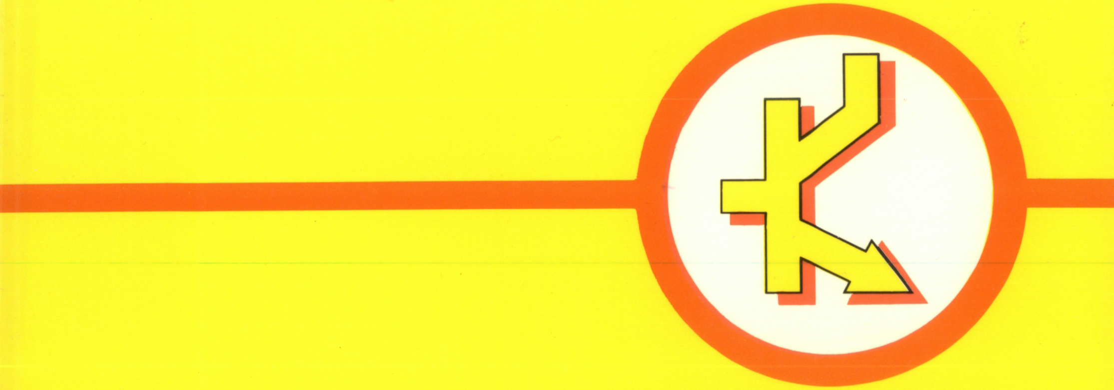
Technical Handbook
1990

# SUPER E-LINE TRANSISTORS



ZETEX

# Super E-line transistors

## ALTERNATIVE PACKAGE PIN-OUT CENTRE COLLECTOR

The data in this handbook relates to the Standard E-line package with collector-base-emitter pin out. Many devices in the range are also available with alternative base-collector-emitter pin out. Such devices are identified by the prefix FXT, and are electrically identical to the equivalent standard devices.

The FXT range is available with leadforms suitable for both through-hole and surface mount applications. Full details of the package outlines can be found on pages SE222 and SE223 of this handbook.

### CROSS REFERENCE

| Standard type | Centre Collector equivalent |
|---|---|
| BCX38C | FXT38C |
| MPSA42 | FXTA42 |
| MPSA92 | FXTA92 |
| ZTX449 | FXT449 |
| ZTX450 | FXT450 |
| ZTX451 | FXT451 |
| ZTX453 | FXT453 |
| ZTX455 | FXT455 |
| ZTX549 | FXT549 |
| ZTX550 | FXT550 |
| ZTX551 | FXT551 |
| ZTX553 | FXT553 |
| ZTX555 | FXT555 |
| ZTX557 | FXT557 |

| Standard type | Centre Collector equivalent |
|---|---|
| ZTX601B | FXT601B |
| ZTX603 | FXT603 |
| ZTX605 | FXT605 |
| ZTX649 | FXT649 |
| ZTX651 | FXT651 |
| ZTX653 | FXT653 |
| ZTX655 | FXT655 |
| ZTX657 | FXT657 |
| ZTX704 | FXT704 |
| ZTX749 | FXT749 |
| ZTX751 | FXT751 |
| ZTX753 | FXT753 |
| ZTX755 | FXT755 |
| ZTX757 | FXT757 |

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# Super E-line transistors

## -CONTENTS-

# Super E-line transistors

## GENERAL INFORMATION

This product guide contains full data on the Zetex range of Super E-line, medium power E-line and high voltage E-line plastic encapsulated transistors, as well as abbreviated data for quick reference. Application notes covering typical circuits are also included. The catalogue has been specifically designed to enable the engineer and buyer to rapidly select a Zetex preferred product. It contains five principle sections:

(a) Descriptions of Super E-line chip and package

(b) Product index - listings of commercial and quality assured products

(c) Selector tables - details of device types within application groups arranged to highlight the important characteristics in an easy to use format

(d) Technical data - full technical data for the individual types listed

(e) Application notes - covering typical examples of circuits using Super E-line transistors

## NEW PRODUCTS

The continual evolution of new products means that the Zetex range is being constantly updated. If your particular requirement is not covered herein, please do not hesitate to contact us for new product information.

## APPLICATIONS LABORATORY

An experienced team of applications engineers is available to give advice and active assistance with circuit design and system problems.

## CUSTOMER SPECIFICATIONS

Devices may be supplied against 'in-house' Zetex specifications to suit individual customer requirements for:

*(a)* Non-standard electrical, mechanical or environmental specifications.

*(b)* Customer procurement specifications.

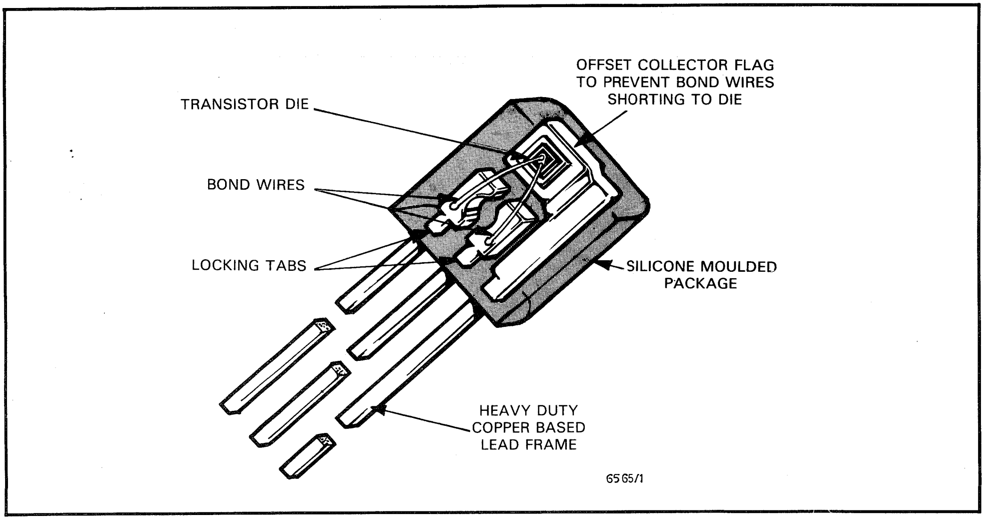
Device pricing will be dependant on the basic type, additional work involved, test yield and the quantity required.

# PRODUCT DESCRIPTION

## DESIGN FEATURES

The Zetex Super E-line range of complementary NPN and PNP transistors brings together advanced chip technology and assembly techniques to give Superior performance in a TO-92 style package. Parallel studies into chip design and assembly techniques have combined to produce the outstanding features of the Super E-line.

## E-line package - constructed for reliability



The Zetex E-line package has built a reputation for its reliability and advanced design. The Super E-line demanded even better performance, and a major study of eutectic die attach techniques produced void free die attach to give improved thermal and electrical characteristics.

## HIGH DISSIPATION

The improved chip construction together with void free die attach and silicone encapsulant has given a device with a true 1W dissipation at room temperature (25°C). this allows a practical power dissipation of up to 1.5W when the collector lead is soldered to an equivalent of 1 square inch of copper. An in-depth study of heat sink techniques in conjunction with Super E-line packages has shown that up to 2.5W can be handled.

## ENVIRONMENTAL PROTECTION

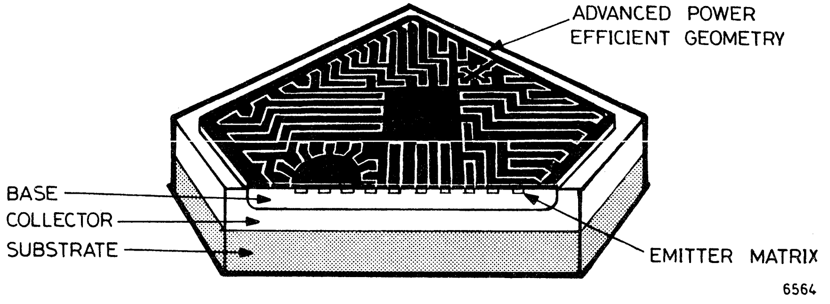
The silicone plastic used for the Zetex E-line encapsulation protects the active semiconductor chip from exposure to corrosive agents, moisture and extreme enironmental conditions.

The absence of ionic contamination in the Silicone allows chip operation up to 200°C without risk of failure. In regular tests conducted by the Zetex Reliability Group, E-line devices are operated at $T_{amb} = 230°C$ under reverse bias conditions. All devices must survive without degradation. This permits the wide operating and storage temperature range normally associated only with metal-can devices.

The E-line manufacturing process includes a resin backfill stage - a unique step that involves vacuum impregnation of the moulded package with silicone resin. This seals any voids which might exist between the lead frame and the encapsulant giving the package hermeticity properties approaching those of metal-can devices.

# Super E-line transistors

## Super E-line chip



### HIGH CURRENT GAIN

A major objective of the chip design was to produce a transistor with improved gain properties at high current levels. By utilising advanced power efficient geometries and diffusion techniques, minimum gains of 40 have been achieved at collector currents of 2A.

### LOW SATURATION VOLTAGE

Improvements in high current gain performance together with improved die attach techniques have combined to give an extremely low $V_{CE(sat)}$ specification.

### COMPLEMENTARY PAIRS

Selective chip design has produced the ZTX650 (NPN) and ZTX750 (PNP) series with excellent gain linearity, ideal for consumer applications including audio amplifiers and complementary drivers.

### WIDE VOLTAGE AND GAIN RANGES

Both NPN and PNP series are specified up to a $V_{CEO}$ maximum of 300V with d.c. gain specified up to 6A.

### HIGH CURRENT HANDLING CAPABILITY

Improvements in equalising current distribution across the chip (avoiding 'hot spots') has produced a continuous current ($I_C$) rating of 2A and peak pulse currents ($I_{CM}$) of 6A. This makes the ZTX650 and ZTX750 series ideal for applications such as solenoids, actuators, relays, lamp drivers, motor drivers and photo flash units.

### FAST SWITCHING - HIGH $f_T$

The planar epitaxial construction gives inherently fast switching speeds - 25ns turn on time at $I_C = 500mA$, and high $f_T$ - typically 175MHz for the ZTX650 and 140MHz for the ZTX750 at 100MHz.

### THE RESULT - MORE POWER FROM E-LINE

The Zetex Super E-line gives performance and reliability beyond standard TO-92 products and metal-can transistors. The package is approved over and beyond the full military temperature range. Zetex E-line transistors are currently in use in many military applications and have been approved for 20 years application use in telecommunication equipment.

## PERFORMANCE

As a direct result of the design features described, Zetex Super E-line transistors out perform similar types of plastic transistors. In addition to the wide range of industry standard types, Zetex has produced three ranges that fully exploit the unique features of E-line.

### Super E-LINE

Designated the ZTX650 and ZTX750 series.

The ultimate performance in E-line, featuring:

- Complementary NPN and PNP ranges
- 1W dissipation at $T_{amb}=25°C$
- 1.5W practical power dissipation
- Voltages up to 300V ($V_{CEO}$)
- Gains specified up to 6A
- Continuous current ($I_C$) to 2A
- Peak current to 6A
- Fast switching
- Excellent gain linearity

The Super E-line is designed to replace TO-39, TO-126, TO-202, TO-220 and TO-237 in free standing applications.

If your application demands continuous current up to 2A or peak currents up to 6A the Super E-line gives that performance at lower cost.

### HIGH PERFORMANCE E-LINE

Designated the ZTX450 and ZTX550 series, the range consists of NPN and PNP complementary types featuring:

- $V_{CEO}$ up to 300V
- $P_{tot}=1W$ at $T_{amb}=25°C$
- Continuous current ($I_C$) to 1A
- Peak current to 2A
- Gain specified up to 1A

The ZTX450/550 series are intended as full replacements for TO-39/TO-18 metal can transistors, and for medium current applications where a guaranteed gain up to 1A is required.

### HIGH VOLTAGE E-LINE

Designated for applications which require high voltages, low saturation voltages and low capacitance.

- $V_{CEO}$ up to 350V
- $I_C=500mA$
- $P_{tot}$ up to 1W at $T_{amb}=25°C$

# Super E-line transistors

## PACKAGE PERFORMANCE

The E-line package is formed by transfer moulding a silicone plastic specially selected to provide a rugged one-piece encapsulation, resistant to severe environments and allow the high junction temperature operation normally associated with metal-can devices. E-line encapsulated devices are approved for use in military, industrial and professional equipments.

The standard lead formation is collector-base-emitter (c-b-e) 'in-line'. Alternative lead configurations are available as plug-in replacements for TO-5/39 and TO-18 metal-can types, as well as for flat mounting and wider spacing.

The basic performance of E-line is dependent, to a certain degree, on the type of chip used in the package. The following summary may be used as a basic guide:

| | |
|---|---|
| Maximum collector current (continuous) | up to 2A* |
| Power dissipation (at $T_{amb}=25°C$) | 500 up to 1000mW* |
| Operating and storage temperature range | −55 to +200°C |

*Dependent on chip size.

## LEAD CONFIGURATION

The alternative lead configurations are denoted by a suffix such as K, L, M or S at the end of the part number.

e.g. ZTX650K where the K denotes that the leads are preformed to the TO-5/39 pin circle.

The available lead formations may be listed as:

| | |
|---|---|
| In-line | No suffix |
| TO-5/39 pin circle | Suffix K |
| TO-18 pin circle | Suffix L |
| Flat mounting | Suffix M |
| In-line wide-spacing | Suffix S |

## TAPED PRODUCT

E-line transistors can be supplied on tape for automatic insertion. Two types of packaging are available:

(a) Devices mounted on tape and the put on a reel which is then packed in a cardboard box.

(b) Devices mounted on tape and then folded in a concertina (or Z) form directly into a cardboard box (Ammo pack).

See page SE180 for further details of taped product.

## ORDERING INFORMATION

To order E-line transistors with alternative lead configurations, the following format should be used.

e.g. ZTX650L where L refers to TO-18 lead formation.

To order E-line transistors on tape, the following format should be used.

(a) Suffix 'STO' for product taped and supplied on reels.

(b) Orientation (option A or B).

(c) Suffix 'STZ' for product taped and folded (Ammo pack).

e.g. ZTX650STOA.

Orders in multiples of 2000 pieces only will be accepted for taped product.

*For pricing, ordering or technical information, contact:*

## BS 9000

At Zetex, quality and reliability are built into the product by rigorous control of all processing operations and by minimising random defects. Process management involves full documentation of procedures, recording of batch data, employment of extensive traceability procedures and the provision of appropriate equipment and facilities.

Statistical Process Control (SPC) is used extensively throughout the various process routes, with PPM programs in place on all product packaging lines.

Zetex is an approved vendor to major Aerospace, Automotive and Telecommunications manufacturers.

## QUALITY IMPROVEMENT

Zetex operates an active Quality Improvement System involving every employee in the organisation. The main goals are:

*The permanent elimination of defects and errors.*

*The continuing involvement of all employees in the improvement process.*

## CECC

Zetex, as a discrete semiconductor manufacturer, is approved by:

1. **The Civil Aviation Authority.**
2. **MOD(PE)** — DQAB to AQAP-1.
3. **British Standards Institution** to BS 9000, CECC 50 000 and IECQ 750 000.

BS, CECC and IECQ approved discrete semiconductors as listed in PD 9002 (qualified parts list) can be provided.

Where Zetex is not listed as an approved supplier or where approval is pending we may supply devices which have been subjected to the full quality assurance procedures as "tested to ..." subject to the basic types being available from Zetex. Similarly, Zetex may supply on a partial release basis such as "released to group A tests only."

Zetex can also generate detail specifications to customers' specific requirements that conform to BS, CECC, IECQ rules. E.g. British Telecom 20-year life requirement (D3007).

All products are shipped with a Certificate of Conformance to a minimum approval of AQAP-1.

# Super E-line transistors

## PRODUCT INDEX

| Device Type | BS/CECC number |  | Selector table | Technical data (page No.) |
|---|---|---|---|---|
|  | Prefix | Number |  |  |
| BCX38 |  |  | 5 | SE17 |
| BF391 |  |  | 4 | SE23 |
| BF392 |  |  | 7 | SE23 |
| BF393 |  |  | 7 | SE23 |
| BF491 |  |  | 7 | SE27 |
| BF492 |  |  | 7 | SE27 |
| BF493 |  |  | 7 | SE27 |
| BF493SP |  |  | 7 | SE31 |
| MPSA42 |  |  | 7 | SE33 |
| MPSA43 |  |  | 7 | SE33 |
| MPSA92 |  |  | 7 | SE37 |
| MPSA93 |  |  | 7 | SE37 |
| ZTX449 |  |  | 4 | SE41 |
| ZTX450 | BS9365 | F137(P) | 4 | SE47 |
|  | BS9365 | F139(Q) |  |  |
| ZTX451 | BS9365 | F138(P) | 4 | SE47 |
|  | BS9365 | F140(Q) |  |  |
| ZTX452 |  |  | 4 | SE53 |
| ZTX453 |  |  | 4 | SE53 |
| ZTX454 |  |  | 4 | SE59 |
| ZTX455 |  |  | 4 | SE59 |
| ZTX549 |  |  | 4 | SE65 |
| ZTX550 | BS9365 | F143(F)* | 4 | SE71 |
| ZTX551 | BS9365 | F144(F)* | 4 | SE71 |
| ZTX552 |  |  | 4 | SE77 |
| ZTX553 |  |  | 4 | SE77 |
| ZTX554 |  |  | 4,7 | SE83 |
| ZTX555 |  |  | 4,7 | SE83 |
| ZTX556 |  |  | 7 | SE83 |
| ZTX557 |  |  | 7 | SE83 |
| ZTX576 |  |  | 7 | SE91 |
| ZTX600 | 50002 | 286(F)* | 5 | SE97 |
| ZTX601 | 50002 | 286(F)* | 5 | SE97 |
| ZTX602 | 50002 | 288(F)* | 5 | SE103 |
| ZTX603 | 50002 | 288(F)* | 5 | SE103 |
| ZTX604 | 50002 | 288(F)* | 5 | SE109 |
| ZTX605 | 50002 | 288(F)* | 5 | SE109 |

## PRODUCT INDEX

| Device Type | BS/CECC number | | Selector table | Technical data (page No.) |
|---|---|---|---|---|
| | Prefix | Number | | |
| ZTX614 | | | 5 | SE115 |
| ZTX649 | | | 1 | SE117 |
| ZTX650 | 50002 | 138(F)* | 1 | SE123 |
| ZTX651 | 50002 | 138(F)* | 1 | SE123 |
| ZTX652 | 50002 | 138(F)* | 1 | SE123 |
| ZTX653 | 50002 | 138(F)* | 1 | SE123 |
| ZTX654 | | | 7 | SE133 |
| ZTX655 | | | 7 | SE133 |
| ZTX656 | | | 7 | SE139 |
| ZTX657 | | | 7 | SE139 |
| ZTX689B | | | 2 | SE145 |
| ZTX690B | | | 2 | SE145 |
| ZTX692B | | | 2 | SE145 |
| ZTX694B | | | 2 | SE145 |
| ZTX704 | 50002 | 287(F)* | 6 | SE149 |
| ZTX705 | 50002 | 287(F)* | 6 | SE149 |
| ZTX712 | | | 6 | SE155 |
| ZTX749 | | | 1 | SE157 |
| ZTX750 | 50002 | 137(F)* | 1 | SE163 |
| ZTX751 | 50002 | 137(F)* | 1 | SE163 |
| ZTX752 | 50002 | 137(F)* | 1 | SE163 |
| ZTX753 | 50002 | 137(F)* | 1 | SE163 |
| ZTX754 | | | 7 | SE173 |
| ZTX755 | | | 7 | SE173 |
| ZTX756 | | | 7 | SE179 |
| ZTX757 | | | 7 | SE179 |
| ZTX776 | | | 7 | SE185 |
| 2N6714 | | | 3 | SE191 |
| 2N6715 | | | 3 | SE191 |
| 2N6716 | | | 3 | SE194 |
| 2N6717 | | | 3 | SE194 |
| 2N6718 | | | 3 | SE194 |
| 2N6724 | | | 3 | SE195 |
| 2N6725 | | | 3 | SE195 |
| 2N6726 | | | 3 | SE191 |
| 2N6727 | | | 3 | SE191 |
| 2N6728 | | | 3 | SE193 |
| 2N6729 | | | 3 | SE193 |
| 2N6730 | | | 3 | SE193 |
| 2N6731 | | | 3 | SE197 |
| 2N6732 | | | 3 | SE197 |

Note: (F), (P) or (Q) are BS categories.
Cat. F–* indicates full plus additional assessment.

# Super E-line transistors

## TABLE 1 : NPN/PNP SUPER E-LINE

These devices offer the ultimate performance for TO-92 style package. they have been designed to operate and provide useful gain at current levels up to 6A with power dissipation capabilities in excess of 1W at 25°C ambient temperature.

| Type | $V_{CBO}$ | $V_{CEO}$ | Max. cont $I_C$ | Max. $I_{CM}$ | Max. $V_{CE(sat)}$ at | | | $h_{FE}$ at | | Min. $f_T$ at | | $P_{tot}$ at $T_{amb}$ =25°C | Complement |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | V | V | A | A | V | $I_C$ A | $I_B$ A | Min. | $I_C$ A | MHz | $I_C$ mA | mW | |
| **NPN** | | | | | | | | | | | | | |
| ZTX653 | 120 | 100 | 2 | 6 | 0.5 | 2 | 0.2 | 25 | 2 | 140 | 100 | 1000 | ZTX753 |
| ZTX652 | 100 | 80 | 2 | 6 | 0.5 | 2 | 0.2 | 25 | 2 | 140 | 100 | 1000 | ZTX752 |
| ZTX651 | 80 | 60 | 2 | 6 | 0.5 | 2 | 0.2 | 40 | 2 | 140 | 100 | 1000 | ZTX751 |
| ZTX650 | 60 | 45 | 2 | 6 | 0.5 | 2 | 0.2 | 40 | 2 | 140 | 100 | 1000 | ZTX750 |
| ZTX649 | 35 | 25 | 2 | 6 | 0.5 | 2 | 0.2 | 75 | 2 | 150 | 100 | 1000 | ZTX749 |
| **PNP** | | | | | | | | | | | | | |
| ZTX753 | 120 | 100 | 2 | 6 | 0.5 | 2 | 0.2 | 40 | 2 | 100 | 100 | 1000 | ZTX653 |
| ZTX752 | 100 | 80 | 2 | 6 | 0.5 | 2 | 0.2 | 40 | 2 | 100 | 100 | 1000 | ZTX652 |
| ZTX751 | 80 | 60 | 2 | 6 | 0.5 | 2 | 0.2 | 25 | 2 | 100 | 100 | 1000 | ZTX651 |
| ZTX750 | 60 | 45 | 2 | 6 | 0.5 | 2 | 0.2 | 25 | 2 | 100 | 100 | 1000 | ZTX650 |
| ZTX749 | 35 | 25 | 2 | 6 | 0.5 | 2 | 0.2 | 75 | 2 | 100 | 100 | 1000 | ZTX649 |

## TABLE 2 : NPN HIGH GAIN SUPER E-LINE

A range of high gain, high performance, medium power devices designed to replace Darlington transistors in applications where low saturation voltages are required. Ideally suited for battery-driven applications.

| Type | $V_{CBO}$ $V_{CEO}$ | Max. cont $I_C$ | Max. $I_{CM}$ | Max. $V_{CE(sat)}$ at | | | $h_{FE}$ at | | Min. $f_T$ at | | $P_{tot}$ at $T_{amb}$ =25°C |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | V | A | A | V | $I_C$ mA | $I_B$ mA | Min. | $I_C$ mA | MHz | $I_C$ mA | mW |
| ZTX694B | 120 | 0.5 | 1 | 0.5 | 400 | 5 | 400 | 200 | 150 | 50 | 1000 |
| ZTX692B | 70 | 1 | 2 | 0.5 | 1000 | 10 | 400 | 500 | 150 | 50 | 1000 |
| ZTX690B | 45 | 2 | 6 | 0.5 | 2000 | 40 | 400 | 1000 | 150 | 50 | 1000 |
| ZTX689B | 20 | 3 | 8 | 0.5 | 2000 | 10 | 400 | 2000 | 150 | 50 | 1000 |

## TABLE 3 : 2N6700 SERIES MEDIUM POWER TRANSISTORS

| NPN | PNP | $V_{CBO}$ V | $V_{CEO}$ V | Max. Cont. $I_C$ A | Max. $I_{CM}$ A | Max. $V_{CE(sat)}$ at V | $I_C$ mA | $I_B$ mA | $h_{FE}$ at Min. | Max. | $I_C$ mA | Min. $f_T$ at MHz | $I_C$ mA | $P_{tot}$ at $T_{amb}$ =25°C mW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2N6714 | 2N6726 | 40 | 30 | 1 | 2 | 0.5 | 1000 | 100 | 50 | 250 | 1000 | 50 | 50 | 1000 |
| 2N6715 | 2N6727 | 50 | 40 | 1 | 2 | 0.5 | 1000 | 100 | 50 | 250 | 1000 | 50 | 50 | 1000 |
| 2N6724 | – | 50 | 40 | 1 | 2 | 1.5 | 1000 | 2 | 4K | 40K | 1000 | – | – | 1000 |
| 2N6725 | – | 60 | 50 | 1 | 2 | 1.5 | 1000 | 2 | 4K | 40K | 1000 | – | – | 1000 |
| 2N6716 | 2N6728 | 60 | 60 | 1 | 2 | 0.35 | 250 | 25 | 50 | 250 | 250 | 50 | 50 | 1000 |
| 2N6717 | 2N6729 | 80 | 80 | 1 | 2 | 0.35 | 250 | 25 | 50 | 250 | 250 | 50 | 50 | 1000 |
| 2N6731 | 2N6732 | 100 | 80 | 1 | 2 | 0.35 | 350 | 35 | 100 | 300 | 350 | 50 | 200 | 1000 |
| 2N6718 | 2N6730 | 100 | 100 | 1 | 2 | 0.35 | 250 | 25 | 50 | 250 | 250 | 50 | 50 | 1000 |

## TABLE 4 : NPN/PNP HIGH PERFORMANCE E-LINE

The devices shown in this table have been designed to operate and provide useful gain at current levels up to 1A with power dissipation capabilities up to 1W at 25°C ambient temperature.

| Type | $V_{CBO}$ V | $V_{CEO}$ V | Max. cont $I_C$ A | Max. $I_{CM}$ A | Max. $V_{CE(sat)}$ at V | $I_C$ mA | $I_B$ mA | $h_{FE}$ at Min. | $I_C$ mA | Min. $f_T$ at MHz | $I_C$ mA | $P_{tot}$ at $T_{amb}$ =25°C mW | Complement |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **NPN** | | | | | | | | | | | | | |
| ZTX455 | 160 | 140 | 1 | 2 | 0.7 | 150 | 15 | 100 | 150 | 100 | 50 | 1000 | ZTX555 |
| ZTX454 | 140 | 120 | 1 | 2 | 0.7 | 150 | 15 | 100 | 150 | 100 | 50 | 1000 | ZTX554 |
| ZTX453 | 120 | 100 | 1 | 2 | 0.7 | 150 | 15 | 40 | 150 | 150 | 50 | 1000 | ZTX553 |
| ZTX452 | 100 | 80 | 1 | 2 | 0.7 | 150 | 15 | 40 | 150 | 150 | 50 | 1000 | ZTX552 |
| ZTX451 | 80 | 60 | 1 | 2 | 0.35 | 150 | 15 | 50 | 150 | 150 | 50 | 1000 | ZTX551 |
| ZTX450 | 60 | 45 | 1 | 2 | 0.25 | 150 | 15 | 100 | 150 | 150 | 50 | 1000 | ZTX550 |
| ZTX449 | 50 | 30 | 1 | 2 | 0.5 | 1000 | 100 | 100 | 500 | 150 | 50 | 1000 | ZTX549 |
| **PNP** | | | | | | | | | | | | | |
| ZTX555 | 160 | 150 | 1 | 2 | 0.3 | 100 | 10 | 50 | 300 | 100 | 50 | 1000 | ZTX455 |
| ZTX554 | 140 | 125 | 1 | 2 | 0.3 | 100 | 10 | 50 | 300 | 100 | 50 | 1000 | ZTX454 |
| ZTX553 | 120 | 100 | 1 | 2 | 0.25 | 150 | 15 | 40 | 150 | 150 | 50 | 1000 | ZTX453 |
| ZTX552 | 100 | 80 | 1 | 2 | 0.25 | 150 | 15 | 40 | 150 | 150 | 50 | 1000 | ZTX452 |
| ZTX551 | 80 | 60 | 1 | 2 | 0.35 | 150 | 15 | 50 | 150 | 150 | 50 | 1000 | ZTX451 |
| ZTX550 | 60 | 45 | 1 | 2 | 0.25 | 150 | 15 | 100 | 150 | 150 | 50 | 1000 | ZTX450 |
| ZTX549 | 35 | 30 | 1 | 2 | 0.5 | 1000 | 100 | 100 | 500 | 100 | 100 | 1000 | ZTX449 |

# Super E-line transistors

## TABLE 5 : NPN HIGH PERFORMANCE DARLINGTONS

The devices shown in this table are designed for applications requiring very high current gain at current levels up to 1A and power dissipation up to 1W.

| Type | $V_{CBO}$ | $V_{CEO}$ | Max. $I_C$ cont. | Max. $I_{CM}$ | Max $V_{CE(sat)}$ at | | | $h_{FE}$ | | at | $f_T$ MHz | $P_{tot}$ at $T_{amb} =$ 25°C | Complement |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | V | V | A | A | V | $I_C$ mA | $I_B$ mA | Min. | Max. | $I_C$ mA | Min. | mW | |
| ZTX601 | 180 | 160 | 1 | 4 | 1.2 | 1000 | 10 | 2000 | 100,000 | 500 | 150 | 1000 | — |
| ZTX600 | 160 | 140 | 1 | 4 | 1.2 | 1000 | 10 | 2000 | 100,000 | 500 | 150 | 1000 | — |
| ZTX605 | 140 | 120 | 1 | 4 | 1.5 | 1000 | 1 | 5000 | — | 500 | 150 | 1000 | ZTX705 |
| ZTX604 | 120 | 100 | 1 | 4 | 1.5 | 1000 | 1 | 5000 | — | 500 | 150 | 1000 | ZTX704 |
| ZTX614 | 120 | 100 | 0.8 | 2 | 1.25 | 800 | 8 | 10000 | — | 500 | — | 1000 | |
| ZTX603 | 100 | 80 | 1 | 4 | 1.0 | 1000 | 1 | 5000 | — | 500 | 150 | 1000 | — |
| ZTX602 | 80 | 60 | 1 | 4 | 1.0 | 1000 | 1 | 5000 | — | 500 | 150 | 1000 | — |
| BCX38C | 80 | 60 | 0.8 | 2 | 1.25 | 800 | 8 | 10000 | — | 500 | — | 1000 | ZTX712 |
| BCX38B | 80 | 60 | 0.8 | 2 | 1.25 | 800 | 8 | 4000 | — | 500 | — | 1000 | — |
| BCX38A | 80 | 60 | 0.8 | 2 | 1.25 | 800 | 8 | 1000 | — | 500 | — | 1000 | — |

## TABLE 6 : PNP HIGH PERFORMANCE DARLINGTONS

| Type | $V_{CBO}$ | $V_{CEO}$ | Max. $I_C$ cont. | Max. $I_{CM}$ | Max $V_{CE(sat)}$ at | | | $h_{FE}$ | | at | $f_T$ MHz | $P_{tot}$ at $T_{amb} =$ 25°C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | V | V | A | A | V | $I_C$ mA | $I_B$ mA | Min. | Max. | $I_C$ mA | Min. | mW |
| ZTX705 | 140 | 120 | 1 | 4 | 1.3 | 1000 | 1 | 3000 | 30000 | 1000 | — | 1000 |
| ZTX704 | 120 | 100 | 1 | 4 | 1.3 | 1000 | 1 | 3000 | 30000 | 1000 | — | 1000 |
| ZTX712 | 80 | 60 | 0.8 | 2 | 1.25 | 800 | 8 | 10000 | — | — | — | 1000 |

## TABLE 7 : NPN/PNP HIGH VOLTAGE TRANSISTORS

The transistors shown in this table are designed for driving numerical indicator tubes, neon lamps and other applications requiring high voltage capability.

| Type | $V_{CBO}$ V | $V_{CEO}$ V | Max $I_C$ mA | Max $V_{CE(sat)}$ V | at $I_C$ mA | at $I_B$ mA | $h_{FE}$ Min | $h_{FE}$ Max | at $I_C$ mA | Max $I_{CBO}$ µA | at $V_{CB}$ V | $P_{tot}$ at $T_{amb}$ = 25°C mW | Complement |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **NPN** | | | | | | | | | | | | | |
| ZTX657 | 300 | 300 | 500 | 0.5 | 100 | 10 | 50 | – | 100 | 0.1 | 200 | 1000 | ZTX757 |
| MPSA42 | 300 | 300 | 500 | 0.5 | 20 | 2.0 | 40 | – | 10 | 0.1 | 200 | 680 | MPSA92 |
| BF393 | 300 | 300 | 500 | 2.0 | 20 | 2.0 | 40 | – | 10 | 0.1 | 200 | 625 | BF493 |
| BF392 | 250 | 250 | 500 | 2.0 | 20 | 2.0 | 40 | – | 10 | 0.1 | 200 | 625 | BF492 |
| ZTX656 | 200 | 200 | 500 | 0.5 | 100 | 10 | 50 | – | 100 | 0.1 | 160 | 1000 | ZTX756 |
| MPSA43 | 200 | 200 | 500 | 0.4 | 20 | 2.0 | 40 | – | 10 | 0.1 | 160 | 680 | MPSA93 |
| BF391 | 200 | 200 | 500 | 2.0 | 20 | 2.0 | 40 | – | 10 | 0.1 | 160 | 625 | BF491 |
| ZTX655 | 150 | 150 | 1000 | 0.5 | 1000 | 200 | 50 | – | 500 | 0.1 | 125 | 1000 | ZTX755 |
| ZTX455 | 160 | 140 | 1000 | 0.7 | 150 | 15 | 100 | 300 | 150 | 0.1 | 140 | 1000 | ZTX555 |
| ZTX654 | 125 | 125 | 1000 | 0.5 | 1000 | 200 | 50 | – | 500 | 0.1 | 100 | 1000 | ZTX754 |
| ZTX454 | 140 | 120 | 1000 | 0.7 | 150 | 15 | 100 | 300 | 150 | 0.1 | 120 | 1000 | ZTX554 |
| **PNP** | | | | | | | | | | | | | |
| BF493SP | 350 | 350 | 500 | 2.0 | 20 | 2.0 | 40 | – | 10 | 0.005 | 250 | 625 | – |
| ZTX757 | 300 | 300 | 500 | 0.5 | 100 | 10 | 50 | – | 100 | 0.1 | 200 | 1000 | ZTX657 |
| ZTX557 | 300 | 300 | 500 | 0.3 | 50 | 5 | 50 | 300 | 50 | 0.1 | 200 | 1000 | – |
| MPSA92 | 300 | 300 | 500 | 0.5 | 20 | 2.0 | 40 | – | 10 | 0.1 | 200 | 680 | MPSA42 |
| BF493 | 300 | 300 | 500 | 2.0 | 20 | 2.0 | 40 | – | 10 | 0.1 | 200 | 625 | BF393 |
| BF492 | 250 | 250 | 500 | 2.0 | 20 | 2.0 | 40 | – | 10 | 0.1 | 200 | 625 | BF392 |
| ZTX776 | 200 | 200 | 1000 | 0.5 | 1000 | 200 | 50 | – | 500 | 0.1 | 160 | 1000 | – |
| ZTX576 | 200 | 200 | 1000 | 0.3 | 100 | 10 | 50 | 300 | 300 | 0.1 | 160 | 1000 | – |
| ZTX756 | 200 | 200 | 500 | 0.5 | 100 | 10 | 50 | – | 100 | 0.1 | 160 | 1000 | ZTX656 |
| ZTX556 | 200 | 200 | 500 | 0.3 | 50 | 5 | 50 | 300 | 50 | 0.1 | 160 | 1000 | – |
| MPSA93 | 200 | 200 | 500 | 0.4 | 20 | 2.0 | 40 | – | 10 | 0.1 | 160 | 680 | MPSA43 |
| BF491 | 200 | 200 | 500 | 2.0 | 20 | 2.0 | 40 | – | 10 | 0.1 | 160 | 625 | BF391 |
| ZTX755 | 150 | 150 | 1000 | 0.5 | 1000 | 200 | 50 | – | 500 | 0.1 | 125 | 1000 | ZTX655 |
| ZTX555 | 160 | 150 | 1000 | 0.3 | 100 | 10 | 50 | 300 | 300 | 0.1 | 140 | 1000 | ZTX455 |
| ZTX754 | 125 | 125 | 1000 | 0.5 | 1000 | 200 | 50 | – | 500 | 0.1 | 100 | 1000 | ZTX654 |
| ZTX554 | 140 | 125 | 1000 | 0.3 | 100 | 10 | 50 | 300 | 300 | 0.1 | 120 | 1000 | ZTX454 |

# TECHNICAL DATA

## CONTENTS

# NPN Silicon Planar Medium Power Darlington Transistors

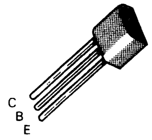
## BCX38A
## BCX38B
## BCX38C

### FEATURES

- 1.5W power dissipation
- 0.8A continuous collector current
- $h_{FE}$ up to 10,000 at $I_C = 500\,mA$
- Fast switching

### DESCRIPTION

The BCX38 series of silicon planar Darlington transistors is designed for medium power applications requiring very high current gain and high input impedance. The monolithic construction has the inherent advantages of fast switching times, low saturation voltages and low leakage currents. Application areas include: driver and output stages of audio amplifiers; direct interfacing with integrated circuits; lamp, relay and hammer driving.



Plastic E-Line
(TO-92 Compatible)

The E-line package is formed by transfer moulding a silicone plastic specially selected to provide a rugged one-piece encapsulation resistant to severe environments and allow the high junction temperature operation normally associated with metal can devices.

E-line encapsulated devices are approved for use in military, industrial and professional equipments.

Alternative lead configurations are available as plug-in replacements to TO-5/39 and TO-18 metal can types, and for surface mounting.

### ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | Value | Unit |
|---|---|---|---|
| Collector-Base Voltage | $V_{CBO}$ | 80 | V |
| Collector-Emitter Voltage (Note 1) | $V_{CEO}$ | 60 | V |
| Emitter-Base Voltage | $V_{EBO}$ | 10 | V |
| Peak Pulse Current | $I_{CM}$ | 2 | A |
| Continuous Collector Current | $I_C$ | 800 | mA |
| Practical Power Dissipation (Note 2) | $P_{totp}$ | 1.5 | W |
| Power Dissipation at $T_{amb} = 25°C$<br>at $T_{case} = 25°C$ | $P_{tot}$ | 1<br>2 | W<br>W |
| Operating and Storage Temperature Range (Note 1) | | −55 to +200 | °C |

Note 1: The maximum values of $V_{CEO}$ and Power Dissipation are dependent on operating temperature. See Voltage Derating Graph (Fig. 1) for maximum power dissipation and operating temperature in a given application.

Note 2: The power which can be dissipated assuming device mounted in typical manner on PCB with copper equal to 1 sq. inch minimum.

# BCX38A, BCX38B, BCX38C

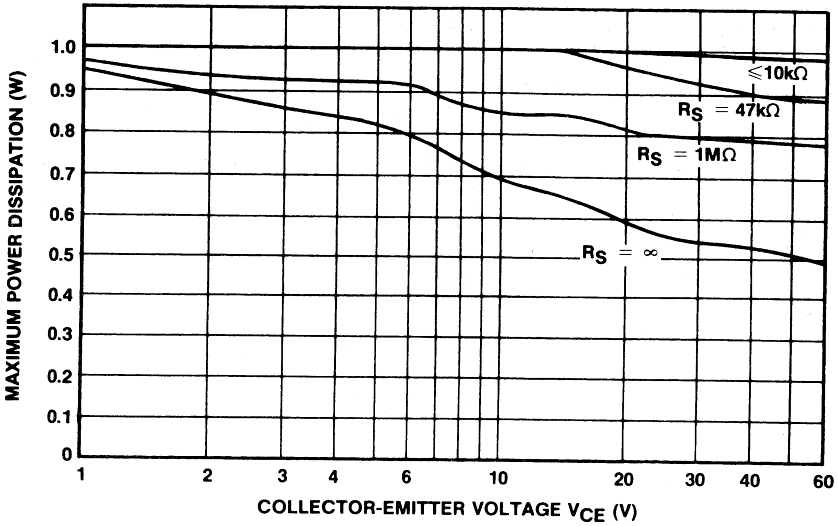
ELECTRICAL CHARACTERISTICS (at $T_{amb} = 25°C$).

| Parameter | Symbol | Min. | Max. | Unit | Test Conditions |
|---|---|---|---|---|---|
| Collector-base breakdown voltage | $V_{(BR)CBO}$ | 80 | – | V | $I_C = 10\mu A$, $I_E = 0$ |
| Collector-emitter sustaining voltage | $V_{CEO(sus)}$ | 60 | – | V | $I_C = 10mA$, $I_B = 0$ |
| Emitter-base breakdown voltage | $V_{(BR)EBO}$ | 10 | – | V | $I_E = 10\mu A$, $I_C = 0$ |
| Collector-base cut-off current | $I_{CBO}$ | – | 100 | nA | $V_{CB} = 60V$, $I_E = 0$ |
| Emitter-base cut-off current | $I_{EBO}$ | – | 100 | nA | $V_{EB} = 8V$, $I_C = 0$ |
| Static forward current transfer ratio | $h_{FE}$ | | | | |
| **BCX38A** | | 500<br>1000 | –<br>– | –<br>– | $I_C = 100mA$, $V_{CE} = 5V$*<br>$I_C = 500mA$, $V_{CE} = 5V$* |
| **BCX38B** | | 2000<br>4000 | –<br>– | –<br>– | $I_C = 100mA$, $V_{CE} = 5V$*<br>$I_C = 500mA$, $V_{CE} = 5V$* |
| **BCX38C** | | 5000<br>10000 | –<br>– | –<br>– | $I_C = 100mA$, $V_{CE} = 5V$*<br>$I_C = 500mA$, $V_{CE} = 5V$* |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | – | 1.25 | V | $I_C = 800mA$, $I_B = 8mA$* |
| Base-emitter on voltage | $V_{BE(on)}$ | – | 1.8 | V | $I_C = 800mA$, $V_{CE} = 5V$* |

*Measured under pulsed conditions. Pulse width $= 300\mu s$. Duty cycle $\leqslant 2\%$.

THERMAL CHARACTERISTICS

| Characteristic | Symbol | Max. Value | Unit |
|---|---|---|---|
| Thermal Resistance: Junction to Ambient | $R_{th(j-amb)}$ | 175.0 | °C/W |
| Junction to Case | $R_{th(j-case)}$ | 87.5 | °C/W |



Voltage derating graph

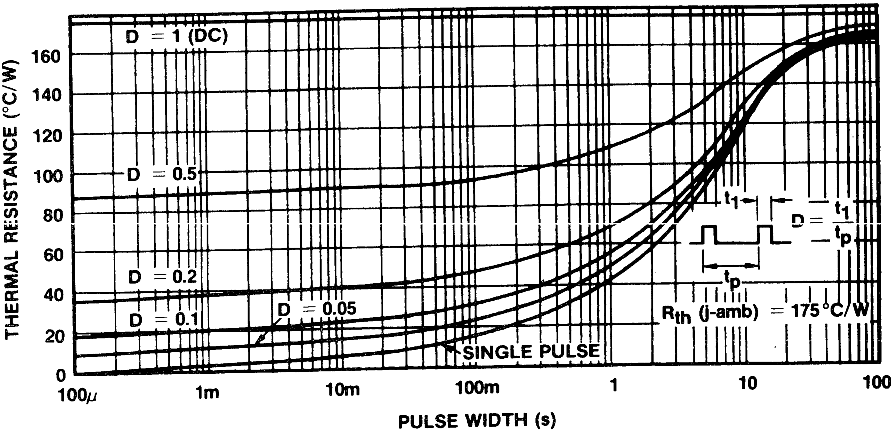
The maximum permissible operational temperature can be obtained from Fig. 1 using the equation:

$$T_{amb(max)} = \frac{\text{Power (max)} - \text{Power (actual)}}{0.0057} + 25°\text{C}$$

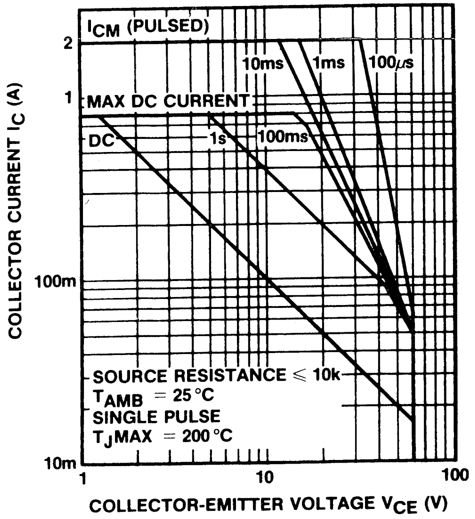
$T_{amb(max)}$ = Maximum operating ambient temperature.

Power (max) = Maximum power dissipation figure, obtained from Fig. 1 for a given $V_{CE}$ and source resistance ($R_S$).

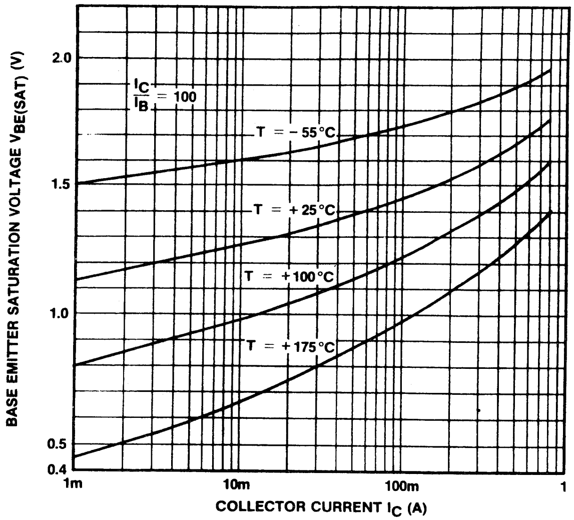
Power (actual) = Actual power dissipation in users circuit.



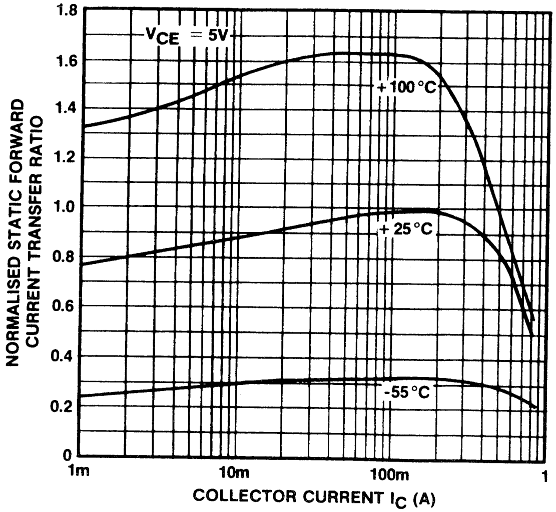
Maximum transient thermal impedance curves



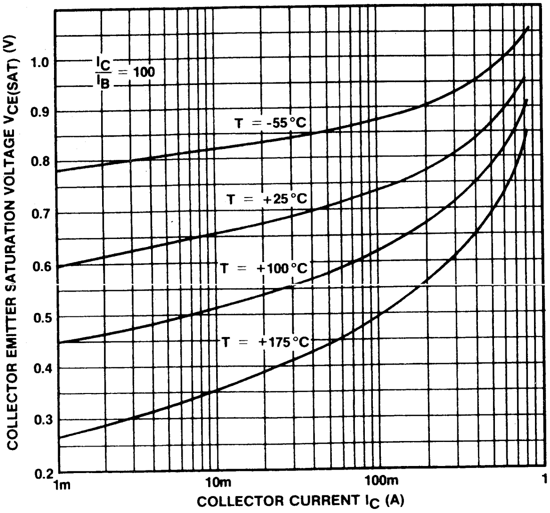
Safe operating area at $T_{amb} = 25°C$ (single pulse)



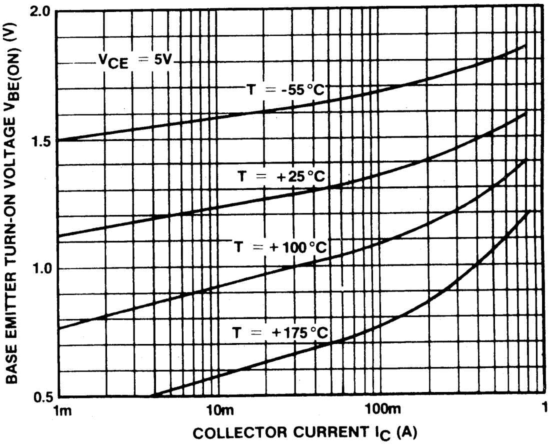
Typical base-emitter saturation voltages plotted against collector current



Typical static forward current transfer ratio plotted against collector current



Typical collector-emitter saturation voltages plotted against collector current



Typical base-emitter turn-on voltages plotted against collector current

# NPN Silicon Planar High Voltage Transistors

# BF391 BF392 BF393

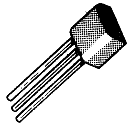
## DESCRIPTION

These plastic encapsulated, general purpose transistors are designed for applications requiring high breakdown voltage, low saturation voltages, and low capacitance.

The E-line package is formed by transfer moulding a silicone plastic specially selected to provide a rugged one-piece encapsulation resistant to severe environments and allow the high junction temperature operation normally associated with metal can devices.

E-line encapsulated devices are approved for use in military, industrial and professional equipments.

Alternative lead configurations are available as plug-in replacements of TO-5/39 and TO-18 metal can types, and for surface mounting.



Plastic E-Line
(TO-92 Compatible)

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | BF391 | BF392 | BF393 | Unit |
|---|---|---|---|---|---|
| Collector-base voltage | $V_{CBO}$ | 200 | 250 | 300 | V |
| Collector-emitter voltage | $V_{CEO}$ | 200 | 250 | 300 | V |
| Emitter-base voltage | $V_{EBO}$ | 6 | | | V |
| Continuous collector current | $I_C$ | 500 | | | mA |
| Power dissipation at ($T_{amb} = 25°C$)<br>at $T_{case} = 25°C$ | $P_{tot}$ | 625<br>1.5 | | | mW<br>W |
| Operating and storage temperature range | $T_j$:$T_{stg}$ | −55 to +175 | | | °C |

## THERMAL CHARACTERISTICS

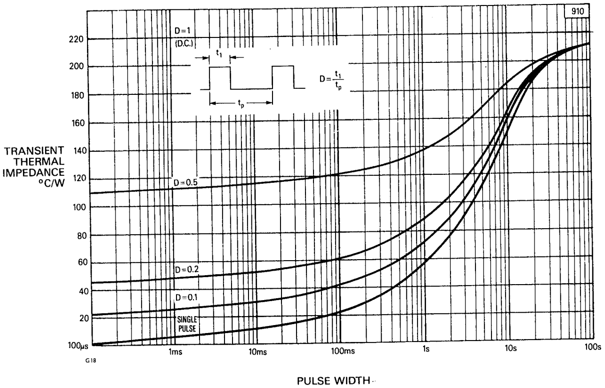
| Parameter | Symbol | Maximum | Unit |
|---|---|---|---|
| Thermal resistance: Junction to ambient | $R_{th(j-amb)}$ | 220 | °C/W |
| Junction to case | $R_{th(j-case)}$ | 80 | °C/W |

# BF391 BF392 BF393

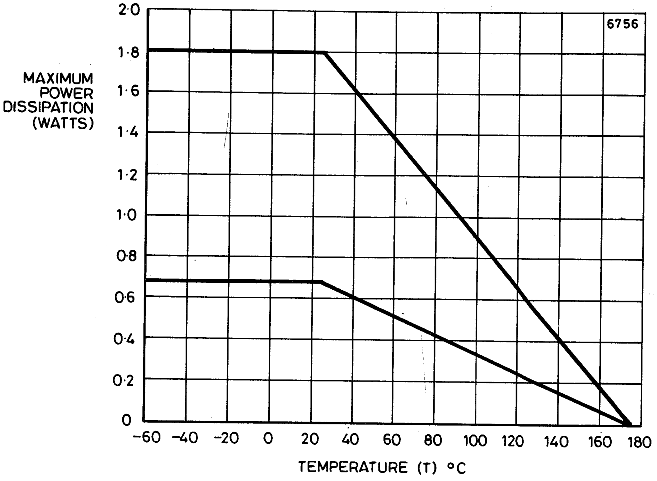
CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

| Parameter | Symbol | BF391 | | BF392 | | BF393 | | Unit | Conditions |
|---|---|---|---|---|---|---|---|---|---|
| | | Min. | Max. | Min. | Max. | Min. | Max. | | |
| Collector-base breakdown voltage | $V_{(BR)CBO}$ | 200 | – | 250 | – | 300 | – | V | $I_C = 100\mu A$, $I_E = 0$ |
| Collector-emitter breakdown voltage | $V_{(BR)CEO}$ | 200 | – | 250 | – | 300 | – | V | $I_C = 10mA$*, $I_B = 0$ |
| Emitter-base breakdown voltage | $V_{(BR)EBO}$ | 6 | – | 6 | – | 6 | – | V | $I_E = 100\mu A$, $I_C = 0$ |
| Collector cut-off current | $I_{CBO}$ | – | 0.1 | – | – | – | – | μA | $V_{CB} = 160V$, $I_E = 0$ |
| | | – | – | – | 0.1 | – | 0.1 | μA | $V_{CB} = 200V$, $I_E = 0$ |
| Emitter cut-off current | $I_{EBO}$ | – | 0.1 | – | – | – | – | μA | $V_{BE} = 4V$, $I_C = 0$ |
| | | – | – | – | 0.1 | – | 0.1 | μA | $V_{BE} = 6V$, $I_C = 0$ |
| Static forward current transfer ratio | $h_{FE}$ | 25 | – | 25 | – | 25 | – | | $I_C = 1mA$, $V_{CE} = 10V$* |
| | | 40 | – | 40 | – | 40 | – | | $I_C = 10mA$, $V_{CE} = 10V$* |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | – | 2 | – | 2 | – | 2 | V | $I_C = 20mA$, $I_B = 2mA$ |
| Collector-base saturation voltage | $V_{BE(sat)}$ | – | 2 | – | 2 | – | 2 | V | $I_C = 20mA$, $I_B = 2mA$ |
| Transition frequency | $f_T$ | 50 | – | 50 | – | 50 | – | MHz | $I_C = 10mA$, $V_{CE} = 20V$<br>$f = 20MHz$ |
| Collector-base capacitance | $C_{re}$ | – | 1.6 | – | 1.6 | – | 1.6 | pF | $V_{CE} = 60V$, $I_E = 0$<br>$f = 1MHz$ |

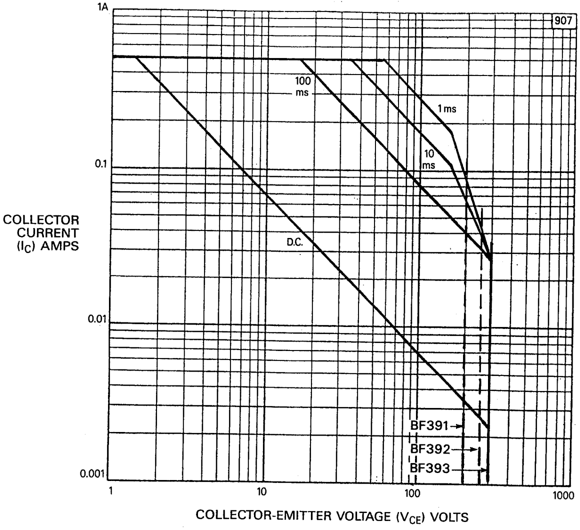
*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ⩽2%.



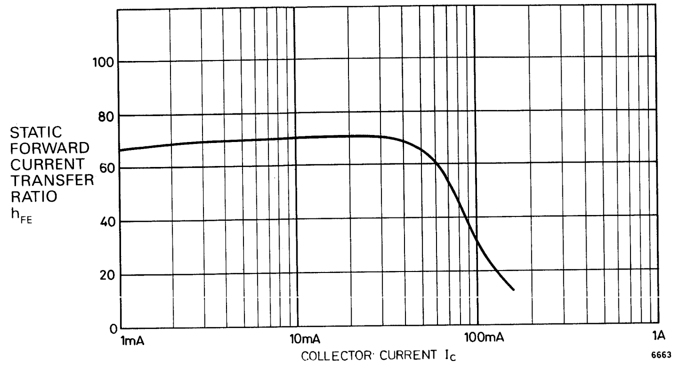
**Maximum transient thermal impedance curves**

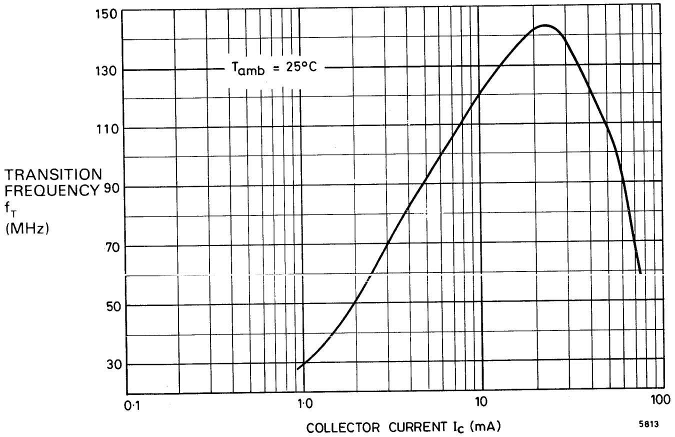


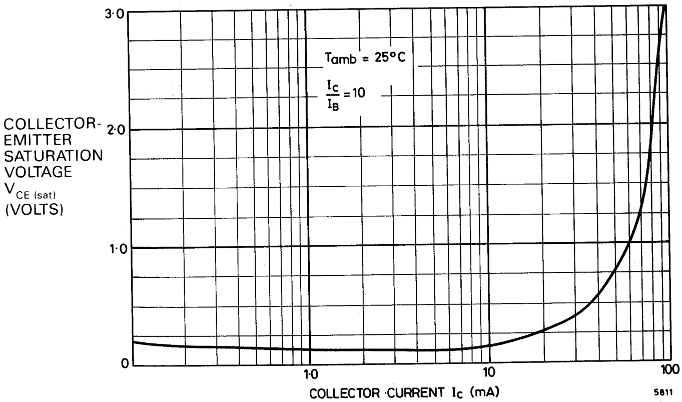
Dissipation derating curve



Safe operating area at $T_{amb} = 25°C$ (single pulse)







**Typical characteristics**

# PNP Silicon Planar High Voltage Transistors

# BF491 BF492 BF493

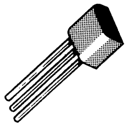
## DESCRIPTION

These plastic encapsulated, general purpose transistors are designed for applications requiring high breakdown voltage, low saturation voltages, and low capacitance.

The E-line package is formed by transfer moulding a silicone plastic specially selected to provide a rugged one-piece encapsulation resistant to severe environments and allow the high junction temperature operation normally associated with metal can devices.

E-line encapsulated devices are approved for use in military, industrial and professional equipments.

Alternative lead configurations are available as plug-in replacements of TO-5/39 and TO-18 metal can types, and for surface mounting.



Plastic E-Line
(TO-92 Compatible)

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | BF491 | BF492 | BF493 | Unit |
|---|---|---|---|---|---|
| Collector-base voltage | $V_{CBO}$ | −200 | −250 | −300 | V |
| Collector-emitter voltage | $V_{CEO}$ | −200 | −250 | −300 | V |
| Emitter-base voltage | $V_{EBO}$ | −6 | | | V |
| Continuous collector current | $I_C$ | −500 | | | mA |
| Power dissipation at $T_{amb} = 25°C$<br>at $T_{case} = 25°C$ | $P_{tot}$ | 625<br>1.5 | | | mW<br>W |
| Operating and storage temperature range | $T_j$:$T_{stg}$ | −55 to +175 | | | °C |

## THERMAL CHARACTERISTICS

| Parameter | Symbol | Maximum | Unit |
|---|---|---|---|
| Thermal resistance: Junction to ambient | $R_{th(j-amb)}$ | 220 | °C/W |
| Junction to case | $R_{th(j-case)}$ | 80 | °C/W |

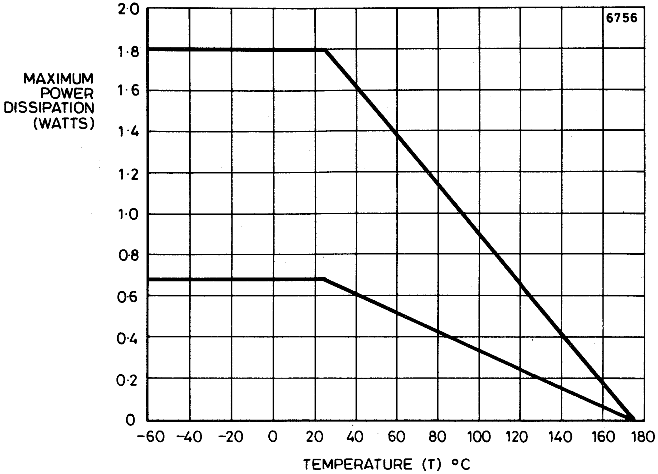
# BF491 BF492 BF493

CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

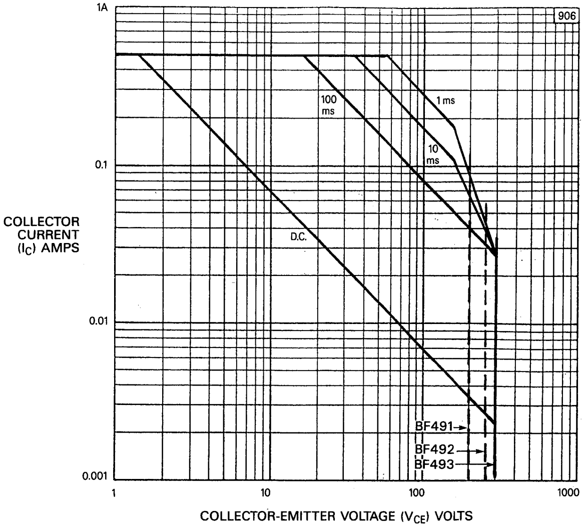
| Parameter | Symbol | BF491 | | BF492 | | BF493 | | Unit | Conditions |
|---|---|---|---|---|---|---|---|---|---|
| | | Min. | Max. | Min. | Max. | Min. | Max. | | |
| Collector-base breakdown voltage | $V_{(BR)CBO}$ | −200 | – | −250 | – | −300 | – | V | $I_C = -100\mu A$<br>$I_E = 0$ |
| Collector-emitter breakdown voltage | $V_{(BR)CEO}$ | −200 | – | −250 | – | −300 | – | V | $I_C = -10mA$<br>$I_B = 0$* |
| Emitter-base breakdown voltage | $V_{(BR)EBO}$ | −6 | – | −6 | – | −6 | – | V | $I_E = -100\mu A$<br>$I_C = 0$ |
| Collector cut-off current | $I_{CBO}$ | – | −0.1 | – | – | – | – | μA | $V_{CB} = -160V$<br>$I_E = 0$ |
| | | – | – | – | −0.1 | – | −0.1 | μA | $V_{CB} = -200V$<br>$I_E = 0$ |
| Emitter cut-off current | $I_{EBO}$ | – | −0.1 | – | – | – | – | μA | $V_{BE} = -4V$<br>$I_C = 0$ |
| | | – | – | – | −0.1 | – | −0.1 | μA | $V_{BE} = -6V$<br>$I_C = 0$ |
| Static forward current transfer ratio | $h_{FE}$ | 25 | – | 25 | – | 25 | – | | $I_C = -1mA$<br>$V_{CE} = -10V$* |
| | | 40 | – | 40 | – | 40 | – | | $I_C = -10mA$<br>$V_{CE} = -10V$* |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | – | −2 | – | −2 | – | −2 | V | $I_C = -20mA$<br>$I_B = -2mA$ |
| Collector-base saturation voltage | $V_{BE(sat)}$ | – | −2 | – | −2 | – | −2 | V | $I_C = -20mA$<br>$I_B = -2mA$ |
| Transition frequency | $f_T$ | 50 | – | 50 | – | 50 | – | MHz | $I_C = -10mA$<br>$V_{CE} = -20V$<br>$f = 20MHz$ |
| Collector-base capacitance | $C_{re}$ | – | 1.6 | – | 1.6 | – | 1.6 | pF | $V_{CE} = -100V$<br>$I_E = 0$<br>$f = 1MHz$ |

*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ⩽2%.

