# PHILIPS 

Data handbook

## Semiconductors

## Phitips

 PHIL $+\frac{t}{\square}$Electronic components and materials

Book S2b 1987

## Thyristors

## Triacs

## Accessories

## THYRISTORS AND TRIACS

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## 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

The contents of each series are listed on pages iv to vii.
The data handbooks contain all pertinent data available at the time of publication, and each is revised and reissued periodically.
When ratings or specifications differ from those published in the preceding edition they are indicated with arrows in the page margin. Where application information is given it is advisory and does not form part of the product specification.
Condensed data on the preferred products of Philips Electronic Components and Materials Division is given in our Preferred Type Range catalogue (issued annually).
Information on current Data Handbooks and on how to obtain a subscription for future issues is available from any of the Organizations listed on the back cover.
Product specialists are at your service and enquiries will be answered promptly.

## ELECTRON TUBES (BLUE SERIES)

The blue series of data handbooks comprises:
T1 Tubes for r.f. heating
T2a Transmitting tubes for communications, glass types
T2b Transmitting tubes for communications, ceramic types
T3 . Klystrons

T4 Magnetrons for microwave heating
T5 Cathode-ray tubes
Instrument tubes, monitor and display tubes, C.R. tubes for special applications
T6 Geiger-Müller tubes
T8 Colour display systems
Colour TV picture tubes, colour data graphic display tube assemblies, deflection units

T9 Photo and electron multipliers
T10 Plumbicon camera tubes and accessories
T11 Microwave semiconductors and components
T12 Vidicon and Newvicon camera tubes

T13 Image intensifiers and infrared detectors
T15 Dry reed switches

T16 Monochrome tubes and deflection units
Black and white TV picture tubes, monochrome data graphic display tubes, deflection units

## SEMICONDUCTORS (RED SERIES)

The red series of data handbooks comprises:

## S1 Diodes

Small-signal silicon diodes, voltage regulator diodes ( $<1,5 \mathrm{~W}$ ), voltage reference diodes, tuner diodes, rectifier diodes

S2a Power diodes

S2b Thyristors and triacs

S3 Small-signal transistors

S4a Low-frequency power transistors and hybrid modules

S4b High-voltage and switching power transistors
S5 Field-effect transistors

S6 R.F. power transistors and modules

S7 Surface mounted semiconductors

S8a Light-emitting diodes

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

S9 Power MOS transistors

S10 Wideband transistors and wideband hybrid IC modules

S11 Microwave transistors

S12 Surface acoustic wave devices

S13 Semiconductor sensors
*S14 Liquid Crystal Displays
*To be issued shortly.

## INTEGRATED CIRCUITS (PURPLE SERIES)

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

| ICO1 | Radio, audio and associated systems Bipolar, MOS | new issue 1986 IC01N 1985 |
| :---: | :---: | :---: |
| IC02a/b | Video and associated systems Bipolar, MOS | new issue 1986 ICO2Na/b 1985 |
| IC03 | Integrated circuits for telephony Bipolar, MOS | new issue 1987 ICO3N 1985 |
| ICO4 | HE4000B logic family CMOS | $\begin{aligned} & \text { new issue } 1986 \\ & \text { IC4 } 1983 \end{aligned}$ |
| IC05N | $\begin{aligned} & \text { HE4000B logic family - uncased ICs } \\ & \text { CMOS } \end{aligned}$ | published 1984 |
| IC06N | High -speed CMOS; PC74HC/HCT/HCU Logic family | published 1986 |
| IC08 | ECL 10 K and 100K logic families | New issue 1986 ICO8N 1984 |
| IC09N | TTL logic series | published 1986 |
| IC10 | Memories <br> MOS, TTL, ECL | $\begin{aligned} & \text { new issue } 1986 \\ & \text { IC7 } 1982 \end{aligned}$ |
| IC11N | Linear LSI | published 1985 |
| Supplement to IC11N | Linear LSI | published 1986 |
| IC12 | $1^{2} \mathrm{C}$-bus compatible ICs | not yet issued |
| IC13 | Semi-custom <br> Programmable Logic Devices (PLD) | new issue 1986 IC13N 1985 |
| IC14 | Microcontrollers and peripherals Bipolar, MOS | published 1986 |
| IC15 | FAST TTL logic series | new issue 1986 IC15N 1985 |
| IC16 | CMOS integrated circuits for clocks and watches | first issue 1986 |
| IC17 | Integrated Services Digital Networks (ISDN) | not yet issued |
| IC18 | Microprocessors and peripherals | new issue 1986 |

## COMPONENTS AND MATERIALS (GREEN SERIES)

The green series of data handbooks comprises:
C2 Television tuners, coaxial aerial input assemblies, surface acoustic wave filters
C3 Loudspeakers
C4 Ferroxcube potcores, square cores and cross cores
C5 Ferroxcube for power, audio/video and accelerators
C6 Synchronous motors and gearboxes
C7 Variable capacitors
C8 Variable mains transformers
C9 Piezoelectric quartz devices
C11 Varistors, thermistors and sensors
C12 Potentiometers, encoders and switches
$\mathbf{C 1 3}$ Fixed resistors
C14 Electrolytic and solid capacitors
C15 Ceramic capacitors
C16 Permanent magnet materials
C17 Stepping motors and associated electronics
C18 Direct current motors
C19 Piezoelectric ceramics
C20 Wire-wound components for TVs and monitors
C22 Film capacitors

## SELECTION GUIDE

GATE TURN-OFF THYRISTORS

| $I_{\text {I }}(\mathrm{AV})$ |  |  | Outline | $\mathrm{V}_{\text {DRMmax }}(\mathrm{V})$ |  |  |  |  |  |  | Page |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| max. <br> (A) | max. <br> (A) |  |  |  |  | 850 | 1000 | 1200 | 1300 | 1500 |  |
| 3.2 | 12 | BT157 | TO-220AB |  |  |  |  |  |  | . | 39 |
| 6.5 | 25 | BTW58 | TO-220AB |  |  |  |  |  |  |  | 163 |
| 10 | 25 | BTV58 | TO-220AB |  |  |  |  |  |  |  | 75 |
| 10 | 50 | BTR59 | SOT-93 |  |  |  |  |  |  |  | 51 |
| 15 | 50 | BTS59 | SOT-93 |  |  |  |  |  |  |  | 63 |
| 15 | 50 | BTV59 | TO-238AA |  |  |  |  |  |  |  | 87 |
| 15 | 50 | BTV59D | TO-238AA |  |  |  |  |  |  |  | 99 |
| 15 | 50 | BTV70 | T0-238AA |  |  |  |  |  |  |  | 137 |
| 15 | 50 | BTV70D | TO-238AA |  |  |  |  |  |  |  | 149 |
| 25 | 120 | BTV60 | TO-238AA |  |  |  |  |  |  |  | 113 |
| 25 | 120 | BTV60D | TO-238AA |  |  |  |  |  |  |  | 123 |

## THYRISTORS

General purpose thyristors

| IT(RMS) max <br> (A) |  | Outline |
| :---: | :--- | :--- |
| $\mathbf{0 . 8}$ | BT169 | TO-92 |
| $\mathbf{4}$ | BT150 | TO-220AB |
| $\mathbf{9}$ | BT151F | SOT-186 |
| $\mathbf{1 2}$ | BT151 | TO-220AB |
| $\mathbf{1 6}$ | BTY79 | TO-64 |
| $\mathbf{1 6}$ | BTW38 | TO-64 |
| $\mathbf{1 6}$ | BTW42 | TO-64 |
| $\mathbf{2 0}$ | BT152 | TO-220AB |
| $\mathbf{2 5}$ | BT145 | TO-220AB |
| $\mathbf{2 5}$ | BTW45 | TO-48 |
| $\mathbf{2 5}$ | BTY91 | TO-48 |
| $\mathbf{3 2}$ | BTW40 | TO-48 |



## THYRISTORS (Cont.)

Fast turn-off thyristors

| $I_{T}(\text { RMS })_{\text {max }}$ <br> (A) |  | Outline | $V_{\text {DRMmax }}(\mathrm{V})$ |  |  |  | Page |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | 500 | 600 | 800 | 1000 |  |  |
| 6 | BT 153 | TO-220AB |  |  |  | 1 | 225 |  |
| 28 | BTW62 | TO-238AA |  |  |  |  | 267 | (ASCR construction) |
| 28 | BTW62D | T0-238AA |  |  |  |  | 275 | (ASCR construction) |
| 40 | BTW63 | TO-48 |  |  |  |  |  | (ASCR construction) |

TRIACS

| IT(RMS) max <br> (A) |  | Outline |
| :---: | :--- | :--- |
| $\mathbf{4}$ | BT136 | TO-220AB |
| 4 | BT136F | SOT-186 |
| 8 | BT137 | TO-220AB |
| 8 | BT137F | SOT-186 |
| 12 | BT138 | TO-220AB |
| 12 | BT138F | SOT-186 |
| 15 | BTW43 | TO-64 |
| 16 | BT139 | TO-220AB |
| 16 | BT139F | SOT-186 |
| 25 | BTA140 | TO-220AB |



[^0]
## GENERAL SECTION

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

## PRO ELECTRON TYPE DESIGNATION CODE FOR SEMICONDUCTOR DEVICES

This type designation code applies to discrete semiconductor devices - as opposed to integrated circuits -, multiples of such devices and semiconductor chips.
"Although not all type numbers accord with the Pro Electron system, the following explanation is given for the ones that do."

A basic type number consists of:
TWO LETTERS FOLLOWED BY A SERIAL NUMBER

## FIRST LETTER

The first letter gives information about the material used for the active part of the devices.
A. GERMANIUM or other material with band gap of 0,6 to $1,0 \mathrm{eV}$.
B. SILICON or other material with band gap of 1,0 to $1,3 \mathrm{eV}$.
C. GALLIUM-ARSENIDE or other material with band gap of $1,3 \mathrm{eV}$ 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 $\left(R_{\text {th } j-m b}>15 \mathrm{~K} / \mathrm{W}\right)$
D. TRANSISTOR; power, audio frequency ( $R_{\text {th } j-\mathrm{mb}} \leqslant 15 \mathrm{~K} / \mathrm{W}$ )
E. DIODE; tunnel
F. TRANSISTOR; low power, high frequency ( $R_{\text {th } j-m b}>15 \mathrm{~K} / \mathrm{W}$ )
G. MULTIPLE OF DISSIMILAR DEVICES - MISCELLANEOUS; e.g. oscillator
H. DIODE; magnetic sensitive
L. TRANSISTOR; power, high frequency ( $R_{\text {th } \mathrm{j}-\mathrm{mb}} \leqslant 15 \mathrm{~K} / \mathrm{W}$ )
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 ( $R_{\text {th }} \mathrm{j}-\mathrm{mb}>15 \mathrm{~K} / \mathrm{W}$ )
S. TRANSISTOR; low power, switching ( $R_{\text {th } j-\mathrm{mb}}>15 \mathrm{~K} / \mathrm{W}$ )
T. CONTROL AND SWITCHING DEVICE; e.g. thyristor, power ( $R_{\text {th } j-m b} \leqslant 15 \mathrm{~K} / \mathrm{W}$ )
U. TRANSISTOR; power, switching ( $R_{\text {th }}$ j-mb $\leqslant 15 \mathrm{~K} / W$ )
X. DIODE: multiplier, e.g. varactor, step recovery
Y. DIODE; rectifying, booster
Z. DIODE; voltage reference or regulator (transient suppressor diode, with third letter W)

## TYPE <br> DESIGNATION

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, $\mathrm{V}_{\mathrm{R} R}$, or the rated repetitive peak off-state voltage, $\mathrm{V}_{\text {DRM }}$, whichever value is lower, in volts for each type.
The final letter $\mathbf{R}$ 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 $\mathrm{V}_{\mathrm{Z}}$.
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 $\mathrm{V}_{\mathrm{Z}}$ for each type at the nominal operating current $\mathrm{I}_{\mathrm{Z}}$ rating of the range.

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

## Example:

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

## RATING SYSTEMS

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

## DEFINITIONS OF TERMS USED

Electronic device. An electronic tube or valve, transistor or other semiconductor device.
Note
This definition excludes inductors, capacitors, resistors and similar components.
Characteristic. A characteristic is an inherent and measurable property of a device. Such a property may be electrical, mechanical, thermal, hydraulic, electro-magnetic, or nuclear, and can be expressed as a value for stated or recognized conditions. A characteristic may also be a set of related values, usually shown in graphical form.

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

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

Note
Limiting conditions may be either maxima or minima.
Rating system. The set of principles upon which ratings are established and which determine their interpretation.
Note
The rating system indicates the division of responsibility between the device manufacturer and the circuit designer, with the object of ensuring that the working conditions do not exceed the ratings.

## ABSOLUTE MAXIMUM RATING SYSTEM (As used throughout this book)

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

These values are chosen by the device manufacturer to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environmental variations, and the effects of changes in operating conditions due to variations in the characteristics of the device under consideration and of all other electronic devices in the equipment.
The equipment manufacturer should design so that, initially and throughout life, no absolute maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply voltage variation, equipment component variation, equipment control adjustment, load variations, signal variation, environmental conditions, and variations in characteristics of the device under consideration and of all other electronic devices in the equipment.

## DESIGN MAXIMUM RATING SYSTEM

Design maximum ratings are limiting values of operating and environmental conditions applicable to a bogey electronic device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.
These values are chosen by the device manufacturer to provide acceptable serviceability of the device, taking responsibility for the effects of changes in operating conditions due to variations in the characteristics of the electronic device under consideration.

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

## DESIGN CENTRE RATING SYSTEM

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

These values are chosen by the device manufacturer to provide acceptable serviceability of the device in average applications, taking responsibility for normal changes in operating conditions due to rated supply voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in the characteristics of all electronic devices.
The equipment manufacturer should design so that, initially, no design centre value for the intended service is exceeded with a bogey electronic device in equipment operating at the stated normal supply voltage.

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

## LETTER SYMBOLS FOR CURRENTS, VOLTAGES AND POWERS

Basic letters: - The basic letters to be used are:
I, i=current
$\mathrm{V}, \mathrm{v}=$ voltage
$P, p=$ power

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

## Subscripts

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

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

[^1]Example of the use of letter symbols


Simplified thyristor characteristic together with an anodecathode 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 $0.01 \%=100 \mathrm{ppm}$ ). 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 50000.
CECC 50000 offers a choice of four screening sequences: ' $A^{\prime}$, ' $B$ ', ' $C$ ', ' $D$ '. 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 50000.
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:
$V_{\text {DSM }}$ the non-repetitive transient voltage.
$V_{\text {DRM }}$ the repetitive peak voltage, with a short duty cycle (less than $5 \%$ ).
$V_{\text {DW }}$ the crest working voltage, which is the repetitive peak voltage with a duty cycle of up to 50\%.
$V_{D} \quad$ 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 gateanode 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 ( $\mathrm{V}_{\mathrm{T}}$ ) can be reduced to some extent by maintaining a forward gate current and this is indicated in data graphs of $\mathrm{V}_{\mathrm{T}}$ versus $\mathrm{I}_{\mathrm{T}}$. 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 $\mathrm{I}_{\mathrm{GT}}$ 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 $\mathrm{I}_{\mathrm{GT}}$ value given in data, to ensure fast turn-on. All turn-on times in data are defined under these conditions.

## $\mathbf{d l}_{\mathbf{T}} / \mathrm{dt}$ 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 $\mathrm{dl}^{\top} / \mathrm{dt}$ up to 2000A/ $\mu \mathrm{s}$.

# GENERAL <br> EXPLANATORY NOTES 

## 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 ( $I_{\mathrm{TC}}$ ) is a function of the rate of rise of reapplied voltage ( $\mathrm{d} \mathrm{V}_{\mathrm{D}} / \mathrm{dt}$ ). In order to take advantage of the high peak current handling capabilities of the GTO, it is normally necessary to use a form of $d V_{D} / d t$ 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 ( $\mathrm{C}_{\mathrm{S}}$ ) from charging up through the bottom GTO, and vice versa.

## GENERAL EXPLANATORY NOTES

## Turn-off (cont)

In all cases, the applied $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ is defined by the equation:

$$
I_{T}=C_{S} \times d V_{D} / d t
$$

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 $I_{T C}$ versus $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$. In resonant circuits, of course, $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ 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 $V_{\text {Dmax. }}$ ) are as follows:

| GTO | max. $\mathrm{C}_{\mathrm{S}}$ |
| :--- | ---: |
| 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 $d V_{D} / d t$, excessive inductance will reduce the value of $I_{T C}$ 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 ( $\mathrm{C}_{\mathrm{S}}=20 \mathrm{nF}, \mathrm{T}_{\mathrm{mb}}=25^{\circ} \mathrm{C}$ )

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 $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$. 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 $\mathrm{R}_{\mathrm{S}}$. For a supply voltage equal to the $\mathrm{V}_{\mathrm{Dmax}}$ rating of the GTO, a safe period to ensure adequate discharge of the capacitor is given by:

$$
\mathrm{t}_{\mathrm{on}}=5 \times \mathrm{R}_{\mathrm{S}} \times \mathrm{C}_{\mathrm{S}}
$$

where $t_{o n}$ is in microseconds, $\mathrm{R}_{\mathrm{S}}$ is in ohms and $\mathrm{C}_{\mathrm{S}}$ 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.

## GENERAL EXPLANATORY NOTES

## 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 $\mathrm{I}_{\mathrm{GR}}$ will flow. The ratio $I_{A} / I_{G R}$ 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 $\mathrm{I}_{\mathrm{GR}}$ 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 $\left(-\mathrm{dl}_{\mathrm{G}} / \mathrm{dt}\right)$ 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 ( $\mathrm{V}_{\mathrm{GR}}$ ) of approx. 10 V when the $\mathrm{V}_{\text {CEsat }}$ 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 $I_{T C}$ falls with reducing $V_{G R}$.
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 $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ the GTO is capable of turning off the current given by the data graph of $I_{T C}$ versus $d V_{D} / d t$ up to the full rated $V_{D R M}$ of the device. The RB SOAR curve is therefore a rectangle bounded by $I_{T C}$ and $V_{D R M}$.

## 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:

$$
E_{o n}=V_{D} \times I_{T} \times t_{r} \times 1 / 6
$$

$\rightarrow$ where $\mathrm{E}_{\text {on }}$ is in microjoules, $\mathrm{V}_{\mathrm{D}}$ is the voltage from which the GTO is being turned on, $\mathrm{I}_{\mathrm{T}}$ 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 $d V_{D} / \mathrm{dt}$, 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 $\left(t_{d}\right)$. 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 $\left(V_{D}\right)$.
b) On-state current $\left(I_{\top}\right)$.
c) Gate trigger current $\left(\mathrm{I}_{\mathrm{G}}\right)$ - high gate currents reduce turn-on time.
d) Rate of rise of gate trigger current $\left(\mathrm{dI}_{\mathrm{G}} / \mathrm{dt}\right)$ - high values reduce turn-on time.
e) Junction temperature $\left(\mathrm{T}_{\mathrm{j}}\right)$ - 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 $\left(\mathrm{t}_{\mathrm{q}}\right)$ 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 ( $\mathrm{I}_{\mathrm{T}}$ ) - high peak currents mean longer turn-off times.
b) Reverse voltage $\left(\mathrm{V}_{\mathrm{R}}\right)$ - 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 ( $\mathrm{d} / / \mathrm{dt}$ ) - high rates mean shorter turn-off times.
d) Rate of rise of reapplied off-state voltage ( $\mathrm{d} \mathrm{V}_{\mathrm{D}} / \mathrm{dt}$ ) - high rates mean longer turn-off times.
e) Temperature ( $T_{j}$ or $T_{m b}$ ) - high temperatures mean longer turn-off times.
f) Gate conditions ( $-\mathrm{V}_{\mathrm{GG}}, \mathrm{R}_{\text {tot }}$ ) - 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 ( $\mathrm{V}_{\mathrm{RGMmax}}$ ).

The waveforms are shown in the following diagram:


## TRIACS

## COMMUTATION dV com $/ \mathrm{dt}$

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 $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ in such a fashion that the device's ability to withstand high rates of reapplication of voltage is impaired. For this reason the commutation $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ is invariably worse than the static $\mathrm{d} \mathrm{V}_{\mathrm{D}} / \mathrm{dt}$.
The conditions which need to be specified are:
a) R.M.S. current ( $\left.{ }_{\mathrm{T}}^{\mathrm{T}} \mathrm{RMS}\right)$ ) - high currents make commutation harder.
b) Re-applied off-state voltage ( $V_{D}$ ), normally $V_{D R M}$ max. - high voltage will make commutation harder.
c) Temperature ( $T_{j}$ or $T_{m b}$ ) - high temperatures make commutation harder.
d) $-\mathrm{dI} / \mathrm{dt}$ - 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:

| $\frac{v_{\text {RSM }}}{v_{\text {RWM }}}$ | RC across primary of transformer |  | RC across secondary of transformer |  |
| :---: | :---: | :---: | :---: | :---: |
|  | C $(\mu \mathrm{F})$ | R ( $\Omega$ ) | C $(\mu \mathrm{F})$ | R ( $\Omega$ ) |
| 2.0 | $200 \frac{I_{\mathrm{mag}}}{\mathrm{~V}_{1}}$ | $\frac{150}{C}$ | $225 \frac{\mathrm{mag}^{T^{2}}}{\mathrm{~V}_{1}}$ | $\frac{200}{C}$ |
| 1.5 | $400 \frac{I_{\mathrm{mag}}}{\mathrm{~V}_{1}}$ | $\frac{225}{C}$ | $450 \frac{I_{\mathrm{mag}} \mathrm{~T}^{2}}{\mathrm{~V}_{1}}$ | $\frac{275}{C}$ |
| 1.25 | $550 \frac{I_{\mathrm{mag}}}{\mathrm{~V}_{1}}$ | $\frac{260}{\mathrm{C}}$ | $620 \frac{I_{\mathrm{mag}} \mathrm{~T}^{2}}{\mathrm{~V}_{1}}$ | $\frac{310}{C}$ |
| 1.0 | $800 \frac{I_{\mathrm{mag}}}{\mathrm{~V}_{1}}$ | $\frac{300}{c}$ | $900 \frac{\mathrm{Imag}^{\mathrm{m}^{2}}}{\mathrm{~V}_{1}}$ | $\frac{350}{c}$ |

$$
\text { where } \begin{aligned}
I_{\text {mag }} & =\text { magnetising primary r.m.s. current }(\mathrm{A}) \\
\mathrm{V}_{1} & =\text { transformer primary r.m.s. voltage }(\mathrm{V}) \\
\mathrm{V}_{2} & =\text { transformer secondary r.m.s. voltage }(\mathrm{V}) \\
\mathrm{T} & =\mathrm{V}_{1} / \mathrm{V}_{2} \\
\mathrm{~V}_{\mathrm{RSM}} & =\text { the transient voltage peak produced by the transformer } \\
\mathrm{V}_{\mathrm{RWM}} & =\text { the actually applied crest working reverse voltage }
\end{aligned}
$$

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

Heat sinks 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 ( $\mathrm{R}_{\text {th }}$ in ${ }^{\circ} \mathrm{C} / \mathrm{W}$ ) analogous to the electric resistance ( R in (2).
Fig. 1 shows the heat path from junction to ambient as three thermal resistances in series:
$R_{\text {th }} j-m b \quad$ The thermal resistance from junction to mounting base. Its value is given in the data sheets of a device.
$R_{\text {th mb-h }}$ The thermal resistance from mounting base to heatsink (contact thermal resistance). It is caused by the imperfect nature and limited size of the contact between the two. Its value is also given in the data sheets.
$R_{\text {th h-a }} \quad$ 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: $T_{j}-T_{a m b}=P x\left(R_{t h j-m b}+R_{t h m b-h}+R_{t h h-a}\right)$


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 in take 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 $\mathrm{R}_{\text {th }}$-a to keep the total thermal resistance below the maximum given for $P$ and $T_{a m b}$. 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. 5 Single phase full wave rectifier with diodes of different polarity on extruded aluminium heatsinks


Fig. 4 Extruded aluminium heatsink with two diodes


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 $\mathrm{T}_{\mathrm{amb}}=50^{\circ} \mathrm{C}$. Further assume: average forward current per diode $I_{F(A V)}=65 \mathrm{~A}$; contact thermal resistance $R_{\text {th mb-h }}=0,1^{\circ} \mathrm{C} / \mathrm{W}$.


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

| Type | Free convection | Forced cooling |
| :--- | :---: | :---: |
| flat, blackened <br> bright | - | $125 \mathrm{~cm}^{2} ; 2 \mathrm{~m} / \mathrm{s}$ or $300 \mathrm{~cm}^{2} ; 1 \mathrm{~m} / \mathrm{s}$ |
| $175 \mathrm{~cm}^{2} ; 2 \mathrm{~m} / \mathrm{s}$ |  |  |$|$| diecast 56280 |
| :--- |
| applicable |

[^2]
## 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 $\mathrm{T}_{\mathrm{amb}}=40^{\circ} \mathrm{C}$. Further assume: average forward current per diode $I_{F}(A V)=10 \mathrm{~A}$; contact thermal resistance:
$\mathrm{R}_{\mathrm{th} \mathrm{mb}-\mathrm{h}}=0,5^{\circ} \mathrm{C} / \mathrm{W}$; repetitive peak reverse power in the avalanche region ( $\mathrm{t}=40 \mu \mathrm{~s}$ ) $\mathrm{P}_{\mathrm{RRM}}=2 \mathrm{~kW}$ (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 $\mathrm{P}_{\text {tot }}=19,5 \mathrm{~W}$ per diode (point A ). The average reverse power in the avalanche region, averaged over any cycle, follows from
$\mathrm{P}_{\mathrm{R}(\mathrm{AV})}=\delta \times \mathrm{P}_{\mathrm{RRM}}$, where the duty cycle $\delta=\frac{40 \mu \mathrm{~s}}{20 \mathrm{~ms}}=0,002$.
Thus $\mathrm{P}_{\mathrm{R}}(\mathrm{AV})=0,002 \times 2 \mathrm{~kW}=4 \mathrm{~W}$.
Therefore the total device power dissipation $P_{\text {tot }}=19,5+4=23,5 \mathrm{~W}$ (point B). From the righthand graph it follows that $\mathrm{R}_{\mathrm{th} \mathrm{mb}-\mathrm{a}}=4^{\circ} \mathrm{C} / \mathrm{W}$. Hence the heatsink thermal resistance should be:

$$
\mathrm{R}_{\mathrm{th} \mathrm{~h}-\mathrm{a}}=\mathrm{R}_{\mathrm{th} \mathrm{mb}-\mathrm{a}}-\mathrm{R}_{\mathrm{th} \mathrm{mb}}=(4-0,5)^{\circ} \mathrm{C} / \mathrm{W}=3,5^{\circ} \mathrm{C} / \mathrm{W} .
$$

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

## Flat heatsink

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


Studs: 10-32UNF
Mounting bases, across the flats: max. $11,0 \mathrm{~mm}$



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


Stud: $1 / 4^{\prime \prime} \times 28$ UNF
Mounting base, across the flats: max. 17 mm


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



## 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 | $\mathrm{V}_{\text {DRM }}$ | max. | 1300 | 1500 | v |
| Non-repetitive peak on-state current | ITSM | max. |  |  | A |
| Controllable anode current | ${ }^{\text {ITCRM }}$ | max. |  |  | A |
| Average on-state current | ${ }^{\prime} \mathrm{T}(\mathrm{AV})$ | max. |  |  | A |
| Fall time | $\mathrm{t}_{\mathrm{f}}$ | max. |  |  | ns |

MECHANICAL DATA
Dimensions in mm
Fig. 1 TO-220AB


Net mass: 2 g


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

## RATINGS

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

| Anode to cathode |  |  | BT157-1300R | 1500R |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Transient off-state voltage | $\mathrm{V}_{\text {DSM }}$ | max. | 1500 | 1650 | V* |
| Repetitive peak off-state voltage | $V_{\text {DRM }}$ | max. | 1300 | 1500 | V* |
| Working off-state voltage | $V_{\text {DW }}$ | max. | 1200 | 1300 | V* |
| Continuous off-state voltage | $\mathrm{V}_{\mathrm{D}}$ | max. | 750 | 800 | V* |
| Average on-state current (averaged over any 20 ms period) up to $\mathrm{T}_{\mathrm{mb}}=80^{\circ} \mathrm{C}$ | ${ }^{1} \mathrm{~T}(\mathrm{AV})$ | max. |  |  | A |
| Controllable anode current | ${ }^{\text {ITCRM }}$ | max. |  |  | A |
| Non-repetitive peak on-state current $\mathrm{t}=10 \mathrm{~ms}$; half-sinewave; $\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$ prior to surge | ${ }^{\text {ITSM }}$ | max. |  |  | A |
| $1^{2} \mathrm{t}$ for fusing; $\mathrm{t}=10 \mathrm{~ms}$ | $1^{2} \mathrm{t}$ | max. |  | 2 | $A^{2} \mathrm{~S}$ |
| Total power dissipation up to $\mathrm{T}_{\mathrm{mb}}=25^{\circ} \mathrm{C}$ | $\mathrm{P}_{\text {tot }}$ | max. |  |  | W |

## Gate to cathode

Repetitive peak on-state current
$\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$ prior to surge
gate-cathode forward; $\mathrm{t}=1 \mathrm{~ms}$;
half-sinewave
gate-cathode reverse; t=20 $\mu \mathrm{s}$
Average power dissipation (averaged over any 20 ms period)

| IGFM | max. | 25 | A |
| :--- | :--- | :--- | :--- |
| IGRM | max. | 15 | A |
|  |  |  |  |
| $P_{G}(A V)$ | max. | 2.5 | W |

## Temperatures

| Storage temperature | $\mathrm{T}_{\text {stg }}$ |  | -40 to +150 | ${ }^{\circ} \mathrm{C}$ |
| :---: | :---: | :---: | :---: | :---: |
| Operating junction temperature | $\mathrm{T}_{\mathrm{j}}$ | max. | 120 | ${ }^{\circ} \mathrm{C}$ |
| THERMAL RESISTANCE |  |  |  |  |
| From junction to mounting base | $\mathrm{R}_{\text {th } \mathrm{j}-\mathrm{mb}}$ | $=$ | 2.0 | K/W |
| From mounting base to heatsink with heatsink compound | $\mathrm{R}_{\text {th mb-h }}$ | = | 0.3 | K/W |
| with 56367 alumina insulator and heatsink compound (clip-mounted) | $\mathrm{R}_{\text {th mb-h }}$ | = | 0.8 | K/W |
| From junction to ambient in free air, mounted on a printed circuit board | $\mathrm{R}_{\text {th } \mathrm{j}-\mathrm{a}}$ | $=$ | 60 | K/W |

[^3]
## CHARACTERISTICS

## Anode to cathode

On-state voltage
$I_{T}=2.5 \mathrm{~A} ; \mathrm{I}_{\mathrm{G}}=0.2 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$
$\mathrm{V}_{\mathrm{T}}$
$<$
$3.4 \quad V^{*}$

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

$$
\mathrm{V}_{\mathrm{D}}=2 / 3 \mathrm{~V}_{\mathrm{Dmax}} ; \mathrm{V}_{\mathrm{GR}}=5 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} \quad \mathrm{~d} \mathrm{~V}_{\mathrm{D}} / \mathrm{dt} \quad<\quad 10 \mathrm{kV} / \mathrm{s}
$$

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

$$
\mathrm{I}_{\mathrm{T}}=1.8 \mathrm{~A} ; \mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DRMmax}} ; \mathrm{V}_{G R}=10{\mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} \quad \mathrm{dV} \mathrm{~V}_{\mathrm{D}} / \mathrm{dt} \quad<\quad 1.5 \mathrm{kV} / \mathrm{s} \mathrm{~s} .}^{2}
$$

## Off-state current

$\mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\text {Dmax }} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$
Latching current; $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$

| ID | $<$ | 2.0 | $m A$ |
| :--- | :--- | ---: | :--- |
| IL | typ. | 0.75 | A** $^{*}$ |

## Gate to cathode

Voltage that will trigger all devices
$\mathrm{V}_{\mathrm{D}}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C} \quad \mathrm{V}_{\mathrm{GT}} \quad>\quad 1.5 \mathrm{~V}$
Current that will trigger all devices
$\mathrm{V}_{\mathrm{D}}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
IGT $>\quad 200 \mathrm{~mA}$

Minimum reverse breakdown voltage
$\mathrm{I}_{\mathrm{GRM}}=1.0 \mathrm{~mA} \quad \mathrm{~V}_{(\mathrm{BR}) \mathrm{GR}} \gg 10 \mathrm{~V}$

## Switching characteristics (resistive load)

Turn-on when switched to $\mathrm{I}_{\mathrm{T}}=2.5 \mathrm{~A}$ from $\mathrm{V}_{\mathrm{D}}=250 \mathrm{~V}$
with $\mathrm{I}_{\mathrm{GF}}=0.4 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
delay time
$t_{d}$
rise time
$t_{r}$
$<\quad 0.25$
$<\quad 1.0$ $\mu \mathrm{s}$
$\mu \mathrm{s}$


Fig. 2 Waveforms

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

Switching characteristics (inductive load)
Turn-off when switched from $I_{T}=2.5 A$ to $V_{D}=V_{D R M}$ max.
$\mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{L}_{\mathrm{G}} \leqslant 1.5 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H}, \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$

| storage time | $\mathrm{t}_{\mathrm{s}}$ | $<$ | 0.5 | $\mu \mathrm{~s}$ |
| :--- | :--- | :--- | ---: | :--- |
| fall time | $\mathrm{t}_{\mathrm{f}}$ | $<$ | 0.20 | $\mu \mathrm{~s}$ |
| peak reverse gate current | $\mathrm{I}_{\mathrm{GR}}$ | $<$ | 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.
$a=$ form factor $=\frac{\mathrm{I} T(R M S)}{\mathrm{I}_{\mathrm{T}}(A V)}$
$P=$ Power excluding switching losses


Fig. 6 Anode current which can be turned off versus anode voltage; inductive load, $\mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{L}_{\mathrm{G}} \leqslant 1.5 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=85^{\circ} \mathrm{C}$ ${ }^{*} d V_{D} / d t$ is calculated from $I_{T} / C_{S}$.


Fig. 7 Anode current which can be turned off versus applied $d V_{D} / \mathrm{dt}^{*}$; inductive load; $\mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V}$; $\mathrm{L}_{\mathrm{G}} \leqslant 1.5 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} ;{ }^{*} \mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ is calculated from $\mathrm{I}_{\mathrm{T}} / \mathrm{C}_{\mathrm{S}}$.


Fig. 8 Anode current which can be turned off versus applied $d V_{D} / d t$; inductive load; $V_{G R}=5 \mathrm{~V}$. $\mathrm{L}_{\mathrm{G}} \leqslant 1.5 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} ;{ }^{*} \mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ is calculated from $\mathrm{I}_{\mathrm{T}} / \mathrm{C}_{\mathrm{S}}$.


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


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


Fig. 11 Maximum $\mathrm{V}_{\mathrm{T}}$ versus $\mathrm{I}_{\mathrm{T}}$;


Fig. 12 Peak reverse gate current versus anode current at turn-off; inductive load; $\mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V}$; $\mathrm{I}_{\mathrm{G}}=0.2 \mathrm{~A} ; \mathrm{L}_{\mathrm{G}}=0.8 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$; maximum values.


Fig. 13 Peak reverse gate current versus applied gate voltage; inductive load; $I_{T}=2.5 \mathrm{~A}$;
$\mathrm{I}_{\mathrm{G}}=0.2 \mathrm{~A} ; \mathrm{L}_{\mathrm{G}}=0.8 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$; maximum values.


Fig. 14 Switching times as a function of junction temperature; $\mathrm{V}_{\mathrm{D}} \geqslant 250 \mathrm{~V} ; \mathrm{I}_{\mathrm{T}}=2.5 \mathrm{~A} ; \mathrm{I}_{\mathrm{GF}}=0.4 \mathrm{~A}$; $\mathrm{I}_{\mathrm{G}}=0.2 \mathrm{~A} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{L}_{\mathrm{G}}=0.8 \mu \mathrm{H}$; maximum values.


Fig. 15 Transient thermal impedance.


Fig. 1.6 Storage and fall times versus applied reverse gate voltage; inductive load; $\mathrm{I}_{\mathrm{T}}=2.5 \mathrm{~A} ; \mathrm{L}_{\mathrm{G}}=0.8 \mu \mathrm{H} ; \mathrm{I}_{\mathrm{G}}=0.2 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$; maximum values.


Fig. 17 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ (calculated from $\mathrm{I}_{\mathrm{T}} / \mathrm{C}_{\mathrm{S}}$ ); reapplied voltage sinsusoidal up to $\mathrm{V}_{\mathrm{DRM}}=1200 \mathrm{~V} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V}$; $\mathrm{I}_{\mathrm{G}}=0.2 \mathrm{~A} ; \mathrm{L}_{\mathrm{G}} \leqslant 1.5 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$.


Fig. 18 Energy loss at turn off as a function of junction temperature; $\mathrm{I}_{\mathrm{G}}=0.2 \mathrm{~A} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V}$. Normalised to $\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$.

## FAST GATE TURN-OFF THYRISTORS

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

QUICK REFERENCE DATA

| Repetitive peak off-state voltage | $V_{\text {DRM }}$ | BTR59-800R |  | $\frac{1300 R}{1300}$ | V |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | max. | 800 |  |  |
| Controllable anode current | $I_{\text {ITCRM }}$ | max. |  |  | A |
| Average on-state current | ${ }^{1} \mathrm{~T}(\mathrm{AV})$ | max. |  |  | A |
| Circuit commutated turn-off time | $\mathrm{t}_{\mathrm{q}}$ | < |  |  | $\mu \mathrm{s}$ |

MECHANICAL DATA
Dimensions in mm
Fig. 1 SOT93; anode connected to mounting base.


M2282


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

## RATINGS

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

## Anode to cathode

Transient off-state voltage
Repetitive peak off-state voltage
Working off-state voltage
Continuous off-state voltage
Average on-state current (averaged over any 20 ms period) up to $\mathrm{T}_{\mathrm{mb}}=85^{\circ} \mathrm{C}$
R.M.S. on-state current

Controllable anode current
Non-repetitive peak on-state current
$\mathrm{t}=10 \mathrm{~ms}$; half-sinewave;
$\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$ prior to surge
$1^{2} \mathrm{t}$ for fusing; $\mathrm{t}=10 \mathrm{~ms}$
Total power dissipation up to $\mathrm{T}_{\mathrm{mb}}=25^{\circ} \mathrm{C}$

## Gate to cathode

Repetitive peak current $\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$ prior to surge
gate-cathode forward; $\mathrm{t}=10 \mathrm{~ms}$;
half-sinewave
gate-cathode reverse; t $=20 \mu \mathrm{~s}$
Average power dissipation (averaged over any 20 ms period)

IGFM max.
IGRM
$\mathrm{P}_{\mathrm{G}}(\mathrm{AV})$
max.
5.0

| Storage temperature | $\mathrm{T}_{\text {stg }}$ | -40 to +125 |  | ${ }^{\circ} \mathrm{C}$ |
| :---: | :---: | :---: | :---: | :---: |
| Operating junction temperature | $\mathrm{T}_{\mathrm{j}}$ | max. | 120 | ${ }^{\circ} \mathrm{C}$ |
| THERMAL RESISTANCE |  |  |  |  |
| From mounting base to heatsink; with heatsink compound | $\mathrm{R}_{\text {th mb-h }}$ | $=$ | 0.2 | K/W |
| From junction to mounting base | $\mathrm{R}_{\text {th j-mb }}$ | $=$ | 0.9 | K/W |

THERMAL RESISTANCE
From mounting base to heatsink; with heatsink compound

From junction to mounting base

| BTR59-800R |  | 1300 R |  |
| ---: | ---: | ---: | :--- |
| max. | 800 | 1300 | $\mathrm{~V}^{*}$ |
| $\max$. | 800 | 1300 | $\mathrm{~V}^{*}$ |
| $\max$. | 600 | 1000 | $\mathrm{~V}^{*}$ |
| $\max$. | 400 | 750 | $\mathrm{~V}^{*}$ |

max. 10
max. 16.5
max.
50

| max. | 100 |
| :--- | ---: |
| $\max$. | 50 |
| $\max$. | 105 |

A
$\mathrm{A}^{2} \mathrm{~s}$
W

## Temperatures

[^4]
## CHARACTERISTICS

## Anode to cathode

On－state voltage

$$
\mathrm{I}_{\mathrm{T}}=10 \mathrm{~A} ; \mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} \quad \mathrm{~V}_{\mathrm{T}} \quad<\quad 3.0 \quad \mathrm{~V}^{*}
$$

Rate of rise of off－state voltage that will not
trigger any off－state device；exponential method
$\mathrm{V}_{\mathrm{D}}=2 / 3 \mathrm{~V}_{\text {Dmax }} ; \mathrm{V}_{\mathrm{GR}}=5 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} \quad \mathrm{dV} / \mathrm{dt}<10 \mathrm{kV} / \mu \mathrm{s}$
Rate of rise of off－state voltage that will not trigger
any device following conduction，linear method
$\mathrm{I}_{\mathrm{T}}=20 \mathrm{~A} ; \mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DRMmax}} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} \quad \mathrm{dV}_{\mathrm{D}} / \mathrm{dt} \quad<\quad 1.0 \mathrm{kV} / \mu \mathrm{s}$
Off－state current
$\mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\text {Dmax }} \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$
$I_{D} \quad<\quad 5.0 \quad \mathrm{~mA}$

Latching current； $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
$\mathrm{I}_{\mathrm{L}}$ typ． $1.5 \mathrm{~A}^{* *}$

## Gate to cathode

Voltage that will trigger all devices
$V_{D}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
Current that will trigger all devices
$\mathrm{V}_{\mathrm{D}}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
$\mathrm{V}_{\mathrm{GT}} \gg 1.5 \mathrm{~V}$

Minimum reverse breakdown voltage
$I_{\mathrm{GR}}=1.0 \mathrm{~mA}$
IGT $\gg 500 \mathrm{~mA}$

## Switching characteristics（resistive load）

Turn－on when switched to $I_{T}=10 \mathrm{~A}$ from $\mathrm{V}_{\mathrm{D}}=250 \mathrm{~V}$
with $\mathrm{I}_{\mathrm{GF}}=2.5 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
delay time

| $\mathrm{t}_{\mathrm{d}}$ | $<$ | 0.3 | $\mu \mathrm{~s}$ |
| :--- | :--- | :--- | :--- |
| $\mathrm{t}_{\mathrm{r}}$ | $<$ | 1.5 | $\mu \mathrm{~s}$ |



Fig． 2 Waveforms．

[^5]
## Switching characteristics (inductive load)

| Turn-off when switched from $\mathrm{I}_{\mathrm{T}}=10 \mathrm{~A}$ to $\mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\text {Dmax }}$; |  |  |  |
| :---: | :---: | :---: | :---: |
| $\mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{L}_{\mathrm{G}} \leqslant 0.5 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} ; \mathrm{C}_{\mathrm{S}} \geqslant 20 \mathrm{nF} ; \mathrm{T}_{\mathrm{j}}=85^{\circ} \mathrm{C}$ |  |  |  |
| storage time | $\mathrm{t}_{\mathrm{s}}$ | $<$ | 0.60 |
| fall time | $\mathrm{t}_{\mathrm{f}}$ | $<$ | 0.25 |
| peak reverse gate current | ${ }^{\prime} \mathrm{GR}$ | < | 10 |




Fig. 3 Waveforms.


Fig. 4 Inductive load test circuit.
*Indicates stray series inductance only.

## Switching characteristics (circuit-commutated)*

> Turn-off time $$
I_{T}=50 \mathrm{~A} ;-\mathrm{d} I_{T} / \mathrm{dt}=10 \mathrm{~A} / \mu \mathrm{s} ; \mathrm{dV} \mathrm{D} / \mathrm{dt}=200 \mathrm{~V} / \mu \mathrm{s} \text {; }
$$

$\mathrm{V}_{\mathrm{GR}}=5 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} \quad \mathrm{t}_{\mathrm{q}} \quad<\quad 1.0 \quad \mu \mathrm{~s}$


Fig. 5 Circuit-commutated turn-off time definition.
*Figs. $7,11,12,13,15,16,17$ do not apply to commutated turn-off.

## BTR59 SERIES



Fig. 6 The right hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.
$a=$ form factor $=\frac{I_{T}(R M S)}{I_{T}(A V)}$
$P=$ power excluding switching losses.


Fig. 7 Anode current which can be turned off versus applied $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}^{*}$; inductive load; $\mathrm{L}_{\mathrm{G}} \leqslant 0.5 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$.
${ }^{*} d V_{D} / d t$ is calculated from $I_{T} / C_{S}$.


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


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


Fig. 10 Maximum $\mathrm{V}_{\mathrm{T}}$ versus $\mathrm{I}_{\mathrm{T}} ;---\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C} ;-\mathrm{T}_{\mathrm{j}}=120^{\circ}{ }^{\circ} \mathrm{C} ; \mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A}$.

Fast gate turn-off thyristors


Fig. 12 Peak reverse gate current versus applied reverse gate voltage; inductive load;
$\mathrm{I}_{\mathrm{T}}=10 \mathrm{~A} ; \mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A} ; \mathrm{L}_{\mathrm{G}}=0.4 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} ;$ maximum values.


Fig. 13 Switching times as a function of junction temperature; $V_{D} \geqslant 250 \mathrm{~V}$; $I_{T}=10 \mathrm{~A}$; $\mathrm{I}_{\mathrm{GF}}=1.0 \mathrm{~A} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A} ; \mathrm{L}_{\mathrm{G}}=0.4 \mu \mathrm{H}$; maximum values.


Fig. 14 Transient thermal impedance.


Fig. 15 Storage and fall times versus applied reverse gate voltage; inductive load, $\mathrm{I}_{\mathrm{T}}=10 \mathrm{~A} ; \mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A} ; \mathrm{L}_{\mathrm{G}}=0.4 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$; maximum values.


Fig. 16 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ (calculated from $\mathrm{I}_{\mathrm{T}} / \mathrm{C}_{\mathrm{S}}$ ); $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ linear up to $\mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DWmax}} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A}$; $\mathrm{L}_{\mathrm{G}}<0.5 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}}<0.25 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$.


Fig. 17 Energy loss at turn-off as a function of junction temperature; $\mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V}$. Normalised to $T_{j}=120^{\circ} \mathrm{C}$.

## BTS59 SERIES

## FAST GATE TURN-OFF THYRISTORS

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

## QUICK REFERENCE DATA

|  |  | BTS59-850R |  | 1000R | 1200R |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Repetitive peak off-state voltage | $V_{\text {DRM }}$ | max. | 850 | 1000 | 1200 | V |
| Non-repetitive peak on-state current | ${ }^{1}$ TSM | max. |  | 100 |  | A |
| Controllable anode current | ITCRM | max. |  | 50 |  | A |
| Average on-state current | ${ }^{\text {I }}$ (AV) | max. |  | 15 |  | A |
| Fall time | $\mathrm{t}_{\mathrm{f}}$ | < |  | 250 |  | ns |

## MECHANICAL DATA

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


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

## RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134)
Anode to cathode
Transient off-state voltage
Repetitive peak off-state voltage
Working off-state voltage
Continuous off-state voltage

|  | BTS59-850R |  | 1000 R | 1200 R |  |
| :--- | ---: | ---: | ---: | ---: | :--- |
| $\mathrm{V}_{\text {DSM }}$ | max. | 1000 | 1100 | 1300 | $\mathrm{~V}^{*}$ |
| $\mathrm{~V}_{\text {DRM }}$ | max. | 850 | 1000 | 1200 | $\mathrm{~V}^{*}$ |
| $\mathrm{~V}_{\text {DW }}$ | max. | 600 | 800 | 1000 | $\mathrm{~V}^{*}$ |
| $\mathrm{~V}_{\mathrm{D}}$ | max. | 500 | 650 | 750 | $\mathrm{~V}^{*}$ |

Average on-state current (averaged over any

| 20 ms period) up to $\mathrm{T}_{\mathrm{mb}}=85^{\circ} \mathrm{C}$ | $\mathrm{I} \mathrm{T}(\mathrm{AV})$ | max. | 15 | A |
| :--- | :--- | :--- | ---: | :--- |
| Controllable anode current | ITCRM | max. | 50 | A |
| Non-repetitive peak on-state current <br> $\mathrm{t}=10 \mathrm{~ms} ;$ half-sinewave; |  |  |  |  |
| $\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$ prior to surge | $\mathrm{I}^{2} \mathrm{TSM}$ | max. | 100 | A |
| $2^{2} \mathrm{t}$ for fusing; $\mathrm{t}=10 \mathrm{~ms}$ | $\mathrm{I}^{2} \mathrm{t}$ | max. | 50 | $\mathrm{~A}^{2} \mathrm{~s}$ |
| Total power dissipation up to $\mathrm{T}_{\mathrm{mb}}=25^{\circ} \mathrm{C}$ | $\mathrm{P}_{\text {tot }}$ | max. | 105 | W |

## Gate to cathode

Repetitive peak current
$\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$ prior to surge
gate-cathode forward; $\mathrm{t}=10 \mathrm{~ms}$;
half-sinewave
gate-cathode reverse; $\mathrm{t}=20 \mu \mathrm{~s}$

| IGFM | max. | 25 | A |
| :--- | :--- | :--- | :--- |
| IGRM | max. | 25 | A |
|  |  |  |  |
| $P_{G}(A V)$ | max. | 5.0 | W |

## Temperatures

Storage temperature
Operating junction temperature

| $\mathrm{T}_{\text {stg }}$ |  | -40 to +125 |
| :--- | ---: | ---: |
| $\mathrm{~T}_{\mathrm{j}}$ | max. | 120 |

${ }^{\circ} \mathrm{C}$
${ }^{\circ} \mathrm{C}$

## THERMAL RESISTANCE

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

K/W
0.9

K/w

[^6]
## CHARACTERISTICS

## Anode to cathode

On-state voltage

$$
I_{\mathrm{T}}=10 \mathrm{~A} ; \mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} \quad \mathrm{~V}_{\mathrm{T}} \quad<\quad 2.3 \quad \mathrm{~V}^{*}
$$

Rate of rise of off-state voltage that will not
trigger any off-state device; exponential method
$\mathrm{V}_{\mathrm{D}}=2 / 3 \mathrm{~V}_{\text {Dmax }} ; \mathrm{V}_{\mathrm{GR}}=5 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} \quad \mathrm{dV}_{\mathrm{D}} / \mathrm{dt} \quad<\quad 10 \mathrm{kV} / \mu \mathrm{s}$
Rate of rise of off-state voltage that will not trigger any device following conduction, linear method
$I_{T}=20 \mathrm{~A} ; \mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DRMmax}} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} \quad \mathrm{d} \mathrm{V}_{\mathrm{D}} / \mathrm{dt} \quad<\quad 1.0 \mathrm{kV} / \mu \mathrm{s}$
Off-state current.
$V_{D}=V_{\text {Dmax }} ; T_{j}=120^{\circ} \mathrm{C}$
Latching current; $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$

| $I_{\mathrm{D}}$ | $<$ | 5.0 | mA |
| :--- | :--- | :--- | :--- |
| $\mathrm{I}_{\mathrm{L}}$ | typ. | 1.5 | $\mathrm{~A}^{* *}$ |

## Gate to cathode

Voltage that will trigger all devices
$\mathrm{V}_{\mathrm{D}}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$

| $\mathrm{V}_{\mathrm{GT}}$ | $>$ | 1.5 | V |
| :--- | :--- | :--- | :--- |
| $\mathrm{I}_{\mathrm{GT}}$ | $>$ | 300 | mA |
| $\mathrm{~V}_{(\mathrm{BR}) \mathrm{GR}}$ | $>$ | 10 | V |

## Switching characteristics (resistive load)

Turn-on when switched to $I_{T}=10 \mathrm{~A}$ from $\mathrm{V}_{\mathrm{D}}=250 \mathrm{~V}$
with $\mathrm{I}_{\mathrm{GF}}=1.5 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$

| delay time | $\mathrm{t}_{\mathrm{d}}$ | $<$ | 0.3 | $\mu \mathrm{~s}$ |
| :--- | :--- | :--- | :--- | :--- |
| rise time | $\mathrm{t}_{\mathrm{r}}$ | $<$ | 1.5 | $\mu \mathrm{~s}$ |



Fig. 2 Waveforms

[^7]
## Switching characteristics (inductive load)

Turn-off when switched from $I_{T}=10 \mathrm{~A}$ to $\mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{Dmax}} ;$
$\rightarrow \quad V_{G R}=10 \mathrm{~V} ; \mathrm{L}_{\mathrm{G}} \leqslant 0.5 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} ; \mathrm{C}_{\mathrm{S}} \geqslant 20 \mathrm{nF} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$ storage time
fall time
peak reverse gate current

| $\mathrm{t}_{\mathrm{s}}$ | $<$ | 0.60 | $\mu \mathrm{~s}$ |
| :--- | :--- | ---: | :--- |
| $\mathrm{t}_{\mathrm{f}}$ | $<$ | 0.25 | $\mu \mathrm{~s}$ |
| $\mathrm{I}_{\mathrm{GR}}$ | $<$ | 10 | A |



Fig. 3 Waveforms.


Fig. 4 Inductive load test circuit.


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 $=\frac{I_{T}(R M S)}{I_{T}(A V)}$
$P=$ power excluding switching losses.


Fig. 6 Anode current which can be turned off versus anode voltage; inductive load; $\mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{L}_{\mathrm{G}} \leqslant 0.5 \mu \mathrm{H}$;
$\mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$.
${ }^{*} \mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ is calculated from $\mathrm{I}_{\mathrm{T}} / \mathrm{C}_{\mathrm{S}}$.


Fig. 7 Anode current which can be turned off versus applied $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}^{*}$; inductive load; $\mathrm{L}_{\mathrm{G}} \leqslant 0.5 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} .{ }^{*} \mathrm{~d} \mathrm{~V}_{\mathrm{D}} / \mathrm{dt}$ is calculated from $\mathrm{I}_{\mathrm{T}} / \mathrm{C}_{\mathrm{S}}$.


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


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


Fig. 10 Maximum $\mathrm{V}_{\mathrm{T}}$ versus $\mathrm{I}_{\mathrm{T}} ;-\quad \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C} ;----\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$.


Fig. 11 Peak reverse gate current versus anode current at turn-off; inductive load;
$\mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A} ; \mathrm{L}_{\mathrm{G}}=0.4 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$; maximum values.


Fig. 12 Peak reverse gate current versus applied reverse gate voltage; inductive load; $\mathrm{I}_{\mathrm{T}}=10 \mathrm{~A} ; \mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A}, \mathrm{~L}_{\mathrm{G}}=0.4 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$; maximum values.


Fig. 13 Switching times as a function of junction temperature; $\mathrm{V}_{\mathrm{D}} \geqslant 250 \mathrm{~V}$; $\mathrm{I}_{\mathrm{T}}=10 \mathrm{~A}$; $\mathrm{I}_{\mathrm{GF}}=1.0 \mathrm{~A} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A} ; \mathrm{L}_{\mathrm{G}}=0.4 \mu \mathrm{H}$; maximum values.


Fig. 14 Transient thermal impedance.


Fig. 15 Storage and fall times versus applied reverse gate voltage; inductive load; $\mathrm{I}_{\mathrm{T}}=10 \mathrm{~A} ; \mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A} ; \mathrm{L}_{\mathrm{G}}=0.4 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$; maximum values.


Fig. 16 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ (calculated from $\mathrm{I}_{\mathrm{T}} / \mathrm{C}_{\mathrm{S}}$ ); $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ linear up to $\mathrm{V}_{\mathrm{Dmax}}=600 \mathrm{~V} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A}$; $\mathrm{L}_{\mathrm{G}} \leqslant 0.5 \mu \mathrm{H}$; $\mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$.


Fig. 17 Energy loss at turn off as a function of junction temperature; $\mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V}$. Normalised to $\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$.

## 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 | $\mathrm{V}_{\text {DRM }}$ | max. | 600 | 850 | 1000 | v |
| Non-repetitive peak on-state current | ${ }^{\text {T TSM }}$ | max. |  | 75 |  | A |
| Controllable anode current | ${ }^{\text {It }}$ TCRM | max. |  | 25 |  | A |
| Average on-state current | $I_{\text {If }}(\mathrm{AV})$ | max. |  | 10 |  | A |
| Fall time | $\mathrm{t}_{\mathrm{f}}$ | max. |  | 250 |  | ns |

## MECHANICAL DATA

Dimensions in mm
Fig. 1 TO-220AB.


Net mass: $\mathbf{2 g}$


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

Transient off-state voltage*
Repetitive peak off-state voltage *
Working off-state voltage *
Continuous off-state voltage *
Average on-state current (averaged over any
20 ms period) up to $\mathrm{T}_{\mathrm{mb}}=80^{\circ} \mathrm{C}$
Controllable anode current

|  | BTV58-600R |  | 850 R | 1000 R |
| :--- | :--- | :--- | ---: | ---: |
| $\mathrm{V}_{\text {DSM }}$ | max. | 750 | 1000 | 1100 V |
| $\mathrm{~V}_{\text {DRM }}$ | max. | 600 | 850 | 1000 V |
| $\mathrm{~V}_{\text {DW }}$ | max. | 400 | 600 | 800 V |
| $\mathrm{~V}_{\mathrm{D}}$ | max. | 400 | 500 | 650 V |
|  |  |  | 10 | A |
| IT(AV) | max. |  | 25 | A |

Non-repetitive peak on-state current

$$
t=10 \mathrm{~ms} \text {; half-sinewave; }
$$

$\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$ prior to surge $\quad$ ITSM max. 75 A
$1^{2} t$ for fusing; $t=10 \mathrm{~ms}$
Total power dissipation up to $\mathrm{T}_{\mathrm{mb}}=25^{\circ} \mathrm{C}$

| $\mathrm{I}^{2} \mathrm{t}$ | max. |
| :--- | :--- |
| $\mathrm{P}_{\text {tot }}$ | max. |

28
$P_{\text {tot }} \max .65$
W

## Gate to cathode

Repetitive peak on-state current
$\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$ prior to surge
gate-cathode forward; $\mathrm{t}=10 \mathrm{~ms}$; half-sinewave
IGFM max. 25

A gate-cathode reverse; $\mathrm{t}=20 \mu \mathrm{~s}$

IGRM
max.
25
A
Average power dissipation (averaged over any 20 ms period)
$\mathrm{P}_{\mathrm{G}}(\mathrm{AV})$ max. $\quad 2,5 \quad \mathrm{~W}$

## Temperatures

Storage temperature
Operating junction temperature
THERMAL RESISTANCE

| From junction to mounting base |  |  |  |
| :--- | :--- | :--- | :--- |
| From mounting base to heatsink <br> with heatsink compound | $\mathrm{R}_{\text {th j-mb }}=$ | 1,5 | $\mathrm{~K} / \mathrm{W}$ |
| with 56367 alumina insulator and <br> heatsink compound (clip-mounted) | $\mathrm{R}_{\text {th mb-h }}=$ | 0,3 | $\mathrm{~K} / \mathrm{W}$ |
| th mb-h $=$ | 0,8 | $\mathrm{~K} / \mathrm{W}$ |  |

[^8]
## CHARACTERISTICS

## Anode to cathode

On-state voltage

$$
\mathrm{I}_{\mathrm{T}}=5 \mathrm{~A} ; \mathrm{I}_{\mathrm{G}}=0.2 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} \quad \mathrm{~V}_{\mathrm{T}} \quad<\quad 1.8 \quad \mathrm{~V}^{*}
$$

Rate of rise of off-state voltage that will not trigger any off-state device; exponential method $\mathrm{V}_{\mathrm{D}}=2 / 3 \mathrm{~V}_{\text {Dmax }} ; \mathrm{V}_{\mathrm{GR}}=5 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$

$$
\begin{equation*}
\mathrm{d} \mathrm{~V}_{\mathrm{D}} / \mathrm{dt} \tag{10}
\end{equation*}
$$

$\mathrm{kV} / \mu \mathrm{s}$
Rate of rise of off-state voltage that will not trigger any device following conduction, linear method $\mathrm{I}_{\mathrm{T}}=5 \mathrm{~A} ; \mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DRMmax}} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} \quad \mathrm{dV} / \mathrm{dt} \ll 1.5 \mathrm{kV} / \mathrm{s}$

Off-state current
$\mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\text {Dmax }} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$
${ }^{1} D$
Latching current; $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
IL typ. 1.0 A**

## Gate to cathode

Voltage that will trigger all devices

$$
\mathrm{V}_{\mathrm{D}}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}
$$

Current that will trigger all devices

$$
V_{D}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}
$$

| $\mathrm{V}_{\mathrm{GT}}$ | $>$ | 1.5 | V |
| :--- | :--- | :--- | :--- |
| $\mathrm{I}_{\mathrm{GT}}$ | $>$ | 200 | mA |

Minimum reverse breakdown voltage

$$
\mathrm{I}_{\mathrm{GR}}=1.0 \mathrm{~mA}
$$

$\mathrm{V}_{(\mathrm{BR}) \mathrm{GR}} \gg 10 \mathrm{~V}$

## Switching characteristics (resistive load)

Turn-on when switched to $\mathrm{I}_{\mathrm{T}}=5 \mathrm{~A}$ from $\mathrm{V}_{\mathrm{D}}=250 \mathrm{~V}$
with $\mathrm{I}_{\mathrm{GF}}=0.5 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
delay time $t_{d}$

| $\mathrm{t}_{\mathrm{d}}$ | $<$ | 0.25 | $\mu \mathrm{~s}$ |
| :--- | :--- | ---: | ---: |
| $\mathrm{t}_{\mathrm{r}}$ | $<$ | 1.0 | $\mu \mathrm{~s}$ |



Fig. 2 Waveforms

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


## BTV58 SERIES

## Switching characteristics (inductive load)

$\begin{array}{llrrr}\text { Turn-off when switched from } I_{T}=5 \mathrm{~A} \text { to } \mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{Dmax}} ; \\ \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{L}_{\mathrm{G}} \leqslant 1.0 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=25{ }^{\circ} \mathrm{C} & & & \\ \text { storage time } & \mathrm{t}_{\mathrm{S}} & < & 0.5 & \mu \mathrm{~s} \\ \text { fall time } & \mathrm{t}_{\mathrm{f}} & < & 0.25 & \mu \mathrm{~s} \\ \text { peak reverse gate current } & \mathrm{I}_{\mathrm{GR}} & < & 6 & \mathrm{~A}\end{array}$



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 $=\frac{\operatorname{l} T(R M S)}{\operatorname{l} T(A V)}$
$P=$ power excluding switching losses.
${ }^{*}$ Mounting-base temperature scale is for comparison purposes and is correct only for $R_{\text {th }} \mathrm{mb}-\mathrm{a}<9.6 \mathrm{~K} / \mathrm{W}$.


