PHILIPS

Data handbook

PHILIPS
Electronic
components
and materials

Semiconductors

Book S2b 1985

Thyristors

Isolated power modules

Triacs

Accessories

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THYRISTORS AND TRIACS

DATA HANDBOOK SYSTEM

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

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

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

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 is comprised of the following parts:

T1	**Tubes for r.f. heating**
T2a	**Transmitting tubes for communications, glass types**
T2b	**Transmitting tubes for communications, ceramic types**
T3	**Klystrons, travelling-wave tubes, microwave diodes**
ET3	**Special Quality tubes, miscellaneous devices** (will not be reprinted)
T4	**Magnetrons**
T5	**Cathode-ray tubes** Instrument tubes, monitor and display tubes, C.R. tubes for special applications
T6	**Geiger-Müller tubes**
T7	**Gas-filled tubes** Segment indicator tubes, indicator tubes, dry reed contact units, thyratrons, industrial rectifying tubes, ignitrons, high-voltage rectifying tubes, associated accessories
T8	**Picture tubes and components** Colour TV picture tubes, black and white TV picture tubes, colour monitor tubes for data graphic display, monochrome monitor tubes for data graphic display, components for colour television, components for black and white television and monochrome data graphic display
T9	**Photo and electron multipliers** Photomultiplier tubes, phototubes, single channel electron multipliers, channel electron multiplier plates
T10	**Camera tubes and accessories**
T11	**Microwave semiconductors and components**
T12	**Vidicons and Newvicons**
T13	**Image intensifiers**
T14	**Infrared detectors**

SEMICONDUCTORS (RED SERIES)

The red series of data handbooks comprises:

S1	**Diodes** Small-signal germanium diodes, small-signal silicon diodes, voltage regulator diodes(< 1,5 W), voltage reference diodes, tuner diodes, rectifier diodes
S2	**Power diodes, thyristors, triacs** Rectifier diodes, voltage regulator diodes (> 1,5 W), rectifier stacks, thyristors, 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	**Microminiature semiconductors for hybrid circuits**
S8	**Devices for optoelectronics** Photosensitive diodes and transistors, light-emitting diodes, displays, photocouplers, infrared sensitive devices, photoconductive devices.
S9	**Power MOS transistors**
S10	**Wideband transistors and wideband hybrid IC modules**

INTEGRATED CIRCUITS (PURPLE SERIES)

The purple series of data handbooks comprises:

EXISTING SERIES

IC1	**Bipolar ICs for radio and audio equipment**
IC2	**Bipolar ICs for video equipment**
IC3	**ICs for digital systems in radio, audio and video equipment**
IC4	**Digital integrated circuits** CMOS HE4000B family
IC5	**Digital integrated circuits – ECL** ECL10 000 (GX family), ECL100 000 (HX family), dedicated designs
IC6	**Professional analogue integrated circuits**
IC7	**Signetics bipolar memories**
IC8	**Signetics analogue circuits**
IC9	**Signetics TTL logic**
IC10	**Signetics Integrated Fuse Logic (IFL)**
IC11	**Microprocessors, microcomputers and peripheral circuitry**

NEW SERIES

IC01N	**Radio, audio and associated systems** Bipolar, MOS	
IC02N	**Video and associated systems** Bipolar, MOS	
IC03N	**Telephony equipment** Bipolar, MOS	
IC04N	**HE4000B logic family** CMOS	
IC05N	**HE4000B logic family uncased integrated circuits** CMOS	(published 1984)
IC06N	**PC54/74HC/HCU/HCT logic families** HCMOS	
IC07N	**PC54/74HC/HCU/HCT uncased integrated circuits** HCMOS	
IC08N	**10K and 100K logic family** ECL	
IC09N	**Logic series** TTL	(published 1984)
IC10N	**Memories** MOS, TTL, ECL	
IC11N	**Analogue - industrial**	
IC12N	**Semi-custom gate arrays & cell libraries** ISL, ECL, CMOS	
IC13N	**Semi-custom integrated fuse logic** IFL series 20/24/28	
IC14N	**Microprocessors, microcontrollers & peripherals** Bipolar, MOS	
IC15N	**Logic series** FAST TTL	(published 1984)

Note

Books available in the new series are shown with their date of publication.

COMPONENTS AND MATERIALS (GREEN SERIES)

The green series of data handbooks comprises:

C1	**Assemblies for industrial use** PLC modules, PC20 modules, HNIL FZ/30 series, NORbits 60-, 61-, 90-series, input devices, hybrid ICs
C2	**Television tuners, video modulators, 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** Quartz crystal units, temperature compensated crystal oscillators, compact integrated oscillators, quartz crystal cuts for temperature measurements
C10	**Connectors**
C11	**Non-linear resistors** Voltage dependent resistors (VDR), light dependent resistors (LDR), negative temperature coefficient thermistors (NTC), positive temperature coefficient thermistors (PTC)
C12	**Variable resistors and test switches**
C13	**Fixed resistors**
C14	**Electrolytic and solid capacitors**
C15	**Film capacitors, ceramic capacitors**
C16	**Permanent magnet materials**
C17	**Stepping motors and associated electronics**
C18	**D.C. motors**
C19	**Piezoelectric ceramics**
C20	**Wire-wound components for TVs and monitors**

SELECTION GUIDE

GATE TURN-OFF THYRISTORS

$I_{T(AV)}$ max. (A)	I_{TCRM} max. (A)		V_{DRMmax} (V) 600	850	1000	1200	1300	1500	Page
3.2	12	BT157					●	●	39
6.5	25	BTW58			●		●	●	85
10	25	BTV58	●	●	●				51
13.5	50	BTW59					●	●	97
15	50	BTV59	●	●	●				63
25	120	BTV60		●	●	●			75

THYRISTORS

General purpose thyristors

$I_{T(RMS)max}$ (A)		V_{RRMmax} (V) 50	100	200	300	400	500	600	650	800	1000	1200	1400	1600	Page
1	BT149	●	●	●		●	●	●							113
1.6	BTX18		●	●	●	●	●								215
12	BT151						●		●	●					117
16	BTY79					●	●	●		●	●				223
16	BTW38							●		●	●				175
16	BTW42							●		●	●				189
20	BT152					●		●		●					127
25	BTW45					●		●		●	●	●			193
25	BTY91					●	●	●		●					233
32	BTW40					●		●		●					183
32	BTW92									●	●	●	●	●	207
70	BTV24							●		●		●	●		155
140	BTW23							●		●	●	●	●	●	165

Fast turn-off thyristors

$I_{T(RMS)max}$ (A)		V_{DRMmax} (V) 500	600	800	1000	Page	
6	BT153	●				135	
15	BT155		●	●		147	(ASCR construction)
40	BTW63		●	●	●	199	(ASCR construction)

ISOLATED POWER MODULES

Thyristor — thyristor modules

$I_{T(AV)max}$ (A)		V_{DRM}; V_{RRMmax} (V) 600	800	1200	1400	Page
40	BGX12	●	●	●	●	243
50	BGX13	●	●	●	●	255
55	BGX14	●	●	●	●	265
65	BGX15	●	●	●	●	275
90	BGX17	●	●	●	●	287

TRIACS

$I_{T(RMS)max}$ (A)		V_{DRMmax} (V) 400	500	600	800	1000	1200	1400	Page
4	BT136		●	●	●				301
8	BT137		●	●	●				313
12	BT138		●	●	●				325
15	BTW43			●	●	●	●		357
16	BT139		●	●	●				337
25	BTX94	●		●	●	●	●		365
55	BTV34			●	●		●	●	349

	Page
Bi-directional trigger device BR100/03: $V_{(BO)}$ = 28 to 36 V; I_{FRMmax} = 2 A	111

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.

A basic type number consists of:

TWO LETTERS FOLLOWED BY A SERIAL NUMBER

FIRST LETTER

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

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

SECOND LETTER

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

A. DIODE; signal, low power
B. DIODE; variable capacitance
C. TRANSISTOR; low power, audio frequency ($R_{th\,j\text{-}mb} > 15\ ^{o}C/W$)
D. TRANSISTOR; power, audio frequency ($R_{th\,j\text{-}mb} \leqslant 15\ ^{o}C/W$)
E. DIODE; tunnel
F. TRANSISTOR; low power, high frequency ($R_{th\,j\text{-}mb} > 15\ ^{o}C/W$)
G. MULTIPLE OF DISSIMILAR DEVICES – MISCELLANEOUS; e.g. oscillator
H. DIODE; magnetic sensitive
L. TRANSISTOR; power, high frequency ($R_{th\,j\text{-}mb} \leqslant 15\ ^{o}C/W$)
N. PHOTO-COUPLER
P. RADIATION DETECTOR; e.g. high sensitivity phototransistor
Q. RADIATION GENERATOR; e.g. light-emitting diode (LED)
R. CONTROL AND SWITCHING DEVICE; e.g. thyristor, low power ($R_{th\,j\text{-}mb} > 15\ ^{o}C/W$)
S. TRANSISTOR; low power, switching ($R_{th\,j\text{-}mb} > 15\ ^{o}C/W$)
T. CONTROL AND SWITCHING DEVICE; e.g. thyristor, power ($R_{th\,j\text{-}mb} \leqslant 15\ ^{o}C/W$)
U. TRANSISTOR; power, switching ($R_{th\,j\text{-}mb} \leqslant 15\ ^{o}C/W$)
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 AND TRIACS

LETTER SYMBOLS FOR CURRENTS, VOLTAGES AND POWERS

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

I, i = current

V, v = voltage

P, p = power

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

Subscripts

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

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

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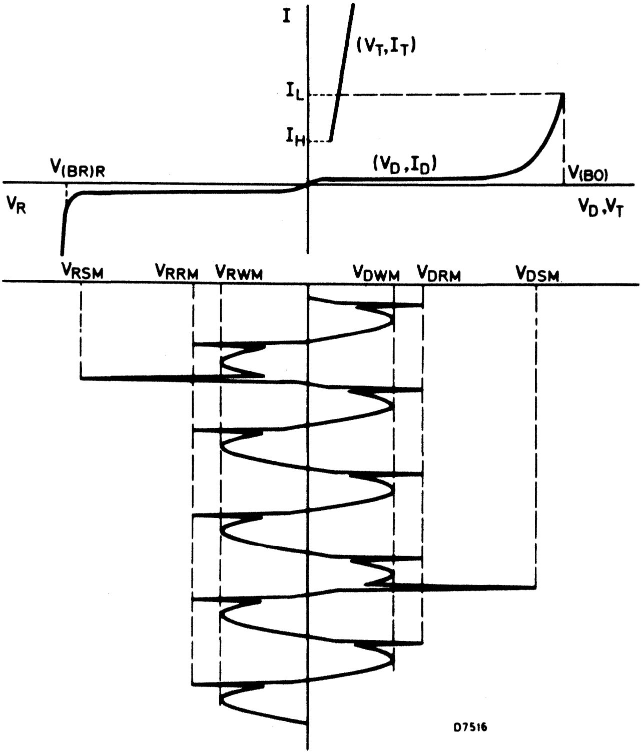
1) For the anode-cathode voltage of thyristors and triacs, F is replaced either by D or T, to distinguish between 'off-state' (non-triggered) and 'on-state' (triggered).

Example of the use of letter symbols



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

QUALITY CONFORMANCE AND RELIABILITY

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

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

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

CONFORMANCE

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

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

RELIABILITY

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

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

Sequence 'C'

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

Sequence 'D'

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

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

GATE TURN-OFF THYRISTORS

INTRODUCTION

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

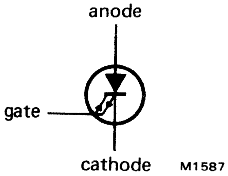


Fig.1 GTO circuit symbol.

FORWARD CHARACTERISTICS

Forward blocking

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

V_{DSM}	the non-repetitive transient voltage.
V_{DRM}	the repetitive peak voltage, with a short duty cycle (less than 5%).
V_{DW}	the crest working voltage, which is the repetitive peak voltage with a duty cycle of up to 50%.
V_D	the continuous d.c. anode to cathode voltage for the required life at maximum junction temperature.

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

Forward blocking (cont)

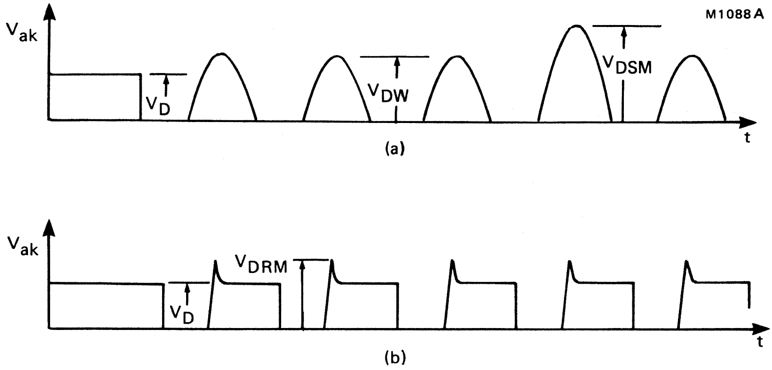


Fig.2

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

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

Forward conduction

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

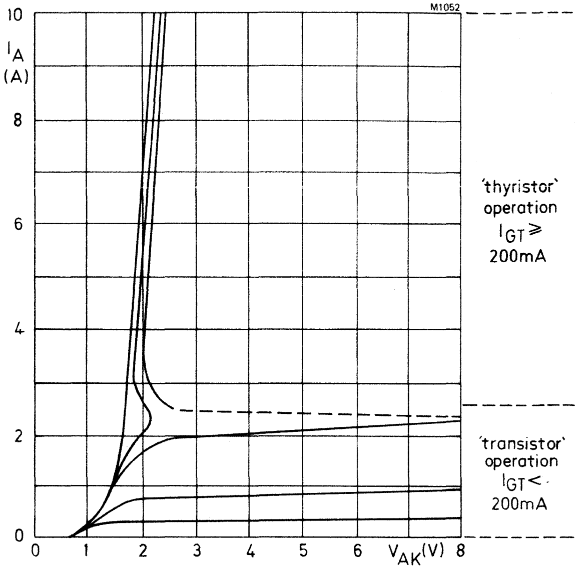


Fig.3 On-state current as a function of the on-state voltage with gate current as a parameter for the BTV59 GTO.

REVERSE CHARACTERISTICS

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

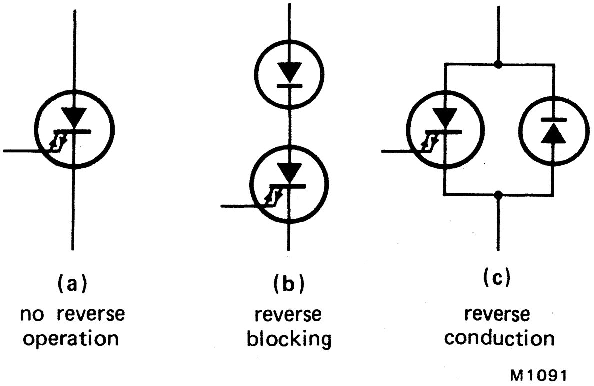


Fig.4 The use of additional diodes to change the reverse characteristic of the GTO circuit.

SWITCHING CHARACTERISTICS

Turn-on

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

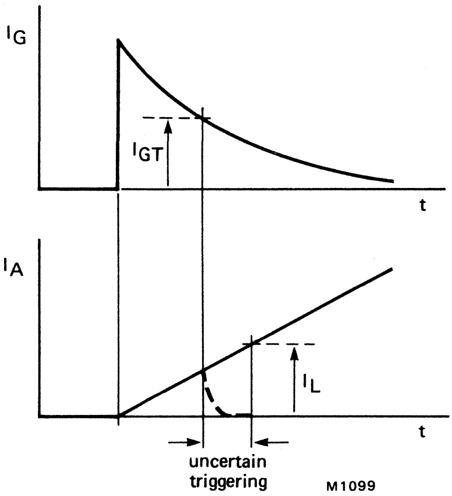


Fig.5a To ensure good triggering the anode current must rise above the latching level before the gate current falls below the minimum level required to ensure triggering.

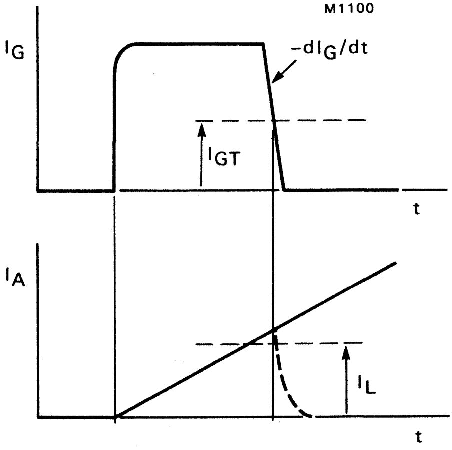


Fig.5b Unlatching can occur if the anode current is only slightly higher than the latching level during a rapid fall in gate current.

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

dI_T/dt limitation

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

Turn-off

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

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

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

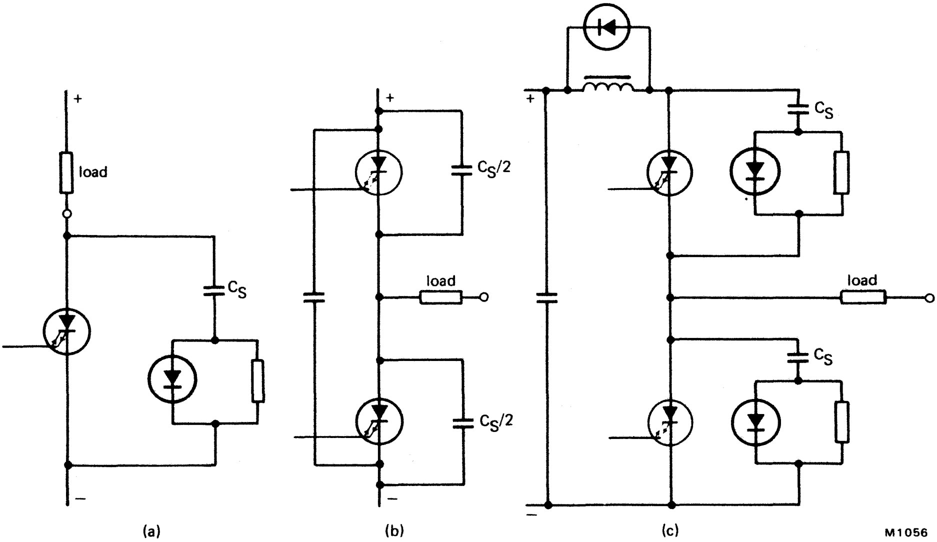


Fig.6 Snubber networks.

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

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

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

Turn-off (cont)

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

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

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

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

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

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

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

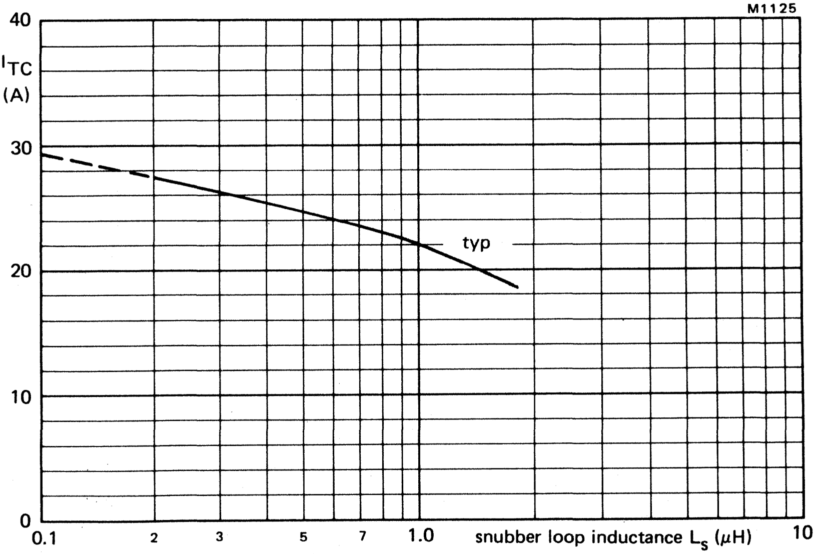


Fig.7 Typical anode current which can be turned off, as a function of snubber loop inductance for the BTV59 (C_S = 20 nF, T_{mb} = 25 °C)

When using an RCD snubber network, in which the current transferred from the GTO to the snubber capacitor must pass through the diode, care should be taken in the selection of the diode used, since (particularly in 'fast-recovery' gold-doped diodes) a high transient forward voltage can appear when the forward current through the diode is increased rapidly from zero. This voltage will have exactly the same effect as that due to stray inductance, and must be minimised. In general, the effect of snubber inductance will increase with increasing anode current and reducing dV_D/dt.

Another factor which should be taken into account when designing an RCD snubber network is the need for the snubber capacitor to be fully discharged before the device is turned off. When the GTO is turned on, the capacitor is, of course, charged up to the d.c. supply voltage, and must discharge through the snubber resistance R_S. For a supply voltage equal to the V_{Dmax} rating of the GTO, a safe period to ensure adequate discharge of the capacitor is given by:

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

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

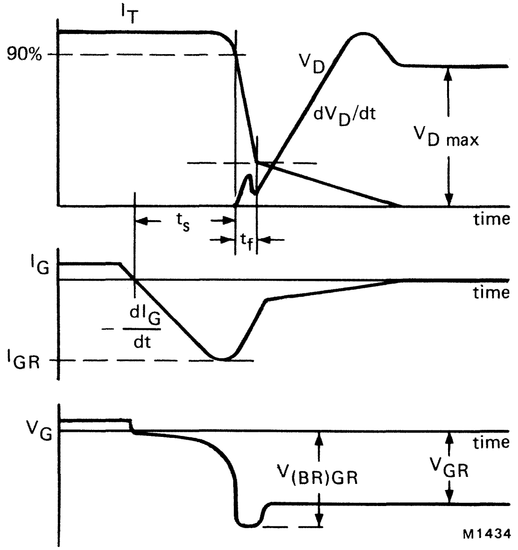


Fig.8 Typical turn-off waveforms.

Gate circuit design

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

Gate circuit design (cont)

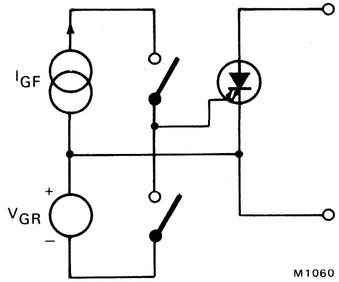


Fig.9 Idealised gate circuit.

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

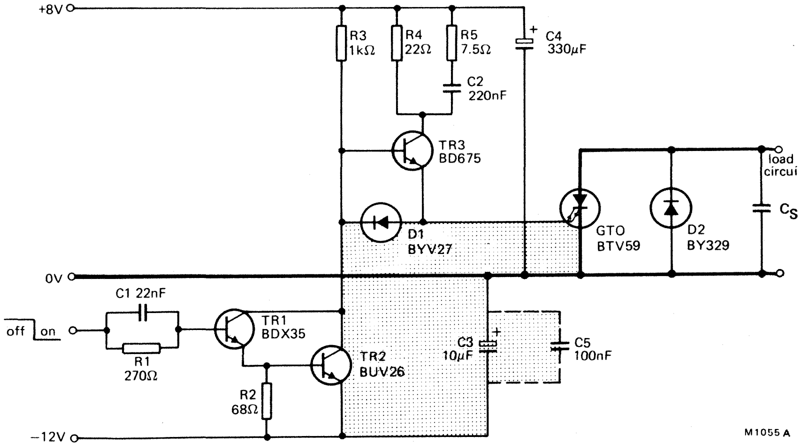


Fig.10 Practical drive circuit suitable for a BTV59. The turn-off loop (shaded) should have minimum inductance, and the small decoupling capacitor (shown in dashed lines), should be wired as close as possible to the electrolytic capacitor.

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

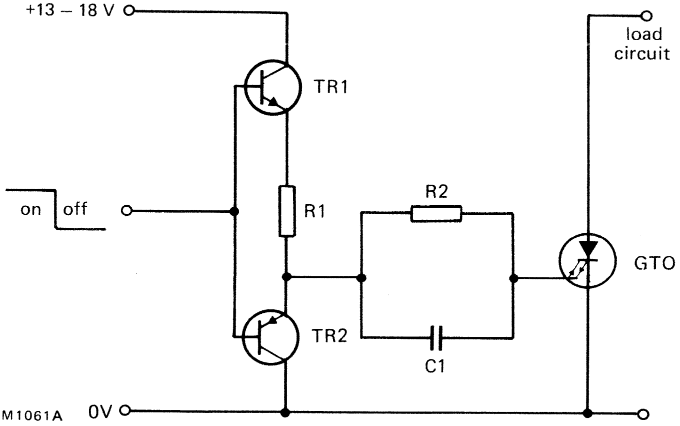


Fig.11 Simple gate circuit

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

SAFE OPERATING AREA (SOAR)

Forward-biased SOAR

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

Reversed-biased SOAR

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

SWITCHING LOSSES

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

Turn-on Losses

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

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

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

Turn-off Losses

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

THYRISTORS AND TRIACS

SWITCHING CHARACTERISTICS

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

Gate-controlled turn-on time

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

a) Off-state voltage (V_D).

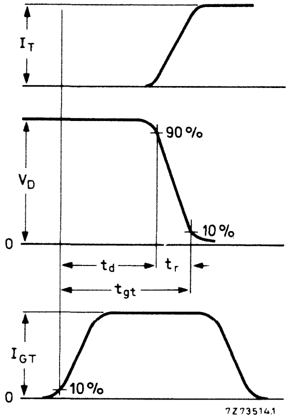
b) On-state current (I_T).

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

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

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

The waveforms are shown in the following diagram:



THYRISTORS

CIRCUIT-COMMUTATED TURN-OFF TIME

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

The conditions which need to be specified are:

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

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

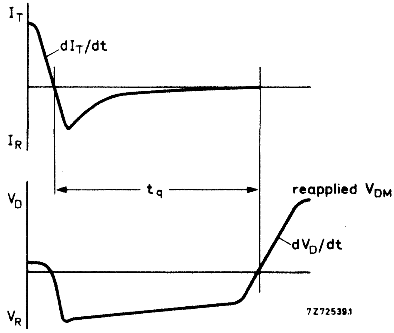
c) Rate of fall of anode current (dI/dt) – high rates mean shorter turn-off times.

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

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

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

The waveforms are shown in the following diagram:



TRIACS

COMMUTATION dV_{com}/dt

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

The conditions which need to be specified are:

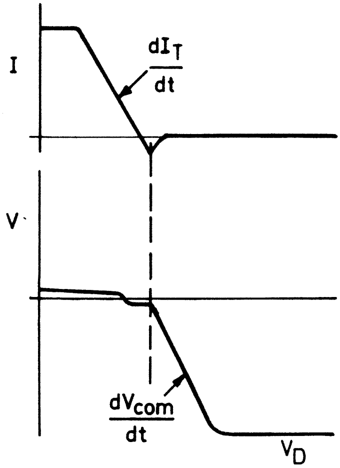
a) R.M.S. current ($I_{T(RMS)}$) – high currents make commutation harder.

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

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

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

The waveforms are shown in the following diagram:



THYRISTORS

OPERATING NOTES

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

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

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

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

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

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

T = V_1/V_2

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

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

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

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

HEAT TRANSFER PATH

In, for example, a silicon rectifier the heat is generated inside the wafer and flows mainly by way of the base, through a heatsink to the ambient air.
The heat flow can be likened to the flow of electric current, with thermal resistance (R_{th} in $^{0}C/W$)analogous to the electric resistance (R in Ω).
Fig. 1 shows the heat path from junction to ambient as three thermal resistances in series:

$R_{th\ j\text{-}mb}$	The thermal resistance from junction to mounting base. Its value is given in the data sheets of a device.
$R_{th\ mb\text{-}h}$	The thermal resistance from mounting base to heatsink (contact thermal resistance). It is caused by the imperfect nature and limited size of the contact between the two. Its value is also given in the data sheets.
$R_{th\ h\text{-}a}$	The thermal resistance between the contact surface mentioned above and the ambient air.

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

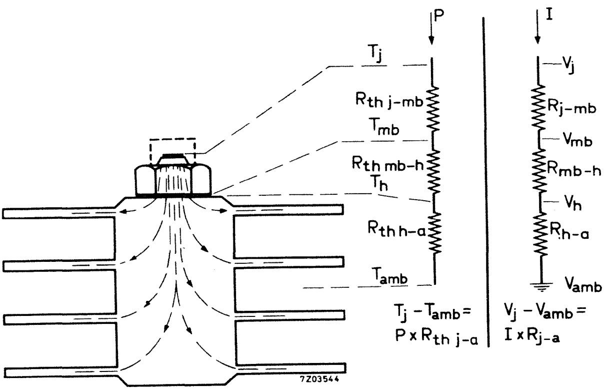


Fig. 1

IMPROVING HEAT TRANSFER

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

Contact thermal resistance

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

Heatsink thermal resistance

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

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

INSULATED MOUNTING

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

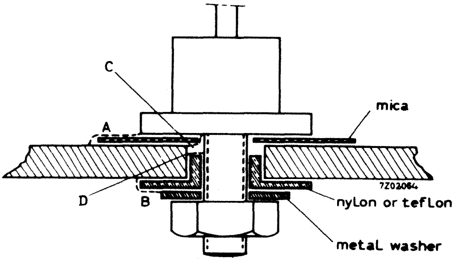


Fig. 2 Creepage distances with an insulated diode

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

CONSTRUCTIONS

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

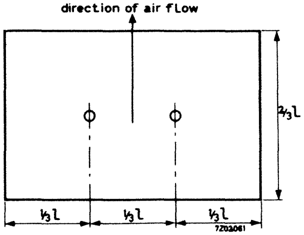


Fig. 3 Plain cooling fin with two diodes

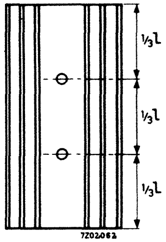


Fig. 4 Extruded aluminium heatsink with two diodes

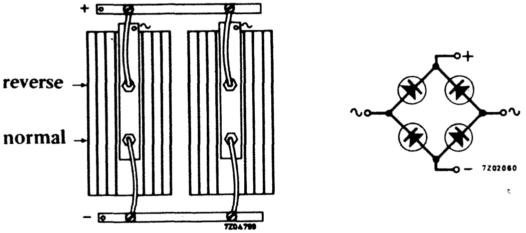


Fig. 5 Single phase full wave rectifier with diodes of different polarity on extruded aluminium heatsinks

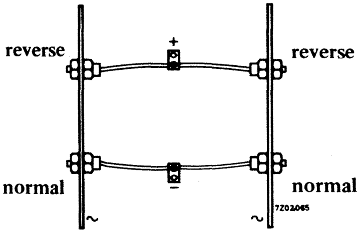


Fig. 6 Single phase full wave rectifier with diodes of different polarity on plain cooling fins (top view)

CONSTRUCTIONS (continued)

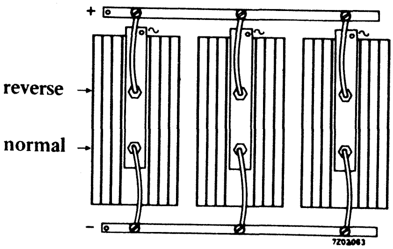


Fig. 7 Three phase full wave rectifier with diodes of different polarity on extruded aluminium heatsinks

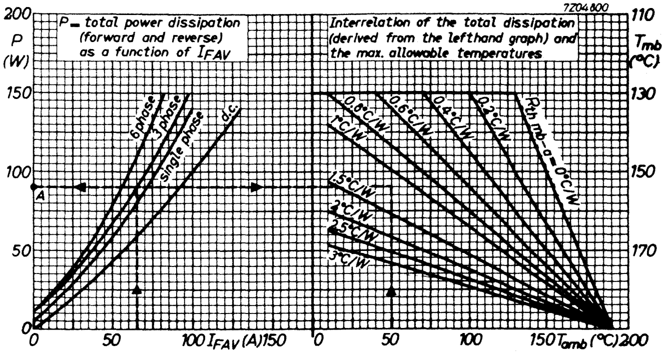
EXAMPLES OF HEATSINK CALCULATION

1. Devices without controlled avalanche properties.

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

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

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



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

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

---

1) Practical minimum length

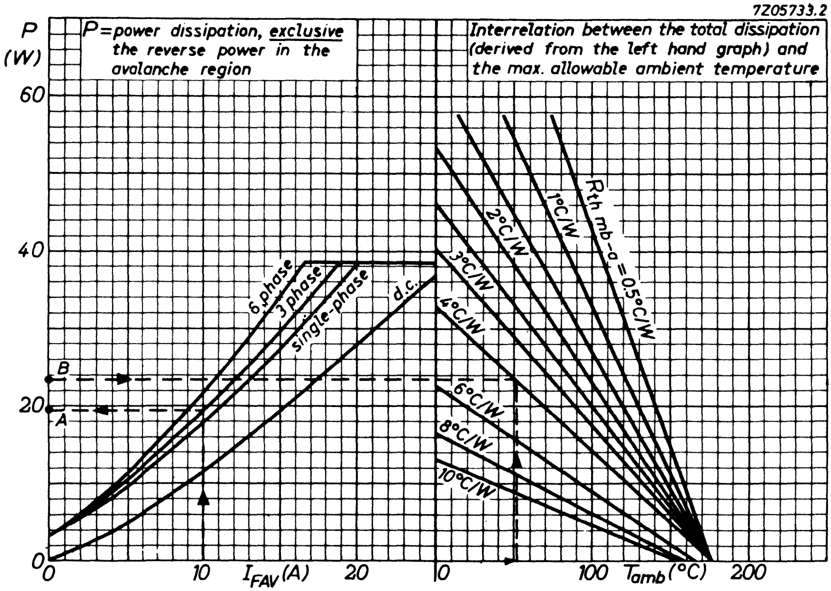
EXAMPLES OF HEATSINK CALCULATION (continued)

2. Devices with controlled avalanche properties

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

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

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



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

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

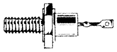
Thus $P_{R(AV)} = 0,002 \times 2\ kW = 4\ W$.

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

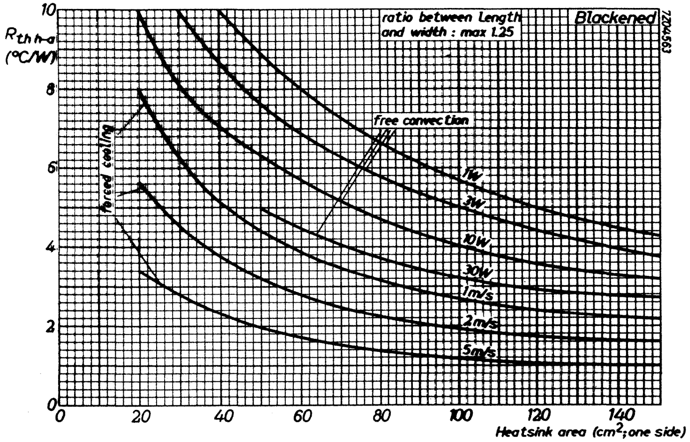
$$R_{th\ h\text{-}a} = R_{th\ mb\text{-}a} - R_{th\ mb\text{-}h} = (4 - 0,5)\ °C/W = 3,5\ °C/W.$$

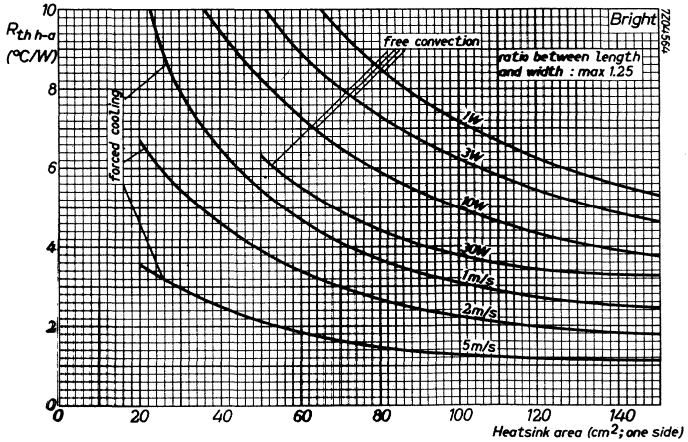
A table of applicable heatsinks, similar to that on the foregoing page, can de derived for this case.

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



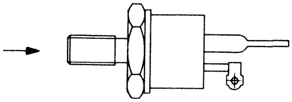
Studs: 10-32UNF
Mounting bases, across the flats: max. 11,0 mm



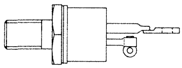


Flat heatsink

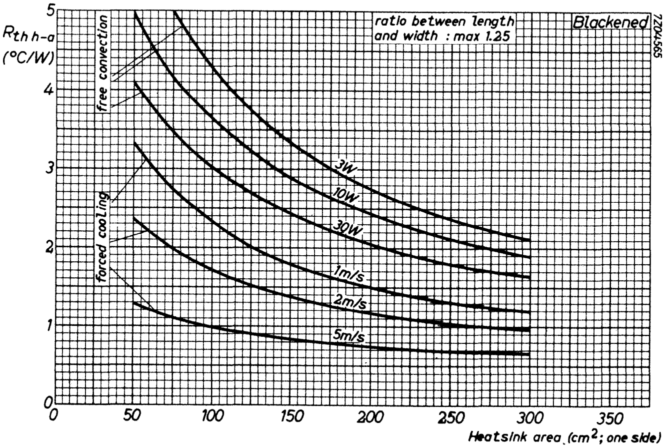
Thermal resistance of flat heatsinks of 2 mm copper or 3 mm aluminium.
The graphs are valid for the combination of device and heatsink.

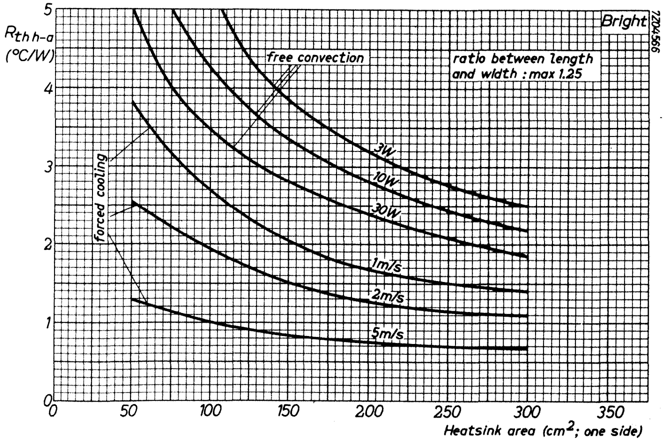


Stud: ¼" x 28 UNF
Mounting base, across the flats: max. 17 mm



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





GATE TURN-OFF THYRISTORS

FAST GATE TURN-OFF THYRISTORS

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

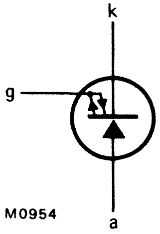
QUICK REFERENCE DATA

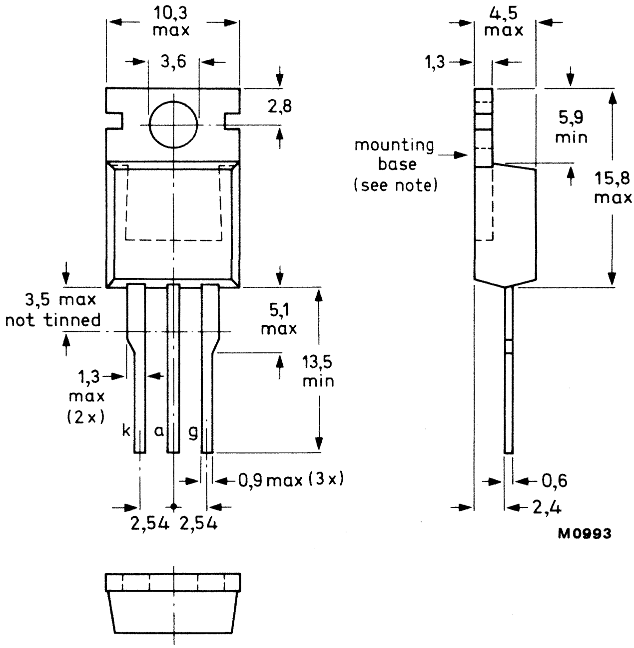
			BT157–1300R	1500R	
Repetitive peak off-state voltage	V_{DRM}	max.	1300	1500	V
Non-repetitive peak on-state current	I_{TSM}	max.	20		A
Controllable anode current	I_{TCRM}	max.	12		A
Average on-state current	$I_{T(AV)}$	max.	3.2		A
Fall time	t_f	max.	200		ns

MECHANICAL DATA

Dimensions in mm

Fig.1 TO-22AB.





Net mass: 2 g

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

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

RATINGS

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

Anode to cathode			BT157–1300R	1500R	
Transient off-state voltage	V_{DSM}	max.	1500	1650	V*
Repetitive peak off-state voltage	V_{DRM}	max.	1300	1500	V*
Working off-state voltage	V_{DW}	max.	1200	1300	V*
Continuous off-state voltage	V_D	max.	750	800	V*
Average on-state current (averaged over any 20 ms period) up to T_{mb} = 80 °C	$I_{T(AV)}$	max.	3.2		A
Controllable anode current	I_{TCRM}	max.	12		A
Non-repetitive peak on-state current t = 10 ms; half-sinewave; T_j = 120 °C prior to surge	I_{TSM}	max.	20		A
I^2t for fusing; t = 10 ms	I^2t	max.	2		A^2s
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	47.5		W

Gate to cathode

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

Temperatures

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

THERMAL RESISTANCE

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

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* Measured with gate-cathode connected together.

CHARACTERISTICS

Anode to cathode

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

Gate to cathode

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

Switching characteristics (resistive load)

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

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

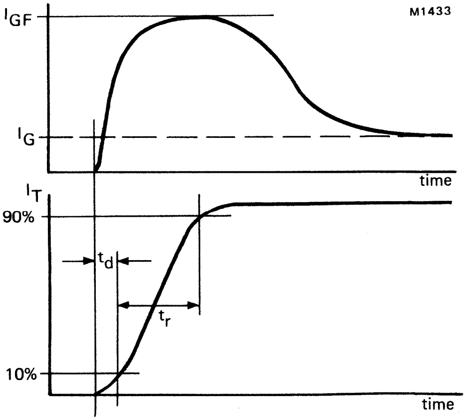

Fig.2 Waveforms

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* Measured under pulse conditions to avoid excessive dissipation.

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

→ **Switching characteristics (inductive load)**

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

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

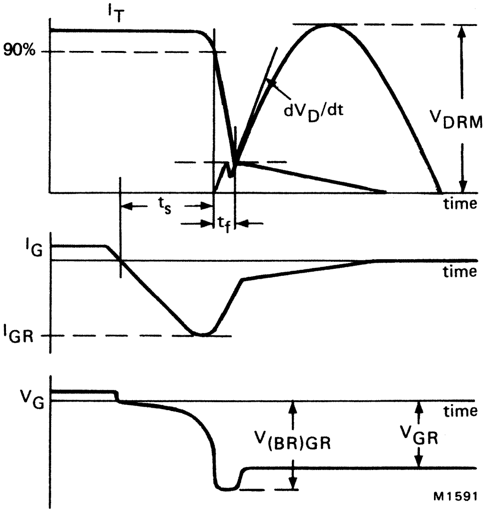


Fig.3 Waveforms

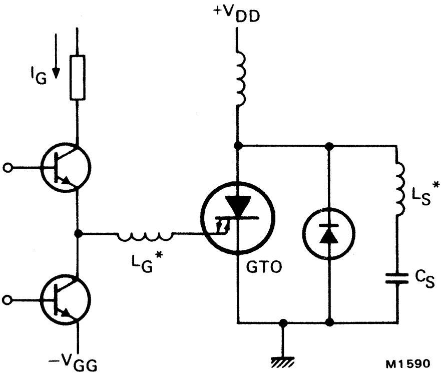


Fig.4 Inductive load test circuit

*Indicates stray series inductance only.

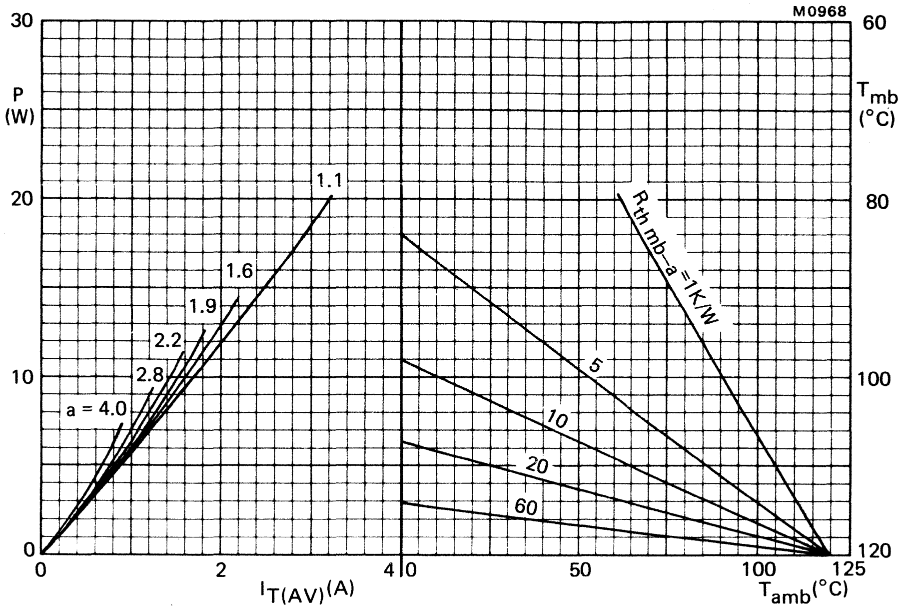
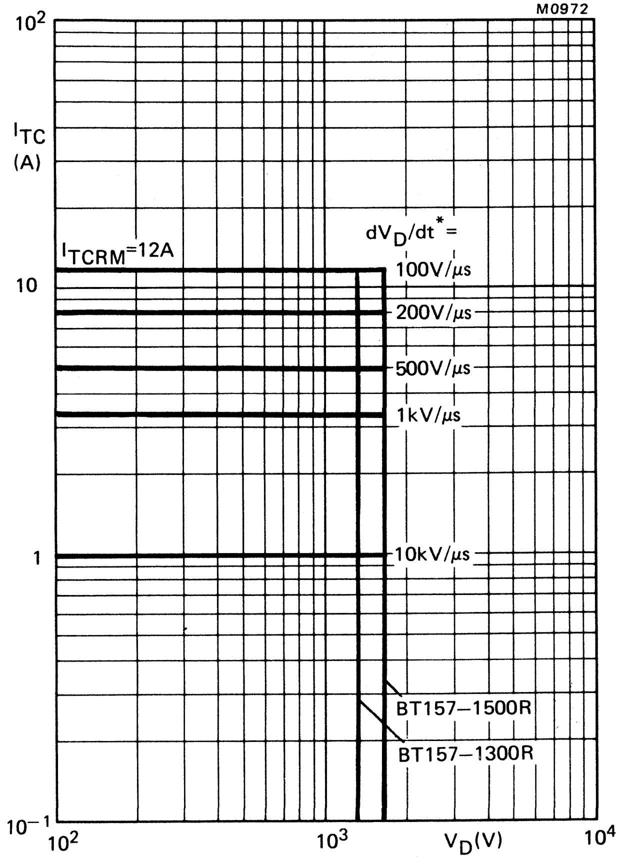


Fig.5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

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

P = Power excluding switching losses



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

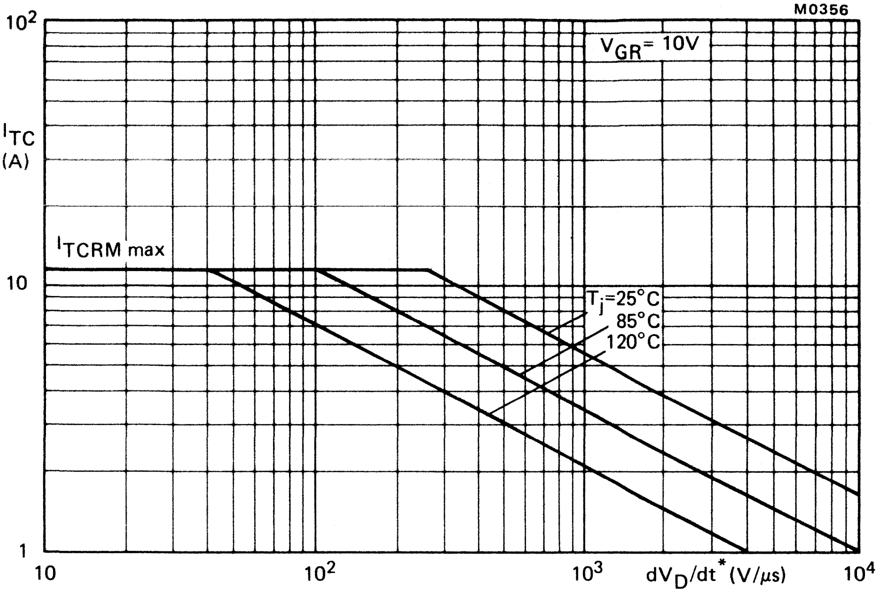


Fig.7 Anode current which can be turned off versus applied dV_D/dt^*; inductive load; V_{GR} = 10 V; $L_G \leqslant 1.5$ μH; $L_S \leqslant 0.25$ μH; $^*dV_D/dt$ is calculated from I_T/C_S.

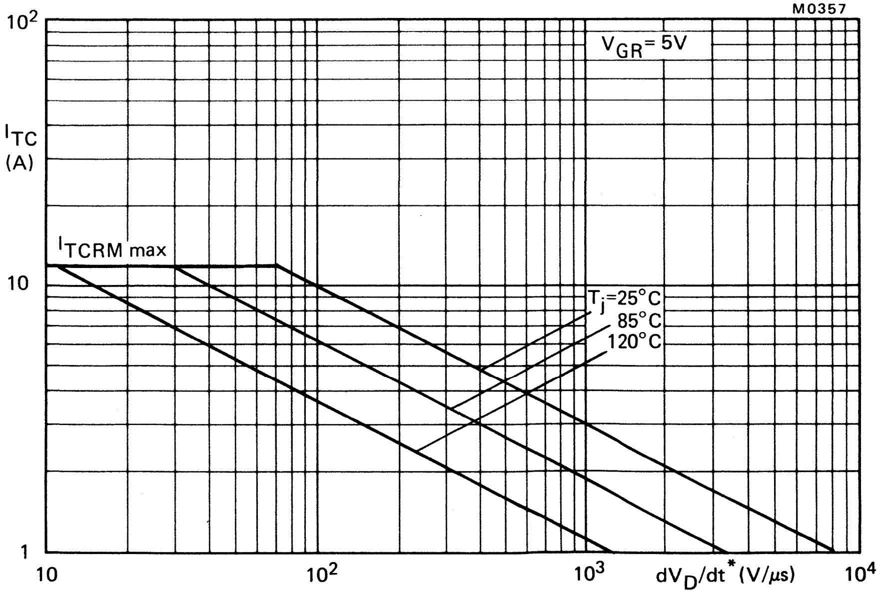


Fig. 8 Anode current which can be turned off versus applied dV_D/dt; inductive load; V_{GR} = 5 V. $L_G \leqslant 1.5$ μH; $L_S \leqslant 0.25$ μH; $^*dV_D/dt$ is calculated from I_T/C_S.

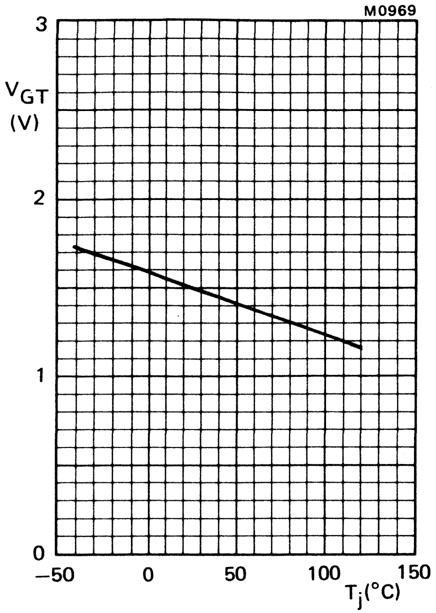


Fig.9 Minimum gate voltage that will trigger all devices as a function of junction temperature; V_D = 12 V.

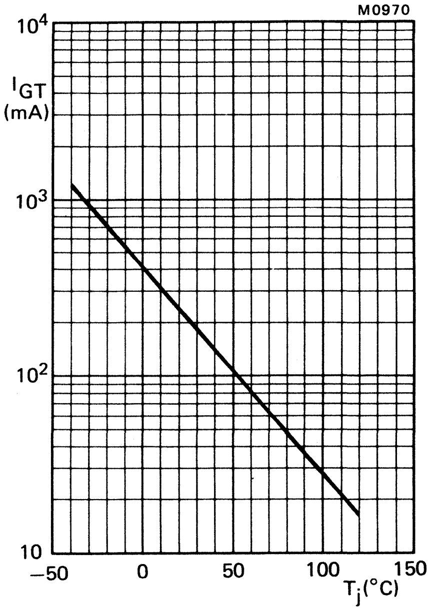


Fig.10 Minimum gate current that will trigger all devices as a function of junction temperature; V_D = 12 V.

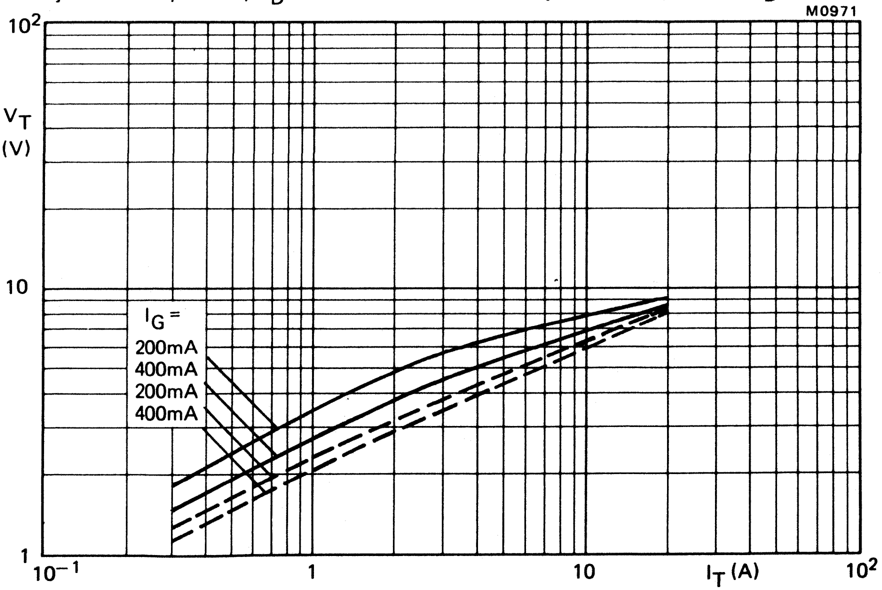


Fig.11 Maximum V_T versus I_T; —— T_j = 25 °C; – – – T_j = 120 °C.

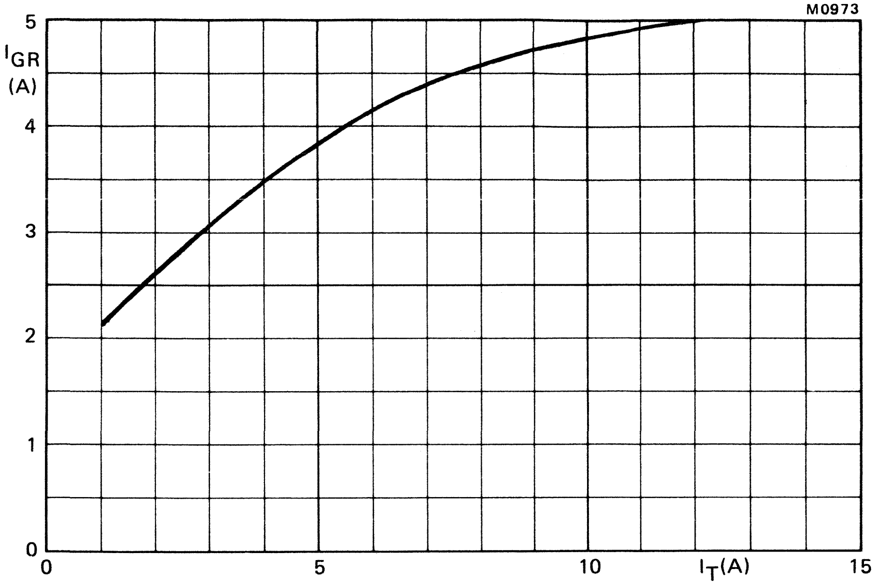


Fig.12 Peak reverse gate current versus anode current at turn-off; inductive load; V_{GR} = 10 V; I_G = 0.2 A; L_G = 0.8 μH; T_j = 120 °C; maximum values.

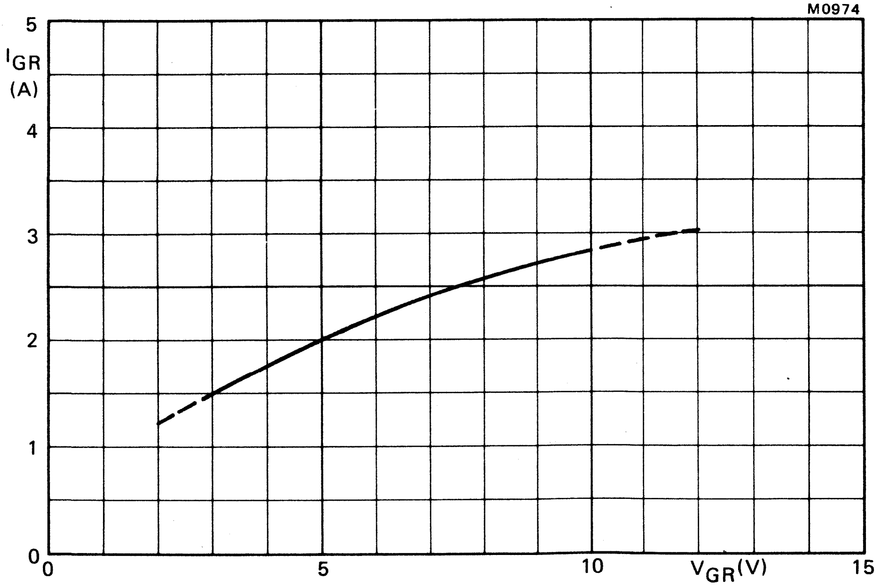
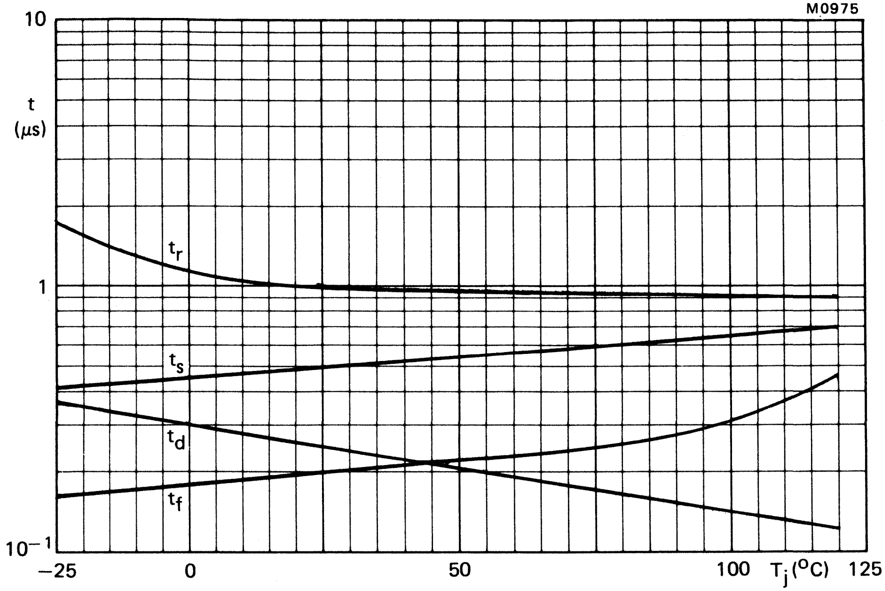


Fig.13 Peak reverse gate current versus applied gate voltage; inductive load; I_T = 2.5 A; I_G = 0.2 A; L_G = 0.8 μH; T_j = 120 °C; maximum values.



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

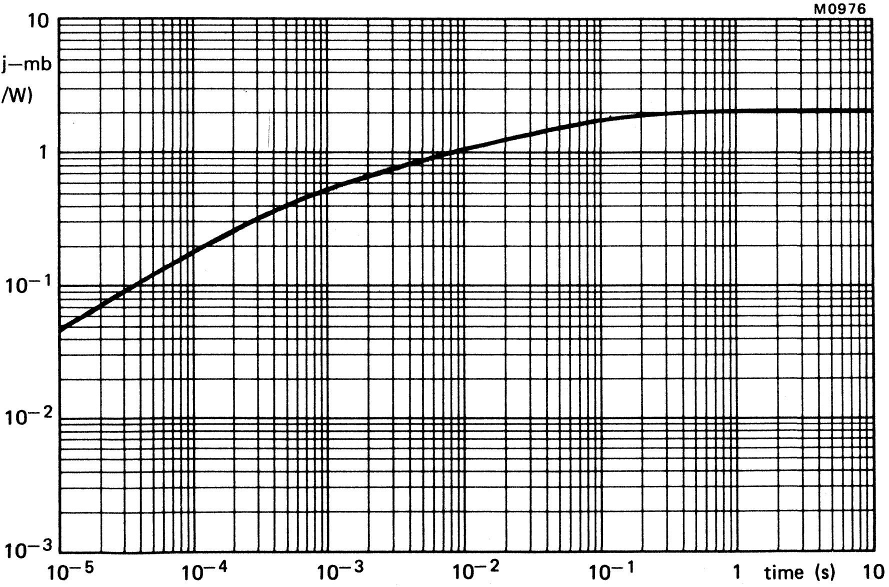


Fig.15 Transient thermal impedance.

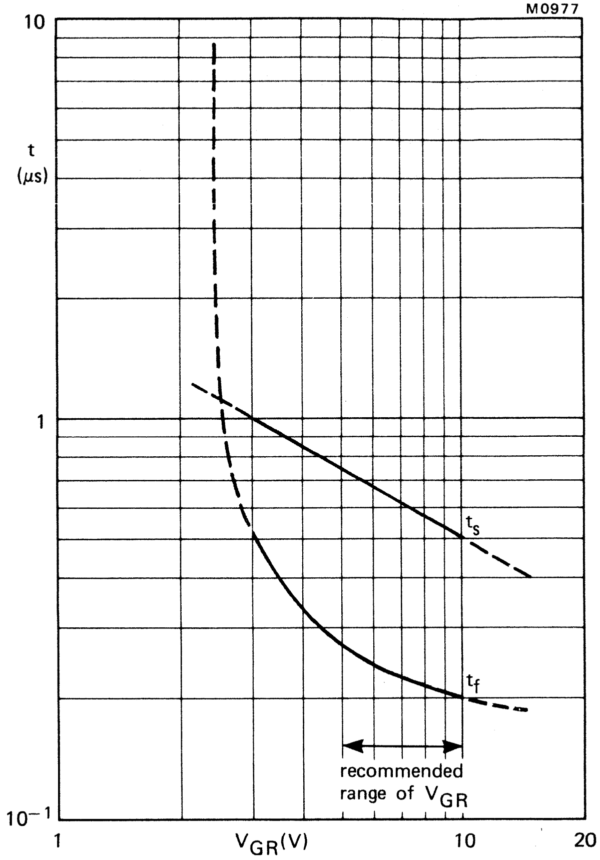


Fig. 16 Storage and fall times versus applied reverse gate voltage; inductive load; $I_T = 2.5$ A; $L_G = 0.8$ μH; $I_G = 0.2$ A; $T_j = 25$ °C; maximum values.

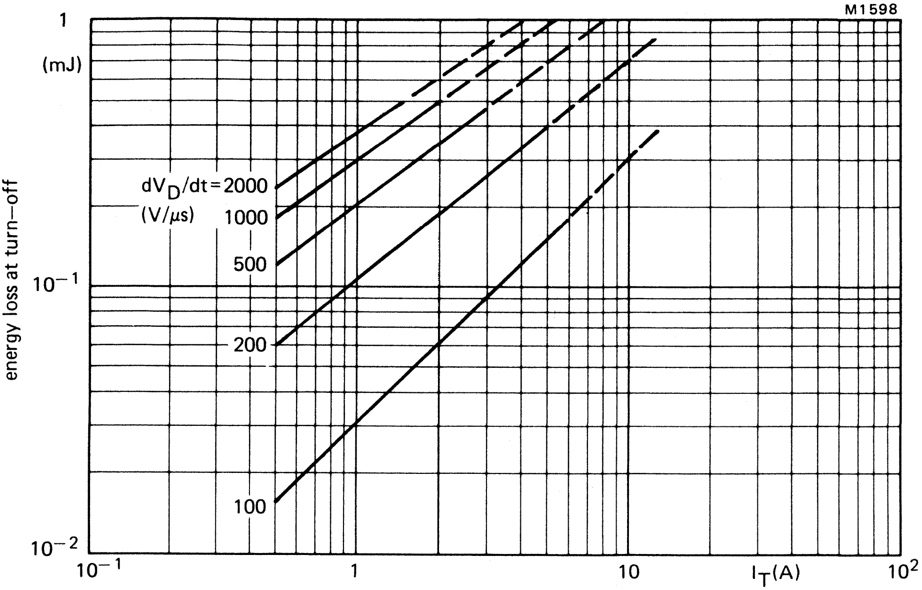


Fig. 17 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied dV_D/dt (calculated from I_T/C_S); reapplied voltage sinsusoidal up to V_{DRM} = 1200 V; V_{GR} = 10 V; I_G = 0.2 A; $L_G \leqslant 1.5\ \mu H$; $L_S \leqslant 0.25\ \mu H$; T_j = 120 °C.

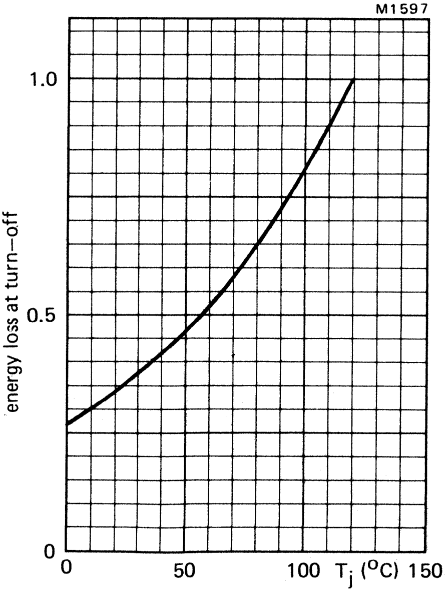


Fig. 18 Energy loss at turn off as a function of junction temperature; I_G = 0.2 A; V_{GR} = 10 V. Normalised to T_j = 120 °C.

FAST GATE TURN-OFF THYRISTORS

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

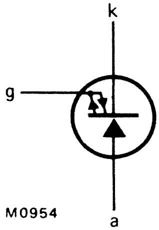
QUICK REFERENCE DATA

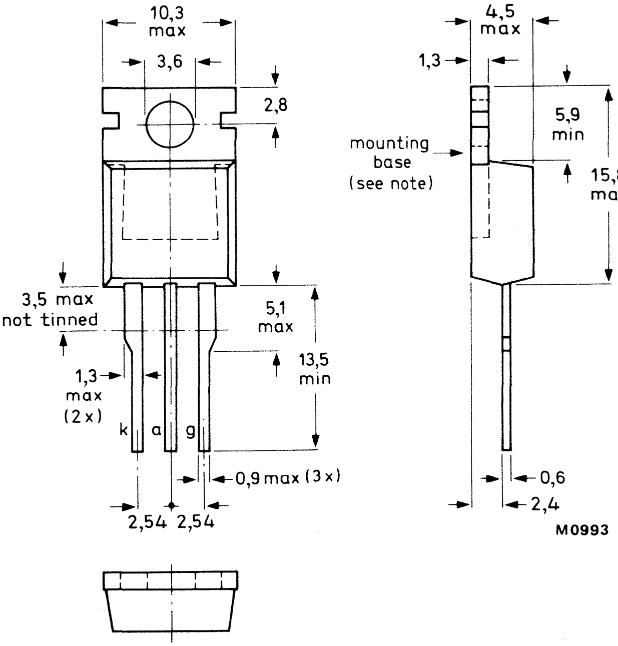
			BTV58–600R	850R	1000R	
Repetitive peak off-state voltage	V_{DRM}	max.	600	850	1000	V
Non-repetitive peak on-state current	I_{TSM}	max.	75			A
Controllable anode current	I_{TCRM}	max.	25			A
Average on-state current	$I_{T(AV)}$	max.	10			A
Fall time	t_f	max.	250			ns

MECHANICAL DATA

Dimensions in mm

Fig.1 TO-220AB.





Net mass: 2 g

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

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

RATINGS

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

Anode to cathode			BTV58-600R	850R	1000R	
Transient off-state voltage*	V_{DSM}	max.	750	1000	1100	V
Repetitive peak off-state voltage*	V_{DRM}	max.	600	850	1000	V
Working off-state voltage*	V_{DW}	max.	400	600	800	V
Continuous off-state voltage*	V_D	max.	400	500	650	V
Average on-state current (averaged over any 20 ms period) up to T_{mb} = 80 °C	$I_{T(AV)}$	max.		10		A
Controllable anode current	I_{TCRM}	max.		25		A
Non-repetitive peak on-state current t = 10 ms; half-sinewave; T_j = 120 °C prior to surge	I_{TSM}	max.		75		A
I^2t for fusing; t = 10 ms	I^2t	max.		28		A^2s
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		65		W

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

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

THERMAL RESISTANCE

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

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* Measured with gate connected to cathode.

CHARACTERISTICS

Anode to cathode

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

Gate to cathode

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

Switching characteristics (resistive load)

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

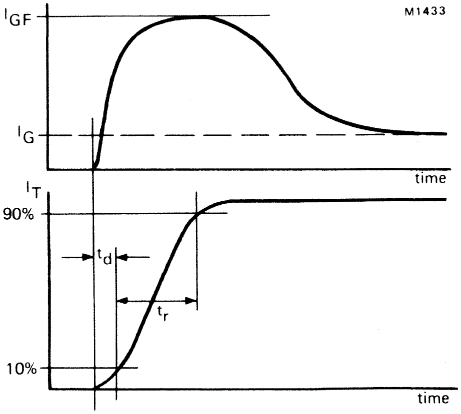

Fig.2 Waveforms

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* Measured under pulse conditions to avoid excessive dissipation.

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

→ **Switching characteristics (inductive load)**

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

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

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

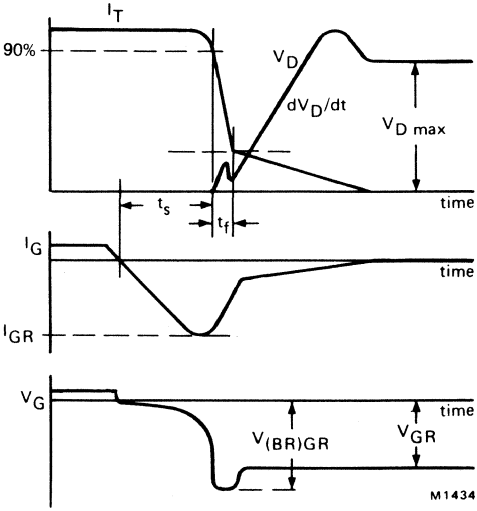

Fig.3 Waveforms.

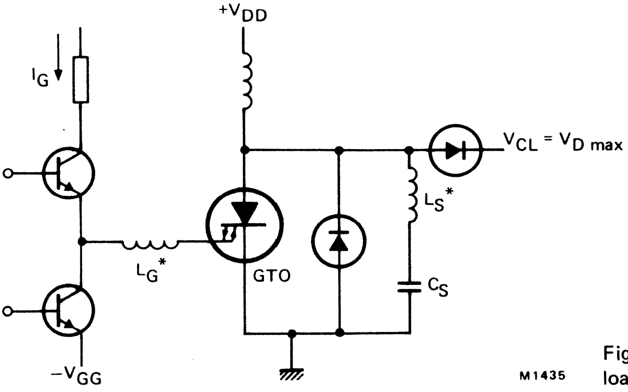

Fig.4 Inductive load test circuit.

*indicates stray series inductance only.

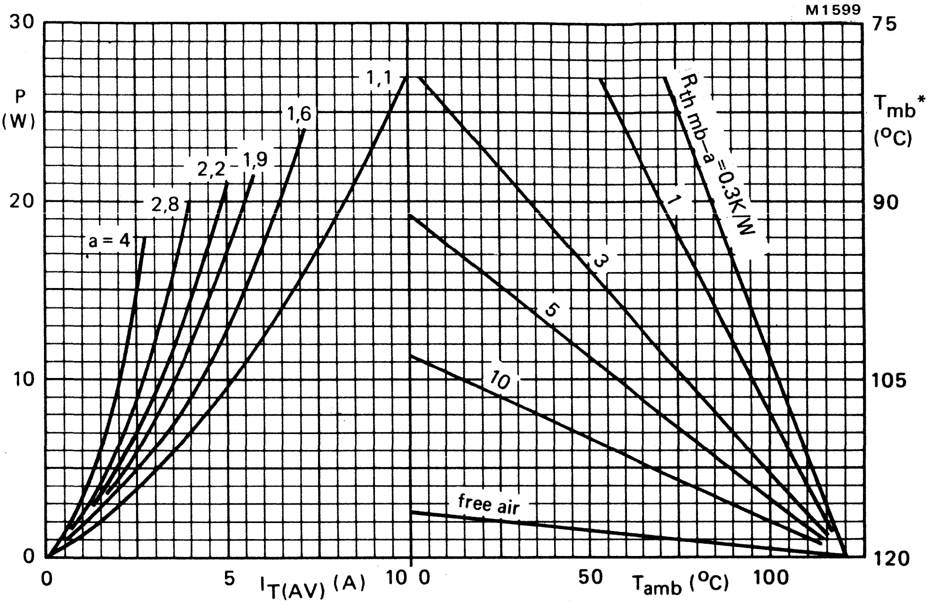

Fig.5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

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

P = power excluding switching losses.

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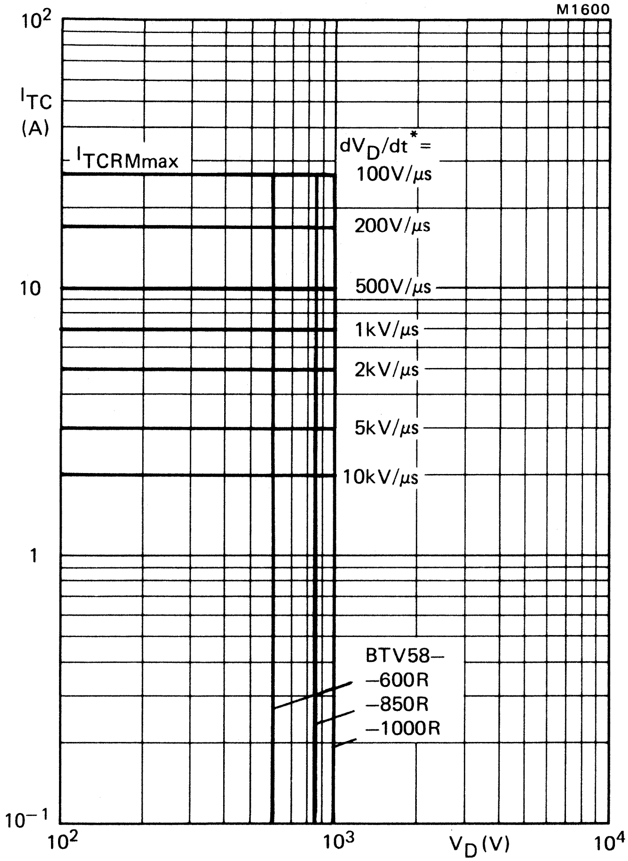
*Mounting-base temperature scale is for comparison purposes and is correct only for $R_{th\ mb\text{-}a} < 9.6$ K/W.



→

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

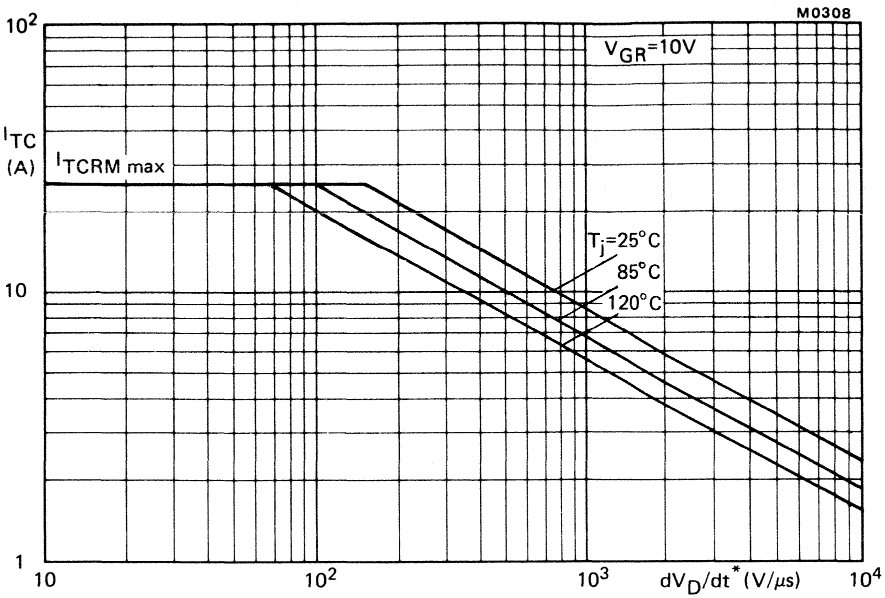


Fig.7 Anode current which can be turned off versus applied dV_D/dt^*; inductive load; V_{GR} = 10 V. $L_G \leqslant 1.0\ \mu H$; $L_S \leqslant 0.25\ \mu H$. $^*dV_D/dt$ is calculated from I_T/C_S. ←

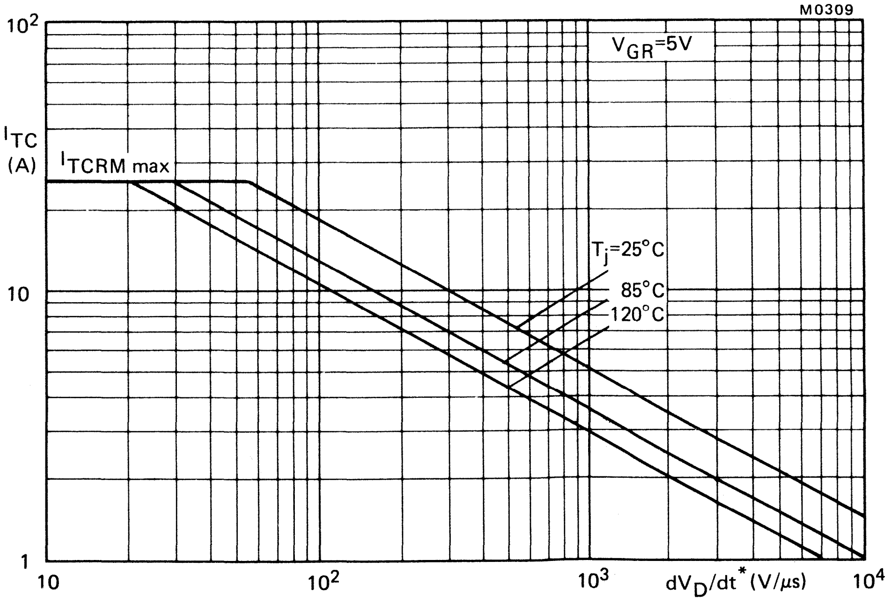


Fig.8 Anode current which can be turned off versus applied dV_D/dt^*; inductive load; V_{GR} = 5 V. $L_G \leqslant 1.0\ \mu H$; $L_S \leqslant 0.25\ \mu H$; $^*dV_D/dt$ is calculated from I_T/C_S. ←

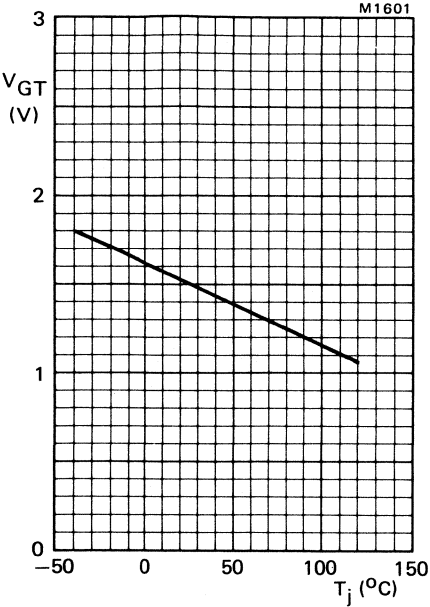


Fig.9 Minimum gate voltage that will trigger all devices as a function of junction temperature; V_D = 12 V.

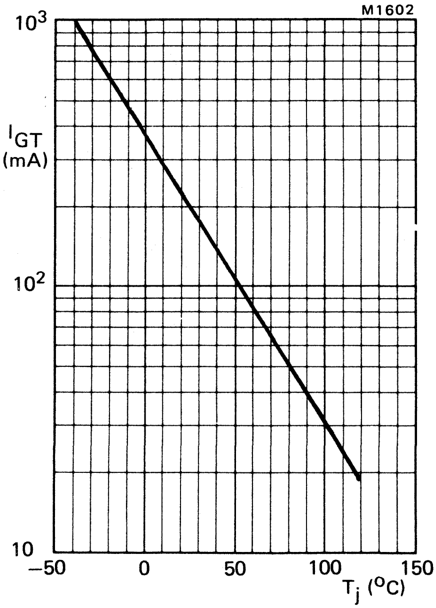


Fig.10 Minimum gate current that will trigger all devices as a function of junction temperature; V_D = 12 V.

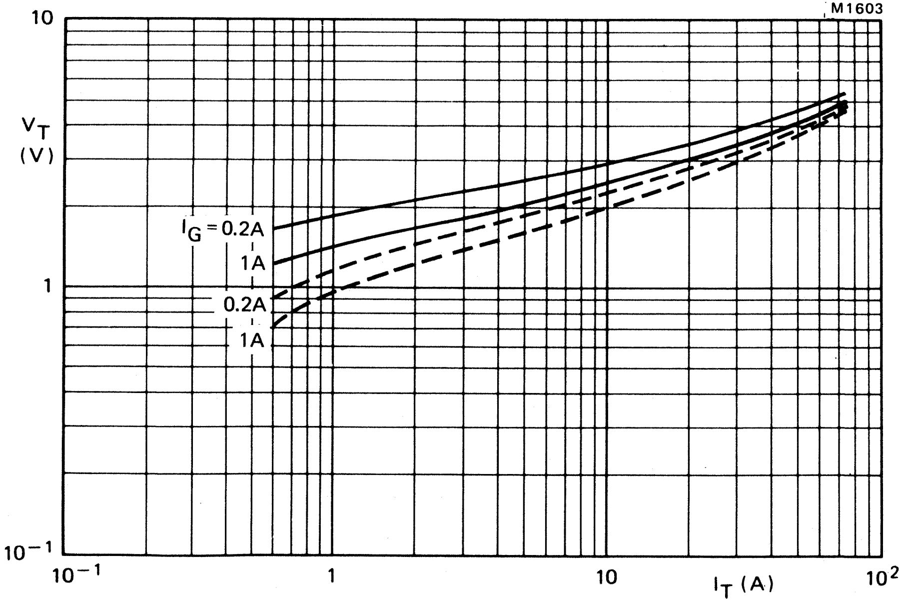


Fig.11 Maximum V_T versus I_T; ——— T_j = 25 °C; – – – – T_j = 120 °C.

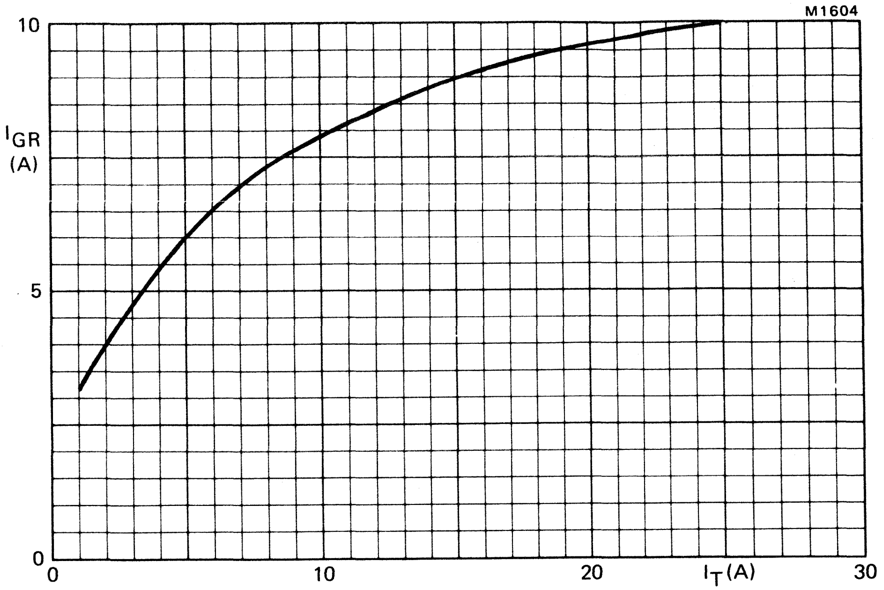


Fig.12 Peak reverse gate current versus anode current at turn-off; inductive load; V_{GR} = 10 V; I_G = 0.2 A; L_G = 0.8 μH; T_j = 120 °C; maximum values.

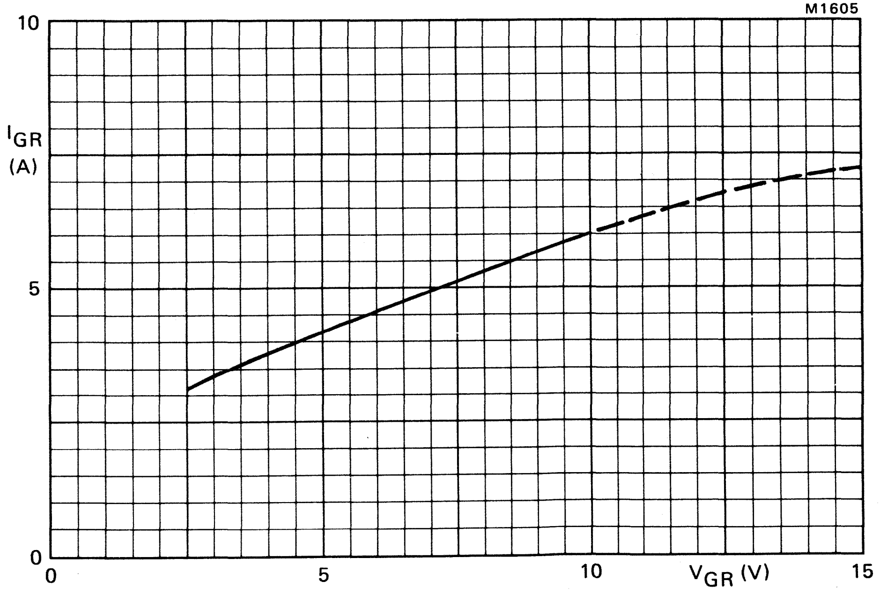


Fig.13 Peak reverse gate current versus applied reverse gate voltage; inductive load; I_T = 5 A; I_G = 0.2 A; L_G = 0.8 μH; T_j = 120 °C; maximum values.

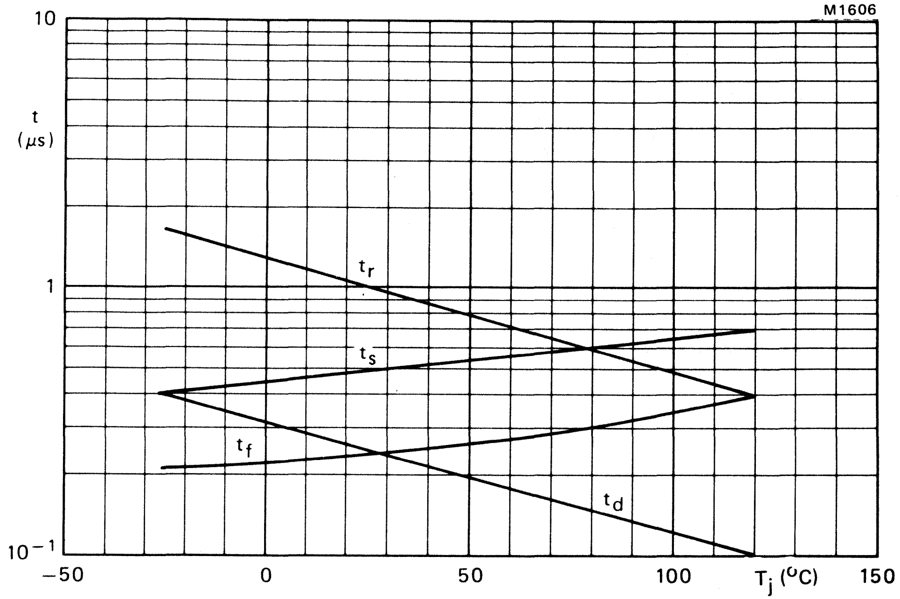


Fig.14 Switching times as a function of junction temperature; $V_D \geqslant 250$ V; $I_T = 5$ A; $I_{GF} = 0.5$ A; $V_{GR} = 10$ V; $I_G = 0.2$ A; $L_G = 0.8$ μH; maximum values.

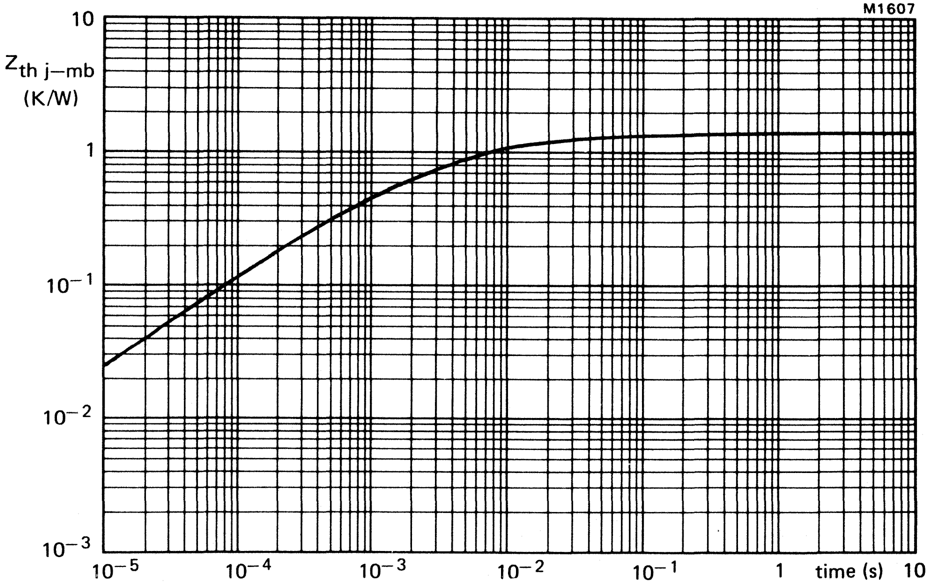


Fig.15 Transient thermal impedance.

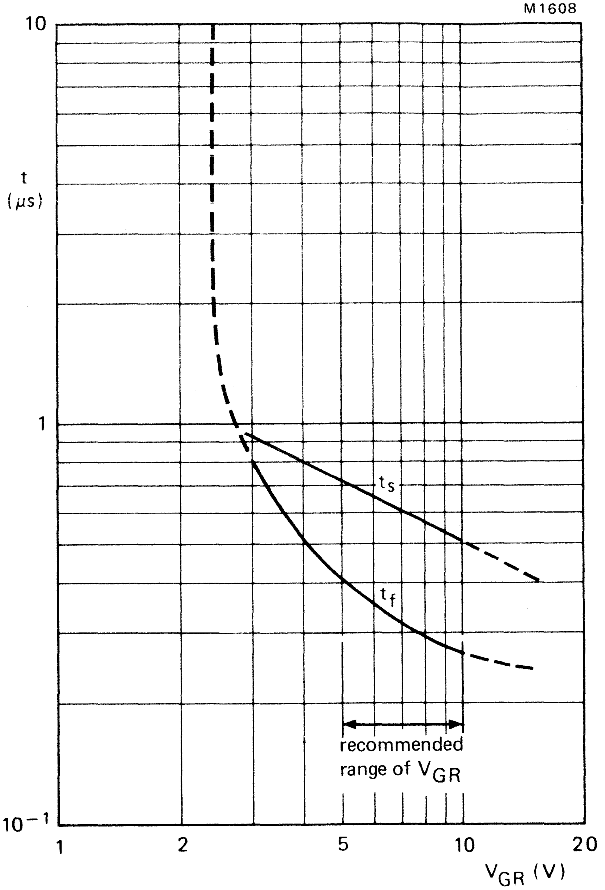


Fig. 16 Storage and fall times versus applied reverse gate voltage; inductive load; I_T = 5 A; I_G = 0.2 A; L_G = 0.8 μH; T_j = 25 °C; maximum values.

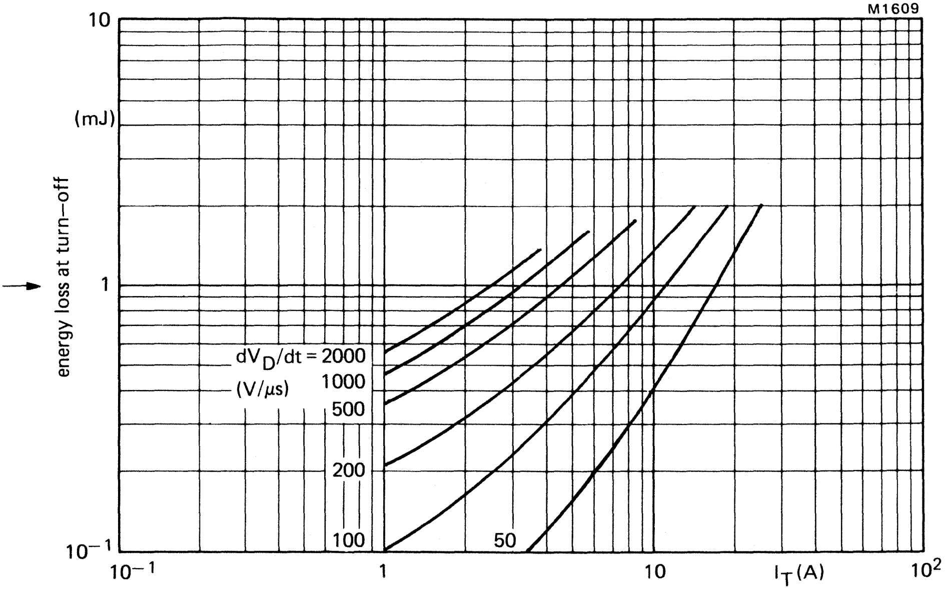


Fig. 17 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied dV_D/dt (calculated from I_T/C_S); dV_D/dt linear up to V_{Dmax} = 600 V; V_{GR} = 10 V; I_G = 0.2 A; $L_G \leqslant 1.0$ µH; $L_S \leqslant 0.25$ µH; T_j = 120 °C.

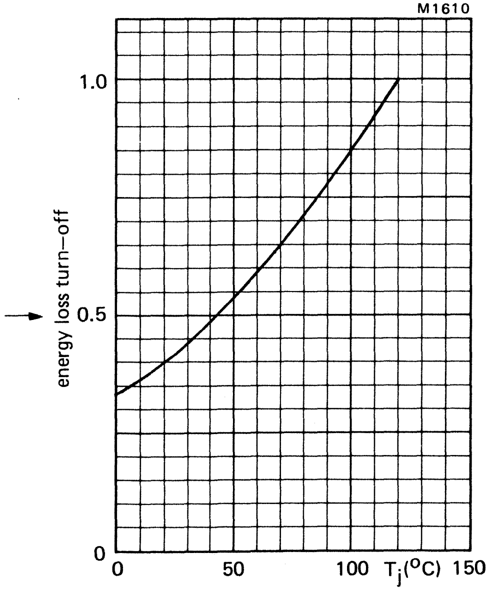


Fig. 18 Energy loss at turn off as a function of junction temperature; I_G = 0.2 A; V_{GR} = 10 V. Normalised to T_j = 120 °C.

FAST GATE TURN-OFF THYRISTORS

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

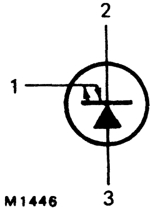
QUICK REFERENCE DATA

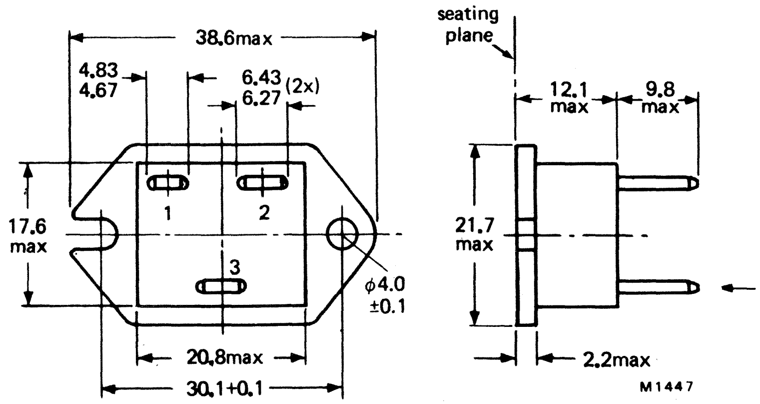
			BTV59-600R	850R	1000R	
Repetitive peak off-state voltage	V_{DRM}	max.	600	850	1000	V
Non-repetitive peak on-state current	I_{TSM}	max.		100		A
Controllable anode current	I_{TCRM}	max.		50		A
Average on-state current	$I_{T(AV)}$	max.		15		A
Fall time	t_f	<		250		ns

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-238AA





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

RATINGS

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

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

→ Average on-state current (averaged over any 20 ms period) up to T_{mb} = 60 °C	$I_{T(AV)}$	max.	15	A
Controllable anode current	I_{TCRM}	max.	50	A
Non-repetitive peak on-state current t = 10 ms; half-sinewave; T_j = 120 °C prior to surge	I_{TSM}	max.	100	A
I^2t for fusing; t = 10 ms	I^2t	max.	50	A^2s
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	60	W
Gate to cathode				
Repetitive peak on-state current T_j = 120 °C prior to surge				
gate-cathode forward; t = 10 ms; half-sinewave	I_{GFM}	max.	25	A
gate-cathode reverse; t = 20 µs	I_{GRM}	max.	25	A
→ Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	5.0	W
Temperatures				
Storage temperature	T_{stg}		−40 to +150	°C
Operating junction temperature	T_j	max.	120	°C

ISOLATION**

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

THERMAL RESISTANCE

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

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* Measured with gate-cathode connected together.

** From baseplate to all terminals strapped together.

CHARACTERISTICS ←

Anode to cathode

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

Gate to cathode

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

Switching characteristics (resistive load)

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

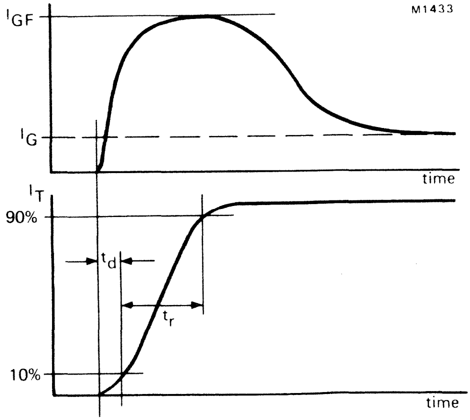

Fig.2 Waveforms

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* Measured under pulse conditions to avoid excessive dissipation.

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

→ **Switching characteristics (inductive load)**

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

V_{GR} = 10 V; $L_G \leqslant 0.5\ \mu H$; $L_S \leqslant 0.25\ \mu H$; T_j = 25 °C

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

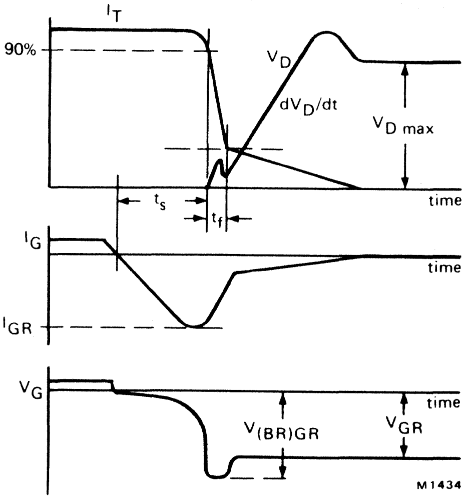


Fig.3 Waveforms.

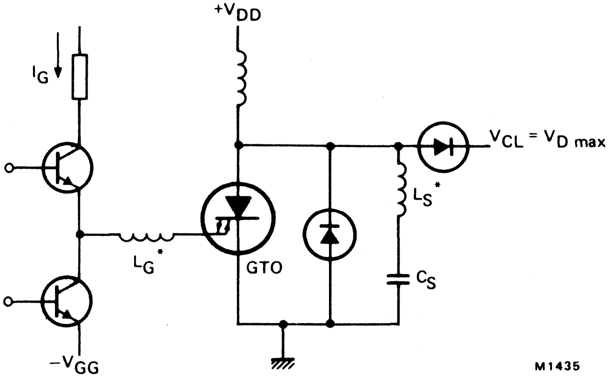


Fig.4 Inductive load test circuit.

*Indicates stray series inductance only.

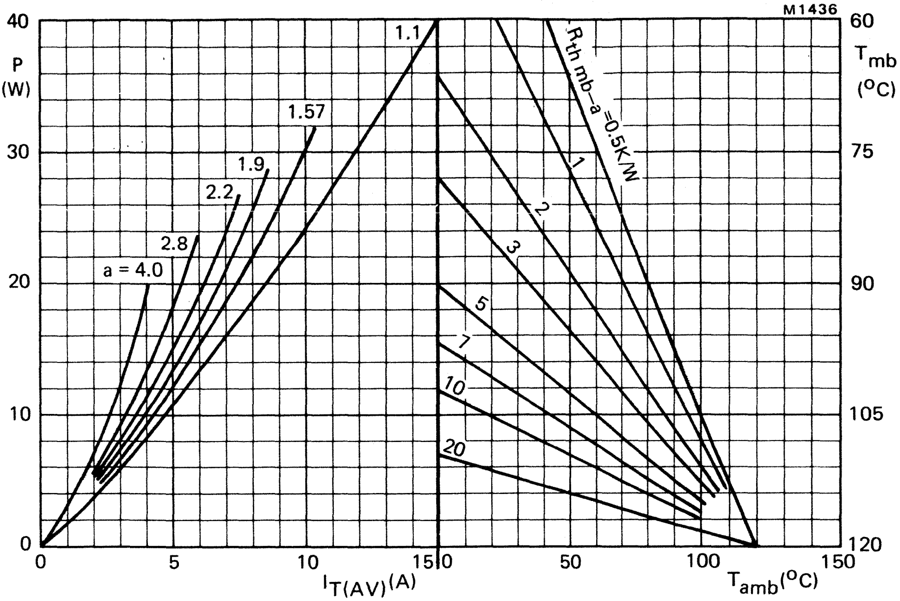


Fig. 5 The right hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

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

P = power excluding switching losses.

