Technical Handbook

SUPER E-LINE TRANSISTORS

FERRANTI
Semiconductors

Printed in England HK&R

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Super E-line transistors

GENERAL INFORMATION

This product guide contains full data on the Ferranti 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 Ferranti 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 Ferranti 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' Ferranti specifications to suit individual customer requirements for:

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

(b) Customer procurement specifications.

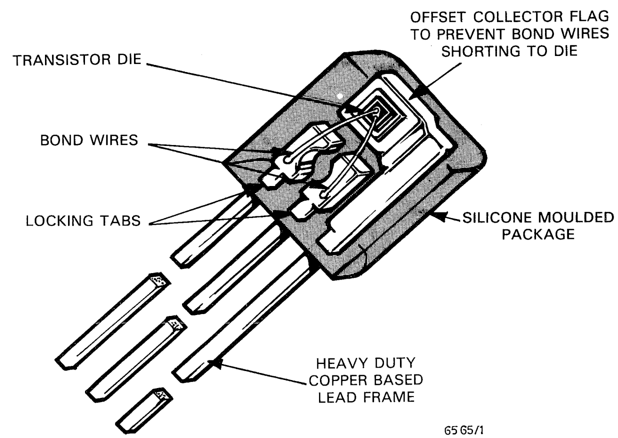
Device pricing will be dependant on the basic type, additional work involved, test yield and the quantity required.

PRODUCT DESCRIPTION

DESIGN FEATURES

The Ferranti 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 Ferranti 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

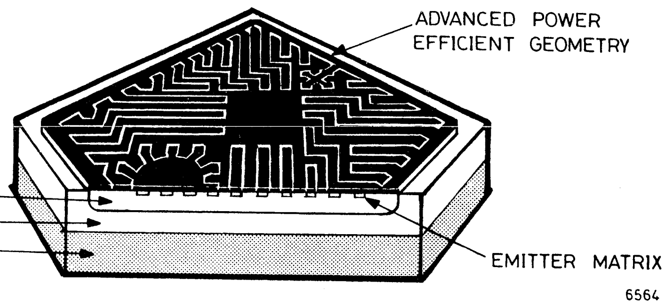
The silicone plastic used for the Ferranti E-line encapsulation protects the active semiconductor chip from exposure to corrosive agents, moisture and extreme enironmental conditions.

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 Ferranti 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 Ferranti 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. Ferranti 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, Ferranti Super E-line transistors out perform similar types of plastic transistors. In addition to the wide range of industry standard types, Ferranti 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 applicatios 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 300V
- $I_C=500mA$
- 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 SE 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) Suffix 'STZ' for product taped and folded (Ammo pack).

(c) Orientation (option A or B).

e.g. ZTX650STOA.

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

For pricing, ordering or technical information, contact:

Discrete Component Marketing (061-624 0515)
or your nearest Ferranti Sales Office.

QUALITY ASSURANCE

The Ferranti E-line transistor range has been designed to reproduce the electrical and environmental qualities of metal-can devices with added benefits of the product consistency normally associated with automated production techniques and the consequent cost savings.

Ferranti has been successful in perfecting the E-line device to achieve the standards of quality and reliability necessary for their release to the appropriate British Standards specification for electronic components of assessed quality.

In order to qualify for BS approval the E-line device must be subjected to, and have survived without degradation, the following environmental tests:

1. *Rapid change of temperature, thermal shock in air*

   Device cycled from −55 to +175°C for 400 excursions.

2. *Damp heat climatic test with reverse bias*

   Device subjected for 2000 hours to a relative humidity of 98% at a temperature of 55°C, with the collector-base reverse biased.

3. *Thermally accelerated test*

   Device subjected to a temperature of 230°C with collector-base and emitter-base reverse biased for a duration of 160 hours minimum.

It is important to note that **all** the E-line devices detailed in this product guide are manufactured with the same degree of care and process quality as those subject to BS9300 qualification procedures.

The Ferranti quality assurance programme is, in general, linked to the British Standards scheme and the range of available standards may be listed as:

1 **Commercial** – with factory acceptance quality levels (AQL).

1 **BS Approval** – to BS9300 series – categories P and Q.

3 **CECC harmonised European Standard** – 50000 series approval (categories F and L).

4 **CECC** – 50000 series approval +20 year life requirement to meet British Telecom D3007 approval.

5 **Release to Defence Standard** (DEF STAN 05-21) conditions i.e. 6/49 release.

6 **Release to Civil Aviation Authority** (CAA) conditions.

7 **CV/DEF STAN** specifications where the appropriate device is approved – until such time as they are incorporated into the BS scheme.

8 **Non-approved types** – where Ferranti 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 type being available from Ferranti. Similarly, we may supply on a partial release basis such as 'release to group A tests only' etc.

If any additional information on the Ferranti quality assurance programme is required contact: **Discrete Component Marketing (061-624 0515).**

Super E-line transistors

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MPSA93			4	SE29
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	BS9365	F139(Q)		
	BS9365	F205(F)§		
ZTX451	BS9365	F138(P)	2	SE39
	BS9365	F140(Q)		
	BS9365	F205(F)§		
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ZTX455			2,4	SE51
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ZTX551	BS9365	F144(F)*	2	SE63
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ZTX557			2,4	SE75
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ZTX602			3	SE89
ZTX603			3	SE89
ZTX604			3	SE91
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ZTX651	50002	138(F)*	1	SE99

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Device type	BS/CECC number		Selector table	Technical data (page No.)
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ZTX653	50002	138(F)*	1	SE99
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ZTX753	50002	137(F)*	1	SE127
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ZTX757			4	SE143

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

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
						I_C	I_B	Min.	I_C		I_C		
	V	V	A	A	V	A	A		A	MHz	mA	mW	
NPN													
ZTX653	120	100	2	6	0.5	2	0.2	40	2	140	100	1000	ZTX753
ZTX652	100	80	2	6	0.5	2	0.2	40	2	140	100	1000	ZTX752
ZTX651	80	60	2	6	0.5	2	0.2	25	2	140	100	1000	ZTX751
ZTX650	60	45	2	6	0.5	2	0.2	25	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/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 A	I_B A	h_{FE} Min.	at I_C A	Min. f_T MHz	at 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	140	1	2	0.3	100	10	50	300	100	50	1000	ZTX455
ZTX554	140	120	1	2	0.3	100	10	50	300	100	50	1000	ZTX454
ZTX553	120	100	1	2	0.7	150	15	40	150	150	50	1000	ZTX453
ZTX552	100	80	1	2	0.7	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

TABLE 3 : 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	V_{CEO} V	Max. I_C cont. A	Max. I_{CM} A	Max. $V_{CE(sat)}$ at V	I_C mA	I_B mA	h_{FE} Min.	Max.	at I_C mA	f_T MHz Min.	P_{tot} at T_{amb} = 25°C mW
ZTX600	160	140	1	4	1.2	1000	10	2000	100,000	500	150	1000
ZTX601	180	160	1	4	1.2	1000	10	2000	100,000	500	150	1000
ZTX602	80	60	1	4	1	1000	1	5000	–	1000	150	1000
ZTX603	100	80	1	4	1	1000	1	5000	–	1000	150	1000
ZTX604	120	100	1	4	1.5	1000	1	5000	–	500	150	1000
ZTX605	140	120	1	4	1.5	1000	1	5000	–	500	150	1000

Super E-line transistors

TABLE 4 : 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_{CEO}	Max I_C	Max $V_{CE(sat)}$	at I_C	I_B	h_{FE} Min	Max	at I_C	Max I_{CBO}	at V_{CB}	P_{tot} at T_{amb} = 25°C	Complement
	V	V	mA	V	mA	mA			mA	µA	V	mW	
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													
BF4935P	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
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

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NPN silicon planar high voltage transistors

BF391 BF392 BF393

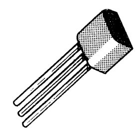
DESCRIPTION

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 ($T_{amb}=25°C$) at $T_{case}=25°C$	P_{tot}		625 1.5		mW W
Operating and storage temperature range	T_j:T_{stg}		−55 to +175		°C

THERMAL CHARACTERISTICS

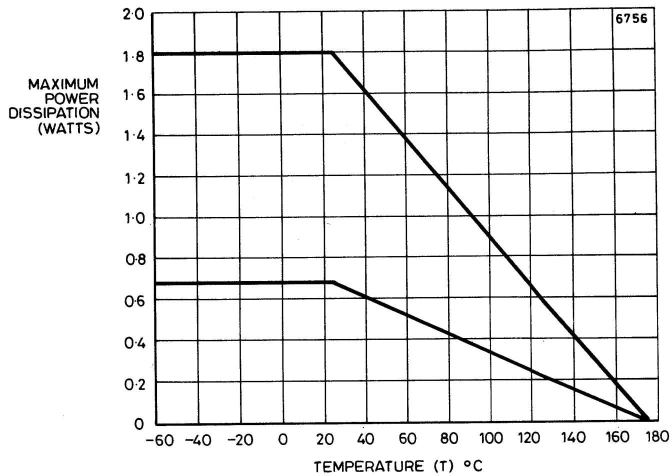
Parameter	Symbol	Maximum	Unit
Thermal resistance: Junction to ambient	$R_{th(j\text{-}amb)}$	220	°C/W
Junction to case	$R_{th(j\text{-}case)}$	80	°C/W

BF391 BF392 BF393

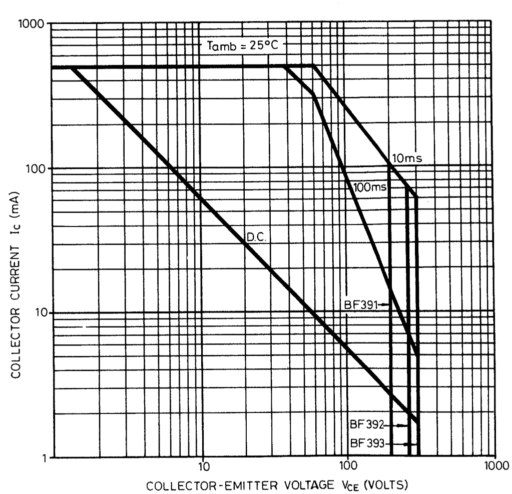
ELECTRICAL CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

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	$I_C = 10mA$, $V_{CE} = 20V$ $f = 20MHz$
Collector-base capacitance	C_{re}	–	1.6	–	1.6	–	1.6	pF	$V_{CE} = 60V$, $I_E = 0$ $f = 1MHz$

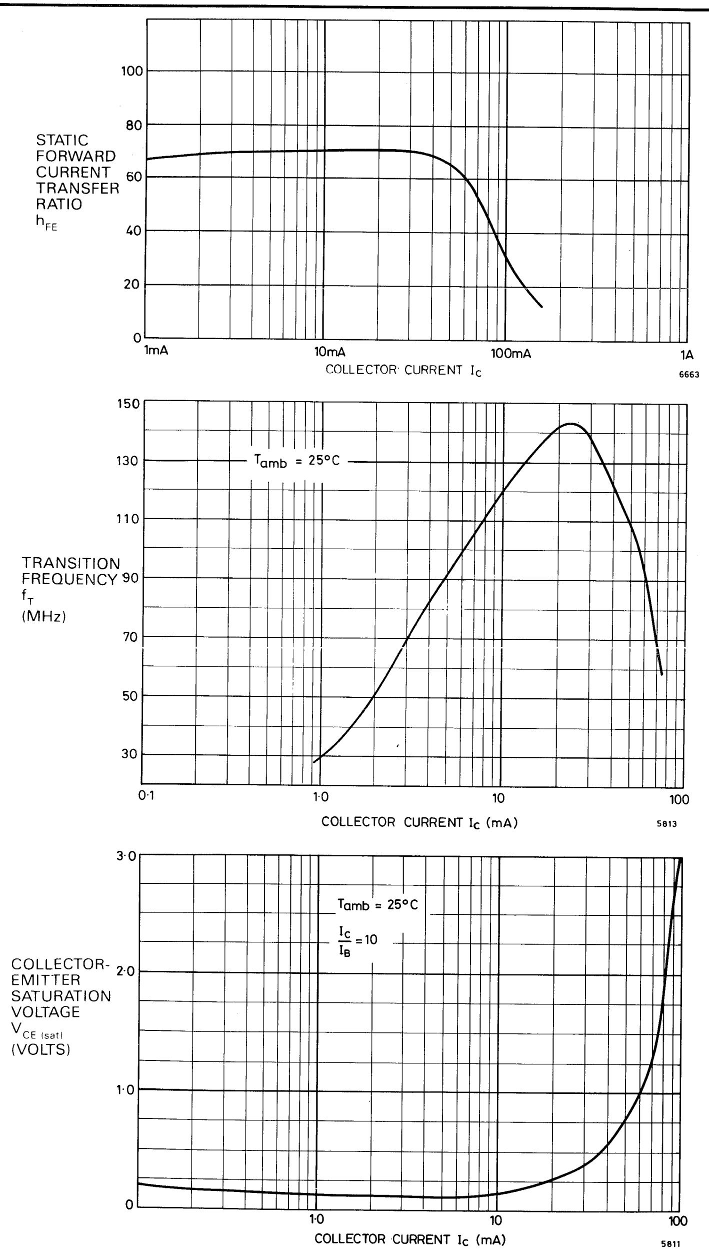
*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ⩽2%.



Dissipation derating curve



Safe operating area (single pulse)



Typical characteristics

PNP silicon planar high voltage transistors

BF491 BF492 BF493

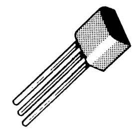
DESCRIPTION

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 ($T_{amb}=25°C$) at $T_{case}=25°C$	P_{tot}	625 1.5			mW W
Operating and storage temperature range	T_j:T_{stg}	−55 to +175			°C

THERMAL CHARACTERISTICS

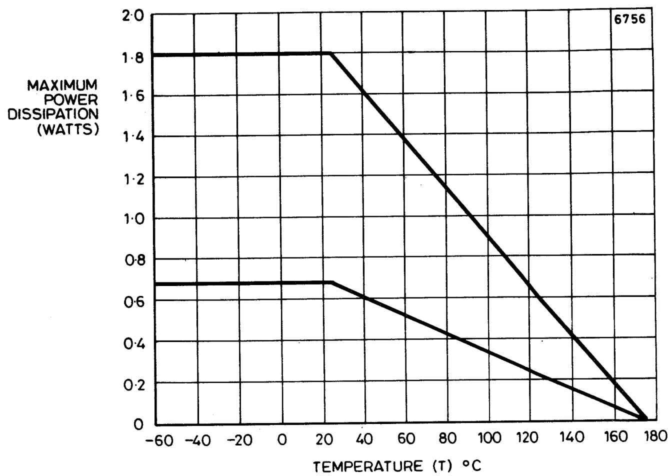
Parameter	Symbol	Maximum	Unit
Thermal resistance: Junction to ambient	$R_{th(j\text{-}amb)}$	220	°C/W
Junction to case	$R_{th(j\text{-}case)}$	80	°C/W

BF491 BF492 BF493

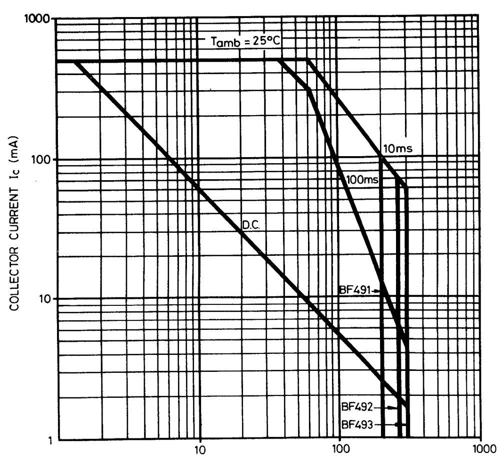
ELECTRICAL CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

Parameter	Symbol	BF491		BF492		BF493		Unit	Conditions
		Min.	Max.	Min.	Max.	Min.	Max.		
Collector-base breakdown voltage	$V_{(BR)CBO}$	−200	–	−250	–	−300	–	V	$I_C = -100\mu A$ $I_E = 0$
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	$I_C = -10mA$ $V_{CE} = -20V$ $f = 20MHz$
Collector-base capacitance	C_{re}	–	1.6	–	1.6	–	1.6	pF	$V_{CE} = -100V$ $I_E = 0$ $f = 1MHz$

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

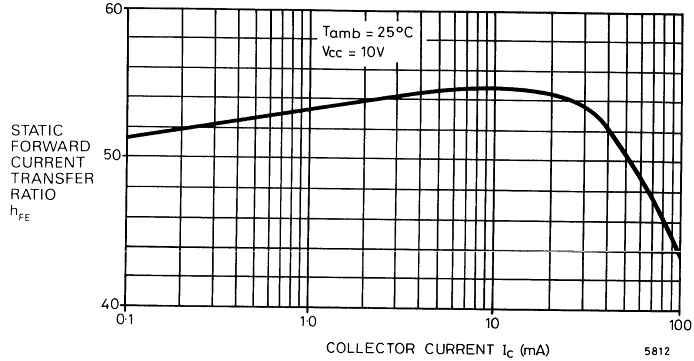


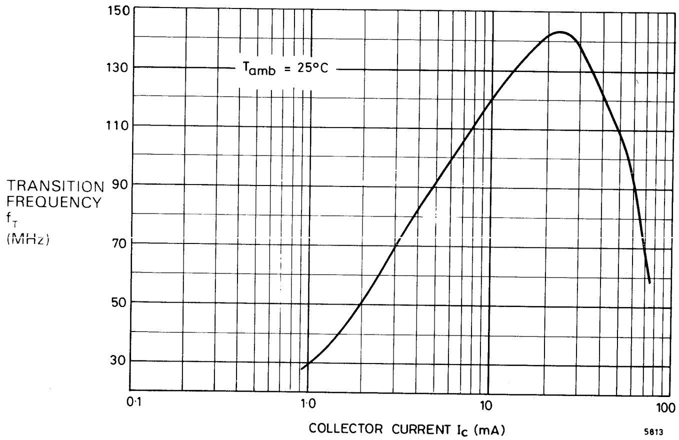
Dissipation derating curve

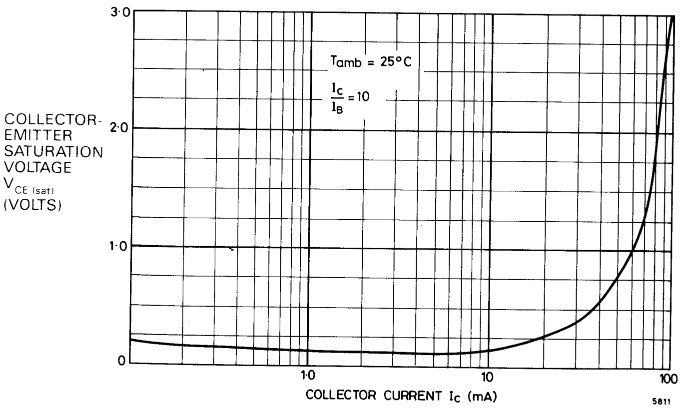


Safe operating area (single pulse)

BF491 BF492 BF493







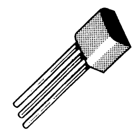
Typical characteristics

PNP silicon planar high voltage transistor

BF493SP

FEATURES

- 350V V_{CEO}
- Low leakage currents



Plastic E-line
(TO-92 compatible)

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.

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 $T_{amb}=25°C$ at $T_{case}=25°C$	P_{tot}	625 1.5	mW 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

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	$I_C = -10mA$, $V_{CE} = -20V$ $f = 20MHz$
Collector-base capacitance	C_{re}	–	1.6	pF	$V_{CE} = -100V$, $I_E = 0$ $f = 1MHz$

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

Refer to BF491/2/3 for graphs

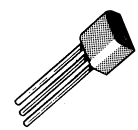
NPN silicon planar high voltage transistors

MPSA42
MPSA43

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.



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 MPSA92 and MPSA93.

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	MPSA42	MPSA43	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 $T_{amb}=25°C$ at $T_{case}=25°C$	P_{tot}	680 1.8		mW W
Operating and storage temp. range	T_j;T_{stg}	−55 to +175		°C

THERMAL CHARACTERISTICS

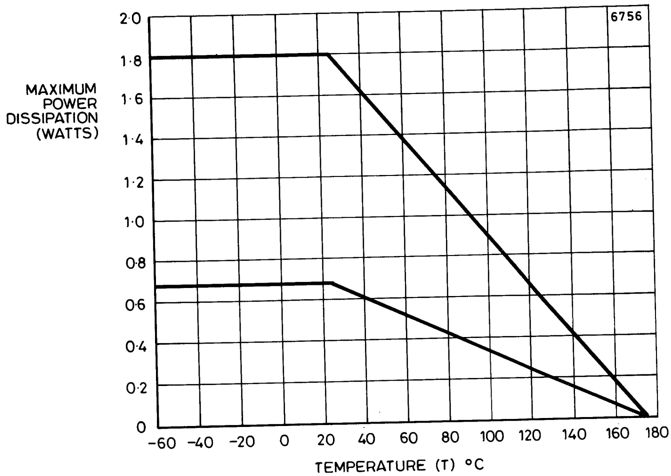
Parameter	Symbol	Maximum	Unit
Thermal resistance Junction to ambient Junction to case	$R_{th(j-amb)}$ $R_{th(j-case)}$	220 80	°C/W °C/W

MPSA42 MPSA43

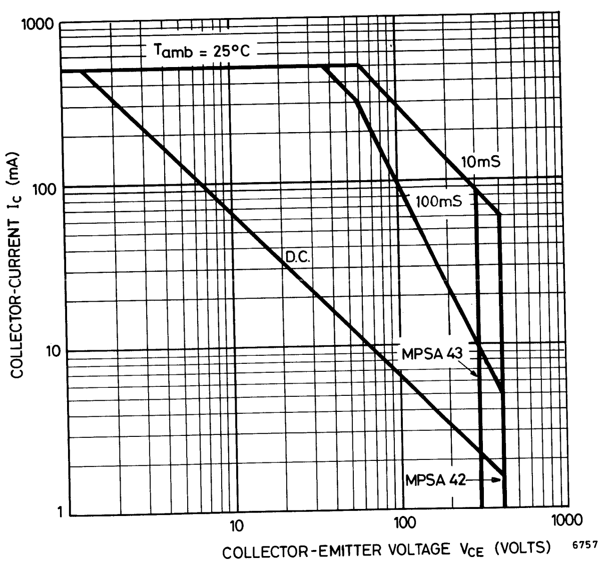
CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

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	$I_C = 10mA$, $V_{CE} = 20V$, $f = 20MHz$
Output capacitance	C_{obo}	–	6	–	6	pF	$V_{CB} = 20V$, $I_E = 0$, $f = 1MHz$

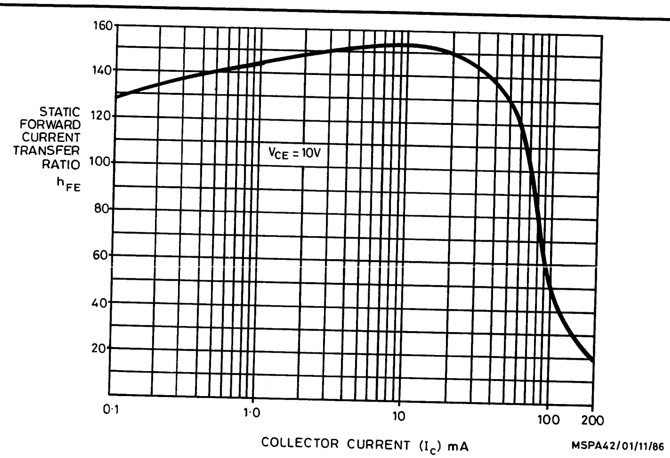
*Measured under pulsed conditions. Pulse width = 200μs. Duty cycle = 2%.

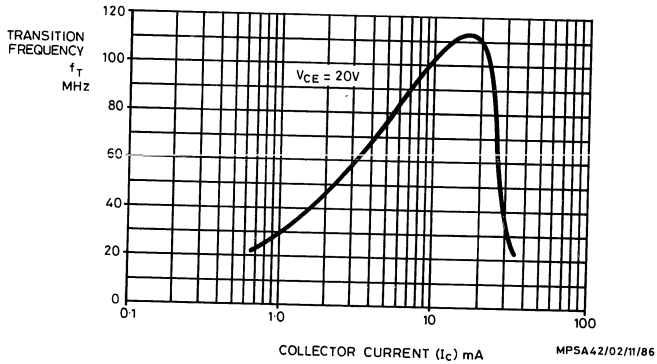


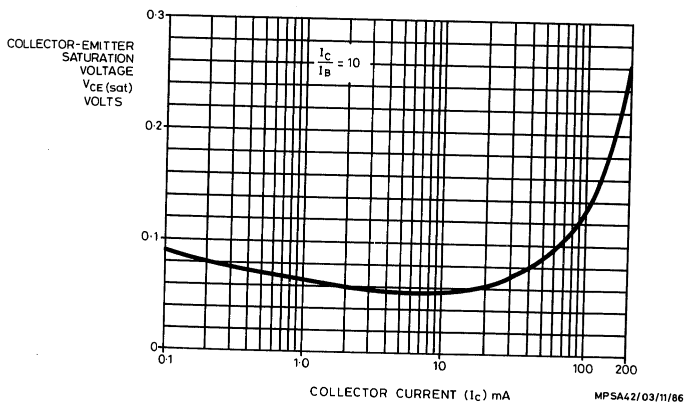
Dissipation derating curve



Safe operating area (Single Pulse)







Typical characteristics

PNP silicon planar high voltage transistors

MPSA92
MPSA93

DESCRIPTION

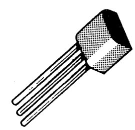
These plastic encapsulated, general purpose transistors are designed for applications requiring high breakdown voltages, low saturation voltages, and low capacitance.

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 $T_{amb}=25°C$ at $T_{case}=25°C$	P_{tot}	680 1.8		mW W
Operating and storage temp. range	$T_j;T_{stg}$	−55 to +175		°C

THERMAL CHARACTERISTICS

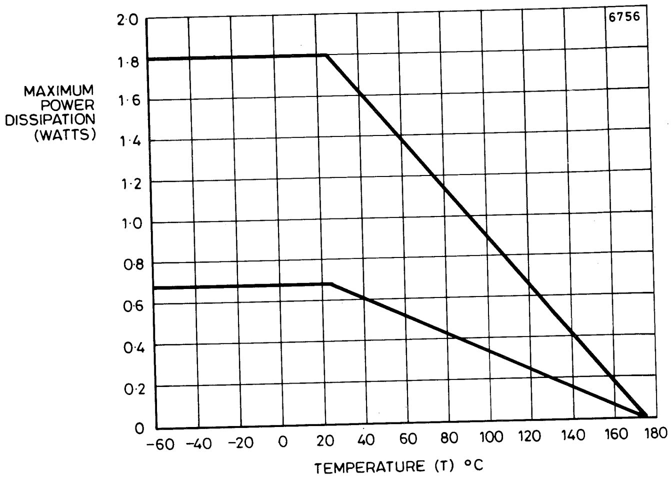
Parameter	Symbol	Maximum	Unit
Thermal resistance Junction to ambient Junction to case	$R_{th(j-amb)}$ $R_{th(j-case)}$	220 80	°C/W °C/W

MPSA92 MPSA93

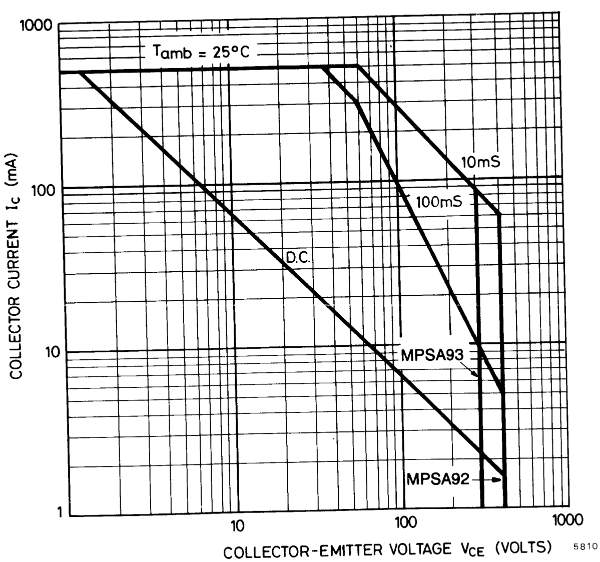
CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

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	$I_C = -20mA$ $I_B = -2mA$
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	–		$I_C = -10mA$ $V_{CE} = -10V$*
		25	–	30	150		$I_C = -30mA$ $V_{CE} = -10V$*
Transition frequency	f_T	50	–	50	–	MHz	$I_C = -10mA$ $V_{CE} = -20V$ $f = 20MHz$
Output capacitance	C_{obo}	–	6	–	8	pF	$V_{CB} = -20V$ $f = 1MHz$

*Measured under pulsed conditions. Pulse width $= 200\mu s$. Duty cycle $= 2\%$.

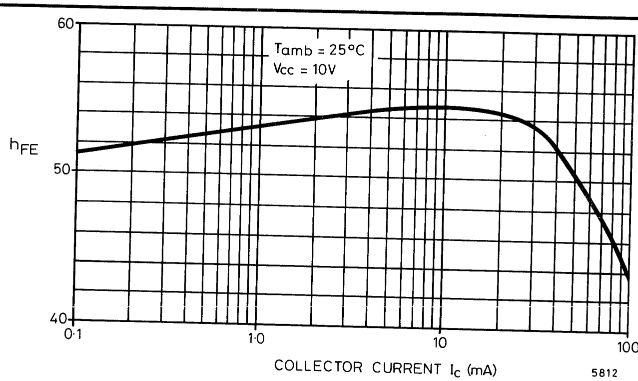


Dissipation derating curve

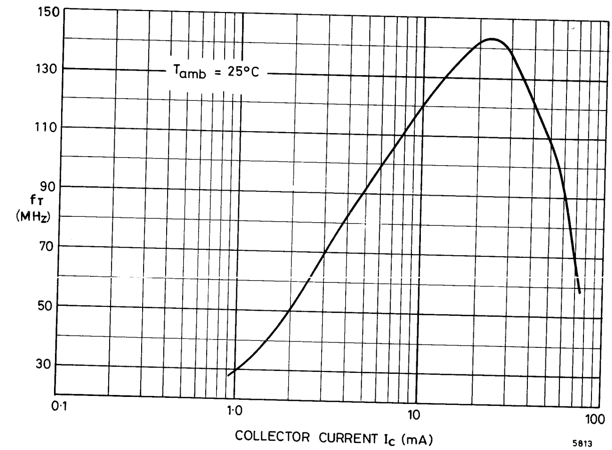


Safe operating area (Single Pulse)

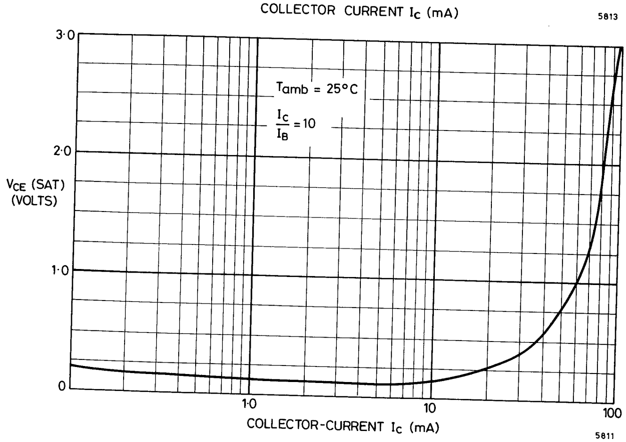
STATIC FORWARD CURRENT TRANSFER RATIO



TRANSITION FREQUENCY



COLLECTOR-EMITTER SATURATION VOLTAGE



Typical characteristics

NPN silicon planar medium power transistor

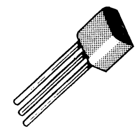
ZTX449

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 $T_{amb}=25°C$ at $T_{case}=25°C$	P_{tot}	1 2	W W
Operating and storage temperature range		−55 to +200	°C

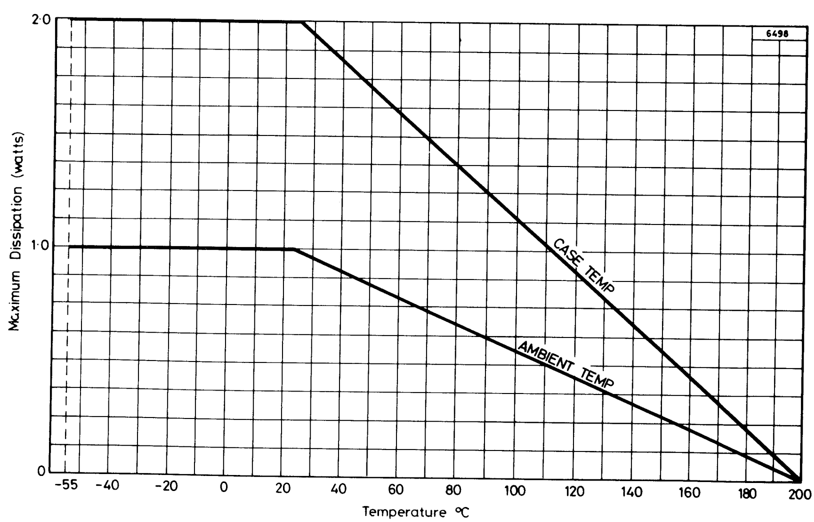
Note: Measured under pulsed conditions. Pulse width = 3400μs. Duty cycle ⩽ 2%.

ZTX449

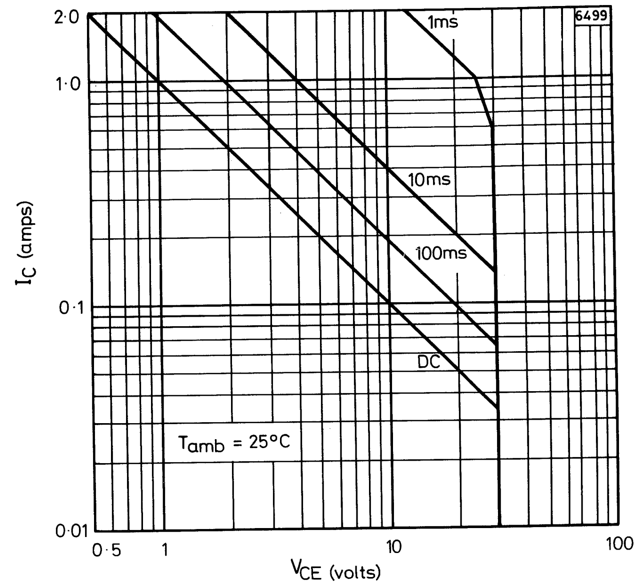
CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

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	$I_C = 50mA$, $V_{CE} = 10V$ $f = 100MHz$
Output capacitance	C_{obo}	–	15	pF	$V_{CB} = 10V$, $f = 1MHz$

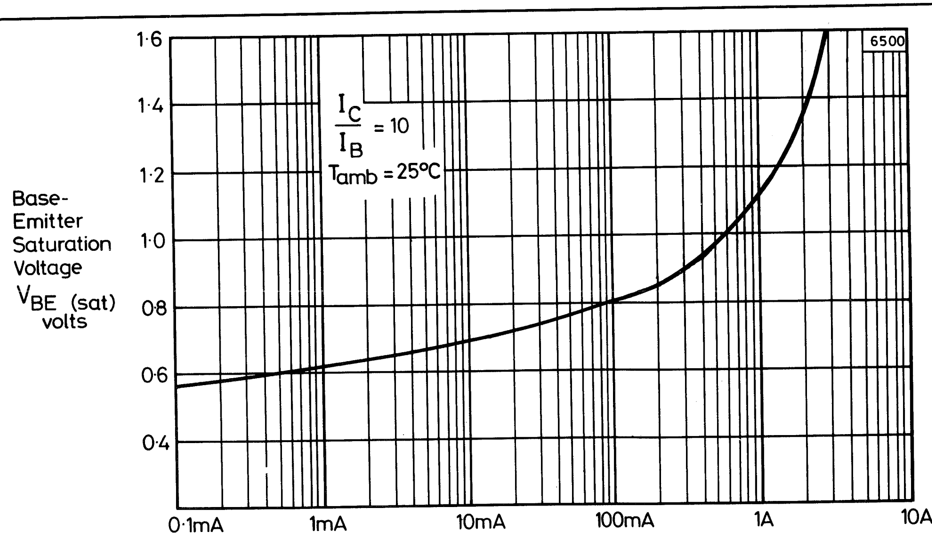
*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ≤ 2%.



