PHILIPS

Data handbook

PHILIPS Electronic components and materials

Semiconductors

Part 4 September 1981

Low-frequency power transistors

Low-frequency power hybrid modules

SEMICONDUCTORS AND INTEGRATED CIRCUITS

PART 4 - SEPTEMBER 1981

LOW-FREQUENCY POWER TRANSISTORS

DATA HANDBOOK SYSTEM

Our Data Handbook System is a comprehensive source of information on electronic components, sub-assemblies and materials; it is made up of four series of handbooks each comprising several parts.

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

The several parts contain all pertinent data available at the time of publication, and each is revised and reissued periodically.

Where ratings or specifications differ from those published in the preceding edition they are pointed out by arrows. Where application information is given it is advisory and does not form part of the product specification.

If you need confirmation that the published data about any of our products are the latest available, please contact our representative. He is at your service and will be glad to answer your inquiries.

ELECTRON TUBES (BLUE SERIES)

Starting in 1980, new part numbers and corresponding codes are being introduced. The former code of the preceding issue is given in brackets under the new code.

Part 1	February 1980	T1 02-80 (ET1a 12-75)	**Tubes for r.f. heating**
Part 2	April 1980	T2 04-80 (ET1b 08-77)	**Transmitting tubes for communications**
Part 2b	May 1978	ET2b 05-78	**Microwave semiconductors and components** Gunn, Impatt and noise diodes, mixer and detector diodes, backward diodes, varactor diodes, Gunn oscillators, sub-assemblies, circulators and isolators.
Part 3	June 1980	T3 06-80 (ET2a 11-77)	**Klystrons, travelling-wave tubes, microwave diodes**
Part 3	January 1975	ET3 01-75	**Special Quality tubes, miscellaneous devices**
Part 4	September 1980	T4 09-80 (ET2a 11-77)	**Magnetrons**
Part 5	August 1981	T5 08-81	**Cathode-ray tubes** Instrument tubes, monitor and display tubes, C.R. tubes for special applications.
Part 6	July 1980	T6 07-80 (ET6 01-77)	**Geiger-Müller tubes**
Part 7a	March 1977	ET7a 03-77	**Gas-filled tubes** Thyratrons, industrial rectifying tubes, ignitrons, high-voltage rectifying tubes.
Part 7b	May 1979	ET7b 05-79	**Gas-filled tubes** Segment indicator tubes, indicator tubes, switching diodes, dry reed contact units.
Part 8	July 1979	ET8 07-79	**Picture tubes and components** Colour TV picture tubes, black and white TV picture tubes, monitor tubes, components for colour television, components for black and white television.
Part 9	June 1980	T9 06-80 (ET9 03-78)	**Photo and electron multipliers** Photomultiplier tubes, phototubes, single channel electron multipliers, channel electron multiplier plates.
Part 10	May 1981	T10 05-81 (ET5b 12-78)	**Camera tubes and accessories, image intensifiers**

SEMICONDUCTORS (RED SERIES)

Starting in 1980, new part numbers and corresponding codes are being introduced. The former code of the preceding issue is given in brackets under the new code.

Part 1	**March 1980**	**S1 03-80** **(SC1b 05-77)**	**Diodes** Small-signal germanium diodes, small-signal silicon diodes, special diodes, voltage regulator diodes (< 1,5 W), voltage reference diodes, tuner diodes, rectifier diodes
Part 2	**May 1980**	**S2 05-80** **(SC1a 08-78)**	**Power diodes, thyristors, triacs** Rectifier diodes, voltage regulator diodes (> 1,5 W), rectifier stacks, thyristors, triacs
Part 3	**April 1980**	**S3 04-80** **(SC2 11-77, partly)** **(SC3 01-78, partly)**	**Small-signal transistors**
Part 4	**September 1981**	**S4 09-81** **(SC2 06-79)**	**Low-frequency power transistors**
Part 4a	**December 1978**	**SC4a12-78**	**Transmitting transistors and modules**
Part 5	**October 1980**	**S5 10-80** **(SC3 01-78, partly)**	**Field-effect transistors**
Part 7	**December 1980**	**S7 12-80** **(SC4c 07-78)**	**Microminiature semiconductors for hybrid circuits**
Part 8	**April 1980**	**S8 06-81** **(SC4b 09-78)**	**Devices for optoelectronics** Photosensitive diodes and transistors, light-emitting diodes, displays, photocouplers, infrared sensitive devices, photoconductive devices
Part 10	**September 1981**	**S10 09-81** **(SC3 01-78, partly)**	**Wideband transistors and wideband hybrid IC modules**

INTEGRATED CIRCUITS (PURPLE SERIES)

Starting in 1980, new part numbers and corresponding codes are being introduced. The former code of the preceding issue is given in brackets under the new code. Books with the purple cover will replace existing red covered editions as each is revised.

Part 1	**May 1980**	**IC1 05-80** **(SC5b 03-77)**	**Bipolar ICs for radio and audio equipment**
Part 2	**May 1980**	**IC2 05-80** **(SC5b 03-77)**	**Bipolar ICs for video equipment**
Part 5a	**November 1976**	**SC5a 11-76**	**Professional analogue integrated circuits**
Part 4	**October 1980**	**IC4 10-80** **(SC6 10-77)**	**Digital integrated circuits** LOCMOS HE4000B family
Part 6b	**August 1979**	**SC6b 08-79**	**ICs for digital systems in radio and television receivers**
Signetics integrated circuits			Bipolar and MOS memories 1979 Bipolar and MOS microprocessors 1978 Analogue circuits 1979 Logic - TTL 1978

COMPONENTS AND MATERIALS (GREEN SERIES)

Starting in 1980, new part numbers and corresponding codes are being introduced. The former code of the preceding issue is given in brackets under the new code.

Part 1	July 1979	CM1 07-79	**Assemblies for industrial use** PLC modules, high noise immunity logic FZ/30 series, NORbits 60-series, 61-series, 90-series, input devices, hybrid integrated circuits, peripheral devices.
Part 2	June 1981	C2 06-81 (CM3a 09-78)	**FM tuners, television tuners, video modulators, surface acoustic wave filters**
Part 3	January 1981	C3 01-81 (CM3b 10-78)	**Loudspeakers**
Part 4a	November 1978	CM4a 11-78	**Soft Ferrites** Ferrites for radio, audio and television, beads and chokes, Ferroxcube potcores and square cores, Ferroxcube transformer cores
Part 4b	February 1979	CM4b 02-79	**Piezoelectric ceramics, permanent magnet materials**
Part 6	May 1981	C6 05-81 (CM6 04-77)	**Electric motors and accessories** Permanent magnet synchronous motors, stepping motors, direct current motors
Part 7a	January 1979	CM7a 01-79	**Assemblies** Circuit blocks 40-series and CSA70 (L), counter modules 50-series, input/output devices
Part 8	June 1979	CM8 06-79	**Variable mains transformers**
Part 9	August 1979	CM9 08-79	**Piezoelectric quartz devices** Quartz crystal units, temperature compensated crystal oscillators
Part 10	October 1980	C10 10-80	**Connectors**
Part 11	December 1979	CM11 12-79	**Non-linear resistors** Voltage dependent resistors (VDR), light dependent resistors (LDR), negative temperature coefficient thermistors (NTC), positive temperature coefficient thermistors (PTC)
Part 12	November 1979	CM12 11-79	**Variable resistors and test switches**
Part 13	December 1979	CM13 12-79	**Fixed resistors**
Part 14	April 1980	C14 04-80 (CM2b 02-78)	**Electrolytic and solid capacitors**
Part 15	May 1980	C15 05-80 (CM2b 02-78)	**Film capacitors, ceramic capacitors, variable capacitors**

INDEX

INDEX OF TYPE NUMBERS

Data Handbooks S1 to S10

The inclusion of a type number in this publication does not necessarily imply its availability.

type no.	book	section	type no.	book	section	type no.	book	section
AA119	S1	PC	BAS21	S7	Mm	BB110G	S1	T
AAZ13	S1	GB	BAT17	S7	Mm	BB119	S1	T
AAZ15	S1	GB	BAT18	S7	Mm	BB204B	S1	T
AAZ17	S1	GB	BAV10	S1	WD	BB204G	S1	T
AAZ18	S1	GB	BAV18	S1	WD	BB212	S1	T
BA182	S1	T	BAV19	S1	WD	BB405B	S1	T
BA220	S1	WD	BAV20	S1	WD	BB405G	S1	T
BA221	S1	WD	BAV21	S1	WD	BBY31	S7	Mm
BA223	S1	T	BAV45	S1	Sp	BBY40	S7	Mm
BA243	S1	T	BAV70	S7	Mm	BC107	S3	Sm
BA244	S1	T	BAV99	S7	Mm	BC108	S3	Sm
BA280	S1	T	BAW56	S7	Mm	BC109	S3	Sm
BA314	S1	Vrg	BAW62	S1	WD	BC140	S3	Sm
BA315	S1	Vrg	BAX12	S1	WD	BC141	S3	Sm
BA316	S1	WD	BAX12A	S1	WD	BC146	S3	Sm
BA317	S1	WD	BAX13	S1	WD	BC147	S3	Sm
BA318	S1	WD	BAX14A	S1	WD	BC148	S3	Sm
BA379	S1	T	BAX16	S1	WD	BC149	S3	Sm
BA482	S1	T	BAX17	S1	WD	BC157	S3	Sm
BA483	S1	T	BAX18A	S1	WD	BC158	S3	Sm
BAS11	S1	WD	BB105B	S1	T	BC159	S3	Sm
BAS16	S7	Mm	BB105G	S1	T	BC160	S3	Sm
BAS17	S7	Mm	BB106	S1	T	BC161	S3	Sm
BAS19	S7	Mm	BB109G	S1	T	BC177	S3	Sm
BAS20	S7	Mm	BB110B	S1	T	BC178	S3	Sm

GB = Germanium gold bonded diodes
Mm = Microminiature semiconductors for hybrid circuits
PC = Germanium point contact diodes
Sm = Small-signal transistors
Sp = Special diodes
T = Tuner diodes
Vrg = Voltage regulator diodes
WD = Silicon whiskerless diodes

* = series
FET = Field-effect transistors
Mm = Microminiature semiconductors for hybrid circuits
P = Low-frequency power transistors
Sm = Small-signal transistors

type no.	book	section	type no.	book	section	type no.	book	section
BD433	S4	P	BD843	S4	P	BDT32B	S4	P
BD434	S4	P	BD844	S4	P	BDT32C	S4	P
BD435	S4	P	BD933	S4	P	BDT41	S4	P
BD436	S4	P	BD934	S4	P	BDT41A	S4	P
BD437	S4	P	BD935	S4	P	BDT41B	S4	P
BD438	S4	P	BD936	S4	P	BDT41C	S4	P
BD645	S4	P	BD937	S4	P	BDT42	S4	P
BD646	S4	P	BD938	S4	P	BDT42A	S4	P
BD647	S4	P	BD939	S4	P	BDT42B	S4	P
BD648	S4	P	BD940	S4	P	BDT42C	S4	P
BD649	S4	P	BD941	S4	P	BDT60	S4	P
BD650	S4	P	BD942	S4	P	BDT60A	S4	P
BD651	S4	P	BD943	S4	P	BDT60B	S4	P
BD652	S4	P	BD944	S4	P	BDT60C	S4	P
BD675	S4	P	BD945	S4	P	BDT61	S4	P
BD676	S4	P	BD946	S4	P	BDT61A	S4	P
BD677	S4	P	BD947	S4	P	BDT61B	S4	P
BD678	S4	P	BD948	S4	P	BDT61C	S4	P
BD679	S4	P	BD949	S4	P	BDT62	S4	P
BD680	S4	P	BD950	S4	P	BDT62A	S4	P
BD681	S4	P	BD951	S4	P	BDT62B	S4	P
BD682	S4	P	BD952	S4	P	BDT62C	S4	P
BD683	S4	P	BD953	S4	P	BDT63	S4	P
BD684	S4	P	BD954	S4	P	BDT63A	S4	P
BD813	S4	P	BD955	S4	P	BDT63B	S4	P
BD814	S4	P	BD956	S4	P	BDT63C	S4	P
BD815	S4	P	BDT29	S4	P	BDT64	S4	P
BD816	S4	P	BDT29A	S4	P	BDT64A	S4	P
BD817	S4	P	BDT29B	S4	P	BDT64B	S4	P
BD818	S4	P	BDT29C	S4	P	BDT64C	S4	P
BD825	S4	P	BDT30	S4	P	BDT65	S4	P
BD826	S4	P	BDT30A	S4	P	BDT65A	S4	P
BD827	S4	P	BDT30B	S4	P	BDT65B	S4	P
BD828	S4	P	BDT30C	S4	P	BDT65C	S4	P
BD829	S4	P	BDT31	S4	P	BDT91	S4	P
BD830	S4	P	BDT31A	S4	P	BDT92	S4	P
BD839	S4	P	BDT31B	S4	P	BDT93	S4	P
BD840	S4	P	BDT31C	S4	P	BDT94	S4	P
BD841	S4	P	BDT32	S4	P	BDT95	S4	P
BD842	S4	P	BDT32A	S4	P	BDT96	S4	P

P = Low-frequency power transistors

FET = Field-effect transistors
Mm = Microminiature semiconductors for hybrid circuits
P = Low-frequency power transistors
Sm = Small-signal transistors

FET = Field-effect transistors
Mm = Microminiature semiconductors for hybrid circuits
P = Low-frequency power transistors
Sm = Small-signal transistors
Tra = Transmitting transistors and modules
WBM = Wideband hybrid IC modules
WBT = Wideband transistors

Mm = Microminiature semiconductors for hybrid circuits
PDT = Photodiodes or transistors
Sm = Small-signal transistors
Th = Thyristors
Tra = Transmitting transistors and modules
WBM = Wideband hybrid IC modules

* = series
FET = Field-effect transistors
Mm = Microminiature semiconductors for hybrid circuits
P = Low-frequency power transistors
R = Rectifier diodes
Sm = Small-signal transistors
Th = Thyristors
Tri = Triacs

* = series
D = Displays
FET = Field-effect transistors
GB = Germanium gold bonded diodes
I = Infrared devices
LED = Light-emitting diodes
Mm = Microminiature semiconductors for hybrid circuits
P = Low-frequency power transistors
PC = Germanium point contact diodes
Ph = Photoconductive devices

PhC = Photocouplers
R = Rectifier diodes
Sm = Small-signal transistors
St = Rectifier stacks
TS = Transient suppressor diodes
Vrf = Voltage reference diodes
Vrg = Voltage regulator diodes
WBM = Wideband hybrid IC modules
WBT = Wideband transistors
WD = Silicon whiskerless diodes

A = Accessories
DH = Diecast heatsinks
FET = Field-effect transistors
HE = Heatsink extrusions
I = Infrared devices
PDT = Photodiodes or transistors
Sm = Small-signal transistors
Tra = Transmitting transistors and modules

MAINTENANCE TYPE LIST

The type numbers listed below are included in this handbook except for those marked with an asterisk.
Detailed information will be supplied on request.

BD291	BU204*
BD292	BU205*
BD293	BU206*
BD294	BU207A*
BD295	BU209A*
BD296	

TYPE NUMBER SURVEY
SELECTION GUIDE

TYPE NUMBER SURVEY POWER TRANSISTORS

In this alphanumeric list we present all low-frequency power transistors mentioned in this handbook.

type number		envelope	P_{tot}	type number		envelope	P_{tot}
NPN	PNP		W	NPN	PNP		W
BD131	BD132	TO-126	15	BD825	BD826	TO-202	2
BD135	BD136	TO-126	8	BD827	BD828	TO-202	2
BD137	BD138	TO-126	8	BD829	BD830	TO-202	2
BD139	BD140	TO-126	8	BD839	BD840	TO-202	2
BD201	BD202	TO-220	60	BD841	BD842	TO-202	2
BD203	BD204	TO-220	60	BD843	BD844	TO-202	2
BD226	BD227	TO-126	12,5	BD933	BD934	TO-220	30
BD228	BD229	TO-126	12,5	BD935	BD936	TO-220	30
BD230	BD231	TO-126	12,5	BD937	BD938	TO-220	30
BD233	BD234	TO-126	25	BD939	BD940	TO-220	30
BD235	BD236	TO-126	25	BD941	BD942	TO-220	30
BD237	BD238	TO-126	25	BD943	BD944	TO-220	40
BD291	BD292	SOT-82	60	BD945	BD946	TO-220	40
BD293	BD294	SOT-82	60	BD947	BD948	TO-220	40
BD295	BD296	SOT-82	60	BD949	BD950	TO-220	40
BD329	BD330	TO-126	15	BD951	BD952	TO-220	40
BD331	BD332	SOT-82	60	BD953	BD954	TO-220	40
BD333	BD334	SOT-82	60	BD955	BD956	TO-220	40
BD335	BD336	SOT-82	60	BDT29	BDT30	TO-220	30
BD337	BD338	SOT-82	60	BDT29A	BDT30A	TO-220	30
BD433	BD434	TO-126	36	BDT29B	BDT30B	TO-220	30
BD435	BD436	TO-126	36	BDT29C	BDT30C	TO-220	30
BD437	BD438	TO-126	36	BDT31	BDT32	TO-220	40
BD645	BD646	TO-220	62,5	BDT31A	BDT32A	TO-220	40
BD647	BD648	TO-220	62,5	BDT31B	BDT32B	TO-220	40
BD649	BD650	TO-220	62,5	BDT31C	BDT32C	TO-220	40
BD651	BD652	TO-220	62,5	BDT41	BDT42	TO-220	65
BD675	BD676	TO-126	40	BDT41A	BDT42A	TO-220	65
BD677	BD678	TO-126	40	BDT41B	BDT42B	TO-220	65
BD679	BD680	TO-126	40	BDT41C	BDT42C	TO-220	65
BD681	BD682	TO-126	40	BDT61	BDT60	TO-220	50
BD683	BD684	TO-126	40	BDT61A	BDT60A	TO-220	50
BD813	BD814	TO-202	2	BDT61B	BDT60B	TO-220	50
BD815	BD816	TO-202	2	BDT61C	BDT60C	TO-220	50
BD817	BD818	TO-202	2	BDT63	BDT62	TO-220	90

type number		envelope	P_{tot}	type number		envelope	P_{tot}
NPN	PNP		W	NPN	PNP		W
BDT63A	BDT62A	TO-220	90	BDX93	BDX94	TO-3	90
BDT63B	BDT62B	TO-220	90	BDX95	BDX96	TO-3	90
BDT63C	BDT62C	TO-220	90	BDY90		TO-3	40
BDT65	BDT64	TO-220	125	BDY90A		TO-3	40
BDT65A	BDT64A	TO-220	125	BDY91		TO-3	40
BDT65B	BDT64B	TO-220	125	BDY92		TO-3	40
BDT65C	BDT64C	TO-220	125	BF419		TO-126	6
BDT91	BDT92	TO-220	90	BF457		TO-126	6
BDT93	BDT94	TO-220	90	BF458		TO-126	6
BDT95	BDT96	TO-220	90	BF459		TO-126	6
BDV65	BDV64	SOT-93	125	BF469	BF470	TO-126	1,8
BDV65A	BDV64A	SOT-93	125	BF471	BF472	TO-126	1,8
BDV65B	BDV64B	SOT-93	125	BF819		TO-202	6
BDV65C	BDV64C	SOT-93	125	BF857		TO-202	6
BDV91	BDV92	SOT-93	100	BF858		TO-202	6
BDV93	BDV94	SOT-93	100	BF859		TO-202	6
BDV95	BDV96	SOT-93	100	BF869	BF870	TO-202	5
BDW55	BDW56	TO-126	8	BF871	BF872	TO-202	5
BDW57	BDW58	TO-126	8	BU208A		TO-3	80
BDW59	BDW60	TO-126	8	BU326;A		TO-3	60
BDX35		TO-126	15	BU426;A		SOT-93	70
BDX36		TO-126	15	BU433		SOT-93	70
BDX37		TO-126	15	BUS11;A		TO-3	100
BDX42	BDX45	TO-126	5	BUS12;A		TO-3	125
BDX43	BDX46	TO-126	5	BUS13;A		TO-3	175
BDX44	BDX47	TO-126	5	BUS14;A		TO-3	250
BDX63	BDX62	TO-3	90	BUV82;83		SOT-93	70
BDX63A	BDX62A	TO-3	90	BUW84;85		SOT-82	50
BDX63B	BDX62B	TO-3	90	BUX46;A		TO-3	100
BDX63C	BDX62C	TO-3	90	BUX47;A		TO-3	125
BDX65	BDX64	TO-3	117	BUX48;A		TO-3	175
BDX65A	BDX64A	TO-3	117	BUX80;81		TO-3	100
BDX65B	BDX64B	TO-3	117	BUX82;83		TO-3	60
BDX65C	BDX64C	TO-3	117	BUX84;85		TO-220	40
BDX67	BDX66	TO-3	150	BUX86;87		TO-126	20
BDX67A	BDX66A	TO-3	150	BUX98;A		TO-3	250
BDX67B	BDX66B	TO-3	150	BUY89		TO-3	80
BDX67C	BDX66C	TO-3	150				
BDX77	BDX78	TO-220	60				
BDX91	BDX92	TO-3	90				

TYPE NUMBER SURVEY ACCESSORIES

type number	description	envelope
56201d	mica washer (up to 500 V)	TO-3
56201j	insulating bushes (up to 500 V)	TO-3
56261a	insulating bushes (up to 500 V)	TO-3
56326	metal washer	TO-126
56333	metal washer mica washer insulating bush } (up to 250 V)	TO-126
56339	mica washer (500 to 2000 V)	TO-3
56352	insulating mounting support	
56353	spring clip	TO-126/SOT-82
56354	mica insulator	TO-126/SOT-82
56359b	mica washer (up to 1000 V)	TO-220
56359c	insulating bush (up to 800 V)	TO-220
56359d	rectangular insulating bush (up to 1000 V)	TO-220
56360a	rectangular washer (brass)	TO-220
56363	spring clip (direct mounting)	TO-220
56364	spring clip (insulated mounting)	TO-220
56367	alumina insulator (up to 2000 V)	TO-220
56368a	mica insulator (up to 800 V)	SOT-93
56368b	insulating bush (up to 800 V)	SOT-93
56369	mica insulator (up to 2 kV	TO-220
56378	mica insulator (up to 1500 V)	SOT-93
56379	spring clip	SOT-93
56387a	mica insulator (up to 300 V)	TO-126
56387b	insulating bush (up to 300 V)	TO-126

SELECTION GUIDE

GENERAL PURPOSE POWER TRANSISTORS

I_C A	pol.	collector-emitter voltage (open base) V_{CEO} (V) 20	22	32	45	60	80	100	120 V	P_{tot} W	case
1	N				BD135	BD137	BD139			8	TO-126
	P				BD136	BD138	BD140				
	N				BD825	BD827	BD829				TO-202
	P				BD826	BD828	BD830				
	N				BDW55	BDW57	BDW59				TO-126
	P				BDW56	BDW58	BDW60				
	N				BDT29	BDT29A	BDT29B	BDT29C		30	TO-220
	P				BDT30	BDT30A	BDT30B	BDT30C			
1,5	N				BD226	BD228	BD230			12,5	TO-126
	P				BD227	BD229	BD231				
	N				BD839	BD841	BD843			10	TO-202
	P				BD840	BD842	BD844				
2	N				BD233	BD235	BD237			25	TO-126
	P				BD234	BD236	BD238				
	N				BD813	BD815	BD817			12,5	TO-202
	P				BD814	BD816	BD818				
3	N				BD131					15	TO-126
	P				BD132						
	N	BD329									
	P	BD330									
	N				BD933	BD935	BD937	BD939	BD941	30	TO-220
	P				BD934	BD936	BD938	BD940	BD942		
	N				BDT31	BDT31A	BDT31B	BDT31C			
	P				BDT32	BDT32A	BDT32B	BDT32C			
4	N		BD433	BD435	BD437					36	TO-126
	P		BD434	BD436	BD438						

GENERAL PURPOSE POWER TRANSISTORS

I_C A	pol.	collector-emitter voltage (open base) V_{CEO} (V) 20	22	32	45	60	80	100	120 V	P_{tot} W	case
5	N					BDX35	BDX37			15	TO-126
	N					BDX36					
	N		BD943	BD945	BD947	BD949	BD951	BD953	BD955	40	TO-220
	P		BD944	BD946	BD948	BD950	BD952	BD954	BD956		
6	N				BD291	BD293	BD295			60	SOT-82
	P				BD292	BD294	BD296				
	N				BDT41	BDT41A	BDT41B	BDT41C		65	TO-220
	P				BDT42	BDT42A	BDT42B	BDT42C			
8	N				BD201	BD203	BDX77			60	TO-220
	P				BD202	BD204	BDX78				
	N					BDX91	BDX93	BDX95		90	TO-3
	P					BDX92	BDX94	BDX96			
10	N					BDT91	BDT93	BDT95		90	TO-220
	P					BDT92	BDT94	BDT96			
	N					BDV91	BDV93	BDV95		100	SOT-93
	P					BDV92	BDV94	BDV96			

HIGH-VOLTAGE TRANSISTORS video output - deflection - SMPS - motorcontrol

I_C A	pol.	collector-emitter voltage (open base) V_{CEO} (V)								P_{tot} W	case
		160	250	300	375	400	450	700	800		
0,05	N		BF469	BF471*						1,8	TO-126
	P		BF470	BF472*							
	N		BF869	BF871*						5	TO-202
	P		BF870	BF872*							
0,1	N		BF419							6	TO-126
	N	BF457	BF458	BF459							
	N		BF819							6	TO-202
	N	BF857	BF858	BF859							
0,5	N					BUX86	BUX87			20	TO-126
2	N					BUW84	BUW85			50	SOT-82
	N					BUX84	BUX85			40	TO-220
5	N							BU208A		80	TO-3
	N					BUS11	BUS11A			100	TO-3
6	N				BU326	BU326A				60	TO-3
	N				BU426	BU426A				70	SOT-93
	N				BU433						
	N					BUX82	BUX83			60	TO-3
	N					BUV82	BUV83			70	SOT-93
	N								BUY89	80	TO-3
8	N					BUS12	BUS12A			125	TO-3
10	N					BUX80	BUX81			100	TO-3
15	N					BUS13	BUS13A			175	TO-3
30	N					BUS14	BUS14A			250	TO-3

GENERAL PURPOSE DARLINGTON TRANSISTORS

I_C A	pol.	collector-emitter voltage (open base) V_{CEO} (V)					P_{tot} W	case
		45	60	80	100	120 V		
1	N	BDX42*	BDX43*	BDX44*			5	TO-126
	P	BDX45*	BDX46*	BDX47*				
4	N	BD675	BD677	BD679	BD681	BD683	40	TO-126
	P	BD676	BD678	BD680	BD682	BD684		
4	N		BDT61	BDT61A	BDT61B	BDT61C	50	TO-220
	P		BDT60	BDT60A	BDT60B	BDT60C		
6	N		BD331	BD333	BD335	BD337	60	SOT-82
	P		BD332	BD334	BD336	BD338		
8	N		BD645	BD647	BD649	BD651	62,5	TO-220
	P		BD646	BD648	BD650	BD652		
8	N		BDX63	BDX63A	BDX63B	BDX63C	90	TO-3
	P		BDX62	BDX62A	BDX62B	BDX62C		
10	N		BDT63	BDT63A	BDT63B	BDT63C	90	TO-220
	P		BDT62	BDT62A	BDT62B	BDT62C		
12	N		BDT65	BDT65A	BDT65B	BDT65C	125	TO-220
	P		BDT64	BDT64A	BDT64B	BDT64C		
12	N		BDV65	BDV65A	BDV65B	BDV65C	125	SOT-93
	P		BDV64	BDV64A	BDV64B	BDV64C		
12	N		BDX65	BDX65A	BDX65B	BDX65C	117	TO-3
	P		BDX64	BDX64A	BDX64B	BDX64C		
16	N		BDX67	BDX67A	BDX67B	BDX67C	150	TO-3
	P		BDX66	BDX66A	BDX66B	BDX66C		

LOW-VOLTAGE SWITCHING TRANSISTORS

I_C A	pol.	collector-emitter voltage (open base) V_{CEO} (V)					P_{tot} W	case
		45	60	80	100	120 V		
10	N		BDY92	BDY91	BDY90			TO-3
12	N				BDY90A			TO-3

ACCESSORIES

CLIP MOUNTING

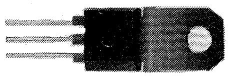
envelope	direct mounting		insulated mounting			
	clip		mica	clip		
TO-126 (SOT-32)	56353		56354	56353		
SOT-82	56353		56354	56353		
TO-220 (SOT-78)	56363		56369 or 56467	56364		
SOT-93	56379		56378	56379		

SCREW MOUNTING

envelope	direct mounting		insulated mounting			
	metal washer	mounting material	mica washer	insul. bush	metal washer	mounting material
TO-126 (SOT-32)	56326	M3				
up to 250 V				← 56333 →		M2,5
up to 300 V			56387a	56387b	56326	M2,5
TO-220 (SOT-78)	56360a	M3				
up to 800 V			56359b	56359c	56360a	M3
up to 1000 V			56359b	56359d	56360a	M3
SOT-93	-	M4	56368a	56368b		M3
TO-3 (SOT-3)	-	M4				
up to 500 V			56201d	56201j or 56261a		M3
up to 2000 V			56339	56352		M3

The accessories mentioned can be supplied on request.

See also chapter Mounting Instructions.



TO-202
(SOT-128)

type number		P_{tot}	V_{CEO}
NPN	PNP	W	V
BF869	BF870	5(1,6)	250
BF871	BF872		300*
BF819		6(1,2)	250
BF857		6(2)	160
BF858			250
BF859			300

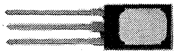
type number		P_{tot}	V_{CEO}
NPN	PNP	W	V
BD825	BD826	8(2)	45
BD827	BD828		60
BD829	BD830		80
BD839	BD840	10(2)	45
BD841	BD842		60
BD843	BD844		80
BD813	BD814	12,5 (2)	45
BD815	BD816		60
BD817	BD818		80

TO-126
(SOT-32)

( ) free air dissipation.

type number		P_{tot}	V_{CEO}
NPN	PNP	W	V
BF469	BF470	1,8	250
BF471	BF472		300*
BDX42	BDX45	5	45*
BDX43	BDX46		60*
BDX44	BDX47		80*
BF419		6	250
BF457			160
BF458			250
BF459			300
BD135	BD136	8	45
BD137	BD138		60
BD139	BD140		80
BDW55	BDW56	8	45
BDW57	BDW58		60
BDW59	BDW60		80
BD226	BD227	12,5	45
BD228	BD229		60
BD230	BD231		80

type number		P_{tot}	V_{CEO}
NPN	PNP	W	V
BD131	BD132	15	45
BD329	BD330		20
BDX35			60
BDX36			60
BDX37			80
BUX86		20	400
BUX87			450
BD233	BD234	25	45
BD235	BD236		60
BD237	BD238		80
BD433	BD434	36	22
BD435	BD436		32
BD437	BD438		45
BD675	BD676	40	45
BD677	BD678		60
BD679	BD680		80
BD681	BD682		100
BD683	BD684		120



SOT-82
(SOT-82)

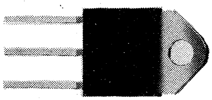
type number NPN	PNP	P_{tot} W	V_{CEO} V
BUW84		50	400
BUW85			450
BD291	BD292	60	45
BD293	BD294		60
BD295	BD296		80

type number NPN	PNP	P_{tot} W	V_{CEO} V
BD331	BD332	60	60
BD333	BD334		80
BD335	BD336		100
BD337	BD338		120

TO-220
(SOT-78)

type number NPN	PNP	P_{tot} W	V_{CEO} V
BD933	BD934	30	45
BD935	BD939		60
BD937	BD938		80
BD939	BD940		100
BD941	BD942		120
BDT29	BDT30		40
BDT29A	BDT30A		60
BDT29B	BDT30B		80
BDT29C	BDT30C		100
BD943	BD944	40	22
BD945	BD946		32
BD947	BD948		45
BD949	BD950		60
BD951	BD952		80
BD953	BD954		100
BD955	BD956		120
BDT31	BDT32		45
BDT31A	BDT32A		60
BDT31B	BDT32B		80
BDT31C	BDT32C		100
BUX84		40	400
BUX85			450
BDT61	BDT60	50	60
BDT61A	BDT60A		80
BDT61B	BDT60B		100
BDT61C	BDT60C		120

type number NPN	PNP	P_{tot} W	V_{CEO} V
BD201	BD202	60	45
BD203	BD204		60
BDX77	BDX78		80
BD645	BD646	62,5	60
BD647	BD648		80
BD649	BD650		100
BD651	BD652		120
BDT41	BDT42	65	40
BDT41A	BDT42A		60
BDT41B	BDT42B		80
BDT41C	BDT42C		100
BDT91	BDT92	90	60
BDT93	BDT94		80
BDT95	BDT96		100
BDT63	BDT62	90	60
BDT63A	BDT62A		80
BDT63B	BDT62B		100
BDT63C	BDT62C		120
BDT65	BDT64	125	60
BDT65A	BDT64A		80
BDT65B	BDT64B		100
BDT65C	BDT64C		120



SOT-93
(SOT-93)

type number NPN	type number PNP	P_{tot} W	V_{CEO} V
BU426		70	375
BU426A			400
BU433			375
BUV82			400
BUV83			450

type number NPN	type number PNP	P_{tot} W	V_{CEO} V
BDV91	BDV92	100	60
BDV93	BDV94		80
BDV95	BDV96		100
BDV65	BDV64	125	60
BDV65A	BDV64A		80
BDV65B	BDV64B		100
BDV65C	BDV64C		120

TO-3
(SOT-3)

type number NPN	type number PNP	P_{tot} W	V_{CEO} V
BDY90		40	100
BDY90A			100
BDY91			80
BDY92			60
BU326		60	375
BU326A			400
BUX82		60	400
BUX83			450
BU208A		80	700
BUY89			800
BDX63	BDX62	90	60
BDX91	BDX92		60
BDX63A	BDX62A		80
BDX93	BDX94		80
BDX63B	BDX62B		100
BDX95	BDX96		100
BDX63C	BDX62C		120
BUS11		100	400
BUS11A			450
BUX80		100	400
BUX81			450

type number NPN	type number PNP	P_{tot} W	V_{CEO} V
BDX65	BDX64	117	60
BDX65A	BDX64A		80
BDX65B	BDX64B		100
BDX65C	BDX64C		120
BUS12		125	400
BUS12A			450
BDX67	BDX66	150	60
BDX67A	BDX66A		80
BDX67B	BDX66B		100
BDX67C	BDX66C		120
BUS13		175	400
BUS13A			450
BUS14		250	400
BUS14A			450

GENERAL

Type designation
Rating systems
Transistor ratings
Letter symbols
SOAR curves

PRO ELECTRON TYPE DESIGNATION CODE
FOR SEMICONDUCTOR DEVICES

This type designation code applies to discrete semiconductor devices – as opposed to integrated circuits –, multiples of such devices and semiconductor chips.

A basic type number consists of:

TWO LETTERS FOLLOWED BY A SERIAL NUMBER

FIRST LETTER

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

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

SECOND LETTER

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

A. DIODE; signal, low power
B. DIODE; variable capacitance
C. TRANSISTOR; low power, audio frequency ($R_{th\ j\text{-}mb} > 15$ °C/W)
D. TRANSISTOR; power, audio frequency ($R_{th\ j\text{-}mb} \leqslant 15$ °C/W)
E. DIODE; tunnel
F. TRANSISTOR; low power, high frequency ($R_{th\ j\text{-}mb} > 15$ °C/W)
G. MULTIPLE OF DISSIMILAR DEVICES – MISCELLANEOUS; e.g. oscillator
H. DIODE; magnetic sensitive
L. TRANSISTOR; power, high frequency ($R_{th\ j\text{-}mb} \leqslant 15$ °C/W)
N. PHOTO-COUPLER
P. RADIATION DETECTOR; e.g. high sensitivity phototransistor
Q. RADIATION GENERATOR; e.g. light-emitting diode (LED)
R. CONTROL AND SWITCHING DEVICE; e.g. thyristor, low power ($R_{th\ j\text{-}mb} > 15$ °C/W)
S. TRANSISTOR; low power, switching ($R_{th\ j\text{-}mb} > 15$ °C/W)
T. CONTROL AND SWITCHING DEVICE; e.g. thyristor, power ($R_{th\ j\text{-}mb} \leqslant 15$ °C/W)
U. TRANSISTOR; power, switching ($R_{th\ j\text{-}mb} \leqslant 15$ °C/W)
X. DIODE: multiplier, e.g. varactor, step recovery
Y. DIODE; rectifying, booster
Z. DIODE; voltage reference or regulator (transient suppressor diode, with third letter **W**)

SERIAL NUMBER

Three figures, running from 100 to 999, for devices primarily intended for consumer equipment.
One letter (Z, Y, X, etc.) and two figures, running from 10 to 99, for devices primarily intended for industrial/professional equipment.
This letter has no fixed meaning except W, which is used for transient suppressor diodes.

VERSION LETTER

It indicates a minor variant of the basic type either electrically or mechanically. The letter never has a fixed meaning, except letter R, indicating reverse voltage, e.g. collector to case or anode to stud.

SUFFIX

Sub-classification can be used for devices supplied in a wide range of variants called associated types. Following sub-coding suffixes are in use:

1. VOLTAGE REFERENCE and VOLTAGE REGULATOR DIODES: *ONE LETTER and ONE NUMBER*
   The LETTER indicates the nominal tolerance of the Zener (regulation, working or reference) voltage
   A. 1% (according to IEC 63: series E96)
   B. 2% (according to IEC 63: series E48)
   C. 5% (according to IEC 63: series E24)
   D. 10% (according to IEC 63: series E12)
   E. 20% (according to IEC 63: series E6)
   The number denotes the typical operating (Zener) voltage related to the nominal current rating for the whole range.
   The letter 'V' is used instead of the decimal point.

2. TRANSIENT SUPPRESSOR DIODES: *ONE NUMBER*
   The NUMBER indicates the maximum recommended continuous reversed (stand-off) voltage V_R. The letter 'V' is used as above.

3. CONVENTIONAL and CONTROLLED AVALANCHE RECTIFIER DIODES and THYRISTORS: *ONE NUMBER*
   The NUMBER indicates the rated maximum repetitive peak reverse voltage (V_{RRM}) or the rated repetitive peak off-state voltage (V_{DRM}), whichever is the lower. Reversed polarity is indicated by letter R, immediately after the number.

4. RADIATION DETECTORS: *ONE NUMBER,* preceded by a hyphen (–)
   The NUMBER indicates the depletion layer in μm. The resolution is indicated by a version LETTER.

5. ARRAY OF RADIATION DETECTORS and GENERATORS: *ONE NUMBER,* preceded by a stroke (/).
   The NUMBER indicates how many basic devices are assembled into the array.

TRANSISTOR RATINGS

The ratings are presented as voltage, current, power and temperature ratings. The list of these ratings and their definitions is given as follows:

Transistor voltage ratings

Collector to base voltage ratings

V_{CBmax}	The maximum permissible instantaneous voltage between collector and base terminals. The collector voltage is negative with respect to base in PNP transistors and positive with respect to base in NPN types.
V_{CBmax} (IE = 0)	The maximum permissible instantaneous voltage between collector and base terminals, when the emitter terminal is open circuited.

Emitter to base voltage ratings

V_{EBmax}	The maximum permissible instantaneous reverse voltage between emitter and base terminal. The emitter voltage is negative with respect to base for PNP transistor and positive with respect to base for NPN types.
V_{EBmax} ($I_C = 0$)	The maximum permissible instantaneous reverse voltage between emitter and base terminals when the collector terminal is open circuited.

Collector to emitter voltage ratings

V_{CEmax}	The maximum permissible instantaneous voltage between collector and emitter terminals. The collector voltage is negative with respect to emitter in PNP transistors and positive with respect to emitter in NPN types. This rating is very dependent on circuit conditions and collector current and it is necessary to refer to the curve of V_{CE} versus I_C for the appropriate circuit condition in order to obtain the correct rating.
V_{CEmax} (Cut-off)	The maximum permissible instantaneous voltage between collector and emitter terminals when the emitter current is reduced to zero by means of a reverse emitter base voltage, i.e. the base voltage is normally positive with respect to emitter for PNP transistor and negative with respect to emitter for NPN types.

NOTE: The term "cut-off" is sometimes replaced by $V_{BE} > x$ volts, or $\frac{R_B}{R_E}, \leqslant y$ which are equivalent conditions under which the device may be cut-off.

V_{CEmax} ($I_C = x$ mA)	The maximum permissible instantaneous voltage between collector and emitter terminals when the collector current is at a high value, often the max. rated value.
V_{CEmax} ($I_B = 0$)	The maximum permissible instantaneous voltage between collector and emitter terminals when the base terminal is open circuited or when a very high resistance is in series with the base terminal. Special care must be taken to ensure that thermal runaway due to excessive collector leakage current does not occur in this condition.

Due to the current dependency of V_{CE} it is usual to present this information as a voltage rating chart which is a curve of collector current versus collector to emitter voltage (see Fig. 1).

This curve is divided into two areas:

A permissible area of operation under all conditions of base drive provided the dissipation rating is not exceeded (area 1) and an area where operation is allowable under certain specified conditions (area 2). To assist in determining the rating in this second area, further curves are provided relating the voltage rating to external circuit conditions, for example:

$$\frac{R_B}{R_E},\ R_B,\ Z_{Bg},\ V_{BE},\ I_B \text{ or } \frac{V_{BB}}{R_B}.$$

An example of this type of curve is given in Fig. 2 as V_{CE} versus $\frac{R_B}{R_E}$ for two different values of collector current.

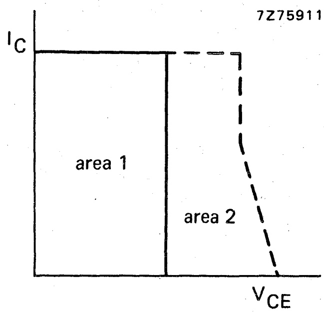


Fig. 1.

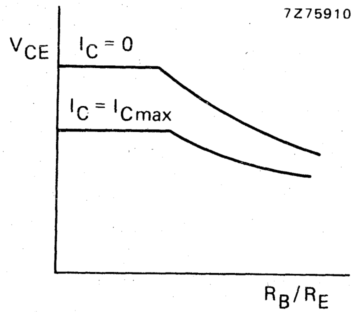


Fig. 2.

It should be noted that when R_E is shunted by a capacitor, the collector voltage V_{CE} during switching must be restricted to a value which does not rely on the effect of R_E.
In the case of an inductive load and when an energy rating is given, it may be permissible to operate outside the rated area provided the spcified energy rating is not exceeded.

Transistor current ratings

Collector current ratings

I_{Cmax}	The maximum permissible collector current. Without further qualification, the d.c. value is implied.
$I_{C(AV)max}$	The maximum permissible average value of the total collector current
I_{CM}	The maximum permissible instantaneous value of the total collector current.

Emitter current ratings

I_{Emax}	The maximum permissible emitter current. Without further qualification, the d.c. value is implied.
$I_{E(AV)max}$	The maximum permissible average value of the total emitter current.
$I_{ER(AV)max}$	The maximum permissible average value of the total emitter current when operating in the reverse emitter-base breakdown region.
I_{EM}	The maximum permissible instantaneous value of the total emitter current.
I_{ERM}	The maximum permissible instantaneous value of the total reverse emitter current allowable in the reverse breakdown region.

Base current ratings

I_{Bmax}	The maximum permissible base current. Without further qualification, the d.c. value is implied.
$I_{B(AV)max}$	The maximum permissible average value of the total base current.
$I_{BR(AV)max}$	The maximum permissible average value of the total reverse base current allowable in the reverse breakdown region.
I_{BM}	The maximum permissible instantaneous value of the total base current. The rating also includes the switch off current.
I_{BRM}	The maximum permissible instantaneous value of the total reverse current allowable in the reverse breakdown region.

Transistor power ratings

P_{tot} max: The total maximum permissible continuous power dissipation in the transistor and includes both the collector-base dissipation and the emitter-base dissipation. Under steady state conditions the total power is given by the expression:

$$P_{tot} = V_{CE} \times I_C + V_{BE} \times I_B.$$

In order to distinguish between "steady state" and "pulse" conditions the terms "steady state power (P_S)" and "pulse power (P_P)" are often used. The permissible total power dissipation is dependent upon temperature and its relationship is shown by means of a chart as shown in Fig. 3.

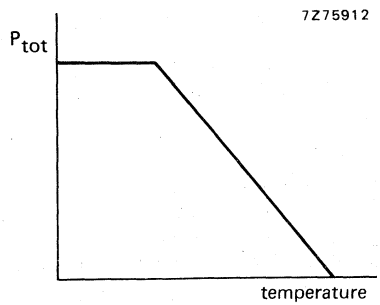


Fig. 3.

The temperature may be ambient, case or mounting base temperatures. Where a cooling clip or a heatsink is attached to the device, the allowable power dissipation is also dependent on the efficiency of the heatsink.

The efficiency of this clip or heatsink is measured in terms of its thermal resistance ($R_{th\ h}$) normally expressed in degrees centigrade per watt (°C/W). For mounting base rated device, the added effect of the contact resistance ($R_{th\ i}$) must be taken into account.

The effect of heatsinks of various thermal resistance and contact resistance is often included in the above chart.

Thus for any heatsink of known thermal resistance and any given ambient temperature, the maximum permissible power dissipation can be established. Alternatively, knowing the power dissipation which will occur and the ambient temperature, the necessary heatsink thermal resistance can be calculated.

A general expression from which the total permissible steady state power dissipation can be calculated is:

$$P_{tot} = \frac{T_j - T_{amb}}{R_{th\ j\text{-}a}}$$

where $R_{th\ j\text{-}a}$ is the thermal resistance from the transistor junction to the ambient. For case rated or mounting base rated devices, the thermal resistance $R_{th\ j\text{-}a}$ is made up of the thermal resistance junction to case or mounting base $(R_{th\ j\text{-}mb})$, the contact thermal resistance $(R_{th\ i})$ and the heatsink thermal resistance $R_{th\ h}$.

For the calculation of pulse power operation P_p, the maximum pulse power is obtained by the aid of a chart as shown in Fig. 4.

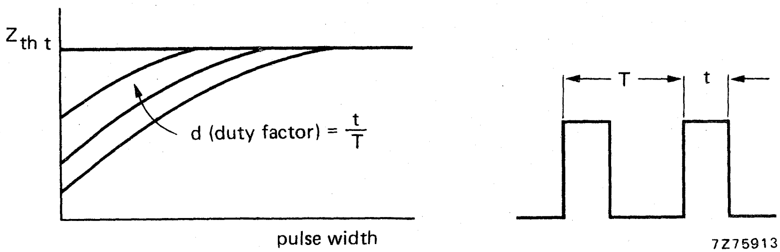


Fig. 4.

The general expression from which the maximum pulse power dissipation can be calculated is:

$$P_p = \frac{T_j - T_{amb} - P_s \times R_{th\ j\text{-}a}}{Z_{th\ t} + d\ (R_{th\ c\text{-}a})}$$

where $Z_{th\ t}$ and d are given in the above chart and $R_{th\ c\text{-}a}$ is the thermal resistance between case and ambient for case rated device. For mounting base rated device, it is equal to $R_{th\ h} + R_{th\ i}$ and is zero for free air rated device because the effect of the temperature rise of the case over the ambient for a pulse train is already included in $Z_{th\ t}$.

Temperature ratings

T_{jmax}	The maximum permissible junction temperature which is used as the basis for the calculation of power ratings. Unless otherwise stated, the continuous value is implied.
T_{jmax} (continous operation)	The maximum permissible continuous value.
T_{jmax} (intermittent operation)	The maximum permissible instantaneous junction temperature usually allowed for a total duration of 200 hours.
T_{mb}	The temperature of the surface making contact with a heatsink. This is confined to devices where a flange or stud for fixing onto a heatsink forms an integral part of the envelope.
T_{case}	The temperature of the envelope. This is confined to devices to which may be attached a clip-on cooling fin.

RATING SYSTEMS

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

DEFINITIONS OF TERMS USED

Electronic device. An electronic tube or valve, transistor or other semiconductor device.

Note
This definition excludes inductors, capacitors, resistors and similar components.

Characteristic. A characteristic is an inherent and measurable property of a device. Such a property may be electrical, mechanical, thermal, hydraulic, electro-magnetic, or nuclear, and can be expressed as a value for stated or recognized conditions. A characteristic may also be a set of related values, usually shown in graphical form.

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

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

Note
Limiting conditions may be either maxima or minima.

Rating system. The set of principles upon which ratings are established and which determine their interpretation.

Note
The rating system indicates the division of responsibility between the device manufacturer and the circuit designer, with the object of ensuring that the working conditions do not exceed the ratings.

ABSOLUTE MAXIMUM RATING SYSTEM

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

These values are chosen by the device manufacturer to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environmental variations, and the effects of changes in operating conditions due to variations in the characteristics of the device under consideration and of all other electronic devices in the equipment.

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

6

DESIGN MAXIMUM RATING SYSTEM

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

These values are chosen by the device manufacturer to provide acceptable serviceability of the device, taking responsibility for the effects of changes in operating conditions due to variations in the characteristics of the electronic device under consideration.

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

DESIGN CENTRE RATING SYSTEM

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

These values are chosen by the device manufacturer to provide acceptable serviceability of the device in average applications, taking responsibility for normal changes in operating conditions due to rated supply voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in the characteristics of all electronic devices.

The equipment manufacturer should design so that, initially, no design centre value for the intended service is exceeded with a bogey electronic device in equipment operating at the stated normal supply voltage.

LETTER SYMBOLS FOR TRANSISTORS AND SIGNAL DIODES

based on IEC Publication 148

LETTER SYMBOLS FOR CURRENTS, VOLTAGES AND POWERS

Basic letters

The basic letters to be used are:

I, i = current
V, v = voltage
P, p = power.

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

Subscripts

A, a	Anode terminal
(AV), (av)	Average value
B, b	Base terminal, for MOS devices: Substrate
(BR)	Breakdown
C, c	Collector terminal
D, d	Drain terminal
E, e	Emitter terminal
F, f	Forward
G, g	Gate terminal
K, k	Cathode terminal
M, m	Peak value
O, o	As third subscript: The terminal not mentioned is open circuited
R, r	As first subscript: Reverse. As second subscript: Repetitive. As third subscript: With a specified resistance between the terminal not mentioned and the reference terminal.
(RMS), (rms)	R.M.S. value
S, s	As first or second subscript: Source terminal (for FETS only) As second subscript: Non-repetitive (not for FETS) As third subscript: Short circuit between the terminal not mentioned and the reference terminal
X, x	Specified circuit
Z, z	Replaces R to indicate the actual working voltage, current or power of voltage reference and voltage regulator diodes.

Note: No additional subscript is used for d.c. values.

Upper-case subscripts shall be used for the indication of:

a) continuous (d.c.) values (without signal)

Example I_B

b) instantaneous total values

Example i_B

c) average total values

Example $I_{B(AV)}$

d) peak total values

Example I_{BM}

e) root-mean-square total values

Example $I_{B(RMS)}$

Lower-case subscripts shall be used for the indication of values applying to the varying component alone:

a) instantaneous values

Example i_b

b) root-mean-square values

Example $I_{b(rms)}$

c) peak values

Example I_{bm}

d) average values

Example $I_{b(av)}$

Note: If more than one subscript is used, subscript for which both styles exist shall either be all upper-case or all lower-case.

Additional rules for subscripts

Subscripts for currents

Transistors: If it is necessary to indicate the terminal carrying the current, this should be done by the first subscript (conventional current flow from the external circuit into the terminal is positive).

Examples: I_B, i_B, i_b, I_{bm}

Diodes: To indicate a forward current (conventional current flow into the anode terminal) the subscript F or f should be used; for a reverse current (conventional current flow out of the anode terminal) the subscript R or r should be used.

Examples: I_F, I_R, i_F, $I_{f(rms)}$

Subscripts for voltages

Transistors: If it is necessary to indicate the points between which a voltage is measured, this should be done by the first two subscripts. The first subscript indicates the terminal at which the voltage is measured and the second the reference terminal or the circuit node. Where there is no possibility of confusion, the second subscript may be omitted.

Examples: V_{BE}, v_{BE}, v_{be}, V_{bem}

Diodes: To indicate a forward voltage (anode positive with respect to cathode), the subscript F or f should be used; for a reverse voltage (anode negative with respect to cathode) the subscript R or r should be used.

Examples: V_F, V_R, v_F, V_{rm}

Subscripts for supply voltages or supply currents

Supply voltages or supply currents shall be indicated by repeating the appropriate terminal subscript.

Examples: V_{CC}, I_{EE}

Note: If it is necessary to indicate a reference terminal, this should be done by a third subscript

Example : V_{CCE}

Subscripts for devices having more than one terminal of the same kind

If a device has more than one terminal of the same kind, the subscript is formed by the appropriate letter for the terminal followed by a number; in the case of multiple subscripts, hyphens may be necessary to avoid misunderstanding.

Examples: I_{B2} = continuous (d.c.) current flowing into the second base terminal

V_{B2-E} = continuous (d.c.) voltage between the terminals of second base and emitter

Subscripts for multiple devices

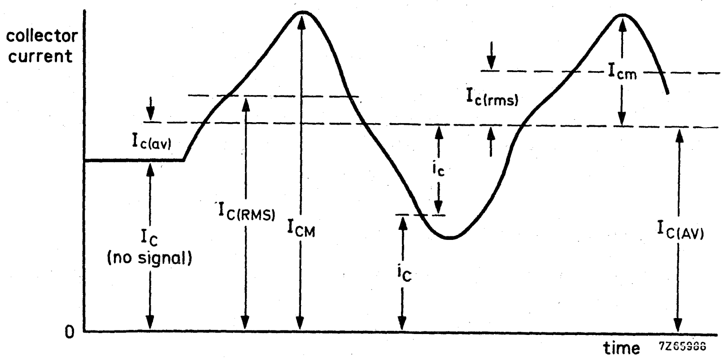
For multiple unit devices, the subscripts are modified by a number preceding the letter subscript; in the case of multiple subscripts, hyphens may be necessary to avoid misunderstanding.

Examples: I_{2C} = continuous (d.c.) current flowing into the collector terminal of the second unit

V_{1C-2C} = continuous (d.c.) voltage between the collector terminals of the first and the second unit.

Application of the rules

The figure below represents a transistor collector current as a function of time. It consists of a continuous (d.c.) current and a varying component.



LETTER SYMBOLS FOR ELECTRICAL PARAMETERS

Definition

For the purpose of this Publication, the term "electrical parameter" applies to four-pole matrix parameters, elements of electrical equivalent circuits, electrical impedances and admittances, inductances and capacitances.

Basic letters

The following is a list of the most important basic letters used for electrical parameters of semiconductor devices.

B, b = susceptance; imaginary part of an admittance

C = capacitance

G, g = conductance; real part of an admittance

H, h = hybrid parameter

L = inductance

R, r = resistance; real part of an impedance

X, x = reactance; imaginary part of an impedance

Y, y = admittance;

Z, z = impedance;

Upper-case letters shall be used for the representation of:

a) electrical parameters of external circuits and of circuits in which the device forms only a part;

b) all inductances and capacitances.

Lower-case letters shall be used for the representation of electrical parameters inherent in the device (with the exception of inductances and capacitances).

Subscripts

General subscripts

The following is a list of the most important general subscripts used for electrical parameters of semiconductor devices:

F, f	= forward; forward transfer
I, i (or 1)	= input
L, l	= load
O, o (or 2)	= output
R, r	= reverse; reverse transfer
S, s	= source

Examples: Z_S, h_f, h_F

The upper-case variant of a subscript shall be used for the designation of static (d.c.) values.

Examples : h_{FE} = static value of forward current transfer ratio in common-emitter configuration (d.c. current gain)

R_E = d.c. value of the external emitter resistance.

Note: The static value is the slope of the line from the origin to the operating point on the appropriate characteristic curve, i.e. the quotient of the appropriate electrical quantities at the operating point.

The lower-case variant of a subscript shall be used for the designation of small-signal values.

Examples: h_{fe} = small-signal value of the short-circuit forward current transfer ratio in common-emitter configuration

$Z_e = R_e + jX_e$ = small-signal value of the external impedance

Note: If more than one subscript is used, subscripts for which both styles exist shall either be all upper-case or all lower-case

Examples: h_{FE}, y_{RE}, h_{fe}

Subscripts for four-pole matrix parameters

The first letter subscript (or double numeric subscript) indicates input, output, forward transfer or reverse transfer

Examples: h_i (or h_{11})
h_o (or h_{22})
h_f (or h_{21})
h_r (or h_{12})

A further subscript is used for the identification of the circuit configuration. When no confusion is possible, this further subscript may be omitted.

Examples: h_{fe} (or h_{21e}), h_{FE} (or h_{21E})

Distinction between real and imaginary parts

If it is necessary to distinguish between real and imaginary parts of electrical parameters, no additional subscripts should be used. If basic symbols for the real and imaginary parts exist, these may be used.

Examples: $Z_i = R_i + jX_i$
$y_{fe} = g_{fe} + jb_{fe}$

If such symbols do not exist or if they are not suitable, the following notation shall be used:

Examples: Re (h_{ib}) etc. for the real part of h_{ib}
Im (h_{ib}) etc. for the imaginary part of h_{ib}

TRANSISTOR SAFE OPERATING AREA

If a power transistor is to give reliable service, four operating limits must be observed:

- Maximum collector current.
- Maximum collector-emitter voltage.
- Maximum power dissipation.
- Second breakdown limit.

These limits are all specified in the data sheets; the purpose here is to enable designers to make the best use of that information.

Collector current

Maximum collector current I_{Cmax} is specified in the data sheets for d.c. operation. For pulsed operation a higher collector current I_{Cmax} is permitted, for a defined maximum pulse length (usually 10 ms) and duty factor (usually 0,01).

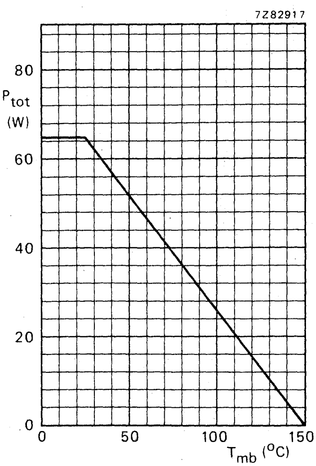
For power switching transistors I_{Csat} is given; this is the value at which switching times and saturation voltage is measured.

Collector-emitter voltage

Maximum collector-emitter voltage V_{CEO} is also specified in the data sheets, but no extension is allowed for pulsed operation. In the case of power transistors specifically designed for switching inductive loads some extension may be allowed, but then only under specified conditions of collector current, base-emitter voltage and emitter-base resistance as stated in the relevant data sheets.

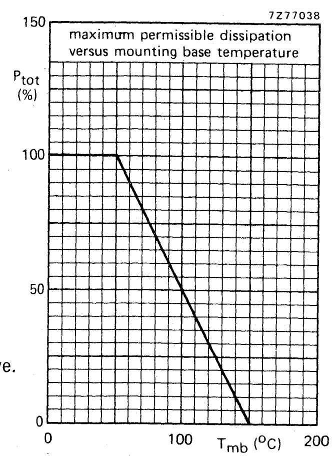
Power dissipation

Maximum power dissipation $P_{tot\,max}$ is specified in the data sheets for a given mounting base temperature. This is usually 25 °C but may be any, much higher temperature. $P_{tot\,max}$ applies up to the stated temperature; above it derating must be applied. A power derating curve of the form shown in Fig. 1a and 1b given in the data sheets. With it, maximum allowable power dissipation can be calculated for any mounting base temperature up to $T_{j\,max}$.



(a)

Fig. 1 Power derating curve.



(b)

Total power dissipation is given by

$$P_{tot} = I_C V_{CE} + I_B V_{BE}.$$

The second term can usually be disregarded, so $P_{tot} \approx I_C V_{CE}$.
Heat dissipated in the collector-base junction flows through the thermal resistance between junction and mounting base, see Fig. 2.

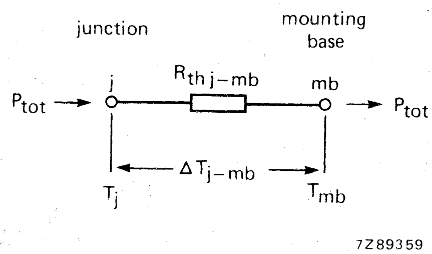


Fig. 2 Heat transport in a transistor with power dissipation constant with respect to time.

By analogy with Ohm's law, under steady-state conditions (d.c. operation)

$$P_{tot} = \frac{T_j - T_{mb}}{R_{th\,j\text{-}mb}}.$$

There are two limitations to P_{tot}
– When $T_{mb} \leqslant T_{mb\,spec}$

$$P_{tot\,max} = \frac{\Delta T_{j\text{-}mb\,max}}{R_{th\,j\text{-}mb}}.$$

– when $T_{mb} > T_{mb\,spec}$

$$P_{tot\,max} = \frac{\Delta T_{j\,max} - T_{mb}}{R_{th\,j\text{-}mb}}$$

$T_{mb\,spec}$ being the mounting base temperature at which $P_{tot\,max}$ is specified in the data sheets, and

$$\Delta T_{j\text{-}mb\,max} = T_{j\,max} - T_{mb\,spec}.$$

For pulsed operation a higher dissipation is permitted, because
– the junction does not have time to heat up fully unless the pulses are so long as to approximate steady-state conditions;
– the junction has time wholly or partly to cool down in the interval between pulses, except with very high duty factors.

Analogy with

$$P_{tot} = \frac{T_j - T_{mb}}{R_{th\,j\text{-}mb}}$$

yields

$$P_{tot\,M} = \frac{T_j - T_{mb}}{Z_{th\,j\text{-}mb}}$$

where $P_{tot\,M}$ is the total pulsed power and $Z_{th\,j\text{-}mb}$ is the thermal impedance between junction and mounting base. Thermal impedance depends on pulse duration t_p and duty factor $\delta = t_p/T$. T is the pulse period. A family of curves of thermal impedance against pulse duration with duty factor as parameter is shown in Fig. 3.

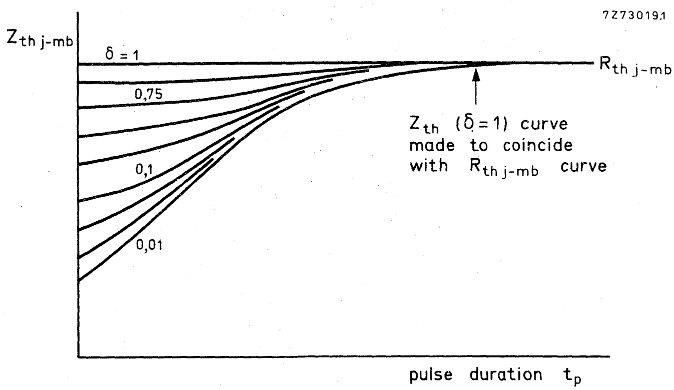


Fig. 3 A typical family of $Z_{th\,j\text{-}mb}$ curves for a power transistor.

Similar limitations apply as in the steady-state conditions:

(a) When $T_{mb} \leqslant T_{mb\,spec}$

$$P_{tot\,M\,max} = \frac{T_{j\text{-}mb\,max}}{Z_{th\,j\text{-}mb}}$$

(b) When $T_{mb} > T_{mb\,spec}$

$$P_{tot\,M\,max} = \frac{T_{j\,max} - T_{mb}}{Z_{th\,j\text{-}mb}}.$$

In essence, at or below $T_{mb\,spec}$ there is a fixed limit to $P_{tot\,M\,max}$; above $T_{mb\,spec}$, $P_{tot\,M\,max}$ declines linearly with increasing mounting base temperature. As illustrated in Fig. 4, for non-rectangular pulses

$$P_{tot\,max} \cdot t_p = \int_{t_1}^{t_2} P \cdot t_p.$$

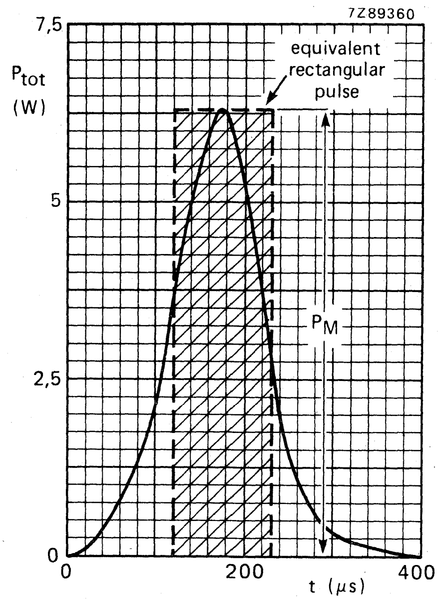


Fig. 4.

Second breakdown

In the forward-biased condition second breakdown is thermally triggered. Consider the chip as a large number of elemental transistors in parallel, some of which will have a lower forward voltage drop than others. Current will tend to concentrate in these, raising their temperature and further lowering their forward voltage drop. Current will concentrate still further, leading to local overheating and eventually to a short circuit between emitter and collector. This effect is independent of mounting base temperature, which is related to the average junction temperature. Under reverse-bias conditions, when V_{CE} is greater than V_{CEOmax}, the chance of second breakdown is always present. This is a particular hazard in timebase and converter applications.

THE SOAR BOUNDARIES

The four limits just described form the boundaries of the Safe Operating ARea. Figure 5 shows a SOAR plotted on a log-log grid. The right-hand boundary is formed by V_{CEOmax}, which extends up to a collector current of about 300 mA. Above this point, as I_C is increased V_{CE} must be reduced to prevent second breakdown.

The upper boundary is formed by I_{Cmax}, which extends to where the product of I_{Cmax} and V_{CE} equals the maximum allowable power dissipation. From this point I_C must be reduced with increasing V_{CE}, thus forming the maximum power dissipation boundary. The maximum power dissipation boundary normally intersects the second breakdown boundary at some point. However, for values of T_{mb} above T_{mbspec}, $P_{tot\,max}$ must be reduced (as shown by the broken line in Fig. 5), so that the boundary of maximum power dissipation intersects the second breakdown boundary at a lower point. With high values of T_{mb}, the second breakdown boundary may be excluded altogether.

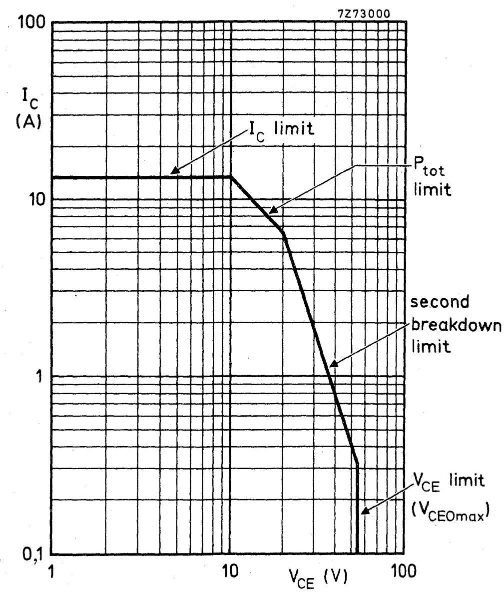


Fig. 5 A typical SOAR graph with boundaries named.

EXTENDING THE SOAR FOR SINGLE-SHOT AND REPETITIVE PULSED OPERATION

The data sheets for power transistors contain, apart from the d.c. SOAR, a set of curves that apply under specific pulse conditions. These will cover some 90% of applications. In addition to these, SOAR curves can be constructed by the circuit designer for specific operating conditions. The various extensions dealt with below will refer to Figs 5,6 and 8.

I_{CMmax}

The extent to which the I_C boundary can be extended for pulse operation depends on pulse duration and duty factor, the limit being I_{CMmax}, which applies at a duty factor of 0,01 and a pulse length of 20 ms or less. Together the I_{CMmax} and V_{CEOmax} boundaries form a rectangle that in no circumstance should be exceeded. Moreover, the rectangle may be reduced by further restrictions imposed by power dissipation and second breakdown. The example shown in Fig. 6 is for an I_{CMmax} of 12 A and a V_{CEOmax} of 60 V.

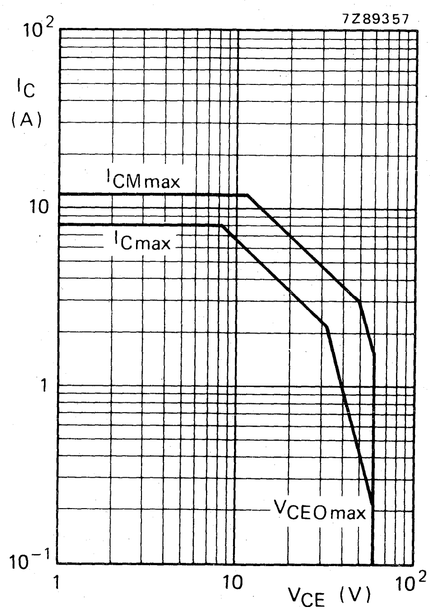


Fig. 6 Maximum collector current and collector-emitter voltage boundaries.

$P_{tot\,max}$

The $P_{tot\,max}$ boundary given in the data sheet usually applies to:

T_{mb} = 25 °C; δ = 0,01 and t_p = a range of values, say, 5 μs to 2 ms.

For any deviations from these values a new $P_{tot\,max}$ boundary must be constructed.
From

$$P_{tot\,M\,max} = \frac{T_{j\,max} - T_{mb}}{Z_{th\,j\text{-}mb}};$$

$T_{j\,max}$ is stated in the data sheets; $Z_{th\,j\text{-}mb}$ can be read from the curve, similar to Fig. 3, also given in the data sheets. Thus $P_{tot\,M\,max}$ can be calculated and an appropriate boundary can be drawn in the SOAR curve parallel to the $P_{tot\,max}$ line. An example will illustrate this. Assume:

$T_{j\,max}$ = 150 °C; $T_{mb\,spec}$ = 25 °C; t_p = 0,2 ms and δ = 0,1.

From Fig. 7, $Z_{th\,j\text{-}mb}$ = 0,42 K/W for the given values of t_p and δ.

$$P_{tot\,M\,max} = \frac{150 - 80}{0,42} = 166\ \text{W}.$$

Thus from an arbitary point (say 8,3 A, 20 V) we can draw a line parallel to the $P_{tot\,max}$ line (see Fig. 6).

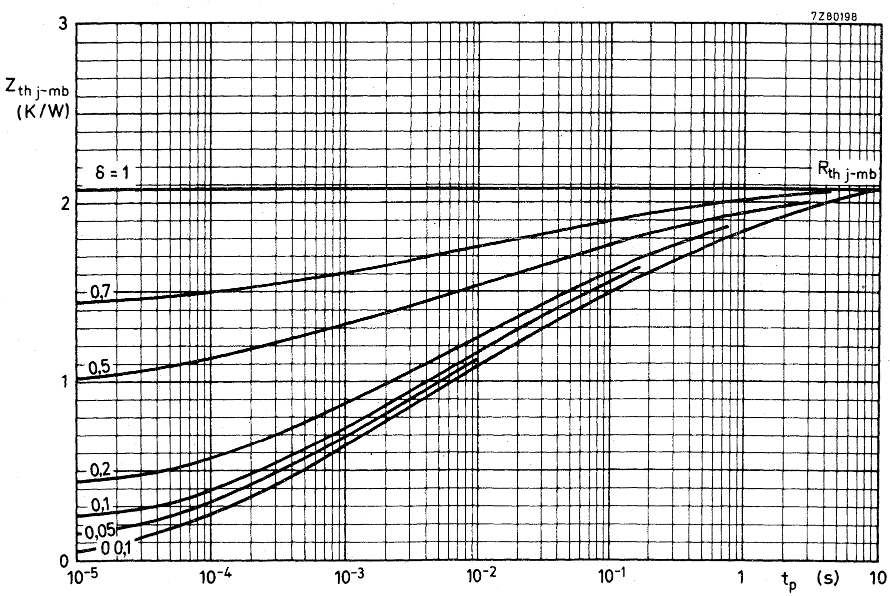


Fig. 7 Transient thermal impedance for example.