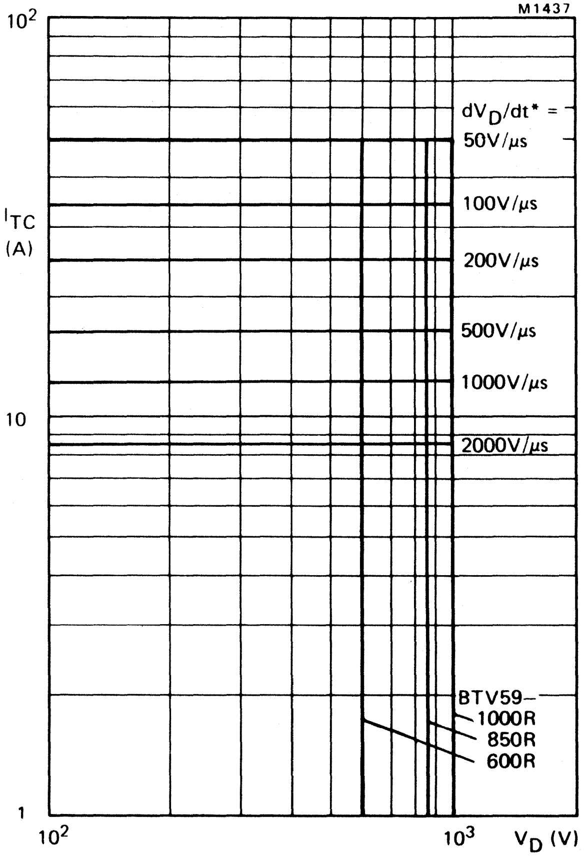


Fig. 6 Anode current which can be turned off versus anode voltage; inductive load; V_{GR} = 10 V; $L_G \leqslant 0.5$ µH; $L_S \leqslant 0.25$ µH; T_j = 85 °C.
$^*dV_D/dt$ is calculated from I_T/C_S.

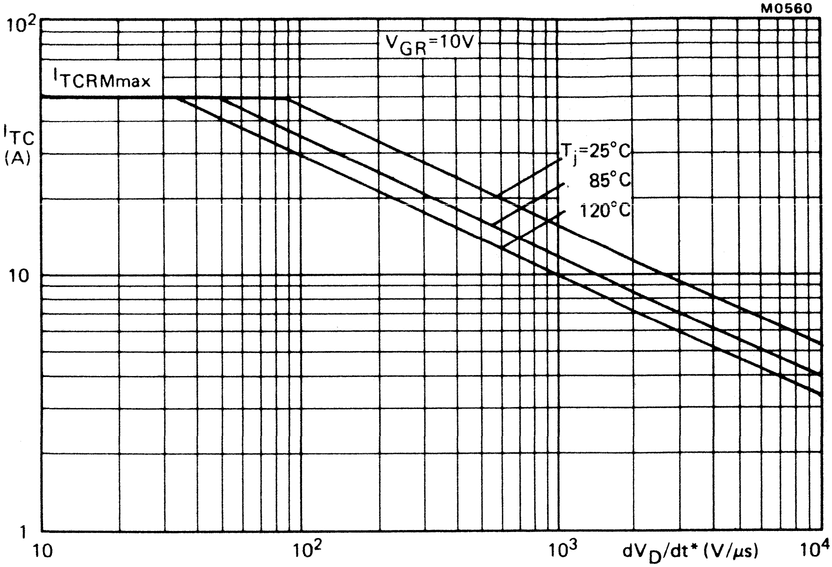


Fig.7 Anode current which can be turned off versus applied dV_D/dt^*; inductive load; V_{GR} = 10 V; $L_G \leqslant 0.5$ μH; $L_S \leqslant 0.25$ μH. $^*dV_D/dt$ is calculated from I_T/C_S.

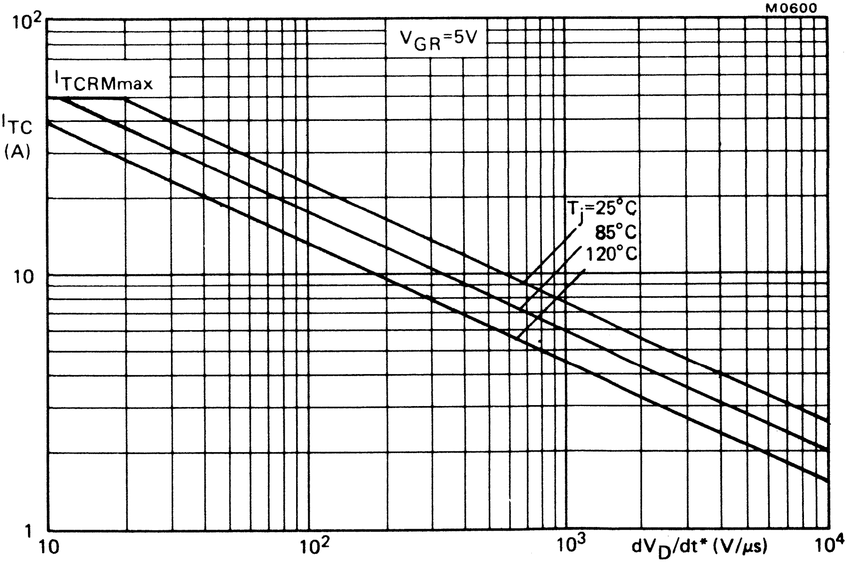


Fig.8 Anode current which can be turned off versus applied dV_D/dt^*; inductive load; V_{GR} = 5 V; $L_G \leqslant 0.5$ μH; $L_S \leqslant 0.25$ μH. $^*dV_D/dt$ is calculated from I_T/C_S.

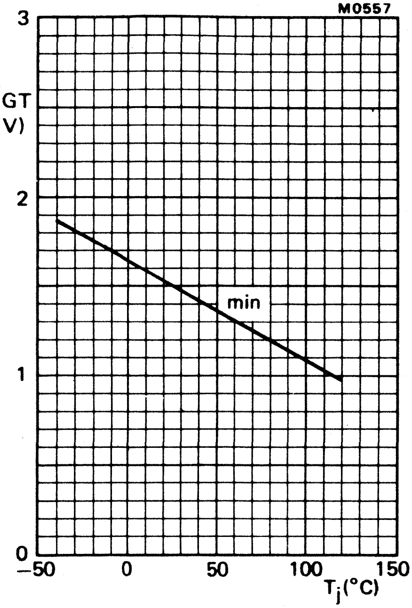


Fig.9 Minimum gate voltage that will trigger all devices as a function of junction temperature; V_D = 12 V.

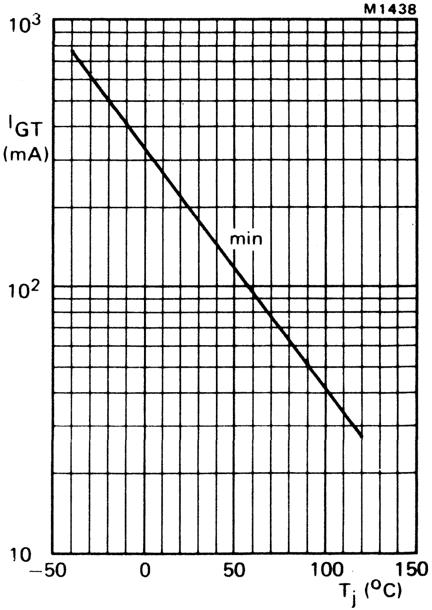


Fig.10 Minimum gate current that will trigger all devices as a function of junction temperature; V_D = 12 V.

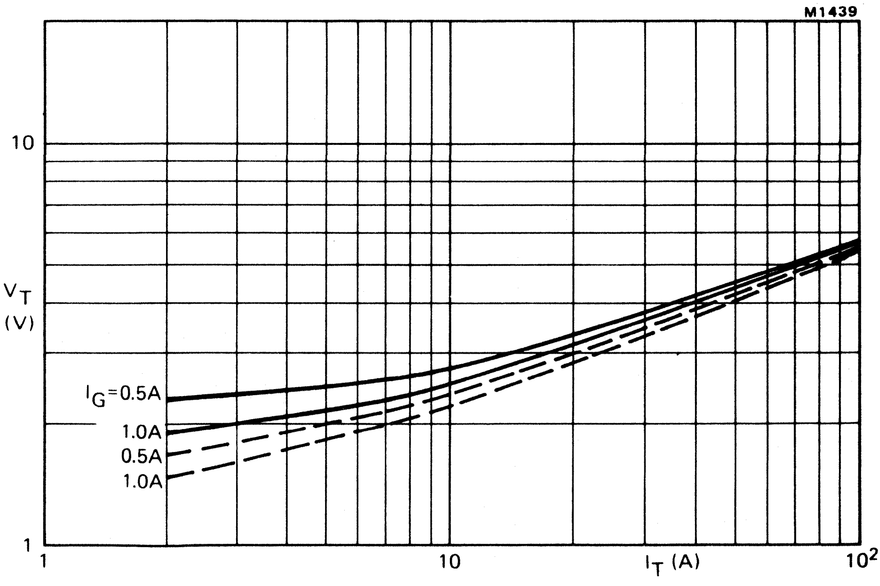


Fig.11 Maximum V_T versus I_T; —— T_j = 25 °C; – – – – T_j = 120 °C.

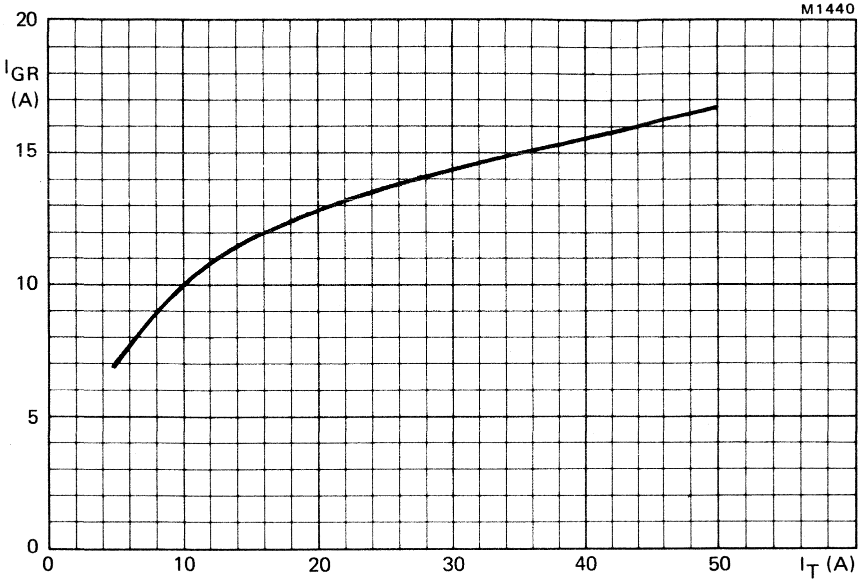


Fig. 12 Peak reverse gate current versus anode current at turn-off; inductive load; V_{GR} = 10 V; I_G = 0.5 A; L_G = 0.4 μH; T_j = 120 °C; maximum values.

←

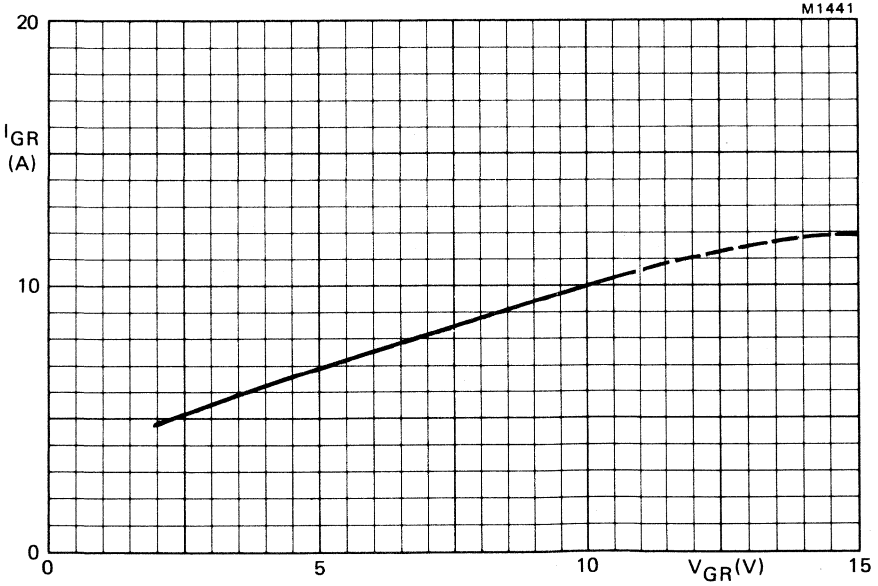


Fig. 13 Peak reverse gate current versus applied reverse gate voltage; inductive load; I_T = 10 A; I_G = 0.5 A; L_G = 0.4 μH; T_j = 120 °C; maximum values.

←

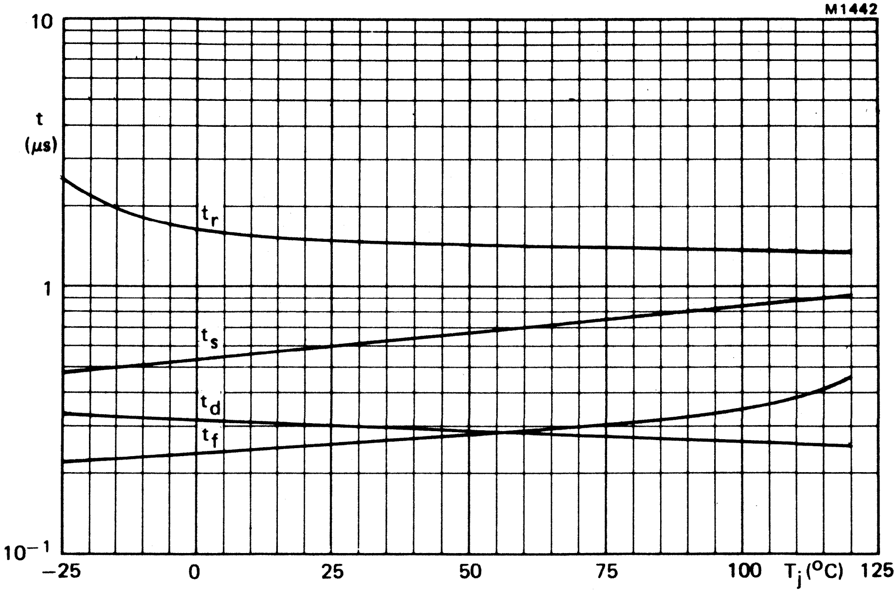


Fig. 14 Switching times as a function of junction temperature; $V_D \geqslant 250$ V; $I_T = 10$ A; $I_{GF} = 1.0$ A; $V_{GR} = 10$ V; $I_G = 0.5$ A; $L_G = 0.4$ μH; maximum values.

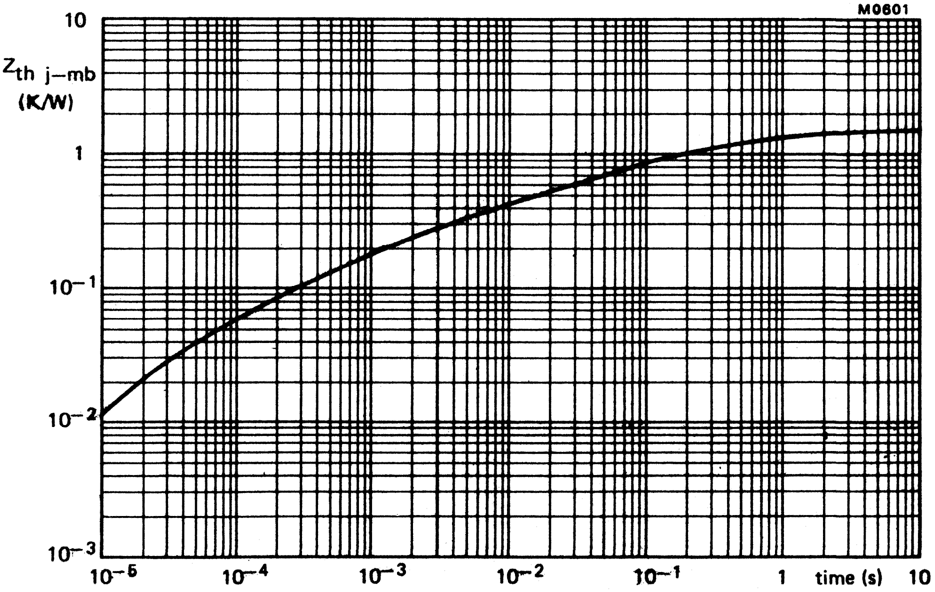


Fig. 15 Transient thermal impedance.

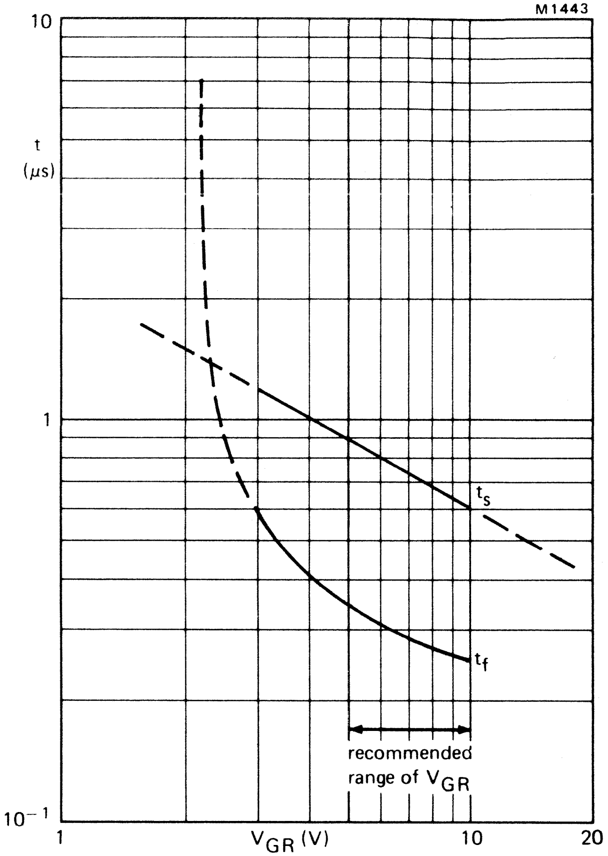


Fig.16 Storage and fall times versus applied reverse gate voltage; inductive load; I_T = 10 A; I_G = 0.5 A; L_G = 0.4 μH; T_j = 25 °C; maximum values.

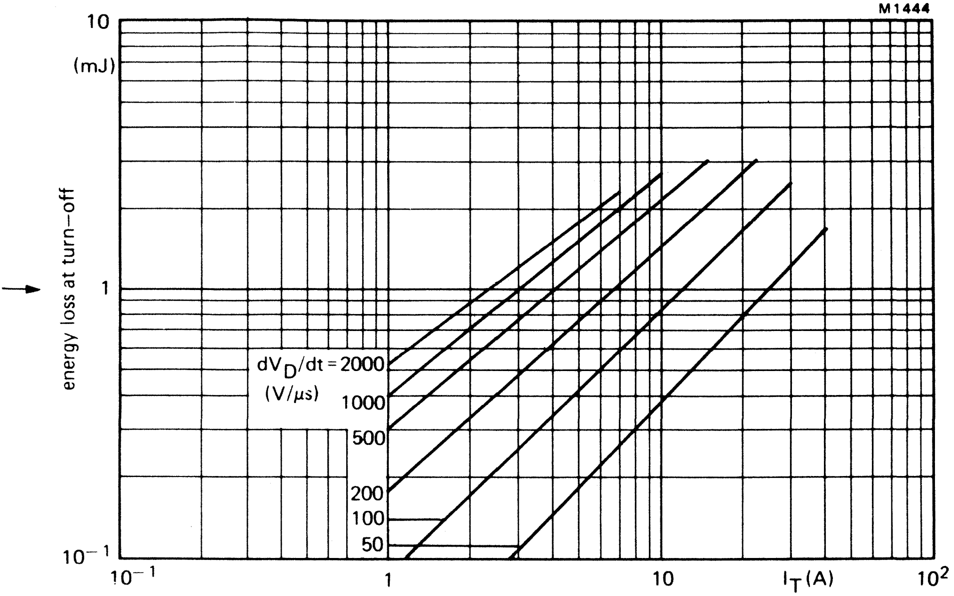


Fig. 17 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied dV_D/dt (calculated from I_T/C_S); dV_D/dt linear up to V_{Dmax} = 600 V; V_{GR} = 10 V; I_G = 0.5 A; $L_G \leqslant 0.5$ μH; $L_S \leqslant 0.25$ μH; T_j = 120 °C.

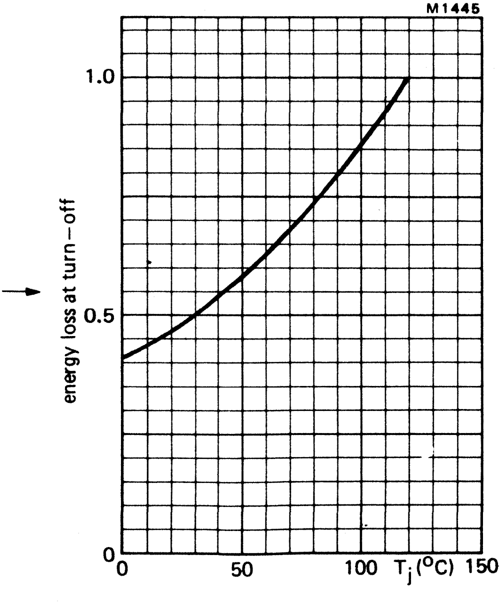


Fig. 18 Energy loss at turn off as a function of junction temperature; I_G = 0.5 A; V_{GR} = 10 V. Normalised to T_j = 120 °C.

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.

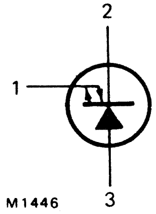
QUICK REFERENCE DATA

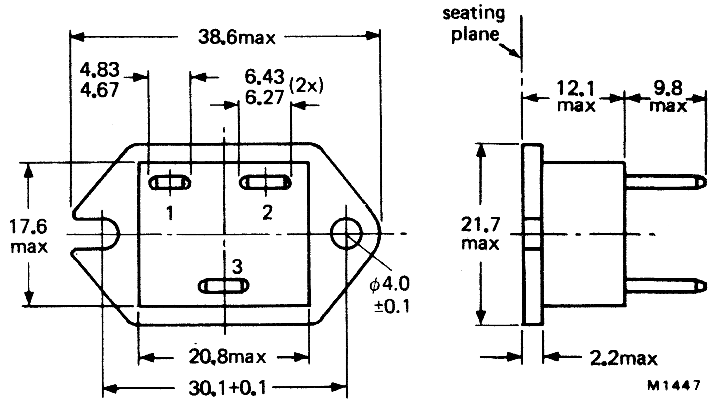
			BTV60–850R	1000R	1200R	
Repetitive peak off-state voltage	V_{DRM}	max.	850	1000	1200	V
Non-repetitive peak on-state current	I_{TSM}	max.		150		A
Controllable anode current	I_{TCRM}	max.		120		A
Average on-state current	$I_{T(AV)}$	max.		25		A
Fall time	t_f	<		300		ns

MECHANICAL DATA

Dimensions in mm

Fig.1 TO-238AA





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

RATINGS

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

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

Average on-state current (averaged over any 20 ms period) up to T_{mb} = 70 °C	$I_{T(AV)}$	max.	25	A
Controllable anode current	I_{TCRM}	max.	120	A
Non-repetitive peak on-state current t = 10 ms; half-sinewave; T_j = 120 °C prior to surge	I_{TSM}	max.	150	A
I^2t for fusing; t = 10 ms	I^2t	max.	112	A^2s
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	120	W
Gate to cathode				
Repetitive peak on-state current T_j = 120 °C prior to surge				
gate-cathode forward; t = 10 ms; half-sinewave	I_{GFM}	max.	35	A
gate-cathode reverse; t = 20 µs	I_{GRM}	max.	50	A
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	10	W
Temperatures				
Storage temperature	T_{stg}		–40 to +150	°C
Operating junction temperature	T_j	max.	120	°C

ISOLATION**

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

THERMAL RESISTANCE

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

* Measured with gate-cathode connected together.

** From baseplate to all terminals strapped together.

CHARACTERISTICS

Anode to cathode

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

Gate to cathode

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

Switching characteristics (resistive load)

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

delay time	t_d	<	0.5	μs
rise time	t_r	<	2.0	μs

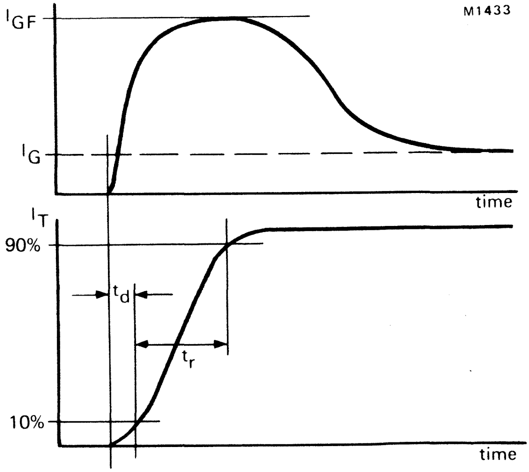


Fig.2 Waveforms.

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*Measured under pulse conditions to avoid excessive dissipation.

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

Switching characteristics (inductive load)

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

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

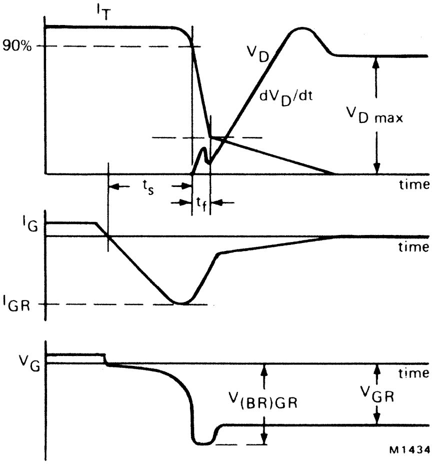


Fig.3 Waveforms.

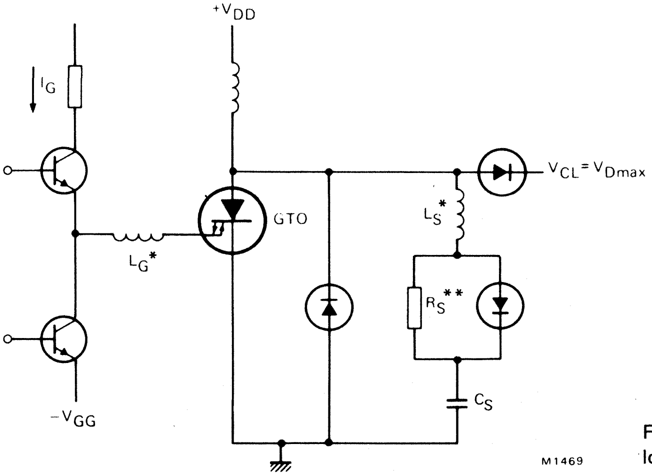


Fig.4 Inductive load test circuit.

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

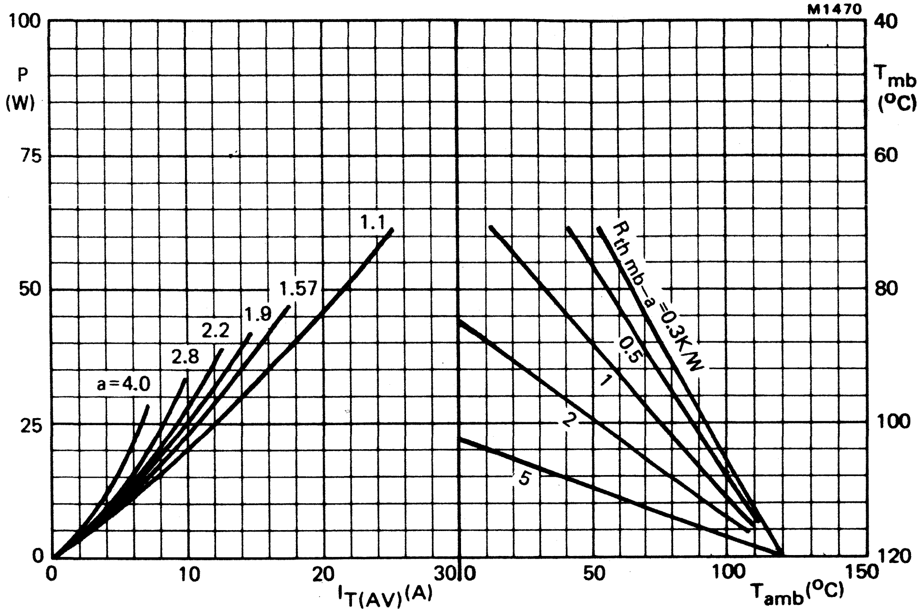


Fig.5 The right hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

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

P = power excluding switching losses.

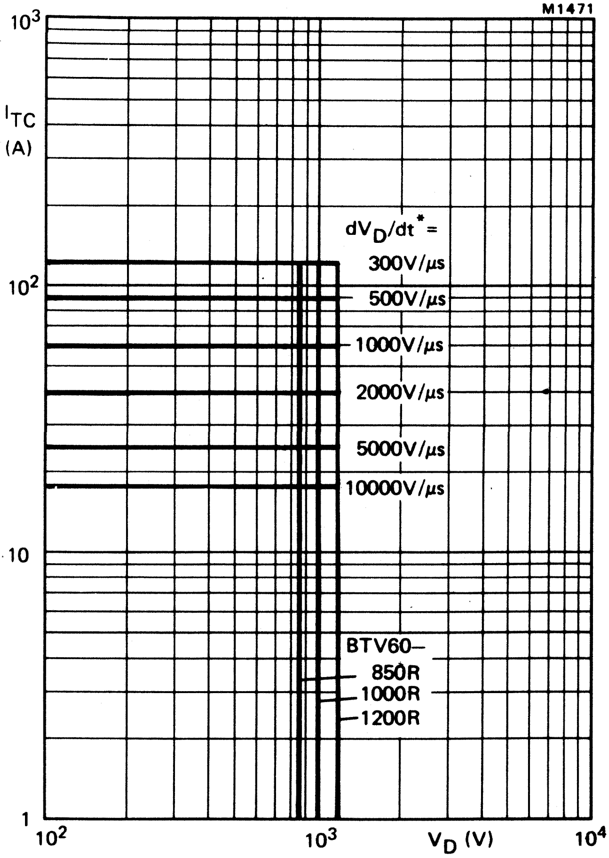


Fig.6 Anode current which can be turned off versus anode voltage; inductive load; V_{GR} = 10 V; $L_G \leqslant 0.5\ \mu H$; $L_S \leqslant 0.25\ \mu H$; T_j = 120 °C.
*dV_D/dt is calculated from I_T/C_S.

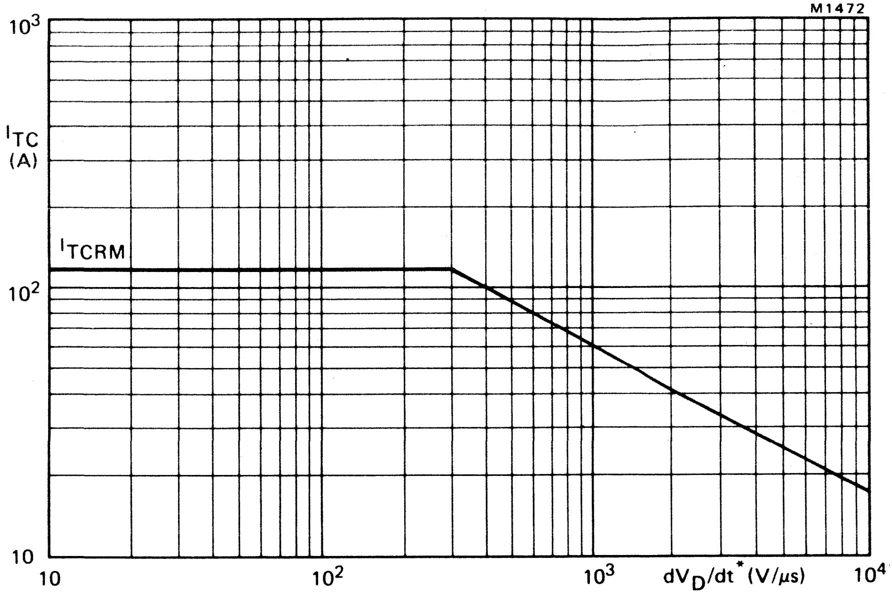


Fig.7 Anode current which can be turned off versus applied dV_D/dt^*; inductive load; V_{GR} = 10 V; $L_G \leqslant 0.5$ μH; $L_S \leqslant 0.25$ μH; T_j = 120 °C. *dV_D/dt is calculated from I_T/C_S.

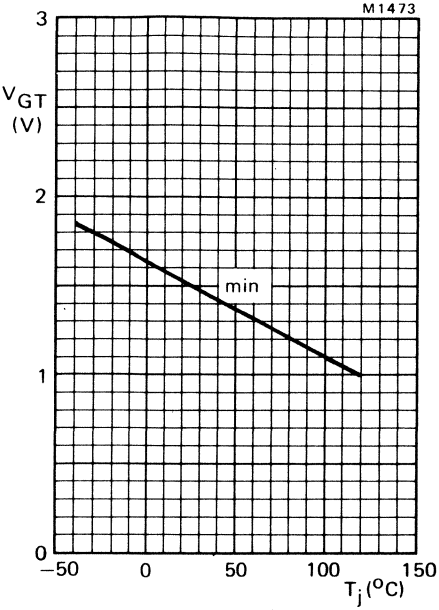


Fig.8 Minimum gate voltage that will trigger all devices as a function of junction temperature; V_D = 12 V.

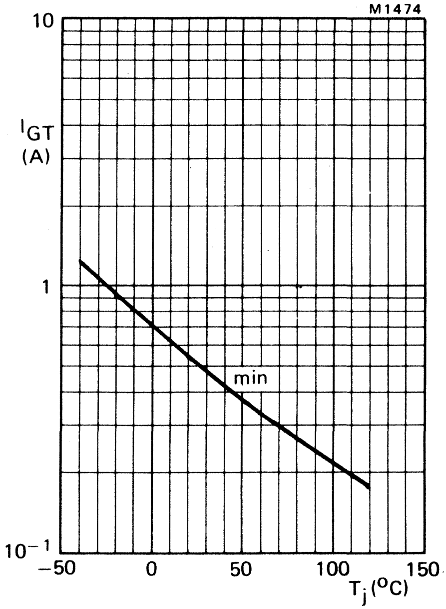


Fig.9 Minimum gate current that will trigger all devices as a function of junction temperature; V_D = 12 V.

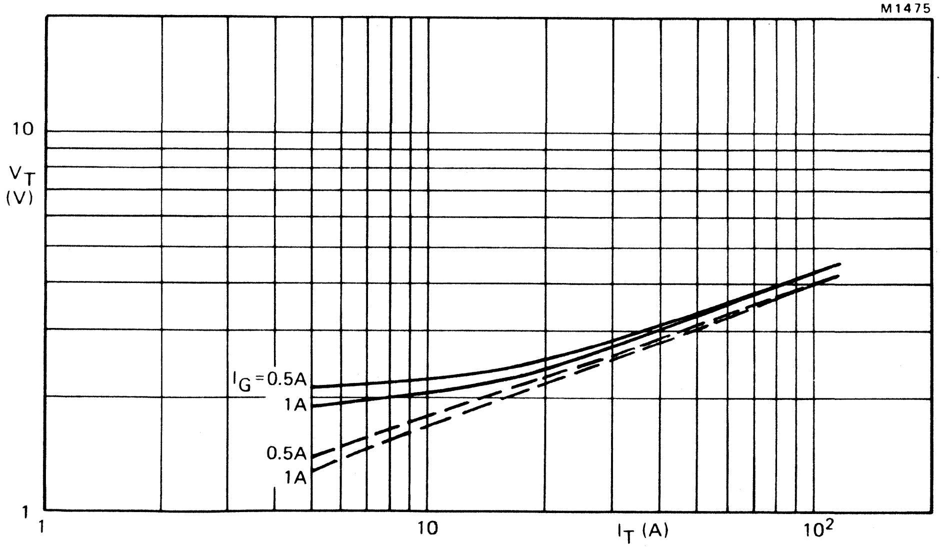


Fig.10 Maximum V_T versus I_T; —— T_j = 25 °C; – – – – T_j = 120 °C.

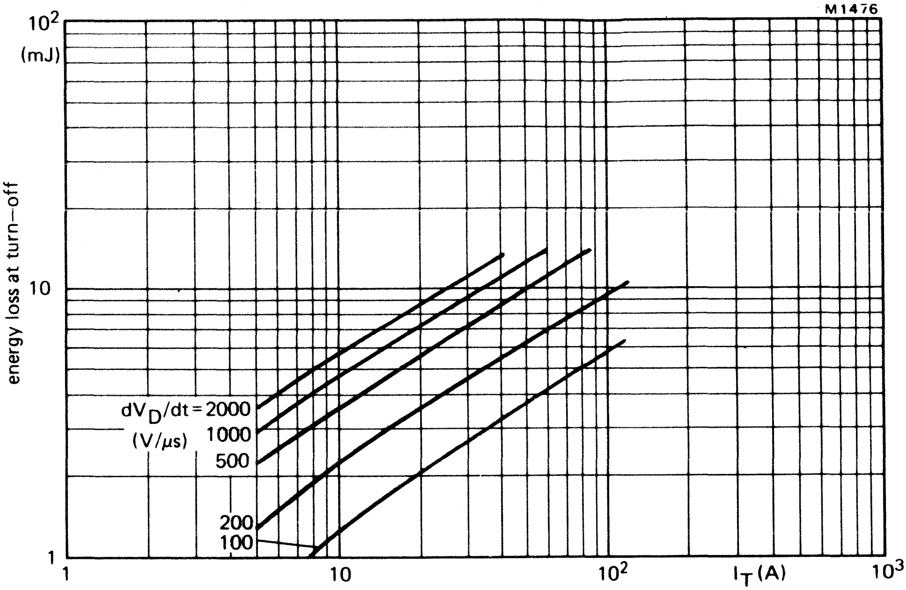


Fig.11 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied dV_D/dt (calculated from I_T/C_S); dV_D/dt linear up to V_{Dmax} = 600 V; V_{GR} = 10 V; I_G = 0.5 A; $L_G \leqslant 0.5\ \mu H$; $L_S \leqslant 0.25\ \mu H$; T_j = 120 °C.

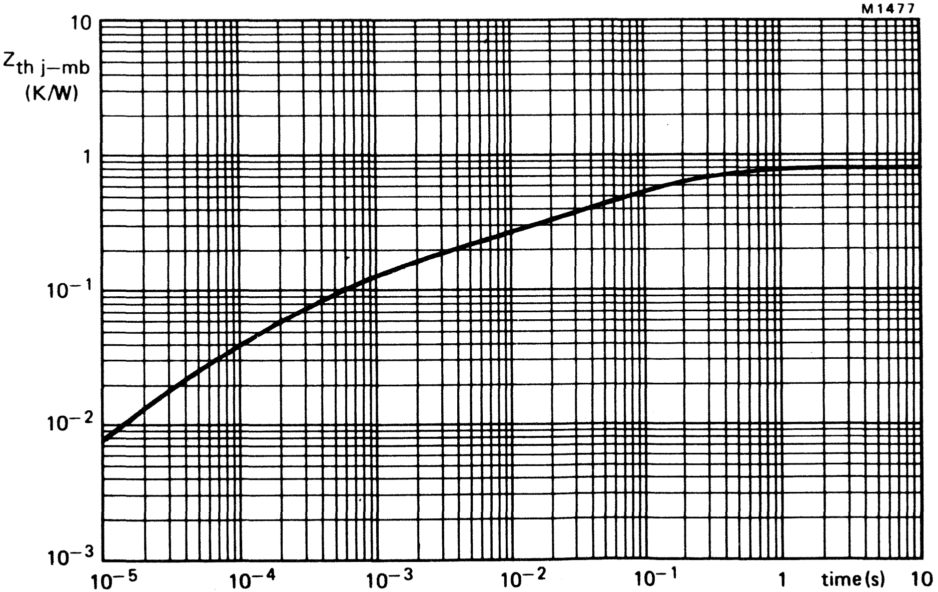


Fig.12 Transient thermal impedance.

FAST GATE TURN-OFF THYRISTORS

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

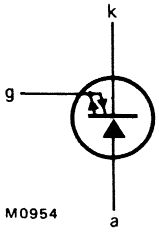
QUICK REFERENCE DATA

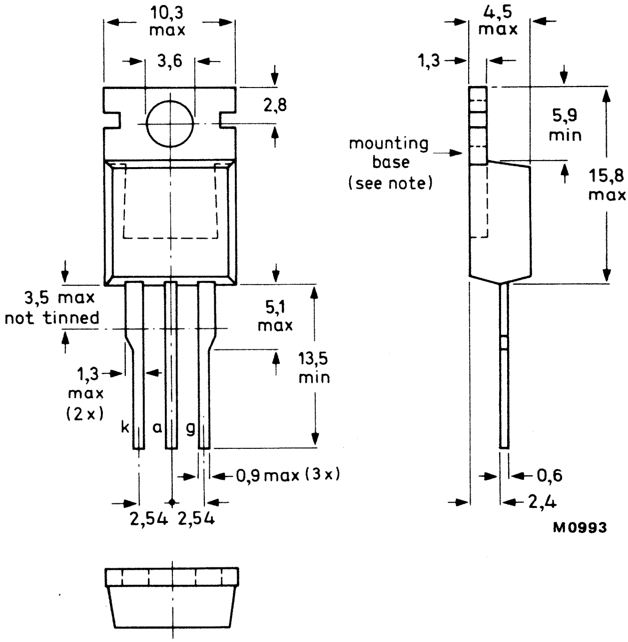
			BTW58–1000R	1300R	1500R	
Repetitive peak off-state voltage	V_{DRM}	max.	1000	1300	1500	V
Non-repetitive peak on-state current	I_{TSM}	max.		50		A ←
Controllable anode current	I_{TCRM}	max.		25		A
Average on-state current	$I_{T(AV)}$	max.		6.5		A
Fall time	t_f	<		250		ns

MECHANICAL DATA

Dimensions in mm

Fig.1 TO-220AB





Net mass: 2 g

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

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

RATINGS

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

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

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

Gate to cathode

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

Temperatures

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

THERMAL RESISTANCE

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

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*Measured with gate-cathode connected together.

CHARACTERISTICS

Anode to cathode

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

Gate to cathode

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

Switching characteristics (resistive load)

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

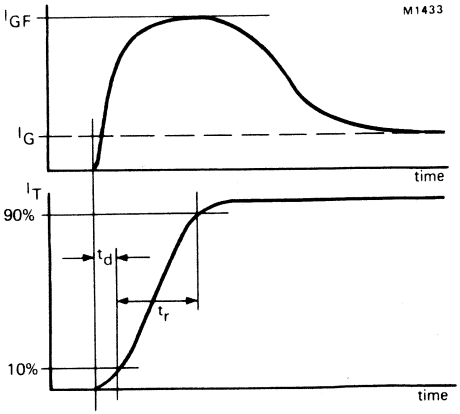

Fig.2 Waveforms

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* Measured under pulse conditions to avoid excessive dissipation.

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

→ Switching characteristics (inductive load)

Turn-off when switched from $I_T = 5$ A to $V_D = V_{DRMmax}$.

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

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

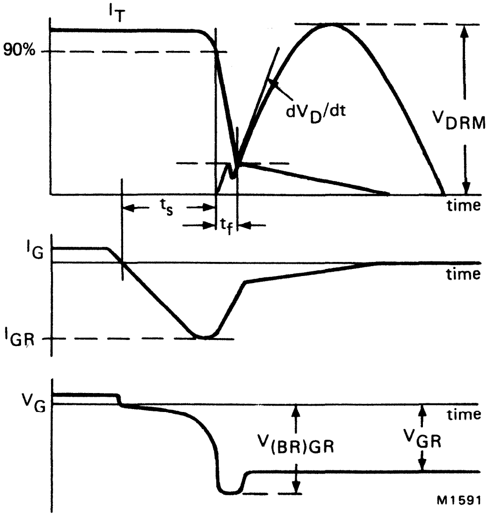


Fig.3 Waveforms.

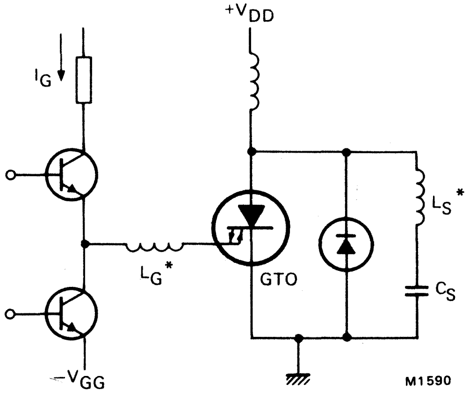


Fig.4 Inductive load test circuit

*Indicates stray series inductance only.

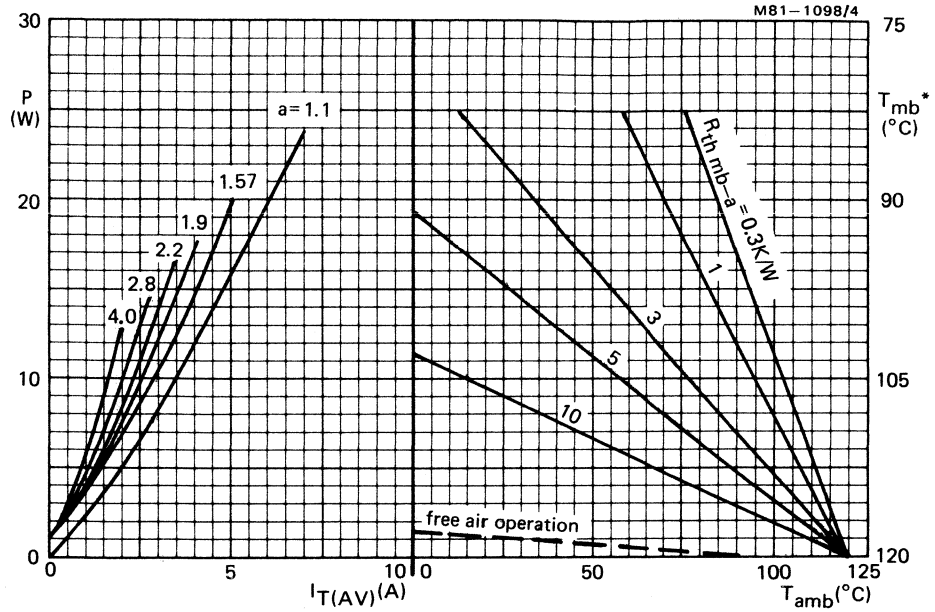
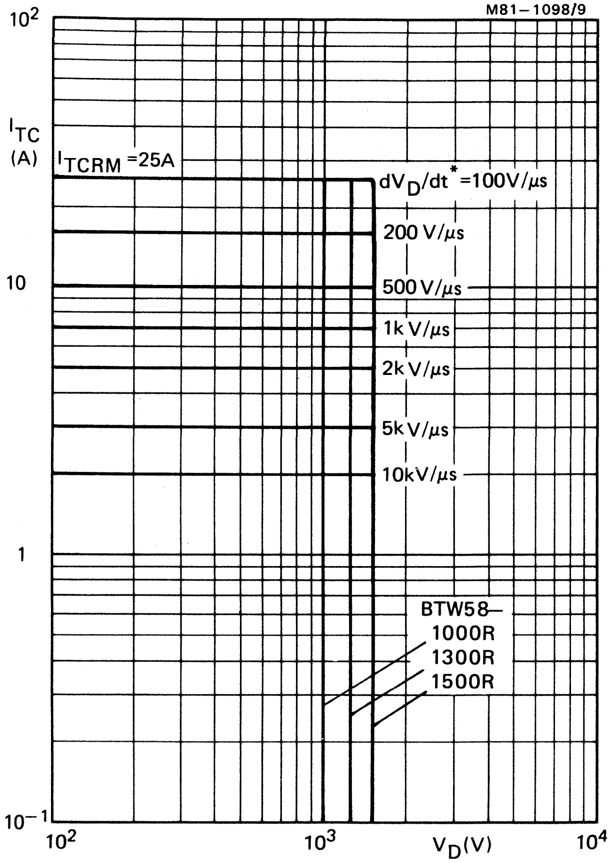


Fig.5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

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

P = power excluding switching losses.

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



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

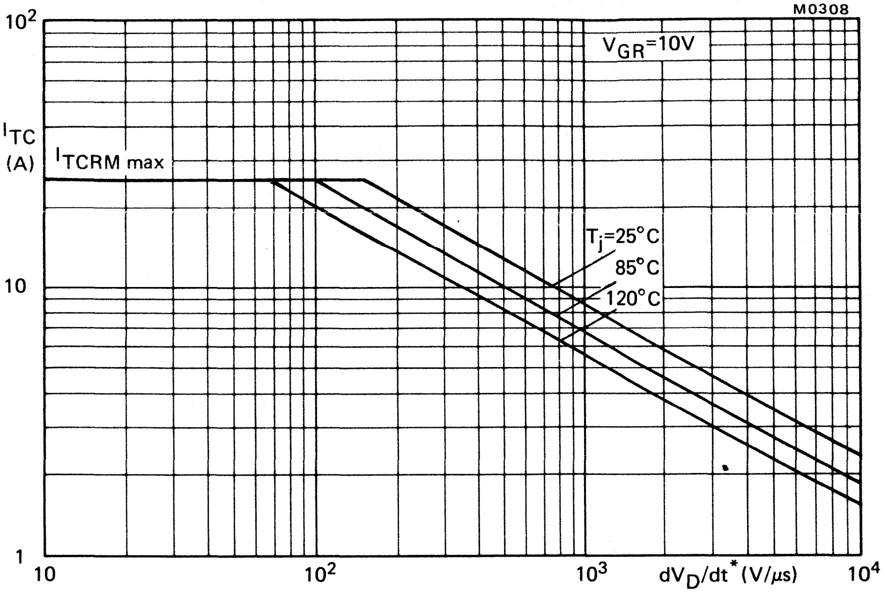


Fig.7 Anode current which can be turned off versus applied dV_D/dt^*; inductive load; V_{GR} = 10 V; $L_G \leqslant 1.0$ µH; $L_S \leqslant 0.25$ µH. *dV_D/dt is calculated from I_T/C_S.

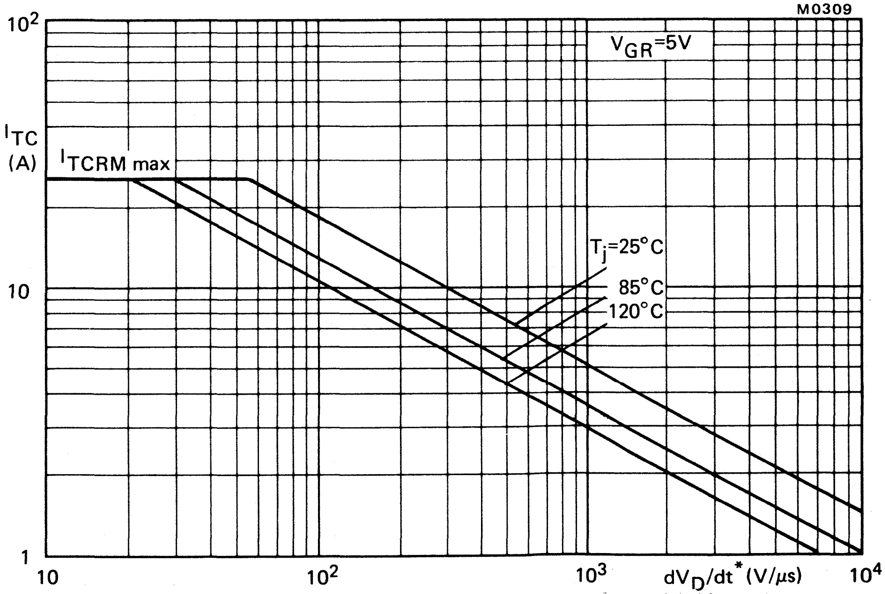


Fig.8 Anode current which can be turned off versus applied dV_D/dt^*; inductive load; V_{GR} = 5 V; $L_G \leqslant 1.0$ µH; $L_S \leqslant 0.25$ µH. *dV_D/dt is calculated from I_T/C_S.

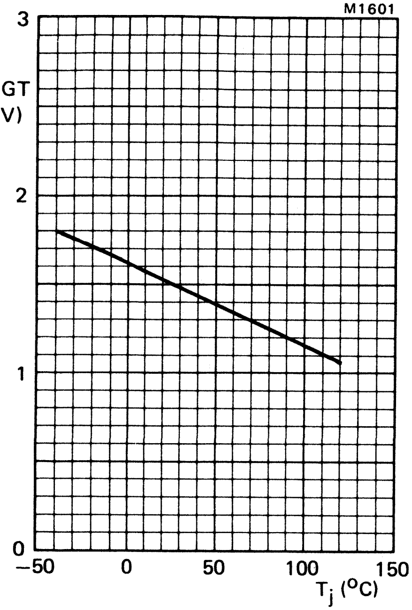


Fig.9 Minimum gate voltage that will trigger all devices as a function of junction temperature; V_D = 12 V.

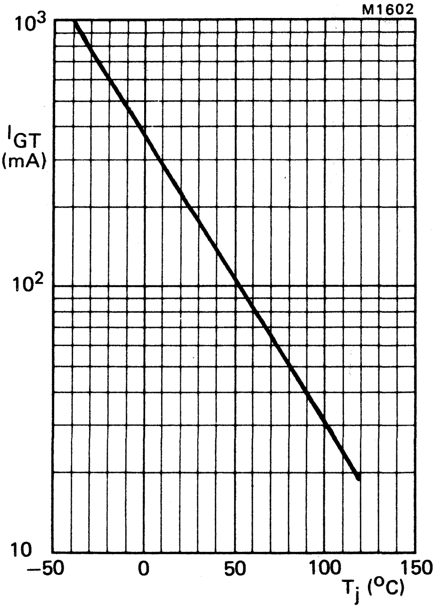


Fig.10 Minimum gate current that will trigger all devices as a function of junction temperature; V_D = 12 V.

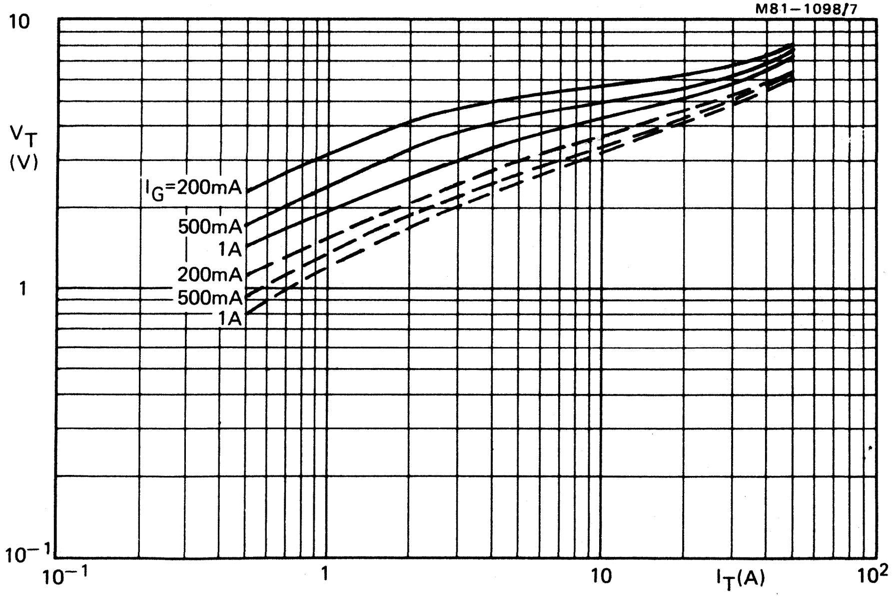


Fig.11 Maximum V_T versus I_T; —— T_j = 25 °C; – – – –T_j = 120 °C.

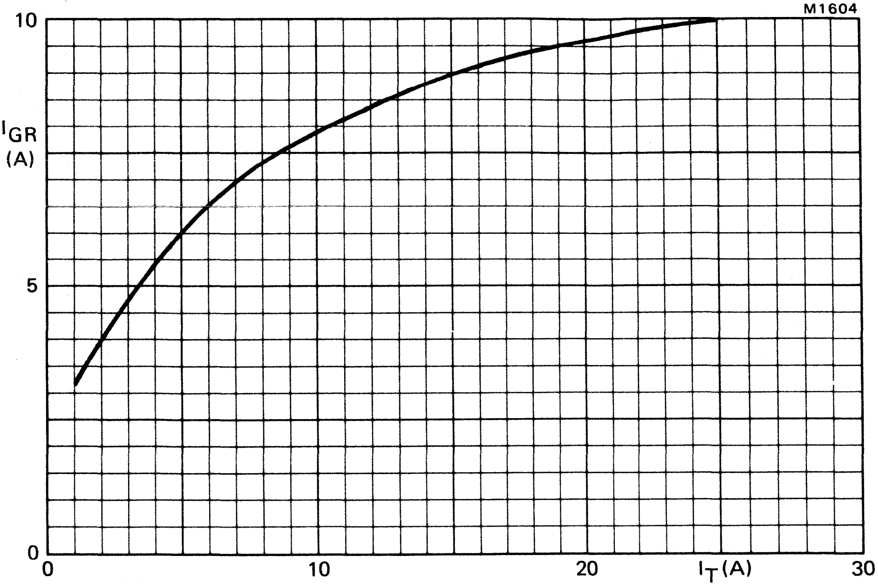


Fig.12 Peak reverse gate current versus anode current at turn-off; inductive load; V_{GR} = 10 V; I_G = 0.2 A; L_G = 0.8 μH; T_j = 120 °C; maximum values.

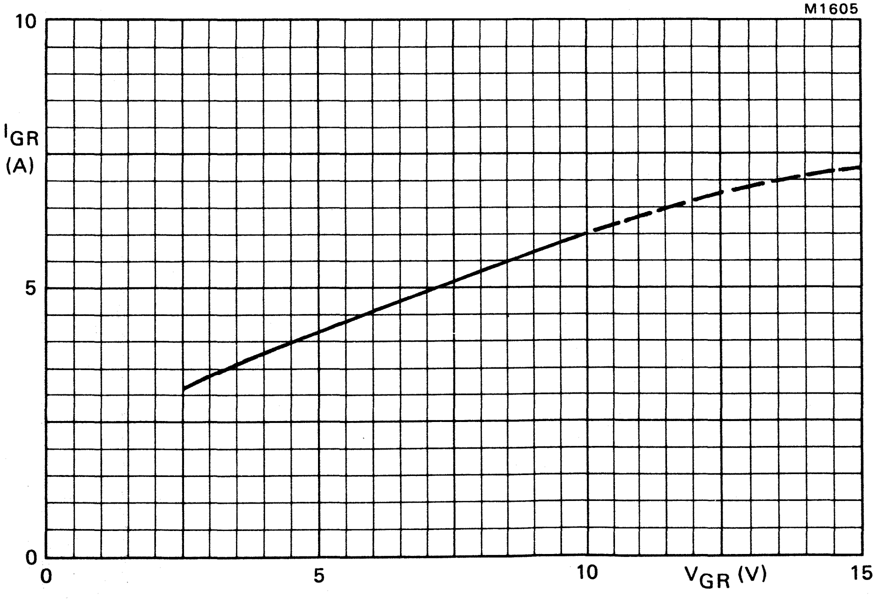


Fig.13 Peak reverse gate current versus applied reverse gate voltage; inductive load; I_T = 5 A; I_G = 0.2 A; L_G = 0.8 μH; T_j = 120 °C; maximum values.

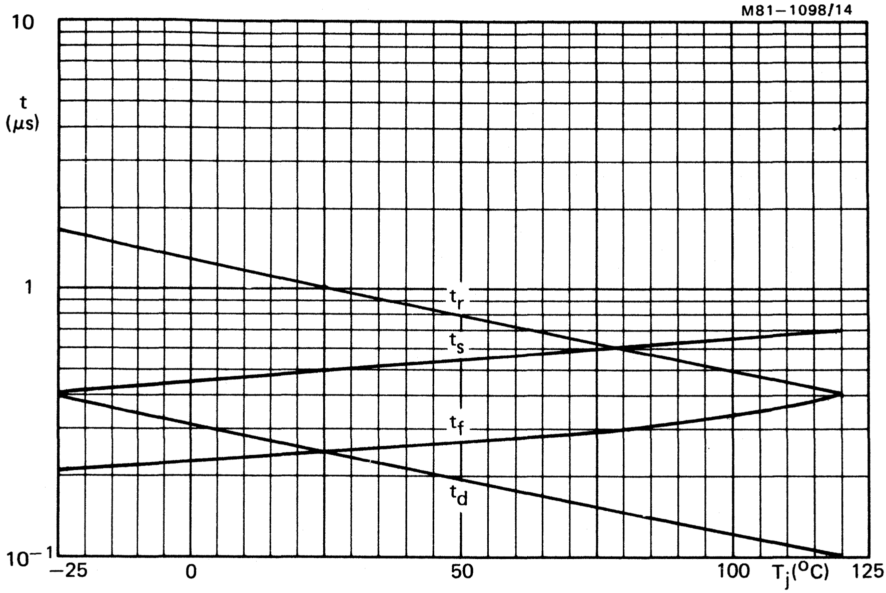


Fig.14 Switching times as a function of junction temperature; $V_D \geq 250$ V; $I_T = 5$ A; $I_{GF} = 0.5$ A; $V_{GR} = 10$ V; $I_G = 0.2$ A; $L_G = 0.8$ μH; maximum values.

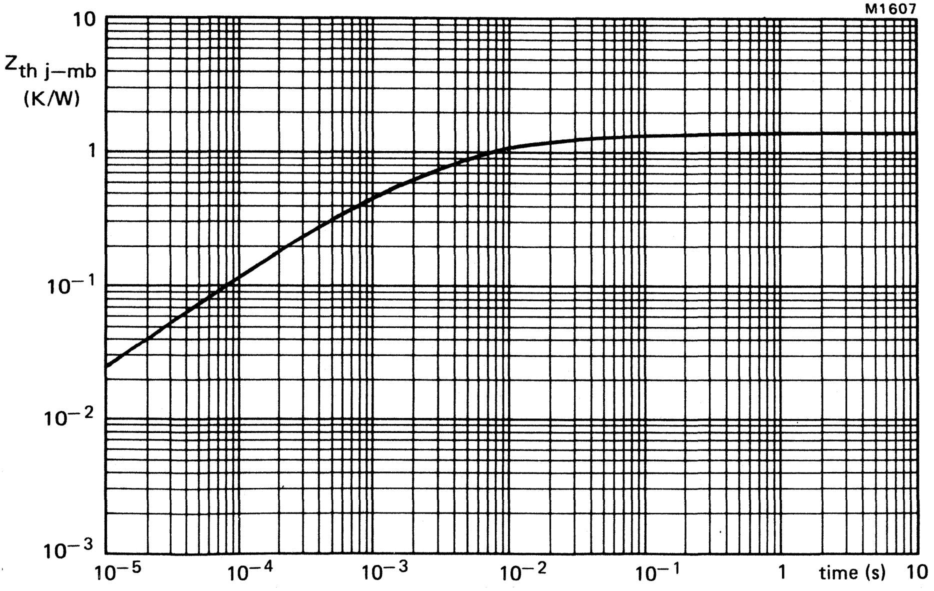


Fig.15 Transient thermal impedance.

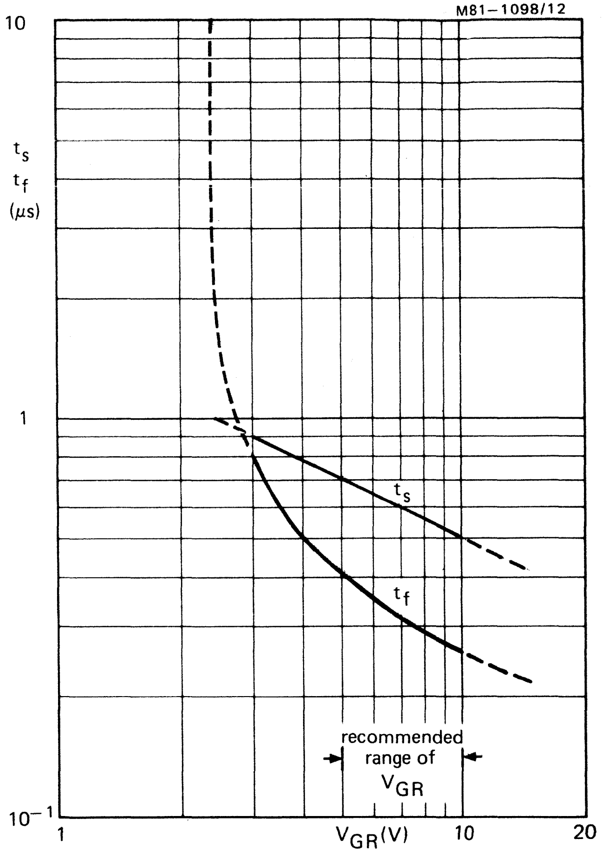


Fig.16 Storage and fall times versus applied reverse gate voltage; inductive load; I_T = 5 A; I_G = 0.2 A; L_G = 0.8 μH; T_j = 25 °C; maximum values.

←

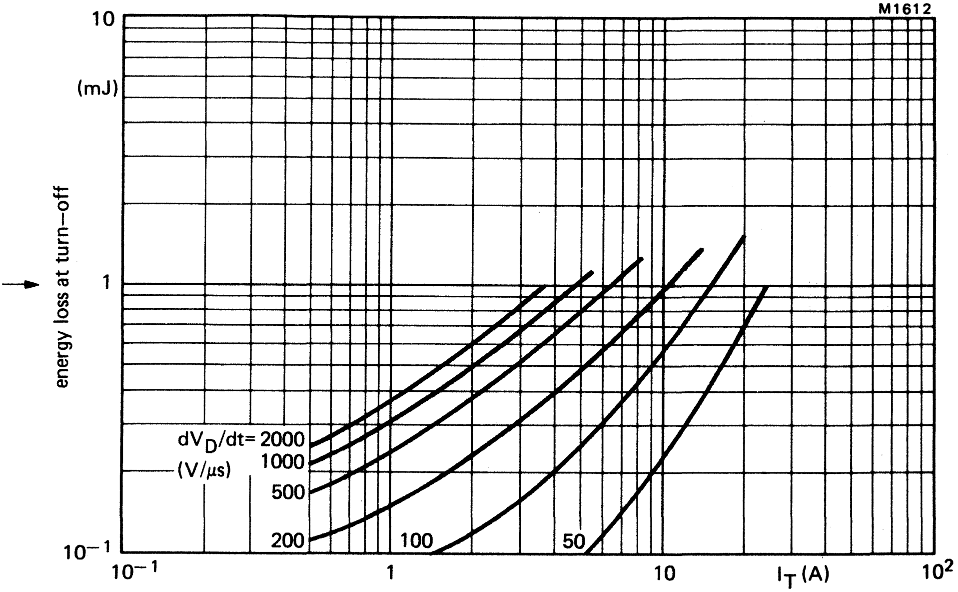


Fig.17 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied dV_D/dt (calculated from I_T/C_S); reapplied voltage sinsusoidal up to V_{DRM} = 1200 V; V_{GR} = 10 V; I_G = 0.2 A; $L_G \leqslant 1.0\ \mu H$; $L_S \leqslant 0.25\ \mu H$; T_j = 120 °C.

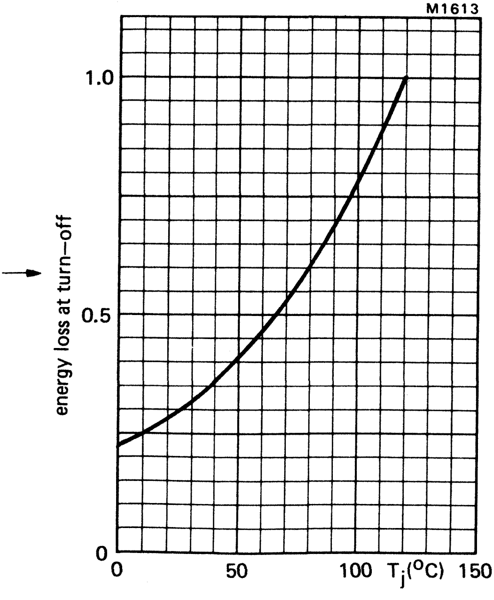


Fig.18 Energy loss at turn off as a function of junction temperature; I_G = 0.2 A; V_{GR} = 10 V. Normalised to T_j = 120 °C.

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, resonant 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.

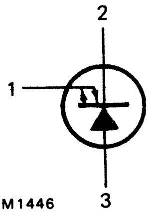
QUICK REFERENCE DATA

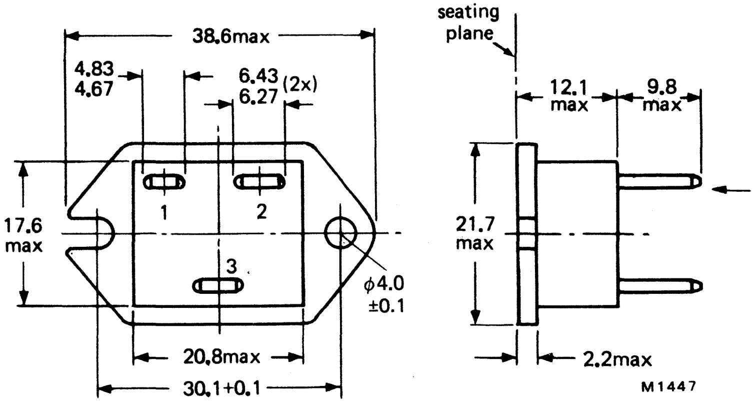
			BTW59 – 1300R	1500R	
Repetitive peak off-state voltage	V_{DRM}	max.	1300	1500	V
Non-repetitive peak on-state current	I_{TSM}	max.	100		A
Controllable anode current	I_{TCRM}	max.	50		A
Average on-state current	$I_{T(AV)}$	max.	13.5		A
Fall time	t_f	<	250		ns

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 (IEC 134).

Anode to cathode			BTW59 – 1300R	1500R	
Transient off-state voltage	V_{DSM}	max.	1500	1650	V*
Repetitive peak off-state voltage	V_{DRM}	max.	1300	1500	V*
Working off-state voltage	V_{DW}	max.	1200	1300	V*
Continuous off-state voltage	V_D	max.	750	800	V*
Average on-state current (averaged over any 20 ms period) up to T_{mb} = 40 °C	$I_{T(AV)}$	max.	13.5		A
Controllable anode current	I_{TCRM}	max.	50		A
Non-repetitive peak on-state current t = 10 ms; half-sinewave; T_j = 120 °C prior to surge	I_{TSM}	max.	100		A
I^2t for fusing; t = 10 ms	I^2t	max.	50		A^2s
Total power dissipation up to T_{mb} = 30 °C	P_{tot}	max.	60		W
Gate to cathode					
Repetitive peak on-state current T_j = 120 °C prior to surge gate-cathode forward; t = 10 ms; half-sinewave	I_{GFM}	max.	25		A
gate-cathode reverse; t = 20 µs	I_{GRM}	max.	25		A
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	5.0		W
Temperatures					
Storage temperature	T_{stg}		–40 to +150		°C
Operating junction temperature	T_j	max.	120		°C

ISOLATION**

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

THERMAL RESISTANCE

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

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* Measured with gate-cathode connected together.

** From baseplate to all terminals strapped together.

CHARACTERISTICS

Anode to cathode

On-state voltage				
$I_T = 10$ A; $I_G = 0.5$ A; $T_j = 120$ °C	V_T	$<$	3.3	V*
Rate of rise of off-state voltage that will not trigger any off-state device; exponential method				
$V_D = 2/3\ V_{Dmax}$; $V_{GR} = 5$ V; $T_j = 120$ °C	dV_D/dt	$<$	10	kV/μs
Rate of rise of off-state voltage that will not trigger any device following conduction, linear method				
$I_T = 10$ A; $V_D = V_{DRM\ max}$; $V_{GR} = 10$ V; $T_j = 120$ °C	dV_D/dt	$<$	1.0	kV/μs
Off-state current				
$V_D = V_{Dmax}$; $T_j = 120$ °C	I_D	$<$	5.0	mA
Latching current; $T_j = 25$ °C	I_L	typ.	2.5	A**

Gate to cathode

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

Switching characteristics (resistive load)

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

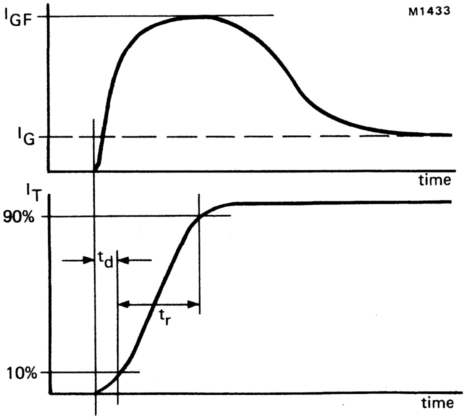

Fig.2 Waveforms.

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* Measured under pulse conditions to avoid excessive dissipation.

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

→ Switching characteristics (inductive load)

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

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

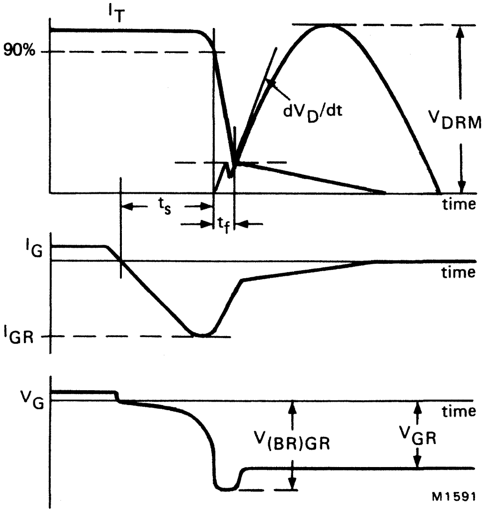


Fig.3 Waveforms.

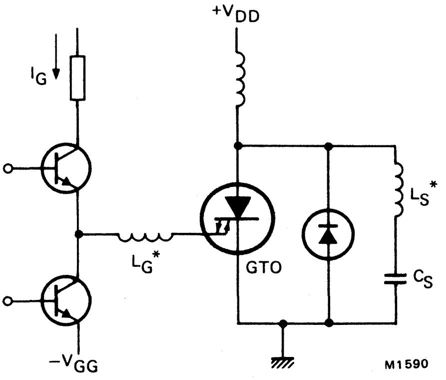


Fig.4 Inductive load test circuit.

*Indicates stray series inductance only.

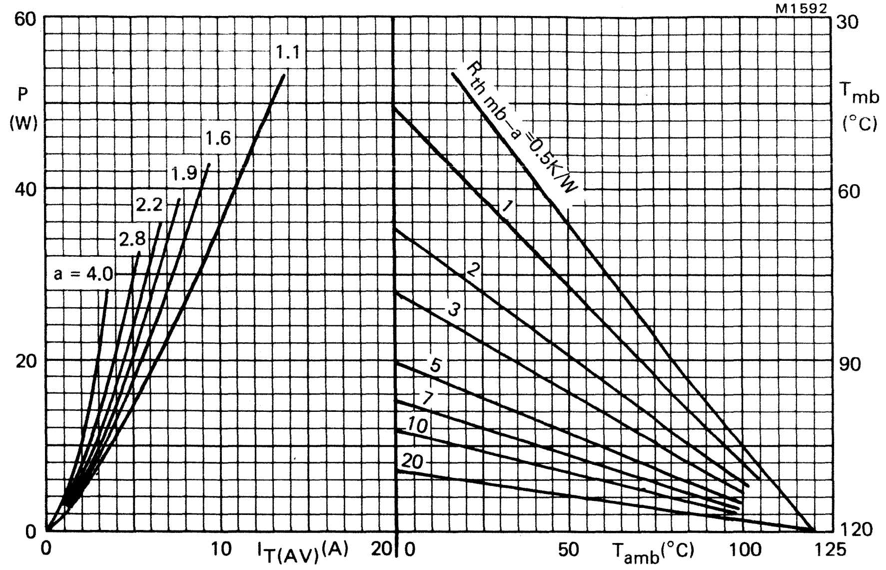


Fig.5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

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

P = Power excluding switching losses. ←

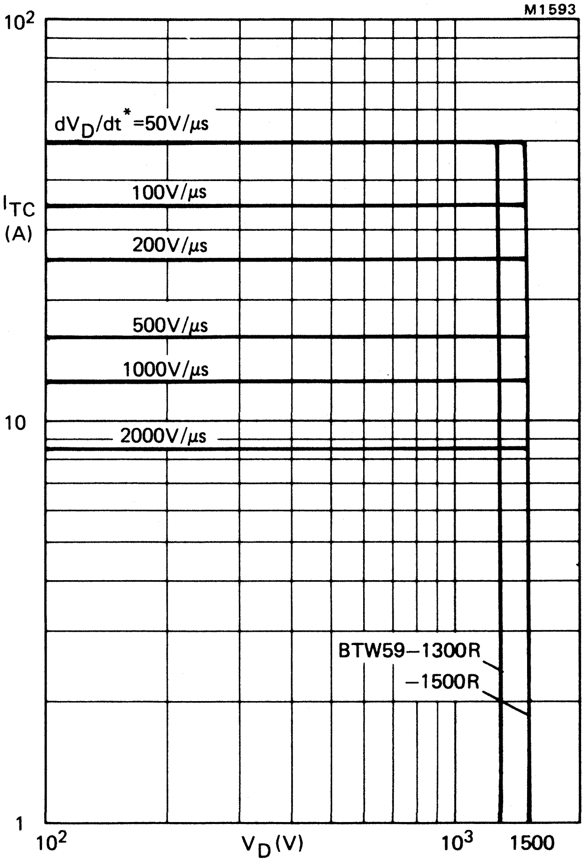


Fig.6 Anode current which can be turned off versus anode voltage; inductive load; V_{GR} = 10 V; $L_G \leqslant 0.5\ \mu H$; $L_S \leqslant 0.25\ \mu H$; T_j = 85 °C.
*dV_D/dt is calculated from I_T/C_S.

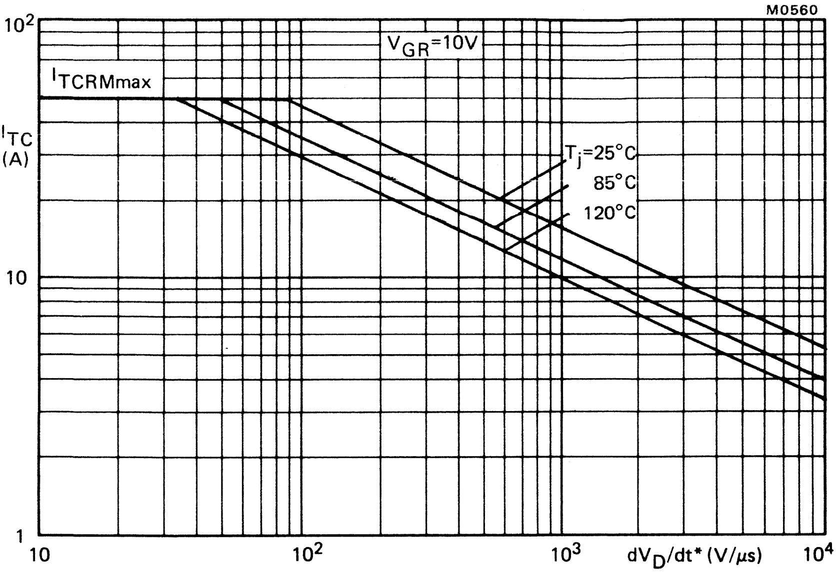


Fig.7 Anode current which can be turned off versus applied dV_D/dt^*; inductive load; V_{GR} = 10 V; $L_G \leqslant 0.5\ \mu H$; $L_S \leqslant 0.25\ \mu H$. $^*dV_D/dt$ is calculated from I_T/C_S.

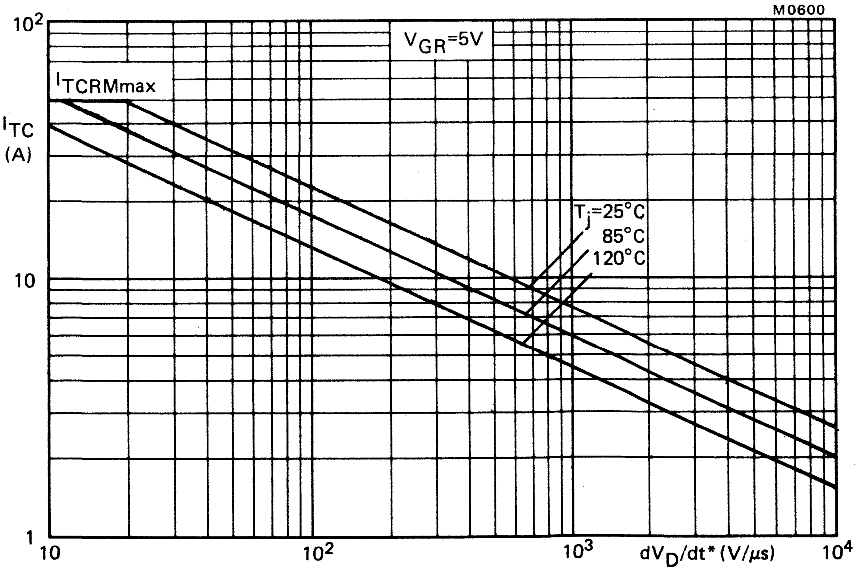


Fig.8 Anode current which can be turned off versus applied dV_D/dt^*; inductive load; V_{GR} = 5 V; $L_G \leqslant 0.5\ \mu H$; $L_S \leqslant 0.25\ \mu H$. $^*dV_D/dt$ is calculated from I_T/C_S.

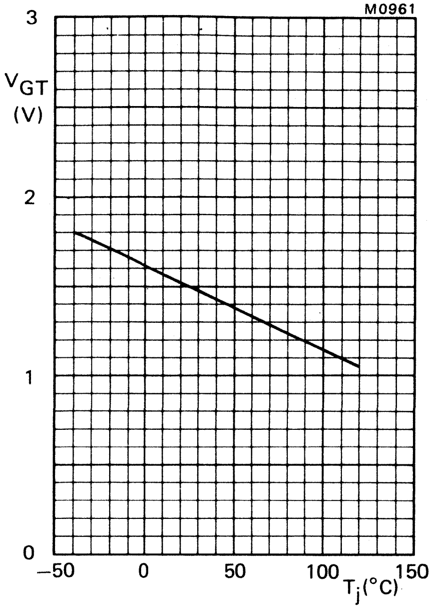


Fig.9 Minimum gate voltage that will trigger all devices as a function of junction temperature; V_D = 12 V.

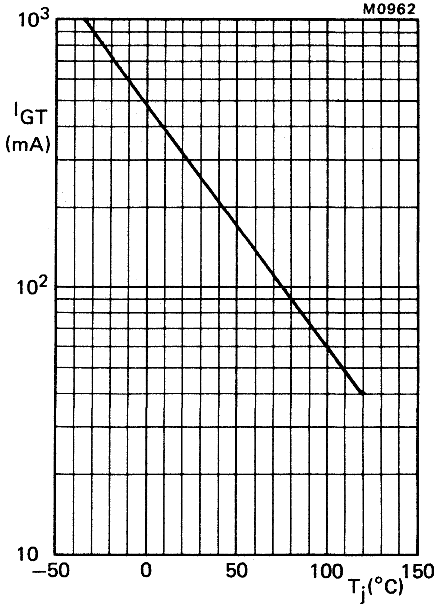


Fig.10 Minimum gate current that will trigger all devices as a function of junction temperature; V_D = 12 V.

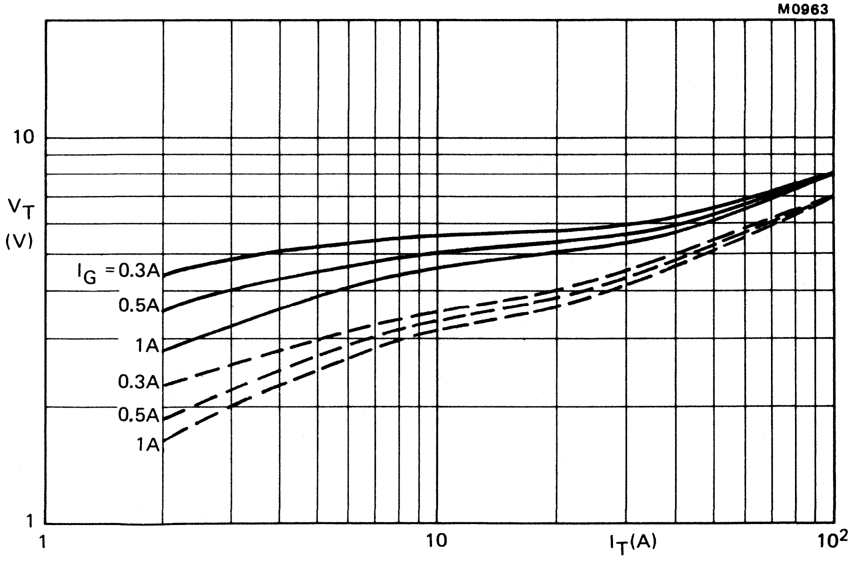


Fig.11 Maximum V_T versus I_T; —— T_j = 25 °C, – – – T_j = 120 °C.

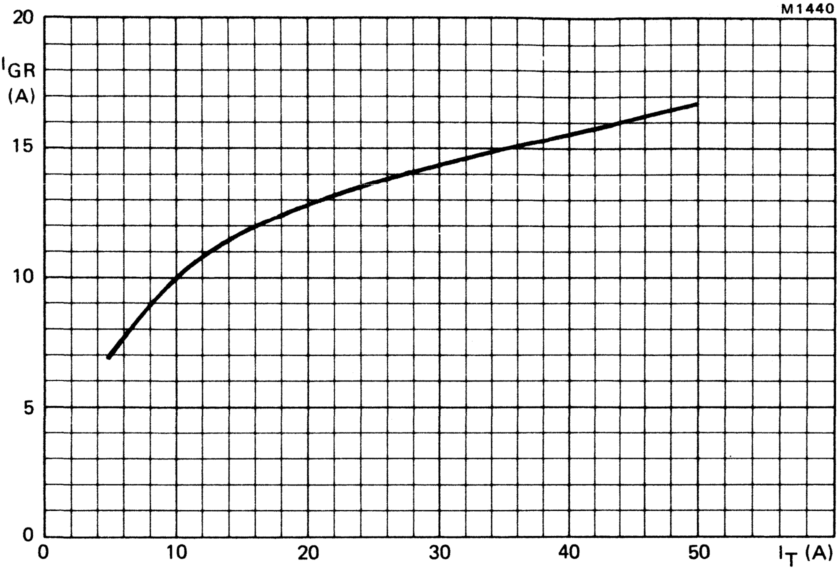


Fig.12 Peak reverse gate current versus anode current at turn-off; inductive load; V_{GR} = 10 V; I_G = 0.5 A; L_G = 0.4 μH; T_j = 120 °C; maximum values.

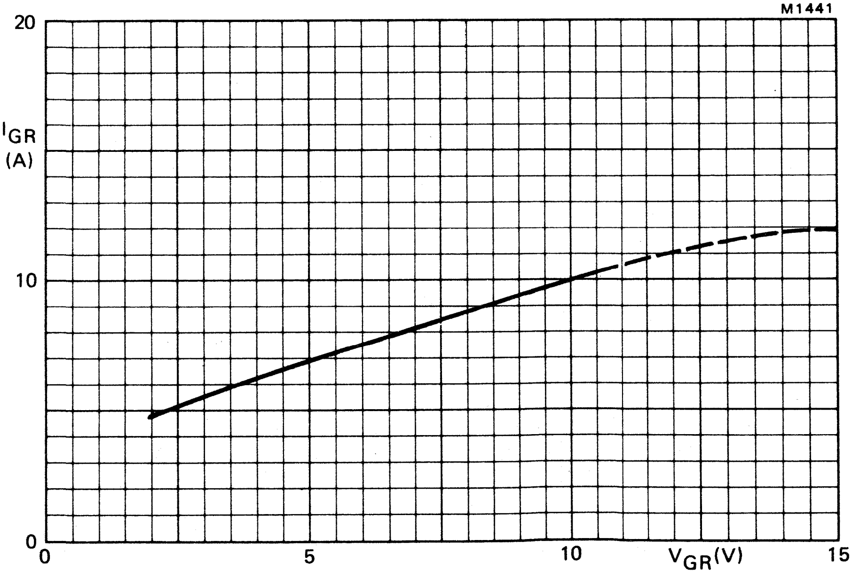


Fig.13 Peak reverse gate current versus applied reverse gate voltage; inductive load; I_T = 10 A; I_G = 0.5 A; L_G = 0.4 μH; T_j = 120 °C; maximum values.

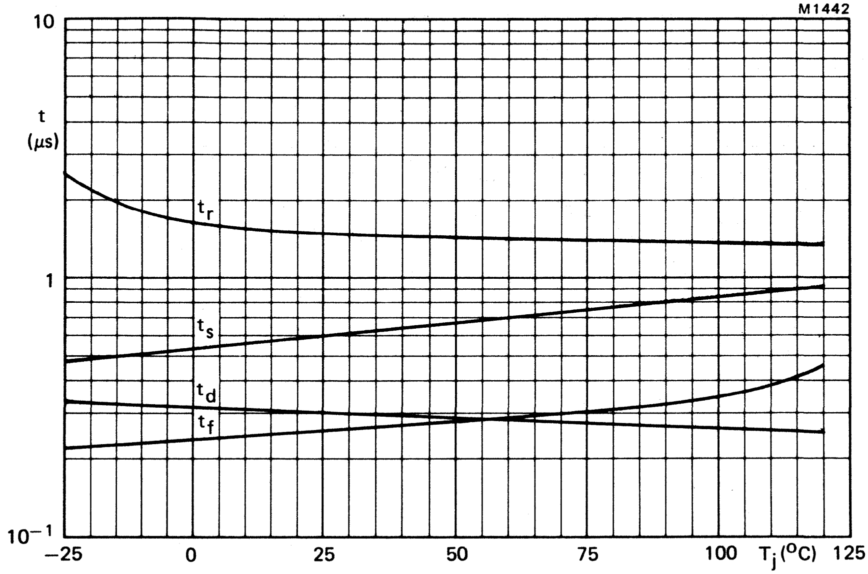


Fig. 14 Switching times as a function of junction temperature; $V_D \geqslant 250$ V; $I_T = 10$ A; $I_{GF} = 1.5$ A; $V_{GR} = 10$ V; $I_G = 0.5$ A; $L_G = 0.4$ μH; maximum values.

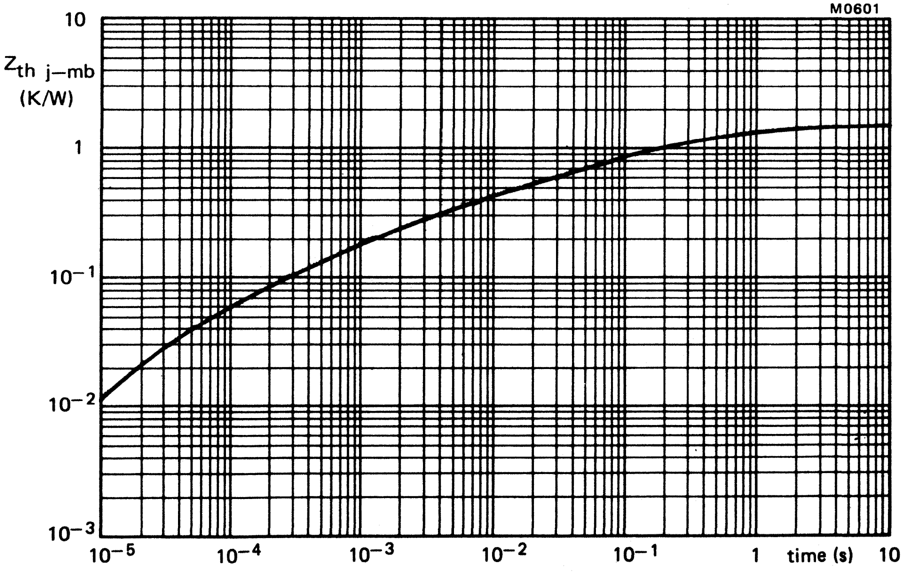


Fig. 15 Transient thermal impedance.

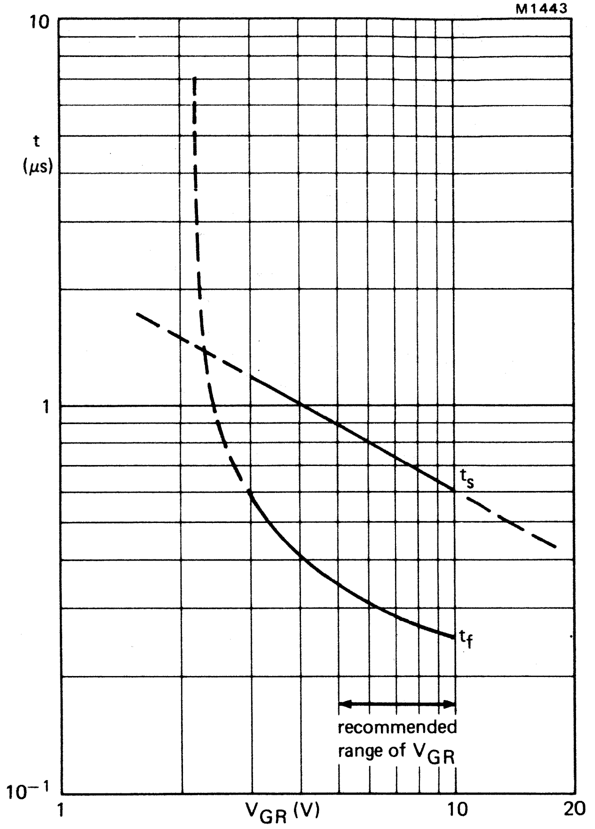


Fig. 16 Storage and fall times versus applied reverse gate voltage; inductive load; I_T = 10 A; I_G = 0.5 A; L_G = 0.4 μH; T_j = 25 °C; maximum values.

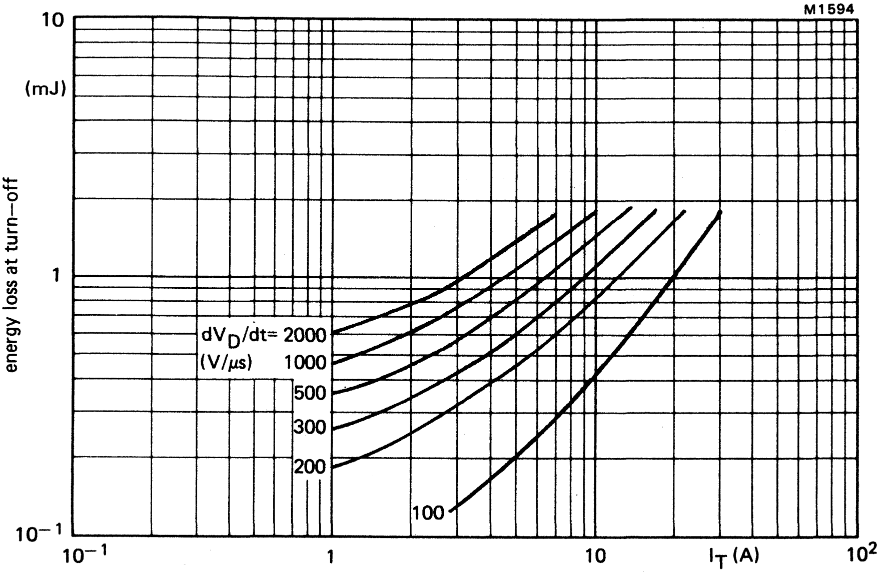


Fig.17 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied dV_D/dt (calculated from I_T/C_S); reapplied voltage sinusoidal up to V_{DRM} = 1200 V; V_{GR} = 10 V; I_G = 0.5 A; $L_G \leqslant$ 0.5 μH; $L_S \leqslant$ 0.25 μH; T_j = 120 °C

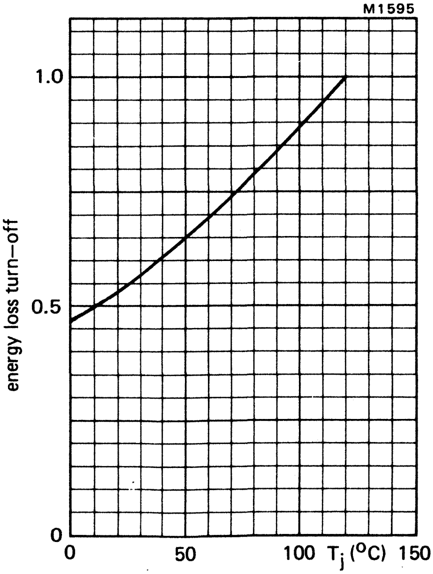


Fig.18 Energy loss at turn off as a function of junction temperature; I_G = 0.5 A; V_{GR} = 10 V. Normalised to T_j = 120 °C.

THYRISTORS

SILICON BI-DIRECTIONAL TRIGGER DEVICE

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

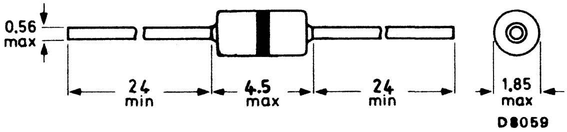
QUICK REFERENCE DATA

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

MECHANICAL DATA

Dimensions in mm

Fig. 1



RATINGS

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

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

THERMAL RESISTANCE

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

CHARACTERISTICS

$T_j = 25\ ^{o}C$

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

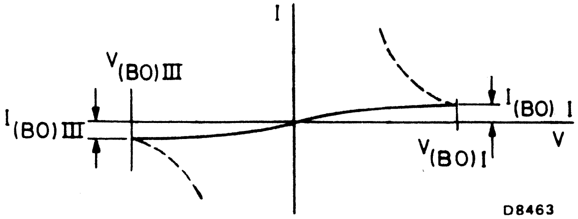


Fig.2

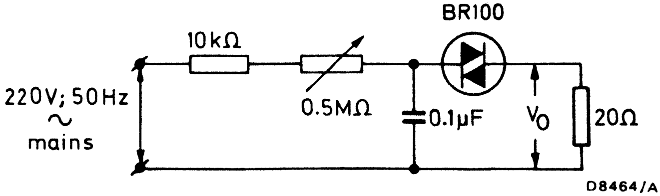


Fig. 3 Test circuit for output voltage

THYRISTORS

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

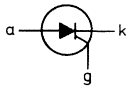
QUICK REFERENCE DATA

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

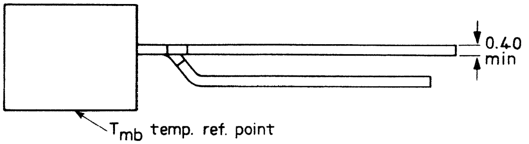
MECHANICAL DATA

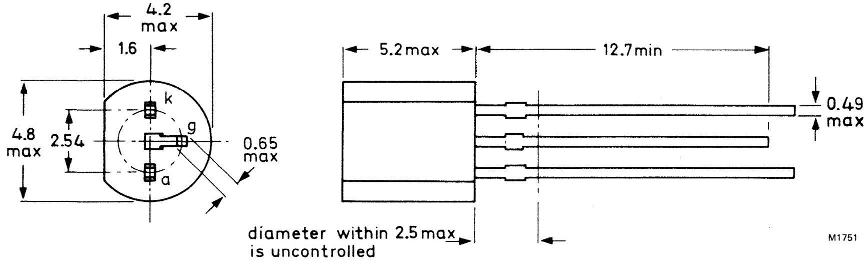
Dimensions in mm

Fig.1 TO–92 variant

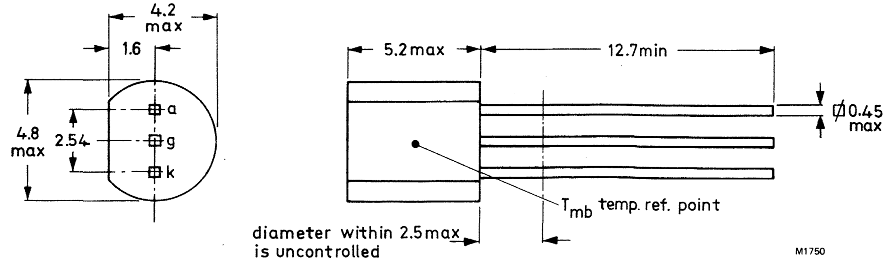


BT149–F,A,B,D,E





BT149–M



→ RATINGS

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

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

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

→ THERMAL RESISTANCE

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

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*R_{GK} = 1 kΩ

CHARACTERISTICS

Anode to cathode

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

Gate to cathode

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

Switching characteristics

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

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*Measured under pulse conditions to avoid excessive dissipation.

THYRISTORS

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

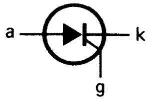
QUICK REFERENCE DATA

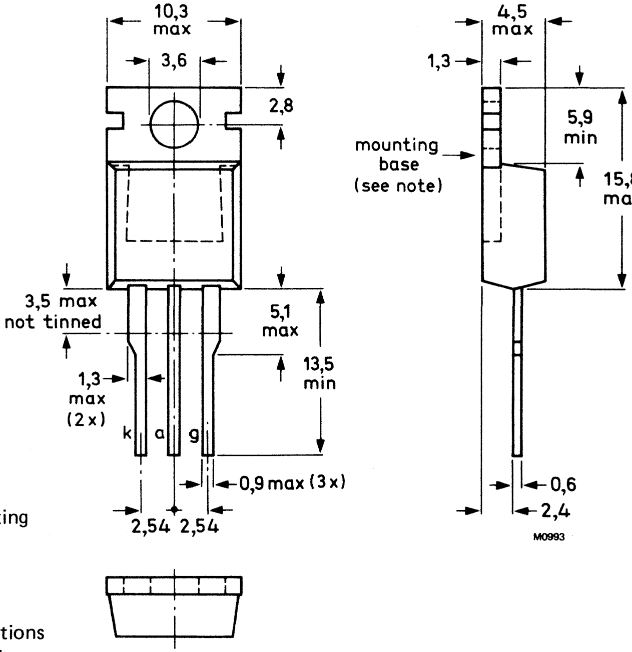
			BT151-500R	650R	800R	
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	500	650	800	V
Average on-state current	$I_{T(AV)}$	max.		7.5		A
R.M.S. on-state current	$I_{T(RMS)}$	max.		12		A
Non-repetitive peak on-state current	I_{TSM}	max.		100		A

MECHANICAL DATA

Fig.1 TO-220AB.