Derating curve

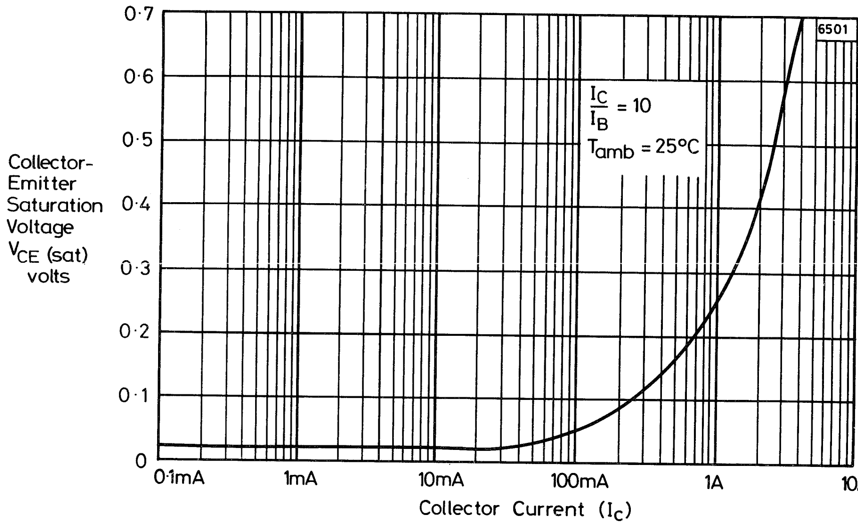


Safe operating area at $T_{amb} = 25°C$ (Single Pulse)

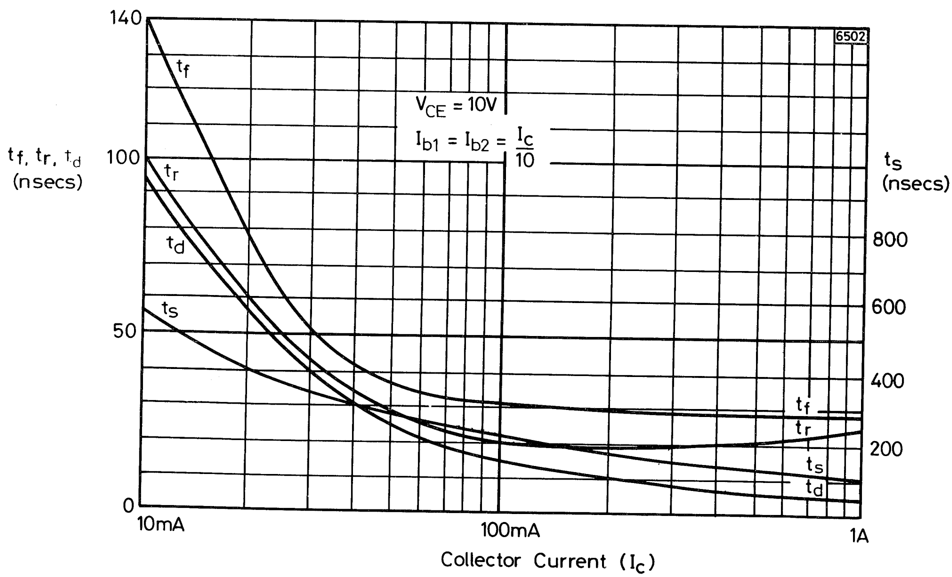


Typical base-emitter saturation voltages plotted against collector current

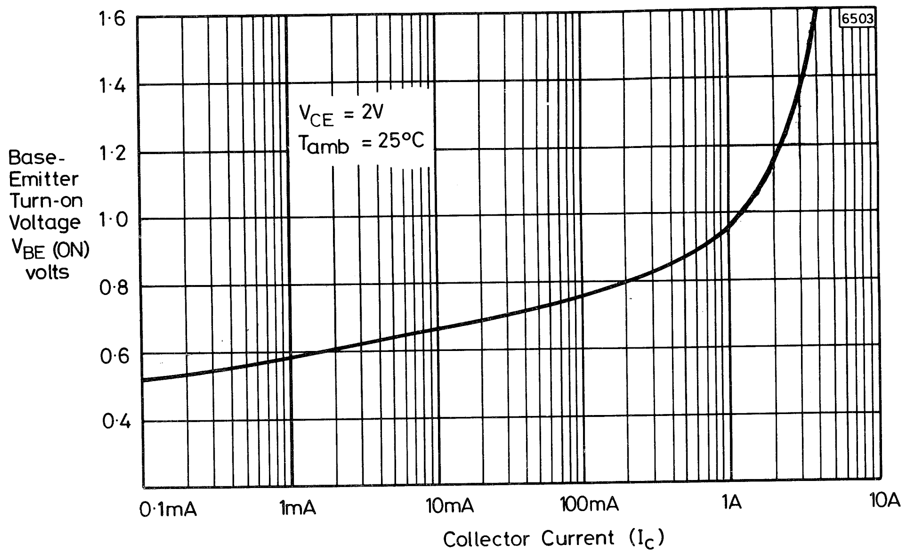
ZTX449



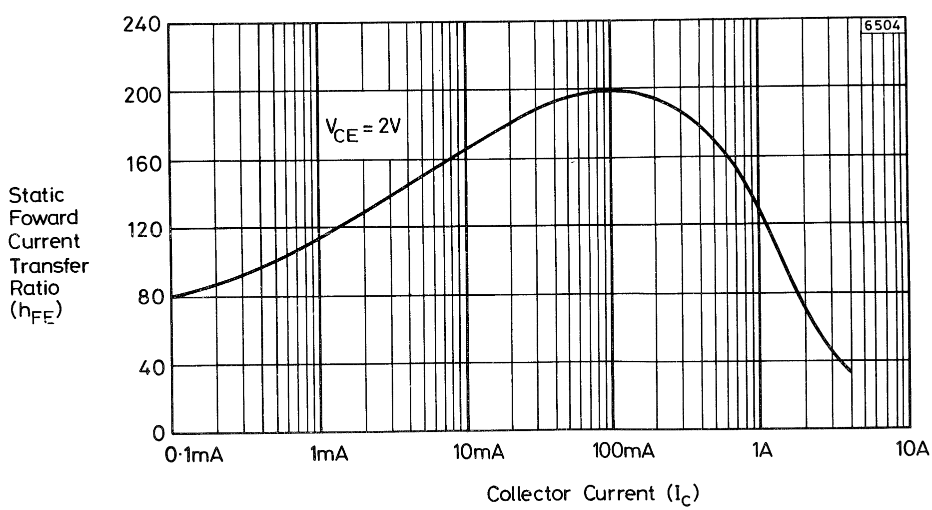
Typical collector-emitter saturation voltages plotted against collector current



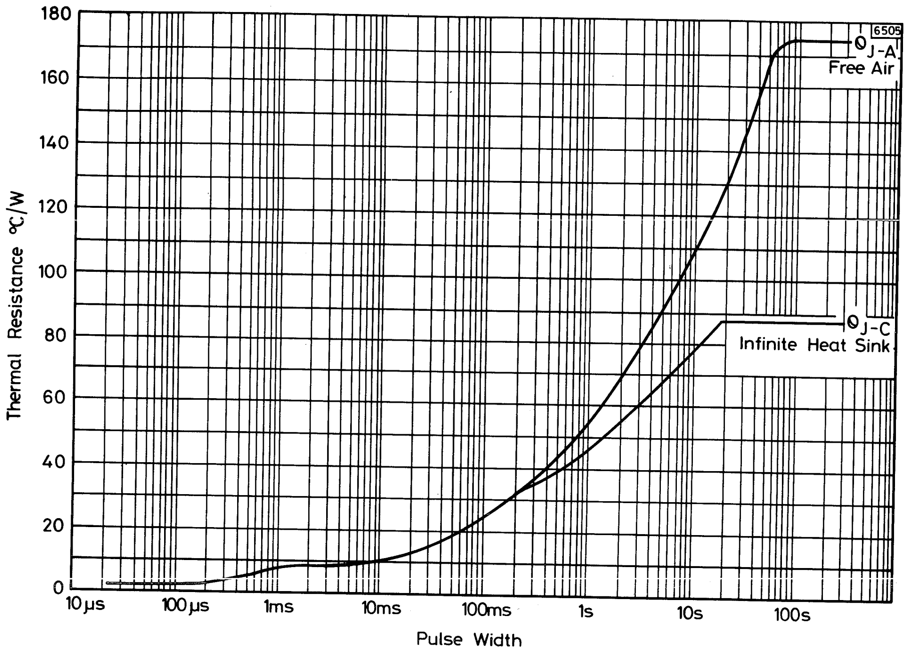
Typical switching speeds



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



Typical static forward current transfer ratio plotted against collector current



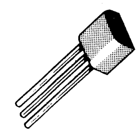
Transient thermal resistance

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



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, 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.

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 F205 - Category F.

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 $T_{amb} = 25°C$ at $T_{case} = 25°C$	P_{tot}	1 2		W W
Operating and storage temperature range		−55 to +200		°C

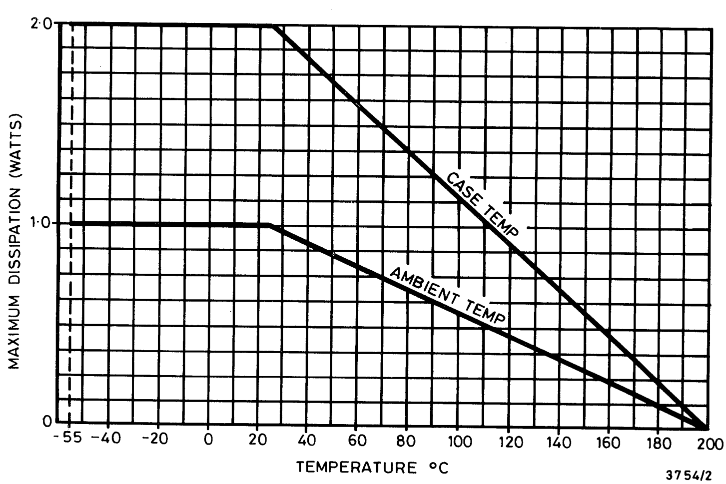
Note: Pulse width = 300μs. Duty cycle ⩽ 2%.

ZTX450 ZTX451

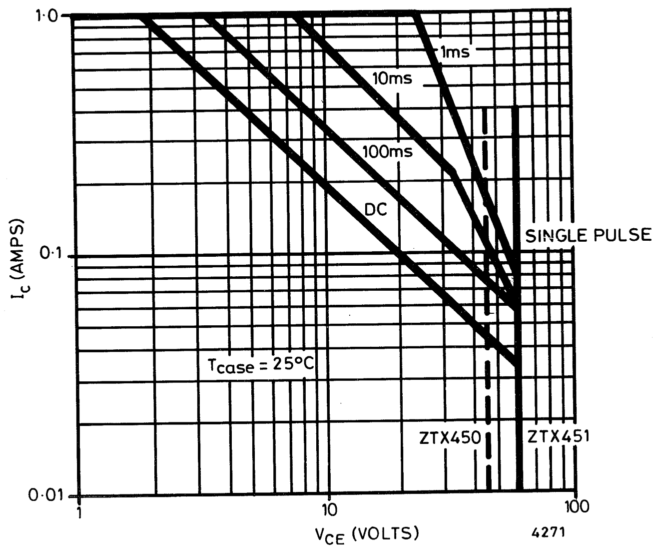
CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

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	$I_C = 50mA$, $V_{CE} = 10V$ f = 100MHz
Output capacitance	C_{obo}	–	15	–	15	pF	$V_{CB} = 10V$, f = 1MHz

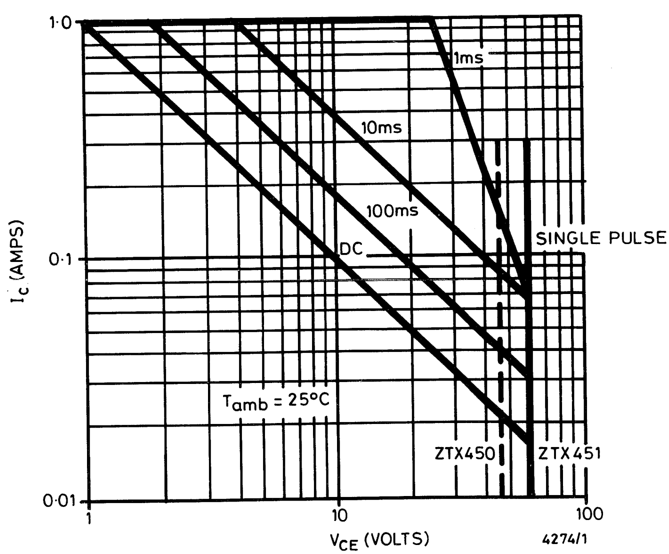
*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ≤ 2%.



Derating curve

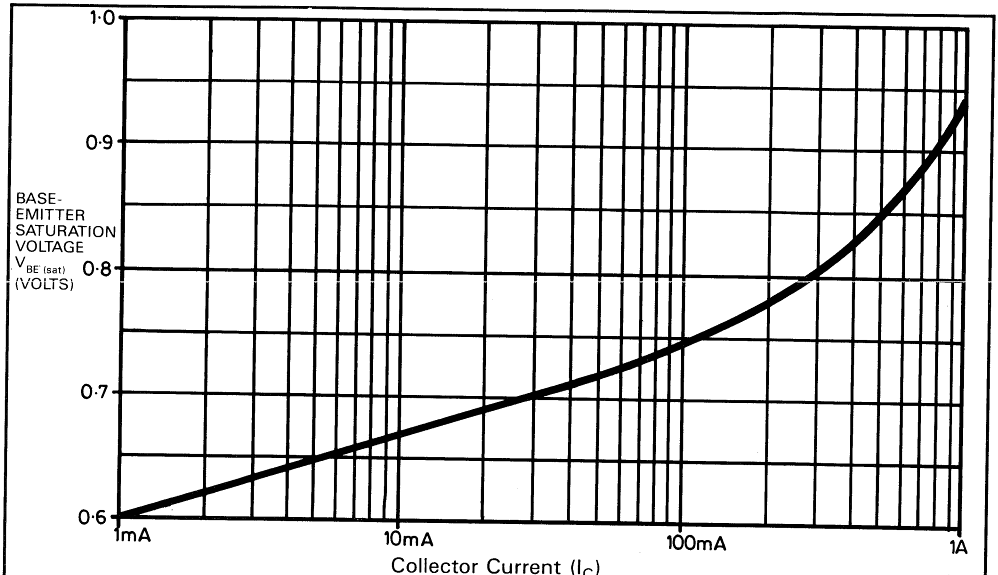


Safe operating area at T_{case} = 25°C (single pulse)

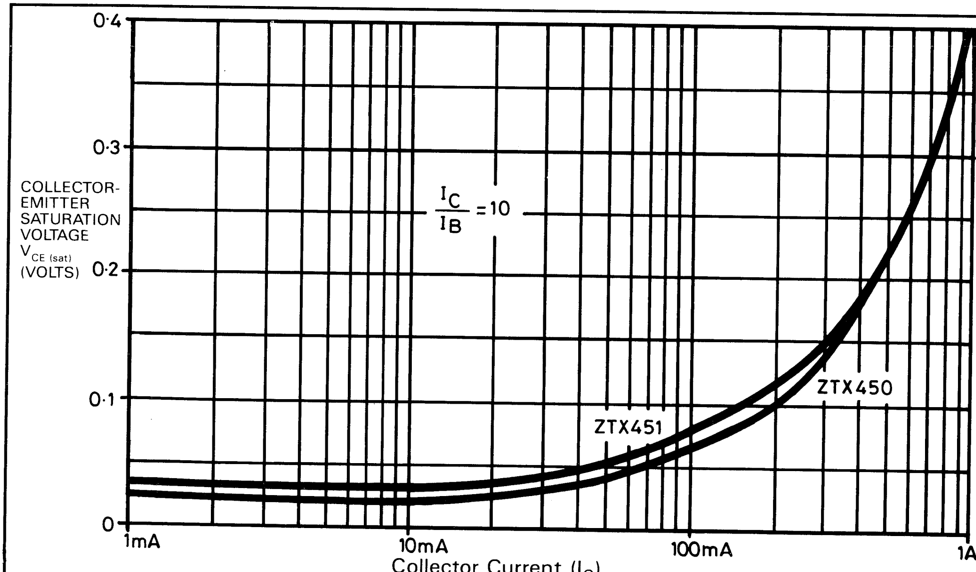


Safe operating area at T_{amb} = 25°C (single pulse)

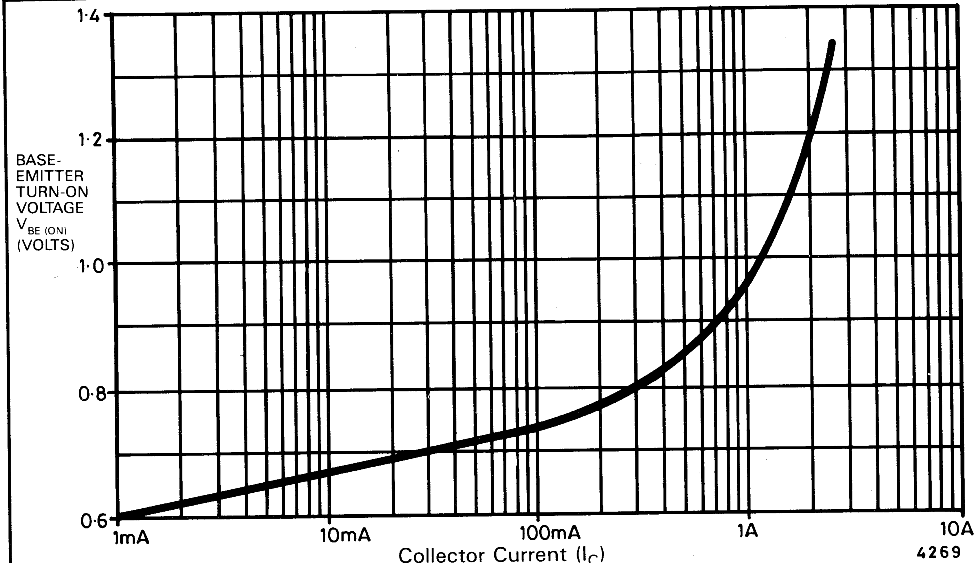
ZTX450 ZTX451



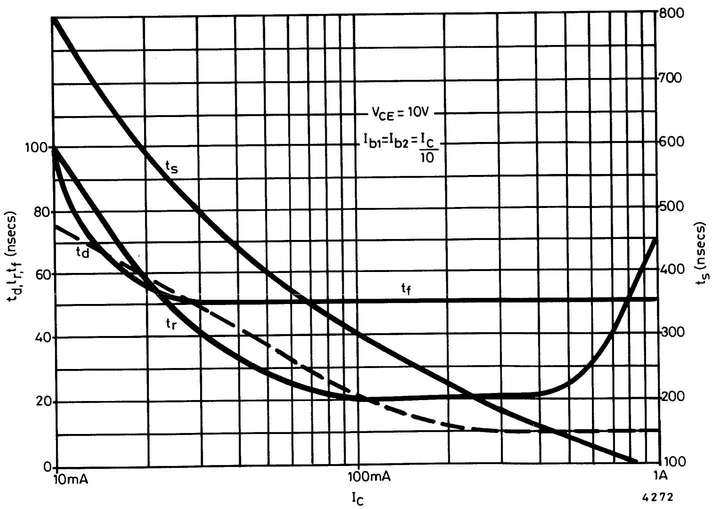
Typical base-emitter saturation voltages plotted against collector current



Typical collector-emitter saturation voltages plotted against collector current

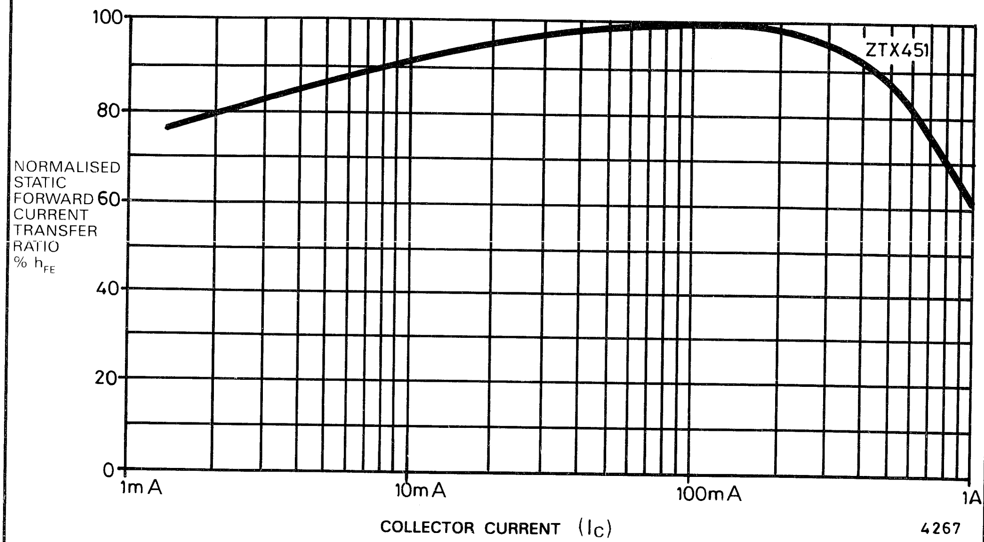


Typical base-emitter turn-on voltages plotted against collector current

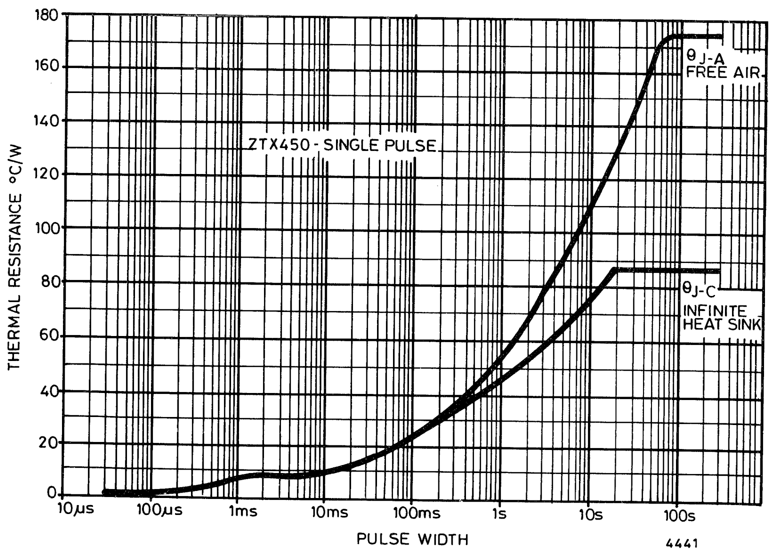


Collector Current (IC)

Typical switching speeds



Typical static forward current transfer ratio plotted against collector current



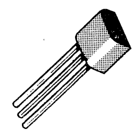
Transient thermal resistance

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 $T_{amb} = 25°C$ at $T_{case} = 25°C$	P_{tot}	1 2		W W
Operating and storage temperature range		−55 to +200		°C

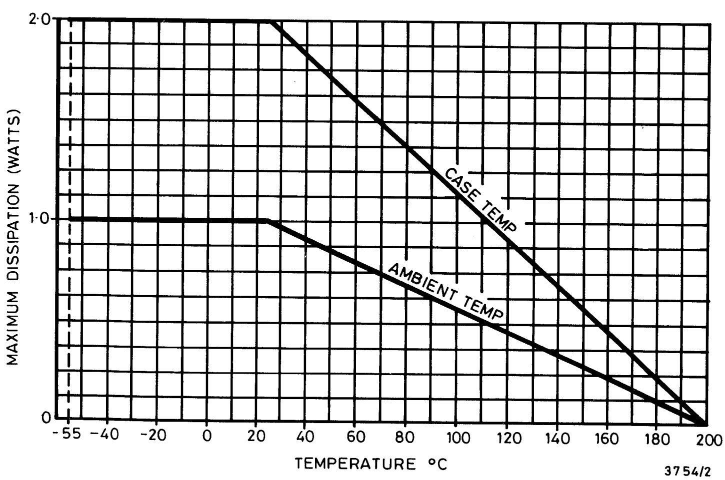
Note: Pulse width = 300μs. Duty cycle ≤ 2%.

ZTX452 ZTX453

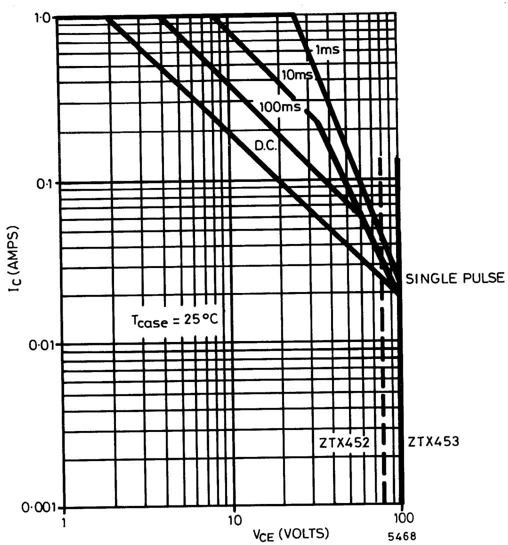
CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

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	$I_C = 50mA$, $V_{CE} = 10V$ f = 100MHz
Output capacitance	C_{obo}	–	15	–	15	pF	$V_{CB} = 10V$, f = 1MHz

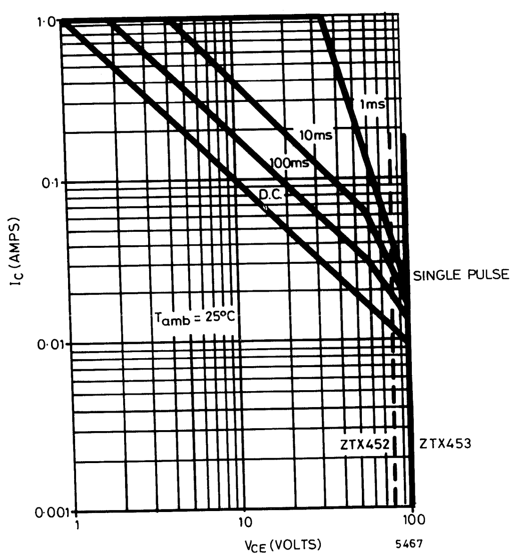
*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ≤ 2%.



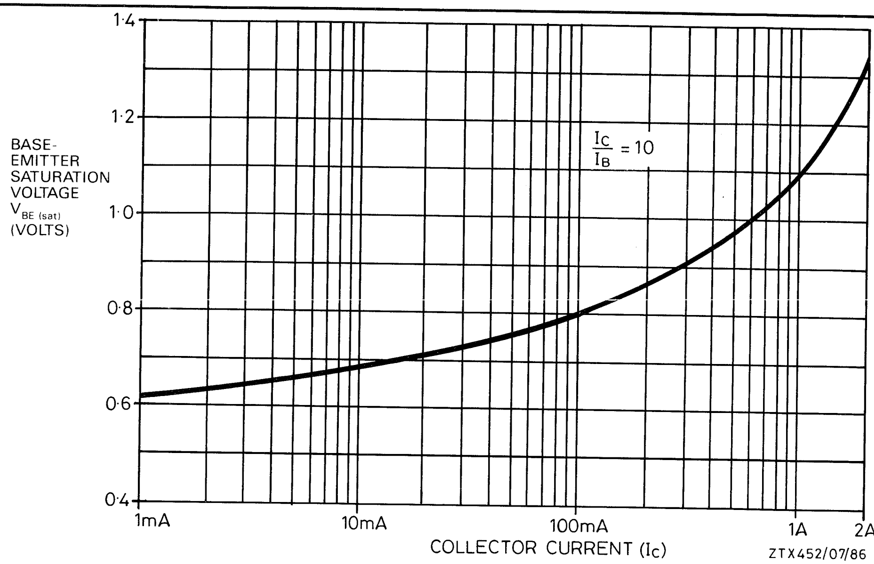
Derating curve



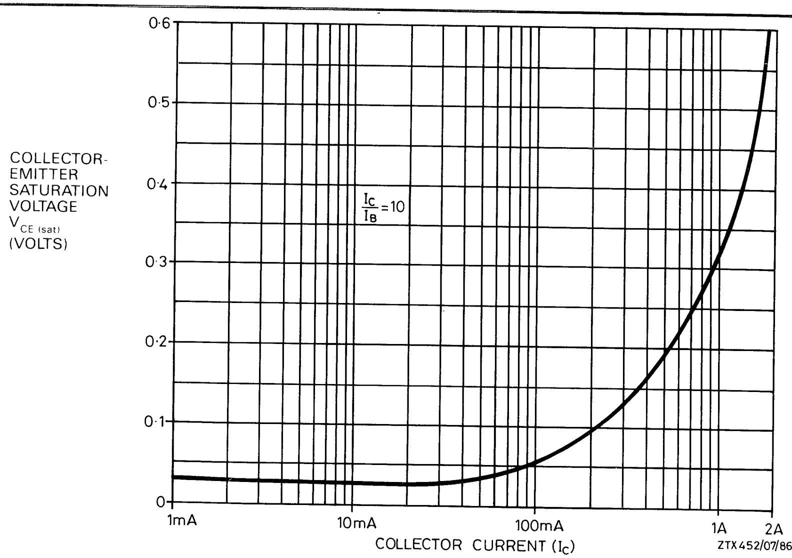
Safe operating area at $T_{CASE} = 25°C$ (Single Pulse)



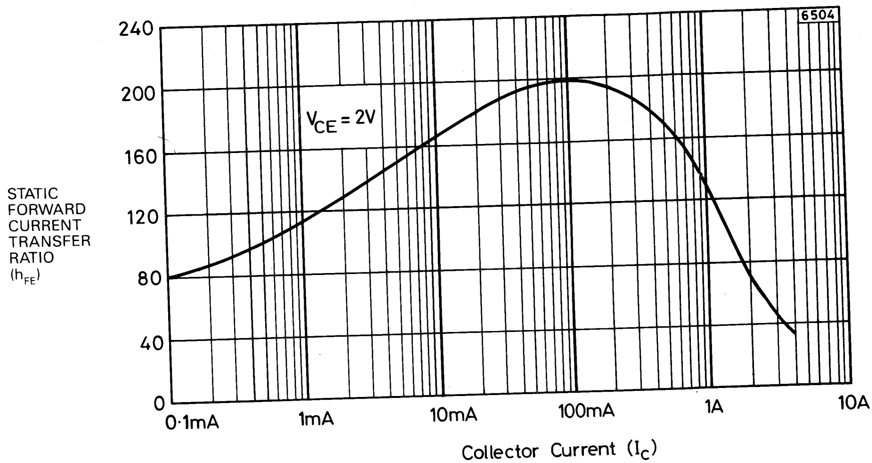
Safe operating area at $T_{amb} = 25°C$ (Single Pulse)



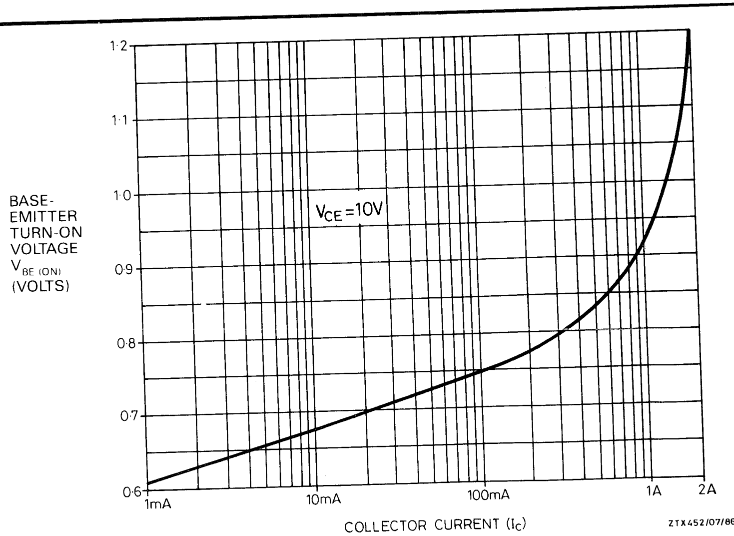
Typical base-emitter saturation voltage plotted against collector current



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

SE50

NPN silicon planar medium power transistors

ZTX454
ZTX455

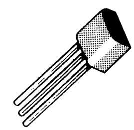
DESCRIPTION

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*	I_{CM}	2		A
Continuous direct current	I_C	1		A
Base current	I_B	200		mA
Power dissipation at $T_{amb} = 25°C$ at $T_{case} = 25°C$	P_{tot}	1 2		W W
Operating and storage temp. range	$T_j;T_{stg}$	−55 to +200		°C

THERMAL CHARACTERISTICS

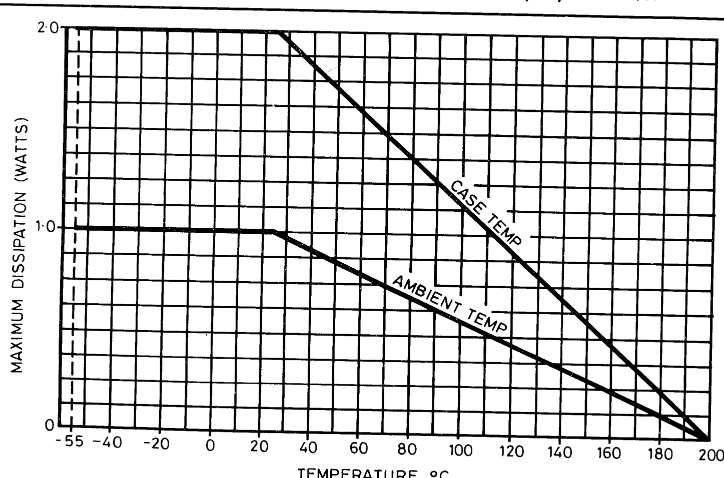
Parameter	Symbol	Maximum	Unit
Thermal resistance: Junction to ambient Junction to case	$R_{th(j-amb)}$ $R_{th(j-case)}$	175 87.5	°C/W °C/W

ZTX454 ZTX455

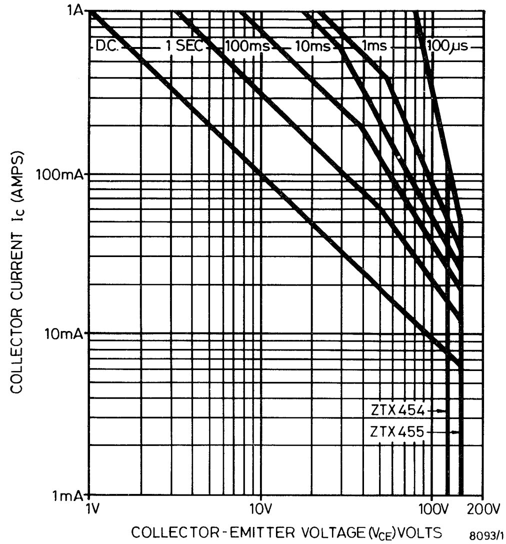
CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

Parameter	Symbol	ZTX454			ZTX455			Unit	Conditions
		Min.	Typ.	Max.	Min.	Typ.	Max.		
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	$I_C = 50mA$, $V_{CE} = 10V$ f = 100MHz
Output capacitance	C_{obo}	–	–	15	–	–	15	pF	$V_{CB} = 10V$, f = 1MHz

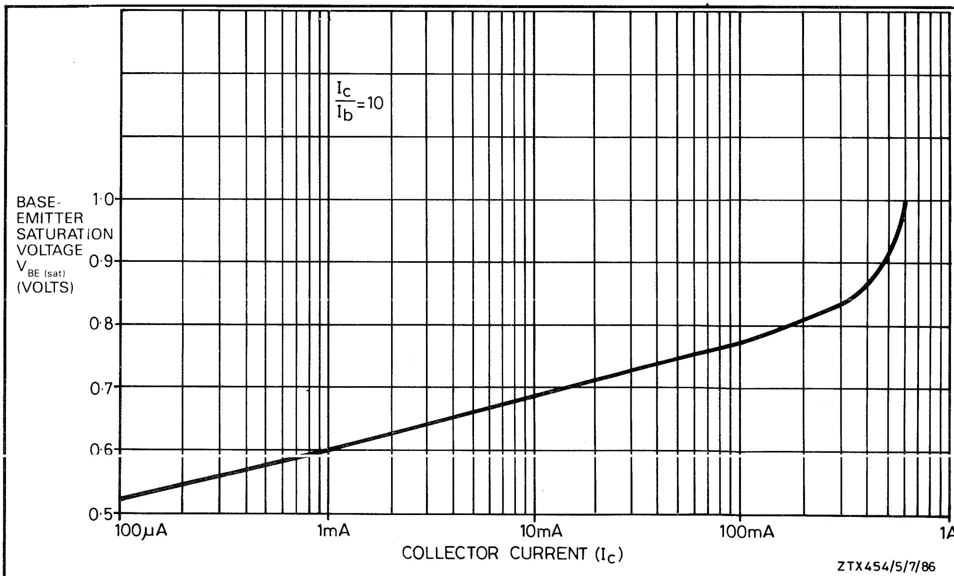
*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle = 2%.