Second breakdown

The permissible extension to the second breakdown boundary is found with the aid of two multiplying factors:

M_V – the voltage multiplying factor
M_I – the current multiplying factors.*

Curves for these two factors are given in the data sheets as functions of pulse time with duty factor as parameter (see Fig. 8).

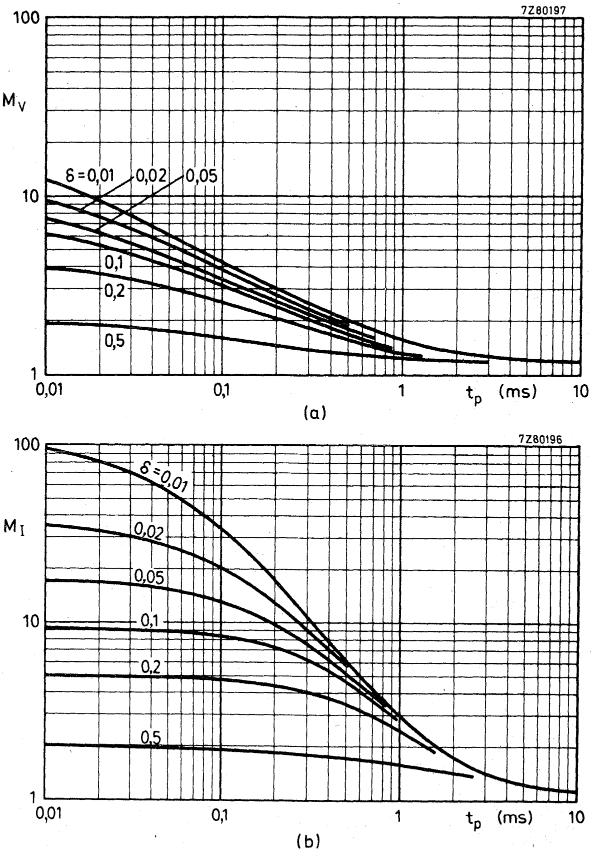


Fig. 8 Second breakdown multiplying factors as a function of pulse time, with duty factor as a parameter.

M_V is used to calculate the point on the V_{CEOmax} boundary at which voltage derating must commence as I_C increases. Similarly, M_I is used to calculate the point on the I_{CMmax} line at which current derating must commence as V_{CE} increases.

* Prior to 1973 M_V was known as $M_{SB(I)}$ and M_I as $M_{SB(V)}$.

Referring to Fig. 9, where B is the point on the V_{CEOmax} boundary at which voltage derating commences, B′ can be calculated by:

$I_{C(B')} = I_{C(B)} \times M_I$.

Similarly for I_C; although here A, the point on the I_C curve at which current derating commences, is first determined by extending the second breakdown boundary to where the two would intersect if $P_{tot\,max}$ did not intervene. A′ is then given by

$V_{CA(S')} = V_{CE(A)} \times M_V$.

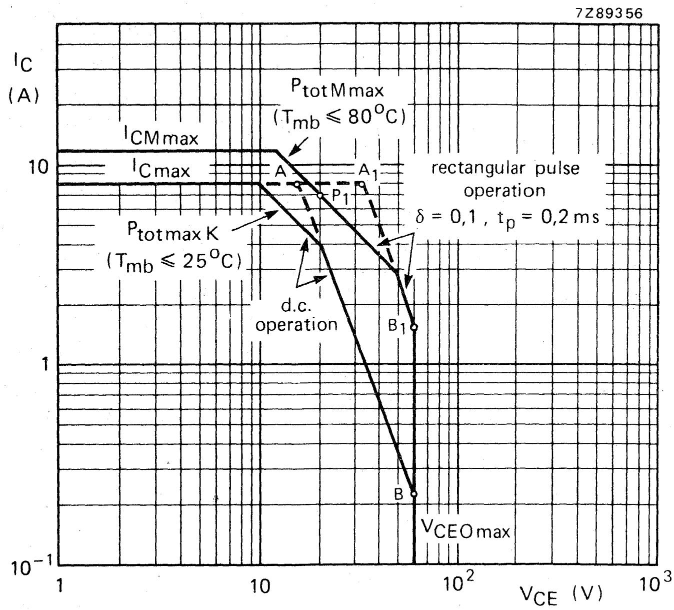


Fig. 9 Construction of the pulse operating area.

An example is worked in Fig. 9 for t_p = 0,2 ms and δ = 0,1.
From Fig. 8, M_V = 2,4 and M_I = 7,3:

$I_{C(B')}$ = 0,22 x 7,3 = 1,6 A
$V_{CE(A')}$ = 13 x 2,4 = 31 V.

These two points are then joined as in Fig. 9.

PULSE TRAINS AND COMPOSITE WAVEFORMS

Straightforward techniques exist for calculating the thermal and second breakdown effects of pulse trains and composite waveforms.

Thermal considerations

Consider a train of rectangular pulses as shown in Fig. 10. The junction will alternately heat and partly cool until a steady-state temperature is reached as shown in the lower part of Fig. 10. To approximate the final junction temperature only the effects of the first two or three pulses need be considered.

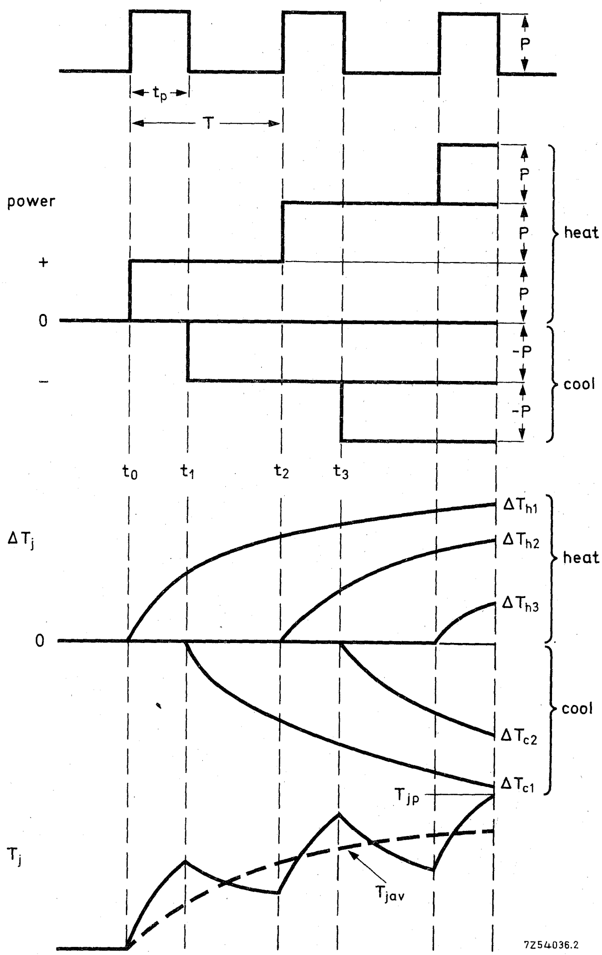


Fig. 10 The heating effect of three equidistant, equal-magnitude pulses. $T_{j\,av}$ is the average junction temperature. P = 100 W, t_p = 100 μs; T = 1 ms and δ = 0,1.

Referring to Fig. 10, where P = 100 W, t_p = 100 μs and δ = 0,1, the first pulse causes the junction to heat up; at the end of the pulse it starts to cool down until the second pulse recommences the heating cycle. We can replace the first pulse with a *continuous* heating pulse at t_0 and a *continuous* cooling pulse starting at t_1. Similarly for the second pulse, we can superimpose a continuous heating pulse starting at t_2 and a cooling pulse starting at t_3. Repeating this for successive pulses allows us to calculate T_j for any point in the pulse train. For instance, the cumulative change in junction temperature at the end of the third pulse is:

$$\Delta T_j = \Delta T_{h1} - \Delta T_{c1} + \Delta T_{h2} - \Delta T_{c2} + \Delta T_{h3},$$

where the subscripts h and c refer to heating and cooling respectively. With times taken from Fig. 10,

$$T_{h1} = PZ_{th}(2{,}1\ \text{ms})$$
$$T_{h2} = PZ_{th}(1{,}1\ \text{ms})$$
$$T_{h3} = PZ_{th}(0{,}1\ \text{ms})$$

and

$$T_{c1} = -PZ_{th}(2{,}0\ \text{ms})$$
$$T_{c2} = -PZ_{th}(1{,}0\ \text{ms})$$

Taking values for Z_{th} from Fig. 11 we get

$$\Delta T_j = 100(0{,}58 - 0{,}56 + 0{,}51 - 0{,}51 + 0{,}32) = 34\ ^{\circ}\text{C}.$$

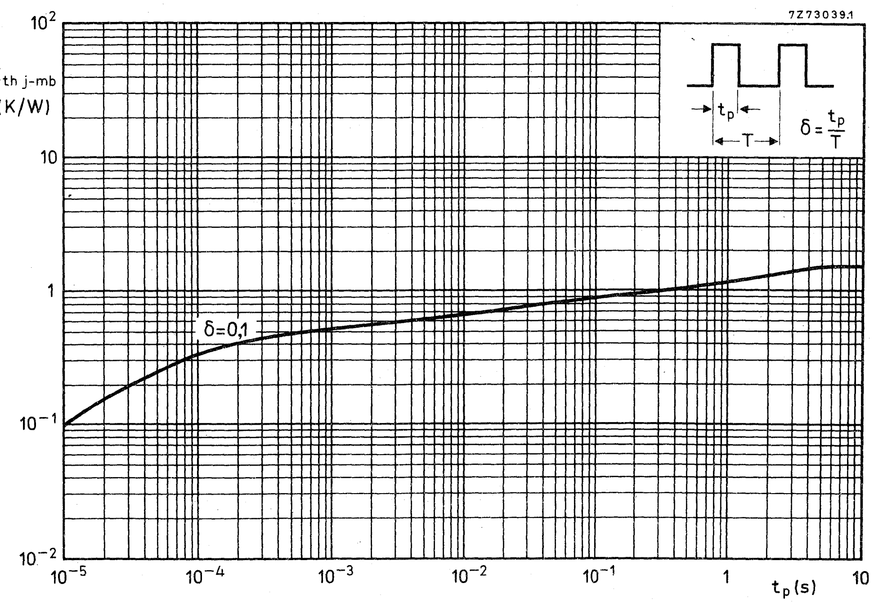


Fig. 11 Curve of $Z_{th\ j\text{-}mb} = f(t_p)$.

The same procedure can be used for long or continuous pulse trains, but calculating for a large number of pulses is very tedious. A sufficiently close approximation can be made by calculating for two pulses, assuming that the first is preceded by a continuous pulse of P_{av} as shown in Fig. 12. By this method

$$\Delta T_j = \Delta T_{h\,av} + \Delta T_{h1} - \Delta T_{c1} + \Delta T_{h2}.$$

The calculations are then made as before. To remove any doubt as to the closeness of the approximation the effect of a third pulse can be calculated. Composite waveforms can be treated similarly: divide the composite waveform into equivalent rectangular pulses and calculate the junction temperature accordingly.

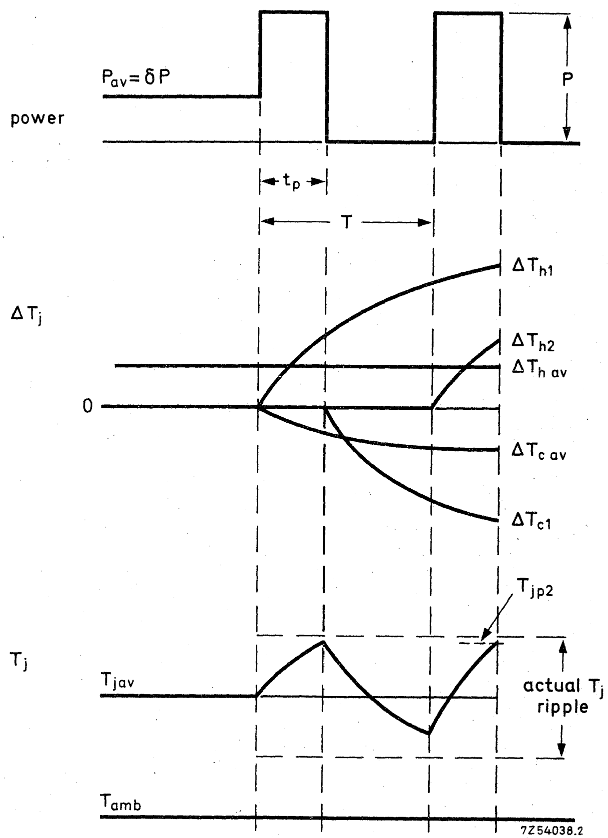


Fig. 12.

Figure 13 shows the current, voltage and power waveforms of the out put transistor in a television receiver vertical output stage. P_{tot} has been divided into four equivalent rectangular parts having the same peak values and energy content as the original waveform.

$$P_{tot\,av} = P_1\delta_1 + P_2\delta_2 + P_3\delta_3 + P_4\delta_4$$
$$= (16 \times 0{,}003) + (13 \times 0{,}11) +$$
$$+ (5{,}2 \times 0{,}66) + (40 \times 0{,}0007)$$
$$= 4{,}936\ \text{W}.$$

Assuming that the $R_{th\ j\text{-}mb}$ for the transistor is 2,5 K/W, the average rise in mounting base temperature will be about 12,5 °C.

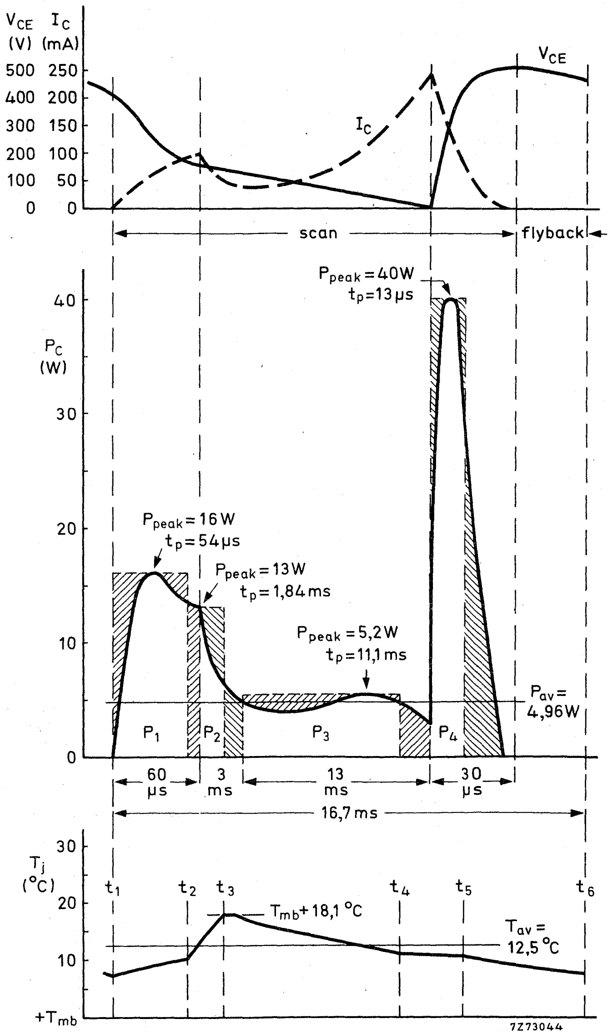


Fig. 13 Power waveforms showing their division into rectangular pulses and the junction temperature variations which they cause.

Using the same method as for pulse trains, peak temperatures at the end of each pulse can be calculated by

$$T_{j\text{-}mb(t1)} = P_{av}R_{th\ j\text{-}mb} - P_{av}Z_{th\ j\text{-}mb(16,1\ ms)} + P_1Z_{th(16,1\ ms)}.$$

For the temperature at the end of the second pulse (t_2) two further terms are added:

$$-P_1Z_{th(16,04\ ms)} + P_2Z_{th(16,04\ ms)}.$$

For t_3 yet another two terms:

$$-P_3Z_{th(13,02\ ms)} + P_4Z_{th(13,03\ ms)}.$$

For each successive pulse a negative term (end of the previous pulse) and a positive term (start of the succeeding pulse) are added. Calculated temperatures are shown in Table 1: note that the highest temperature is reached at the end of pulse 2 (t_3). Even assuming a T_{mb} of 100 °C, T_j will remain within the $T_{j\ max}$ of 150 °C specified for this transistor.

TABLE 1 Calculated temperatures for the power waveform of Fig. 13.

time	t_1	t_2	t_3	t_4	t_5	$t_6(t_s)$	
$\Delta T_{j\text{-}mb}$	8,54	11,34	18,1	12,76	12,3	8,54	°C

EXAMPLE OF A SOAR CALCULATION

To illustrate the foregoing we will take the example of a BU426A transistor operating in a 200 W switched-mode power supply (SMPS).

Waveforms of collector current, collector-emitter voltage and power dissipation are shown in Figs 14, 15 and 16. These are translated into an equivalent rectangular pulse train in Fig. 17. This will enable us to calculate peak junction temperature at any instant.

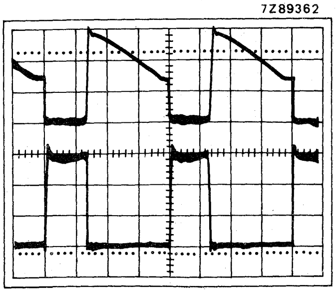


Fig. 14 Collector-current and collector-emitter voltage waveforms of a BU426A transistor in a 200 W SMPS.

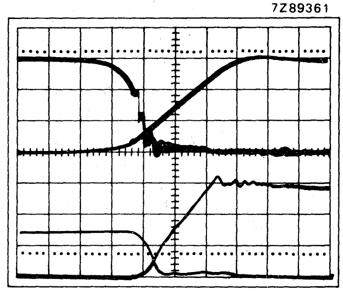


Fig. 15 Waveforms during turn-on and turn-off (lower part).

The duration of this equivalent pulse train is then given by

$$t_p' = \frac{P_{tot\,av} \times T}{P_M'} \text{ and } \delta' = \frac{t_p'}{T}.$$

First, from Fig. 17, heating and cooling pulses are plotted as in Fig. 18. Parameters are then tabulated as shown:

$P_{turn\text{-}on}$ = 66 W	P_{sat} = 10 W	$P_{turn\text{-}off}$ = 56 W
$t_{p\,on}$ = 0,8 μs	$t_{p\,sat}$ = 2,2 μs	$t_{p\,off}$ = 0,6 μs
δ_{on} = 0,04	δ_{sat} = 0,11	δ_{off} = 0,03

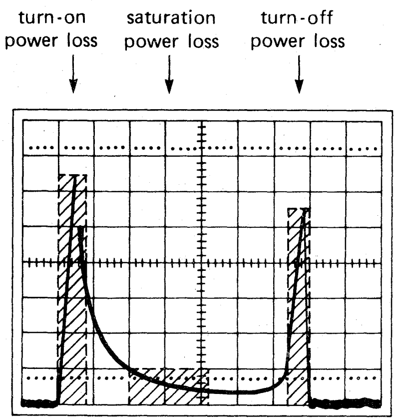


Fig. 16 Power loss and resultant rectangular power pulses.

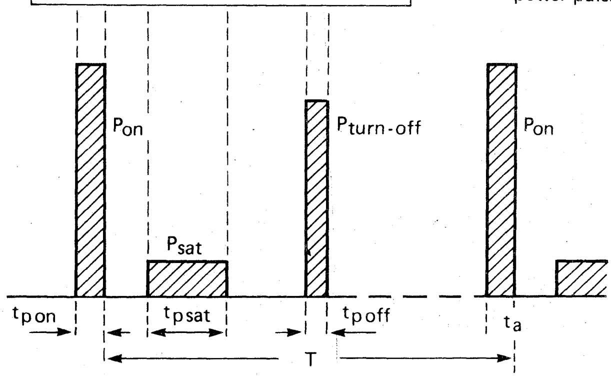


Fig. 17.

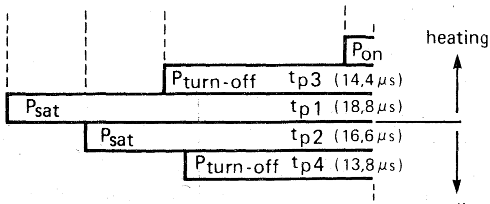


Fig. 18.

From Fig. 17 we can determine δ_p and t_p for each condition and from the BU426 data sheets the relevant Z_{th}.

	p1	p2	p3	p4	p5	unit
t	18,8	16,6	14,4	13,8	0,8	µs
δ	0,94	0,83	0,72	0,7	0,04	
Z_{th}	1,05	0,95	0,85	0,8	0,06	K/W

From

$$\Delta T_j = \Delta T_{h1} - \Delta T_{c1} + \Delta T_{h2} - \Delta T_{c2} + \Delta T_{h3}$$

$$\Delta T_{j\text{-}mb(ta)} = (P_{sat} \times Z_{th(tp1)}) - (P_{sat} \times Z_{th(tp2)}) +$$
$$+ (P_{turn\text{-}off} \times Z_{th(tp3)}) - (P_{turn\text{-}off} \times Z_{th(tp4)}) + (P_{on} \times Z_{th(tp\,on)})$$

$$\Delta T_{j\text{-}mb(ta)} = 10(1{,}05 - 0{,}95) + 56(0{,}83 - 0{,}8) + 66(0{,}06) = 7{,}76\ \text{K}.$$

Thus, at time t_a the peak junction temperature is 7,76 K higher than the average mounting base temperature. The $\Delta T_{j\text{-}mb}$ arising from the other power pulses can be calculated in the same way.

Average mounting base temperature depends on the size of the heatsink, ambient temperature (T_a) and average dissipation.

From

$$P_{tot\,av} = P_1\delta_1 + P_2\delta_2 + P_3\delta_3 + P_4\delta_4.$$

$$P_{tot\,av} = \delta_{on} \times P_{on} + \delta_{sat} \times P_{sat} + \delta_{turn\text{-}off} \times P_{off}$$

$$= 0{,}04 \times 66 + 0{,}11 \times 10 + 0{,}03 \times 56 = 5{,}4\ \text{W}.$$

Assuming a maximum mounting base temperature of 100 °C and an ambient temperature of 60 °C the thermal resistance of the heatsink required will be

$$R_{th\,mb\text{-}a} = \frac{T_{mb} - T_a}{P_{tot\,av}} = \frac{100 - 60}{5{,}4} = 7{,}4\ \text{K/W}.$$

If this is the case, the peak junction temperature at the end of the turn-on power pulse will be 107,76 °C, which is well within the maximum allowable junction temperature of 150 °C.

The pulse SOAR can be calculated using M_I, M_V and Z_{th} factors as described earlier. The turn-on, saturation and turn-off power pulses should be combined into a single pulse of amplitude P′ equal to the highest amplitude power pulse (here, P_{on}) and duration t'_p.

$$P_{tot\,av} = P' = 66\ \text{W}.$$

$$\delta' = \frac{5{,}4}{66} = 0{,}082.$$

$$t'_p + \delta' T = 1{,}64\ \mu\text{s}.$$

From the BU426A data, for this power pulse $Z_{th\,j\text{-}mb} = 0{,}10$ K/W; $M_I \approx 12$; $M_V \approx 7{,}5$; $V_{CE(A')} = 7{,}5 \times 12 = 90$ V; $I_{C(B')} = 12 \times 40 = 480$ mA.

$$P_{tot\,max} = \frac{T_j - T_{mb}}{Z_{th\,j\text{-}mb}} = \frac{150 - 100}{0,1} = 500\ W.$$

The relevant pulse SOAR is shown in Fig. 19, in which the operating point for the full cycle has also been plotted. It can be seen that it remains well within the SOAR.

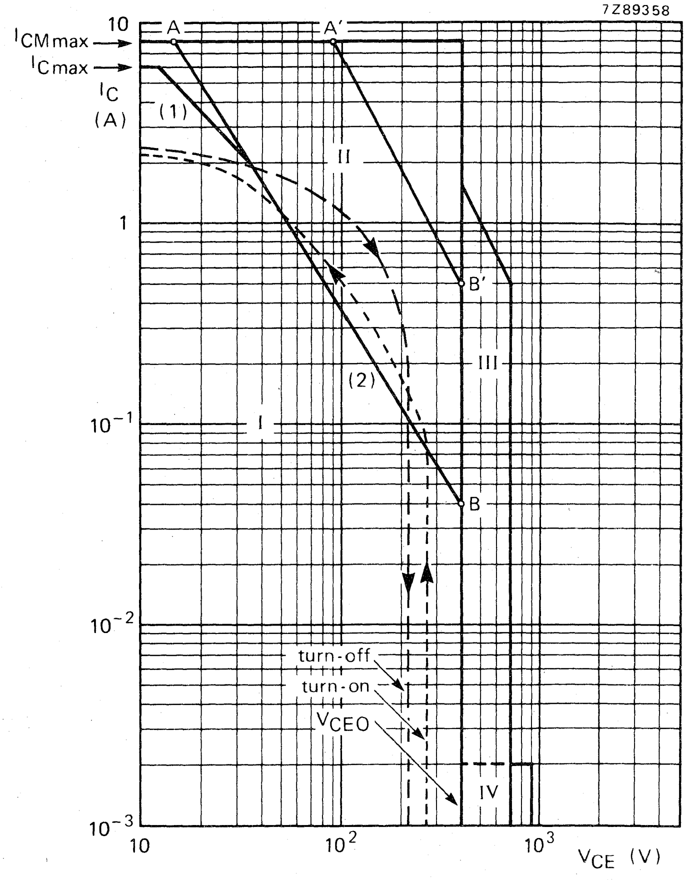


Fig. 19 Safe Operating ARea BU426A at $T_{mb} \leqslant 73\ ^oC$.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

III Area of permissible operation during turn-on in single-transistor converters, provided $R_{BE} \leqslant 100\ \Omega$ and $t_p \leqslant 0,6\ \mu s$.

IV Repetitive pulse operation in this region is permissible, provided $V_{BE} \leqslant 0$ and $t_p \leqslant 2$ ms.

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.

(2) Second-breakdown limits (independent of temperature).

TRANSISTOR DATA

SILICON PLANAR EPITAXIAL POWER TRANSISTOR

N-P-N transistor in a SOT-32 plastic envelope for general purpose, medium power applications. P-N-P complement is BD132.

QUICK REFERENCE DATA

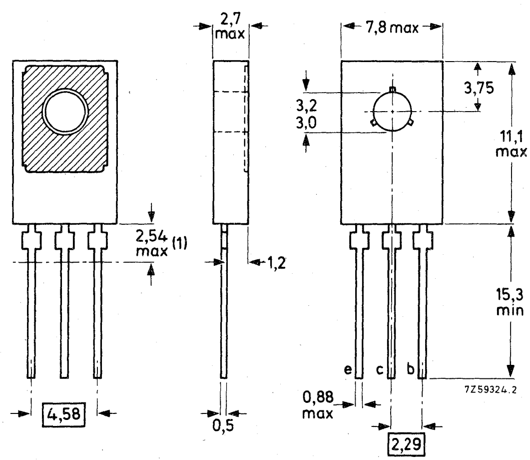
Collector-base voltage (open emitter)	V_{CBO}	max.	70	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	V
Collector current (peak value)	I_{CM}	max.	6	A
Total power dissipation up to T_{mb} = 60 °C	P_{tot}	max.	15	W
Junction temperature	T_j	max.	150	°C
D.C. current gain I_C = 0,5 A; V_{CE} = 12 V	h_{FE}	>	40	
Transition frequency at f = 35 MHz I_C = 0,25 A; V_{CE} = 5 V	f_T	>	60	MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-126 (SOT-32).

Collector connected to metal part of mounting surface.



See also chapters Mounting instructions and Accessories.

(1) Within this region the cross-section of the leads is uncontrolled.

RATINGS

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

Collector-base voltage (open emitter)	V_{CBO}	max.	70	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	V
Emitter-base voltage (open collector)	V_{EBO}	max.	6	V
Collector current (d.c.)	I_C	max.	3	A
Collector current (peak value)	I_{CM}	max.	6	A
Base current (peak value)	I_{BM}	max.	0,5	A
Reverse base current (peak value)	$-I_{BM}$	max.	0,5	A
Total power dissipation up to T_{mb} = 60 °C	P_{tot}	max.	15	W
Storage temperature	T_{stg}		−65 to + 150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	6	°C/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current			
$I_E = 0$; $V_{CB} = 50$ V	I_{CBO}	<	5 μA
$I_E = 0$; $V_{CB} = 50$ V; $T_j = 150$ °C	I_{CBO}	<	500 μA
Emitter cut-off current			
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	5 μA
Saturation voltages			
$I_C = 0{,}5$ A; $I_B = 50$ mA	V_{CEsat}	<	0,3 V
	V_{BEsat}	<	1,2 V
$I_C = 2$ A; $I_B = 200$ mA	V_{CEsat}	<	0,7 V
	V_{BEsat}	<	1,5 V
D.C. current gain			
$I_C = 0{,}5$ A; $V_{CE} = 12$ V	h_{FE}	>	40
$I_C = 2$ A; $V_{CE} = 1$ V	h_{FE}	>	20
Collector capacitance at f = 1 MHz			
$I_E = I_e = 0$; $V_{CB} = 5$ V	C_c	<	60 pF
Transition frequency at f = 35 MHz			
$I_C = 0{,}25$ A; $V_{CE} = 5$ V; $T_{amb} = 25$ °C	f_T	>	60 MHz
D.C. current gain ratio of the complementary pairs			
$I_C = 0{,}5$ A; $V_{CE} = 12$ V	h_{FE1}/h_{FE2}	<	1,2

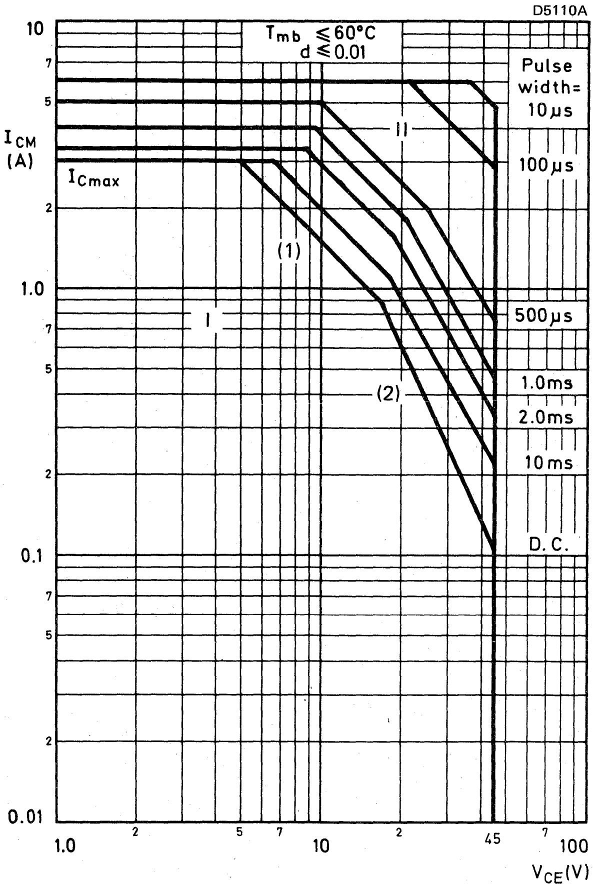


Fig. 2 Safe Operating ARea with the transistor forward biased.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.

(2) Second breakdown limits (independent of temperature).

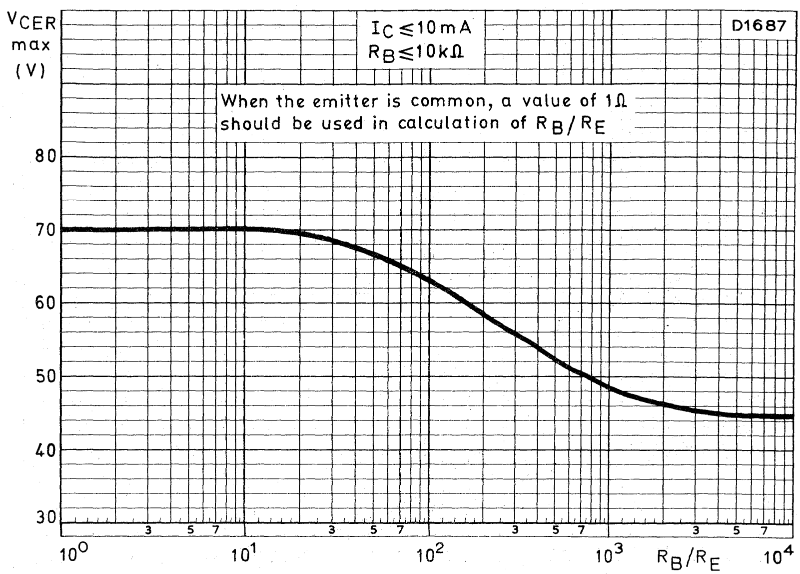


Fig. 3 Maximum allowable collector-emitter voltage as a function of base-emitter resistance.

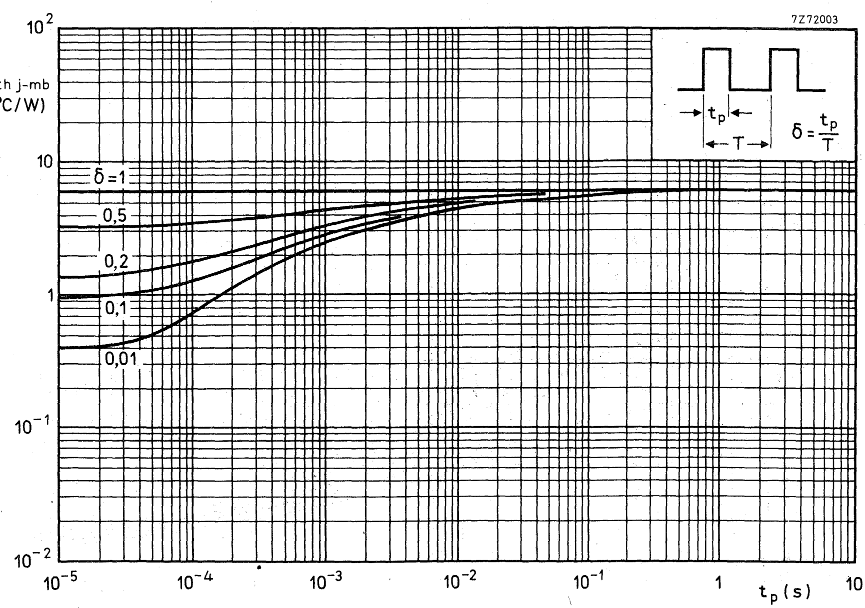


Fig. 4 Pulse power rating chart.

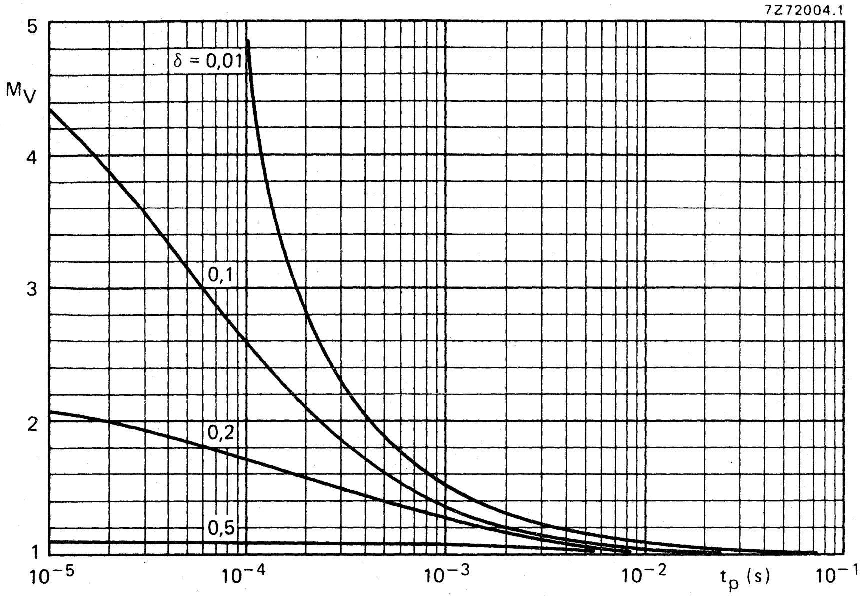


Fig. 5 S.B. voltage multiplying factor at the I_{Cmax} level.

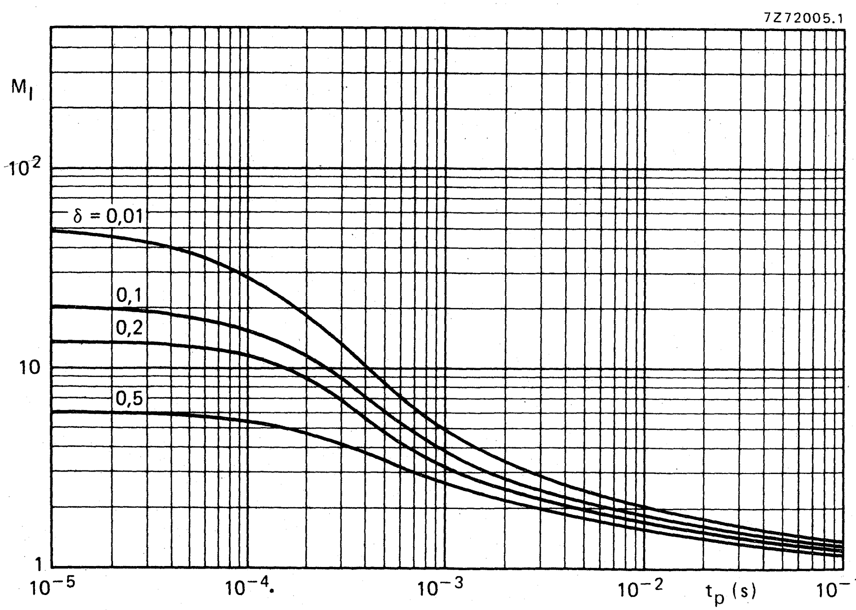


Fig. 6 S.B. current multiplying factor at the V_{CEOmax} level.

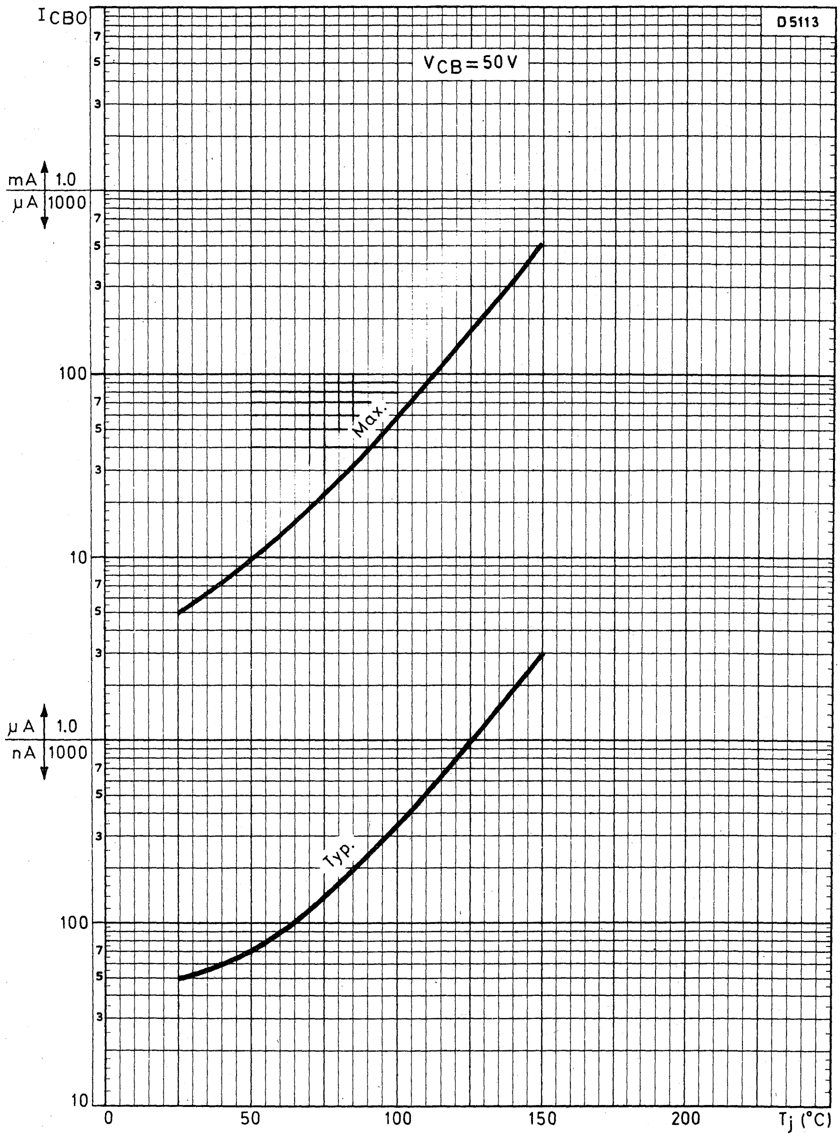


Fig. 7 Collector-base current (open emitter) as a function of the junction temperature.

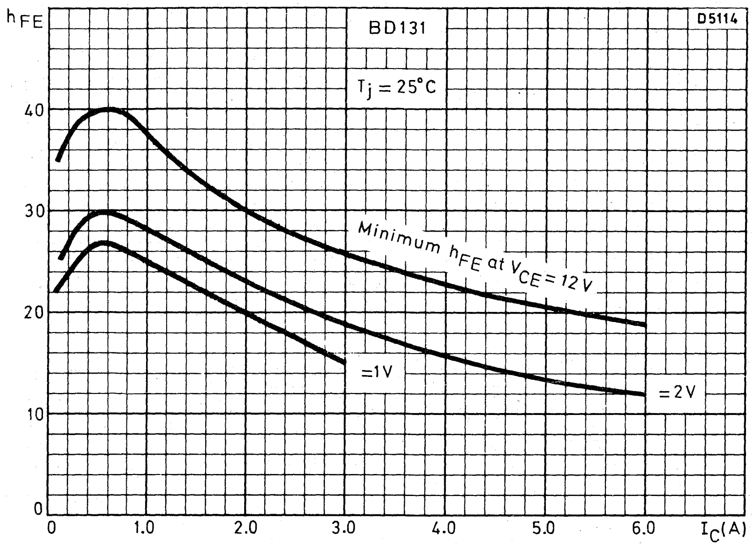

hFE
BD131
D5114
Tj = 25°C
40
30
20
10
0
Minimum hFE at VCE = 12 V
=1V
=2V
0
1.0
2.0
3.0
4.0
5.0
6.0
IC(A)

Fig. 8.

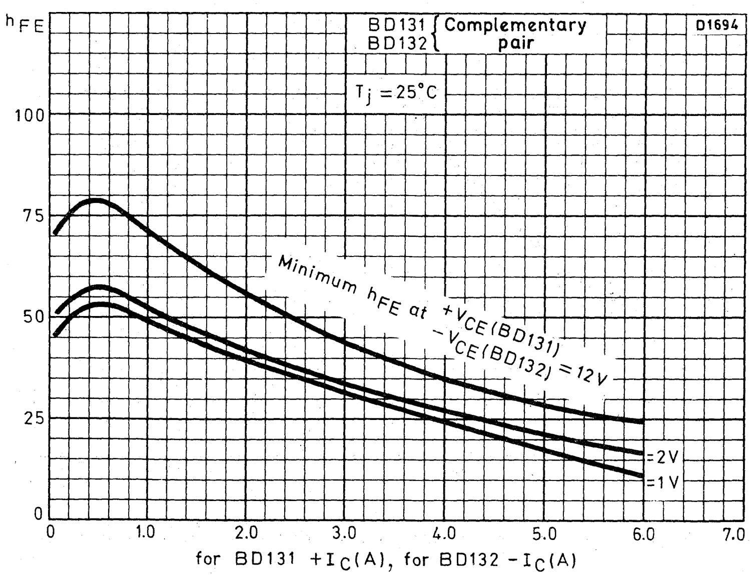

hFE
BD131 { Complementary
BD132 { pair
D1694
Tj = 25°C
100
75
50
25
0
Minimum hFE at +VCE(BD131)
−VCE(BD132) = 12 V
=2V
=1V
0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
for BD131 +IC(A), for BD132 −IC(A)

Fig. 9.

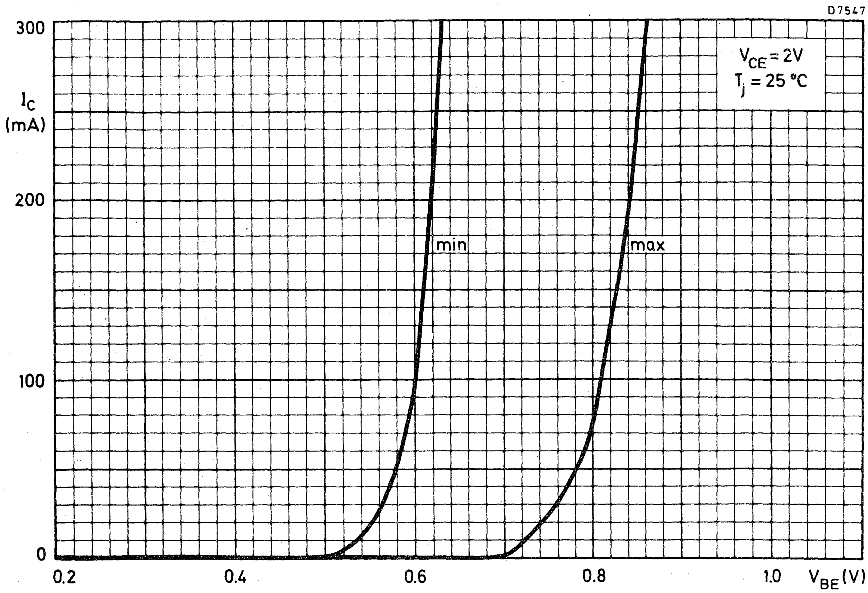

D7547
300
200
100
0
I_C
(mA)
V_{CE} = 2V
T_j = 25 °C
min
max
0.2
0.4
0.6
0.8
1.0
V_{BE}(V)

Fig. 10.

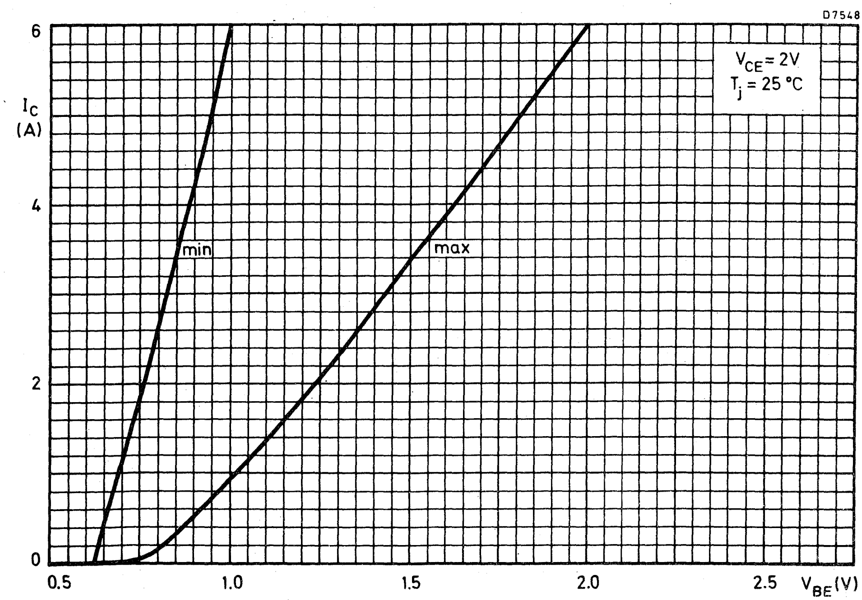

D7548
6
4
2
0
I_C
(A)
V_{CE} = 2V
T_j = 25 °C
min
max
0.5
1.0
1.5
2.0
2.5
V_{BE}(V)

Fig. 11.

SILICON PLANAR EPITAXIAL POWER TRANSISTOR

P-N-P transistor in a SOT-32 plastic envelope for general purpose, medium power applications. N-P-N complement is BD131.

QUICK REFERENCE DATA

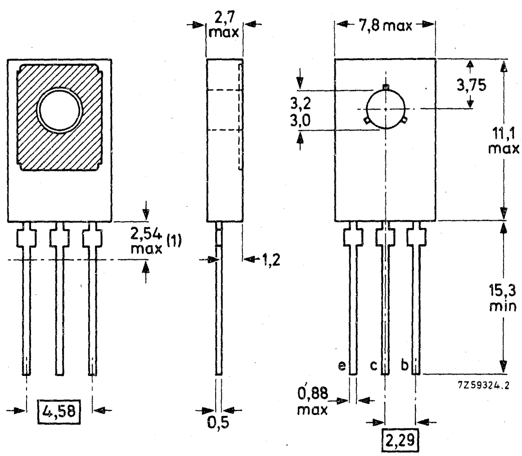
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	V
Collector current (peak value)	$-I_{CM}$	max.	6	A
Total power dissipation up to T_{mb} = 60 °C	P_{tot}	max.	15	W
Junction temperature	T_j	max.	150	°C
D.C. current gain $-I_C$ = 0,5 A; $-V_{CE}$ = 12 V	h_{FE}	>	40	
Transition frequency at f = 35 MHz $-I_C$ = 0,25 A; $-V_{CE}$ = 5 V	f_T	>	60	MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-126 (SOT-32)

Collector connected to metal part of mounting surface.



See also chapters Mounting instructions and Accessories.

(1) Within this region the cross-section of the leads is uncontrolled.

RATINGS

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

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45 V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	4 V
Collector current (d.c.)	$-I_C$	max.	3 A
Collector current (peak value)	$-I_{CM}$	max.	6 A
Base current (peak value)	$-I_{BM}$	max.	0,5 A
Reverse base current (peak value)	$+I_{BM}$	max.	0,5 A
Total power dissipation up to T_{mb} = 60 °C	P_{tot}	max.	15 W
Storage temperature	T_{stg}	−65 to + 150 °C	
Junction temperature	T_j	max.	150 °C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	6 °C/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current			
$I_E = 0$; $-V_{CB} = 40$ V	$-I_{CBO}$	<	5 µA
$I_E = 0$; $-V_{CB} = 40$ V; $T_j = 150$ °C	$-I_{CBO}$	<	500 µA
Emitter cut-off current			
$I_C = 0$; $-V_{EB} = 3$ V	$-I_{EBO}$	<	5 µA
Saturation voltages			
$-I_C = 0{,}5$ A; $-I_B = 50$ mA	$-V_{CEsat}$	<	0,3 V
	$-V_{BEsat}$	<	1,2 V
$-I_C = 2$ A; $-I_B = 200$ mA	$-V_{CEsat}$	<	0,7 V
	$-V_{BEsat}$	<	1,5 V
D.C. current gain			
$-I_C = 0{,}5$ A; $-V_{CE} = 12$ V	h_{FE}	>	40
$-I_C = 2$ A; $-V_{CE} = 1$ V	h_{FE}	>	20
Transition frequency at f = 35 MHz			
$-I_C = 0{,}25$ A; $-V_{CE} = 5$ V; $T_{amb} = 25$ °C	f_T	>	60 MHz
D.C. current gain ratio of the complementary pairs			
$-I_C = 500$ mA; $-V_{CE} = 12$ V	h_{FE1}/h_{FE2}	<	1,2

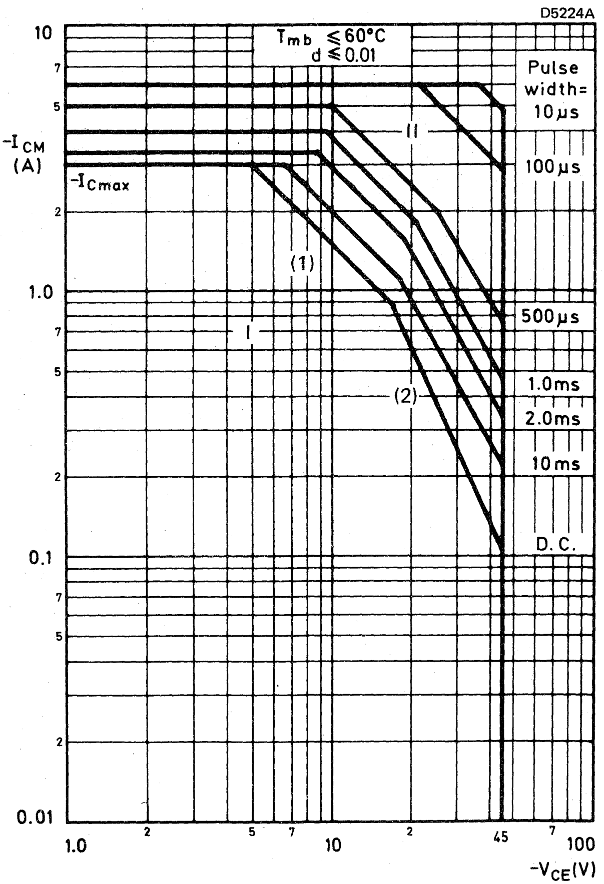


Fig. 2 Safe Operating ARea with the transistor forward biased.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.

(2) Second breakdown limits (independent of temperature).

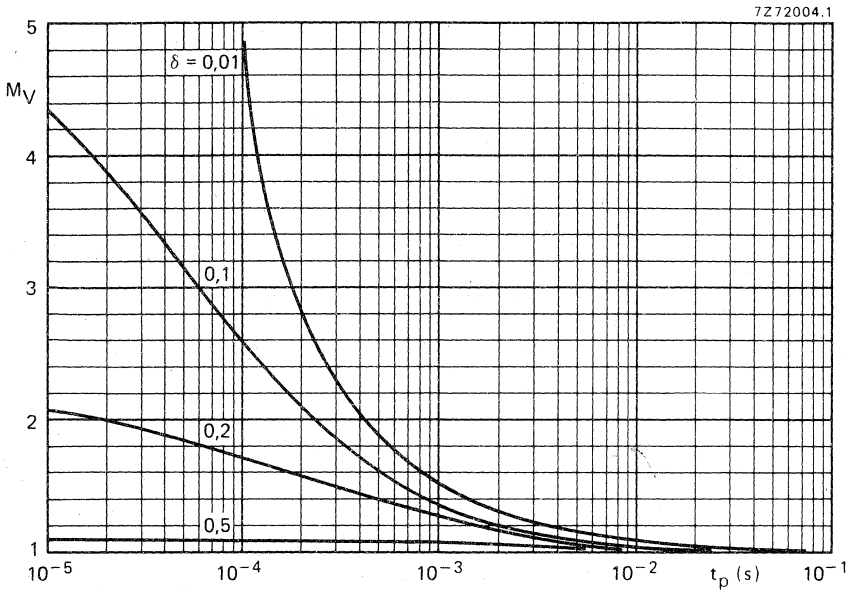


Fig. 3 S.B. voltage multiplying factor at the $-I_{Cmax}$ level.

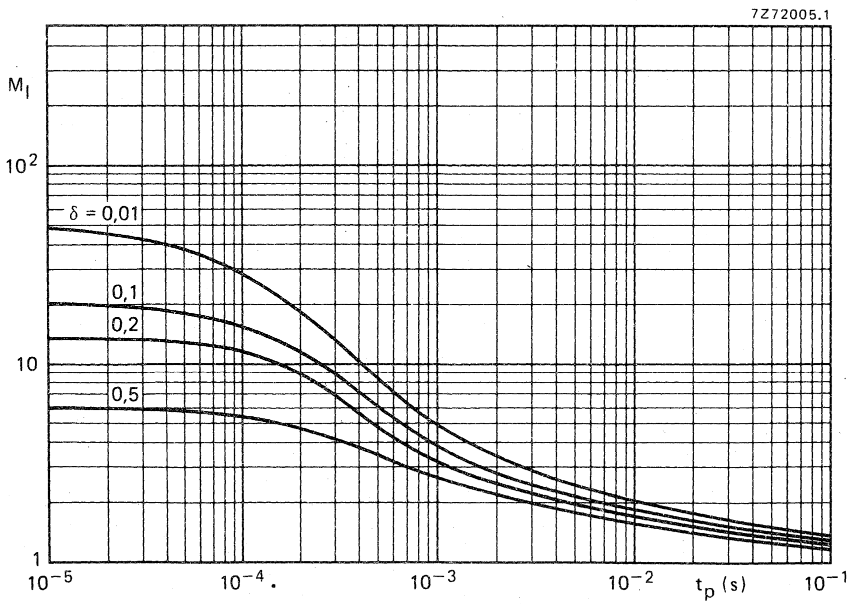


Fig. 4 S.B. current multiplying factor at the $-V_{CEOmax}$ level.

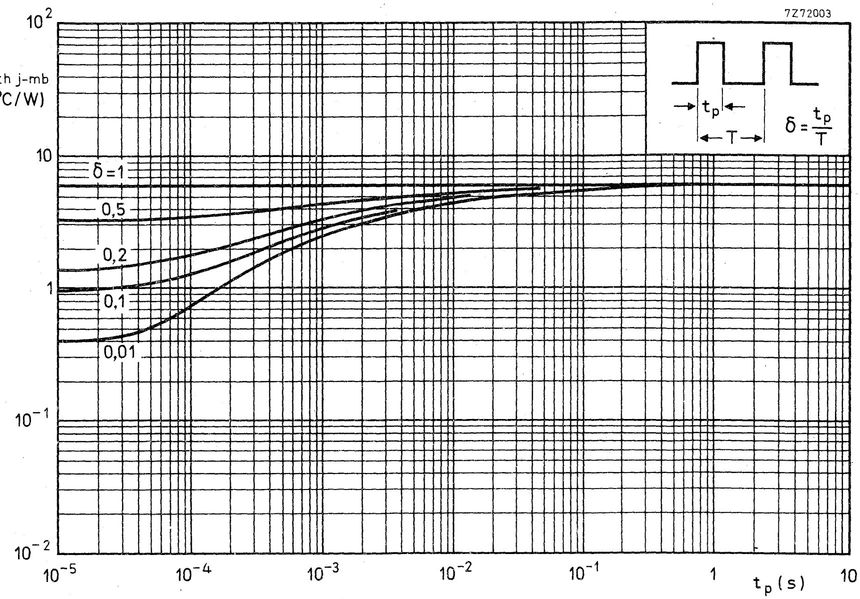


Fig. 5 Pulse power rating chart.

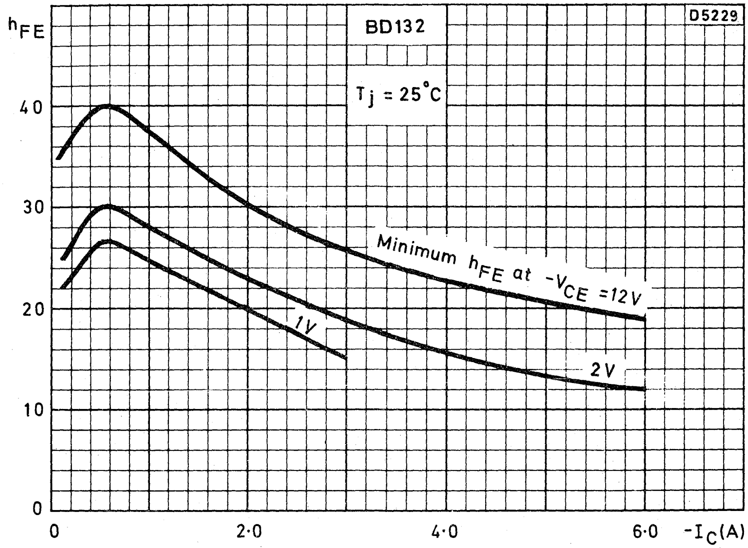


Fig. 6 D.C. current gain.

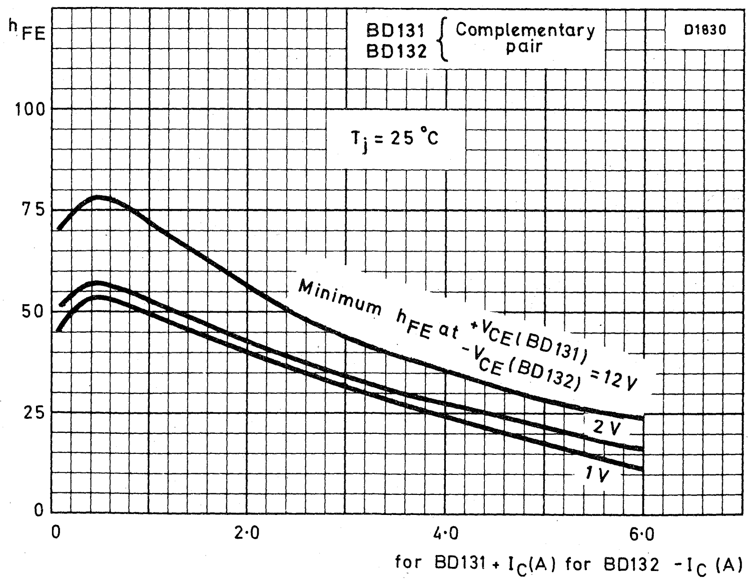


Fig. 7 D.C. current gain ratio.

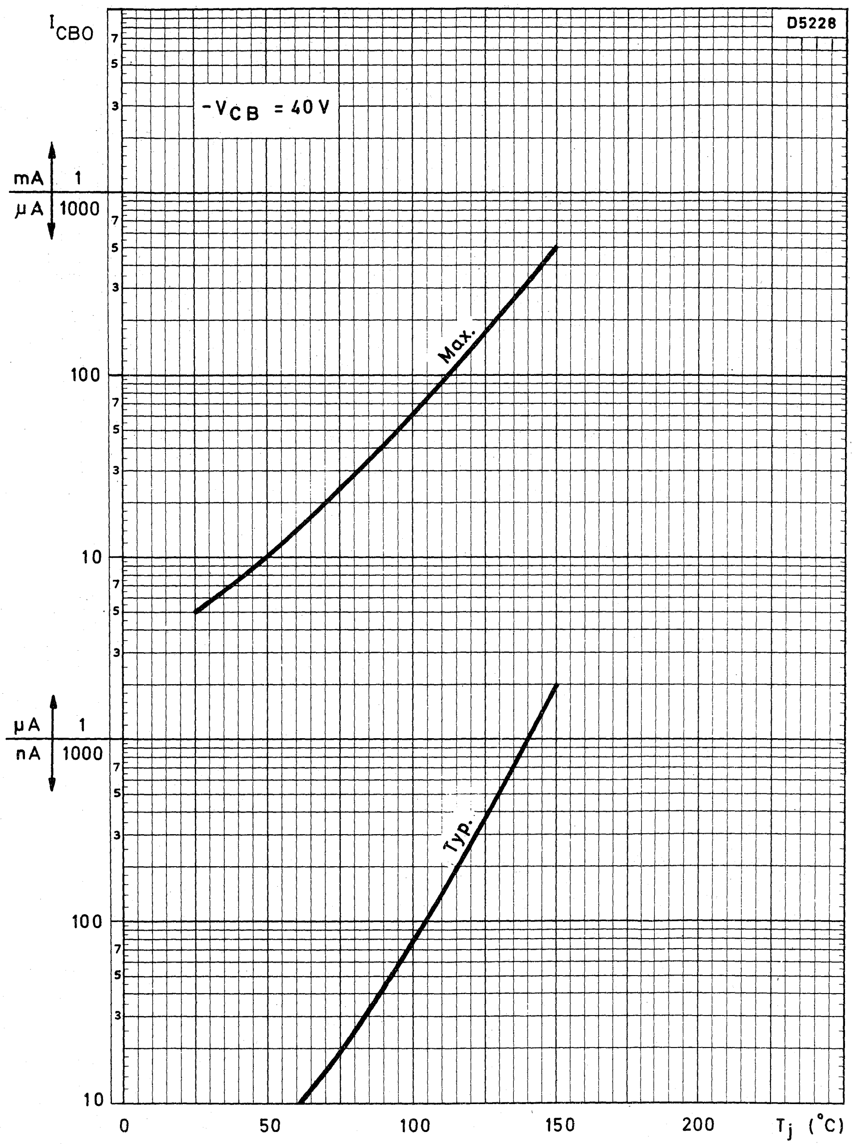


Fig. 8 Collector-base current (open emitter) as a function of the junction temperature.

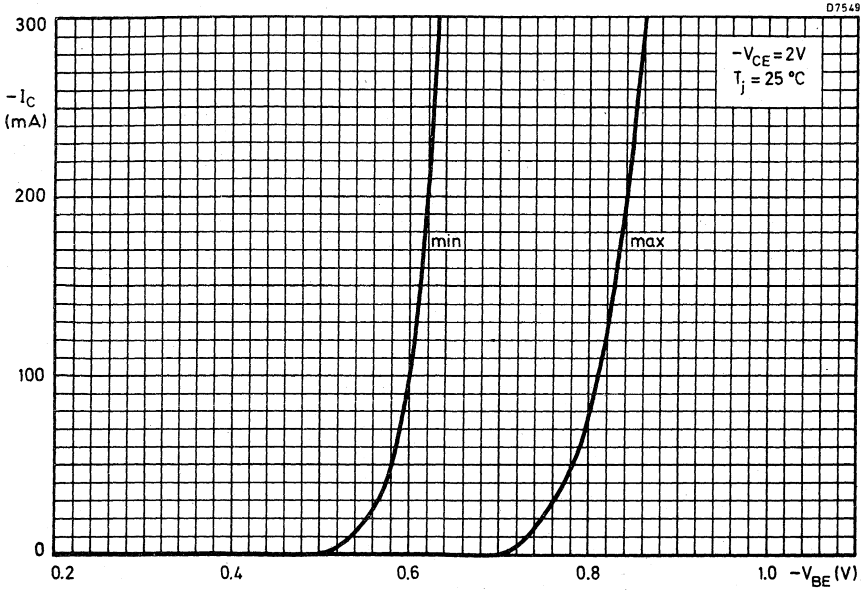

D7549
300
200
100
0
$-I_C$
(mA)
0.2
0.4
0.6
0.8
1.0
$-V_{BE}$ (V)
$-V_{CE} = 2V$
$T_j = 25\ °C$
min
max

Fig. 9.

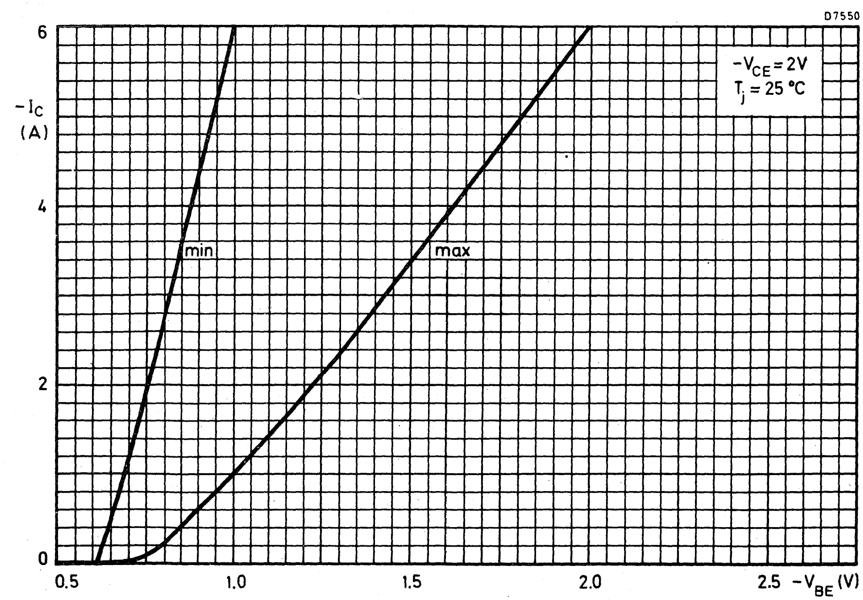

D7550
6
4
2
0
$-I_C$
(A)
0.5
1.0
1.5
2.0
2.5
$-V_{BE}$ (V)
$-V_{CE} = 2V$
$T_j = 25\ °C$
min
max

Fig. 10.

SILICON PLANAR EPITAXIAL POWER TRANSISTORS

General purpose n-p-n transistors in SOT-32 plastic envelope, recommended for driver stages in hi-fi amplifiers and television circuits.
The BD136, BD138 and BD140 are complementary to the BD135, BD137 and BD139 respectively.

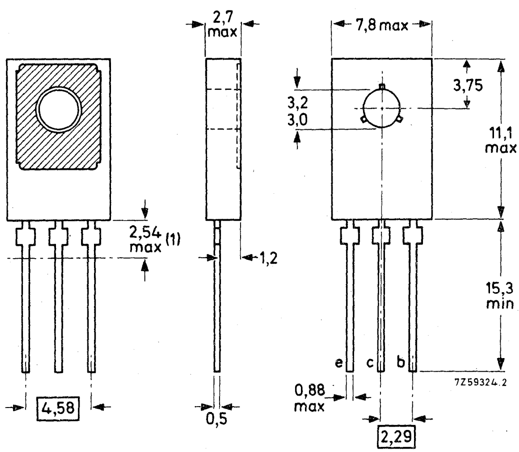
QUICK REFERENCE DATA

			BD135	BD137	BD139	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	V_{CER}	max.	45	60	100	V
Collector current (peak value)	I_{CM}	max.	1,5	1,5	1,5	A
Total power dissipation up to T_{mb} = 70 °C	P_{tot}	max.	8	8	8	W
Junction temperature	T_j	max.	150	150	150	°C
D.C. current gain						
I_C = 150 mA; V_{CE} = 2 V	h_{FE}	>	40	40	40	
		<	250	250	250	
Transition frequency						
I_C = 50 mA; V_{CE} = 5 V	f_T	typ.	250	250	250	MHz

MECHANICAL DATA Dimensions in mm

TO-126 (SOT-32)

Collector connected to metal part of mounting surface



For mounting instructions see section Accessories type 56326 for non-insulated mounting and set 56333 for insulated mounting.

[1]) Within this region the cross-section of the leads is uncontrolled.

