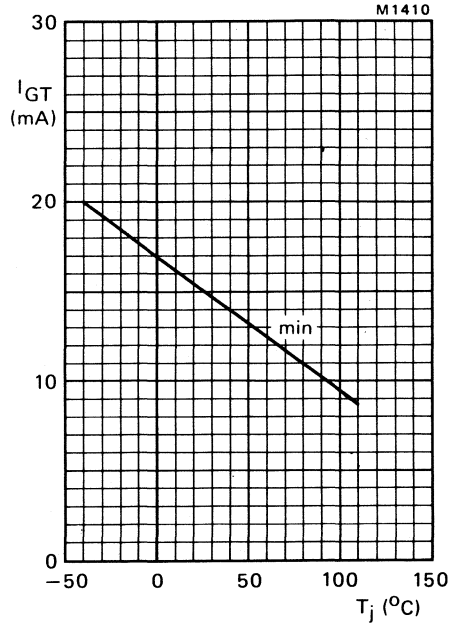


Fig.7 Minimum gate current that will trigger all devices as a function of junction temperature.

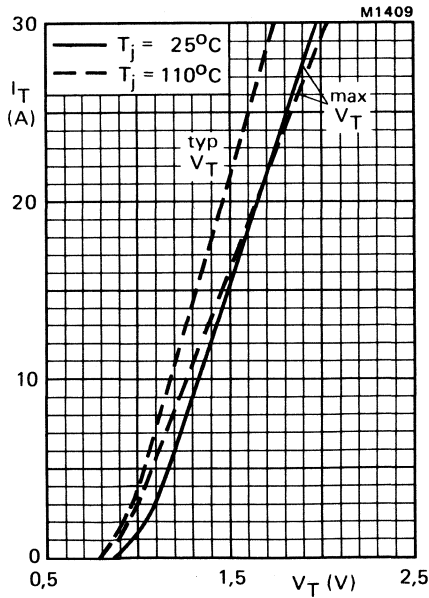


Fig.8.

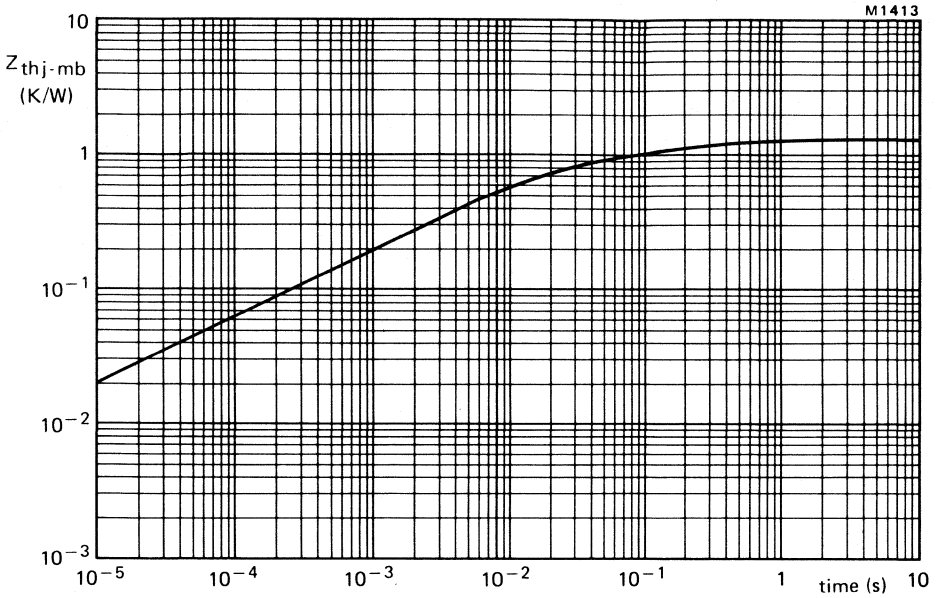


Fig.9

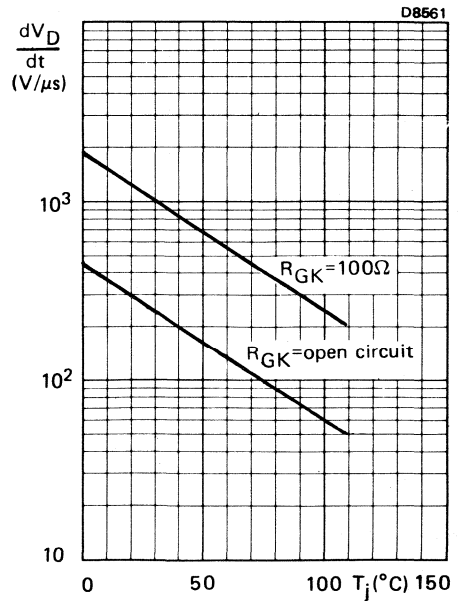


Fig.10 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of junction temperature.





## 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.

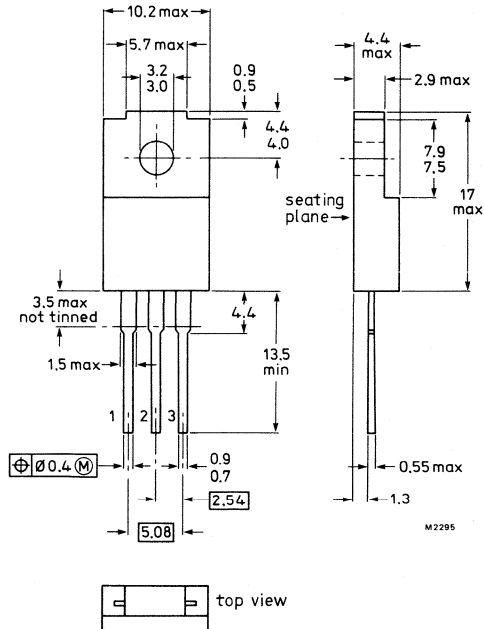
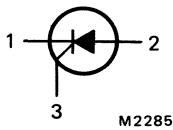
### QUICK REFERENCE DATA

		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)

		BT151F-500	650	800		
<b>Anode to cathode</b>						
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
$I^2 t$ for fusing (t = 10 ms)	$I^2 t$	max.		50		A <sup>2</sup> s
Rate of rise of on-state current after triggering with $I_G = 50$ mA to $I_T = 20$ A; $dI_G/dt = 50$ mA/ $\mu$ s	$dI_T/dt$	max.		50		A/ $\mu$ s
<b>Gate to cathode</b>						
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
<b>Temperatures</b>						
Storage temperature	$T_{stg}$			-40 to +125		°C
Operating junction temperature	$T_j$	max.		110		°C
<b>ISOLATION</b>						
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/ $\mu$ s.

## THERMAL RESISTANCE

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

Thermal resistance from junction to external heatsink

With heatsink compound

$$R_{th\ j-h} = 4.5 \text{ K/W}$$

Without heatsink compound

$$R_{th\ j-h} = 6.5 \text{ K/W}$$

## 2. Free-air operation

The quoted values of  $R_{th\ j-a}$  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

$$R_{th\ j-a} = 55 \text{ K/W}$$

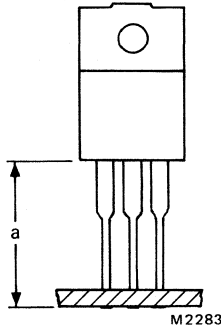


Fig.2.

**CHARACTERISTICS**

**Anode to cathode**

On-state voltage

$I_T = 23 \text{ A}; T_j = 25 \text{ }^\circ\text{C}$   $V_T < 1.75 \text{ V}^*$

Rate of rise of off-state voltage that will not trigger any device;  $T_j = 110 \text{ }^\circ\text{C}$ ; see Fig.10

$R_{GK} = \text{open circuit}$   $dV_D/dt < 50 \text{ V}/\mu\text{s}$   
 $R_{GK} = 100 \text{ } \Omega$   $dV_D/dt < 200 \text{ V}/\mu\text{s}$

Reverse current

$V_R = V_{RWMmax}; T_j = 110 \text{ }^\circ\text{C}$   $I_R < 0.5 \text{ mA}$

Off-state current

$V_D = V_{DWMmax}; T_j = 110 \text{ }^\circ\text{C}$   $I_D < 0.5 \text{ mA}$

Latching current;  $T_j = 25 \text{ }^\circ\text{C}$

$I_L < 40 \text{ mA}$

Holding current;  $T_j = 25 \text{ }^\circ\text{C}$

$I_H < 20 \text{ mA}$

**Gate to cathode**

Voltage that will trigger all devices

$V_D = 6 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$   $V_{GT} > 1.5 \text{ V}$

$V_D = 6 \text{ V}; T_j = -40 \text{ }^\circ\text{C}$   $V_{GT} > 2.3 \text{ V}$

Voltage that will not trigger any device

$V_D = V_{DRMmax}; T_j = 110 \text{ }^\circ\text{C}$   $V_{GD} < 250 \text{ mV}$

Current that will trigger all devices

$V_D = 6 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$   $I_{GT} > 15 \text{ mA}$

$V_D = 6 \text{ V}; T_j = -40 \text{ }^\circ\text{C}$   $I_{GT} > 20 \text{ mA}$

**Switching characteristics**

Gate-controlled turn-on time ( $t_{gt} = t_d + t_r$ ) when switched from  $V_D = V_{DRMmax}$  to  $I_T = 40 \text{ A}$ ;

$I_{GT} = 100 \text{ mA}; dI_G/dt = 5 \text{ A}/\mu\text{s}; T_j = 25 \text{ }^\circ\text{C}$   $t_{gt} \text{ typ. } 2 \text{ } \mu\text{s}$

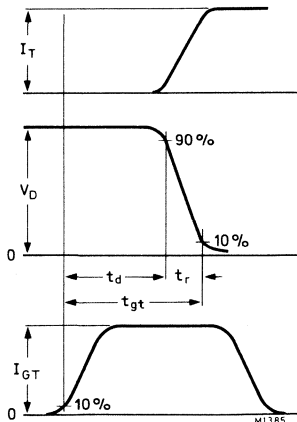


Fig.3 Gate controlled turn-on time definition.

\*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  $R_{th\ j-h}$  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  $R_{th\ j-h}$  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.

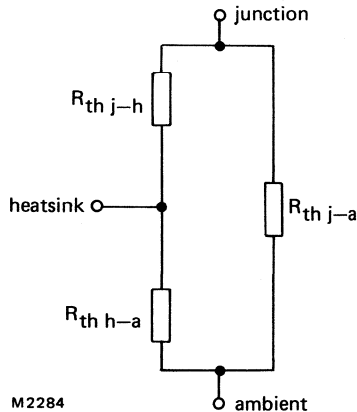
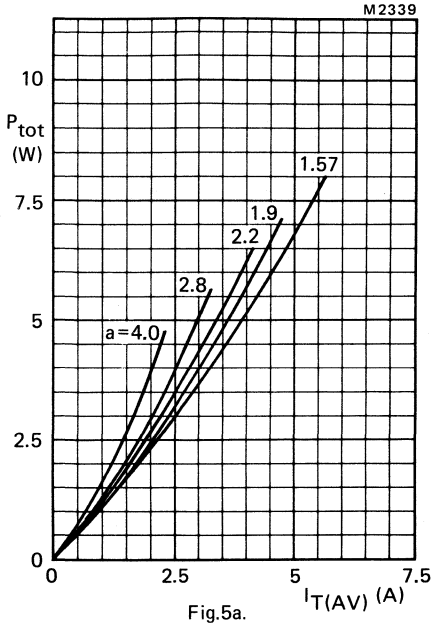


Fig.4.

- 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  $R_{th\ h-a}$ , the required heatsink thermal resistance value.

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



$\alpha$  = conduction angle per half cycle

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



$\alpha$	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.

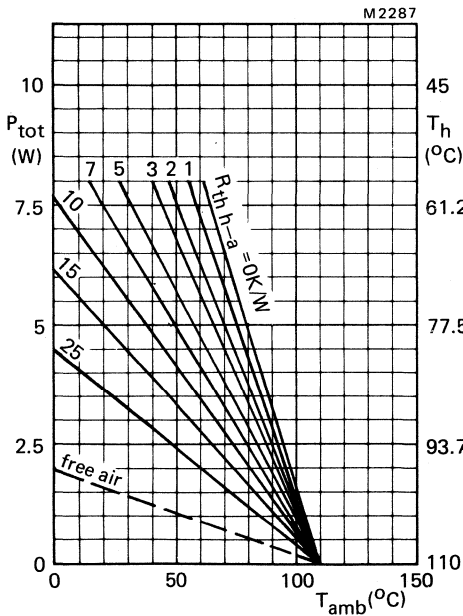


Fig.5b Without heatsink compound.

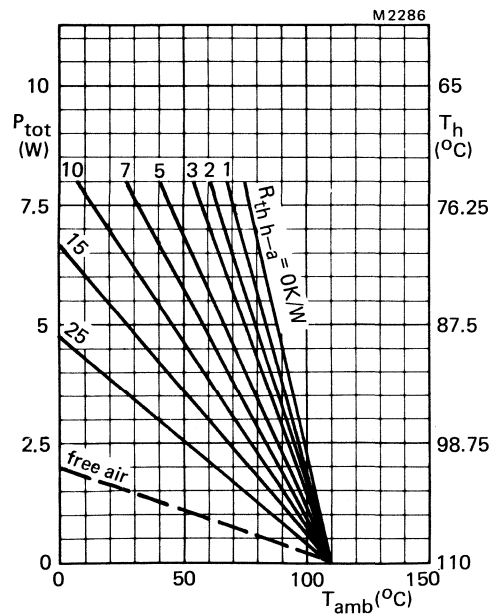


Fig.5c With heatsink compound.

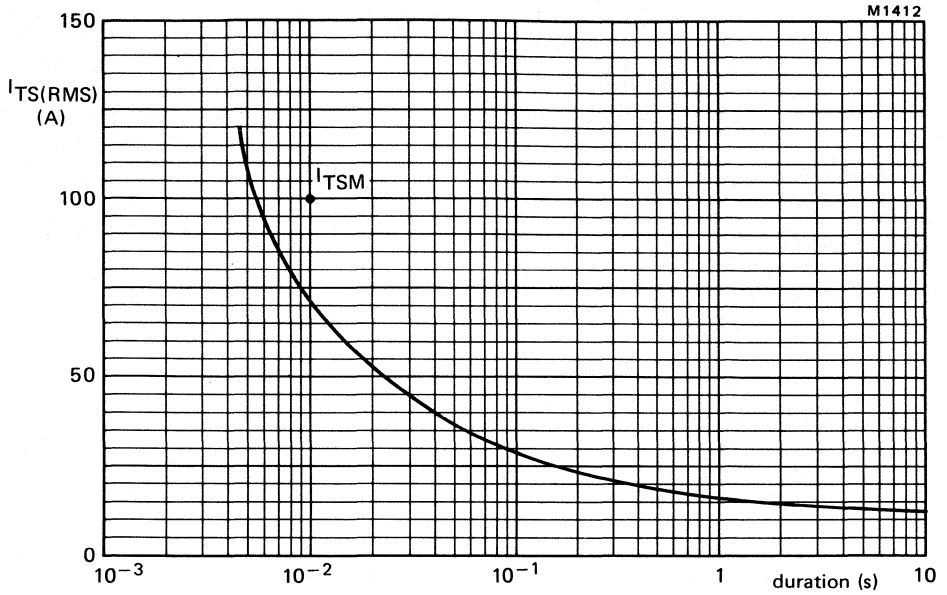
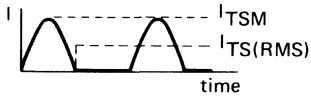


Fig.6 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents ( $f = 50$  Hz);  $T_j = 110$  °C prior to surge; with reapplied  $V_{RWMmax}$ .



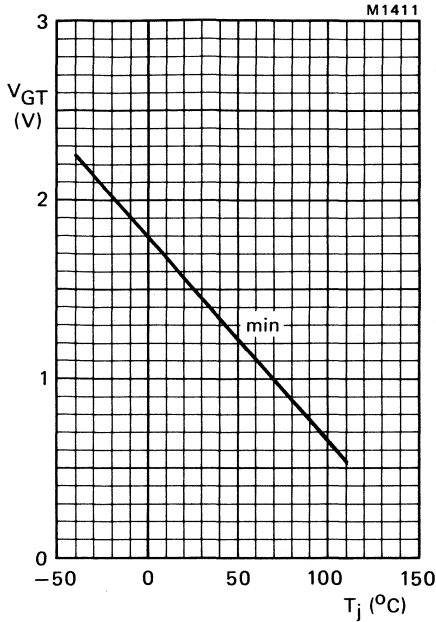


Fig.7 Minimum gate voltage that will trigger all devices as a function of junction temperature.

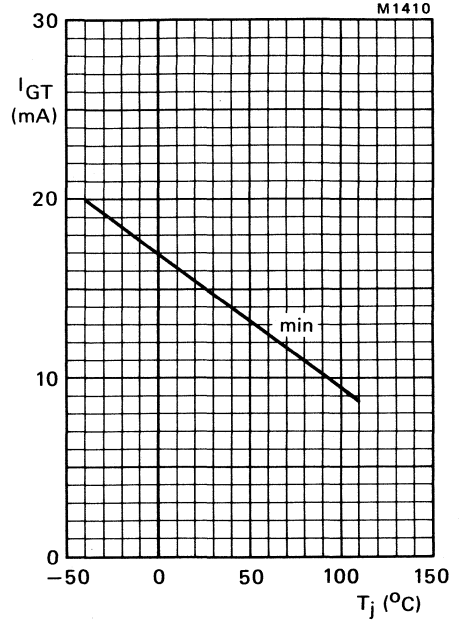


Fig.8 Minimum gate current that will trigger all devices as a function of junction temperature.

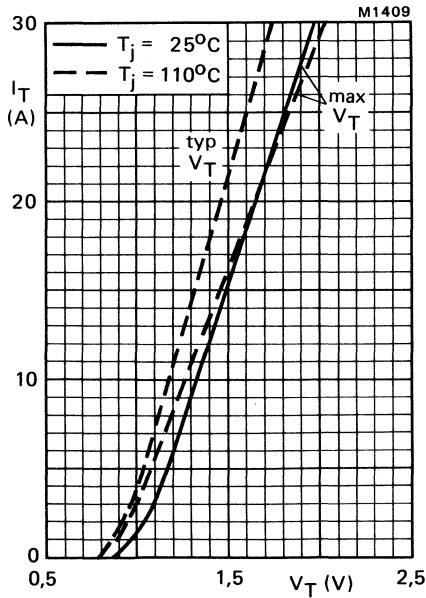


Fig.9.



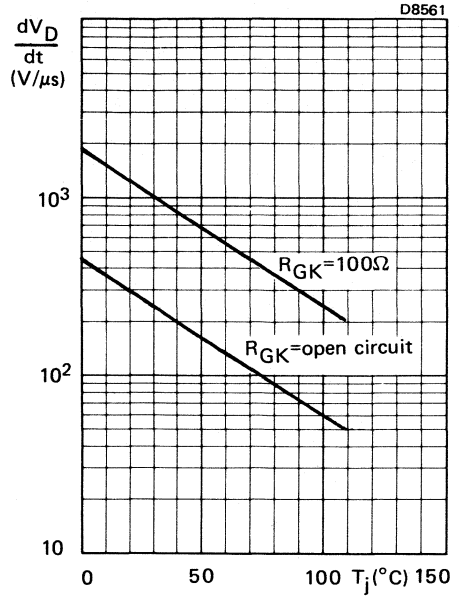


Fig.10 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of junction temperature.

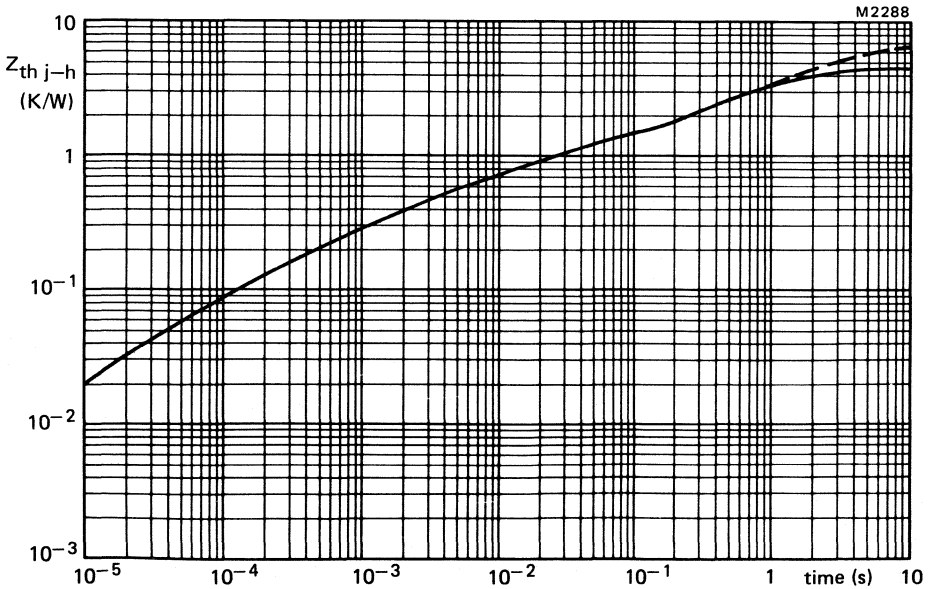


Fig.11 Transient thermal impedance; — with heatsink compound; - - - without heatsink compound.



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.

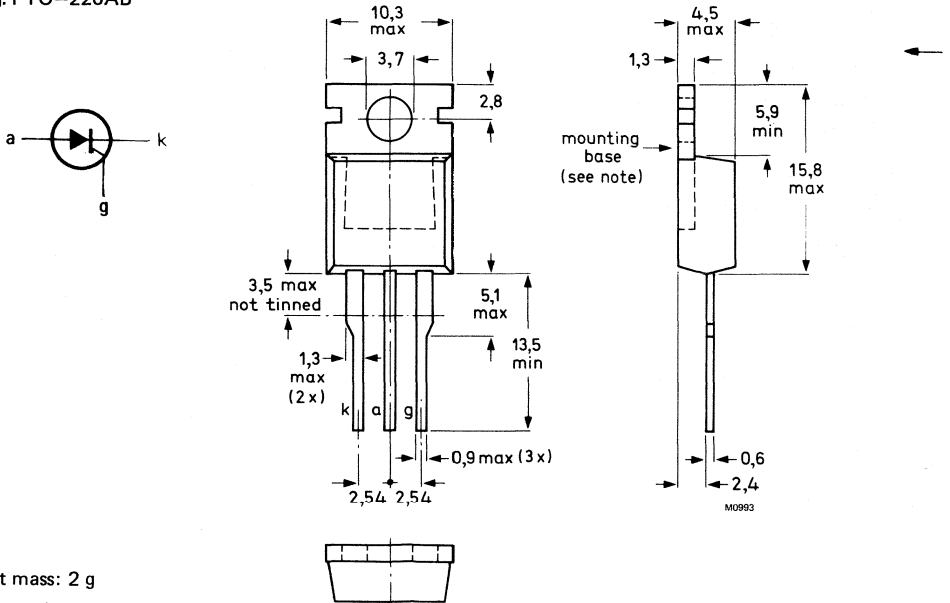
**QUICK REFERENCE DATA**

		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)

<b>Anode to cathode</b>		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 $T_{mb} = 93\text{ }^{\circ}\text{C}$		$I_T(AV)$	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; $t = 10\text{ ms}$ ; half sine-wave; $T_j = 115\text{ }^{\circ}\text{C}$ prior to surge; with reapplied $V_{RWMmax}$		$I_{TSM}$	max. 200		A
$I^2 t$ for fusing ( $t = 10\text{ ms}$ )		$I^2 t$	max. 200		$A^2 s$
Rate of rise of on-state current after triggering with $I_G = 160\text{ mA}$ to $I_T = 50\text{ A}$ ; $dI_G/dt = 160\text{ A/ms}$		$dI_T/dt$	max. 200		$A/\mu s$
<b>Gate to cathode</b>					
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; $t \leq 10\text{ }\mu s$		$P_{GM}$	max. 20		W
<b>Temperature</b>					
Storage temperature		$T_{stg}$	-40 to +150		$^{\circ}\text{C}$
Junction temperature		$T_j$	max. 115		$^{\circ}\text{C}$

**THERMAL RESISTANCE**

From junction to mounting base

$$R_{th\ j-mb} = 1.1\ \text{K/W}$$

Transient thermal impedance;  $t = 1\ \text{ms}$ 

$$Z_{th\ j-mb} = 0.12\ \text{K/W}$$

**Influence of mounting method**

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

Thermal resistance from mounting base to heatsink

a. with heatsink compound

$$R_{th\ mb-h} = 0.3\ \text{K/W}$$

b. with heatsink compound and 0.06 mm maximum mica insulator

$$R_{th\ mb-h} = 1.4\ \text{K/W}$$

c. with heatsink compound and 0.1 mm maximum mica insulator (56369)

$$R_{th\ mb-h} = 2.2\ \text{K/W}$$

d. with heatsink compound and 0.25 mm max. alumina insulator (56367)

$$R_{th\ mb-h} = 0.8\ \text{K/W}$$

e. without heatsink compound

$$R_{th\ mb-h} = 1.4\ \text{K/W}$$

## 2. Free-air operation

The quoted values of  $R_{th\ j-a}$  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

$$R_{th\ j-a} = 60\ \text{K/W}$$

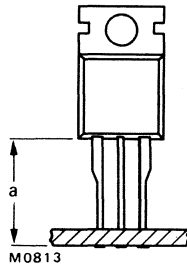


Fig. 2.

**CHARACTERISTICS**

**Anode to cathode**

On-state voltage (measured under pulse conditions)

$I_T = 40 \text{ A}; T_j = 25 \text{ }^\circ\text{C}$

$V_T < 1.75 \text{ V}$

Rate of rise of off-state voltage that will not trigger any device

$T_j = 115 \text{ }^\circ\text{C}; R_{GK} = \text{open circuit}$

$dV_D/dt < 200 \text{ V}/\mu\text{s}$

Reverse current

$V_R = V_{RWMmax}; T_j = 115 \text{ }^\circ\text{C}$

$I_R < 1.0 \text{ mA}$

Off-state current

$V_D = V_{DWMmax}; T_j = 115 \text{ }^\circ\text{C}$

$I_D < 1.0 \text{ mA}$

Latching current;  $T_j = 25 \text{ }^\circ\text{C}$

$I_L < 80 \text{ mA}$

Holding current;  $T_j = 25 \text{ }^\circ\text{C}$

$I_H < 60 \text{ mA}$

**Gate to cathode**

Voltage that will trigger all devices

$V_D = 12 \text{ V}; T_j = -40 \text{ }^\circ\text{C}$

$V_{GT} > 1.5 \text{ V}$

$V_D = 12 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$

$V_{GT} > 1.0 \text{ V}$

Voltage that will not trigger any device

$V_D = V_{DRMmax}; T_j = 115 \text{ }^\circ\text{C}$

$V_{GD} < 0.25 \text{ V}$

Current that will trigger all devices

$V_D = 12 \text{ V}; T_j = -40 \text{ }^\circ\text{C}$

$I_{GT} > 50 \text{ mA}$

$V_D = 12 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$

$I_{GT} > 32 \text{ mA}$

**Switching characteristics**

Gate-controlled turn-on time ( $t_{gt} = t_d + t_r$ ) when

switched from  $V_D = V_{DRMmax}$  to  $I_T = 40 \text{ A}$ ;

$I_{GT} = 100 \text{ mA}; dI_G/dt = 5 \text{ A}/\mu\text{s}; T_j = 25 \text{ }^\circ\text{C}$

$t_{gt} \text{ typ. } 2 \text{ } \mu\text{s}$

Circuit-commutated turn-off time when switched

from  $I_T = 40 \text{ A}$  to  $V_R > 50 \text{ V}$  with  $-dI_T/dt = 10 \text{ A}/\mu\text{s}$ ;

$dV_D/dt = 50 \text{ V}/\mu\text{s}; T_j = 115 \text{ }^\circ\text{C}$

$t_q \text{ typ. } 35 \text{ } \mu\text{s}$

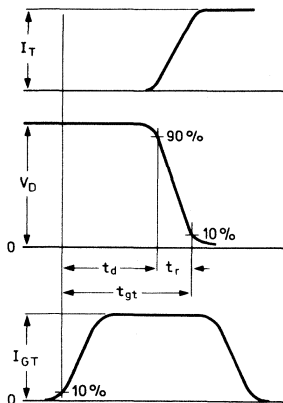


Fig.3a Gate-controlled turn-on time definition.

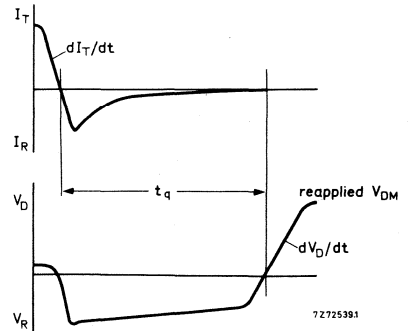


Fig.3b Circuit-commutated turn-off time definition.

### 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  $R_{th\ mb-h}$  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  $R_{th\ mb-h}$  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.

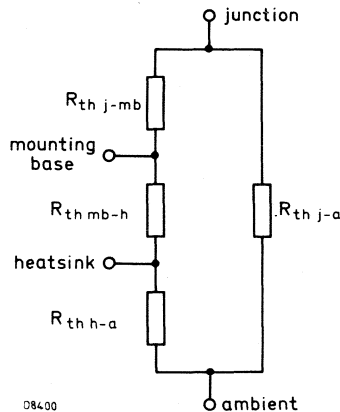


Fig.4

- b. The method of using Fig.5 is as follows:  
Starting with the required current on the  $I_T(A_V)$  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  $R_{th\ mb-a}$ . The heatsink thermal resistance value ( $R_{th\ h-a}$ ) can now be calculated from:

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

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

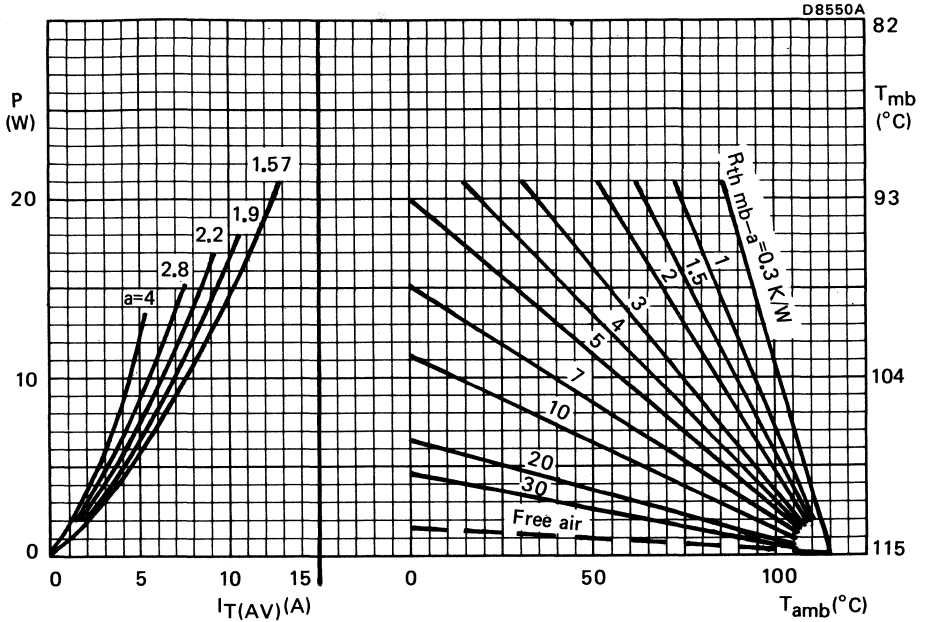


Fig.5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha$  = conduction angle per half cycle

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

$\alpha$	a
30 $^{\circ}$	4
60 $^{\circ}$	2.8
90 $^{\circ}$	2.2
120 $^{\circ}$	1.9
180 $^{\circ}$	1.57



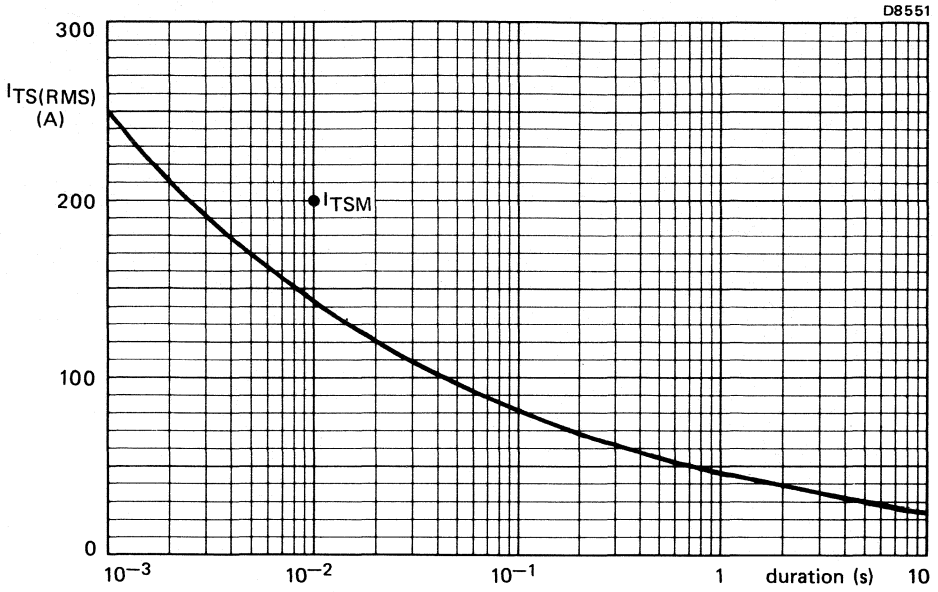


Fig.6 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents ( $f = 50$  Hz);  $T_j = 115$  °C prior to surge; with reapplied  $V_{RWMmax}$ .

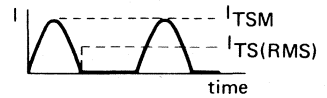
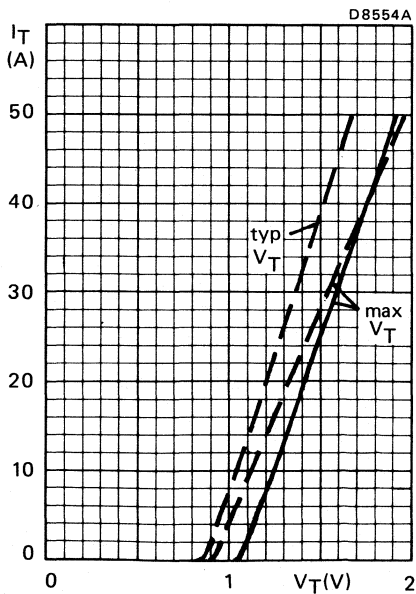


Fig.7 —  $T_j = 25$  °C; - - -  $T_j = 115$  °C

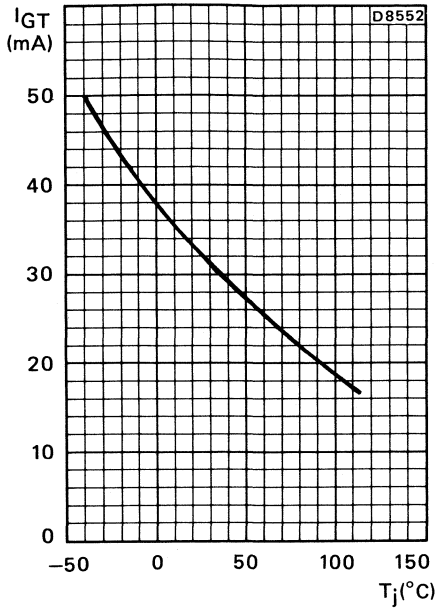


Fig. 8 Minimum gate current that will trigger all devices as a function of junction temperature.

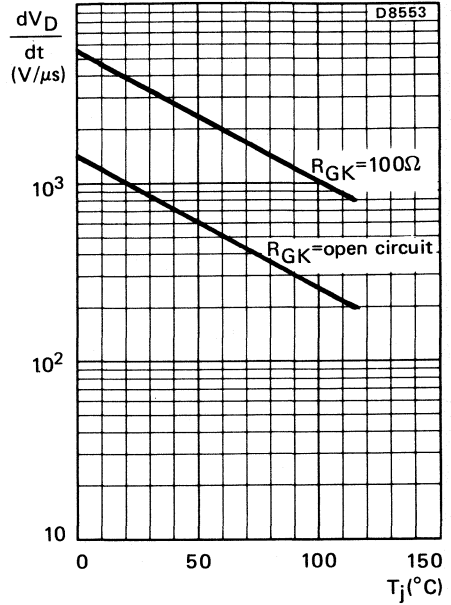


Fig. 9 Maximum rate of rise of off-state voltage that will not trigger any device as a function of junction temperature.

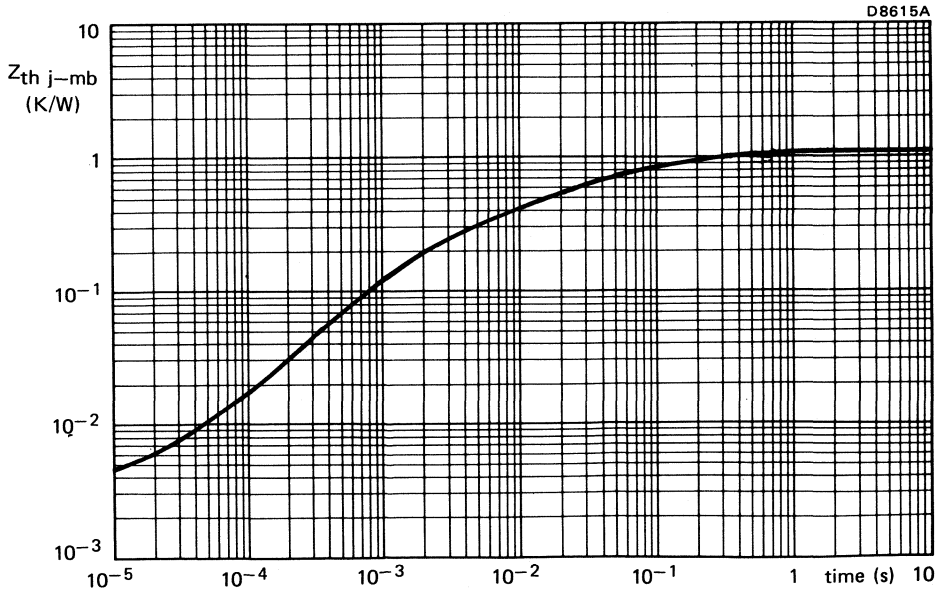


Fig. 10

## 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.

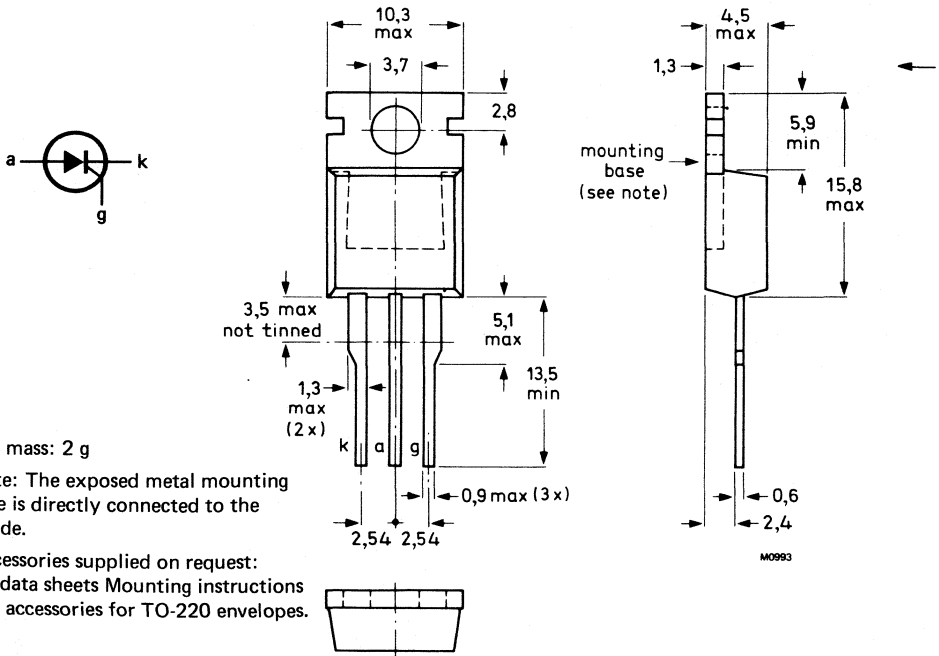
## QUICK REFERENCE DATA

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 $\mu s$

## MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.



**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 <sup>2</sup> s
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/ $\mu$ s

**Gate to cathode**

Average power dissipation (averaged over any 20 ms period)	$P_G(AV)$	max.	1 W
Peak power dissipation; $t = 10$ $\mu$ s	$P_{GM}$	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

$$R_{th\ j-mb} = 1,5\ ^\circ C/W$$

Transient thermal impedance;  $t = 1\ ms$ 

$$Z_{th\ j-mb} = 0,2\ ^\circ C/W$$

**Influence of mounting method**

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from mounting base to heatsink

a. with heatsink compound

$$R_{th\ mb-h} = 0,3\ ^\circ C/W$$

b. with heatsink compound and 0,06 mm maximum mica insulator

$$R_{th\ mb-h} = 1,4\ ^\circ C/W$$

c. with heatsink compound and 0,1 mm maximum mica insulator (56369)

$$R_{th\ mb-h} = 2,2\ ^\circ C/W$$

d. with heatsink compound and 0,25 mm max. alumina insulator (56367)

$$R_{th\ mb-h} = 0,8\ ^\circ C/W$$

e. without heatsink compound

$$R_{th\ mb-h} = 1,4\ ^\circ C/W$$

2. Free-air operation

The quoted values of  $R_{th\ j-a}$  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

$$R_{th\ j-a} = 60\ ^\circ C/W$$

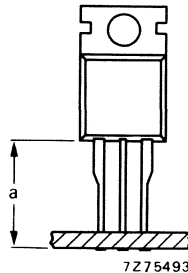


Fig. 2.

**CHARACTERISTICS**

**Anode to cathode**

On-state voltage

$I_T = 10 \text{ A}; T_j = 25 \text{ }^\circ\text{C}$

$V_T < 2,5 \text{ V}^*$

Rate of rise of off-state voltage that will not trigger any device;  $T_j \leq 110 \text{ }^\circ\text{C}$

$dV_D/dt < 200 \text{ V}/\mu\text{s}$

Off-state current

$V_D = V_{DRMmax}; T_j = 110 \text{ }^\circ\text{C}$

$I_D < 1,5 \text{ mA}$

Holding current;  $T_j = 25 \text{ }^\circ\text{C}$

$I_H < 100 \text{ mA}$

**Gate to cathode**

Voltage that will trigger all devices

$V_D = 6 \text{ V}; T_j = 25 \text{ }^\circ\text{C}; t_p \geq 5 \mu\text{s}$

$V_{GT} > 2,5 \text{ V}$

Current that will trigger all devices

$V_D = 6 \text{ V}; T_j = 25 \text{ }^\circ\text{C}; t_p \geq 5 \mu\text{s}$

$I_{GT} > 40 \text{ mA}$

**Switching characteristics**

Circuit-commutated turn-off time (in regulating circuits)

when switched from  $I_T = 10 \text{ A}$  to  $V_R \geq 50 \text{ V}$  with  $-dI_T/dt = 10 \text{ A}/\mu\text{s}$ ;  $dV_D/dt = 200 \text{ V}/\mu\text{s}$ ;  $V_{DM} = 500 \text{ V}$ ;  $R_{GK} = 68 \text{ } \Omega$ ;  $T_{mb} = 80 \text{ }^\circ\text{C}$ ;  $t_p \leq 50 \mu\text{s}$

$t_q < 20 \mu\text{s}$

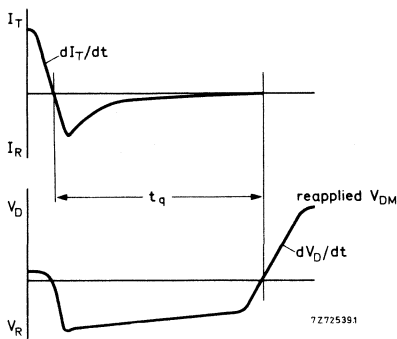


Fig. 3 Circuit-commutated turn-off time definition.

\* 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  $R_{th\ mb-h}$  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  $R_{th\ mb-h}$  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.

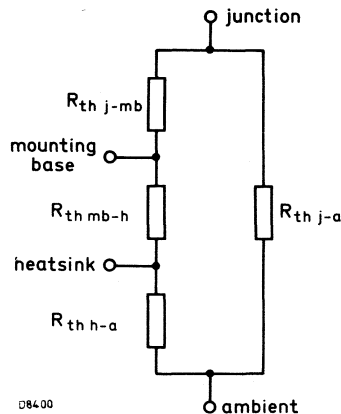


Fig.4

- 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  $R_{th\ mb-a}$ . The heatsink thermal resistance value ( $R_{th\ h-a}$ ) can now be calculated from:

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

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

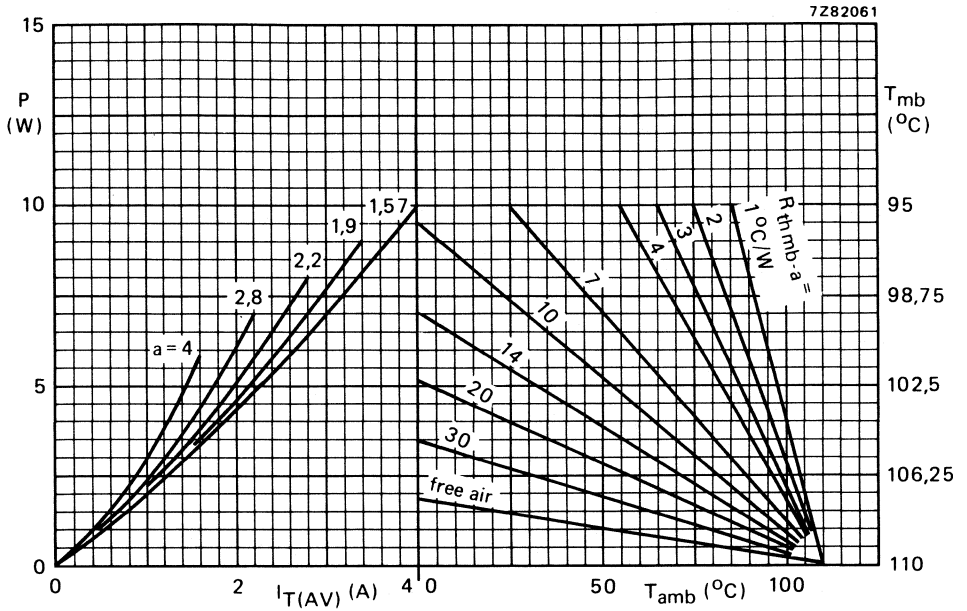


Fig. 5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha$  = conduction angle per half cycle

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

$\alpha$	a
30°	4
60°	2,8
90°	2,2
120°	1,9
180°	1,57



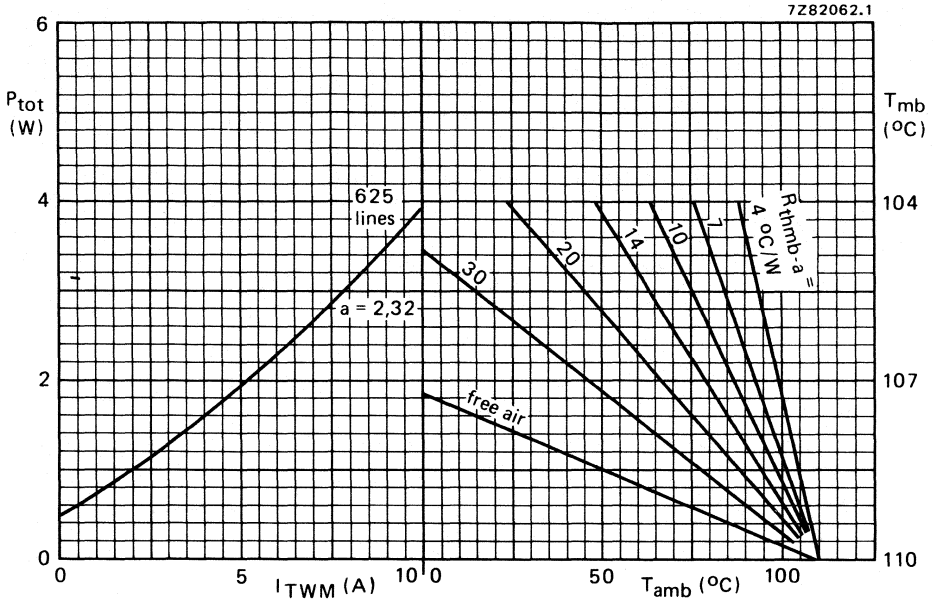


Fig. 6 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

$P_{tot}$  = maximum power dissipation including gate and switching losses.

$I_{TWM}$  = maximum working peak on-state current.

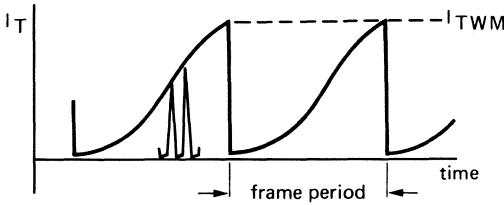


Fig. 7 Waveform defining  $I_{TWM}$ .

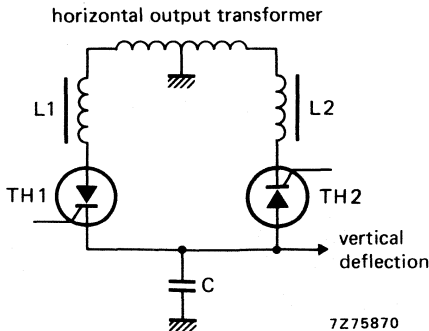


Fig. 8 Basic circuit of a vertical deflection system.

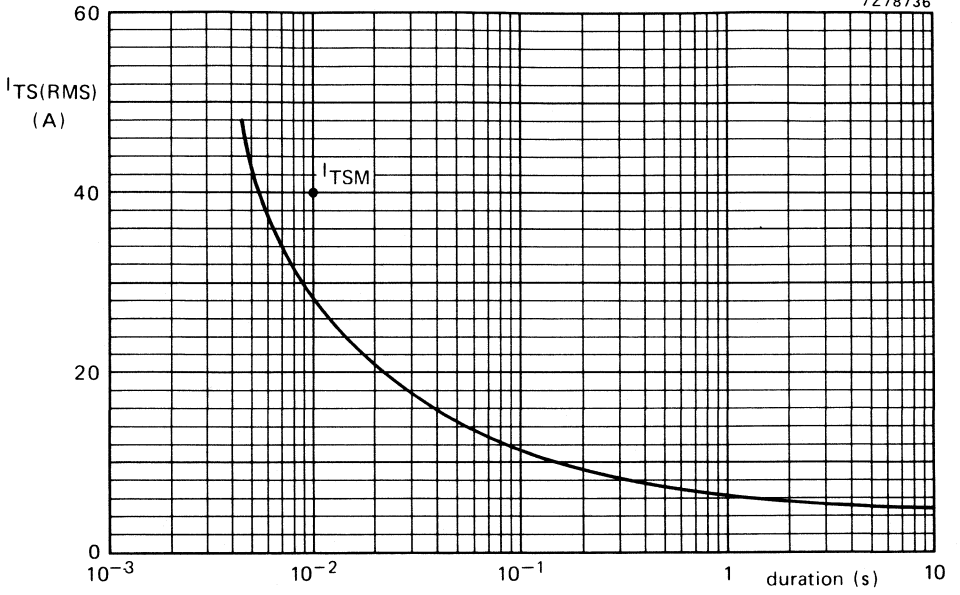
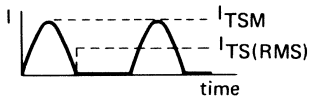


Fig. 9 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents ( $f = 50$  Hz);  $T_j = 110$  °C prior to surge; with reapplied  $V_{RWMmax}$ .



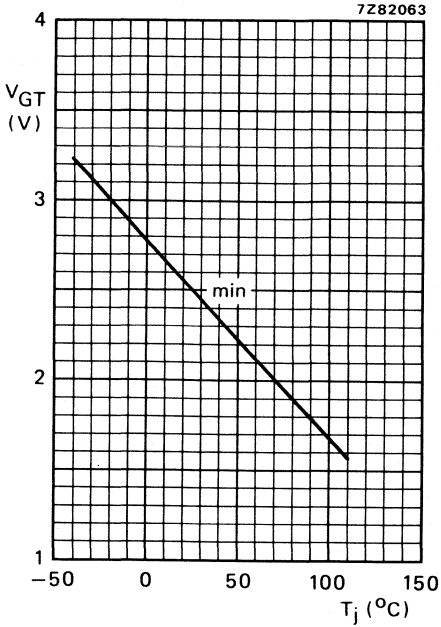


Fig. 10 Minimum gate voltage that will trigger all devices as a function of junction temperature.

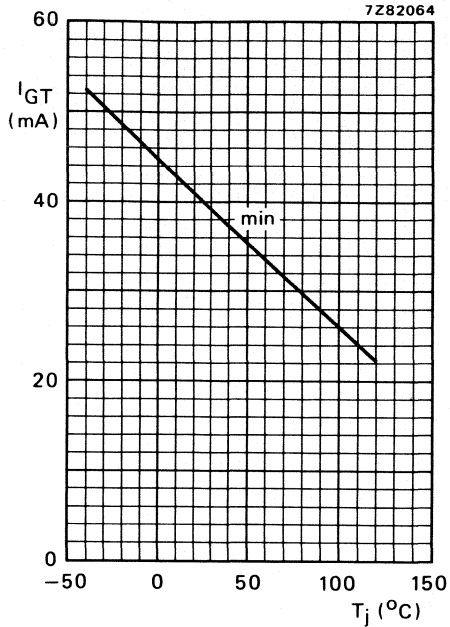


Fig. 11 Minimum gate current that will trigger all devices as a function of junction temperature.

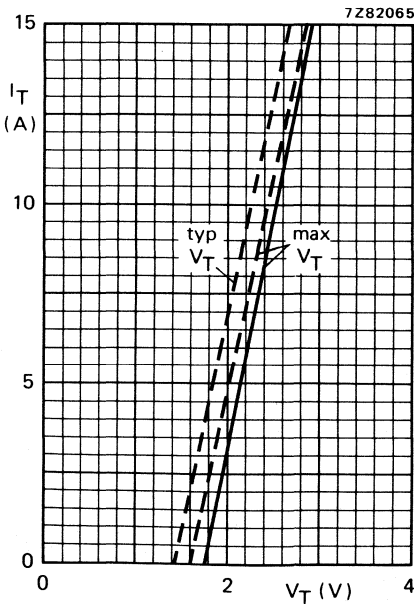


Fig. 12 —  $T_j = 25^{\circ}\text{C}$ ; - - -  $T_j = 110^{\circ}\text{C}$ .

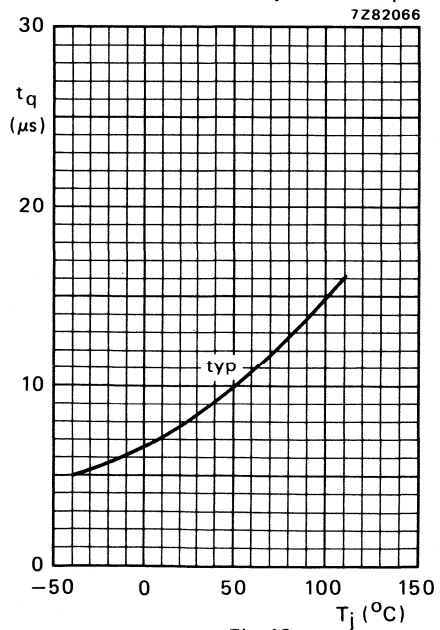


Fig. 13.

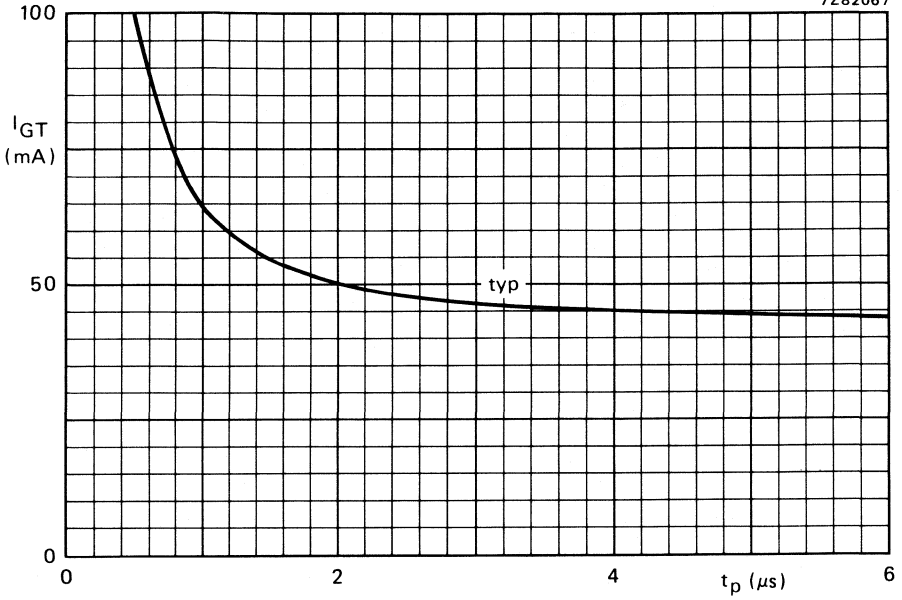
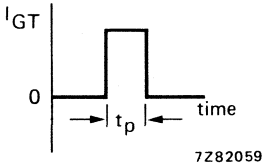


Fig. 14 Gate current that will trigger all devices as a function of rectangular pulse width;  $T_j = 25\text{ }^\circ\text{C}$ .



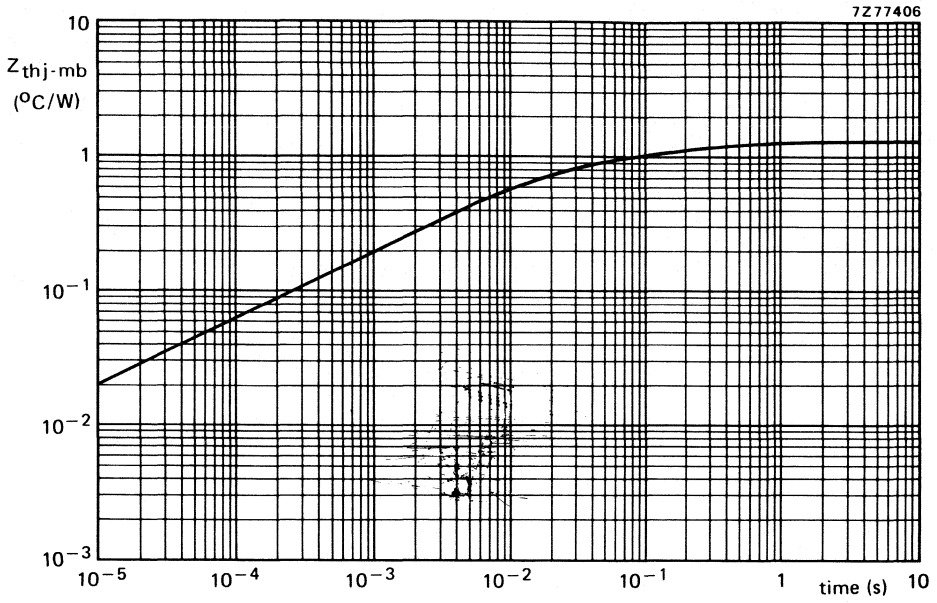


Fig. 15.



## 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.

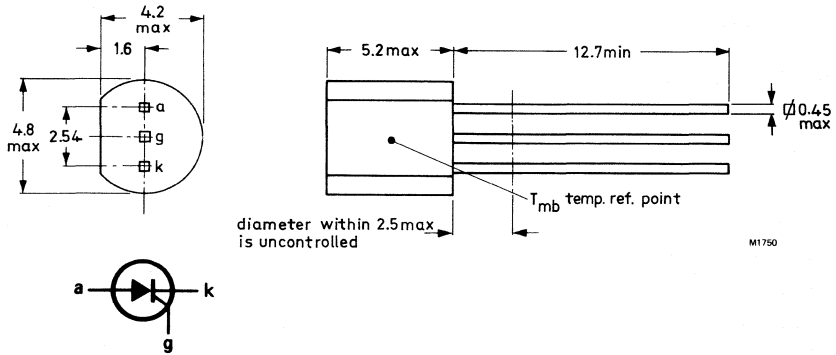
### QUICK REFERENCE DATA

			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).

<b>Anode to cathode</b>		BT169-B	D	M	
Non-repetitive peak voltages ( $t \leq 10$ ms)	$V_{DSM}/V_{RSM}$ max.	200	400	600	V*
Repetitive peak voltages ( $\delta \leq 0.01$ )	$V_{DRM}/V_{RRM}$ 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
$I^2 t$ for fusing ( $t = 10$ ms)	$I^2 t$ max.		0.32		A <sup>2</sup> s
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/ $\mu$ s	$dI_T/dt$ max.		30		A/ $\mu$ s
<b>Gate to cathode</b>					
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
<b>Temperatures</b>					
Storage temperature	$T_{stg}$		-40 to +150		°C
Operating junction temperature	$T_j$ max.		125		°C
<b>THERMAL RESISTANCE</b>					
From junction to mounting base	$R_{th j-mb}$ =		100		K/W
From junction to ambient in free air, mounted on a p.c.b. with any lead length	$R_{th j-a}$ =		200		K/W

\* $R_{GK} = 1$  k $\Omega$ .



**CHARACTERISTICS****Anode to cathode**

On-state voltage

$I_T = 1 \text{ A}; T_j = 25 \text{ }^\circ\text{C}$

$V_T < 1.35 \text{ V}^*$

Rate of rise of off-state voltage that will not trigger any device; exponential method;

$V_D = 2/3 V_{DRMmax}; R_{GK} = 1 \text{ k}\Omega; T_j = 125 \text{ }^\circ\text{C}$

$dV_D/dt < 100 \text{ V}/\mu\text{s}$

Reverse current

$V_R = V_{RRMmax}; R_{GK} = 1 \text{ k}\Omega; T_j = 125 \text{ }^\circ\text{C}$

$I_R < 0.1 \text{ mA}$

Off-state current

$V_D = V_{DRMmax}; R_{GK} = 1 \text{ k}\Omega; T_j = 125 \text{ }^\circ\text{C}$

$I_D < 0.1 \text{ mA}$

Latching current

$V_D = 6 \text{ V}; R_{GK} = 1 \text{ k}\Omega; T_j = 25 \text{ }^\circ\text{C}$

$I_L < 6 \text{ mA}$

Holding current

$V_D = 6 \text{ V}; R_{GK} = 1 \text{ k}\Omega; T_j = 25 \text{ }^\circ\text{C}$

$I_H < 5 \text{ mA}$

**Gate to cathode**

Voltage that will trigger all devices

$V_D = 6 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$

$V_{GT} > 0.8 \text{ V}$

Current that will trigger all devices

$V_D = 6 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$

$I_{GT} > 0.2 \text{ mA}$

**Switching characteristics**

Gate-controlled delay time when switched

$\text{from } V_D = V_{DRMmax} \text{ to } I_T = 1.5 \text{ A}; I_{GT} = 10 \text{ mA}; dI_G/dt = 0.1 \text{ A}/\mu\text{s}; T_j = 25 \text{ }^\circ\text{C}$

$t_d < 1.0 \mu\text{s}$

Circuit-commutated turn-off time when switched

$\text{from } I_T = 0.5 \text{ A to } V_R > 35 \text{ V with } -dI_T/dt = 110 \text{ A}/\mu\text{s}; dV_D/dt = 50 \text{ V}/\mu\text{s}; T_j = 125 \text{ }^\circ\text{C}$

$t_q < 100 \mu\text{s}$

\*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

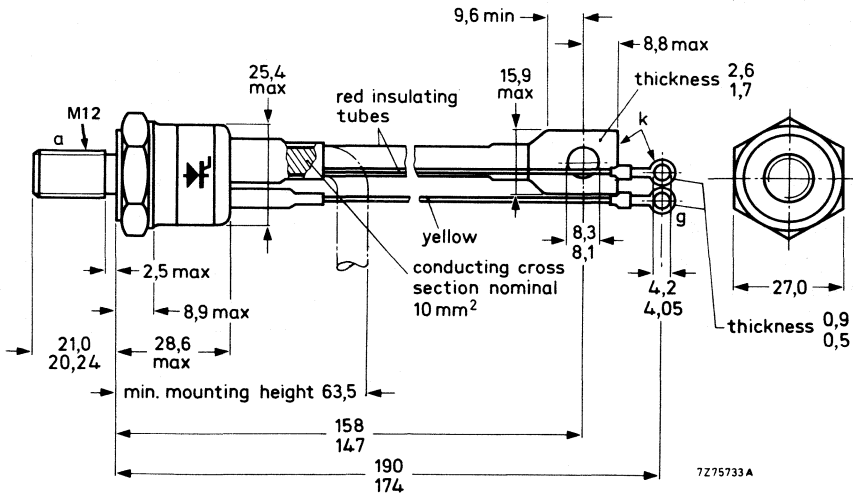
	BTW23-600R	800R	1000R	1200R	1400R	1600R
Repetitive peak voltages $V_{DRM} = V_{RRM}$	max. 600	800	1000	1200	1400	1600 V
Average on-state current				$I_{T(AV)}$	max. 90 A	
R.M.S. on-state current				$I_{T(RMS)}$	max. 140 A	
Non-repetitive peak on-state current				$I_{TSM}$	max. 2000 A	
Rate of rise of off-state voltage that will not trigger any device				$dV_D/dt$	< 200 V/ $\mu$ s	
On request (see Ordering Note)				$dV_D/dt$	< 1000 V/ $\mu$ s	

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-94: with metric M12 stud ( $\phi$  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 <sup>2</sup> s
Rate of rise of on-state current after triggering with $I_G = 750$ mA to $I_T = 300$ A; $dI_G/dt = 1$ A/ $\mu$ s				$dI_T/dt$	max.		300 A/ $\mu$ s

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

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

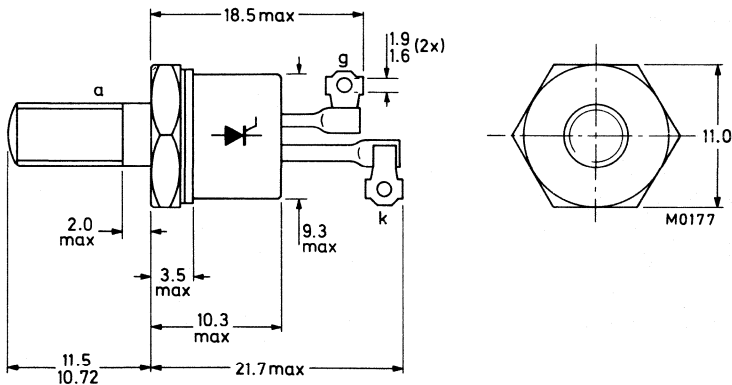
QUICK REFERENCE DATA

		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 ( $\phi 5$  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
$I^2 t$ for fusing ( $t = 10$ ms)	$I^2 t$	max.		112 A <sup>2</sup> s
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/ $\mu$ s	$dI_T/dt$	max.		50 A/ $\mu$ s
<b>Gate to cathode</b>				
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.		0.5 W
Peak power dissipation	$P_{GM}$	max.		5 W
<b>Temperatures</b>				
Storage temperature	$T_{stg}$		-55 to +125	°C
Junction temperature	$T_j$	max.		125 °C
<b>THERMAL RESISTANCE</b>				
From junction to mounting base	$R_{th j-mb}$	=		1.8 K/W
From mounting base to heatsink with heatsink compound	$R_{th mb-h}$	=		0.5 K/W
From junction to ambient in free air	$R_{th j-a}$	=		45 K/W
Transient thermal impedance ( $t = 1$ ms)	$Z_{th j-mb}$	=		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:  $R_{th j-a} < 4$  K/W (d.c. blocking) or  $< 8$  K/W (a.c.). For smaller heat-sinks  $T_{j max}$  should be derated. For a.c. see Fig.3.