Fig. 6 Anode current which can be turned off versus anode voltage; inductive load; $\mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{L}_{\mathrm{G}} \leqslant 1.0 \mu \mathrm{H}$; $\mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=85^{\circ} \mathrm{C}$.
${ }^{*} \mathrm{~d}_{\mathrm{D}} / \mathrm{dt}$ is calculated from $\mathrm{I}_{\mathrm{T}} / \mathrm{C}_{\mathrm{S}}$.


Fig. 7 Anode current which can be turned off versus applied $\mathrm{d} \mathrm{V}_{\mathrm{D}} / \mathrm{dt}^{*}$; inductive load; $\mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V}$. $\mathrm{L}_{\mathrm{G}} \leqslant 1.0 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H}$. ${ }^{*} \mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ is calculated from $\mathrm{I}_{\mathrm{T}} / \mathrm{C}_{\mathrm{S}}$.


Fig. 8 Anode current which can be turned off versus applied $\mathrm{d} \mathrm{V}_{\mathrm{D}} / \mathrm{dt}^{*}$; inductive load; $\mathrm{V}_{\mathrm{GR}}=5 \mathrm{~V}$. $\mathrm{L}_{\mathrm{G}} \leqslant 1.0 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} ;{ }^{*} \mathrm{~d} \mathrm{~V}_{\mathrm{D}} / \mathrm{dt}$ is calculated from $\mathrm{I}_{\mathrm{T}} / \mathrm{C}_{\mathrm{S}}$.


Fig. 11 Maximum $\mathrm{V}_{\mathrm{T}}$ versus $\mathrm{I}_{\mathrm{T}} ;-\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C} ;---\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$.

Fast gate turn-off thyristors
BTV58 SERIES


Fig. 12 Peak reverse gate current versus anode current at turn-off; inductive load; $\mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{I}_{\mathrm{G}}=0.2 \mathrm{~A} ; \mathrm{L}_{\mathrm{G}}=0.8 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$; maximum values.


Fig. 13 Peak reverse gate current versus applied reverse gate voltage; inductive load; $I_{T}=5 \mathrm{~A}$; $\mathrm{I}_{\mathrm{G}}=0.2 \mathrm{~A} ; \mathrm{L}_{\mathrm{G}}=0.8 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$; maximum values.


Fig. 14 Switching times as a function of junction temperature; $\mathrm{V}_{\mathrm{D}} \geqslant 250 \mathrm{~V} ; \mathrm{I}_{\mathrm{T}}=5 \mathrm{~A}$; $\mathrm{I}_{\mathrm{GF}}=0.5 \mathrm{~A} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{I}_{\mathrm{G}}=0.2 \mathrm{~A} ; \mathrm{L}_{\mathrm{G}}=0.8 \mu \mathrm{H}$; maximum values.


Fig. 15 Transient thermal impedance.


Fig. 16 Storage and fall times versus applied reverse gate voltage; inductive load; $I_{T}=5 \mathrm{~A} ; \mathrm{I}_{\mathrm{G}}=0.2 \mathrm{~A} ; \mathrm{L}_{\mathrm{G}}=0.8 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$; maximum values.


Fig. 17 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ (calculated from $\mathrm{I}_{\mathrm{T}} / \mathrm{C}_{\mathrm{S}}$ ); $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ linear up to $\mathrm{V}_{\mathrm{Dmax}}=600 \mathrm{~V} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{I}_{\mathrm{G}}=0.2 \mathrm{~A}$; $\mathrm{L}_{\mathrm{G}} \leqslant 1.0 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$.


Fig. 18 Energy loss at turn off as a function of junction temperature; $\mathrm{I}_{\mathrm{G}}=0.2 \mathrm{~A} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V}$. Normalised to $\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$.

## 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 | VDRM | max. | 600 | 850 | 1000 | V |
| Non-repetitive peak on-state current | ITSM | max. |  | 100 |  | A |
| Controllable anode current | $I_{\text {TCRM }}$ | max. |  | 50 |  | A |
| Average on-state current | ${ }^{1} \mathrm{~T}(\mathrm{AV})$ | max. |  | 15 |  | A |
| Fall time | $\mathrm{t}_{\mathrm{f}}$ | < |  | 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

| Transient off-state voltage | V $_{\text {DSM }}$ |
| :--- | :--- |
| Repetitive peak off-state voltage | VDRM |
| Working off-state voltage | VDW |
| Continuous off-state voltage | VD |


| BTV59-600R |  | $850 R$ | $1000 R$ |  |
| :--- | :--- | :---: | ---: | :---: |
| max. | 750 | 1000 | 1100 | $V^{*}$ |
| max. | 600 | 850 | 1000 | $V^{*}$ |
| max. | 400 | 600 | 800 | $V^{*}$ |
| $\max$. | 400 | 500 | 650 | $V^{*}$ |

Average on-state current (averaged over any
20 ms period) up to $\mathrm{T}_{\mathrm{mb}}=60^{\circ} \mathrm{C}$
Controllable anode current

| IT(AV) | max. | 15 | A |
| :--- | :--- | :--- | :--- |
| ITCRM | $\max$. | 50 | A |

Non-repetitive peak on-state current
$\mathrm{t}=10 \mathrm{~ms}$; half-sinewave;

| $\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$ prior to surge | $\mathrm{I}_{\mathrm{TSM}}$ | $\max$. | 100 | A |
| :--- | :--- | :--- | :--- | :--- |
| ${ }^{2} \mathrm{t}$ for fusing; $\mathrm{t}=10 \mathrm{~ms}$ | $\mathrm{I}^{2} \mathrm{t}$ | $\max$. | 50 | $\mathrm{~A}^{2} \mathrm{~s}$ |
| Total power dissipation up to $\mathrm{T}_{\mathrm{mb}}=25^{\circ} \mathrm{C}$ | $\mathrm{P}_{\mathrm{tot}}$ | max. | 60 | W |

## Gate to cathode

Repetitive peak on-state current
$\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$ prior to surge
gate-cathode forward; $t=10 \mathrm{~ms}$;
half-sinewave
gate-cathode reverse; $\mathrm{t}=20 \mu \mathrm{~s}$

| $\mathrm{I}_{\mathrm{GFM}}$ | max. | 25 | A |
| :--- | :--- | :--- | :--- |
| $\mathrm{I}_{\mathrm{GRM}}$ | max. | 25 | A |
| $\mathrm{P}_{\mathrm{G}(\mathrm{AV})}$ | max. | 5.0 | W |

## Temperatures

Storage temperature
Operating junction temperature

| $T_{\text {stg }}$ |  | -40 to +150 | ${ }^{\circ} \mathrm{C}$ |
| :--- | ---: | ---: | ---: |
| $\mathrm{T}_{\mathrm{j}}$ | max. | 120 | ${ }^{\circ} \mathrm{C}$ |
|  |  |  |  |
| $\mathrm{V}_{\text {isol }}$ | min. | 2500 | V |

## THERMAL RESISTANCE

From mounting base to heatsink;
with heatsink compound
From junction to mounting base

| $R_{\text {th } m b-h}=$ | 0.5 | $\mathrm{~K} / \mathrm{W}$ |
| :--- | :--- | :--- |
| $R_{\text {th } j-m b}=$ | 1.5 | $\mathrm{~K} / W$ |

[^9]
## CHARACTERISTICS

## Anode to cathode

On-state voltage
$\mathrm{I}_{\mathrm{T}}=10 \mathrm{~A} ; \mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} \quad \mathrm{V}_{\mathrm{T}} \quad<\quad 2.3 \quad \mathrm{~V}^{*}$
Rate of rise of off-state voltage that will not
trigger any off-state device; exponential method
$\mathrm{V}_{\mathrm{D}}=2 / 3 \mathrm{~V}_{\text {Dmax }} ; \mathrm{V}_{\mathrm{GR}}=5 \mathrm{~V}_{\mathrm{i}} \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} \quad \mathrm{d} \mathrm{V}_{\mathrm{D}} / \mathrm{dt} \quad<\quad 10 \mathrm{kV} / \mu \mathrm{s}$
Rate of rise of off-state voltage that will not trigger
any device following conduction, linear method
$I_{T}=10 \mathrm{~A} ; \mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DRMmax}} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} \quad \mathrm{d} \mathrm{V}_{\mathrm{D}} / \mathrm{dt} \quad<\quad 1.0 \quad \mathrm{kV} / \mu \mathrm{s}$
Off-state current
$V_{D}=V_{\text {Dmax; }} T_{j}=120^{\circ} \mathrm{C}$
Latching current; $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
${ }^{\prime} \mathrm{D}<5.0 \quad \mathrm{~mA}$
$I_{\mathrm{L}}$ typ. $1.5 \quad \mathrm{~A}^{* *}$

## Gate to cathode

Voltage that will trigger all devices

$$
\mathrm{V}_{\mathrm{D}}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}
$$

| VGT $_{\text {G }}$ | $>$ | 1.5 | V |
| :--- | :--- | :--- | :--- |
| IGT | $>$ | 200 | mA |

Minimum reverse breakdown voltage
$I_{G R}=1.0 \mathrm{~mA}$
$\mathrm{V}_{(\mathrm{BR}) \mathrm{GR}} \gg 10 \mathrm{~V}$

## Switching characteristics (resistive load)

Turn-on when switched to $I_{T}=10 \mathrm{~A}$ from $\mathrm{V}_{\mathrm{D}}=250 \mathrm{~V}$
with $\mathrm{I}_{\mathrm{GF}}=1.0 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
delay time $t_{d}$
$\begin{array}{llll}\mathrm{t}_{\mathrm{d}} & < & 0.3 & \mu \mathrm{~s} \\ \mathrm{t}_{\mathrm{r}} & < & 1.5 & \mu \mathrm{~s}\end{array}$


Fig. 2 Waveforms

[^10]
## Switching characteristics (inductive load)





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 $=\frac{I_{T}(R M S)}{I_{T}(A V)}$
$P=$ power excluding switching losses.


Fig. 6 Anode current which can be turned off versus anode voltage; inductive load; $\mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V}$; $\mathrm{L}_{\mathrm{G}} \leqslant 0.5 \mu \mathrm{H}$; $\mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=85^{\circ} \mathrm{C}$.
${ }^{*} \mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ is calculated from $\mathrm{I}_{\mathrm{T}} / \mathrm{C}_{\mathrm{S}}$.


Fig. 7 Anode current which can be turned off versus applied $\mathrm{d} \mathrm{V}_{\mathrm{D}} / \mathrm{dt}^{*}$; inductive load; $\mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V}$; $\mathrm{L}_{\mathrm{G}} \leqslant 0.5 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} .{ }^{*} \mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ is calculated from $\mathrm{I}_{\mathrm{T}} / \mathrm{C}_{\mathrm{S}}$.


Fig. 8 Anode current which can be turned off versus applied $\mathrm{d}_{\mathrm{D}} / \mathrm{dt}^{*}$; inductive load; $\mathrm{V}_{\mathrm{GR}}=5 \mathrm{~V}$; $\mathrm{L}_{\mathrm{G}} \leqslant 0.5 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} .{ }^{*} \mathrm{~d}_{\mathrm{D}} / \mathrm{dt}$ is calculated from $\mathrm{I}_{\mathrm{T}} / \mathrm{C}_{\mathrm{S}}$.


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


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


Fig. 11 Maximum $\mathrm{V}_{\mathrm{T}}$ versus $\mathrm{I}_{\mathrm{T}} ;-\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C} ;-\ldots-\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$.


Fig. 12 Peak reverse gate current versus anode current at turn-off; inductive load; $\mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A} ; \mathrm{L}_{\mathrm{G}}=0.4 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$; maximum values.


Fig. 13 Peak reverse gate current versus applied reverse gate voltage; inductive load; $\mathrm{I}_{\mathrm{T}}=10 \mathrm{~A}$; $\mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A} ; \mathrm{L}_{\mathrm{G}}=0.4 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} ;$ maximum values.


Fig. 14 Switching times as a function of junction temperature; $\mathrm{V}_{\mathrm{D}} \geqslant 250 \mathrm{~V}$; $\mathrm{I}_{\mathrm{T}}=10 \mathrm{~A}$;



Fig. 15 Transient thermal impedance.


Fig. 16 Storage and fall times versus applied reverse gate voltage; inductive load; $\mathrm{I}_{\mathrm{T}}=10 \mathrm{~A} ; \mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A} ; \mathrm{L}_{\mathrm{G}}=0.4 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$; maximum values.


Fig. 17 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied $\mathrm{dV} \mathrm{V}_{\mathrm{D}} / \mathrm{dt}$ (calculated from $\mathrm{I}_{\mathrm{T}} / \mathrm{C}_{\mathrm{S}}$ ); $\mathrm{d} \mathrm{V}_{\mathrm{D}} / \mathrm{dt}$ linear up to $\mathrm{V}_{\mathrm{Dmax}}=600 \mathrm{~V} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A}$; $\mathrm{L}_{\mathrm{G}} \leqslant 0.5 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$.


Fig. 18 Energy loss at turn off as a function of junction temperature; $\mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V}$. Normalised to $\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$.

## FAST GATE TURN-OFF THYRISTORS WITH ANTI-PARALLEL DIODE

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

QUICK REFERENCE DATA

| GTO |  | BTV59D-850R |  | 1000R | 1200R |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Repetitive peak off-state voltage | $V_{\text {DRM }}$ | max. | 850 | 1000 | 1200 | v |
| Non-repetitive peak on-state current | ${ }^{1}$ TSM | max. |  | 100 |  | A |
| Controllable anode current | ${ }^{\text {ITCRM }}$ | max. |  | 50 |  | A |
| Average on-state current | ${ }^{1} \mathrm{~T}(\mathrm{AV})$ | max. |  | 15 |  | A |
| Fall time | $\mathrm{t}_{\mathrm{f}}$ | < |  | 250 |  | ns |
| Diode |  |  |  |  |  |  |
| Average forward current | ${ }^{\prime} \mathrm{F}(\mathrm{AV})$ | max. |  | 9.0 |  | A |
| Non-repetitive peak forward current | $I_{\text {FSSM }}$ | max. |  | 60 |  | A |
| Reverse recovery time | $t_{\text {rr }}$ | < |  | 600 |  | ns |

Fig. 1 TO-238AA


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

For further information see data sheets BTV59 and BY359.

## RATINGS

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

## Anode to cathode

Transient off-state voltage
Repetitive peak off-state voltage
Working off-state voltage
Continuous off-state voltage

|  | BTV59D-850R |  | 1000R | 1200R |
| :---: | :---: | :---: | :---: | :---: |
| $V_{\text {DSM }}$ | max. | 1000 | 1100 | 1300 |
| $V_{\text {DRM }}$ | max. | 850 | 1000 | 1200 |
| $V_{\text {DW }}$ | max. | 600 | 800 | 1000 |
| $V_{D}$ | max. | 500 | 650 | 750 |

Average on-state current (averaged over any 20 ms period) up to $\mathrm{T}_{\mathrm{mb}}=60^{\circ} \mathrm{C} \quad \mathrm{I}(\mathrm{AV})$
$I_{\text {ITAV }}$
ITCRM
max. 15

Controllable anode current
max.
50
Non-repetitive peak on-state current
$\mathrm{t}=10 \mathrm{~ms}$; half-sinewave;
$\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$ prior to surge
$\mathrm{I}^{2} \mathrm{t}$ for fusing; $\mathrm{t}=10 \mathrm{~ms}$
Total power dissipation up to $\mathrm{T}_{\mathrm{mb}}=25^{\circ} \mathrm{C}$
ITSM
max.
$I^{2} t$
$P_{\text {tot }}$
max.
100
max. 50

## Gate to cathode

Repetitive peak on-state current
$\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$ prior to surge
gate-cathode forward; $\mathrm{t}=10 \mathrm{~ms}$;
half-sinewave
gate-cathode reverse; $\mathrm{t}=20 \mu \mathrm{~s}$
Average power dissipation (averaged over any 20 ms period)

IGFM max. 25
A
A
w

## Diode

Average forward current (averaged over any
20 ms period) up to $\mathrm{T}_{\mathrm{mb}}=70^{\circ} \mathrm{C}$
Non-repetitive peak on-state current

$$
\mathrm{t}=10 \mathrm{~ms} \text {; half-sinewave }
$$

$\begin{array}{llll}\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} \text { prior to surge } & \mathrm{I}_{\mathrm{FSM}} & \max & 60\end{array}$

## Temperatures

| Storage temperature | $\mathrm{T}_{\text {stg }}$ |  | -40 to +125 | ${ }^{\circ} \mathrm{C}$ |
| :--- | :--- | :--- | ---: | ---: |
| Operating junction temperature | $\mathrm{T}_{\mathrm{j}}$ | max. | 120 | ${ }^{\circ} \mathrm{C}$ |
| ISOLATION** |  |  |  |  |
| R.M.S. isolation voltage | $\mathrm{V}_{\text {isol }}$ | min. | 2500 | V |

[^11]
## THERMAL RESISTANCE

## GTO

From junction to mounting base
From mounting base to heatsink with heatsink compound

## Diode

From junction to mounting base
From mounting base to heatsink with heatsink compound

| $R_{\text {th j-mb }}$ | $=$ | 1.5 | $\mathrm{~K} / \mathrm{W}$ |
| :--- | :--- | :--- | :--- |
| $R_{\text {th mb-h }}$ | $=$ | 0.3 | $\mathrm{~K} / \mathrm{W}$ |


| $R_{\text {th mb-h }}$ | $=$ | 0.3 | $\mathrm{~K} / \mathrm{W}$ |
| :--- | :--- | :--- | :--- |
| $R_{\text {th j-mb }}$ | $=$ | 3.6 | $\mathrm{~K} / \mathrm{W}$ |
| $R_{\text {th mb-h }}$ | $=$ | 0.3 | $\mathrm{~K} / \mathrm{W}$ |



Fig. 2 Equivalent thermal network.

## GTO CHARACTERISTICS

## Anode to cathode

On-state voltage
$\mathrm{I}_{\mathrm{T}}=10 \mathrm{~A} ; \mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$
$\mathrm{V}_{\mathrm{T}}$
Rate of rise of off-state voltage that will not trigger any off-state device; exponential method $\mathrm{V}_{\mathrm{D}}=2 / 3 \mathrm{~V}_{\text {Dmax }} ; \mathrm{V}_{\mathrm{GR}}=5 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$
$d V_{D} / d t$
$<$
$10 \mathrm{kV} / \mu \mathrm{s}$
Rate of rise of off-state voltage that will not trigger any device following conduction, linear method

$$
\mathrm{I}_{\mathrm{T}}=10 \mathrm{~A} ; \mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DRMmax}} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} \quad \mathrm{~d} \mathrm{~V}_{\mathrm{D}} / \mathrm{dt} \quad<\quad 1.0 \mathrm{kV} / \mu \mathrm{s}
$$

Off-state current
$V_{D}=V_{\text {Dmax }} ; T_{j}=120^{\circ} \mathrm{C}$
Latching current; $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$


Gate to cathode
Voltage that will trigger all devices
$\mathrm{V}_{\mathrm{D}}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
$\mathrm{V}_{\mathrm{GT}} \quad>\quad 1.5 \quad \mathrm{~V}$
Current that will trigger all devices
$\mathrm{V}_{\mathrm{D}}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
Minimum reverse breakdown voltage

$$
\mathrm{I}_{\mathrm{GR}}=1.0 \mathrm{~mA}
$$

$\mathrm{V}_{(\mathrm{BR}) \mathrm{GR}} \gg 10 \mathrm{~V}$

## Switching characteristics (resistive load)

Turn-on when switched to $I_{T}=10 \mathrm{~A}$ from $\mathrm{V}_{\mathrm{D}}=250 \mathrm{~V}$
with $\mathrm{I}_{\mathrm{GF}}=1.0 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
delay time
rise time

| $\mathrm{t}_{\mathrm{d}}$ | $<$ | 0.3 | $\mu \mathrm{~s}$ |
| :--- | :--- | :--- | :--- |
| $\mathrm{t}_{\mathrm{r}}$ | $<$ | 1.5 | $\mu \mathrm{~s}$ |



Fig. 3 Waveforms.

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


## Fast gate turn-off thyristors

## GTO (cont.)

## Switching characteristics (inductive load)

Turn-off when switched from $I_{T}=10 \mathrm{~A}$ to $\mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\text {Dmax }}$;
$\mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{L}_{\mathrm{G}} \leqslant 0.5 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
storage time
fall time
peak reverse gate current

| $\mathrm{t}_{\mathrm{s}}$ | $<$ | 0.60 | $\mu \mathrm{~s}$ |
| :--- | ---: | ---: | ---: |
| $\mathrm{t}_{\mathrm{f}}$ | $<$ | 0.25 | $\mu \mathrm{~s}$ |
| $\mathrm{I}_{\mathrm{GR}}$ | $<$ | 10 | A |



Fig. 4 Waveforms.


Fig. 5 Inductive load test circuit.
*Indicates stray series inductance only

GTO (cont.)


Fig. 6 The right hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.
$a=$ form factor $=\frac{I_{T}(R M S)}{I_{T}(A V)}$
$P=$ power excluding switching losses.
Values given on the right hand graph assume that the diode is not dissipating significant power.

Fast gate turn-off thyristors
BTV59D SERIES

GTO (cont.)


Fig. 7 Anode current which can be turned off versus applied $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}^{*}$; inductive load; $\mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V}$; $\mathrm{L}_{\mathrm{G}} \leqslant 0.5 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} .{ }^{*} \mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ is calculated from $\mathrm{I}_{\mathrm{T}} / \mathrm{C}_{\mathrm{S}}$.


Fig. 8 Anode current which can be turned off versus applied $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}^{*}$; inductive load; $\mathrm{V}_{\mathrm{GR}}=5 \mathrm{~V}$; $\mathrm{L}_{\mathrm{G}} \leqslant 0.5 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} .{ }^{*} \mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ is calculated from $\mathrm{I}_{\mathrm{T}} / \mathrm{C}_{\mathrm{S}}$.

## BTV59D SERIES



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


Fig. 10 Minimum gate current that will trigger all devices as a function of junction temperature; $\mathrm{V}_{\mathrm{D}}=12 \mathrm{~V}$. ${ }_{\text {M1439 }}$


Fig. 11 Maximum $V_{T}$ versus $I_{T} ; — T_{j}=25^{\circ} \mathrm{C} ;-\ldots-T_{j}=120^{\circ} \mathrm{C}$.

Fast gate turn-off thyristors


Fig. 12 Peak reverse gate current versus anode current at turn-off; inductive load;
$\mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A} ; \mathrm{L}_{\mathrm{G}}=0.4 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} ;$ maximum values.


Fig. 13 Transient thermal impedance.


Fig. 14 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ (calculated from $\mathrm{I}_{\mathrm{T}} / \mathrm{C}_{\mathrm{S}}$ ); $\mathrm{d} \mathrm{V}_{\mathrm{D}} / \mathrm{dt}$ linear up to $\mathrm{V}_{\mathrm{Dmax}}=600 \mathrm{~V} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A}$; $\mathrm{L}_{\mathrm{G}} \leqslant 0.5 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$.


Fig. 15 Energy loss at turn off as a function of junction temperature; $\mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V}$. Normalised to $\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$.

## DIODE CHARACTERISTICS

Forward voltage

$$
I_{F}=10 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C} \quad \mathrm{~V}_{\mathrm{F}} \quad<\quad 2.0 \quad V^{*}
$$

Reverse recovery when switched from
$\mathrm{I}_{\mathrm{F}}=2 \mathrm{~A}$ to $\mathrm{V}_{\mathrm{R}} \geqslant 30 \mathrm{~V}$ with $-\mathrm{dI}_{\mathrm{F}} / \mathrm{dt}=20 \mathrm{~A} / \mu \mathrm{s} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
recovered charge

| $\mathrm{O}_{\mathrm{s}}$ | $<$ | 2.0 | $\mu \mathrm{C}$ |
| :--- | :--- | :--- | :--- |
| $\mathrm{t}_{\mathrm{rr}}$ | $<$ | 0.6 | $\mu \mathrm{~s}$ |

recovery time
$\mathrm{t}_{\mathrm{r}}$
0.6
$\mu \mathrm{s}$
Forward recovery when switched to
$I_{F}=5 A$ with $t_{r}=0.1 \mu \mathrm{~s} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
recovery time
$t_{f r}<\quad 1.0 \quad \mu \mathrm{~s}$


Fig. 16 Definition of $t_{r r}$ and $Q_{s}$.


Fig. 17 Definition of $\mathrm{t}_{\mathrm{fr}}$.
*Measured under pulse conditions to avoid excessive dissipation

DIODE (cont.)


Fig. 18 The right hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.
$a=$ form factor $=\frac{I^{\prime}(R M S)}{I_{F}(A V)}$
Values given on the right hand graph assume that the GTO is not dissipating significant power.


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


Fig. 20 Peak reverse recovery current versus $-\mathrm{dl} \mathrm{F}_{\mathrm{F}} / \mathrm{dt} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$; maximum values.

BTV59D SERIES

DIODE (cont.)


Fig. 21 Transient thermal impedance.

## FAST GATE TURN-OFF THYRISTORS

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

QUICK REFERENCE DATA

| Repetitive peak off-state voltage | VDRM | BTV60-850R |  | 1000R | 1200R |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | max. | 850 | 1000 | 1200 | V |
| Non-repetitive peak on-state current | ITSM | $\max$. |  | 240 |  | A |
| Controllable anode current | ITCRM | max. |  | 120 |  | A |
| Average on-state current | IT(AV) | max. |  | 25 |  | A |
| Fall time | $\mathrm{t}_{\mathrm{f}}$ | < |  | 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

| Transient off-state voltage | $\mathrm{V}_{\mathrm{DSM}}$ |
| :--- | :--- |
| Repetitive peak off-state voltage | $\mathrm{V}_{\mathrm{DRM}}$ |
| Working off-state voltage | $\mathrm{V}_{\mathrm{DW}}$ |
| Continuous off-state voltage | $\mathrm{V}_{\mathrm{D}}$ |


| BTV60-850R |  | 1000 R | 1200 R |  |
| :--- | ---: | ---: | ---: | :--- |
|  |  |  |  |  |
| max. | 1000 | 1100 | 1300 | $\mathrm{~V}^{*}$ |
| $\max$. | 850 | 1000 | 1200 | $\mathrm{~V}^{*}$ |
| $\max$. | 600 | 800 | 1000 | $\mathrm{~V}^{*}$ |
| $\max$. | 500 | 650 | 750 | $\mathrm{~V}^{*}$ |

Average on-state current (averaged over any
20 ms period) up to $\mathrm{T}_{\mathrm{mb}}=70^{\circ} \mathrm{C}$
Controllable anode current
Non-repetitive peak on-state current
$\mathrm{t}=10 \mathrm{~ms}$; half-sinewave;
$\rightarrow \quad \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$ prior to surge
$\longrightarrow 1^{2} t$ for fusing; $t=10 \mathrm{~ms}$
Total power dissipation up to $\mathrm{T}_{\mathrm{mb}}=25^{\circ} \mathrm{C}$
$I_{\text {TSM }}$
$I^{2} \mathrm{t}$
$\mathrm{P}_{\text {tot }}$
max. 240
max. 290
max. 120
$\mathrm{dl}_{\mathrm{T}} / \mathrm{dt} \max .1000$
A/ $\mu \mathrm{s}$
Gate to cathode
Repetitive peak on-state current $\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$ prior to surge gate-cathode forward; $\mathrm{t}=10 \mathrm{~ms}$; half-sinewave
gate-cathode reverse; $\mathrm{t}=20 \mu \mathrm{~s}$
Average power dissipation (averaged over any 20 ms period)

## Temperatures

| Storage temperature | $\mathrm{T}_{\text {stg }}$ | -40 to +150 |  | ${ }^{\circ} \mathrm{C}$ |
| :---: | :---: | :---: | :---: | :---: |
| Operating junction temperature | $\mathrm{T}_{\mathrm{j}}$ | max. | 120 | ${ }^{\circ} \mathrm{C}$ |
| ISOLATION** |  |  |  |  |
| R.M.S. isolation voltage | $\mathrm{V}_{\text {isol }}$ | min. | 2500 | V |
| THERMAL RESISTANCE |  |  |  |  |
| From mounting base to heatsink, with heatsink compound | $\mathrm{R}_{\text {th mb-h }}$ | = | 0.3 | K/W |
| From junction to mounting base | $\mathrm{R}_{\text {th j-mb }}$ |  | 0.8 | K/W |

[^12]
## CHARACTERISTICS

## Anode to cathode

On-state voltage

$$
\mathrm{I}_{\mathrm{T}}=20 \mathrm{~A} ; \mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}
$$

$\mathrm{V}_{\mathrm{T}}$
Rate of rise of off-state voltage that will not
trigger any off-state device; exponential method $\mathrm{V}_{\mathrm{D}}=2 / 3 \mathrm{~V}_{\text {Dmax }} ; \mathrm{V}_{\mathrm{GR}}=5 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$
$d V_{D} / d t$ $<\quad 2.2$

V*

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

$$
\mathrm{I}_{\mathrm{T}}=60 \mathrm{~A} ; \mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DRMmax}} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} \quad \mathrm{dV} / \mathrm{dt} \quad<1.0 \mathrm{kV} / \mu \mathrm{s}
$$

Off-state current

$$
V_{D}=V_{D \max } ; T_{j}=120^{\circ} \mathrm{C}
$$

Latching current; $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$

| $I_{D}$ | $<$ | 5.0 | $m A$ |
| :--- | :--- | :--- | :--- |
| $I_{L}$ | typ. | 5.0 | $A^{* *}$ |

## Gate to cathode

Voltage that will trigger all devices

$$
V_{D}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}
$$

$\mathrm{V}_{\mathrm{GT}}$
Current that will trigger all devices

$$
V_{D}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}
$$

| $\mathrm{I}_{\mathrm{GT}}$ | $>$ | 500 | mA |
| :--- | :--- | :--- | :--- |
| $\mathrm{~V}_{(\mathrm{BR}) \mathrm{GR}}$ | $>$ | 10 | V |

## Switching characteristics (resistive load)

Turn-on when switched to $\mathrm{I}_{\mathrm{T}}=50 \mathrm{~A}$ from $\mathrm{V}_{\mathrm{D}}=250 \mathrm{~V}$
with $\mathrm{I}_{\mathrm{GF}}=2.5 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$ delay time rise time


Fig. 2 Waveforms.

[^13]
## Switching characteristics (inductive load)

$$
\begin{aligned}
& \text { Turn-off when switched from } \mathrm{I}_{\mathrm{T}}=50 \mathrm{~A} \text { to } \mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\text {Dmax }} \text {; } \\
& \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{L}_{\mathrm{G}} \leqslant 0.5 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}
\end{aligned}
$$



Fig. 3 Waveforms.


Fig. 4 Inductive load test circuit.

* Indicates stray series inductance only.
${ }^{* *}$ Minimum permissible GTO on-time $(\mu \mathrm{S})=\mathrm{R}_{\mathrm{S}}(\Omega) \times \mathrm{C}_{\mathrm{S}}(\mu \mathrm{F}) \times 5$.


Fig. 5 The right hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.
$a=$ form factor $=\frac{\mathrm{I} T(\mathrm{RMS})}{\mathrm{I}(\mathrm{AV})}$
$P=$ power excluding switching losses.


Fig. 6 Anode current which can be turned off versus anode voltage; inductive load; $\mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{L}_{\mathrm{G}} \leqslant 0.5 \mu \mathrm{H}$;
$L_{S} \leqslant 0.25 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$.
${ }^{*} \mathrm{~d}_{\mathrm{D}} / \mathrm{dt}$ is calculated from $\mathrm{I}_{\mathrm{T}} / \mathrm{C}_{\mathrm{S}}$.


Fig. 7 Anode current which can be turned off versus applied $d V_{D} / d^{*}$; inductive load; $\mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V}$; $\mathrm{L}_{\mathrm{G}} \leqslant 0.5 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$. ${ }^{*} \mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ is calculated from $\mathrm{I}_{\mathrm{T}} / \mathrm{C}_{\mathrm{S}}$.

## BTV60 SERIES



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


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


Fig. 10 Maximum $\mathrm{V}_{\mathrm{T}}$ versus $\mathrm{I}_{\mathrm{T}} ; — \mathrm{~T}_{\mathrm{j}}=25^{\circ} \mathrm{C} ;---\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$.


Fig. 11 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ (calculated from $\mathrm{I}_{\mathrm{T}} / \mathrm{C}_{\mathrm{S}}$ ); $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ linear up to $\mathrm{V}_{\mathrm{Dmax}}=600 \mathrm{~V} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A}$; $\mathrm{L}_{\mathrm{G}} \leqslant 0.5 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$.


Fig. 12 r ransient thermal impedance.

## FAST GATE TURN-OFF THYRISTORS WITH ANTI-PARALLEL DIODE

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

QUICK REFERENCE DATA

| GTO | $V_{\text {DRM }}$ | BTV60D-850R |  | 1000R | 1200R |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Repetitive peak off-state voltage |  | max. | 850 | 1000 | 1200 | v |
| Non-repetitive peak on-state current | ITSM | max. |  | 240 |  | A |
| Controllable anode current | ItCRM | max. |  | 120 |  | A |
| Average on-state current | ${ }^{\text {I }}$ ( $A \mathrm{AV}$ ) | max. |  | 25 |  | A |
| Fall time | $\mathrm{t}_{\mathrm{f}}$ | $<$ |  | 300 |  | ns |
| Diode |  |  |  |  |  |  |
| Average forward current | ${ }^{\prime} \mathrm{F}(\mathrm{AV})$ | max. |  | 14 |  | A |
| Non-repetitive peak forward current | ${ }^{\text {IFSM }}$ | max. |  | 100 |  | A |
| Reverse recovery time | $\mathrm{trr}^{\text {r }}$ | < |  | 600 |  | ns |

MECHANICAL DATA
Dimensions in mm
Fig. 1 TO-238AA


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

## RATINGS

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

| BTV60D-850R | 1000R | 1200 R |  |  |
| :--- | :---: | :---: | ---: | :--- |
| max. | 1000 | 1100 | 1300 | $\mathrm{~V}^{*}$ |
| $\max$. | 850 | 1000 | 1200 | $\mathrm{~V}^{*}$ |
| $\max$. | 600 | 800 | 1000 | $\mathrm{~V}^{*}$ |
| $\max$. | 500 | 650 | 750 | $\mathrm{~V}^{*}$ |

Transient off-state voltage
Repetitive peak off-state voltage
Working off-state voltage
Continuous off-state voltage
Average on-state current (averaged over any 20 ms period) up to $\mathrm{T}_{\mathrm{mb}}=70^{\circ} \mathrm{C}$
Controllable anode current
Non-repetitive peak on-state current
$\mathrm{t}=10 \mathrm{~ms}$; half-sinewave;
$\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$ prior to surge
$I^{2} t$ for fusing; $t=10 \mathrm{~ms} \quad \mathrm{I}^{2} \mathrm{t}$
Total power dissipation up to $T_{m b}=25^{\circ} \mathrm{C}$
$V_{\text {DSM }}$
$V_{\text {DRM }}$
$V_{\text {DW }}$
$V_{D}$
${ }^{\text {I }} \mathrm{t}(\mathrm{AV})$
ItCRM

ITSM max. 240
$\mathrm{I}^{2} \mathrm{t}$
$\mathrm{P}_{\text {tot }}$
Maximum rate of rise of anode current
at turn-on $V_{D}=V_{\text {Dmax }}$;
$\mathrm{I}_{\mathrm{GF}}=2.5 \mathrm{~A} ; \mathrm{I}_{\mathrm{T}}=200 \mathrm{~A}$
$\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}$
max.
1000

## Gate to cathode

Repetitive peak on-state current gate-cathode forward; t = 1 ms ; gate-cathode reverse; $\mathrm{t}=20 \mu \mathrm{~s}$
Average power dissipation (averaged over any 20 ms period)

| IGFM | max. | 35 | A |
| :--- | :--- | :--- | :--- |
| IGRM | max. | 50 | $A$ |

$\mathrm{P}_{\mathrm{G}(\mathrm{AV})} \max .10 \quad \mathrm{~W}$

A
A

A
$\mathrm{A}^{2} \mathrm{~s}$
w
$\mathrm{A} / \mu \mathrm{s}$

## Diode

Average forward current (averaged over any 20 ms period) up to $\mathrm{T}_{\mathrm{mb}}=70^{\circ} \mathrm{C}$
Non-repetitive peak forward current $\mathrm{t}=10 \mathrm{~ms}$, half-sinewave
$\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$ prior to surge

## Temperatures

| Storage temperature | $\mathrm{T}_{\text {stg }}$ |  | -40 to +125 | ${ }^{\circ} \mathrm{C}$ |
| :--- | :--- | :--- | ---: | ---: |
| Operating junction temperature | $\mathrm{T}_{\mathrm{j}}$ | max. | 120 | ${ }^{\circ} \mathrm{C}$ |
| ISOLATION** |  |  |  |  |
| R.M.S. isolation voltage | $\mathrm{V}_{\text {isol }}$ | min. | 2500 | V |

[^14]
## BTV60D SERIES

## Fast gate turn-off thyristors

## THERMAL RESISTANCE

## GTO

From junction to mounting base
From mounting base to heatsink with heatsink compound

Diode
From junction to mounting base
From mounting base to heatsink with heatsink compound


Fig. 2 Equivalent thermal network.

## GTO CHARACTERISTICS

## Anode to cathode

On -state voltage

$$
\mathrm{I}_{\mathrm{T}}=20 \mathrm{~A} ; \mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}
$$

$\mathrm{V}_{\mathrm{T}} \quad<$
V*
Rate of rise of off-state voltage that will not trigger any off-state device; exponential method $\mathrm{V}_{\mathrm{D}}=2 / 3 \mathrm{~V}_{\text {Dmax }} ; \mathrm{V}_{\mathrm{GR}}=5 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$
$d V_{D} / d t$
$<$
10
$\mathrm{kV} / \mu \mathrm{s}$
Rate of rise of off-state voltage that will not
trigger any device following conduction, linear method
$\mathrm{I}_{\mathrm{T}}=60 \mathrm{~A} ; \mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DRMmax}} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} \quad \mathrm{dV} \mathrm{V}_{\mathrm{D}} / \mathrm{dt} \quad<\quad 1.0 \mathrm{kV} / \mu \mathrm{s}$
Off-state current
$\mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\text {Dmax }} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$
$I_{D}<5.0 \mathrm{~mA}$
Latching current; $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
IL
typ. 5.0 A**

## Gate to cathode

Voltage that will trigger all devices

$$
V_{D}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}
$$

Current that will trigger all devices
$\mathrm{V}_{\mathrm{D}}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$

| $\mathrm{V}_{\mathrm{GT}}$ | $>$ | 1.5 | V |
| :--- | :--- | ---: | :--- |
| $\mathrm{I}_{\mathrm{GT}}$ | $>$ | 500 | mA |
| $\mathrm{~V}_{(\mathrm{BR}) \mathrm{GR}}$ | $>$ | 10 | V |

Minimum reverse breakdown voltage
$I_{\mathrm{GR}}=1.0 \mathrm{~mA}$
$\mathrm{V}_{\text {(BR)GR }} \gg 10 \mathrm{~V}$

## Switching characteristics (resistive load)

Turn-on when switched to $I_{T}=50 \mathrm{~A}$ from $\mathrm{V}_{\mathrm{D}}>250 \mathrm{~V}$
with $\mathrm{I}_{\mathrm{GF}}=2.5 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
delay time $t_{d}$
rise time
$t_{r}$
$\begin{array}{lll}< & 0.5 & \mu \mathrm{~s} \\ < & 2.0 & \mu \mathrm{~s}\end{array}$


Fig. 3 Waveforms.

[^15]
## GTO(cont.)

## Switching characteristics (inductive load)

Turn-off when switched from $I_{T}=50 A$ to $V_{D}=V_{D m a x}$;
$V_{G R}=10 \mathrm{~V} ; \mathrm{L}_{\mathrm{G}} \leqslant 0.4 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H}, \mathrm{C}_{\mathrm{S}} \geqslant 50 \mathrm{nF}, \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$ storage time
fall time
peak reverse gate current

| $\mathrm{t}_{\mathrm{s}}$ | $<$ | 1.0 | $\mu \mathrm{~s}$ |
| :--- | :--- | :--- | :--- |
| $\mathrm{t}_{\mathrm{f}}$ | $<$ | 0.3 | $\mu \mathrm{~s}$ |
| $\mathrm{I}_{\mathrm{GR}}$ | $<$ | 25 | A |



Fig. 4 Waveforms.


Fig. 5 Inductive load test circuit.

[^16]

Fig.6a GTO (maximum values).

Fig. 6 ( $a, b$ ) Power dissipation as a function of average current
$a=$ form factor $=I_{T}(R M S)^{\prime} I_{T}(A V)$
$\mathrm{P}=$ power excluding switching losses.

M 2720


Fig.6b Diode.

GTO


Fig. 7 Anode current which can be turned off versus anode voltage; inductive load; $\mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{L}_{\mathrm{G}} \leqslant 0.5 \mu \mathrm{H}$;
$\mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$.
${ }^{*} \mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ is calculated from $\mathrm{I}_{\mathrm{T}} / \mathrm{C}_{\mathrm{S}}$.

## GTO (cont.)



Fig. 8 Anode current which can be turned off versus applied $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}^{*}$; inductive load; $\mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V}$; $\mathrm{L}_{\mathrm{G}} \leqslant 0.5 \mu \mathrm{H}$; $\mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$.
${ }^{*} \mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ is calculated from $\mathrm{I}_{\mathrm{T}} / \mathrm{C}_{\mathrm{S}}$.


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


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


Fig. 11 Maximum $V_{T}$ versus $I_{T} ; — T_{j}=25^{\circ} \mathrm{C} ; —-T_{j}=120^{\circ} \mathrm{C}$.


Fig. 12 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ (calculated from $\mathrm{I}_{\mathrm{T}} / \mathrm{C}_{\mathrm{S}}$ ); $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ linear up to $\mathrm{V}_{\mathrm{Dmax}}=600 \mathrm{~V} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A}$; $\mathrm{L}_{\mathrm{G}} \leqslant 0.5 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$.


Fig. 13 Transient thermal impedance.

## DIODE CHARACTERISTICS

## Forward voltage

$I_{F}=20 A ; T_{j}=25^{\circ} \mathrm{C}$
$V_{F}<2.5 \quad V^{*}$

Reverse recovery when switched from
$\mathrm{I}_{\mathrm{F}}=2 \mathrm{~A}$ to $\mathrm{V}_{\mathrm{R}} \geqslant 30 \mathrm{~V}$ with $-\mathrm{d} I_{\mathrm{F}} / \mathrm{dt}=20 \mathrm{~A} / \mu \mathrm{s} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$ recovered charge
recovery time
Forward recovery when switched to
$\mathrm{I}_{\mathrm{F}}=5$ A with $\mathrm{t}_{\mathrm{r}}=0.1 \mu \mathrm{~s} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$ recovery time


Fig. 15 Definition of $t_{f r}$.
*Measured under pulse conditions to avoid excessive dissipation.

DIODE (cont.)


Fig. 16 Forward voltage as a function of forward current; maximum values;
$-\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C} ;--\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$.


Fig. 17 Peak reverse recovery current versus $-\mathrm{dl}_{\mathrm{F}} / \mathrm{dt} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$; maximum values.

DIODE (cont.)


Fig. 18 Transient thermal impedance.

## FAST GATE TURN-OFF THYRISTORS

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

QUICK REFERENCE DATA

|  |  | BTV70-850R |  | 1000R | 1200R |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Repetitive peak off-state voltage | $V_{\text {DRM }}$ | max. | 850 | 1000 | 1200 | V |
| Non-repetitive peak on-state current | 1 TSM | max. |  | 100 |  | A |
| Controllable anode current | $I_{\text {TCRM }}$ | max. |  | 50 |  | A |
| Average on-state current | IT(AV) | max. |  | 15 |  | A |
| Fall time | $\mathrm{t}_{\mathrm{f}}$ | < |  | 250 |  | ns |

MECHANICAL DATA
Dimensions in mm
Fig. 1 TO-238AA


[^17]
## RATINGS

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

## Anode to cathode

Transient off-state voltage
Repetitive peak off-state voltage
Working off-state voltage
Continuous off-state voltage
Average on-state current (averaged over any 20 ms period) up to $\mathrm{T}_{\mathrm{mb}}=60^{\circ} \mathrm{C}$
Controllable anode current
Non-repetitive peak on-state current
$\mathrm{t}=10 \mathrm{~ms}$; half-sinewave;
$\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$ prior to surge
$1^{2} t$ for fusing; $t=10 \mathrm{~ms}$
Total power dissipation up to $\mathrm{T}_{\mathrm{mb}}=25^{\circ} \mathrm{C}$
Gate to cathode
Repetitive peak current
$\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$ prior to surge
gate-cathode forward; $\mathrm{t}=10 \mathrm{~ms}$;
half-sinewave IGFM max. 2
IGRM max. 25
Average power dissipation (averaged over any 20 ms period)
$\mathrm{P}_{\mathrm{G}}(\mathrm{AV})$ max
5.0

## Temperatures

| Storage temperature | $\mathrm{T}_{\text {stg }}$ |  | -40 to +125 | ${ }^{\circ} \mathrm{C}$ |
| :--- | :--- | :--- | ---: | ---: |
| Operating junction temperature | $\mathrm{T}_{\mathrm{j}}$ | max. | 120 | ${ }^{\circ} \mathrm{C}$ |
| ISOLATION** |  |  |  |  |
| R.M.S. isolation voltage | $\mathrm{V}_{\text {isol }}$ | min. | 2500 | V |

## THERMAL RESISTANCE

From mounting base to heatsink; with heatsink compound
From junction to mounting base

| BTV70-850R |  | 1000 R | 1200 R |  |
| :--- | ---: | :---: | :---: | :---: |
| $\max$. | 1000 | 1100 | 1300 | $\mathrm{~V}^{*}$ |
| $\max$. | 850 | 1000 | 1200 | $\mathrm{~V}^{*}$ |
| $\max$. | 600 | 800 | 1000 | $\mathrm{~V}^{*}$ |
| $\max$. | 500 | 650 | 750 | $\mathrm{~V}^{*}$ |

$I_{T(A V)} \quad \max .15$
ITCRM max. 50

| ITSM | max. | 100 | A |
| :--- | :--- | ---: | :--- |
| $I^{2} t$ | max. | 50 | $\mathrm{~A}^{2} \mathrm{~s}$ |
| $\mathrm{P}_{\text {tot }}$ | max. | 60 | W |

[^18]
## CHARACTERISTICS

## Anode to cathode

On-state voltage

$$
\mathrm{I}_{\mathrm{T}}=10 \mathrm{~A} ; \mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} \quad \mathrm{~V}_{\mathrm{T}} \quad<\quad 2.3 \mathrm{~V}^{*}
$$

Rate of rise of off-state voltage that will not trigger any off-state device, exponential method
$\mathrm{V}_{\mathrm{D}}=2 / 3 \mathrm{~V}_{\text {Dmax }} ; \mathrm{V}_{\mathrm{GR}}=5 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} \quad \mathrm{d} \mathrm{V}_{\mathrm{D}} / \mathrm{dt} \quad<\quad 10 \mathrm{kV} / \mu \mathrm{s}$
Rate of rise of off-state voltage that will not trigger
any device following conduction, linear method
$I_{T}=20 \mathrm{~A} ; \mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DRMmax}} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}} 120^{\circ} \mathrm{C} \quad \mathrm{d} \mathrm{V}_{\mathrm{D}} / \mathrm{dt} \quad<\quad 1.0 \mathrm{kV} / \mu \mathrm{s}$
Off-state current
$V_{D}=V_{\text {Dmax }} ; T_{j}=120^{\circ} \mathrm{C}$
ID $\quad<\quad 5.0 \mathrm{~mA}$

Latching current; $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
$I_{\mathrm{L}} \quad$ typ. $1.5 \quad \mathrm{~A}^{* *}$

## Gate to cathode

Voltage that will trigger all devices

$$
\begin{equation*}
\mathrm{V}_{\mathrm{D}}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C} \tag{GT}
\end{equation*}
$$

Current that will trigger all devices
$\mathrm{V}_{\mathrm{D}}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
$\mathrm{I}_{\mathrm{GT}} \gg 300 \mathrm{~mA}$

Minimum reverse breakdown voltage
$I_{G R}=1.0 \mathrm{~mA}$
$\mathrm{V}_{(\mathrm{BR}) \mathrm{GR}} \gg 10 \mathrm{~V}$

Switching characteristics (resistive load)
Turn-on when switched to $I_{T}=10 \mathrm{~A}$ from $\mathrm{V}_{\mathrm{D}}=250 \mathrm{~V}$
with $\mathrm{I}_{\mathrm{GF}}=1.5 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
delay time

| $\mathrm{t}_{\mathrm{d}}$ | $<$ | 0.3 | $\mu \mathrm{~s}$ |
| :--- | :--- | :--- | :--- |
| $\mathrm{t}_{\mathrm{r}}$ | $<$ | 1.5 | $\mu \mathrm{~s}$ |



Fig. 2 Waveforms.

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


## Switching characteristics (inductive load)

Turn-off when switched from $I_{T}=10 \mathrm{~A}$ to $\mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{Dmax}}$;
$\mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{L}_{\mathrm{G}} \leqslant 0.5 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$ storage time
fall time
peak reverse gate current

| $\mathrm{t}_{\mathrm{s}}$ | $<$ | 0.60 | $\mu \mathrm{~s}$ |
| :--- | :---: | ---: | :---: |
| $\mathrm{t}_{\mathrm{f}}$ | $<$ | 0.25 | $\mu \mathrm{~s}$ |
| $\mathrm{I}_{\mathrm{GR}}$ | $<$ | 10 | A |




Fig. 3 Waveforms.


Fig. 4 Inductive load test circuit.


Fig. 5 The right hand part shows the interrelationship between the power (derived from the left hand part) and the maximum permissible temperatures.
$\mathrm{a}=$ form factor $=\frac{\mathrm{I}_{\mathrm{T}}(\mathrm{RMS})}{\mathrm{I}_{\mathrm{T}}(\mathrm{AV})}$
$P=$ power excluding switching losses.


Fig. 6 Anode current which can be turned off versus anode voltage; inductive load;

$$
V_{G R}=10 \mathrm{~V} ; \mathrm{L}_{\mathrm{G}} \leqslant 0.5 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} .
$$

${ }^{*} d V_{D} / d t$ is calculated from $I_{T} / C_{S}$.


Fig. 7 Anode current which can be turned off versus applied $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}^{*}$; inductive load; $\mathrm{L}_{\mathrm{G}} \leqslant 0.5 \mu \mathrm{H}, \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H}, \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} ;$
${ }^{*} d V_{\mathrm{D}} / \mathrm{dt}$ is calculated from $\mathrm{I}_{\mathrm{T}} / \mathrm{C}_{\mathrm{S}}$.


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


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


Fig. 10 Maximum $V_{T}$ versus $I_{T} ; — T_{j}=25^{\circ} \mathrm{C} ;---T_{j}=120^{\circ} \mathrm{C}$.

Fast gate turn-off thyristors


Fig. 11 Peak reverse gate current versus anode current at turn-off; inductive load; $\mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A} ; \mathrm{L}_{\mathrm{G}}=0.4 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} ;$ maximum values.


Fig. 12 Peak reverse gate current versus applied reverse gate voltage; inductive load; $\mathrm{I}_{\mathrm{T}}=10 \mathrm{~A} ; \mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A} ; \mathrm{L}_{\mathrm{G}}=0.4 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$; maximum values.


Fig. 13 Switching times as a function of junction temperature; $\mathrm{V}_{\mathrm{D}} \geqslant 250 \mathrm{~V} ; \mathrm{I}_{\mathrm{T}}=10 \mathrm{~A}$; $\mathrm{I}_{\mathrm{GF}}=1.0 \mathrm{~A} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A} ; \mathrm{L}_{\mathrm{G}}=0.4 \mu \mathrm{H}$; maximum values.


Fig. 14 Transient thermal impedance.


Fig. 15 Storage and fall times versus applied reverse gate voltage; inductive load; $\mathrm{I}_{\mathrm{T}}=10 \mathrm{~A} ; \mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A} ; \mathrm{L}_{\mathrm{G}}=0.4 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$; maximum values.


Fig. 16 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ (calculated from $\mathrm{I}_{\mathrm{T}} / \mathrm{C}_{\mathrm{S}}$ ); $\mathrm{dV} \mathrm{V}_{\mathrm{D}} / \mathrm{dt}$ linear up to $\mathrm{V}_{\mathrm{Dmax}}=600 \mathrm{~V} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A}$; $\mathrm{L}_{\mathrm{G}} \leqslant 0.5 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$.


Fig. 17 Energy loss at turn-off as a function of junction temperature; $\mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V}$. Normalised to $\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$.

## FAST GATE TURN-OFF THYRISTORS WITH ANTI-PARALLEL DIODE

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

## QUICK REFERENCE DATA

| GTO |  | BTV70D | 850R | 1000R | 1200R |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Repetitive peak off-state voltage | VDRM | max. | 850 | 1000 | 1200 | V |
| Non-repetitive peak on-state current | $I_{\text {ISSM }}$ | max. |  | 100 |  | A |
| Controllable anode current | ITCRM | max. |  | 50 |  | A |
| Average on-state current | $I_{\text {I }}(\mathrm{AV})$ | max. |  | 15 |  | A |
| Fall time | $t_{f}$ | $<$ |  | 250 |  | ns |
| Diode |  |  |  |  |  |  |
| Average forward current | IF(AV) | max. |  | 9.0 |  | A |
| Non-repetitive peak forward current | $I^{\prime}$ FSM | max. |  | 60 |  | A |
| Reverse recovery time | $\mathrm{trr}_{\text {r }}$ | < |  | 600 |  | ns |

MECHANICAL DATA
Dimensions in mm
Fig. 1 TO-238AA


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

For further information see data sheets BTV70 and BY359.

## RATINGS

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

## Anode to cathode

Transient off-state voltage
Repetitive peak off-state voltage
Working off-state voltage
Continuous off-state voltage
Average on-state current (averaged over any 20 ms period) up to $\mathrm{T}_{\mathrm{mb}}=60^{\circ} \mathrm{C}$

Controllable anode current
Non-repetitive peak on-state current
$\mathrm{t}=10 \mathrm{~ms}$; half-sinewave;
$\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$ prior to surge
$I^{2} t$ for fusing; $t=10 \mathrm{~ms}$
Total power dissipation
up to $\mathrm{T}_{\mathrm{mb}}=25^{\circ} \mathrm{C}$

|  | BTV70D | 850 R | 1000 R | 1200 R |  |
| :--- | :--- | ---: | ---: | ---: | :--- |
| $\mathrm{V}_{\text {DSM }}$ | max. | 1000 | 1100 | 1300 | $\mathrm{~V}^{*}$ |
| $\mathrm{~V}_{\text {DRM }}$ | $\max$. | 850 | 1000 | 1200 | $\mathrm{~V}^{*}$ |
| $\mathrm{~V}_{\text {DW }}$ | $\max$. | 600 | 800 | 1000 | $\mathrm{~V}^{*}$ |
| $\mathrm{~V}_{\mathrm{D}}$ | $\max$. | 500 | 650 | 750 | $\mathrm{~V}^{*}$ |

${ }^{1} \mathrm{~T}(\mathrm{AV})$
max.
15
A
ITCRM
max.
50
A

| ITSM | max. | 100 | A |
| :--- | :--- | ---: | :--- |
| $I^{2} t$ | max. | 50 | $A^{2} s$ |

$P_{\text {tot }} \max .60$
w

## Gate to cathode

Repetitive peak on-state current
$\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$ prior to surge
gate-cathode forward; $\mathrm{t}=10 \mathrm{~ms}$;
half-sinewave
gate-cathode reverse; t $=20 \mu \mathrm{~s}$
IGFM max
25
IGRM max.
25
$P_{G}(A V)$ max.
5.0

A
A
Average power dissipation (averaged over any 20 ms period)

## Diode

Average forward current (averaged over any 20 ms period) up to $\mathrm{T}_{\mathrm{mb}}=70^{\circ} \mathrm{C} \quad \mathrm{I}_{\mathrm{F}}(\mathrm{AV}) \quad \max \quad 9.0 \quad \mathrm{~A}$
Non-repetitive peak on-state current
$\mathrm{t}=10 \mathrm{~ms}$; half-sinewave;
$\begin{array}{llll}T_{j}=120^{\circ} \mathrm{C} \text { prior to surge } & \text { IFSM max. } & 60 & A\end{array}$
Temperatures

| Storage temperature | $T_{\text {stg }}$ |  | -40 to +125 | ${ }^{\circ} \mathrm{C}$ |
| :--- | :--- | :--- | ---: | :--- |
| Operating junction temperature | $T_{j}$ | max. | 120 | $0^{\circ} \mathrm{C}$ |
| ISOLATION** |  |  |  |  |
| R.M.S. isolation voltage | $\mathrm{V}_{\text {isol }}$ | min. | 2500 | V |

[^19]THERMAL RESISTANCE

## GTO

From junction to mounting base
From mounting base to heatsink with heatsink compound

| $R_{\text {th j-mb }}$ | $=$ | 1.5 | $\mathrm{~K} / \mathrm{W}$ |
| :--- | :--- | :--- | :--- |
| $R_{\text {th mb-h }}$ | $=$ | 0.3 | $\mathrm{~K} / \mathrm{W}$ |
| $R_{\text {th j-mb }}$ | $=$ | 3.6 | $\mathrm{~K} / \mathrm{W}$ |
| $R_{\text {th mb-h }}$ | $=$ | 0.3 | $\mathrm{~K} / \mathrm{W}$ |



Fig. 2 Equivalent thermal network.