Dissipation derating curve

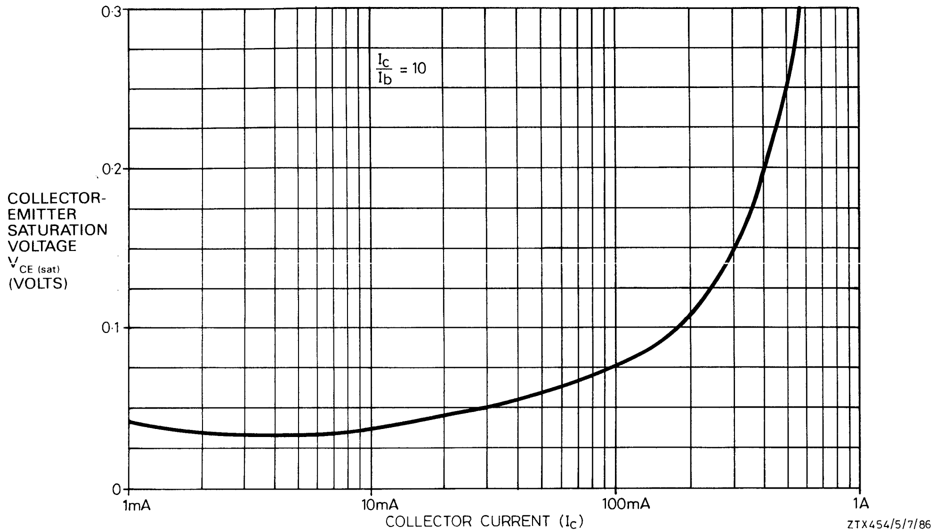


Safe operating area at $T_{amb} = 25°C$ (single-pulse)

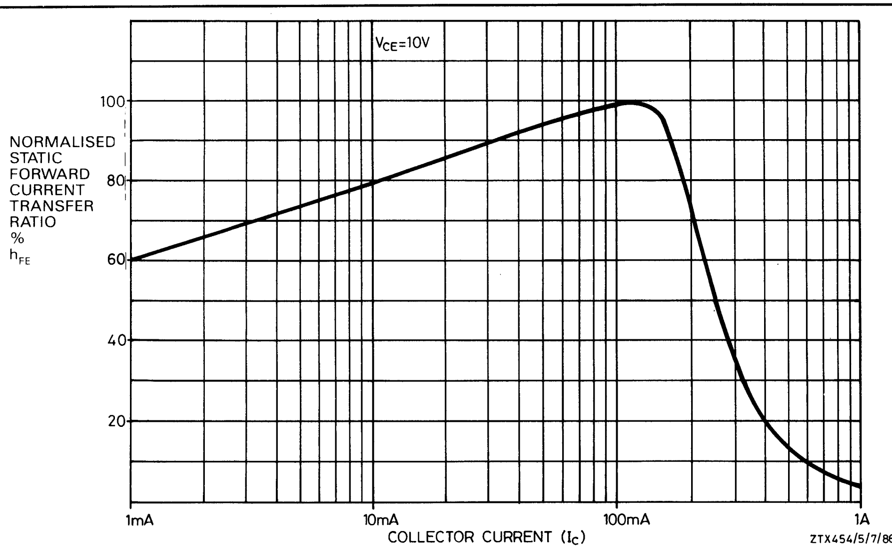


Typical base-emitter saturation voltage plotted against collector current

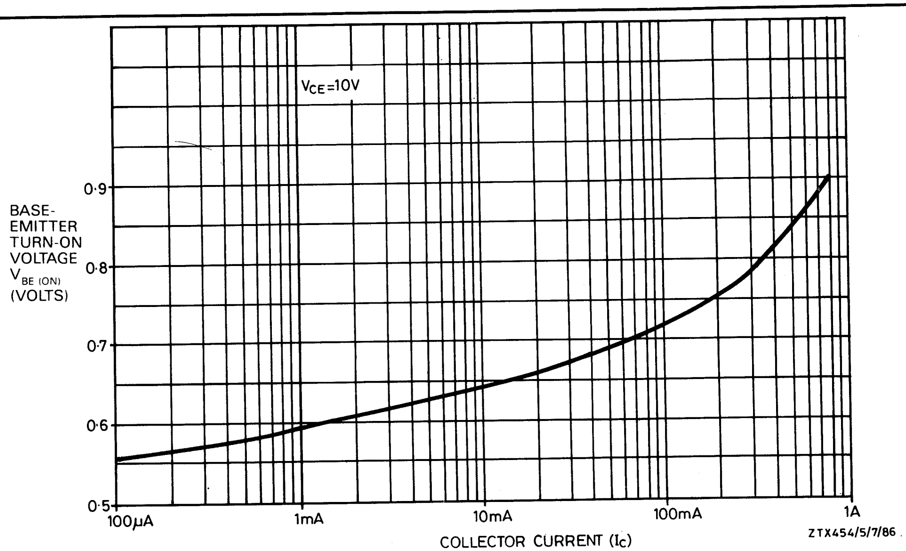
ZTX454 ZTX455



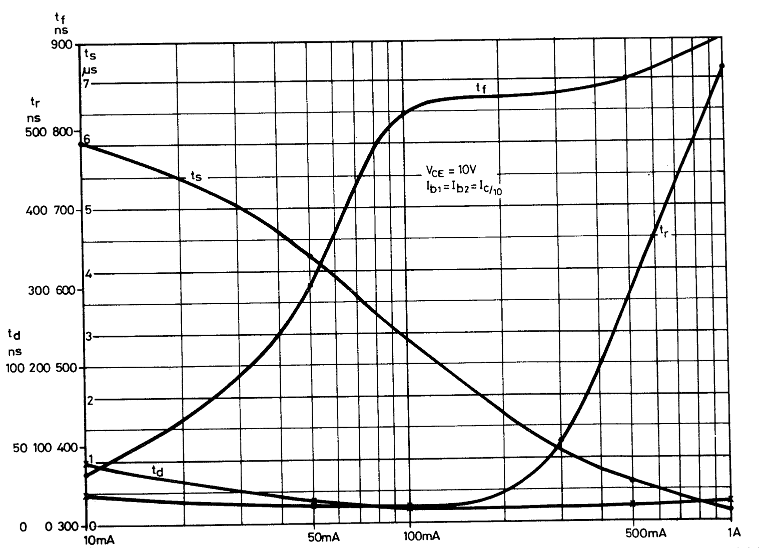
Typical collector-emitter saturation voltage plotted against collector current



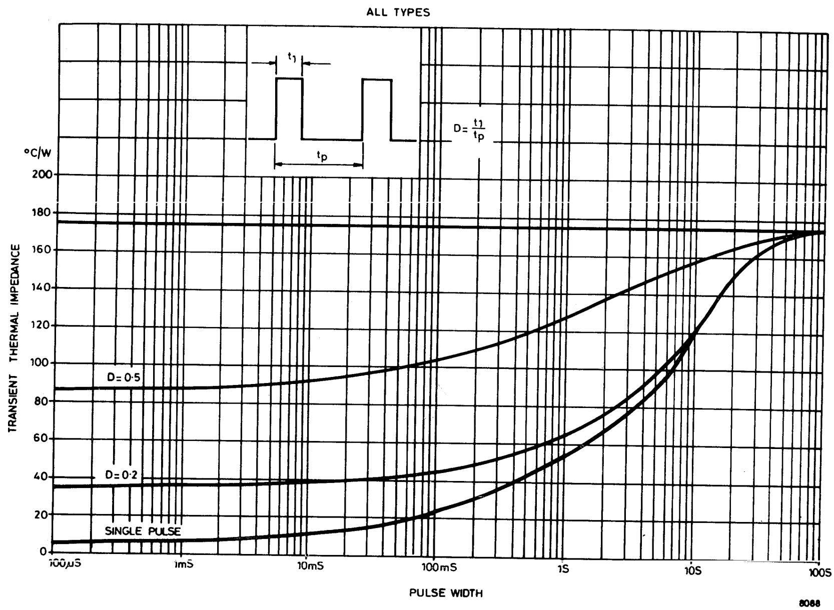
Typical static forward current transfer ratio plotted against collector current



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



Typical switching speeds



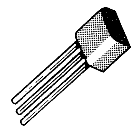
Typical transient thermal impedance curves

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*	I_{CM}	−2	A
Continuous collector current	I_C	−1	A
Power dissipation: at $T_{amb} = 25°C$ derate above 25°C	P_{tot}	1 5.7	W mW/°C
Operating and storage temperature range		−55 to +200	°C

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

ZTX549

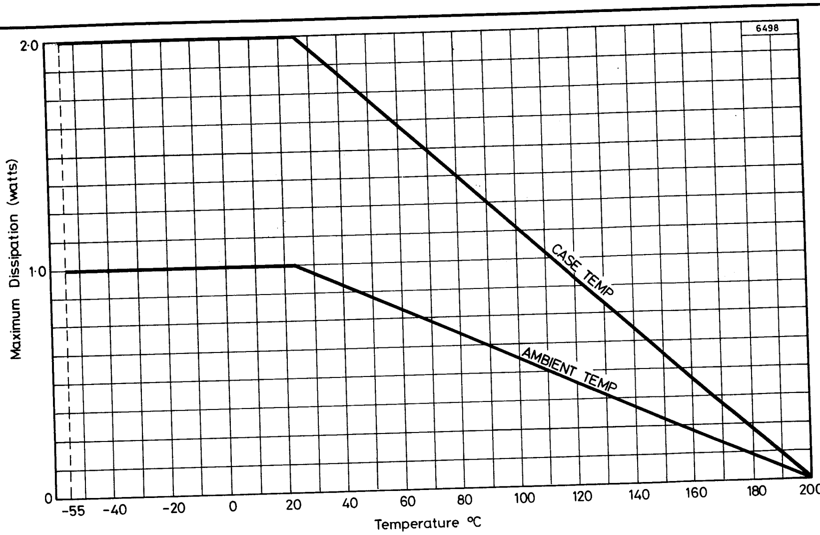
CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

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	$I_C = -100mA$, $V_{CE} = -5V$ $f = 100MHz$
Output capacitance	C_{obo}	–	–	25	pF	$V_{CB} = -10V$, $f = 1MHz$
Switching times	T_{on}	–	300	–	ns	$I_C = -500mA$ $I_{B1} = I_{B2} = -50mA$ $V_{CC} = -10V$
	T_{off}	–	50	–	ns	

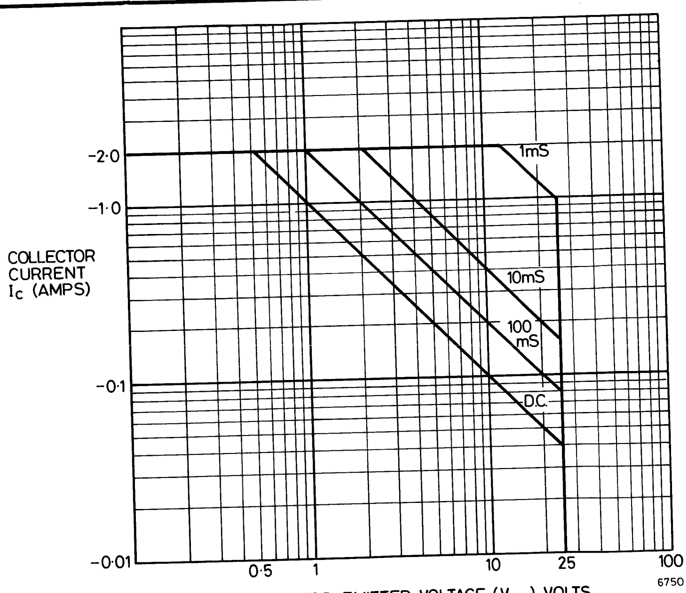
*Measured under pulsed conditions. Pulse width = 300μS. Duty cycle ≤2%.

THERMAL CHARACTERISTICS

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

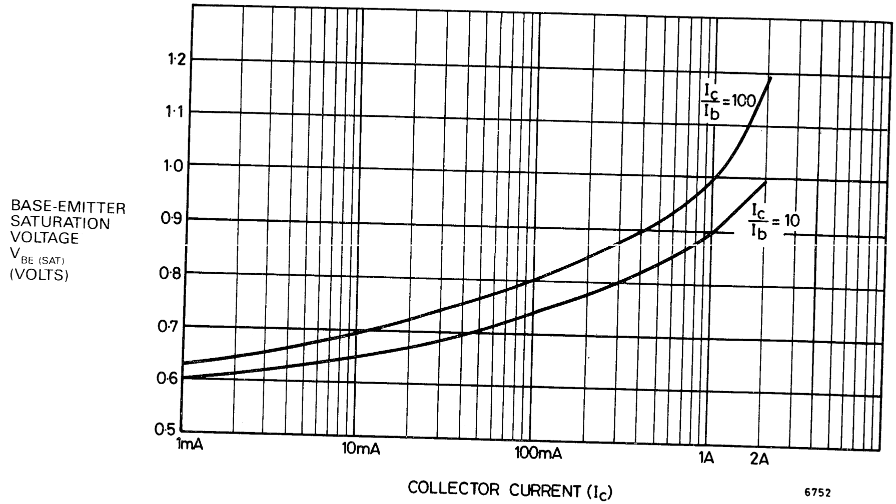


Dissipation derating curve

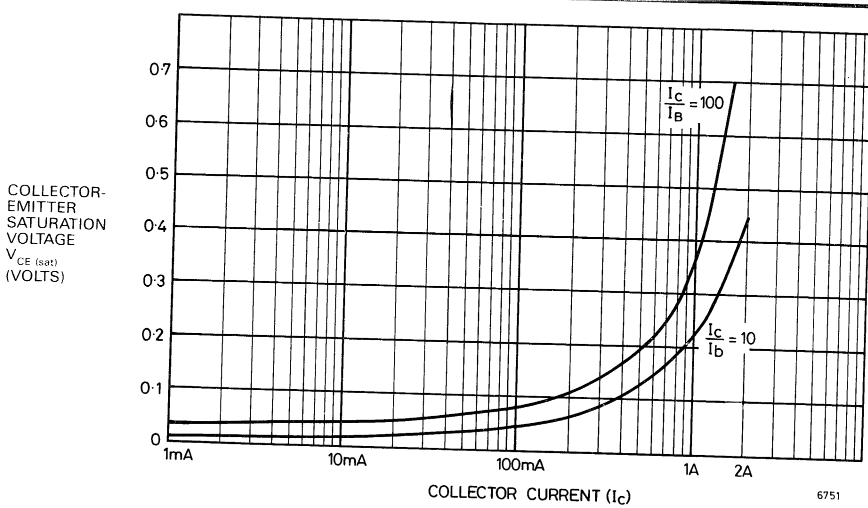


Safe operating area at $T_{amb} = 25°C$
(single-pulse)

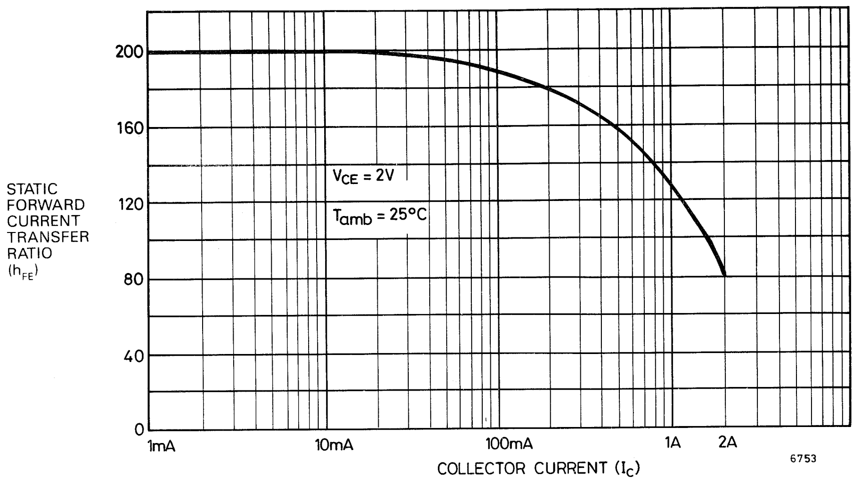
ZTX549



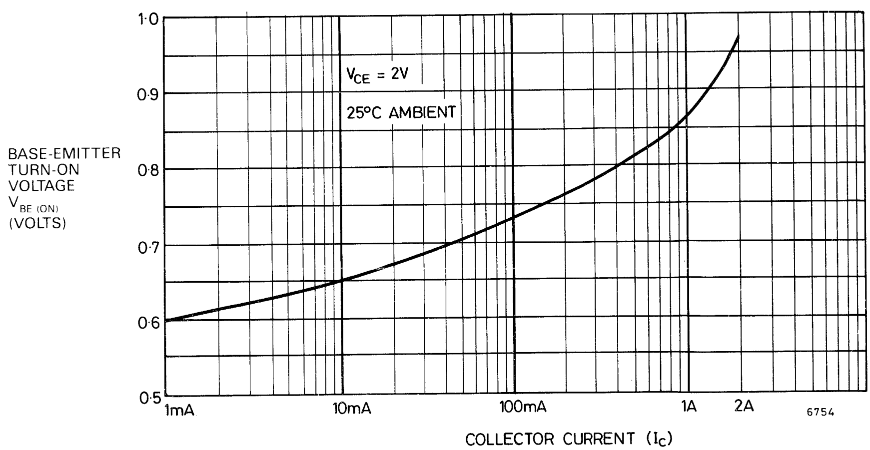
Typical base-emitter saturation voltage plotted against collector current



Typical collector-emitter saturation voltage plotted against collector current

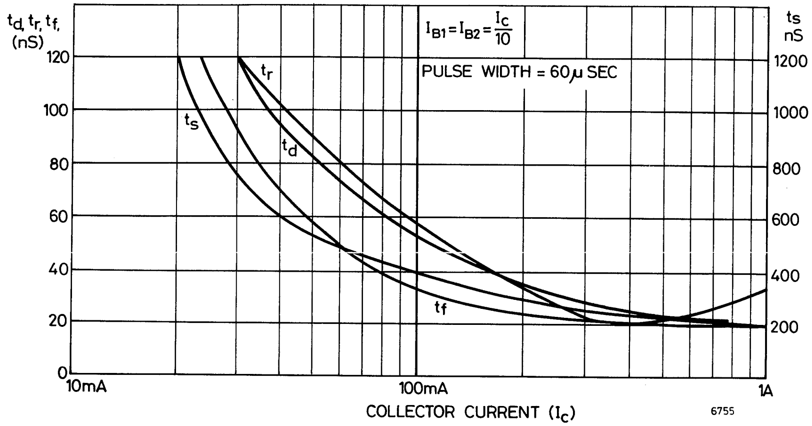


Typical static forward current transfer ratio plotted against collector current

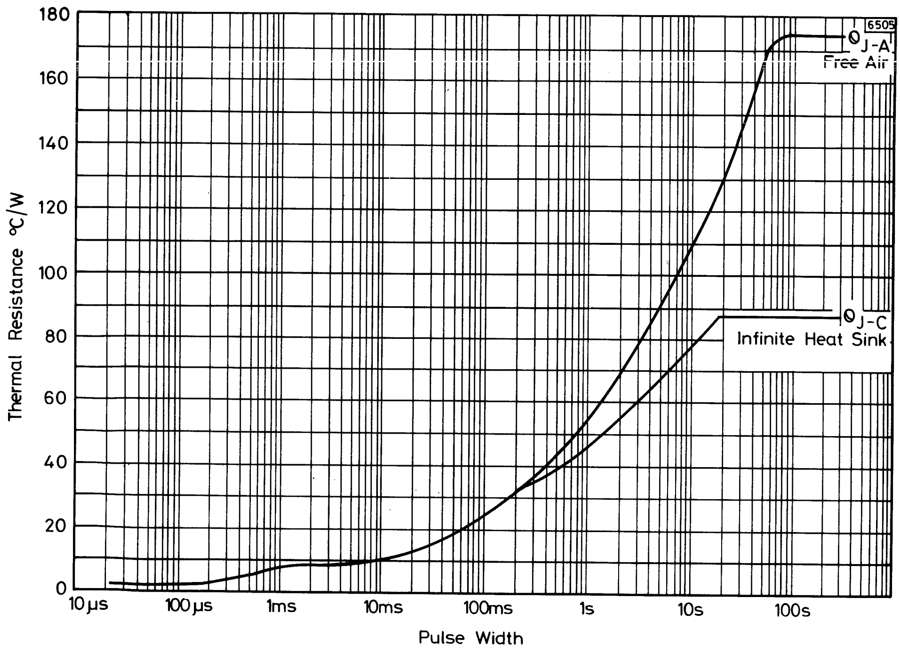


Typical base-emitter turn-on voltage plotted against collector current

ZTX549



Typical switching speeds



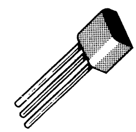
Typical transient thermal impedance curves

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



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, 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.

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 $T_{amb}=25°C$ at $T_{case}=25°C$	P_{tot}	1 2		W W
Operating and storage temperature range		−55 to +200		°C

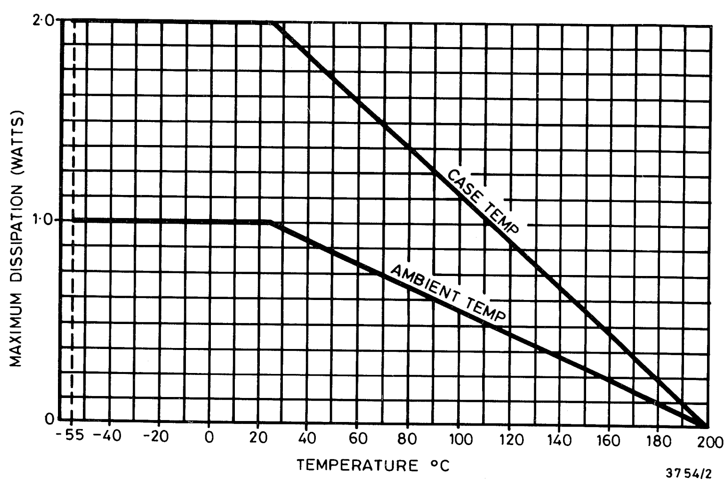
Note: Pulse width = 300µs. Duty cycle ≤ 2%.

ZTX550 ZTX551

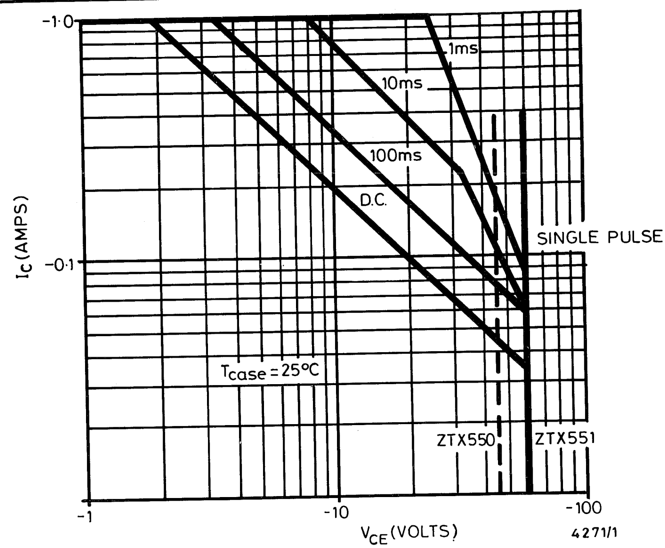
CHARACTERISTICS (at $T_{amb} = 25°C$ unless otherwise stated).

Parameter	Symbol	ZTX550 Min.	ZTX550 Max.	ZTX551 Min.	ZTX551 Max.	Unit	Conditions
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	$I_C = -50mA$, $V_{CE} = -10V$ f = 100MHz
Output capacitance	C_{obo}	–	25	–	25	pF	$V_{CB} = -10V$, f = 1MHz

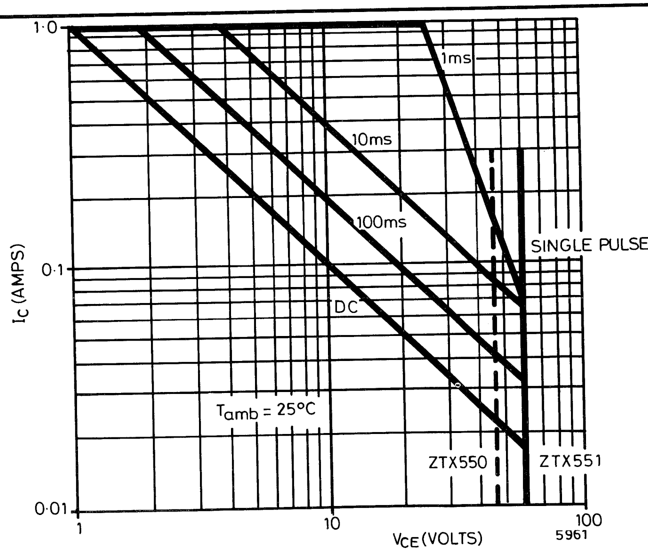
*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ≤ 2%.



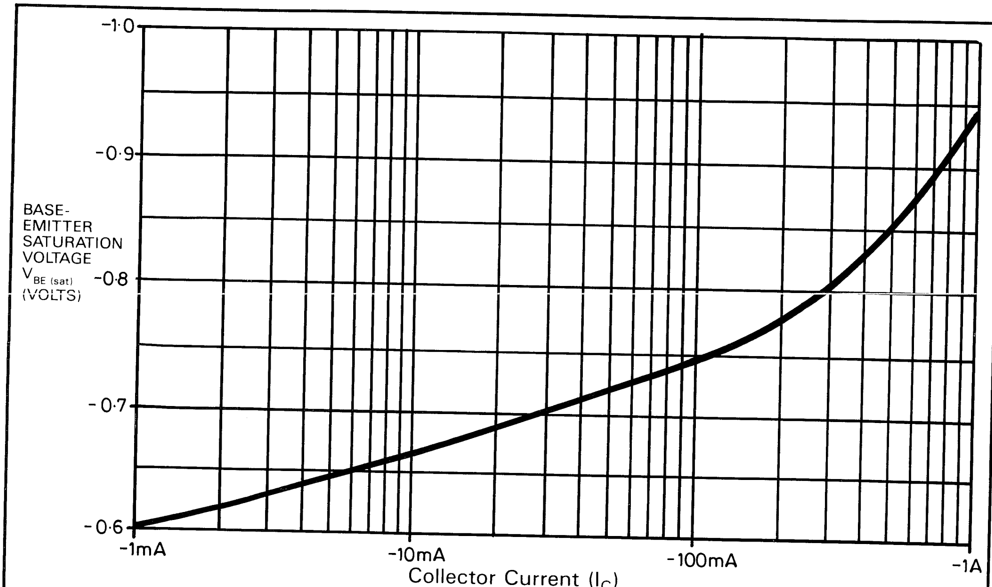
Dissipation derating curve



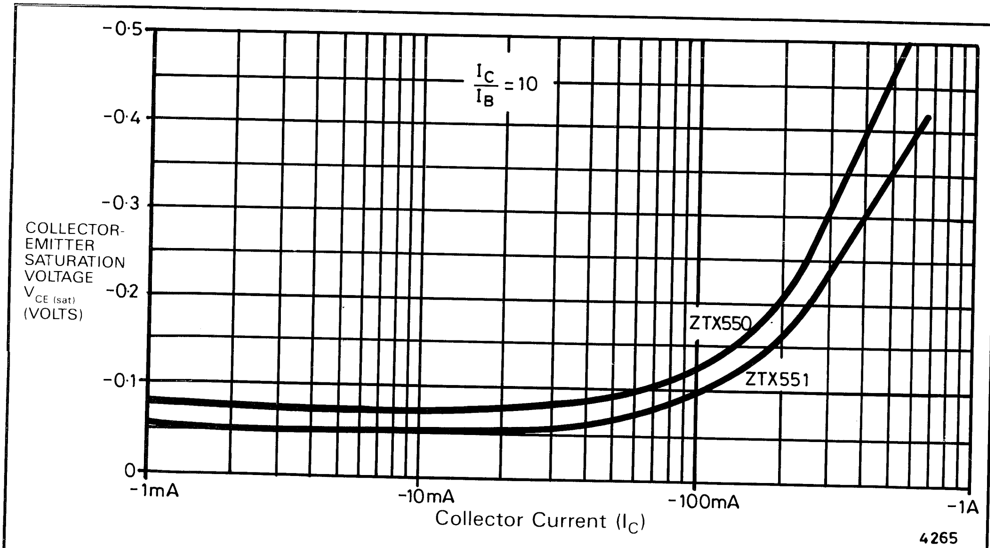
Safe operating area at $T_{case} = 25°C$ (single pulse)



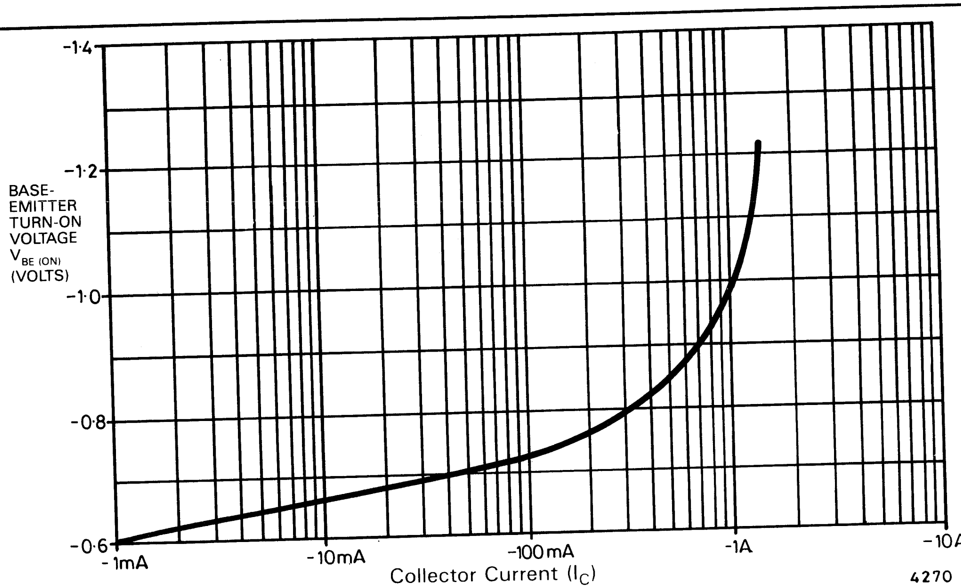
Safe operating area at $T_{amb} = 25°C$ (single pulse)
Typical characteristics



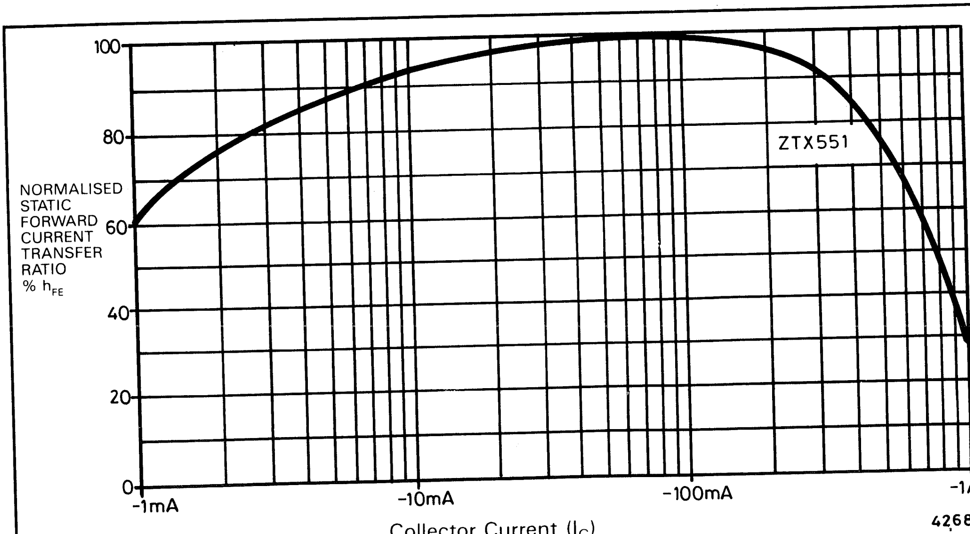
Typical base-emitter saturation voltages plotted against collector current



Typical collector-emitter saturation voltages plotted against collector current

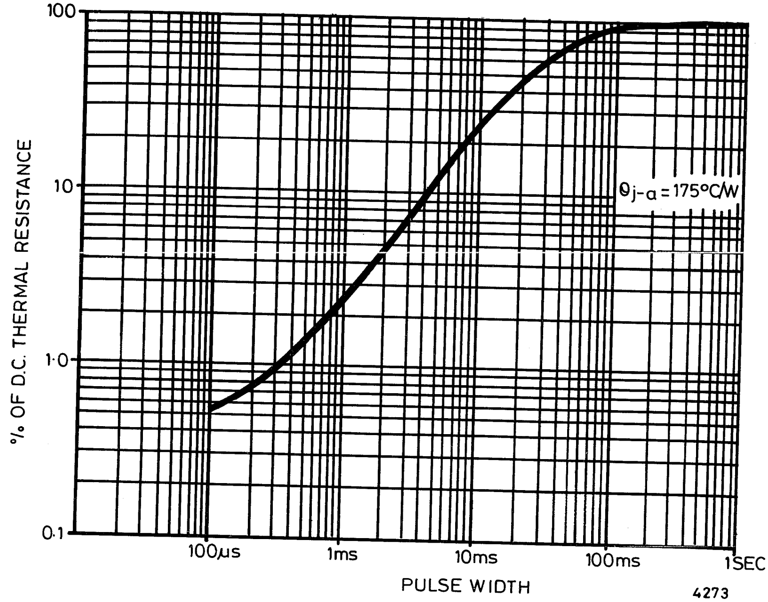


Typical base-emitter turn-on voltages plotted against collector current



Typical static forward current transfer ratio plotted against collector current

ZTX550 ZTX551



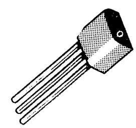
Transient thermal resistance

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



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, 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.