**CHARACTERISTICS**

**Anode to cathode**

On-state voltage (measured under pulse conditions)

$I_T = 20 \text{ A}; T_j = 25 \text{ }^\circ\text{C}$

$V_T < 2 \text{ V}$

Rate of rise of off-state voltage that will not trigger any device; exponential method;

$V_D = 2/3 V_{DRMmax}; T_j = 125 \text{ }^\circ\text{C}$

$dV_D/dt < 200 \text{ V}/\mu\text{s}$

Reverse current

$V_R = V_{RWMmax}; T_j = 125 \text{ }^\circ\text{C}$

$I_R < 3 \text{ mA}$

Off-state current

$V_D = V_{DWMmax}; T_j = 125 \text{ }^\circ\text{C}$

$I_D < 3 \text{ mA}$

Latching current;  $T_j = 25 \text{ }^\circ\text{C}$

$I_L < 150 \text{ mA}$

Holding current;  $T_j = 25 \text{ }^\circ\text{C}$

$I_H < 75 \text{ mA}$

**Gate to cathode**

Voltage that will trigger all devices

$V_D = 6 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$

$V_{GT} > 1.5 \text{ V}$

Voltage that will not trigger any device

$V_D = V_{DRMmax}; T_j = 125 \text{ }^\circ\text{C}$

$V_{GD} < 200 \text{ mV}$

Current that will trigger all devices

$V_D = 6 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$

$I_{GT} > 50 \text{ mA}$

**Switching characteristics**

Gate-controlled turn-on time ( $t_{gt} = t_d + t_r$ ) when switched from  $V_D = V_{DRMmax}$  to  $I_T = 40 \text{ A}$ ;  $I_{GT} = 100 \text{ mA}$ ;  $dI_G/dt = 5 \text{ A}/\mu\text{s}$ ;  $T_j = 25 \text{ }^\circ\text{C}$

$t_{gt} \text{ typ. } 2 \text{ } \mu\text{s}$

Circuit-commutated turn-off time when switched from  $I_T = 40 \text{ A}$  to  $V_R > 50 \text{ V}$  with  $-dI_T/dt = 10 \text{ A}/\mu\text{s}$ ;  $dV_D/dt = 50 \text{ V}/\mu\text{s}$ ;  $T_j = 115 \text{ }^\circ\text{C}$

$t_q \text{ typ. } 35 \text{ } \mu\text{s}$

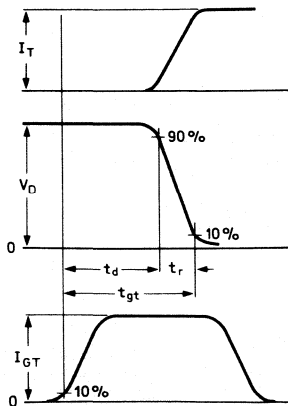


Fig.2a Gate-controlled turn-on time definition.

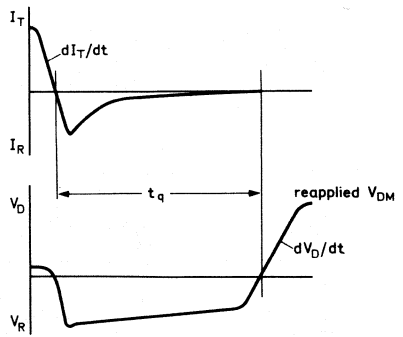


Fig.2b Circuit-commutated turn-off time definition.

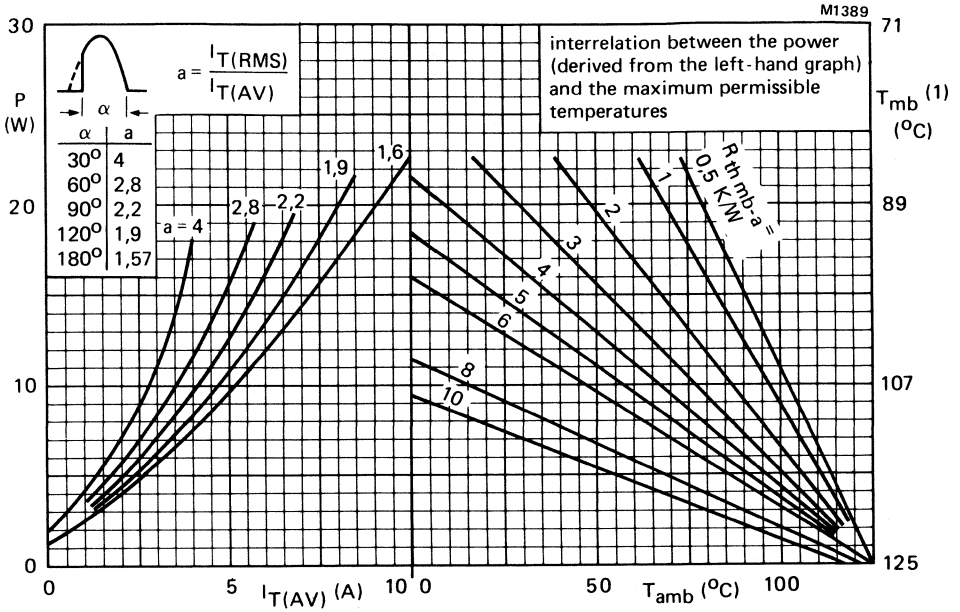


Fig. 3 (1)  $T_{mb}$ -scale is for comparison purposes only and is correct only for  $R_{th\ mb-a} \leq 6\ K/W$

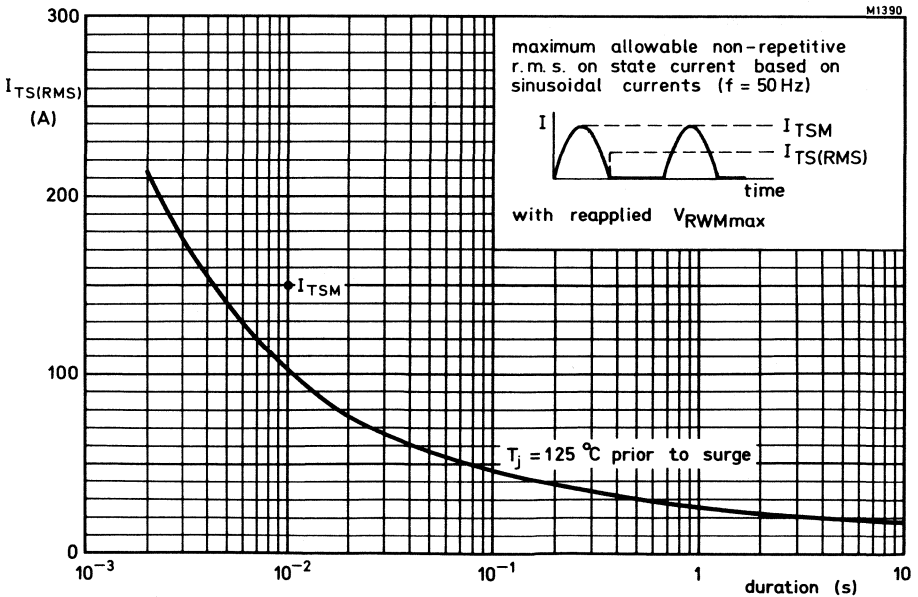


Fig. 4.



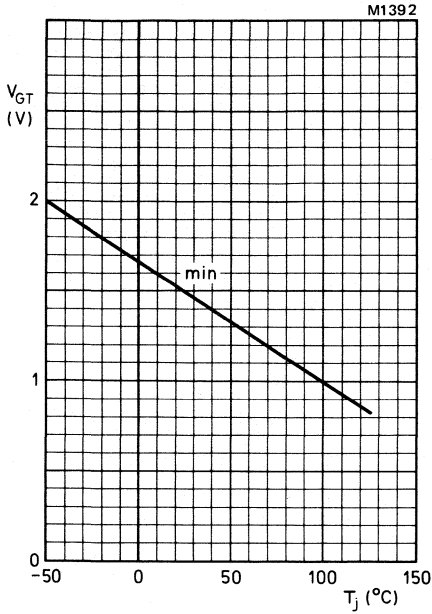


Fig. 5 Minimum gate voltage that will trigger all devices as a function of  $T_j$ .

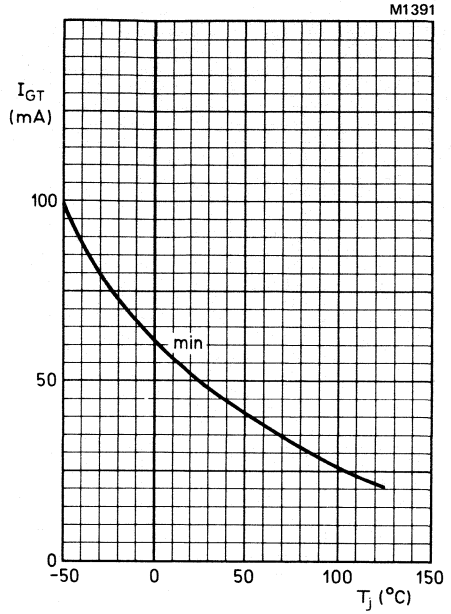


Fig. 6 Minimum gate current that will trigger all devices as a function of  $T_j$ .

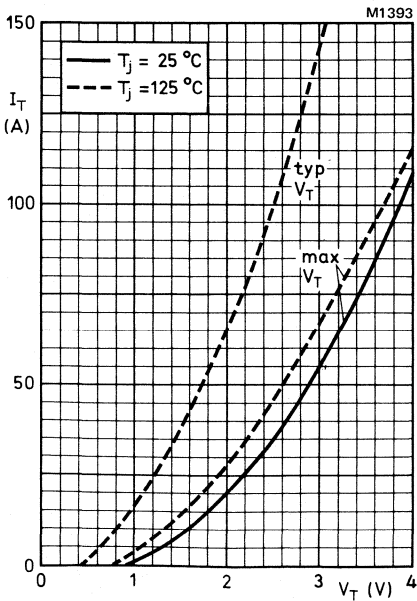


Fig. 7.

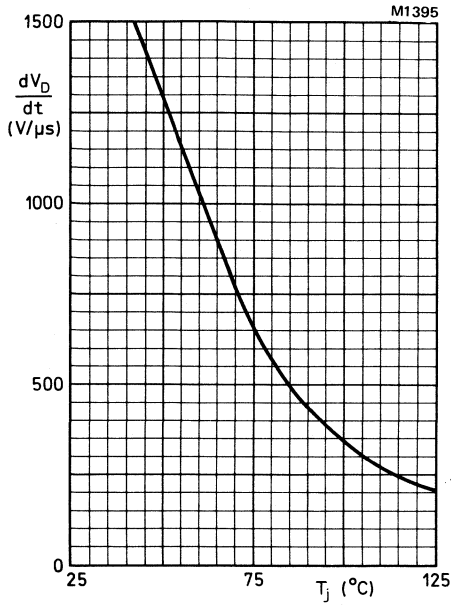


Fig. 8 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of  $T_j$ .

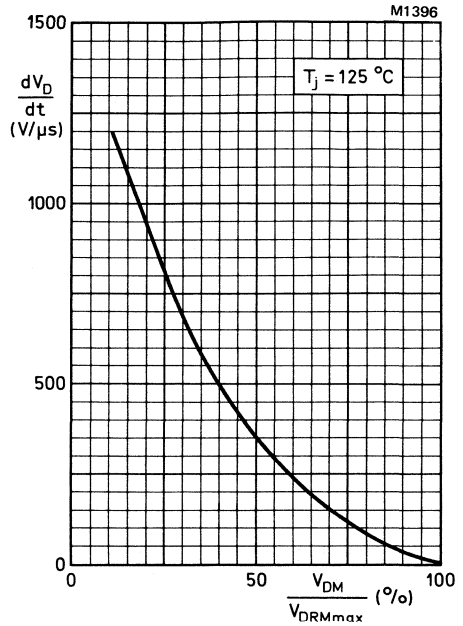


Fig. 9 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of applied voltage.

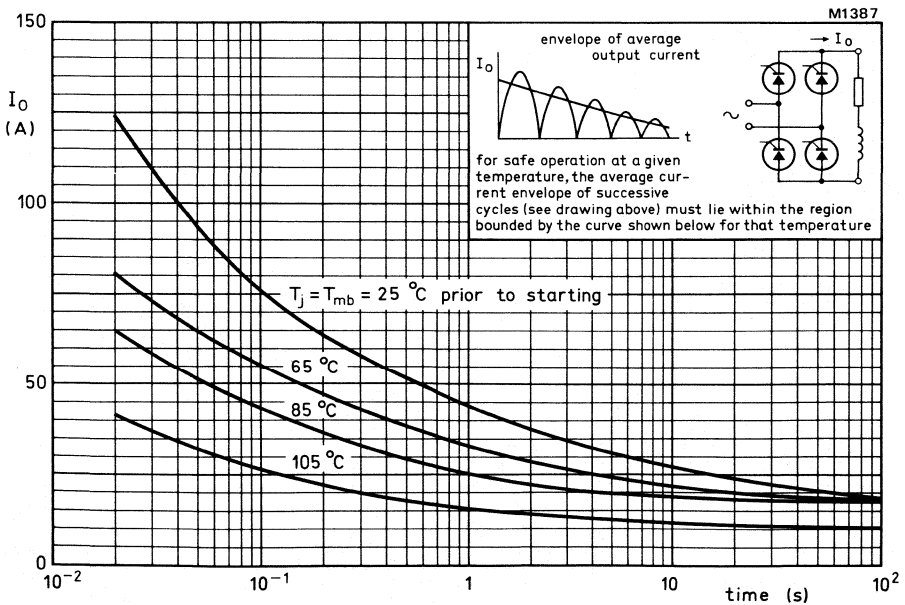
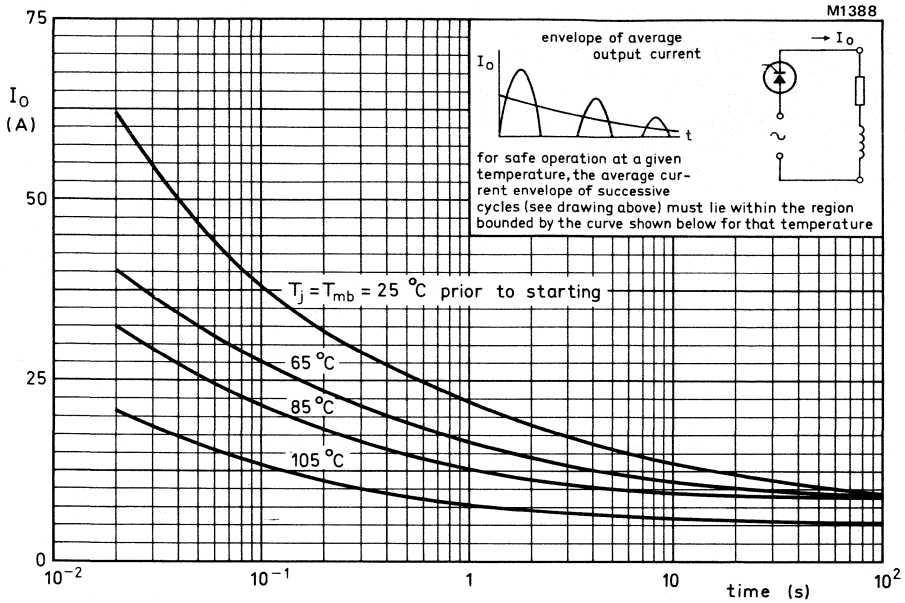


Fig. 10 Limits for starting or inrush currents.

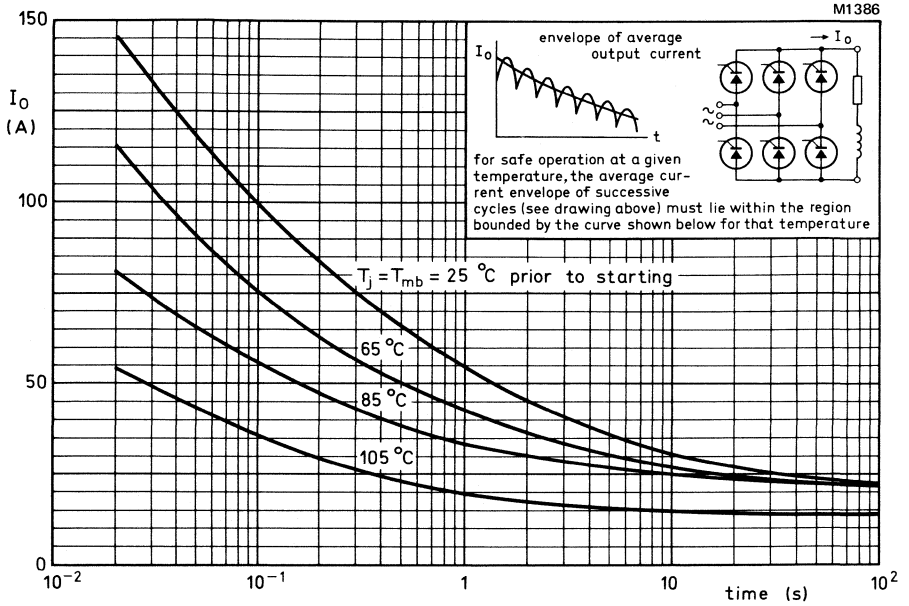


Fig. 11 Limits for starting or inrush currents.

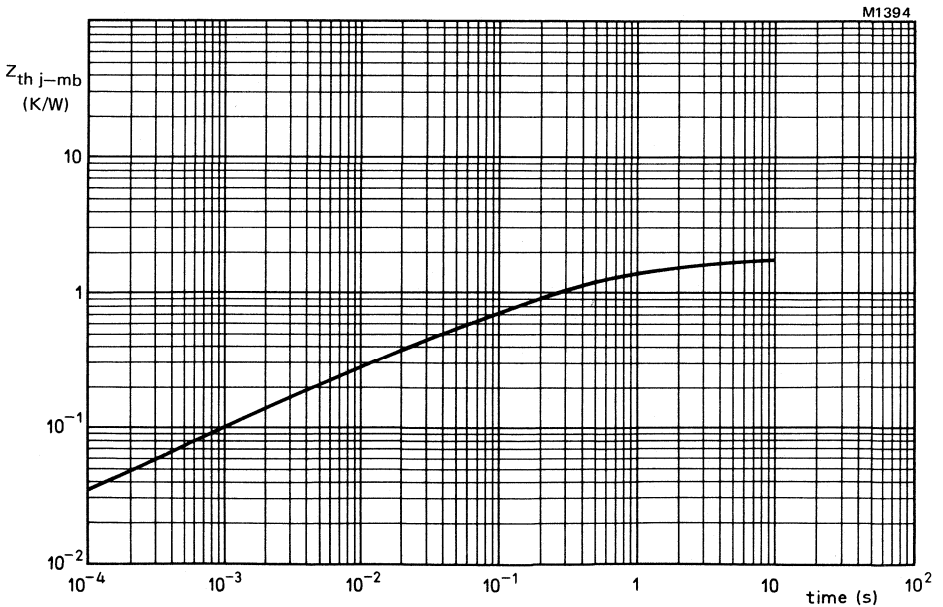


Fig. 12.

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 consists of reverse polarity types (anode to stud) identified by a suffix R: BTW40-400R to 800R.

QUICK REFERENCE DATA

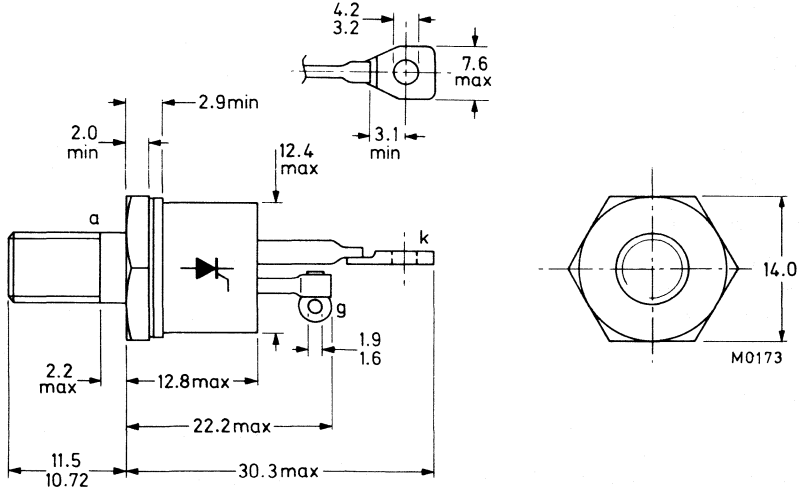
	$V_{DRM}/V_{RRM}$	BTW40-400R	600R	800R
		max.	400	600
Average on-state current	$I_T(AV)$	max.		20 A
R.M.S. on-state current	$I_T(RMS)$	max.		32 A
Non-repetitive peak on-state current	$I_{TSM}$	max.		400 A

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-48: with metric M6 stud ( $\phi$  6 mm); e.g. BTW40-400R.

Types with  $\frac{1}{4}$  in x 28 UNF stud ( $\phi$  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

$\frac{1}{4}$  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 ( $t \leq 10$ 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 <sup>2</sup> s
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/ $\mu$ s	$dI_T/dt$	max.	100	A/ $\mu$ s

### 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	$R_{th j-mb}$	=	1	°C/W
From mounting base to heatsink with heatsink compound	$R_{th mb-h}$	=	0,2	°C/W
Transient thermal impedance ( $t = 1$ ms)	$Z_{th j-mb}$	=	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:  $R_{th j-a} < 6,5$  °C/W (d.c. blocking) or  $< 13$  °C/W (a.c.). For smaller heatsinks  $T_{jmax}$  should be derated. For a.c. see Fig. 3.

**CHARACTERISTICS**

**Anode to cathode**

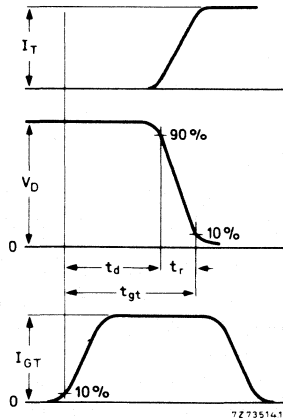
On-state voltage $I_T = 50 \text{ A}; T_j = 25 \text{ }^\circ\text{C}$	$V_T$	<	2,1 V *
Rate of rise of off-state voltage that will not trigger any device; exponential method; $V_D = 2/3 V_{DRMmax}$ ; $T_j = 125 \text{ }^\circ\text{C}$	$dV_D/dt$	<	100 V/ $\mu$ s
Reverse current $V_R = V_{RWMmax}; T_j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

**Gate to cathode**

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

**Switching characteristics**

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



Gate-controlled turn-on time definition

\*Measured under pulse conditions to avoid excessive dissipation.

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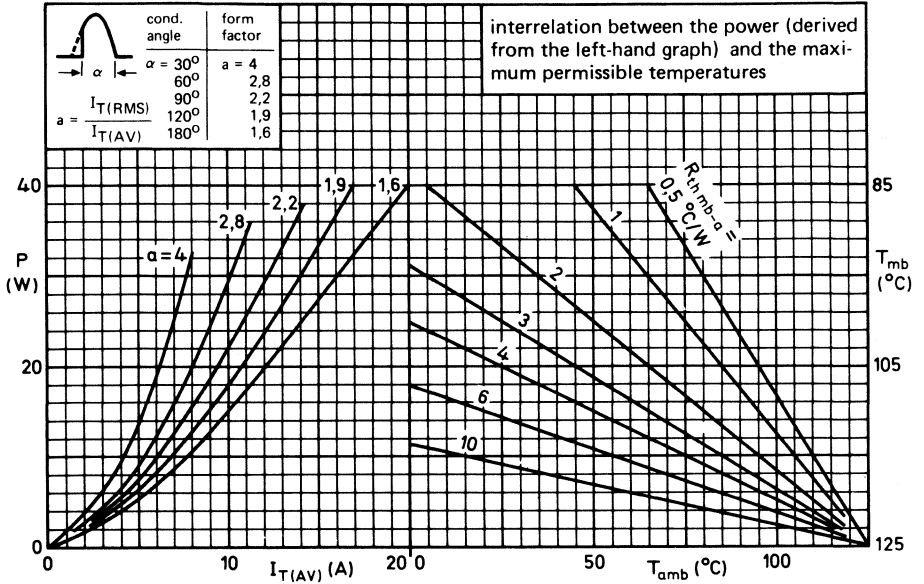


Fig. 2.

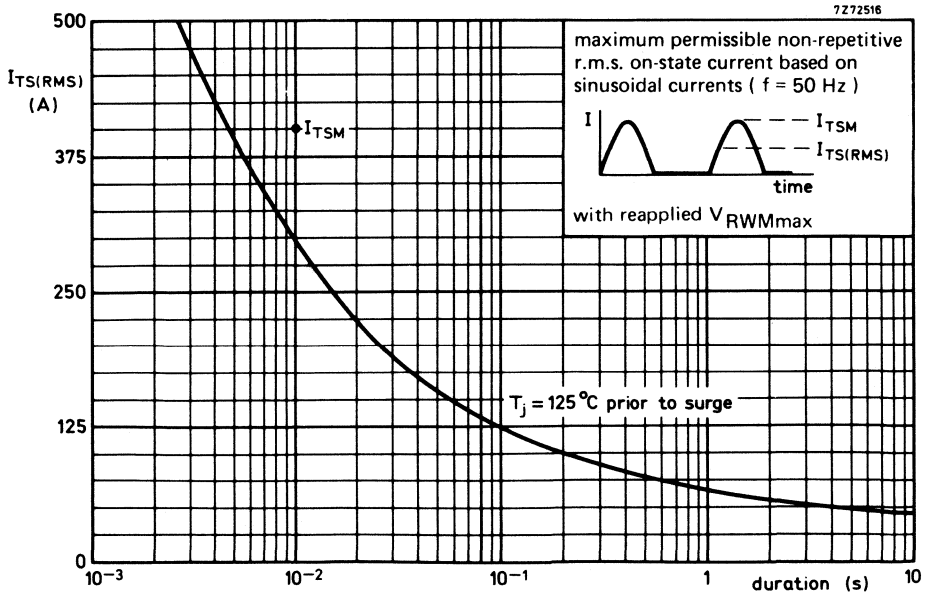


Fig. 3.



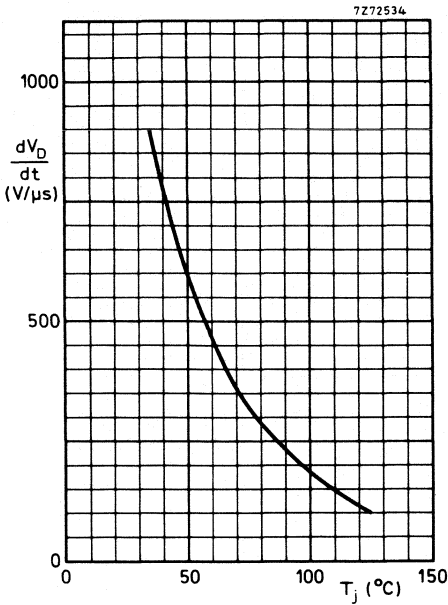


Fig. 4 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of  $T_j$ .

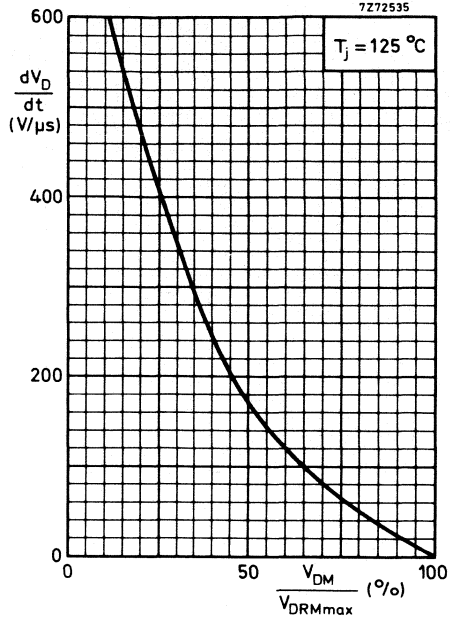


Fig. 5 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of applied voltage.

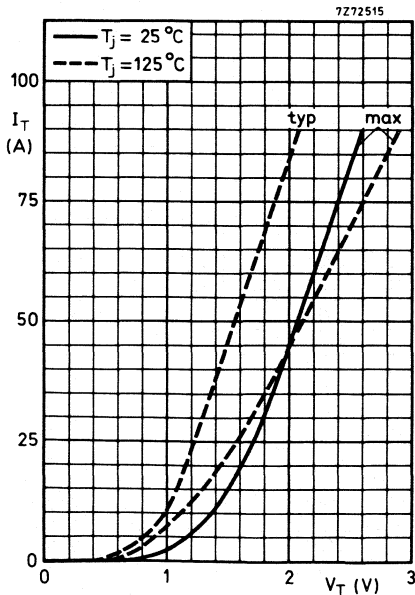


Fig. 6.

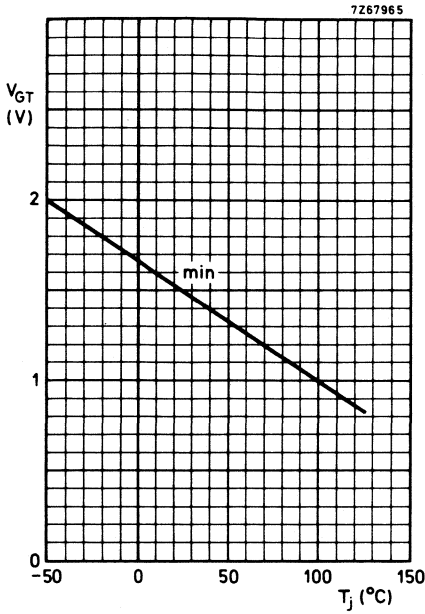


Fig. 7 Minimum gate voltage that will trigger all devices as a function of  $T_j$ .

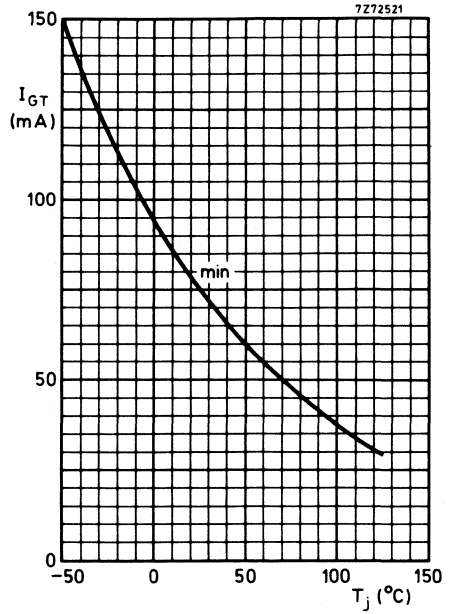


Fig. 8 Minimum gate current that will trigger all devices as a function of  $T_j$ .

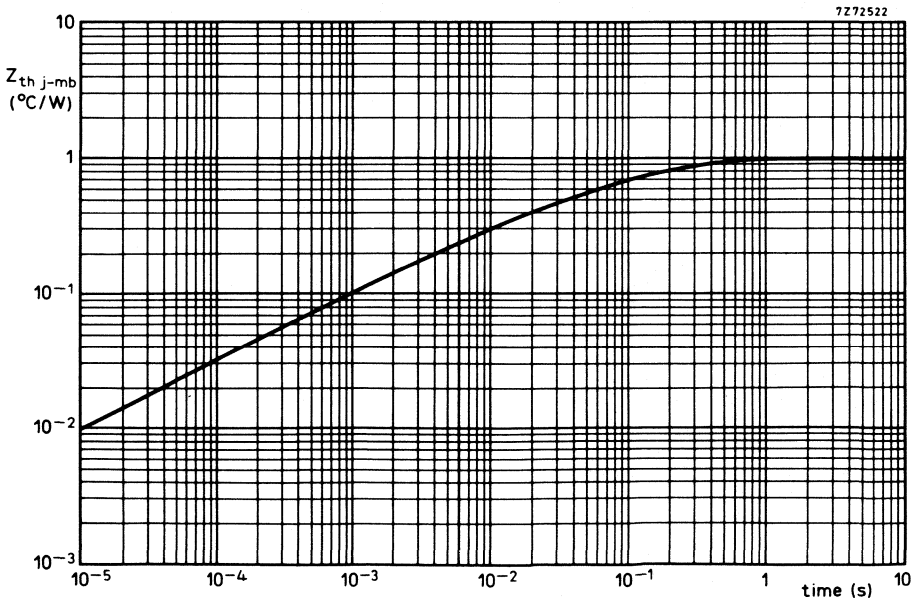


Fig. 9.

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.

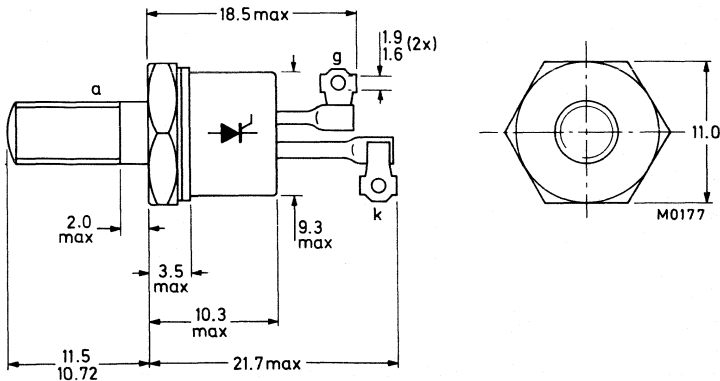
QUICK REFERENCE DATA

		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/ $\mu$ s
On request (see Ordering Note)	$dV_D/dt$	<	1000				V/ $\mu$ s

MECHANICAL DATA

Dimensions in mm

Fig.1 TO-64: with metric M5 stud ( $\phi 5$  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 <sup>2</sup> s
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/ $\mu$ s	$dI_T/dt$	max.		50 A/ $\mu$ s

### 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	$R_{th j-mb}$	=	1,8 K/W
From mounting base to heatsink with heatsink compound	$R_{th mb-h}$	=	0,5 K/W
From junction to ambient in free air	$R_{th j-a}$	=	45 K/W
Transient thermal impedance ( $t = 1$ ms)	$Z_{th j-mb}$	=	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/ $\mu$ s are available on request. Add suffix C to the type number when ordering; e.g. BTW42-600RC.

\*To ensure thermal stability:  $R_{th j-a} < 4$  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)

$I_T = 20 \text{ A}; T_j = 25 \text{ }^\circ\text{C}$

$V_T < 2 \text{ V}$

Rate of rise of off-state voltage that will not trigger any device; exponential method;

$V_D = 2/3 V_{DRMmax}; T_j = 125 \text{ }^\circ\text{C}$

$dV_D/dt < 500 \text{ V}/\mu\text{s}$

Reverse current

$V_R = V_{RWMmax}; T_j = 125 \text{ }^\circ\text{C}$

$I_R < 3 \text{ mA}$

Off-state current

$V_D = V_{DWMmax}; T_j = 125 \text{ }^\circ\text{C}$

$I_D < 3 \text{ mA}$

Latching current;  $T_j = 25 \text{ }^\circ\text{C}$

$I_L < 150 \text{ mA}$

Holding current;  $T_j = 25 \text{ }^\circ\text{C}$

$I_H < 75 \text{ mA}$

**Gate to cathode**

Voltage that will trigger all devices

$V_D = 6 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$

$V_{GT} > 1.5 \text{ V}$

Voltage that will not trigger any device

$V_D = V_{DRMmax}; T_j = 125 \text{ }^\circ\text{C}$

$V_{GD} < 200 \text{ mV}$

Current that will trigger all devices

$V_D = 6 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$

$I_{GT} > 50 \text{ mA}$

**Switching characteristics**

Gate-controlled turn-on time ( $t_{gt} = t_d + t_r$ ) when switched from  $V_D = V_{DRMmax}$  to  $I_T = 40 \text{ A}$ ;  
 $I_{GT} = 100 \text{ mA}; dI_G/dt = 5 \text{ A}/\mu\text{s}; T_j = 25 \text{ }^\circ\text{C}$

$t_{gt}$  typ. 2  $\mu\text{s}$

Circuit-commutated turn-off time when switched from  $I_T = 40 \text{ A}$  to  $V_R > 50 \text{ V}$  with  
 $-dI_T/dt = 10 \text{ A}/\mu\text{s}; dV_D/dt = 50 \text{ V}/\mu\text{s}; T_j = 115 \text{ }^\circ\text{C}$

$t_q$  typ. 35  $\mu\text{s}$

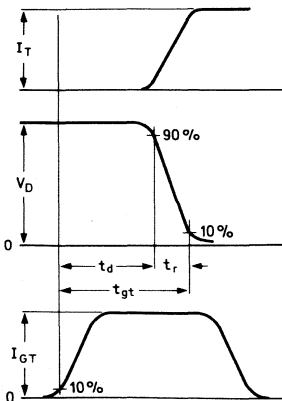


Fig. 2a Gate-controlled turn-on time definition.

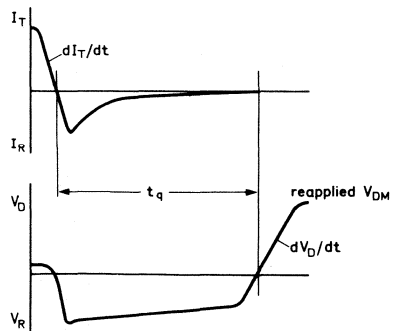


Fig. 2b Circuit-commutated turn-off time definition.

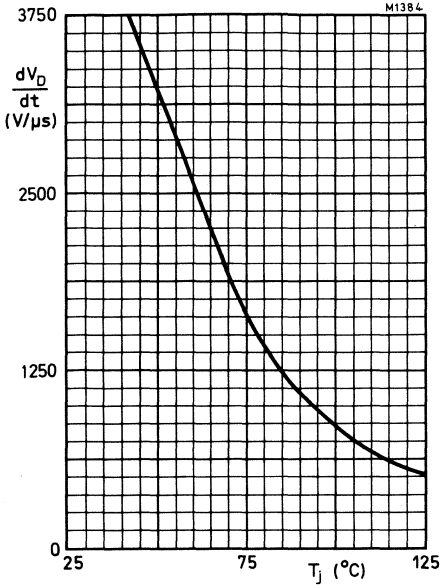


Fig.3 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of  $T_j$ .

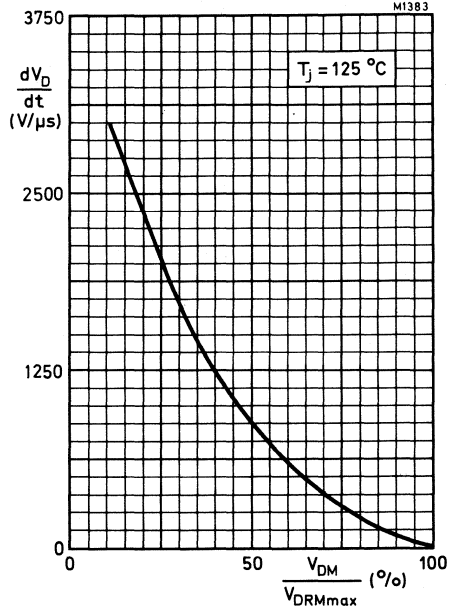


Fig.4 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of applied voltage.

FOR FURTHER DETAILS REFER TO BTW38 DATA.

THYRISTORS



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

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

QUICK REFERENCE DATA

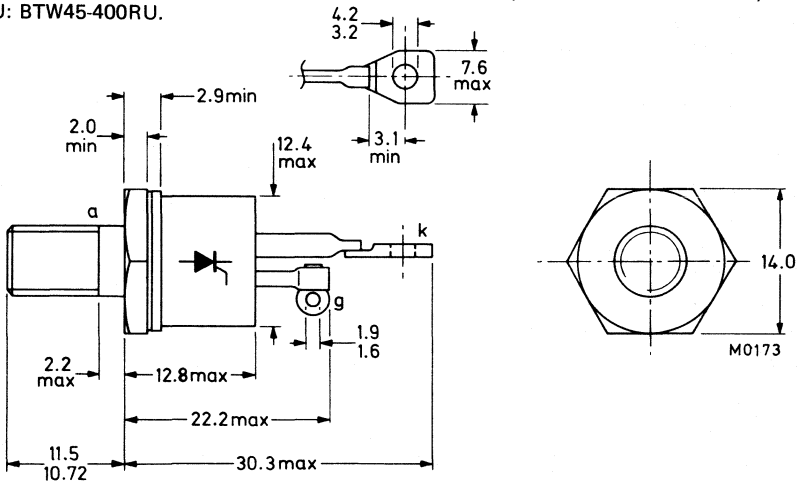
	BTW45-400R	600R	800R	1000R	1200R
Repetitive peak voltages $V_{DRM} = V_{RRM}$	max. 400	600	800	1000	1200 V
Average on-state current			$I_T(AV)$	max. 16	A
R.M.S. on-state current			$I_T(RMS)$	max. 25	A
Non-repetitive peak on-state current			$I_{TSM}$	max. 300	A
Rate of rise of off-state voltage that will not trigger any device			$dV_D/dt$	< 200	V/ $\mu s$
On request (see Ordering Note)			$dV_D/dt$	< 1000	V/ $\mu s$

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-48: with metric M6 stud ( $\phi$  6 mm); e.g. BTW45-400R.

Types with  $\frac{1}{4}$  in x 28 UNF stud ( $\phi$  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  
 $\frac{1}{4}$  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 ( $t \leq 10$ 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
$I^2 t$ for fusing ( $t = 10$ ms)				$I^2 t$	max.	450 A <sup>2</sup> s
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/ $\mu$ s				$dI_T/dt$	max.	100 A/ $\mu$ s

**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	$R_{th j-mb}$	=	1,33 °C/W
From mounting base to heatsink; with heatsink compound	$R_{th mb-h}$	=	0,2 °C/W
Transient thermal impedance ( $t = 1$ ms)	$Z_{th j-mb}$	=	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:  $R_{th j-a} < 6,5$  °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

$$I_T = 50 \text{ A}; T_j = 25 \text{ }^\circ\text{C}$$

$$V_T < 2 \text{ V}^*$$

Rate of rise of off-state voltage that will not trigger

any device; exponential method;  $V_D = 2/3 V_{DRM \text{ max}}$ ;

$$T_j = 125 \text{ }^\circ\text{C}$$

$$dV_D/dt < 200 \text{ V}/\mu\text{s}$$

Reverse current

$$V_R = V_{RWM \text{ max}}; T_j = 125 \text{ }^\circ\text{C}$$

$$I_R < 3 \text{ mA}$$

Off-state current

$$V_D = V_{DWM \text{ max}}; T_j = 125 \text{ }^\circ\text{C}$$

$$I_D < 3 \text{ mA}$$

Latching current;  $T_j = 25 \text{ }^\circ\text{C}$

$$I_L < 150 \text{ mA}$$

Holding current;  $T_j = 25 \text{ }^\circ\text{C}$

$$I_H < 75 \text{ mA}$$

**Gate to cathode**

Voltage that will trigger all devices

$$V_D = 6 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$$

$$V_{GT} > 1,5 \text{ V}$$

Voltage that will not trigger any device

$$V_D = V_{DRM \text{ max}}; T_j = 125 \text{ }^\circ\text{C}$$

$$V_{GD} < 200 \text{ mV}$$

Current that will trigger all devices

$$V_D = 6 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$$

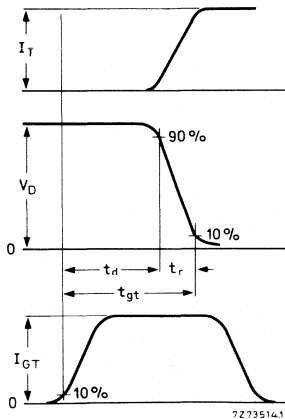
$$I_{GT} > 75 \text{ mA}$$

**Switching characteristics**

Gate-controlled turn-on time ( $t_{gt} = t_d + t_r$ ) when switched from  $V_D = V_{DWM \text{ max}}$  to  $I_T = 100 \text{ A}$ ;  
 $I_{GT} = 400 \text{ mA}$ ;  $dI_G/dt = 1 \text{ A}/\mu\text{s}$ ;  $T_j = 25 \text{ }^\circ\text{C}$

$$t_{gt} < 1 \mu\text{s}$$

$$t_r < 0,5 \mu\text{s}$$



Gate-controlled turn-on time definition.

**ORDERING NOTE**

Types with  $dV_D/dt$  of  $1000 \text{ V}/\mu\text{s}$  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.

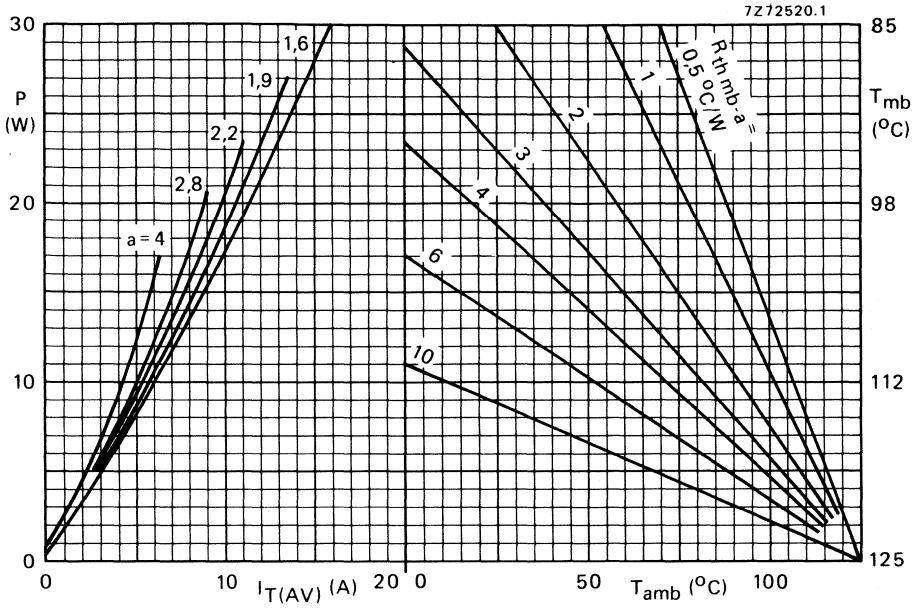


Fig. 2.

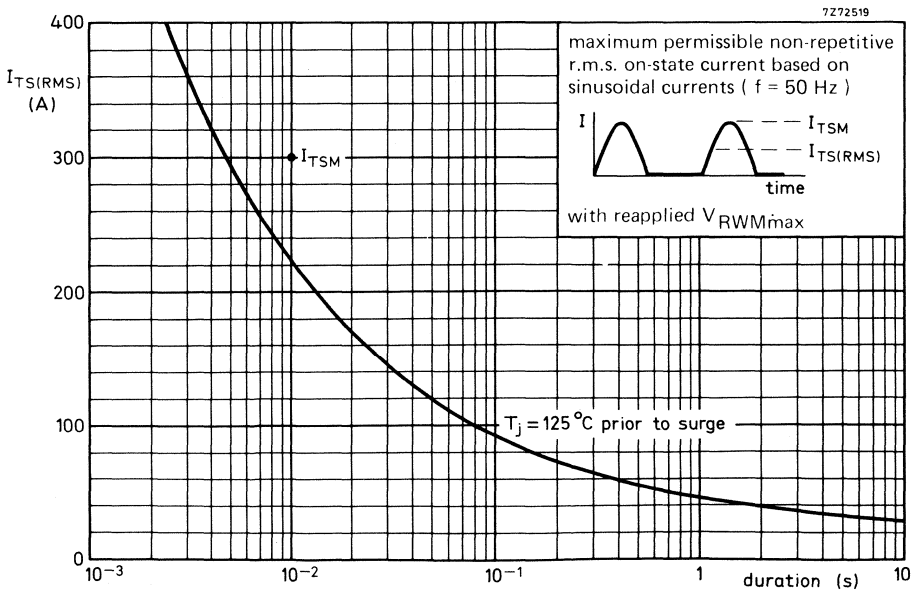


Fig. 3.

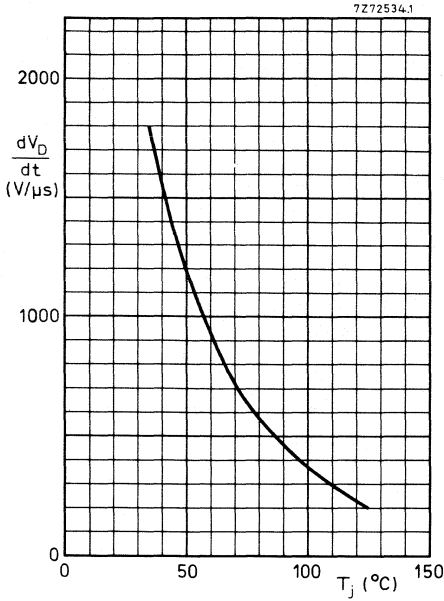


Fig. 4 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of  $T_j$ .

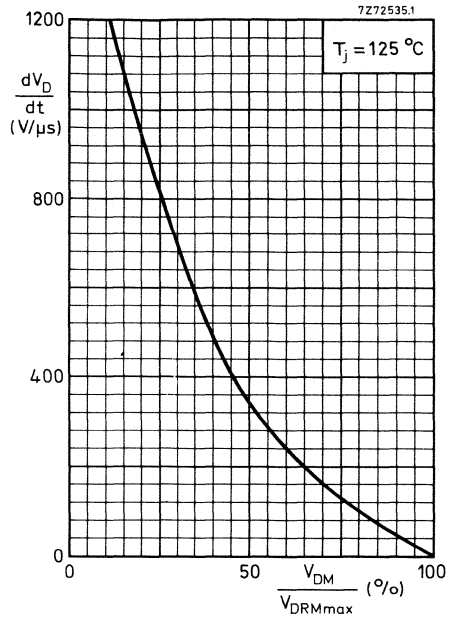


Fig. 5 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of applied voltage.

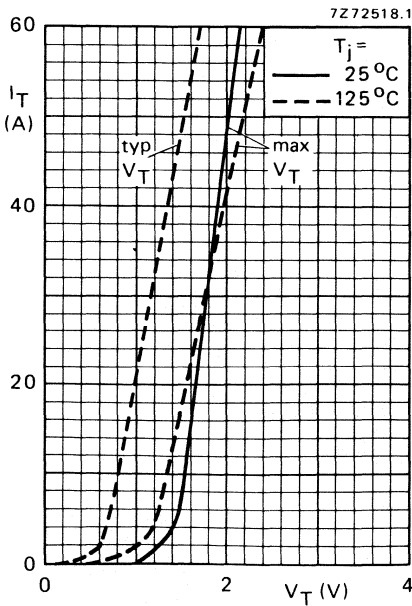


Fig. 6.

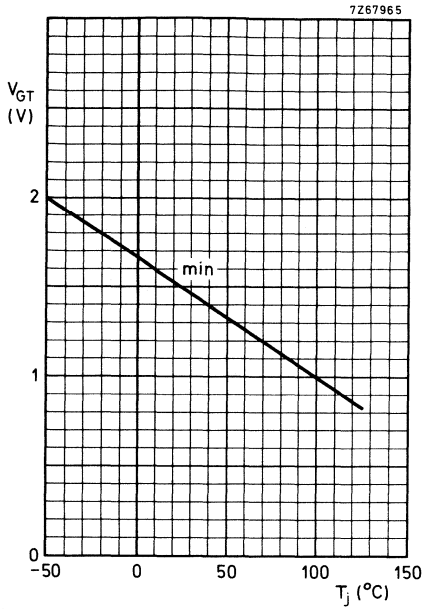


Fig. 7 Minimum gate voltage that will trigger all devices as a function of  $T_j$ .

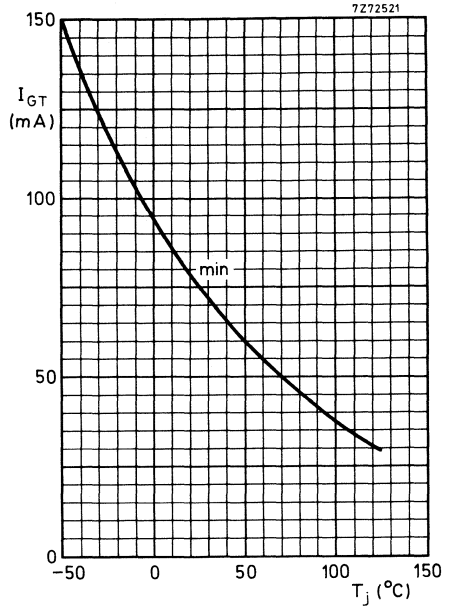


Fig. 8 Minimum gate current that will trigger all devices as a function of  $T_j$ .

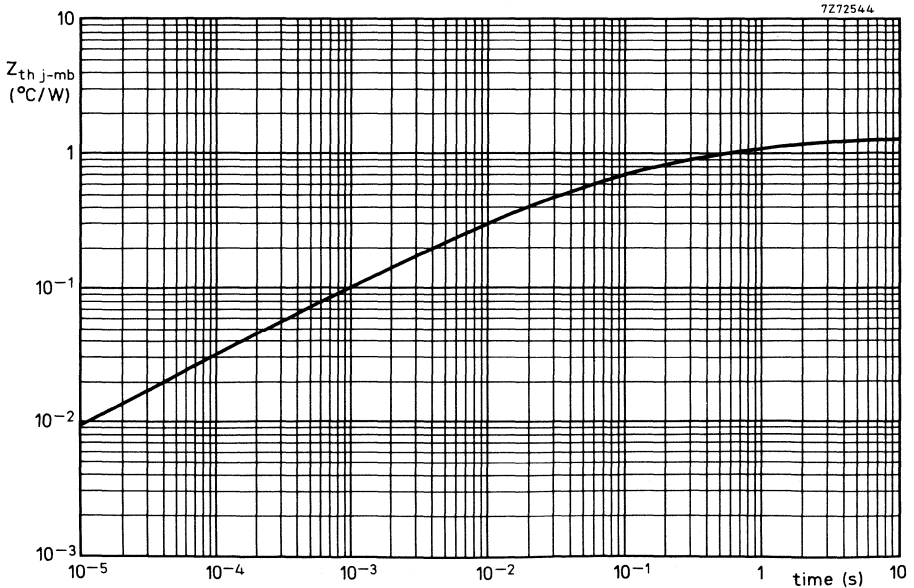


Fig. 9.

## 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.

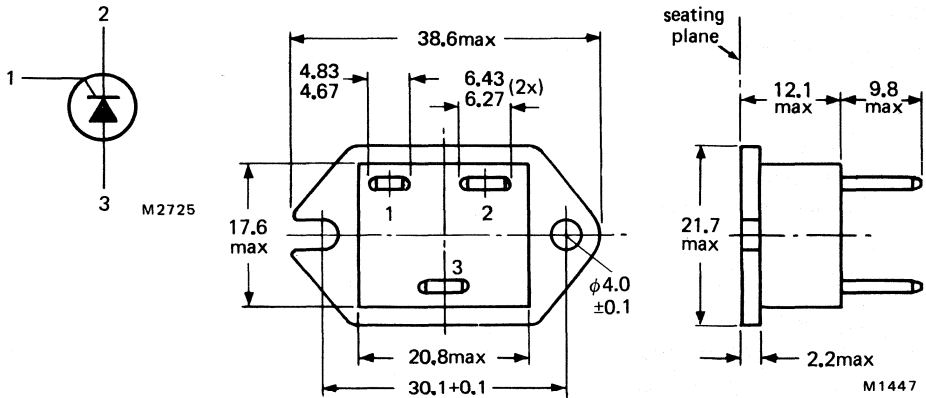
### QUICK REFERENCE DATA

		BTW62-600R			800R	1000R	
		max.	600	800	1000	V	
Repetitive peak off-state voltage	$V_{DRM}$						
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			$\mu s$
	suffix N	$t_q$	<	6			$\mu s$

### 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).

		BTW62-600R			800R	1000R	
		max.	800	1000	1000		
<b>Anode to cathode</b>							
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 $T_{mb} = 85^\circ C$		$I_T(AV)$	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 $T_j = 125^\circ C$ prior to surge; $t = 10 ms$ ; half sine-wave		$I_{TSM}$	max.	200		A	
$I^2 t$ for fusing; $t = 10 ms$		$I^2 t$	max.	200		$A^2 s$	
Rate of rise of on-state current after triggering with $I_G = 1.25 A$ ; $I_T = 80 A$		$dI_T/dt$	max.	1000		$A/\mu s$	
<b>Gate to cathode</b>							
Average power dissipation (averaged over any 20 ms period)		$P_G(AV)$	max.	1		W	
Peak power dissipation; $t = 10 \mu s$		$P_{GM}$	max.	10		W	
<b>Temperatures</b>							
Storage temperature		$T_{stg}$		-40 to +125		$^\circ C$	
Operating junction temperature		$T_j$	max.	125		$^\circ C$	
<b>ISOLATION*</b>							
R.M.S. isolation voltage		$V_{isol}$	min.	2500		V	
<b>THERMAL RESISTANCE</b>							
From junction to mounting base		$R_{th j-mb}$	=	1.1		$K/W$	
From mounting base to heatsink with heatsink compound		$R_{th mb-h}$	=	0.2		$K/W$	

\*From baseplate to all three terminals connected together.

**CHARACTERISTICS**

**Anode to cathode**

On-state voltage $I_T = 50 \text{ A}; T_j = 25 \text{ }^\circ\text{C}$	$V_T$	<	2.6	V*
Off-state current $V_D = V_{Dmax}; T_j = 125 \text{ }^\circ\text{C}$	$I_D$	<	6.0	mA
Holding current; $T_j = 25 \text{ }^\circ\text{C}$	$I_H$	<	400	mA

**Gate to cathode**

Voltage that will trigger all devices $V_D = 12 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$	$V_{GT}$	>	2.0	V
Current that will trigger all devices $V_D = 12 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$	$I_{GT}$	>	250	mA

**Switching characteristics (see Fig.2)**

Circuit commutated turn-off time  
 $dV_D/dt = 500 \text{ V}/\mu\text{s}$  (linear to  $V_{DRMmax}$ );  
 $R_{GK} = 10 \text{ } \Omega; V_G = 0; T_j = 125 \text{ }^\circ\text{C};$   
 when switched from  $I_T = 100 \text{ A}; t_p = 150 \text{ } \mu\text{s}$

$-dI_T/dt = 50 \text{ A}/\mu\text{s}$				
suffix K	$t_q$	<	6	$\mu\text{s}$
suffix N	$t_q$	<	9	$\mu\text{s}$
$-dI_T/dt = 10 \text{ A}/\mu\text{s}$				
suffix K	$t_q$	<	4	$\mu\text{s}$
suffix N	$t_q$	<	6	$\mu\text{s}$

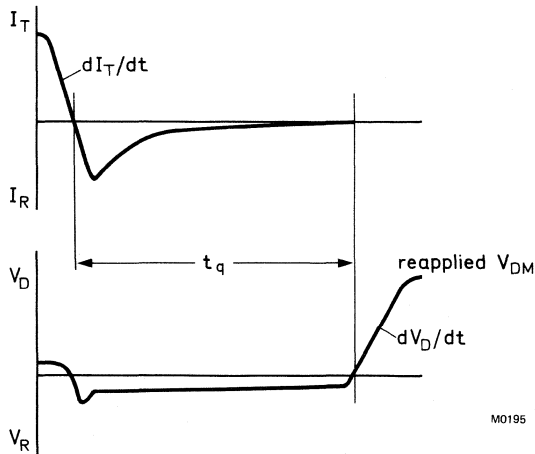


Fig.2 Circuit-commutated turn-off time definition.

\*Measured under pulse conditions to avoid excessive dissipation.

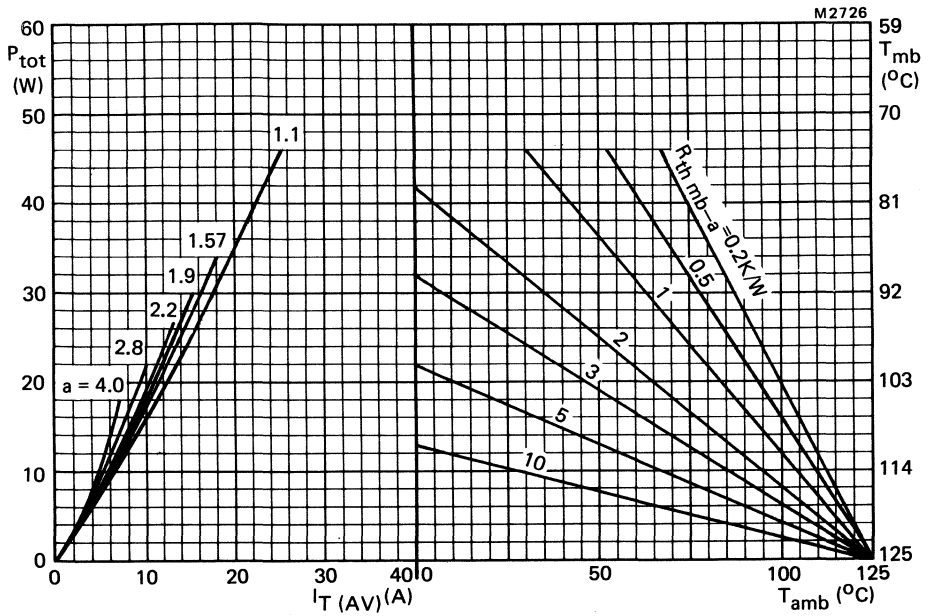


Fig.3 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

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



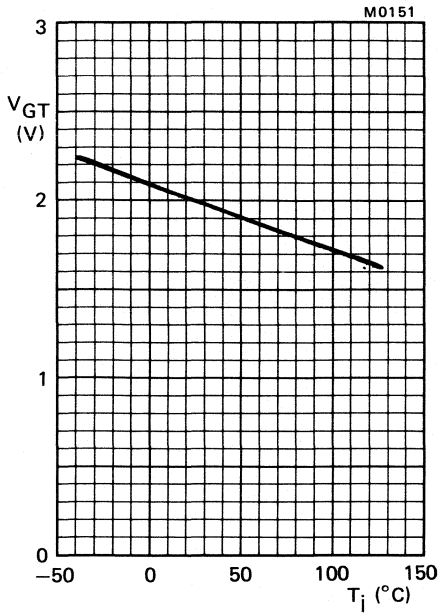


Fig.4 Minimum gate voltage that will trigger all devices plotted against junction temperature.

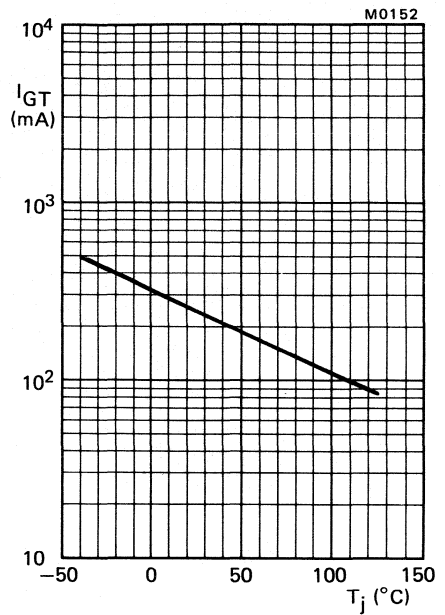


Fig.5 Minimum gate current that will trigger all devices plotted against junction temperature.

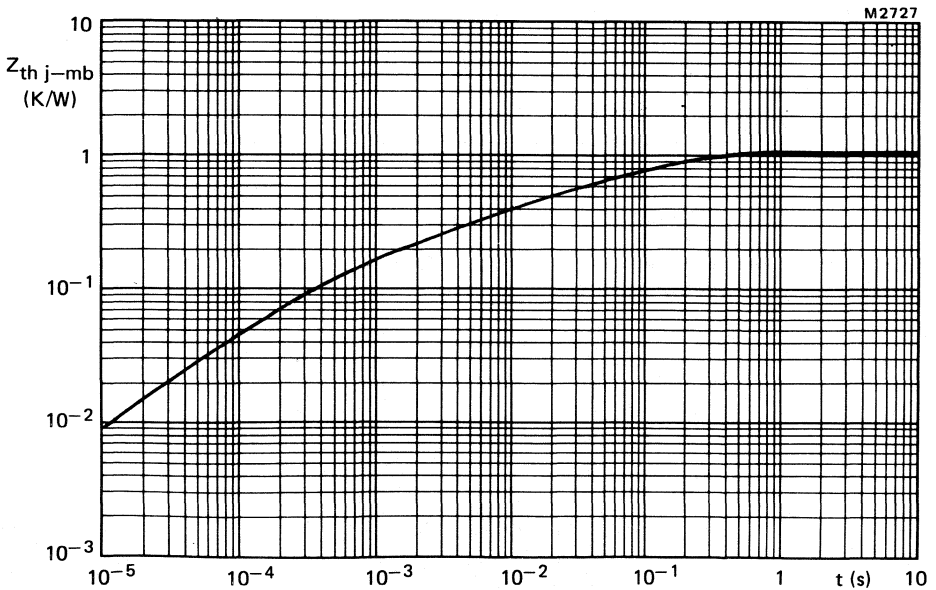


Fig.6 Transient thermal impedance.