## GTO CHARACTERISTICS

## Anode to cathode

On-state voltage
$I_{T}=10 \mathrm{~A} ; \mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$
$V_{T} \quad<$
2.3
V*

Rate of rise of off-state voltage that will not
trigger any off-state device; exponential method
$V_{D}=2 / 3 V_{D \max } ; \mathrm{V}_{\mathrm{GR}}=5 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} \quad \mathrm{dV} / \mathrm{dt} \quad<\quad 10 \mathrm{kV} / \mu \mathrm{s}$
Rate of rise of off-state voltage that will not trigger
any device following conduction, linear method
$\mathrm{I}_{\mathrm{T}}=20 \mathrm{~A} ; \mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DRMmax}} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V}_{;} \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} \quad \mathrm{dV} \mathrm{V}_{\mathrm{D}} / \mathrm{dt} \quad<\quad 1.0 \mathrm{kV} / \mu \mathrm{s}$
Off-state current

$$
V_{D}=V_{\text {Dmax }} ; T_{j}=120^{\circ} \mathrm{C}
$$

${ }^{\prime} D$
'L
typ.
1.5 A**

## Gate to cathode

Voltage that will trigger all devices

$$
V_{D}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}
$$

$\mathrm{V}_{\mathrm{GT}} \quad>\quad 1.5 \mathrm{~V}$

Current that will trigger all devices
$\mathrm{V}_{\mathrm{D}}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
IGT $>\quad 300 \mathrm{~mA}$

Minimum reverse breakdown voltage
$I_{G R}=1.0 \mathrm{~mA}$
$\mathrm{V}_{(\mathrm{BR}) \mathrm{GR}} \gg 10 \mathrm{~V}$

## Switching characteristics (resistive load)

Turn-on when switched to $\mathrm{I}_{\mathrm{T}}=10 \mathrm{~A}$ from $\mathrm{V}_{\mathrm{D}}=250 \mathrm{~V}$
with $\mathrm{I}_{\mathrm{GF}}=1.5 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
delay time
rise time

Fig. 3 Waveforms.

[^20]
## GTO (cont.)

## Switching characteristics (inductive load)

Turn-off when switched from $I_{T}=10 A$ to $V_{D}=V_{D m a x}$;
$\mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{L}_{\mathrm{G}} \leqslant 0.5 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$

| storage time | $\mathrm{t}_{\mathrm{s}}$ | $<$ | 0.60 | $\mu \mathrm{~s}$ |
| :--- | :--- | :--- | ---: | :--- |
| fall time | $\mathrm{t}_{\mathrm{f}}$ | $<$ | 0.25 | $\mu \mathrm{~s}$ |
| peak reverse gate current | $\mathrm{I}_{\mathrm{GR}}$ | $<$ | 10 | A |



Fig. 4 Waveforms.


GTO (cont.)


Fig. 6 The right hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.
$a=$ form factor $=\frac{I_{\mathrm{T}}(\mathrm{RMS})}{I_{\mathrm{T}}(\mathrm{AV})}$
$P=$ power excluding switching losses.
Values given on the right hand graph assume that the diode is not dissipating significant power.

## GTO (cont.)



Fig. 7 Anode current which can be turned off versus applied $d V_{D} / \mathrm{dt}^{*}$; inductive load; $\mathrm{L}_{\mathrm{G}} \leqslant 0.5 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$.
${ }^{*} \mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ is calculated from $\mathrm{I}_{\mathrm{T}} / \mathrm{C}_{\mathrm{S}}$.


Fig. 8 Minimum gate voltage that will trigger all devices as a function of junction temperature, $\mathrm{V}_{\mathrm{D}}=12 \mathrm{~V}$.


Fig. 9 Minimum gate current that will trigger all devices as a function of junction temperature; $\mathrm{V}_{\mathrm{D}}=12 \mathrm{~V}$. M1439


Fig. 10 Maximum $\mathrm{V}_{\mathrm{T}}$ versus $\mathrm{I}_{\mathrm{T}} ;-\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C} ;----\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$.


Fig. 11 Peak reverse gate current versus anode current at turn-off; inductive load;


Fig. 12 Transient thermal impedance.

GTO (cont.)


Fig. 13 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied $\mathrm{d} \mathrm{V}_{\mathrm{D}} / \mathrm{dt}$ (calculated from $\mathrm{I}_{\mathrm{T}} / \mathrm{C}_{\mathrm{S}}$ ); $\mathrm{d} \mathrm{V}_{\mathrm{D}} / \mathrm{dt}$ linear up to $\mathrm{V}_{\mathrm{Dmax}}=600 \mathrm{~V} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A}$; $\mathrm{L}_{\mathrm{G}} \leqslant 0.5 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$.


Fig. 14 Energy loss at turn off as a function of junction temperature; $\mathrm{I}_{\mathrm{G}}=0.5 \mathrm{~A} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V}$. Normalised to $\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$.

## DIODE CHARACTERISTICS

Forward voltage
$I_{F}=10 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
$\mathrm{V}_{\mathrm{F}}<2.0 \quad \mathrm{~V}^{*}$

Reverse recovery when switched from
$\mathrm{I}_{\mathrm{F}}=2 \mathrm{~A}$ to $\mathrm{V}_{\mathrm{R}} \geqslant 30 \mathrm{~V}$ with $-\mathrm{dI}_{\mathrm{F}} / \mathrm{dt}=20 \mathrm{~A} / \mu \mathrm{s} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
recovered charge
recovery time

| $\mathrm{O}_{\mathrm{s}}$ | $<$ | 2.0 | $\mu \mathrm{C}$ |
| :--- | :--- | :--- | :--- |
| $\mathrm{t}_{\mathrm{rr}}$ | $<$ | 0.6 | $\mu \mathrm{~s}$ |

Forward recovery when switched to
$I_{F}=5 A$ with $t_{r}=0.1 \mu \mathrm{~s} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
recovery time
$\mathrm{t}_{\mathrm{fr}}<1.0 \quad \mu \mathrm{~s}$


Fig. 15 Definition of $\mathrm{t}_{\mathrm{rr}}$ and $\mathrm{Q}_{\mathrm{s}}$.


Fig. 16 Definition of $\mathrm{t}_{\mathrm{fr}}$.

[^21]
## BTV70D SERIES

DIODE (cont.)


Fig. 17 The right hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.
$a=$ form factor $=\frac{I F(R M S)}{I_{F}(A V)}$
Values given on the right hand graph assume that the GTO is not dissipating significant power.

DIODE (cont.)


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


Fig. 19 Peak reverse recovery current versus $-\mathrm{dl}_{\mathrm{F}} / \mathrm{dt} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$; maximum values.

DIODE (cont.)


Fig. 20 Transient thermal impedance.

## FAST GATE TURN-OFF THYRISTORS

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

QUICK REFERENCE DATA

|  |  |  | BTW58-1000R | 1300R | 1500R |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Repetitive peak off-state voltage | VDRM | max. | 1000 | 1300 | 1500 | V |
| Non-repetitive peak on-state current | ITSM | max. |  | 50 |  | A |
| Controllable anode current | ITCRM | max. |  | 25 |  | A |
| Average on-state current | $I_{\text {I }}(\mathrm{AV})$ | max. |  | 6.5 |  | A |
| Fall time | $\mathrm{t}_{\mathrm{f}}$ | < |  | 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 |  |  |
| :--- | :--- | :--- |
| Transient off-state voltage | $\mathrm{V}_{\mathrm{DSM}}$ | max. |
| Repetitive peak off-state voltage | $\mathrm{V}_{\mathrm{DRM}}$ | max. |
| Working off-state voltage | $\mathrm{V}_{\mathrm{DW}}$ | max. |
| Continuous off-state voltage | $\mathrm{V}_{\mathrm{D}}$ | max. |

Average on-state current (averaged over any 20 ms period) up to $\mathrm{T}_{\mathrm{mb}}=85^{\circ} \mathrm{C}$

Controllable anode current
Non-repetitive peak on-state current
$\mathrm{t}=10 \mathrm{~ms}$; half-sinewave;
$\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$ prior to surge
$1^{2} \mathrm{t}$ for fusing; $\mathrm{t}=10 \mathrm{~ms}$
Total power dissipation up to $\mathrm{T}_{\mathrm{mb}}=25^{\circ} \mathrm{C}$

| $I_{\text {TSM }}$ | max. | 50 | A |
| :--- | :--- | ---: | :--- |
| $I^{2} \mathrm{t}$ | max. | 12.5 | A $^{2} \mathrm{~s}$ |
| $\mathrm{P}_{\text {tot }}$ | max. | 65 | W |

## Gate to cathode

Repetitive peak on-state current $\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$ prior to surge gate-cathode forward; $\mathrm{t}=10 \mathrm{~ms}$; half-sinewave gate-cathode reverse; $\mathrm{t}=20 \mu \mathrm{~s}$
Average power dissipation (averaged over any 20 ms period)

| $I_{G F M}$ | max. | 25 | A |
| :--- | :--- | :--- | :--- |
| $I_{\mathrm{GRM}}$ | max. | 25 | A |
| $\mathrm{P}_{\mathrm{G}(\mathrm{AV})}$ | max. | 2.5 | W |

## Temperatures

Storage temperature
Operating junction temperature

## THERMAL RESISTANCE

From junction to mounting base
From mounting base to heatsink with heatsink compound with 56367 alumina insulator and heatsink compound (clip-mounted)

| BTW58-1000R | 1300 R | 1500 R |  |
| ---: | ---: | ---: | :--- |
| 1200 | 1500 | 1650 | V* |
| 1000 | 1300 | 1500 | $\mathrm{~V}^{*}$ |
| 650 | 1200 | 1300 | $\mathrm{~V}^{*}$ |
| 650 | 750 | 800 | $\mathrm{~V}^{*}$ |


| IT(AV) | max. | 6.5 | A |
| :--- | :--- | ---: | :--- |
| ITCRM | max. | 25 | A |

max.
25 A

| $\mathrm{T}_{\text {stg }}$ |  | -40 to +150 | ${ }^{\circ} \mathrm{C}$ |
| :--- | ---: | ---: | ---: |
| $\mathrm{T}_{\mathrm{j}}$ | max. | 120 | ${ }^{\circ} \mathrm{C}$ |

${ }^{\circ} \mathrm{C}$
C

| $R_{\text {th j-mb }}$ | $=$ | 1.5 | $\mathrm{~K} / \mathrm{W}$ |
| :--- | :--- | :--- | :--- |
| $R_{\text {th mb-h }}$ | $=$ | 0.3 | $\mathrm{~K} / W$ |
| $R_{\text {th mb-h }}$ | $=$ |  |  |
|  | 0.8 | $\mathrm{~K} / W$ |  |

[^22]
## CHARACTERISTICS

## Anode to cathode

On-state voltage

$$
\mathrm{I}_{\mathrm{T}}=5 \mathrm{~A} ; \mathrm{I}_{\mathrm{G}}=0.2 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} \quad \mathrm{~V}_{\mathrm{T}} \quad<\quad 3.0 \mathrm{~V}^{*}
$$

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

$$
\mathrm{V}_{\mathrm{D}}=2 / 3 \mathrm{~V}_{\mathrm{Dmax}} ; \mathrm{V}_{G R}=5 \mathrm{~V}_{;} \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}
$$

$$
\mathrm{dV}_{\mathrm{D}} / \mathrm{dt} \quad<\quad 10 \mathrm{kV} / \mu \mathrm{s}
$$

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

$$
\begin{array}{lllll}
\quad \mathrm{I}_{\mathrm{T}}=5 \mathrm{~A} ; \mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DRMmax}} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} & \mathrm{~d} \mathrm{~V}_{\mathrm{D}} / \mathrm{dt} & < & 1.5 & \mathrm{kV} / \mu \mathrm{s} \\
\text { Off-state current } & & & & \\
\quad \mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{Dmax}} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} & \mathrm{I}_{\mathrm{D}} & < & 3.0 & \mathrm{~mA} \\
\text { Latching current; } \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C} & \mathrm{I}_{\mathrm{L}} & \text { typ. } & 1.0 & \mathrm{~A}^{* *}
\end{array}
$$

## Gate to cathode

Voltage that will trigger all devices
$\mathrm{V}_{\mathrm{D}}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
$\mathrm{V}_{\mathrm{GT}} \quad>\quad 1.5 \mathrm{~V}$

Current that will trigger all devices

$$
V_{D}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}
$$

$$
\mathrm{I}_{\mathrm{GT}} \quad>\quad 200 \mathrm{~mA}
$$

Minimum reverse breakdown voltage

$$
\mathrm{I}_{\mathrm{GR}}=1.0 \mathrm{~mA}
$$

$V_{(B R) G R}>10 \quad \mathrm{~V}$

## Switching characteristics (resistive load)

Turn-on when switched to $I_{T}=5 \mathrm{~A}$ from $\mathrm{V}_{\mathrm{D}}=250 \mathrm{~V}$
with $\mathrm{I}_{\mathrm{GF}}=0.5 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
delay time

| $\mathrm{t}_{\mathrm{d}}$ | $<$ | 0.25 | $\mu \mathrm{~s}$ |
| :--- | :--- | ---: | :--- |
| $\mathrm{t}_{\mathrm{r}}$ | $<$ | 1.0 | $\mu \mathrm{~s}$ |

rise time


Fig. 2 Waveforms

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


## Switching characteristics (inductive load)

| Turn-off when switched from $I_{T}=5 \mathrm{~A}$ to $V_{D}=V_{D R M m a x .}$ |  |  |  |  |
| :--- | :--- | :--- | ---: | :--- |
| $V_{G R}=10 \mathrm{~V} ; \mathrm{L}_{\mathrm{G}} \leqslant 1.0 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$ |  |  |  |  |
|  |  |  |  |  |
| storage time | $\mathrm{t}_{\mathrm{s}}$ | $<$ | 0.5 | $\mu \mathrm{~s}$ |
| fall time | $\mathrm{t}_{\mathrm{f}}$ | $<$ | 0.25 | $\mu \mathrm{~S}$ |
| peak reverse gate current | $\mathrm{I}_{\mathrm{GR}}$ | $<$ | 6 | A |



Fig. 3 Waveforms.


Fig. 4 Inductive load test circuit

[^23]

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 $=\frac{I_{T}(R M S)}{I_{T}(A V)}$
$P=$ power excluding switching losses.
${ }^{*} T_{m b}$ scale is for comparison purposes and is correct only for $R_{t h} m b-a<9.6 K / W$.


Fig. 6 Anode current which can be turned off versus anode voltage;
inductive load; $\mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{L}_{\mathrm{G}} \leqslant 1.0 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=85^{\circ} \mathrm{C}$.
${ }^{*} \mathrm{~d}_{\mathrm{D}} / \mathrm{dt}$ is calculated from $\mathrm{I}_{\mathrm{T}} / \mathrm{C}_{\mathrm{S}}$.


Fig. 7 Anode current which can be turned off versus applied $\mathrm{d} \mathrm{V}_{\mathrm{D}} / \mathrm{dt}^{*}$; inductive load; $\mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V}$; $\mathrm{L}_{\mathrm{G}} \leqslant 1.0 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} .{ }^{*} \mathrm{~d}_{\mathrm{D}} / \mathrm{dt}$ is calculated from $\mathrm{I}_{\mathrm{T}} / \mathrm{C}_{\mathrm{S}}$.


Fig. 8 Anode current which can be turned off versus applied $d V_{D} / \mathrm{dt}^{*}$; inductive load; $\mathrm{V}_{\mathrm{GR}}=5 \mathrm{~V}$; $\mathrm{L}_{\mathrm{G}} \leqslant 1.0 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} .{ }^{*} \mathrm{~d}_{\mathrm{D}} / \mathrm{dt}$ is calculated from $\mathrm{I}_{\mathrm{T}} / \mathrm{C}_{\mathrm{S}}$.


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


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


Fig. 11 Maximum $\mathrm{V}_{\mathrm{T}}$ versus $\mathrm{I}_{\mathrm{T}} ;-\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C} ;----\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$.


Fig. 12 Peak reverse gate current versus anode current at turn-off; inductive load; $\mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{I}_{\mathrm{G}}=0.2 \mathrm{~A} ; \mathrm{L}_{\mathrm{G}}=0.8 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$; maximum values.


Fig. 13 Peak reverse gate current versus applied reverse gate voltage; inductive load; $I_{T}=5$; $\mathrm{I}_{\mathrm{G}}=0.2 \mathrm{~A} ; \mathrm{L}_{\mathrm{G}}=0.8 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$; maximum values.


Fig. 14 Switching times as a function of junction temperature; $\mathrm{V}_{\mathrm{D}} \geqslant 250 \mathrm{~V} ; \mathrm{I}_{\mathrm{T}}=5 \mathrm{~A}$; $\mathrm{I}_{\mathrm{GF}}=0.5 \mathrm{~A} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{I}_{\mathrm{G}}=0.2 \mathrm{~A} ; \mathrm{L}_{\mathrm{G}}=0.8 \mu \mathrm{H}$; maximum values.



Fig. 16 Storage and fall times versus applied reverse gate voltage; inductive load; $\mathrm{I}_{\mathrm{T}}=5 \mathrm{~A} ; \mathrm{I}_{\mathrm{G}}=0.2 \mathrm{~A} ; \mathrm{L}_{\mathrm{G}}=0.8 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$; maximum values.


Fig. 17 Maximum energy loss at turn-off (per cycle) as a function of anode current and applied $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ (calculated from $\mathrm{I}_{\mathrm{T}} / \mathrm{C}_{\mathrm{S}}$ ); reapplied voltage sinsusoidal up to $\mathrm{V}_{\mathrm{DRM}}=1200 \mathrm{~V}$; $\mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V} ; \mathrm{I}_{\mathrm{G}}=0.2 \mathrm{~A} ; \mathrm{L}_{\mathrm{G}} \leqslant 1.0 \mu \mathrm{H} ; \mathrm{L}_{\mathrm{S}} \leqslant 0.25 \mu \mathrm{H} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$.


Fig. 18 Energy loss at turn off as a function of junction temperature; $\mathrm{I}_{\mathrm{G}}=0.2 \mathrm{~A} ; \mathrm{V}_{\mathrm{GR}}=10 \mathrm{~V}$. Normalised to $\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$.

## 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 | $\mathrm{V}_{(\mathrm{BO})}$ |  | 28 to 36 | V |
| :--- | :--- | :--- | ---: | ---: |
| Output voltage | $\mathrm{V}_{\mathrm{O}}$ | $>$ | 5 | V |
| Repetitive peak current | IFRM | 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 $T_{a m b}=50^{\circ} \mathrm{C}$
Repetitive peak current ( $\mathrm{t} \leqslant 20 \mu \mathrm{~s}$ )
Storage temperature
Junction temperature

| $P_{\text {tot }}$ | max. | 150 | mW |
| :--- | :--- | ---: | :--- |
| $\mathrm{I}_{\mathrm{FRM}}$ | max. | 2 | A |
| $\mathrm{~T}_{\text {stg }}$ |  | -55 to +125 | ${ }^{\circ} \mathrm{C}$ |
| $\mathrm{T}_{\mathrm{j}}$ | max. | 100 | ${ }^{\circ} \mathrm{C}$ |

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

## CHARACTERISTICS

$\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
Breakover voltage at $\frac{\mathrm{dV}}{\mathrm{dt}}=10 \mathrm{~V} / \mathrm{ms} \quad \mathrm{V}_{(\mathrm{BO})} \quad 28$ to $36 \quad \mathrm{~V}$

Breakover voltage symmetry $\quad\left|\mathrm{V}_{(\mathrm{BO}) I}-\mathrm{V}_{(\mathrm{BO}) \mathrm{III}}\right| \ll \mathrm{V}$

| Output voltage at $\frac{\mathrm{dV}}{\mathrm{dt}}=10 \mathrm{~V} / \mathrm{ms}$ | $\mathrm{V}_{\mathrm{O}}$ | $>$ | 5 | V |
| :--- | :--- | :--- | :--- | :--- |
| Breakover current at $\mathrm{V}=0.98 \mathrm{~V}_{(\mathrm{BO})}$ | $\mathrm{I}_{(\mathrm{BO})}$ | $<$ | 100 | $\mu \mathrm{~A}$ |



Fig. 2


Fig. 3 Test circuit for output voltage

## THYRISTORS

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

## QUICK REFERENCE DATA

| Repetitive peak voltages | $\mathrm{V}_{\text {DRM }} / \mathrm{V}_{\text {RRM }}$ | BT 145-500R |  | 600R | 800R |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | max. | 500 | 600 | 800 | V |
| Average on-state current | ${ }^{1} \mathrm{~T}(\mathrm{AV})$ | max. |  | 16 |  | A |
| R.M.S. on-state current | ${ }^{\prime} \mathrm{T}$ (RMS) | max. |  | 25 |  | A |
| Non-repetitive peak on-state current | $I_{\text {TSM }}$ | max. |  | 300 |  | A |

## MECHANICAL DATA

Dimensions in mm
Fig. 1 TO-220AB


Net mass: 2 g
Note: The exposed metal mounting base is directly connected to the
 anode.
Accessories supplied on request: see data sheets Mounting instructions and accessories for TO-220 envelopes.

## RATINGS

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

## Anode to cathode

No-repetitive peak voltages
Repetitive peak voltages
Crest working voltages
$V_{D S M} / V_{R S M}$
$V_{D R M} / V_{R R M}$
$V_{D W M} / V_{\text {RWM }}$

| BT145-500R |  | $600 R$ | $800 R$ |  |
| :--- | ---: | :--- | :--- | :--- |
| max. | 500 | 600 | 800 | $V$ |
| max. | 500 | 600 | 800 | $V$ |
| max. | 400 | 400 | 400 | $V$ |

Average on-state current (averaged over any 20 ms period) up to $\mathrm{T}_{\mathrm{mb}}=93^{\circ} \mathrm{C}$
R.M.S. on-state current

Repetitive peak on-state current

| IT(AV) | max. | 16 | A |
| :--- | ---: | ---: | ---: |
| IT(RMS) | max. | 25 | A |
| ITRM | max. | 300 | A |

Non-repetitive peak on-state current; $\mathrm{t}=10 \mathrm{~ms}$;
half sine-wave; $\mathrm{T}_{\mathrm{j}}=115^{\circ} \mathrm{C}$ prior to surge;
with reapplied $V_{\text {RWMmax }} \quad$ ITSM max. 300 A
$I^{2} t$ for fusing ( $t=10 \mathrm{~ms}$ )
$1^{2} t$
max. 450
$A^{2} s$
Rate of rise of on-state current after triggering with $\mathrm{I}_{\mathrm{G}}=160 \mathrm{~mA}$ to $\mathrm{I}_{\mathrm{T}}=50 \mathrm{~A} ; \mathrm{dI}_{\mathrm{G}} / \mathrm{dt}=160 \mathrm{~A} / \mathrm{ms}$ $\mathrm{dl}_{\mathrm{T}} / \mathrm{dt} \quad \max .200$
$\mathrm{A} / \mu \mathrm{s}$
Gate to cathode

| Reverse peak voltage | V $_{R G M}$ | max. | 5 | $V$ |
| :--- | :---: | :---: | :---: | :---: |
| Average power dissipation (averaged over any 20 ms period) | $\mathrm{P}_{\mathrm{G}}(\mathrm{AV})$ | $\max$ | 0.5 | W |
| Peak power dissipation; $\mathrm{t} \leqslant 10 \mu \mathrm{~s}$ | $\mathrm{P}_{\mathrm{GM}}$ | max. | 20 | W |

## Temperature

Storage temperature
Juction temperature

| $T_{\text {stg }}$ | -40 to +150 | ${ }^{\circ} \mathrm{C}$ |
| :--- | ---: | ---: |
| $\mathrm{T}_{\mathrm{j}}$ | $\max$. | 110 |${ }^{{ }^{\circ} \mathrm{C}}$

## THERMAL RESISTANCE

From junction to mounting base
From mounting base to heatsink with heatsink compound

| $R_{\text {th j-mb }}$ | $=$ | 1.0 | $\mathrm{~K} / \mathrm{W}$ |
| :--- | :--- | :--- | :--- |
| $R_{\text {th mb-h }}$ | $=$ | 0.3 | $\mathrm{~K} / \mathrm{W}$ |

## THERMAL RESISTANCE

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

## Influence of mounting method

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

Thermal resistance from mounting base to heatsink
a. with heatsink compound
$R_{\text {th mb-h }}=0.3 \mathrm{~K} / \mathrm{W}$
$R_{\text {th mb-h }}=1.4 \mathrm{~K} / \mathrm{W}$
b. with heatsink compound and 0.06 mm maximum mica insulator
c. with heatsink compound and 0.1 mm maximum mica insulator (56369)
$\mathrm{R}_{\text {th mb-h }}=2.2 \mathrm{~K} / \mathrm{W}$
d. with heatsink compound and 0.25 mm maximum alumina insulator (56367)
e. without heatsink compound
$R_{\text {th mb-h }}=0.8 \mathrm{~K} / \mathrm{W}$
$R_{\text {th mb-h }}=1.4 \mathrm{~K} / \mathrm{W}$
2. Free-air operation

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

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


Fig. 2.

## CHARACTERISTICS

## Anode to cathode

On-state voltage (measured under pulse conditions)

$$
I_{T}=30 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C} \quad \mathrm{~V}_{\mathrm{T}} \quad<\quad 1.5 \quad \mathrm{~V}
$$

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

$$
\mathrm{T}_{\mathrm{j}}=110^{\circ} \mathrm{C} ; \mathrm{R}_{\mathrm{GK}}=\text { open circuit } \quad \mathrm{dV}_{\mathrm{D}} / \mathrm{dt} \quad<\quad 200 \mathrm{~V} / \mu \mathrm{s}
$$

## Reverse current

$$
V_{R}=V_{R W M \max } ; T_{j}=110^{\circ} \mathrm{C}
$$

$$
I_{R}
$$

Off-state current
$\mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DWM} \text { max }} ; \mathrm{T}_{\mathrm{j}}=110^{\circ} \mathrm{C}$
Latching current; $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
Holding current; $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
Gate to cathode
Voltage that will trigger all devices

$$
\begin{aligned}
& V_{D}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=-40^{\circ} \mathrm{C} \\
& \mathrm{~V}_{\mathrm{D}}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}
\end{aligned}
$$

| $\mathrm{V}_{\mathrm{GT}}$ | $>$ | 1.5 | V |
| :--- | :--- | :--- | :--- |
| $\mathrm{~V}_{\mathrm{GT}}$ | $>$ | 1.0 | V |
|  |  |  |  |
| $\mathrm{~V}_{\mathrm{GD}}$ | $<$ | 0.25 | V |
|  |  |  |  |
| $\mathrm{I}_{\mathrm{GT}}$ | $>$ | 55 | mA |
| $\mathrm{I}_{\mathrm{GT}}$ | $>$ | 35 | mA |

## Switching characteristics

Gate-controlled turn-on time ( $\mathrm{t}_{\mathrm{gt}}=\mathrm{t}_{\mathrm{d}}+\mathrm{t}_{\mathrm{r}}$ )

$$
\text { when switched from } V_{D}=V_{D R M m a x} \text { to } I_{T}=40 \mathrm{~A} \text {; }
$$

$$
\mathrm{I}_{\mathrm{GT}}=100 \mathrm{~mA} ; \mathrm{dI}_{\mathrm{G}} / \mathrm{dt}=5 \mathrm{~A} / \mu \mathrm{s} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C} \quad \mathrm{t}_{\mathrm{gt}} \quad \text { typ. } \quad 2 \quad \mu \mathrm{~s}
$$



Fig. 3 Gate controlled turn-on time definition.

## MOUNTING INSTRUCTIONS

1. The device may be soldered directly into the circuit, but the maximum permissible temperature of the soldering iron or bath is $275^{\circ} \mathrm{C}$; it must not be in contact with the joint for more than 5 seconds. Soldered joints must be at least 4.7 mm from the seal.
2. The leads should not be bent less than 2.4 mm from the seal, and should be supported during bending. The leads can be bent, twisted or straightened by $90^{\circ}$ maximum. The minimum bending radius is 1 mm .
3. 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 $R_{\text {th }} m b-h$ 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 $R_{\text {th }} \mathrm{mb}$-h given for mounting with heatsink compound refer to the use of a metallic oxide-loaded compound. Ordinary silicone grease is not recommended.
6. Rivet mounting (only possible for non-insulated mounting).

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

## OPERATING NOTES

Dissipation and heatsink considerations:
a. The various components of junction temperature rise above ambient are illustrated in Fig. 4.


Fig. 4
b. The method of using Fig. 5 is as follows:

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

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

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


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


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



Fig. 6 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents ( $f=50 \mathrm{~Hz}$ ) with re-applied $V_{R W M m a x} ; T_{j}=110{ }^{\circ} \mathrm{C}$ prior to surge.



Fig. $7 — T_{j}=25^{\circ} \mathrm{C} ;--T_{j}=110^{\circ} \mathrm{C}^{\circ}$.


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


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


Fig. 10 Transient thermal impedance.

## THYRISTORS

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

## QUICK REFERENCE DATA



## 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

| Non-repetitive peak voltages |
| :--- |
| $\quad(\mathrm{t} \leqslant 10 \mathrm{~ms}$ ) |

Repetitive peak voltages $(\delta \leqslant 0.01)$

|  | BT149-F | A | B | D | E | M |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\mathrm{V}_{\text {DSM }} / \mathrm{V}_{\text {RSM }}$ | max. 50 | 100 | 200 | 400 | 500 | 600 | V* |
| $\mathrm{V}_{\text {DRM }} / \mathrm{V}_{\text {RRM }}$ | max. 50 | 100 | 200 | 400 | 500 | 600 | V |

Average on-state current (averaged over any
20 ms period) up to $\mathrm{T}_{\mathrm{mb}}=55^{\circ} \mathrm{C}$

## R.M.S. on-state current

Repetitive peak on-state current
Non-repetitive peak on-state current; t=10 ms; half sine-wave; $\mathrm{T}_{\mathrm{j}}=125^{\circ} \mathrm{C}$ prior to surge; with reapplied $\mathrm{V}_{\text {RWMmax }}$
$I^{2} t$ for fusing ( $\mathrm{t}=10 \mathrm{~ms}$ )
Rate of rise of on-state current after triggering with $\mathrm{I}_{\mathrm{G}}=1 \mathrm{~mA}$ to $\mathrm{I}_{\mathrm{T}}=1.8 \mathrm{~A} ; \mathrm{dI}_{\mathrm{G}} / \mathrm{dt}=4 \mathrm{~mA} / \mu \mathrm{s}$
$\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}$

| Peak reverse voltage | $\mathrm{V}_{\text {RGM }}$ | max. | 8 | V |
| :---: | :---: | :---: | :---: | :---: |
| Average power dissipation (averaged over any 20 ms period) | $\mathrm{P}_{\mathrm{G}}(\mathrm{AV})$ | max. | 0.1 | w |
| Peak power dissipation | $\mathrm{P}_{\mathrm{GM}}$ | max. | 2 | W |
| Temperatures |  |  |  |  |
| Storage temperature | $\mathrm{T}_{\text {stg }}$ |  | -40 to +150 | ${ }^{\circ} \mathrm{C}$ |
| Operating junction temperature | $\mathrm{T}_{\mathrm{j}}$ | max. | 125 | ${ }^{\circ} \mathrm{C}$ |
| THERMAL RESISTANCE |  |  |  |  |
| From junction to mounting base | $\mathrm{R}_{\text {th j-mb }}$ | = | 100 | K/W |
| From junction to ambient in free air, mounted on a p.c.b. with any lead length | $\mathrm{R}_{\text {th } \mathrm{j}-\mathrm{a}}$ | $=$ | 200 | K/W |

## Temperatures

Storage temperature
Operating junction temperature

| Peak reverse voltage | $\mathrm{V}_{\text {RGM }}$ | max. | 8 | V |
| :---: | :---: | :---: | :---: | :---: |
| Average power dissipation (averaged over any 20 ms period) | $\mathrm{P}_{\mathrm{G}}(\mathrm{AV})$ | max. | 0.1 | w |
| Peak power dissipation | $\mathrm{P}_{\mathrm{GM}}$ | max. | 2 | W |
| Temperatures |  |  |  |  |
| Storage temperature | $\mathrm{T}_{\text {stg }}$ |  | -40 to +150 | ${ }^{\circ} \mathrm{C}$ |
| Operating junction temperature | $\mathrm{T}_{\mathrm{j}}$ | max. | 125 | ${ }^{\circ} \mathrm{C}$ |
| THERMAL RESISTANCE |  |  |  |  |
| From junction to mounting base | $\mathrm{R}_{\text {th j-mb }}$ | = | 100 | K/W |
| From junction to ambient in free air, mounted on a p.c.b. with any lead length | $\mathrm{R}_{\text {th } \mathrm{j}-\mathrm{a}}$ | $=$ | 200 | K/W |

## THERMAL RESISTANCE

From junction to mounting base

| ITSM | max. | 8 | A |
| :--- | :--- | ---: | :--- |
| $I^{2} \mathrm{t}$ | $\max$. | 0.32 | $\mathrm{~A}^{2} \mathrm{~s}$ |

## Gate to cathode

[^24]
## THYRISTORS

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

## QUICK REFERENCE DATA

| Repetitive peak voltages | $V_{\text {DRM }} / V_{\text {RRM }}$ | max. | 500 | V |
| :---: | :---: | :---: | :---: | :---: |
| Average on-state current | ${ }^{1} \mathrm{~T}(\mathrm{AV})$ | max. | 2.5 | A |
| rms on-state current | $I_{\text {I (RMS }}$ ) | max. | 4 | A |
| Non-repetitive on-state current | ITSM | max. | 25 | A |

## MECHANICAL DATA

Dimensions in mm
Fig. 1 TO-220AB


Net mass: 2 g
Note: The exposed metal mounting base is directly connected to the anode.
Accessories supplied on request, see data sheets Mounting instructions and accessories for TO-220 envelopes.

## RATINGS

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

## Anode to cathode

Non-repetitive peak voltages ( $\mathrm{t} \leqslant 10 \mathrm{~ms}$ )
Repetitive peak voltage ( $\delta \leqslant 0.01$ )
Crest working voltages
Continuous voltages
Average on-state current (averaged over any 20 ms period) up to $\mathrm{T}_{\mathrm{mb}}=98^{\circ} \mathrm{C}$
R.M.S. on-state current

Repetitive peak on-state current
Non-repetitive peak on-state current $t=10 \mathrm{~ms}$; half sine-wave;
$\mathrm{T}_{\mathrm{j}}=110^{\circ} \mathrm{C}$ prior to surge;
with reapplied $V_{\text {RWMmax }}$
$I^{2} t$ for fusing ( $t=10 \mathrm{~ms}$ )
Rate of rise of on-state current
after triggering with $I_{G}=50 \mathrm{~mA}$;
to $\mathrm{I}_{\mathrm{T}}=10 \mathrm{~A}$;
$\mathrm{dl}_{\mathrm{G}} / \mathrm{dt}=50 \mathrm{~mA} / \mu \mathrm{s} \quad \mathrm{dl}_{\mathrm{T}} / \mathrm{dt} \quad \max .50 \quad \mathrm{~A} / \mu \mathrm{s}$

## Gate to cathode

Average power dissipation (averaged over any 20 ms period)
Peak power dissipation

## Temperatures

Storage temperature
Junction temperature

| $V_{D S M} / V_{R S M}$ | max. | 500 | $V^{*}$ |
| :--- | :--- | ---: | :--- |
| $V_{D R M} / V_{R R M}$ | max. | 500 | $V$ |
| $V_{D W M} / V_{\text {RWM }}$ | max. | 400 | $V$ |
| $V_{D} / V_{R}$ | max. | 400 | $V$ |
|  |  |  |  |
| $I_{T(A V)}$ | max. | 2.5 | A |
| $I_{T(R M S)}$ | max. | 4 | A |
| $I_{T R M}$ | max. | 25 | A |


| ITSM | max. | 25 | $A$ |
| :--- | :--- | ---: | :--- |
| $I^{2} t$ | max. | 3 | $A^{2} s$ |


| $P_{G}(A V)$ | max. | 0.5 | $W$ |
| :--- | :--- | ---: | :--- |
| $P_{G M}$ | $\max$. | 5 | $W$ |


| $T_{s t g}$ |  | -40 to +125 | ${ }^{\circ} \mathrm{C}$ |
| :--- | ---: | ---: | ---: |
| $T_{j}$ | $\max$ | 110 | ${ }^{\circ} \mathrm{C}$ |

*Although not recommended, higher off-state voltages may be applied without damage, but the thyristor may switch into the on-state. The rate of rise of on-state current should not exceed $15 \mathrm{~A} / \mu \mathrm{s}$.

## THERMAL RESISTANCE

From junction to mounting base
Transient thermal impedance; $\mathrm{t}=1 \mathrm{~ms}$

| $R_{\text {th } j-m b}$ | $=$ | 2.5 | $\mathrm{~K} / \mathrm{W}$ |
| :--- | :--- | :--- | :--- |
| $Z_{\text {th j-mb }}$ | $=$ | 0.2 | $\mathrm{~K} / \mathrm{W}$ |

## Influence of mounting method

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from mounting base to heatsink
a. with heatsink compound

| $R_{\text {th mb-h }}$ | $=$ | 0.3 | $\mathrm{~K} / \mathrm{W}$ |
| :--- | :--- | :--- | :--- |
| $R_{\text {th mb-h }}$ | $=$ | 1.4 | $\mathrm{~K} / \mathrm{W}$ |
| $R_{\text {th mb-h }}$ | $=$ | 2.2 | $\mathrm{~K} / \mathrm{W}$ |
| $R_{\text {th mb-h }}$ | $=$ | 0.8 | $\mathrm{~K} / \mathrm{W}$ |
| $R_{\text {th mb-h }}$ | $=$ | 1.4 | $\mathrm{~K} / \mathrm{W}$ |

e. without heatsink compound
$\mathrm{R}_{\text {th mb-h }}=1.4 \mathrm{~K} / \mathrm{W}$
2. Free air operation

The quoted values of $R_{\text {th }} j$-a should be used only when no leads of other dissipating components run to the same tie-point.
Thermal resistance from junction to ambient in free air; mounted on a printed-circuit board at a = any lead length
$R_{\text {th j-a }}=60 \mathrm{~K} / \mathrm{W}$


Fig. 2

CHARACTERISTICS $\left(\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}\right.$ unless otherwise stated)

## Anode to cathode

On-state voltage

$$
\mathrm{I}_{\mathrm{T}}=5 \mathrm{~A}
$$

Rate of rise of off-state voltage that will not trigger any device
$R_{G K}=100 \Omega ; T_{j}=110^{\circ} \mathrm{C}$
Reverse current
$\mathrm{V}_{\mathrm{R}}=\mathrm{V}_{\mathrm{RWM} \text { max }} ; \mathrm{T}_{\mathrm{j}}=110^{\circ} \mathrm{C}$
Off-state current
$V_{D}=V_{D W M m a x} ; T_{j}=110^{\circ} \mathrm{C}$
Latching curent
Holding current

## Gate to cathode

Voltage that will trigger all devices

$$
\begin{aligned}
& V_{D}=12 \mathrm{~V} \\
& V_{D}=12 \mathrm{~V} ; T_{j}=-40^{\circ} \mathrm{C}
\end{aligned}
$$

Voltage that will not trigger any device
$V_{D}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=110^{\circ} \mathrm{C}$
Current that will trigger all devices
$V_{D}=12 \mathrm{~V}$
$V_{D}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=-40^{\circ} \mathrm{C}$

## Switching characteristics

Gate-controlled turn-on time ( $\mathrm{t}_{\mathrm{gt}}=\mathrm{t}_{\mathrm{d}}+\mathrm{t}_{\mathrm{r}}$ )
with switched from $V_{D}=V_{D W M m a x}$ to $I_{T}=10 A$;
$\mathrm{I}_{\mathrm{GT}}=5 \mathrm{~mA} ; \mathrm{dI}_{\mathrm{G}} / \mathrm{dt}=0.2 \mathrm{~A} / \mu \mathrm{s} \quad \mathrm{t}_{\mathrm{gt}}$


Fig. 3 Gate-controlled turn-on time definition.
*Measured under pulse conditions to avoid excessive dissipation.

## MOUNTING INSTRUCTIONS

1. The device may be soldered directly into the circuit, but the maximum permissible temperature of the soldering iron or bath is $275^{\circ} \mathrm{C}$; it must not be in contact with the joint for more than 5 seconds. Soldered joints must be at least 4.7 mm from the seal.
2. The leads should not be bent less than 2.4 mm from the seal, and should be supported during bending. The leads can be bent, twisted or straightened by $90^{\circ}$ maximum. The minimum bending radius is 1 mm .
3. 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 $R_{\text {th }} m b-h$ 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 $\mathrm{R}_{\mathrm{th} \text { mb-h }}$ given for mounting with heatsink compound refer to the use of a metallic oxide-loaded compound. Ordinary silicone grease is not recommended.
6. Rivet mounting (only possible for non-insulated mounting).

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

## OPERATING NOTES

Dissipation and heatsink considerations:
a. The various components of junction temperature rise above ambient are illustrated in Fig. 4.


Fig. 4
b. The method of using Fig. 5 is as follows:

Starting with the required current on the $\mathrm{I}_{\mathrm{T}(\mathrm{AV}) \text { axis, trace upwards to meet the appropriate form }}$ factor curve. Trace right horizontally and upwards from the appropriate value on the $\mathrm{T}_{\mathrm{amb}}$ scale.
 now be calculated from:

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

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


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

$\alpha=$ conduction angle per half cycle
$a=$ form factor $=\frac{I T(R M S)}{I_{T}(A V)}$

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



Fig. 6 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents ( $f=50 \mathrm{~Hz}$ ) with reapplied $V_{R W M m a x} \cdot T_{j}=110^{\circ} \mathrm{C}$ prior to surge.

$\underbrace{\prime}_{\text {time }}$

Fig. $7-T_{j}=25^{\circ} \mathrm{C} ;--\mathrm{T}_{\mathrm{j}}=110^{\circ} \mathrm{C}$.


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


Fig. 10 Transient thermal impedance.

## THYRISTORS

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

## QUICK REFERENCE DATA

|  |  | BT151-500R |  | 650R | 800R |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Repetitive peak voltages | $\mathrm{V}_{\text {DRM }} / \mathrm{V}_{\text {RRM }}$ | max. | 500 | 650 | 800 | V |
| Average on-state current | ${ }^{\prime} \mathrm{T}(\mathrm{AV})$ | max. |  | 7.5 |  | A |
| R.M.S. on-state current | ${ }^{1} \mathrm{~T}$ (RMS) | max. |  | 12 |  | A |
| Non-repetitive peak on-state current | ITSM | max. |  | 100 |  | A |

## MECHANICAL DATA

Fig. 1 TO-220AB.
Dimensions in mm

g


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 | 00R | 650R | 800R |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Non-repetitive peak voltages ( $\mathrm{t} \leqslant 10 \mathrm{~ms}$ ) | $\mathrm{V}_{\text {DSM }} / \mathrm{V}_{\text {RSM }}$ | max. | 500 | 650 | 800 | V* |
| Repetitive peak voltages ( $\delta \leqslant 0.01$ ) | $\mathrm{V}_{\text {DRM }} / \mathrm{V}_{\text {RRM }}$ | max. | 500 | 650 | 800 | V |
| Crest working voltages | $V_{\text {DWM }} / V_{\text {RWM }}$ | 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 $\mathrm{T}_{\mathrm{mb}}=95^{\circ} \mathrm{C}$ | ${ }^{\prime} \mathrm{T}(\mathrm{AV})$ | max. |  | 7.5 |  | A |
| R.M.S. on-state current | $I^{T}$ (RMS) | max. |  | 12 |  | A |
| Repetitive peak on-state current | ITRM | max. |  | 65 |  | A |
| Non-repetitive peak on-state current; $t=10 \mathrm{~ms}$; half sine-wave; $\mathrm{T}_{\mathrm{j}}=110^{\circ} \mathrm{C}$ prior to surge; with reapplied $V_{\text {RWMmax }}$ | ITSM | max. |  | 100 |  | A |
| $\mathrm{I}^{2} \mathrm{t}$ for fusing ( $\mathrm{t}=10 \mathrm{~ms}$ ) | $\mathrm{I}^{2} \mathrm{t}$ | max. |  | 50 |  | $A^{2} \mathrm{~s}$ |
| Rate of rise of on-state current after triggering with $\mathrm{I}_{\mathrm{G}}=50 \mathrm{~mA}$ to $\mathrm{I}_{\mathrm{T}}=20 \mathrm{~A} ; \mathrm{dl}_{\mathrm{G}} / \mathrm{dt}=50 \mathrm{~mA} / \mu \mathrm{s}$ | $\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}$ | max. |  | 50 |  | $\mathrm{A} / \mu \mathrm{s}$ |
| Gate to cathode |  |  |  |  |  |  |
| Reverse peak voltage | $\mathrm{V}_{\text {RGM }}$ | max. |  | 5 |  | V |
| Average power dissipation (averaged over any 20 ms period) | $\mathrm{P}_{\mathrm{G}(\mathrm{AV})}$ | max. |  | 0.5 |  | W |
| Peak power dissipation | $\mathrm{P}_{\mathrm{GM}}$ | max. |  | 5 |  | W |
| Temperatures |  |  |  |  |  |  |
| Storage temperature | $\mathrm{T}_{\text {stg }}$ |  | -40 t | +125 |  | ${ }^{\circ} \mathrm{C}$ |
| Operating junction temperature | Tj | max. |  | 110 |  | ${ }^{\circ} \mathrm{C}$ |

[^25]
## THERMAL RESISTANCE

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

$$
\mathrm{Z}_{\text {th } j-\mathrm{mb}}=0.2 \mathrm{~K} / \mathrm{W}
$$

## Influence of mounting method

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from mounting base to heatsink
a. with heatsink compound
$R_{\text {th mb-h }}=0.3 \mathrm{~K} / \mathrm{W}$
b. with heatsink compound and 0.06 mm maximum mica insulator
c. with heatsink compound and 0.1 mm maximum mica insulator (56369)
d. with heatsink compound and 0.25 mm max. alumina insulator (56367)
e. without heatsink compound

| $R_{\text {th mb-h }}=1.4$ | $\mathrm{~K} / \mathrm{W}$ |
| :--- | :--- | :--- |
| $R_{\text {th mb-h }}=2.2$ | $\mathrm{~K} / \mathrm{W}$ |
| $R_{\text {th mb-h }}=0.8$ | $\mathrm{~K} / \mathrm{W}$ |
| $R_{\text {th } m b-h}=1.4 \mathrm{~K} / \mathrm{W}$ |  |

2. Free-air operation

The quoted values of $R_{t h} j$-a should be used only when no leads of other dissipating components run to the same tie-point.
Thermal resistance from junction to ambient in free air: mounted on a printed-circuit board at $a=$ any lead length and with copper laminate

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



Fig. 2.

## CHARACTERISTICS

## Anode to cathode

On-state voltage

$$
\mathrm{I}_{\mathrm{T}}=23 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}
$$

Rate of rise of off-state voltage that will not trigger any
device; $T_{j}=110^{\circ} \mathrm{C}$; see Fig. 10
$\mathrm{R}_{\mathrm{GK}}=$ open circuit
$R_{G K}=100 \Omega$

## Reverse current

$\mathrm{V}_{\mathrm{R}}=\mathrm{V}_{\mathrm{RWM} \text { max }} ; \mathrm{T}_{\mathrm{j}}=110^{\circ} \mathrm{C}$
Off-state current
$V_{D}=V_{D W M \max } ; T_{j}=110^{\circ} \mathrm{C}$
Latching current; $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
Holding current; $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$

## Gate to cathode

Voltage that will trigger all devices
$V_{D}=6 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
$V_{D}=6 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=-40^{\circ} \mathrm{C}$
Voltage that will not trigger any device
$V_{D}=V_{D R M m a x} ; T_{j}=110^{\circ} \mathrm{C}$
Current that will trigger all devices
$\mathrm{V}_{\mathrm{D}}=6 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
$V_{D}=6 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=-40^{\circ} \mathrm{C}$

| $\mathrm{V}_{\mathrm{GT}}$ | $>$ | $1,5 \mathrm{~V}$ |
| :--- | :--- | :--- | :--- |
| $\mathrm{~V}_{\mathrm{GT}}$ | $>$ | $2,3 \mathrm{~V}$ |
| $\mathrm{~V}_{\mathrm{GD}}$ | $<$ | 250 mV |
| $\mathrm{I}_{\mathrm{GT}}$ | $>$ | 15 mA |
| $\mathrm{I}_{\mathrm{GT}}$ | $>$ | 20 mA |

## Switching characteristics

Gate-controlled turn-on time ( $t_{g t}=t_{d}+t_{r}$ ) when
switched from $V_{D}=V_{D R M m a x}$ to $I_{T}=40 \mathrm{~A}$;
$\mathrm{I}_{\mathrm{GT}}=100 \mathrm{~mA} ; \mathrm{dI}_{\mathrm{G}} / \mathrm{dt}=5 \mathrm{~A} / \mu \mathrm{s} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
tgt typ. $2 \mu \mathrm{~s}$


Fig.2a Gate controlled turn-on time definition.
*Measured under pulse conditions to avoid excessive dissipation.

## MOUNTING INSTRUCTIONS

1. The device may be soldered directly into the circuit, but the maximum permissible temperature of the soldering iron or bath is $275^{\circ} \mathrm{C}$; it must not be in contact with the joint for more than 5 seconds. Soldered joints must be at least 4.7 mm from the seal.
2. The leads should not be bent less than 2.4 mm from the seal, and should be supported during bending. The leads can be bent, twisted or straightened by $90^{\circ}$ maximum. The minimum bending radius is 1 mm .
3. 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 $R_{\text {th }} m b-h$ 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 $R_{\text {th }} \mathrm{mb}$-h given for mounting with heatsink compound refer to the use of a metallic-oxide loaded compound. Ordinary silicone grease is not recommended.
6. Rivet mounting (only possible for non-insulated mounting)

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

## OPERATING NOTES

Dissipation and heatsink considerations:
a. The various components of junction temperature rise above ambient are illustrated in Fig. 3.


Fig. 3.
b. The method of using Fig. 4 is as follows:

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

$$
R_{t h ~ h-a}=R_{t h ~ m b-a}-R_{t h ~ m b-h}
$$

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


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

|  |  | $\alpha=$ conduction angle per half cycle |
| :---: | :---: | :---: |
|  |  | $a=\text { form factor }=\underline{T}(\mathrm{RMS})$ |
|  |  | ${ }^{1} \mathrm{~T}(\mathrm{AV})$ |
| $\alpha$ | a |  |
| $30^{\circ}$ | 4 |  |
| $60^{\circ}$ | 2,8 |  |
| $90^{\circ}$ | 2,2 |  |
| $120^{\circ}$ | 1,9 |  |
| $180^{\circ}$ | 1,57 |  |



Fig. 5 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents ( $f=50 \mathrm{~Hz}$ ); $\mathrm{T}_{\mathrm{j}}=110^{\circ} \mathrm{C}$ prior to surge; with reapplied $\mathrm{V}_{\mathrm{RWMmax}}$.



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


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


Fig. 8.


Fig. 9

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


## FULL-PACK THYRISTORS

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

## QUICK REFERENCE DATA

|  |  | BT151F-500 | 650 | 800 |
| :--- | :--- | :--- | ---: | ---: |
| Repetitive peak voltages | V $_{\text {DRM }} / V_{\text {RRM }}$ | max. | 500 | 650 |
|  |  |  | 800 | V |
| Average on-state current | IT(AV) | max. | 5.7 |  |
| R.M.S. on-state current | IT(RMS) | max. | 9 | A |
| Non-repetitive peak on-state current | ITSM | $\max$. | 100 | A |

## MECHANICAL DATA

Dimensions in mm
Fig. 1 SOT-186


Net mass 2 g .
The seating plane is electrically isolated from all three terminals.

## RATINGS

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

| Anode to cathode |  | BT15 | 500 | 650 | 800 |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Non-repetitive peak voltages ( $\mathrm{t} \leqslant 10 \mathrm{~ms}$ ) | $\mathrm{V}_{\text {DSM }} / \mathrm{V}_{\text {RSM }}$ | max. | 500 | 650 | 800 | V* |
| Repetitive peak voltages ( $\delta \leqslant 0.01$ ) | $V_{\text {DRM }} / V_{\text {RRM }}$ | max. | 500 | 650 | 800 | V |
| Crest working voltages | $V_{\text {DWM }} / V_{\text {RWM }}$ | max. | 400 | 400 | 400 | V |
| Continuous voltages | $\mathrm{V}_{\mathrm{D}} / \mathrm{V}_{\mathrm{R}}$ | $\max$. | 400 | 400 | 400 | V |
| Average on-state current (averaged over any 20 ms period) up to $\mathrm{T}_{\mathrm{h}}=74^{\circ} \mathrm{C}$ | $1 \mathrm{~T}(\mathrm{AV})$ | max. |  | 5.7 |  | A |
| R.M.S. on-state current | IT(RMS) | max. |  | 9 |  | A |
| Repetitive peak on-state current | ITRM | max. |  | 65 |  | A |
| Non-repetitive peak on-state current $\mathrm{t}=10 \mathrm{~ms}$; half-sinewave; $\mathrm{T}_{\mathrm{j}}=110^{\circ} \mathrm{C}$ prior to surge; with reapplied $\mathrm{V}_{\mathrm{RW}}$ Mmax | ${ }^{1}$ TSM | max. |  | 100 |  | A |
| $1^{2} t$ for fusing ( $\mathrm{t}=10 \mathrm{~ms}$ ) | $1^{2} \mathrm{t}$ | max. |  | 50 |  | $A^{2} \mathrm{~s}$ |
| Rate of rise of on-state current after triggering with $\mathrm{I}_{\mathrm{G}}=50 \mathrm{~mA}$ to $\mathrm{I}_{\mathrm{T}}=20 \mathrm{~A} ; \mathrm{dI}_{\mathrm{G}} / \mathrm{dt}=50 \mathrm{~mA} / \mu \mathrm{s}$ | $\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}$ | max. |  | 50 |  | A/ $\mu \mathrm{s}$ |
| Gate to cathode |  |  |  |  |  |  |
| Reverse peak voltage | $V_{\text {RGM }}$ | max. |  | 5 |  | V |
| Average power dissipation (averaged over any 20 ms period) | $\mathrm{P}_{\mathrm{G}}(\mathrm{AV})$ | max. |  | 0.5 |  | W |
| Peak power dissipation | $\mathrm{P}_{\mathrm{GM}}$ | max. |  | 5 |  | W |
| Temperatures |  |  |  |  |  |  |
| Storage temperature | $\mathrm{T}_{\text {stg }}$ |  | -40 | +125 |  | ${ }^{\circ} \mathrm{C}$ |
| Operating junction temperature | $\mathrm{T}_{\mathrm{j}}$ | max. |  | 110 |  | ${ }^{\circ} \mathrm{C}$ |
| ISOLATION |  |  |  |  |  |  |
| From all three terminals to external heatsink (peak) | $\mathrm{V}_{\text {isol }}$ | $\min$. |  | 1000 |  | V |
| Capacitance from anode to external heatsink | $\mathrm{C}_{\text {isol }}$ | typ. |  | 12 |  | pF |

[^26]
## THERMAL RESISTANCE

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

Thermal resistance from junction to external heatsink
With heatsink compound

| $R_{\text {th } j-h}$ | $=$ | 4.5 | $\mathrm{~K} / \mathrm{W}$ |
| :--- | :--- | :--- | :--- |
| $R_{\text {th } j-h}$ | $=$ | 6.5 | $\mathrm{~K} / \mathrm{W}$ |

2. Free-air operation

The quoted values of $R_{t h} j$-a should be used only when no leads of other dissipating components run to the same tie-point.
Thermal resistance from junction to ambient in free air; mounted on a printed-circuit board at a = any lead length and with copper laminate
$R_{\text {th j-a }}=55 \mathrm{~K} / \mathrm{W}$


Fig.2.

## CHARACTERISTICS

## Anode to cathode

On-state voltage

$$
\mathrm{I}_{\mathrm{T}}=23 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C} \quad \mathrm{~V}_{\mathrm{T}} \quad<\quad 1.75 \quad \mathrm{~V}^{*}
$$

Rate of rise of off-state voltage that will not trigger any device; $\mathrm{T}_{\mathrm{j}}=110^{\circ} \mathrm{C}$; see Fig. 10
$\mathrm{R}_{\mathrm{GK}}=$ open circuit

| $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ | $<$ | 50 | $\mathrm{~V} / \mu \mathrm{s}$ |
| :--- | :--- | ---: | ---: |
| $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ | $<$ | 200 | $\mathrm{~V} / \mu \mathrm{s}$ |
|  |  |  |  |
| $\mathrm{I}_{\mathrm{R}}$ |  | 0.5 | mA |
|  |  |  |  |
| $\mathrm{I}_{\mathrm{D}}$ | $<$ | 0.5 | mA |
| $\mathrm{I}_{\mathrm{L}}$ | $<$ | 40 | mA |
| $\mathrm{I}_{\mathrm{H}}$ | $<$ | 20 | mA |

## Gate to cathode

Voltage that will trigger all devices
$V_{D}=6 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$

|  |  | 1.5 | V |
| :--- | :--- | ---: | :--- |
| $\mathrm{~V}_{\mathrm{GT}}$ | $>$ | 2.3 | V |
| $\mathrm{~V}_{\mathrm{GT}}$ | $>$ |  |  |
|  |  |  |  |
| $\mathrm{V}_{\mathrm{GD}}$ | $<$ | 250 | mV |
|  |  |  |  |
| $\mathrm{I}_{\mathrm{GT}}$ | $>$ | 15 | mA |
| $\mathrm{I}_{\mathrm{GT}}$ | $>$ | 20 | mA |

## Switching characteristics

Gate-controlled turn-on time ( $\mathrm{t}_{\mathrm{gt}}=\mathrm{t}_{\mathrm{d}}+\mathrm{t}_{\mathrm{r}}$ ) when
switched from $V_{D}=V_{D R M m a x}$ to $I_{T}=40 \mathrm{~A}$;
$\mathrm{I}_{\mathrm{G} T}=100 \mathrm{~mA} ; \mathrm{dl}_{\mathrm{G}} / \mathrm{dt}=5 \mathrm{~A} / \mu \mathrm{s} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C} \quad \mathrm{t}_{\mathrm{gt}} \quad$ typ. $2 \mu \mathrm{~s}$


Fig. 3 Gate controlled turn-on time definition.
*Measured under pulse conditions to avoid excessive dissipation.

## MOUNTING INSTRUCTIONS

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

## OPERATING NOTES

Dissipation and heatsink considerations:
a. The various components of junction temperature rise above ambient are illustrated in Fig.4.


Fig. 4.
b. The method of using Fig. 5 is as follows:

Starting with the required current on the $I_{T}(A V)$ axis of Fig.5a, trace upwards to meet the appropriate form factor curve and read off the power $P$ on the left hand scale. Using this value of $P$, on either Fig. 5 b or c , trace right horizontally and upwards from the appropriate value on the $\mathrm{T}_{\mathrm{amb}}$ scale. The intersection determines $R_{t h} h-a$, the required heatsink thermal resistance value.
c. Any measurement of heatsink temperature should be made immediately adjacent to the device.



Fig.5b Without heatsink compound.
$\alpha=$ conduction angle per half cycle
$a=$ form factor $=\frac{I_{T}(R M S)}{\mathrm{I}_{T}(\mathrm{AV})}$


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

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


Fig.5c With heatsink compound.


Fig. 6 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents ( $f=50 \mathrm{~Hz}$ ); $\mathrm{T}_{\mathrm{j}}=110^{\circ} \mathrm{C}$ prior to surge; with reapplied $\mathrm{V}_{\mathrm{RWMmax}}$.



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


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


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



Fig. 11 Transient thermal impedance; $\qquad$ with heatsink compound; - - - without heatsink compound.