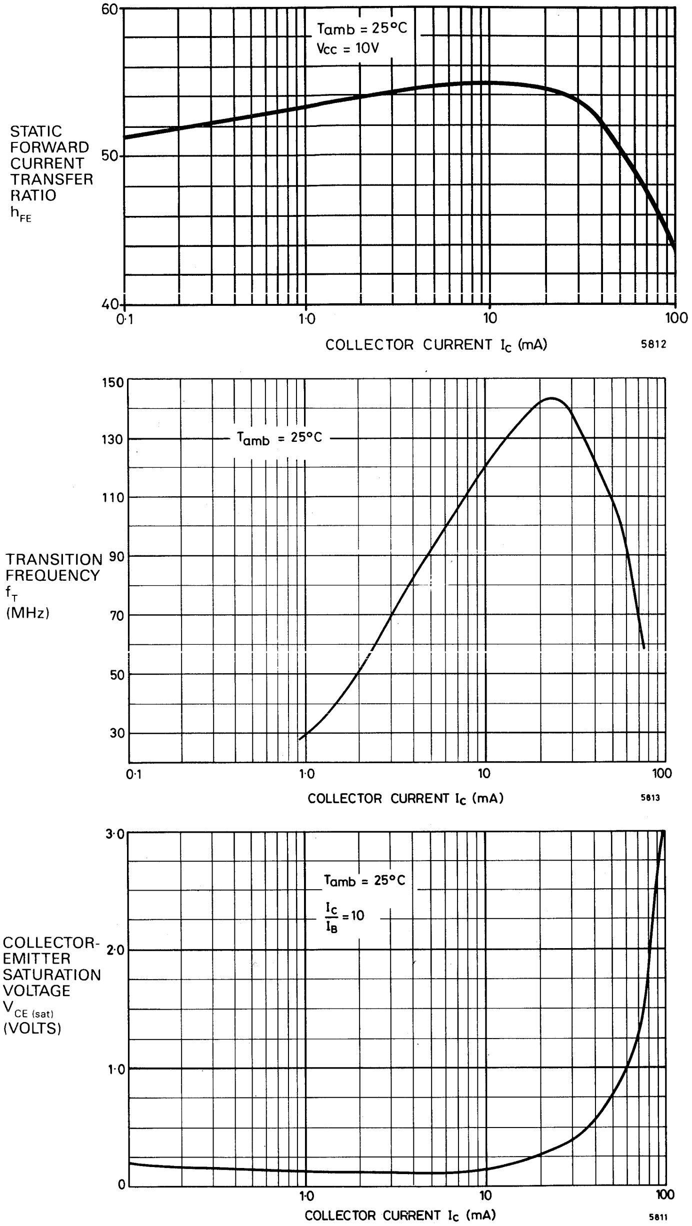
**For maximum transient thermal impedance curves, refer to BF391-3 data**



Dissipation derating curve



Safe operating area at $T_{amb} = 25°C$ (single pulse)



**Typical characteristics**

# PNP Silicon Planar High Voltage Transistor

# BF493SP

## FEATURES

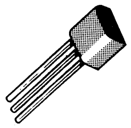
- 350V $V_{CEO}$
- Low leakage currents

## DESCRIPTION

This transistor is designed specifically for use in colour television receiver and monitor applications requiring high breakdown voltage and low leakage currents.

The E-line package is formed by transfer moulding a silicone plastic specially selected to provide a rugged one-piece encapsulation resistant to severe environments and allow the high junction temperature operation normally associated with metal can devices.

E-line encapsulated devices are approved for use in military, industrial and professional equipments.



**Plastic E-Line**
**(TO-92 Compatible)**

Alternative lead configurations are available as plug-in replacements of TO-5/39 and TO-18 metal can types, and for surface mounting. Also available on tape for automatic handling.

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | Value | Unit |
|---|---|---|---|
| Collector-base voltage | $V_{CBO}$ | −350 | V |
| Collector-emitter voltage | $V_{CEO}$ | −350 | V |
| Emitter-base voltage | $V_{EBO}$ | −6 | V |
| Continuous collector current | $I_C$ | −500 | mA |
| Power dissipation: at $T_{amb} = 25°C$<br>at $T_{case} = 25°C$ | $P_{tot}$ | 625<br>1.5 | mW<br>W |
| Operating and storage temperature range | $T_j : T_{stg}$ | −55 to +175 | °C |

## THERMAL CHARACTERISTICS

| Parameter | Symbol | Maximum | Unit |
|---|---|---|---|
| Thermal resistance: Junction to ambient | $R_{th(j\text{-}amb)}$ | 220 | °C/W |
| Junction to case | $R_{th(j\text{-}case)}$ | 80 | °C/W |

# BF493SP

CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

| Parameter | Symbol | Min. | Max. | Units | Test conditions |
|---|---|---|---|---|---|
| Collector-base breakdown voltage | $V_{(BR)CBO}$ | −350 | – | V | $I_C = -100\mu A$, $I_E = 0$ |
| Collector-emitter breakdown voltage | $V_{(BR)CEO}$ | −350 | – | V | $I_C = -1mA$, $I_B = 0$* |
| Emitter-base breakdown voltage | $V_{(BR)EBO}$ | −6 | – | V | $I_E = -100\mu A$, $I_C = 0$ |
| Collector cut-off current | $I_{CES}$ | – | −0.01 | μA | $V_{CE} = -250V$ |
| Emitter cut-off current | $I_{EBO}$ | – | −0.1 | μA | $V_{EB} = -6V$ |
| Collector cut-off current | $I_{CBO}$ | – | −0.005 | μA | $V_{CB} = -250V$, $T_{amb} = 25°C$ |
|  |  | – | −1 | μA | $V_{CB} = -250V$, $T_{amb} = 100°C$ |
| Static forward current transfer ratio | $h_{FE}$ | 25 | – |  | $I_C = -1mA$, $V_{CE} = -10V$* |
|  |  | 40 | – |  | $I_C = -10mA$, $V_{CE} = -10V$* |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | – | −2 | V | $I_C = -20mA$, $I_B = -2mA$ |
| Collector-base saturation voltage | $V_{BE(sat)}$ | – | −2 | V | $I_C = -20mA$, $I_B = -2mA$ |
| Transition frequency | $f_T$ | 50 | – | MHz | $I_C = -10mA$, $V_{CE} = -20V$<br>$f = 20MHz$ |
| Collector-base capacitance | $C_{re}$ | – | 1.6 | pF | $V_{CE} = -100V$, $I_E = 0$<br>$f = 1MHz$ |

*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ⩽ 2%.

**Refer to BF491/BF492/BF493 for graphs**

# NPN Silicon Planar High Voltage Transistors

# MPSA42
# MPSA43

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## DESCRIPTION

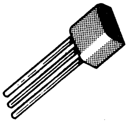
These plastic encapsulated, general purpose transistors are designed for applications requiring high breakdown voltages, low saturation voltages, and low capacitance.

The E-line package is formed by transfer moulding a silicone plastic specially selected to provide a rugged one-piece encapsulation resistant to severe environments and allow the high junction temperature operation normally associated with metal can devices.

E-line encapsulated devices are approved for use in military, industrial and professional equipments.

Alternative lead configurations are available as plug-in replacements of TO-5/39 and TO-18 metal can types, and for surface mounting.

Complementary to MPSA92 and MPSA93.



Plastic E-Line
(TO-92 Compatible)

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | MPSA42 | MPSA42 | Unit |
|---|---|---|---|---|
| Collector-base voltage | $V_{CBO}$ | 300 | 200 | V |
| Collector-emitter voltage | $V_{CEO}$ | 300 | 200 | V |
| Emitter-base voltage | $V_{EBO}$ | 6 | | V |
| Continuous collector current | $I_C$ | 500 | | mA |
| Power dissipation at $T_{amb} = 25°C$<br>at $T_{case} = 25°C$ | $P_{tot}$ | 680<br>1.8 | | mW<br>W |
| Operating and storage temp. range | $T_j;T_{stg}$ | −55 to +175 | | °C |

## THERMAL CHARACTERISTICS

| Parameter | Symbol | Maximum | Unit |
|---|---|---|---|
| Thermal resistance Junction to ambient<br>Junction to case | $R_{th(j\text{-}amb)}$<br>$R_{th(j\text{-}case)}$ | 220<br>80 | °C/W<br>°C/W |

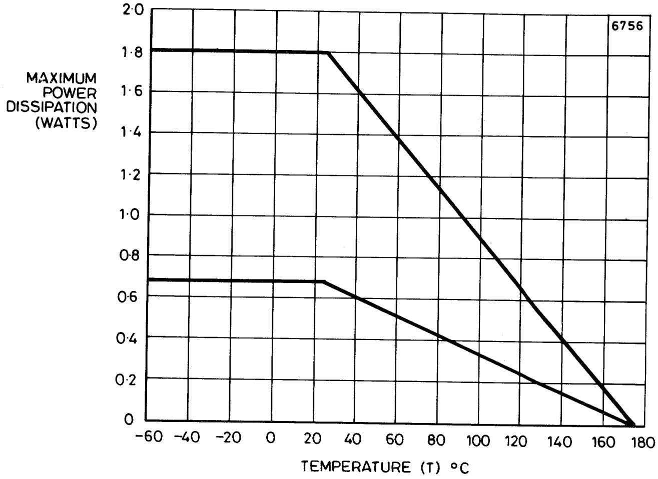
# MPSA42 MPSA43

CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

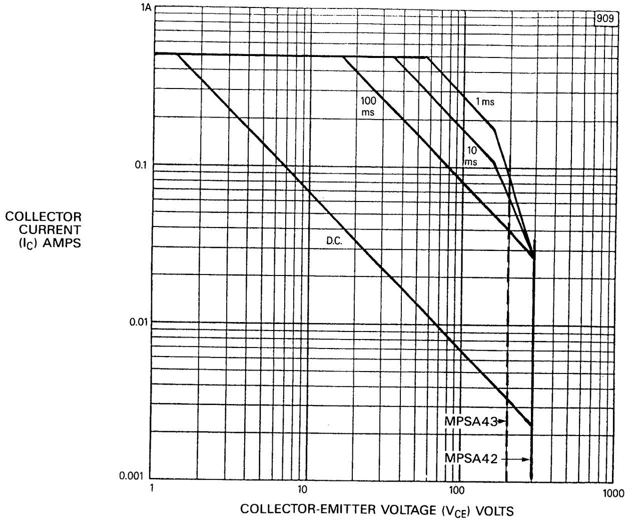
| Parameter | Symbol | MPSA42 | | MPSA43 | | Unit | Conditions |
|---|---|---|---|---|---|---|---|
| | | Min. | Max. | Min. | Max. | | |
| Collector-base breakdown voltage | $V_{(BR)CBO}$ | 300 | – | 200 | – | V | $I_C = 100\mu A$, $I_E = 0$ |
| Collector-emitter breakdown voltage | $V_{(BR)CEO}$ | 300 | – | 200 | – | V | $I_C = 1mA$, $I_B = 0$* |
| Emitter-base breakdown voltage | $V_{(BR)EBO}$ | 6 | – | 6 | – | V | $I_E = 100\mu A$, $I_C = 0$ |
| Collector cut-off current | $I_{CBO}$ | – | 0.1 | – | – | μA | $V_{CB} = 200V$, $I_E = 0$ |
| | | – | – | – | 0.1 | μA | $V_{CB} = 160V$, $I_E = 0$ |
| Emitter cut-off current | $I_{EBO}$ | – | 0.1 | – | – | μA | $V_{EB} = 6V$, $I_C = 0$ |
| | | – | – | – | 0.1 | μA | $V_{EB} = 4V$, $I_C = 0$ |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | – | 0.5 | – | 0.4 | V | $I_C = 20mA$, $I_B = 2mA$ |
| Collector-base saturation voltage | $V_{BE(sat)}$ | – | 0.9 | – | 0.9 | V | $I_C = 20mA$, $I_B = 2mA$ |
| Static forward current transfer ratio | $h_{FE}$ | 25 | – | 25 | – | | $I_C = 1mA$, $V_{CE} = 10V$* |
| | | 40 | – | 40 | – | | $I_C = 10mA$, $V_{CE} = 10V$* |
| | | 40 | – | 50 | 200 | | $I_C = 30mA$, $V_{CE} = 10V$* |
| Transition frequency | $f_T$ | 50 | – | 50 | – | MHz | $I_C = 10mA$, $V_{CE} = 20V$<br>$f = 20MHz$ |
| Output capacitance | $C_{obo}$ | – | 6 | – | 6 | pF | $V_{CB} = 20V$, $I_E = 0$<br>$f = 1MHz$ |

*Measured under pulsed conditions. Pulse width = 200μs. Duty cycle ≤ 2%.

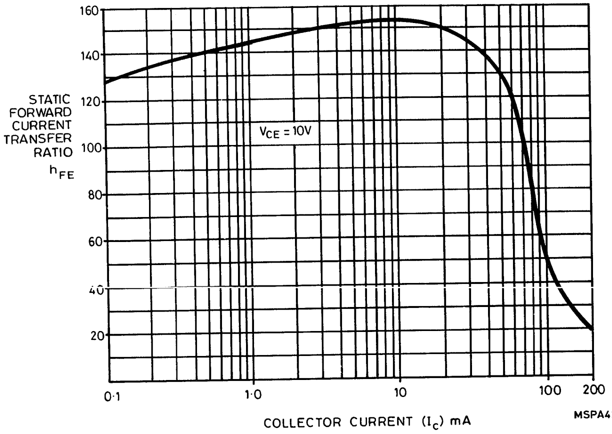
**For maximum transient thermal impedance curves, refer to BF391-3 data**



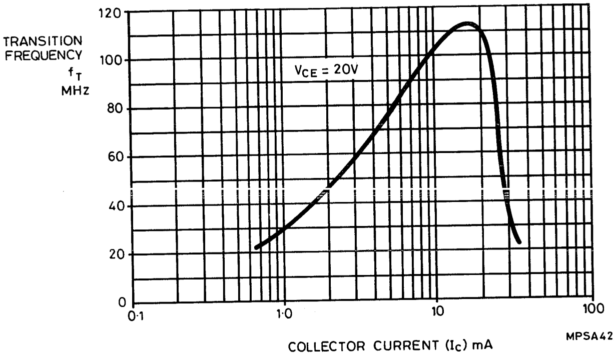
**Dissipation derating curve**



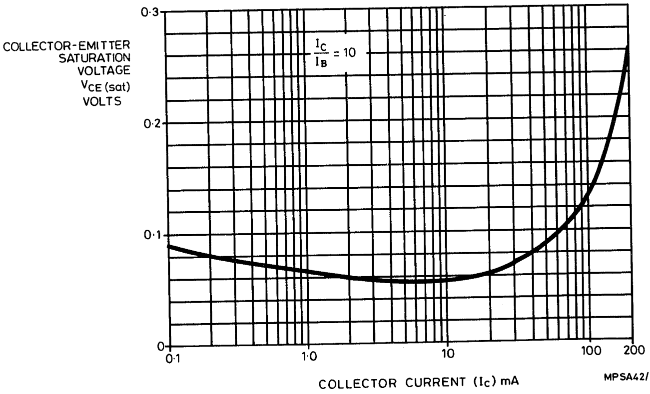
**Safe operating area at $T_{amb} = 25°C$ (single pulse)**



MSPA42/01/11/86



MPSA42/02/11/86



MPSA42/03/11/86

**Typical characteristics**

# PNP Silicon Planar High Voltage Transistors

# MPSA92
# MPSA93

## DESCRIPTION

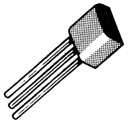
These plastic encapsulated, general purpose transistors are designed for applications requiring high breakdown voltages, low saturation voltages, and low capacitance.

The E-line package is formed by transfer moulding a silicone plastic specially selected to provide a rugged one-piece encapsulation resistant to severe environments and allow the high junction temperature operation normally associated with metal can devices.

E-line encapsulated devices are approved for use in military, industrial and professional equipments.

Alternative lead configurations are available as plug-in replacements of TO-5/39 and TO-18 metal can types, and for surface mounting.

Complementary to MPSA42 and MPSA43.



Plastic E-Line
(TO-92 Compatible)

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | MPSA92 | MPSA93 | Unit |
|---|---|---|---|---|
| Collector-base voltage | $V_{CBO}$ | −300 | −200 | V |
| Collector-emitter voltage | $V_{CEO}$ | −300 | −200 | V |
| Emitter-base voltage | $V_{EBO}$ | −5 | | V |
| Continuous collector current | $I_C$ | −500 | | mA |
| Power dissipation at $T_{amb} = 25°C$<br>at $T_{case} = 25°C$ | $P_{tot}$ | 680<br>1.8 | | mW<br>W |
| Operating and storage temp. range | $T_j;T_{stg}$ | −55 to +175 | | °C |

## THERMAL CHARACTERISTICS

| Parameter | Symbol | Maximum | Unit |
|---|---|---|---|
| Thermal resistance Junction to ambient<br>Junction to case | $R_{th(j\text{-}amb)}$<br>$R_{th(j\text{-}case)}$ | 220<br>80 | °C/W<br>°C/W |

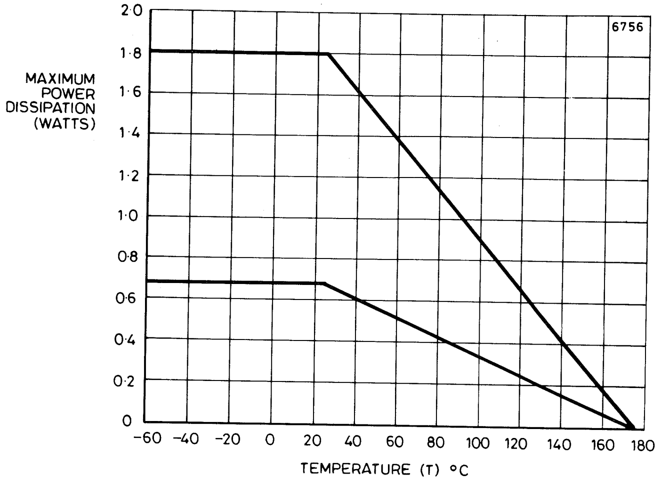
# MPSA92 MPSA93

CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

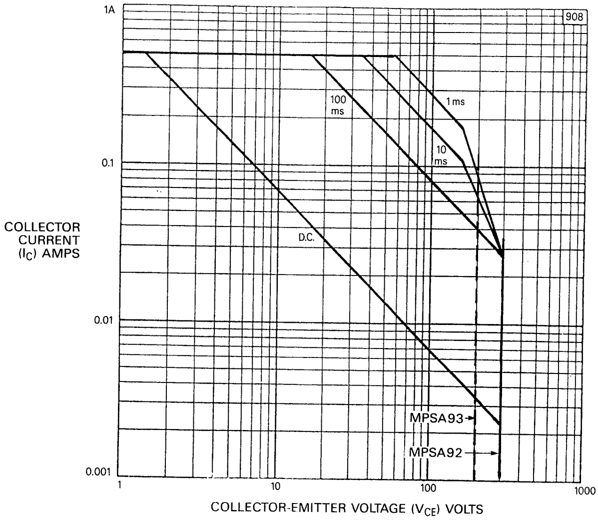
| Parameter | Symbol | MPSA92 | | MPSA93 | | Unit | Conditions |
|---|---|---|---|---|---|---|---|
| | | Min. | Max. | Min. | Max. | | |
| Collector-base breakdown voltage | $V_{(BR)CBO}$ | −300 | – | −200 | – | V | $I_C = -100\mu A$, $I_E = 0$ |
| Collector-emitter breakdown voltage | $V_{(BR)CEO}$ | −300 | – | −200 | – | V | $I_C = -1mA$*, $I_B = 0$ |
| Emitter-base breakdown voltage | $V_{(BR)EBO}$ | −5 | – | −5 | – | V | $I_E = -10\mu A$, $I_C = 0$ |
| Collector cut-off current | $I_{CBO}$ | – | −0.25 | – | – | μA | $V_{CB} = -200V$, $I_E = 0$ |
| | | – | – | – | −0.25 | μA | $V_{CB} = -160V$, $I_E = 0$ |
| Emitter cut-off current | $I_{EBO}$ | – | −0.1 | – | −0.1 | μA | $V_{EB} = -3V$, $I_E = 0$ |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | – | −0.5 | – | −0.4 | V | $I_C = -20mA$<br>$I_B = -2mA$ |
| Collector-base saturation voltage | $V_{BE(sat)}$ | – | −0.9 | – | −0.9 | V | $I_C = -20mA$<br>$I_B = -2mA$ |
| Static forward current transfer ratio | $h_{FE}$ | 25 | – | 25 | – | | $I_C = -1mA$<br>$V_{CE} = -10V$* |
| | | 40 | – | 40 | – | | $I_C = -10mA$<br>$V_{CE} = -10V$* |
| | | 25 | – | 30 | 150 | | $I_C = -30mA$<br>$V_{CE} = -10V$* |
| Transition frequency | $f_T$ | 50 | – | 50 | – | MHz | $I_C = -10mA$<br>$V_{CE} = -20V$<br>$f = 20MHz$ |
| Output capacitance | $C_{obo}$ | – | 6 | – | 8 | pF | $V_{CB} = -20V$<br>$f = 1MHz$ |

*Measured under pulsed conditions. Pulse width = 200μs. Duty cycle ≤ 2%.

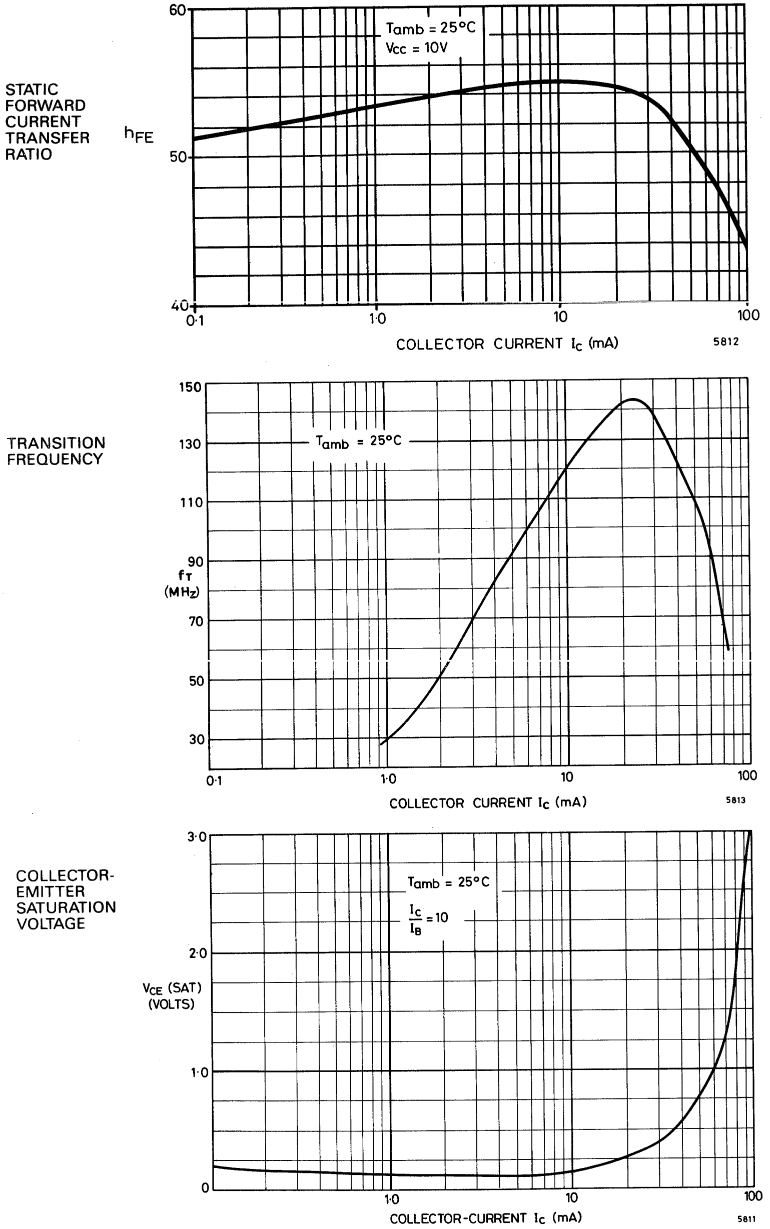
**For maximum transient thermal impedance curves, refer to BF391-3 data**



Dissipation derating curve



Safe operating area at $T_{amb} = 25°c$ (single pulse)



**Typical characteristics**

# NPN Silicon Planar Medium Power Transistor

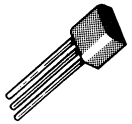
# ZTX449

## DESCRIPTION

The ZTX449 is a high current transistor encapsulated in the popular E-line package. The device is intended for low voltage, high current L.F. applications and features high power dissipation, 1W at 25°C ambient temperature, and excellent gain characterisitics up to 2A.

The E-line package is formed by transfer moulding a silicone plastic specially selected to provide a rugged one-piece encapsulation resistant to severe environments and allow the high junction temperature operation normally associated with metal can devices.

E-line encapsulated devices are approved for use in military, industrial and professional equipments.



Plastic E-Line
(TO-92 Compatible)

Alternative lead configurations are available as plug-in replacements of TO-5/39 and TO-18 metal can types and for surface mounting.

Complementary to the ZTX549.

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | Maximum | Unit |
|---|---|---|---|
| Collector-base voltage | $V_{CBO}$ | 50 | V |
| Collector-emitter voltage | $V_{CEO}$ | 30 | V |
| Emitter-base voltage | $V_{EBO}$ | 5 | V |
| Peak pulse current (see note below) | $I_{CM}$ | 2 | A |
| Continuous collector current | $I_C$ | 1 | A |
| Base current | $I_B$ | 200 | mA |
| Power dissipation at $T_{amb} = 25°C$<br>at $T_{case} = 25°C$ | $P_{tot}$ | 1<br>2 | W<br>W |
| Operating and storage temperature range | | −55 to +200 | °C |

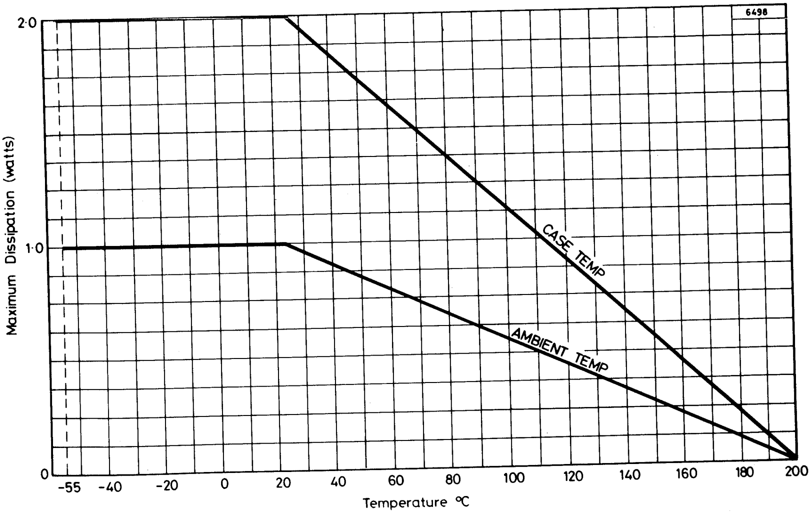
Note: Consult Safe Operating Area graph for conditions.

# ZTX449

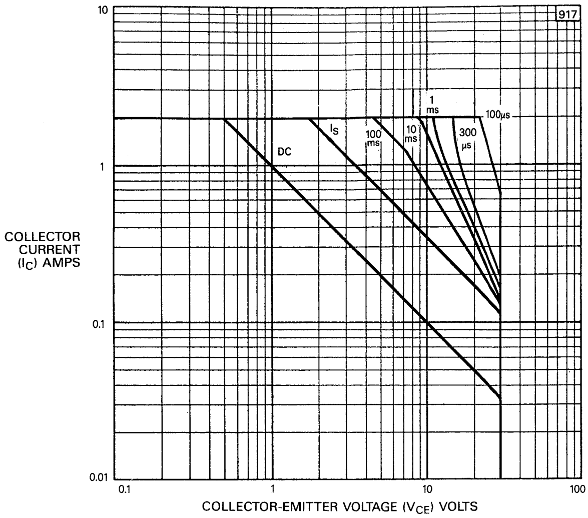
CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

| Parameter | Symbol | Min. | Max. | Units | Test Conditions |
|---|---|---|---|---|---|
| Collector-base cut-off current | $I_{CBO}$ | – | 0.1 | μA | $V_{CB} = 40V$ |
| | | – | 10 | μA | $V_{CB} = 40V$, $T_{amb} = 100°C$ |
| Emitter-base cut-off current | $I_{EBO}$ | – | 0.1 | μA | $V_{EB} = 4V$ |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | – | 0.5 | V | $I_C = 1A$, $I_B = 0.1A$* |
| | | – | 1 | V | $I_C = 2A$, $I_B = 0.2A$* |
| Base-emitter saturation voltage | $V_{BE(sat)}$ | – | 1.25 | V | $I_C = 1A$, $I_B = 0.1A$* |
| Base-emitter turn-on time | $V_{BE(on)}$ | – | 1 | V | $I_C = 1A$, $V_{CE} = 2V$* |
| Static forward current transfer ratio | $h_{FE}$ | 70 | – | | $I_C = 50mA$, $V_{CE} = 2V$* |
| | | 100 | 300 | | $I_C = 500mA$, $V_{CE} = 2V$* |
| | | 80 | – | | $I_C = 1A$, $V_{CE} = 2V$* |
| | | 40 | – | | $I_C = 2A$, $V_{CE} = 2V$* |
| Transition frequency | $f_T$ | 150 | – | MHz | $I_C = 50mA$, $V_{CE} = 10V$<br>$f = 100MHz$ |
| Output capacitance | $C_{obo}$ | – | 15 | pF | $V_{CB} = 10V$, $f = 1MHz$ |

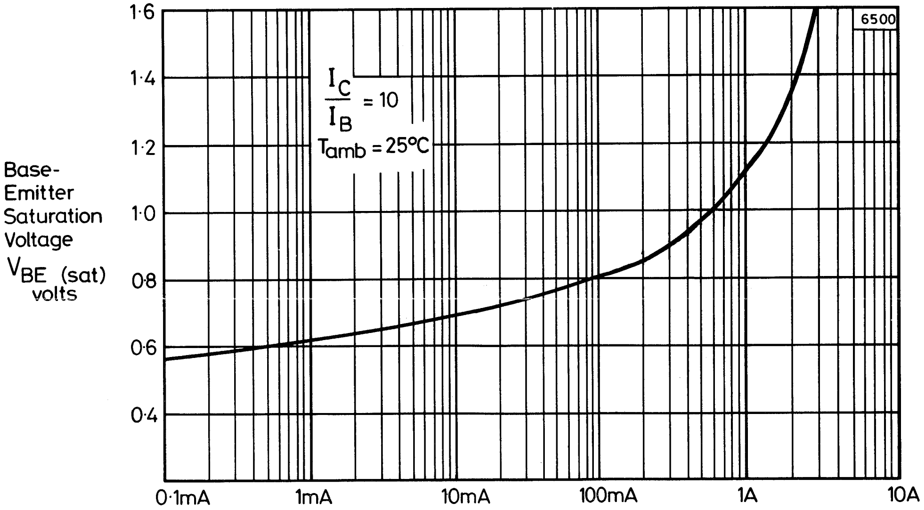
*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ⩽2%.



Derating curve

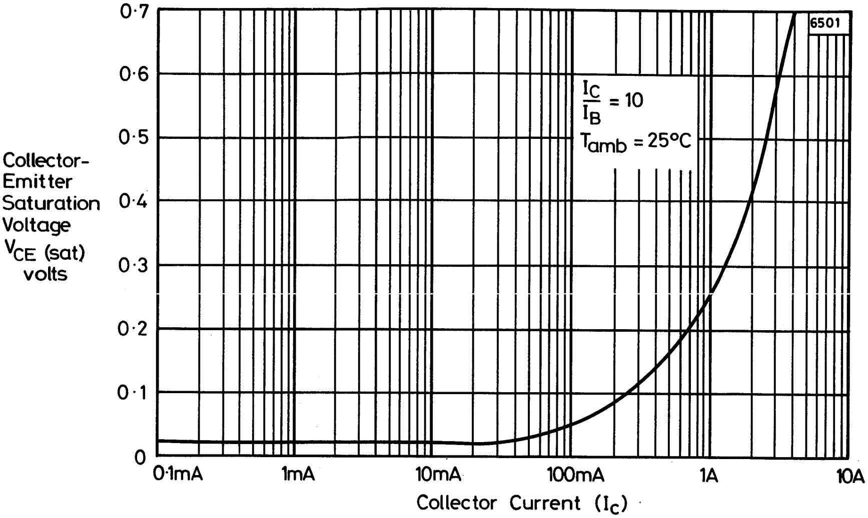


**Safe operating at $T_{amb} = 25°C$ (single pulse)**

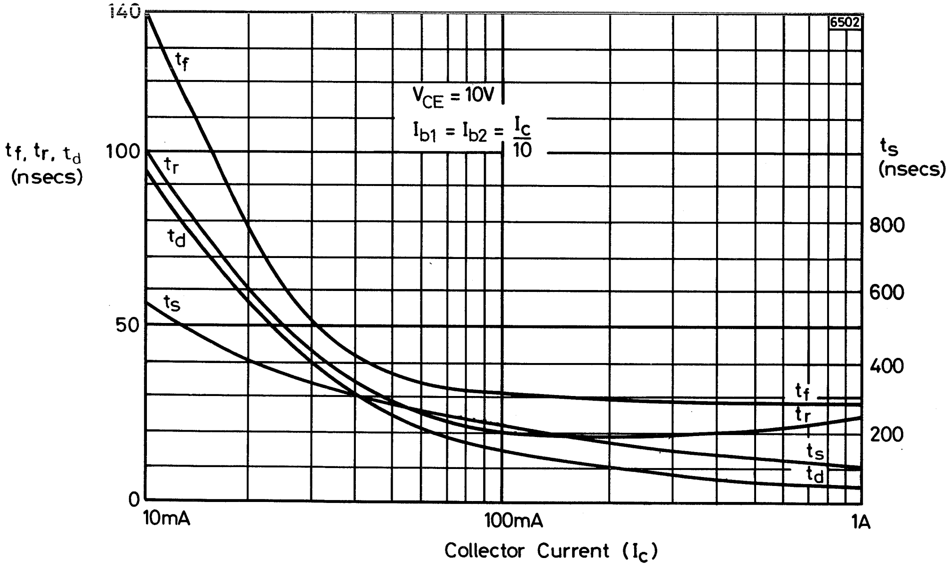


**Typical base-emitter saturation voltages plotted against collector current**

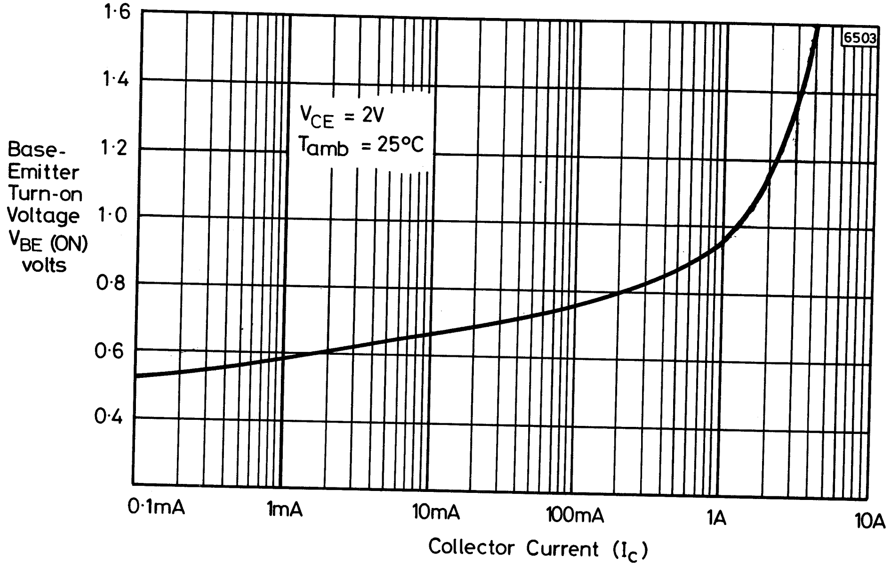
# ZTX449



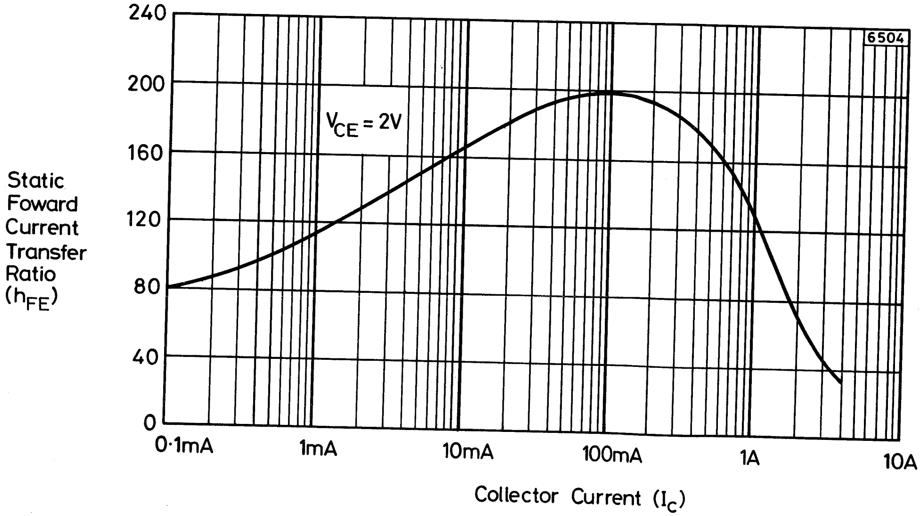
**Typical collector-emitter saturation voltages plotted against collector current**



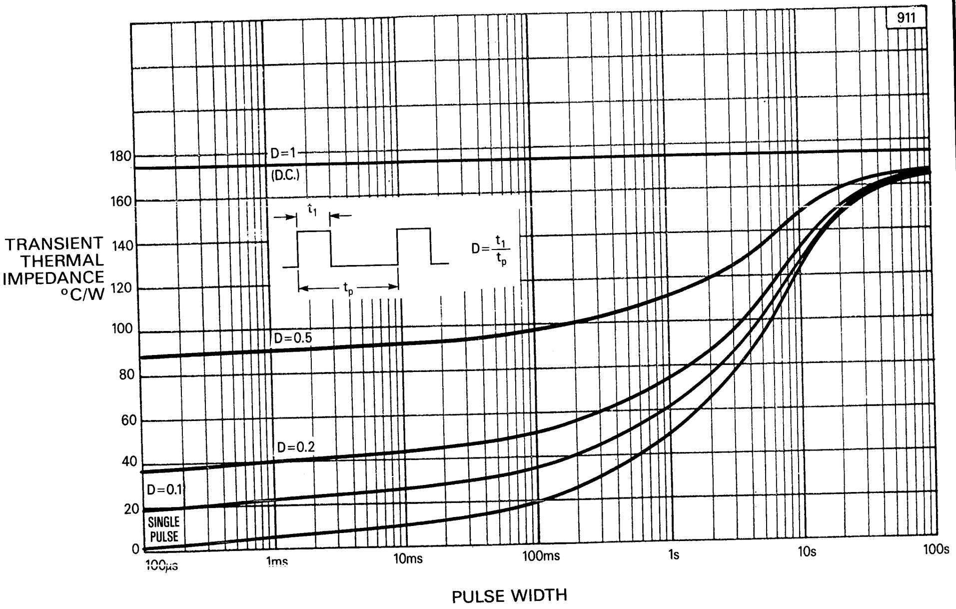
**Typical switching speeds**



**Typical base-emitter turn-on voltages plotted against collector current**



**Typical static forward current transfer ratio plotted against collector current**



Maximum transient thermal impedance curves

# NPN Silicon Planar Medium Power Transistors

# ZTX450
# ZTX451

## FEATURES

- High power dissipation: 1W at $T_{amb} = 25°C$
- $h_{FE}$ specified up to 1A
- High $f_T$: 200MHz typical

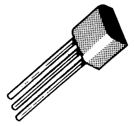
## DESCRIPTION

These are plastic encapsulated general purpose transistors designed for small and medium signal amplification from d.c. to radio frequencies.

Application areas include: audio frequency amplifiers, driver and output stages, oscillators and general purpose switching.

The E-line package is formed by transfer moulding a silicone plastic specially selected to provide a rugged one-piece encapsulation resistant to severe environments and allow the high junction temperature operation normally associated with metal can devices.

E-line encapsulated devices are approved for use in military, industrial and professional equipments.



Plastic E-Line
(TO-92 Compatible)

Alternative lead configurations are available as plug-in replacements of TO-5/39 and TO-18 metal can types, and for surface mounting.

Complementary to ZTX550 and ZTX551 PNP transistors.

The ZTX450 and ZTX451 transistors approved for use in military equipment are identified by the following numbers.

BS9365 F137 & F138 - Category P.

BS9365 F139 & F140 - Category Q.

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | ZTX450 | ZTX451 | Unit |
|---|---|---|---|---|
| Collector-base voltage | $V_{CBO}$ | 60 | 80 | V |
| Collector-emitter voltage | $V_{CEO}$ | 45 | 60 | V |
| Emitter-base voltage | $V_{EBO}$ | 5 | | V |
| Peak pulse current (see note below) | $I_{CM}$ | 2 | | A |
| Continuous collector current | $I_C$ | 1 | | A |
| Base current | $I_B$ | 200 | | mA |
| Power dissipation at $T_{amb} = 25°C$<br>at $T_{case} = 25°C$ | $P_{tot}$ | 1<br>2 | | W<br>W |
| Operating and storage temperature range | | −55 to +200 | | °C |

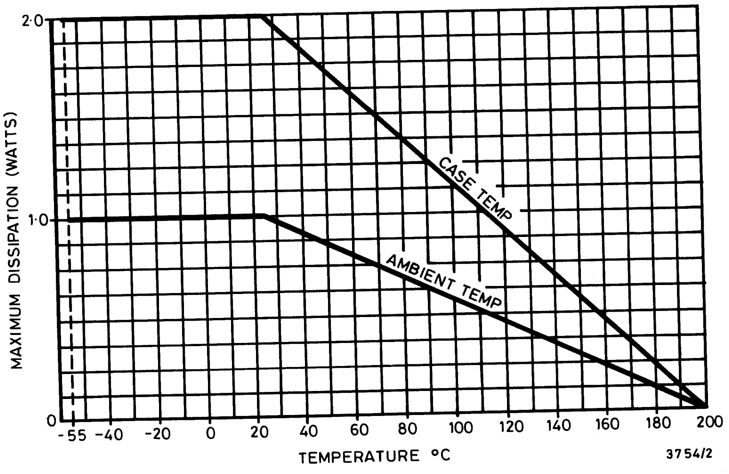
Note: Consult Safe Operating Area graph for conditions.

# ZTX450 ZTX451

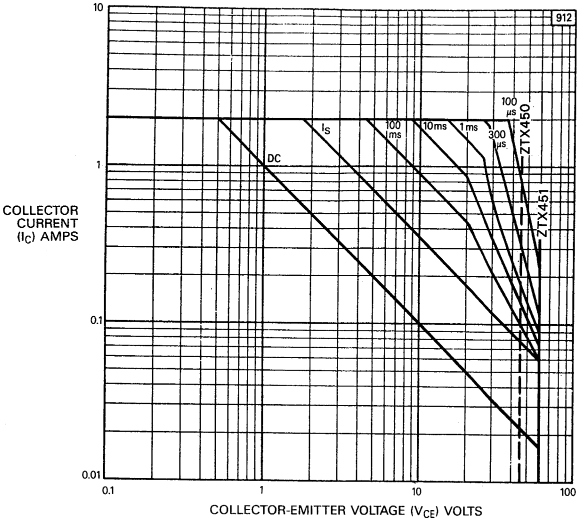
CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

| Parameter | Symbol | ZTX450 | | ZTX451 | | Unit | Conditions |
|---|---|---|---|---|---|---|---|
| | | Min. | Max. | Min. | Max. | | |
| Collector-base cut-off current | $I_{CBO}$ | – | 0.1 | – | – | μA | $V_{CB} = 45V$ |
| | | – | – | – | 0.1 | μA | $V_{CB} = 60V$ |
| Emitter-base cut-off current | $I_{EBO}$ | – | 0.1 | – | 0.1 | μA | $V_{EB} = 4V$ |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | – | 0.25 | – | 0.35 | V | $I_C = 150mA$, $I_B = 15mA$* |
| Base-emitter saturation voltage | $V_{BE(sat)}$ | – | 1.1 | – | 1.1 | V | $I_C = 150mA$, $I_B = 15mA$* |
| Collector-emitter sustaining voltage | $V_{CEO(sus)}$ | 45 | – | 60 | – | V | $I_C = 10mA$* |
| Static forward current transfer ratio | $h_{FE}$ | 100 | 300 | 50 | 150 | | $I_C = 150mA$, $V_{CE} = 10V$* |
| | | 15 | – | 10 | – | | $I_C = 1A$, $V_{CE} = 10V$* |
| Transition frequency | $f_T$ | 150 | – | 150 | – | MHz | $I_C = 50mA$, $V_{CE} = 10V$<br>$f = 100MHz$ |
| Output capacitance | $C_{obo}$ | – | 15 | – | 15 | pF | $V_{CB} = 10V$, $f = 1MHz$ |

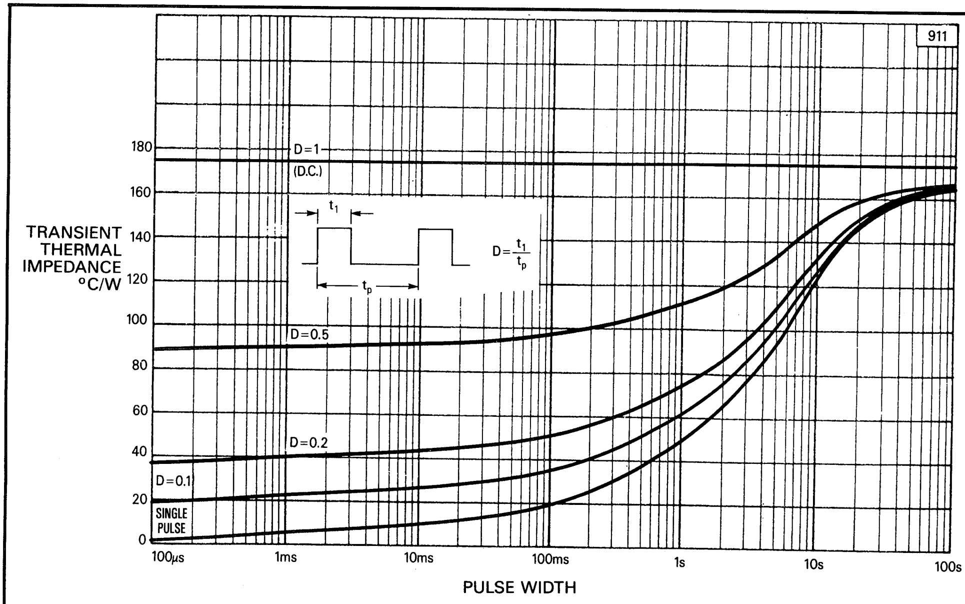
*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ⩽ 2%.



**Derating curve**

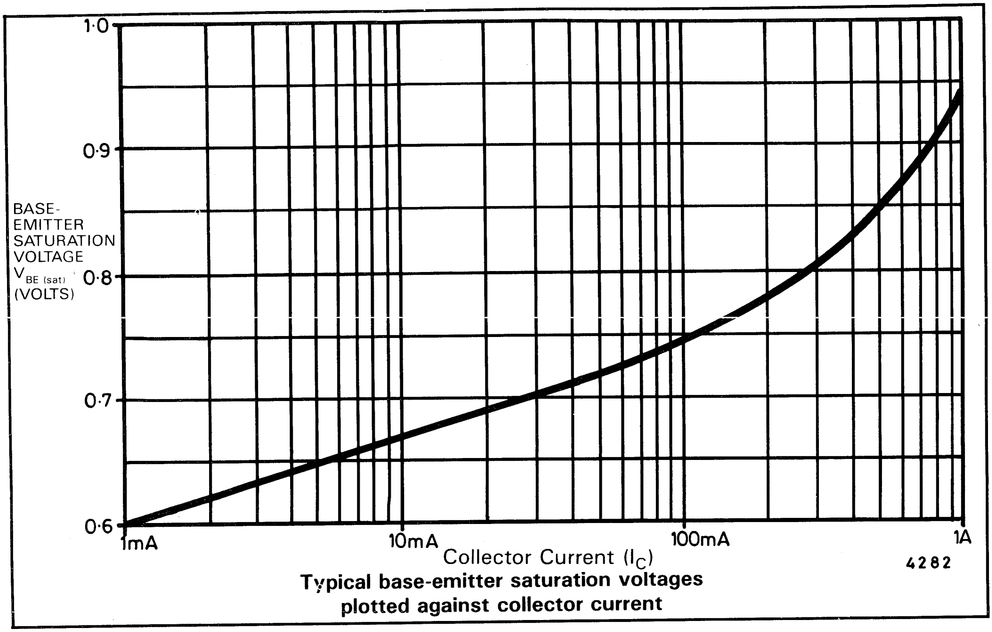


Safe operating area at $T_{amb} = 25°C$ (single pulse)

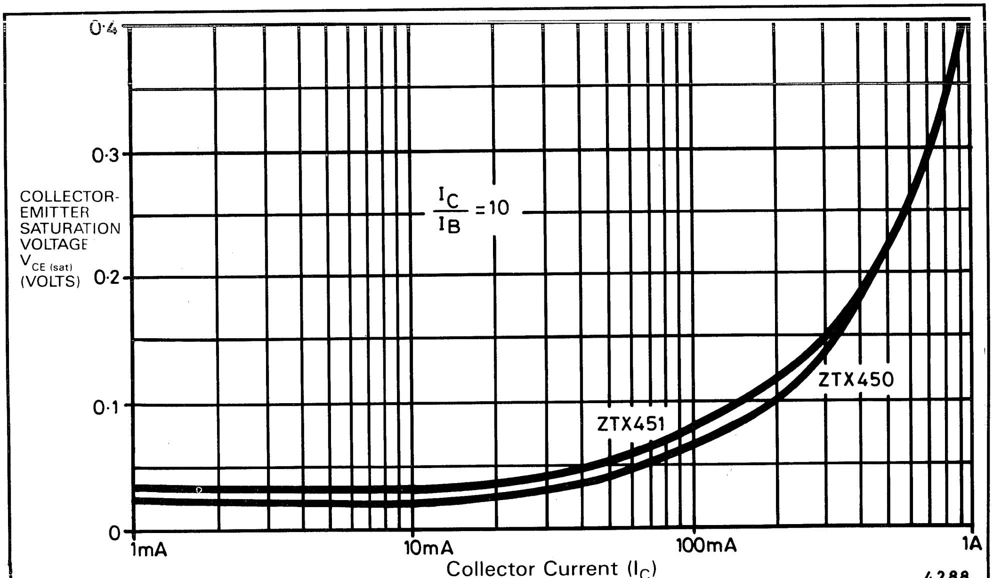


Maximum transient thermal impedance curves

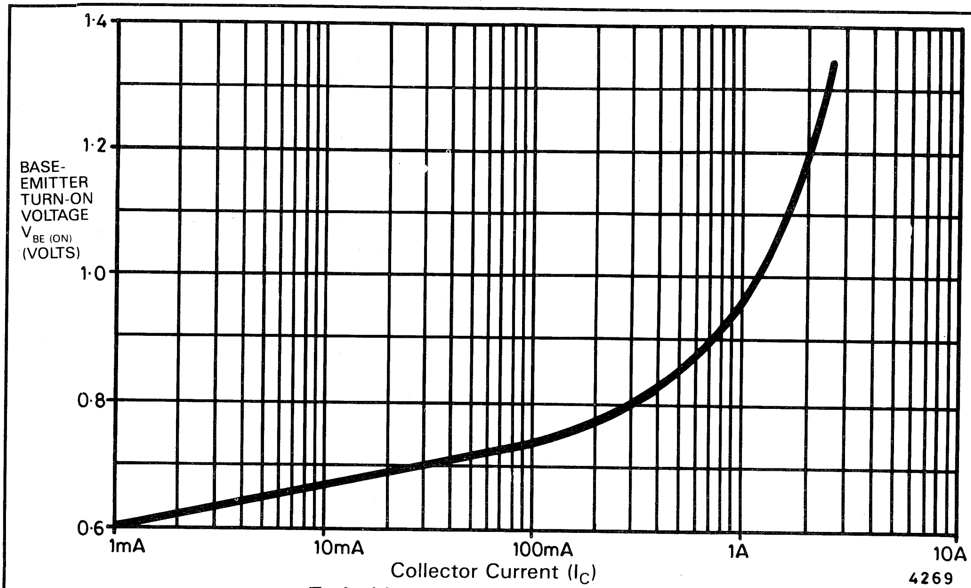
## ZTX450 ZTX451



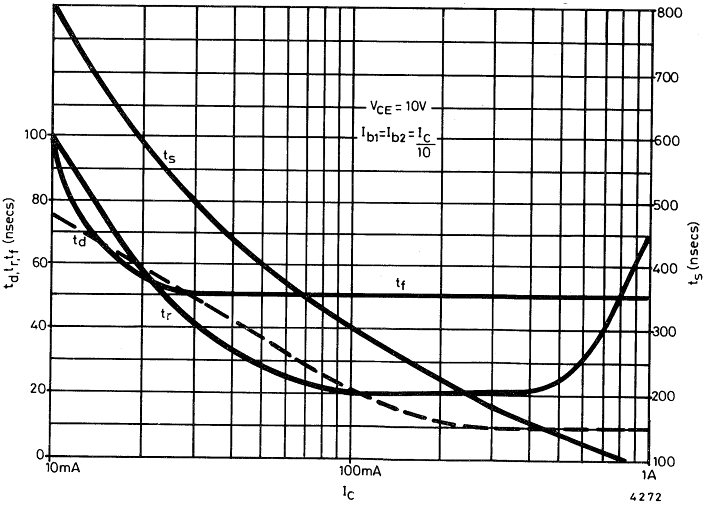
**Typical base-emitter saturation voltages plotted against collector current**



**Typical collector-emitter saturation voltages plotted against collector current**



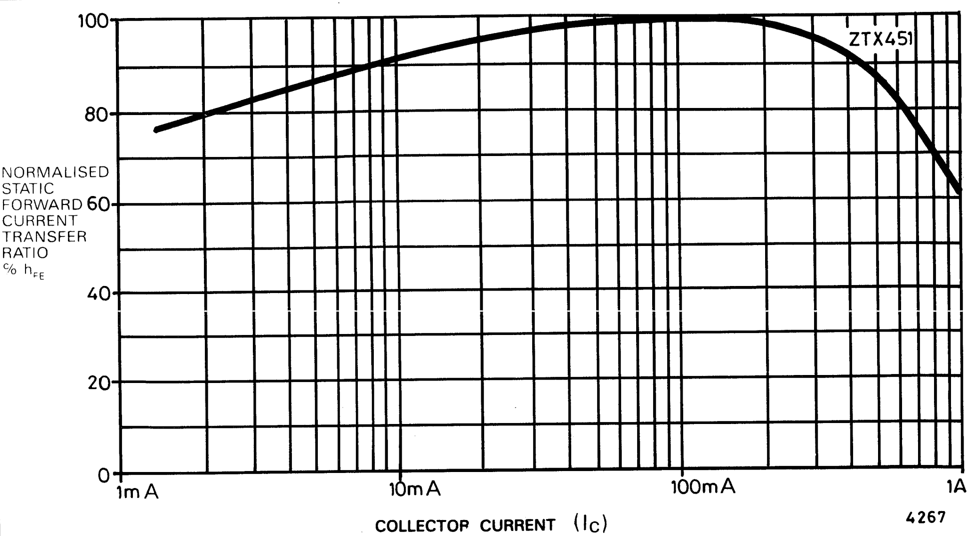
**Typical base-emitter turn-on voltages plotted against collector current**



Collector Current ($I_C$)

**Typical switching speeds**

# ZTX450 ZTX451



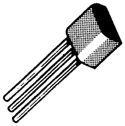
**Typical static forward current transfer ratio plotted against collector current**

# NPN Silicon Planar Medium Power Transistors

# ZTX452
# ZTX453

## FEATURES

- High power dissipation: 1W at $T_{amb} = 25°C$
- $h_{FE}$ specified up to 1A
- High $V_{CEO}$ uo tp 100V
- ZTX452 complementary to ZTX552



Plastic E-Line
(TO-92 Compatible)

## DESCRIPTION

These are plastic encapsulated, general purpose transistors designed for small and medium signal amplification from d.c. to radio frequencies.

Application areas include: audio frequency amplifiers, drivers and output stages, oscillators and general purpose switching.

The E-line package is formed by transfer moulding a silicone plastic specially selected to provide a rugged one-piece encapsulation resistant to severe environments and allow the high junction temperature operation normally associated with metal can devices.

E-line encapsulated devices are approved for use in military, industrial and professional equipments.

Alternative lead configurations are available as plug-in replacements of TO-5/39 and TO-18 metal can types, and for surface mounting.

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | ZTX452 | ZTX453 | Unit |
|---|---|---|---|---|
| Collector-base voltage | $V_{CBO}$ | 100 | 120 | V |
| Collector-emitter voltage | $V_{CEO}$ | 80 | 100 | V |
| Emitter-base voltage | $V_{EB}$ | 5 | | V |
| Peak pulse current (see note below) | $I_{CM}$ | 2 | | A |
| Continuous d.c. current | $I_C$ | 1 | | A |
| Base current | $I_B$ | 200 | | mA |
| Power dissipation at $T_{amb} = 25°C$<br>at $T_{case} = 25°C$ | $P_{tot}$ | 1<br>2 | | W<br>W |
| Operating and storage temperature range | | −55 to +200 | | °C |

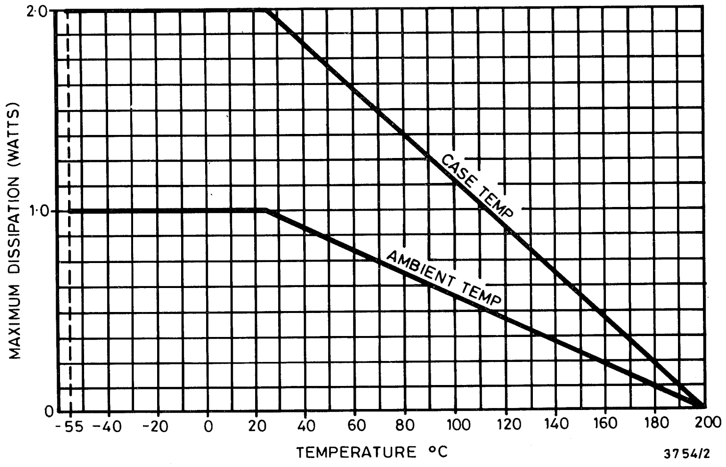
Note: Consult Safe Operating Area graph for conditions.

# ZTX452 ZTX453

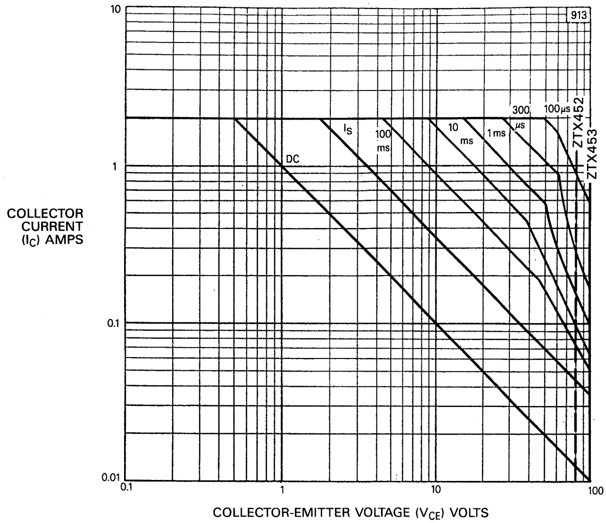
CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

| Parameter | Symbol | ZTX452 | | ZTX453 | | Unit | Conditions |
|---|---|---|---|---|---|---|---|
| | | Min. | Max. | Min. | Max. | | |
| Collector-base cut-off current | $I_{CBO}$ | – | 0.1 | – | – | μA | $V_{CB} = 80V$ |
| | | – | – | – | 0.1 | μA | $V_{CB} = 100V$ |
| Emitter-base cut-off current | $I_{EBO}$ | – | 0.1 | – | 0.1 | μA | $V_{EB} = 4V$ |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | – | 0.7 | – | 0.7 | V | $I_C = 150mA, I_B = 15mA$ |
| Base-emitter saturation voltage | $V_{BE(sat)}$ | – | 1.3 | – | 1.3 | V | $I_C = 150mA, I_B = 15mA$ |
| Collector-emitter sustaining voltage | $V_{CEO(sus)}$ | 80 | – | 100 | – | V | $I_C = 10mA$ |
| Static forward current transfer ratio | $h_{FE}$ | 40 | 150 | 40 | 200 | | $I_C = 150mA, V_{CE} = 10V$* |
| | | 10 | – | 10 | – | | $I_C = 1A, V_{CE} = 10V$* |
| Transition frequency | $f_T$ | 150 | – | 150 | – | MHz | $I_C = 50mA, V_{CE} = 10V$<br>$f = 100MHz$ |
| Output capacitance | $C_{obo}$ | – | 15 | – | 15 | pF | $V_{CB} = 10V, f = 1MHz$ |

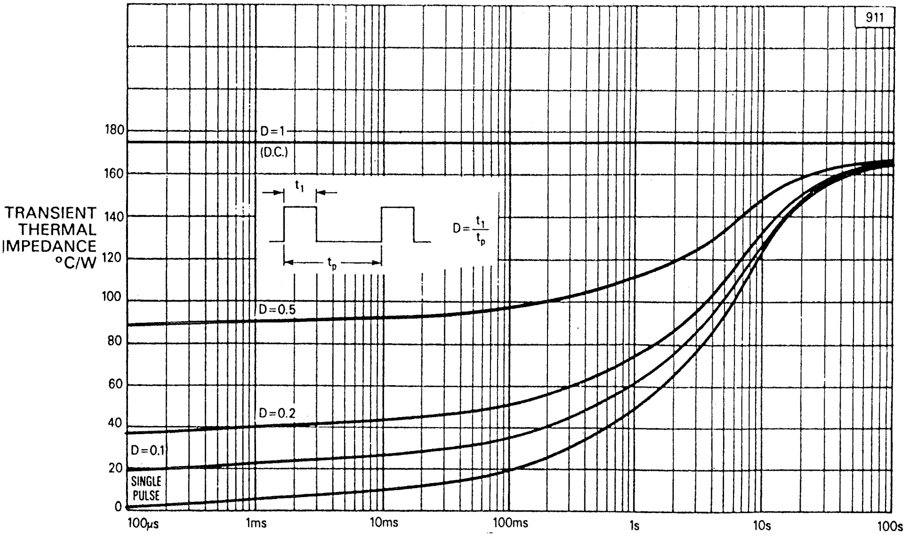
*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ≤ 2%.



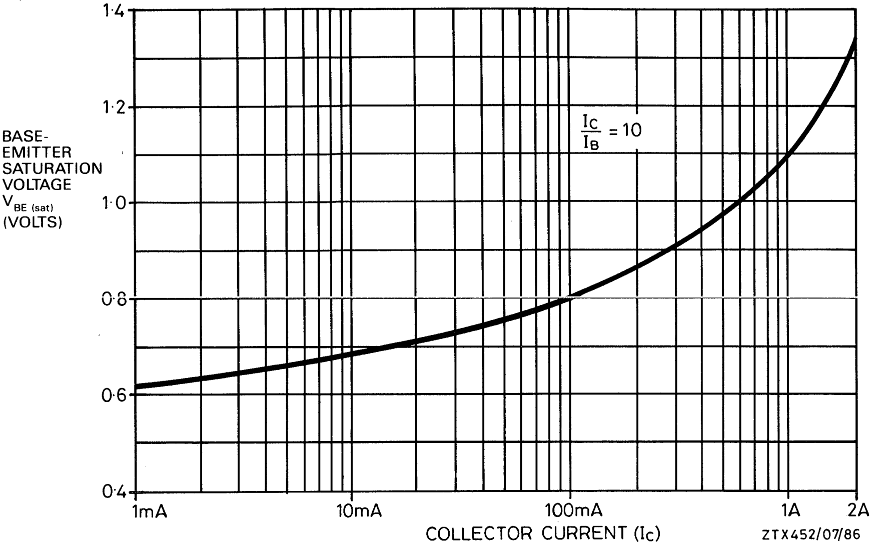
**Derating curve**



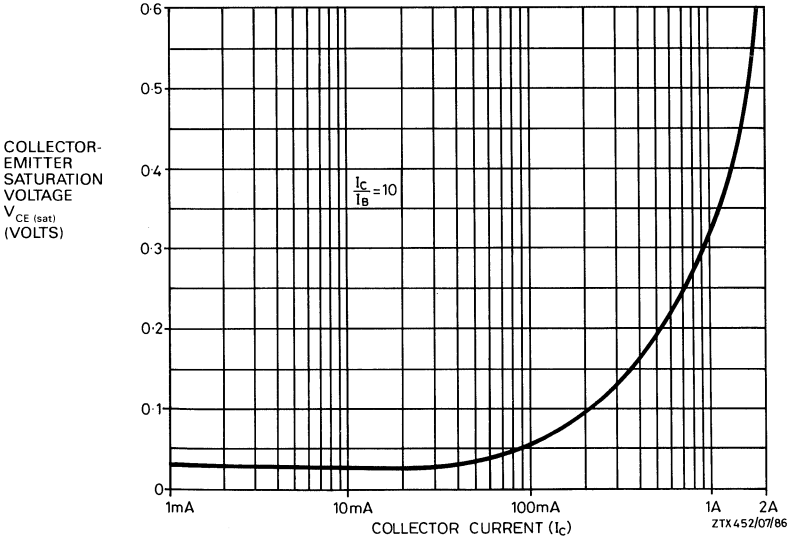
Safe operating area at $T_{amb} = 25°C$ (single pulse)



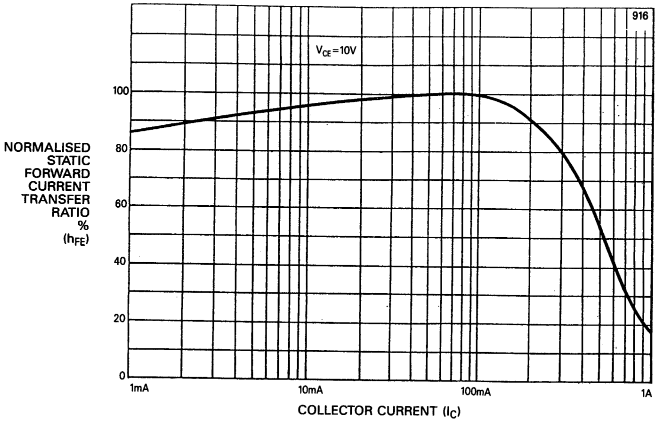
Maximum transient thermal impedance curves



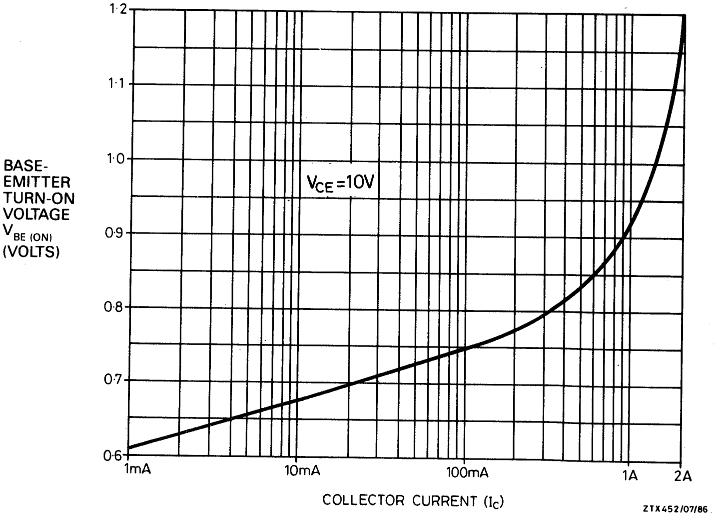
**Typical base-emitter saturation voltage plotted against collector current**



**Typical collector-emitter saturation voltage plotted against collector current**



Typical static forward current transfer ratio plotted against collector current



Typical base-emitter turn-on voltage plotted against collector current

# NPN Silicon Planar Medium Power Transistors

# ZTX454
# ZTX455

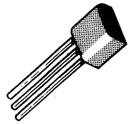
## DESCRIPTION

These are plastic encapsulated, general purpose transistors deigned for small and medium signal amplification from d.c. to radio frequencies.