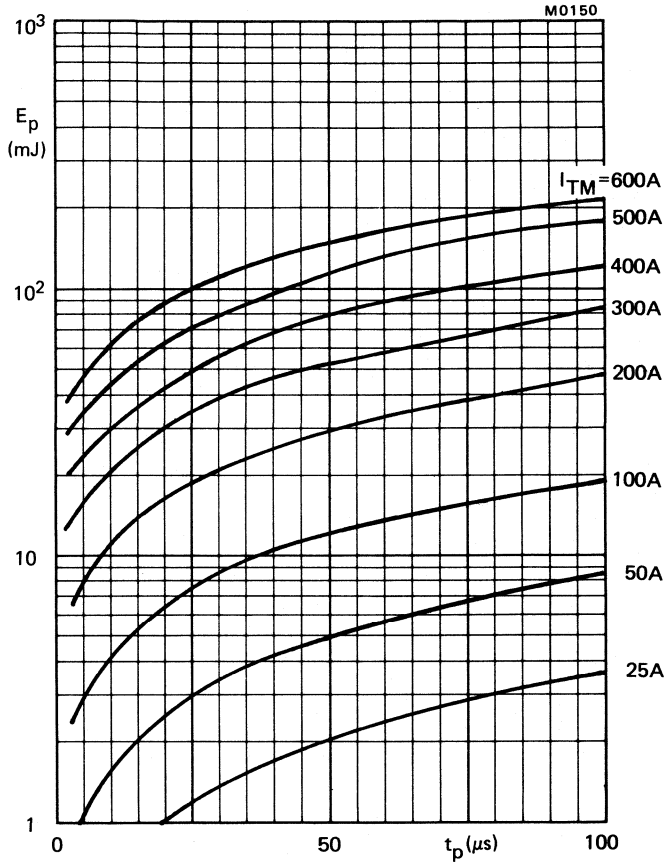


Fig.7 Maximum total energy loss per pulse when switching a half-sinusoidal pulse from 600 V.  
 Device power (W) = Energy per pulse (J) x No. of pulses per second.  
 For pulse widths > 100  $\mu s$  use Fig.3.

Fig.8 ———  $T_j = 25^\circ\text{C}$ ; - - -  $T_j = 125^\circ\text{C}$ ;  
 $t_p = 200 \mu\text{s}$ .

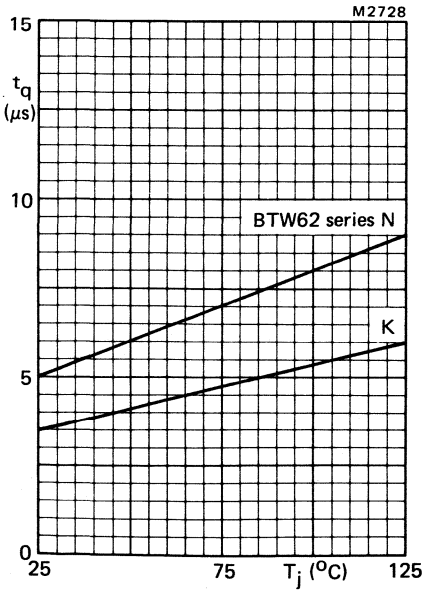
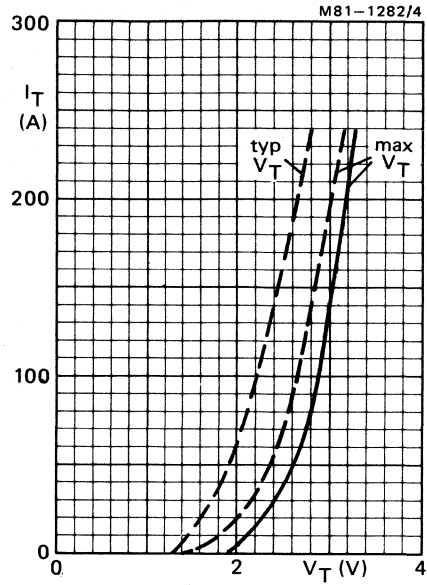


Fig.9 Variation of  $t_q$  with  $T_j$ ;  
 $-di_T/dt = 50 \text{ A}/\mu\text{s}$ ;  $dV_D/dt = 500 \text{ V}/\mu\text{s}$   
 (linear to  $V_{DRMmax}$ );  $I_T = 100 \text{ A}$ ;  $t_p = 150 \mu\text{s}$ ;  
 $R_{GK} = 10 \Omega$ ;  $V_G = 0$ ; maximum values.

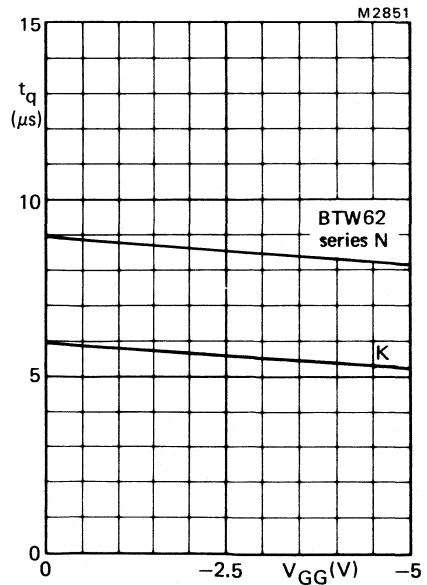


Fig.10 Variation of  $t_q$  with negative bias;  
 $-di_T/dt = 50 \text{ A}/\mu\text{s}$ ;  $dV_D/dt = 500 \text{ V}/\mu\text{s}$   
 (linear to  $V_{DRMmax}$ );  $I_T = 100 \text{ A}$ ;  $t_p = 150 \mu\text{s}$ ;  
 $T_j = 125^\circ\text{C}$ ; maximum values.



## 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.

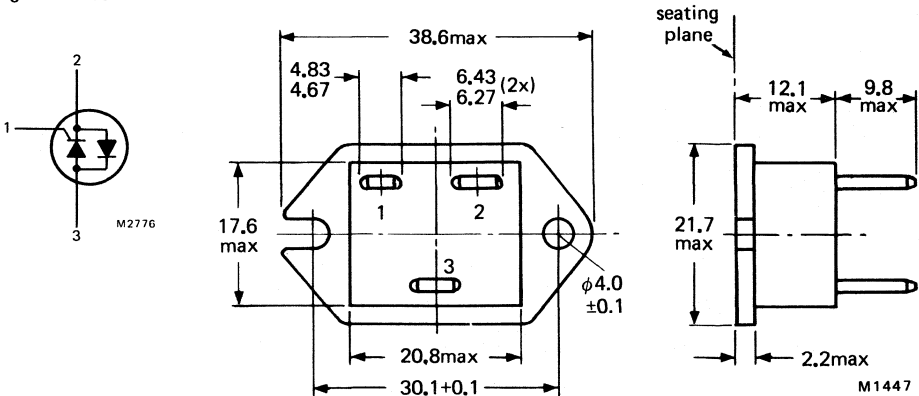
### QUICK REFERENCE DATA

Thyristor		BTW62D-600R			800R	1000R	
		max.	600	800	1000		
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		$\mu s$	
suffix N	$t_q$	<		6		$\mu s$	
<b>Diode</b>							
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 $T_{mb} = 85^\circ\text{C}$ )					
R.M.S. on-state current	$I_T(AV)$	max.	18		A
Repetitive peak on-state current; $t_p = 50 \mu\text{s}; \delta = 0.05$	$I_T(RMS)$	max.	28		A
Non-repetitive peak on-state current $T_j = 125^\circ\text{C}$ prior to surge; $t = 10 \text{ ms}$ ; half sine-wave	$I_{TRM}$	max.	175		A
$I^2 t$ for fusing; $t = 10 \text{ ms}$	$I_{TSM}$	max.	200		A
Rate of rise of on-state current after triggering with $I_G = 1.25 \text{ A}; I_T = 80 \text{ A}$	$I^2 t$	max.	200		$\text{A}^2 \text{ s}$
	$di_T/dt$	max.	1000		$\text{A}/\mu\text{s}$
<b>Gate to cathode</b>					
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	1		W
Peak power dissipation; $t = 10 \mu\text{s}$	$P_{GM}$	max.	10		W
<b>DIODE</b>					
Average forward current (averaged over any 20 ms period) up to $T_{mb} = 85^\circ\text{C}$	$I_F(AV)$	max.	8		A
Non-repetitive peak on-state current $t = 10 \text{ ms}$ ; half sine-wave $T_j = 125^\circ\text{C}$ prior to surge	$I_{FSM}$	max.	60		A
<b>Temperatures</b>					
Storage temperature	$T_{stg}$		-40 to +125		$^\circ\text{C}$
Operating junction temperature	$T_j$	max.	125		$^\circ\text{C}$
<b>ISOLATION*</b>					
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	$R_{th\ j-mb}$	=	1.1	K/W
From mounting base to heatsink, with heatsink compound	$R_{th\ mb-h}$	=	0.2	K/W

**Diode**

From junction to mounting base	$R_{th\ j-mb}$	=	2.8	K/W
From mounting base to heatsink, with heatsink compound	$R_{th\ mb-h}$	=	0.2	K/W

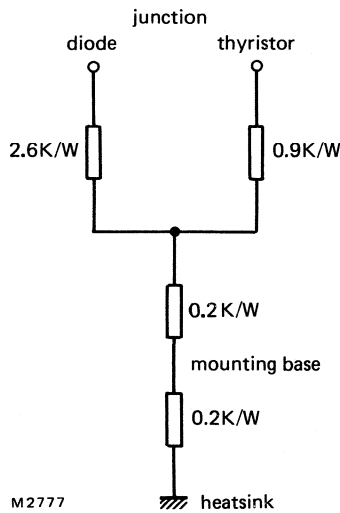


Fig.2 Equivalent thermal network.

**THYRISTOR CHARACTERISTICS**

**Anode to cathode**

On-state voltage

$$I_T = 50 \text{ A}; T_j = 25 \text{ }^\circ\text{C} \quad V_T < 2.6 \text{ V}^*$$

Off-state current

$$V_D = V_{Dmax}; T_j = 125 \text{ }^\circ\text{C} \quad I_D < 6.0 \text{ mA}$$

Holding current;  $T_j = 25 \text{ }^\circ\text{C}$

$$I_H < 400 \text{ mA}$$

**Gate to cathode**

Voltage that will trigger all devices

$$V_D = 12 \text{ V}; T_j = 25 \text{ }^\circ\text{C} \quad V_{GT} > 2.0 \text{ V}$$

Current that will trigger all devices

$$V_D = 12 \text{ V}; T_j = 25 \text{ }^\circ\text{C} \quad I_{GT} > 250 \text{ mA}$$

**Switching characteristics (see Fig.6)**

Circuit-commutated turn-off time

$$dV_D/dt = 500 \text{ V}/\mu\text{s} \text{ (linear to } V_{DRMmax}\text{);}$$

$$R_{GK} = 10 \text{ } \Omega; V_G = 0; T_j = 125 \text{ }^\circ\text{C};$$

$$\text{when switched from } I_T = 100 \text{ A}; t_p = 150 \text{ } \mu\text{s}$$

$$-dI_T/dt = 50 \text{ A}/\mu\text{s}$$

suffix K  $t_q < 6 \text{ } \mu\text{s}$

suffix N  $t_q < 9 \text{ } \mu\text{s}$

$$-dI_T/dt = 10 \text{ A}/\mu\text{s}$$

suffix K  $t_q < 4 \text{ } \mu\text{s}$

suffix N  $t_q < 6 \text{ } \mu\text{s}$

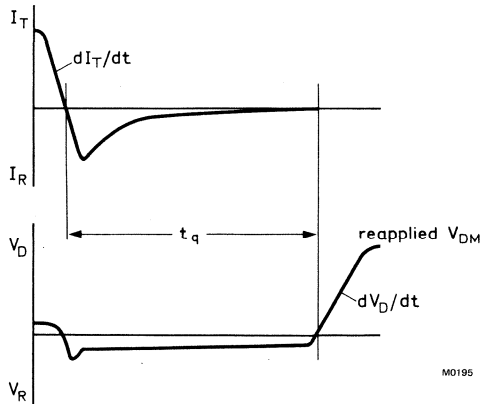


Fig.3 Circuit-commutated turn-off time definition.

\*Measured under pulse conditions to avoid excessive dissipation.



THYRISTOR

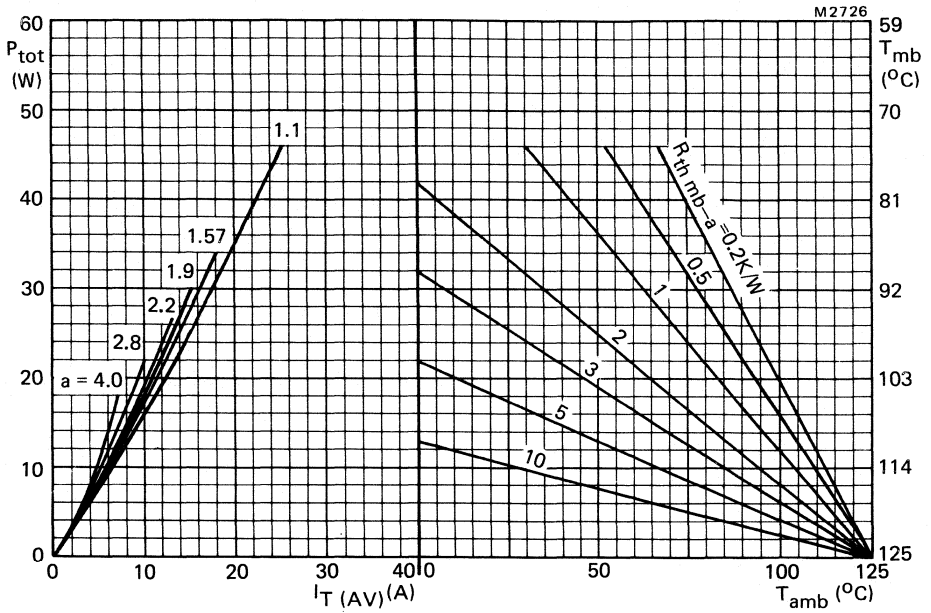


Fig.4 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

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

THYRISTOR

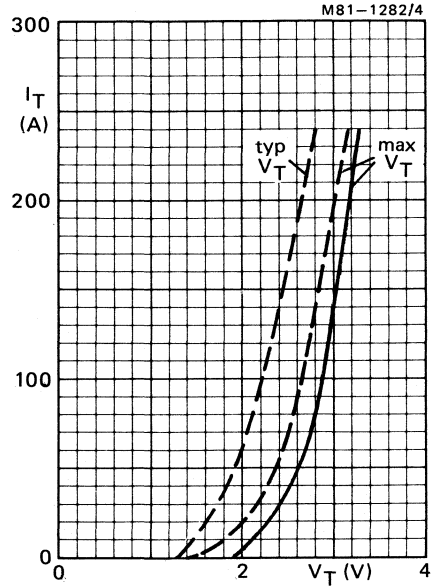


Fig.5 —  $T_j = 25\text{ }^\circ\text{C}$ ; ---  $T_j = 125\text{ }^\circ\text{C}$ ;  
 $t_p = 200\text{ }\mu\text{s}$ .

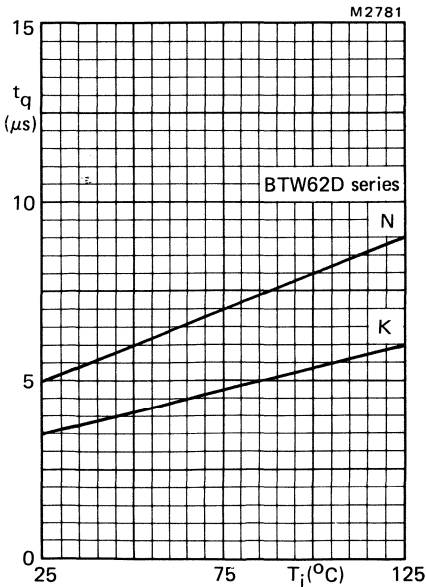


Fig.6a Variation of  $t_q$  with  $T_j$ ;  
 $-di_T/dt = 50\text{ A}/\mu\text{s}$ ;  $dV_D/dt = 500\text{ V}/\mu\text{s}$   
 (linear to  $V_{DRMmax}$ );  $I_T = 100\text{ A}$ ;  $t_p = 150\text{ }\mu\text{s}$ ;  
 $R_{GK} = 10\text{ }\Omega$ ;  $V_G = 0$ ; maximum values.

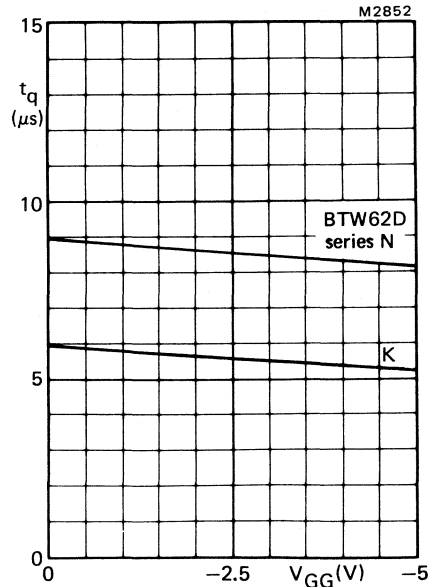


Fig.6b Variation of  $t_q$  with negative bias;  
 $-di_T/dt = 50\text{ A}/\mu\text{s}$ ;  $dV_D/dt = 500\text{ V}/\mu\text{s}$   
 (linear to  $V_{DRMmax}$ );  $I_T = 100\text{ A}$ ;  $t_p = 150\text{ }\mu\text{s}$ ;  
 $T_j = 125\text{ }^\circ\text{C}$ ; maximum values.

THYRISTOR

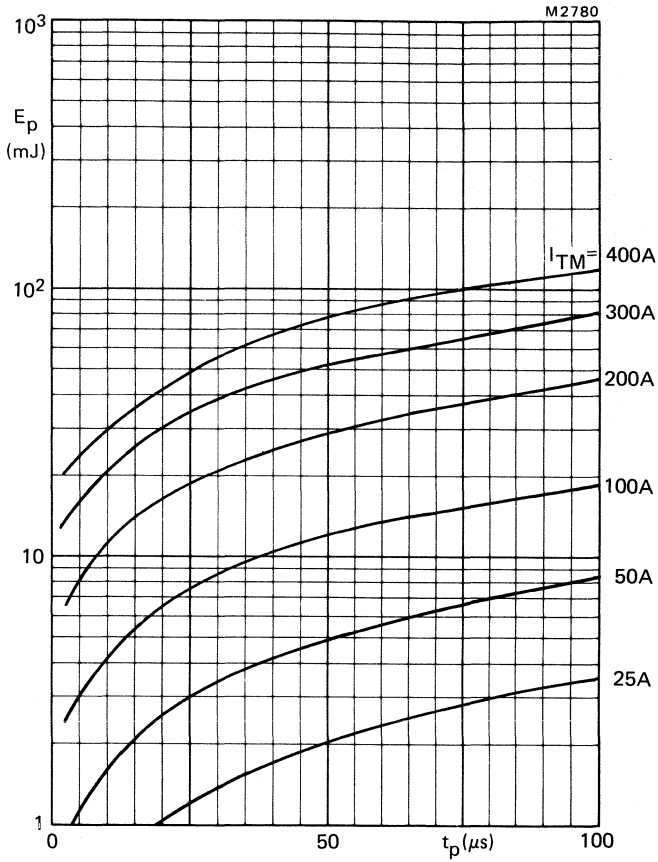


Fig.7 Maximum total energy loss per pulse when switching a half-sinusoidal pulse from 600 V.  
Device power (W) = Energy per pulse (J) x No. of pulses per second.  
For pulse widths > 100  $\mu s$  use Fig.4.

THYRISTOR

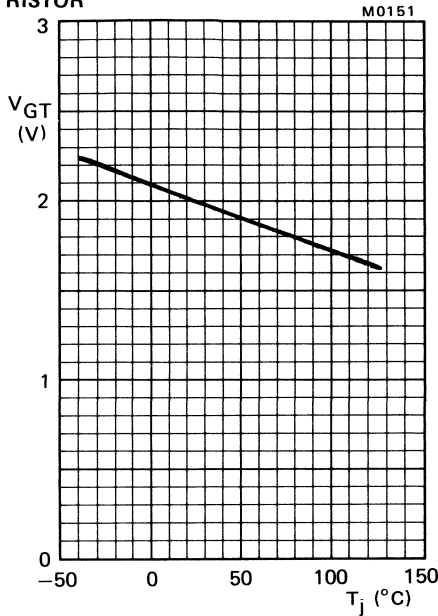


Fig.8 Minimum gate voltage that will trigger all devices plotted against junction temperature.

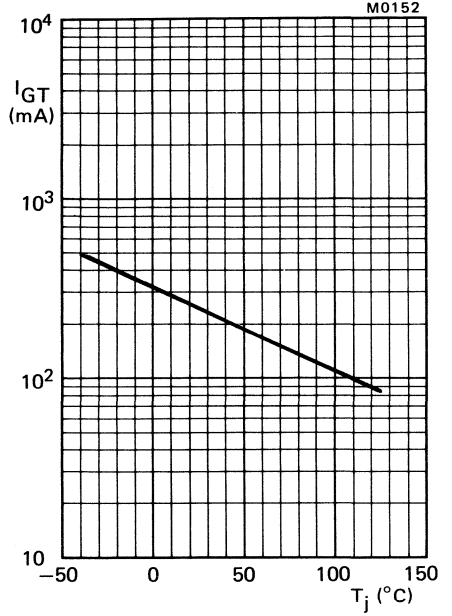


Fig.9 Minimum gate current that will trigger all devices plotted against junction temperature.

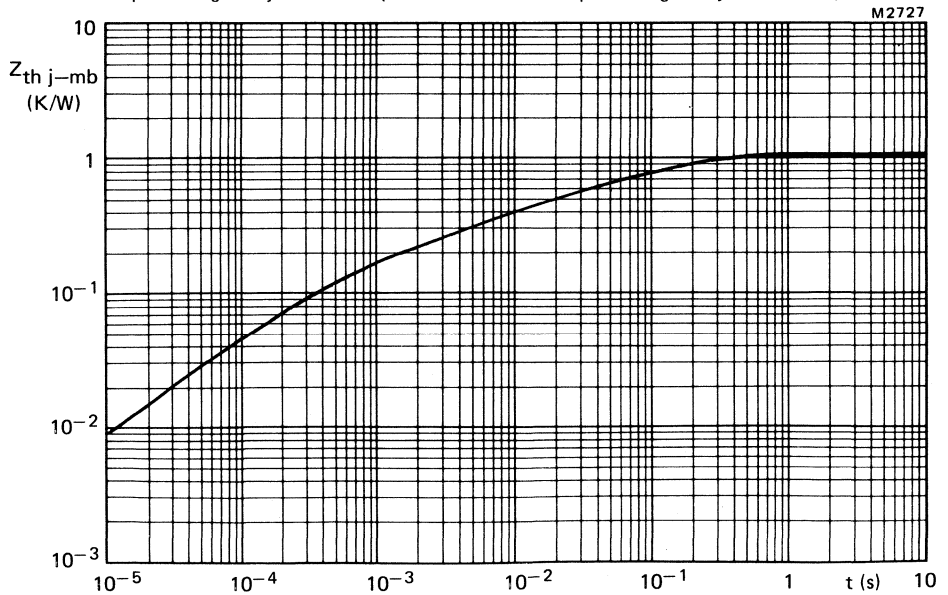


Fig.10 Transient thermal impedance.

**DIODE CHARACTERISTICS**

Forward voltage

$$I_F = 10 \text{ A}; T_j = 25 \text{ }^\circ\text{C}$$

$$V_F < 2.0 \text{ V}^*$$

Reverse recovery when switched from

$$I_F = 2 \text{ A to } V_R \geq 30 \text{ V with}$$

$$-di_F/dt = 20 \text{ A}/\mu\text{s}; T_j = 25 \text{ }^\circ\text{C}$$

recovered charge

$$Q_s < 2.0 \text{ } \mu\text{C}$$

recovery time

$$t_{rr} < 0.6 \text{ } \mu\text{s}$$

Forward recovery when switched to

$$I_F = 5 \text{ A with } t_r = 0.1 \text{ } \mu\text{s}; T_j = 25 \text{ }^\circ\text{C}$$

recovery time

$$t_{fr} < 2.0 \text{ } \mu\text{s}$$

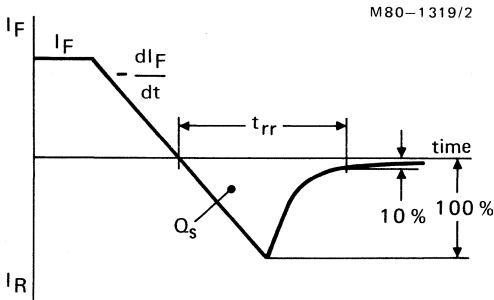


Fig.11 Definition of  $t_{rr}$  and  $Q_s$ .

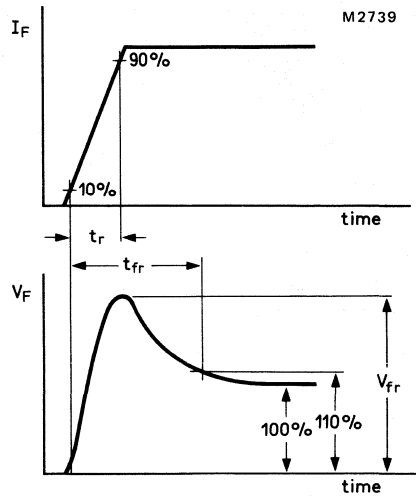


Fig.12 Definition of  $t_{fr}$ .

\*Measured under pulse conditions to avoid excessive dissipation.

DIODE

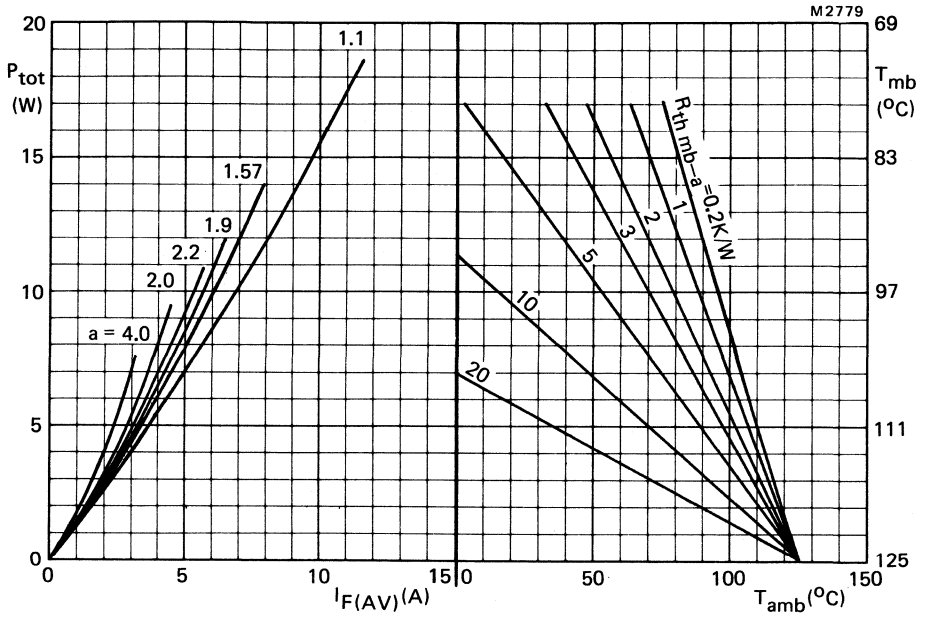


Fig.13 The right hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

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

DIODE

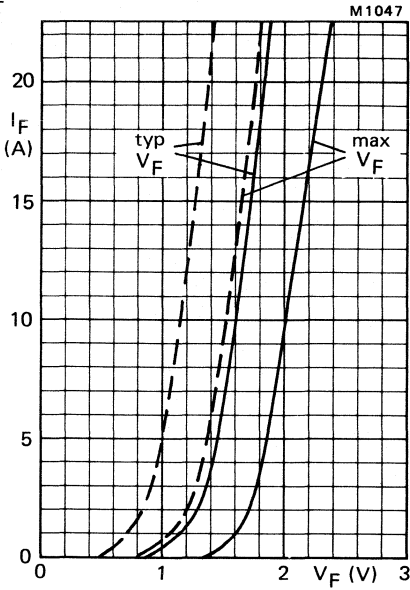


Fig.14 —  $T_j = 25\text{ }^\circ\text{C}$ ; - - -  $T_j = 125\text{ }^\circ\text{C}$ .

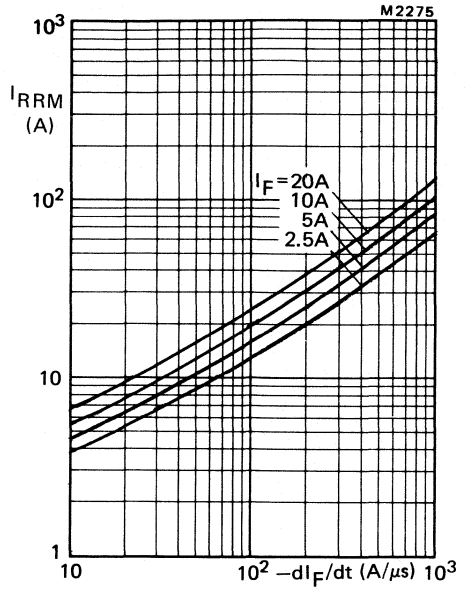


Fig.15 Peak reverse recovery current versus  $-dI_F/dt$ ;  $T_j = 25\text{ }^\circ\text{C}$ ; maximum values.

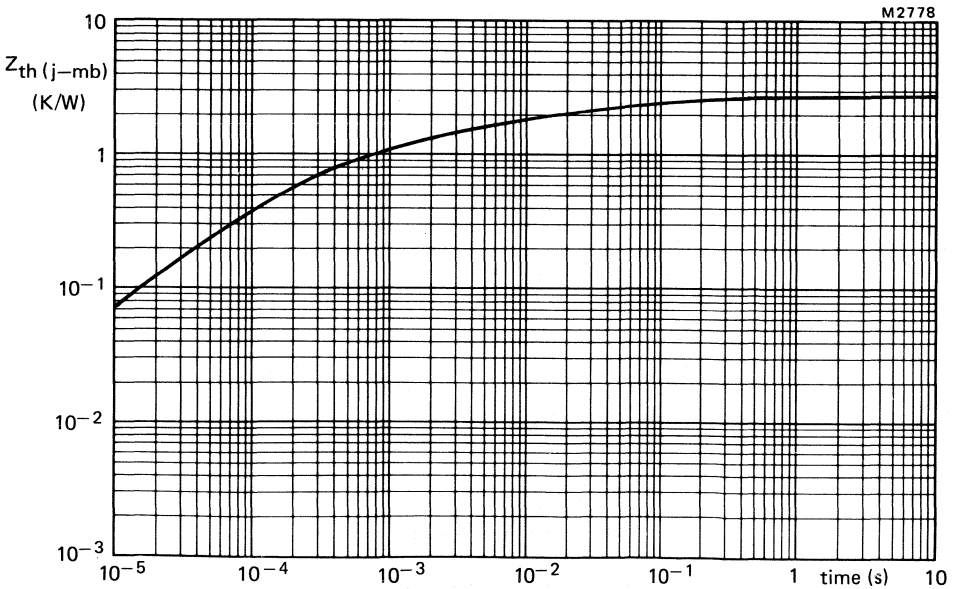


Fig.16 Transient thermal impedance.





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.

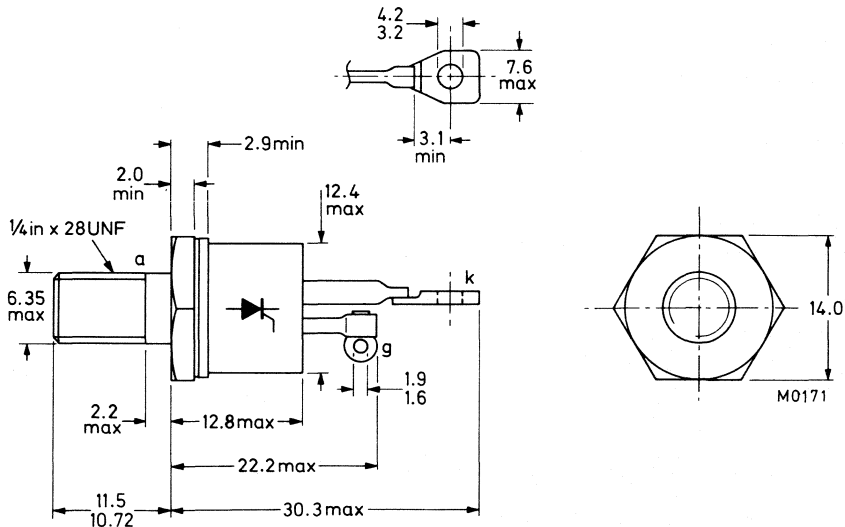
QUICK REFERENCE DATA

		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				$\mu s$
suffix N	$t_q$	<	6				$\mu s$

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)

<b>Anode to cathode</b>		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 ( $t_p \leq 5 \mu s$ )		$V_{RSM}$	max.	15	V
Average on-state current averaged over any 20 ms period; → up to $T_{mb} = 85^\circ C$	$I_{T(AV)}$	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 $T_j = 125^\circ C$ prior to surge; $t = 10$ ms; half sine-wave	$I_{TSM}$	max.	370	A	
$I^2 t$ for fusing; $t = 10$ ms	$I^2 t$	max.	700	$A^2 s$	
Rate of rise of on-state current after triggering with $I_G = 1.25$ A; $I_T = 80$ A	$dI_T/dt$	max.	1000	$A/\mu s$	
<b>Gate to cathode</b>					
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	1	W	
Peak power dissipation; $t = 10 \mu s$	$P_{GM}$	max.	10	W	
<b>Temperatures</b>					
Storage temperature	$T_{stg}$		-40 to +125	$^\circ C$	
Operating junction temperature	$T_j$	max.	125	$^\circ C$	
<b>THERMAL RESISTANCE</b>					
→ From junction to mounting base	$R_{th j-mb}$	=	0.8	$K/W$	
From mounting base to heatsink with heatsink compound	$R_{th mb-h}$	=	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

$I_T = 50 \text{ A}; T_j = 25 \text{ }^\circ\text{C}$

$V_T$	<	2.6	V*
-------	---	-----	----

Off-state current

$V_D = V_{Dmax}; T_j = 125 \text{ }^\circ\text{C}$

$I_D$	<	6.0	mA
-------	---	-----	----

Holding current;  $T_j = 25 \text{ }^\circ\text{C}$

$I_H$	<	400	mA
-------	---	-----	----

**Gate to cathode**

Voltage that will trigger all devices

$V_D = 12 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$

$V_{GT}$	>	2.0	V
----------	---	-----	---

Current that will trigger all devices

$V_D = 12 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$

$I_{GT}$	>	250	mA
----------	---	-----	----

**Switching characteristics (see Fig.2)**

Circuit commutated turn-off time

$dV_D/dt = 500 \text{ V}/\mu\text{s}$  (linear to  $V_{DRMmax}$ );

$R_{GK} = 10 \text{ } \Omega; V_G = 0; T_j = 125 \text{ }^\circ\text{C};$

when switched from  $I_T = 100 \text{ A}; t_p = 150 \text{ } \mu\text{s}$

$-dI_T/dt = 50 \text{ A}/\mu\text{s}$

suffix K

suffix N

$t_q$	<	6	$\mu\text{s}$
-------	---	---	---------------

$t_q$	<	9	$\mu\text{s}$
-------	---	---	---------------

$-dI_T/dt = 10 \text{ A}/\mu\text{s}$

suffix K

suffix N

$t_q$	<	4	$\mu\text{s}$
-------	---	---	---------------

$t_q$	<	6	$\mu\text{s}$
-------	---	---	---------------

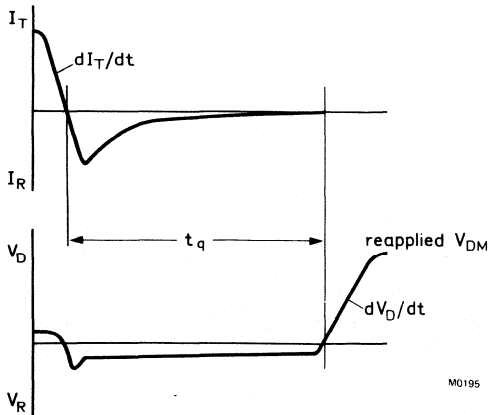


Fig.2 Circuit-commutated turn-off time definition.

\*Measured under pulse conditions to avoid excessive dissipation.

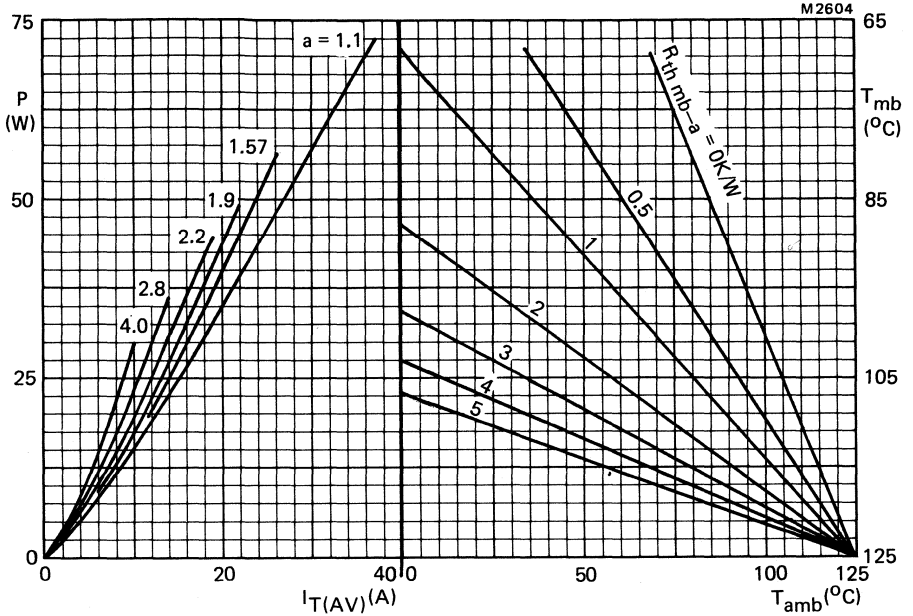


Fig.3 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

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

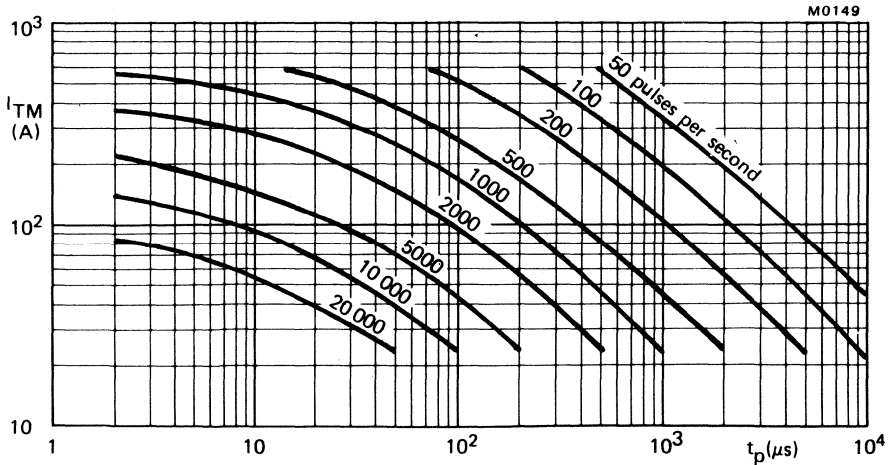


Fig.4 Maximum allowable peak on-state current versus pulse width;  $T_{mb} = 85$  °C.

Fig.5 —  $T_j = 25\text{ }^\circ\text{C}$ ; - - -  $T_j = 125\text{ }^\circ\text{C}$ ;  
 $t_p = 200\text{ }\mu\text{s}$ .

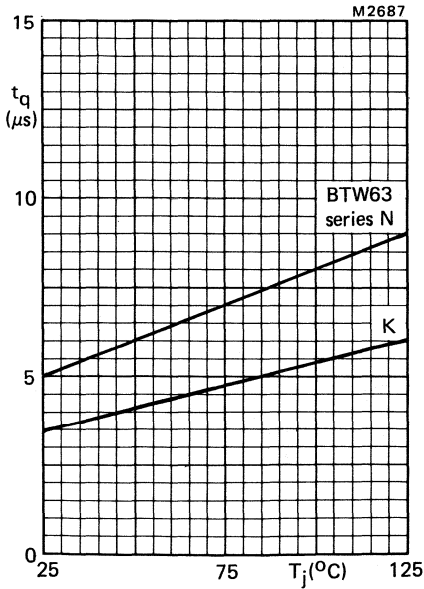
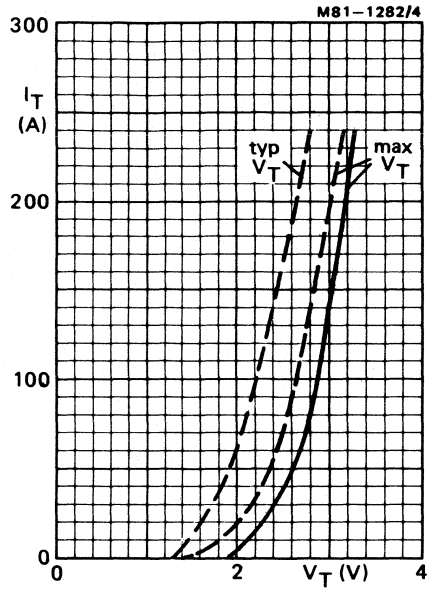


Fig.6a Variation of  $t_q$  with  $T_j$ ;  
 $-di_T/dt = 50\text{ A}/\mu\text{s}$ ;  $dV_D/dt = 500\text{ V}/\mu\text{s}$   
 (linear to  $V_{DRMmax}$ );  $I_T = 100\text{ A}$ ;  $t_p = 150\text{ }\mu\text{s}$ ;  
 $R_{GK} = 10\text{ }\Omega$ ;  $V_G = 0$ ; maximum values.

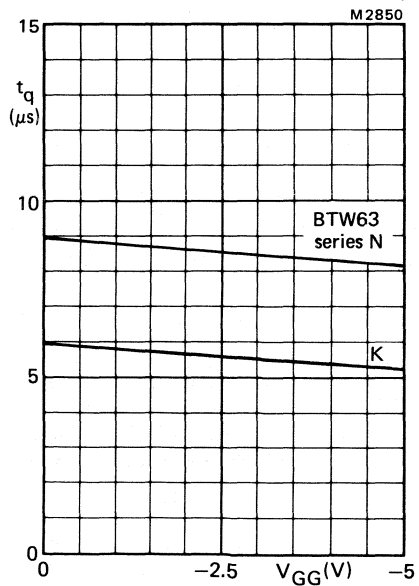


Fig.6b Variation of  $t_q$  with negative bias;  
 $-di_T/dt = 50\text{ A}/\mu\text{s}$ ;  $dV_D/dt = 500\text{ V}/\mu\text{s}$   
 (linear to  $V_{DRMmax}$ );  $I_T = 100\text{ A}$ ;  $t_p = 150\text{ }\mu\text{s}$ ;  
 $T_j = 125\text{ }^\circ\text{C}$ ; maximum values.

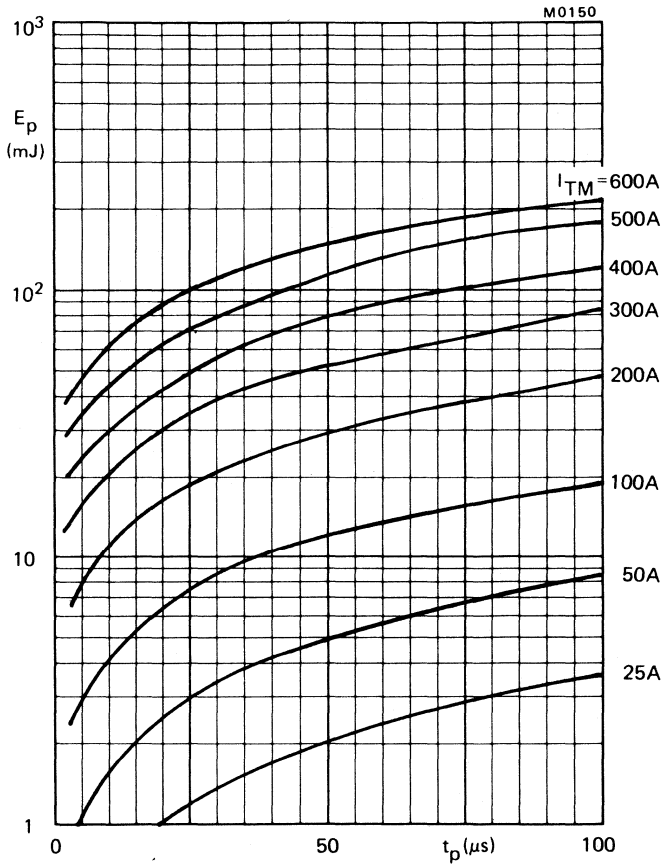


Fig.7 Maximum total energy loss per pulse when switching a half-sinusoidal pulse from 600 V.  
 Device power (W) = Energy per pulse (J) x No. of pulses per second.  
 For pulse widths > 100  $\mu s$  use Fig.3.

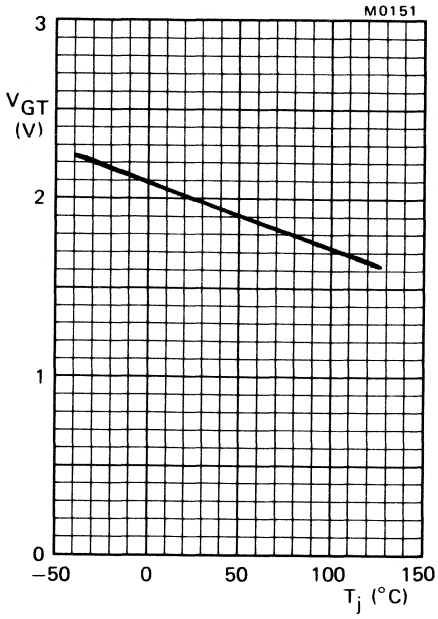


Fig.8 Minimum gate voltage that will trigger all devices plotted against junction temperature.

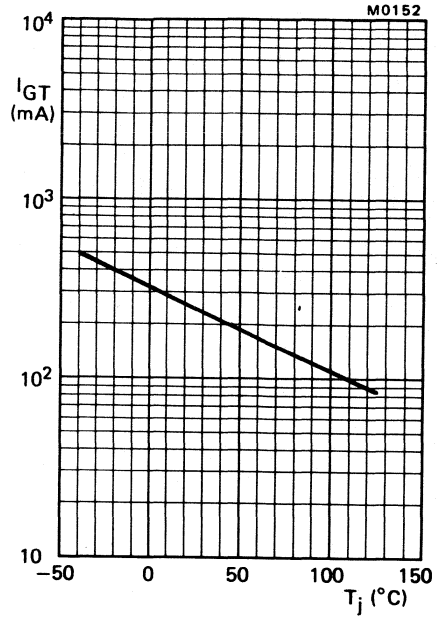


Fig.9 Minimum gate current that will trigger all devices plotted against junction temperature.





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 consists of reverse polarity types (anode to stud) identified by a suffix R: BTY79-400R to 1000R.

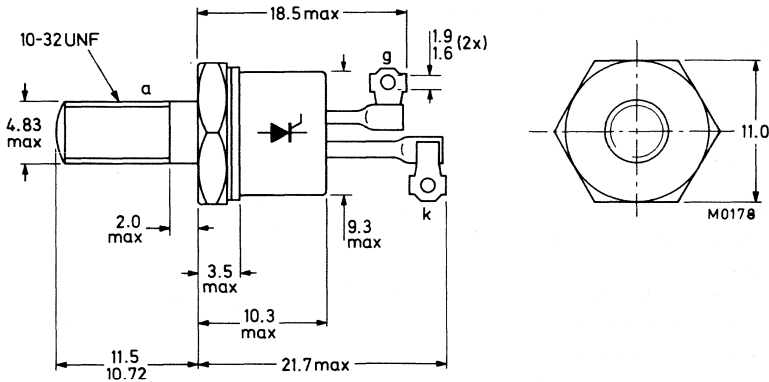
QUICK REFERENCE DATA

	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 ( $\phi$  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

$I^2 t$  for fusing ( $t = 10$  ms)

$I^2 t$  max. 112 A<sup>2</sup>s

Rate of rise of on-state current after triggering with  $I_G = 150$  mA to  $I_T = 30$  A;  $dI_T/dt = 0,25$  A/ $\mu$ s

$dI_T/dt$  max. 50 A/ $\mu$ s

**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

$R_{th j-mb} = 1,8$  °C/W

From mounting base to heatsink with heatsink compound

$R_{th mb-h} = 0,5$  °C/W

From junction to ambient in free air

$R_{th j-a} = 45$  °C/W

Transient thermal impedance ( $t = 1$  ms)

$Z_{th j-mb} = 0,1$  °C/W

\* To ensure thermal stability:  $R_{th j-a} < 4$  °C/W (d.c. blocking) or  $< 8$  °C/W (a.c.). For smaller heat-sinks  $T_{j max}$  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/ $\mu$ s.

**CHARACTERISTICS**

**Anode to cathode**

On-state voltage (measured under pulse conditions)

$I_T = 20 \text{ A}; T_j = 25 \text{ }^\circ\text{C}$

$V_T < 2 \text{ V}$

Rate of rise of off-state voltage that will not trigger any device; exponential method;

$V_D = 2/3 V_{DRMmax}; T_j = 125 \text{ }^\circ\text{C}$

$dV_D/dt < 200 \text{ V}/\mu\text{s}$

Reverse current

$V_R = V_{RWMmax}; T_j = 125 \text{ }^\circ\text{C}$

$I_R < 3 \text{ mA}$

Off-state current

$V_D = V_{DWMmax}; T_j = 125 \text{ }^\circ\text{C}$

$I_D < 3 \text{ mA}$

Latching current;  $T_j = 25 \text{ }^\circ\text{C}$

$I_L < 150 \text{ mA}$

Holding current;  $T_j = 25 \text{ }^\circ\text{C}$

$I_H < 75 \text{ mA}$

**Gate to cathode**

Voltage that will trigger all devices

$V_D = 6 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$

$V_{GT} > 1.5 \text{ V}$

Voltage that will not trigger any device

$V_D = V_{DRMmax}; T_j = 125 \text{ }^\circ\text{C}$

$V_{GD} < 200 \text{ mV}$

Current that will trigger all devices

$V_D = 6 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$

$I_{GT} > 30 \text{ mA}$

On request (see Ordering Note)

$I_{GT} > 20 \text{ mA}$

**Switching characteristics**

Gate-controlled turn-on time ( $t_{gt} = t_d + t_r$ ) when switched from  $V_D = V_{DRMmax}$  to  $I_T = 40 \text{ A}$ ;  $I_{GT} = 100 \text{ mA}$ ;  $dI_G/dt = 5 \text{ A}/\mu\text{s}$ ;  $T_j = 25 \text{ }^\circ\text{C}$

$t_{gt}$  typ. 2  $\mu\text{s}$

Circuit-commutated turn-off time when switched from  $I_T = 40 \text{ A}$  to  $V_R > 50 \text{ V}$  with  $-dI_T/dt = 10 \text{ A}/\mu\text{s}$ ;  $dV_D/dt = 50 \text{ V}/\mu\text{s}$ ;  $T_j = 115 \text{ }^\circ\text{C}$

$t_q$  typ. 35  $\mu\text{s}$

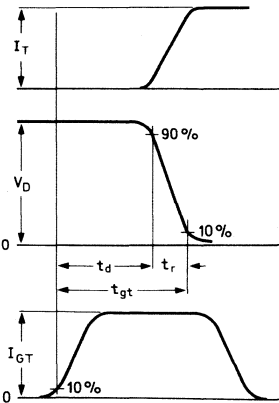


Fig.2a Gate-controlled turn-on time definition.

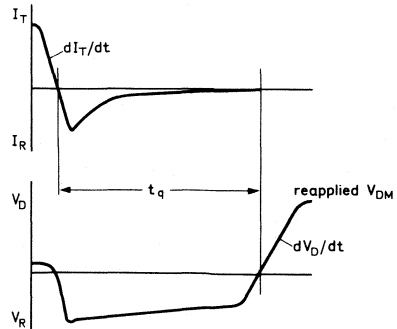


Fig.2b Circuit-commutated turn-off time definition.

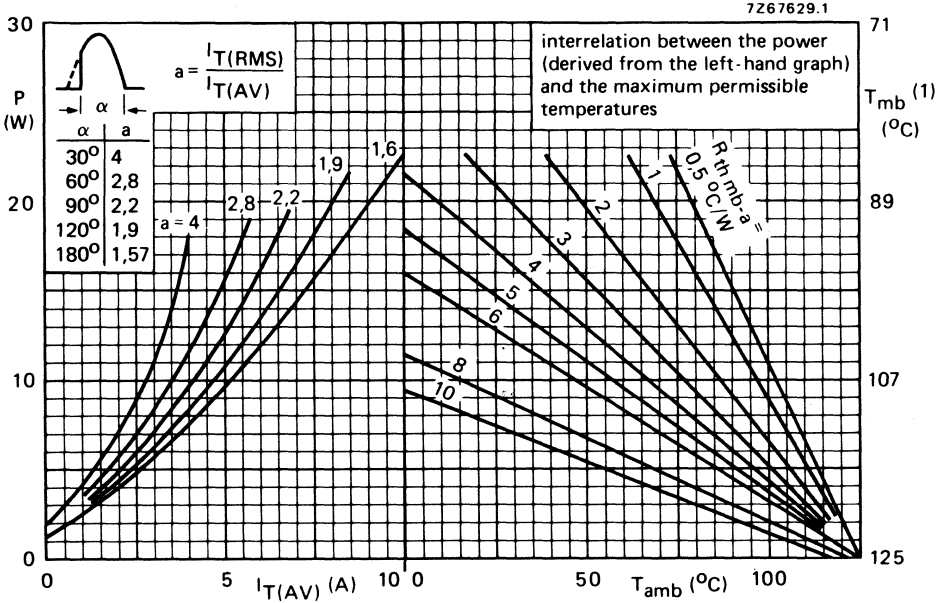
**OPERATING NOTE**

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,  $I_{GT} > 20 \text{ mA}$ , 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  $R_{th\ mb-a} \leq 6 \text{ } ^\circ\text{C/W}$ .

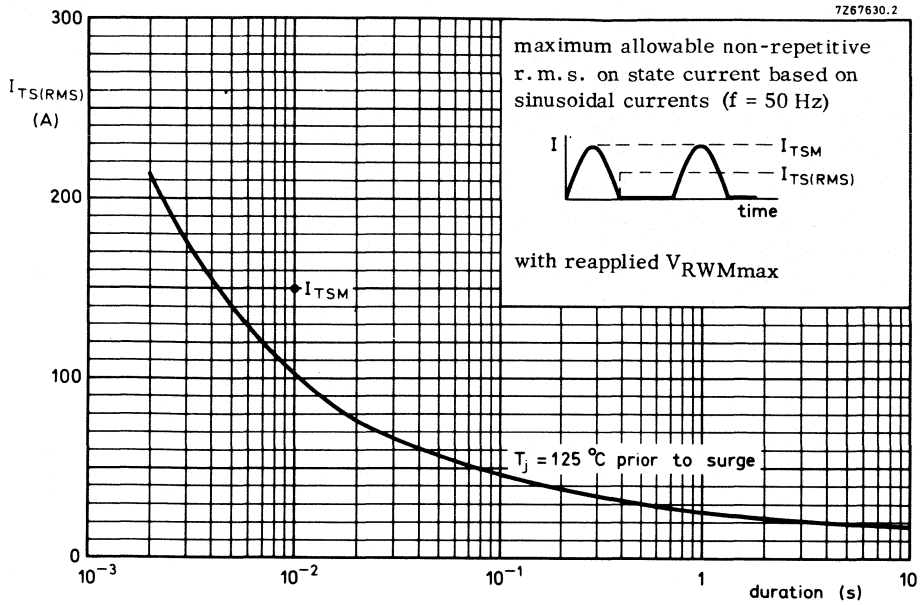


Fig. 4.

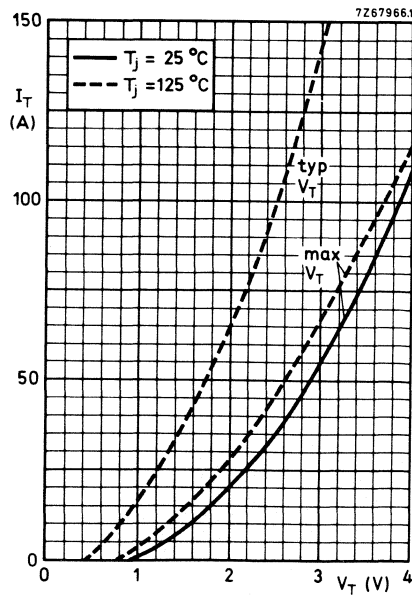


Fig. 5.

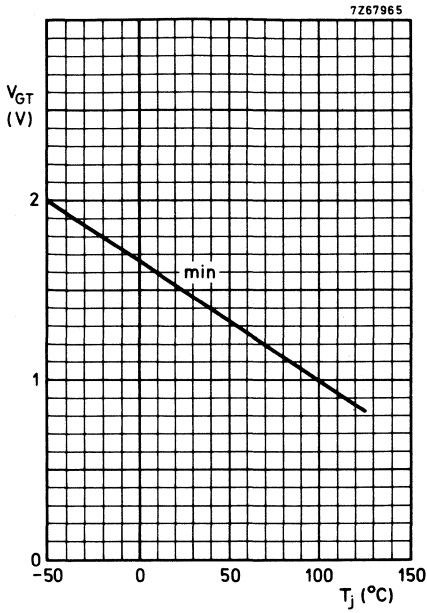


Fig. 6 Minimum gate voltage that will trigger all devices as a function of  $T_j$ .

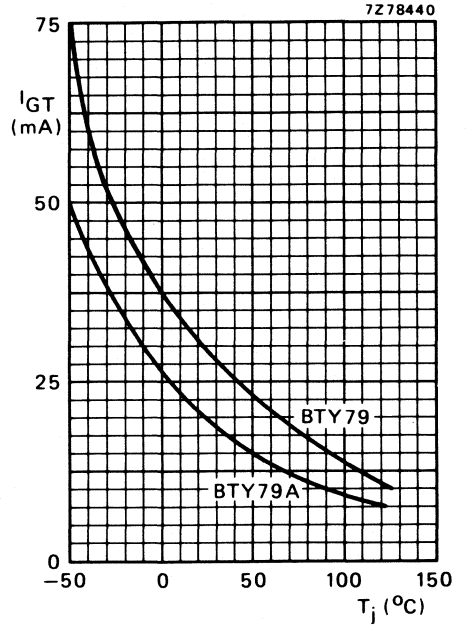


Fig. 7 Minimum gate current that will trigger all devices as a function of  $T_j$ .

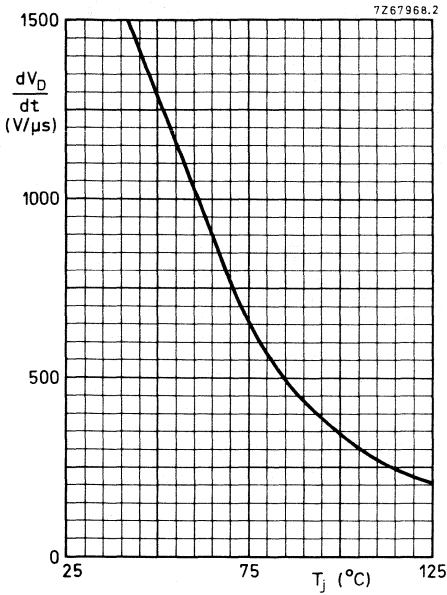


Fig. 8 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of  $T_j$ .

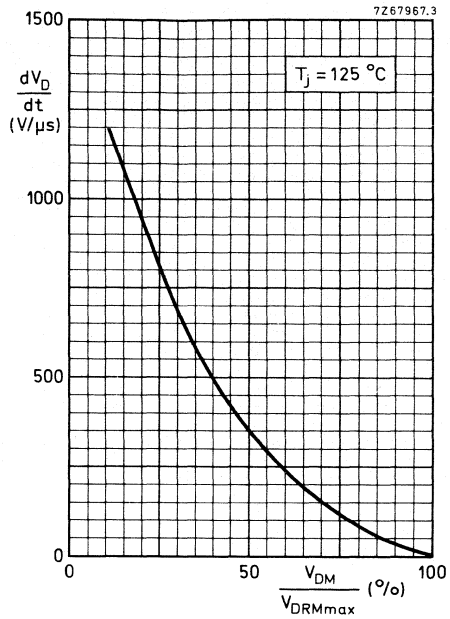


Fig. 9 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of applied voltage.

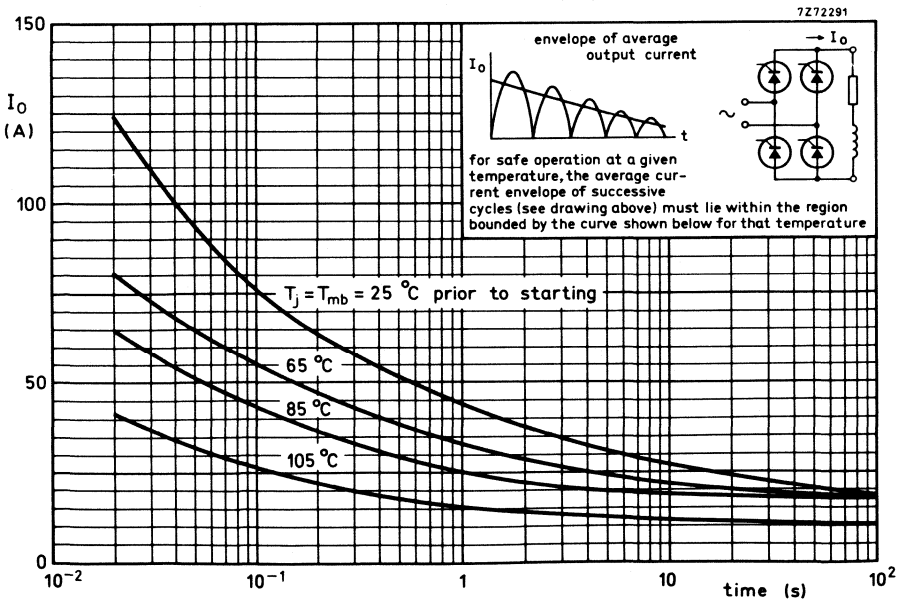
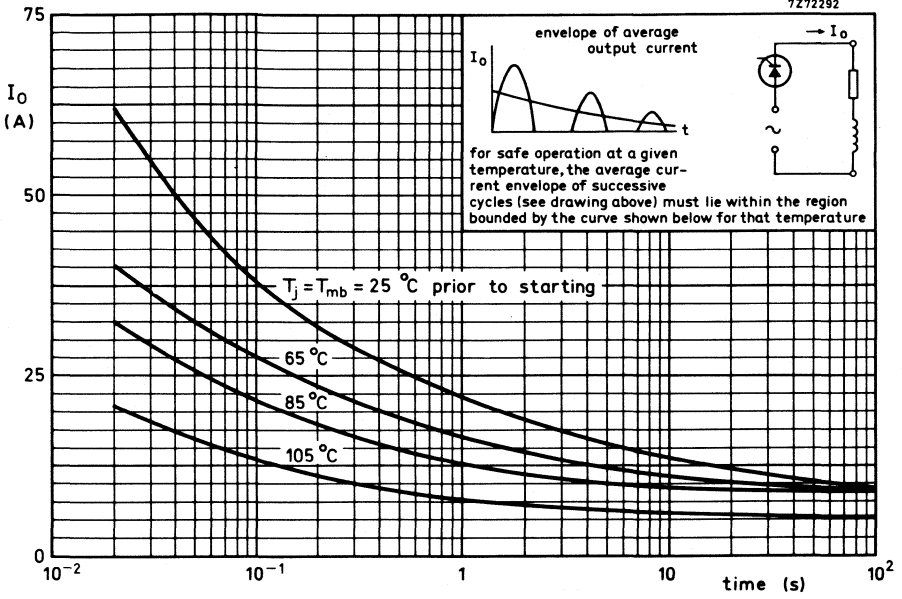


Fig. 10 Limits for starting or inrush currents.



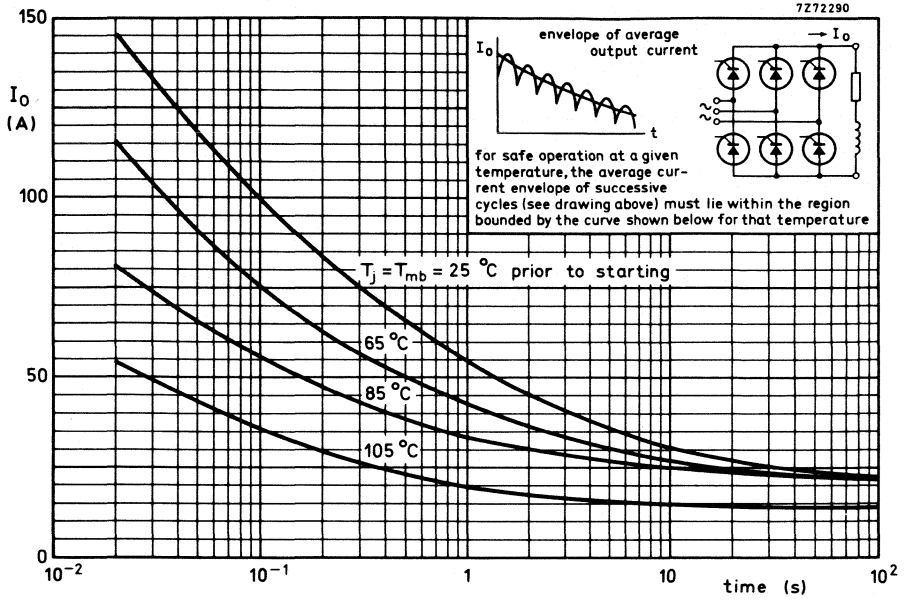


Fig. 11 Limits for starting or inrush currents.

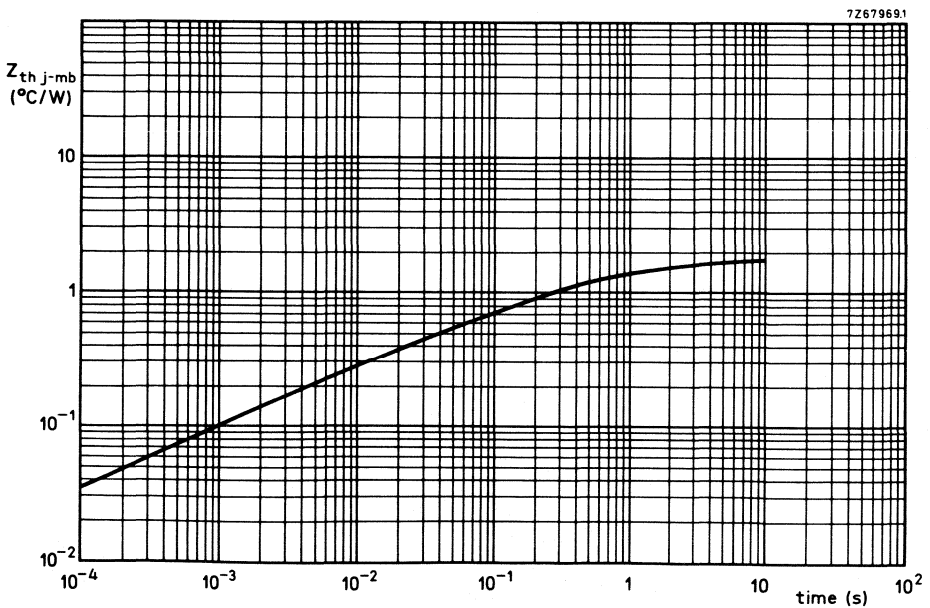


Fig. 12.