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 $T_{amb}=25°C$ at $T_{case}=25°C$	P_{tot}	1 2		W W
Operating and storage temperature range		−55 to +200		°C

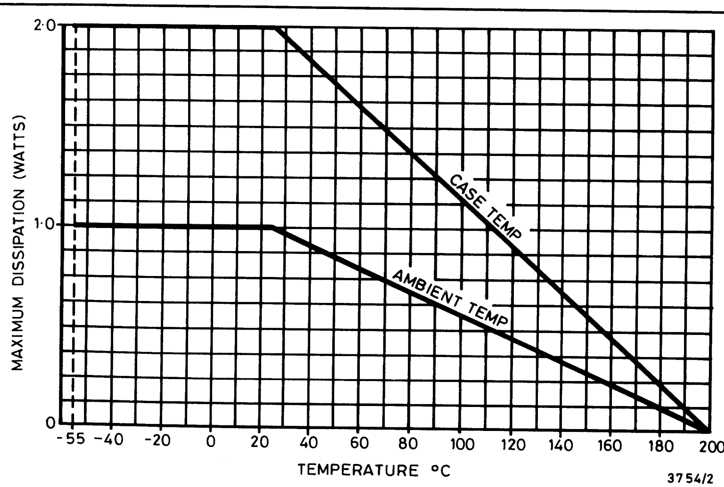
Note: Pulse width = 300μs. Duty cycle ⩽ 2%.

ZTX552 ZTX553

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

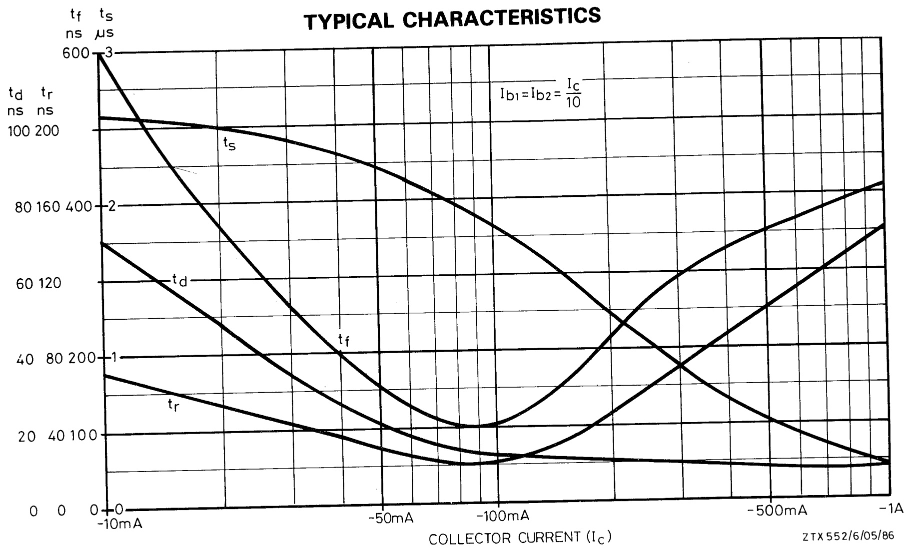
Parameter	Symbol	ZTX552 Min.	ZTX552 Max.	ZTX553 Min.	ZTX553 Max.	Unit	Conditions
Collector-base cut-off current	I_{CBO}	–	−0.1	–	–	μA	$V_{CB} = -80V$
		–	–	–	−0.1	μA	$V_{CB} = -100V$
Emitter-base cut-off current	I_{EBO}	–	−0.1	–	−0.1	μA	$V_{EB} = -4V$
Collector-emitter saturation voltage	$V_{CE(sat)}$	–	−0.25	–	−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	$I_C = -50mA$, $V_{CE} = -10V$ f = 100MHz
Output capacitance	C_{obo}	–	12	–	12	pF	$V_{CB} = -10V$, f = 1MHz

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

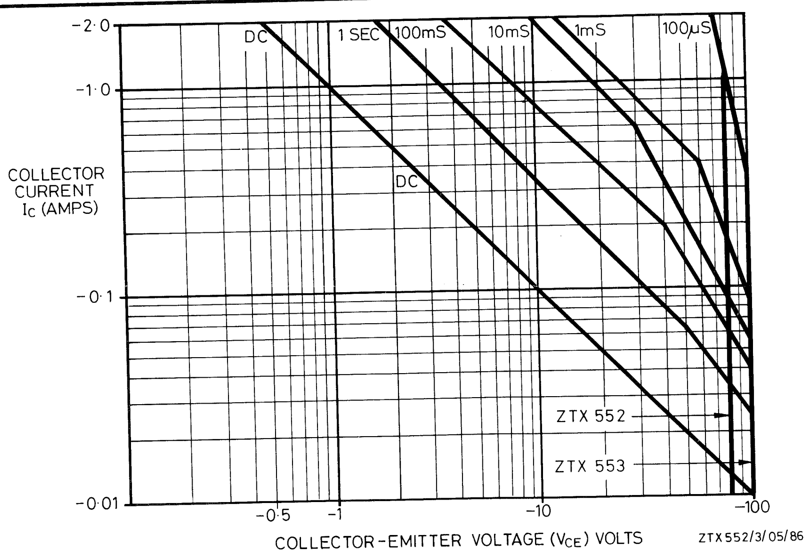


Derating curve

TYPICAL CHARACTERISTICS

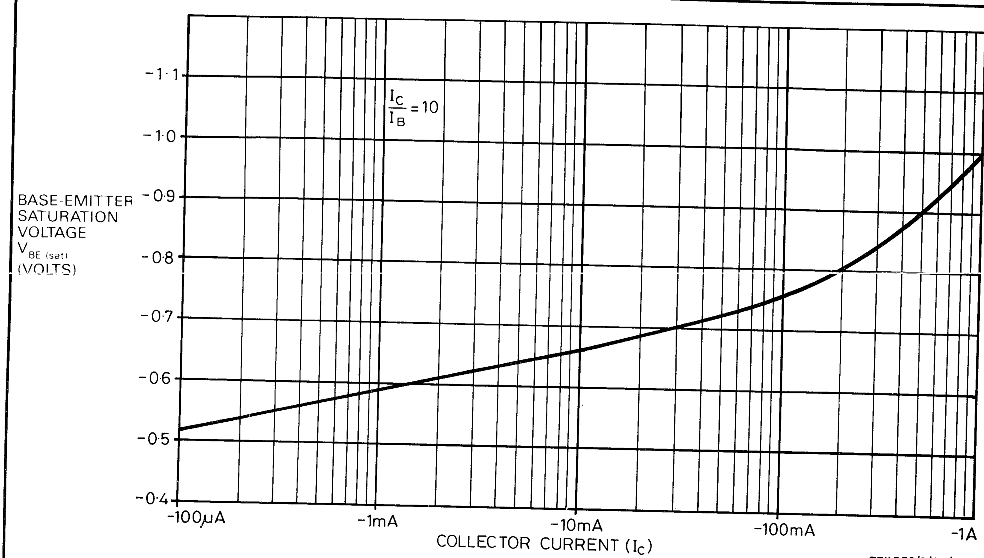


Typical switching speeds

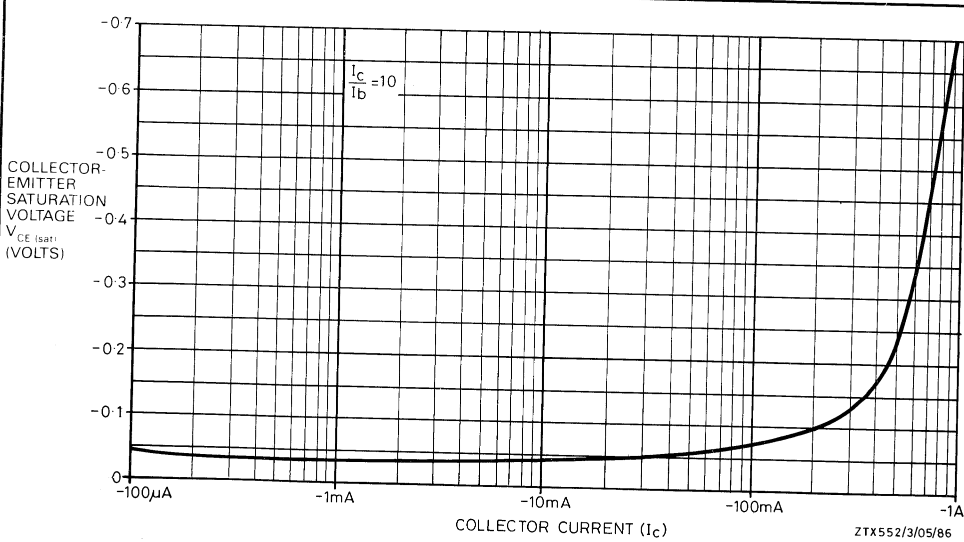


Safe operating area at $T_{amb} = 25°C$ (single pulse)

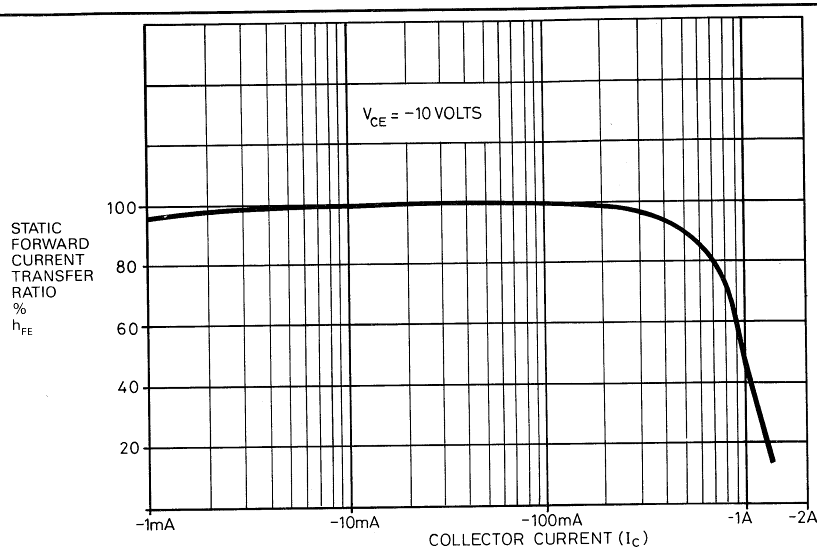
ZTX552 ZTX553



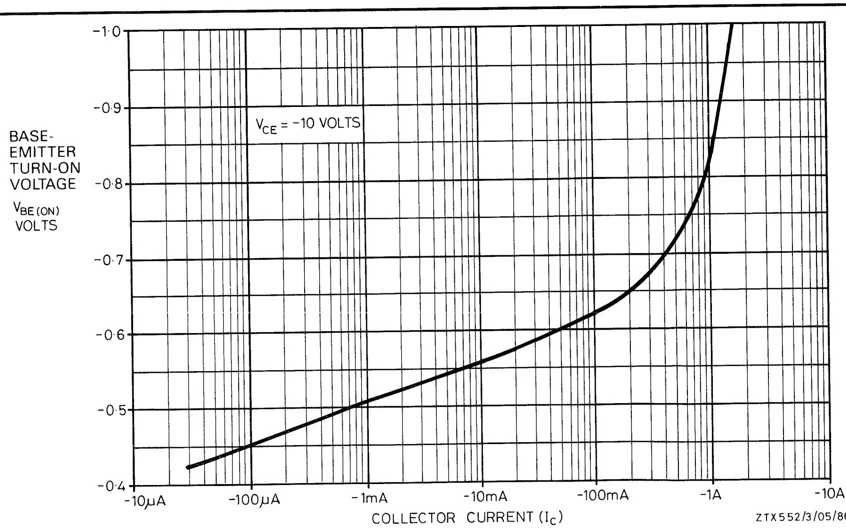
Typical base-emitter saturation voltage plotted against collector current



Typical collector-emitter saturation voltage plotted against collector current

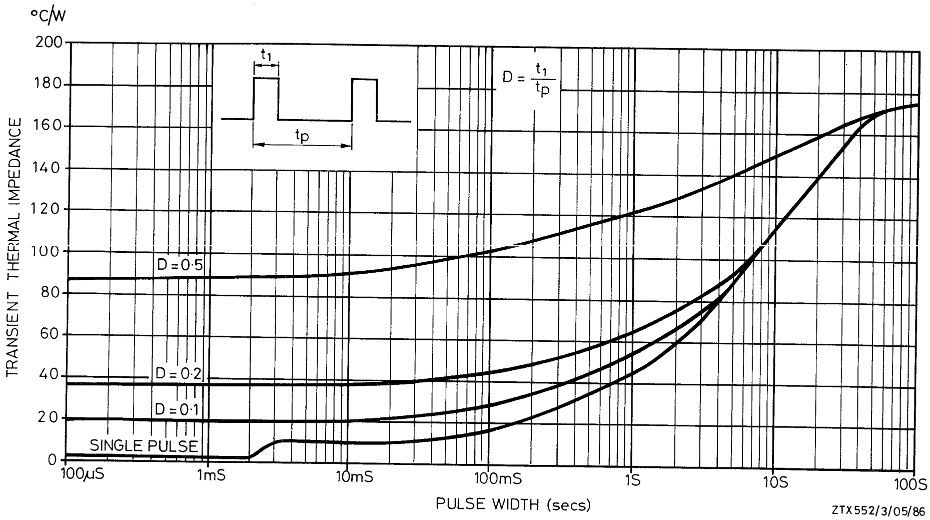


Typical static forward current transfer ratio plotted against collector current



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

ZTX552 ZTX553



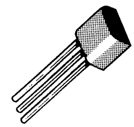
Transient thermal impedance

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*	I_{CM}	−2		−1		A
Continuous collector current	I_C	−1		−0.5		A
Power dissipation at $T_{amb} = 25°C$ at $T_{case} = 25°C$	P_{tot}	1 2				W W
Operating & storage temp. range		−55 to +200				°C

*Pulse width = 300μs. Duty cycle ≤ 2%.

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	$V_{CB}=-120V$ $T_{amb}=100°C$
		–	–	–	−0.1	μA	$V_{CB}=-140V$
		–	–	–	−10	μA	$V_{CB}=-140V$ $T_{amb}=100°C$
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	$I_C=-100mA$* $I_B=-10mA$
Base-emitter saturation voltage	$V_{BE(sat)}$	–	−1	–	−1	V	$I_C=100mA$* $I_B=-10mA$
Base-emitter turn-on voltage	$V_{BE(on)}$	–	−1	–	−1	V	$I_C=-100mA$* $V_{CE}=-10V$
Static forward current transfer ratio	h_{FE}	50	–	50	–		$I_C=-10mA$* $V_{CE}=-10V$
		50	300	50	300		$I_C=-300mA$* $V_{CE}=-10V$
Transition frequency	f_T	100	–	100	–	MHz	$I_C=-50mA$ $V_{CE}=-10V$ $f=100MHz$
Output capacitance	C_{obo}	–	10	–	10	pF	$V_{CE}=-10V$ $f=1MHz$

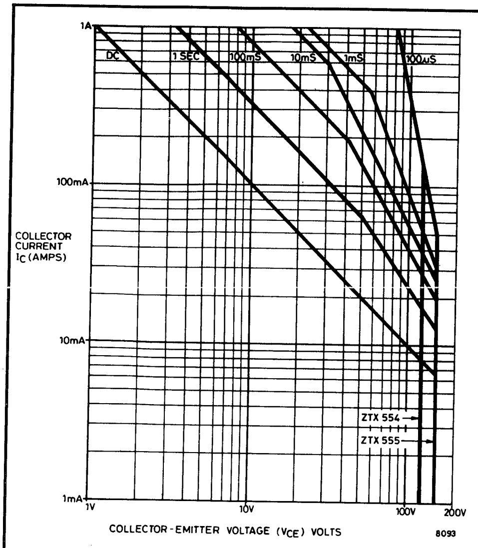
*Measured under pulsed conditions. Pulse width $=300\mu s$. Duty cycle $\leqslant 2\%$.

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

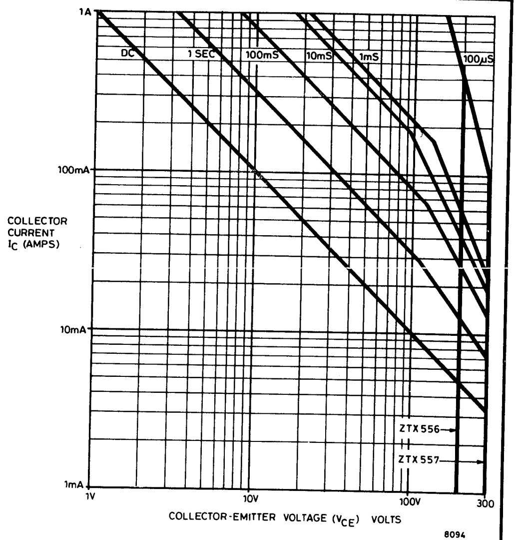
Parameter	Symbol	ZTX556		ZTX557		Unit	Conditions
		Min.	Max.	Min.	Max.		
Collector-base breakdown voltage	$V_{(BR)CBO}$	−200	–	−300	–	V	$I_C = 100\mu A$
Collector-emitter breakdown voltage	$V_{(BR)CEO}$	−200	–	−300	–	V	$I_C = -10mA$*
Emitter-base breakdown voltage	$V_{(BR)EBO}$	−5	–	−5	–	V	$I_E = -100\mu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

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

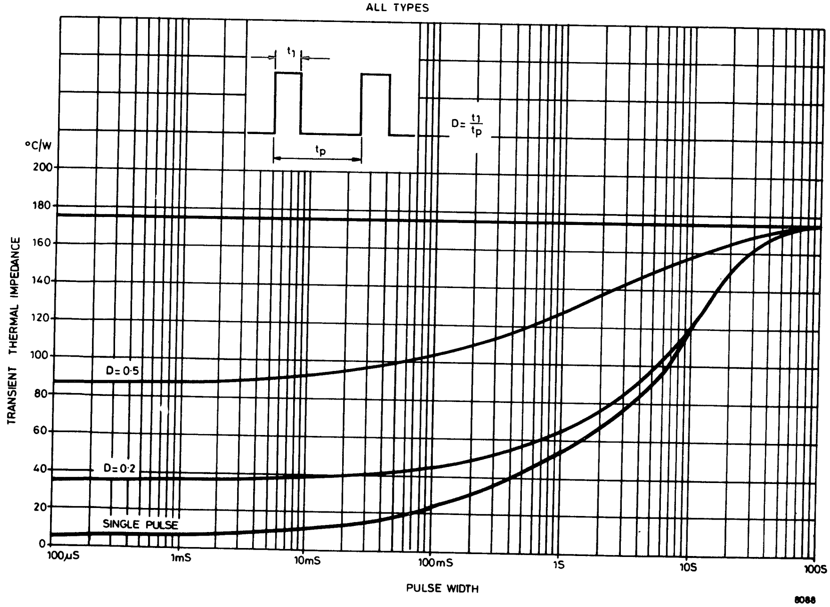
ZTX554 ZTX555 ZTX556 ZTX557



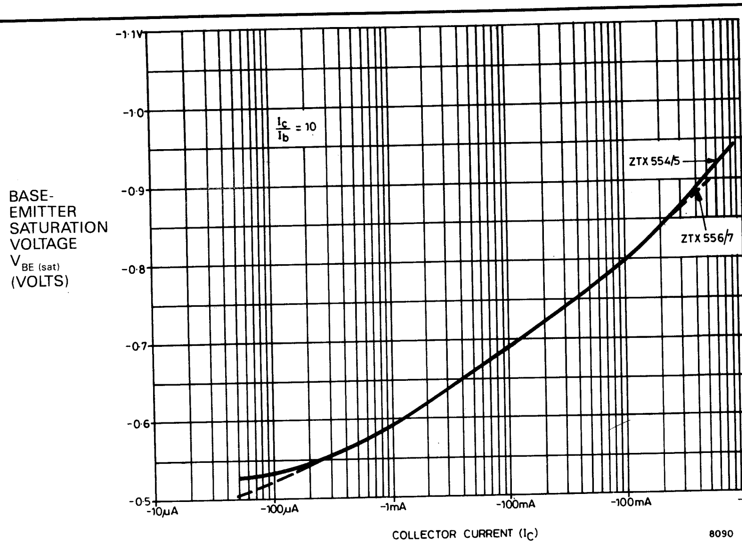
Safe operating area at $T_{amb} = 25°C$ ZTX554/5 (Single pulse)



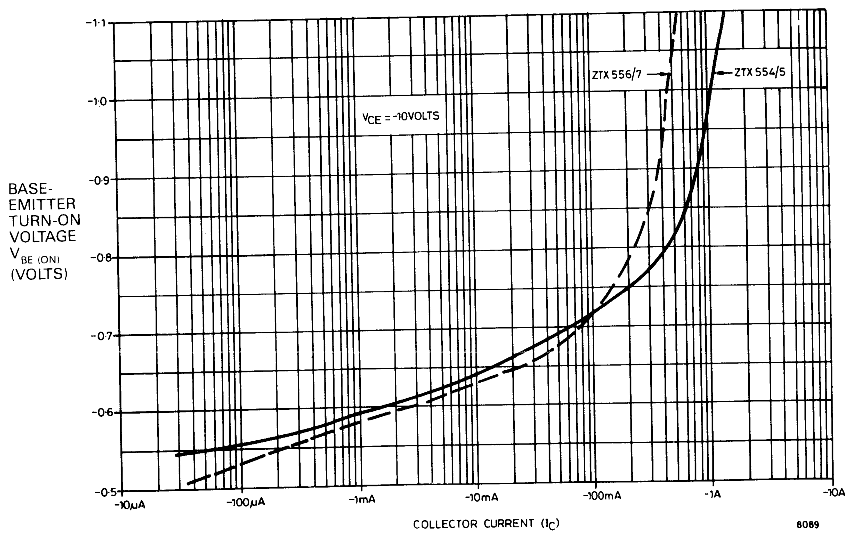
Safe operating area at $T_{amb} = 25°C$ ZTX556/7 (Single pulse)



Typical transient thermal impedance curves

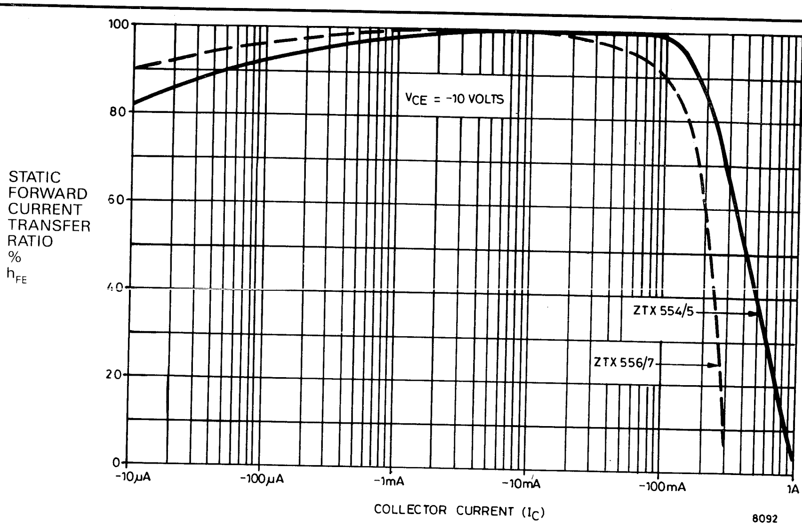


Typical base-emitter saturation voltages plotted against collector current

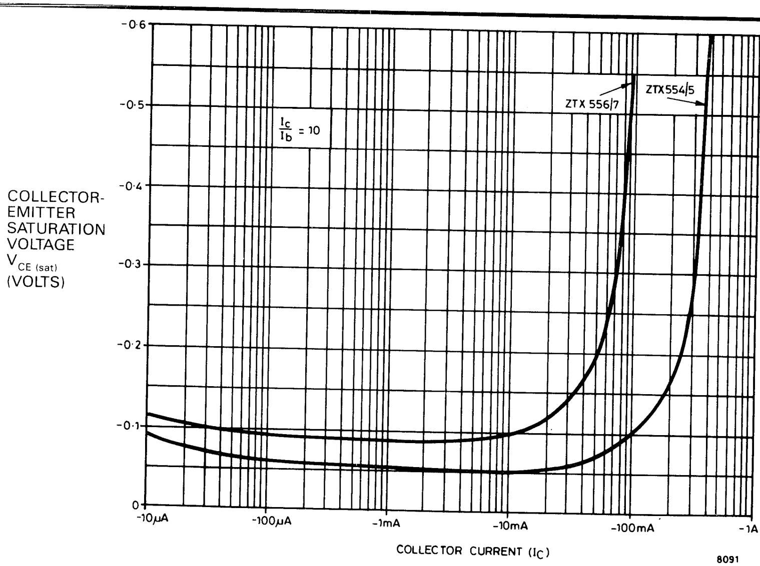


Typical base-emitter turn on voltages plotted against collector current

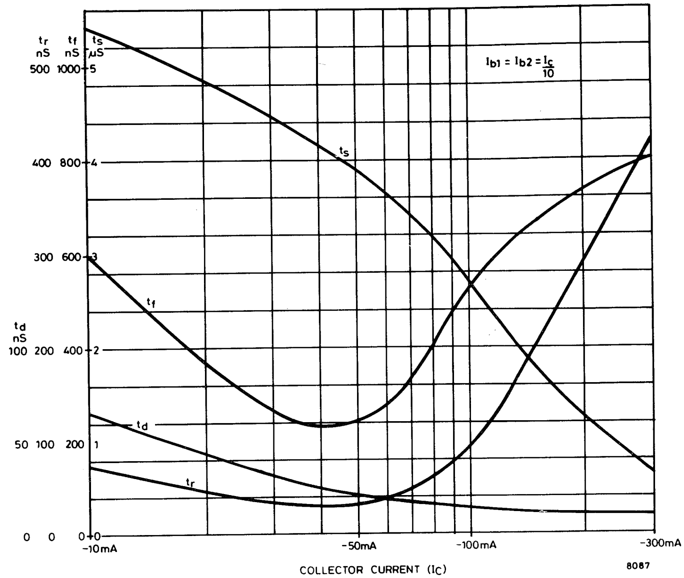
ZTX554 ZTX555 ZTX556 ZTX557



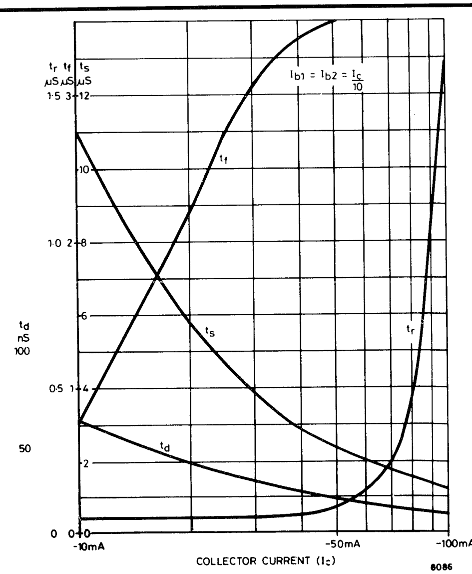
Typical static forward current transfer ratio plotted against collector current



Typical collector-emitter saturation voltages plotted against collector current



Typical switching speeds (ZTX554/5)



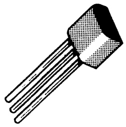
Typical switching speeds (ZTX556/7)

NPN silicon medium power Darlington transistors

ZTX600 ZTX601

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



Plastic E-line
(TO-92 compatible)

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) at $T_{case}=25°C$	P_{tot}	1 2.5		W 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 (Fig. 1) for maximum power dissipation and operating temperature in a given application.

Note 2: Measured under pulsed conditions. Pulse width = 300μs. Duty cycle $\leqslant$ 2%.

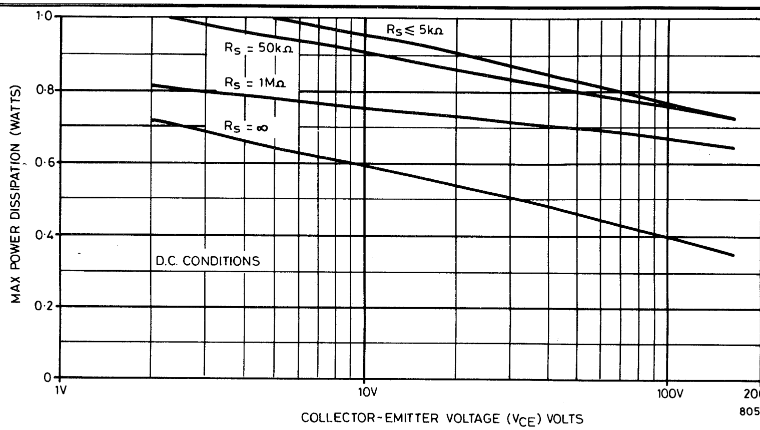
Note 3: The power which can be dissipated assuming that the device is mounted in a typical manner on a PCB with copper equal to 1sq.inch minimum.

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	$I_C = 100mA$, $V_{CE} = 10V$ f = 20MHz
Switching times	t_{on}	–	0.75	–	–	0.75	–	μs	$I_C = 0.5A$, $V_{CE} = 10V$
	t_{off}	–	2.2	–	–	2.2	–	μs	$I_{B1} = I_{B2} = 0.5mA$
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

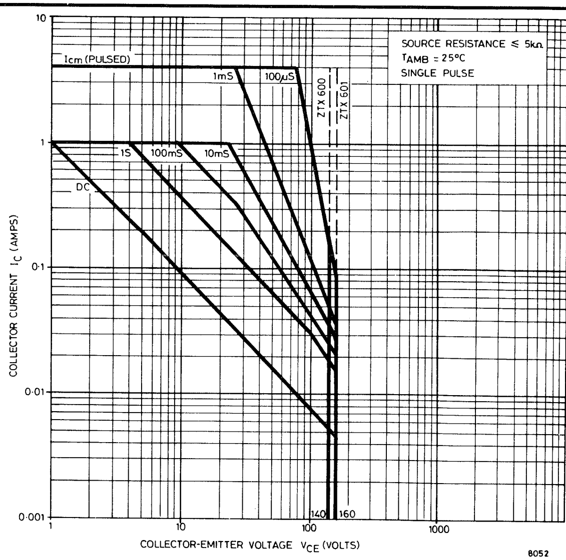
The maximum permissible operating temperature can be obtained from this graph using the equation

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

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

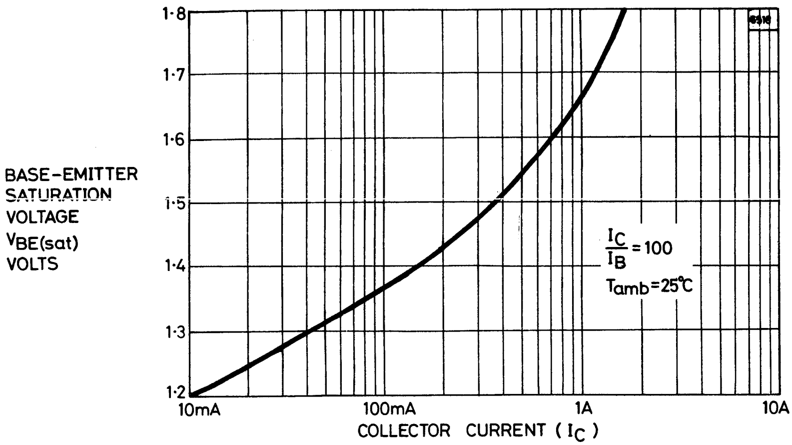
Power (max) = Maximum power dissipation figure, obtained from the above graph for a given V_{CE} and source resistance (R_S).

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

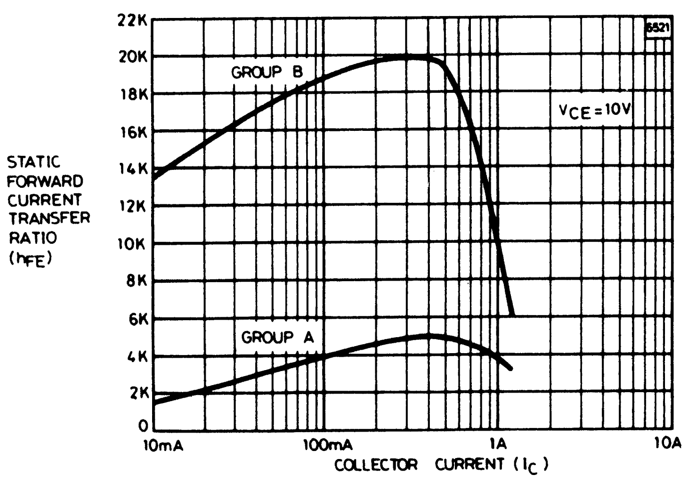


Safe operating area at T_{amb} = 25°C (Single pulse)

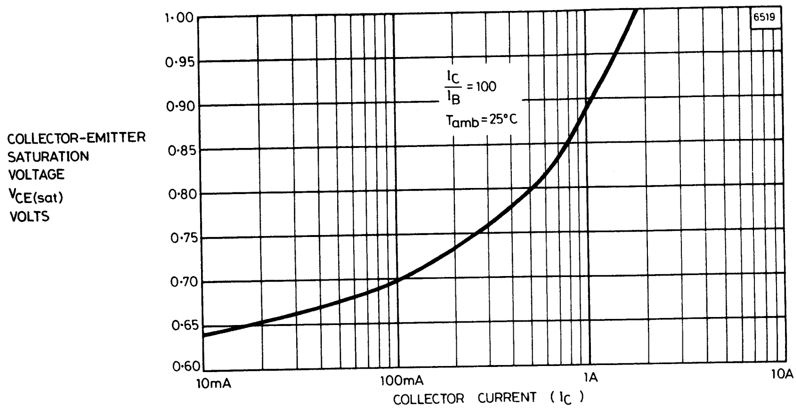
ZTX600 ZTX601



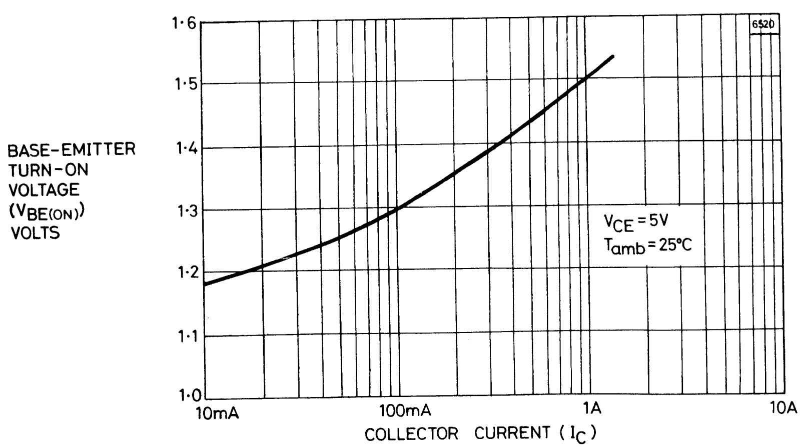
Typical base-emitter saturation voltages plotted against collector current



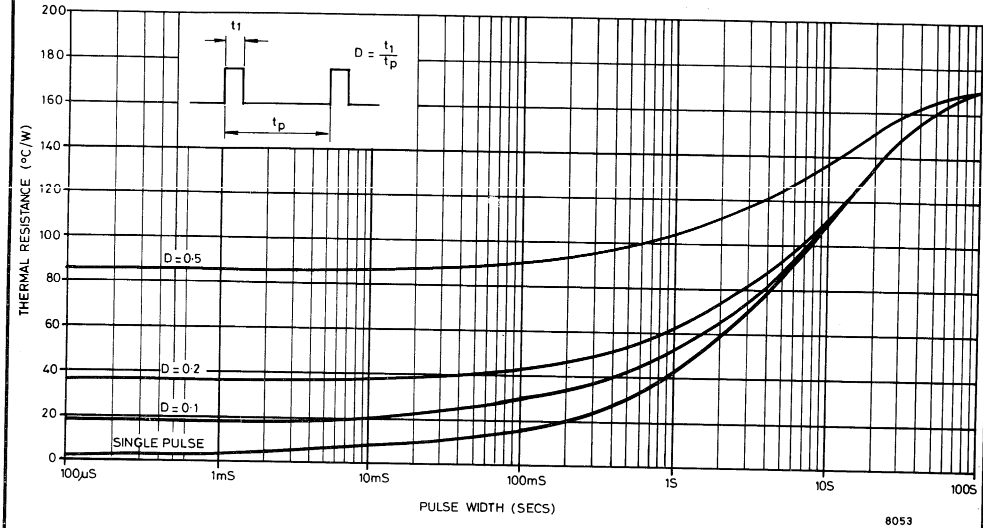
Typical static forward current transfer ratio plotted against collector current



Typical collector-emitter saturation voltages plotted against collector current



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



Transient thermal resistance

NPN silicon planar medium power Darlington transistors

Provisional information only

ZTX602
ZTX603

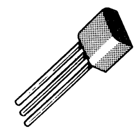
FEATURES

- 1.5W power dissipation
- 1A continuous collector current
- Guaranteed h_{FE} specified up to 2A

DESCRIPTION

High performance medium power Darlington amplifier transistors encapsulated in the popular E-line plastic package.