Application areas include: audio frequency amplifiers, drivers and output stages, oscillators and general purpose switching.

The E-line package is formed by transfer moulding a silicone plastic specially selected to provide a rugged one-piece encapsulation resistant to severe environments and allow the high junction temperature operation normally associated with metal can devices.

E-line encapsulated devices are approved for use in military, industrial and professional equipments.



Plastic E-Line
(TO-92 Compatible)

Alternative lead configurations are available as plug-in replacements of TO-5/39 and TO-18 metal can types, and for surface mounting.

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | ZTX454 | ZTX455 | Unit |
|---|---|---|---|---|
| Collector-base voltage | $V_{CBO}$ | 140 | 160 | V |
| Collector-emitter voltage | $V_{CEO}$ | 120 | 140 | V |
| Emitter-base voltage | $V_{EBO}$ | 5 | | V |
| Peak pulse current (see note below) | $I_{CM}$ | 2 | | A |
| Continuous direct current | $I_C$ | 1 | | A |
| Base current | $I_B$ | 200 | | mA |
| Power dissipation at $T_{amb} = 25°C$<br>at $T_{case} = 25°C$ | $P_{tot}$ | 1<br>2 | | W<br>W |
| Operating and storage temp. range | $T_j;T_{stg}$ | −55 to +200 | | °C |

## THERMAL CHARACTERISTICS

| Parameter | Symbol | Maximum | Unit |
|---|---|---|---|
| Thermal resistance: Junction to ambient<br>Junction to case | $R_{th(j-amb)}$<br>$R_{th(j-case)}$ | 175<br>87.5 | °C/W<br>°C/W |

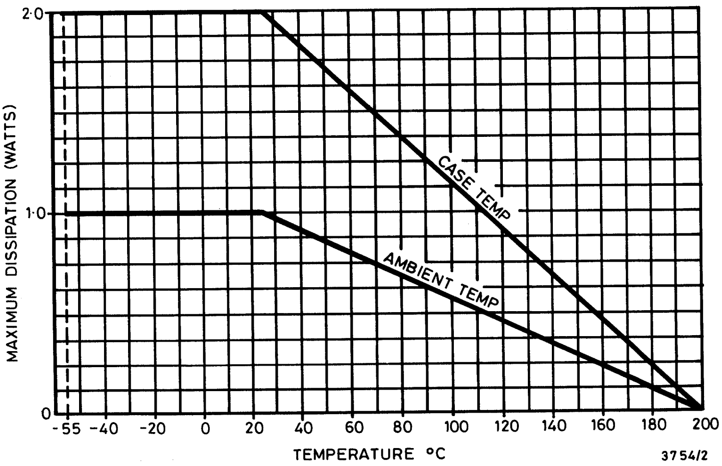
Note: Consult Safe Operating Area graph for conditions.

# ZTX454 ZTX455

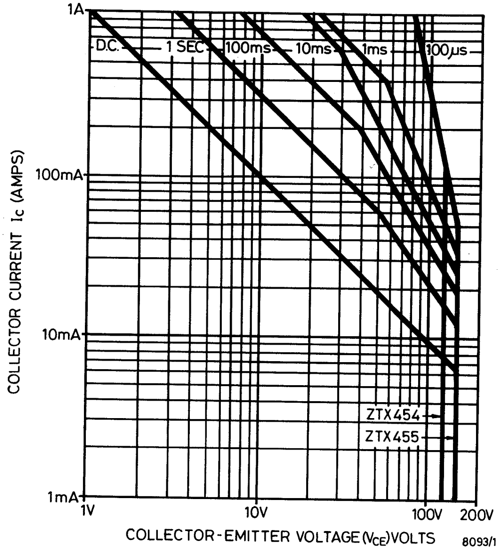
CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

| Parameter | Symbol | ZTX454 Min. | ZTX454 Typ. | ZTX454 Max. | ZTX455 Min. | ZTX455 Typ. | ZTX455 Max. | Unit | Conditions |
|---|---|---|---|---|---|---|---|---|---|
| Collector-base cut-off current | $I_{CBO}$ | – | – | 0.1 | – | – | – | μA | $V_{BC} = 120V$ |
| | | – | – | – | – | – | 0.1 | μA | $V_{CB} = 140V$ |
| Emitter-base cut-off current | $I_{EBO}$ | – | – | 0.1 | – | – | 0.1 | μA | $V_{EB} = 4V$ |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | – | – | 0.7 | – | – | 0.7 | V | $I_C = 150mA$, $I_B = 15mA$ |
| | | – | – | 1 | – | – | – | V | $I_C = 200mA$, $I_B = 20mA$ |
| Collector-emitter sustaining voltage | $V_{CEO(sus)}$ | 120 | – | – | 140 | – | – | V | $I_C = 10mA$ |
| Static forward current transfer ratio | $h_{FE}$ | 100 | – | 300 | 100 | – | 300 | | $I_C = 150mA$, $V_{CE} = 10V$* |
| | | 30 | – | – | – | – | – | | $I_C = 200mA$, $V_{CE} = 1V$* |
| | | – | 10 | – | – | 10 | – | | $I_C = 1A$, $V_{CE} = 10V$* |
| Transition frequency | $f_T$ | 100 | – | – | 100 | – | – | MHz | $I_C = 50mA$, $V_{CE} = 10V$<br>$f = 100MHz$ |
| Output capacitance | $C_{obo}$ | – | – | 15 | – | – | 15 | pF | $V_{CB} = 10V$, $f = 1MHz$ |

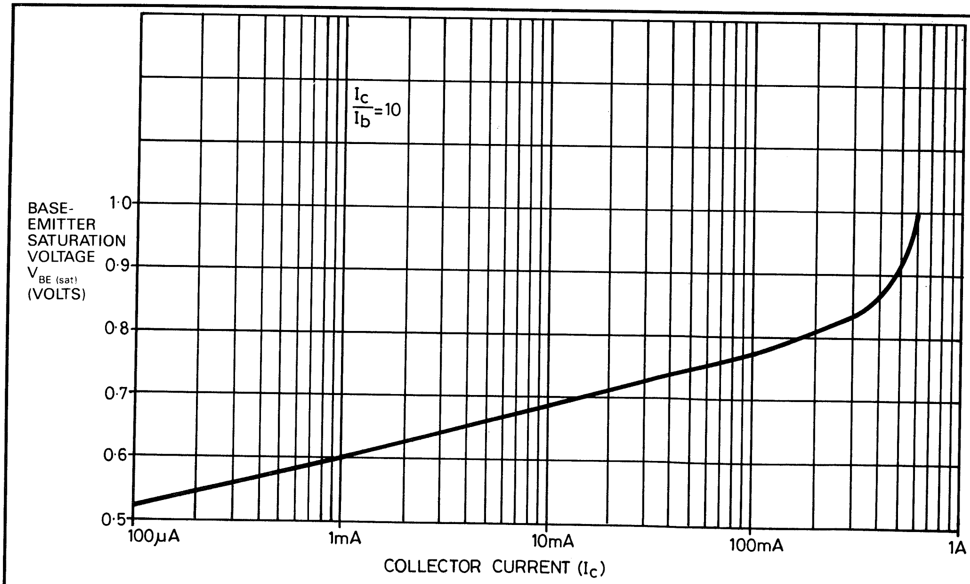
*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ≤ 2%.



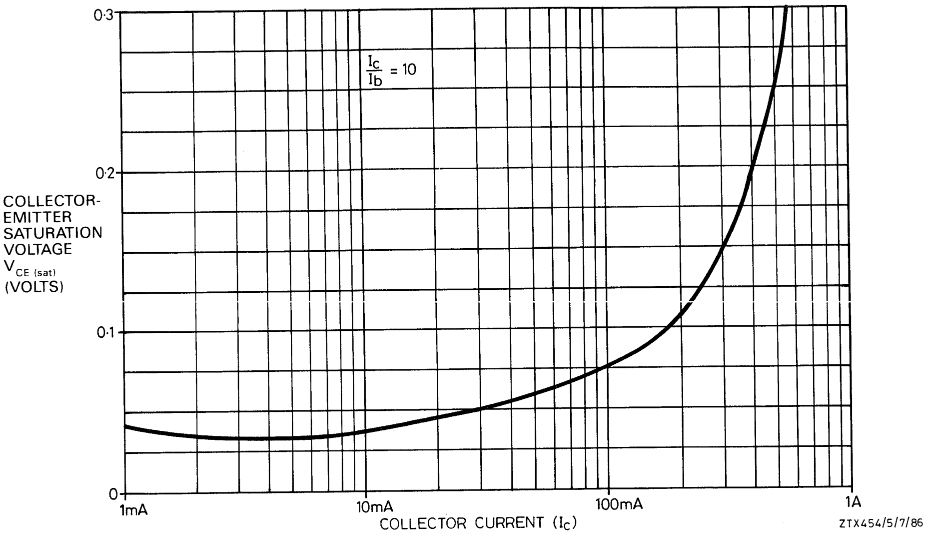
**Dissipation derating curve**



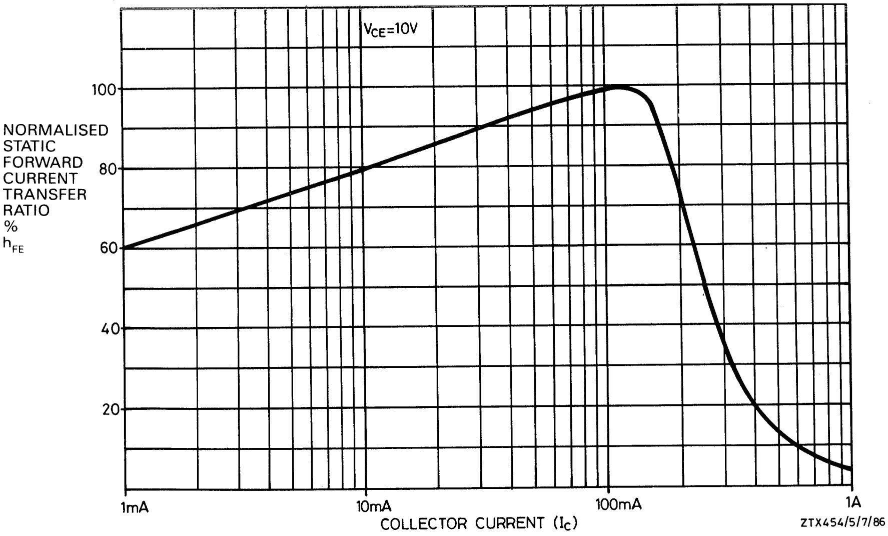
**Safe operating area at $T_{amb} = 25°C$ (single-pulse)**



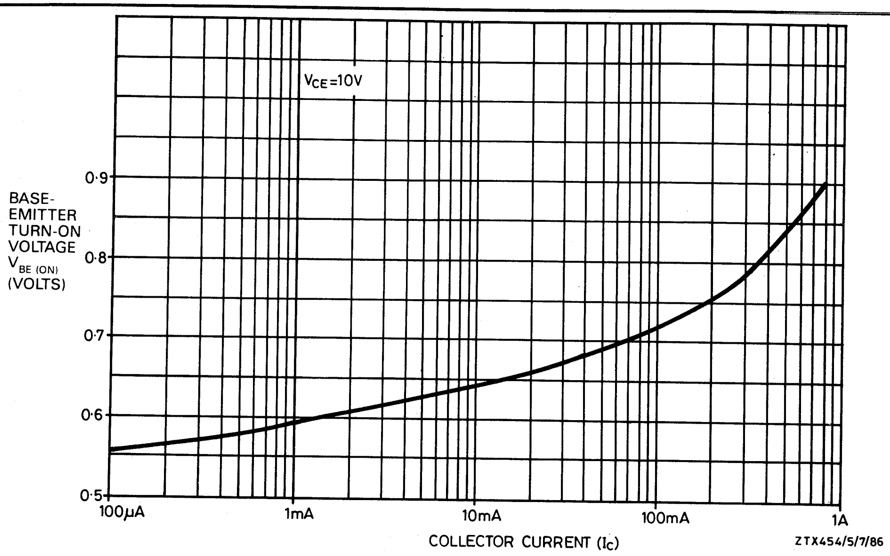
**Typical base-emitter saturation voltage plotted against collector current**



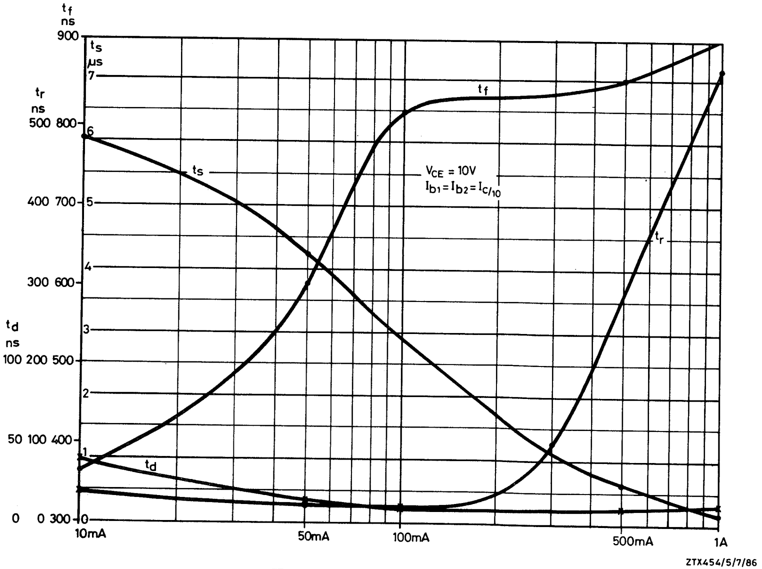
Typical collector-emitter saturation voltage plotted against collector current



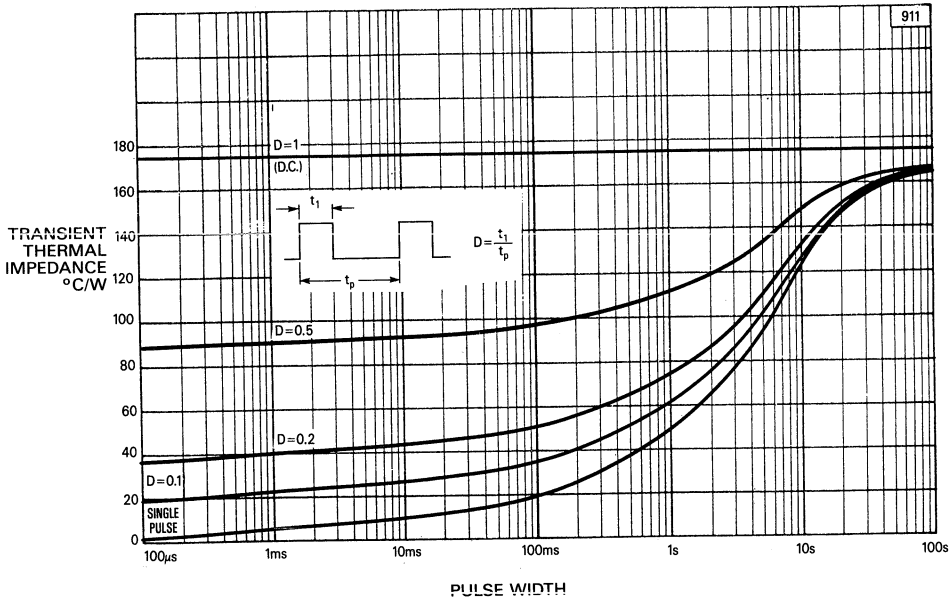
Typical static forward current transfer ratio plotted against collector current



**Typical base-emitter turn-on voltage plotted against collector current**



**Typical switching speeds**



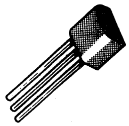
**Maximum transient thermal impedance curves**

# PNP Silicon Planar Medium Power Transistor

# ZTX549

## FEATURES

- 1W power dissipation at $T_{amb} = 25°C$
- 2A peak pulse current
- Excellent gain characteristics up to 2A (pulsed)
- Low saturation voltages
- Fast switching
- NPN complementary type available



Plastic E-Line
(TO-92 Compatible)

## DESCRIPTION

A high performance transistor encapsulated in the popular E-line (TO-92) plastic package.

The 2A, 1W performance and excellent gain characteristics up to 2A permit use in a wide range of industrial and consumer applications.

The specially selected silicone encapsulation provides resistance to severe environments comparable with metal can devices. In addition the small size of the E-line package assists where space is at a premium.

Complementary to the ZTX449

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | ZTX549 | Unit |
|---|---|---|---|
| Collector-base voltage | $V_{CBO}$ | −35 | V |
| Collector-emitter voltage | $V_{CEO}$ | −30 | V |
| Emitter-base voltage | $V_{EBO}$ | −5 | V |
| Peak pulse current (see note below) | $I_{CM}$ | −2 | A |
| Continuous collector current | $I_C$ | −1 | A |
| Power dissipation: at $T_{amb} = 25°C$<br>derate above 25°C | $P_{tot}$ | 1<br>5.7 | W<br>mW/°C |
| Operating and storage temperature range | | −55 to +200 | °C |

Note: Consult Safe Operating Area graph for conditions.

# ZTX549

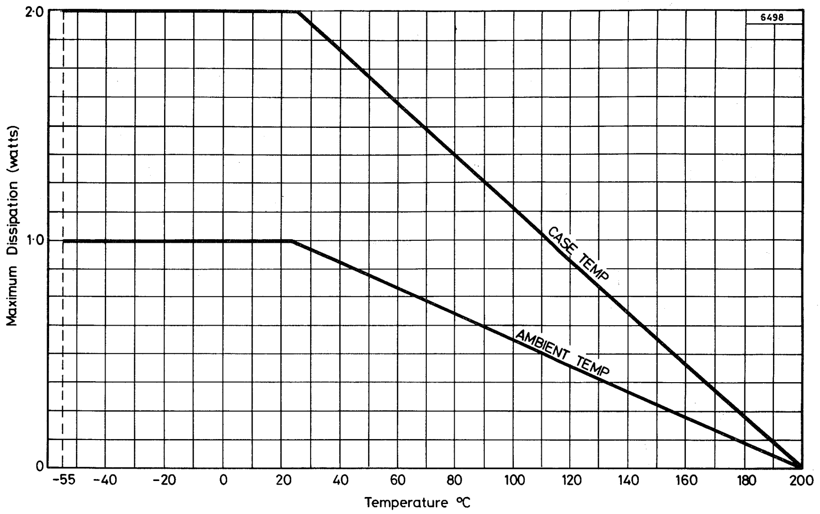
CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Conditions |
|---|---|---|---|---|---|---|
| Collector-base breakdown voltage | $V_{(BR)CBO}$ | −35 | – | – | V | $I_C = -100\mu A$ |
| Collector-emitter breakdown voltage | $V_{(BR)CEO}$ | −30 | – | – | V | $I_C = -10mA$ |
| Emitter-base breakdown voltage | $V_{(BR)EBO}$ | −5 | – | – | V | $I_E = -100\mu A$ |
| Collector cut-off current | $I_{CBO}$ | – | – | −0.1 | μA | $V_{CB} = -30V$ |
| | | – | – | −10 | μA | $V_{CB} = -30V$, $T_{amb} = 100°C$ |
| Emitter cut-off current | $I_{EBO}$ | – | – | −0.1 | μA | $V_{EB} = -4V$ |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | – | −0.25 | −0.5 | V | $I_C = -1A$, $I_B = -100mA$* |
| | – | – | −0.50 | −0.75 | V | $I_C = -2A$, $I_B = -200mA$* |
| Base-emitter saturation voltage | $V_{BE(sat)}$ | – | −0.90 | −1.25 | V | $I_C = -1A$, $I_B = -100mA$* |
| Base-emitter turn on voltage | $V_{BE(ON)}$ | – | −0.85 | −1 | V | $I_C = -1A$, $V_{CE} = -2V$* |
| Static forward current transfer ratio | $h_{FE}$ | 70 | 200 | – | | $I_C = -50mA$, $V_{CE} = -2V$* |
| | | 100 | 160 | 300 | | $I_C = -500mA$, $V_{CE} = -2V$* |
| | | 80 | 130 | – | | $I_C = -1A$, $V_{CE} = -2V$* |
| | | 40 | 80 | – | | $I_C = -2A$, $V_{CE} = -2V$* |
| Transition frequency | $f_T$ | 100 | – | – | MHz | $I_C = -100mA$, $V_{CE} = -5V$<br>$f = 100MHz$ |
| Output capacitance | $C_{obo}$ | – | – | 25 | pF | $V_{CB} = -10V$, $f = 1MHz$ |
| Switching times | $T_{on}$ | – | 300 | – | ns | $I_C = -500mA$<br>$I_{B1} = I_{B2} = -50mA$<br>$V_{CC} = -10V$ |
| | $T_{off}$ | – | 50 | – | ns | |

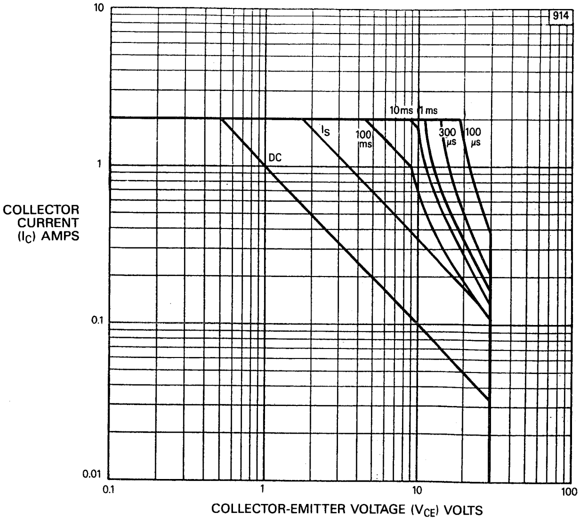
*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ⩽2%.

## THERMAL CHARACTERISTICS

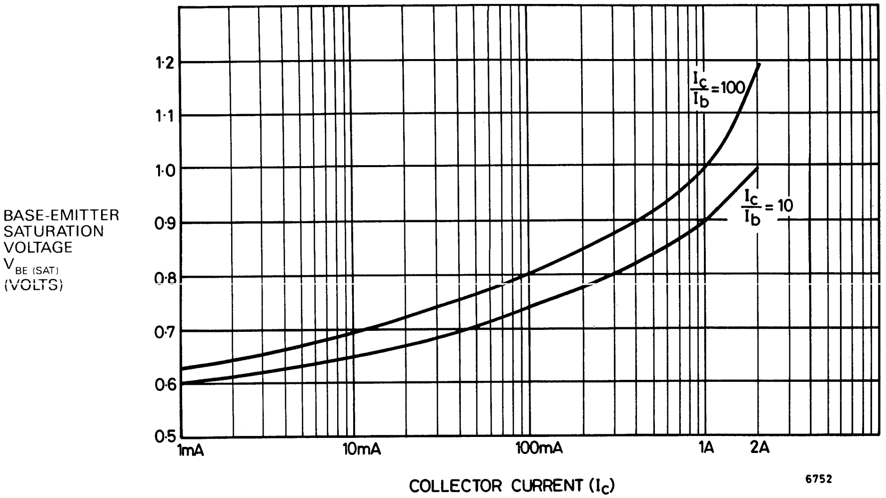
| Parameter | Symbol | Maximum | Unit |
|---|---|---|---|
| Thermal resistance: Junction to ambient | $R_{th(j\text{-}amb)}$ | 175 | °C/W |
| Junction to case | $R_{th(j\text{-}case)}$ | 87.5 | °C/W |



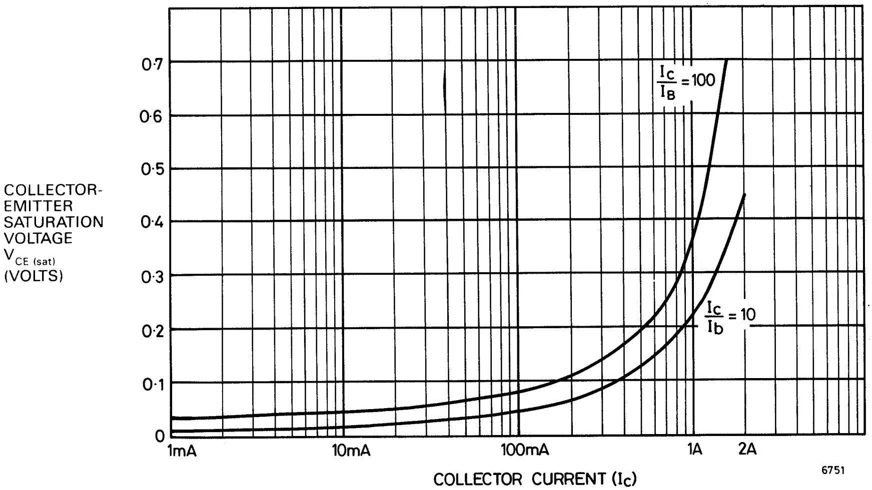
**Dissipation derating curve**



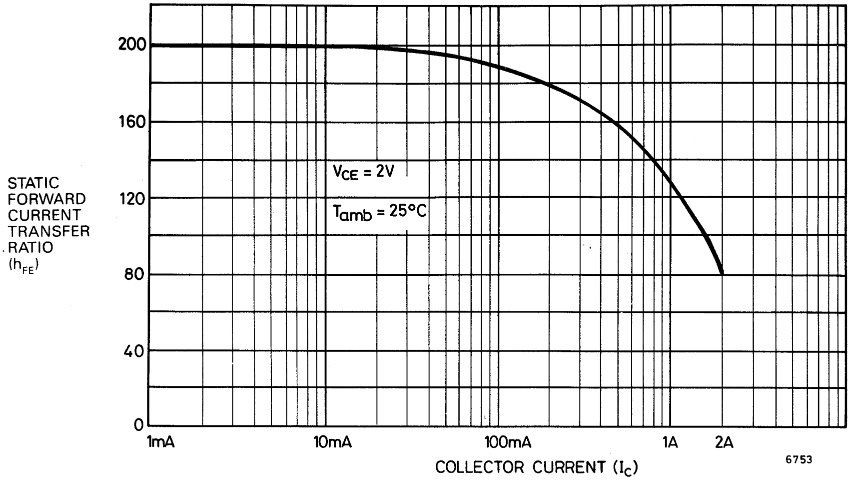
**Safe operating area at $T_{amb} = 25°C$ (single-pulse)**



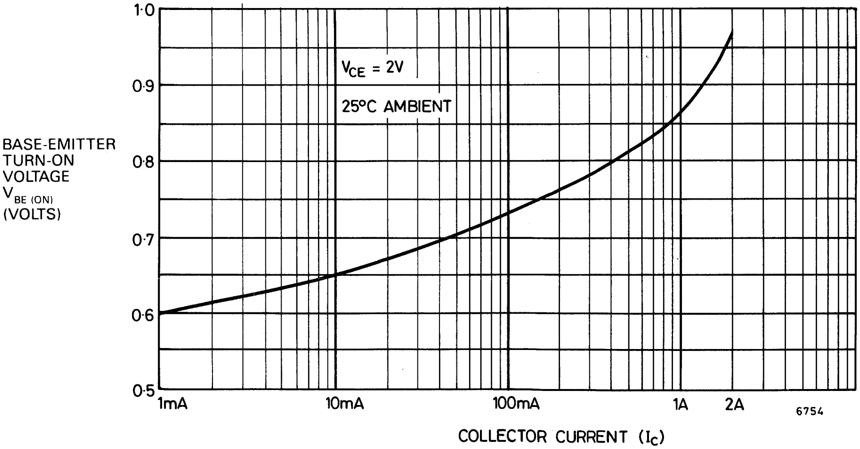
Typical base-emitter saturation voltage plotted against collector current



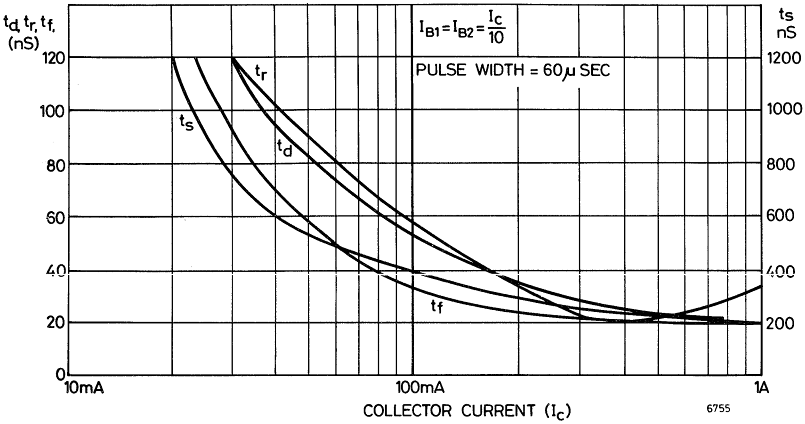
Typical collector-emitter saturation voltage plotted against collector current



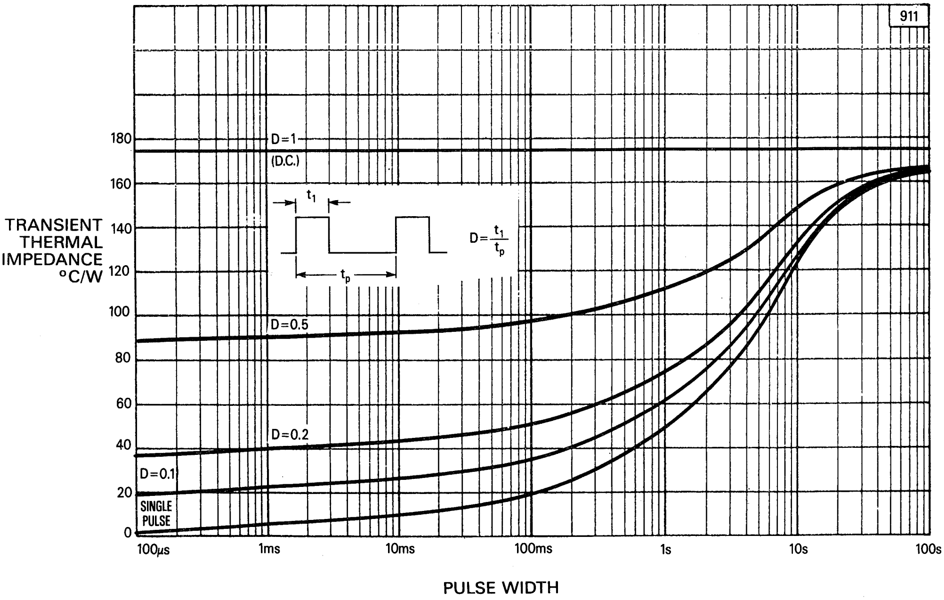
**Typical static forward current transfer ratio plotted against collector current**



**Typical base-emitter turn-on voltage plotted against collector current**



Typical switching speeds



Maximum transient thermal impedance curves

# PNP Silicon Planar Medium Power Transistors

# ZTX550
# ZTX551

## FEATURES

- High power dissipation: 1W at $T_{amb} = 25°C$
- $h_{FE}$ specified up to 1A
- High $f_T$: 200MHz typical

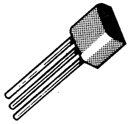
## DESCRIPTION

These are plastic encapsulated, general purpose transistors designed for small and medium signal amplification from d.c. to radio frequencies.

Application areas include: audio frequency amplifiers, driver and output stages, oscillators and general purpose switching.

The E-line package is formed by transfer moulding a silicone plastic specially selected to provide a rugged one-piece encapsulation resistant to severe environments and allow the high junction temperature operation normally associated with metal can devices.

E-line encapsulated devices are approved for use in military, industrial and professional equipments.



Plastic E-Line
(TO-92 Compatible)

Alternative lead configurations are available as plug-in replacements of TO-5/39 and TO-18 metal can types, and for surface mounting.

Complementary to ZTX450 and ZTX451 NPN transistors.

The ZTX550 and ZTX551 transistors approved for use in military equipment are identified by the following numbers:

BS9365 F143 & F144 - Category F.

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | ZTX550 | ZTX551 | Unit |
|---|---|---|---|---|
| Collector-base voltage | $V_{CBO}$ | −60 | −80 | V |
| Collector-emitter voltage | $V_{CEO}$ | −45 | −60 | V |
| Emitter-base voltage | $V_{EBO}$ | −5 | | V |
| Peak pulse current (see note below) | $I_{CM}$ | −2 | | A |
| Continuous collector current | $I_C$ | −1 | | A |
| Base current | $I_B$ | −200 | | mA |
| Power dissipation at $T_{amb} = 25°C$<br>at $T_{case} = 25°C$ | $P_{tot}$ | 1<br>2 | | W<br>W |
| Operating and storage temperature range | | −55 to +200 | | °C |

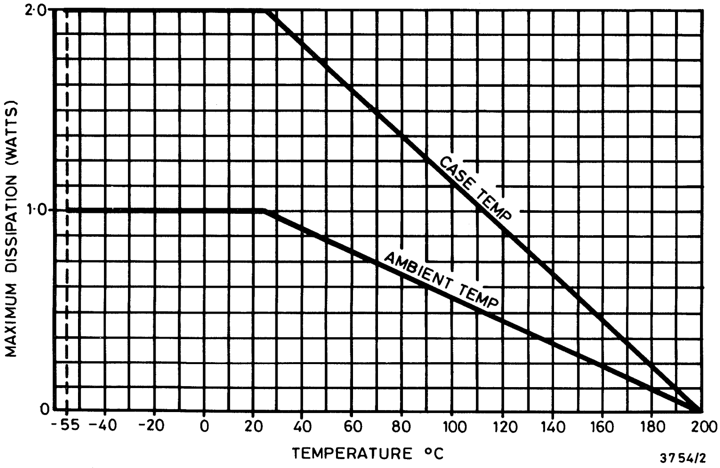
Note: Consult Safe Operating Area graph for conditions.

# ZTX550 ZTX551

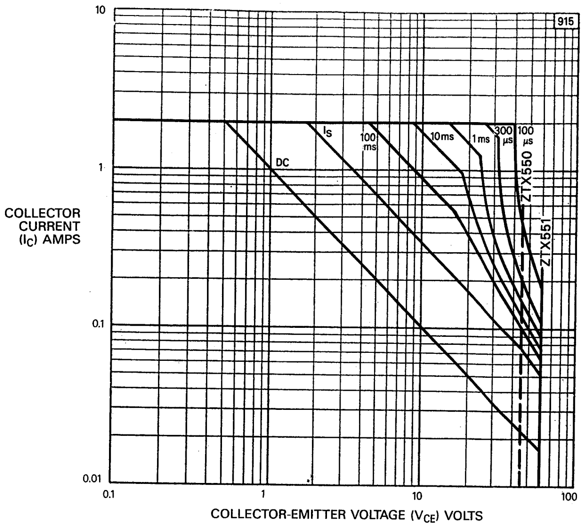
CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

| Parameter | Symbol | ZTX550 | | ZTX551 | | Unit | Conditions |
|---|---|---|---|---|---|---|---|
| | | Min. | Max. | Min. | Max. | | |
| Collector-base cut-off current | $I_{CBO}$ | – | –0.1 | – | – | μA | $V_{CB} = -45V$ |
| | | – | – | – | –0.1 | μA | $V_{CB} = -60V$ |
| Emitter-base cut-off current | $I_{EBO}$ | – | –0.1 | – | –0.1 | μA | $V_{EB} = -4V$ |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | – | –0.25 | – | –0.35 | V | $I_C = -150mA$, $I_B = -15mA$* |
| Base-emitter saturation voltage | $V_{BE(sat)}$ | – | –1.1 | – | –1.1 | V | $I_C = -150mA$, $I_B = -15mA$* |
| Collector-emitter sustaining voltage | $V_{CEO(sus)}$ | –45 | – | –60 | – | V | $I_C = -10mA$* |
| Static forward current transfer ratio | $h_{FE}$ | 100 | 300 | 50 | 150 | | $I_C = -150mA$, $V_{CE} = -10V$* |
| | | 15 | – | 10 | – | | $I_C = -1A$, $V_{CE} = -10V$* |
| Transition frequency | $f_T$ | 150 | – | 150 | – | MHz | $I_C = -50mA$, $V_{CE} = -10V$<br>$f = 100MHz$ |
| Output capacitance | $C_{obo}$ | – | 25 | – | 25 | pF | $V_{CB} = -10V$, $f = 1MHz$ |

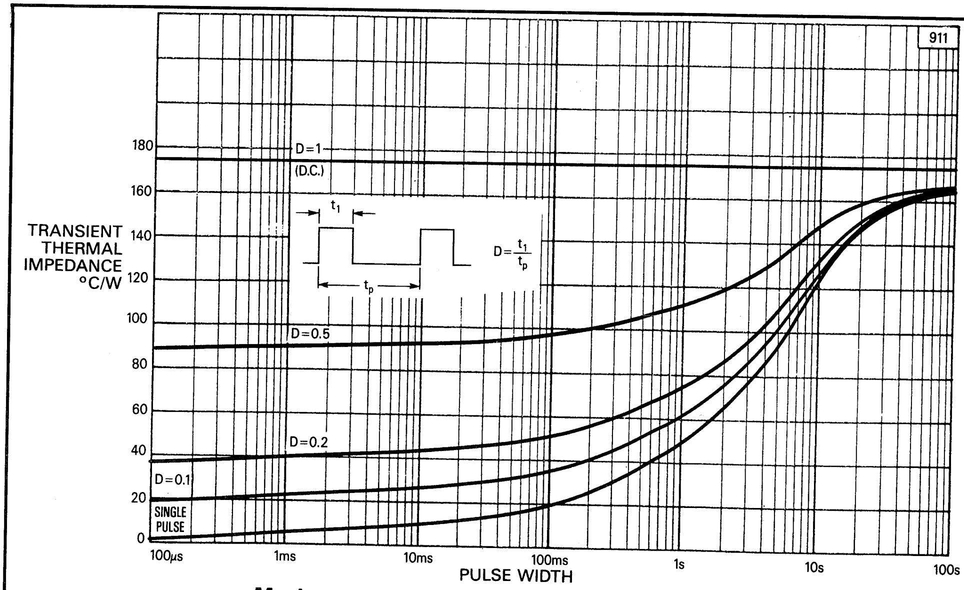
*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ≤ 2%.



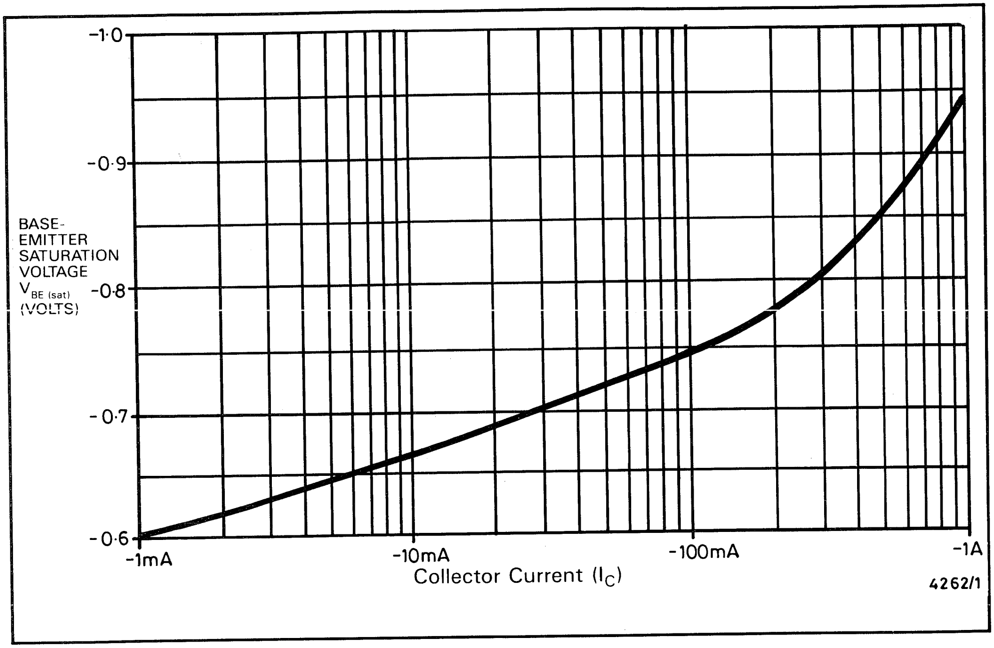
Dissipation derating curve

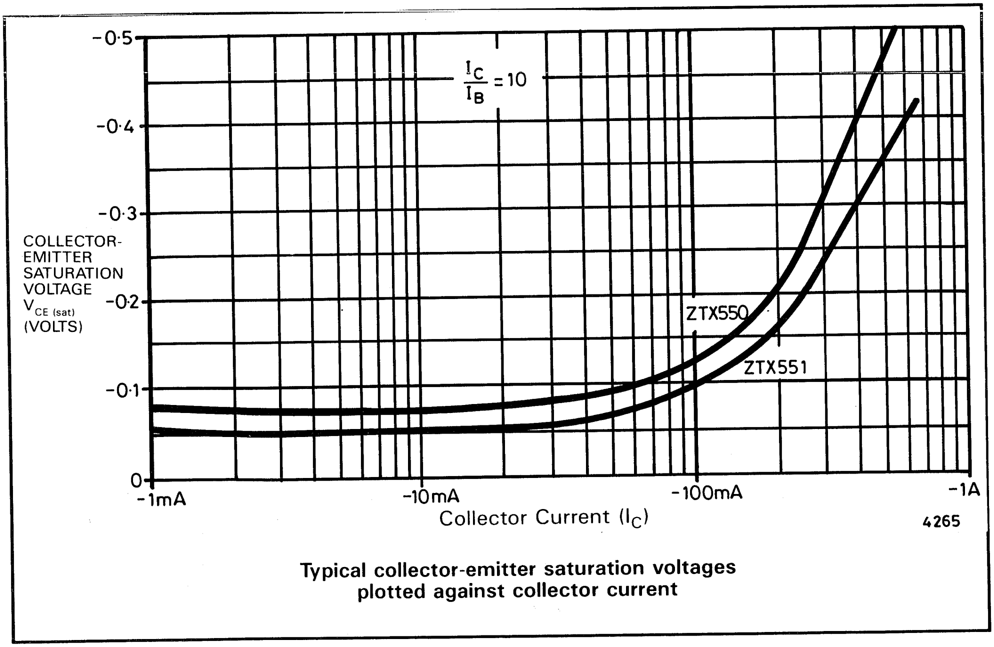


**Safe operating area at $T_{case} = 25°C$ (single pulse)**

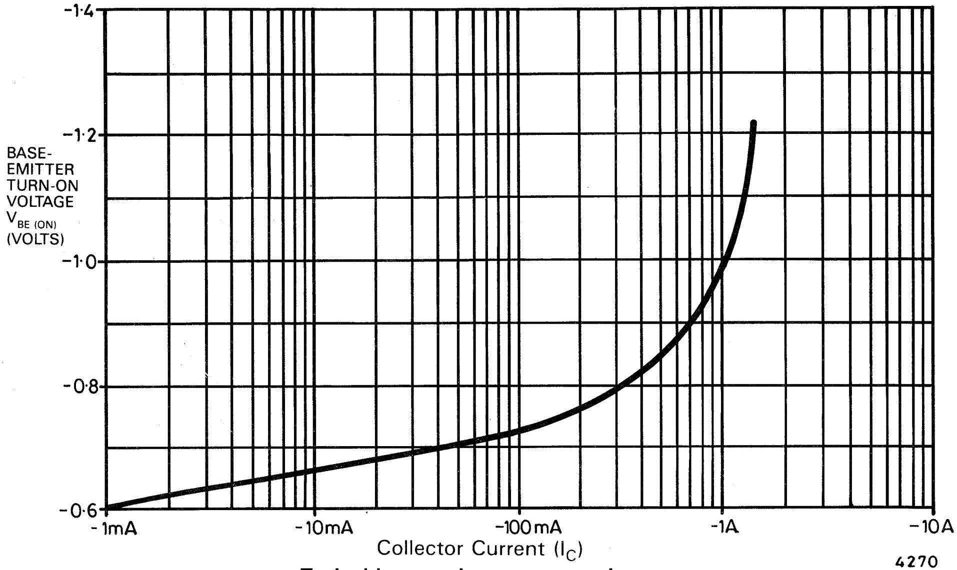


**Maximum transient thermal impedance curves**

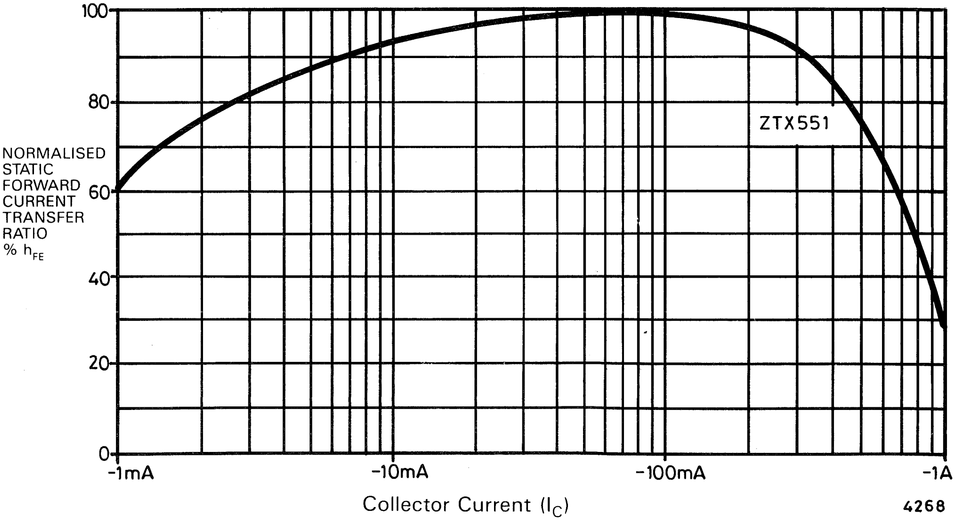




**Typical collector-emitter saturation voltages plotted against collector current**



**Typical base-emitter turn-on voltages plotted against collector current**



**Typical static forward current transfer ratio plotted against collector current**

# PNP Silicon Planar Medium Power Transistors

# ZTX552
# ZTX553

## FEATURES

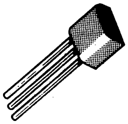
- High power dissipation: 1W at $T_{amb} = 25°C$
- $h_{FE}$ specified up to 1A
- High $f_T$: 200MHz typical

## DESCRIPTION

These are plastic encapsulated, general purpose transistors designed for small and medium signal amplification from d.c. to radio frequencies.

Application areas include: audio frequency amplifiers, driver and output stages, oscillators and general purpose switching.

The E-line package is formed by transfer moulding a silicone plastic specially selected to provide a rugged one-piece encapsulation resistant to severe environments and allow the high junction temperature operation normally associated with metal can devices.



Plastic E-Line
(TO-92 Compatible)

E-line encapsulated devices are approved for use in military, industrial and professional equipments.

Alternative lead configurations are available as plug-in replacements of TO-5/39 and TO-18 metal can types, and for surface mounting.

Complementary to ZTX452 and ZTX453 NPN transistors.

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | ZTX552 | ZTX553 | Unit |
|---|---|---|---|---|
| Collector-base voltage | $V_{CBO}$ | −100 | −120 | V |
| Collector-emitter voltage | $V_{CEO}$ | −80 | −100 | V |
| Emitter-base voltage | $V_{EBO}$ | −5 | | V |
| Peak pulse current (see note below) | $I_{CM}$ | −2 | | A |
| Continuous collector current | $I_C$ | −1 | | A |
| Base current | $I_B$ | −200 | | mA |
| Power dissipation at $T_{amb} = 25°C$<br>at $T_{case} = 25°C$ | $P_{tot}$ | 1<br>2 | | W<br>W |
| Operating and storage temperature range | | −55 to +200 | | °C |

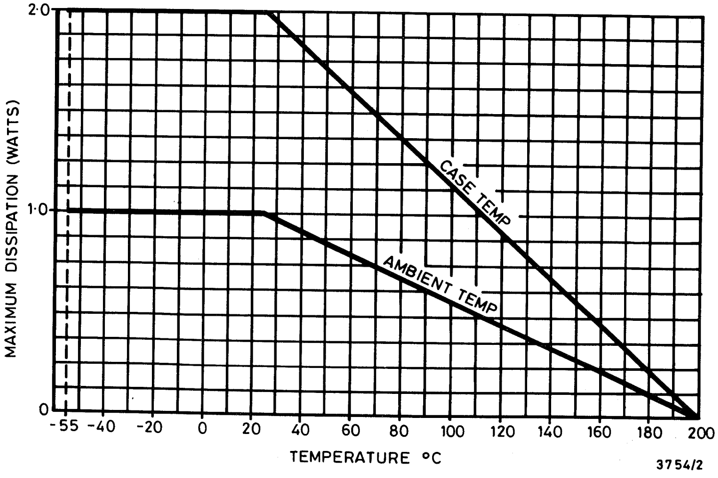
Note: Consult Safe Operating Area graph for conditions.

# ZTX552 ZTX553

CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

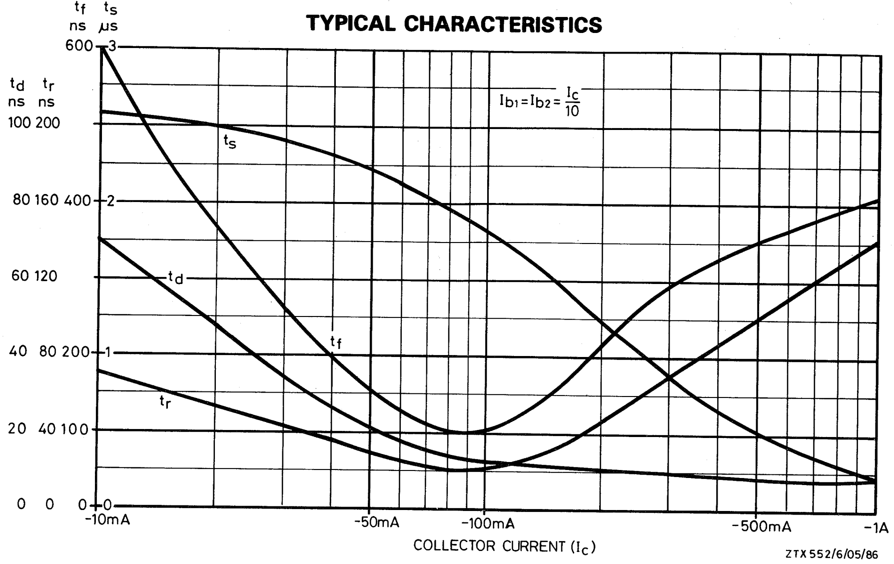
| Parameter | Symbol | ZTX552 | | ZTX553 | | Unit | Conditions |
|---|---|---|---|---|---|---|---|
| | | Min. | Max. | Min. | Max. | | |
| Collector-base cut-off current | $I_{CBO}$ | – | −0.1 | – | – | sA | $V_{CB} = -80V$ |
| | | – | – | – | −0.1 | sA | $V_{CB} = -100V$ |
| Emitter-base cut-off current | $I_{EBO}$ | – | −0.1 | – | −0.1 | sA | $V_{EB} = -4V$ |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | – | −0.25 | – | −0.25 | V | $I_C = -150mA$, $I_B = -15mA$* |
| Base-emitter saturation voltage | $V_{BE(sat)}$ | – | −1.1 | – | −1.1 | V | $I_C = -150mA$, $I_B = -15mA$* |
| Base-emitter turn-on voltage | $V_{BE(on)}$ | – | −1 | – | −1 | V | $I_C = -150mA$, $V_{CE} = -10V$* |
| Collector-emitter sustaining voltage | $V_{CEO(sus)}$ | −80 | – | −100 | – | V | $I_C = -10mA$* |
| Static forward current transfer ratio | $h_{FE}$ | 40 | 150 | 40 | 200 | | $I_C = -150mA$, $V_{CE} = -10V$* |
| | | 10 | – | 10 | – | | $I_C = -1A$, $V_{CE} = -10V$* |
| Transition frequency | $f_T$ | 150 | – | 150 | – | MHz | $I_C = -50mA$, $V_{CE} = -10V$<br>$f = 100MHz$ |
| Output capacitance | $C_{obo}$ | – | 12 | – | 12 | pF | $V_{CB} = -10V$, $f = 1MHz$ |

*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ⩽ 2%.

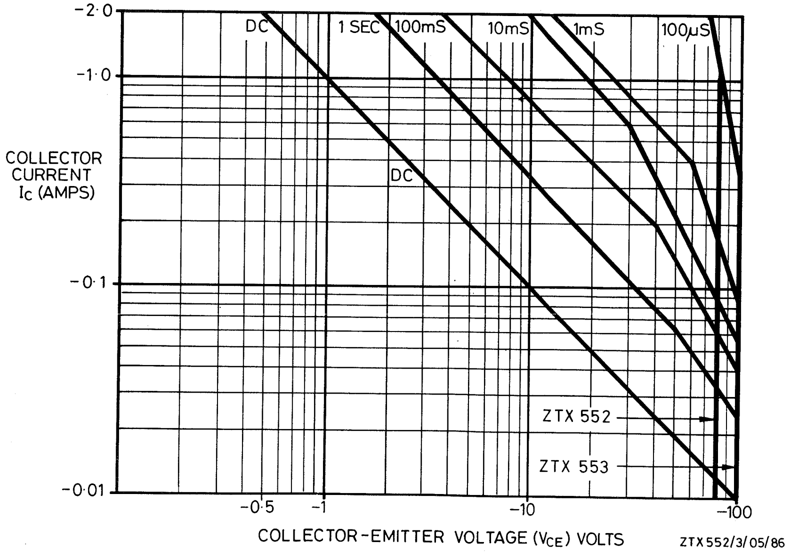


**Derating curve**

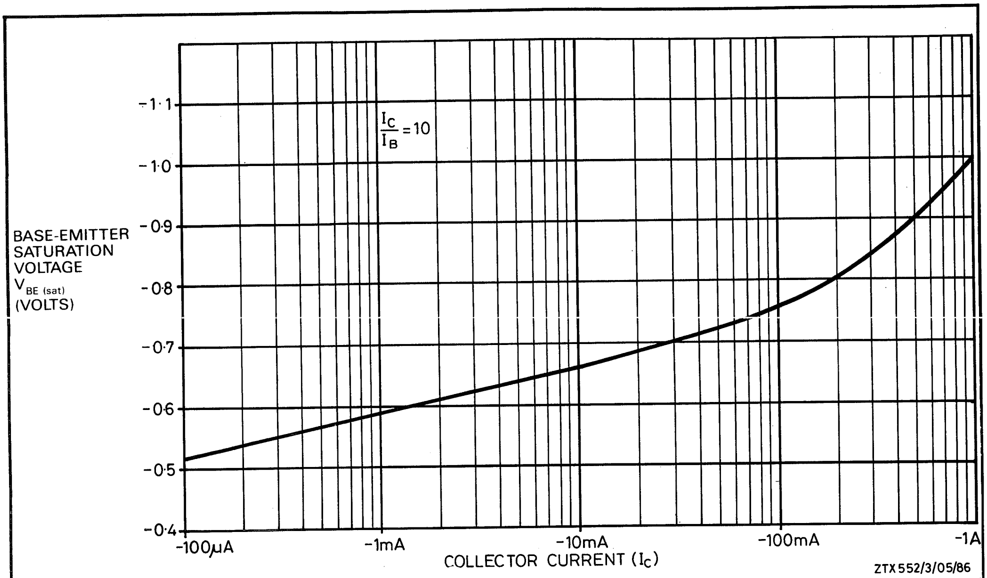
## TYPICAL CHARACTERISTICS



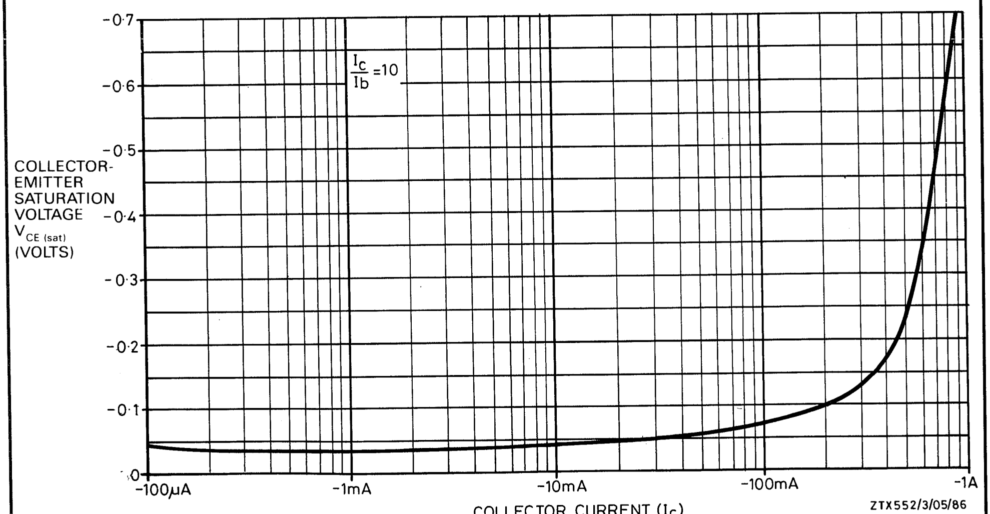
**Typical switching speeds**



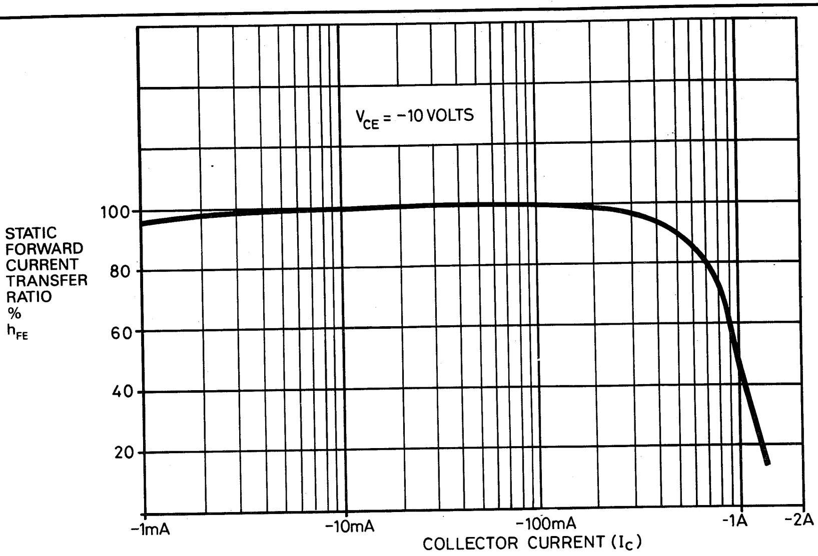
**Safe operating area at $T_{amb} = 25°C$ (single pulse)**



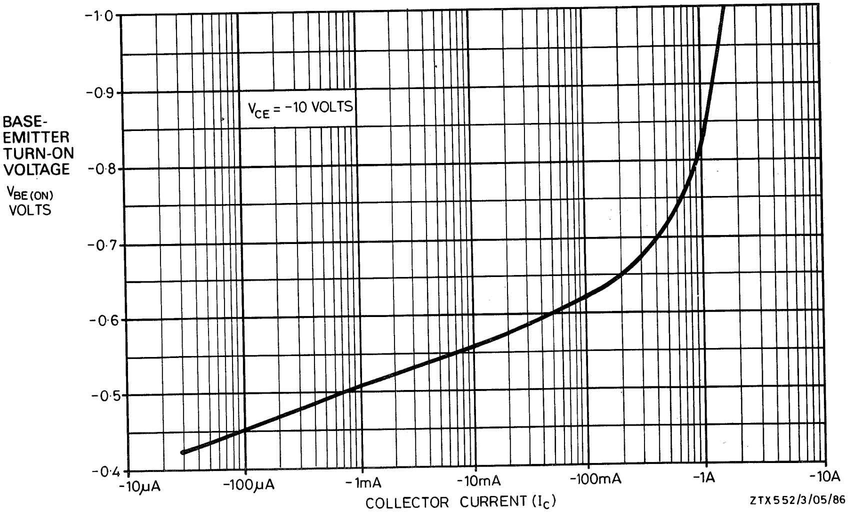
**Typical base-emitter saturation voltage plotted against collector current**



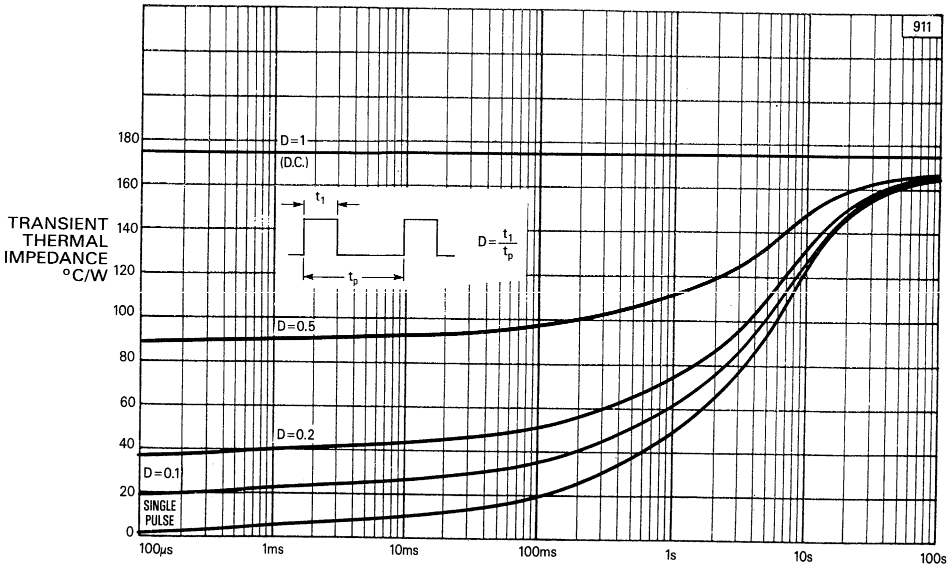
**Typical collector-emitter saturation voltage plotted against collector current**



**Typical static forward current transfer ratio plotted against collector current**



**Typical base-emitter turn-on voltage plotted against collector current**



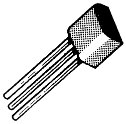
**Maximum transient thermal impedance curves**

# PNP Silicon Planar Medium Power Transistors

## ZTX554 ZTX555
## ZTX556 ZTX557

### FEATURES

- 1W power dissipation at $T_{amb} = 25°C$
- Voltages up to 300V
- Excellent gain characteristics up to 300mA
- Low saturation voltages
- 1A continuous $I_C$



**Plastic E-Line**
**(TO-92 Compatible)**

### DESCRIPTION

A range of high voltage, high performance transistors encapsulated in the popular E-line (TO-92) plastic package.

Application areas include: audio frequency amplifiers, drivers and output stages, oscillators and general purpose switching.

The E-line package is formed by transfer moulding a silicone plastic specially selected to provide a rugged one-piece encapsulation resistant to severe environments and allow the high junction temperature operation normally associated with metal can devices.

E-line encapsulated devices are approved for use in military, industrial and professional equipments.

### ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | ZTX554 | ZTX555 | ZTX556 | ZTX557 | Unit |
|---|---|---|---|---|---|---|
| Collector-base voltage | $V_{CBO}$ | −140 | −160 | −200 | −300 | V |
| Collector-emitter voltage | $V_{CEO}$ | −125 | −150 | −200 | −300 | V |
| Emitter-base voltage | $V_{EBO}$ | −5 | | | | V |
| Peak pulse current (see note below) | $I_{CM}$ | −2 | | −1 | | A |
| Continuous collector current | $I_C$ | −1 | | −0.5 | | A |
| Power dissipation at $T_{amb} = 25°C$ | $P_{tot}$ | 1 | | | | W |
| at $T_{case} = 25°C$ | | 2 | | | | W |
| Operating & storage temp. range | | −55 to +200 | | | | °C |

Note: Consult Safe Operating Area graph for conditions.