## 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.

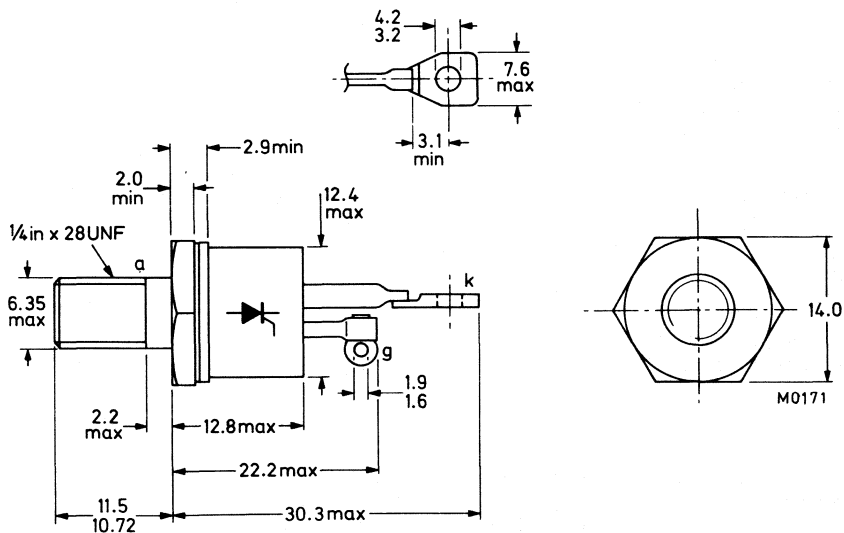
### QUICK REFERENCE DATA

	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 1/4 in x 28 UNF stud ( $\phi$  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)

		BTY91-400R	500R	600R	800R
<b>Anode to cathode</b>					
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 at $T_{mb} = 85$ °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 $V_{RWMmax}$		$I_{TSM}$	max.	200	A
$I^2t$ for fusing ( $t = 10$ ms)		$I^2t$	max.	200	A <sup>2</sup> s
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/ $\mu$ s
<b>Gate to cathode</b>					
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
<b>Temperatures</b>					
Storage temperature		$T_{stg}$		-55 to + 125	°C
Junction temperature		$T_j$	max.	125	°C
<b>THERMAL RESISTANCE</b>					
From junction to mounting base		$R_{th j-mb}$	=	1,6	°C/W
From mounting base to heatsink with heatsink compound		$R_{th mb-h}$	=	0,2	°C/W
Transient thermal impedance ( $t = 1$ ms)		$Z_{th j-mb}$	=	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:  $R_{th j-a} < 4,5$  °C/W (d.c. blocking) or  $< 9$  °C/W (a.c.). For smaller heat-sinks  $T_{j max}$  should be derated. For a.c. see Fig. 3.

**CHARACTERISTICS**

**Anode to cathode**

On-state voltage $I_T = 50 \text{ A}; T_j = 25 \text{ }^\circ\text{C}$	$V_T$	<	2 V *
Rate of rise of off-state voltage that will not trigger any device; exponential method; $V_D = 2/3 V_{DRMmax}; T_j = 125 \text{ }^\circ\text{C}$	$dV_D/dt$	<	200 V/ $\mu$ s
Reverse current $V_R = V_{RWMmax}; T_j = 125 \text{ }^\circ\text{C}$	$I_R$	<	3 mA
Off-state current $V_D = V_{DWMmax}; T_j = 125 \text{ }^\circ\text{C}$	$I_D$	<	3 mA
Latching current; $T_j = 25 \text{ }^\circ\text{C}$	$I_L$	typ.	50 mA
Holding current; $T_j = 25 \text{ }^\circ\text{C}$	$I_H$	typ.	25 mA

**Gate to cathode**

Voltage that will trigger all devices $V_D = 6 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$	$V_{GT}$	>	3 V
Voltage that will not trigger any device $V_D = V_{DRMmax}; T_j = 125 \text{ }^\circ\text{C}$	$V_{GD}$	<	200 mV
Current that will trigger all devices $V_D = 6 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$	$I_{GT}$	>	40 mA

**Switching characteristics**

Gate-controlled turn-on time ( $t_{gt} = t_d + t_r$ ) when switched from $V_D = 400 \text{ V}$ to $I_T = 10 \text{ A}; I_{GT} = 200 \text{ mA}; T_j = 25 \text{ }^\circ\text{C}$	$t_{gt}$	typ.	2 $\mu$ s
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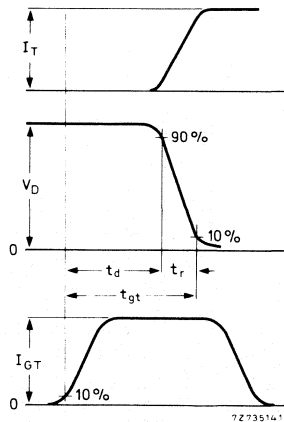


Fig. 2 Gate-controlled turn-on time definitions.

\* Measured under pulse conditions to avoid excessive dissipation.

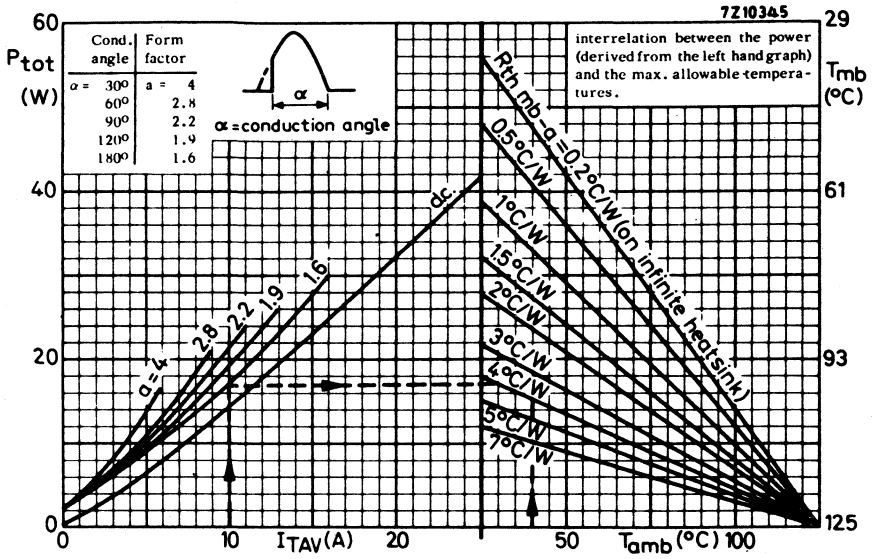


Fig. 3.

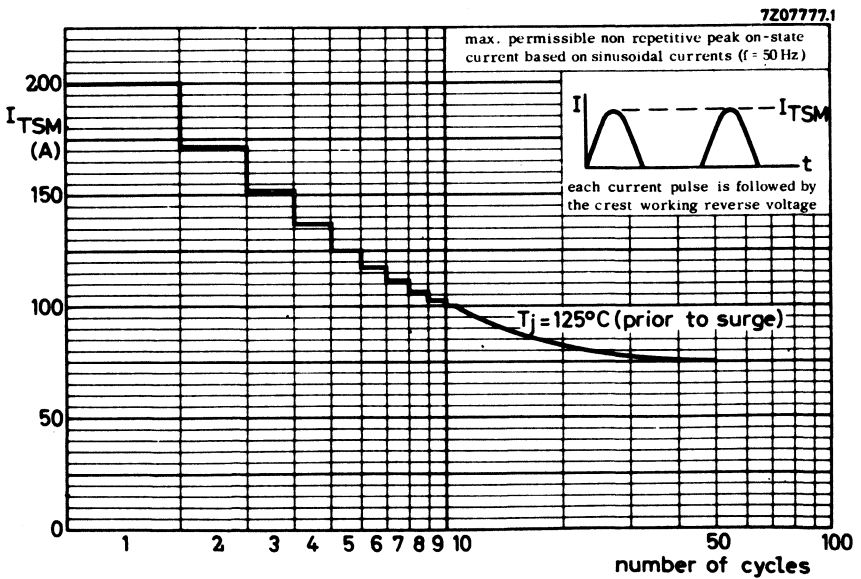


Fig. 4.

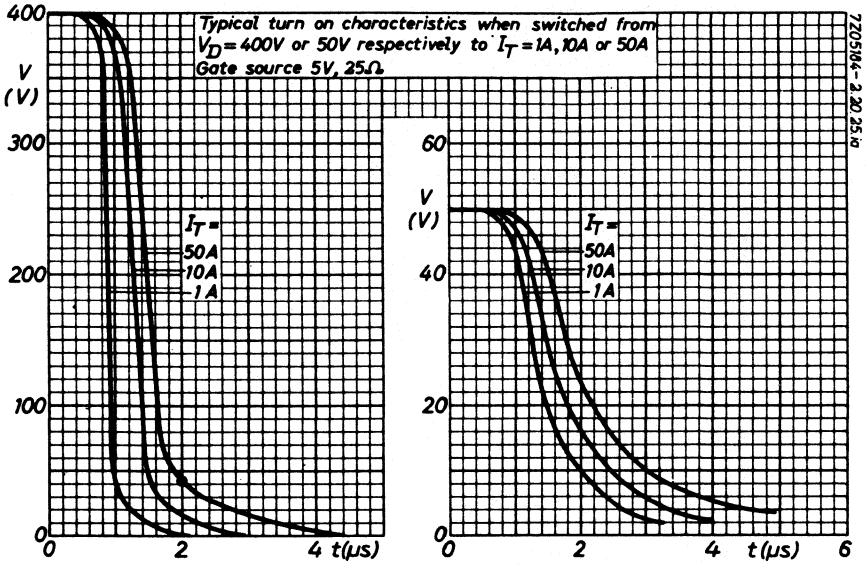


Fig. 5.

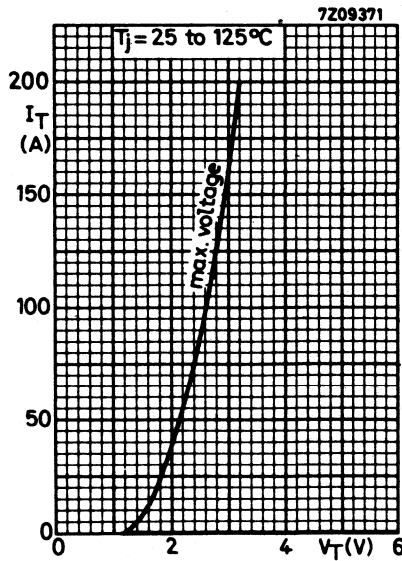


Fig. 6.

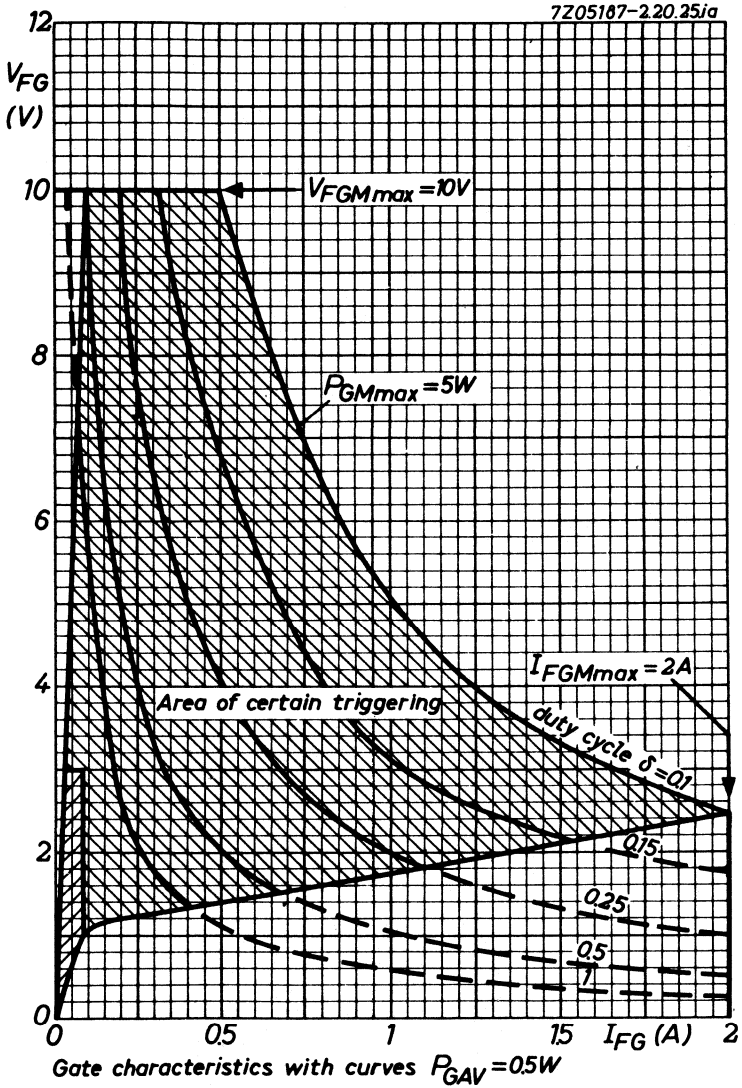


Fig. 7.



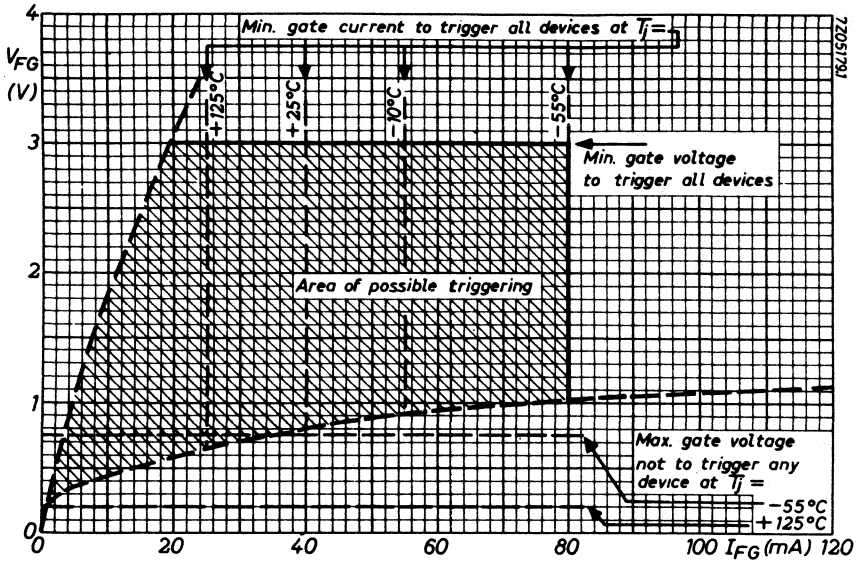


Fig. 8.

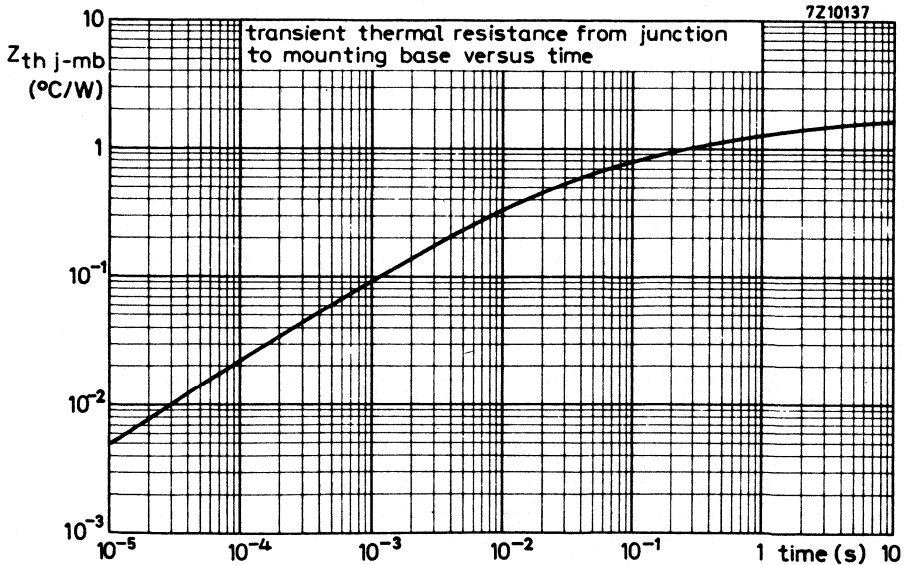


Fig. 9.

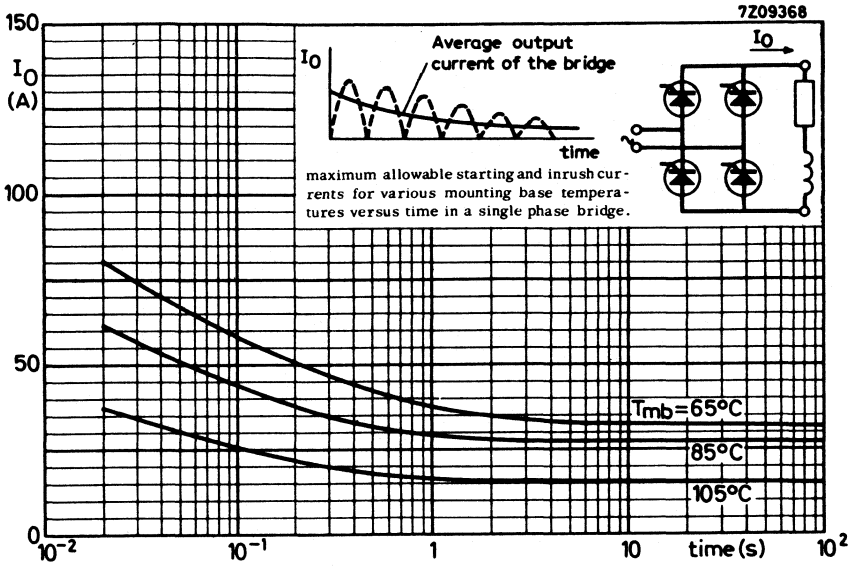


Fig. 10.

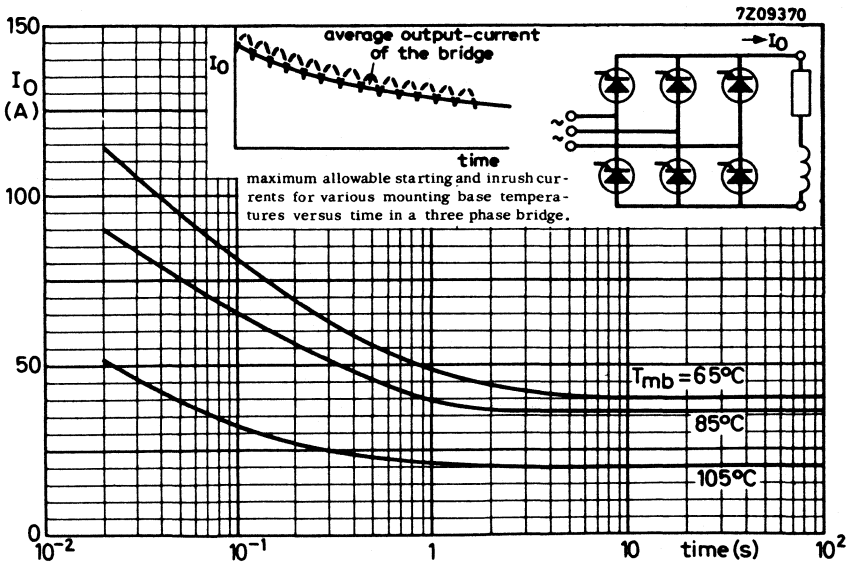


Fig. 11.

# 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.

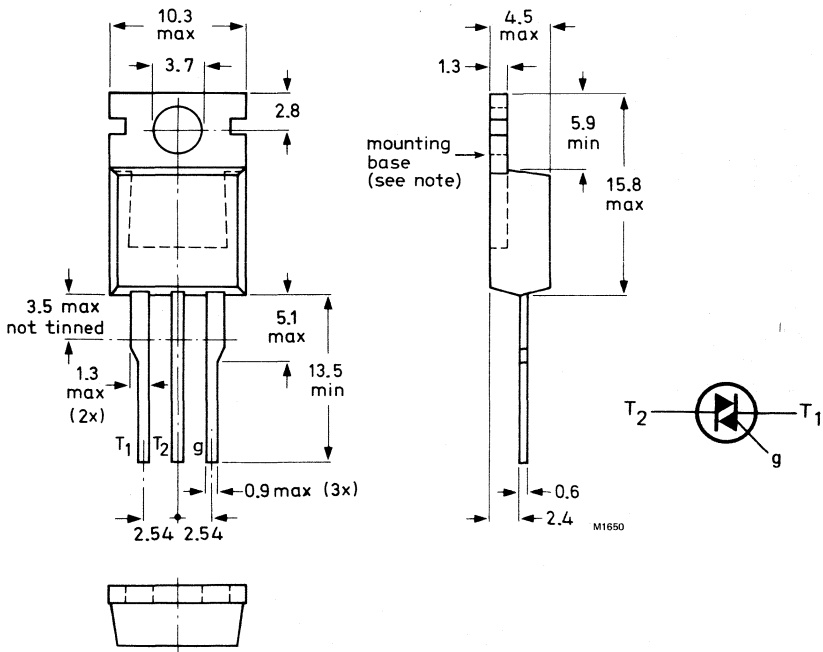
### QUICK REFERENCE DATA

		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<sub>2</sub>.

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	
<b>Voltages</b> (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
<b>Currents</b> (in either direction)					
R.M.S. on-state current (conduction angle $360^\circ$ )					
up to $T_{mb} = 102^\circ\text{C}$	$I_{T(RMS)}$ max.		4		A
Repetitive peak on-state current	$I_{TRM}$ max.		25		A
Non-repetitive peak on-state current;					
$T_j = 120^\circ\text{C}$ prior to surge;					
$t = 20$ ms; full sine-wave	$I_{TSM}$ max.		25		A
$I^2 t$ for fusing ( $t = 10$ ms)	$I^2 t$ max.		4		$A^2 s$
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/ $\mu$ s					
	$dI_T/dt$ max.		10		A/ $\mu$ s

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	$^\circ\text{C}$
Operating junction temperature			
full-cycle operation	$T_j$ max.	120	$^\circ\text{C}$
half-cycle operation	$T_j$ max.	110	$^\circ\text{C}$

\*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/ $\mu$ s.

**THERMAL RESISTANCE**

From junction to mounting base

full-cycle operation

$R_{th\ j-mb} = 3.0\ K/W$

half-cycle operation

$R_{th\ j-mb} = 3.7\ K/W$

Transient thermal impedance;  $t = 1\ ms$ 

$Z_{th\ j-mb} = 0.6\ K/W$

**Influence of mounting method**

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from mounting base to heatsink

a. with heatsink compound

$R_{th\ mb-h} = 0.3\ K/W$

b. with heatsink compound and 0.06 mm maximum mica insulator

$R_{th\ mb-h} = 1.4\ K/W$

c. with heatsink compound and 0.1 mm max. mica insulator (56369)

$R_{th\ mb-h} = 2.2\ K/W$

d. with heatsink compound and 0.25 mm max. alumina insulator (56367)

$R_{th\ mb-h} = 0.8\ K/W$

e. without heatsink compound

$R_{th\ mb-h} = 1.4\ K/W$

2. Free-air operation

The quoted value of  $R_{th\ j-a}$  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

$R_{th\ j-a} = 60\ K/W$

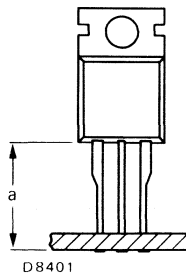


Fig.2.

**CHARACTERISTICS** ( $T_j = 25\text{ }^\circ\text{C}$  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)

$$I_T = 5\text{ A} \qquad V_T < 1.70\text{ V}$$

Rate of rise of off-state voltage that will not trigger any device;  $T_j = 120\text{ }^\circ\text{C}$ ; gate open circuit

BT136 series	$dV_D/dt$	<	100	V/ $\mu\text{s}$
BT136 series G	$dV_D/dt$	<	200	V/ $\mu\text{s}$
BT136 series F	$dV_D/dt$	<	50	V/ $\mu\text{s}$
BT136 series E	$dV_D/dt$	typ.	50	V/ $\mu\text{s}$
BT136 – 500D	$dV_D/dt$	typ.	5	V/ $\mu\text{s}$

Rate of change of commutating voltage that will not trigger any device when  $-di_{com}/dt = 1.8\text{ A/ms}$ ;

$$I_T(\text{RMS}) = 4\text{ A}; T_{mb} = 85\text{ }^\circ\text{C}; \text{gate open circuit}; V_D = V_{DWM\text{max}}$$

BT136 series	$dV_{com}/dt$	typ.	10	V/ $\mu\text{s}$
BT136 series G	$dV_{com}/dt$	<	10	V/ $\mu\text{s}$
BT136 series F	$dV_{com}/dt$	typ.	10	V/ $\mu\text{s}$

Off-state current

$$V_D = V_{DWM\text{max}}; T_j = 120\text{ }^\circ\text{C} \qquad I_D < 0.5\text{ mA}$$

Gate voltage that will trigger all devices

$$V_{GT} > 1.5\text{ V}$$

Gate voltage that will not trigger any device

$$V_D = V_{DWM\text{max}}; T_j = 120\text{ }^\circ\text{C}; T_2 \text{ and G positive or negative} \qquad V_{GD} < 250\text{ mV}$$

Gate current that will trigger all devices ( $I_{GT}$ ); G to  $T_1$

Holding current ( $I_H$ )

Latching current ( $I_L$ );  $V_D = 12\text{ V}$

			$T_2^+$ 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<sub>2</sub>, 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<sub>th mb-h</sub> 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<sub>th mb-h</sub> 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.

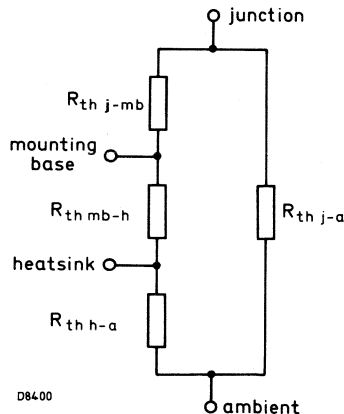


Fig.3.

- b. The method of using Fig.4 is as follows:
 

Starting with the required current on the I<sub>T(RMS)</sub> axis, trace upwards to meet the appropriate conduction angle curve. Trace right horizontally and upwards from the appropriate value on the T<sub>amb</sub> scale. The intersection determines the R<sub>th mb-a</sub>. The heatsink thermal resistance value (R<sub>th h-a</sub>) can now be calculated from:

$$R_{th h-a} = R_{th mb-a} - R_{th mb-h}$$

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

FULL-CYCLE OPERATION

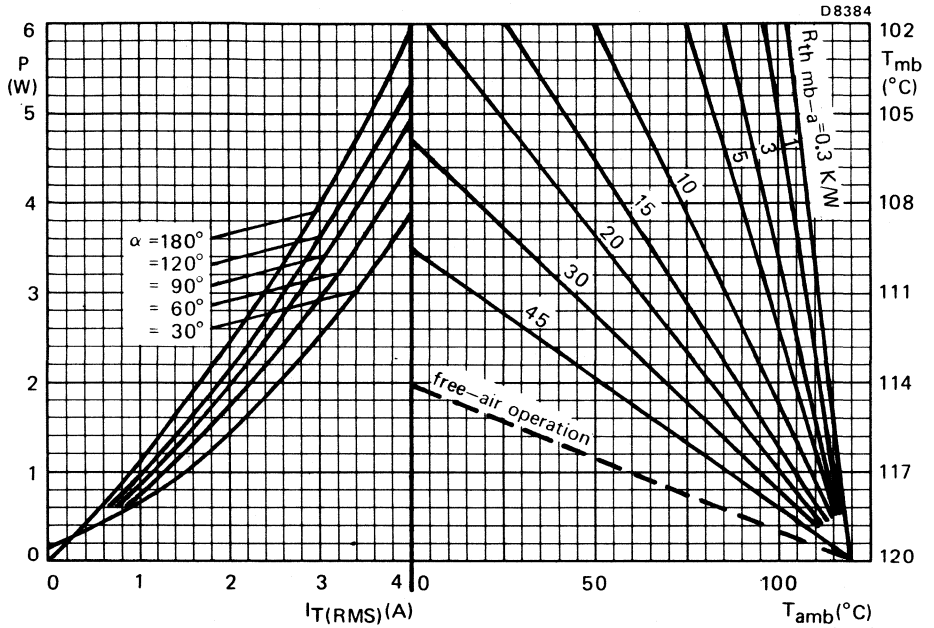
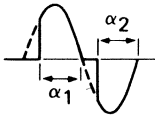


Fig.4 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha = \alpha_1 = \alpha_2$ : 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

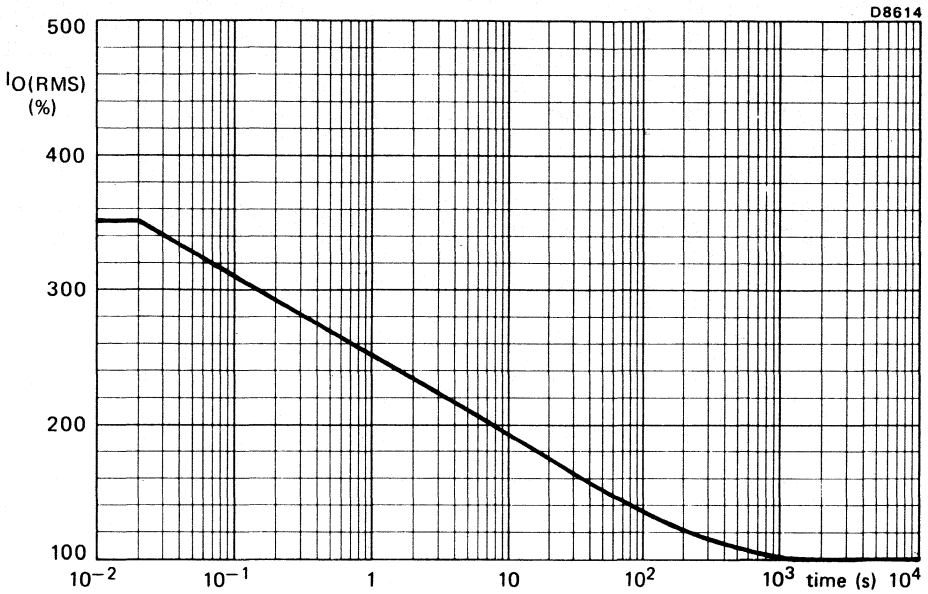


Fig.5 Maximum permissible duration of steady overload (provided that  $T_{mb}$  does not exceed  $120^\circ\text{C}$  during and after overload) expressed as a percentage of the steady state r.m.s. rated current. For high r.m.s. overload currents precautions should be taken so that the temperature of the terminals does not exceed  $125^\circ\text{C}$ . During these overload conditions the triac may lose control. Therefore the overload should be terminated by a separate protection device.

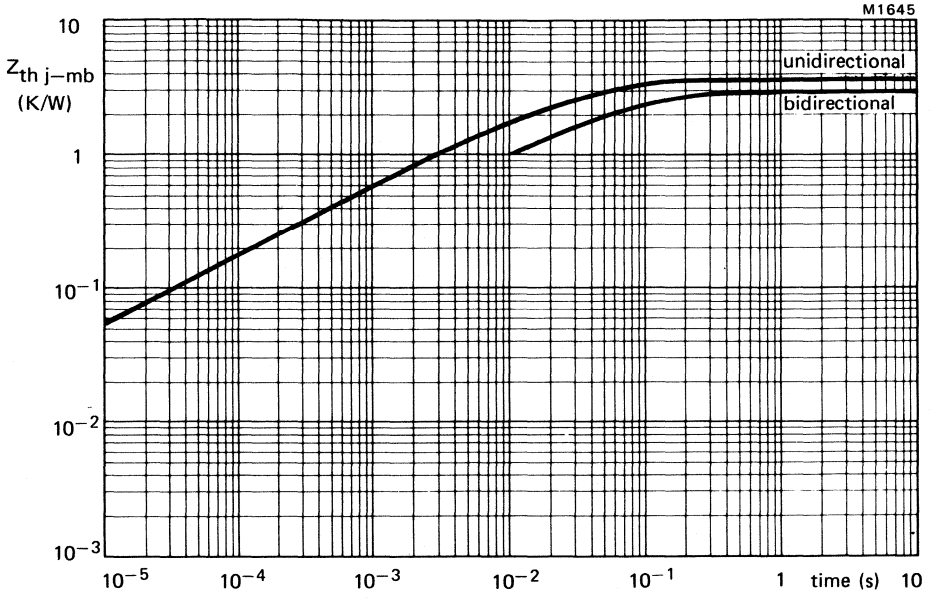


Fig. 6

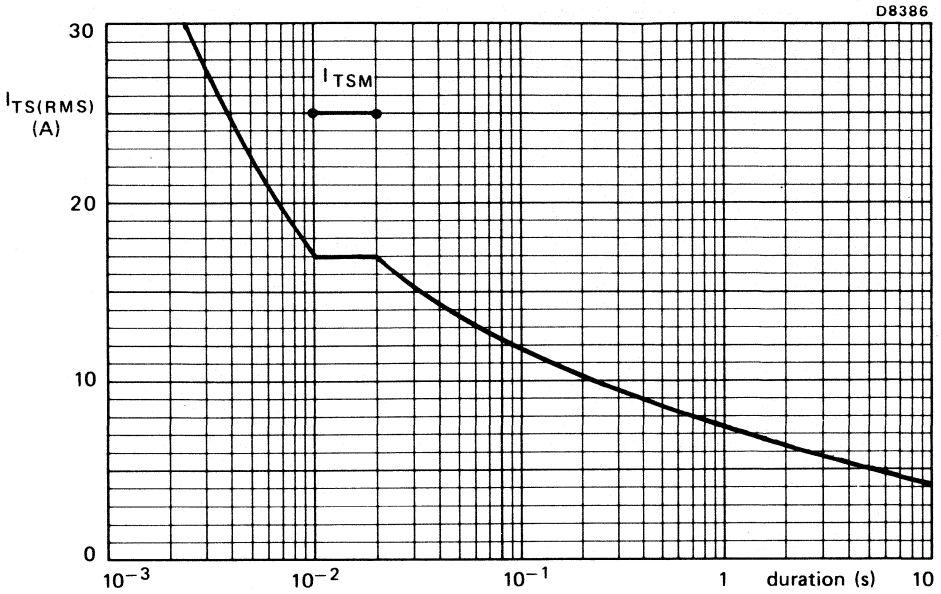


Fig.7 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents ( $f = 50$  Hz);  $T_j = 120$  °C prior to surge. The triac may temporarily lose control following the surge.

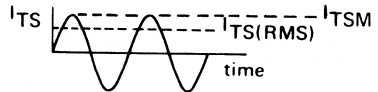
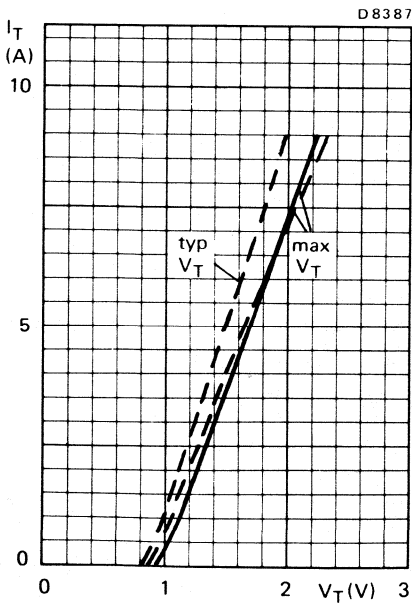


Fig.8 —  $T_j = 25$  °C; - - -  $T_j = 120$  °C

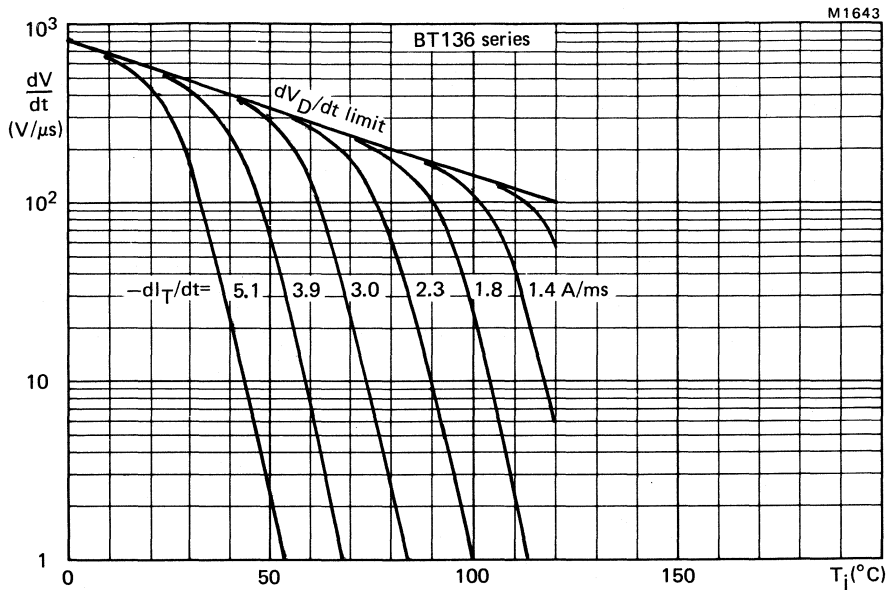


Fig.9 Typical commutation  $dV/dt$  for BT136 series versus  $T_j$ . The triac should commute when the  $dV/dt$  is below the value on the appropriate curve for pre-commutation  $di_T/dt$ .

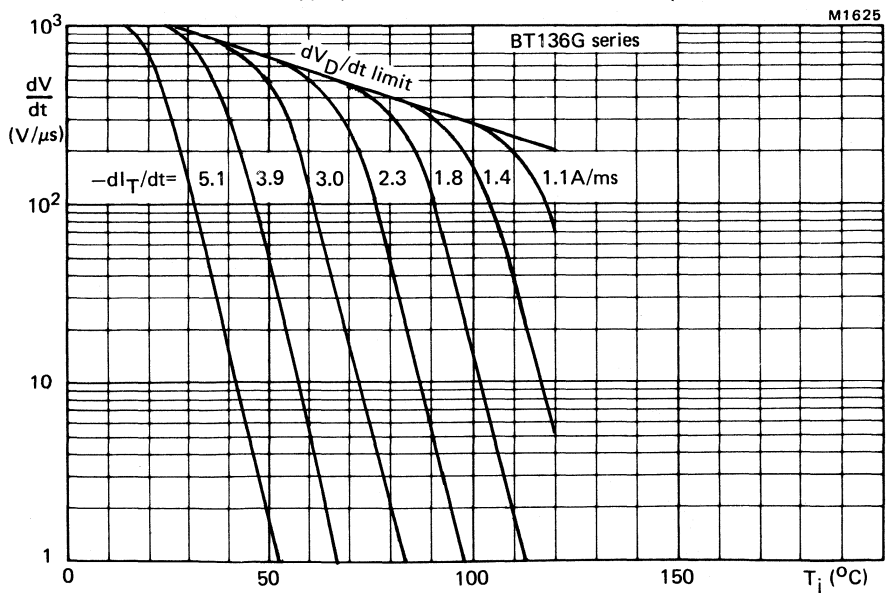


Fig.10 Limit commutation  $dV/dt$  for BT136G series versus  $T_j$ . The triac should commute when the  $dV/dt$  is below the value on the appropriate curve for pre-commutation  $di_T/dt$ .

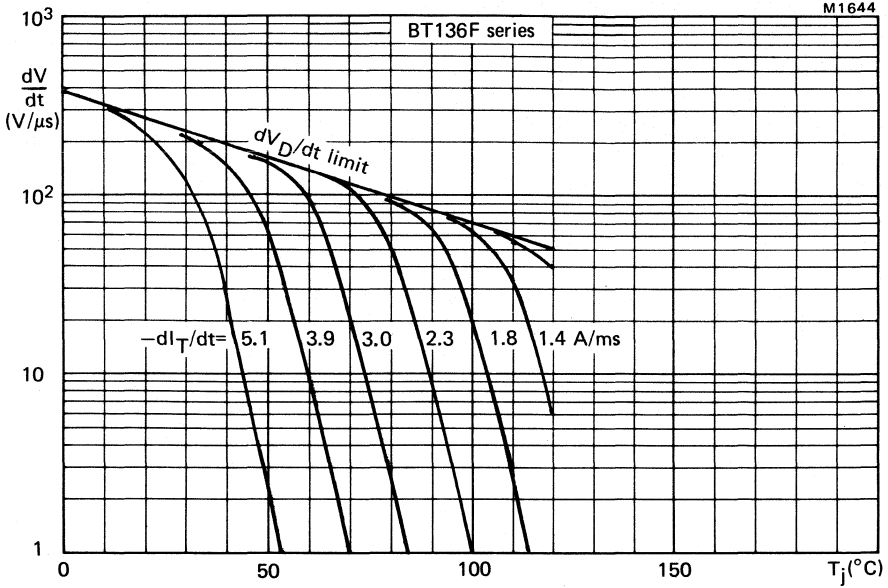


Fig.11 Typical commutation  $dV/dt$  for BT136F series versus  $T_j$ . The triac should commute when the  $dV/dt$  is below the value on the appropriate curve for pre-commutation  $di_T/dt$ .

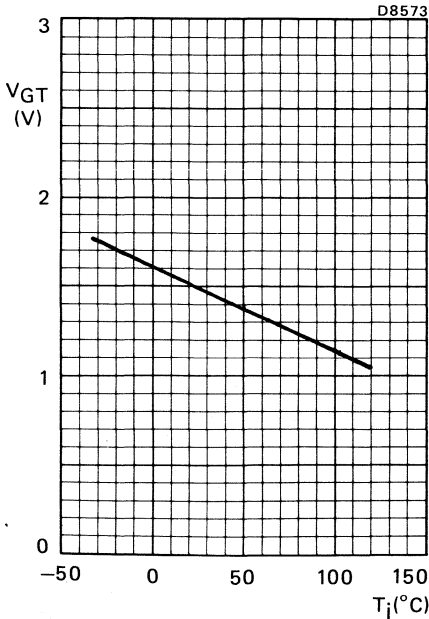


Fig.12 Minimum gate voltage that will trigger all devices; all conditions.

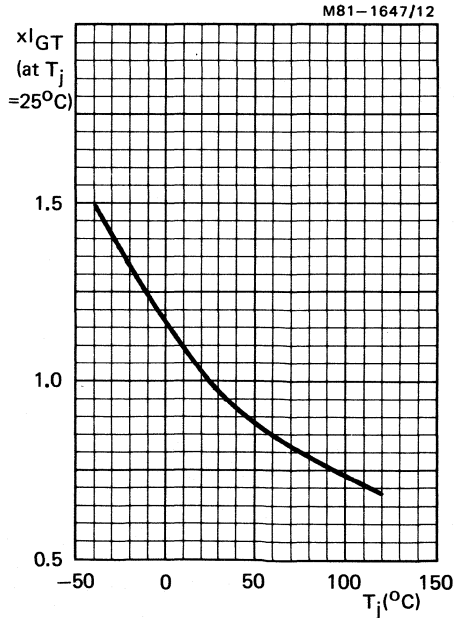


Fig.13 Normalised gate current that will trigger all devices; all conditions.





## 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.

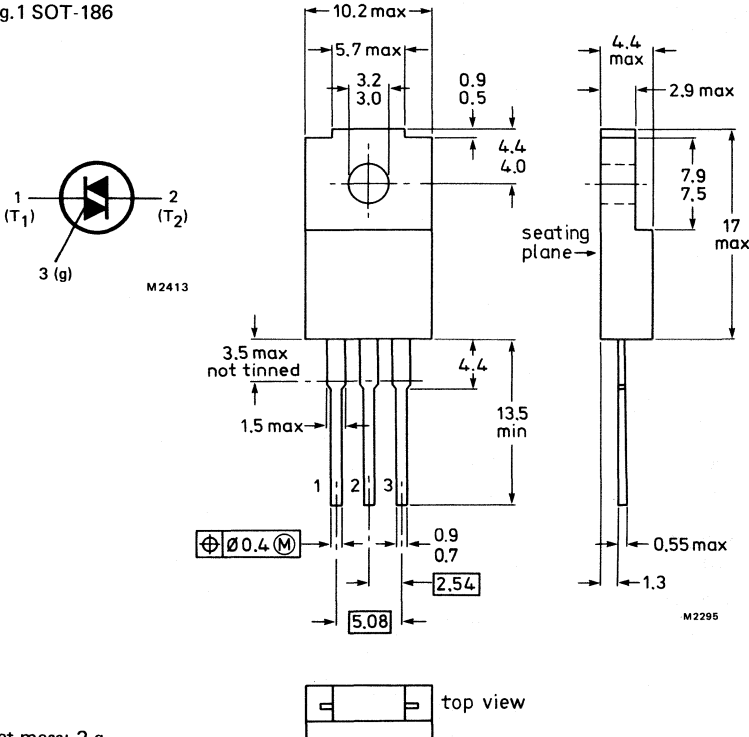
### QUICK REFERENCE DATA

		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 $360^\circ$ ) up to $T_h = 86^\circ C$	$I_T(RMS)$	max.		4	A
Repetitive peak on-state current	$I_{TRM}$	max.		25	A
Non-repetitive peak on-state current; $T_j = 120^\circ C$ prior to surge; $t = 20$ ms; full sine-wave	$I_{TSM}$	max.		25	A
$I^2 t$ for fusing ( $t = 10$ ms)	$I^2 t$	max.		4	$A^2 s$
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/ $\mu s$	$dI_T/dt$	max.		10	A/ $\mu s$

*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	$^\circ C$
Operating junction temperature full-cycle operation	$T_j$	max.		120	$^\circ C$
half-cycle operation	$T_j$	max.		110	$^\circ C$

**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/ $\mu s$ .

**THERMAL RESISTANCE**

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from junction to external heatsink

With heatsink compound

$$R_{th\ j-h} = 5.5\ K/W$$

Without heatsink compound

$$R_{th\ j-h} = 7.2\ K/W$$

2. Free-air operation

The quoted values of  $R_{th\ j-a}$  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

$$R_{th\ j-a} = 55\ K/W$$

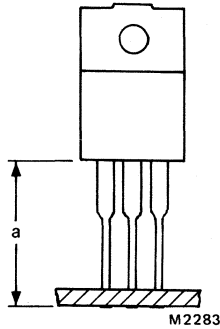


Fig.2.

## CHARACTERISTICS ( $T_j = 25\text{ }^\circ\text{C}$ 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)

$I_T = 5\text{ A}$   $V_T < 1.70\text{ V}$

Rate of rise of off-state voltage that will not trigger

any device;  $T_j = 120\text{ }^\circ\text{C}$ ; gate open circuit

BT136F series	$dV_D/dt <$	$100$	$V/\mu\text{s}$
BT136F series G	$dV_D/dt <$	$200$	$V/\mu\text{s}$
BT136F series F	$dV_D/dt <$	$50$	$V/\mu\text{s}$
BT136F series E	$dV_D/dt \text{ typ.}$	$50$	$V/\mu\text{s}$
BT136F-500D	$dV_D/dt \text{ typ.}$	$5$	$V/\mu\text{s}$

Rate of change of commutating voltage that will not

trigger any device when  $-di_{com}/dt = 1.8\text{ A/ms}$ ;

$I_T(\text{RMS}) = 4\text{ A}$ ;  $T_h = 70\text{ }^\circ\text{C}$ ; gate open circuit;  $V_D = V_{DWM\text{max}}$

BT136F series	$dV_{com}/dt \text{ typ.}$	$10$	$V/\mu\text{s}$
BT136F series G	$dV_{com}/dt <$	$10$	$V/\mu\text{s}$
BT136F series F	$dV_{com}/dt \text{ typ.}$	$10$	$V/\mu\text{s}$

Off-state current

$V_D = V_{DWM\text{max}}$ ;  $T_j = 120\text{ }^\circ\text{C}$

$I_D < 0.5\text{ mA}$

Gate voltage that will trigger all devices

$V_{GT} > 1.5\text{ V}$

Gate voltage that will not trigger any device

$V_D = V_{DWM\text{max}}$ ;  $T_j = 120\text{ }^\circ\text{C}$ ;

$T_2$  and G positive or negative

$V_{GD} < 250\text{ mV}$

Gate current that will trigger all devices ( $I_{GT}$ ); G to  $T_1$

Holding current ( $I_H$ )

	$T_2^+$	$T_2^+$	$T_2^-$	$T_2^-$
	G+	G-	G-	G+

Latching current ( $I_L$ );  $V_D = 12\text{ V}$

			$T_2^+$	$T_2^+$	$T_2^-$	$T_2^-$	
			G+	G-	G-	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 °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  $R_{th\ j-h}$  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  $R_{th\ j-h}$  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.

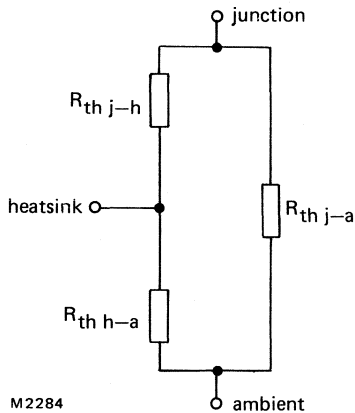


Fig.3.

- b. The method of using Figs.4 and 5 is as follows:

Starting with the required current on the  $I_T(\text{RMS})$  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  $R_{th\ h-a}$ , required heatsink thermal resistance.

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

FULL-WAVE CONDUCTION (with heatsink compound)

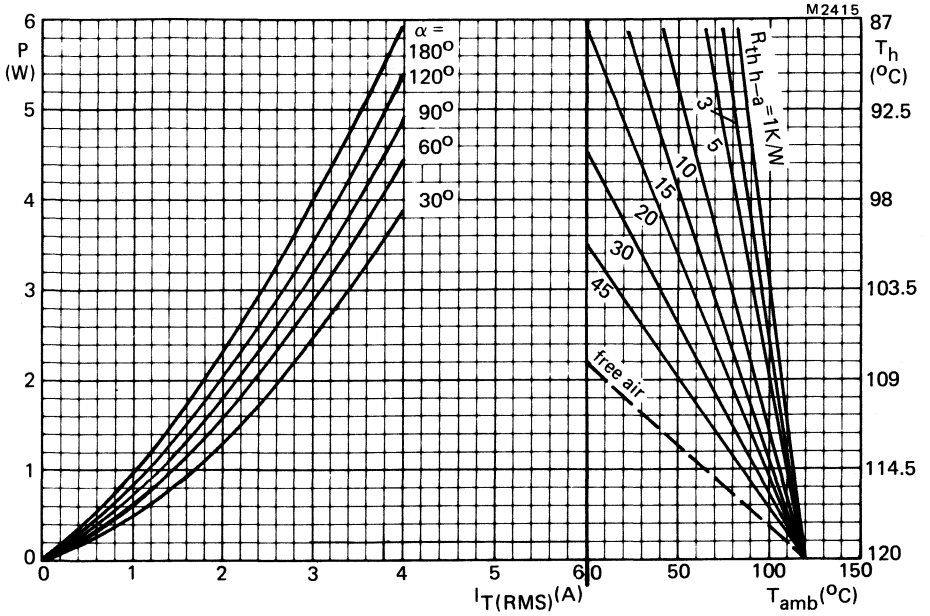
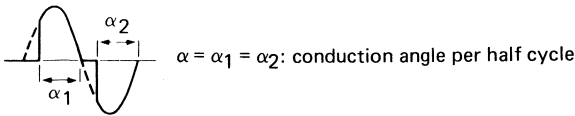


Fig.4 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



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)

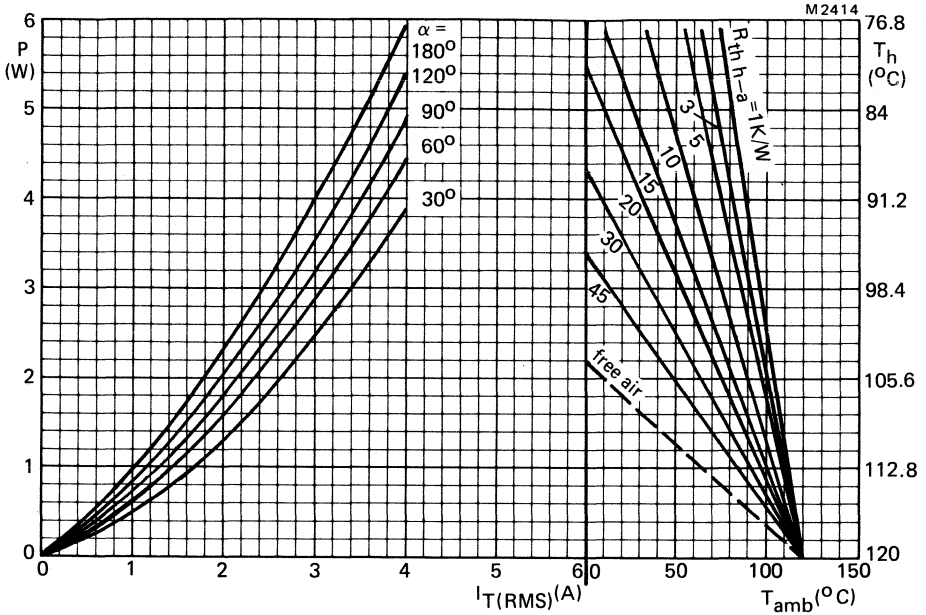
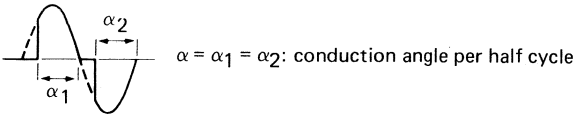


Fig.5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



Note: For the type BT136F-500D only, any operating point derived from Fig.5 should be derated by a further 10 °C.

OVERLOAD OPERATION

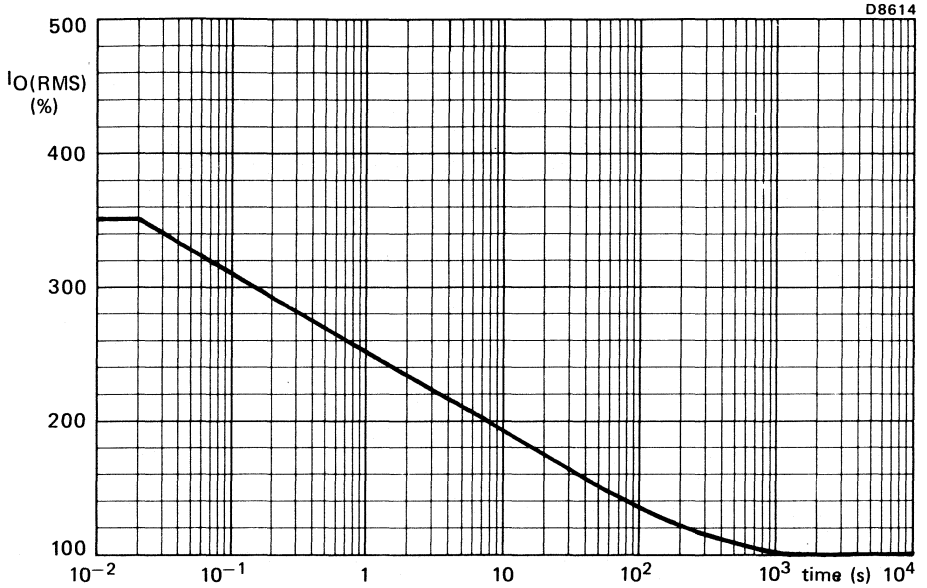


Fig.6 Maximum permissible duration of steady overload (provided that  $T_h$  does not exceed  $120^\circ\text{C}$  during and after overload) expressed as a percentage of the steady state r.m.s. rated current. For high r.m.s. overload currents precautions should be taken so that the temperature of the terminals does not exceed  $125^\circ\text{C}$ . During these overload conditions the triac may lose control. Therefore the overload should be terminated by a separate protection device.



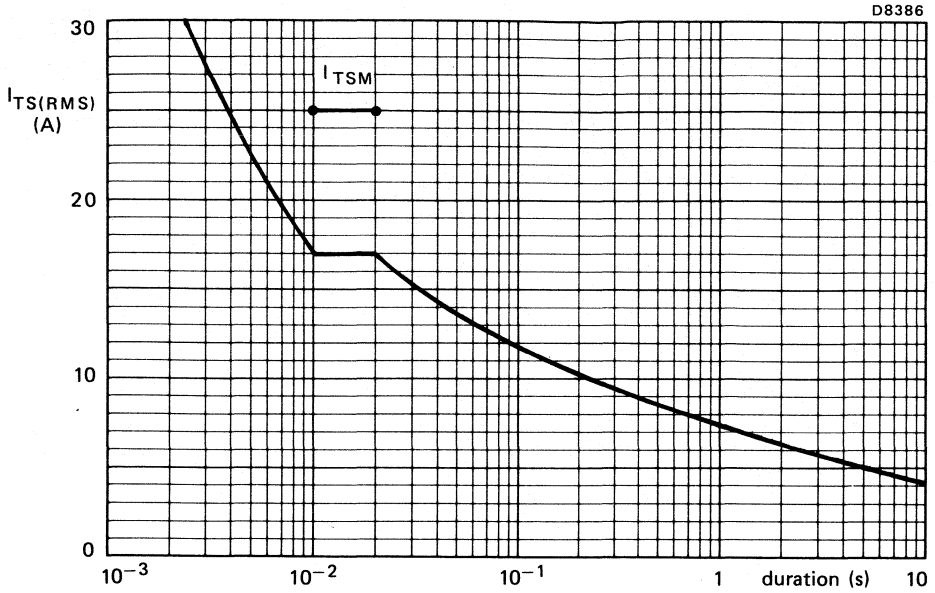


Fig.7 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents ( $f = 50$  Hz);  $T_j = 120$  °C prior to surge. The triac may temporarily lose control following the surge.

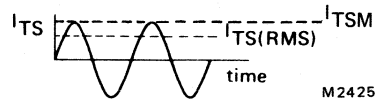
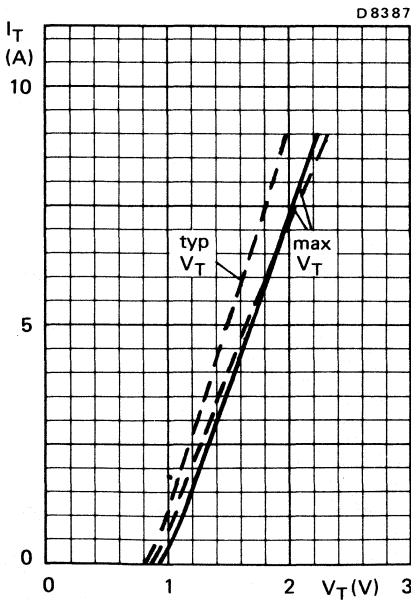


Fig.8 —  $T_j = 25$  °C; ---  $T_j = 120$  °C.

M2416

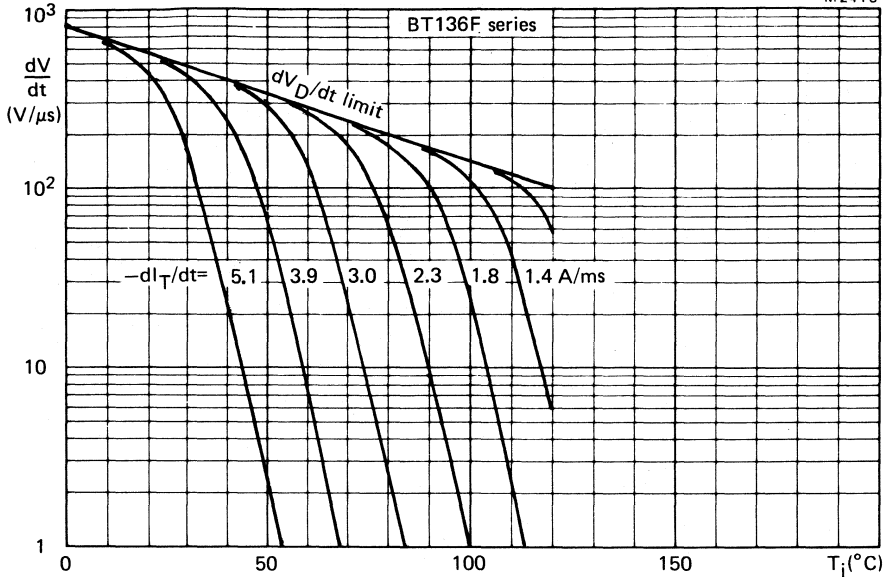


Fig.9 Typical commutation  $dV/dt$  for BT136F series versus  $T_j$ . The triac should commute when the  $dV/dt$  is below the value on the appropriate curve for pre-commutation  $di_T/dt$ .

M2417

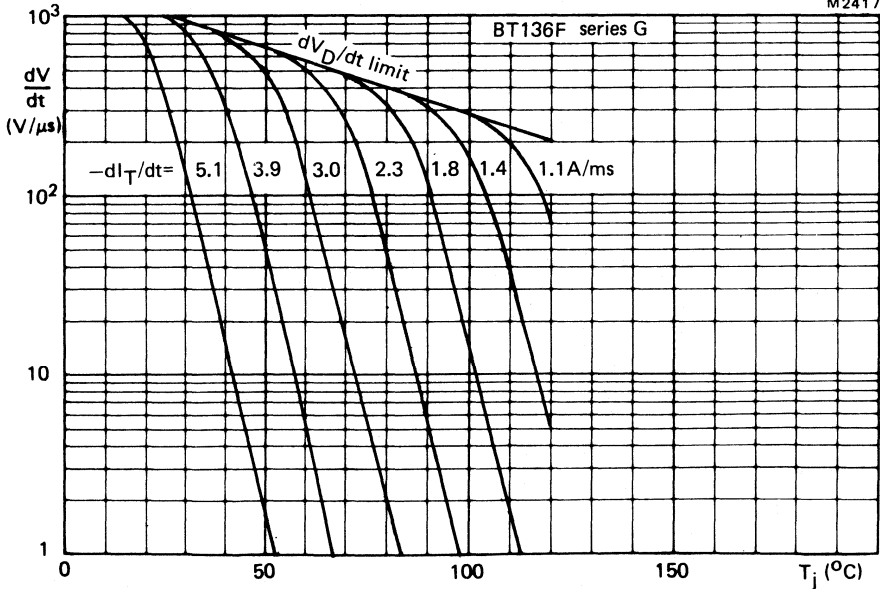


Fig.10 Limit commutation  $dV/dt$  for BT136F series G versus  $T_j$ . The triac should commute when the  $dV/dt$  is below the value on the appropriate curve for pre-commutation  $di_T/dt$ .

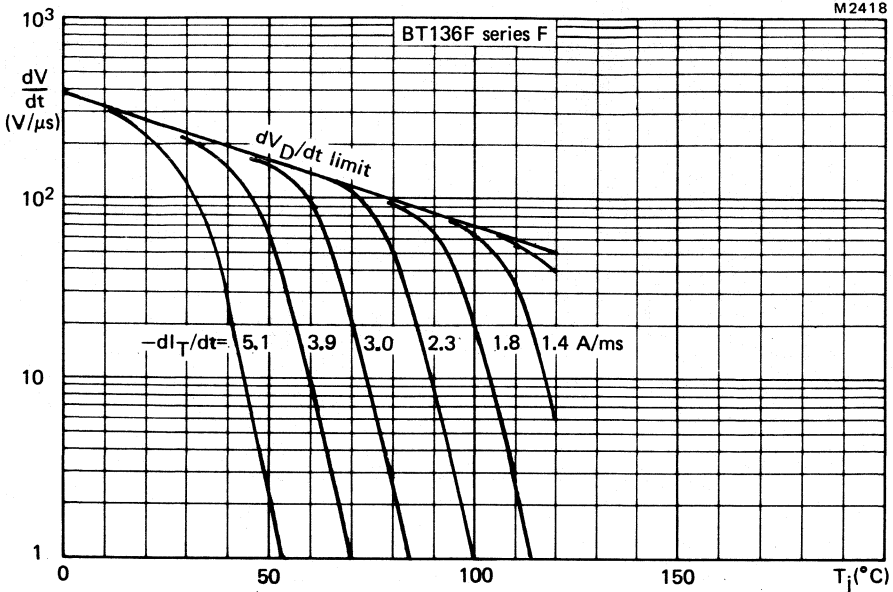


Fig.11 Typical commutation  $dV/dt$  for BT136F series F versus  $T_j$ . The triac should commute when the  $dV/dt$  is below the value on the appropriate curve for pre-commutation  $di_T/dt$ .

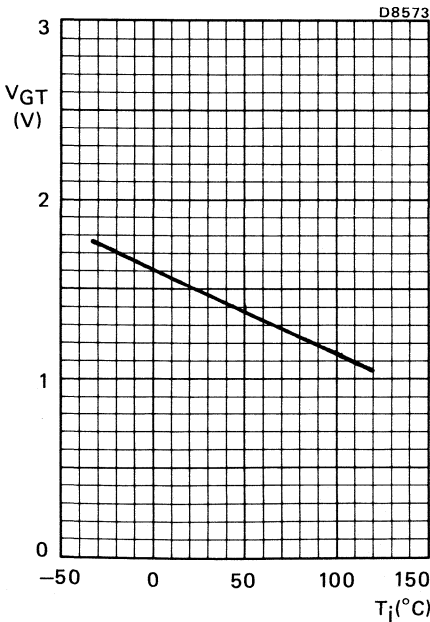


Fig.12 Minimum gate voltage that will trigger all devices; all conditions.

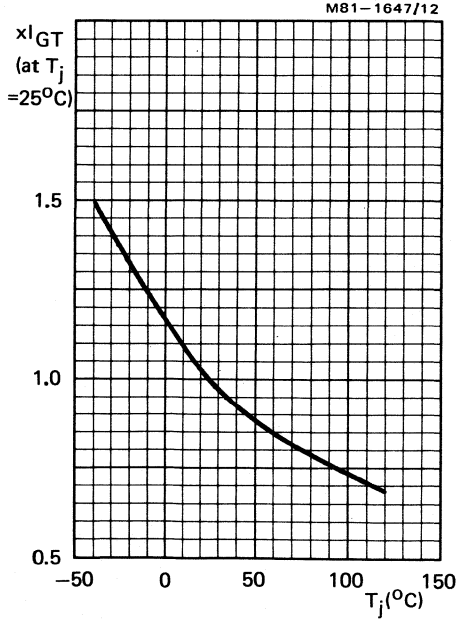


Fig.13 Normalised gate current that will trigger all devices; all conditions.