Dimensions in mm





Net mass: 2 g

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

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

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

RATINGS

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

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

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

THERMAL RESISTANCE

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

Influence of mounting method

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from mounting base to heatsink

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

2. Free-air operation

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

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

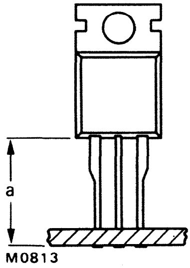


Fig. 2.

CHARACTERISTICS

Anode to cathode

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

Gate to cathode

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

Switching characteristics

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

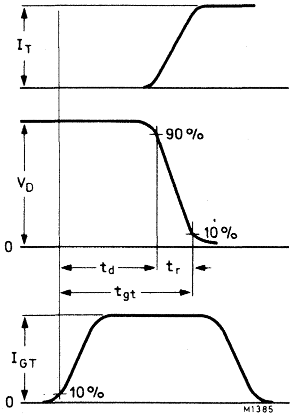


Fig.2a Gate controlled turn-on time definition.

*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.
3. It is recommended that the circuit connection be made to the anode tag, rather than direct to the heatsink.
4. Mounting by means of a spring clip is the best mounting method because it offers:
   a. a good thermal contact under the crystal area and slightly lower $R_{th\ mb\text{-}h}$ values than screw mounting.
   b. safe isolation for mains operation.
   However, if a screw is used, it should be M3 cross-recess pan-head. Care should be taken to avoid damage to the plastic body.
5. For good thermal contact heatsink compound should be used between mounting base and heatsink. Values of $R_{th\ mb\text{-}h}$ given for mounting with heatsink compound refer to the use of a metallic-oxide loaded compound. Ordinary silicone grease is not recommended.
6. Rivet mounting (only possible for non-insulated mounting)

   Devices may be rivetted to flat heatsinks; such a process **must neither** deform the mounting tab, **nor** enlarge the mounting hole.

OPERATING NOTES

Dissipation and heatsink considerations:

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

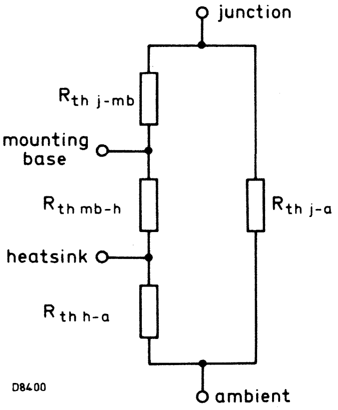


Fig. 3.

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

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

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

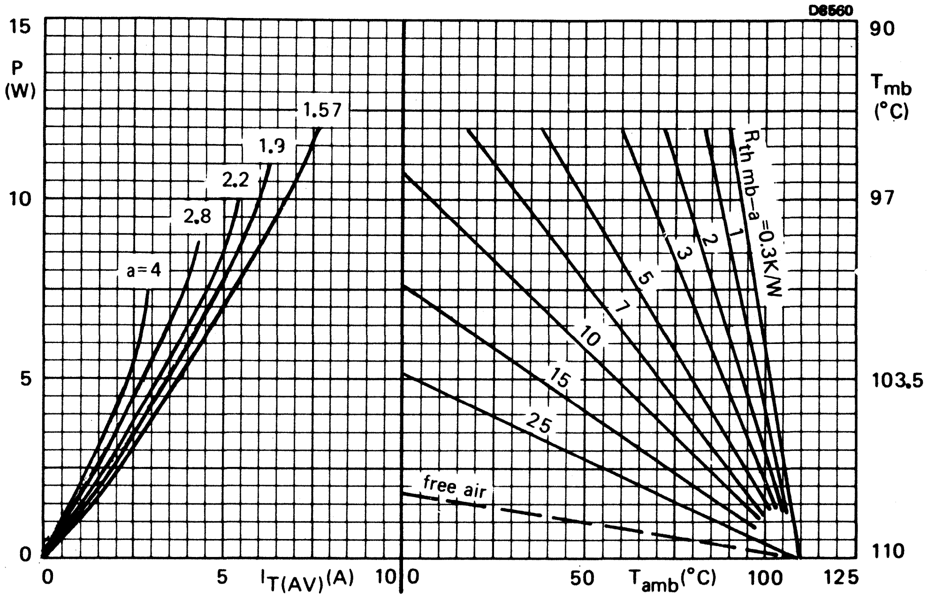
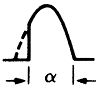


Fig.4 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



α = conduction angle per half cycle

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

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

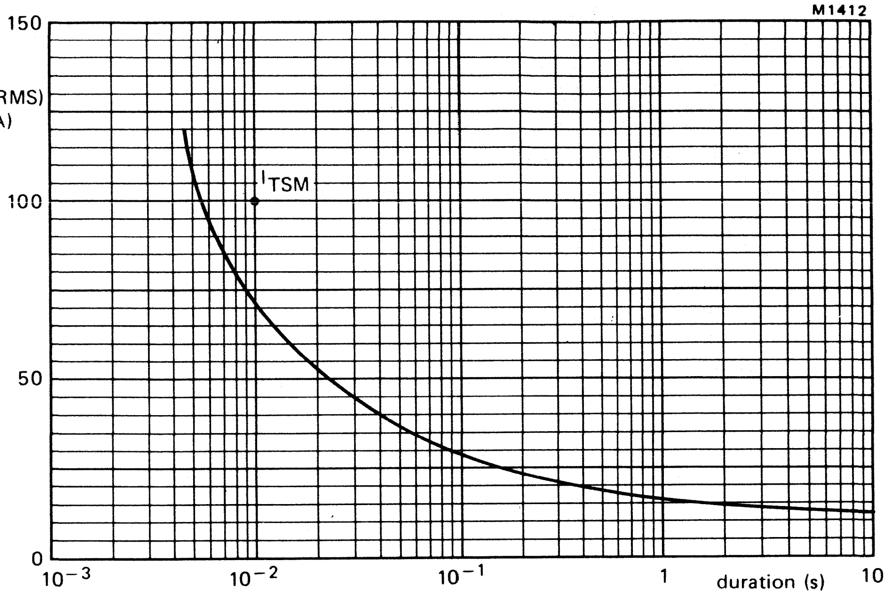
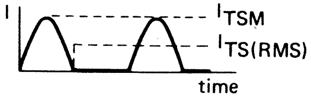


Fig.5 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents (f = 50 Hz); T_j = 110 °C prior to surge; with reapplied V_{RWMmax}.



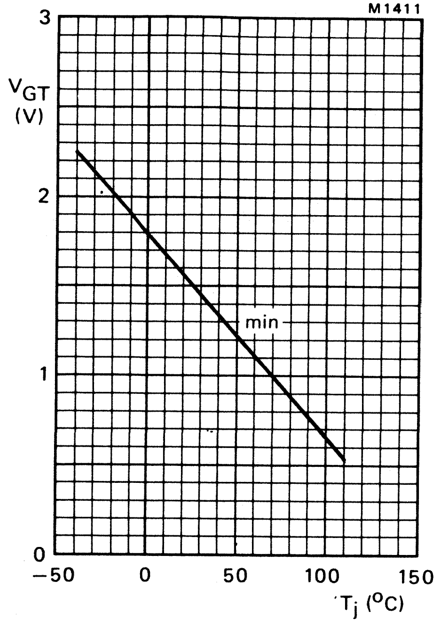


Fig.6 Minimum gate voltage that will trigger all devices as a function of junction temperature.

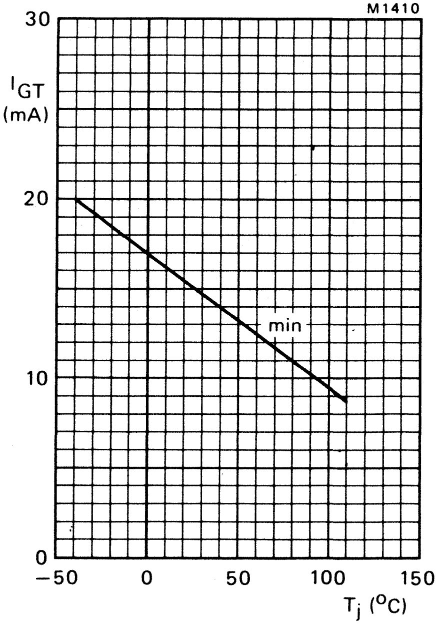


Fig.7 Minimum gate current that will trigger all devices as a function of junction temperature.

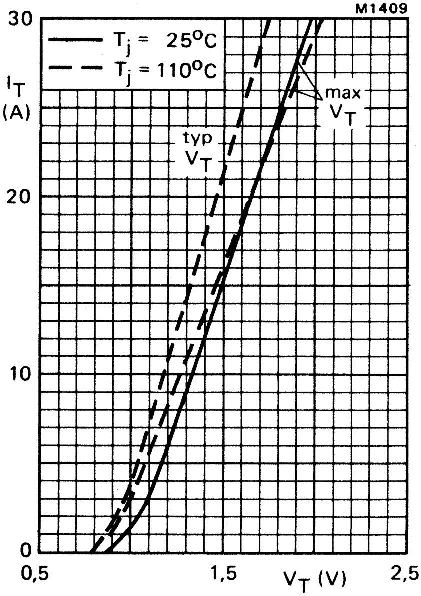


Fig.8.

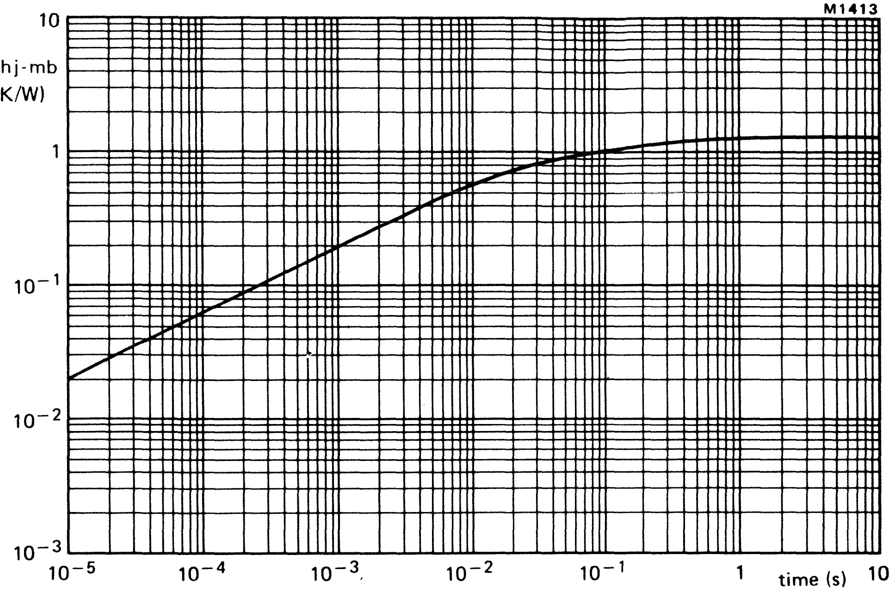


Fig.9

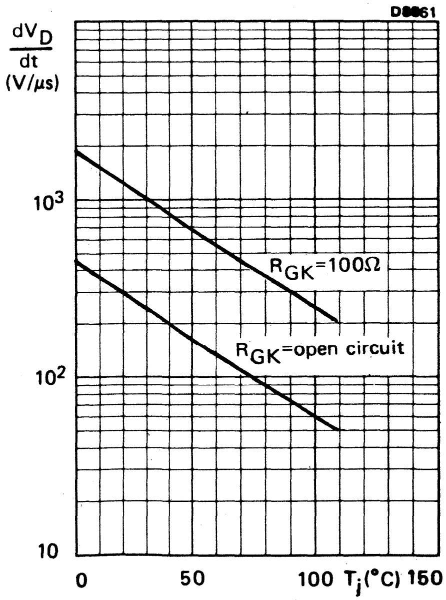


Fig.10 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of junction temperature.

THYRISTORS

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

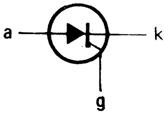
QUICK REFERENCE DATA

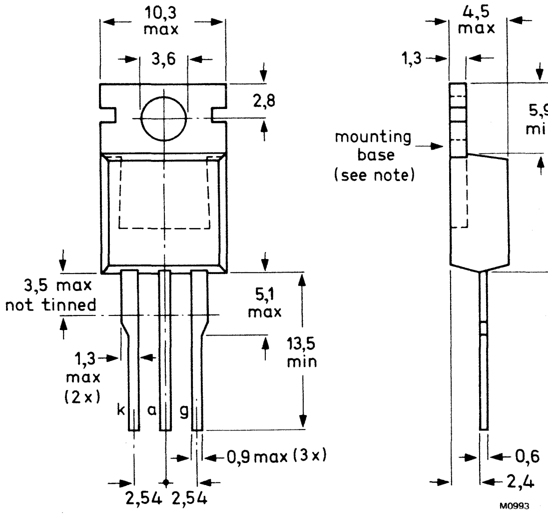
			BT152–400R	600R	800R	
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	400	600	800	V
Average on-state current	$I_{T(AV)}$	max.		13		A
R.M.S. on-state current	$I_{T(RMS)}$	max.		20		A
Non-repetitive peak on-state current	I_{TSM}	max.		200		A

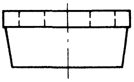
MECHANICAL DATA

Dimensions in mm

Fig.1 TO–220AB







Net mass: 2 g

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

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

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

RATINGS

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

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

Average on-state current (averaged over any 20 ms period) up to $T_{mb} = 93\ ^{o}C$	$I_{T(AV)}$	max.	13	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	20	A
Repetitive peak on-state current	I_{TRM}	max.	200	A
Non-repetitive peak on-state current; t = 10 ms; half sine-wave; $T_j = 115\ ^{o}C$ prior to surge; with reapplied V_{RWMmax}	I_{TSM}	max.	200	A
I^2t for fusing (t = 10 ms)	I^2t	max.	200	A^2s
Rate of rise of on-state current after triggering with I_G = 160 mA to I_T = 50 A; dI_G/dt = 160 A/ms	dI_T/dt	max.	200	A/μs
Gate to cathode				
Reverse peak voltage	V_{RGM}	max.	5	V
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	0.5	W
Peak power dissipation; $t \leqslant 10\ \mu s$	P_{GM}	max.	20	W
Temperature				
Storage temperature	T_{stg}		–40 to +150	^{o}C
Junction temperature	T_j	max.	115	^{o}C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1.1	$^{o}C/W$
From mounting base to heatsink with heatsink compound	$R_{th\ mb\text{-}h}$	=	0.3	$^{o}C/W$

CHARACTERISTICS

Anode to cathode

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

Gate to cathode

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

Switching characteristics

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

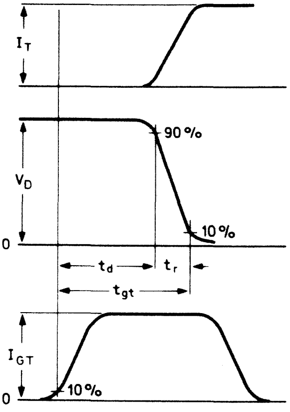


Fig.2 Gate-controlled turn-on time definition.

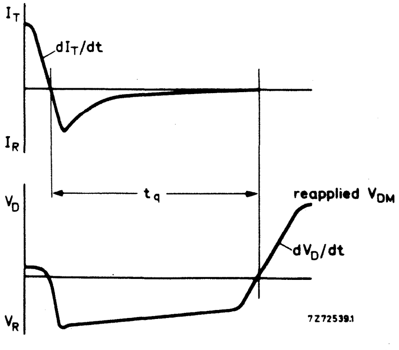


Fig.3 Circuit-commutated turn-off time definition.

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.
3. It is recommended that the circuit connection be made to the anode tag, rather than direct to the heatsink.
4. Mounting by means of a spring clip is the best mounting method because it offers:
   a. a good thermal contact under the crystal area and slightly lower $R_{th\ mb\text{-}h}$ values than screw mounting.
   b. safe isolation for mains operation.
   However, if a screw is used, it should be M3 cross-recess pan-head. Care should be taken to avoid damage to the plastic body.
5. For good thermal contact heatsink compound should be used between mounting base and heatsink. Values of $R_{th\ mb\text{-}h}$ given for mounting with heatsink compound refer to the use of a metallic-oxide loaded compound. Ordinary silicone grease is not recommended.
6. Rivet mounting (only possible for non-insulated mounting)

   Devices may be rivetted to flat heatsinks; such a process **must neither** deform the mounting tab, **nor** enlarge the mounting hole.

OPERATING NOTES

Dissipation and heatsink considerations:

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

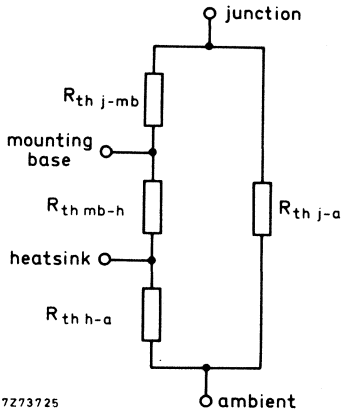


Fig.4

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

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

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

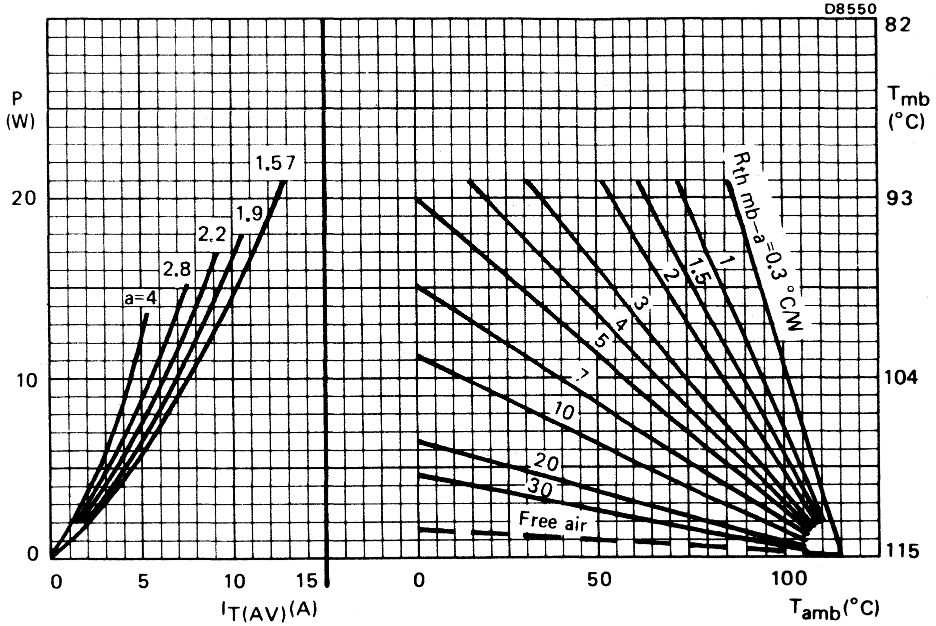
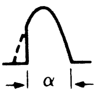


Fig.5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



α = conduction angle per half cycle

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

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

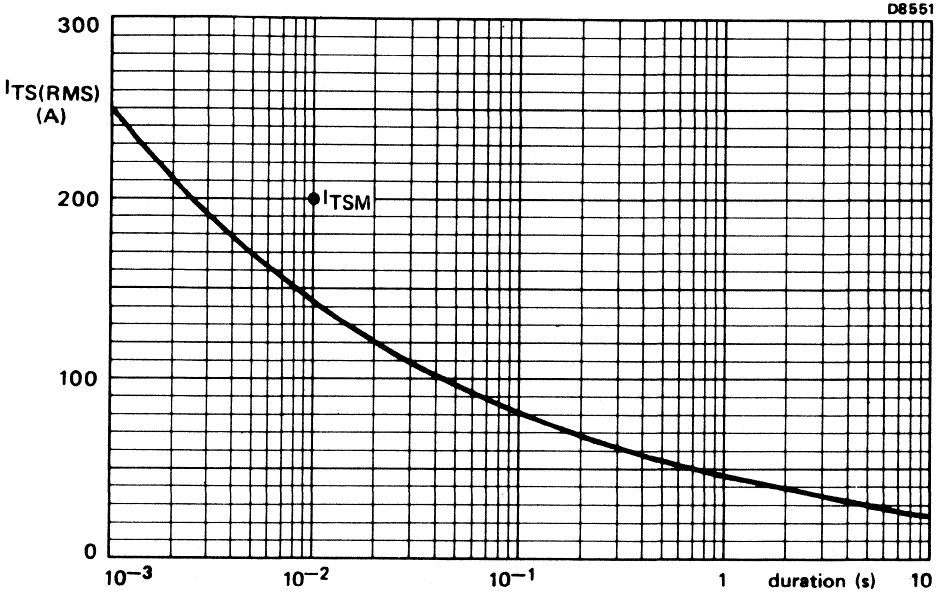
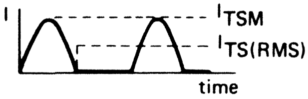


Fig.6 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents (f = 50 Hz); T_j = 115 °C prior to surge; with reapplied V_{RWMmax}.



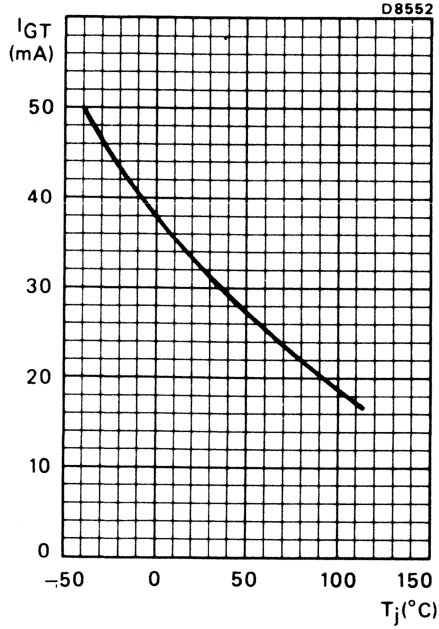


Fig. 7 Minimum gate current that will trigger all devices as a function of junction temperature.

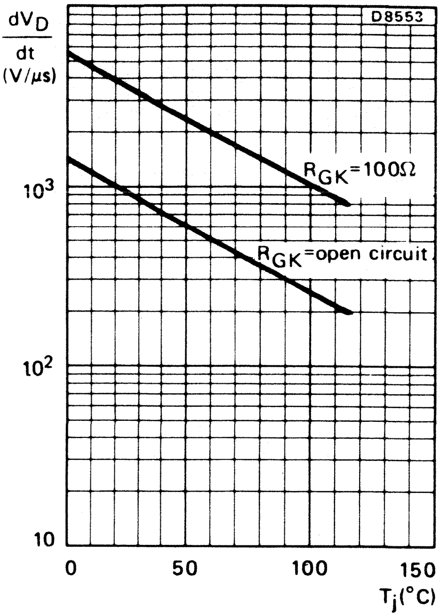


Fig.8 Maximum rate of rise of off-state voltage that will not trigger any device as a function of junction temperature.

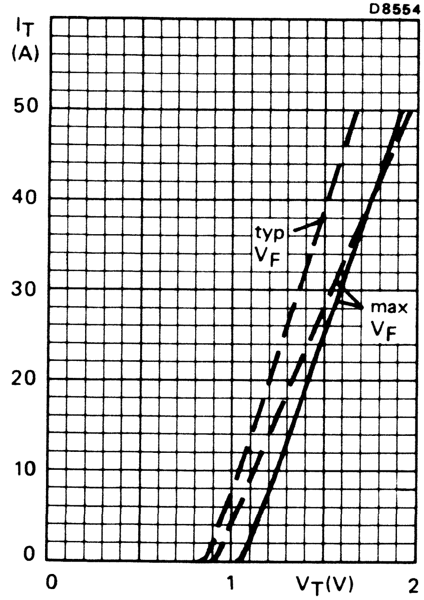


Fig.9 —— T_j = 25 °C; – – – T_j = 115 °C

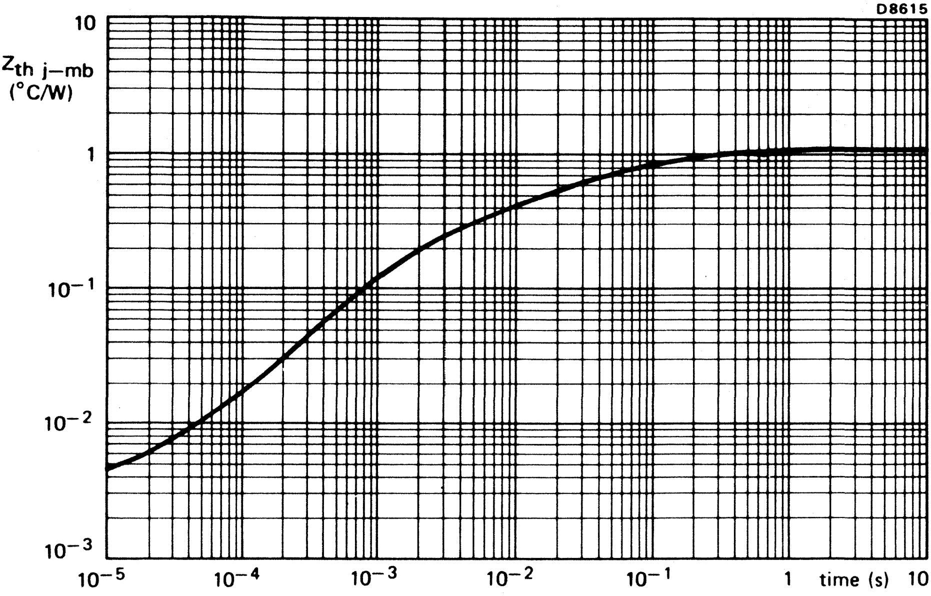


Fig. 10

FAST TURN-OFF THYRISTOR

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

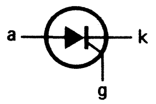
QUICK REFERENCE DATA

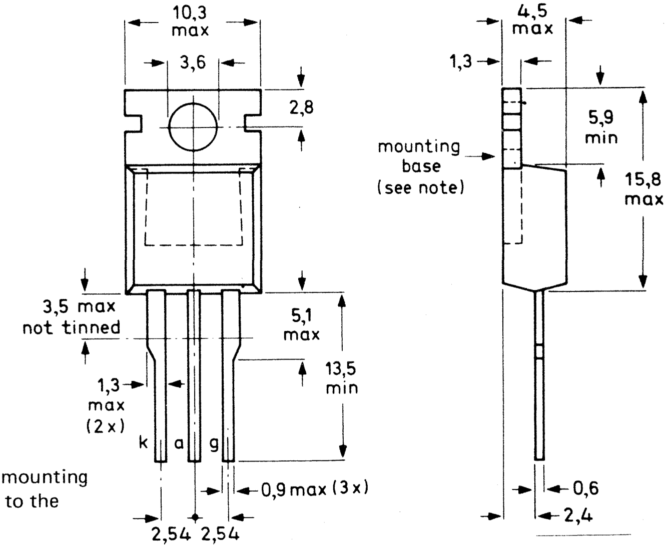
Repetitive peak off-state voltage	V_{DRM}	max.	500	V
Average on-state current	$I_{T(AV)}$	max.	4	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	6	A
Repetitive peak on-state current	I_{TRM}	max.	30	A
Circuit-commutated turn-off time	t_q	<	20	μs

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

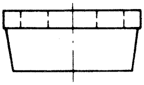




Net mass: 2 g

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

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



RATINGS

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

Anode to cathode				
Non-repetitive peak voltages ($t \leqslant 10$ ms)	V_{DSM}/V_{RSM}	max.	550	V
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	500	V
Working voltages	V_{DW}/V_{RW}	max.	400	V *
Average on-state current (averaged over any 20 ms period) up to T_{mb} = 95 °C	$I_{T(AV)}$	max.	4	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	6	A
Working peak on-state current	I_{TWM}	max.	10	A
Repetitive peak on-state current	I_{TRM}	max.	30	A
Non-repetitive peak on-state current; t = 10 ms; half sine-wave; T_j = 110 °C prior to surge; with reapplied V_{RWMmax}	I_{TSM}	max.	40	A
I^2t for fusing; t = 10 ms; T_j = 25 °C	I^2t	max.	10	A^2s
Rate of rise of on-state current after triggering up to f = 20 kHz; V_{DM} = 300 V to I_{TM} = 6 A	dI_T/dt	max.	200	A/μs
Gate to cathode				
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	1	W
Peak power dissipation; t = 10 μs	P_{GM}	max.	25	W
Temperatures				
Storage temperature	T_{stg}	−40 to + 125		°C
Operating junction temperature	T_j	max.	110	°C

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* Voltage shapes as occurring in the intended application.

THERMAL RESISTANCE

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

Influence of mounting method

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from mounting base to heatsink

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

2. Free-air operation

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

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

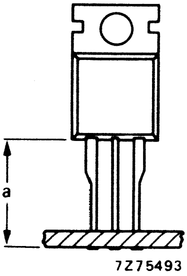

Fig. 2.

CHARACTERISTICS

Anode to cathode

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

Gate to cathode

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

Switching characteristics

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

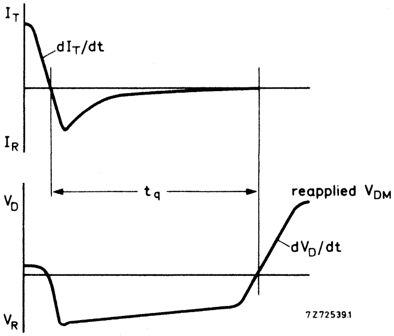

Fig. 3 Circuit-commutated turn-off time definition.

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* 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. It is recommended that the circuit connection be made to the anode tag, rather than direct to the heatsink.
4. Mounting by means of a spring clip is the best mounting method because it offers:
   a. a good thermal contact under the crystal area and slightly lower $R_{th\ mb\text{-}h}$ values than screw mounting.
   b. safe isolation for mains operation.

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

   Devices may be rivetted to flat heatsinks; such a process **must neither** deform the mounting tab, **nor** enlarge the mounting hole.

OPERATING NOTES

Dissipation and heatsink considerations:

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

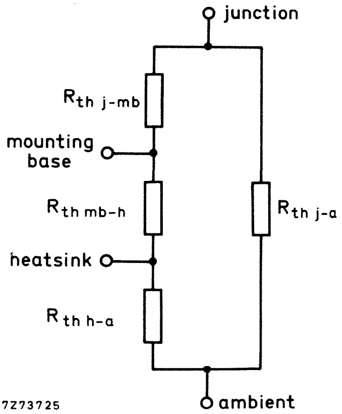


Fig. 4.

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

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

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

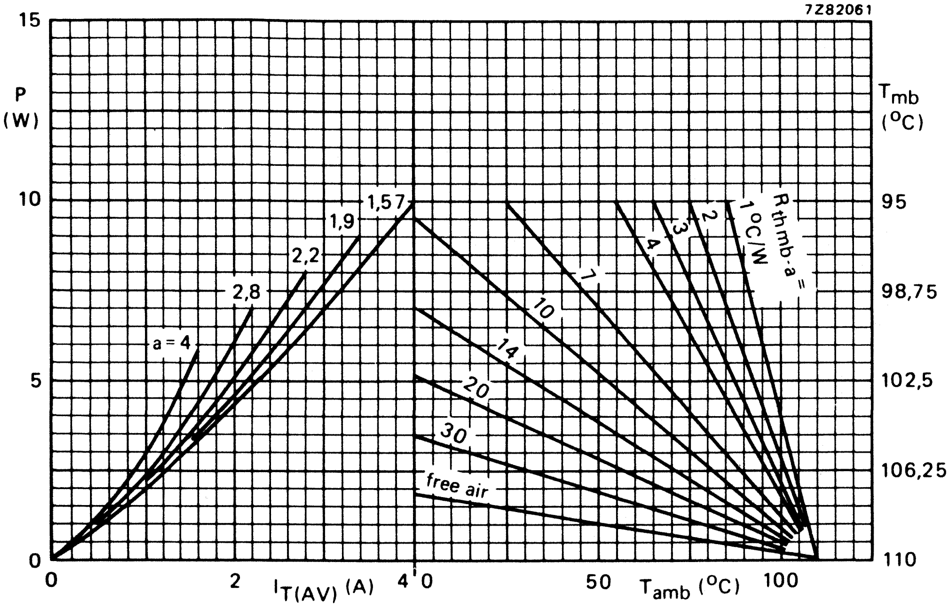
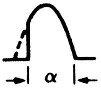


Fig. 5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



α = conduction angle per half cycle

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

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

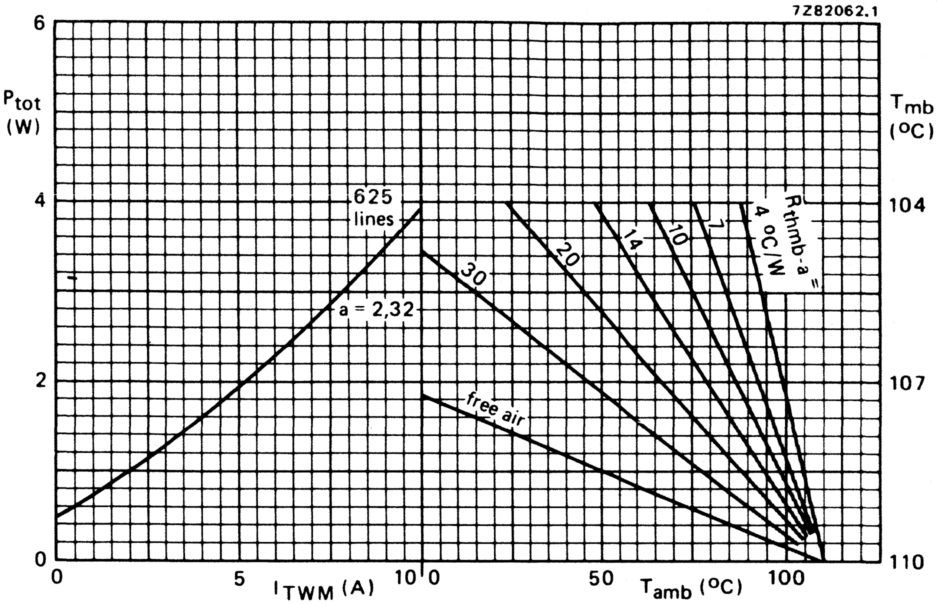


Fig. 6 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.
P_{tot} = maximum power dissipation including gate and switching losses.
I_{TWM} = maximum working peak on-state current.

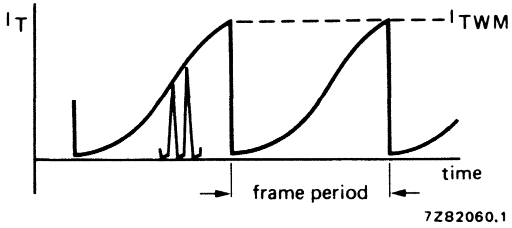


Fig. 7 Waveform defining I_{TWM}.

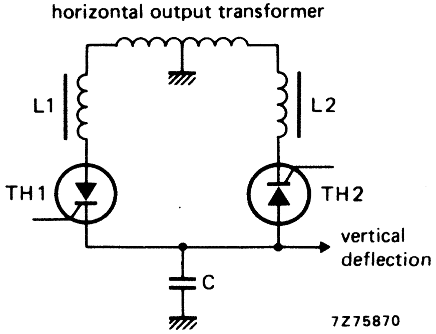


Fig. 8 Basic circuit of a vertical deflection system.

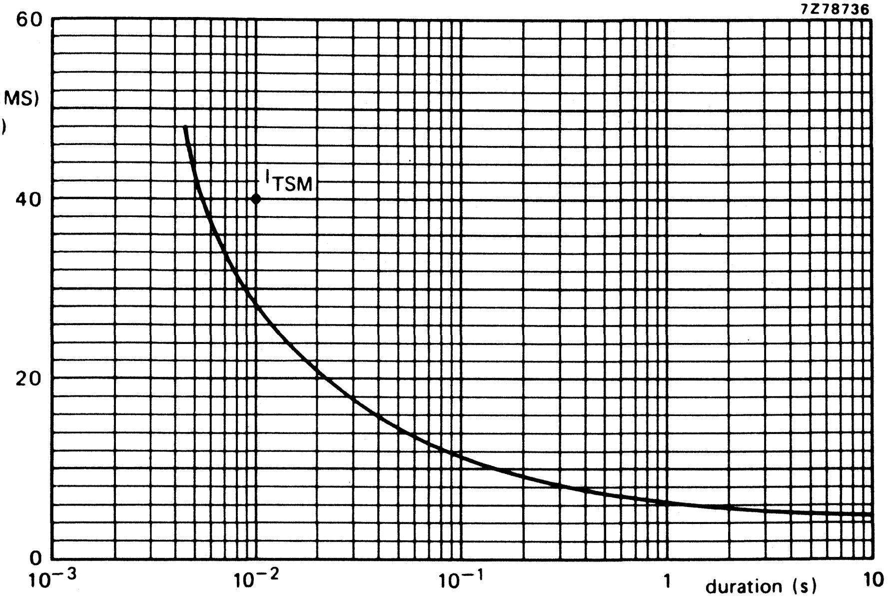
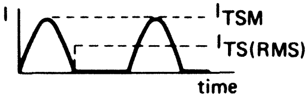


Fig. 9 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents (f = 50 Hz); T_j = 110 °C prior to surge; with reapplied V_{RWMmax}.



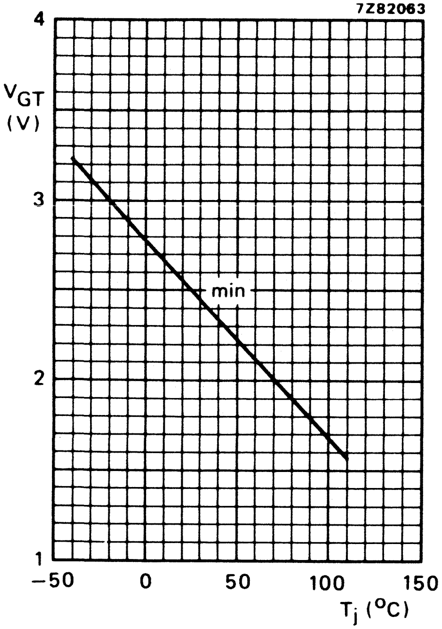


Fig. 10 Minimum gate voltage that will trigger all devices as a function of junction temperature.

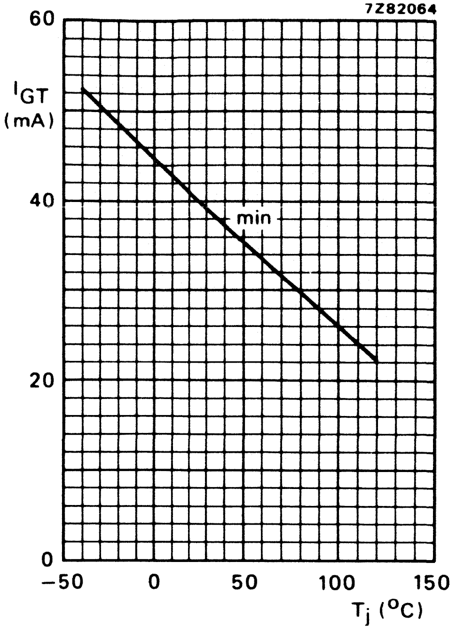


Fig. 11 Minimum gate current that will trigger all devices as a function of junction temperature.

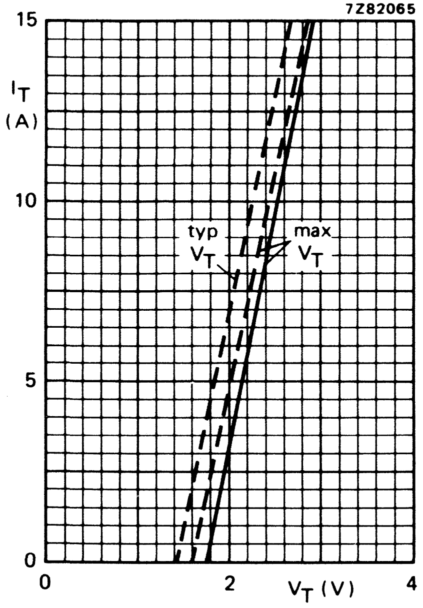


Fig. 12 —— $T_j = 25\ ^{\circ}C$; – – – $T_j = 110\ ^{\circ}C$.

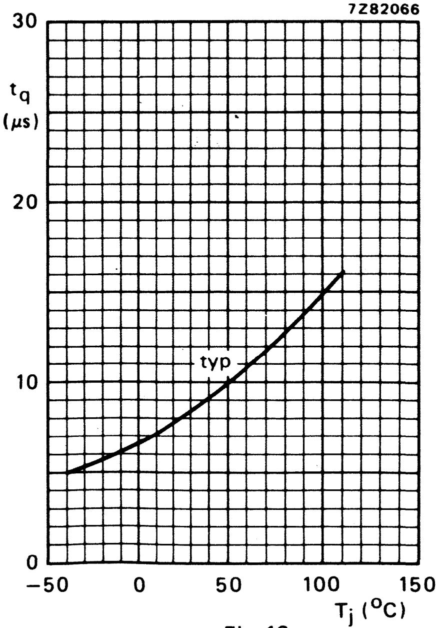


Fig. 13.

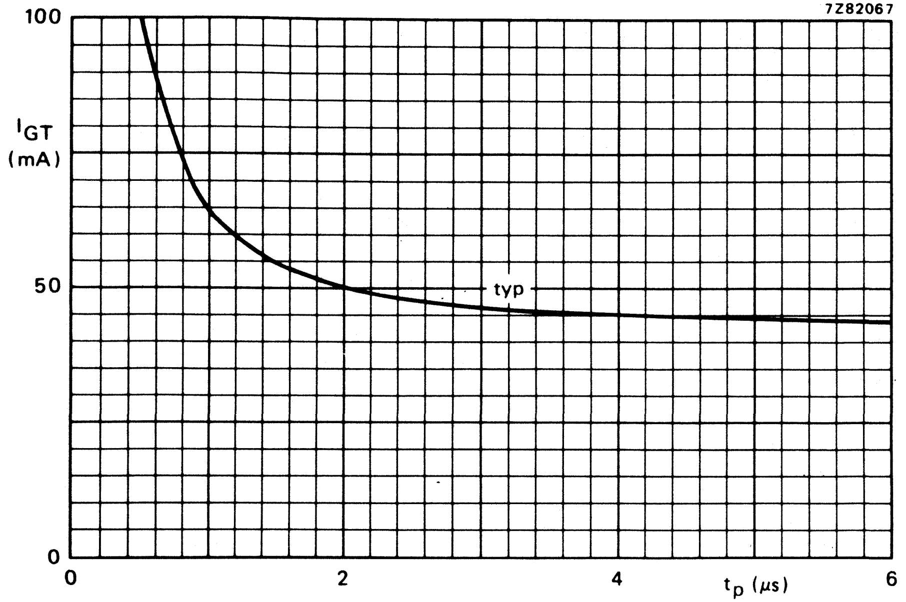
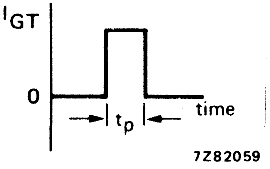


Fig. 14 Gate current that will trigger all devices as a function of rectangular pulse width; T_j = 25 °C.



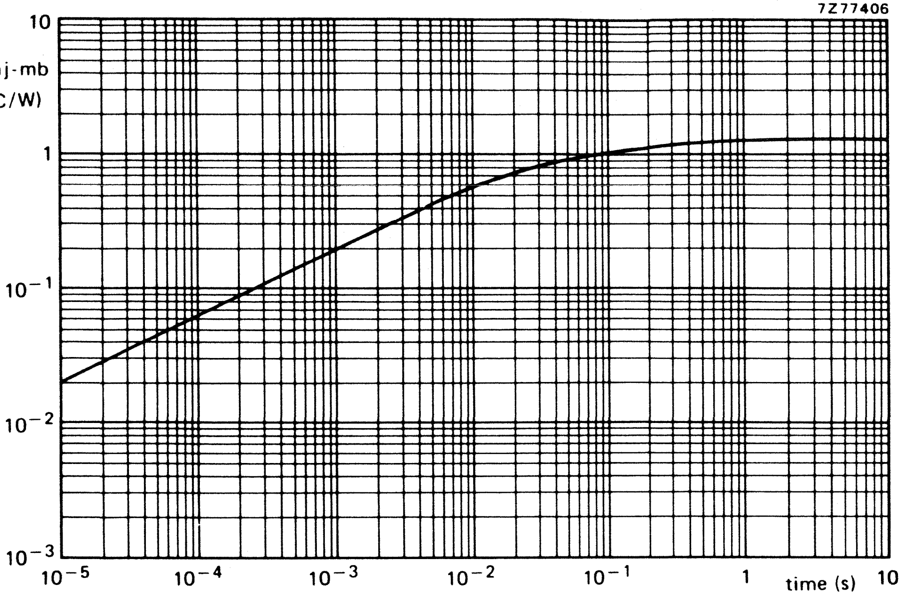

7Z77406
Z_{thj-mb} (°C/W)
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
time (s)
10

Fig. 15.

FAST TURN-OFF THYRISTORS

Glass-passivated, asymmetrical, fast turn-off, forward blocking thyristors (ASCR) in TO-220AB 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.

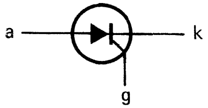
QUICK REFERENCE DATA

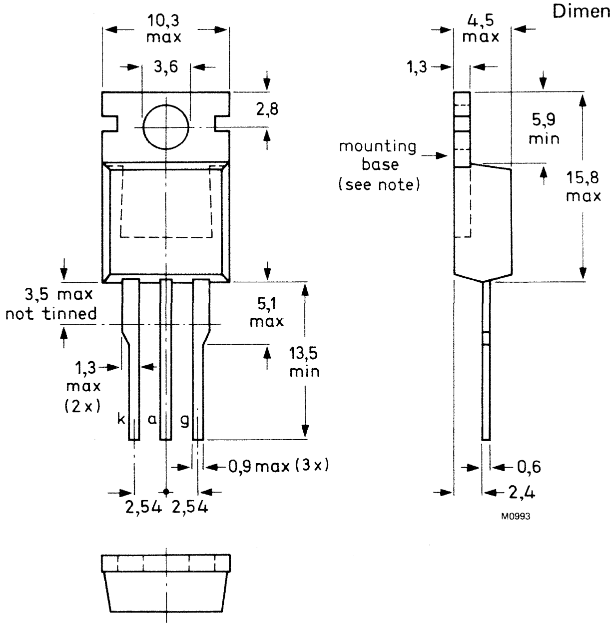
			BT155–600R	800R	
Repetitive peak off-state voltage	V_{DRM}	max.	600	800	V
Average on-state current	$I_{T(AV)}$	max.	9.5		A
Repetitive peak on-state current	I_{TRM}	max.	90		A
Circuit-commutated turn-off time					
suffix K	t_q	<	4		μs
suffix N	t_q	<	6		μs
suffix P	t_q	<	8		μs

MECHANICAL DATA

Dimensions in mm

Fig.1 TO–220AB





Net mass: 2 g

Note: The exposed metal mounting base is directly connected to the anode.
Accessories supplied on request: see data sheets 'Mounting instructions and accessories for TO-220 envelopes.'

Products approved to CECC 50 011-009 available on request. ←

RATINGS

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

Anode to cathode

			BT155–600R	800R	
Transient off-state voltage	V_{DSM}	max.	800	1000	V
Repetitive peak off-state voltage	V_{DRM}	max.	600	800	V
Continuous off-state voltage	V_D	max.	500	650	V

Transient reverse voltage ($t_p \leqslant 5\ \mu s$)	V_{RSM}	max.	15	V
Average on-state current (averaged over any 20 ms period)				
up to T_{mb} = 72 °C	$I_{T(AV)}$	max.	9.5	A
at T_{mb} = 85 °C	$I_{T(AV)}$	max.	6.5	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	15	A
Repetitive peak on-state current; $t_p = 50\ \mu s$; $\delta \leqslant 0.05$	I_{TRM}	max.	90	A
Non-repetitive peak on-state current T_j = 110 °C prior to surge; t = 10 ms; half sine-wave	I_{TSM}	max.	110	A
I^2t for fusing; t = 10 ms	I^2t	max.	60	A^2s

Gate to cathode

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

Temperatures

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

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2.0	°C/W
From mounting base to heatsink				
with heatsink compound	$R_{th\ mb\text{-}h}$	=	0.3	°C/W
with 56369 mica insulator and heatsink compound (clip-mounted)	$R_{th\ mb\text{-}h}$	=	2.2	°C/W
with heatsink compound and alumina insulator 56367	$R_{th\ mb\text{-}h}$	=	0.8	°C/W

CHARACTERISTICS

Anode to cathode

On-state voltage I_T = 20 A; T_j = 25 °C	V_T	<	2.65	V*
Off-state current $V_D = V_{Dmax}$; T_j = 110 °C	I_D	<	1.5	mA
Holding current; T_j = 25 °C	I_H	<	200	mA

Gate to cathode

Voltage that will trigger all devices V_D = 12 V; T_j = 25 °C	V_{GT}	>	2.0	V
Current that will trigger all devices V_D = 12 V; T_j = 25 °C	I_{GT}	>	100	mA

Switching characteristics (see Figs. 6 and 7)

Circuit commutated turn-off time
$-dI_T/dt$ = 30 A/µs; dV_D/dt = 500 V/µs (linear to V_{DRMmax})
R_{GK} = 10 Ω; T_j = 110 °C

V_G = 0; when switched from:				
suffix K: I_T = 30 A and t_p = 200 µs	t_q	<	6	µs
suffix N: I_T = 30 A and t_p = 200 µs	t_q	<	9	µs
suffix P: I_T = 90 A and t_p = 60 µs	t_q	<	12	µs
$-V_G$ = 4 V; when switched from:				
suffix K: I_T = 30 A and t_p = 150 µs	t_q	<	4	µs
suffix N: I_T = 30 A and t_p = 150 µs	t_q	<	6	µs
suffix P: I_T = 90 A and t_p = 150 µs	t_q	<	8	µs

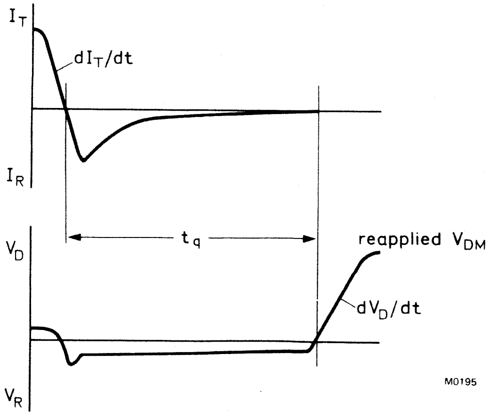


Fig.2 Circuit-commutated turn-off time definition.

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*Measured under pulse conditions to avoid excessive dissipation.

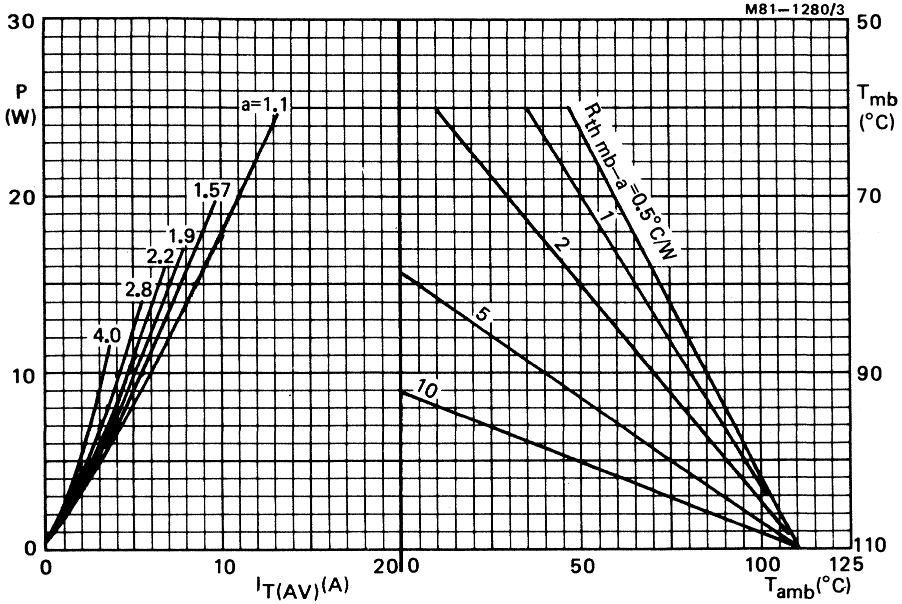
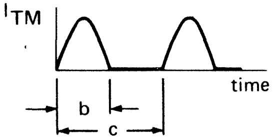


Fig.3 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



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

b/c	a
1	1.11
1/2	1.57
1/3	1.92
1/4	2.22
1/6.4	2.8
1/13	4.0

$$I_{T(RMS)} = \frac{I_{TM}}{\sqrt{2}} \sqrt{\frac{b}{c}}$$

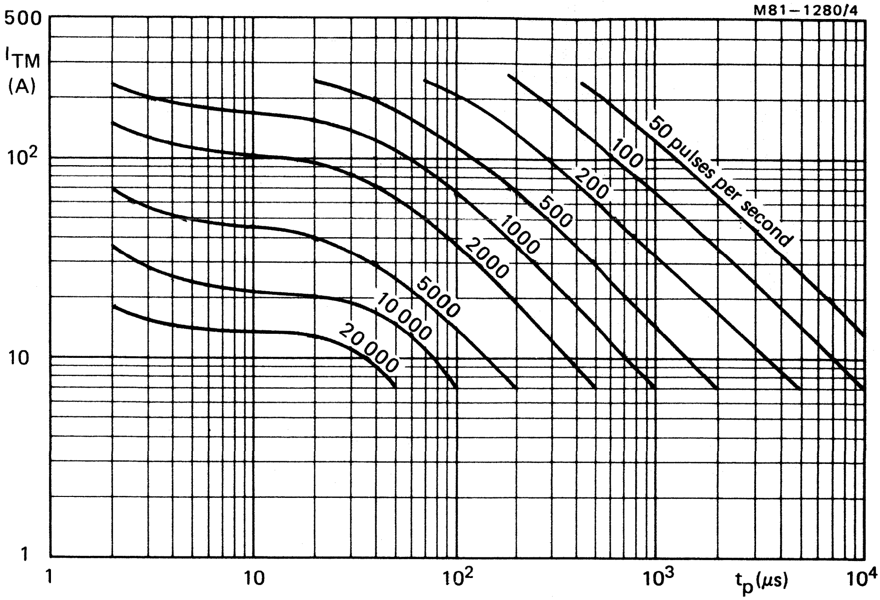


Fig.4 Maximum allowable peak on-state current versus pulse width (T_{mb} = 85 °C).

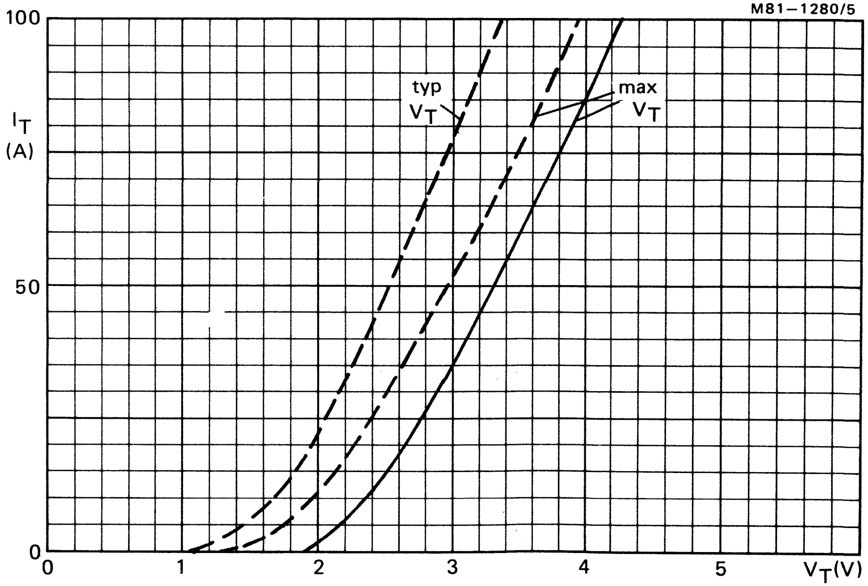


Fig.5 —— T_j = 25 °C; – – – T_j = 110 °C; t_p = 200 µs

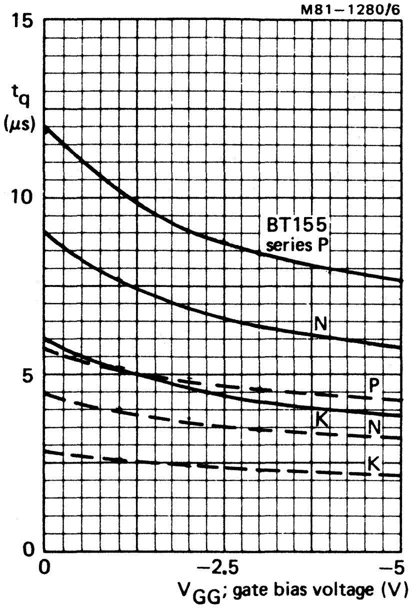


Fig.6 —— T_j = 110 °C; – – –T_j = 25 °C; maximum values.

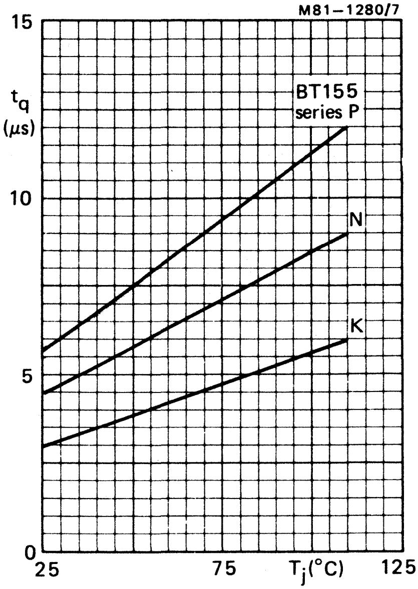


Fig.7 V_{GG} = 0; maximum values.

Conditions for Figs.6 and 7:

$-dI_T/dt$ = 30 A/μs; dV_D/dt = 500 V/μs (linear to V_{DRMmax}); R_{GK} = 10 Ω;
when switched from: suffix K, N: I_T = 30 A and t_p = 200 μs
suffix P: I_T = 90 A and t_p = 60 μs

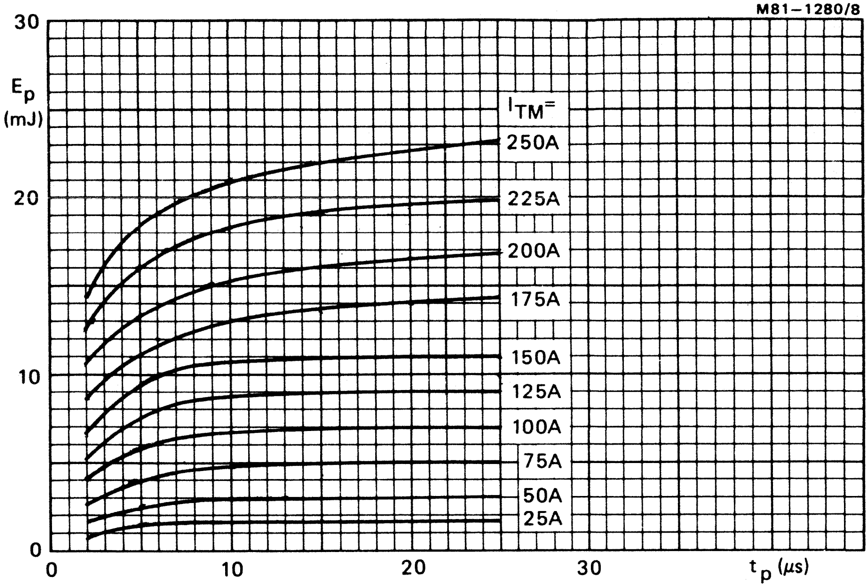


Fig.8 Maximum energy loss per pulse when switching a half-sinusoidal pulse from 600 V.
Device power (W) = Energy per pulse (J) x No. of pulses per second.

THYRISTORS

Glass-passivated thyristors in TO-65 envelopes, intended for general purpose three-phase or single-phase mains operation.
The series consists of reverse polarity types (anode to stud) identified by suffix R: BTV24-600R to 1400R.

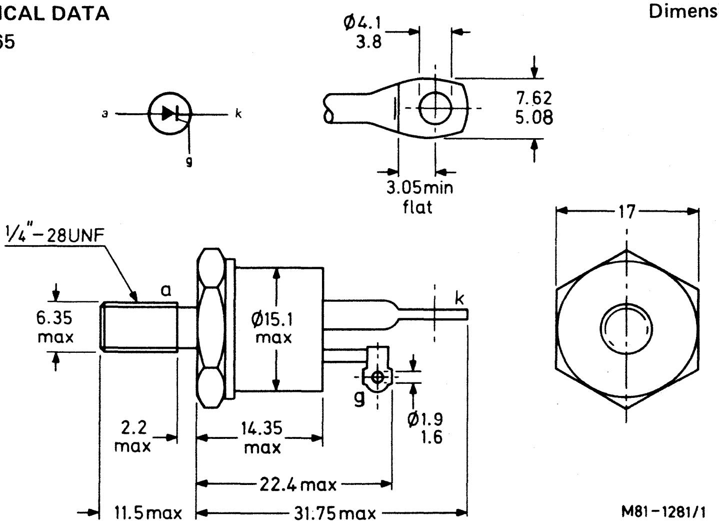
QUICK REFERENCE DATA

			BTV24-600R	800R	1200R	1400R	
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	600	800	1200	1400	V
Average on-state current	$I_{T(AV)}$	max.	45				A
R.M.S. on-state current	$I_{T(RMS)}$	max.	70				A
Non-repetitive peak on-state current	I_{TSM}	max.	800				A
Rate of rise of off-state voltage that will not trigger any device	dV_D/dt	<	200				V/µs

MECHANICAL DATA

Dimensions in mm

Fig.1 TO-65



Net mass: 22 g
Diameter of clearance hole: max. 6.5 mm
Accessories supplied on request:
see ACCESSORIES section

Supplied with device: 1 nut, 1 lock washer
Nut dimensions across the flats: 11.1 mm
Torque on nut: min. 1.7 Nm (17 kg cm)
max. 3.5 Nm (35 kg cm) ←

RATINGS

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

Anode to cathode

			BTV24–600R	800R	1200R	1400R	
Non-repetitive peak voltages ($t \leqslant 10$ ms)	V_{DSM}/V_{RSM}	max.	600	800	1200	1400	V
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	600	800	1200	1400	V
Crest working voltages	V_{DWM}/V_{RWM}	max.	400	600	800	800	V

Average on-state current (averaged over any 20 ms period) up to T_{mb} = 85 °C	$I_{T(AV)}$	max.	45	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	70	A
Repetitive peak on-state current	I_{TRM}	max.	500	A
Non-repetitive peak on-state current (see Fig. 4)	I_{TSM}	max.	800	A
I^2t for fusing (t = 10 ms)	I^2t	max.	3200	A^2s
Rate of rise of on-state current after triggering with I_G = 500 mA to I_T = 100A; dI_G/dt = 1 A/µs	dI_T/dt	max.	100	A/µs

Gate to cathode

Reverse peak voltage	V_{RGM}	max.	5	V
Peak gate current (t = 10 µs)	I_{GRM}	max.	5	A
Average gate power	$P_{G(AV)}$	max.	1	W

Temperatures

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

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	0.50	°C/W
From mounting base to heatsink; with heatsink compound	$R_{th\ mb\text{-}h}$	=	0.20	°C/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 $I_T = 100$ A; $T_j = 25$ °C	V_T	<	1.6	V*
Rate of rise of off-state voltage that will not trigger any device; exponential method; $V_D = 2/3\ V_{DRMmax}$; $T_j = 125$ °C	dV_D/dt	<	200	V/µs
Reverse current $V_R = V_{RWMmax}$; $T_j = 125$ °C	I_R	<	8	mA
Off-state current $V_D = V_{DWMmax}$; $T_j = 125$ °C	I_D	<	8	mA
Latching current; $I_G = I_{GT}$; $T_j = 25$ °C	I_L	<	300	mA
Holding current; $T_j = 25$ °C	I_H	<	200	mA

Gate to cathode

Voltage that will trigger all devices $V_D = 12$ V; $T_j = 25$ °C	V_{GT}	>	2.5	V
Voltage that will not trigger any device $V_D = V_{DRMmax}$; $T_j = 125$ °C	V_{GD}	<	250	mV
Current that will trigger all devices $V_D = 12$ V; $T_j = 25$ °C	I_{GT}	>	100	mA

Switching characteristics

Gate-controlled turn-on time ($t_{gt} = t_d + t_r$) when switched from $V_D = V_{DWMmax}$ to $I_T = 140$ A; $I_{GT} = 200$ mA; $dI_G/dt = 1$ A/µs; $T_j = 25$ °C	t_{gt} t_r	typ. typ.	5 2	µs µs

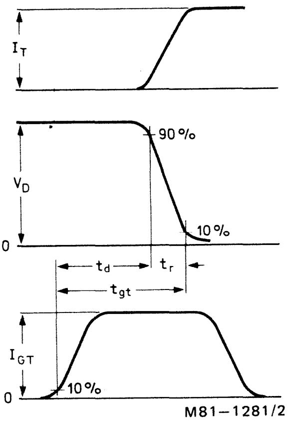


Fig.2 Gate-controlled turn-on time definition.

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*Measured under pulse conditions to avoid excessive dissipation.

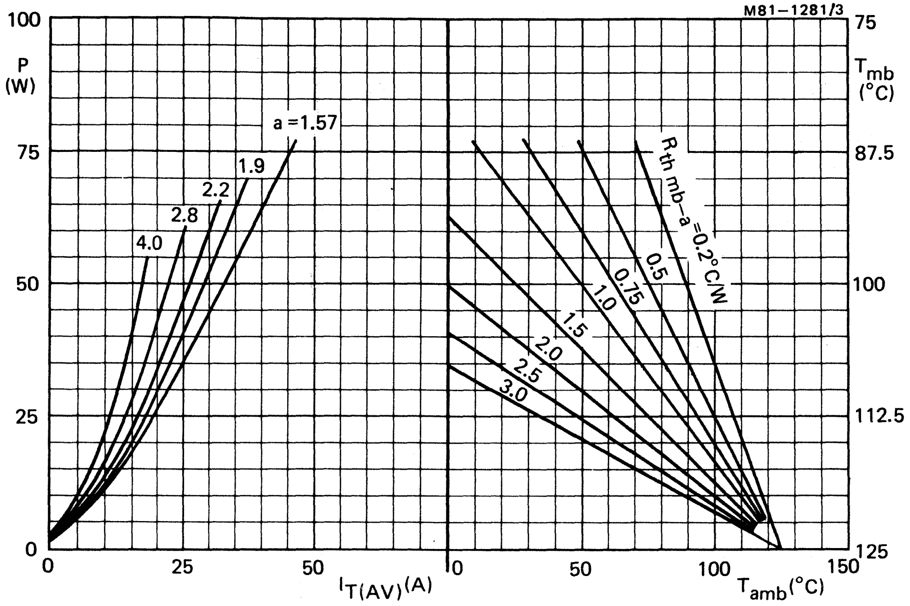
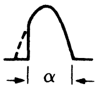


Fig.3 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



α = conduction angle per half cycle

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

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

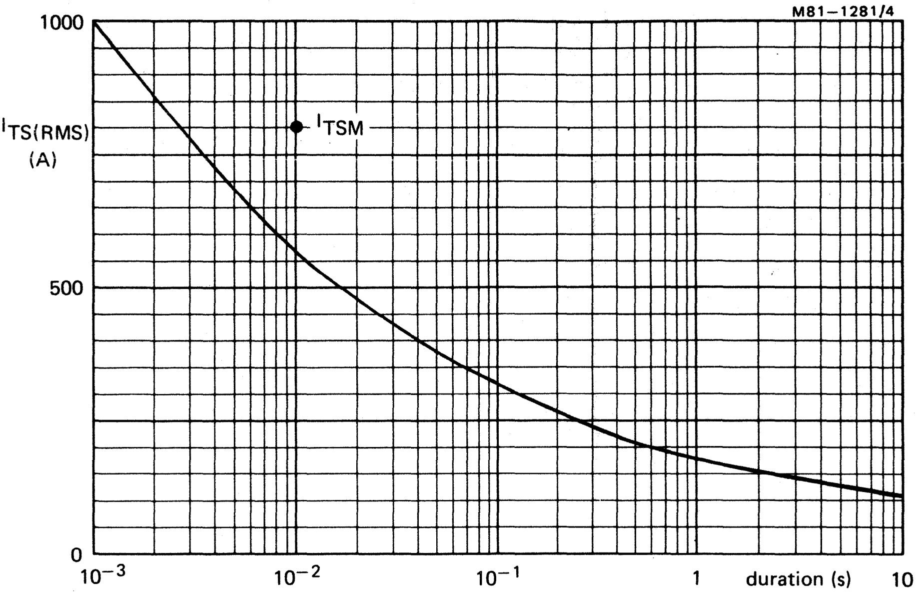
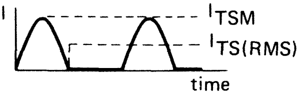


Fig.4 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents (f = 50 Hz); T_j = 125 °C prior to surge; with reapplied V_{RWMmax}.



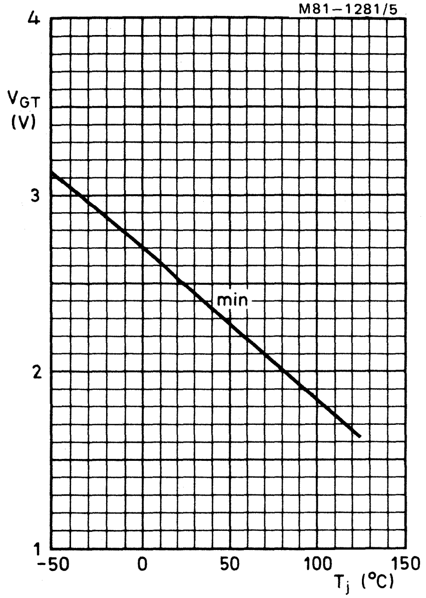


Fig.5 Minimum gate voltage that will trigger all devices plotted against junction temperature.

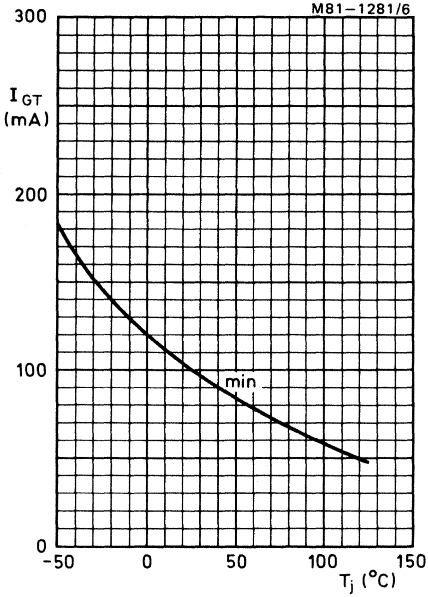


Fig.6 Minimum gate current that will trigger all devices plotted against junction temperature.

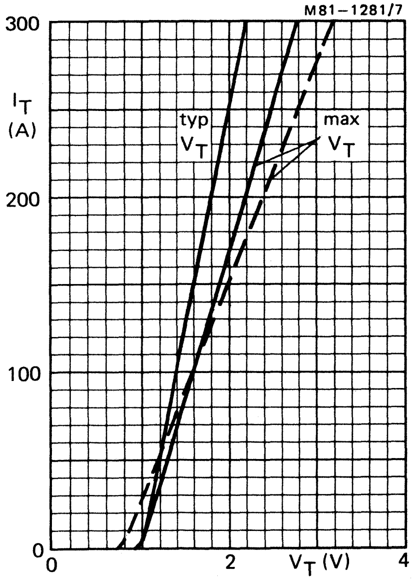


Fig.7 —— T_j = 25 °C; – – – T_j = 125 °C.

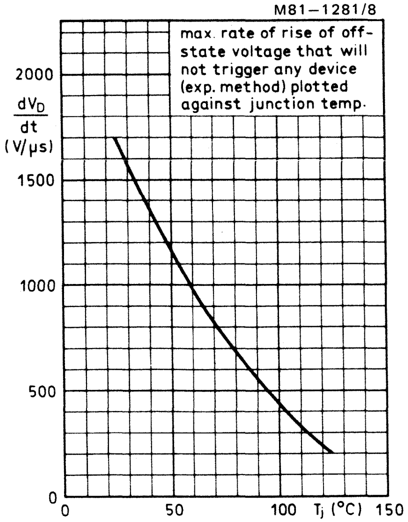


Fig.8

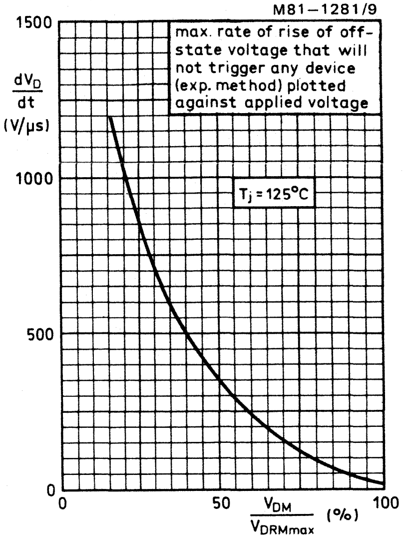


Fig. 9

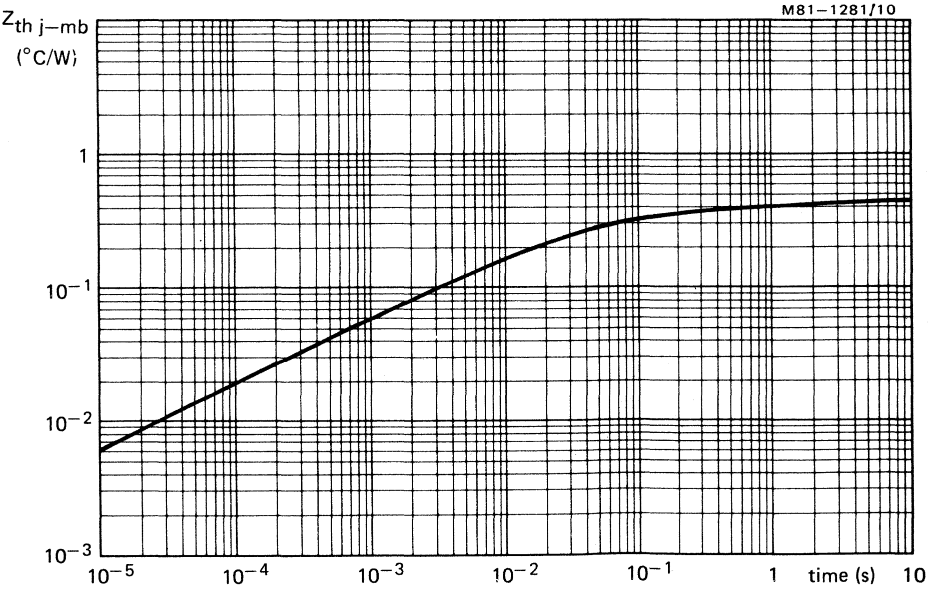


Fig.10

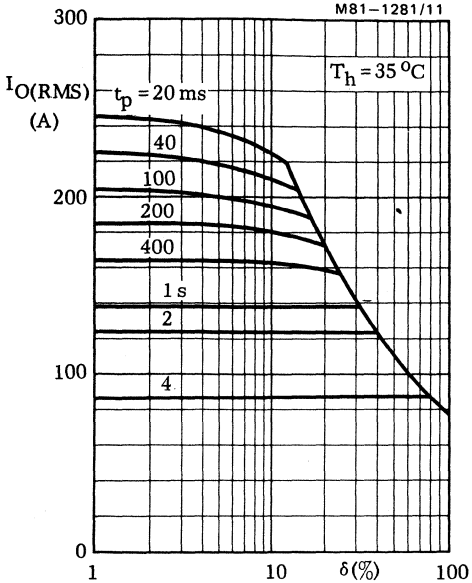


Fig.11

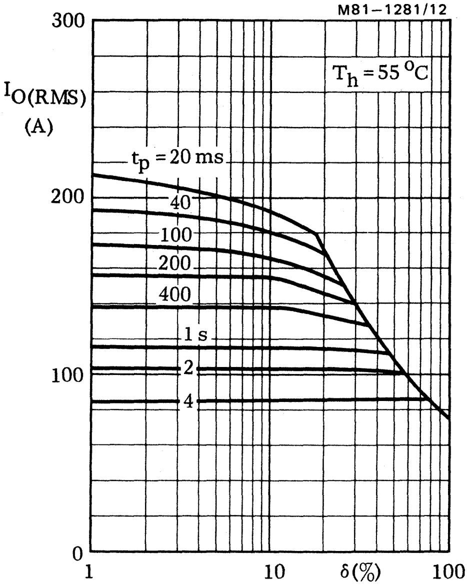
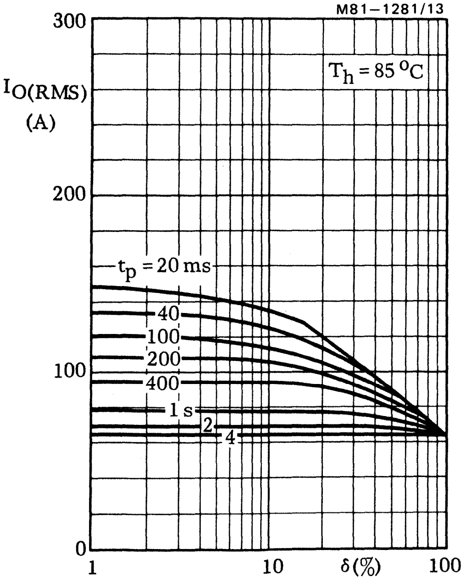


Fig.12



Figs. 11, 12 and 13

Intermittent overload capability of two BTV24 thyristors in anti-parallel connection in a single phase a.c. control circuit (e.g. welding); conduction angle: 360 °.

Fig.13

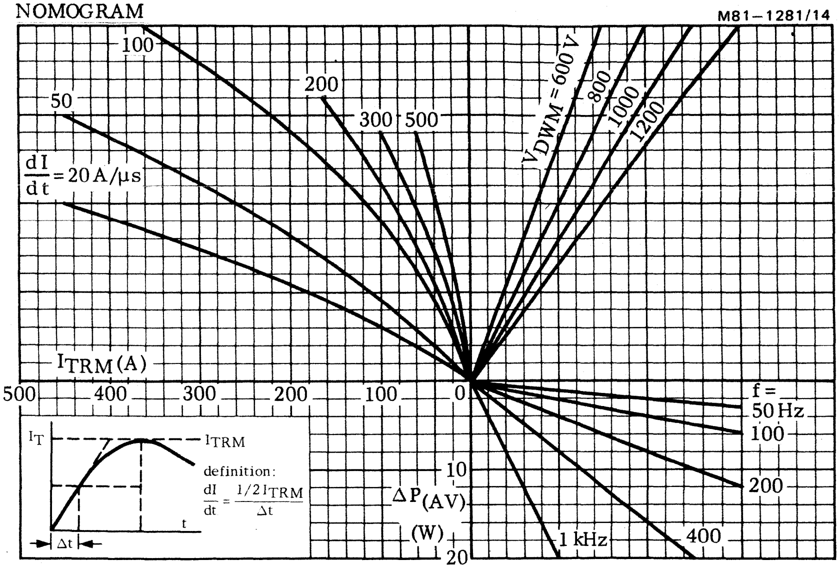


Fig.14 Power loss $\Delta P_{(AV)}$ due to switching-on; T_j = 125 °C; I_G = 500 mA; dI_G/dt = 1 A/µs.

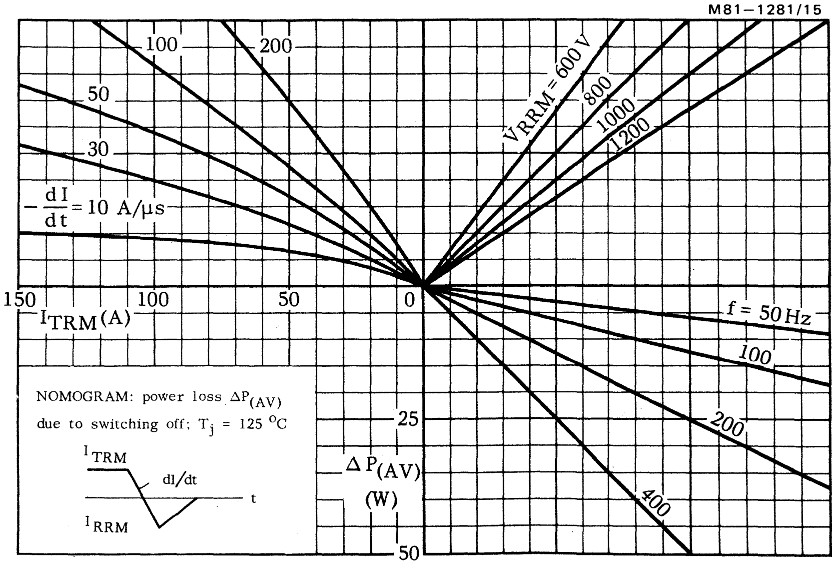


Fig.15

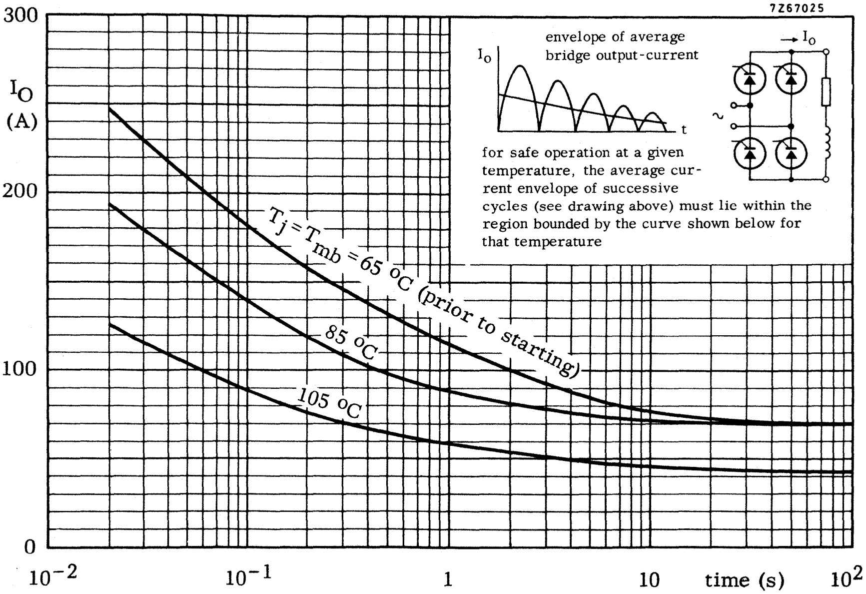


Fig.16 Limits for starting or inrush currents

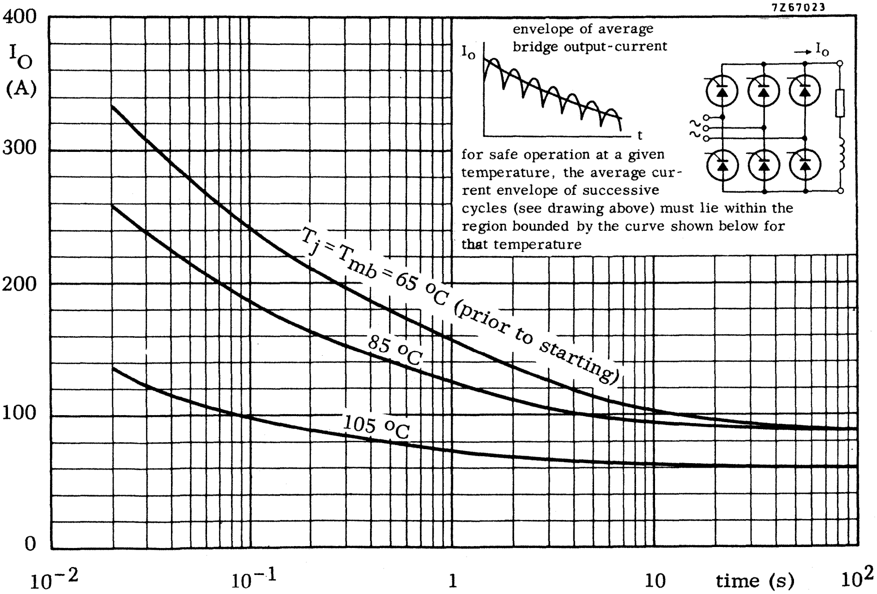


Fig.17 Limits for starting or inrush currents

THYRISTORS

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

QUICK REFERENCE DATA

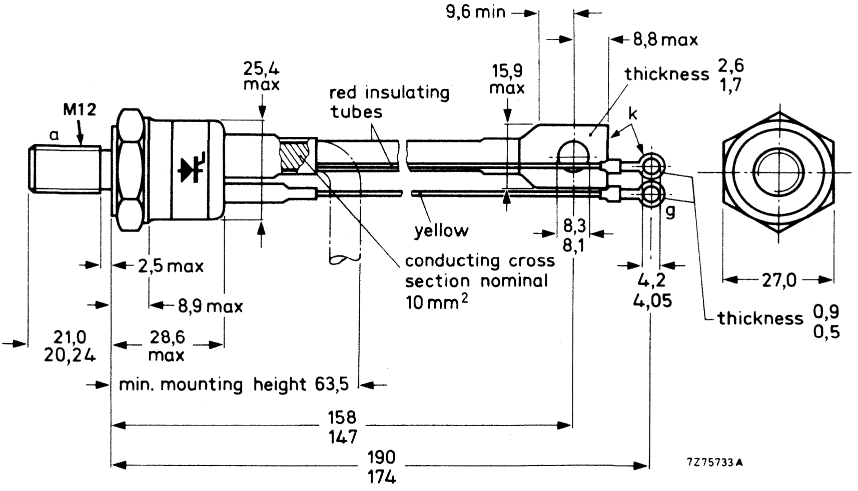
		BTW23-600R	800R	1000R	1200R	1400R	1600R	
Repetitive peak voltages $V_{DRM} = V_{RRM}$	max.	600	800	1000	1200	1400	1600	V

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

MECHANICAL DATA

Dimensions in mm

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



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

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

RATINGS

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

Anode to cathode

			BTW23-600R	800R	1000R	1200R	1400R	1600R	
Non-repetitive peak voltages ($t \leqslant 10$ 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 $T_{mb} = 85\ ^{o}C$	$I_{T(AV)}$	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; $T_j = 125\ ^{o}C$ prior to surge; with reapplied $V_{RWM\,max}$	I_{TSM}	max.	2000	A
I^2t for fusing (t = 10 ms)	I^2t	max.	20 000	A^2s
Rate of rise of on-state current after triggering with $I_G = 750$ mA to $I_T = 300$ A; $dI_G/dt = 1$ A/μs	dI_T/dt	max.	300	A/μs
Rate of change of commutation current	see Fig. 14			

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	^{o}C
Junction temperature	T_j	max.	125	^{o}C

THERMAL RESISTANCE

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

---

* To ensure thermal stability: $R_{th\ j\text{-}a} < 0,75\ ^{o}C/W$ (d.c. blocking) or $< 1,5\ ^{o}C/W$ (a.c.). For smaller heatsinks $T_{j\ max}$ should be derated. For a.c. see Fig. 4.

CHARACTERISTICS

Anode to cathode

On-state voltage $I_T = 500$ A; $T_j = 25$ °C	V_T	$<$	2,2	V*
Rate of rise of off-state voltage that will not trigger any device; exponential method; $V_D = 2/3\ V_{DRM\ max}$; $T_j = 125$ °C	dV_D/dt	$<$	200	V/µs
Reverse current $V_R = V_{RWM\ max}$; $T_j = 125$ °C	I_R	$<$	15	mA
Off-state current $V_D = V_{DWM\ max}$; $T_j = 125$ °C	I_D	$<$	15	mA
Holding current; $T_j = 25$ °C	I_H	$<$	200	mA

Gate to cathode

Voltage that will trigger all devices $V_D = 6$ V; $T_j = 25$ °C	V_{GT}	$>$	2,5	V
Voltage that will not trigger any device $V_D = V_{DRM\ max}$; $T_j = 125$ °C	V_{GD}	$<$	250	mV
Current that will trigger any device $V_D = 6$ V; $T_j = 25$ °C	I_{GT}	$>$	150	mA

Switching characteristics

Gate-controlled turn-on time ($t_{gt} = t_d + t_r$) when switched from $V_D = V_{DWM\ max}$ to $I_T = 100$ A; $I_{GT} = 200$ mA; $dI_G/dt = 1$ A/µs; $T_j = 25$ °C	t_{gt}	$<$	2,5	µs
	t_r	typ.	1	µs

* Measured under pulse conditions to avoid excessive dissipation.

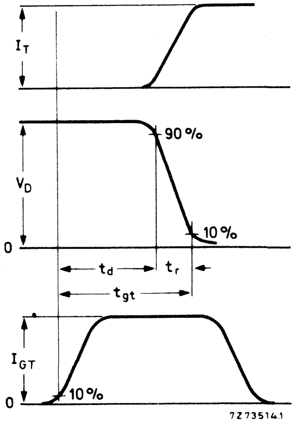


Fig. 2 Gate-controlled turn-on time definitions.

CHARACTERISTICS (continued)

Circuit-commutated turn-off when switched
from I_T = 50 A to $V_R \geqslant$ 50 V with $-dI_T/dt$ = 50 A/µs;
dV_D/dt = 200 V/µs;

T_j = 125 °C	t_q	typ.	100 µs
		<	200 µs
T_j = 25 °C	t_q	typ.	60 µs
		<	120 µs

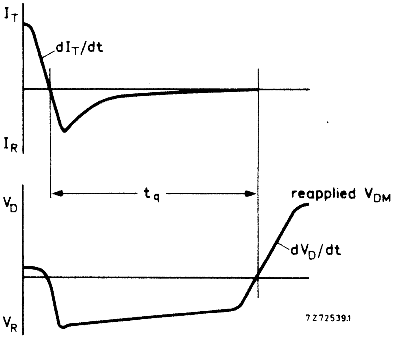


Fig. 3 Circuit-commutated turn-off time definition.

OPERATING NOTE

Switching losses in commutation

For applications in which the thyristor is forced to switch from an on-state current I_{TRM} to a high reverse voltage at a high commutation rate ($-dI_T/dt$), consult Fig. 14 (nomogram) to find the increase in total average power. This increase must be added to the loss from the curves in Fig. 4.

ORDERING NOTE

Types with dV_D/dt of 1000 V/µs are available on request. Add suffix C to the type number when ordering; e.g. BTW23-600RC.

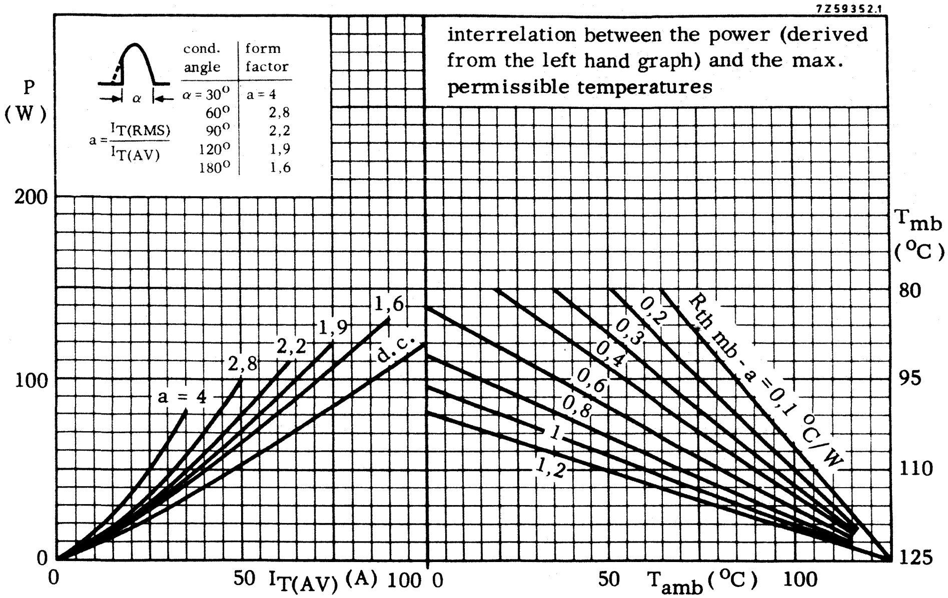

7Z59352.1
cond. angle
form factor
α
$a = \frac{I_{T(RMS)}}{I_{T(AV)}}$
α = 30° | a = 4
60° | 2,8
90° | 2,2
120° | 1,9
180° | 1,6
interrelation between the power (derived from the left hand graph) and the max. permissible temperatures
P (W)
200
100
0
0
50
$I_{T(AV)}$ (A)
100
a = 4
2,8
2,2
1,9
1,6
d.c.
0
50
T_{amb} (°C)
100
T_{mb} (°C)
80
95
110
125
$R_{th\ mb-a}$ = 0,1 °C/W
0,2
0,3
0,4
0,6
0,8
1
1,2

Fig. 4.

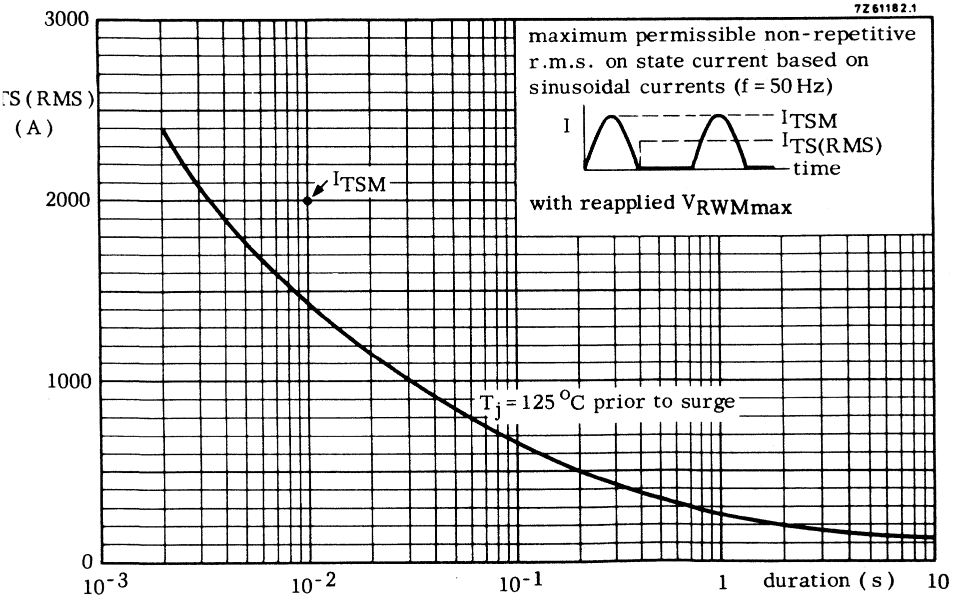

7Z61182.1
maximum permissible non-repetitive r.m.s. on state current based on sinusoidal currents (f = 50 Hz)
I
I_{TSM}
$I_{TS(RMS)}$
time
with reapplied V_{RWMmax}
3000
TS (RMS)
(A)
2000
1000
0
I_{TSM}
T_j = 125 °C prior to surge
10^{-3}
10^{-2}
10^{-1}
1
duration (s)
10

Fig. 5.

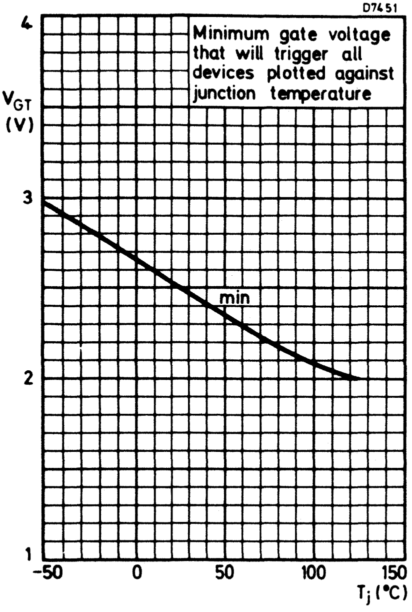


Fig. 6.

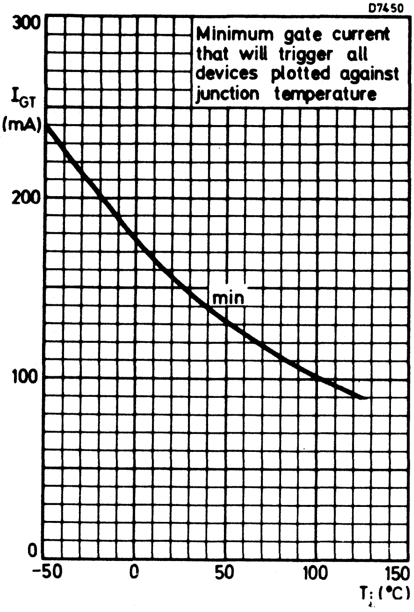


Fig. 7.

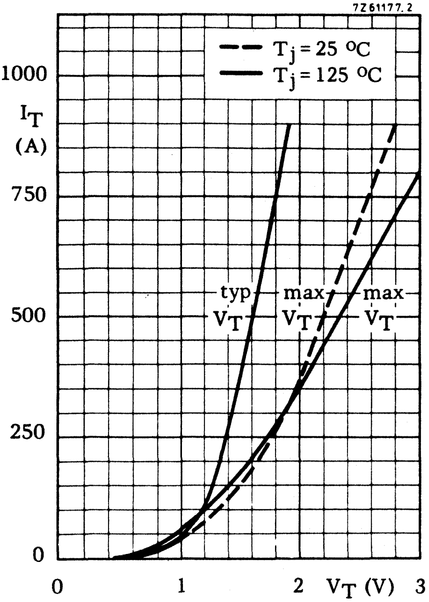


Fig. 8.

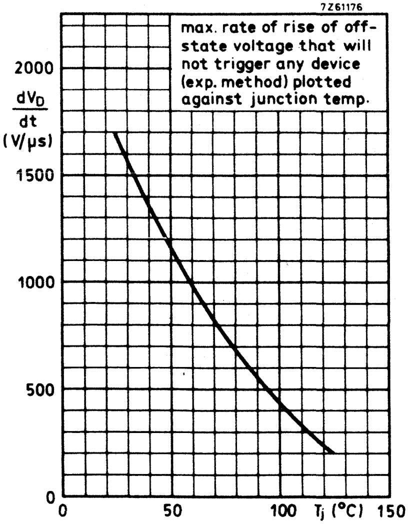


Fig. 9.

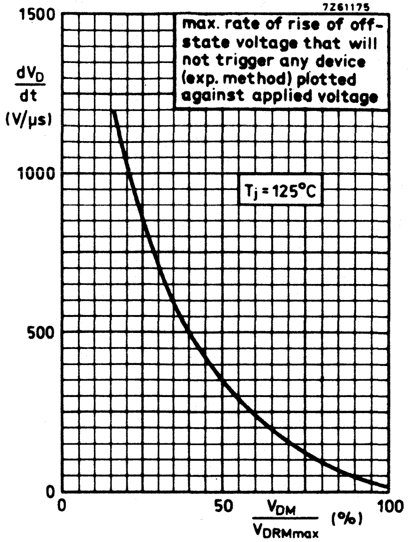


Fig. 10.

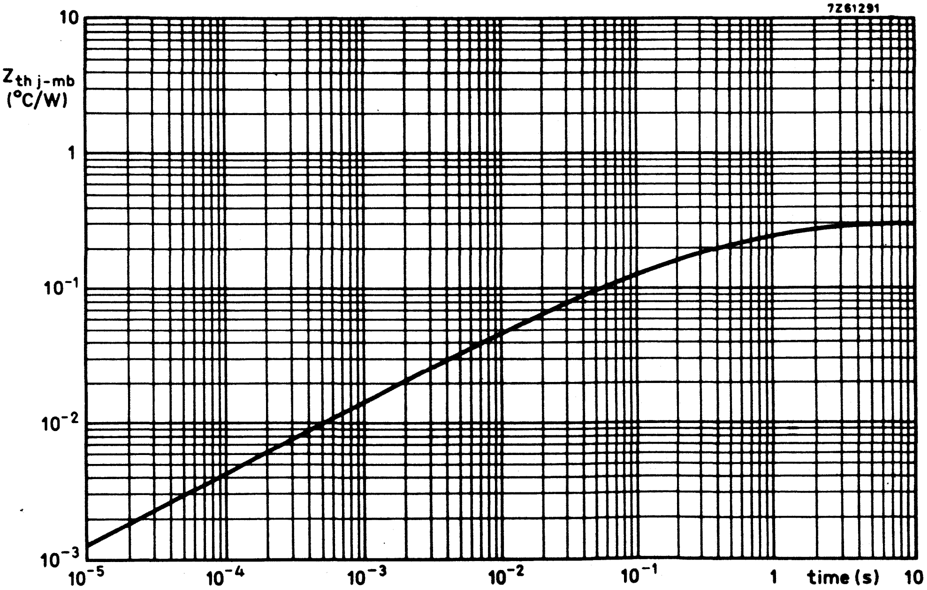


Fig. 11.