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

Voltages			BD135	BD137	BD139	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	V_{CER}	max.	45	60	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V
Currents						
Collector current (d.c.)	I_C	max.	1,0	1,0	1,0	A
Collector current (peak value)	I_{CM}	max.	1,5	1,5	1,5	A

Power dissipation

Total power dissipation up to T_{mb} = 70 °C	P_{tot}	max.	8	W

Temperatures

Storage temperature	T_{stg}		−65 to +150	°C
Junction temperature	T_j	max.	150	°C

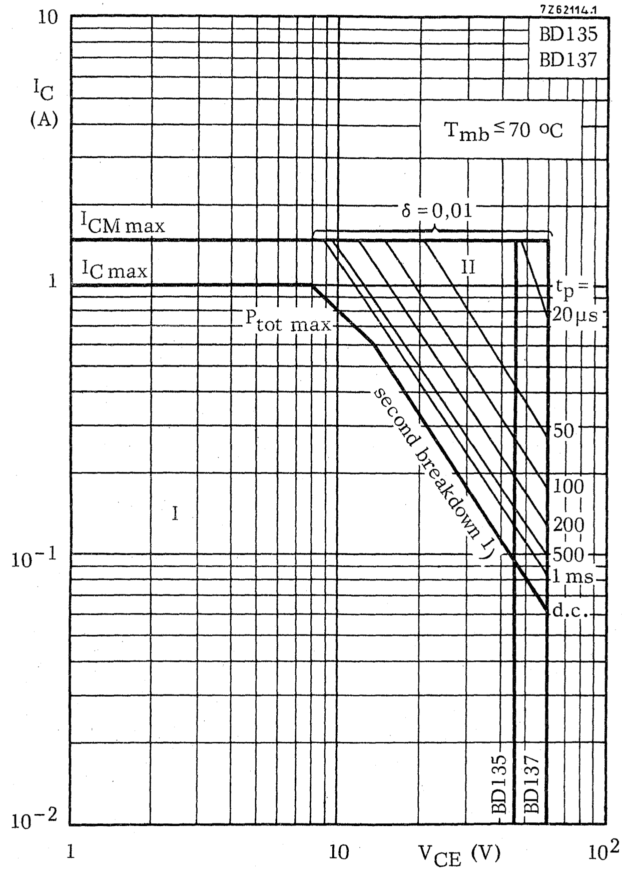
THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	100	°C/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	10	°C/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

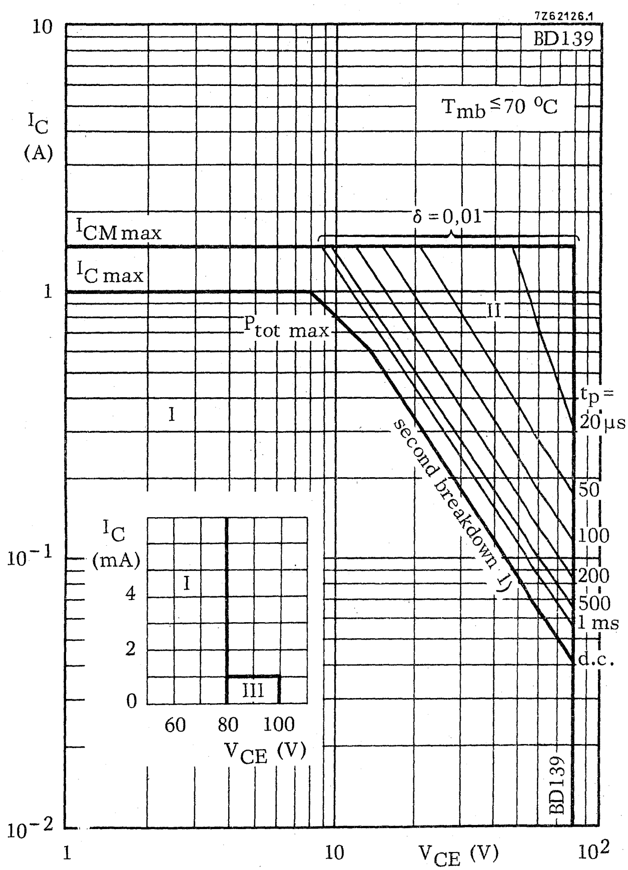
Collector cut-off current			
I_E = 0; V_{CB} = 30 V	I_{CBO}	<	100 nA
I_E = 0; V_{CB} = 30 V; T_j = 125 °C	I_{CBO}	<	10 μA
Emitter cut-off current			
I_C = 0; V_{EB} = 5 V	I_{EBO}	<	10 μA
Base-emitter voltage			
I_C = 500 mA; V_{CE} = 2 V	V_{BE}	<	1 V
Saturation voltage			
I_C = 500 mA; I_B = 50 mA	V_{CEsat}	<	0,5 V
D.C. current gain			
I_C = 5 mA; V_{CE} = 2 V	h_{FE}	>	25
I_C = 150 mA; V_{CE} = 2 V	h_{FE}		40 to 250
I_C = 500 mA; V_{CE} = 2 V	h_{FE}	>	25
Transition frequency at f = 35 MHz			
I_C = 50 mA; V_{CE} = 5 V	f_T	typ	250 MHz
D.C. current gain ratio of matched pairs			
BD135/BD136; BD137/BD138; BD139/BD140			
$\|I_C\|$ = 150 mA; $\|V_{CE}\|$ = 2 V	h_{FE1}/h_{FE2}	typ <	1,3 1,6



Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation

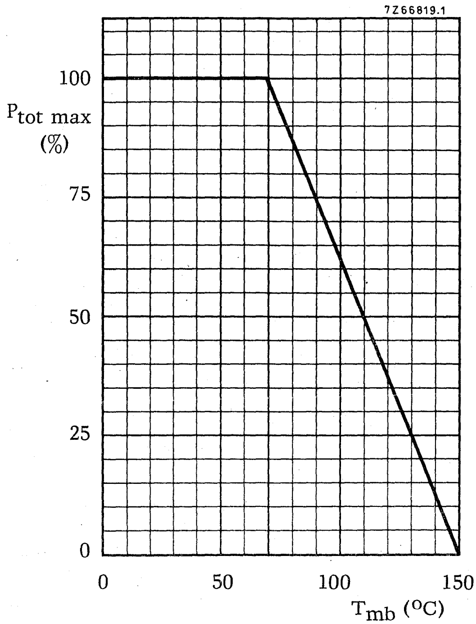
1) Independent of temperature

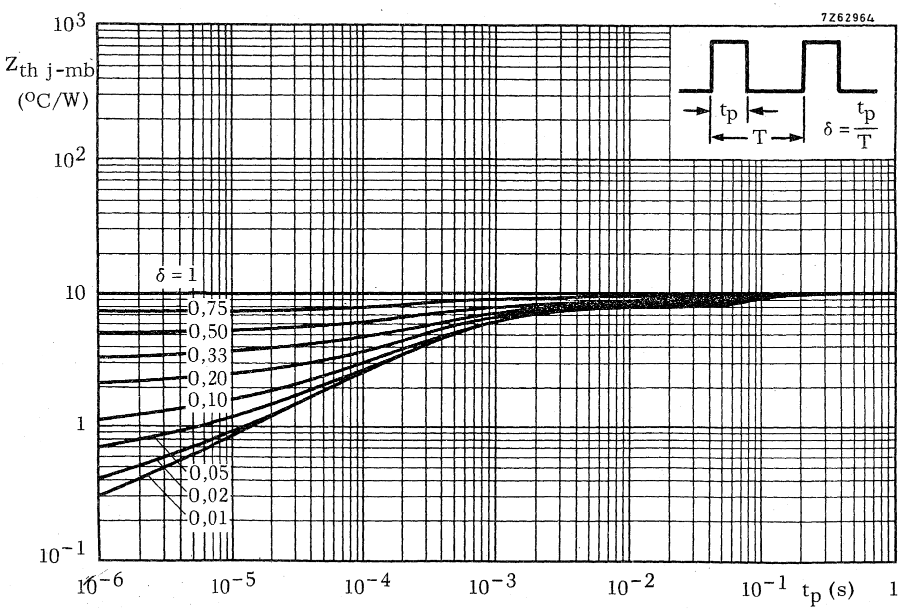


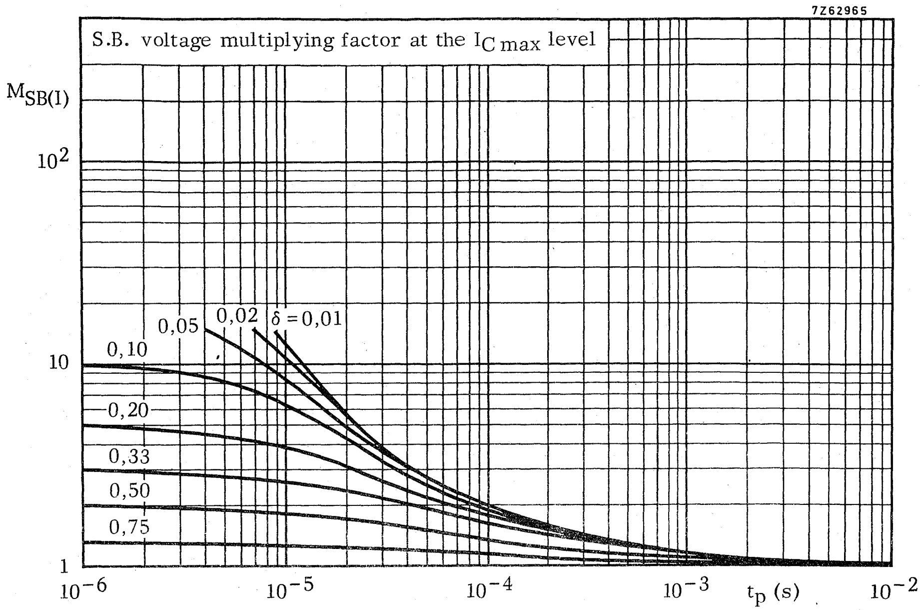
Safe Operating Area with the transistor forward biased

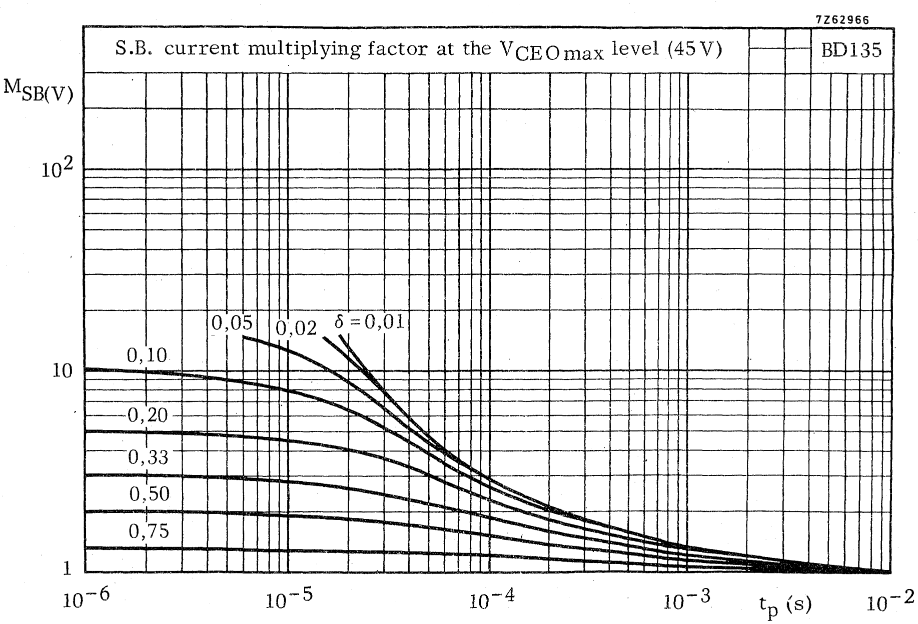
I Region of permissible d.c. operation
II Permissible extension for repetitive pulsed operation
III Repetitive pulse operation in this region is allowable, provided $R_{BE} \leq 1$ kΩ

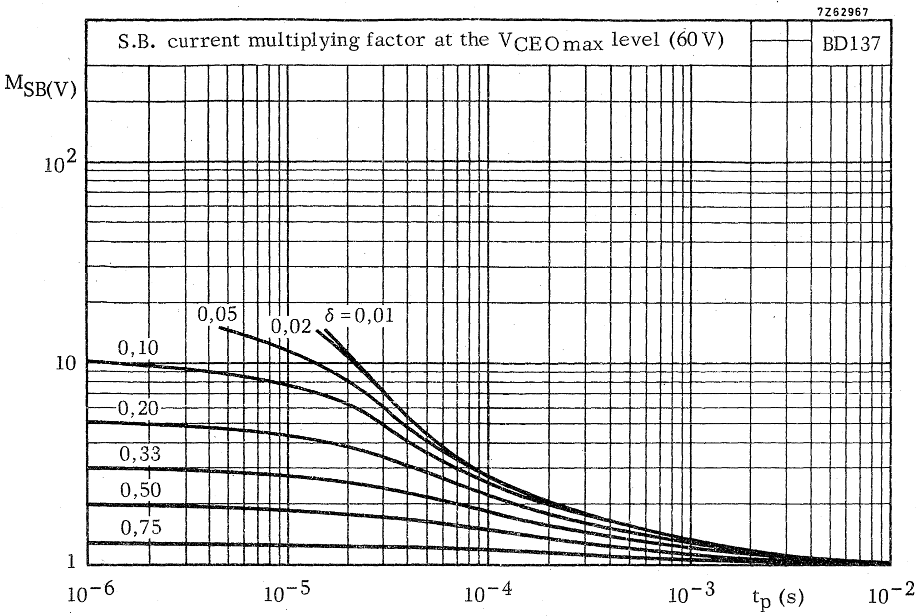
1) Independent of temperature

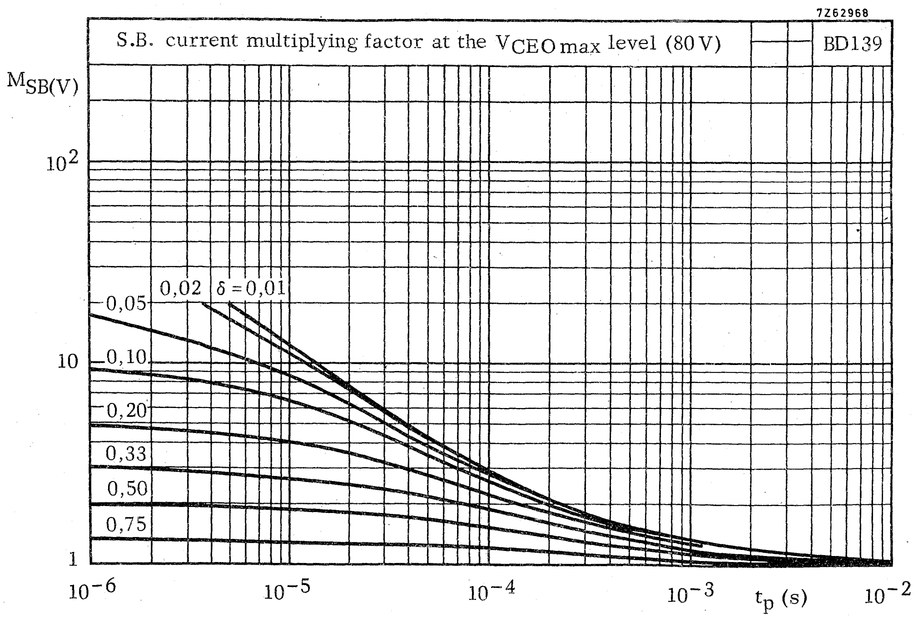

7Z66819.1
100
$P_{tot\ max}$
(%)
75
50
25
0
0
50
100
150
T_{mb} (°C)

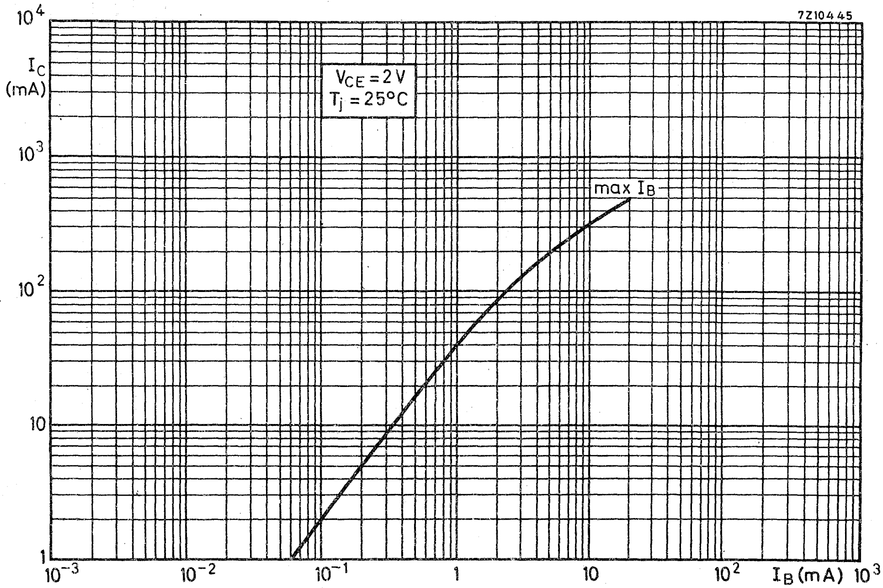

7Z62964
10^3
$Z_{th\ j\text{-}mb}$
(°C/W)
10^2
10
1
10^{-1}
t_p
T
$\delta = \frac{t_p}{T}$
$\delta = 1$
0,75
0,50
0,33
0,20
0,10
0,05
0,02
0,01
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
t_p (s)
1

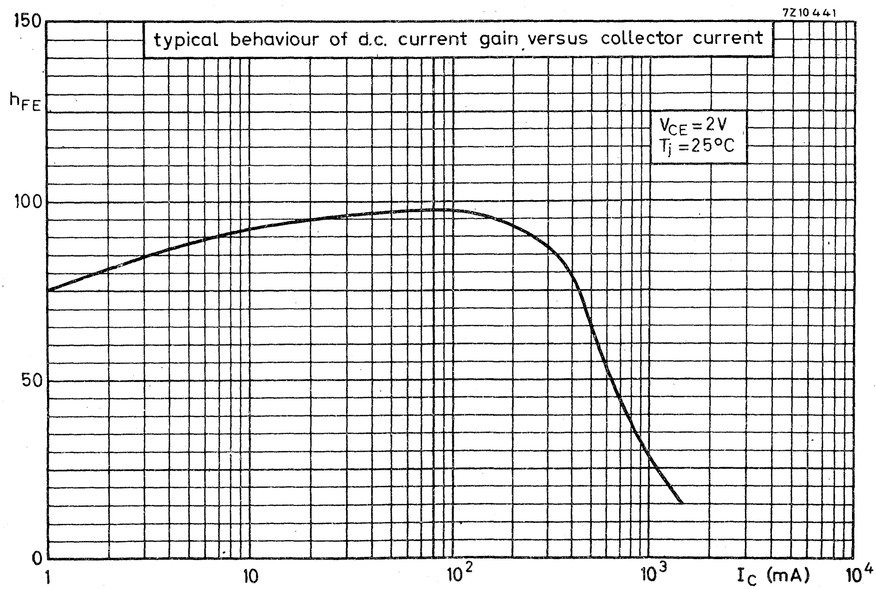

7Z62965
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

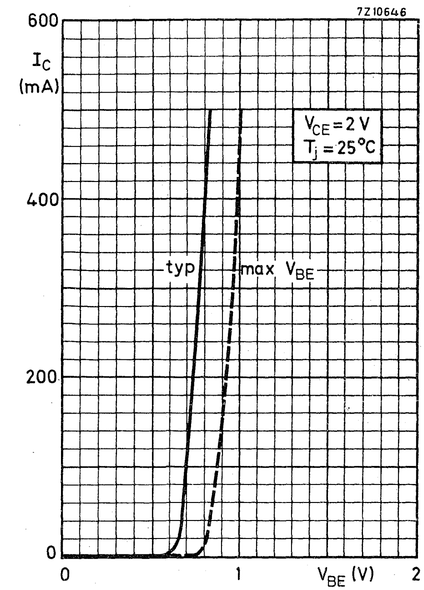

7Z62966
S.B. current multiplying factor at the $V_{CEO\,max}$ level (45 V)
BD135
$M_{SB(V)}$
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

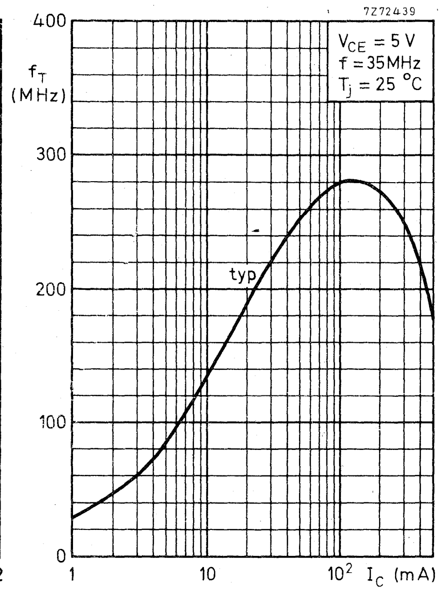

7Z62967
S.B. current multiplying factor at the VCEOmax level (60 V)
BD137
MSB(V)
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^-6
10^-5
10^-4
10^-3
tp (s)
10^-2

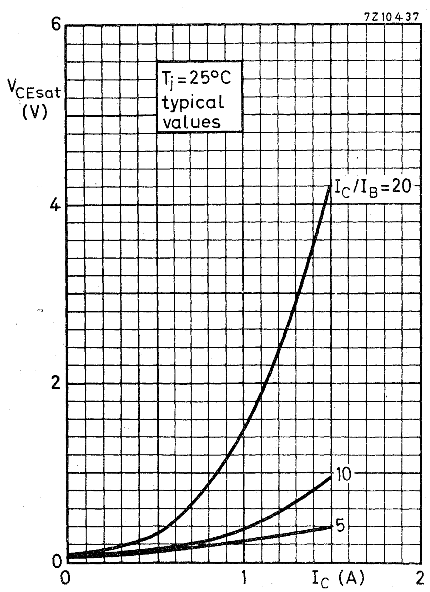

7Z62968
S.B. current multiplying factor at the VCEOmax level (80 V)
BD139
MSB(V)
10^2
10
1
0,02
δ = 0,01
0,05
0,10
0,20
0,33
0,50
0,75
10^-6
10^-5
10^-4
10^-3
tp (s)
10^-2

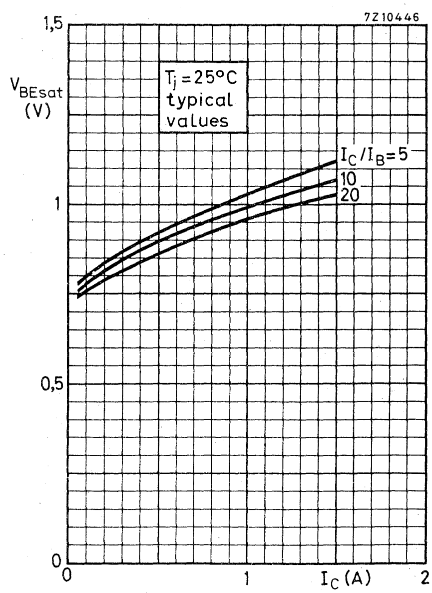

7Z10445
10^4
I_C (mA)
$V_{CE} = 2$ V
$T_j = 25$ °C
10^3
max I_B
10^2
10
1
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
I_B (mA)
10^3


7Z10441
typical behaviour of d.c. current gain versus collector current
150
h_{FE}
$V_{CE} = 2$ V
$T_j = 25$ °C
100
50
0
1
10
10^2
10^3
I_C (mA)
10^4


7Z10646
600
400
200
0
I_C
(mA)
V_{CE} = 2 V
T_j = 25 °C
typ
max V_{BE}
0
1
V_{BE} (V)
2


7Z72439
400
300
200
100
0
f_T
(MHz)
V_{CE} = 5 V
f = 35 MHz
T_j = 25 °C
typ
1
10
10^2
I_C (mA)


7Z10437
6
4
2
0
V_{CEsat}
(V)
T_j = 25 °C
typical
values
I_C/I_B = 20
10
5
0
1
I_C (A)
2


7Z10446
1,5
1
0,5
0
V_{BEsat}
(V)
T_j = 25 °C
typical
values
I_C/I_B = 5
10
20
0
1
I_C (A)
2

SILICON PLANAR EPITAXIAL POWER TRANSISTORS

General purpose p-n-p transistors in SOT-32 plastic envelope, recommended for driver stages in hi-fi amplifiers and television circuits.
The BD135, BD137 and BD139 are complementary to the BD136, BD138 and BD140 respectively.

QUICK REFERENCE DATA

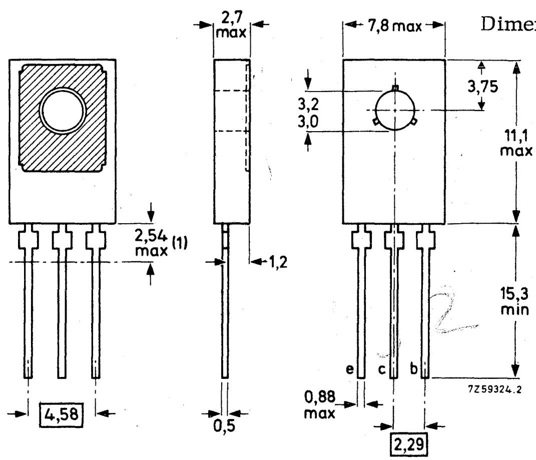
			BD136	BD138	BD140	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	$-V_{CER}$	max.	45	60	100	V
Collector current (peak value)	$-I_{CM}$	max.	1,5	1,5	1,5	A
Total power dissipation up to T_{mb} = 70 °C	P_{tot}	max.	8	8	8	W
Junction temperature	T_j	max.	150	150	150	°C
D.C. current gain $-I_C$ = 150 mA; $-V_{CE}$ = 2 V	h_{FE}	>	40	40	40	
		<	250	250	250	
Transition frequency $-I_C$ = 50 mA; $-V_{CE}$ = 5 V	f_T	typ.	75	75	75	MHz

MECHANICAL DATA

Dimensions in mm

TO-126 (SOT-32)

Collector connected to metal part of mounting surface



For mounting instructions see section Accessories type 56326 for non-insulated mounting and set 56333 for insulated mounting.

1) Within this region the cross-section of the leads is uncontrolled.

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

Voltages

			BD136	BD138	BD140	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	$-V_{CER}$	max.	45	60	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V
Currents						
Collector current (d.c.)	$-I_C$	max.	1,0	1,0	1,0	A
Collector current (peak value)	$-I_{CM}$	max.	1,5	1,5	1,5	A

Power dissipation

Total power dissipation up to T_{mb} = 70 °C	P_{tot}	max.	8	W

Temperatures

Storage temperature	T_{stg}		−65 to +150	°C
Junction temperature	T_j	max.	150	°C

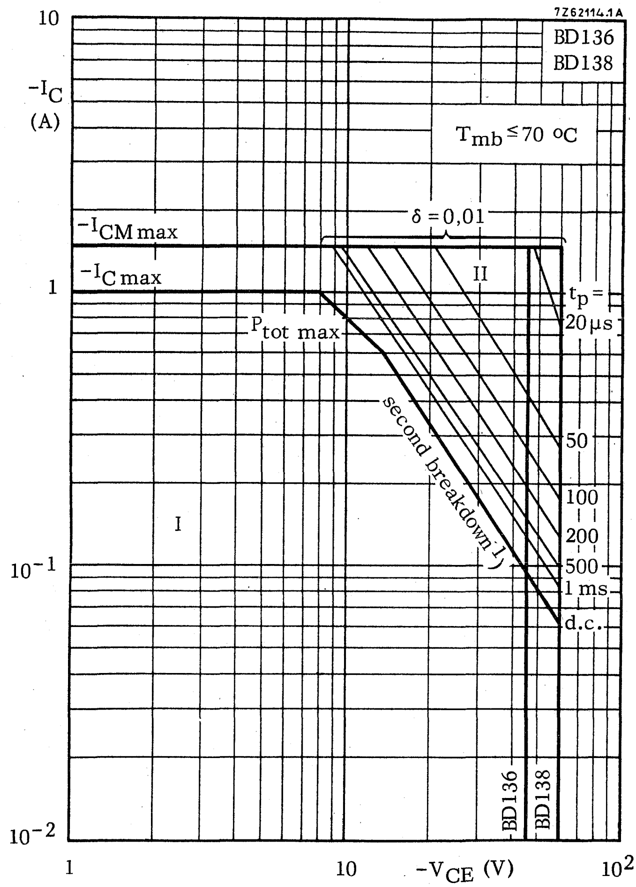
THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	100	°C/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	10	°C/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

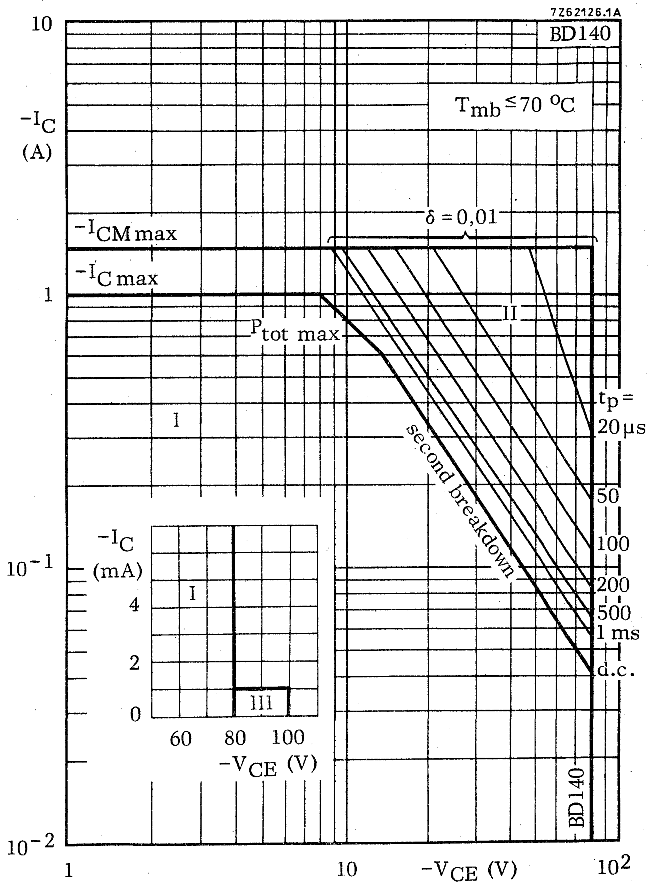
Collector cut-off current			
$I_E = 0; -V_{CB} = 30$ V	$-I_{CBO}$	<	100 nA
$I_E = 0; -V_{CB} = 30$ V; $T_j = 125$ °C	$-I_{CBO}$	<	10 μA
Emitter cut-off current			
$I_C = 0; -V_{EB} = 5$ V	$-I_{EBO}$	<	10 μA
Base-emitter voltage			
$-I_C = 500$ mA; $-V_{CE} = 2$ V	$-V_{EB}$	<	1 V
Saturation voltage			
$-I_C = 500$ mA; $-I_B = 50$ mA	$-V_{CEsat}$	<	0,5 V
D.C. current gain			
$-I_C = 5$ mA; $-V_{CE} = 2$ V	h_{FE}	>	25
$-I_C = 150$ mA; $-V_{CE} = 2$ V	h_{FE}		40 to 250
$-I_C = 500$ mA; $-V_{CE} = 2$ V	h_{FE}	>	25
Transition frequency at f = 35 MHz			
$-I_C = 50$ mA; $-V_{CE} = 5$ V	f_T	typ	75 MHz
D.C. current gain ratio of matched pairs			
BD135/BD136; BD137/BD138; BD139/BD140			
$\lvert I_C \rvert = 150$ mA; $\lvert V_{CE} \rvert = 2$ V	h_{FE1}/h_{FE2}	typ	1,3
		<	1,6



Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation

1) Independent of temperature



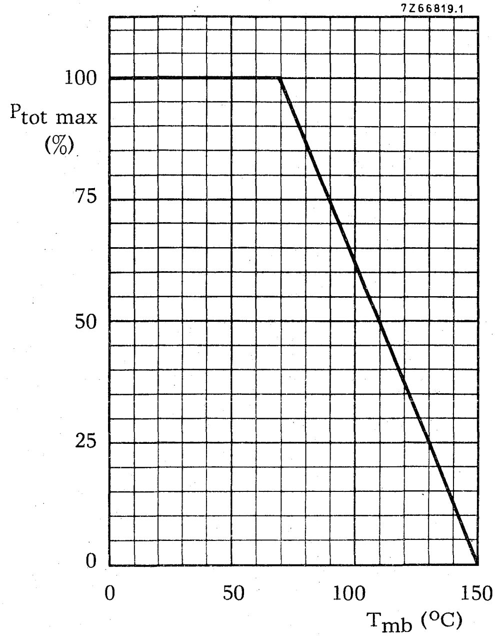
Safe Operating Area with the transistor forward biased

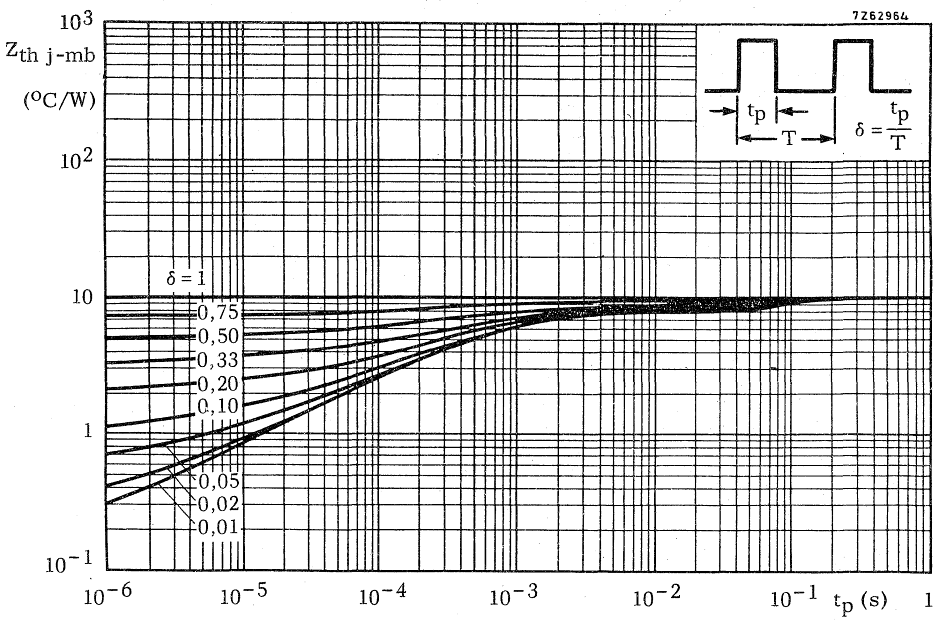
I Region of permissible d.c. operation

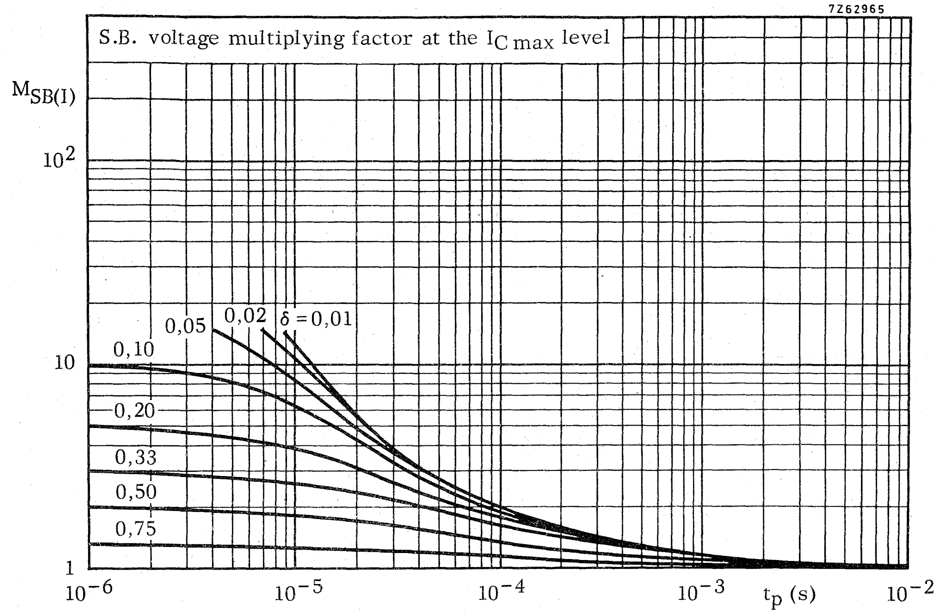
II Permissible extension for repetitive pulse operation

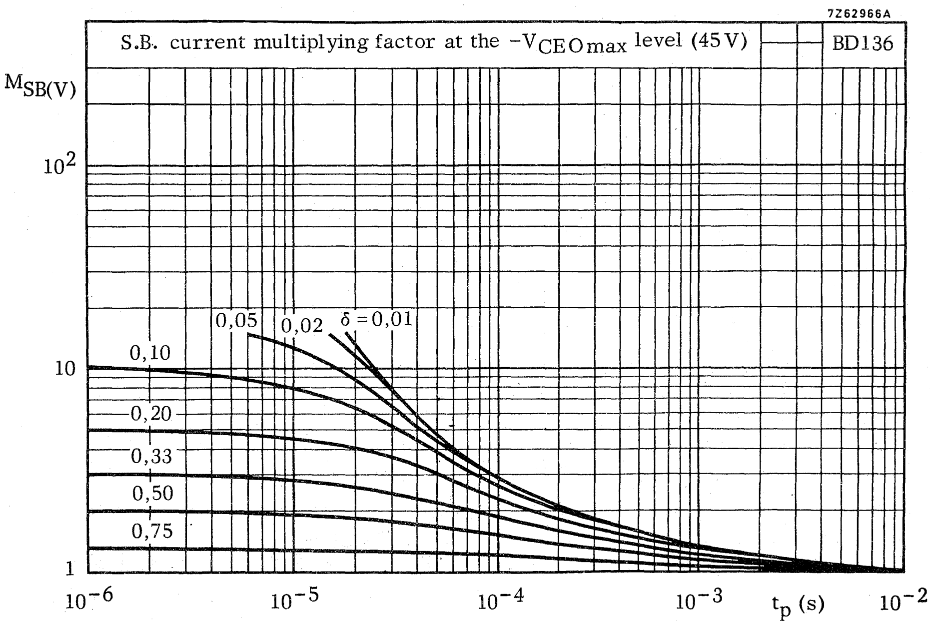
III Repetitive pulse operation in this region is allowable, provided $R_{BE} \leq 1\ k\Omega$.

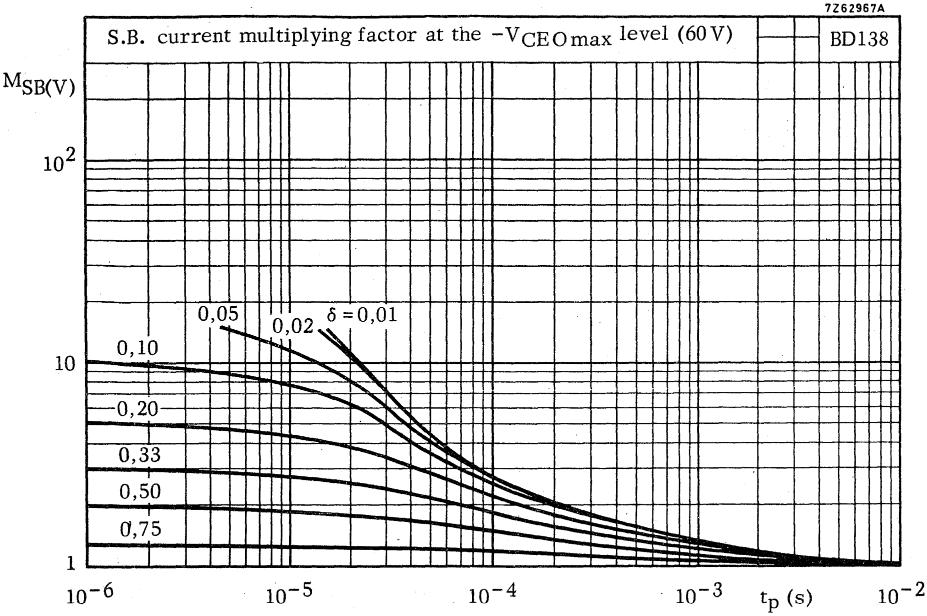
[1]) Independent of temperature

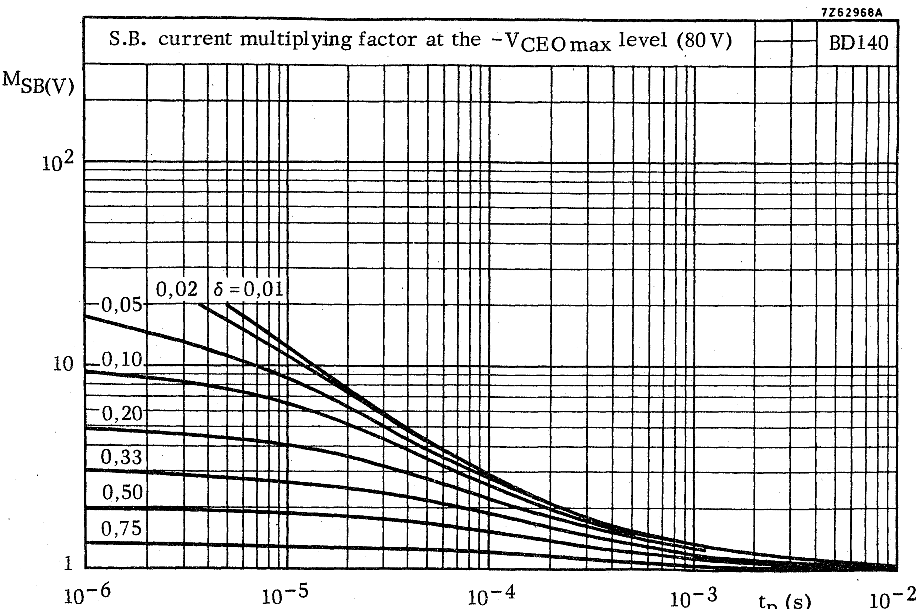

7Z66819.1
100
$P_{tot\ max}$ (%)
75
50
25
0
0
50
100
150
T_{mb} (°C)

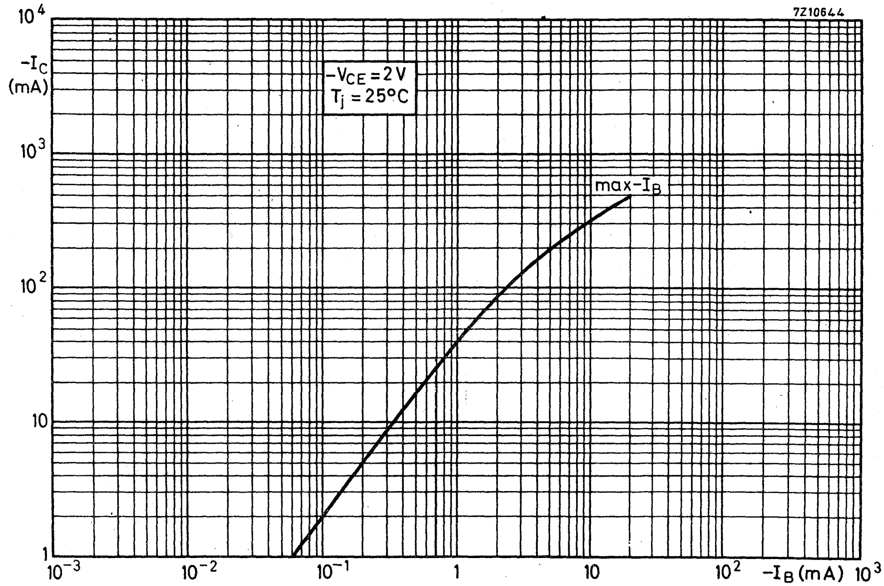

7Z62964
10^3
$Z_{th\ j\text{-}mb}$ (°C/W)
10^2
10
1
10^{-1}
δ = 1
0,75
0,50
0,33
0,20
0,10
0,05
0,02
0,01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
t_p (s)
1

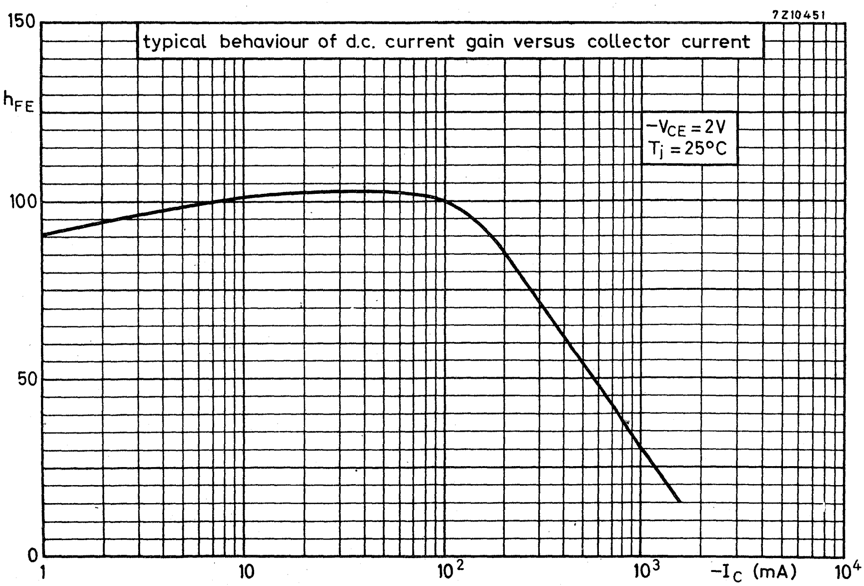

7Z62965
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

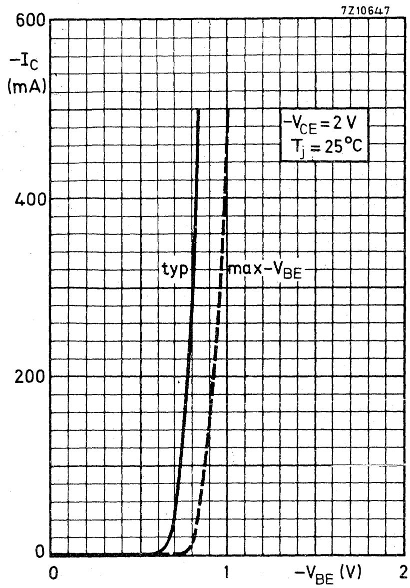

7Z62966A
S.B. current multiplying factor at the $-V_{CEO\,max}$ level (45 V)
BD136
$M_{SB(V)}$
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

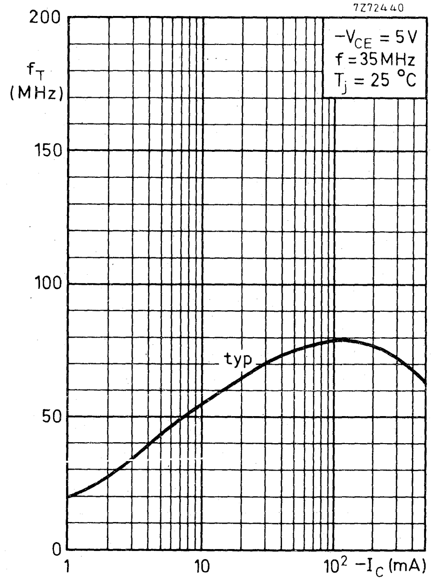

7Z62967A
S.B. current multiplying factor at the $-V_{CEO\,max}$ level (60 V)
BD138
$M_{SB(V)}$
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

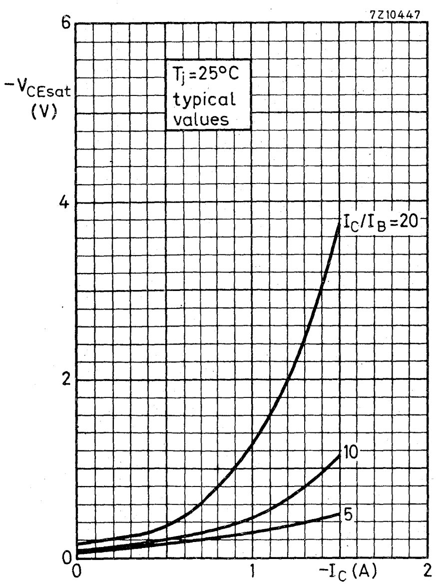

7Z62968A
S.B. current multiplying factor at the $-V_{CEO\,max}$ level (80 V)
BD140
$M_{SB(V)}$
10^2
10
1
0,02
δ = 0,01
0,05
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

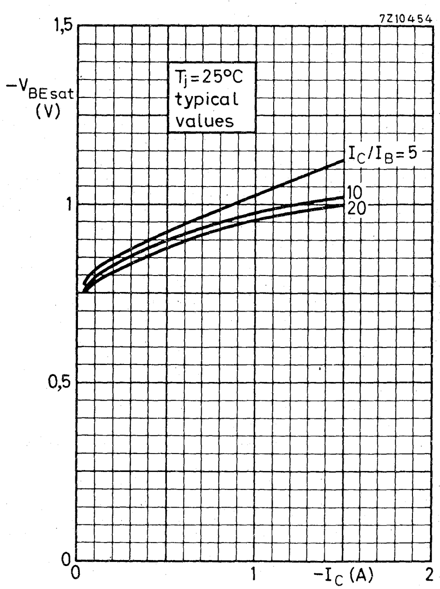

7Z10644
10^4
$-I_C$ (mA)
$-V_{CE} = 2$ V
$T_j = 25$°C
10^3
max-I_B
10^2
10
1
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
$-I_B$ (mA)
10^3


7Z10451
150
typical behaviour of d.c. current gain versus collector current
h_{FE}
$-V_{CE} = 2$V
$T_j = 25$°C
100
50
0
1
10
10^2
10^3
$-I_C$ (mA)
10^4


7Z10647
600
$-I_C$
(mA)
400
200
0
$-V_{CE} = 2$ V
$T_j = 25$°C
typ
max
$-V_{BE}$
0
1
$-V_{BE}$ (V)
2


7Z72440
200
f_T
(MHz)
150
100
50
0
$-V_{CE} = 5$ V
f = 35 MHz
$T_j = 25$ °C
typ
1
10
10^2 $-I_C$ (mA)


7Z10447
6
$-V_{CEsat}$
(V)
4
2
0
$T_j = 25$°C
typical
values
$I_C/I_B = 20$
10
5
0
1
$-I_C$ (A)
2


7Z10454
1,5
$-V_{BEsat}$
(V)
1
0,5
0
$T_j = 25$°C
typical
values
$I_C/I_B = 5$
10
20
0
1
$-I_C$ (A)
2

SILICON EPITAXIAL-BASE POWER TRANSITSTORS

N-P-N transistors in a plastic envelope. With their p-n-p complements BD202 and BD204 they are primarily intended for use in hi-fi equipment delivering an output of 15 to 25 W into a 4 Ω or 8 Ω load.

QUICK REFERENCE DATA

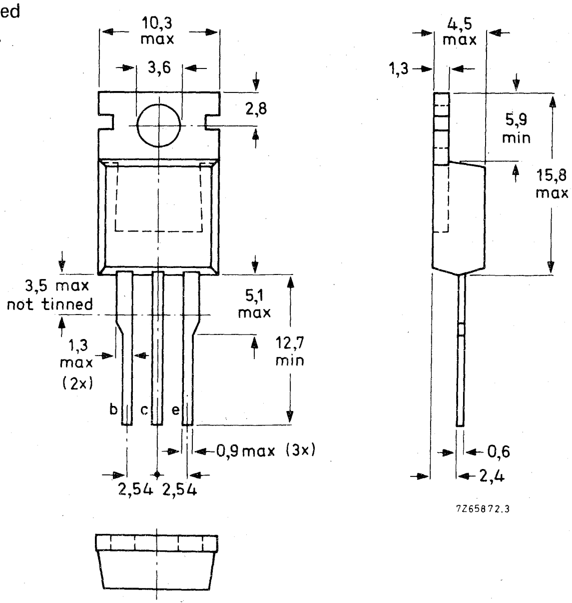
			BD201	BD203	
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	V
Collector current (d.c.)	I_C	max.	8	8	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	60	60	W
Cut-off frequency I_C = 0,3 A; V_{CE} = 3 V	f_{hfe}	>	25	25	kHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220.

Collector connected to mounting base.



See also chapters Mounting Instructions and Accessories.

RATINGS

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

			BD201	BD203	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	60	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	V
Collector current (d.c.)	I_C	max.	8		A
Collector current (peak value, $t_p \leqslant 10$ ms)	I_{CM}	max.	12		A
Collector current (non-repetitive peak value, $t_p \leqslant 2$ ms)	I_{CSM}	max.	25		A
→ Base current (d.c.)	I_B	max.	3		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	60		W
Storage temperature	T_{stg}		−65 to + 150		°C
Junction temperature	T_j	max.	150		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2,08	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	70	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_B = 0$; $V_{CE} = 30$ V	I_{CEO}	<	1	mA
$I_E = 0$; $V_{CB} = 40$ V; $T_j = 150$ °C	I_{CBO}	<	1	mA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	5	mA
Base-emitter voltage*				
$I_C = 3$ A; $V_{CE} = 2$ V	V_{BE}	<	1,5	V
Knee voltage*				
$I_C = 3$ A; I_B = value for which $I_C = 3{,}3$ A at $V_{CE} = 2$ V	V_{CEK}	typ.	1	V
Saturation voltage*				
$I_C = 3$ A; $I_B = 0{,}3$ A	V_{CEsat}	<	1	V
→ $I_C = 6$ A; $I_B = 0{,}6$ A	V_{CEsat}	<	1,5	V
→	V_{BEsat}	<	2	V
D.C. current gain*				
BD201; $I_C = 3$ A; $V_{CE} = 2$ V	h_{FE}	>	30	
BD203; $I_C = 2$ A; $V_{CE} = 2$ V	h_{FE}	>	30	
$I_C = 1$ A; $V_{CE} = 2$ V	h_{FE}	>	30	
Cut-off frequency				
$I_C = 0{,}3$ A; $V_{CE} = 3$ V	f_{hfe}	>	25	kHz

* Measured under pulse conditions: $t_p < 300$ μs, $\delta < 2\%$.

Transition frequency at f = 1 MHz I_C = 0,3 A; V_{CE} = 3 V	f_T	>	3 MHz	
D.C. current gain ratio of matched complementary pairs I_C = 1 A; V_{CE} = 2 V	h_{FE1}/h_{FE2}	<	2,5	←
Forward bias second breakdown collector current V_{CE} = 40 V; t_p = 0,1 s; T_{amb} = 25 °C	$I_{(SB)}$	>	1,5 A	←
Switching times I_{Con} = 2 A; I_{Bon} = $-I_{Boff}$ = 0,2 A Turn-on time	t_{on}	<	1 μs	←
Turn-off time	t_{off}	<	4 μs	

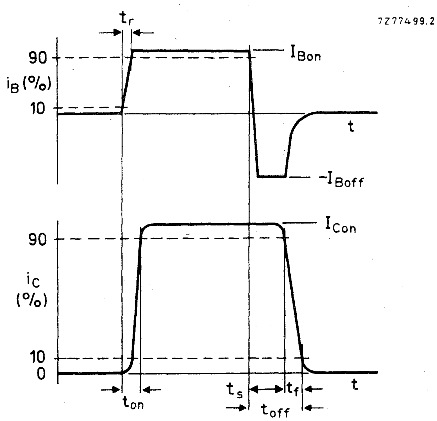


Fig. 2 Switching time waveforms.

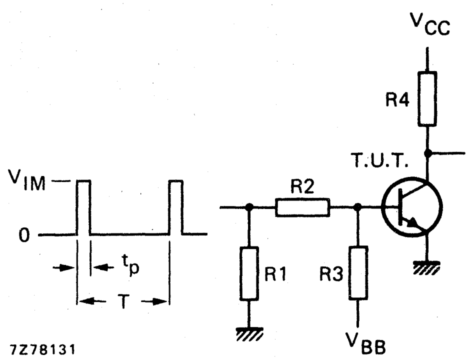


Fig. 3 Switching times test circuit.

V_{IM} = 15 V		R3 = 22 Ω	
V_{CC} = 20 V		R4 = 10 Ω	
V_{BB} = −4 V		$t_r = t_f$ ⩽ 15 ns	
R1 = −		t_p = 20 μs	
R2 = 33 Ω		T = 500 μs	

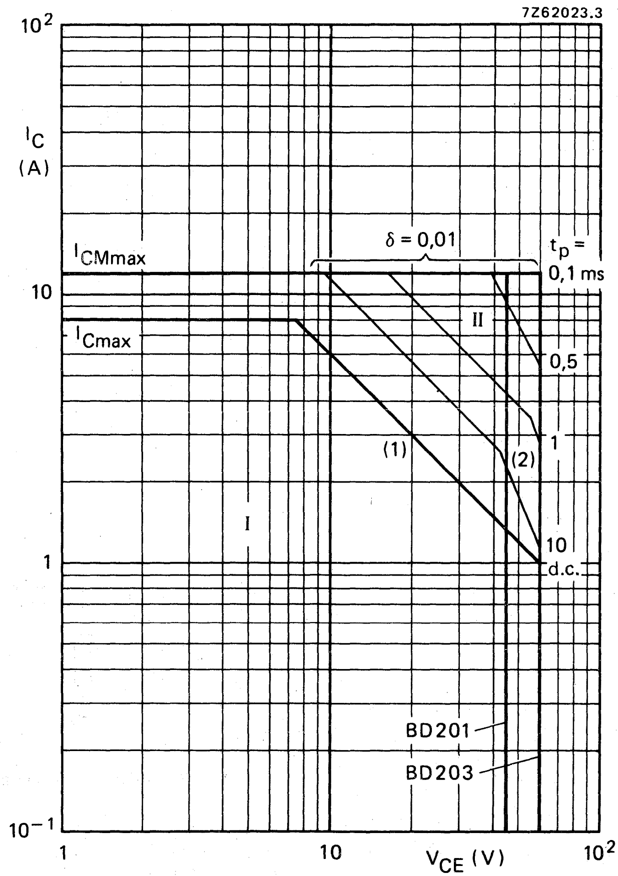


Fig. 4 Safe Operating ARea, $T_{mb} \leqslant 25$ °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.

(2) Second-breakdown limits (independent of temperature).

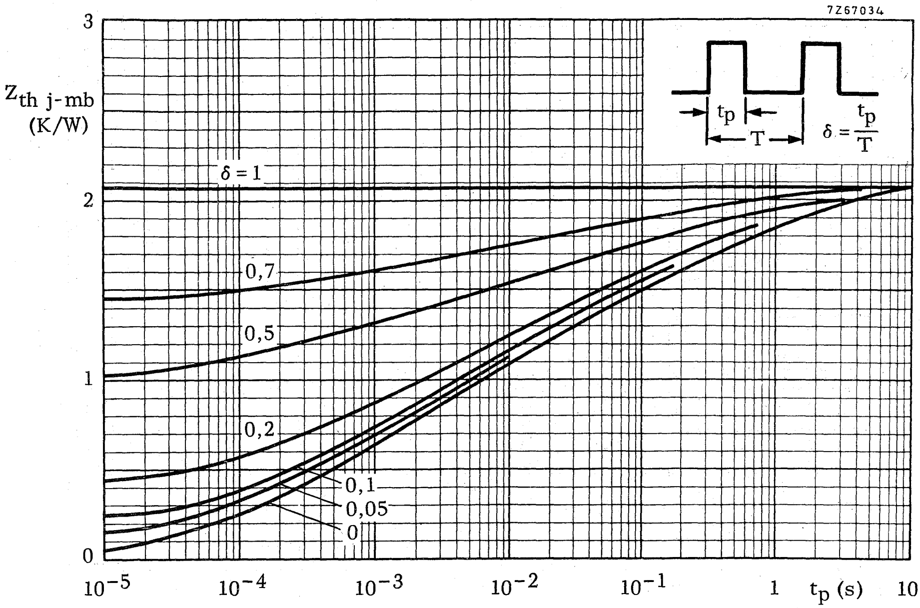


Fig. 5 Pulse power rating chart.

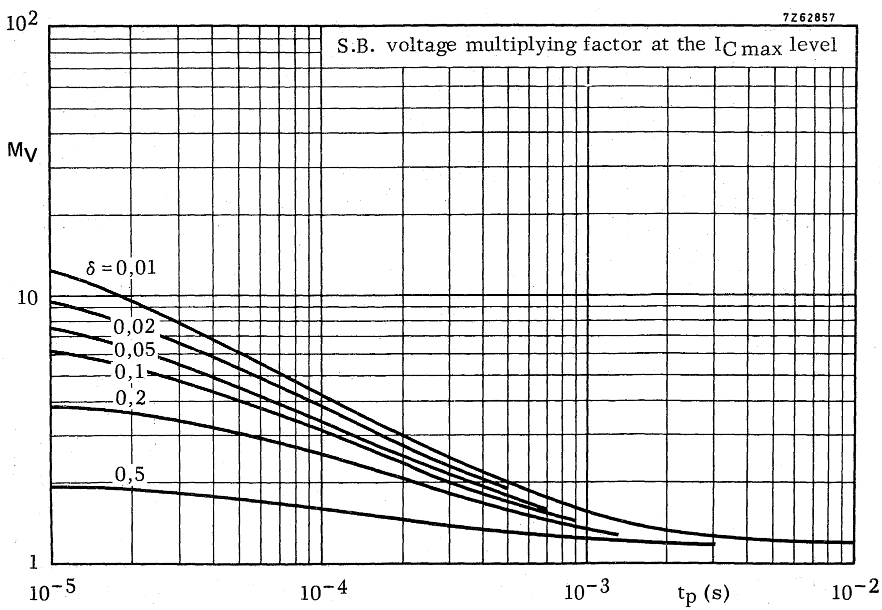


Fig. 6 S.B. voltage multiplying factor at the I_{Cmax} level.

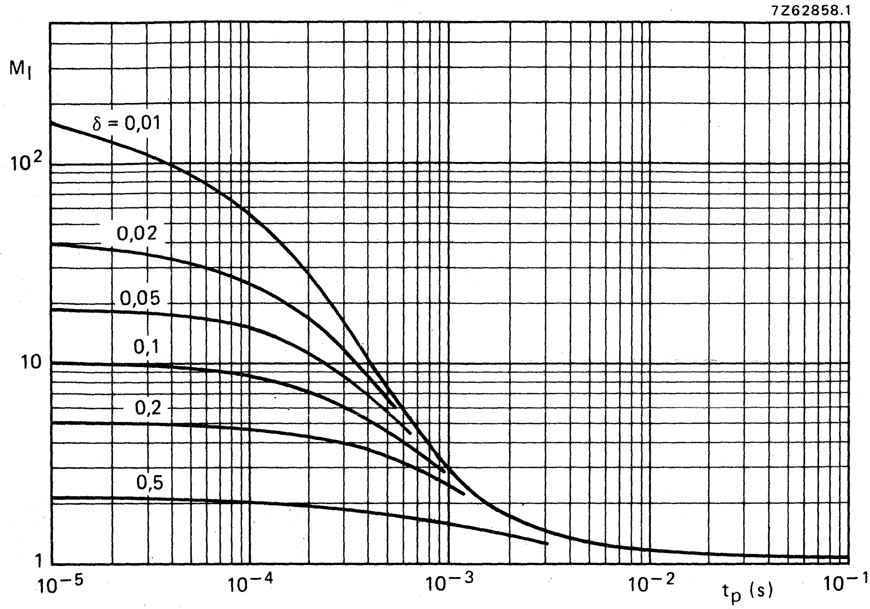


Fig. 7 S.B. current multiplying factor at the $V_{CEO\,max}$ level.

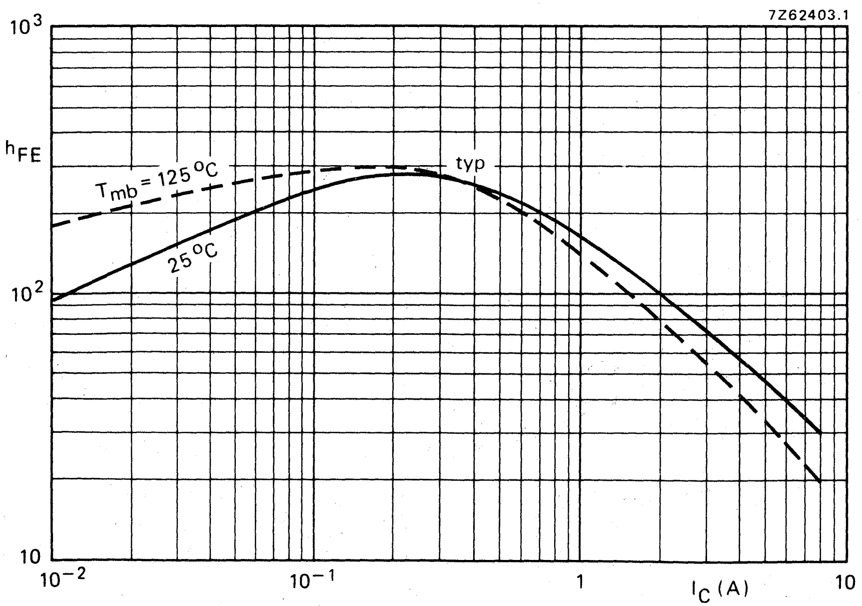


Fig. 8 D.C. current gain. V_{CE} = 2 V.

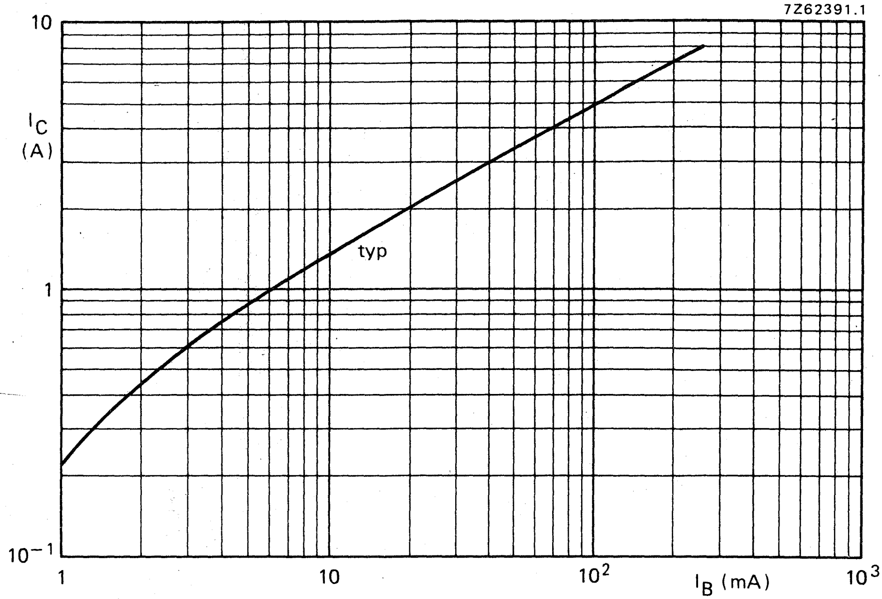


Fig. 9 Collector current as a function of base current. $V_{CE} = 2$ V; $T_j = 25$ °C.

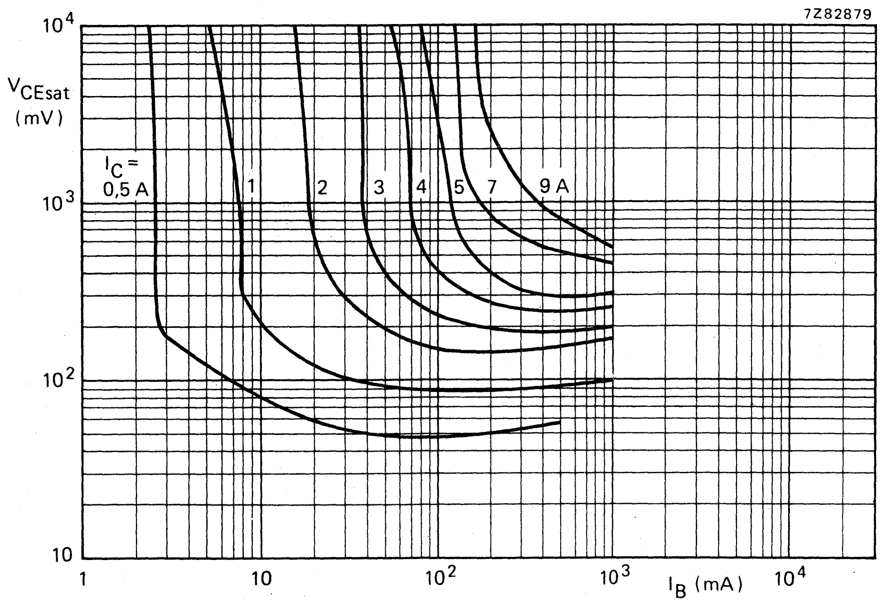


Fig. 10 Typical collector-emitter saturation voltage. $T_j = 25$ °C.

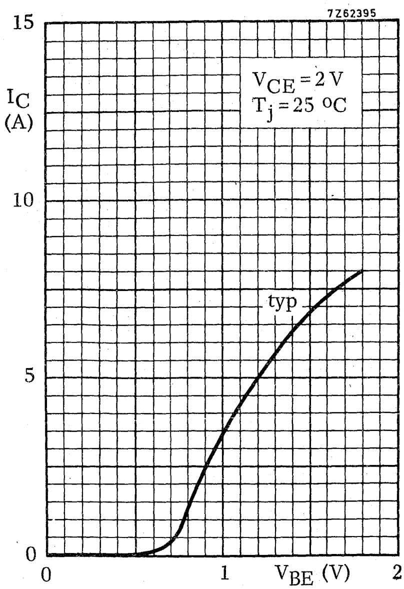


Fig. 11.

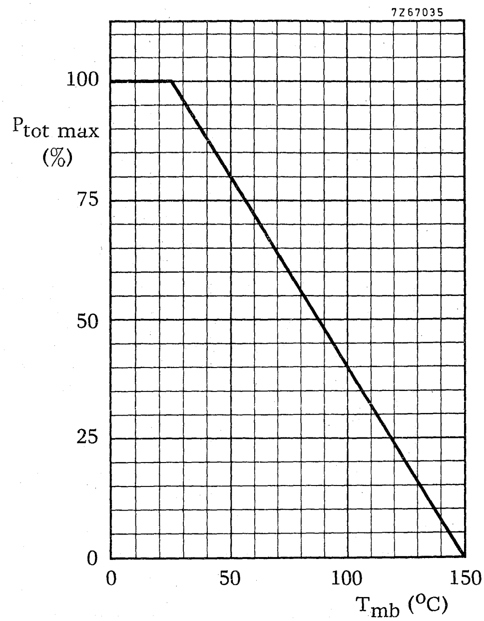


Fig. 12.

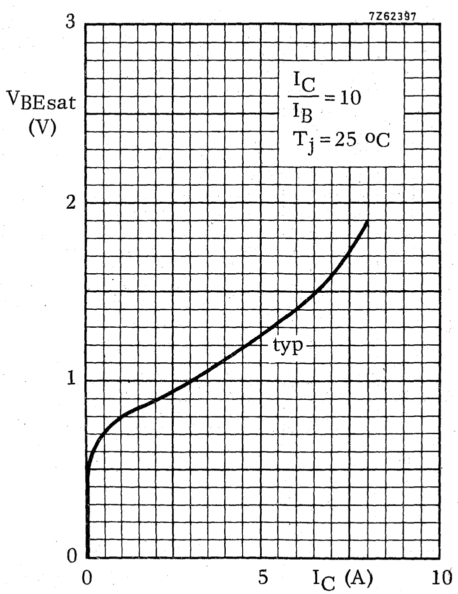


Fig. 13.