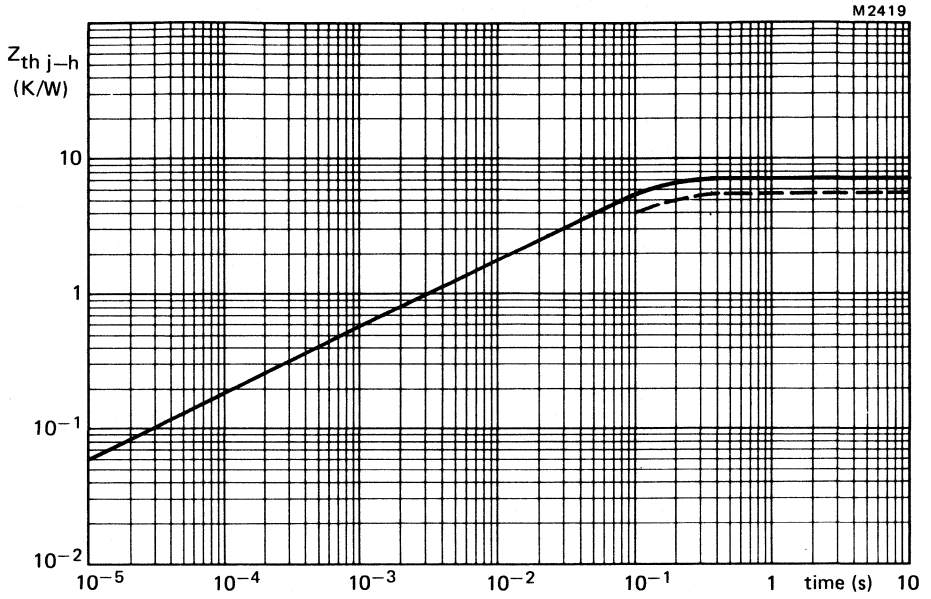


Fig.14 Transient thermal impedance, - - - with heatsink compound; — without heatsink compound.

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.

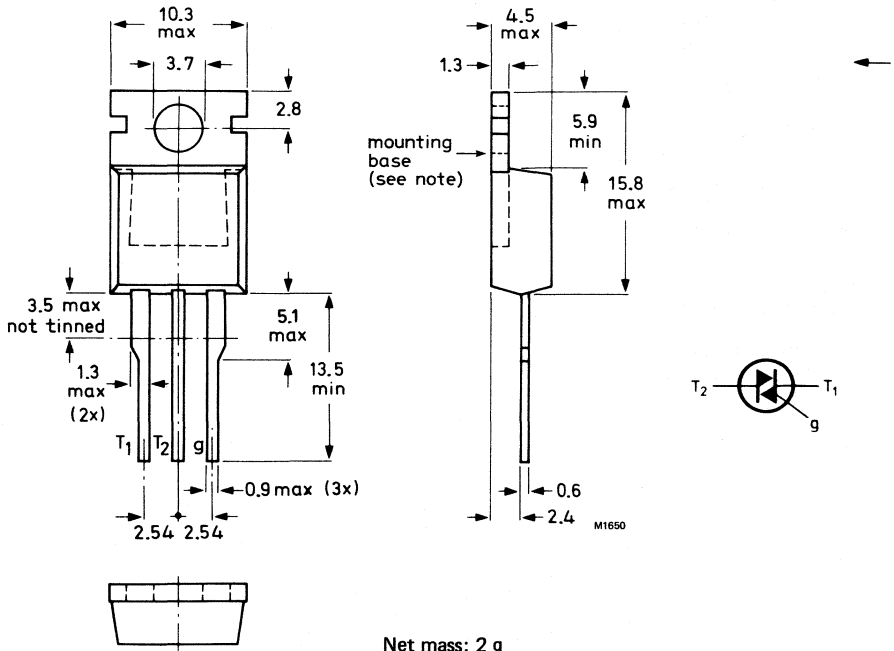
QUICK REFERENCE DATA

		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
<b>Currents (in either direction)</b>					
R.M.S. on-state current (conduction angle $360^\circ$ ) up to $T_{mb} = 97^\circ\text{C}$	$I_{T(RMS)}$	max.	8		A
Repetitive peak on-state current	$I_{TRM}$	max.	55		A
Non-repetitive peak on-state current; $T_j = 120^\circ\text{C}$ prior to surge; $t = 20$ ms; full sine-wave	$I_{TSM}$	max.	55		A
$I^2 t$ for fusing ( $t = 10$ ms)	$I^2 t$	max.	15		$A^2 s$
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/ $\mu s$	$di_T/dt$	max.	20		A/ $\mu s$
<i>Gate to terminal 1</i>					
<b>POWER DISSIPATION</b>					
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	0.5		W
Peak power dissipation	$P_{GM}$	max.	5		W
<b>Temperatures</b>					
Storage temperature	$T_{stg}$		-40 to +125		$^\circ\text{C}$
Operating junction temperature					
full-cycle operation	$T_j$	max.	120		$^\circ\text{C}$
half-cycle operation	$T_j$	max.	110		$^\circ\text{C}$

\*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/ $\mu s$ .

**THERMAL RESISTANCE**

From junction to mounting base

full-cycle operation

$$R_{th\ j-mb} = 2.0\ K/W$$

half-cycle operation

$$R_{th\ j-mb} = 2.4\ K/W$$

Transient thermal impedance;  $t = 1\ ms$ 

$$Z_{th\ j-mb} = 0.3\ K/W$$

**Influence of mounting method**

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from mounting base to heatsink

a. with heatsink compound

$$R_{th\ mb-h} = 0.3\ K/W$$

b. with heatsink compound and 0.06 mm maximum mica insulator

$$R_{th\ mb-h} = 1.4\ K/W$$

c. with heatsink compound and 0.1 mm max. mica insulator (56369)

$$R_{th\ mb-h} = 2.2\ K/W$$

d. with heatsink compound and 0.25 mm max. alumina insulator (56367)

$$R_{th\ mb-h} = 0.8\ K/W$$

e. without heatsink compound

$$R_{th\ mb-h} = 1.4\ K/W$$

2. Free-air operation

The quoted values of  $R_{th\ j-a}$  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

$$R_{th\ j-a} = 60\ K/W$$

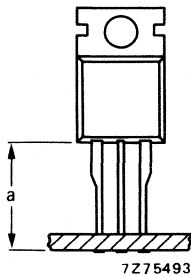


Fig.2

## CHARACTERISTICS (T<sub>j</sub> = 25 °C unless otherwise stated)

Polarities, positive or negative, are identified with respect to T<sub>1</sub>.

### Voltages and currents (in either direction)

On-state voltage (measured under pulse conditions to prevent excessive dissipation)

$$I_T = 10 \text{ A} \qquad V_T < 1.65 \text{ V}$$

Rate of rise of off-state voltage that will not trigger

any device; T<sub>j</sub> = 120 °C; gate open circuit

BT137 series	dV <sub>D</sub> /dt	<	100	V/μs
BT137 series G	dV <sub>D</sub> /dt	<	200	V/μs
BT137 series F	dV <sub>D</sub> /dt	<	50	V/μs
BT137 series E	dV <sub>D</sub> /dt	typ.	50	V/μs
BT137 - 500D	dV <sub>D</sub> /dt	typ.	5	V/μs

Rate of change of commutating voltage that will not

trigger any device when -di<sub>com</sub>/dt = 3.6 A/ms;

I<sub>T(RMS)</sub> = 8 A; T<sub>mb</sub> = 70 °C; gate open circuit ; V<sub>D</sub> = V<sub>DWMmax</sub>

BT137 series	dV <sub>com</sub> /dt	typ.	10	V/μs
BT137 series G	dV <sub>com</sub> /dt	<	10	V/μs
BT137 series F	dV <sub>com</sub> /dt	typ.	10	V/μs

Off-state current

V<sub>D</sub> = V<sub>DWMmax</sub>; T<sub>j</sub> = 120 °C

$$I_D < 0.5 \text{ mA}$$

Gate voltage that will trigger all devices

$$V_{GT} > 1.5 \text{ V}$$

Gate voltage that will not trigger any device

V<sub>D</sub> = V<sub>DWMmax</sub>; T<sub>j</sub> = 120 °C;

T<sub>2</sub> and G positive or negative

$$V_{GD} < 250 \text{ mV}$$

Gate current that will trigger all devices (I<sub>GT</sub>); G to T<sub>1</sub>

Holding current (I<sub>H</sub>)

T <sub>2</sub> <sup>+</sup> G <sup>+</sup>	T <sub>2</sub> <sup>+</sup> G <sup>-</sup>	T <sub>2</sub> <sup>-</sup> G <sup>-</sup>	T <sub>2</sub> <sup>-</sup> G <sup>+</sup>
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Latching current (I<sub>L</sub>); V<sub>D</sub> = 12 V

	I <sub>GT</sub>	>	35	35	35	70	mA
BT137 series	I <sub>H</sub>	<	20	20	20	20	mA
	I <sub>L</sub>	<	30	45	30	45	mA
	I <sub>GT</sub>	>	50	50	50	100	mA
BT137 series G	I <sub>H</sub>	<	40	40	40	40	mA
	I <sub>L</sub>	<	45	60	45	60	mA
	I <sub>GT</sub>	>	25	25	25	70	mA
BT137 series F	I <sub>H</sub>	<	20	20	20	20	mA
	I <sub>L</sub>	<	30	45	30	45	mA
	I <sub>GT</sub>	>	10	10	10	25	mA
BT137 series E	I <sub>H</sub>	<	20	20	20	20	mA
	I <sub>L</sub>	<	25	35	25	35	mA
	I <sub>GT</sub>	>	5	5	5	10	mA
BT137 - 500D	I <sub>H</sub>	<	15	15	15	15	mA
	I <sub>L</sub>	<	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 °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<sub>2</sub>, 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  $R_{th\ mb-h}$  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  $R_{th\ mb-h}$  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.

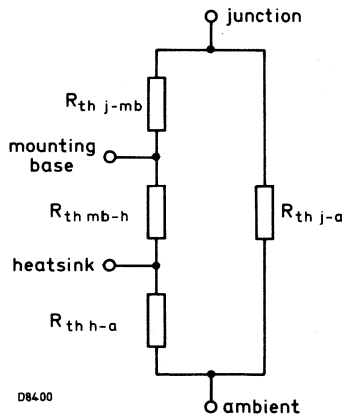


Fig.3.

- 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  $R_{th\ mb-a}$ . The heatsink thermal resistance value ( $R_{th\ h-a}$ ) can now be calculated from:

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

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

FULL-CYCLE OPERATION

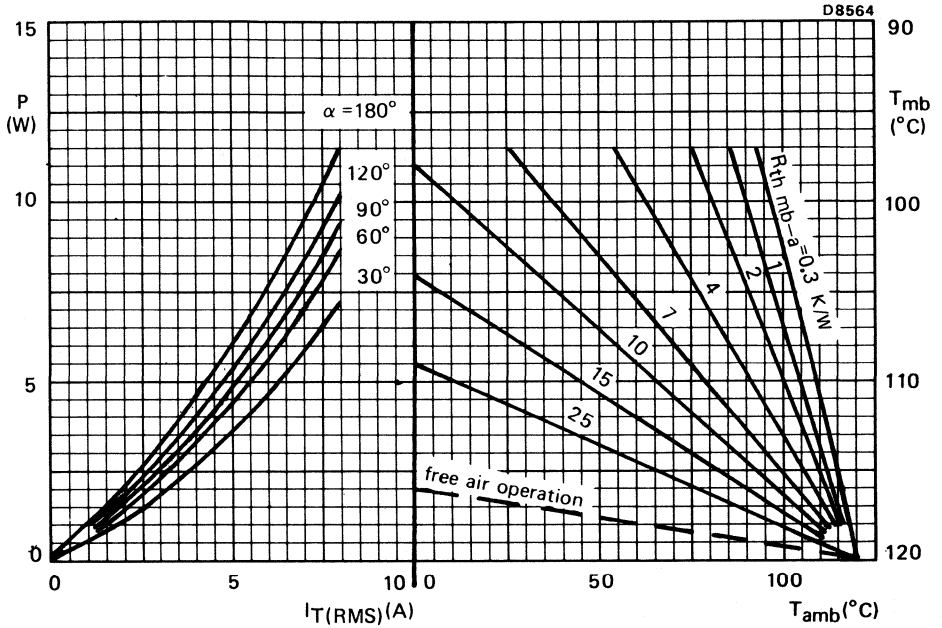
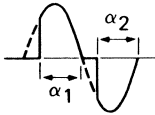


Fig.4 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha = \alpha_1 = \alpha_2$ : 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  $10^{\circ}C$ .

## OVERLOAD OPERATION

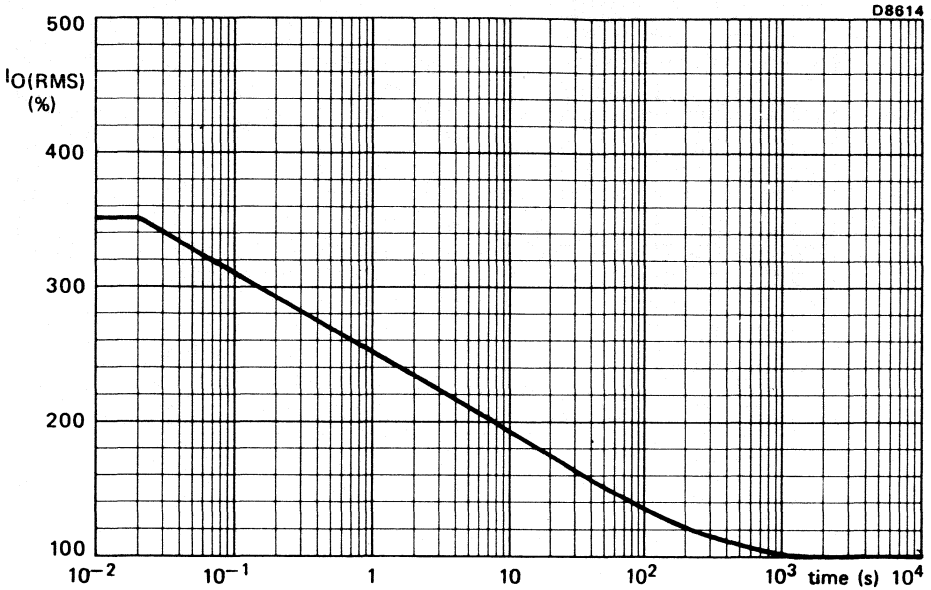


Fig. 5 Maximum permissible duration of steady overload (provided that  $T_{mb}$  does not exceed  $120^\circ\text{C}$  during and after overload) expressed as a percentage of the steady state r.m.s. rated current. For high r.m.s. overload currents precautions should be taken so that the temperature of the terminals does not exceed  $125^\circ\text{C}$ . During these overload conditions the triac may lose control. Therefore the overload should be terminated by a separate protection device.

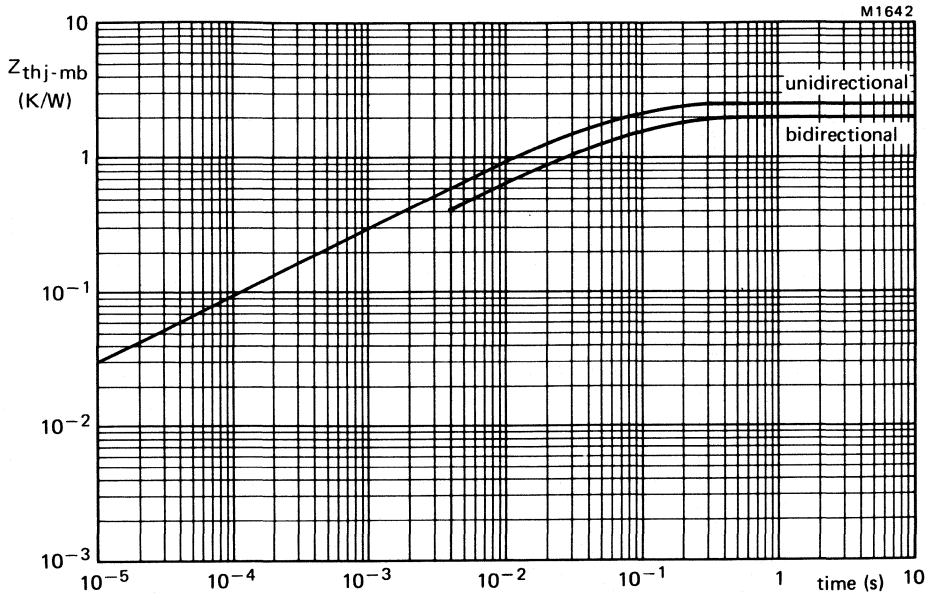


Fig. 6

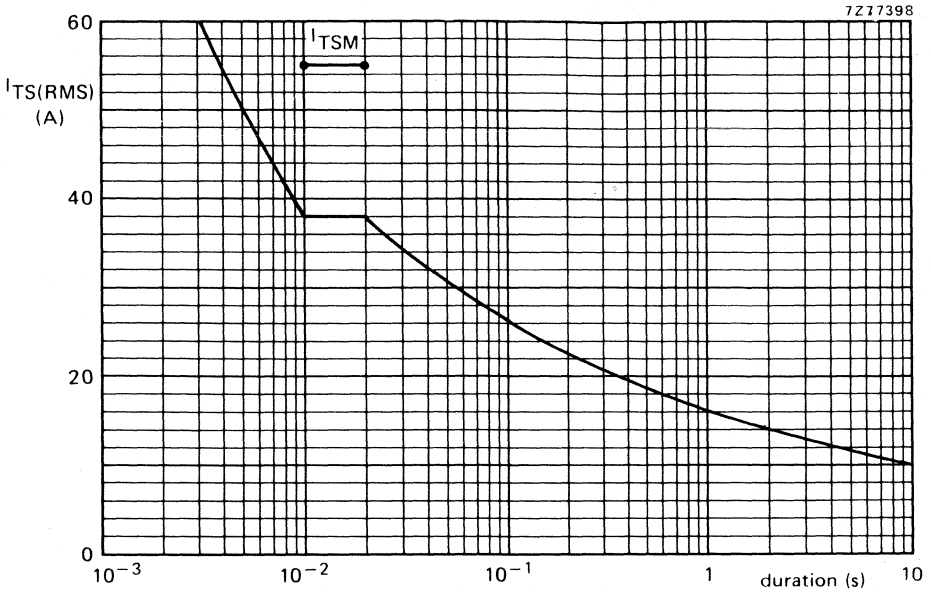


Fig.7 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents ( $f = 50$  Hz);  $T_j = 120$  °C prior to surge. The triac may temporarily lose control following the surge.

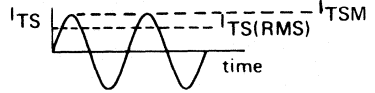
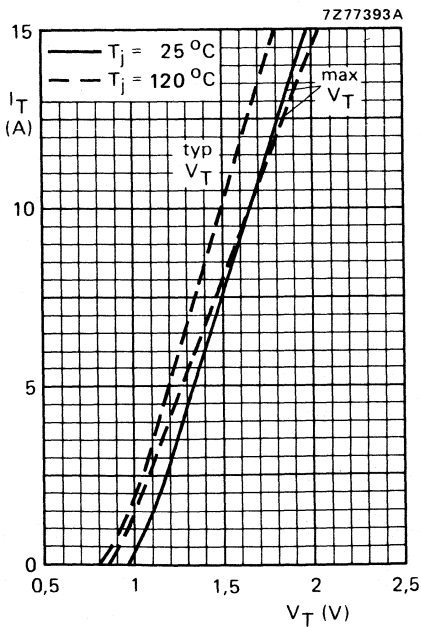


Fig.8

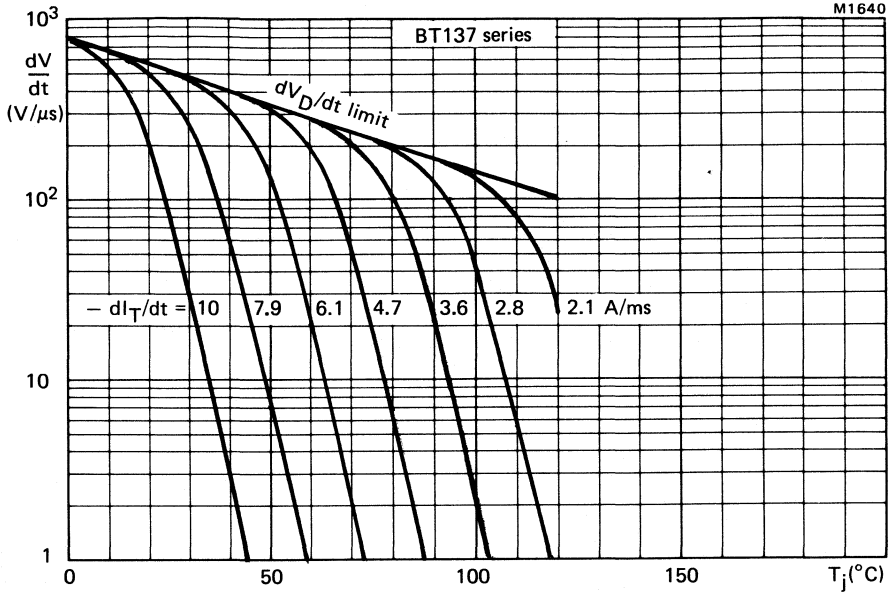


Fig.9 Typical commutation  $dV/dt$  for BT137 series versus  $T_j$ . The triac should commute when the  $dV/dt$  is below the value on the appropriate curve for pre-commutation  $di_T/dt$ .

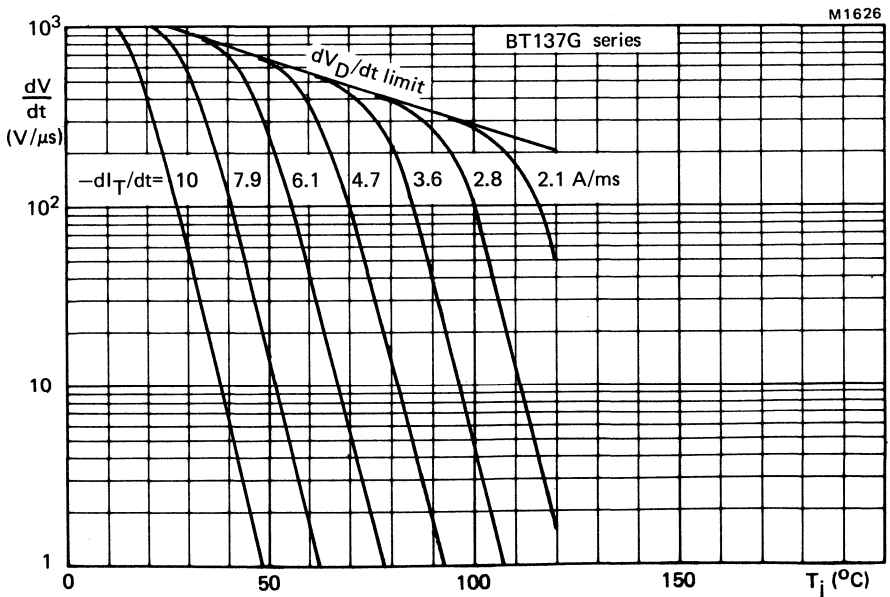


Fig.10 Limit commutation  $dV/dt$  for BT137G series versus  $T_j$ . The triac should commute when the  $dV/dt$  is below the value on the appropriate curve for pre-commutation  $di_T/dt$ .

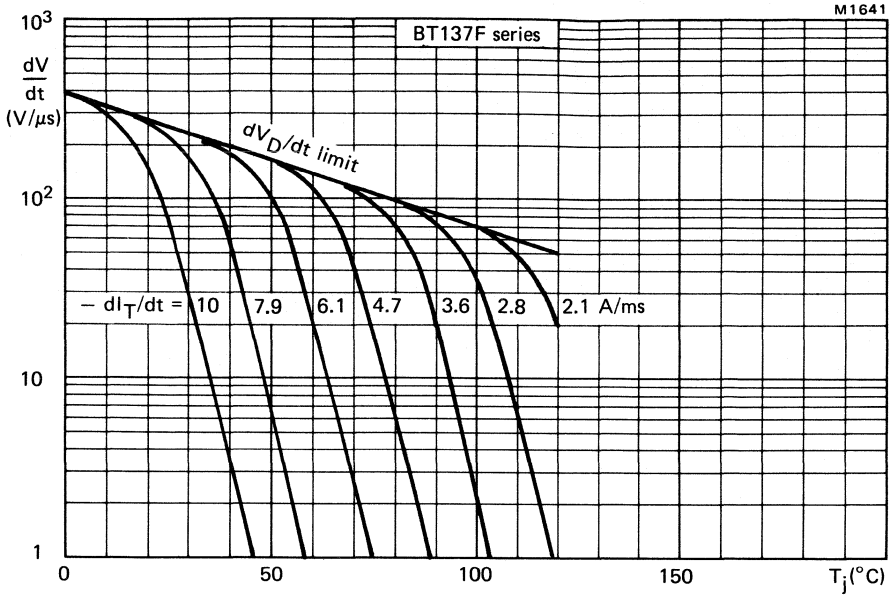


Fig.11 Typical commutation  $dV/dt$  for BT137F series versus  $T_j$ . The triac should commute when the  $dV/dt$  is below the value on the appropriate curve for pre-commutation  $dI_T/dt$ .

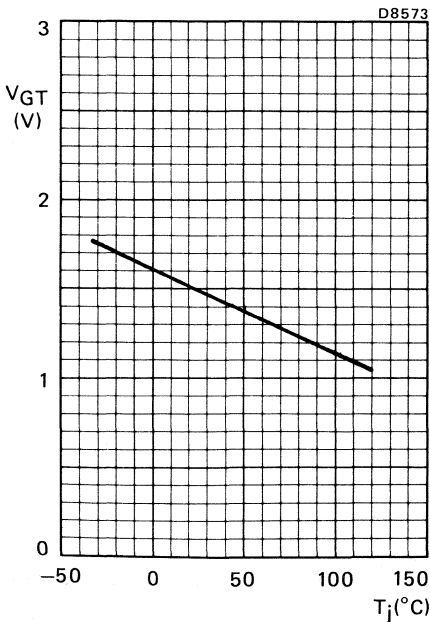


Fig.12 Minimum gate voltage that will trigger all devices; all conditions.

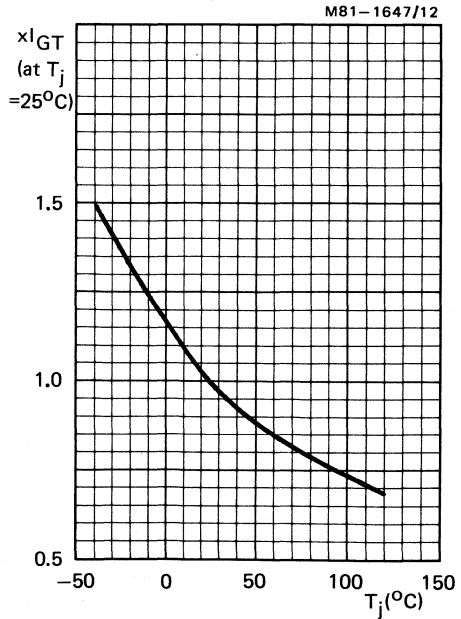


Fig.13 Normalised gate current that will trigger all devices; all conditions.





## FULL-PACK TRIACS

Glass-passivated 8 Ampere triacs in SOT-186 envelopes, which feature an electrically isolated seating 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.

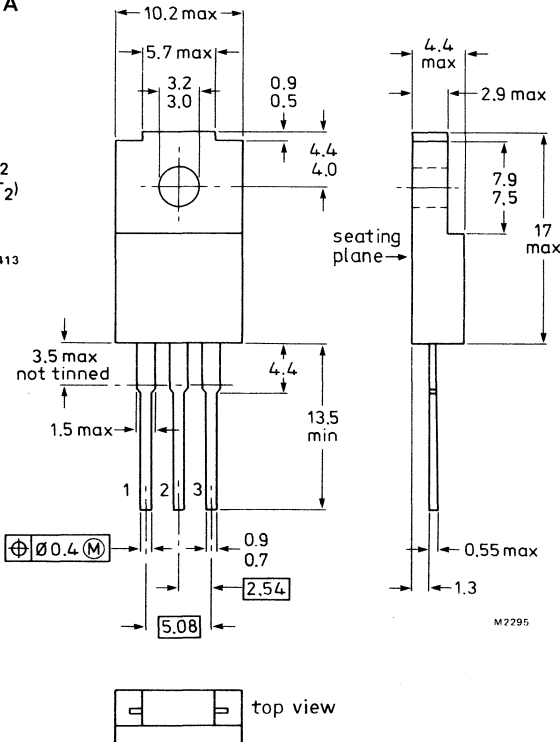
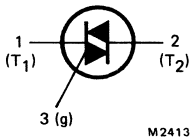
### QUICK REFERENCE DATA

		BT137F-500			V
		500	600	800	
Repetitive peak off-state voltage	$V_{DRM}$	max. 500	600	800	
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

Fig.1 SOT-186

Dimensions in mm



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 ( $t \leq 10$ 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 $360^\circ$ ) up to $T_h = 71^\circ\text{C}$	$I_T(\text{RMS})$	max.		8	A
Repetitive peak on-state current	$I_{TRM}$	max.		55	A
Non-repetitive peak on-state current; $T_j = 120^\circ\text{C}$ prior to surge; $t = 20$ ms; full sine-wave	$I_{TSM}$	max.		55	A
$I^2 t$ for fusing ( $t = 10$ ms)	$I^2 t$	max.		15	$\text{A}^2\text{s}$
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/ $\mu\text{s}$	$dI_T/dt$	max.		20	A/ $\mu\text{s}$

### 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	$^\circ\text{C}$
Operating junction temperature full-cycle operation	$T_j$	max.		120	$^\circ\text{C}$
half-cycle operation	$T_j$	max.		110	$^\circ\text{C}$

## 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/ $\mu\text{s}$ .

**THERMAL RESISTANCE**

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from junction to external heatsink

With heatsink compound

$$R_{th\ j-h} = 4.5\ K/W$$

Without heatsink compound

$$R_{th\ j-h} = 6.5\ K/W$$

2. Free-air operation

The quoted values of  $R_{th\ j-a}$  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

$$R_{th\ j-a} = 55\ K/W$$

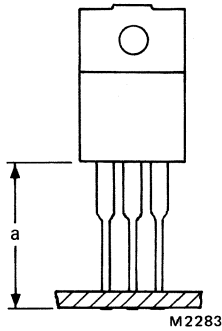


Fig.2.

**CHARACTERISTICS** ( $T_j = 25\text{ }^\circ\text{C}$  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)

$I_T = 10\text{ A}$	$V_T$	<	1.65	V
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Rate of rise of off-state voltage that will not trigger any device;  $T_j = 120\text{ }^\circ\text{C}$ ; gate open circuit

BT137F series	$dV_D/dt$	<	100	V/ $\mu\text{s}$
BT137F series G	$dV_D/dt$	<	200	V/ $\mu\text{s}$
BT137F series F	$dV_D/dt$	<	50	V/ $\mu\text{s}$
BT137F series E	$dV_D/dt$	typ.	50	V/ $\mu\text{s}$
BT137F-500D	$dV_D/dt$	typ.	5	V/ $\mu\text{s}$

Rate of change of commutating voltage that will not trigger any device when  $-di_{com}/dt = 3.6\text{ A/ms}$ ;

$I_T(\text{RMS}) = 8\text{ A}$ ; $T_h = 54\text{ }^\circ\text{C}$ ; gate open circuit; $V_D = V_{DWM\text{max}}$				
BT137F series	$dV_{com}/dt$	typ.	10	V/ $\mu\text{s}$
BT137F series G	$dV_{com}/dt$	<	10	V/ $\mu\text{s}$
BT137F series F	$dV_{com}/dt$	typ.	10	V/ $\mu\text{s}$

Off-state current

$V_D = V_{DWM\text{max}}$ ; $T_j = 120\text{ }^\circ\text{C}$	$I_D$	<	0.5	mA
---	-------	---	-----	----

Gate voltage that will trigger all devices

$V_{GT}$	>	1.5	V
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Gate voltage that will not trigger any device

$V_D = V_{DWM\text{max}}$ ; $T_j = 120\text{ }^\circ\text{C}$ ; $T_2$ and G positive or negative				
$V_{GD}$	<	250	mV	

Gate current that will trigger all devices ( $I_{GT}$ ); G to  $T_1$

		$T_2^+$ G+	$T_2^+$ G-	$T_2^-$ G-	$T_2^-$ G+	
Holding current ( $I_H$ )						
Latching current ( $I_L$ ); $V_D = 12\text{ V}$						
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  $R_{th\ j-h}$  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  $R_{th\ j-h}$  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.

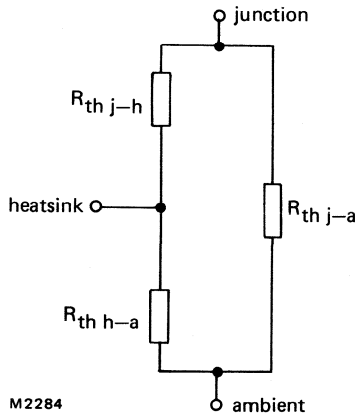


Fig.3.

- 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  $R_{th\ h-a}$ , required heatsink thermal resistance.

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

FULL-WAVE CONDUCTION (with heatsink compound)

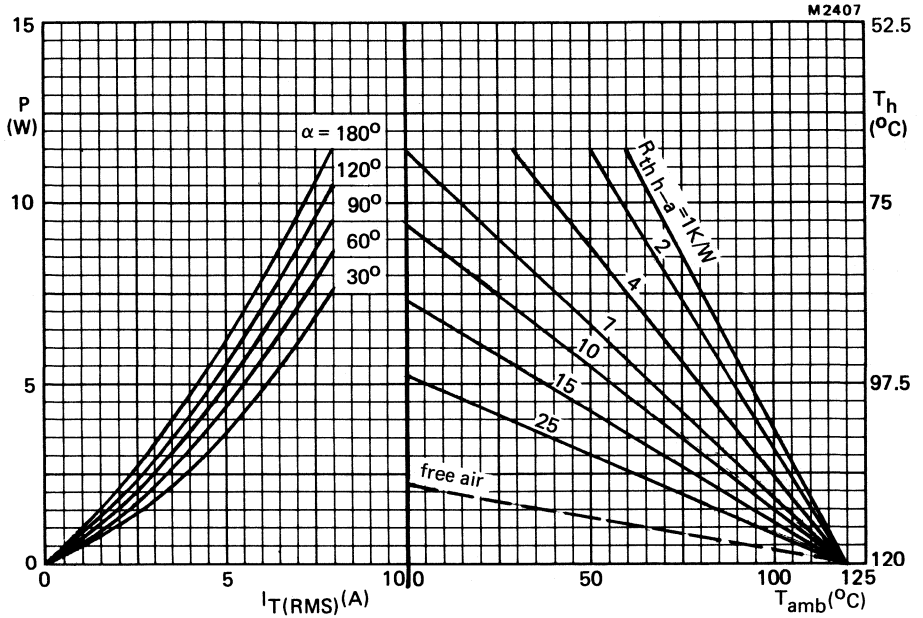
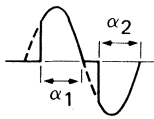


Fig.4 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha = \alpha_1 = \alpha_2$ : 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)

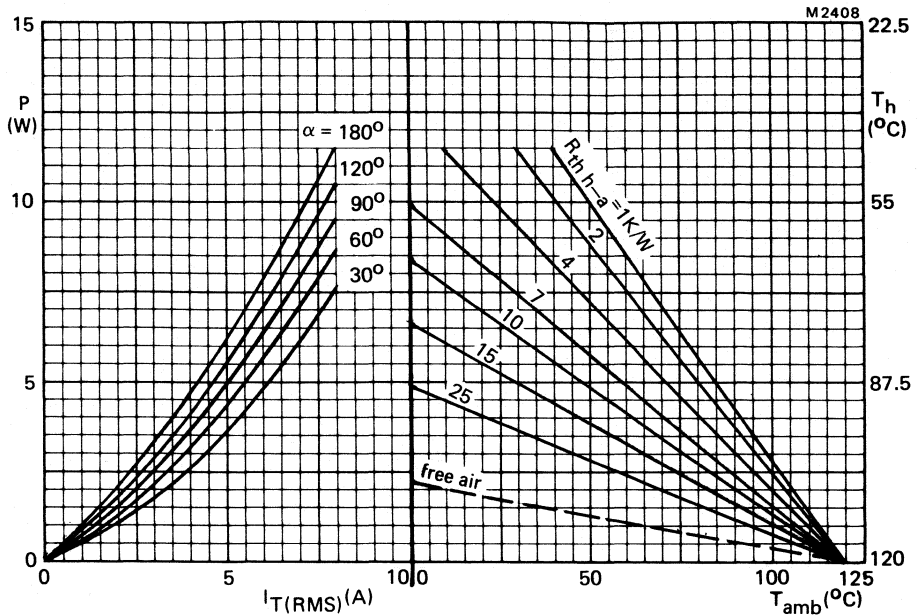
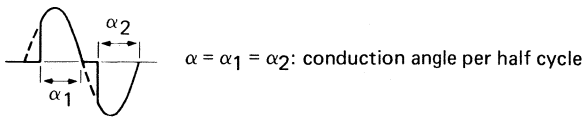


Fig.5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



Note: For the type BT137F-500D only, any operating point derived from Fig.5 should be derated by a further 10 °C.

OVERLOAD OPERATION

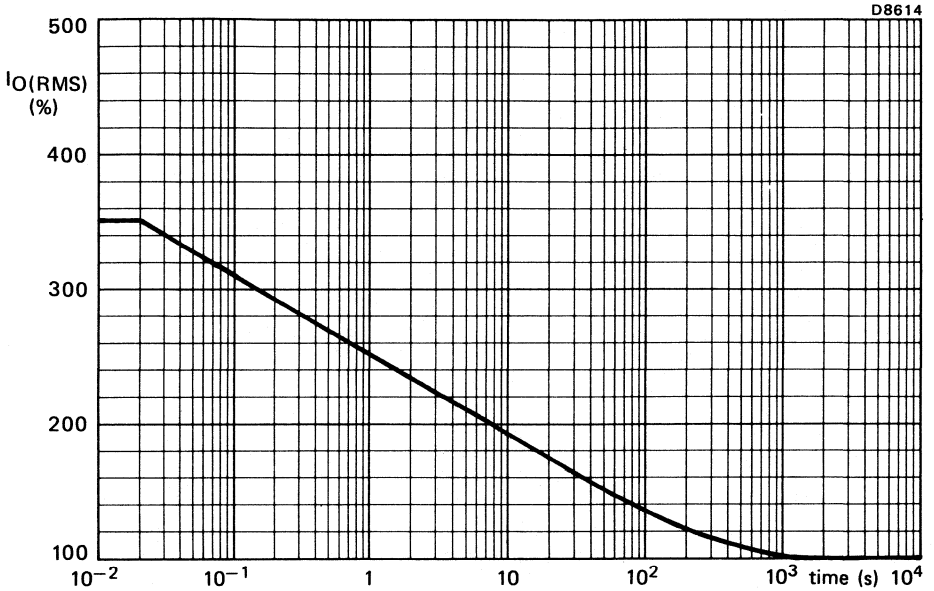


Fig.6 Maximum permissible duration of steady overload (provided that  $T_H$  does not exceed  $120^\circ\text{C}$  during and after overload) expressed as a percentage of the steady state r.m.s. rated current. For high r.m.s. overload currents precautions should be taken so that the temperature of the terminals does not exceed  $125^\circ\text{C}$ . During these overload conditions the triac may lose control. Therefore the overload should be terminated by a separate protection device.



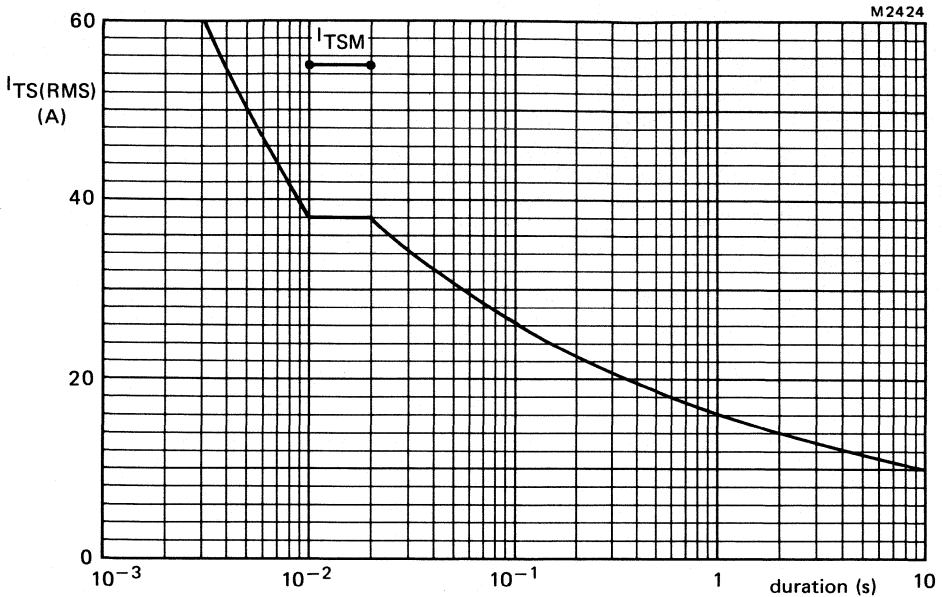


Fig.7 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents ( $f = 50 \text{ Hz}$ ;  $T_j = 120^\circ\text{C}$  prior to surge. The triac may temporarily lose control following the surge.

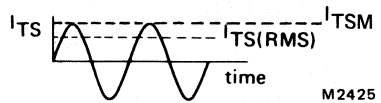
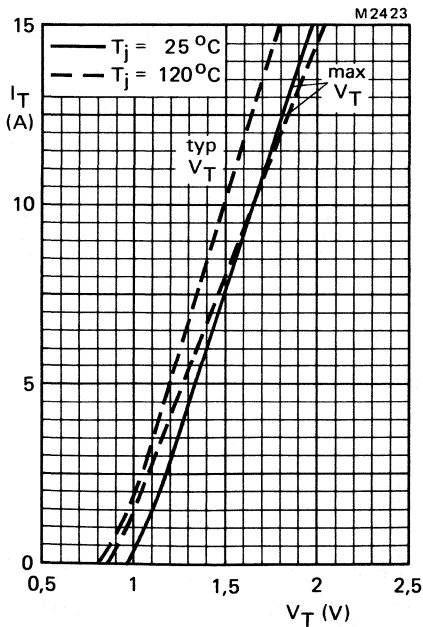


Fig.8.

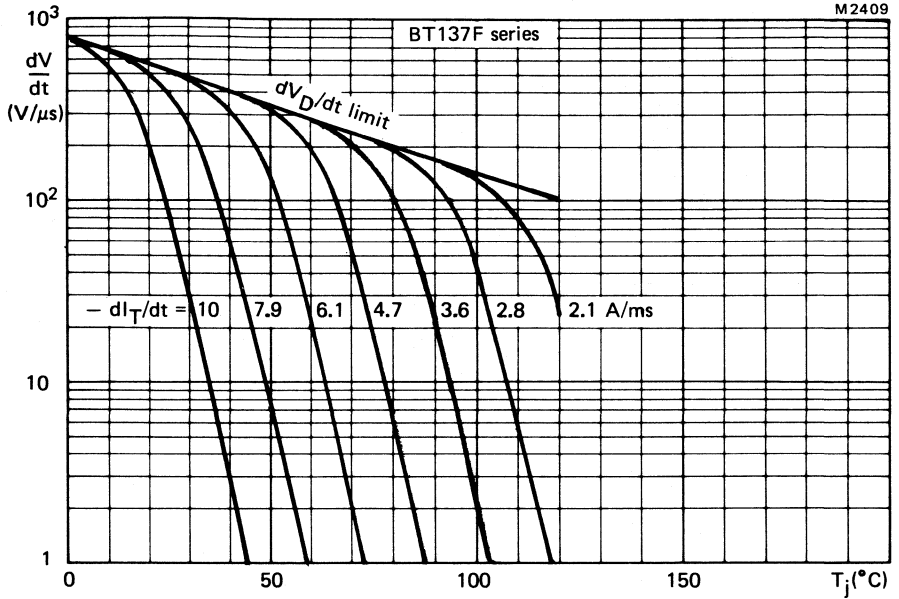


Fig.9 Typical commutation  $dV/dt$  for BT137F series versus  $T_j$ . The triac should commute when the  $dV/dt$  is below the value on the appropriate curve for pre-commutation  $dI_T/dt$ .

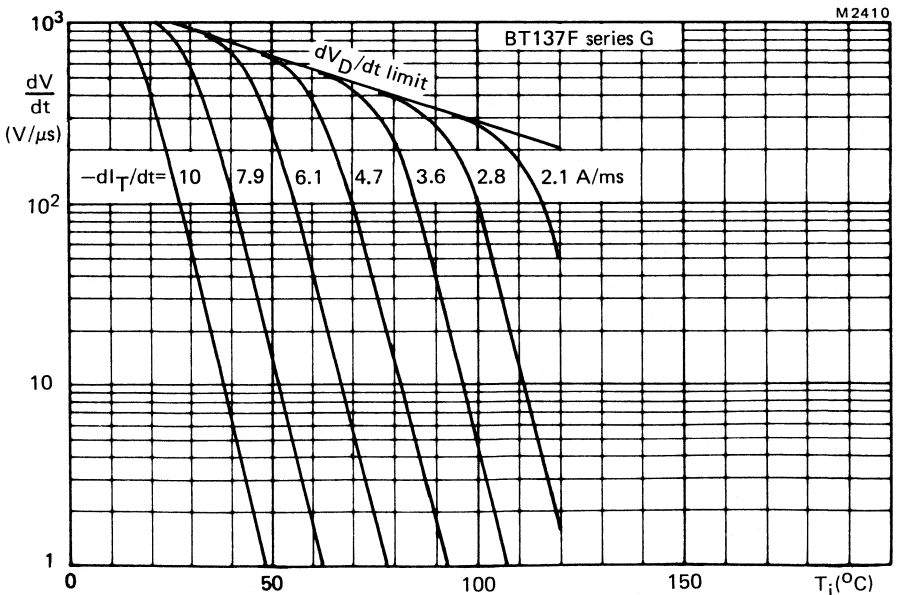


Fig.10 Limit commutation  $dV/dt$  for BT137F series G versus  $T_j$ . The triac should commute when the  $dV/dt$  is below the value on the appropriate curve for pre-commutation  $dI_T/dt$ .

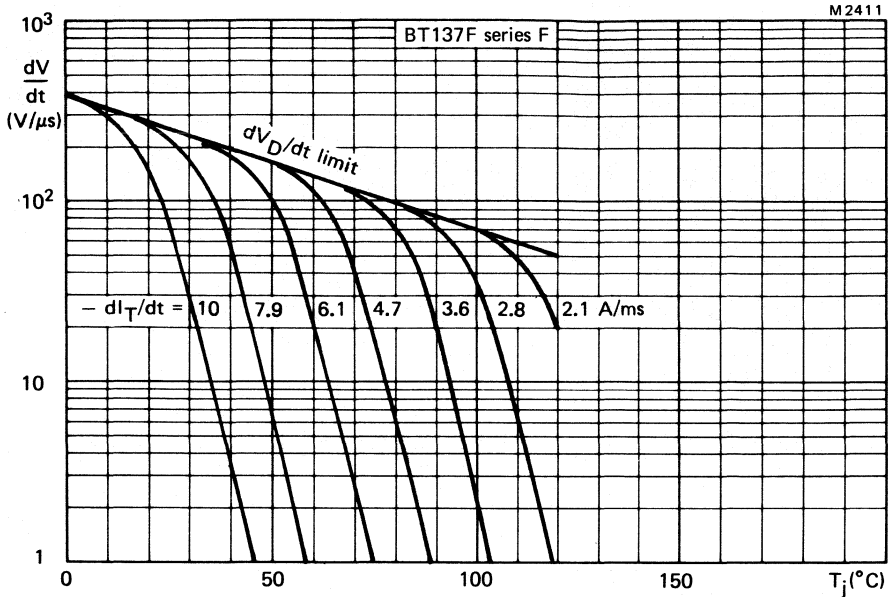


Fig.11 Typical commutation  $dV/dt$  for BT137F series F versus  $T_j$ . The triac should commute when the  $dV/dt$  is below the value on the appropriate curve for pre-commutation  $di_T/dt$ .

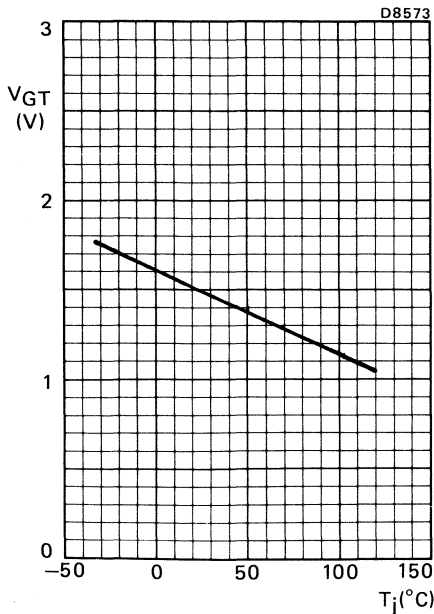


Fig.12 Minimum gate voltage that will trigger all devices; all conditions.

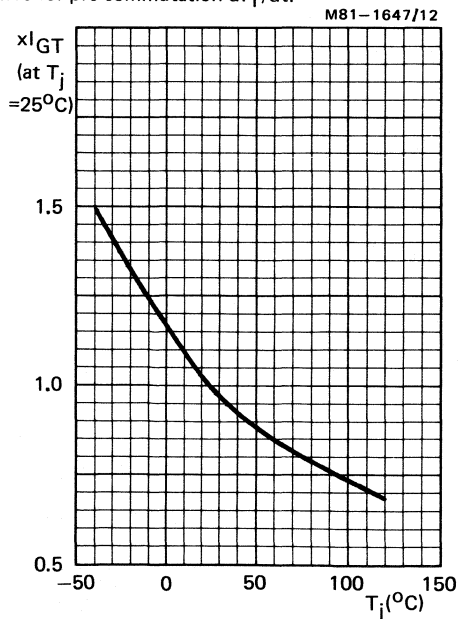


Fig.13 Normalised gate current that will trigger all devices; all conditions.

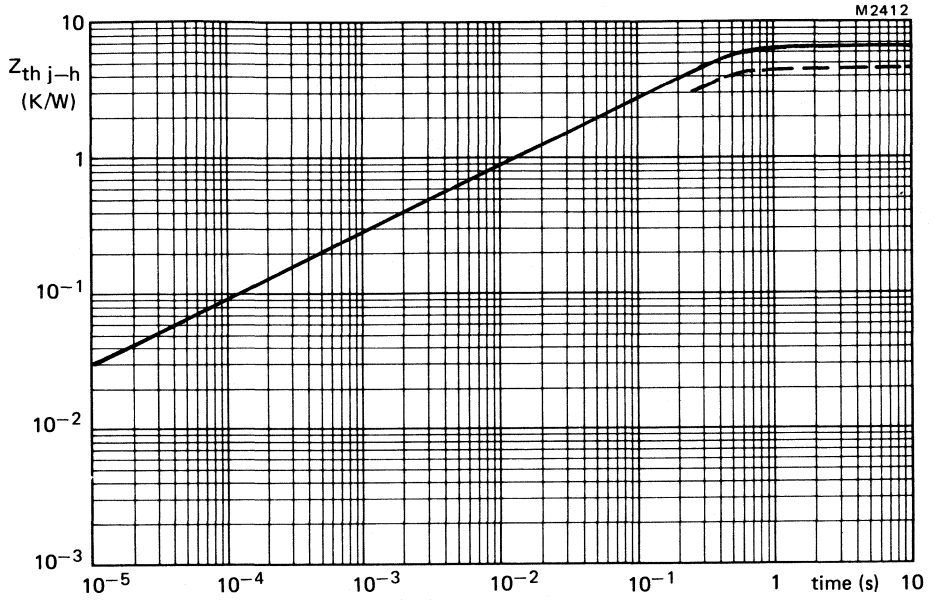


Fig.14 Transient thermal impedance, - - - with heatsink compound; — without heatsink compound.

## 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.

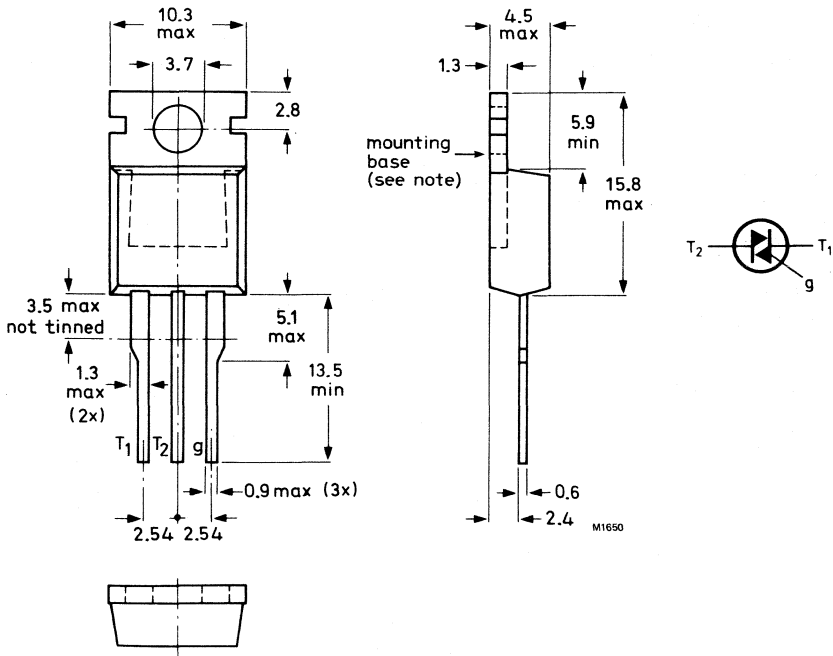
### QUICK REFERENCE DATA

		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<sub>2</sub>.

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 ( $t \leq 10$ 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 $T_{mb} = 95$ °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
$I^2 t$ for fusing ( $t = 10$ ms)	$I^2 t$	max.	40	A <sup>2</sup> s
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/ $\mu$ s	$dI_T/dt$	max.	30	A/ $\mu$ s

*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	$T_j$		
full-cycle operation		max. 120	°C
half-cycle operation		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/ $\mu$ s.

**THERMAL RESISTANCE**

From junction to mounting base

full-cycle operation

half-cycle operation

$R_{th\ j-mb} = 1.5\ K/W$

$R_{th\ j-mb} = 2.0\ K/W$

Transient thermal impedance;  $t = 1\ ms$ 

$Z_{th\ j-mb} = 0.1\ K/W$

**Influence of mounting method**

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from mounting base to heatsink

a. with heatsink compound

$R_{th\ mb-h} = 0.3\ K/W$

b. with heatsink compound and 0.06 mm maximum mica insulator

$R_{th\ mb-h} = 1.4\ K/W$

c. with heatsink compound and 0.1 mm maximum mica insulator (56369)

$R_{th\ mb-h} = 2.2\ K/W$

d. with heatsink compound and 0.25 mm maximum alumina insulator (56367)

$R_{th\ mb-h} = 0.8\ K/W$

e. without heatsink compound

$R_{th\ mb-h} = 1.4\ K/W$

2. Free-air operation

The quoted values of  $R_{th\ j-a}$  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

$R_{th\ j-a} = 60\ K/W$

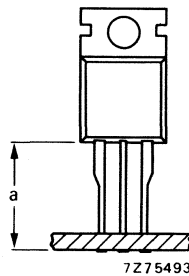


Fig.2

**CHARACTERISTICS** ( $T_j = 25\text{ }^\circ\text{C}$  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)

$$I_T = 15\text{ A} \qquad V_T < 1.65\text{ V}$$

Rate of rise of off-state voltage that will not trigger any device;  $T_j = 120\text{ }^\circ\text{C}$ ; gate open circuit

BT138 series	$dV_D/dt$	<	100	V/ $\mu$ s
BT138 series G	$dV_D/dt$	<	200	V/ $\mu$ s
BT138 series F	$dV_D/dt$	<	50	V/ $\mu$ s
BT138 series E	$dV_D/dt$	typ.	50	V/ $\mu$ s

Rate of change of commutating voltage that will not trigger any device when  $-di_{com}/dt = 5.4\text{ A/ms}$ ;

$I_T(\text{RMS}) = 12\text{ A}$ ;  $T_{mb} = 70\text{ }^\circ\text{C}$ ; gate open circuit;  $V_D = V_{DWMmax}$

BT138 series	$dV_{com}/dt$	typ.	10	V/ $\mu$ s
BT138 series G	$dV_{com}/dt$	<	10	V/ $\mu$ s
BT138 series F	$dV_{com}/dt$	typ.	10	V/ $\mu$ s

Off-state current

$$V_D = V_{DWMmax}; T_j = 120\text{ }^\circ\text{C}; \qquad I_D < 0.5\text{ mA}$$

Gate voltage that will trigger all devices

$$V_{GT} > 1.5\text{ V}$$

Gate voltage that will not trigger any device

$V_D = V_{DWMmax}$ ;  $T_j = 120\text{ }^\circ\text{C}$ ;  
 $T_2$  and G positive or negative

$$V_{GD} < 250\text{ mV}$$

Gate current that will trigger all devices ( $I_{GT}$ ); G to  $T_1$

Holding current ( $I_H$ )

Latching current ( $I_L$ );  $V_D = 12\text{ V}$

		$T_2^+$ 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<sub>2</sub>, 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<sub>th mb-h</sub> 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<sub>th mb-h</sub> 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.

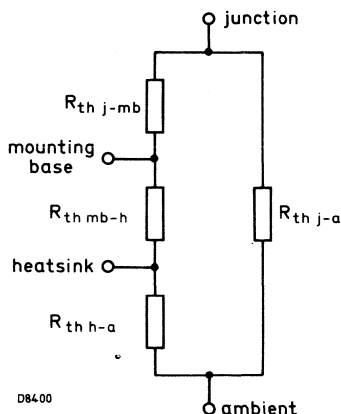


Fig.3.

- b. The method of using Fig.4 is as follows:  
Starting with the required current on the I<sub>T(RMS)</sub> axis, trace upwards to meet the appropriate conduction angle curve. Trace right horizontally and upwards from the appropriate value on the T<sub>amb</sub> scale. The intersection determines the R<sub>th mb-a</sub>. The heatsink thermal resistance value (R<sub>th h-a</sub>) can now be calculated from:

$$R_{th h-a} = R_{th mb-a} - R_{th mb-h}$$

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

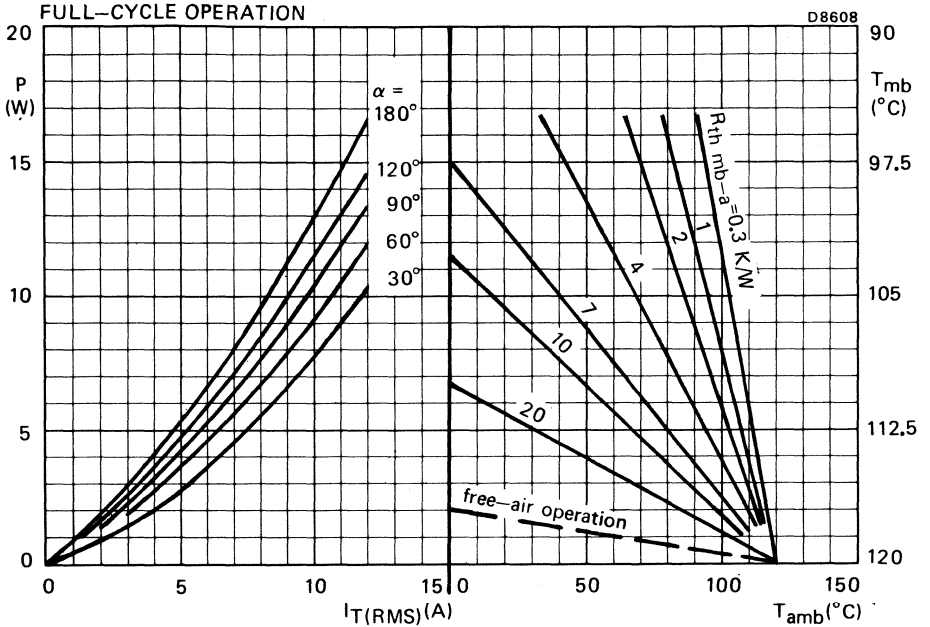
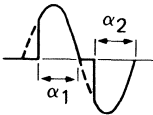


Fig.4 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha = \alpha_1 = \alpha_2$ : conduction angle per half cycle

OVERLOAD OPERATION

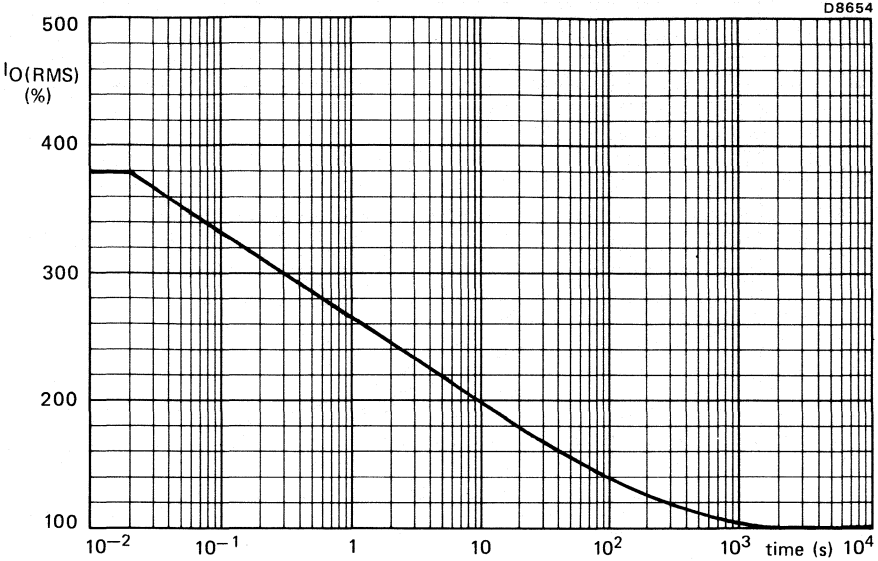


Fig.5 Maximum permissible duration of steady overload (provided that  $T_{mb}$  does exceed  $120\text{ }^\circ\text{C}$  during and after overload) expressed as a percentage of the steady state r.m.s. rated current. For high r.m.s. overload currents precautions should be taken so that the temperature of the terminals does not exceed  $125\text{ }^\circ\text{C}$ . During these overload conditions the triac may lose control. Therefore the overload should be terminated by a separate protection device.