The 1.5W, 1A performance permits use in a wide range of industrial and consumer equipment.



Plastic E-line
(TO-92 compatible)

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	ZTX602	ZTX603	Unit
Collector-base voltage	V_{CBO}	80	100	V
Collector-emitter voltage	V_{CEO}	60	80	V
Emitter-base voltage	V_{EBO}	10		V
Peak pulse current*	I_{CM}	4		A
Continuous collector current	I_C	1		A
Practical power dissipation†	P_{totp}	1.5		W
Power dissipation at $T_{amb}=25°C$	P_{tot}	1		W

*Pulse width = 300μs. Duty cycle ⩽ 2%.

†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	$I_C = 100\mu A$
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}	–	0.1	–	–	μA	$V_{CB} = 60V$
		–	–	–	0.1	μA	$V_{CB} = 80V$
Emitter cut-off current	I_{EBO}	–	0.1	–	0.1	μA	$V_{EB} = 8V$
Collector-emitter saturation voltage	$V_{CE(sat)}$	–	1	–	1	V	$I_C = 1A$*, $I_B = 1mA$
		–	1	–	1	V	$I_C = 0.4A$*, $I_B = 0.4mA$
Base-emitter saturation voltage	$V_{BE(sat)}$	–	1.8	–	1.8	V	$I_C = 1A$*, $I_B = 1mA$
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	$I_C = 100mA$, $V_{CE} = 10V$ f = 20MHz

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

NPN silicon planar medium power Darlington transistors

ZTX604
ZTX605

Provisional information only

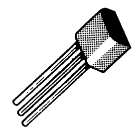
FEATURES

- 1.5W power dissipation
- 1A continuous collector current
- Guaranteed h_{FE} specified up to 1A

DESCRIPTION

High performance medium power Darlington amplifier transistors encapsulated in the popular E-line plastic package.

The 1.5W, 1A performance permits use in a wide range of industrial and consumer equipment.



Plastic E-line
(TO-92 compatible)

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	ZTX604	ZTX605	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*	I_{CM}	4		A
Continuous collector current	I_C	1		A
Practical power dissipation†	P_{totp}	1.5		W
Power dissipation at $T_{amb}=25°C$	P_{tot}	1		W

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

†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}	–	0.1	–	–	μA	$V_{CB} = 100V$
		–	–	–	0.1	μA	$V_{CB} = 120V$
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	–	1	V	$I_C = 0.25A$* $I_B = 0.25mA$
Base-emitter saturation voltage	$V_{BE(sat)}$	–	1.8	–	1.8	V	$I_C = 1A$*, $I_B = 1mA$
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		$I_C = 1A$*, $V_{CE} = 5V$
Transition frequency	f_T	150	–	150	–	MHz	$I_C = 100mA$, $V_{CE} = 10V$ f = 20MHz

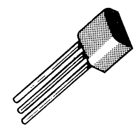
*Measured under pulsed conditions. Pulse width = 300μs. Duty cycle ≤ 2%.

NPN silicon planar medium 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*	I_{CM}	6	A
Continuous collector current	I_C	2	A
Practical power dissipation†	P_{totP}	1.5	W
Power dissipation: at $T_{amb} = 25°C$ derate above 25°C	P_{tot}	1 5.7	W mW/°C
Operating & storage temperature range		−55 to +200	°C

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

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

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	$I_C = 100mA$, $V_{CE} = 5V$ f = 100MHz
Output capacitance	C_{obo}	–	25	50	pF	$V_{CB} = 10V$, f = 1MHz
Switching times	T_{on}	–	55	–	ns	$I_C = 500mA$, $V_{CC} = 10V$ $I_{B1} = I_{B2} = 50mA$
	T_{off}	–	300	–	ns	

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

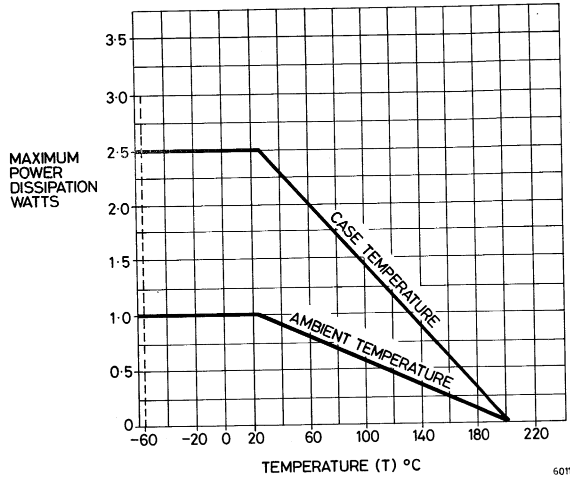
THERMAL CHARACTERISTICS

Parameter		Symbol	Maximum	Unit
Thermal Resistance:	Junction to ambient₁	$R_{th(j-amb)1}$	175	°C/W
	Junction to ambient₂	$R_{th(j-amb)2}$†	116	°C/W
	Junction to case	$R_{th(j-case)}$	70	°C/W

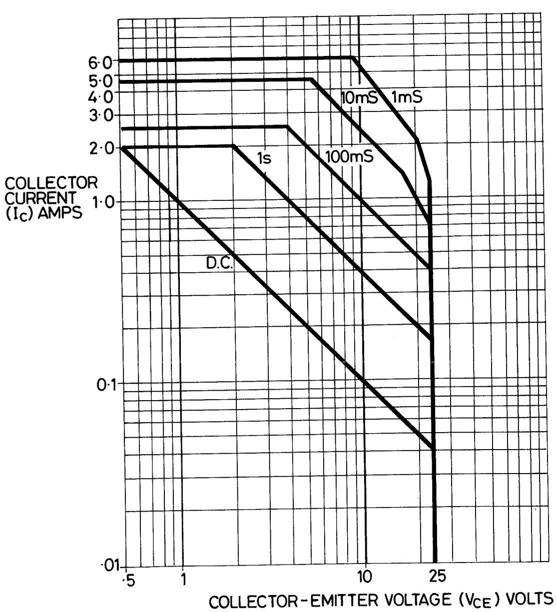
†Device mounted on P.C.B. with copper equal to 1sq.inch minimum.

Note: Practical power dissipation. Where space does not permit 1 sq.inch copper the device fitted with Staver heat clip type F2-7 will offer the following:

Power dissipation at $T_{amb} = 25°C$ (P_{tot}) 1.4W
Derate above 25°C .. .. 8mW/°C
Thermal resistance, Junction to ambient .. .. 125°C/W

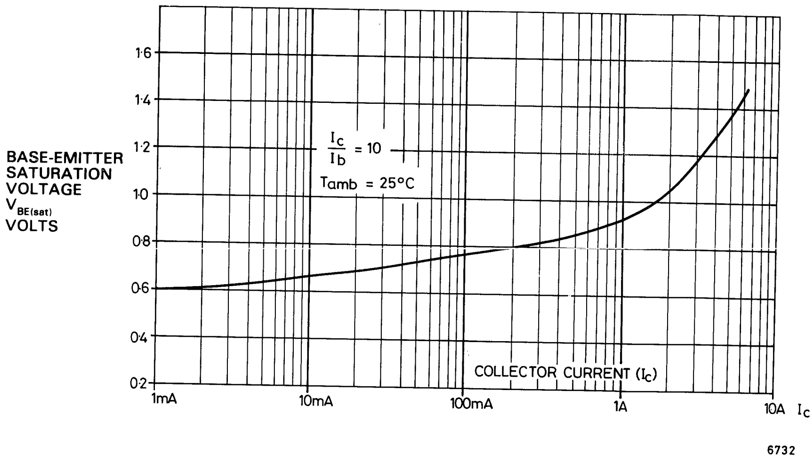


Dissipation derating curve

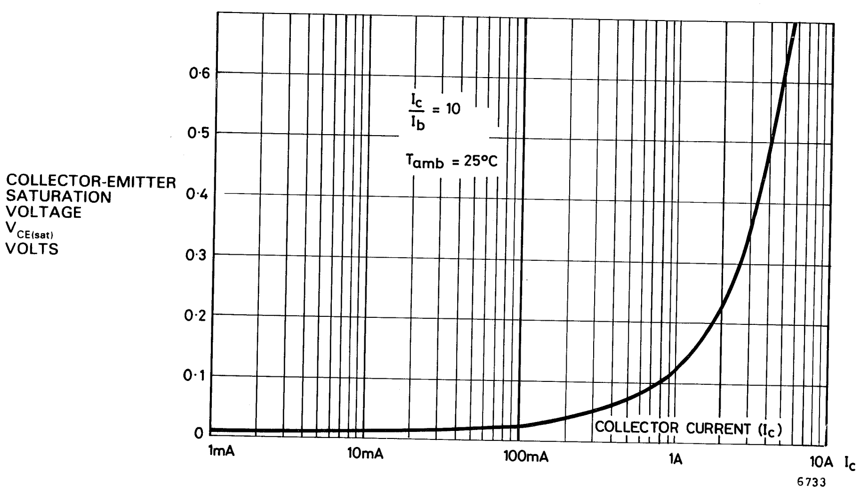


Safe operating area at $T_{amb} = 25°C$
(single-pulse)

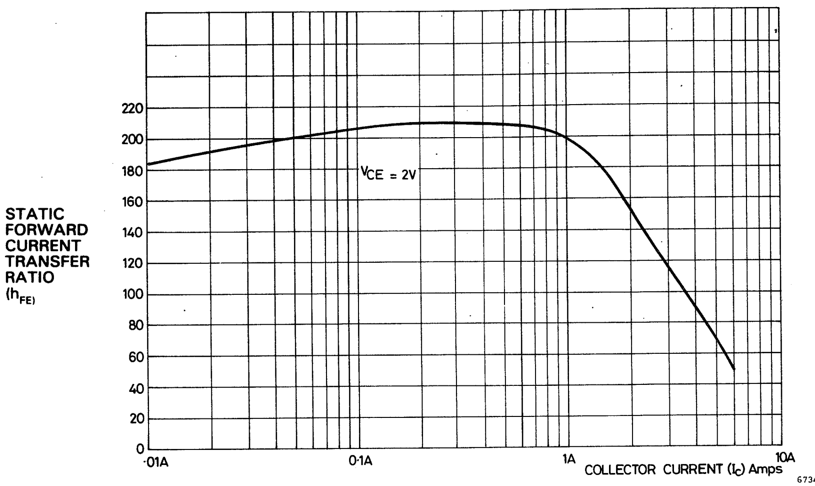
ZTX649



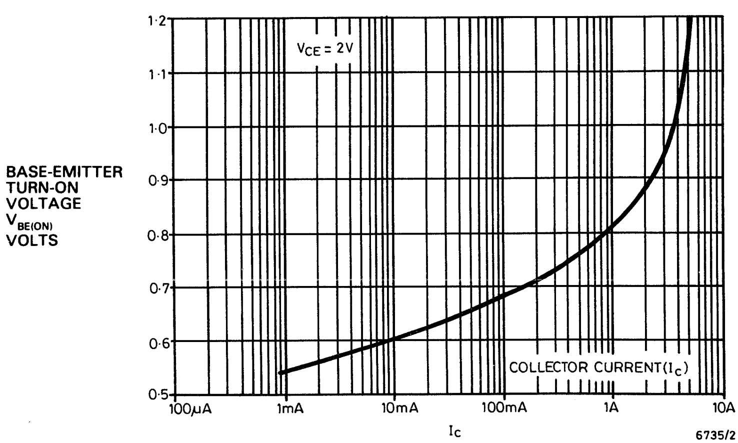
Typical base-emitter saturation voltage plotted against collector current



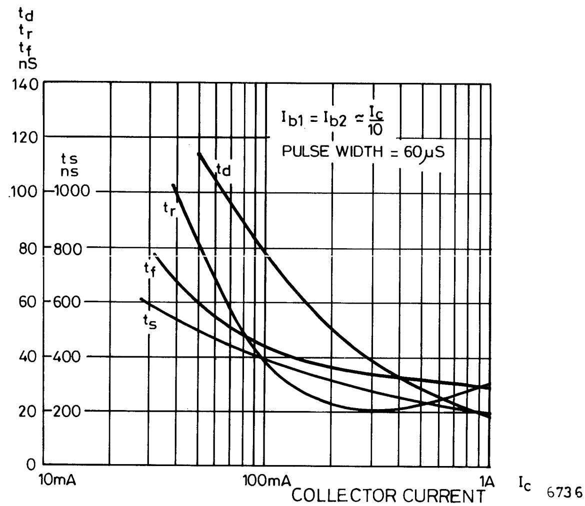
Typical collector-emitter saturation voltage plotted against collector current



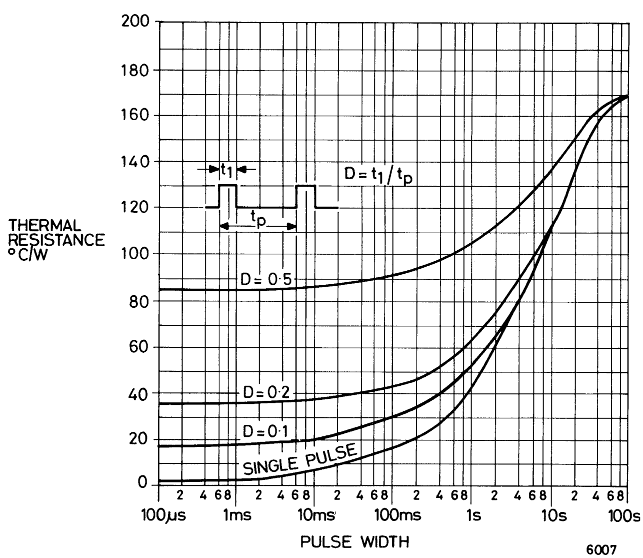
Typical static forward current transfer ratio plotted against collector current



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



Typical switching speeds



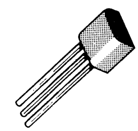
Typical transient thermal impedance curves

NPN silicon planar medium power transistors

ZTX650 ZTX651 ZTX652 ZTX653

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 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*	I_{CM}	6				A
Continuous collector current	I_C	2				A
Practical power dissipation†	P_{totP}	1.5				W
Power dissipation at $T_{amb} = 25°C$ derate above 25°C at $T_{case} = 25°C$	P_{tot}	1 5.7 2.5				W mW/°C W
Operating & storage temp. range	$t_j : t_{stg}$	−55 to +200				°C

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

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

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	$I_C=100mA$, $V_{CE}=5V$ $f=100MHz$
Switching times	T_{on}	–	45	–	–	45	–	ns	$I_C=500mA$, $I_{B1}=50mA$ $I_{B2}=50mA$, $V_{CC}=10V$
	T_{off}	–	800	–	–	800	–	ns	

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

THERMAL CHARACTERISTICS (ZTX650/3)

Parameter	Symbol	Maximum	Unit
Thermal resistance: Junction to ambient$_1$	$R_{th(j-amb)1}$	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.

ZTX650 ZTX651 ZTX652 ZTX653

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

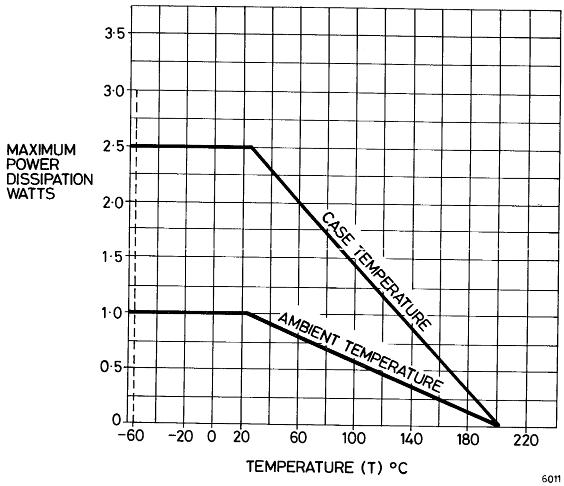
Parameter	Symbol	ZTX652			ZTX653			Unit	Conditions
		Min.	Typ.	Max.	Min.	Typ.	Max.		
Collector-base breakdown voltage	$V_{(BR)CBO}$	100	–	–	120	–	–	V	$I_C = 100\mu A$
Collector-emitter breakdown voltage	$V_{(BR)CEO}$	80	–	–	100	–	–	V	$I_C = 10mA$
Emitter-base breakdown voltage	$V_{(BR)EBO}$	5	–	–	5	–	–	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	–		$I_C = 2V^*$, $V_{CE} = 2V^*$
Transition frequency	f_T	140	175	–	140	175	–	MHz	$I_C = 100mA$, $V_{CE} = 5V$ $f = 100MHz$
Switching times	T_{on}	–	80	–	–	80	–	ns	$I_C = 500mA$, $I_{B1} = 50mA$ $I_{B2} = 50mA$, $V_{CC} = 10V$
	T_{off}	–	1200	–	–	1200	–	ns	

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

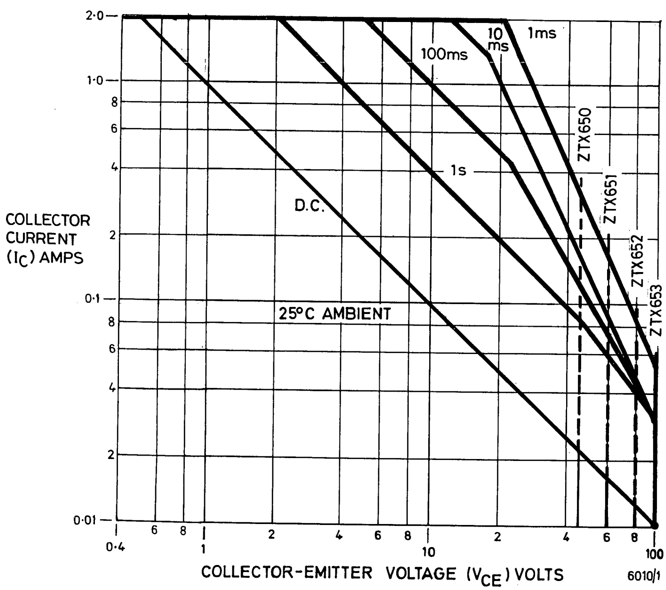
Note: Practical power dissipation. Where space does not permit 1 sq.inch copper the device fitted with Staver heat clip type F2-7 will offer the following:

Power dissipation at $T_{amb} = 25°C$ (P_{tot}) 1.4W
Derating above 25°C . . . . 8mW/°C
Thermal resistance, junction to ambient . . . . 125°C/W

ZTX650 ZTX651 ZTX652 ZTX653

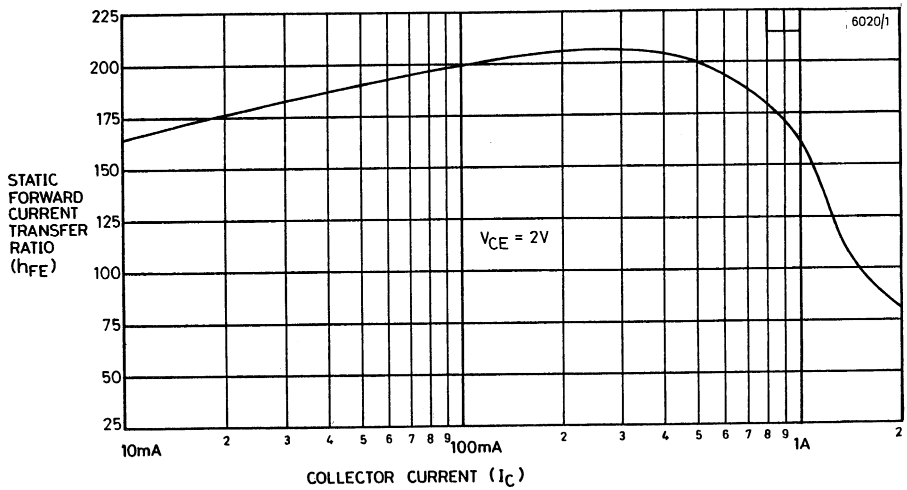


Dissipation derating curve for all types

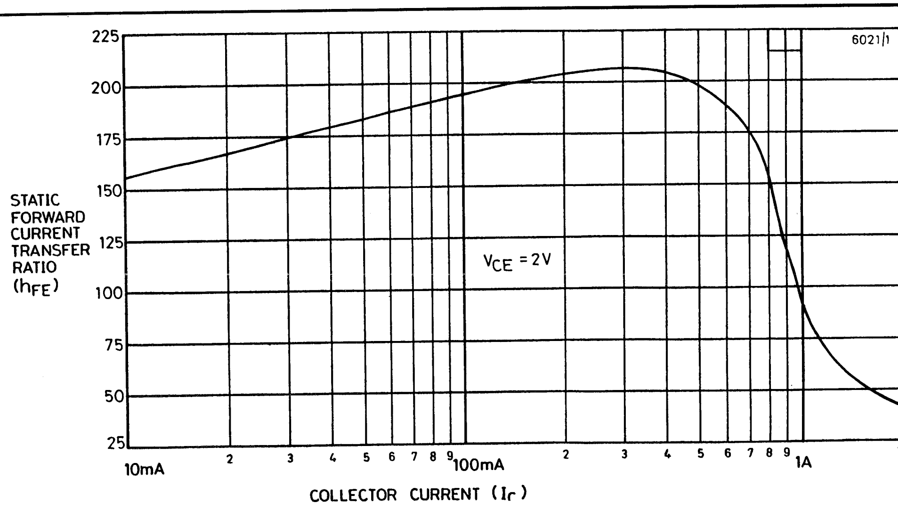


Safe operating area at $T_{amb} = 25°C$ (single pulse)

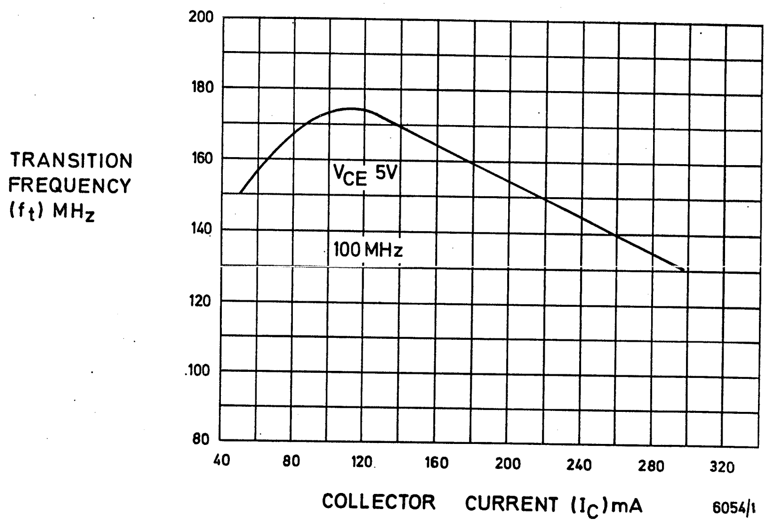
Typical characteristics



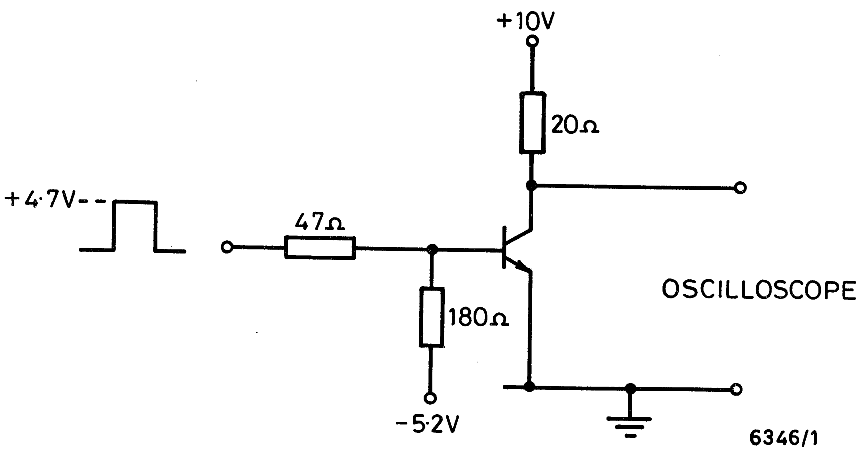
Static forward current transfer ratio plotted against collector current for ZTX650/ZTX651



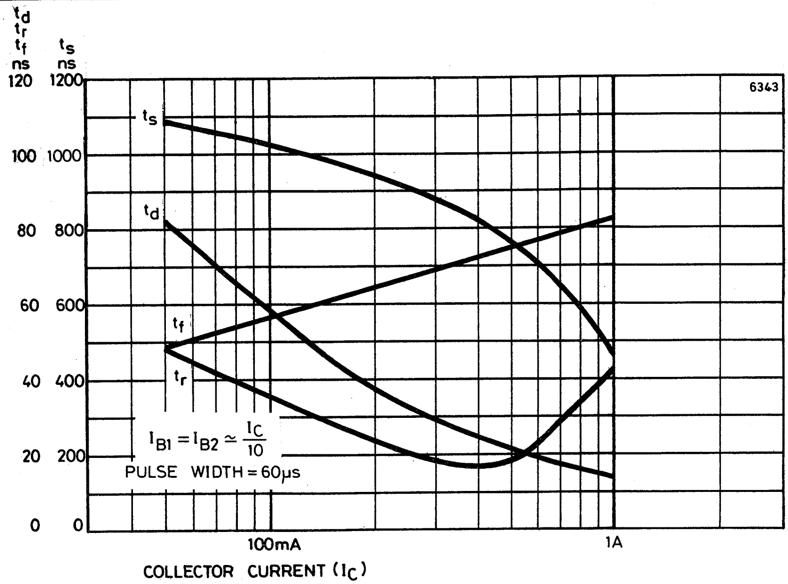
Static forward current transfer ratio plotted against collector current for ZTX652/ZTX653



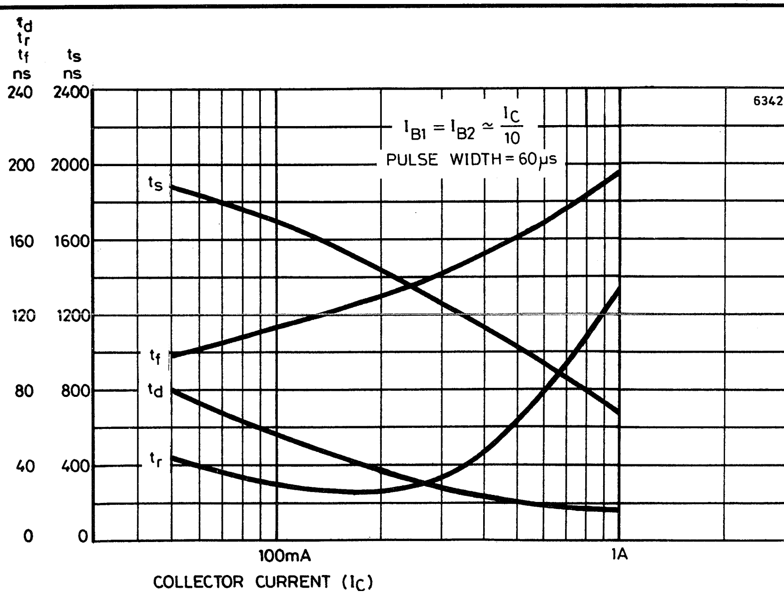
Typical transition frequency plotted against collector current for ZTX650



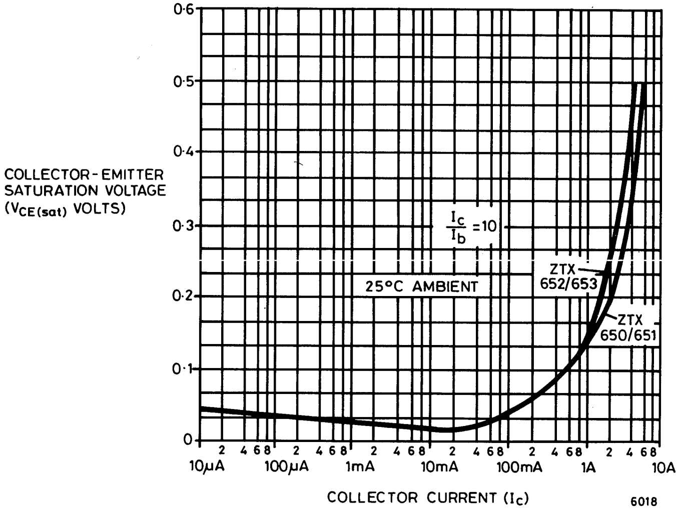
Switching speeds test circuit



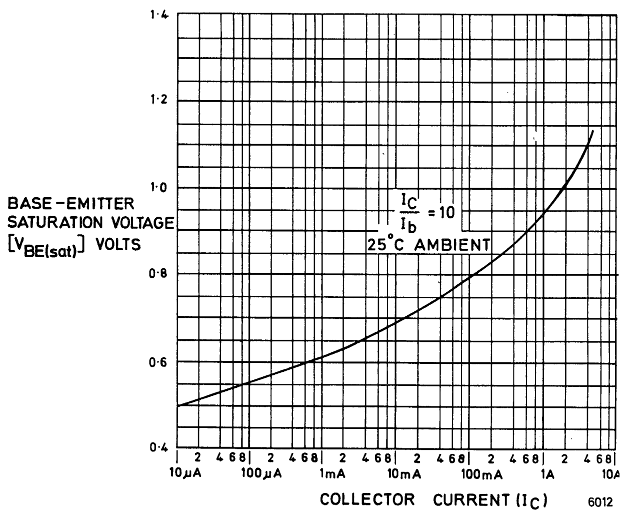
Typical switching speeds (ZTX650/ZTX651)



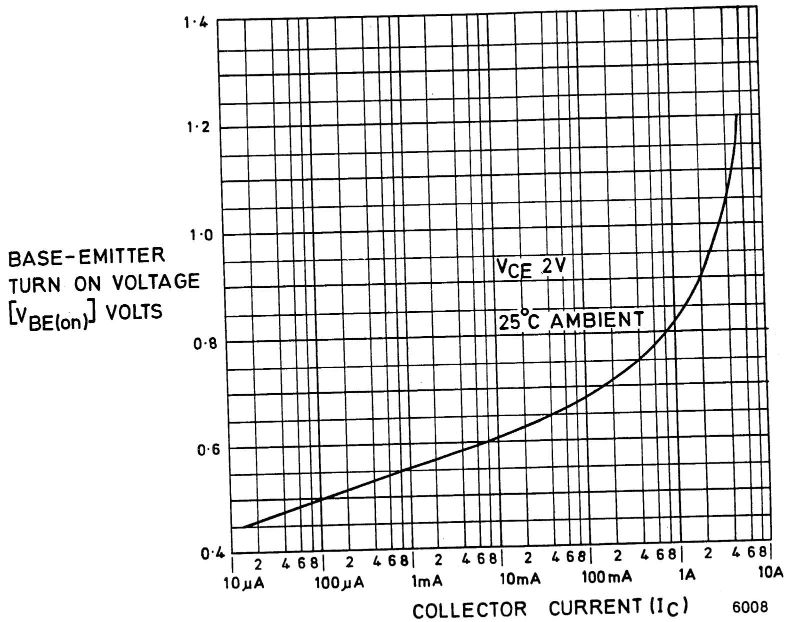
Typical switching speeds (ZTX652/ZTX653)



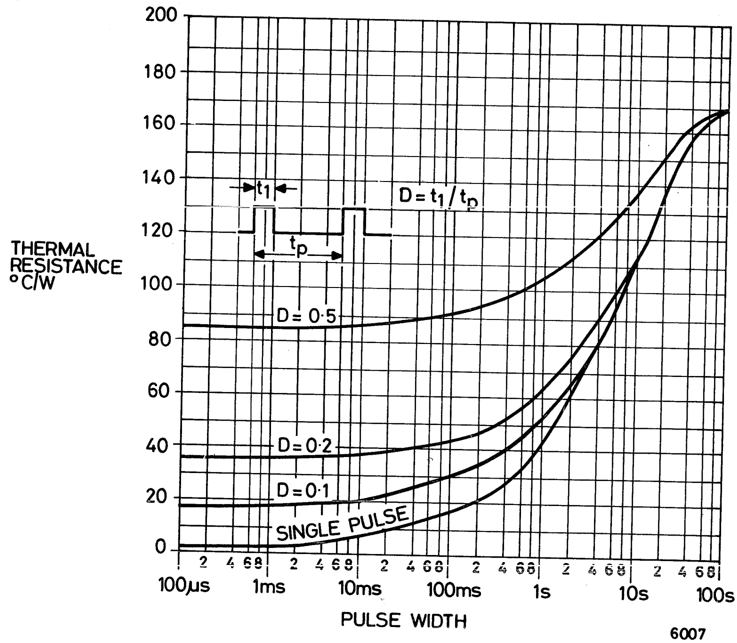
Typical collector-emitter saturation voltages plotted against collector current



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



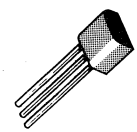
Typical transient thermal impedance curves

NPN silicon planar medium power high voltage transistors

ZTX654
ZTX655

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 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*	I_{CM}	2		A
Continuous collector current	I_C	1		A
Practical power dissipation†	P_{totP}	1.5		W
Power dissipation : at $T_{amb} = 25°C$ derate above 25°C	P_{tot}	1 5.7		W mW/°C
Operating and storage temperature range	$t_j : t_{stg}$	−55 to +200		°C

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

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

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	$I_C = 10mA$, $V_{CE} = 20V$ f = 20MHz
Output capacitance	C_{obo}	–	20	–	20	pF	$V_{CB} = 20V$, f = 1MHz

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

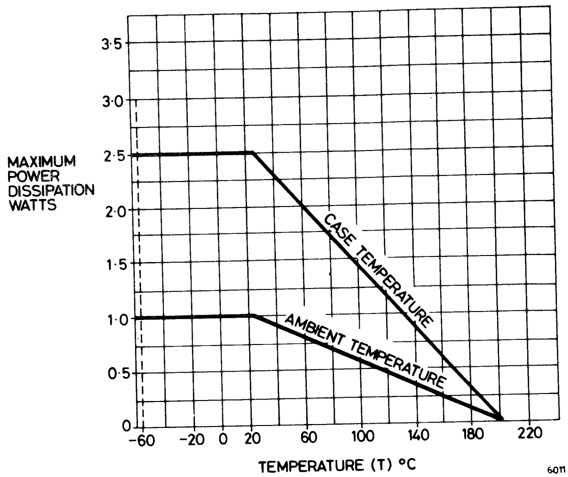
THERMAL CHARACTERISTICS

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.