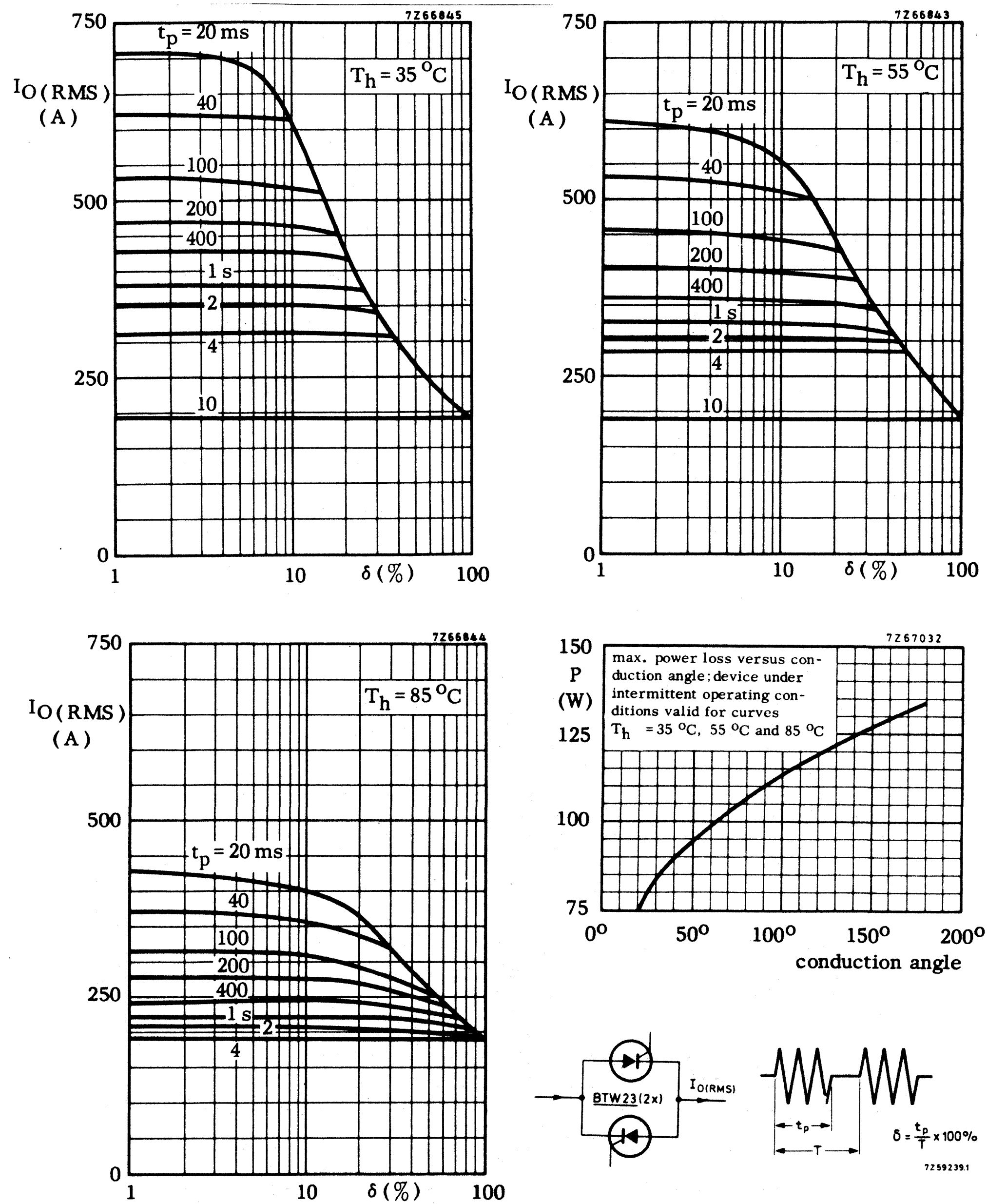


Fig. 12 Intermittent overload capability of two BTW23 thyristors in anti-parallel connection in a single phase a.c. control circuit (e.g. welding); conduction angle 360°.

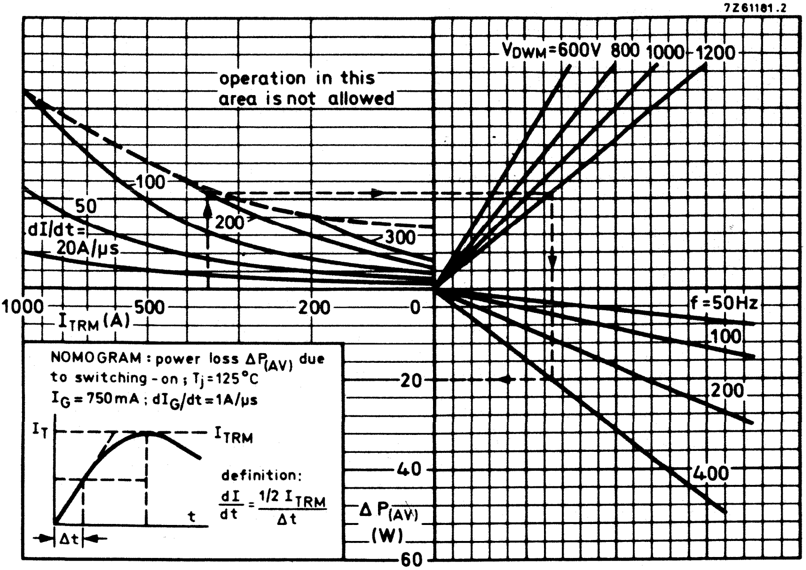

7Z61181.2
VDWM=600V
800
1000
1200
operation in this area is not allowed
100
50
200
300
dI/dt=
20A/µs
1000
500
200
0
ITRM (A)
f=50Hz
100
200
400
20
40
60
Δ P(AV)
(W)
NOMOGRAM : power loss ΔP(AV) due to switching-on ; Tj=125°C
IG=750mA ; dIG/dt=1A/µs
IT
ITRM
t
Δt
definition:
dI/dt = 1/2 ITRM / Δt

Fig. 13.

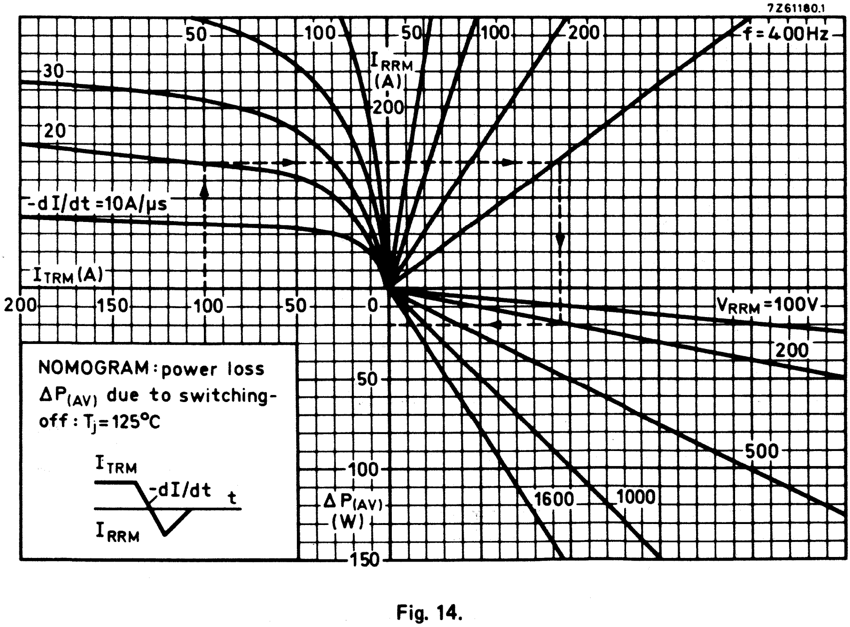
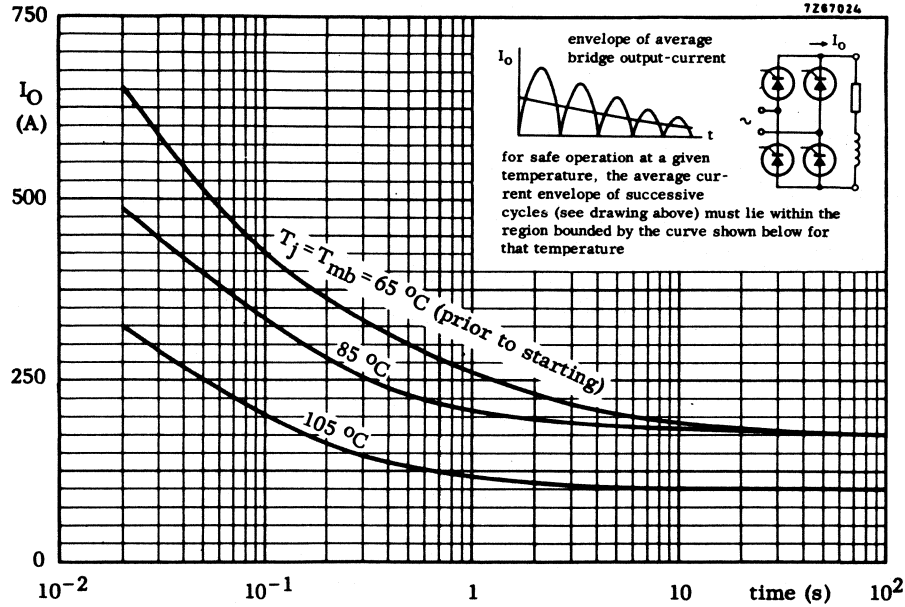

7Z61180.1
50
100
50
100
200
f=400Hz
IRRM
(A)
200
30
20
-dI/dt=10A/µs
ITRM (A)
200
150
100
50
0
VRRM=100V
200
500
1000
1600
50
100
150
Δ P(AV)
(W)
NOMOGRAM: power loss ΔP(AV) due to switching-off : Tj=125°C
ITRM
-dI/dt
t
IRRM

Fig. 14.



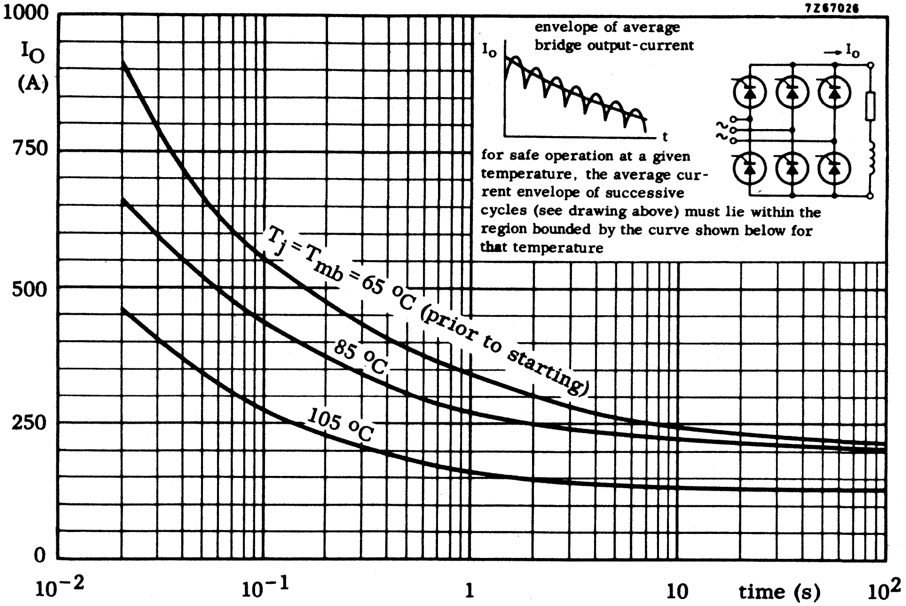


Fig. 15 Limits for starting or inrush currents.

THYRISTORS

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

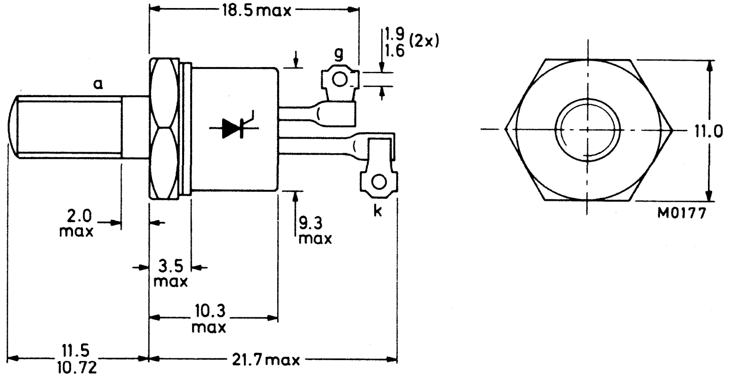
QUICK REFERENCE DATA

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

MECHANICAL DATA

Dimensions in mm

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



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

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

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

RATINGS

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

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

Average on-state current (averaged over any 20 ms period) up to T_{mb} = 85 °C	$I_{T(AV)}$	max.	10	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	16	A
Repetitive peak on-state current	I_{TRM}	max.	75	A
Non-repetitive peak on-state current; t = 10 ms; half sine-wave; T_j = 125 °C prior to surge; with reapplied V_{RWMmax}	I_{TSM}	max.	150	A
I^2t for fusing (t = 10 ms)	I^2t	max.	112	A^2s
Rate of rise of on-state current after triggering with I_G = 250 mA to I_T = 25 A; dI_G/dt = 0.25 A/µs	dI_T/dt	max.	50	A/µs
Gate to cathode				
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	0.5	W
Peak power dissipation	P_{GM}	max.	5	W
Temperatures				
Storage temperature	T_{stg}		−55 to +125	°C
Junction temperature	T_j	max.	125	°C

THERMAL RESISTANCE

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

OPERATING NOTE

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

---

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

CHARACTERISTICS

Anode to cathode

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

Gate to cathode

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

Switching characteristics ←

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

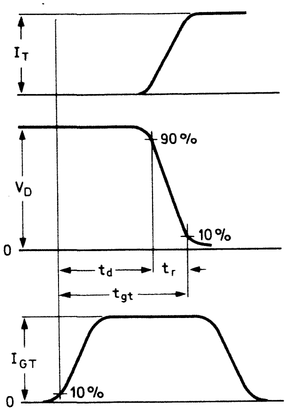


Fig.2a Gate-controlled turn-on time definition.

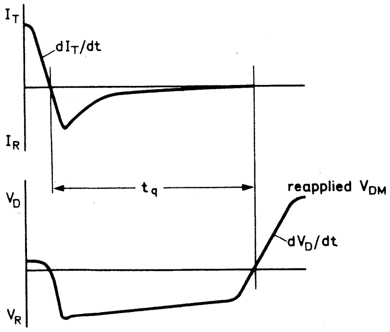


Fig.2b Circuit-commutated turn-off time definition.

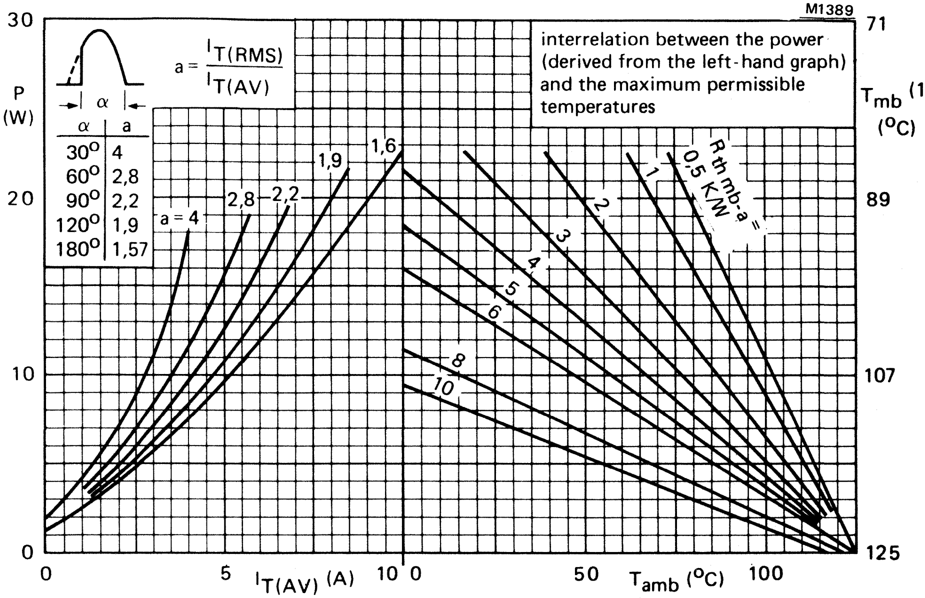


Fig. 3 (1) T_{mb}-scale is for comparison purposes only and is correct only for $R_{th\,mb\text{-}a} \leqslant 6$ K/W

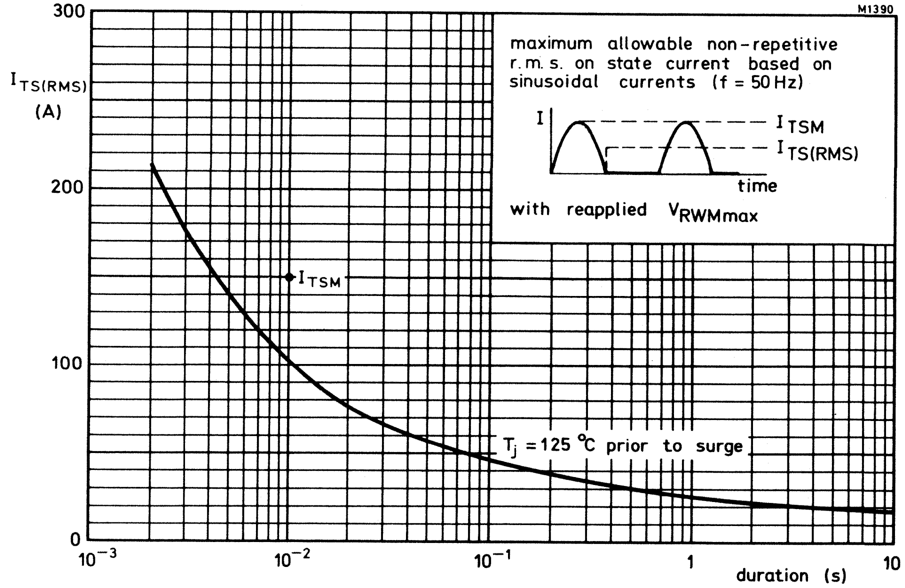


Fig. 4.

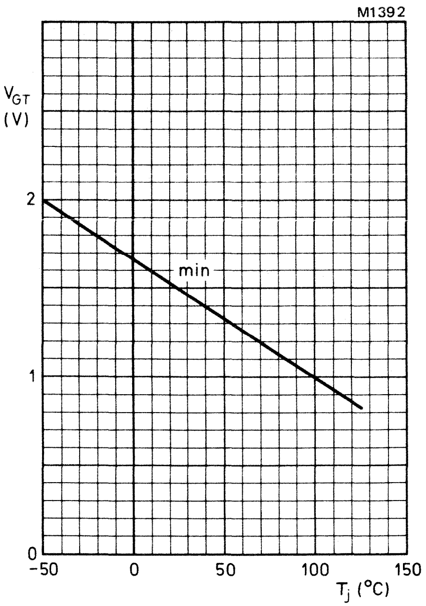


Fig. 5 Minimum gate voltage that will trigger all devices as a function of T_j.

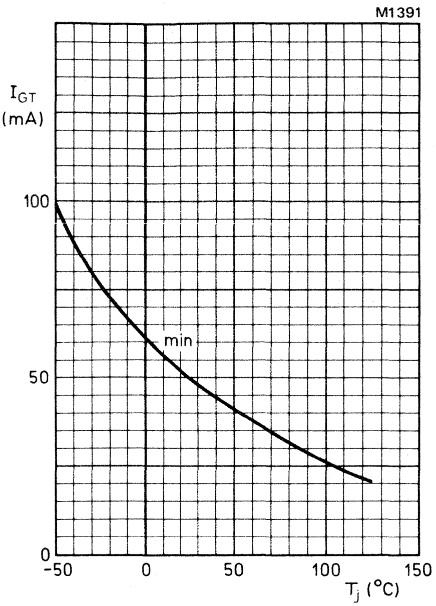


Fig. 6 Minimum gate current that will trigger all devices as a function of T_j.

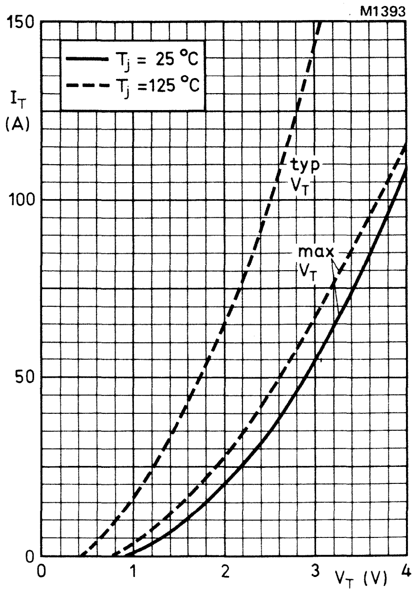


Fig. 7.

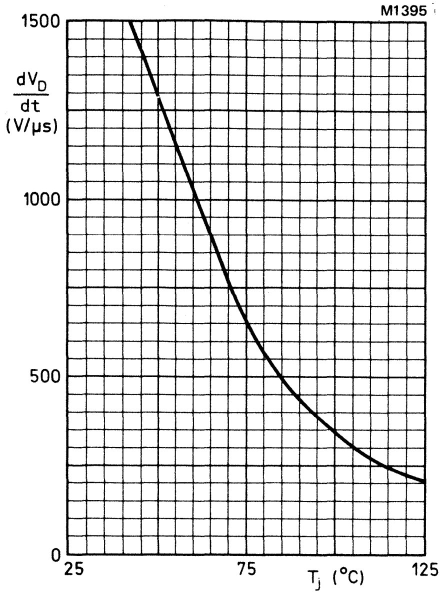


Fig. 8 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of T_j.

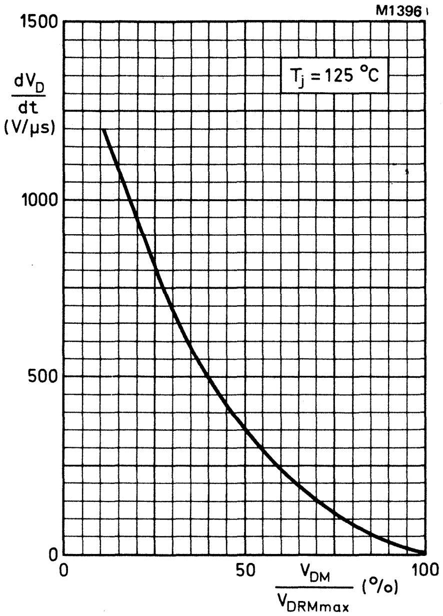
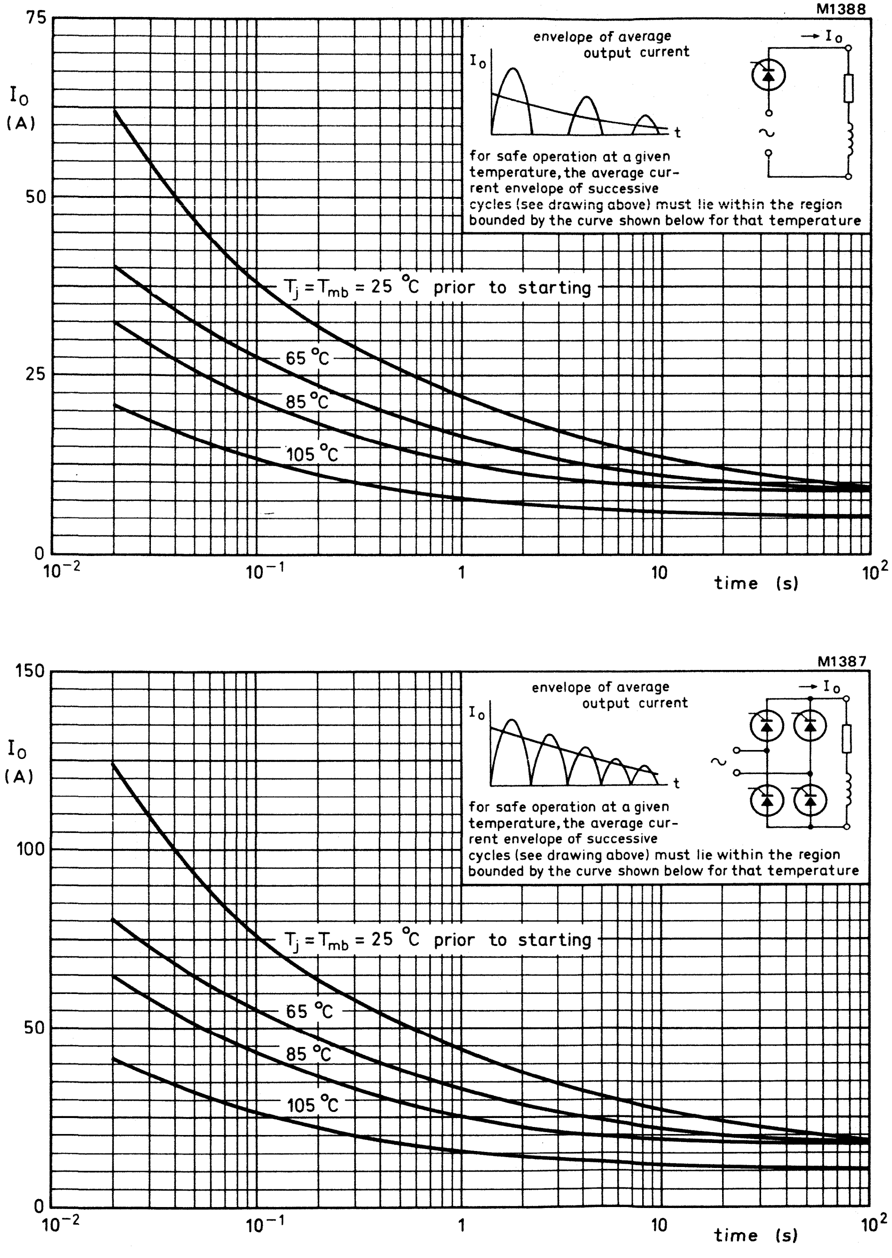


Fig. 9 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of applied voltage.



for safe operation at a given temperature, the average current envelope of successive cycles (see drawing above) must lie within the region bounded by the curve shown below for that temperature

for safe operation at a given temperature, the average current envelope of successive cycles (see drawing above) must lie within the region bounded by the curve shown below for that temperature

Fig. 10 Limits for starting or inrush currents.

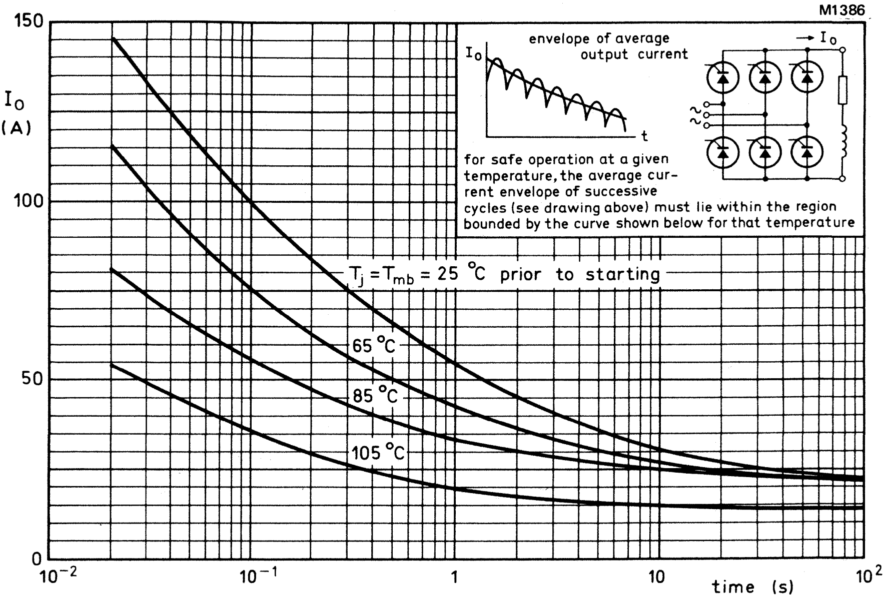


Fig. 11 Limits for starting or inrush currents.

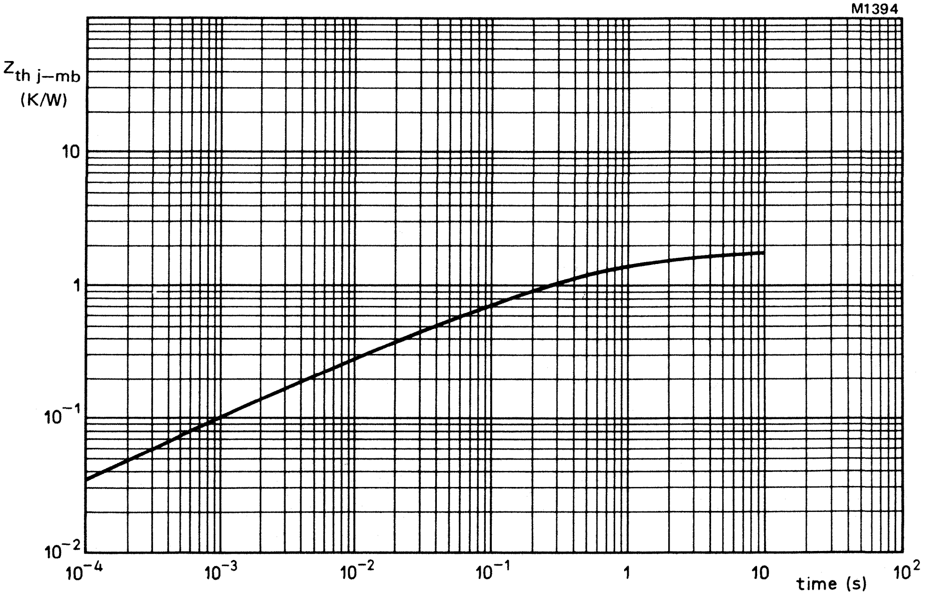


Fig. 12.

THYRISTORS

Also available to BS9341-F083

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

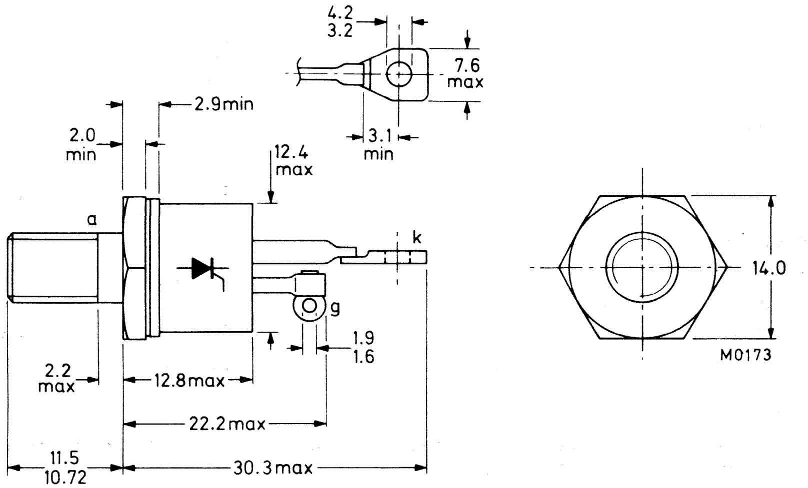
QUICK REFERENCE DATA

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

MECHANICAL DATA

Dimensions in mm

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



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

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

RATINGS

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

Anode to cathode

			BTW40-400R	600R	800R	
Non-repetitive peak voltages ($t \leq 10$ 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^2s
Rate of rise of on-state current after triggering with I_G = 400 mA to I_T = 60 A; dI_G/dt = 0,4 A/µs	dI_T/dt	max.	100	A/µs

Gate to cathode

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

Temperatures

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

THERMAL RESISTANCE

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

OPERATING NOTE

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

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

CHARACTERISTICS

Anode to cathode

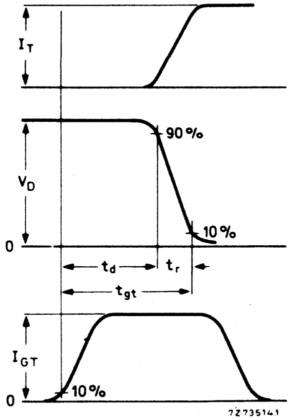
On-state voltage $I_T = 50$ A; $T_j = 25$ °C	V_T	<	2,1	V *
Rate of rise of off-state voltage that will not trigger any device; exponential method; $V_D = 2/3\ V_{DRMmax}$; $T_j = 125$ °C	dV_D/dt	<	100	V/µs
Reverse current $V_R = V_{RWMmax}$; $T_j = 125$ °C	I_R	<	3	mA
Off-state current $V_D = V_{DWMmax}$;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

Gate to cathode

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

Switching characteristics

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



Gate-controlled turn-on time definition

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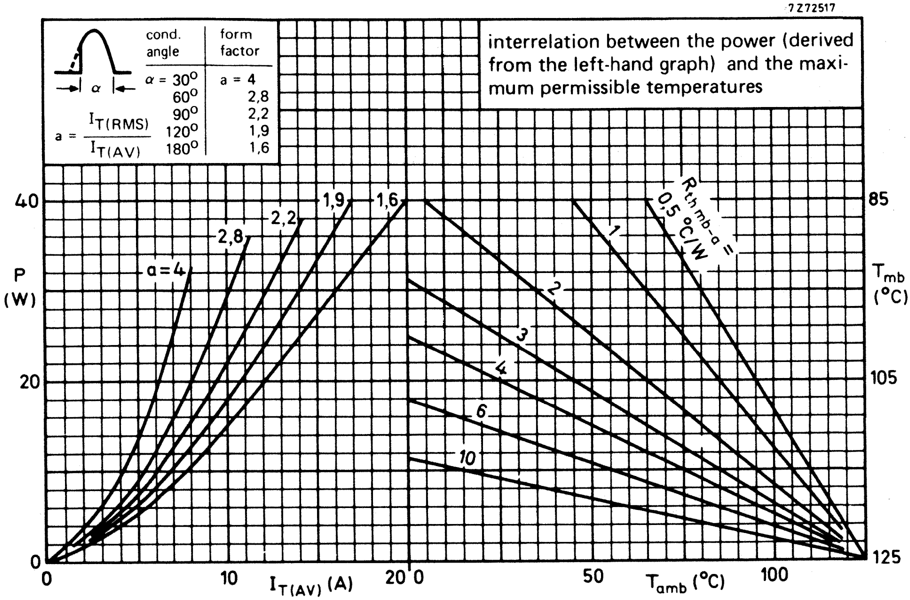
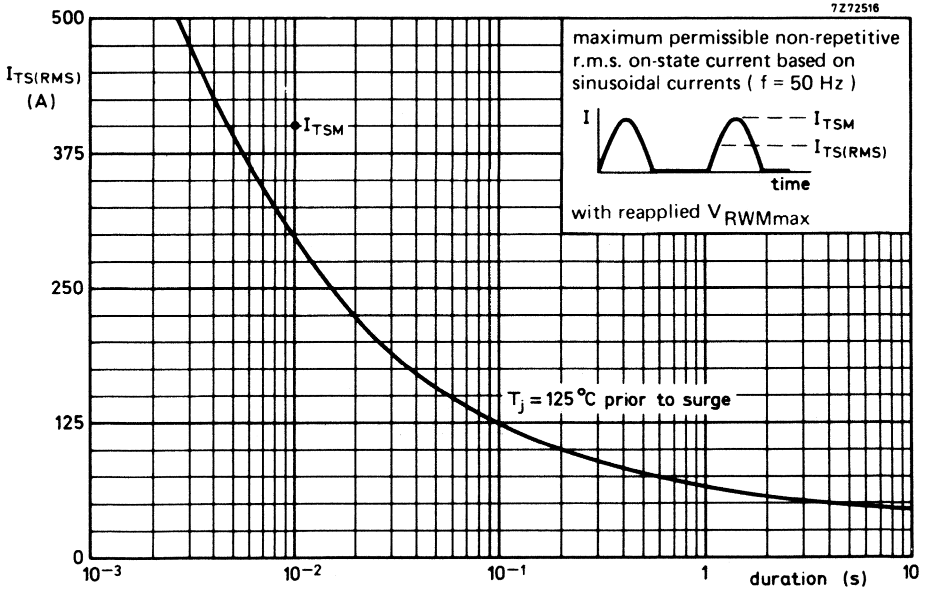
*Measured under pulse conditions to avoid excessive dissipation.



interrelation between the power (derived from the left-hand graph) and the maximum permissible temperatures

Fig. 2.



maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents (f = 50 Hz)

with reapplied V_{RWMmax}

Fig. 3.

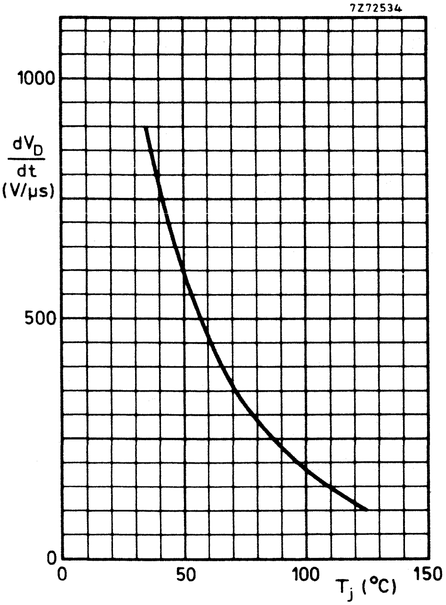


Fig. 4 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of T_j.

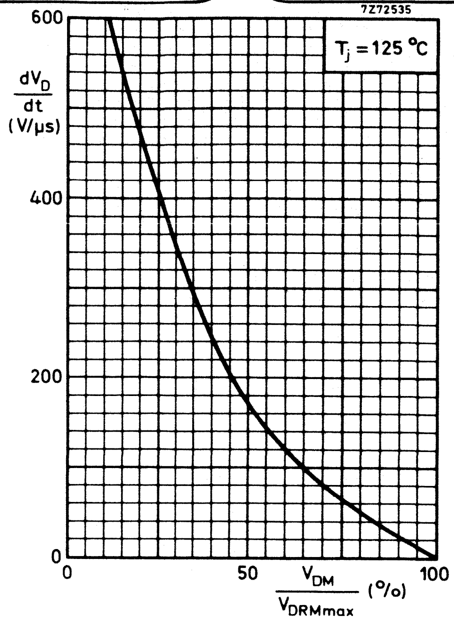


Fig. 5 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of applied voltage.

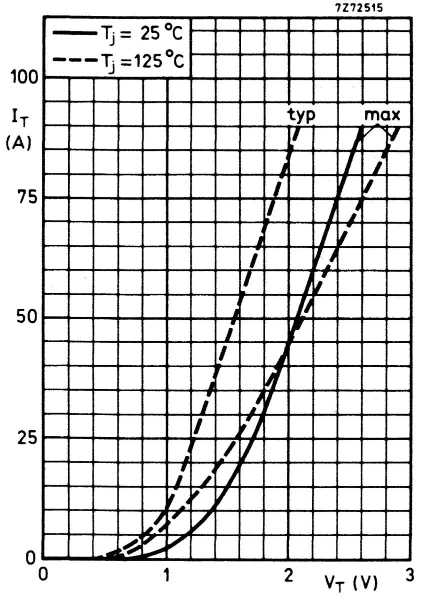


Fig. 6.

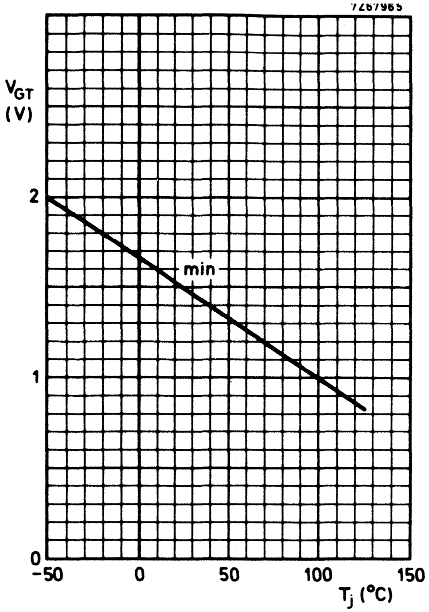


Fig. 7 Minimum gate voltage that will trigger all devices as a function of T_j.

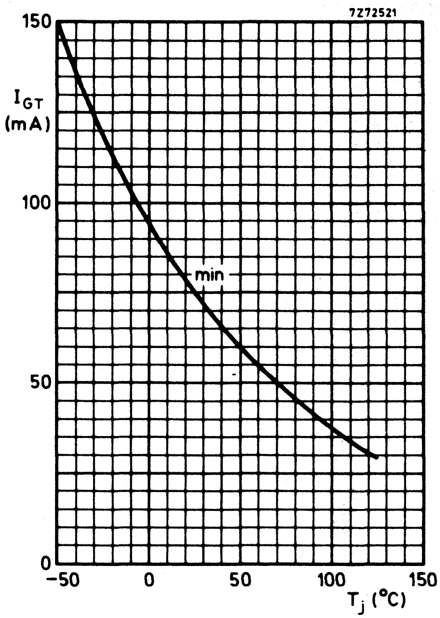


Fig. 8 Minimum gate current that will trigger all devices as a function of T_j.

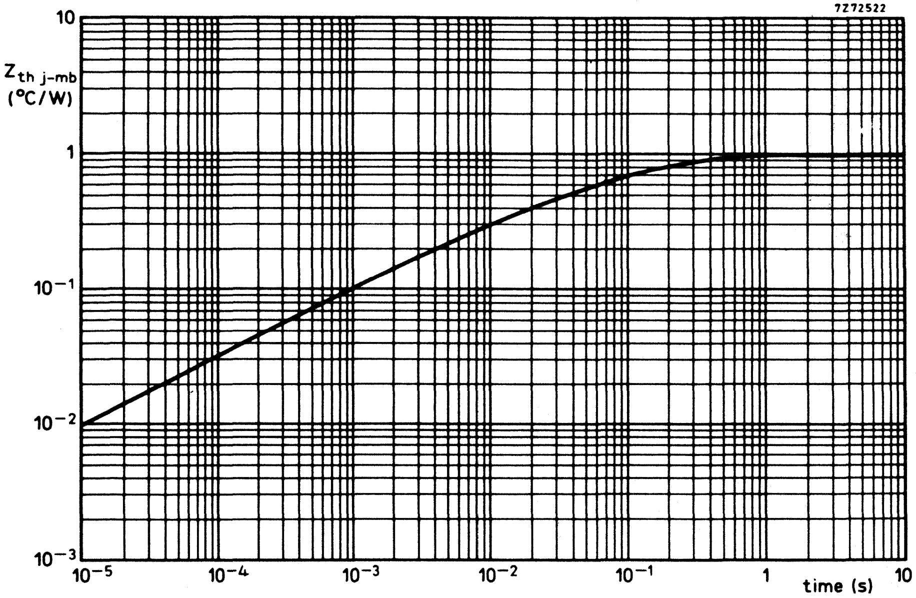


Fig. 9.

THYRISTORS

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

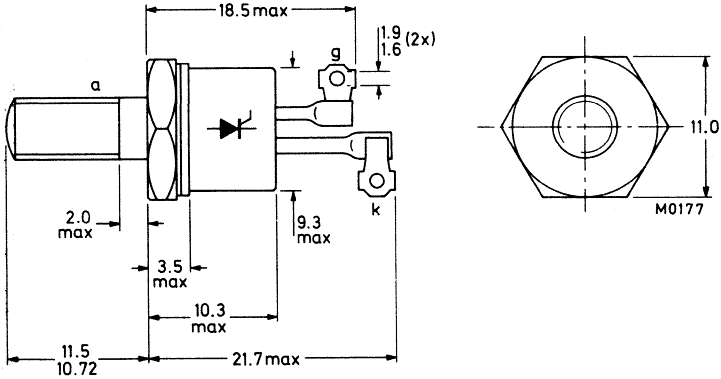
QUICK REFERENCE DATA

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

MECHANICAL DATA

Dimensions in mm

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



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

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

←

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

RATINGS

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

Anode to cathode

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

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

Gate to cathode

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

Temperatures

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

THERMAL RESISTANCE

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

OPERATING NOTE

The terminals should neither be bent nor twisted; they should be soldered into the circuit so that there is no strain on them.

During soldering the heat conduction to the junction should be kept to a minimum.

ORDERING NOTE

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

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

CHARACTERISTICS

Anode to cathode

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

Gate to cathode

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

Switching characteristics

←

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

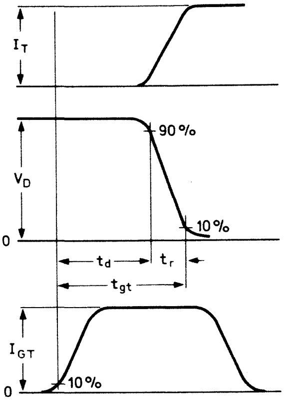


Fig.2a Gate-controlled turn-on time definition.

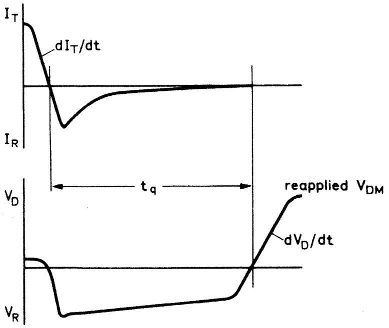


Fig.2b Circuit-commutated turn-off time definition.

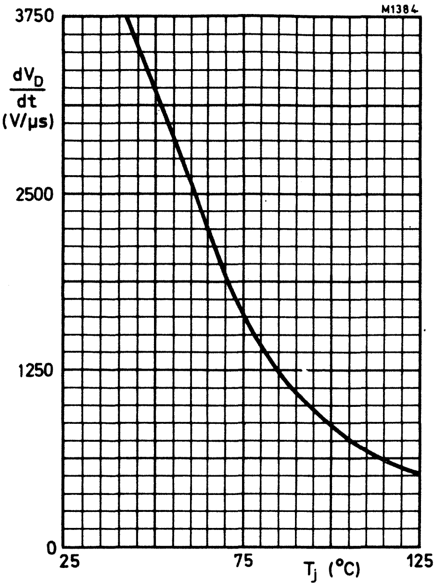


Fig.3 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of T_j.

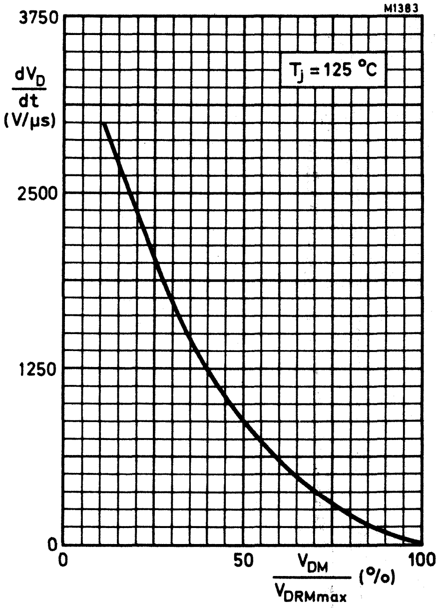


Fig.4 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of applied voltage.

FOR FURTHER DETAILS REFER TO BTW38 DATA.

THYRISTORS

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

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

QUICK REFERENCE DATA

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

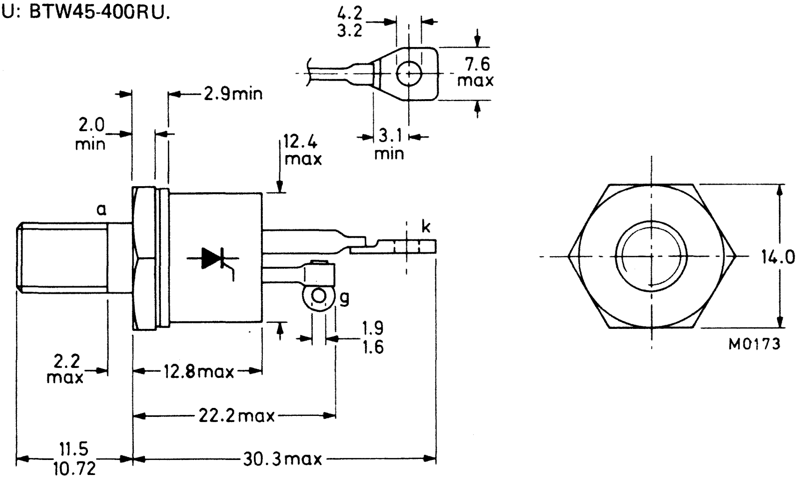
Average on-state current	$I_{T(AV)}$	max.	16	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	25	A
Non-repetitive peak on-state current	I_{TSM}	max.	300	A
Rate of rise of off-state voltage that will not trigger any device	dV_D/dt	$<$	200	V/μs
On request (see Ordering Note)	dV_D/dt	$<$	1000	V/μs

MECHANICAL DATA

Dimensions in mm

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

Types with ¼ in x 28 UNF stud (ϕ 6,35 mm) are available on request. These are indicated by the suffix U: BTW45-400RU.



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

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

Products approved to CECC 50 011-002, available on request

RATINGS

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

Anode to cathode

			BTW45-400R	600R	800R	1000R	1200R	
Non-repetitive peak voltages ($t \leqslant 10$ ms)	V_{DSM}/V_{RSM}	max.	400	600	800	1000	1200	V
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	400	600	800	1000	1200	V
Crest working voltages	V_{DWM}/V_{RWM}	max.	300	400	600	700	800	V*

Average on-state current (averaged over any 20 ms period) up to T_{mb} = 85 °C	$I_{T(AV)}$	max.	16	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	25	A
Repetitive peak on-state current	I_{TRM}	max.	200	A
Non-repetitive peak on-state current; t = 10 ms; half sine-wave; T_j = 125 °C prior to surge; with reapplied $V_{RWM\,max}$	I_{TSM}	max.	300	A
I^2t for fusing (t = 10 ms)	I^2t	max.	450	A^2s
Rate of rise of on-state current after triggering with I_G = 400 mA to I_T = 60 A; dI_G/dt = 0,4 A/µs	dI_T/dt	max.	100	A/µs

Gate to cathode

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

Temperatures

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

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,33	°C/W
From mounting base to heatsink; with heatsink compound	$R_{th\ mb\text{-}h}$	=	0,2	°C/W
Transient thermal impedance (t = 1 ms)	$Z_{th\ j\text{-}mb}$	=	0,1	°C/W

OPERATING NOTE

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

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* To ensure thermal stability: $R_{th\ j\text{-}a} < 6{,}5$ °C/W (d.c. blocking) or < 13 °C/W (a.c.). For smaller heatsinks $T_{j\ max}$ should be derated. For a.c. see Fig. 2.

CHARACTERISTICS

Anode to cathode

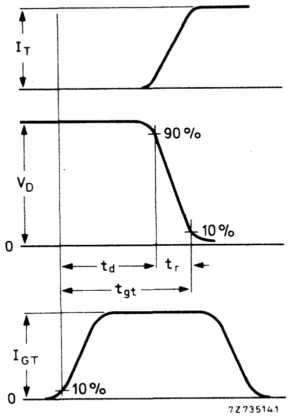
On-state voltage $I_T = 50$ A; $T_j = 25$ °C	V_T	<	2	V*
Rate of rise of off-state voltage that will not trigger any device; exponential method; $V_D = 2/3\ V_{DRM\,max}$; $T_j = 125$ °C	dV_D/dt	<	200	V/μs
Reverse current $V_R = V_{RWM\,max}$; $T_j = 125$ °C	I_R	<	3	mA
Off-state current $V_D = V_{DWM\,max}$; $T_j = 125$ °C	I_D	<	3	mA
Latching current; $T_j = 25$ °C	I_L	<	150	mA
Holding current; $T_j = 25$ °C	I_H	<	75	mA

Gate to cathode

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

Switching characteristics

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

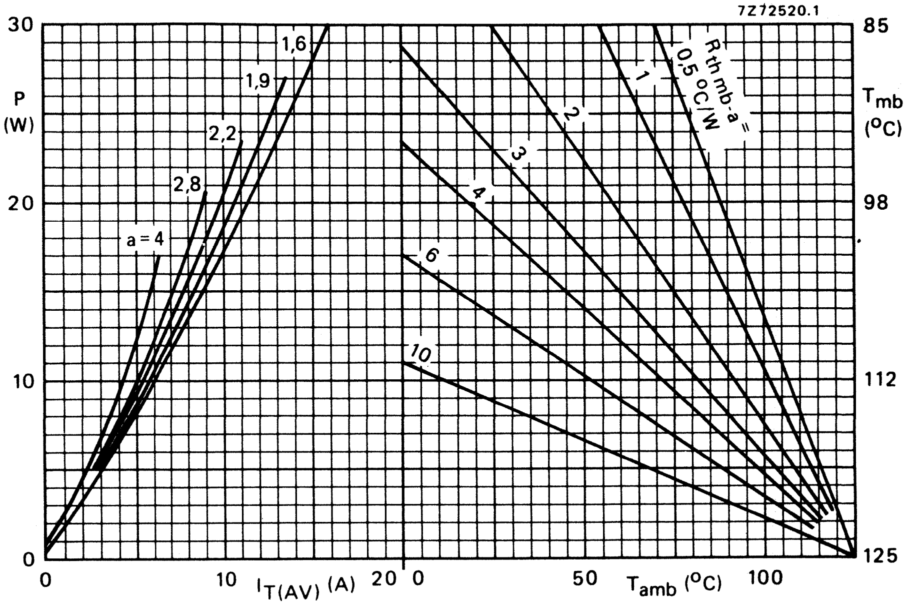


Gate-controlled turn-on time definition.

ORDERING NOTE

Types with dV_D/dt of 1000 V/μs are available on request. Add suffix C to the type number when ordering; e.g. BTW45-400RC.

*Measured under pulse conditions to avoid excessive dissipation.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P
(W)
30
20
10
0
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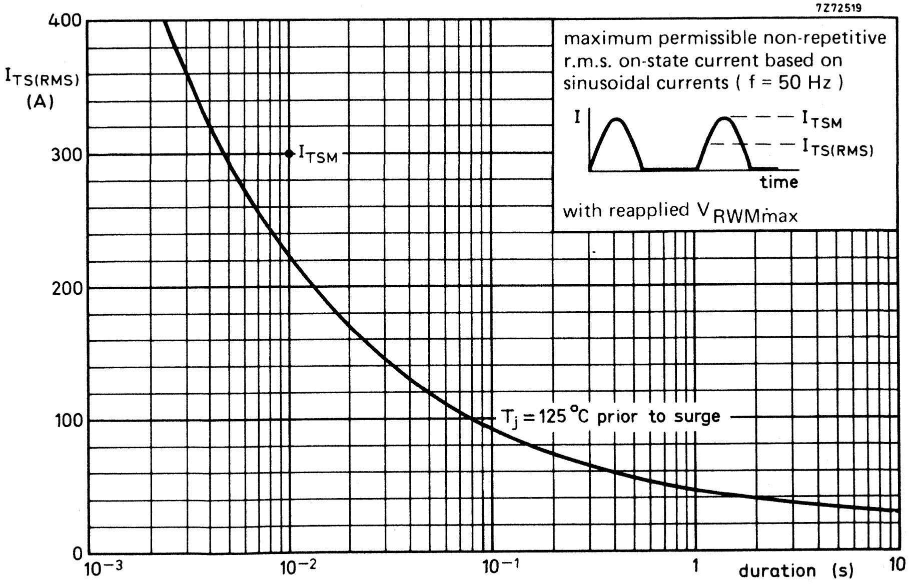
10
20
I T(AV) (A)
a = 4
2,8
2,2
1,9
1,6
0
50
100
Tamb (°C)
Rth mb-a =
0,5 °C/W
1
2
3
4
6
10
Tmb
(°C)
85
98
112
125

Fig. 2.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(A)
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300
200
100
0
10^{-3}
10^{-2}
10^{-1}
1
10
duration (s)
ITSM
maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents (f = 50 Hz)
I
ITSM
ITS(RMS)
time
with reapplied VRWMmax
Tj = 125 °C prior to surge

Fig. 3.

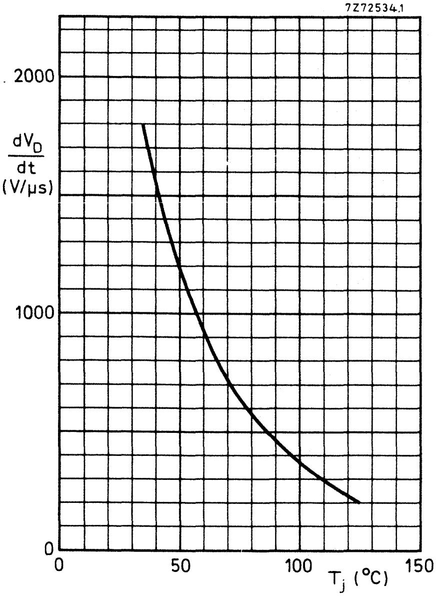


Fig. 4 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of T_j.

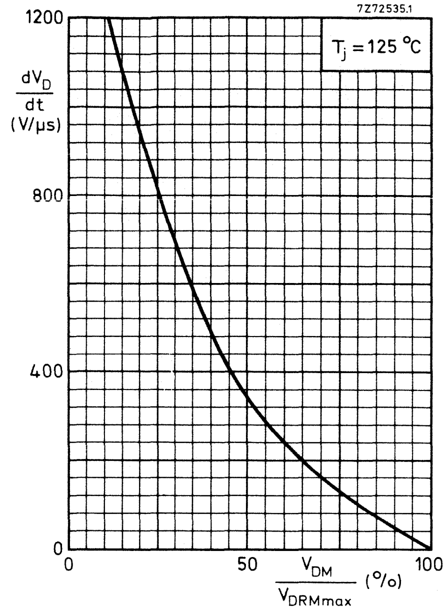


Fig. 5 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of applied voltage.

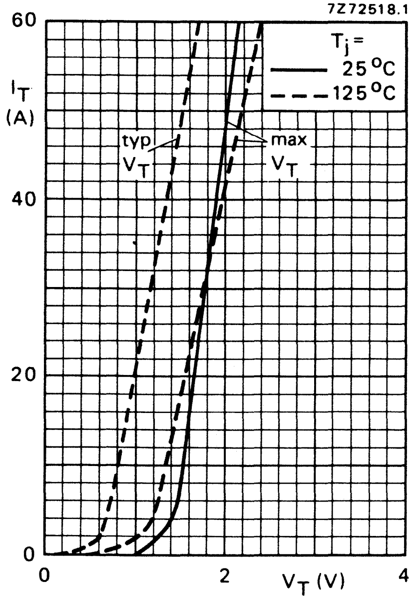


Fig. 6.

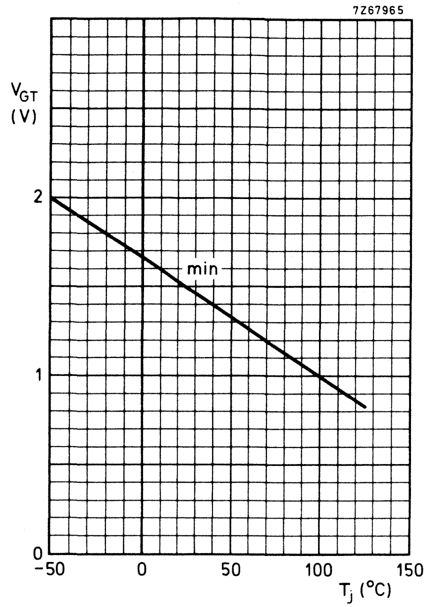


Fig. 7 Minimum gate voltage that will trigger all devices as a function of T_j.

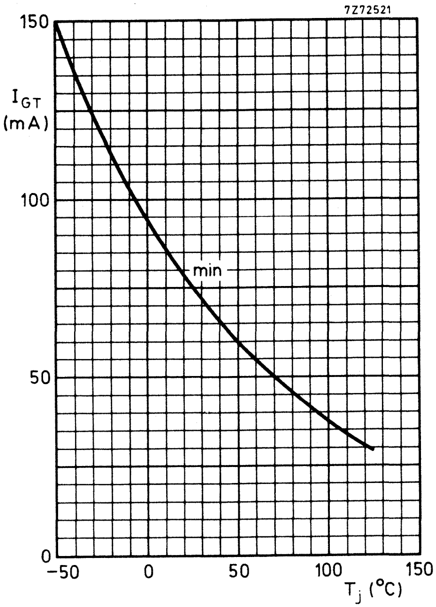


Fig. 8 Minimum gate current that will trigger all devices as a function of T_j.

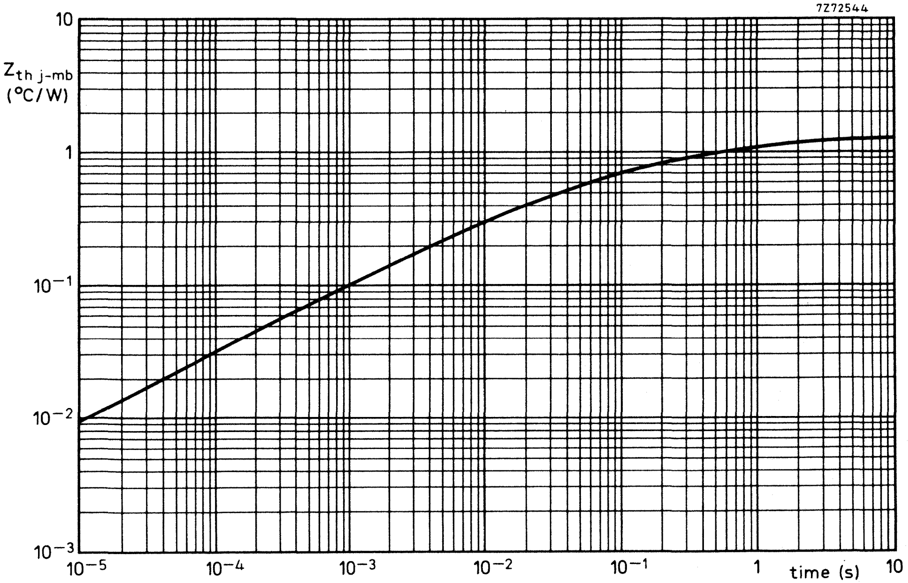


Fig. 9.

FAST TURN-OFF THYRISTORS

Glass-passivated, asymmetrical, fast turn-off, forward blocking thyristors (ASCR) in TO-48 envelopes, suitable for operation in fast power inverters. For reverse-blocking operation use with a series diode, for reverse-conducting operation use with an anti-parallel diode.

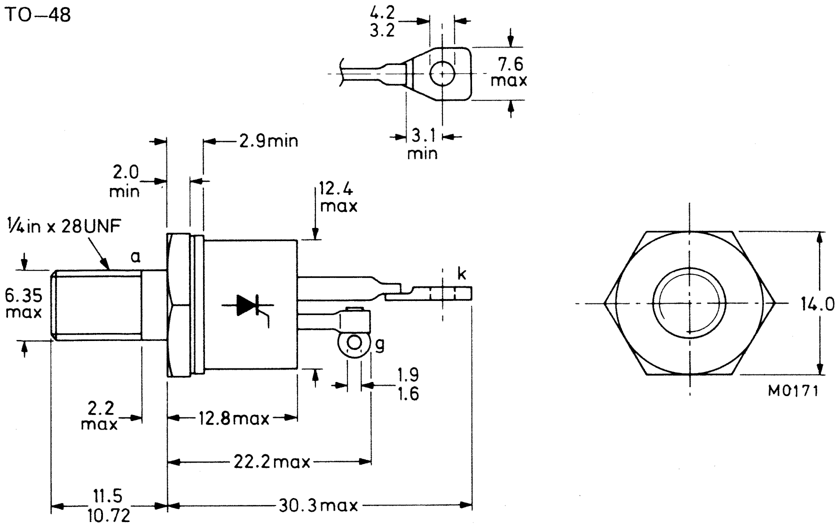
QUICK REFERENCE DATA

			BTW63–600R	800R	1000R	
Repetitive peak off-state voltage	V_{DRM}	max.	600	800	1000	V
Average on-state current	$I_{T(AV)}$	max.		25		A
Repetitive peak on-state current	I_{TRM}	max.		250		A
Circuit-commutated turn-off time						
suffix K	t_q	<		4		μs
suffix N	t_q	<		6		μs
suffix P	t_q	<		8		μs

MECHANICAL DATA

Dimensions in mm

Fig.1 TO–48



Net mass: 14 g
Diameter of clearance hole: max. 6.5 mm
Accessories supplied on request:
see ACCESSORIES section.

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

RATINGS

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

→ **Anode to cathode**			BTW63–600R	800R	1000R	
Transient off-state voltage	V_{DSM}	max.	800	1000	1000	V
Repetitive peak off-state voltage	V_{DRM}	max.	600	800	1000	V
Continuous off-state voltage	V_D	max.	500	650	700	V

Transient reverse voltage ($t_p \leqslant 5\ \mu s$)	V_{RSM}	max.	15	V
Average on-state current (averaged over any 20 ms period)				
up to $T_{mb} = 75\ ^oC$	$I_{T(AV)}$	max.	25	A
at $T_{mb} = 85\ ^oC$	$I_{T(AV)}$	max.	22	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	40	A
Repetitive peak on-state current; $t_p = 50\ \mu s$; $\delta = 0.05$	I_{TRM}	max.	250	A
Non-repetitive peak on-state current $T_j = 125\ ^oC$ prior to surge; t = 10 ms; half sine-wave	I_{TSM}	max.	370	A
I^2t for fusing; t = 10 ms	I^2t	max.	700	A^2s
→ Rate of rise of on-state current after triggering with $I_G = 1.25$ A; $I_T = 80$ A	dI_T/dt	max.	1000	A/μs

Gate to cathode

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

Temperatures

Storage temperature	T_{stg}		−40 to +125	^oC
Operating junction temperature	T_j	max.	125	^oC

THERMAL RESISTANCE

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

OPERATING NOTE

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

CHARACTERISTICS

Anode to cathode

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

Gate to cathode

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

Switching characteristics (see Fig.5)

Circuit commutated turn-off time

$dV_D/dt = 500$ V/μs (linear to V_{DRMmax});
$R_{GK} = 10\ \Omega$; $V_G = 0$; $T_j = 125$ °C;
when switched from $I_T = 100$ A; $t_p = 150$ μs

$-dI_T/dt = 50$ A/μs				
suffix K	t_q	$<$	6	μs
suffix N	t_q	$<$	9	μs
suffix P	t_q	$<$	12	μs
$-dI_T/dt = 10$ A/μs				
suffix K	t_q	$<$	4	μs
suffix N	t_q	$<$	6	μs
suffix P	t_q	$<$	8	μs

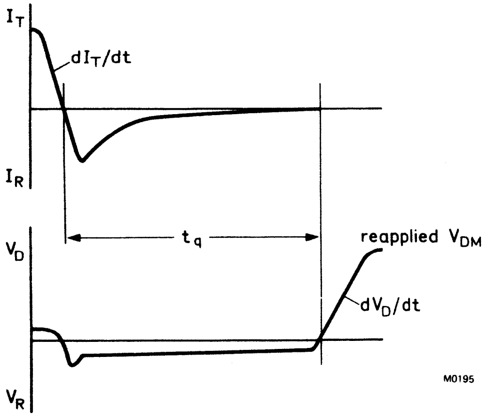


Fig.2 Circuit-commutated turn-off time definition.

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*Measured under pulse conditions to avoid excessive dissipation.

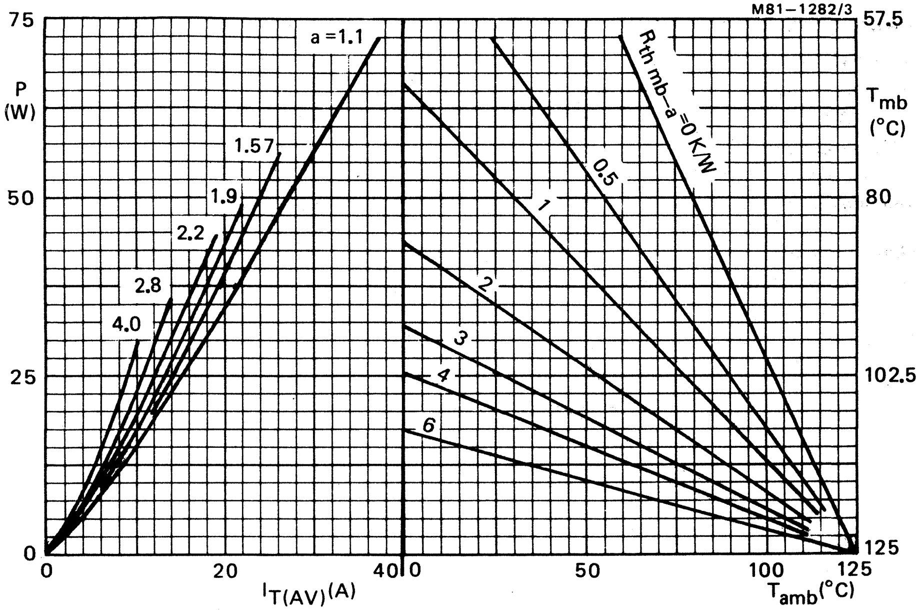


Fig.3 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

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

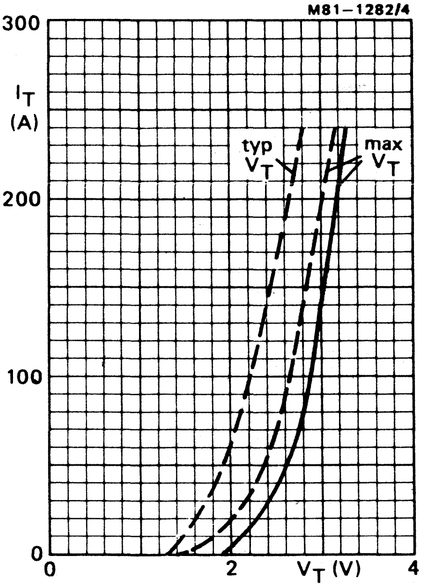


Fig.4 —— T_j = 25 °C; – – – T_j = 125 °C; t_p = 200 μs.

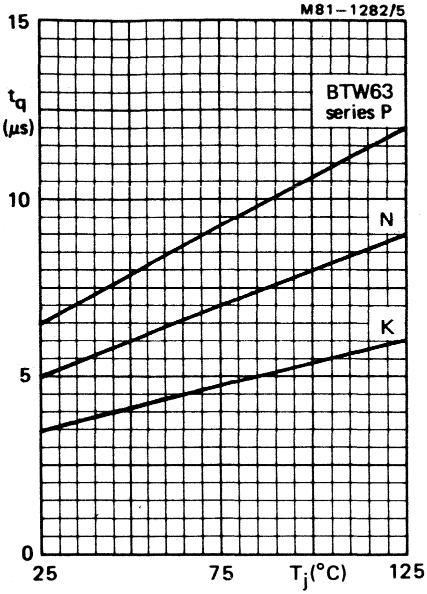


Fig.5 $-dI_T/dt$ = 50 A/μs; dV_D/dt = 500 V/μs (linear to $V_{DRMmax.}$); I_T = 100 A; t_p = 150 μs; R_{GK} = 10 Ω; V_G = 0; maximum values.

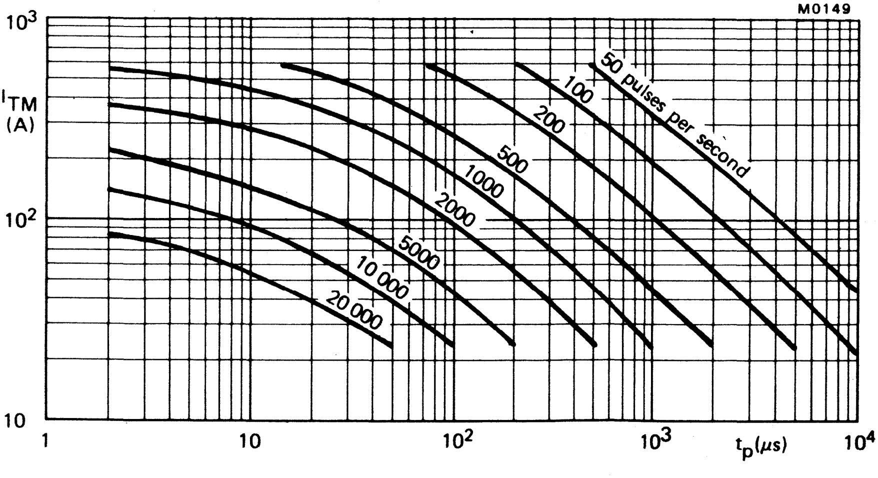


Fig.6 Maximum allowable peak on-state current versus pulse width; T_{mb} = 85 °C

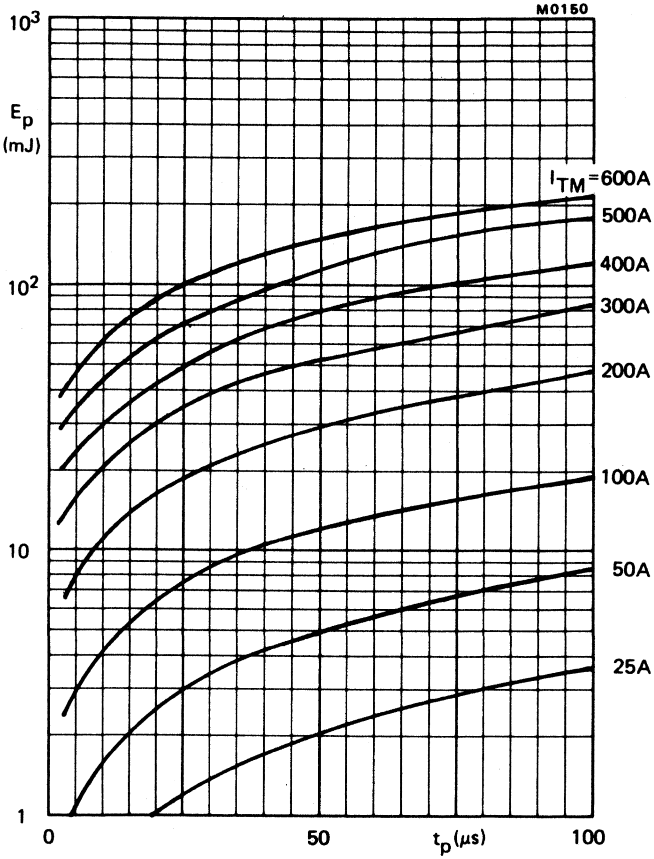


Fig.7 Maximum total energy loss per pulse when switching a half-sinusoidal pulse from 600 V.
Device power (W) = Energy per pulse (J) x No. of pulses per second.
For pulse widths > 100 µs use Fig.3.

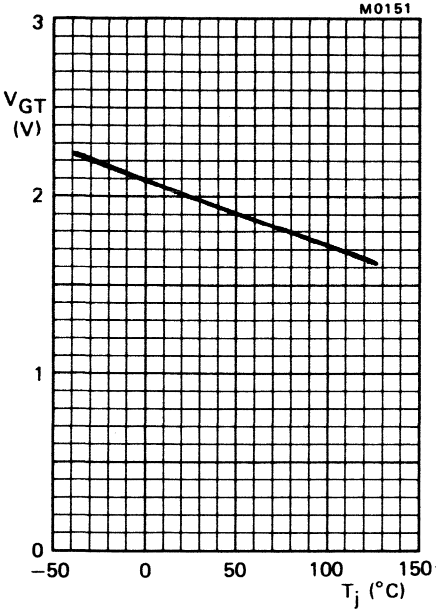


Fig.8 Minimum gate voltage that will trigger all devices plotted against junction temperature.

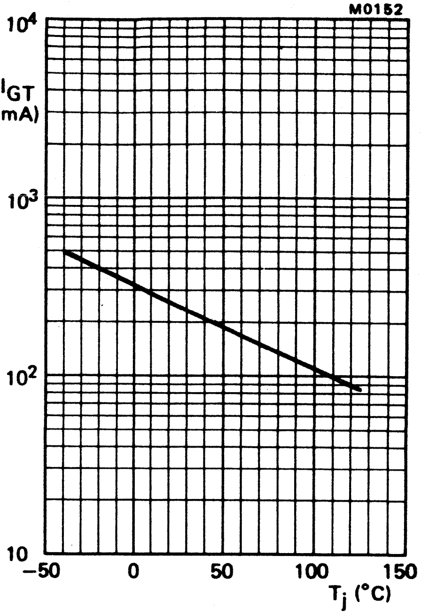


Fig.9 Minimum gate current that will trigger all devices plotted against junction temperature.

THYRISTORS

Also available to BS9341-F039

Glass-passivated silicon thyristors in metal envelopes, intended for use in general purpose three-phase power control circuits.

The series consists of reverse polarity types (anode to stud) identified by a suffix R: BTW92-800R to 1600R.

QUICK REFERENCE DATA

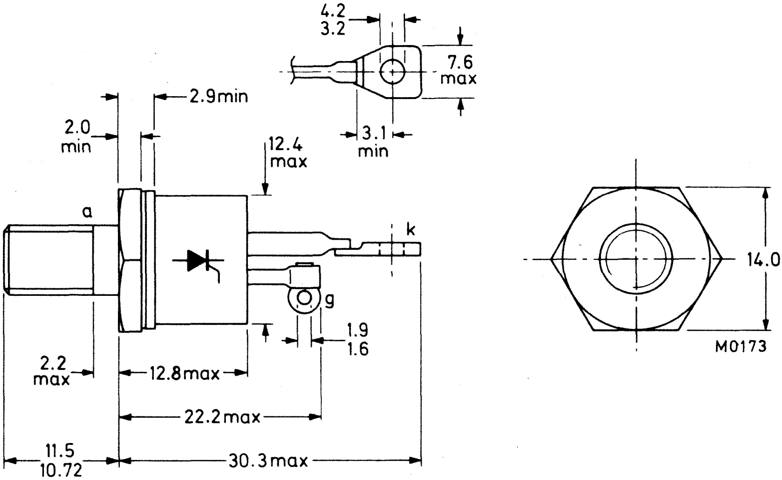
			BTW92-800R	1000R	1200R	1400R	1600R	
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	800	1000	1200	1400	1600	V

Average on-state current	$I_{T(AV)}$	max.	20	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	31	A
Non-repetitive peak on-state current	I_{TSM}	max.	400	A
Rate of rise of off-state voltage that will not trigger any device	dV_D/dt	$<$	300	V/μs
On request (see Ordering Note)	dV_D/dt	$<$	1000	V/μs

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-48: with metric M6 stud (ϕ 6 mm); e.g. **BTW92-800R**.
Types with ¼ in x 28 UNF stud (ϕ 6,35 mm) are available on request. These are indicated by the suffix U: BTW92-800RU.



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

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

RATINGS

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

Anode to cathode

			BTW92-800R	1000R	1200R	1400R	1600R	
Non-repetitive peak voltages (t ⩽ 10 ms)	V_{DSM}/V_{RSM}	max.	800	1000	1200	1400	1600	V
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	800	1000	1200	1400	1600	V
Crest working voltages	V_{DWM}/V_{RWM}	max.	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.	20	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	31	A
Repetitive peak on-state current	I_{TRM}	max.	200	A
Non-repetitive peak on-state current; t = 10 ms; half sine-wave; T_j = 125 °C prior to surge; with reapplied V_{RWMmax}	I_{TSM}	max.	400	A
I^2t for fusing (t = 10 ms)	I^2t	max.	800	A^2s
Rate of rise of on-state current after triggering with I_G = 500 mA to I_T = 60 A	dI_T/dt	max.	300	A/µs
Rate of change of commutation current	see Fig. 9			

Gate to cathode

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

Temperatures

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

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1	°C/W
From mounting base to heatsink	$R_{th\ mb\text{-}h}$	=	0,2	°C/W
Transient thermal impedance (t = 1 ms)	$Z_{th\ j\text{-}mb}$	=	0,06	°C/W

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* To ensure thermal stability: $R_{th\ j\text{-}a} < 1{,}5$ °C/W (d.c. blocking) or < 3 °C/W (a.c.). For smaller heatsinks $T_{j\ max}$ should be derated. For a.c. see Fig. 3.

CHARACTERISTICS

Anode to cathode

On-state voltage $I_T = 50$ A; $T_j = 25$ °C	V_T	<	2,3 V *
Rate of rise of off-state voltage that will not trigger any device; exponential method; $V_D = 2/3\ V_{DRMmax}$; $T_j = 125$ °C	dV_D/dt	<	300 V/μs
Reverse current $V_R = V_{RWMmax}$; $T_j = 125$ °C	I_R	<	5 mA
Off-state current $V_D = V_{DWMmax}$; $T_j = 125$ °C	I_D	<	5 mA
Latching current; $T_j = 25$ °C	I_L	<	200 mA
Holding current; $T_j = 25$ °C	I_H	<	200 mA

Gate to cathode

Voltage that will trigger all devices $V_D = 6$ V; $T_j = 25$ °C	V_{GT}	>	3,5 V
Voltage that will not trigger any device $V_D = V_{DRMmax}$; $T_j = 125$ °C	V_{GD}	<	200 mV
Current that will trigger all devices $V_D = 6$ V; $T_j = 25$ °C	I_{GT}	>	100 mA

Switching characteristics

Gate-controlled turn-on time ($t_{gt} = t_d + t_r$) when switched from $V_D = V_{DWMmax}$ to $I_T = 10$ A; $I_{GT} = 150$ mA; $dI_G/dt = 1$ A/μs; $T_j = 25$ °C	t_{gt} t_r	typ. typ.	2 μs 1,2 μs

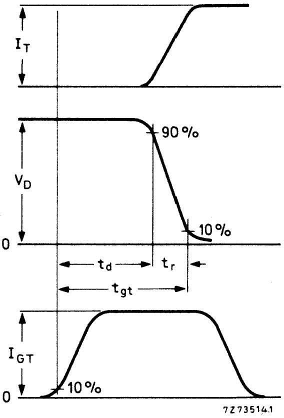


Fig. 2 Gate-controlled turn-on time definitions.

* Measured under pulse conditions to avoid excessive dissipation.

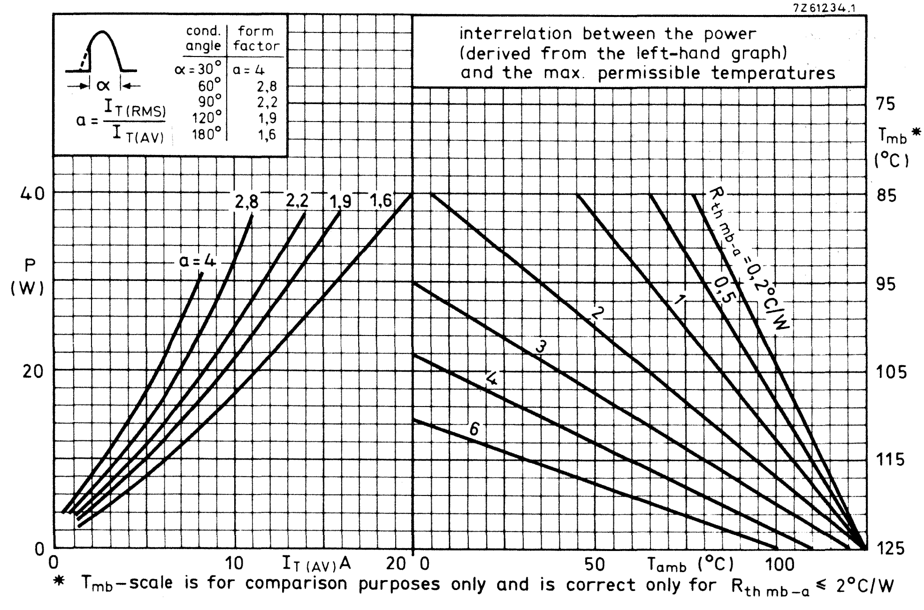
OPERATING NOTES

1. 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.
2. Switching losses in commutation.

   For applications in which the thyristor is forced to switch from an on-state current I_{TRM} to a high reverse voltage at a high commutation rate ($-dI_T/dt$), consult Fig. 9 (nomogram) to find the increase in total average power. This increase must be added to the loss from the curves in Fig. 3.

ORDERING NOTE

Types with dV_D/dt of 1000 V/µs are available on request. Add suffix C to the type number when ordering; e.g. BTW92-800RC.



* T_{mb}−scale is for comparison purposes only and is correct only for $R_{th\,mb-a} \leq 2$°C/W

Fig. 3.

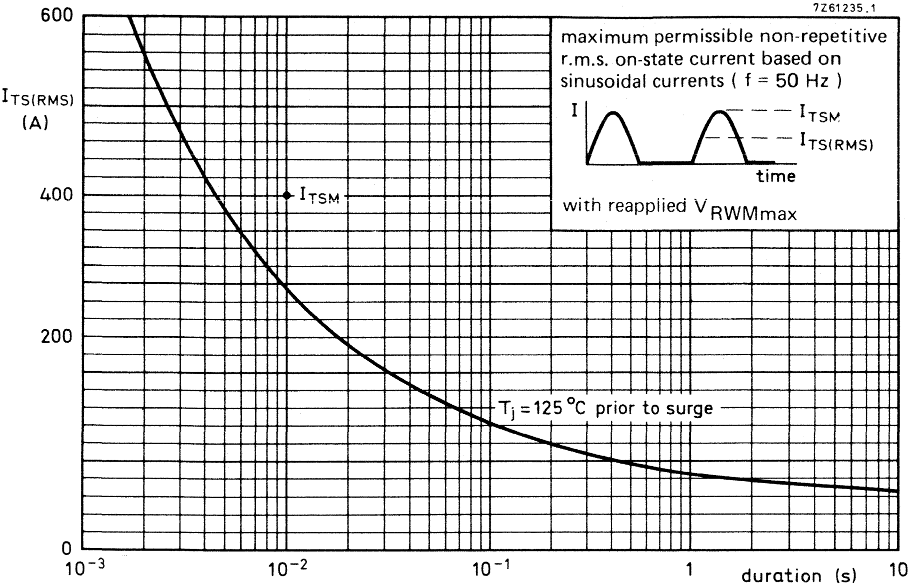


Fig. 4.

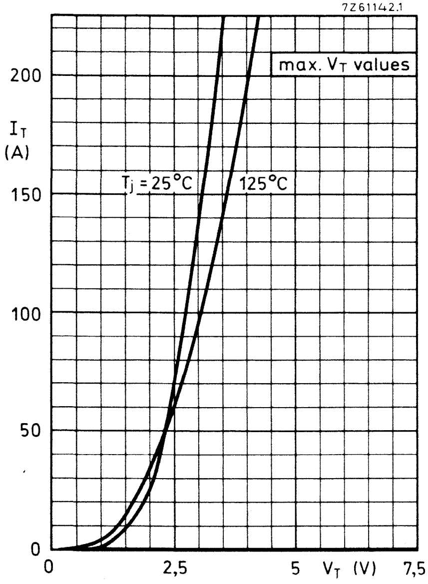


Fig. 5.

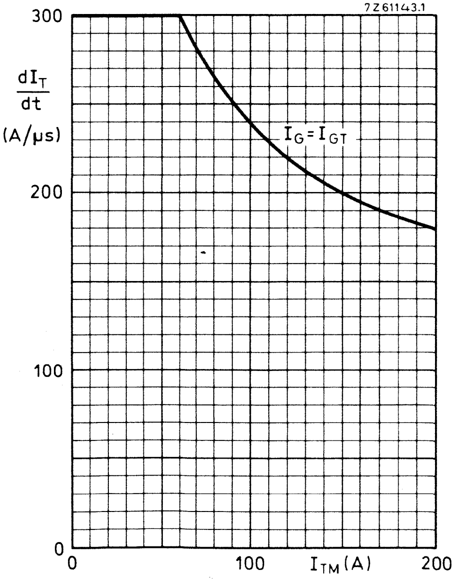


Fig. 6.

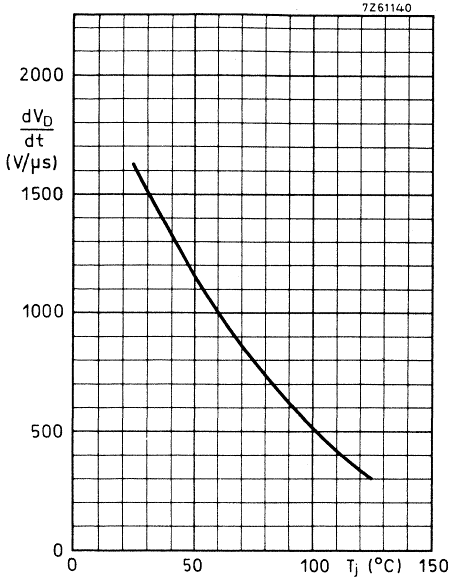


Fig. 7 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of T_j.

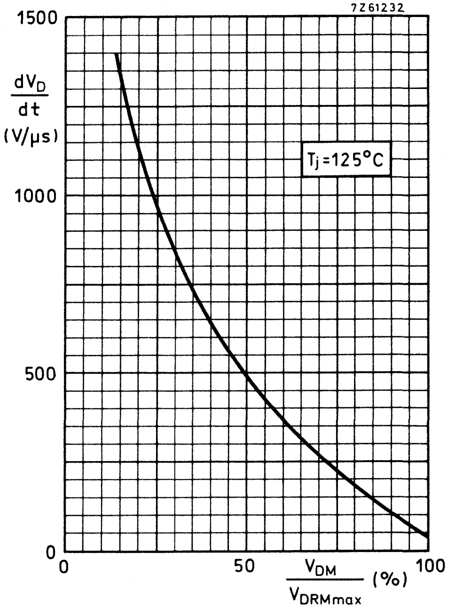


Fig. 8 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of applied voltage.

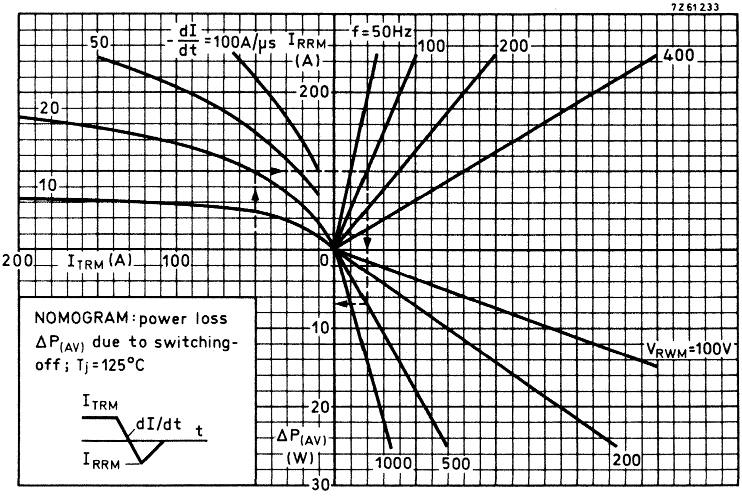


Fig. 9.

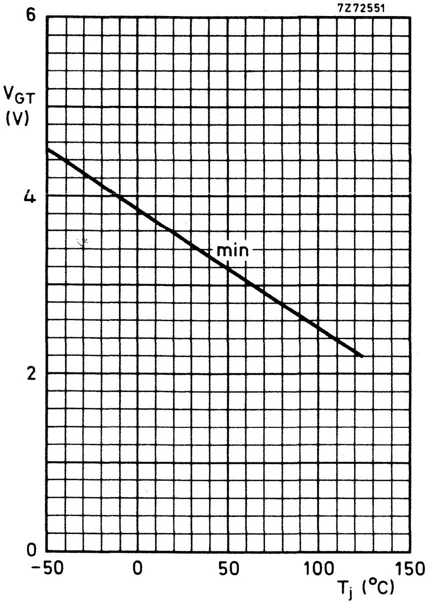


Fig. 10 Minimum gate voltage that will trigger all devices as a function of T_j.

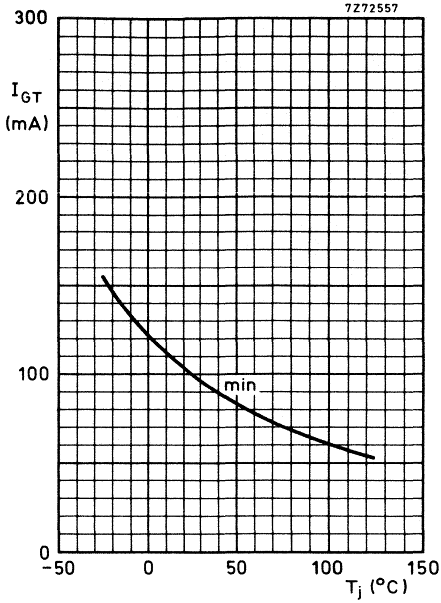


Fig. 11 Minimum gate current that will trigger all devices as a function of T_j.

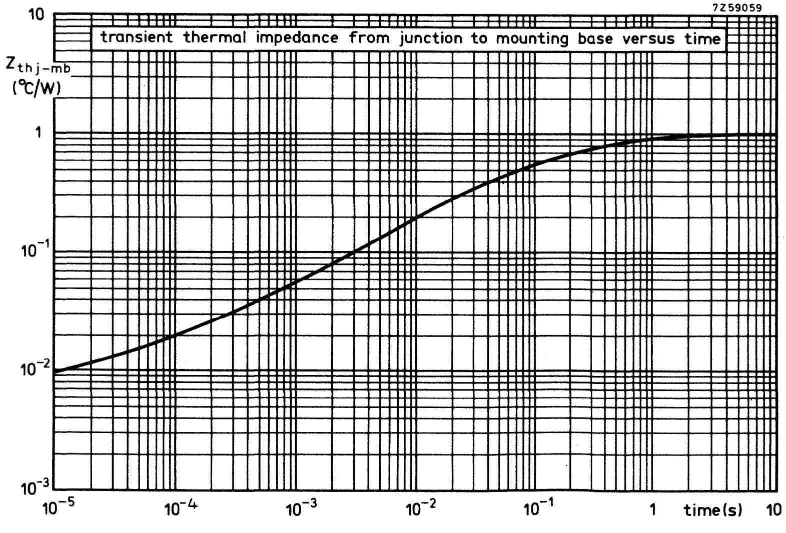


Fig. 12.

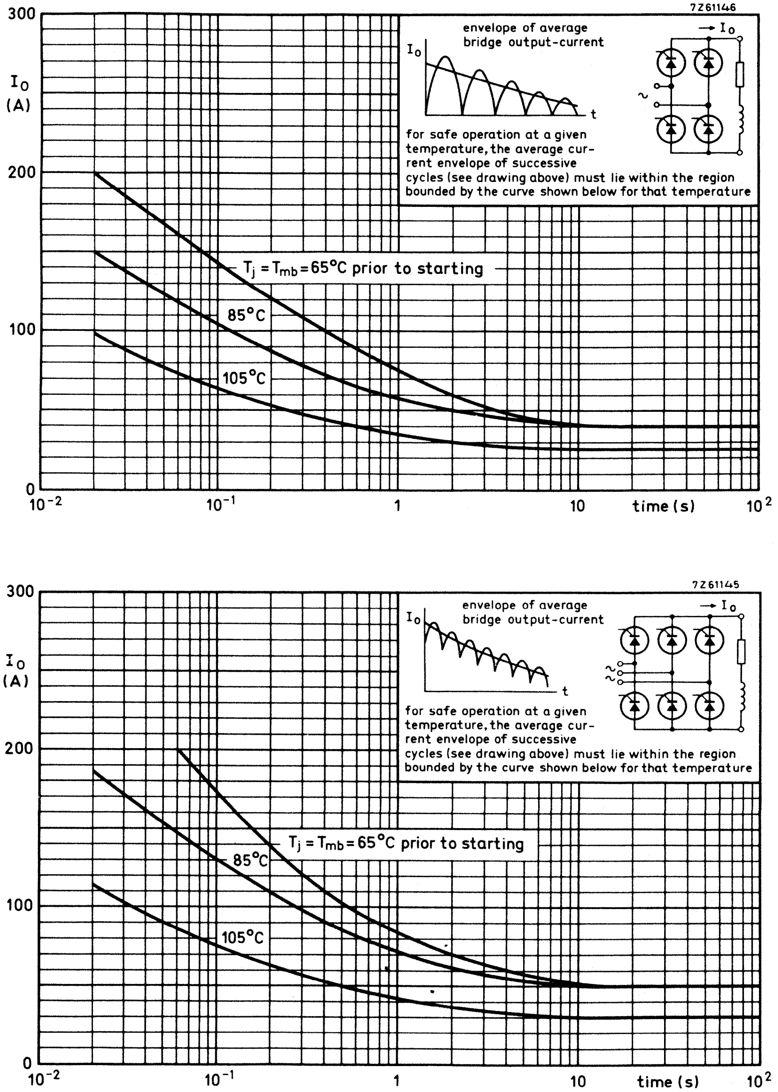


Fig. 13 Limits for starting or inrush currents.

SILICON THYRISTORS

The BTX18series is a range of p-gate reverse blocking thyristors, in a TO-5 metal envelope, intended for use in general low power applications up to 1 A average on-state current

QUICK REFERENCE DATA

			BTX18-100	200	300	400	500	
Crest working reverse voltage	V_{RWM}	max.	100	200	300	400	500	V
Crest working off-state voltage	V_{DWM}	max.	100	200	300	400	500	V

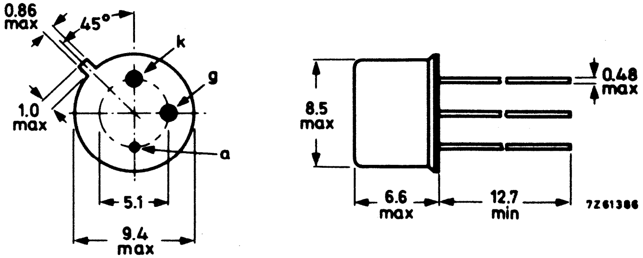
Average on-state current up to T_{case} = 105 °C	$I_{T(AV)}$	max.	1.0	A
T_{amb} = 60 °C; in free air	$I_{T(AV)}$	max.	250	mA
Non-repetitive peak on-state current t = 10 ms; T_j = 125 °C prior to surge	**I_{TSM}**	**max.**	**10**	**A**
Junction temperature	**T_j**	**max.**	**125**	**°C**

MECHANICAL DATA

Dimensions in mm

Anode connected to the case

TO-39



Accessories **supplied on request: 56218; 56245.**

All information applies to frequencies up to 400 Hz

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

ANODE TO CATHODE

Voltages [1]			BTX18-100	200	300	400	500	
Continuous reverse voltage	V_R	max.	100	200	300	400	500	V
Crest working reverse voltage	V_{RWM}	max.	100	200	300	400	500	V
Repetitive peak reverse voltage ($\delta = 0.01$; f = 50 Hz)	V_{RRM}	max.	120	240	350	500	600	V
Non-repetitive peak reverse voltage ($t \leq 10$ ms)	V_{RSM}	max.	120	240	350	500	600	V
Continuous off-state voltage	V_D	max.	100	200	300	400	500	V
Crest working off-state voltage	V_{DWM}	max.	100	200	300	400	500	V
Repetitive peak off-state voltage ($\delta = 0.01$; f = 50 Hz)	V_{DRM}	max.	120	240	350	500	600	V [2]
Non-repetitive peak off-state voltage ($t \leq 10$ ms)	V_{DSM}	max.	120	240	350	500	600	V [2]

Currents				
Average on-state current (averaged over any 20 ms period) up to $T_{case} = 105$ °C	$I_{T(AV)}$	max.	1.0	A
at $T_{amb} = 60$ °C	$I_{T(AV)}$	max.	250	mA
On-state current (d.c.) $T_{case} = 100$ °C	I_T	max.	1.6	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	1.6	A
Repetitive peak on-state current	I_{TRM}	max.	10	A
Non-repetitive peak on-state current (t = 10 ms, half sinewave)	I_{TSM}	max.	10	A

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[1] These ratings apply for zero or negative bias on the gate with respect to the cathode, and when a resistor $R \leq 1$ kΩ is connected between gate and cathode.

[2] The device is not suitable for operation in the forward breakover mode.

RATINGS

GATE TO CATHODE (with 1 kΩ resistor between gate and cathode)

Voltages				
Forward peak voltage	V_{FGM}	max.	10	V
Reverse peak voltage	V_{RGM}	max.	5	V
Current				
Forward peak current	I_{FGM}	max.	0.2	A
Power dissipation				
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	0.05	W
Peak power dissipation	P_{GM}	max.	0.5	W
TEMPERATURES				
Storage temperature	T_{stg}	-55 to +125		°C
Junction temperature	T_j	max.	125	°C

THERMAL RESISTANCE

From junction to case	$R_{th\ j-c}$	=	10	°C/W
From junction to ambient	$R_{th\ j-a}$	=	200	°C/W
Transient thermal resistance (t = 10 ms)	$Z_{th\ j-c}$	=	2.5	°C/W

CHARACTERISTICS

ANDODE TO CATHODE

			BTX18-100	200	300	400	500	
Voltages								
On-state voltage $I_T = 1.0$ A; $T_j = 25$ °C	V_T	<	1.5	1.5	1.5	1.5	1.5	V 1)
Rate of rise of off-state voltage that will not trigger any device $R_{GK} = 1$ kΩ; $T_j = 125$ °C	$\frac{dV_D}{dt}$		See page 6					
Currents								
Peak reverse current $V_{RM} = V_{RWMmax}$; $T_j = 125$ °C	I_{RM}	<	800	400	275	200	160	µA
Peak off-state current $V_{DM} = V_{DWMmax}$; $T_j = 125$ °C	I_{DM}	<	800	400	275	200	160	µA

---

1) V_T is measured along the leads at 1 cm from the case.

CHARACTERISTICS (continued)

Latching current; T_j = 125 °C	I_L	typ.	10	mA	
Holding current; T_j = 25 °C	I_H	<	5.0	mA	1)

GATE TO CATHODE (with 1 kΩ resistor between gate and cathode)

Voltages

Voltage that will trigger all devices; T_j = 25 °C	V_{GT}	>	2.0	V
Voltage that will not trigger any device; T_j = 125 °C	V_{GD}	<	200	mV

Current

Current that will trigger all devices; T_j = 25 °C	I_{GT}	>	5.0	mA

SWITCHING CHARACTERISTICS

Turn off time when switched from

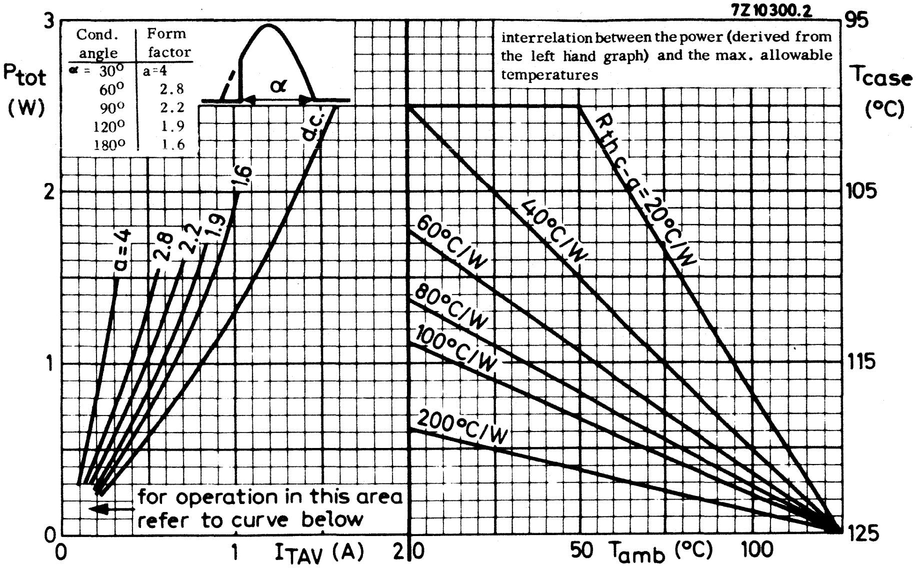
I_T = 300 mA to I_R = 175 mA; T_j = 25 °C	t_q	typ.	20	µs
T_j = 125 °C	t_q	typ.	35	µs

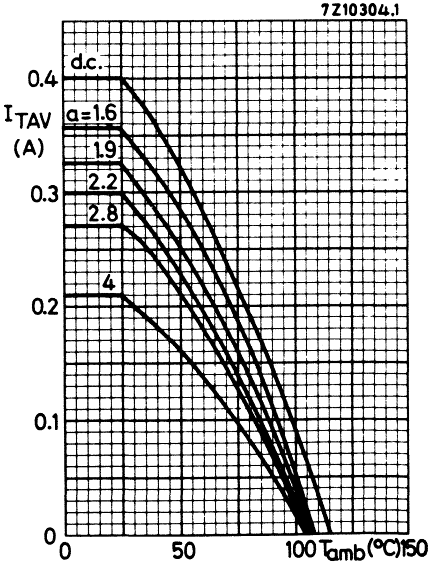
NOTES

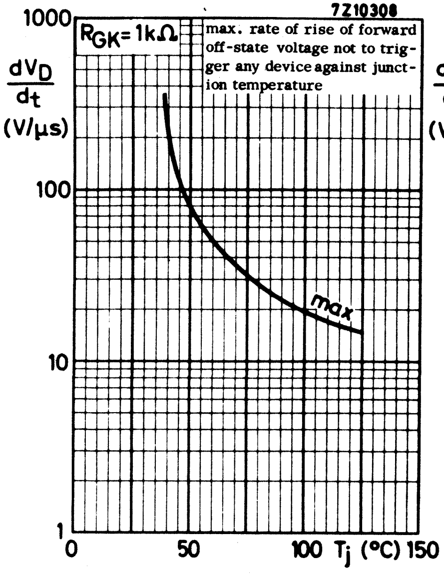
1. When using a soldering iron the thyristor may be soldered directly into the circuit, but the heat conduction to the junction should be kept to a minimum by using a thermal shunt.
2. Thyristors may be dip soldered at a solder temperature of 245 °C, for a maximum soldering time of 5 seconds. The case temperature during dip soldering must not at any time exceed the maximum storage temperature. These recommendations apply to a thyristor mounted flush on a board with punched-through holes, or spaced 1.5 mm above a board having plated-through holes.
3. Care should be taken not to bend the leads nearer than 1.5 mm from the seal.