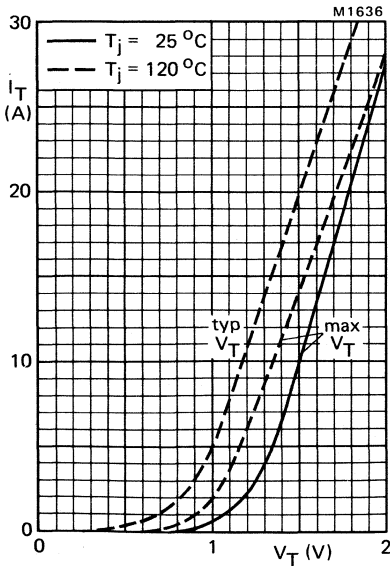


Fig.6

LIMITS FOR STARTING OR INRUSH CURRENTS – FULL-CYCLE OPERATION

M1630A

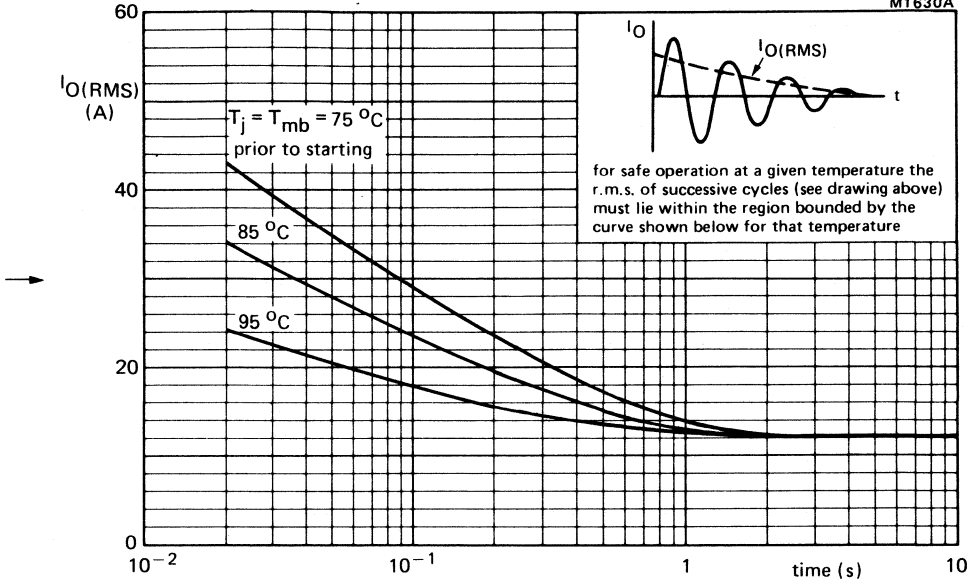


Fig. 7

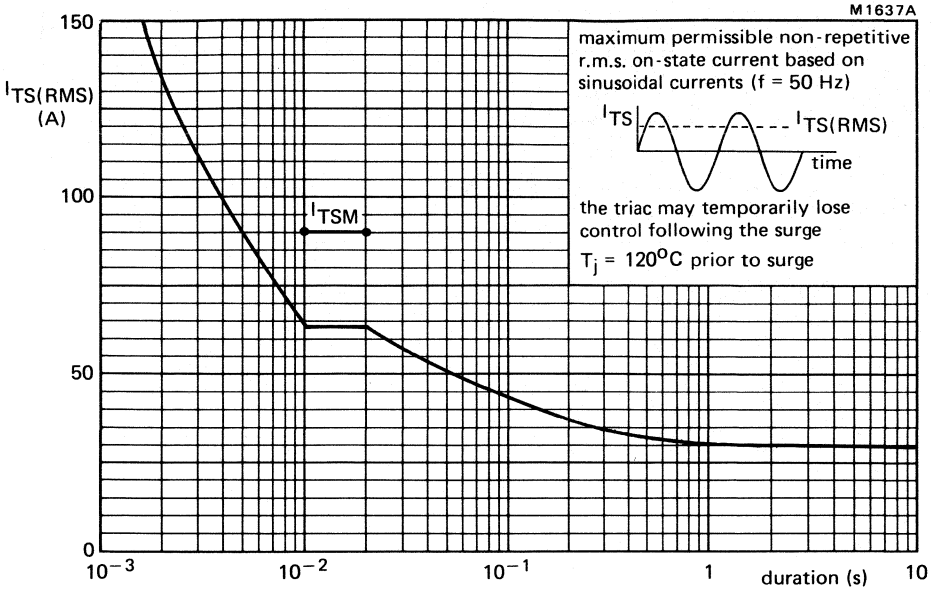


Fig.8

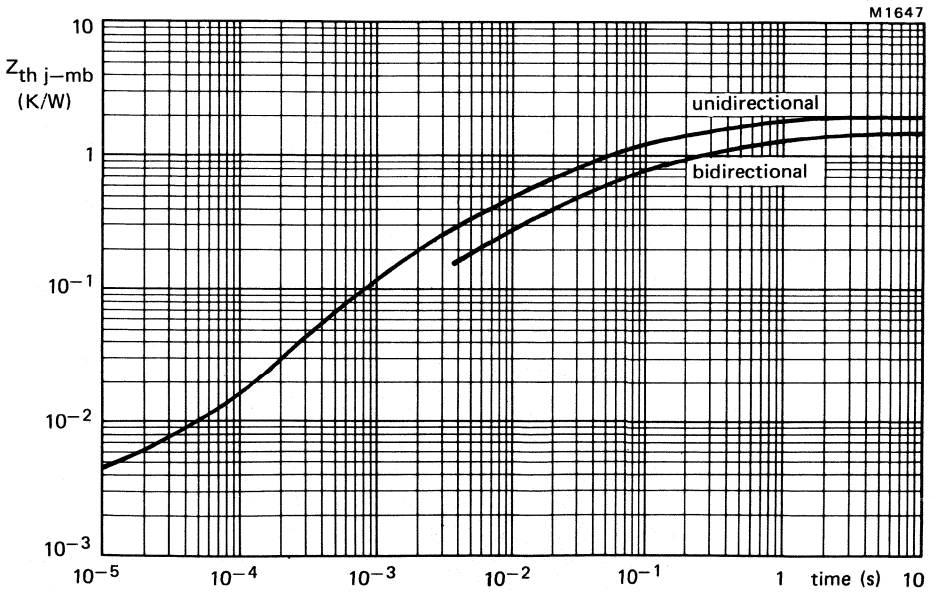


Fig.9

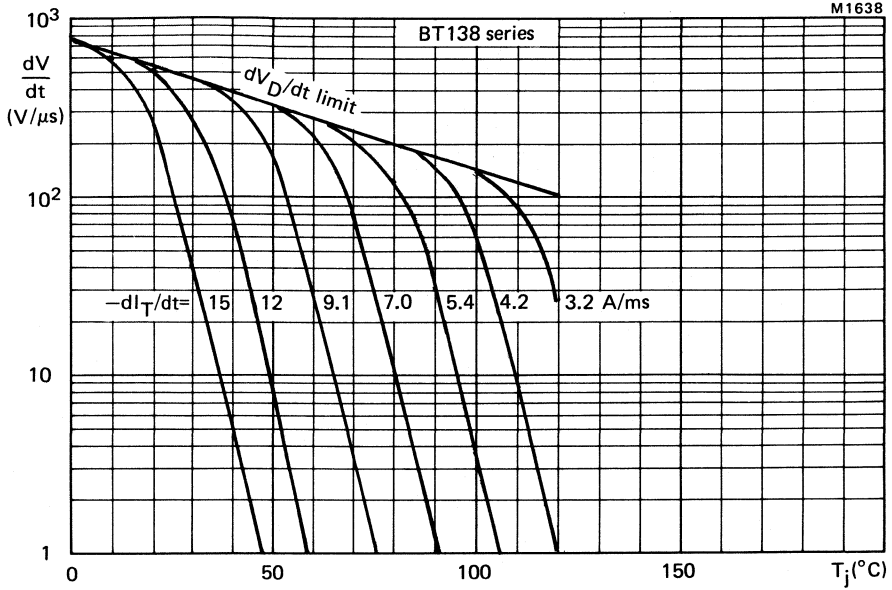


Fig.10 Typical commutation  $dV/dt$  for BT138 series versus  $T_j$ . The triac should commute when  $dV/dt$  is below the value on the appropriate curve for pre-commutation  $di_T/dt$ .

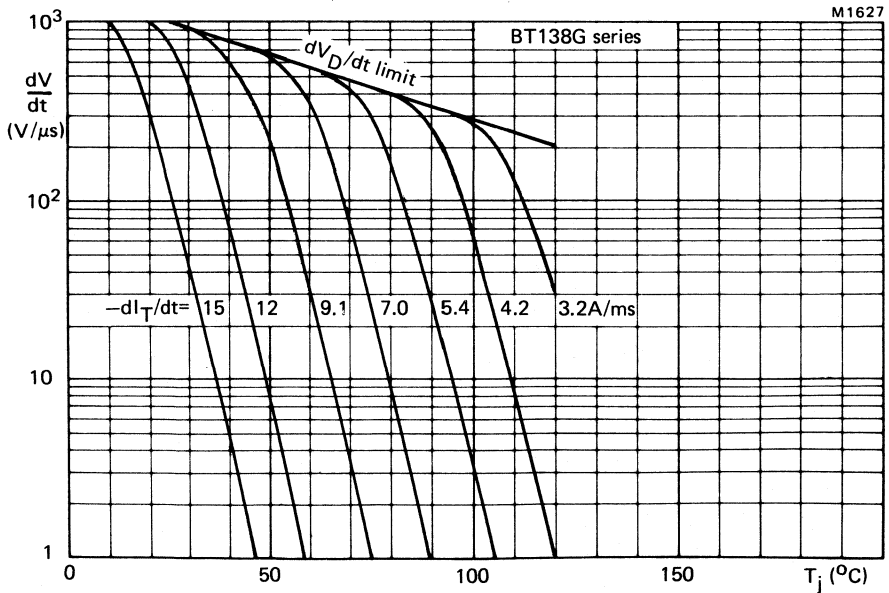


Fig.11 Limit commutation  $dV/dt$  for BT138G series versus  $T_j$ . The triac should commute when the  $dV/dt$  is below the value on the appropriate curve for pre-commutation  $di_T/dt$ .

M1639

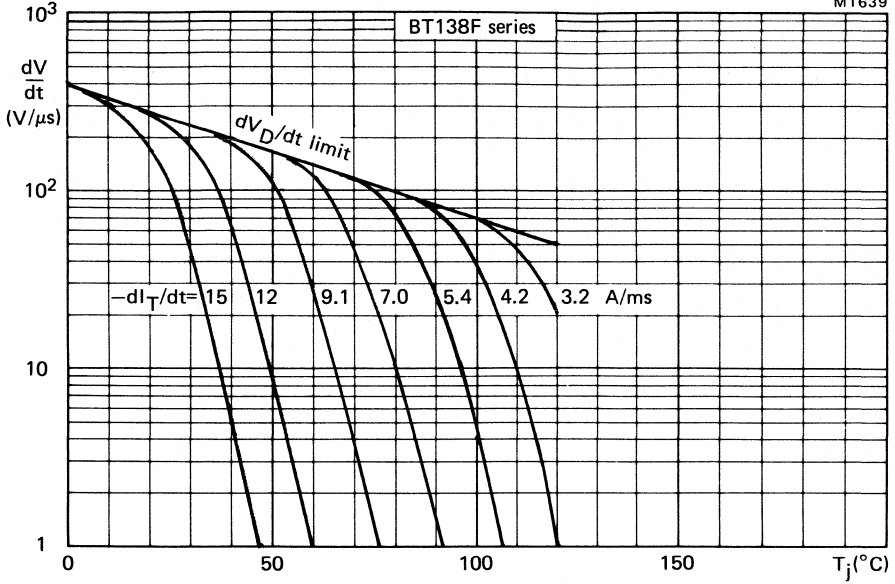


Fig.12 Typical commutation  $dV/dt$  for BT138F series versus  $T_j$ . The triac should commute when the  $dV/dt$  is below the value on the appropriate curve for pre-commutation  $di_T/dt$ .

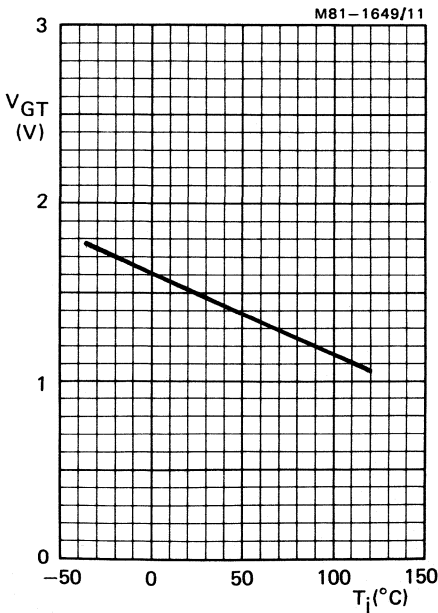


Fig.13 Minimum gate voltage that will trigger all devices; all conditions.

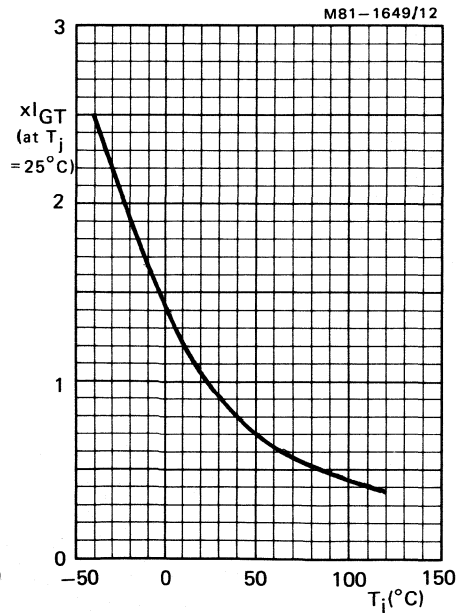


Fig.14 Normalised gate current that will trigger all devices; all conditions.





## 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. ←

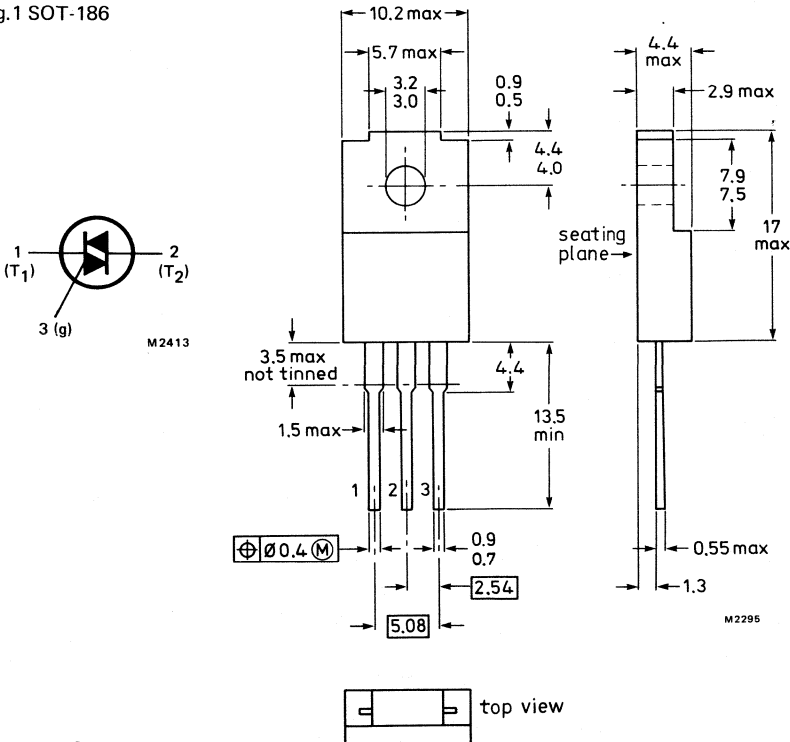
### QUICK REFERENCE DATA

		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 ( $t \leq 10$ 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 $360^\circ$ ) up to $T_h = 52^\circ\text{C}$	$I_T(\text{RMS})$	max.		12		A	←
Repetitive peak on-state current	$I_{TRM}$	max.		90		A	
Non-repetitive peak on-state current; $T_j = 120^\circ\text{C}$ prior to surge; $t = 20$ ms; full sine-wave	$I_{TSM}$	max.		90		A	
$I^2 t$ for fusing ( $t = 10$ ms)	$I^2 t$	max.		40		$\text{A}^2\text{s}$	
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/ $\mu\text{s}$	$di_T/dt$	max.		30		A/ $\mu\text{s}$	

*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		$^\circ\text{C}$	
Operating junction temperature full-cycle operation	$T_j$	max.		120		$^\circ\text{C}$	
half-cycle operation	$T_j$	max.		110		$^\circ\text{C}$	

**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/ $\mu\text{s}$ .

**THERMAL RESISTANCE**

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

Thermal resistance from junction to external heatsink

With heatsink compound

$$R_{th\ j-h} = 4.0 \text{ K/W}$$

Without heatsink compound

$$R_{th\ j-h} = 5.5 \text{ K/W}$$

## 2. Free-air operation

The quoted values of  $R_{th\ j-a}$  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

$$R_{th\ j-a} = 55 \text{ K/W}$$

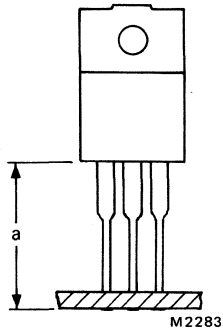


Fig.2.



### MOUNTING INSTRUCTIONS

1. The triac may be soldered directly into the circuit, but the maximum permissible temperature of the soldering iron or bath is  $275^{\circ}\text{C}$ ; 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  $90^{\circ}$  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  $R_{\text{th } j-h}$  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  $R_{\text{th } j-h}$  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.

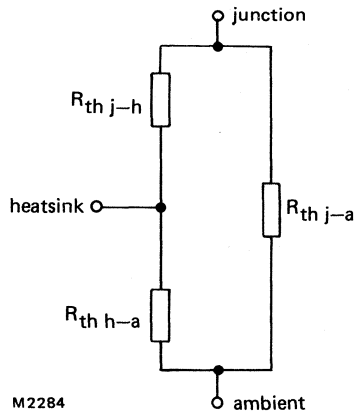


Fig.3.

- b. The method of using Figs.4 and 5 is as follows:

Starting with the required current on the  $I_T(\text{RMS})$  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  $T_{\text{amb}}$ , intersect with  $T_h$  determines  $R_{\text{th } h-a}$ , required heatsink thermal resistance.

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

FULL-WAVE CONDUCTION (with heatsink compound)

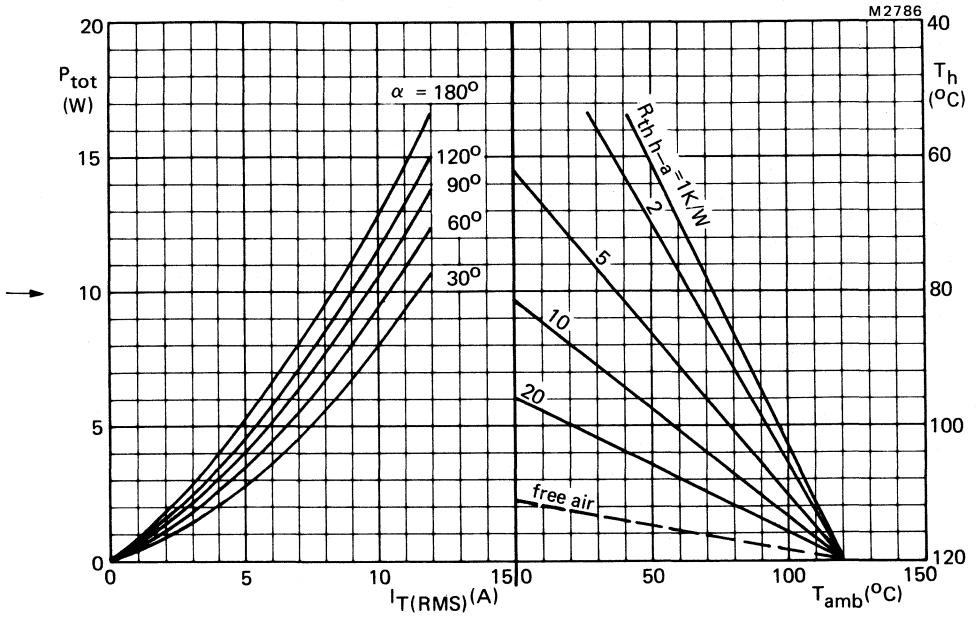
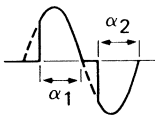


Fig.4 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha = \alpha_1 = \alpha_2$ : conduction angle per half cycle

FULL-WAVE CONDUCTION (without heatsink compound)

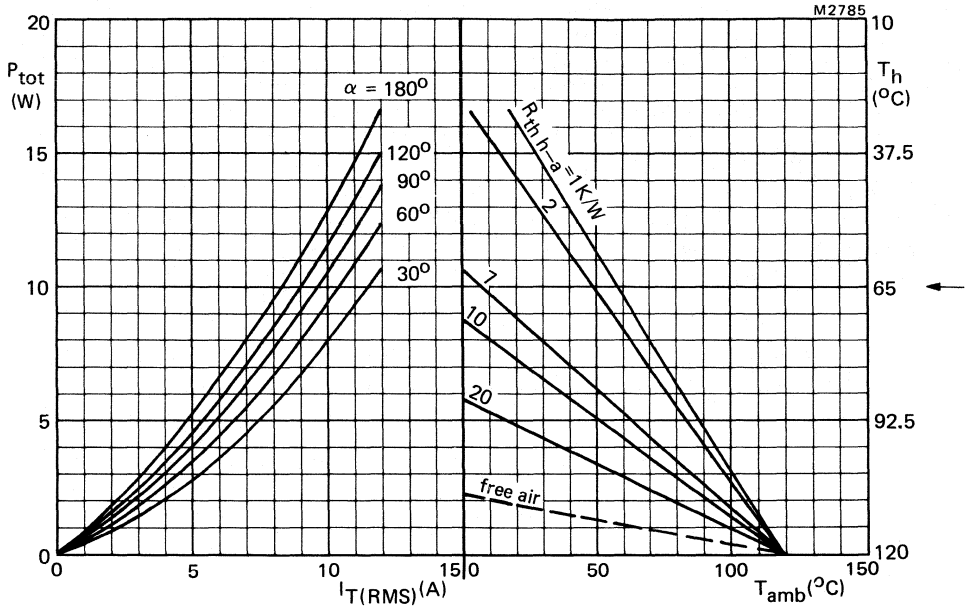
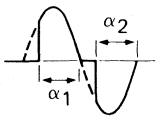


Fig.5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha = \alpha_1 = \alpha_2$ : conduction angle per half cycle

OVERLOAD OPERATION

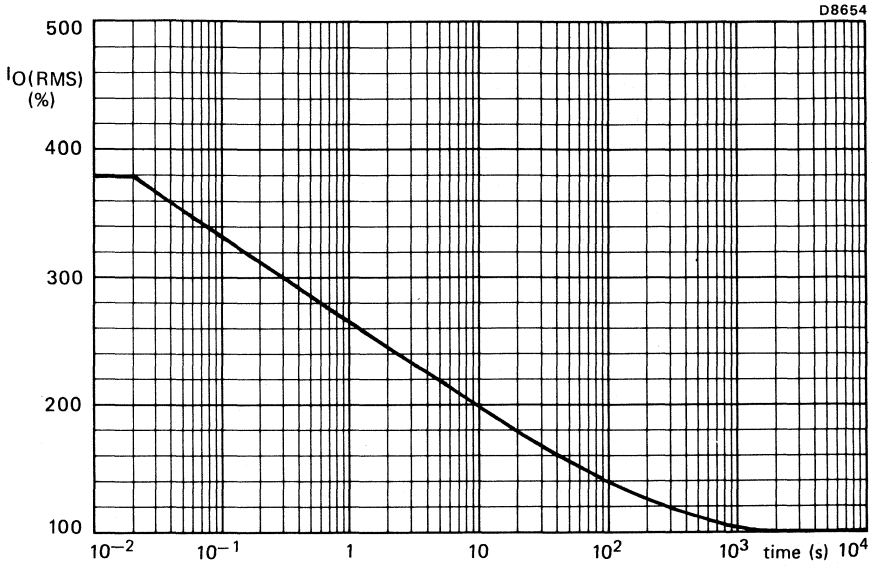


Fig.6 Maximum permissible duration of steady overload (provided that  $T_h$  does not exceed  $120^\circ\text{C}$  during and after overload) expressed as a percentage of the steady state r.m.s. rated current. For high r.m.s. overload currents precautions should be taken so that the temperature of the terminals does not exceed  $125^\circ\text{C}$ . During these overload conditions the triac may lose control. Therefore the overload should be terminated by a separate protection device.

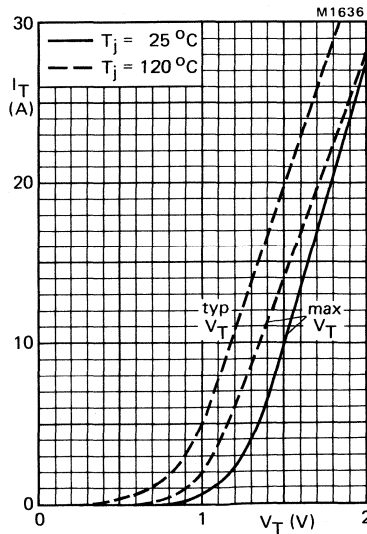


Fig.7.



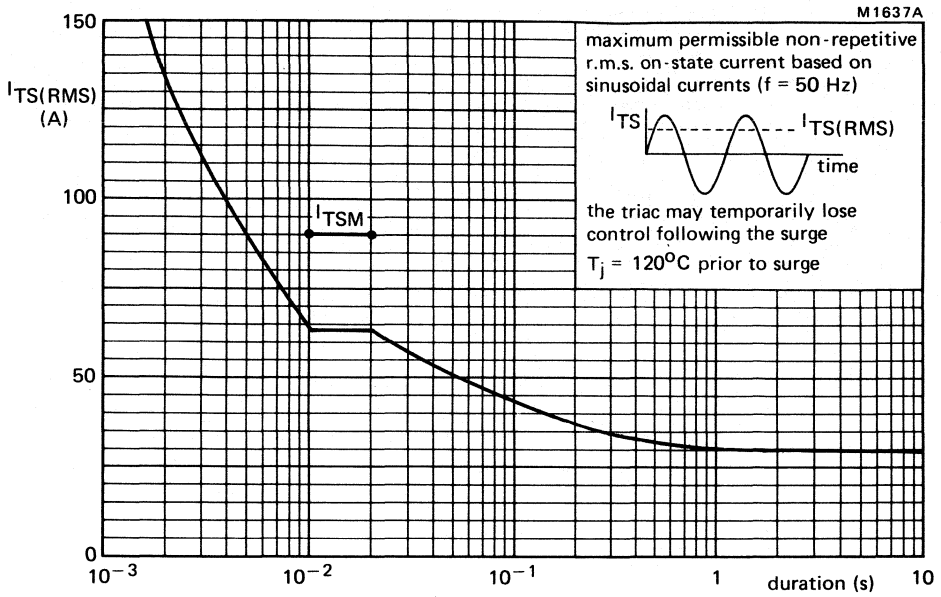


Fig.8.

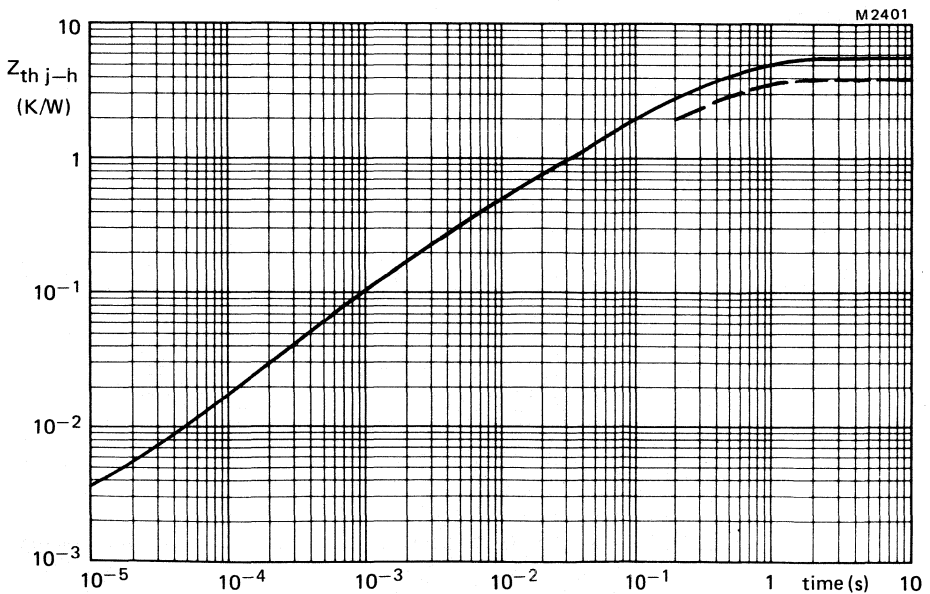


Fig.9 Transient thermal impedance; --- with heatsink compound; — without heatsink compound.

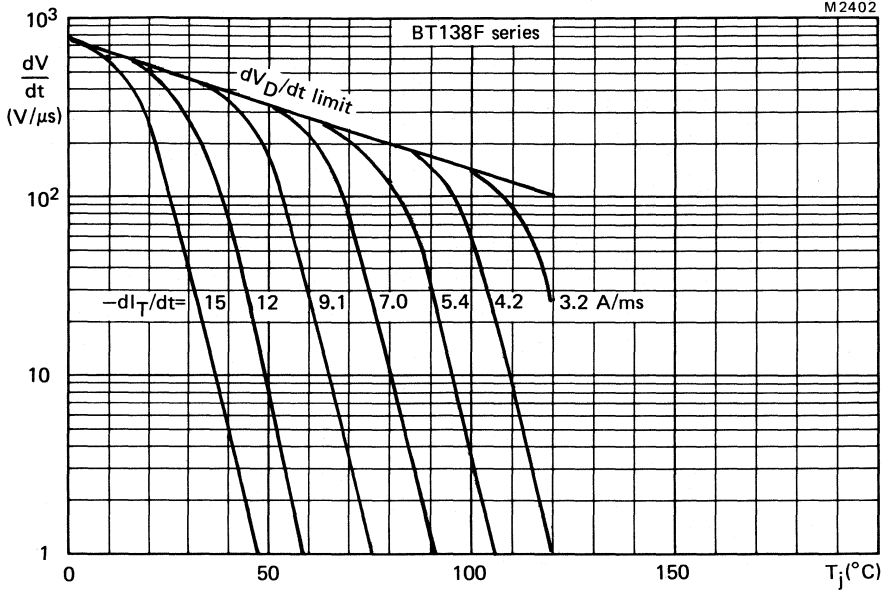


Fig.10 Typical commutation  $dV/dt$  for BT138F series versus  $T_j$ . The triac should commute when  $dV/dt$  is below the value on the appropriate curve for pre-commutation  $di_T/dt$ .

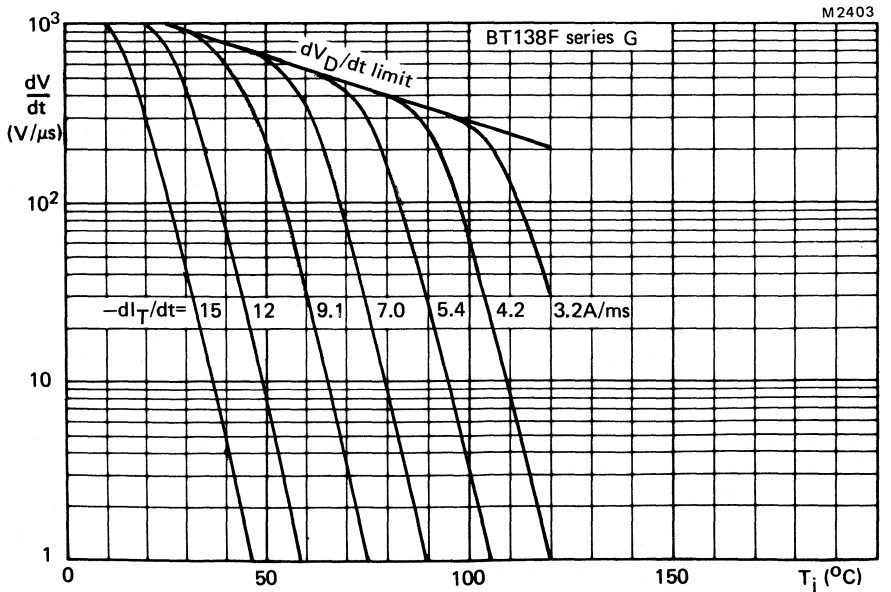


Fig.11 Limit commutation  $dV/dt$  for BT138F series G versus  $T_j$ . The triac should commute when the  $dV/dt$  is below the value on the appropriate curve for pre-commutation  $di_T/dt$ .

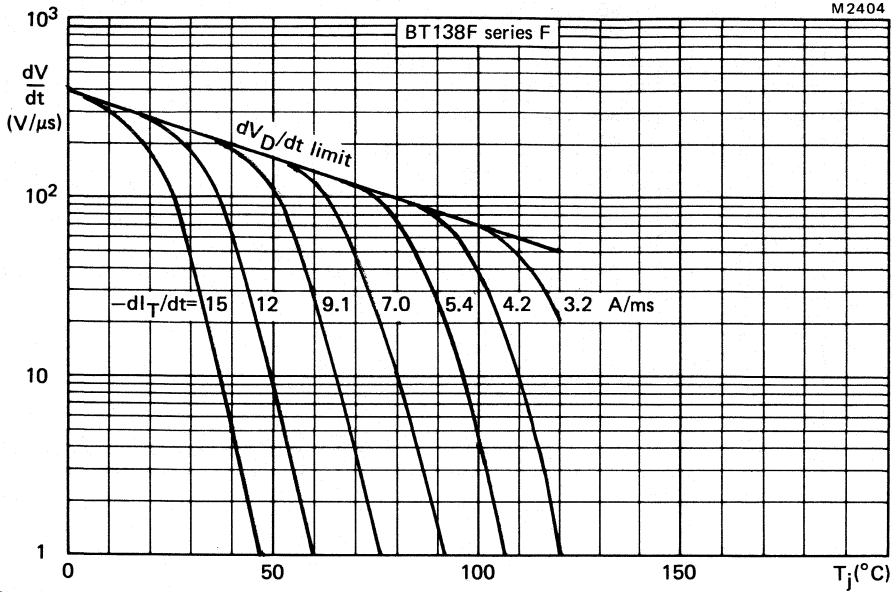


Fig.12 Typical commutation  $dV/dt$  for BT138F series F versus  $T_j$ . The triac should commute when the  $dV/dt$  is below the value on the appropriate curve for pre-commutation  $di_T/dt$ .

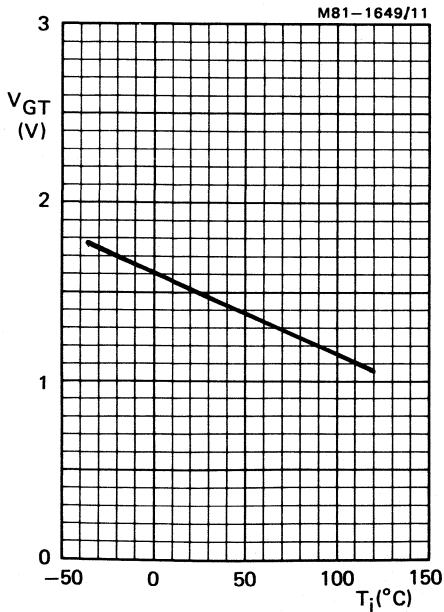


Fig.13 Minimum gate voltage that will trigger all devices; all conditions.

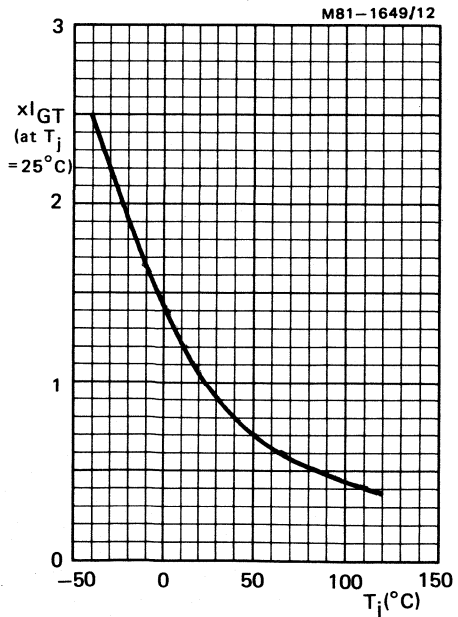


Fig.14 Normalised gate current that will trigger all devices; all conditions.

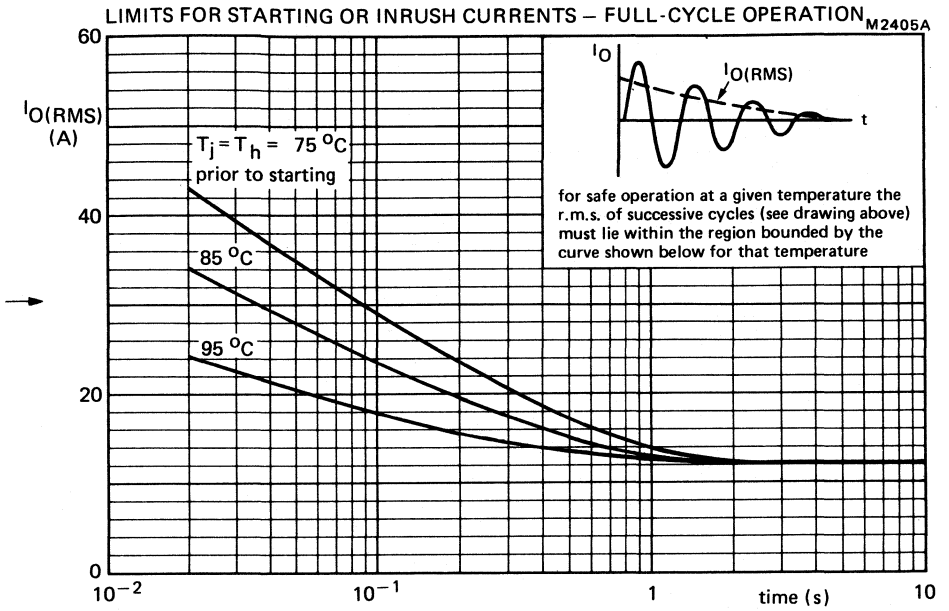


Fig.15

## 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.

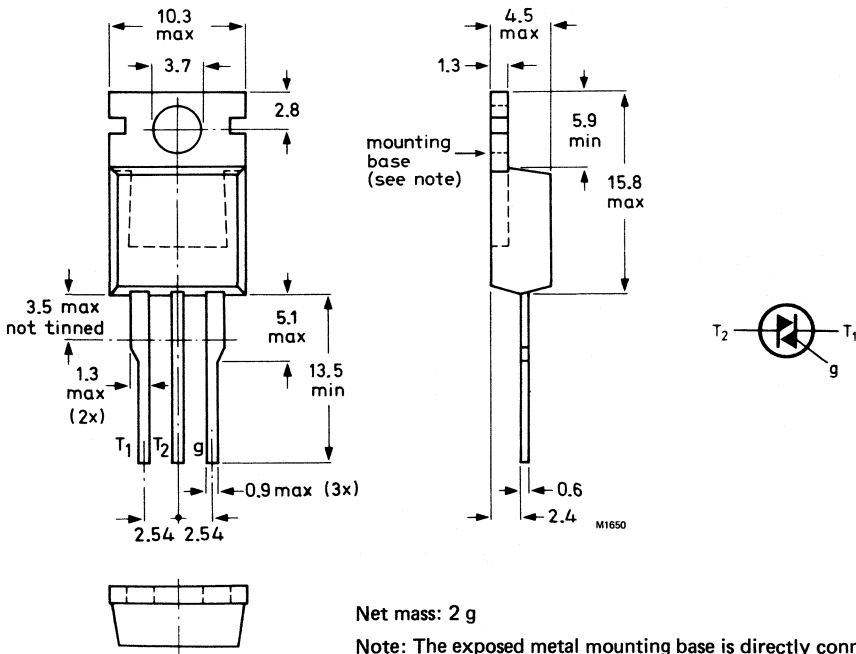
### QUICK REFERENCE DATA

		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<sub>2</sub>.

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 ( $t \leq 10$ 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 $360^\circ$ ) up to $T_{mb} = 93^\circ\text{C}$	$I_{T(RMS)}$	max.	16	A
→ Repetitive peak on-state current	$I_{TRM}$	max.	140	A
→ Non-repetitive peak on-state current; $T_j = 120^\circ\text{C}$ 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	$\text{A}^2\text{s}$
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/ $\mu\text{s}$	$dI_T/dt$	max.	30	A/ $\mu\text{s}$

### 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	$^\circ\text{C}$
Operating junction temperature			
full-cycle operation	$T_j$	max. 120	$^\circ\text{C}$
half-cycle operation	$T_j$	max. 110	$^\circ\text{C}$

\*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/ $\mu\text{s}$ .

**THERMAL RESISTANCE**

From junction to mounting base

- full-cycle operation
- half-cycle operation

$R_{th\ j-mb} = 1.2\ K/W$

$R_{th\ j-mb} = 1.7\ K/W$

Transient thermal impedance;  $t = 1\ ms$ 

$Z_{th\ j-mb} = 0.1\ K/W$

**Influence of mounting method**

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from mounting base to heatsink

- a. with heatsink compound
- b. with heatsink compound and 0.06 mm maximum mica insulator
- c. with heatsink compound and 0.1 mm maximum mica insulator (56369)
- d. with heatsink compound and 0.25 mm maximum alumina insulator (56367)
- e. without heatsink compound

$R_{th\ mb-h} = 0.3\ K/W$

$R_{th\ mb-h} = 1.4\ K/W$

$R_{th\ mb-h} = 2.2\ K/W$

$R_{th\ mb-h} = 0.8\ K/W$

$R_{th\ mb-h} = 1.4\ K/W$

2. Free-air operation

The quoted values of  $R_{th\ j-a}$  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

$R_{th\ j-a} = 60\ K/W$

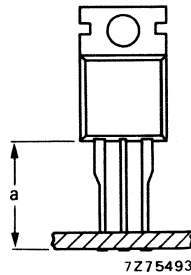


Fig.2

**CHARACTERISTICS** ( $T_j = 25\text{ }^\circ\text{C}$  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)

$I_T = 20\text{ A}$	$V_T$	<	1.6	V
---------------------	-------	---	-----	---

Rate of rise of off-state voltage that will not trigger any device;  $T_j = 120\text{ }^\circ\text{C}$ ; gate open circuit

BT139 series	$dV_D/dt$	<	100	V/ $\mu\text{s}$
BT139 series G	$dV_D/dt$	<	200	V/ $\mu\text{s}$
BT139 series F	$dV_D/dt$	<	50	V/ $\mu\text{s}$
BT139 series E	$dV_D/dt$	typ.	50	V/ $\mu\text{s}$

Rate of change of commutating voltage that will not trigger any device when  $-di_{com}/dt = 7.2\text{ A/ms}$ ;

$I_T(\text{RMS}) = 16\text{ A}$ ; $T_{mb} = 70\text{ }^\circ\text{C}$ ; gate open circuit; $V_D = V_{DWMmax}$				
BT139 series	$dV_{com}/dt$	typ.	10	V/ $\mu\text{s}$
BT139 series G	$dV_{com}/dt$	<	10	V/ $\mu\text{s}$
BT139 series F	$dV_{com}/dt$	typ.	10	V/ $\mu\text{s}$

Off-state current

$V_D = V_{DWMmax}$ ; $T_j = 120\text{ }^\circ\text{C}$ ;	$I_D$	<	0.5	mA
--	-------	---	-----	----

Gate voltage that will trigger all devices

$V_{GT}$	>	1.5	V
----------	---	-----	---

Gate voltage that will not trigger any device

$V_D = V_{DWMmax}$ ; $T_j = 120\text{ }^\circ\text{C}$ ;	$V_{GD}$	<	250	mV
$T_2$ and G positive or negative				

Gate current that will trigger all devices ( $I_{GT}$ ); G to  $T_1$

			$T_2^+$ G <sup>+</sup>	$T_2^+$ G <sup>-</sup>	$T_2^-$ G <sup>-</sup>	$T_2^-$ G <sup>+</sup>	
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<sub>2</sub>, 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<sub>th mb-h</sub> 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<sub>th mb-h</sub> 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.

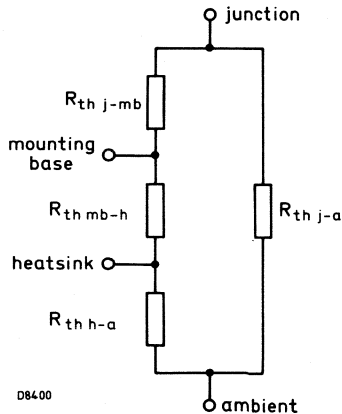


Fig.3.

- b. The method of using Fig.4 is as follows:  
Starting with the required current on the I<sub>T(RMS)</sub> axis, trace upwards to meet the appropriate conduction angle curve. Trace right horizontally and upwards from the appropriate value on the T<sub>amb</sub> scale. The intersection determines the R<sub>th mb-a</sub>. The heatsink thermal resistance value (R<sub>th h-a</sub>) can now be calculated from:

$$R_{th h-a} = R_{th mb-a} - R_{th mb-h}$$

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

FULL-CYCLE OPERATION

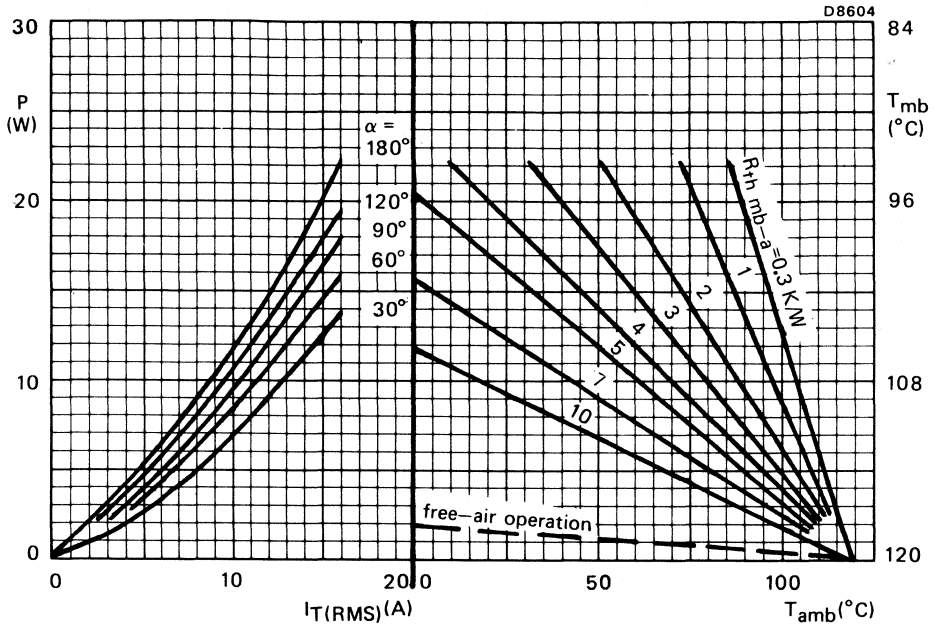
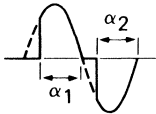


Fig. 4 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha = \alpha_1 = \alpha_2$ : conduction angle per half cycle

OVERLOAD OPERATION

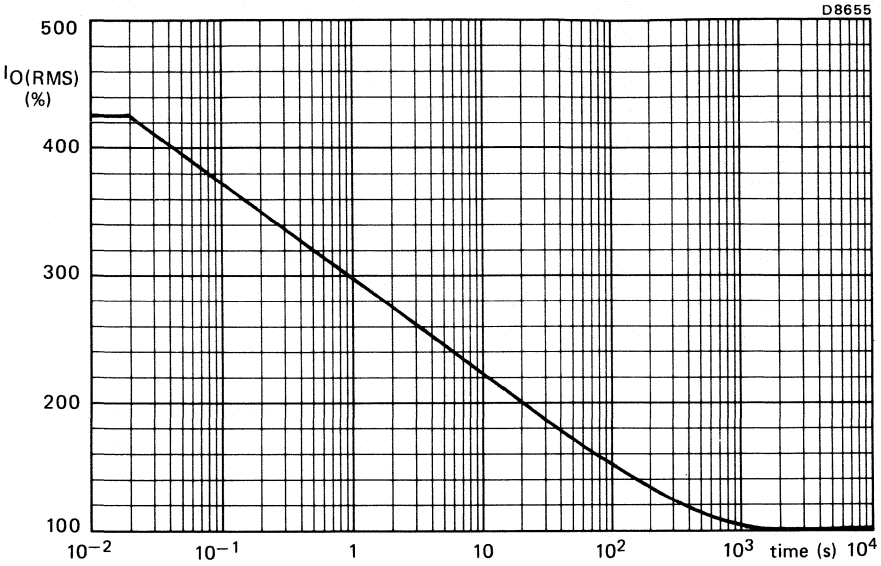


Fig.6 Maximum permissible duration of steady overload (provided that  $T_{mb}$  does not exceed  $120^{\circ}C$  during and after overload) expressed as a percentage of the steady state r.m.s. rated current. For high r.m.s. overload currents precautions should be taken so that the temperature of the terminals does not exceed  $125^{\circ}C$ . During these overload conditions the triac may lose control. Therefore the overload should be terminated by a separate protection device.

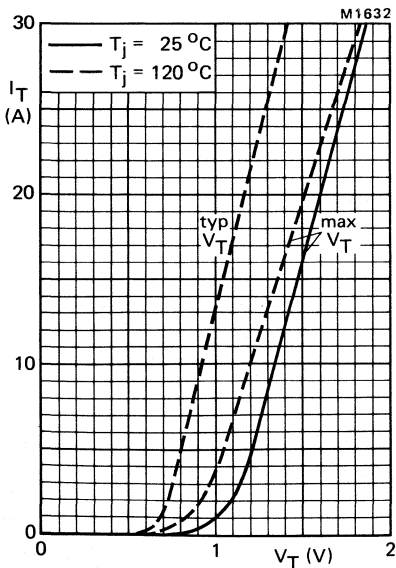


Fig.7

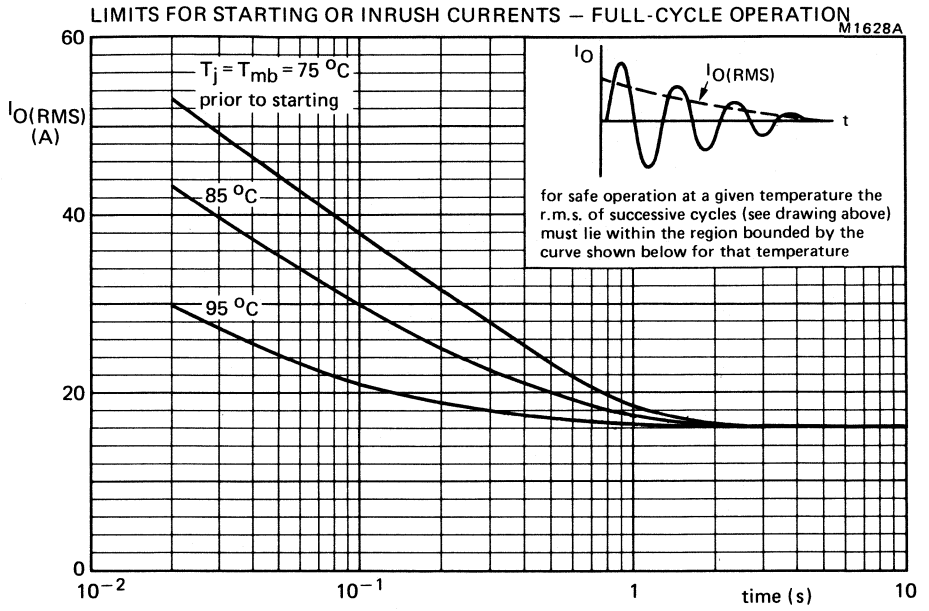


Fig.15

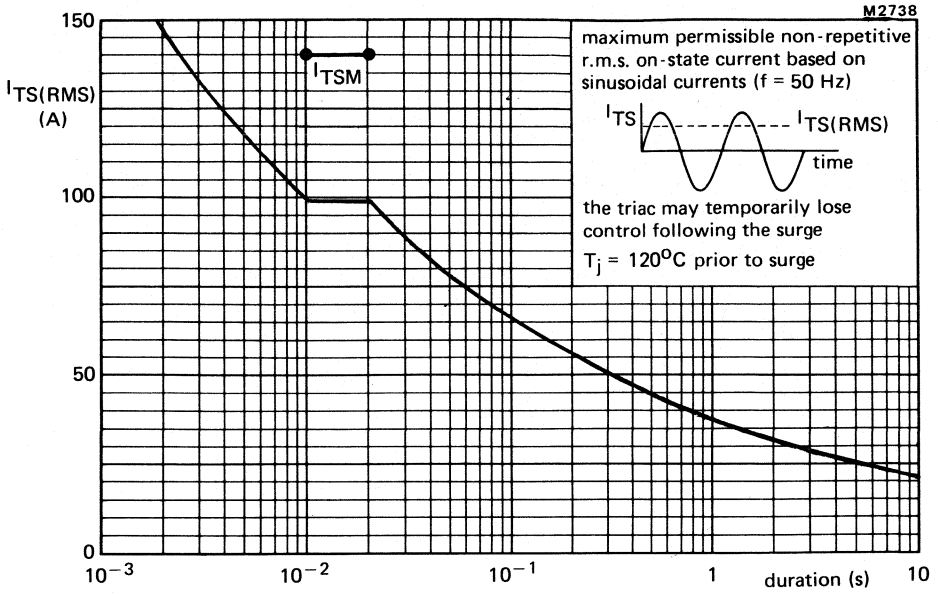


Fig.8

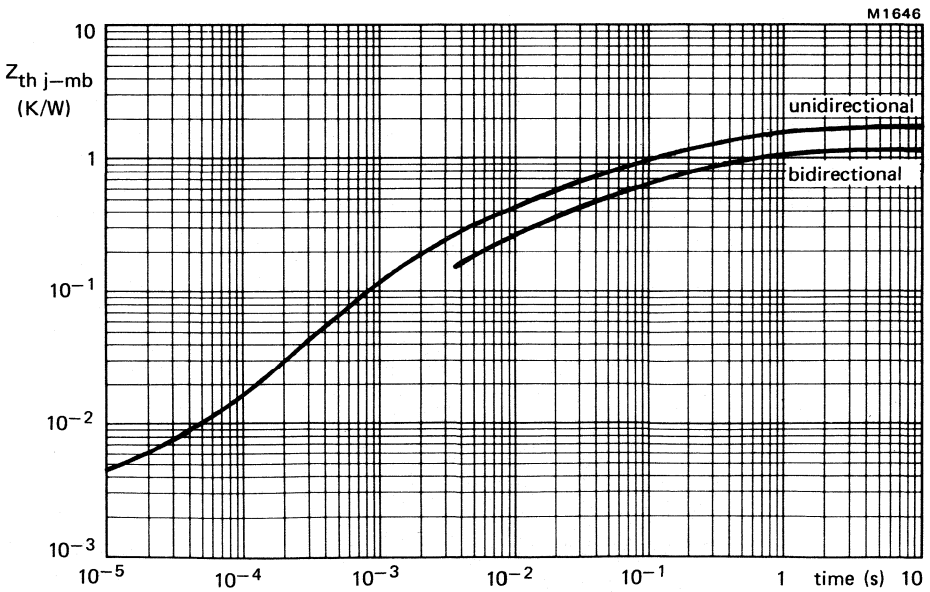


Fig.9

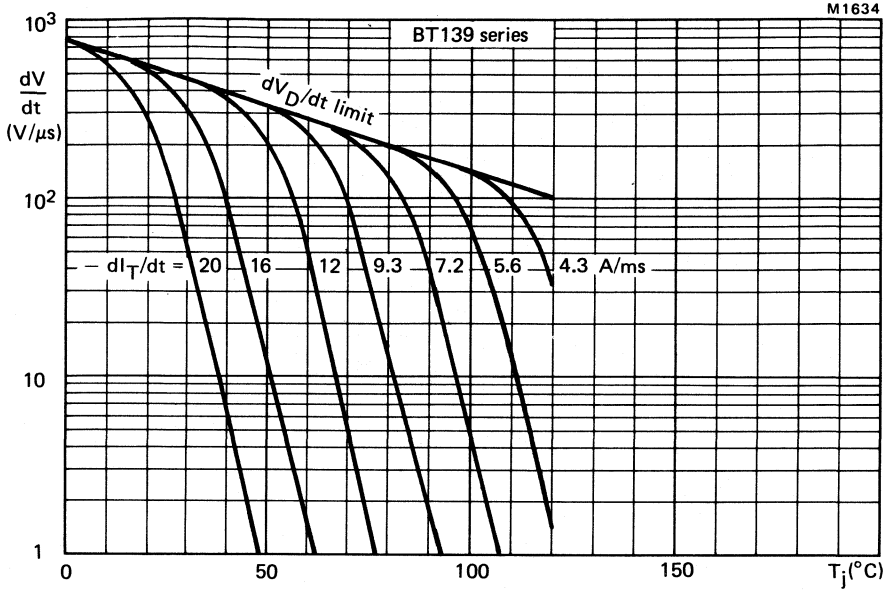


Fig.10 Typical commutation  $dV/dt$  for BT139 series versus  $T_j$ . The triac should commute when the  $dV/dt$  is below the value on the appropriate curve for pre-commutation  $dI_T/dt$ .

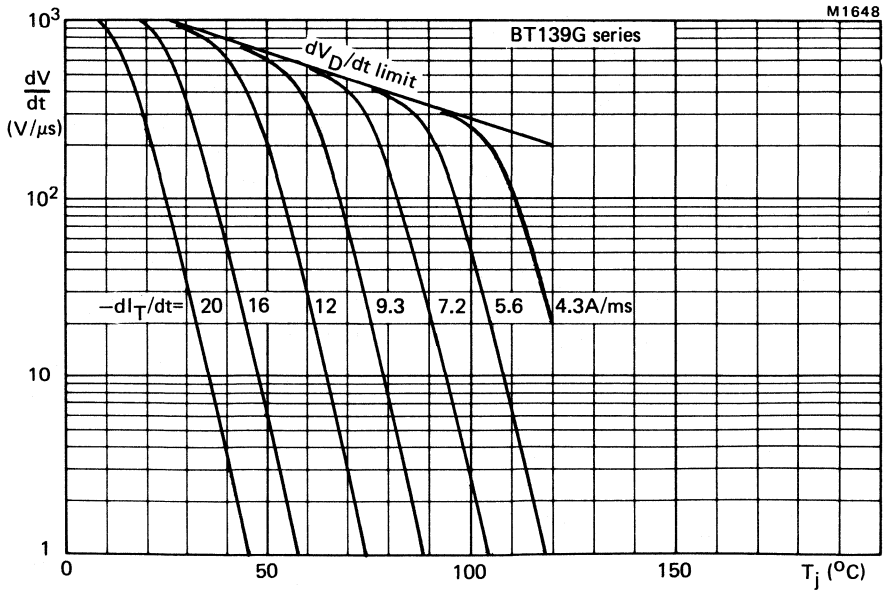


Fig.11 Limit commutation  $dV/dt$  for BT139G series versus  $T_j$ . The triac should commute when the  $dV/dt$  is below the value on the appropriate curve for pre-commutation  $dI_T/dt$ .

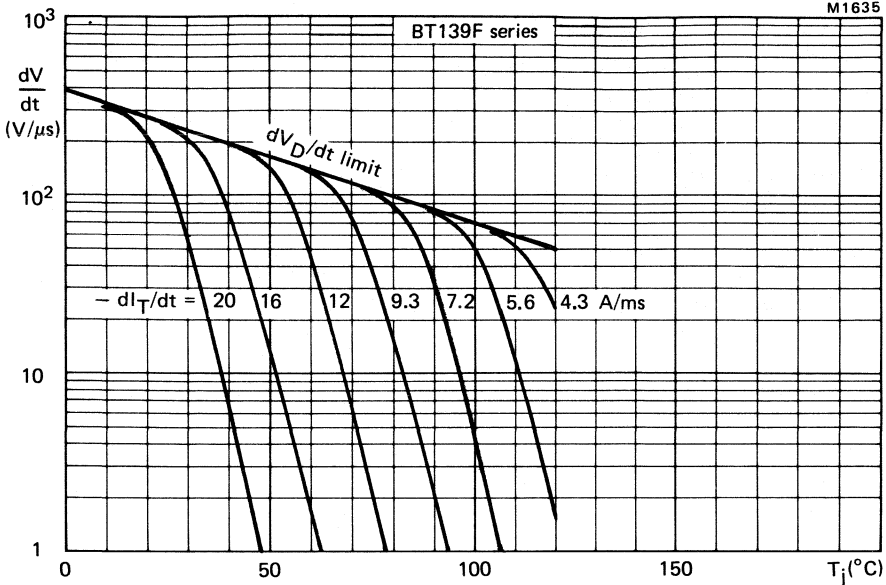


Fig.12 Typical commutation  $dV/dt$  for BT139F series versus  $T_j$ . The triac should commute when the  $dV/dt$  is below the value on the appropriate curve for pre-commutation  $di_T/dt$ .

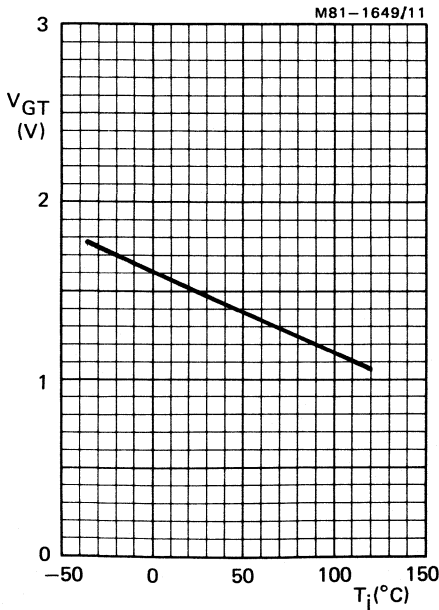


Fig.13 Minimum gate voltage that will trigger all devices; all conditions.

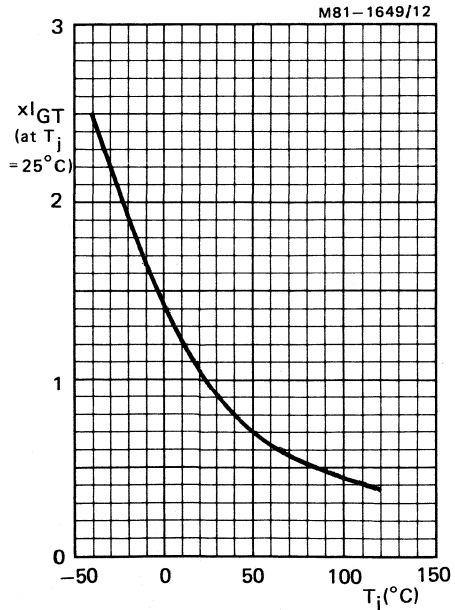


Fig.14 Normalised gate current that will trigger all devices; all conditions.







## RATINGS

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

### Voltages (in either direction)

		BT139F-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 $360^\circ$ ) up to $T_h = 67^\circ\text{C}$	$I_{T(RMS)}$	max.	16	A
Repetitive peak on-state current	$I_{TRM}$	max.	140	A
Non-repetitive peak on-state current; $T_j = 120^\circ\text{C}$ prior to surge; $t = 20$ ms; full sine-wave	$I_{TSM}$	max.	140	A
$I^2 t$ for fusing ( $t = 10$ ms)	$I^2 t$	max.	95	$\text{A}^2 \text{s}$
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/ $\mu\text{s}$	$dI_T/dt$	max.	30	A/ $\mu\text{s}$

### 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	$^\circ\text{C}$
Full-cycle operating temperature	$T_j$	max.	120	$^\circ\text{C}$

### 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/ $\mu\text{s}$ .

**THERMAL RESISTANCE**

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

Thermal resistance from junction to external heatsink

With heatsink compound

$$R_{th\ j-h} = 3.5 \text{ K/W}$$

Without heatsink compound

$$R_{th\ j-h} = 4.5 \text{ K/W}$$

## 2. Free-air operation

The quoted values of  $R_{th\ j-a}$  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

$$R_{th\ j-a} = 55 \text{ K/W}$$

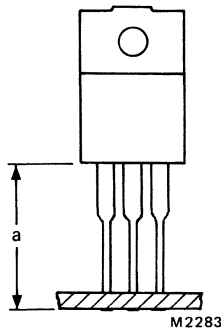


Fig.2

## CHARACTERISTICS ( $T_j = 25\text{ }^\circ\text{C}$ 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)

$I_T = 20\text{ A}$	$V_T$	<	1.6	V
---------------------	-------	---	-----	---

Rate of rise of off-state voltage that will not trigger any device;  $T_j = 120\text{ }^\circ\text{C}$ ; gate open circuit

BT139F series	$dV_D/dt$	<	100	V/ $\mu\text{s}$
BT139F series G	$dV_D/dt$	<	200	V/ $\mu\text{s}$
BT139F series F	$dV_D/dt$	<	50	V/ $\mu\text{s}$
BT139F series E	$dV_D/dt$	typ.	50	V/ $\mu\text{s}$

Rate of change of commutating voltage that will not trigger any device when  $-di_{com}/dt = 7.2\text{ A/ms}$ ;

$I_T(\text{RMS}) = 16\text{ A}$ ;  $T_h = 70\text{ }^\circ\text{C}$ ; gate open circuit;

$V_D = V_{DWMmax}$

BT139F series	$dV_{com}/dt$	typ.	10	V/ $\mu\text{s}$
BT139F series G	$dV_{com}/dt$	<	10	V/ $\mu\text{s}$
BT139F series F	$dV_{com}/dt$	typ.	10	V/ $\mu\text{s}$

Off-state current

$V_D = V_{DWMmax}$ ;  $T_j = 120\text{ }^\circ\text{C}$ ;

$I_D$	<	0.5	mA
-------	---	-----	----

Gate voltage that will trigger all devices

$V_{GT}$	>	1.5	V
----------	---	-----	---

Gate voltage that will not trigger any device

$V_D = V_{DWMmax}$ ;  $T_j = 120\text{ }^\circ\text{C}$

$T_2$  and G positive or negative

$V_{GD}$	<	250	mV
----------	---	-----	----

Gate current that will trigger all devices ( $I_{GT}$ ); G to  $T_1$

Holding current ( $I_H$ )

$T_2^+$	$T_2^+$	$T_2^-$	$T_2^-$
G+	G-	G-	G+

Latching current ( $I_L$ );  $V_D = 12\text{ V}$

			$T_2^+$ 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 °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  $R_{th\ j-h}$  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  $R_{th\ j-h}$  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.

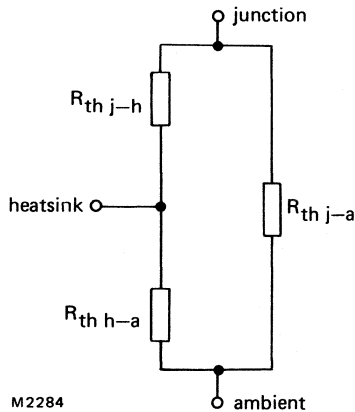


Fig.3.

- 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  $R_{th\ h-a}$ , required heatsink thermal resistance.