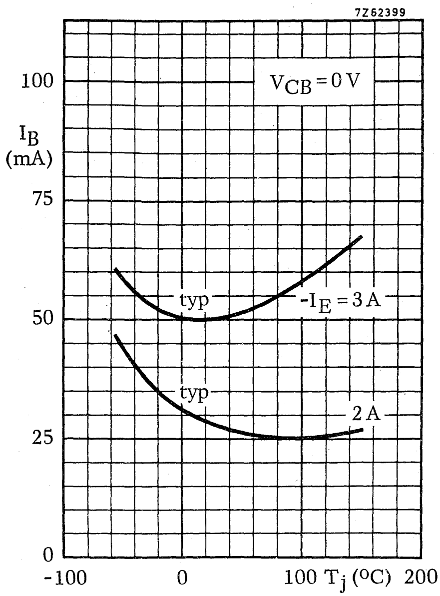


Fig. 14.

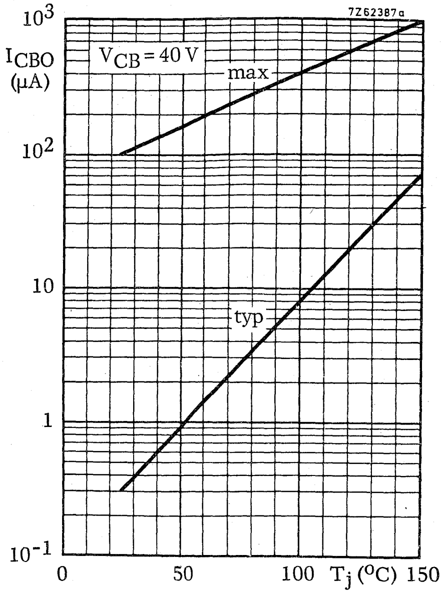


Fig. 15.

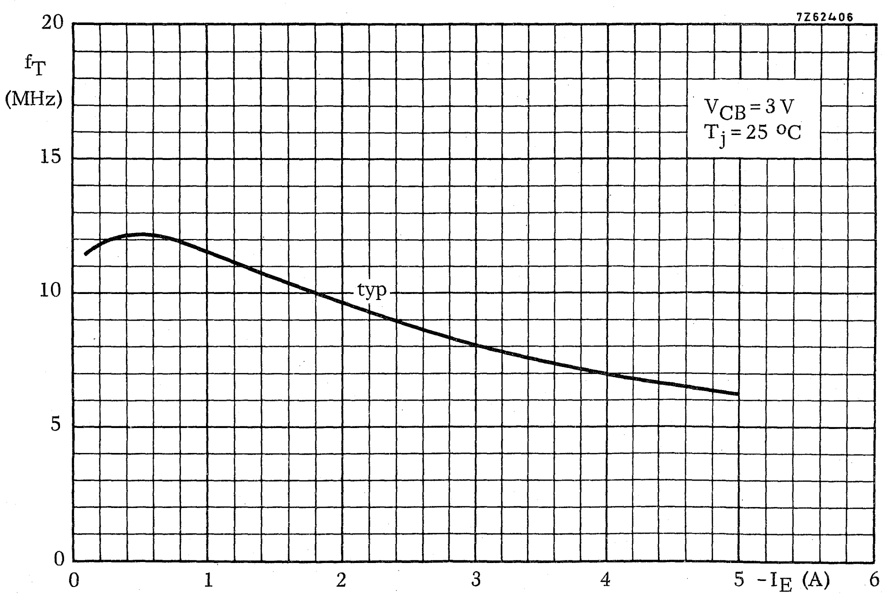


Fig. 16.

SILICON EPITAXIAL-BASE POWER TRANSISTORS

P-N-P transistors in a plastic envelope. With their n-p-n complements BD201 and BD203 they are primarily intended for use in hi-fi equipment delivering an output of 15 to 25 W into a 4 Ω or 8 Ω load.

QUICK REFERENCE DATA

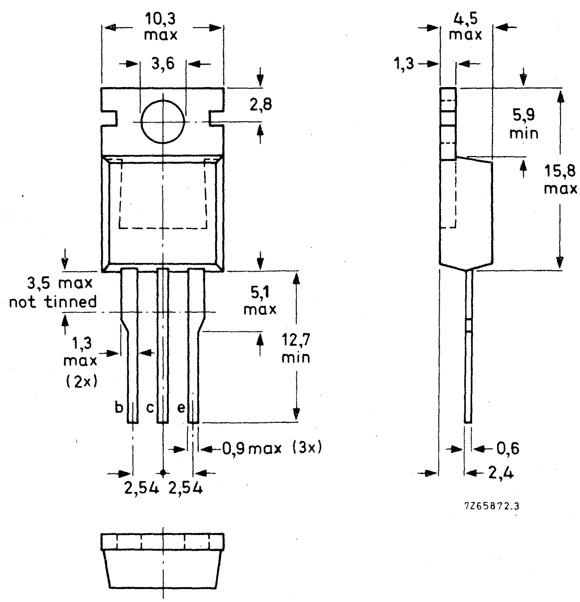
			BD202	BD204	
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	V
Collector current (d.c.)	$-I_C$	max.	8	8	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	60	60	W
Cut-off frequency $-I_C$ = 0,3 A; $-V_{CE}$ = 3 V	f_{hfe}	>	25	25	kHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220.

Collector connected to mounting base.



See also chapters Mounting Instructions and Accessories.

RATINGS

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

			BD202	BD204	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	60	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	V
Collector current (d.c.)	$-I_C$	max.	8		A
Collector current (peak value, $t_p \leqslant 10$ ms)	$-I_{CM}$	max.	12		A
Collector current (non-repetitive peak value, $t_p \leqslant 2$ ms)	$-I_{CSM}$	max.	25		A
Base current (d.c.)	$-I_B$	max.	3		A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot}	max.	60		W
Storage temperature	T_{stg}		−65 to + 150		°C
Junction temperature	T_j	max.	150		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2,08	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	70	K/W

CHARACTERISTICS

$T_j = 25$ °C unless otherwise specified

Collector cut-off current				
$I_B = 0$; $-V_{CE} = 30$ V	$-I_{CEO}$	<	1	mA
$I_E = 0$; $-V_{CB} = 40$ V; $T_j = 150$ °C	$-I_{CBO}$	<	1	mA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	5	mA
Collector-emitter breakdown voltage				
$I_C = 0,2$ A; $I_B = 0$ BD202	$-V_{(BR)CEO}$	>	45	V
$I_C = 0,2$ A; $I_B = 0$ BD204	$-V_{(BR)CEO}$	>	60	V
Base-emitter voltage *				
$-I_C = 3$ A; $-V_{CE} = 2$ V	$-V_{BE}$	<	1,5	V
Knee voltage *				
$-I_C = 3$ A; $-I_B$ = value at which $-I_C = 3,3$ A at $-V_{CE} = 2$ V	$-V_{CEK}$	typ.	1	V
Saturation voltages*				
$-I_C = 3$ A; $-I_B = 0,3$ A	$-V_{CEsat}$	<	1	V
$-I_C = 6$ A; $-I_B = 0,6$ A	$-V_{CEsat}$	<	1,5	V
	$-V_{BEsat}$	<	2	V
D.C. current gain*				
$-I_C = 3$ A; $-V_{CE} = 2$ V BD202	h_{FE}	>	30	
$-I_C = 2$ A; $-V_{CE} = 2$ V BD204	h_{FE}	>	30	
$-I_C = 1$ A; $-V_{CE} = 2$ V	h_{FE}	>	30	

* Measured under pulse conditions: $t_p < 300$ µs, $\delta < 2\%$.

Cut-off frequency			
$-I_C = 0{,}3$ A; $-V_{CE} = 3$ V	f_{hfe}	>	25 kHz
Transition frequency at f = 1 MHz			
$-I_C = 0{,}3$ A; $-V_{CE} = 3$ V	f_T	>	3 MHz
D.C. current gain ratio of matched complementary pairs			
$-I_C = 1$ A; $-V_{CE} = 2$ V	h_{FE1}/h_{FE2}	<	2,5 ←
Forward bias second breakdown collector current			
$V_{CE} = 40$ V; $t_p = 0{,}1$ s	I_{SB}	>	1,5 A
Switching times			
$-I_{Con} = 2$ A; $-I_{Bon} = I_{Boff} = 0{,}2$ A			
turn-on time	t_{on}	<	1 μs
turn-off time	t_{off}	<	2 μs

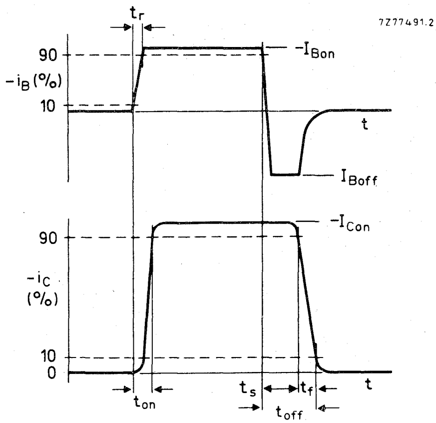


Fig. 2 Switching times waveforms.

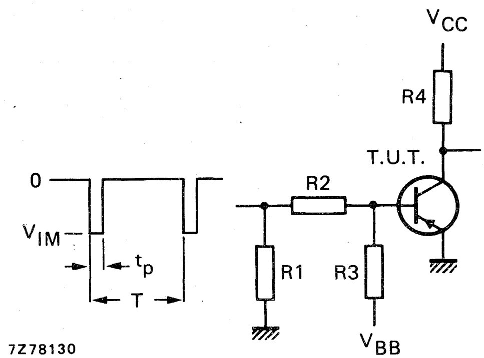


Fig. 3 Switching times test circuit.

$-V_{IM}$	= 15 V	R3	= 22 Ω
$-V_{CC}$	= 20 V	R4	= 10 Ω
$+V_{BB}$	= 4 V	$t_r = t_f$	= 15 ns
R1	= 56 Ω	t_p	= 10 μs
R2	= 33 Ω	T	= 500 μs

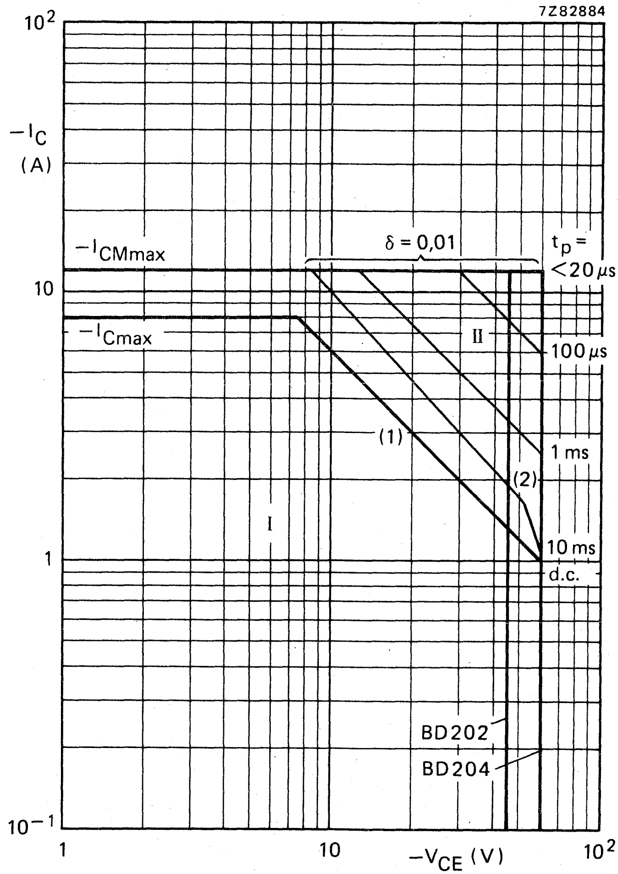


Fig. 4 Safe Operating ARea; T_{mb} = 25 °C.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.
(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.
(2) Second-breakdown limits (independent of temperature).

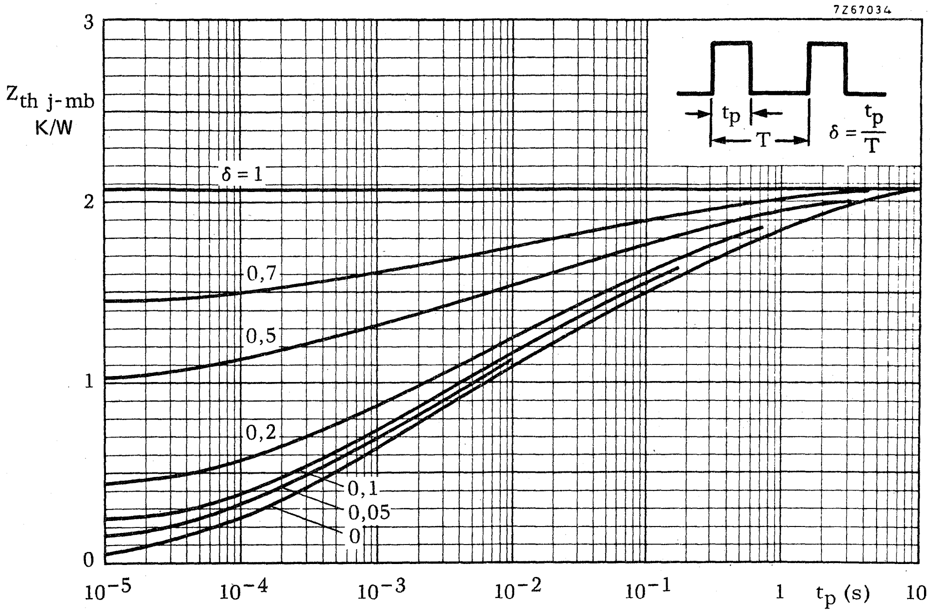


Fig. 5 Pulse power rating chart.

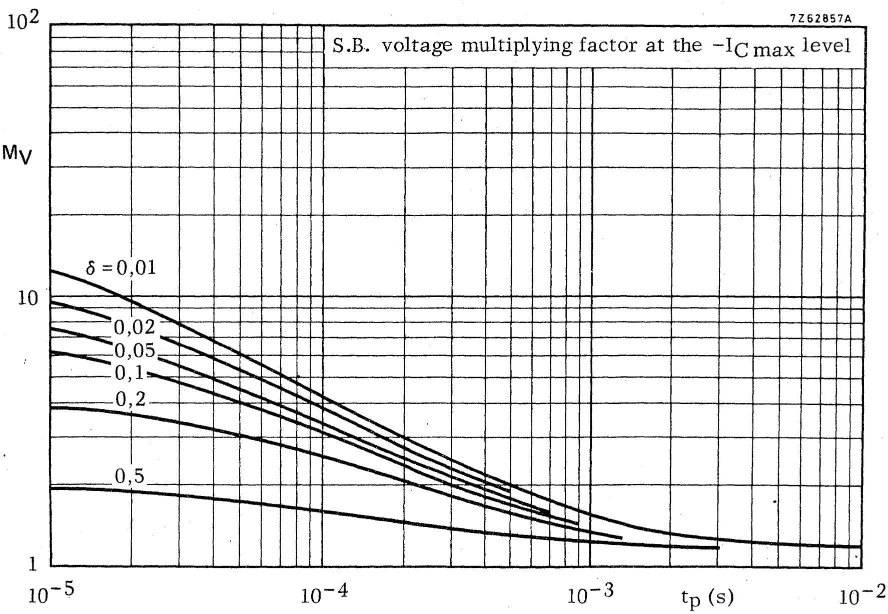


Fig. 6 S.B. voltage multiplying factor at the $-I_{Cmax}$ level.

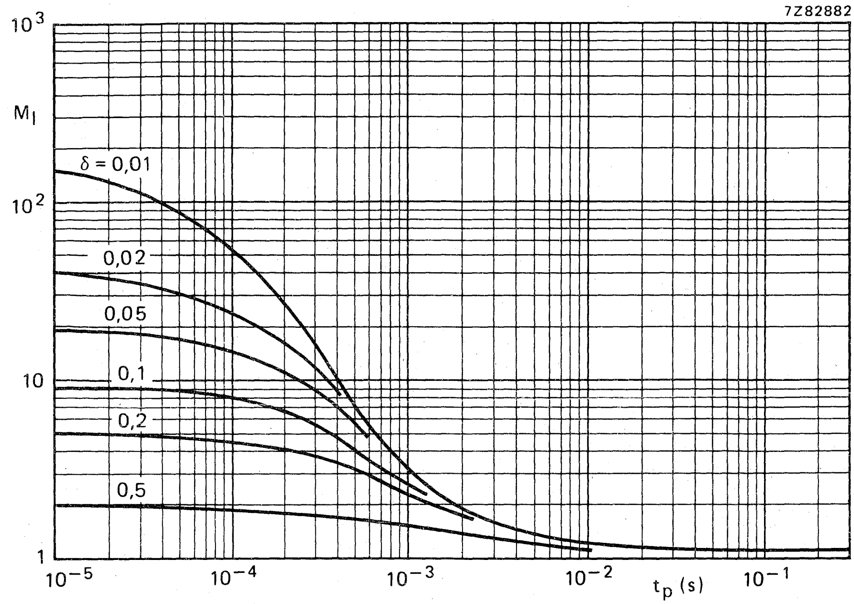


Fig. 7 S.B. current multiplying factor at the $-V_{CEOmax}$ level.

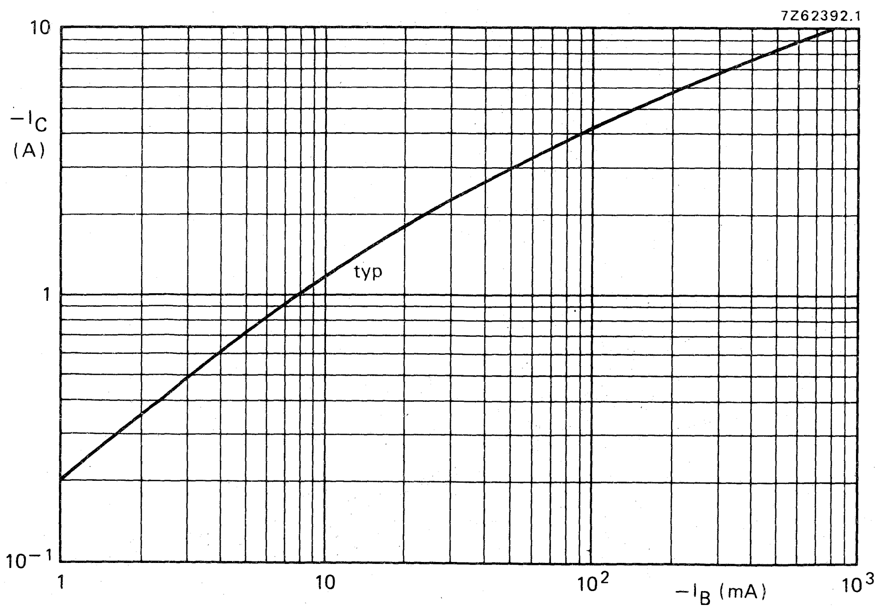


Fig. 8 Typical collector current as a function of base current. $-V_{CE}$ = 2 V; T_j = 25 °C.

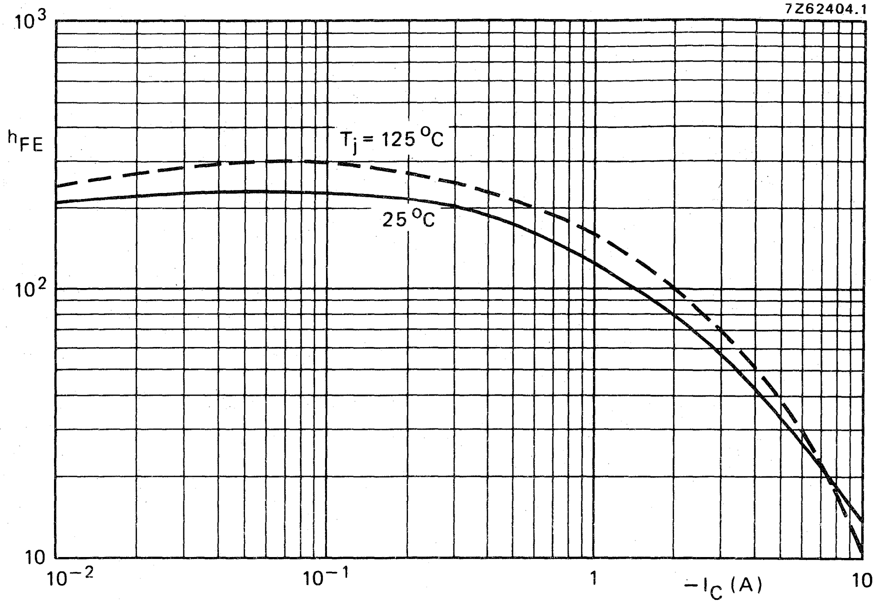


Fig. 9 Typical forward current transfer ratio at $-V_{CE}$ = 2 V.

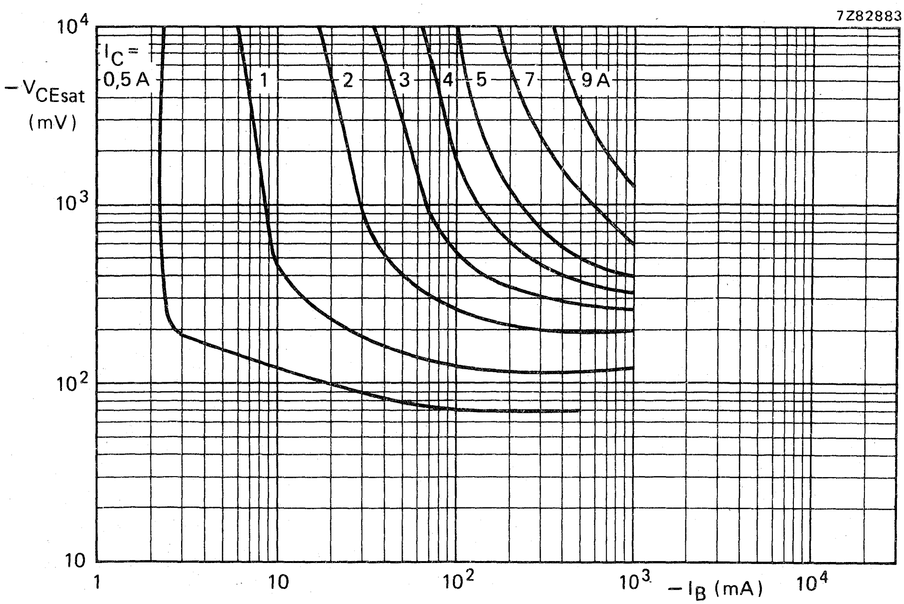


Fig. 10 Typical collector-emitter saturation voltage. T_j = 25 °C.

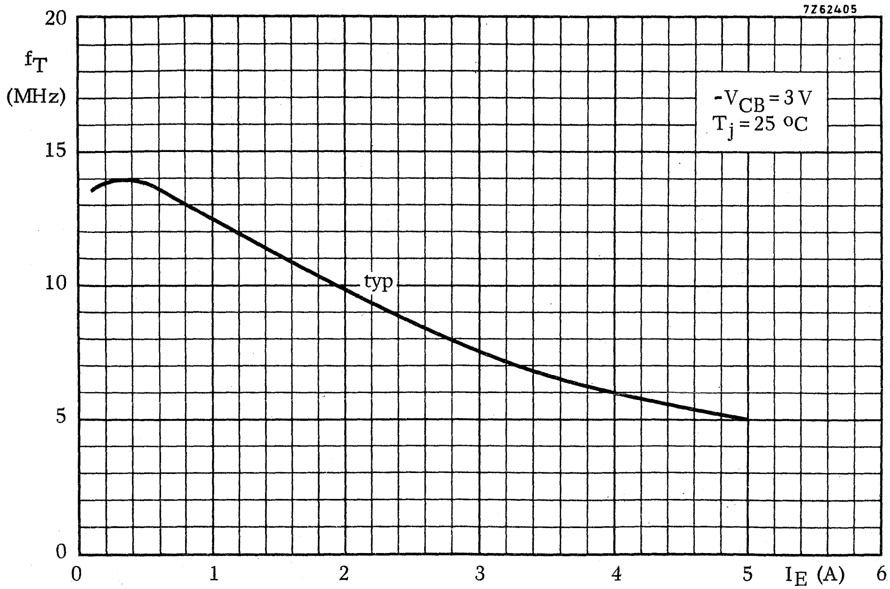


Fig. 11 Typical transition frequency.

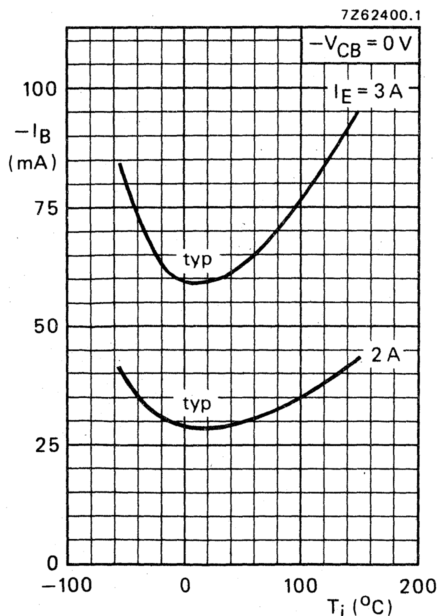


Fig. 12 Typical base current.

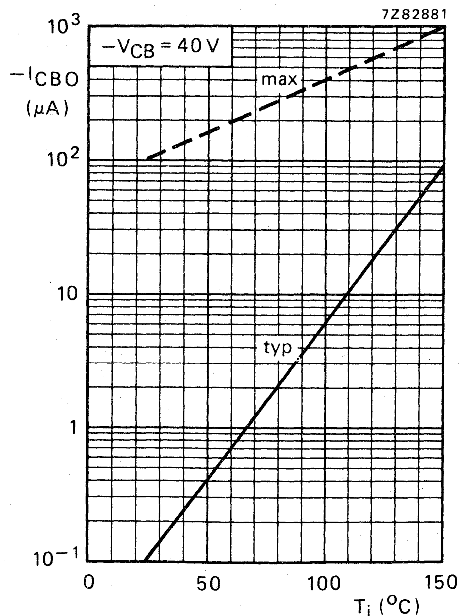


Fig. 13 Collector-base cut-off current.

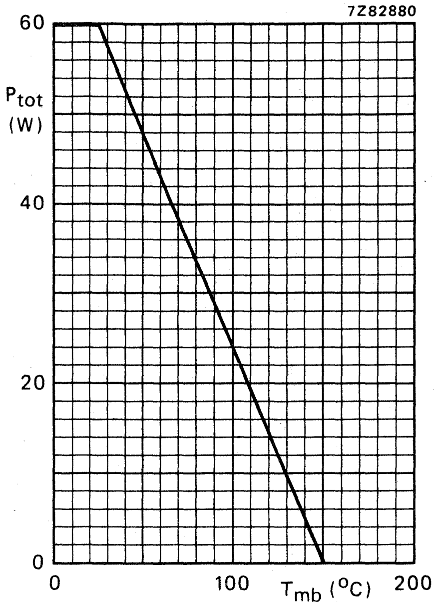


Fig. 14 Total power dissipation

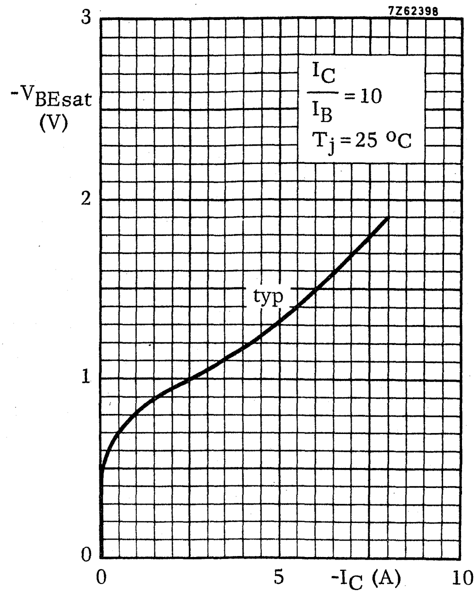


Fig. 15 Base-emitter saturation voltage.

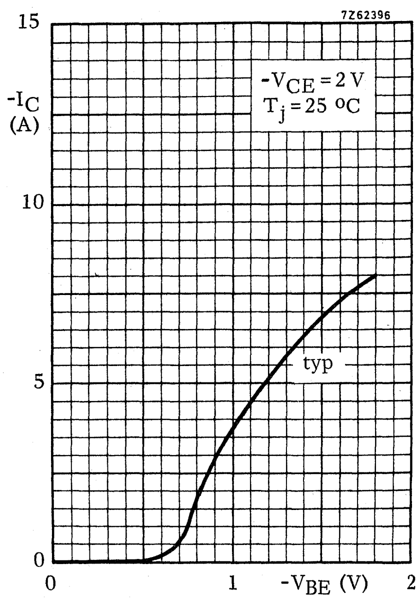


Fig. 16 Typical collector current.

SILICON PLANAR EPITAXIAL POWER TRANSISTORS

General purpose n-p-n transistors in a SOT-32 plastic envelope especially recommended for television circuits. Their complements are BD227, BD229 and BD231.

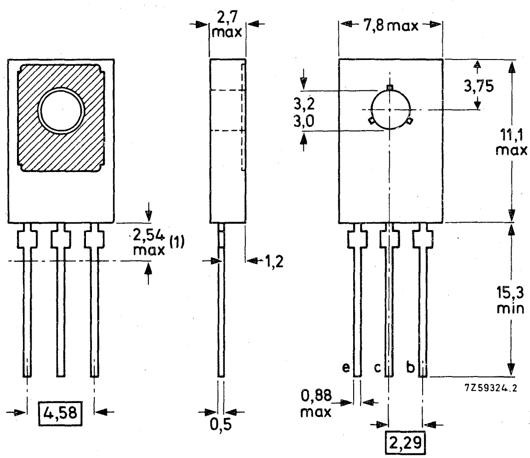
QUICK REFERENCE DATA

			BD226	BD228	BD230	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	V_{CER}	max.	45	60	100	V
Collector current (peak value)	I_{CM}	max.	3	3	3	A
Total power dissipation up to T_{mb} = 62 °C	P_{tot}	max.	12,5	12,5	12,5	W
Junction temperature	T_j	max.	150	150	150	°C
D.C. current gain						
I_C = 150 mA; V_{CE} = 2 V	h_{FE}	>	40	40	40	
		<	250	160	160	
I_C = 1 A; V_{CE} = 2 V	h_{FE}	>	25	25	25	
Transition frequency						
I_C = 50 mA; V_{CE} = 5 V	f_T	typ.	125	125	125	MHz

MECHANICAL DATA Dimensions in mm

TO-126 (SOT-32)

Collector connected to metal part of mounting surface



For mounting instructions see section Accessories, type 56326 for non-insulated mounting and type 56333 for insulated mounting.

1) Within this region the cross-section of the leads is uncontrolled.

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

			BD226	BD228	BD230	
Voltages						
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	V_{CER}	max.	45	60	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V

Currents

Collector current (d.c.)	I_C	max.	1,5	A
Collector current (peak value)	I_{CM}	max.	3	A

Power dissipation

Total power dissipation up to T_{mb} = 62 °C	P_{tot}	max.	12,5	W

Temperatures

Storage temperature	T_{stg}		−65 to +150	°C
Junction temperature	T_j	max.	150	°C

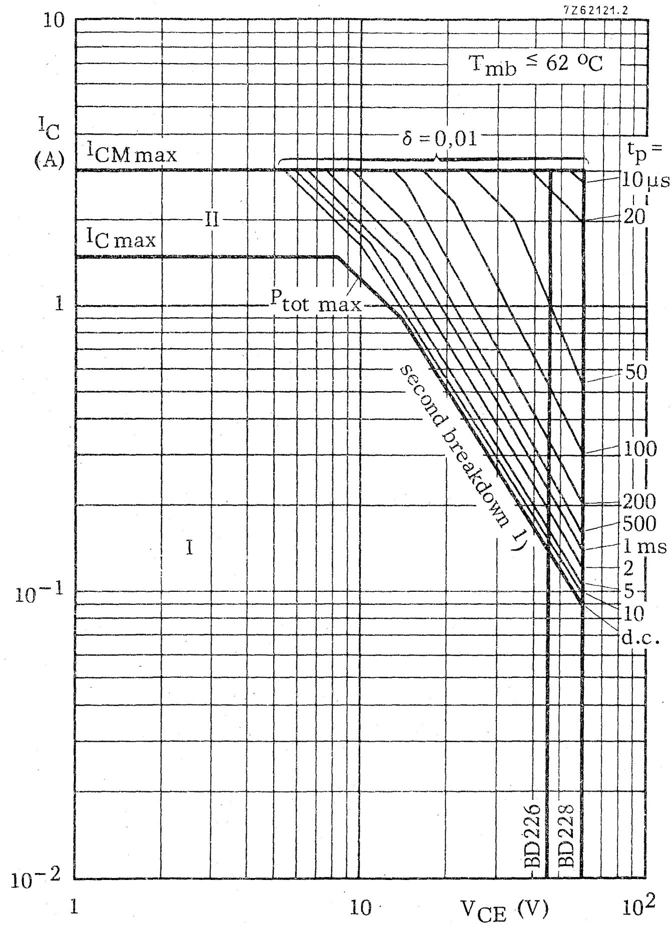
THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	100	°C/W
From junction to mounting base	$R_{th\ j-mb}$	=	7	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current						
I_E = 0; V_{CB} = 30 V	I_{CBO}	<	100			nA
I_E = 0; V_{CB} = 30 V; T_j = 125 °C	I_{CBO}	<	10			μA
Emitter cut-off current						
I_C = 0; V_{EB} = 5 V	I_{EBO}	<	10			μA
Base-emitter voltage [1]						
I_C = 1 A; V_{CE} = 2 V	V_{BE}	<	1,3			V
Saturation voltage						
I_C = 1 A; I_B = 0.1 A	V_{CEsat}	<	0,8			V
D.C. current gain			BD226	BD228	BD230	
I_C = 5 mA; V_{CE} = 2 V	h_{FE}	>	25	25	25	
I_C = 150 mA; V_{CE} = 2 V	h_{FE}	>	40	40	40	
		<	250	160	160	
I_C = 1 A ; V_{CE} = 2 V	h_{FE}	>	25	25	25	
Transition frequency at f = 35 MHz						
I_C = 50 mA; V_{CE} = 5 V	f_T	typ.	125			MHz
D.C. current gain ratio of matched pairs						
BD226/BD227; BD228/BD229; BD230/BD231						
$\lvert I_C \rvert$ = 150 mA; $\lvert V_{CE} \rvert$ = 2 V	h_{FE1}/h_{FE2}	typ.	1,3			
		<	1,6			

1) V_{BE} decreases by about 2,3 mV/°C with increasing temperature.

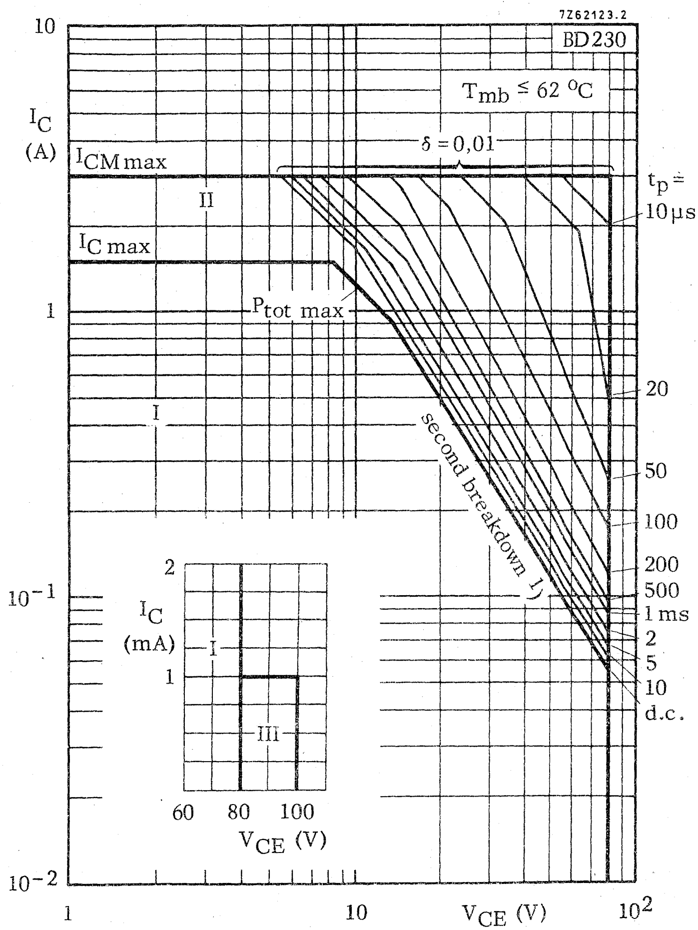


Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

1) Independent of temperature



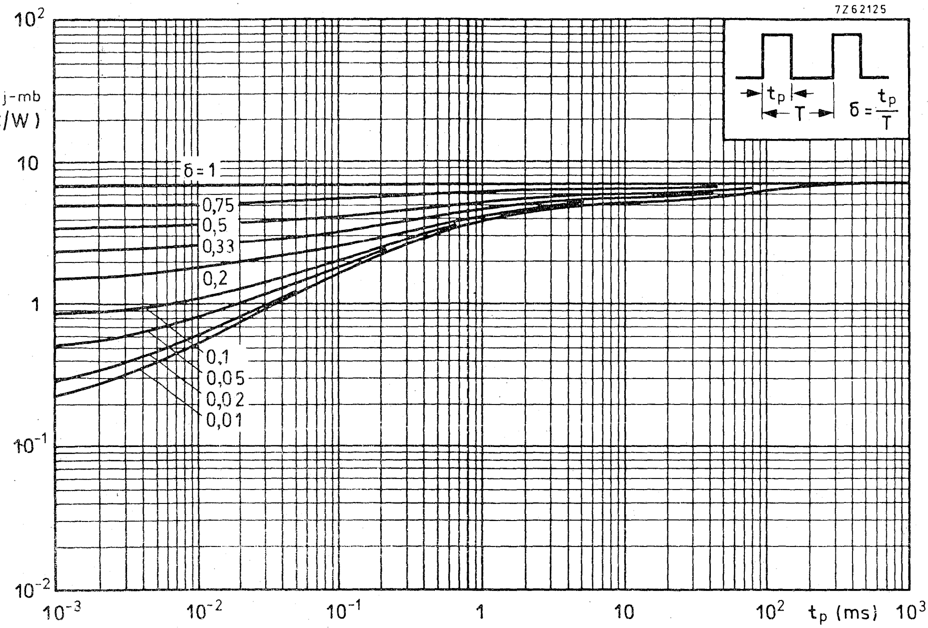
Safe Operating Area with the transistor forward biased

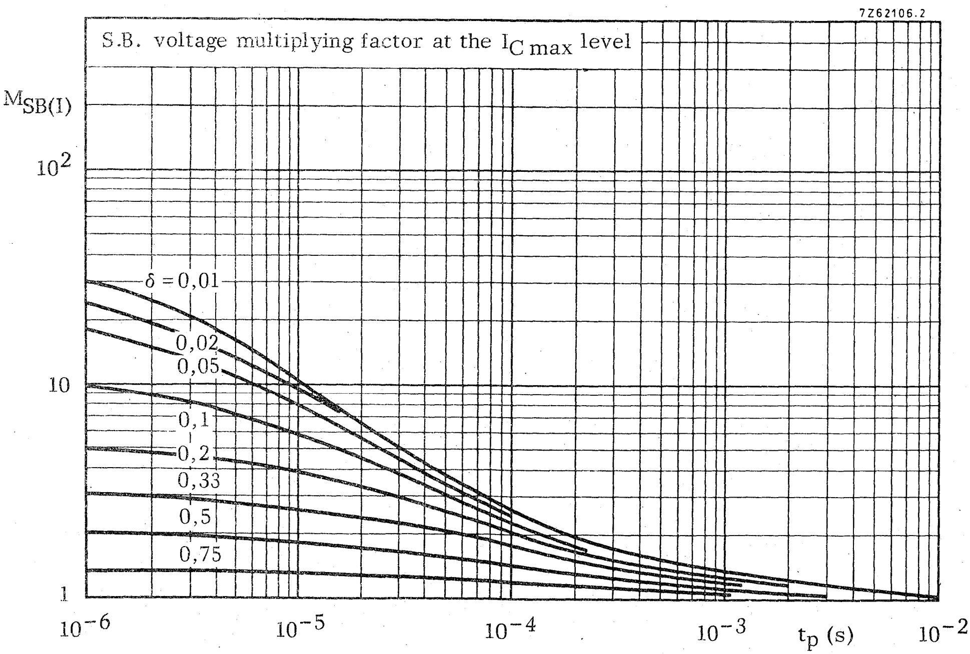
I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

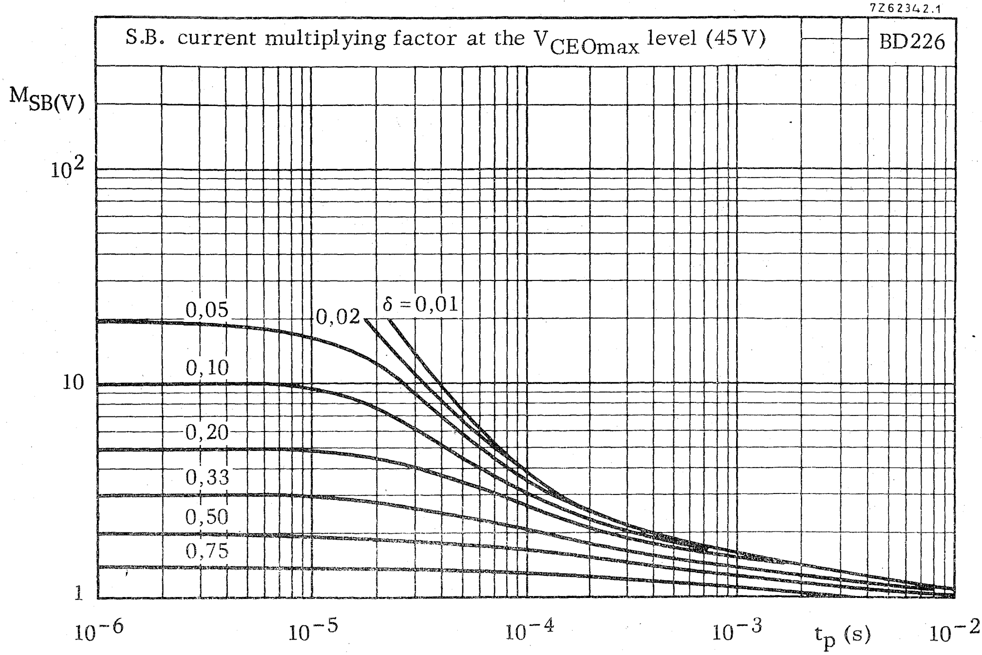
III Repetitive pulse operation in this region is allowable, provided $R_{BE} \leq 1\ k\Omega$

1) Independent of temperature

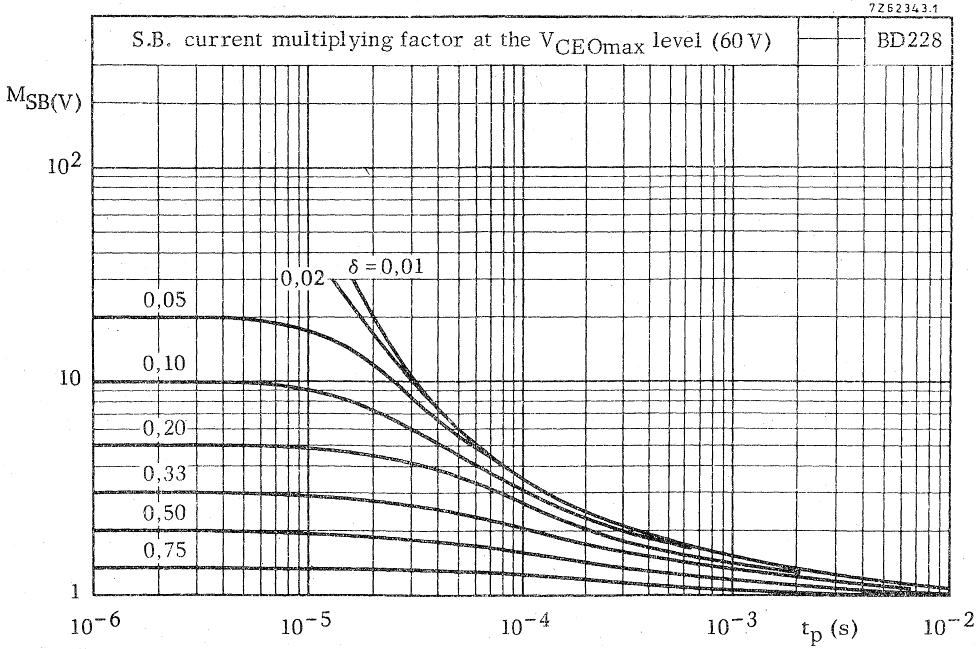

7Z62125
Z_{thj-mb} (°C/W)
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
$\delta = \frac{t_p}{T}$
t_p (ms)

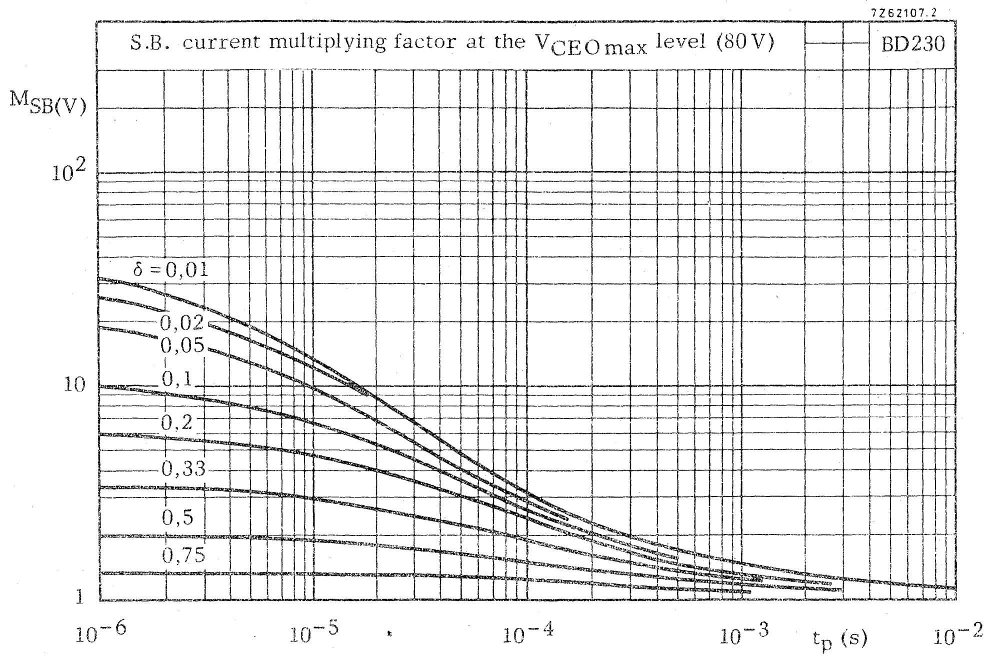

7Z62106.2
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
t_p (s)

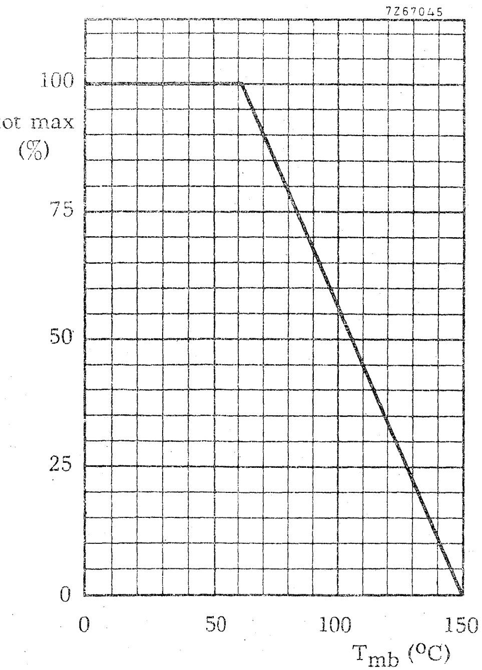
7Z62342.1

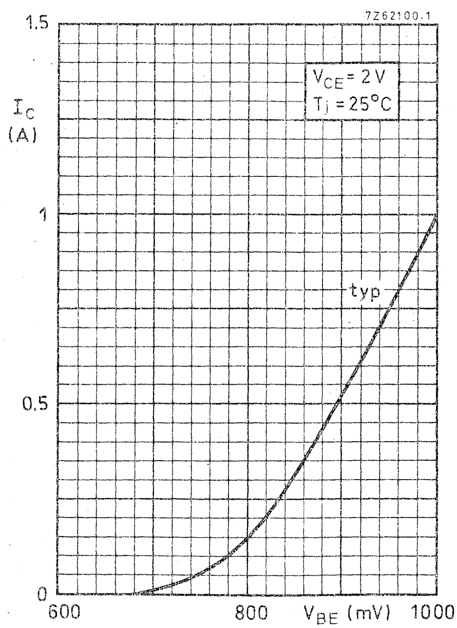


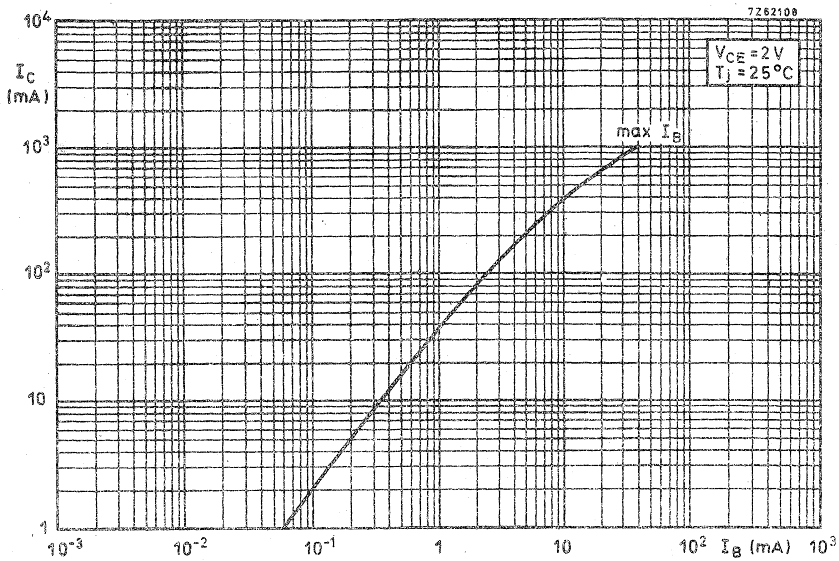
7Z62343.1

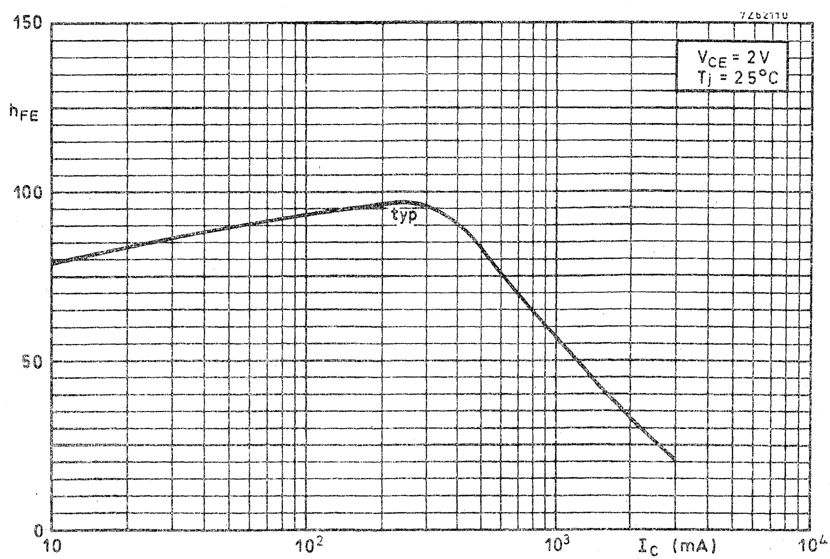


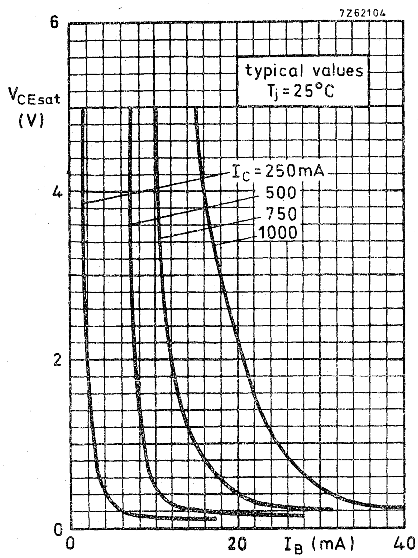

7Z62107.2
S.B. current multiplying factor at the VCEO max level (80 V)
BD230
MSB(V)
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^-6
10^-5
10^-4
10^-3
tp (s)
10^-2

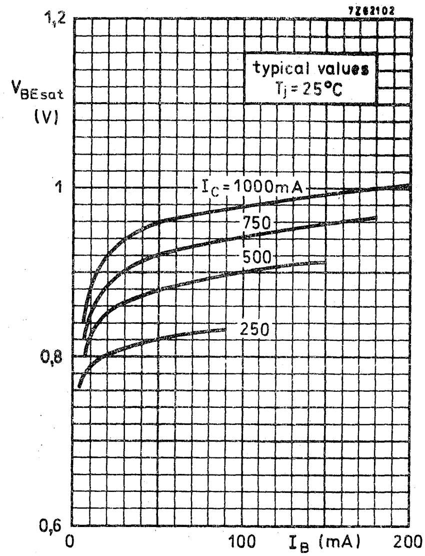

7Z67045
Ptot max
(%)
100
75
50
25
0
0
50
100
150
Tmb (°C)

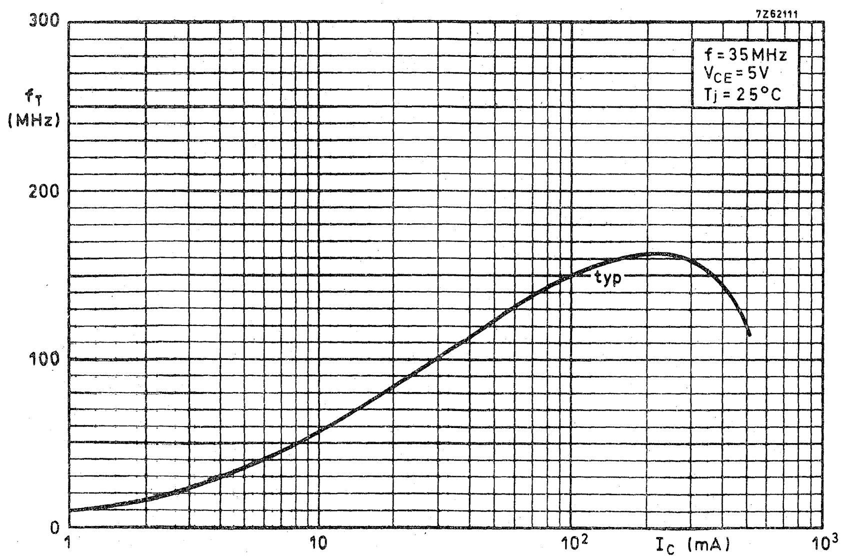

7Z62100.1
IC
(A)
1.5
1
0.5
0
VCE = 2 V
Tj = 25°C
typ
600
800
VBE (mV)
1000


7Z62100
V_{CE} = 2 V
T_j = 25°C
I_C (mA)
max I_B
10^4
10^3
10^2
10
1
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
I_B (mA)
10^3


7Z62110
V_{CE} = 2 V
T_j = 25°C
h_{FE}
typ
150
100
50
0
10
10^2
10^3
I_C (mA)
10^4


7Z62104
typical values
$T_j = 25°C$
V_{CEsat}
(V)
$I_C = 250mA$
500
750
1000
6
4
2
0
0
20
40
I_B (mA)


7Z62102
typical values
$T_j = 25°C$
V_{BEsat}
(V)
$I_C = 1000mA$
750
500
250
1,2
1
0,8
0,6
0
100
200
I_B (mA)


7Z62111
f = 35 MHz
$V_{CE} = 5V$
$T_j = 25°C$
f_T
(MHz)
typ
300
200
100
0
1
10
10^2
10^3
I_C (mA)

SILICON PLANAR EPITAXIAL POWER TRANSISTORS

General purpose p-n-p transistors in a SOT-32 plastic envelope especially recommended for television circuits. Their complements are BD226, BD228 and BD230.

QUICK REFERENCE DATA

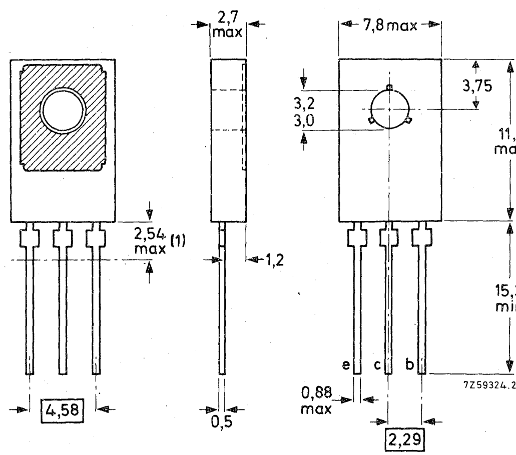
			BD227	BD229	BD231	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	$-V_{CER}$	max.	45	60	100	V
Collector current (peak value)	$-I_{CM}$	max.	3	3	3	A
Total power dissipation up to T_{mb} = 62 °C	P_{tot}	max.	12,5	12,5	12,5	W
Junction temperature	T_j	max.	150	150	150	°C
D.C. current gain						
$-I_C$ = 150 mA; $-V_{CE}$ = 2 V	h_{FE}	>	40	40	40	
		<	250	160	160	
$-I_C$ = 1 A; $-V_{CE}$ = 2 V	h_{FE}	>	25	25	25	
Transition frequency						
$-I_C$ = 50 mA; $-V_{CE}$ = 5 V	f_T	typ.	50	50	50	MHz

MECHANICAL DATA

Dimensions in mm

TO-126 (SOT-32)

Collector connected to metal part of mounting surface



For mounting instructions see section Accessories, type 56326 for non-insulated mounting and type 56333 for insulated mounting.

1) Within this region the cross-section of the leads is uncontrolled.

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

Voltages

			BD227	BD229	BD231	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	$-V_{CER}$	max.	45	60	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V

Currents

Collector current (d.c.)	$-I_C$	max.	1,5	A
Collector current (peak value)	$-I_{CM}$	max.	3	A

Power dissipation

Total power dissipation up to T_{mb} = 62 °C	P_{tot}	max.	12,5	W

Temperatures

Storage temperature	T_{stg}		−65 to +150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

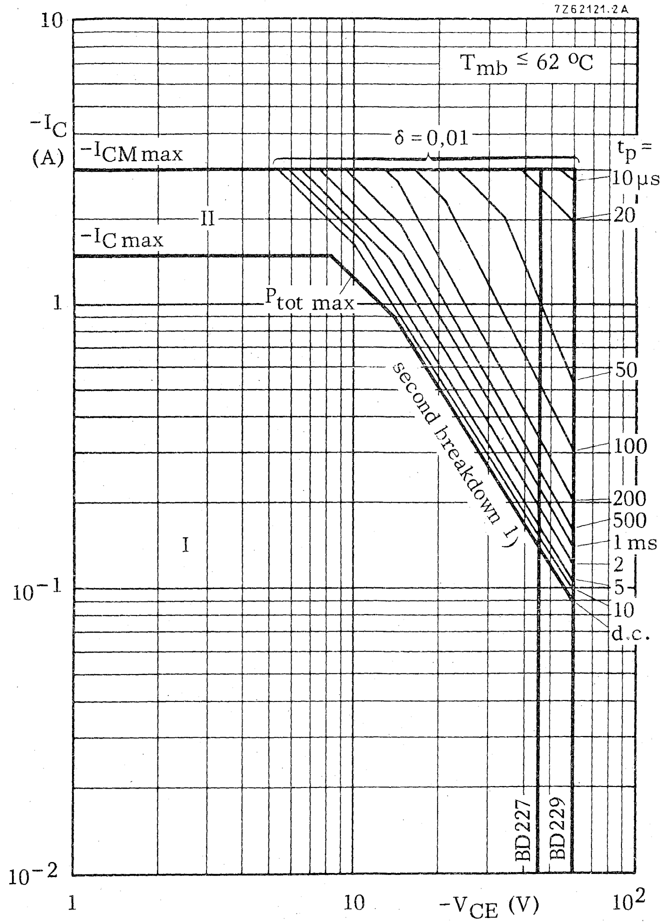
From junction to ambient in free air	$R_{th\ j-a}$	=	100	°C/W
From junction to mounting base	$R_{th\ j-mb}$	=	7	°C/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current						
$I_E = 0$; $-V_{CB} = 30$ V	$-I_{CBO}$	<	100			nA
$I_E = 0$; $-V_{CB} = 30$ V; $T_j = 125$ °C	$-I_{CBO}$	<	10			μA
Emitter cut-off current						
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	10			μA
Base-emitter voltage [1]						
$-I_C = 1$ A; $-V_{CE} = 2$ V	$-V_{BE}$	<	1,3			V
Saturation voltage						
$-I_C = 1$ A; $-I_B = 0.1$ A	$-V_{CEsat}$	<	0,8			V
			BD227	BD229	BD231	
D.C. current gain						
$-I_C$ = 5 mA; $-V_{CE} = 2$ V	h_{FE}	>	25	25	25	
$-I_C$ = 150 mA; $-V_{CE} = 2$ V	h_{FE}	>	40	40	40	
		<	250	160	160	
$-I_C$ = 1 A; $-V_{CE} = 2$ V	h_{FE}	>	25	25	25	
Transition frequency at f = 35 MHz						
$-I_C$ = 50 mA; $-V_{CE} = 5$ V	f_T	typ.	50			MHz
D.C. current gain ratio of matched pairs						
BD226/BD227; BD228/BD229; BD230/BD231						
$\|I_C\| = 150$ mA; $\|V_{CE}\| = 2$ V	h_{FE1}/h_{FE2}	typ.	1,3			
		<	1,6			

[1] $-V_{BE}$ decreases by about 2,3 mV/°C with increasing temperature.