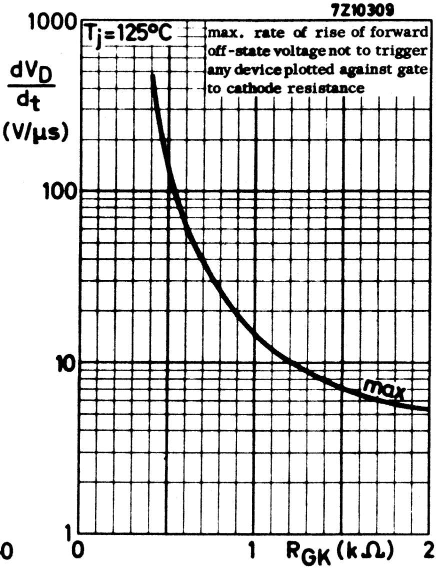
---

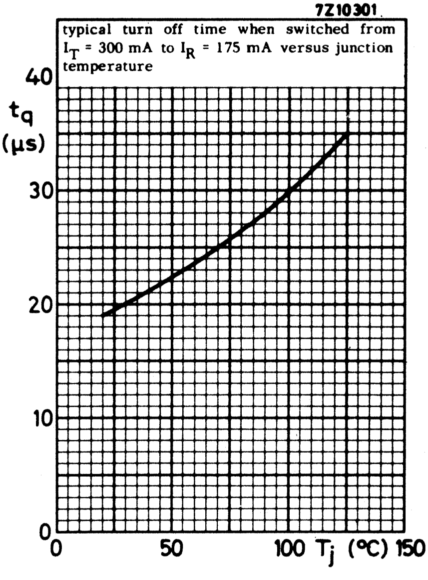
1) Measured under the following conditions: Anode supply voltage = +6.0 V.
Initial on-state current after gate triggering = 50 mA.
The current is reduced until the device turns of.

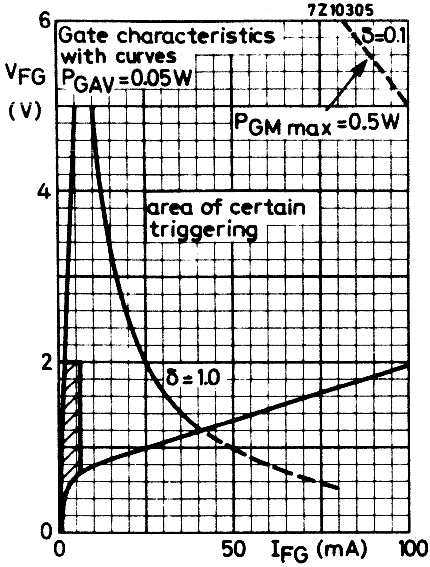

7Z10300.2
Ptot (W)
3
2
1
0
Cond. angle
Form factor
α = 30° a=4
60° 2.8
90° 2.2
120° 1.9
180° 1.6
α
d.c.
1.6
1.9
2.2
2.8
a=4
for operation in this area refer to curve below
0
1
ITAV (A)
2
interrelation between the power (derived from the left hand graph) and the max. allowable temperatures
Rth c-a=20°C/W
40°C/W
60°C/W
80°C/W
100°C/W
200°C/W
0
50
Tamb (°C)
100
Tcase (°C)
95
105
115
125

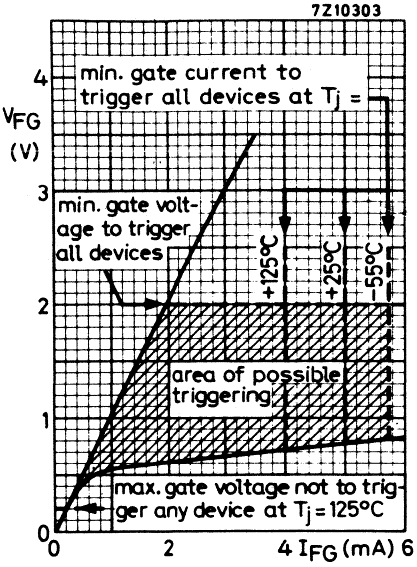

7Z10304.1
ITAV (A)
0.4
0.3
0.2
0.1
0
d.c.
a=1.6
1.9
2.2
2.8
4
0
50
100
Tamb (°C)
150

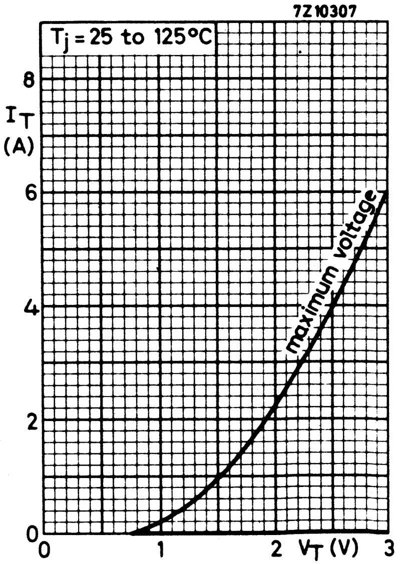

7Z10308
R_{GK} = 1kΩ
max. rate of rise of forward off-state voltage not to trigger any device against junction temperature
$\frac{dV_D}{dt}$ (V/μs)
1000
100
10
1
0
50
100
150
T_j (°C)
max

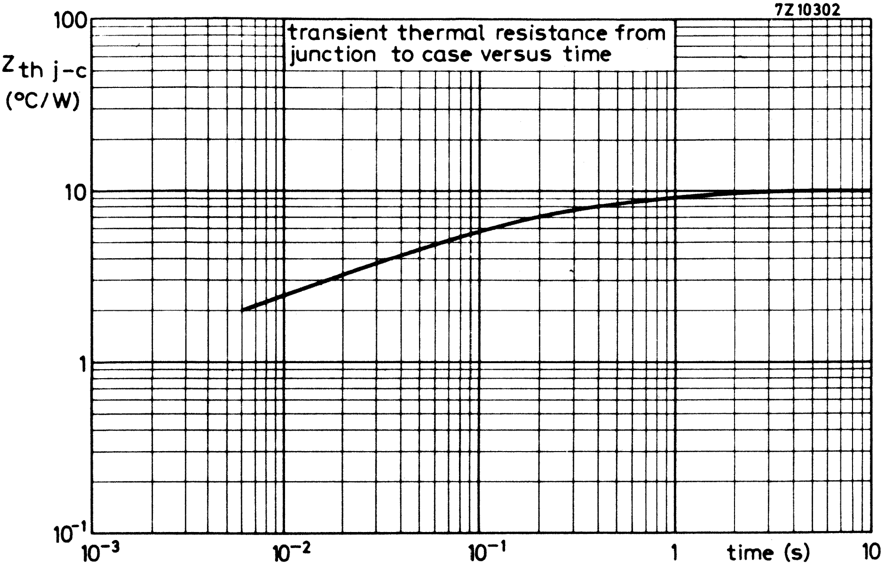

7Z10309
T_j=125°C
max. rate of rise of forward off-state voltage not to trigger any device plotted against gate to cathode resistance
$\frac{dV_D}{dt}$ (V/μs)
1000
100
10
1
0
1
2
R_{GK} (kΩ)
max

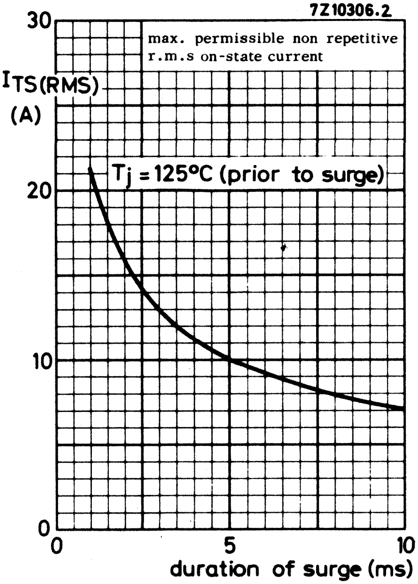

7Z10301
typical turn off time when switched from I_T = 300 mA to I_R = 175 mA versus junction temperature
t_q (μs)
40
30
20
10
0
0
50
100
150
T_j (°C)


7Z10305
Gate characteristics
with curves
P_{GAV} = 0.05 W
δ = 0.1
$P_{GM\,max}$ = 0.5 W
area of certain
triggering
δ = 1.0
V_{FG}
(V)
6
4
2
0
0
50
I_{FG} (mA)
100


7Z10303
min. gate current to
trigger all devices at T_j =
min. gate volt-
age to trigger
all devices
+125°C
+25°C
−55°C
area of possible
triggering
max. gate voltage not to trig-
ger any device at T_j = 125°C
V_{FG}
(V)
4
3
2
1
0
0
2
4
I_{FG} (mA)
6


7Z10307
T_j = 25 to 125°C
maximum voltage
I_T
(A)
8
6
4
2
0
0
1
2
V_T (V)
3


7Z10302
transient thermal resistance from junction to case versus time
$Z_{th\ j-c}$
(°C/W)
100
10
1
10^{-1}
10^{-3}
10^{-2}
10^{-1}
1
time (s)
10


7Z10306.2
max. permissible non repetitive r.m.s on-state current
$I_{TS(RMS)}$
(A)
T_j = 125°C (prior to surge)
30
20
10
0
0
5
10
duration of surge (ms)

THYRISTORS

Glass-passivated silicon thyristors in metal envelopes, intended for use in power control circuits (e.g. light and motor control) and power switching systems.
The series consistos of reverse polarity types (anode to stud) identified by a suffix R: BTY79-400R to 1000R.

QUICK REFERENCE DATA

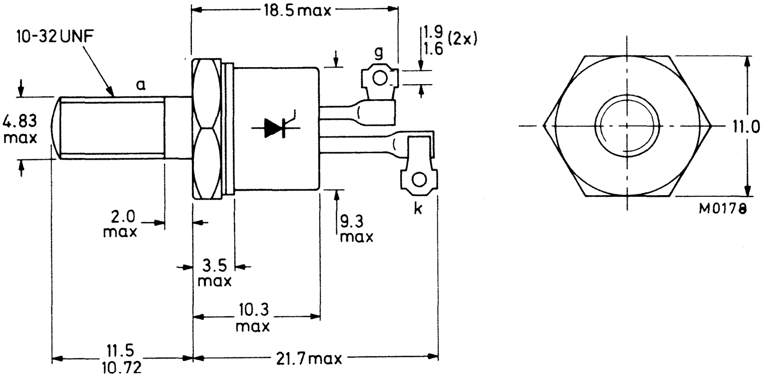
		BTY79-400R	500R	600R	800R	1000R	
Repetitive peak voltages V_{DRM}/V_{RRM}	max.	400	500	600	800	1000	V

Average on-state current	$I_{T(AV)}$	max.	10	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	16	A
Non-repetitive peak on-state current	I_{TSM}	max.	150	A

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-64: with 10-32 UNF stud (ϕ 4,83 mm).



Net mass: 7 g
Diameter of clearance hole: max. 5,2 mm
Accessories supplied on request:
see ACCESSORIES section

Torque on nut: min. 0,9 Nm
(9 kg cm)
max. 1,7 Nm
(17 kg cm)

Supplied with device: 1 nut, 1 lock washer.
Nut dimensions: across the flats: 9,5 mm.
Products approved to CECC 50 011-006 available on request.

RATINGS

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

Anode to cathode

			BTY79–400R	500R	600R	800R	1000R	
Non-repetitive peak off-state voltage ($t \leqslant 10$ ms)	V_{DSM}**	max.	500	1100	1100	1100	1100	V
Non-repetitive peak reverse voltage ($t \leqslant 5$ ms)	V_{RSM}	max.	500	600	720	960	1100	V
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	400	500	600	800	1000	V
Crest working voltages	V_{DWM}/V_{RWM}	max.	400	500	600	800	1000	V*

Average on-state current (averaged over any 20 ms period) up to T_{mb} = 85 °C	$I_{T(AV)}$	max.	10	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	16	A
Repetitive peak on-state current	I_{TRM}	max.	75	A
Non-repetitive peak on-state current; t = 10 ms; half sine-wave; T_j = 125 °C prior to surge; with reapplied V_{RWMmax}	I_{TSM}	max.	150	A
I^2t for fusing (t = 10 ms)	I^2t	max.	112	A^2s
Rate of rise of on-state current after triggering with I_G = 150 mA to I_T = 30 A; dI_G/dt = 0,25 A/µs	dI_T/dt	max.	50	A/µs

Gate to cathode

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

Temperatures

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

THERMAL RESISTANCE

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

---

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

** Although not recommended, higher off-state voltages may be applied without damage, but the thyristor may switch into the on-state. The rate of rise of on-state current should not exceed 100 A/µs.

CHARACTERISTICS

Anode to cathode

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

Gate to cathode

Voltage that will trigger all devices $V_D = 6$ V; $T_j = 25$ °C	V_{GT}	>	1.5	V
Voltage that will not trigger any device $V_D = V_{DRMmax}$; $T_j = 125$ °C	V_{GD}	<	200	mV
Current that will trigger all devices $V_D = 6$ V; $T_j = 25$ °C	I_{GT}	>	30	mA
On request (see Ordering Note)	I_{GT}	>	20	mA

Switching characteristics

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

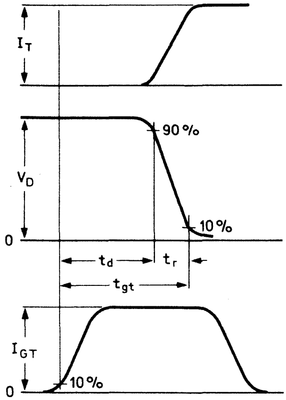


Fig.2a Gate-controlled turn-on time definition.

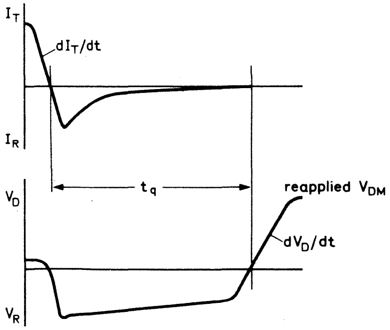


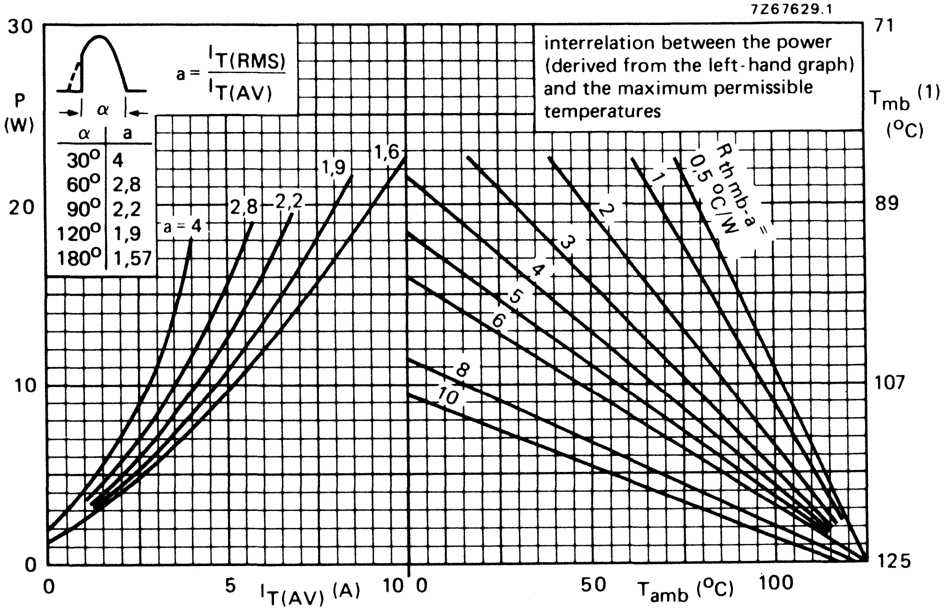
Fig.2b Circuit-commutated turn-off time definition.

OPERATING NOTE

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

ORDERING NOTE

Types with low gate trigger current, $I_{GT} > 20$ mA, are available on request. Add suffix A to the type number when ordering: e.g. BTY79A-400R.



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

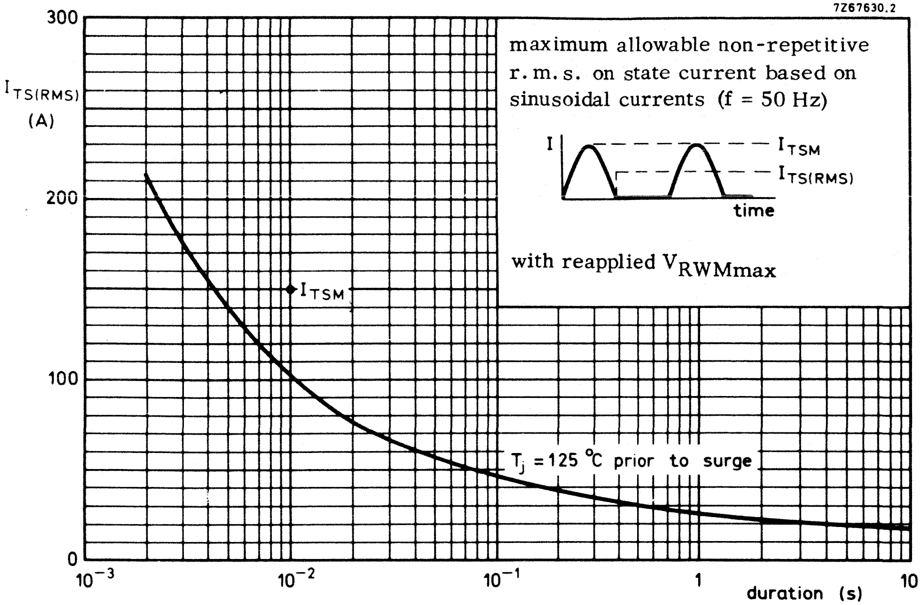

7Z67630.2
300
200
100
0
$I_{TS(RMS)}$ (A)
10^{-3}
10^{-2}
10^{-1}
1
10
duration (s)
I_{TSM}
maximum allowable non-repetitive r.m.s. on state current based on sinusoidal currents (f = 50 Hz)
I
I_{TSM}
$I_{TS(RMS)}$
time
with reapplied V_{RWMmax}
T_j = 125 °C prior to surge

Fig. 4.

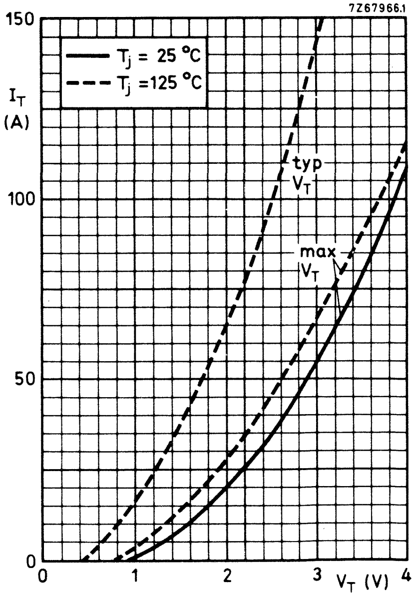

7Z67966.1
150
100
50
0
I_T (A)
0
1
2
3
4
V_T (V)
T_j = 25 °C
T_j =125 °C
typ V_T
max V_T

Fig. 5.

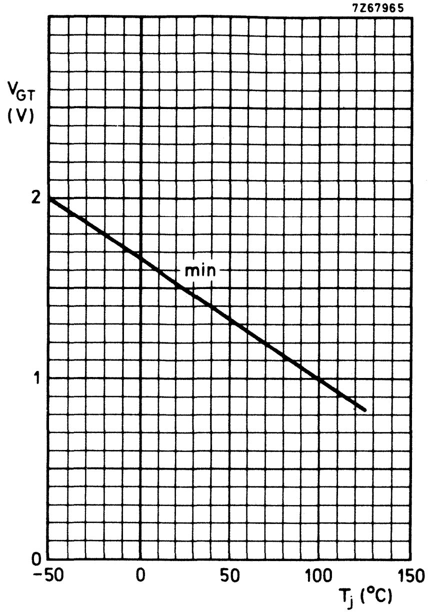


Fig. 6 Minimum gate voltage that will trigger all devices as a function of T_j.

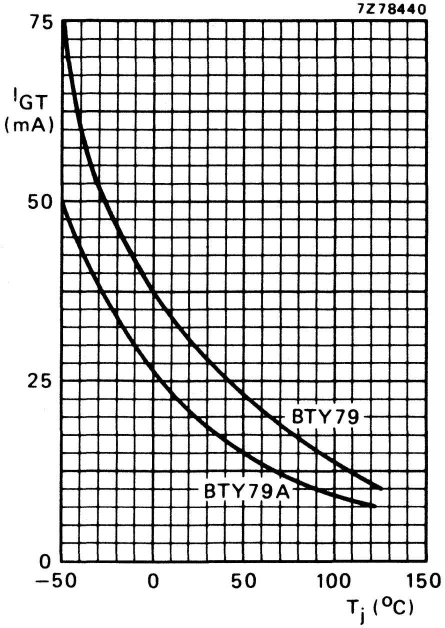


Fig. 7 Minimum gate current that will trigger all devices as a function of T_j.

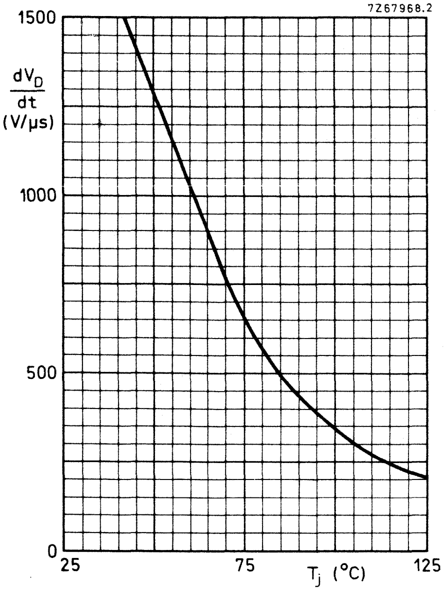


Fig. 8 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of T_j.

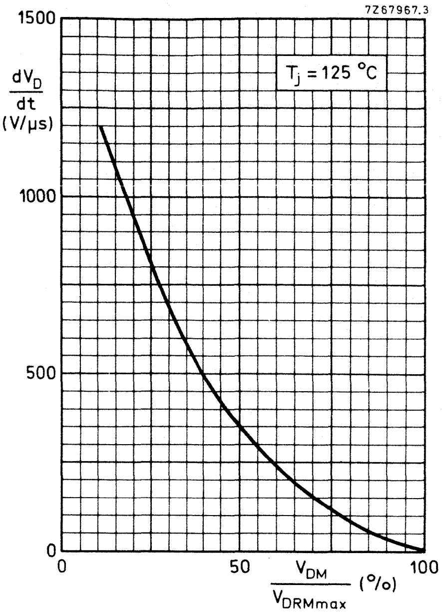
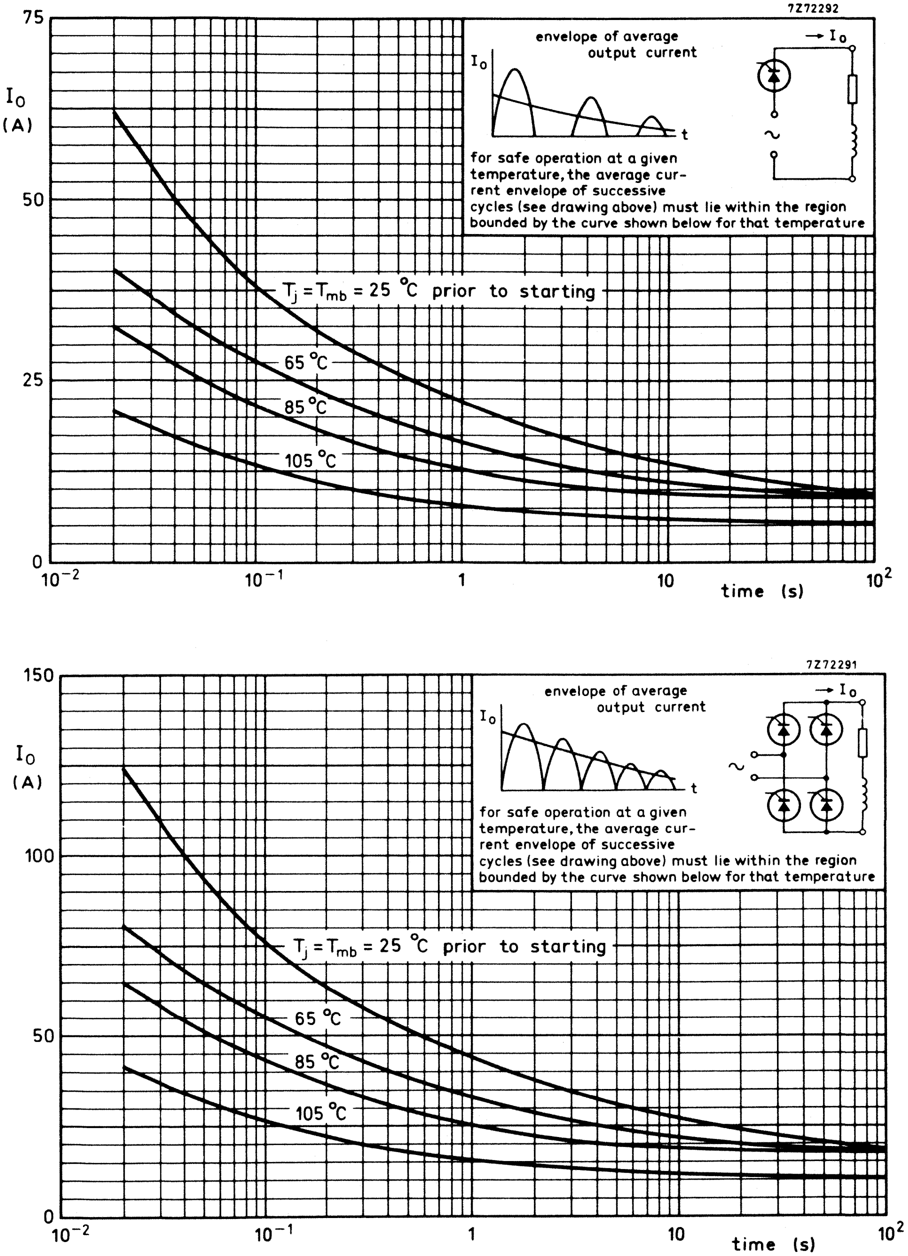


Fig. 9 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of applied voltage.



for safe operation at a given temperature, the average current envelope of successive cycles (see drawing above) must lie within the region bounded by the curve shown below for that temperature

for safe operation at a given temperature, the average current envelope of successive cycles (see drawing above) must lie within the region bounded by the curve shown below for that temperature

Fig. 10 Limits for starting or inrush currents.

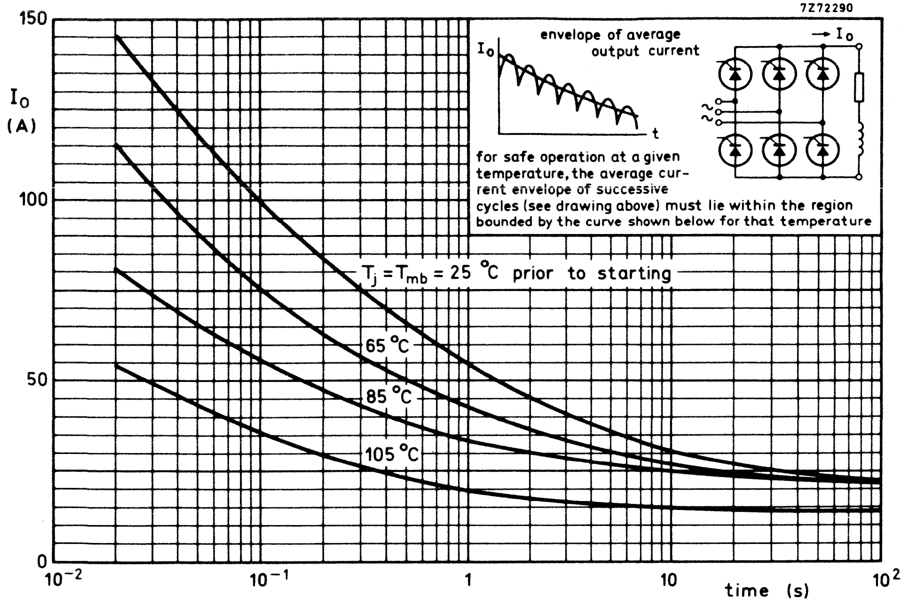


Fig. 11 Limits for starting or inrush currents.

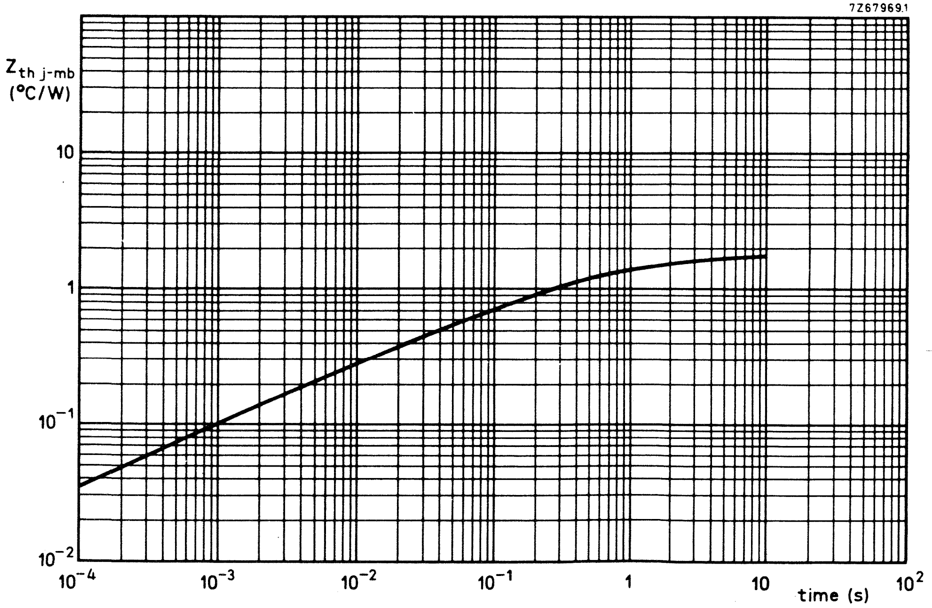


Fig. 12.

THYRISTORS

Glass-passivated silicon thyristors in metal envelopes, intended for power control and power switching applications.
The series consists of reverse polarity types (anode to stud) identified by a suffix R: BTY91-400R to 800R.

QUICK REFERENCE DATA

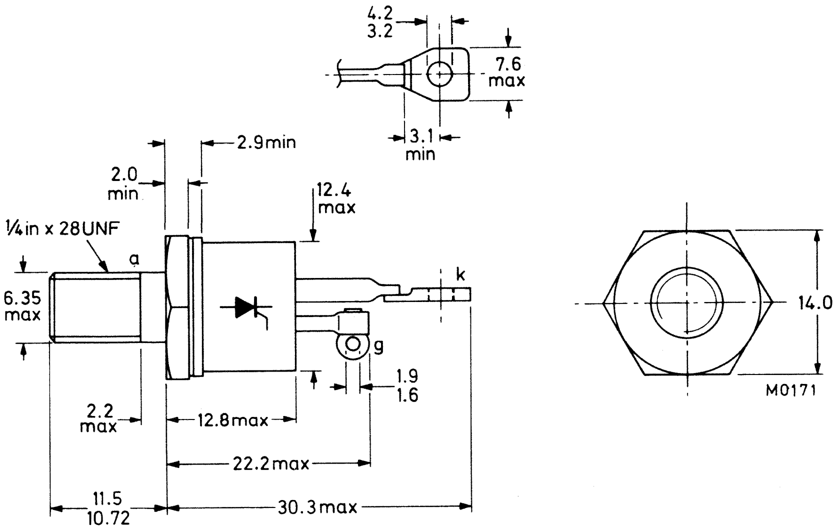
			BTY91-400R	500R	600R	800R	
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	400	500	600	800	V

Average on-state current	$I_{T(AV)}$	max.	16	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	25	A
Non-repetitive peak on-state current	I_{TSM}	max.	200	A

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-48: with ¼ in x 28 UNF stud (φ 6,35 mm)



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

Torque on nut: min. 1,7 Nm (17 kg cm)
max. 3,5 Nm (35 kg cm)
Supplied with the device:
1 nut, 1 lock washer
Nut dimensions across the flats: 11,1 mm

RATINGS

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

Anode to cathode

			BTY91-400R	500R	600R	800R	
Non-repetitive peak off-state voltage ($t \leqslant 10$ ms)	V_{DSM}	max.	500	850	850	850	V
Non-repetitive peak reverse voltage ($t \leqslant 5$ ms)	V_{RSM}	max.	500	600	720	960	V
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	400	500	600	800	V
Crest working voltages	V_{DWM}/V_{RWM}	max.	400	500	600	800	V *

Average on-state current (averaged over any 20 ms period) up to $T_{mb} = 77$ °C	$I_{T(AV)}$	max.	16	A
at $T_{mb} = 85$ °C	$I_{T(AV)}$	max.	14	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	25	A
Repetitive peak on-state current	I_{TRM}	max.	200	A
Non-repetitive peak on-state current; t = 10 ms; half sine-wave; $T_j = 125$ °C prior to surge; with reapplied V_{RWMmax}	I_{TSM}	max.	200	A
I^2t for fusing (t = 10 ms)	I^2t	max.	200	A^2s
Rate of rise of on-state current after triggering with $I_G = 200$ mA to $I_T = 50$ A	dI_T/dt	max.	20	A/µs

Gate to cathode

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

Temperatures

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

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,6	°C/W
From mounting base to heatsink with heatsink compound	$R_{th\ mb\text{-}h}$	=	0,2	°C/W
Transient thermal impedance (t = 1 ms)	$Z_{th\ j\text{-}mb}$	=	0,09	°C/W

OPERATING NOTE

The terminals should neither be bent nor twisted; they should be soldered into the circuit so that there is no strain on them.

During soldering the heat conduction to the junction should be kept to a minimum.

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* To ensure thermal stability: $R_{th\ j\text{-}a} < 4{,}5$ °C/W (d.c. blocking) or < 9 °C/W (a.c.). For smaller heatsinks $T_{j\ max}$ should be derated. For a.c. see Fig. 3.

CHARACTERISTICS

Anode to cathode

On-state voltage I_T = 50 A; T_j = 25 °C	V_T	<	2	V *
Rate of rise of off-state voltage that will not trigger any device; exponential method; V_D = 2/3 V_{DRMmax}; T_j = 125 °C	dV_D/dt	<	200	V/µs
Reverse current V_R = V_{RWMmax}; T_j = 125 °C	I_R	<	3	mA
Off-state current V_D = V_{DWMmax}; T_j = 125 °C	I_D	<	3	mA
Latching current; T_j = 25 °C	I_L	typ.	50	mA
Holding current; T_j = 25 °C	I_H	typ.	25	mA

Gate to cathode

Voltage that will trigger all devices V_D = 6 V; T_j = 25 °C	V_{GT}	>	3	V
Voltage that will not trigger any device V_D = V_{DRMmax}; T_j = 125 °C	V_{GD}	<	200	mV
Current that will trigger all devices V_D = 6 V; T_j = 25 °C	I_{GT}	>	40	mA

Switching characteristics

Gate-controlled turn-on time ($t_{gt} = t_d + t_r$) when switched from V_D = 400 V to I_T = 10 A; I_{GT} = 200 mA; T_j = 25 °C	t_{gt}	typ.	2	µs

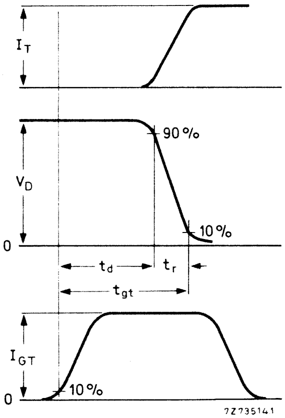

Fig. 2 Gate-controlled turn-on time definitions.

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* Measured under pulse conditions to avoid excessive dissipation.

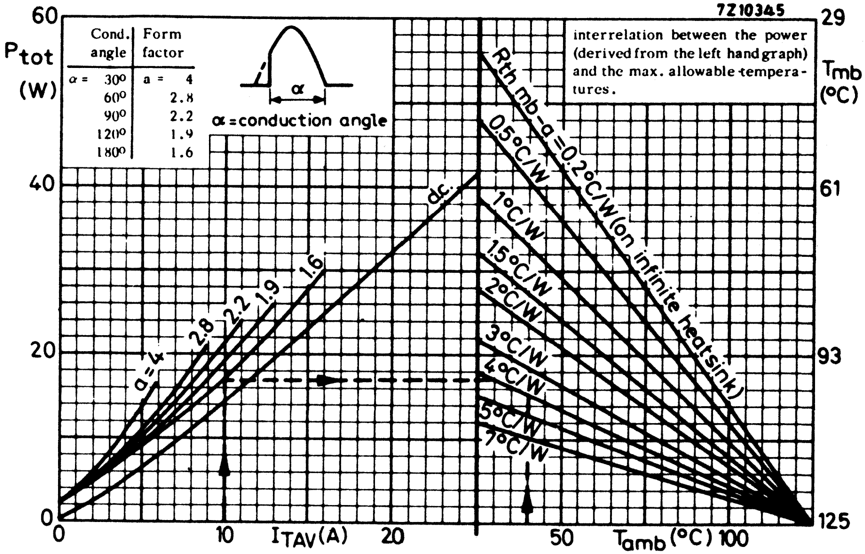

7Z10345
Ptot (W)
60
40
20
0
Cond. angle
Form factor
α = 30° a = 4
60° 2.8
90° 2.2
120° 1.9
180° 1.6
α
α = conduction angle
a = 4
2.8
2.2
1.9
1.6
d.c.
0
10
ITAV (A)
20
50
Tamb (°C)
100
interrelation between the power (derived from the left hand graph) and the max. allowable temperatures.
Rth mb-a = 0.2°C/W (on infinite heatsink)
0.5°C/W
1°C/W
1.5°C/W
2°C/W
3°C/W
4°C/W
5°C/W
7°C/W
Tmb (°C)
29
61
93
125

Fig. 3.

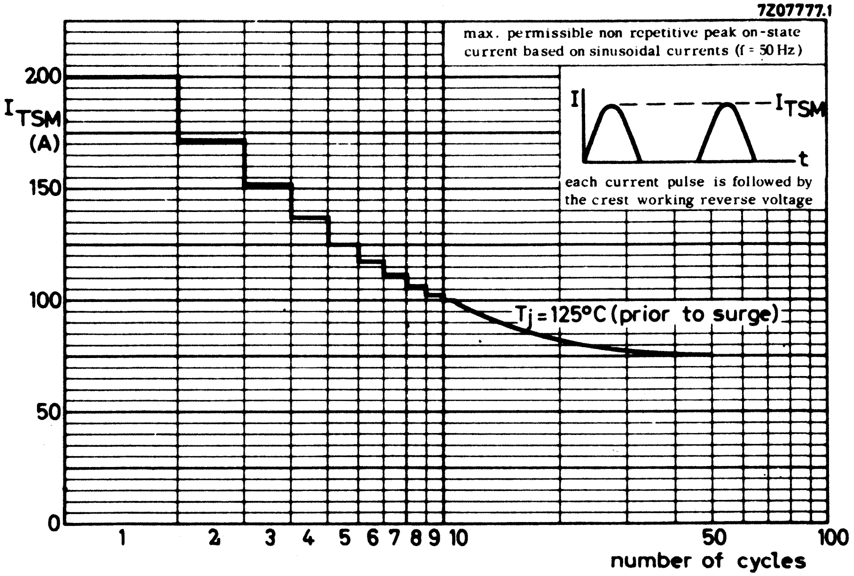

7Z07777.1
max. permissible non repetitive peak on-state current based on sinusoidal currents (f = 50 Hz)
I
ITSM
t
each current pulse is followed by the crest working reverse voltage
ITSM (A)
200
150
100
50
0
Tj = 125°C (prior to surge)
1
2
3
4
5
6
7
8
9
10
50
100
number of cycles

Fig. 4.

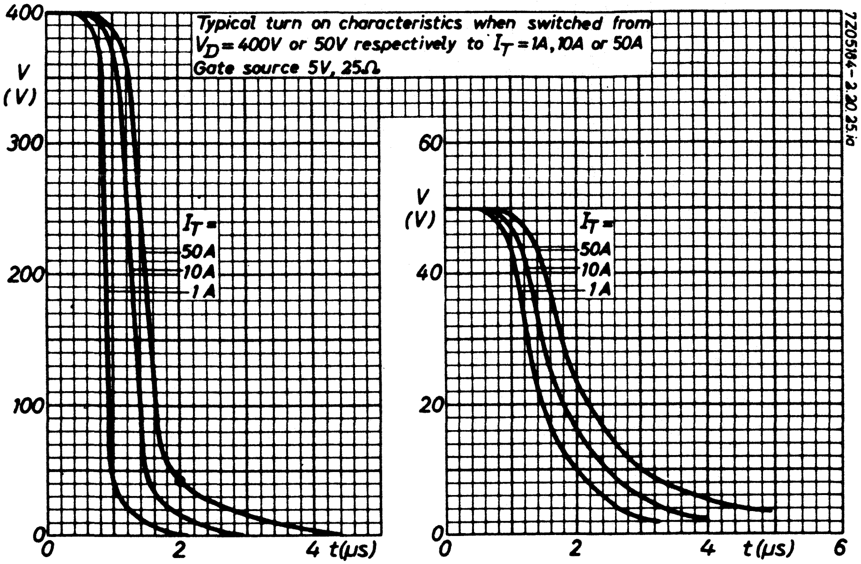

Typical turn on characteristics when switched from V_D = 400V or 50V respectively to I_T = 1A, 10A or 50A
Gate source 5V, 25Ω
7Z05184–2.20.25.io
V (V)
400
300
200
100
0
I_T =
50A
10A
1A
0
2
4
t(μs)
V (V)
60
40
20
0
I_T =
50A
10A
1A
0
2
4
t(μs)
6

Fig. 5.

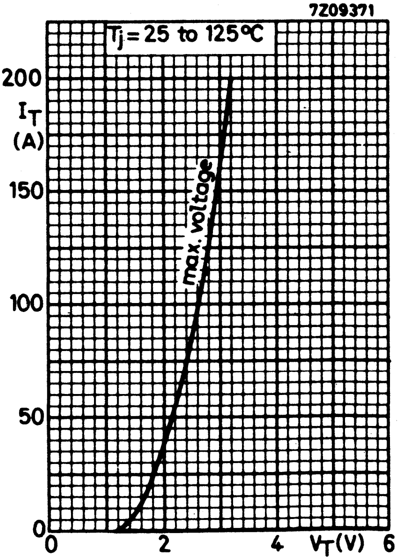

7Z09371
T_j = 25 to 125°C
200
I_T (A)
150
100
50
0
max. voltage
0
2
4
V_T(V)
6

Fig. 6.

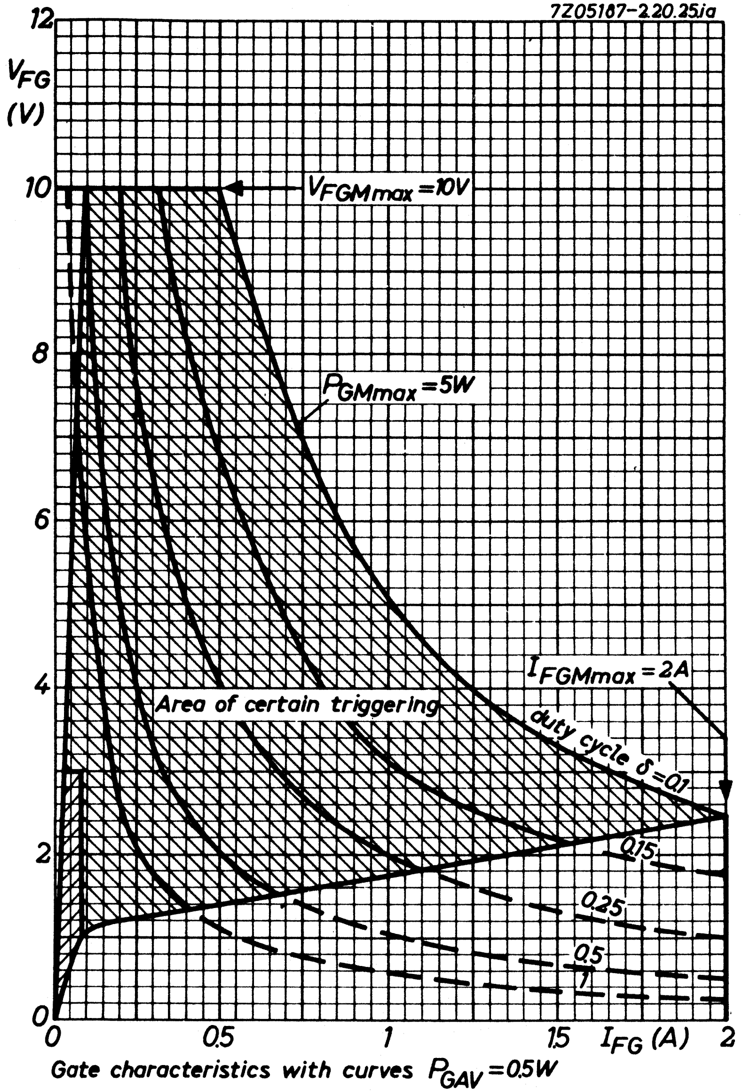

7Z05187-2.20.25.ia
V_{FG} (V)
12
10
8
6
4
2
0
V_{FGMmax} = 10V
P_{GMmax} = 5W
I_{FGMmax} = 2A
duty cycle δ = 0.1
0.15
0.25
0.5
1
Area of certain triggering
0
0.5
1
1.5
I_{FG} (A)
2
Gate characteristics with curves P_{GAV} = 0.5W

Fig. 7.

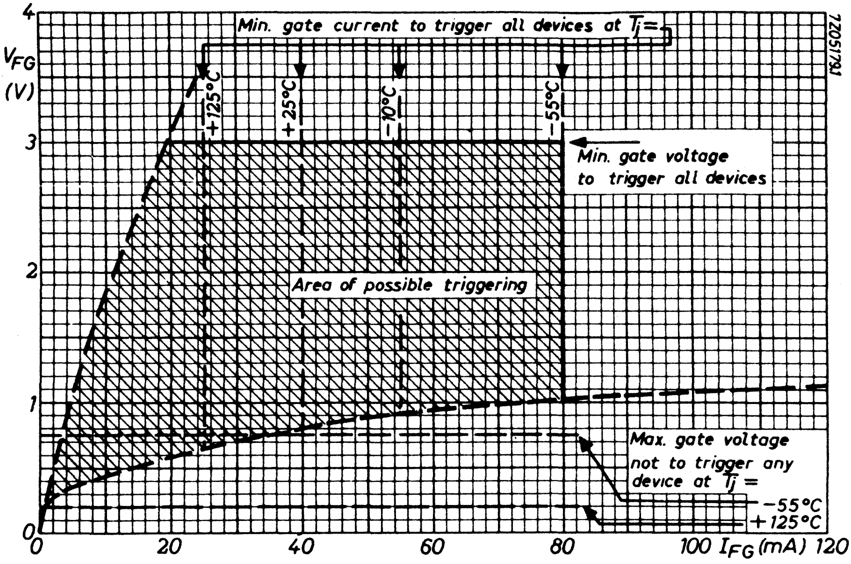

7Z05178.1
V_{FG} (V)
4
3
2
1
0
Min. gate current to trigger all devices at T_j =
+125°C
+25°C
−10°C
−55°C
Min. gate voltage to trigger all devices
Area of possible triggering
Max. gate voltage not to trigger any device at T_j =
−55°C
+125°C
0
20
40
60
80
100
I_{FG} (mA)
120

Fig. 8.

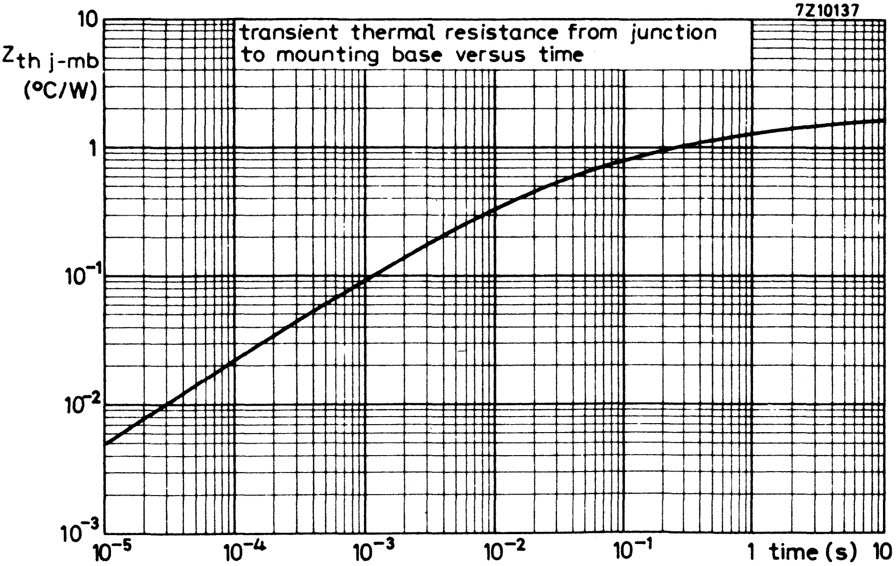
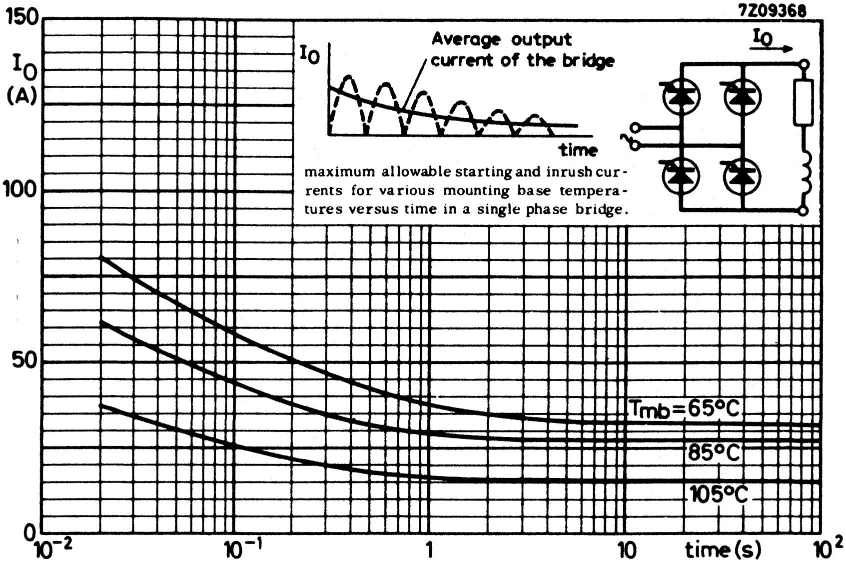
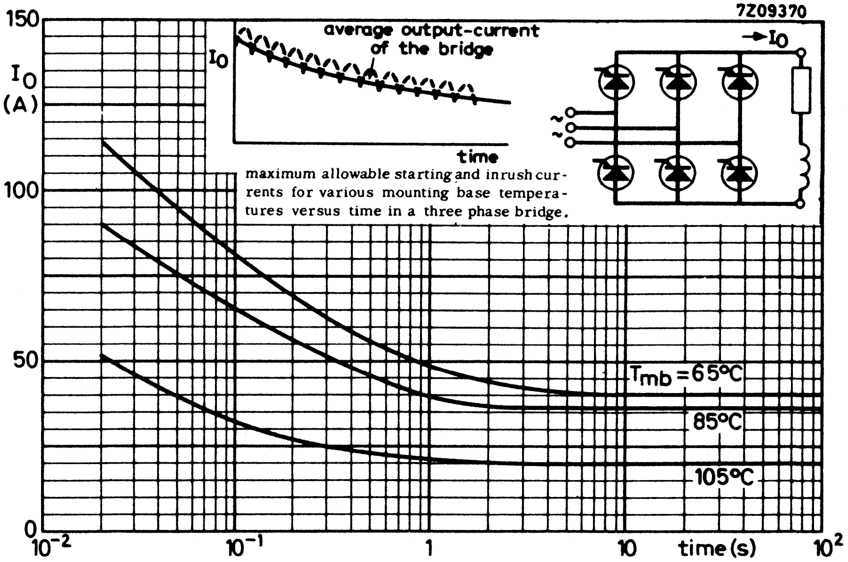

7Z10137
transient thermal resistance from junction to mounting base versus time
$Z_{th\ j\text{-}mb}$ (°C/W)
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
time (s)
10

Fig. 9.



maximum allowable starting and inrush currents for various mounting base temperatures versus time in a single phase bridge.

Fig. 10.



maximum allowable starting and inrush currents for various mounting base temperatures versus time in a three phase bridge.

Fig. 11.

ISOLATED POWER MODULES

ISOLATED THYRISTOR MODULES

Two-thyristor modules incorporating glass-passivated devices in a plastic package, with electrically-isolated metal baseplate. The modules are intended for use in general-purpose single and three-phase applications.

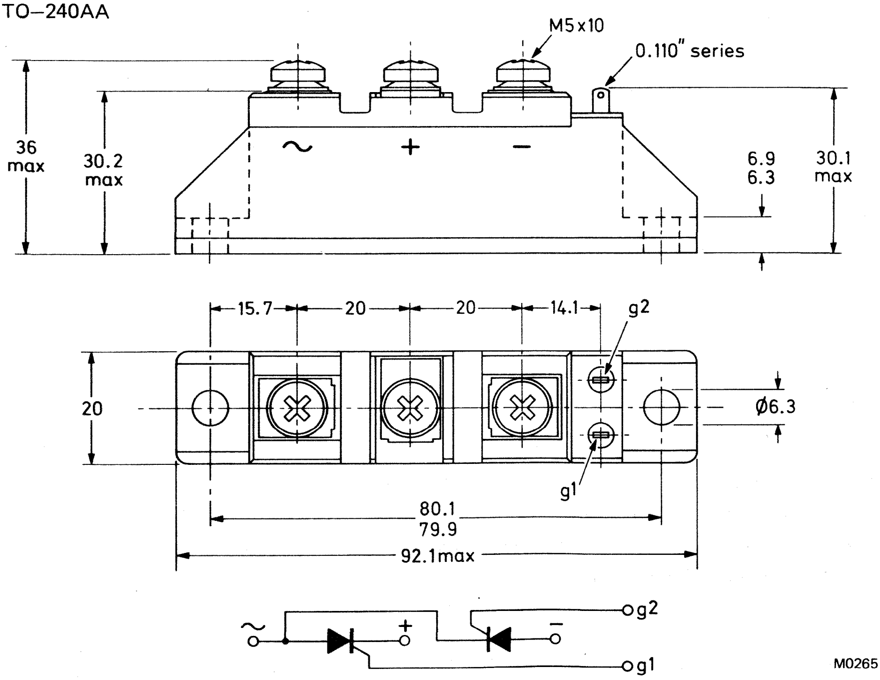
QUICK REFERENCE DATA

Per thyristor			BGX12–600	800	1200	1200C	1400C–TT	
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	600	800	1200	1200	1400	V
R.M.S. on-state current	$I_{T(RMS)}$	max.	75					A
Average on-state current	$I_{T(AV)}$	max.	40					A
Non-repetitive peak on-state current	I_{TSM}	max.	700					A
Rate of rise of off-state voltage that will not trigger any device	dV_D/dt	<	200			1000		V/μs

MECHANICAL DATA (see also next page)

Dimensions in mm

Fig.1 TO–240AA



MECHANICAL DATA (continued)

Recommended mounting screws:
Hexagon socket head screws – high tensile M5 or M6 with flat and spring washers.

Mounting torque on heatsink:			
a. for good thermal contact	min.	2.6	Nm
b. maximum allowable	max.	6.5	Nm
Mounting torque for bus-bars	min.	2.5	Nm
	max.	3.5	Nm
Net mass	=	130	g

RATINGS (per thyristor)

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

Anode to cathode			BGX12–600	800	1200	1200C	1400C–TT	
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	600	800	1200	1200	1400	V
Crest working voltages	V_{DWM}/V_{RWM}	max.	400	600	800	800	800	V

Average on-state current (averaged over any 20 ms period) up to T_{mb} = 85 °C	$I_{T(AV)}$	max.	40	A
R.M.S. on-state current	$I_{T(RMS)}$	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.	700	A
I^2t for fusing (t = 10 ms)	I^2t	max.	2450	A^2s
Rate of rise of on-state current after triggering with I_G = 500 mA to I_T = 125 A; dI_G/dt = 1 A/μs	dI_T/dt	max.	100	A/μs
Gate to cathode				
Peak reverse voltage	V_{RGM}	max.	5	V
Peak forward current (t_p = 10 μs)	I_{GM}	max.	5	A
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	0.5	W
Temperatures				
Storage temperature	T_{stg}		−40 to +125	°C
Junction temperature	T_j	max.	125	°C
Isolation*				
R.M.S. isolation voltage	V_{isol}	min.	2500	V

THERMAL RESISTANCE (per module with both thyristors conducting)

From junction to mounting baseplate	$R_{th\ j\text{-}mb}$	=	0.34	°C/W
From mounting base to heatsink; with heatsink compound	$R_{th\ mb\text{-}h}$	=	0.1	°C/W
Transient thermal impedance (t = 1 ms ; per thyristor)	$Z_{th\ j\text{-}mb}$	=	0.04	°C/W

*From baseplate to all terminals strapped together

CHARACTERISTICS (per individual thyristor)

Anode to cathode

On-state voltage I_T = 100 A; T_j = 25 °C	V_T	<	1.7	V*
Threshold voltage	$V_{T(TO)}$	=	1	V
Slope resistance	r_T	<	7	mΩ
Rate of rise of off-state voltage that will not trigger any device; exponential method; $V_D = 2/3\ V_{DRMmax}$; T_j = 125 °C	dV_D/dt	<	200	V/μs
for types with additional letter 'C'	dV_D/dt	<	1000	V/μs
Reverse current $V_R = V_{RWMmax}$; T_j = 125 °C	I_R	<	8	mA
Off-state current $V_D = V_{DWMmax}$; T_j = 125 °C	I_D	<	8	mA
Latching current; T_j = 25 °C	I_L	<	300	mA
Holding current; T_j = 25 °C	I_H	<	200	mA

Gate to cathode

Voltage that will trigger all devices V_D = 12 V; T_j = 25 °C	V_{GT}	>	1.5	V
Voltage that will not trigger any device $V_D = V_{DRMmax}$; T_j = 125 °C	V_{GD}	<	250	mV
Current that will trigger all devices V_D = 12 V; T_j = 25 °C	I_{GT}	>	100	mA

MOUNTING INSTRUCTIONS

Before mounting, the heatsink surface and the underside of the module should be coated with a heatsink compound (for example, Dow-Corning DC340).
It is recommended that after a period of about 3 hours, the mounting screws be again tightened to compensate for spreading of the heatsink compound under pressure.
Bus-bars should always be used for connection to the heavy current terminals.
The use of cable lugs is not recommended other than for the auxiliary cathode connections.

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*Measured under pulse conditions to avoid excessive dissipation.

Two BGX12 modules connected as:
SINGLE-PHASE BRIDGE RECTIFIER

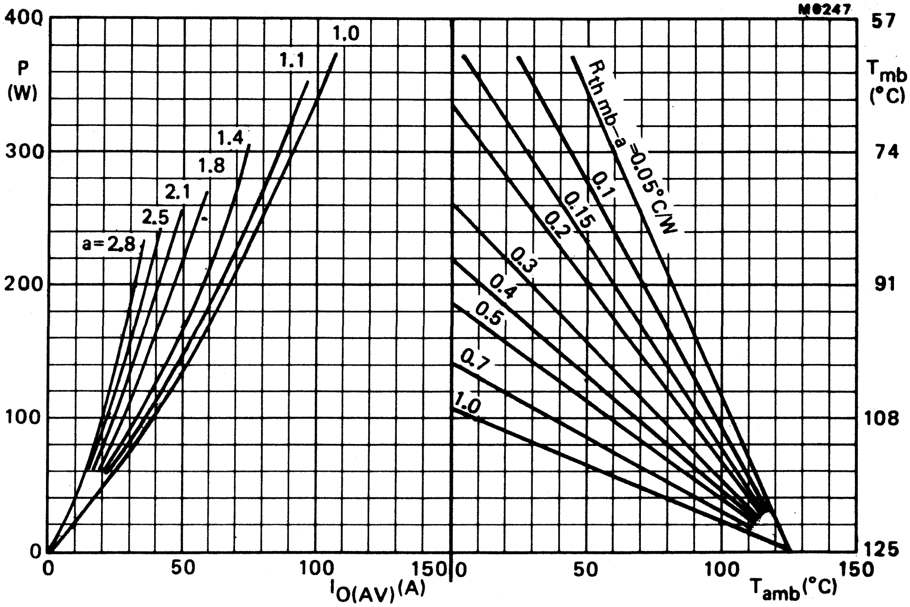
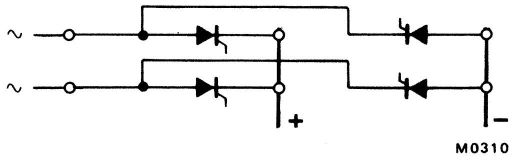


Fig.2 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.
Output form factor $a_o = I_{O(RMS)}/I_{O(AV)} = 0.707 \times I_{T(RMS)}/I_{T(AV)}$ per thyristor.
P = total power dissipation of two modules.



Two BGX12 modules connected as
single - phase bridge rectifier.

Three BGX12 modules connected as:

THREE-PHASE BRIDGE RECTIFIER

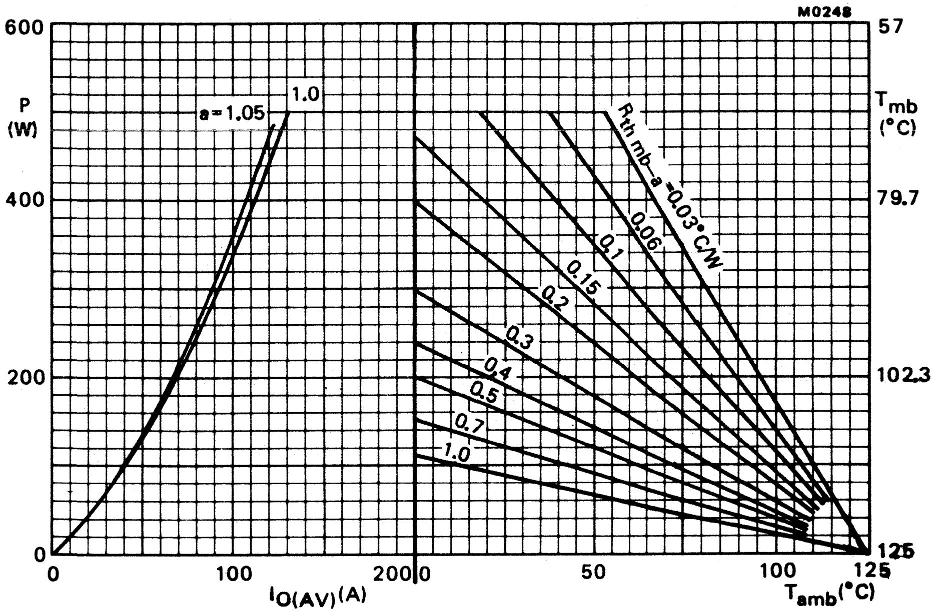
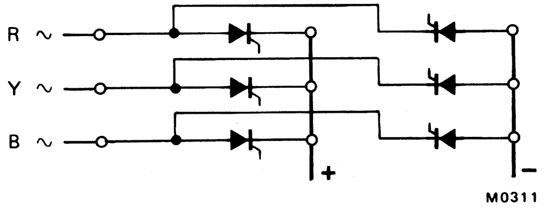


Fig.3 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

P = total power dissipation of three modules.



Three BGX12 modules connected as three- phase bridge rectifier.

One BGX12 module connected as:
SINGLE-PHASE A.C. CONTROLLER

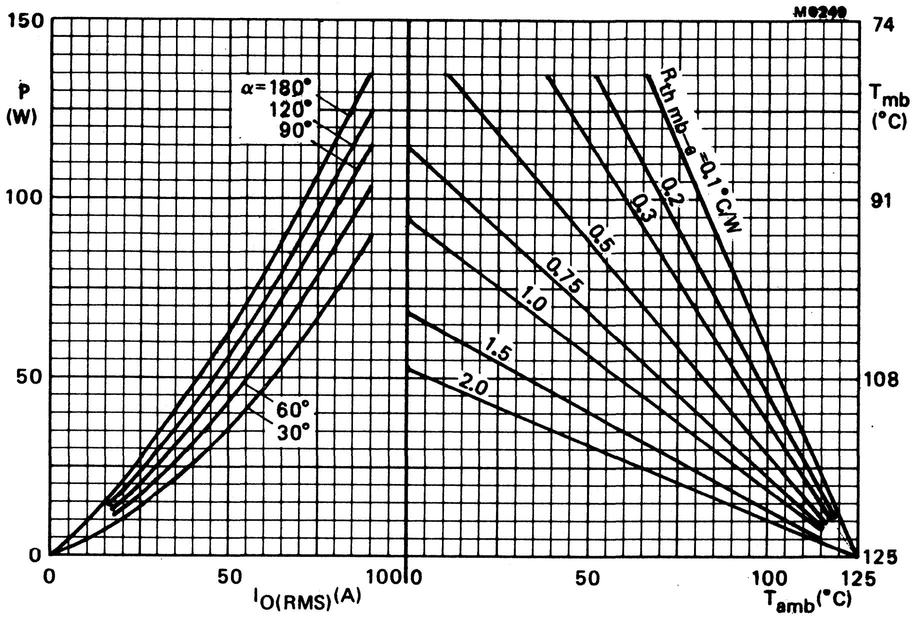
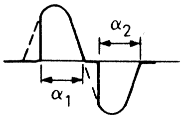
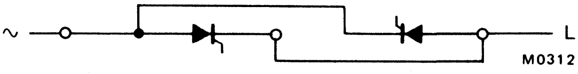


Fig.4 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha = \alpha_1 = \alpha_2$: conduction angle per half cycle



One BGX12 module connected as
single- phase a.c. controller.

Three BGX12 modules connected as:

THREE-PHASE A.C. CONTROLLER

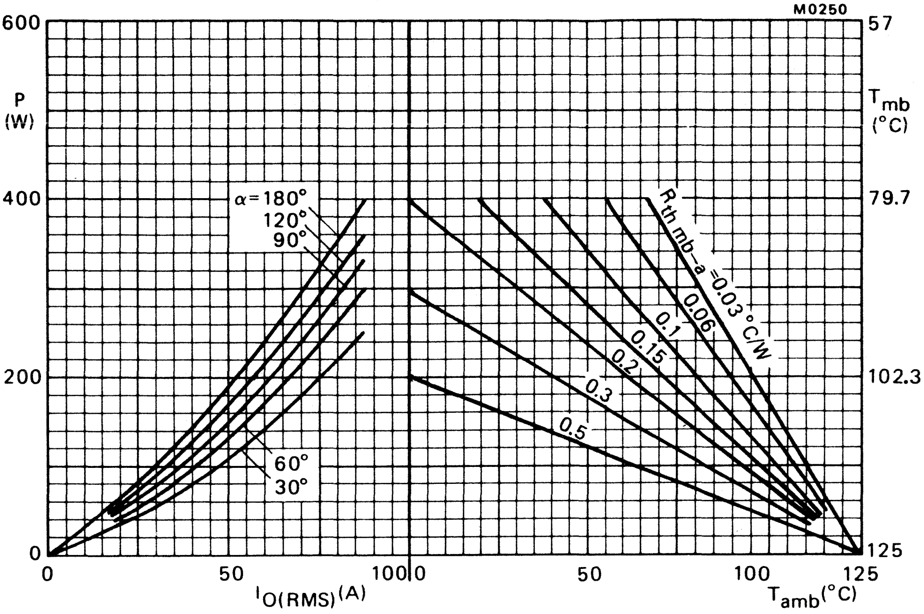
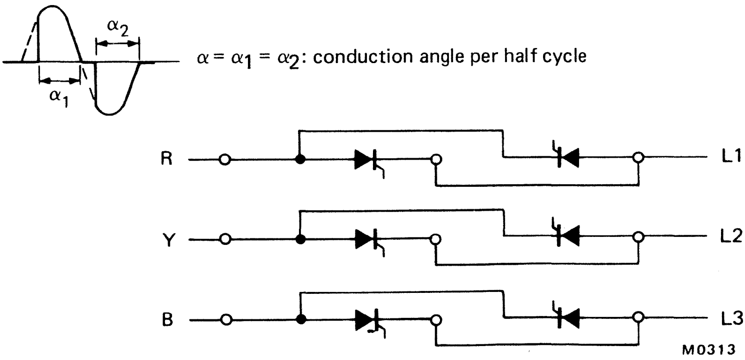


Fig.5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

P = total power dissipation of three modules.



Three BGX12 modules connected as three- phase a.c. controller.

ONE THYRISTOR CONDUCTING

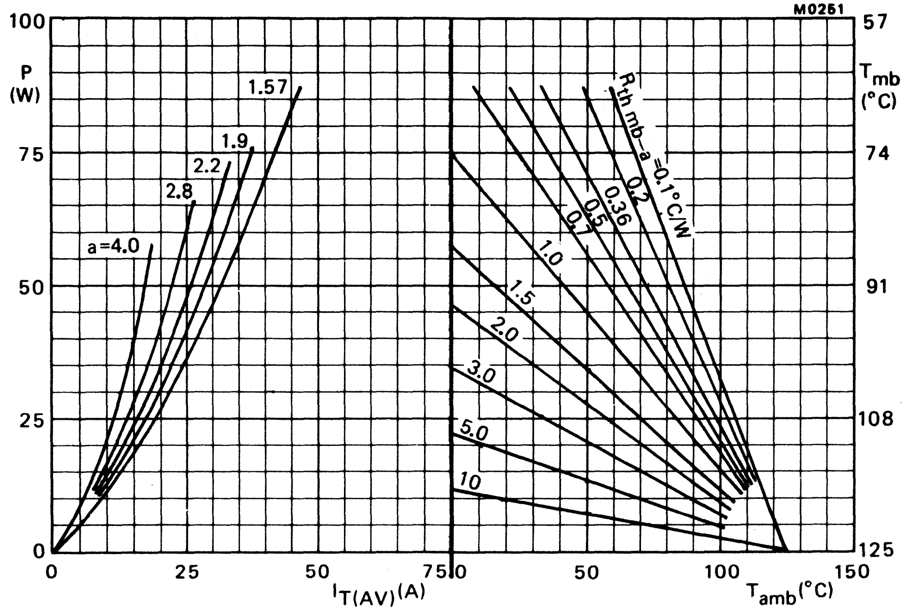
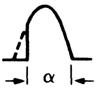


Fig.6 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



α = conduction angle per half cycle

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

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

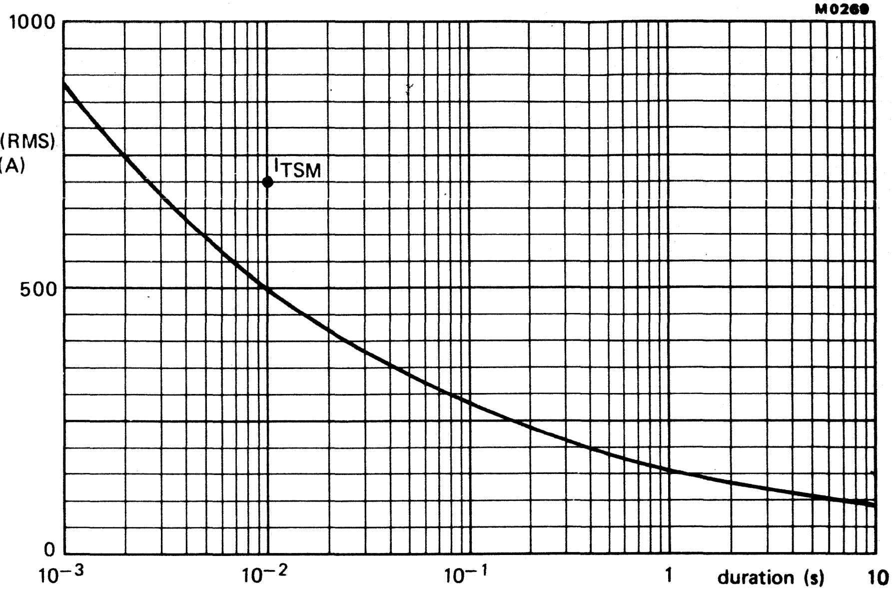
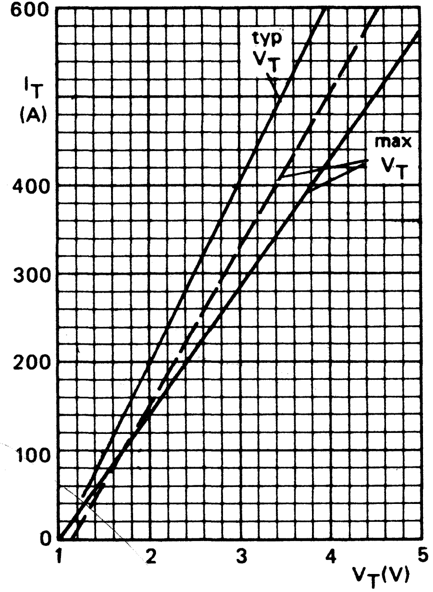


Fig.7 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents (f = 50 Hz); T_j = 125 °C prior to surge; with reapplied V_{RWMmax}; per thyristor.



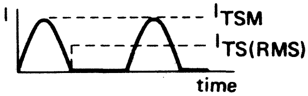


Fig.8 ---- T_j = 25 °C; —— T_j = 125 °C; per thyristor; pulse conditions.

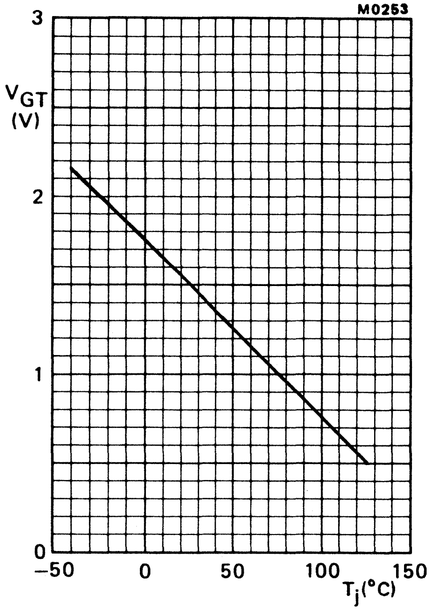


Fig.9 Minimum gate voltage that will trigger all devices as a function of T_j; per thyristor.

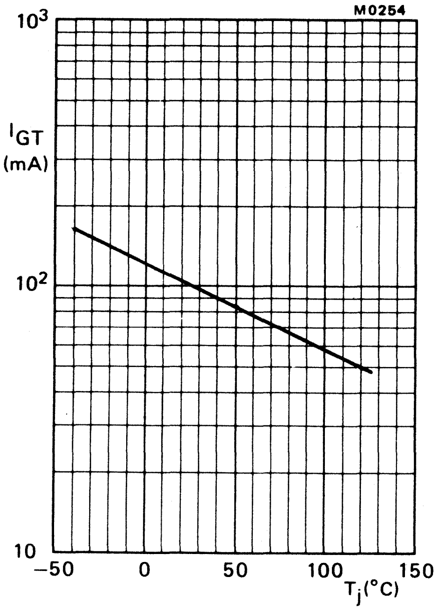


Fig.10 Minimum gate current that will trigger all devices as a function of T_j; per thyristor.

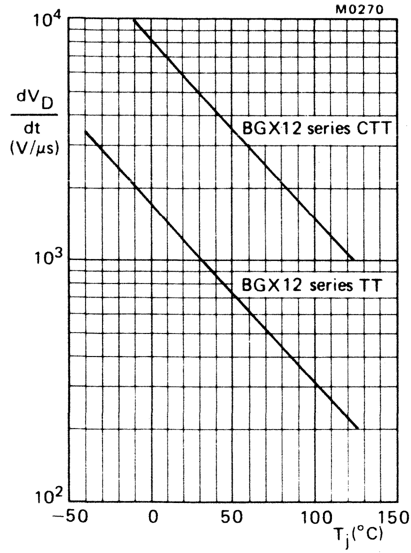


Fig.11 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of T_j; per thyristor.

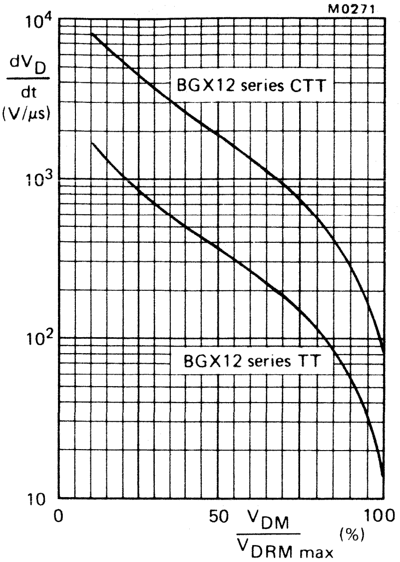


Fig.12 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of peak off-state voltage; T_j = 125 °C; per thyristor.

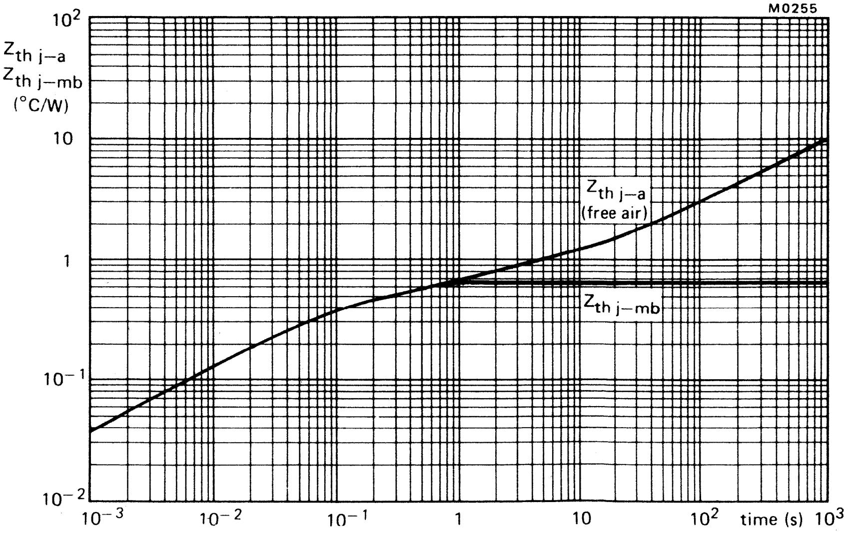


Fig.13 Transient thermal impedance of one thyristor plotted against time.

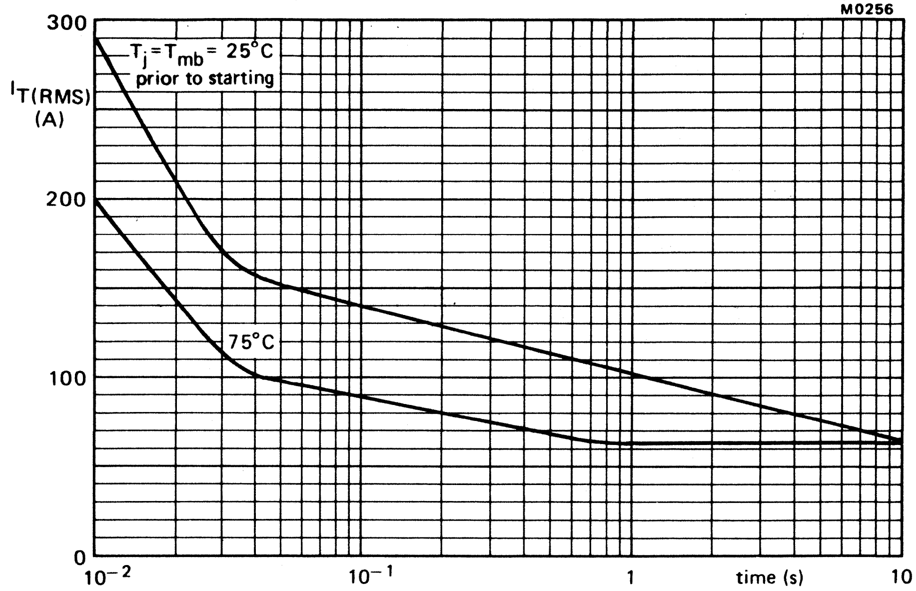


Fig.14 Limits of starting or inrush current; half-cycle operation; one thyristor conducting.

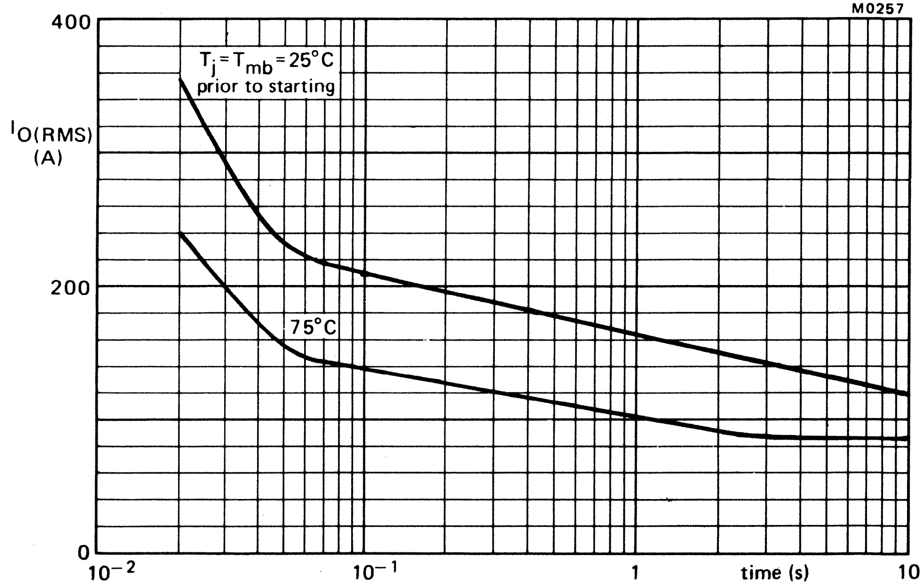


Fig.15 Limits of starting or inrush current; full-wave operation; two thyristors conducting (a.c. controller).

ISOLATED THYRISTOR MODULES

Two-thyristor modules incorporating glass-passivated devices in a plastic package, with electrically-isolated metal baseplate. The modules are intended for use in general-purpose single and three-phase applications.

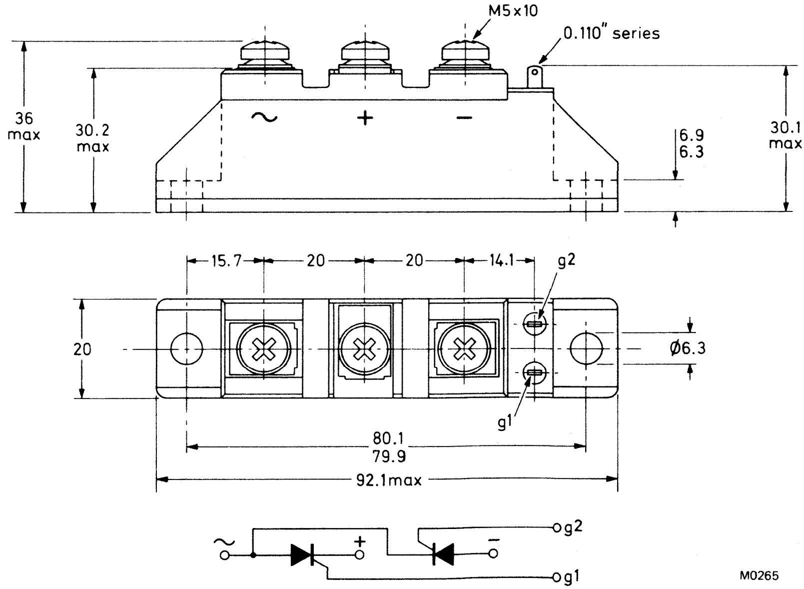
QUICK REFERENCE DATA

Per thyristor			BGX13–600	800	1200	1200C	1400C–TT	
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	600	800	1200	1200	1400	V
R.M.S. on-state current	$I_{T(RMS)}$	max.	80					A
Average on-state current	$I_{T(AV)}$	max.	50					A
Non-repetitive peak on-state current	I_{TSM}	max.	1000					A
Rate of rise of off-state voltage that will not trigger any device	dV_D/dt	<	200			1000		V/μs

MECHANICAL DATA (see also next page)

Dimensions in mm

Fig.1



MECHANICAL DATA (continued)

Recommended mounting screws:
Hexagon socket head screws — high tensile M5 with flat and spring washers.

Mounting torque on heatsink:			
a. for good thermal contact	min.	2.5	Nm
b. maximum allowable	max.	3.7	Nm
Mounting torque for bus-bars	min.	2.5	Nm
	max.	3.7	Nm
Net mass	=	150	g

RATINGS (per thyristor)

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

Anode to cathode			BGX13–600	800	1200	1200C	1400C–TT	
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	600	800	1200	1200	1400	V
Crest working voltages	V_{DWM}/V_{RWM}	max.	400	600	800	800	800	V

R.M.S. on-state current	$I_{T(RMS)}$	max.	80	A
Average on-state current (averaged over any 20 ms period) up to T_{mb} = 85 °C	$I_{T(AV)}$	max.	50	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.	1000	A
I^2t for fusing (t = 10 ms)	I^2t	max.	5000	A^2s
Rate of rise of on-state current after triggering with I_G = 150 mA to I_T = 60 A; dI_G/dt = 150 mA/μs	dI_T/dt	max.	100	A/μs
Gate to cathode				
Peak power dissipation (t_p = 500 μs)	P_{GM}	max.	5	W
Temperatures				
Storage temperature	T_{stg}		−40 to +125	°C
Junction temperature	T_j	max.	125	°C
Isolation*				
R.M.S. isolation voltage	V_{isol}	min.	2500	V

THERMAL RESISTANCE (per module with both thyristors conducting)

From junction to mounting baseplate	$R_{th\ j\text{-}mb}$	=	0.3	K/W
From mounting base to heatsink; with heatsink compound	$R_{th\ mb\text{-}h}$	=	0.1	K/W

---

*From baseplate to all terminals strapped together.

CHARACTERISTICS (per individual thyristor)

Anode to cathode

On-state voltage				
I_T = 150 A; T_j = 25 °C	V_T	<	1.65	V*
Threshold voltage	$V_{T(TO)}$	=	1	V
Slope resistance	r_T	<	4.5	mΩ
Rate of rise of off-state voltage that will not trigger any device; exponential method;				
V_D = 2/3 V_{DRMmax}; T_j = 125 °C	dV_D/dt	<	200	V/μs
for types with additional letter 'C'	dV_D/dt	<	1000	V/μs
Reverse current				
V_R = V_{RWMmax}; T_j = 125 °C	I_R	<	12	mA
Off-state current				
V_D = V_{DWMmax}; T_j = 125 °C	I_D	<	12	mA
Latching current; T_j = 25 °C	I_L	<	400	mA
Holding current; T_j = 25 °C	I_H	<	250	mA

Gate to cathode

Voltage that will trigger all devices				
V_D = 6 V; T_j = 25 °C	V_{GT}	>	1.5	V
Voltage that will not trigger any device				
V_D = V_{DRMmax}; T_j = 125 °C	V_{GD}	<	250	mV
Current that will trigger all devices				
V_D = 6 V; T_j = 25 °C	I_{GT}	>	150	mA

MOUNTING INSTRUCTIONS

Before mounting, the heatsink surface and the underside of the module should be coated with a heatsink compound (for example, Dow-Corning DC340).
It is recommended that after a period of about 3 hours, the mounting screws be again tightened to compensate for spreading of the heatsink compound under pressure.
Bus-bars should always be used for connection to the heavy current terminals.
The use of cable lugs is not recommended other than for the auxiliary cathode connections.

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*Measured under pulse conditions to avoid excessive dissipation.

Two BGX13 modules connected as:

SINGLE-PHASE BRIDGE RECTIFIER

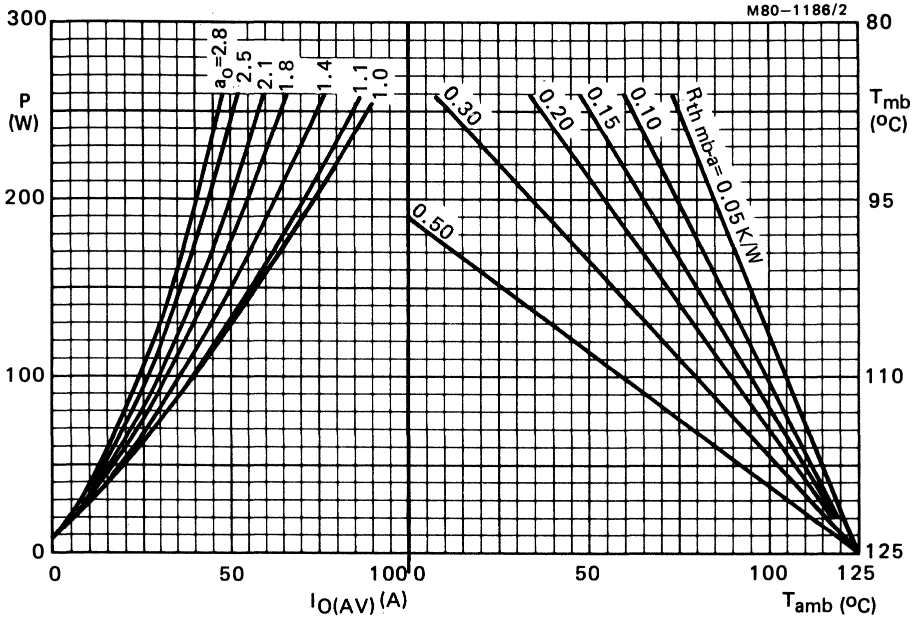


Fig.2 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

Output form factor $a_o = I_{O(RMS)}/I_{O(AV)} = 0.707 \times I_{T(RMS)}/I_{T(AV)}$ per thyristor.

P = total power dissipation of two modules.

Three BGX13 modules connected as:

THREE-PHASE BRIDGE RECTIFIER

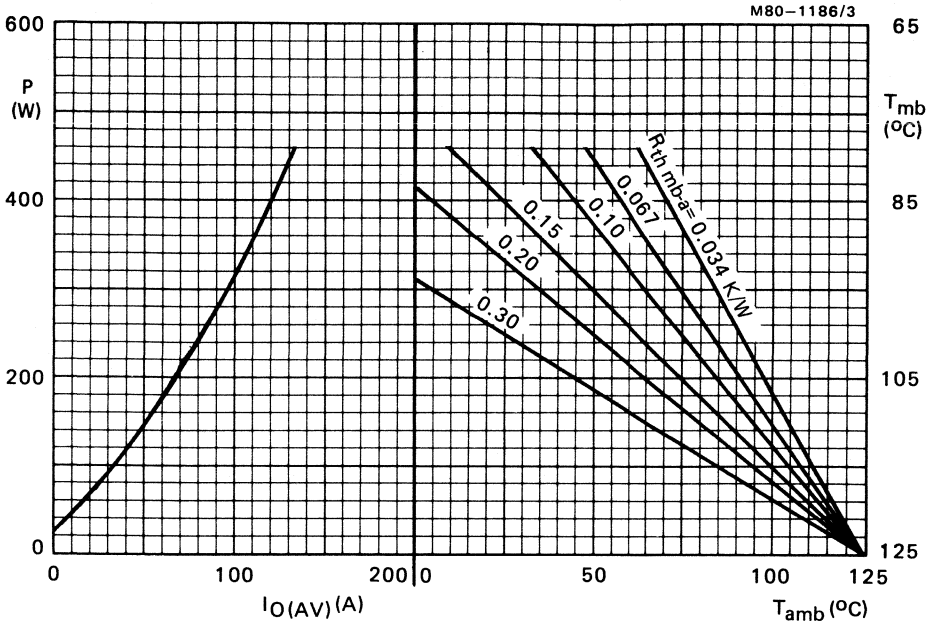


Fig.3 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

P = total power dissipation of three modules.

One BGX13 module connected as:

SINGLE-PHASE A.C. CONTROLLER

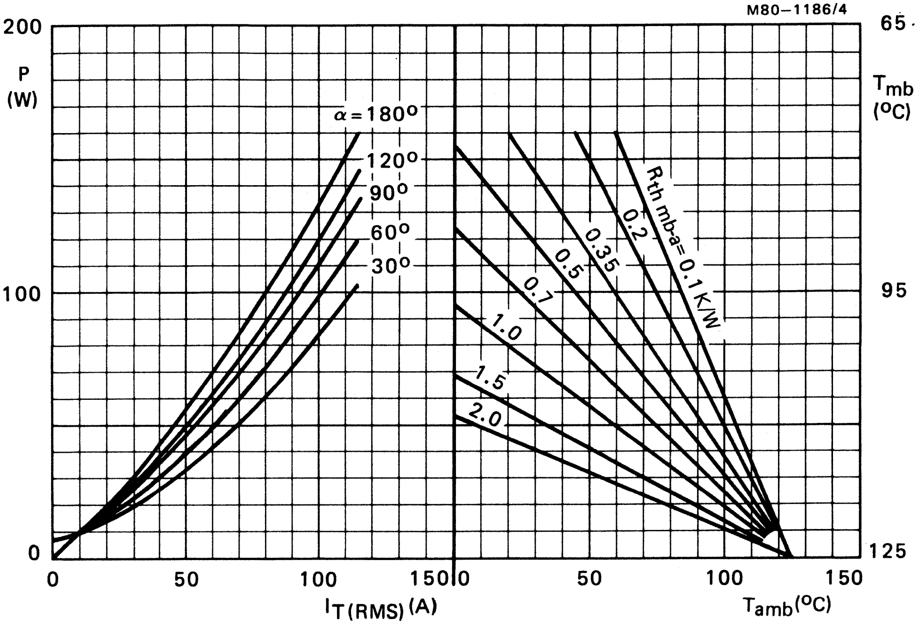
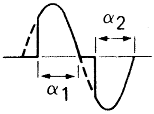


Fig.4 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha = \alpha_1 = \alpha_2$: conduction angle per half cycle

Three BGX13 modules connected as:

THREE-PHASE A.C. CONTROLLER

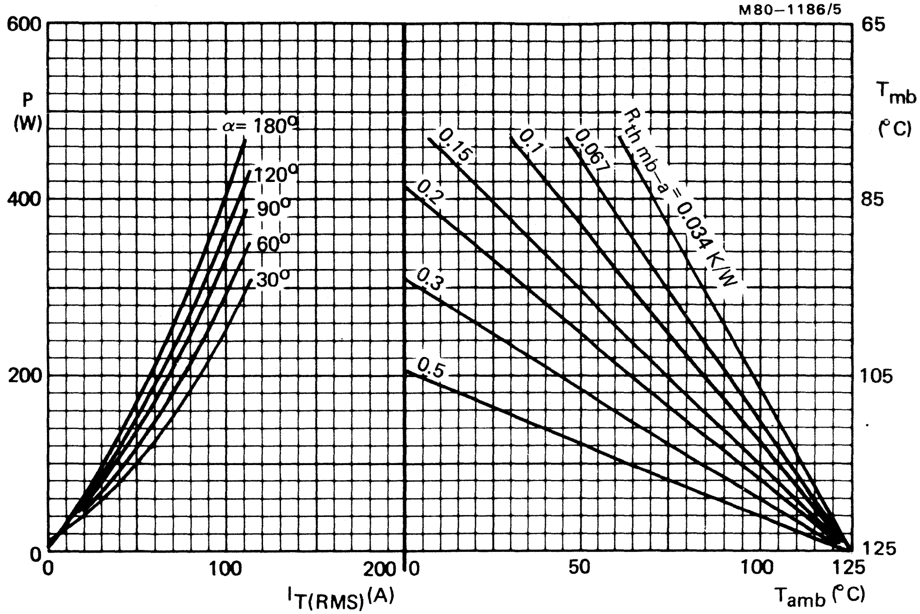
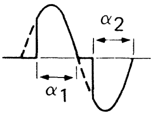


Fig.5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

P = total power dissipation of three modules.



$\alpha = \alpha_1 = \alpha_2$: conduction angle per half cycle

ONE THYRISTOR CONDUCTING

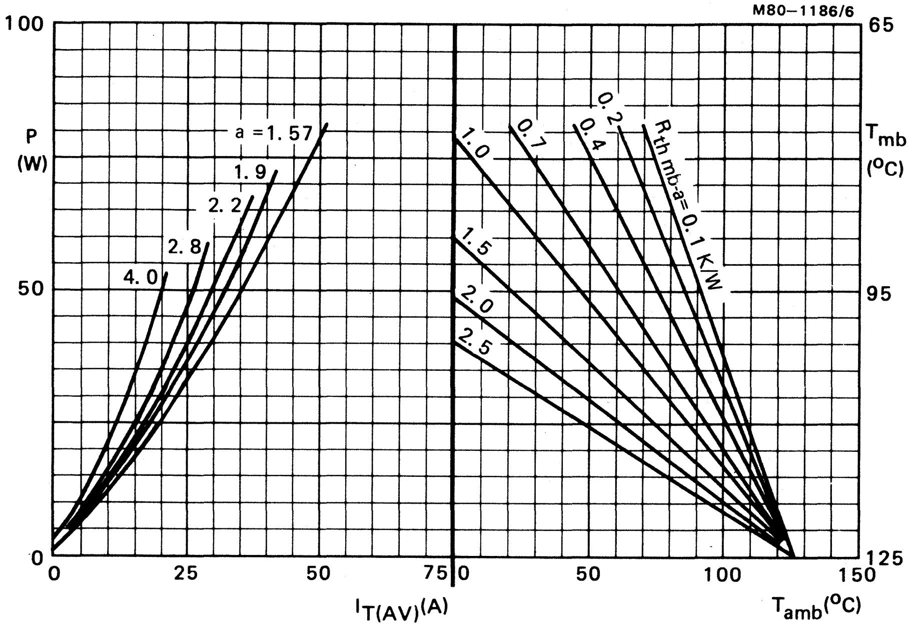
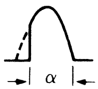


Fig.6 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



α = conduction angle per half cycle

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

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

ONE THYRISTOR CONDUCTING

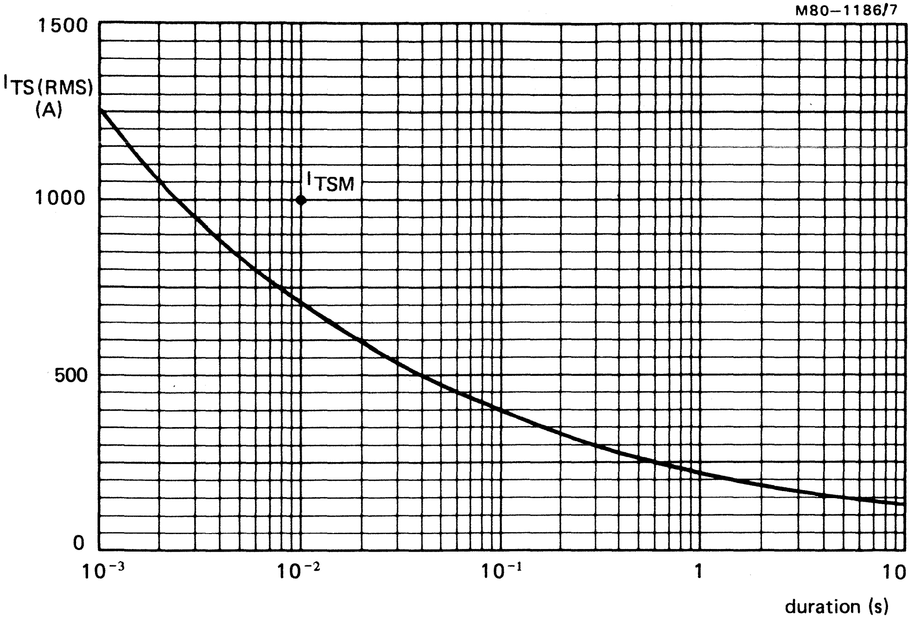
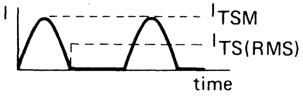


Fig.7 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents (f = 50 Hz); T_j = 125 °C prior to surge; with reapplied V_{RWMmax}.



ISOLATED THYRISTOR MODULES

Two-thyristor modules incorporating glass-passivated devices in a plastic package, with electrically-isolated metal baseplate. The modules are intended for use in general-purpose single and three-phase applications.