## THYRISTORS

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

## QUICK REFERENCE DATA

|  |  | BT152-400R |  | 600R | 800R |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Repetitive peak voltages | $\mathrm{V}_{\text {DRM }} / \mathrm{V}_{\text {RRM }}$ | max. | 400 | 600 | 800 | $v$ |
| Average on-state current | ${ }^{1} \mathrm{~T}(\mathrm{AV})$ | max. |  | 13 |  | A |
| R.M.S. on-state current | ${ }^{\text {IT(RMS }}$ ) | max. |  | 20 |  | A |
| Non-repetitive peak on-state current | ${ }^{\text {ITSM }}$ | 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.

를 Products approved to CECC $50011-011$ available on request.

## RATINGS

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

## Anode to cathode

Non-repetitive peak voltages
Repetitive peak voltages
Crest working voltages
$\mathrm{V}_{\mathrm{DSM}} / \mathrm{V}_{\text {RSM }}$
$\mathrm{V}_{\text {DRM }} / \mathrm{V}_{\text {RRM }}$
$\mathrm{V}_{\text {DWM }} / \mathrm{V}_{\text {RWM }}$

| BT152-400R |  |  | 600 R | 800 R |
| :--- | :--- | :--- | :--- | :--- |
| max. | 450 | 650 | 850 | V |
| max. | 400 | 600 | 800 | V |
| max. | 400 | 400 | 400 | V |

Average on-state current (averaged over
any 20 ms period) up to $\mathrm{T}_{\mathrm{mb}}=93^{\circ} \mathrm{C}$
R.M.S. on-state current

Repetitive peak on-state current

| IT(AV) | max. | 13 | A |
| :--- | ---: | ---: | ---: |
| IT(RMS) | max. | 20 | A |
| ITRM | max. | 200 | A |

Non-repetitive peak on-state current; $\mathrm{t}=10 \mathrm{~ms}$; half sine-wave; $\mathrm{T}_{\mathrm{j}}=115^{\circ} \mathrm{C}$ prior to surge;
with reapplied $\mathrm{V}_{\text {RWMmax }}$
$1^{2} t$ for fusing ( $\mathrm{t}=10 \mathrm{~ms}$ )
Rate of rise of on-state current after triggering
with $\mathrm{I}_{\mathrm{G}}=160 \mathrm{~mA}$ to $\mathrm{I}_{\mathrm{T}}=50 \mathrm{~A} ; \mathrm{dl}_{\mathrm{G}} / \mathrm{dt}=160 \mathrm{~A} / \mathrm{ms}$
Gate to cathode

| Reverse peak voltage | $\mathrm{V}_{\mathrm{RGM}}$ | $\max$. | 5 | V |
| :--- | :--- | :--- | ---: | :--- |
| Average power dissipation (averaged over any 20 ms period) | $\mathrm{P}_{\mathrm{G}(\mathrm{AV})}$ | $\max$. | 0.5 | W |
| Peak power dissipation; $\mathrm{t} \leqslant 10 \mu \mathrm{~s}$ | $\mathrm{P}_{\mathrm{GM}}$ | $\max$. | 20 | W |
| Temperature |  |  |  |  |
| Storage temperature | $\mathrm{T}_{\text {stg }}$ | -40 to +150 | ${ }^{\circ} \mathrm{C}$ |  |
| Junction temperature | $\mathrm{T}_{\mathrm{j}}$ | $\max$. | 115 | ${ }^{\circ} \mathrm{C}$ |

## THERMAL RESISTANCE

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

## Influence of mounting method

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from mounting base to heatsink
a. with heatsink compound
b. with heatsink compound and 0.06 mm maximum mica insulator
c. with heatsink compound and 0.1 mm maximum mica insulator (56369)
d. with heatsink compound and 0.25 mm max. alumina insulator (56367)
e. without heatsink compound

| $R_{\text {th } m b-h}=0.3$ | $\mathrm{~K} / \mathrm{W}$ |
| :--- | :--- | :--- |
| $R_{\text {th } m b-h}=1.4$ | $\mathrm{~K} / \mathrm{W}$ |
| $R_{\text {th } m b-h}=2.2$ | $\mathrm{~K} / \mathrm{W}$ |
| $R_{\text {th } m b-h}=0.8$ | $\mathrm{~K} / \mathrm{W}$ |
| $R_{\text {th } m b-h}=1.4$ | $\mathrm{~K} / \mathrm{W}$ |

2. Free-air operation

The quoted values of $\mathrm{R}_{\mathrm{th} \mathrm{j}-\mathrm{a}}$ 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

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



Fig. 2.

## CHARACTERISTICS

## Anode to cathode

On-state voltage (measured under pulse conditions)

$$
\mathrm{I}_{\mathrm{T}}=40 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}
$$

$$
\mathrm{V}_{\mathrm{T}} \quad<\quad 1.75
$$

| $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ | $<$ | 200 | $\mathrm{~V} / \mu \mathrm{s}$ |
| :--- | :---: | :---: | :---: |
| $\mathrm{I}_{\mathrm{R}}$ | $<$ | 1.0 | mA |
|  |  |  |  |
| $\mathrm{I}_{\mathrm{D}}$ | $<$ | 1.0 | mA |
| $\mathrm{I}_{\mathrm{L}}$ | $<$ | 80 | mA |
| $\mathrm{I}_{\mathrm{H}}$ | $<$ | 60 | mA |

## Gate to cathode

Voltage that will trigger all devices

$$
\begin{aligned}
& \mathrm{V}_{\mathrm{D}}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=-40^{\circ} \mathrm{C} \\
& \mathrm{~V}_{\mathrm{D}}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}
\end{aligned}
$$

Voltage that will not trigger any device
$\mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DRMmax}} \mathrm{T}_{\mathrm{j}}=115{ }^{\circ} \mathrm{C}$
Current that will trigger all devices
$\mathrm{V}_{\mathrm{D}}=12 \mathrm{~V}_{\mathrm{i}} \mathrm{T}_{\mathrm{j}}=-40^{\circ} \mathrm{C}$
$\mathrm{V}_{\mathrm{D}}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$

| $\mathrm{V}_{\mathrm{GT}}$ | $>$ | 1.5 | V |
| :--- | :---: | :--- | :--- |
| $\mathrm{~V}_{\mathrm{GT}}$ | $>$ | 1.0 | V |
| $\mathrm{~V}_{\mathrm{GD}}$ | $<$ | 0.25 | V |
|  |  |  |  |
| $\mathrm{I}_{\mathrm{GT}}$ | $>$ | 50 | mA |
| IGT $_{\mathrm{GI}}$ | $>$ | 32 | mA |

## Switching characteristics

Gate-controlled turn-on time ( $\mathrm{t}_{\mathrm{gt}}=\mathrm{t}_{\mathrm{d}}+\mathrm{t}_{\mathrm{r}}$ ) when
switched from $V_{D}=V_{D R M m a x}$ to $I_{T}=40 \mathrm{~A}$; ${ }^{\mathrm{I}} \mathrm{GT}=100 \mathrm{~mA} ; \mathrm{dI}_{\mathrm{G}} / \mathrm{dt}=5 \mathrm{~A} / \mu \mathrm{s} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
Circuit-commutated turn-off time when switched
from $\mathrm{I}_{\mathrm{T}}=40 \mathrm{~A}$ to $\mathrm{V}_{\mathrm{R}}>50 \mathrm{~V}$ with $-\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}=10 \mathrm{~A} / \mu \mathrm{s}$;


Fig.3a Gate-controlled turn-on time definition.
$\mathrm{t}_{\mathrm{gt}} \quad$ typ. $\quad 2 \quad \mu \mathrm{~s}$
$\mathrm{t}_{\mathrm{q}} \quad$ typ. $\quad 35 \quad \mu \mathrm{~s}$


Fig. 3 b 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 $275^{\circ} \mathrm{C}$; it must not be in contact with the joint for more than 5 seconds. Soldered joints must be at least 4.7 mm from the seal.
2. The leads should not be bent less than 2.4 mm from the seal, and should be supported during bending. The leads can be bent, twisted or straightened by $90^{\circ}$ maximum. The minimum bending radius is 1 mm .
3. 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 $R_{t h} m b-h$ 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 $R_{\text {th }} \mathrm{mb}$-h given for mounting with heatsink compound refer to the use of a metallic-oxide loaded compound. Ordinary silicone grease is not recommended.
6. Rivet mounting (only possible for non-insulated mounting)

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

## OPERATING NOTES

Dissipation and heatsink considerations:
a. The various components of junction temperature rise above ambient are illustrated in Fig. 4.


Fig. 4
b. The method of using Fig. 5 is as follows:

Starting with the required current on the $I_{T}(A V)$ axis, trace upwards to meet the appropriate form factor curve. Trace right horizontally and upwards from the appropriate value on the $T_{\text {amb }}$ scale. The intersection determines the $R_{t h} m b-a$. The heatsink thermal resistance value ( $R_{t h} h-a$ ) can now be calculated from:

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

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


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


$$
\begin{aligned}
& \alpha=\text { conduction angle per half cycle } \\
& a=\text { form factor }=\frac{I_{T}(R M S)}{I_{T}(A V)}
\end{aligned}
$$

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



Fig. 6 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents ( $f=50 \mathrm{~Hz}$ ); $\mathrm{T}_{\mathrm{j}}=115^{\circ} \mathrm{C}$ prior to surge; with reapplied $\mathrm{V}_{\mathrm{RWM}}$ max.



Fig. $7 \longrightarrow T_{j}=25^{\circ} \mathrm{C} ;--T_{j}=115^{\circ} \mathrm{C}$


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


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


Fig. 10

## FAST TURN-OFF THYRISTOR

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

## QUICK REFERENCE DATA

| Repetitive peak off-state voltage | $\mathrm{V}_{\mathrm{DRM}}$ | $\max$. | 500 V |
| :--- | :--- | :--- | ---: |
| Average on-state current | $\mathrm{I}_{\mathrm{T}(\mathrm{AV})}$ | $\max$. | 4 A |
| R.M.S. on-state current | $\mathrm{I}_{\mathrm{T}(\mathrm{RMS})}$ | $\max$. | 6 A |
| Repetitive peak on-state current | $\mathrm{I}_{\mathrm{TRM}}$ | $\max$. | 30 A |
| Circuit-commutated turn-off time | $\mathrm{t}_{\mathrm{q}}$ | $<$ | $20 \mu \mathrm{~s}$ |
| 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.


## BT153

## RATINGS

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

## Anode to cathode

Non-repetitive peak voltages ( $\mathrm{t} \leqslant 10 \mathrm{~ms}$ )
Repetitive peak voltages
Working voltages
Average on-state current (averaged over any 20 ms period) up to $\mathrm{T}_{\mathrm{mb}}=95^{\circ} \mathrm{C}$
R.M.S. on-state current

Working peak on-state current
Repetitive peak on-state current
Non-repetitive peak on-state current; $\mathrm{t}=10 \mathrm{~ms}$; half sine-wave; $\mathrm{T}_{\mathrm{j}}=1{10^{\circ}}^{\circ} \mathrm{C}$ prior to surge; with reapplied $\mathrm{V}_{\mathrm{RWMmax}}$
$I^{2} t$ for fusing; $t=10 \mathrm{~ms} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
Rate of rise of on-state current after triggering up to $f=20 \mathrm{kHz} ; V_{D M}=300 \mathrm{~V}$ to $\mathrm{I}_{\mathrm{TM}}=6 \mathrm{~A}$

## Gate to cathode

Average power dissipation (averaged over any 20 ms period)

Peak power dissipation; t = $10 \mu \mathrm{~s}$

## Temperatures

## Storage temperature

Operating junction temperature

| $V_{D S M} / V_{R S M}$ | max. | 550 V |
| :--- | :--- | ---: |
| $V_{D R M} / V_{R R M}$ | $\max$. | 500 V |
| $V_{D W} / V_{R W}$ | $\max$. | $400 \mathrm{~V} *$ |
|  |  |  |
| $I_{T}(A V)$ | $\max$. | 4 A |
| $I_{T}(R M S)$ | $\max$. | 6 A |
| $I_{T W M}$ | $\max$. | 10 A |
| $I_{T R M}$ | max. | 30 A |


| ITSM $^{2}$ | max. | 40 A |
| :--- | :--- | :--- |
| $\mathrm{I}^{2} \mathrm{t}$ | $\max$. | $10 \mathrm{~A}^{2} \mathrm{~s}$ |
|  |  |  |
| $\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}$ | max. | $200 \mathrm{~A} / \mu \mathrm{s}$ |


| $P_{G}(A V)$ | max. | 1 W |
| :--- | :--- | ---: |
| $P_{G M}$ | $\max$. | 25 W |

[^27]-40 to $+125{ }^{\circ} \mathrm{C}$
max. $110^{\circ} \mathrm{C}$

* Voltage shapes as occurring in the intended application.


## THERMAL RESISTANCE

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

## Influence of mounting method

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from mounting base to heatsink
a. with heatsink compound
b. with heatsink compound and 0,06 mm maximum mica insulator
c. with heatsink compound and $0,1 \mathrm{~mm}$ maximum mica insulator (56369)
d. with heatsink compound and 0,25 mm max. alumina insulator (56367)
e. without heatsink compound
$R_{\text {th mb-h }}=0,3{ }^{\circ} \mathrm{C} / \mathrm{W}$
$R_{\text {th mb-h }}=1,4{ }^{\circ} \mathrm{C} / \mathrm{W}$
$R_{\text {th mb-h }}=2,2{ }^{\circ} \mathrm{C} / \mathrm{W}$
$R_{\text {th mb-h }}=0,8{ }^{\circ} \mathrm{C} / \mathrm{W}$
$R_{\text {th mb-h }}=1,4{ }^{\circ} \mathrm{C} / \mathrm{W}$
2. Free-air operation

The quoted values of $R_{t h} j$-a should be used only when no leads of other dissipating components run to the same tie-point.
Thermal resistance from junction to ambient in free air: mounted on a printed-circuit board at a = any lead length and with copper laminate

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



Fig. 2.

## BT153

## CHARACTERISTICS

## Anode to cathode

On-state voltage
$\mathrm{I}_{\mathrm{T}}=10 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C} \quad \mathrm{V}_{\mathrm{T}}<2,5 \mathrm{~V}$ *
Rate of rise of off-state voltage that will not
trigger any device; $\mathrm{T}_{\mathrm{j}} \leqslant 110^{\circ} \mathrm{C}$
$\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}<200 \mathrm{~V} / \mu \mathrm{s}$
Off-state current
$\mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DRMmax}} ; \mathrm{T}_{\mathrm{j}}=110^{\circ} \mathrm{C}$
Holding current; $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
$\mathrm{I}_{\mathrm{D}}<1,5 \mathrm{~mA}$

## Gate to cathode

Voltage that will trigger all devices $\mathrm{V}_{\mathrm{D}}=6 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C} ; \mathrm{t}_{\mathrm{p}} \geqslant 5 \mu \mathrm{~s}$
$\mathrm{V}_{\mathrm{GT}}>2,5 \mathrm{~V}$

Current that will trigger all devices
$\mathrm{V}_{\mathrm{D}}=6 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C} ; \mathrm{t}_{\mathrm{p}} \geqslant 5 \mu \mathrm{~s}$
$\mathrm{I}_{\mathrm{GT}} \gg 40 \mathrm{~mA}$

## Switching characteristics

Circuit-commutated turn-off time (in regulating circuits) when switched from $\mathrm{I}_{\mathrm{T}}=10 \mathrm{~A}$ to $\mathrm{V}_{\mathrm{R}} \geqslant 50 \mathrm{~V}$ with
$-\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}=10 \mathrm{~A} / \mu \mathrm{s} ; \mathrm{dV}_{\mathrm{D}} / \mathrm{dt}=200 \mathrm{~V} / \mu \mathrm{s} ; \mathrm{V}_{\mathrm{DM}}=500 \mathrm{~V}$;
$R_{G K}=68 \Omega ; \mathrm{T}_{\mathrm{mb}}=80^{\circ} \mathrm{C} ; \mathrm{t}_{\mathrm{p}} \leqslant 50 \mu \mathrm{~s} \quad \mathrm{t}_{\mathrm{q}}<20 \mu \mathrm{~s}$


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

* Measured under pulse conditions to avoid excessive dissipation.


## MOUNTING INSTRUCTIONS

1. The device may be soldered directly into the circuit, but the maximum permissible temperature of the soldering iron or bath is $275^{\circ} \mathrm{C}$; it must not be in contact with the joint for more than 5 seconds. Soldered joints must be at least 4.7 mm from the seal.
2. The leads should not be bent less than 2.4 mm from the seal, and should be supported during bending. The leads can be bent, twisted or straightened by $90^{\circ}$ maximum. The minimum bending radius is 1 mm .
3. 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 $R_{t h} m b-h$ 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 $R_{\text {th mb-h given for mounting with heatsink compound refer to the use of a }}$ metallic-oxide loaded compound. Ordinary silicone grease is not recommended.
6. Rivet mounting (only possible for non-insulated mounting)

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

## OPERATING NOTES

Dissipation and heatsink considerations:
a. The various components of junction temperature rise above ambient are illustrated in Fig. 4.


Fig. 4
b. The method of using Fig. 5 is as follows:

Starting with the required current on the $I_{T}(A V)$ axis, trace upwards to meet the appropriate form factor curve. Trace right horizontally and upwards from the appropriate value on the $T_{a m b}$ scale. The intersection determines the $R_{\text {th mb-a. }}$. The heatsink thermal resistance value ( $R_{t h} h-a$ ) can now be calculated from:

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

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


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

$\alpha=$ conduction angle per half cycle
$a=$ form factor $=\frac{I_{T}(R M S)}{I_{T}(A V)}$

| $\alpha$ | a |
| ---: | :--- |
| $30^{\circ}$ | 4 |
| $60^{\circ}$ | 2,8 |
| $90^{\circ}$ | 2,2 |
| $120^{\circ}$ | 1,9 |
| $180^{\circ}$ | 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.
$P_{\text {tot }}=$ maximum power dissipation including gate and switching losses.
ITWM = maximum working peak on-state current.

horizontal output transformer


Fig. 7 Waveform defining ITWM-

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 ( $f=50 \mathrm{~Hz}$ ); $\mathrm{T}_{\mathrm{j}}=110^{\circ} \mathrm{C}$ prior to surge; with reapplied $\mathrm{V}_{\text {RWMmax }}$.

$$
\underbrace{\text { ITSM }}_{\text {time }}
$$




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

Fig. $12-T_{j}=25^{\circ} \mathrm{C} ;--\mathrm{T}_{\mathrm{j}}=110^{\circ} \mathrm{C}$.


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

Fig. 13.

## BT153



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



Fig. 15.

## THYRISTORS

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

## QUICK REFERENCE DATA

|  |  |  | BT169-B | D | M |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Repetitive peak voltages | $\mathrm{V}_{\text {DRM }} / \mathrm{V}_{\text {RRM }}$ | max. | 200 | 400 | 600 | v |
| Average on-state current | ${ }^{\prime} \mathrm{T}(\mathrm{AV})$ | max. |  | 0.5 |  | A |
| R.M.S. on-state current | IT(RMS) | max. |  | 0.8 |  | A |
| Non-repetitive peak on-state current | ${ }^{\text {ITSM }}$ | max. |  | 8 |  | A |

MECHANICAL DATA
Dimensions in mm
Fig. 1 TO-92 variant



## RATINGS

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

## Anode to cathode

Non-repetitive peak voltages
( $\mathrm{t} \leqslant 10 \mathrm{~ms}$ )
Repetitive peak voltages $(\delta \leqslant 0.01)$

| $V_{D S M} / V_{R S M}$ | $\max$. |
| :--- | :--- |
| $V_{\text {DRM }} / V_{\text {RRM }}$ | $\max$. |

Average on-state current (averaged over any 20 ms period) up to $\mathrm{T}_{\mathrm{mb}}=55^{\circ} \mathrm{C}$
R.M.S. on-state current

Repetitive peak on-state current
Non-repetitive peak on-state current; t = 10 ms ;
half sine-wave; $\mathrm{T}_{\mathrm{j}}=125^{\circ} \mathrm{C}$ prior to surge;
with reapplied $\mathrm{V}_{\text {RWMmax }}$
$1^{2} t$ for fusing ( $t=10 \mathrm{~ms}$ )
Rate of rise of on-state current after triggering with $\mathrm{I}_{\mathrm{G}}=1 \mathrm{~mA}$ to $\mathrm{I}_{\mathrm{T}}=1.8 \mathrm{~A} ; \mathrm{dl}_{\mathrm{G}} / \mathrm{dt}=4 \mathrm{~mA} / \mu \mathrm{s}$
$\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}$

VRGM max
$P_{G}(A V)$
$P_{G M}$

| Storage temperature | $\mathrm{T}_{\text {stg }}$ | -40 to +150 |  | ${ }^{\circ} \mathrm{C}$ |
| :---: | :---: | :---: | :---: | :---: |
| Operating junction temperature | Tj | max. | 125 | ${ }^{\circ} \mathrm{C}$ |
| THERMAL RESISTANCE |  |  |  |  |
| From junction to mounting base | $\mathrm{R}_{\text {th j-mb }}$ | $=$ | 100 | K/W |
| From junction to ambient in free air, mounted on a p.c.b. with any lead length | $\mathrm{R}_{\text {th } \mathrm{j}-\mathrm{a}}$ | = | 200 | K/W |

## THERMAL RESISTANCE

From junction to mounting base
From junction to ambient in free air, mounted on a p.c.b. with any lead length

| I $T(A V)$ | max. | 0.5 | A |
| :--- | :--- | ---: | :--- |
| IT(RMS) | max. | 0.8 | $A$ |
| $I_{T R M}$ | max. | 8 | $A$ |

## Gate to cathode

Peak reverse voltage

| ITSM $^{2}$ | max. | 8 | $A$ |
| :--- | :--- | ---: | :--- |
| $I^{2} t$ | max. | 0.32 | $A^{2} s$ |
|  |  |  |  |
| $\mathrm{dI}_{\mathrm{T}} / \mathrm{dt}$ | max. | 30 | $\mathrm{~A} / \mu \mathrm{s}$ |

Average power dissipation (averaged over any 20 ms period)
Peak power dissipation
max.
0.1

W

## Temperatures

[^28]
## CHARACTERISTICS

## Anode to cathode

On-state voltage

$$
\mathrm{I}_{\mathrm{T}}=1 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}
$$

Rate of rise of off-state voltage that will not
trigger any device; exponential method;
$V_{D}=2 / 3 V_{D R M \max } ; R_{G K}=1 \mathrm{k} \Omega ; T_{j}=125{ }^{\circ} \mathrm{C}$
$\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}<100 \mathrm{~V} / \mu \mathrm{s}$

Reverse current
$V_{R}=V_{R R M m a x} ; R_{G K}=1 \mathrm{k} \Omega ; T_{j}=125{ }^{\circ} \mathrm{C}$
$I_{R}$
$\mathrm{V}_{\mathrm{T}}<1.35 \quad \mathrm{~V}^{*}$

Off-state current
$V_{D}=V_{D R M m a x} ; R_{G K}=1 \mathrm{k} \Omega ; T_{j}=125{ }^{\circ} \mathrm{C}$
$\mathrm{I}_{\mathrm{D}}<0.1 \mathrm{~mA}$
Latching current
$\mathrm{V}_{\mathrm{D}}=6 \mathrm{~V} ; \mathrm{R}_{\mathrm{GK}}=1 \mathrm{k} \Omega ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
$\mathrm{I}_{\mathrm{L}}<66 \mathrm{~mA}$
Holding current
$V_{D}=6 \mathrm{~V} ; R_{G K}=1 \mathrm{k} \Omega ; T_{j}=25^{\circ} \mathrm{C}$
$\mathrm{I}_{\mathrm{H}}<5 \quad 5 \mathrm{~mA}$

## Gate to cathode

Voltage that will trigger all devices

$$
\mathrm{V}_{\mathrm{D}}=6 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}
$$

Current that will trigger all devices
$V_{D}=6 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$

| $\mathrm{V}_{\mathrm{GT}}$ | $>$ | 0.8 | V |
| :--- | :--- | :--- | :--- |
| $\mathrm{I}_{\mathrm{GT}}$ | $>$ | 0.2 | mA |

## Switching characteristics

Gate-controlled delay time when switched from $V_{D}=V_{D R M m a x}$ to $I_{T}=1.5 \mathrm{~A}$; $\mathrm{I}_{\mathrm{G} T}=10 \mathrm{~mA} ; \mathrm{dI}_{\mathrm{G}} / \mathrm{dt}=0.1 \mathrm{~A} / \mu \mathrm{s} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
$\mathrm{t}_{\mathrm{d}} \quad<\quad 1.0 \quad \mu \mathrm{~s}$

Circuit-commutated turn-off time when switched
from $\mathrm{I}_{\mathrm{T}}=0.5 \mathrm{~A}$ to $\mathrm{V}_{\mathrm{R}}>35 \mathrm{~V}$ with $-\mathrm{dl} \mathrm{T}^{2} / \mathrm{dt}=110 \mathrm{~A} / \mu \mathrm{s} ; \mathrm{dV}_{\mathrm{D}} / \mathrm{dt}=50 \mathrm{~V} / \mu \mathrm{s} ; \mathrm{T}_{\mathrm{j}}=125^{\circ} \mathrm{C} \quad \mathrm{t}_{\mathrm{q}} \quad<\quad 100 \quad \mu \mathrm{~s}$
*Measured under pulse conditions to avoid excessive dissipation.

## THYRISTORS

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

## QUICK REFERENCE DATA

|  | BTW23-600R | $800 R$ | $1000 R$ | $1200 R$ | $1400 R$ | $1600 R$ |
| :--- | ---: | ---: | ---: | ---: | ---: | ---: |
| Repetitive peak voltages <br> VDRM | VRRM |  |  |  |  |  |

Average on-state current
R.M.S. on-state current

Non-repetitive peak on-state current
Rate of rise of off-state voltage
that will not trigger any device
On request (see Ordering Note)

| $I_{T}(A V)$ | max. | 90 A |
| :--- | :--- | ---: |
| $\mathrm{I}_{\mathrm{T}(\mathrm{RMS})}$ | max. | 140 A |
| $\mathrm{I}_{\mathrm{TSM}}$ | max. | 2000 A |

MECHANICAL DATA
Dimensions in mm
Fig. 1 TO-94: with metric M12 stud ( $\phi 12 \mathrm{~mm}$ ).
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: $\min .9 \mathrm{Nm}(90 \mathrm{~kg} \mathrm{~cm})$ max. $17,5 \mathrm{Nm}(175 \mathrm{~kg} \mathrm{~cm})$

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



Average on-state current (averaged over
any 20 ms period) up to $\mathrm{T}_{\mathrm{mb}}=85^{\circ} \mathrm{C}$
R.M.S. on-state current

Repetitive peak on-state current
Non-repetitive peak on-state current; t=10 ms;
half sine-wave; $\mathrm{T}_{\mathrm{j}}=125^{\circ} \mathrm{C}$ prior to surge;
with reapplied $\mathrm{V}_{\text {RWM max }} \quad \mathrm{I}_{\mathrm{TSM}}$ max. 2000 A
$I^{2} t$ for fusing ( $t=10 \mathrm{~ms}$ )
Rate of rise of on-state current after triggering
with $\mathrm{I}_{\mathrm{G}}=750 \mathrm{~mA}$ to $\mathrm{I}_{\mathrm{T}}=300 \mathrm{~A} ; \mathrm{dI}_{\mathrm{G}} / \mathrm{dt}=1 \mathrm{~A} / \mu \mathrm{s}$
$I_{T}(A V)$ max. 90 A
IT(RMS) max. 140 A
ITRM max. 1250 A
ITSM max. 2000 A
$I^{2} t \quad$ max. $20000 A^{2} s$
$\mathrm{dl}_{\mathrm{T}} / \mathrm{dt} \quad \max \quad 300 \mathrm{~A} / \mu \mathrm{s}$

## Gate to cathode

Reverse peak voltage
Average power dissipation (averaged over any 20 ms period)
Peak power dissipation
$V_{\text {RGM }} \max \quad 10 \mathrm{~V}$

| $\mathrm{P}_{\mathrm{G}}(\mathrm{AV})$ | $\max$ | 2 W |
| :--- | ---: | ---: |
| $\mathrm{P}_{\mathrm{GM}}$ | $\max$ | 10 W |

## Temperatures

Storage temperature
Junction temperature
THERMAL RESISTANCE
From junction to mounting base
From mounting base to heatsink
Transient thermal impedance ( $\mathrm{t}=\mathbf{1} \mathrm{ms}$ )
$R_{\text {th j-mb }}=0,3{ }^{\circ} \mathrm{C} / \mathrm{W}$
$R_{\text {th mb-h }}=0,1^{\circ} \mathrm{C} / \mathrm{W}$
$Z_{\text {th j-mb }}=0,015{ }^{\circ} \mathrm{C} / \mathrm{W}$

[^29]
## BTW38 SERIES

## 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 | $\mathrm{V}_{\text {DRM }} / \mathrm{V}_{\text {RRM }}$ | max. | 600 | 800 | 1000 | V |
| Average on-state current | ${ }^{1} \mathrm{~T}(\mathrm{AV})$ | max. |  | 10 |  | A |
| R.M.S. on-state current | 1 T (RMS) | max. |  | 16 |  | A |
| Non-repetitive peak on-state current | ITSM | max. |  | 150 |  | A |

## MECHANICAL DATA

Dimensions in mm
Fig. 1 TO-64: with metric M5 stud ( $\phi 5 \mathrm{~mm}$ ); 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. $0.9 \mathrm{Nm}(9 \mathrm{~kg} \mathrm{~cm})$ max. 1.7 Nm ( 17 kg cm ) Nut dimensions across the flats: 8.0 mm .

## RATINGG

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

## Anode to cathode

Non-repetitive peak voltages ( $\mathrm{t} \leqslant 10 \mathrm{~ms}$ )

Repetitive peak voltages
Crest working voltages

|  |  | BTW38-600R | 800R | 1000R |
| :---: | :---: | :---: | :---: | :---: |
| $\mathrm{V}_{\text {DSM }} / \mathrm{V}_{\text {RSM }}$ | max. | 600 | 800 | 1000 |
| $V_{\text {DRM }} / V_{\text {RRM }}$ | max. | 600 | 800 | 1000 |
| $V_{\text {DWM }} / V_{\text {RWM }}$ | max. | 400 | 600 | 700 |

Average on-state current (averaged over
any 20 ms period) up to $\mathrm{T}_{\mathrm{mb}}=85^{\circ} \mathrm{C}$
R.M.S. on-state current

Repetitive peak on-state current

| $I_{\text {It }}(\mathrm{AV})$ | max. | 10 | A |
| :---: | :---: | :---: | :---: |
| $\mathrm{I}_{\text {( }}$ (RMS) | max. | 16 | A |
| ITRM | max. | 75 | A |
| ${ }^{\text {ITSM }}$ | max. | 150 | A |
| $1^{2} \mathrm{t}$ | max. | 112 | $A^{2} \mathrm{~s}$ |
| $\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}$ | max. | 50 | A/ $/ \mathrm{s}$ |

Gate to cathode
Average power dissipation (averaged over any 20 ms
period)
Peak power dissipation
$\mathrm{P}_{\mathrm{G}}(\mathrm{AV})$
$\mathrm{P}_{\mathrm{GM}}$
max.
0.5 W max.

5 W

## Temperatures

Storage temperature
Junction temperature

|  |  |  |  |
| :--- | :--- | ---: | :--- |
| $T_{\text {stg }}$ |  |  |  |
| $T_{j}$ | max. | -55 to +125 | ${ }^{\circ} \mathrm{C}$ |
|  | 125 | ${ }^{\circ} \mathrm{C}$ |  |

$R_{\text {th j-mb }}=$

| $R_{\text {th mb-h }}$ | $=$ | 0.5 | $\mathrm{~K} / \mathrm{W}$ |
| :--- | :--- | ---: | :--- |
| $R_{\text {th j-a }}$ | $=$ | 45 | $\mathrm{~K} / \mathrm{W}$ |
| $Z_{\text {th j-mb }}$ | $=$ | 0.1 | $\mathrm{~K} / \mathrm{W}$ |

## 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.

[^30]
## CHARACTERISTICS

## Anode to cathode

On-state voltage (measured under pulse conditions)

$$
\mathrm{I}_{\mathrm{T}}=20 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}
$$

Rate of rise of off-state voltage that will not
trigger any device; expontential method;
$V_{D}=2 / 3 V_{D R M m a x} ; T_{j}=125^{\circ} \mathrm{C}$
Reverse current
$V_{R}=V_{R W M m a x} ; T_{j}=125{ }^{\circ} \mathrm{C}$
Off-state current
$V_{D}=V_{D W M m a x} ; T_{j}=125{ }^{\circ} \mathrm{C}$
Latching current; $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
Holding current; $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$

## Gate to cathode

Voltage that will trigger all devices

$$
V_{D}=6 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}
$$

Voltage that will not trigger any device
$V_{D}=V_{D R M m a x} ; T_{j}=125^{\circ} \mathrm{C}$
Current that will trigger all devices
$V_{D}=6 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$

## Switching characteristics

Gate-controlled turn-on time ( $t_{g t}=t_{d}+t_{r}$ ) when switched from $V_{D}=V_{D R M m a x}$ to $I_{T}=40 \mathrm{~A}$; ${ }^{\mathrm{I}} \mathrm{GT}=100 \mathrm{~mA} ; \mathrm{dl}_{\mathrm{G}} / \mathrm{dt}=5 \mathrm{~A} / \mu \mathrm{s} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
Circuit-commutated turn-off time when switched from $I_{T}=40 \mathrm{~A}$ to $\mathrm{V}_{\mathrm{R}}>50 \mathrm{~V}$ with

$$
-\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}=10 \mathrm{~A} / \mu \mathrm{s} ; \mathrm{dV}_{\mathrm{D}} / \mathrm{dt}=50 \mathrm{~V} / \mu \mathrm{s} ; \mathrm{T}_{\mathrm{j}}=115^{\circ} \mathrm{C}
$$



Fig.2a Gate-controlled turn-on time definition.
$V_{T}<2 \quad V$
$d V_{D} / \mathrm{dt}<200 \mathrm{~V} / \mu \mathrm{s}$
$\mathrm{I}_{\mathrm{R}}<3 \quad 3 \mathrm{~mA}$

| $I_{D}$ | $<$ | 3 | mA |
| :--- | :--- | ---: | ---: |
| $\mathrm{I}_{\mathrm{L}}$ | $<$ | 150 | mA |
| $\mathrm{I}_{\mathrm{H}}$ | $<$ | 75 | mA |

$\mathrm{V}_{\mathrm{GT}} \gg \quad 1.5 \quad \mathrm{~V}$
$\mathrm{V}_{\mathrm{GD}}<200 \mathrm{mV}$
IGT $\quad>\quad 50 \mathrm{~mA}$
$\mathrm{t}_{\mathrm{gt}} \quad$ typ. $\quad 2 \quad \mu \mathrm{~s}$
$\mathrm{t}_{\mathrm{q}} \quad$ typ. $\quad 35 \quad \mu \mathrm{~s}$


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

M1389


Fig. 3 (1) $\mathrm{T}_{\mathrm{mb}}$-scale is for comparison purposes only and is correct only for $\mathrm{R}_{\text {th } \mathrm{mb}-\mathrm{a}} \leqslant 6 \mathrm{~K} / \mathrm{W}$


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 $\mathrm{T}_{\mathrm{j}}$.


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


Fig. 10 Limits for starting or inrush currents.


Fig. 11 Limits for starting or inrush currents.


Fig. 12.

## THYRISTORS

Also available to BS9341-F083
Glass-passivated silicon thyristors in metal envelopes, intended for use in power control applications in general, and lighting control (in a.c. controller circuit) up to $2,5 \mathrm{~kW}$ 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 | $\mathrm{V}_{\text {DRM }} / \mathrm{V}_{\text {RRM }}$ | max. | 400 | 600 | 800 V |
| Average on-state current |  | ${ }^{1} \mathrm{~T}(\mathrm{AV})$ | m | ax. | 20 A |
| R.M.S. on-state current |  | IT(RMS) | ) m | ax. | 32 A |
| Non-repetitive peak on-state current |  | ITSM | m | ax. | 400 A |

## MECHANICAL DATA

Dimensions in mm
Fig. 1 TO-48: with metric M6 stud ( $\phi 6 \mathrm{~mm}$ ); e.g. BTW40-400R.
Types with $1 / 4$ in $\times 28$ UNF stud ( $\phi 6,35 \mathrm{~mm}$ ) 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: $\min .1,7 \mathrm{Nm}(17 \mathrm{~kg} \mathrm{~cm})$ max. $3,5 \mathrm{Nm}(35 \mathrm{~kg} \mathrm{~cm})$
Supplied with the device:
1 nut, 1 lock washer
Nut dimensions across the flats;
M6: 10 mm
$1 / 4 \mathrm{in} \times 28$ UNF: $11,1 \mathrm{~mm}$

## RATINGS

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

|  |  | BTW40-400R |  | 600R | 800R |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Non-repetitive peak voltages ( $\mathrm{t} \leqslant 10 \mathrm{~ms}$ ) | $\mathrm{V}_{\text {DSM }} / \mathrm{V}_{\text {RSM }}$ | max. | 400 | 600 | 800 | V |
| Repetitive peak voltages | $V_{\text {DRM }} / V_{\text {RRM }}$ | max. | 400 | 600 | 800 | V |
| Crest working voltages | $V_{\text {DWM }} / V_{\text {RWM }}$ | max. | 300 | 400 | 600 | V* |
| Average on-state current (averaged over any 20 ms period) up to $\mathrm{T}_{\mathrm{mb}}=85^{\circ} \mathrm{C}$ |  | ${ }^{1} \mathrm{~T}(\mathrm{AV})$ |  | ax. | 20 | A |
| R.M.S. on-state current |  | ${ }^{1} \mathrm{~T}$ (RMS |  | ax. | 32 | A |
| Repetitive peak on-state current |  | ITRM | max | max. | 200 | A |

Non-repetitive peak on-state current; $\mathbf{t}=10 \mathrm{~ms}$;
half sine-wave; $\mathrm{T}_{\mathrm{j}}=125^{\circ} \mathrm{C}$ prior to surge;
with reapplied $\mathrm{V}_{\mathrm{RWM}}$ max
$I^{2} t$ for fusing ( $t=10 \mathrm{~ms}$ )
Rate of rise of on-state current after triggering with $\mathrm{I}_{\mathrm{G}}=400 \mathrm{~mA}$ to $\mathrm{I}_{\mathrm{T}}=60 \mathrm{~A} ; \mathrm{dI}_{\mathrm{G}} / \mathrm{dt}=0,4 \mathrm{~A} / \mu \mathrm{s}$

| ITSM | max. | 400 | A |
| :---: | :---: | :---: | :---: |
| $1^{2} \mathrm{t}$ | max. | 800 | $A^{2} \mathrm{~s}$ |
| $\mathrm{dI}_{\mathrm{T}} / \mathrm{dt}$ | max. | 100 |  |

## Gate to cathode

Reverse peak voltage
Average power dissipation (averaged over any 20 ms period)
Peak power dissipation

| $\mathrm{V}_{\mathrm{RGM}}$ | $\max$. | 10 V |
| :--- | :--- | :--- |
|  |  |  |
| $\mathrm{P}_{\mathrm{G}(\mathrm{AV})}$ | $\max$. | 1 W |
| $\mathrm{P}_{\mathrm{GM}}$ | $\max$. | 5 W |

## Temperatures

| Storage temperature | $\mathrm{T}_{\text {stg }}$ | -55 to $+125{ }^{\circ} \mathrm{C}$ |  |  |
| :---: | :---: | :---: | :---: | :---: |
| Junction temperature | T ${ }_{\text {j }}$ | max. | 125 | ${ }^{\circ} \mathrm{C}$ |
| THERMAL RESISTANCE |  |  |  |  |
| From junction to mounting base | $R_{\text {th j-mb }}$ | = | 1 | ${ }^{\circ} \mathrm{C} / \mathrm{W}$ |
| From mounting base to heatsink with heatsink compound | $\mathrm{R}_{\text {th mb-h }}$ | = | 0,2 | ${ }^{\circ} \mathrm{C} / \mathrm{W}$ |
| Transient thermal impedance ( $\mathrm{t}=1 \mathrm{~ms}$ ) | $\mathrm{Z}_{\text {th }} \mathrm{j}-\mathrm{mb}$ | $=$ | 0,1 | ${ }^{\circ} \mathrm{C} / \mathrm{W}$ |

## 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.

[^31]
## CHARACTERISTICS

## Anode to cathode

On-state voltage

$$
\mathrm{I}_{\mathrm{T}}=50 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}
$$

$\mathrm{V}_{\mathrm{T}} \quad<\quad 2,1 \mathrm{~V}^{*}$
Rate of rise of off-state voltage that will not trigger any device; exponential method; $\mathrm{V}_{\mathrm{D}}=2 / 3 \mathrm{~V}_{\mathrm{DRMmax}}$; $\mathrm{T}_{\mathrm{j}}=125^{\circ} \mathrm{C}$
Reverse current

$$
V_{R}=V_{R W M m a x} ; T_{j}=125^{\circ} \mathrm{C}
$$

$\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}<100 \mathrm{~V} / \mu \mathrm{s}$

Off-state current

$$
\mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DWM} \text { max }} ; \mathrm{T}_{\mathrm{j}}=125^{\circ} \mathrm{C}
$$

Latching current; $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
Holding current; $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
$\mathrm{I}_{\mathrm{R}}<\quad 3 \mathrm{~mA}$

## Gate to cathode

Voltage that will trigger all devices

$$
V_{D}=6 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}
$$

Voltage that will not trigger any device

$$
\mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DRMmax}} ; \mathrm{T}_{\mathrm{j}}=125^{\circ} \mathrm{C}
$$

Current that will trigger all devices
$\mathrm{V}_{\mathrm{D}}=6 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$

| $\mathrm{V}_{\mathrm{GT}}$ | $>$ | $1,5 \mathrm{~V}$ |
| :--- | :--- | :--- |
| $\mathrm{~V}_{\mathrm{GD}}$ | $<$ | 200 mV |
| $\mathrm{I}_{\mathrm{GT}}$ | $>$ | 75 mA |

## Switching characteristics

Gate-controlled turn-on time ( $\left.\mathrm{t}_{\mathrm{gt}}=\mathrm{t}_{\mathrm{d}}+\mathrm{t}_{\mathrm{r}}\right)$ when switched from $V_{D}=V_{D W M m a x}$ to $I_{T}=100 \mathrm{~A}$; $\mathrm{I}_{\mathrm{GT}}=400 \mathrm{~mA} ; \mathrm{dl}_{\mathrm{G}} / \mathrm{dt}=1 \mathrm{~A} / \mu \mathrm{s} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$

| $\mathrm{t}_{\mathrm{gt}}$ |  |
| :--- | ---: |
| $\mathrm{t}_{\mathrm{r}}$ | $<$ |$\quad$| $1 \mu \mathrm{~s}$ |
| ---: |
| $0,5 \mu \mathrm{~s}$ |



Gate-controlled turn-on time definition

[^32]

Fig. 2.


Fig. 3.


Fig. 4 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of $\mathrm{T}_{\mathrm{j}}$.



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 $\mathrm{T}_{\mathrm{j}}$.


Fig. 8 Minimum gate current that will trigger all devices as a function of $\mathrm{T}_{\mathrm{j}}$.


Fig. 9.

## BTW42 SERIES

## THYRISTORS

Glass-passivated silicon thyristors in metal envelopes with high $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ 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 | $\mathrm{V}_{\text {DRM }} / V_{\text {RRM }}$ | max. | 600 | 800 | 1000 | V |
| Average on-state current | ${ }^{1} \mathrm{~T}(\mathrm{AV})$ | max. |  | 10 |  | A |
| R.M.S. on-state current | ${ }^{1} \mathrm{~T}$ (RMS) | max. |  | 16 |  | A |
| Non-repetitive peak on-state current | $I_{\text {TSM }}$ | max. |  | 150 |  | A |
| Rate of rise of off-state voltage that will not trigger any device | $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ | $<$ |  | 500 |  | $\mathrm{V} / \mu \mathrm{s}$ |
| On request (see Ordering Note) | $d V_{D} / \mathrm{dt}$ | $<$ |  | 1000 |  | $\mathrm{V} / \mu \mathrm{s}$ |

## MECHANICAL DATA

Dimensions in mm
Fig. 1 TO-64: with metric M5 stud ( $\phi 5 \mathrm{~mm}$ ); 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: $\min .0 .9 \mathrm{Nm}(9 \mathrm{~kg} \mathrm{~cm})$
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

Non-repetitive peak voltages
$\quad(t \leqslant 10 \mathrm{~ms})$
Repetitive peak voltages
Crest working voltages
Average on-state current (averaged over any 20 ms period) up to $\mathrm{T}_{\mathrm{mb}}=85^{\circ} \mathrm{C}$
R.M.S. on-state current

Repetitive peak on-state current
Non-repetitive peak on-state current; t = 10 ms ; half sine-wave; $\mathrm{T}_{\mathrm{j}}=125^{\circ} \mathrm{C}$ prior to surge; with reapplied $\mathrm{V}_{\text {RWMmax }}$
$I^{2} t$ for fusing ( $t=10 \mathrm{~ms}$ )
Rate of rise of on-state current after triggering

$$
\text { with } \mathrm{I}_{\mathrm{G}}=250 \mathrm{~mA} \text { to } \mathrm{I}_{\mathrm{T}}=25 \mathrm{~A} ; \mathrm{dI}_{\mathrm{G}} / \mathrm{dt}=0,25 \mathrm{~A} / \mu \mathrm{s}
$$

## Gate to cathode

Average power dissipation (averaged over any 20 ms period)
Peak power dissipation

## Temperatures

Storage temperature
Junction temperature

## THERMAL RESISTANCE

From junction to mounting base
From mounting base to heatsink with heatsink compound
From junction to ambient in free air
Transient thermal impedance ( $\mathrm{t}=1 \mathrm{~ms}$ )

|  | BTW42-600R |  | 800 R | 1000 R |
| :--- | :--- | :--- | :--- | :---: |
|  | max. | 600 | 800 | 1000 V |
| $\mathrm{~V}_{\text {DSM }} / \mathrm{V}_{\text {RSM }}$ |  |  |  |  |
| $\mathrm{V}_{\text {DRM }} / \mathrm{V}_{\text {RRM }}$ | $\max$. | 600 | 800 | 1000 V |
| $\mathrm{~V}_{\text {DWM }} / \mathrm{V}_{\text {RWM }}$ | $\max$. | 400 | 600 | $700 \mathrm{~V}^{*}$ |


|  |  |  |
| :--- | :--- | :--- |
| $I_{T}(A V)$ | $\max$. | 10 A |
| $I_{T}(R M S)$ | $\max$. | 16 A |
| $I_{T R M}$ | $\max$. | 75 A |


| $\mathrm{I}_{\mathrm{TSM}}$ | max. | 150 A |
| :--- | :--- | :--- |
| $\mathrm{I}^{2} \mathrm{t}$ | $\max$. | $112 \mathrm{~A}^{2} \mathrm{~s}$ |
|  |  |  |
| $\mathrm{dI}_{\mathrm{T}} / \mathrm{dt}$ | max. | $50 \mathrm{~A} / \mu \mathrm{s}$ |


| $P_{G}(A V)$ | max. | $0,5 \mathrm{~W}$ |
| :--- | :--- | ---: |
| $P_{G M}$ | max. | 5 W |


| $\mathrm{T}_{\text {stg }}$ | -55 to $+125{ }^{\circ} \mathrm{C}$ |
| :--- | :--- |
| $\mathrm{T}_{\mathrm{j}}$ | $\max$. |
|  | $125{ }^{\circ} \mathrm{C}$ |


| $R_{\text {th j-mb }}$ | $=$ | $1,8 \mathrm{~K} / \mathrm{W}$ |
| :--- | :--- | ---: |
| $R_{\text {th mb-h }}$ | $=$ | $0,5 \mathrm{~K} / \mathrm{W}$ |
| $R_{\text {th j-a }}$ | $=$ | $45 \mathrm{~K} / \mathrm{W}$ |
| $Z_{\text {th j-mb }}$ | $=$ | $0,1 \mathrm{~K} / \mathrm{W}$ |

## 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 $d V_{D} / d t$ of $1000 \mathrm{~V} / \mu \mathrm{s}$ are available on request. Add suffix C to the type number when ordering; e.g. BTW42-600RC.
*To ensure thermal stability: $\mathrm{R}_{\text {th } \mathrm{j}-\mathrm{a}}<4 \mathrm{~K} / \mathrm{W}$ (d.c. blocking) or $<8 \mathrm{~K} / \mathrm{W}$ (a.c.). For smaller heatsinks $\mathrm{T}_{\mathrm{j} \text { max }}$ should be derated. For a.c. see Fig. 3 (BTW38 data).

## CHARACTERISTICS

## Anode to cathode

On -state voltage (measured under pulse conditions)

$$
\mathrm{I}_{\mathrm{T}}=20 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}
$$

Rate of rise of off-state voltage that will not
trigger any device; expontential method;
$V_{D}=2 / 3 V_{D R M m a x} ; T_{j}=125^{\circ} \mathrm{C}$
Reverse current
$V_{R}=V_{R W M m a x} ; T_{j}=125^{\circ} \mathrm{C}$
Off-state current
$V_{D}=V_{D W M \max } ; T_{j}=125^{\circ} \mathrm{C}$
Latching current; $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
Holding current; $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$

## Gate to cathode

Voltage that will trigger all devices
$V_{D}=6 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
Voltage that will not trigger any device
$V_{D}=V_{D R M m a x} ; T_{j}=125{ }^{\circ} \mathrm{C}$
Current that will trigger all devices
$V_{D}=6 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$

## Switching characteristics

Gate-controlled turn-on time ( $\mathrm{t}_{\mathrm{gt}}=\mathrm{t}_{\mathrm{d}}+\mathrm{t}_{\mathrm{r}}$ ) when switched from $V_{D}=V_{D R M m a x}$ to $I_{T}=40 \mathrm{~A}$; $\mathrm{I}_{\mathrm{G} T}=100 \mathrm{~mA} ; \mathrm{dI}_{\mathrm{G}} / \mathrm{dt}=5 \mathrm{~A} / \mu \mathrm{s} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
Circuit-commutated turn-off time when switched from $I_{T}=40 \mathrm{~A}$ to $\mathrm{V}_{\mathrm{R}}>50 \mathrm{~V}$ with
$-\mathrm{dI}_{\mathrm{T}} / \mathrm{dt}=10 \mathrm{~A} / \mu \mathrm{s} ; \mathrm{dV}_{\mathrm{D}} / \mathrm{dt}=50 \mathrm{~V} / \mu \mathrm{s} ; \mathrm{T}_{\mathrm{j}}=115^{\circ} \mathrm{C}$


Fig.2a Gate-controlled turn-on time definition.
$\mathrm{V}_{\mathrm{T}}<2 \quad 2 \quad \mathrm{~V}$
$\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}<500 \mathrm{~V} / \mu \mathrm{s}$
$I_{R}<3 \quad 3 \mathrm{~mA}$
${ }^{\prime} \mathrm{D}<3 \mathrm{~mA}$
$\mathrm{I}_{\mathrm{L}}<150 \mathrm{~mA}$
$\mathrm{I}_{\mathrm{H}}<75 \mathrm{~mA}$

| $\mathrm{V}_{\mathrm{GT}}$ | $>$ | 1.5 | V |
| :--- | :--- | :--- | :--- |
| $\mathrm{~V}_{\mathrm{GD}}$ | $<$ | 200 | mV |
| $\mathrm{I}_{\mathrm{GT}}$ | $>$ | 50 | mA |

tgt typ. $2 \quad \mu \mathrm{~s}$
$\mathrm{t}_{\mathrm{q}} \quad$ typ. $\quad 35 \quad \mu \mathrm{~s}$


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 $\mathrm{T}_{\mathrm{j}}$.


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 | 1200 |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Repetitive peak voltages $V_{\text {DRM }}=V_{\text {RRM }}$ | max. | 400 | 600 | 800 | 1000 | 1200 | V |
| Average on-state current |  |  |  | ${ }^{\prime} \mathrm{T}(\mathrm{AV})$ | max. | 16 | A |
| R.M.S. on-state current |  |  |  | IT(RMS) | max. | 25 | A |
| Non-repetitive peak on-state current |  |  |  | ITSM | max. | 300 | A |
| Rate of rise of off-state voltage that will not trigger any device |  |  |  | $\mathrm{dV} \mathrm{D}_{\mathrm{D}} / \mathrm{dt}$ | $<$ | 200 | $\mathrm{V} / \mu \mathrm{s}$ |
| On request (see Ordering Note) |  |  |  | $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ | $<$ | 1000 | $\mathrm{V} / \mathrm{\mu s}$ |

## MECHANICAL DATA

Dimensions in mm
Fig. 1 TO-48: with metric M6 stud ( $\phi \mathbf{6 m}$ ); e.g. BTW45-400R.
Types with $1 / 4$ in $\times 28$ UNF stud ( $\phi 6,35 \mathrm{~mm}$ ) are available on request. These are indicated by the suffix U: BTW45-400RU.


Net mass: 14 g
Diameter of clearance hole: max. $6,5 \mathrm{~mm}$
Accessories supplied on request:
see ACCESSORIES section

Torque on nut: min. $1,7 \mathrm{Nm}(17 \mathrm{~kg} \mathrm{~cm})$ max. $3,5 \mathrm{Nm}(35 \mathrm{~kg} \mathrm{~cm})$
Supplied with the device:
1 nut, 1 lock washer
Nut dimensions across the flats;
M6: 10 mm
$1 / 4 \mathrm{in} \times 28$ UNF: $11,1 \mathrm{~mm}$

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

Non-repetitive peak voltages
( $\mathrm{t} \leqslant 10 \mathrm{~ms}$ )
Repetitive peak voltages
Crest working voltages

|  | BTW45-400R | 600R | 800R | 1000R | 1200R |
| :---: | :---: | :---: | :---: | :---: | :---: |
| $\mathrm{V}_{\text {DSM }} / \mathrm{V}_{\text {RSM }}$ | max. 400 | 600 | 800 | 1000 | 1200 V |
| $V_{\text {DRM }} / V_{\text {RRM }}$ | max. 400 | 600 | 800 | 1000 | 1200 V |
| $V_{\text {DWM }} / V_{\text {RWM }}$ | max. 300 | 400 | 600 | 700 | 800 V* |

Average on-state current (averaged over any 20 ms period) up to $\mathrm{T}_{\mathrm{mb}}=85^{\circ} \mathrm{C}$
R.M.S. on-state current

Repetitive peak on-state current

| IT(AV) | max. | 16 A |
| :--- | :--- | ---: |
| IT(RMS) | max. | 25 A |
| $I_{T R M}$ | max. | 200 A |

Non-repetitive peak on-state current; $\mathrm{t}=10 \mathrm{~ms}$; half sine-wave; $\mathrm{T}_{\mathrm{j}}=125^{\circ} \mathrm{C}$ prior to surge;
with reapplied $V_{\text {RWM max }} \quad$ ITSM max. 300 A
$I^{2} t$ for fusing ( $t=10 \mathrm{~ms}$ )
Rate of rise of on-state current after triggering
with $\mathrm{I}_{\mathrm{G}}=400 \mathrm{~mA}$ to $\mathrm{I}_{\mathrm{T}}=60 \mathrm{~A} ; \mathrm{dI}_{\mathrm{G}} / \mathrm{dt}=0,4 \mathrm{~A} / \mu \mathrm{s} \quad \mathrm{dl} / \mathrm{dt} \quad \mathrm{max} .100 \mathrm{~A} / \mu \mathrm{s}$

## Gate to cathode

Reverse peak voltage
Average power dissipation (averaged over
any 20 ms period) $\quad \mathrm{V}_{\mathrm{RGM}} \quad$ max. 10 V

## Temperatures

| Storage temperature | $\mathrm{T}_{\text {stg }}$ | -55 to $+125{ }^{\circ} \mathrm{C}$ |
| :--- | :--- | :--- |
| Junction temperature | $\mathrm{T}_{\mathrm{j}}$ | $\max .125{ }^{\circ} \mathrm{C}$ |

## THERMAL RESISTANCE

From junction to mounting base
From mounting base to heatsink; with heatsink compound
Transient thermal impedance ( $\mathrm{t}=1 \mathrm{~ms}$ )

| $R_{\text {th j-mb }}$ | $=$ | $1,33{ }^{\circ}{ }^{\circ} \mathrm{C} / \mathrm{W}$ |
| :--- | :--- | ---: |
| $R_{\text {th mb-h }}$ | $=$ | $0,2{ }^{\circ} \mathrm{C} / \mathrm{W}$ |
| $Z_{\text {th j-mb }}$ | $=$ | $0,1{ }^{\circ} \mathrm{C} / \mathrm{W}$ |

## 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.

[^33]
## CHARACTERISTICS

## Anode to cathode

On-state voltage
$I_{T}=50 \quad A ; T_{j}=25^{\circ} \mathrm{C}$
Rate of rise of off-state voltage that will not trigger
any device; exponential method; $\mathrm{V}_{\mathrm{D}}=2 / 3 \mathrm{~V}_{\mathrm{DRM} \text { max; }}$
$\mathrm{T}_{\mathrm{j}}=125^{\circ} \mathrm{C}$
Reverse current
$\mathrm{V}_{\mathrm{R}}=\mathrm{V}_{\mathrm{RWM} \text { max } ;} \mathrm{T}_{\mathrm{j}}=125^{\circ} \mathrm{C}$
Off-state current
$\mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DWM}}$ max $; \mathrm{T}_{\mathrm{j}}=125^{\circ} \mathrm{C}$
Latching current; $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
Holding current; $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$

$$
\begin{array}{ll}
\mathrm{dV}_{\mathrm{D}} / \mathrm{dt} & <200 \mathrm{~V} / \mu \mathrm{s} \\
& <3 \mathrm{~mA} \\
\mathrm{I}_{\mathrm{R}} & <3 \mathrm{~mA} \\
& <150 \mathrm{~mA} \\
\mathrm{I}_{\mathrm{D}} & <75 \mathrm{~mA} \\
\mathrm{I}_{\mathrm{L}} & <2 \\
\mathrm{I}_{\mathrm{H}} & <2
\end{array}
$$

## Gate to cathode

Voltage that will trigger all devices

$$
\mathrm{V}_{\mathrm{D}}=6 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}
$$

Voltage that will not trigger any device

$$
V_{D}=V_{D R M \text { max }} ; T_{j}=125^{\circ} \mathrm{C}
$$

Current that will trigger all devices
$V_{D}=6 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
$\mathrm{V}_{\mathrm{GT}}>1,5 \mathrm{~V}$

$$
\mathrm{V}_{\mathrm{GD}}<200 \mathrm{mV}
$$

$$
\mathrm{I}_{\mathrm{GT}} \quad>\quad 75 \mathrm{~mA}
$$

Switching characteristics
Gate-controlled turn-on time ( $\mathrm{t}_{\mathrm{gt}}=\mathrm{t}_{\mathrm{d}}+\mathrm{t}_{\mathrm{r}}$ ) when
switched from $V_{D}=V_{D W M}$ max to $I_{T}=100 \mathrm{~A}$;
$\mathrm{I}_{\mathrm{G} T}=400 \mathrm{~mA} ; \mathrm{dl}_{\mathrm{G}} / \mathrm{dt}=1 \mathrm{~A} / \mu \mathrm{s} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$

$$
\mathrm{V}_{\mathrm{T}} \quad<\quad 2 \mathrm{~V}^{*}
$$

$$
\mathrm{I}_{\mathrm{GT}}=400 \mathrm{~mA} ; \mathrm{dl}_{\mathrm{G}} / \mathrm{dt}=1 \mathrm{~A} / \mu \mathrm{s} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}
$$



| $\mathrm{t}_{\mathrm{gt}}$ | $<$ |
| :--- | :--- |
| $\mathrm{t}_{\mathrm{r}}$ | $<$ |
| $0,5 \mu \mathrm{~s}$ |  |

Gate-controlled turn-on time definition.

## ORDERING NOTE

Types with $d V_{D} / d t$ of $1000 \mathrm{~V} / \mu \mathrm{s}$ are available on request. Add suffix C to the type number when ordering; e.g. BTW45-400RC.
*Measured under pulse conditions to avoid excessive dissipation.


Fig. 2.


Fig. 3.