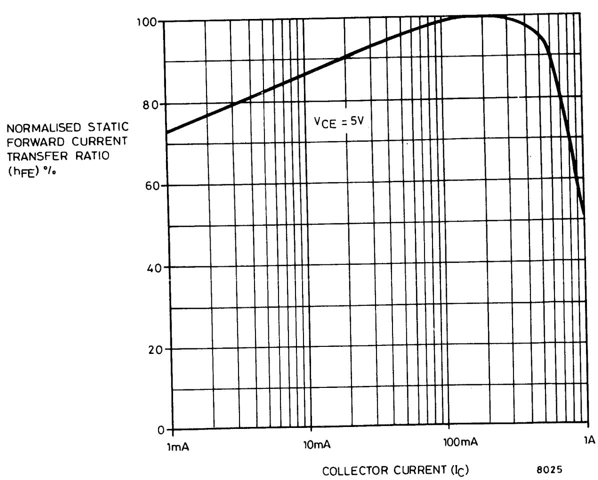
Note: Practical power dissipation. Where space does not permit 1 sq.inch copper the device fitted with Staver heat clip type F2-7 will offer the following:

Power dissipation at $T_{amb} = 25°C$ (P_{tot}) 1.4W
Derate above 25°C .. .. 8mW/°C
Thermal resistance, junction to ambient .. .. .. 125°C/W



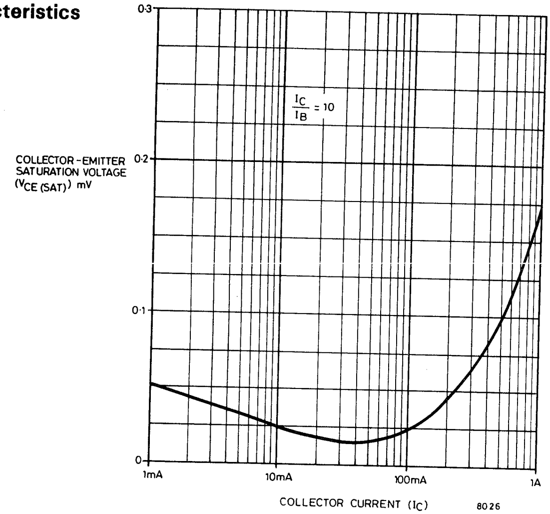
Dissipation derating curve for all types

Typical characteristics

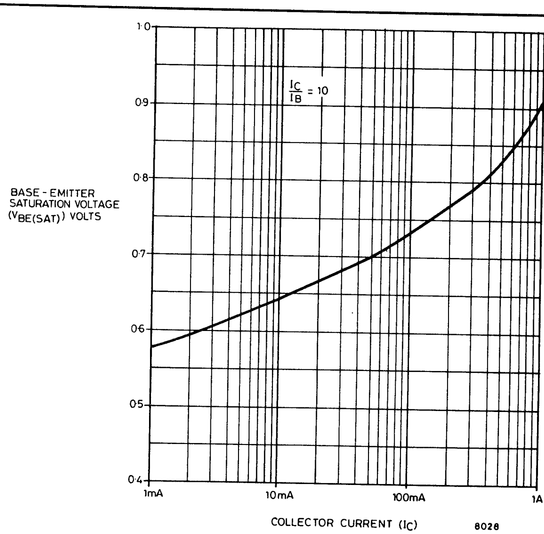


Typical static forward current transfer ratio plotted against collector current

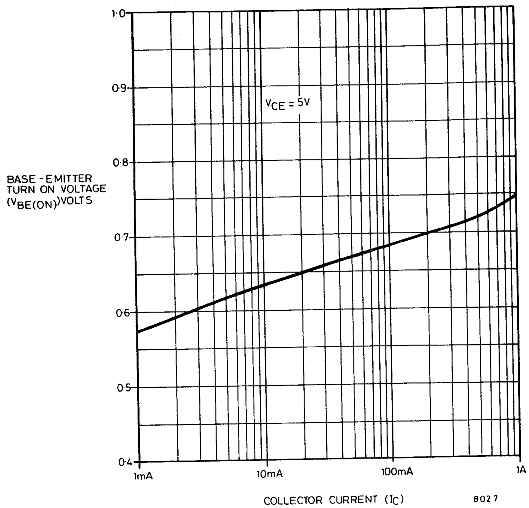
Typical Characteristics



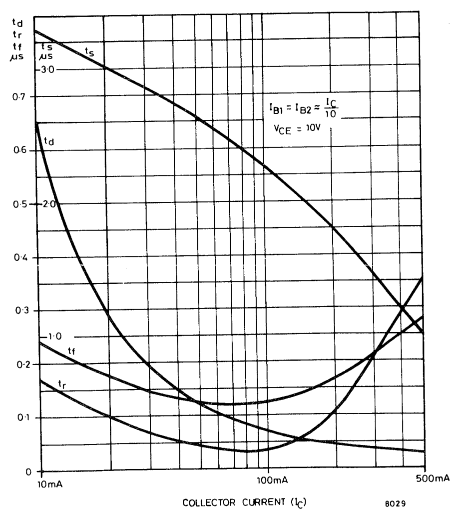
Typical collector-emitter saturation voltages plotted against collector current



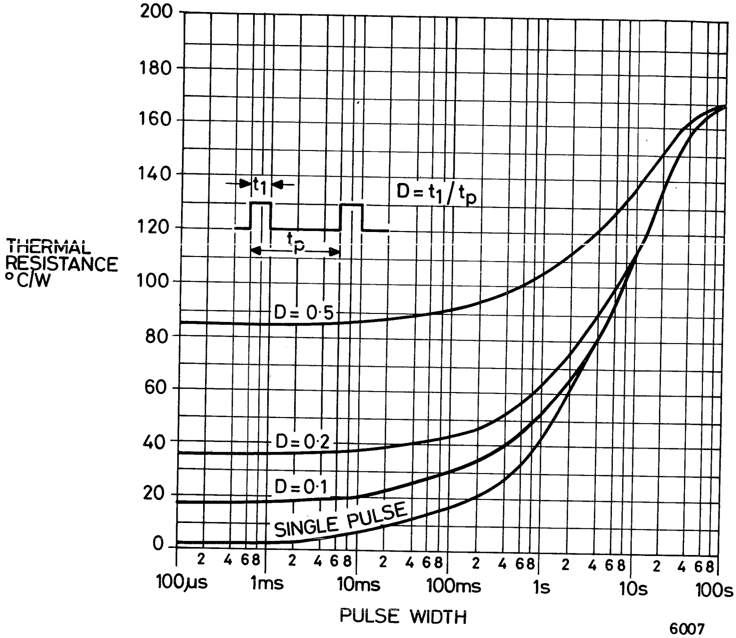
Typical base-emitter saturation voltages plotted against collector current



Typical base-emitter turn on voltages plotted against collector current



Typical switching speeds



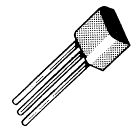
Typical transient thermal impedance curves

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



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 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*	I_{CM}	1		A
Continuous collector current	I_C	0.5		A
Practical power dissipation†	P_{totP}	1.5		W
Power dissipation : at $T_{amb} = 25°C$ derate above 25°C	P_{tot}	1 5.7		W mW/°C
Operating and storage temperature range	$t_j : t_{stg}$	−55 to +200		°C

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

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

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	$I_C=10mA$, $V_{CE}=20V$ f=20MHz
Output capacitance	C_{obo}	–	20	–	20	pF	$V_{CB}=20V$, f=1MHz

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

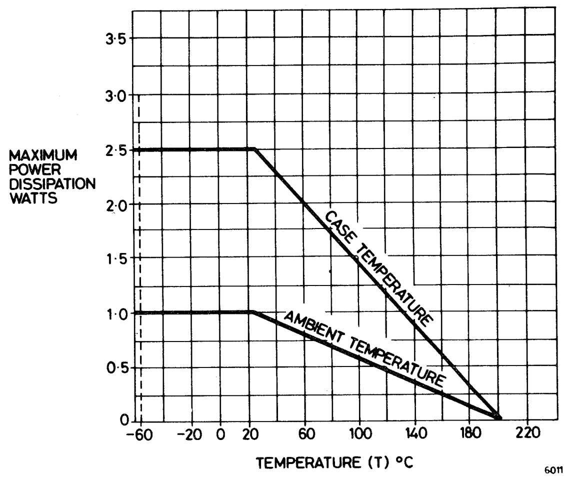
THERMAL CHARACTERISTICS

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.

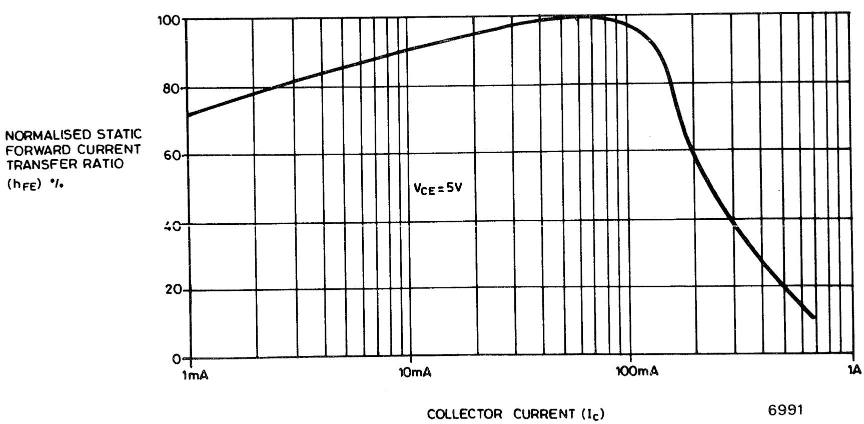
Note: Practical power dissipation. Where space does not permit 1 sq.inch copper the device fitted with Staver heat clip type F2-7 will offer the following:

Power dissipation at $T_{amb}=25°C$ (P_{tot}) 1.4W
Derate above 25°C . . . . 8mW/°C
Thermal resistance, junction to ambient . . . . 125°C/W



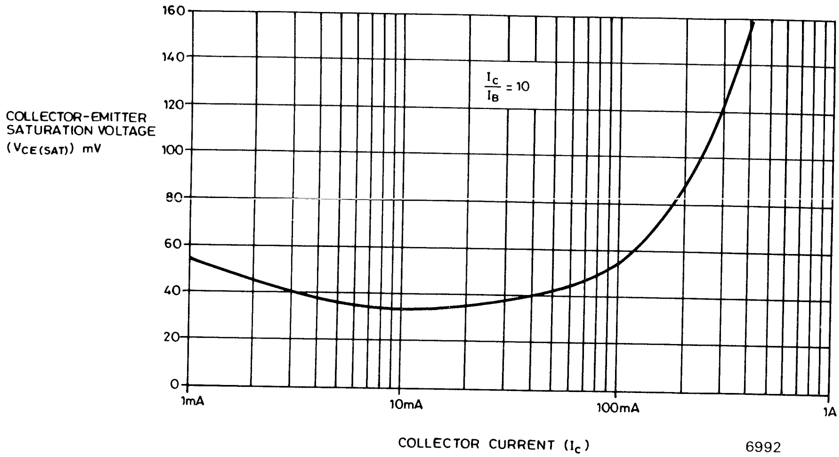
Dissipation derating curve for all types

Typical characteristics

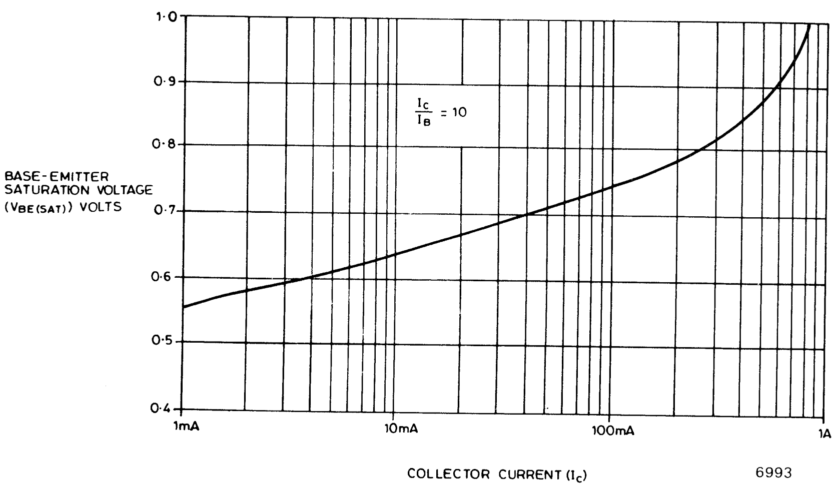


Typical static forward current transfer ratio plotted against collector current

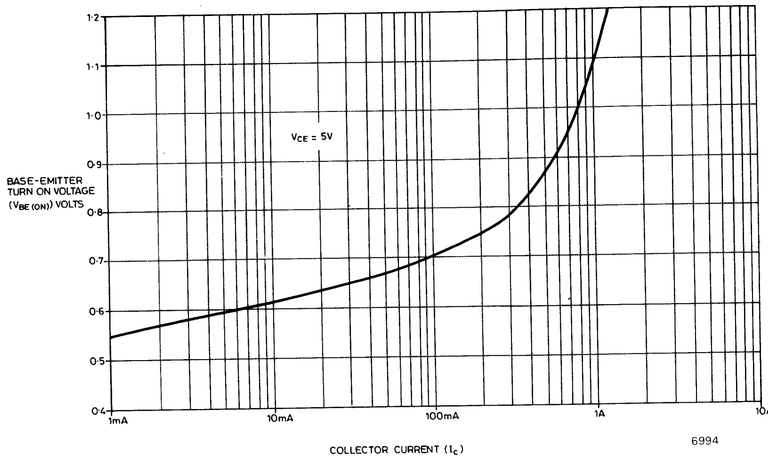
Typical characteristics



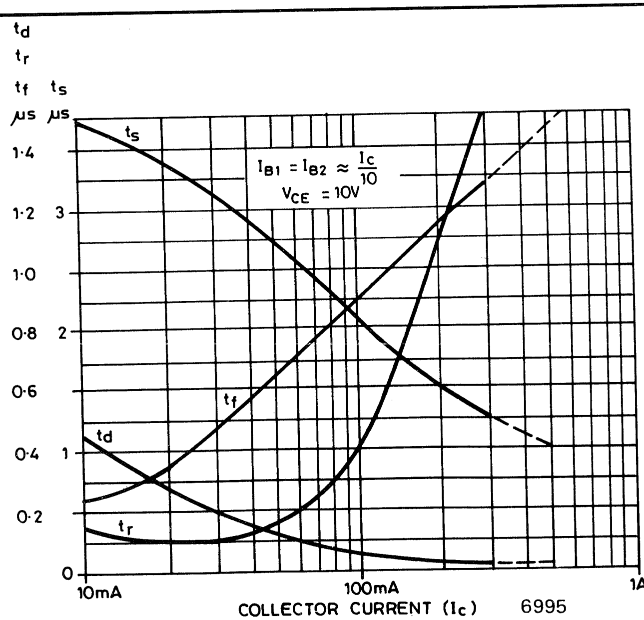
Typical collector-emitter saturation voltages plotted against collector current



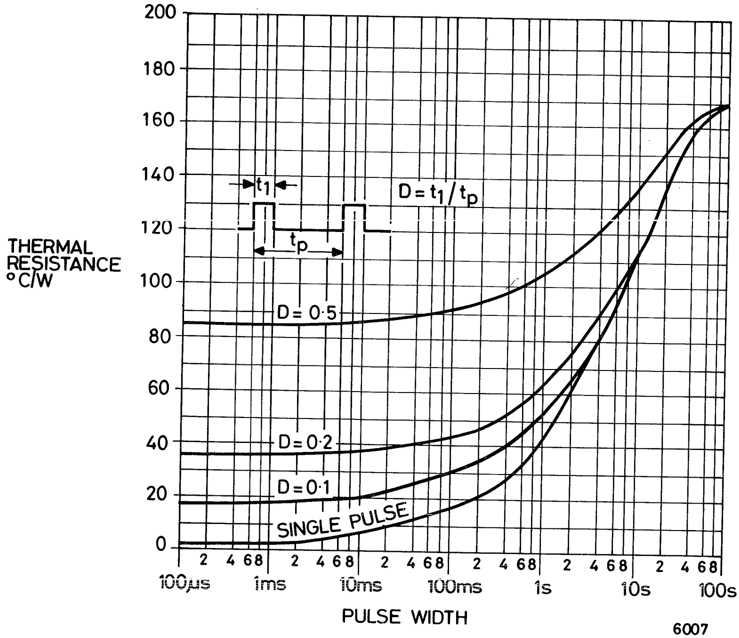
Typical base-emitter saturation voltages plotted against collector current



Typical base-emitter turn on voltages plotted against collector current



Typical switching speeds



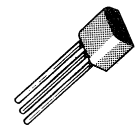
Typical transient thermal impedance curves

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*	i_{CM}	−6	A
Continuous collector current	I_C	−2	A
Practical power dissipation†	P_{totP}	1.5	W
Power dissipation: at $T_{amb} = 25°C$ derate above 25°C	P_{tot}	1 5.7	W mW/°C
Operating and storage temperature range	$t_j : t_{stg}$	−55 to +200	°C

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

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

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	$I_C = -100mA$, $V_{CE} = -5V$ f = 100MHz
Output capacitance	C_{obo}		55	100	pF	$V_{CB} = -10V$, f = 1MHz
Switching times	T_{on}	–	40		nS	$I_C = -500mA$, $V_{CC} = -10V$ $I_{B1} = I_{B2} = -50mA$
	T_{off}		500		nS	

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

THERMAL CHARACTERISTICS

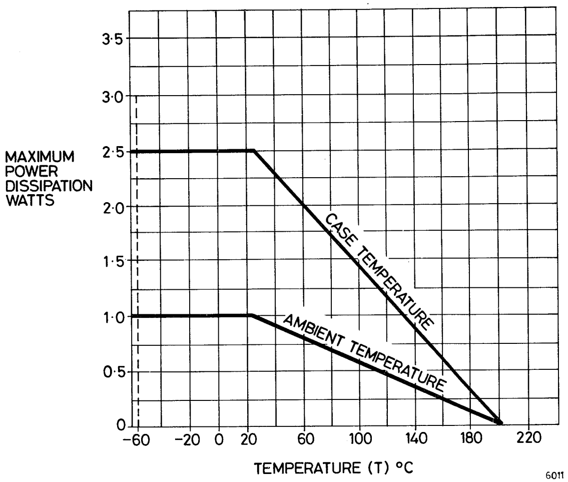
Parameter		Symbol	Maximum	Unit
Thermal resistance:	Junction to ambient$_1$	$R_{th(j\text{-}amb)1}$	175	°C/W
	Junction to ambient$_2$	$R_{th(j\text{-}amb)2}$†	116	°C/W
	Junction to case	$R_{th(j\text{-}case)}$	70	°C/W

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

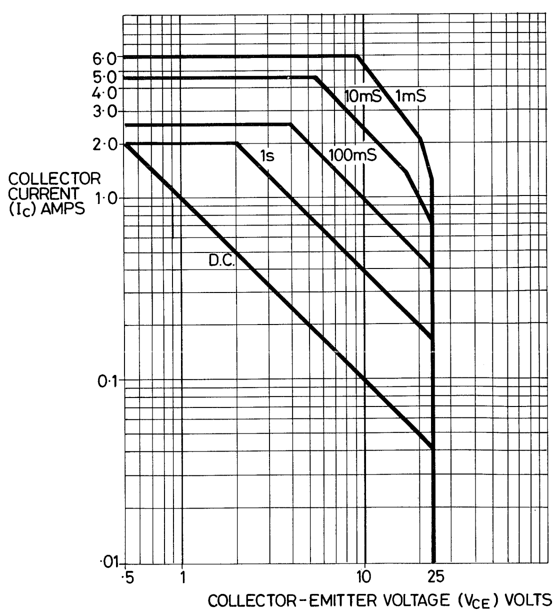
Note: Practical power dissipation. Where space does not permit 1 sq.inch copper the device fitted with Staver heat clip type F2-7 will offer the following:

Power dissipation at T_{amb} = 25°C (P_{tot})	1.4W
Derate above 25°C	8mW/°C
Thermal resistance, junction to ambient	125°C/W

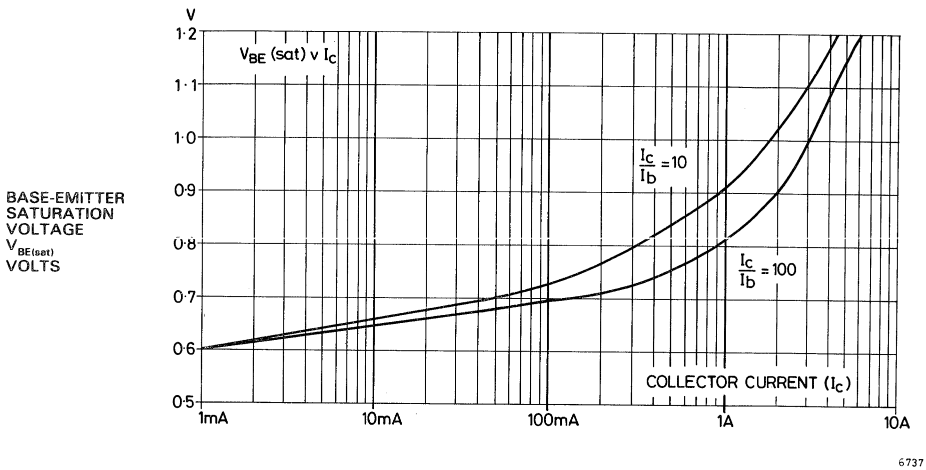
ZTX749



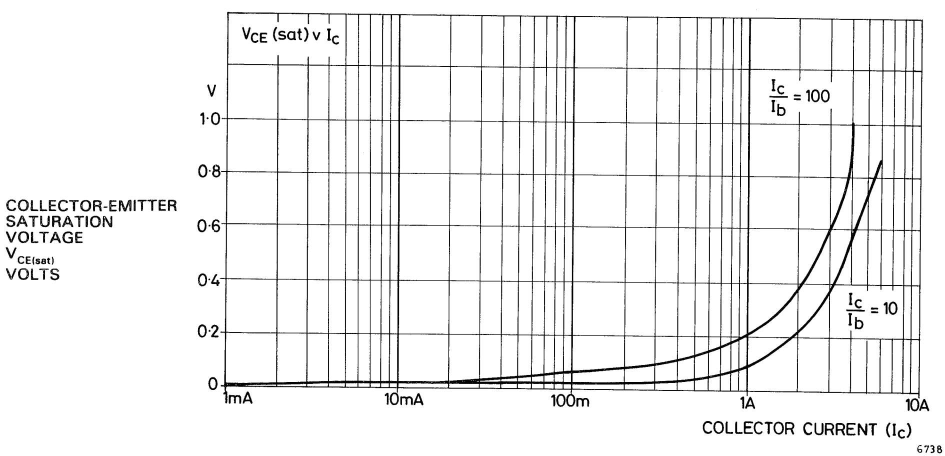
Dissipation derating curve



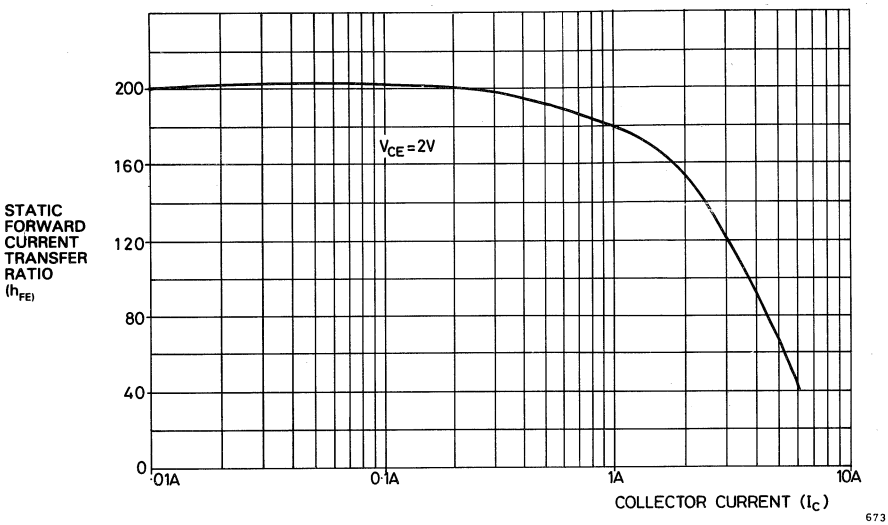
Safe operating area at $T_{amb} = 25°C$ (single-pulse)



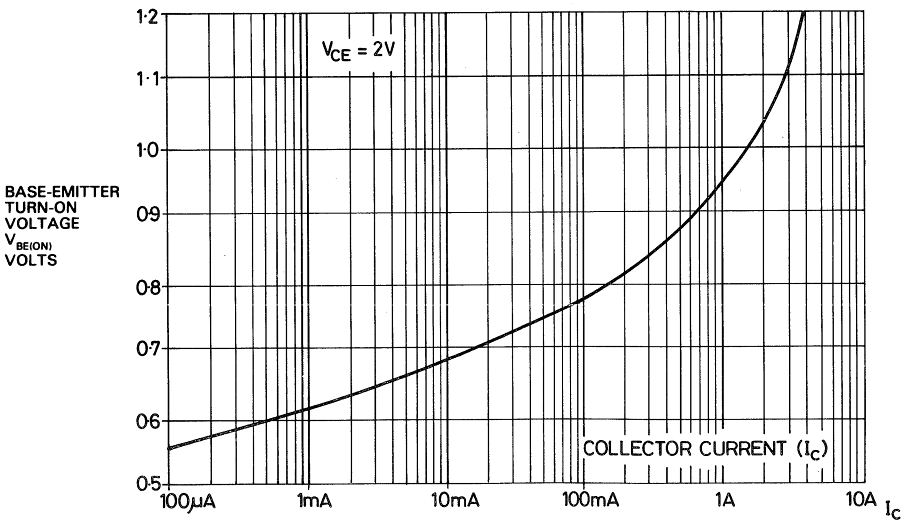
Typical base-emitter saturation voltages plotted against collector current



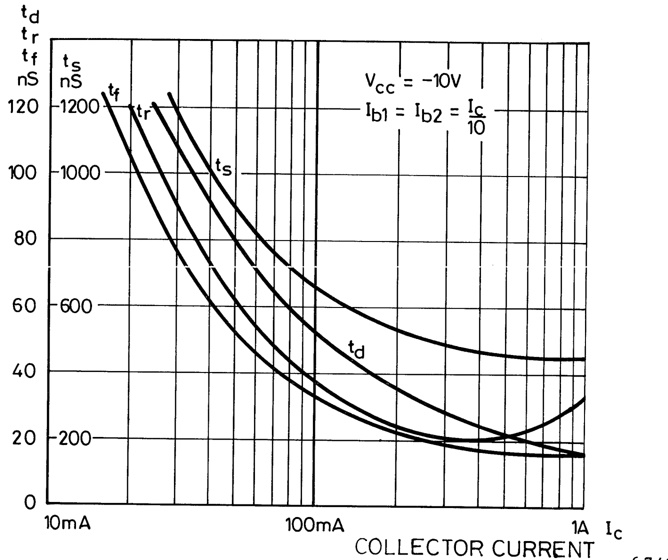
Typical collector-emitter saturation voltages plotted against collector current



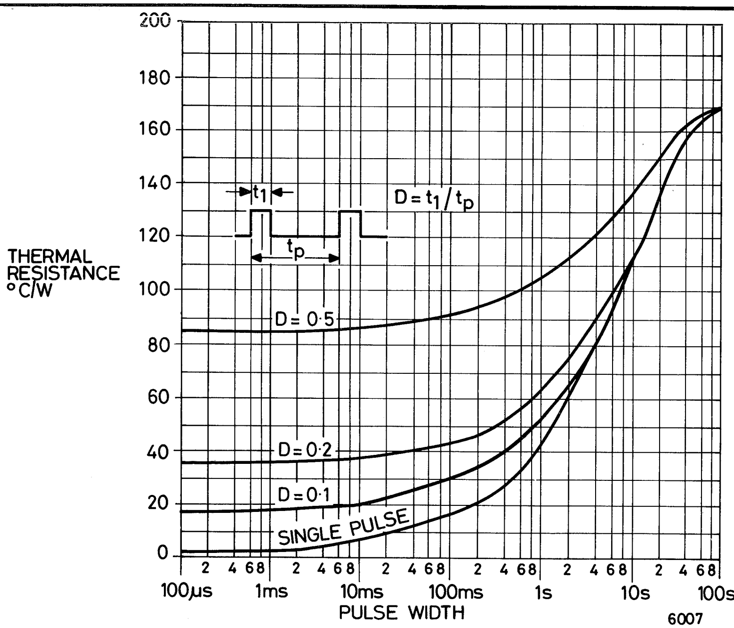
Typical static forward current transfer ratio plotted against collector current



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



Typical switching speeds



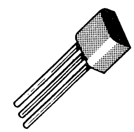
Typical transient thermal impedance curves

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}	−45	−60	−80	−100	V
Emitter-base voltage	V_{EBO}	−5				V
Peak pulse current*	I_{CM}	−6				A
Continuous collector current	I_C	−2				A
Practical power dissipation†	P_{totP}	1.5				W
Power dissipation at $T_{amb}=25°C$ derate above 25°C at $T_{case}=25°C$	P_{tot}	1 5.7 2.5				W mW/°C W
Operating & storage temp. range	$t_j : t_{stg}$	−55 to +200				°C

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

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

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	–		$I_C=-2V$*, $V_{CE}=-2V$*
Transition frequency	f_T	100	140	–	100	140	–	MHz	$I_C=-100mA$, $V_{CE}=-5V$ f = 100MHz
Switching times	T_{on}	–	40	–	–	40	–	ns	$I_C=-500mA$, $I_{B_1}=-50mA$
	T_{off}	–	450	–	–	450	–	ns	$I_{B_2}=-50mA$, $V_{CC}=-10V$

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

THERMAL CHARACTERISTICS (ZTX750/3)

Parameter	Symbol	Maximum	Unit
Thermal resistance: Junction to ambient₁	$R_{th(j-amb)1}$	175	°C/W
Junction to ambient₂	$R_{th(j-amb)2}$†	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).