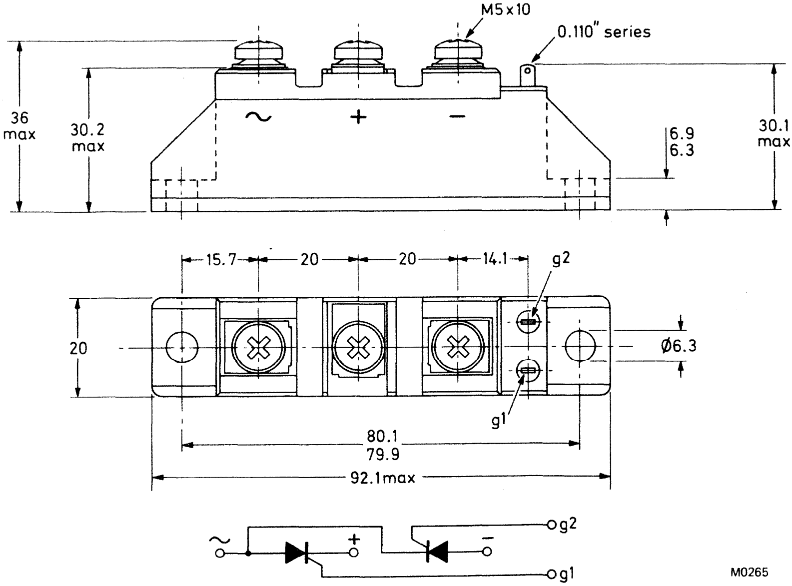
QUICK REFERENCE DATA

Per thyristor			BGX14–600	800	1200	1200C	1400C–TT	
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	600	800	1200	1200	1400	V
R.M.S. on-state current	$I_{T(RMS)}$	max.	95					A
Average on-state current	$I_{T(AV)}$	max.	55					A
Non-repetitive peak on-state current	I_{TSM}	max.	1350					A
Rate of rise of off-state voltage that will not trigger any device	dV_D/dt	<	200			1000		V/μs

MECHANICAL DATA (see also next page)

Dimensions in mm

Fig.1



MECHANICAL DATA (continued)

Recommended mounting screws:
Hexagon socket-head screws – high tensile M5 with flat and spring washers.

Mounting torque on heatsink:			
a. for good thermal contact	min.	2.5	Nm
b. maximum allowable	max.	3.7	Nm
Mounting torque for bus-bars	min.	2.5	Nm
	max.	3.7	Nm
Net mass	=	150	g

RATINGS (per thyristor)

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

Anode to cathode			BGX14–600	800	1200	1200C	1400C–TT	
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	600	800	1200	1200	1400	V
Crest working voltages	V_{DWM}/V_{RWM}	max.	400	600	800	800	800	V

R.M.S. on-state current	$I_{T(RMS)}$	max.	95	A
Average on-state current (averaged over any 20 ms period) up to T_{mb} = 85 °C	$I_{T(AV)}$	max.	55	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.	1350	A
I^2t for fusing (t = 10 ms)	I^2t	max.	9100	A^2s
Rate of rise of on-state current after triggering with I_G = 150 mA to I_T = 60 A; dI_G/dt = 150 mA/μs	dI_T/dt	max.	100	A/μs
Gate to cathode				
Peak power dissipation (t_p = 500 μs)	P_{GM}	max.	5	W
Temperatures				
Storage temperature	T_{stg}		−40 to +125	°C
Junction temperature	T_j	max.	125	°C
Isolation*				
R.M.S. isolation voltage	V_{isol}	min.	2500	V

THERMAL RESISTANCE (per module with both thyristors conducting)

From junction to mounting baseplate	$R_{th\ j\text{-}mb}$	=	0.25	K/W
From mounting base to heatsink; with heatsink compound	$R_{th\ mb\text{-}h}$	=	0.1	K/W

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*From baseplate to all terminals strapped together.

CHARACTERISTICS (per individual thyristor)

Anode to cathode

On-state voltage $I_T = 175$ A; $T_j = 25$ °C	V_T	$<$	1.75	V*
Threshold voltage	$V_{T(TO)}$	=	1	V
Slope resistance	r_T	$<$	3.35	mΩ
Rate of rise of off-state voltage that will not trigger any device; exponential method; $V_D = 2/3\ V_{DRMmax}$; $T_j = 125$ °C	dV_D/dt	$<$	200	V/µs
for types with additional letter 'C'	dV_D/dt	$<$	1000	V/µs
Reverse current $V_R = V_{RWMmax}$; $T_j = 125$ °C	I_R	$<$	12	mA
Off-state current $V_D = V_{DWMmax}$; $T_j = 125$ °C	I_D	$<$	12	mA
Latching current; $T_j = 25$ °C	I_L	$<$	400	mA
Holding current; $T_j = 25$ °C	I_H	$<$	250	mA

Gate to cathode

Voltage that will trigger all devices $V_D = 6$ V; $T_j = 25$ °C	V_{GT}	$>$	1.5	V
Voltage that will not trigger any device $V_D = V_{DRMmax}$; $T_j = 125$ °C	V_{GD}	$<$	250	mV
Current that will trigger all devices $V_D = 6$ V; $T_j = 25$ °C	I_{GT}	$>$	150	mA

MOUNTING INSTRUCTIONS

Before mounting, the heatsink surface and the underside of the module should be coated with a heatsink compound (for example, Dow-Corning DC340).
It is recommended that after a period of about 3 hours, the mounting screws be again tightened to compensate for spreading of the heatsink compound under pressure.
Bus-bars should always be used for connection to the heavy current terminals.
The use of cable lugs is not recommended other than for the auxiliary cathode connections.

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*Measured under pulse conditions to avoid excessive dissipation.

Two BGX14 modules connected as:
SINGLE-PHASE BRIDGE RECTIFIER

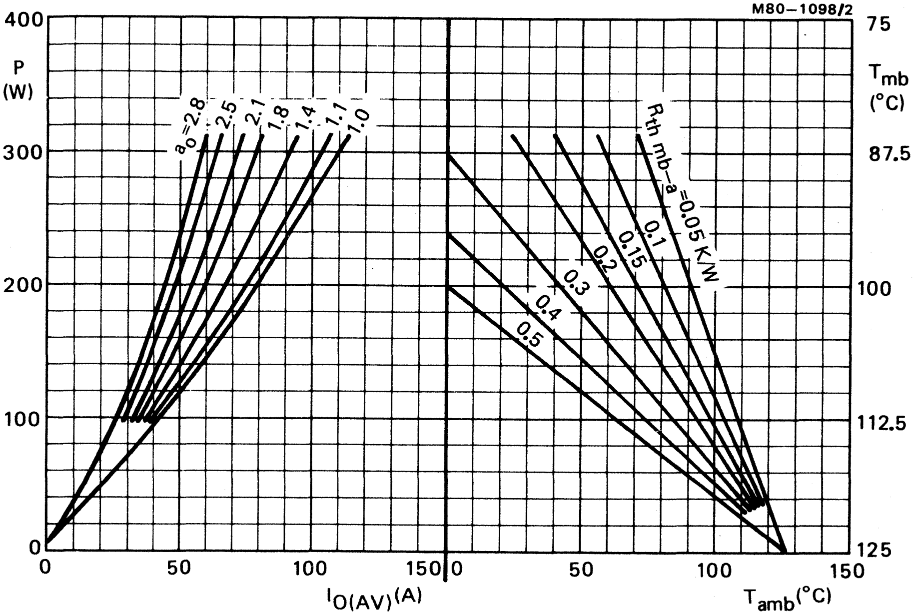


Fig.2 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

Output form factor $a_o = I_{O(RMS)}/I_{O(AV)} = 0.707 \times I_{T(RMS)}/I_{T(AV)}$ per thyristor.

P = total power dissipation of two modules.

Three BGX14 modules connected as:

THREE-PHASE BRIDGE RECTIFIER

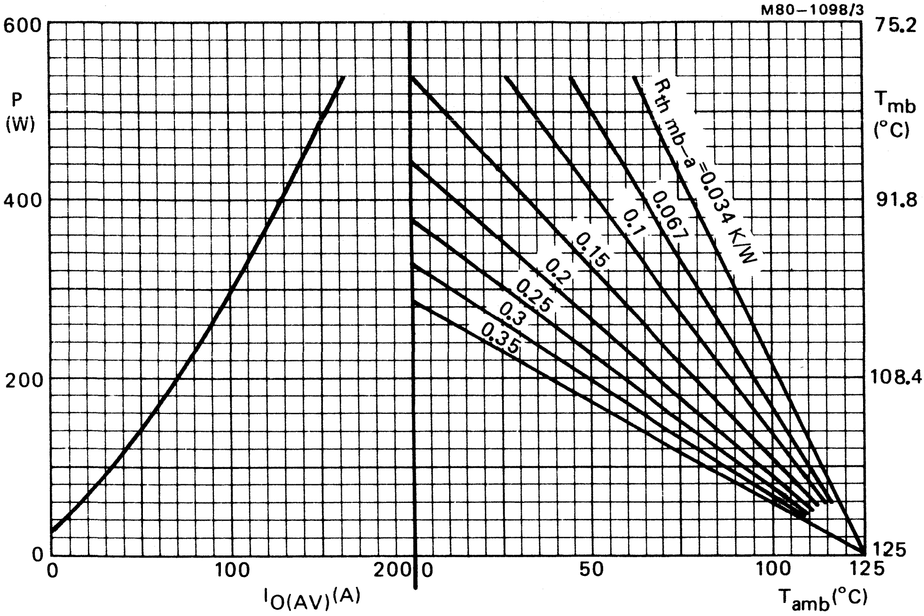


Fig.3 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

P = total power dissipation of three modules.

One BGX14 module connected as:
SINGLE-PHASE A.C. CONTROLLER

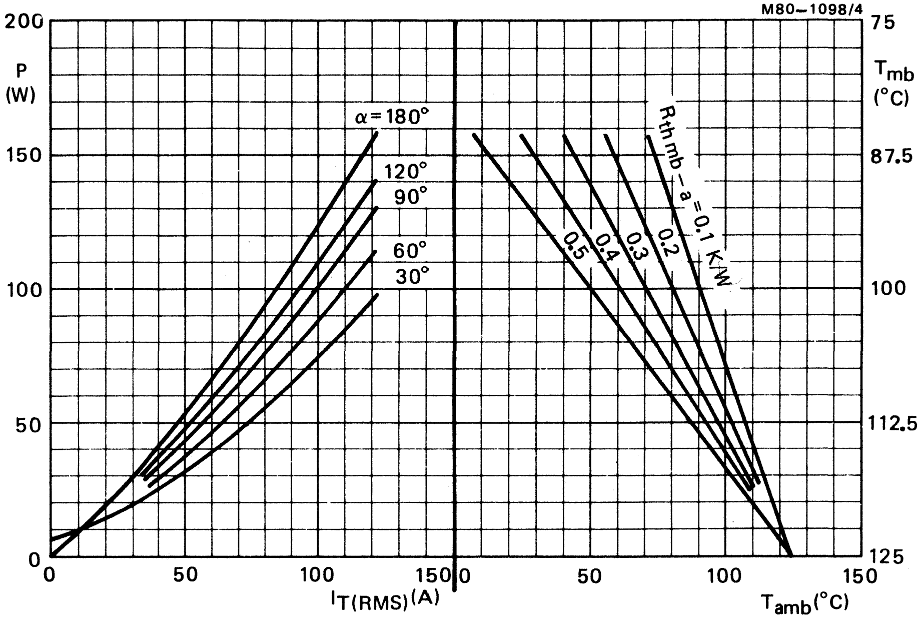
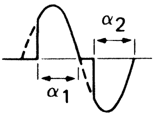


Fig.4 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha = \alpha_1 = \alpha_2$: conduction angle per half cycle

Three BGX14 modules connected as:

THREE-PHASE A.C. CONTROLLER

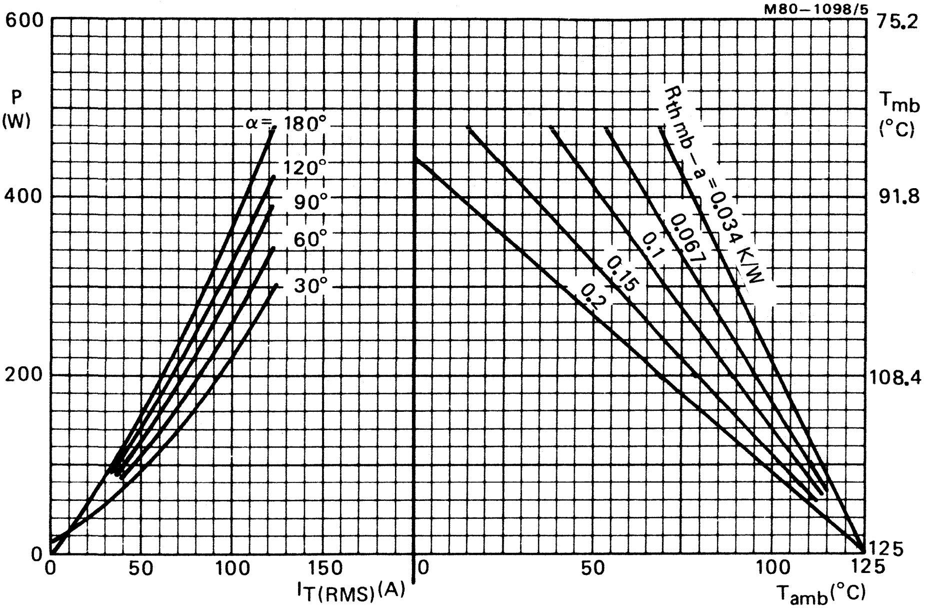
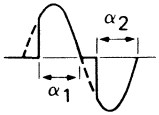


Fig.5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

P = total power dissipation of three modules.



$\alpha = \alpha_1 = \alpha_2$: conduction angle per half cycle

ONE THYRISTOR CONDUCTING

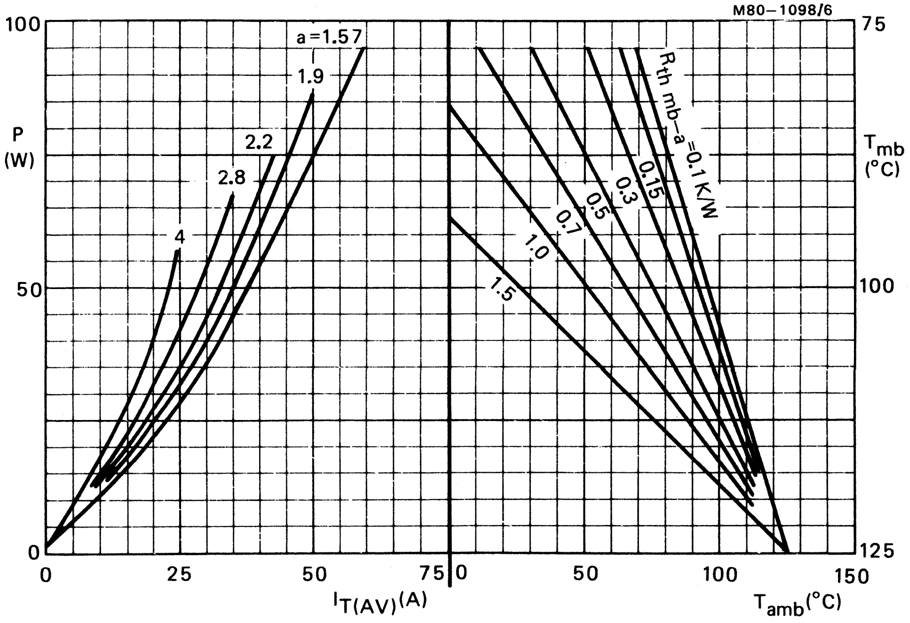
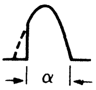


Fig.6 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



α = conduction angle per half cycle

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

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

ONE THYRISTOR CONDUCTING

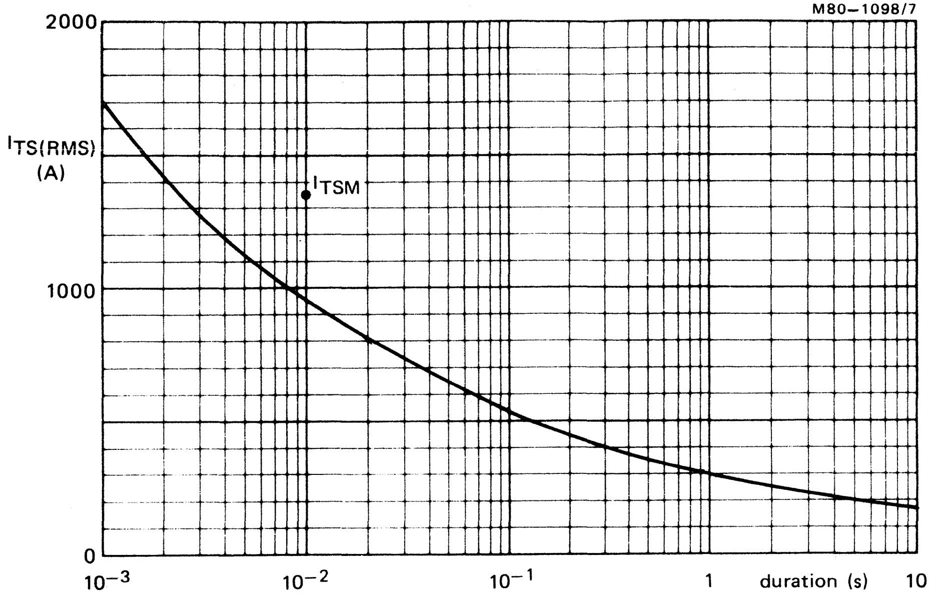
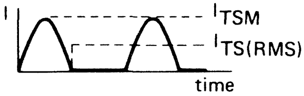


Fig.7 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents (f = 50 Hz); T_j = 125 °C prior to surge; with reapplied V_{RWMmax}.



ISOLATED THYRISTOR MODULES

Two-thyristor modules incorporating glass-passivated devices in a plastic package, with electrically-isolated metal baseplate. The modules are intended for use in general-purpose single and three-phase applications.

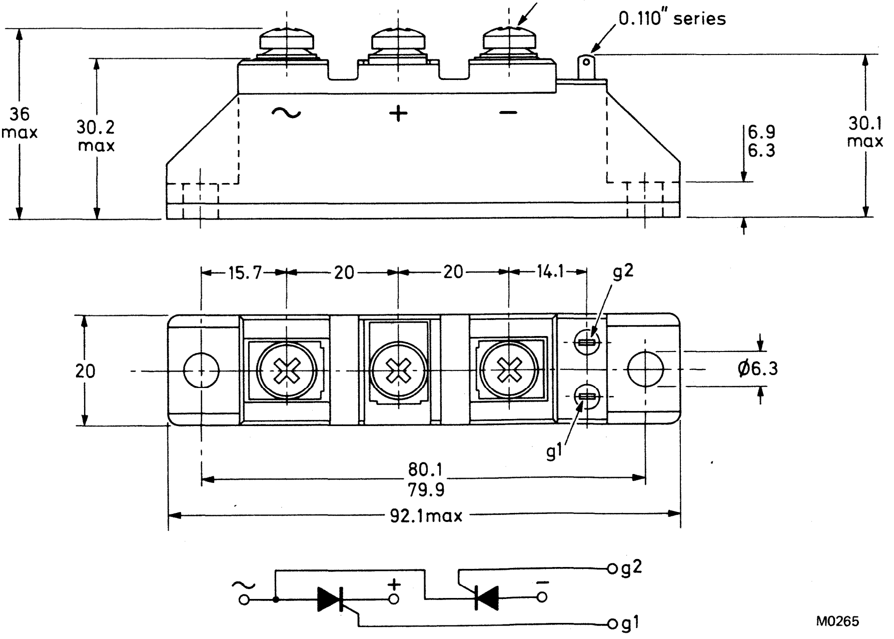
QUICK REFERENCE DATA

Per thyristor			BGX15–600	800	1200	1200C	1400C–TT	
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	600	800	1200	1200	1400	V
R.M.S. on-state current	$I_{T(RMS)}$	max.	110					A
Average on-state current	$I_{T(AV)}$	max.	65					A
Non-repetitive peak on-state current	I_{TSM}	max.	1500					A
Rate of rise of off-state voltage that will not trigger any device	dV_D/dt	<	200			1000		V/µs

MECHANICAL DATA (see also next page)

Dimensions in mm

Fig.1 TO-240AA



MECHANICAL DATA (continued)

Recommended mounting screws:
Hexagon socket head screws — high tensile M5 or M6 with flat and spring washers.

Mounting torque on heatsink:			
a. for good thermal contact	min.	2.6	Nm
b. maximum allowable	max.	6.5	Nm
Mounting torque for bus-bars	min.	2.5	Nm
	max.	3.5	Nm
Net mass	=	130	g

RATINGS (per thyristor)

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

Anode to cathode			BGX15–600	800	1200	1200C	1400C–TT	
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	600	800	1200	1200	1400	V
Crest working voltages	V_{DWM}/V_{RWM}	max.	400	600	800	800	800	V

Average on-state current (averaged over any 20 ms period) up to T_{mb} = 85 °C	$I_{T(AV)}$	max.	65	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	110	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.	1500	A
I^2t for fusing (t = 10 ms)	I^2t	max.	11250	A^2s
Rate of rise of on-state current after triggering with I_G = 750 mA to I_T = 200 A; dI_G/dt = 1.5 A/µs	dI_T/dt	max.	100	A/µs

Gate to cathode

Peak reverse voltage	V_{RGM}	max.	5	V
Peak forward current (t_p = 10 µs)	I_{GM}	max.	5	A
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	0.5	W

Temperatures

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

Isolation*

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

THERMAL RESISTANCE (per module with both thyristors conducting)

From junction to mounting baseplate	$R_{th\ j\text{-}mb}$	=	0.2	°C/W
From mounting base to heatsink; with heatsink compound	$R_{th\ mb\text{-}h}$	=	0.1	°C/W
Transient thermal impedance (t = 1 ms; per thyristor)	$Z_{th\ j\text{-}mb}$	=	0.02	°C/W

*From baseplate to all terminals strapped together

CHARACTERISTICS (per individual thyristor)

Anode to cathode

On-state voltage I_T = 200 A; T_j = 25 °C	V_T	<	1.6	V*
Threshold voltage	$V_{T(TO)}$	=	1	V
Slope resistance	r_T	<	3	mΩ
Rate of rise of off-state voltage that will not trigger any device; exponential method; V_D = 2/3 V_{DRMmax}; T_j = 125 °C	dV_D/dt	<	200	V/µs
for types with additional letter 'C'	dV_D/dt	<	1000	V/µs
Reverse current $V_R = V_{RWMmax}$; T_j = 125 °C	I_R	<	15	mA
Off-state current $V_D = V_{DWMmax}$; T_j = 125 °C	I_D	<	15	mA
Latching current; T_j = 25 °C	I_L	<	400	mA
Holding current; T_j = 25 °C	I_H	<	250	mA

Gate to cathode

Voltage that will trigger all devices V_D = 12 V; T_j = 25 °C	V_{GT}	>	1.5	V
Voltage that will not trigger any device $V_D = V_{DRMmax}$; T_j = 125 °C	V_{GD}	<	250	mV
Current that will trigger all devices V_D = 12 V; T_j = 25 °C	I_{GT}	>	150	mA

MOUNTING INSTRUCTIONS

Before mounting, the heatsink surface and the underside of the module should be coated with a heatsink compound (for example, Dow-Corning DC340).
It is recommended that after a period of about 3 hours, the mounting screws be again tightened to compensate for spreading of the heatsink compound under pressure.
Bus-bars should always be used for connection to the heavy current terminals.
The use of cable lugs is not recommended other than for making auxiliary cathode connections.

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*Measured under pulse conditions to avoid excessive dissipation.

Two BGX15 modules connected as:
SINGLE-PHASE BRIDGE RECTIFIER

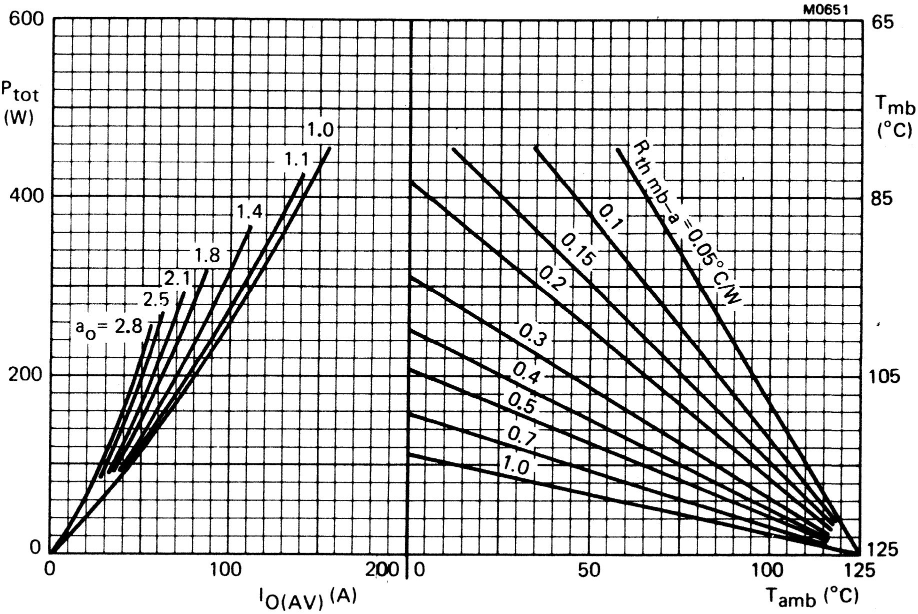
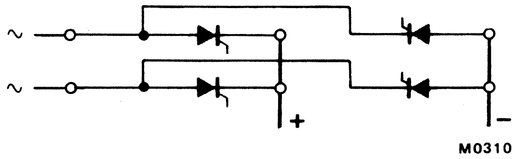


Fig.2 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

Output form factor $a_o = I_{O(RMS)}/I_{O(AV)} = 0.707 \times I_{T(RMS)}/I_{T(AV)}$ per thyristor.

P = total power dissipation of two modules.



Two BGX15 modules connected as
single - phase bridge rectifier.

Three BGX15 modules connected as:

THREE-PHASE BRIDGE RECTIFIER

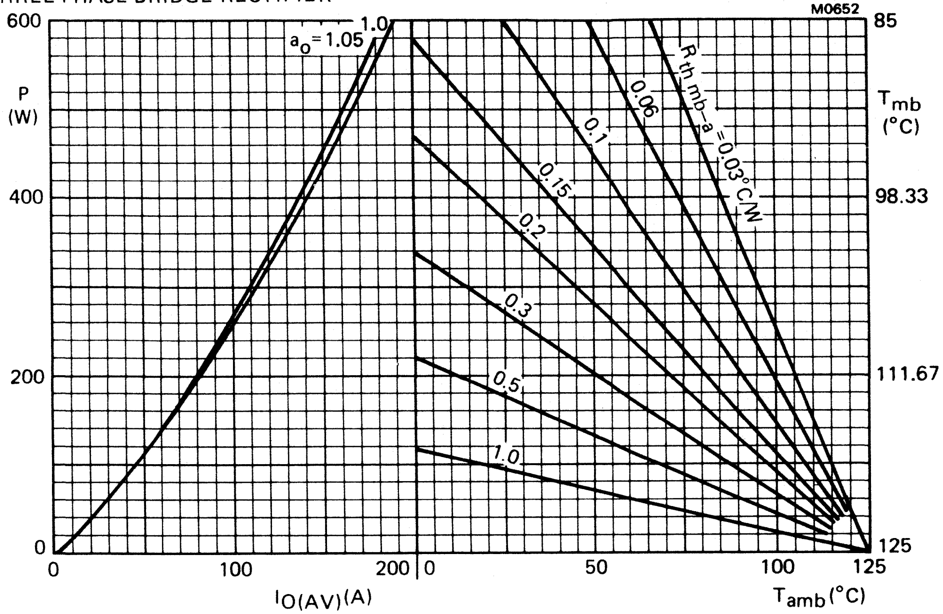
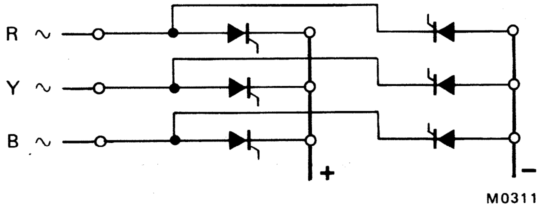


Fig.3 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

Output form factor $a_o = I_{O(RMS)}/I_{O(AV)}$.

P = total power dissipation of three modules.



Three BGX15 modules connected as three- phase bridge rectifier.

One BGX15 module connected as:

SINGLE-PHASE A.C. CONTROLLER

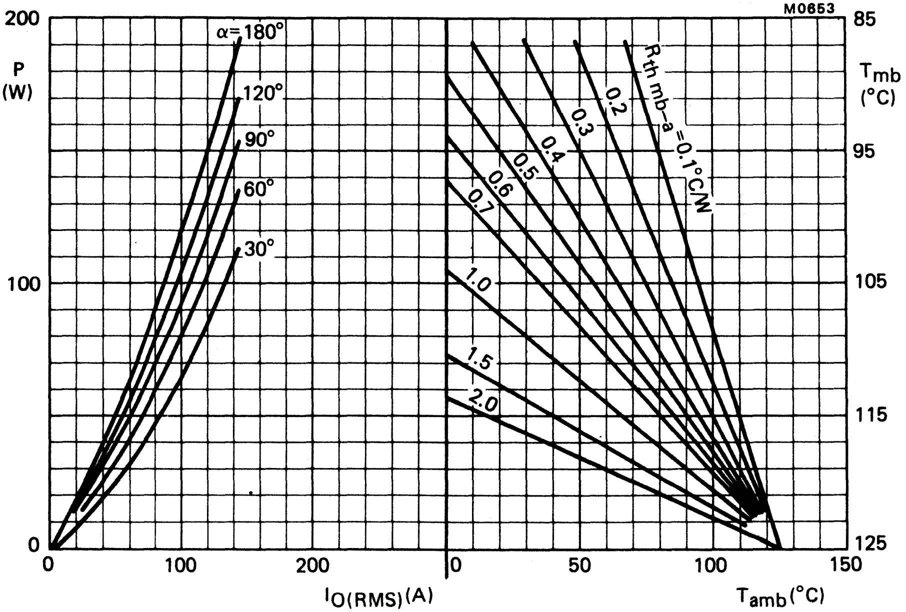
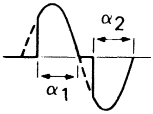
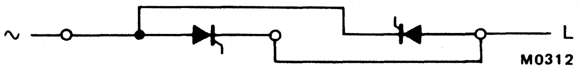


Fig.4 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha = \alpha_1 = \alpha_2$: conduction angle per half cycle



One BGX15 module connected as single- phase a.c. controller.

Three BGX15 modules connected as:

THREE-PHASE A.C. CONTROLLER

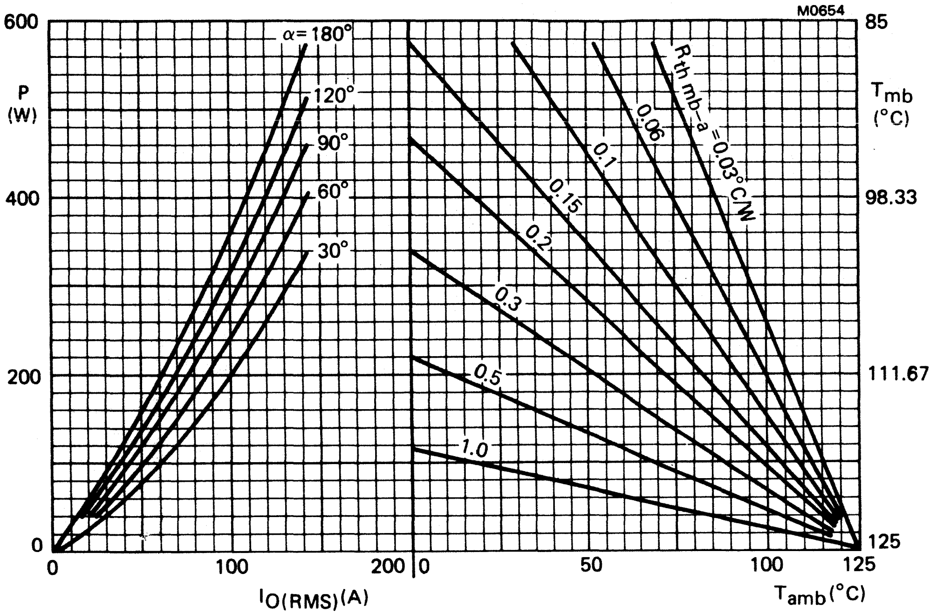
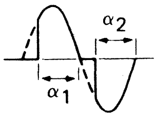
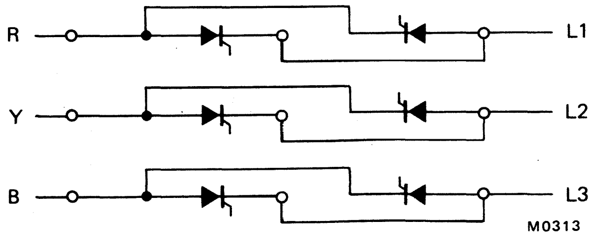


Fig.5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

P = total power dissipation of three modules.



$\alpha = \alpha_1 = \alpha_2$: conduction angle per half cycle



Three BGX15 modules connected as three- phase a.c. controller.

ONE THYRISTOR CONDUCTING

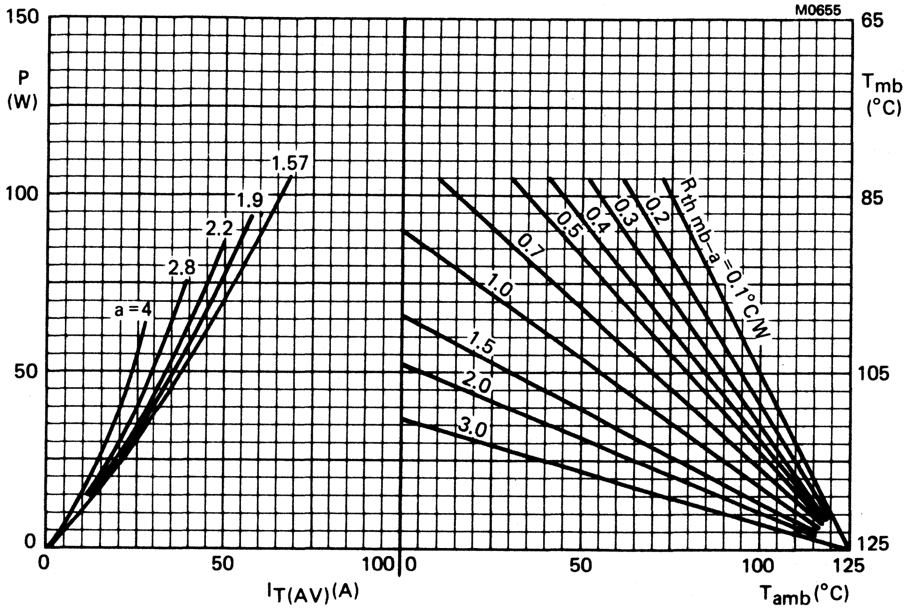
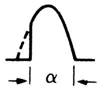


Fig.6 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



α = conduction angle per half cycle

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

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

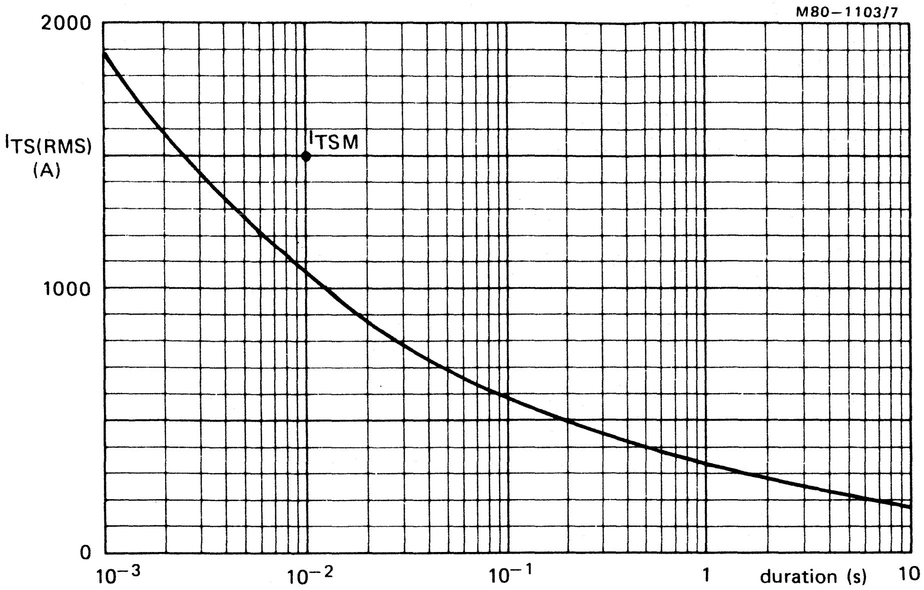
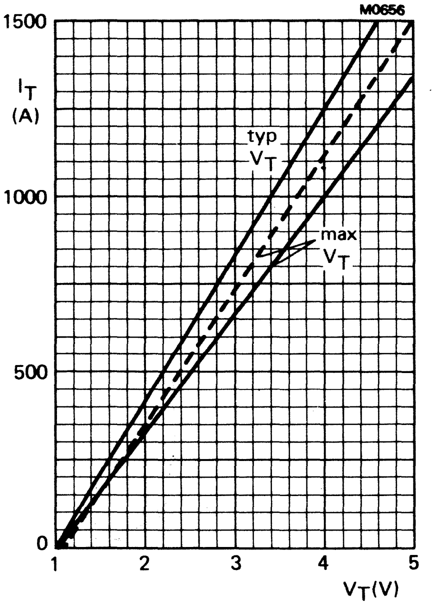


Fig.7 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents (f = 50 Hz); T_j = 125 °C prior to surge; with reapplied V_{RWMmax}; per thyristor.



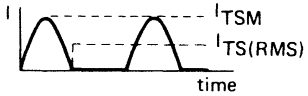


Fig.8 - - - T_j = 25 °C; —— T_j = 125 °C; per thyristor; pulse conditions.

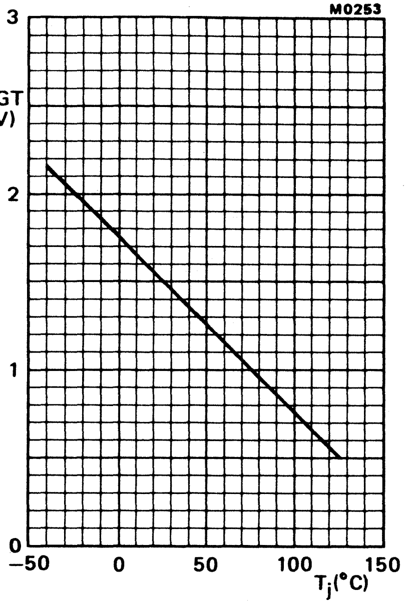


Fig.9 Minimum gate voltage that will trigger all devices as a function of T_j; per thyristor.

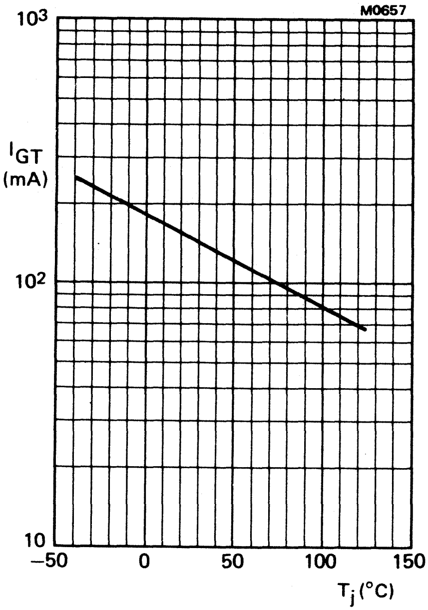


Fig.10 Miminum gate current that will trigger all devices as a function of T_j; per thyristor.

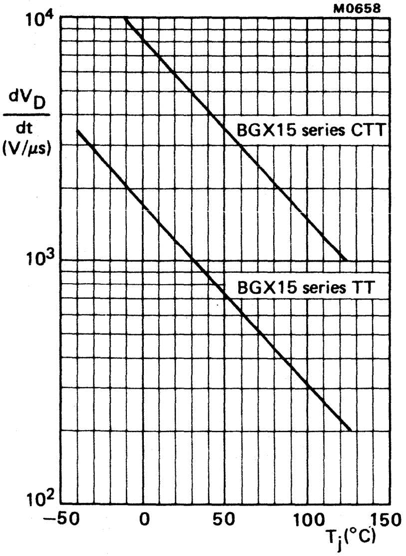


Fig.11 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of T_j; per thyristor.

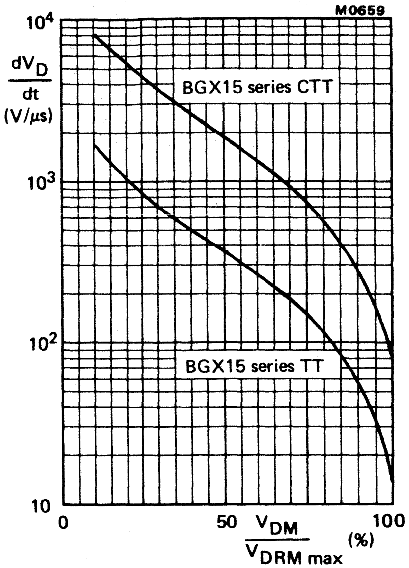


Fig. 12 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of peak off-state voltage; T_j = 125 °C; per thyristor.

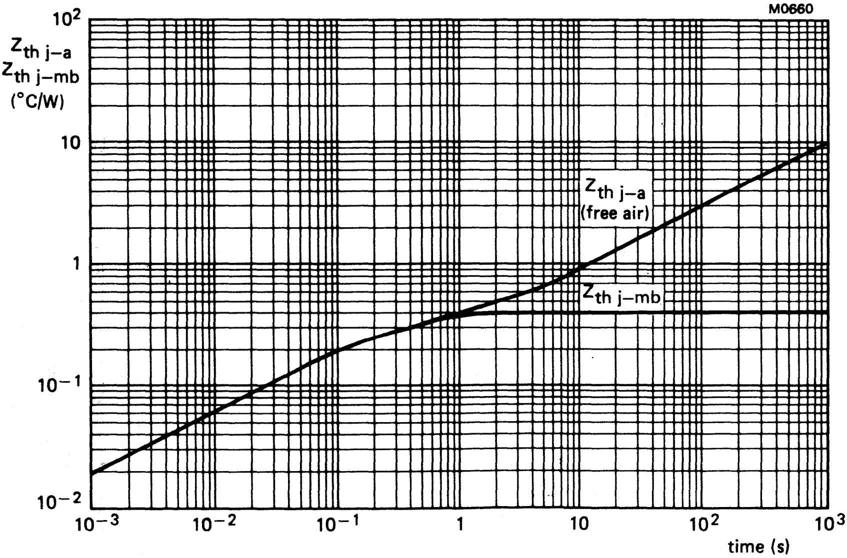


Fig.13 Transient thermal impedance of one thyristor plotted against time.

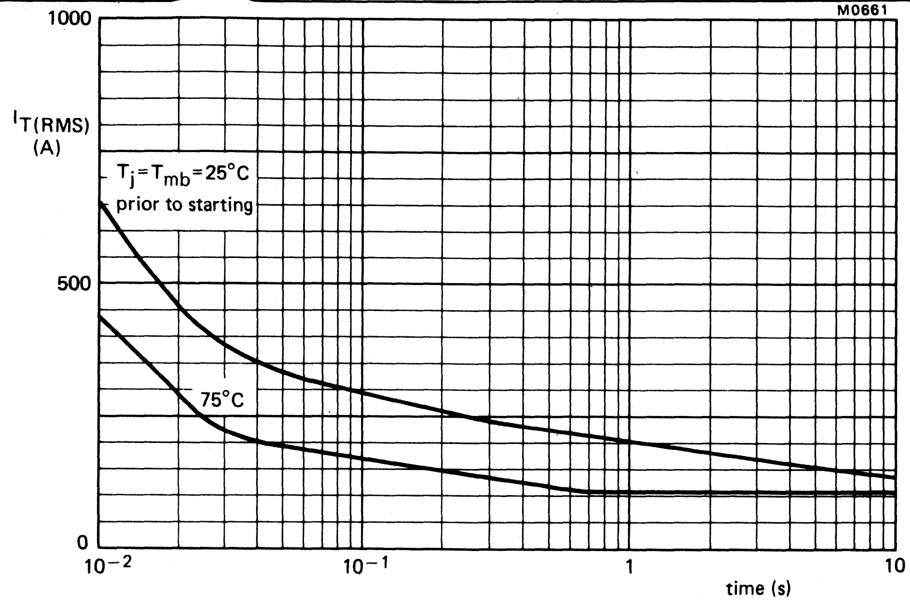


Fig. 14 Limits of starting or inrush current; half-cycle operation; one thyristor conducting.

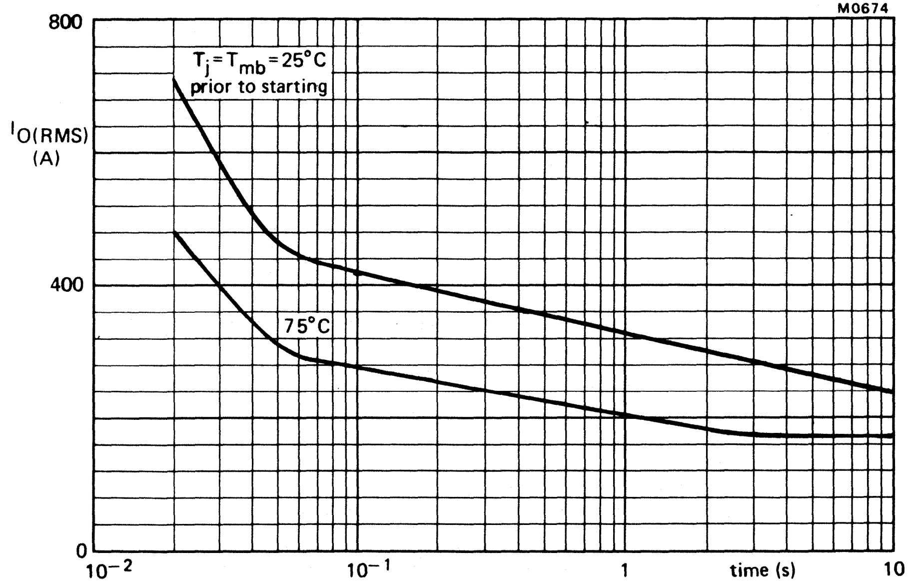


Fig. 15 Limits of starting or inrush current; full-wave operation; two thyristors conducting (a.c. controller).

ISOLATED THYRISTOR MODULES

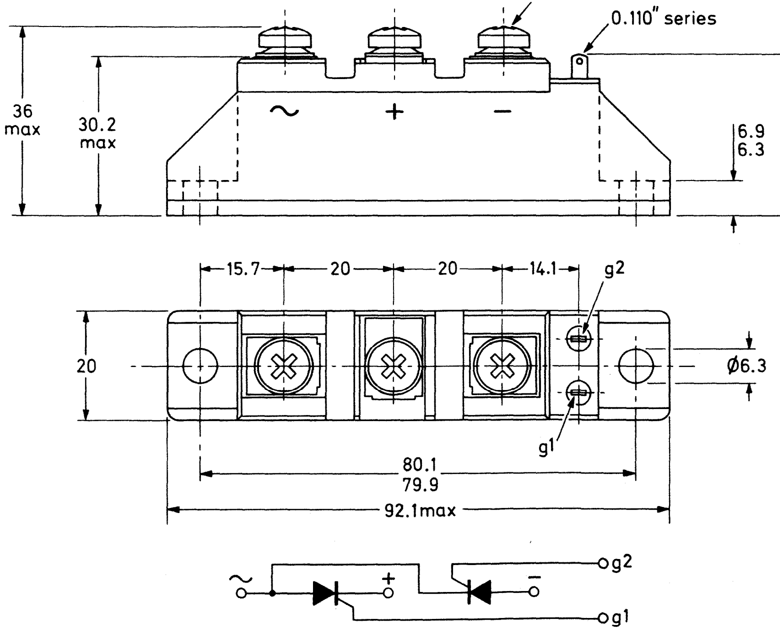
Two-thyristor modules incorporating glass-passivated devices in a plastic package, with electrically-isolated metal baseplate. The modules are intended for use in general-purpose single and three-phase applications.

QUICK REFERENCE DATA

Per thyristor			BGX17–600	800	1200	1200C	1400C–TT	
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	600	800	1200	1200	1400	V
R.M.S. on-state current	$I_{T(RMS)}$	max.	140					A
Average on-state current	$I_{T(AV)}$	max.	90					A
Non-repetitive peak on-state current	I_{TSM}	max.	1700					A
Rate of rise of off-state voltage that will not trigger any device	dV_D/dt	<	200			1000		V/μs

MECHANICAL DATA (see also next page) Dimensions in mm

Fig.1 TO-240AA



MECHANICAL DATA (continued)

Recommended mounting screws:
Hexagon socket head screws – high tensile M5 or M6 with flat and spring washers.

Mounting torque on heatsink:			
a. for good thermal contact	min.	2.6	Nm
b. maximum allowable	max.	6.5	Nm
Mounting torque for bus-bars	min.	2.5	Nm
	max.	3.5	Nm
Net mass	=	130	g

RATINGS (per thyristor)

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

Anode to cathode			BGX17–600	800	1200	1200C	1400C–TT	
Repetitive peak voltages	V_{DRM}/V_{RRM}	max.	600	800	1200	1200	1400	V
Crest working voltages	V_{DWM}/V_{RWM}	max.	400	600	800	800	800	V

Average on-state current (averaged over any 20 ms period) up to T_{mb} = 75 °C	$I_{T(AV)}$	max.	90	A
R.M.S. on-state current	$I_{T(RMS)}$	max.	140	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.	1700	A
I^2t for fusing (t = 10 ms)	I^2t	max.	14450	A^2s
Rate of rise of on-state current after triggering with I_G = 750 mA to I_T = 280 A; dI_G/dt = 1.5 A/µs	dI_T/dt	max.	100	A/µs

Gate to cathode

Peak reverse voltage	V_{RGM}	max.	5	V
Peak forward current (t_p = 10 µs)	I_{GM}	max.	5	A
Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	0.5	W

Temperatures

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

Isolation*

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

THERMAL RESISTANCE (per module with both thyristors conducting)

From junction to mounting baseplate	$R_{th\ j\text{-}mb}$	=	0.2	°C/W
From mounting base to heatsink; with heatsink compound	$R_{th\ mb\text{-}h}$	=	0.1	°C/W
Transient thermal impedance (t = 1 ms; per thyristor)	$Z_{th\ j\text{-}mb}$	=	0.02	°C/W

---

*From baseplate to all terminals strapped together

CHARACTERISTICS (per individual thyristor)

Anode to cathode

On-state voltage				
I_T = 250 A; T_j = 25 °C	V_T	$<$	1.5	V*
Threshold voltage	$V_{T(TO)}$	=	1	V
Slope resistance	r_T	$<$	2	mΩ
Rate of rise of off-state voltage that will not trigger any device; exponential method;				
V_D = 2/3 V_{DRMmax}; T_j = 125 °C	dV_D/dt	$<$	200	V/µs
for types with additional letter 'C'	dV_D/dt	$<$	1000	V/µs
Reverse current				
$V_R = V_{RWMmax}$; T_j = 125 °C	I_R	$<$	15	mA
Off-state current				
$V_D = V_{DWMmax}$; T_j = 125 °C	I_D	$<$	15	mA
Latching current; T_j = 25 °C	I_L	$<$	400	mA
Holding current; T_j = 25 °C	I_H	$<$	250	mA

Gate to cathode

Voltage that will trigger all devices				
V_D = 12 V; T_j = 25 °C	V_{GT}	$>$	1.5	V
Voltage that will not trigger any device				
$V_D = V_{DRMmax}$; T_j = 125 °C	V_{GD}	$<$	250	mV
Current that will trigger all devices				
V_D = 12 V; T_j = 25 °C	I_{GT}	$>$	150	mA

MOUNTING INSTRUCTIONS

Before mounting, the heatsink surface and the underside of the module should be coated with a heatsink compound (for example, Dow-Corning DC340).
It is recommended that after a period of about 3 hours, the mounting screws be again tightened to compensate for spreading of the heatsink compound under pressure.
Bus-bars should always be used for connection to the heavy current terminals.
The use of cable lugs is not recommended other than for making auxiliary cathode connections.

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*Measured under pulse conditions to avoid excessive dissipation.

Two BGX17 modules connected as:

SINGLE-PHASE BRIDGE RECTIFIER

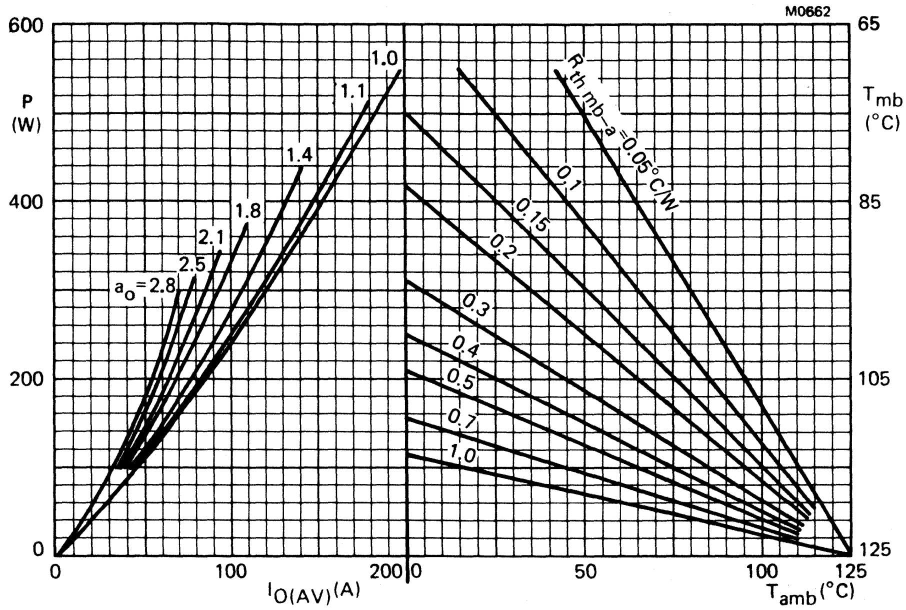
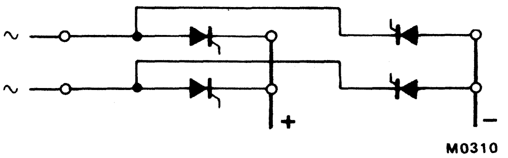


Fig.2 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

Output form factor $a_o = I_{O(RMS)}/I_{O(AV)} = 0.707 \times I_{T(RMS)}/I_{T(AV)}$ per thyristor.

P = total power dissipation of two modules.



Two BGX17 modules connected as single-phase bridge rectifier.

Three BGX17 modules connected as:

THREE-PHASE BRIDGE RECTIFIER

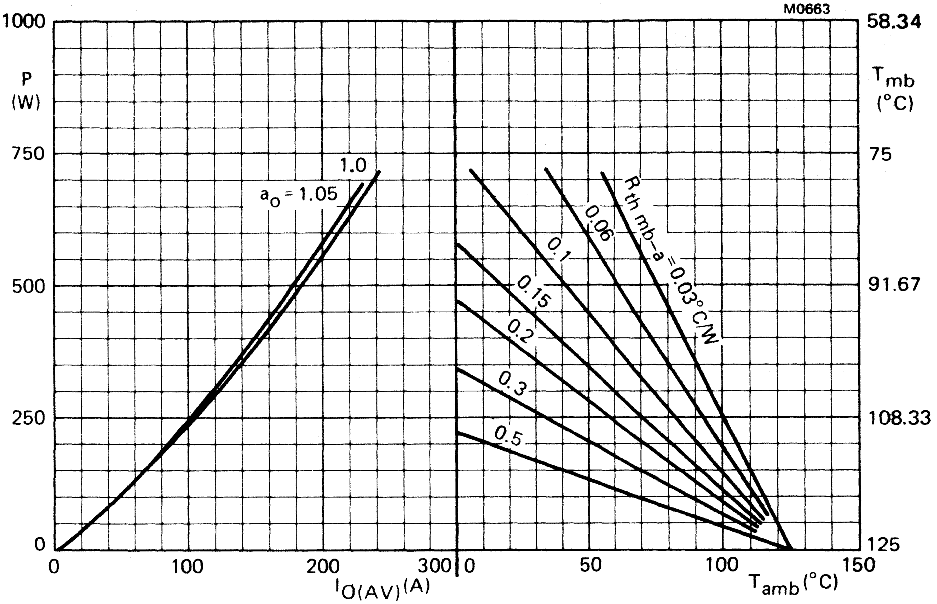
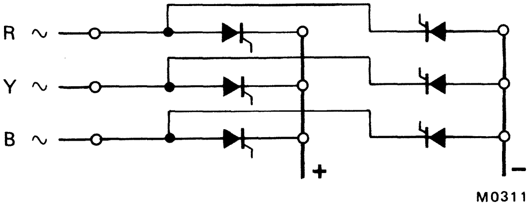


Fig.3 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

Output form factor $a_o = I_{O(RMS)}/I_{O(AV)}$.

P = total power dissipation of three modules.



Three BGX17 modules connected as three-phase bridge rectifier

One BGX17 module connected as:

SINGLE-PHASE A.C. CONTROLLER

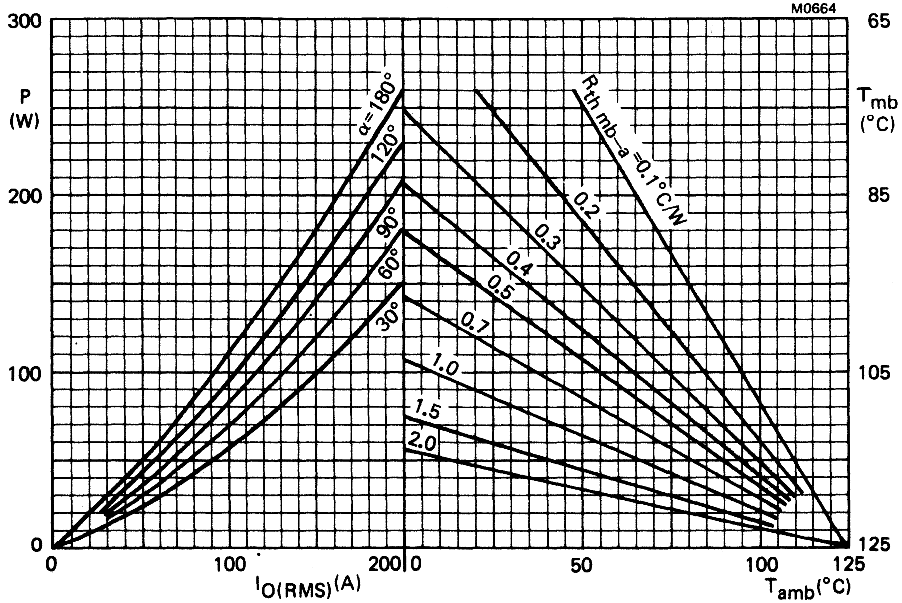
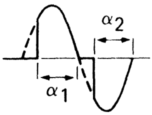
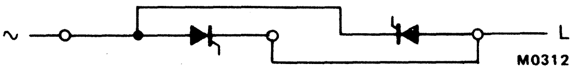


Fig.4 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha = \alpha_1 = \alpha_2$: conduction angle per half cycle



One BGX17 module connected as single-phase a.c. controller.

Three BGX17 modules connected as:
THREE-PHASE A.C. CONTROLLER

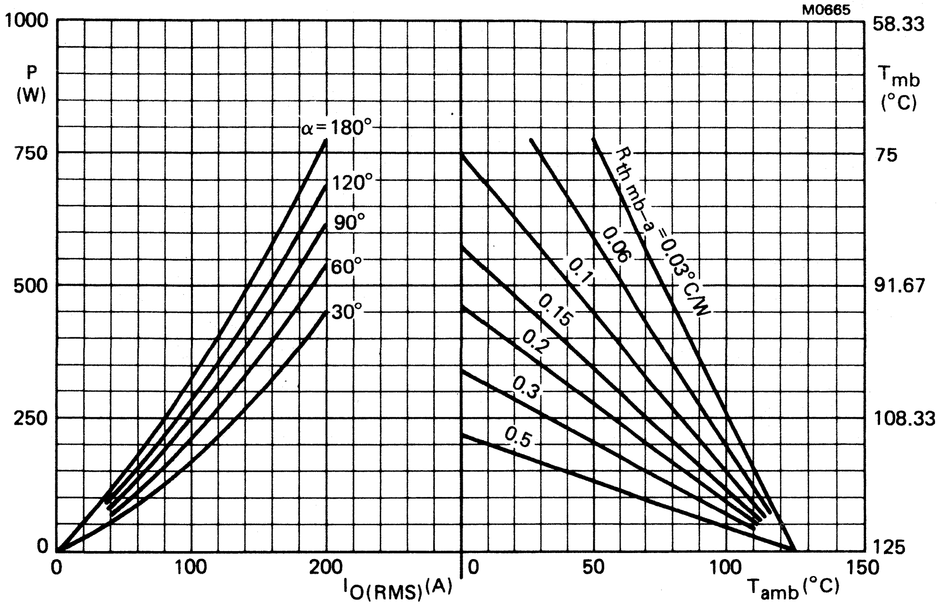
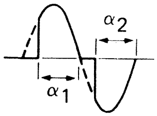
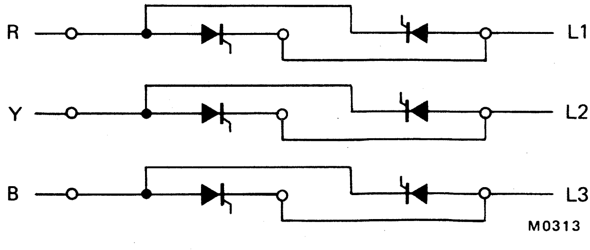


Fig.5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.

P = total power dissipation of three modules.



$\alpha = \alpha_1 = \alpha_2$: conduction angle per half cycle



Three BGX17 modules connected as
three-phase a.c. controller.

ONE THYRISTOR CONDUCTING

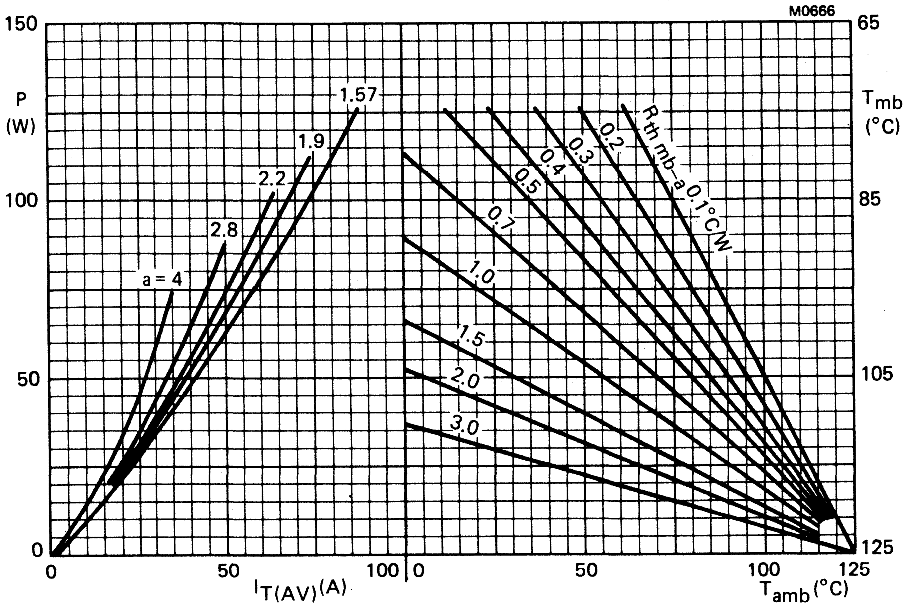
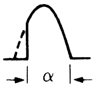


Fig.6 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



α = conduction angle per half cycle

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

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

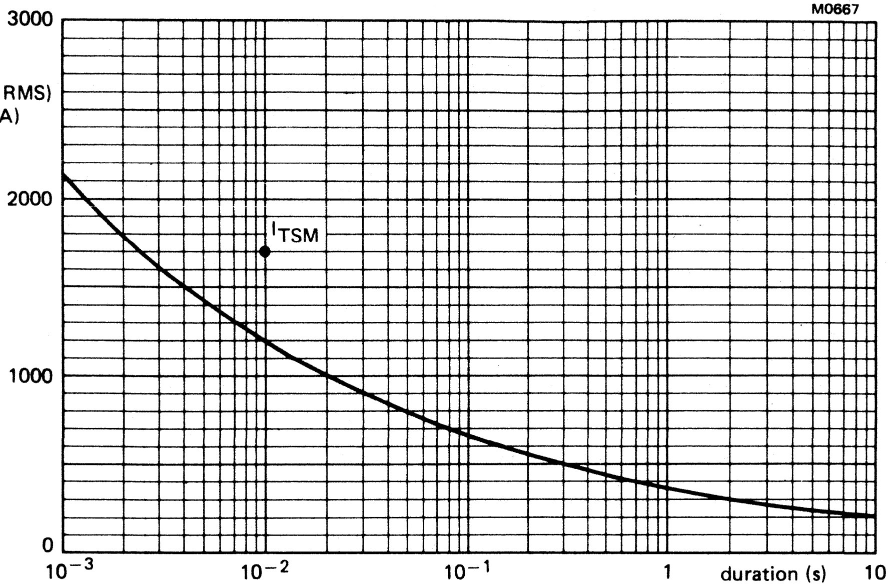
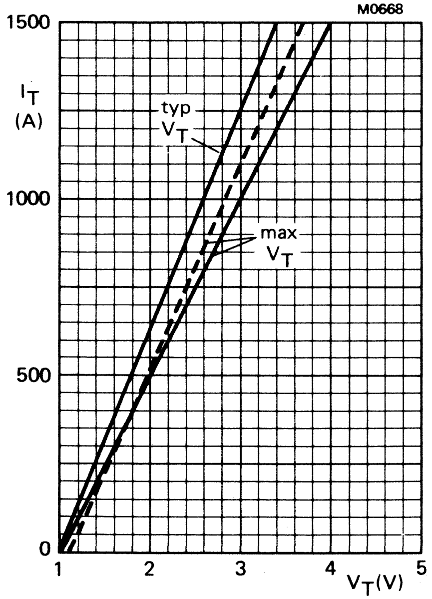


Fig.7 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents (f = 50 Hz); T_j = 125 °C prior to surge; with reapplied V_{RWMmax}; per thyristor



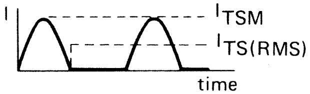


Fig.8 — — — T_j = 25 °C; ——— T_j = 125 °C per thyristor; pulse conditions.

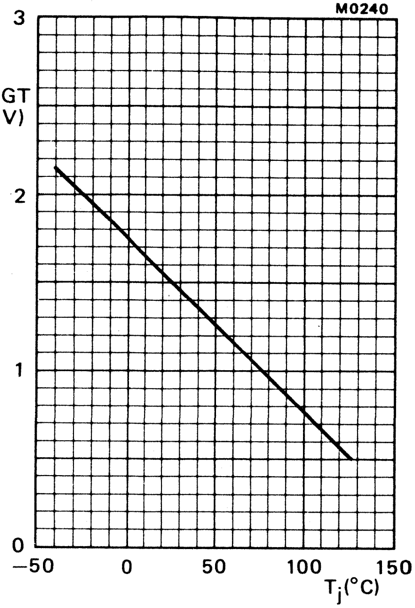


Fig.9 Minimum gate voltage that will trigger all devices as a function of T_j; per thyristor.

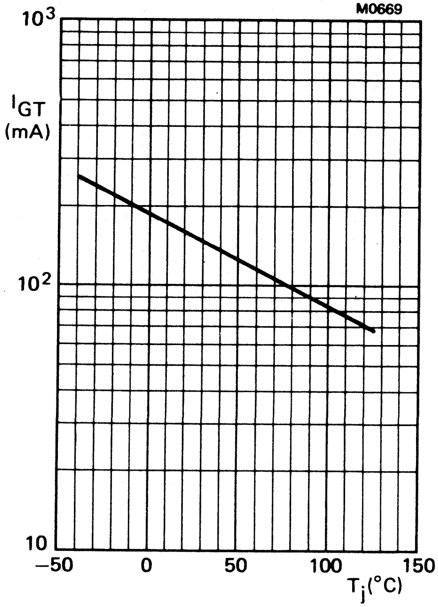


Fig.10 Minimum gate current that will trigger all devices as a function of T_j; per thyristor.

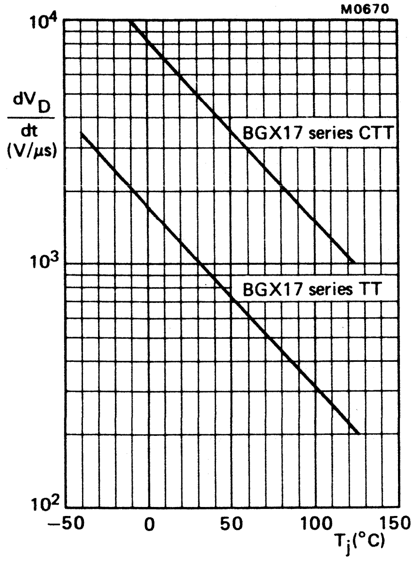


Fig.11 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of T_j; per thyristor

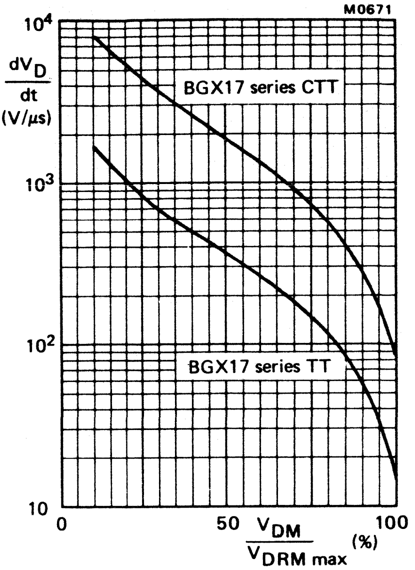


Fig.12 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of peak off-state voltage; T_j = 125 °C; per thyristor.

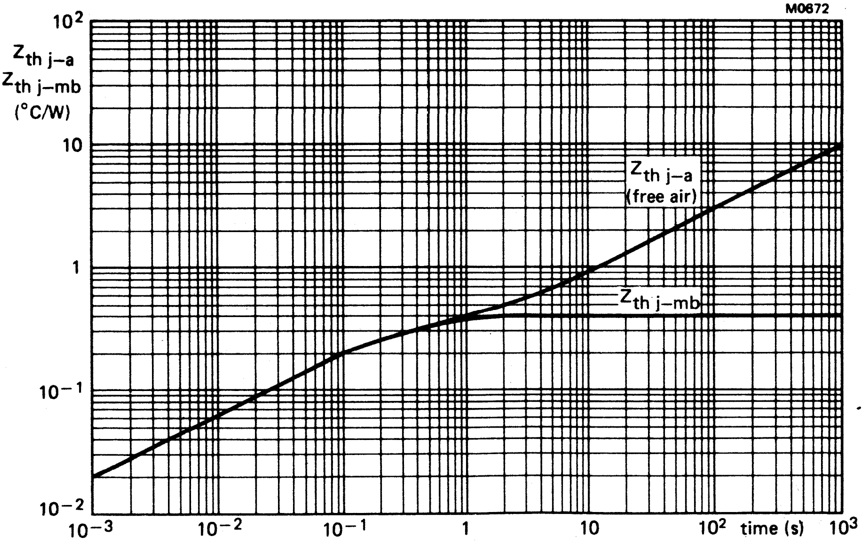


Fig.13 Transient thermal impedance of one thyristor plotted against time.

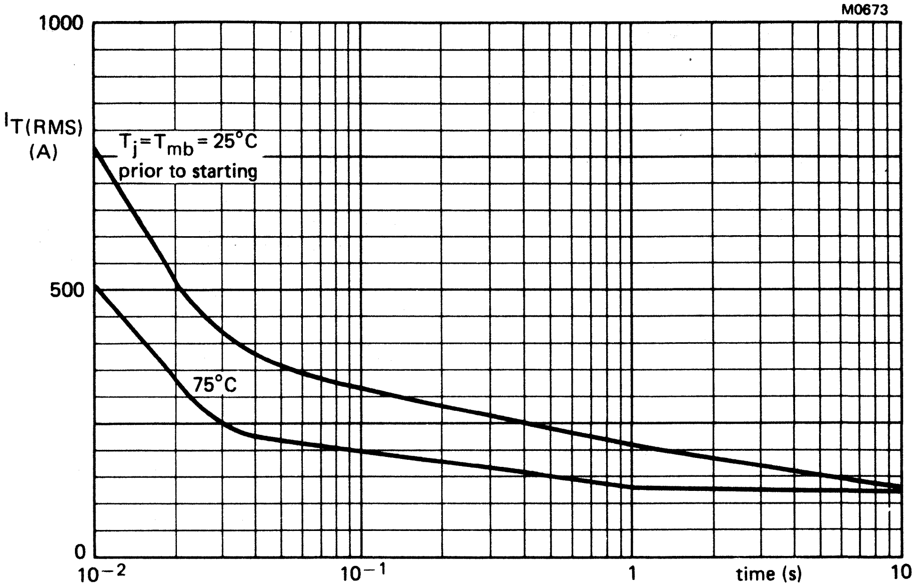


Fig.14 Limits for starting or inrush current; half-cycle operation; one thyristor conducting.

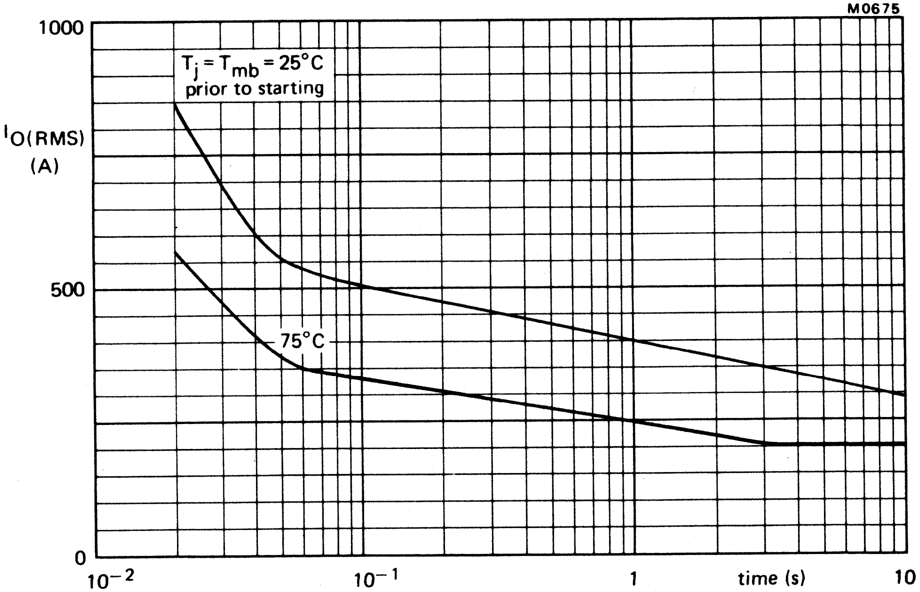


Fig.15 Limits for starting or inrush current; full-wave operation; two thyristors conducting (a.c. controller).

TRIACS

TRIACS

Glass-passivated 4 ampere triacs intended for use in applications requiring high bidirectional transient and blocking voltage capability, and high thermal cycling performance with very low thermal resistances, e.g. a.c. power control applications such as lighting, industrial and domestic heating, motor control and switching systems.

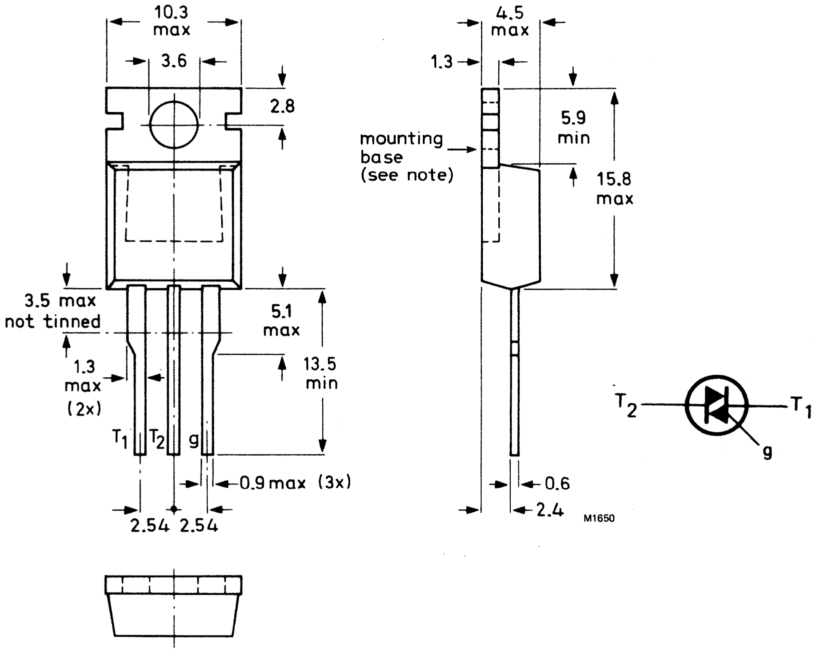
QUICK REFERENCE DATA

			BT136–500	600	800	
Repetitive peak off-state voltage	V_{DRM}	max.	500	600	800	V
R.M.S. on-state current	$I_{T(RMS)}$	max.		4		A
Non-repetitive peak on-state current	I_{TSM}	max.		25		A

MECHANICAL DATA

Dimensions in mm

Fig.1 TO–220AB



Net mass: 2 g

Note: The exposed metal mounting base is directly connected to terminal T_2.

Supplied on request: accessories (see data sheets Mounting instructions and accessories for TO–220 envelopes).

RATINGS

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

Voltages (in either direction)			BT136–500	600	800	
Non-repetitive peak off-state voltage ($t \leqslant 10$ ms)	V_{DSM}	max.	500*	600*	800	V
Repetitive peak off-state voltage ($\delta \leqslant 0.01$)	V_{DRM}	max.	500	600	800	V
Crest working off-state voltage	V_{DWM}	max.	400	400	400	V

Currents (in either direction)				
R.M.S. on-state current (conduction angle 360°) up to $T_{mb} = 102$ °C	$I_{T(RMS)}$	max.	4	A
Average on-state current for half-cycle operation (averaged over any 20 ms period) up to $T_{mb} = 92$ °C	$I_{T(AV)}$	max.	2.5	A
Repetitive peak on-state current	I_{TRM}	max.	25	A
Non-repetitive peak on-state current; $T_j = 120$ °C prior to surge; $t = 20$ ms; full sine-wave	I_{TSM}	max.	25	A
I^2t for fusing ($t = 10$ ms)	I^2t	max.	4	A^2s
Rate of rise of on-state current after triggering with $I_G = 200$ mA to $I_T = 6$ A; $dI_G/dt = 0.2$ A/µs	dI_T/dt	max.	10	A/µs

Gate to terminal 1

POWER DISSIPATION

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

Temperatures

Storage temperature	T_{stg}		−40 to +125	°C
Operating junction temperature full-cycle operation	T_j	max.	120	°C
Operating junction temperature half-cycle operation	T_j	max.	110	°C

*Although not recommended, off-state voltages up to 800 V may be applied without damage, but the triac may switch into the on-state. The rate of rise of on-state current should not exceed 3 A/µs.

THERMAL RESISTANCE

From junction to mounting base

full-cycle operation $R_{th\ j\text{-}mb}$ = 3.0 K/W

half-cycle operation $R_{th\ j\text{-}mb}$ = 3.7 K/W

Transient thermal impedance; t = 1 ms $Z_{th\ j\text{-}mb}$ = 0.6 K/W

Influence of mounting method

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from mounting base to heatsink

a. with heatsink compound $R_{th\ mb\text{-}h}$ = 0.3 K/W

b. with heatsink compound and 0.06 mm maximum mica insulator $R_{th\ mb\text{-}h}$ = 1.4 K/W

c. with heatsink compound and 0.1 mm max. mica insulator (56369) $R_{th\ mb\text{-}h}$ = 2.2 K/W

d. with heatsink compound and 0.25 mm max. alumina insulator (56367) $R_{th\ mb\text{-}h}$ = 0.8 K/W

e. without heatsink compound $R_{th\ mb\text{-}h}$ = 1.4 K/W

2. Free-air operation

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

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

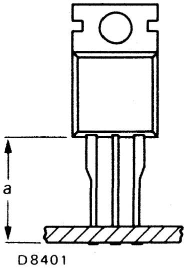


Fig.2.

CHARACTERISTICS

Polarities, positive or negative, are identified with respect to T_1.

Voltages and currents (in either direction)

On-state voltage (measured under pulse conditions to prevent excessive dissipation)				
$I_T = 5$ A; $T_j = 25$ °C	V_T	<	1.70	V
Rate of rise of off-state voltage that will not trigger any device; $T_j = 120$ °C; gate open circuit				
→ BT136 series	dV_D/dt	<	100	V/µs
→ BT136 series G	dV_D/dt	<	200	V/µs
BT136 series F	dV_D/dt	<	50	V/µs
BT136 series E	dV_D/dt	typ.	50	V/µs
BT136 – 500D	dV_D/dt	typ.	5	V/µs
Rate of change of commutating voltage that will not trigger any device when $-dI_{com}/dt = 1.8$ A/ms; $I_{T(RMS)} = 4$ A; $T_{mb} = 85$ °C; gate open circuit; $V_D = V_{DWMmax}$				
BT136 series	dV_{com}/dt	typ.	10	V/µs
BT136 series G	dV_{com}/dt	<	10	V/µs
BT136 series F	dV_{com}/dt	typ.	10	V/µs
Off-state current				
$V_D = V_{DWMmax}$; $T_j = 120$ °C	I_D	<	0.5	mA
Gate voltage that will trigger all devices	V_{GT}	>	1.5	V
Gate voltage that will not trigger any device				
$V_D = V_{DWMmax}$; $T_j = 120$ °C; T_2 and G positive or negative	V_{GD}	<	250	mV

Gate current that will trigger all devices (I_{GT}); G to T_1

Holding current (I_H)

Latching current (I_L); $V_D = 12$ V; $T_j = 25$ °C

			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 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.
3. It is recommended that the circuit connection be made to tag T_2, rather than direct to the heatsink.
4. Mounting by means of a spring clip is the best mounting method because it offers:
   a. a good thermal contact under the crystal area and slightly lower $R_{th\ mb\text{-}h}$ values than screw mounting.
   b. safe isolation for mains operation.
   However, if a screw is used, it should be M3 cross-recess pan-head. Care should be taken to avoid damage to the plastic body.
5. For good thermal contact heatsink compound should be used between mounting base and heatsink. Values of $R_{th\ mb\text{-}h}$ given for mounting with heatsink compound refer to the use of a metallic-oxide loaded compound. Ordinary silicone grease is not recommended.
6. Rivet mounting (only possible for non-insulated mounting)
   Devices may be rivetted to flat heatsinks; such a process **must neither** deform the mounting tab, **nor** enlarge the mounting hole.

OPERATING NOTES

Dissipation and heatsink considerations:

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

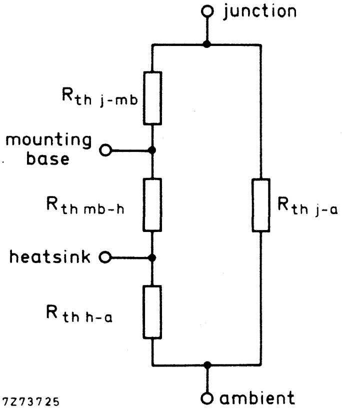


Fig.3

b. The method of using Figs.4 and 5 is as follows:
Starting with the required current on the $I_{T(AV)}$ or $I_{T(RMS)}$ axis, trace upwards to meet the appropriate form factor or conduction angle curve. Trace right horizontally and upwards from the appropriate value on the T_{amb} scale. The intersection determines the $R_{th\ mb\text{-}a}$. The heatsink thermal resistance value ($R_{th\ h\text{-}a}$) can now be calculated from:

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

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

FULL-CYCLE OPERATION

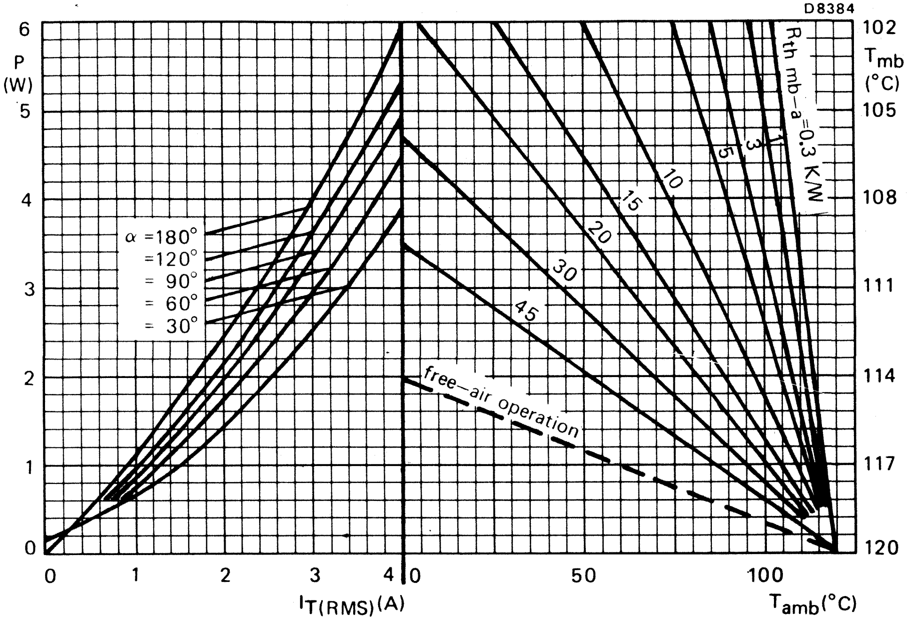
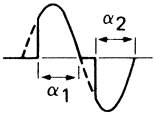


Fig.4 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha = \alpha_1 = \alpha_2$: conduction angle per half cycle

Note: For the type BT136–500D only, any operating point derived from Fig.4 should be derated by a further 10 °C.

HALF-CYCLE OPERATION

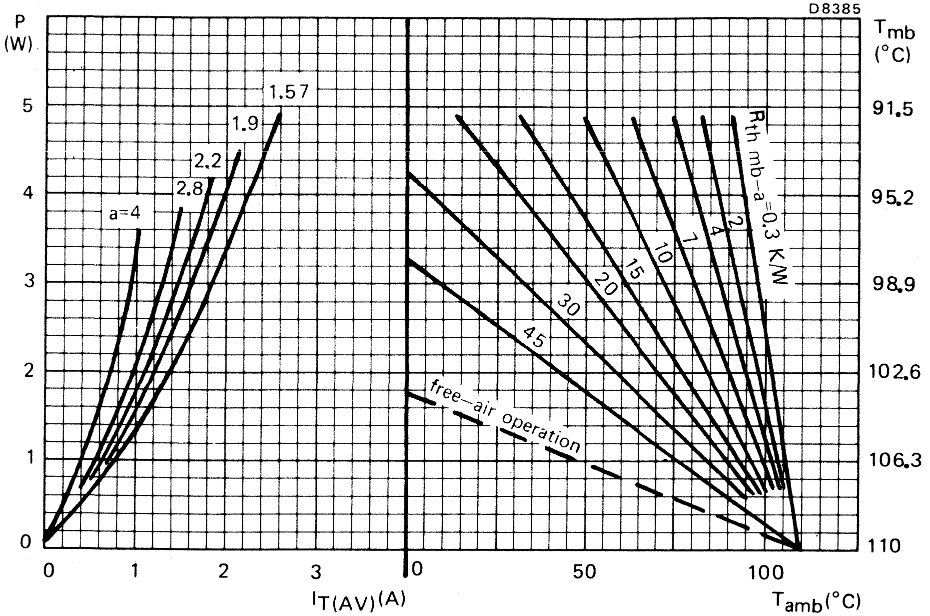
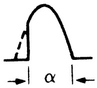


Fig.5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



α = conduction angle per half cycle

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

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

Note: For the type BT136–500D only, any operating point derived from Fig.5 should be derated by a further 10 °C.

OVERLOAD OPERATION

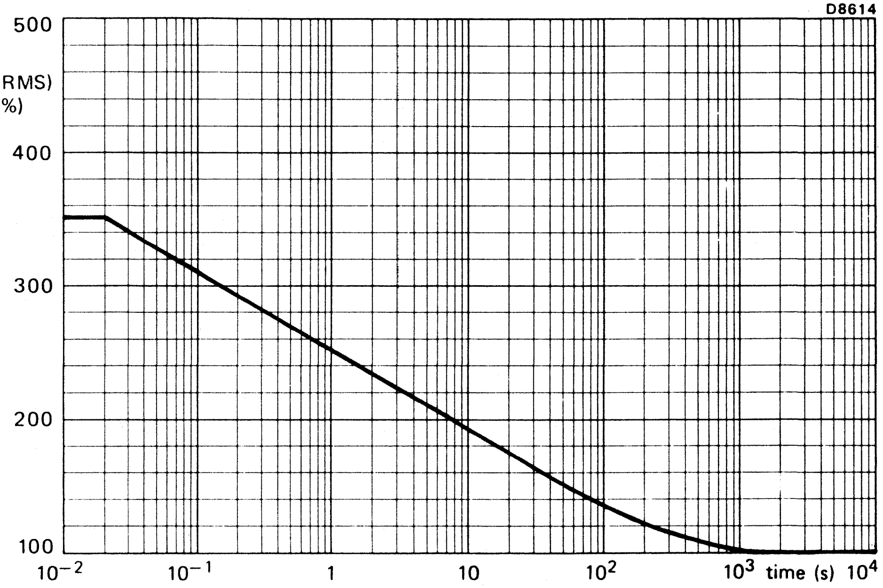


Fig.6 Maximum permissible duration of steady overload (provided that T_{mb} does not exceed 120 °C during and after overload) expressed as a percentage of the steady state r.m.s. rated current. For high r.m.s. overload currents precautions should be taken so that the temperature of the terminals does not exceed 125 °C. During these overload conditions the triac may lose control. Therefore the overload should be terminated by a separate protection device.

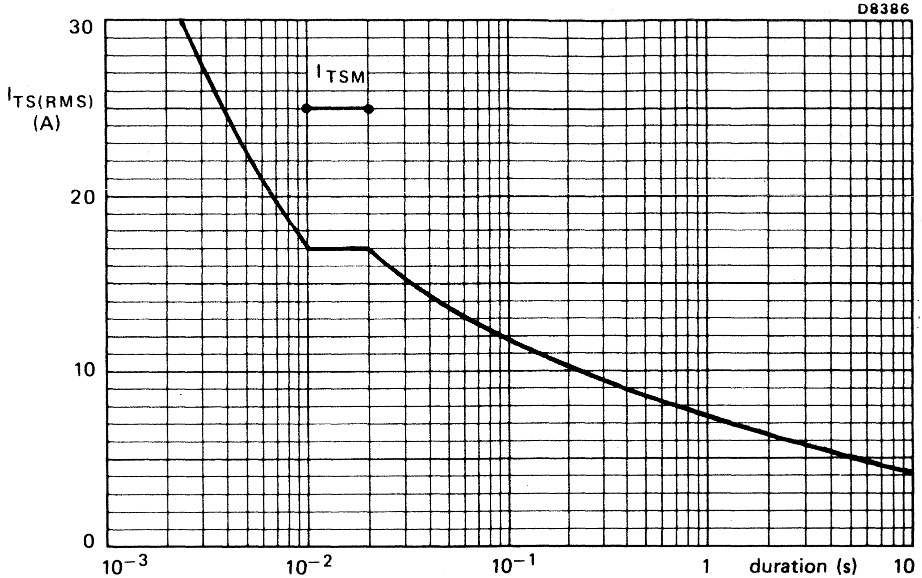
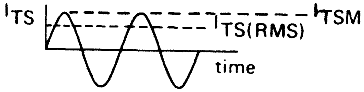


Fig.7 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents (f = 50 Hz); T_j = 120 °C prior to surge. The triac may temporarily lose control following the surge.



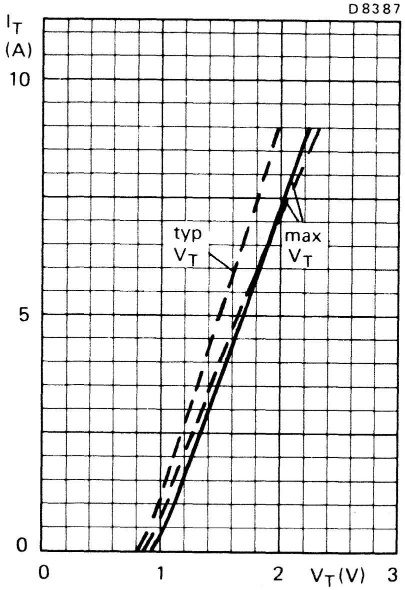


Fig.8 —— T_j = 25 °C; – – – T_j = 120 °C

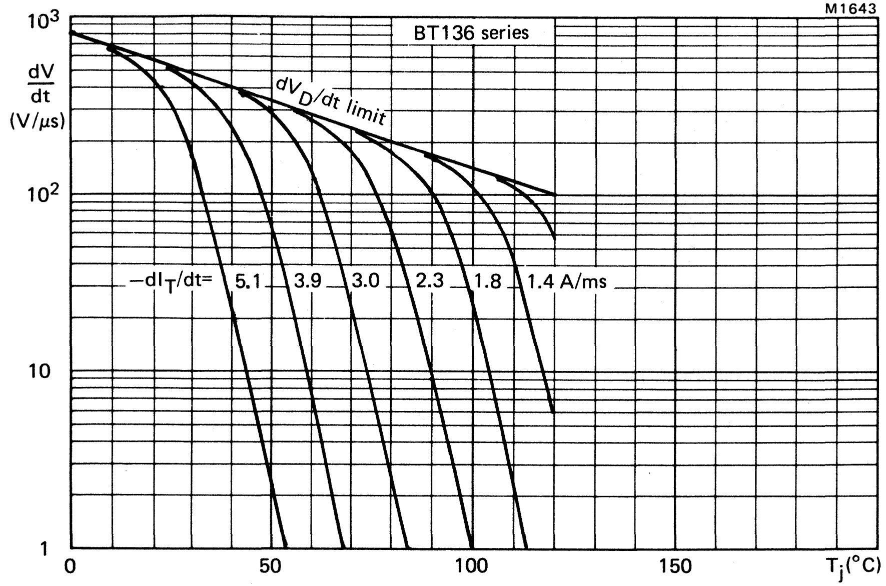


Fig.9 Typical commutation dV/dt for BT136 series versus T_j. The triac should commutate when the dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

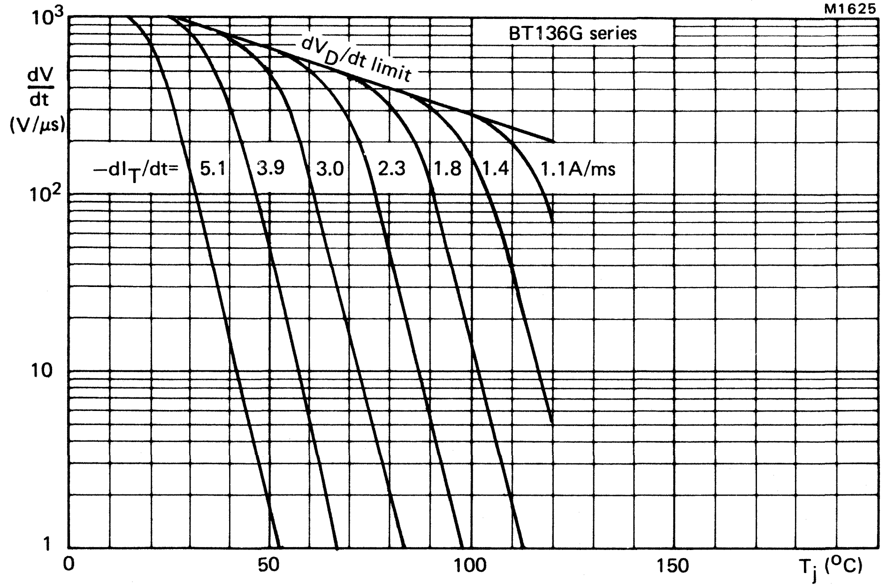


Fig.10 Limit commutation dV/dt for BT136G series versus T_j. The triac should commutate when the dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

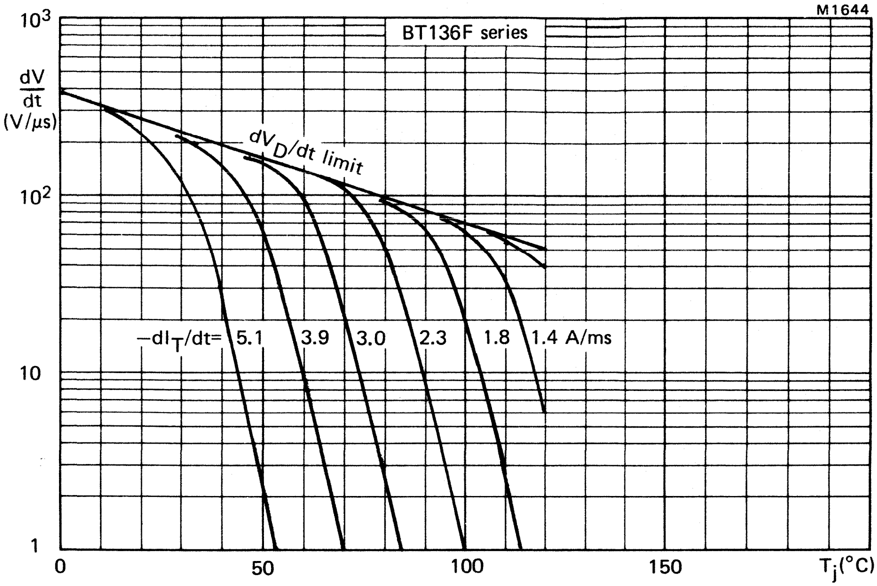


Fig.11 Typical commutation dV/dt for BT136F series versus T_j. The triac should commutate when the dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

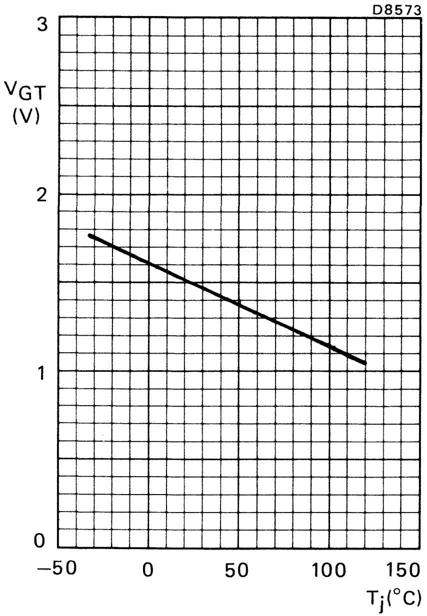


Fig.12 Minimum gate voltage that will trigger all devices; all conditions.

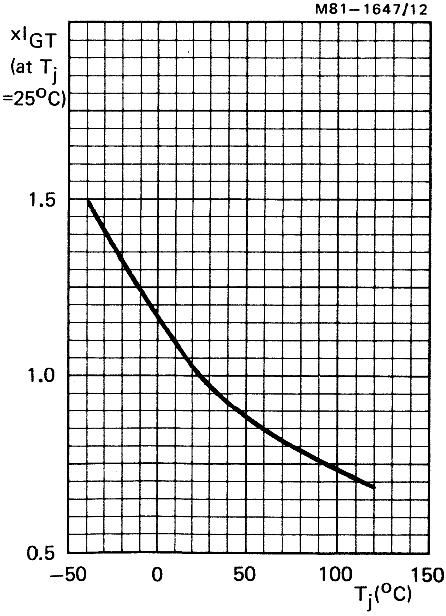


Fig.13 Normalised gate current that will trigger all devices; all conditions.

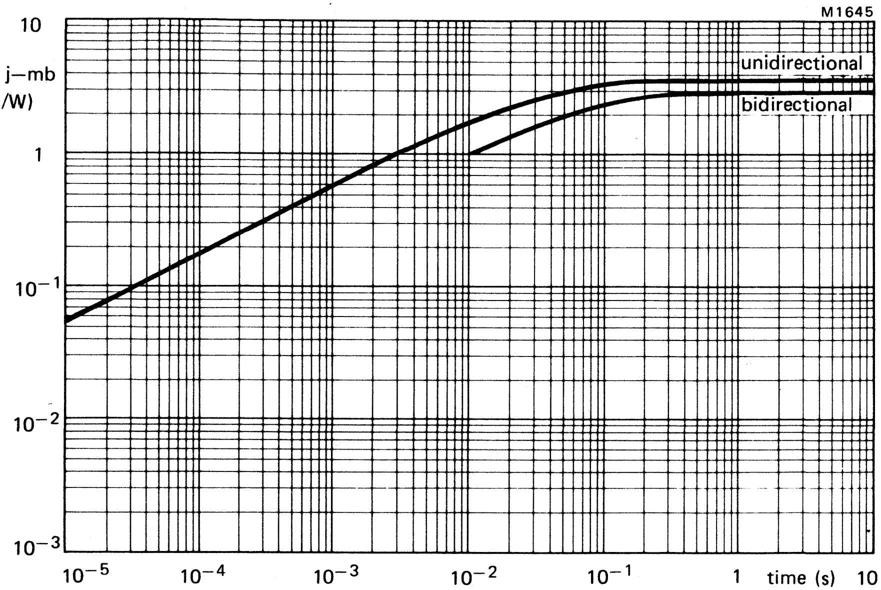

M1645
10
$Z_{th\ j-mb}$
(K/W)
1
10^{-1}
10^{-2}
10^{-3}
unidirectional
bidirectional
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
time (s)
10

Fig.14

TRIACS

Glass-passivated 8 ampere triacs intended for use in applications requiring high bidirectional transient and blocking voltage capability, and high thermal cycling performance with very low thermal resistances, e.g. a.c. power control applications such as lighting, industrial and domestic heating, motor control and switching systems.

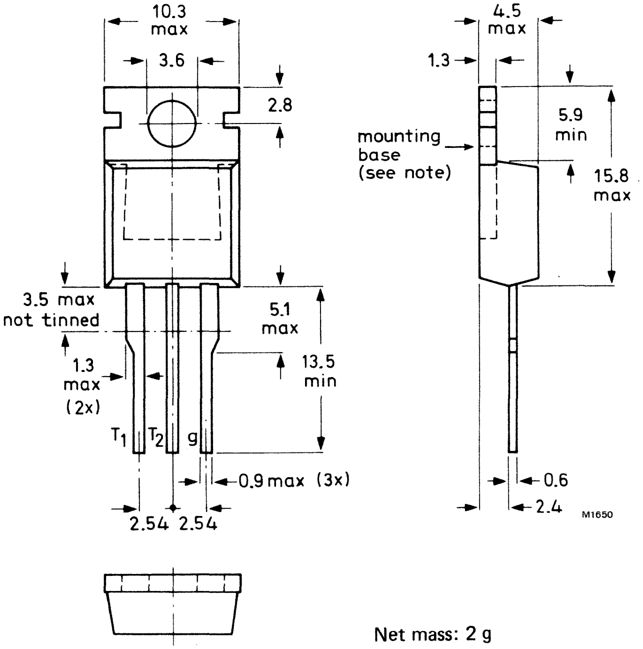
QUICK REFERENCE DATA

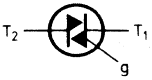
			BT137–500	600	800	
Repetitive peak off-state voltage	V_{DRM}	max.	500	600	800	V
R.M.S. on-state current	$I_{T(RMS)}$	max.	8			A
Non-repetitive peak on-state current	I_{TSM}	max.	55			A

MECHANICAL DATA

Dimensions in mm

Fig.1 TO-220AB.