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

FULL-CYCLE OPERATION (with heatsink compound)

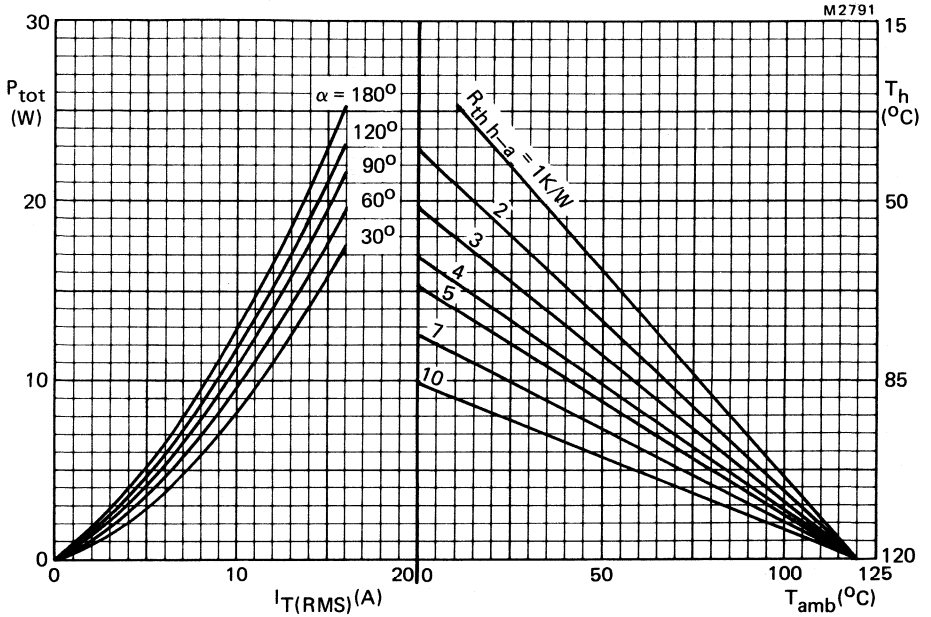
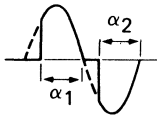


Fig. 4 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha = \alpha_1 = \alpha_2$ : conduction angle per half cycle

FULL-WAVE CONDUCTION (without heatsink compound)

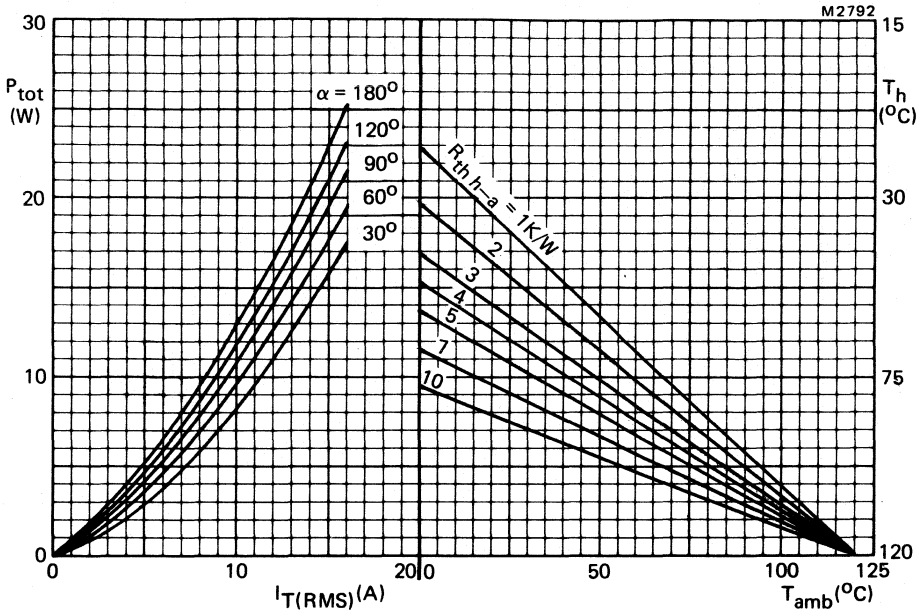
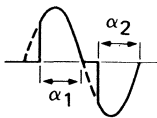


Fig.5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha = \alpha_1 = \alpha_2$ : conduction angle per half cycle

OVERLOAD OPERATION

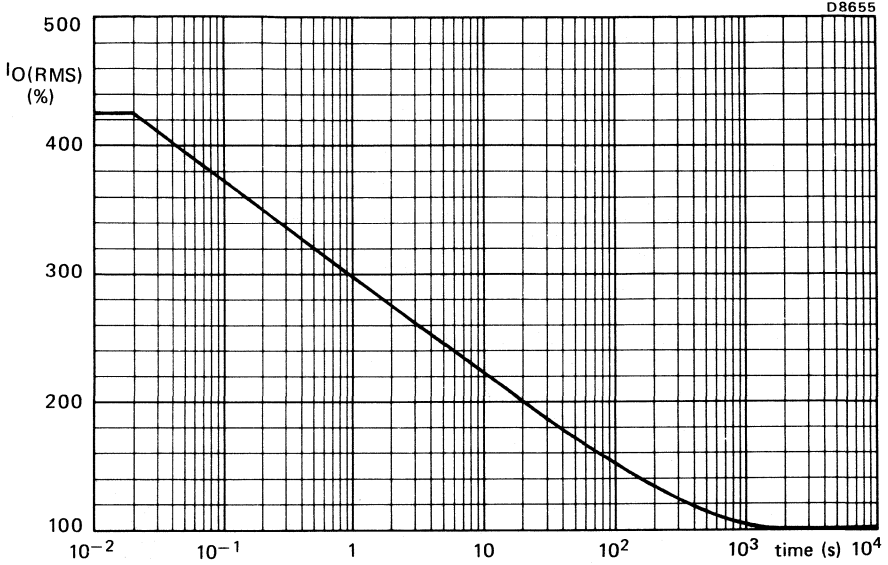


Fig.6 Maximum permissible duration of steady overload (provided that  $T_{mb}$  does not exceed  $120^{\circ}\text{C}$  during and after overload) expressed as a percentage of the steady state r.m.s. rated current. For high r.m.s. overload currents precautions should be taken so that the temperature of the terminals does not exceed  $125^{\circ}\text{C}$ . During these overload conditions the triac may lose control. Therefore the overload should be terminated by a separate protection device.

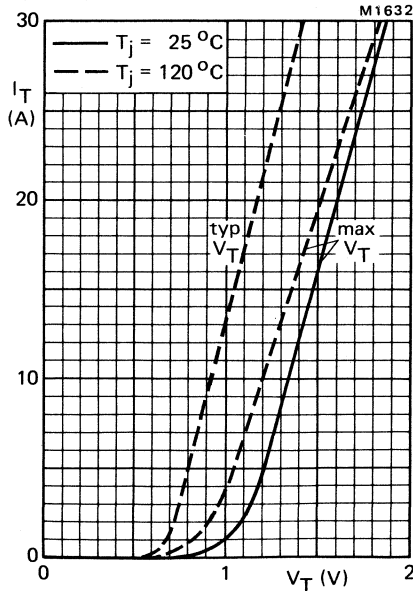


Fig.7



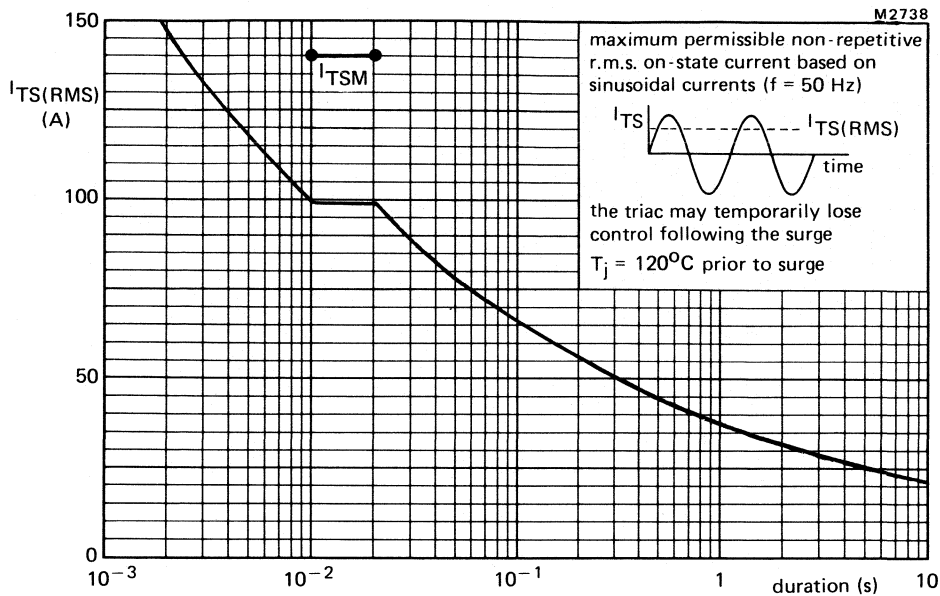


Fig.8

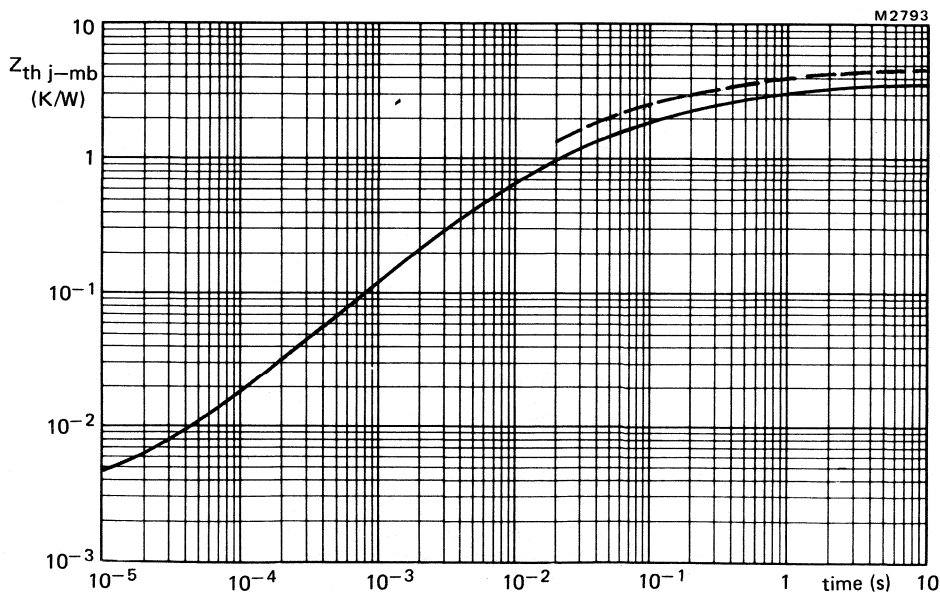


Fig.9 Transient thermal impedance; — with heatsink compound; - - - without heatsink compound.

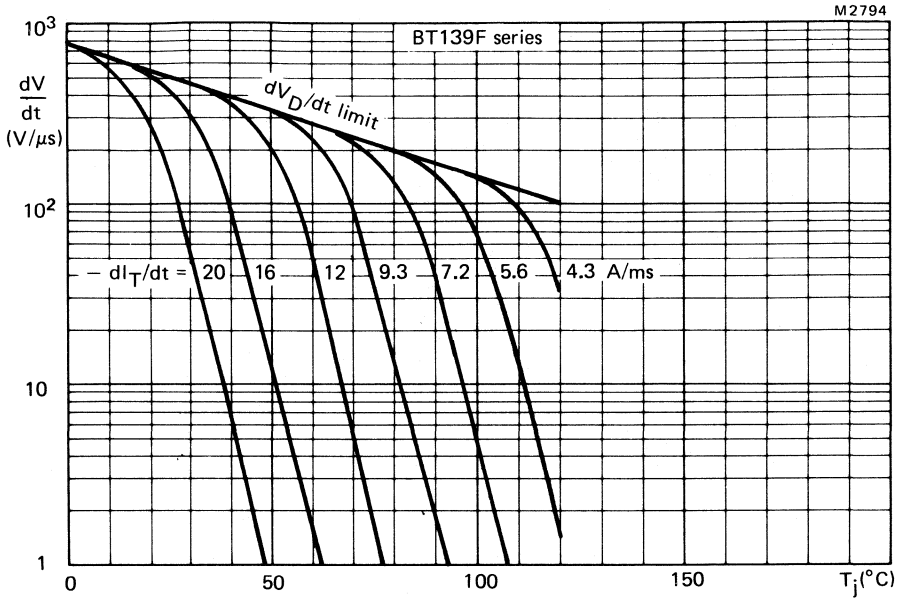


Fig.10 Typical commutation  $dV/dt$  for BT139F series versus  $T_j$ . The triac should commute when the  $dV/dt$  is below the value on the appropriate curve for pre-commutation  $di_T/dt$ .

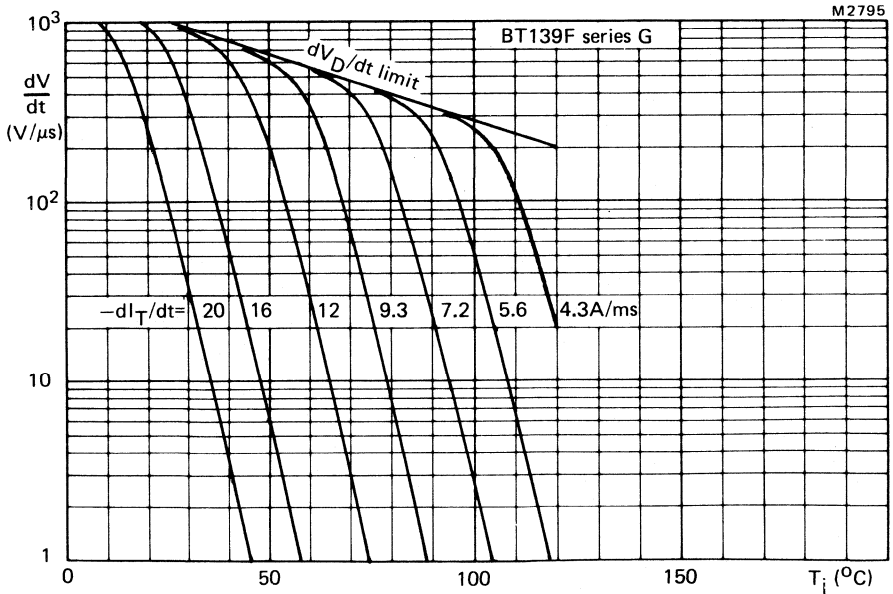


Fig.11 Limit commutation  $dV/dt$  for BT139F series G versus  $T_j$ . The triac should commute when the  $dV/dt$  is below the value on the appropriate curve for pre-commutation  $di_T/dt$ .

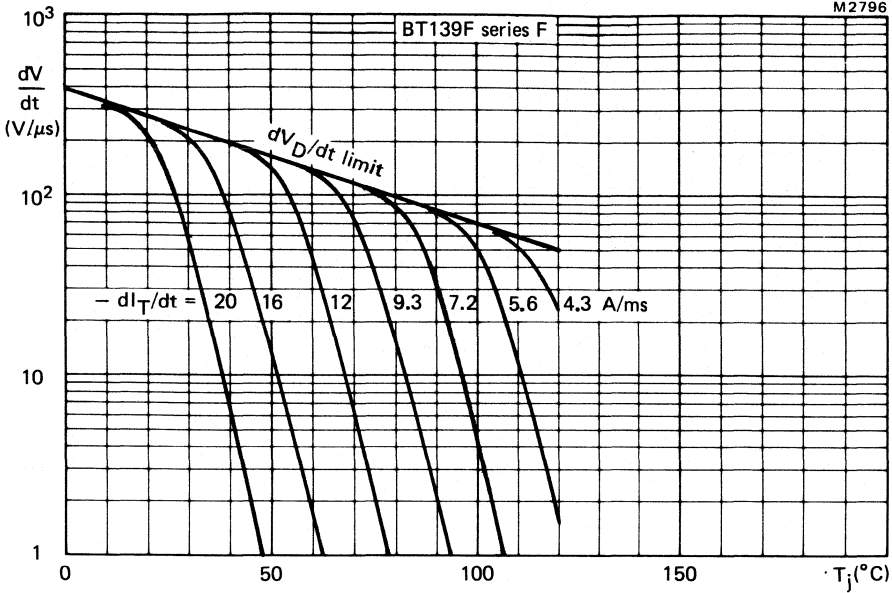


Fig.12 Typical commutation  $dV/dt$  for BT139F series F versus  $T_j$ . The triac should commute when the  $dV/dt$  is below the value on the appropriate curve for pre-commutation  $di_T/dt$ .

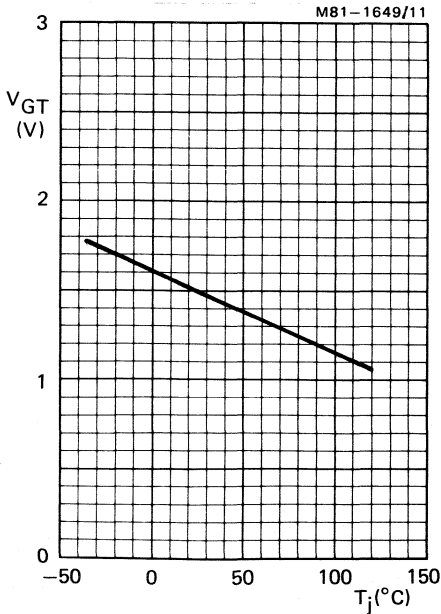


Fig. 13 Minimum gate voltage that will trigger all devices; all conditions.

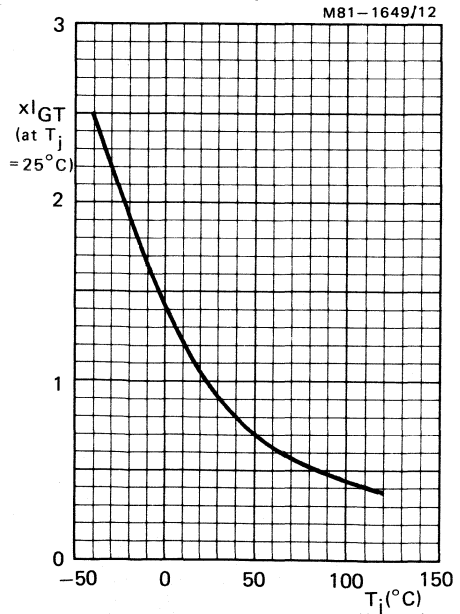


Fig. 14 Normalised gate current that will trigger all devices; all conditions.

LIMITS FOR STARTING OR INRUSH CURRENTS – FULL-CYCLE OPERATION

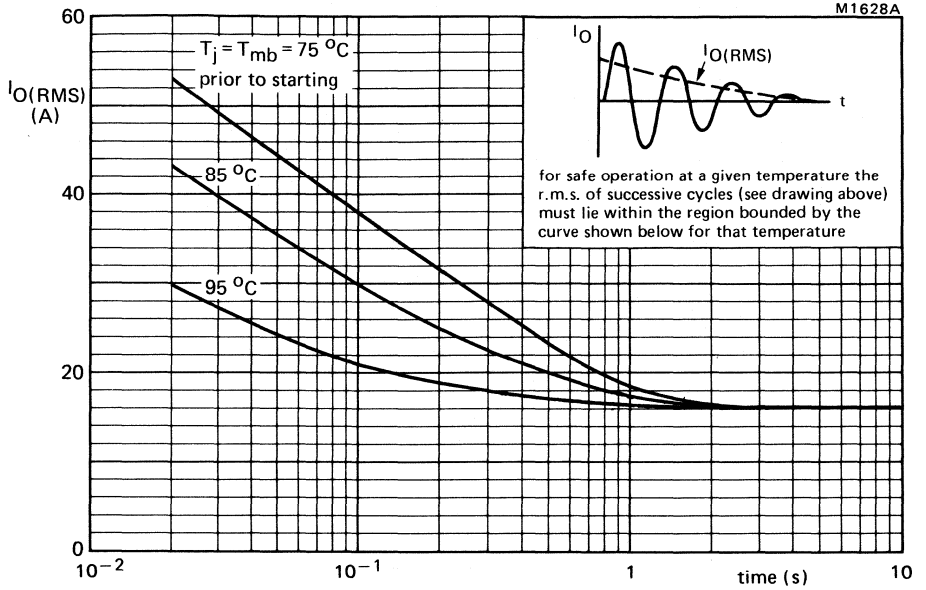


Fig.15.

## 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.

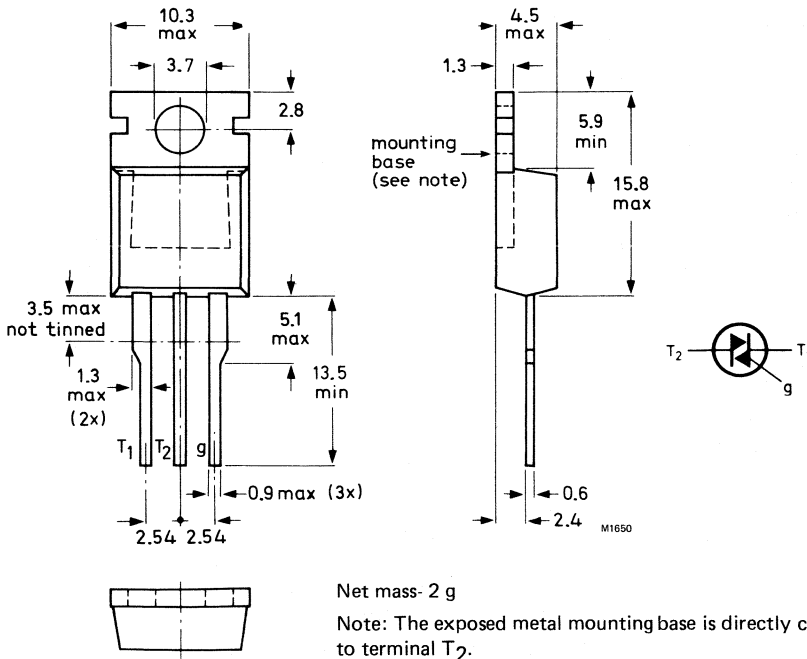
### QUICK REFERENCE DATA

		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



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 $360^\circ$ ) up to $T_{mb} = 89^\circ\text{C}$	$I_T(\text{RMS})$	max.	25 A
Average on-state current for half-cycle operation (averaged over any 20 ms period) up to $T_{mb} = 85^\circ\text{C}$	$I_T(\text{AV})$	max.	18 A
Repetitive peak on-state current	$I_{TRM}$	max.	180 A
Non-repetitive peak on-state current; $T_j = 120^\circ\text{C}$ prior to surge; full sine-wave	$I_{TSM}$	max.	180 A
$t = 20$ ms	$I_{TSM}$	max.	200 A
$t = 16.7$ ms	$I_{TSM}$	max.	200 A
$I^2 t$ for fusing ( $t = 10$ ms)	$I^2 t$	max.	160 $\text{A}^2\text{s}$
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/ $\mu\text{s}$	$dI_T/dt$	max.	30 A/ $\mu\text{s}$

### Gate to terminal 1

#### Power dissipation

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

#### Temperatures

Storage temperature	$T_{stg}$	-40 to +125 $^\circ\text{C}$	
Operating junction temperature	$T_j$		
full-cycle operation	$T_j$	max.	120 $^\circ\text{C}$
half-cycle operation	$T_j$	max.	110 $^\circ\text{C}$

\* 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/ $\mu\text{s}$ .

**THERMAL RESISTANCE**

From junction to mounting base

full-cycle operation

$$R_{th\ j-mb} = 1.0\ K/W$$

half-cycle operation

$$R_{th\ j-mb} = 1.4\ K/W$$

Transient thermal impedance;  $t = 1\ ms$ 

$$Z_{th\ j-mb} = 0.1\ K/W$$

**Influence of mounting method**

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from mounting base to heatsink

a. with heatsink compound

$$R_{th\ mb-h} = 0.3\ K/W$$

b. with heatsink compound and 0.06 mm maximum mica insulator

$$R_{th\ mb-h} = 1.4\ K/W$$

c. with heatsink compound and 0.1 mm maximum mica insulator (56369)

$$R_{th\ mb-h} = 2.2\ K/W$$

d. with heatsink compound and 0.25 mm maximum alumina insulator (56367)

$$R_{th\ mb-h} = 0.8\ K/W$$

e. without heatsink compound

$$R_{th\ mb-h} = 1.4\ K/W$$

2. Free-air operation

The quoted values of  $R_{th\ j-a}$  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

$$R_{th\ j-a} = 60\ K/W$$

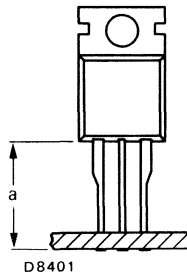


Fig.2

## CHARACTERISTICS ( $T_j = 25\text{ }^\circ\text{C}$ 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)

$$I_T = 30\text{ A} \qquad V_T < 1.55\text{ V}$$

$$\text{Rate of rise of off-state voltage that will not trigger any device; } T_j = 120\text{ }^\circ\text{C; gate open circuit} \qquad dV_D/dt < 100\text{ V}/\mu\text{s}$$

$$\begin{aligned} &\text{Rate of change of commutating voltage that will not trigger any device when } -di_{com}/dt = 9.0\text{ A/ms} \\ &I_T(\text{RMS}) = 25\text{ A; } T_{mb} = 75\text{ }^\circ\text{C; gate open circuit;} \\ &V_D = V_{DWMmax} \qquad dV_{com}/dt \text{ typ. } 10\text{ V}/\mu\text{s} \end{aligned}$$

Off-state current

$$V_D = V_{DWMmax}; T_j = 120\text{ }^\circ\text{C} \qquad I_D < 0.5\text{ mA}$$

$$\text{Gate voltage that will trigger all devices} \qquad V_{GT} > 1.5\text{ V}$$

Gate voltage that will not trigger any device

$$\begin{aligned} &V_D = V_{DWMmax}; T_j = 120\text{ }^\circ\text{C;} \\ &T_2 \text{ and G positive or negative} \qquad V_{GD} < 250\text{ mV} \end{aligned}$$

			$T_2^+$ 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; $V_D = 12\text{ V; } T_j = 25\text{ }^\circ\text{C}$	$I_L$	<	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 °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<sub>2</sub>, 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<sub>th mb-h</sub> 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<sub>th mb-h</sub> 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.

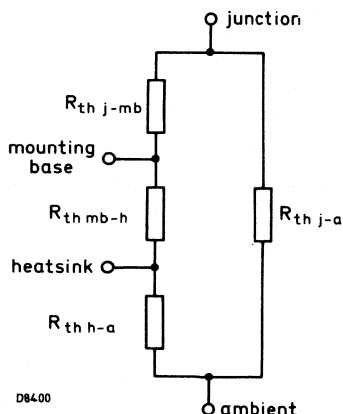


Fig.3.

- b. The method of using Fig.4 is as follows:
 

Starting with the required current on the I<sub>T(RMS)</sub> axis, trace upwards to meet the appropriate conduction angle curve. Trace right horizontally and upwards from the appropriate value on the T<sub>amb</sub> scale. The intersection determines the R<sub>th mb-a</sub>. The heatsink thermal resistance value (R<sub>th h-a</sub>) can now be calculated from:

$$R_{th h-a} = R_{th mb-a} - R_{th mb-h}$$

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

FULL-CYCLE OPERATION

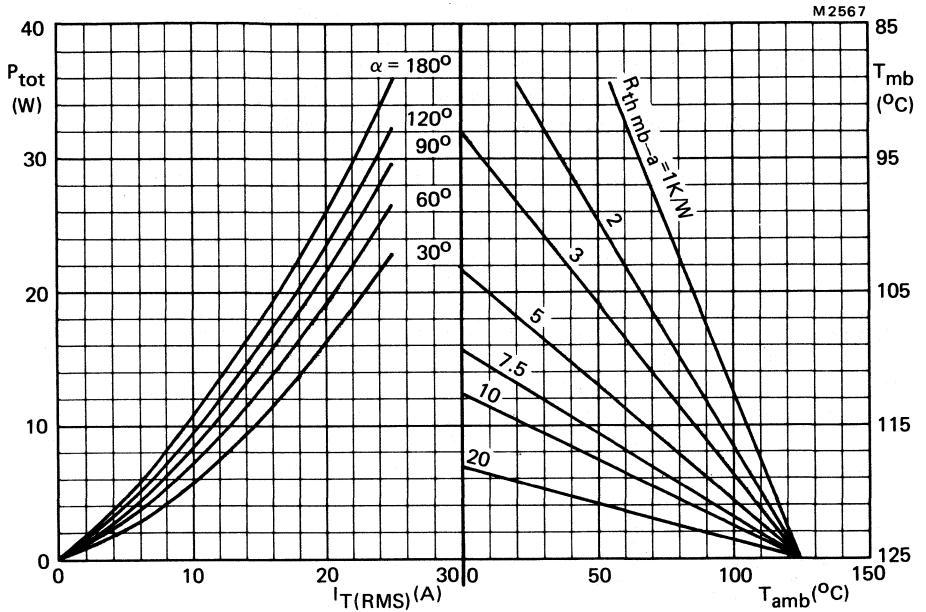
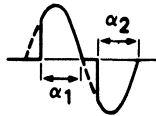


Fig.4 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha = \alpha_1 = \alpha_2$ : conduction angle per half cycle

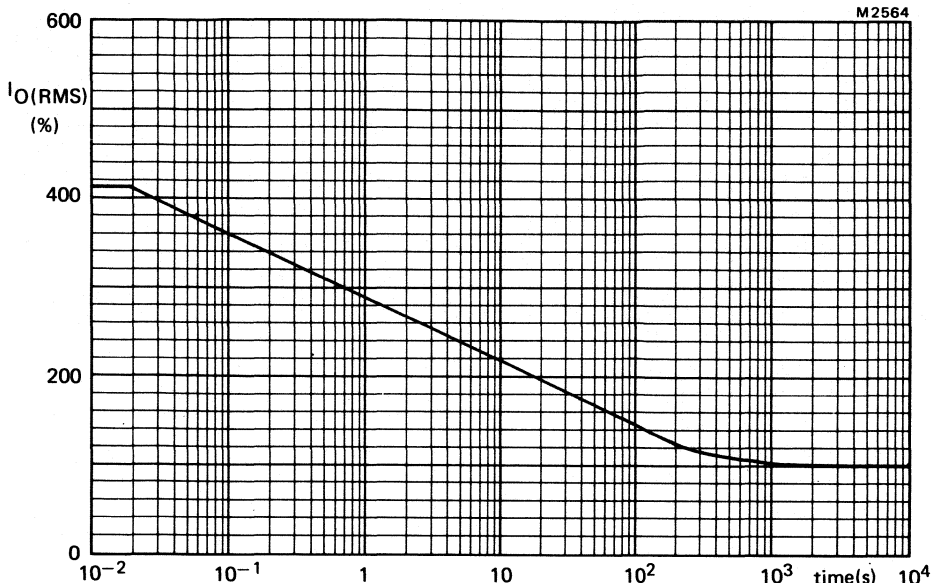


Fig.5 Maximum permissible duration of steady overload (provided that  $T_{mb}$  does not exceed  $120^\circ\text{C}$  during and after overload) expressed as a percentage of the steady state r.m.s. rated current. For high r.m.s. overload currents precautions should be taken so that the temperature of the terminals does not exceed  $125^\circ\text{C}$ . During these overload conditions the triac may lose control. Therefore the overload should be terminated by a separate protection device.

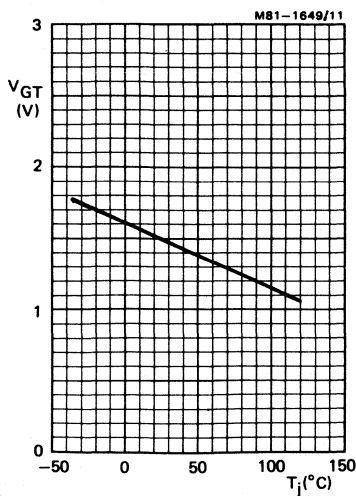


Fig.6 Minimum gate voltage that will trigger all devices; all conditions.

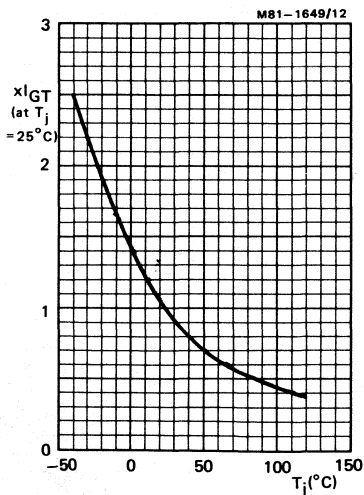


Fig.7 Normalised gate current that will trigger all devices; all conditions.

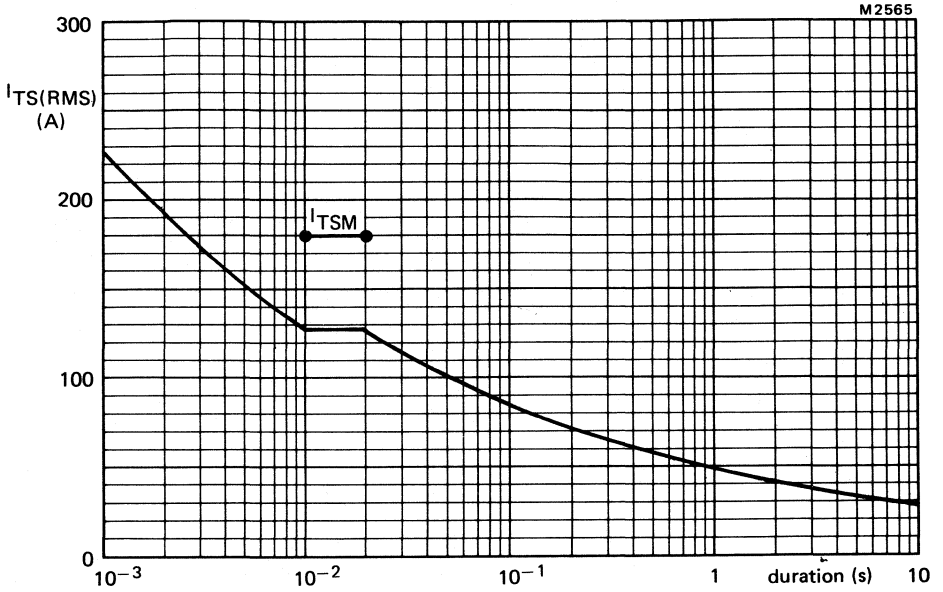


Fig.8 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents ( $f = 50$  Hz;  $T_j = 120$  °C prior to surge. The triac may temporarily lose control following the surge.

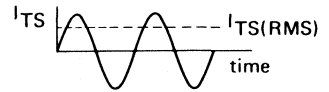
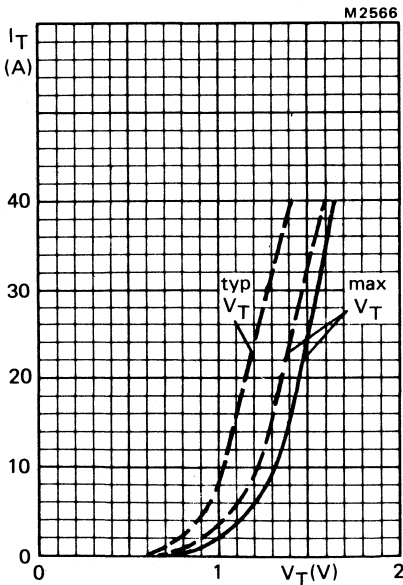


Fig.9 —  $T_j = 25$  °C; - - -  $T_j = 120$  °C.

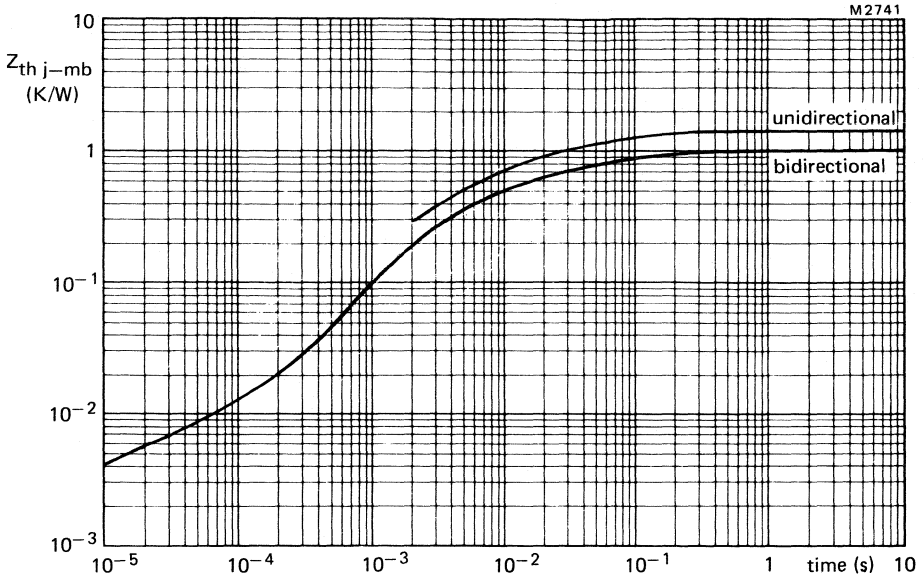


Fig.10 Transient thermal impedance.

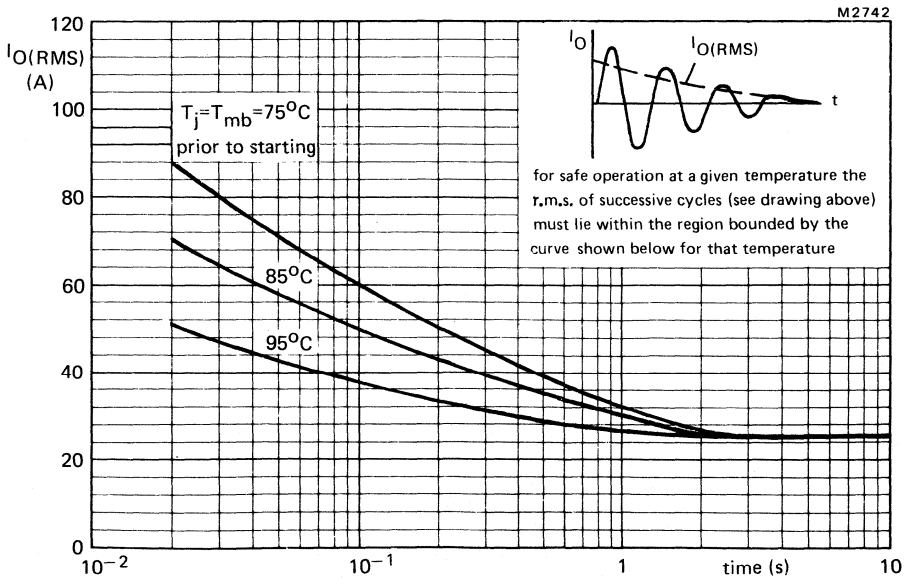


Fig.11 Limits for starting or inrush currents – full-cycle operation



## 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).

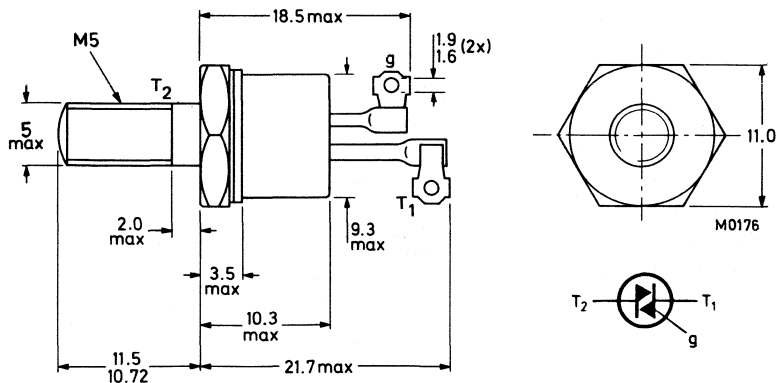
### QUICK REFERENCE DATA

	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 ( $t \leq 10$ 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

at  $T_{mb} = 85$  °C

$I_T(RMS)$  max. 15 A

$I_T(RMS)$  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

$I^2 t$  for fusing ( $t = 10$  ms)

$I^2 t$  max. 72 A<sup>2</sup> s

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/ $\mu$ s

$dI_T/dt$  max. 50 A/ $\mu$ s

### 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

$R_{th j-mb}$  = 2,0 K/W

half-cycle operation

$R_{th j-mb}$  = 4,0 K/W

From mounting base to heatsink with heatsink compound

$R_{th mb-h}$  = 0,5 K/W

Transient thermal impedance;  $t = 1$  ms

$Z_{th j-mb}$  = 0,2 K/W

\* To ensure thermal stability:  $R_{th j-a} < 6$  K/W (full-cycle or half-cycle operation). For smaller heat-sinks  $T_j$  should be derated (see Fig.2).



**CHARACTERISTICS** ( $T_j = 25\text{ }^\circ\text{C}$  unless otherwise stated)Polarities positive or negative, are identified with respect to  $T_1$ .**Voltages** (in either direction)

On-state voltage

$I_T = 20\text{ A}$

$V_T < 2,2\text{ V}^*$

Rate of rise of off-state voltage that will not trigger any device;  
exponential method;  $V_D = 2/3 V_{DRMmax}$ ;  $T_j = 125\text{ }^\circ\text{C}$ 

$dV_D/dt < 200\text{ V}/\mu\text{s}$

Rate of rise of commutating voltage that will not trigger any device;

$I_{T(RMS)} = 12\text{ A}$ ;  $V_D = V_{DWMmax}$ ;  $T_{mb} = 85\text{ }^\circ\text{C}$

$dV_{com}/dt\text{ (V}/\mu\text{s)}$  |  $-dI_T/dt\text{ (A/ms)}$

BTW43-600G to 1200G

$< 10$  |  $5$

BTW43-600H to 1200H

$< 10$  |  $12$

**Currents** (in either direction)

Off-state current

$V_D = V_{DWMmax}$ ;  $T_j = 125\text{ }^\circ\text{C}$

$I_D < 5\text{ mA}$

Latching current

G positive

$I_L < 200$  |  $200\text{ mA}$

G negative

$I_L < 200$  |  $200\text{ mA}$

Holding current

G positive or negative

$I_H < 100$  |  $100\text{ mA}$

**Gate to terminal 1**

Voltage and current that will trigger all devices

$V_D = 12\text{ V}$

G positive

$\{ V_{GT} > 2,5$  |  $5,0\text{ V}$

$\{ I_{GT} > 100$  |  $200\text{ mA}$

G negative

$\{ -V_{GT} > 2,5$  |  $2,5\text{ V}$

$\{ -I_{GT} > 100$  |  $100\text{ mA}$

Voltage that will not trigger any device

$V_D = V_{DRMmax}$ ;  $T_j = 125\text{ }^\circ\text{C}$ ; G positive or negative

$V_{GD} < 0,2$  |  $0,2\text{ V}$

\* Measured under pulse conditions to avoid excessive dissipation.

FULL CYCLE OPERATION

M2631

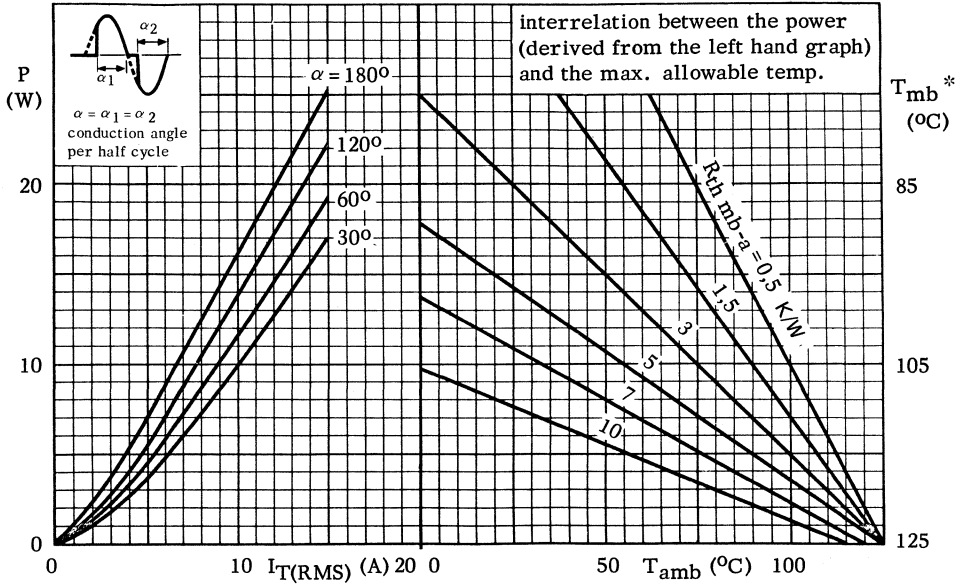


Fig.2 \*  $T_{mb}$ -scale is for comparison purposes only and is correct only for  $R_{th\ mb-a} \leq 4\ K/W$ .

FULL CYCLE OPERATION

M2637

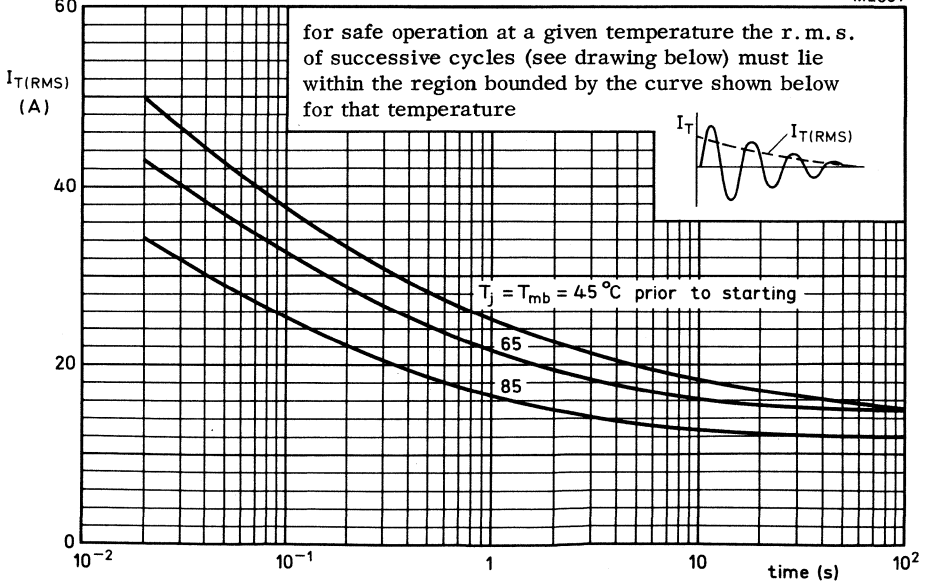


Fig.3

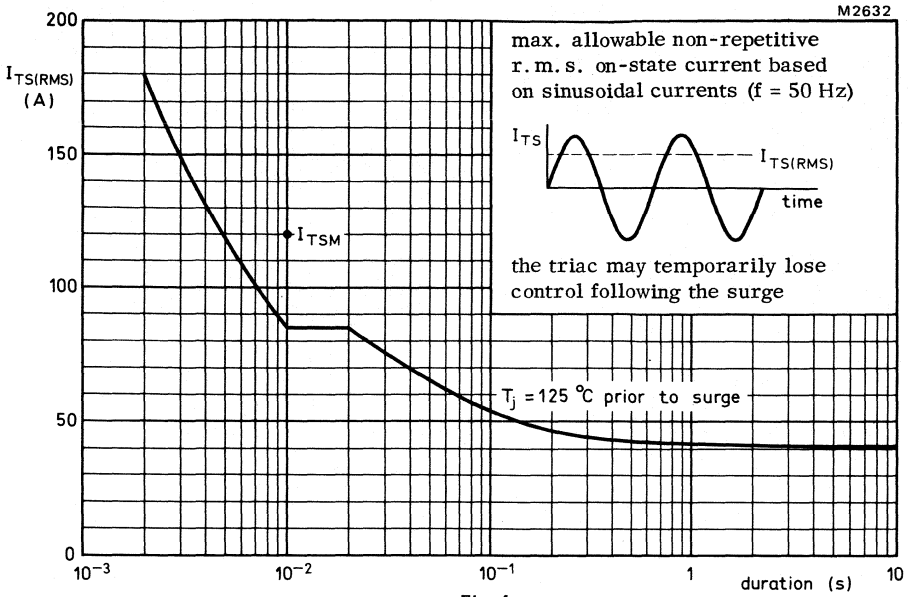


Fig. 4.

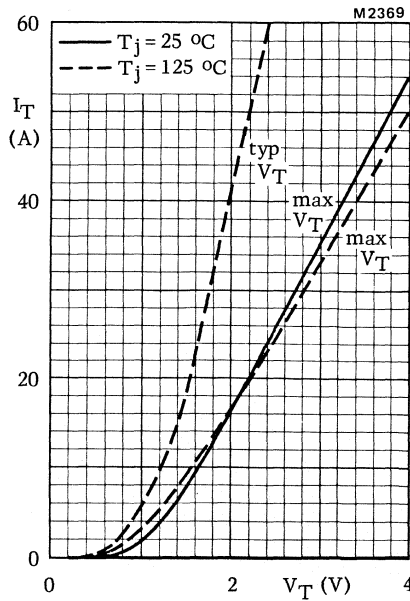


Fig. 5.

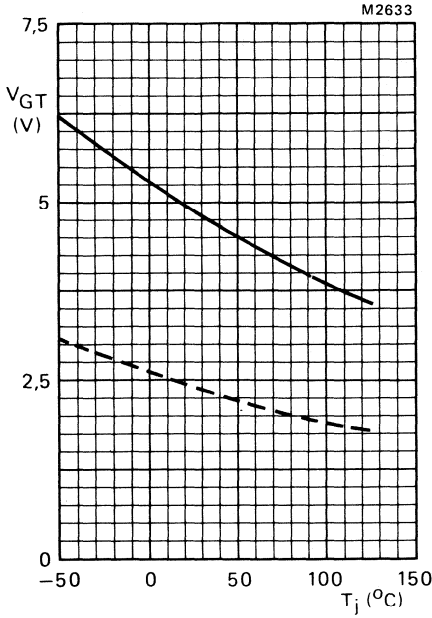


Fig. 6 Minimum gate voltage that will trigger all devices as a function of  $T_j$ .

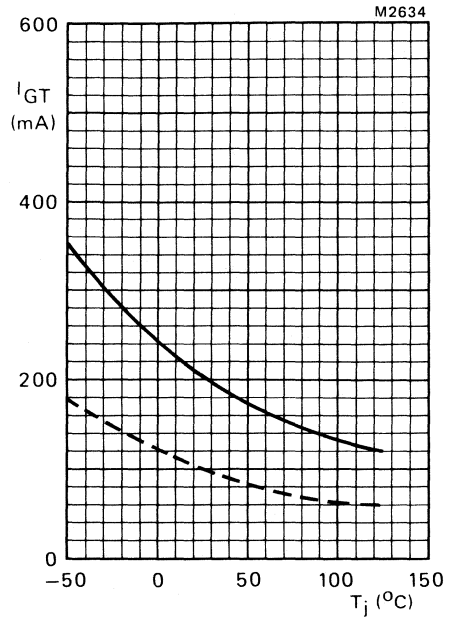


Fig. 7 Minimum gate current that will trigger all devices as a function of  $T_j$ .

Conditions for Figs 6 and 7:

- $T_2$  negative, gate positive with respect to  $T_1$
- all other conditions

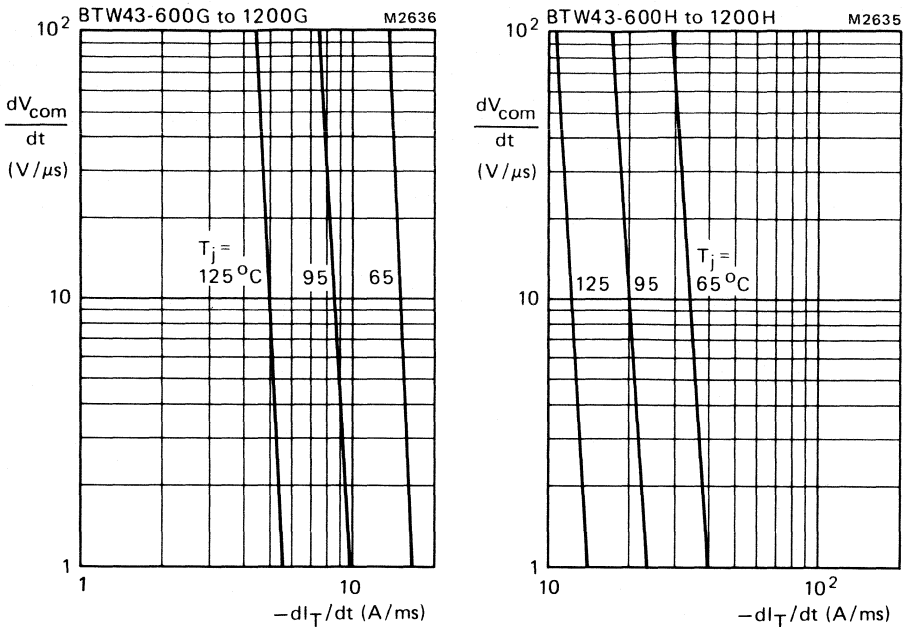


Fig. 8 Maximum rate of rise of commutating voltage that will not trigger any device as a function of rate of fall of on-state current;  $I_T(\text{RMS}) = 12 \text{ A}$ ;  $V_D = V_{DWM\text{max}}$ .

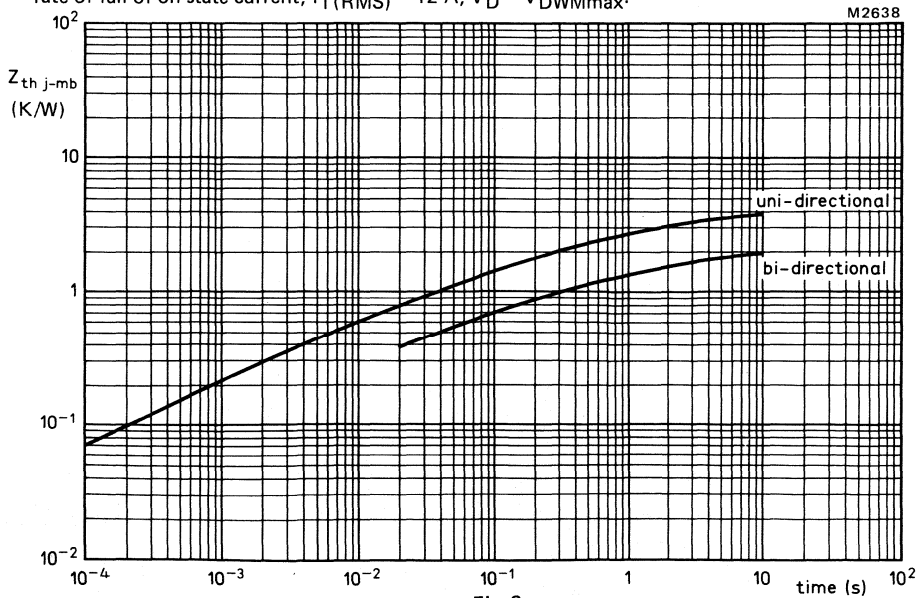


Fig. 9.



# **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

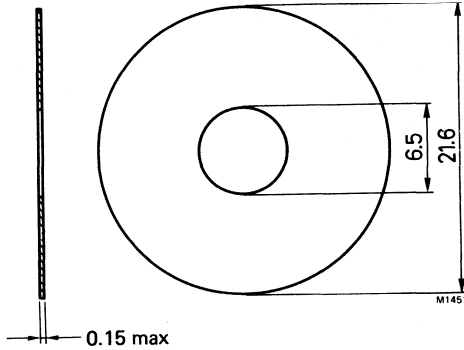
56264a

MICA WASHER

Insulator up to 2000 V

MECHANICAL DATA

Dimensions in mm

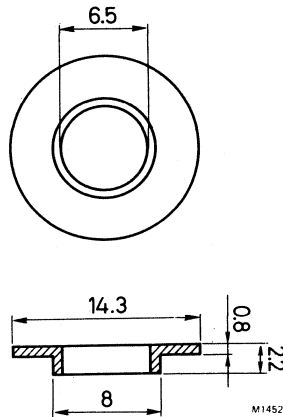


56264b

INSULATING BUSH

MECHANICAL DATA

Dimensions in mm



THERMAL RESISTANCE

From mounting base to heatsink  
with mica washer, without heatsink compound  
with mica washer, with heatsink compound

$R_{th\ mb-h}$	=	5	K/W
$R_{th\ mb-h}$	=	2.5	K/W

TEMPERATURE

Maximum allowable temperature

$T_{max}$	=	175	°C
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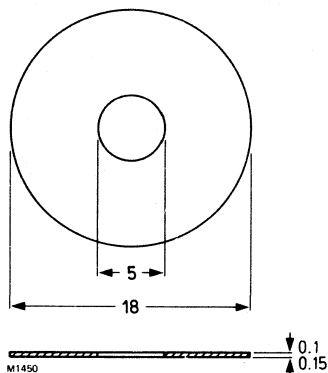
56295a

MICA WASHER

Insulator up to 2 kV.

MECHANICAL DATA

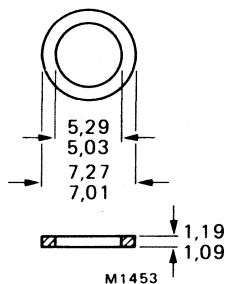
Dimensions in mm



56295b PTFE RING

MECHANICAL DATA

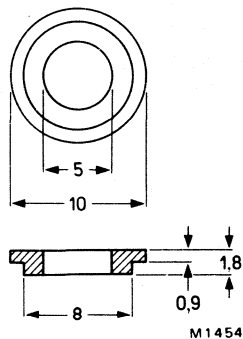
Dimensions in mm



56295c INSULATING BUSH

MECHANICAL DATA

Dimensions in mm



THERMAL RESISTANCE

From mounting base to heatsink  
without heatsink compound  
with heatsink compound

$R_{th\ mb-h}$	=	5	K/W
$R_{th\ mb-h}$	=	2.5	K/W

TEMPERATURE

Maximum allowable temperature

$T_{max}$	=	175	°C
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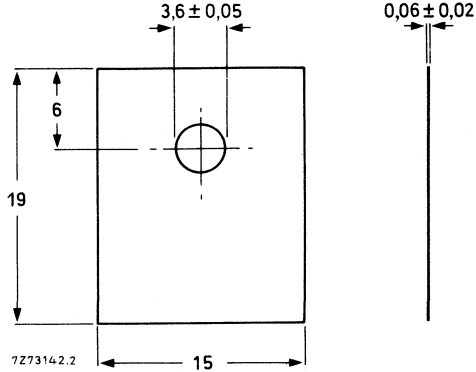
56359b

MICA WASHER

Insulator up to 1000 V.

MECHANICAL DATA

Dimensions in mm



56359c

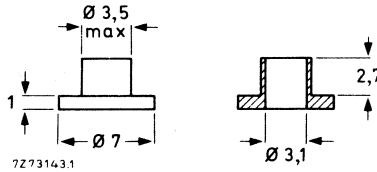
INSULATING BUSH

Insulator up to 800 V.

MECHANICAL DATA

Material: polyester

Dimensions in mm



TEMPERATURE

Maximum permissible  
temperature

$$T_{\max} = 150 \text{ }^{\circ}\text{C}$$

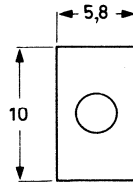
56359d

RECTANGULAR INSULATING BUSH

Insulator up to 1000 V.

MECHANICAL DATA

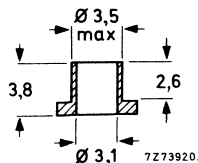
Dimensions in mm



TEMPERATURE

Maximum permissible  
temperature

$$T_{\max} = 150 \text{ }^{\circ}\text{C}$$



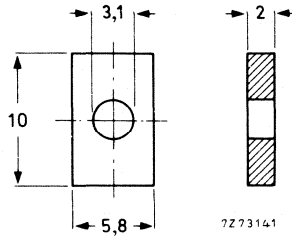
56360a

RECTANGULAR WASHER (For TO-220)

For direct and insulated mounting.

MECHANICAL DATA

Material: brass; nickel plated.



Dimensions in mm

56363

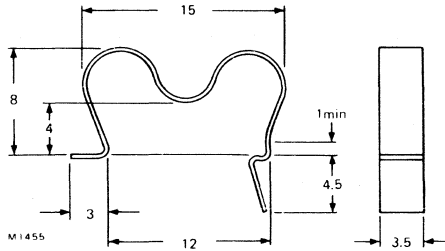
SPRING CLIP (For TO-220 and SOT-186)

For direct mounting.

MECHANICAL DATA

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).



Dimensions in mm

56364

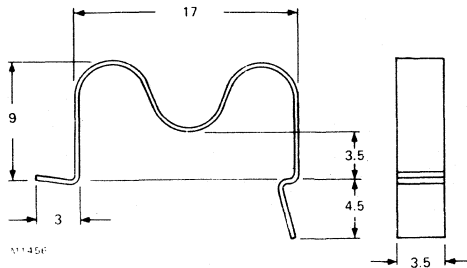
SPRING CLIP (For TO-220)

For insulated mounting.

MECHANICAL DATA

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).



Dimensions in mm

To be used in conjunction with insulators 56367 or 56369

56367

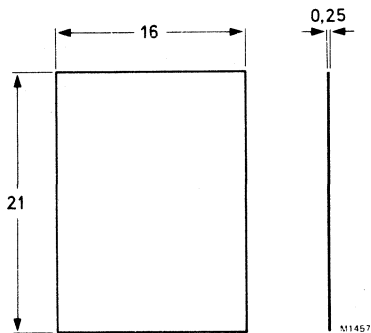
ALUMINA INSULATOR

For insulated clip mounting up to 2 kV.

MECHANICAL DATA

Material: 96-alumina.

Dimensions in mm



\*Because alumina is brittle, extreme care must be taken when mounting devices not to crack the alumina, particularly when used without heatsink compound.

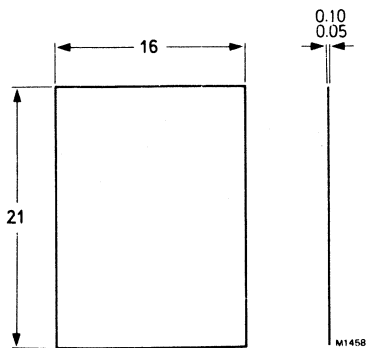
56369

MICA INSULATOR

For insulated clip mounting up to 2 kV.

MECHANICAL DATA

Dimensions in mm



56368b

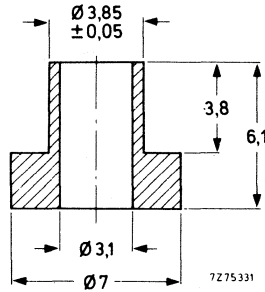
INSULATING BUSH

For insulated screw mounting up to 800 V.

MECHANICAL DATA

Material: polyester

Dimensions in mm



TEMPERATURE

Maximum permissible temperature

$T_{max} = 150\text{ }^{\circ}\text{C}$

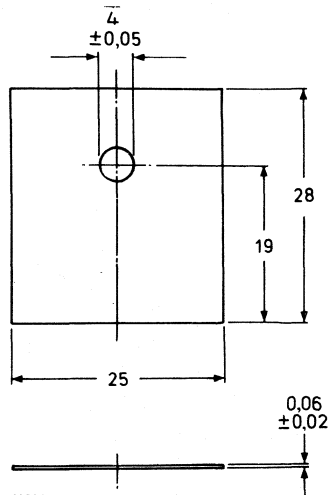
56368c

MICA INSULATOR

For insulated screw mounting up to 800 V.

MECHANICAL DATA

Dimensions in mm



56369: see preceding page.

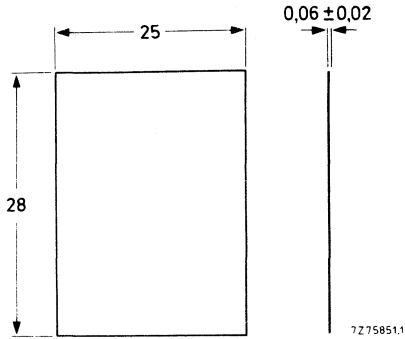
56378

MICA INSULATOR

For clip mounting up to 1500 V.

MECHANICAL DATA

Dimensions in mm



56379

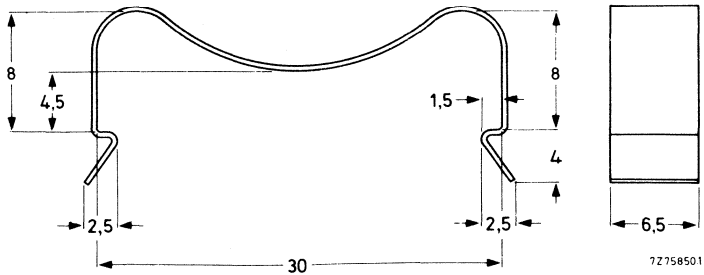
SPRING CLIP

For direct and insulated mounting of SOT-93 and SOT-112 envelopes.

MECHANICAL DATA

Dimensions in mm

Material:  
CrNi steel NLN-939;  
thickness  $0.4 \pm 0.04$ .





# **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 ( $R_{th\ mb-h}$ ) 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  $R_{th\ mb-h}$  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-riveted 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	$R_{th\ mb-h}$	= 0,3	0,5	K/W
without heatsink compound, direct mounting	$R_{th\ mb-h}$	= 1,4	1,4	K/W
with heatsink compound and 0,1 mm maximum mica washer	$R_{th\ mb-h}$	= 2,2	—	K/W
with heatsink compound and 0,25 mm maximum alumina insulator	$R_{th\ mb-h}$	= 0,8	—	K/W
with heatsink compound and 0,05 mm mica washer insulated up to 500 V	$R_{th\ mb-h}$	= —	1,4	K/W
insulated up to 800 V/1000 V	$R_{th\ mb-h}$	= —	1,6	K/W
without heatsink compound and 0,05 mm mica washer insulated up to 500 V	$R_{th\ mb-h}$	= —	3,0	K/W
insulated up to 800 V/1000 V	$R_{th\ mb-h}$	= —	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° 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  $T_j\ max \leq 175$  °C, soldering temperature  $T_{sld}\ max = 275$  °C.

Devices with  $T_j\ max \leq 110$  °C, soldering temperature  $T_{sld}\ max = 240$  °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  $\leq 200$  °C (tab-temperature).

Soldering cycle duration including pre-heating  $\leq 30$  sec.

For good soldering and avoiding damage to the encapsulation pre-heating is recommended to a temperature  $\leq 165$  °C at a duration  $\leq 10$  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  $10^{\circ}$  to  $30^{\circ}$  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.

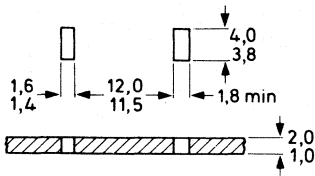


Fig. 1 Heatsink requirements.

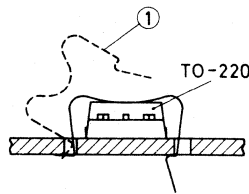


Fig. 2 Mounting.  
(1) spring clip 56363.

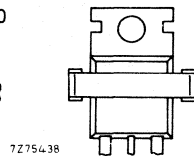


Fig. 2a Position of device (top view).

### 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  $10^{\circ}$  to  $30^{\circ}$  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.

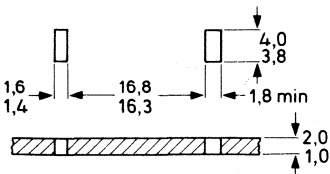


Fig. 3 Heatsink requirements.

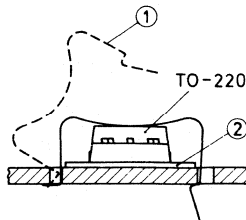


Fig. 4 Mounting.  
(1) spring clip 56364.  
(2) insulator 56369 or 56367.

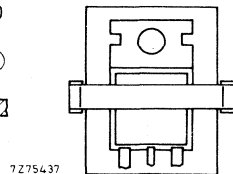


Fig.4a Position of device (top view).

INSTRUCTIONS FOR SCREW MOUNTING

Dimensions in mm

Direct mounting with screw and spacing washer

- *through heatsink with nut*

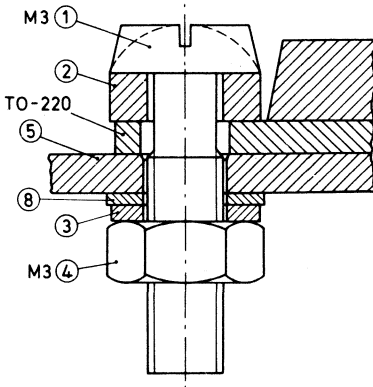
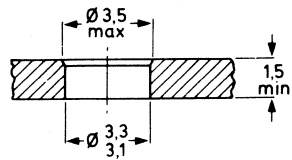


Fig. 5 Assembly.

- (1) M3 screw.
- (2) rectangular washer (56360a).
- (3) lock washer.
- (4) M3 nut.
- (5) heatsink.
- (8) plain washer.



72 69693.2

Fig. 6 Heatsink requirements.

- *into tapped heatsink*

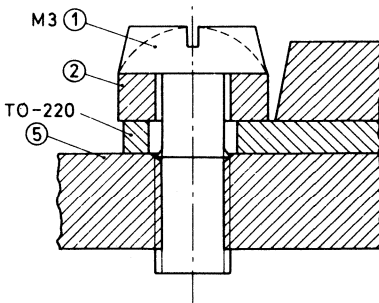
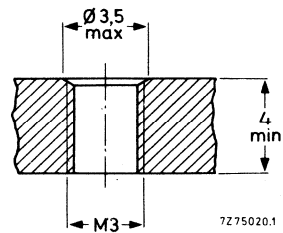


Fig. 7 Assembly.