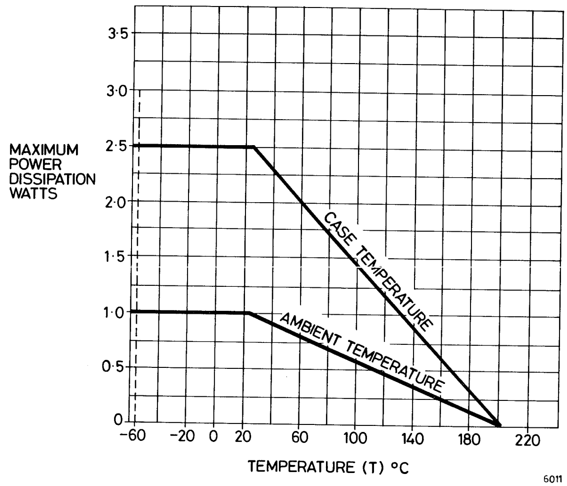
Parameter	Symbol	ZTX752			ZTX753			Unit	Conditions
		Min.	Typ.	Max.	Min.	Typ.	Max.		
Collector-base breakdown voltage	$V_{(BR)CBO}$	−100	–	–	−120	–	–	V	$I_C = -100\mu A$
Collector-emitter breakdown voltage	$V_{(BR)CEO}$	−80	–	–	−100	–	–	V	$I_C = -10mA$
Emitter-base breakdown voltage	$V_{(BR)EBO}$	−5	–	–	−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	–		$I_C = -2V$*, $V_{CE} = -2V$*
Transition frequency	f_T	100	140	–	100	140	–	MHz	$I_C = -100mA$, $V_{CE} = -5V$ f = 100MHz
Switching times	T_{on}	–	40	–	–	40	–	ns	$I_C = -500mA$, $I_{B_1} = -50mA$
	T_{off}	–	600	–	–	600	–	ns	$I_{B_2} = -50mA$, $V_{CC} = -10V$

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

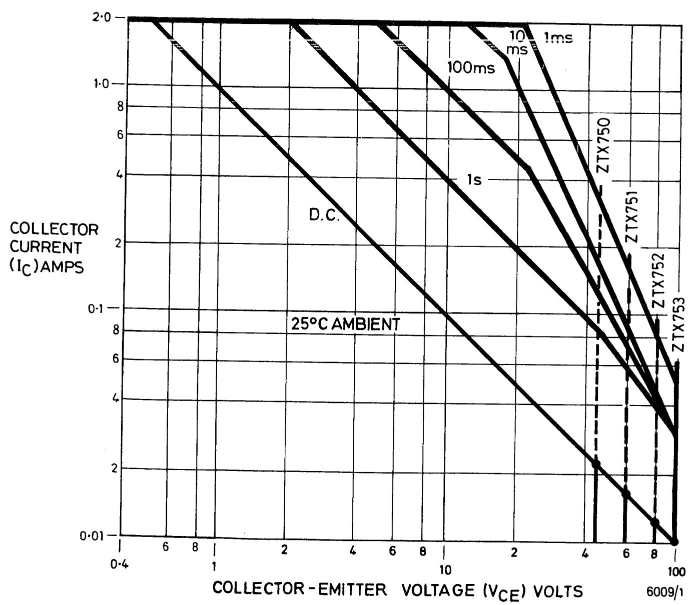
Note: Practical power dissipation. Where space does not permit 1 sq.inch copper the device fitted with Staver heat clip type F2-7 will offer the following:

Power dissipation at $T_{amb} = 25°C$ (P_{tot})	1.4W
Derating above 25°C	8mW/°C
Thermal resistance, junction to ambient	125°C/W

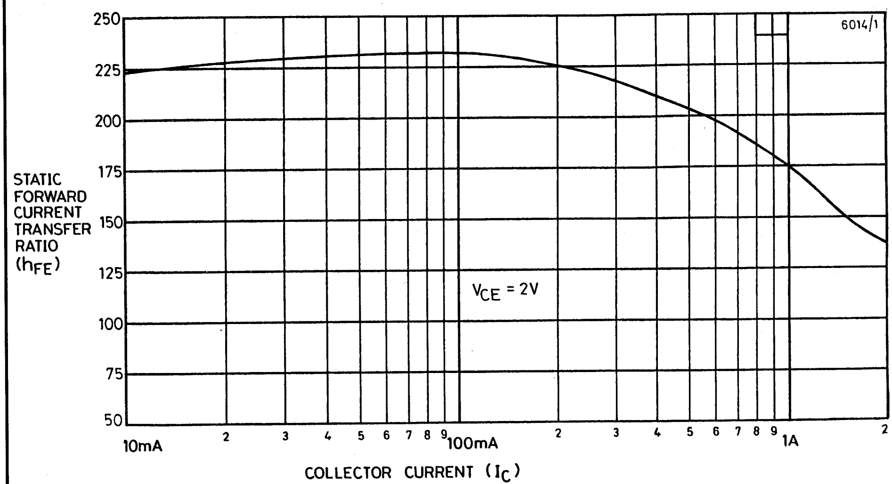
ZTX750 ZTX751 ZTX752 ZTX753



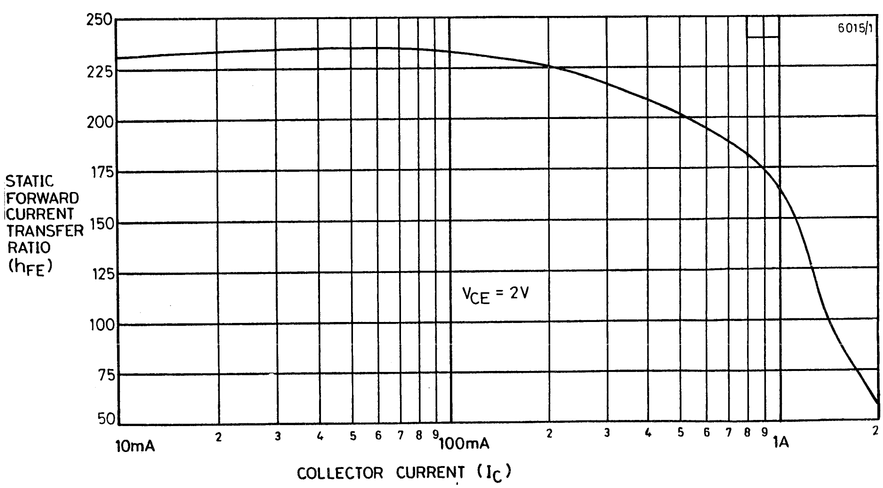
Dissipation derating curve for all types



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



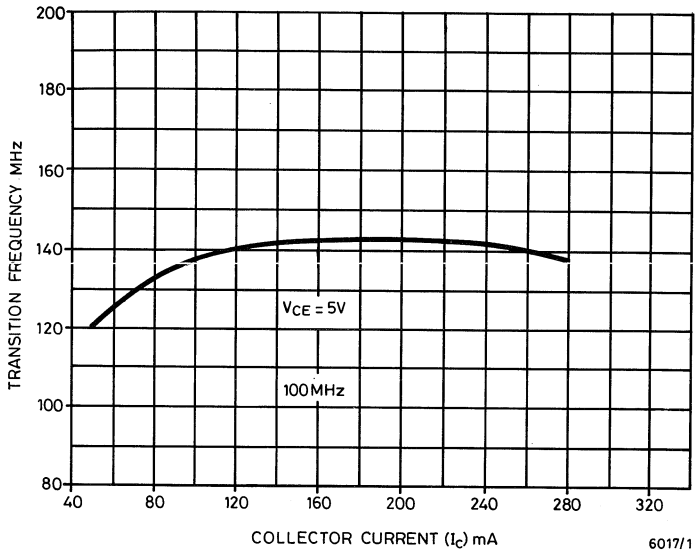
Static forward current transfer ratio plotted against collector current for ZTX750/ZTX751



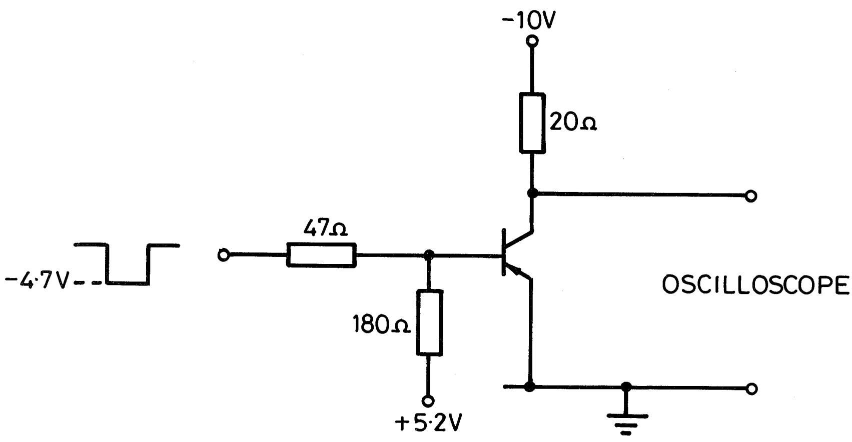
Static forward current transfer ratio plotted against collector current for ZTX752/753

Typical characteristics

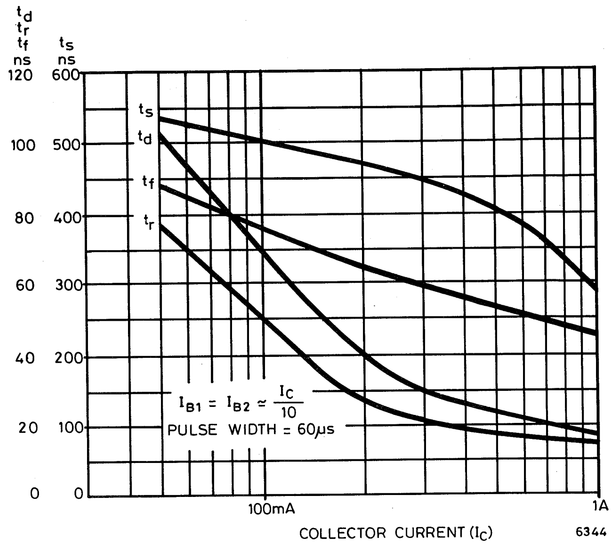
ZTX750 ZTX751 ZTX752 ZTX753



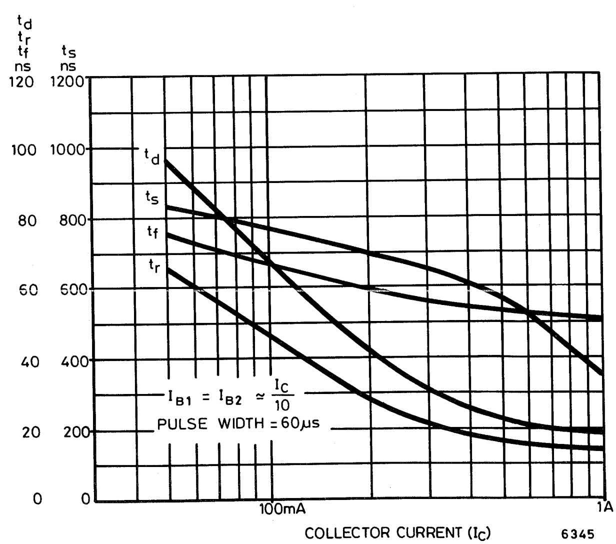
Typical transition frequency plotted against collector current for ZTX750



Switching speeds test circuit

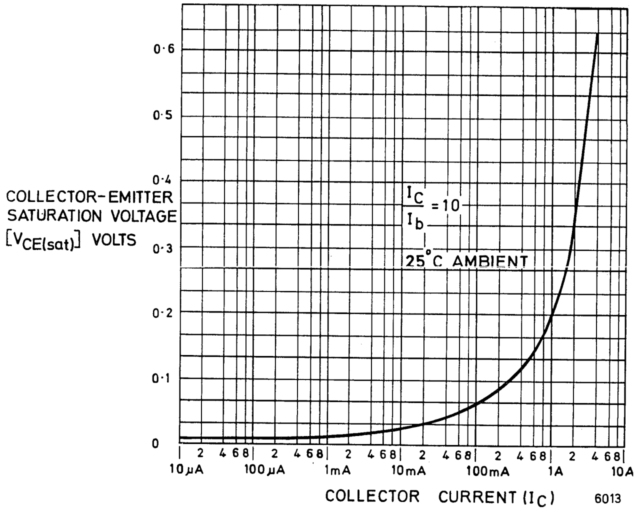


Typical switching speeds (ZTX750/751)

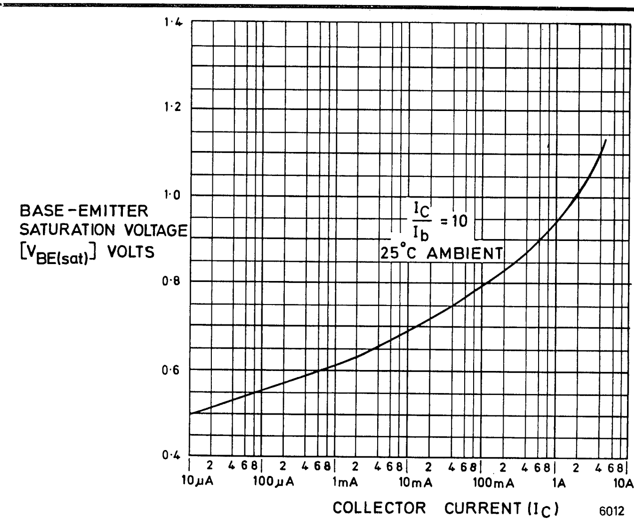


Typical switching speeds (ZTX752/753)

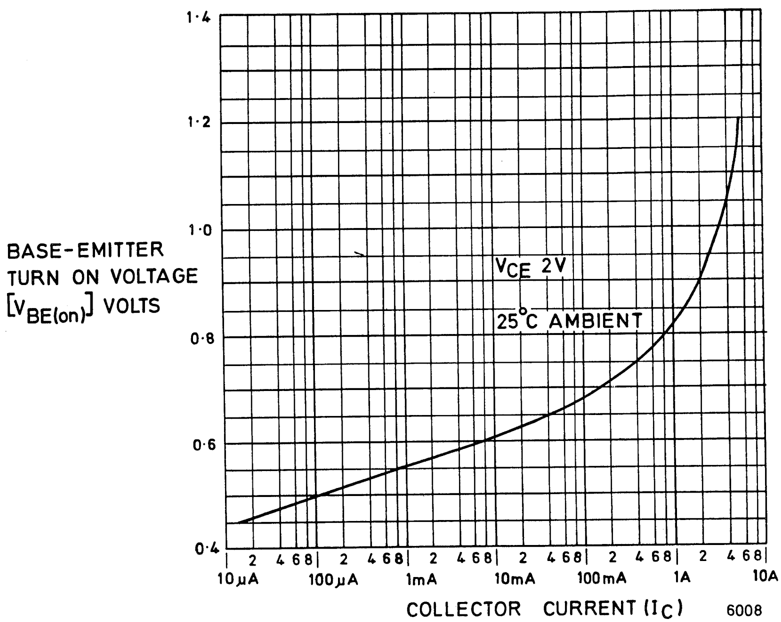
ZTX750 ZTX751 ZTX752 ZTX753



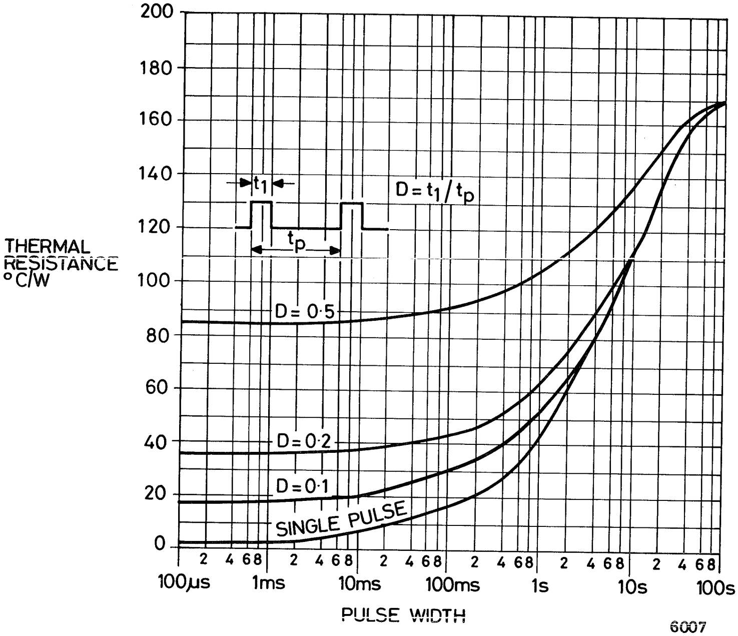
Typical collector-emitter saturation voltages plotted against collector current for all types



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



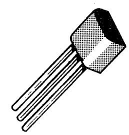
Typical transient thermal impedance curves

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*	I_{CM}	−2		A
Continuous collector current	I_C	−1		A
Practical power dissipation†	P_{totP}	1.5		W
Power dissipation : at $T_{amb}=25°C$ derate above 25°C	P_{tot}	1 5.7		W mW/°C
Operating and storage temperature range	$t_j : t_{stg}$	−55 to +200		°C

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

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

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	$I_C = -10mA$, $V_{CE} = -20V$ $f = 20MHz$
Output capacitance	C_{obo}	–	20	–	20	pF	$V_{CB} = -20V$, $f = 1MHz$

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

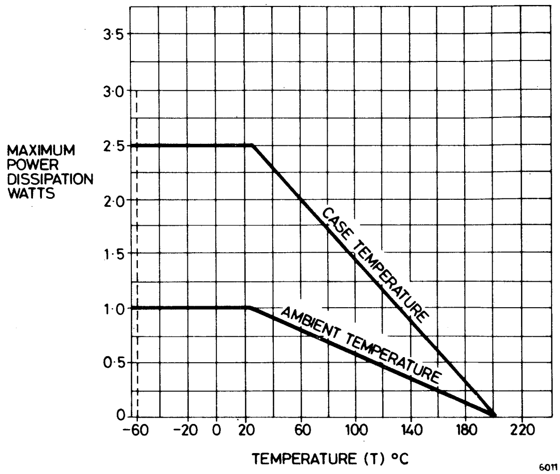
THERMAL CHARACTERISTICS

Parameter		Symbol	Maximum	Unit
Thermal resistance:	Junction to ambient₁	$R_{th(j-amb)1}$	175	°C/W
	Junction to ambient₂	$R_{th(j-amb)2}$†	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.

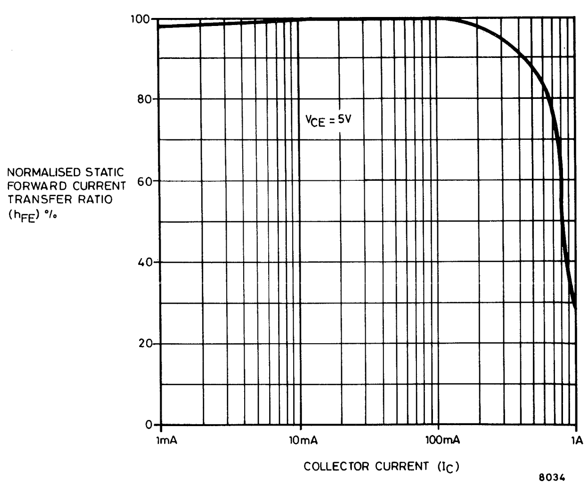
Note: Practical power dissipation. Where space does not permit 1 sq.inch copper the device fitted with Staver heat clip type F2-7 will offer the following:

Power dissipation at $T_{amb} = 25°C$ (P_{tot}) 1.4W
Derate above 25°C .. .. 8mW/°C
Thermal resistance, junction to ambient .. .. 125°C/W

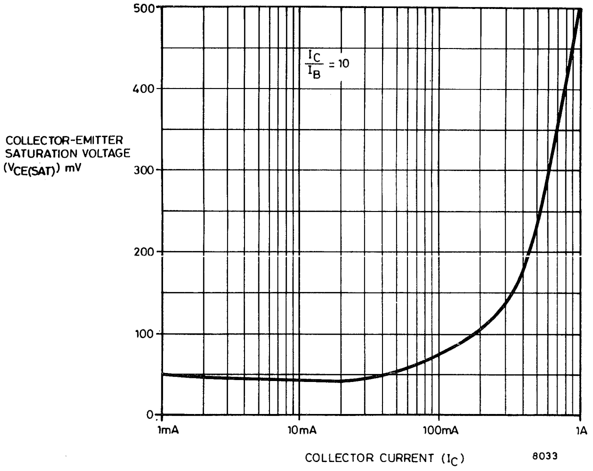


Dissipation derating curve for all types

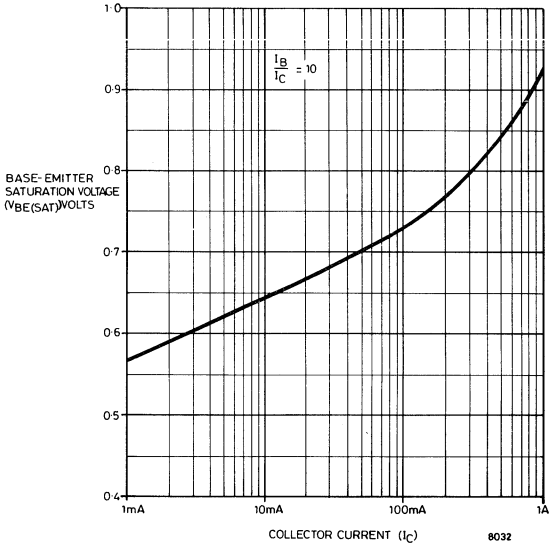
Typical characteristics



Typical static forward current transfer ratio plotted against collector current

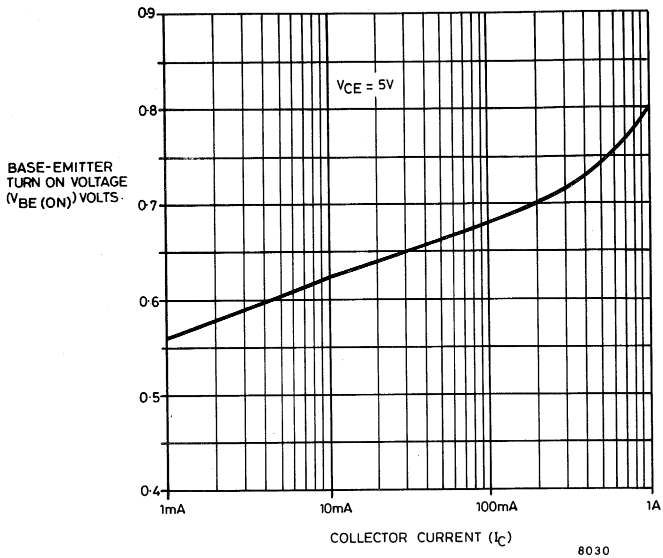


Typical collector-emitter saturation voltages plotted against collector current

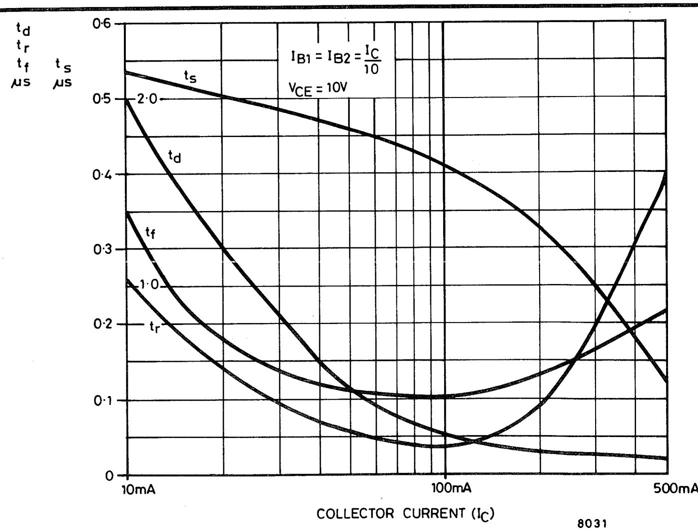


Typical base-emitter saturation voltages plotted against collector current

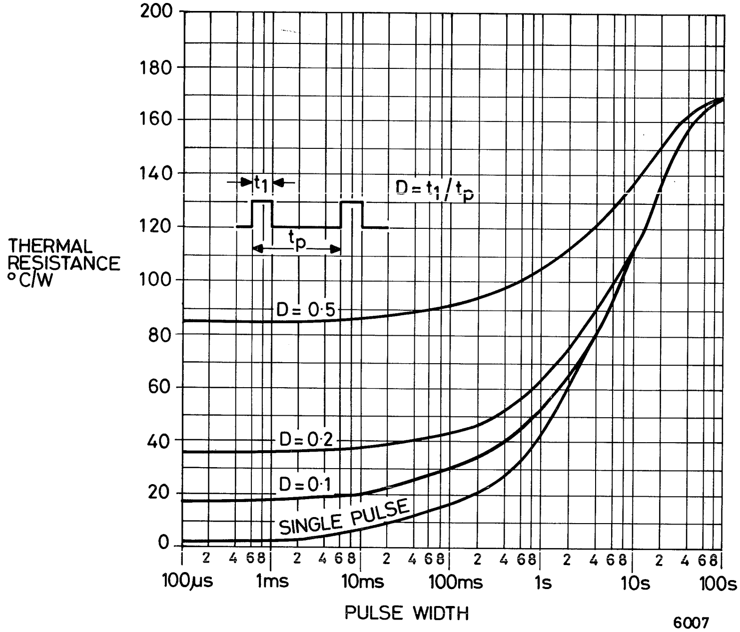
Typical characteristics



Typical base-emitter turn on voltages plotted against collector current



Typical switching speeds



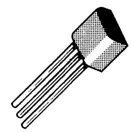
Typical transient thermal impedance curves

PNP silicon planar medium power high voltage transistors

ZTX756
ZTX757

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



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 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*	I_{CM}	−1		A
Continuous collector current	I_C	−0.5		A
Practical power dissipation†	P_{totP}	1.5		W
Power dissipation : at $T_{amb} = 25°C$ derate above 25°C	P_{tot}	1 5.7		W mW/°C
Operating and storage temperature range	$t_j : t_{stg}$	−55 to +200		°C

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

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

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	$I_C = -10mA$, $V_{CE} = -20V$ $f = 20MHz$
Output capacitance	C_{obo}	–	20	–	20	pF	$V_{CB} = -20V$, $f = 1MHz$

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

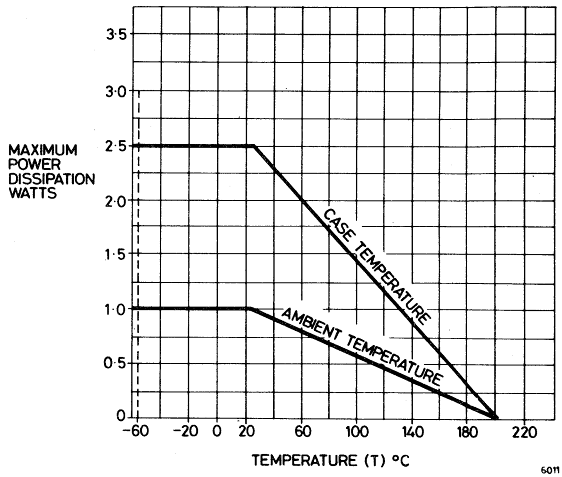
THERMAL CHARACTERISTICS

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.

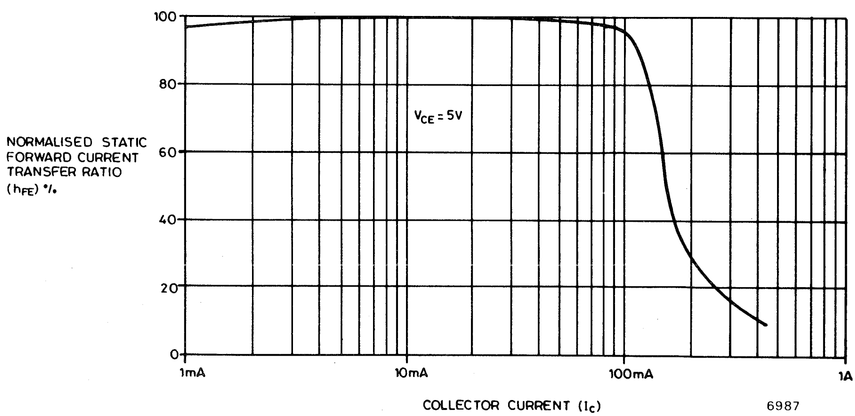
Note: Practical power dissipation. Where space does not permit 1 sq.inch copper the device fitted with Staver heat clip type F2-7 will offer the following:

Power dissipation at $T_{amb} = 25°C$ (P_{tot}) 1.4W
Derate above 25°C . . . . 8mW/°C
Thermal resistance, junction to ambient . . . . 125°C/W



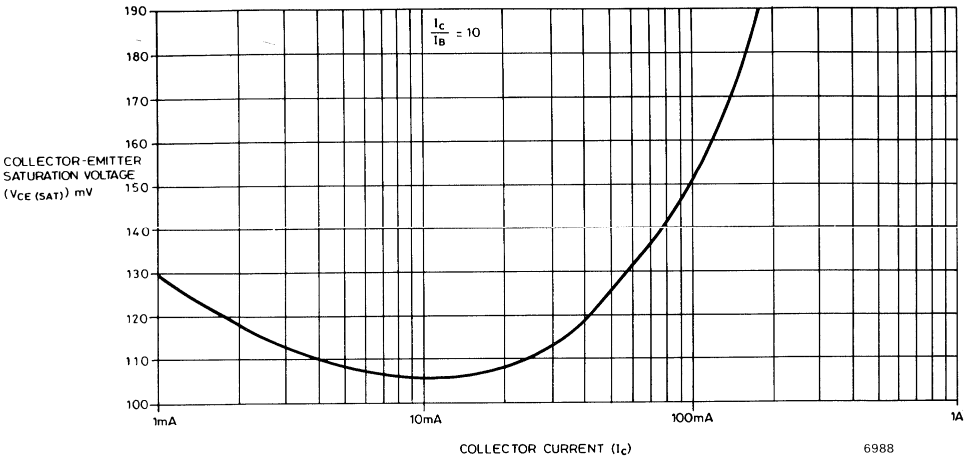
Dissipation derating curve for all types

Typical characteristics

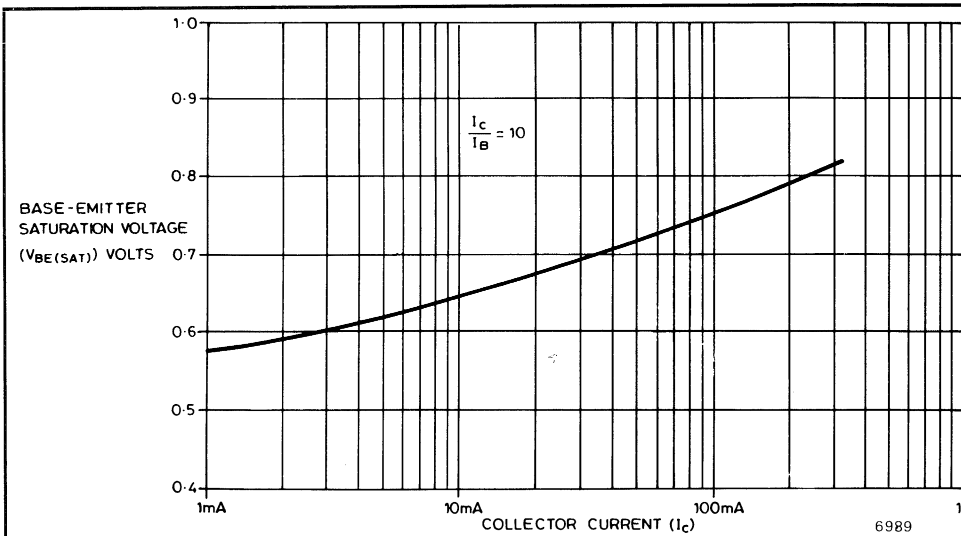


h_{FE}/I_C
Typical static forward current transfer ratio plotted against collector current

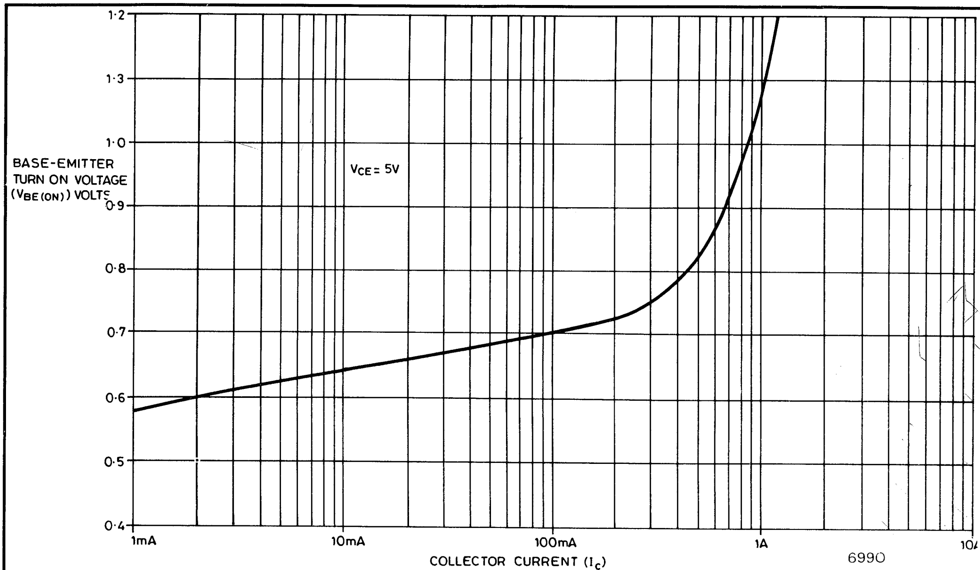
Typical characteristics



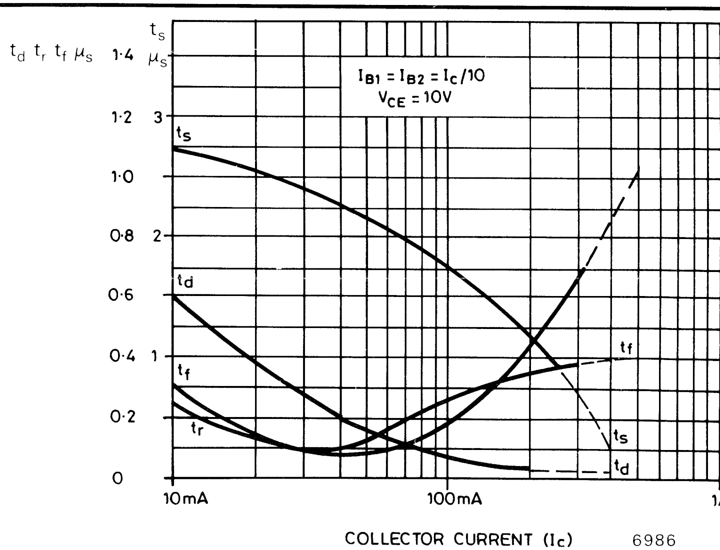
Typical collector-emitter saturation voltages plotted against collector current



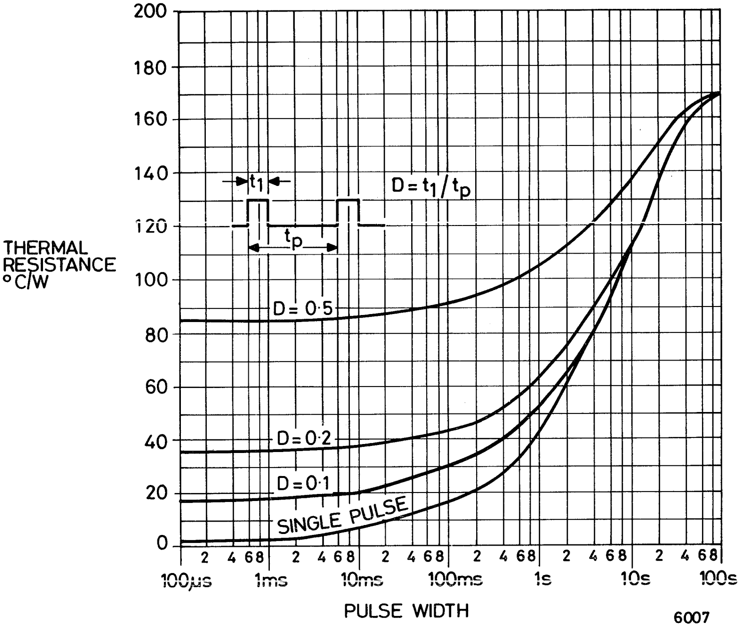
Typical base-emitter saturation voltages plotted against collector current



Typical base-emitter turn on voltages plotted against collector current



Typical switching speeds



Typical transient thermal impedance curves

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.

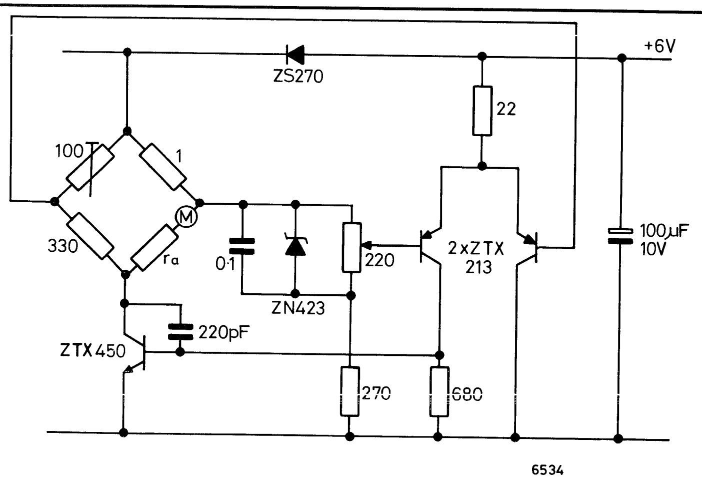


Fig. 1.1

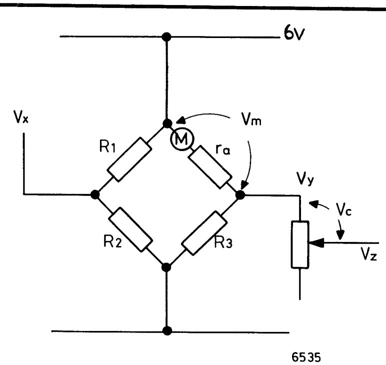


Fig. 1.2

Theory

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

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

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

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

but $V_m = V_a + I_m r_a$

substituting in 1.

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

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%.