Net mass: 2 g

Note: The exposed metal mounting base is directly connected to terminal T_2.

Supplied on request: accessories (see data sheets Mounting instructions and accessories for TO-220 envelopes).

RATINGS

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

Voltages (in either direction)			BT137–500	600	800	
Non-repetitive peak off-state voltage ($t \leq 10$ ms)	V_{DSM}	max.	500*	600*	800	V
Repetitive peak off-state voltage ($\delta \leq 0.01$)	V_{DRM}	max.	500	600	800	V
Crest working off-state voltage	V_{DWM}	max.	400	400	400	V

Currents (in either direction)				
R.M.S. on-state current (conduction angle 360°) up to $T_{mb} = 97$ °C	$I_{T(RMS)}$	max.	8	A
Average on-state current for half-cycle operation (averaged over any 20 ms period) up to $T_{mb} = 87$ °C	$I_{T(AV)}$	max.	5	A
Repetitive peak on-state current	I_{TRM}	max.	55	A
Non-repetitive peak on-state current; $T_j = 120$ °C prior to surge; $t = 20$ ms; full sine-wave	I_{TSM}	max.	55	A
I^2t for fusing ($t = 10$ ms)	I^2t	max.	15	A^2s
Rate of rise of on-state current after triggering with $I_G = 200$ mA to $I_T = 12$ A; $dI_G/dt = 0.2$ A/µs	dI_T/dt	max.	20	A/µs

Gate to terminal 1

POWER DISSIPATION

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

Temperatures

Storage temperature	T_{stg}		−40 to +125	°C
Operating junction temperature				
full-cycle operation	T_j	max.	120	°C
half-cycle operation	T_j	max.	110	°C

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*Although not recommended, off-state voltages up to 800 V may be applied without damage, but the triac may switch into the on-state. The rate of rise of on-state current should not exceed 6 A/µs.

THERMAL RESISTANCE

From junction to mounting base

full-cycle operation $R_{th\ j\text{-}mb} = 2.0$ K/W

half-cycle operation $R_{th\ j\text{-}mb} = 2.4$ K/W

Transient thermal impedance; t = 1 ms $Z_{th\ j\text{-}mb} = 0.3$ K/W

Influence of mounting method

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from mounting base to heatsink

a. with heatsink compound $R_{th\ mb\text{-}h} = 0.3$ K/W

b. with heatsink compound and 0.06 mm maximum mica insulator $R_{th\ mb\text{-}h} = 1.4$ K/W

c. with heatsink compound and 0.1 mm max. mica insulator (56369) $R_{th\ mb\text{-}h} = 2.2$ K/W

d. with heatsink compound and 0.25 mm max. alumina insulator (56367) $R_{th\ mb\text{-}h} = 0.8$ K/W

e. without heatsink compound $R_{th\ mb\text{-}h} = 1.4$ K/W

2. Free-air operation

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

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

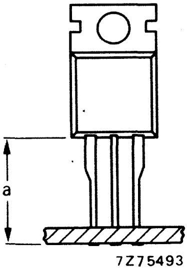


Fig.2

CHARACTERISTICS

Polarities, positive or negative, are identified with respect to T_1.

Voltages and currents (in either direction)

On-state voltage (measured under pulse conditions to prevent excessive dissipation)				
$I_T = 10$ A; $T_j = 25$ °C	V_T	$<$	1.65	V
Rate of rise of off-state voltage that will not trigger any device; $T_j = 120$ °C; gate open circuit				
→ BT137 series	dV_D/dt	$<$	100	V/μs
→ BT137 series G	dV_D/dt	$<$	200	V/μs
BT137 series F	dV_D/dt	$<$	50	V/μs
BT137 series E	dV_D/dt	typ.	50	V/μs
BT137 – 500D	dV_D/dt	typ.	5	V/μs
Rate of change of commutating voltage that will not trigger any device when $-dI_{com}/dt = 3.6$ A/ms; $I_{T(RMS)} = 8$ A; $T_{mb} = 70$ °C; gate open circuit ; $V_D = V_{DWMmax}$				
BT137 series	dV_{com}/dt	typ.	10	V/μs
BT137 series G	dV_{com}/dt	$<$	10	V/μs
BT137 series F	dV_{com}/dt	typ.	10	V/μs
Off-state current				
$V_D = V_{DWMmax}$; $T_j = 120$ °C	I_D	$<$	0.5	mA
Gate voltage that will trigger all devices	V_{GT}	$>$	1.5	V
Gate voltage that will not trigger any device $V_D = V_{DWMmax}$; $T_j = 120$ °C; T_2 and G positive or negative	V_{GD}	$<$	250	mV

Gate current that will trigger all devices (I_{GT}); G to T_1

Holding current (I_H)

Latching current (I_L); $V_D = 12$ V; $T_j = 25$ °C

			T_2+ G+	T_2+ G–	T_2– G–	T_2– G+	
BT137 series	I_{GT}	$>$	35	35	35	70	mA
	I_H	$<$	20	20	20	20	mA
	I_L	$<$	30	45	30	45	mA
BT137 series G	I_{GT}	$>$	50	50	50	100	mA
	I_H	$<$	40	40	40	40	mA
	I_L	$<$	45	60	45	60	mA
BT137 series F	I_{GT}	$>$	25	25	25	70	mA
	I_H	$<$	20	20	20	20	mA
	I_L	$<$	30	45	30	45	mA
BT137 series E	I_{GT}	$>$	10	10	10	25	mA
	I_H	$<$	20	20	20	20	mA
	I_L	$<$	25	35	25	35	mA
BT137 – 500D	I_{GT}	$>$	5	5	5	10	mA
	I_H	$<$	15	15	15	15	mA
	I_L	$<$	15	20	15	20	mA

MOUNTING INSTRUCTIONS

1. The 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.
3. It is recommended that the circuit connection be made to tag T_2, rather than direct to the heatsink.
4. Mounting by means of a spring clip is the best mounting method because it offers:
   a. a good thermal contact under the crystal area and slightly lower $R_{th\ mb\text{-}h}$ values than screw mounting.
   b. safe isolation for mains operation.
   However, if a screw is used, it should be M3 cross-recess pan-head. Care should be taken to avoid damage to the plastic body.
5. For good thermal contact heatsink compound should be used between mounting base and heatsink. Values of $R_{th\ mb\text{-}h}$ given for mounting with heatsink compound refer to the use of a metallic-oxide loaded compound. Ordinary silicone grease is not recommended.
6. Rivet mounting (only possible for non-insulated mounting)
   Devices may be rivetted to flat heatsinks; such a process **must neither** deform the mounting tab, **nor** enlarge the mounting hole.

OPERATING NOTES

Dissipation and heatsink considerations:

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

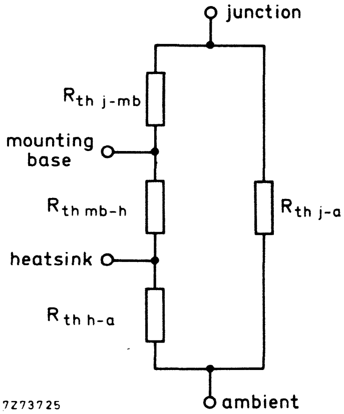


Fig.3

b. The method of using Figs.4 and 5 is as follows:
Starting with the required current on the $I_{T(AV)}$ or $I_{T(RMS)}$ axis, trace upwards to meet the appropriate form factor or conduction angle curve. Trace right horizontally and upwards from the appropriate value on the T_{amb} scale. The intersection determines the $R_{th\ mb\text{-}a}$. The heatsink thermal resistance value ($R_{th\ h\text{-}a}$) can now be calculated from:

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

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

FULL-CYCLE OPERATION

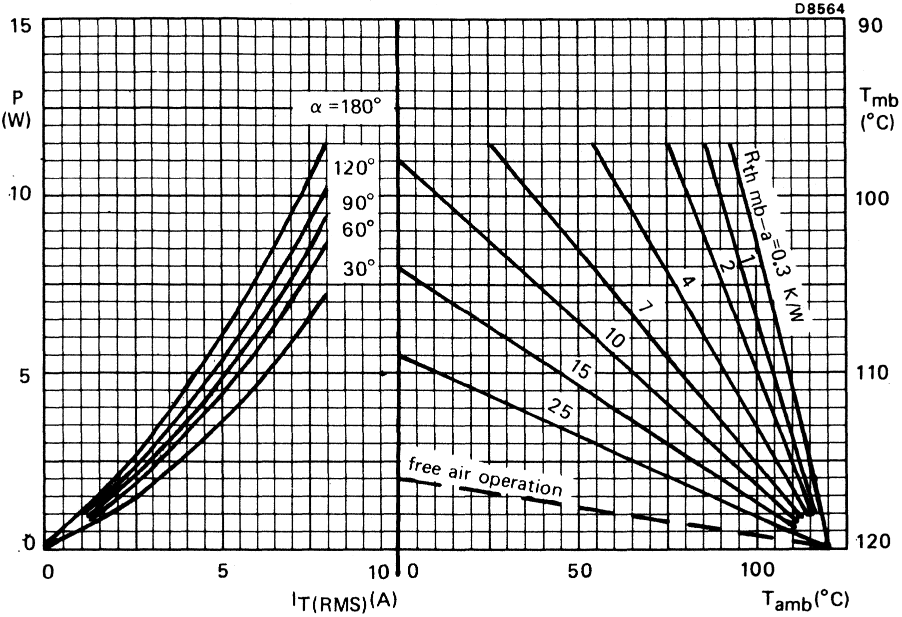
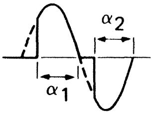


Fig.4 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha = \alpha_1 = \alpha_2$: conduction angle per half cycle

Note: For the type BT137–500D only, any operating point derived from Fig.4 should be derated by a further 10 °C.

HALF-CYCLE OPERATION

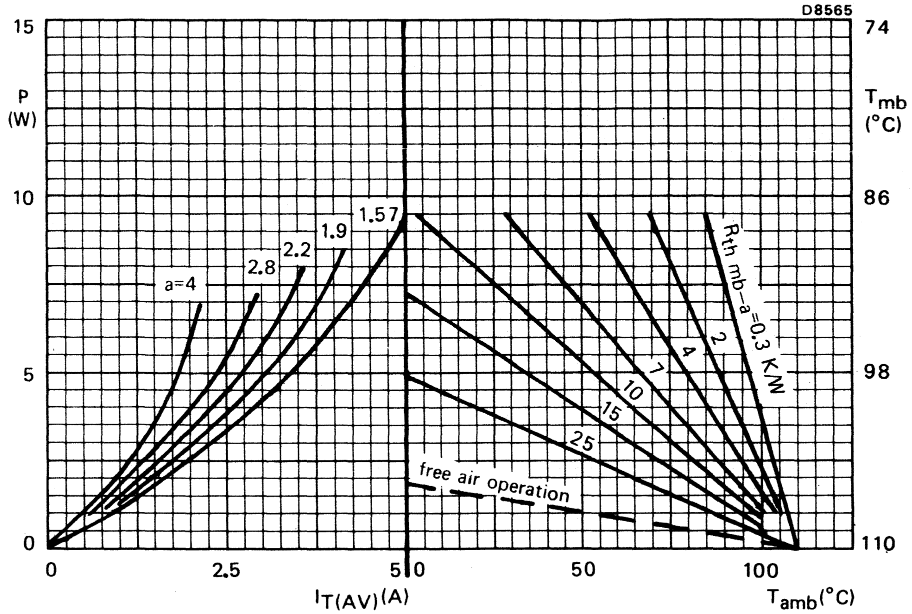
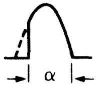


Fig. 5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



α = conduction angle per half cycle

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

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

Note: For the type BT137–500D only, any operating point derived from Fig.5 should be derated by a further 10 °C.

OVERLOAD OPERATION

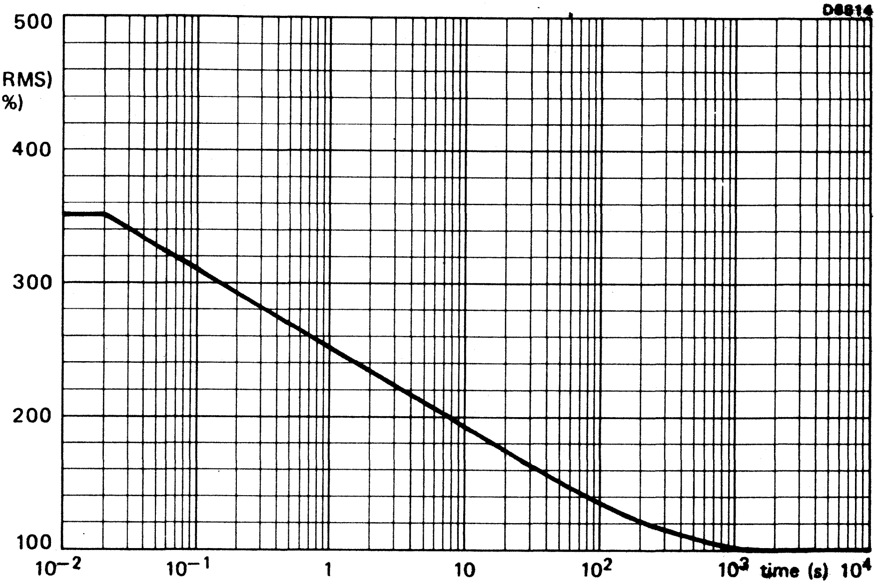


Fig.6 Maximum permissible duration of steady overload (provided that T_{mb} does not exceed 120 °C during and after overload) expressed as a percentage of the steady state r.m.s. rated current. For high r.m.s. overload currents precautions should be taken so that the temperature of the terminals does not exceed 125 °C. During these overload conditions the triac may lose control. Therefore the overload should be terminated by a separate protection device.

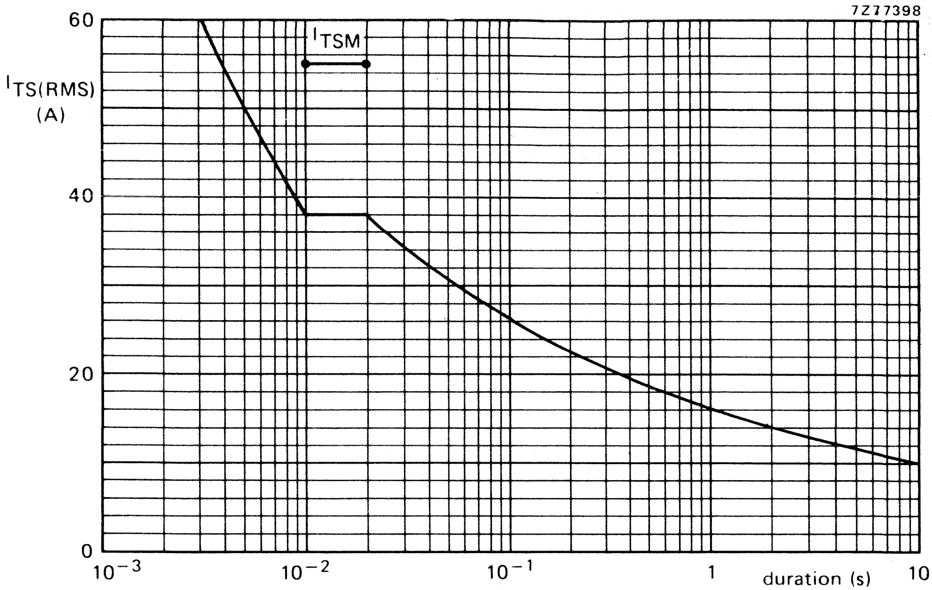
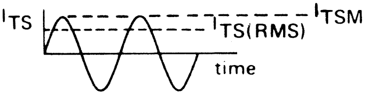


Fig.7 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents (f = 50 Hz); T_j = 120 °C prior to surge. The triac may temporarily lose control following the surge.



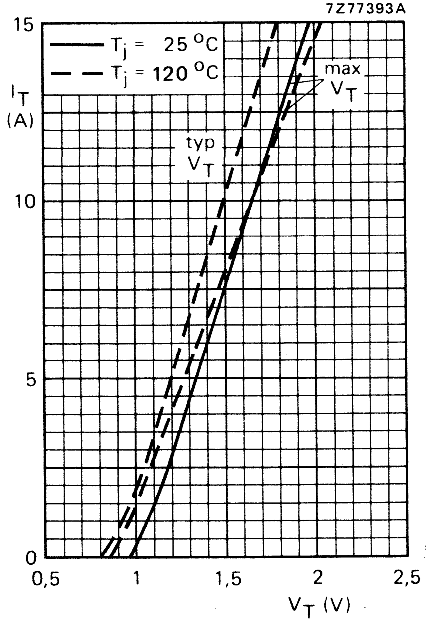


Fig.8

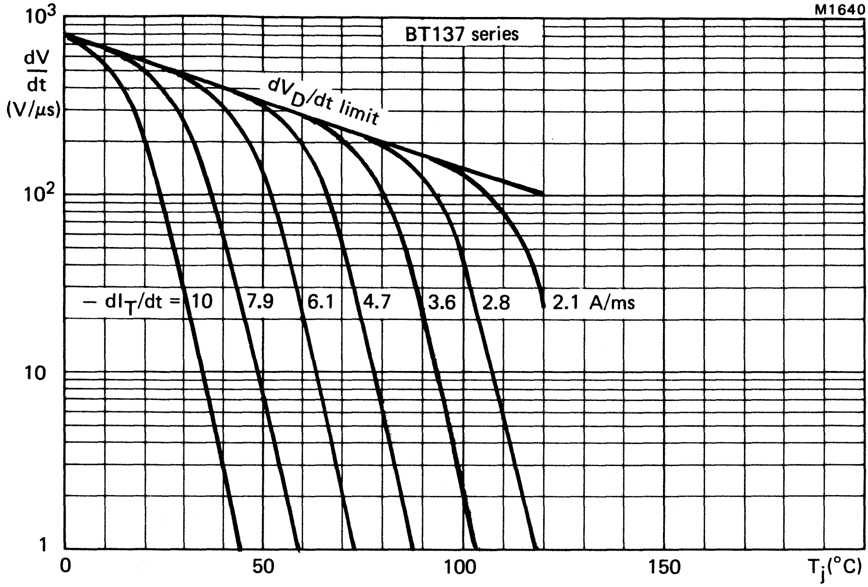


Fig.9 Typical commutation dV/dt for BT137 series versus T_j. The triac should commutate when the dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

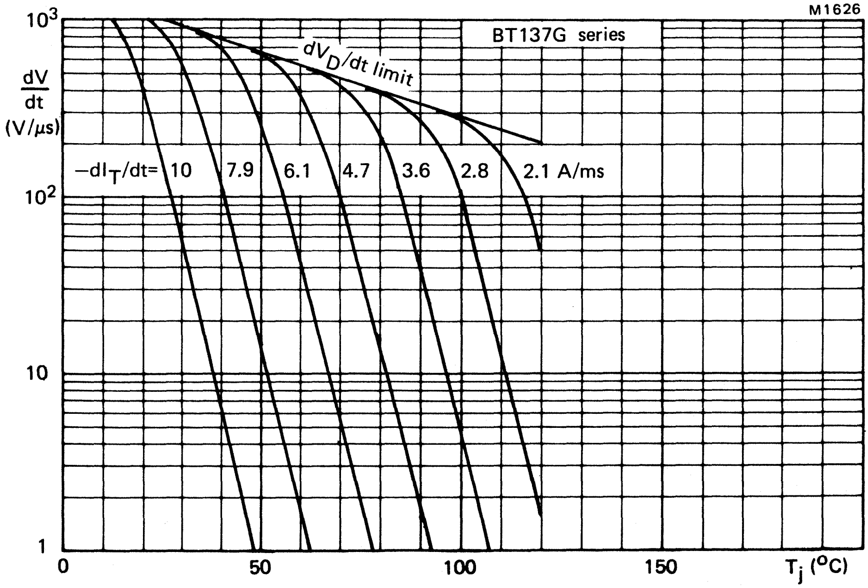


Fig.10 Limit commutation dV/dt for BT137G series versus T_j. The triac should commutate when the dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

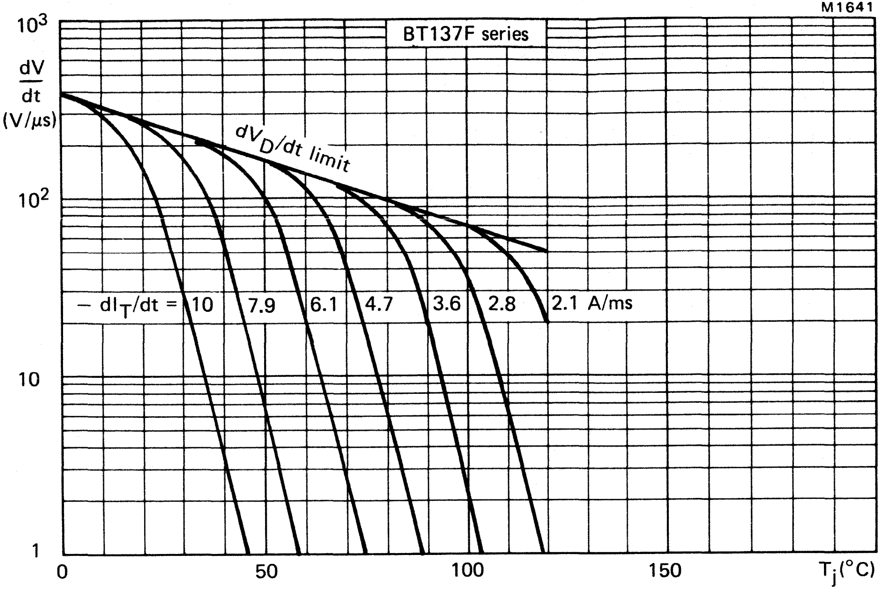


Fig.11 Typical commutation dV/dt for BT137F series versus T_j. The triac should commutate when the dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

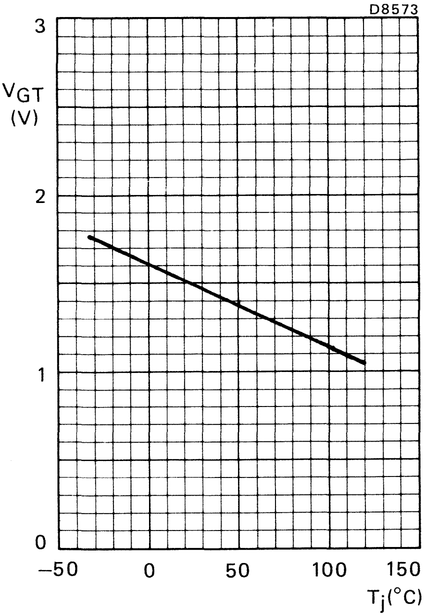


Fig.12 Minimum gate voltage that will trigger all devices; all conditions.

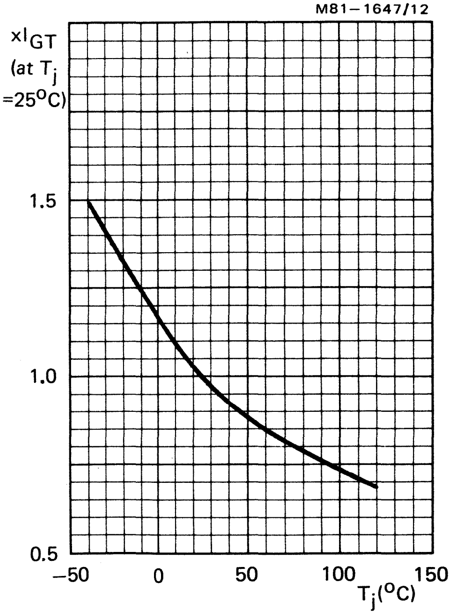


Fig.13 Normalised gate current that will trigger all devices; all conditions.

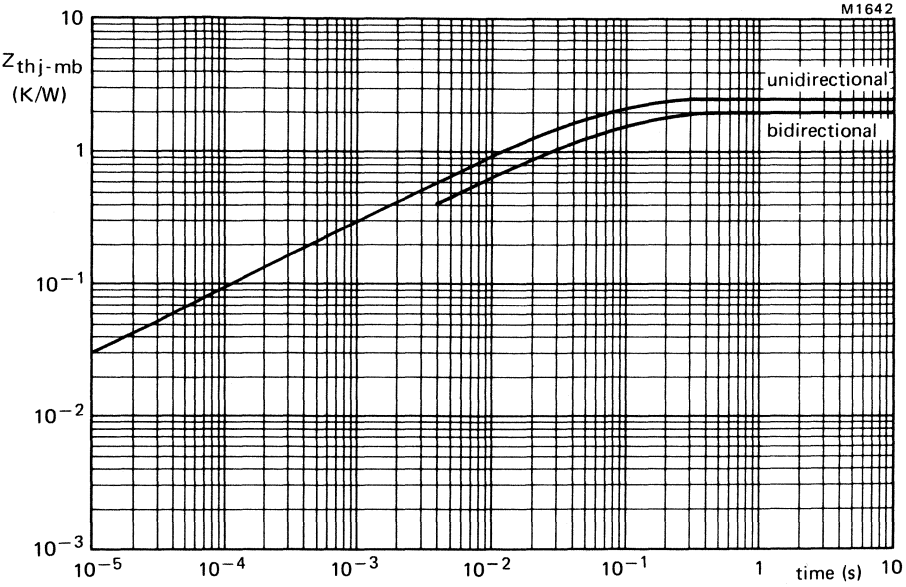

M1642
10
Z_{thj-mb}
(K/W)
1
10^{-1}
10^{-2}
10^{-3}
unidirectional
bidirectional
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
time (s)
10

Fig.14

TRIACS

Glass-passivated 12 ampere triacs intended for use in applications requiring high bidirectional transient and blocking voltage capability, and high thermal cycling performance with very low thermal resistances, e.g. a.c. power control applications such as motor, industrial lighting, industrial and domestic heating control and static switching systems.

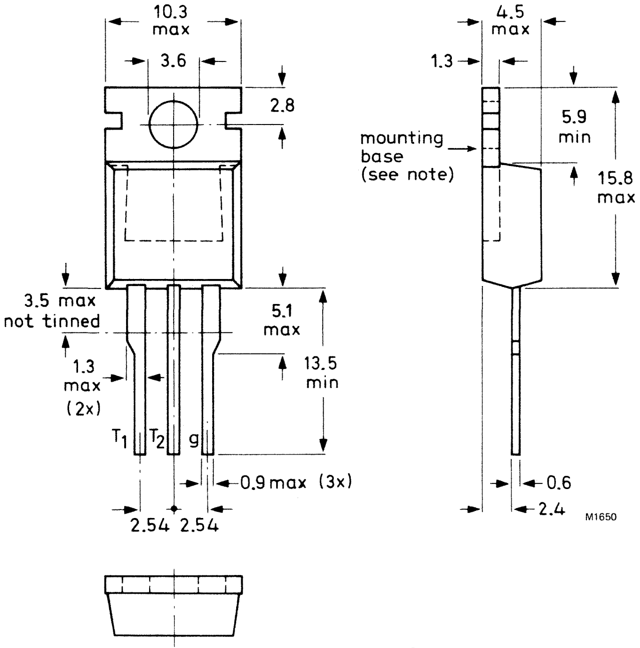
QUICK REFERENCE DATA

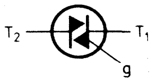
			BT138–500	600	800	
Repetitive peak off-state voltage	V_{DRM}	max.	500	600	800	V
R.M.S. on-state current	$I_{T(RMS)}$	max.		12		A
Non-repetitive peak on-state current	I_{TSM}	max.		90		A

MECHANICAL DATA

Dimensions in mm

Fig.1 TO-220AB





Net mass: 2 g

Note: The exposed metal mounting base is directly connected to terminal T_2.

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

RATINGS

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

Voltages (in either direction)

			BT138–500	600	800	
Non-repetitive peak off-state voltage ($t \leqslant 10$ ms)	V_{DSM}	max.	500*	600*	800	V
Repetitive peak off-state voltage ($\delta \leqslant 0.01$)	V_{DRM}	max.	500	600	800	V
Crest working off-state voltage	V_{DWM}	max.	400	400	400	V

Currents (in either direction)

R.M.S. on-state current (conduction angle 360°) up to T_{mb} = 95 °C	$I_{T(RMS)}$	max.	12	A
Average on-state current for half-cycle operation (averaged over any 20 ms period) up to T_{mb} = 83 °C	$I_{T(AV)}$	max.	7.5	A
Repetitive peak on-state current	I_{TRM}	max.	90	A
Non-repetitive peak on-state current; T_j = 120 °C prior to surge; t = 20 ms; full sine-wave	I_{TSM}	max.	90	A
I^2t for fusing (t = 10 ms)	I^2t	max.	40	A^2s
Rate of rise of on-state current after triggering with I_G = 200 mA to I_T = 20 A; dI_G/dt = 0.2 A/μs	dI_T/dt	max.	30	A/μs

Gate to terminal 1

Power dissipation

Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	0.5	W
Peak power dissipation	P_{GM}	max.	5.0	W

Temperatures

Storage temperature	T_{stg}		–40 to +125	°C
Operating junction temperature				
full-cycle operation	T_j	max.	120	°C
half-cycle operation	T_j	max.	110	°C

---

*Although not recommended, off-state voltages up to 800 V may be applied without damage, but the triac may switch into the on-state. The rate of rise of on-state current should not exceed 15 A/μs.

THERMAL RESISTANCE

From junction to mounting base
full-cycle operation $R_{th\ j\text{-}mb}$ = 1.5 K/W
half-cycle operation $R_{th\ j\text{-}mb}$ = 2.0 K/W

Transient thermal impedance; t = 1 ms $Z_{th\ j\text{-}mb}$ = 0.1 K/W

Influence of mounting method

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from mounting base to heatsink

a. with heatsink compound $R_{th\ mb\text{-}h}$ = 0.3 K/W

b. with heatsink compound and 0.06 mm maximum mica insulator $R_{th\ mb\text{-}h}$ = 1.4 K/W

c. with heatsink compound and 0.1 mm maximum mica insulator (56369) $R_{th\ mb\text{-}h}$ = 2.2 K/W

d. with heatsink compound and 0.25 mm maximum alumina insulator (56367) $R_{th\ mb\text{-}h}$ = 0.8 K/W

e. without heatsink compound $R_{th\ mb\text{-}h}$ = 1.4 K/W

2. Free-air operation

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

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

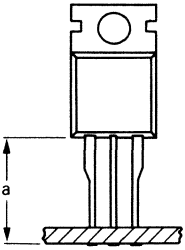


Fig.2

CHARACTERISTICS

Polarities, positive or negative, are identified with respect to T_1.

Voltages and currents (in either direction)

On-state voltage (measured under pulse conditions to prevent excessive dissipation)

$I_T = 15$ A; $T_j = 25\ ^\circ C$	V_T	<	1.65	V

Rate of rise of off-state voltage that will not trigger any device; $T_j = 120\ ^\circ C$; gate open circuit

→ BT138 series	dV_D/dt	<	100	V/µs
→ BT138 series G	dV_D/dt	<	200	V/µs
BT138 series F	dV_D/dt	<	50	V/µs
BT138 series E	dV_D/dt	typ.	50	V/µs

Rate of change of commutating voltage that will not trigger any device when $-dI_{com}/dt = 5.4$ A/ms; $I_{T(RMS)} = 12$ A; $T_{mb} = 70\ ^\circ C$; gate open circuit ;$V_D = V_{DWMmax}$

BT138 series	dV_{com}/dt	typ.	10	V/µs
BT138 series G	dV_{com}/dt	<	10	V/µs
BT138 series F	dV_{com}/dt	typ.	10	V/µs

Off-state current

$V_D = V_{DWMmax}$; $T_j = 120\ ^\circ C$;	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 $V_D = V_{DWMmax}$; $T_j = 120\ ^\circ C$; T_2 and G positive or negative	V_{GD}	<	250	mV

Gate current that will trigger all devices (I_{GT}); G to T_1

Holding current (I_H)

Latching current (I_L); $V_D = 12$ V; $T_j = 25\ ^\circ C$

			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 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.
3. It is recommended that the circuit connection be made to tag T_2, rather than direct to the heatsink.
4. Mounting by means of a spring clip is the best mounting method because it offers:
   a. a good thermal contact under the crystal area and slightly lower $R_{th\ mb\text{-}h}$ values than screw mounting.
   b. safe isolation for mains operation.
   However, if a screw is used, it should be M3 cross-recess pan-head. Care should be taken to avoid damage to the plastic body.
5. For good thermal contact heatsink compound should be used between mounting base and heatsink. Values of $R_{th\ mb\text{-}h}$ given for mounting with heatsink compound refer to the use of a metallic-oxide loaded compound. Ordinary silicone grease is not recommended.
6. Rivet mounting (only possible for non-insulated mounting)
   Devices may be rivetted to flat heatsinks; such a process **must neither** deform the mounting tab, **nor** enlarge the mounting hole.

OPERATING NOTES

Dissipation and heatsink considerations:

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

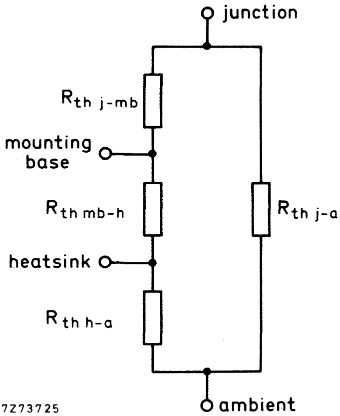


Fig.3

b. The method of using Figs.4 and 5 is as follows:
Starting with the required current on the $I_{T(AV)}$ or $I_{T(RMS)}$ axis, trace upwards to meet the appropriate form factor or conduction angle curve. Trace right horizontally and upwards from the appropriate value on the T_{amb} scale. The intersection determines the $R_{th\ mb\text{-}a}$. The heatsink thermal resistance value ($R_{th\ h\text{-}a}$) can now be calculated from:

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

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

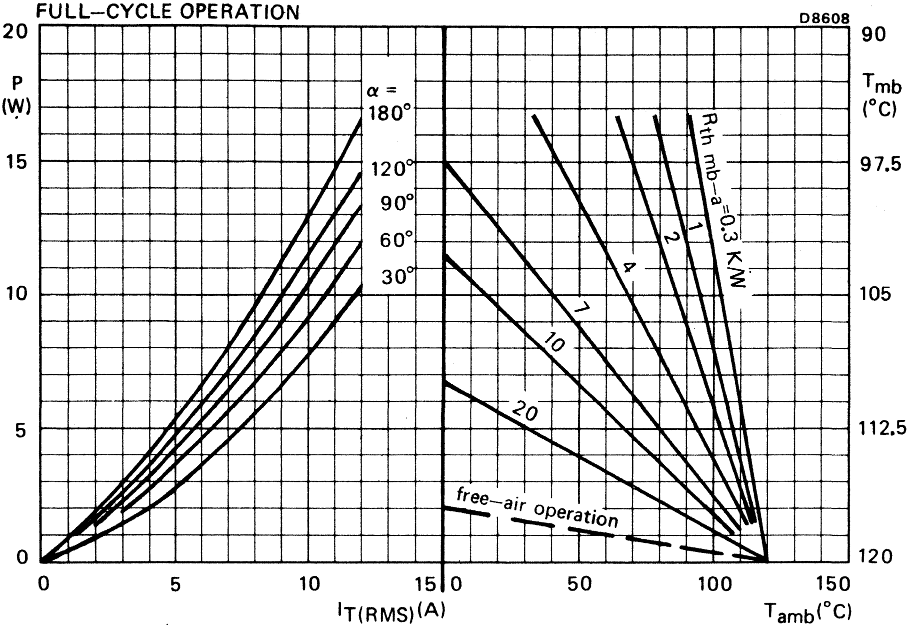
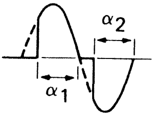


Fig.4 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha = \alpha_1 = \alpha_2$: conduction angle per half cycle

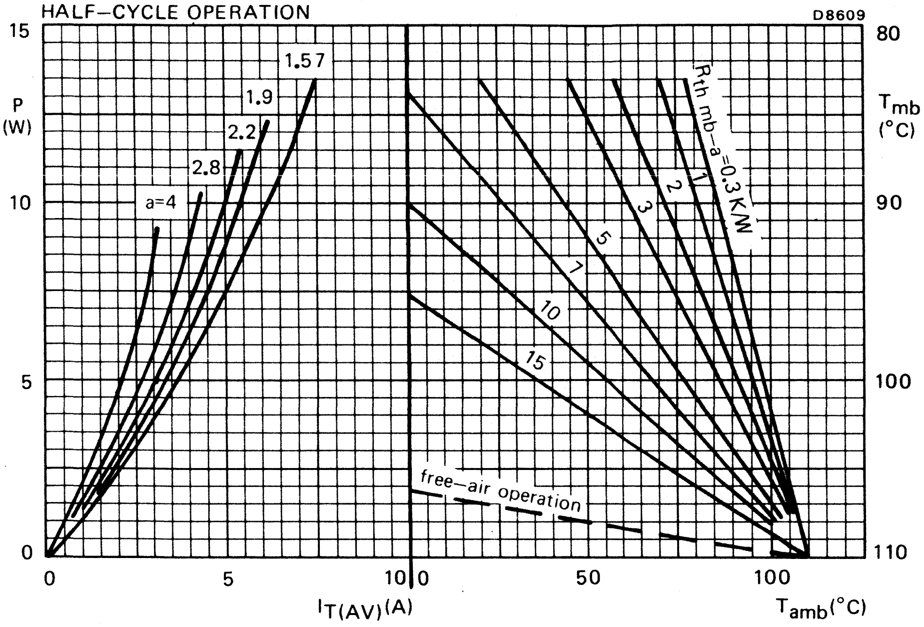
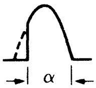


Fig.5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



α = conduction angle per half cycle

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

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

OVERLOAD OPERATION

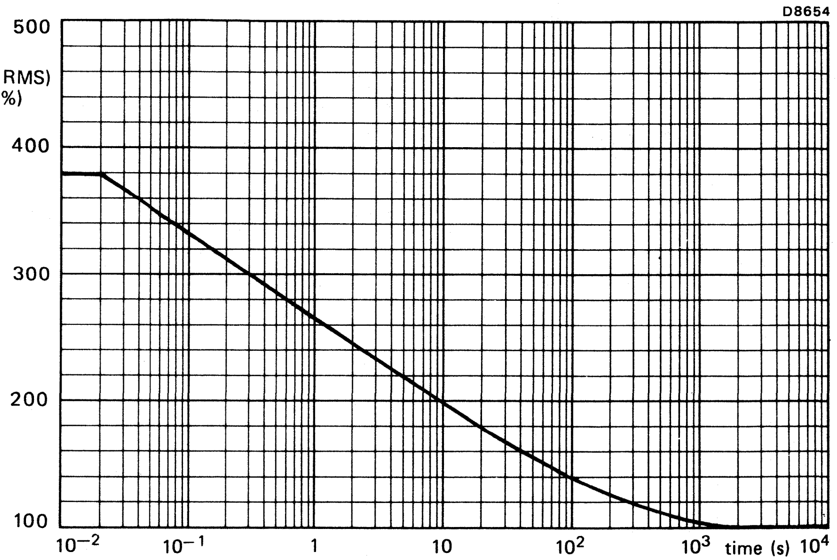


Fig.6 Maximum permissible duration of steady overload (provided that T_{mb} does exceed 120 °C during and after overload) expressed as a percentage of the steady state r.m.s. rated current. For high r.m.s. overload currents precautions should be taken so that the temperature of the terminals does not exceed 125 °C. During these overload conditions the triac may lose control. Therefore the overload should be terminated by a separate protection device.

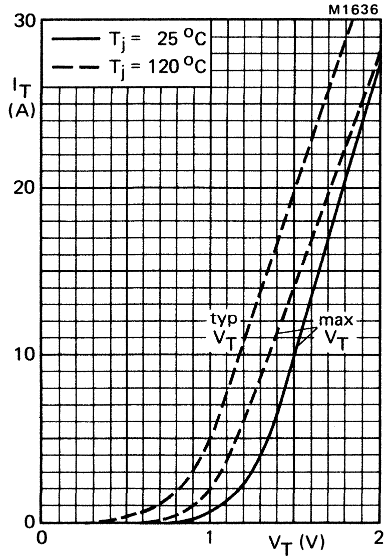


Fig.7

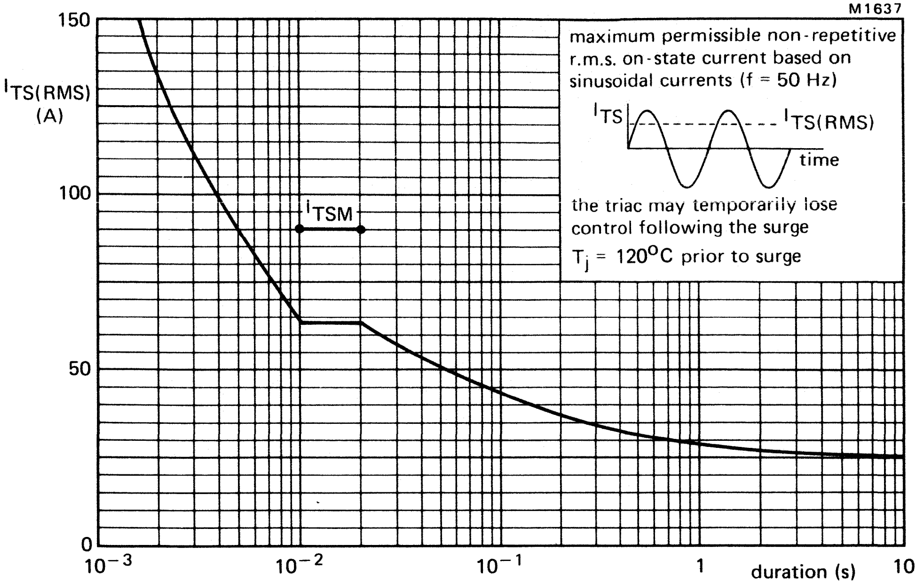

M1637
150
100
50
0
$I_{TS(RMS)}$ (A)
I_{TSM}
10^{-3}
10^{-2}
10^{-1}
1
duration (s)
10
maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents (f = 50 Hz)
I_{TS}
$I_{TS(RMS)}$
time
the triac may temporarily lose control following the surge
T_j = 120°C prior to surge

Fig.8

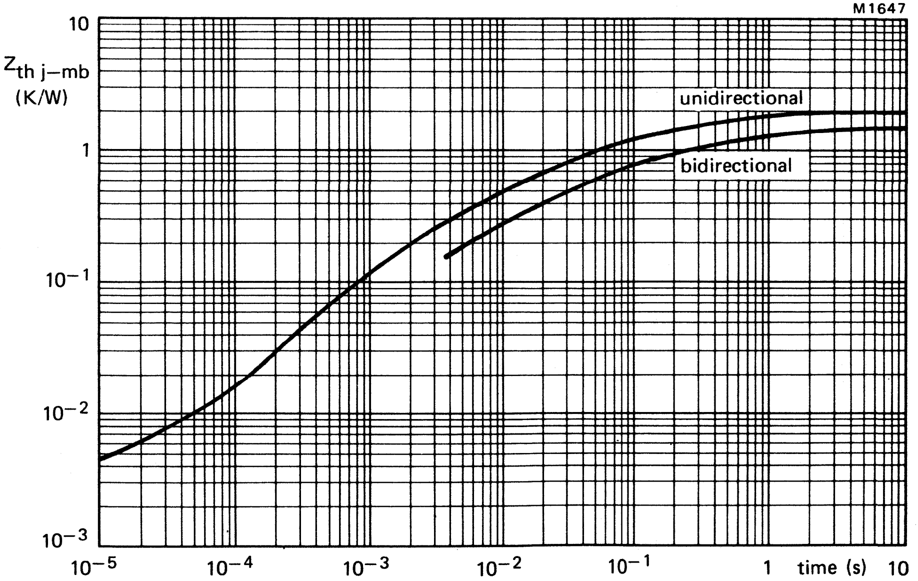

M1647
10
1
10^{-1}
10^{-2}
10^{-3}
$Z_{th\ j-mb}$ (K/W)
unidirectional
bidirectional
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
time (s)
10

Fig.9

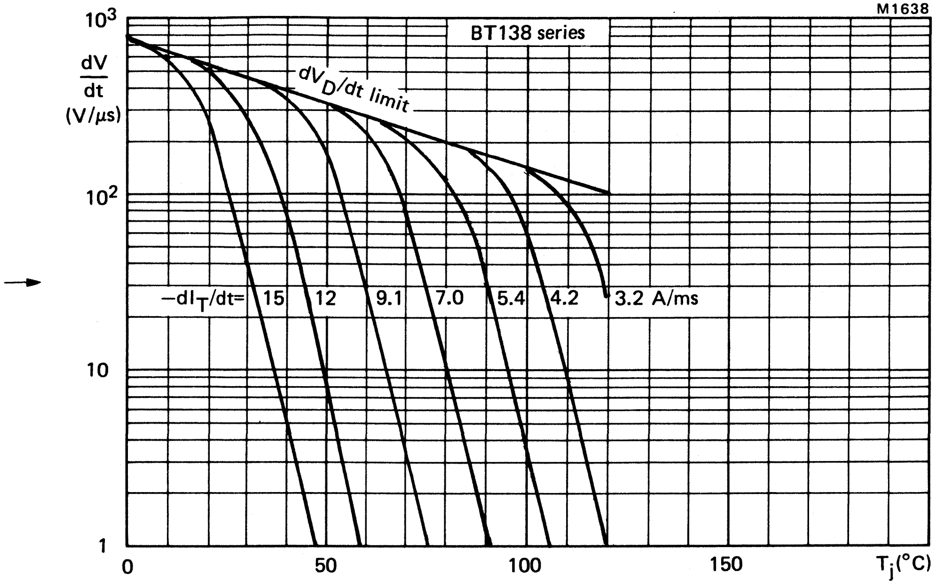


Fig.10 Typical commutation dV/dt for BT138 series versus T_j. The triac should commutate when dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

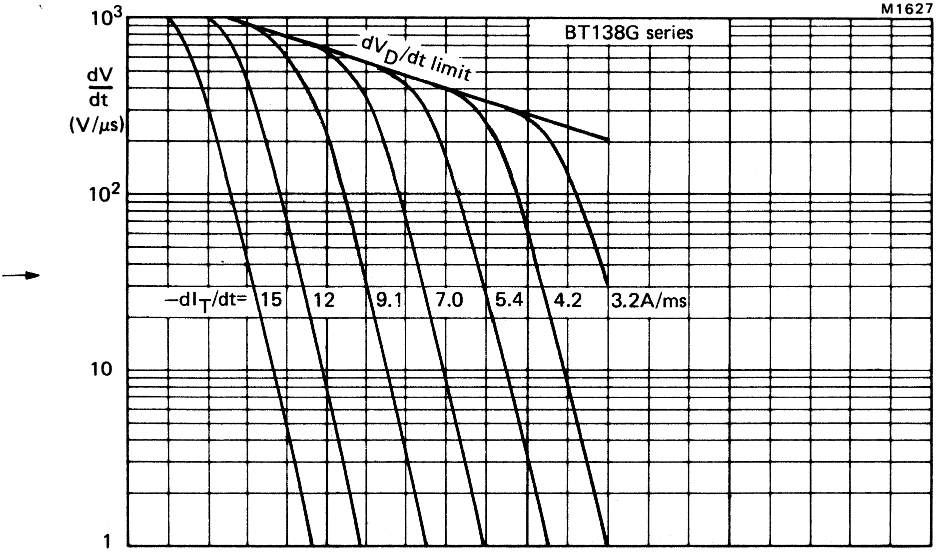


Fig.11 Limit commutation dV/dt for BT138G series versus T_j. The triac should commutate when the dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

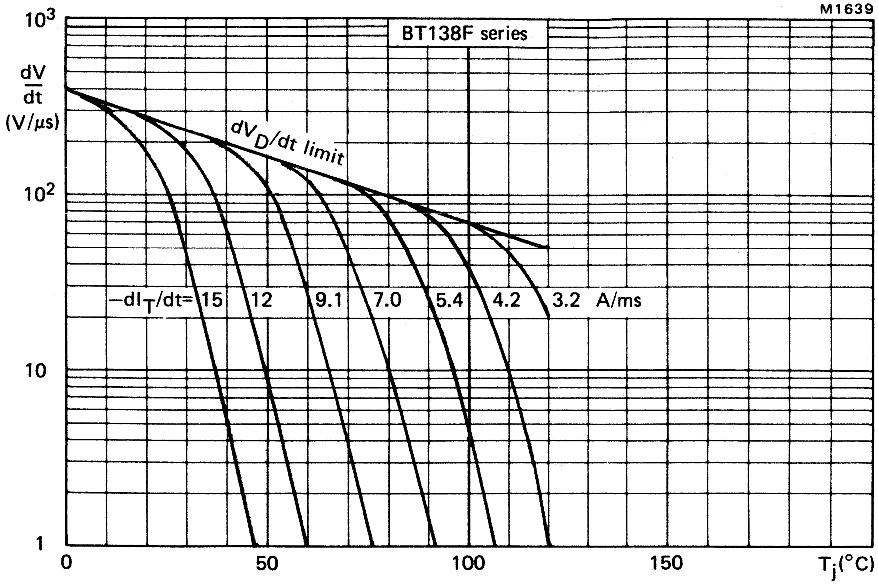


Fig.12 Typical commutation dV/dt for BT138F series versus T_j. The triac should commutate when the dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

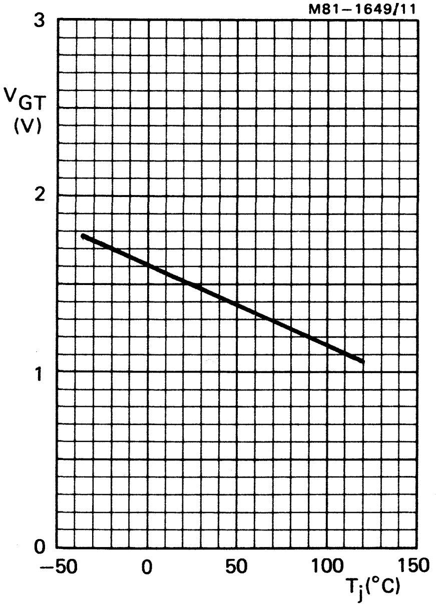


Fig.13 Minimum gate voltage that will trigger all devices; all conditions.

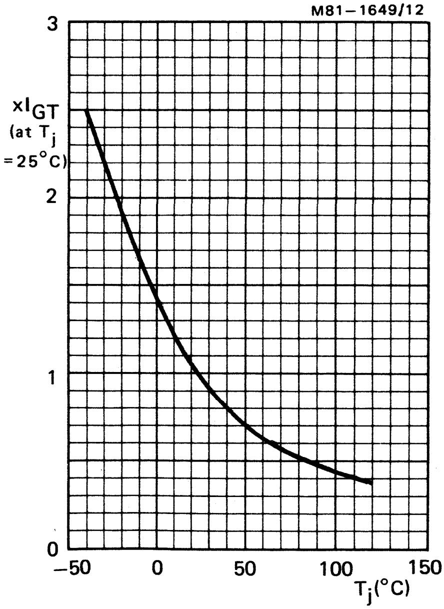
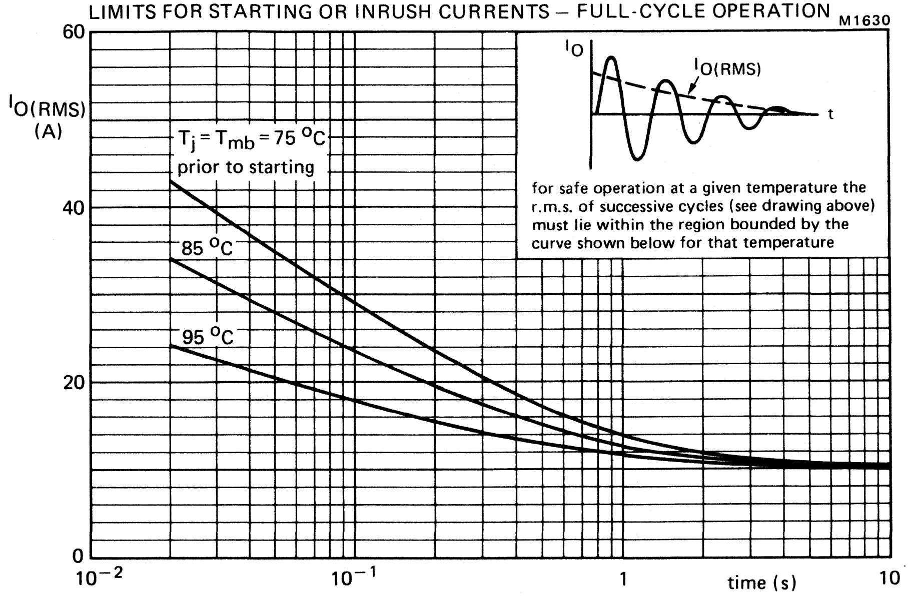


Fig.14 Normalised gate current that will trigger all devices; all conditions.

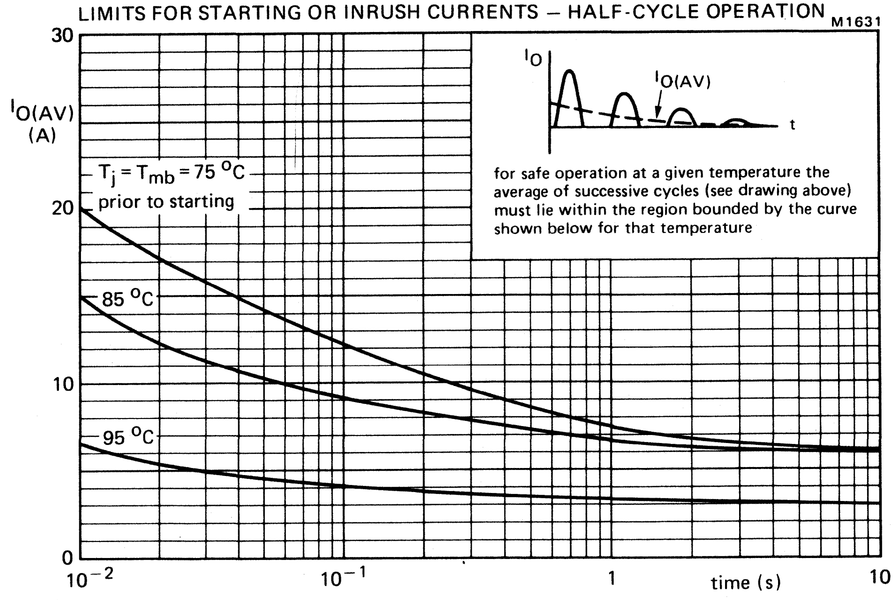
LIMITS FOR STARTING OR INRUSH CURRENTS — FULL-CYCLE OPERATION



for safe operation at a given temperature the r.m.s. of successive cycles (see drawing above) must lie within the region bounded by the curve shown below for that temperature

Fig.15

LIMITS FOR STARTING OR INRUSH CURRENTS — HALF-CYCLE OPERATION



for safe operation at a given temperature the average of successive cycles (see drawing above) must lie within the region bounded by the curve shown below for that temperature

Fig.16

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.

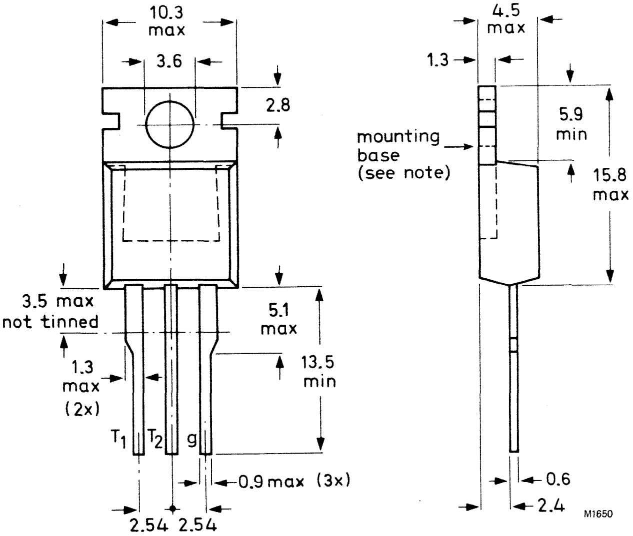
QUICK REFERENCE DATA

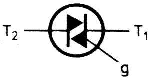
			BT139–500	600	800	
Repetitive peak off-state voltage	V_{DRM}	max.	500	600	800	V
R.M.S. on-state current	$I_{T(RMS)}$	max.		16		A
Non-repetitive peak on-state current	I_{TSM}	max.		115		A

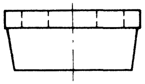
MECHANICAL DATA

Dimensions in mm

Fig.1 TO-220AB







Net mass: 2 g

Note: The exposed metal mounting base is directly connected to terminal T_2.

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

RATINGS

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

Voltages (in either direction)			BT139–500	600	800	
Non-repetitive peak off-state voltage ($t \leqslant 10$ ms)	V_{DSM}	max.	500*	600*	800	V
Repetitive peak off-state voltage ($\delta \leqslant 0.01$)	V_{DRM}	max.	500	600	800	V
Crest working off-state voltage	V_{DWM}	max.	400	400	400	V

Currents (in either direction)				
R.M.S. on-state current (conduction angle 360°) up to T_{mb} = 93 °C	$I_{T(RMS)}$	max.	16	A
Average on-state current for half-cycle operation (averaged over any 20 ms period) up to T_{mb} = 79 °C	$I_{T(AV)}$	max.	10	A
Repetitive peak on-state current	I_{TRM}	max.	115	A
Non-repetitive peak on-state current; T_j = 120 °C prior to surge; t = 20 ms; full sine-wave	I_{TSM}	max.	115	A
I^2t for fusing (t = 10 ms)	I^2t	max.	65	A^2s
Rate of rise of on-state current after triggering with I_G = 200 mA to I_T = 20 A; dI_G/dt = 0.2 A/µs	dI_T/dt	max.	30	A/µs

Gate to terminal 1

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

Temperatures				
Storage temperature	T_{stg}		−40 to +125	°C
Operating junction temperature				
full-cycle operation	T_j	max.	120	°C
half-cycle operation	T_j	max.	110	°C

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*Although not recommended, off-state voltages up to 800 V may be applied without damage, but the triac may switch into the on-state. The rate of rise of on-state current should not exceed 15 A/µs.

THERMAL RESISTANCE

From junction to mounting base				
full-cycle operation	$R_{th\ j\text{-}mb}$	=	1.2	K/W
half-cycle operation	$R_{th\ j\text{-}mb}$	=	1.7	K/W
Transient thermal impedance; t = 1 ms	$Z_{th\ j\text{-}mb}$	=	0.1	K/W

Influence of mounting method

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from mounting base to heatsink

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

2. Free-air operation

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

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

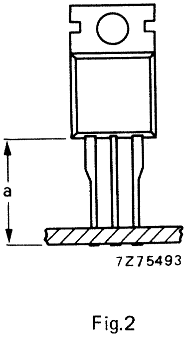


Fig.2

CHARACTERISTICS

Polarities, positive or negative, are identified with respect to T_1.

Voltages and currents (in either direction)

On-state voltage (measured under pulse conditions to prevent excessive dissipation)				
$I_T = 20$ A; $T_j = 25$ °C	V_T	$<$	1.6	V
Rate of rise of off-state voltage that will not trigger any device; $T_j = 120$ °C; gate open circuit				
→ BT139 series	dV_D/dt	$<$	100	V/µs
→ BT139 series G	dV_D/dt	$<$	200	V/µs
BT139 series F	dV_D/dt	$<$	50	V/µs
BT139 series E	dV_D/dt	typ.	50	V/µs
Rate of change of commutating voltage that will not trigger any device when $-dI_{com}/dt = 7.2$ A/ms; $I_{T(RMS)} = 16$ A; $T_{mb} = 70$ °C; gate open circuit ;$V_D = V_{DWMmax}$				
BT139 series	dV_{com}/dt	typ.	10	V/µs
BT139 series G	dV_{com}/dt	$<$	10	V/µs
BT139 series F	dV_{com}/dt	typ.	10	V/µs
Off-state current				
$V_D = V_{DWMmax}$; $T_j = 120$ °C;	I_D	$<$	0.5	mA
Gate voltage that will trigger all devices	V_{GT}	$>$	1.5	V
Gate voltage that will not trigger any device $V_D = V_{DWMmax}$; $T_j = 120$ °C; T_2 and G positive or negative	V_{GD}	$<$	250	mV

Gate current that will trigger all devices (I_{GT}); G to T_1

Holding current (I_H)

Latching current (I_L); $V_D = 12$ V; $T_j = 25$ °C

			T_2+ G+	T_2+ G−	T_2- G−	T_2- G+	
BT139 series	I_{GT}	$>$	35	35	35	70	mA
	I_H	$<$	30	30	30	30	mA
	I_L	$<$	40	60	40	60	mA
BT139 series G	I_{GT}	$>$	50	50	50	100	mA
	I_H	$<$	60	60	60	60	mA
	I_L	$<$	60	90	60	90	mA
BT139 series F	I_{GT}	$>$	25	25	25	70	mA
	I_H	$<$	30	30	30	30	mA
	I_L	$<$	40	60	40	60	mA
BT139 series E	I_{GT}	$>$	10	10	10	25	mA
	I_H	$<$	30	30	30	30	mA
	I_L	$<$	30	40	30	40	mA

MOUNTING INSTRUCTIONS

1. The 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.
3. It is recommended that the circuit connection be made to tag T_2, rather than direct to the heatsink.
4. Mounting by means of a spring clip is the best mounting method because it offers:
   a. a good thermal contact under the crystal area and slightly lower $R_{th\ mb\text{-}h}$ values than screw mounting.
   b. safe isolation for mains operation.
   However, if a screw is used, it should be M3 cross-recess pan-head. Care should be taken to avoid damage to the plastic body.
5. For good thermal contact heatsink compound should be used between mounting base and heatsink. Values of $R_{th\ mb\text{-}h}$ given for mounting with heatsink compound refer to the use of a metallic-oxide loaded compound. Ordinary silicone grease is not recommended.
6. Rivet mounting (only possible for non-insulated mounting)
   Devices may be rivetted to flat heatsinks; such a process **must neither** deform the mounting tab, **nor** enlarge the mounting hole.

OPERATING NOTES

Dissipation and heatsink considerations:

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

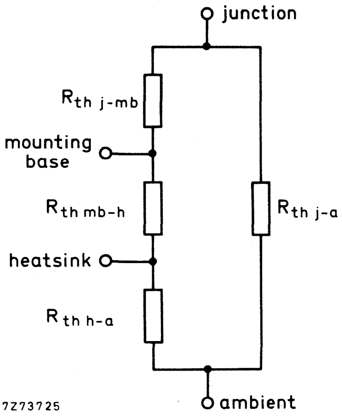


Fig.3

b. The method of using Figs.4 and 5 is as follows:
Starting with the required current on the $I_{T(AV)}$ or $I_{T(RMS)}$ axis, trace upwards to meet the appropriate form factor or conduction angle curve. Trace right horizontally and upwards from the appropriate value on the T_{amb} scale. The intersection determines the $R_{th\ mb\text{-}a}$. The heatsink thermal resistance value ($R_{th\ h\text{-}a}$) can now be calculated from:

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

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

FULL-CYCLE OPERATION

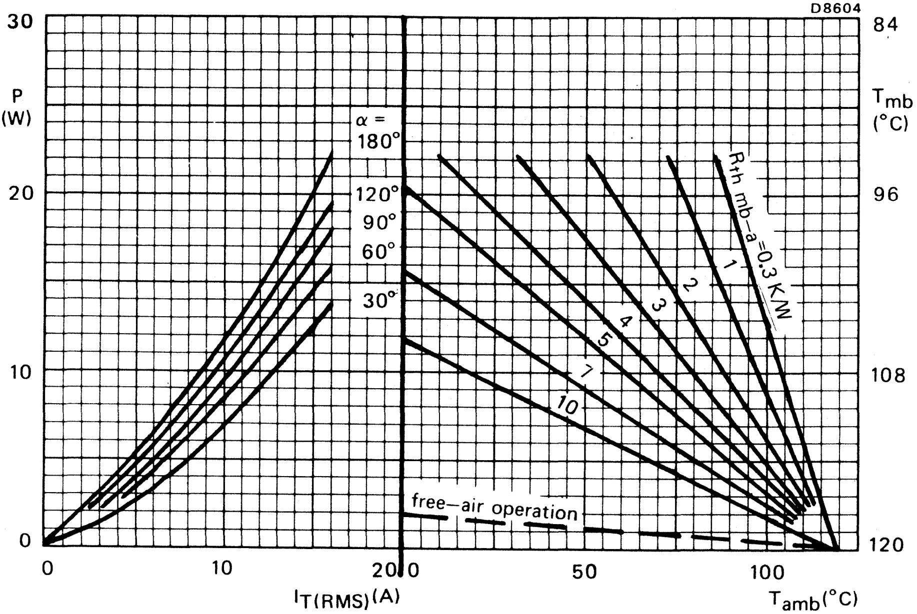
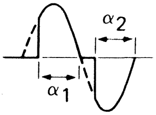


Fig. 4 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



$\alpha = \alpha_1 = \alpha_2$: conduction angle per half cycle

HALF-CYCLE OPERATION

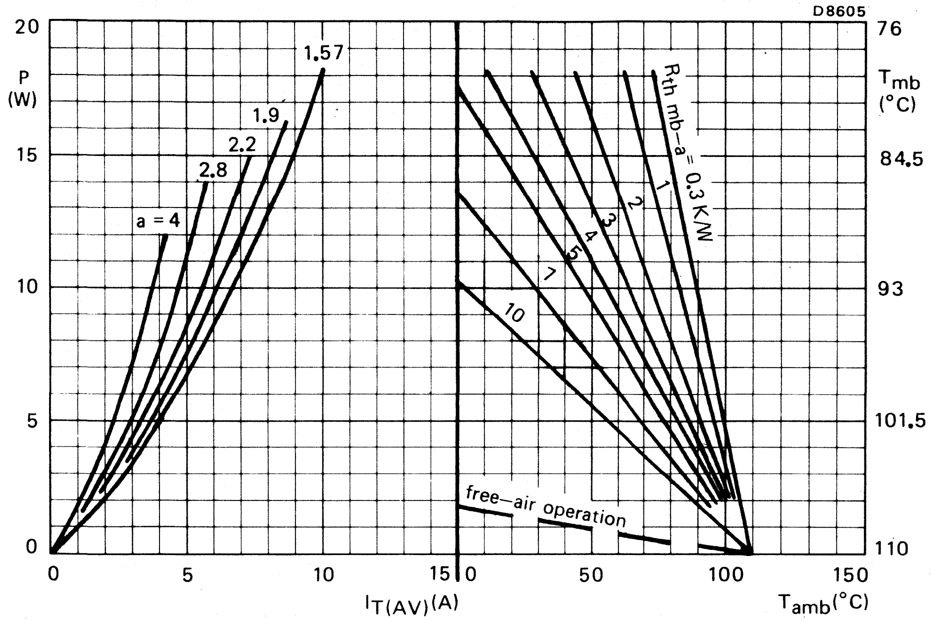
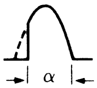


Fig.5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.



α = conduction angle per half cycle

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

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

OVERLOAD OPERATION

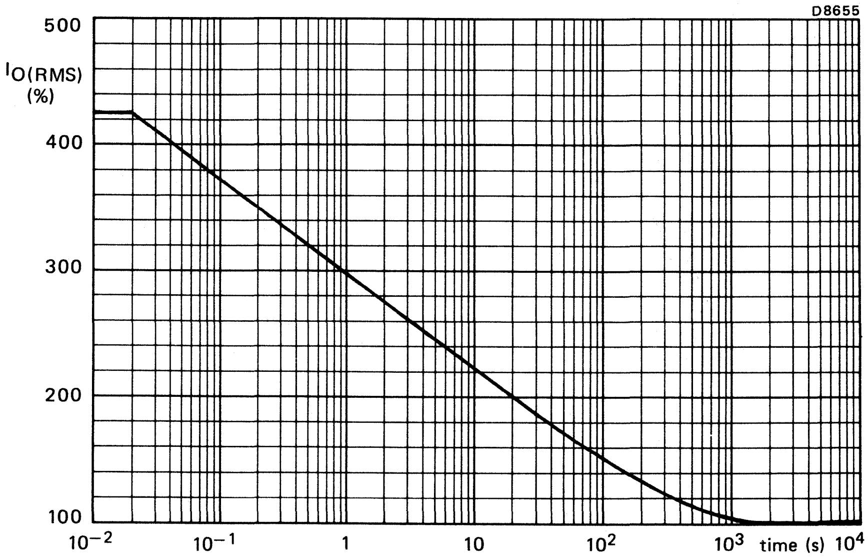


Fig.6 Maximum permissible duration of steady overload (provided that T_{mb} does not exceed 120 °C during and after overload) expressed as a percentage of the steady state r.m.s. rated current. For high r.m.s. overload currents precautions should be taken so that the temperature of the terminals does not exceed 125 °C. During these overload conditions the triac may lose control. Therefore the overload should be terminated by a separate protection device.

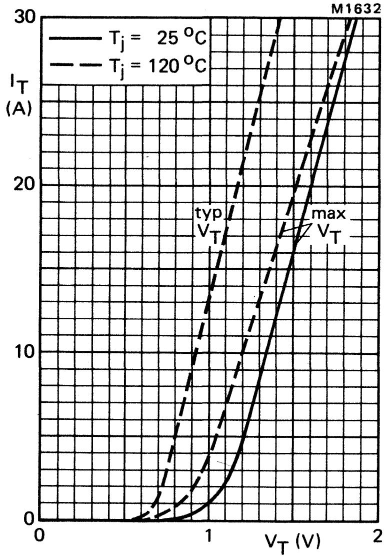


Fig.7

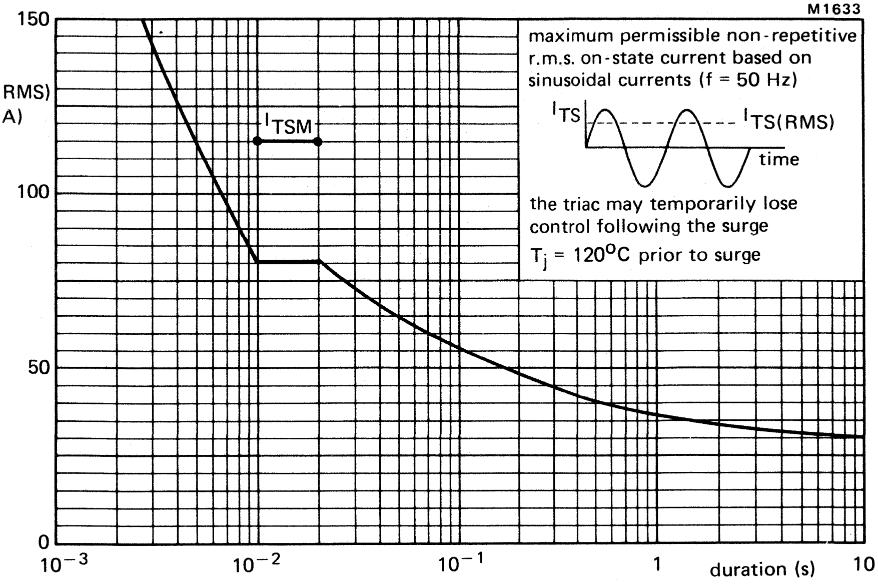

M1633
150
$I_{TS(RMS)}$
(A)
100
50
0
I_{TSM}
maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents (f = 50 Hz)
I_{TS}
$I_{TS(RMS)}$
time
the triac may temporarily lose control following the surge
T_j = 120°C prior to surge
10^{-3}
10^{-2}
10^{-1}
1
duration (s)
10

Fig.8

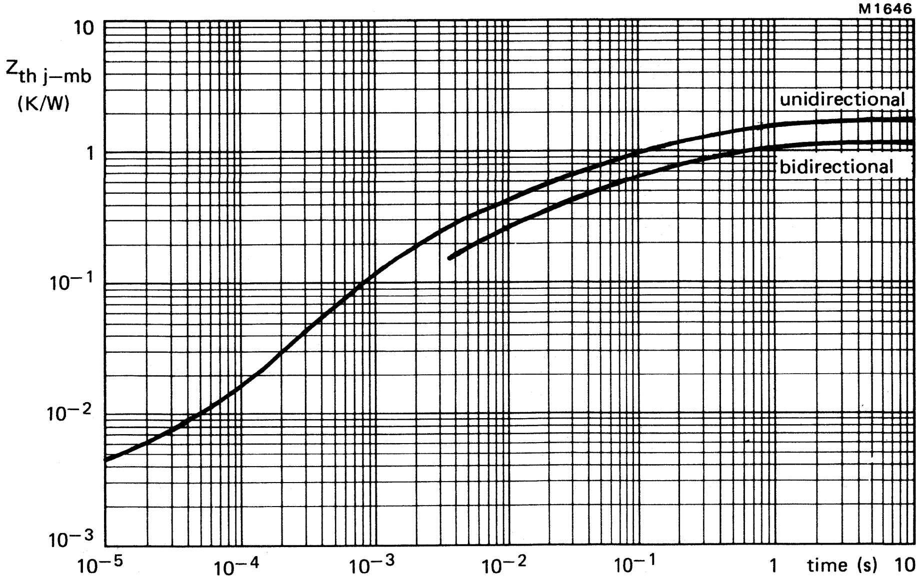

M1646
10
$Z_{th\ j-mb}$
(K/W)
1
10^{-1}
10^{-2}
10^{-3}
unidirectional
bidirectional
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
time (s)
10

Fig.9

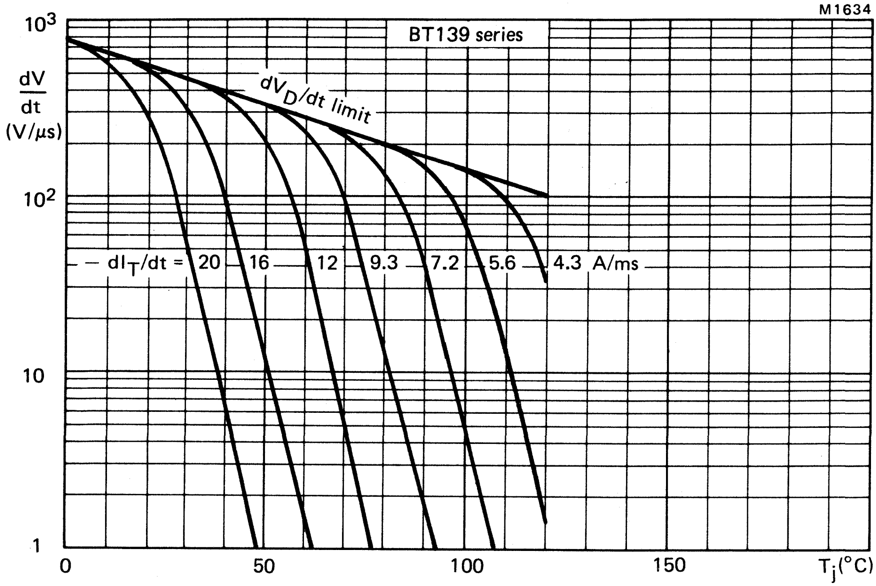


Fig.10 Typical commutation dV/dt for BT139 series versus T_j. The triac should commutate when the dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

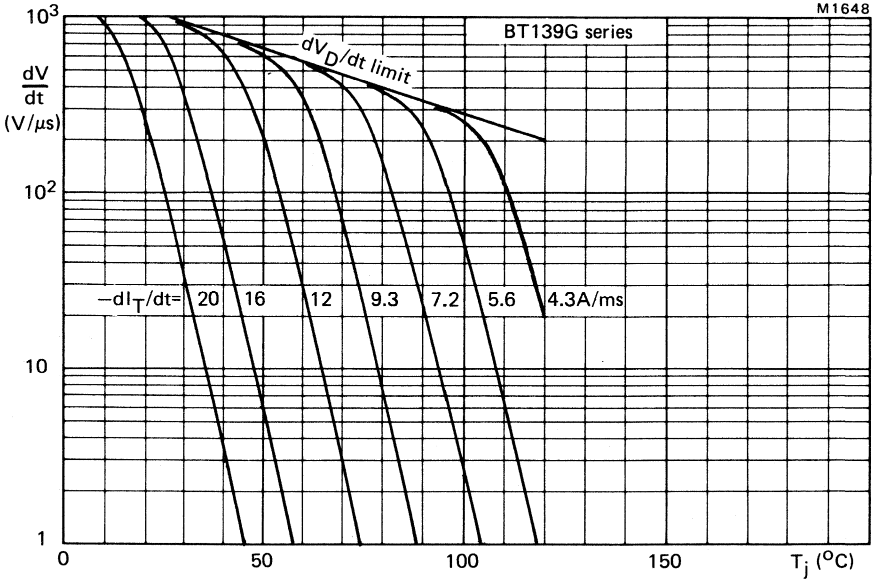


Fig.11 Limit commutation dV/dt for BT139G series versus T_j. The triac should commutate when the dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

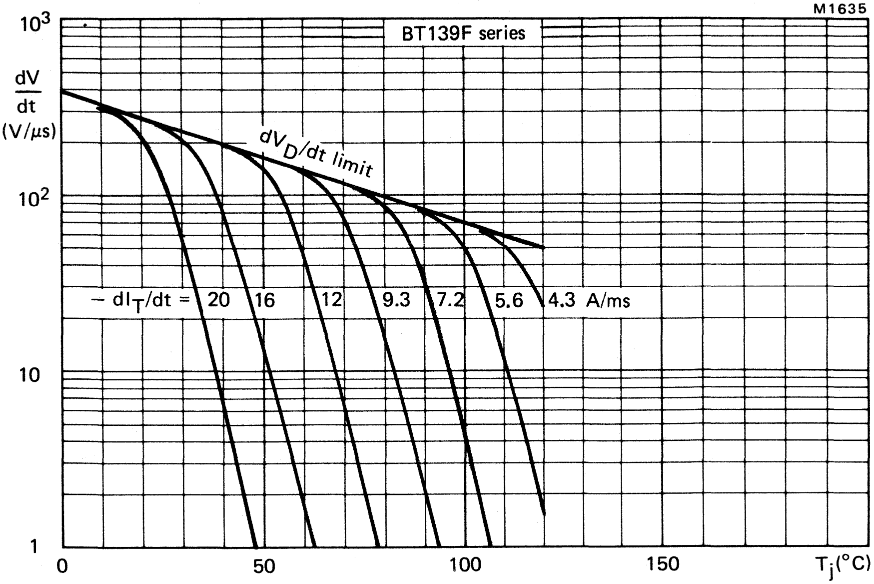


Fig.12 Typical commutation dV/dt for BT139F series versus T_j. The triac should commutate when the dV/dt is below the value on the appropriate curve for pre-commutation dI_T/dt.

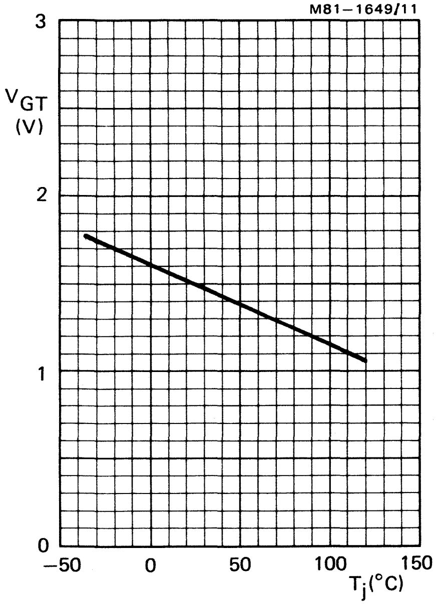


Fig.13 Minimum gate voltage that will trigger all devices; all conditions.

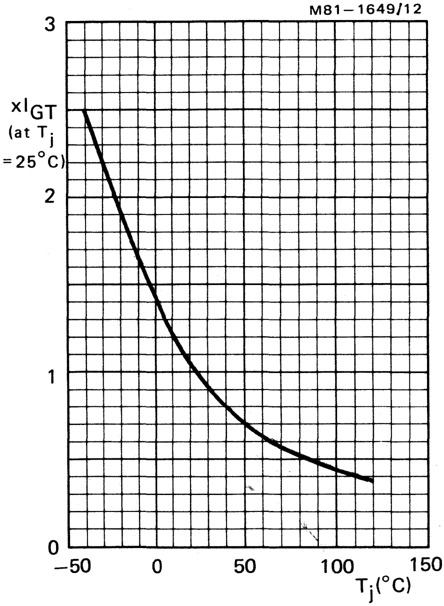
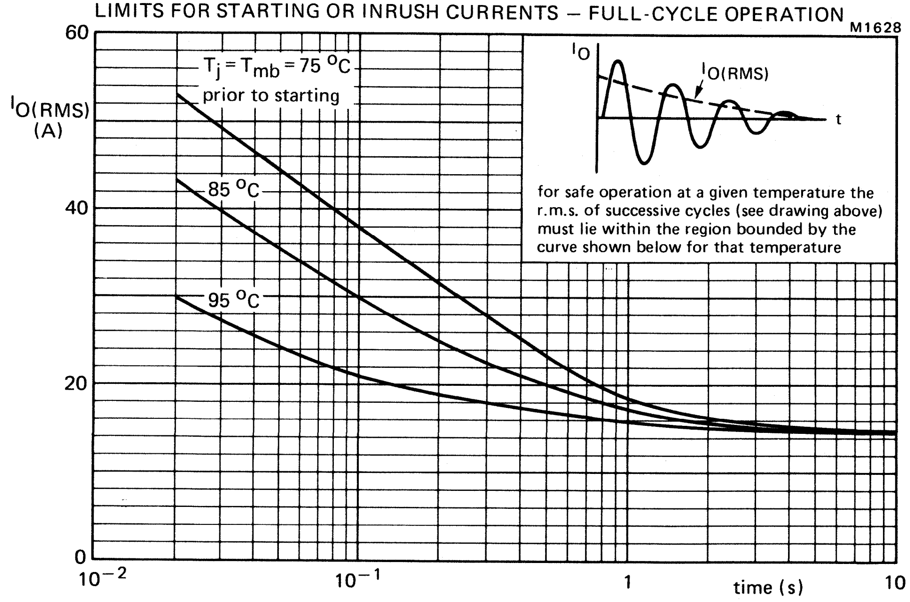
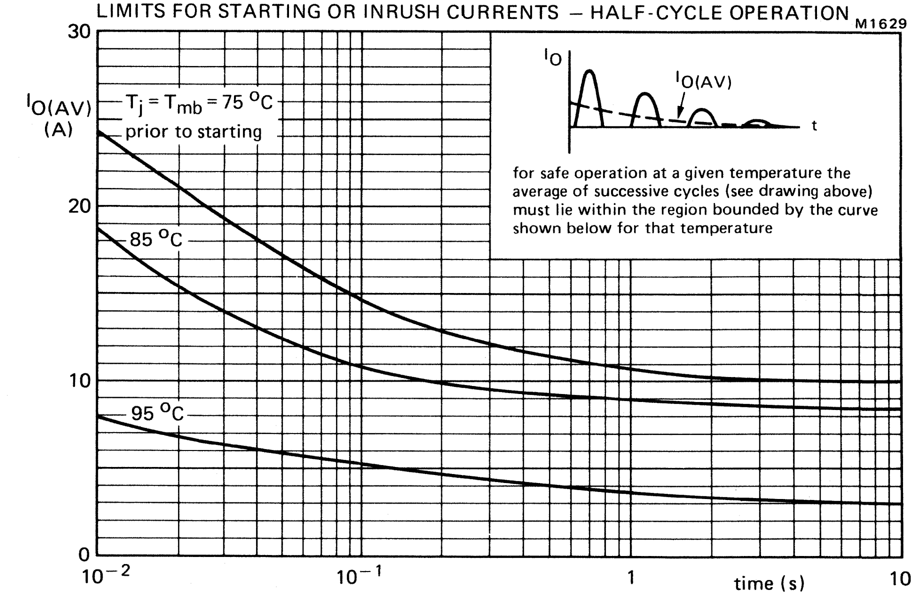


Fig.14 Normalised gate current that will trigger all devices; all conditions.


LIMITS FOR STARTING OR INRUSH CURRENTS — FULL-CYCLE OPERATION

for safe operation at a given temperature the r.m.s. of successive cycles (see drawing above) must lie within the region bounded by the curve shown below for that temperature

Fig.15


LIMITS FOR STARTING OR INRUSH CURRENTS — HALF-CYCLE OPERATION

for safe operation at a given temperature the average of successive cycles (see drawing above) must lie within the region bounded by the curve shown below for that temperature

Fig.16

TRIACS

Glass-passivated silicon triacs in metal envelopes, intended for industrial a.c. power control, and are 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 55 A. Two grades of commutation performance are available, 30 V/μs at 25 A/ms (suffix G) and 30 V/μs at 50 A/ms (suffix H).

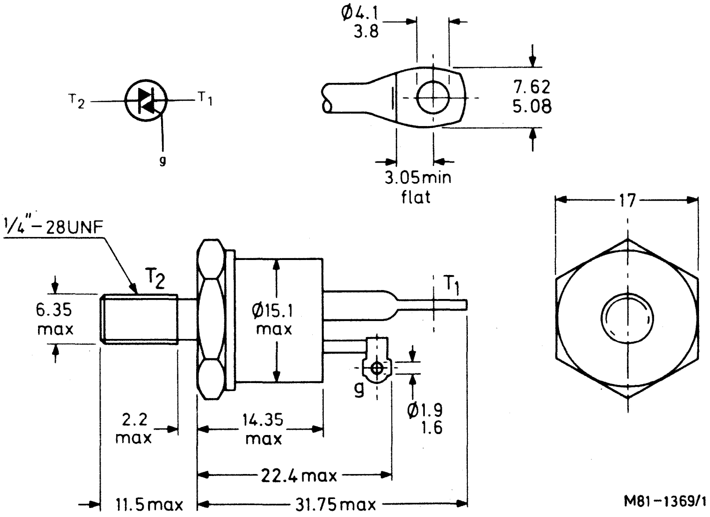
QUICK REFERENCE DATA

			BTV34–600	800	1200	1400	
Repetitive peak off-state voltage	V_{DRM}	max.	600	800	1200	1400	V
R.M.S. on-state current	$I_{T(RMS)}$	max.	55				A
Non-repetitive peak on-state current	I_{TSM}	max.	350				A
Rate of rise of commutating voltage that will not trigger any device (see Characteristics)	dV_{com}/dt	<	30				V/μs

MECHANICAL DATA

Dimensions in mm

Fig.1 TO–65



Net mass: 22 g
Diameter of clearance hole: max. 6.5 mm
Torque on nut: min. 1.7 Nm (17 kg cm)
max. 3.5 Nm (35 kg cm)

Supplied with device: 1 nut, 1 lock washer
Nut dimensions across the flats: 11.1 mm
Accessories supplied on request:
see ACCESSORIES section

RATINGS

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

Voltages (in either direction)*

			BTV34–600	800	1200	1400	
Non-repetitive peak off-state voltage ($t \leqslant 10$ ms)	V_{DSM}	max.	600	800	1200	1400	V**
Repetitive peak off-state voltage	V_{DRM}	max.	600	800	1200	1400	V
Crest working off-state voltage	V_{DWM}	max.	400	600	800	800	V

Currents (in either direction)

R.M.S. on-state current (conduction angle 360°) up to T_{mb} = 75 °C	$I_{T(RMS)}$	max.	55	A
at T_{mb} = 85 °C	$I_{T(RMS)}$	max.	45	A
Average on-state current for half-cycle operation (averaged over any 20 ms period) at T_{mb} = 85 °C	$I_{T(AV)}$	max.	21	A
Repetitive peak on-state current	I_{TRM}	max.	300	A
Non-repetitive peak on-state current T_j = 125 °C prior to surge; t = 20 ms; full sine-wave	I_{TSM}	max.	350	A
I^2t for fusing (t = 10 ms)	I^2t	max.	612	A^2s
Rate of rise of on-state current after triggering with I_G = 1 A to I_T = 100 A; dI_G/dt = 1 A/µs	dI_T/dt	max.	50	A/µs

Gate to terminal 1

Power dissipation

Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	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 full-cycle operation	$R_{th\ j\text{-}mb}$	=	0.6	°C/W
half-cycle operation	$R_{th\ j\text{-}mb}$	=	1.2	°C/W
From mounting base to heatsink with heatsink compound	$R_{th\ mb\text{-}h}$	=	0.2	°C/W
Transient thermal impedance; t = 1 ms	$Z_{th\ j\text{-}mb}$	=	0.08	°C/W

* To ensure thermal stability: $R_{th\ j\text{-}a} < 2$ °C/W (full-cycle or half-cycle operation). For smaller heatsinks $T_{j\ max}$ should be derated (see Figs.2 and 3).

** Although not recommended, higher off-state voltages 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 20 A/µs.

CHARACTERISTICS

Polarities, positive or negative, are identified with respect to T_1.

Voltages (in either direction)

On-state voltage I_T = 65 A; T_j = 25 °C	V_T	<	2.1	V*
Rate of rise of off-state voltage that will not trigger any device; exponential method; V_D = 2/3 $V_{DRM\,max}$; T_j = 125 °C	dV_D/dt	<	200	V/μs

Rate of rise of commutating voltage that will not trigger any device; $I_{T(RMS)}$ = 45 A; V_D = $V_{DWM\,max}$; T_{mb} = 85 °C

	dV_{com}/dt (V/μs)	$-dI_T/dt$ (A/ms)
BTV34–600G to 1400G	< 30	25
BTV34–600H to 1400H	< 30	50

Currents (in either direction)

Off-state current V_D = $V_{DWM\,max}$; T_j = 125 °C	I_D	<	10	mA

Latching current; T_j = 25 °C		T_2 pos.	T_2 neg.	
G positive	I_L	< 300	–	mA
G negative	I_L	< 750	300	mA
Holding current; T_j = 25 °C G positive or negative	I_H	< 200	200	mA
Gate to terminal 1				
Voltage and current that will trigger all devices V_D = 12 V; T_j = 25 °C				
G positive	V_{GT}	> 2.5	–	V
	I_{GT}	> 200	–	mA
G negative	$-V_{GT}$	> 2.5	2.5	V
	$-I_{GT}$	> 200	200	mA
Voltage that will not trigger any device V_D = $V_{DRM\,max}$; T_j = 125 °C; G positive or negative	V_{GD}	< 0.2	0.2	V

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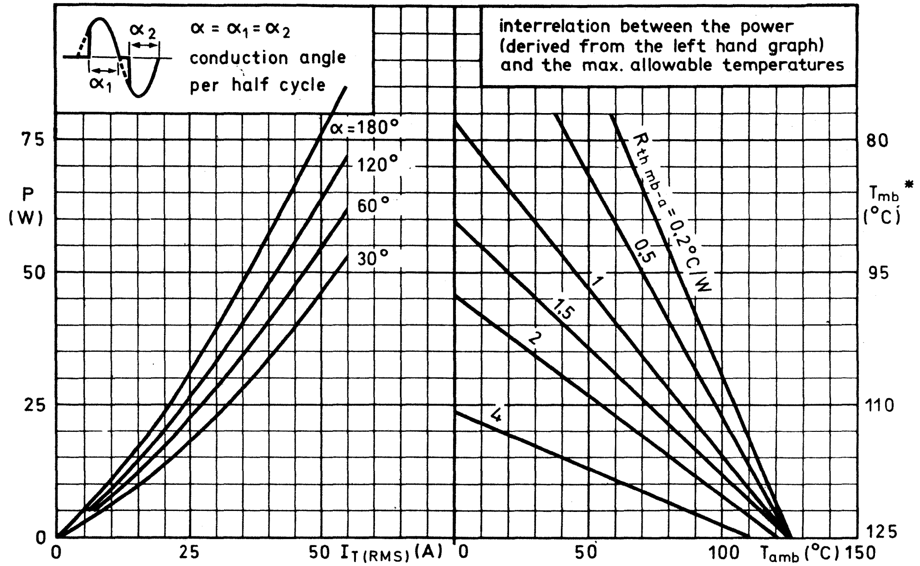
*Measured under pulse conditions to avoid excessive dissipation

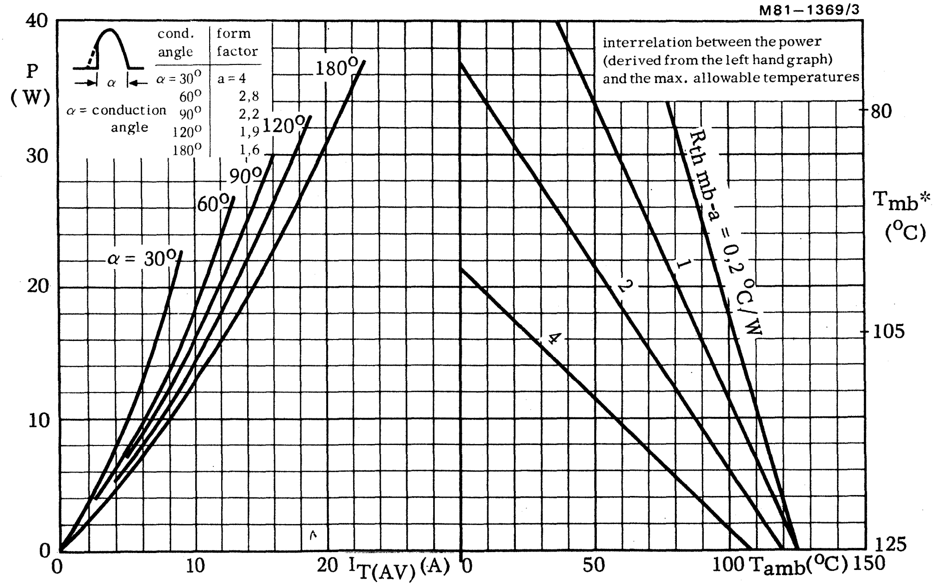
FULL-CYCLE OPERATION



* T_{mb}-scale is for comparison purposes only and is correct only for $R_{th\ mb\text{-}a} \leqslant 1.4$ °C/W

Fig.2

HALF-CYCLE OPERATION



*T_{mb}-scale is for comparison purposes only and is correct only for $R_{th\ mb\text{-}a} \leqslant 0.8$ °C/W

Fig.3

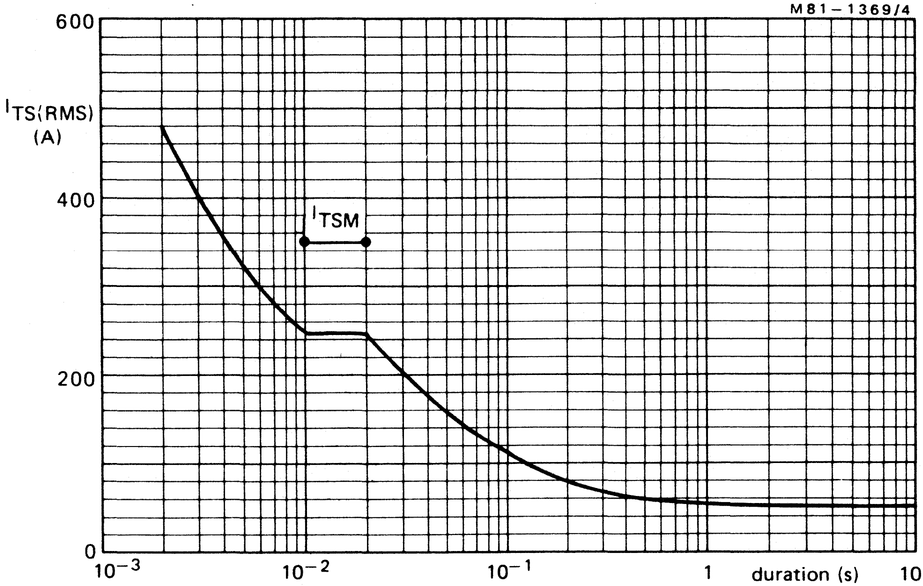
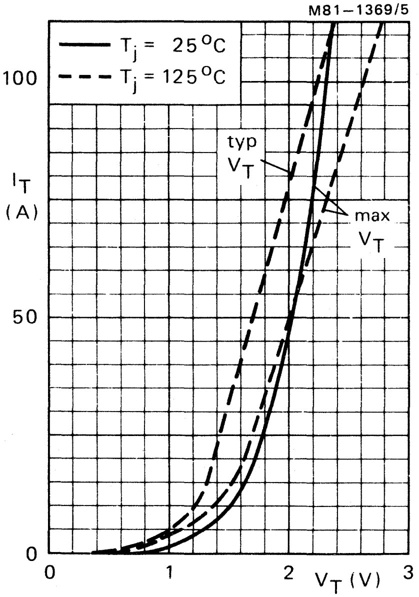


Fig.4 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents (f = 50 Hz); T_j = 125 °C prior to surge. The triac may temporarily lose control following the surge.



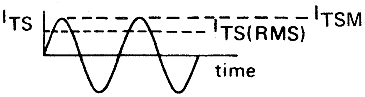


Fig.5

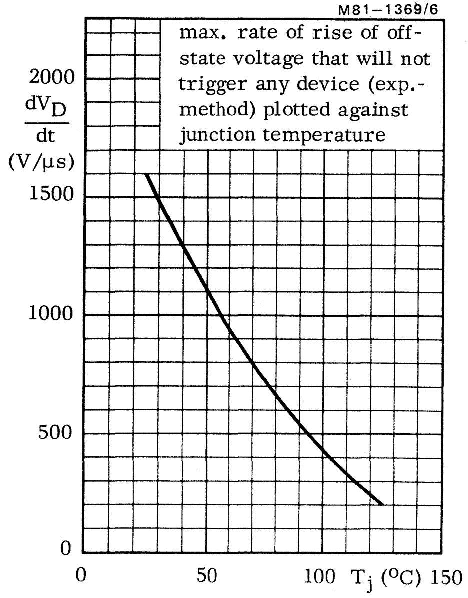


Fig.6

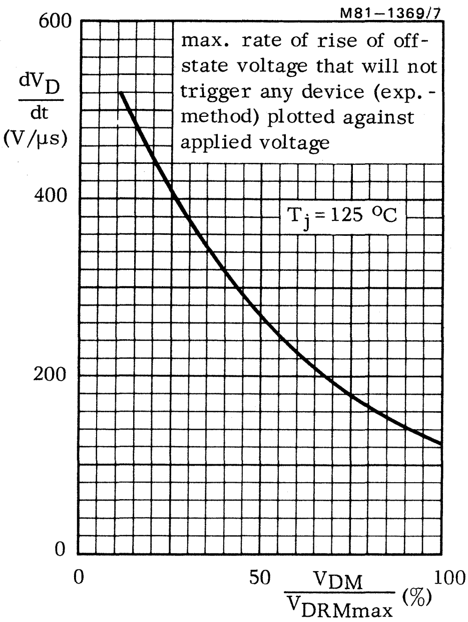


Fig.7

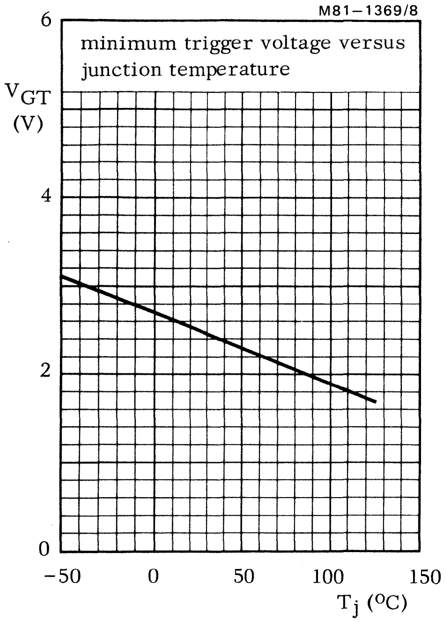


Fig.8

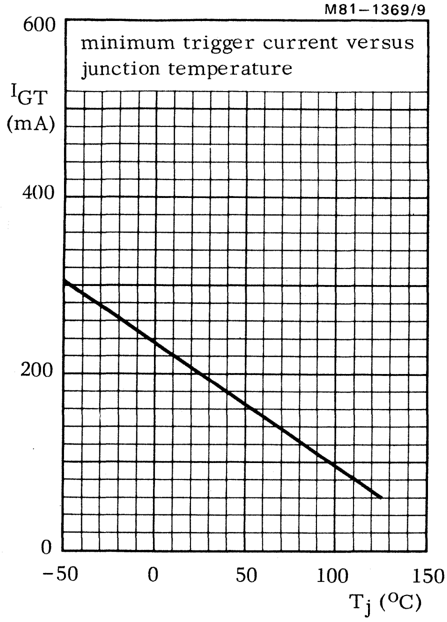
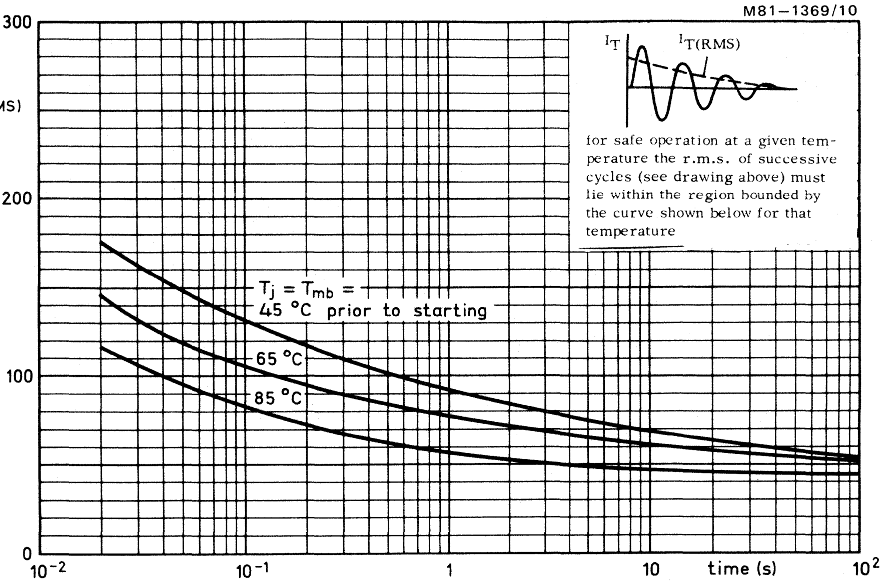


Fig.9

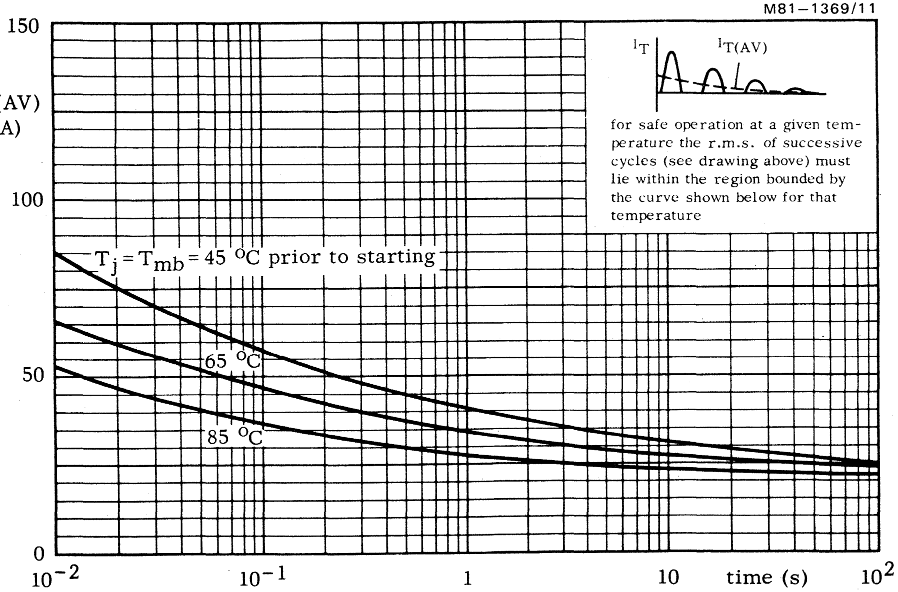
FULL-CYCLE OPERATION



for safe operation at a given temperature the r.m.s. of successive cycles (see drawing above) must lie within the region bounded by the curve shown below for that temperature

Fig.10

HALF-CYCLE OPERATION



for safe operation at a given temperature the r.m.s. of successive cycles (see drawing above) must lie within the region bounded by the curve shown below for that temperature

Fig.11

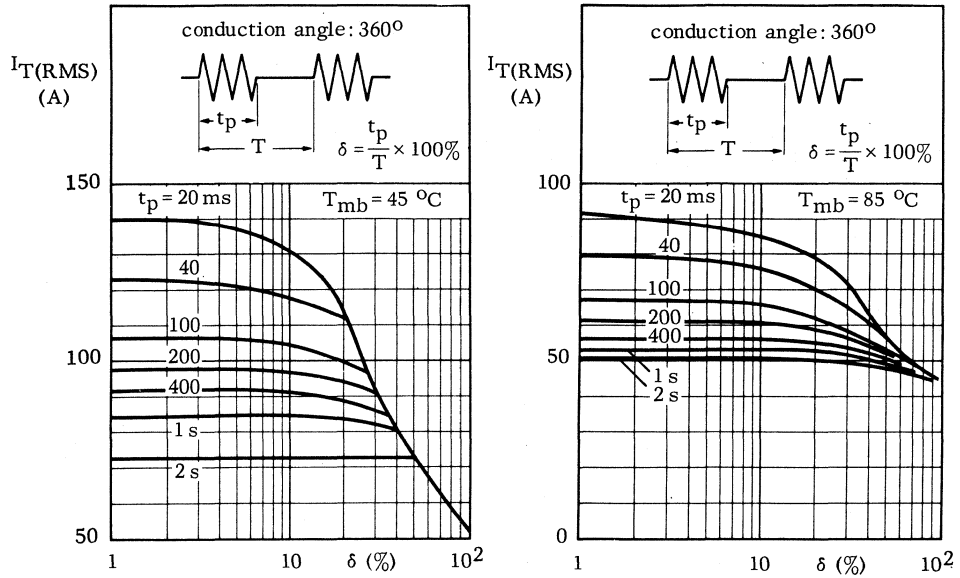


Fig.12 Intermittent overload capability of one triac in a single-phase a.c. control circuit.