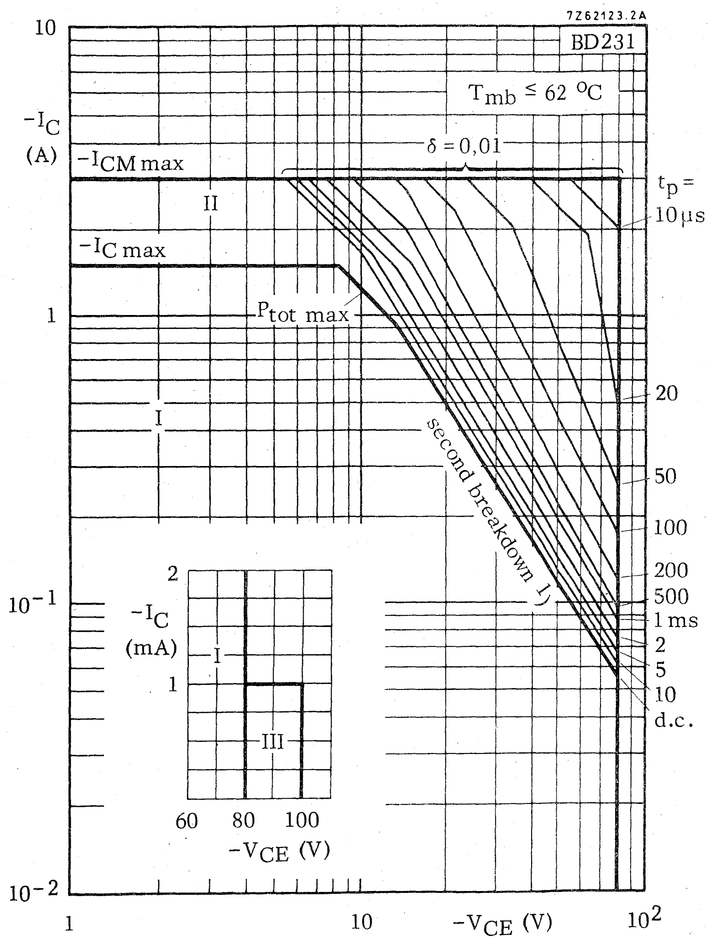


Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

1) Independent of temperature



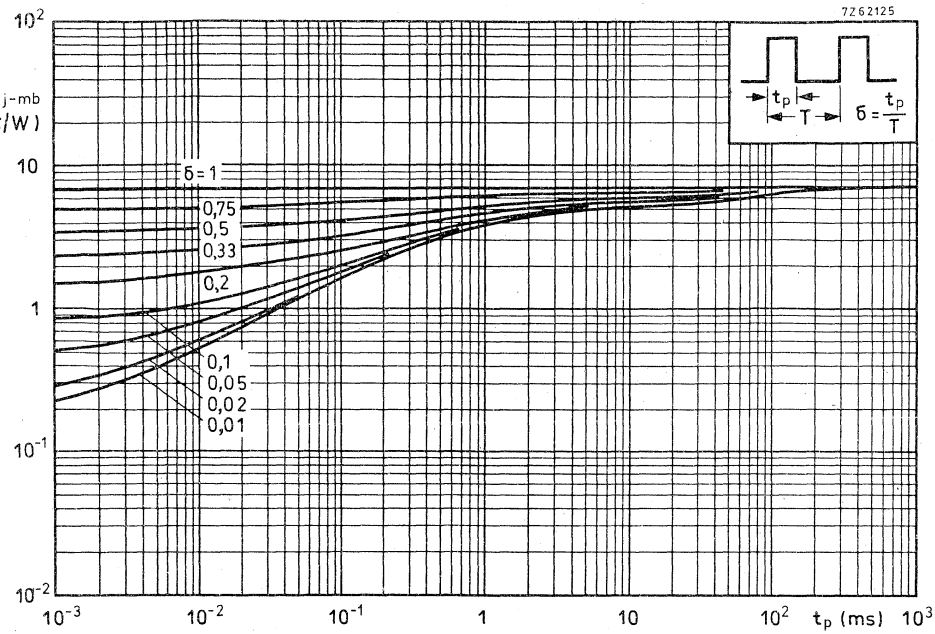
Safe Operating Area with the transistor forward biased

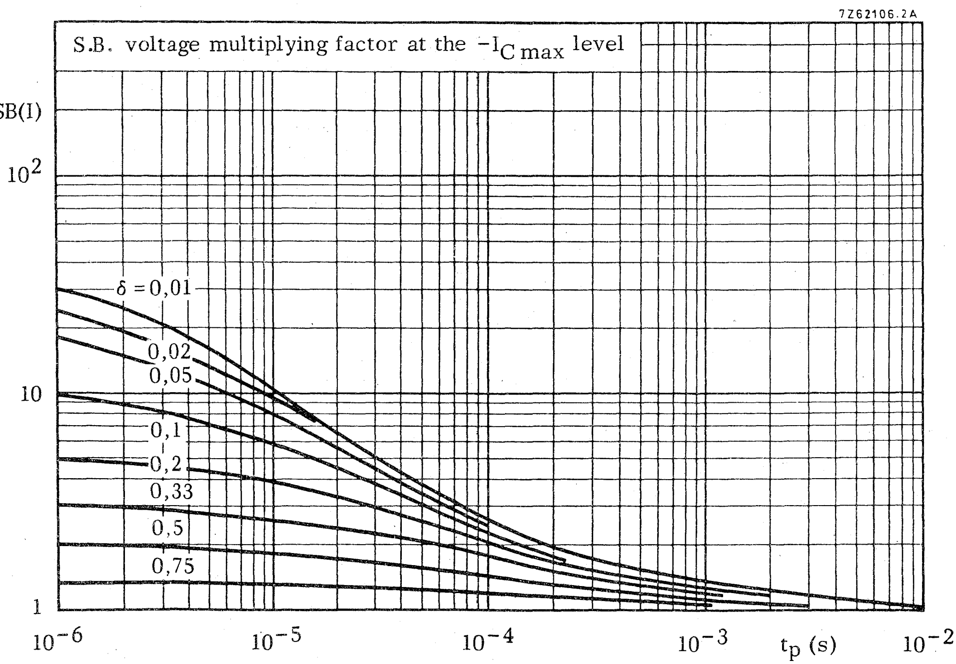
I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

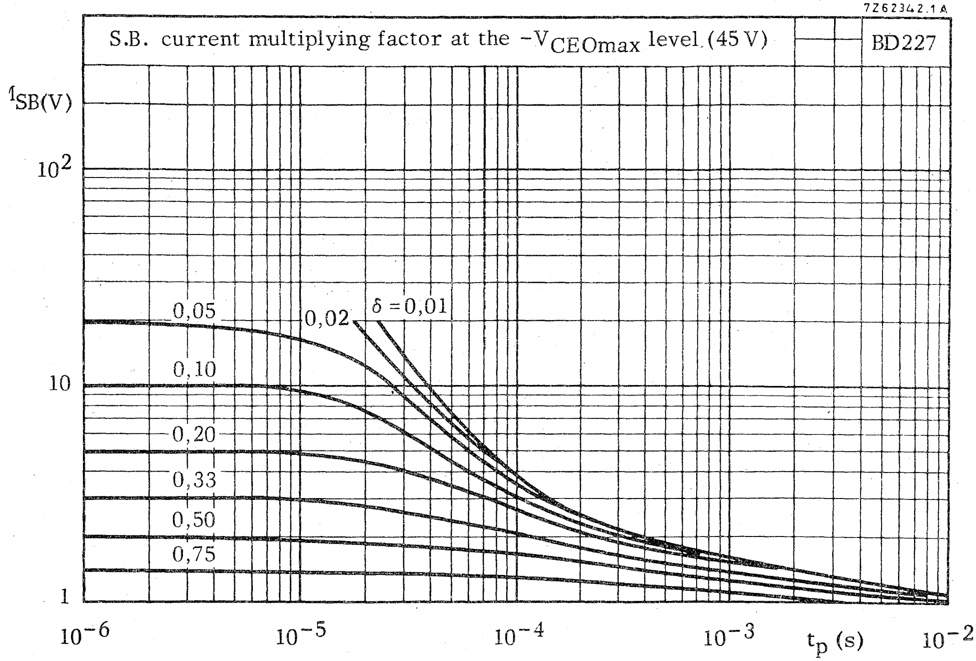
III Repetitive pulse operation in this region is allowable, provided $R_{BE} \leq 1\ k\Omega$

1) Independent of temperature

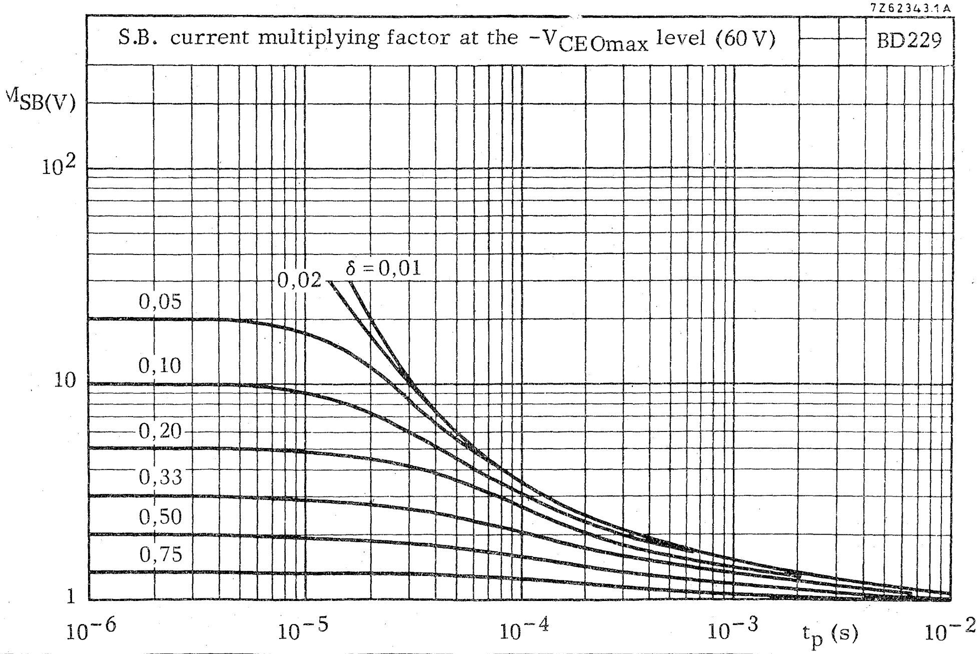

7Z62125
$Z_{th\,j\text{-}mb}$
(°C/W)
10^2
10
1
10^{-1}
10^{-2}
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3

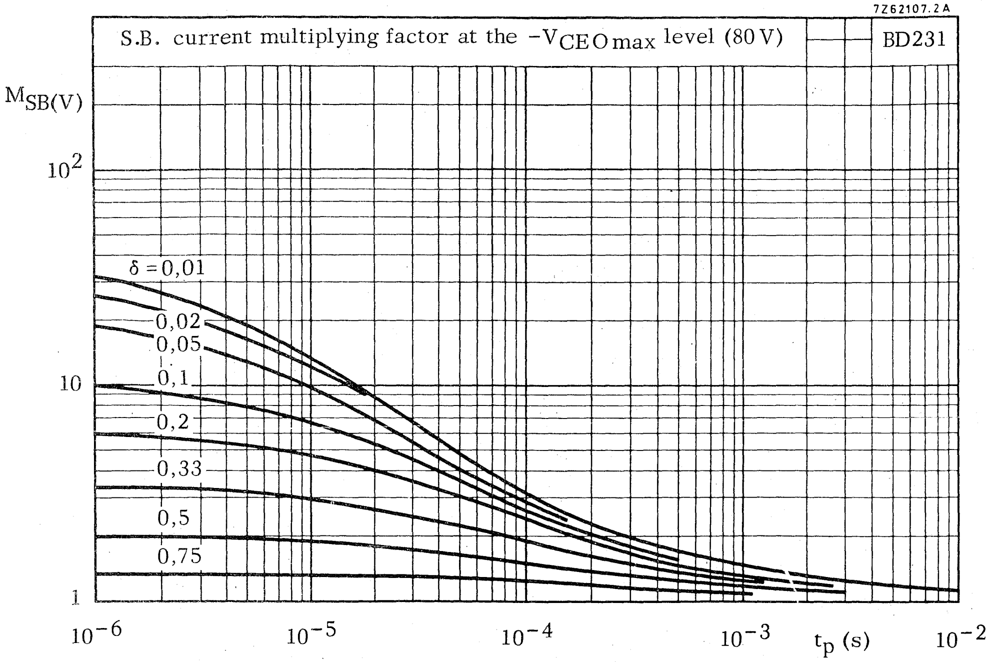

7Z62106.2A
S.B. voltage multiplying factor at the $-I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

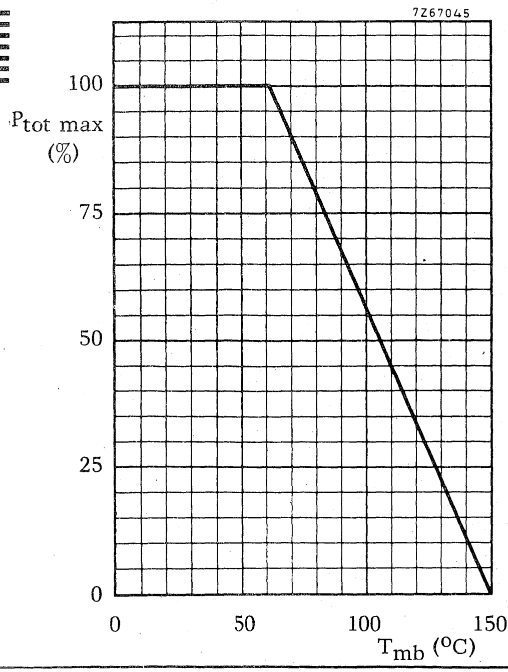
7Z62342.1A

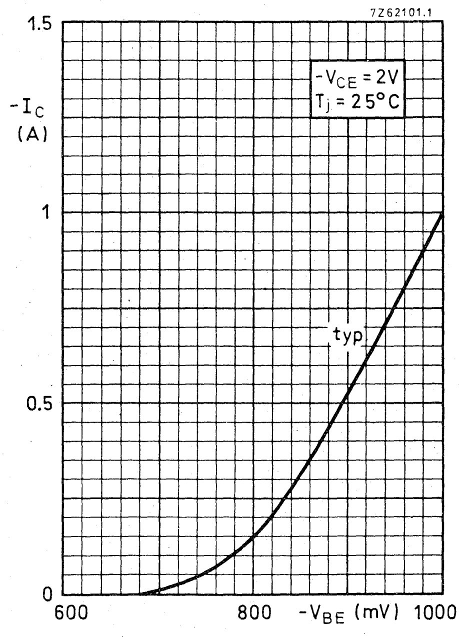


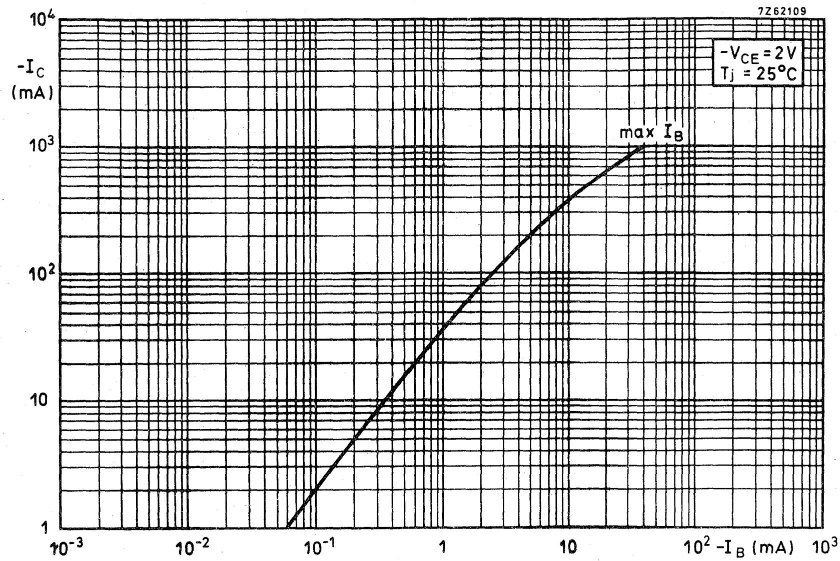
7Z62343.1A

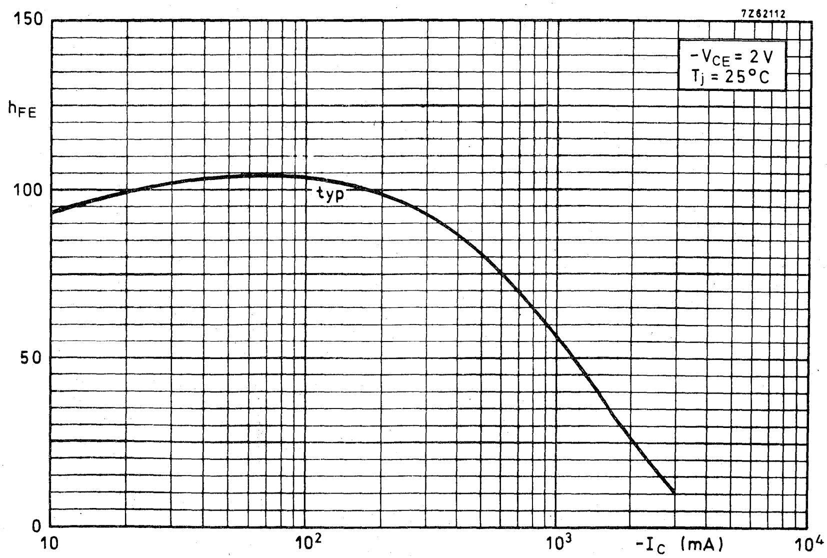


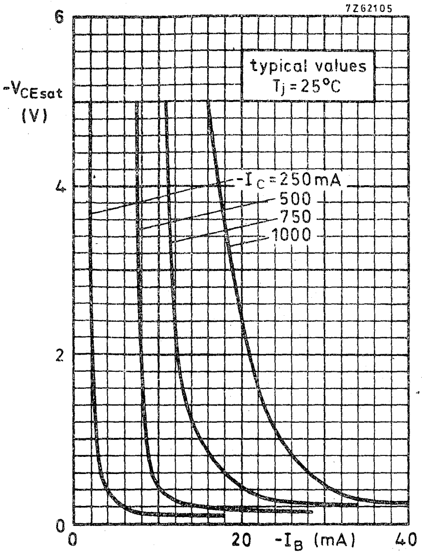

7Z62107.2A
S.B. current multiplying factor at the $-V_{CEO\,max}$ level (80 V)
BD231
$M_{SB(V)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

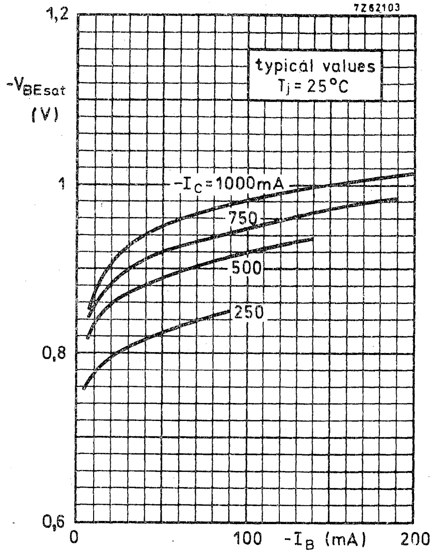

7Z67045
100
$P_{tot\,max}$ (%)
75
50
25
0
0
50
100
150
T_{mb} (°C)

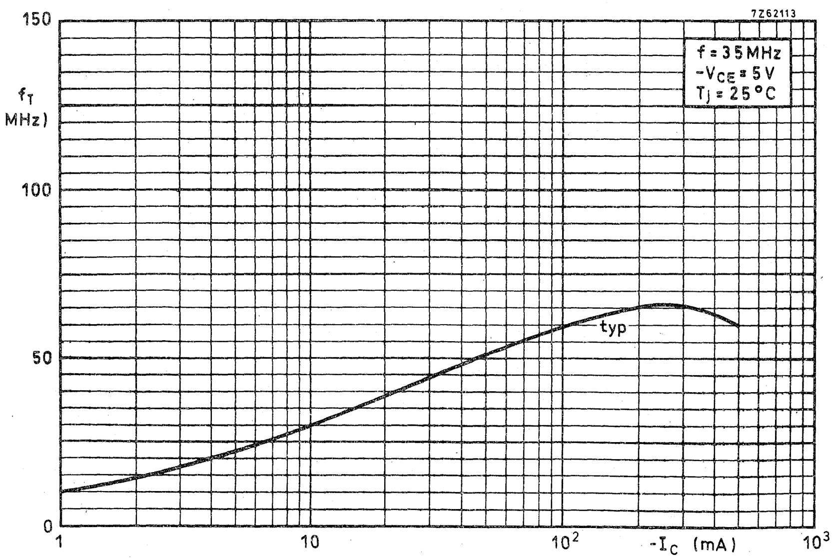

7Z62101.1
1.5
$-I_C$ (A)
1
0.5
0
$-V_{CE}$ = 2V
T_j = 25°C
typ
600
800
$-V_{BE}$ (mV)
1000


7Z62109
10^4
$-I_C$ (mA)
10^3
10^2
10
1
$-V_{CE} = 2$ V
$T_j = 25°C$
max I_B
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
$-I_B$ (mA)
10^3


7Z62112
150
h_{FE}
100
50
0
$-V_{CE} = 2$ V
$T_j = 25°C$
typ
10
10^2
10^3
$-I_C$ (mA)
10^4


7Z62105
typical values
Tj = 25°C
-VCEsat
(V)
-IC = 250 mA
500
750
1000
6
4
2
0
0
20
-IB (mA)
40


7Z62103
typical values
Tj = 25°C
-VBEsat
(V)
-IC = 1000 mA
750
500
250
1,2
1
0,8
0,6
0
100
-IB (mA)
200


7Z62113
f = 35 MHz
-VCE = 5 V
Tj = 25 °C
fT
MHz)
typ
150
100
50
0
1
10
10²
-IC (mA)
10³

SILICON EPITAXIAL-BASE POWER TRANSISTORS

N-P-N transistors in a SOT-32 plastic envelope intended for use in television and audio amplifier circuits where high peak powers can occur. P-N-P complements are BD234, BD236 and BD238. Matched pairs can be supplied.

QUICK REFERENCE DATA

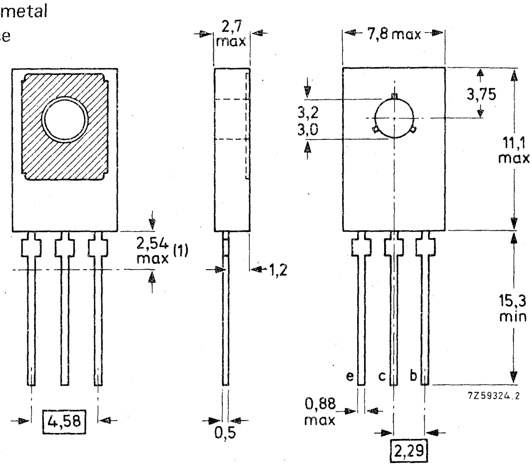
			BD233	BD235	BD237	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	V_{CER}	max.	45	60	100	V
Collector current (peak value)	I_{CM}	max.		6		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		25		W
Junction temperature	T_j	max.		150		°C
D.C. current gain I_C = 1 A; V_{CE} = 2 V	h_{FE}	>		25		
Transition frequency I_C = 250 mA; V_{CE} = 10 V	f_T	>		3		MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-126 (SOT-32).

Collector connected to metal part of mounting surface



(1) Within this region the cross-section of the leads is uncontrolled.

See also chapters Mounting Instructions and Accessories.

RATINGS

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

			BD233	BD235	BD237	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	V_{CER}	max.	45	60	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V
Collector current (d.c.)	I_C	max.		2		A
Collector current (peak value)	I_{CM}	max.		6		A
→ Base current (d.c.)	I_B	max.		0,5		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		25		W
Storage temperature	T_{stg}			−65 to + 150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	100	K/W
From junction to mounting base	$R_{th\ j-mb}$	=	5	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

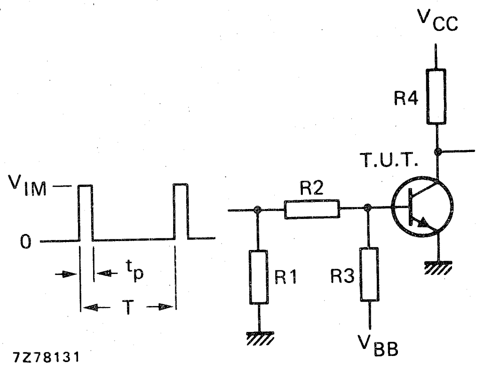
Collector cut-off current				
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	<	100	μA
$I_E = 0$; $V_{CB} = V_{CBOmax}$; T_j = 150 °C	I_{CBO}	<	3	mA
Emitter cut-off current				
$I_C = 0$; V_{EB} = 5 V	I_{EBO}	<	1	mA
Second-breakdown collector current				
V_{CE} = 40 V; t_p = 20 ms	$I_{(SB)C}$	<	0,5	A
Base-emitter voltage*				
I_C = 1 A; V_{CE} = 2 V	V_{BE}	<	1,3	V
Saturation voltage*				
I_C = 1 A; I_B = 0,1 A	V_{CEsat}	<	0,6	V
D.C. current gain*				
I_C = 150 mA; V_{CE} = 2 V	h_{FE}		40 to 250	
I_C = 1 A; V_{CE} = 2 V	h_{FE}	>	25	
Transition frequency at f = 1 MHz				
I_C = 250 mA; V_{CE} = 10 V	f_T	>	3	MHz

* Measured under pulse conditions: $t_p < 300\ \mu s$, $\delta < 2\%$.

CHARACTERISTICS (continued)

T_j = 25 °C unless otherwise specified.

D.C. current gain ratio of matched complementary pairs* $\lvert I_C \rvert$ = 150 mA; $\lvert V_{CE} \rvert$ = 2 V	h_{FE1}/h_{FE2}	<	1,6	
Switching times I_{Con} = 1 A; $I_{Bon} = -I_{Boff}$ = 0,1 A				
turn-on time	t_{on}	typ.	0,4	μs
		<	1	μs
turn-off time	t_{off}	typ.	1,5	μs
		<	3	μs



V_{IM} = 16 V
V_{CC} = 20 V
$-V_{BB}$ = 6,4 V
R1 = 82 Ω
R2 = 82 Ω
R3 = 82 Ω
R4 = 20 Ω
$t_r = t_f$ = 15 ns
t_p = 10 μs
T = 500 μs

Fig. 2 Test circuit.

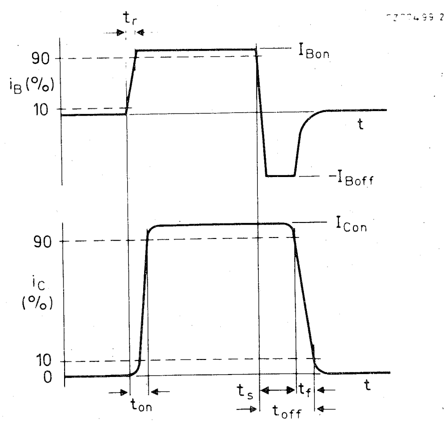


Fig. 3 Switching times waveforms.

* Measured under pulse conditions; $t_p < 300$ μs, $\delta < 2\%$.

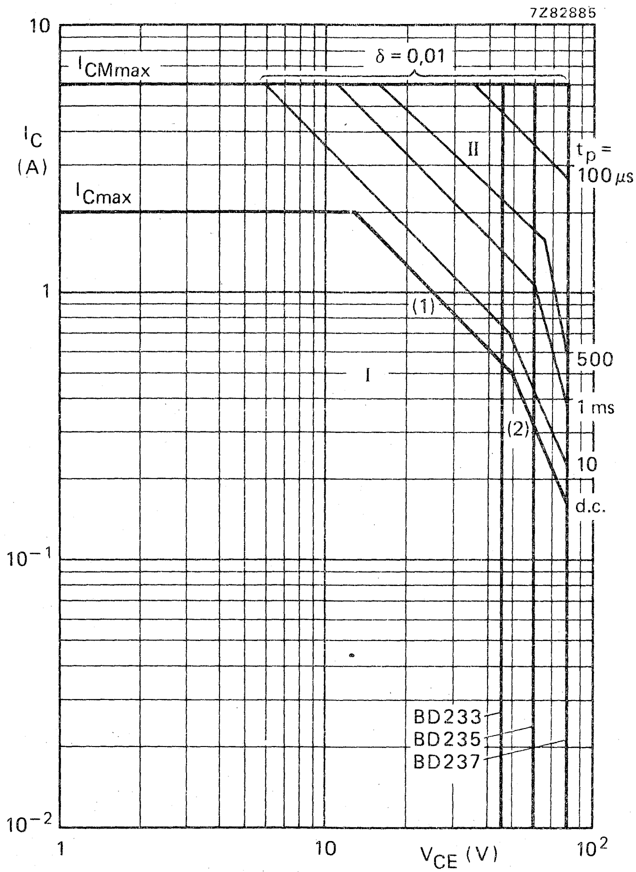


Fig. 4 Safe Operating Area with the transistor forward biased, $T_{mb} \leq 25\ ^oC$.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.
(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.
(2) Second breakdown limits (independent of temperature).

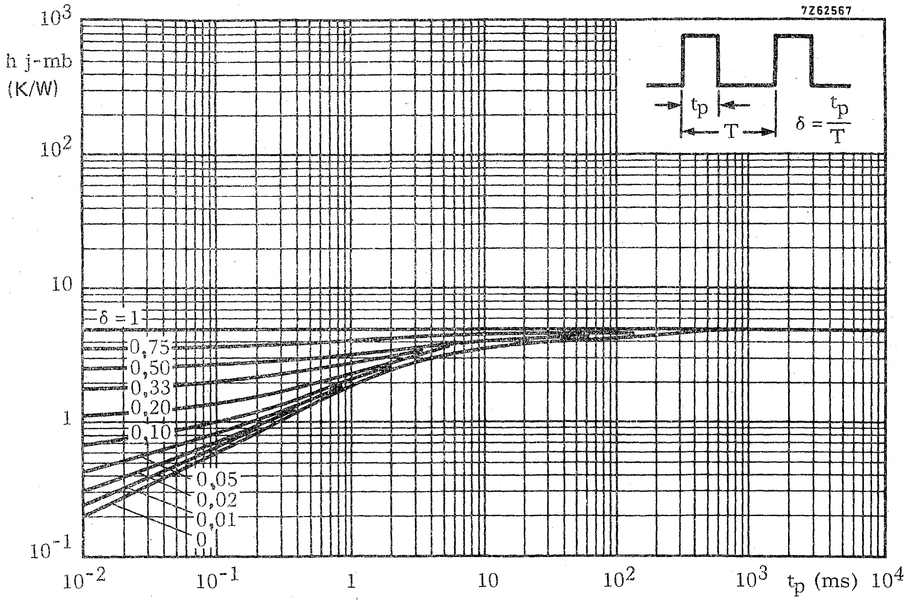
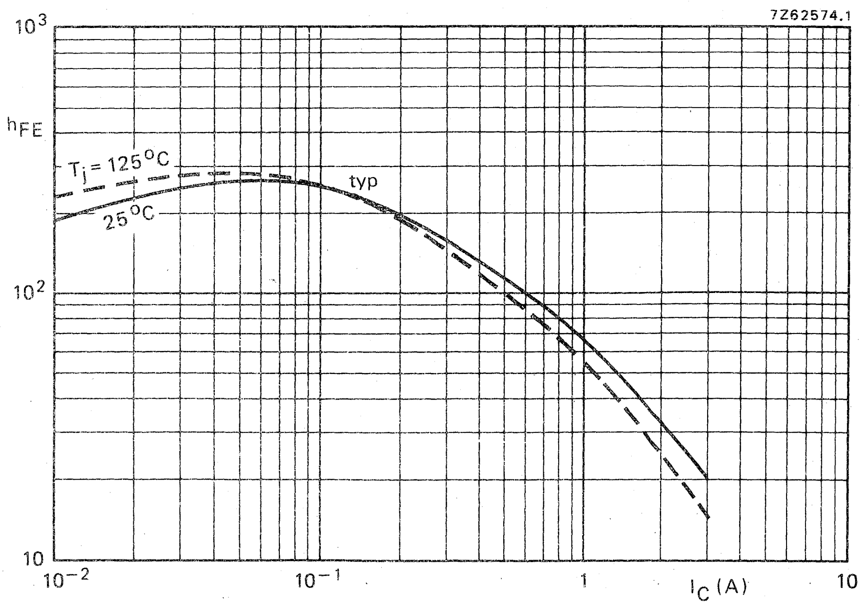


Fig. 5 Pulse power rating chart.



D.C. current gain; V_{CE} = 2 V.

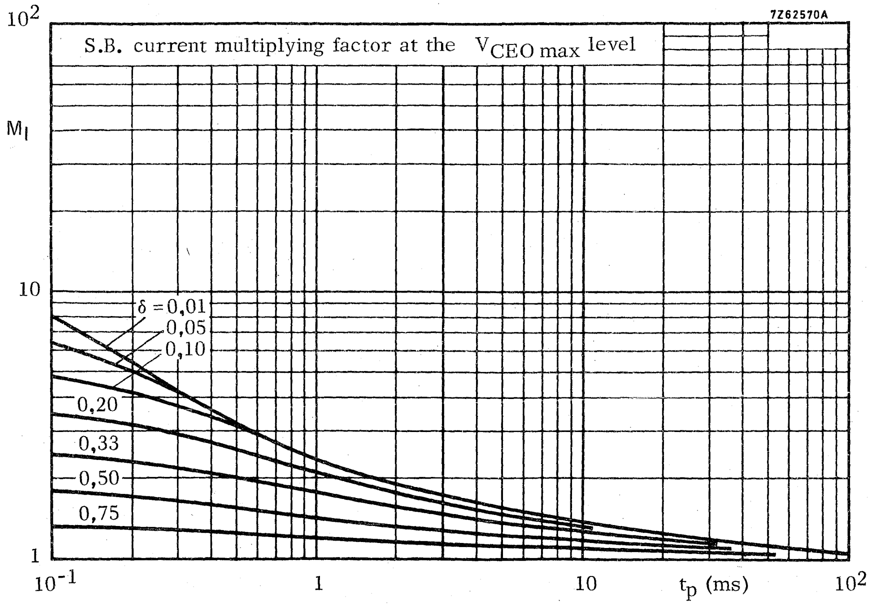


Fig. 7 S.B. current multiplying factor at the V_{CEOmax} level.

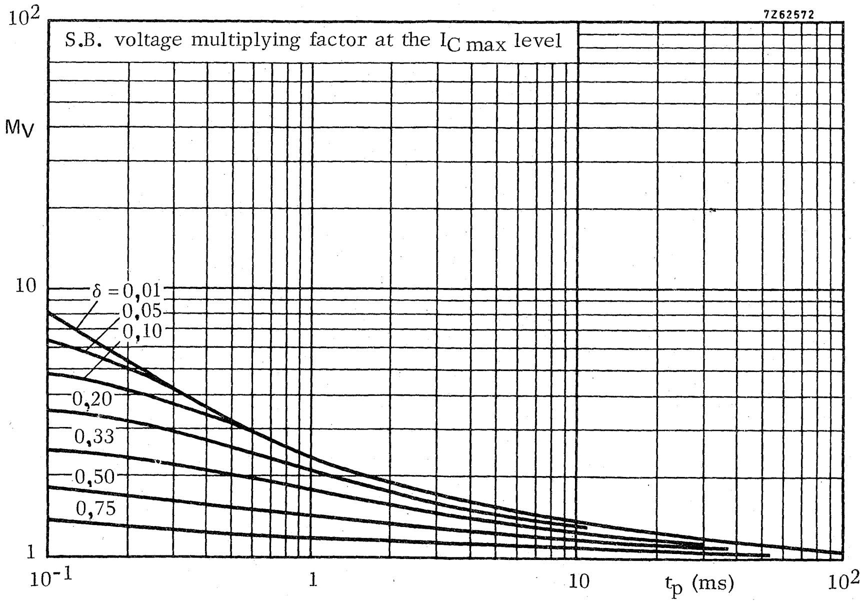


Fig. 8 S.B. voltage multiplying factor at the I_{Cmax} level.

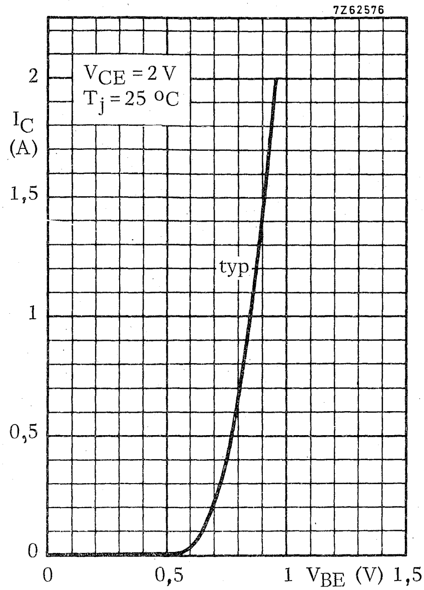

7Z62576
V_{CE} = 2 V
T_j = 25 °C
I_C (A)
2
1,5
1
0,5
0
typ
0
0,5
1
V_{BE} (V)
1,5

Fig. 9.

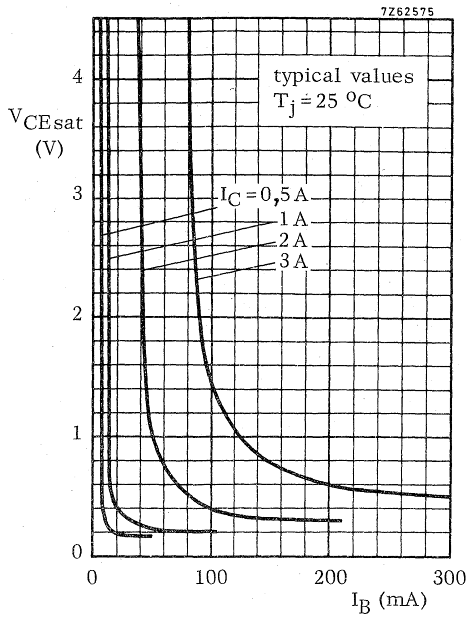

7Z62575
typical values
T_j = 25 °C
V_{CEsat} (V)
4
3
2
1
0
I_C = 0,5 A
1 A
2 A
3 A
0
100
200
300
I_B (mA)

Fig. 10.

SILICON EPITAXIAL-BASE POWER TRANSISTORS

P-N-P transistors in a SOT-32 plastic envelope intended for use in television and audio amplifier circuits where high peak powers can occur. N-P-N complements are BD233, BD235 and BD237. Matched pairs can be supplied.

QUICK REFERENCE DATA

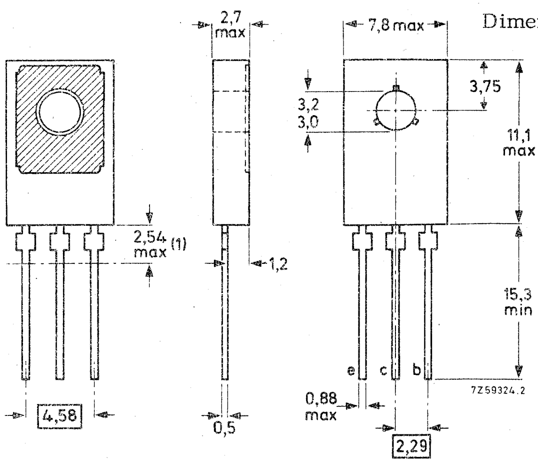
			BD234	BD236	BD238	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	$-V_{CER}$	max.	45	60	100	V
Collector current (peak value)	$-I_{CM}$	max.		6		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		25		W
Junction temperature	T_j	max.		150		°C
D.C. current gain $-I_C$ = 1 A; $-V_{CE}$ = 2 V	h_{FE}	>		25		
Transition frequency $-I_C$ = 250 mA; $-V_{CE}$ = 10 V	f_T	>		3		MHz

MECHANICAL DATA

Dimensions in mm

TO-126 (SOT-32)

Collector connected to metal part of mounting surface



For mounting instructions see section Accessories, type 56326 for direct mounting and set 56333 for insulated mounting.

[1]) Within this region the cross-section of the leads is uncontrolled.

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

Voltages			BD234	BD236	BD238	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	$-V_{CER}$	max.	45	60	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V

Currents				
Collector current (d.c.)	$-I_C$	max.	2	A
Collector current (peak value)	$-I_{CM}$	max.	6	A
Power dissipation				
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	25	W
Temperatures				
Storage temperature	T_{stg}		−65 to +150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	100	°C/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	5	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

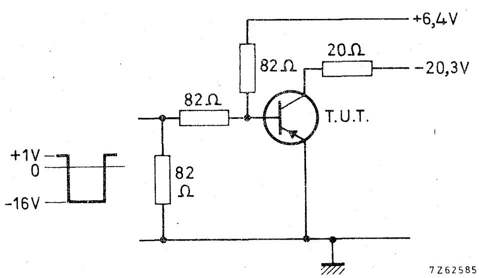
Collector cut-off current				
$I_E = 0$; $-V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	100	μA
$I_E = 0$; $-V_{CB} = -V_{CBOmax}$; T_j = 150 °C	$-I_{CBO}$	<	3	mA
Emitter cut-off current				
$I_C = 0$; $-V_{EB}$ = 5 V	$-I_{EBO}$	<	1	mA

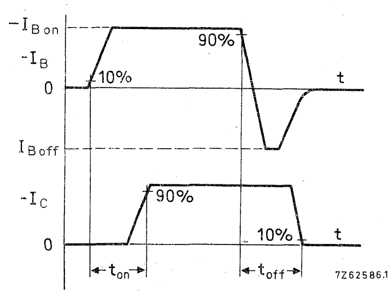
CHARACTERISTICS (continued)

T_j = 25 °C

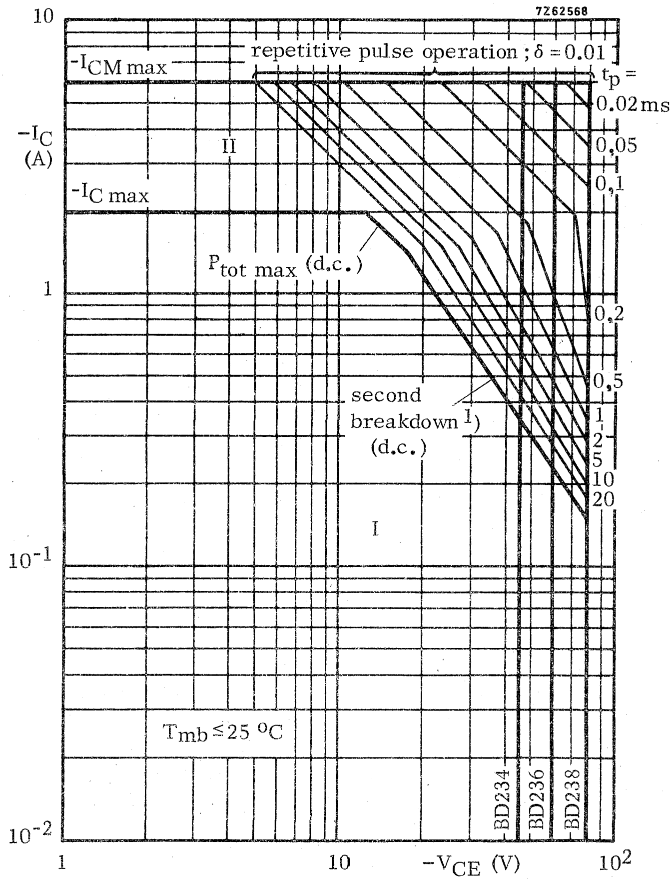
Base-emitter voltage				
$-I_C$ = 1 A; $-V_{CE}$ = 2 V	$-V_{BE}$	<	1,3	V
Saturation voltage				
$-I_C$ = 1 A; $-I_B$ = 0,1 A	$-V_{CEsat}$	<	0,6	V
D.C. current gain				
$-I_C$ = 150 mA; $-V_{CE}$ = 2 V	h_{FE}		40 to 250	
$-I_C$ = 1 A; $-V_{CE}$ = 2 V	h_{FE}	>	25	
Transition frequency at f = 1 MHz				
$-I_C$ = 250 mA; $-V_{CE}$ = 10 V	f_T	>	3	MHz
D.C. current gain ratio of matched pairs BD233/BD234; BD235/BD236; BD237/BD238				
$\|I_C\|$ = 150 mA; $\|V_{CE}\|$ = 2 V	h_{FE1}/h_{FE2}	<	1,6	
Switching times				
$-I_{Con}$ = 1 A; $-I_{Bon}$ = I_{Boff} = 0,1 A				
turn-on time	t_{on}	typ	0,3	μs
turn-off time	t_{off}	typ	0,7	μs

Test circuit





Input pulse:
$t_r = t_f$ = 15 ns
t_p = 10 μs
T = 500 μs

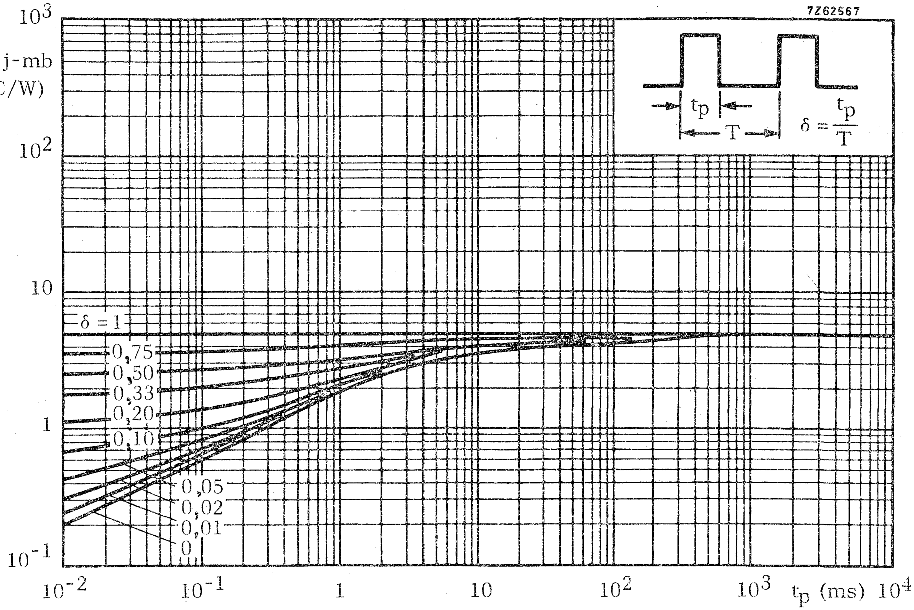


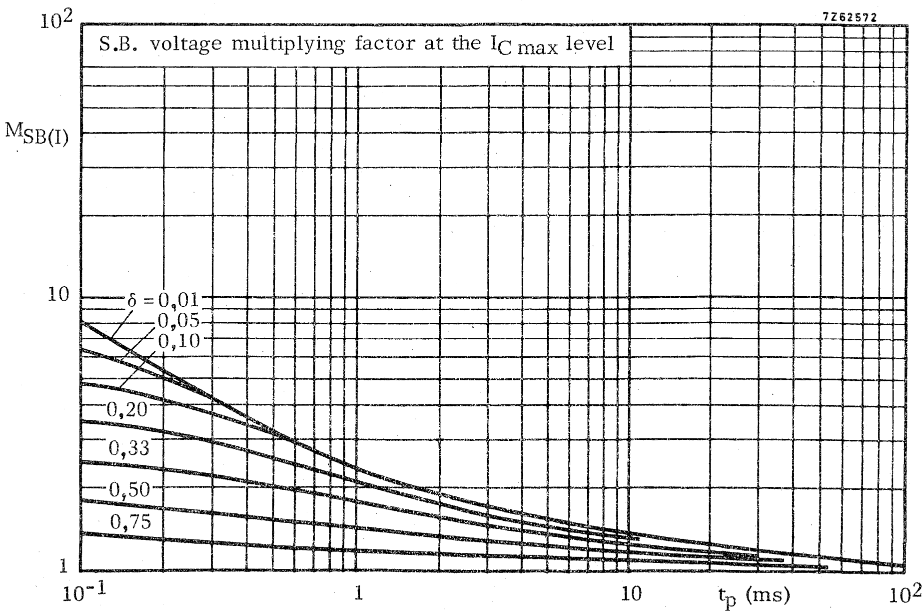
Safe Operating Area with the transistor forward biased

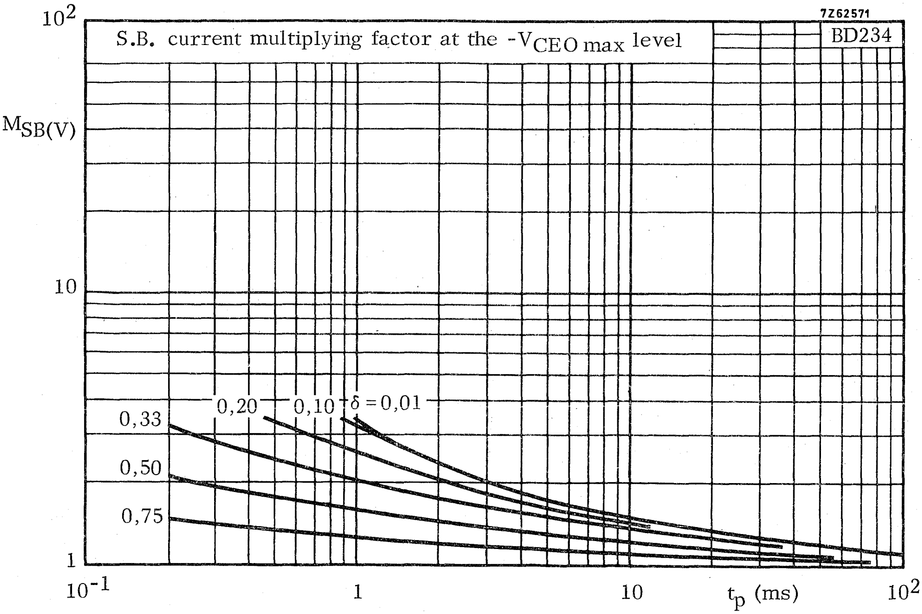
I Region of permissible d.c. operation

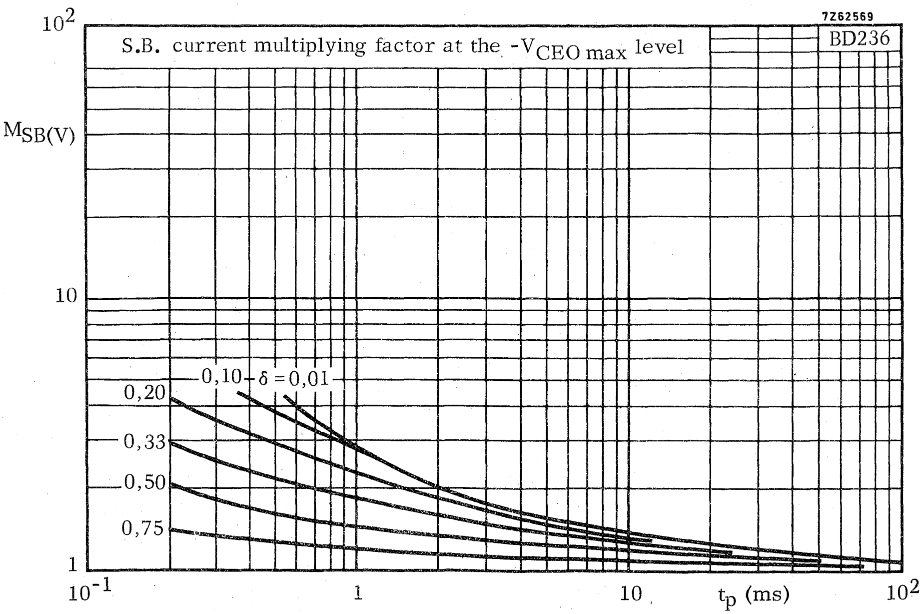
II Permissible extension for repetitive pulse operation

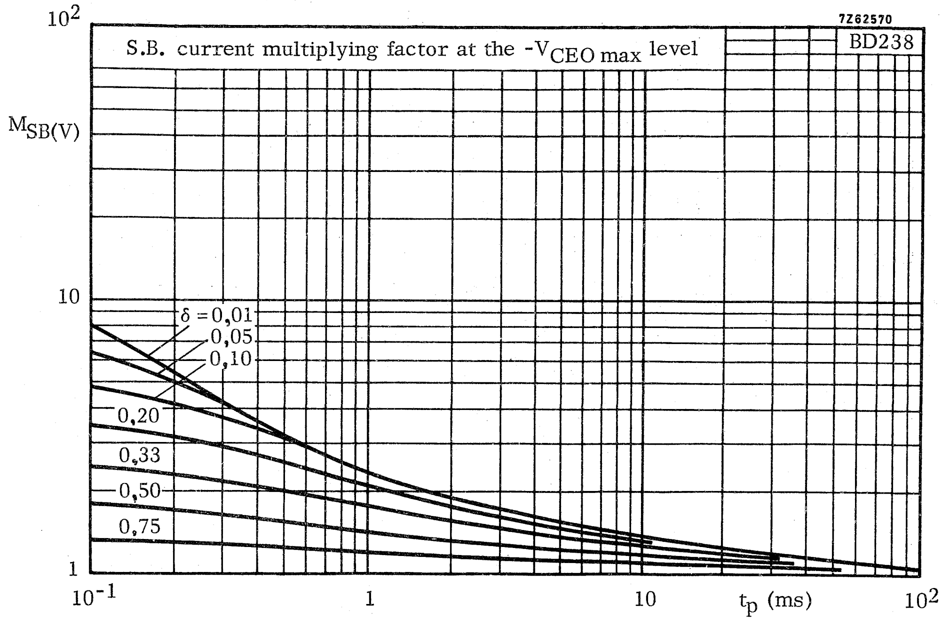
1) Independent of temperature.

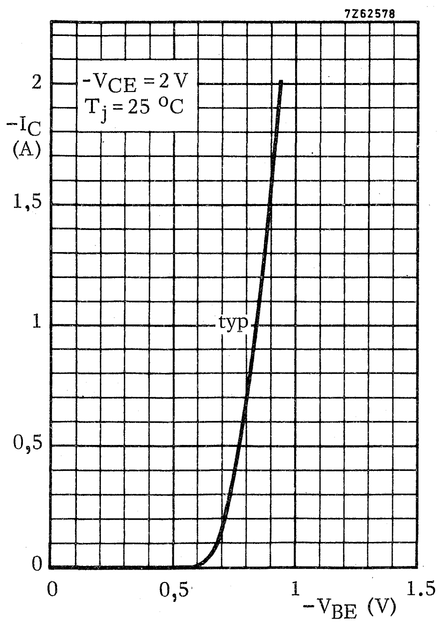

7Z62567
$Z_{th\ j\text{-}mb}$ (°C/W)
δ = 1
0,75
0,50
0,33
0,20
0,10
0,05
0,02
0,01
0
tp
T
δ = tp/T
tp (ms)

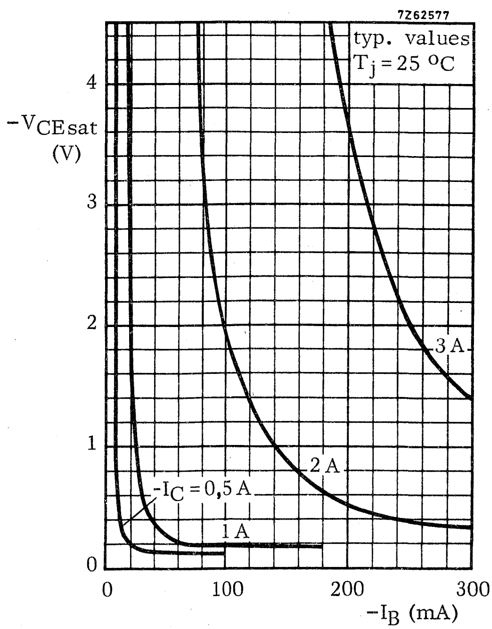

7Z62572
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
δ = 0,01
0,05
0,10
0,20
0,33
0,50
0,75
tp (ms)

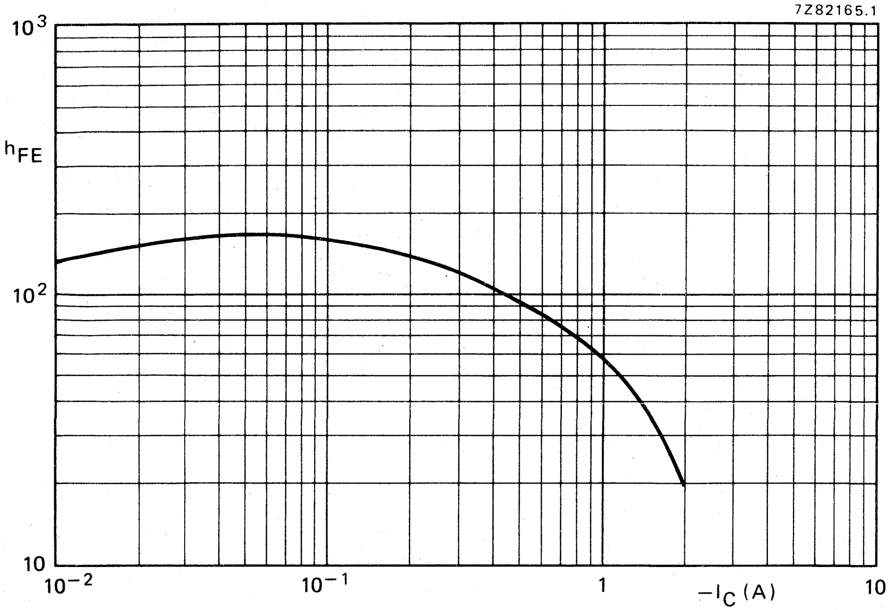

7Z62571
S.B. current multiplying factor at the $-V_{CEO\,max}$ level
BD234
$M_{SB(V)}$
10^2
10
1
0,20
0,10
δ = 0,01
0,33
0,50
0,75
10^{-1}
1
10
t_p (ms)
10^2


7Z62569
S.B. current multiplying factor at the $-V_{CEO\,max}$ level
BD236
$M_{SB(V)}$
10^2
10
1
0,10
δ = 0,01
0,20
0,33
0,50
0,75
10^{-1}
1
10
t_p (ms)
10^2


7Z62570
S.B. current multiplying factor at the $-V_{CEO\,max}$ level
BD238
$M_{SB(V)}$
10^2
10
1
δ = 0,01
0,05
0,10
0,20
0,33
0,50
0,75
10^{-1}
1
10
t_p (ms)
10^2


7Z62578
$-V_{CE}$ = 2 V
T_j = 25 °C
$-I_C$ (A)
2
1,5
1
0,5
0
typ
0
0,5
1
1.5
$-V_{BE}$ (V)


7Z62577
typ. values
T_j = 25 °C
$-V_{CEsat}$ (V)
4
3
2
1
0
3 A
2 A
$-I_C$ = 0,5 A
1 A
0
100
200
300
$-I_B$ (mA)



Typical static forward current transfer ratio as a function of the collector current.
$-V_{CE} = 2$ V; $T_j \leq 25$ °C.

SILICON EPITAXIAL-BASE POWER TRANSISTORS

General purpose n-p-n transistors in plastic SOT-82 envelopes for clip mounting; can also be soldered or adhesive mounted into a hybrid circuit. Recommended for use with p-n-p complements BD292, 294 and 296 in class-B output stages. In a hi-fi circuit the combinations can deliver 20 W into 4 Ω or 8 Ω load. Matched pairs can be supplied.

QUICK REFERENCE DATA

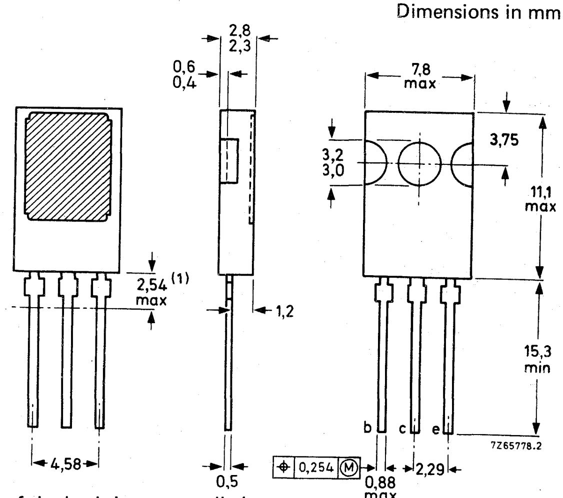
			BD291	BD293	BD295	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	80	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Collector-current (d.c.)	I_C	max.		6		A
Collector-current (peak) $t_p < 10$ ms; $\delta < 0{,}1$	I_{CM}	max.		10		A
Base current (d.c.)	I_B	max.		2,5		A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot}	max.		60		W
D.C. current gain $I_C = 1$ A; $V_{CE} = 2$ V	h_{FE}	>		30		
Transition frequency $I_C = 300$ mA; $V_{CE} = 3$ V	f_T	>		3		MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT-82.

Collector connected to metal part of mounting surface



(1) Within this region the cross-section of the leads is uncontrolled.

See also chapters Mounting Instructions and Accessories.

RATINGS

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

			BD291	BD293	BD295	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	80	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Emitter-base voltage	V_{EBO}	max.	5	5	5	V
Collector current (d.c.)	I_C	max.		6		A
Collector current (peak value) $t_p < 10$ ms; $\delta < 0,1$	I_{CM}	max.		10		A
Base current (d.c.)	I_B	max.		2,5		A
Emitter current (d.c.)	$-I_E$	max.		6		A
Total power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.		60		W
Storage temperature	T_{stg}			–65 to + 150		^oC
Junction temperature	T_j	max.		150		^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	100	$^oC/W$
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2,08	$^oC/W$

CHARACTERISTICS

$T_j = 25\ ^oC$ unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 40$ V; $T_j = 150\ ^oC$	I_{CBO}	<	1	mA
$I_B = 0$; $V_{CE} = 30$ V	I_{CEO}	<	1	mA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	5	mA
Collector-emitter saturation voltage				
$I_C = 3$ A; $I_B = 0,3$ A	V_{CEsat}	<	1	V
Base-emitter voltage*				
$I_C = 3$ A; $V_{CE} = 3$ V	V_{BE}	<	1,5	V
D.C. current gain**				
$I_C = 1$ A; $V_{CE} = 2$ V $I_C = 2$ A; $V_{CE} = 2$ V : BD293 : BD295 $I_C = 3$ A; $V_{CE} = 2$ V : BD291	h_{FE}	>	30	
Transition frequency at f = 1 MHz				
$I_C = 300$ mA; $V_{CE} = 3$ V	f_T	>	3	MHz
D.C. current gain ratio of matched complementary pairs				
$I_C = 1$ A; $V_{CE} = 2$ V	h_{FE1}/h_{FE2}	typ.	1,3	
		<	2,5	

* V_{BE} decreases by about 1,8 mV/^oC with increasing temperature.
** Measured under pulse conditions ; $t_p < 300\ \mu s$; $\delta < 2\%$.

SILICON EPITAXIAL-BASE POWER TRANSISTORS

General purpose p-n-p transistors in plastic SOT-82 envelopes for clip mounting; can also be soldered or adhesive mounted into a hybrid circuit. Recommended for use with n-p-n complements BD291, 293 and 295 in class-B output stages. In a hi-fi circuit the combinations can deliver 20 W into 4 Ω or 8 Ω load. Matched pairs can be supplied.

QUICK REFERENCE DATA

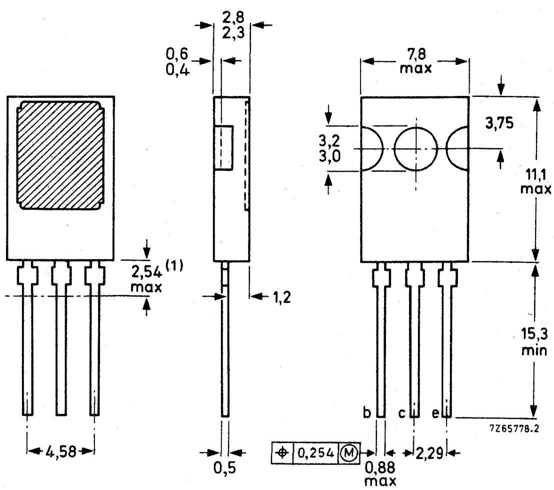
			BD292	BD294	BD296	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	80	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	V
Collector-current (d.c.)	$-I_C$	max.		6		A
Collector-current (peak) $t_p < 10$ ms; $\delta < 0,1$	$-I_{CM}$	max.		10		A
Base current (d.c.)	$-I_B$	max.		2,5		A
Total power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.		60		W
D.C. current gain $-I_C = 1$ A; $-V_{CE} = 2$ V	h_{FE}	>		30		
Transition frequency $-I_C = 300$ mA; $-V_{CE} = 3$ V	f_T	>		3		MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT-82.

Collector connected to metal part of mounting surface.



(1) Within this region the cross-section of the leads is uncontrolled.

See also chapters Mounting Instructions and Accessories.

RATINGS

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

			BD292	BD294	BD296	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	80	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	V
Emitter-base voltage	$-V_{EBO}$	max.	5	5	5	V
Collector current (d.c.)	$-I_C$	max.		6		A
Collector current (peak value) $t_p < 10$ ms; $\delta < 0{,}1$	$-I_{CM}$	max.		10		A
Base current (d.c.)	$-I_B$	max.		2,5		A
Emitter current (d.c.)	I_E	max.		6		A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot}	max.		60		W
Storage temperature	T_{stg}			−65 to + 150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	100	°C/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2,08	°C/W

CHARACTERISTICS

$T_j = 25$ °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $-V_{CB} = 40$ V; $T_j = 150$ °C	$-I_{CBO}$	<	1	mA
$I_B = 0$; $-V_{CE} = 30$ V	$-I_{CEO}$	<	1	mA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	5	mA
Collector-emitter saturation voltage				
$-I_C = 3$ A; $-I_B = 0{,}3$ A	$-V_{CEsat}$	<	1	V
Base-emitter voltage *				
$-I_C = 3$ A; $-V_{CE} = 2$ V	$-V_{BE}$	<	1,5	V
D.C. current gain **				
$-I_C = 1$ A; $-V_{CE} = 2$ V	h_{FE}	>	30	
$-I_C = 2$ A; $-V_{CE} = 2$ V: BD294; BD296	h_{FE}	>	30	
$-I_C = 3$ A; $-V_{CE} = 2$ V: BD292	h_{FE}	>	30	
Transition frequency at f = 1 MHz				
$-I_C = 300$ mA: $-V_{CE} = 3$ V	f_T	>	3	MHz
D.C. current gain ratio of matched complementary pairs				
$-I_C = 1$ A; $-V_{CE} = 2$ V	h_{FE1}/h_{FE2}	typ.	1,3	
		<	2,5	

* V_{BE} decreases by about 1,8 mV/°C with increasing temperature.
** Measured under pulse conditions; $t_p < 300$ μs, $\delta < 2\%$.

SILICON PLANAR EPITAXIAL POWER TRANSISTOR

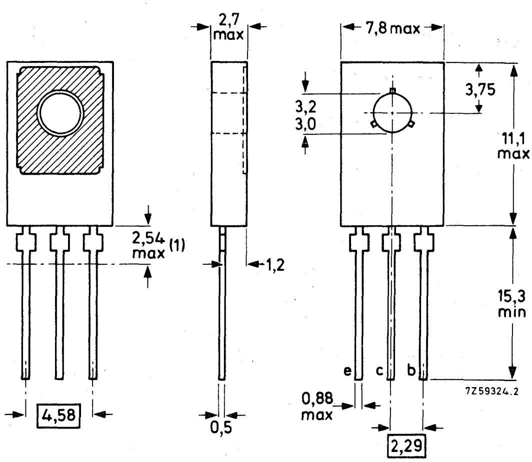
N-P-N transistor in a SOT-32 plastic envelope intended for car-radio output stages. P-N-P complement is BD330. Matched pairs can be supplied.

QUICK REFERENCE DATA				
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	32	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Collector current (peak value)	I_{CM}	max.	3	A
Total power dissipation up to T_{mb} = 45 °C	P_{tot}	max.	15	W
Junction temperature	T_j	max.	150	°C
D.C. current gain I_C = 0,5 A; V_{CE} = 1 V	h_{FE}		85 to 375	
Transition frequency I_C = 50 mA; V_{CE} = 5 V	f_T	typ.	130	MHz

MECHANICAL DATA Dimensions in mm

TO-126 (SOT-32)

Collector connected to metal part of mounting surface



For mounting instructions see section Accessories, type 56326 for non-insulated mounting and set 56333 for insulated mounting.

1) Within this region the cross-section of the leads is uncontrolled.

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

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	32	V
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	32	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V

Currents

Collector current (d.c.)	I_C	max.	3	A
Collector current (peak value)	I_{CM}	max.	3	A
Base current (d.c.)	I_B	max.	1	A
Emitter current (d.c.)	$-I_E$	max.	3	A

Power dissipation

Total power dissipation up to T_{mb} = 45 °C	P_{tot}	max.	15	W

Temperatures

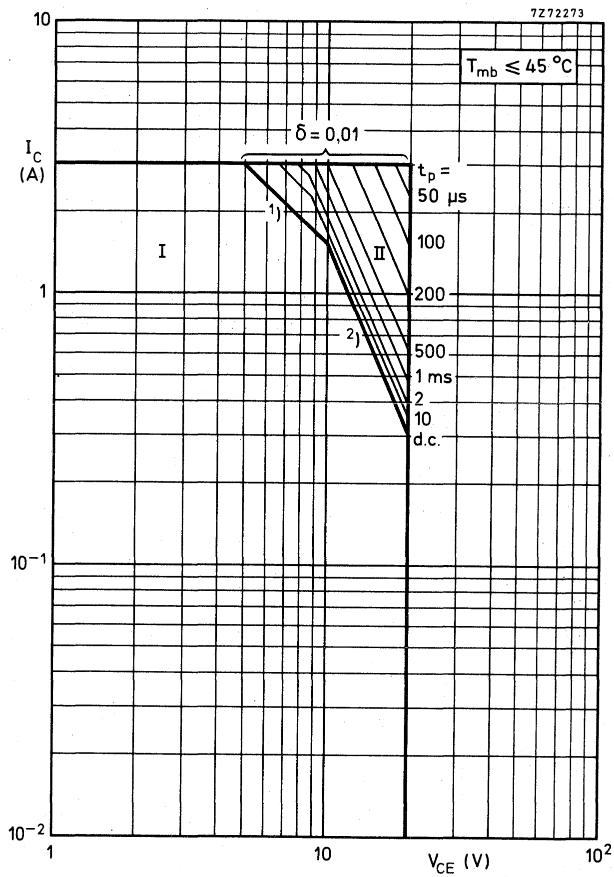
Storage temperature	T_{stg}		− 65 to +150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	7	°C/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	100	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current				
I_E = 0; V_{CB} = 32 V	I_{CBO}	<	10	μA
I_E = 0; V_{CB} = 32 V; T_j = 150 °C	I_{CBO}	<	1	mA
Emitter cut-off current				
I_C = 0; V_{EB} = 5 V	I_{EBO}	<	10	μA
Base-emitter voltage				
I_C = 5 mA; V_{CE} = 10 V	V_{BE}	typ.	0,6	V
I_C = 2 A; V_{CE} = 1 V	V_{BE}	<	1,2	V
Collector-emitter saturation voltage				
I_C = 2 A; I_B = 0,2 A	V_{CEsat}	<	0,5	V
D.C. current gain				
I_C = 5 mA; V_{CE} = 10 V	h_{FE}	>	50	
I_C = 0,5 A; V_{CE} = 1 V	h_{FE}		85 to 375	
I_C = 2 A; V_{CE} = 1 V	h_{FE}	>	40	
Transition frequency at f = 35 MHz				
I_C = 50 mA; V_{CE} = 5 V	f_T	typ.	130	MHz
D.C. current gain ratio of matched pairs				
BD329/BD330				
$\lvert I_C \rvert$ = 0,5 A; $\lvert V_{CE} \rvert$ = 1 V	h_{FE1}/h_{FE2}	<	1,6	

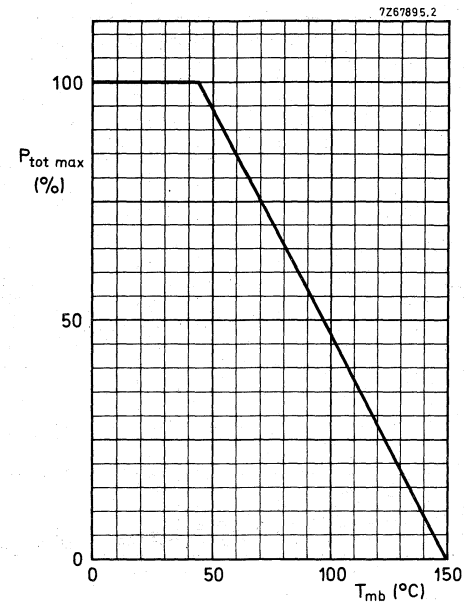


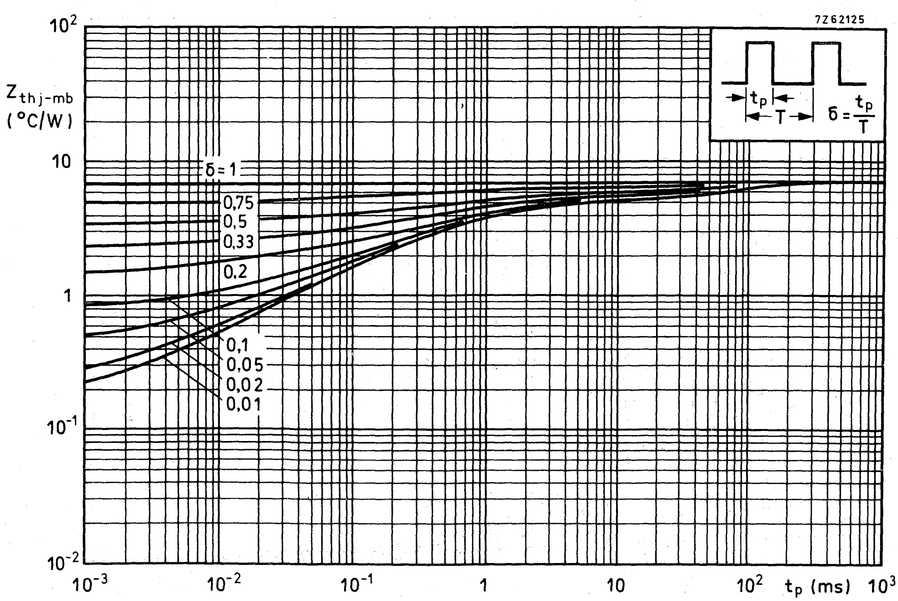
Safe Operating ARea with the transistor forward biased

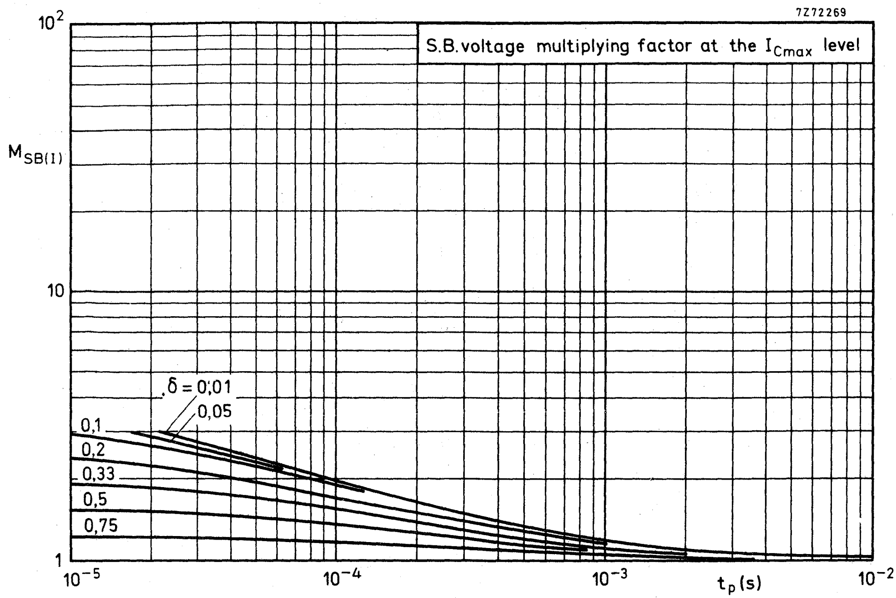
I Region of permissible d.c. operation
II Permissible extension for repetive pulse operation

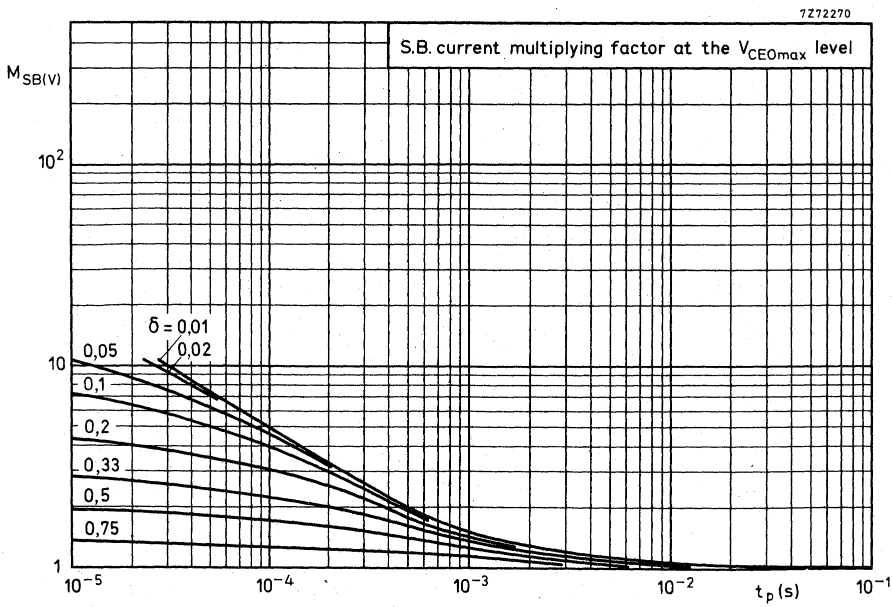
---

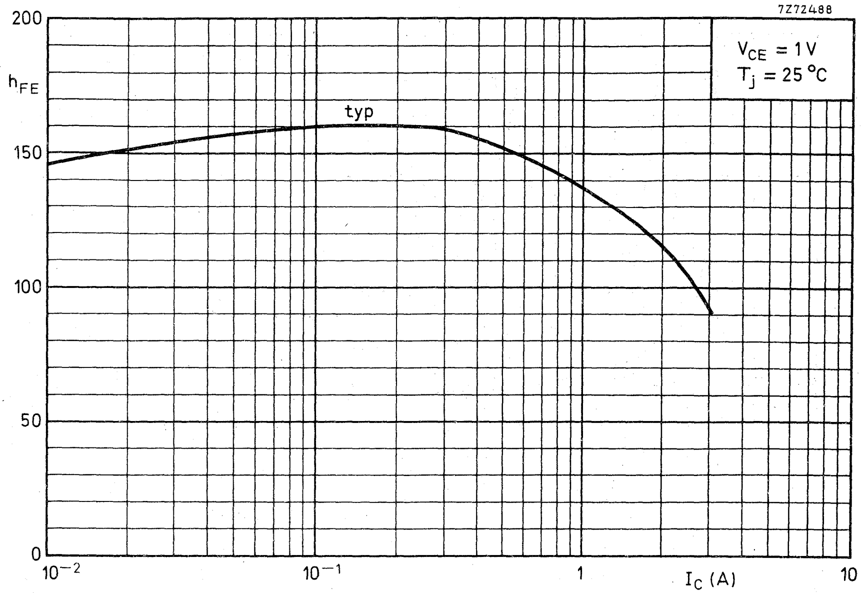
1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.
2) Second-breakdown limits (independent of temperature).