# ZTX554 ZTX555 ZTX556 ZTX557

CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

| Parameter | Symbol | ZTX554 | | ZTX555 | | Unit | Conditions |
|---|---|---|---|---|---|---|---|
| | | Min. | Max. | Min. | Max. | | |
| Collector-base breakdown voltage | $V_{(BR)CBO}$ | −140 | – | −160 | – | V | $I_C = 100\mu A$ |
| Collector-emitter breakdown voltage | $V_{(BR)CEO}$ | −125 | – | −150 | – | V | $I_C = -10mA$* |
| Emitter-base breakdown voltage | $V_{(BR)EBO}$ | −5 | – | −5 | – | V | $I_E = -100\mu A$ |
| Collector cut-off current | $I_{CBO}$ | – | −0.1 | – | – | μA | $V_{CB} = -120V$ |
| | | – | −10 | – | – | μA | $V_{CB} = -120V$<br>$T_{amb} = 100°C$ |
| | | – | – | – | −0.1 | μA | $V_{CB} = -140V$ |
| | | – | – | – | −10 | μA | $V_{CB} = -140V$<br>$T_{amb} = 100°C$ |
| Emitter cut-off current | $I_{EBO}$ | – | −0.1 | – | −0.1 | μA | $V_{EB} = -4V$ |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | – | −0.3 | – | −0.3 | V | $I_C = -100mA$*<br>$I_B = -10mA$ |
| Base-emitter saturation voltage | $V_{BE(sat)}$ | – | −1 | – | −1 | V | $I_C = 100mA$*<br>$I_B = -10mA$ |
| Base-emitter turn-on voltage | $V_{BE(on)}$ | – | −1 | – | −1 | V | $I_C = -100mA$*<br>$V_{CE} = -10V$ |
| Static forward current transfer ratio | $h_{FE}$ | 50 | – | 50 | – | | $I_C = -10mA$*<br>$V_{CE} = -10V$ |
| | | 50 | 300 | 50 | 300 | | $I_C = -300mA$*<br>$V_{CE} = -10V$ |
| Transition frequency | $f_T$ | 100 | – | 100 | – | MHz | $I_C = -50mA$<br>$V_{CE} = -10V$<br>$f = 100MHz$ |
| Output capacitance | $C_{obo}$ | – | 10 | – | 10 | pF | $V_{CE} = -10V$<br>$f = 1MHz$ |

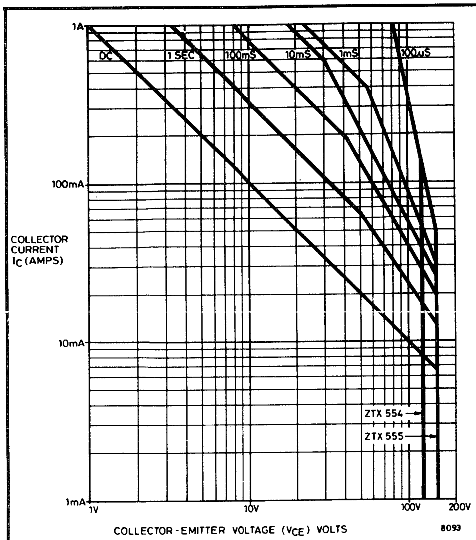
*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ⩽ 2%.

CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

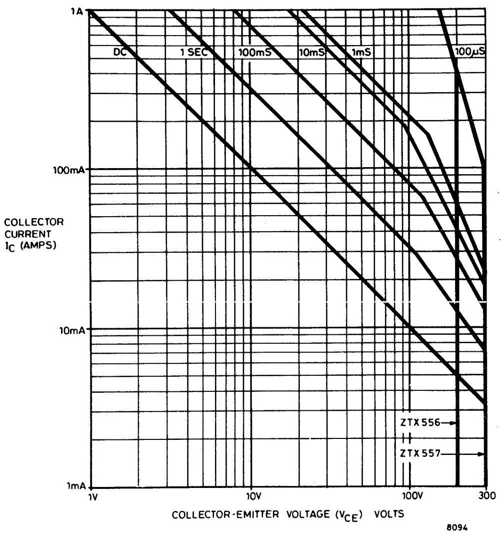
| Parameter | Symbol | ZTX556 | | ZTX557 | | Unit | Conditions |
|---|---|---|---|---|---|---|---|
| | | Min. | Max. | Min. | Max. | | |
| Collector-base breakdown voltage | $V_{(BR)CBO}$ | −200 | – | −300 | – | V | $I_C = 100\mu A$ |
| Collector-emitter breakdown voltage | $V_{(BR)CEO}$ | −200 | – | −300 | – | V | $I_C = -10mA$* |
| Emitter-base breakdown voltage | $V_{(BR)EBO}$ | −5 | – | −5 | – | V | $I_E = -100\mu A$ |
| Collector cut-off current | $I_{CBO}$ | – | −0.1 | – | – | μA | $V_{CB} = -160V$ |
| | | – | −10 | – | – | μA | $V_{CB} = -160V$<br>$T_{amb} = 100°C$ |
| | | – | – | – | −0.1 | μA | $V_{CB} = -200V$ |
| | | – | – | – | −10 | μA | $V_{CB} = -200V$<br>$T_{amb} = 100°C$ |
| Emitter cut-off current | $I_{EBO}$ | – | −0.1 | – | −0.1 | μA | $V_{EB} = -4V$ |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | – | −0.3 | – | −0.3 | V | $I_C = -50mA$*<br>$I_B = -5mA$ |
| Base-emitter saturation voltage | $V_{BE(sat)}$ | – | −1 | – | −1 | V | $I_C = -50mA$*<br>$I_B = -5mA$ |
| Base-emitter turn-on voltage | $V_{BE(on)}$ | – | −1 | – | −1 | V | $I_C = -50mA$*<br>$V_{CE} = -10V$ |
| Static forward current transfer ratio | $h_{FE}$ | 50 | – | 50 | – | | $I_C = -10mA$*<br>$V_{CE} = -10V$ |
| | | 50 | 300 | 50 | 300 | | $I_C = -50mA$*<br>$V_{CE} = -10V$ |
| Transition frequency | $f_T$ | 75 | – | 75 | – | MHz | $I_C = -50mA$<br>$V_{CE} = -10V$<br>$f = 100MHz$ |
| Output capacitance | $C_{obo}$ | – | 10 | – | 10 | pF | $V_{CE} = -10V$<br>$f = 1MHz$ |

*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ⩽ 2%.

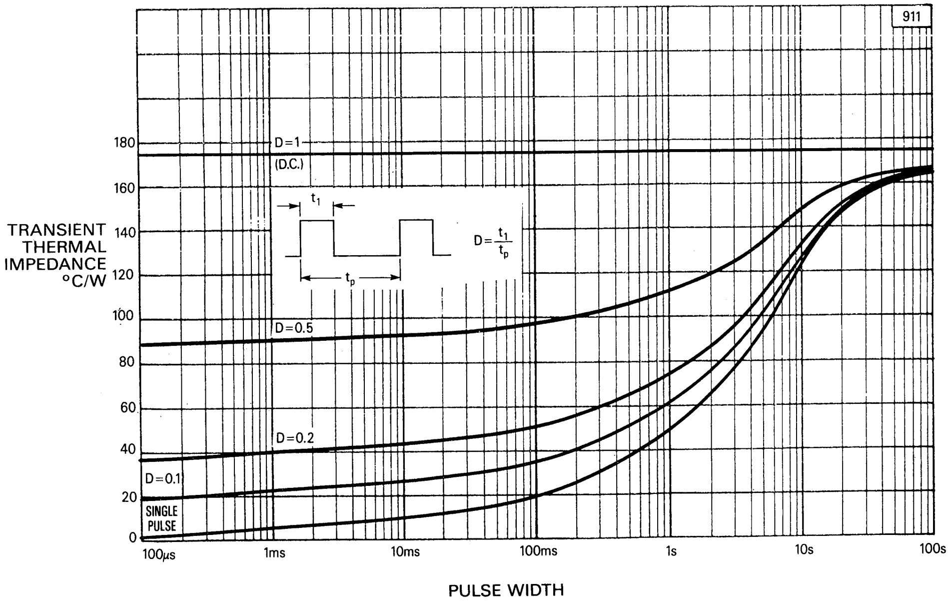
# ZTX554 ZTX555 ZTX556 ZTX557



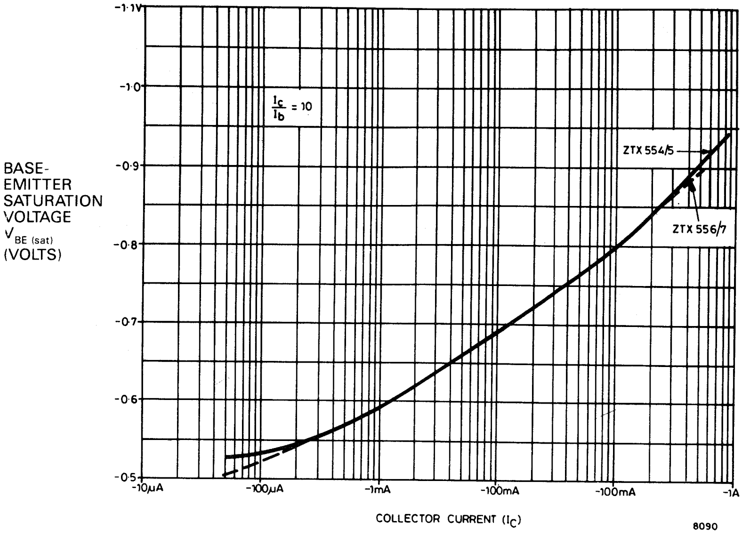
**Safe operating area at $T_{amb} = 25°C$**
**ZTX554/5 (Single pulse)**



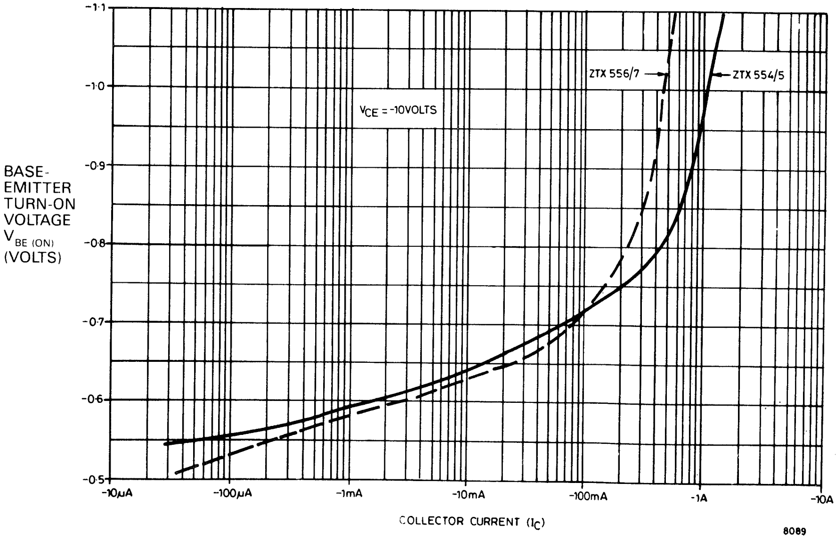
**Safe operating area at $T_{amb} = 25°C$**
**ZTX556/7 (Single pulse)**



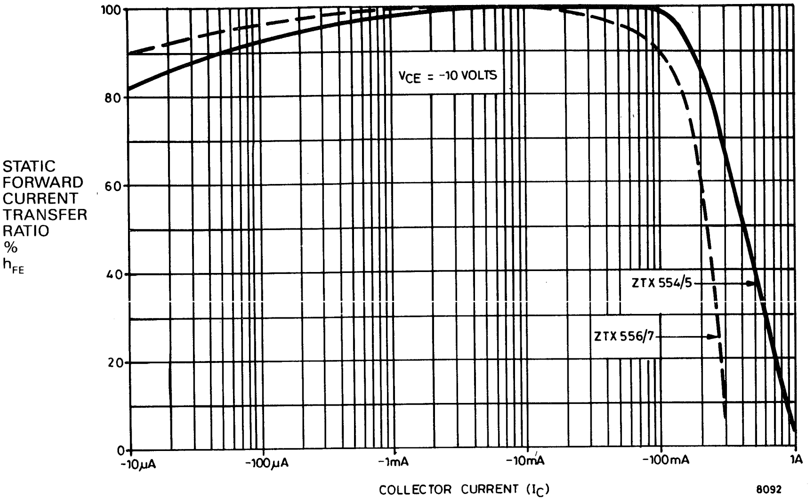
**Maximum transient thermal impedance curves**



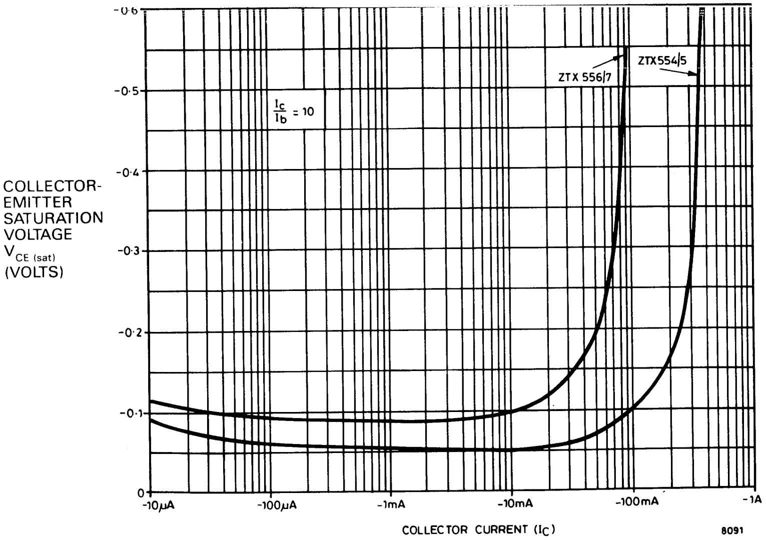
Typical base-emitter saturation voltages plotted against collector current



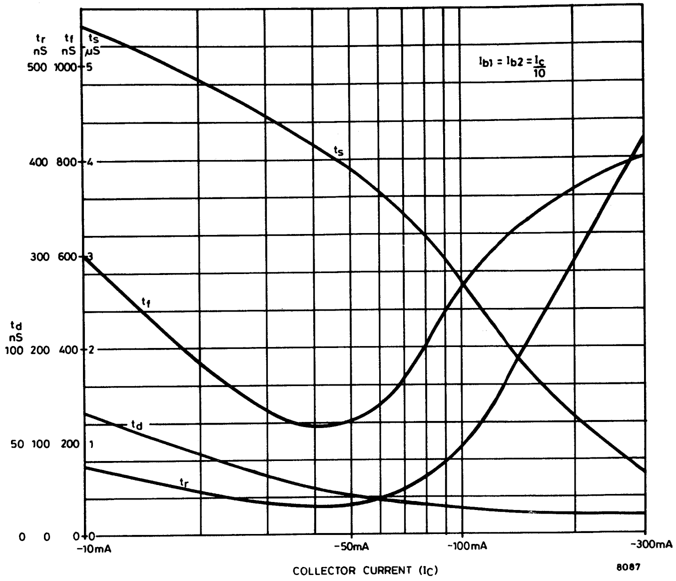
Typical base-emitter turn-on voltages plotted against collector current



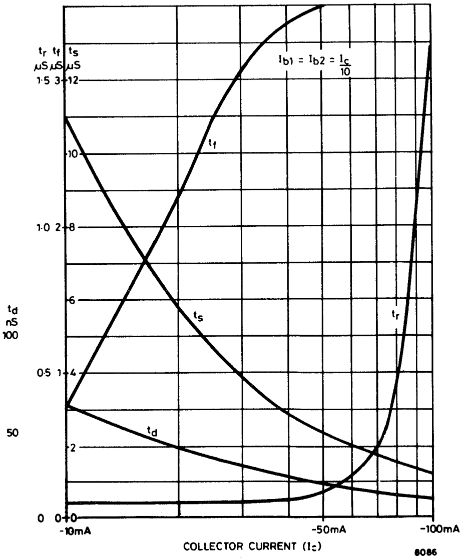
**Typical static forward current transfer ratio plotted against collector current**



**Typical collector-emitter saturation voltages plotted against collector current**



Typical switching speeds (ZTX554/ZTX555)



Typical switching speeds (ZTX556/ZTX557)

# PNP Silicon Planar Medium Power High Voltage Transistor

# ZTX576

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## FEATURES

- 1.5W power dissipation at $T_{amb} = 25°C$†
- 1 A continuous $I_C$
- Guaranteed $h_{FE}$ specified up to 1 A
- 200 V $V_{CEO}$
- Low saturation voltage

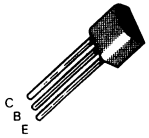
## DESCRIPTION

This plastic encapsulated medium power transistor is designed for applications requiring high breakdwon voltages and low saturation voltages.

This E-line package is formed by transfer moulding a SILICONE plastic specially selected to provide a rugged one-piece encapsulation resistant to severe environments and allow the high junction temperature operation normally associated with metal can devices.

E-line encapsulated devices are approved for use in military, industrial and professional equipments.

Alternative lead configurations are available as plug-in replacements of TO-5/39 and TO-18 metal can types, and for flat surface mounting. Also available on tape for automatic handling.



Plastic E-Line
(TO-92 Compatible)

*Fig. 1. Pin Connections*

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | Value | Unit |
|---|---|---|---|
| Collector-Base Voltage | $V_{CBO}$ | −200 | V |
| Collector-Emitter Voltage | $V_{CEO}$ | −200 | V |
| Emitter-Base Voltage | $V_{EBO}$ | −5 | V |
| Peak Pulse Collector Current (see note below) | $I_{CM}$ | −2 | A |
| Continuous Collector Current | $I_C$ | −1 | A |
| Practical Power Dissipation † | $P_{totp}$ | 1.5 | W |
| Power Dissipation at $T_{amb} = 25°C$<br>derate above 25°C | $P_{tot}$ | 1.0<br>5.7 | W<br>mW/°C |
| Operating and Storage Temperature Range | | −55 to +200 | °C |

Note: Consult Safe Operating Area graph for conditions.

†The power which can be dissipated assuming the device mounted in typical manner on PCB with copper equal to 1 sq. inch minimum.

# ZTX 576

ELECTRICAL CHARACTERISTICS (at $T_{amb} = 25°C$).

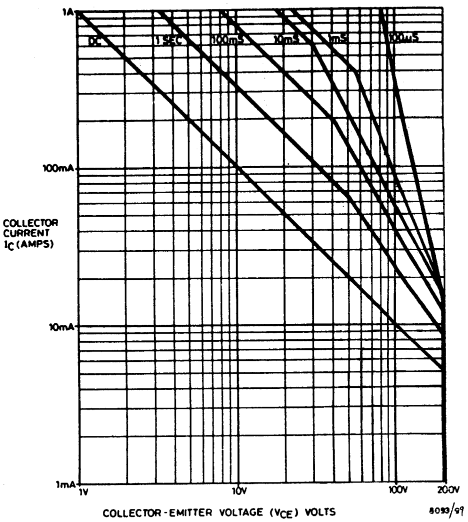
| Parameter | Symbol | Min. | Max. | Unit | Test Conditions |
|---|---|---|---|---|---|
| Collector-base breakdown voltage | $V_{(BR)CBO}$ | −200 | — | V | $I_C = -100\mu A$ |
| Collector-emitter breakdown voltage | $V_{(BR)CEO}$ | −200 | — | V | $I_C = -10mA$ |
| Emitter-base breakdown voltage | $V_{(BR)EBO}$ | −5 | — | V | $I_E = -100\mu A$ |
| Collector cut-off current | $I_{CBO}$ | — | −100 | nA | $V_{CB} = -160V$ |
| Emitter cut-off current | $I_{EBO}$ | — | −100 | nA | $V_{EB} = -4V$ |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | — | −0.3 | V | $I_C = -100mA$,* $I_B = -10mA$ |
| Base-emitter saturation voltage | $V_{BE(sat)}$ | — | −1.0 | V | $I_C = -100mA$,* $I_B = -10mA$ |
| Static forward current transfer ratio | $h_{FE}$ | 50<br>50 | —<br>300 | | $I_C = -10mA$, $V_{CE} = -10V$<br>$I_C = -300mA$,* $V_{CE} = -10V$ |
| Base-emitter turn-on voltage | $V_{BE(on)}$ | — | −1.0 | V | $I_C = -100mA$,* $V_{CE} = -10V$ |
| Transition frequency | $f_T$ | 100 | — | MHz | $I_C = -50mA$, $V_{CE} = -10V$<br>$f = 100MHz$ |

*Measured under pulsed conditions. Pulse width $= 300\mu s$. Duty cycle $\leqslant 2\%$.

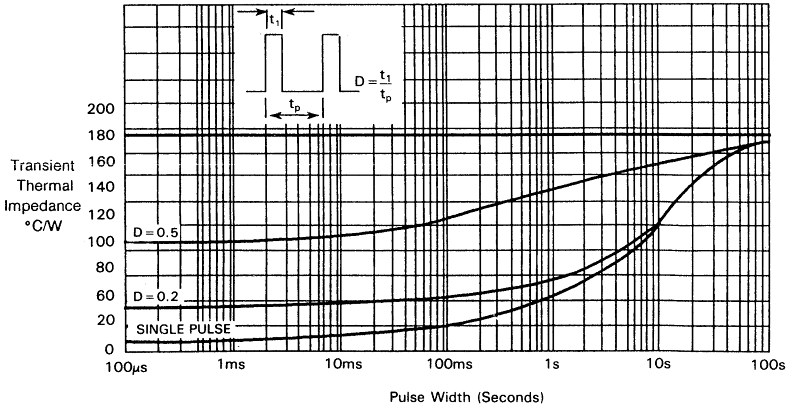
THERMAL CHARACTERISTICS

| Characteristic | Symbol | Max. Value | Unit |
|---|---|---|---|
| Thermal Resistance: Junction to Ambient$_1$ | $R_{th(j-amb)1}$ | 175 | °C/W |
| Junction to Ambient $_2$ | $R_{th(j-amb)2}$† | 116 | °C/W |
| Junction to Case | $R_{th(j-case)}$ | 70 | °C/W |

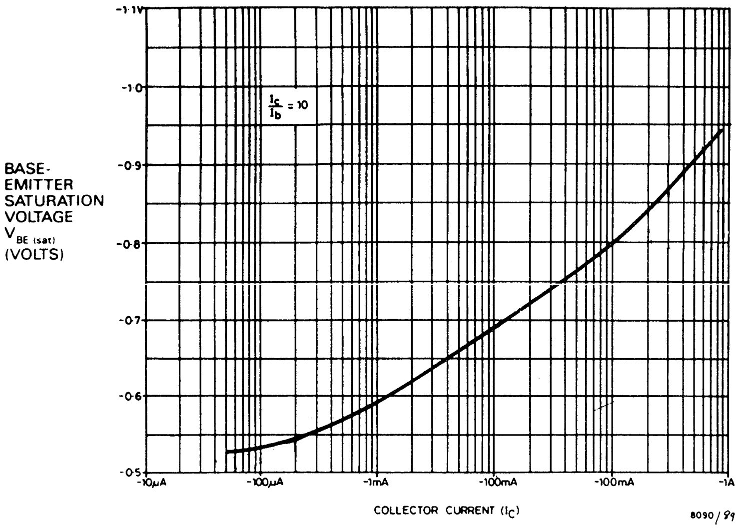
† Device mounterd on PCB with copper equal to 1 sq. inch minimum.



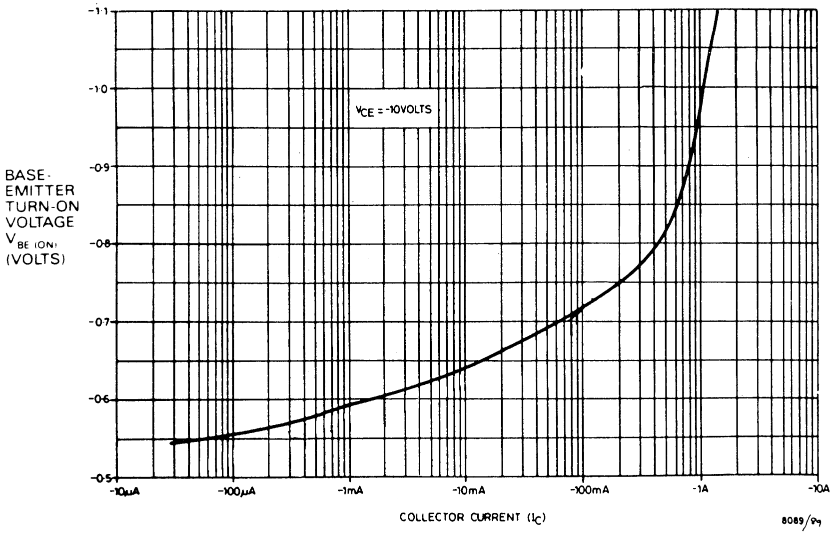
**Safe operating area at $T_{amb} = 25°C$ (single pulse)**



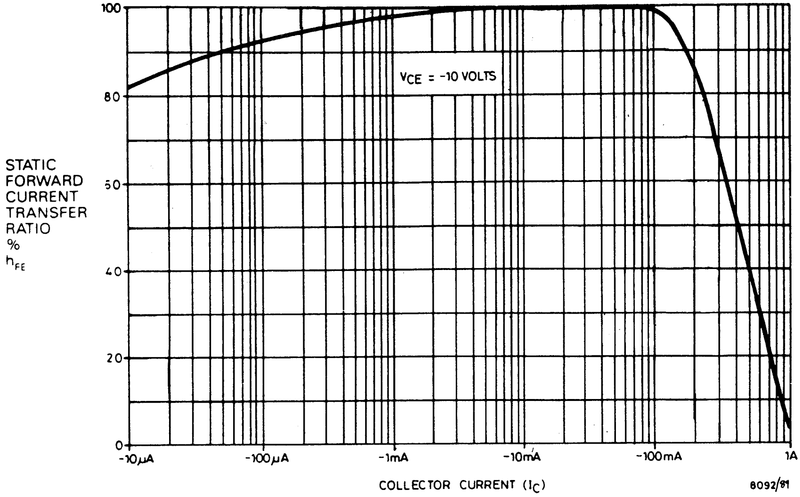
**Maximum transient thermal impedance curves**



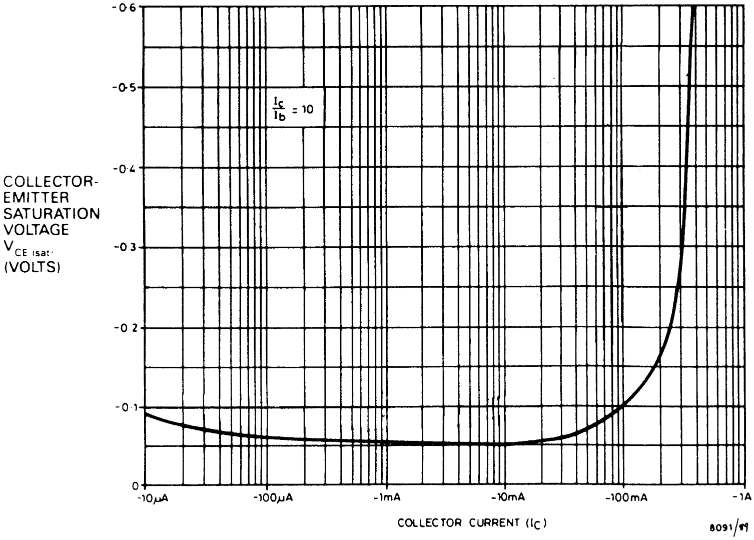
**Typical base-emitter saturation voltages plotted against collector current**



**Typical base-emitter turn-on voltages plotted against collector current**

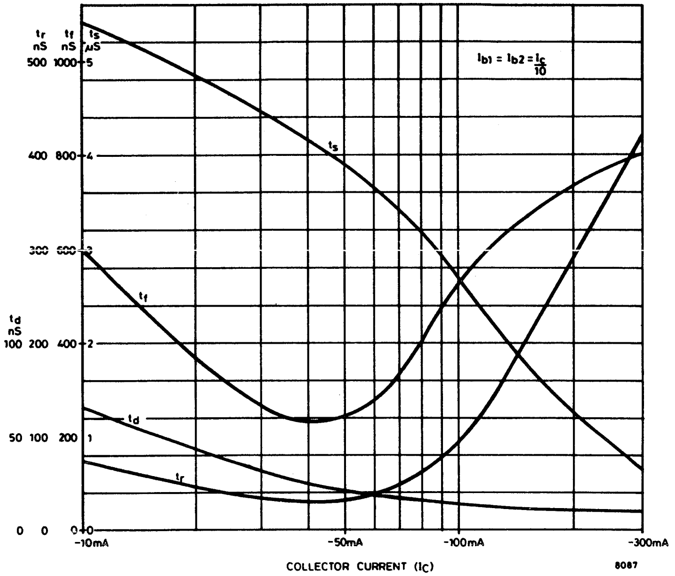


**Typical static forward current transfer ratio plotted against collector current**



**Typical collector-emitter saturation voltages plotted against collector current**

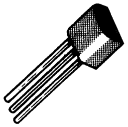
# ZTX576



Typical switching speeds

# NPN Silicon Medium Power Darlington Transistors

# ZTX600
# ZTX601



**Plastic E-Line**
**(TO-92 Compatible)**

## FEATURES

- 1.5W power dissipation at $T_{amb} = 25°C$
- 1A continuous collector current
- High $V_{CEO}$ up to 160V
- Guaranteed $h_{FE}$ specified up to 1A
- Fast switching

## DESCRIPTION

The ZTX600 and ZTX601 are high performance medium power Darlington amplified transistors encapsulated in the popular E-line (TO-92) plastic package.

The 1A performance permits use in a wide variety of industrial consumer applications.

The E-line package is formed by transfer moulding a silicone plastic specially selected to provide a rugged one-piece encapsulation resistant to severe environments and allow the high junction temperature operation normally associated with metal can devices.

E-line encapsulated devices are approved for use in military, industrial and professional equipments.

Alternative lead configurations are available as plug-in replacements of TO-5/39 and TO-18 metal can types, and for surface mounting.

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | ZTX600 | ZTX601 | Unit |
|---|---|---|---|---|
| Collector-base voltage | $V_{CBO}$ | 160 | 180 | V |
| Collector-emitter voltage (note 1) | $V_{CEO}$ | 140 | 160 | V |
| Emitter-base voltage | $V_{EBO}$ | 10 | | V |
| Peak pulse current (note 2) | $I_{CM}$ | 4 | | A |
| Continuous collector current | $I_C$ | 1 | | A |
| Practical power dissipation (note 3) | $P_{totp}$ | 1.5 | | W |
| Power dissipation at $T_{amb} = 25°C$ (note 1)<br>at $T_{case} = 25°C$ | $P_{tot}$ | 1<br>2.5 | | W<br>W |
| Operating & storage temp. range (note 1) | | −55 to +200 | | °C |

Note 1: The maximum values of $V_{CEO}$ and power dissipation are dependent on operating temperature. See Voltage derating graph for maximum power dissipation and operating temperature in a given application.

Note 2: Consult Safe Operating Area graph for conditions.

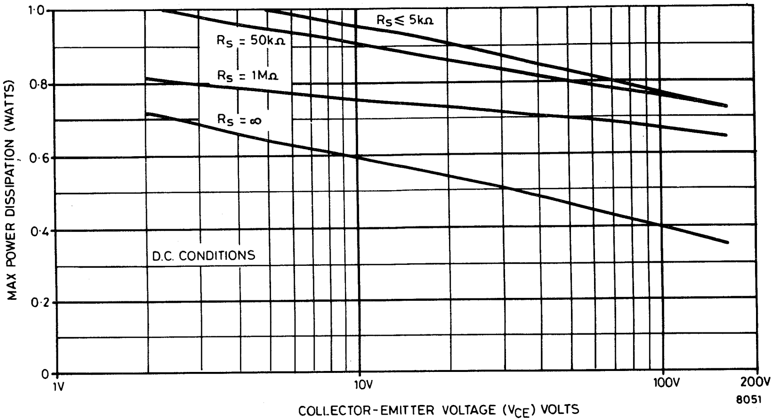
Note 3: The power which can be dissipated assuming that the device is mounted in a typical manner on a PCB with copper equal to 1sq.inch minimum.

# ZTX600 ZTX601

CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

| Parameter | Symbol | ZTX600 | | | ZTX601 | | | Unit | Conditions |
|---|---|---|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | Min. | Typ. | Max. | | |
| Collector-base breakdown voltage | $V_{(BR)CBO}$ | 160 | – | – | 180 | – | – | V | $I_C = 100\mu A$ |
| Collector-emitter breakdown voltage | $V_{(BR)CEO}$ | 140 | – | – | 160 | – | – | V | $I_C = 10mA$* |
| Emitter-base breakdown voltage | $V_{(BR)EBO}$ | 10 | – | – | 10 | – | – | V | $I_E = 100\mu A$ |
| Collector cut-off current | $I_{CBO}$ | – | – | 0.01 | – | – | – | μA | $V_{CB} = 140V$ |
| | | – | – | 10 | – | – | – | μA | $V_{CB} = 140V$, $T_{amb} = 100°C$ |
| | | – | – | – | – | – | 0.01 | μA | $V_{CB} = 160V$ |
| | | – | – | – | – | – | 10 | μA | $V_{CB} = 160V$, $T_{amb} = 100°C$ |
| Collector-emitter cut-off current | $I_{CES}$ | – | – | 10 | – | – | – | μA | $V_{CES} = 140V$ |
| | | – | – | – | – | – | 10 | μA | $V_{CES} = 160V$ |
| Emitter cut-off current | $I_{EBO}$ | – | – | 0.1 | – | – | 0.1 | μA | $V_{EB} = 8V$ |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | – | 0.75 | 1.1 | – | 0.75 | 1.1 | V | $I_C = 0.5A$, $I_B = 5mA$* |
| | | – | 0.85 | 1.2 | – | 0.85 | 1.2 | V | $I_C = 1A$, $I_B = 10mA$* |
| Base-emitter saturation voltage | $V_{BE(sat)}$ | – | 1.7 | 1.9 | – | 1.7 | 1.9 | V | $I_C = 1A$, $I_B = 10mA$* |
| Base-emitter turn-on voltage | $V_{BE(on)}$ | – | 1.5 | 1.7 | – | 1.5 | 1.7 | V | $I_C = 1A$, $V_{CE} = 5V$* |
| Static forward current transfer ratio | $h_{FE}$ | 1K | – | – | 1K | – | – | | $I_C = 50mA$, $V_{CE} = 10V$* |
| | | 2K | – | 100K | 2K | – | 100K | | $I_C = 0.5A$, $V_{CE} = 10V$* |
| | | 1K | – | – | 1K | – | – | | $I_C = 1A$, $V_{CE} = 10V$* |
| Group A | | 1K | 2K | – | 1K | 2K | – | | $I_C = 50mA$, $V_{CE} = 10V$* |
| | | 2K | 5K | 20K | 2K | 5K | 20K | | $I_C = 0.5A$, $V_{CE} = 10V$* |
| | | 1K | 3K | – | 1K | 3K | – | | $I_C = 1A$, $V_{CE} = 10V$* |
| Group B | | 5K | 10K | – | 5K | 10K | – | | $I_C = 50mA$, $V_{CE} = 10V$* |
| | | 10K | 20K | 100K | 10K | 20K | 100K | | $I_C = 0.5A$, $V_{CE} = 10V$* |
| | | 5K | 10K | – | 5K | 10K | – | | $I_C = 1A$, $V_{CE} = 10V$* |
| Transition frequency | $f_T$ | 150 | 250 | – | 150 | 250 | – | MHz | $I_C = 100mA$, $V_{CE} = 10V$<br>$f = 20MHz$ |
| Switching times | $t_{on}$<br>$t_{off}$ | –<br>– | 0.75<br>2.2 | –<br>– | –<br>– | 0.75<br>2.2 | –<br>– | μs<br>μs | $I_C = 0.5A$, $V_{CE} = 10V$<br>$I_{B1} = I_{B2} = 0.5mA$ |
| Input capacitance | $C_{ibo}$ | – | 60 | 90 | – | 60 | 90 | pF | $V_{EB} = 0.5V$, $f = 1MHz$ |
| Output capacitance | $C_{obo}$ | – | 10 | 15 | – | 10 | 15 | pF | $V_{CE} = 10V$, $f = 1MHz$ |

*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ≤ 2%.



**Voltage derating graph**

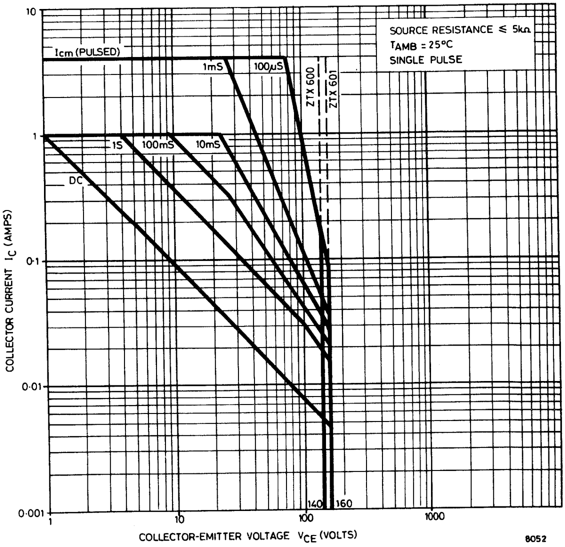
The maximum permissible operating temperature can be obtained from this graph using the equation

$$T_{amb(max)} = \frac{\text{Power (max)} - \text{Power (actual)}}{0.0057} + 25°C$$

$T_{amb(max)}$ = Maximum operating ambient temperature.

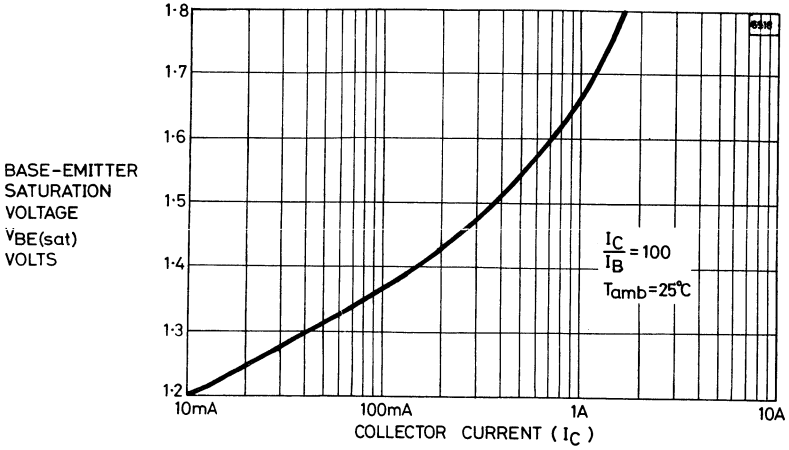
Power (max) = Maximum power dissipation figure, obtained from the above graph for a given $V_{CE}$ and source resistance ($R_S$).

Power (actual) = Actual power dissipation in users circuit.

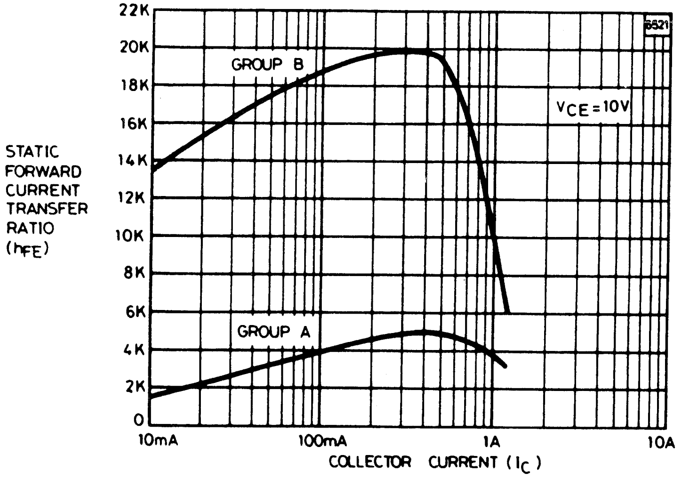


**Safe operating area at $T_{amb} = 25°C$ (single pulse)**

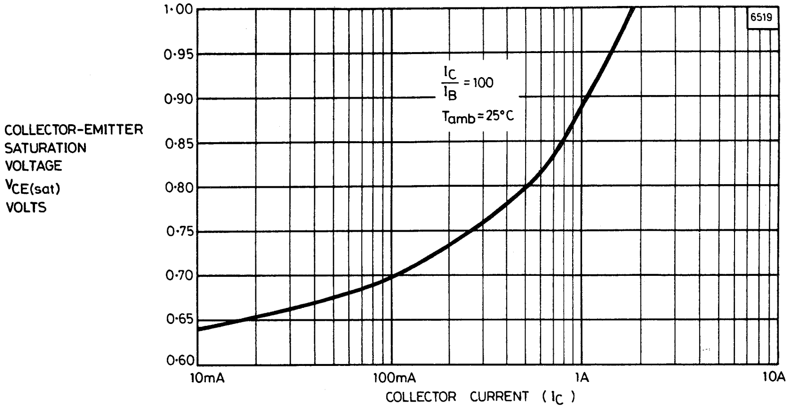
# ZTX600 ZTX601



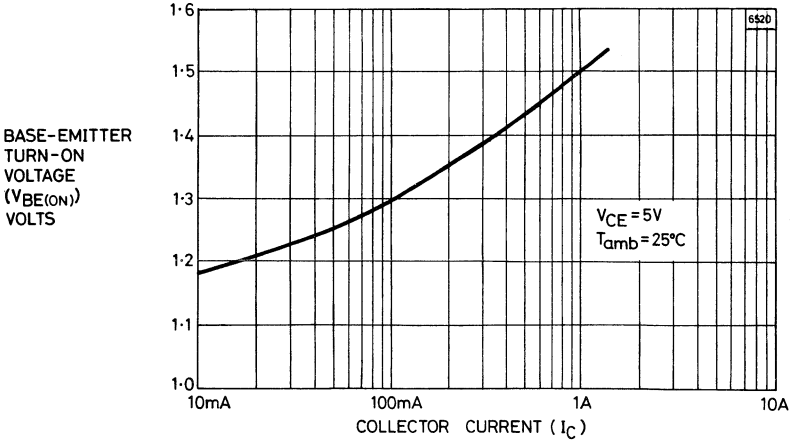
**Typical base-emitter saturation voltages plotted against collector current**



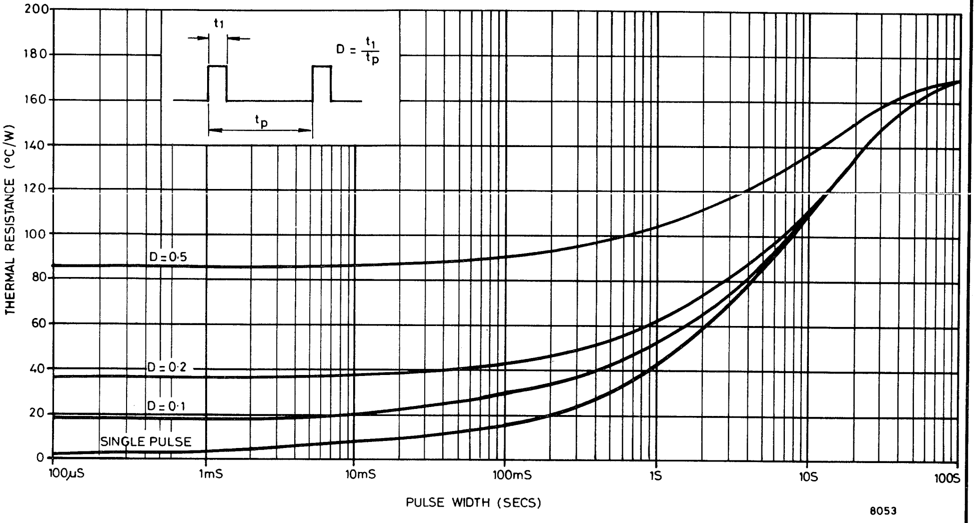
**Typical static forward current transfer ratio plotted against collector current**



Typical collector-emitter saturation voltages plotted against collector current



Typical base-emitter turn-on voltages plotted against collector current



**Maximum transient thermal impedance curves**

# NPN Silicon Planar Medium Power Darlington Transistors

# ZTX602
# ZTX603

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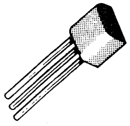
## FEATURES

- 1.5W power dissipation
- 1A continuous collector current
- 4A peak collector current
- Guaranteed $h_{FE}$ specified up to 2A
- Fast switching



Plastic E-Line
(TO-92 Compatible)

## DESCRIPTION

The ZTX602 and ZTX603 are high performance medium power Darlington amplifier transistors encapsulated in the popular E-line (TO-92) plastic package.

The 1A performance permits use in a wide range of industrial consumer applications.

The E-line package is formed by transfer moulding a SILICONE plastic specially selected to provide a rugged one-piece encapsulation resistant to severe environments and allow the high junction temperature operation normally associated with metal can devices.

E-line encapsulated devices are approved for use in military, industrial and professional equipments.

Alternative lead configurations are available as plug-in replacements of TO-5/39 and TO-18 metal can types, and for flat mounting.

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | ZTX602 | ZTX603 | Unit |
|---|---|---|---|---|
| Collector-base voltage | $V_{CBO}$ | 80 | 100 | V |
| Collector-emitter voltage (note 1) | $V_{CEO}$ | 60 | 80 | V |
| Emitter-base voltage | $V_{EBO}$ | 10 | | V |
| Peak pulse current (note 2) | $I_{CM}$ | 4 | | A |
| Continuous collector current | $I_C$ | 1 | | A |
| Practical power dissipation (note 3) | $P_{totp}$ | 1.5 | | W |
| Power dissipation at $T_{amb} = 25°C$ (note 1)<br>at $T_{case} = 25°C$ | $P_{tot}$ | 1<br>2.5 | | W<br>W |
| Operating & storage temp. range (note 1) | | −55 to +200 | | °C |

Note 1: The maximum values of $V_{CEO}$ and Power Dissipation are dependent on operating temperature. See Voltage Derating Graph for maximum power dissipation and operating temperature in a given application.

Note 2: Consult Safe Operating Area graph for conditions.

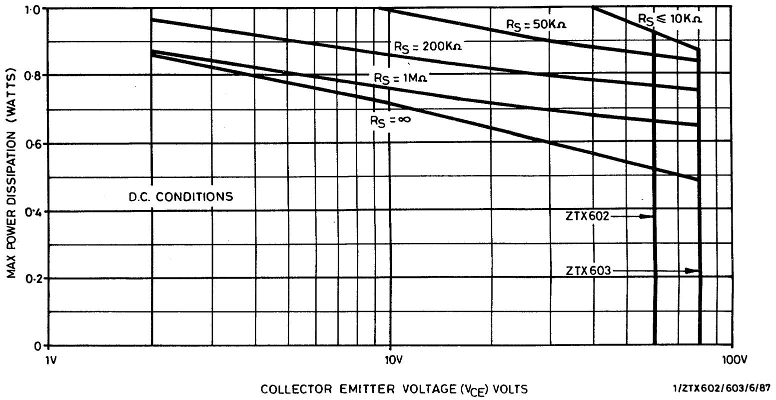
Note 3: The power which can be dissipated assuming device mounted in typical manner on P.C.B. with copper equal to 1sq.inch minimum.

# ZTX602 ZTX603

CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

| Parameter | Symbol | ZTX602 |  | ZTX603 |  | Unit | Conditions |
|---|---|---|---|---|---|---|---|
|  |  | Min. | Max. | Min. | Max. |  |  |
| Collector-base breakdown voltage | $V_{(BR)CBO}$ | 80 | – | 100 | – | V | $I_C = 100sA$ |
| Collector-emitter breakdown voltage | $V_{(BR)CEO}$ | 60 | – | 80 | – | V | $I_C = 10mA$* |
| Emitter-base breakdown voltage | $V_{(BR)EBO}$ | 10 | – | 10 | – | V | $I_E = 100\mu A$ |
| Collector cut-off current | $I_{CBO}$ | – | 0.01 | – | – | μA | $V_{CB} = 60V$ |
|  |  |  | 10 |  |  | μA | $V_{CB} = 60V$, $T_{amb} = 100°C$ |
|  |  | – | – | – | 0.01 | μA | $V_{CB} = 80V$ |
|  |  |  |  |  | 10 | μA | $V_{CB} = 80V$, $T_{amb} = 100°C$ |
| Collector-emitter cut-off current | $I_{CES}$ | – | 10 | – | –<br>10 | μA<br>μA | $V_{CES} = 60V$<br>$V_{CES} = 80V$ |
| Emitter cut-off current | $I_{EBO}$ | – | 0.1 | – | 0.1 | μA | $V_{EB} = 8V$ |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | –<br>– | 1.0<br>1.0 | –<br>– | 1.0<br>1.0 | V<br>V | $I_C = 1A, I_B = 1mA$*<br>$I_C = 0.4A$, $I_B = 0.4mA$* |
| Base-emitter saturation voltage | $V_{BE(sat)}$ | – | 1.8 | – | 1.8 | V | $I_C = 1A$, $I_B = 1mA$* |
| Base-emitter turn-on voltage | $V_{BE(on)}$ | – | 1.7 | – | 1.7 | V | $I_C = 1A$, $V_{CE} = 5V$* |
| Static forward current transfer ratio | $h_{FE}$ | 2000 | – | 2000 | – |  | $I_C = 50mA$, $V_{CE} = 5V$ |
|  |  | 5000 | – | 5000 | – |  | $I_C = 500mA$, $V_{CE} = 5V$* |
|  |  | 2000 | 100,000 | 2000 | 100,000 |  | $I_C = 1A$, $V_{CE} = 5V$* |
|  |  | 500 | – | 500 | – |  | $I_C = 2A$, $V_{CE} = 5V$* |
| Transition frequency | $f_T$ | 150 | – | 150 | – | MHz | $I_C = 100mA$, $V_{CE} = 10V$<br>$f = 20MHz$ |
| Input capacitance | $C_{ibo}$ | 90 typ. |  |  |  | pF | $V_{EB} = 0.5V$, $f = 1MHz$ |
| Output capacitance | $C_{obo}$ | 15 typ. |  |  |  | pF | $V_{CE} = 10V$, $f = 1MHz$ |
| Switching times | $t_{on}$<br>$t_{off}$ | 0.5 typ.<br>1.1 typ. |  |  |  | μs<br>μs | $I_C = 0.5A$, $V_{CE} = 10V$<br>$I_{B1} = I_{B2} = 0.5mA$ |

*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ⩽ 2%.



Voltage derating graph

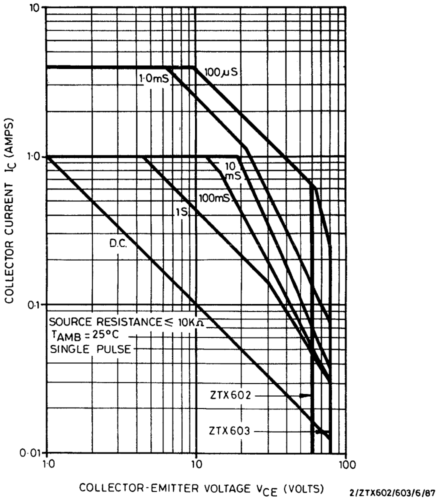
The maximum permissible operation temperature can be obtained from this graph using the equation

$$T_{amb(max)} = \frac{\text{Power (max)} - \text{Power (actual)}}{0.0057} + 25°C$$

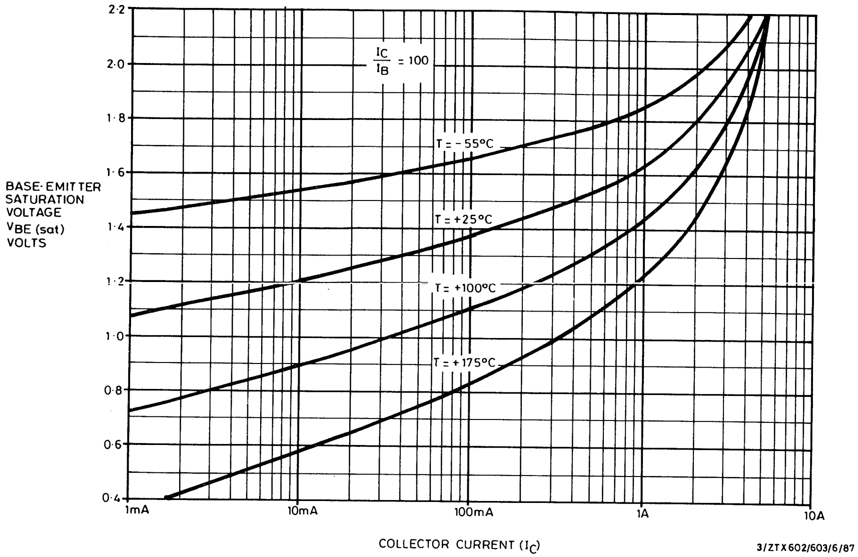
$T_{amb(max)}$ = Maximum operating ambient temperature.

Power (max) = Maximum power dissipation figure, obtained from the above graph for a given $V_{CE}$ and source resistance ($R_s$).

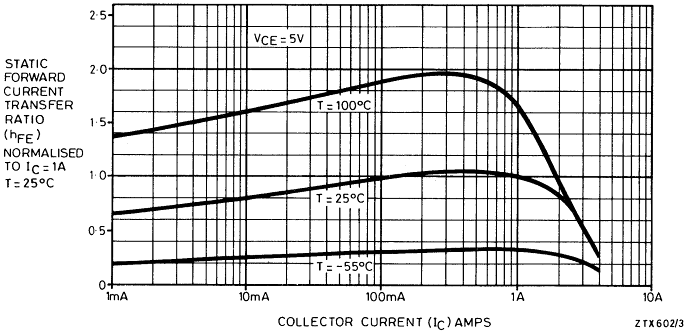
Power (actual) = Actual power dissipation in users circuit.



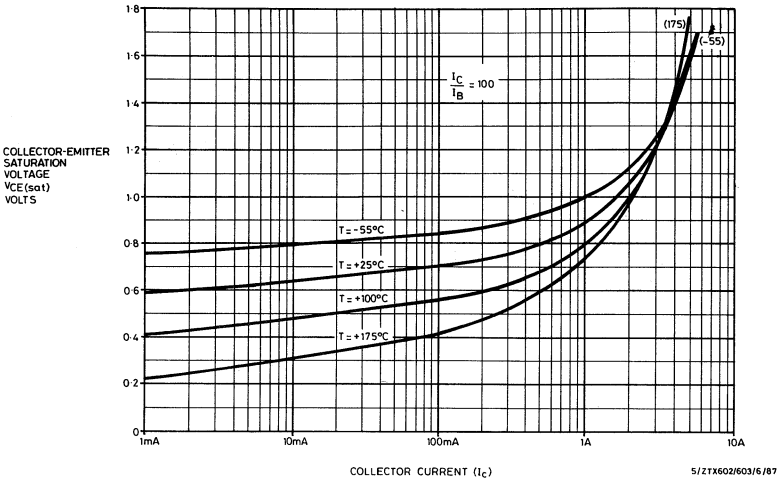
Safe operating area at $T_{amb}$ = 25°C (Single pulse)



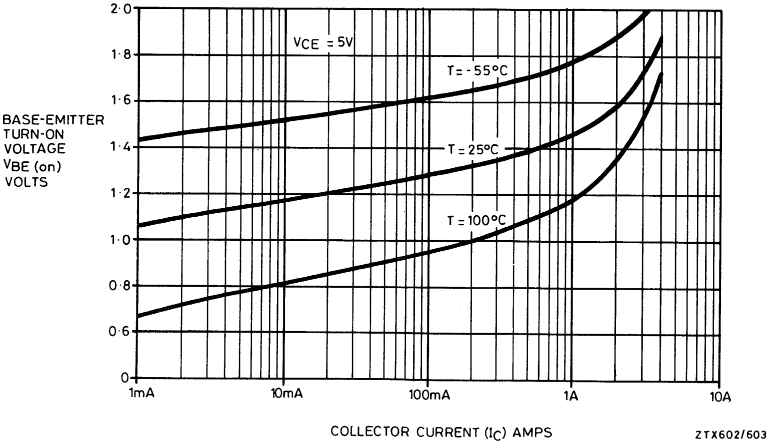
Typical base-emitter saturation voltages plotted against collector current



Typical static forward current transfer ratio plotted against collector current

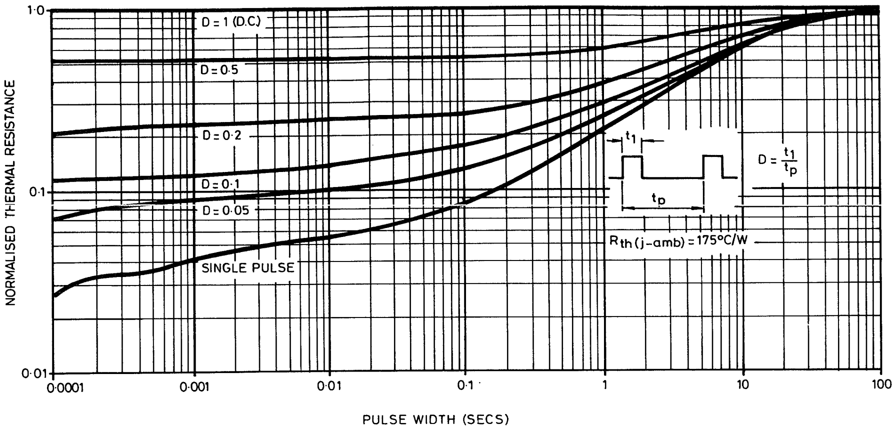


Typical collector-emitter saturation voltages plotted against collector current



Typical base-emitter turn-on voltages plotted against collector current

# ZTX602 ZTX603



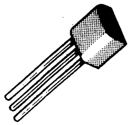
**Maximum transient thermal impedance curves**

# NPN Silicon Planar Medium Power Darlington Transistors

# ZTX604
# ZTX605

## FEATURES

- 1.5W power dissipation
- 1A continuous collector current
- 4A peak collector current
- Guaranteed $h_{FE}$ specified up to 2A
- Fast switching



Plastic E-Line
(TO-92 Compatible)

## DESCRIPTION

The ZTX604 and ZTX605 are high performance medium power Darlington amplifier transistors encapsulated in the popular E-line (TO-92) plastic package.

The 1A performance permits use in a wide range of industrial consumer applications.

The E-line package is formed by transfer moulding a SILICONE plastic specially selected to provide a rugged one-piece encapsulation resistant to severe environments and allow the high junction temperature operation normally associated with metal can devices.

E-line encapsulated devices are approved for use in military, industrial and professional equipments.

Alternative lead configurations are available as plug-in replacements of TO-5/39 and TO-18 metal can types, and for flat mounting.

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | ZTX604 | ZTX605 | Unit |
|---|---|---|---|---|
| Collector-base voltage | $V_{CBO}$ | 120 | 140 | V |
| Collector-emitter voltage (note 1) | $V_{CEO}$ | 100 | 120 | V |
| Emitter-base voltage | $V_{EBO}$ | 10 | | V |
| Peak pulse current (note 2) | $I_{CM}$ | 4 | | A |
| Continuous collector current | $I_C$ | 1 | | A |
| Practical power dissipation (note 3) | $P_{totp}$ | 1.5 | | W |
| Power dissipation at $T_{amb}=25°C$ (note 1)<br>at $T_{case}=25°C$ | $P_{tot}$ | 1<br>2.5 | | W<br>W |
| Operating & storage temp. range (note 1) | | −55 to +200 | | °C |

Note 1: The maximum values of $V_{CEO}$ and Power Dissipation are dependent on operating temperature. See Voltage Derating Graph for maximum power dissipation and operating temperature in a given application.

Note 2: Consult Safe Operating Area graph for conditions.

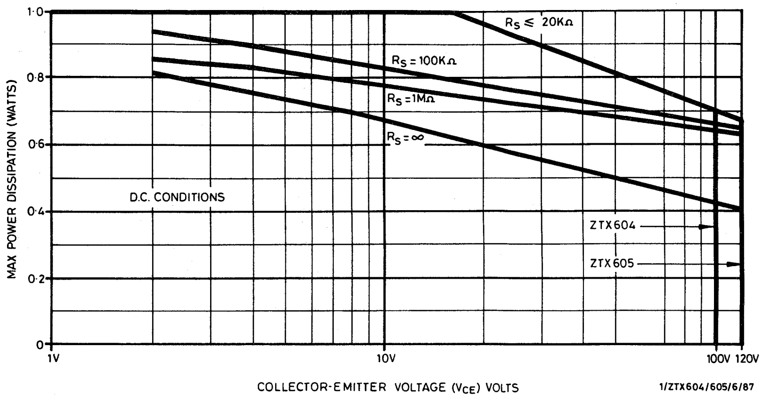
Note 3: The power which can be dissipated assuming device mounted in typical manner on P.C.B. with copper equal to 1sq.inch minimum.

# ZTX604 ZTX605

CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

| Parameter | Symbol | ZTX604 | | ZTX605 | | Unit | Conditions |
|---|---|---|---|---|---|---|---|
| | | Min. | Max. | Min. | Max. | | |
| Collector-base breakdown voltage | $V_{(BR)CBO}$ | 120 | – | 140 | – | V | $I_C = 100\mu A$ |
| Collector-emitter breakdown voltage | $V_{(BR)CEO}$ | 100 | – | 120 | – | V | $I_C = 10mA$* |
| Emitter-base breakdown voltage | $V_{(BR)EBO}$ | 10 | – | 10 | – | V | $I_E = 100\mu A$ |
| Collector cut-off current | $I_{CBO}$ | – | 0.01 | – | – | μA | $V_{CB} = 100V$ |
| | | | 10 | | | μA | $V_{CB} = 100V$, $T_{amb} = 100°C$ |
| | | – | – | – | 0.01 | μA | $V_{CB} = 120V$ |
| | | | | | 10 | μA | $V_{CB} = 120V$, $T_{amb} = 100°C$ |
| Collector-emitter cut-off current | $I_{CES}$ | – | 10 | – | – | μA | $V_{CES} = 100V$ |
| | | | | | 10 | μA | $V_{CES} = 120V$ |
| Emitter cut-off current | $I_{EBO}$ | – | 0.1 | – | 0.1 | μA | $V_{EB} = 8V$ |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | – | 1.5 | – | 1.5 | V | $I_C = 1A, I_B = 1mA$* |
| | | – | 1.0 | – | 1.0 | V | $I_C = 0.25A$, $I_B = 0.25mA$* |
| Base-emitter saturation voltage | $V_{BE(sat)}$ | – | 1.8 | – | 1.8 | V | $I_C = 1A$, $I_B = 1mA$* |
| Base-emitter turn-on voltage | $V_{BE(on)}$ | – | 1.7 | – | 1.7 | V | $I_C = 1A$, $V_{CE} = 5V$* |
| Static forward current transfer ratio | $h_{FE}$ | 2000 | – | 2000 | – | | $I_C = 50mA$, $V_{CE} = 5V$ |
| | | 5000 | – | 5000 | – | | $I_C = 500mA$, $V_{CE} = 5V$* |
| | | 2000 | 100,000 | 2000 | 100,000 | | $I_C = 1A$, $V_{CE} = 5V$* |
| | | 500 | – | 500 | – | | $I_C = 2A$, $V_{CE} = 5V$* |
| Transition frequency | $f_T$ | 150 | – | 150 | – | MHz | $I_C = 100mA$, $V_{CE} = 10V$<br>$f = 20MHz$ |
| Input capacitance | $C_{ibo}$ | 90 typ. | | | | pF | $V_{EB} = 0.5V$, $f = 1MHz$ |
| Output capacitance | $C_{obo}$ | 15 typ. | | | | pF | $V_{CE} = 10V$, $f = 1MHz$ |
| Switching times | $t_{on}$<br>$t_{off}$ | 0.5 typ.<br>1.6 typ. | | | | μs<br>μs | $I_C = 0.5A$, $V_{CE} = 10V$<br>$I_{B1} = I_{B2} = 0.5mA$ |

*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ⩽ 2%.



1/ZTX604/605/6/87

**Voltage derating graph**

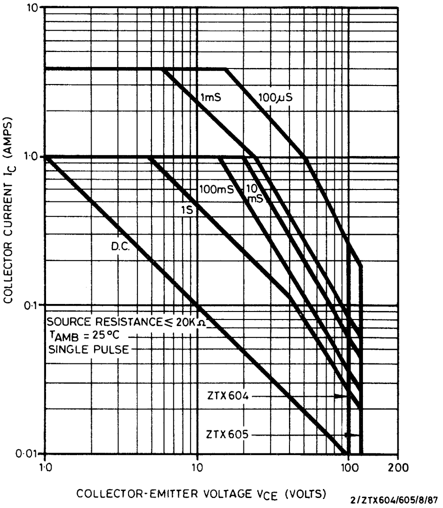
The maximum permissible operation temperature can be obtained from this graph using the equation

$$T_{amb(max)} = \frac{\text{Power (max)} - \text{Power (actual)}}{0.0057} + 25°C$$

$T_{amb(max)}$ = Maximum operating ambient temperature.

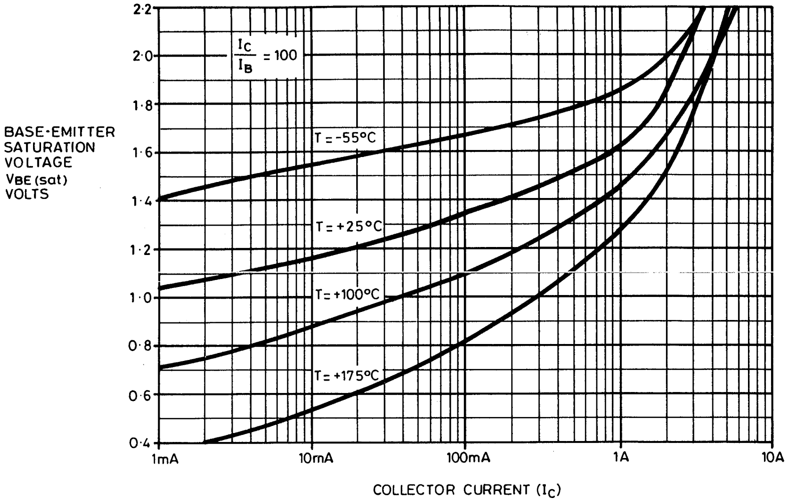
Power (max) = Maximum power dissipation figure, obtained from the above graph for a given $V_{CE}$ and source resistance ($R_s$).

Power (actual) = Actual power dissipation in users circuit.