Fig. 4 Maximum rate of rise of off-state voltage that will not trigger any device (exponential method) as a function of $\mathrm{T}_{\mathrm{j}}$.



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 $\mathrm{T}_{\mathrm{j}}$.


Fig. 8 Minimum gate current that will trigger all devices as a function of $\mathrm{T}_{\mathrm{j}}$.


Fig. 9.

## BTW62 SERIES

## FAST TURN-OFF THYRISTORS

Asymmetrical thyristors (ASCR) in TO-238AA envelopes with electrically isolated metal baseplates, suitable for use in high-frequency inverters, power supplies, motor control systems etc. For reverse blocking operation use with a series diode, for reverse conducting operation use with an anti-parallel diode.

## QUICK REFERENCE DATA

|  |  | BTW62-600R |  | 800R | 1000R |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Repetitive peak off-state voltage | $V_{\text {DRM }}$ | max. | 600 | 800 | 1000 | V |
| Average on-state current | ${ }^{1} \mathrm{~T}(\mathrm{AV})$ | max. |  | 18 |  | A |
| Repetitive peak on-state current | ITRM | max. |  | 175 |  | A |
| Circuit-commutated turn-off time suffix K suffix N | $\begin{aligned} & \mathrm{t}_{\mathrm{q}} \\ & \mathrm{t}_{\mathrm{q}} \end{aligned}$ | < |  | 4 6 |  | $\mu \mathrm{S}$ $\mu \mathrm{S}$ |

MECHANICAL DATA
Dimensions in mm
Fig. 1 TO-238AA


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

## RATINGS

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

## Anode to cathode

Transient off-state voltage
Repetitive peak off-state voltage
Continuous off-state voltage

|  | BTW62-600R |  |  | 800 R | 1000 R |
| :--- | :--- | :--- | ---: | ---: | :--- |
|  |  |  |  |  |  |
| $\mathrm{V}_{\mathrm{DSM}}$ | $\max$. | 800 | 1000 | 1000 | V |
| $\mathrm{~V}_{\mathrm{DRM}}$ | $\max$. | 600 | 800 | 1000 | V |
| $\mathrm{~V}_{\mathrm{D}}$ | $\max$. | $\underbrace{500}$ | 650 | 700 | V |

Transient reverse voltage;
$\mathrm{t}_{\mathrm{p}}<5 \mu \mathrm{~s}$
Average on-state current
(averaged over any 20 ms period)
up to $T_{m b}=85^{\circ} \mathrm{C}$
R.M.S. on-state current

Repetitive peak on-state current;
$t_{p}=50 \mu \mathrm{~s} ; \delta=0.05$
VRSM max. 15
on-repetitive peak on-state current
$\mathrm{T}_{\mathrm{j}}=125^{\circ} \mathrm{C}$ prior to surge;
$t=10 \mathrm{~ms}$; half sine-wave $\quad$ ITSM max. $200 \quad$ A
$1^{2} t$ for fusing; $t=10 \mathrm{~ms}$
$I^{2} t \quad \max \quad 200$
Rate of rise of on-state current after triggering with $\mathrm{I}_{\mathrm{G}}=1.25 \mathrm{~A} ; \mathrm{I}_{\mathrm{T}}=80 \mathrm{~A}$
$\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}$
max.
1000

## Gate to cathode

Average power dissipation
(averaged over any 20 ms period)
Peak power dissipation; $t=10 \mu \mathrm{~s}$

| $P_{G}(A V)$ | max. | 1 | $W$ |
| :--- | :--- | ---: | :--- |
| $P_{G M}$ | max. | 10 | $W$ |

## Temperatures

| Storage temperature | $\mathrm{T}_{\text {stg }}$ |  | -40 to +125 | ${ }^{\circ} \mathrm{C}$ |
| :---: | :---: | :---: | :---: | :---: |
| Operating junction temperature | $\mathrm{T}_{\mathrm{j}}$ | max. | 125 | ${ }^{\circ} \mathrm{C}$ |
| ISOLATION* |  |  |  |  |
| R.M.S. isolation voltage | $V_{\text {isol }}$ | $\min$. | 2500 | V |
| THERMAL RESISTANCE |  |  |  |  |
| From junction to mounting base | $R_{\text {th }}$ j-mb | = | 1.1 | K/W |
| From mounting base to heatsink with heatsink compound | $\mathrm{R}_{\text {th mb-h }}$ | $=$ | 0.2 | K/W |

[^34]
## CHARACTERISTICS

## Anode to cathode

On-state voltage

$$
\mathrm{I}_{\mathrm{T}}=50 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}
$$

Off-state current
$\mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\text {Dmax }} ; \mathrm{T}_{\mathrm{j}}=125^{\circ} \mathrm{C}$
Holding current; $T_{j}=25^{\circ} \mathrm{C}$

| $\mathrm{V}_{\mathrm{T}}$ | $<$ | 2.6 | $\mathrm{~V}^{*}$ |
| :--- | :--- | ---: | :--- |
|  |  | 6.0 | mA |
| $\mathrm{I}_{\mathrm{D}}$ | $<$ | 600 | mA |

## Gate to cathode

Voltage that will trigger all devices $\mathrm{V}_{\mathrm{D}}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
Current that will trigger all devices
$V_{D}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$

| $\mathrm{V}_{\mathrm{GT}}$ | $>$ | 2.0 | V |
| :--- | :--- | :--- | :--- |
| $\mathrm{I}_{\mathrm{GT}}$ | $>$ | 250 | mA |

## Switching characteristics (see Fig.2)

Circuit commutated turn-off time
$\mathrm{d} \mathrm{V}_{\mathrm{D}} / \mathrm{dt}=500 \mathrm{~V} / \mu \mathrm{s}$ (linear to $\mathrm{V}_{\mathrm{DRMmax}}$ );
$\mathrm{R}_{\mathrm{GK}}=10 \Omega ; \mathrm{V}_{\mathrm{G}}=0 ; \mathrm{T}_{\mathrm{j}}=125{ }^{\circ} \mathrm{C}$;
when switched from $\mathrm{I}_{\mathrm{T}}=100 \mathrm{~A} ; \mathrm{t}_{\mathrm{p}}=150 \mu \mathrm{~s}$
$-\mathrm{d} \mathrm{I}_{\mathrm{T}} / \mathrm{dt}=50 \mathrm{~A} / \mu \mathrm{s}$
suffix K
suffix N
$-\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}=10 \mathrm{~A} / \mu \mathrm{s}$
suffix K
suffix N

| ${ }^{\mathrm{t}_{\mathrm{q}}}$ | $<$ | 6 | $\mu \mathrm{~s}$ |
| :--- | :--- | :--- | :--- |
| ${ }_{\mathrm{q}}$ | $<$ | 9 | $\mu \mathrm{~s}$ |
|  |  |  |  |
| ${ }^{\mathrm{t}_{\mathrm{q}}}$ | $<$ | 4 | $\mu \mathrm{~s}$ |
| ${ }^{\mathrm{t}_{\mathrm{q}}}$ | $<$ | 6 | $\mu \mathrm{~s}$ |



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

[^35]BTW62 SERIES


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

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

Fast turn-off thyristors


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


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


Fig. 6 Transient thermal impedance.


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

Fig. $8-\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$; $--\mathrm{T}_{\mathrm{j}}=125^{\circ} \mathrm{C}$; $\mathrm{t}_{\mathrm{p}}=200 \mu \mathrm{~s}$.


Fig. 9 Variation of $\mathrm{t}_{\mathrm{q}}$ with $\mathrm{T}_{\mathrm{j}}$;
$-\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}=50 \mathrm{~A} / \mu \mathrm{s} ; \mathrm{dV}_{\mathrm{D}} / \mathrm{dt}=500 \mathrm{~V} / \mu \mathrm{s}$
(linear to $V_{D R M m a x}$ ) $; I_{T}=100 \mathrm{~A} ; \mathrm{t}_{\mathrm{p}}=150 \mu \mathrm{~s}$; $\mathrm{R}_{\mathrm{GK}}=10 \Omega ; \mathrm{V}_{\mathrm{G}}=0$; maximum values.



Fig. 10 Variation of $t_{q}$ with negative bias;
$-\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}=50 \mathrm{~A} / \mu \mathrm{s} ; \mathrm{dV}_{\mathrm{D}} / \mathrm{dt}=500 \mathrm{~V} / \mu \mathrm{s}$
(linear to $V_{D R M m a x}$ ); $\mathrm{I}_{\mathrm{T}}=100 \mathrm{~A} ; \mathrm{t}_{\mathrm{p}}=150 \mu \mathrm{~s}$; $\mathrm{T}_{\mathrm{j}}=125^{\circ} \mathrm{C}$; maximum values.

## FAST TURN-OFF THYRISTORS WITH ANTI-PARALLEL DIODES

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

## QUICK REFERENCE DATA

| Thyristor |  | BTW62D-600R |  | 800R | 1000R |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Repetitive peak off-state voltage | $V_{\text {DRM }}$ | max. | 600 | 800 | 1000 | V |
| Average on-state current | ${ }^{\prime} \mathrm{T}(\mathrm{AV})$ | max. |  | 18 |  | A |
| Repetitive peak on-state current | ${ }^{\prime}$ TRM | max. |  | 175 |  | A |
| Circuit-commutated turn-off time suffix K suffix $N$ | $\begin{gathered} \mathrm{t}_{\mathrm{q}} \\ \mathrm{t}_{\mathrm{q}} \end{gathered}$ | $<$ $<$ |  | 4 6 |  | $\mu \mathrm{S}$ $\mu \mathrm{S}$ |
| Diode |  |  |  |  |  |  |
| Average forward current | ${ }^{\prime} \mathrm{F}(\mathrm{AV})$ | max. |  | 8 |  | A |
| Reverse recovery time | $\mathrm{t}_{\mathrm{rr}}$ | $<$ |  | 600 |  | ns |

MECHANICAL DATA
Dimensions in mm
Fig. 1 TO-238AA


Pin $1=$ gate (AMP187 series)
$2=k$ (thyristor), a(diode) ; (AMP250 series)
$3=a$ (thyristor), $k$ (diode) ; (AMP250 series)
Baseplate is electrically isolated.

## RATINGS

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

## THYRISTOR

## Anode to cathode

| Transient off-state voltage | $\mathrm{V}_{\mathrm{DSM}}$ |
| :--- | :--- |
| Repetitive peak off-state voltage | $\mathrm{V}_{\mathrm{DRM}}$ |
| Continuous off-state voltage | $\mathrm{V}_{\mathrm{D}}$ |

Average on-state current (averaged over any 20 ms period) up to $T_{m b}=85^{\circ} \mathrm{C}$
R.M.S. on-state current

Repetitive peak on-state current;

$$
\mathrm{t}_{\mathrm{p}}=50 \mu \mathrm{~s} ; \delta=0.05
$$

Non-repetitive peak on-state current
$\mathrm{T}_{\mathrm{j}}=125^{\circ} \mathrm{C}$ prior to surge;
$\mathrm{t}=10 \mathrm{~ms}$; half sine-wave $\quad \mathrm{I}_{\mathrm{TSM}}$
$I^{2} t$ for fusing; $t=10 \mathrm{~ms}$

## Gate to cathode

Average power dissipation (averaged over. any 20 ms period)
Peak power dissipation; t $=10 \mu \mathrm{~s}$
Rate of rise of on-state current after triggering with $\mathrm{I}_{\mathrm{G}}=1.25 \mathrm{~A} ; \mathrm{I}_{\mathrm{T}}=80 \mathrm{~A}$

## DIODE

Average forward current (averaged over any 20 ms period) up to $\mathrm{T}_{\mathrm{mb}}=85^{\circ} \mathrm{C}$

Non-repetitive peak on-state current
$\mathrm{t}=10 \mathrm{~ms}$; half sine-wave
$\mathrm{T}_{\mathrm{j}}=125^{\circ} \mathrm{C}$ prior to surge

## Temperatures

| Storage temperature | $\mathrm{T}_{\text {stg }}$ | -40 to +125 | ${ }^{\circ} \mathrm{C}$ |  |
| :--- | :--- | :--- | ---: | :--- |
| Operating junction temperature | $\mathrm{T}_{\mathrm{j}}$ | max. | 125 | ${ }^{\circ} \mathrm{C}$ |
| ISOLATION* |  |  |  |  |
| R.M.S. isolation voltage |  |  |  |  |
| (isol | min. | 2500 | V |  |

[^36]| ${ }^{\mathrm{I}} \mathrm{T}(\mathrm{AV})$ | max. | 18 | A |
| :--- | :--- | ---: | :--- |
| ${ }^{\mathrm{I}} \mathrm{T}(\mathrm{RMS})$ | max. | 28 | A |
| ${ }^{\text {I TRM }}$ | max. | 175 | A |

ITSM
$I^{2} \mathrm{t}$
max. 200
A
$A^{2} s$
$\mathrm{A} / \mu \mathrm{s}$
$P_{G(A V)}$
$P_{G M}$
max
max. 200

1000
A
$\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}$
max.
max.

IF (AV) max.
8
A

IFSM max
60
A

| BTW62D-600R |  | 800 R | 1000 R |  |
| :--- | ---: | ---: | ---: | :--- |
| max. | 800 | 1000 | 1000 | V |
| $\max$. | 600 | 800 | 1000 | V |
| max. | 500 | 650 | 700 | V |

A
A

W
$\mathrm{V}_{\text {isol }} \quad \mathrm{min}$.
2500V

## THERMAL RESISTANCE

## Thyristor

| From junction to mounting base | $R_{\text {th } \mathrm{j}-\mathrm{mb}}$ | $=$ | 1.1 | $\mathrm{~K} / \mathrm{W}$ |
| :--- | :--- | :--- | :--- | :--- |
| From mounting base to heatsink, <br> with heatsink compound | $\mathrm{R}_{\text {th mb-h }}$ | $=$ | 0.2 | $\mathrm{~K} / \mathrm{W}$ |
| Diode | $\mathrm{R}_{\text {th j-mb }}$ | $=$ | 2.8 | $\mathrm{~K} / \mathrm{W}$ |
| From junction to mounting base | $\mathrm{R}_{\text {th mb-h }}$ | $=$ | 0.2 | $\mathrm{~K} / \mathrm{W}$ |



Fig. 2 Equivalent thermal network.

## THYRISTOR CHARACTERISTICS

## Anode to cathode

On-state voltage

| $\mathrm{I}_{\mathrm{T}}=50 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$ | $\mathrm{V}_{\mathrm{T}}$ | $<$ | 2.6 | $\mathrm{~V}^{*}$ |
| :--- | :---: | :---: | :---: | :---: |
| ff-state current |  |  |  |  |
| $\mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\text {Dmax }} ; \mathrm{T}_{\mathrm{j}}=125^{\circ} \mathrm{C}$ | $\mathrm{I}_{\mathrm{D}}$ | $<$ | 6.0 | mA |
| olding current $; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$ | $\mathrm{I}_{\mathrm{H}}$ | $<$ | 400 | mA |

## Gate to cathode

Voltage that will trigger all devices

$$
\begin{array}{lllll}
\mathrm{V}_{\mathrm{D}}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C} & \mathrm{~V}_{\mathrm{GT}} & > & 2.0 & \mathrm{~V} \\
\text { Current that will trigger all devices } & & & & \\
\mathrm{V}_{\mathrm{D}}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C} & \mathrm{I}_{\mathrm{GT}} & > & 250 & \mathrm{~mA}
\end{array}
$$

## Switching characteristics (see Fig.6)

Circuit-commutated turn-off time
$\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}=500 \mathrm{~V} / \mu \mathrm{s}$ (linear to $\mathrm{V}_{\mathrm{DRMmax}}$ );
$\mathrm{R}_{\mathrm{GK}}=10 \Omega ; \mathrm{V}_{\mathrm{G}}=0 ; \mathrm{T}_{\mathrm{j}}=125^{\circ} \mathrm{C}$;
when switched from $\mathrm{I}_{\mathrm{T}}=100 \mathrm{~A}$; $\mathrm{t}_{\mathrm{p}}=150 \mu \mathrm{~s}$
$-\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}=50 \mathrm{~A} / \mu \mathrm{s}$
$\begin{array}{lcccc}\operatorname{suffix~} \mathrm{K} & \mathrm{t}_{\mathrm{q}} & < & 6 & \mu \mathrm{~s} \\ \operatorname{suffix} \mathrm{~N} & \mathrm{t}_{\mathrm{q}} & < & 9 & \mu \mathrm{~s} \\ -\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}=10 \mathrm{~A} / \mu \mathrm{s} & & & & \\ \text { suffix } \mathrm{K} & \mathrm{t}_{\mathrm{q}} & < & 4 & \mu \mathrm{~s} \\ \operatorname{suffix} \mathrm{~N} & \mathrm{t}_{\mathrm{q}} & < & 6 & \mu \mathrm{~s}\end{array}$


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

[^37]THYRISTOR


Fig. 4 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.
$a=$ form factor $=\frac{{ }^{\mathrm{I}}(\mathrm{RMS})}{\mathrm{I}_{\mathrm{T}(\mathrm{AV})}}$

THYRISTOR

Fig. $5-\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C} ;---\mathrm{T}_{\mathrm{j}}=125^{\circ} \mathrm{C}$;
$\mathrm{t}_{\mathrm{p}}=200 \mu \mathrm{~s}$.


Fig.6a Variation of $t_{q}$ with $T_{j}$;
$-\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}=50 \mathrm{~A} / \mu \mathrm{s} ; \mathrm{dV}_{\mathrm{D}} / \mathrm{dt}=500 \mathrm{~V} / \mu \mathrm{s}$
(linear to $V_{D R M m a x}$ ); $I_{T}=100 \mathrm{~A} ; \mathrm{t}_{\mathrm{p}}=150 \mu \mathrm{~s}$;
$\mathrm{R}_{\mathrm{GK}}=10 \Omega ; \mathrm{V}_{\mathrm{G}}=0$; maximum values.


Fig.6b Variation of $t_{q}$ with negative bias;
$-\mathrm{dl} \mathrm{T} / \mathrm{dt}=50 \mathrm{~A} / \mu \mathrm{s} ; \mathrm{dV}_{\mathrm{D}} / \mathrm{dt}=500 \mathrm{~V} / \mu \mathrm{s}$
(linear to $V_{D R M m a x}$ ); $I_{T}=100 \mathrm{~A} ; \mathrm{t}_{\mathrm{p}}=150 \mu \mathrm{~s}$; $\mathrm{T}_{\mathrm{j}}=125^{\circ} \mathrm{C}$; maximum values.

Fast turn-off thyristors
BTW62D SERIES

THYRISTOR


Fig. 7 Maximum total energy loss per pulse when switching a halfsinusoidal pulse from 600 V .
Device power $(W)=$ Energy per pulse $(J) \times$ No. of pulses per second.
For pulse widths $>100 \mu$ s use Fig. 4 .

THYRISTOR


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

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


Fig. 10 Transient thermal impedance.

## DIODE CHARACTERISTICS

## Forward voltage

$$
\mathrm{I}_{\mathrm{F}}=10 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}
$$

## Reverse recovery when switched from

$\mathrm{I}_{\mathrm{F}}=2 \mathrm{~A}$ to $\mathrm{V}_{\mathrm{R}} \geqslant 30 \mathrm{~V}$ with
$-\mathrm{dl}_{\mathrm{F}} / \mathrm{dt}=20 \mathrm{~A} / \mu \mathrm{s} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
recovered charge
recovery time
$\mathrm{V}_{\mathrm{F}} \ll 2.0$
V*


Fig. 12 Definition of $\mathrm{t}_{\mathrm{fr}}$.

Fig. 11 Definition of $\mathrm{t}_{\mathrm{rr}}$ and $\mathrm{Q}_{\mathrm{s}}$.
*Measured under pulse conditions to avoid excessive dissipation.


Fig. 13 The right hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.
$a=$ form factor $=\frac{I_{T(R M S)}}{I_{T}(A V)}$

DIODE


Fig. $14 — \mathrm{~T}_{\mathrm{j}}=25^{\circ} \mathrm{C} ;---\mathrm{T}_{\mathrm{j}}=125^{\circ} \mathrm{C}$.


Fig. 15 Peak reverse recovery current versus $-\mathrm{dI}_{\mathrm{F}} / \mathrm{dt} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$; maximum values.


Fig. 16 Transient thermal impedance.

## FAST TURN-OFF THYRISTORS

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

## QUICK REFERENCE DATA

| Repetitive peak off-state voltage | VDRM | BTW63-600R |  | 800R \| 1000R |  | V |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | max. | 600 | 800 | 1000 |  |
| Average on-state current | ${ }^{\prime} \mathrm{T}(\mathrm{AV})$ | max. |  | 25 |  | A |
| Repetitive peak on-state current | ITRM | max. |  | 250 |  | A |
| Circuit-commutated turn-off time |  |  |  |  |  |  |
| suffix K | $\mathrm{t}_{\mathrm{q}}$ | $<$ |  | 4 |  | $\mu \mathrm{s}$ |
| suffix N | $\mathrm{t}_{\mathrm{q}}$ | $<$ |  | 6 |  | $\mu \mathrm{s}$ |

MECHANICAL DATA
Dimensions in mm
Fig. 1 TO-48


Net Mass: 14 g

Diameter of clearance hole: max. 6.5 mm
Accessories supplied on request:
56264a (mica washer);
56264b (insulating bush).

Supplied with device: 1 nut, 1 lock washer.
Torque on nut: min. $1.7 \mathrm{Nm}(17 \mathrm{~kg} \mathrm{~cm})$ $\max .3 .5 \mathrm{Nm}(35 \mathrm{~kg} \mathrm{~cm})$
Nut dimensions across the flats: 11.1 mm

Products approved to CECC 50 011-010 available on request.

## RATINGS

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

## Anode to cathode

Transient off-state voltage
Repetitive peak off-state voltage
Continuous off-state voltage

|  | BTW63-600R |  | 800 R | 1000 R |  |
| :--- | :--- | :--- | ---: | ---: | :--- |
| $\mathrm{V}_{\text {DSM }}$ | max. | 800 | 1000 | 1000 | V |
| $\mathrm{~V}_{\text {DRM }}$ | $\max$. | 600 | 800 | 1000 | V |
| $\mathrm{~V}_{\mathrm{D}}$ | $\max$. | $\underbrace{500}_{\text {max. }}$ | 650 | 700 | V |
|  | $\mathrm{~V}_{\text {RSM }}$ | V |  |  |  |

Average on-state current averaged over any 20 ms period;
$\rightarrow u p$ to $T_{m b}=85^{\circ} \mathrm{C}$
R.M.S. on-state current

Repetitive peak on-state current; $\mathrm{t}_{\mathrm{p}}=50 \mu \mathrm{~s} ; \delta=0.05$

| IT(AV) | max. | 25 | A |
| :--- | :--- | ---: | ---: |
| IT(RMS) | max. | 40 | A |
| ITRM | max. | 250 | A |

Non-repetitive peak on-state current

$$
\mathrm{T}_{\mathrm{j}}=125^{\circ} \mathrm{C} \text { prior to surge; }
$$

$t=10 \mathrm{~ms}$; half sine-wave $\quad$ ITSM max. 370 A
$1^{2} t$ for fusing; $t=10 \mathrm{~ms}$
Rate of rise of on-state current after triggering with $I_{G}=1.25 \mathrm{~A} ; I_{T}=80 \mathrm{~A}$

| $\mathrm{I}^{2} \mathrm{t}$ | max. | 700 | $\mathrm{~A}^{2} \mathrm{~s}$ |
| :--- | :--- | :--- | :--- |
|  |  |  |  |
| $\mathrm{dI}_{\mathrm{T}} / \mathrm{dt}$ | max. | 1000 | $\mathrm{~A} / \mu \mathrm{s}$ |

## Gate to cathode

Average power dissipation (averaged over any 20 ms period)

Peak power dissipation; $t=10 \mu \mathrm{~s}$

| $P_{G(A V)}$ | max. | 1 | $W$ |
| :--- | :--- | ---: | :--- |
| $P_{G M}$ | $\max$. | 10 | $W$ |

## Temperatures

Storage temperature
Operating junction temperature

| $T_{\text {stg }}$ | -40 to +125 | ${ }^{\circ} \mathrm{C}$ |
| :--- | ---: | ---: |
| $\mathrm{T}_{\mathrm{j}}$ | max. | 125 |${ }^{\circ} \mathrm{C}$

## THERMAL RESISTANCE

$\rightarrow$ From junction to mounting base
From mounting base to heatsink with heatsink compound

| $R_{\text {th j-mb }}$ | $=$ | 0.8 | $\mathrm{~K} / \mathrm{W}$ |
| :--- | :--- | :--- | :--- |
| $R_{\text {th mb-h }}$ | $=$ | 0.2 | $\mathrm{~K} / \mathrm{W}$ |

## 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

$$
\mathrm{I}_{\mathrm{T}}=50 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}
$$

Off-state current
$V_{D}=V_{\text {Dmax }} ; T_{j}=125^{\circ} \mathrm{C}$
Holding current; $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$

| $\mathrm{V}_{\mathrm{T}}$ | $<$ | 2.6 | $\mathrm{~V}^{*}$ |
| :--- | :--- | ---: | :--- |
| $\mathrm{I}_{\mathrm{D}}$ | $<$ | 6.0 | mA |
| $\mathrm{I}_{\mathrm{H}}$ | $<$ | 400 | mA |

## Gate to cathode

Voltage that will trigger all devices

$$
\mathrm{V}_{\mathrm{D}}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}
$$

Current that will trigger all devices
$\mathrm{V}_{\mathrm{D}}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$

| $\mathrm{V}_{\mathrm{GT}}$ | $>$ | 2.0 | V |
| :--- | :--- | :--- | :--- |
| $\mathrm{I}_{\mathrm{GT}}$ | $>$ | 250 | mA |

## Switching characteristics (see Fig. 2)

Circuit commutated turn-off time
$d V_{D} / d t=500 \mathrm{~V} / \mu \mathrm{s}$ (linear to $V_{D R M m a x}$ );
$\mathrm{R}_{\mathrm{GK}}=10 \Omega ; \mathrm{V}_{\mathrm{G}}=0 ; \mathrm{T}_{\mathrm{j}}=125^{\circ} \mathrm{C}$;
when switched from $I_{T}=100 \mathrm{~A} ; \mathrm{t}_{\mathrm{p}}=150 \mu \mathrm{~s}$
$-\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}=50 \mathrm{~A} / \mu \mathrm{s}$
suffix K
suffix N
$-\mathrm{dl} \mathrm{T}_{\mathrm{T}} / \mathrm{dt}=10 \mathrm{~A} / \mu \mathrm{s}$
suffix K
suffix $N$

| $\mathrm{t}_{\mathrm{q}}$ | $<$ | 6 | $\mu \mathrm{~s}$ |
| :---: | :---: | :---: | :---: |
| $\mathrm{t}_{\mathrm{q}}$ | $<$ | 9 | $\mu \mathrm{~s}$ |
|  |  |  |  |
|  |  |  |  |
| $\mathrm{t}_{\mathrm{q}}$ | $<$ | 4 | $\mu \mathrm{~s}$ |
| $\mathrm{t}_{\mathrm{q}}$ | $<$ | 6 | $\mu \mathrm{~s}$ |



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

[^38]

Fig. 3 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.
$a=$ form factor $=\frac{I_{T}(R M S)}{I_{T}(A V)}$


Fig. 4 Maximum allowable peak on-state current versus pulse width; $T_{m b}=85^{\circ} \mathrm{C}$.

Fast turn-off thyristors

Fig. $5-\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C} ;---\mathrm{T}_{\mathrm{j}}=125^{\circ} \mathrm{C}$; $\mathrm{t}_{\mathrm{p}}=200 \mu \mathrm{~s}$.


Fig.6a Variation of $t_{q}$ with $T_{j}$;
$-\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}=50 \mathrm{~A} / \mu \mathrm{s} ; \mathrm{dV}_{\mathrm{D}} / \mathrm{dt}=500 \mathrm{~V} / \mu \mathrm{s}$
(linear to $V_{D R M m a x}$ ); $I_{T}=100 \mathrm{~A} ; \mathrm{t}_{\mathrm{p}}=150 \mu \mathrm{~s}$;
$\mathrm{R}_{\mathrm{GK}}=10 \Omega ; \mathrm{V}_{\mathrm{G}}=0$; maximum values.



Fig. 6 b Variation of $\mathrm{t}_{\mathrm{q}}$ with negative bias;
$-\mathrm{dl} \mathrm{T} / \mathrm{dt}=50 \mathrm{~A} / \mu \mathrm{s} ; \mathrm{dV}_{\mathrm{D}} / \mathrm{dt}=500 \mathrm{~V} / \mu \mathrm{s}$
(linear to $V_{\text {DRMmax }}$ ) $I_{T}=100 \mathrm{~A} ; \mathrm{t}_{\mathrm{p}}=150 \mu \mathrm{~s}$; $\mathrm{T}_{\mathrm{j}}=125^{\circ} \mathrm{C}$; maximum values.


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

Fast turn-off thyristors
BTW63 SERIES


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


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

## THYRISTORS

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

## QUICK REFERENCE DATA

|  | BTY79-400R |  | 500R | 600R | 800R | 1000R |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Repetitive peak voltages $\mathrm{V}_{\text {DRM }} / \mathrm{V}_{\text {RRM }}$ | max. | 400 | 500 | 600 | 800 | 1000 | V |
| Average on-state current |  |  |  |  | max. | 10 | A |
| R.M.S. on-state current |  |  |  | ${ }^{\prime} \mathrm{T}$ | S) max. | 16 | A |
| Non-repetitive peak on-state current |  |  |  | ITS | max. | 150 | A |

## MECHANICAL DATA

Dimensions in mm
Fig. 1 TO-64: with 10-32 UNF stud ( $\phi 4,83 \mathrm{~mm}$ ).



Torque on nut: min. $0,9 \mathrm{Nm}$
( 9 kg cm )
$\max .1,7 \mathrm{Nm}$
( 17 kg cm )

Supplied with device: 1 nut, 1 lock washer.
Nut dimensions: across the flats: $9,5 \mathrm{~mm}$.
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

Non-repetitive peak off-state voltage
$(\mathrm{t} \leqslant 10 \mathrm{~ms})$

Non-repetitive peak reverse voltage ( $\mathrm{t} \leqslant 5 \mathrm{~ms}$ )
Repetitive peak voltages
Crest working voltages


## Gate to cathode

Average power dissipation (averaged over any 20 ms period)
Peak power dissipation

| $\mathrm{P}_{\mathrm{G}}(\mathrm{AV})$ | $\max$. | $0,5 \mathrm{~W}$ |
| :--- | ---: | ---: |
| $\mathrm{P}_{\mathrm{GM}}$ | $\max$. | 5 W |

## Temperatures

Storage temperature
Junction temperature

| $\mathrm{T}_{\text {stg }}$ | -55 to $+125{ }^{\circ} \mathrm{C}$ |
| :--- | ---: |
| $\mathrm{T}_{\mathrm{j}}$ | max. $\quad 125^{\circ} \mathrm{C}$ |

## THERMAL RESISTANCE

From junction to mounting base

| $R_{\text {th j-mb }}$ | $=1,8{ }^{\circ} \mathrm{C} / \mathrm{W}$ |
| :--- | :--- |
| $R_{\text {th mb-h }}$ | $=0,5{ }^{\circ} \mathrm{C} / \mathrm{W}$ |
| $R_{\text {th j-a }}$ | $=45{ }^{\circ} \mathrm{C} / \mathrm{W}$ |
| $\mathrm{Z}_{\text {th j-mb }}$ | $=0,1{ }^{\circ} \mathrm{C} / \mathrm{W}$ |

From mounting base to heatsink with heatsink compound
From junction to ambient in free air
Transient thermal impedance ( $\mathrm{t}=1 \mathrm{~ms}$ )

* To ensure thermal stability: $R_{\text {th } j \text {-a }}<4^{\circ} \mathrm{C} / \mathrm{W}$ (d.c. blocking) or $<8^{\circ} \mathrm{C} / \mathrm{W}$ (a.c.). For smaller heatsinks $\mathrm{T}_{\mathrm{j} \text { max }}$ 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 $100 \mathrm{~A} / \mu \mathrm{s}$.


## CHARACTERISTICS

## Anode to cathode

On-state voltage (measured under pulse conditions)

$$
\mathrm{I}_{\mathrm{T}}=20 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}
$$

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

$$
V_{D}=2 / 3 V_{\text {DRMmax }} ; T_{j}=125^{\circ} \mathrm{C}
$$

Reverse current
$\mathrm{V}_{\mathrm{R}}=\mathrm{V}_{\mathrm{RWM} \text { max }} ; \mathrm{T}_{\mathrm{j}}=125^{\circ} \mathrm{C}$
Off-state current
$\mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DWMmax}} ; \mathrm{T}_{\mathrm{j}}=125^{\circ} \mathrm{C}$
Latching current; $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
Holding current; $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$

## Gate to cathode

Voltage that will trigger all devices

$$
V_{D}=6 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}
$$

Voltage that will not trigger any device

$$
\mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DRM} \text { max }} ; \mathrm{T}_{\mathrm{j}}=125^{\circ} \mathrm{C}
$$

Current that will trigger all devices

$$
V_{D}=6 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}
$$

On request (see Ordering Note)

## Switching characteristics

Gate-controlled turn-on time ( $\mathrm{t}_{\mathrm{gt}}=\mathrm{t}_{\mathrm{d}}+\mathrm{t}_{\mathrm{r}}$ ) when switched from $V_{D}=V_{D R M m a x}$ to $I_{T}=40 \mathrm{~A}$; $\mathrm{I}_{\mathrm{GT}}=100 \mathrm{~mA} ; \mathrm{dl}_{\mathrm{G}} / \mathrm{dt}=5 \mathrm{~A} / \mu \mathrm{s} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
Circuit-commutated turn-off time when switched from $I_{T}=40 \mathrm{~A}$ to $\mathrm{V}_{\mathrm{R}}>50 \mathrm{~V}$ with $-\mathrm{dl} \mathrm{T}_{\mathrm{T}} / \mathrm{dt}=10 \mathrm{~A} / \mu \mathrm{s} ; \mathrm{dV}_{\mathrm{D}} / \mathrm{dt}=50 \mathrm{~V} / \mu \mathrm{s} ; \mathrm{T}_{\mathrm{j}}=115{ }^{\circ}{ }^{\circ} \mathrm{C}$


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

$$
\begin{aligned}
& \mathrm{V}_{\mathrm{T}} \ll 2 \mathrm{~V} \\
& \mathrm{dV}_{\mathrm{D}} / \mathrm{dt}<200 \mathrm{~V} / \mu \mathrm{s} \\
& \mathrm{I}_{\mathrm{R}}<3 \mathrm{~mA} \\
& \text { ID }<3 \mathrm{~mA} \\
& \mathrm{I}_{\mathrm{L}}<150 \mathrm{~mA} \\
& \mathrm{I}_{\mathrm{H}}<75 \mathrm{~mA} \\
& \mathrm{t}_{\mathrm{q}} \quad \text { typ. } \quad 35 \\
& \mu \mathrm{~s}
\end{aligned}
$$

## BTY79 SERIES

## 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, $I_{G T}>20 \mathrm{~mA}$, are available on request. Add suffix $A$ to the type number when ordering: e.g. BTY79A-400R.

(1) $\mathrm{T}_{\mathrm{mb}}$-scale is for comparison purposes only and is correct only for $\mathrm{R}_{\text {th }} \mathrm{mb}$-a $\leqslant 6^{\circ} \mathrm{C} / \mathrm{W}$.


Fig. 4.


Fig. 5.


Fig. 6 Minimum gate voltage that will trigger all devices as a function of $\mathrm{T}_{\mathrm{j}}$.


Fig. 7 Minimum gate current that will trigger all devices as a function of $\mathrm{T}_{\mathrm{j}}$.


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


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


Fig. 10 Limits for starting or inrush currents.


Fig. 11 Limits for starting or inrush currents.


Fig. 12.

## THYRISTORS

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

## QUICK REFERENCE DATA

|  |  | BTY91-400R |  | 500R | 600R | 800 R |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Repetitive peak voltages | $\mathrm{V}_{\text {DRM }} / \mathrm{V}_{\text {RRM }}$ | max. | 400 | 500 | 600 | 800 | V |
| Average on-state current |  |  | It(AV) |  | max. | 16 | A |
| R.M.S. on-state current |  |  | IT(RMS) |  | max. | 25 | A |
| Non-repetitive peak on-state current |  |  | ITSM |  | max. | 200 | A |

## MECHANICAL DATA

Dimensions in mm
Fig. 1 TO-48: with $1 / 4$ in $\times 28$ UNF stud ( $\phi 6,35 \mathrm{~mm}$ ).


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

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

## 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 ( $\mathrm{t} \leqslant 10 \mathrm{~ms}$ ) $\quad V_{\text {DSM }}$ | max. | 500 | 850 | 850 | 850 V |
| Non-repetitive peak reverse voltage ( $\mathrm{t} \leqslant 5 \mathrm{~ms}$ ) $\quad \mathrm{V}_{\text {RSM }}$ | max. | 500 | 600 | 720 | 960 V |
| Repetitive peak voltages $\mathrm{V}_{\text {DRM }} / \mathrm{V}_{\text {RRM }}$ | max. | 400 | 500 | 600 | 800 V |
| Crest working voltages $\quad \mathrm{V}_{\text {DWM }} / \mathrm{V}_{\text {RWM }}$ | max. | 400 | 500 | 600 | 800 V * |
| Average on-state current (averaged over any 20 ms period) up to $\mathrm{T}_{\mathrm{mb}}=77^{\circ} \mathrm{C}$ at $T_{m b}=85^{\circ} \mathrm{C}$ |  | $\begin{aligned} & \mathrm{I} T(A V) \\ & \mathrm{I}(\mathrm{~T}(\mathrm{AV}) \end{aligned}$ |  |  | $\begin{aligned} & 16 \mathrm{~A} \\ & 14 \mathrm{~A} \end{aligned}$ |
| R.M.S. on-state current |  | ${ }^{\prime} \mathrm{T}$ (RMS) |  | max. | 25 A |
| Repetitive peak on-state current |  | ITRM |  | max. | 200 A |
| Non-repetitive peak on-state current; $\mathrm{t}=10 \mathrm{~ms}$; half sine-wave; $\mathrm{T}_{\mathrm{j}}=125^{\circ} \mathrm{C}$ prior to surge; with reapplied $\mathrm{V}_{\text {RWMmax }}$ |  | ITSM |  | max. | 200 A |
| $\mathrm{I}^{2} \mathrm{t}$ for fusing ( $\mathrm{t}=10 \mathrm{~ms}$ ) |  | $1^{2} \mathrm{t}$ |  | max. | $200 \mathrm{~A}^{2} \mathrm{~s}$ |
| Rate of rise of on-state current after triggering with $\mathrm{I}_{\mathrm{G}}=200 \mathrm{~mA}$ to $\mathrm{I}_{\mathrm{T}}=50 \mathrm{~A}$ |  | dIT/dt |  | max. | $20 \mathrm{~A} / \mu \mathrm{s}$ |

Gate to cathode
Reverse peak voltage

| $V_{R G M}$ | max. | 5 V |
| :--- | :--- | ---: |
|  |  |  |
| $P_{G}(A V)$ | $\max$. | $0,5 \mathrm{~W}$ |
| $P_{G M}$ | $\max$. | 5 W |

## Temperatures

Storage temperature
Junction temperature

| $T_{\text {stg }}$ | -55 to $+125{ }^{\circ} \mathrm{C}$ |
| :--- | :--- |
| $T_{j}$ | max. $\quad 125{ }^{\circ} \mathrm{C}$ |

## THERMAL RESISTANCE

From junction to mounting base

| $R_{\text {th j-mb }}$ | $=1,6{ }^{\circ} \mathrm{C} / \mathrm{W}$ |
| :--- | :--- |
| $R_{\text {th mb-h }}$ | $=$ |
| $Z_{\text {th j-mb }}$ | $=0,2{ }^{\circ} \mathrm{C} / \mathrm{W}$ |
|  | $0,09{ }^{\circ} \mathrm{C} / \mathrm{W}$ |

## 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.

[^39]
## CHARACTERISTICS

## Anode to cathode

On-state voltage
$I_{T}=50 \mathrm{~A} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
$\mathrm{V}_{\mathrm{T}} \ll \quad 2 \mathrm{~V}^{*}$

Rate of rise of off-state voltage that will not trigger any device;
exponential method; $V_{D}=2 / 3 V_{D R M m a x} ; T_{j}=125{ }^{\circ} \mathrm{C}$
$\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}<200 \mathrm{~V} / \mu \mathrm{s}$

Reverse current
$V_{R}=V_{R W M m a x} ; T_{j}=125^{\circ} \mathrm{C}$
$\mathrm{I}_{\mathrm{R}} \ll \quad 3 \mathrm{~mA}$

Off-state current
$V_{D}=V_{D W M \max } ; T_{j}=125^{\circ} \mathrm{C}$
Latching current; $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
Holding current; $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$

## Gate to cathode

Voltage that will trigger all devices
$V_{D}=6 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
Voltage that will not trigger any device
$V_{D}=V_{D R M m a x} ; T_{j}=125^{\circ} \mathrm{C}$
Current that will trigger all devices
$V_{D}=6 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$
$\mathrm{V}_{\mathrm{GT}}>\quad 3 \mathrm{~V}$
$\mathrm{V}_{\mathrm{GD}} \ll \quad 200 \mathrm{mV}$

Switching characteristics
Gate-controlled turn-on time ( $\mathrm{t}_{\mathrm{gt}}=\mathrm{t}_{\mathrm{d}}+\mathrm{t}_{\mathrm{r}}$ ) when switched

$$
\text { from } \mathrm{V}_{\mathrm{D}}=400 \mathrm{~V} \text { to } \mathrm{I}_{\mathrm{T}}=10 \mathrm{~A} ; \mathrm{I}_{\mathrm{GT}}=200 \mathrm{~mA} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C} \quad \mathrm{t}_{\mathrm{gt}} \quad \text { typ. } \quad 2 \mu \mathrm{~s}
$$



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

[^40]

Fig. 3.


Fig. 4.


Fig. 5.


Fig. 6.


Fig. 7.


Fig. 8.


Fig. 9.


Fig. 10.


Fig. 11.

## TRIACS

- 


## TRIACS

Glass-passivated 4 ampere triacs intended for use in applications requiring high bidirectional transient and blocking voltage capability, and high thermal cycling performance with very low thermal resistances, e.g. a.c. power control applications such as lighting, industrial and domestic heating, motor control and switching systems.

## QUICK REFERENCE DATA

|  |  | BT136-500 |  | 600 | 800 |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Repetitive peak off-state voltage | $\mathrm{V}_{\text {DRM }}$ | max. | 500 | 600 | 800 | V |
| R.M.S. on-state current | $I_{\text {T }}$ (RMS $)$ | max. |  | 4 |  | A |
| Non-repetitive peak on-state current | ITSM | 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 $\mathrm{T}_{2}$.
Supplied on request: accessories (see data sheets Mounting instructions and accessories for TO-220 envelopes).

## RATINGS

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

|  |  | BT136-500 |  | 600 | 800 |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Voltages (in either direction) |  |  |  |  |  |  |
| Non-repetitive peak off-state voltage $(\mathrm{t} \leqslant 10 \mathrm{~ms})$ | $\mathrm{V}_{\text {DSM }}$ | max. | $500^{*}$ | $600^{*}$ | 800 | V |
| Repetitive peak off-state voltage $(\delta \leqslant 0.01)$ | $\mathrm{V}_{\text {DRM }}$ | max. | 500 | 600 | 800 | V |
| Crest working off-state voltage | $\mathrm{V}_{\text {DWM }}$ | max. | 400 | 400 | 400 | V |

## Currents (in either direction)

R.M.S. on-state current (conduction angle $360^{\circ}$ )
up to $T_{m b}=102^{\circ} \mathrm{C}$
Repetitive peak on-state current
Non-repetitive peak on-state current;
$\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$ prior to surge;
$\mathrm{t}=20 \mathrm{~ms}$; full sine-wave
$1^{2} t$ for fusing ( $\mathrm{t}=10 \mathrm{~ms}$ )
Rate of rise of on-state current after
triggering with $\mathrm{I}_{\mathrm{G}}=200 \mathrm{~mA}$ to
$\mathrm{I}_{\mathrm{T}}=6 \mathrm{~A} ; \mathrm{dI}_{\mathrm{G}} / \mathrm{dt}=0.2 \cdot \mathrm{~A} / \mu \mathrm{s}$

## Gate to terminal 1

## POWER DISSIPATION

Average power dissipation
(averaged over any 20 ms period)
Peak power dissipation

## Temperatures

| Storage temperature | $T_{\text {stg }}$ |  | -40 to +125 | ${ }^{\circ} \mathrm{C}$ |
| :--- | :---: | :--- | :---: | :---: |
| Operating junction temperature <br> full-cycle operation |  |  |  | ${ }^{\circ} \mathrm{C}$ |
| half-cycle operation | $\mathrm{T}_{\mathrm{j}}$ | max. | 120 | ${ }^{\circ} \mathrm{C}$ |
|  | $\mathrm{T}_{\mathrm{j}}$ | max. | 110 | ${ }^{\circ} \mathrm{C}$ |

[^41]
## THERMAL RESISTANCE

From junction to mounting base
full-cycle operation
half-cycle operation
Transient thermal impedance; $t=1 \mathrm{~ms}$
$R_{\text {th } \mathrm{j}-\mathrm{mb}}=3.0 \mathrm{~K} / \mathrm{W}$
$R_{\text {th } j-\mathrm{mb}}=3.7 \mathrm{~K} / \mathrm{W}$
$Z_{\text {th } j-m b}=0.6 \mathrm{~K} / \mathrm{W}$

## Influence of mounting method

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from mounting base to heatsink
a. with heatsink compound
b. with heatsink compound and 0.06 mm maximum mica insulator
c. with heatsink compound and 0.1 mm max. mica insulator (56369)
d. with heatsink compound and 0.25 mm max. alumina insulator (56367)
$R_{\text {th mb-h }}=0.3 \mathrm{~K} / \mathrm{W}$
$R_{\text {th mb-h }}=1.4 \mathrm{~K} / \mathrm{W}$
$R_{\text {th mb-h }}=2.2 \mathrm{~K} / \mathrm{W}$
$R_{\text {th mb-h }}=0.8 \mathrm{~K} / \mathrm{W}$
$R_{\text {th mb-h }}=1.4 \mathrm{~K} / \mathrm{W}$
2. Free-air operation

The quoted value of $R_{t h} \mathrm{j}$-a should be used only when no leads of other dissipating components run to the same tie-point.
Thermal resistance from junction to ambient in free air: mounted on a printed-circuit board at $a=$ any lead length $R_{\text {th } j-a}=60 \mathrm{~K} / \mathrm{W}$


D840 1
Fig.2.

CHARACTERISTICS ( $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$ unless otherwise stated)
Polarities, positive or negative, are identified with respect to $T_{1}$.
Voltages and currents (in either direction)
On-state voltage (measured under pulse conditions to prevent excessive dissipation)

$$
\mathrm{I}_{\mathrm{T}}=5 \mathrm{~A} \quad \mathrm{~V}_{\mathrm{T}} \quad<1.70 \mathrm{~V}
$$

Rate of rise of off-state voltage that will not trigger
any device; $T_{j}=120^{\circ} \mathrm{C}$; gate open circuit

| BT136 series | $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ | < | 100 | $\mathrm{V} / \mu \mathrm{s}$ |
| :---: | :---: | :---: | :---: | :---: |
| BT136 series G | $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ | $<$ | 200 | $\mathrm{V} / \mu \mathrm{s}$ |
| BT136 series F | $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ | < | 50 | $\mathrm{V} / \mu \mathrm{s}$ |
| BT136 series E | $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ | typ. | 50 | $\mathrm{V} / \mu \mathrm{s}$ |
| BT136-500D | $\mathrm{dV} \mathrm{D}_{\mathrm{D}} / \mathrm{dt}$ | typ. | 5 | $\mathrm{V} / \mu \mathrm{s}$ |

Rate of change of commutating voltage that will not
trigger any device when $-\mathrm{dl}_{\text {com }} / \mathrm{dt}=1.8 \mathrm{~A} / \mathrm{ms}$;
$I_{T(R M S)}=4 A ; T_{m b}=85^{\circ} \mathrm{C}$; gate open circuit ; $V_{D}=V_{D W M m a x}$
BT136 series
$\mathrm{dV}_{\text {com }} / \mathrm{dt}$ typ. $10 \mathrm{~V} / \mu \mathrm{s}$
BT136 series G
$\mathrm{dV}_{\text {com }} / \mathrm{dt}<10 \mathrm{~V} / \mu \mathrm{s}$
BT136 series F
$\mathrm{dV}_{\text {com }} / \mathrm{dt}$ typ. $10 \mathrm{~V} / \mu \mathrm{s}$
Off-state current

$$
\begin{array}{llll}
\mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DWMmax}} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} & \mathrm{I}_{\mathrm{D}} & <0.5 \mathrm{~mA} \\
\text { e voltage that will trigger all devices } & \mathrm{V}_{\mathrm{GT}} & > & 1.5 \mathrm{~V}
\end{array}
$$

Gate voltage that will trigger all devices
Gate voltage that will not trigger any device
$\mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DWMmax}} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$;
$T_{2}$ and $G$ positive or negative
$\mathrm{V}_{\mathrm{GD}}<250 \mathrm{mV}$
Gate current that will trigger all devices ( $\mathrm{I}_{\mathrm{GT}}$ ); G to $\mathrm{T}_{1}$
Holding current ( $I_{H}$ )
Latching current ( $I_{L}$ ); $V_{D}=12 \mathrm{~V}$

| BT136 series | $\mathrm{I}_{\mathrm{GT}}$ | > | 35 | 35 | 35 | 70 | mA |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | $\mathrm{I}_{\mathrm{H}}$ | $<$ | 15 | 15 | 15 | 15 | mA |
|  | $\mathrm{I}_{\mathrm{L}}$ | $<$ | 20 | 30 | 20 | 30 | mA |
| BT136 series G | $\mathrm{I}_{\mathrm{GT}}$ | > | 50 | 50 | 50 | 100 | mA |
|  | ${ }^{\prime} \mathrm{H}$ | $<$ | 30 | 30 | 30 | 30 | mA |
|  | $I_{L}$ | $<$ | 30 | 45 | 30 | 45 | mA |
| BT136 series F | $\mathrm{I}_{\mathrm{GT}}$ | > | 25 | 25 | 25 | 70 | mA |
|  | $\mathrm{I}_{\mathrm{H}}$ | $<$ | 15 | 15 | 15 | 15 | mA |
|  | 'L | $<$ | 20 | 30 | 20 | 30 | mA |
| BT136 series E | $\mathrm{I}_{\mathrm{GT}}$ | > | 10 | 10 | 10 | 25 | mA |
|  | $\mathrm{I}_{\mathrm{H}}$ | $<$ | 15 | 15 | 15 | 15 | mA |
|  | $\mathrm{I}_{\mathrm{L}}$ | $<$ | 15 | 20 | 15 | 20 | mA |
| BT136-500D | $\mathrm{I}_{\mathrm{GT}}$ | > | 5 | 5 | 5 | 10 | mA |
|  | $\mathrm{I}_{\mathrm{H}}$ | $<$ | 10 | 10 | 10 | 10 | mA |
|  | IL | $<$ | 10 | 15 | 10 | 15 | mA |

## MOUNTING INSTRUCTIONS

1. The device may be soldered directly into the circuit, but the maximum permissible temperature of the soldering iron or bath is $275^{\circ} \mathrm{C}$; it must not be in contact with the joint for more than 5 seconds. Soldered joints must be at least 4.7 mm from the seal.
2. The leads should not be bent less than 2.4 mm from the seal, and should be supported during bending. The leads can be bent, twisted or straightened by $90^{\circ}$ maximum. The minimum bending radius is 1 mm .
3. It is recommended that the circuit connection be made to tag $\mathrm{T}_{2}$, 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 $R_{\text {th }} \mathrm{mb}$-h values than screw mounting. .
b. safe isolation for mains operation.

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

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

## OPERATING NOTES

Dissipation and heatsink considerations:
a. The various components of junction temperature rise above ambient are illustrated in Fig.3.


Fig. 3.
b. The method of using Fig. 4 is as follows:

Starting with the required current on the IT(RMS) axis, trace upwards to meet the appropriate conduction angle curve. Trace right horizontally and upwards from the appropriate value on the $T_{a m b}$ scale. The intersection determines the $R_{t h} \mathrm{mb}-\mathrm{a}$. The heatsink thermal resistance value ( $\mathrm{R}_{\text {th }}^{\mathrm{h}-\mathrm{a}}$ ) can now be calculated from:

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

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 $10^{\circ} \mathrm{C}$.

## OVERLOAD OPERATION



Fig. 5 Maximum permissible duration of steady overload (provided that $T_{m b}$ does not exceed $120{ }^{\circ} \mathrm{C}$ during and after overload) expressed as a percentage of the steady state r.m.s. rated current. For high r.m.s. overload currents precautions should be taken so that the temperature of the terminals does not exceed $125^{\circ} \mathrm{C}$. During these overload conditions the triac may lose control. Therefore the overload should be terminated by a separate protection device.


Fig. 6


Fig. 7 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents ( $f=50 \mathrm{~Hz}$ ); $T_{j}=120^{\circ} \mathrm{C}$ prior to surge. The triac may temporarily lose control following the surge.

'Ts

Fig. $8 —$ T $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C} ;--\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$


Fig. 9 Typical commutation $\mathrm{dV} / \mathrm{dt}$ for BT 136 series versus $\mathrm{T}_{\mathrm{j}}$. The triac should commutate when the $\mathrm{dV} / \mathrm{dt}$ is below the value on the appropriate curve for pre-commutation $\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}$.


Fig. 10 Limit commutation $\mathrm{dV} / \mathrm{dt}$ for BT 136 G series versus $\mathrm{T}_{\mathrm{j}}$. The triac should commutate when the $\mathrm{dV} / \mathrm{dt}$ is below the value on the appropriate curve for pre-commutation $\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}$.


Fig. 11 Typical commutation $\mathrm{dV} / \mathrm{dt}$ for BT136F series versus $\mathrm{T}_{\mathrm{j}}$. The triac should commutate when the $\mathrm{dV} / \mathrm{dt}$ is below the value on the appropriate curve for pre-commutation $\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}$.


Fig. 12 Minimum gate voltage that will trigger all devices; all conditions.

Fig. 13 Normalised gate current that will trigger all devices; all conditions.

## FULL-PACK TRIACS

Glass-passivated 4 ampere triacs in SOT-186 envelopes, which feature an electrically isolated seating plane. They are intended for use in applications requiring high bidirectional transient and blocking voltage capability. Typical applications include a.c. power control circuits such as lighting, industrial and domestic heating, motor control and switching systems.

## QUICK REFERENCE DATA

|  |  | BT136F-500 |  | 600 | 800 |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Repetitive peak off-state voltage | $V_{\text {DRM }}$ | max. | 500 | 600 | 800 | V |
| R.M.S. on-state current | $I^{T}($ RMS $)$ | max. |  | 4 |  | A |
| Non-repetitive peak on-state current | ITSM | max. |  | 25 |  | A |

MECHANICAL DATA Dimensions in mm
Fig. 1 SOT-186


Net mass: 2 g .


The seating plane is electrically isolated from all terminals.
Accessories supplied on request (see data sheets Mounting instructions for F-pack devices and Accessories for SOT-186 envelopes).

## RATINGS

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

Non-repetitive peak off-state voltage
( $\mathrm{t} \leqslant 10 \mathrm{~ms}$ )
Repetitive peak off-state voltage ( $\delta \leqslant 0.01$ )
Crest working off-state voltage VDWM

## Currents (in either direction)

R.M.S. on-state current (conduction angle $360^{\circ}$ )

| up to $T_{h}=86^{\circ} \mathrm{C}$ | ${ }^{1} \mathrm{~T}$ (RMS) | max. | 4 | A |
| :---: | :---: | :---: | :---: | :---: |
| Repetitive peak on-state current | ITRM | max. | 25 | A |
| Non-repetitive peak on-state current; $\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$ prior to surge; $\mathrm{t}=20 \mathrm{~ms}$; full sine-wave | ITSM | max. | 25 | A |
| $1^{2} \mathrm{t}$ for fusing ( $\mathrm{t}=10 \mathrm{~ms}$ ) | $\mathrm{I}^{2} \mathrm{t}$ | max. | 4 | $A^{2} \mathrm{~s}$ |
| Rate of rise of on-state current after triggering with $\mathrm{I}_{\mathrm{G}}=200 \mathrm{~mA} \text { to } \mathrm{I}_{\mathrm{T}}=6 \mathrm{~A} \text {; }$ $\mathrm{dl}_{\mathrm{G}} / \mathrm{dt}=0.2 \mathrm{~A} / \mu \mathrm{s}$ | $\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}$ | max. | 10 | A/ $\mu \mathrm{S}$ |

## Gate to terminal 1

## POWER DISSIPATION

Average power dissipation

| (averaged over any 20 ms period) | $\mathrm{P}_{\mathrm{G}}(\mathrm{AV})$ | $\max$ | 0.5 | W |
| :---: | :--- | ---: | ---: | :--- |
| Peak power dissipation | $\mathrm{P}_{\mathrm{GM}}$ | $\max$. | 5 | W |

## Temperatures

Storage temperature
Operating junction temperature
full-cycle operation
half-cycle operation

## ISOLATION

From all three terminals to external heatsink (peak)

Capacitance from $\mathrm{T}_{2}$ to
external heatsink

|  | BT136F-500 |  | 600 | 800 |  |
| :--- | :--- | :--- | :--- | :--- | :--- |
|  |  |  |  |  |  |
| $V_{\text {DSM }}$ | max. | $500^{*}$ | $600^{*}$ | 800 | $V$ |
| $V_{\text {DRM }}$ | max. | 500 | 600 | 800 | $V$ |
| $V_{\text {DWM }}$ | max. | 400 | 400 | 400 | $V$ |

$\mathrm{A} / \mu \mathrm{s}$

## THERMAL RESISTANCE

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from junction to external heatsink
With heatsink compound
Without heatsink compound

| $R_{\text {th } j-h}$ | $=$ | 5.5 | $\mathrm{~K} / \mathrm{W}$ |
| :--- | :--- | :--- | :--- |
| $R_{\text {th } j-h}$ | $=$ | 7.2 | $\mathrm{~K} / \mathrm{W}$ |

2. Free-air operation

The quoted values of $R_{\text {th } j \text {-a }}$ 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
$R_{\text {th j-a }}=55 \mathrm{~K} / \mathrm{W}$


Fig.2.