- (1) M3 screw.
- (2) rectangular washer 56360a.
- (5) heatsink.



72 75020.1

Fig. 8 Heatsink requirements.

**Insulated mounting with screw and spacing washer**  
(not recommended where mounting tab is on mains voltage)

Dimensions in mm

• *through heatsink with nut*

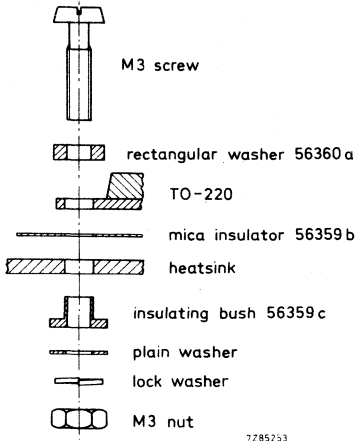


Fig. 9 Insulated screw mounting with rectangular washer. Known as a "bottom mounting".

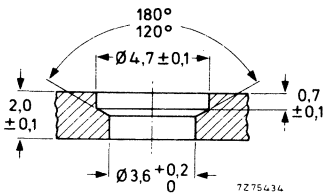


Fig. 10 Heatsink requirements for 500 V insulation.

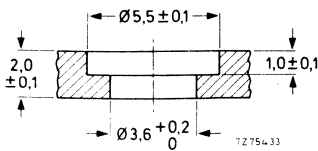


Fig. 11 Heatsink requirements for 800 V insulation.

• *into tapped heatsink*

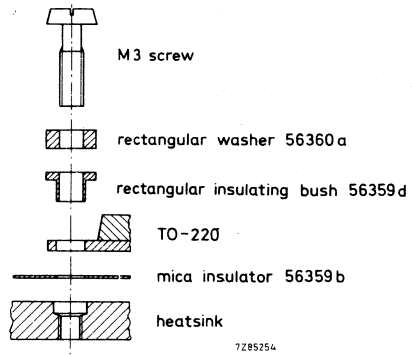


Fig. 12 Insulated screw mounting with rectangular washer into tapped heatsink. Known as a "top mounting".

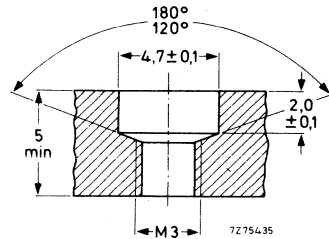


Fig. 13 Heatsink requirements for 500 V insulation.

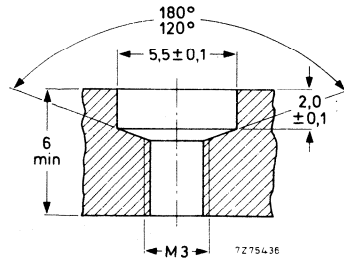


Fig. 14 Heatsink requirements for 1000 V insulation.





## 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 acquaint 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 "Accessories 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 "Accessories 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.

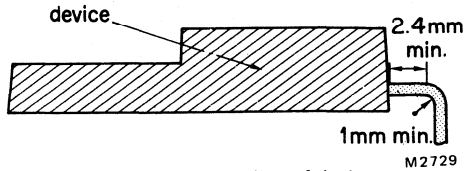


Fig.1 Lead bending of devices.

## Soldering

Lead soldering temperature at >3mm from body for  $t_{sld} < 5$  seconds:

Devices with  $T_j \text{ max.} \leq 175^\circ\text{C}$ ,  $T_{sld} \text{ max.} = 275^\circ\text{C}$ .

Devices with  $T_j \text{ max.} \leq 110^\circ\text{C}$ ,  $T_{sld} \text{ max.} = 240^\circ\text{C}$ .

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).

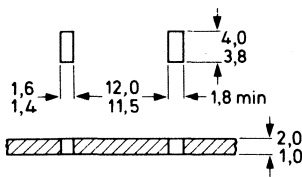


Fig.2 Heatsink requirements

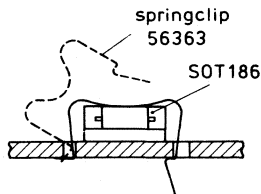


Fig.3 Mounting.

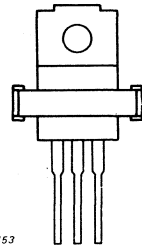


Fig.3a Position of device (top view).

## INSTRUCTIONS FOR SCREW MOUNTING

### Screw through heatsink with nut

Dimensions in mm

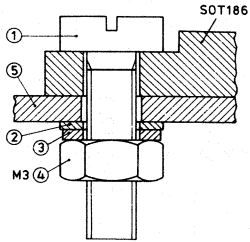


Fig.4 Assembly.

- (1) M3 screw
- (2) plain washer
- (3) lock washer
- (4) M3 nut
- (5) heatsink

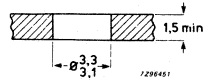


Fig.5 Heatsink requirements.

### Into tapped heatsink

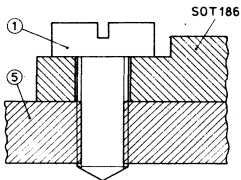


Fig.6 Assembly.

- (1) M3 screw
- (5) heatsink

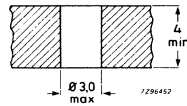
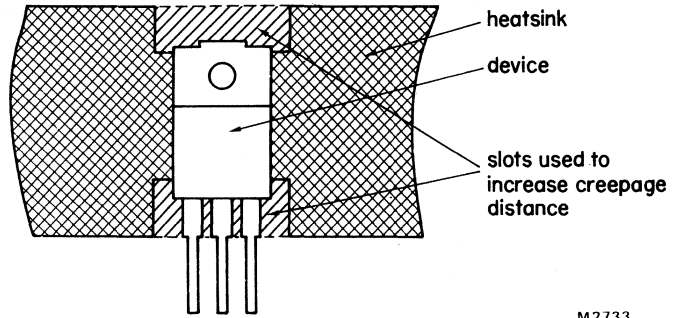


Fig.7 Heatsink requirements.

**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.



M2733

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 ( $R_{th\ mb-h}$ ) 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  $\leq 175$  °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).

Thermal resistance from mounting base to heatsink

direct mounting

with heatsink compound  
without heatsink compound

with 0,05 mm mica washer  
with heatsink compound  
without heatsink compound

	clip mounting	screw mounting
$R_{th\ mb-h}$	= 0,3	0,3 K/W
$R_{th\ mb-h}$	= 1,5	0,8 K/W
$R_{th\ mb-h}$	= 0,8	0,8 K/W
$R_{th\ mb-h}$	= 3,0	2,2 K/W

**INSTRUCTIONS FOR CLIP MOUNTING**

**Direct mounting with clip 56379**

- Place the device on the heatsink, applying heatsink compound to the mounting base.
- 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).
- 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)).

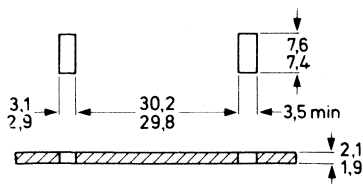


Fig. 1a Heatsink requirements.

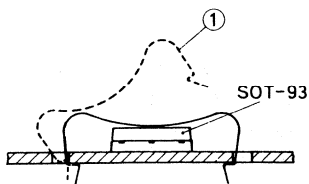


Fig. 1b Mounting.  
(1) = spring clip 56379.

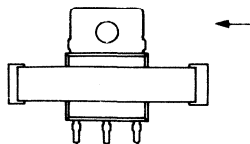


Fig. 1c Position of the device.

**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.

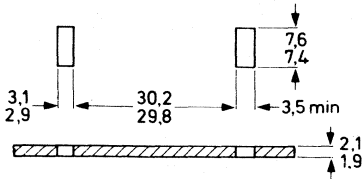


Fig. 2a Heatsink requirements.

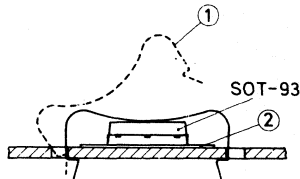


Fig. 2b Mounting.  
(1) = spring clip 56379  
(2) = insulator 56378

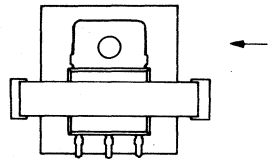


Fig. 2c Position of the device.

**INSTRUCTIONS FOR SCREW MOUNTING**

**Direct mounting**

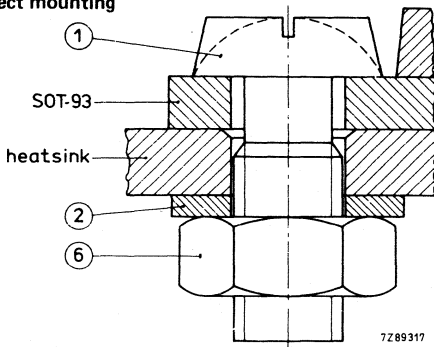


Fig. 3a Assembly through heatsink with nut.

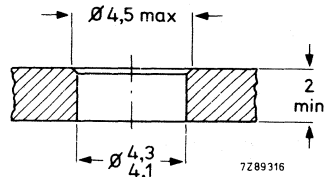


Fig. 3b Heatsink requirements.

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.

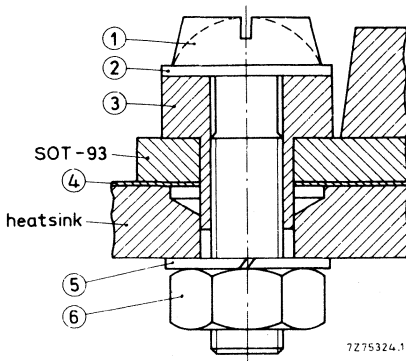


Fig. 4 Assembly.  
See also Fig. 9.

- (1) M3 screw
- (2) plain washer
- (3) insulating bush (56368b)
- (4) mica insulator (56368c)
- (5) lock washer
- (6) M3 nut

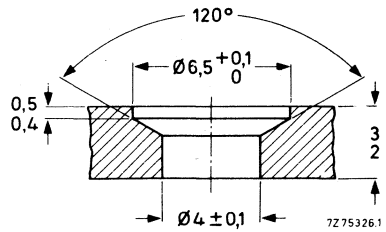


Fig. 5 Heatsink requirements  
up to 800 V insulation.

Insulated screw mounting with tapped hole; up to 800 V.

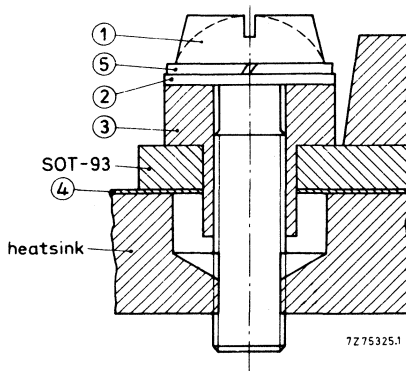


Fig. 6 Assembly.  
See also Fig. 9.

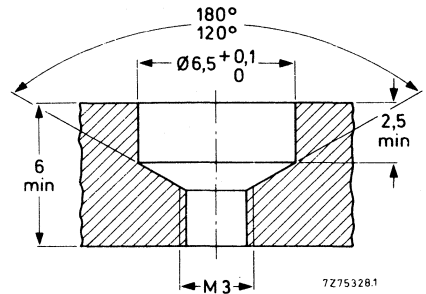


Fig. 7 Heatsink requirements  
up to 800 V insulation.

- (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

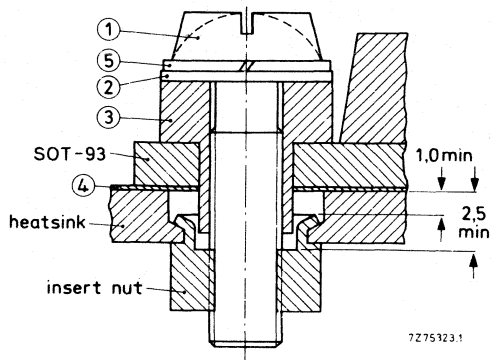


Fig. 8 Assembly and heatsink requirements for 500 V insulation. See also Fig. 3.

- (1) M3 screw
- (2) plain washer
- (3) insulating bush (56368b)
- (4) mica insulator (56368c)
- (5) lock washer

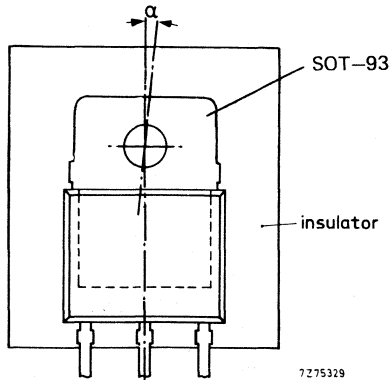


Fig. 9 Mica insulator.

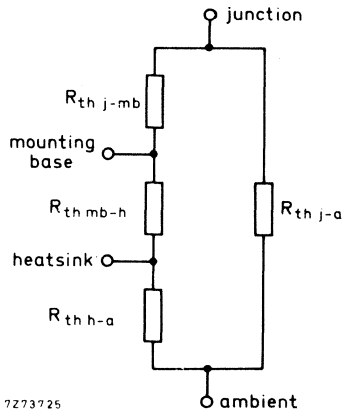
The axial deviation ( $\alpha$ ) between SOT-93 and mica should not exceed 5°.

**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  $R_{th\ j-mb}$ . The second is the contact thermal resistance  $R_{th\ mb-h}$  and finally there is the thermal resistance of the heatsink  $R_{th\ h-a}$ .

In the rating curves, the contact thermal resistance and heatsink thermal resistances are combined as a single figure -  $R_{th\ mb-a}$ .

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  $Z_{th\ j-mb}$  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)  
Maximum torque (to avoid damaging device)

0.9 Nm (9 kg cm)  
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  
with heatsink compound

$R_{th\ mb-h}$	=	5	K/W
$R_{th\ mb-h}$	=	2.5	K/W

**MOUNTING INSTRUCTIONS FOR UP TO 2000 V INSULATION**

Using 56295c insulating bush and 56295a mica washer.

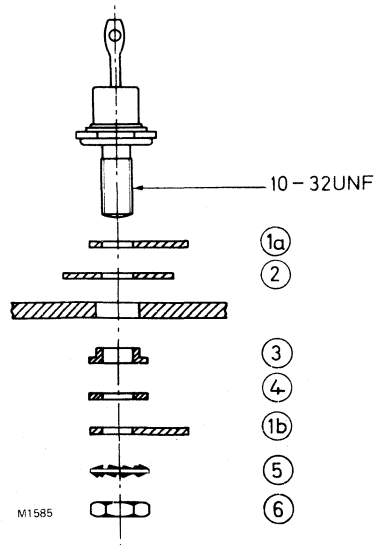


Fig.1

- (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 DO-4; TO-64

## MOUNTING INSTRUCTIONS FOR UP TO 2000 V INSULATION

Using insulating ring 56295b and two mica washers 56295a.

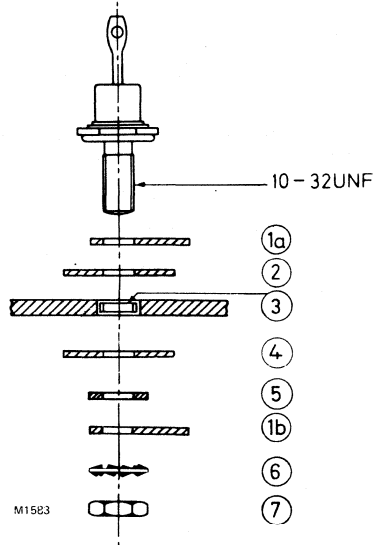


Fig. 2

- (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 ( $R_{th\ mb-h}$ ) 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

$R_{th\ mb-h} = 5$  K/W

with heatsink compound

$R_{th\ mb-h} = 2.5$  K/W

### MOUNTING INSTRUCTIONS FOR UP TO 2000 V INSULATION

Using insulating bush 56264b and mica washer 56264a.

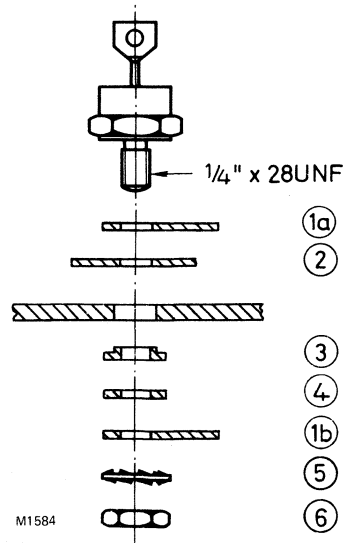


Fig. 1

- (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) 1/4" x 28 UNF nut (supplied with device)



# INDEX





Type No.	Page
BR100/03	177
BT136 series	315
BT136F series	327
BT137 series	339
BT137F series	351
BT138 series	363
BT138F series	375
BT139 series	387
BT139F series	399
BT145 series	179
BT149 series	187
BT150	189
BT151 series	197
BT151F series	207
BT152 series	217
BT153	225
BT157 series	39
BT169 series	237
BTA140 series	411
BTR59 series	51
BTS59 series	63
BTV58 series	75
BTV59 series	87
BTV59D series	99
BTV60 series	113
BTV60D series	123

Type No.	Page
BTV70 series	137
BTV70D series	149
BTW23 series	241
BTW38 series	243
BTW40 series	251
BTW42 series	257
BTW43 series	421
BTW45 series	261
BTW58 series	163
BTW62 series	267
BTW62D series	275
BTW63 series	287
BTY79 series	295
BTY91 series	305
56264a,b	432
56295a,b,c	433
56395b,c,d	434
56360a	435
56363	435
56364	435
56367	436
56368b,c	437
56369	436
56378	438
56379	438



## INDEX OF TYPE NUMBERS

The inclusion of a type number in this publication does not necessarily imply its availability.

type no.	book	section	type no.	book	section	type no.	book	section
BA220	S1	SD	BAS29	S7/S1	Mm/SD	BAV99	S7/S1	Mm/SD
BA221	S1	SD	BAS31	S7/S1	Mm/SD	BAV100	S7/S1	Mm/SD
BA223	S1	T	BAS32	S7/S1	Mm/SD	BAV101	S7/S1	Mm/SD
BA281	S1	SD	BAS35	S7/S1	Mm/SD	BAV102	S7/S1	Mm/SD
BA314	S1	Vrg	BAS45	S1	SD	BAV103	S7/S1	Mm/SD
BA315	S1	Vrg	BAS56	S1/S7	SD/Mm	BAW56	S7/S1	Mm/SD
BA316	S1	SD	BAT17	S7/S1	Mm/T	BAW62	S1	SD
BA317	S1	SD	BAT18	S7/S1	Mm/T	BAX12	S1	SD
BA318	S1	SD	BAT54	S1/S7	SD/Mm	BAX14	S1	SD
BA423	S1	T	BAT74	S1/S7	SD/Mm	BAX18	S1	SD
BA480	S1	T	BAT81	S1	T	BAY80	S1	SD
BA481	S1	T	BAT82	S1	T	BB112	S1	T
BA482	S1	T	BAT83	S1	T	BB119	S1	T
BA483	S1	T	BAT85	S1	T	BB130	S1	T
BA484	S1	T	BAT86	S1	T	BB204B	S1	T
BA682	S1/S7	T/Mm	BAV10	S1	SD	BB204G	S1	T
BA683	S1/S7	T/Mm	BAV18	S1	SD	BB212	S1	T
BAS11	S1	SD	BAV19	S1	SD	BB215	S7/S1	Mm/SD
BAS15	S1	SD	BAV20	S1	SD	BB219	S7/S1	Mm/SD
BAS16	S7/S1	Mm/SD	BAV21	S1	SD	BB405B	S1	T
BAS17	S7/S1	Mm/Vrg	BAV23	S7/S1	Mm/SD	BB417	S1	T
BAS19	S7/S1	Mm/SD	BAV45	S1	Sp	BB809	S1	T
BAS20	S7/S1	Mm/SD	BAV45A	S1	Sp	BB909A	S1	T
BAS21	S7/S1	Mm/SD	BAV70	S7/S1	Mm/SD	BB909B	S1	T
BAS28	S7/S1	Mm/SD	BAV74	S1	SD	BBY31	S7/S1	Mm/T

Mm = Microminiature semiconductors  
for hybrid circuits  
SD = Small-signal diodes

Sp = Special diodes  
T = Tuner diodes  
Vrg = Voltage regulator diodes

# INDEX

type no.	book	section	type no.	book	section	type no.	book	section
BBY39	S1	T	BC639	S3	Sm	BCW72;R	S7	Mm
BBY40	S7/S1	Mm/T	BC640	S3	Sm	BCW81;R	S7	Mm
BC107	S3	Sm	BC807	S7	Mm	BCW89;R	S7	Mm
BC108	S3	Sm	BC808	S7	Mm	BCX17;R	S7	Mm
BC109	S3	Sm	BC817	S7	Mm	BCX18;R	S7	Mm
BC140	S3	Sm	BC818	S7	Mm	BCX19;R	S7	Mm
BC141	S3	Sm	BC846	S7	Mm	BCX20;R	S7	Mm
BC146	S3	Sm	BC847	S7	Mm	BCX51	S7	Mm
BC160	S3	Sm	BC848	S7	Mm	BCX52	S7	Mm
BC161	S3	Sm	BC849	S7	Mm	BCX53	S7	Mm
BC177	S3	Sm	BC850	S7	Mm	BCX54	S7	Mm
BC178	S3	Sm	BC856	S7	Mm	BCX55	S7	Mm
BC179	S3	Sm	BC857	S7	Mm	BCX56	S7	Mm
BC200	S3	Sm	BC858	S7	Mm	BCX68	S7	Mm
BC264A	S5	FET	BC859	S7	Mm	BCX69	S7	m
BC264B	S5	FET	BC860	S7	Mm	BCX70*	S7	Mm
BC264C	S5	FET	BC868	S7	Mm	BCX71*	S7	Mm
BC264D	S5	FET	BC869	S7	Mm	BCY56	S3	Sm
BC327;A	S3	Sm	BCF29;R	S7	Mm	BCY57	S3	Sm
BC328	S3	Sm	BCF30;R	S7	Mm	BCY58	S3	Sm
BC337;A	S3	Sm	BCF32;R	S7	Mm	BCY59	S3	Sm
BC338	S3	Sm	BCF33;R	S7	Mm	BCY70	S3	Sm
BC368	S3	Sm	BCF70;R	S7	Mm	BCY71	S3	Sm
BC369	S3	Sm	BCF81;R	S7	Mm	BCY72	S3	Sm
BC375	S3	Sm	BCV26	S7	Mm	BCY78	S3	Sm
BC376	S3	Sm	BCV27	S7	Mm	BCY79	S3	Sm
BC546	S3	Sm	BCV61	S7	Mm	BCY87	S3	Sm
BC547	S3	Sm	BCV62	S7	Mm	BCY88	S3	Sm
BC548	S3	Sm	BCV71;R	S7	Mm	BCY89	S3	Sm
BC549	S3	Sm	BCV72;R	S7	Mm	BD131	S4a	P
BC550	S3	Sm	BCW29;R	S7	Mm	BD132	S4a	P
BC556	S3	Sm	BCW30;R	S7	Mm	BD135	S4a	P
BC557	S3	Sm	BCW31;R	S7	Mm	BD136	S4a	P
BC558	S3	Sm	BCW32;R	S7	Mm	BD137	S4a	P
BC559	S3	Sm	BCW33;R	S7	Mm	BD138	S4a	P
BC560	S3	Sm	BCW60*	S7	Mm	BD139	S4a	P
BC635	S3	Sm	BCW61*	S7	Mm	BD140	S4a	P
BC636	S3	Sm	BCW69;R	S7	Mm	BD201	S4a	P
BC637	S3	Sm	BCW70;R	S7	Mm	BD202	S4a	P
BC638	S3	Sm	BCW71;R	S7	Mm	BD203	S4a	P

\* = series

FET = Field-effect transistors

Mm = Microminiature semiconductors  
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P = Low-frequency power transistors

Sm = Small-signal transistors

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type no.	book	section	type no.	book	section	type no.	book	section
BD204	S4a	P	BD332	S4a	P	BD828	S4a	P
BD226	S4a	P	BD333	S4a	P	BD829	S4a	P
BD227	S4a	P	BD334	S4a	P	BD830	S4a	P
BD228	S4a	P	BD335	S4a	P	BD839	S4a	P
BD229	S4a	P	BD336	S4a	P	BD840	S4a	P
BD230	S4a	P	BD337	S4a	P	BD841	S4a	P
BD231	S4a	P	BD338	S4a	P	BD842	S4a	P
BD233	S4a	P	BD433	S4a	P	BD843	S4a	P
BD234	S4a	P	BD434	S4a	P	BD844	S4a	P
BD235	S4a	P	BD435	S4a	P	BD845	S4a	P
BD236	S4a	P	BD436	S4a	P	BD846	S4a	P
BD237	S4a	P	BD437	S4a	P	BD847	S4a	P
BD238	S4a	P	BD438	S4a	P	BD848	S4a	P
BD239	S4a	P	BD645	S4a	P	BD849	S4a	P
BD239A	S4a	P	BD646	S4a	P	BD850	S4a	P
BD239B	S4a	P	BD647	S4a	P	BD933	S4a	P
BD239C	S4a	P	BD648	S4a	P	BD934	S4a	P
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BD240B	S4a	P	BD651	S4a	P	BD937	S4a	P
BD240C	S4a	P	BD652	S4a	P	BD938	S4a	P
BD241	S4a	P	BD675	S4a	P	BD939	S4a	P
BD241A	S4a	P	BD676	S4a	P	BD940	S4a	P
BD241B	S4a	P	BD677	S4a	P	BD941	S4a	P
BD241C	S4a	P	BD678	S4a	P	BD942	S4a	P
BD242	S4a	P	BD679	S4a	P	BD943	S4a	P
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BD242B	S4a	P	BD681	S4a	P	BD945	S4a	P
BD242C	S4a	P	BD682	S4a	P	BD946	S4a	P
BD243	S4a	P	BD683	S4a	P	BD947	S4a	P
BD243A	S4a	P	BD684	S4a	P	BD948	S4a	P
BD243B	S4a	P	BD813	S4a	P	BD949	S4a	P
BD243C	S4a	P	BD814	S4a	P	BD950	S4a	P
BD244	S4a	P	BD815	S4a	P	BD951	S4a	P
BD244A	S4a	P	BD816	S4a	P	BD952	S4a	P
BD244B	S4a	P	BD817	S4a	P	BD953	S4a	P
BD244C	S4a	P	BD818	S4a	P	BD954	S4a	P
BD329	S4a	P	BD825	S4a	P	BD955	S4a	P
BD330	S4a	P	BD826	S4a	P	BD956	S4a	P
BD331	S4a	P	BD827	S4a	P	BDT20	S4a	P

P = Low-frequency power transistors

# INDEX

type no.	book	section	type no.	book	section	type no.	book	section
BDT21	S4a	P	BDT61C	S4a	P	BDV66B	S4a	P
BDT29	S4a	P	BDT62	S4a	P	BDV66C	S4a	P
BDT29A	S4a	P	BDT62A	S4a	P	BDV66D	S4a	P
BDT29B	S4a	P	BDT62B	S4a	P	BDV67A	S4a	P
BDT29C	S4a	P	BDT62C	S4a	P	BDV67B	S4a	P
BDT30	S4a	P	BDT63	S4a	P	BDV67C	S4a	P
BDT30A	S4a	P	BDT63A	S4a	P	BDV67D	S4a	P
BDT30B	S4a	P	BDT63B	S4a	P	BDV91	S4a	P
BDT30C	S4a	P	BDT63C	S4a	P	BDV92	S4a	P
BDT31	S4a	P	BDT64	S4a	P	BDV93	S4a	P
BDT31A	S4a	P	BDT64A	S4a	P	BDV94	S4a	P
BDT31B	S4a	P	BDT64B	S4a	P	BDV95	S4a	P
BDT31C	S4a	P	BDT64C	S4a	P	BDV96	S4a	P
BDT32	S4a	P	BDT65	S4a	P	BDW55	S4a	P
BDT32A	S4a	P	BDT65A	S4a	P	BDW56	S4a	P
BDT32B	S4a	P	BDT65B	S4a	P	BDW57	S4a	P
BDT32C	S4a	P	BDT65C	S4a	P	BDW58	S4a	P
BDT41	S4a	P	BDT81	S4a	P	BDW59	S4a	P
BDT41A	S4a	P	BDT82	S4a	P	BDW60	S4a	P
BDT41B	S4a	P	BDT83	S4a	P	BDX35	S4a	P
BDT41C	S4a	P	BDT84	S4a	P	BDX36	S4a	P
BDT42	S4a	P	BDT85	S4a	P	BDX37	S4a	P
BDT42A	S4a	P	BDT86	S4a	P	BDX42	S4a	P
BDT42B	S4a	P	BDT87	S4a	P	BDX43	S4a	P
BDT42C	S4a	P	BDT88	S4a	P	BDX44	S4a	P
BDT51	S4a	P	BDT91	S4a	P	BDX45	S4a	P
BDT52	S4a	P	BDT92	S4a	P	BDX46	S4a	P
BDT53	S4a	P	BDT93	S4a	P	BDX47	S4a	P
BDT54	S4a	P	BDT94	S4a	P	BDX62	S4a	P
BDT55	S4a	P	BDT95	S4a	P	BDX62A	S4a	P
BDT56	S4a	P	BDT96	S4a	P	BDX62B	S4a	P
BDT57	S4a	P	BDV64	S4a	P	BDX62C	S4a	P
BDT58	S4a	P	BDV64A	S4a	P	BDX63	S4a	P
BDT60	S4a	P	BDV64B	S4a	P	BDX63A	S4a	P
BDT60A	S4a	P	BDV64C	S4a	P	BDX63B	S4a	P
BDT60B	S4a	P	BDV65	S4a	P	BDX63C	S4a	P
BDT60C	S4a	P	BDV65A	S4a	P	BDX64	S4a	P
BDT61	S4a	P	BDV65B	S4a	P	BDX64A	S4a	P
BDT61A	S4a	P	BDV65C	S4a	P	BDX64B	S4a	P
BDT61B	S4a	P	BDV66A	S4a	P	BDX64C	S4a	P

P = Low-frequency power transistors

type no.	book	section	type no.	book	section	type no.	book	section
BDX65	S4a	P	BF247B	S5	FET	BF585	S4b	HVP
BDX65A	S4a	P	BF247C	S5	FET	BF587	S4b	HVP
BDX65B	S4a	P	BF256A	S5	FET	BF591	S4b	HVP
BDX65C	S4a	P	BF256B	S5	FET	BF593	S4b	HVP
BDX66	S4a	P	BF256C	S5	FET	BF620	S7	Mm
BDX66A	S4a	P	BF324	S3	Sm	BF621	S7	Mm
BDX66B	S4a	P	BF370	S3	Sm	BF622	S7	Mm
BDX66C	S4a	P	BF410A	S5	FET	BF623	S7	Mm
BDX67	S4a	P	BF410B	S5	FET	BF660;R	S7	Mm
BDX67A	S4a	P	BF410C	S5	FET	BF689K	S10	WBT
BDX67B	S4a	P	BF410D	S5	FET	BF763	S10	WBT
BDX67C	S4a	P	BF419	S4b	HVP	BF767	S7	Mm
BDX68	S4a	P	BF420	S3	Sm	BF819	S4b	HVP
BDX68A	S4a	P	BF421	S3	Sm	BF820	S7	Mm
BDX68B	S4a	P	BF422	S3	Sm	BF821	S7	Mm
BDX68C	S4a	P	BF423	S3	Sm	BF822	S7	Mm
BDX69	S4a	P	BF450	S3	Sm	BF823	S7	Mm
BDX69A	S4a	P	BF451	S3	Sm	BF824	S7	Mm
BDX69B	S4a	P	BF457	S4b	HVP	BF840	S7	Mm
BDX69C	S4a	P	BF458	S4b	HVP	BF841	S7	Mm
BDX77	S4a	P	BF459	S4b	HVP	BF857	S4b	HVP
BDX78	S4a	P	BF469	S4b	HVP	BF858	S4b	HVP
BDX91	S4a	P	BF470	S4b	HVP	BF859	S4b	HVP
BDX92	S4a	P	BF471	S4b	HVP	BF869	S4b	HVP
BDX93	S4a	P	BF472	S4b	HVP	BF870	S4b	HVP
BDX94	S4a	P	BF483	S3	Sm	BF871	S4b	HVP
BDX95	S4a	P	BF485	S3	Sm	BF872	S4b	HVP
BDX96	S4a	P	BF487	S3	Sm	BF926	S3	Sm
BDY90	S4a	P	BF494	S3	Sm	BF936	S3	Sm
BDY90A	S4a	P	BF495	S3	Sm	BF939	S3	Sm
BDY91	S4a	P	BF496	S3	Sm	BF960	S5	FET
BDY92	S4a	P	BF510	S7/S5	Mm/FET	BF964	S5	FET
BF198	S3	Sm	BF511	S7/S5	Mm/FET	BF966	S5	FET
BF199	S3	Sm	BF512	S7/S5	Mm/FET	BF967	S3	Sm
BF240	S3	Sm	BF513	S7/S5	Mm/FET	BF970	S3	Sm
BF241	S3	Sm	BF536	S7	Mm	BF979	S3	Sm
BF245A	S5	FET	BF550;R	S7	Mm	BF980	S5	FET
BF245B	S5	FET	BF569	S7	Mm	BF981	S5	FET
BF245C	S5	FET	BF579	S7	Mm	BF982	S5	FET
BF247A	S5	FET	BF583	S4b	HVP	BF989	S7/S5	Mm/FET

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

# INDEX

type no.	book	section	type no.	book	section	type no.	book	section
BF990	S7/S5	Mm/FET	BFQ51	S10	WBT	BFT24	S10	WBT
BF991	S7/S5	Mm/FET	BFQ51C	S10	WBT	BFT25;R	S7	Mm
BF992	S7/S5	Mm/FET	BFQ52	S10	WBT	BFT44	S3	Sm
BF994	S7/S5	Mm/FET	BFQ53	S10	WBT	BFT45	S3	Sm
BF996	S7/S5	Mm/FET	BFQ63	S10	WBT	BFT46	S7/S5	Mm/FET
BFG23	S10	WBT	BFQ65	S10	WBT	BFT92;R	S7	Mm
BFG32	S10	WBT	BFQ66	S10	WBT	BFT93;R	S7	Mm
BFG34	S10	WBT	BFQ67	S7	Mm	BFW10	S5	FET
BFG51	S10	WBT	BFQ68	S10	WBT	BFW11	S5	FET
BFG65	S10	WBT	BFQ136	S10	WBT	BFW12	S5	FET
BFG67	S7	Mm	BFR29	S5	FET	BFW13	S5	FET
BFG90A	S10	WBT	BFR30	S7/S5	Mm/FET	BFW16A	S10	WBT
BFG91A	S10	WBT	BFR31	S7/S5	Mm/FET	BFW17A	S10	WBT
BFG96	S10	WBT	BFR49	S10	WBT	BFW30	S10	WBT
BFP90A	S10	WBT	BFR53;R	S7	Mm	BFW61	S5	FET
BFP91A	S10	WBT	BFR54	S3	Sm	BFW92	S10	WBT
BFP96	S10	WBT	BFR64	S10	WBT	BFW92A	S10	WBT
BFQ10	S5	FET	BFR65	S10	WBT	BFW93	S10	WBT
BFQ11	S5	FET	BFR84	S5	FET	BFX29	S3	Sm
BFQ12	S5	FET	BFR90	S10	WBT	BFX30	S3	Sm
BFQ13	S5	FET	BFR90A	S10	WBT	BFX34	S3	Sm
BFQ14	S5	FET	BFR91	S10	WBT	BFX84	S3	Sm
BFQ15	S5	FET	BFR91A	S10	WBT	BFX85	S3	Sm
BFQ16	S5	FET	BFR92;R	S7	Mm	BFX86	S3	Sm
BFQ17	S7	Mm	BFR92A;R	S7	Mm	BFX87	S3	Sm
BFQ18A	S7	Mm	BFR93;R	S7	Mm	BFX88	S3	Sm
BFQ19	S7	Mm	BFR93A;R	S7	Mm	BFX89	S10	WBT
BFQ22S	S10	WBT	BFR94	S10	WBT	BFY50	S3	Sm
BFQ23	S10	WBT	BFR95	S10	WBT	BFY51	S3	Sm
BFQ23C	S10	WBT	BFR96	S10	WBT	BFY52	S3	Sm
BFQ24	S10	WBT	BFR96S	S10	WBT	BFY55	S3	Sm
BFQ32	S10	WBT	BFR101A;B	S7/S5	Mm/FET	BFY90	S10	WBT
BFQ32C	S10	WBT	BFS17;R	S7	Mm	BG2000	S1	RT
BFQ32S	S10	WBT	BFS18;R	S7	Mm	BG2097	S1	RT
BFQ33	S10	WBT	BFS19;R	S7	Mm	BGD102	S10	WBM
BFQ34	S10	WBT	BFS20;R	S7	Mm	BGD102E	S10	WBM
BFQ34T	S10	WBT	BFS21	S5	FET	BGD104	S10	WBM
BFQ42	S6	RFP	BFS21A	S5	FET	BGD104E	S10	WBM
BFQ43	S6	RFP	BFS22A	S6	RFP	BGY22	S6	RFP
BFQ43S	S6	RFP	BFS23A	S6	RFP	BGY22A	S6	RFP

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



type no.	book	section	type no.	book	section	type no.	book	section
BGY23	S6	RFP	BGY85A	S10	WBM	BLV57	S6	RFP
BGY23A	S6	RFP	BGY90A	S6	RFP	BLV59	S6	RFP
BGY32	S6	RFP	BGY90B	S6	RFP	BLV75/12	S6	RFP
BGY33	S6	RFP	BGY93*	S6	RFP	BLV80/28	S6	RFP
BGY35	S6	RFP	BGY94*	S6	RFP	BLV90	S6	RFP
BGY36	S6	RFP	BGY95A	S6	RFP	BLV90/SL	S6	RFP
BGY40A	S6	RFP	BGY95B	S6	RFP	BLV91	S6	RFP
BGY40B	S6	RFP	BGY96A	S6	RFP	BLV91/SL	S6	RFP
BGY41A	S6	RFP	BGY96B	S6	RFP	BLV92	S6	RFP
BGY41B	S6	RFP	BLF146	S6	RFP/FET	BLV93	S6	RFP
BGY43	S6	RFP	BLF242	S6	RFP/FET	BLV94	S6	RFP
BGY45A	S6	RFP	BLF244	S6	RFP/FET	BLV95	S6	RFP
BGY45B	S6	RFP	BLF245	S6	RFP/FET	BLV97	S6	RFP
BGY46A	S6	RFP	BLT90/SL	S6	RFP	BLV98	S6	RFP
BGY46B	S6	RFP	BLT91/SL	S6	RFP	BLV99	S6	RFP
BGY47*	S6	RFP	BLT92/SL	S6	RFP	BLW29	S6	RFP
BGY48*	S6	RFP	BLU20/12	S6	RFP	BLW31	S6	RFP
BGY50	S10	WBM	BLU30/12	S6	RFP	BLW32	S6	RFP
BGY51	S10	WBM	BLU45/12	S6	RFP	BLW33	S6	RFP
BGY52	S10	WBM	BLU50	S6	RFP	BLW34	S6	RFP
BGY53	S10	WBM	BLU51	S6	RFP	BLW50F	S6	RFP
BGY54	S10	WBM	BLU52	S6	RFP	BLW60	S6	RFP
BGY55	S10	WBM	BLU53	S6	RFP	BLW60C	S6	RFP
BGY56	S10	WBM	BLU60/12	S6	RFP	BLW76	S6	RFP
BGY57	S10	WBM	BLU97	S6	RFP	BLW77	S6	RFP
BGY58	S10	WBM	BLU98	S6	RFP	BLW78	S6	RFP
BGY58A	S10	WBM	BLU99	S6	RFP	BLW79	S6	RFP
BGY59	S10	WBM	BLV10	S6	RFP	BLW80	S6	RFP
BGY60	S10	WBM	BLV11	S6	RFP	BLW81	S6	RFP
BGY61	S10	WBM	BLV20	S6	RFP	BLW83	S6	RFP
BGY65	S10	WBM	BLV21	S6	RFP	BLW84	S6	RFP
BGY67	S10	WBM	BLV25	S6	RFP	BLW85	S6	RFP
BGY67A	S10	WBM	BLV30	S6	RFP	BLW86	S6	RFP
BGY70	S10	WBM	BLV30/12	S6	RFP	BLW87	S6	RFP
BGY71	S10	WBM	BLV31	S6	RFP	BLW89	S6	RFP
BGY74	S10	WBM	BLV32F	S6	RFP	BLW90	S6	RFP
BGY75	S10	WBM	BLV33	S6	RFP	BLW91	S6	RFP
BGY84	S10	WBM	BLV33F	S6	RFP	BLW95	S6	RFP
BGY84A	S10	WBM	BLV36	S6	RFP	BLW96	S6	RFP
BGY85	S10	WBM	BLV45/12	S6	RFP	BLW97	S6	RFP

\* = series

FET = Field-effect transistors

RFP = R.F. power transistors and modules

WBM = Wideband hybrid IC modules

# INDEX

type no.	book	section	type no.	book	section	type no.	book	section
BLW98	S6	RFP	BPW71	S8b	PDT	BSR30	S7	Mm
BLW99	S6	RFP	BPX25	S8b	PDT	BSR31	S7	Mm
BLX13	S6	RFP	BPX29	S8b	PDT	BSR32	S7	Mm
BLX13C	S6	RFP	BPX40	S8b	PDT	BSR33	S7	Mm
BLX14	S6	RFP	BPX41	S8b	PDT	BSR40	S7	Mm
BLX15	S6	RFP	BPX42	S8b	PDT	BSR41	S7	Mm
BLX39	S6	RFP	BPX61	S8b	PDT	BSR42	S7	Mm
BLX65	S6	RFP	BPX61P	S8b	PDT	BSR43	S7	Mm
BLX65E	S6	RFP	BPX71	S8b	PDT	BSR50	S3	Sm
BLX65ES	S6	RFP	BPX72	S8b	PDT	BSR51	S3	Sm
BLX67	S6	RFP	BR100/03	S2b	Th	BSR52	S3	Sm
BLX68	S6	RFP	BR101	S3	Sm	BSR56	S7/S5	Mm/FET
BLX69A	S6	RFP	BR210*	S2a	Th	BSR57	S7/S5	Mm/FET
BLX91A	S6	RFP	BR216*	S2a	Th	BSR58	S7/S5	Mm/FET
BLX91CB	S6	RFP	BR220*	S2a	Th	BSR60	S3	Sm
BLX92A	S6	RFP	BRY39	S3	Sm	BSR61	S3	Sm
BLX93A	S6	RFP	BRY56	S3	Sm	BSR62	S3	Sm
BLX94A	S6	RFP	BRY61	S7	Mm	BSS38	S3	Sm
BLX94C	S6	RFP	BRY62	S7	Mm	BSS50	S3	Sm
BLX95	S6	RFP	BS107	S5	FET	BSS51	S3	Sm
BLX96	S6	RFP	BS170	S5	FET	BSS52	S3	Sm
BLX97	S6	RFP	BSD10	S5	FET	BSS60	S3	Sm
BLX98	S6	RFP	BSD12	S5	FET	BSS61	S3	Sm
BLY87A	S6	RFP	BSD20	S5/7	FET	BSS62	S3	Sm
BLY87C	S6	RFP	BSD22	S5/7	FET	BSS63;R	S7	Mm
BLY88A	S6	RFP	BSD212	S5	FET	BSS64;R	S7	Mm
BLY88C	S6	RFP	BSD213	S5	FET	BSS68	S3	Sm
BLY89A	S6	RFP	BSD214	S5	FET	BSS83	S5/7	FET/Mm
BLY89C	S6	RFP	BSD215	S5	FET	BST15	S7	Mm
BLY90	S6	RFP	BSR12;R	S7	Mm	BST16	S7	Mm
BLY91A	S6	RFP	BSR13;R	S7	Mm	BST39	S7	Mm
BLY91C	S6	RFP	BSR14;R	S7	Mm	BST40	S7	Mm
BLY92A	S6	RFP	BSR15;R	S7	Mm	BST50	S7	Mm
BLY92C	S6	RFP	BSR16;R	S7	Mm	BST51	S7	Mm
BLY93A	S6	RFP	BSR17;R	S7	Mm	BST52	S7	Mm
BLY93C	S6	RFP	BSR17A;R	S7	Mm	BST60	S7	Mm
BLY94	S6	RFP	BSR18;R	S7	Mm	BST61	S7	Mm
BPF24	S8b	PDT	BSR18A;R	S7	Mm	BST62	S7	Mm
BPW22A	S8a/b	PDT	BSR19; A	S7	Mm	BST70A	S5	FET
BPW50	S8a/b	PDT	BSR20; A	S7	Mm	BST72A	S5	FET

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

type no.	book	section	type no.	book	section	type no.	book	section
BST74A	S5	FET	BT139*	S2b	Tri	BU508D	S4b	SP
BST76A	S5	FET	BT139F*	S2b	Tri	BU705	S4b	SP
BST78	S5	FET	BT145*	S2b	Tri	BU706	S4b	SP
BST80	S5/S7	FET/Mm	BT149*	S2b	Th	BU706D	S4b	SP
BST82	S5/S7	FET/Mm	BT150	S2b	Th	BU806	S4b	SP
BST84	S5/S7	FET/Mm	BT151*	S2b	Th	BU807	S4b	SP
BST86	S5/S7	FET/Mm	BT151F*	S2b	Th	BU808	S4b	SP
BST90	S5	FET	BT152*	S2b	Th	BU824	S4b	SP
BST97	S5	FET	BT153	S2b	Th	BU826	S4b	SP
BST100	S5	FET	BT157*	S2b	Th	BUP22*	S4b	SP
BST110	S5	FET	BT169*	S2b	Th	BUP23*	S4b	SP
BST120	S5/S7	FET/Mm	BTA140*	S2b	Tri	BUS11;A	S4b	SP
BST122	S5/S7	FET/Mm	BTR59*	S2b	Tri	BUS12;A	S4b	SP
BSV15	S3	Sm	BTS59*	S2b	Tri	BUS13;A	S4b	SP
BSV16	S3	Sm	BTV58*	S2b	Th	BUS14;A	S4b	SP
BSV17	S3	Sm	BTV59*	S2b	Th	BUS21*	S4b	SP
BSV52;R	S7	Mm	BTV59D*	S2b	Th	BUS22*	S4b	SP
BSV64	S3	Sm	BTV60*	S2b	Th	BUS23*	S4b	SP
BSV78	S5	FET	BTV60D*	S2b	Th	BUT11;A	S4b	SP
BSV79	S5	FET	BTV70*	S2b	Th	BUT11A	S4b	SP
BSV80	S5	FET	BTV70D*	S2b	Th	BUT11AF	S4b	SP
BSV81	S5	FET	BTW23*	S2b	Th	BUV82	S4b	SP
BSW66A	S3	Sm	BTW38*	S2b	Th	BUV83	S4b	SP
BSW67A	S3	Sm	BTW40*	S2b	Th	BUV89	S4b	SP
BSW68A	S3	Sm	BTW42*	S2b	Th	BUV90;A	S4b	SP
BSX19	S3	Sm	BTW43*	S2b	Tri	BUW11;A	S4b	SP
BSX20	S3	Sm	BTW45*	S2b	Th	BUW12;A	S4b	SP
BSX45	S3	Sm	BTW58*	S2b	Th	BUW13;A	S4b	SP
BSX46	S3	Sm	BTW62*	S2b	Th	BUW84	S4b	SP
BSX47	S3	Sm	BTW62D*	S2b	Th	BUW85	S4b	SP
BSX59	S3	Sm	BTW63*	S2b	Th	BUX46;A	S4b	SP
BSX60	S3	Sm	BTY79*	S2b	Th	BUX47;A	S4b	SP
BSX61	S3	Sm	BTY91*	S2b	Th	BUX48;A	S4b	SP
BSY95A	S3	Sm	BU426	S4b	SP	BUX80	S4b	SP
BT136*	S2b	Tri	BU426A	S4b	SP	BUX81	S4b	SP
BT136F*	S2b	Tri	BU433	S4b	SP	BUX82	S4b	SP
BT137*	S2b	Tri	BU505	S4b	SP	BUX83	S4b	SP
BT137F*	S2b	Tri	BU506	S4b	SP	BUX84	S4b	SP
BT138*	S2b	Tri	BU506D	S4b	SP	BUX84F	S4b	SP
BT138F*	S2b	Tri	BU508A	S4b	SP	BUX85	S4b	SP

\* = 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

# INDEX

type no.	book	section	type no.	book	section	type no.	book	section
BUX85F	S4b	SP	BUZ54	S9	PM	BY609	S1	R
BUX86	S4b	SP	BUZ54A	S9	PM	BY610	S1	R
BUX87	S4b	SP	BUZ60	S9	PM	BY614	S1	R
BUX88	S4b	SP	BUZ60B	S9	PM	BY619	S1	R
BUX90	S4b	SP	BUZ63	S9	PM	BY620	S1	R
BUX98	S4b	SP	BUZ63B	S9	PM	BY627	S1	R
BUX98A	S4b	SP	BUZ64	S9	PM	BY707	S1	R
BUX99	S4b	SP	BUZ71	S9	PM	BY708	S1	R
BUY89	S4b	SP	BUZ71A	S9	PM	BY709	S1	R
BUZ10	S9	PM	BUZ72	S9	PM	BY710	S1	R
BUZ10A	S9	PM	BUZ72A	S9	PM	BY711	S1	R
BUZ11	S9	PM	BUZ73A	S9	PM	BY712	S1	R
BUZ11A	S9	PM	BUZ74	S9	PM	BY713	S1	R
BUZ14	S9	PM	BUZ74A	S9	PM	BY714	S1	R
BUZ15	S9	PM	BUZ76	S9	PM	BYD13*	S1	R
BUZ20	S9	PM	BUZ76A	S9	PM	BYD14*	S1	R
BUZ21	S9	PM	BUZ80	S9	PM	BYD17*	S1	R
BUZ23	S9	PM	BUZ80A	S9	PM	BYD33*	S1	R
BUZ24	S9	PM	BUZ83	S9	PM	BYD37*	S1	R
BUZ25	S9	PM	BUZ83A	S9	PM	BYD73*	S1	R
BUZ30	S9	PM	BUZ84	S9	PM	BYD74*	S1	R
BUZ31	S9	PM	BUZ84A	S9	PM	BYD77*	S1	R
BUZ32	S9	PM	BY224*	S2a	R	BYM26*	S1	R
BUZ33	S9	PM	BY225*	S2a	R	BYM36*	S1	R
BUZ34	S9	PM	BY228	S1	R	BYM56*	S1	R
BUZ35	S9	PM	BY229*	S2a	R	BYP21*	S2a	R
BUZ36	S9	PM	BY229F*	S2a	R	BYP22*	S2a	R
BUZ40	S9	PM	BY249*	S2a	R	BYP59*	S2a	R
BUZ41A	S9	PM	BY260*	S2a	R	BYQ28*	S2a	R
BUZ42	S9	PM	BY261*	S2a	R	BYR29*	S2a	R
BUZ43	S9	PM	BY329*	S2a	R	BYR29F*	S2a	R
BUZ44A	S9	PM	BY359*	S2a	R	BYT28*	S2a	R
BUZ45	S9	PM	BY438	S1	R	BYT79*	S2a	R
BUZ45A	S9	PM	BY448	S1	R	BYV10	S1	R
BUZ45B	S9	PM	BY458	S1	R	BYV18*	S2a	R
BUZ45C	S9	PM	BY505	S1	R	BYV19*	S2a	R
BUZ46	S9	PM	BY509	S1	R	BYV20*	S2a	R
BUZ50A	S9	PM	BY527	S1	R	BYV21*	S2a	R
BUZ50B	S9	PM	BY584	S1	R	BYV22*	S2a	R
BUZ53A	S9	PM	BY588	S1	R	BYV23*	S2a	R

\* = 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

# INDEX

type no.	book	section	type no.	book	section	type no.	book	section
CNY57A	S8b	PhC	CQW10B(L)S8a	S8a	LED	CQY97A	S8a	LED
CNY57AU	S8b	PhC	CQW10U(L)S8a	S8a	LED	Fresnel-	S8b	A
CNY57U	S8b	PhC	CQW11B(L)S8a	S8a	LED	lens		
CNY62	S8b	PhC	CQW12B(L)S8a	S8a	LED	H11A1	S8b	PhC
CNY63	S8b	PhC	CQW20A	S8a	LED	H11A2	S8b	PhC
CQF24	S8b	Ph	CQW21	S8a	LED	H11A3	S8b	PhC
CQL10A	S8b	Ph	CQW22	S8a	LED	H11A4	S8b	PhC
CQL13A	S8b	Ph	CQW24(L)S8a	S8a	LED	H11A5	S8b	PhC
CQL16	S8b	Ph	CQW54	S8a	LED	H11B1	S8b	PhC
CQ551L	S8a	LED	CQW60(L)S8a	S8a	LED	H11B2	S8b	PhC
CQ554	S8a	LED	CQW60A(L)S8a	S8a	LED	H11B3	S8b	PhC
CQ582L	S8a	LED	CQW60U(L)S8a	S8a	LED	H11B255	S8b	PhC
CQ582AL	S8a	LED	CQW61(L)S8a	S8a	LED	KMZ10A	S13	SEN
CQ584L	S8a	LED	CQW62(L)S8a	S8a	LED	KMZ10B	S13	SEN
CQ586L	S8a	LED	CQW89A	S8a/b	I	KMZ10C	S13	SEN
CQ593	S8a	LED	CQW93	S8a	LED	KP100A	S13	SEN
CQ593E	S8a	LED	CQW95	S8a	LED	KP101A	S13	SEN
CQ593L	S8a	LED	CQW97	S8a	LED	KPZ20G	S13	SEN
CQ595	S8a	LED	CQX24(L)S8a	S8a	LED	KPZ21G	S13	SEN
CQ595E	S8a	LED	CQX51(L)S8a	S8a	LED	KTY81*	S13	SEN
CQ595L	S8a	LED	CQX54(L)S8a	S8a	LED	KTY83*	S13	SEN
CQ597	S8a	LED	CQX54D	S8a	LED	KTY84*	S13	SEN
CQ597E	S8a	LED	CQX64(L)S8a	S8a	LED	LAE2001R	S11	M
CQ597L	S8a	LED	CQX64D	S8a	LED	LAE4001Q	S11	M
CQT10B	S8a	LED	CQX74(L)S8a	S8a	LED	LAE4001R	S11	M
CQT24	S8a	LED	CQX74D	S8a	LED	LAE4002S	S11	M
CQT60	S8a	LED	CQY11B	S8b	LED	LAE6000Q	S11	M
CQT70	S8a	LED	CQY11C	S8b	LED	LBE1004R	S11	M
CQT80L	S8a	LED	CQY24B(L)S8a	S8a	LED	LBE1010R	S11	M
CQV70(L)	S8a	LED	CQY49B	S8b	LED	LBE2003S	S11	M
CQV70A(L)S8a	S8a	LED	CQY49C	S8b	LED	LBE2005Q	S11	M
CQV70U(L)S8a	S8a	LED	CQY50	S8b	LED	LBE2008T	S11	M
CQV71A(L)S8a	S8a	LED	CQY52	S8b	LED	LBE2009S	S11	M
CQV72(L)S8a	S8a	LED	CQY53S	S8b	LED	LCE1010R	S11	M
CQV80L	S8a	LED	CQY54A	S8a	LED	LCE2003S	S11	M
CQV80AL	S8a	LED	CQY58A	S8a/b	I	LCE2005Q	S11	M
CQV80UL	S8a	LED	CQY89A	S8a/b	I	LCE2008T	S11	M
CQV81L	S8a	LED	CQY94B(L)S8a	S8a	LED	LCE2009S	S11	M
CQV82L	S8a	LED	CQY95B	S8a	LED	LJE42002T	S11	M
CQW10A(L)S8a	S8a	LED	CQY96(L)S8a	S8a	LED	LKE1004R	S11	M

\* = series

A = Accessories

I = Infrared devices

LED = Light-emitting diodes

M = Microwave transistors

Ph = Photoconductive devices

PhC = Photocouplers

SEN = Sensors

type no.	book	section	type no.	book	section	type no.	book	section
LKE2002T	S11	M	OM320	S10	WBM	PDE1003U	S11	M
LKE2004T	S11	M	OM321	S10	WBM	PDE1005U	S11	M
LKE2015T	S11	M	OM322	S10	WBM	PDE1010U	S11	M
LKE21004R	S11	M	OM323	S10	WBM	PEE1001U	S11	M
LKE21015T	S11	M	OM323A	S10	WBM	PEE1003U	S11	M
LKE21050T	S11	M	OM335	S10	WBM	PEE1005U	S11	M
LKE27010R	S11	M	OM336	S10	WBM	PEE1010U	S11	M
LKE27025R	S11	M	OM337	S10	WBM	PH2222;R	S3	Sm
LKE32002T	S11	M	OM337A	S10	WBM	PH2222A;R	S3	Sm
LKE32004T	S11	M	OM339	S10	WBM	PH2369	S3	Sm
LTE42005S	S11	M	OM345	S10	WBM	PH2907;R	S3	Sm
LTE42008R	S11	M	OM350	S10	WBM	PH2907A;R	S3	Sm
LTE42012R	S11	M	OM360	S10	WBM	PH2955T	S4a	P
LV1721E50R	S11	M	OM361	S10	WBM	PH3055T	S4a	P
LV2024E45R	S11	M	OM370	S10	WBM	PH5415	S3	Sm
LV2327E40R	S11	M	OM386B	S13	SEN	PH5416	S3	Sm
LV3742E16R	S11	M	OM386M	S13	SEN	PH13002	S4b	SP
LV3742E24R	S11	M	OM387B	S13	SEN	PH13003	S4b	SP
LWE2015R	S11	M	OM387M	S13	SEN	PHSD51	S2a	R
LWE2025R	S11	M	OM388B	S13	SEN	PKB3001U	S11	M
LZ1418E100RS11	M		OM389B	S13	SEN	PKB3003U	S11	M
MCA230	S8b	PhC	OM931	S4a	P	PKB3005U	S11	M
MCA231	S8b	PhC	OM961	S4a	P	PKB12005U	S11	M
MCA255	S8b	PhC	OSB9115	S2a	St	PKB20010U	S11	M
MCT2	S8b	PhC	OSB9215	S2a	St	PKB23001U	S11	M
MCT26	S8b	PhC	OSB9415	S2a	St	PKB23003U	S11	M
MKB12040WS	S11	M	OSM9115	S2a	St	PKB23005U	S11	M
MKB12100WS	S11	M	OSM9215	S2a	St	PKB25006T	S11	M
MKB12140W	S11	M	OSM9415	S2a	St	PKB32001U	S11	M
MO6075B200ZS11	M		OSM9510	S2a	St	PKB32003U	S11	M
MO6075B400ZS11	M		OSM9511	S2a	St	PKB32005U	S11	M
MRB12175YR	S11	M	OSM9512	S2a	St	PMBF4391	S7	Mm
MRB12350YR	S11	M	OSS9115	S2a	St	PMBF4392	S7	Mm
MS1011B700YS11	M		OSS9215	S2a	St	PMBF4392	S7	Mm
MS6075B800ZS11	M		OSS9415	S2a	St	PMLL4148	S1	SD
MSB12900Y	S11	M	P2105	S8b	I	PMLL4150	S1	SD
MZ0912B75Y	S11	M	PBMF4391	S5	FET	PMLL4151	S1	SD
MZ0912B150YS11	M		PBMF4392	S5	FET	PMLL4153	S1	SD
OM286; M	S13	SEN	PBMF4393	S5	FET	PMLL4446	S1	SD
OM287; M	S13	SEN	PDE1001U	S11	M	PMLL4448	S1	SD

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

# INDEX

type no.	book	section	type no.	book	section	type no.	book	section
PMLL5225B			RZ1214B125YS11	M		TIP127	S4a	P
to	S1	SD	RZ1214B150YS11	M		TIP130	S4a	P
PMLL5267B			RZ2833B45W	S11	M	TIP131	S4a	P
PO44	S8b	PhC	RZ3135B15U	S11	M	TIP132	S4a	P
PO44A	S8b	PhC	RZ3135B15W	S11	M	TIP135	S4a	P
PPC5001T	S11	M	RZ3135B25U	S11	M	TIP136	S4a	P
PQC5001T	S11	M	RZ3135B30W	S11	M	TIP137	S4a	P
PTB23001X	S11	M	RZB12100Y	S11	M	TIP140	S4a	P
PTB23003X	S11	M	RZB12350Y	S11	M	TIP141	S4a	P
PTB23005X	S11	M	RZZ1214B300YS11	M		TIP145	S4a	P
PTB32001X	S11	M	SL5500	S8b	PhC	TIP146	S4a	P
PTB32003X	S11	M	SL5501	S8b	PhC	TIP147	S4a	P
PTB32005X	S11	M	SL5502R	S8b	PhC	TIP2955	S4a	P
PTB42001X	S11	M	SL5504	S8b	PhC	TIP3055	S4a	P
PTB42002X	S11	M	SL5504S	S8b	PhC	1N821;A	S1	Vrf
PTB42003X	S11	M	SL5505S	S8b	PhC	1N823;A	S1	Vrf
PV3742B4X	S11	M	SL5511	S8b	PhC	1N825;A	S1	Vrf
PVB42004X	S11	M	TIP29*	S4a	P	1N827;A	S1	Vrf
PZ1418B15U	S11	M	TIP30*	S4a	P	1N829;A	S1	Vrf
PZ1418B30U	S11	M	TIP31*	S4a	P	1N914	S1	SD
PZ1721B12U	S11	M	TIP32*	S4a	P	1N916	S1	SD
PZ1721B25U	S11	M	TIP33*	S4a	P	1N3879	S2a	R
PZ2024B10U	S11	M	TIP34*	S4a	P	1N3880	S2a	R
PZ2024B20U	S11	M	TIP41*	S4a	P	1N3881	S2a	R
PZB16035U	S11	M	TIP42*	S4a	P	1N3882	S2a	R
PZB27020U	S11	M	TIP47	S4a	P	1N3883	S2a	R
RPY97	S8b	I	TIP48	S4a	P	1N3889	S2a	R
RPY100	S8b	I	TIP49	S4a	P	1N3890	S2a	R
RPY101	S8b	I	TIP50	S4a	P	1N3891	S2a	R
RPY102	S8b	I	TIP110	S4a	P	1N3892	S2a	R
RPY103	S8b	I	TIP111	S4a	P	1N3893	S2a	R
RPY107	S8b	I	TIP112	S4a	P	1N3909	S2a	R
RPY109	S8b	I	TIP115	S4a	P	1N3910	S2a	R
RV3135B5X	S11	M	TIP116	S4a	P	1N3911	S2a	R
RX1214B300YS11	M		TIP117	S4a	P	1N3912	S2a	R
RXB12350Y	S11	M	TIP120	S4a	P	1N3913	S2a	R
RZ1214B35Y	S11	M	TIP121	S4a	P	1N4001G	S1	R
RZ1214B60W	S11	M	TIP122	S4a	P	1N4002G	S1	R
RZ1214B65Y	S11	M	TIP125	S4a	P	1N4003G	S1	R
RZ1214B125WS11	M		TIP126	S4a	P	1N4004G	S1	R

\* = 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



type no.	book	section	type no.	book	section	type no.	book	section
1N4005G	S1	R	2N2907	S3	Sm	2N5400	S3	Sm
1N4006G	S1	R	2N2907A	S3	Sm	2N5401	S3	Sm
1N4007G	S1	R	2N3019	S3	Sm	2N5415	S3	Sm
1N4148	S1	SD	2N3020	S3	Sm	2N5416	S3	Sm
1N4150	S1	SD	2N3053	S3	Sm	2N5550	S3	Sm
1N4151	S1	SD	2N3375	S6	RFP	2N5551	S3	Sm
1N4153	S1	SD	2N3553	S6	RFP	2N6659	S5	FET
1N4446	S1	SD	2N3632	S6	RFP	2N6660	S5	FET
1N4448	S1	SD	2N3822	S5	FET	2N6661	S5	FET
1N4531	S1	SD	2N3823	S5	FET	4N25	S8b	PhC
1N4532	S1	SD	2N3866	S6	RFP	4N25A	S8b	PhC
1N5059	S1	R	2N3903	S3	Sm	4N26	S8b	PhC
1N5060	S1	R	2N3904	S3	Sm	4N27	S8b	PhC
1N5061	S1	R	2N3905	S3	Sm	4N28	S8b	PhC
1N5062	S1	R	2N3906	S3	Sm	4N35	S8b	PhC
1N5225B to	S1	SD	2N3924	S6	RFP	4N36	S8b	PhC
1N5267B			2N3926	S6	RFP	4N37	S8b	PhC
2N918	S10	WBT	2N3927	S6	RFP	4N38	S8b	PhC
2N929	S3	Sm	2N3966	S5	FET	4N38A	S8b	PhC
			2N4030	S3	Sm	502CQF	S8b	Ph
2N930	S3	Sm	2N4031	S3	Sm	503CQF	S8b	Ph
2N1613	S3	Sm	2N4032	S3	Sm	504CQL	S8b	Ph
2N1711	S3	Sm	2N4033	S3	Sm	516CQF-B	S8b	Ph
2N1893	S3	Sm	2N4091	S5	FET	56201d	S4b	A
2N2219	S3	Sm	2N4092	S5	FET	56201j	S4b	A
2N2219A	S3	Sm	2N4093	S5	FET	56245	S3, 10	A
2N2222	S3	Sm	2N4123	S3	Sm	56246	S3, 10	A
2N2222A	S3	Sm	2N4124	S3	Sm	56261a	S4b	A
2N2297	S3	Sm	2N4125	S3	Sm	56264	S2a/b	A
2N2368	S3	Sm	2N4126	S3	Sm	56295	S2a/b	A
2N2369	S3	Sm	2N4391	S5	FET	56326	S4b	A
2N2369A	S3	Sm	2N4392	S5	FET	56339	S4b	A
2N2483	S3	Sm	2N4393	S5	FET	56352	S4b	A
2N2484	S3	Sm	2N4427	S6	RFP	56353	S4b	A
2N2904	S3	Sm	2N4856	S5	FET	56354	S4b	A
2N2904A	S3	Sm	2N4857	S5	FET	56359b	S2, 4b	A
2N2905	S3	Sm	2N4858	S5	FET	56359c	S2, 4b	A
2N2905A	S3	Sm	2N4859	S5	FET	56359d	S2, 4b	A
2N2906	S3	Sm	2N4860	S5	FET	56360a	S2, 4b	A
2N2906A	S3	Sm	2N4861	S5	FET	56363	S2, 4b	A

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

# INDEX

type no.	book	section
56364	S2, 4b	A
56367	S2a/b	A
56368b	S2, 4b	A
56368c	S2, 4b	A
56369	S2, 4b	A
56378	S2, 4b	A
56379	S2, 4b	A
56387a, b	S4b	A
56397	S8b	A

A = Accessories



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AS53

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