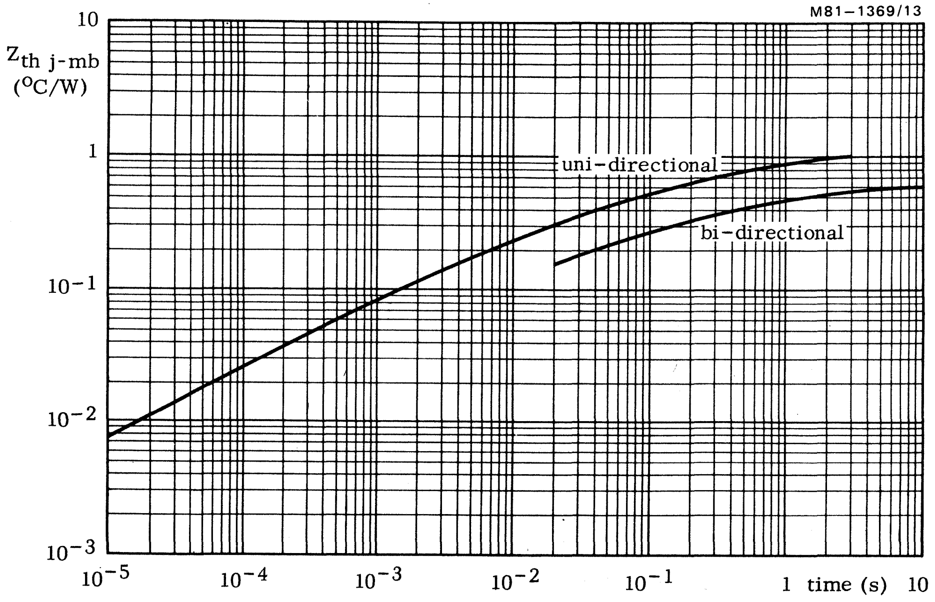


Fig.13

TRIACS

Also available to BS9343-F001

Silicon triacs in metal envelopes, intended for industrial a.c. power control and are 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

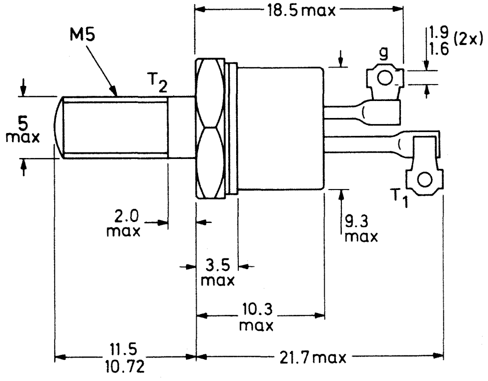
			BTW43–600	800	1000	1200	
Repetitive peak off-state voltage	V_{DRM}	max.	600	800	1000	1200	V

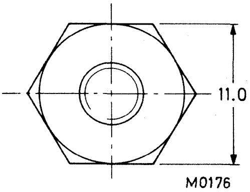
R.M.S. on-state current	$I_{T(RMS)}$	max.	15	A
Non-repetitive peak on-state current	I_{TSM}	max.	120	A
Rate of rise of commutating voltage that will not trigger any device (see Characteristics)	dV_{com}/dt	<	10	V/μs

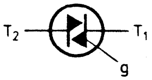
MECHANICAL DATA

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:
see ACCESSORIES section

Torque on nut: min. 0,9 Nm
(9 kg cm)
max. 1,7 Nm
(17 kg cm)

Supplied with the device: 1 nut, 1 lock washer
Nut dimensions across the flats: 8,0 mm

RATINGS

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

Voltages (in either direction)*

			BTW43–600	800	1000	1200	
Non-repetitive peak off-state voltage (t ⩽ 10 ms)	V_{DSM}	max.	600	800	1000	1200	V
Repetitive peak off-state voltage	V_{DRM}	max.	600	800	1000	1200	V
Crest working off-state voltage	V_{DWM}	max.	400	600	700	800	V

Currents (in either direction)

R.M.S. on-state current (conduction angle 360°)				
up to T_{mb} = 75 °C	$I_{T(RMS)}$	max.	15	A
at T_{mb} = 85 °C	$I_{T(RMS)}$	max.	12	A
Average on-state current for half-cycle operation (averaged over any 20 ms period)				
up to T_{mb} = 35 °C	$I_{T(AV)}$	max.	9,5	A
at T_{mb} = 85 °C	$I_{T(AV)}$	max.	5,5	A
Repetitive peak on-state current	I_{TRM}	max.	50	A
Non-repetitive peak on-state current T_j = 125 °C prior to surge; t = 20 ms; full sine-wave	I_{TSM}	max.	120	A
I^2t for fusing (t = 10 ms)	I^2t	max.	72	A^2s
Rate of rise of on-state current after triggering with I_G = 0,5 A to I_T = 25 A; dI_G/dt = 0,5 A/μs	dI_T/dt	max.	50	A/μs

Gate to terminal 1

Power dissipation

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

Temperatures

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

THERMAL RESISTANCE

From junction to mounting base				
full-cycle operation	$R_{th\ j\text{-}mb}$	=	2,0	°C/W
half-cycle operation	$R_{th\ j\text{-}mb}$	=	4,0	°C/W
From mounting base to heatsink with heatsink compound	$R_{th\ mb\text{-}h}$	=	0,5	°C/W
Transient thermal impedance; t = 1 ms	$Z_{th\ j\text{-}mb}$	=	0,2	°C/W

---

* To ensure thermal stability: $R_{th\ j\text{-}a} < 6$ °C/W (full-cycle or half-cycle operation). For smaller heatsinks $T_{j\ max}$ should be derated (see Figs 2 and 3).

CHARACTERISTICS

Polarities positive or negative, are identified with respect to T_1.

Voltages (in either direction)

On-state voltage $I_T = 20$ A; $T_j = 25$ °C	V_T	$<$	2,2 V*
Rate of rise of off-state voltage that will not trigger any device; exponential method; $V_D = 2/3\ V_{DRMmax}$; $T_j = 125$ °C	dV_D/dt	$<$	200 V/µs

Rate of rise of commutating voltage that will not trigger any device;
$I_{T(RMS)} = 12$ A; $V_D = V_{DWMmax}$; $T_{mb} = 85$ °C

	dV_{com}/dt (V/µs)	$-dI_T/dt$ (A/ms)
BTW43-600G to 1200G	< 10	5
BTW43-600H to 1200H	< 10	12

Currents (in either direction)

Off-state current $V_D = V_{DWMmax}$; $T_j = 125$ °C	I_D	$<$	5 mA

		T_2 pos.	T_2 neg.
Latching current; $T_j = 25$ °C			
G positive	I_L	< 200	200 mA
G negative	I_L	< 200	200 mA
Holding current; $T_j = 25$ °C			
G positive or negative	I_H	< 100	100 mA
Gate to terminal 1			
Voltage and current that will trigger all devices $V_D = 12$ V; $T_j = 25$ °C			
G positive	V_{GT}	$> 2,5$	5,0 V
	I_{GT}	> 100	200 mA
G negative	$-V_{GT}$	$> 2,5$	2,5 V
	$-I_{GT}$	> 100	100 mA
Voltage that will not trigger any device $V_D = V_{DRMmax}$; $T_j = 125$ °C; G positive or negative	V_{GD}	$< 0,2$	0,2 V

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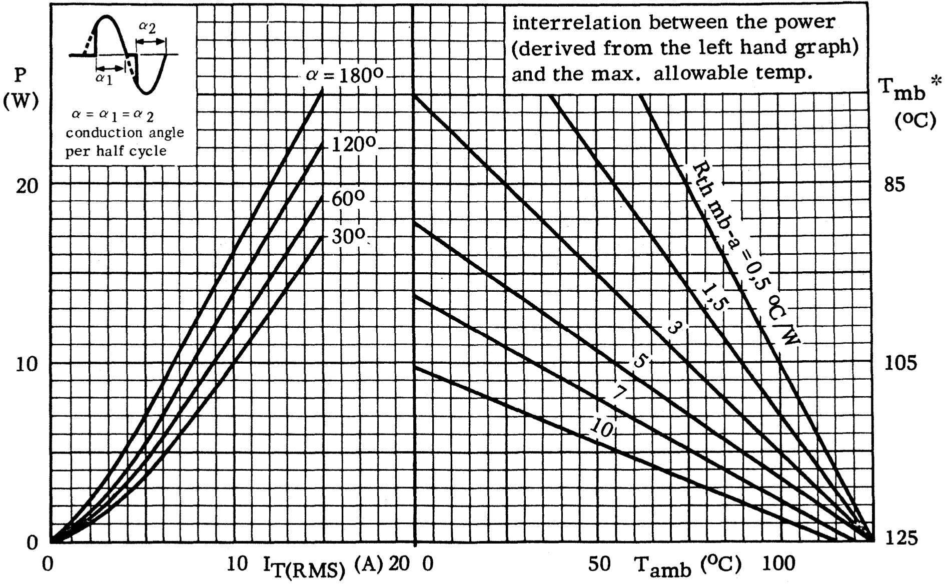
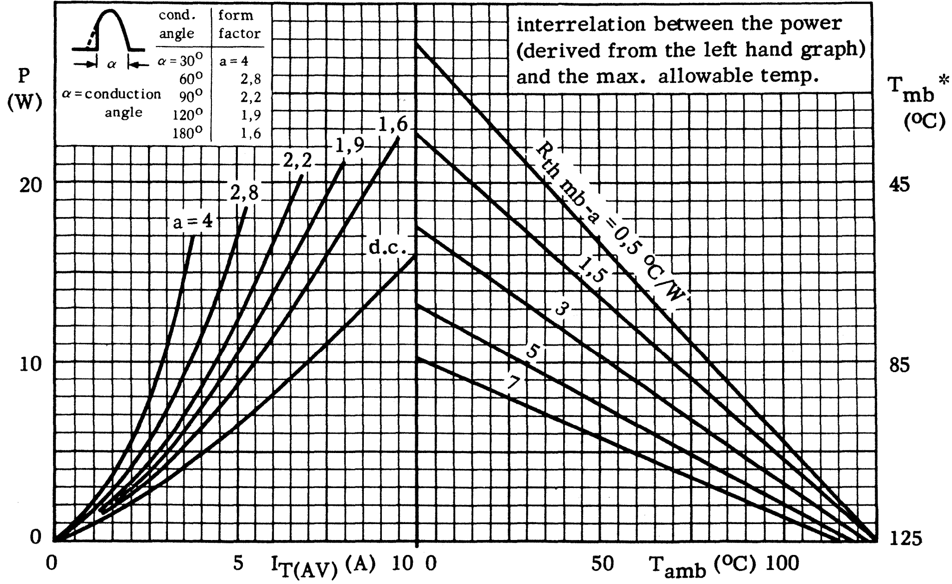
* Measured under pulse conditions to avoid excessive dissipation.

Fig. 2 . FULL CYCLE OPERATION



* T_{mb}-scale is for comparison purposes only and is correct only for $R_{th\ mb\text{-}a} \leqslant 4$ °C/W.

Fig. 3. HALF-CYCLE OPERATION



* T_{mb}-scale is for comparison purposes only and is correct only for $R_{th\ mb\text{-}a} \leqslant 2$ °C/W.

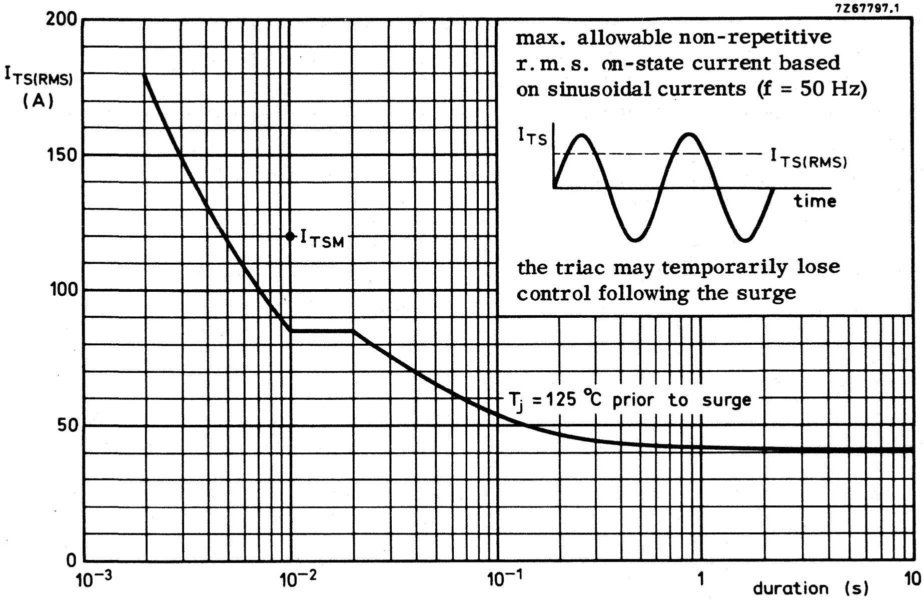

7Z67797.1
$I_{TS(RMS)}$ (A)
200
150
100
50
0
10^{-3}
10^{-2}
10^{-1}
1
10
duration (s)
I_{TSM}
max. allowable non-repetitive r.m.s. on-state current based on sinusoidal currents (f = 50 Hz)
I_{TS}
$I_{TS(RMS)}$
time
the triac may temporarily lose control following the surge
T_j = 125 °C prior to surge

Fig. 4.

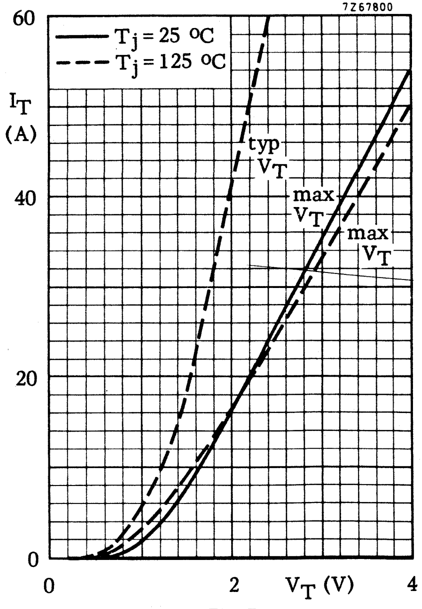

7Z67800
T_j = 25 °C
T_j = 125 °C
I_T (A)
60
40
20
0
2
4
V_T (V)
typ V_T
max V_T
max V_T

Fig. 5.

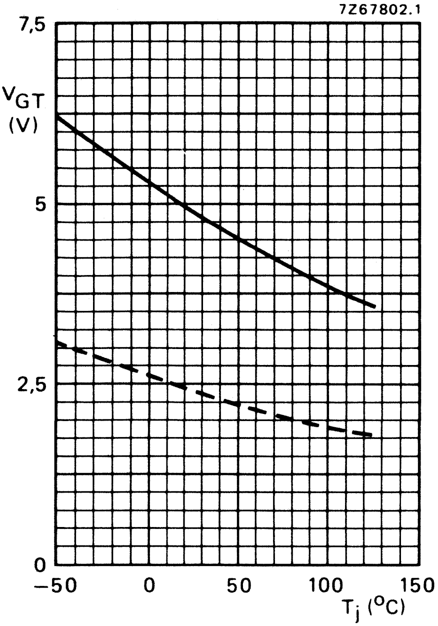


Fig. 6 Minimum gate voltage that will trigger all devices as a function of T_j.

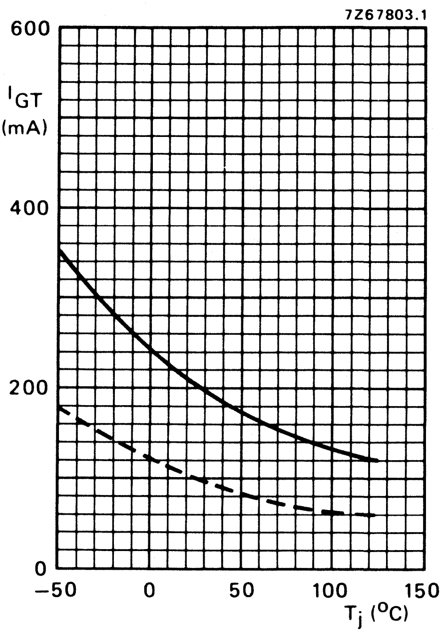


Fig. 7 Minimum gate current that will trigger all devices as a function of T_j.

Conditions for Figs 6 and 7:

——— T_2 negative, gate positive with respect to T_1
– – – – all other conditions

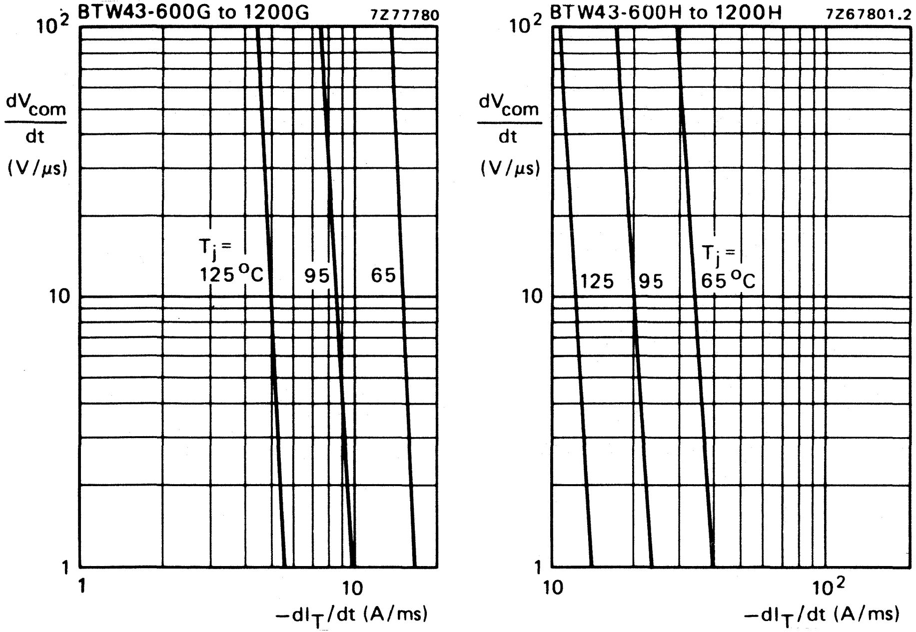


Fig. 8 Maximum rate of rise of commutating voltage that will not trigger any device as a function of rate of fall of on-state current; $I_{T(RMS)}$ = 12 A; $V_D = V_{DWMmax}$.

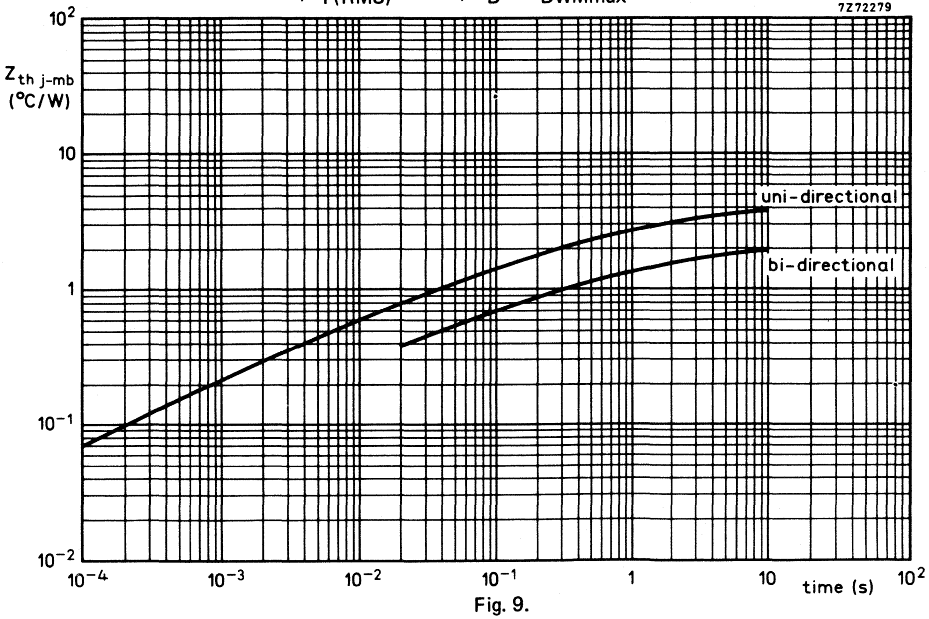
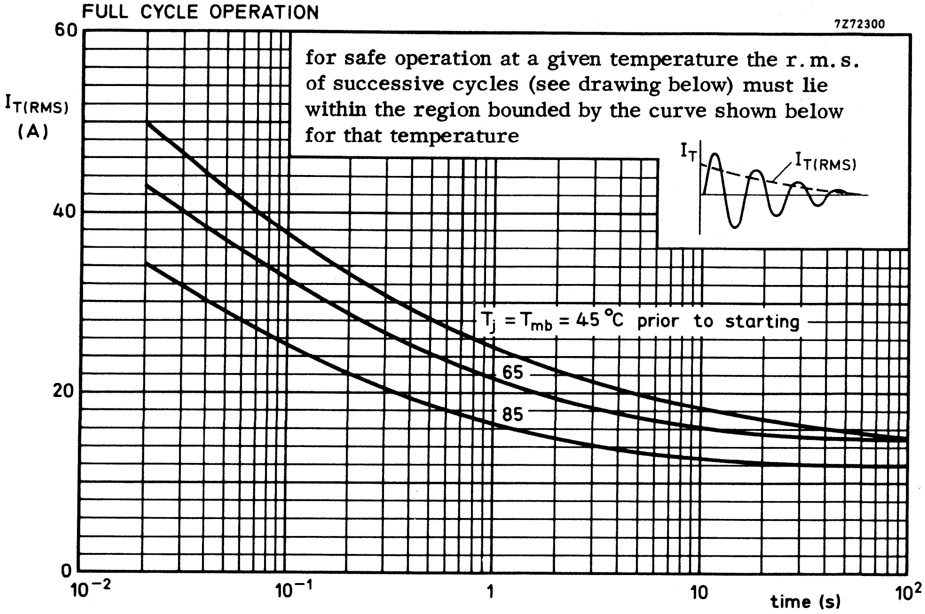


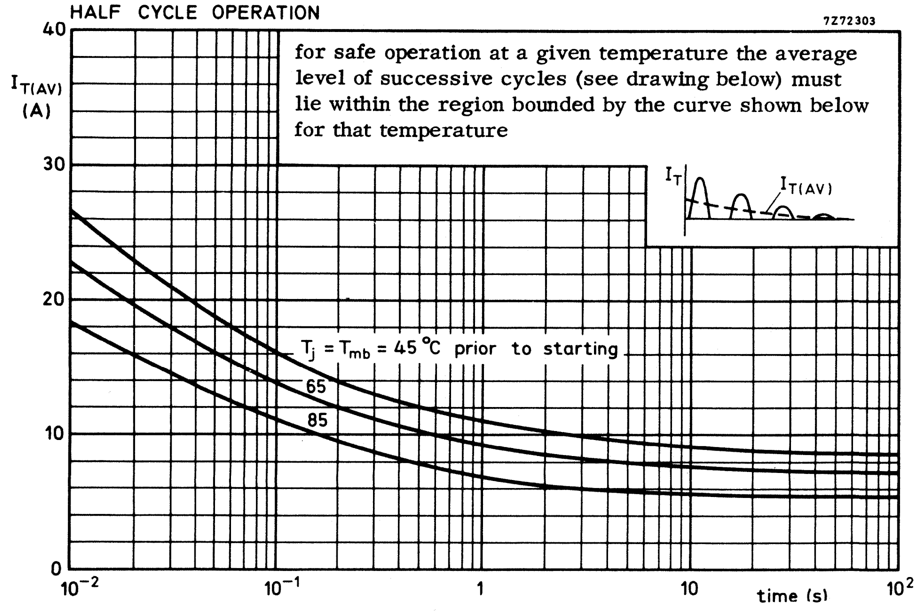
Fig. 9.



FULL CYCLE OPERATION

for safe operation at a given temperature the r.m.s. of successive cycles (see drawing below) must lie within the region bounded by the curve shown below for that temperature

Fig. 10.



HALF CYCLE OPERATION

for safe operation at a given temperature the average level of successive cycles (see drawing below) must lie within the region bounded by the curve shown below for that temperature

Fig. 11.

TRIACS

Glass-passivated silicon triacs in metal envelopes, intended for industrial single-phase and three-phase inductive load applications such as regenerative motor control systems. They are also suitable for furnace temperature control and static switching systems.
Two grades of commutation performance are available, 30 V/μs at 25 A/ms (suffix H) and 30 V/μs at 50 A/ms (suffix J).

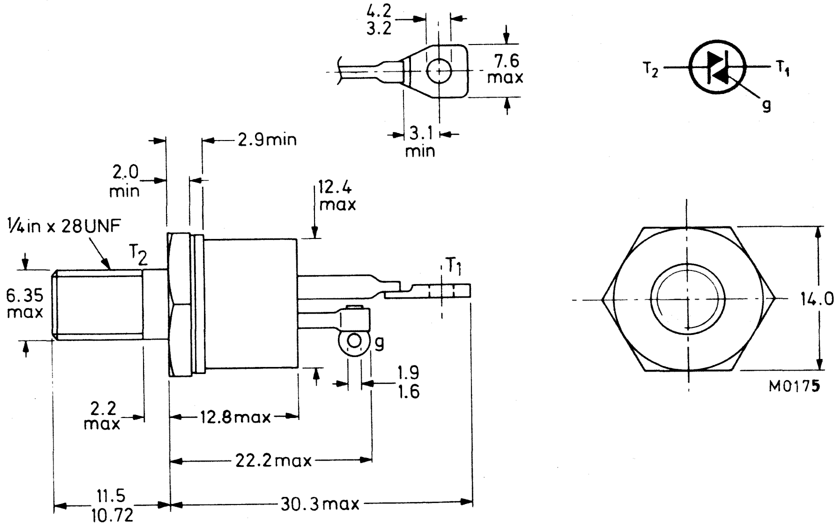
QUICK REFERENCE DATA

			BTX94-400	600	800	1000	1200	
Repetitive peak off-state voltage	V_{DRM}	max.	400	600	800	1000	1200	V
R.M.S. on-state current	$I_{T(RMS)}$	max.	25					A
Non-repetitive peak on-state current	I_{TSM}	max.	250					A
Rate of rise of commutating voltage that will not trigger any device (see Characteristics)	dV_{com}/dt	$<$	30					V/μs

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-48.



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

Voltages (in either direction) *

			BTX94-400	600	800	1000	1200	
Non-repetitive peak off-state voltage ($t \leqslant 10$ ms)	V_{DSM}	max.	400	600	800	1000	1200	V **
Repetitive peak off-state voltage	V_{DRM}	max.	400	600	800	1000	1200	V
Crest working off-state voltage	V_{DWM}	max.	200	400	600	700	800	V

Currents (in either direction)

R.M.S. on-state current (conduction angle 360°) at $T_{mb} = 85$ °C	$I_{T(RMS)}$	max.	25	A
Repetitive peak on-state current	I_{TRM}	max.	100	A
Non-repetitive peak on-state current $T_j = 125$ °C prior to surge; $t = 20$ ms; full sine-wave	I_{TSM}	max.	250	A
I^2t for fusing ($t = 10$ ms)	I^2t	max.	320	A^2s
Rate of rise of on-state current after triggering with $I_G = 750$ mA to $I_T = 100$ A	dI_T/dt	max.	50	A/µs

Gate to terminal 1

Power dissipation

Average power dissipation (averaged over any 20 ms period)	$P_{G(AV)}$	max.	1	W
Peak power dissipation	P_{GM}	max.	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 full-cycle operation	$R_{th\ j\text{-}mb}$	=	1,0	°C/W
half-cycle operation	$R_{th\ j\text{-}mb}$	=	2,0	°C/W
From mounting base to heatsink with heatsink compound	$R_{th\ mb\text{-}h}$	=	0,2	°C/W
Transient thermal impedance; $t = 1$ ms	$Z_{th\ j\text{-}mb}$	=	0,12	°C/W

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* To ensure thermal stability: $R_{th\ j\text{-}a} < 3{,}5$ °C/W (full-cycle or half-cycle operation). For smaller heatsinks $T_{j\ max}$ should be derated (see Figs 2 and 3).

** Although not recommended, higher off-state voltages 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 50 A/µs.

CHARACTERISTICS

Polarities, positive or negative, are identified with respect to T_1.

Voltages (in either direction)

On-state voltage
$I_T = 50$ A; $T_j = 25$ °C V_T < 2 V *

Rate of rise of off-state voltage that will not trigger any device; exponential method;
$V_D = 2/3\ V_{DRMmax}$; $T_j = 125$ °C dV_D/dt < 100 V/µs

Rate of rise of commutating voltage that will not trigger any device;
$I_{T(RMS)} = 25$ A; $V_D = V_{DWMmax}$; $T_{mb} = 85$ °C

	dV_{com}/dt (V/µs)	$-dI_T/dt$ (A/ms)
BTX94-400H to 1200H	< 30	25
BTX94-400J to 1200J	< 30	50

Currents (in either direction)

Off-state current
$V_D = V_{DWMmax}$; $T_j = 125$ °C I_D < 5 mA

Latching current; $T_j = 25$ °C

		T_2 pos.	T_2 neg.
G positive	I_L	< 150	150 mA
G negative	I_L	< 350	150 mA

Gate to terminal 1

Voltage and current that will trigger all devices
$V_D = 12$ V; $T_j = 25$ °C

		T_2 pos.	T_2 neg.
G positive	V_{GT}	> 3,0	5,0 V
	I_{GT}	> 150	200 mA
G negative	$-V_{GT}$	> 3,0	3,0 V
	$-I_{GT}$	> 150	150 mA

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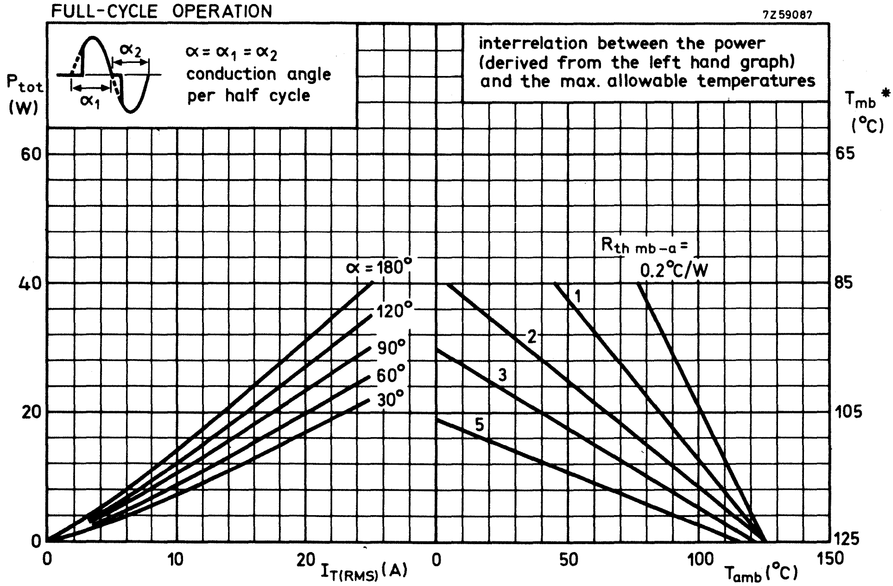
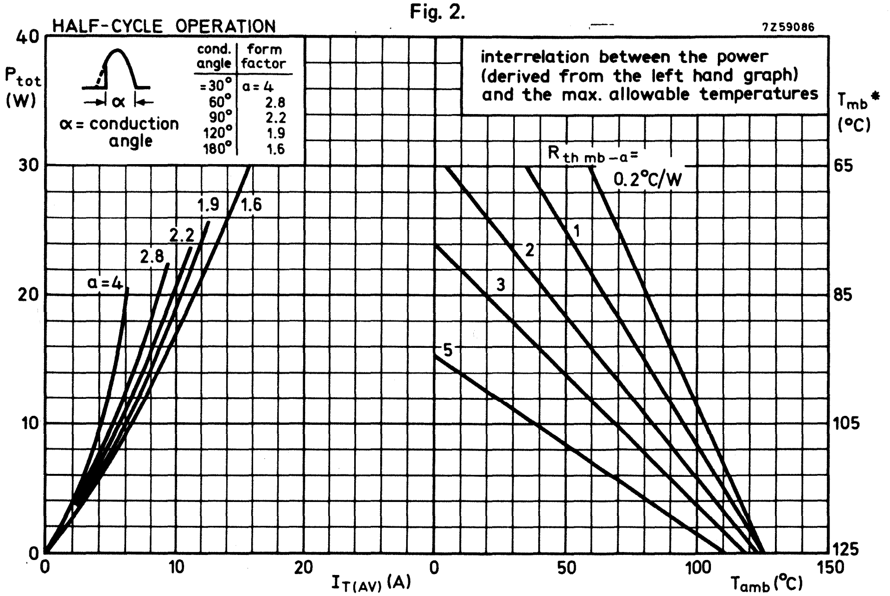
* Measured under pulse conditions to avoid excessive dissipation.



* T_{mb} – scale is for comparison purposes only and is correct only for $R_{th\ mb-a} \leq 2.5\ °C/W$

Fig. 2.



* T_{mb} – scale is for comparison purposes only and is correct only for $R_{th\ mb-a} \leq 1.5\ °C/W$

Fig. 3.

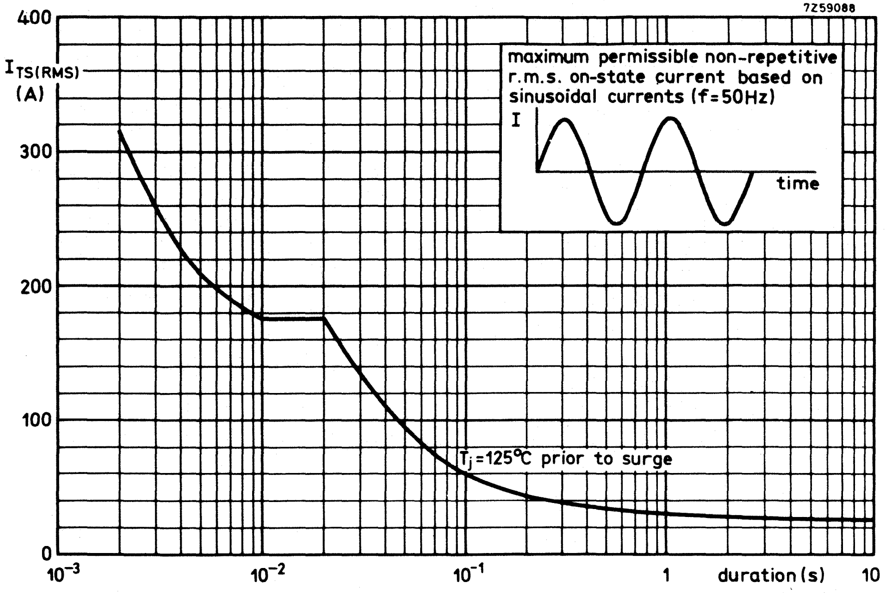

7Z59088
400
$I_{TS(RMS)}$ (A)
300
200
100
0
10^{-3}
10^{-2}
10^{-1}
1
duration (s)
10
maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents (f=50Hz)
I
time
T_j=125°C prior to surge

Fig. 4.

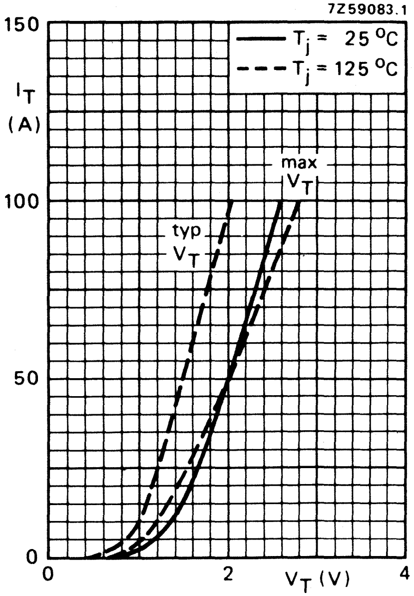

7Z59083.1
150
I_T (A)
100
50
0
0
2
V_T (V)
4
T_j = 25 °C
T_j = 125 °C
typ V_T
max V_T

Fig. 5.

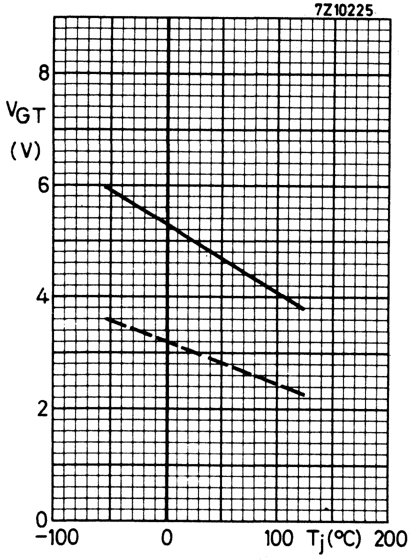


Fig. 6 Minimum gate voltage that will trigger all devices as a function of T_j.

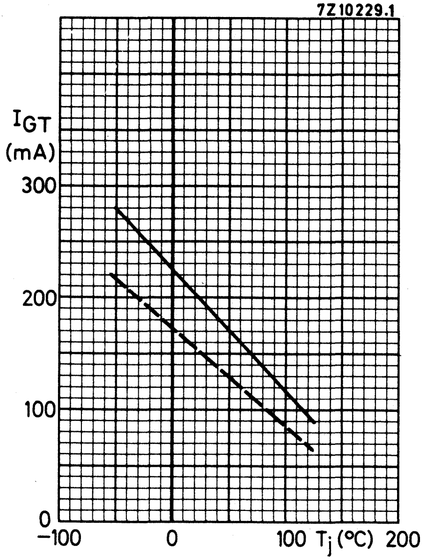
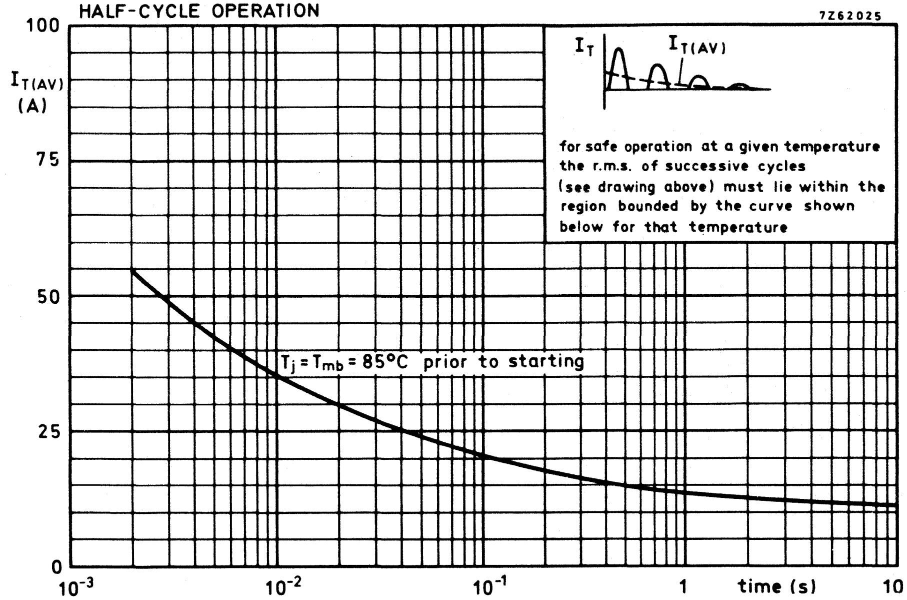


Fig. 7 Minimum gate current that will trigger all devices as a function of T_j.

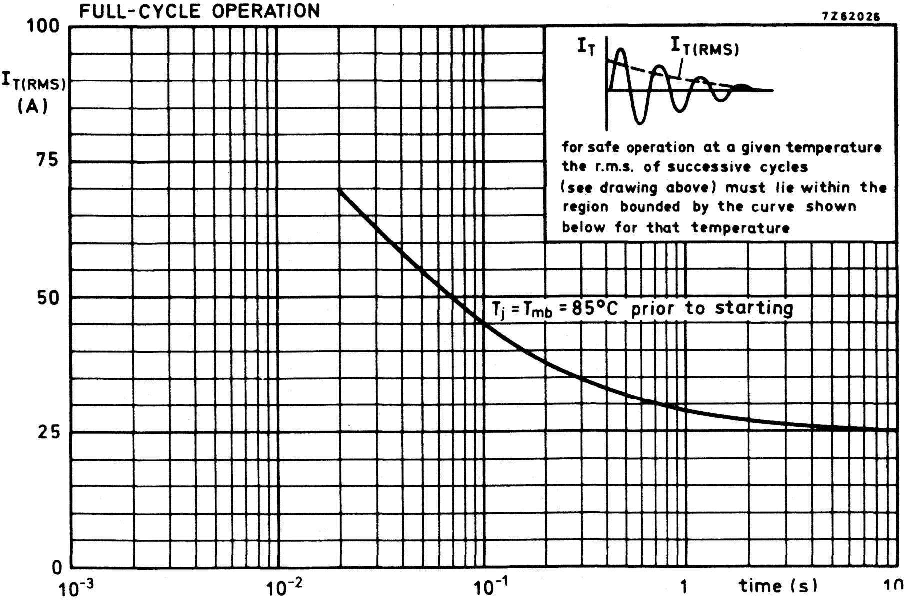
Conditions for Figs 6 and 7:

——— T_2 negative, gate positive with respect to T_1
– – – all other conditions



for safe operation at a given temperature the r.m.s. of successive cycles (see drawing above) must lie within the region bounded by the curve shown below for that temperature

Fig. 8.



for safe operation at a given temperature the r.m.s. of successive cycles (see drawing above) must lie within the region bounded by the curve shown below for that temperature

Fig. 9.

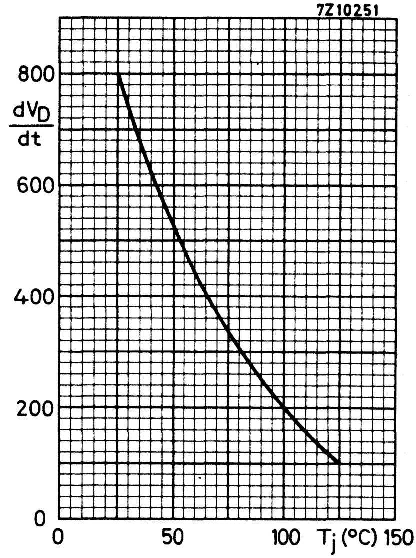


Fig. 10 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of T_j.

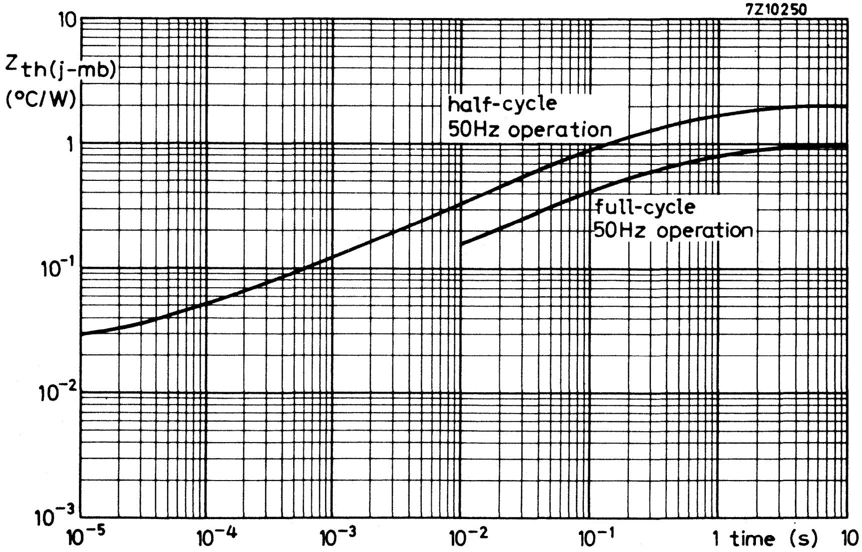


Fig. 11.

ACCESSORIES

TYPE NUMBER SUMMARY

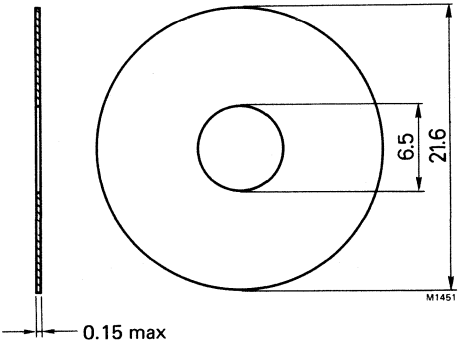
type number	description	envelope
56264a	mica washer (up to 2000 V)	DO-5, TO-48, TO-65
56264b	insulating bush	DO-5, TO-48, TO-65
56295a	mica washer (up to 2000 V)	DO-4, TO-64
56295b	PTFE ring	DO-4, TO-64
56295c	insulating bush	DO-4, TO-64
56359b	mica washer (up to 1000 V)	TO-220
56359c	insulating bush (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
56364	spring clip (insulated mounting)	TO-220
56367	alumina insulator (up to 2000 V)	TO-220
56368a	mica insulator (up to 800 V)	SOT-93
56368b	insulating bush (up to 800 V)	SOT-93
56369	mica insulator (up to 2000 V)	TO-220
56378	mica insulator (up to 1500 V)	SOT-93
56379	spring clip	SOT-93, SOT-112

56264a MICA WASHER

Insulator up to 2000 V

MECHANICAL DATA

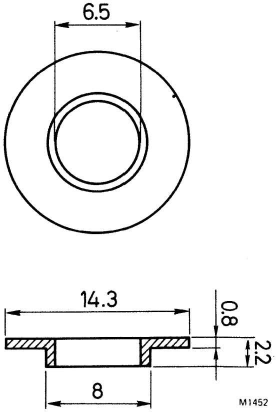
Dimensions in mm



56264b INSULATING BUSH

MECHANICAL DATA

Dimensions in mm



THERMAL RESISTANCE

From mounting base to heatsink
with mica washer, without heatsink compound $R_{th\ mb\text{-}h}$ = 5 K/W
with mica washer, with heatsink compound $R_{th\ mb\text{-}h}$ = 2.5 K/W

TEMPERATURE

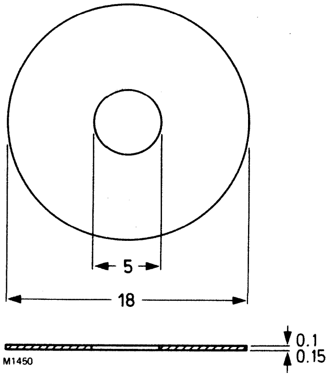
Maximum allowable temperature T_{max} = 175 °C

56295a MICA WASHER

Insulator up to 2 kV.

MECHANICAL DATA

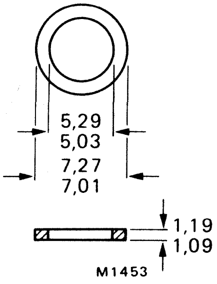
Dimensions in mm



56295b PTFE RING

MECHANICAL DATA

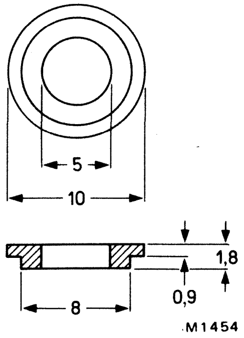
Dimensions in mm



56295c INSULATING BUSH

MECHANICAL DATA

Dimensions in mm



THERMAL RESISTANCE

From mounting base to heatsink				
without heatsink compound	$R_{th\ mb\text{-}h}$	=	5	K/W
with heatsink compound	$R_{th\ mb\text{-}h}$	=	2.5	K/W

TEMPERATURE

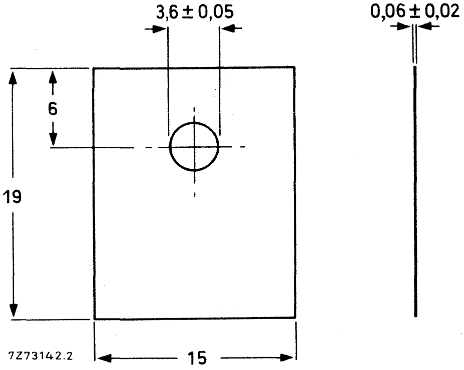
Maximum allowable temperature	T_{max}	=	175	°C

56359b MICA WASHER

Insulator up to 1000 V.

MECHANICAL DATA

Dimensions in mm



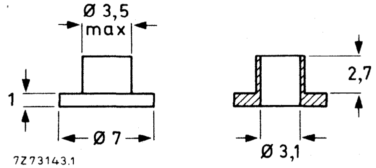
56359c INSULATING BUSH

Insulator up to 800 V.

MECHANICAL DATA

Material: polyester

Dimensions in mm



TEMPERATURE

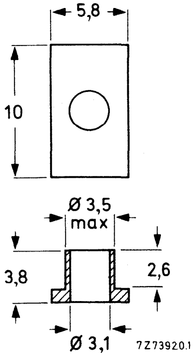
Maximum pemissible temperature T_{max} = 150 °C

56359d RECTANGULAR INSULATING BUSH

Insulator up to 1000 V.

MECHANICAL DATA

Dimensions in mm



TEMPERATURE

Maximum permissible temperature T_{max} = 150 °C

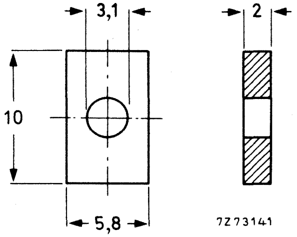
56360a RECTANGULAR WASHER

For direct and insulated mounting.

MECHANICAL DATA

Material: brass; nickel plated.

Dimensions in mm



56363 SPRING CLIP

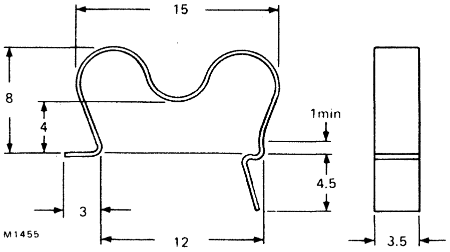
For direct mounting.

MECHANICAL DATA

Dimensions in mm

Material: stainless steel; for mounting on heatsink of 1.0 to 2.0 mm.

Recommended force of clip on device is 20 N (2 kgf).



56364 SPRING CLIP

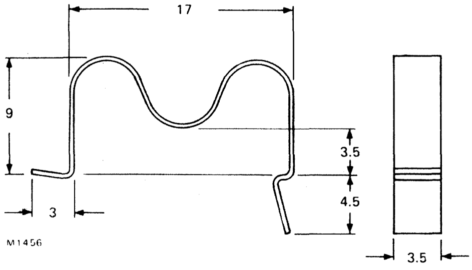
For insulated mounting.

MECHANICAL DATA

Dimensions in mm

Material: stainless steel; for mounting on heatsink of 1.0 to 1.5 mm.

Recommended force of clip on device is 20 N (2 kgf).



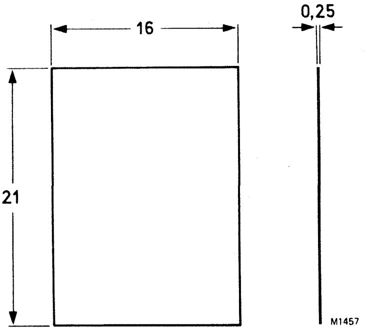
To be used in conjunction with insulators **56367** or **56369**

56367 ALUMINA INSULATOR

For insulated clip mounting up to 2 kV.

MECHANICAL DATA Dimensions in mm

Material: 96-alumina.

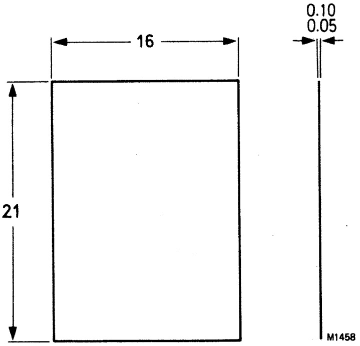


*Because alumina is brittle, extreme care must be taken when mounting devices not to crack the alumina, particularly when used without heatsink compound.

56369 MICA INSULATOR

For insulated clip mounting up to 2 kV.

MECHANICAL DATA Dimensions in mm



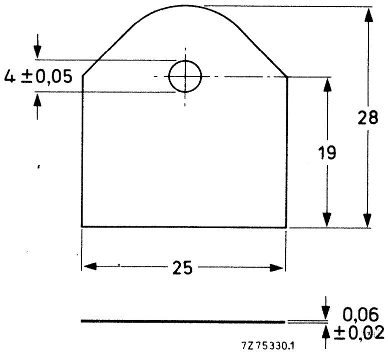
56368a

MICA INSULATOR

For insulated screw mounting up to 800 V.

MECHANICAL DATA

Dimensions in mm



56368b

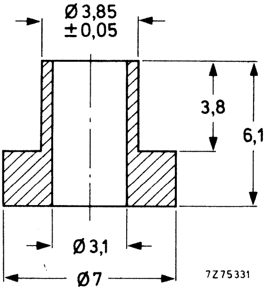
INSULATING BUSH

For insulated screw mounting up to 800 V.

MECHANICAL DATA

Dimensions in mm

Material: polyester



TEMPERATURE

Maximum permissible temperature T_{max} = 150 °C

56369: see preceding page.

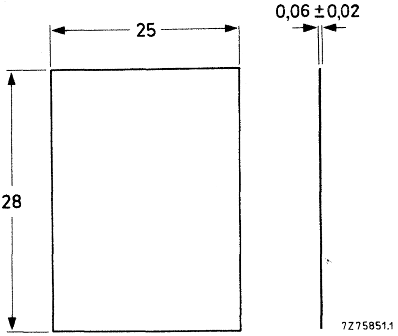
56378

MICA INSULATOR

For clip mounting up to 1500 V.

MECHANICAL DATA

Dimensions in mm



56379

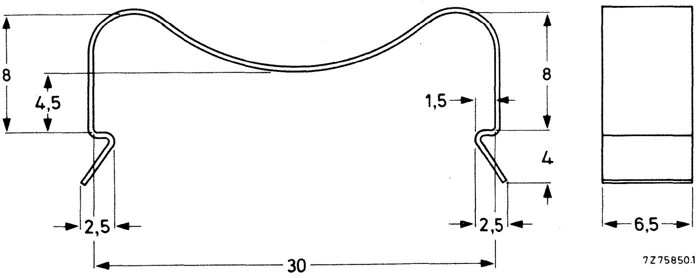
SPRING CLIP

For direct and insulated mounting of SOT-93 and SOT-112 envelopes.

MECHANICAL DATA

Dimensions in mm

Material:
CrNi steel NLN-939;
thickness 0.4 ± 0.04.



MOUNTING INSTRUCTIONS

MOUNTING INSTRUCTIONS FOR TO-220 ENVELOPES

GENERAL DATA AND INSTRUCTIONS

General rules

1. First fasten the device to the heatsink before soldering the leads.
2. Avoid axial stress to the leads.
3. Keep mounting tool (e.g. screwdriver) clear of the plastic body.
4. The rectangular washer may only touch the plastic part of the body; it should not exert any force on that part (screw mounting).

Heatsink requirements

Flatness in the mounting area: 0,02 mm maximum per 10 mm.
Mounting holes must be deburred, see further mounting instructions.

Heatsink compound

Values of the thermal resistance from mounting base to heatsink ($R_{th\ mb\text{-}h}$) given for mounting with heatsink compound refer to the use of a metallic oxide-loaded compound. Ordinary silicone grease is not recommended.

For insulated mounting, the compound should be applied to the bottom of both device and insulator.

Mounting methods for power devices

1. Clip mounting

   Mounting with a spring clip gives:

   a. A good thermal contact under the crystal area, and slightly lower $R_{th\ mb\text{-}h}$ values than screw mounting.
   b. Safe insulation for mains operation.

2. M3 screw mounting

   It is recommended that the rectangular spacing washer is inserted between screw head and mounting tab.

   Mounting torque for screw mounting:

   (For thread-forming screws these are final values. Do not use self-tapping screws.)

Minimum torque (for good heat transfer)	0,55 Nm (5,5 kgcm)
Maximum torque (to avoid damaging the device)	0,80 Nm (8,0 kgcm)

N.B.: When a nut or screw is not driven direct against a curved spring washer or lock washer (not for thread-forming screw), the torques are as follows:

Minimum torque (for good heat transfer)	0,4 Nm (4 kgcm)
Maximum torque (to avoid damaging the device)	0,6 Nm (6 kgcm)

N.B.: Data on accessories are given in separate data sheets.

3. Rivet mounting non-insulated

The device should not be pop-rivetted to the heatsink. However, it is permissible to press-rivet providing that eyelet rivets of soft material are used, and the press forces are slowly and carefully controlled so as to avoid shock and deformation of either heatsink or mounting tab.

Thermal data

			clip mounting	screw mounting	
From mounting base to heatsink					
with heatsink compound, direct mounting	$R_{th\ mb\text{-}h}$	=	0,3	0,5	K/W
without heatsink compound, direct mounting	$R_{th\ mb\text{-}h}$	=	1,4	1,4	K/W
with heatsink compound and 0,1 mm maximum mica washer	$R_{th\ mb\text{-}h}$	=	2,2	–	K/W
with heatsink compound and 0,25 mm maximum alumina insulator	$R_{th\ mb\text{-}h}$	=	0,8	–	K/W
with heatsink compound and 0,05 mm mica washer					
insulated up to 500 V	$R_{th\ mb\text{-}h}$	=	–	1,4	K/W
insulated up to 800 V/1000 V	$R_{th\ mb\text{-}h}$	=	–	1,6	K/W
without heatsink compound and 0,05 mm mica washer					
insulated up to 500 V	$R_{th\ mb\text{-}h}$	=	–	3,0	K/W
insulated up to 800 V/1000 V	$R_{th\ mb\text{-}h}$	=	–	4,5	K/W

Lead bending

Maximum permissible tensile force on the body, for 5 seconds is 20 N (2 kgf).

The leads can be bent through 90° 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 ≤ 200 °C (tab-temperature).
Soldering cycle duration including pre-heating ≤ 30 sec.

For good soldering and avoiding damage to the encapsulation pre-heating is recommended to a temperature ≤ 165 °C at a duration ≤ 10 s.

INSTRUCTIONS FOR CLIP MOUNTING

Direct mounting with clip 56363

1. Apply heatsink compound to the mounting base, then place the device on the heatsink.
2. Push the short end of the clip into the narrow slot in the heatsink with clip at an angle of 10° to 30° to the vertical (see Figs 1 and 2).
3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body, not on the tab (see Fig.2a).
   Do not insert more than 1 mm beyond final position.

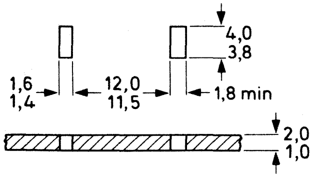


Fig. 1 Heatsink requirements.

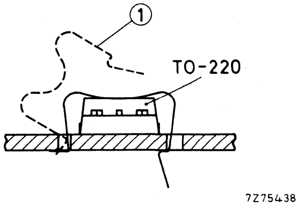


Fig. 2 Mounting.
(1) spring clip 56363.

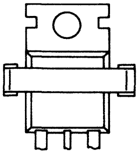


Fig. 2a Position of transistor (top view).

Insulated mounting with clip 56364

With the insulators 56367 or 56369 insulation up to 2 kV is obtained.

1. Apply heatsink compound to the bottom of both device and insulator, then place the device with the insulator on the heatsink.
2. Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10° to 30° to the vertical (see Figs 3 and 4).
3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body, not on the tab. Ensure that the device is centred on the mica insulator to prevent creepage.
   Do not insert more than 1 mm beyond final position.

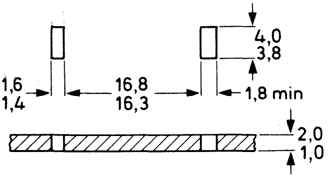


Fig. 3 Heatsink requirements.

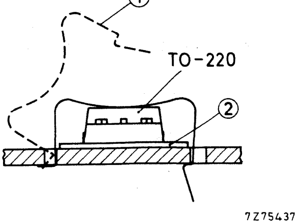


Fig. 4 Mounting.
(1) spring clip 56364.
(2) insulator 56369 or 56367.

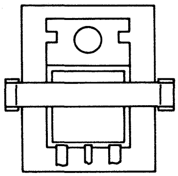


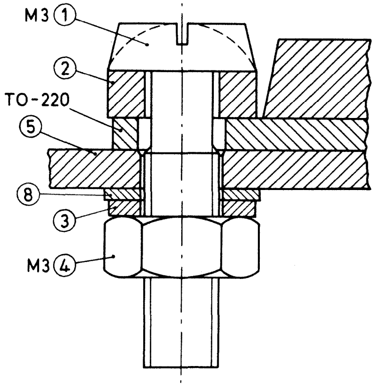
Fig.4a Position of device (top view).

INSTRUCTIONS FOR SCREW MOUNTING

Dimensions in mm

Direct mounting with screw and spacing washer

- *through heatsink with nut*



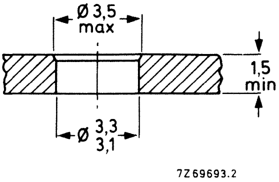
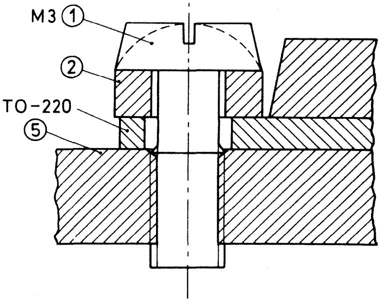


Fig. 5 Assembly.

Fig. 6 Heatsink requirements.

(1) M3 screw.
(2) rectangular washer (56360a).
(3) lock washer.
(4) M3 nut.
(5) heatsink.
(8) plain washer.

- *into tapped heatsink*



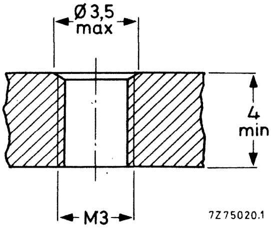


Fig. 7 Assembly.

Fig. 8 Heatsink requirements.

(1) M3 screw.
(2) rectangular washer 56360a.
(5) heatsink.

Insulated mounting with screw and spacing washer
(not recommended where mounting tab is on mains voltage)

Dimensions in mm

- *through heatsink with nut*

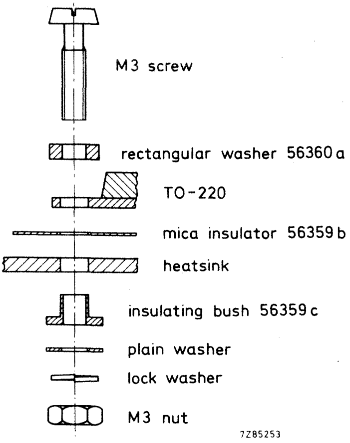


Fig. 9 Insulated screw mounting with rectangular washer. Known as a "bottom mounting".

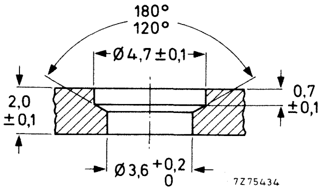


Fig. 10 Heatsink requirements for 500 V insulation.

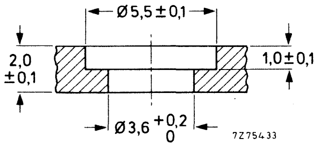


Fig. 11 Heatsink requirements for 800 V insulation.

- *into tapped heatsink*

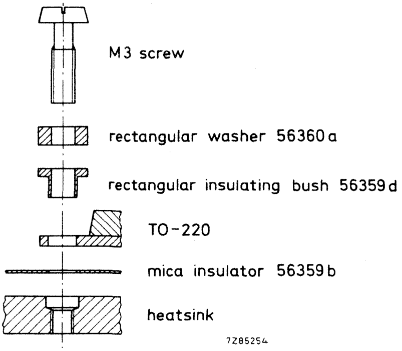


Fig. 12 Insulated screw mounting with rectangular washer into tapped heatsink. Known as a "top mounting".

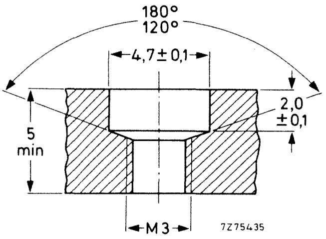


Fig. 13 Heatsink requirements for 500 V insulation.

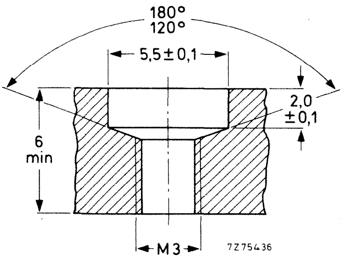


Fig. 14 Heatsink requirements for 1000 V insulation.

MOUNTING INSTRUCTIONS FOR 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.

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.

N.B.: Data on accessories are given in chapter Accessories.

Soldering

Recommendations for devices with a maximum junction temperature rating ⩽ 175 °C:

a. Dip or wave soldering

Maximum permissible solder temperature is 260 °C at a distance from the body of > 5 mm and for a total contact time with soldering bath or waves of < 7 s.

b. Hand soldering

Maximum permissible temperature is 275 °C at a distance from the body of > 3 mm and for a total contact time with the soldering iron of < 5 s.

The body of the device must not touch anything with a temperature > 200 °C.

It is not permitted to solder the metal tab of the device to a heatsink, otherwise the junction temperature rating will be exceeded.

Avoid any force on body and leads during or after soldering; do not correct the position of the device or of its leads after soldering.

Thermal data

			clip mounting	screw mounting	
Thermal resistance from mounting base to heatsink					
direct mounting					
with heatsink compound	$R_{th\ mb\text{-}h}$	=	0,3	0,3	K/W
without heatsink compound	$R_{th\ mb\text{-}h}$	=	1,5	0,8	K/W
with 0,05 mm mica washer					
with heatsink compound	$R_{th\ mb\text{-}h}$	=	0,8	0,8	K/W
without heatsink compound	$R_{th\ mb\text{-}h}$	=	3,0	2,2	K/W

INSTRUCTIONS FOR CLIP MOUNTING

Direct mounting with clip 56379

1. Place the device on the heatsink, applying heatsink compound to the mounting base.
2. Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10° to 20° to the vertical (see Fig. 1b).
3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body, not on the tab (see Fig. 1(c)).

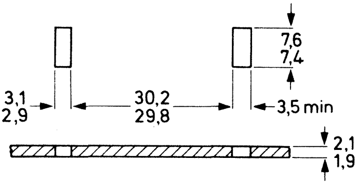


Fig. 1a Heatsink requirements.

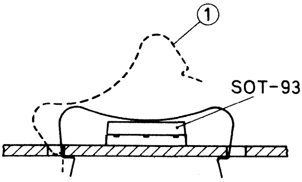


Fig. 1b Mounting.
(1) = spring clip 56379.

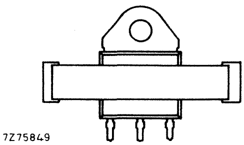


Fig. 1c Position of the device.

Insulated mounting with clip 56379

With the mica 56378 insulation up to 1500 V is obtained.

1. Place the device with the insulator on the heatsink, applying heatsink compound to the bottom of both device and insulator.
2. Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10° to 20° to the vertical (see Figs 2a and 2b).
3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body, not on the tab (see Fig. 2c). There should be minimum 3 mm distance between the device and the edge of the insulator for adequate creepage.

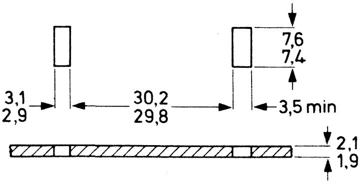


Fig. 2a Heatsink requirements.

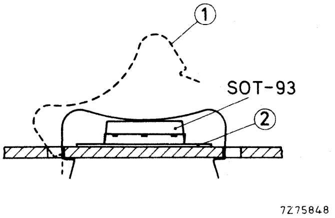


Fig. 2b Mounting.
(1) = spring clip 56379
(2) = insulator 56378

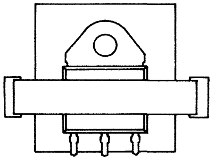


Fig. 2c Position of the device.

INSTRUCTIONS FOR SCREW MOUNTING

Direct mounting

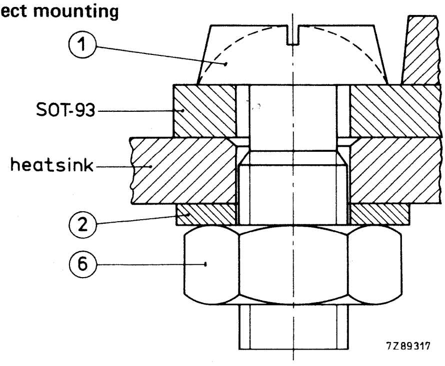


Fig. 3a Assembly through heatsink with nut.

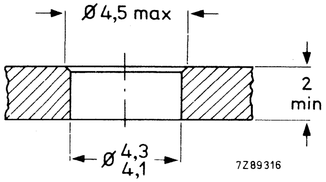


Fig. 3b Heatsink requirements.

When screw mounting the SOT-93 envelope, it is particularly important to apply a thin, even layer of heatsink compound to the mounting base, and to apply torque to the screw slowly so that the compound has time to flow and the mounting base is not deformed. Most SOT-93 envelopes contain a crystal larger than that in the other plastic envelopes, and it is more likely to crack if the mounting base is deformed.

Legend: (1) M4 screw; (2) plain washer; (6) M4 nut.
Where vibrations are to be expected the use of a lock washer or of a curved spring washer is recommended, with a plain washer between aluminium heatsink and spring washer.

Insulated screw mounting with nut; up to 800 V.

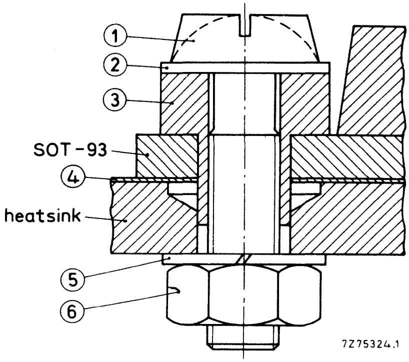


Fig. 4 Assembly.
See also Fig. 9.

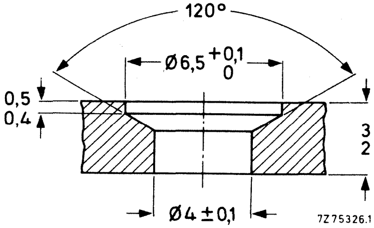


Fig. 5 Heatsink requirements up to 800 V insulation.

(1) M3 screw
(2) plain washer
(3) insulating bush (56368b)
(4) mica insulator (56368a)
(5) lock washer
(6) M3 nut

Insulated screw mounting with tapped hole; up to 800 V.

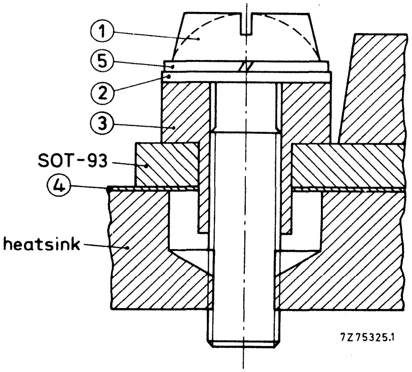


Fig. 6 Assembly.
See also Fig. 9.

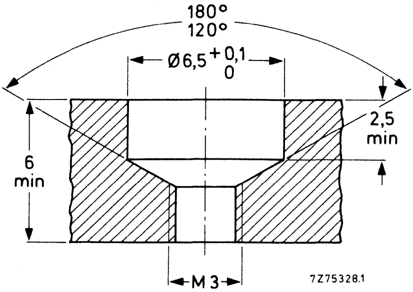


Fig. 7 Heatsink requirements up to 800 V insulation.

(1) M3 screw
(2) plain washer
(3) insulating bush (56368b)
(4) mica insulator (56368a)
(5) lock washer

Insulated screw mounting with insert nut; up to 500 V

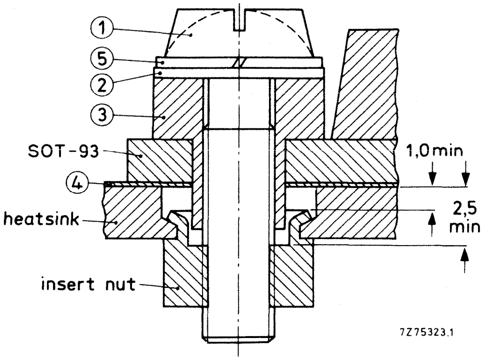


Fig. 8 Assembly and heatsink requirements for 500 V insulation. See also Fig. 3.

(1) M3 screw	
(2) plain washer	
(3) insulating bush	(56368b)
(4) mica insulator	(56368a)
(5) lock washer	

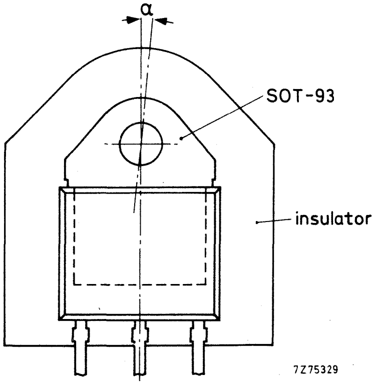
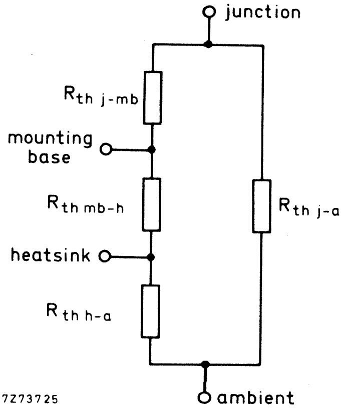


Fig. 9 Mica insulator.

The axial deviation (α) between SOT-93 and mica should not exceed 5°.

MOUNTING CONSIDERATIONS FOR STUD-MOUNTED DEVICES

Losses generated in a silicon device must flow through the case and to a lesser extent the leads.
The greatest proportion of the losses flow out through the case into a heat exchanger which can be either free convection cooled, forced convection or even liquid cooled. For the majority of devices in our range natural convection is generally adequate, however, where other considerations such as space saving must be taken into account then methods such as forced convection etc. can be considered.
The thermal path from junction to ambient may be considered as a number of resistances in series.
The first thermal resistance will be that of junction to mounting base, usually denoted by $R_{th\ j\text{-}mb}$.
The second is the contact thermal resistance $R_{th\ mb\text{-}h}$ and finally there is the thermal resistance of the heatsink $R_{th\ h\text{-}a}$.
In the rating curves, the contact thermal resistance and heatsink thermal resistances are combined as a single figure - $R_{th\ mb\text{-}a}$.
In addition to the steady state thermal conditions of the system, consideration should also be given to the possibility of any transient thermal excursions. These can be caused for example by starting conditions or overloads and in order to calculate the effect on the device, a graph of transient thermal resistance $Z_{th\ j\text{-}mb}$ as a function of time is given in each data sheet.



When mounting the device on the heatsink, care should be taken that the contact surfaces are free from burrs or projections of any kind and must be thoroughly clean.
In the case where an anodised heatsink is used, the anodising should be removed from the contact surface ensuring good electrical and thermal contact.
The contact surfaces should be smeared with a metallic oxide-loaded grease to ensure good heat transfer.
Where the device is mounted in a tapped hole, care should be taken that the hole is perpendicular to the surface of the heatsink. When mounting the device to the heatsink, it is essential that a proper torque wrench is used, applying the correct amount of torque as specified in the published data.
Excessive torque can distort the threads of the device and may even cause mechanical stress on the wafer, leading to the possible failure.
Where isolation of the device from the heatsink is required, it is common practice to use a mica washer between contact surfaces, and where a clearance hole is used, a p.t.f.e. insulating bush is inserted. A metallic oxide-loaded heatsink compound should be smeared on all contact surfaces, including the mica washer, to ensure optimum heat transfer. The use of ordinary silicone grease is not recommended.

MOUNTING INSTRUCTIONS FOR DO-4 AND TO-64 ENVELOPES

GENERAL DATA AND INSTRUCTIONS

Mounting instructions for up to 2000 V insulation using 56295c insulating bush and 56295a mica washer.

Mounting instructions for up to 2000 V insulation using 56295b insulating ring and two 56295a mica washers.

HEATSINK REQUIREMENTS

Mounting holes must be deburred.

MOUNTING TORQUES

Minimum torque (for good heat transfer)	0.9 Nm (9 kg cm)
Maximum torque (to avoid damaging device)	1.7 Nm (17 kg cm)

THERMAL DATA

The thermal resistance from mounting base to heatsink ($R_{th\ mb\text{-}h}$) can be reduced by applying a heat conducting compound between device and heatsink. For insulated mounting the compound should be applied to the bottom of both device and insulator.

Thermal resistance from mounting base to heatsink (insulated mounting using 56295a mica washer)

without heatsink compound	$R_{th\ mb\text{-}h}$	=	5	K/W
with heatsink compound	$R_{th\ mb\text{-}h}$	=	2.5	K/W

MOUNTING INSTRUCTIONS FOR UP TO 2000 V INSULATION

Using 56295c insulating bush and 56295a mica washer.

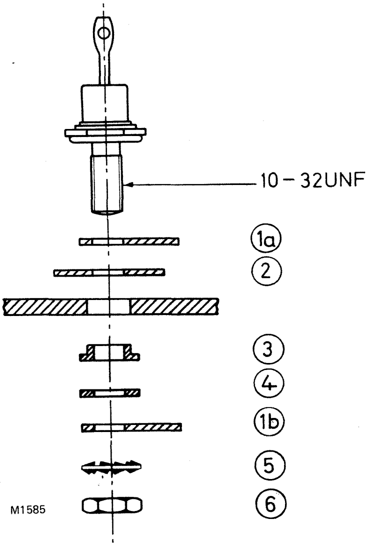


Fig.1

(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)	lock washer (supplied with device)
(6)	10-32 UNF nut (supplied with device)

MOUNTING INSTRUCTIONS FOR UP TO 2000 V INSULATION

Using insulating ring 56295b and two mica washers 56295a.

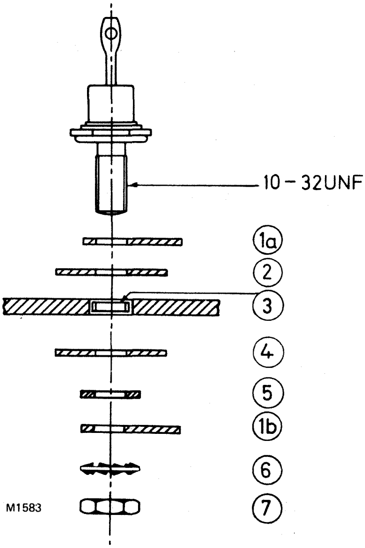


Fig. 2

(1a); (1b)	tag – alternative positions
(2)	mica washer 56295a
(3)	insulating ring 56295b
(4)	mica washer 56295a
(5)	plain washer (may be omitted if tag used in position 1b)
(6)	lock washer (supplied with device)
(7)	10-32 nut (supplied with device)

MOUNTING INSTRUCTIONS FOR DO-5, TO 48 AND TO-65 ENVELOPES

GENERAL DATA AND INSTRUCTIONS

Mounting instructions for up to 2000 V insulation using 56264b insulating bush and 56264a mica washer.

HEATSINK REQUIREMENTS

Mounting holes must be deburred.

MOUNTING TORQUES

Minimum torque (for good heat transfer)	1.7 Nm (17 kg cm)
Maximum torque (to avoid damaging device)	3.5 Nm (35 kg cm)

THERMAL DATA

The thermal resistance from mounting base to heatsink ($R_{th\ mb\text{-}h}$) can be reduced by applying a heat conducting compound between device and heatsink. For insulated mounting the compound should be applied to the bottom of both device and insulator.

Thermal resistance from mounting base to heatsink (insulated mounting using 56264a mica washer)

without heatsink compound	$R_{th\ mb\text{-}h}$	=	5	K/W
with heatsink compound	$R_{th\ mb\text{-}h}$	=	2.5	K/W

MOUNTING INSTRUCTIONS FOR UP TO 2000 V INSULATION

Using insulating bush 56264b and mica washer 56264a.

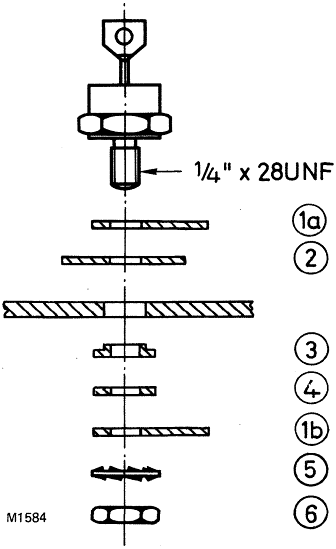


Fig.1

(1a); (1b)	tag – alternative positions
(2)	mica washer 56264a
(3)	insulating bush 56264b
(4)	plain washer (may be omitted if tag used in position 1b)
(5)	lock washer (supplied with device)
(6)	¼" x 28 UNF nut (supplied with device)

MOUNTING INSTRUCTIONS FOR SOT-112 ENVELOPE

GENERAL DATA AND INSTRUCTIONS

Mounting instructions using 56379 spring clip.

THERMAL DATA

The thermal resistance from mounting base to heatsink ($R_{th\ mb\text{-}h}$) can be reduced by applying a metallic oxide heatsink compound between the contact surfaces.

Thermal resistance from mounting base to heatsink

with a metallic oxide loaded compound	$R_{th\ mb\text{-}h}$	=	1.0	K/W
without heatsink compound	$R_{th\ mb\text{-}h}$	=	2.0	K/W

INSTRUCTIONS FOR MOUNTING

1. Place the device on the heatsink, applying a metallic oxide loaded compound to the mounting base.
2. Push the short end of the clip into the narrow slot of the heatsink with the clip at an angle of 10 ° to 30 ° to the vertical (see Fig. 1b).
3. Push down the clip over the device until the long end of the clip snaps into the wide slot. The clip should bear down on the middle of the plastic body.

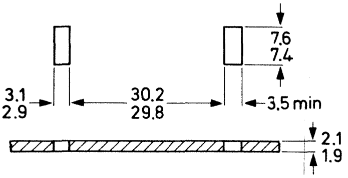


Fig. 1a Heatsink requirements.

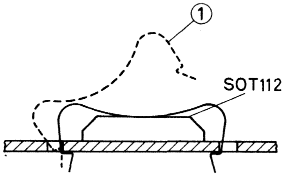


Fig. 1b Mounting.
(1) = spring clip 56379

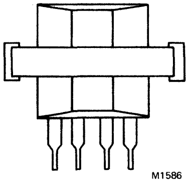


Fig. 1c Position of the device.

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INDEX OF TYPE NUMBERS

Data Handbooks Semiconductor Devices

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AA119	S1	GD
AAZ15	S1	GD
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AAZ18	S1	GD
BA220	S1	SD
BA221	S1	SD
BA223	S1	T
BA243	S1	T
BA244	S1	T
BA280	S1	T
BA314	S1	Vrg
BA315	S1	Vrg
BA316	S1	SD
BA317	S1	SD
BA318	S1	SD
BA379	S1	T
BA423	S1	T
BA481	S1	T
BA482	S1	T
BA483	S1	T
BA484	S1	T
BAS11	S1	SD
BAS16	S7/S1	Mm/SD
BAS17	S7/S1	Mm/Vrg
BAS18	S1	SD
BAS19	S7/S1	Mm/SD
BAS20	S7/S1	Mm/SD
BAS21	S7/S1	Mm/SD
BAT17	S7/S1	Mm/T
BAT18	S7/S1	Mm/T
BAT81	S1	T
BAT82	S1	T
BAT83	S1	T
BAT85	S1	T
BAV10	S1	SD
BAV18	S1	SD
BAV19	S1	SD
BAV20	S1	SD
BAV21	S1	SD
BAV45	S1	Sp
BAV70	S7/S1	Mm/SD
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BAW56	S7/S1	Mm/SD
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BAX12	S1	SD
BAX12A	S1	SD
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BB105B	S1	T
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BB204B	S1	T
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BB212	S1	T
BB405B	S1	T
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BB417	S1	T
BB809	S1	T
BB909A	S1	T
BB909B	S1	T
BBY31	S7/S1	Mm/T
BBY40	S7/S1	Mm/T
BC107	S3	Sm
BC108	S3	Sm
BC109	S3	Sm
BC146	S3	Sm
BC177	S3	Sm
BC178	S3	Sm
BC179	S3	Sm
BC200	S3	Sm
BC264A	S5	FET
BC264B	S5	FET

FET = Field-effect transistors
GD = Germanium diodes
Mm = Microminiature semiconductors for hybrid circuits
SD = Small-signal diodes
Sm = Small-signal transistors
Sp = Special diodes
T = Tuner diodes
Vrg = Voltage regulator diodes

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BC264C	S5	FET
BC264D	S5	FET
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BC328	S3	Sm
BC337;A	S3	Sm
BC338	S3	Sm
BC368	S3	Sm
BC369	S3	Sm
BC375	S3	Sm
BC376	S3	Sm
BC546	S3	Sm
BC547	S3	Sm
BC548	S3	Sm
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BC557	S3	Sm
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BC559	S3	Sm
BC560	S3	Sm
BC635	S3	Sm
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BCF30;R	S7	Mm
BCF32;R	S7	Mm
BCF33;R	S7	Mm
BCF70;R	S7	Mm
BCF81;R	S7	Mm
BCV71;R	S7	Mm
BCV72;R	S7	Mm
BCW29;R	S7	Mm
BCW30;R	S7	Mm
BCW31;R	S7	Mm
BCW32;R	S7	Mm
BCW33;R	S7	Mm
BCW60*	S7	Mm
BCW61*	S7	Mm
BCW69;R	S7	Mm
BCW70;R	S7	Mm
BCW71;R	S7	Mm
BCW72;R	S7	Mm
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BCX18;R	S7	Mm
BCX19;R	S7	Mm
BCX20;R	S7	Mm
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BCX56	S7	Mm
BCX70*	S7	Mm
BCX71*	S7	Mm
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BCY57	S3	Sm
BCY58	S3	Sm
BCY59	S3	Sm
BCY70	S3	Sm
BCY71	S3	Sm
BCY72	S3	Sm
BCY78	S3	Sm
BCY79	S3	Sm
BCY87	S3	Sm
BCY88	S3	Sm
BCY89	S3	Sm
BD131	S4a	P
BD132	S4a	P
BD135	S4a	P
BD136	S4a	P
BD137	S4a	P
BD138	S4a	P
BD139	S4a	P
BD140	S4a	P
BD201	S4a	P
BD202	S4a	P
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BD239A	S4a	P
BD239B	S4a	P
BD239C	S4a	P
BD240	S4a	P
BD240A	S4a	P
BD240B	S4a	P
BD240C	S4a	P
BD241	S4a	P

* = series
FET = Field-effect transistors
Mm = Microminiature semiconductors for hybrid circuits
P = Low-frequency power transistors
Sm = Small-signal transistors

P = Low-frequency power transistors

type no.	book	section
BDT42A	S4a	P
BDT42B	S4a	P
BDT42C	S4a	P
BDT60	S4a	P
BDT60A	S4a	P
BDT60B	S4a	P
BDT60C	S4a	P
BDT61	S4a	P
BDT61A	S4a	P
BDT61B	S4a	P
BDT61C	S4a	P
BDT62	S4a	P
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BDT62B	S4a	P
BDT62C	S4a	P
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BDT64B	S4a	P
BDT64C	S4a	P
BDT65	S4a	P
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BDV65C	S4a	P
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BDV66B	S4a	P
BDV66C	S4a	P
BDV66D	S4a	P
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BDY91	S4a	P
BDY92	S4a	P
BF180	S3	Sm
BF181	S3	Sm
BF182	S3	Sm
BF183	S3	Sm
BF198	S3	Sm
BF199	S3	Sm

P = Low-frequency power transistors
Sm = Small-signal transistors

FET = Field-effect transistors
HVP = High-voltage power transistors
Mm = Microminiature semiconductors for hybrid circuits
RFP = R.F. power transistors and modules
Sm = Small-signal transistors
WBT = Wideband hybrid IC transistors

type no.	book	section
BFR84	S5	FET
BFR90	S10	WBT
BFR90A	S10	WBT
BFR91	S10	WBT
BFR91A	S10	WBT
BFR92;R	S7	Mm
BFR92A;R	S7	Mm
BFR93;R	S7	Mm
BFR93A;R	S7	Mm
BFR94	S10	WBT
BFR95	S10	WBT
BFR96	S10	WBT
BFR96S	S10	WBT
BFR101A;B	S7/S5	Mm/FET
BFS17;R	S7	Mm
BFS18;R	S7	Mm
BFS19;R	S7	Mm
BFS20;R	S7	Mm
BFS21	S5	FET
BFS21A	S5	FET
BFS22A	S6	RFP
BFS23A	S6	RFP
BFT24	S10	WBT
BFT25;R	S7	Mm
BFT44	S3	Sm
BFT45	S3	Sm
BFT46	S7/S5	Mm/FET
BFT92;R	S7	Mm
BFT93;R	S7	Mm
BFW10	S5	FET
BFW11	S5	FET
BFW12	S5	FET
BFW13	S5	FET
BFW16A	S10	WBT
BFW17A	S10	WBT
BFW30	S10	WBT
BFW61	S5	FET
BFW92	S10	WBT
BFW92A	S10	WBT
BFW93	S10	WBT
BFX29	S3	Sm
BFX30	S3	Sm
BFX34	S3	Sm
BFX84	S3	Sm
BFX85	S3	Sm
BFX86	S3	Sm
BFX87	S3	Sm
BFX88	S3	Sm
BFX89	S10	WBT
BFY50	S3	Sm
BFY51	S3	Sm
BFY52	S3	Sm
BFY55	S3	Sm
BFY90	S10	WBT
BG2000	S1	RT
BG2097	S1	RT
BGX11*	S2b	ThM
BGX12*	S2b	ThM
BGX13*	S2b	ThM
BGX14*	S2b	ThM
BGX15*	S2b	ThM
BGX17*	S2b	ThM
BGX25	S2a	ThM
BGY22	S6	RFP
BGY22A	S6	RFP
BGY23	S6	RFP
BGY23A	S6	RFP
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BGY93A	S6	RFP
BGY93B	S6	RFP
BGY93C	S6	RFP
BLU20/12	S6	RFP
BLU30/12	S6	RFP
BLU45/12	S6	RFP
BLU50	S6	RFP
BLU51	S6	RFP
BLU52	S6	RFP
BLU53	S6	RFP
BLU60/12	S6	RFP
BLU97	S6	RFP
BLU98	S6	RFP
BLU99	S6	RFP
BLV10	S6	RFP
BLV11	S6	RFP
BLV20	S6	RFP
BLV21	S6	RFP
BLV25	S6	RFP
BLV30	S6	RFP

* = series
FET = Field-effect transistors
Mm = Microminiature semiconductors for hybrid circuits
RFP = R.F. power transistors and modules
RT = Tripler
Sm = Small-signal transistors
ThM = Thyristor Modules
WBM = Wideband hybrid IC modules
WBT = Wideband hybrid IC transistors

type no.	book	section	type no.	book	section	type no.	book	section
BLV30/12	S6	RFP	BLW86	S6	RFP	BLY92A	S6	RFP
BLV31	S6	RFP	BLW87	S6	RFP	BLY92C	S6	RFP
BLV32F	S6	RFP	BLW89	S6	RFP	BLY93A	S6	RFP
BLV33	S6	RFP	BLW90	S6	RFP	BLY93C	S6	RFP
BLV33F	S6	RFP	BLW91	S6	RFP	BLY94	S6	RFP
BLV36	S6	RFP	BLW95	S6	RFP	BLY97	S6	RFP
BLV37	S6	RFP	BLW96	S6	RFP	BPF10	S8	PDT
BLV45/12	S6	RFP	BLW97	S6	RFP	BPF24	S8	PDT
BLV57	S6	RFP	BLW98	S6	RFP	BPW22A	S8	PDT
BLV59	S6	RFP	BLW99	S6	RFP	BPW50	S8	PDT
BLV75/12	S6	RFP	BLX13	S6	RFP	BPX25	S8	PDT
BLV80/28	S6	RFP	BLX13C	S6	RFP	BPX29	S8	PDT
BLV90	S6	RFP	BLX14	S6	RFP	BPX40	S8	PDT
BLV91	S6	RFP	BLX15	S6	RFP	BPX41	S8	PDT
BLV92	S6	RFP	BLX39	S6	RFP	BPX42	S8	PDT
BLV93	S6	RFP	BLX65	S6	RFP	BPX71	S8	PDT
BLV94	S6	RFP	BLX65E	S6	RFP	BPX72	S8	PDT
BLV95	S6	RFP	BLX67	S6	RFP	BPX95C	S8	PDT
BLV96	S6	RFP	BLX68	S6	RFP	BR100/03	S2b	Th
BLV97	S6	RFP	BLX69A	S6	RFP	BR101	S3	Sm
BLV98	S6	RFP	BLX91A	S6	RFP	BRY39	S3	Sm
BLV99	S6	RFP	BLX91CB	S6	RFP	BRY56	S3	Sm
BLW29	S6	RFP	BLX92A	S6	RFP	BRY61	S7	Mm
BLW31	S6	RFP	BLX93A	S6	RFP	BRY62	S7	Mm
BLW32	S6	RFP	BLX94A	S6	RFP	BSD10	S5	FET
BLW33	S6	RFP	BLX94C	S6	RFP	BSD12	S5	FET
BLW34	S6	RFP	BLX95	S6	RFP	BSD20	S5	FET
BLW50F	S6	RFP	BLX96	S6	RFP	BSD22	S5	FET
BLW60	S6	RFP	BLX97	S6	RFP	BSD212	S5	FET
BLW60C	S6	RFP	BLX98	S6	RFP	BSD213	S5	FET
BLW76	S6	RFP	BLY85	S6	RFP	BSD214	S5	FET
BLW77	S6	RFP	BLY87A	S6	RFP	BSD215	S5	FET
BLW78	S6	RFP	BLY87C	S6	RFP	BSR12;R	S7	Mm
BLW79	S6	RFP	BLY88A	S6	RFP	BSR13;R	S7	Mm
BLW80	S6	RFP	BLY88C	S6	RFP	BSR14;R	S7	Mm
BLW81	S6	RFP	BLY89A	S6	RFP	BSR15;R	S7	Mm
BLW82	S6	RFP	BLY89C	S6	RFP	BSR16;R	S7	Mm
BLW83	S6	RFP	BLY90	S6	RFP	BSR17;R	S7	Mm
BLW84	S6	RFP	BLY91A	S6	RFP	BSR17A;R	S7	Mm
BLW85	S6	RFP	BLY91C	S6	RFP	BSR18;R	S7	Mm

FET = Field-effect transistors
Mm = Microminiature semiconductors for hybrid circuits
PDT = Photodiodes or transistors
RFP = R.F. power transistors and modules
Sm = Small-signal transistors
Th = Thyristors

* = series
FET = Field-effect transistors
Mm = Microminiature semiconductors for hybrid circuits
Sm = Small-signal transistors
SP = Low-frequency switching power transistors
Th = Thyristors
Tri = Triacs

* = series
PM = Power MOS transistors
R = Rectifier diodes
SP = Low-frequency switching power transistors

type no.	book	section
BYW29*	S2a	R
BYW30*	S2a	R
BYW31*	S2a	R
BYW54	S1	R
BYW55	S1	R
BYW56	S1	R
BYW92*	S2a	R
BYW93*	S2a	R
BYW94*	S2a	R
BYW95A	S1	R
BYW95B	S1	R
BYW95C	S1	R
BYW96D	S1	R
BYW96E	S1	R
BYX10	S1	R
BYX25*	S2a	R
BYX30*	S2a	R
BYX32*	S2a	R
BYX38*	S2a	R
BYX39*	S2a	R
BYX42*	S2a	R
BYX46*	S2a	R
BYX50*	S2a	R
BYX52*	S2a	R
BYX56*	S2a	R
BYX90	S1	R
BYX94	S1	R
BYX96*	S2a	R
BYX97*	S2a	R
BYX98*	S2a	R
BYX99*	S2a	R
BZT03	S1	Vrg
BZV10	S1	Vrf
BZV11	S1	Vrf
BZV12	S1	Vrf
BZV13	S1	Vrf
BZV14	S1	Vrf
BZV37	S1	Vrf
BZV46	S1	Vrg
BZV49*	S1/S7	Vrg
BZV85	S1	Vrg
BZW70*	S2a	TS
BZW86*	S2a	TS
BZW91*	S2a	TS
BZX55	S1	Vrg
BZX70*	S2a	Vrg
BZX75	S1	Vrg
BZX79*	S1	Vrg
BZX84*	S7/S1	Mm/Vrg
BZX87*	S1	Vrg
BZX90	S1	Vrf
BZX91	S1	Vrf
BZX92	S1	Vrf
BZX93	S1	Vrf
BZX94	S1	Vrf
BZY91*	S2a	Vrg
BZY93*	S2a	Vrg
BZY95*	S2a	Vrg
BZY96*	S2a	Vrg
CNX21	S8	PhC
CNX35	S8	PhC
CNX36	S8	PhC
CNX37	S8	PhC
CNX38	S8	PhC
CNX44	S8	PhC
CNX48	S8	PhC
CNX62	S8	PhC
CNY50	S8	PhC
CNY52	S8	PhC
CNY53	S8	PhC
CNY57	S8	PhC
CNY57A	S8	PhC
CNY62	S8	PhC
CNY63	S8	PhC
CQ209S	S8	D
CQ216X	S8	D
CQ216Y	S8	D
CQ327;R	S8	D
CQ330;R	S8	D
CQ331;R	S8	D
CQ332;R	S8	D
CQ427;R	S8	D
CQ430;R	S8	D
CQ431;R	S8	D
CQ432;R	S8	D
CQF24	S8	Ph
CQL10A	S8	Ph
CQL13	S8	Ph
CQL13A	S8	Ph
CQL14A	S8	Ph
CQL14B	S8	Ph
CQN10	S8	LED
CQN11	S8	LED
CQT10	S8	LED
CQT11	S8	LED
CQT12	S8	LED
CQV60(L)	S8	LED
CQV60A(L)	S8	LED
CQV61A(L)	S8	LED
CQV62(L)	S8	LED
CQV70(L)	S8	LED
CQV70A(L)	S8	LED
CQV71A(L)	S8	LED
CQV72(L)	S8	LED
CQV80L	S8	LED
CQV80AL	S8	LED
CQV81L	S8	LED
CQV82L	S8	LED
CQW10(L)	S8	LED
CQW10A(L)	S8	LED
CQW10B(L)	S8	LED
CQW11A(L)	S8	LED
CQW11B(L)	S8	LED
CQW12(L)	S8	LED
CQW12B(L)	S8	LED
CQW20A	S8	LED
CQW21	S8	LED
CQW22	S8	LED
CQW24(L)	S8	LED
CQW54	S8	LED

* = series
D = Displays
LED = Light-emitting diodes
Mm = Microminiature semiconductors for hybrid circuits
Ph = Photoconductive devices
PhC = Photocouplers
R = Rectifier diodes
TS = Transient suppressor diodes
Vrf = Voltage reference diodes
Vrg = Voltage regulator diodes

GD = Germanium diodes
I = Infrared devices
LED = Light-emitting diodes
P = Low-frequency power transistors
Ph = Photoconductive devices
R = Rectifier diodes
SD = Small-signal diodes
Sm = Small-signal transistors
St = Rectifier stacks
Vrf = Voltage reference diodes
WBM = Wideband hybrid IC modules

A = Accessories
I = Infrared devices
FET = Field-effect transistors
Ph = Photoconductive devices
R = Rectifier diodes
RFP = R.F. power transistors and modules
SD = Small-signal diodes
Sm = Small-signal transistors
WBT = Wideband hybrid IC transistors

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