CHARACTERISTICS ( $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$ unless otherwise stated)
Polarities, positive or negative, are identified with respect to $\mathrm{T}_{1}$.
Voltages and currents (in either direction)
On-state voltage (measured under pulse conditions to prevent excessive dissipation)

| $I_{T}=5 \mathrm{~A}$ | $\mathrm{~V}_{\mathrm{T}}$ | $<$ | 1.70 | V |
| :--- | :--- | :--- | ---: | :--- |
| ate of rise of off-state voltage that will not trigger |  |  |  |  |
| any device; $T_{j}=120^{\circ} \mathrm{C}$; gate open circuit |  |  |  |  |
| BT136F series | $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ | $<$ | 100 | $\mathrm{~V} / \mu \mathrm{s}$ |
| BT136F series G | $\mathrm{dV} / \mathrm{dt}$ | $<$ | 200 | $\mathrm{~V} / \mu \mathrm{s}$ |
| BT136F series F | $\mathrm{dV} / \mathrm{dt}$ | $<$ | 50 | $\mathrm{~V} / \mu \mathrm{s}$ |
| BT136F series E | $\mathrm{dV} / \mathrm{dt}$ | typ. | 50 | $\mathrm{~V} / \mu \mathrm{s}$ |
| BT136F-500D | $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ | typ. | 5 | $\mathrm{~V} / \mu \mathrm{s}$ |

Rate of change of commutating voltage that will not
trigger any device when $-\mathrm{dl}_{\text {com }} / \mathrm{dt}=1.8 \mathrm{~A} / \mathrm{ms}$;
$I_{T(R M S)}=4 \mathrm{~A} ; \mathrm{T}_{\mathrm{h}}=70^{\circ} \mathrm{C}$; gate open circuit; $\mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DWM}}$ max
BT136F series

| dV ${ }_{\text {com }} / \mathrm{dt}$ | typ. | 10 | $\mathrm{V} / \mu \mathrm{s}$ |
| :---: | :---: | :---: | :---: |
| $\mathrm{dV}_{\text {com }} / \mathrm{dt}$ | < | 10 | $\mathrm{V} / \mu \mathrm{s}$ |
| dV $\mathrm{com}^{\text {/ }} \mathrm{dt}$ | typ | 10 | $\mathrm{V} / \mu \mathrm{s}$ |

BT136F series $F$
$d V_{\text {com }} / \mathrm{dt}$ typ
$\mathrm{V} / \mu \mathrm{s}$
Off-state current
$V_{D}=V_{D W M m a x} ; T_{j}=120^{\circ} \mathrm{C}$
Gate voltage that will trigger all devices
$I_{D}<\quad 0.5 \mathrm{~mA}$
$\mathrm{V}_{\mathrm{GT}} \gg 1.5 \mathrm{~V}$
Gate voltage that will not trigger any device
$V_{D}=V_{D W M m a x} ; T_{j}=120^{\circ} \mathrm{C}$;
$T_{2}$ and $G$ positive or negative
Gate current that will trigger all devices ( $\mathrm{I}_{\mathrm{GT}}$ ); G to $\mathrm{T}_{1}$
Holding current $\left(I_{H}\right)$
Latching current ( $\mathrm{I}_{\mathrm{L}}$ ); $\mathrm{V}_{\mathrm{D}}=12 \mathrm{~V}$


## MOUNTING INSTRUCTIONS

1. The triac may be soldered directly into the circuit, but the maximum permissible temperature of the soldering iron or bath is $275^{\circ} \mathrm{C}$; it must not be in contact with the joint for more than 5 seconds. Soldered joints must be at least 4.7 mm from the seal.
2. The leads should not be bent less than 2.4 mm from the seal, and should be supported during bending. The leads can be bent, twisted or straightened by $90^{\circ}$ maximum. The minimum bending radius is 1 mm .
3. Mounting by means of a spring clip is the best mounting method because it offers good thermal contact under the crystal area and slightly lower $\mathrm{R}_{\text {th }} \mathrm{j}$-h values than screw mounting.
However, if a screw is used, it should be M3 cross-recess pan-head. Care should be taken to avoid damage to the plastic body.
4. For good thermal contact heatsink compound should be used between seating plane and heatsink. Values of $\mathrm{R}_{\mathrm{th} j} \mathrm{j}$ h given for mounting with heatsink compound refer to the use of a metallic-oxide loaded compound. Ordinary silicone grease is not recommended.
5. Rivet mounting is not recommended.
6. The heatsink must have a flatness in the mounting area of 0.02 mm maximum per 10 mm . Mounting holes must be deburred.

## OPERATING NOTES

Dissipation and heatsink considerations:
a. The various components of junction temperature rise above ambient are illustrated in Fig. 3.


Fig. 3.
b. The method of using Figs. 4 and 5 is as follows:

Starting with the required current on the $\mathrm{I}_{\mathrm{T}(\mathrm{RMS}) \text { axis (I.h. graph) trace upwards to meet the }}$ appropriate conduction angle curve. Trace left from curve to obtain power $P$. Trace right from curve to obtain $T_{h}$ (r.h. graph). Trace upwards from $T_{a m b}$, intersect with $T_{h}$ determines $R_{t h} h-a$, required heatsink thermal resistance.
c. Any measurement of heatsink temperature should be made immediately adjacent to the device.

FULL-WAVE CONDUCTION (with heatsink compound)


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


Note: For the type BT136F-500D only, any operating point derived from Fig. 4 should be derated by a further $10^{\circ} \mathrm{C}$.

FULL-WAVE CONDUCTION (without heatsink compound)


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


Note: For the type BT136F-500D only, any operating point derived from Fig. 5 should be derated by a further $10^{\circ} \mathrm{C}$.

## BT136F SERIES

OVERLOAD OPERATION


Fig. 6 Maximum permissible duration of steady overload (provided that $T_{h}$ does not exceed $120^{\circ} \mathrm{C}$ during and after overload) expressed as a percentage of the steady state r.m.s. rated current. For high r.m.s. overload currents precautions should be taken so that the temperature of the terminals does not exceed $125^{\circ} \mathrm{C}$. 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 ( $f=50 \mathrm{~Hz}$ ); $T_{j}=120^{\circ} \mathrm{C}$ prior to surge. The triac may temporarily lose control following the surge.

TSS

Fig. $8-T_{j}=25^{\circ} \mathrm{C} ;---T_{j}=120^{\circ} \mathrm{C}$.


Fig. 9 Typical commutation $\mathrm{dV} / \mathrm{dt}$ for BT136F series versus $\mathrm{T}_{\mathrm{j}}$. The triac should commutate when the $\mathrm{dV} / \mathrm{dt}$ is below the value on the appropriate curve for pre-commutation $\mathrm{dI}_{\mathrm{T}} / \mathrm{dt}$.


Fig. 10 Limit commutation $\mathrm{dV} / \mathrm{dt}$ for BT 136 F series G versus $\mathrm{T}_{\mathrm{j}}$. The triac should commutate when the $\mathrm{dV} / \mathrm{dt}$ is below the value on the appropriate curve for pre-commutation $\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}$.

Triacs
BT136F SERIES


Fig. 11 Typical commutation $\mathrm{dV} / \mathrm{dt}$ tor BT 136 F series F versus $\mathrm{T}_{\mathrm{j}}$. The triac should commutate when the $\mathrm{dV} / \mathrm{dt}$ is below the value on the appropriate curve for pre-commutation $\mathrm{dl} \mathrm{T}^{\mathrm{T}} / \mathrm{dt}$.


Fig. 12 Minimum gate voltage that will trigger all devices; all conditions.


Fig. 14 Transient thermal impedance, - - - with heatsink compound; ——without heatsink compound.

## TRIACS

Glass-passivated 8 ampere triacs intended for use in applications requiring high bidirectional transient and blocking voltage capability, and high thermal cycling performance with very low thermal resistances, e.g. a.c. power control applications such as lighting, industrial and domestic heating, motor control and switching systems.

## QUICK REFERENCE DATA

|  |  | BT137-500 |  | 600 | 800 |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Repetitive peak off-state voltage | $V_{\text {DRM }}$ | max. | 500 | 600 | 800 | v |
| R.M.S. on-state current | IT(RMS) | max. |  | 8 |  | A |
| Non-repetitive peak on-state current | ${ }^{\text {TTSM }}$ | 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 $\mathrm{T}_{2}$.
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)
Non-repetitive peak off-state voltage ( $\mathrm{t} \leqslant 10 \mathrm{~ms}$ )
Repetitive peak off-state voltage ( $\delta \leqslant 0.01$ )
Crest working off-state voltage
$V_{\text {DWM }}$

| BT137-500 | 600 | 800 |  |  |
| :--- | :--- | :--- | :--- | :--- |
| $\max$. | $500^{*}$ | $600^{*}$ | 800 | V |
| $\max$. | 500 | 600 | 800 | V |
| $\max$. | 400 | 400 | 400 | V |

Currents (in either direction)
R.M.S. on-state current (conduction angle $360^{\circ}$ )
up to $\mathrm{T}_{\mathrm{mb}}=97^{\circ} \mathrm{C}$
Repetitive peak on-state current
$I^{T}($ RMS $)$

ITRM max. 8 max. 55

Non-repetitive peak on-state current;

$$
\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} \text { prior to surge; }
$$

$\mathrm{t}=20 \mathrm{~ms}$; full sine-wave
$1^{2} t$ for fusing ( $\mathrm{t}=10 \mathrm{~ms}$ )
Rate of rise of on-state current after triggering with $\mathrm{I}_{\mathrm{G}}=200 \mathrm{~mA}$ to $\mathrm{I}_{\mathrm{T}}=12 \mathrm{~A} ; \mathrm{dl}_{\mathrm{G}} / \mathrm{dt}=0.2 \mathrm{~A} / \mu \mathrm{s}$
$\mathrm{dl}_{\mathrm{T}} / \mathrm{dt} \quad \max$. max.55

15
A
$A^{2} s$
$1^{2} t$
max.

20
$\mathrm{A} / \mu \mathrm{s}$

## Gate to terminal 1

POWER DISSIPATION
Average power dissipation (averaged over any 20 ms period)

Peak power dissipation

## Temperatures

Storage temperature
Operating junction temperature
full-cycle operation
half-cycle operation

| $P_{G}(A V)$ | max. | 0.5 | $W$ |
| :--- | :--- | ---: | ---: |
| $P_{G M}$ | max. | 5 | $W$ |


|  |  |  |
| :--- | :--- | :--- |
| $T_{\text {stg }}$ | -40 to +125 | ${ }^{\circ} \mathrm{C}$ |


|  | max. | 120 | ${ }^{\circ} \mathrm{C}$ |
| :--- | :--- | :--- | :--- |
| $\mathrm{T}_{\mathrm{j}}$ | max. | 110 | ${ }^{\circ} \mathrm{C}$ |

[^42]
## THERMAL RESISTANCE

From junction to mounting base
full-cycle operation
$R_{\text {th } j-\mathrm{mb}}=2.0 \mathrm{~K} / \mathrm{W}$
$R_{\text {th } j-\mathrm{mb}}=2.4 \mathrm{~K} / \mathrm{W}$
$Z_{\text {th } j-m b}=0.3 \mathrm{~K} / \mathrm{W}$

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

## Influence of mounting method

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from mounting base to heatsink
a. with heatsink compound
$R_{\text {th mb-h }}=0.3 \mathrm{~K} / \mathrm{W}$
$R_{\text {th } \mathrm{mb}}=\mathrm{h}=1.4 \mathrm{~K} / \mathrm{W}$
$R_{\text {th mb-h }}=2.2 \mathrm{~K} / \mathrm{W}$
$R_{\text {th mb-h }}=0.8 \mathrm{~K} / \mathrm{W}$
$R_{\text {th mb-h }}=1.4 \mathrm{~K} / \mathrm{W}$

## 2. Free-air operation

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

Thermal resistance from junction to ambient in free air: mounted on a printed-circuit board at a = any lead length

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



7275493
Fig. 2

CHARACTERISTICS ( $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$ unless otherwise stated)
Polarities, positive or negative, are identified with respect to $\mathrm{T}_{\mathbf{1}}$.
Voltages and currents (in either direction)
On-state voltage (measured under pulse conditions to prevent excessive dissipation)

$$
\mathrm{I}_{\mathrm{T}}=10 \mathrm{~A} \quad \mathrm{~V}_{\mathrm{T}} \quad<\quad 1.65 \mathrm{~V}
$$

Rate of rise of off-state voltage that will not trigger
any device; $\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$; gate open circuit

| BT137 series | $d V_{D} / d t$ | $<$ | 100 | $\mathrm{~V} / \mu \mathrm{s}$ |
| :--- | :--- | :--- | ---: | :--- |
| BT137 series G | $d V_{\mathrm{D}} / \mathrm{dt}$ | $<$ | 200 | $\mathrm{~V} / \mu \mathrm{s}$ |
| BT137 series F | $d V_{\mathrm{D}} / \mathrm{dt}$ | $<$ | 50 | $\mathrm{~V} / \mu \mathrm{s}$ |
| BT137 series E | $d V_{\mathrm{D}} / \mathrm{dt}$ | typ. | 50 | $\mathrm{~V} / \mu \mathrm{s}$ |
| BT137 - 500D | $\mathrm{d} \mathrm{V}_{\mathrm{D}} / \mathrm{dt}$ | typ. | 5 | $\mathrm{~V} / \mu \mathrm{s}$ |

Rate of change of commutating voltage that will not
trigger any device when $-\mathrm{dl}_{\text {com }} / \mathrm{dt}=3.6 \mathrm{~A} / \mathrm{ms}$;
$\mathrm{I}_{\mathrm{T}(\mathrm{RMS})}=8 \mathrm{~A} ; \mathrm{T}_{\mathrm{mb}}=70^{\circ} \mathrm{C}$; gate open circuit $; \mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DWMmax}}$
BT137 series
$\mathrm{dV}_{\text {com }} / \mathrm{dt}$
BT137 series G
BT137 series F
$\mathrm{dV}_{\text {com }} / \mathrm{dt}$
typ. $\quad 10 \quad \mathrm{~V} / \mu \mathrm{s}$
$\mathrm{dV}_{\text {com }} / \mathrm{dt}$
$<$
typ.
Off-state current
$\mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\text {DWMmax }} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$
Gate voltage that will trigger all devices
$\mathrm{I}_{\mathrm{D}} \quad<\quad 0.5 \mathrm{~mA}$
$\mathrm{V}_{\mathrm{GT}}$
$>1.5 \mathrm{~V}$
Gate voltage that will not trigger any device
$\mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DWMmax}} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$;
$T_{2}$ and $G$ positive or negative
Gate current that will trigger all devices ( $\mathrm{I}_{\mathrm{GT}}$ ); G to $\mathrm{T}_{1}$
Holding current $\left(I_{H}\right)$
Latching current ( $\mathrm{I}_{\mathrm{L}}$ ); $\mathrm{V}_{\mathrm{D}}=12 \mathrm{~V}$

| BT137 series | $\begin{aligned} & \mathrm{I}_{\mathrm{GT}} \\ & \mathrm{I}_{\mathrm{H}} \\ & \mathrm{I}_{\mathrm{L}} \end{aligned}$ | $\begin{aligned} & > \\ & < \\ & < \end{aligned}$ | $\begin{aligned} & 35 \\ & 20 \\ & 30 \end{aligned}$ | $\begin{aligned} & 35 \\ & 20 \\ & 45 \end{aligned}$ | 35 20 30 | 70 20 45 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| BT137 series G | $\begin{aligned} & \mathrm{I}_{\mathrm{GT}} \\ & \mathrm{I}_{\mathrm{H}} \\ & \mathrm{I}_{\mathrm{L}} \end{aligned}$ | $>$ $<$ | $\begin{aligned} & 50 \\ & 40 \\ & 45 \end{aligned}$ | $\begin{aligned} & 50 \\ & 40 \\ & 60 \end{aligned}$ | 50 40 45 | 100 40 60 |
| BT137 series F | $\begin{aligned} & \mathrm{I}_{\mathrm{GT}} \\ & \mathrm{I}_{\mathrm{H}} \\ & \mathrm{I}_{\mathrm{L}} \end{aligned}$ | $\begin{aligned} & > \\ & < \\ & < \end{aligned}$ | $\begin{aligned} & 25 \\ & 20 \\ & 30 \end{aligned}$ | $\begin{aligned} & 25 \\ & 20 \\ & 45 \end{aligned}$ | $\begin{aligned} & 25 \\ & 20 \\ & 30 \end{aligned}$ | 70 20 45 |
| BT137 series E | $\begin{aligned} & \mathrm{I}_{\mathrm{GT}} \\ & \mathrm{I}_{\mathrm{H}} \end{aligned}$ | $\begin{aligned} & > \\ & < \\ & < \end{aligned}$ | $\begin{aligned} & 10 \\ & 20 \\ & 25 \end{aligned}$ | $\begin{aligned} & 10 \\ & 20 \\ & 35 \end{aligned}$ | $\begin{aligned} & 10 \\ & 20 \\ & 25 \end{aligned}$ | 25 20 35 |
| BT137-500D | $\begin{aligned} & \mathrm{I}_{\mathrm{GT}} \\ & \mathrm{I}_{\mathrm{H}} \\ & \mathrm{I}_{\mathrm{L}} \end{aligned}$ | $\begin{aligned} & > \\ & < \\ & < \end{aligned}$ | $\begin{array}{r} 5 \\ 15 \\ 15 \end{array}$ | $\begin{array}{r} 5 \\ 15 \\ 20 \end{array}$ | 5 15 15 | 10 15 20 |

## MOUNTING INSTRUCTIONS

1. The device may be soldered directly into the circuit, but the maximum permissible temperature of the soldering iron or bath is $275^{\circ} \mathrm{C}$; it must not be in contact with the joint for more than 5 seconds. Soldered joints must be at least 4.7 mm from the seal.
2. The leads should not be bent less than 2.4 mm from the seal, and should be supported during bending. The leads can be bent, twisted or straightened by $90^{\circ}$ maximum. The minimum bending radius is 1 mm .
3. It is recommended that the circuit connection be made to $\operatorname{tag} \mathrm{T}_{2}$, 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 $R_{t h} m b-h$ 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 $R_{\text {th }} \mathrm{mb}$-h given for mounting with heatsink compound refer to the use of a metallic-oxide loaded compound. Ordinary silicone grease is not recommended.
6. Rivet mounting (only possible for non-insulated mounting)

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

## OPERATING NOTES

Dissipation and heatsink considerations:
a. The various components of junction temperature rise above ambient are illustrated in Fig.3.


Fig.3.
b. The method of using Fig. 4 is as follows:

Starting with the required current on the $I_{T}(R M S)$ axis, trace upwards to meet the appropriate conduction angle curve. Trace right horizontally and upwards from the appropriate value on the $T_{a m b}$ scale. The intersection determines the $R_{\text {th mb-a }}$. The heatsink thermal resistance value ( $R_{\text {th }} h-a$ ) can now be calculated from:

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

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

FULL-CYCLE OPERATION


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

$\alpha=\alpha_{1}=\alpha_{2}$ : conduction angle per half cycle

Note: For the type BT137-500D only, any operating point derived from Fig. 4 should be derated by a further $10^{\circ} \mathrm{C}$.

OVERLOAD OPERATION


Fig. 5 Maximum permissible duration of steady overload (provided that $T_{m b}$ does not exceed $120{ }^{\circ} \mathrm{C}$ during and after overload) expressed as a percentage of the steady state r.m.s. rated current. For high r.m.s. overload currents precautions should be taken so that the temperature of the terminals does not exceed $125^{\circ} \mathrm{C}$. During these overload conditions the triac may lose control. Therefore the overload should be terminated by a separate protection device.


Fig. 6


Fig. 7 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents ( $f=50 \mathrm{~Hz}$ ); $\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$ prior to surge. The triac may temporarily lose control following the surge.


Fig. 8


Fig. 9 Typical commutation $\mathrm{dV} / \mathrm{dt}$ for BT 137 series versus $\mathrm{T}_{\mathrm{j}}$. The triac should commutate when the $\mathrm{dV} / \mathrm{dt}$ is below the value on the appropriate curve for pre-commutation $\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}$.


Fig. 10 Limit commutation $\mathrm{dV} / \mathrm{dt}$ for BT 137 G series versus $\mathrm{T}_{\mathrm{j}}$. The triac should commutate when the $\mathrm{dV} / \mathrm{dt}$ is below the value on the appropriate curve for pre-commutation $\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}$.


Fig. 11 Typical commutation $\mathrm{dV} / \mathrm{dt}$ for BT137F series versus $\mathrm{T}_{\mathrm{j}}$. The triac should commutate when the $\mathrm{dV} / \mathrm{dt}$ is below the value on the appropriate curve for pre-commutation $\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}$.


Fig. 12 Minimum gate voltage that will trigger all devices; all conditions.


Fig. 13 Normalised gate current that will trigger all devices; all conditions.

## FULL-PACK TRIACS

Glass-passivated 8 Ampere triacs in SOT-186 envelopes, which feature an electrically isolated seating plan . They are intended for use in applications requiring high bidirectional transient and blocking voltage capability. Typical applications include a.c. power control circuits such as lighting, industrial and domestic heating, motor control and switching systems.

## QUICK REFERENCE DATA

|  |  | BT137F-500 | 600 | 800 |  |
| :--- | :--- | :--- | :--- | :--- | :--- |
| Repetitive peak off-state voltage | VDRM | max. | 500 | 600 | 800 |
| R.M.S. on-state current |  |  |  | V |  |
| Non-repetitive peak on-state current | IT(RMS) | max. | 8 |  |  |

MECHANICAL DATA
Dimensions in mm
Fig. 1 SOT-186


Net mass: 2 g .
The seating plane is electrically isolated from all terminals.
Accessories supplied on request (see data sheets Mounting instructions for F-pack devices and Accessories for SOT-186 envelopes).

## RATINGS

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

Non-repetitive peak off-state voltage ( $\mathrm{t} \leqslant 10 \mathrm{~ms}$ )
Repetitive peak off-state voltage ( $\delta \leqslant 0.01$ )
Crest working off-state voltage
Currents (in either direction)
R.M.S. on-state current (conduction angle $360^{\circ}$ )
up to $T_{h}=71^{\circ} \mathrm{C}$
Repetitive peak on-state current
Non-repetitive peak on-state current;
$\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$ prior to surge;
$\mathrm{t}=20 \mathrm{~ms}$; full sine-wave
$1^{2} \mathrm{t}$ for fusing ( $\mathrm{t}=10 \mathrm{~ms}$ )
Rate of rise of on-state current after
triggering with
$\mathrm{I}_{\mathrm{G}}=200 \mathrm{~mA}$ to $\mathrm{I}_{\mathrm{T}}=12 \mathrm{~A}$;
$\mathrm{dl}_{\mathrm{G}} / \mathrm{dt}=0.2 \mathrm{~A} / \mu \mathrm{s}$

|  | BT137F-500 |  | 600 | 800 |  |
| :--- | :--- | :--- | :--- | :--- | :--- |
|  |  |  |  |  |  |
| $V_{\text {DSM }}$ | max. | $500^{*}$ | $600^{*}$ | 800 | V |
| $V_{\text {DRM }}$ | max. | 500 | 600 | 800 | V |
| $V_{\text {DWM }}$ | max. | 400 | 400 | 400 | V |

## Gate to terminal 1

## POWER DISSIPATION

Average power dissipation

| (averaged over any 20 ms period) | $\mathrm{P}_{\mathrm{G}}(\mathrm{AV})$ | max. | 0.5 | W |
| :--- | :--- | :--- | ---: | :--- |
|  | $\mathrm{P}_{\mathrm{GM}}$ | $\max$ | 5 | W |

## Temperatures

| Storage temperature | $\mathrm{T}_{\text {stg }}$ |  | -40 to +125 | ${ }^{\circ} \mathrm{C}$ |
| :--- | :--- | :--- | ---: | :--- |
| Operating junction temperature <br> full-cycle operation |  |  |  |  |
| half-cycle operation | $\mathrm{T}_{\mathrm{j}}$ | $\max$. | 120 | ${ }^{\circ} \mathrm{C}$ |
|  | $\mathrm{T}_{\mathrm{j}}$ | $\max$. | 110 | ${ }^{\circ} \mathrm{C}$ |

## ISOLATION

From all three terminals to external heatsink (peak)

Capacitance from $T_{2}$ to external heatsink
$V_{\text {isol }} \quad$ min. 1000

V
pF

[^43]
## THERMAL RESISTANCE

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from junction to external heatsink

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

## 2. Free-air operation

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

Thermal resistance from junction to ambient in free air: mounted on a printed-circuit board at $a=$ any lead length $\quad R_{\text {th } j-a}=55 \mathrm{~K} / \mathrm{W}$


M2283
Fig.2.

CHARACTERISTICS ( $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$ unless otherwise stated)
Polarities, positive or negative, are identified with respect to $\mathrm{T}_{1}$.
Voltages and currents (in either direction)
On-state voltage (measured under pulse conditions to prevent excessive dissipation)
$\mathrm{I}_{\mathrm{T}}=10 \mathrm{~A} \quad \mathrm{~V}_{\mathrm{T}} \ll 1.65 \mathrm{~V}$
Rate of rise of off-state voltage that will not trigger
any device; $T_{j}=120^{\circ} \mathrm{C}$; gate open circuit

| BT137F series | $d V_{D} / \mathrm{dt}$ | $<$ | 100 | $\mathrm{V} / \mu \mathrm{s}$ |
| :---: | :---: | :---: | :---: | :---: |
| BT137F series G | $d V_{D} / \mathrm{dt}$ | < | 200 | $\mathrm{V} / \mu \mathrm{s}$ |
| BT137F series $F$ | $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ | $<$ | 50 | $\mathrm{V} / \mu \mathrm{s}$ |
| BT137F series E | $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ | typ. | 50 | $\mathrm{V} / \mu \mathrm{s}$ |
| BT137F-500D | $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ | typ. | 5 | $\mathrm{V} / \mu \mathrm{s}$ |

Rate of change of commutating voltage that will not
trigger any device when $-\mathrm{dl}_{\mathrm{com}} / \mathrm{dt}=3.6 \mathrm{~A} / \mathrm{ms}$;
$I_{T}(R M S)=8 \mathrm{~A} ; \mathrm{T}_{\mathrm{h}}=54^{\circ} \mathrm{C}$; gate open circuit; $\mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DWM}}$ max
$\begin{array}{lllll}\text { BT137F series } & \mathrm{dV}_{\text {com }} / \mathrm{dt} & \text { typ. } & 10 & \mathrm{~V} / \mu \mathrm{s} \\ \text { BT137F series G } & \mathrm{dV} \mathrm{com}_{\text {com }} / \mathrm{dt} & < & 10 & \mathrm{~V} / \mu \mathrm{s}\end{array}$
$\mathrm{dV}_{\text {com }} / \mathrm{dt}<10 \mathrm{~V} / \mu \mathrm{s}$
BT137F series $F$
$\mathrm{dV}_{\text {com }} / \mathrm{dt}$ typ. $10 \mathrm{~V} / \mu \mathrm{s}$
Off-state current
$V_{D}=V_{D W M m a x} ; T_{j}=120^{\circ} \mathrm{C}$
${ }^{\prime} \mathrm{D}<0.5 \mathrm{~mA}$
Gate voltage that will trigger all devices
$\mathrm{V}_{\mathrm{GT}} \gg 1.5 \mathrm{~V}$
Gate voltage that will not trigger any device
$V_{D}=V_{D W M m a x} ; T_{j}=120^{\circ} \mathrm{C}$;
$T_{2}$ and $G$ positive or negative
$\mathrm{V}_{\mathrm{GD}} \ll 250 \mathrm{mV}$
Gate current that will trigger all devices $\left(I_{G T}\right) ; G$ to $T_{1}$


## MOUNTING INSTRUCTIONS

1. The triac may be soldered directly into the circuit, but the maximum permissible temperature of the soldering iron or bath is $275^{\circ} \mathrm{C}$; it must not be in contact with the joint for more than 5 seconds. Soldered joints must be at least 4.7 mm from the seal.
2. The leads should not be bent less than 2.4 mm from the seal, and should be supported during bending. The leads can be bent, twisted or straightened by $90^{\circ}$ maximum. The minimum bending radius is 1 mm .
3. Mounting by means of a spring clip is the best mounting method because it offers good thermal contact under the crystal area and slightly lower $R_{\text {th }} j$-h values than screw mounting.
However, if a screw is used, it should be M3 cross-recess pan-head. Care should be taken to avoid damage to the plastic body.
4. For good thermal contact heatsink compound should be used between seating plane and heatsink. Values of $R_{\text {th }} j$-h given for mounting with heatsink compound refer to the use of a metallic-oxide loaded compound. Ordinary silicone grease is not recommended.
5. Rivet mounting is not recommended.
6. The heatsink must have a flatness in the mounting area of 0.02 mm maximum per 10 mm . Mounting holes must be deburred.

## OPERATING NOTES

Dissipation and heatsink considerations:
a. The various components of junction temperature rise above ambient are illustrated in Fig.3.


Fig. 3.
b. The method of using Figs. 4 and 5 is as follows:

Starting with the required current on the $I^{( } /$RMS ) axis (l.h. graph) trace upwards to meet the appropriate conduction angle curve. Trace left from curve to obtain power $P$. Trace right from curve to obtain $T_{h}$ (r.h. graph). Trace upwards from $T_{\text {amb }}$, intersect with $T_{h}$ determines $R_{\text {th } h-a}$, required heatsink thermal resistance.
c. Any measurement of heatsink temperature should be made immediately adjacent to the device.

## FULL-WAVE CONDUCTION (with heatsink compound)



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


Note: For the type BT137F-500D only, any operating point derived from Fig. 4 should be derated by a further $10^{\circ} \mathrm{C}$.

FULL-WAVE CONDUCTION (without heatsink compound)


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

$\alpha=\alpha_{1}=\alpha_{2}$ : conduction angle per half cycle

Note: For the type BT137F-500D only, any operating point derived from Fig. 5 should be derated by a further $10^{\circ} \mathrm{C}$.

## OVERLOAD OPERATION



Fig. 6 Maximum permissible duration of steady overload (provided that $T_{h}$ does not exceed $120^{\circ} \mathrm{C}$ during and after overload) expressed as a percentage of the steady state r.m.s. rated current. For high r.m.s. overload currents precautions should be taken so that the temperature of the terminals does not exceed $125^{\circ} \mathrm{C}$. During these overload conditions the triac may lose control. Therefore the overload should be terminated by a separate protection device.

Triacs
BT137F SERIES


Fig. 7 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents
$(f=50 \mathrm{~Hz}) ; T_{j}=120^{\circ} \mathrm{C}$ prior to surge. The triac may temporarily lose control following the surge.

ITs


Fig. 8.


Fig. 9 Typical commutation $\mathrm{dV} / \mathrm{dt}$ for BT 137 F series versus $\mathrm{T}_{\mathrm{j}}$. The triac should commutate when the $\mathrm{dV} / \mathrm{dt}$ is below the value on the appropriate curve for pre-commutation $\mathrm{dl} \mathrm{T} / \mathrm{dt}$.


Fig. 10 Limit commutation $\mathrm{dV} / \mathrm{dt}$ for BT 137 F series G versus $\mathrm{T}_{\mathrm{j}}$. The triac should commutate when the $\mathrm{dV} / \mathrm{dt}$ is below the value on the appropriate curve for pre-commutation $\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}$.


Fig. 11 Typical commutation $d V / d t$ for $B T 137 F$ series $F$ versus $T_{j}$. The triac should commutate when the $\mathrm{dV} / \mathrm{dt}$ is below the value on the appropriate curve for pre-commutation $\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}$.


Fig. 12 Minimum gate voltage that will trigger all devices; all conditions.


Fig. 13 Normalised gate current that will trigger all devices; all conditions.


Fig. 14 Transient thermal impedance, - - - with heatsink compound; ——without heatsink compound.

## TRIACS

Glass-passivated 12 ampere triacs intended for use in applications requiring high bidirectional transient and blocking voltage capability, and high thermal cycling performance with very low thermal resistances, e.g. a.c. power control applications such as motor, industrial lighting, industrial and domestic heating control and static switching systems.
QUICK REFERENCE DATA

|  |  | BT138-500 |  | 600 | 800 |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Repetitive peak off-state voltage | $V_{\text {DRM }}$ | max. | 500 | 600 | 800 | v |
| R.M.S. on-state current | IT(RMS) | max. |  | 12 |  | A |
| Non-repetitive peak on-state current | ${ }^{\text {ITSM }}$ | 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 $\mathrm{T}_{2}$.

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 ( $\mathrm{t} \leqslant 10 \mathrm{~ms}$ ) | $V_{\text {DSM }}$ | max. | 500* | 600* | 800 |
| Repetitive peak off-state voltage ( $\delta \leqslant 0.01$ ) | VDRM | max. | 500 | 600 | 800 |
| Crest working off-state voltage | VDWM | max. | 400 | 400 | 400 |

## Currents (in either direction)

R.M.S. on-state current (conduction angle $360^{\circ}$ )

$$
\text { up to } \mathrm{T}_{\mathrm{mb}}=95^{\circ} \mathrm{C}
$$

Repetitive peak on-state current
Non-repetitive peak on-state current;

$$
\begin{aligned}
& \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} \text { prior to surge; } \\
& \mathrm{t}=20 \mathrm{~ms} ; \text { full sine-wave }
\end{aligned}
$$

$\mathrm{I}^{2} \mathrm{t}$ for fusing ( $\mathrm{t}=10 \mathrm{~ms}$ )
Rate of rise of on-state current after triggering with

$$
\mathrm{I}_{\mathrm{G}}=200 \mathrm{~mA} \text { to } \mathrm{I}_{\mathrm{T}}=20 \mathrm{~A} ;
$$

$$
\mathrm{dl}_{\mathrm{G}} / \mathrm{dt}=0.2 \mathrm{~A} / \mu \mathrm{s} \quad \mathrm{dl}_{\mathrm{T}} / \mathrm{dt} \quad \max \quad 30 \quad \mathrm{~A} / \mu \mathrm{s}
$$

## Gate to terminal 1

## Power dissipation

| Average power dissipation (averaged over any 20 ms period) | $\mathrm{P}_{\mathrm{G}}(\mathrm{AV})$ | max. | 0.5 | W |
| :---: | :---: | :---: | :---: | :---: |
| Peak power dissipation | $\mathrm{P}_{\mathrm{GM}}$ | max. | 5.0 | W |
| Temperatures |  |  |  |  |
| Storage temperature | $\mathrm{T}_{\text {stg }}$ | -40 to +125 |  | ${ }^{\circ} \mathrm{C}$ |
| Operating junction temperature |  |  |  |  |
| full-cycle operation | $\mathrm{T}_{\mathrm{j}}$ | $\max$. | 120 | ${ }^{\circ} \mathrm{C}$ |
| half-cycle operation | Tj | max. | 110 | ${ }^{\circ} \mathrm{C}$ |

[^44]
## THERMAL RESISTANCE

From junction to mounting base
full-cycle operation
half-cycle operation
Transient thermal impedance; $\mathrm{t}=1 \mathrm{~ms}$
$R_{\text {th } j-m b}=1.5 \mathrm{~K} / \mathrm{W}$
$R_{\text {th } j-m b}=2.0 \mathrm{~K} / \mathrm{W}$
$Z_{\text {th } j-m b}=0.1 \mathrm{~K} / \mathrm{W}$

## Influence of mounting method

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from mounting base to heatsink
a. with heatsink compound

| $R_{\text {th mb-h }}=0.3$ | $\mathrm{~K} / \mathrm{W}$ |
| :--- | :--- | :--- |
| $R_{\text {th mb-h }}=1.4$ | $\mathrm{~K} / \mathrm{W}$ |
| $R_{\text {th mb-h }}=2.2$ | $\mathrm{~K} / \mathrm{W}$ |

c. with heatsink compound and 0.1 mm maximum mica insulator (56369)
$R_{\text {th mb-h }}=2.2 \mathrm{~K} / \mathrm{W}$
d. with heatsink compound and 0.25 mm maximum alumina insulator (56367)
$R_{\text {th mb-h }}=0.8 \mathrm{~K} / \mathrm{W}$
e. without heatsink compound
2. Free-air operation

The quoted values of $R_{t h} j$-a should be used only when no leads of other dissipating components run to the same tie-point.
Thermal resistance from junction to ambient in free air: mounted on a printed-circuit board at a $=$ any lead length

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



Fig. 2

## CHARACTERISTICS ( $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$ unless otherwise stated)

Polarities, positive or negative, are identified with respect to $\mathrm{T}_{1}$.
Voltages and currents (in either direction)
On-state voltage (measured under pulse conditions to prevent excessive dissipation)
$I_{T}=15 \mathrm{~A}$
$V_{T}$
$<1.65 \mathrm{~V}$

Rate of rise of off-state voltage that will not trigger
any device; $\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$; gate open circuit
$\begin{array}{lllrl}\text { BT138 series } & \mathrm{dV} / \mathrm{dt} & < & 100 & \mathrm{~V} / \mu \mathrm{s} \\ \text { BT138 series G } & \mathrm{dV} / \mathrm{dt} & < & 200 & \mathrm{~V} / \mu \mathrm{s} \\ \text { BT138 series F } & \mathrm{dV} / \mathrm{dt} & < & 50 & \mathrm{~V} / \mu \mathrm{s} \\ \text { BT138 series E } & \mathrm{dV} / \mathrm{dt} & \text { typ. } & 50 & \mathrm{~V} / \mu \mathrm{s}\end{array}$
Rate of change of commutating voltage that will not
trigger any device when $-\mathrm{dl}_{\mathrm{com}} / \mathrm{dt}=5.4 \mathrm{~A} / \mathrm{ms}$;
$\mathrm{I}_{\mathrm{T}(\mathrm{RMS})}=12 \mathrm{~A} ; \mathrm{T}_{\mathrm{mb}}=70^{\circ} \mathrm{C}$; gate open circuit $; \mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DWM}}$ max
$\begin{array}{lllll}\text { BT138 series } & \mathrm{dV} \text { com } / \mathrm{dt} & \text { typ. } & 10 & \mathrm{~V} / \mu \mathrm{s} \\ \text { BT138 series G } & \mathrm{dV} \text { com } / \mathrm{dt} & < & 10 & \mathrm{~V} / \mu \mathrm{s} \\ \text { BT138 series F } & \mathrm{dV} \text { com } / \mathrm{dt} & \text { typ. } & 10 & \mathrm{~V} / \mu \mathrm{s}\end{array}$
Off-state current
$\mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DWMmax}} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} ;$
ID $<0.5 \mathrm{~mA}$
Gate voltage that will trigger all devices
$\mathrm{V}_{\mathrm{GT}}>1.5 \mathrm{~V}$
Gate voltage that will not trigger any device
$\mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DWM}}$ max $; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$;
$\mathrm{T}_{2}$ and G positive or negative $\quad \mathrm{V}_{\mathrm{GD}}<250 \mathrm{mV}$
Gate current that will trigger all devices ( $\mathrm{I}_{\mathrm{GT}}$ ); G to $\mathrm{T}_{1}$

| Holding current ( $\mathrm{I}_{\mathrm{H}}$ ) <br> Latching current ( $\mathrm{I}_{\mathrm{L}}$ ) $\mathrm{V}_{\mathrm{D}}=12 \mathrm{~V}$ |  |  | $\begin{aligned} & \mathrm{T}_{2+}^{+} \\ & \mathrm{G}+ \end{aligned}$ | $\begin{aligned} & \mathrm{T}_{2^{+}} \\ & \mathrm{G}- \end{aligned}$ | $\begin{aligned} & \mathrm{T}_{2}- \\ & \mathrm{G}- \end{aligned}$ | $\begin{aligned} & \mathrm{T}_{2}- \\ & \mathrm{G}+ \end{aligned}$ |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| BT138 series | $\begin{aligned} & \mathrm{I}_{\mathrm{GT}} \\ & \mathrm{I}_{\mathrm{H}} \\ & \mathrm{I}_{\mathrm{L}} \end{aligned}$ | $>3$ $<$ $<$ | $\begin{aligned} & 35 \\ & 30 \\ & 40 \end{aligned}$ | $\begin{aligned} & 35 \\ & 30 \\ & 60 \end{aligned}$ | $\begin{aligned} & 35 \\ & 30 \\ & 40 \end{aligned}$ | $\begin{aligned} & 70 \\ & 30 \\ & 60 \end{aligned}$ | $m A$ $m A$ $m A$ |
| BT138 series G | $\begin{aligned} & \mathrm{I}_{\mathrm{GT}} \\ & \mathrm{I}_{\mathrm{H}} \\ & \mathrm{I}_{\mathrm{L}} \end{aligned}$ | $\begin{aligned} & >5 \\ & <6 \\ & <6 \end{aligned}$ | $\begin{aligned} & 50 \\ & 60 \\ & 60 \end{aligned}$ | $\begin{aligned} & 50 \\ & 60 \\ & 90 \end{aligned}$ | $\begin{aligned} & 50 \\ & 60 \\ & 60 \end{aligned}$ | $\begin{array}{r} 100 \\ 60 \\ 90 \end{array}$ | mA mA mA |
| BT138 series F | $\begin{aligned} & \mathrm{I}_{\mathrm{GT}} \\ & \mathrm{I}_{\mathrm{H}} \\ & \mathrm{I}_{\mathrm{L}} \end{aligned}$ | $\begin{aligned} & > \\ & < \\ & < \end{aligned}$ | $\begin{aligned} & 25 \\ & 30 \\ & 40 \end{aligned}$ | $\begin{aligned} & 25 \\ & 30 \\ & 60 \end{aligned}$ | $\begin{aligned} & 25 \\ & 30 \\ & 40 \end{aligned}$ | $\begin{aligned} & 70 \\ & 30 \\ & 60 \end{aligned}$ | mA $m A$ $m A$ |
| BT138 series E | $\begin{aligned} & \mathrm{I}_{\mathrm{GT}} \\ & \mathrm{I}_{\mathrm{H}} \\ & \mathrm{I}_{\mathrm{L}} \end{aligned}$ | $\begin{aligned} & > \\ & < \\ & < \end{aligned}$ | $\begin{aligned} & 10 \\ & 30 \\ & 30 \end{aligned}$ | $\begin{aligned} & 10 \\ & 30 \\ & 40 \end{aligned}$ | $\begin{aligned} & 10 \\ & 30 \\ & 30 \end{aligned}$ | $\begin{aligned} & 25 \\ & 30 \\ & 40 \end{aligned}$ | $m A$ $m A$ $m A$ |

## MOUNTING INSTRUCTIONS

1. The device may be soldered directly into the circuit, but the maximum permissible temperature of the soldering iron or bath is $275^{\circ} \mathrm{C}$; it must not be in contact with the joint for more than 5 seconds. Soldered joints must be at least 4.7 mm from the seal.
2. The leads should not be bent less than 2.4 mm from the seal, and should be supported during bending. The leads can be bent, twisted or straightened by $90^{\circ}$ maximum. The minimum bending radius is 1 mm .
3. It is recommended that the circuit connection be made to $\operatorname{tag} T_{2}$, 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 $R_{\text {th }}$ mb-h values than screw mounting.
b. safe isolation for mains operation.

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

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

## OPERATING NOTES

Dissipation and heatsink considerations:
a. The various components of junction temperature rise above ambient are illustrated in Fig.3.


Fig. 3.
b. The method of using Fig. 4 is as follows:

Starting with the required current on the $I_{T}(R M S)$ axis, trace upwards to meet the appropriate conduction angle curve. Trace right horizontally and upwards from the appropriate value on the $T_{a m b}$ scale. The intersection determines the $R_{t h} \mathrm{mb}-\mathrm{a}$. The heatsink thermal resistance value ( $R_{\text {th }} h-a$ ) can now be calculated from:

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

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

FULL-CYCLE OPERATION


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

$\alpha=\alpha_{1}=\alpha_{2}$ : conduction angle per half cycle


Fig. 5 Maximum permissible duration of steady overload (provided that $T_{m b}$ does exceed $120^{\circ} \mathrm{C}$ during and after overload) expressed as a percentage of the steady state r.m.s. rated current. For high r.m.s. overload currents precautions should be taken so that the temperature of the terminals does not exceed $125^{\circ} \mathrm{C}$. During these overload conditions the triac may lose control. Therefore the overload should be terminated by a separate protection device.


Fig. 6


Fig. 7


Fig. 8


Fig. 9


Fig. 10 Typical commutation $\mathrm{dV} / \mathrm{dt}$ for BT 138 series versus $\mathrm{T}_{\mathrm{j}}$. The triac should commutate when $\mathrm{dV} / \mathrm{dt}$ is below the value on the appropriate curve for pre-commutation $\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}$.


Fig. 11 Limit commutation $\mathrm{dV} / \mathrm{dt}$ for BT 138 G series versus $\mathrm{T}_{\mathrm{j}}$. The triac should commutate when the $\mathrm{dV} / \mathrm{dt}$ is below the value on the appropriate curve for pre-commutation $\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}$.


Fig. 12 Typical commutation $\mathrm{dV} / \mathrm{dt}$ for BT 138 F series versus $\mathrm{T}_{\mathrm{j}}$. The triac should commutate when the $\mathrm{dV} / \mathrm{dt}$ is below the value on the appropriate curve for pre-commutation $\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}$.


Fig. 13 Minimum gate voltage that will trigger all devices; all conditions.


Fig. 14 Normalised gate current that will trigger all devices; all conditions.

## FULL-PACK TRIACS

Glass-passivated 12 ampere triacs in SOT-186 envelopes, which feature an electrically isolated seating plane. They are intended for use in applications requiring high bidirectional transient and blocking voltage capability. Typical applications include a.c. power control circuits such as lighting, industrial and domestic heating, motor control and switching systems.

## OUICK REFERENCE DATA

| Repetitive peak off-state voltage | $V_{\text {DRM }}$ | BT138F-500 |  | 600 | 800 |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | max. | 500 | 600 | 800 | v |
| R.M.S. on-state current | $\mathrm{I}_{\text {( }}$ RMS $)$ | max. |  | 12 |  | A |
| Non-repetitive peak on-state current | ${ }^{\text {ITSM }}$ | max. |  | 90 |  | A |

MECHANICAL DATA
Dimensions in mm
Fig. 1 SOT-186


Net mass: 2 g .


The seating plane is electrically isolated from all terminals.
Accessories supplied on request (see data sheets Mounting instructions for F-pack devices and Accessories for SOT-186 envelopes).

## RATINGS

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

Non-repetitive peak off-state voltage
( $\mathrm{t} \leqslant 10 \mathrm{~ms}$ )
Crest working off-state voltage

## Currents (in either direction)

R.M.S. on-state current (conduction angle $360^{\circ}$ ) up to $T_{h}=52^{\circ} \mathrm{C}$
Repetitive peak on-state current
Non-repetitive peak on-state current;

$$
\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C} \text { prior to surge; }
$$

$\mathrm{t}=20 \mathrm{~ms}$; full sine-wave
$1^{2} t$ for fusing ( $\mathrm{t}=10 \mathrm{~ms}$ )
Rate of rise of on-state current after triggering with

$$
\mathrm{I}_{\mathrm{G}}=200 \mathrm{~mA} \text { to } \mathrm{I}_{\mathrm{T}}=20 \mathrm{~A} \text {; }
$$

$$
\mathrm{dl}_{\mathrm{G}} / \mathrm{dt}=0.2 \mathrm{~A} / \mu \mathrm{s}
$$

Gate to terminal 1

## Power dissipation

Average power dissipation
(averaged over any 20 ms period)
Peak power dissipation
$P_{G}(A V)$
$P_{G M}$
max.
0.5

W
max.
5.0
w

## Temperatures

Storage temperature

| $\mathrm{T}_{\text {stg }}$ |  | -40 to +125 | ${ }^{\circ} \mathrm{C}$ |
| :--- | ---: | ---: | ---: |
|  |  |  |  |
| $\mathrm{T}_{\mathrm{j}}$ | max. | 120 | ${ }^{\circ} \mathrm{C}$ |
| $\mathrm{T}_{\mathrm{j}}$ | max. | 110 | ${ }^{\circ} \mathrm{C}$ |

## ISOLATION

From all three terminals to external heatsink (peak)
Capacitance from $\mathrm{T}_{2}$ to external heatsink
$V_{\text {isol }}$
$\min$.
1000

12
${ }^{\prime}$ T(RMS)

A

| ITSM | max. | 90 | $A$ |
| :--- | :--- | :--- | :--- |
| $I^{2} \mathrm{t}$ | $\max$. | 40 | $\mathrm{~A}^{2} \mathrm{~s}$ |

$$
\mathrm{dl}_{\mathrm{T}} / \mathrm{dt} \quad \max .
$$

$\mathrm{dl}_{\mathrm{T}} / \mathrm{dt} \quad \max$.

$$
30
$$

Operating junction temperature full-cycle operation half-cycle operation
$\max .110$
${ }^{\circ} \mathrm{C}$
*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 $15 \mathrm{~A} / \mu \mathrm{s}$.

## THERMAL RESISTANCE

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from junction to external heatsink With heatsink compound

Without heatsink compound

| $R_{\text {th } j-h}$ | $=$ | 4.0 | $\mathrm{~K} / \mathrm{W}$ |
| :--- | :--- | :--- | :--- |
| $R_{\text {th } \mathrm{j}-\mathrm{h}}$ | $=$ | 5.5 | $\mathrm{~K} / \mathrm{W}$ |

2. Free-air operation

The quoted values of $R_{\text {th } j \text {-a }}$ 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
$R_{\text {th j-a }}=55 \mathrm{~K} / \mathrm{W}$


Fig.2.

CHARACTERISTICS ( $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$ unless otherwise stated)
Polarities, positive or negative, are identified with respect to $\mathrm{T}_{1}$.

## Voltage and currents (in either direction)

On-state voltage (measured under pulse conditions to prevent excessive dissipation)
$\mathrm{I}_{\mathrm{T}}=15 \mathrm{~A} \quad \mathrm{~V}_{\mathrm{T}} \quad<\quad 1.65 \mathrm{~V}$

Rate of rise of off-state voltage that will not trigger
any device; $T_{j}=120^{\circ} \mathrm{C}$; gate open circuit
$\begin{array}{lllrl}\text { BT138F series } & \mathrm{dV} / \mathrm{D} / \mathrm{dt} & < & 100 & \mathrm{~V} / \mu \mathrm{s} \\ \text { BT138F series G } & \mathrm{dV} / \mathrm{dt} & < & 200 & \mathrm{~V} / \mu \mathrm{s} \\ \text { BT138F series F } & \mathrm{dV} / \mathrm{dt} & < & 50 & \mathrm{~V} / \mu \mathrm{s} \\ \text { BT138F series E } & \mathrm{dV} / \mathrm{dt} & \text { typ. } & 50 & \mathrm{~V} / \mu \mathrm{s}\end{array}$
Rate of change of commutating voltage that will not
trigger any device when $-\mathrm{dl}_{\mathrm{com}} / \mathrm{dt}=5.4 \mathrm{~A} / \mathrm{ms}$;
$\mathrm{I}_{\mathrm{T}}(\mathrm{RMS})=12 \mathrm{~A} ; \mathrm{T}_{\mathrm{h}}=40^{\circ} \mathrm{C}$; gate open circuit; $\mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DWM}}$ max
BT138F series

| dV com $/ \mathrm{dt}$ | typ. | 10 | $\mathrm{~V} / \mu \mathrm{s}$ |
| :--- | :--- | :--- | :--- |
| dV com $/ \mathrm{dt}$ | $<$ | 10 | $\mathrm{~V} / \mu \mathrm{s}$ |
| dV com $/ \mathrm{dt}$ | typ. | 10 | $\mathrm{~V} / \mu \mathrm{s}$ |

Off-state current
$\mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DWM} \text { max }} ; \mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$;
Gate voltage that will trigger all devices

| $\mathrm{I}_{\mathrm{D}}$ | $<$ | 0.5 | mA |
| :--- | :--- | :--- | :--- |
| $\mathrm{~V}_{\mathrm{GT}}$ | $>$ | 1.5 | V |

Gate voltage that will not trigger any device
$V_{D}=V_{D W M \text { max }} ; T_{j}=120^{\circ} \mathrm{C}$;
$T_{2}$ and $G$ positive or negative
$\mathrm{V}_{\mathrm{GD}}<250$
mV
Gate current that will trigger all devices ( $I_{G T}$ ); $G$ to $T_{1}$

| Holding current ( ${ }^{( } \mathbf{H}$ ) <br> Latching current ( $I_{L}$ ); $V_{D}=12 \mathrm{~V}$ |  |  | $\begin{aligned} & \mathrm{T}_{2}+ \\ & \mathrm{G}+ \end{aligned}$ | $\begin{aligned} & \mathrm{T}_{2^{+}} \\ & \mathrm{G}- \end{aligned}$ | $\begin{aligned} & \mathrm{T}_{2}- \\ & \mathrm{G}- \end{aligned}$ | $\begin{aligned} & \mathrm{T}_{2}- \\ & \mathrm{G}+ \end{aligned}$ |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| BT138F series | IGT | > | 35 | 35 | 35 | 70 | mA |
|  | ${ }^{\mathrm{I}} \mathrm{H}$ | < | 30 | 30 | 30 | 30 | mA |
|  | ${ }_{L}$ | $<$ | 40 | 60 | 40 | 60 | mA |
| BT138F series G | $I_{\text {GT }}$ | > | 50 | 50 | 50 | 100 | mA |
|  | ${ }^{\text {H }} \mathrm{H}$ | $<$ | 60 | 60 | 60 | 60 | mA |
|  | IL | $<$ | 60 | 90 | 60 | 90 | mA |
| BT138F series F | ${ }^{\prime} \mathrm{GT}$ | > | 25 | 25 | 25 | 70 | mA |
|  | $\mathrm{I}_{\mathrm{H}}$ | < | 30 | 30 | 30 | 30 | mA |
|  | ${ }_{\mathrm{L}}^{\mathrm{L}}$ | $<$ | 40 | 60 | 40 | 60 | mA |
| BT138F series E | IGT | > | 10 | 10 | 10 | 25 | mA |
|  | $\mathrm{I}_{\mathrm{H}}$ | $<$ | 30 | 30 | 30 | 30 | mA |
|  | $\mathrm{I}_{\mathrm{L}}$ | $<$ | 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 $275^{\circ} \mathrm{C}$; it must not be in contact with the joint for more than 5 seconds. Soldered joints must be at least 4.7 mm from the seal.
2. The leads should not be bent less than 2.4 mm from the seal, and should be supported during bending. The leads can be bent, twisted or straightened by $90^{\circ}$ maximum. The minimum bending radius is 1 mm .
3. Mounting by means of a spring clip is the best mounting method because it offers good thermal contact under the crystal area and slightly lower $\mathrm{R}_{\text {th }} \mathrm{j}$-h values than screw mounting.
However, if a screw is used, it should be M3 cross-recess pan-head. Care should be taken to avoid damage to the plastic body.
4. For good thermal contact heatsink compound should be used between seating plane and heatsink. Values of $R_{\text {th }} j-h$ given for mounting with heatsink compound refer to the use of a metallic-oxide loaded compound. Ordinary silicone grease is not recommended.
5. Rivet mounting is not recommended.
6. The heatsink must have a flatness in the mounting area of 0.02 mm maximum per 10 mm . Mounting holes must be deburred.

## OPERATING NOTES

Dissipation and heatsink considerations:
a. The various components of junction temperature rise above ambient are illustrated in Fig. 3 .


Fig.3.
b. The method of using Figs. 4 and 5 is as follows:

Starting with the required current on the $\mathrm{I}_{\mathrm{T}(\mathrm{RMS}) \text { axis (1.h. graph) trace upwards to meet the }}$ appropriate conduction angle curve. Trace left from curve to obtain power $P$. Trace right from curve to obtain $T_{h}$ (r.h. graph). Trace upwards from $T_{a m b}$, intersect with $T_{h}$ determines $R_{\text {th } h-a, ~}^{\text {, }}$ required heatsink thermal resistance.
c. Any measurement of heatsink temperature should be made immediately adjacent to the device.

## BT138F SERIES

FULL-WAVE CONDUCTION (with heatsink compound)


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

FULL-WAVE CONDUCTION (without heatsink compound)


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

$\alpha=\alpha_{1}=\alpha_{2}$ : conduction angle per half cycle

OVERLOAD OPERATION


Fig. 6 Maximum permissible duration of steady overload (provided that $T_{h}$ does not exceed $120^{\circ} \mathrm{C}$ during and after overload) expressed as a percentage of the steady state r.m.s. rated current. For high r.m.s. overload currents precautions should be taken so that the temperature of the terminals does not exceed $125^{\circ} \mathrm{C}$. During these overload conditions the triac may lose control. Therefore the overload should be terminated by a separate protection device.


Fig.7.


Fig.8.


Fig. 9 Transient thermal impedance; ——— with heatsink compound; - without heatsink compound.


Fig. 10 Typical commutation $\mathrm{dV} / \mathrm{dt}$ for BT 138 F series versus $\mathrm{T}_{\mathrm{j}}$. The triac should commutate when $\mathrm{dV} / \mathrm{dt}$ is below the value on the appropriate curve for pre-commutation $\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}$.


Fig. 11 Limit commutation dV/dt for BT138F series $G$ versus $\mathrm{T}_{\mathrm{j}}$. The triac should commutate when the $\mathrm{dV} / \mathrm{dt}$ is below the value on the appropriate curve for pre-commutation $\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}$.


Fig. 12 Typical commutation $\mathrm{dV} / \mathrm{dt}$ for BT 138 F series F versus $\mathrm{T}_{\mathrm{j}}$. The triac should commutate when the $\mathrm{dV} / \mathrm{dt}$ is below the value on the appropriate curve for pre-commutation $\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}$.


Fig. 13 Minimum gate voltage that will trigger all devices; all conditions.


Fig. 14 Normalised gate current that will trigger all devices; all conditions.


Fig. 15

## BT139 SERIES

## 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 | $V_{\text {DRM }}$ | max. | 500 | 600 | 800 | v |
| R.M.S. on-state current | It(RMS) | max. |  | 16 |  | A |
| Non-repetitive peak on-state current | ITSM | max. |  | 140 |  | A |

## MECHANICAL DATA

Dimensions in mm
Fig. 1 TO-220AB


Net mass: 2 g
Note: The exposed metal mounting base is directly connected to terminal $\mathrm{T}_{2}$.
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)
Non-repetitive peak off-state voltage ( $\mathrm{t} \leqslant 10 \mathrm{~ms}$ )
Repetitive peak off-state voltage ( $\delta \leqslant 0.01$ )
Crest working off-state voltage

|  | BT139-500 |  | 600 | 800 |  |
| :--- | :--- | :--- | :--- | :--- | :--- |
|  |  |  |  |  |  |
| $V_{\text {DSM }}$ | max. | $500^{*}$ | $600^{*}$ | 800 | $V$ |
| $V_{\text {DRM }}$ | $\max$. | 500 | 600 | 800 | $V$ |
| $V_{\text {DWM }}$ | $\max$. | 400 | 400 | 400 | $V$ |

Currents (in either direction)
R.M.S. on-state current (conduction angle $360^{\circ}$ ) up to $T_{m b}=93^{\circ} \mathrm{C}$
$\rightarrow$ Repetitive peak on-state current
Non-repetitive peak on-state current; $\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$ prior to surge; $\mathrm{t}=\mathbf{2 0} \mathrm{ms}$; full sine-wave
$1^{2} t$ for fusing ( $\mathrm{t}=10 \mathrm{~ms}$ )

| IT(RMS) | max. | 16 | A |
| :--- | :--- | ---: | :--- |
| ITRM | max. | 140 | A |

Rate of rise of on-state current after triggering with $\mathrm{I}_{\mathrm{G}}=200 \mathrm{~mA}$ to $\mathrm{I}_{\mathrm{T}}=20 \mathrm{~A} ; \mathrm{dI}_{\mathrm{G}} / \mathrm{dt}=0.2 \mathrm{~A} / \mu \mathrm{s}$
$\mathrm{dl}_{\mathrm{T}} / \mathrm{dt} \quad \max \quad 30 \mathrm{~A} / \mu \mathrm{s}$
Gate to terminal 1

## Power dissipation

| Average power dissipation (averaged over any 20 ms period) | $\mathrm{P}_{\mathrm{G}(\mathrm{AV})}$ | max. | 0.5 | W |
| :--- | :--- | :--- | ---: | :--- |
| Peak power dissipation | $\mathrm{P}_{\mathrm{GM}}$ | $\max$. | 5 | W |
| Temperatures |  |  |  |  |
| Storage temperature | $\mathrm{T}_{\mathrm{stg}}$ | -40 to +125 | ${ }^{\circ} \mathrm{C}$ |  |
| Operating junction temperature <br> full-cycle operation <br> half-cycle operation | $\mathrm{T}_{\mathrm{j}}$ | max. | 120 | ${ }^{\circ} \mathrm{C}$ |
|  | $\mathrm{T}_{\mathrm{j}}$ | $\max$. | 110 | ${ }^{\circ} \mathrm{C}$ |

*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 $15 \mathrm{~A} / \mu \mathrm{s}$.