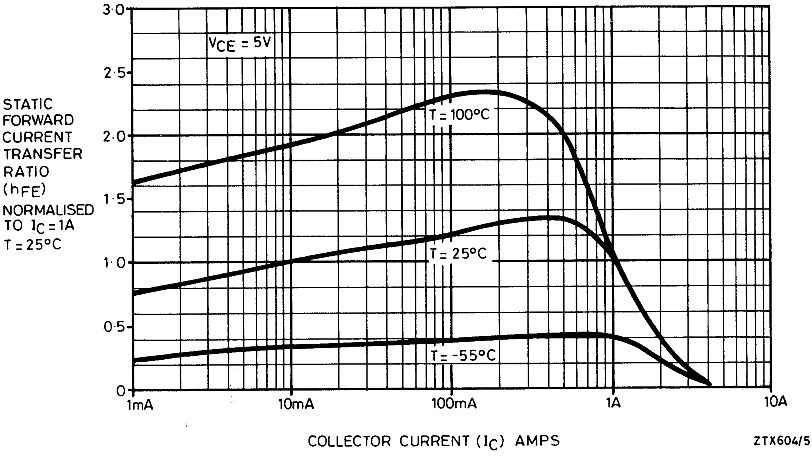


2/ZTX604/605/8/87

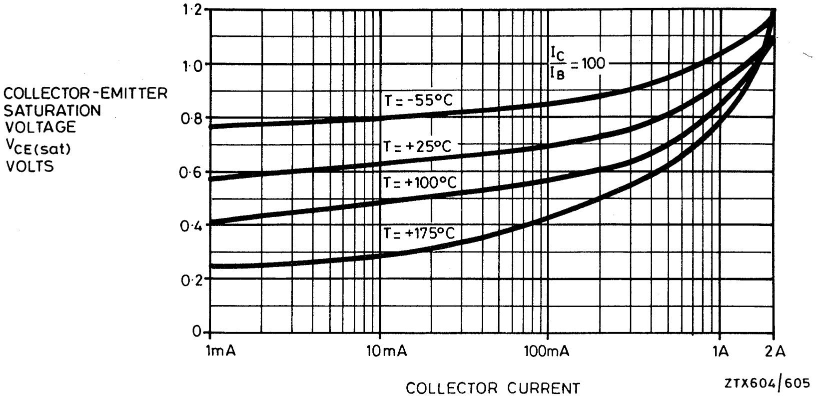
**Safe operating area at $T_{amb} = 25°C$ (Single pulse)**



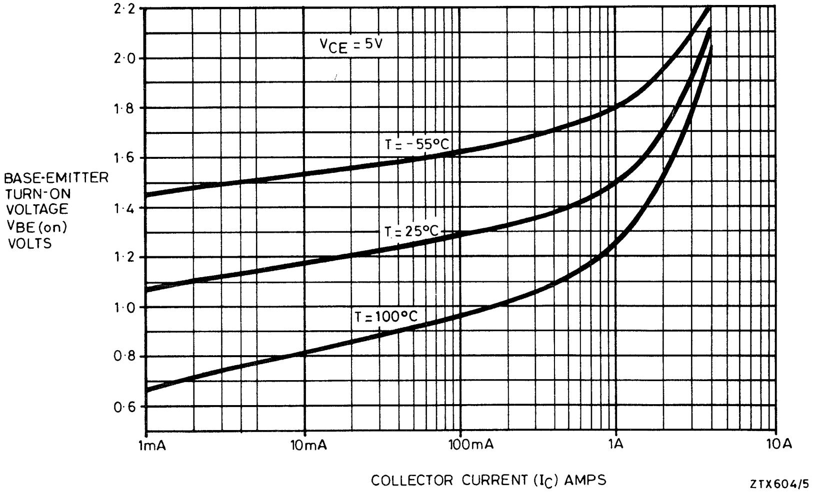
Typical base-emitter saturation voltages plotted against collector current



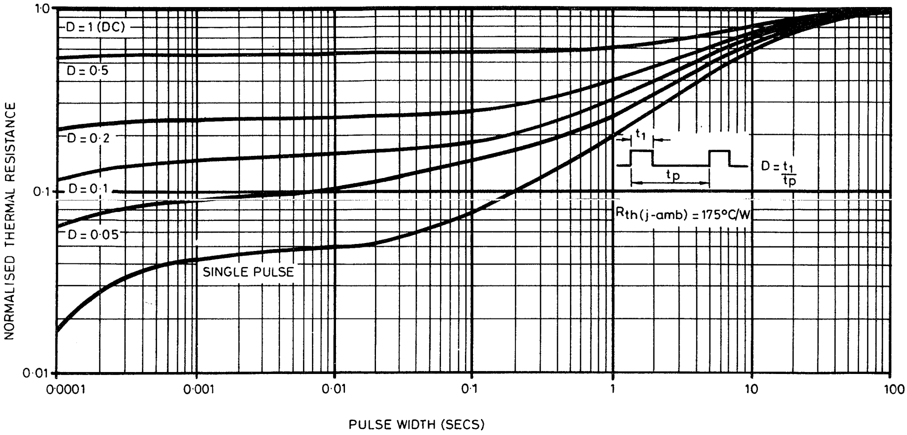
Typical static forward current transfer ratio plotted against collector current



**Typical collector-emitter saturation voltages plotted against collector current**



**Typical base-emitter turn-on voltages plotted against collector current**



Maximum transient thermal impedance curves

# NPN Silicon Planar Medium Power Darlington Transistor

# ZTX614

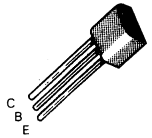
## FEATURES

- 1.5W power dissipation*
- 0.8A continuous collector current
- $h_{FE}$ up to 10,000 at $I_C = 500mA$
- Fast switching

## DESCRIPTION

The ZTX614 is a high voltage Darlington transistor designed for medium power applications requiring very high current gain and high input impedance. The monolithic construction has the inherent advantages of fast switching times, low saturation voltages and low leakage currents. Application areas include: driver and output stages of audio amplifiers; direct interfacing with integrated circuits; lamp, relay and hammer driving.

The E-line package is formed by transfer moulding a silicone plastic specially selected to provide a rugged one-piece encapsulation resistant to severe environments and allow the high junction temperature operation normally associated with metal can devices.



**Plastic E-Line**
**(TO-92 Compatible)**

E-line encapsulated devices are approved for use in military, industrial and professional equipments.

Alternative lead configurations are available as plug-in replacements to TO-5/39 and TO-18 metal can types, and for surface mounting.

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | Value | Unit |
|---|---|---|---|
| Collector-Base Voltage | $V_{CBO}$ | 120 | V |
| Collector-Emitter Voltage | $V_{CEO}$ | 100 | V |
| Emitter-Base Voltage | $V_{EBO}$ | 10 | V |
| Continuous Collector Current | $I_C$ | 800 | mA |
| Practical Power Dissipation* | $P_{totp}$ | 1.5 | W |
| Power Dissipation at $T_{amb} = 25°C$<br>derate above 25°C | tot | 1.0<br>5.7 | W<br>mW/°C |
| Operating and Storage Temperature Range | | −55 to +200 | °C |

*The power which can be dissipated assuming the device mounted in typical manner on PCB with copper equal to 1 sq. inch minimum.

# ZTX614

ELECTRICAL CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

| Parameter | Symbol | Min. | Max. | Unit | Test Conditions |
|---|---|---|---|---|---|
| Collector-base breakdown voltage | $V_{(BR)CBO}$ | 120 | — | V | $I_C = 10\mu A$, $I_E = 0$ |
| Collector-emitter sustaining voltage | $V_{CEO(sus)}$ | 100 | — | V | $I_C = 10mA$, $I_B = 0$ |
| Emitter-base breakdown voltage | $V_{(BR)EBO}$ | 10 | — | V | $I_E = 10\mu A$, $I_C = 0$ |
| Collector-base cut-off current | $I_{CBO}$ | — | 100 | nA | $V_{CB} = 60V$, $I_E = 0$ |
| Emitter-base cut-off current | $I_{EBO}$ | — | 100 | nA | $V_{EB} = 8V$, $I_C = 0$ |
| Static forward current transfer ratio | $h_{FE}$ | 5,000<br>10,000 | —<br>— | | $I_C = 100mA$<br>$I_C = 500mA$ } $V_{CE} = 5V$* |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | — | 1.25 | V | $I_C = 800mA$, $I_B = 8mA$* |
| Base-emitter on voltage | $V_{BE(on)}$ | — | 1.8 | V | $I_C = 800mA$, $V_{CE} = 5V$* |

*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ⩽ 2%.

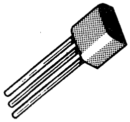
**Refer to BCX38 for graphs.**

# NPN Silicon Planar Medium Power Power Transistor

# ZTX649

## FEATURES

- 1.5W power dissipation at $T_{amb} = 25°C$*
- 2A continuous $I_C$
- Excellent gain characteristics up to 6A (pulsed)
- Low saturation voltages
- Fast switching
- PNP complementary type available



Plastic E-Line
(TO-92 Compatible)

## DESCRIPTION

A high performance transistor encapsulated in the popular E-line (TO-92) plastic package.

The 1.5W performance and outstanding electrical characteristics permit use in a wide range of industrial and consumer applications including lamp and solenoid drivers.

In addition the excellent gain characteristics at high collector current levels makes the device ideal in pulsed applications.

The specially selected silicone encapsulation provides resistance to severe environments comparable with metal can devices.

Complementary to the ZTX749

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | ZTX649 | Unit |
|---|---|---|---|
| Collector-base voltage | $V_{CBO}$ | 35 | V |
| Collector-emitter voltage | $V_{CEO}$ | 25 | V |
| Emitter-base voltage | $V_{EBO}$ | 5 | V |
| Peak pulse current (see note below) | $I_{CM}$ | 6 | A |
| Continuous collector current | $I_C$ | 2 | A |
| Practical power dissipation* | $P_{totP}$ | 1.5 | W |
| Power dissipation: at $T_{amb} = 25°C$<br>derate above 25°C | $P_{tot}$ | 1<br>5.7 | W<br>mW/°C |
| Operating & storage temperature range | | −55 to +200 | °C |

Note: Consult Safe Operating Area guide for conditions.

*The power which can be dissipated assuming device mounted in typical manner on P.C.B. with copper equal to 1 sq.inch minimum.

# ZTX649

CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

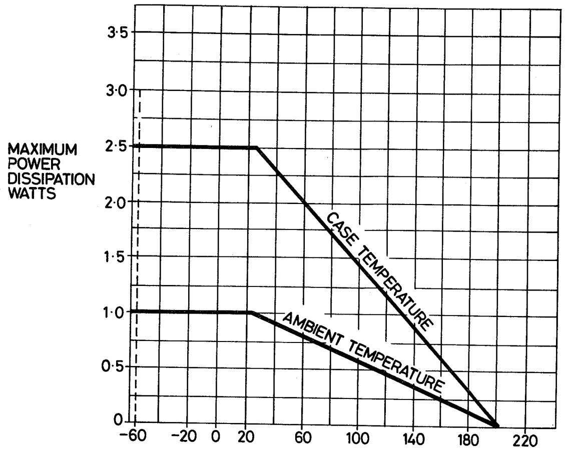
| Parameter | Symbol | Min. | Typ. | Max. | Unit | Conditions |
|---|---|---|---|---|---|---|
| Collector-base breakdown voltage | $V_{(BR)CBO}$ | 35 | – | – | V | $I_C = 100\mu A$ |
| Collector-emitter breakdown voltage | $V_{(BR)CEO}$ | 25 | – | – | V | $I_C = 10mA$ |
| Emitter-base breakdown voltage | $V_{(BR)EBO}$ | 5 | – | – | V | $I_E = 100\mu A$ |
| Collector cut-off current | $I_{CBO}$ | | | 0.1 | μA | $V_{CB} = 30V$ |
| | | – | – | 10 | μA | $V_{CB} = 30V$, $T_{amb} = 100°C$ |
| Emitter cut-off current | $I_{EBO}$ | | | 0.1 | μA | $V_{EB} = 4V$ |
| Collector-emitter saturation voltage | $V_{CE(SAT)}$ | | 0.12 | 0.3 | V | $I_C = 1A$, $I_B = 100mA$* |
| | | – | 0.23 | 0.5 | V | $I_C = 2A$, $I_B = 200mA$* |
| Base-emitter saturation voltage | $V_{BE(SAT)}$ | – | 0.9 | 1.25 | V | $I_C = 1A$, $I_B = 100mA$* |
| Base-emitter turn on voltage | $V_{BE(ON)}$ | – | 0.8 | 1 | V | $I_C = 1A$, $V_{CE} = 2V$* |
| Static forward current transfer ratio | $h_{FE}$ | 70 | 200 | – | | $I_C = 50mA$, $V_{CE} = 2V$* |
| | | 100 | 200 | 300 | | $I_C = 1A$, $V_{CE} = 2V$* |
| | | 75 | 150 | – | | $I_C = 2A$, $V_{CE} = 2V$* |
| | | 15 | 50 | – | | $I_C = 6A$, $V_{CE} = 2V$* |
| Transition frequency | $f_T$ | 150 | 240 | – | MHz | $I_C = 100mA$, $V_{CE} = 5V$<br>$f = 100MHz$ |
| Output capacitance | $C_{obo}$ | – | 25 | 50 | pF | $V_{CB} = 10V$, $f = 1MHz$ |
| Switching times | $T_{on}$ | – | 55 | – | ns | $I_C = 500mA$, $V_{CC} = 10V$<br>$I_{B1} = I_{B2} = 50mA$ |
| | $T_{off}$ | – | 300 | – | ns | |

*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ⩽2%.

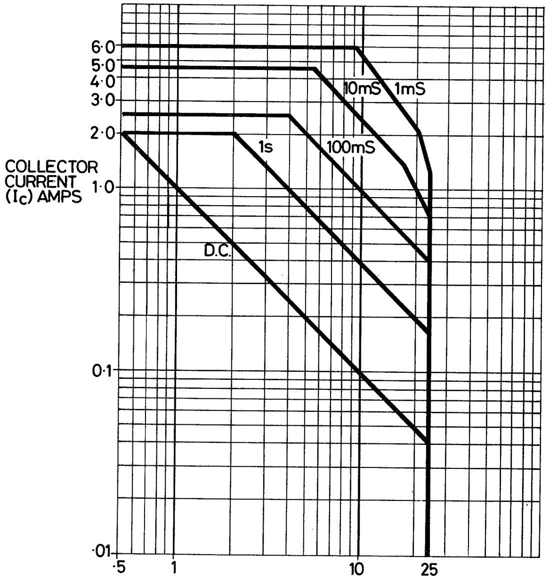
## THERMAL CHARACTERISTICS

| Parameter | | Symbol | Maximum | Unit |
|---|---|---|---|---|
| Thermal Resistance: | Junction to ambient$_1$ | $R_{th(j-amb)_1}$ | 175 | °C/W |
| | Junction to ambient$_2$ | $R_{th(j-amb)_2}$† | 116 | °C/W |
| | Junction to case | $R_{th(j-case)}$ | 70 | °C/W |

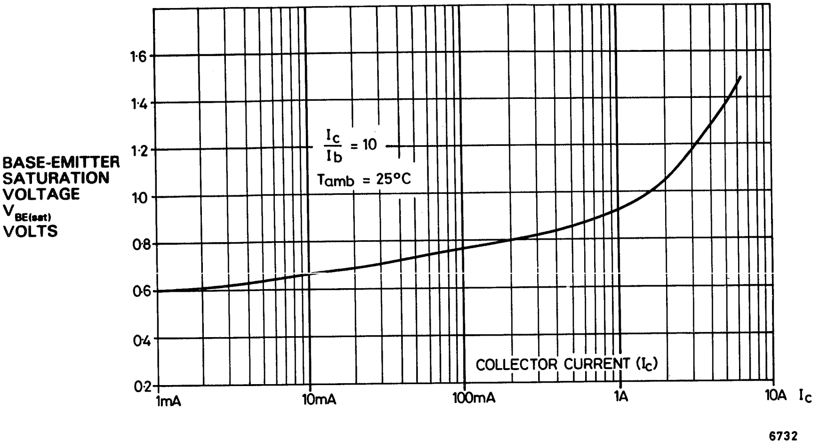
†Device mounted on P.C.B. with copper equal to 1sq.inch minimum.



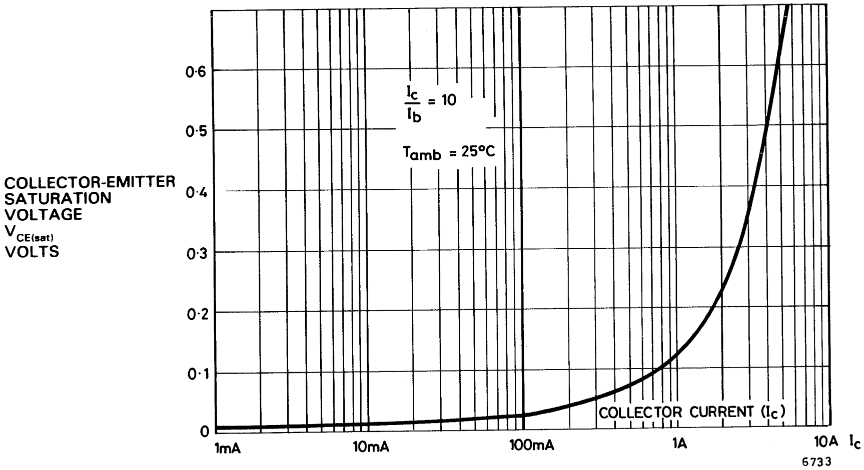
**Dissipation derating curve**



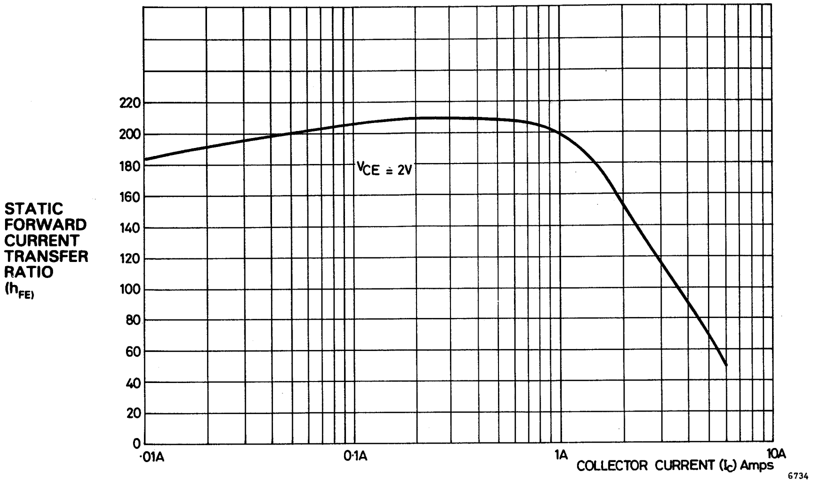
**Safe operating area at $T_{amb} = 25°C$**
**(single-pulse)**



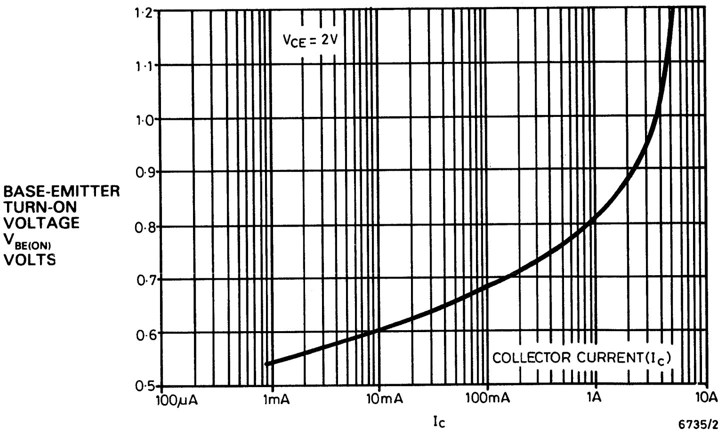
Typical base-emitter saturation voltage plotted against collector current



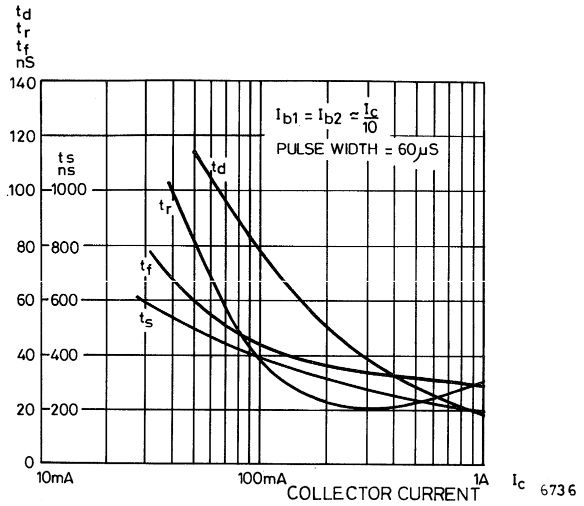
Typical collector-emitter saturation voltage plotted against collector current



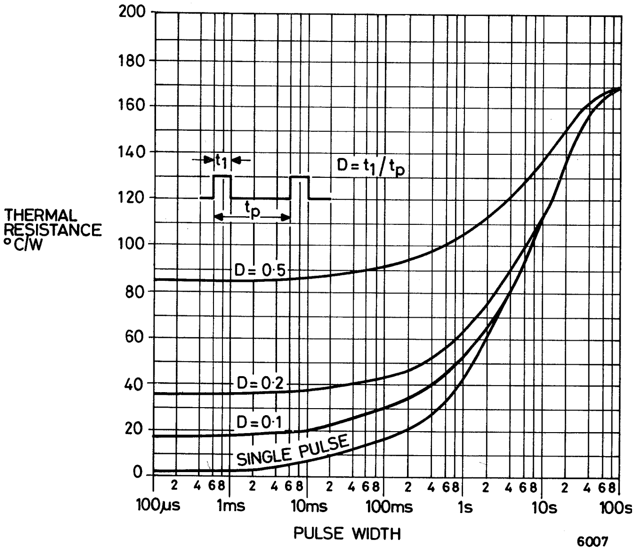
Typical static forward current transfer ratio plotted against collector current



Typical base-emitter turn-on voltage plotted against collector current



**Typical switching speeds**



**Maximum transient thermal impedance curves**

# NPN Silicon Planar Medium Power Transistors

# ZTX650 ZTX651
# ZTX652 ZTX653

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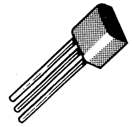


Plastic E-Line
(TO-92 Compatible)

## FEATURES

- 1.5W power dissipation at $T_{amb} = 25°C$*
- 2V continuous $I_C$
- Excellent gain characteristics to 2A
- High $V_{CEO}$: up to 100V
- Low saturation voltages
- Guaranteed $h_{FE}$ specified up to 2A
- Fast switching
- Exceptional price-to-power ratio
- Complementary types

## DESCRIPTION

A range of high performance medium power transistors encapsulated in the popular E-line (TO-92) plastic package.

The 1.5W performance and outstanding electrical characteristics permit use in a wide variety of industrial and consumer applications including lamp and solenoid drivers, audio amplifiers and complementary drivers for hi-fi amplifiers.

In addition to achieving excellent linearity the devices are designed to function as high speed power switching transistors.

The specially selected silicone encapsulation provides resistance to severe environments comparable with metal can devices.

Complementary to ZTX750 series.

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | ZTX650 | ZTX651 | ZTX652 | ZTX653 | Unit |
|---|---|---|---|---|---|---|
| Collector-base voltage | $V_{CBO}$ | 60 | 80 | 100 | 120 | V |
| Collector-emitter voltage | $V_{CEO}$ | 45 | 60 | 80 | 100 | V |
| Emitter-base voltage | $V_{EBO}$ | 5 | | | | V |
| Peak pulse current (see note) | $I_{CM}$ | 6 | | | | A |
| Continuous collector current | $I_C$ | 2 | | | | A |
| Practical power dissipation* | $P_{totP}$ | 1.5 | | | | W |
| Power dissipation at $T_{amb} = 25°C$<br>derate above 25°C<br>at $T_{case} = 25°C$ | $P_{tot}$ | 1<br>5.7<br>2.5 | | | | W<br>mW/°C<br>W |
| Operating & storage temp. range | $t_j : t_{stg}$ | −55 to +200 | | | | °C |

Note: Consult Safe Operating Area graph for conditions.

*The power which can be dissipated assuming device mounted in typical manner on P.C.B. with copper equal to 1 sq.inch minimum.

# ZTX650 ZTX651 ZTX652 ZTX653

CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

| Parameter | Symbol | ZTX650 | | | ZTX651 | | | Unit | Conditions |
|---|---|---|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | Min. | Typ. | Max. | | |
| Collector-base breakdown voltage | $V_{(BR)CBO}$ | 60 | – | – | 80 | – | – | V | $I_C = 100\mu A$ |
| Collector-emitter breakdown voltage | $V_{(BR)CEO}$ | 45 | – | – | 60 | – | – | V | $I_C = 10mA$ |
| Emitter-base breakdown voltage | $V_{(BR)EBO}$ | 5 | – | – | 5 | – | – | V | $I_E = 100\mu A$ |
| Collector cut-off current | $I_{CBO}$ | – | – | 0.1 | – | – | – | μA | $V_{CB} = 45V$ |
| | | – | – | 10 | – | – | – | μA | $V_{CB} = 45V$, $T_{amb} = 100°C$ |
| | | – | – | – | – | – | 0.1 | μA | $V_{CB} = 60V$ |
| | | – | – | – | – | – | 10 | μA | $V_{CB} = 60V$, $T_{amb} = 100°C$ |
| Emitter cut-off current | $I_{EBO}$ | – | – | 0.1 | – | – | 0.1 | μA | $V_{EB} = 4V$ |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | – | 0.12 | 0.3 | – | 0.12 | 0.3 | V | $I_C = 1A$, $I_B = 100mA$* |
| | | – | 0.23 | 0.5 | – | 0.23 | 0.5 | V | $I_C = 2A$, $I_B = 200mA$* |
| Base-emitter saturation voltage | $V_{BE(sat)}$ | – | 0.90 | 1.25 | – | 0.90 | 1.25 | V | $I_C = 1A$, $I_B = 100mA$* |
| Base-emitter turn-on voltage | $V_{BE(on)}$ | – | 0.8 | 1 | – | 0.8 | 1 | V | $I_C = 1A$, $V_{CE} = 2V$* |
| Static forward current transfer ratio | $h_{FE}$ | 70 | 200 | – | 70 | 200 | – | | $I_C = 50mA$, $V_{CE} = 2V$* |
| | | 100 | 200 | 300 | 100 | 200 | 300 | | $I_C = 500mA$, $V_{CE} = 2V$* |
| | | 80 | 170 | – | 80 | 170 | – | | $I_C = 1A$, $V_{CE} = 2V$* |
| | | 40 | 80 | – | 40 | 80 | – | | $I_C = 2V$, $V_{CE} = 2V$* |
| Transition frequency | $f_T$ | 140 | 175 | – | 140 | 175 | – | MHz | $I_C = 100mA$, $V_{CE} = 5V$<br>$f = 100MHz$ |
| Switching times | $T_{on}$ | – | 45 | – | – | 45 | – | ns | $I_C = 500mA$, $I_{B1} = 50mA$<br>$I_{B2} = 50mA$, $V_{CC} = 10V$ |
| | $T_{off}$ | – | 800 | – | – | 800 | – | ns | |
| Output capacitance | $C_{obo}$ | – | – | 30 | – | – | 30 | pF | $V_{CB} = 10V$, $f = 1MHz$ |

*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ≤ 2%.

**THERMAL CHARACTERISTICS** (ZTX650/3)

| Parameter | Symbol | Maximum | Unit |
|---|---|---|---|
| Thermal resistance: Junction to ambient$_1$ | $R_{th(j\text{-}amb)1}$ | 175 | °C/W |
| Junction to ambient$_2$ | $R_{th(j\text{-}amb)2}$† | 116 | °C/W |
| Junction to case | $R_{th(j\text{-}case)}$ | 70 | °C/W |

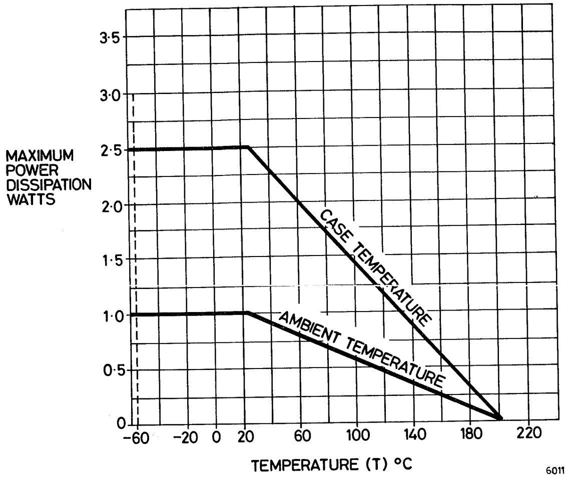
†Device mounted on P.C.B. with copper equal to 1 sq.inch minimum.

CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

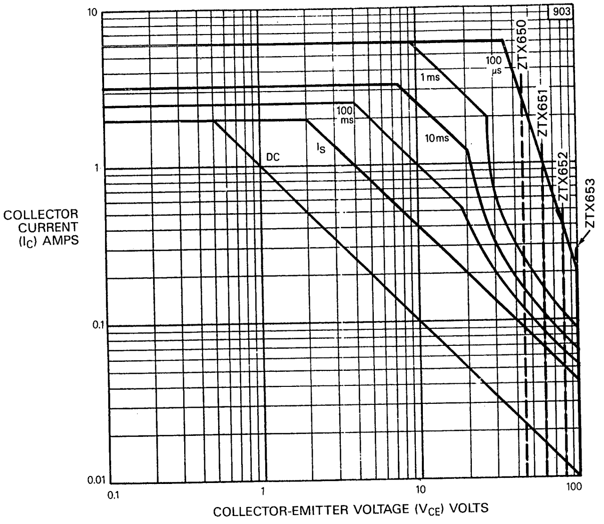
| Parameter | Symbol | ZTX652 | | | ZTX653 | | | Unit | Conditions |
|---|---|---|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | Min. | Typ. | Max. | | |
| Collector-base breakdown voltage | $V_{(BR)CBO}$ | 100 | – | – | 120 | – | – | V | $I_C = 100\mu A$ |
| Collector-emitter breakdown voltage | $V_{(BR)CEO}$ | 80 | – | – | 100 | – | – | V | $I_C = 10mA$ |
| Emitter-base breakdown voltage | $V_{(BR)EBO}$ | 5 | – | – | 5 | – | – | V | $I_E = 100\mu A$ |
| Collector cut-off current | $I_{CBO}$ | – | – | 0.1 | – | – | – | μA | $V_{CB} = 80V$ |
| | | – | – | 10 | – | – | – | μA | $V_{CB} = 80V$, $T_{amb} = 100°C$ |
| | | – | – | – | – | – | 0.1 | μA | $V_{CB} = 100V$ |
| | | – | – | – | – | – | 10 | μA | $V_{CB} = 100V$, $T_{amb} = 100°C$ |
| Emitter cut-off current | $I_{EBO}$ | – | – | 0.1 | – | – | 0.1 | μA | $V_{EB} = 4V$ |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | – | 0.13 | 0.3 | – | 0.13 | 0.3 | V | $I_C = 1A$, $I_B = 100mA$* |
| | | – | 0.23 | 0.5 | – | 0.23 | 0.5 | V | $I_C = 2A$, $I_B = 200mA$* |
| Base-emitter saturation voltage | $V_{BE(sat)}$ | – | 0.90 | 1.25 | – | 0.90 | 1.25 | V | $I_C = 1A$, $I_B = 100mA$* |
| Base-emitter turn-on voltage | $V_{BE(on)}$ | – | 0.8 | 1 | – | 0.8 | 1 | V | $I_C = 1A$, $V_{CE} = 2V$* |
| Static forward current transfer ratio | $h_{FE}$ | 70 | 200 | – | 70 | 200 | – | | $I_C = 50mA$, $V_{CE} = 2V$* |
| | | 100 | 200 | 300 | 100 | 200 | 300 | | $I_C = 500mA$, $V_{CE} = 2V$* |
| | | 55 | 110 | – | 55 | 110 | – | | $I_C = 1A$, $V_{CE} = 2V$* |
| | | 25 | 55 | – | 25 | 55 | – | | $I_C = 2A$, $V_{CE} = 2V$* |
| Transition frequency | $f_T$ | 140 | 175 | – | 140 | 175 | – | MHz | $I_C = 100mA$, $V_{CE} = 5V$<br>$f = 100MHz$ |
| Switching times | $T_{on}$ | – | 80 | – | – | 80 | – | ns | $I_C = 500mA$, $I_{B1} = 50mA$<br>$I_{B2} = 50mA$, $V_{CC} = 10V$ |
| | $T_{off}$ | – | 1200 | – | – | 1200 | – | ns | |
| Output capacitance | $C_{obo}$ | – | – | 30 | – | – | 30 | pF | $V_{CB} = 10V$, $f = 1MHz$ |

*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ⩽ 2%.

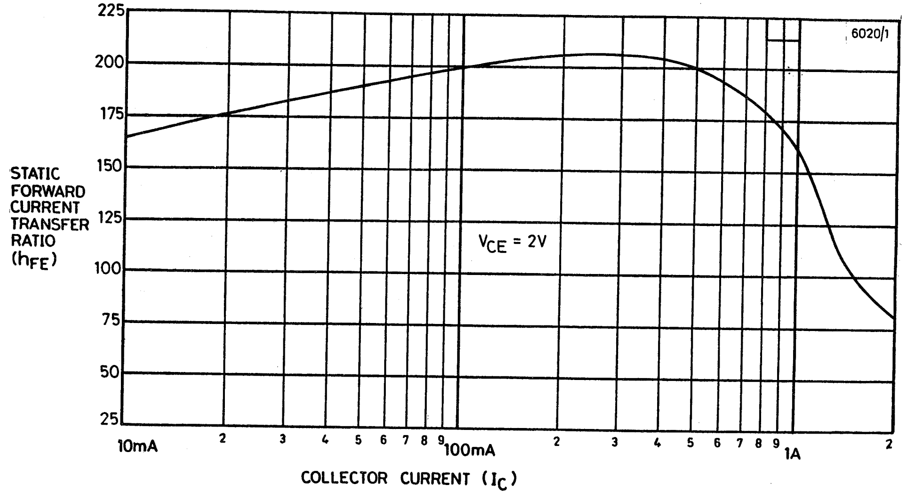
# ZTX650 ZTX651 ZTX652 ZTX653



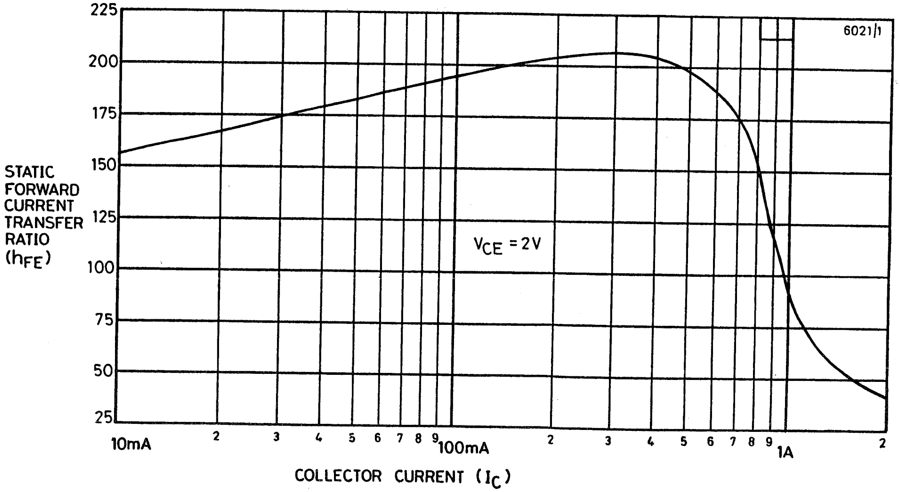
Dissipation derating curve for all types



Safe operating area at $T_{amb} = 25°C$ (single pulse)

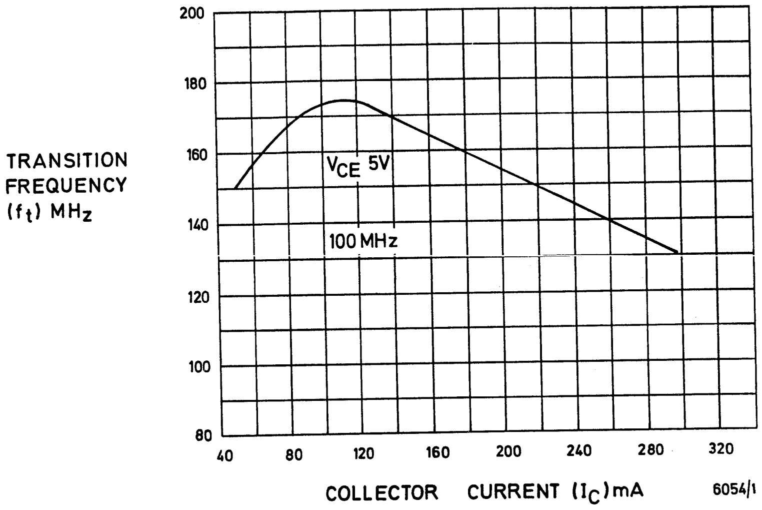


**Static forward current transfer ratio plotted against collector current for ZTX650/ZTX651**

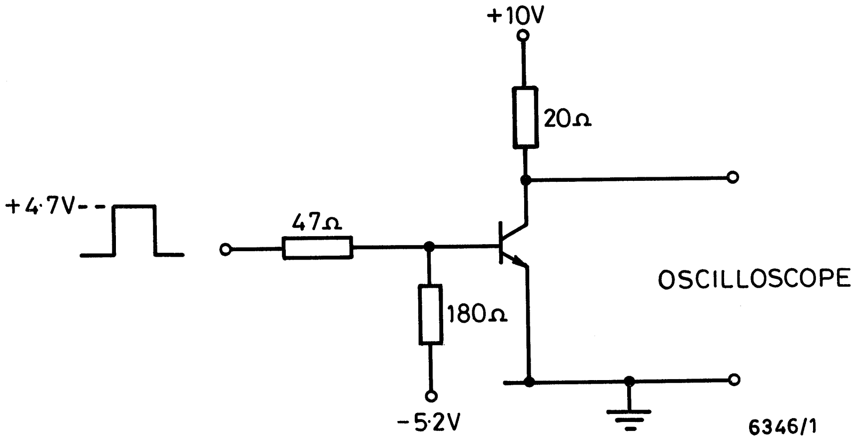


**Static forward current transfer ratio plotted against collector current for ZTX652/ZTX653**

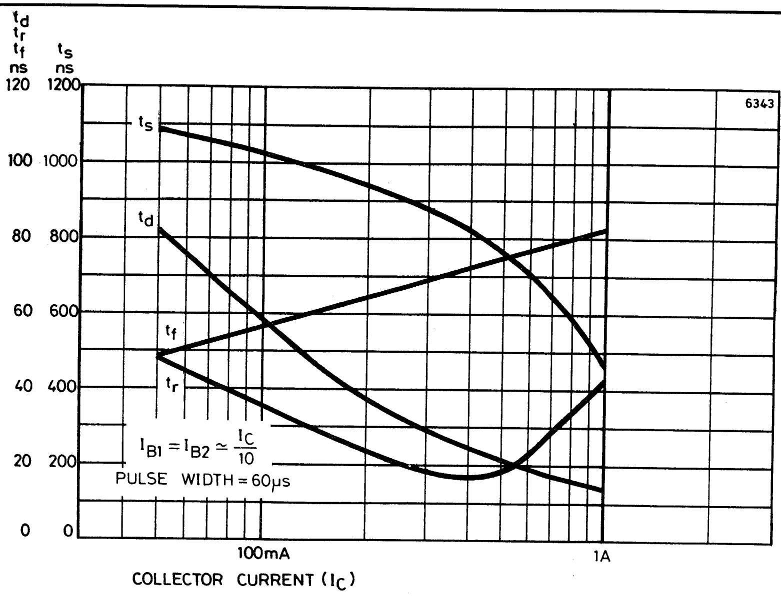
# ZTX650 ZTX651 ZTX652 ZTX653



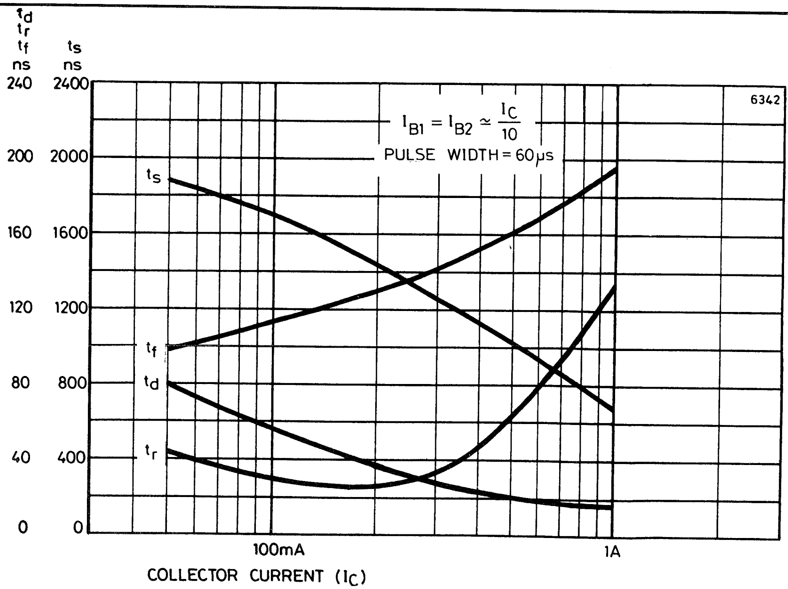
Typical transition frequency plotted against collector current for ZTX650



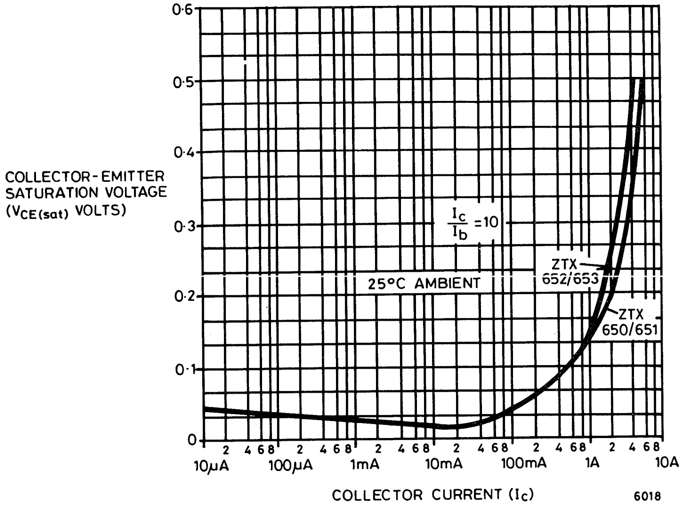
Switching speeds test circuit



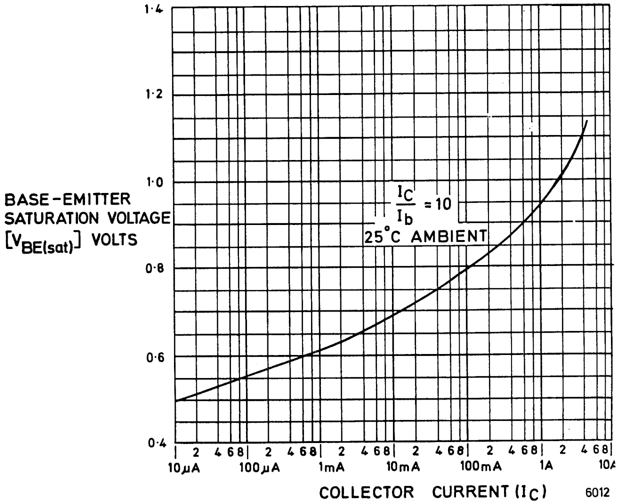
Typical switching speeds (ZTX650/ZTX651)



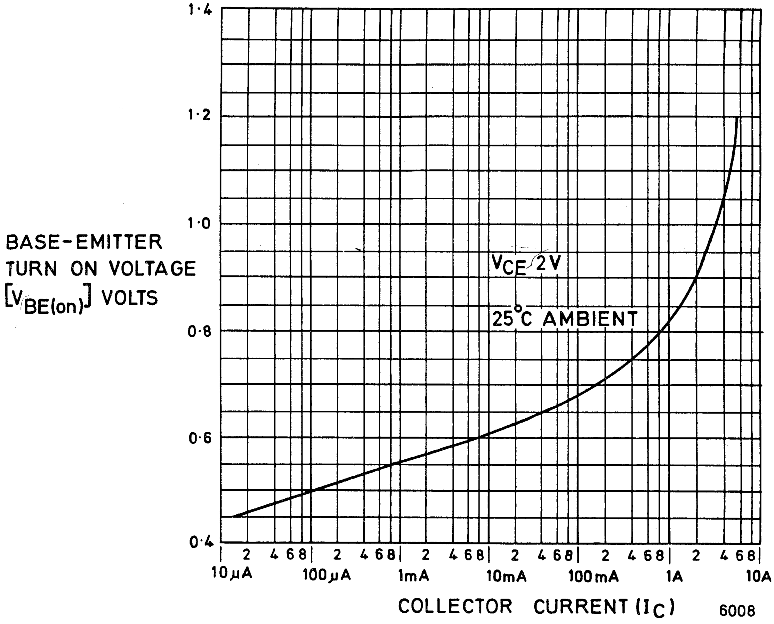
Typical switching speeds (ZTX652/ZTX653)



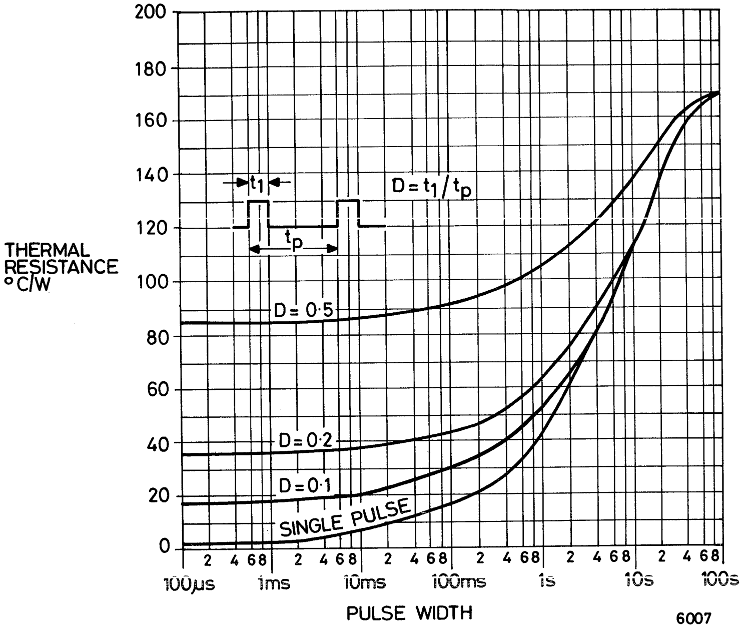
Typical collector-emitter saturation voltages plotted against collector current



Typical base-emitter saturation voltages plotted against collector current for all types



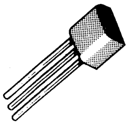
Typical base-emitter turn-on voltages
plotted against collector current for all types



**Maximum transient thermal impedance curves**

# NPN Silicon Planar Medium Power High Voltage Transistors

# ZTX654
# ZTX655



Plastic E-Line
(TO-92 Compatible)

## FEATURES

- 1.5W power dissipation at $T_{amb} = 25°C$*
- 1A continuous $I_C$
- Guaranteed $h_{FE}$ specified up to 1A
- Voltages up to 150V
- Low saturation voltages
- Complementary types

## DESCRIPTION

These plastic encapsulated, medium power transistors are designed for applications requiring high breakdown voltages and low saturation voltages.

The E-line package is formed by transfer moulding a silicone plastic specially selected to provide a rugged one-piece encapsulation resistant to severe environments and allow the high junction temperature operation normally associated with metal can devices.

E-line encapsulated devices are approved for use in military, industrial and professional equipments.

Alternative lead configurations are available as plug-in replacements of TO-5/39 and TO-18 metal can types, and for surface mounting. Also available on tape for automatic handling.

Complementary to ZTX754 and ZTX755.

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | ZTX654 | ZTX655 | Unit |
|---|---|---|---|---|
| Collector-base voltage | $V_{CBO}$ | 125 | 150 | V |
| Collector-emitter voltage | $V_{CEO}$ | 125 | 150 | V |
| Emitter-base voltage | $V_{EBO}$ | 5 | | V |
| Peak collector current (see note below) | $I_{CM}$ | 2 | | A |
| Continuous collector current | $I_C$ | 1 | | A |
| Practical power dissipation* | $P_{totP}$ | 1.5 | | W |
| Power dissipation : at $T_{amb} = 25°C$<br>derate above 25°C | $P_{tot}$ | 1<br>5.7 | | W<br>mW/°C |
| Operating and storage temperature range | $t_j : t_{stg}$ | −55 to +200 | | °C |

Note: Consult Safe Operating Area graph for conditions.

*The power which can be dissipated assuming device mounted in typical manner on P.C.B. with copper equal to 1 sq.inch minimum.

# ZTX654 ZTX655

CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

| Parameter | Symbol | ZTX654 | | ZTX655 | | Unit | Conditions |
|---|---|---|---|---|---|---|---|
| | | Min. | Max. | Min. | Max. | | |
| Collector-base breakdown voltage | $V_{(BR)CBO}$ | 125 | – | 150 | – | V | $I_C = 100\mu A$ |
| Collector-emitter breakdown voltage | $V_{(BR)CEO}$ | 125 | – | 150 | – | V | $I_C = 10mA$ |
| Emitter-base breakdown voltage | $V_{(BR)EBO}$ | 5 | – | 5 | – | V | $I_E = 100\mu A$ |
| Collector cut-off current | $I_{CBO}$ | – | 100 | – | – | nA | $V_{CB} = 100V$ |
| | | – | – | – | 100 | nA | $V_{CB} = 125V$ |
| Emitter cut-off current | $I_{EBO}$ | – | 100 | – | 100 | nA | $V_{EB} = 3V$ |
| Collector-emitter saturation voltage | $V_{CE(SAT)}$ | – | 0.5 | – | 0.5 | V | $I_C = 500mA$, $I_B = 50mA$* |
| | | – | 0.5 | – | 0.5 | V | $I_C = 1A$, $I_B = 200mA$* |
| Base-emitter saturation voltage | $V_{BE(SAT)}$ | – | 1.1 | – | 1.1 | V | $I_C = 500mA$, $I_B = 50mA$* |
| Static forward current transfer ratio | $h_{FE}$ | 50 | – | 50 | – | | $I_C = 10mA$, $V_{CE} = 5V$ |
| | | 50 | – | 50 | – | | $I_C = 500mA$, $V_{CE} = 5V$* |
| | | 20 | – | 20 | – | | $I_C = 1A$, $V_{CE} = 5V$* |
| Base-emitter turn on voltage | $V_{BE(ON)}$ | – | 1 | – | 1 | V | $I_C = 500mA$, $V_{CE} = 5V$* |
| Transition frequency | $f_T$ | 30 | – | 30 | – | MHz | $I_C = 10mA$, $V_{CE} = 20V$<br>$f = 20MHz$ |
| Output capacitance | $C_{obo}$ | – | 20 | – | 20 | pF | $V_{CB} = 20V$, $f = 1MHz$ |

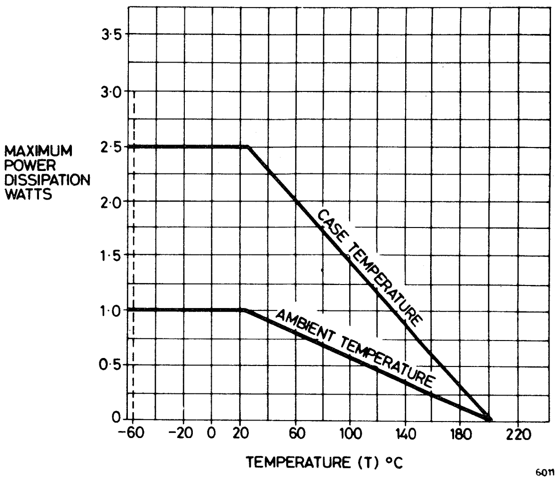
*Measured under pulsed conditions. Pulse width = 300μS. Duty cycle ⩽2%.

## THERMAL CHARACTERISTICS

| Parameter | | Symbol | Maximum | Unit |
|---|---|---|---|---|
| Thermal resistance: | Junction to ambient$_1$ | $R_{th(j-amb)1}$ | 175 | °C/W |
| | Junction to ambient$_2$ | $R_{th(j-amb)2}$† | 116 | °C/W |
| | Junction to case | $R_{th(j-case)}$ | 70 | °C/W |

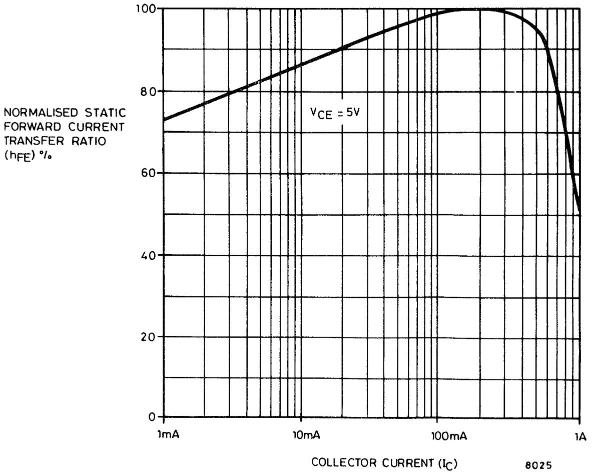
†Device mounted on P.C.B. with copper equal to 1 sq.inch minimum.

CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).



**Dissipation derating curve for all types**

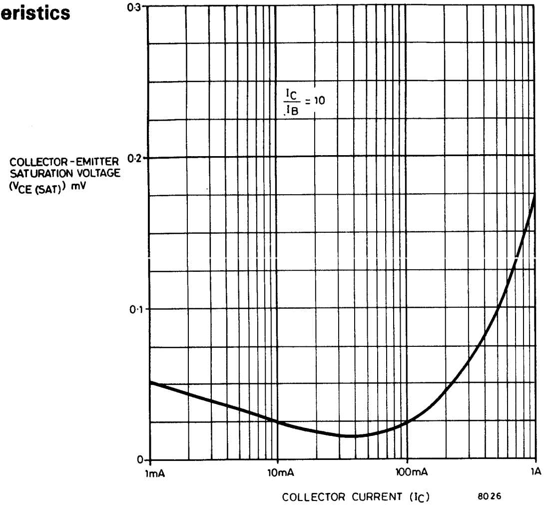
**Typical characteristics**



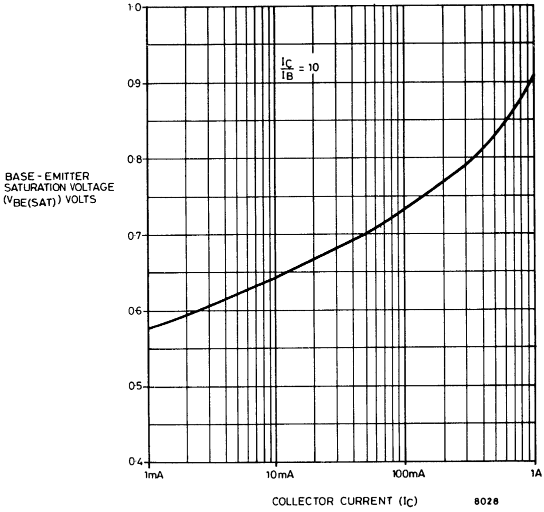
**Typical static forward current transfer ratio plotted against collector current**

CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

**Typical Characteristics**

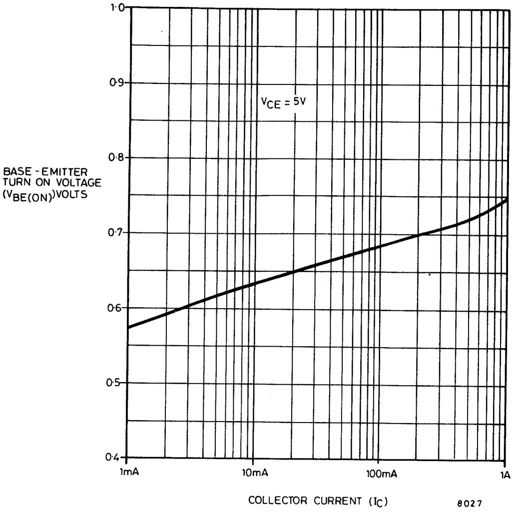


Typical collector-emitter saturation voltages plotted against collector current

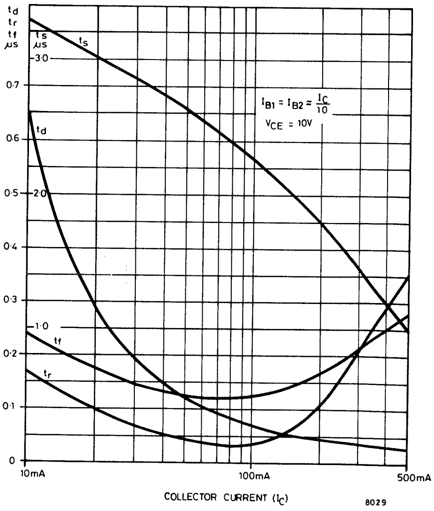


Typical base-emitter saturation voltages plotted against collector current

CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).



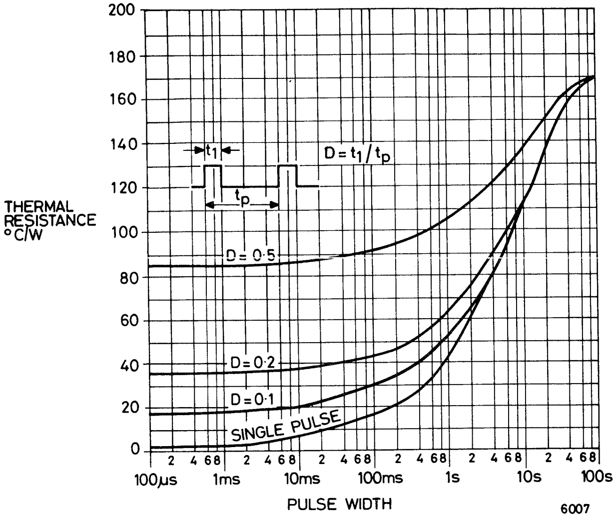
**Typical base-emitter turn on voltages plotted against collector current**



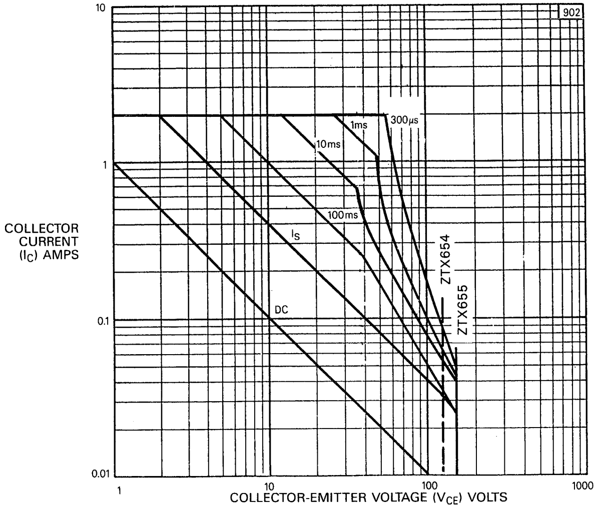
**Typical switching speeds**

# ZTX654 ZTX655

CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).



**Maximum transient thermal impedance curves**



**Safe operating area at $T_{amb} = 25°C$ (single pulse)**

# NPN Silicon Planar Medium Power High Voltage Transistors

## ZTX656
## ZTX657

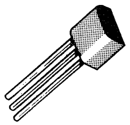
### FEATURES

- 1W power dissipation at $T_{amb} = 25°C$
- Excellent gain characteristics at $I_C = 100mA$
- Voltages up to 300V
- Low saturation voltages
- Complementary types

### DESCRIPTION

These plastic encapsulated, medium power transistors are designed for applications requiring high breakdown voltages and low saturation voltages.

The E-line package is formed by transfer moulding a silicone plastic specially selected to provide a rugged one-piece encapsulation resistant to severe environments and allow the high junction temperature operation normally associated with metal can devices.



Plastic E-Line
(TO-92 Compatible)

E-line encapsulated devices are approved for use in military, industrial and professional equipments.

Alternative lead configurations are available as plug-in replacements of TO-5/39 and TO-18 metal can types, and for surface mounting. Also available on tape for automatic handling.

Complementary to ZTX756 and ZTX757.

### ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | ZTX656 | ZTX657 | Unit |
|---|---|---|---|---|
| Collector-base voltage | $V_{CBO}$ | 200 | 300 | V |
| Collector-emitter voltage | $V_{CEO}$ | 200 | 300 | V |
| Emitter-base voltage | $V_{EBO}$ | 5 | | V |
| Peak collector current (see note below) | $I_{CM}$ | 1 | | A |
| Continuous collector current | $I_C$ | 0.5 | | A |
| Practical power dissipation† | $P_{totP}$ | 1.5 | | W |
| Power dissipation : at $T_{amb} = 25°C$<br>derate above 25°C | $P_{tot}$ | 1<br>5.7 | | W<br>mW/°C |
| Operating and storage temperature range | $t_j : t_{stg}$ | −55 to +200 | | °C |

Note: Consult Safe Operating Area graph for conditions.

† The power which can be dissipated assuming device mounted in typical manner on P.C.B. with copper equal to 1 sq.inch minimum.

# ZTX656 ZTX657

CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

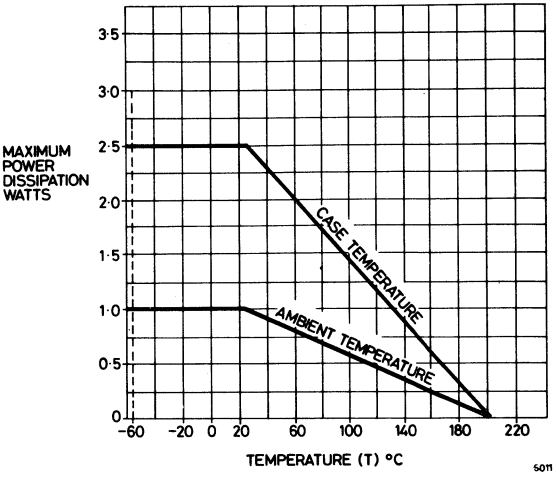
| Parameter | Symbol | ZTX656 | | ZTX657 | | Unit | Conditions |
|---|---|---|---|---|---|---|---|
| | | Min. | Max. | Min. | Max. | | |
| Collector-base breakdown voltage | $V_{(BR)CBO}$ | 200 | – | 300 | – | V | $I_C = 100\mu A$ |
| Collector-emitter breakdown voltage | $V_{(BR)CEO}$ | 200 | – | 300 | – | V | $I_C = 10mA$ |
| Emitter-base breakdown voltage | $V_{(BR)EBO}$ | 5 | – | 5 | – | V | $I_E = 100\mu A$ |
| Collector cut-off current | $I_{CBO}$ | – | 100 | – | – | nA | $V_{CB} = 160V$ |
| | | – | – | – | 100 | nA | $V_{CB} = 200V$ |
| Emitter cut-off current | $I_{EBO}$ | – | 100 | – | 100 | nA | $V_{EB} = 3V$ |
| Collector-emitter saturation voltage | $V_{CE(SAT)}$ | – | 0.5 | – | 0.5 | V | $I_C = 100mA$*, $I_B = 10mA$ |
| Base-emitter saturation voltage | $V_{BE(SAT)}$ | – | 1 | – | 1 | V | $I_C = 100mA$*, $I_B = 10mA$ |
| Static forward current transfer ratio | $h_{FE}$ | 50 | – | 50 | – | | $I_C = 100mA$*, $V_{CE} = 5V$ |
| | | 40 | – | 40 | – | | $I_C = 10mA$, $V_{CE} = 5V$ |
| Base-emitter turn on voltage | $V_{BE(ON)}$ | – | 1 | – | 1 | V | $I_C = 100mA$*, $V_{CE} = 5V$ |
| Transition frequency | $f_T$ | 30 | – | 30 | – | MHz | $I_C = 10mA$, $V_{CE} = 20V$<br>$f = 20MHz$ |
| Output capacitance | $C_{obo}$ | – | 20 | – | 20 | pF | $V_{CB} = 20V$, $f = 1MHz$ |

*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ⩽2%.

## THERMAL CHARACTERISTICS

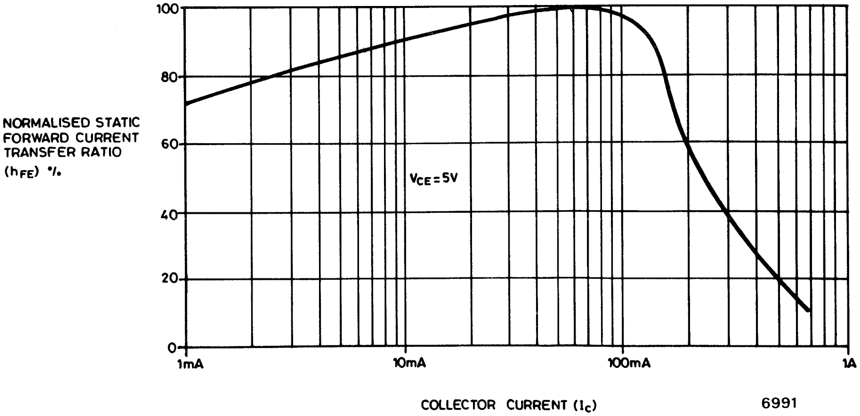
| Parameter | | Symbol | Maximum | Unit |
|---|---|---|---|---|
| Thermal resistance: | Junction to ambient$_1$ | $R_{th(j-amb)1}$ | 175 | °C/W |
| | Junction to ambient$_2$ | $R_{th(j-amb)2}$† | 116 | °C/W |
| | Junction to case | $R_{th(j-case)}$ | 70 | °C/W |

†Device mounted on P.C.B. with copper equal to 1 sq.inch minimum.