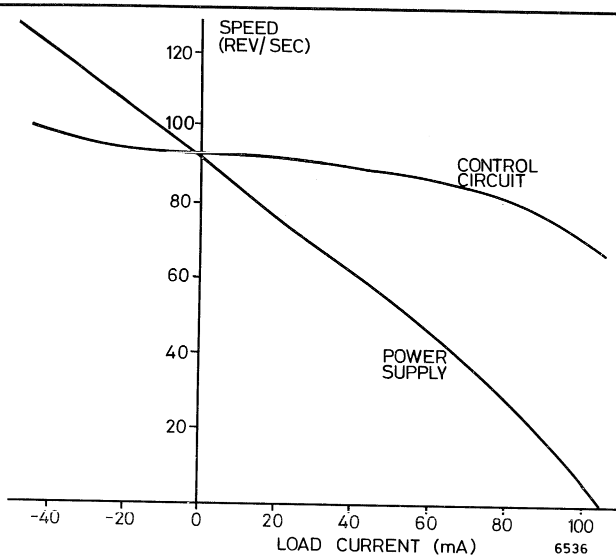


Fig. 1.3

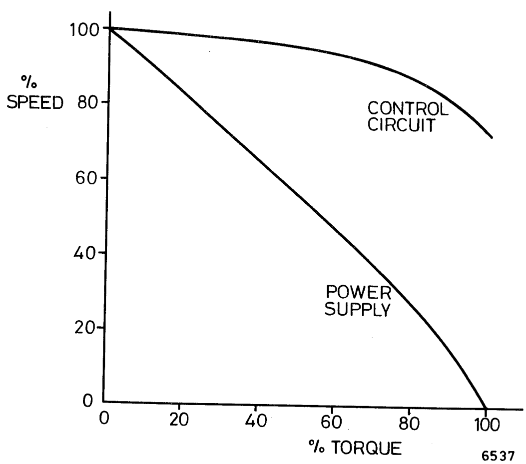


Fig. 1.4

2. 60W FLASHING LIGHT

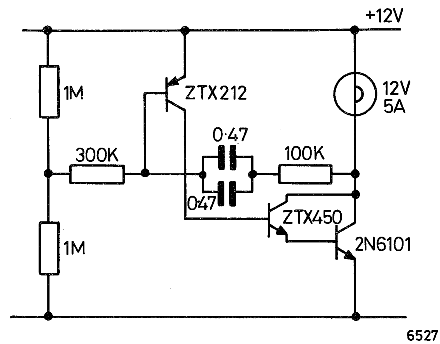


Fig. 2.1

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

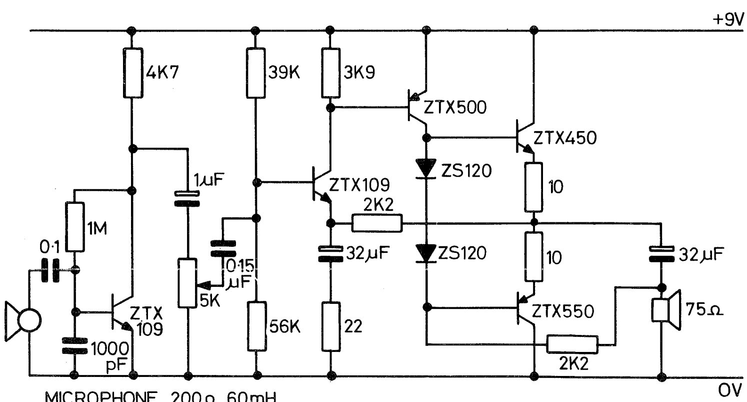


Fig. 3.1

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

4. 12V LATCH CIRCUIT

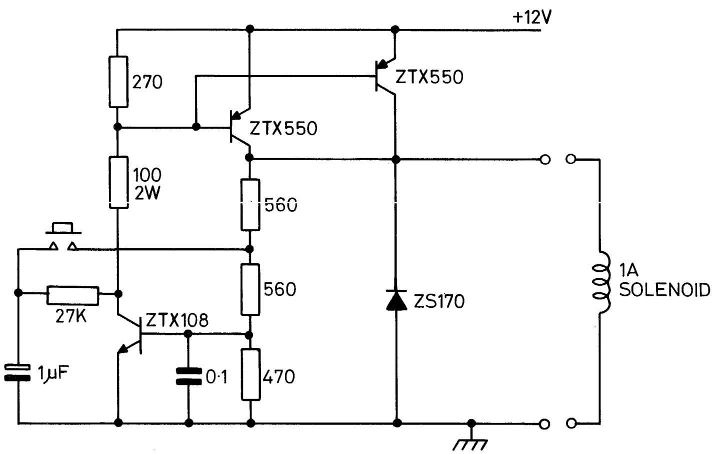


Fig. 4.1

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

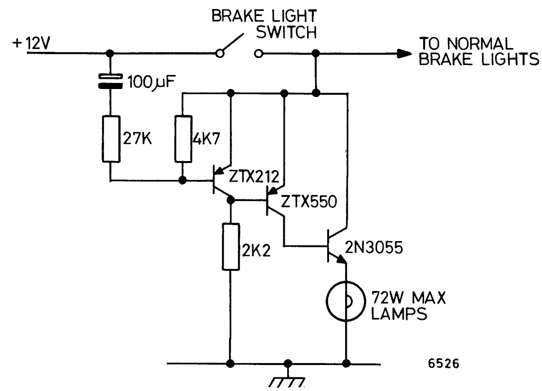


Fig. 5.1

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

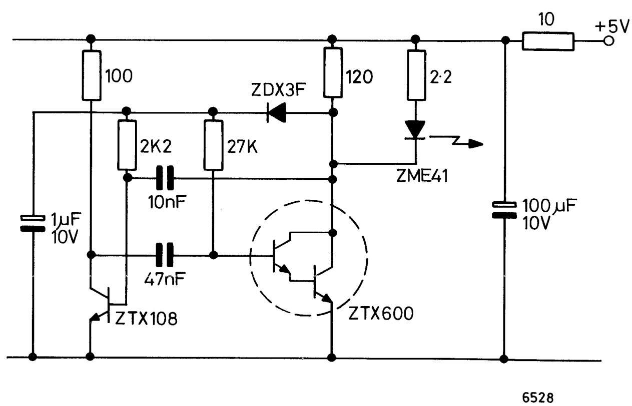


Fig. 6.1

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

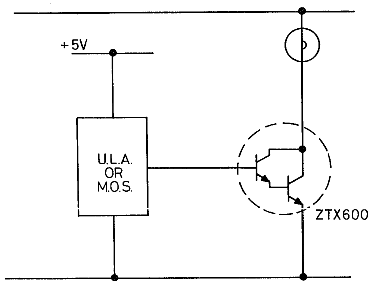


Fig. 7.1

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

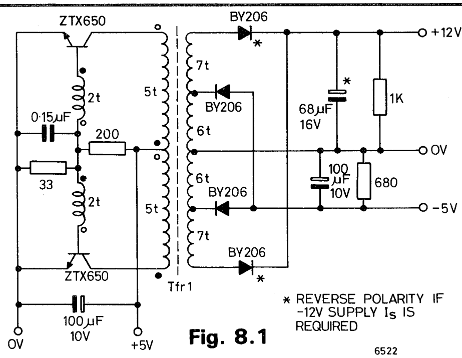


Fig. 8.1

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} = 20Ω 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} = 500Ω Output current (mA)
12.2	10
11.8	100
11.6	200
11.4	300
11.2	400
10.8	500
10.6	600

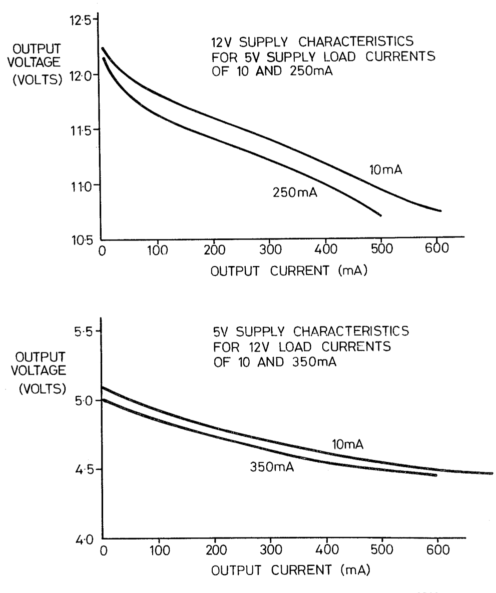


Fig. 8.2

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.

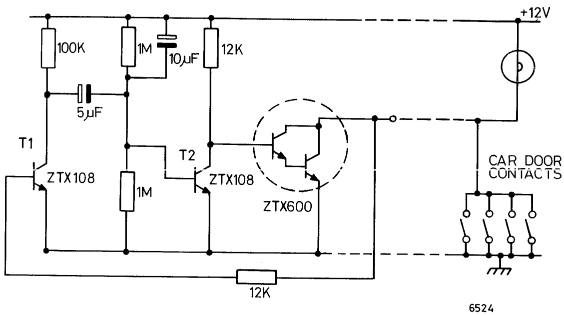


Fig. 9.1

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

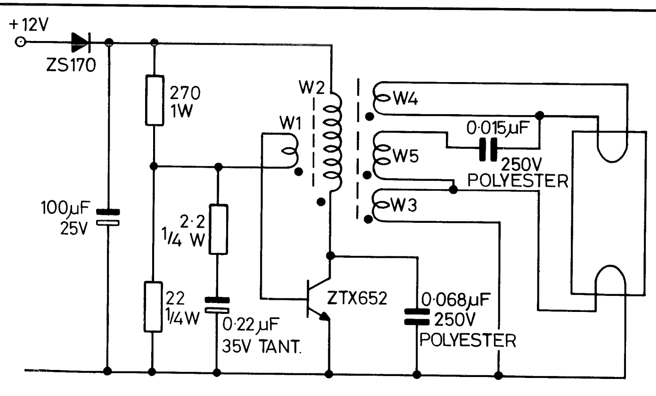


Fig. 10.1

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. 〃 〃 〃

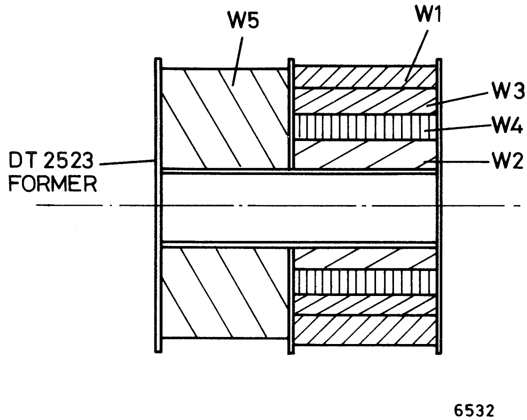


Fig. 10.2

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 0.68μF 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 similar applications, no heat-sink is necessary.

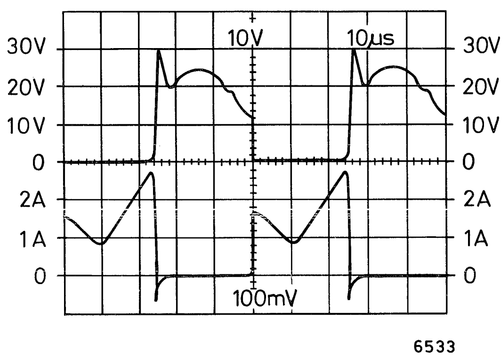


Fig. 10.3

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.

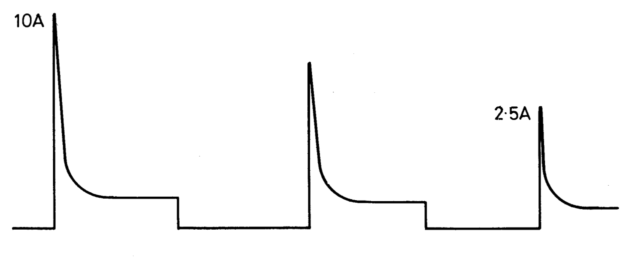


Fig. 11.1

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

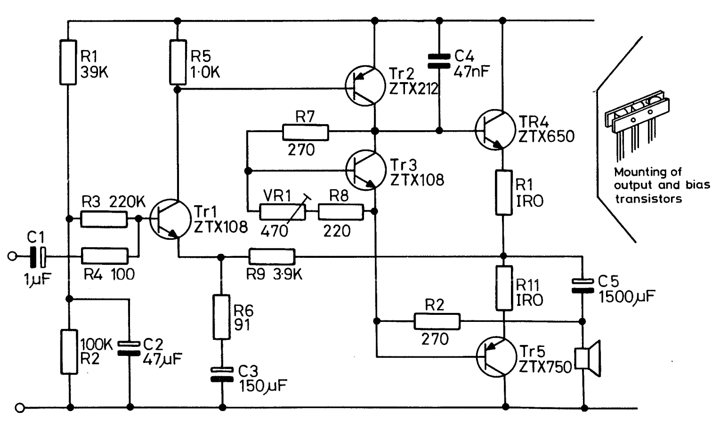


Fig. 12.1

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

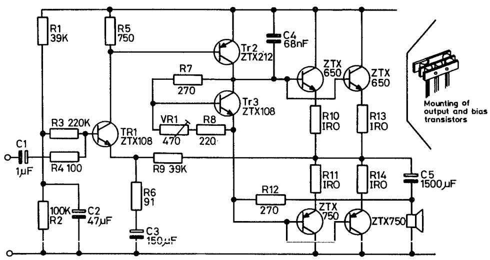


Fig. 13.1

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

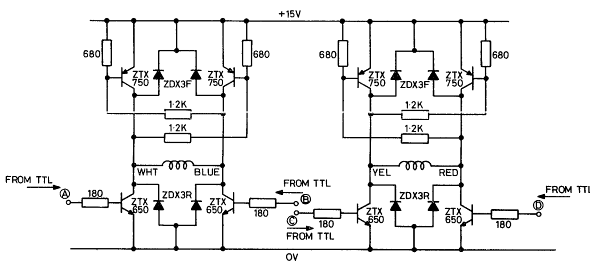


Fig. 14.1

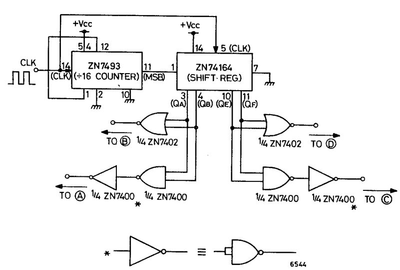


Fig. 14.2

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

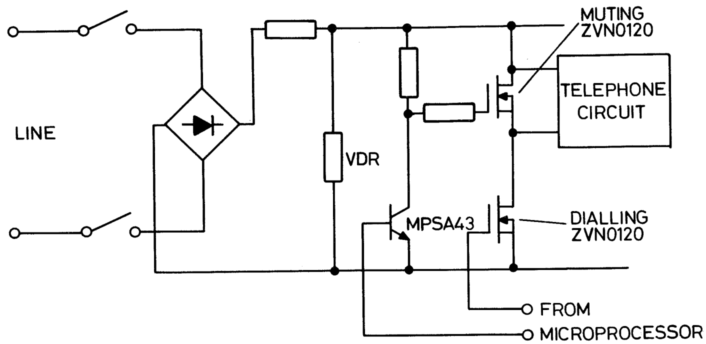


Fig. 15.1

6541

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 lightening 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

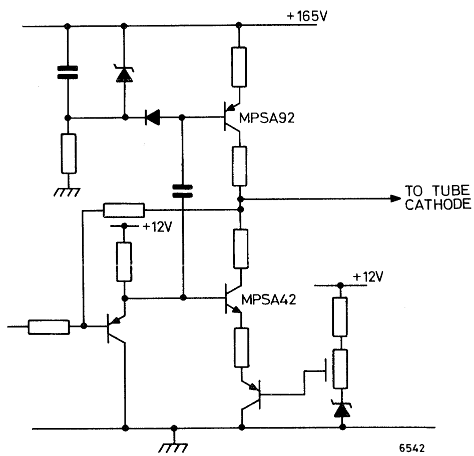


Fig. 16.1

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

Super E-line transistors

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.

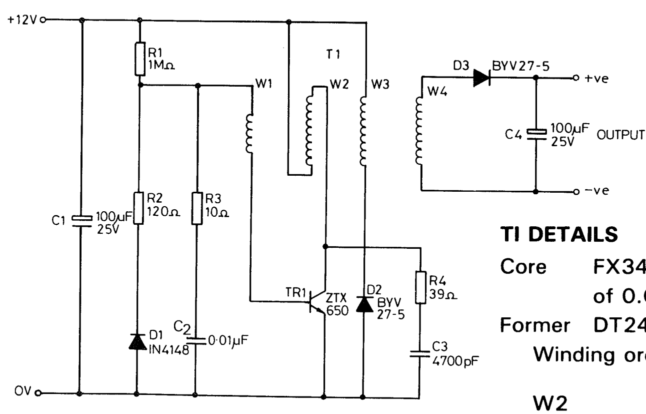
A self oscillating flyback converter will meet most of these requirements, being particularly suited to operating over a wide output voltage range. However, the standard circuit needs modifications to cope satisfactorily with short and open circuit loads. These changes include a special biasing circuit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



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.

Fig. 17.1

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:

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

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:

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

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 14μS. the inductance of transformer winding W2 can now be calculated using:

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

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-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.

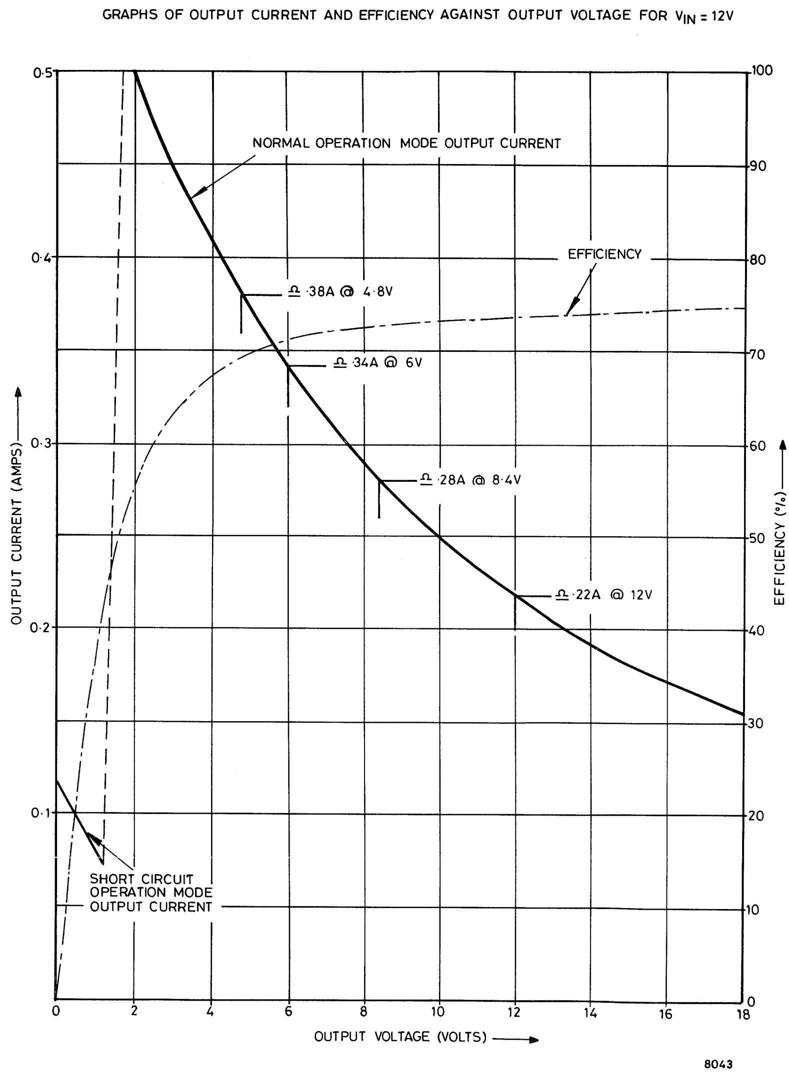

GRAPHS OF OUTPUT CURRENT AND EFFICIENCY AGAINST OUTPUT VOLTAGE FOR V_{IN} = 12V
NORMAL OPERATION MODE OUTPUT CURRENT
EFFICIENCY
≏ ·38A @ 4·8V
≏ ·34A @ 6V
≏ ·28A @ 8·4V
≏ ·22A @ 12V
SHORT CIRCUIT OPERATION MODE OUTPUT CURRENT
OUTPUT CURRENT (AMPS)
EFFICIENCY (%)
OUTPUT VOLTAGE (VOLTS)
0·5
0·4
0·3
0·2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

Fig. 17.2

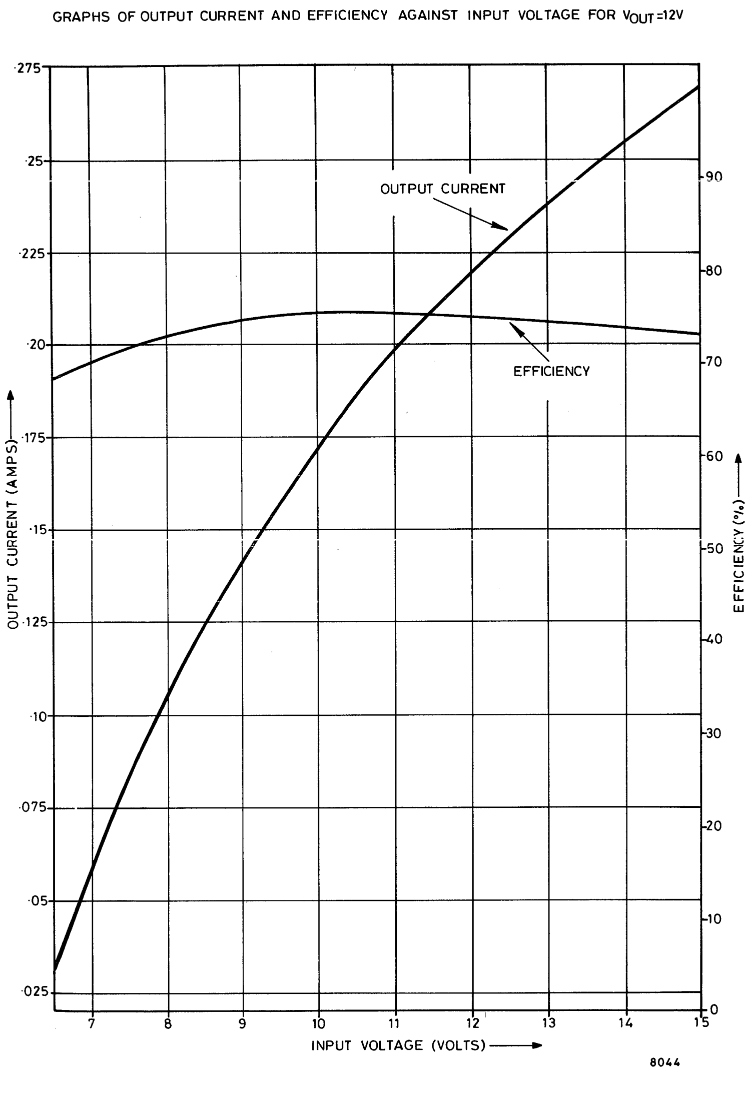
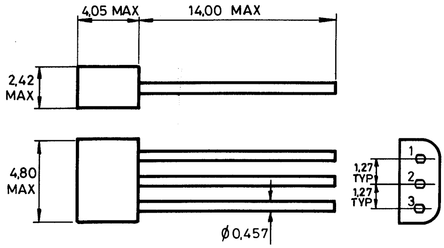

GRAPHS OF OUTPUT CURRENT AND EFFICIENCY AGAINST INPUT VOLTAGE FOR VOUT=12V
OUTPUT CURRENT
EFFICIENCY
OUTPUT CURRENT (AMPS)
EFFICIENCY (%)
INPUT VOLTAGE (VOLTS)
·275
·25
·225
·20
·175
·15
·125
·10
·075
·05
·025
90
80
70
60
50
40
30
20
10
0
7
8
9
10
11
12
13
14
15
8044

Fig. 17.3

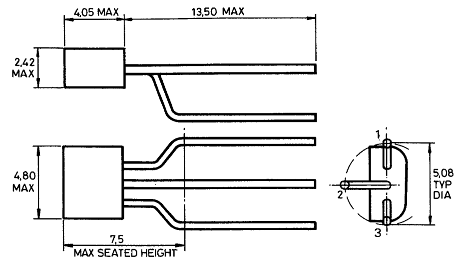
PACKAGE OUTLINES

LEAD CONFIGURATIONS

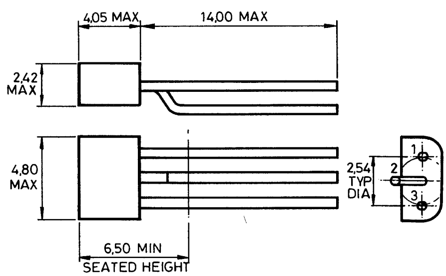
Devices can be ordered with the following lead configurations by adding the indicated suffix to the part number.



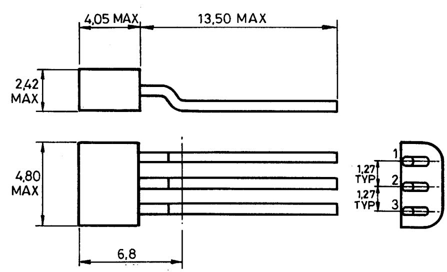
Standard package
BS 3934 .. SO-94



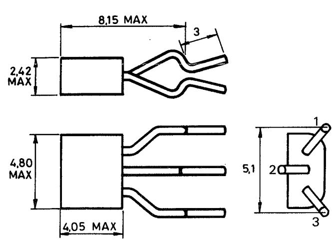
'K' lead formation
for TO-5 and TO-39
compatibility
BS3934 .. SO-95



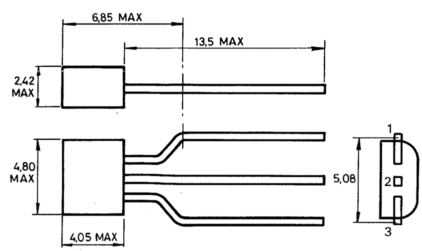
'L' lead formation
for TO-18 compatibility
BS 3923 .. SO-97



'M' lead formation
for flat mounting
BS 3934 .. SO-96



'Q' lead formation



'S' lead formation

PIN OUT

1 = collector 2 = base 3 = emitter

Dimensions in millimetres

NOTE

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

Super E-line transistors

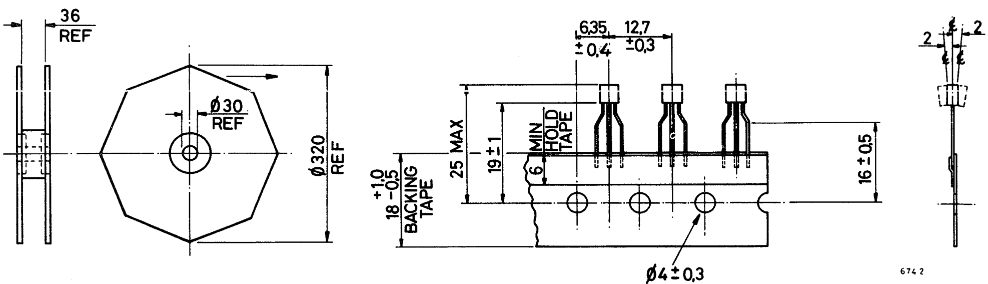
TAPED PRODUCT

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

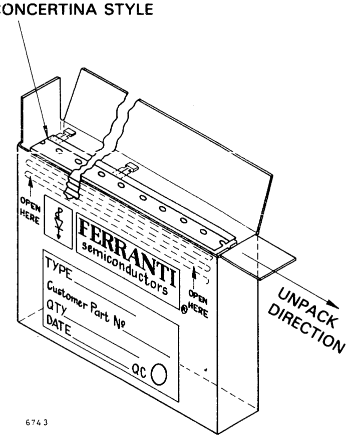
(a) The tape, bearing the devices, is wound on a reel and supplied in a cardboard box.

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

DIRECTION OF UNREELING



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.

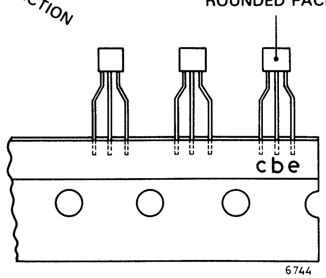
To order E-line transistors on tape the following format should be used:

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

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

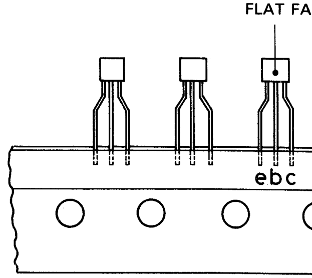
(c) Orientation (Option A or B).
e.g. ZTX 650 STOA

ROUNDED FACE



OPTION A

FLAT FACE



OPTION B

STAVER HEAT CLIP

The Staver heat clip type F2-7 referred to on certain data sheets can be obtained from:

STAVER THERMAL PRODUCTS (U.K.) LTD.,
Industrial Estate, Wickford,
Essex SS1 8QR
Tel: Wickford (03744) 3346 Telex: 995689

GLOSSARY

EXPLANATION OF SYMBOLS USED IN TABLES AND DATA

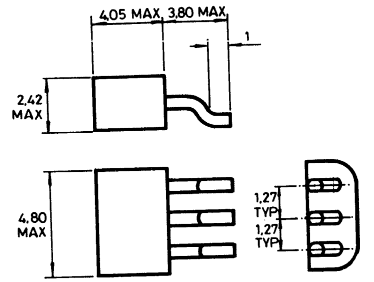
Symbol	Parameter
C_{obo}	Output capacitance
$-C_{re}$	Feedback capacitance
f	Frequency
f_T	Transition frequency
h_{FE}	Static forward current transfer ratio
I_B	Base current
I_{B1}	Control current
I_{B2}	Turn-off base current
I_C	Collector current
I_{CBO}	Collector-base cut-off current
I_{CEO}	Collector-emitter 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

Super E-line transistors

E-LINE M1 IN 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 Ferranti E-line and Super E-line transistors in Surface Mountable form.

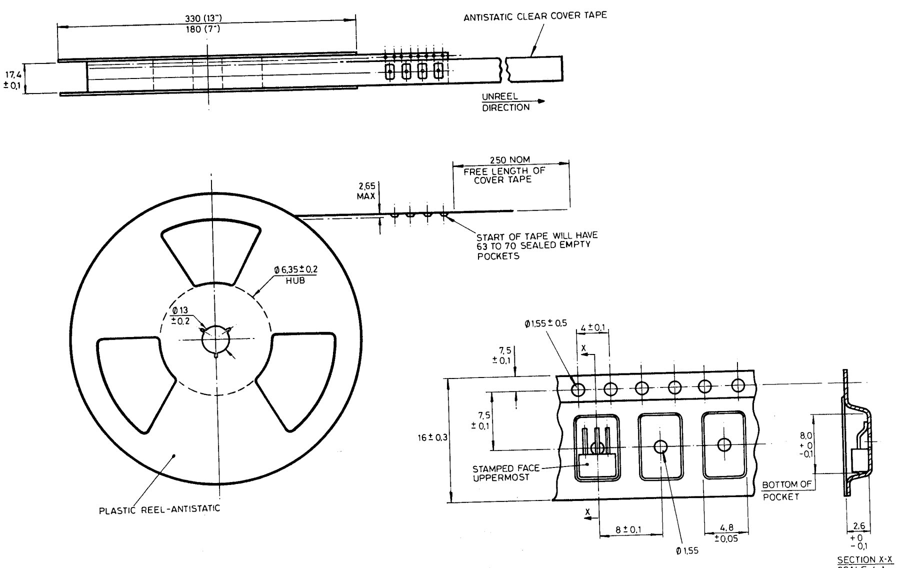


M1 lead formation
BS 3934 S0-96

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



CUSTOMER SERVICE INFORMATION

Our Customer Service is designed to deal quickly and efficiently with your enquiries.

DELIVERY ENQUIRIES, TECHNICAL ENQUIRIES AND QUOTATIONS 061-624 0515

Information on the current delivery position of any of our range of products will be given by members of our staff who attend to these questions personally.

In the Sales Department we have a staff of engineers who are able to furnish you with price quotations and with technical advice on problems relating to your individual requirements. These engineers are assigned to specific areas and are thus familiar with many of your company's needs. They are also in constant touch with our **Field Sales Engineers** who will be pleased to call upon you to discuss your semiconductor requirements.

DISTRIBUTORS

Orders under £100 in value are dealt with by our distributors, whose addresses are shown below under their geographical areas.

The distributor's area is **not** limited to his geographical location.

UNITED KINGDOM

Celdis Limited
37/39 Loverock Road
Reading
Berkshire RG3 1ED
Tel: 0734 585171
Telex: 848370

Farnell Electronic Components Limited
Canal Road, Leeds LS12 2TU
Tel: 0532 636311
Telex: 55147

H.B. Electronics Limited
(Opto Products only)
Lever Street, Bolton BL3 6BJ
Tel: 0204 386361
Telex: 62478

Lucas Semicomps Limited
Halifax Road
Keighley
West Yorkshire BD21 5HR
Tel: 0535 65191
Telex: 517343

RR Electronics Limited.
St. Martins Way
Cambridge Road
Bedford MK42 0LF
Tel: Bedford (0234) 47211
Direct Sales (0234) 47188
Telex: 826251

S.T.C. Electronic Ser
Edinburgh Way
Harlow
Essex CM20 2DF
Tel: 0279 26777
Telex: 818801

Surface Mounted Technology Limited
(Surface Mounted components only)
Electron House
Cray Avenue, St. Mary Cray
Orpington, Kent BR5 3PN
Tel: 0689 77071
Telex: 896141

Unitel Limited
Unitel House,
Fishers Green Road,
Stevenage, Herts SG1 2PT
Tel: 0438 312393 (Sales)
0438 314393 (Admin.)
Telex: 825637, 826080

NORTHERN EUROPE

BELGIUM

Velleman NV
Industrie Terrein 19
B-9751 Gavere
(Asper)
Belgium
Tel: 091 843611
Telex: 11668 Velman B

HOLLAND

United Electric Eindhoven B.V.
Rode-Kruislaan 119
Postbus 1052

SWEDEN

Ferner Electronics A.B.
P.O. Box 125
S 161-26 Stockholm-Bromma
Tel: 8-80-25-40
Telex: 10312 FERNER S

DENMARK

A/S Nordisk Elektronik
Transformervej 17, DK-2730
Herlev
Tel: (0 04 52) 84 20 00
Telex: 35200

FINLAND

OY-Atomica A.B.
PL 22,
02171 Espoo 17
Tel: 0-423-533
Telex: 121080 ATOM SF

EASTERN EUROPE

Empexion Division of
CTL Components Limited
Falcon House
19 Deer Park Road
London SW19 3UX
Tel: 01-543 0911
Cables: Empex London
Telex: 928472 FALCON G

ı McKeever and Co. Limited
House
ımberland Road
4
31604 or 681582
5608 MCK EI

UNITED ELECTRIC
Rode Kruislaan 119 – 5628 GD Eindhoven
Postbus 1052 – 5602 BB Eindhoven
Telefoon 040-421191 – Telex 59083

FERRANTI ELECTRONICS LIMITED

FIELDS NEW ROAD, CHADDERTON, OLDHAM OL9 8NP, ENGLAND
Tel: (061)-624 0515 Telex: 668038 Fax: (061)-626 4946

Tel: … 3 0118

UNITED ELECTRIC

Rode Kruislaan 119 – 5628 GD Eindhoven
Postbus 1052 – 5602 BB Eindhoven
Telefoon 040-421191 – Telex 59083

Tel: (08)-52 07 20 Telex: 17041 REMA S

Ferranti Computer Systems (Australia) Pty Limited
2A Mavis Street, Revesby, New South Wales 2212, Australia
Tel: (02)-708 6655 Telex: AA 25383 FERSY Fax: (02)-708 6440

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THE QUEEN'S AWARD FOR EXPORT ACHIEVEMENT

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