## THERMAL RESISTANCE

From junction to mounting base
full-cycle operation
$R_{\text {th } j-m b}=1.2 \mathrm{~K} / \mathrm{W}$
$R_{\text {th } j-m b}=1.7 \mathrm{~K} / \mathrm{W}$
$Z_{\text {th } j-m b}=0.1 \mathrm{~K} / \mathrm{W}$

Transient thermal impedance; $\mathrm{t}=1 \mathrm{~ms}$
$Z_{\text {th j-mb }}=0.1 \mathrm{~K} / \mathrm{W}$

## Influence of mounting method

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from mounting base to heatsink
a. with heatsink compound
$R_{\text {th mb-h }}=0.3 \mathrm{~K} / \mathrm{W}$
b. with heatsink compound and 0.06 mm maximum mica insulator
$R_{\text {th mb-h }}=1.4 \mathrm{~K} / \mathrm{W}$
c. with heatsink compound and 0.1 mm maximum mica insulator (56369)
$R_{\text {th mb-h }}=2.2 \mathrm{~K} / \mathrm{W}$
d. with heatsink compound and 0.25 mm maximum alumina insulator (56367)
e. without heatsink compound
$R_{\text {th mb-h }}=1.4 \mathrm{~K} / \mathrm{W}$
2. Free-air operation

The quoted values of $R_{\text {th }} \mathrm{j}$-a should be used only when no leads of other dissipating components run to the same tie-point.
Thermal resistance from junction to ambient in free air: mounted on a printed-circuit board at a = any lead length
$R_{\text {th j-a }}=60 \mathrm{~K} / \mathrm{W}$


Fig. 2

## BT139 SERIES

CHARACTERISTICS $\quad\left(T_{j}=25^{\circ} \mathrm{C}\right.$ unless otherwise stated)
Polarities, positive or negative, are identified with respect to $\mathrm{T}_{1}$.
Voltages and currents (in either direction)
On-state voltage (measured under pulse conditions to prevent excessive dissipation)
$I_{T}=20 \mathrm{~A}$
$V_{T}$
1.6 V

Rate of rise of off-state voltage that will not trigger
any device; $T_{j}=120^{\circ} \mathrm{C}$; gate open circuit
$\begin{array}{lllrl}\text { BT139 series } & \mathrm{dV} \mathrm{D}_{\mathrm{D}} / \mathrm{dt} & < & 100 & \mathrm{~V} / \mu \mathrm{s} \\ \text { BT139 series G } & \mathrm{dV} \mathrm{D}_{\mathrm{D}} / \mathrm{dt} & < & 200 & \mathrm{~V} / \mu \mathrm{s} \\ \text { BT139 series F } & \mathrm{dV} \mathrm{D}_{\mathrm{D}} / \mathrm{dt} & < & 50 & \mathrm{~V} / \mu \mathrm{s} \\ \text { BT139 series E } & \mathrm{dV} \mathrm{D}_{\mathrm{D}} / \mathrm{dt} & \text { typ. } & 50 & \mathrm{~V} / \mu \mathrm{s}\end{array}$
Rate of change of commutating voltage that will not
trigger any device when $-\mathrm{dl}_{\text {com }} / \mathrm{dt}=7.2 \mathrm{~A} / \mathrm{ms}$;
$\mathrm{I}_{\mathrm{T}(\mathrm{RMS})}=16 \mathrm{~A} ; \mathrm{T}_{\mathrm{mb}}=70^{\circ} \mathrm{C}$; gate open circuit $; \mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DWM}}$ max
BT139 series
BT139 series G
BT139 series $F$

| $d V_{\text {com }} / \mathrm{dt}$ | typ. | 10 | $\mathrm{~V} / \mu \mathrm{s}$ |
| :--- | :--- | :--- | :--- |
| $d V_{\text {com }} / \mathrm{dt}$ | $<$ | 10 | $\mathrm{~V} / \mu \mathrm{s}$ |
| $d V_{\text {com }} / \mathrm{dt}$ | typ. | 10 | $\mathrm{~V} / \mu \mathrm{s}$ |

Off-state current
$V_{D}=V_{D W M m a x} ; T_{j}=120^{\circ} \mathrm{C} ;$
Gate voltage that will trigger all devices

| $\mathrm{I}_{\mathrm{D}}$ | $<$ | 0.5 | mA |
| :--- | :--- | :--- | :--- |
| $\mathrm{~V}_{\mathrm{GT}}$ | $>$ | 1.5 | V |

Gate voltage that will not trigger any device
$V_{D}=V_{D W M m a x} ; T_{j}=120^{\circ} \mathrm{C}$;
$T_{2}$ and G positive or negative $\quad V_{G D}<250 \mathrm{mV}$
Gate current that will trigger all devices ( $I_{\mathrm{G}}$ ); G to $\mathrm{T}_{1}$
Holding current ( $I_{H}$ )
Latching current ( $I_{\mathrm{L}}$ ); $\mathrm{V}_{\mathrm{D}}=12 \mathrm{~V}$

| BT139 series | $\begin{aligned} & \mathrm{I}_{\mathrm{GT}} \\ & \mathrm{I}_{\mathrm{H}} \\ & \mathrm{I}_{\mathrm{L}} \end{aligned}$ | $>$ $<$ $<$ | $\begin{aligned} & 35 \\ & 30 \\ & 40 \end{aligned}$ | $\begin{aligned} & 35 \\ & 30 \\ & 60 \end{aligned}$ | 35 30 40 | $\begin{aligned} & 70 \\ & 30 \\ & 60 \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| BT139 series G | $\begin{aligned} & \mathrm{I}_{\mathrm{GT}} \\ & \mathrm{I}_{\mathrm{H}} \\ & \mathrm{I}_{\mathrm{L}} \end{aligned}$ | $\begin{aligned} & > \\ & < \\ & < \end{aligned}$ | $\begin{aligned} & 50 \\ & 60 \\ & 60 \end{aligned}$ | $\begin{aligned} & 50 \\ & 60 \\ & 90 \end{aligned}$ | 50 60 60 | $\begin{array}{r} 100 \\ 60 \\ 90 \end{array}$ |
| BT139 series F | $\begin{aligned} & \mathrm{I}_{\mathrm{GT}} \\ & \mathrm{I}_{\mathrm{H}} \\ & \mathrm{I}_{\mathrm{L}} \end{aligned}$ | > | $\begin{aligned} & 25 \\ & 30 \\ & 40 \end{aligned}$ | $\begin{aligned} & 25 \\ & 30 \\ & 60 \end{aligned}$ | 25 30 40 | 70 30 60 |
| BT139 series E | $\begin{aligned} & \mathrm{I}_{\mathrm{GT}} \\ & \mathrm{I}_{\mathrm{H}} \\ & \mathrm{I}_{\mathrm{L}} \end{aligned}$ | $>$ $<$ | 10 30 30 | 10 30 40 | 10 30 30 | 25 30 40 |

## MOUNTING INSTRUCTIONS

1. The device may be soldered directly into the circuit, but the maximum permissible temperature of the soldering iron or bath is $275^{\circ} \mathrm{C}$; it must not be in contact with the joint for more than 5 seconds. Soldered joints must be at least 4.7 mm from the seal.
2. The leads should not be bent less than 2.4 mm from the seal, and should be supported during bending. The leads can be bent, twisted or straightened by $90^{\circ}$ maximum. The minimum bending radius is 1 mm .
3. It is recommended that the circuit connection be made to tag $\mathrm{T}_{2}$, 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 $R_{\text {th }} \mathrm{mb}$-h values than screw mounting.
b. safe isolation for mains operation.

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

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

## OPERATING NOTES

Dissipation and heatsink considerations:
a. The various components of junction temperature rise above ambient are illustrated in Fig. 3.


Fig. 3.
b. The method of using Fig. 4 is as follows:

Starting with the required current on the IT(RMS) axis, trace upwards to meet the appropriate conduction ang!e curve. Trace right horizontally and upwards from the appropriate value on the $T_{a m b}$ scale. The intersection determines the $R_{\text {th mb-a }}$. The heatsink thermal resistance value ( $R_{\text {th }} \mathrm{h}-\mathrm{a}$ ) can now be calculated from:

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

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

## BT139 SERIES

FULL-CYCLE OPERATION


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

$\alpha=\alpha_{1}=\alpha_{2}$ : conduction angle per half cycle


Fig. 6 Maximum permissible duration of steady overload (provided that $\mathrm{T}_{\mathrm{mb}}$ does not exceed $120^{\circ} \mathrm{C}$ during and after overload) expressed as a percentage of the steady state r.m.s. rated current. For high r.m.s. overload currents precautions should be taken so that the temperature of the terminals does not exceed $125^{\circ} \mathrm{C}$. During these overload conditions the triac may lose control. Therefore the overload should be terminated by a separate protection device.


Fig. 7


Fig. 15

Triacs

## BT139 SERIES



Fig. 8


Fig. 9


Fig. 10 Typical commutation $\mathrm{dV} / \mathrm{dt}$ for BT 139 series versus $\mathrm{T}_{\mathrm{j}}$. The triac should commutate when the $\mathrm{dV} / \mathrm{dt}$ is below.the value on the appropriate curve for pre-commutation $\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}$.


Fig. 11 Limit commutation dV/dt for BT139G series versus $\mathrm{T}_{\mathrm{j}}$. The triac should commutate when the $\mathrm{dV} / \mathrm{dt}$ is below the value on the appropriate curve for pre-commutation $\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}$.


Fig. 12 Typical commutation $\mathrm{dV} / \mathrm{dt}$ for BT 139 F series versus $\mathrm{T}_{\mathrm{j}}$. The triac should commutate when the $\mathrm{dV} / \mathrm{dt}$ is below the value on the appropriate curve for pre-commutation $\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}$.


Fig. 13 Minimum gate voltage that will trigger all devices; all conditions.

Fig. 14 Normalised gate current that will trigger all devices; all conditions.

## FULL-PACK TRIACS

Glass-passivated 16 ampere triacs in SOT-186 envelopes, which feature an electrically isolated seating plane. They are intended for use in applications requiring high bidirectional transient and blocking voltage capability. Typical applications include a.c. power control circuits such as lighting, industrial and domestic heating, motor control and switching systems.

## QUICK REFERENCE DATA

|  |  | BT139F-500 | 600 | 800 |
| :--- | :--- | :--- | :--- | :--- |
| Repetitive peak off-state voltage | V $_{\text {DRM }}$ | $\max$. | 500 | 600 |
| R.M.S. on-state current | max. | 800 |  |  |
| Non-repetitive peak on-state current | $I_{T S M}$ | Vax. | 16 |  |

## MECHANICAL DATA

Dimensions in mm
Fig. 1 SOT-186


Net mass: 2 g
The seating plane is electrically isolated from all terminals.
Accessories supplied on request (see data sheets Mounting instructions for F-pack devices and Accessories for SOT-186 envelopes).

## RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134).
Voltages (in either direction)
Non-repetitive peak off-state voltage

$$
(t \leqslant 10 \mathrm{~ms})
$$

Repetitive peak off-state voltage ( $\delta \leqslant 0.01$ )
Crest working off-state voltage

|  | BT 139F-500 |  | 600 | 800 |  |
| :--- | :--- | :--- | :--- | :--- | :--- |
|  |  |  |  |  |  |
| $V_{\text {DSM }}$ | max. | $500^{*}$ | $600^{*}$ | 800 | V |
| $\mathrm{~V}_{\text {DRM }}$ | max. | 500 | 600 | 800 | V |
| $\mathrm{~V}_{\text {DWM }}$ | max. | 400 | 400 | 400 | V |

## Currents (in either direction)

R.M.S. on-state current (conduction angle $360^{\circ}$ ) up to $\mathrm{T}_{\mathrm{h}}=67^{\circ} \mathrm{C}$
Repetitive peak on-state current

| ${ }^{\text {I T(RMS) }}$ | max. | 16 | A |
| :--- | :--- | ---: | :--- |
| ${ }^{\text {ITRM }}$ | max. | 140 | A |

Non-repetitive peak on-state current;
$\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$ prior to surge;
$\mathrm{t}=\mathbf{2 0} \mathrm{ms}$; full sine-wave
$1^{2} t$ for fusing ( $\mathrm{t}=10 \mathrm{~ms}$ )
${ }^{\text {ITSM }}$ max. 140

A
$1^{2} t \quad \max \quad 9$

Rate of rise of on-state current after
triggering with
$\mathrm{I}_{\mathrm{G}}=200 \mathrm{~mA}$ to $\mathrm{I}_{\mathrm{T}}=20 \mathrm{~A}$;
$\mathrm{dl}_{\mathrm{G}} / \mathrm{dt}=0.2 \mathrm{~A} / \mu \mathrm{s}$
$\mathrm{dl}_{\mathrm{T}} / \mathrm{dt} \quad \max$
30
A/ $\mu \mathrm{S}$

## Gate to terminal 1

## Power dissipation

Average power dissipation
(averaged over any 20 ms period)
Peak power dissipation

| $\mathrm{P}_{\mathrm{G}(\mathrm{AV})}$ | max. | 0.5 | W |
| :--- | :--- | :--- | :--- |
| $\mathrm{P}_{\mathrm{GM}}$ | max. | 5.0 | W |

## Temperatures

Storage temperature
Full-cycle operating temperature

| $\mathrm{T}_{\text {stg }}$ |  | -40 to +125 | ${ }^{\circ} \mathrm{C}$ |
| :--- | ---: | ---: | ---: |
| $\mathrm{T}_{\mathrm{j}}$ | max. | 120 | ${ }^{\circ} \mathrm{C}$ |

## ISOLATION

From all three terminals to external heatsink (peak)

| $\mathrm{V}_{\text {isol }}$ | min. | 1000 | V |
| :--- | :---: | :---: | :---: |
| $\mathrm{C}_{\text {isol }}$ | typ. | 12 | pF |

[^45]
## THERMAL RESISTANCE

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

Thermal resistance from junction to external heatsink
With heatsink compound
Without heatsink compound

| $R_{\text {th j-h }}$ | $=$ | 3.5 | $\mathrm{~K} / \mathrm{W}$ |
| :--- | :--- | :--- | :--- |
| $R_{\text {th } j-\mathrm{h}}$ | $=$ | 4.5 | $\mathrm{~K} / \mathrm{W}$ |

2. Free-air operation

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

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


Fig. 2

CHARACTERISTICS ( $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$ unless otherwise stated)
Polarities, positive or negative, are identified with respect to $\mathrm{T}_{1}$.
Voltages and currents (in either direction)
On-state voltage (measured under pulse conditions to prevent excessive dissipation)
$I_{T}=20 \mathrm{~A}$
Rate of rise of off-state voltage that will not trigger
any device; $\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$; gate open circuit
BT139F series
BT 139F series G
BT139F series $F$
BT139F series E

| $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ | $<$ | 100 | $\mathrm{~V} / \mu \mathrm{s}$ |
| :--- | :--- | ---: | :--- |
| $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ | $<$ | 200 | $\mathrm{~V} / \mu \mathrm{s}$ |
| $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ | $<$ | 50 | $\mathrm{~V} / \mu \mathrm{s}$ |
| $\mathrm{dV}_{\mathrm{D}} / \mathrm{dt}$ | typ. | 50 | $\mathrm{~V} / \mu \mathrm{s}$ |

Rate of change of commutating voltage that will not
trigger any device when $-\mathrm{dl}_{\text {com }} / \mathrm{dt}=7.2 \mathrm{~A} / \mathrm{ms}$;
$\mathrm{I}_{\mathrm{T}(\mathrm{RMS})}=16 \mathrm{~A} ; \mathrm{T}_{\mathrm{h}}=70^{\circ} \mathrm{C}$; gate open circuit;
$V_{D}=V_{\text {DWMmax }}$
BT139F series
BT139F series G
BT139F series $F$

| $\mathrm{dV}_{\text {com }} / \mathrm{dt}$ | typ. | 10 | $\mathrm{~V} / \mu \mathrm{s}$ |
| :--- | :---: | :---: | :---: |
| $\mathrm{dV}_{\text {com }} / \mathrm{dt}$ | $<$ | 10 | $\mathrm{~V} / \mu \mathrm{s}$ |
| $\mathrm{dV}_{\text {com }} / \mathrm{dt}$ | typ. | 10 | $\mathrm{~V} / \mu \mathrm{s}$ |
|  |  |  |  |
| $\mathrm{I}_{\mathrm{D}}$ | $<$ | 0.5 | mA |
| $\mathrm{~V}_{\mathrm{GT}}$ | $>$ | 1.5 | V |

Gate voltage that will not trigger any device
$V_{D}=V_{\text {DWMmax }} ; T_{j}=120^{\circ} \mathrm{C}$
$T_{2}$ and $G$ positive or negative
$\mathrm{V}_{\mathrm{GD}}<250 \mathrm{mV}$
Gate current that will trigger all devices ( $\mathrm{I}_{\mathrm{GT}}$ ); G to $\mathrm{T}_{1}$
Holding current ( $\mathrm{I}_{\mathrm{H}}$ )
Latching current ( $I_{L}$ ); $\mathrm{V}_{\mathrm{D}}=12 \mathrm{~V}$

## MOUNTING INSTRUCTIONS

1. The triac may be soldered directly into the circuit, but the maximum permissible temperature of the soldering iron or bath is $275^{\circ} \mathrm{C}$; it must not be in contact with the joint for more than 5 seconds. Soldered joints must be at least 4.7 mm from the seal.
2. The leads should not be bent less than 2.4 mm from the seal, and should be supported during bending. The leads can be bent, twisted or straightened by $90^{\circ}$ maximum. The minimum bending radius is 1 mm .
3. Mounting by means of a spring clip is the best mounting method because it offers good thermal contact under the crystal area and slightly lower $R_{\text {th }} j$-h values than screw mounting.
However, if a screw is used, it should be M3 cross-recess pan-head. Care should be taken to avoid damage to the plastic body.
4. For good thermal contact heatsink compound should be used between seating plane and heatsink. Values of $R_{\text {th }} j$-h given for mounting with heatsink compound refer to the use of a metallic-oxide loaded compound. Ordinary silicone grease is not recommended.
5. Rivet mounting is not recommended.
6. The heatsink must have a flatness in the mounting area of 0.02 mm maximum per 10 mm . Mounting holes must be deburred.

## OPERATING NOTES

Dissipation and heatsink considerations:
a. The various components of junction temperature rise above ambient are illustrated in Fig. 3.


Fig.3.
b. The method of using Figs. 4 and 5 is as follows:

Starting with the required current on the IT(RMS) axis (I.h. graph) trace upwards to meet the appropriate conduction angle curve. Trace left from curve to obtain power $P$. Trace right from curve to obtain $T_{h}$ (r.h. graph). Trace upwards from $T_{a m b}$, intersect with $T_{h}$ determines $R_{t h} h-a$, required heatsink thermal resistance.
c. Any measurement of heatsink temperature should be made immediately adjacent to the device.

FULL-CYCLE OPERATION (with heatsink compound)


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

A분
$\alpha=\alpha_{1}=\alpha_{2}$ : conduction angle per half cycle

FULL-WAVE CONDUCTION (without heatsink compound)


Fig. 5 The right-hand part shows the interrelationship between the power (derived from the left-hand part) and the maximum permissible temperatures.
$\xrightarrow[\alpha_{1}]{\substack{\alpha_{2}}}$
$\alpha=\alpha_{1}=\alpha_{2}$ : conduction angle per half cycle


Fig. 6 Maximum permissible duration of steady overload (provided that $\mathrm{T}_{\mathrm{mb}}$ does not exceed $120^{\circ} \mathrm{C}$ during and after overload) expressed as a percentage of the steady state r.m.s. rated current. For high r.m.s. overload currents precautions should be taken so that the temperature of the terminals does not exceed $125^{\circ} \mathrm{C}$. During these overload conditions the triac may lose control. Therefore the overload should be terminated by a separate protection device.


Fig. 7


Fig. 8


Fig. 9 Transient thermal impedance; - with heatsink compound; - - without heatsink compound.


Fig. 10 Typical commutation $\mathrm{dV} / \mathrm{dt}$ for BT 139 F series versus $\mathrm{T}_{\mathrm{j}}$. The triac should commutate when the $\mathrm{dV} / \mathrm{dt}$ is below the value on the appropriate curve for pre-commutation $\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}$.


Fig. 11 Limit commutation $d V / d t$ for $B T 139 F$ series $G$ versus $T_{j}$. The triac should commutate when the $\mathrm{dV} / \mathrm{dt}$ is below the value on the appropriate curve for pre-commutation $\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}$.


Fig. 12 Typical commutation $\mathrm{dV} / \mathrm{dt}$ for BT 139 F series F versus $\mathrm{T}_{\mathrm{j}}$. The triac should commutate when the $\mathrm{dV} / \mathrm{dt}$ is below the value on the appropriate curve for pre-commutation $\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}$.


Fig. 13 Minimum gate voltage that will trigger all devices; all conditions.

Fig. 14 Normalised gate current that will trigger all devices; all conditions.

LIMITS FOR STARTING OR INRUSH CURRENTS - FULL-CYCLE OPERATION


Fig. 15.

## TRIACS

Glass-passivated 25 ampere triacs intended for use in applications requiring high bidirectional transient and blocking voltage capability and high thermal cycling performance with very low thermal resistances. These triacs feature a high surge current capability. Typical applications include a.c. power control applications such as motor, industrial lighting, industrial and domestic heating control and static switching systems.

## QUICK REFERENCE DATA

|  |  | BTA140-500 | 600 | 800 |
| :--- | :--- | :--- | :--- | :--- |
| Repetitive peak off-state voltage | VDRM | max. | 500 | 600 |
| R.M.S. on-state current | IT(RMS) | max. | 800 | V |
| Non-repetitive peak on-state current $(50 \mathrm{~Hz})$ | ITSM | max. | 25 | A |
| Non-repetitive peak on-state current $(60 \mathrm{~Hz})$ | ITSM | max. | 180 | A |
| MECHANICAL DATA |  | 200 | A |  |

Fig. 1 TO-220AB


Net mass- 2 g
Note: The exposed metal mounting base is directly connected to terminal $\mathrm{T}_{2}$.

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)
Non-repetitive peak off-state voltage ( $\mathrm{t} \leqslant 10 \mathrm{~ms}$ )
Repetitive peak off-state voltage ( $\delta \leqslant 0.01$ )
Crest working off-state voltage
Currents (in either direction)
R.M.S. on-state current (conduction angle $360^{\circ}$ ) up to $T_{m b}=89^{\circ} \mathrm{C}$
Average on-state current for half-cycle operation
(averaged over any 20 ms period) up to $\mathrm{T}_{\mathrm{mb}}=85^{\circ} \mathrm{C}$
Repetitive peak on-state current
Non-repetitive peak on-state current; $\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$ prior to surge; full sine-wave

$$
t=20 \mathrm{~ms}
$$

$$
\mathrm{t}=16.7 \mathrm{~ms}
$$

$I^{2} t$ for fusing ( $t=10 \mathrm{~ms}$ )
Rate of rise of on-state current after triggering with

$$
\mathrm{I}_{\mathrm{G}}=200 \mathrm{~mA} \text { to } \mathrm{I}_{\mathrm{T}}=30 \mathrm{~A} ; \mathrm{dI}_{\mathrm{G}} / \mathrm{dt}=0.2 \mathrm{~A} / \mu \mathrm{s}
$$

Gate to terminal 1

## Power dissipation

Average power dissipation (averaged over any 20 ms period)
Peak power dissipation

## Temperatures

Storage temperature
Operating junction temperature
full-cycle operation
half-cycle operation

| IT(RMS) | max. | 25 A |
| :--- | :--- | ---: |
|  |  |  |
| IT(AV) | max. | 18 A |
| ITRM | max. | 180 A |


| ITSM | max. | 180 A |
| :--- | :--- | :--- |
| ITSM | max. | 200 A |
| $\mathrm{I}^{2} \mathrm{t}$ | $\max$. | $160 \mathrm{~A}^{2} \mathrm{~s}$ |
|  |  |  |
| $\mathrm{dI}_{\mathrm{T}} / \mathrm{dt}$ | $\max$. | $30 \mathrm{~A} / \mu \mathrm{s}$ |


| $P_{G}(A V)$ | max. | 0.5 W |
| :--- | ---: | ---: |
| $P_{G M}$ | $\max$. | 5 W |

* 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 $15 \mathrm{~A} / \mu \mathrm{s}$.


## THERMAL RESISTANCE

From junction to mounting base
full-cycle operation

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

half-cycle operation
Transient thermal impedance; $t=1 \mathrm{~ms}$

$$
R_{\text {th } j-\mathrm{mb}}=1.4 \mathrm{~K} / \mathrm{W}
$$

$$
\mathrm{Z}_{\mathrm{th} \mathrm{j}-\mathrm{mb}}=0.1 \mathrm{~K} / \mathrm{W}
$$

## Influence of mounting method

1. Heatsink mounted with clip (see mounting instructions)

Thermal resistance from mounting base to heatsink
a. with heatsink compound
b. with heatsink compound and 0.06 mm maximum mica insulator
c. with heatsink compound and 0.1 mm maximum mica insulator (56369)

$$
\begin{aligned}
& R_{\text {th mb-h }}=0.3 \mathrm{~K} / \mathrm{W} \\
& R_{\text {th mb-h }}=1.4 \mathrm{~K} / \mathrm{W} \\
& R_{\text {th mb-h }}=2.2 \mathrm{~K} / \mathrm{W} \\
& R_{\text {th mb-h }}=0.8 \mathrm{~K} / \mathrm{W} \\
& R_{\text {th mb-h }}=1.4 \mathrm{~K} / \mathrm{W}
\end{aligned}
$$

d. with heatsink compound and 0.25 mm maximum alumina insulator (56367)
e. without heatsink compound
2. Free-air operation

The quoted values of $R_{\text {th }} \mathrm{j}$-a should be used only when no leads of other dissipating components run to the same tie-point.
Thermal resistance from junction to ambient in free air:
mounted on a printed-circuit board at $a=$ any lead length

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



Fig. 2

## BTA140 SERIES

## CHARACTERISTICS ( $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$ unless otherwise stated)

Polarities, positive or negative, are identified with respect to $\mathrm{T}_{1}$.
Voltages and currents (in either direction)
On-state voltage (measured under pulse conditions to prevent excessive dissipation)
$I_{T}=30 \mathrm{~A}$
Rate of rise of off-state voltage that will not trigger any device; $T_{j}=120^{\circ} \mathrm{C}$; gate open circuit
$V_{T}$
$d V_{D} / \mathrm{dt} \quad<\quad 100$
$d V_{\text {com }} / \mathrm{dt} \quad$ typ. $10 \quad \mathrm{~V} / \mu \mathrm{s}$
$V_{D}=V_{D W M m a x}$
Off-state current
$V_{D}=V_{D W M m a x} ; T_{j}=120^{\circ} \mathrm{C}$
Gate voltage that will trigger all devices
Gate voltage that will not trigger any device
$V_{D}=V_{D W M m a x} ; T_{j}=120^{\circ} \mathrm{C} ;$
$T_{2}$ and $G$ positive or negative

Gate current that will trigger all devices;

| G to $T_{1}$ | $\mathrm{I}_{\mathrm{G} T}$ | $>$ | 35 | 35 | 35 | 70 | mA |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Holding Current | $\mathrm{I}_{\mathrm{H}}$ | $<$ | 30 | 30 | 30 | 30 | mA |
| Latching current; $\mathrm{V}_{\mathrm{D}}=12 \mathrm{~V} ; \mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$ | $\mathrm{I}_{\mathrm{L}}$ | $<$ | 40 | 60 | 40 | 60 | mA |

## MOUNTING INSTRUCTIONS

1. The device may be soldered directly into the circuit, but the maximum permissible temperature of the soldering iron or bath is $275^{\circ} \mathrm{C}$; it must not be in contact with the joint for more than 5 seconds. Soldered joints must be at least 4.7 mm from the seal.
2. The leads should not be bent less than 2.4 mm from the seal, and should be supported during bending. The leads can be bent, twisted or straightened by $90^{\circ}$ maximum. The minimum bending radius is 1 mm .
3. It is recommended that the circuit connection be made to tag $\mathrm{T}_{2}$, 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 $R_{\text {th }} m b-h$ 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 $R_{\text {th }} \mathrm{mb}$-h given for mounting with heatsink compound refer to the use of a metallic oxide-loaded compound. Ordinary silicone grease is not recommended.
6. Rivet mounting (only possible for non-insulated mounting)

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

## OPERATING NOTES

Dissipation and heatsink considerations:
a. The various components of junction temperature rise above ambient are illustrated in Fig. 3.


Fig. 3.
b. The method of using Fig. 4 is as follows:

Starting with the required current on the $I_{T}(R M S)$ axis, trace upwards to meet the appropriate conduction angle curve. Trace right horizontally and upwards from the appropriate value on the $T_{a m b}$ scale. The intersection determines the $R_{t h} \mathrm{mb}-\mathrm{a}$. The heatsink thermal resistance value ( $R_{\text {th }} h-a$ ) can now be calculated from:

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

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

FULL-CYCLE OPERATION


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


Fig. 5 Maximum permissible duration of steady overload (provided that $\mathrm{T}_{\mathrm{mb}}$ does not exceed $120^{\circ} \mathrm{C}$ during and after overload) expressed as a percentage of the steady state r.m.s. rated current. For high r.m.s. overload currents precautions should be taken so that the temperature of the terminals does not exceed $125^{\circ} \mathrm{C}$. During these overload conditions the triac may lose control. Therefore the overload should be terminated by a separate protection device.


Fig. 6 Minimum gate voltage that will trigger all devices; all conditions.


Fig. 7 Normalised gate current that will trigger all devices; all conditions.

## BTA140 SERIES



Fig. 8 Maximum permissible non-repetitive r.m.s. on-state current based on sinusoidal currents $\left(f=50 \mathrm{~Hz}\right.$ ) ; $\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$ prior to surge. The triac may temporarily lose control following the surge.


ITS

Fig. $9 — T_{j}=25^{\circ} \mathrm{C} ;--\mathrm{T}_{\mathrm{j}}=120^{\circ} \mathrm{C}$.


Fig. 10 Transient thermal impedance.


Fig. 11 Limits for starting or inrush currents - full-cycle operation

## TRIACS

Glass-passivated silicon triacs in metal envelopes, intended for industrial a.c. power control and particularly suitable for static switching of 3-phase induction motors. They may also be used for furnace control, lighting control and other static switching applications up to an r.m.s. on-state current of 15 A .

Two grades of commutation performance are available, $10 \mathrm{~V} / \mu \mathrm{s}$ at $5 \mathrm{~A} / \mathrm{ms}$ (suffix G ) and $10 \mathrm{~V} / \mu \mathrm{s}$ at $12 \mathrm{~A} / \mathrm{ms}$ (suffix H ).

QUICK REFERENCE DATA

|  | BTW43-600 |  | 800 | 1000 | 1200 |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Repetitive peak off-state voltage $\quad V_{\text {DRM }}$ | max. | 600 | 800 | 1000 | 1200 | V |
| R.M.S. on-state current |  | ${ }^{\prime}$ ( |  | max. | 15 | A |
| Non-repetitive peak on-state current |  | ${ }^{\text {ITSM }}$ |  | max. | 120 | A |
| Rate of rise of commutating voltage that will not trigger any device (see Characteristics) |  | $\mathrm{dV}_{\text {co }}$ |  | < | 10 | $\mathrm{V} / \mu \mathrm{s}$ |

## MECHANICAL DATA

Dimensions in mm
Fig. 1 TO-64: with metric M5 stud ( $\phi 5 \mathrm{~mm}$ ).



Torque on nut: min. 0,9 Nm
( 9 kg cm ) max. $1,7 \mathrm{Nm}$ ( 17 kg cm )

Net mass: 7 g
Diameter of clearance hole: max. $5,2 \mathrm{~mm}$
Accessories supplied on request: 56295a (mica washer); 56295b (PTFE ring); 56295c (insulating bush).

Supplied with the device: 1 nut, 1 lock washer
Nut dimensions across the flats: $8,0 \mathrm{~mm}$

## RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134)
Voltages (in either direction)*
Non-repetitive peak off-state voltage ( $\mathrm{t} \leqslant 10 \mathrm{~ms}$ )
Repetitive peak off-state voltage
Crest working off-state voltage

|  | BTW43-600 | 800 | 1000 | 1200 |  |
| :--- | ---: | ---: | ---: | ---: | ---: |
|  | max. | 600 | 800 | 1000 | 1200 V |
| $V_{\text {DSM }}$ | max. | 600 | 800 | 1000 | 1200 V |
| $\mathrm{~V}_{\text {DRM }}$ |  |  |  |  |  |
| $\mathrm{V}_{\text {DWM }}$ | max. | 400 | 600 | 700 | 800 V |

## Currents (in either direction)

R.M.S. on-state current (conduction angle $360^{\circ}$ )

$$
\text { up to } \mathrm{T}_{\mathrm{mb}}=75^{\circ} \mathrm{C}
$$

$$
\text { at } T_{\mathrm{mb}}=85^{\circ} \mathrm{C}
$$

## Repetitive peak on-state current

Non-repetitive peak on-state current
$\mathrm{T}_{\mathrm{j}}=125^{\circ} \mathrm{C}$ prior to surge; $\mathrm{t}=20 \mathrm{~ms}$; full sine-wave
$I^{2} t$ for fusing ( $\mathrm{t}=10 \mathrm{~ms}$ )
Rate of rise of on-state current after triggering with

$$
\mathrm{I}_{\mathrm{G}}=0,5 \mathrm{~A} \text { to } \mathrm{I}_{\mathrm{T}}=25 \mathrm{~A} ; \mathrm{dl}_{\mathrm{G}} / \mathrm{dt}=0,5 \mathrm{~A} / \mu \mathrm{s}
$$

| $\mathrm{I}_{\mathrm{T}(\mathrm{RMS})}$ | max. | 15 A |
| :--- | :--- | :--- |
| $\mathrm{I}_{\mathrm{T}(\mathrm{RMS})}$ | $\max$. | 12 A |
| $\mathrm{I}_{\mathrm{TRM}}$ | $\max$. | 50 A |
|  |  |  |
| $\mathrm{I}^{2} \mathrm{TSM}$ | $\max$. | 120 A |
| $\mathrm{I}^{2} \mathrm{t}$ | $\max$. | $72 \mathrm{~A}^{2} \mathrm{~s}$ |
|  |  |  |
| $\mathrm{dl}_{\mathrm{T}} / \mathrm{dt}$ | $\max$. | $50 \mathrm{~A} / \mu \mathrm{s}$ |

## Gate to terminal 1

## Power dissipation

Average power dissipation (averaged over any 20 ms period)
Peak power dissipation

| $\mathrm{P}_{\mathrm{G}(\mathrm{AV})}$ | $\max$. | 1 W |
| :--- | ---: | ---: |
| $\mathrm{P}_{\mathrm{GM}}$ | $\max$. | 10 W |

## Temperatures

Storage temperature
Junction temperature

| $\mathrm{T}_{\text {stg }}$ | -55 to $+125{ }^{\circ} \mathrm{C}$ |
| :--- | ---: |
| $\mathrm{T}_{\mathrm{j}}$ | $\max$. |
|  | $125{ }^{\circ} \mathrm{C}$ |

## THERMAL RESISTANCE

From junction to mounting base
full-cycle operation
half-cycle operation
From mounting base to heatsink with heatsink compound
Transient thermal impedance; $\mathrm{t}=1 \mathrm{~ms}$

| $R_{\text {th } j-m b}$ | $=2,0 \mathrm{~K} / \mathrm{W}$ |
| :--- | :--- |
| $R_{\text {th } j-m b}$ | $=$ |
| $R_{\text {th mb-h }}$ | $=0 \mathrm{~K} / \mathrm{W}$ |
| $Z_{\text {th j-mb }}$ | $=0,5 \mathrm{~K} / \mathrm{W}$ |
|  | $0,2 \mathrm{~K} / \mathrm{W}$ |

[^46]CHARACTERISTICS ( $\mathrm{T}_{\mathrm{j}}=25^{\circ} \mathrm{C}$ unless otherwise stated)
Polarities positive or negative, are identified with respect to $\mathrm{T}_{1}$.
Voltages (in either direction)
On-state voltage
$I_{T}=20 \mathrm{~A} \quad \mathrm{~V}_{\mathrm{T}}<2,2 \mathrm{~V}^{*}$

Rate of rise of off-state voltage that will not trigger any device; exponential method; $V_{D}=2 / 3 V_{D R M m a x} ; T_{j}=125{ }^{\circ} \mathrm{C}$
$\mathrm{dV}_{\mathrm{D}} / \mathrm{dt} \quad<\quad 200 \mathrm{~V} / \mu \mathrm{s}$
Rate of rise of commutating voltage that will not trigger any device;

| $\mathrm{I}_{\mathrm{T}(\mathrm{RMS})}=12 \mathrm{~A} ; \mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DWMmax}} ; \mathrm{T}_{\mathrm{mb}}=85{ }^{\circ} \mathrm{C}$ | $\mathrm{d} \mathrm{V}_{\mathrm{com}} / \mathrm{dt}(\mathrm{V} / \mu \mathrm{s})$ | $-\mathrm{d} \mathrm{I}_{\mathrm{T}} / \mathrm{dt}(\mathrm{A} / \mathrm{ms})$ |
| :--- | :---: | :---: |
| BTW43-600G to 1200 G | $<10$ | 5 |
| BTW43-600H to 1200 H | $<10$ | 12 |

Currents (in either direction)
Off-state current


[^47]FULL CYCLE OPERATION

| (W) |
| :---: |
| (WULL CYCLE OPERATION |

Fig.2 * $\mathrm{T}_{\mathrm{mb}}$-scale is for comparison purposes only and is correct only for $\mathrm{R}_{\text {th } \mathrm{mb}-\mathrm{a}} \leqslant 4 \mathrm{~K} / \mathrm{W}$.


Fig. 3

Triacs


Fig. 4.


Fig. 5.


Fig. 6 Minimum gate voltage that will trigger all devices as a function of $T_{j}$.


Fig. 7 Minimum gate current that will trigger all devices as a function of $T_{j}$.

Conditions for Figs 6 and 7:
_- $T_{2}$ negative, gate positive with respect to $T_{1}$
---- all other conditions


Fig. 8 Maximum rate of rise of commutating voltage that will not trigger any device as a function of rate of fall of on-state current; $\mathrm{I}_{\mathrm{T}}(\mathrm{RMS})=12 \mathrm{~A} ; \mathrm{V}_{\mathrm{D}}=\mathrm{V}_{\mathrm{DWMmax}}$.


Fig. 9.

## ACCESSORIES

## TYPE NUMBER SUMMARY

| type number | description | envelope |
| :--- | :--- | :--- |
| 56264 a | mica washer (up to 2000 V ) | DO-5, TO-48 |
| 56264 b | insulating bush | DO-5, TO-48 |
| 56295 a | mica washer (up to 2000 V ) | DO-4, TO-64 |
| $56295 b$ | PTFE ring | DO-4, TO-64 |
| 56295 c | mica washer (up to 1000 V ) | DO-4, TO-64 |
| 56359 b | insulating bush (up to 800 V ) | TO-220 |
| 56359 c | rectangular insulating bush (up to 1000 V ) | TO-220 |
| 56359 d | spring clip (direct mounting) | TO-220 |
| 56360 a | spring clip (insulated mounting) | TO-220, SOT-186 |
| 56363 | alumina insulator (up to 2000 V ) | TO-220 |
| 56364 | insulating bush (up to 800 V ) | TO-220 |
| 56367 | mica insulator (up to 800 V ) | SOT-93 |
| 56368 b | mica insulator (up to 2000 V ) | TO-220 |
| 56368 c | mica insulator (up to 1500 V ) | SOT-93, SOT-112 |
| 56369 | spring clip |  |

## 56264a

## MICA WASHER

Insulator up to 2000 V
MECHANICAL DATA


56264b
INSULATING BUSH

## MECHANICAL DATA



Dimensions in mm


## THERMAL RESISTANCE

From mounting base to heatsink
with mica washer, without heatsink compound with mica washer, with heatsink compound

| $R_{\text {th mb-h }}$ | $=$ | 5 | $\mathrm{~K} / \mathrm{W}$ |
| :--- | :--- | ---: | :--- |
| $R_{\text {th mb-h }}$ | $=$ | 2.5 | $\mathrm{~K} / \mathrm{W}$ |

## TEMPERATURE

Maximum allowable temperature
$T_{\text {max }}$

## 56295a

## MICA WASHER.

Insulator up to 2 kV .

## MECHANICAL DATA



## 56295b PTFE RING

## MECHANICAL DATA

Dimensions in mm


## 56295c INSULATING BUSH

## MECHANICAL DATA

Dimensions in mm


## THERMAL RESISTANCE

From mounting base to heatsink without heatsink compound with heatsink compound

## TEMPERATURE

Maximum allowable temperature

| $R_{\text {th mb-h }}$ | $=$ | 5 |
| :--- | ---: | ---: |
| $R_{\text {th mb-h }}$ | $=$ | $\mathrm{K} / \mathrm{W}$ |
|  |  |  |

$\mathrm{T}_{\text {max }}=175 \quad{ }^{\circ} \mathrm{C}$

## 56359b

Insulator up to 1000 V .
MECHANICAL DATA

## MICA WASHER



## 56359c

Insulator up to 800 V .
MECHANICAL DATA
Material: polyester

## TEMPERATURE



Maximum pemissible temperature

## INSULATING BUSH



$$
7273143.1
$$

## 56359d RECTANGULAR INSULATING BUSH

Insulator up to 1000 V.

$$
T_{\max }=150^{\circ} \mathrm{C}
$$

MECHANICAL DATA

TEMPERATURE
Maximum permissible temperature


## 56360a

For direct and insulated mounting.
MECHANICAL DATA
Material: brass; nickel plated.


Dimensions in mm

56363
SPRING CLIP (For TO-220 and SOT-186)
For direct mounting.

## MECHANICAL DATA

Dimensions in mm
Material: stainless steel; for mounting on heatsink of 1.0 to 2.0 mm .
Recommended force of clip on device is 20 N ( 2 kgf ).


## 56364

SPRING CLIP (For To-220)
For insulated mounting.

## MECHANICAL DATA

Dimensions in mm
Material: stainless steel; for mounting on heatsink of 1.0 to 1.5 mm .
Recommended force of clip on device is $20 \mathrm{~N}(2 \mathrm{kgf})$.


To be used in conjunction with insulators 56367 or 56369

## 56367 <br> ALUMINA INSULATOR

For insulated clip mounting up to 2 kV .

## MECHANICAL DATA

Dimensions in mm
Material: 96-alurnina.

*Because alumina is brittle, extreme care must be taken when mounting devices not to crack the alumina, particularly when used without heatsink compound.

56369
MICA INSULATOR

For insulated clip mounting up to 2 kV .

MECHANICAL DATA
Dimensions in mm


## 56368b

## INSULATING BUSH

For insulated screw mounting up to 800 V .

## MECHANICAL DATA

Dimensions in mm
Material: polyester


## TEMPERATURE

Maximum permissible temperature
56368C
MICA INSULATOR
For insulated screw mounting up to 800 V .

## MECHANICAL DATA

56369: see preceding page.


For clip mounting up to 1500 V .

MECHANICAL DATA

Dimensions in mm


For direct and insulated mounting of SOT-93 and SOT-112 envelopes.

MECHANICAL DATA
Dimensions in mm

Material:
CrNi steel NLN-939;
thickness $0.4 \pm 0.04$.


## MOUNTING INSTRUCTIONS

## MOUNTING INSTRUCTIONS FOR TO-220 ENVELOPES

## GENERAL DATA AND INSTRUCTIONS

## General rules

1. First fasten the device to the heatsink before soldering the leads.
2. Avoid axial stress to the leads.
3. Keep mounting tool (e.g. screwdriver) clear of the plastic body.
4. The rectangular washer may only touch the plastic part of the body; it should not exert any force on that part (screw mounting).

## Heatsink requirements

Flatness in the mounting area: $0,02 \mathrm{~mm}$ 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 ( $R_{\text {th }} \mathrm{mb}$-h) given for mounting with heatsink compound refer to the use of a metallic oxide-loaded compound. Ordinary silicone grease is not recommended.

For insulated mounting, the compound should be applied to the bottom of both device and insulator.

## Mounting methods for power devices

1. Clip mounting

Mounting with a spring clip gives:
a. A good thermal contact under the crystal area, and slightly lower $R_{t h}$ mb-h values than screw mounting.
b. Safe insulation for mains operation.
2. M3 screw mounting

It is recommended that the rectangular spacing washer is inserted between screw head and mounting tab.
Mounting torque for screw mounting:
(For thread-forming screws these are final values. Do not use self-tapping screws.)

| Minimum torque (for good heat transfer) | $0,55 \mathrm{Nm}(5,5 \mathrm{kgcm})$ |
| :--- | :--- |
| Maximum torque (to avoid damaging the device) | $0,80 \mathrm{Nm}(8,0 \mathrm{kgcm})$ |

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:
$\begin{array}{ll}\text { Minimum torque (for good heat transfer) } & 0,4 \mathrm{Nm}(4 \mathrm{kgcm}) \\ \text { Maximum torque (to avoid damaging the device) } & 0,6 \mathrm{Nm}(6 \mathrm{kgcm})\end{array}$
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

$\rightarrow$ (Typical figures, for exact figures see data for each device type).
From mounting base to heatsink with heatsink compound, direct mounting without heatsink compound, direct mounting with heatsink compound and $0,1 \mathrm{~mm}$ maximum mica washer
with heatsink compound and $0,25 \mathrm{~mm}$ maximum alumina insulator with heatsink compound and $0,05 \mathrm{~mm}$ mica washer insulated up to 500 V insulated up to $800 \mathrm{~V} / 1000 \mathrm{~V}$
without heatsink compound and $0,05 \mathrm{~mm}$ mica washer insulated up to 500 V insulated up to $800 \mathrm{~V} / 1000 \mathrm{~V}$

| type). | clip mounting |  | screw mounting |  |
| :---: | :---: | :---: | :---: | :---: |
| $\mathrm{R}_{\text {th mb-h }}$ | = | 0,3 | 0,5 | K/W |
| $\mathrm{R}_{\text {th mb-h }}$ | $=$ | 1,4 | 1,4 | K/W |
| $\mathrm{R}_{\text {th mb-h }}$ | = | 2,2 | - | K/W |
| $\mathrm{R}_{\text {th mb-h }}$ | = | 0,8 | - | K/W |
| $\mathrm{R}_{\text {th mb-h }}$ | $=$ | - | 1,4 | K/W |
| $\mathrm{R}_{\text {th mb-h }}$ | $=$ | - | 1,6 | K/W |
| $\mathrm{R}_{\text {th mb-h }}$ | = | - | 3,0 | K/W |
| $\mathrm{R}_{\text {th }} \mathrm{mb}$-h | = | - | 4,5 | K/W |

## Lead bending

Maximum permissible tensile force on the body, for 5 seconds is 20 N ( 2 kgf ).
The leads can be bent through $90^{\circ}$ maximum, twisted or straightened. To keep forces within the abovementioned limits, the leads are generally clamped near the body, using pliers. The leads should neither be bent nor twisted less than $2,4 \mathrm{~mm}$ from the body.

## Soldering

Lead soldering temperature at $>3 \mathrm{~mm}$ from the body; $\mathrm{t}_{\text {sld }}<5 \mathrm{~s}$ :
Devices with $\mathrm{T}_{\mathrm{j} \text { max }} \leqslant 175^{\circ} \mathrm{C}$, soldering temperature $\mathrm{T}_{\text {sld } \max }=275^{\circ} \mathrm{C}$.
Devices with $\mathrm{T}_{\mathrm{j} \text { max }} \leqslant 110^{\circ} \mathrm{C}$, soldering temperature $\mathrm{T}_{\text {sld }}$ max $=240^{\circ} \mathrm{C}$.
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)
$62 \mathrm{Sm} / 36 \mathrm{~Pb} / 2 \mathrm{Ag}$ or $60 \mathrm{Sn} / 40 \mathrm{~Pb}$.
Maximum soldering temperature $\leqslant 200^{\circ} \mathrm{C}$ (tab-temperature).
Soldering cycle duration including pre-heating $\leqslant 30 \mathrm{sec}$.
For good soldering and avoiding damage to the encapsulation pre-heating is recommended to a temperature $\leqslant 165^{\circ} \mathrm{C}$ at a duration $\leqslant 10 \mathrm{~s}$.

## INSTRUCTIONS FOR CLIP MOUNTING

## Direct mounting with clip 56363

1. Apply heatsink compound to the mounting base, then place the device on the heatsink.
2. Push the short end of the clip into the narrow slot in the heatsink with clip at an angle of $10^{\circ}$ to $30^{\circ}$ to the vertical (see Figs 1 and 2).
3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body, not on the tab (see Fig.2a).
Do not insert more than 1 mm beyond final position.


Fig. 1 Heatsink requirements.


7275438


Fig. 2 Mounting.
(1) spring clip 56363.

Fig. 2a Position of device (top view).

## Insulated mounting with clip 56364

With the insulators 56367 or 56369 insulation up to 2 kV is obtained.

1. Apply heatsink compound to the bottom of both device and insulator, then place the device with the insulator on the heatsink.
2. Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of $10^{0}$ to $30^{\circ}$ to the vertical (see Figs 3 and 4).
3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body, not on the tab. Ensure that the device is centred on the mica insulator to prevent creepage.
Do not insert more than 1 mm beyond final position.


Fig. 3 Heatsink requirements.


7275437

Fig. 4 Mounting.
(1) spring clip 56364.
(2) insulator 56369 or 56367.

Fig.4a Position of device (top view).

## INSTRUCTIONS FOR SCREW MOUNTING

## Direct mounting with screw and spacing washer

- through heatsink with nut


Fig. 5 Assembly.
(1) M3 screw.
(2) rectangular washer (56360a).
(3) lock washer.
(4) M3 nut.
(5) heatsink.
(8) plain washer.

- 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
Dimensions in mm
(not recommended where mounting tab is on mains voltage)

- through heatsink with nut


Fig. 9 Insulated screw mounting with rectangular washer. Known as a "bottom mounting".


Fig. 10 Heatsink requirements for 500 V insulation.


Fig. 11 Heatsink requirements for 800 V insulation.

- into tapped heatsink


Fig. 12 Insulated screw mounting with rectangular washer into tapped heatsink. Known as a "top mounting".


Fig. 13 Heatsink requirements for 500 V insulation.


Fig. 14 Heatsink requirements for 1000 V insulation.

## MOUNTING INSTRUCTIONS FOR TO-220 FULL-PACK (SOT-186) DEVICES

Use of full-pack (SOT-186 envelope) devices allows an insulated mounting with up to 1 kV isolation. These devices require the assembly of less components than TO-220 devices with insulating washers.

## GENERAL DATA AND INSTRUCTIONS

## General rules

1.Mounting instructions for voltage isolation are given for guidance. Users should aquaint themselves with the relevant statutory and mandatory regulations if the heatsink is earthed or may be touched.
2. Fasten device to heatsink before soldering the leads.
3.Avoid axial stress to the leads.
4.Be careful to avoid damaging plastic with mounting tool (e.g. screwdriver).
5.If a rectangular washer (part no. 56360a) is used in screw mounting it may only touch the main part of the body, it should not exert any force on this part.

## Heatsink requirements

Flatness in the mounting area: 0.02 mm maximum per 10 mm .
Mounting holes must be deburred.

## Heatsink compound

Values of thermal resistance given using heatsink compound refer to the use of a metallic oxideloaded compound. Ordinary silicone grease is not recommended.

## Mounting methods for power devices

1.Clip mounting:

This gives better thermal contact under the crystal area than screw mounting.
For details of mounting force for spring clip mounting see data sheet "Accesories for TO-220".
2.M3 screw mounting:

It is recommended that a rectangular spacing washer (part no. 56360a) is inserted between the screw head and plastic mounting tab.
N.B. Data on accessories are given in separate data sheet "Accesories for TO-220".

Mounting torque for screw mounting:
(For thread-forming screws these are final values. Do not use self-tapping screws.)
$\begin{array}{ll}\text { Minimum torque (for good heat transfer) } & 0.55 \mathrm{Nm}(5.5 \mathrm{kgcm}) \\ \text { Maximum torque (to avoid damaging the device) } & 0.80 \mathrm{Nm}(8.0 \mathrm{kgcm})\end{array}$
N.B. When a nut or screw is not driven against a curved spring washer or lock washer (not for thread-forming screws) the torques are as follows:
$\begin{array}{ll}\text { Minimum torque (for good heat transfer) } & 0.40 \mathrm{Nm}(4.0 \mathrm{kgcm}) \\ \text { Maximum torque (to avoid damaging device) } & 0.60 \mathrm{Nm}(6.0 \mathrm{kgcm})\end{array}$
Maximum torque (to avoid damaging device)
$0.60 \mathrm{Nm}(6.0 \mathrm{kgcm})$
3. Rivet mounting:

This method is NOT recommended because it will damage the plastic encapsulation.

## Lead bending

(Maximum permissible tensile force on the body, for 5 seconds is 20 N ( 2 kgf ).
The leads should not be bent less than 2.4 mm from the seal, and should be supported during bending.
The leads can be bent, twisted or straightened by $90^{\circ}$ maximum. The minimum bending radius is 1 mm .


Fig. 1 Lead bending of devices.

## Soldering

Lead soldering temperature at $>3 \mathrm{~mm}$ from body for $\mathrm{t}_{\text {sld }}<5$ seconds:
Devices with $\mathrm{T}_{\mathrm{j}} \max . \leqslant 175^{\circ} \mathrm{C}, \mathrm{T}_{\text {sld }} \max .=275^{\circ} \mathrm{C}$.
Devices with $\mathrm{T}_{\mathrm{j}}$ max. $\leqslant 110^{\circ} \mathrm{C}, \mathrm{T}_{\text {sld }} \max .=240^{\circ} \mathrm{C}$.
Avoid any force on body and leads during or after soldering. Do not correct the position of the devices or of its leads after soldering.

## INSTRUCTIONS FOR CLIP MOUNTING

1. Apply heatsink compound to the mounting base, then place device on heatsink.
2.Push the short end of clip (part no. 56363) into the narrow slot in the heatsink with the clip at an angle of between $10^{\circ}$ to $30^{\circ}$ to the vertical (see Figs. $2 \& 3$ ).
2. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear down on the main part of the body, not on the tab (see Fig.3a).


Fig. 2 Heatsink requirements


Fig. 3 Mounting.


Fig.3a Position of device (top view).

## INSTRUCTIONS FOR SCREW MOUNTING

## Screw through heatsink with nut



Fig. 4 Assembly.
(1) M3 screw
(2) plain washer
(3) lock washer
(4) M3 nut
(5) heatsink

Into tapped heatsink


Fig. 6 Assembly.
(1) M3 screw
(5) heatsink

Dimensions in mm


Fig. 5 Heatsink requirements.


Fig. 7 Heatsink requirements.

## MOUNTING REQUIREMENTS FOR VOLTAGE ISOLATION

Full-pack devices may be used to maintain voltage isolation between the heatsink and the electrical circuit. However, users must ensure that there is a sufficient creepage distance between the exposed metal of the device (at both the lead and tab ends) and the heatsink. The distance required will vary according to the application and the regulations that may apply.
To increase the creepage distances the heatsink may be formed with slots or holes around the lead and tab ends of the device. The dimensions of the holes will vary according to the creepage distances required. For detail see Fig.8.


Fig. 8 Slots formed in heatsink to increase creepage distance.

## MOUNTING INSTRUCTIONS FOR SOT-93 ENVELOPES

## GENERAL DATA AND INSTRUCTIONS

## General rule

Avoid any sudden forces on leads and body; these forces, such as from falling on a hard surface, are easily underestimated. In the direct screw mounting an M4 screw must be used; an M3 screw in the insulating mounting.

## Heatsink requirements

Flatness in the mounting area: $0,02 \mathrm{~mm}$ maximum per 10 mm .
The mounting hole must be deburred.

## Heatsink compound

The thermal resistance from mounting base to heatsink ( $R_{\text {th mb-h }}$ ) 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) $\quad 0,4 \mathrm{Nm}(4 \mathrm{kgcm})$
Maximum torque (to avoid damaging the device) $\quad 0,6 \mathrm{Nm}(6 \mathrm{kgcm})$
For M4 screw (direct mounting only):
Minimum torque (for good heat transfer)
$0,4 \mathrm{Nm}(4 \mathrm{kgcm})$
Maximum torque (to avoid damaging the device)
$1,0 \mathrm{Nm}$ ( 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 $0,3 \mathrm{~mm}$ from the body of the device.
The leads can be bent through $90^{\circ}$ maximum, twisted or straightened; to keep forces within the abovementioned limits, the leads should be clamped near the body.

## Soldering

Recommendations for devices with a maxin um junction temperature rating $\leqslant 175^{\circ} \mathrm{C}$ :
a. Dip or wave soldering

Maximum permissible solder temperature is $260^{\circ} \mathrm{C}$ at a distance from the body of $>5 \mathrm{~mm}$ and for a total contact time with soldering bath or waves of $<7 \mathrm{~s}$.
b. Hand soldering

Maximum permissible temperature is $275^{\circ} \mathrm{C}$ at a distance from the body of $>3 \mathrm{~mm}$ and for a total contact time with the soldering iron of $<5 \mathrm{~s}$.
The body of the device must not touch anything with a temperature $>200{ }^{\circ} \mathrm{C}$.
It is not permitted to solder the metal tab of the device to a heatsink, otherwise the junction temperature rating will be exceeded.
Avoid any force on body and leads during or after soldering; do not correct the position of the device or of its leads after soldering.

## Thermal data

(Typical figures, for exact figures see data for each device type).
Thermal resistance from mounting base to heatsink direct mounting with heatsink compound without heatsink compound with $0,05 \mathrm{~mm}$ mica washer with heatsink compound without heatsink compound

|  | clip <br> mounting | screw <br> mounting |
| :--- | :--- | ---: |
|  |  |  |
| $R_{\text {th mb-h }}=0,3$ | $0,3 \mathrm{~K} / \mathrm{W}$ |  |
| $\mathrm{R}_{\text {th mb-h }}=1,5$ | $0,8 \mathrm{~K} / \mathrm{W}$ |  |
| $\mathrm{R}_{\text {th mb-h }}=0,8$ | $0,8 \mathrm{~K} / \mathrm{W}$ |  |
| $\mathrm{R}_{\text {th mb-h }}=3,0$ | $2,2 \mathrm{~K} / \mathrm{W}$ |  |

## 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 $10^{\circ}$ to $20^{\circ}$ 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.

# MOUNTING <br> INSTRUCTIONS <br> SOT-93 

## 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 $10^{\circ}$ to $20^{\circ}$ to the vertical (see Figs $2 a$ and $2 b$ ).
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.

## MOUNTING

Insulated screw mounting with nut; up to 800 V.


Fig. 4 Assembly.
See also Fig. 9.
(1) M3 screw
(2) plain washer
(3) insulating bush (56368b)
(4) mica insulator (56368c)
(5) lock washer
(6) M3 nut


Fig. 5 Heatsink requirements up to 800 V insulation.

Insulated screw mounting with tapped hole; up to 800 V.


Fig. 6 Assembly. See also Fig. 9.


Fig. 7 Heatsink requirements up to 800 V insulation.
(1) M3 screw
(2) plain washer
(3) insulating bush (56368b)
(4) mica insulator (56368c)
(5) lock washer

Insulated screw mounting with insert nut; up to 500 V


Fig. 8 Assembly and heatsink requirements for 500 V insulation. See also Fig. 3.
(1) M3 screw
(2) plain washer
(3) insulating bush (56368b)
(4) mica insulator (56368c)
(5) lock washer


Fig. 9 Mica insulator.
The axial deviation $(\alpha)$ between SOT-93 and mica should not exceed 50 .

## 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 $R_{\text {th }} j-\mathrm{mb}$. The second is the contact thermal resistance $R_{\text {th mb-h }}$ and finally there is the thermal resistance of the heatsink $R_{\text {th h-a. }}$
In the rating curves, the contact thermal resistance and heatsink thermal resistances are combined as a single figure - $\mathrm{R}_{\text {th mb-a. }}$
In addition to the steady state thermal conditions of the system, consideration should also be given to the possibility of any transient thermal excursions. These can be caused for example by starting conditions or overloads and in order to calculate the effect on the device, a graph of transient thermal resistance $Z_{\text {th }} \mathrm{j}-\mathrm{mb}$ 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 mechanica! 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 56295 c insulating bush and 56295a mica washer.
Mounting instructions for up to 2000 V insulation using 56295 b insulating ring and two 56295a mica washers.

## HEATSINK REQUIREMENTS

Mounting holes must be deburred.