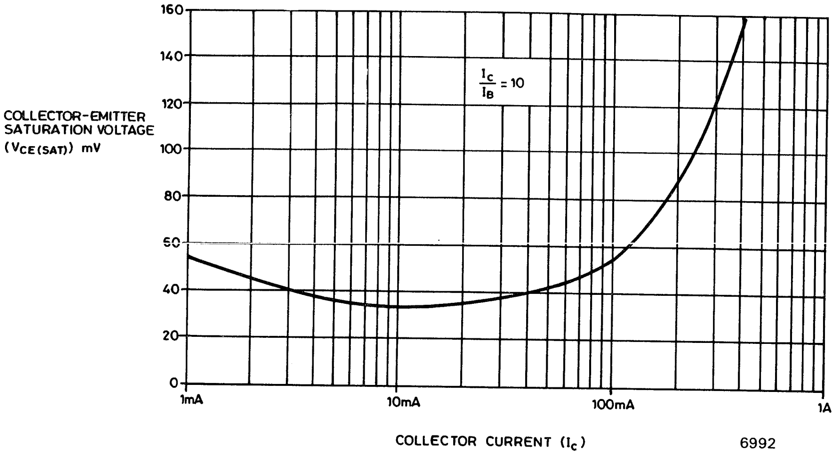
Dissipation derating curve

## Typical characteristics

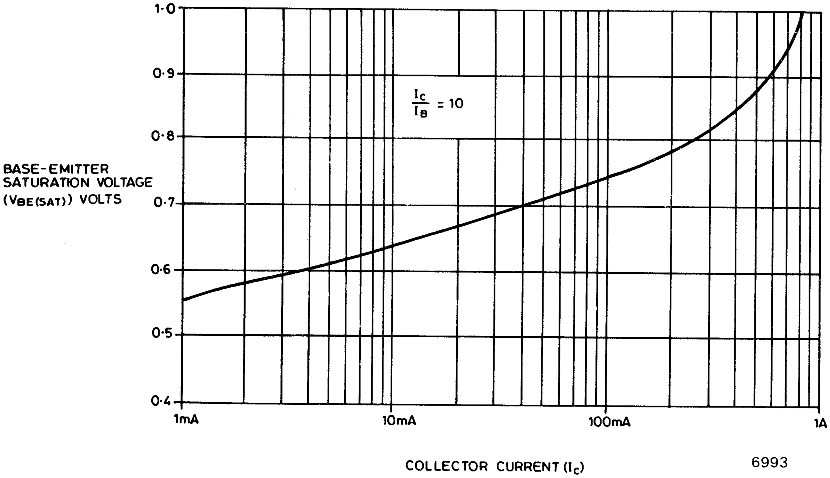


Typical static forward current transfer ratio plotted against collector current

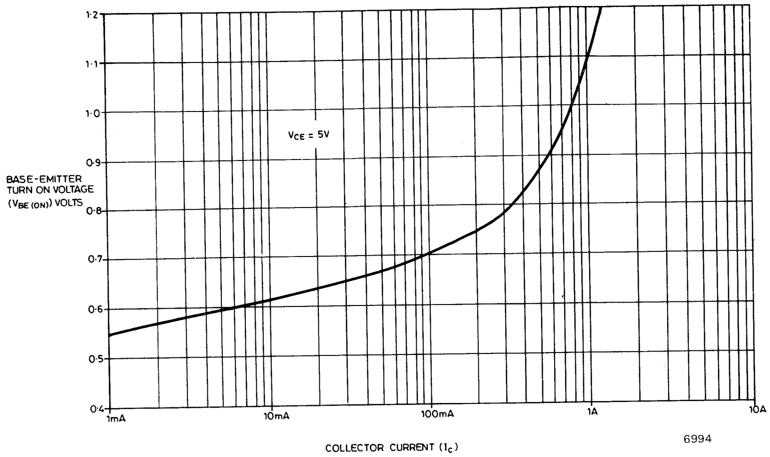
## Typical characteristics



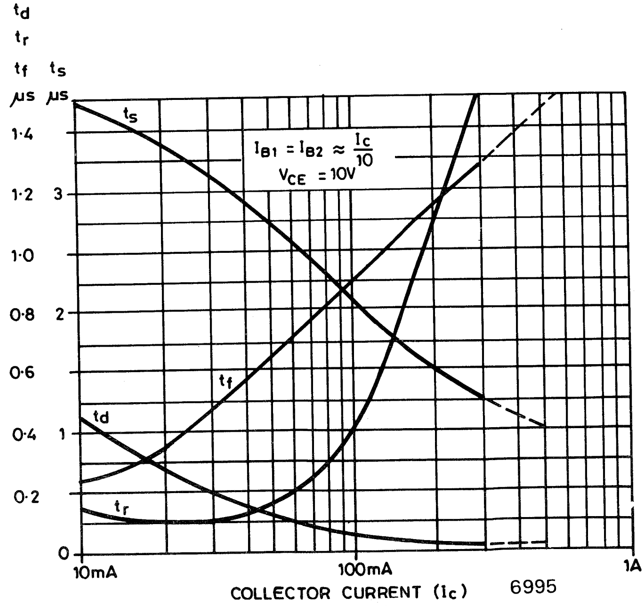
Typical collector-emitter saturation voltages plotted against collector current



Typical base-emitter saturation voltages plotted against collector current

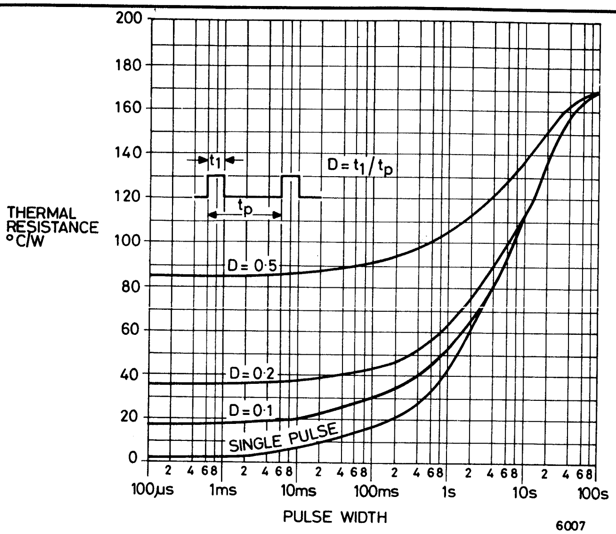


Typical base-emitter turn-on voltages plotted against collector current

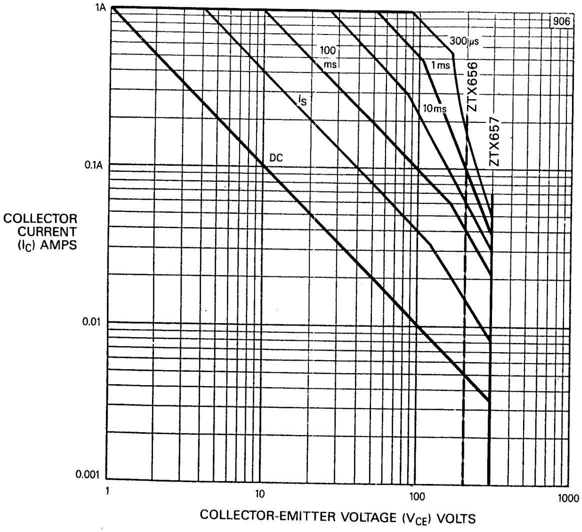


Typical switching speeds

# ZTX656 ZTX657



Maximum transient thermal impedance curves



Safe operating area at $T_{amb} = 25°C$ (single pulse)

# NPN Silicon Planar Medium Power High Gain Transistors

## PRELIMINARY INFORMATION

**ZTX689B ZTX690B**
**ZTX692B ZTX694B**

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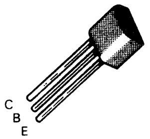
### FEATURES

- High gain — 500 min.
- Up to 3 amps continuous current
- Gain specified up to 6 amps
- 1.5 watt power dissipation at $T_{amb} = 25°C$*
- Voltages up to 120V
- Very low saturation voltages

### DESCRIPTION

A range of high gain, high performance, medium power transistors encapsulated in the popular E-line (TO-92 style) plastic package.

The 1.5 watt performance and outstanding electrical characteristics permit use in a wide variety of applications, including lamp, solenoid and relay drivers, motor drives and DC-DC convertors.



Plastic E-Line
(TO-92 Compatible)

The E-line package is formed by transfer moulding a silicone plastic specially selected to provide a rugged one-piece encapsulation resistant to severe environments and allow the high junction temperature operation normally associated with metal can devices.

### ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | ZTX689B | ZTX690B | ZTX692B | ZTX694B | Unit |
|---|---|---|---|---|---|---|
| Collector-Base Voltage | $V_{CBO}$ | 20 | 45 | 70 | 120 | V |
| Collector-Emitter Voltage | $V_{CEO}$ | 20 | 45 | 70 | 120 | V |
| Emitter-Base Voltage | $V_{EBO}$ | 5 | 5 | 5 | 5 | V |
| Peak Pulse Current | $I_{CM}$ | 8 | 6 | 2 | 1 | A |
| Continuous Collector Current | $I_C$ | 3 | 2 | 1 | 0.5 | A |
| Practical Power Dissipation* | $P_{totP}$ | 1.5 | | | | W |
| Power Dissipation at $T_{amb} = 25°C$<br>derate above 25°C | $P_{tot}$ | 1.0<br>5.7 | | | | W<br>mW/°C |
| Operating & Storage Temperature Range | | −55 to +200 | | | | °C |

*The power which can be dissipated assuming device mounted in typical manner on P.C.B. with copper equal to 1in² minimum.

# ZTX689B, ZTX690B, ZTX692B, ZTX694B

ELECTRICAL CHARACTERISTICS (Test conditions at $T_{amb} = 25°C$ unless otherwise stated).

| Parameter | Symbol | ZTX689B | | | ZTX690B | | | Unit | Conditions |
|---|---|---|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | Min. | Typ. | Max. | | |
| Collector-base breakdown voltage | $V_{(BR)CBO}$ | 20 | — | — | 45 | — | — | V | $I_C = 100\mu A$ |
| Collector-emitter breakdown voltage | $V_{(BR)CEO}$ | 20 | — | — | 45 | — | — | V | $I_C = 10mA$ |
| Emitter-base breakdown voltage | $V_{(BR)EBO}$ | 5 | — | — | 5 | — | — | V | $I_E = 100\mu A$ |
| Collector cut-off current | $I_{CBO}$ | — | — | 0.1 | — | — | — | μA | $V_{CB} = 16V$ |
| | | | | | | | 0.1 | μA | $V_{CB} = 35V$ |
| Emitter cut-off current | $I_{EBO}$ | — | — | 0.1 | — | — | 0.1 | μA | $V_{EB} = 4V$ |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | — | — | 0.1 | — | — | 0.1 | V | $I_C = 100mA$,<br>$I_B = 0.5mA$ |
| | | | | | | | 0.5 | V | $I_C = 1A$,<br>$I_B = 5mA$* |
| | | | | 0.5 | — | — | — | V | $I_C = 2A$,<br>$I_B = 10mA$* |
| Base-emitter saturation voltage | $V_{BE(sat)}$ | — | — | 0.9 | — | — | 0.9 | V | $I_C = 1A$,<br>$I_B = 10mA$* |
| Base-emitter turn-on voltage | $V_{BE(on)}$ | — | — | 0.9 | — | — | 0.9 | V | $I_C = 1A$,<br>$V_{CE} = 2V$* |
| Static forward current transfer ratio | $h_{FE}$ | 500 | — | — | 500 | — | — | | $I_C = 100mA$,<br>$V_{CE} = 2V$ |
| | | — | — | — | 400 | — | — | | $I_C = 1A$,<br>$V_{CE} = 2V$* |
| | | 400 | — | — | 150 | — | — | | $I_C = 2A$,<br>$V_{CE} = 2V$* |
| | | 150 | — | — | — | — | — | | $I_C = 6A$,<br>$V_{CE} = 2V$* |
| Transition frequency | $f_T$ | 150 | — | — | 150 | — | — | MHz | $I_C = 50mA$,<br>$V_{CE} = 5V$<br>$f = 100MHz$ |
| Input capacitance | $C_{ibo}$ | — | 60 | — | — | 50 | — | pF | $V_{EB} = 0.5V$,<br>$f = 1MHz$ |
| Output capacitance | $C_{obo}$ | — | 25 | — | — | 25 | — | pF | $V_{CE} = 10V$,<br>$f = 1MHz$ |
| Switching times | $t_{on}$ | — | 50 | — | — | 50 | — | ns | $I_C = 500mA$,<br>$I_{B1} = 50mA$ |
| | $t_{off}$ | — | 1000 | — | — | 1000 | — | ns | $I_{B2} = 50mA$,<br>$V_{CC} = 10V$ |

*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ⩽ 2%.

ELECTRICAL CHARACTERISTICS (Test conditions at $T_{amb} = 25°C$ unless otherwise stated).

| Parameter | Symbol | ZTX692B | | | ZTX694B | | | Unit | Conditions |
|---|---|---|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | Min. | Typ. | Max. | | |
| Collector-base breakdown voltage | $V_{(BR)CBO}$ | 70 | — | — | 120 | — | — | V | $I_C = 100\mu A$ |
| Collector-emitter breakdown voltage | $V_{(BR)CEO}$ | 70 | — | — | 120 | — | — | V | $I_C = 10mA$ |
| Emitter-base breakdown voltage | $V_{(BR)EBO}$ | 5 | — | — | 5 | — | — | V | $I_E = 100\mu A$ |
| Collector cut-off current | $I_{CBO}$ | — | — | 0.1 | — | — | — | µA | $V_{CB} = 55V$ |
| | | | | | | | 0.1 | µA | $V_{CB} = 100V$ |
| Emitter cut-off current | $I_{EBO}$ | — | — | 0.1 | — | — | 0.1 | µA | $V_{EB} = 4V$ |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | — | — | 0.15 | — | — | 0.25 | V | $I_C = 100mA$, $I_B = 0.5mA$ |
| | | | | | | | 0.5 | V | $I_C = 400mA$, $I_B = 5mA$* |
| | | | | 0.5 | — | — | — | V | $I_C = 1A$, $I_B = 10mA$* |
| Base-emitter saturation voltage | $V_{BE(sat)}$ | — | — | 0.9 | — | — | 0.9 | V | $I_C = 1A$, $I_B = 10mA$* |
| Base-emitter turn-on voltage | $V_{BE(on)}$ | — | — | 0.9 | — | — | 0.9 | V | $I_C = 1A$, $V_{CE} = 2V$* |
| Static forward current transfer ratio | $h_{FE}$ | 500 | — | — | 500 | — | — | | $I_C = 100mA$, $V_{CE} = 2V$ |
| | | — | — | — | 400 | — | — | | $I_C = 200mA$, $V_{CE} = 2V$* |
| | | — | — | — | 150 | — | — | | $I_C = 400mA$, $V_{CE} = 2V$* |
| | | 400 | — | — | — | — | — | | $I_C = 500mA$, $V_{CE} = 2V$* |
| | | 150 | — | — | — | — | — | | $I_C = 1A$, $V_{CE} = 2V$* |
| Transition frequency | $f_T$ | 150 | — | — | 150 | — | — | MHz | $I_C = 50mA$, $V_{CE} = 5V$ $f = 100MHz$ |
| Input capacitance | $C_{ibo}$ | — | 37 | — | — | 33 | — | pF | $V_{EB} = 0.5V$, $f = 1MHz$ |
| Output capacitance | $C_{obo}$ | — | 14 | — | — | 11 | — | pF | $V_{CE} = 10V$, $f = 1MHz$ |
| Switching times | $t_{on}$ | 50 | — | — | — | 200 | — | ns | $I_C = 500mA$, $I_{B1} = 50mA$ $I_{B2} = 50mA$, $V_{CC} = 10V$ |
| | $t_{off}$ | 1200 | — | — | — | 1600 | — | ns | |

*Measured under pulsed conditions. Pulse width = 300µs. Duty cycle ⩽ 2%.

# PNP Silicon Planar Medium Power Darlington Transistor

# ZTX704
# ZTX705

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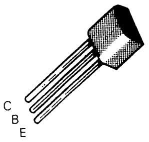
## FEATURES

- 1.5W power dissipation
- 1A continuous collector current
- 4A peak collector current
- Guaranteed $h_{FE}$ specified up to 2A
- Fast switching

## DESCRIPTION

The ZTX704 and ZTX705 are high performance medium power Darlington amplifier transistors, encapsulated in the popular E-line (TO-92) plastic package.

The 1A performance permits use in a wide range of industrial and consumer applications. The E-line package is formed by transfer moulding a SILICONE plastic specially selected to provide a rugged one-piece encapsulation resistant to severe environments and allow the high junction temperature operation normally associated with metal can devices.



Plastic E-Line
(TO-92 Compatible)

*Fig. 1. Pin connections*

E-line encapsulated devices are approved for use in military, industrial and professional equipments.

Alternative lead configurations are available as plug-in replacements of TO-5/39 and TO-18 metal can types, and for flat mounting.

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | ZTX704 | ZTX705 | Unit |
|---|---|---|---|---|
| Collector-Base Voltage | $V_{CBO}$ | −120 | −140 | V |
| Collector-Emitter Voltage | $V_{CEO}$ | −100 | −120 | V |
| Emitter-Base Voltage | $V_{EBO}$ | −10 | | V |
| Peak Pulse Current (note 2) | $I_{CM}$ | −4 | | A |
| Continuous Collector Current | $I_C$ | −1 | | A |
| Practical Power Dissipation (note 3) | $P_{totp}$ | 1.5 | | W |
| Power Dissipation @ $T_{amb} = 25°C$ (note 1)<br>@ $T_{case} = 25°C$ | $P_{tot}$<br>$P_{tot}$ | 1<br>2.5 | | W<br>W |
| Operating & Storage Temperature Range (note 1) | | −55 to +200 | | °C |

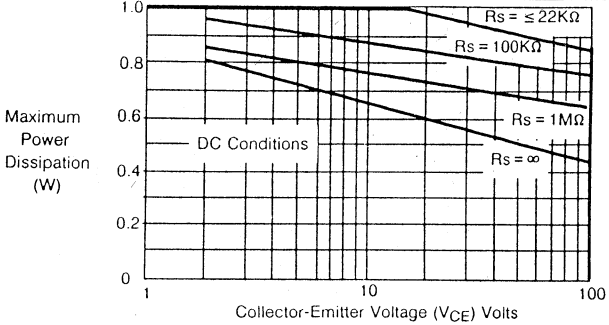
Note 1. The maximum values of $V_{CEO}$ and Power Dissipation are dependent on operating temperature. See Voltage Derating Graph (Fig. 2) for maximum power dissipation and operating temperature in a given application.
Note 2. Consult Safe Operating Area graph for conditions.
Note 3. The power which can be dissipated assuming device mounted in typical manner on PCB with copper equal to 1 sq. inch minimum.

# ZTX704/ZTX705

ELECTRICAL CHARACTERISTICS (Test conditions at $T_{amb} = 25°C$ unless otherwise stated).

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Test Conditions |
|---|---|---|---|---|---|---|
| Collector-base breakdown voltage ZTX705 | $V_{(BR)CBO}$ | $-140$ | — | — | V | $I_C = -100\mu A$ |
| ZTX704 | $V_{(BR)CBO}$ | $-120$ | — | — | V | $I_C = -100\mu A$ |
| Collector-emitter breakdown voltage ZTX705 | $V_{(BR)CEO}$ | $-120$ | — | — | V | $I_C = -10mA$* |
| ZTX704 | $V_{(BR)CEO}$ | $-100$ | — | — | V | $I_C = -10mA$* |
| Emitter-base breakdown voltage | $V_{(BR)EBO}$ | $-10$ | — | — | V | $I_E = -100\mu A$ |
| Collector cut-off current ZTX704 | $I_{CBO}$ | — | — | $-0.1$ | μA | $V_{CB} = -100V$ |
| ZTX705 | $I_{CBO}$ | — | — | $-0.1$ | μA | $V_{CB} = -120V$ |
| ZTX704 | $I_{CBO}$ | — | — | $-10$ | μA | $V_{CB} = -100V$ } $T_{amb} = 100°C$ |
| ZTX705 | $I_{CBO}$ | — | — | $-10$ | μA | $V_{CB} = -120V$ } $T_{amb} = 100°C$ |
| Collector-emitter cut-off current | $I_{CES}$ | — | — | $-10$ | μA | $V_{CES} = -80V$ |
| Emitter cut-off current | $I_{EBO}$ | — | — | $-0.1$ | μA | $V_{EB} = -8V$ |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | — | — | $-1.3$ | V | $I_C = -1A, I_B = -1mA$* |
|  | $V_{CE(sat)}$ | — | — | $-2.5$ | V | $I_C = -2A, I_B = -2mA$* |
| Base-emitter saturation voltage | $V_{BE(sat)}$ | — | — | $-1.8$ | V | $I_C = -1A, I_B = -10mA$ |
| Base-emitter turn-on voltage | $V_{BE(on)}$ | — | — | $-1.7$ | V | $I_C = -1A, V_{CE} = -5V$* |
| Static forward current transfer ratio | $h_{FE}$ | 3000 | — | — | — | $I_C = -10mA, V_{CE} = -5V$ |
|  |  | 3000 | — | — | — | $I_C = -100mA, V_{CE} = -5V$* |
|  |  | 3000 | — | 30000 | — | $I_C = -1A, V_{CE} = -5V$* |
|  |  | 2000 | — | — | — | $I_C = -2A, V_{CE} = -5V$* |
| Transition frequency | $f_T$ | — | 160 | — | MHz | $I_C = -100mA, V_{CE} = -10V$<br>$f = 20MHz$ |
| Input capacitance | $C_{ibo}$ | — | 90 | — | pF | $V_{EB} = -0.5V, f = 1MHz$ |
| Output capacitance | $C_{obo}$ | — | 15 | — | pF | $V_{CE} = -10V, f = 1MHz$ |
| Switching times | $t_{on}$ | — | 0.6 | — | μs | $I_C = -0.5A, V_{CE} = -10V$ |
|  | $t_{off}$ | — | 0.8 | — | μs | $I_{B1} = I_{B2} = -0.5mA$ |

*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ⩽ 2%.



**Voltage Derating Graph**

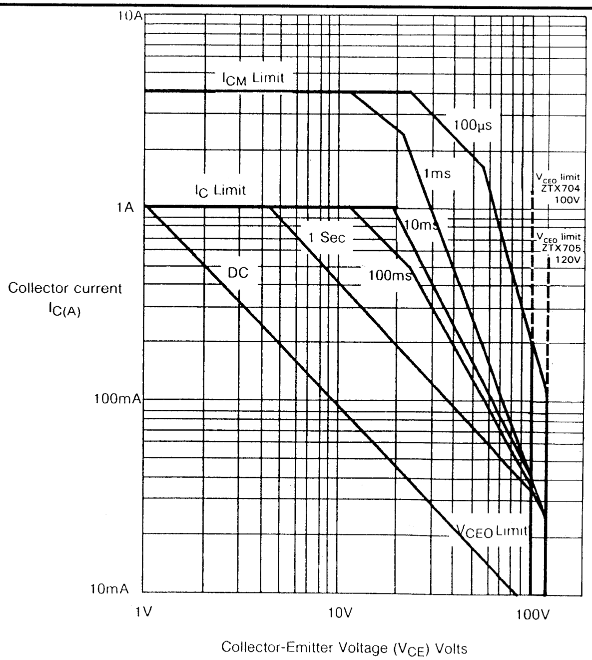
The maximum permissible operational temperature can be obtained from this graph using the following equation

$$T_{amb(max)} = \frac{Power\ (max) - Power\ (act)}{0.0057} + 25°C$$

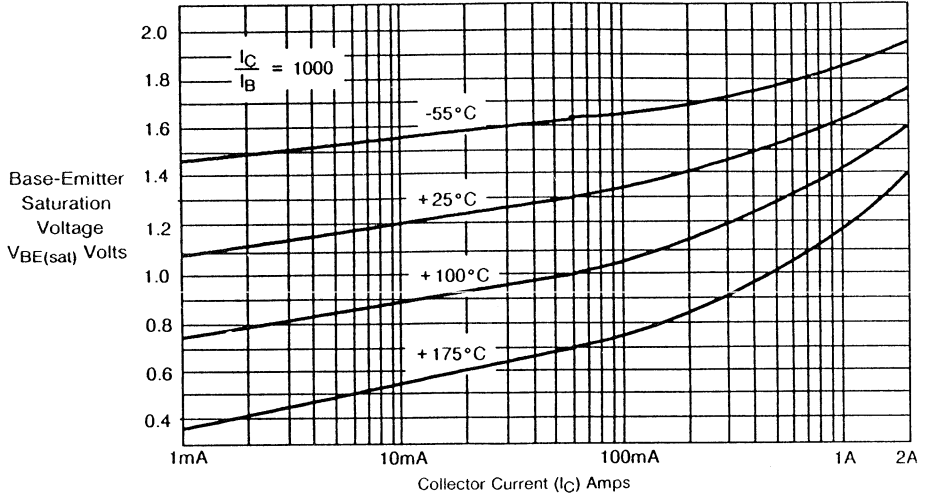
$T_{amb(max)}$ = Maximum operating ambient temperature.

Power(max) = Maximum power dissipation figure, obtained from the above graph for a given $V_{CE}$ and source resistance ($R_S$).

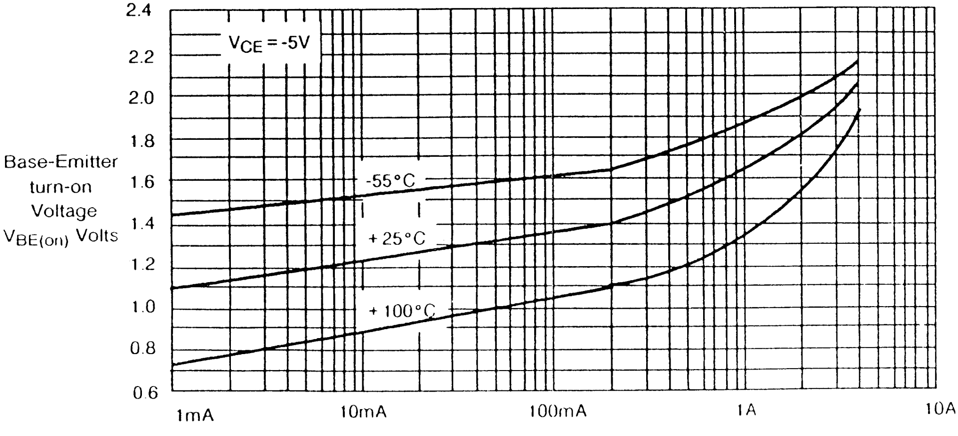
Power(actual) = Actual power dissipation in users circuit.



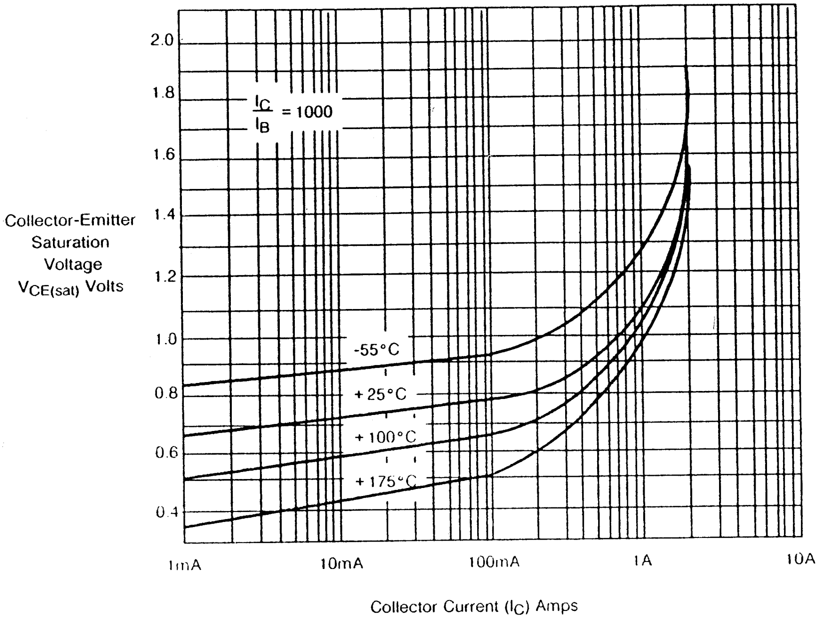
**Safe operating area at $T_{amb} = 25°C$ (single pulse)**



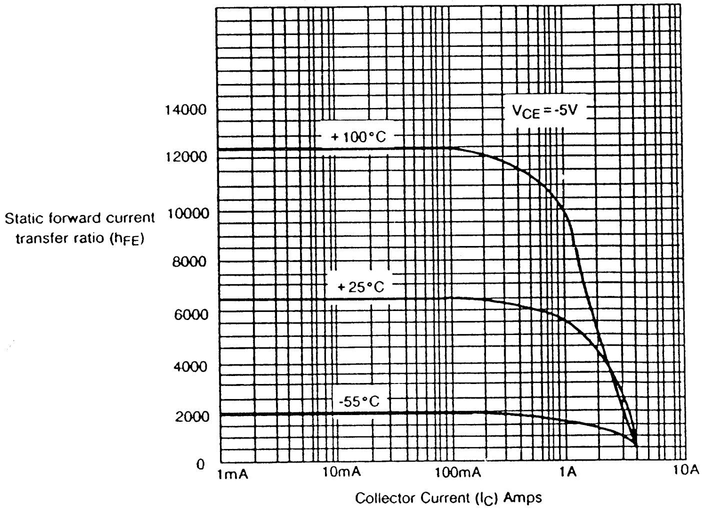
**Typical base-emitter saturation voltage plotted against collector current**



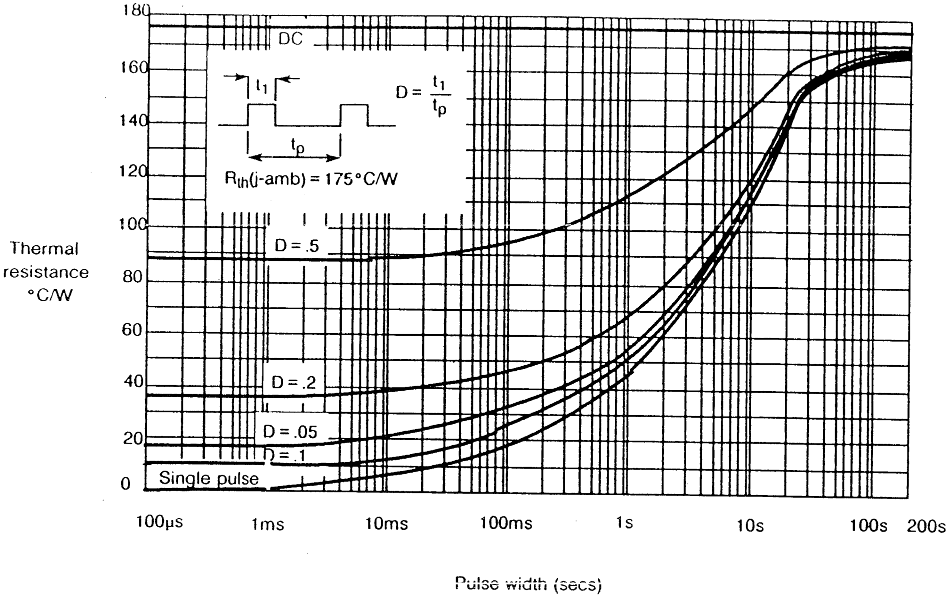
**Typical base-emitter turn-on voltage plotted against collector current**



**Typical collector-emitter saturation voltages plotted against collector current**



**Typical static forward current transfer ratio plotted against collector current**



**Maximum transient thermal impedance curves**

# PNP Silicon Planar Medium Power Darlington Transistor

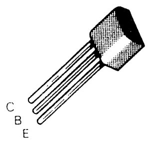
# ZTX712

## FEATURES

- 1.5W power dissipation
- 0.8A continuous collector current
- $h_{FE}$ up to 10,000 at $I_C = 500$ mA
- Fast switching

## DESCRIPTION

The ZTX712 Silicon Planar Darlington Transistor is designed for medium power applications requiring very high current gain and high input impedance. The monolithic construction has the inherent advantages of fast switching times, low saturation voltages and low leakage currents. Application areas include: driver and output stages of audio amplifiers; direct interfacing with integrated circuits; lamp, relay and hammer driving.



Plastic E-Line
(TO-92 Compatible)

The E-line package is formed by transfer moulding a silicone plastic specially selected to provide a rugged one-piece encapsulation resistant to severe environments and allow the high junction temperature operation normally associated with metal can devices.

E-line encapsulated devices are approved for use in military, industrial and professional equipments.

Alternative lead configurations are available as plug-in replacements to TO-5/39 and TO-18 metal can types, and for surface mounting.

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | Value | Unit |
|---|---|---|---|
| Collector-Base Voltage | $V_{CBO}$ | −80 | Volts |
| Collector-Emitter Voltage | $V_{CEO}$ | −60 | Volts |
| Emitter-Base Voltage | $V_{EBO}$ | −10 | Volts |
| Peak Pulse Current | $I_{CM}$ | −2 | A |
| Continuous Collector Current | $I_C$ | −800 | mA |
| Practical Power Dissipation* | $P_{totp}$ | 1.5 | Watts |
| Power Dissipation at $T_{amb} = 25°C$<br>derate above 25°C | $P_{tot}$ | 1<br>5.7 | Watts<br>mW/°C |
| Operating and Storage Temperature Range | | −55 to +200 | °C |

*The power which can be dissipated assuming the device mounted in typical manner on PCB with copper equal to 1 sq. inch minimum.

# ZTX712

ELECTRICAL CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

| Parameter | Symbol | Min. | Max. | Unit | Test Conditions |
|---|---|---|---|---|---|
| Collector-base breakdown voltage | $V_{(BR)CBO}$ | −80 | — | V | $I_C = -10\mu A$, $I_E = 0$ |
| Collector-emitter sustaining voltage | $V_{CEO(sus)}$ | −60 | — | V | $I_C = -10mA$, $I_B = 0$ |
| Emitter-base breakdown voltage | $V_{(BR)EBO}$ | −10 | — | V | $I_E = -10\mu A$, $I_C = 0$ |
| Collector-base cut-off current | $I_{CBO}$ | — | −100 | nA | $V_{CB} = -60V$, $I_E = 0$ |
| Emitter-base cut-off current | $I_{EBO}$ | — | 100 | nA | $V_{EB} = -8V$, $I_C = 0$ |
| Static forward current transfer ratio | $h_{FE}$ | 5,000<br>10,000 | —<br>— | | $I_C = -100mA$<br>$I_C = -500mA$ } $V_{CE} = -5V$* |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | — | −1.25 | V | $I_C = -800mA$, $I_B = -8mA$* |
| Base-emitter on voltage | $V_{BE(on)}$ | — | −1.8 | V | $I_C = -800mA$, $V_{CE} = -5V$* |

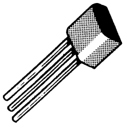
*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ⩽ 2%.

# PNP Silicon Planar Medium Power Transistor

# ZTX749

## FEATURES

- 1.5W power dissipation at $T_{amb} = 25°C$*
- 2A continuous $I_C$
- Excellent gain characteristics up to 6A (pulsed)
- Low saturation voltages
- Fast switching
- NPN complementary type available



Plastic E-Line
(TO-92 Compatible)

## DESCRIPTION

A high performance transistor encapsulated in the popular E-line (TO-92) plastic package.

The 1.5W performance and outstanding electrical characteristics permit use in a wide range of industrial and consumer applications including lamp and solenoid drivers.

In addition the excellent gain characteristics at high collector current levels make the device ideal in pulsed applications.

The specially selected silicone encapsulation provides resistance to severe environments comparable with metal can devices.

Complementary to the ZTX649

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | ZTX749 | Unit |
|---|---|---|---|
| Collector-base voltage | $V_{CBO}$ | −35 | V |
| Collector-emitter voltage | $V_{CEO}$ | −25 | V |
| Emitter-base voltage | $V_{EBO}$ | −5 | V |
| Peak pulse current (see note below) | $I_{CM}$ | −6 | A |
| Continuous collector current | $I_C$ | −2 | A |
| Practical power dissipation* | $P_{totP}$ | 1.5 | W |
| Power dissipation: at $T_{amb} = 25°C$<br>derate above 25°C | $P_{tot}$ | 1<br>5.7 | W<br>mW/°C |
| Operating and storage temperature range | $t_j : t_{stg}$ | −55 to +200 | °C |

Note: Consult Safe Operating Area graph for conditions.

*The power which can be dissipated assuming device mounted in typical manner on P.C.B. with copper equal to 1sq.inch minimum.

# ZTX749

CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

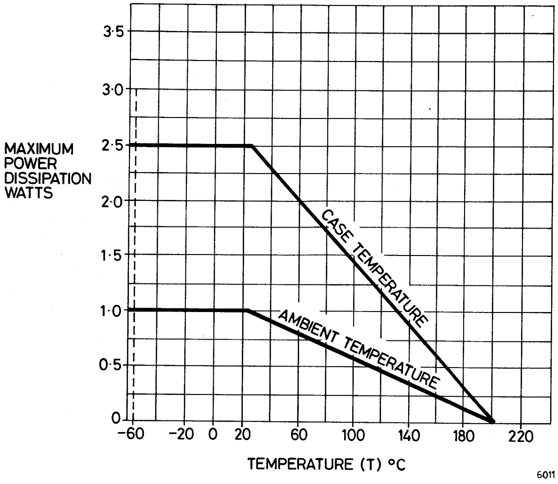
| Parameter | Symbol | Min. | Typ. | Max. | Unit | Conditions |
|---|---|---|---|---|---|---|
| Collector-base breakdown voltage | $V_{(BR)CBO}$ | −35 | | | V | $I_C = -100\mu A$ |
| Collector-emitter breakdown voltage | $V_{(BR)CEO}$ | −25 | | | V | $I_C = -10mA$ |
| Emitter-base breakdown voltage | $V_{(BR)EBO}$ | −5 | | | V | $I_E = -100\mu A$ |
| Collector cut-off current | $I_{CBO}$ | | | −0.1 | μA | $V_{CB} = -30V$ |
| | | | | −10 | μA | $V_{CB} = -30V$, $T_{amb} = 100°C$ |
| Emitter cut-off current | $I_{EBO}$ | | | −0.1 | μA | $V_{EB} = -4V$ |
| Collector-emitter saturation voltage | $V_{CE(SAT)}$ | | −0.12 | −0.3 | V | $I_C = -1A$, $I_B = -100mA$* |
| | | | −0.23 | −0.5 | V | $I_C = -2A$, $I_B = -200mA$* |
| Base-emitter saturation voltage | $V_{BE(SAT)}$ | | −0.9 | −1.25 | V | $I_C = -1A$, $I_B = -100mA$* |
| Base-emitter turn on voltage | $V_{BE(ON)}$ | | −0.8 | −1 | V | $I_C = -1A$, $V_{CE} = -2V$* |
| Static forward current transfer ratio | $h_{FE}$ | 70 | 200 | – | | $I_C = -50mA$, $V_{CE} = -2V$* |
| | | 100 | 200 | 300 | | $I_C = -1A$, $V_{CE} = -2V$* |
| | | 75 | 150 | – | | $I_C = -2A$, $V_{CE} = -2V$* |
| | | 15 | 50 | – | | $I_C = -6A$, $V_{CE} = -2V$* |
| Transition frequency | $f_T$ | 100 | 160 | | MHz | $I_C = -100mA$, $V_{CE} = -5V$<br>$f = 100MHz$ |
| Output capacitance | $C_{obo}$ | | 55 | 100 | pF | $V_{CB} = -10V$, $f = 1MHz$ |
| Switching times | $T_{on}$ | – | 40 | | nS | $I_C = -500mA$, $V_{CC} = -10V$<br>$I_{B1} = I_{B2} = -50mA$ |
| | $T_{off}$ | | 500 | | nS | |

*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ⩽2%.

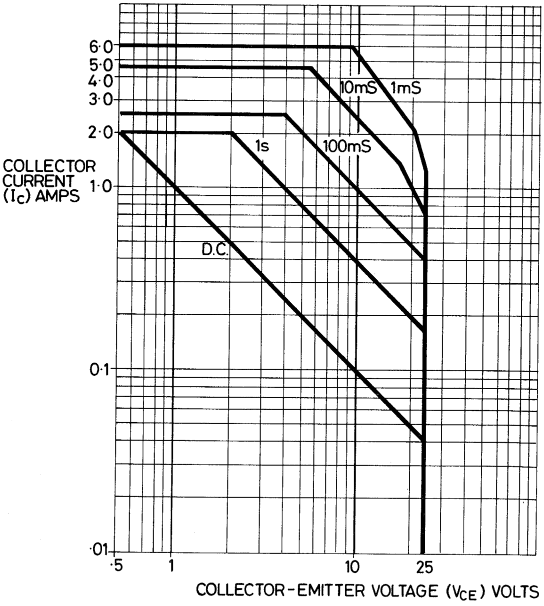
## THERMAL CHARACTERISTICS

| Parameter | | Symbol | Maximum | Unit |
|---|---|---|---|---|
| Thermal resistance: | Junction to ambient$_1$ | $R_{th(j\text{-}amb)_1}$ | 175 | °C/W |
| | Junction to ambient$_2$ | $R_{th(j\text{-}amb)_2}$† | 116 | °C/W |
| | Junction to case | $R_{th(j\text{-}case)}$ | 70 | °C/W |

†Device mounted on P.C.B. with copper equal to 1sq.inch minimum.

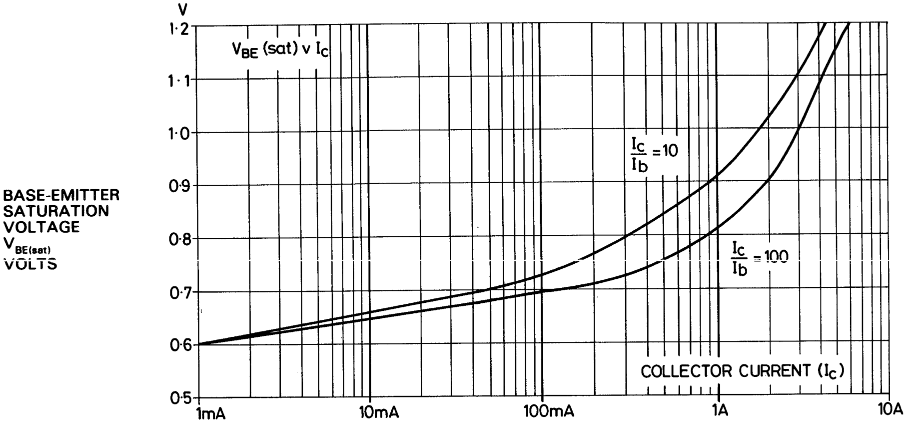


Dissipation derating curve

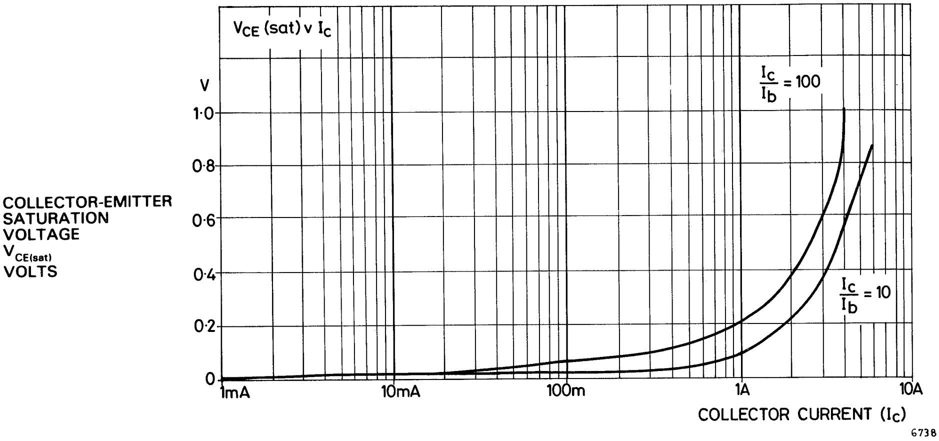


Safe operating area at $T_{amb} = 25°C$
(single pulse)

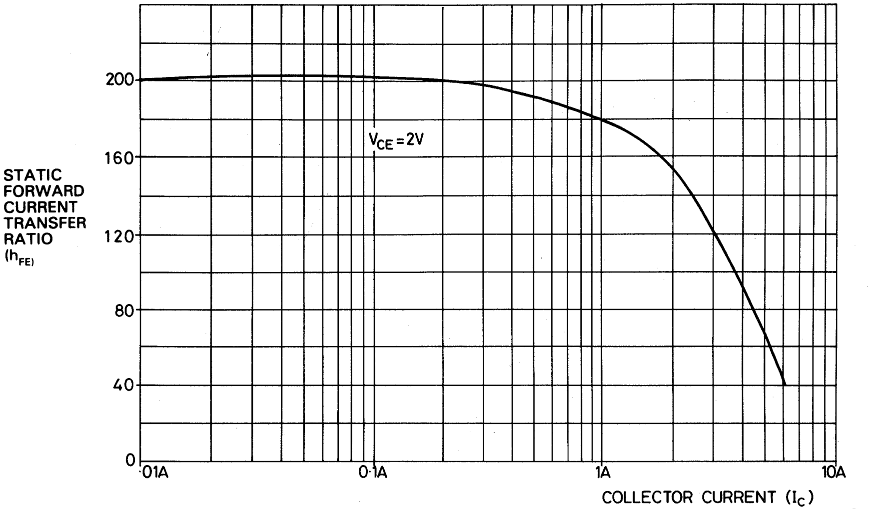
6731



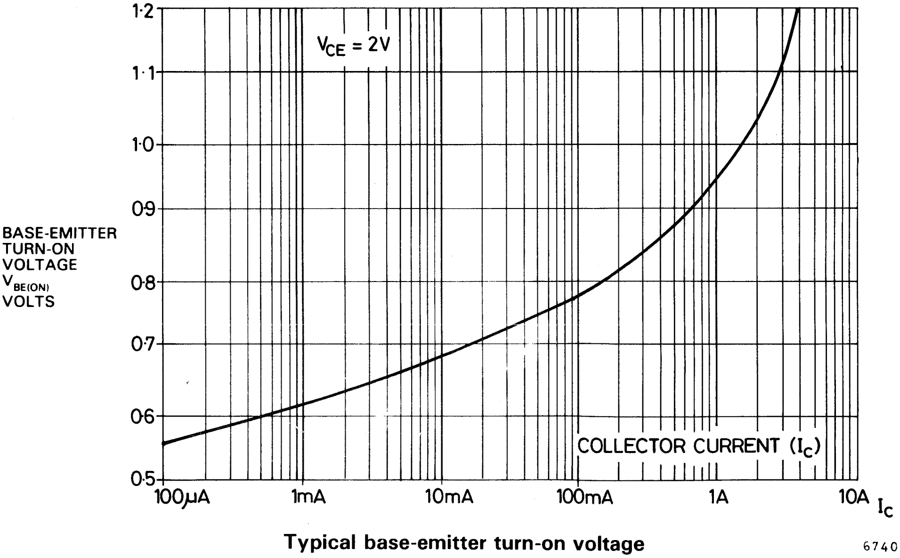
Typical base-emitter saturation voltages plotted against collector current



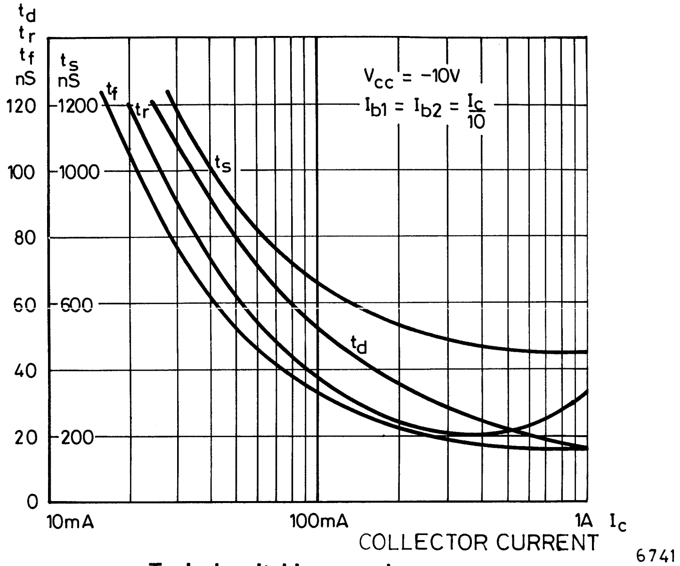
Typical collector-emitter saturation voltages plotted against collector current



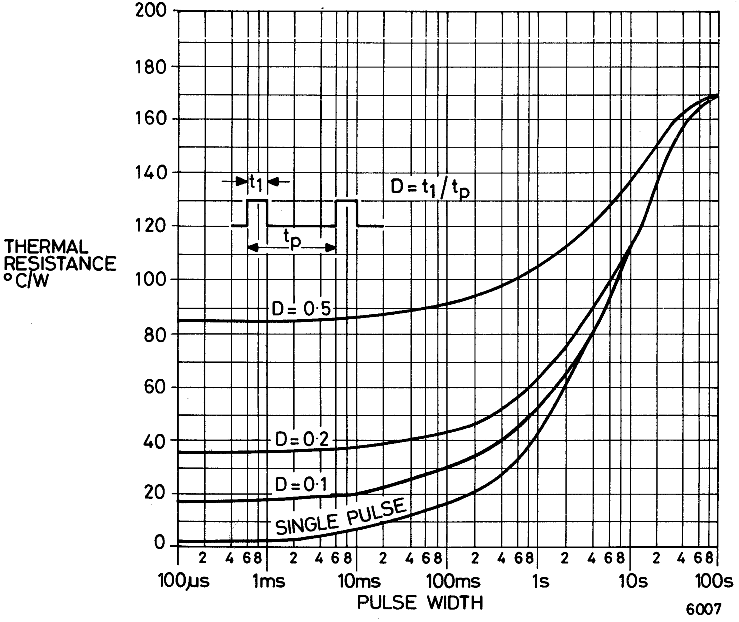
Typical static forward current transfer ratio plotted against collector current



Typical base-emitter turn-on voltage plotted against collector current



Typical switching speeds



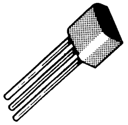
Maximum transient thermal impedance curves

# PNP Silicon Planar Medium Power Transistors

# ZTX750 ZTX751 ZTX752 ZTX753

## FEATURES

- 1.5W power dissipation at $T_{amb} = 25°C$*
- 2V continuous $I_C$
- Excellent gain characteristics to 2A
- High $V_{CEO}$: up to 100V
- Low saturation voltages
- Guaranteed $h_{FE}$ specified up to 2A
- Fast switching
- Exceptional price-to-power ratio
- Complementary types



Plastic E-Line
(TO-92 Compatible)

## DESCRIPTION

A range of high performance medium power transistors encapsulated in the popular E-line (TO-92) plastic package.

The 1.5W performance and outstanding electrical characteristics permit use in a wide variety of industrial and consumer applications including lamp and solenoid drivers, audio amplifiers and complementary drivers for hi-fi amplifiers.

In addition to achieving excellent linearity the devices are designed to function as high speed power switching transistors.

The specially selected silicone encapsulation provides resistance to severe environments comparable with metal can devices.

Complementary to ZTX650 series.

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | ZTX750 | ZTX751 | ZTX752 | ZTX753 | Unit |
|---|---|---|---|---|---|---|
| Collector-base voltage | $V_{CBO}$ | −60 | −80 | −100 | −120 | V |
| Collector-emitter voltage | $V_{CEO}$ | −36 | −60 | −80 | −100 | V |
| Emitter-base voltage | $V_{EBO}$ | −5 | | | | V |
| Peak pulse current (see note below) | $I_{CM}$ | −6 | | | | A |
| Continuous collector current | $I_C$ | −2 | | | | A |
| Practical power dissipation* | $P_{totP}$ | 1.5 | | | | W |
| Power dissipation at $T_{amb} = 25°C$<br>derate above 25°C<br>at $T_{case} = 25°C$ | $P_{tot}$ | 1<br>5.7<br>2.5 | | | | W<br>mW/°C<br>W |
| Operating & storage temp. range | $t_j : t_{stg}$ | −55 to +200 | | | | °C |

Note: Consult Safe Operating Area graph for conditions.

*The power which can be dissipated assuming device mounted in typical manner on P.C.B. with copper equal to 1 sq.inch minimum.

# ZTX750 ZTX751

CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

| Parameter | Symbol | ZTX750 | | | ZTX751 | | | Unit | Conditions |
|---|---|---|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | Min. | Typ. | Max. | | |
| Collector-base breakdown voltage | $V_{(BR)CBO}$ | −60 | – | – | −80 | – | – | V | $I_C = -100\mu A$ |
| Collector-emitter breakdown voltage | $V_{(BR)CEO}$ | −45 | – | – | −60 | – | – | V | $I_C = -10mA$ |
| Emitter-base breakdown voltage | $V_{(BR)EBO}$ | −5 | – | – | −5 | – | – | V | $I_E = -100\mu A$ |
| Collector cut-off current | $I_{CBO}$ | – | – | −0.1 | – | – | – | μA | $V_{CB} = -45V$ |
| | | – | – | −10 | – | – | – | μA | $V_{CB} = -45V$, $T_{amb} = 100°C$ |
| | | – | – | – | – | – | −0.1 | μA | $V_{CB} = -60V$ |
| | | – | – | – | – | – | −10 | μA | $V_{CB} = -60V$, $T_{amb} = 100°C$ |
| Emitter cut-off current | $I_{EBO}$ | – | – | −0.1 | – | – | −0.1 | μA | $V_{EB} = -4V$ |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | – | 0.15 | −0.3 | – | 0.15 | −0.3 | V | $I_C = -1A$, $I_B = -100mA$* |
| | | – | 0.28 | −0.5 | – | 0.28 | −0.5 | V | $I_C = -2A$, $I_B = -200mA$* |
| Base-emitter saturation voltage | $V_{BE(sat)}$ | – | −0.90 | −1.25 | – | −0.90 | −1.25 | V | $I_C = -1A$, $I_B = -100mA$* |
| Base-emitter turn-on voltage | $V_{BE(on)}$ | – | −0.8 | −1.0 | – | −0.8 | −1.0 | V | $I_C = -1A$, $V_{CE} = -2V$* |
| Static forward current transfer ratio | $h_{FE}$ | 70 | 200 | – | 70 | 200 | – | | $I_C = -50mA$, $V_{CE} = -2V$* |
| | | 100 | 200 | 300 | 100 | 200 | 300 | | $I_C = -500mA$, $V_{CE} = -2V$* |
| | | 80 | 170 | – | 80 | 170 | – | | $I_C = -1A$, $V_{CE} = -2V$* |
| | | 40 | 150 | – | 40 | 150 | – | | $I_C = -2A$, $V_{CE} = -2V$* |
| Transition frequency | $f_T$ | 100 | 140 | – | 100 | 140 | – | MHz | $I_C = -100mA$, $V_{CE} = -5V$<br>$f = 100MHz$ |
| Switching times | $T_{on}$ | – | 40 | – | – | 40 | – | ns | $I_C = -500mA$, $I_{B_1} = -50mA$ |
| | $T_{off}$ | – | 450 | – | – | 450 | – | ns | $I_{B_2} = -50mA$, $V_{CC} = -10V$ |
| Output capacitance | $C_{obo}$ | – | – | 30 | – | – | 30 | pF | $V_{CB} = -10V$, $f = 1MHz$ |

*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ⩽ 2%.

**THERMAL CHARACTERISTICS** (ZTX750/3)

| Parameter | Symbol | Maximum | Unit |
|---|---|---|---|
| Thermal resistance: Junction to ambient$_1$ | $R_{th(j-amb)1}$ | 175 | °C/W |
| Junction to ambient$_2$ | $R_{th(j-amb)2}$† | 116 | °C/W |
| Junction to case | $R_{th(j-case)}$ | 70 | °C/W |

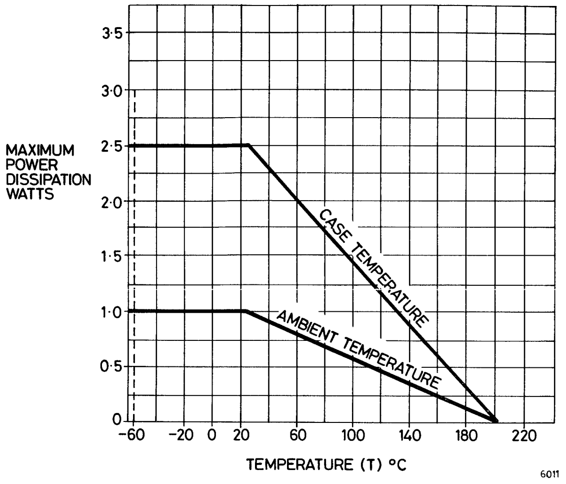
†Device mounted on P.C.B. with copper equal to 1 sq.inch minimum.

# ZTX752 ZTX753

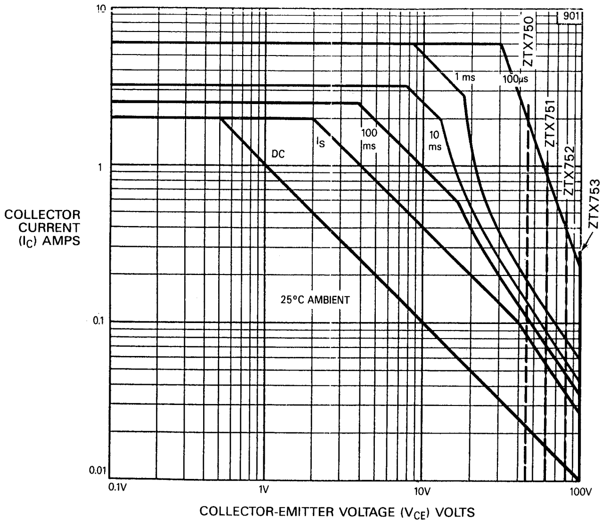
CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

| Parameter | Symbol | ZTX752 | | | ZTX753 | | | Unit | Conditions |
|---|---|---|---|---|---|---|---|---|---|
| | | Min. | Typ. | Max. | Min. | Typ. | Max. | | |
| Collector-base breakdown voltage | $V_{(BR)CBO}$ | −100 | – | – | −120 | – | – | V | $I_C = -100\mu A$ |
| Collector-emitter breakdown voltage | $V_{(BR)CEO}$ | −80 | – | – | −100 | – | – | V | $I_C = -10mA$ |
| Emitter-base breakdown voltage | $V_{(BR)EBO}$ | −5 | – | – | −5 | – | – | V | $I_E = -100\mu A$ |
| Collector cut-off current | $I_{CBO}$ | – | – | −0.1 | – | – | – | μA | $V_{CB} = -80V$ |
| | | – | – | −10 | – | – | – | μA | $V_{CB} = -80V$, $T_{amb} = 100°C$ |
| | | – | – | – | – | – | −0.1 | μA | $V_{CB} = -100V$ |
| | | – | – | – | – | – | −10 | μA | $V_{CB} = -100V$, $T_{amb} = 100°C$ |
| Emitter cut-off current | $I_{EBO}$ | – | – | −0.1 | – | – | −0.1 | μA | $V_{EB} = -4V$ |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | – | 0.17 | −0.3 | – | 0.17 | −0.3 | V | $I_C = -1A$, $I_B = -100mA$* |
| | | – | 0.30 | −0.5 | – | 0.30 | −0.5 | V | $I_C = -2A$, $I_B = -200mA$* |
| Base-emitter saturation voltage | $V_{BE(sat)}$ | – | −0.90 | −1.25 | – | −0.90 | −1.25 | V | $I_C = -1A$, $I_B = -100mA$* |
| Base-emitter turn-on voltage | $V_{BE(on)}$ | – | −0.8 | −1.0 | – | −0.8 | −1.0 | V | $I_C = -1A$, $V_{CE} = -2V$* |
| Static forward current transfer ratio | $h_{FE}$ | 70 | 200 | – | 70 | 200 | – | | $I_C = -50mA$, $V_{CE} = -2V$* |
| | | 100 | 200 | 300 | 100 | 200 | 300 | | $I_C = -500mA$, $V_{CE} = -2V$* |
| | | 55 | 170 | – | 55 | 170 | – | | $I_C = -1A$, $V_{CE} = -2V$* |
| | | 25 | 55 | – | 25 | 55 | – | | $I_C = -2A$, $V_{CE} = -2V$* |
| Transition frequency | $f_T$ | 100 | 140 | – | 100 | 140 | – | MHz | $I_C = -100mA$, $V_{CE} = -5V$<br>$f = 100MHz$ |
| Switching times | $T_{on}$<br>$T_{off}$ | –<br>– | 40<br>600 | –<br>– | –<br>– | 40<br>600 | –<br>– | ns<br>ns | $I_C = -500mA$, $I_{B_1} = -50mA$<br>$I_{B_2} = -50mA$, $V_{CC} = -10V$ |
| Output capacitance | $C_{obo}$ | – | – | 30 | – | – | 30 | pF | $V_{CB} = -10V$, $f = 1MHz$ |

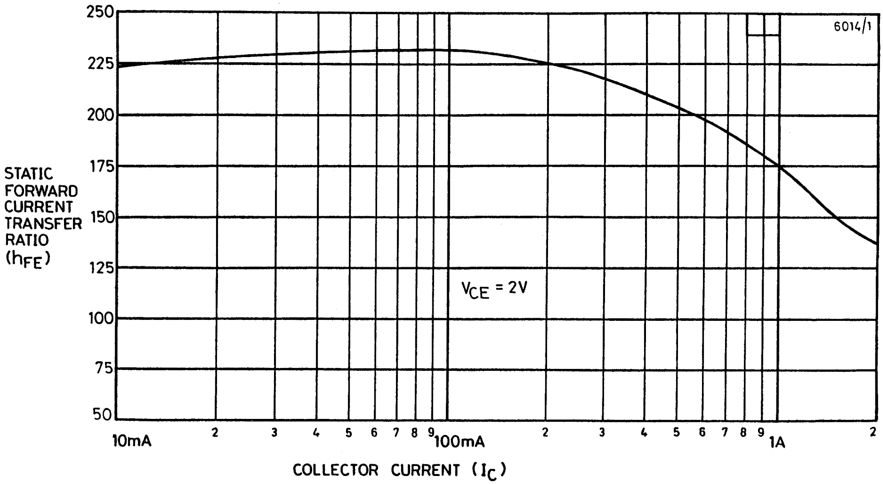
*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ⩽ 2%.