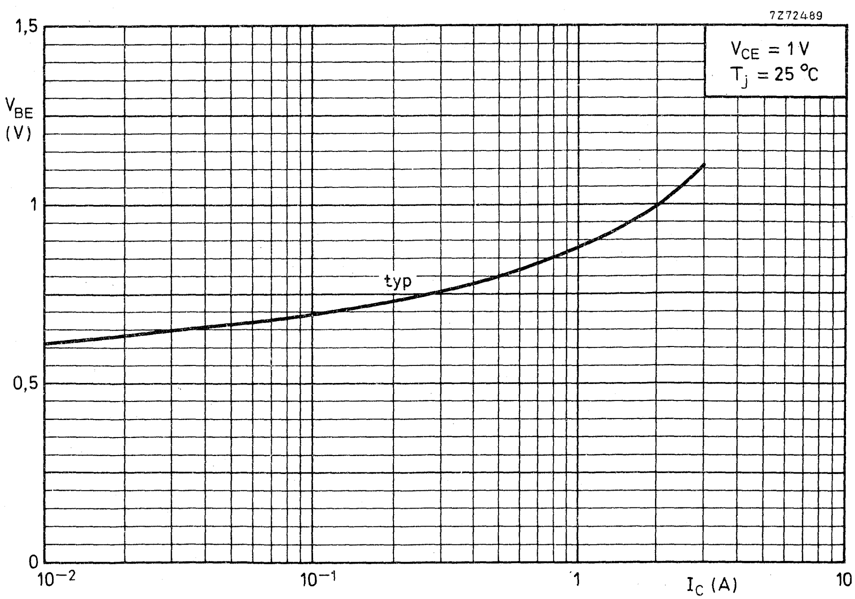

7Z67895.2
100
50
0
$P_{tot\ max}$
(%)
0
50
100
150
T_{mb} (°C)

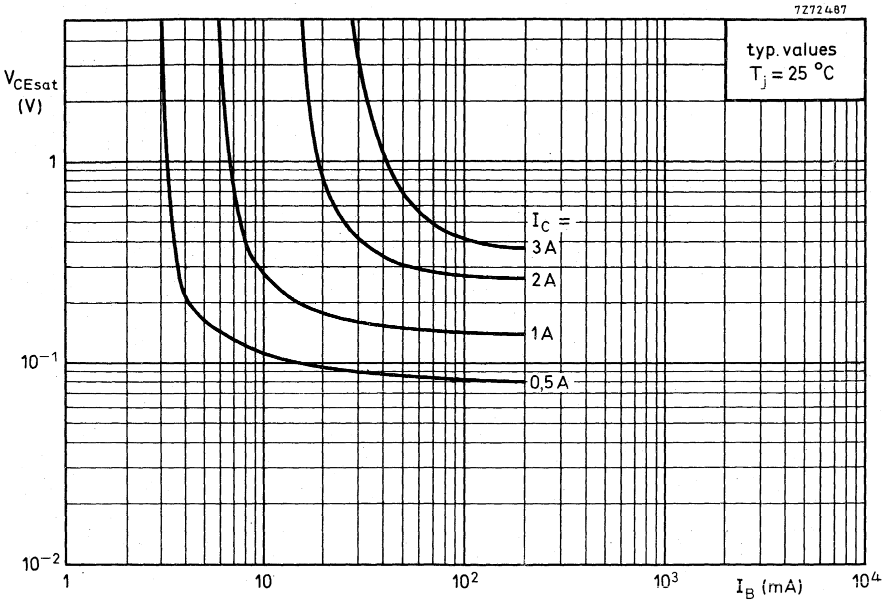

7Z62125
10^2
10
1
10^{-1}
10^{-2}
$Z_{th\ j-mb}$
(°C/W)
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3


7Z72269
S.B. voltage multiplying factor at the I_{Cmax} level
$M_{SB(I)}$
10^2
10
1
δ = 0,01
0,05
0,1
0,2
0,33
0,5
0,75
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}


7Z72270
S.B. current multiplying factor at the V_{CEOmax} level
$M_{SB(V)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-5}
10^{-4}
10^{-3}
10^{-2}
t_p (s)
10^{-1}


7Z72488
200
h_{FE}
150
100
50
0
typ
V_{CE} = 1 V
T_j = 25 °C
10^{-2}
10^{-1}
1
I_C (A)
10


7Z72489
1,5
V_{BE}
(V)
1
0,5
0
typ
V_{CE} = 1 V
T_j = 25 °C
10^{-2}
10^{-1}
1
I_C (A)
10


7Z72487
typ. values
T_j = 25 °C
V_{CEsat}
(V)
1
10^{-1}
10^{-2}
I_C =
3 A
2 A
1 A
0,5 A
1
10
10^2
10^3
I_B (mA)
10^4

SILICON PLANAR EPITAXIAL POWER TRANSISTOR

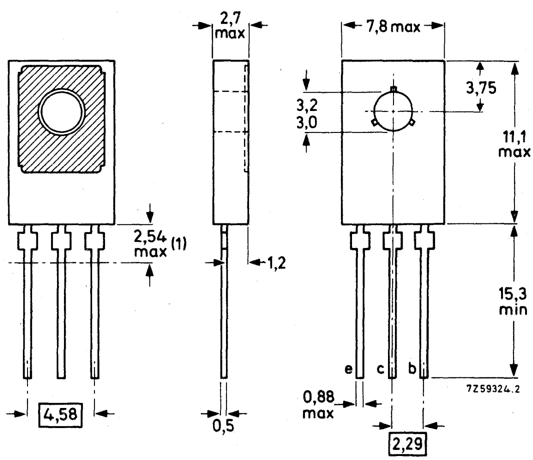
P-N-P transistor in a SOT-32 plastic envelope intended for car-radio output stages. N-P-N complement is BD329. Matched pairs can be supplied.

QUICK REFERENCE DATA				
Collector-emitter voltage (V_{BE} = 0)	$-V_{CES}$	max.	32	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20	V
Collector current (peak value)	$-I_{CM}$	max.	3	A
Total power dissipation up to T_{mb} = 45 °C	P_{tot}	max.	15	W
Junction temperature	T_j	max.	150	°C
D.C. current gain $-I_C$ = 0,5 A; $-V_{CE}$ = 1 V	h_{FE}		85 to 375	
Transition frequency $-I_C$ = 50 mA; $-V_{CE}$ = 5 V	f_T	typ.	100	MHz

MECHANICAL DATA Dimensions in mm

TO-126 (SOT-32)

Collector connected to metal part of mounting surface



For mounting instructions see section Accessories, type 56326 for non-insulated mounting and set 56333 for insulated mounting.

[1]) Within this region the cross-section of the leads is uncontrolled.

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

Voltages

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	32	V
Collector-emitter voltage (V_{BE} = 0)	$-V_{CES}$	max.	32	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	V

Currents

Collector current (d.c.)	$-I_C$	max.	3	A
Collector current (peak value)	$-I_{CM}$	max.	3	A
Base current (d.c.)	$-I_B$	max.	1	A
Emitter current (d.c.)	I_E	max.	3	A

Power dissipation

Total power dissipation up to T_{mb} = 45 ^oC	P_{tot}	max.	15	W

Temperatures

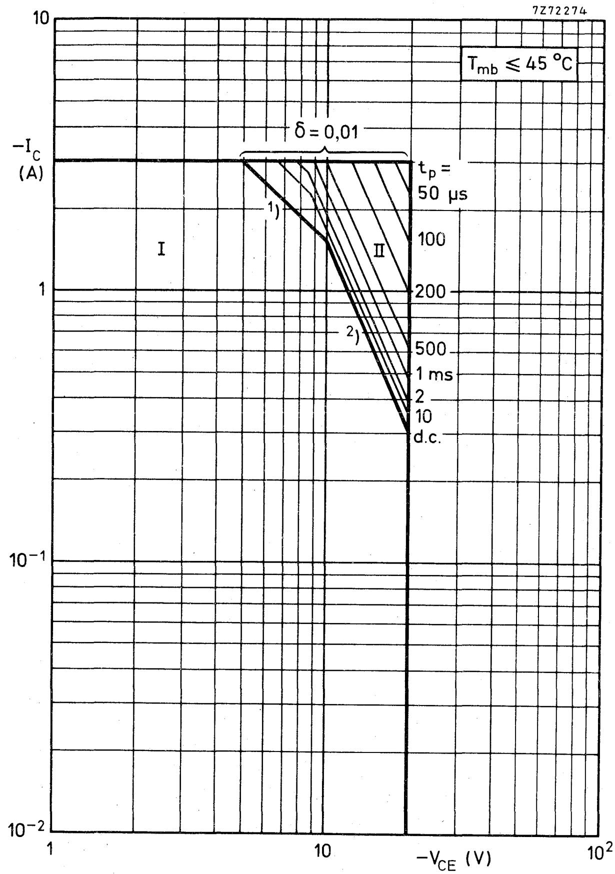
Storage temperature	T_{stg}		− 65 to +150	^oC
Junction temperature	T_j	max.	150	^oC

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=	7	$^oC/W$
From junction to ambient in free air	$R_{th\ j-a}$	=	100	$^oC/W$

CHARACTERISTICS $T_j = 25\ ^oC$ unless otherwise specified

Collector cut-off current				
$I_E = 0;\ -V_{CB} = 32$ V	$-I_{CBO}$	<	10	μA
$I_E = 0;\ -V_{CB} = 32$ V; $T_j = 150\ ^oC$	$-I_{CBO}$	<	1	mA
Emitter cut-off current				
$I_C = 0;\ -V_{EB} = 5$ V	$-I_{EBO}$	<	10	μA
Base-emitter voltage				
$-I_C = 5$ mA; $-V_{CE} = 10$ V	$-V_{BE}$	typ.	0,6	V
$-I_C = 2$ A; $-V_{CE} = 1$ V	$-V_{BE}$	<	1,2	V
Collector-emitter saturation voltage				
$-I_C = 2$ A; $-I_B = 0,2$ A	$-V_{CEsat}$	<	0,5	V
D.C. current gain				
$-I_C = 5$ mA; $-V_{CE} = 10$ V	h_{FE}	>	50	
$-I_C = 0,5$ A; $-V_{CE} = 1$ V	h_{FE}		85 to 375	
$-I_C = 2$ A; $-V_{CE} = 1$ V	h_{FE}	>	40	
Transition frequency at f = 35 MHz				
$-I_C = 50$ mA; $-V_{CE} = 5$ V	f_T	typ.	100	MHz
D.C. current gain ratio of matched pairs				
BD329/BD330				
$\|I_C\| = 0,5$ A; $\|V_{CE}\| = 1$ V	h_{FE1}/h_{FE2}	<	1,6	

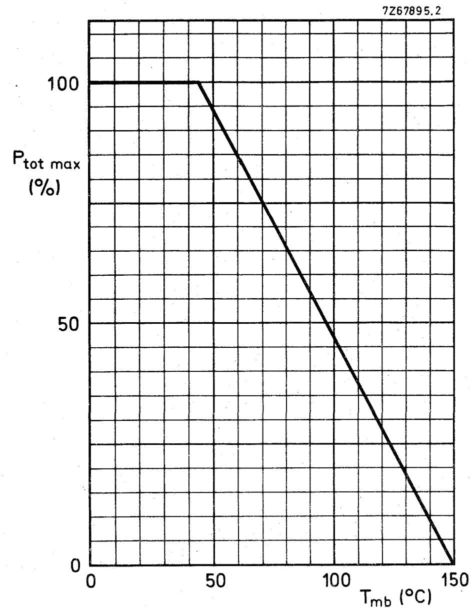


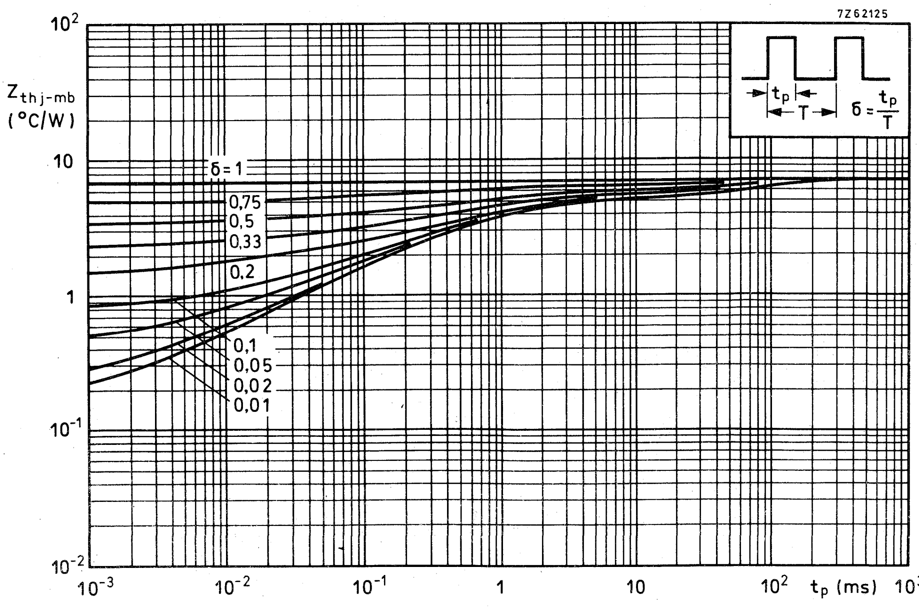
Safe Operating ARea with the transistor forward biased

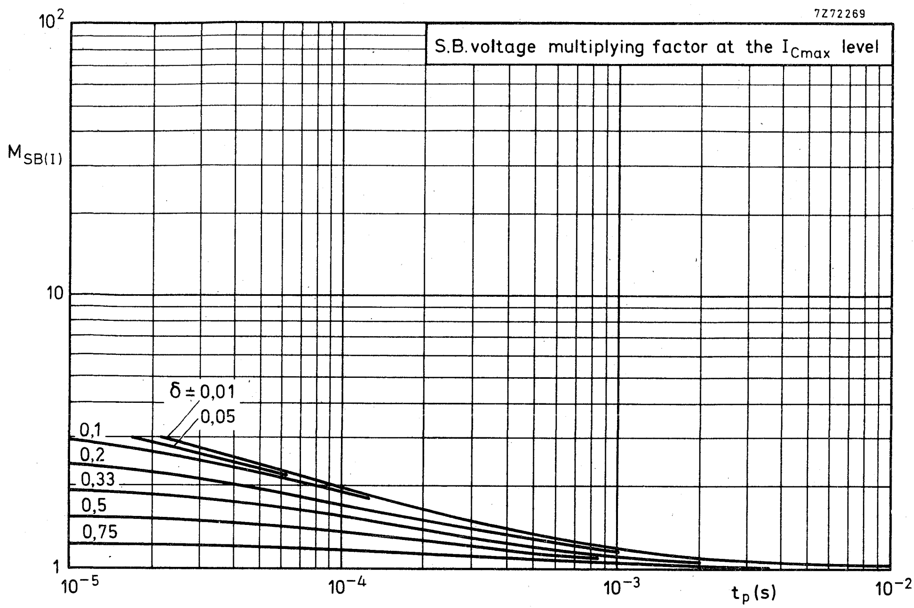
I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation

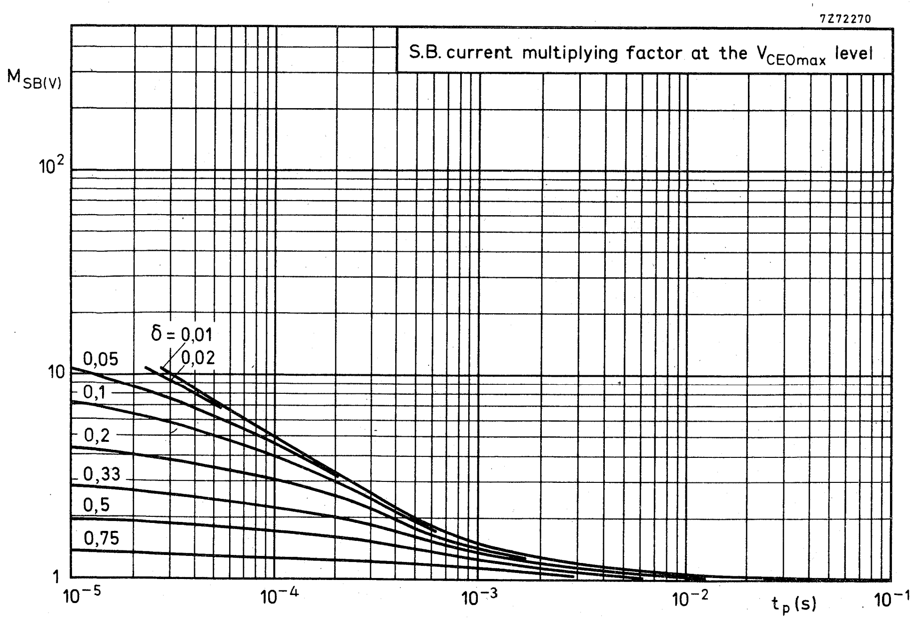
[1]) $P_{tot\ max}$ and $P_{peak\ max}$ lines.

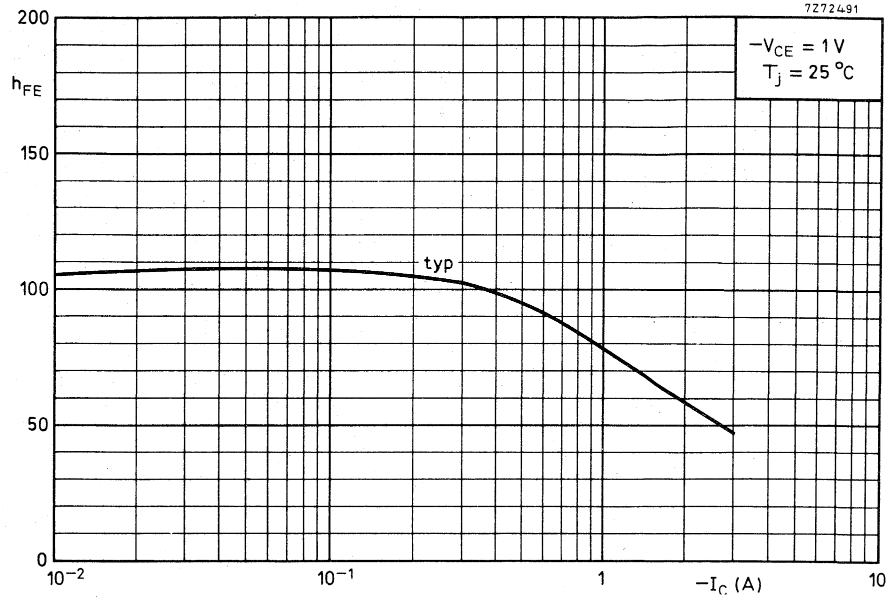
[2]) Second-breakdown limits (independent of temperature).

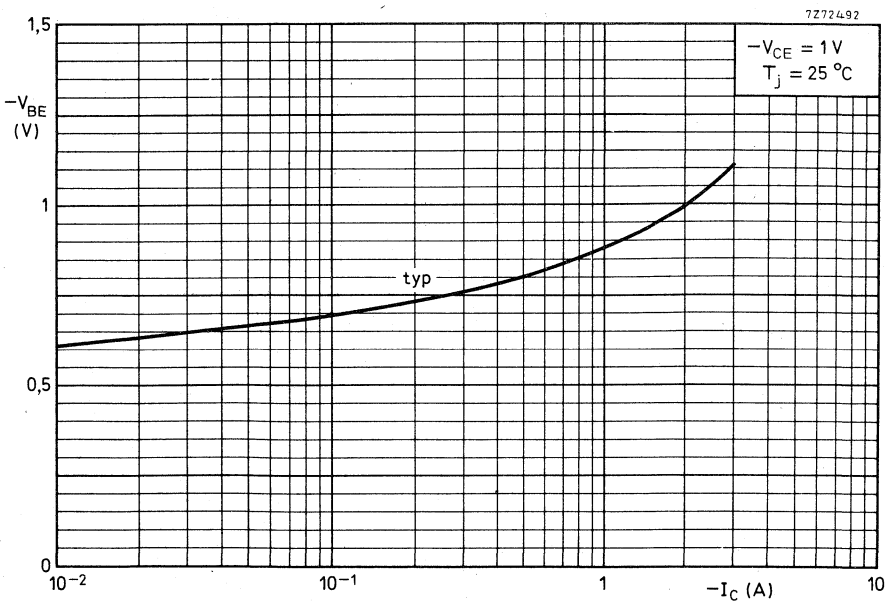

7Z67895.2
100
50
0
$P_{tot\ max}$
(%)
0
50
100
150
T_{mb} (°C)

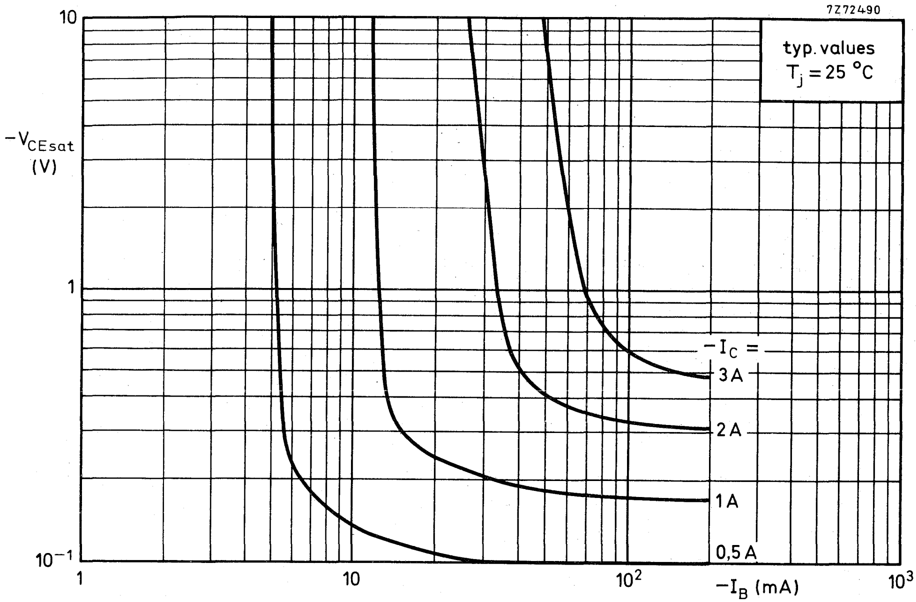

7Z62125
10^2
$Z_{th\ j-mb}$
(°C/W)
10
1
10^{-1}
10^{-2}
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3


7Z72269
S.B. voltage multiplying factor at the I_{Cmax} level
10^2
$M_{SB(I)}$
10
1
δ = 0,01
0,05
0,1
0,2
0,33
0,5
0,75
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}


7Z72270
S.B. current multiplying factor at the V_{CEOmax} level
$M_{SB(V)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-5}
10^{-4}
10^{-3}
10^{-2}
t_p (s)
10^{-1}


7Z72491
$-V_{CE}$ = 1 V
T_j = 25 °C
h_{FE}
200
150
100
50
0
typ
10^{-2}
10^{-1}
1
10
$-I_C$ (A)


7Z72492
$-V_{CE}$ = 1 V
T_j = 25 °C
$-V_{BE}$ (V)
1,5
1
0,5
0
typ
10^{-2}
10^{-1}
1
10
$-I_C$ (A)


7Z72490
typ. values
$T_j = 25\ ^\circ C$
$-V_{CEsat}$ (V)
10
1
10^{-1}
1
10
10^2
10^3
$-I_B$ (mA)
$-I_C =$
3 A
2 A
1 A
0,5 A

SILICON DARLINGTON POWER TRANSISTORS

N-P-N epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications; plastic SOT-82 envelope for clip mounting; can also be soldered or adhesive mounted into a hybrid circuit. P-N-P complements are BD332, BD334, BD336 and BD338.

QUICK REFERENCE DATA

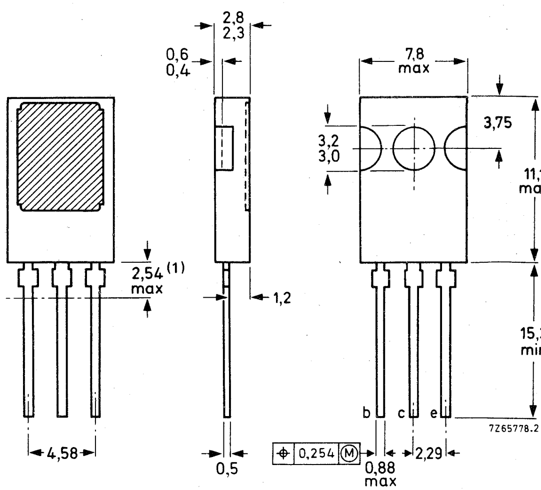
			BD331	333	335	337	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Collector-current (d.c.)	I_C	max.	6				A
Base current (d.c.)	I_B	max.	150				mA
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	60				W
Junction temperature	T_j	max.	150				°C
D.C. current gain I_C = 3,0 A; V_{CE} = 3 V	h_{FE}	>	750				

MECHANICAL DATA

Dimensions in mm

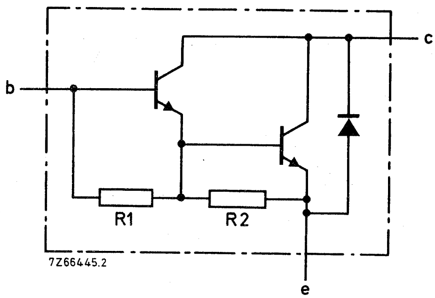
Fig. 1 SOT-82.

Collector connected to metal part of mounting surface



(1) Within this region the cross-section of the leads is uncontrolled.

See also chapters Mounting Instructions and Accessories.



R_1 typ. 4 kΩ
R_2 typ. 100 Ω

Fig. 2 Circuit diagram.

RATINGS

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

			BD331	333	335	337	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	5	V
Collector current (d.c.)	I_C	max.	6				A
Collector current (peak value) $t_p \leq 10$ ms; $\delta \leq 0{,}1$	I_{CM}	max.	10				A
Base current (d.c.)	I_B	max.	150				mA
Total power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.	60				W
Storage temperature	T_{stg}		−65 to + 150				^oC
Junction temperature *	T_j	max.	150				^oC

THERMAL RESISTANCE *

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2,08	$^oC/W$
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	100	$^oC/W$

* Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

CHARACTERISTICS

$T_j = 25\ ^oC$ unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	<	0,2	mA
$I_E = 0$; $V_{CB} = V_{CBOmax}$; $T_j = 150\ ^oC$	I_{CBO}	<	2	mA
$I_B = 0$; $V_{CE} = ½ V_{CEOmax}$	I_{CEO}	<	0,5	mA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	5	mA
D.C. current gain *				
$I_C = 0,5$ A; $V_{CE} = 3$ V	h_{FE}	typ.	1900	←
$I_C = 3$ A; $V_{CE} = 3$ V	h_{FE}	>	750	
$I_C = 6$ A; $V_{CE} = 3$ V	h_{FE}	typ.	3000	←
Base-emitter voltage **				
$I_C = 3$ A; $V_{CE} = 3$ V	V_{BE}	<	2,5	V
Collector-emitter saturation voltage				
$I_C = 3$ A; $I_B = 12$ mA	V_{CEsat}	<	2	V
Cut-off frequency				
$I_C = 3$ A; $V_{CE} = 3$ V	f_{hfe}	typ.	50	kHz
Turn-off breakdown energy with inductive load (see Fig. 12)				
$-I_{Boff} = 0$; $I_{Con} = 4,5$ A	$E_{(BR)}$	>	50	mJ
Diode forward voltage				
$I_F = 3$ A	V_F	typ.	1,8	V
D.C. current gain ratio of complementary matched pairs				
$I_C = 3$ A; $V_{CE} = 3$ V	h_{FE1}/h_{FE2}	<	2,5	
Small signal current gain				
$I_C = 3$ A; $V_{CE} = 3$ V; f = 1 MHz	h_{fe}	typ.	50	←
Second-breakdown collector current				
$V_{CE} = 60$ V; $t_p = 25$ ms	$I_{(SB)}$	>	1	A ←
Switching times ←				
(between 10% and 90% levels)				
$I_{Con} = 3$ A; $I_{Bon} = -I_{Boff} = 12$ mA				
Turn-on time	t_{on}	typ.	1	μs
		<	2	μs
Turn-off time	t_{off}	typ.	5	μs
		<	10	μs

* Measured under pulse conditions: $t_p < 300\ \mu s$, $\delta < 2\%$.

** V_{BE} decreases by about 3,8 mV/^oC with increasing temperature.

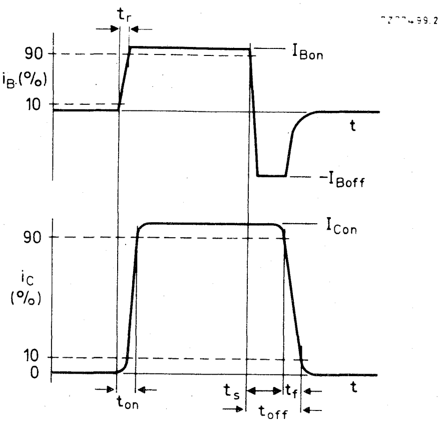
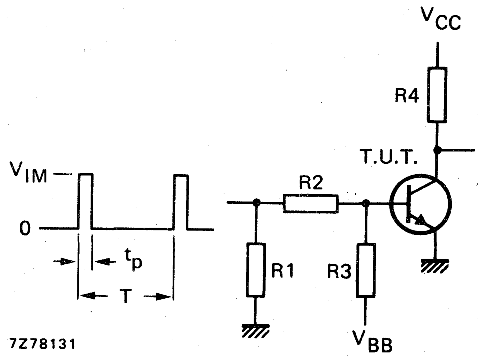
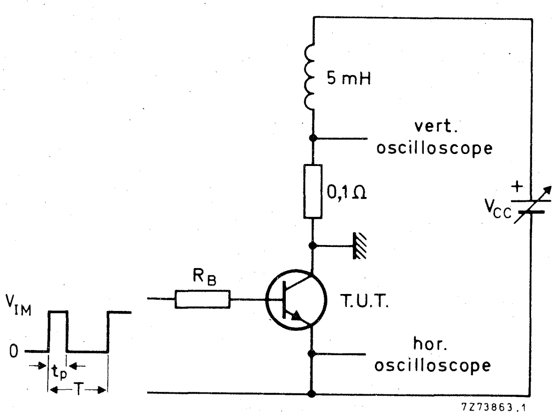


Fig. 3 Switching times waveforms.



V_{IM}	=	10 V
V_{CC}	=	10 V
$-V_{BB}$	=	4 V
R1	=	56 Ω
R2	=	410 Ω
R3	=	560 Ω
R4	=	3 Ω
$t_r = t_f$	=	15 ns
t_p	=	10 μs
T	=	500 μs

Fig. 4 Switching times test circuit.



V_{IM}	=	12 V
R_B	=	270 Ω
I_C	=	4,5 A
δ	=	1 %
t_p	=	1 ms

Fig. 5 Test circuit for turn-off breakdown energy.

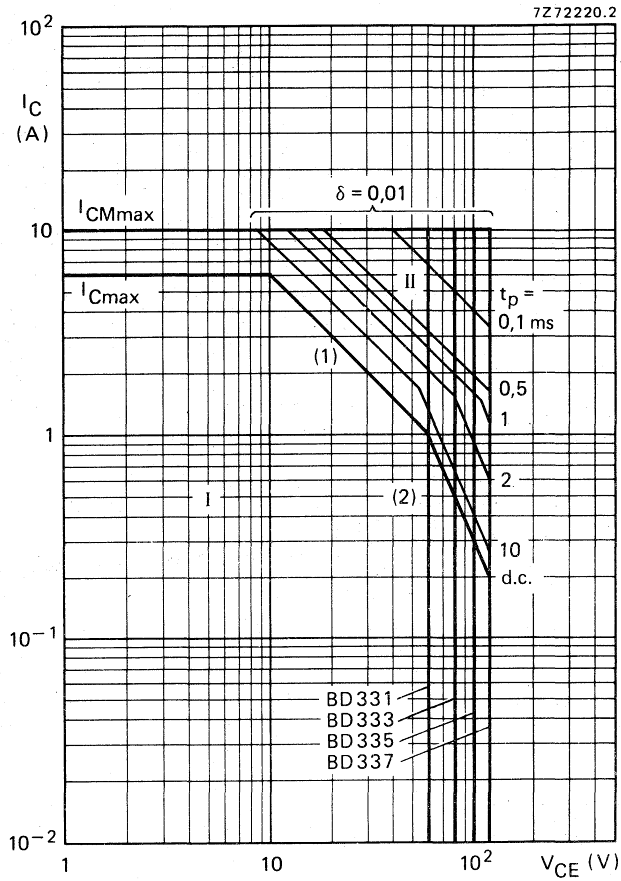


Fig. 6 Safe Operating ARea, $T_{mb} \leqslant 25\ ^oC$.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.

(2) Second-breakdown limits (independent of temperature).

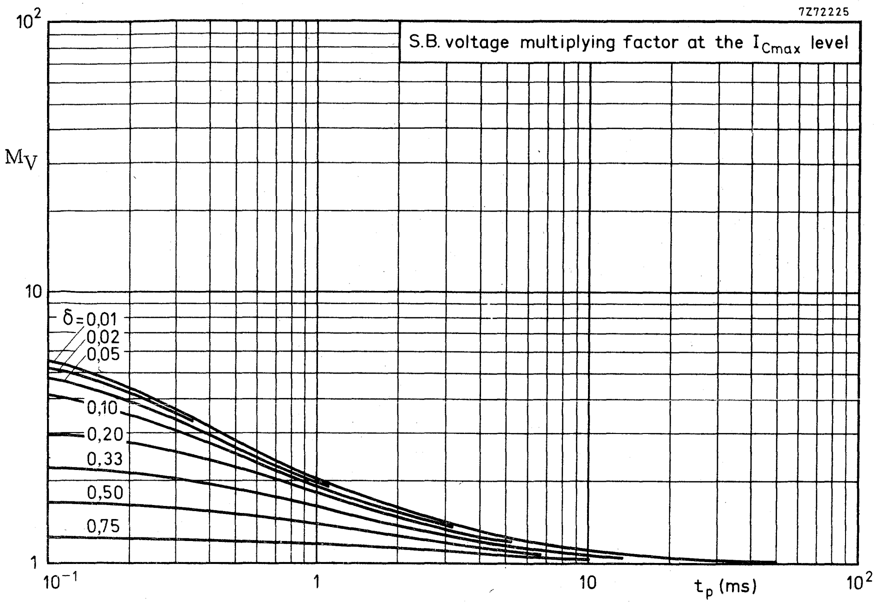


Fig. 7 Second breakdown voltage multiplying factor at I_{Cmax} level.

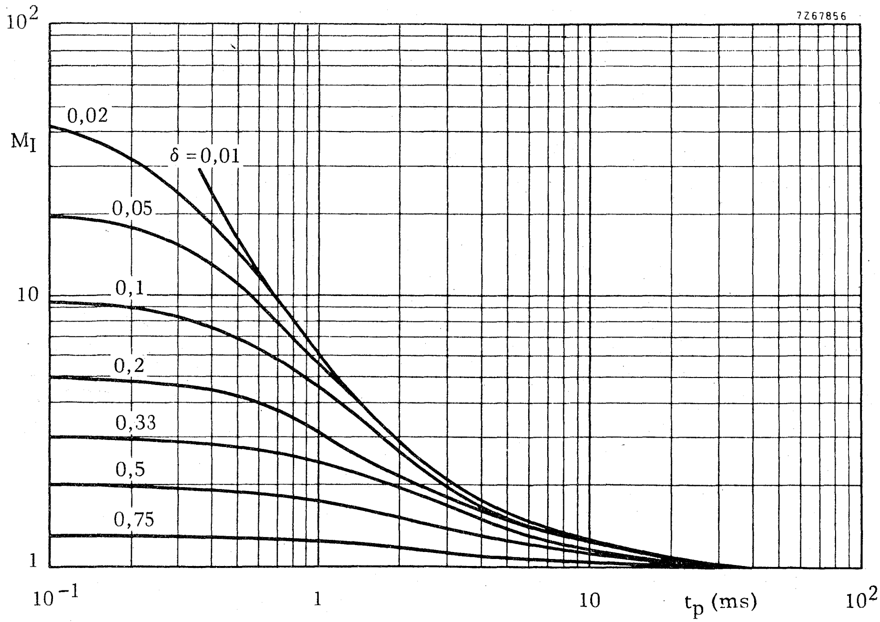


Fig. 8 Second breakdown current multiplying factor at V_{CEOmax} level.

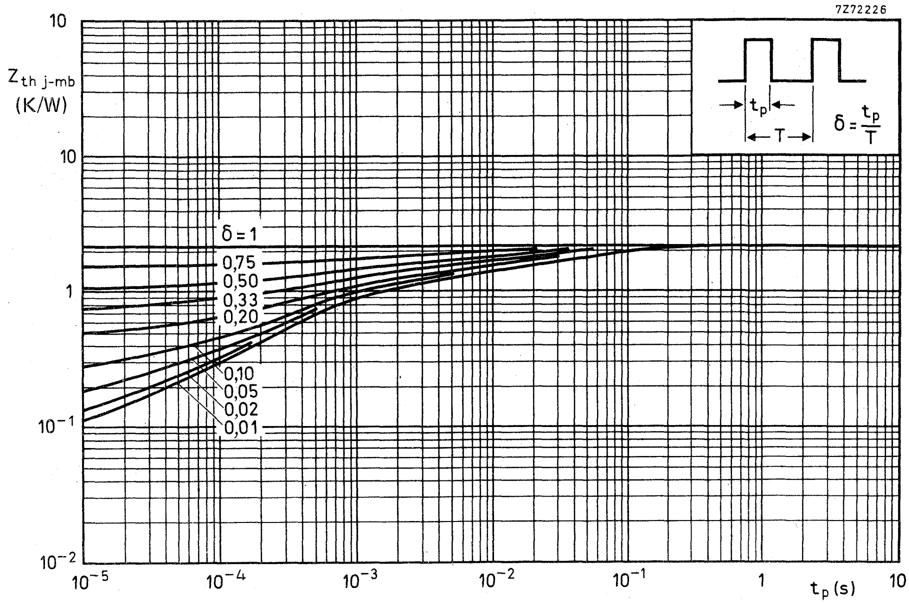


Fig. 9 Pulse power rating chart.

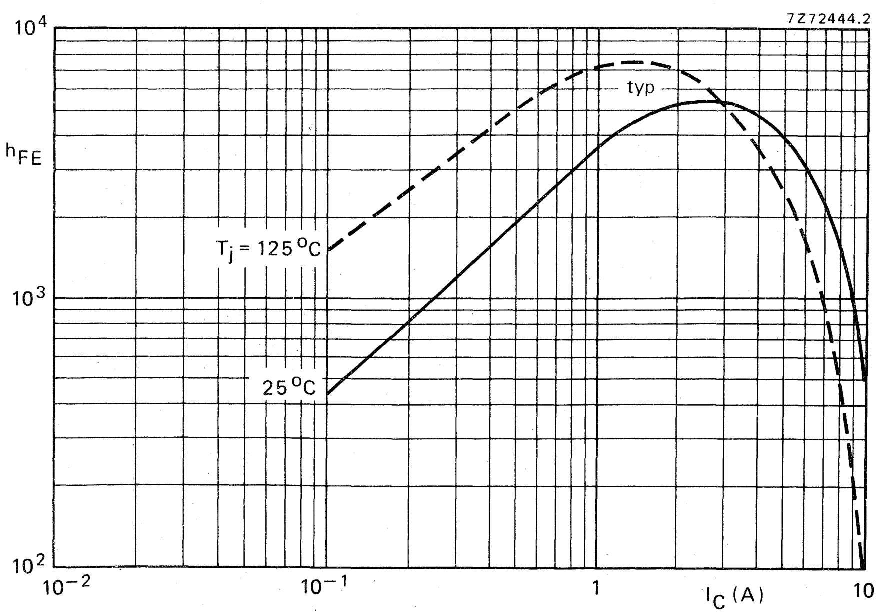


Fig. 10 D.C. current gain. V_{CE} = 3 V.

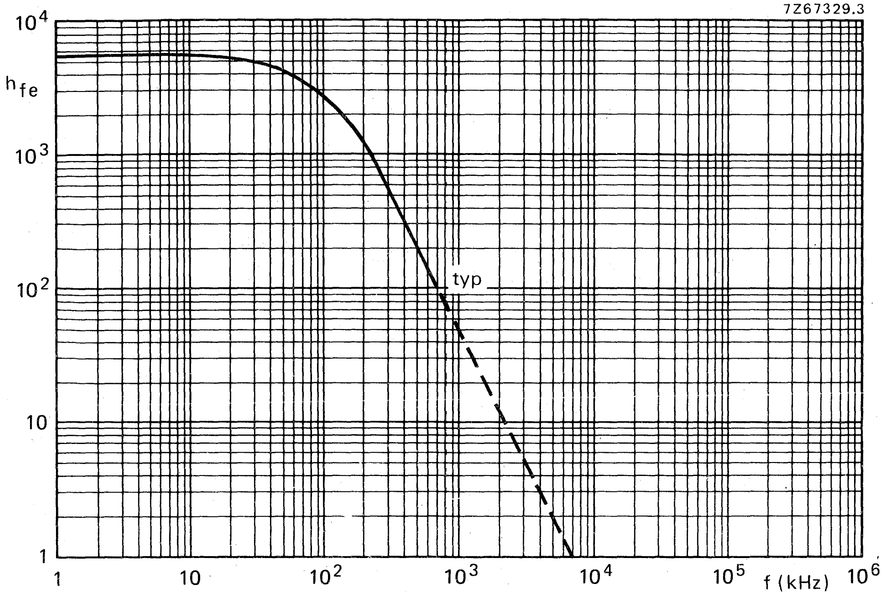


Fig. 11 Small signal current gain at I_C = 3 A; V_{CE} = 3 V.

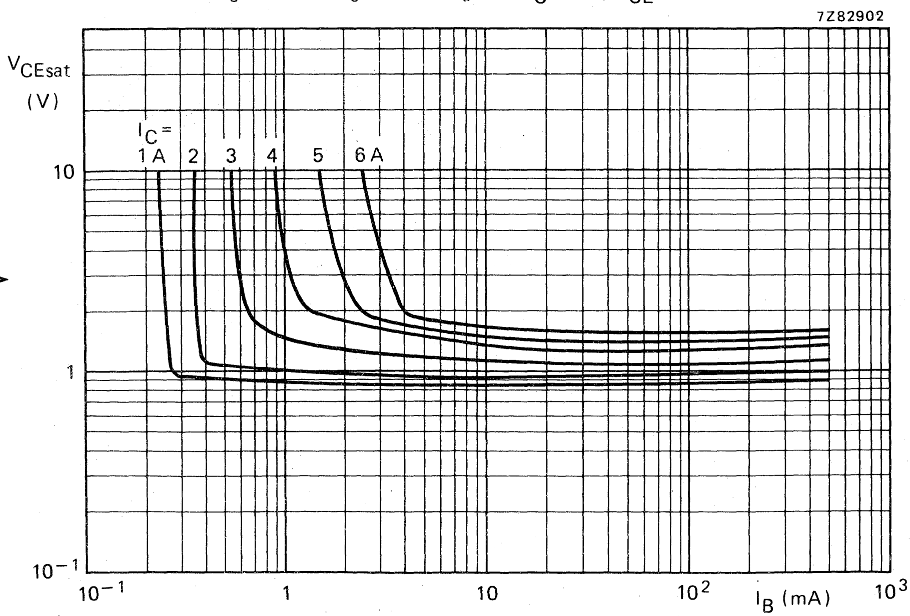


Fig. 12 Typical values collector-emitter saturation. T_j = 25 °C.

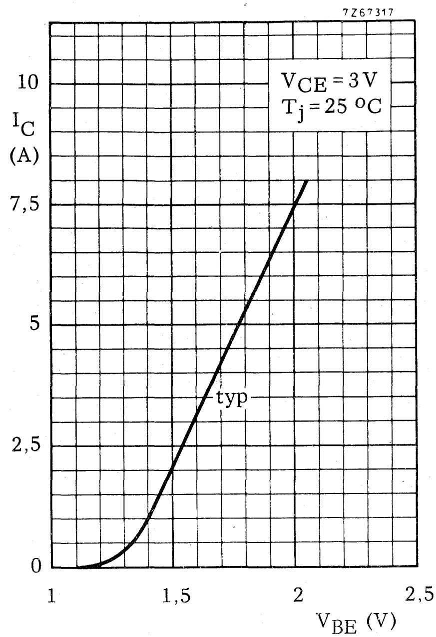


Fig. 13 Collector current.

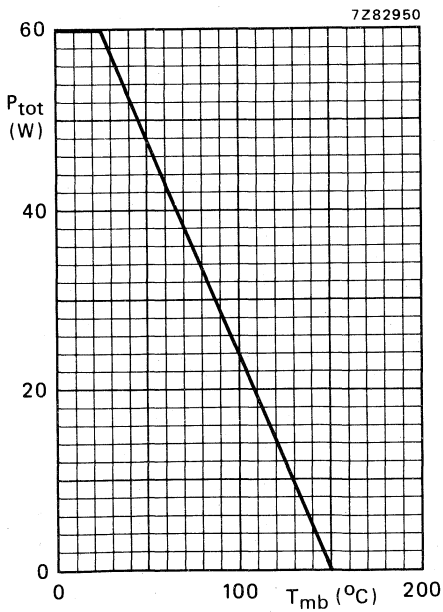


Fig. 14 Power derating curve.

SILICON DARLINGTON POWER TRANSISTORS

P-N-P epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications; plastic SOT-82 envelope for clip mounting; can also be soldered or adhesive mounted into a hybrid circuit. N-P-N complements are BD331, BD333, BD335 and BD337.

QUICK REFERENCE DATA

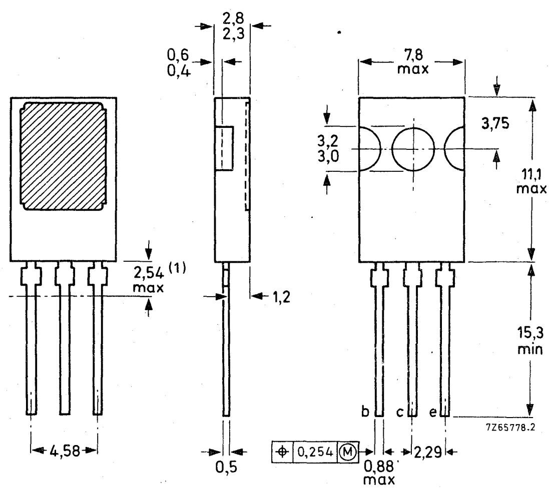
			BD332	334	336	338	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Collector-current (d.c.)	$-I_C$	max.	6				A
Base current (d.c.)	$-I_B$	max.	150				mA
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	60				W
Junction temperature	T_j	max.	150				°C
D.C. current gain $-I_C$ = 3,0 A; $-V_{CE}$ = 3 V	h_{FE}	>	750				

MECHANICAL DATA

Dimensions in mm

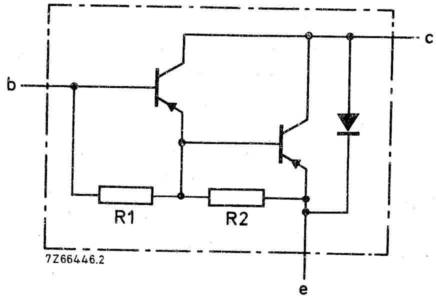
Fig. 1 SOT-82.

Collector connected to metal part of mounting surface.



(1) Within this region the cross-section of the leads is uncontrolled.

See also chapters Mounting instructions and Accessories.



R_1 typ. 4 kΩ
R_2 typ. 80 Ω

Fig. 2 Circuit diagram.

RATINGS

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

			BD332	334	336	338	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	5	V
Collector current (d.c.)	$-I_C$	max.	6				A
Collector current (peak value) $t_p \leqslant 10$ ms; $\delta \leqslant 0,1$	$-I_{CM}$	max.	10				A
Base current (d.c.)	$-I_B$	max.	150				mA
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot}	max.	60				W
Storage temperature	T_{stg}		−65 to + 150				°C
Junction temperature *	T_j	max.	150				°C

THERMAL RESISTANCE *

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2,08	°C/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	100	°C/W

* Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current					
$I_E = 0; -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	0,2	mA	
$I_E = 0; -V_{CB} = -V_{CBOmax}; T_j = 150$ °C	$-I_{CBO}$	<	2	mA	
$I_B = 0; -V_{CE} = -½ V_{CEO}$	$-I_{CEO}$	<	0,5	mA	
Emitter cut-off current					
$I_C = 0; -V_{EB} = 5$ V	$-I_{EBO}$	<	5	mA	
D.C. current gain *					
$-I_C = 0{,}5$ A; $-V_{CE} = 3$ V	h_{FE}	typ.	2700		←
$-I_C = 3$ A; $-V_{CE} = 3$ V	h_{FE}	>	750		
$-I_C = 6$ A; $-V_{CE} = 3$ V	h_{FE}	typ.	400		←
Base-emitter voltage **					
$-I_C = 3$ A; $-V_{CE} = 3$ V	$-V_{BE}$	<	2,5	V	
Collector-emitter saturation voltage					
$-I_C = 3$ A; $-I_B = 12$ mA	$-V_{CEsat}$	<	2	V	
Small signal current gain					
$-I_C = 3$ A; $-V_{CE} = 3$ V; f = 1 MHz	$\|h_{fe}\|$	typ.	150		←
Cut-off frequency					
$-I_C = 3$ A; $-V_{CE} = 3$ V	f_{hfe}	typ.	100	kHz	←
Diode, forward voltage					
$I_F = 3$ A	V_F	typ.	1,8	V	
D.C. current gain ratio of complementary matched pairs					
$-I_C = 3$ A; $-V_{CE} = 3$ V	h_{FE1}/h_{FE2}	<	2,5		
Second breakdown collector current non-repetitive; without heatsink					
$-V_{CE} = 60$ V; $t_p = 25$ ms	$-I_{(SB)}$	>	1	A	←
Switching times (see Figs 3 and 4)					
$-I_{Con} = 3$ A; $-I_{Bon} = I_{Boff} = 12$ mA					
turn-on time	t_{on}	typ.	1	μs	←
		<	2	μs	
turn-off time	t_{off}	typ.	5	μs	
		<	10	μs	

* Measured under pulse conditions: $t_p < 300$ μs, $\delta < 2\%$.
** V_{BE} decreases by about 3,8 mV/°C with increasing temperature.

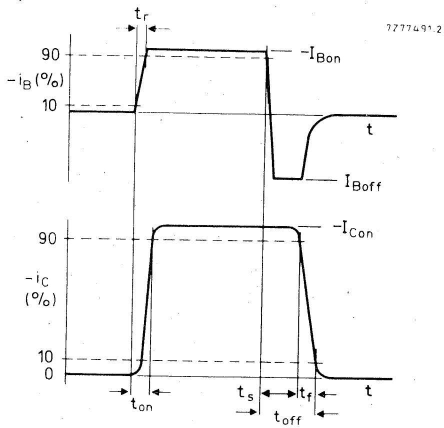
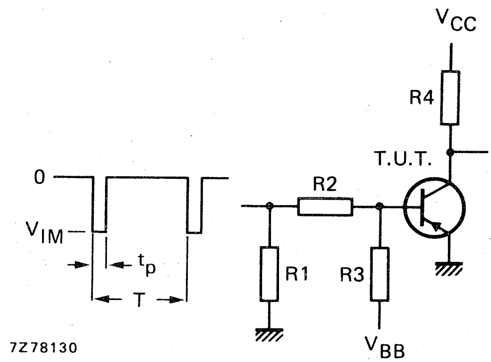


Fig. 3 Switching times waveforms.



$-V_{IM}$	=	10	V
$-V_{CC}$	=	10	V
V_{BB}	=	4	V
R1	=	56	Ω
R2	=	410	Ω
R3	=	560	Ω
R4	=	3	Ω
$t_r = t_f$	=	15	ns
t_p	=	10	μs
T	=	500	μs

Fig. 4 Switching times test circuit.

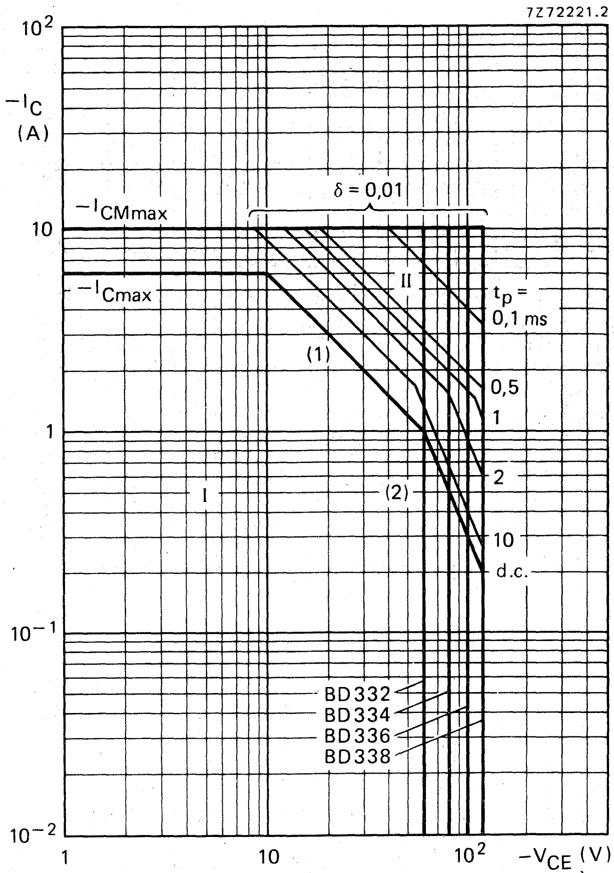


Fig. 5 Safe Operating Area with the transistor forward biased; T_{mb} = 25 °C.

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.

(2) Second breakdown limits (independent of temperature).

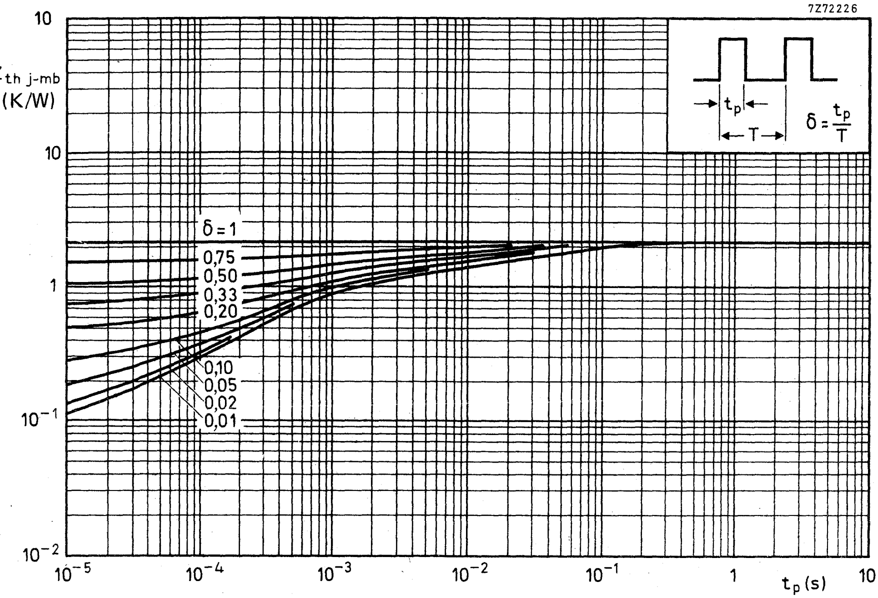


Fig. 6 Pulse power rating chart.

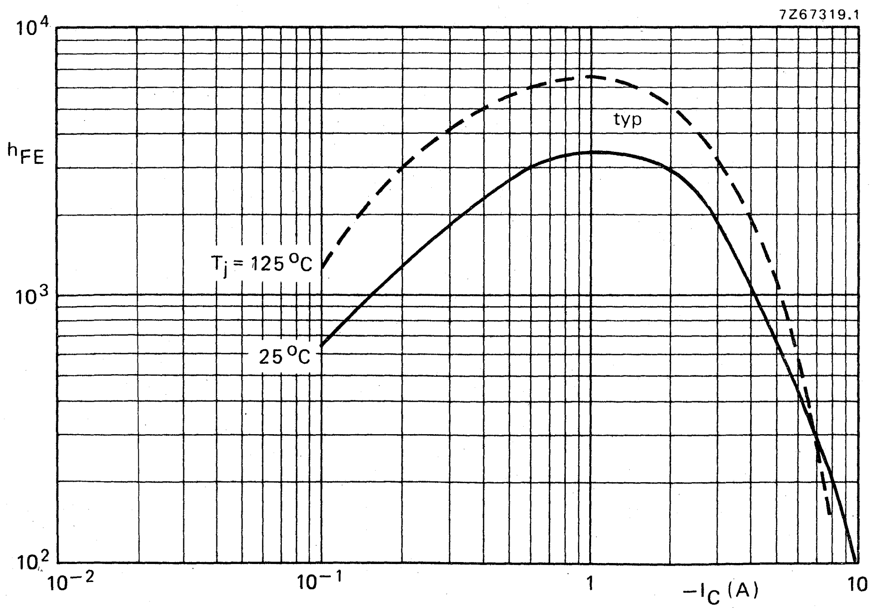


Fig. 7 D.C. current gain at $-V_{CE} = 3$ V.

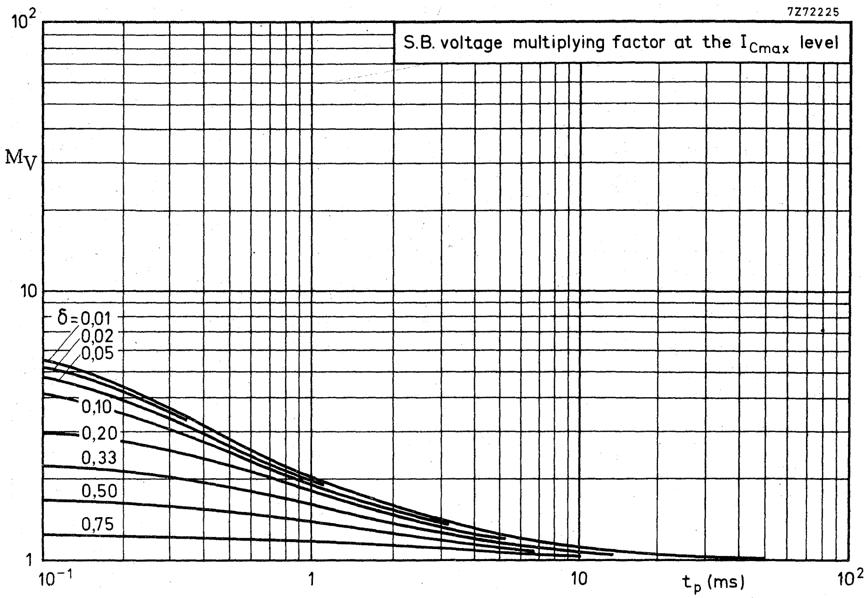


Fig. 8 Second breakdown voltage multiplying factor at the I_{Cmax} level.

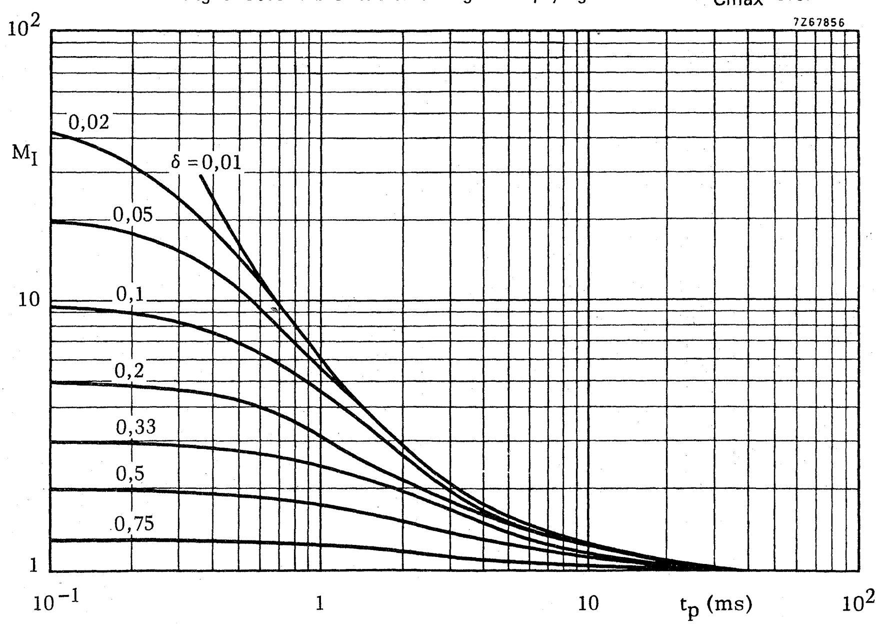


Fig. 9 Second breakdown current multiplying factor at the V_{CEOmax} level.

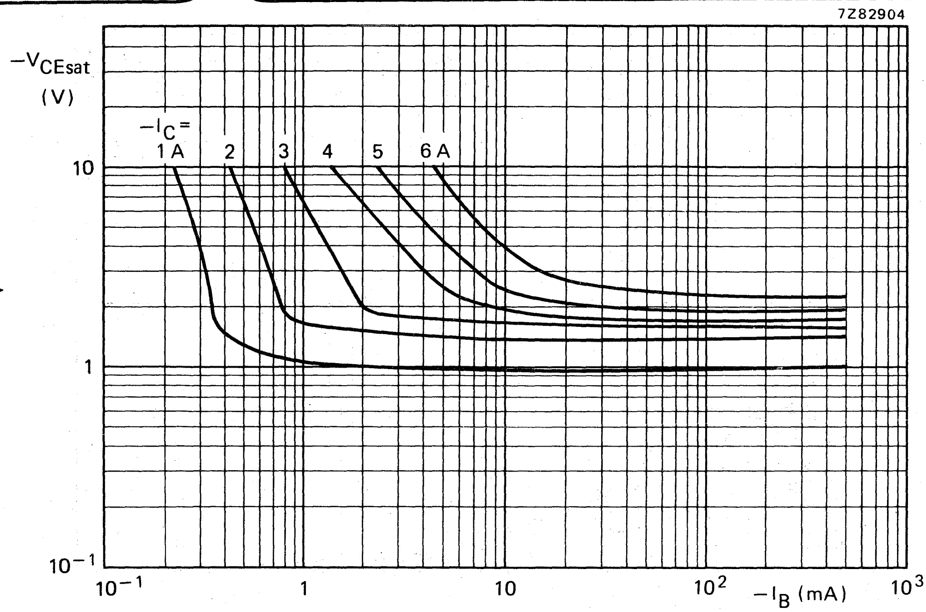


Fig. 10 Typical values collector-emitter saturation voltage. $T_j = 25\ ^oC$.

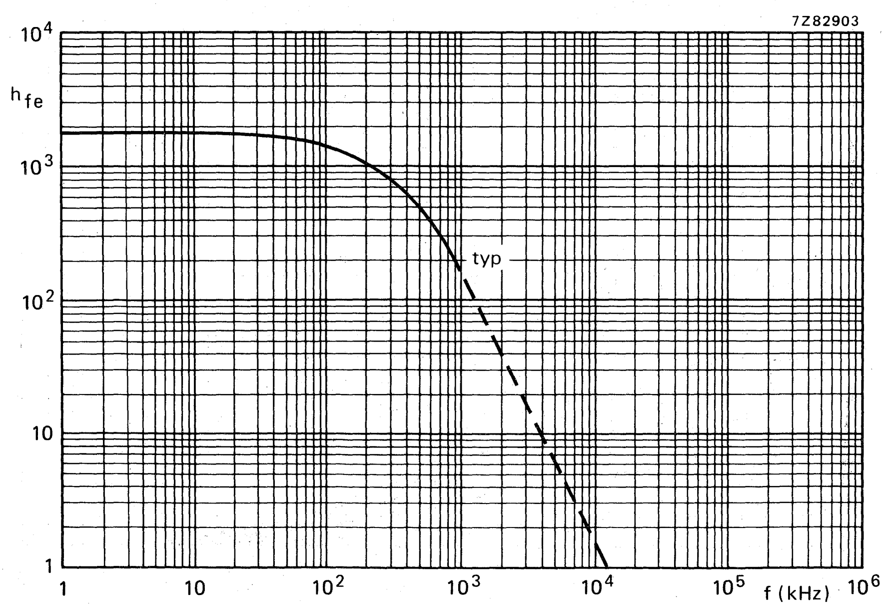


Fig. 11 Small signal current gain. $-I_C = 3$ A; $-V_{CE} = 3$ V.

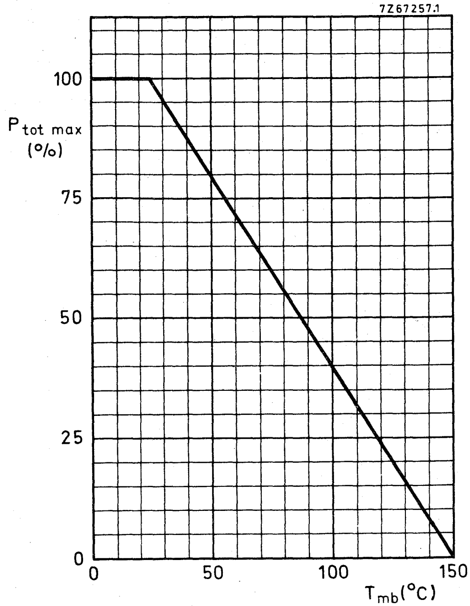


Fig. 12 Power derating curve.

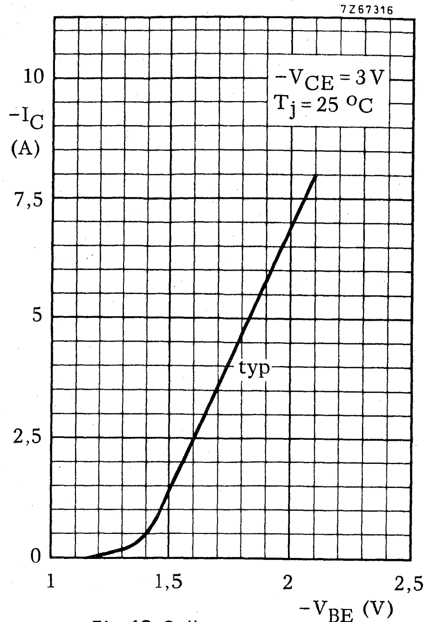


Fig. 13 Collector current.

SILICON EPITAXIAL-BASE POWER TRANSISTORS

N-P-N transistors in a SOT-32 plastic envelope, intended for use in complementary output stages of audio amplifiers up to 15 W.
The complementary pairs are BD433/BD434, BD435/BD436 and BD437/BD438.

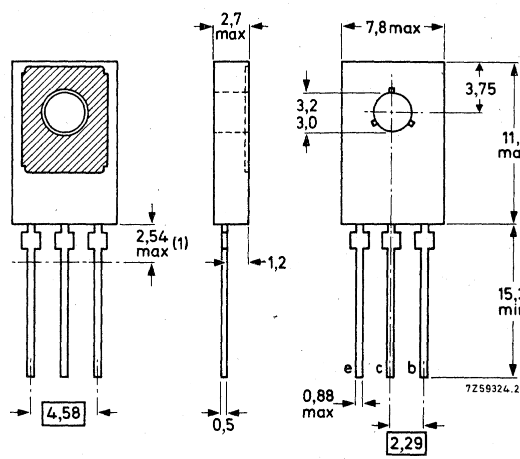
QUICK REFERENCE DATA

			BD433	BD435	BD437	
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	22	32	45	V
Collector-emitter voltage (open base)	V_{CEO}	max.	22	32	45	V
Collector current (peak value)	I_{CM}	max.	7	7	7	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	36	36	36	W
D.C. current gain I_C = 2 A; V_{CE} = 1 V	h_{FE}	>	50	50	40	
Transition frequency I_C = 250 mA; V_{CE} = 1 V	f_T	>	3	3	3	MHz

MECHANICAL DATA Dimensions in mm

TO-126 (SOT-32)

Collector connected to metal part of mounting surface



For mounting instructions see section Accessories, set 56333 for insulated mounting and type 56326 for non-insulated mounting.

[1]) Within this region the cross-section of the leads is uncontrolled.