## MOUNTING TORQUES

Minimum torque (for good heat transfer)
$0.9 \mathrm{Nm}(9 \mathrm{~kg} \mathrm{~cm})$
Maximum torque (to avoid damaging device)
$1.7 \mathrm{Nm}(17 \mathrm{~kg} \mathrm{~cm})$

## THERMAL DATA

The thermal resistance from mounting base to heatsink $\left(R_{\text {th }} \mathrm{mb}-\mathrm{h}\right)$ 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

| $R_{\text {th mb-h }}$ | $=$ | 5 | $\mathrm{~K} / W$ |
| :--- | :--- | ---: | :--- |
| $R_{\text {th mb-h }}$ | $=$ | 2.5 | $\mathrm{~K} / \mathrm{W}$ |

## MOUNTING INSTRUCTIONS FOR UP TO 2000 V INSULATION

Using 56295c insulating bush and 56295a mica washer.

Fig. 1
(1a);(1b) tag - alternative positions
(2) mica washer 56295a
(3) insulating bush 56295c
(4) plain washer (may be omitted if tag used in position 1b)
(5) toothed lock washer (supplied with device)
(6) 10-32 UNF nut (supplied with device)

## MOUNTING INSTRUCTIONS FOR UP TO 2000 V INSULATION

Using insulating ring 56295b and two mica washers 56295a.

Fig. 2
(1a); (1b) tag - alternative positions
(2) mica washer 56295a
(3) insulating ring 56295b
(4) mica washer 56295a
(5) plain washer (may be omitted if tag used in position 1b)
(6) toothed lock washer (supplied with device)
(7) $\quad 10-32$ nut (supplied with device)


## MOUNTING INSTRUCTIONS FOR DO-5 AND TO-48 ENVELOPES

## GENERAL DATA AND INSTRUCTIONS

Mounting instructions for up to 2000 V insulation using 56264b insulating bush and 56264a mica washer.

## HEATSINK REQUIREMENTS

Mounting holes must be deburred.

## MOUNTING TORQUES

Minimum torque (for good heat transfer) $\quad 1.7 \mathrm{Nm}(17 \mathrm{~kg} \mathrm{~cm})$
Maximum torque (to avoid damaging device)

$$
3.5 \mathrm{Nm}(35 \mathrm{~kg} \mathrm{~cm})
$$

## THERMAL DATA

The thermal resistance from mounting base to heatsink ( $R_{\text {th mb-h }}$ ) can be reduced by applying a heat conducting compound between device and heatsink. For insulated mounting the compound should be applied to the bottom of both device and insulator.

Thermal resistance from mounting base to heatsink (insulated mounting using 56264a mica washer)

| without heatsink compound | $R_{\text {th mb-h }}=$ | 5 | $\mathrm{~K} / \mathrm{W}$ |
| :--- | :--- | :--- | :--- | :--- |
| with heatsink compound | $R_{\text {th mb-h }}=$ | 2.5 | $\mathrm{~K} / \mathrm{W}$ |

## 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 56264 b
(4) plain washer (may be omitted if tag used in position 1b)
(5) toothed lock washer (supplied with device)
(6) $\quad 1 / 4^{\prime \prime} \times 28$ UNF nut (supplied with device)


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| $M m=$ | Microminiature semiconductors |
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| BC264C | S5 | FET | BC868 | S7 | Mm | BCX71* | S7 | Mm |
| BC264D | S5 | FET | BC869 | S7 | Mm | BCY56 | S3 | Sm |
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| BC338 | S3 | Sm | BCF33;R | S7 | Mm | BCY70 | S3 | Sm |
| BC368 | S3 | Sm | BCF70;R | S7 | Mm | BCY71 | S3 | Sm |
| BC369 | S3 | Sm | BCF81;R | S7 | Mm | BCY72 | S3 | Sm |
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| BC548 | S3 | Sm | BCV71;R | S7 | Mm | BCY89 | S3 | Sm |
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| $*$ | $=$ series |  |  |
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| FET | $=$ Field-effect transistors | $P=$ Low-frequency power transistors |  |
| $\mathrm{Mm}=$ Microminiature semiconductors |  | $\mathrm{Sm}=$ Small-signal transistors |  |
|  | for hybrid circuits | $\mathrm{T}=$ Tuner diodes |  |


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| BD241B | S4a | P | BD677 | S4a | P | BD941 | S4a | P |
| BD241C | S4a | P | BD678 | S4a | P | BD942 | S4a | P |
| BD242 | S4a | P | BD679 | S4a | P | BD943 | S4a | P |
| BD242A | S4a | P | BD680 | S4a | P | BD944 | S4a | P |
| BD242B | S4a | P | BD681 | S4a | P | BD945 | S4a | P |
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| BD244 | S4a | P | BD815 | S4a | P | BD951 | S4a | P |
| BD244A | S4a | P | BD816 | S4a | P | BD952. | S4a | P |
| BD244B | S4a | P | BD817 | S4a | P | BD953 | S4a | P |
| BD244C | S4a | P | BD818 | S4a | P | BD954 | S4a | P |
| BD329 | S4a | P | BD825 | S4a | p | BD955 | S4a | P |
| BD330 | S4a | P | BD826 | S4a | P | BD956 | S4a | P |
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$P=$ Low-frequency power transistors

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| BDT29A | S4a | p | BDT62A | S4a | P | BDV66D | S4a | P |
| BDT29B | S4a | P | BDT62B | S4a | P | BDV67A | S4a | P |
| BDT29C | S4a | P | BDT62C | S4a | P | BDV67B | S4a | P |
| BDT30 | S4a | P | BDT63 | S4a | P | BDV67C | S4a | p |
| BDT30A | S4a | P | BDT63A | S4a | P | BDV67D | S4a | P |
| BDT30B | S4a | P | BDT63B | S4a | P | BDV91 | S4a | P |
| BDT30C | S4a | P | RDT63C | S4a | P | BDV92 | S4a | P |
| BDT31 | S4a | P | BDT64 | S4a | P | BDV93 | S4a | P |
| BDT31A | S4a | P | BDT64A | S4a | P | BDV94 | S4a | P |
| BDT31B | S4a | P | BDT64B | S4a | P | BDV95 | S4a | P |
| BDT31C | S4a | P | BDT64C | S4a | P | BDV96 | S4a | P |
| BDT32 | S4a | P | BDT65 | S4a | P | BDW55 | S4a | P |
| BDT32A | S4a | P | BDT65A | S4a | P | BDW56 | S4a | P |
| BDT 32B | S4a | P | BDT65B | S4a | P | BDW57 | S4a | P |
| BDT32C | S4a | P | BDT65C | S4a | P | BDW58 | S4a | P |
| BDT41 | S4a | P | BDT81 | S4a | p | BDW59 | S4a | P |
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| BDT42 | S4a | P | BDT85 | S4a | P | BDX37 | S4a | P |
| BDT42A | S4a | P | BDT86 | S4a | P | BDX42 | S4a | P |
| BDT 42B | S4a | P | BDT87 | S4a | P | BDX43 | S4a | P |
| BDT42C | S4a | P | BDT88 | S4a | P | BDX44 | S4a | P |
| BDT51 | S4a | p | BDT91 | S4a | P | BDX45 | S4a | P |
| BDT52 | S4a | P | BDT92 | S4a | P | BDX46 | S4a | P |
| BDT53 | S4a | P | BDT93 | S4a | P | BDX47 | S4a | P |
| BDT54 | S4a | P | BDT94 | S4a | P | BDX62 | S4a | P |
| BDT55 | S4a | P | BDT95 | S4a | P | BDX62A | S4a | P |
| BDT56 | S4a | P | BDT96 | S4a | P | BDX62B | S4a | P |
| BDT57 | S4a | P | BDV64 | S4a | P | BDX62C | S4a | P |
| BDT58 | S4a | P | BDV64A | S4a | P | BDX63 | S4a | P |
| BDT60 | S4a | P | BDV64B | S4a | P | BDX63A | S4a | P |
| BDT60A | S4a | P | BDV64C | S4a | P | BDX63B | S4a | P |
| BDT60B | S4a | P | BDV65 | S4a | P | BDX63C | S4a | P |
| BDT60C | S4a | P | BDV65A | S4a | P | BDX64 | S4a | P |
| BDT61 | S4a | P | BDV65B | S4a | P | BDX64A | S4a | p |
| BDT61A | S4a | P | BDV65C | S4a | P | BDX64B | S4a | P |
| BDT61B | S4a | P | BDV66A | S4a | P | BDX64C | S4a | P |

$P=$ Low-frequency power transistors

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| BDX65A | S4a | P | BF247C | S5 | FET | BF587 | S4b | HVP |
| BDX65B | S4a | P | BF256A | S5 | FET | BF591 | S4b | HVP |
| BDX65C | S4a | P | BF256B | S5 | FET | BF593 | S4b | HVP |
| BDX66 | S4a | P | BF256C | S5 | FET | BF620 | S7 | Mm |
| BDX66A | S4a | P | BF324 | S3 | Sm | BF621 | S7 | Mm |
| BDX66B | S4a | P | BF370 | S3 | Sm | BF622 | S7 | Mm |
| BDX66C | S4a | P | BF410A | S5 | FET | BF623 | S7 | Mm |
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| BDX67A | S4a | P | BF410C | S5 | FET | BF689K | S10 | WBT |
| BDX67B | S4a | P | BF410D | S5 | FET | BF763 | S 10 | WBT |
| BDX67C | S4a | P | BF419 | S4b | HVP | BF767 | S7 | Mm |
| BDX68 | S4a | P | BF420 | S3 | Sm | BF819 | S4b | HVP |
| BDX68A | S4a | P | BF421 | S3 | Sm | BF820 | S7 | Mm |
| BDX68B | S4a | P | BF422 | S3 | Sm | BF821 | S7 | Mm |
| BDX68C | S4a | P | BF423 | S3 | Sm | BF822 | S7 | Mm |
| BDX69 | S4a | P | BF450 | S3 | Sm | BF823 | S7 | Mm |
| BDX69A | S4a | P | BF451 | S3 | Sm | BF824 | S7 | Mm |
| BDX69B | S4a | P | BF457 | S4b | HVP | BF840 | S7 | Mm |
| BDX69C | S4a | P | BF458 | S4b | HVP | BF841 | S7 | Mm |
| BDX77 | S4a | P | BF459 | S4b | HVP | BF857 | S4b | HVP |
| BDX78 | S4a | P | BF469 | S4b | HVP | BF858 | S4b | HVP |
| BDX91 | S4a | P | BF470 | S4b | HVP | BF859 | S4b | HVP |
| BDX92 | S4a | P | BF471 | S4b | HVP | BF869 | S4b | HVP |
| BDX93 | S4a | P | BF472 | S4b | HVP | BF870 | S4b | HVP |
| BDX94 | S4a | P | BF483 | S3 | Sm | BF871 | S4b | HVP |
| BDX95 | S4a | P | BF485 | S3 | Sm | BF872 | S4b | HVP |
| BDX96 | S4a | P | BF487 | S3 | Sm | BF926 | S3 | Sm |
| BDY90 | S4a | P | BF494 | S3 | Sm | BF936 | S3 | Sm |
| BDY90A | S4a | P | BF495 | S3 | Sm | BF939 | S3 | Sm |
| BDY91 | S4a | P | BF496 | S3 | Sm | BF960 | S5 | FET |
| BDY92 | S4a | P | BF5 10 | S7/55 | Mm/FET | BF964 | S5 | FET |
| BF198 | S3 | Sm | BF511 | S7/S5 | Mm/FET | BF966 | S5 | FET |
| BF199 | S3 | Sm | BF5 12 | S7/S5 | Mm/FET | BF967 | S3 | Sm |
| BF240 | S3 | Sm | BF5 13 | S7/S5 | Mm/FET | BF970 | S3 | Sm |
| BF241 | S3 | Sm | BF536 | S7 | Mm | BF979 | S3 | Sm |
| BF245A | S5 | FET | BF550;R | S7 | Mm | BF980 | S5 | FET |
| BF245B | S5 | FET | BF569 | S7 | Mm | BF981 | S5 | FET |
| BF245C | S5 | FET | BF579 | S7 | Mm | BF982 | S5 | FET |
| BF247A | S5 | FET | BF583 | S4b | HVP | BF989 | S7/S5 | Mm/FET |

$\begin{aligned} & \text { FET }= \text { Field-effect transistors } \\ & \text { HVP }=\text { High-voltage power transistors } \\ & M m= \text { Microminiature semiconductors } \\ & \text { for hybrid circuits }\end{aligned}$
P = Low-frequency power transistors
Sm = Small-signal transistors
WBT = Wideband transistors

| type no. | book | section | type no. | book | section | type no. | book | section |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| BF990 | S7/S5 | Mm/FET | BFQ51 | S10 | WBT | BFT24 | S10 | WBT |
| BF991 | S7/S5 | Mm/FET | BFQ51C | S 10 | WBT | BFT25;R | S7 | Mm |
| BF992 | S7/S5 | Mm/FET | BFQ52 | S 10 | WBT | BFT44 | S3 | Sm |
| BF994 | S7/S5 | Mm/FET | BFQ53 | S 10 | WBT | BFT45 | S3 | Sm |
| BF996 | S7/S5 | Mm/FET | BFQ63 | S10 | WBT | BFT46 | S7/S5 | Mm/FET |
| BFG23 | S 10 | WBT | BFQ65 | S 10 | WBT | BFT92;R | S7 | Mm |
| BFG32 | S 10 | WBT | BFQ66 | S10 | WBT | BFT93;R | S7 | Mm |
| BFG34 | S 10 | WBT | BFQ67 | S7 | Mm | BFW10 | S5 | FET |
| BFG5 1 | S10 | WBT | BFQ68 | S10 | WBT | BFW 11 | S5 | FET |
| BFG65 | S 10 | WBT | BFQ136 | S 10 | WBT | BFW12 | S5 | FET |
| BFG67 | S7 | Mm | BFR29 | S5 | FET | BFW 13 | S5 | FET |
| BFG90A | S10 | WBT | BFR30 | S7/55 | Mm/FET | BFW16A | S 10 | WBT |
| BFG9 1A | S 10 | WBT | BFR31 | S7/S5 | Mm/FET | BFW 17A | S 10 | WBT |
| BFG96 | S10 | WBT | BFR49 | S10 | WBT | BFW30 | S10 | WBT |
| BFP90A | S 10 | WBT | BFR53;R | S7 | Mm | BFW61 | S5 | FET |
| BFP91A | S10 | WBT | BFR54 | S3 | Sm | BFW92 | S 10 | WBT |
| BFP96 | S 10 | WBT | BFR64 | S 10 | WBT | BFW92A | S 10 | WBT |
| BFQ10 | S5 | FET | BFR65 | S 10 | WBT | BFW93 | S 10 | WBT |
| BFQ11 | S5 | FET | BFR84 | S5 | FET | BFX29 | S3 | Sm |
| BFQ12 | S5 | FET | BFR90 | S 10 | WBT | BFX30 | S3 | Sm |
| BFQ13 | S5 | FET | BFR90A | S10 | WBT | BFX34 | S3 | Sm |
| BFQ14 | S5 | FET | BFR91 | S 10 | WBT | BFX84 | S3 | Sm |
| BFQ15 | S5 | FET | BFR91A | S10 | WBT | BFX85 | S3 | Sm |
| BFQ16 | S5 | FET | BFR92;R | S7 | Mm | BFX86 | S3 | Sm |
| BFQ17 | S7 | Mm | BFR92A;R | S7 | Mm | BFX87 | S3 | Sm |
| BFQ18A | S7 | Mm | BFR93;R | S7 | Mm | BFX88 | S3 | Sm |
| BFQ19 | S7 | Mm | BFR93A;R | S7 | Mm | BFX89 | S10 | WBT |
| BFQ22S | S10 | WBT | BFR94 | S 10 | WBT | BFY50 | S3 | Sm |
| BFQ23 | S 10 | WBT | BFR95 | S 10 | WBT | BFY51 | S3 | Sm |
| BFQ23C | S10 | WBT | BFR96 | S10 | WBT | BFY52 | S3 | Sm |
| BFQ24 | S 10 | WBT | BFR96S | S 10 | WBT | BFY55 | S3 | Sm |
| BFQ32 | 510 | WBT | BFR101A; | S7/S5 | Mm/FET | BFY90 | S 10 | WBT |
| BFQ32C | S 10 | WBT | BFS17;R | S7 | Mm | BG2000 | S1 | RT |
| BFQ32S | S10 | WBT | BFS18;R | S7 | Mm | BG2097 | S1 | RT |
| BFQ33 | S 10 | WBT | BFS19;R | S7 | Mm | BGD102 | S10 | WBM |
| BFQ34 | S10 | WBT | BFS20; R | S7 | Mm | BGD102E | S 10 | WBM |
| BFQ34T | S 10 | WBT | BFS21 | S5 | FET | BGD104 | S 10 | WBM |
| BFQ42 | S6 | RFP | BFS21A | S5 | FET | BGD104E | S 10 | WBM |
| BFQ43 | S6 | RFP | BFS22A | S6 | RFP | BGY22 | S6 | RFP |
| BFQ43S | S6 | RFP | BFS23A | S6 | RFP | BGY22A | S6 | RFP |

FET $=$ Field-effect transistors
$\mathrm{Mm}=$ Microminiature semiconductors for hybrid circuits
RFP = R.F. power transistors and modules

RT = Tripler
$\mathrm{Sm}=$ Small-signal transistors
WBM = Wideband hybrid IC modules
WBT = Wideband transistors

| type no. | book | section | type no. | book | section | type no. | book | section |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| BGY23 | S6 | RFP | BGY85A | S10 | WBM | BLV57 | S6 | RFP |
| BGY23A | S6 | RFP | BGY90A | S6 | RFP | BLV59 | S6 | RFP |
| BGY32 | S6 | RFP | BGY90B | S6 | RFP | BLV75/12 | S6 | RFP |
| BGY33 | S6 | RFP | BGY93* | S6 | RFP | BLV80/28 | S6 | RFP |
| BGY35 | S6 | RFP | BGY94* | S6 | RFP | BLV90 | S6 | RFP |
| BGY36 | S6 | RFP | BGY95A | S6 | RFP | BLV90/SL | S6 | RFP |
| BGY40A | S6 | RFP | BGY95B | S6 | RFP | BLV91 | S6 | RFP |
| BGY40B | S6 | RFP | BGY96A | S6 | RFP | BLV91/SL | S6 | RFP |
| BGY41A | S6 | RFP | BGY96B | S6 | RFP | BLV92 | S6 | RFP |
| BGY41B | S6 | RFP | BLF146 | S6 | RFP/FET | BLV93 | S6 | RFP |
| BGY43 | S6 | RFP | BLF242 | S6 | RFP/FET | BLV94 | S6 | RFP |
| BGY45A | S6 | RFP | BLF244 | S6 | RFP/FET | BLV95 | S6 | RFP |
| BGY45B | S6 | RFP | BLF245 | S6 | RFP/FET | BLV97 | S6 | RFP |
| BGY46A | S6 | RFP | BLT90/SL | S6 | RFP | BLV98 | S6 | RFP |
| BGY46B | S6 | RFP | BLT91/SL | S6 | RFP | BLV99 | S6 | RFP |
| BGY47* | S6 | RFP | BLT92/SL | S6 | RFP | BLW29 | S6 | RFP |
| BGY48* | S6 | RFP | BLU20/12 | S6 | RFP | BLW31 | S6 | RFP |
| BGY50 | S 10 | WBM | BLU30/12 | S6 | RFP | BLW32 | S6 | RFP |
| BGY51 | S10 | WBM | BLU45/12 | S6 | RFP | BLW33 | S6 | RFP |
| BGY52 | S 10 | WBM | BLU50 | S6 | RFP | BLW34 | S6 | RFP |
| BGY53 | S 10 | WBM | BLU5 1 | S6 | RFP | BLW50F | S6 | RFP |
| BGY54 | S 10 | WBM | BLU52 | S6 | RFP | BLW60 | S6 | RFP |
| BGY55 | S10 | WBM | BLU53 | S6 | RFP | BLW60C | S6 | RFP |
| BGY56 | S 10 | WBM | BLU60/12 | S6 | RFP | BLW76 | S6 | RFP |
| BGY57 | S 10 | WBM | BLU97 | S6 | RFP | BLW77 | S6 | RFP |
| BGY58 | S 10 | WBM | BLU98 | S6 | RFP | BLW78 | S6 | RFP |
| BGY58A | S 10 | WBM | BLU99 | S6 | RFP | BLW79 | S6 | RFP |
| BGY59 | S 10 | WBM | BLV10 | S6 | RFP | BLW80 | S6 | RFP |
| BGY60 | S 10 | WBM | BLV11 | S6 | RFP | BLW81 | S6 | RFP |
| BGY61 | S 10 | WBM | BLV20 | S6 | RFP | BLW83 | S6 | RFP |
| BGY65 | S10 | WBM | BLV2 1 | S6 | RFP | BLW84 | S6 | RFP |
| BGY67 | S 10 | WBM | BLV25 | S6 | RFP | BLW85 | S6 | RFP |
| BGY67A | S10 | WBM | BLV30 | S6 | RFP | BLW86 | S6 | RFP |
| BGY70 | S 10 | WBM | BLV30/12 | S6 | RFP | BLW87 | S6 | RFP |
| BGY71 | S10 | WBM | BLV31 | S6 | RFP | BLW89 | S6 | RFP |
| BGY74 | S 10 | WBM | BLV32F | S6 | RFP | BLW90 | S6 | RFP |
| BGY75 | S10 | WBM | BLV33 | S6 | RFP | BLW9 1 | S6 | RFP |
| BGY84 | S 10 | WBM | BLV33F | S6 | RFP | BLW95 | S6 | RFP |
| BGY84A | S 10 | WBM | BLV36 | S6 | RFP | BLW96 | 56 | RFP |
| BGY85 | S 10 | WBM | BLV45/12 | S6 | RFP | BLW97 | S6 | RFP |

* = series

FET $=$ Field-effect transistors
RFP $=$ R.F. power transistors and modules
WMB = Wideband hybrid IC modules

| type no. | book | section | type no. | book | section | type no. | book | section |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| BLW98 | S6 | RFP | BPW71 | S8b | PDT | BSR30 | 57 | Mm |
| BLW99 | S6 | RFP | BPX25 | S8b | PDT | BSR31 | S7 | Mm |
| BLX13 | S6 | RFP | BPX29 | S8b | PDT | BSR32 | S7 | Mm |
| BLX13C | S6 | RFP | BPX40 | S8b | PDT | BSR33 | S7 | Mm |
| BLX14 | S6 | RFP | BPX41 | S8b | PDT | BSR 40 | S7 | Mm |
| BLX 15 | S6 | RFP | BPX42 | S8b | PDT | BSR41 | S7 | Mm |
| BLX39 | S6 | RFP | BPX61 | S8b | PDT | BSR 42 | S7 | Mm |
| BLX65 | S6 | RFP | BPX61P | S8b | PDT | BSR 43 | S7 | Mm |
| BLX65E | S6 | RFP | BPX71 | S8b | PDT | BSR50 | S3 | Sm |
| BLX65ES | S6 | RFP | BPX72 | S8b | PDT | BSR5 1 | S3 | Sm |
| BLX67 | S6 | RFP | BR 100/03 | S2b | Th | BSR52 | S3 | Sm |
| BLX68 | S6 | RFP | BR101 | S3 | Sm | BSR56 | S7/S5 | Mm/FET |
| BLX69A | S6 | RFP | BR210* | S2a | Th | BSR57 | S7/S5 | Mm/FET |
| BLX9 1A | S6 | RFP | BR216* | S2a | Th | BSR58 | S7/S5 | Mm/FET |
| BLX9 1CB | S6 | RFP | BR220* | S2a | Th | BSR60 | S3 | Sm |
| BLX92A | S6 | RFP | BRY39 | S3 | Sm | BSR61 | S3 | Sm |
| BLX93A | S6 | RFP | BRY56 | S3 | Sm | BSR62 | 53 | Sm |
| BLX94A | S6 | RFP | BRY61 | S7 | Mm | BSS38 | S3 | Sm |
| BLX94C | S6 | RFP | BRY62 | S7 | Mm | BSS50 | S3 | Sm |
| BLX95 | S6 | RFP | BS 107 | S5 | FET | BSS5 1 | 53 | Sm |
| BLX96 | S6 | RFP | BS 170 | S5 | FET | BSS52 | S3 | Sm |
| BLX97 | S6 | RFP | BSD 10 | S5 | FET | BSS60 | 53 | Sm |
| BLX98 | S6 | RFP | BSD 12 | S5 | FET | BSS61 | S3 | Sm |
| BLY87A | S6 | RFP | BSD20 | S5/7 | FET | BSS62 | S3 | Sm |
| BLY87C | S6 | RFP | BSD22 | S5/7 | FET | BSS63;R | S7 | Mm |
| BLY88A | S6 | RFP | BSD212 | S5 | FET | BSS64;R | S7 | Mm |
| BLY88C | S6 | RFP | BSD213 | S5 | FET | BSS68 | 53 | Sm |
| BLY89A | S6 | RFP | BSD214 | S5 | FET | BSS83 | S5/7 | FET/Mm |
| BLY89C | S6 | RFP | BSD215 | S5 | FET | BST15 | S7 | Mm |
| BLY90 | S6 | RFP | BSR12;R | S7 | Mm | BST16 | S7 | Mm |
| BLY91A | S6 | RFP | BSR13;R | S7 | Mm | BST39 | S7 | Mm |
| BLY91C | S6 | RFP | BSR14;R | S7 | Mm | BST40 | S7 | Mm |
| BLY92A | S6 | RFP | BSR15;R | S7 | Mm | BST50 | S7 | Mm |
| BLY92C | S6 | RFP | BSR16;R | S7 | Mm | BST51 | S7 | Mm |
| BLY93A | S6 | RFP | BSR17;R | S7 | Mm | BST52 | S7 | Mm |
| BLY93C | S6 | RFP | BSR17A;R | 57 | Mm | BST60 | 57 | Min |
| BLY94 | S6 | RFP | BSR18;R | S7 | Mm | BST61 | S7 | Mm |
| BPF24 | S8b | PDT | BSR18A;R | S7 | Mm | BST62 | S7 | Mm |
| BPW22A | S8a/b | PDT | BSR19; A | S7 | Mm | BST70A | S5 | FET |
| BPW50 | S8a/b | PDT | BSR20; A | S7 | Mm | BST72A | S5 | FET |

$\begin{aligned} \text { FET }= & \text { Field-effect transistors } \\ \mathrm{Mm}= & \text { Microminiature semiconductors } \\ & \quad \text { for hybrid circuits } \\ \text { PDT }= & \text { Photodiodes or transistors }\end{aligned}$

| type no. | book | section | type no. | book | section | type no. | book | section |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| BST74A | S5 | FET | BT139* | S2b | Tri | BU508D | S4b | SP |
| BST76A | S5 | FET | BT139F* | S2b | Tri | BU705 | S4b | SP |
| BST78 | S5 | FET | BT145* | S2b | Tri | Bu706 | S4b | SP |
| BST80 | S5/S7 | FET/Mm | BT149* | S2b | Th | BU706D | S4b | SP |
| BST82 | S5/S7 | FET/Mm | BT150 | S2b | Th | BU806 | S4b | SP |
| BST84 | S5/S7 | FET/Mm | BT151* | S2b | Th | BU807 | S4b | SP |
| BST86 | S5/S7 | FET/Mm | BT151F* | S2b | Th | BU808 | S4b | SP |
| BST90 | S5 | FET | BT152* | S2b | Th | BU824 | S4b | SP |
| BST97 | S5 | FET | BT 153 | S2b | Th | BU82.6 | S4b | SP |
| BST 100 | S5 | FET | BT157* | S2b | Th | BUP22* | S4b | SP |
| BST 110 | S5 | FET | BT169* | S2b | Th | BUP23* | 54b | SP |
| BST120 | S5/S7 | FET / Mm | BTA140* | S2b | Tri | BUS11; A | S4b | SP |
| BST 122 | S5/57 | FET/Mm | BTR59* | S2b | Tri | BUS12; A | S4b | SP |
| BSV15 | S3 | Sm | BTS59* | S2b | Tri | BUS13; A | S4b | SP |
| BSV16 | S3 | Sm | BTV58* | S2b | Th | BUS14; A | S4b | SP |
| BSV17 | S3 | Sm | BTV59* | S2b | Th | BUS21* | S4h | SP |
| BSV52;R | S7 | Mm | BTV59D* | S2b | Th | BUS22* | S4b | SP |
| BSV64 | S3 | Sm | BTV60* | S2b | Th | BUS23* | S4b | SP |
| BSV78 | 55 | FET | BTV60D* | S2b | Th | BUT11; A | S4b | SP |
| BSV79 | S5 | FET | BTV70* | S2b | Th | BUT11A | S4b | SP |
| BSV80 | S5 | FET | BTV70D* | S2b | Th | BUT11AF | S4b | SP |
| BSV81 | S 5 | FET | BTW23* | S2b | Th | BUV82 | S4b | SP |
| BSW66A | S3 | Sm | BTW38* | S2b | Th | BUV83 | S4b | SP |
| BSW67A | 53 | Sm | BTW40* | S2b | Th | BUV89 | S4b | SP |
| BSW68A | 53 | Sm | BTW42* | S2.b | Th | BuV90; A | S4b | SP |
| BSX 19 | S3 | Sm | BTW43* | S2b | Tri | BuW11; A | S4b | SP |
| BSX20 | S3 | Sm | BTW45* | S2b | Th | BUW12; A | S4b | SP |
| BSX45 | S3 | Sm | BTW58* | S2b | Th | BUW13; A | S4b | SP |
| BSX46 | S3 | Sm | BTW62* | S2.b | Th | BUW84 | S4b | SP |
| BSX47 | S3 | Sm | BTW62D* | S2b | Th | BUW85 | S4b | SP |
| BSX59 | S3 | Sm | BTW63* | S2b | Th | BUX46; A | S4b | SP |
| BSX60 | S3 | Sm | BTY79* | S2b | Th | BUX47; A | S4b | SP |
| BSX61 | 53 | Sm | BTY91* | S2b | Th | BUX48; A | S4b | SP |
| BSY95A | S3 | Sm | BU426 | S4b | SP | BUX80 | S4b | SP |
| BT136* | S2b | Tri | BU426A | S4b | SP | BUX81 | S4b | SP |
| BT 136 F * | S2b | Tri. | BU433 | S4b | SP | BUX82 | S4b | SP |
| BT137* | S2b | Tri | BU505 | S4b | SP | BUX83 | S4b | SP |
| BT 137F* | S2b | Tri | BU506 | 54 b | SP | BUX84 | S4b | SP |
| BT 138* | S2b | Tri | BU506D | S4b | SP | BTIX84F | S4b | SP |
| BT 138F* | S2b | Tri | BU508A | S4b | SP | BUX85 | S4b | SP |

* = series

FET $=$ Field-effect transistors
$\mathrm{Mm}=$ Microminiature semiconductors for hybrid circuits
Sm = Small-signal transistors

SP = Low-frequency switching power transistors
Th = Thyristors
Tri = Triacs

| type no. | book | section | type no. | book | section | type no. | book | section |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| BUX85F | S4b | SP | BUZ54 | S9 | PM | BY609 | S1 | R |
| BUX86 | S4b | SP | BUZ54A | 59 | PM | BY6 10 | S1 | R |
| BUX87 | S4b | SP | BUZ60 | S9 | PM | BY614 | S1 | R |
| BUX88 | S4b | SP | BUZ 60B | S9 | PM | BY619 | S 1 | R |
| BUX90 | S4b | SP | BUZ 63 | S9 | PM | BY620 | S1 | R |
| BUX98 | S4b | SP | BUZ63B | S9 | PM | BY627 | S 1 | R |
| BUX98A | S4b | SP | BUZ64 | S9 | PM | BY707 | S1 | R |
| BUX99 | S4b | SP | BUZ 71 | S9 | PM | BY708 | S 1 | R |
| BUY89 | S4b | SP | BUZ71A | S9 | PM | BY709 | S1 | R |
| BUZ, 10 | S9 | PM | BUZ72 | S9 | PM | BY710 | S1 | R |
| BUZ 10A | 59 | PM | BUZ72A | S9 | PM | BY711 | S1 | R |
| BUZ11 | S9 | PM | BUZ73A | S9 | PM | BY7 12 | S 1 | R |
| BUZ11A | 59 | PM | BUZ74 | S9 | PM | BY713 | S1 | R |
| BUZ 14 | 59 | PM | BUZ74A | 59 | PM | BY714* | S1 | R |
| BUZ 15 | 59 | PM | BUZ76 | S9 | PM | BYD13* | S1 | R |
| BuZ20 | 59 | PM | BUZ76A | 59 | PM | BYD 14* | S1 | R |
| BUZ21 | 59 | PM | BUZ80 | 59 | PM | BYD17* | S1 | R |
| BUZ23 | S9 | PM | BUZ80A | 59 | PM | BYD $33 *$ | S1 | R |
| BUZ24 | S9 | PM | BUZ83 | 59 | PM | BYD $37{ }^{*}$ | S1 | R |
| BUZ25 | 59 | PM | BUZ83A | S9 | PM | BYD73* | S1 | R |
| BUZ30 | S9 | PM | BUZ 84 | S9 | PM | BYD74* | S1 | R |
| BUZ31 | 59 | PM | BUZ84A | S9 | PM | BYD77* | S1 | R |
| BUZ32 | 59 | PM | BY224* | S2a | R | BYM 26 * | S1 | R |
| BUZ33 | 59 | PM | BY225* | S2a | R | BYM 36 * | S1 | R |
| BUZ34 | 59 | PM | BY228 | S1 | R | BYM56* | S1 | R |
| BUZ.35 | S9 | PM | BY229* | S2a | R | BYP21* | S2a | R |
| BUZ36 | S9 | PM | BY229F* | S2a | R | BYP22* | S2a | R |
| BUZ 40 | S9 | PM | BY249* | S2a | R | BYP59* | S2a | R |
| BUZ41A | S9 | PM | BY260* | S2a | R | BYQ28* | S2a | R |
| BUZ 42 | 59 | PM | BY261* | S2a | R | BYR29* | S2a | R |
| BUZ43 | 59 | PM | BY329* | S2a | R | BYR29F* | S2a | R |
| BUZ44A | S9 | PM | BY359* | S2a | R | BYT28* | S2a | R |
| BUZ45 | S9 | PM | BY438 | S 1 | R | BYT79* | S2a | R |
| BUZ45A | S9 | PM | BY448 | S1 | R | BYV 10 | S1 | R |
| BUZ45B | S9 | PM | BY458 | S1 | R | BYV18* | S2a | R |
| BUZ.45C | 59 | PM | BY505 | S1 | R | BYV 19* | S2a | R |
| BUZ46 | S9 | PM | BY509 | S1 | R | BYV20* | S2a | R |
| BUZ50A | S9 | PM | BY527 | S1 | R | BYV21* | S2a | R |
| BUZ50B | S9 | PM | BY584 | S1 | R | BYV22* | S2a | R |
| BUZ 5 3A | S9 | PM | BY588 | S1 | R | BYV23* | S2a | R |

* = series

PM = Power MOS transistors
$R=$ Rectifier diodes
SP = Low-frequency switching power transistors

| type no. | book | section | type no. | book | section | type no. | book | section |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| BYV24** | S2a | R | BYW95A | S1 | R | BZX70* | S2a | Vrg |
| BYV26* | S1/S2a | R | BYW95B | S 1 | R | B2X75* | S1 | Vrg |
| BYV27* | S1/S2a | R | BYW95C | S1 | R | BZX79* | S1 | Vrg |
| BYV28* | S1/S2a | R | BYW96D | S 1 | R | BZX84* | S7/S1 | $\mathrm{Mm} / \mathrm{Vrg}$ |
| BYV29* | S2a | R | BYW96E | S 1 | R | B2Y91* | S2a | Vrg |
| BYV29F* | S2a | R | BYX 10 C | S 1 | R | BZY93* | S2a | Vrg |
| BYV30* | S2a | R | BYX25* | S2a | R | CFX13 | S11 | M |
| BYV31* | S2a | R | BYX $30 *$ | S2a | R | CFX21 | S11 | M |
| BYV32* | S2a | R | BYX32* | S2a | R | CFX30 | S 11 | M |
| BYV32F* | S2a | R | BYX38* | S2a | R | CFX31 | 511 | M |
| BYV33* | S2a | R | BYX39* | S2a | R | CFX 32 | S11 | M |
| BYV33F* | S2a | R | BYX42* | S2a | R | CFX33 | S11 | M |
| BYV34** | S2a | R | BYX46* | S2a | R | CNG35 | S8b | PhC |
| BYV36* | S1 | R | BYX50* | S2a | R | CNG36 | S8b | PhC |
| BYV39* | S2a | R | BYX52* | S2a | R | CNR 36 | S8b | PhC |
| BYV42* | S2a | R | BYX56* | S2a | R | CNX21 | S8b | PhC |
| BYV43* | S2a | R | BYX90G | S1 | R | CNX35 | S8b | PhC |
| BYV43F* | S2a | R | BYX96* | S2a | R | CNX35U | S8b | PhC |
| BYV44* | S2a | R | BYX97* | S2a | R | CNX36 | S8b | PhC |
| BYV60* | S2a | R | BYX98* | S2a | R | CNX36U | S8b | PhC |
| BYV72* | S2a | R | BYX99* | S2a | R | CNX 38 | S8b | PhC |
| BYV73* | S2a | R | B2D23 | S1 | Vrg | CNX38U | S8b | PhC |
| BYV74* | S2a | R | B2D27 | S1 | Vrg | CNX39 | S8b | PhC |
| BYV79* | S2a | R | BZT03 | S1 | Vrg | CNX39U | S8b | PhC |
| BYV92* | S2a | R | BZV10 | S1 | Vrf | CNX44 | S8b | PhC |
| BYV95A | S1 | R | BZV11 | S1 | Vrf | CNX44A | S8b | PhC |
| BYV95B | S1 | R | BZV12 | S 1 | Vrf | CNX46 | S8b | PhC |
| BYV95C | S1 | R | BZV13 | S1 | Vrf | CNX48 | S8b | PhC |
| BYV96D | S1 | R | B2V14 | S 1 | Vrf | CNX48U | 58 b | PhC |
| BYV96E | S1 | R | B2V37 | S1 | Vrf | CNX62 | S8b | PhC |
| BYW25* | S2a | R | BZV46 | S1 | Vrg | CNX72 | S8b | PhC |
| BYW29* | S2a | R | B2V49* | S1/S7 | Vrg/Mm | CNX82 | S8b | PhC |
| BYW29F* | S2a | R | B2V55* | S7 | Mm | CNX83 | S8b | PhC |
| BYW30* | S2a | R | BZV80 | S1 | Vrf | CNX9 1 | S8b | PhC |
| BYW31* | S2a | R | B2V81 | S1 | Vrf | CNX92 | S8b | PhC |
| BYW54 | S1 | R | B2V85** | 51 | Vrg | CNY 17-1 | S8b | PhC |
| BYW55 | S1 | R | BZWO3* | S1 | Vrg | CNY17-2 | S8b | PhC |
| BYW56 | S1 | R | BZW14 | S1 | Vrg | CNY17-3 | S8b | PhC |
| BYW92* | S2a | R | B2W86* | S2a | TS | CNY50 | S8b | PhC |
| BYW93* | S2a | R | BZX55* | S1 | Vrg | CNY57 | S8b | PhC |


| $*$ | $=$ series |
| ---: | :--- |
| M | $=$ Microwave transistors |
| Mm | $=$ Microminiature semiconductors |
|  | for hybrid circuits |
| PhC | $=$ Photocouplers |

R = Rectifier diodes
TS = Transient suppressor diodes
Vrf = Voltage reference diodes
$\mathrm{Vrg}=$ Voltage regulator diodes

INDEX

| type no. | book | section | type no. | book | section | type no. | book | section |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| CNY57A | S8b | PhC | CQW10B(L) | S8a | LED | CQY97A | S8a | LED |
| CNY57AU | S8b | PhC | CQW10U(L) | S8a | LED | Fresnel- | S8b | A |
| CNY57U | S8b | PhC | CQW11B(L) |  | LED | lens |  |  |
| CNY62 | S8b | PhC | CQW12B(L) |  | LED | H11A1 | S8b | PhC |
| CNY63 | S8b | PhC | CQW20A | S8a | LED | H11A2 | S8b | PhC |
| CQF24 | S8b | Ph | CQW2 1 | S8a | LED | H11A3 | 58b | PhC |
| CQL10A | S8b | Ph | CQW22 | S8a | LED | H11A4 | S8b | PhC |
| CQL13A | S8b | Ph | CQW24(L) | S8a | LED | H11A5 | 58b | PhC |
| CQL16 | 58b | Ph | CQW54 | 58a | LED | H11B1 | S8b | PhC |
| CQS51L | S8a | LED | CQW60(L) | S8a | LED | H11B2. | S8b | PhC |
| CQS54 | S8a | LED | CQW60A (L) | S8a | LED | H11B3 | S8b | PhC |
| C.QS82L | S8a | LED | CQW60U(L) |  | LED | H11B255 | S8b | PhC |
| CQS82AL | S8a | LED | CQW61(L) | S8a | LED | KMZ 10A | S 13 | SEN |
| CQS84L | S8a | L.ED | CQW62(L) | S8a | LED | KMZ 10B | S13 | SEN |
| CQS86L | S8a | LED | CQW89A | S8a/b | I | KMZ 10C | S13 | SEN |
| CQS93 | S8a | L.ED | CQW93 | S8a | LED | KP 100A | S13 | SEN |
| CQS93E | S8a | LED | CQW95 | S8a | LED | KP101A | S13 | SEN |
| CQS93L | S8a | LED | CQW97 | S8a | LED | KPZ20G | S13 | SEN |
| CQS95 | S8a | LED | CQX24(L) | S8a | LED | KPZ21G | S13 | SEN |
| CQS95E | S8a | LED | CQX51(L) | S8a | LED | KTY81* | S13 | SEN |
| CQS95L | S8a | LED | CQX54(L) | S8a | LED | KTY83* | S 13 | SEN |
| CQS97 | S8a | LED | CQX54D | 58a | LED | KTY84* | S13 | SEN |
| CQS97E | S8a | LED | CQX64(L) | S8a | LED | LAE2001R | S11 | M |
| CQS97L | S8a | LED | CQX64D | S8a | LED | LAE4001Q | S11 | M |
| CQT 10B | S8a | LED | CQX74(L) | S8a | LED | LAE4001R | S11 | M |
| CQT24 | S8a | LED | CQX74D | S8a | LED | LAE4002S | S11 | M |
| CQT60 | S8a | LED | CQY11B | S8b | LED | LAE6000Q | S11 | M |
| CQT70 | S8a | LED | CQY11C | 58b | LED | LBE1004R | S11 | M |
| CQT80L | S8a | LED | CQY24B(L) | S8a | LED | LBE1010R | S11 | M |
| CQV70(L) | S8a | LED | CQY49B | S8b | LED | LBE2003S | S11 | M |
| CQV70A (L) | S8a | LED | CQY49C | S8b | LED | LBE2005Q | S 11 | M |
| CQV70U(L) | S8a | LED | CQY50 | S8b | LED | IBE2008T | S11 | M |
| CQV71A(L) | S8a | LED | CQY52 | S8b | LED | LBE2009S | 511 | M |
| CQV72(L) | S8a | LED | CQY53S | S8b | LED | LCE1010R | S11 | M |
| CQV80L | S8a | LED | CQY54A | S8a | LED | LCE2003S | S11 | M |
| CQV80AL | S8a | LED | CQY58A | S8a/b | I | LCE2005Q | S11 | M |
| CQV80UL | S8a | LED | CQY89A | S8a/b | I | LCE2008T | S11 | M |
| CQV81L | S8a | LED | CQY94B(L) | S8a | LED | LCE2009S | S11 | M |
| CQV82L | S8a | LED | CQY95B | 58a | LED | LJE42002T | S11 | M |
| CQW10A (L) | S8a | I.ED | CQY96(L) | 58a | LED | LKEE1004R | S 11 | M |

[^49]$\mathrm{Ph}=$ Photoconductive devices
PhC = Photocouplers
SEN $=$ Sensors

| type no. | book | section | type no. | book | section | type no. | book | section |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| LKE2.002.T | S11 | M | OM320 | S10 | WBM | PDE1003U | S11 | M |
| LKE2004T | S11 | M | OM321 | S 10 | WBM | PDE 10050 | S 11 | M |
| LKE2015T | S11 | M | OM322 | S10 | WBM | PDE1010U | S11 | M |
| LKE2 1004R | S 11 | M | OM323 | S 10 | WBM | PEE 10010 | S 11 | M |
| LKE21015T | S11 | M | OM323A | S10 | WBM | PEE1003U | S11 | M |
| LKE2 1050T | S 11 | M | OM. 335 | S 10 | WBM | PEE1005U | S11 | M |
| LKE27010R | S11 | M | OM336 | S10 | WBM | PEE1010U | S 11 | M |
| LKE27025R | S 11 | M | OM337 | S 10 | WBM | PH2222; R | S3 | Sm |
| LKE32002T | S11 | M | OM337A | S10 | WBM | PH2222A; R | S3 | Sm |
| LKE32004T | S11 | M | OM339 | S 10 | WBM | PH2369 | S3 | Sm |
| LTE42005S | S 11 | M | OM345 | S10 | WBM | PH2907; R | S3 | Sm |
| LTE42008R | S 11 | M | OM350 | S 10 | WBM | PH2907A; R | S3 | Sm |
| LTE42012R | S11 | M | OM360 | S10 | WBM | PH2955T | S4a | P |
| LV1721E50R | S 11 | M | OM361 | S 10 | WBM | PH3055T | S4a | P |
| LV2024E45R | S11 | M | OM370 | S10 | WBM | PH5415 | S3 | Sm |
| LV2327E40R | S 11 | M | OM386B | S13 | SEN | PH5416 | S3 | Sm |
| LV3742E16R | S 11 | M | OM386M | S13 | SEN | PH13002 | S4b | SP |
| LV3742E24R | S 11 | M | OM387B | S13 | SEN | PH 13003 | S4b | SP |
| LWE2015R | S11 | M | OM387M | S13 | SEN | PHSD5 1 | S2a | R |
| LWE2025R | S11 | M | OM388B | S13 | SEN | PKB3001U | S11 | M |
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| MCA230 | 58b | PhC | OM931 | S4a | P | PKB3005U | S11 | M |
| MCA231 | S8b | PhC | OM961 | S4a | P | PKB12005U | S 11 | M |
| MCA255 | S8b | PhC | OSB9115 | S2a | St | PKB20010U | S11 | M |
| MCT2 | 58b | PhC | OSB9215 | S2a | St | PKB23001U | S11 | M |
| MCT26 | S8b | PhC | OSB9415 | S2a | St | PKB23003U | S11 | M |
| MKB12040WS | S 11 | M | OSM9115 | S2a | St | PKB23005U | S 11 | M |
| MKB12100WS | S11 | M | OSM9215 | S2a | St | PKB25006T | S11 | M |
| MKB12140W | 511 | M | OSM9415 | S2a | St | PKB32001U | S 11 | M |
| M06075B2002 | 2S11 | M | OSM9510 | S2a | St | PKB32003U | S11 | M |
| M06075B4002 | 2S 11 | M | OSM9511 | S2a | St | PKB32005U | S 11 | M |
| MRB12175YR | S 11 | M | OSM9512 | S2a | St | PMBF4391 | S7 | Mm |
| MRB12.350YR | S 11 | M | OSS9115 | S2a | St. | PMBF4392 | S7 | Mm |
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| MS6075B8002 | ZS 11 | M | OSS9415 | S2a | St | PMLL4148 | S1 | SD |
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| M20912B75Y | S 11 | M | PBMF4391 | S5 | FET | PMLL4151 | S1 | SD |
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| OM287; M | S 13 | SEN | PDE 1001 U | S11 | M | PMLL4448 | S1 | SD |


| FET | $=$ Field-effect transistors |
| :--- | :--- |
| I | $=$ Infrared devices |
| M | $=$ Microwave transistors |
| Mm | $=$ Microminiature semiconductors |
|  | $\quad$ for hybrid circuits |
| P | $=$ Low-frequency power transistors |
| PhC | $=$ Photocouplers |

M = Microwave transistors
$\mathrm{Mm}=$ Microminiature semiconductors for hybrid circuits
P = Low-frequency power transistors
PhC = Photocouplers

R = Rectifier diodes
SD = Small-signal diodes
SEN = Sensors
$\mathrm{Sm}=$ Small-signal transistors
SP = Low-frequency switching power transistors
St = Rectifier stacks
WBM = Wideband hybrid IC modules


| $*=$ series |  |  |
| :--- | :--- | :--- |
| I $=$ Infrared devices | R $=$ Rectifier diodes |  |
| M $=$ Microwave transistors | SD $=$ Small-signal diodes |  |
| P | $=$ Low-frequency power transistors | Vrf $=$ Voltage reference diodes |
| PhC | $=$ Photocouplers |  |


| type no. | book | section | type no. | book | section | type no. | book | section |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1N4005G | S1 | R | 2N2907 | S3 | Sm | 2N5400 | S3 | Sm |
| 1N4006G | S 1 | R | 2N2907A | S3 | Sm | 2N5401 | S3 | Sm |
| 1N4007G | S1 | R | 2N3019 | S3 | Sm | 2N5415 | S3 | Sm |
| 1N4148 | S1 | SD | 2N3020 | S3 | Sm | 2N5416 | S3 | Sm |
| 1N4150 | S1 | SD | 2N3053 | S3 | Sm | 2N5550 | S3 | Sm |
| 1N4151 | S1 | SD | 2N3375 | S6 | RFP | 2N5551 | S3 | Sm |
| 1N4153 | S1 | SD | 2N3553 | S6 | RFP | 2N6659 | S5 | FET |
| 1N4446 | S1 | SD | 2N3632 | S6 | RFP | 2N6660 | S5 | FET |
| 1N4448 | S1 | SD | 2N3822 | S5 | FET | 2N6661 | S5 | FET |
| 1N4531 | S1 | SD | 2N3823 | S5 | FET | 4N25 | S8b | PhC |
| 1N4532 | S1 | SD | 2N3866 | S6 | RFP | 4N25A | S8b | PhC |
| 1N5059 | S 1 | R | 2N3903 | S3 | Sm | 4N26 | S8b | PhC |
| 1N5060 | S1 | R | 2N3904 | S3 | Sm | 4N27 | S8b | PhC |
| 1N5061 | S1 | R | 2N3905 | S3 | Sm | 4N28 | S8b | PhC |
| 1N5062 | S1 | R | 2N3906 | S3 | Sm | 4N35 | S8b | PhC |
| 1N5225B |  |  | 2N3924 | S6 | RFP | 4N36 | S8b | PhC |
| to | S 1 | SD | 2N3926 | S6 | RFP | 4N37 | S8b | PhC |
| 1N5267B |  |  | 2N3927 | S6 | RFP | 4N38 | S8b | PhC |
| 2N918 | 510 | WBT | 2N3966 | S5 | FET | 4N38A | S8b | PhC |
| 2N929 | S3 | Sm | 2N4030 | S3 | Sm | 502CQF | S8b | Ph |
| 2N930 | S3 | Sm | 2N4031 | 53 | Sm | 503CQF | S8b | Ph |
| 2N1613 | S3 | Sm | 2N4032 | S3 | Sm | 504 CQL | S8b | Ph |
| 2N1711 | S3 | Sm | 2N4033 | S3 | Sm | 516CQF-B | S8b | Ph |
| 2N1893 | 53 | Sm | 2N4091 | S5 | FET | 56201d | S4b | A |
| 2N2219 | 53 | Sm | 2N4092 | S5 | FET | 56201j | S4b | A |
| 2N2219A | 53 | Sm | 2N4093 | S5 | FET | 56245 | S3, 10 |  |
| 2N2222 | S3 | Sm | 2N4123 | S3 | Sm | 56246 | S3,10 |  |
| 2N2222A | 53 | Sm | 2N4124 | S3 | Sm | 56261 a | S4b | A |
| 2N2297 | S3 | Sm | 2N4125 | S3 | Sm | 56264 | S2a/b | A |
| 2N2368 | 53 | Sm | 2N4126 | S3 | Sm | 56295 | S2a/b | A |
| 2N2369 | S3 | Sm | 2N4391 | S5 | FET | 56326 | S4b | A |
| 2N2369A | S3 | Sm | 2N4392 | S5 | FET | 56339 | S4b | A |
| 2N2483 | S3 | Sm | 2N4393 | S5 | FET | 56352 | S4b | A |
| 2N2484 | S3 | Sm | 2N4427 | S6 | RFP | 56353 | S4b | A |
| 2N2904 | S3 | Sm | 2N4856 | S5 | FET | 56354 | S4b | A |
| 2N2904A | S3 | Sm | 2N4857 | S5 | FET | 56359b | S2, 4b | A |
| 2N2905 | S3 | Sm | 2N4858 | S5 | FET | 56359c | S2,4b |  |
| 2N2905A | S3 | Sm | 2N4859 | S5 | FET | 56359d | S2,4b |  |
| 2N2906 | S3 | Sm | 2N4860 | S5 | FET | 56360a | S2,4b |  |
| 2N2906A | S3 | Sm | 2N4861 | S5 | FET | 56363 | S2,4b | A |

A = Accessories
FET $=$ Field-effect transistors
$\mathrm{Ph}=$ Photoconductive devices
PhC = Photocouplers
$\mathrm{R}=$ Rectifier diodes

RFP $=$ R.F. power transistors and modules
SD = Small-signal diodes
$\mathrm{Sm}=$ Small-signal transistors
WBT = Wideband transistors

| type no. | book section |
| :--- | :--- |
| 56364 | S2,4bA |
| 56367 | S2a/b A |
| 56368 b | S2,4bA |
| 56368 C | S2,4bA |
| 56369 | S2,4bA |
|  |  |
| 56378 | S2,4bA |
| 56379 | S2,4bA |
| $56387 \mathrm{a}, \mathrm{b}$ | S4b A |
| 56397 | S8b A |

$A=A c c e s s o r i e s$

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[^0]:    Page
    Bi-directional trigger device $B R 100 / 03: V_{(B O)}=28$ to $36 V^{\prime} I_{\text {FRMmax }}=2 \mathrm{~A}$ 177

[^1]:    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).
[^2]:    1) Practical minimum length
[^3]:    * Measured with gate-cathode connected together.

[^4]:    *Measured with gate-cathode connected together.

[^5]:    ＊Measured under pulse conditions to avoid excessive dissipation．
    ＊＊Below latching level the device behaves like a transistor with a gain dependent on current．

[^6]:    * Measured with gate-cathode connected together.

[^7]:    * Measured under pulse conditions to avoid excessive dissipation.
    ** Below latching level the device behaves like a transistor with a gain dependent on current.

[^8]:    * Measured with gate connected to cathode.

[^9]:    * Measured with gate-cathode connected together.
    ** From baseplate to all terminals strapped together.

[^10]:    * Measured under pulse conditions to avoid excessive dissipation.
    **Below latching level the device behaves like a transistor with a gain dependent on current.

[^11]:    * Measured with gate-cathode connected together.
    ** From baseplate to all terminals strapped together.

[^12]:    *Measured with gate-cathode connected together.
    **From baseplate to all terminals strapped together.

[^13]:    *Measured under pulse conditions to avoid excessive dissipation.
    **Below latching level the device behaves like a transistor with a gain dependent on current.

[^14]:    *Measured with gate-cathode connected together.
    **From baseplate to all terminals strapped together.

[^15]:    *Measured under pulse conditions to avoid excessive dissipation.
    **Below latching level the device behaves like a transistor with a gain dependent on current.

[^16]:    * Indicates stray series inductance only.
    ${ }^{*}{ }^{*}$ Minimum permissible GTO on-time $(\mu \mathrm{s})=5 \mathrm{R}_{\mathrm{S}}(\Omega) \mathrm{C}_{\mathrm{S}}(\mu \mathrm{F})$.

[^17]:    Pin 1 = gate (AMP 187 series)
    2 = cathode (AMP 250 series)
    3 = anode (AMP 250 series)
    Baseplate is electrically isolated.

[^18]:    * Measured with gate-cathode connected together.
    ** From baseplate to all terminals strapped together.

[^19]:    * Measured with gate-cathode connected together.
    ** From baseplate to all terminals strapped together.

[^20]:    * Measured under pulse conditions to avoid excessive dissipation.
    ** Below latching level the device behaves like a transistor with a gain dependent on current.

[^21]:    *Measured under pulse conditions to avoid excessive dissipation

[^22]:    *Measured with gate-cathode connected together.

[^23]:    *Indicates stray series inductance only.

[^24]:    ${ }^{*} \mathrm{R}_{\mathrm{GK}}=1 \mathrm{k} \Omega$

[^25]:    *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 $15 \mathrm{~A} / \mu \mathrm{s}$.

[^26]:    *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 $15 \mathrm{~A} / \mu \mathrm{s}$.

[^27]:    $\mathrm{T}_{\mathrm{stg}}$
    Tj

[^28]:    ${ }^{*} \mathrm{R}_{\mathrm{GK}}=1 \mathrm{k} \Omega$.

[^29]:    * To ensure thermal stability: $R_{\text {th } j-\mathrm{a}}<0,75^{\circ} \mathrm{C} / \mathrm{W}$ (d.c. blocking) or $<1,5^{\circ} \mathrm{C} / \mathrm{W}$ (a.c.). For smaller heatsinks $\mathrm{T}_{\mathrm{j} \text { max }}$ should be derated.

[^30]:    *To ensure thermal stability: $\mathrm{R}_{\mathrm{th} \mathrm{j}-\mathrm{a}}<4 \mathrm{~K} / \mathrm{W}$ (d.c. blocking) or $<8 \mathrm{~K} / \mathrm{W}$ (a.c.). For smaller heatsinks $\mathrm{T}_{\mathrm{j} \text { max }}$ should be derated. For a.c. see Fig.3.

[^31]:    * To ensure thermal stability: $R_{\text {th } j \text {-a }}<6,5^{\circ} \mathrm{C} / \mathrm{W}$ (d.c. blocking) or $<13^{\circ} \mathrm{C} / \mathrm{W}$ (a.c.). For smaller heatsinks $\mathrm{T}_{\mathrm{j} \text { max }}$ should be derated. For a.c. see Fig. 3.

[^32]:    *Measured under pulse conditions to avoid excessive dissipation.

[^33]:    * To ensure thermal stability: $R_{\text {th } j-a}<6,5^{\circ} \mathrm{C} / \mathrm{W}$ (d.c. blocking) or $<13^{\circ} \mathrm{C} / \mathrm{W}$ (a.c.). For smaller heatsinks $\mathrm{T}_{\mathrm{j} \text { max }}$ should be derated. For a.c. see Fig. 2.

[^34]:    *From baseplate to all three terminals connected together.

[^35]:    *Measured under pulse conditions to avoid excessive dissipation.

[^36]:    *From baseplate to all three terminals connected together.

[^37]:    *Measured under pulse conditions to avoid excessive dissipation.

[^38]:    *Measured under pulse conditions to avoid excessive dissipation.

[^39]:    * To ensure thermal stability: $R_{\text {th } j-a}<4,5^{\circ} \mathrm{C} / \mathrm{W}$ (d.c. blocking) or $<9^{\circ} \mathrm{C} / \mathrm{W}$ (a.c.). For smaller heatsinks $\mathrm{T}_{\mathrm{j} \text { max }}$ should be derated. For a.c. see Fig. 3.

[^40]:    * Measured under pulse conditions to avoid excessive dissipation.

[^41]:    *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 $3 \mathrm{~A} / \mu \mathrm{s}$.

[^42]:    *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 $6 \mathrm{~A} / \mu \mathrm{s}$.

[^43]:    *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 $6 \mathrm{~A} / \mu \mathrm{s}$.

[^44]:    *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 $15 \mathrm{~A} / \mu \mathrm{s}$.

[^45]:    *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 $15 \mathrm{~A} / \mu \mathrm{s}$.

[^46]:    * To ensure thermal stability: $\mathrm{R}_{\text {th } \mathrm{j}-\mathrm{a}}<6 \mathrm{~K} / \mathrm{W}$ (full-cycle or half-cycle operation). For smaller heat-sinks $T_{j}$ should be derated (see Fig.2).

[^47]:    * Measured under pulse conditions to avoid excessive dissipation.

[^48]:    Sp = Special diodes
    T = Tuner diodes
    $\mathrm{Vrg}=$ Voltage regulator diodes

[^49]:    * = series

    A =Accessories