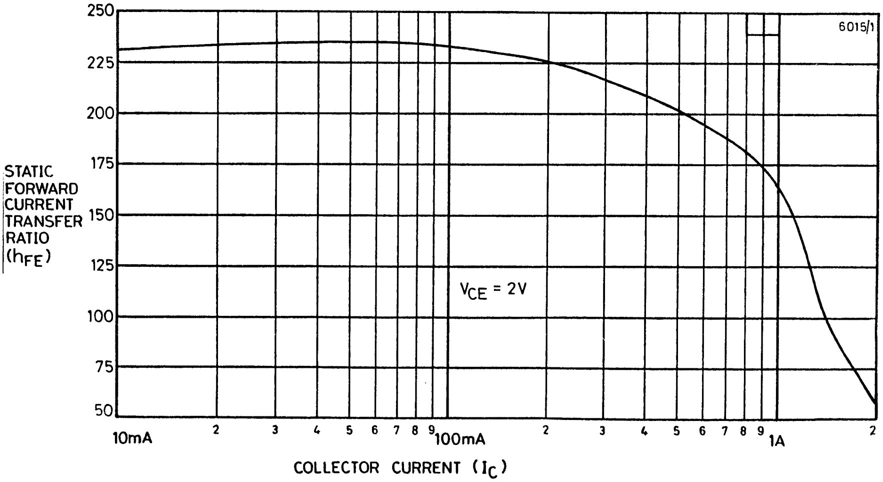
Dissipation derating curve for all types



Safe operating area at $T_{amb} = 25°C$
(single pulse)

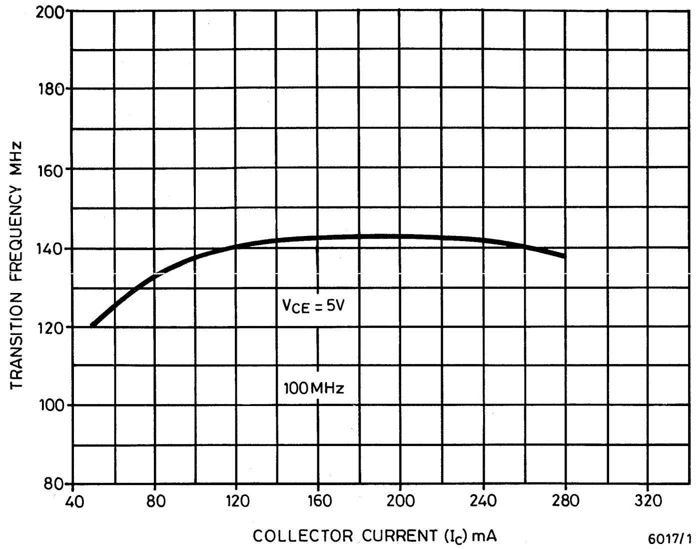


Static forward current transfer ratio
plotted against collector current for ZTX750/ZTX751

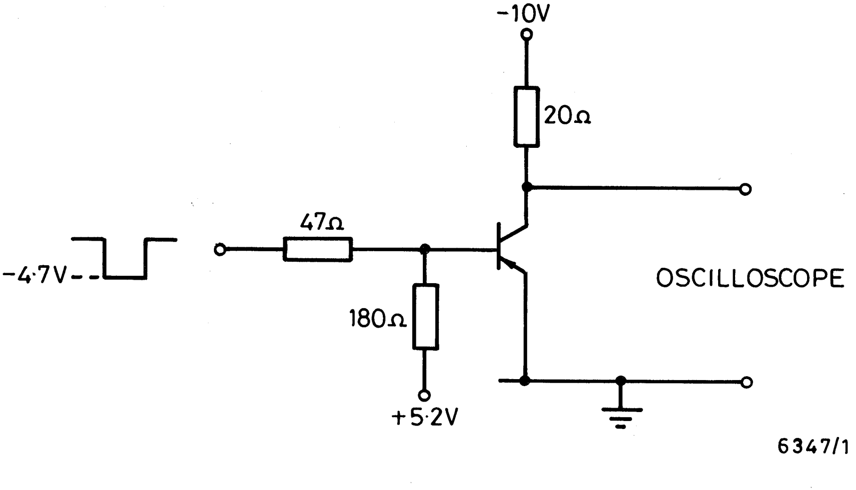


Static forward current transfer ratio
plotted against collector current for ZTX752/ZTX753

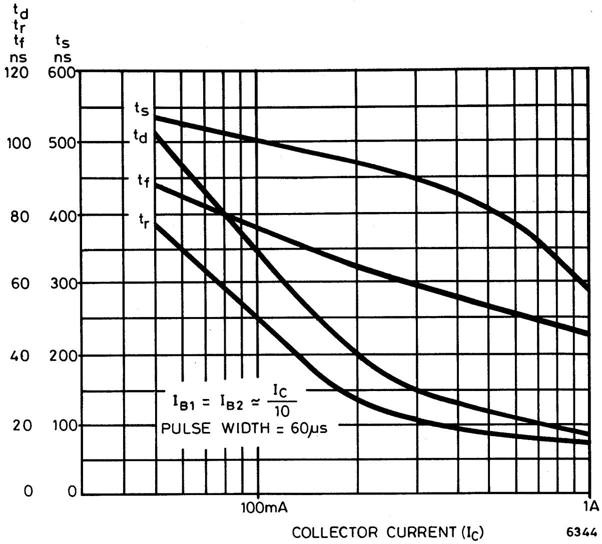
Typical characteristics



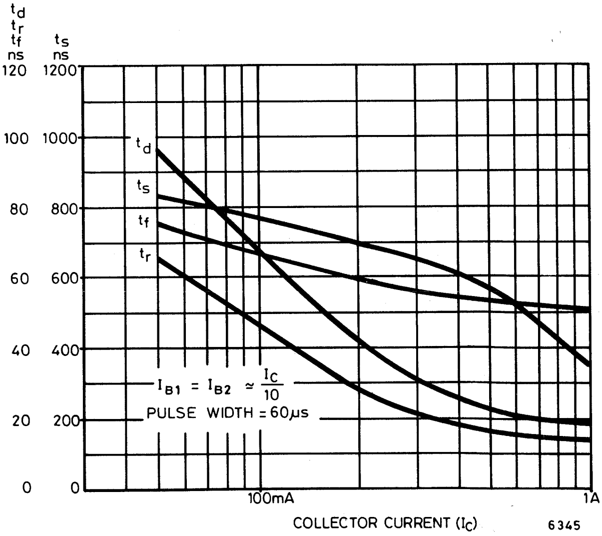
**Typical transition frequency plotted against collector current for ZTX750**



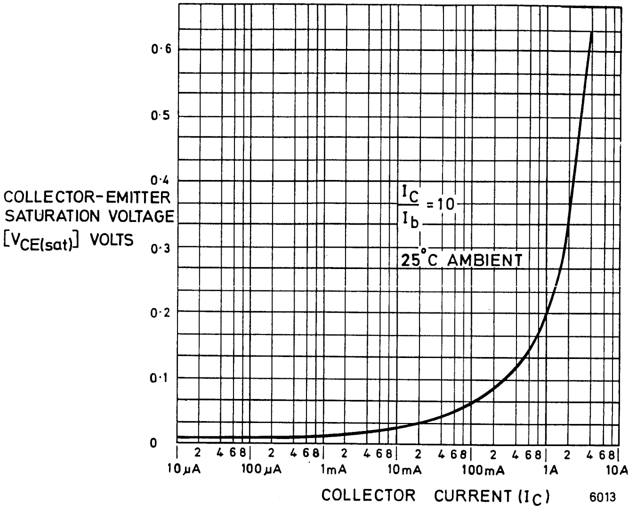
**Switching speeds test circuit**



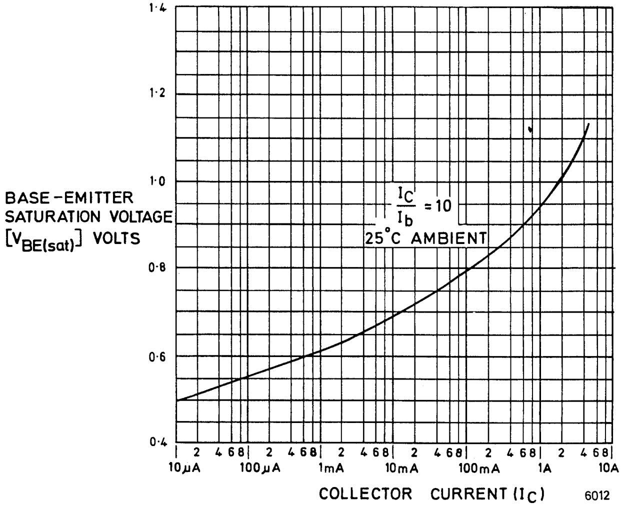
Typical switching speeds (ZTX750/ZTX751)



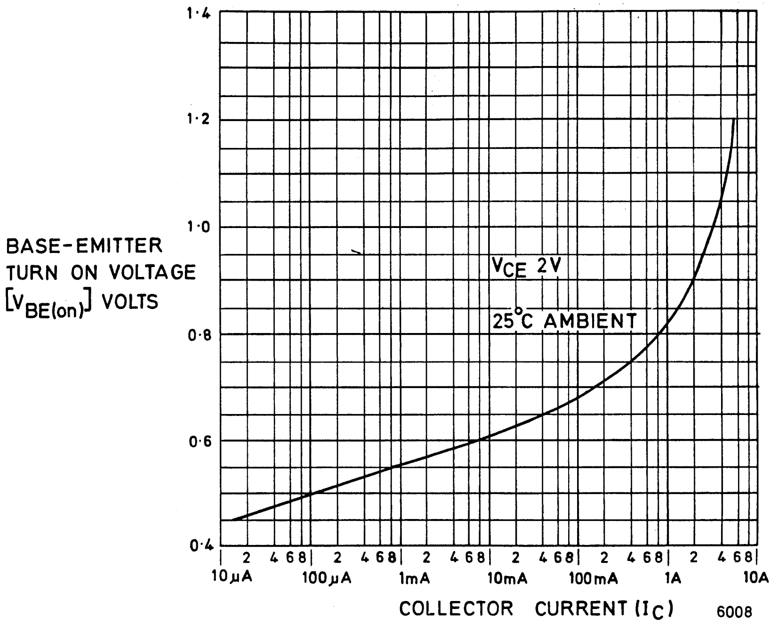
Typical switching speeds (ZTX752/ZTX753)



**Typical collector-emitter saturation voltages plotted against collector current for all types**

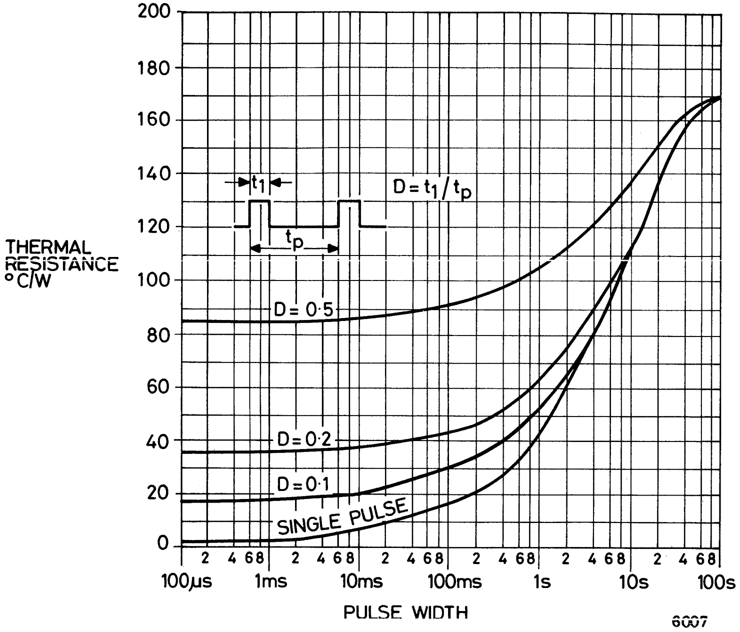


**Typical base-emitter saturation voltages plotted against collector current for all types**



Typical base-emitter turn-on voltages plotted against collector current for all types

# ZTX750 ZTX751 ZTX752 ZTX753



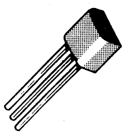
Maximum transient thermal impedance curves

# PNP Silicon Planar Medium Power High Voltage Transistors

# ZTX754
# ZTX755

## FEATURES

- 1.5W power dissipation at $T_{amb} = 25°C$*
- 1A continuous $I_C$
- Guaranteed $h_{FE}$ specified up to 1A
- Voltages up to 150V
- Low saturation voltages
- Complementary types



Plastic E-Line
(TO-92 Compatible)

## DESCRIPTION

These plastic encapsulated, medium power transistors are designed for applications requiring high breakdown voltages and low saturation voltages.

The E-line package is formed by transfer moulding a silicone plastic specially selected to provide a rugged one-piece encapsulation resistant to severe environments and allow the high junction temperature operation normally associated with metal can devices.

E-line encapsulated devices are approved for use in military, industrial and professional equipments.

Alternative lead configurations are available as plug-in replacements of TO-5/39 and TO-18 metal can types, and for surface mounting. Also available on tape for automatic handling.

Complementary to ZTX654 and ZTX655.

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | ZTX754 | ZTX755 | Unit |
|---|---|---|---|---|
| Collector-base voltage | $V_{CBO}$ | −125 | −150 | V |
| Collector-emitter voltage | $V_{CEO}$ | −125 | −150 | V |
| Emitter-base voltage | $V_{EBO}$ | −5 | | V |
| Peak collector current (see note below) | $I_{CM}$ | −2 | | A |
| Continuous collector current | $I_C$ | −1 | | A |
| Practical power dissipation* | $P_{totP}$ | 1.5 | | W |
| Power dissipation : at $T_{amb} = 25°C$<br>derate above 25°C | $P_{tot}$ | 1<br>5.7 | | W<br>mW/°C |
| Operating and storage temperature range | $t_j : t_{stg}$ | −55 to +200 | | °C |

Note: Consult Safe Operating Area graph for conditions.

*The power which can be dissipated assuming device mounted in typical manner on P.C.B. with copper equal to 1 sq.inch minimum.

# ZTX754 ZTX755

CHARACTERISTICS (at $T_{amb}=25°C$ unless otherwise stated).

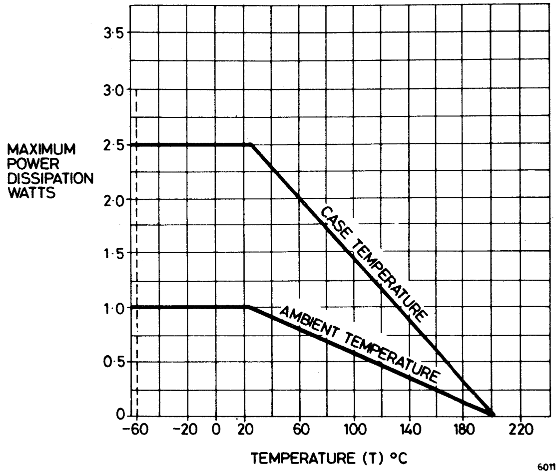
| Parameter | Symbol | ZTX754 |  | ZTX755 |  | Unit | Conditions |
|---|---|---|---|---|---|---|---|
|  |  | Min. | Max. | Min. | Max. |  |  |
| Collector-base breakdown voltage | $V_{(BR)CBO}$ | $-125$ | – | $-150$ | – | V | $I_C=-100\mu A$ |
| Collector-emitter breakdown voltage | $V_{(BR)CEO}$ | $-125$ | – | $-150$ | – | V | $I_C=-10mA$ |
| Emitter-base breakdown voltage | $V_{(BR)EBO}$ | $-5$ | – | $-5$ | – | V | $I_E=-100\mu A$ |
| Collector cut-off current | $I_{CBO}$ | – | $-100$ | – | – | nA | $V_{CB}=-100V$ |
|  |  | – | – | – | $-100$ | nA | $V_{CB}=-125V$ |
| Emitter cut-off current | $I_{EBO}$ | – | $-100$ | – | $-100$ | nA | $V_{EB}=-3V$ |
| Collector-emitter saturation voltage | $V_{CE(SAT)}$ | – | $-0.5$ | – | $-0.5$ | V | $I_C=-500mA$, $I_B=-50mA$* |
|  |  | – | $-0.5$ | – | $-0.5$ | V | $I_C=-1A$, $I_B=-200mA$* |
| Base-emitter saturation voltage | $V_{BE(SAT)}$ | – | $-1.1$ | – | $-1.1$ | V | $I_C=-500mA$, $I_B=-50mA$* |
| Static forward current transfer ratio | $h_{FE}$ | 50 | – | 50 | – |  | $I_C=-10mA$, $V_{CE}=-5V$ |
|  |  | 50 | – | 50 | – |  | $I_C=-500mA$, $V_{CE}=-5V$* |
|  |  | 20 | – | 20 | – |  | $I_C=-1A$, $V_{CE}=-5V$* |
| Base-emitter turn on voltage | $V_{BE(ON)}$ | – | $-1$ | – | $-1$ | V | $I_C=-500mA$, $V_{CE}=-5V$* |
| Transition frequency | $f_T$ | 30 | – | 30 | – | MHz | $I_C=-10mA$, $V_{CE}=-20V$<br>$f=20MHz$ |
| Output capacitance | $C_{obo}$ | – | 20 | – | 20 | pF | $V_{CB}=-20V$, $f=1MHz$ |

*Measured under pulsed conditions. Pulse width $=300\mu s$. Duty cycle $\leqslant 2\%$.

### THERMAL CHARACTERISTICS

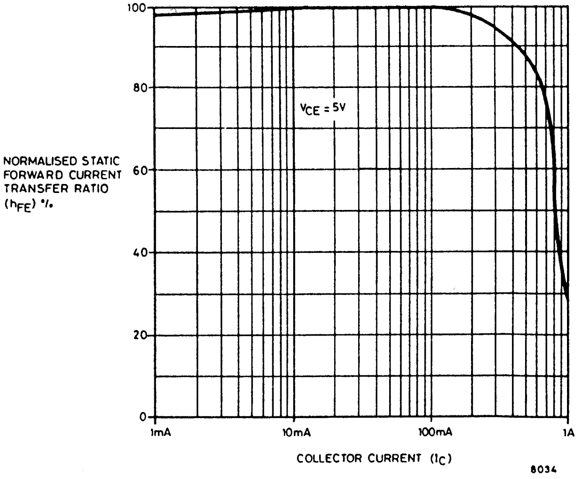
| Parameter |  | Symbol | Maximum | Unit |
|---|---|---|---|---|
| Thermal resistance: | Junction to ambient$_1$ | $R_{th(j\text{-}amb)1}$ | 175 | °C/W |
|  | Junction to ambient$_2$ | $R_{th(j\text{-}amb)2}$† | 116 | °C/W |
|  | Junction to case | $R_{th(j\text{-}case)}$ | 70 | °C/W |

†Device mounted on P.C.B. with copper equal to 1 sq.inch minimum.

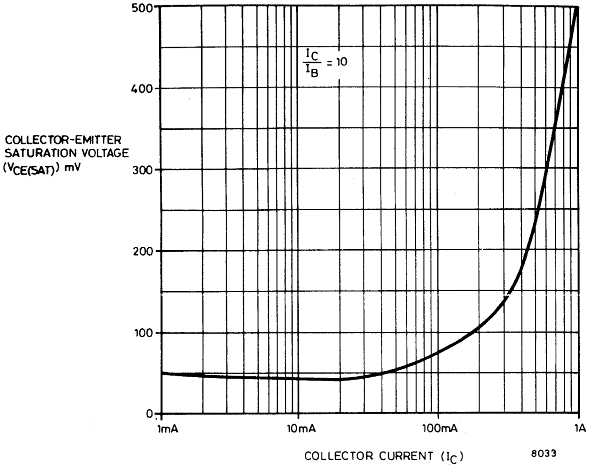


Dissipation derating curve

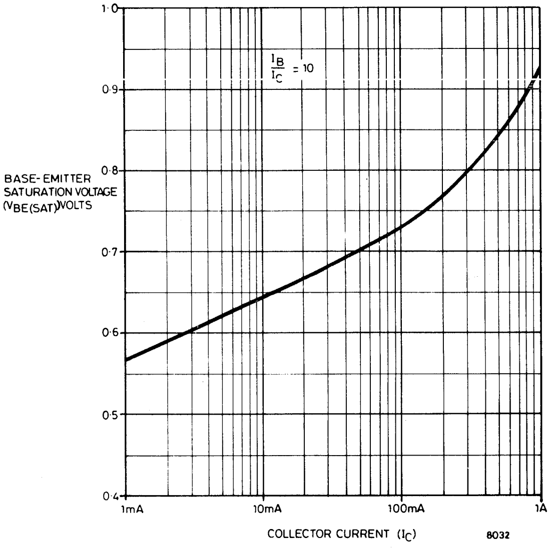
## Typical characteristics



Typical static forward current transfer ratio plotted against collector current

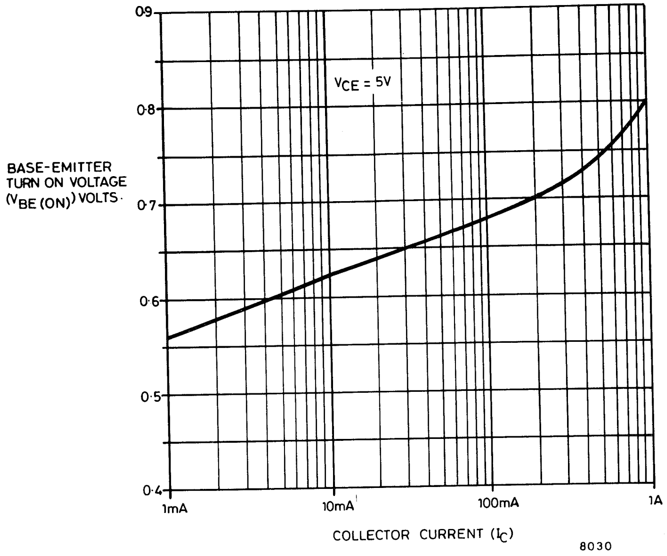


Typical collector-emitter saturation voltages plotted against collector current

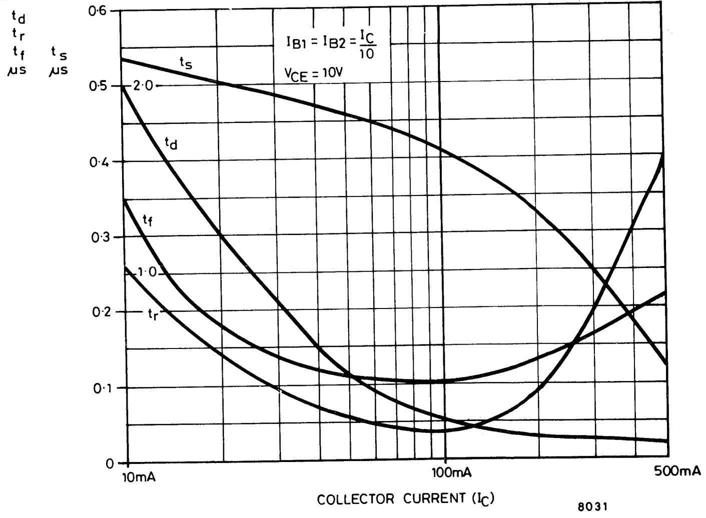


Typical base-emitter saturation voltages plotted against collector current

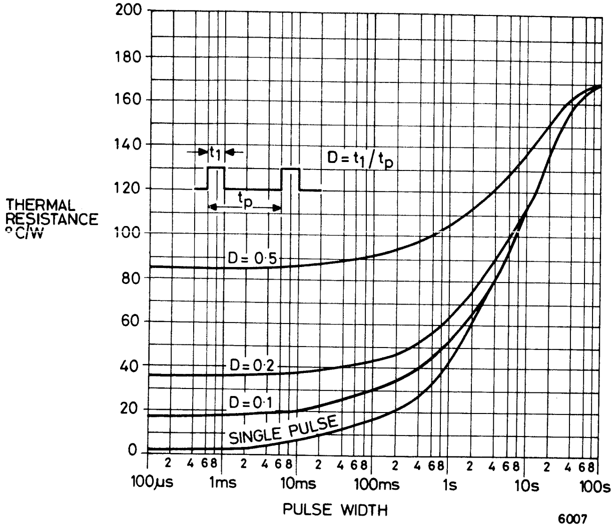
Typical characteristics



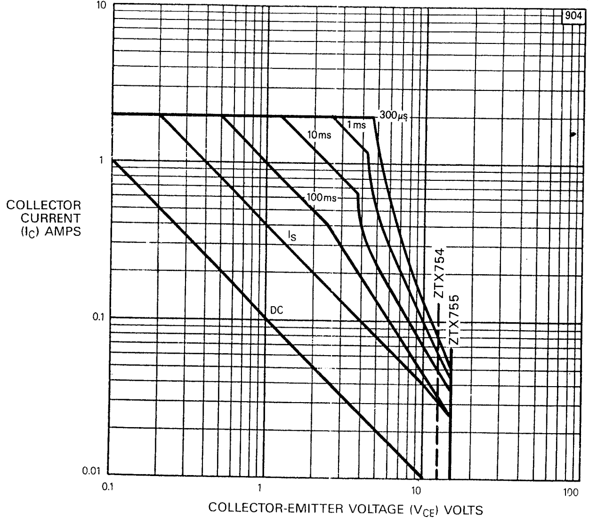
**Typical base-emitter turn on voltages plotted against collector current**



**Typical switching speeds**



Maximum transient thermal impedance curves



Safe operating area at $T_{amb} = 25°C$ (single pulse)

# PNP Silicon Planar Medium Power High Voltage Transistors

# ZTX756
# ZTX757

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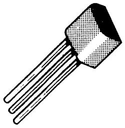
## FEATURES

- 1W power dissipation at $T_{amb} = 25°C$
- Excellent gain characteristics at $I_C = 100mA$
- Voltages up to 300V
- Low saturation voltages
- Complementary types

## DESCRIPTION

These plastic encapsulated, medium power transistors are designed for applications requiring high breakdown voltages and low saturation voltages.

The E-line package is formed by transfer moulding a silicone plastic specially selected to provide a rugged one-piece encapsulation resistant to severe environments and allow the high junction temperature operation normally associated with metal can devices.



Plastic E-Line
(TO-92 Compatible)

E-line encapsulated devices are approved for use in military, industrial and professional equipments.

Alternative lead configurations are available as plug-in replacements of TO-5/39 and TO-18 metal can types, and for surface mounting. Also available on tape for automatic handling.

Complementary to ZTX656 and ZTX657.

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | ZTX756 | ZTX757 | Unit |
|---|---|---|---|---|
| Collector-base voltage | $V_{CBO}$ | −200 | −300 | V |
| Collector-emitter voltage | $V_{CEO}$ | −200 | −300 | V |
| Emitter-base voltage | $V_{EBO}$ | −5 | | V |
| Peak collector current (see note below) | $I_{CM}$ | −1 | | A |
| Continuous collector current | $I_C$ | −0.5 | | A |
| Practical power dissipation* | $P_{totP}$ | 1.5 | | W |
| Power dissipation : at $T_{amb} = 25°C$<br>derate above 25°C | $P_{tot}$ | 1<br>5.7 | | W<br>mW/°C |
| Operating and storage temperature range | $t_j : t_{stg}$ | −55 to +200 | | °C |

Note: Consult Safe Operating Area graph for conditions.

*The power which can be dissipated assuming device mounted in typical manner on P.C.B. with copper equal to 1 sq.inch minimum.

# ZTX756 ZTX757

CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

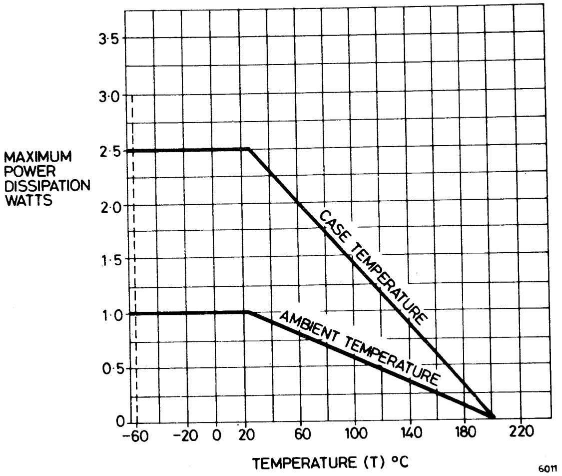
| Parameter | Symbol | ZTX756 | | ZTX757 | | Unit | Conditions |
|---|---|---|---|---|---|---|---|
| | | Min. | Max. | Min. | Max. | | |
| Collector-base breakdown voltage | $V_{(BR)CBO}$ | –200 | – | –300 | – | V | $I_C = -100\mu A$ |
| Collector-emitter breakdown voltage | $V_{(BR)CEO}$ | –200 | – | –300 | – | V | $I_C = -10mA$ |
| Emitter-base breakdown voltage | $V_{(BR)EBO}$ | –5 | – | –5 | – | V | $I_E = -100\mu A$ |
| Collector cut-off current | $I_{CBO}$ | – | –100 | – | – | nA | $V_{CB} = -160V$ |
| | | – | – | – | –100 | nA | $V_{CB} = -200V$ |
| Emitter cut-off current | $I_{EBO}$ | – | –100 | – | –100 | nA | $V_{EB} = -3V$ |
| Collector-emitter saturation voltage | $V_{CE(SAT)}$ | – | –0.5 | – | –0.5 | V | $I_C = -100mA$, $I_B = -10mA$* |
| Base-emitter saturation voltage | $V_{BE(SAT)}$ | – | –1 | – | –1 | V | $I_C = -100mA$, $I_B = -10mA$* |
| Static forward current transfer ratio | $h_{FE}$ | 50 | – | 50 | – | | $I_C = -100mA$, $V_{CE} = 5V$* |
| | | 40 | – | 40 | – | | $I_C = -10mA$, $V_{CE} = -5V$ |
| Base-emitter turn on voltage | $V_{BE(ON)}$ | – | 1 | – | –1 | V | $I_C = -100mA$, $V_{CE} = -5V$* |
| Transition frequency | $f_T$ | 30 | – | 30 | – | MHz | $I_C = -10mA$, $V_{CE} = -20V$<br>$f = 20MHz$ |
| Output capacitance | $C_{obo}$ | – | 20 | – | 20 | pF | $V_{CB} = -20V$, $f = 1MHz$ |

*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ⩽2%.

## THERMAL CHARACTERISTICS

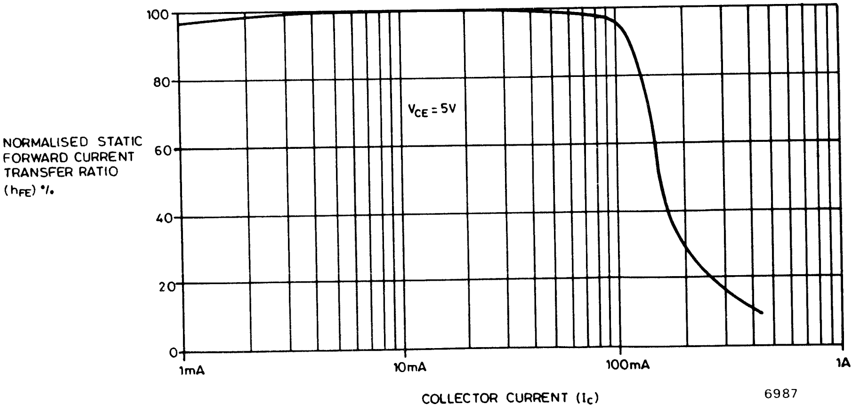
| Parameter | | Symbol | Maximum | Unit |
|---|---|---|---|---|
| Thermal resistance: | Junction to ambient$_1$ | $R_{th(j\text{-}amb)1}$ | 175 | °C/W |
| | Junction to ambient$_2$ | $R_{th(j\text{-}amb)2}$† | 116 | °C/W |
| | Junction to case | $R_{th(j\text{-}case)}$ | 70 | °C/W |

†Device mounted on P.C.B. with copper equal to 1 sq.inch minimum.



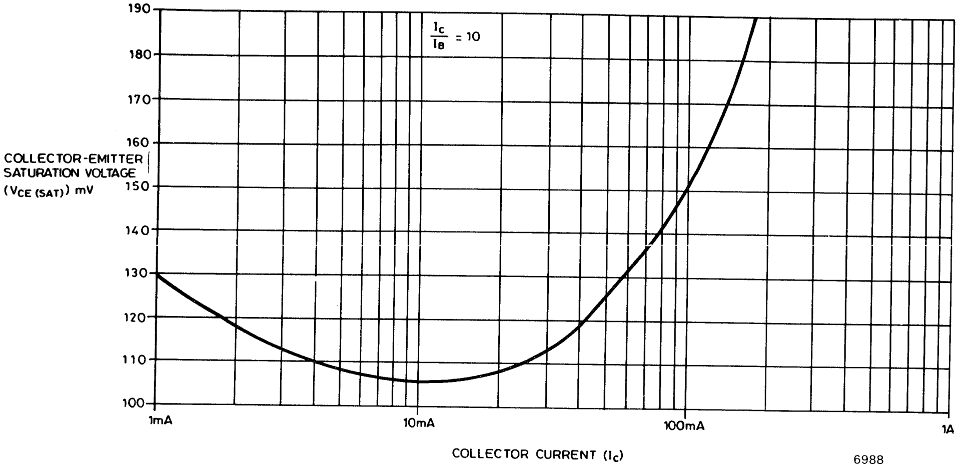
Dissipation derating curve for all types

## Typical characteristics

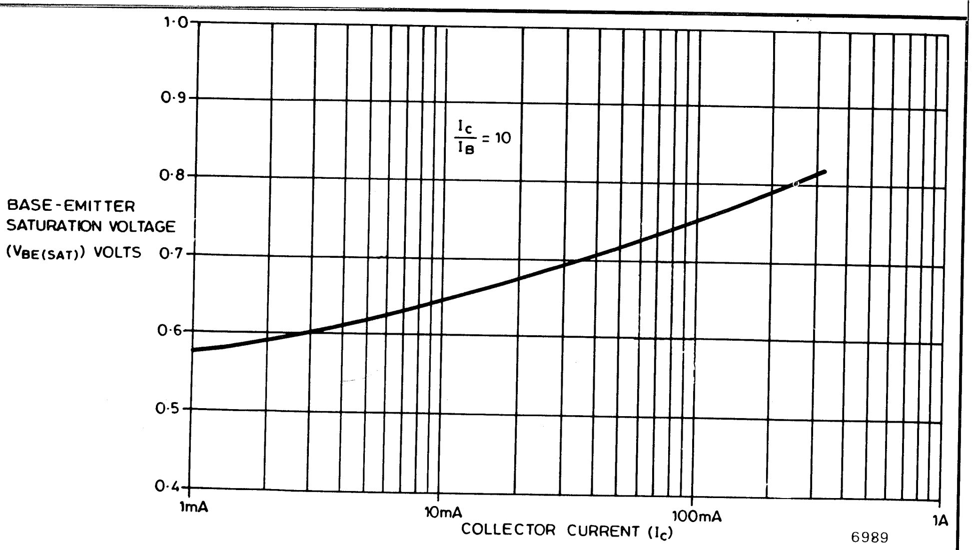


$h_{FE}/I_C$

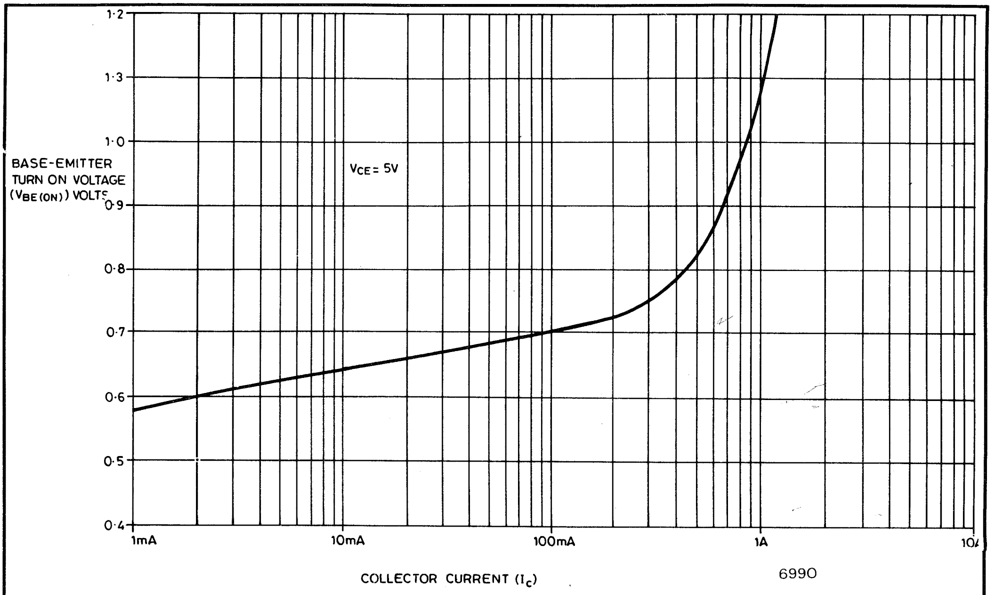
Typical static forward current transfer ratio
plotted against collector current



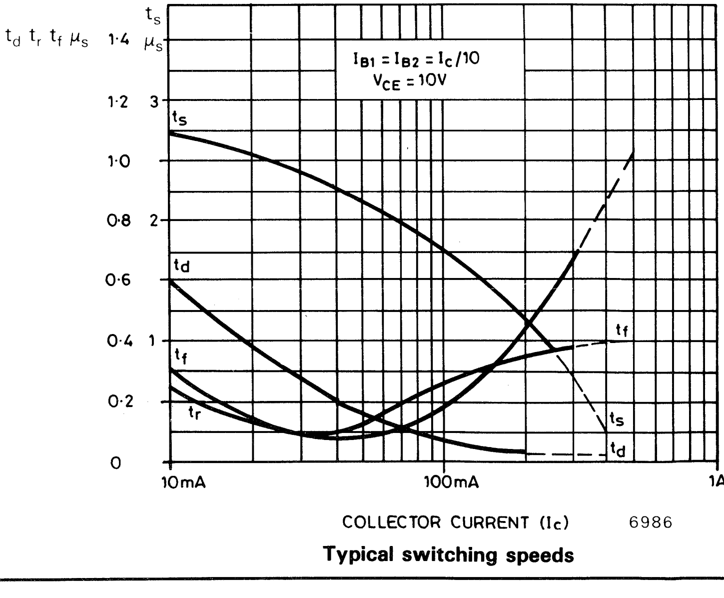
**Typical collector-emitter saturation voltages plotted against collector current**



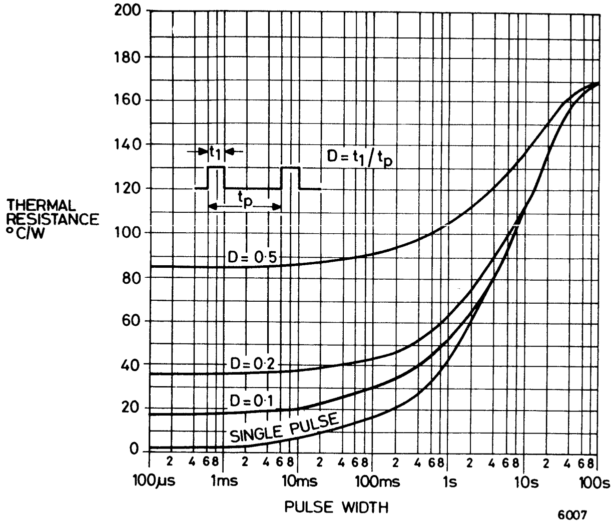
**Typical base-emitter saturation voltages plotted against collector current**



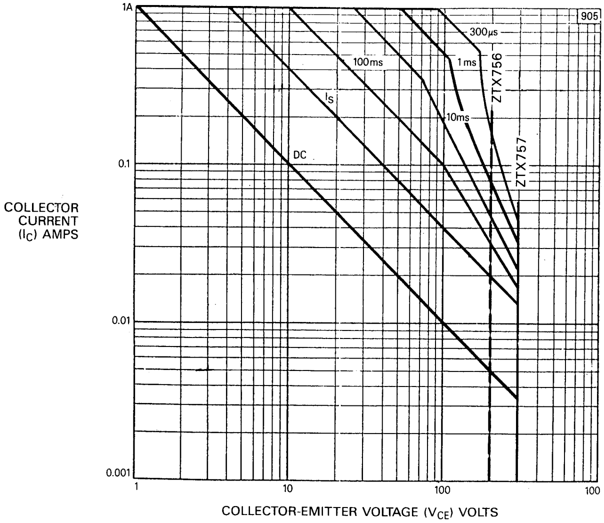
Typical base-emitter turn on voltages plotted against collector current



Typical switching speeds



**Maximum transient thermal impedance curves**



**Safe operating area at $T_{amb}$ = 25°C (single pulse)**

# PNP Silicon Planar Medium Power High Voltage Transistor

# ZTX776

---

## FEATURES

- 1.5W power dissipation at $T_{amb} = 25°C$*
- 1A continuous $I_C$
- Guaranteed $h_{FE}$ specified up to 1A
- 200V $V_{CEO}$
- Low saturation voltage

## DESCRIPTION

This plastic encapsulated medium power transistor is designed for applications requiring high breakdwon voltages and low saturation voltages.

This E-line package is formed by transfer moulding a Silicone plastic specially selected to provide a rugged one-piece encapsulation resistant to severe environments and allow the high junction temperature operation normally associated with metal can devices.

E-line encapsulated devices are approved for use in military, industrial and professional equipments.

Alternative lead configurations are available as plug-in replacements of TO-5/39 and TO-18 metal can types, and for flat surface mounting. Also available on tape for automatic handling.

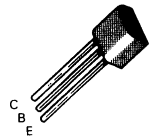


Fig. 1. Plastic E-Line (TO-92 Compatible)

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | Value | Unit |
|---|---|---|---|
| Collector-Base Voltage | $V_{CBO}$ | −200 | V |
| Collector-Emitter Voltage | $V_{CEO}$ | −200 | V |
| Emitter-Base Voltage | $V_{EBO}$ | −5 | V |
| Peak Pulse Collector Current (see note below) | $I_{CM}$ | −2 | A |
| Continuous Collector Current | $I_C$ | −1 | A |
| Practical Power Dissipation* | $P_{totp}$ | 1.5 | W |
| Power Dissipation at $T_{amb} = 25°C$<br>Derate above 25°C | $P_{tot}$ | 1.0<br>5.7 | W<br>mW/°C |
| Operating and Storage Temperature Range | | −55 to +200 | °C |

Note: Consult Safe Operating Area graph for conditions.

*The power which can be dissipated assuming the device mounted in typical manner on P.C.B. with copper equal to 1 sq. inch minimum.

# ZTX776

ELECTRICAL CHARACTERISTICS (at $T_{amb} = 25°C$, unless otherwise stated).

| Parameter | Symbol | Min. | Max. | Unit | Test Conditions |
|---|---|---|---|---|---|
| Collector-base breakdown voltage | $V_{(BR)CBO}$ | −200 | — | V | $I_C = -100\mu A$ |
| Collector-emitter breakdown voltage | $V_{(BR)CEO}$ | −200 | — | V | $I_C = -10mA$ |
| Emitter-base breakdown voltage | $V_{(BR)EBO}$ | −5 | — | V | $I_E = -100\mu A$ |
| Collector cut-off current | $I_{CBO}$ | — | −100 | nA | $V_{CB} = -160V$ |
| Emitter cut-off current | $I_{EBO}$ | — | −100 | nA | $V_{EB} = -4V$ |
| Collector-emitter saturation voltage | $V_{CE(sat)}$ | —<br>— | −0.5<br>−0.5 | V<br>V | $I_C = -500mA$,* $I_B = -50mA$<br>$I_B = -1A$,* $I_B = -200mA$ |
| Base-emitter saturation voltage | $V_{BE(sat)}$ | — | −1.1 | V | $I_C = -500mA$,* $I_B = -50mA$ |
| Static forward current transfer ratio | $h_{FE}$ | 50<br>50<br>20 | —<br>—<br>— | | $I_C = -10mA$, $V_{CE} = -5V$<br>$I_C = -500mA$,* $V_{CE} = -5V$<br>$I_C = -1A$,* $V_{CE} = -5V$ |
| Base-emitter turn-on voltage | $V_{BE(on)}$ | — | −1.0 | V | $I_C = -500mA$,* $V_{CE} = -5V$ |
| Transition frequency | $f_T$ | 30 | — | MHz | $I_C = -10mA$, $V_{CE} = -20V$<br>$f = 20MHz$ |
| Output capacitance | $C_{obo}$ | — | 20 | pF | $V_{CB} = -20V$, $f = 1MHz$ |

*Measured under pulsed conditions. Pulse width $= 300\mu s$. Duty cycle $\leqslant 2\%$.

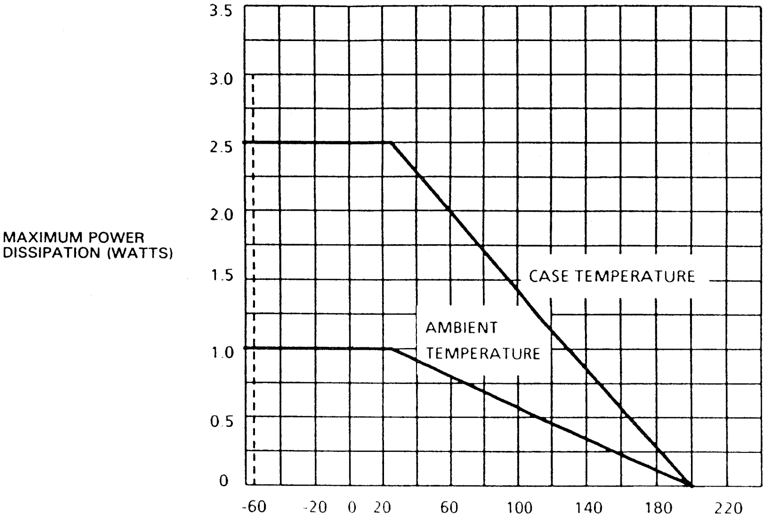
THERMAL CHARACTERISTICS

| Characteristic | Symbol | Max. Value | Unit |
|---|---|---|---|
| Thermal Resistance: Junction to Ambient$_1$ | $R_{th(j\text{-}amb)1}$ | 175 | °C/W |
| Junction to Ambient $_2$ | $R_{th(j\text{-}amb)2}$† | 116 | °C/W |
| Junction to Case | $R_{th(j\text{-}case)}$ | 70 | °C/W |

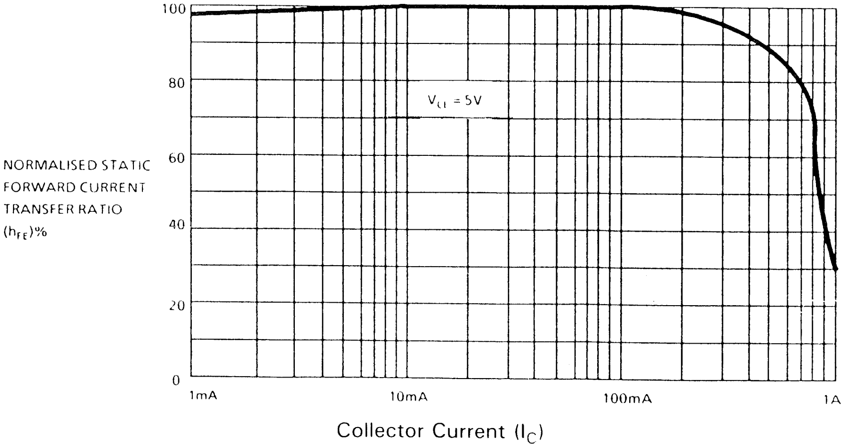
† Device mounted on P.C.B. with copper equal to 1 sq. inch minimum.

**Note:** Practical Power Dissipation. Where space does not permit 1 sq. inch copper the device fitted with a readily available heat clip will offer the following:

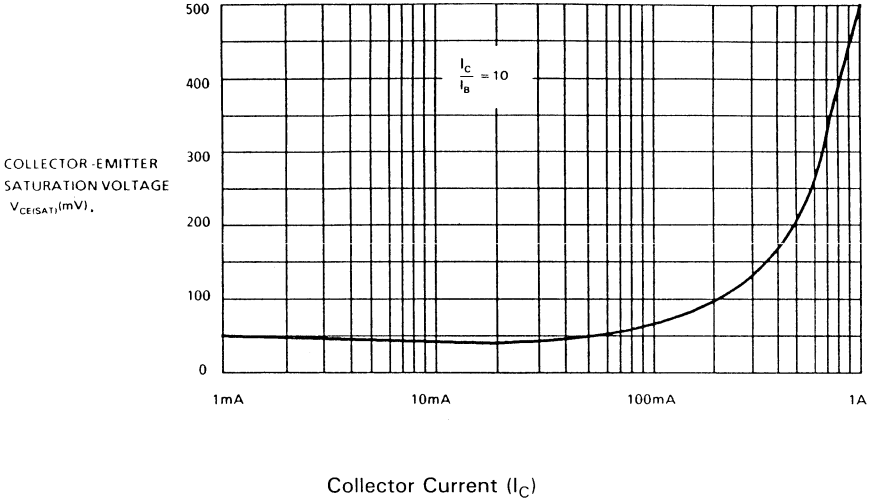
| | |
|---|---|
| Power Dissipation at $T_{amb} = 25°C$ ($P_{tot}$) | 1.4W |
| Derate above 25°C | 8.0mW/°C |
| Thermal Resistance, Junction to Ambient | 125°C/W |



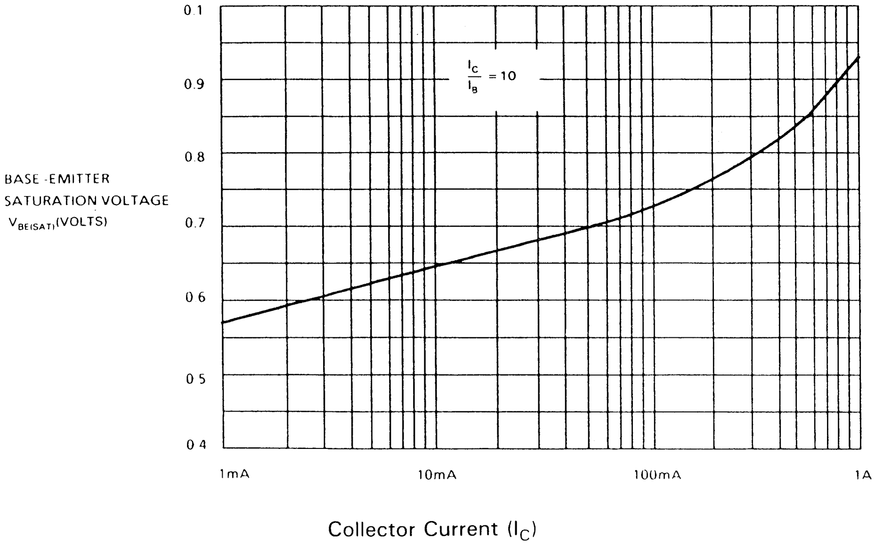
**Dissipation derating curve**



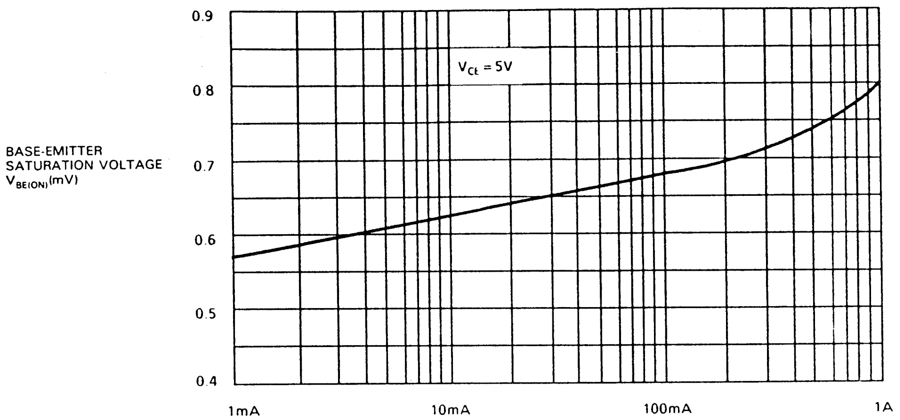
**Typical static forward current transfer ratio plotted against collector current**



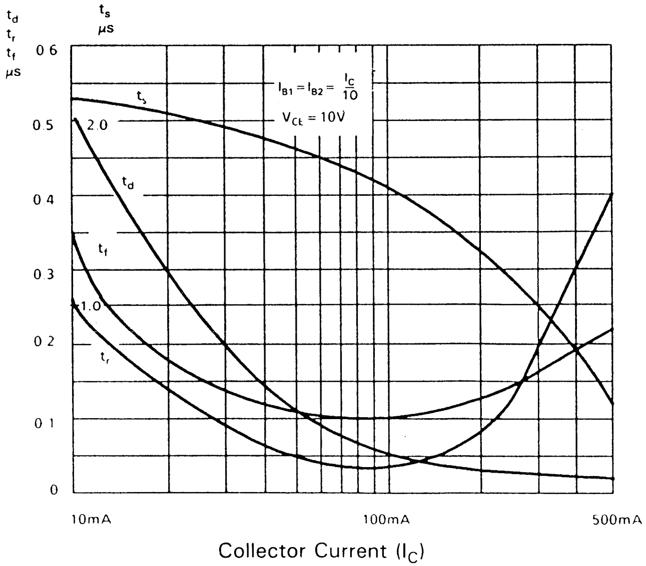
**Typical collector-emitter saturation voltages plotted against collector current**



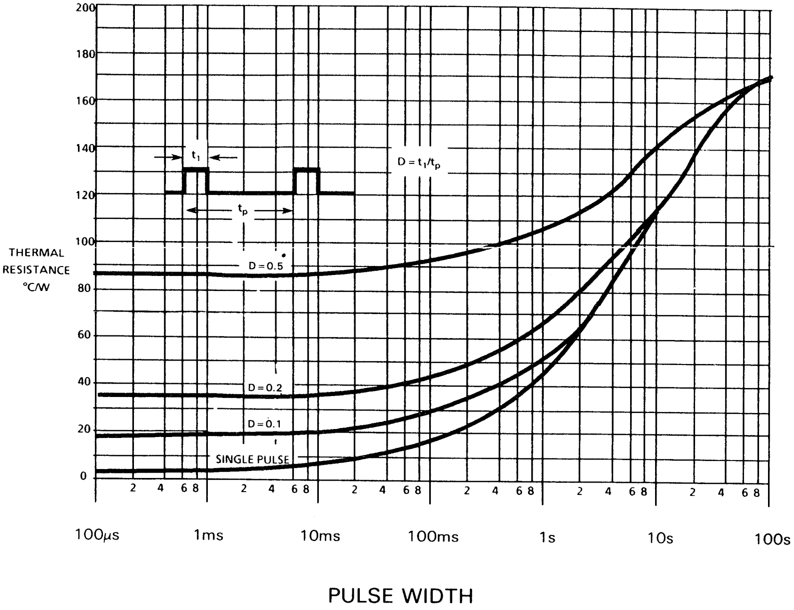
**Typical base-emitter saturation voltages plotted against collector current**



**Typical base-emitter turn-on voltages plotted against collector current**



**Typical switching speeds**



**Maximum transient thermal impedance curves**

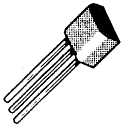
# Silicon Planar Medium Power Transistors

# NPN 2N6714 2N6715
# PNP 2N6726 2N6727

---

## FEATURES

- Exceptional power dissipation capability
  - 2W @ $T_{CASE} = 25°C$
  - 1W @ $T_{amb} = 25°C$
- $h_{FE}$ specified up to 1A
- Low saturation volatages



Plastic E-Line
(TO-92 Compatible)

## DESCRIPTION

A range of high performance transistors encapsulated in the popular E-line (To-92 style) plastic package. The outstanding electrical characteristics permit use in a wide range of applications including audio output & drivers, general purpose switching & lamp drive in industrial & automotive circuits.

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | 2N6714<br>2N6726 | 2N6715<br>2N6727 | Unit |
|---|---|---|---|---|
| Collector-base voltage | $V_{CBO}$ | 40 | 50 | V |
| Collector-emitter voltage | $V_{CEO}$ | 30 | 40 | V |
| Emitter-base voltage | $V_{EBO}$ | 5 | | V |
| Peak pulse current* | $I_{CM}$ | 2 | | A |
| Continuous collector current | $I_C$ | 1 | | A |
| Power dissipation at $T_{amb} = 25°C$<br>at $T_{CASE} = 25°C$ | $P_{tot}$ | 1<br>2 | | W<br>W |
| Operating & storage temp range | | −55 to +200 | | °C |

*Pulse width = 300μs. Duty cycle ⩽2%

# NPN 2N6714 2N6715 PNP 2N6726 2N6727

CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

| Parameter | Symbol | 2N26714,26 | | 2N6715,27 | | Unit | Conditions |
|---|---|---|---|---|---|---|---|
| | | Min. | Max. | Min. | Max. | | |
| Collector-base breakdown voltage | $V_{(BR)CBO}$ | 40 | | 50 | | V | $I_C = 1mA$ |
| Collector-emitter breakdown voltage | $V_{(BR)CEO}$ | 30 | | 40 | | V | $I_C = 10mA$ |
| Emitter-base breakdown voltage | $V_{(BR)EBO}$ | 5 | | 5 | | V | $I_E = 1mA$ |
| Collector cut-off current | $I_{CBO}$ | | 0.1 | | 0.1 | μA<br>μA | $V_{CB} = 40V$<br>$V_{CB} = 50V$ |
| Emitter cut-off current | $I_{EBO}$ | | 0.1 | | 0.1 | μA | $V_{EB} = 5V$ |
| Collector-emitter Saturation voltage | $V_{CE(Sat)}$ | | 0.5 | | 0.5 | V | $I_C = 1A$<br>$I_B = 100mA$ |
| Base emitter turn-on voltage | $V_{BE(on)}$ | | 1.2 | | 1.2 | V | $I_C = 1A$<br>$V_{CE} = 1V$ |
| Static forward current transfer ratio | $h_{FE}$ | 55<br>60<br>50 | <br><br>250 | 55<br>60<br>50 | <br><br>250 | | $\left.\begin{array}{l}I_C = 10mA\\ I_C = 100mA\\ I_C = 1A\end{array}\right\} V_{CE} = 1V$ |
| Collector-base capacitance | $C_{CB}$ | | 30 | | 30 | pF | $V_{CE} = 10V$<br>f = 1MHz |
| Transiton frequency | $f_T$ | 50 | 500 | 50 | 500 | MHz | $V_{CE} = 10V$<br>$I_C = 50mA$ |

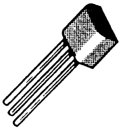
# Silicon Planar Medium Power Transistors

**NPN 2N6716 2N6717 2N6718**
**PNP 2N6728 2N6729 2N6730**

---

## FEATURES

- High $V_{CE}$ ratings up to 100 volts
- Exceptional power dissipation capability
  - 2W @ $T_{CASE} = 25°C$
  - 1W @ $T_{amb} = 25°C$
- $h_{FE}$ specified up to 500mA



Plastic E-Line
(TO-92 Compatible)

## DESCRIPTION

A range of high performance transistors encapsulated in the popular E-line (TO-92 style) plastic package. The specially selected SILICONE encapsulation provides resistance to severe environments comparable to metal can devices.

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | 2N6716<br>2N6728 | 2N6717<br>2N6729 | 2N6718<br>2N6730 | Unit |
|---|---|---|---|---|---|
| Collector-base voltage | $V_{CBO}$ | 60 | 80 | 100 | V |
| Collector-emitter voltage | $V_{CEO}$ | 60 | 80 | 100 | V |
| Emitter-base voltage | $V_{EBO}$ | 5 | | | V |
| Peak pulse current* | $I_{CM}$ | 2 | | | A |
| Continuous collector current | $I_C$ | 1 | | | A |
| Power dissipation at $T_{amb} = 25°C$<br>at $T_{CASE} = 25°C$ | $P_{tot}$ | 1<br>2 | | | W<br>W |
| Operating & storage temp range | | −55 to +200 | | | °C |

*Pulse width = 300µs. Duty cycle ⩽2%

# NPN 2N6716 2N6717 2N6718 PNP 2N6728 2N6729 2N6730

CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

| Parameter | Symbol | 2N26716,28 | | 2N6717,29 | | 2N6718,30 | | Unit | Conditions |
|---|---|---|---|---|---|---|---|---|---|
| | | Min. | Max. | Min. | Max. | Min. | Max. | | |
| Collector-base breakdown voltage | $V_{(BR)CBO}$ | 60 | | 80 | | 100 | | V | $I_C = 0.1mA$ |
| Collector-emitter breakdown voltage | $V_{(BR)CEO}$ | 60 | | 80 | | 100 | | V | $I_C = 1mA$ |
| Emitter-base breakdown voltage | $V_{(BR)EBO}$ | 5 | | 5 | | 5 | | V | $I_E = 1mA$ |
| Collector cut-off current | $I_{CBO}$ | | 1 | | | | | μA | $V_{CB} = 60V$ |
| | | | | | 1 | | | μA | $V_{CB} = 80V$ |
| | | | | | | | 1 | μA | $V_{CB} = 100V$ |
| Emitter cut-off current | $I_{EBO}$ | | 1 | | 1 | | 1 | μA | $V_{EB} = 5V$ |
| Collector-emitter Saturation voltage | $V_{CE(Sat)}$ | | 0.5 | | 0.5 | | 0.5 | V | $I_C = 250mA$<br>$I_B = 10mA$ |
| | | | 0.35 | | 0.35 | | 0.35 | V | $I_C = 250mA$<br>$I_B = 25mA$ |
| Base-emitter turn-on voltage | $V_{BE(on)}$ | | 1.2 | | 1.2 | | 1.2 | V | $I_C = 250mA$<br>$V_{CE} = 1V$ |
| Static forward Current transfer ratio | $h_{FE}$ | 80 | | 80 | | 80 | | | $I_C = 50mA$ |
| | | 50 | 250 | 50 | 250 | 50 | 250 | | $I_C = 250mA$ $V_{CE} = 1V$ |
| | | 20 | | 20 | | 20 | | | $I_C = 500mA$ |
| Collector-base capacitance | $C_{CB}$ | | 30 | | 30 | | 30 | pF | $V_{CE} = 10V$<br>$f = 1MHz$ |
| Transition frequency | $f_T$ | 50 | 500 | 50 | 500 | 50 | 500 | MHz | $V_{CE} = 10V$<br>$I_C = 50mA$ |

# Silicon Planar Medium Power Transistors

# NPN 2N6724 2N6725

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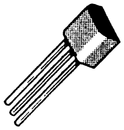
## FEATURES

- High gain
  - 25000 @ 200mA
  - 4000 @ 1A
- 1 Amp current capability
- Low saturation voltages



Plastic E-Line
(TO-92 Compatible)

## DESCRIPTION

A monolithic double diffused planar power Darlington encapsulated in the popular E-line (To-92 style) plastic package. The specially selected SILICONE encapsulation provides resistance to severe environments comparable to metal can devices.

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | 2N6724 | 2N6725 | Unit |
|---|---|---|---|---|
| Collector-base voltage | $V_{CBO}$ | 50 | 60 | V |
| Collector-emitter voltage | $V_{CEO}$ | 40 | 50 | V |
| Emitter-base voltage | $V_{EBO}$ | 10 | | V |
| Peak pulse current* | $I_{CM}$ | 2 | | A |
| Continuous collector current | $I_C$ | 1 | | A |
| Power dissipation at $T_{amb}$ = 25°C<br>at $T_{CASE}$ = 25°C | $P_{tot}$ | 2<br>1 | | W<br>W |
| Operating & storage temp range | | −55 to +200 | | °C |

*Pulse width = 300$\mu$s. Duty cycle ⩽2%

# NPN 2N6724 2N6725

CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

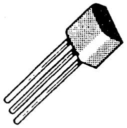
| Parameter | Symbol | 2N26724 | | 2N6725 | | Unit | Conditions |
|---|---|---|---|---|---|---|---|
| | | Min. | Max. | Min. | Max. | | |
| Collector-base breakdown voltage | $V_{(BR)CBO}$ | 50 | | 60 | | V | $I_C = 1\mu A$ |
| Collector-emitter breakdown voltage | $V_{(BR)CEO}$ | 40 | | 50 | | V | $I_C = 1mA$ |
| Emitter-base breakdown voltage | $V_{(BR)EBO}$ | 10 | | 10 | | V | $I_E = 10\mu A$ |
| Collector cut-off current | $I_{CBO}$ | | 1.0 | | | μA | $V_{CB} = 30V$ |
| | | | | | 1.0 | μA | $V_{CB} = 40V$ |
| Emitter cut-off current | $I_{EBO}$ | | 0.1 | | 0.1 | μA | $V_{EB} = 8V$ |
| Collector-emitter Saturation voltage | $V_{CE(Sat)}$ | | 1.0 | | 1.0 | V | $I_C = 200mA$<br>$I_B = 2mA$ |
| | | | 1.5 | | 1.5 | V | $I_C = 1A$, $I_B = 2mA$ |
| Base emitter saturation voltage | $V_{BE(Sat)}$ | | 2.0 | | 2.0 | V | $I_C = 1A$<br>$I_B = 2mA$ |
| Base-emitter turn-on voltage | $V_{BE(on)}$ | | 2.0 | | 2.0 | V | $I_C = 1A$<br>$V_{CE} = 5V$ |
| Static current transfer ratio | $h_{FE}$ | 25000 | | 25000 | | | $I_C = 200mA$, $V_{CE} = 5V$ |
| | | 15000 | | 15000 | | | $I_C = 500mA$ |
| | | 4000 | 40000 | 4000 | 40000 | | $I_C = 1A$ |
| Collector-base capacitance | $C_{CB}$ | | 10 | | 10 | pF | $V_{CB} = 10V$<br>$f = 1MHz$ |

# Silicon Planar Medium Power Transistors

# NPN 2N6731
# PNP 2N6732

## FEATURES

- High $V_{CE}$ratings: $V_{CEO} = 80V$ min
- Exceptional power dissipation capabilities
  - $-2W$ @ $T_{CASE} = 25°C$
  - $-1W$ @ $T_{amb} = 25°C$
- Low saturation voltages



Plastic E-Line
(TO-92 Compatible)

## DESCRIPTION

Complementary power transistors employing double diffused planar structures encapsulated in the popular E-line (TO-92 style) plastic package. The specially selected SILICONE encapsulation provides resistance to severe environments comparable to metal can transistors.

## ABSOLUTE MAXIMUM RATINGS

| Parameter | Symbol | 2N6731 | 2N6732 | Unit |
|---|---|---|---|---|
| Collector-base voltage | $V_{CBO}$ | 100 | | V |
| Collector-emitter voltage | $V_{CEO}$ | 80 | | V |
| Emitter-base voltage | $V_{EBO}$ | 5 | | V |
| Peak pulse current* | $I_{CM}$ | 2 | | A |
| Continuous collector current | $I_C$ | 1 | | A |
| Power dissipation at $T_{amb} = 25°C$<br>at $T_{CASE} = 25°C$ | $P_{tot}$ | 2<br>1 | | W<br>W |
| Operating & storage temp range | | $-55$ to $+200$ | | °C |

*Pulse width $= 300\mu s$. Duty cycle $\leqslant 2\%$

# NPN 2N6731 PNP 2N6732

CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

| Parameter | Symbol | Min. | Max. | Unit | Conditions |
|---|---|---|---|---|---|
| Collector-base breakdown voltage | $V_{(BR)CBO}$ | 100 | | V | $I_C = 0.1mA$ |
| Collector-emitter breakdown voltage | $V_{(BR)CEO}$ | 80 | | V | $I_C = 10mA$ |
| Emitter-base breakdown voltage | $V_{(BR)EBO}$ | 5 | | V | $I_E = 1mA$ |
| Collector cut-off current | $I_{CBO}$ | | 0.1 | μA | $V_{CB} = 80V$ |
| Emitter cut-off current | $I_{EBO}$ | | 10 | μA | $V_{EB} = 5V$ |
| Collector-emitter Saturation voltage | $V_{CE(Sat)}$ | | 0.35 | V | $I_C = 350mA$<br>$I_B = 35mA$ |
| Base emitter turn-on voltage | $V_{BE(on)}$ | | 1.0 | V | $I_C = 350mA$<br>$V_{CE} = 2V$ |
| Static forward current transfer ratio | $h_{FE}$ | 100 | | | $I_C = 10mA$ } $V_{CE} = 2V$ |
| | | 100 | 300 | | $I_C = 350mA$ |
| Collector-base capacitance | $C_{CB}$ | | 20 | pF | $V_{CB} = 10V$<br>$f = 1MHz$ |
| Transition frequency | $f_T$ | 50 | 500 | MHz | $V_{CE} = 5V$<br>$I_C = 200mA$<br>$f = 20MHz$ |

# APPLICATIONS

A series of notes written to give engineers and designers guidance and ideas in the application of the transistors featured in this product guide.

## CONTENTS

| | | Transistors featured |
|---|---|---|
| 1. | D.C. motor speed control | ZTX450 |
| 2. | 60W flashing light | ZTX450 |
| 3. | Microphone amplifier | ZTX450/ZTX550 |
| 4. | 12V latch circuit | ZTX550 |
| 5. | Delayed extra brake light | ZTX550 |
| 6. | Infra-red transmitter | ZTX600 |
| 7. | ZTX600 as a lamp driver | ZTX600 |
| 8. | 6W inverter for MOS logic supplies | ZTX650 |
| 9. | Courtesy light delay switch | ZTX650 |
| 10. | 8W fluorescent lamp driver | ZTX652 |
| 11. | ZTX650/ZTX750 as lamp drivers | ZTX650/ZTX750 |
| 12. | 2W amplifier | ZTX650/ZTX750 |
| 13. | 4.5W amplifier | ZTX650/ZTX750 |
| 14. | Stepping motor drive | ZTX650/ZTX750 |
| 15. | High voltage transistors in telephone circuits | MPSA43 |
| 16. | Video driving transistors for colour television | MPSA42/MPSA92 |
| 17. | Portable Nicad battery charger | ZTX652 |

# Super E-line transistors

## APPLICATIONS

### 1. D.C. MOTOR SPEED CONTROL USING ZTX450

The function of the following circuit is to improve the load/speed regulation of a d.c. machine. One of the main reasons why the speed of a permanent magnet field d.c. motor varies with load is that a voltage drop is current and hence load dependent. The circuit given stabilises the speed of the motor by cancelling out the effect of the motor rotor resistance using a bridge circuit.