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

Voltages

			BD433	BD435	BD437	
Collector-base voltage (open emitter)	V_{CBO}	max.	22	32	45	V
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	22	32	45	V
Collector-emitter voltage (open base)	V_{CEO}	max.	22	32	45	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V

Currents

Collector current (d.c.)	I_C	max.	4	A
Collector current (peak value)	I_{CM}	max.	7	A
Base current (d.c.)	I_B	max.	1	A

Power dissipation

Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	36	W

Temperatures

Storage temperature	T_{stg}		−65 to +150	°C
Junction temperature	T_j	max.	150	°C

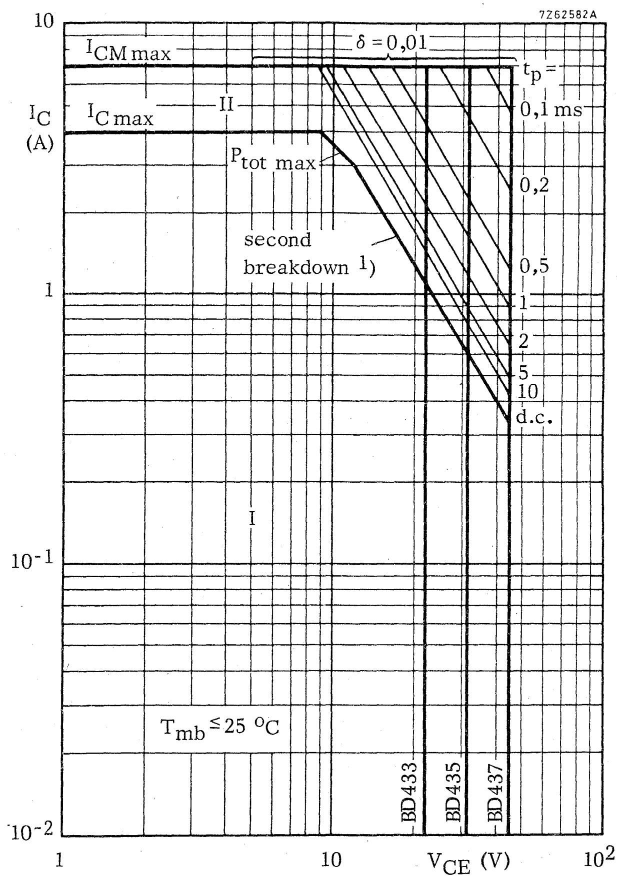
THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	3,5	°C/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	100	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

			BD433	BD435	BD437	
Collector cut-off current						
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	<		100		μA
$I_E = 0$; $V_{CB} = 10$ V; $T_j = 150$ °C	I_{CBO}	<		1		mA
$I_E = 0$; $V_{CB} = V_{CBOmax}$; $T_j = 150$ °C	I_{CBO}	<		3		mA
Emitter cut-off current						
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<		1		mA
Knee voltage						
$I_C = 2$ A; I_B = value for which $I_C = 2,2$ A at $V_{CE} = 1$ V	V_{CEK}	<	0,8	0,8	0,8	V
Base-emitter voltage [1]						
$I_C = 10$ mA; $V_{CE} = 5$ V	V_{BE}	typ.	580	580	580	mV
$I_C = 2$ A; $V_{CE} = 1$ V	V_{BE}	<	1,1	1,1	–	V
$I_C = 3$ A; $V_{CE} = 1$ V	V_{BE}	<	–	–	1,3	V
Collector-emitter saturation voltage						
$I_C = 2$ A; $I_B = 0,2$ A	V_{CEsat}	<	0,5	0,5	–	V
$I_C = 3$ A; $I_B = 0,3$ A	V_{CEsat}	<	–	–	0,7	V
D.C. current gain						
$I_C = 10$ mA; $V_{CE} = 5$ V	h_{FE}	>	25	25	25	
$I_C = 500$ mA; $V_{CE} = 1$ V	h_{FE}	>	85	85	85	
		<	475	475	375	
$I_C = 2$ A; $V_{CE} = 1$ V	h_{FE}	>	50	50	40	
$I_C = 3$ A; $V_{CE} = 1$ V	h_{FE}	>	–	–	30	
Transition frequency at f = 1 MHz						
$I_C = 250$ mA; $V_{CE} = 1$ V	f_T	>		3		MHz
D.C. current gain ratio of the complementary pairs						
$\|I_C\| = 500$ mA; $\|V_{CE}\| = 1$ V						
BD433/BD434 and BD435/BD436	h_{FE1}/h_{FE2}	<		1,4		
BD437/BD438	h_{FE1}/h_{FE2}	<		1,8		

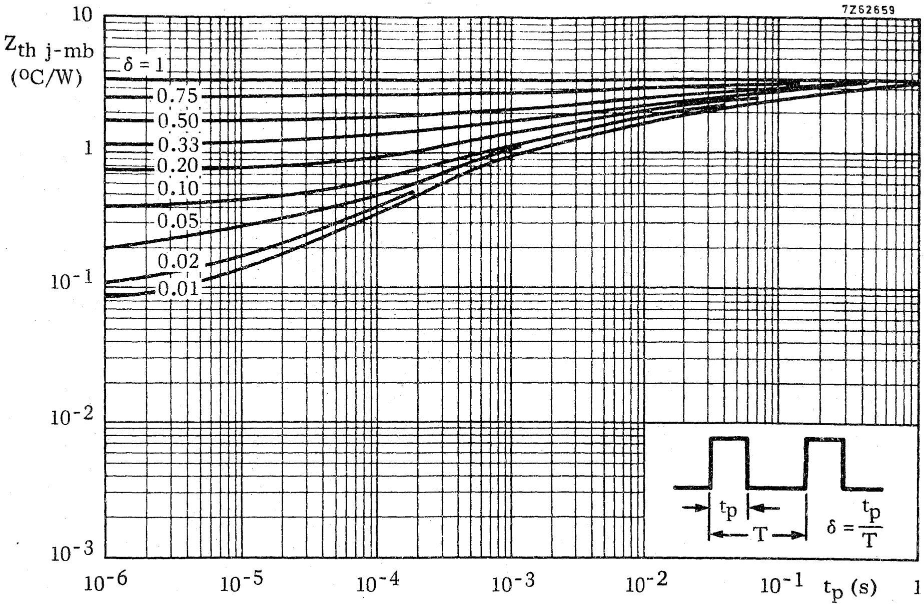
[1] V_{BE} decreases by typ. 2,3 mV/K with increasing temperature.

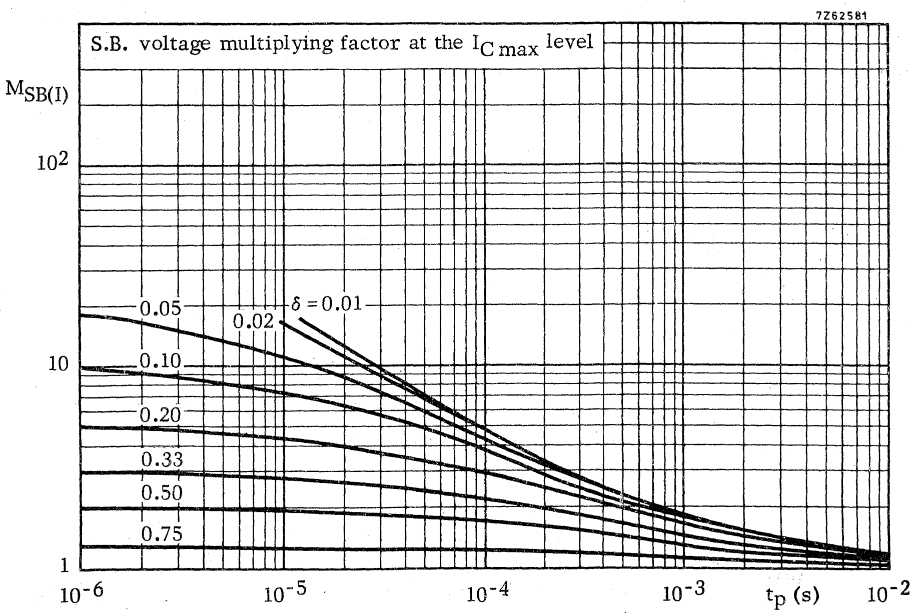


Safe Operating ARea with the transistor forward biased

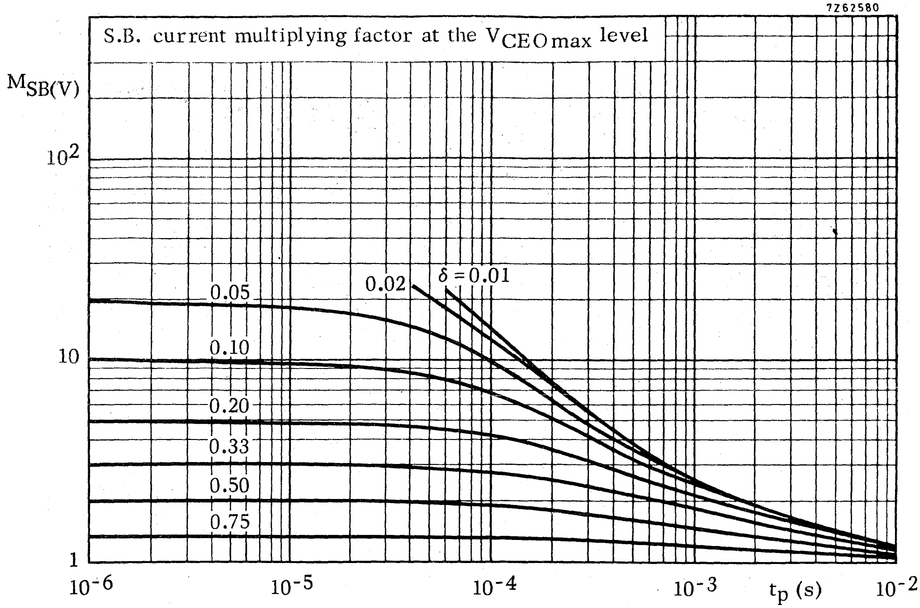
I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation

1) Independent of temperature.

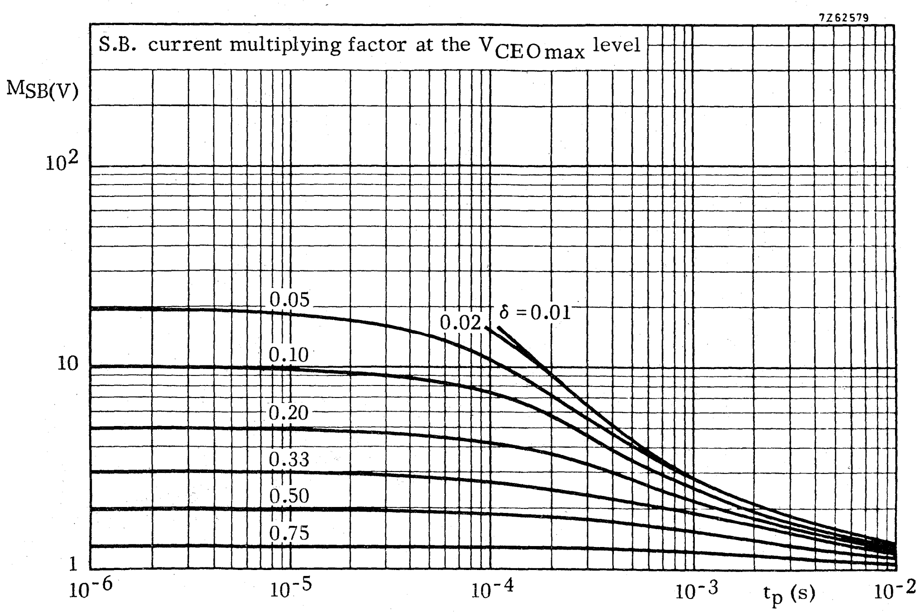

7Z62659
10
$Z_{th\ j\text{-}mb}$
(°C/W)
δ = 1
0.75
0.50
0.33
1
0.20
0.10
0.05
0.02
10^{-1}
0.01
10^{-2}
10^{-3}
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
t_p (s)
1
t_p
T
$\delta = \frac{t_p}{T}$

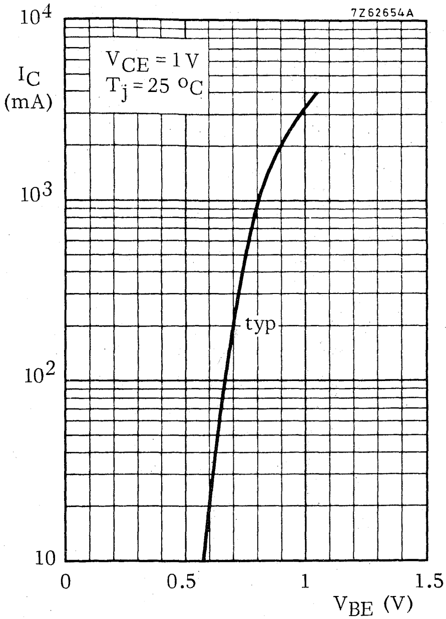

7Z62581
S.B. voltage multiplying factor at the $I_{C\ max}$ level
$M_{SB(I)}$
10^2
0.05
0.02
δ = 0.01
10
0.10
0.20
0.33
0.50
0.75
1
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

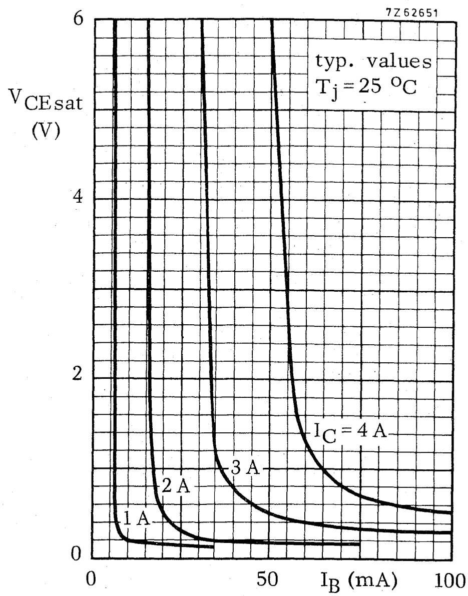
BD433; BD435

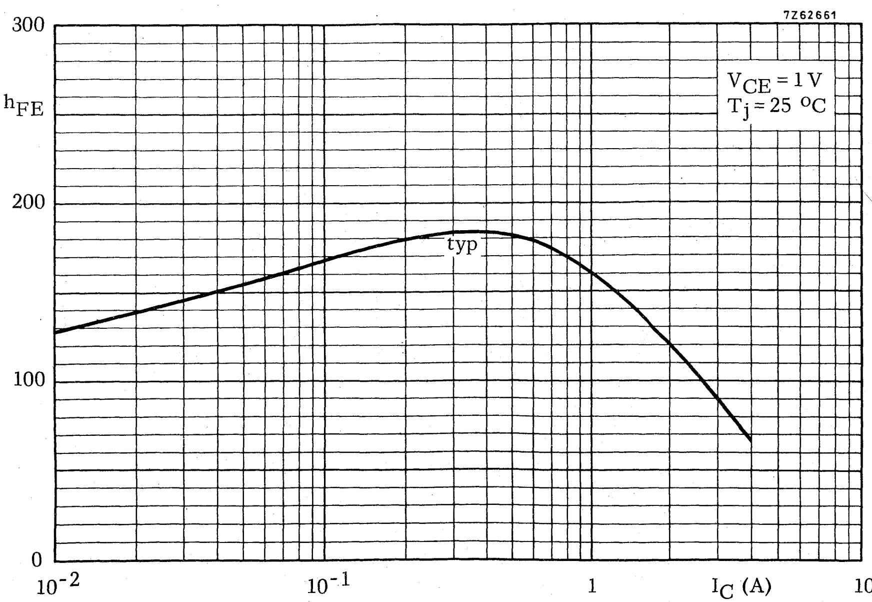


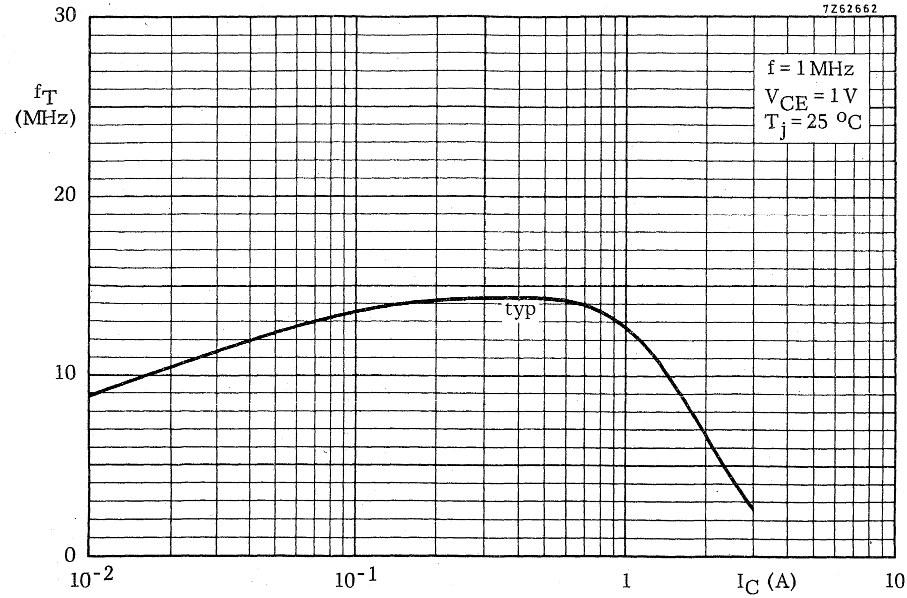
BD437

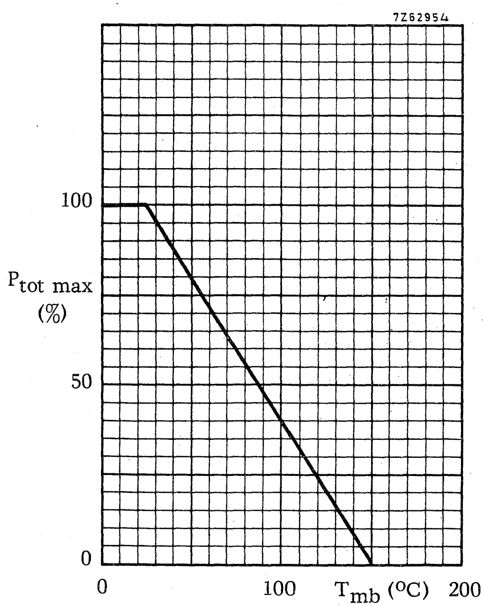



7Z62654A
10^4
I_C
(mA)
$V_{CE} = 1 V$
$T_j = 25\ ^oC$
10^3
typ
10^2
10
0
0.5
1
1.5
V_{BE} (V)


7Z62651
6
V_{CEsat}
(V)
typ. values
$T_j = 25\ ^oC$
4
2
$I_C = 4 A$
3 A
2 A
1 A
0
0
50
I_B (mA)
100


7Z62661
300
h_{FE}
$V_{CE} = 1 V$
$T_j = 25\ ^oC$
200
typ
100
0
10^{-2}
10^{-1}
1
I_C (A)
10


7Z62662
30
20
10
0
f_T (MHz)
f = 1 MHz
V_{CE} = 1 V
T_j = 25 °C
typ
10^{-2}
10^{-1}
1
I_C (A)
10


7Z62954
100
50
0
$P_{tot\ max}$ (%)
0
100
T_{mb} (°C)
200

SILICON EPITAXIAL-BASE POWER TRANSISTORS

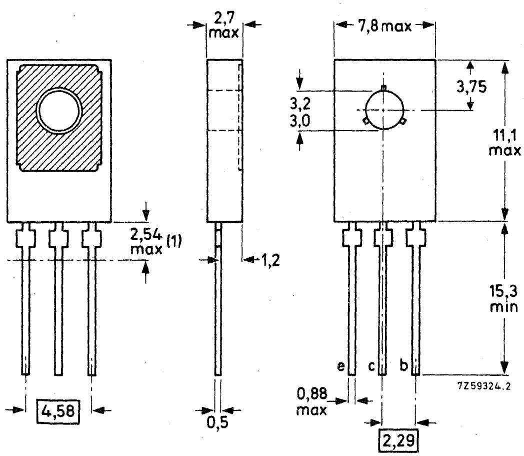
P-N-P transistors in a SOT-32 plastic envelope, intended for use in complementary output stages of audio amplifiers up to 15 W.
The complementary pairs are BD433/BD434, BD435/BD436 and BD437/BD438.

QUICK REFERENCE DATA						
			BD434	BD436	BD438	
Collector-emitter voltage ($-V_{BE}$ = 0)	$-V_{CES}$	max.	22	32	45	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	22	32	45	V
Collector current (peak value)	$-I_{CM}$	max.	7	7	7	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	36	36	36	W
D.C. current gain $-I_C$ = 2 A; $-V_{CE}$ = 1 V	h_{FE}	>	50	50	40	
Transition frequency $-I_C$ = 250 mA; $-V_{CE}$ = 1 V	f_T	>	3	3	3	MHz

MECHANICAL DATA Dimensions in mm

TO-126 (SOT-32)

Collector connected to metal part of mounting surface



For mounting instructions see section Accessories, set 56333 for insulated mounting and 56326 for non-insulated mounting.

1) Within this region the cross-section of the leads is uncontrolled.

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

Voltages

			BD434	BD436	BD438	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	22	32	45	V
Collector-emitter voltage ($-V_{BE}$ = 0)	$-V_{CES}$	max.	22	32	45	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	22	32	45	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V

Currents

Collector current (d.c.)	$-I_C$	max.	4	A
Collector current (peak value)	$-I_{CM}$	max.	7	A
Base current (d.c.)	$-I_B$	max.	1	A

Power dissipation

Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	36	W

Temperatures

Storage temperature	T_{stg}		−65 to +150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	3,5	°C/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	100	°C/W

CHARACTERISTICS $T_j = 25\ ^oC$ unless otherwise specified

Collector cut-off current

$I_E = 0$; $-V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	100	µA
$I_E = 0$; $-V_{CB} = 10$ V; $T_j = 150\ ^oC$	$-I_{CBO}$	<	1	mA
$I_E = 0$; $-V_{CB} = -V_{CBOmax}$; $T_j = 150\ ^oC$	$-I_{CBO}$	<	3	mA

Emitter cut-off current

$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	1	mA

			BD434	BD436	BD438	
Knee voltage						
$-I_C = 2$ A; $-I_B$ = value for which $-I_C = 2,2$ A at $-V_{CE} = 1$ V	$-V_{CEK}$	<	0,8	0,8	0,8	V ←
Base-emitter voltage [1]						
$-I_C = 10$ mA; $-V_{CE} = 5$ V	$-V_{BE}$	typ.	580	580	580	mV
$-I_C = 2$ A; $-V_{CE} = 1$ V	$-V_{BE}$	<	1,1	1,1	–	V
$-I_C = 3$ A; $-V_{CE} = 1$ V	$-V_{BE}$	<	–	–	1,3	V
Collector-emitter saturation voltage						
$-I_C = 2$ A; $-I_B = 0,2$ A	$-V_{CEsat}$	<	0,5	0,5	–	V
$-I_C = 3$ A; $-I_B = 0,3$ A	$-V_{CEsat}$	<	–	–	0,7	V
D.C. current gain						
$-I_C = 10$ mA; $-V_{CE} = 5$ V	h_{FE}	>	25	25	25	
$-I_C = 500$ mA; $-V_{CE} = 1$ V	h_{FE}	>	85	85	85	
		<	475	475	375	
$-I_C = 2$ A; $-V_{CE} = 1$ V	h_{FE}	>	50	50	40	
$-I_C = 3$ A; $-V_{CE} = 1$ V	h_{FE}	>	–	–	30	

Transition frequency at f = 1 MHz

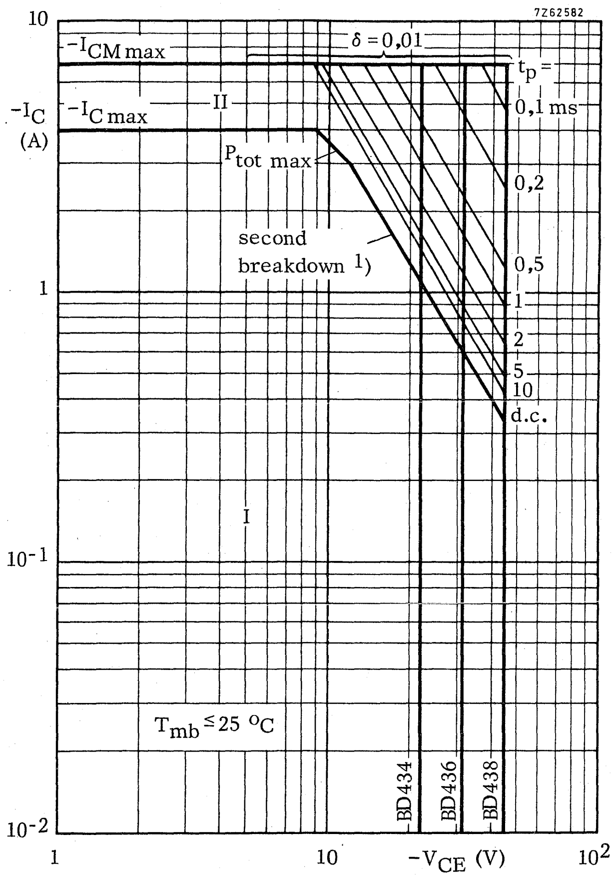
$-I_C = 250$ mA; $-V_{CE} = 1$ V	f_T	>	3	MHz

D.C. current gain ratio of the complementary pairs

$|I_C| = 500$ mA; $|V_{CE}| = 1$ V

BD433/BD434 and BD435/BD436	h_{FE1}/h_{FE2}	<	1,4
BD437/BD438	h_{FE1}/h_{FE2}	<	1,8

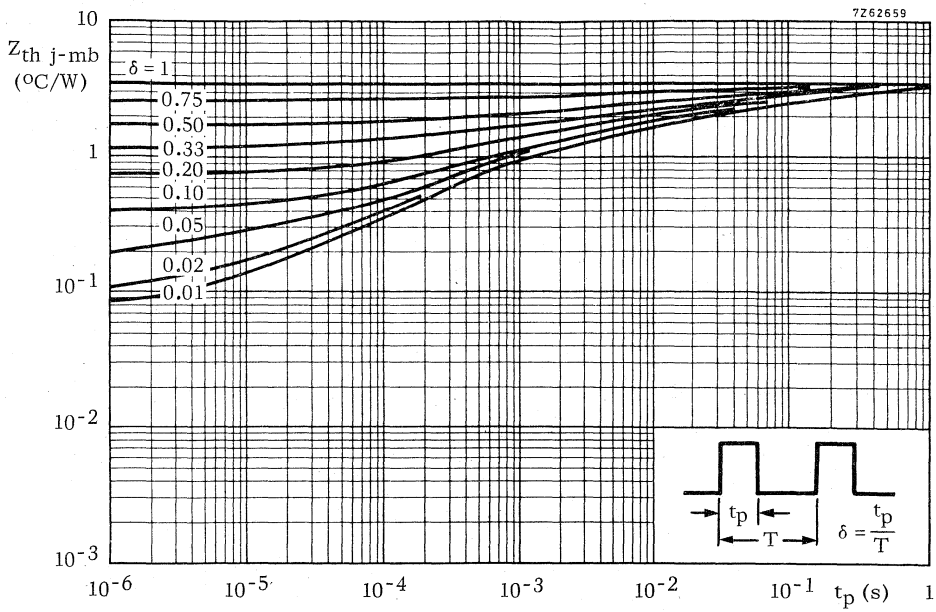
[1]) $-V_{BE}$ decreases by typ. 2,3 mV/K with increasing temperature.

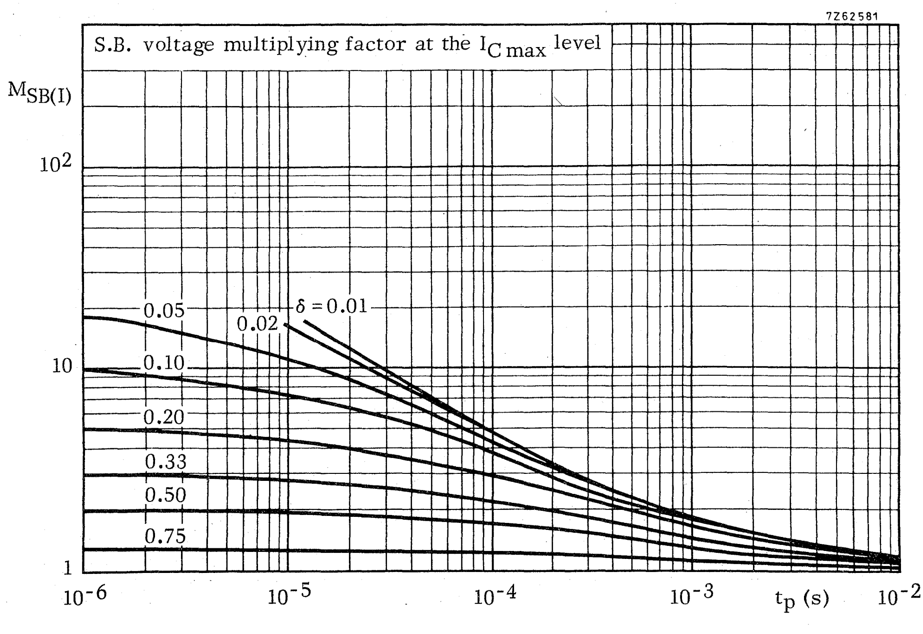


Safe Operating ARea with the transistor forward biased

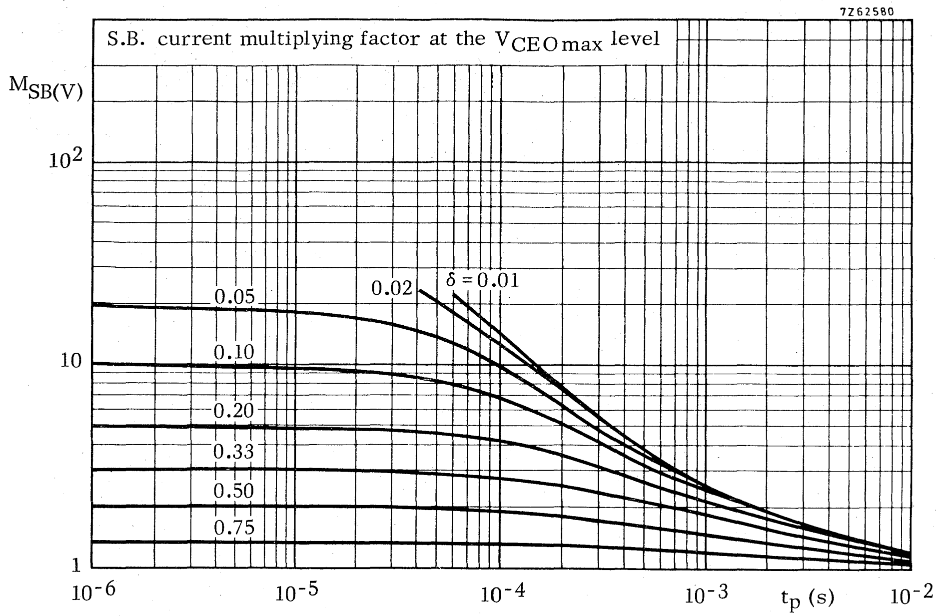
I Region of permissible d. c. operation
II Permissible extension for repetitive pulse operation

1) Independent of temperature.

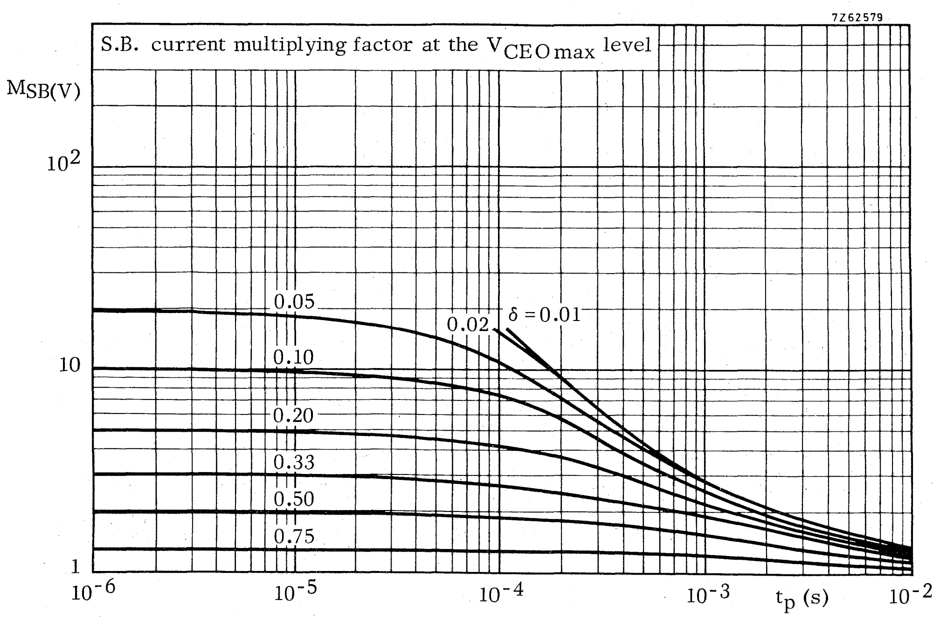

7Z62659
Zth j-mb (°C/W)
10
1
10-1
10-2
10-3
δ = 1
0.75
0.50
0.33
0.20
0.10
0.05
0.02
0.01
tp
T
δ = tp/T
10-6
10-5
10-4
10-3
10-2
10-1
tp (s)
1

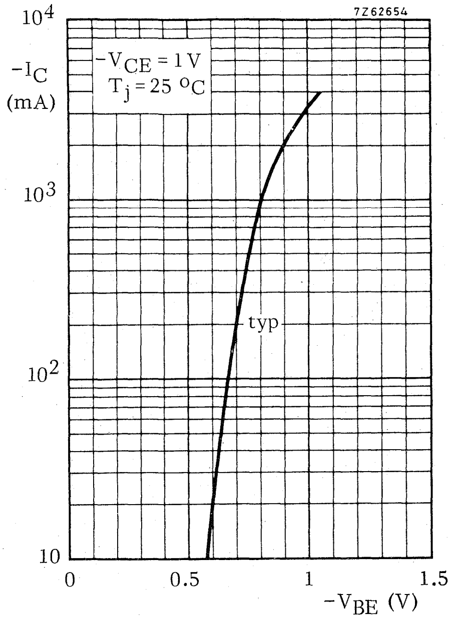

7Z62581
S.B. voltage multiplying factor at the IC max level
MSB(I)
10²
10
1
0.05
0.02
δ = 0.01
0.10
0.20
0.33
0.50
0.75
10-6
10-5
10-4
10-3
tp (s)
10-2

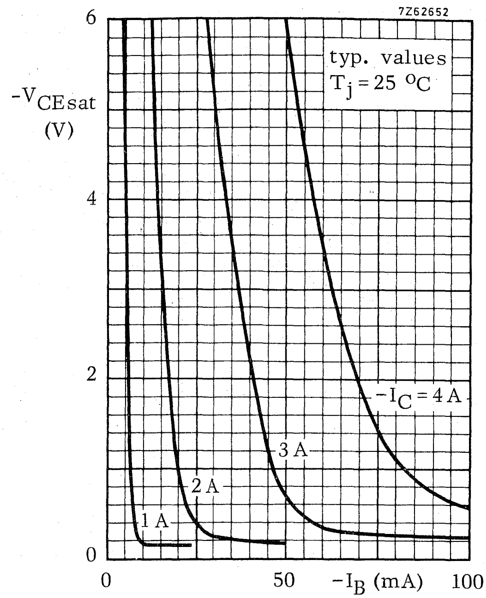
BD434; BD436

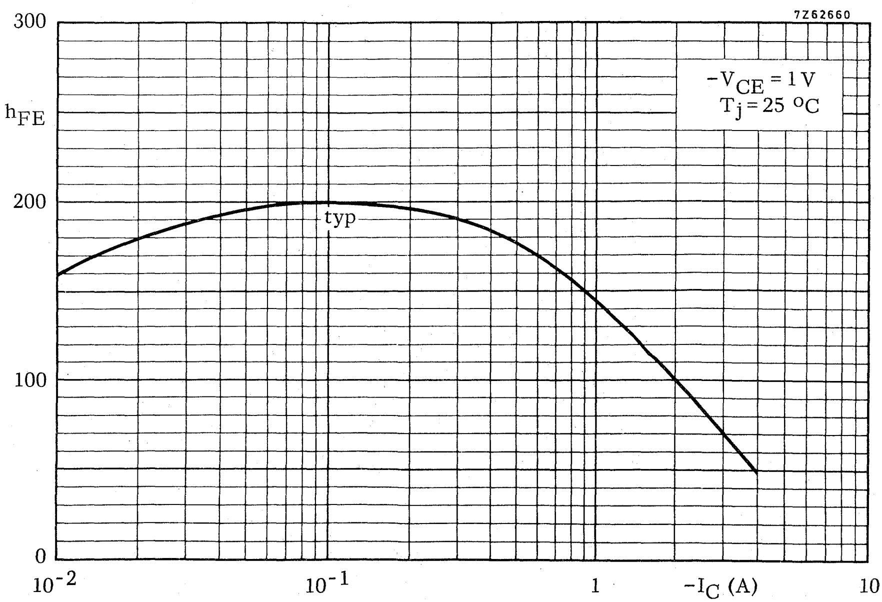


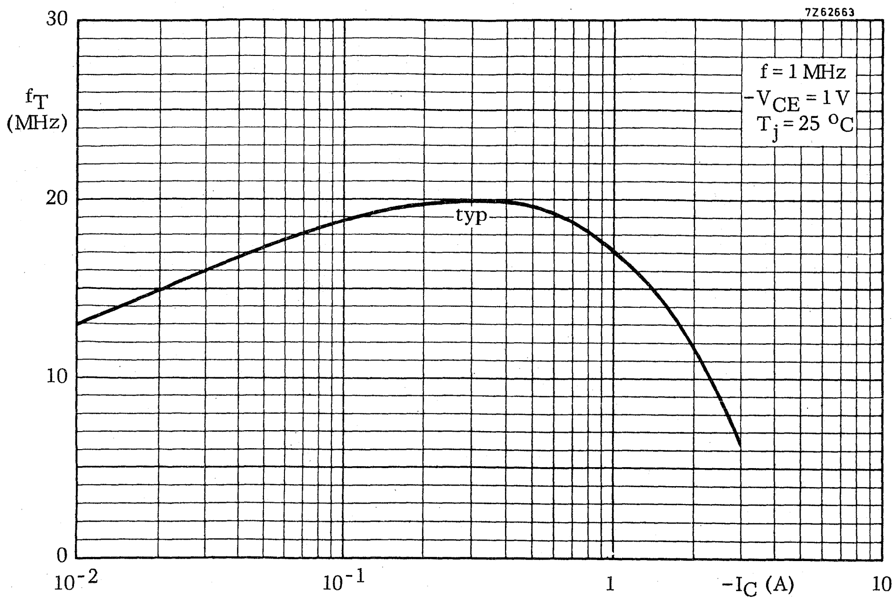
BD438

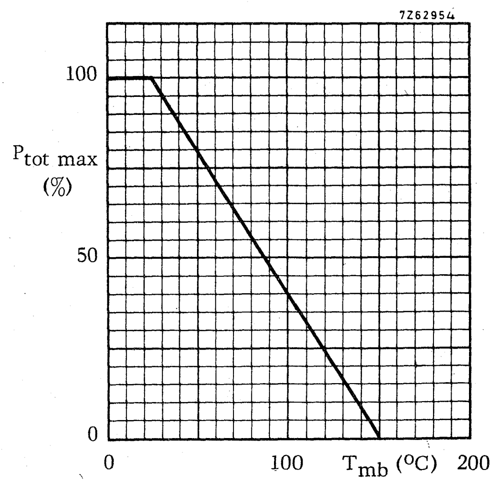



7Z62654
10^4
$-I_C$
(mA)
$-V_{CE} = 1$ V
$T_j = 25$ °C
10^3
typ
10^2
10
0
0.5
1
1.5
$-V_{BE}$ (V)


7Z62652
6
$-V_{CEsat}$
(V)
typ. values
$T_j = 25$ °C
4
2
$-I_C = 4$ A
3 A
2 A
1 A
0
0
50
$-I_B$ (mA)
100


7Z62660
300
h_{FE}
$-V_{CE} = 1$ V
$T_j = 25$ °C
200
typ
100
0
10^{-2}
10^{-1}
1
$-I_C$ (A)
10


7Z62663
30
20
10
0
f_T (MHz)
f = 1 MHz
$-V_{CE}$ = 1 V
T_j = 25 °C
typ
10^{-2}
10^{-1}
1
$-I_C$ (A)
10


7Z62954
100
$P_{tot\ max}$ (%)
50
0
0
100
T_{mb} (°C)
200

SILICON DARLINGTON POWER TRANSISTORS

N-P-N epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications; TO-220 plastic envelope. P-N-P complements are BD646, BD648, BD650 and BD652. Matched complementary pairs can be supplied.

QUICK REFERENCE DATA

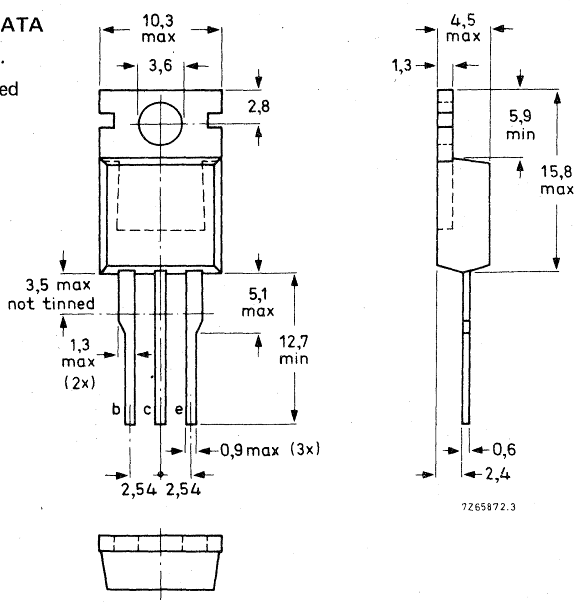
			BD645	647	649	651	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Collector current (peak value)	I_{CM}	max.		12			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		62,5			W
Junction temperature	T_j	max.		150			°C
D.C. current gain:							
I_C = 0,5 A; V_{CE} = 3 V	h_{FE}	typ.		1900			
I_C = 3,0 A; V_{CE} = 3 V	h_{FE}	>		750			
Cut-off frequency: I_C = 3 A; V_{CE} = 3 V	f_{hfe}	typ.		50			kHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base.



See also chapters Mounting Instructions and Accessories.

CIRCUIT DIAGRAM

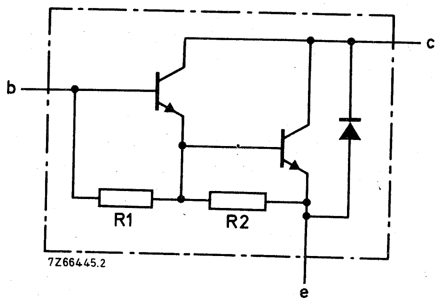


Fig. 2
R_1 typ. 4 kΩ
R_2 typ. 100 Ω

RATINGS

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

			BD645	647	649	651	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	5	V

Collector current (d.c.)	I_C	max.	8	A
Collector current (peak value)	I_{CM}	max.	12	A
Base current (d.c.)	I_B	max.	150	mA
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	62,5	W
Storage temperature	T_{stg}		−65 to + 150	°C
Junction temperature *	T_j	max.	150	°C

THERMAL RESISTANCE *

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	70	K/W

* Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current			
$I_E = 0$; $V_{CBO} = V_{CEOmax}$	I_{CBO}	<	0,2 mA
$I_E = 0$; $V_{CB} = ½ V_{CBOmax}$; T_j = 150 °C	I_{CBO}	<	2 mA
$I_B = 0$; $V_{CE} = ½ V_{CEOmax}$	I_{CEO}	<	0,5 mA
Emitter cut-off current			
$I_C = 0$; V_{EB} = 5 V	I_{EBO}	<	5 mA
D.C. current gain (note 1)			
I_C = 0,5 A; V_{CE} = 3 V	h_{FE}	typ.	1900 ←
I_C = 3 A; V_{CE} = 3 V	h_{FE}	>	750
I_C = 8 A; V_{CE} = 3 V	h_{FE}	typ.	1800 ←
Base-emitter voltage (notes 1 and 2)			
I_C = 3 A; V_{CE} = 3 V	V_{BE}	<	2,5 V
Saturation voltages (note 1)			
I_C = 3 A; I_B = 12 mA	V_{CEsat}	<	2 V
I_C = 5 A; I_B = 50 mA	V_{CEsat}	<	2,5 V ←
	V_{BEsat}	<	3 V ←
Diode forward voltage			
I_F = 3 A	V_F	typ.	1,2 V
Collector capacitance at f = 1 MHz			
$I_E = I_e = 0$; V_{CB} = 10 V	C_c	typ.	75 pF
Cut-off frequency			
I_C = 3 A; V_{CE} = 3 V	f_{hfe}	typ.	50 kHz
Turn-off breakdown energy with inductive load			
$-I_{Boff} = 0$; I_{CM} = 4,5 A; t_p = 1 ms;			
T = 100 ms; see Fig. 3	$E_{(BR)}$	>	50 mJ
D.C. current gain ratio of matched complementary pairs			
I_C = 3 A; V_{CE} = 3 V	h_{FE1}/h_{FE2}	<	2,5
Small signal current gain			
I_C = 3 A; V_{CE} = 3 V; f = 1 MHz	$\|h_{fe}\|$	typ.	50
Second breakdown collector current			
V_{CE} = 60 V; t_p = 0,1 s	$I_{(SB)}$	>	1,04 A ←
Switching times (see Figs 4 and 5)			
I_{Con} = 3 A; $I_{Bon} = -I_{Boff}$ = 12 mA			
turn-on time	t_{on}	typ.	1,0 μs
		<	2,5 μs
turn-off time	t_{off}	typ.	5 μs
		<	10 μs

Notes
1. Measured under pulse conditions: $t_p < 300$ μs, $\delta < 2\%$.
2. V_{BE} decreases by about 3,8 mV/°C with increasing temperature.

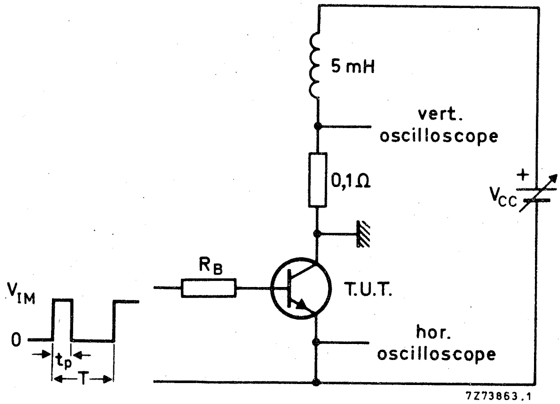


Fig. 3 Test circuit for turn-off breakdown energy.
V_{IM} = 12 V; R_B = 270 Ω;
t_p = 1 ms; δ = 1%.

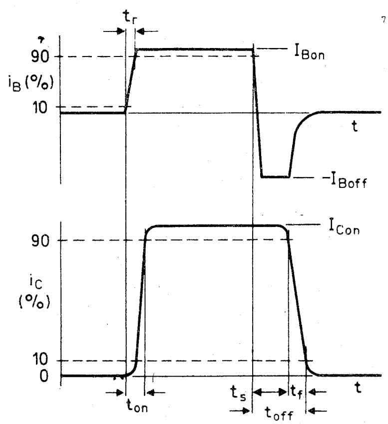
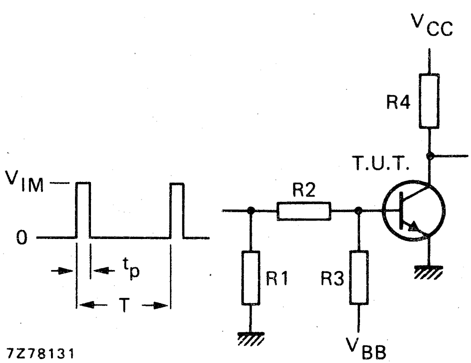


Fig. 4 Switching times waveforms.



V_{CC} = 10 V
V_{IM} = 10 V
$-V_{BB}$ = 4 V
R1 = 56 Ω
R2 = 410 Ω
R3 = 560 Ω
R4 = 3 Ω
$t_r = t_f$ = 15 ns
t_p = 10 μs
T = 500 μs

Fig. 5 Switching times test circuit.

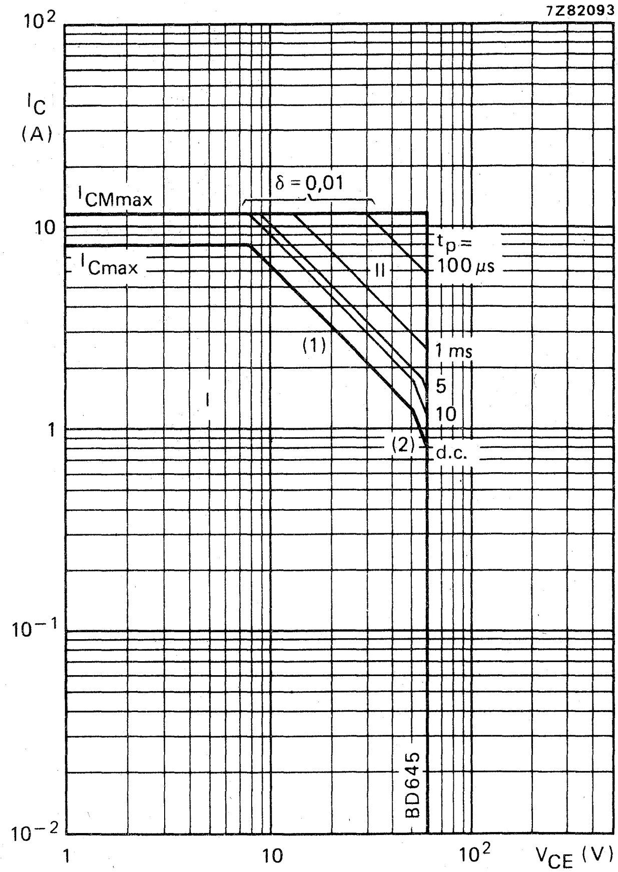


Fig. 6 Safe Operating ARea; T_{mb} = 25 °C

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.
(2) Second-breakdown limits (independent of temperature).

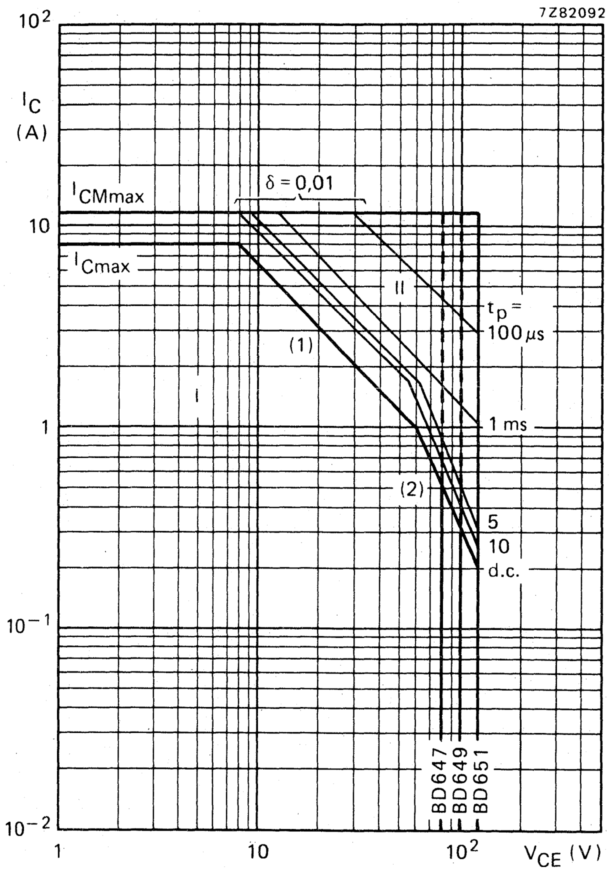


Fig. 7 Safe Operating ARea; T_{mb} = 25 °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.

(2) Second-breakdown limits (independent of temperature).

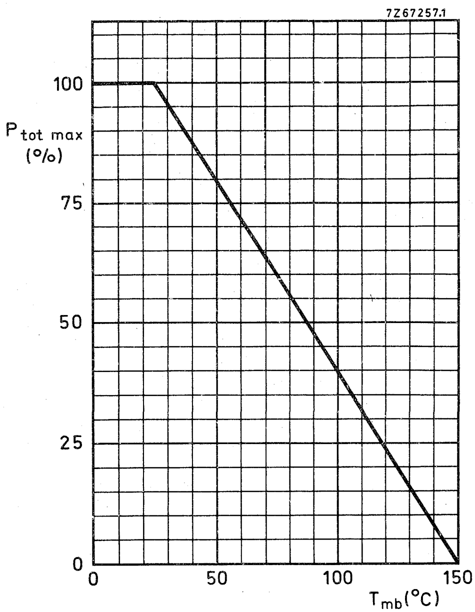


Fig. 8 Power derating curve.

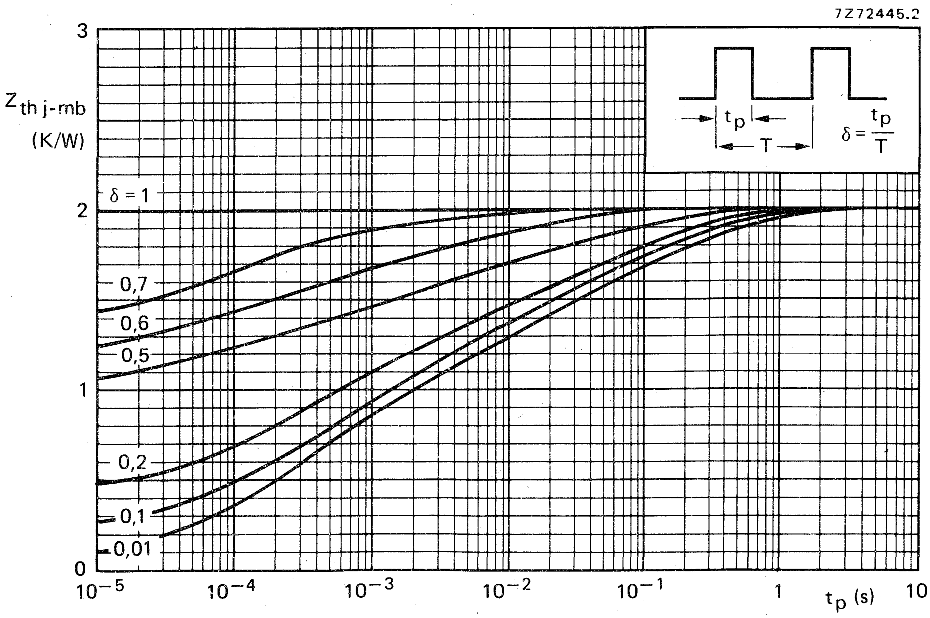


Fig. 9 Pulse power rating chart.

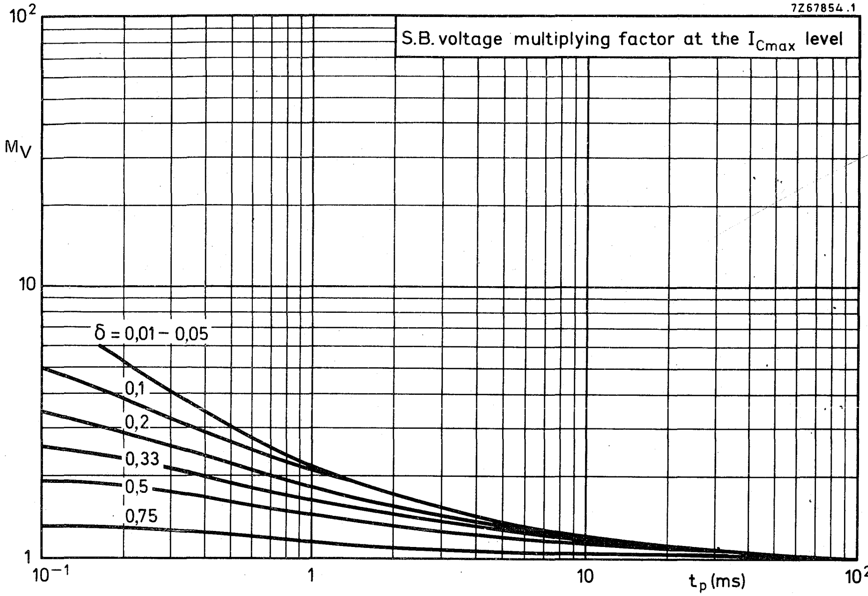

7Z67854.1
S.B. voltage multiplying factor at the I_{Cmax} level
10^2
M_V
10
1
δ = 0,01 – 0,05
0,1
0,2
0,33
0,5
0,75
10^{-1}
1
10
t_p (ms)
10^2

Fig. 10.

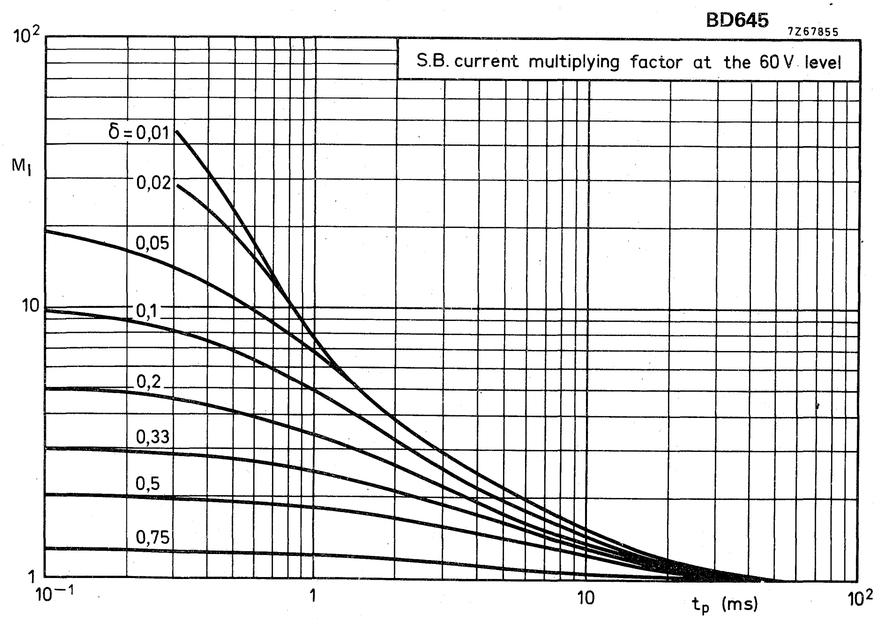

BD645
7Z67855
S.B. current multiplying factor at the 60 V level
10^2
M_I
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-1}
1
10
t_p (ms)
10^2

Fig. 11.

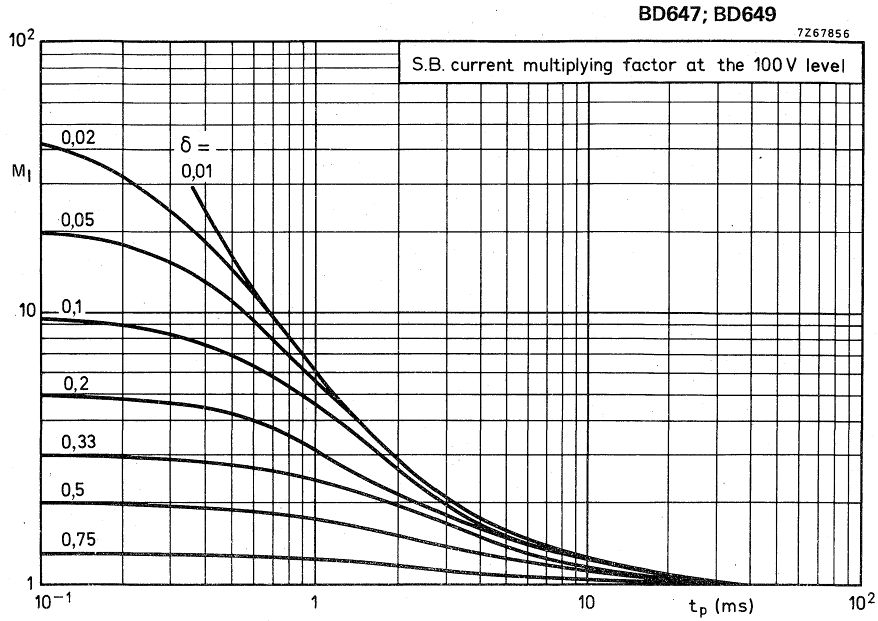


Fig. 12 Second breakdown current multiplying factor at the 100 V level.

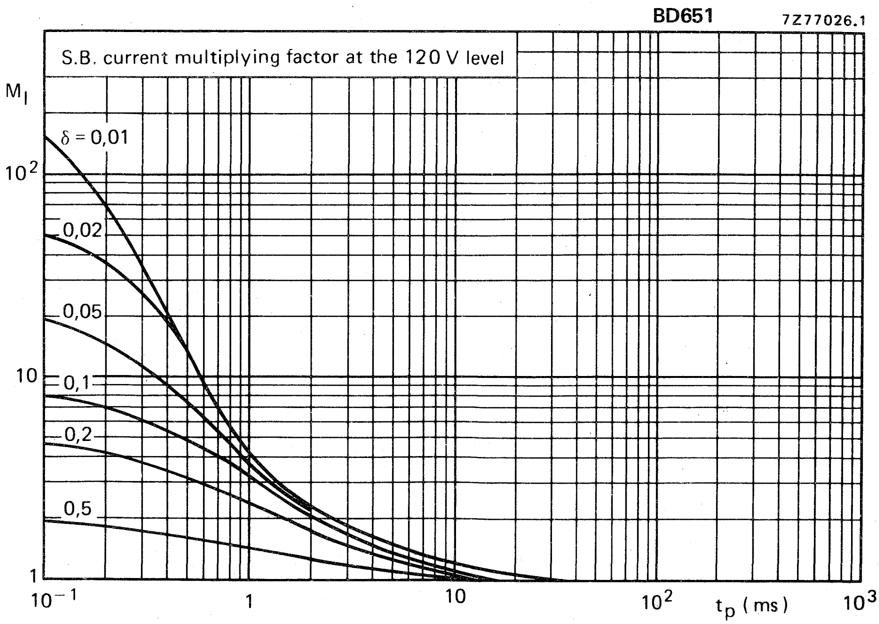


Fig. 13 Second breakdown current multiplying factor at the 120 V level.

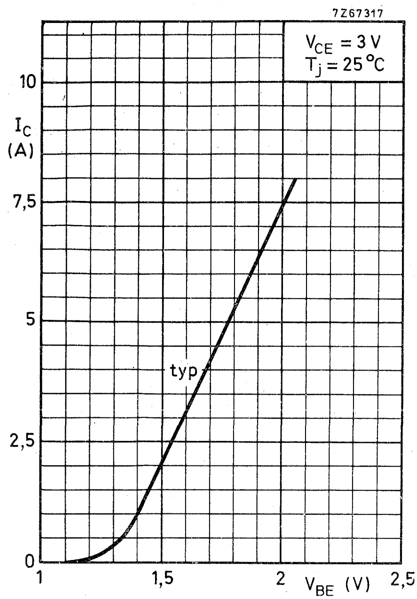


Fig. 14.

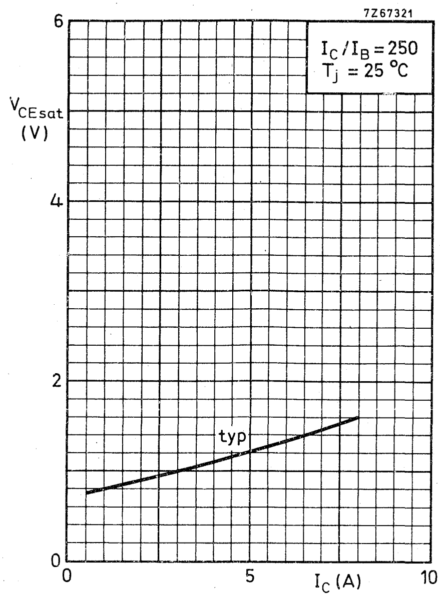


Fig. 15.

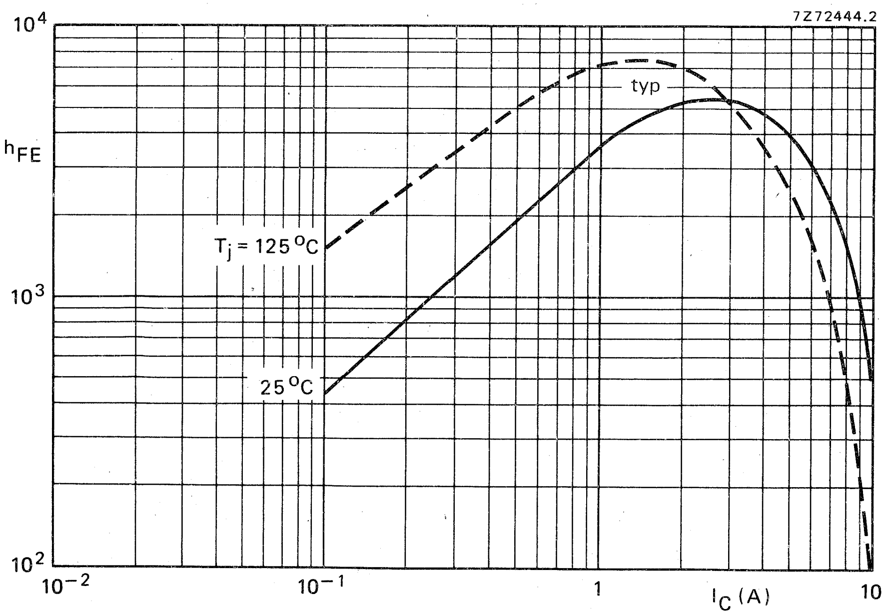


Fig. 16 Typical d.c. current gain. V_{CE} = 3 V.

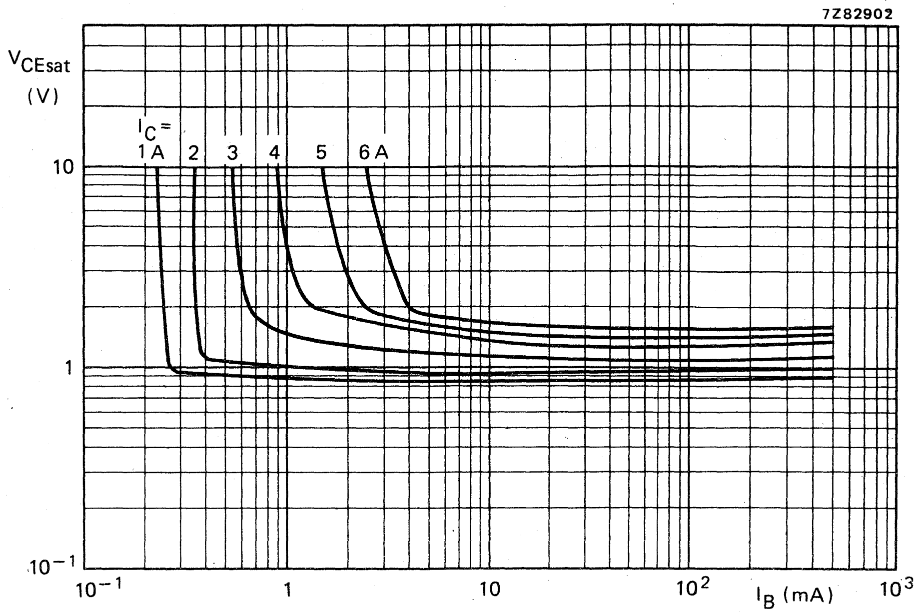


Fig. 17 Typical values collector-emitter saturation voltage. T_j = 25 °C.

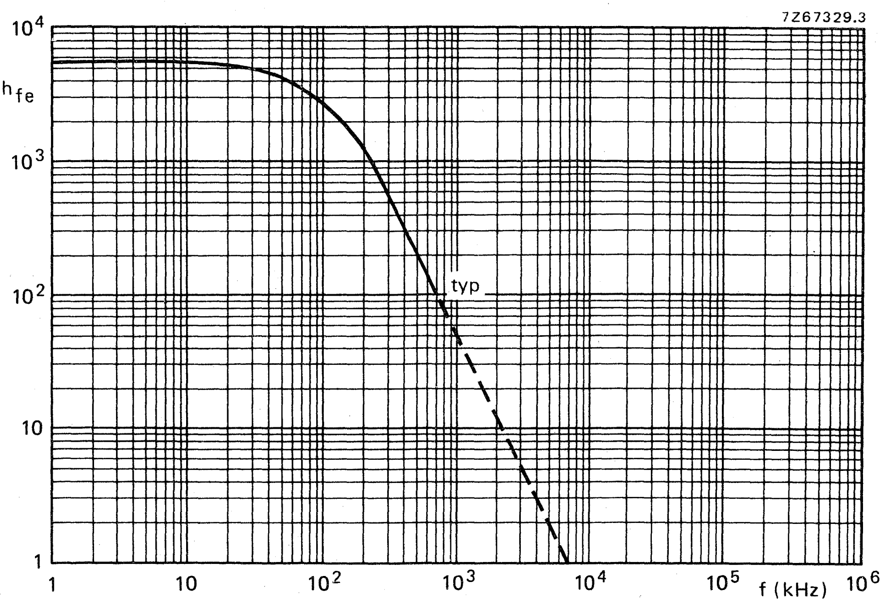


Fig. 18 Small signal current gain at I_C = 3 A; V_{CE} = 3 V.

SILICON DARLINGTON POWER TRANSISTORS

P-N-P epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications; TO-220 plastic envelope. N-P-N complements are BD645, BD647, BD649 and BD651. Matched complementary pairs can be supplied.

QUICK REFERENCE DATA

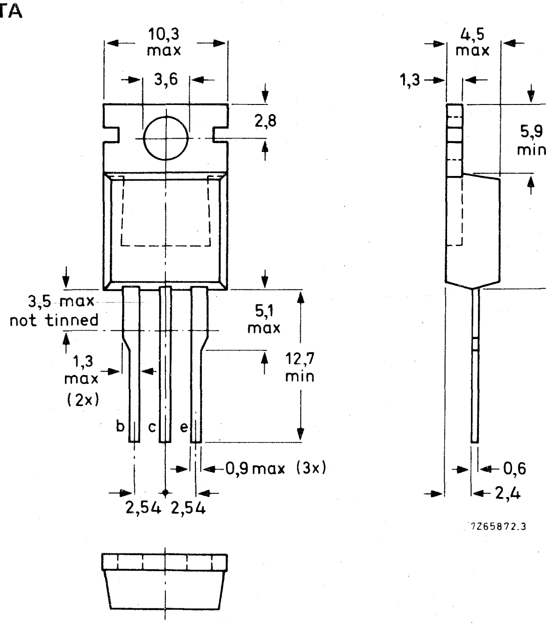
			BD646	648	650	652	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Collector current (peak value)	$-I_{CM}$	max.	12				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	62,5				W
Junction temperature	T_j	max.	150				°C
D.C. current gain:							
$-I_C$ = 0,5 A; $-V_{CE}$ = 3 V	h_{FE}	typ.	2700				
$-I_C$ = 3,0 A; $-V_{CE}$ = 3 V	h_{FE}	>	750				
Cut-off frequency:							
$-I_C$ = 3 A; $-V_{CE}$ = 3 V	f_{hfe}	typ.	100				kHz

MECHANICAL DATA

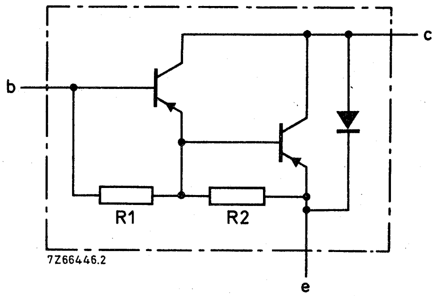
Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base.



See also chapters Mounting Instructions and Accessories.



R_1 typ. 4 kΩ
R_2 typ. 80 Ω

Fig. 2 Darlington circuit diagram.

RATINGS

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

			BD646	648	650	652	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	5	V

Collector current (d.c.)	$-I_C$	max.	8	A
Collector current (peak value)	$-I_{CM}$	max.	12	A
Base current (d.c.)	$-I_B$	max.	150	mA
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	62,5	W
Storage temperature	T_{stg}		−65 to + 150	°C
Junction temperature *	T_j		150	°C

THERMAL RESISTANCE *

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	70	K/W

* Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current			
$I_E = 0$; $-V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	0,2 mA
$I_E = 0$; BD646: $-V_{CB}$ = 40 V; BD648: $-V_{CB}$ = 50 V; BD650: $-V_{CB}$ = 60 V; BD652: $-V_{CB}$ = 70 V; T_j = 150 °C	$-I_{CBO}$	<	2 mA
$I_B = 0$; $-V_{CE} = ½ V_{CEOmax}$	$-I_{CEO}$	<	0,5 mA
Emitter cut-off current			
$I_C = 0$; $-V_{EB}$ = 5 V	$-I_{EBO}$	<	5 mA
D.C. current gain (note 1)			
$-I_C$ = 0,5 A; $-V_{CE}$ = 3 V	h_{FE}	typ.	2700
$-I_C$ = 3 A; $-V_{CE}$ = 3 V	h_{FE}	>	750
$-I_C$ = 8 A; $-V_{CE}$ = 3 V	h_{FE}	typ.	200
Base-emitter voltage (notes 1 and 2)			
$-I_C$ = 3 A; $-V_{CE}$ = 3 V	$-V_{BE}$	<	2,5 V
Saturation voltages (note 1)			
$-I_C$ = 3 A; $-I_B$ = 12 mA	$-V_{CEsat}$	<	2 V
$-I_C$ = 5 A; $-I_B$ = 50 mA	$-V_{CEsat}$	<	2,5 V
	$-V_{BEsat}$	<	3 V
Collector capacitance at f = 1 MHz			
$I_E = I_e = 0$; $-V_{CB}$ = 10 V	C_c	typ.	75 pF
Cut-off frequency			
$-I_C$ = 3 A; $-V_{CE}$ = 3 V	f_{hfe}	typ.	100 kHz
Small-signal current gain			
$-I_C$ = 3 A; $-V_{CE}$ = 3 V; f = 1 MHz	$\|h_{fe}\|$	typ.	150
D.C. current gain ratio of matched complementary pairs			
$-I_C$ = 3 A; $-V_{CE}$ = 3 V	h_{FE1}/h_{FE2}	max.	2,5
Diode, forward voltage			
I_F = 3 A	V_F	typ.	1,8 V
Second-breakdown collector current			
$-V_{CE}$ = 50 V; t_p = 0,1 s	$-I_{(SB)}$	>	1,25 A
Switching times (between 10% and 90% levels) (Fig. 3)			
$-I_{Con}$ = 3 A; $-I_{Bon} = I_{Boff}$ = 12 mA; V_{CC} = −10 V			
Turn-on time	t_{on}	typ.	1 µs
		<	2 µs
Turn-off time	t_{off}	typ.	5 µs
		<	10 µs

Notes
1. Measured under pulse conditions: $t_p < 300$ µs, $\delta < 2\%$.
2. $-V_{BE}$ decreases by about 3,8 mV/°C with increasing temperature.