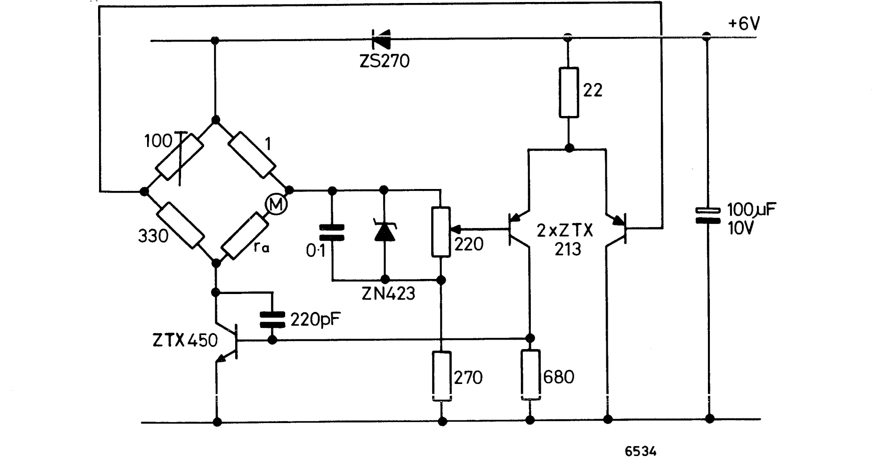


Fig. 1.1

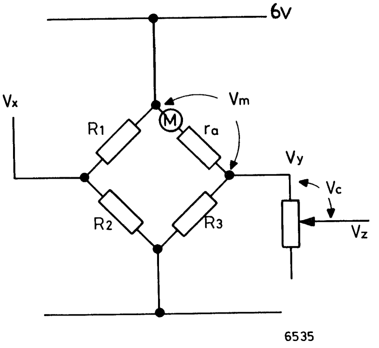


Fig. 1.2

**Theory**

If the bridge and variable resistor are analysed on their own, the following proof can be derived.

$$V_X = [V_m + I_m R_3] \times \frac{R_2}{R_1 + R_2} \qquad \ldots 1$$

$$V_y = I_m R_3 \qquad \ldots 2a$$

$$V_z = V_y + V_c = I_m R_3 + V_c \qquad \ldots 2b$$

but $V_m = V_a + I_m r_a$

substituting in 1.

$$V_x = [V_a + I_m r_a + I_m R_3] \times \frac{R_2}{R_1 + R_2} = [V_a + I_m (r_a + R_3)] \times \frac{R_2}{R_1 + R_2} = \frac{V_a R_2}{R_1 + R_2} + I_m R_2 \frac{(r_a + R_3)}{R_1 + R_2}$$

now $V_x = V_z$ (1st assumption)

$$\text{so } V_z = \frac{V_a R_2}{R_1 + R_2} + I_m R_2 \frac{(r_a + R_3)}{R_1 + R_2}$$

from 2b $V_z = I_m R_3 + V_c$

$$V_c + I_m R_3 = \frac{V_a R_2}{R_1 + R_2} + I_m R_2 \times \frac{r_a + R_3}{R_1 + R_2}$$

Dividing by $R_3$ gives

$$\frac{V_c}{R_3} + I_m = \frac{V_a R_2}{R_3(R_1 + R_2)} + I_m R_2 \frac{r_a + R_3}{R_3(R_1 + R_2)}$$

$$\frac{V_c}{R_3} + I_m = \frac{V_a R_2}{R_3(R_1 + R_2)} + I_m \left[\frac{R_2 r_a + R_2 R_3}{R_1 R_3 + R_2 R_3}\right]$$

now $R_1 R_3 = r_a R_2$ (2nd assumption)

$$\frac{V_c}{R_3} + I_m = \frac{V_a R_2}{R_3(R_1 + R_2)} + I_m$$

$$V_c = \frac{V_a R_2}{R_1 + R_2}$$

Hence the control voltage (i.e. the speed) is not directly dependent on the motor current.

The value of $r_a$ varies from motor to motor, so the bridge must be balanced to suit the motor employed. This can be done by calculation and measurement of the motor resistance, or by adjusting the value of the 100Ω preset resistor until the motor speed just becomes unstable and then backing off a fraction.

# Super E-line transistors

The current/speed and torque/speed characteristics of a test motor have been plotted in Fig. 1.3 and Fig. 1.4, with and without the control circuit to show the improvement in speed stability. Variations in motor speed due to supply changes are also greatly reduced by the circuit. On the test motor a speed change of ±2% was recorded for a supply change of ±20%.

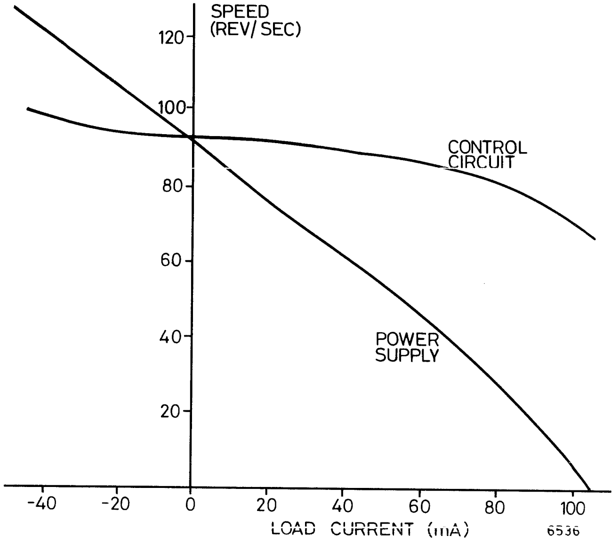


**Fig. 1.3**

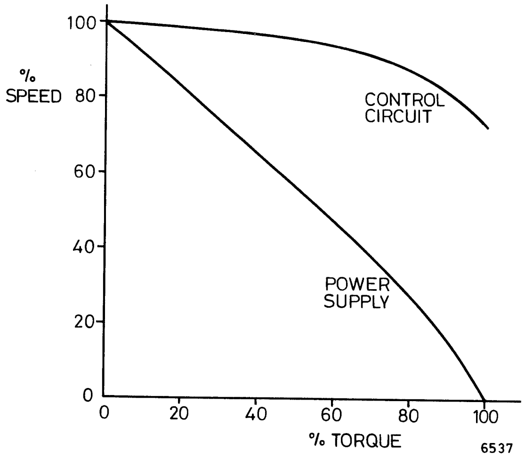


**Fig. 1.4**

## 2. 60W FLASHING LIGHT

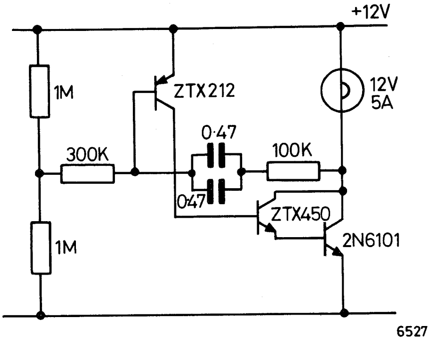


Fig. 2.1

The 2N6101 transistor should be mounted on a small heat sink. The 300kΩ resistor controls the **off** period and may need adjustment if transistor gains are high. The 100kΩ resistor controls the **on** period.

## 3. MICROPHONE AMPLIFIER

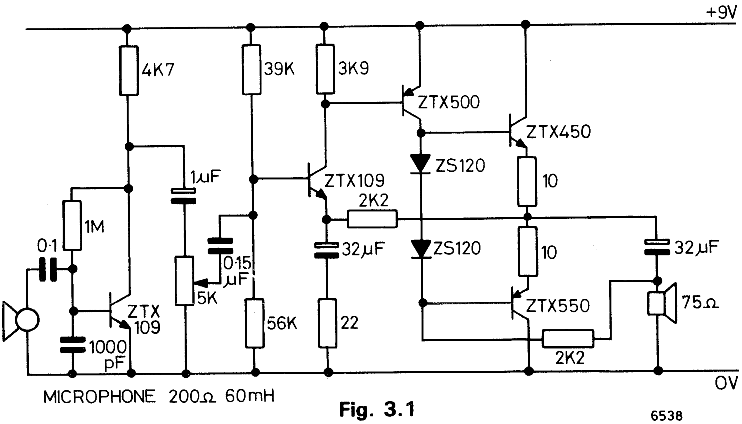


Fig. 3.1

This circuit features the ZTX450/ZTX550 transistors in a push-pull output stage. The following readings were taken at maximum volume:

Input 0.4mV rms

Output 1.8V rms

Voltage gain 4500

Max. output before distortion 2.25V rms - supply current = 15mA

Zero output - supply current = 3.5mA

Wattage 0.034W

Frequency response 250Hz to 28kHz

# Super E-line transistors

## 4. 12V LATCH CIRCUIT

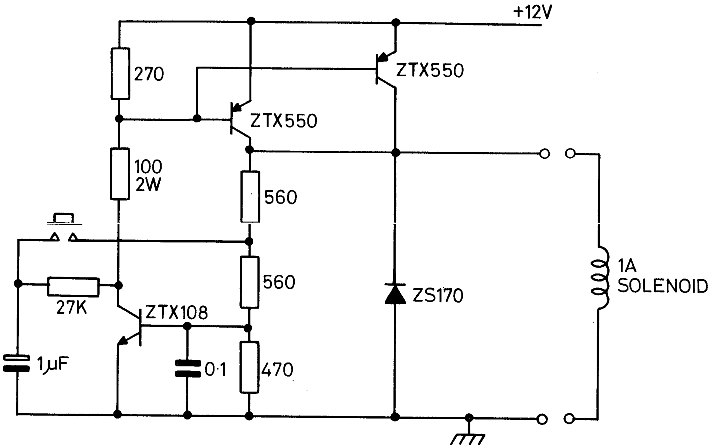


Fig. 4.1

The above circuit has been designed to control a solenoid by the operation of a single push-button switch. It will supply loads of over 1A and can be operated up to a maximum speed of once every 0.6 seconds. When power is first applied to the circuit, the solenoid will always start in its off position. Other features of the circuit are its automatic turn-off if the load is shorted, and its virtually zero power consumption when off.

When the supply is connected, the 470Ω and 270Ω base-emitter resistors ensure all three transistors remain off. The 1µF capacitor charges up to a value approaching that of the supply rail. If the push-button switch is then closed, the charge is transferred to the bias network of the ZTX108, turning it on. This, through the 100Ω and 270Ω bias resistors of the ZTX550's turn these devices on, which energises the load and also through the two 560Ω resistors holds the ZTX108 on, once the charge on the 1µF capacitor has decayed.

Since the ZTX108 is now on, when the push-button is released the 1µF capacitor will be discharged through the transistor via the bleed resistor.

If the push-button is operated again it will connect this discharged capacitor to the bias network of the ZTX108 turning it and thus the output off. Any excess energy stored in the solenoid will be dissipated in the ZS170 protection diode.

When the push-button switch is released, the 1µF capacitor will charge up ready to trigger the latch on again when the switch is operated. The 0.1µF capacitor inhibits false triggering due to transient voltages.

## 5. DELAYED EXTRA BRAKE LIGHT

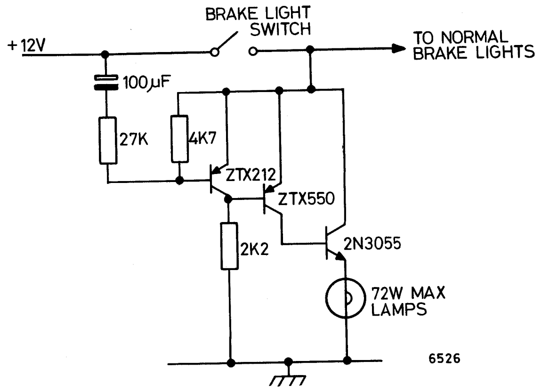


Fig. 5.1

Operating the brake pedal of the car brings on the normal brake lights and then, after a delay, the extra lights are turned on.

A bimetal strip in series with the lights would make them flash.

## 6. INFRA-RED TRANSMITTER

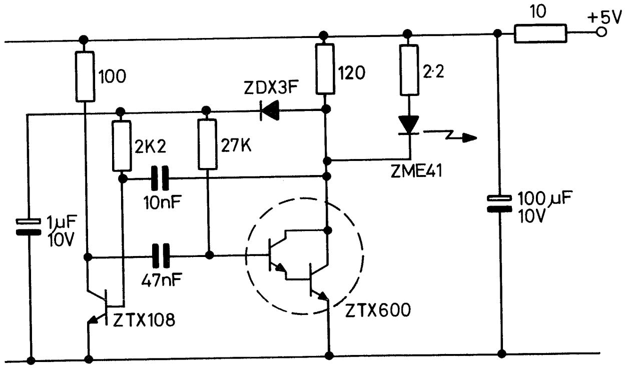


Fig. 6.1

The transmitter consists of an oscillator which drives a high output infra-red emitting diode. The oscillator is a sure start multivibrator circuit that provides an output of 15 to 1000 mark to space ratio at a frequency of 1kHz. This large mark to space ratio allows the infra-red diode to be operated at a high peak current, provided by the ZTX600 Darlington transistor, to maximise the transmitter range. A decoupling network is included in the power supply lead to isolate it from any logic circuitry using the same 5V power supply source. The transmitter supply current is approximately 65mA.

# Super E-line transistors

## 7. THE ZTX600 AS A LAMP DRIVER

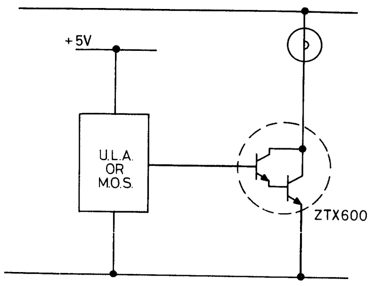


Fig. 7.1

There is often a requirement to drive lamps directly from integrated circuits, for example CMOS or ULA arrays where the drive current is limited to 5mA. In these circumstances the high gain and 1A capability of the ZTX600 can be used to advantage. The following table indicates the performance with various lamps.

| Lamp | Peak cold current (amps) | Peak $V_{CE}$ (volts) | Mean power dissipation (mW) | Transistor dissipation |
|---|---|---|---|---|
| 12V 2×2.2W | 1.6 | 1.25 | 310 | 1.15W/40ms |
| 12V 1×6.0W | 2.7 | 2.25 | 382 | 4.5W/10ms |
| 12V 4×2.2W | 3.3 | 2.30 | 770 | 5.4W/20ms |

## 8. 6W INVERTER FOR MOS LOGIC SUPPLIES

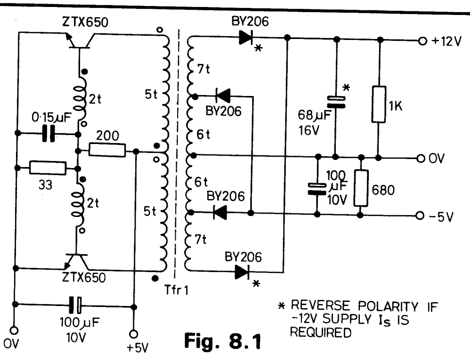


Fig. 8.1

∗ REVERSE POLARITY IF -12V SUPPLY $I_S$ IS REQUIRED

Transformer details: FX3437 cores wound with:
2-0-2t, 29swg.
5-0-5t, 26swg. Bifilar
13-6-0-6-13t, 29swg.

The 6W inverter shown in Fig. 8.1 has been designed to generate the extra power supplies required by popular MOS memories from a normal 5V TTL supply source. It may be used to supply up to eight '2808' read only memories which require supplies of +5V, −5V and +12V, or if the output components of the 12V section are reversed, the circuit will power over ten '5204' ROM's which require +5V and −12V supplies.

The inverter is a simple push-pull circuit which takes advantage of the high current handling capability of the ZTX650 range. It oscillates at a frequency of approximately 25kHz to use a very small transformer (RM6) and also to render the inverter inaudible. The output characteristics are given in Fig. 8.2. Output ripple is approximately 0.15V peak to peak on both outputs.

| $I_{sv} = 250mA$ Output volts | $R_{sv} = 20\Omega$ Output current (ma) |
|---|---|
| 12.1 | 10 |
| 11.6 | 100 |
| 11.4 | 200 |
| 11.2 | 300 |
| 11.0 | 400 |
| 10.7 | 500 |

| $I_{sv} = 10mA$ Output volts | $R_{sv} = 500\Omega$ Output current (mA) |
|---|---|
| 12.2 | 10 |
| 11.8 | 100 |
| 11.6 | 200 |
| 11.4 | 300 |
| 11.2 | 400 |
| 10.8 | 500 |
| 10.6 | 600 |

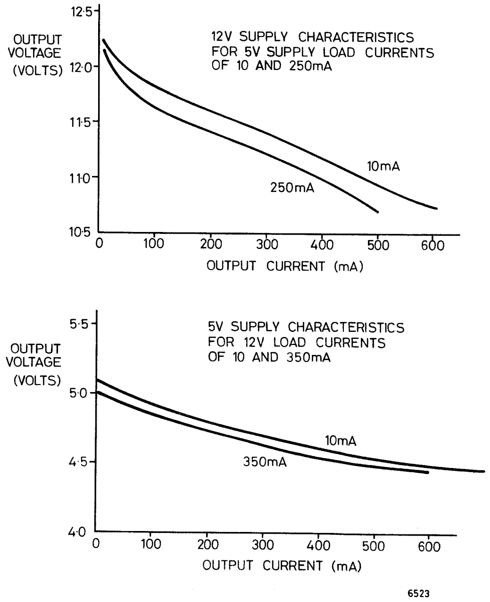


Fig. 8.2

# Super E-line transistors

## 9. COURTESY LIGHT DELAY SWITCH

This circuit holds on the internal light for approximately 1 minute after the car doors are closed.

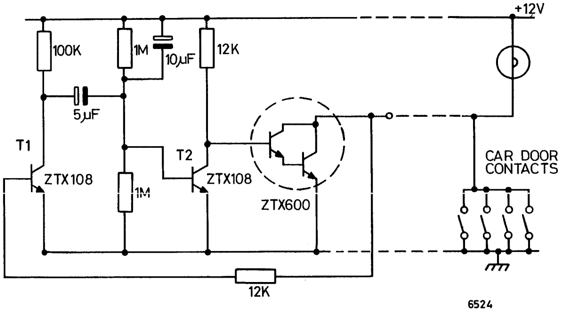


Fig. 9.1

When the door contacts open, a +ve pulse is applied to the base of $T_1$. This transistor turns on, turning off $T_2$ and charging the 10µF capacitor. $T_3$ turns on, holding on the internal light. The capacitor takes 1 minute to discharge when the circuit reverts to its original state.

## 10. 8W FLUORESCENT LAMP INVERTER

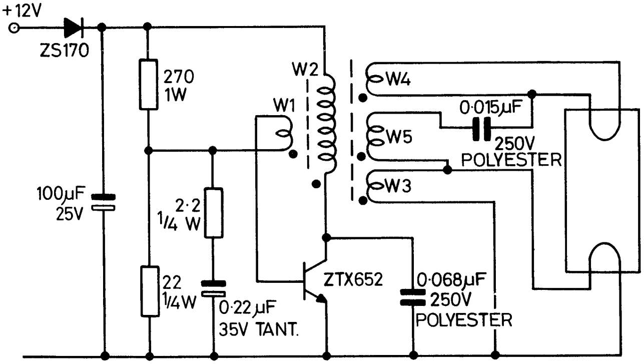


Fig. 10.1

Transformer details. Core type FX3439 with 0.005" (0.125mm) spacer.

Former type DT2523
W1 4 turns 34swg. Enamelled copper wire
W2 17 turns 26swg. " " "
W3 7 turns 28swg. " " "
W4 7 turns 28swg. " " "
W5 130 turns 36swg. " " "

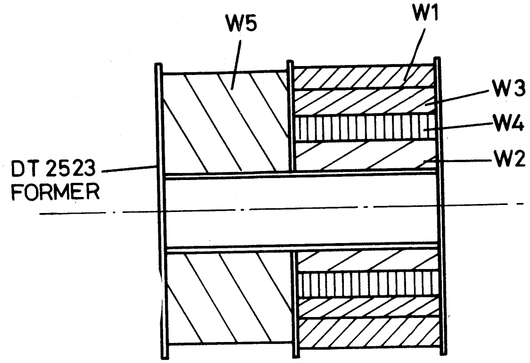


Fig. 10.2

The circuit shown in Fig. 10.1 has been designed to drive an 8W fluorescent lamp from a 12V source using an inexpensive inverter based on the ZTX652 transistor. The inverter will operate from supplies in the range of 10 to 16.5V, thus making it suitable for use in on-charge systems such as caravanettes as well as periodically charged systems such as camping lights or outhouse lights etc. Other features of the inverter are that it oscillates at an inaudible 20kHz and that it includes reverse polarity protection.

## CIRCUIT OPERATION

The 270Ω and 22Ω resistors bias a ZTX652 transistor into conduction, where the positive feedback given to the transistor by $W_1$ drives it into saturation, thus applying the supply voltage across $W_2$. This causes a magnetising current to build up in $W_2$ until the transformer's ferrite core saturates. When this happens, the base drive given to the transistor by $W_1$ decays, causing the transistor to rapidly turn off.

Until the fluorescent tube strikes, the transformer is only loaded by the tube heater filaments which present only a minimal load. Thus when the transistor turns off the transformer 'rings' for half a cycle at a frequency governed by the windings inductance and the 0.068μF capacitor, reversing the magnetising current and turning the transistor on again. This 'ring' induces a high voltage pulse across the fluorescent tube which will cause it to strike once the heaters have warmed up.

Once the tube has struck, it loads the transformer heavily, swamping this ringing action and so greatly reducing the peak voltage induced across $W_2$ and the transistor. This extends the non-conducting period of the inverter cycle and during this period, energy stored in the transformer in the form of magnetising current is dumped into the fluorescent tube. When all this energy has been dumped, the voltage on the transistor collector falls and it switches on once more.

The voltage required to pass current though the tube has now fallen enough for it to conduct during both half cycles of inverter oscillation. Thus when the transistor now turns on, it both drives the fluorescent tube directly and also stores energy in the transformer which drives the tube during the transistor's non-conducting period. The current passed through the tube is controlled by the transformer's leakage inductance and also a series connected 0.015μF capacitor. Waveforms of the transistor' collector voltage and emitter current under normal operating conditions are given in Fig. 10.3

The 2.2Ω resistor and 0.22μF capacitor included in the circuit give the inverter a rapid turn-off characteristic which limits the power dissipation in the transistor to approximately 0.5W with the tube lit and with a 12V supply. However the power dissipation in the transistor is much higher if the tube is broken or removed. Taking the worst case conditions of 16.5V supply and no tube, the transistor will dissipate approximately 1.5W. Thus if the inverter may be operated under these conditions as for instance Public Transport applications etc., the transistor should be clamped to a heatsink better than 15°C per watt.

Where the inverter will not remain energised if the tube does not strike, as in the case of camping lights and similiar applications, no heat-sink is necessary.

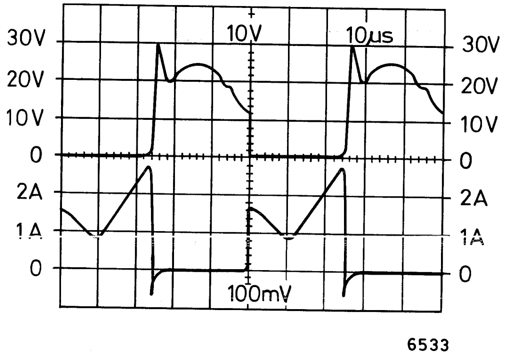


Fig. 10.3

## CONSTRUCTION

Apart from keeping component lead lengths short, the layout of the circuit is not critical. Care should be taken however in winding the transformer (see Fig. 10.2). It is advisable to mount the unit in a metal case as this will provide RF screening of the inverter and also provides a ground plain for the fluorescent tube which significantly reduces its striking voltage. The case could also be used as heatsinking for the ZTX652 transistor when required.

## 11. THE ZTX650/ZTX750 AS LAMP DRIVERS

A 6V 6W lamp, having a normal current of 1A, can have an initial peak current of 10A. Switched repeatedly with equal mark and space periods of one second, the peak current reduces to 2.5A as shown in Fig. 11.1.

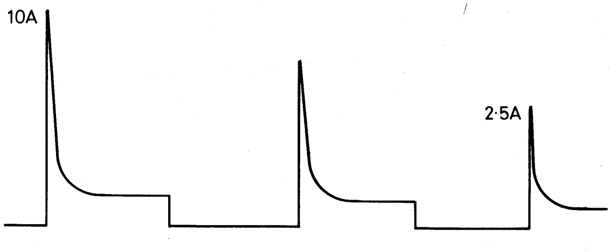


Fig. 11.1

A transistor with a limited current gain at high currents, will be unable to turn on completely. There will thus be a higher **on** voltage across the device and a higher transient power dissipation.

The ZTX650/ZTX750 series, due to their good hold up of gain at high collector currents will reduce this transient dissipation to a minimum.

## 12. 2W AMPLIFIER USING ZTX650/ZTX750

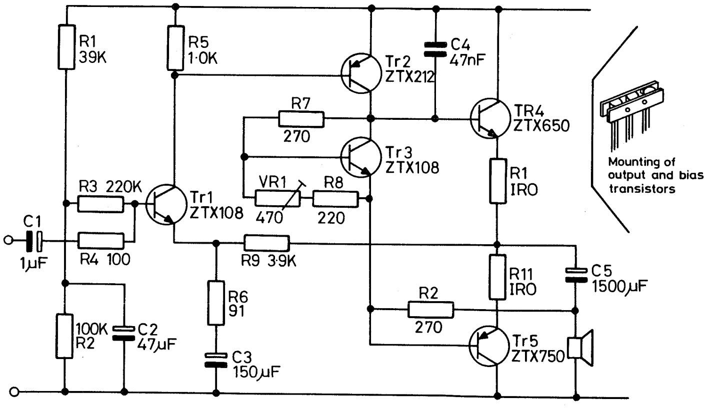


Fig. 12.1

Readings: Output 2W rms – 8Ω load
Supply voltage = 15V
Supply current at 2W = 260mA
Supply current at zero output = 18mA
Frequency response > 20kHz

# Super E-line transistors

## 13. 4.5W AMPLIFIER USING ZTX650/ZTX750

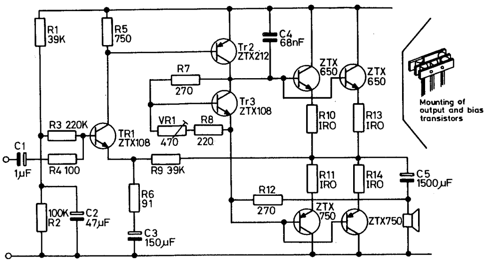


Fig. 13.1

Readings: Output 4.5W – 8Ω load
Supply voltage = 20V
Supply current at 4.5W = 370mA
Supply current at zero output = 35mA
Frequency response > 20kHz

## 14. STEPPING MOTOR DRIVE

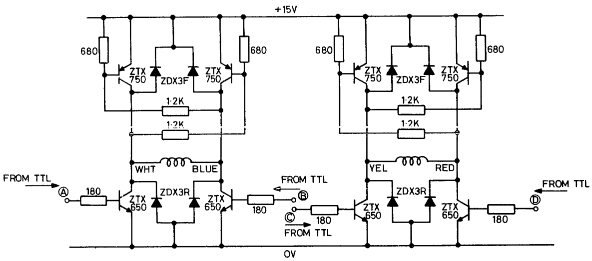


Fig. 14.1

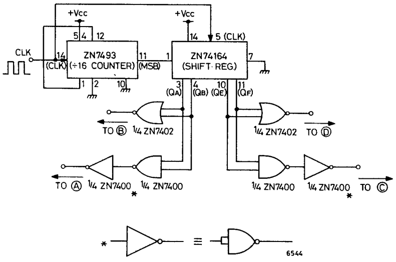


Fig. 14.2

The circuit shown in Fig. 14.1 is designed to drive a 15V two phase bipolar stepping motor, providing a bidirectional single level voltage across each winding at currents of up to 0.6A.

The circuit consists of two identical transistor bridge stages employing complementary NPN and PNP devices. The transistor conduction sequence is determined by external control logic, and the circuit will interface directly with standard TTL. A suitable control logic system is illustrated in Fig. 14.2.

## 15. HIGH VOLTAGE TRANSISTORS IN TELEPHONE CIRCUITS

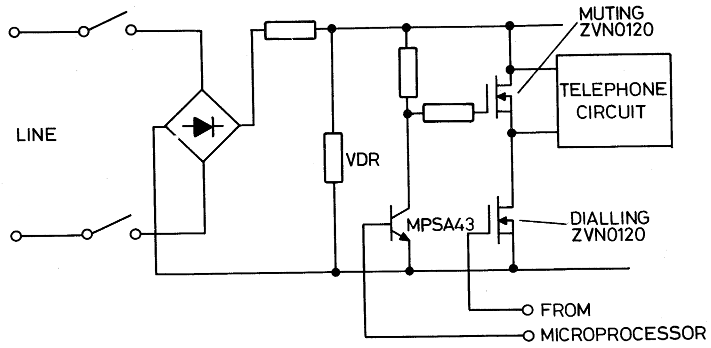


Fig. 15.1

The MPSA43 is shown as a driving transistor for the VMOS muting switch in a typical modern telephone instrument.

British Telecom regulations require the instrument to pass a simulated lightning strike test. A voltage dependent resistor reduces the transient voltage to less than 200V and the high voltage rating of the MPSA42 enables it to survive the remaining surge.

## 16. VIDEO DRIVING TRANSISTORS FOR COLOUR TELEVISION

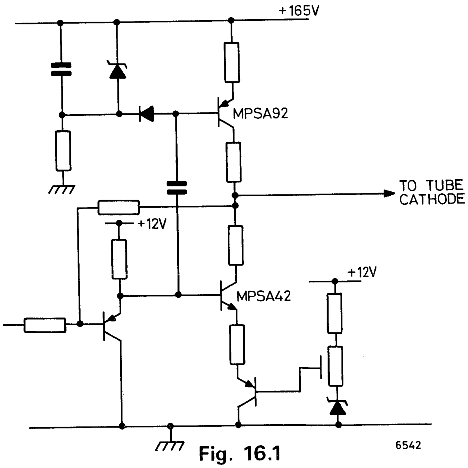


Fig. 16.1

The MPSA42/MPSA92 are shown in a push-pull circuit suitable for driving the cathode of a colour television tube.

## 17. PORTABLE NICAD BATTERY CHARGER

Battery powered video tape recorders that can be used with an electronic camera are becoming a popular means of photographing events such as weddings, holidays, etc. It is common for these recordings to be powered by a 12V rechargable nickel-cadmium battery which rarely has the capacity to power the recorder for more than an hour. So it would be useful if these batteries could be charged from a convenient remote power source such as an automobile battery. The circuit shown in Fig. 17.1 has been designed to allow this to be done.

This circuit was designed to charge 12V, 2 ampere-hour nickel cadmium battery packs from a 12V source, but was made versatile enough to charge packs in the range of 4.8 to 15.6V to increase possible applications. To charge batteries that may reach a higher end voltage than the 12V supply input (even 12V nicads reach an end voltage of about 14.5V), a voltage converter of some kind is required. This converter must be short and open circuit protected, be able to operate efficiently over a wide output voltage range and must be insensitive to input voltage variations.

A self oscillating flyback converter will meet most of these requirements, being particularly suited to operating over a wide output voltage range. However, the standard circuit needs modifications to cope satisfactorily with short and open circuit loads. These changes include a special biasing circuit and an energy recovery winding on the converter transformer.

### CIRCUIT OPERATION

When power is first applied to the circuit, a small bias current supplied by R1 via winding W1 starts to turn on the transistor TR1. This forces a voltage across W2 and the Positive feedback given by the coupling of W1 and W2 causes the transistor to turn hard on, applying the full supply across W2. The base drive voltage induced across W1 makes the junction between R1 and R2 become negative with respect to the 0V supply, forward biasing diode D1 to provide the necessary base current to hold TR1 on.

With the transistor on, a magnetising current builds up in W2 which eventually saturates the ferrite core of transformer T1. This results in a sudden increase on the collector current flowing through TR1, causing its collector-emitter voltage to rise and thus reducing the voltage across W2. With the positive feedback given by windings W1 and W2, a falling voltage across W2 causes TR1 to turn off rapidly.

The current flowing in W2 now forces the collector voltage of the TR1 to swing positive until restricted by transformer output loading. During this "flyback" period, the voltage induced across W4 forward biases the diode D3

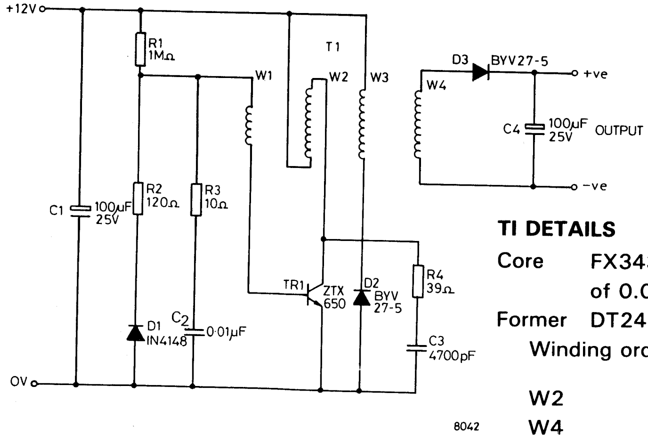


Fig. 17.1

**TI DETAILS**

Core FX3437 With Gap/Spacer of 0.08mm

Former DT2492

Winding order W2, W4, W3 then W1

| | | |
|---|---|---|
| W2 | 40T | 30swg. |
| W4 | 20T | 30swg. |
| W3 | 13T | 36swg. |
| W1 | 12T | 36swg. |

to charge the output capacitor C4. Energy stored in the core of the transformer while the transistor was on is dumped into this capacitor which feeds the load. The collector voltage of TR1 remains high untill the current flowing in W4 falls to zero. The voltage then falls until the positive feedback given by W1 causes TR1 to turn on hard again to start the next cycle of oscillation. If a load (nicad battery) is not connected across C4, the energy dumped into this capacitor will charge it to an ever increasing voltage. To restrict the maximum output voltage, an extra transformer winding, W3, has been added which will return stored energy into the input supply via D2 if the output exceeds 20V.

A resistor-capacitor network comprised of R4 and C3 has been added to the circuit to limit the turn off transient TR1 to within the ratings of the device. A second network, R3 and C2, was added to maintain the loop gain of the circuit when the diode D1 is not conducting i.e., during start up and switching. Without sufficient gain, the circuit will not oscillate.

The capacitor C2 also has an important effect on the operation of the converter when its output is shortened. During the conduction period of TR1, C2 is charged to a negative voltage by winding W1, and this charge remains during the flyback period. This negative bias will inhibit continuous oscillation unless the transformer "rings" sufficiently at the end of the flyback period to produce a transient base drive voltage large enough to overcome the bias. Since an output voltage of at least 1.5V is required to produce sufficient transformer ringing, a short circuit load causes the converter to run in an intermittent mode, consuming very little power.

## CONVERTER DESIGN

The converter is to charge a 12V, 2AH battery pack, which has a recommended charge current rating of 220mA. The power source is a 12V car battery.

Firstly, a transformer core must be chosen that will give the necessary power throughput without the need to operate at an excessive frequency. The choice will be controlled by the peak current passed through winding W2 and the inductance required. The efficiency of the converter can be expected to be around 75%, so with a 12V supply and 12V output load, the average supply current will be:

$$I_S = \frac{I_O \times V_O}{V_S \times \text{Eff}} = \frac{.22}{.75} = 0.29\text{A}$$

The actual supply current taken by the converter will be a linear ramp from zero to $I_{peak}$ followed by a period of no current flow. The ratio of the ramp period to the whole cycle period is the duty cycle. Because of the simple current waveform, once the duty cycle is known, the peak current in W2 can be calculated from the average supply current. The duty cycle is dependent on the input to output turns ratio of the transformer. The smaller the number of turns on the output winding, the higher the flyback voltage across the switching transistor for a given output voltage, resulting in a shorter flyback period. Reducing the flyback period allows a given output power to be achieved with a small peak current in the switching transistor, helping to minimise losses. However this is at the expense of requiring a higher voltage transistor. A compromise duty cycle of 70% was chosen for this design. This gives $I_{Peak}$ as:

$$I_{peak} = \frac{I_S \times 2}{\text{Duty Cy.}} = \frac{.29 \times 2}{.7} = 0.83\text{A}$$

The E-line ZTX652 transistor will yield a high gain at this current and so was chosen as the switching transistor. To keep the converter inaudible yet minimize switching losses, an oscillation frequency in the range of 20 to 50kHz was chosen. This gives a transistor on time (current build up time) of 35 to 14$\mu$S. the inductance of transformer winding W2 can now be calculated using:

$$L_{max} = \frac{V_S \times T_{on}}{I_{peak}} = \frac{12 \times 35\text{e-}6}{0.83} = 0.5\text{mH}$$

Similarly, $L_{min}$ was calculated to be approximately 0.2mH. The energy storage capability of the suitable RM range of transformer cores are described in the form of Hanna curves. These curves relate $I^2 \times L$, $I \times N$ and core spacer. The $I^2 \times L$ value that is required for this transformer is 0.33-3 to 0.17e-3. The smallest core in the RM range will meet this specification. An RMS type FX3437 pair of cores with a 0.08mm spacer will give an $I^2 \times L$ factor of 0.25e-3. This factor is in the required range and also corresponds to a pre gapped RMS core type LA14376 which thus can be used as a convenient substitute. The inductance of W2 will be 0.25e-3/(0.83$^2$) = 0.36mH, requiring 38.5 turns according to the Hanna curves for this core and gap (rounded to 40 turns).

The output winding W4 is determined by:

$$W4 = \frac{V_O \times T_{off} \times W2}{V_S \times T_{on}} = \frac{12.7 \times 30\% \times 40}{12 \times 70\%}$$

$$= 18.4, \text{ rounded to } 20$$

Note the ratio of $T_{on}$ to $T_{off}$ was used above.

The output voltage must be limited to 20V by winding W3 and so this gives:

$$W4 = \frac{(V_S + V_{rec} \times W4}{(V_{max} + V_{rec})} = \frac{12.7 \times 20}{20.7}$$

$$= 12.2, \text{ rounded to } 13$$

The base winding W1, is a compromise between providing sufficient base current for a low gain transistor operating with minimum supplies, and avoiding losses caused by overdriving the transistor under normal circumstances. The transistor is required to pass 0.83A peak and a mimimum gain device at low temperature will need approximately 15mA to achieve this. A base drive voltage of at least 1.4V is needed to pass any current at all through the biasing circuit adopted and a voltage of twice this is desirable if the base current is to be insensitive to supply voltage variations. A base winding of 12 turns will give a drive of 3.3V with a minimum supply of 10.5V. A base resistor of 120Ω gives the required base current from this drive.

Finally, the starting base bias resistor value must be calculated. This resistor must cause the circuit to have sufficient gain to oscillate, yet not cause excessive power dissipation if oscillation does not occur due to incorrect winding phasing or some other fault. To oscillate, the loop gain of the circuit must be greater than one. The feedback gain is 12/40 or about 0.3, so the transistor must give a voltage gain of at least 1/0.3 or 3.3. The transistor voltage gain is mainly dependent on the ratio of collector and emitter loads. The small signal collector loading is the result of the tuned circuits made by the transformer windings and associated capacitors, turning out ot be of the order of 2KΩ. The emitter loading is the intrinsic emitter resistance, given by $r_e = 25e\text{-}3/I_e$. For a voltage gain of 3.3, $r_e$ must be less than 2K/3.3 or 600Ω. The minimum emitter current during start up must be more than 25e-3/600 or 42μA. The $H_{fe}$ of the ZTX652 transistor is not specified at such low currents but it is not expected to be less than 30, so this would set the minimum base current at 1.5μA. However, because of this uncertainty, the bias was raised to 10μA to ensure reliable starting. This value will only cause a worst case power dissipation of about 70mW in the transistor if the circuit fails to oscillate under fault conditions.

## PERFORMANCE

Over the intended operational range, the circuit was found to give an efficiency exceeding 70%, providing a useful output from a supply as low as 0V. Full input and output characteristics of the converter are given in Figs. 17.2 and 17.3. Fig. 17.2 shows the output current given by the circuit for various load voltages. Note the output current at 12V is very close to the design aims. This diagram also shows the efficiency of the converter when operating into these loads. Fig. 17.3 shows how the output current given into a 12V load varies with input supply voltage.

The time required to fully charge the load batteries will depend on their voltage and ampere-hour capacity. The converter was designed to charge the 2AH power pack in about 14 hours. At this charge rate, these vented battery packs will safely stand continuous over charging. If the converter is used to charge a different battery pack, Fig.17.2 should be used to find the output current of the circuit which can then be used to calculate the charge time necessary. In cases where the charge rate is greater than C/10 for vented cells or C/50 for button cells, it is recommended that a timer be included in the circuit to ensure that accidental overcharging does not occur.

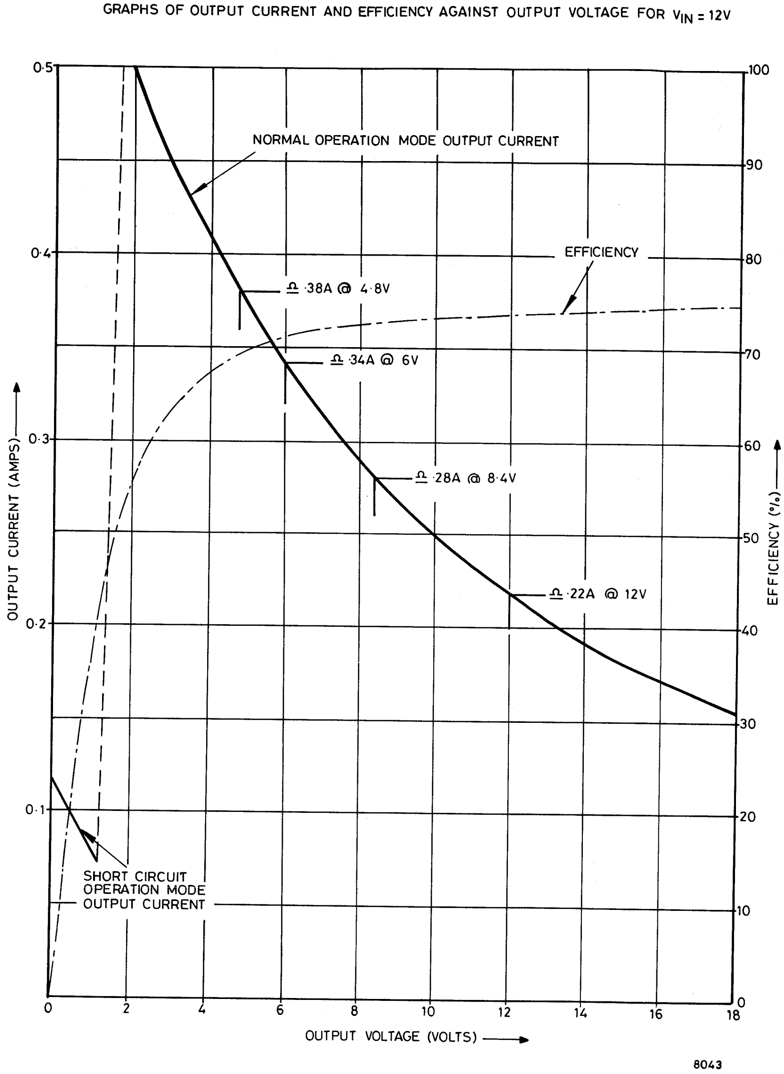

GRAPHS OF OUTPUT CURRENT AND EFFICIENCY AGAINST OUTPUT VOLTAGE FOR $V_{IN}$ = 12V
NORMAL OPERATION MODE OUTPUT CURRENT
EFFICIENCY
Ω ·38A @ 4·8V
Ω ·34A @ 6V
Ω ·28A @ 8·4V
Ω ·22A @ 12V
SHORT CIRCUIT OPERATION MODE OUTPUT CURRENT
OUTPUT CURRENT (AMPS)
EFFICIENCY (%)
OUTPUT VOLTAGE (VOLTS)
0·5
0·4
0·3
0·2
0·1
0
2
4
6
8
10
12
14
16
18
100
90
80
70
60
50
40
30
20
10
0
8043

Fig. 17.2

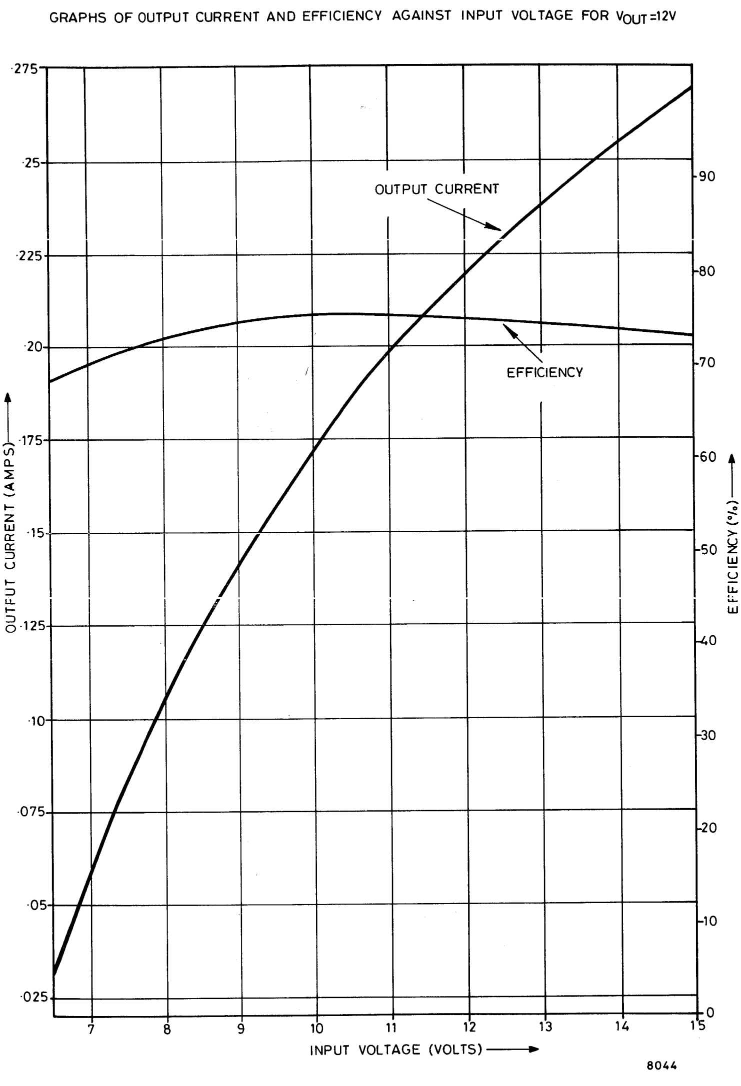
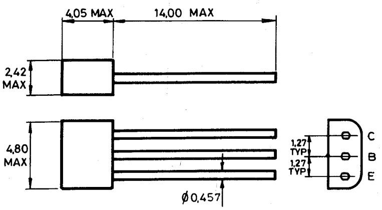

GRAPHS OF OUTPUT CURRENT AND EFFICIENCY AGAINST INPUT VOLTAGE FOR $V_{OUT}$=12V
·275
·25
·225
·20
·175
·15
·125
·10
·075
·05
·025
OUTFUT CURRENT (AMPS)
90
80
70
60
50
40
30
20
10
0
EFFICIENCY (%)
OUTPUT CURRENT
EFFICIENCY
7
8
9
10
11
12
13
14
15
INPUT VOLTAGE (VOLTS)
8044

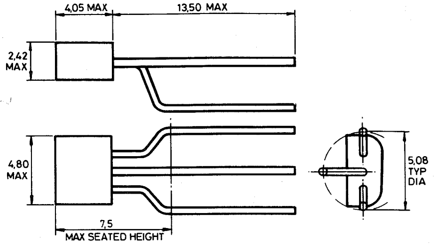
**Fig. 17.3**

## E-LINE (TO-92 STYLE) PACKAGE OUTLINES

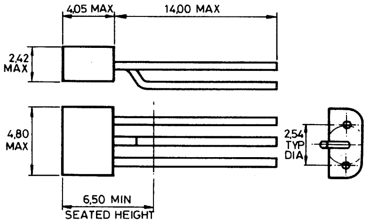
Devices can be ordered with the following lead configurations by adding the indicated suffix to the part number.



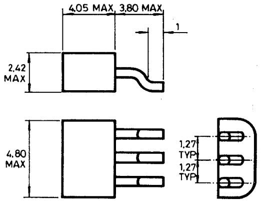
**STANDARD PACKAGE**
**BS 3934 SO-94**



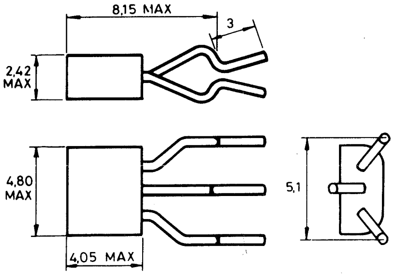
**SUFFIX 'K' LEAD FORMATION**
**for TO-5 and TO-39 compatibility**
**BS 3934 SO-95**



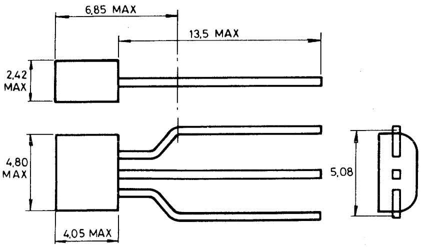
**SUFFIX 'L' LEAD FORMATION**
**for TO-18 compatibility**
**BS 3934 SO-97**



**SUFFIX 'M1' LEAD FORMATION**
**for flat mounting**
**BS 3934 SO-96**



**SUFFIX 'Q' LEAD FORMATION**
**(Lockfit)**



**SUFFIX 'S' LEAD FORMATION**

Dimensions in millimetres

The 'S' type lead formation is pin compatible with the popular TO-202 plastic power transistor.

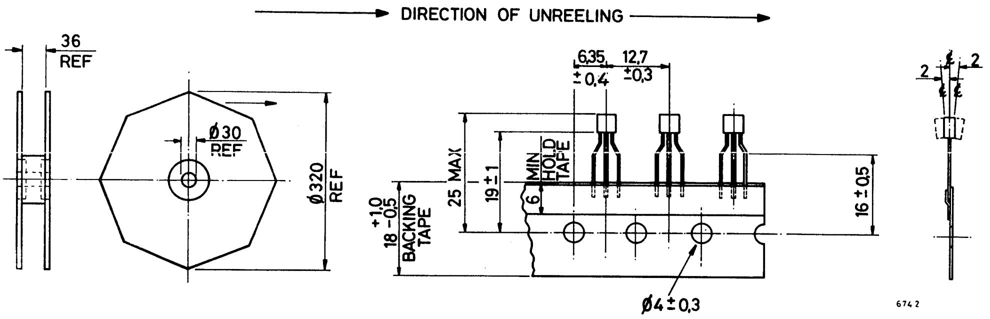
# Super E-line transistors

## TAPED PRODUCT

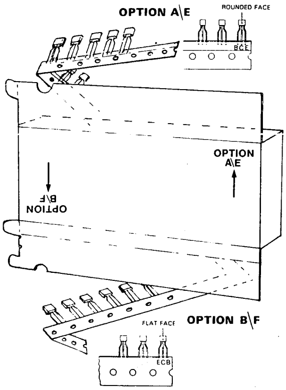
E-line transistors can be supplied on tape for automatic insertion. Two types of packaging are available:

(a) The tape, bearing the devices, is wound on a reel and supplied in a cardboard box.

(b) The tape, bearing the devices, is folded in a concertina (or Z) form and supplied in a cardboard box (Ammo pack).



TAPE FOLDED IN CARTON
CONCERTINA STYLE



### TAPE FEATURES

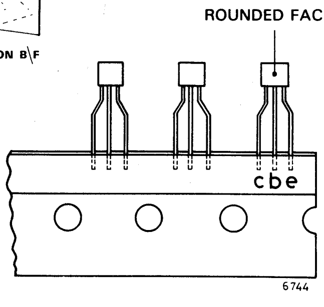
- Each Reel or Box contains 2000 devices.
- No more than 2 consecutive vacant spaces on the tape.
- Minimum of 5 vacant spaces at beginning and end of tape.
- Available with choice of orientation.

To order E-line transistors on tape the following format should be used:

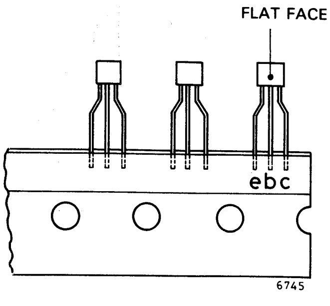
(a) Suffix 'STO' for product taped and put on reels.

(b) Orientation (Option A or B).

(c) Suffix 'STZ' for product taped and folded (Ammo pack).
e.g. ZTX 650 STOA ZTX 650 STZ



OPTION A

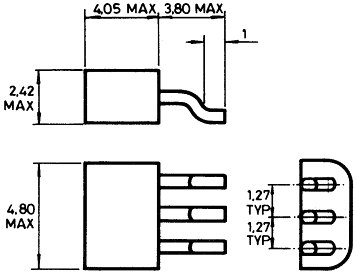


OPTION B

## E-LINE TAPE FOR SURFACE MOUNTING

Super E-line transistors can be supplied with M1 lead form in 16mm embossed carrier tape suitable for automatic placement in Surface Mount Applications. The E-line M1 is particularly useful when the application requires power dissipation in excess of that obtainable with SOT-23.

The M1 option provides designers with the wide choice of Zetex E-line and Super E-line transistors in Surface Mountable form.

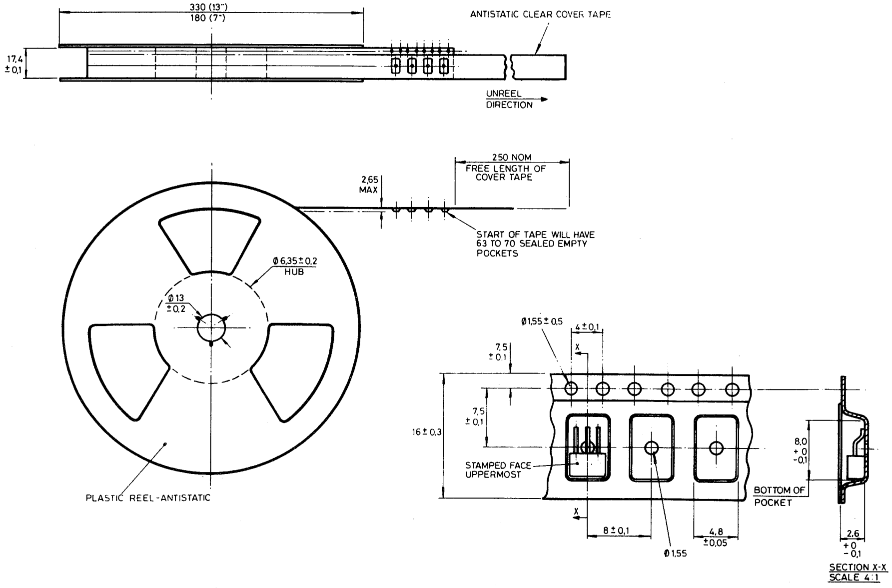


**M1 lead formation**
**BS 3934 SO-96**

## TAPE FEATURES

- Conforms to EIA 481. Rev A
- Start of tape will have 63 to 70 sealed empty pockets
- End of tape on reel hub will have 26 min. sealed empty pockets
- 7″ reel to hold 500 components
- 13″ reel to hold 3000 components
- Peel off strength of cover tape is 0.4 ±0.3 newtons measured at 175°—180° with respect to the component carrier along the longitudinal axis of the carrier tape. The peel-off speed shall be 120 ±5mm/min.
- Semi-conductive carrier tape resistivity less than $10^7 \Omega/\square$

## TAPE SPECIFICATION



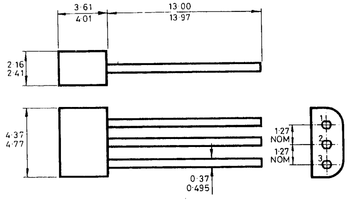
# Super E-line transistors

## CENTRE COLLECTOR E-LINE FOR THROUGH HOLE TECHNOLOGY

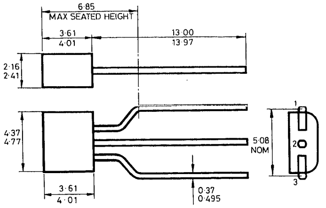
The Zetex centre collector range can be supplied in bulk or on tape for use in through hole applications.

The Super E-line range is designed to replace TO-39, TO-126, TO-220 and TO-237 in free standing applications.

### PACKAGE DETAILS



**STANDARD PACKAGE**



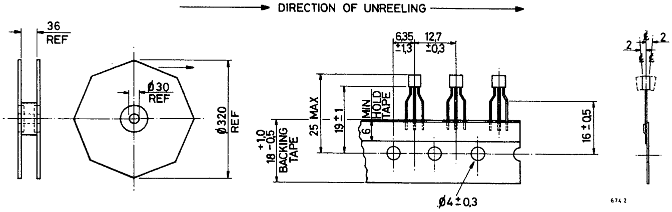
**SUFFIX 'S' LEAD FORMATION**

### TAPED PRODUCT

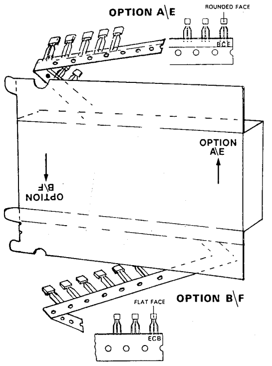
E-line transistors can be supplied on tape for automatic insertion. Two types of packaging are available:

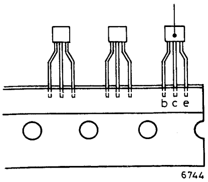
(a) The tape, bearing the devices, is wound on a reel and supplied in a cardboard box.

(b) The tape, bearing the devices, is folded in a concertina (or Z) form and supplied in a cardboard box (Ammo pack).

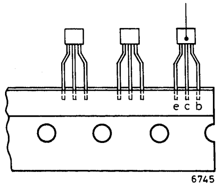


TAPE FOLDED IN CARTON CONCERTINA STYLE





OPTION E



OPTION F

### TAPE FEATURES

- Each reel or box contains 2000 devices.
- No more than 2 consecutive vacant spaces on the tape.
- Minimum of 5 vacant spaces at beginning and end of tape.
- Available with choice of orientation.

To order E-line transistors on tape the following format should be used:

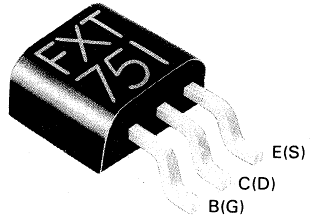
(a) Suffix 'STO' for product taped and put on reels.

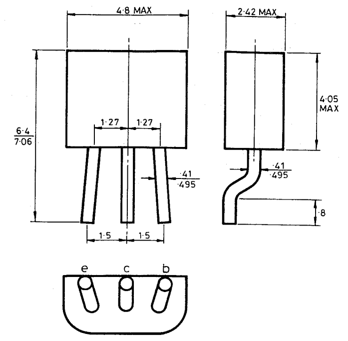
(b) Orientation (Option E or F).
e.g. FXT651STOE

(c) Suffix 'STZ' for product taped and folded (Ammo pack).

# Super E-line transistors

## CENTRE COLLECTOR E-LINE S.M. FOR SURFACE MOUNTING

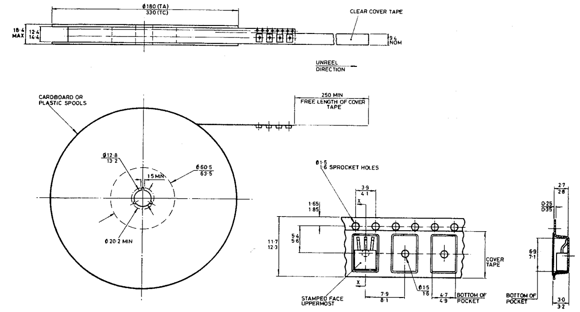




The E-line S.M. outline provides designers with the wide choice of Zetex E-line and Super E-line transistors in a surface mountable form compatible with the SOT-89 footprint. Direct electrical equivalents of popular SOT-89 types are available in E-line S.M.

In many applications E-line S.M. can be used to replace SOT-194, SOT-223 and DPAK.

### TAPE SPECIFICATION



### TAPE FEATURES

- Conforms to EIA 481. Rev A and IEC 286
- Start of tape will have 63 to 70 sealed empty pockets
- End of tape on reel hub will have 26 min. sealed empty pockets
- 7″ reel to hold 500 components
- 13″ reel to hold 3000 components
- Peel off strength of cover tape is 0.4 ± 0.3 newtons measured at 175°-180° with respect to the component carrier along the longitudinal axis of the carrier tape. The peel-off speed shall be 120 ± 5mm/min.
- Semi-conductive carrier tape resistivity less than $10^7\Omega/\square$

### ORDERING INFORMATION

To order E-line S.M. devices, add the suffix SM to the device type i.e. FXT651SM.

To order devices in tape, add suffix SMTA for 7″ reels i.e. FXT651SMTA. 13″ reels FXT651SMTC.

### SOLDERING RECOMMENDATIONS

**Reflow soldering**

E-line S.M. packages may be placed in any orientation using reflow techniques.

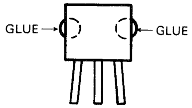
To maintain the position of the component, it may be advisable to glue the device prior to reflow.

**Wave soldering**

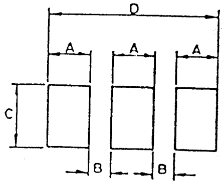
The preferred orientation for wave soldering is with the feet facing the wave. The component may also be positioned at right angles to the wave. An extra sacrificial pad may be necessary to avoid bridging between the leads when used in this orientation.

**Gluing recommendations**

Glue dots at either side of the package are recommended.



### RECOMMENDED FOOTPRINTS FOR WAVE AND REFLOW SOLDERING



| | A | B | C | D | |
|---|---|---|---|---|---|
| Wave soldering | 1.0<br>40 | 0.5<br>20 | 1.5<br>60 | 4.0<br>160 | mm<br>mils. |
| Reflow soldering | 0.8<br>32 | 0.7<br>28 | 1.2<br>48 | 3.8<br>150 | mm<br>mils. |

# Super E-line transistors

## GLOSSARY

### EXPLANATION OF SYMBOLS USED IN TABLES AND DATA

| Symbol | Parameter |
|---|---|
| $C_{obo}$ | Output capacitance |
| $-C_{re}$ | Feedback capacitance |
| $f$ | Frequency |
| $f_T$ | Transition frequency |
| $h_{FE}$ | Static forward current transfer ratio |
| $I_B$ | Base current |
| $I_{B1}$ | Control current |
| $I_{B2}$ | Turn-off base current |
| $I_C$ | Collector current |
| $I_{CBO}$ | Collector-base cut-off current |
| $I_{CEO}$ | Collector-emitter cut-off current |
| $I_{CER}$ | Collector-emitter cut-off current (with external resistor) |
| $I_{CM}$ | Peak pulse current |
| $I_E$ | Emitter current |
| $I_{EBO}$ | Emitter-base cut-off current |
| $P_{tot}$ | Maximum continuous package dissipation |
| $P_{totp}$ | Practical power dissipation |
| $t_d$ | Delay time |
| $t_f$ | Fall time |
| $t_{off}$ | Turn-off time ($t_{off} = t_f + t_{stg}$) |
| $t_{on}$ | Turn-on time ($t_{on} = t_d + t_r$) |
| $t_r$ | Rise time |
| $T_{stg}$ | Storage time |
| $T_{amb}$ | Ambient temperature |
| $T_{case}$ | Case temperature |
| $T_j$ | Junction temperature |
| $T_{stg}$ | Storage temperature |
| $V_{BE}$ | Base-emitter voltage |
| $V_{BE(ON)}$ | Base-emitter turn-on voltage |
| $V_{BE(sat)}$ | Base-emitter saturation voltage |
| $V_{(BR)CBO}$ | Collector-base breakdown voltage |
| $V_{(BR)CEO}$ | Collector-emitter breakdown voltage |
| $V_{(BR)EBO}$ | Emitter-base breakdown voltage |
| $V_{CB}$ | Collector-base voltage |
| $V_{CBO}$ | Collector-base voltage with emitter open ($I_E = 0$) |
| $V_{CEO}$ | Collector-emitter voltage with base open ($I_B = 0$) |
| $V_{CEO(sus)}$ | Collector-emitter sustaining voltage |
| $V_{CE(sat)}$ | Collector-emitter saturation voltage |

Zetex is the largest UK-owned specialist discrete semiconductor manufacturer. Freed from the constraints of a large integrated company — after a recent management-led buy-out — Zetex (formerly Ferranti) can focus more closely on meeting marketing needs.

The company, now in industrial partnership with Telemetrix, provides the best possible discrete components technology and service — all too often a low priority to other semiconductor manufacturers.

Products are based on bipolar and MOSFET chip technology offered in a variety of assemblies suitable for either thru-hole or surface mount applications, for example our Super E-line and SOT-23 ranges, which offer exceptional performance in compact packages.

Zetex's 60,000 square feet production area features class 100 clean rooms with SPC, ESD and PPM programs in place to ensure consistent product quality. All this is now backed up by a dedicated sales and marketing team including full technical and applications support.

For more information on the company and its products, contact your nearest sales office or agent.

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