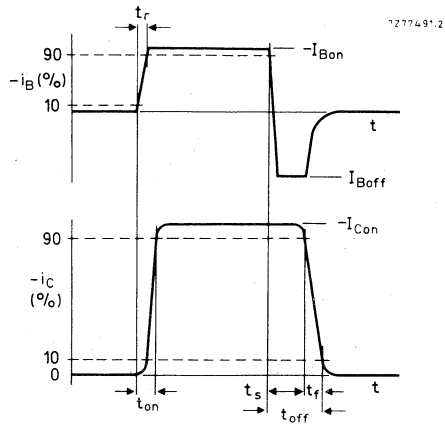
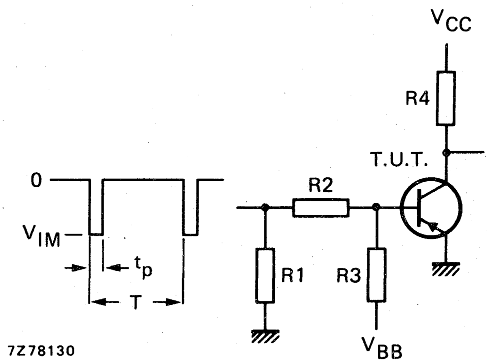


Fig. 3 Switching times waveforms.



$-V_{IM}$	=	10 V
$-V_{CC}$	=	10 V
$+V_{BB}$	=	4 V
R1	=	56 Ω
R2	=	410 Ω
R3	=	560 Ω
R4	=	3 Ω
$t_r = t_f$	=	15 ns
t_p	=	10 μs
T	=	500 μs

Fig. 4 Switching times test circuit.

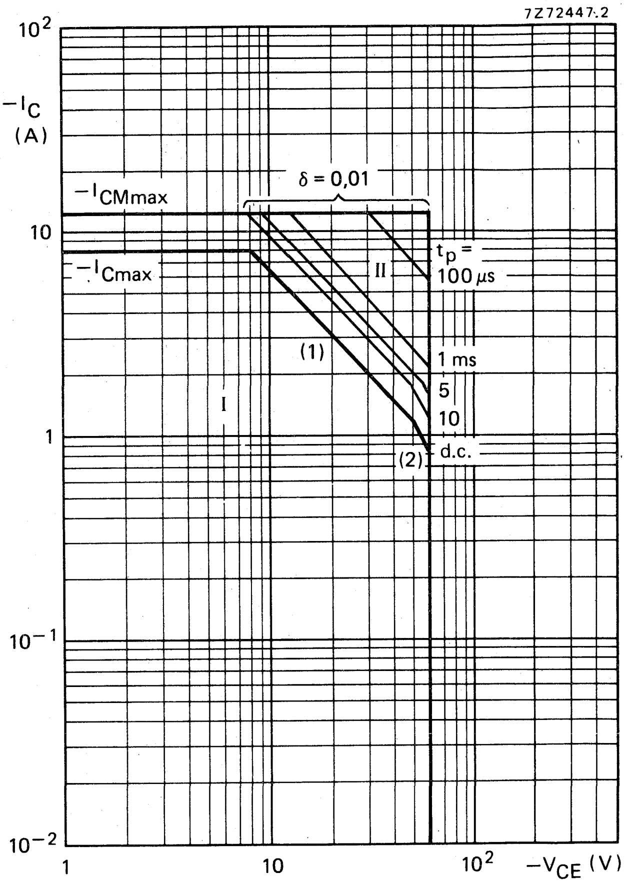


Fig. 5 Safe Operating ARea transistor BD646 at T_{mb} = 25 °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.

(2) Second-breakdown limits (independent of temperature).

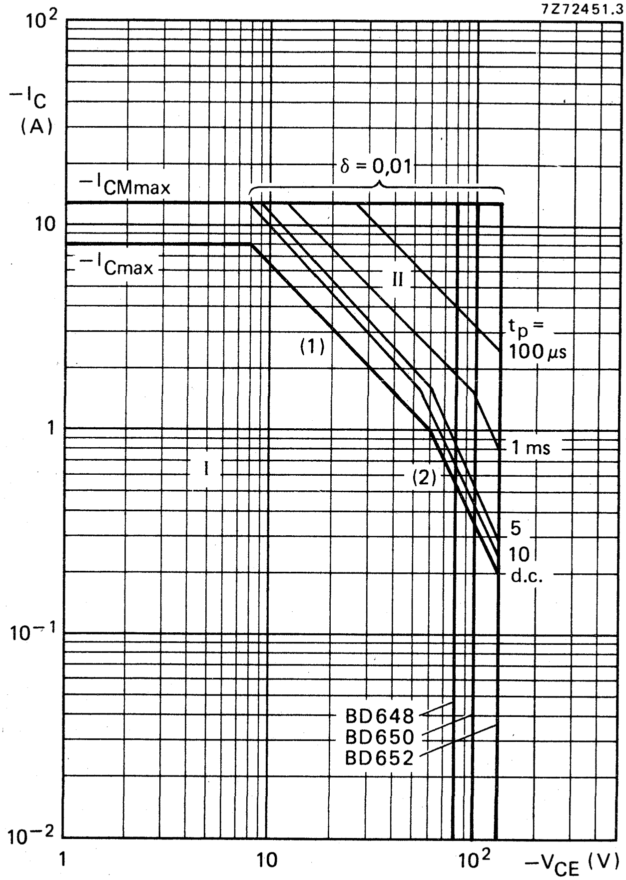


Fig. 6 Safe Operating ARea. T_{mb} = 25 °C

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.
(2) Second-breakdown limits (independent of temperature).

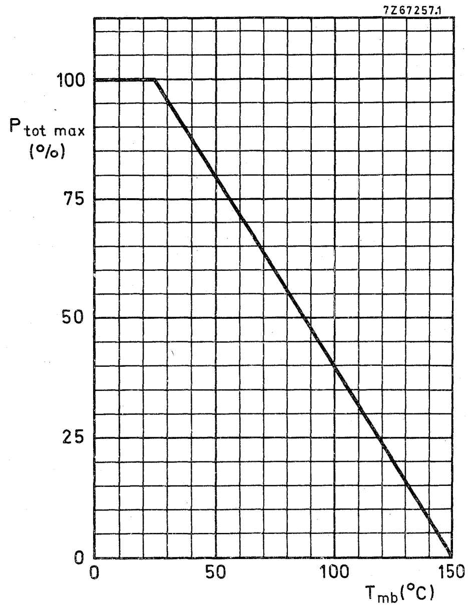


Fig. 7 Power derating curve.

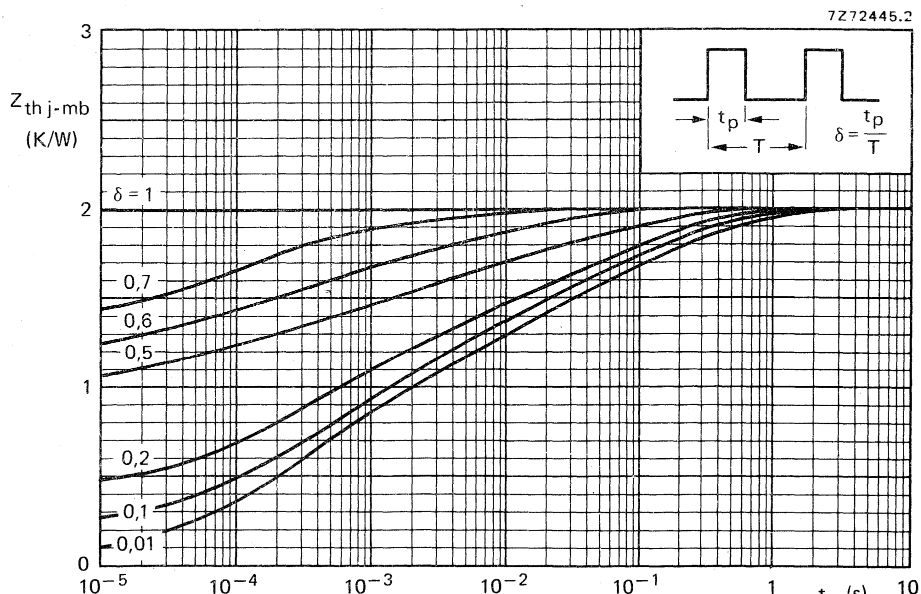


Fig. 8 Pulse power rating chart.

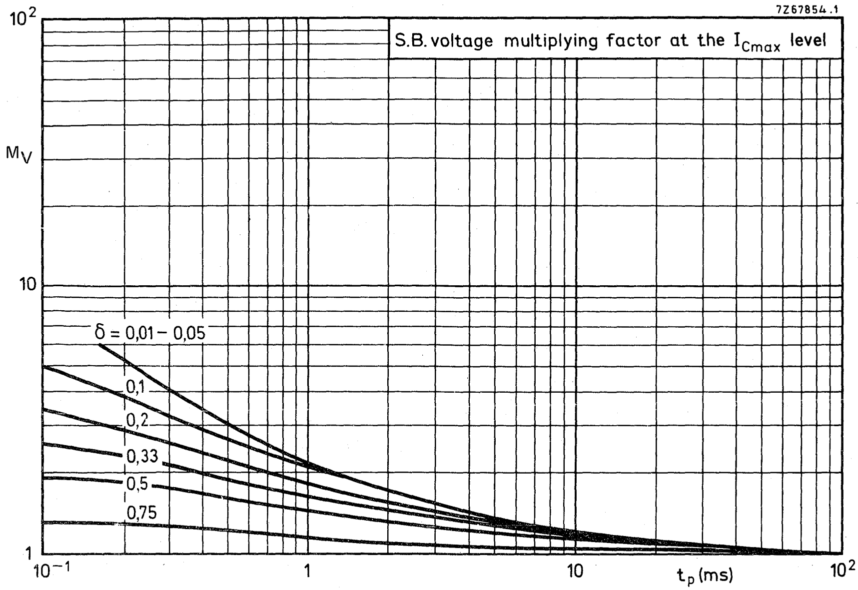


Fig. 9 S.B. voltage multiplying factor at the I_{Cmax} level.

BD646

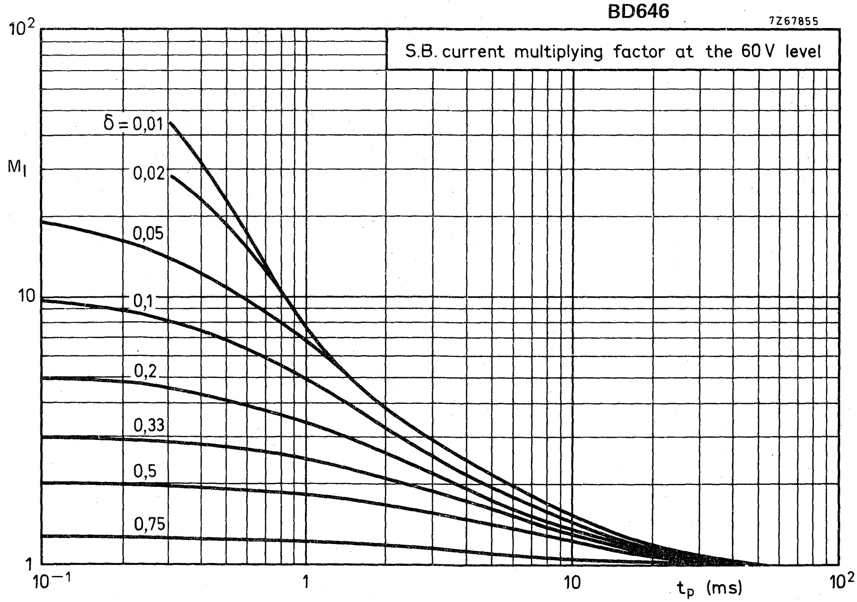


Fig. 10 S.B. current multiplying factor at 60 V level.

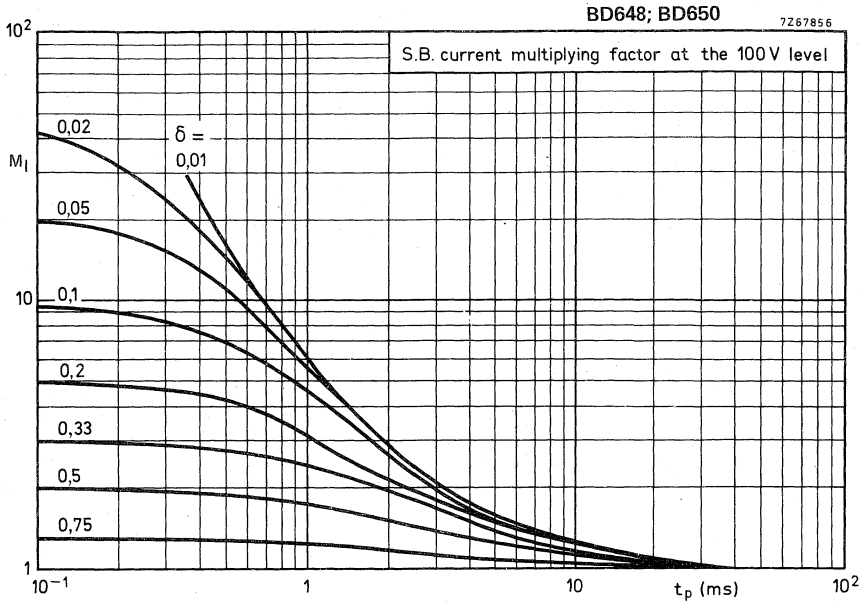

BD648; BD650
7Z67856
S.B. current multiplying factor at the 100 V level
10^2
M_I
10
1
0,02
δ =
0,01
0,05
0,1
0,2
0,33
0,5
0,75
10^{-1}
1
10
t_p (ms)
10^2

Fig. 11.

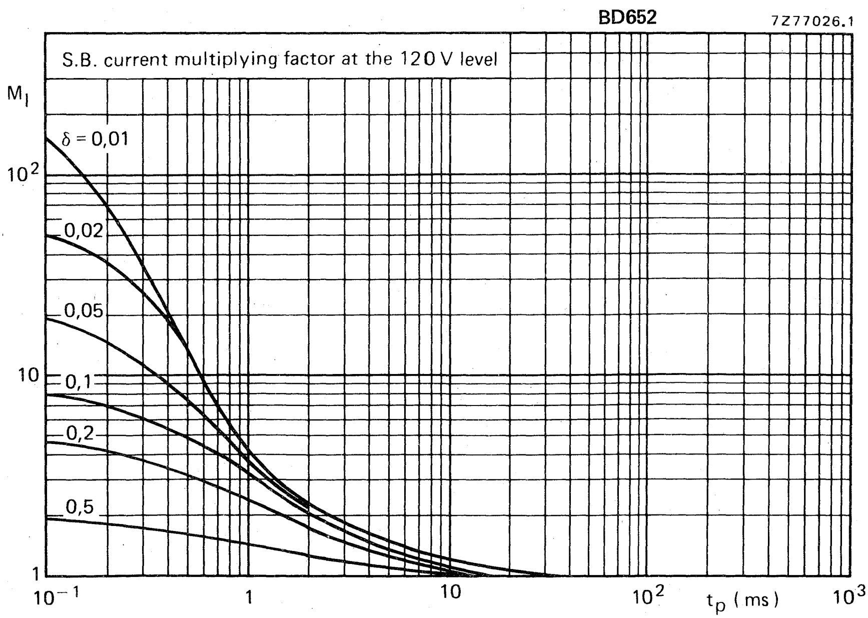

BD652
7Z77026.1
S.B. current multiplying factor at the 120 V level
M_I
δ = 0,01
10^2
0,02
0,05
10
0,1
0,2
0,5
1
10^{-1}
1
10
10^2
t_p (ms)
10^3

Fig. 12.

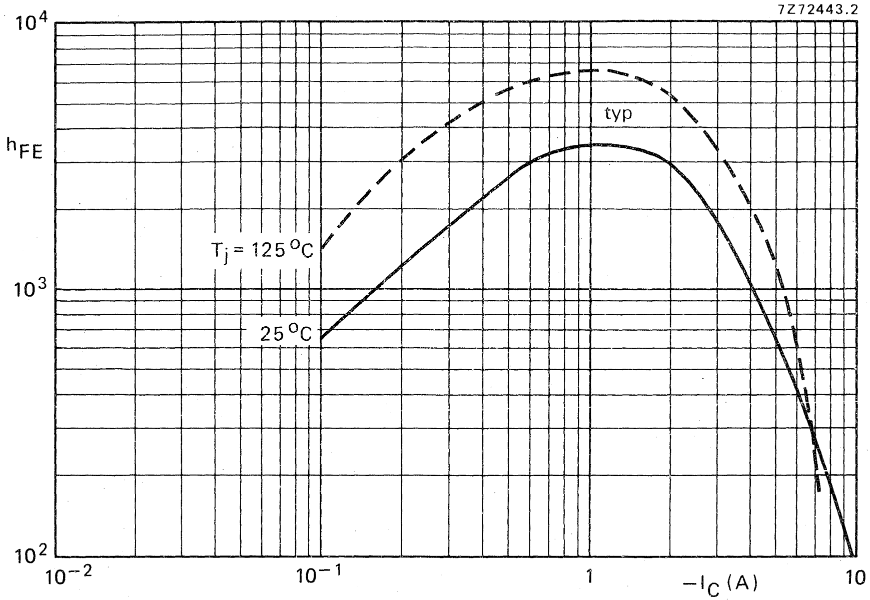


Fig. 13 D.C. current gain at $-V_{CE} = 3$ V.

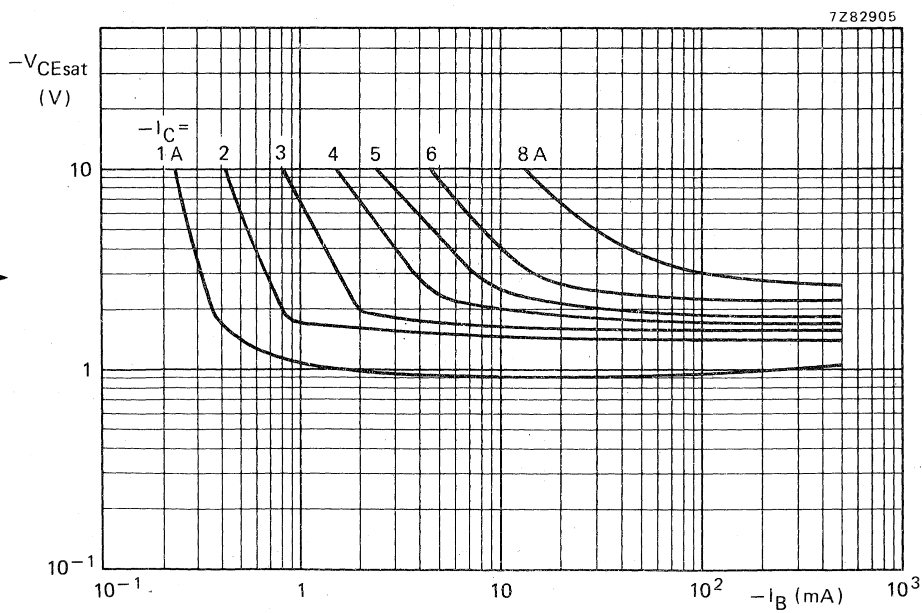


Fig. 14 Typical collector-emitter saturation voltage at $T_j = 25\ ^oC$.

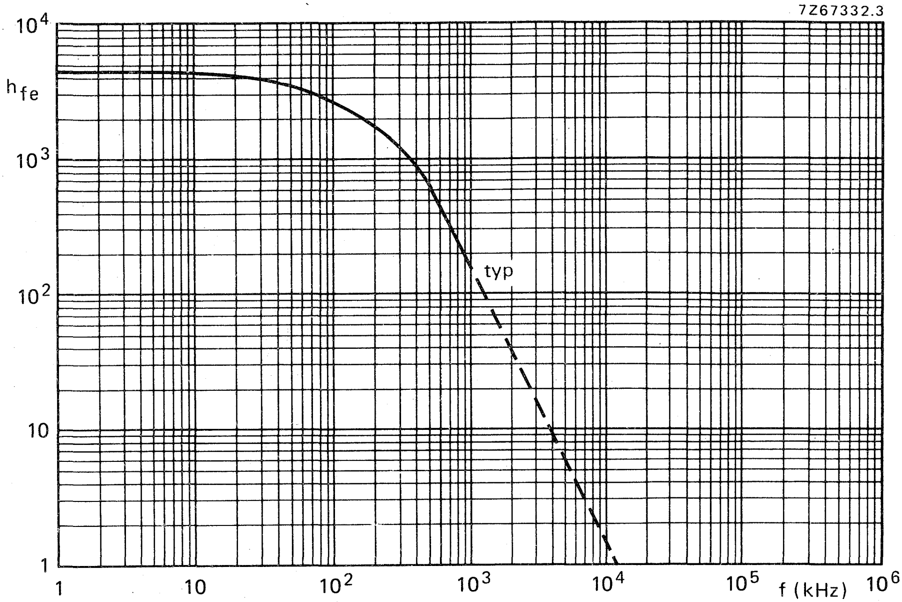


Fig. 15 Small signal current gain at $-I_C = 3$ A; $-V_{CE} = 3$ V.

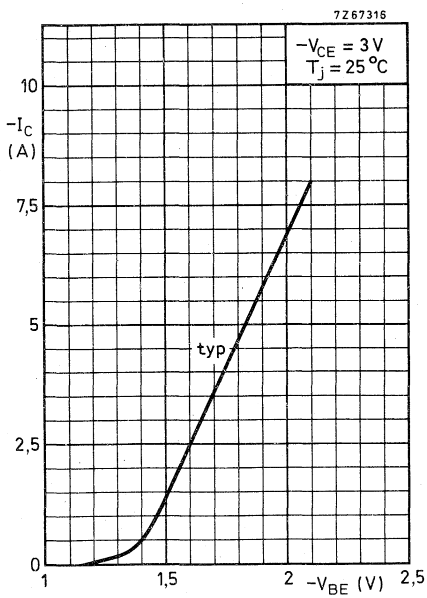


Fig. 16 Collector current.

SILICON DARLINGTON POWER TRANSISTORS

N-P-N epitaxial-base transistors in monolithic Darlington circuit for audio and video applications; SOT-32 plastic envelope. P-N-P complements are BD676, BD678, BD680, BD682 and BD684.

QUICK REFERENCE DATA

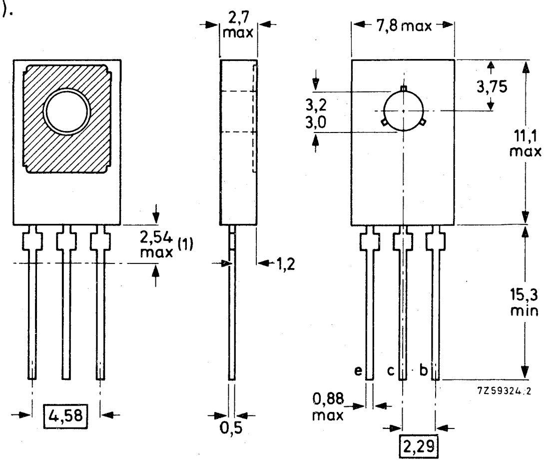
			BD675	677	679	681	683	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	100	120	V
Collector current (peak value)	I_{CM}	max.			6			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.			40			W
Junction temperature	T_j	max.			150			°C
D.C. current gain I_C = 0,5 A; V_{CE} = 3 V	h_{FE}	typ.			2200			
I_C = 1,5 A; V_{CE} = 3 V	h_{FE}	>			750			
Cut-off frequency I_C = 1,5 A; V_{CE} = 3 V	f_{hfe}	typ.			60			kHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-126 (SOT-32).

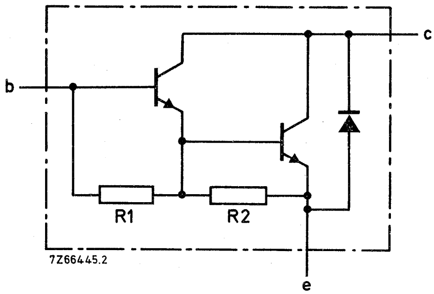
Collector connected to mounting base.



(1) Within this region the cross-section of the leads is uncontrolled.

See also chapters Mounting Instructions and Accessories.

CIRCUIT DIAGRAM



R_1 typ. 3 kΩ
R_2 typ. 120 Ω

Fig. 2 Darlington circuit diagram.

RATINGS

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

			BD675	677	679	681	683	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	5	5	V

Collector current (d.c.)	I_C	max.	4	A
Collector current (peak value)	I_{CM}	max.	6	A
Base current (d.c.)	I_B	max.	100	mA
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	40	W
Storage temperature	T_{stg}		−65 to + 150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	3,12	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	100	K/W

CHARACTERISTICS

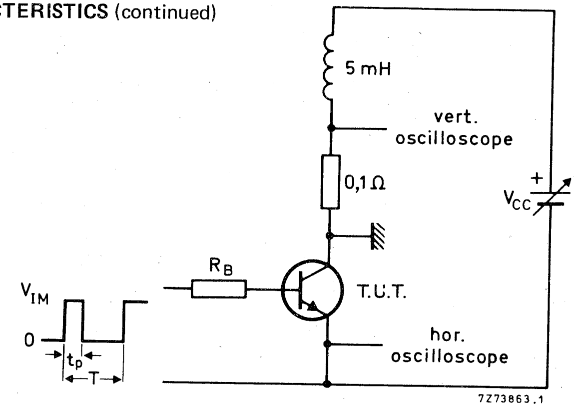
T_j = 25 °C, unless otherwise specified; where I_C = 1,5 A for BD675 read I_C = 2 A.

Collector cut-off current				
$I_E = 0$; $V_{CB} = V_{CEOmax}$	I_{CBO}	<	0,2 mA	
$I_E = 0$; $V_{CB} = ½ V_{CBOmax}$; T_{mb} = 150 °C	I_{CBO}	<	2 mA	
$I_B = 0$; $V_{CE} = ½ V_{CEOmax}$	I_{CEO}	<	0,5 mA	
Emitter cut-off current				
$I_C = 0$; V_{EB} = 5 V	I_{EBO}	<	5 mA	
D.C. current gain (note 1)				
I_C = 0,5 A; V_{CE} = 3 V	h_{FE}	typ.	2200	←
I_C = 1,5 A; V_{CE} = 3 V	h_{FE}	>	750	
I_C = 4 A; V_{CE} = 3 V	h_{FE}	typ.	1500	←
Base-emitter voltage (notes 1 and 2)				
I_C = 1,5 A; V_{CE} = 3 V (BD675; I_C = 2 A)	V_{BE}	<	2,5 V	
Collector-emitter saturation voltage (note 1)				
I_C = 1,5 A; I_B = 6 mA (BD675; I_C = 2 A)	V_{CEsat}	<	2,5 V	
Small signal current gain				
I_C = 1,5 A; V_{CE} = 3 V; f = 1 MHz (BD675; I_C = 2 A)	$\|h_{fe}\|$	typ.	50	
Cut-off frequency				
I_C = 1,5 A; V_{CE} = 3 V (BD675; I_C = 2 A)	f_{hfe}	typ.	60 kHz	
Turn-off breakdown energy with inductive load				
$-I_{Boff} = 0$; I_C = 3,5 A; (Fig. 3)	$E_{(BR)}$	>	30 mJ	
D.C. current gain ratio of matched complementary pairs				
I_C = 1,5 A; V_{CE} = 3 V	h_{FE1}/h_{FE2}	<	2,5	
Diode forward voltage				
I_F = 1,5 A (BD675; I_F = 2 A)	V_F	typ.	1,5 V	
Second-breakdown collector current				
V_{CE} = 50 V; t_p = 20 ms, non rep.; without heatsink	$I_{(SB)}$	>	0,8 A	←
BD675; V_{CE} = 40 V; t_p = ms	$I_{(SB)}$	>	1 A	←
Switching times (between 10% and 90% levels)				
I_{Con} = 1,5 A; $I_{Bon} = -I_{Boff}$ = 6 mA; V_{CC} = 30 V				
Turn-on time	t_{on}	typ.	0,8 µs	←
		<	2 µs	
Turn-off time	t_{off}	typ.	4,5 µs	←
		<	8 µs	

Notes

1. Measured under pulse conditions: $t_p < 300$ µs; $\delta < 2\%$.
2. V_{BE} decreases by about 3,6 mV/°C with increasing temperature.

CHARACTERISTICS (continued)



V_{IM} = 12 V
R_B = 270 Ω
I_{CC} = 3,5 A
T = 1 ms
δ = 1 %

Fig. 3 Test circuit for turn-off breakdown energy.

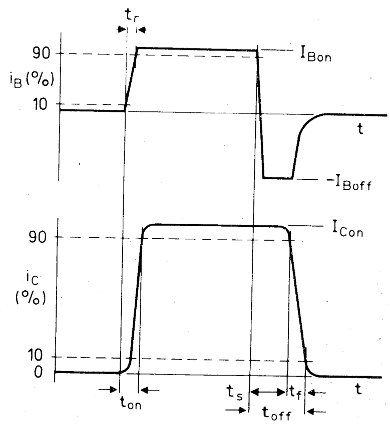
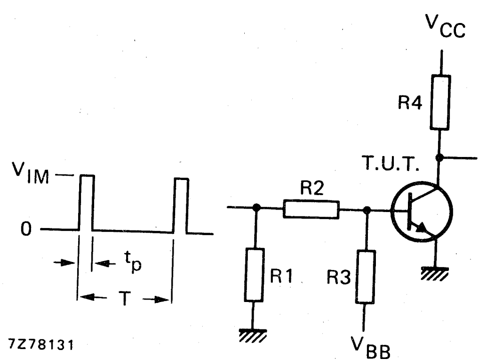


Fig. 4 Switching times waveforms.



V_{IM} = 12 V
V_{CC} = 30 V
V_{BB} = −3 V
R1 = 56 Ω
R2 = 1 kΩ
R3 = 680 Ω
R4 = 22 Ω
$t_r = t_f \leqslant 15$ ns
t_p = 10 μs
T = 500 μs

Fig. 5 Switching times test circuit.

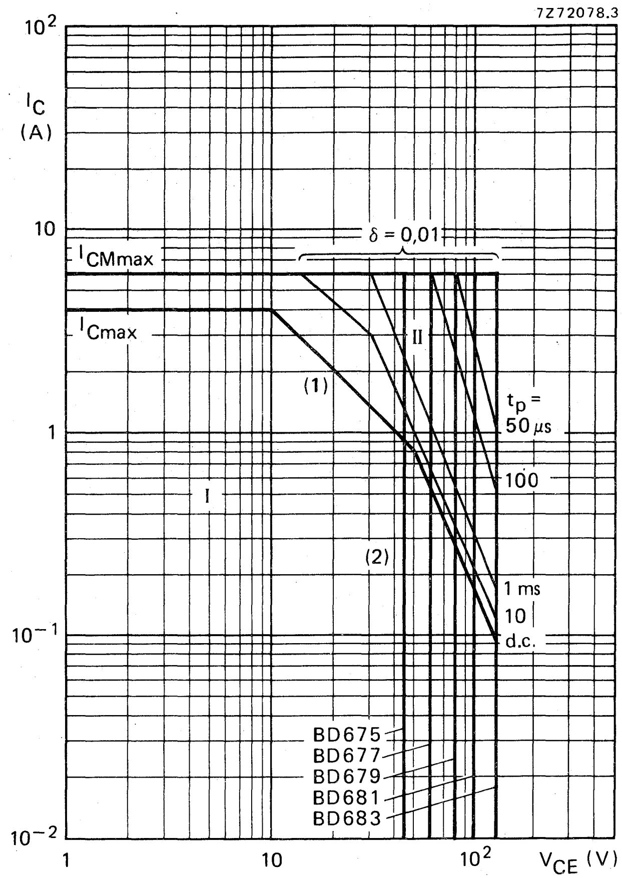


Fig. 6 Safe Operating ARea. T_{mb} = 25 °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ line.

(2) Second-breakdown limits (independent of temperature).

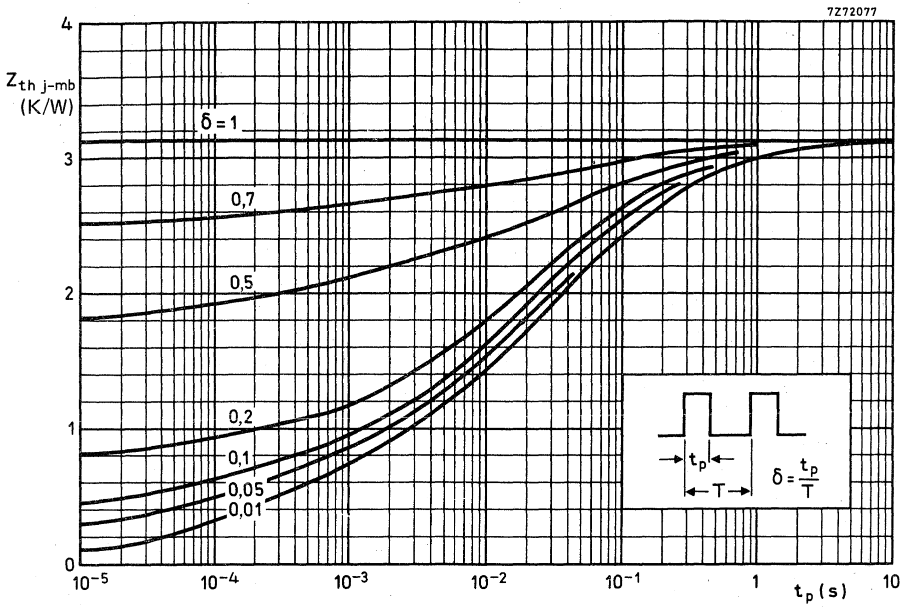


Fig. 7 Pulse power rating chart.

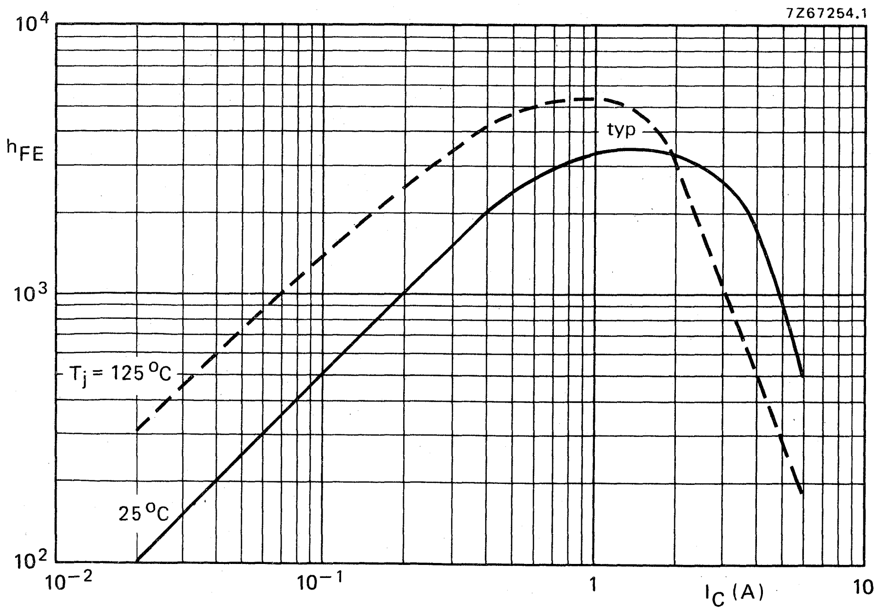


Fig. 8 D.C. current gain at V_{CE} = 3 V.

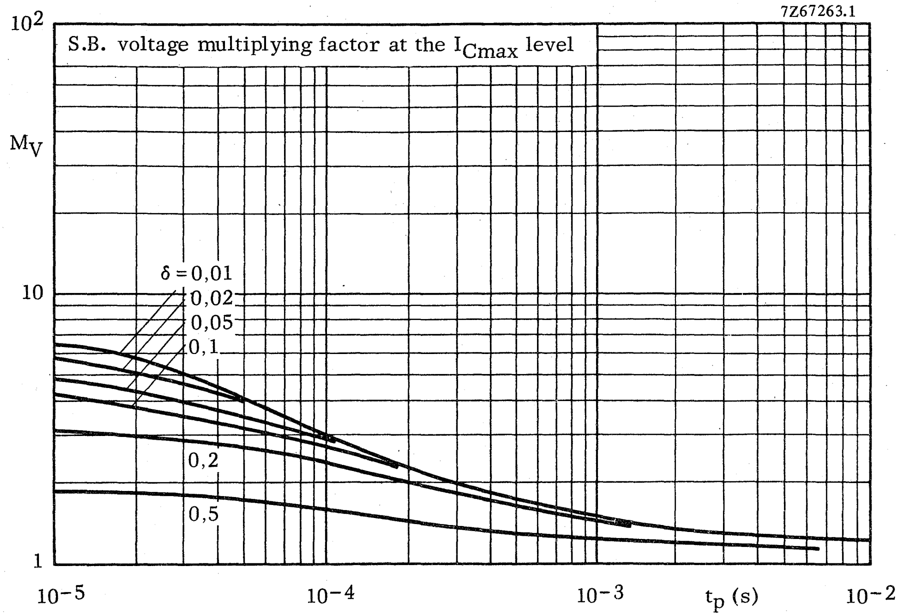


Fig. 9 S.B. voltage multiplying factor at the I_{Cmax} level.

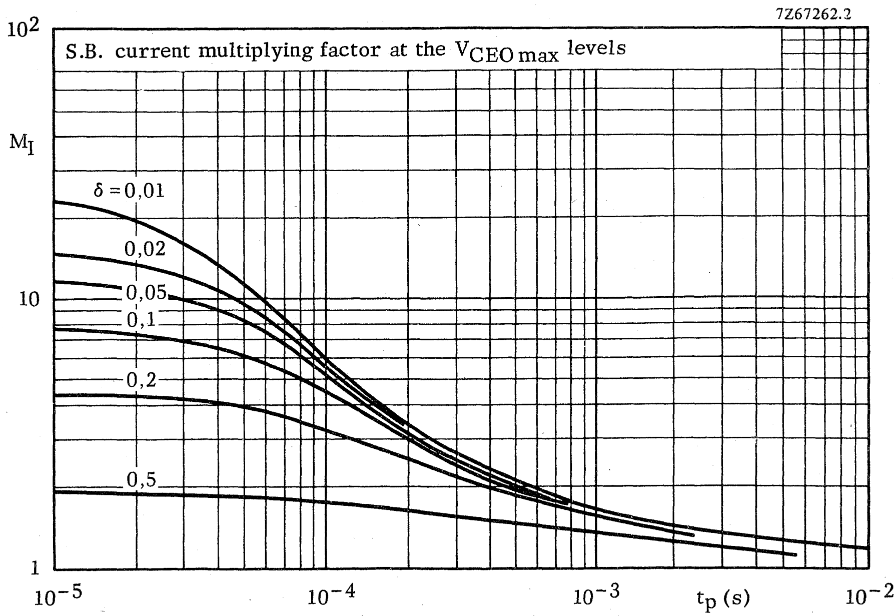


Fig. 10 S.B. current multiplying factor at the V_{CEOmax} levels.

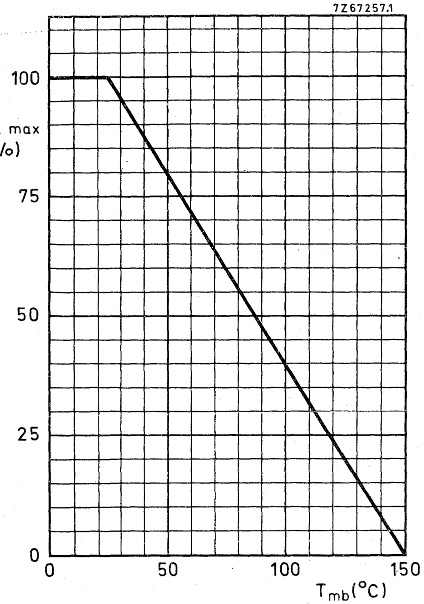


Fig. 11 Power derating curve.

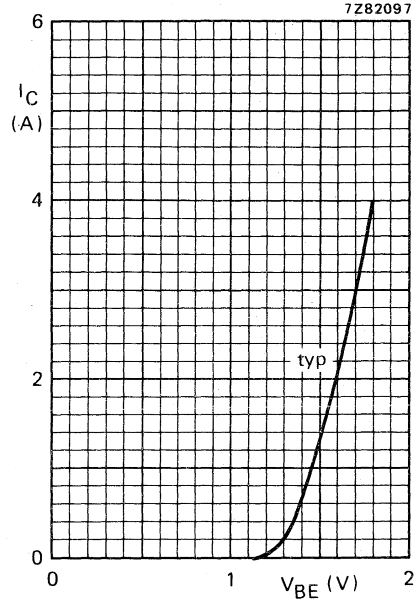


Fig. 12 Typical collector current.

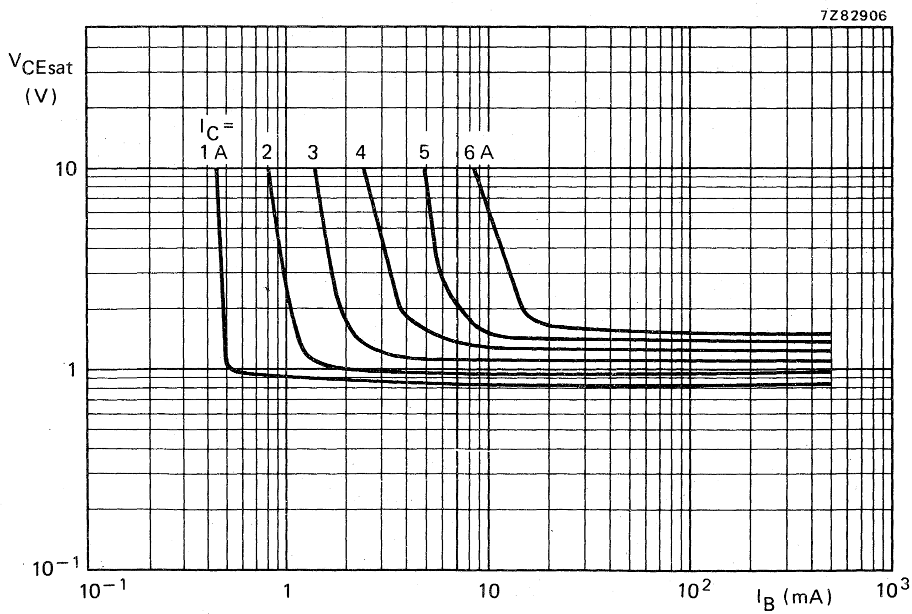


Fig. 13 Typical values collector-emitter saturation voltage. T_{mb} = 25 °C.

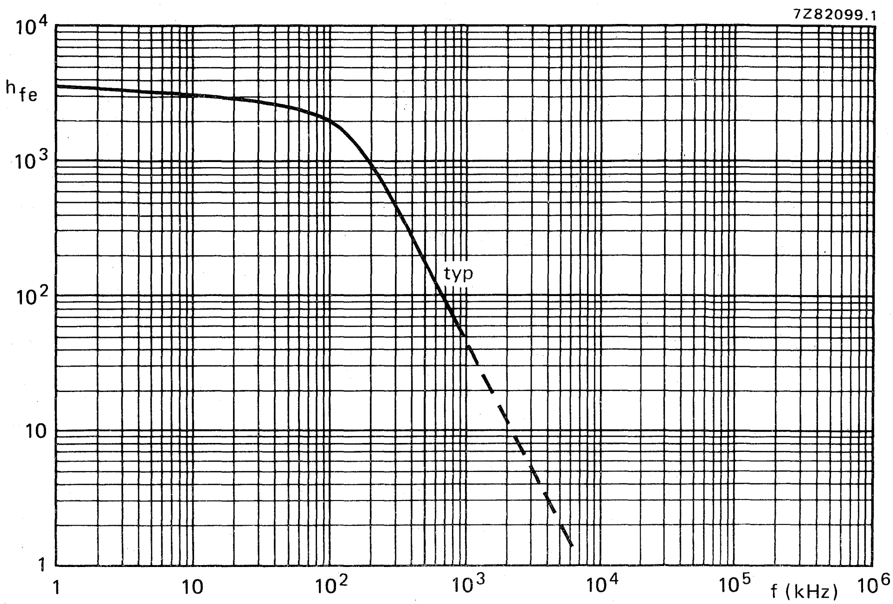


Fig. 14 Small signal current gain. I_C = 1,5 A; V_{CE} = 3 V.

SILICON DARLINGTON POWER TRANSISTORS

P-N-P epitaxial-base transistors in monolithic Darlington circuit for audio and video applications; SOT-32 plastic envelope. N-P-N complements are BD675, BD677, BD679, BD681 and BD683.

QUICK REFERENCE DATA

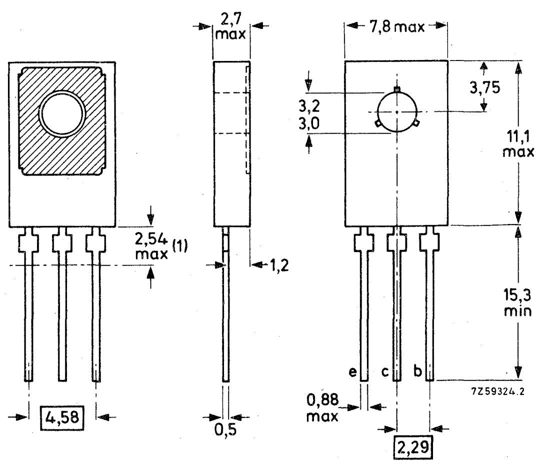
			BD676	678	680	682	684	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	100	120	V
Collector-current (peak value)	$-I_{CM}$	max.			6			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.			40			W
Junction temperature	T_j	max.			150			°C
D.C. current gain								
$-I_C$ = 0,5 A; $-V_{CE}$ = 3 V	h_{FE}	typ.			1000			
$-I_C$ = 1,5 A; $-V_{CE}$ = 3 V	h_{FE}	>			750			
Cut-off frequency								
$-I_C$ = 1,5 A; $-V_{CE}$ = 3 V	f_{hfe}	typ.			60			kHz

MECHANICAL DATA

Dimensions in mm

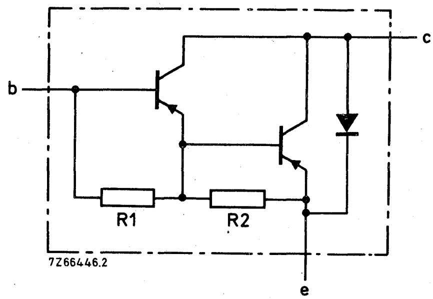
Fig. 1 TO-126 (SOT-32).

Collector connected to mounting base.



(1) Within this region the cross-section of the leads is uncontrolled.

See also chapters Mounting Instructions and Accessories.



R1 typ. 3 kΩ
R2 typ. 80 Ω

Fig. 2 Darlington circuit diagram.

RATINGS

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

			BD676	678	680	682	684	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	5	5	V
Collector current (d.c.)	$-I_C$	max.			4			A
Collector current (peak value)	$-I_{CM}$	max.			6			A
Base current (d.c.)	$-I_B$	max.			100			mA
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.			40			W
Storage temperature	T_{stg}				−65 to + 150			°C
Junction temperature	T_j	max.			150			°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	3,12	°C/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	100	°C/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified; where $-I_C$ = 1,5 A for BD676 read $-I_C$ = 2 A.

Collector cut-off current				
$I_E = 0$; $-V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	0,2	mA
$I_E = 0$; $-V_{CB} = -½\ V_{CBOmax}$; T_{mb} = 150 °C	$-I_{CBO}$	<	2	mA
$I_B = 0$; $-V_{CE} = -½\ V_{CEOmax}$	$-I_{CEO}$	<	0,5	mA
Emitter cut-off current				
$I_C = 0$; $-V_{EB}$ = 5 V	$-I_{EBO}$	<	5	mA
D.C. current gain (note 1)				
$-I_C$ = 0,5 A; $-V_{CE}$ = 3 V	h_{FE}	typ.	1000	
$-I_C$ = 1,5 A; $-V_{CE}$ = 3 V	h_{FE}	>	750	
$-I_C$ = 4 A; $-V_{CE}$ = 3 V	h_{FE}	typ.	500	
Base-emitter voltage (notes 1 and 2)				
$-I_C$ = 1,5 A; $-V_{CE}$ = 3 V	$-V_{BE}$	<	2,5	V
Collector-emitter saturation voltage (note 1)				
$-I_C$ = 1,5 A; $-I_B$ = 6 mA	$-V_{CEsat}$	<	2,5	V
Small-signal current gain				
$-I_C$ = 1,5 A; $-V_{CE}$ = 3 V; f = 1 MHz	$\|h_{fe}\|$	typ.	50	
Cut-off frequency				
$-I_C$ = 1,5 A; $-V_{CE}$ = 3 V	f_{hfe}	typ.	60	kHz
D.C. current gain ratio of matched complementary pairs				
$-I_C$ = 1,5 A; $-V_{CE}$ = 3 V	h_{FE1}/h_{FE2}	<	2,5	
Diode, forward voltage				
I_F = 1,5 A	V_F	typ.	1,5	V

Notes
1. Measured under pulse conditions: $t_p < 300\ \mu s$, $\delta < 2\%$.
2. V_{BE} decreases by about 3,6 mV/°C with increasing temperature.

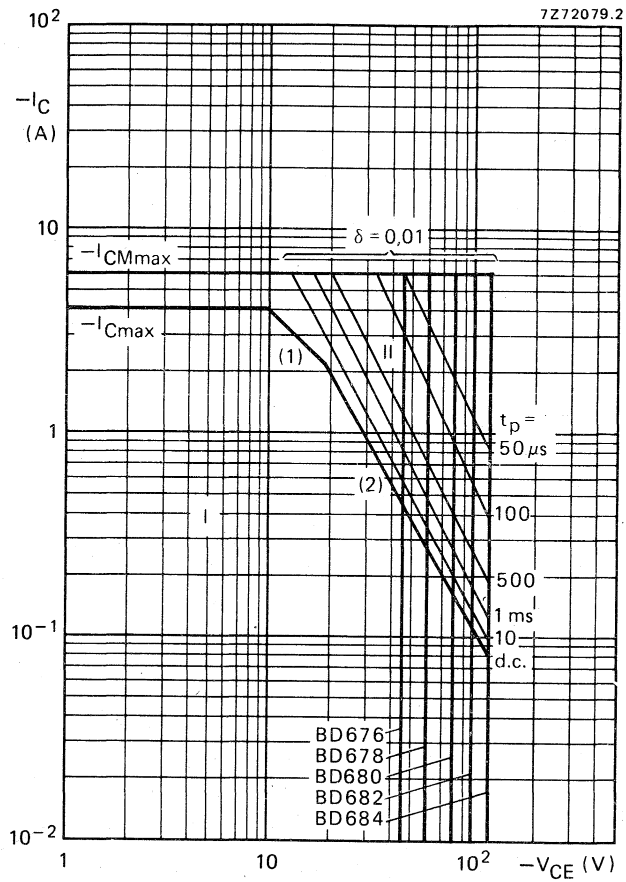


Fig. 3 Safe Operating ARea. T_{mb} = 25 °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ line.

(2) Second-breakdown limits (independent of temperature).

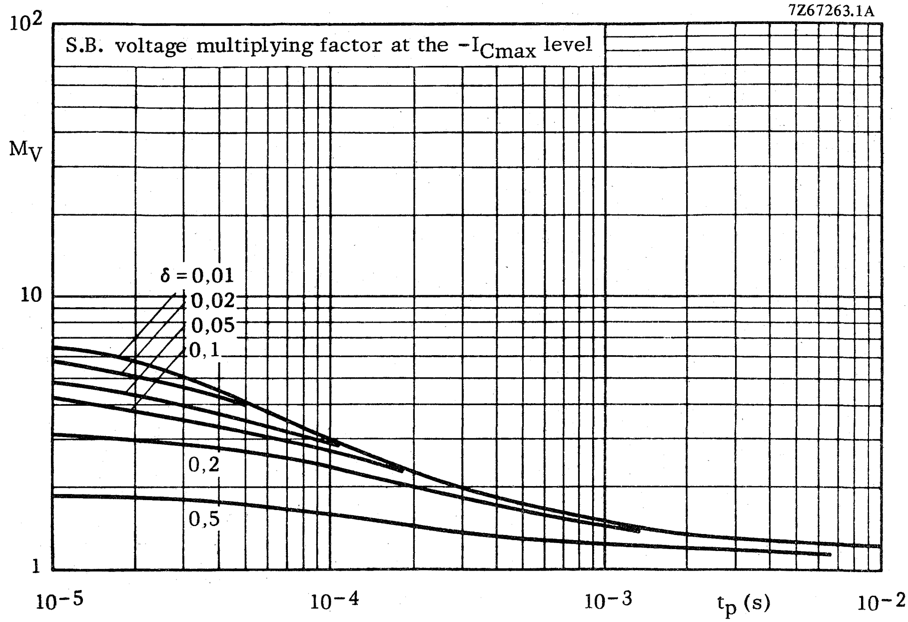


Fig. 4 S.B. voltage multiplying factor at the $-I_{Cmax}$ level.

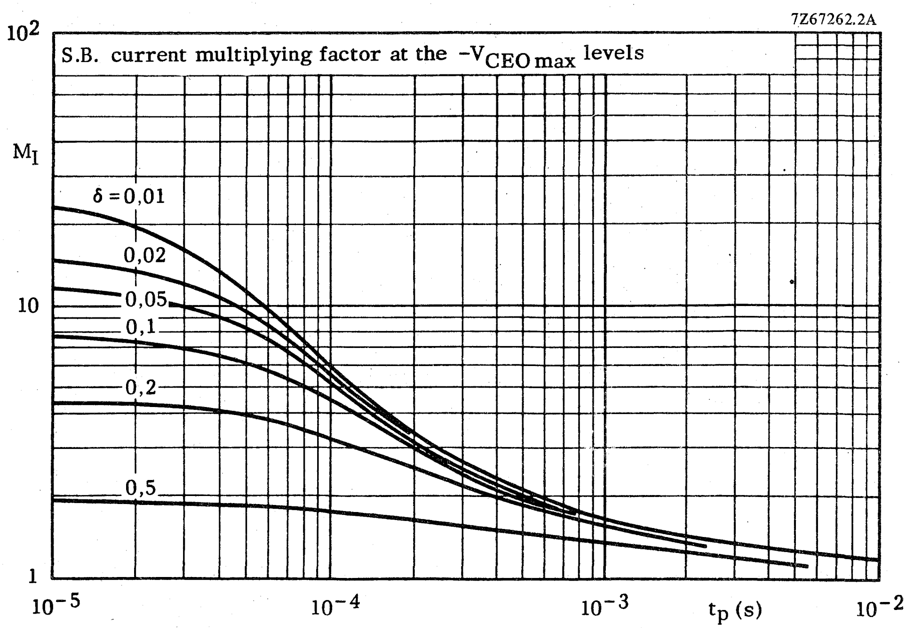


Fig. 5 S.B. current multiplying factor at the $-V_{CEOmax}$ levels.

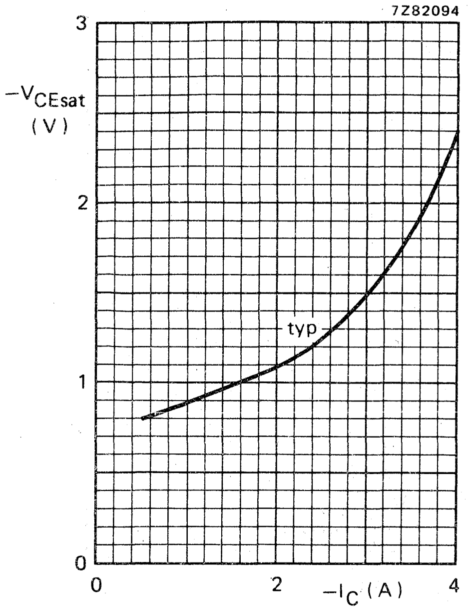


Fig. 6.

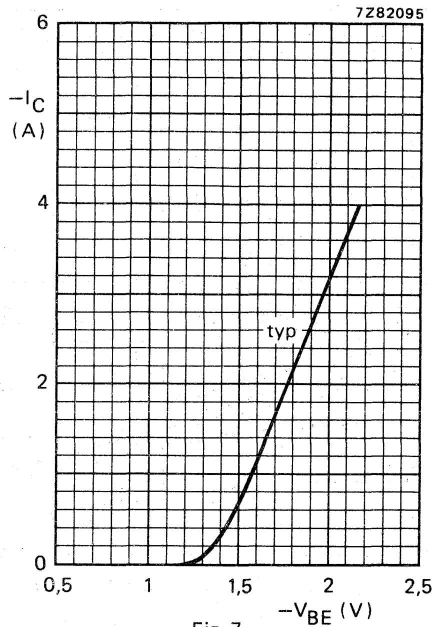


Fig. 7.

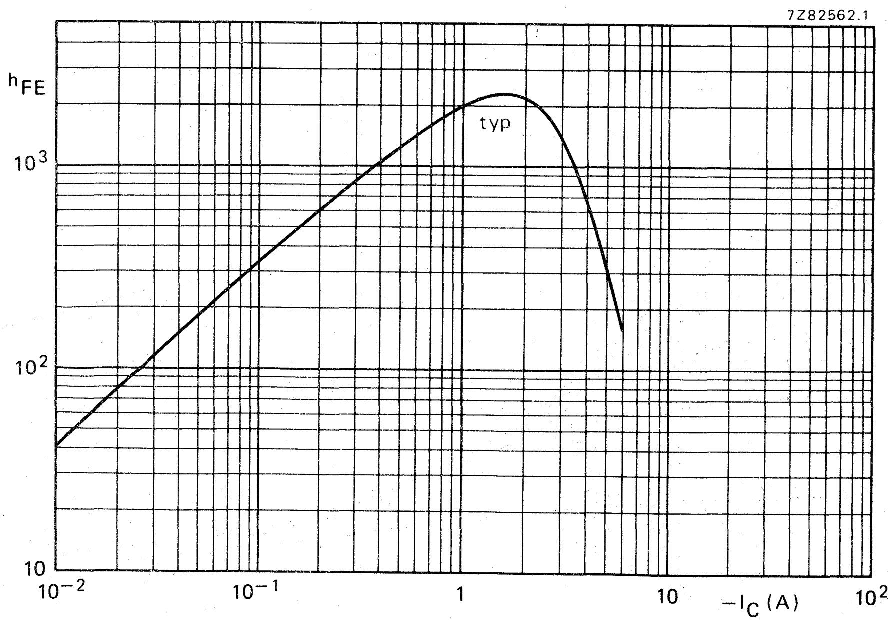


Fig. 8 D.C. current gain. $-V_{CE} = 3$ V; $T_{mb} = 25$ °C.

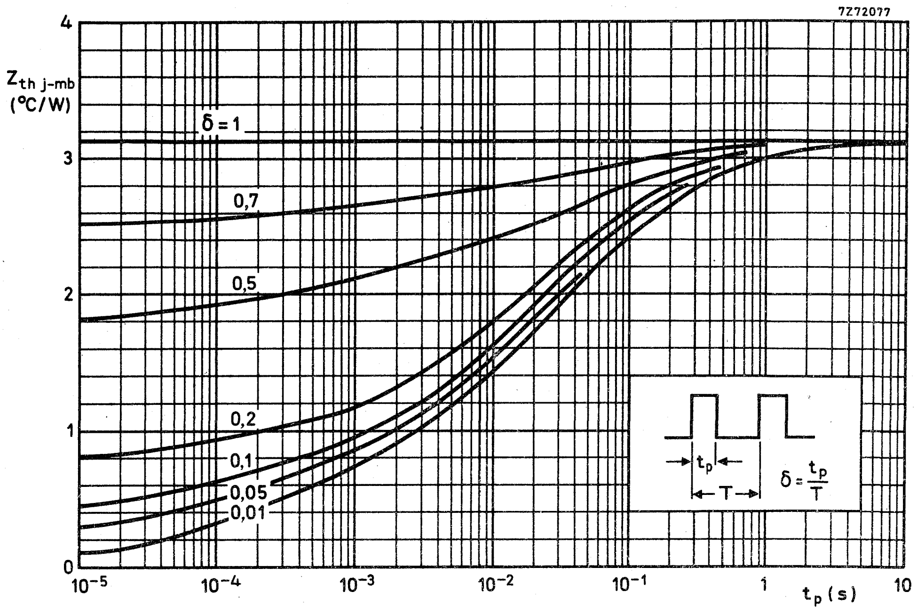


Fig. 9 Pulse power rating chart.

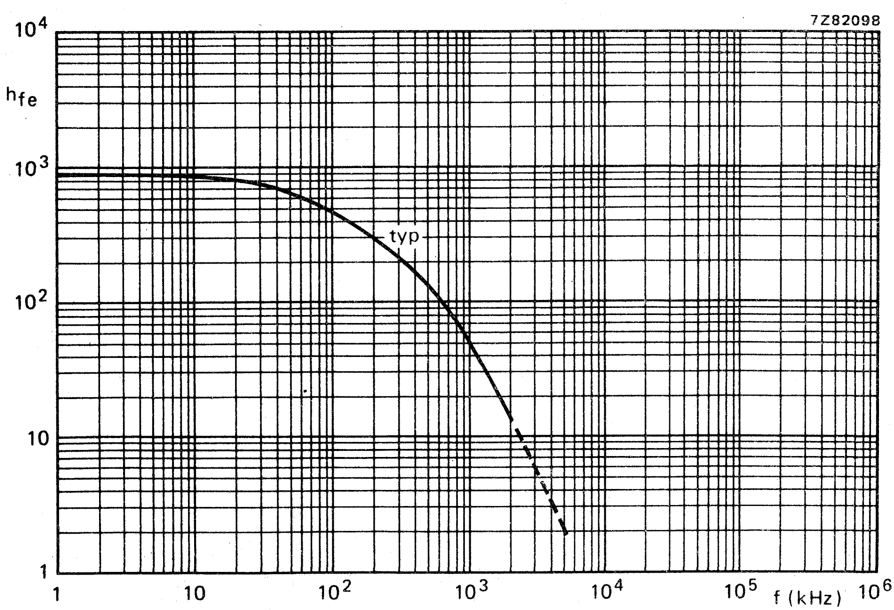


Fig. 10 Small signal current gain. $-I_C$ = 1,5 A; $-V_{CE}$ = 3 V.

SILICON EPITAXIAL-BASE POWER TRANSISTORS

N-P-N transistors in a plastic TO-202 envelope intended for use in television and audio amplifier circuits where high peak powers can occur.
P-N-P complements are BD814, BD816 and BD818. Matched pairs can be supplied.

QUICK REFERENCE DATA

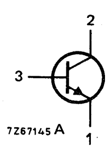
			BD813	BD815	BD817	
Collector-base voltage	V_{CBO}	max.	45	60	100	V
Collector-emitter voltage	V_{CEO}	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	V_{CER}	max.	45	60	100	V
Collector current (peak value)	I_{CM}	max.		6		A
Total power dissipation						
up to T_{amb} = 25 °C	P_{tot}	max.		2		W
up to T_{mb} = 25 °C	P_{tot}	max.		12,5		W
Junction temperature	T_j	max.		150		°C
D.C. current gain						
I_C = 1 A; V_{CE} = 2 V	h_{FE}	>		25		
Transition frequency						
I_C = 250 mA; V_{CE} = 10 V	f_T	>		3		MHz

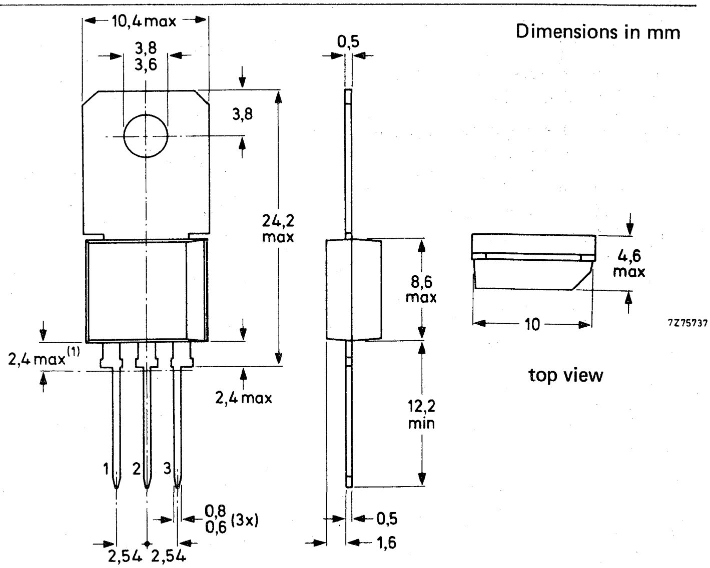
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-202.

Collector connected to mounting base.





(1) Plastic flash allowed within this zone.

RATINGS

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

			BD813	BD815	BD817	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	V_{CER}	max.	45	60	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V
Collector current (d.c.)	I_C	max.		2		A
Collector current (peak value)	I_{CM}	max.		6		A
Total power dissipation						
at T_{amb} = 25 °C (free air)	P_{tot}	max.		2		W
at T_{mb} = 25 °C	P_{tot}	max.		12,5		W
Storage temperature	T_{stg}			−65 to + 150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	62,5	K/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	10	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

Collector cut-off current				
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	<	100	µA
$I_E = 0$; $V_{CB} = V_{CBOmax}$; T_j = 150 °C	I_{CBO}	<	3	mA
Emitter cut-off current				
$I_C = 0$; V_{EB} = 5 V	I_{EBO}	<	1	mA
Base-emitter voltage				
I_C = 1 A; V_{CE} = 2 V	V_{BE}	<	1,3	V
Collector-emitter saturation voltage				
I_C = 1 A; I_B = 0,1 A	V_{CEsat}	<	0,6	V
D.C. current gain				
I_C = 150 mA; V_{CE} = 2 V	h_{FE}		40 to 250	
I_C = 1 A; V_{CE} = 2 V	h_{FE}	>	25	

Transition frequency at f = 1 MHz I_C = 250 mA; V_{CE} = 10 V	f_T	>	3 MHz
D.C. current gain ratio of matched complementary pairs $\|I_C\|$ = 150 mA; $\|V_{CE}\|$ = 2 V	h_{FE1}/h_{FE2}	<	1,6
Switching times I_{Con} = 1 A; $I_{Bon} = -I_{Boff}$ = 0,1 A turn-on time	t_{on}	typ. <	0,4 μs 1 μs
turn-off time	t_{off}	typ. <	1,5 μs 3 μs

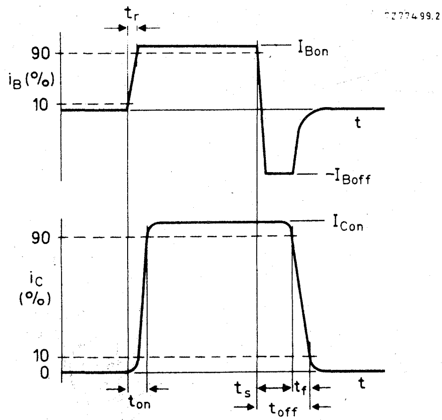
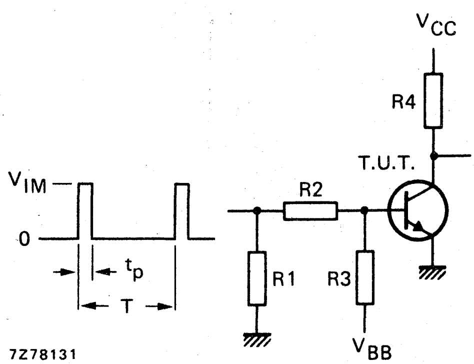


Fig. 2 Switching times waveform.



V_{IM}	=	16 V
V_{CC}	=	20 V
$-V_{BB}$	=	6,4 V
R1	=	82 Ω
R2	=	82 Ω
R3	=	82 Ω
R4	=	20 Ω
$t_r = t_f$	=	15 ns
t_p	=	10 μs
T	=	500 μs

Fig. 3 Switching times test circuit.

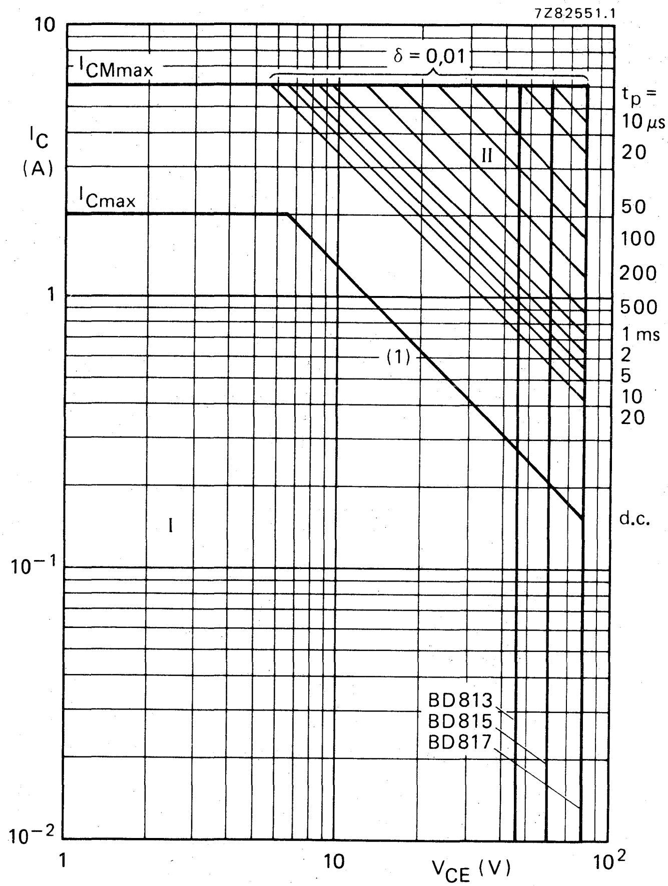


Fig. 4 Safe Operating ARea. $T_{mb} \leqslant 25\ ^oC$.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second-breakdown limits (independent of temperature).

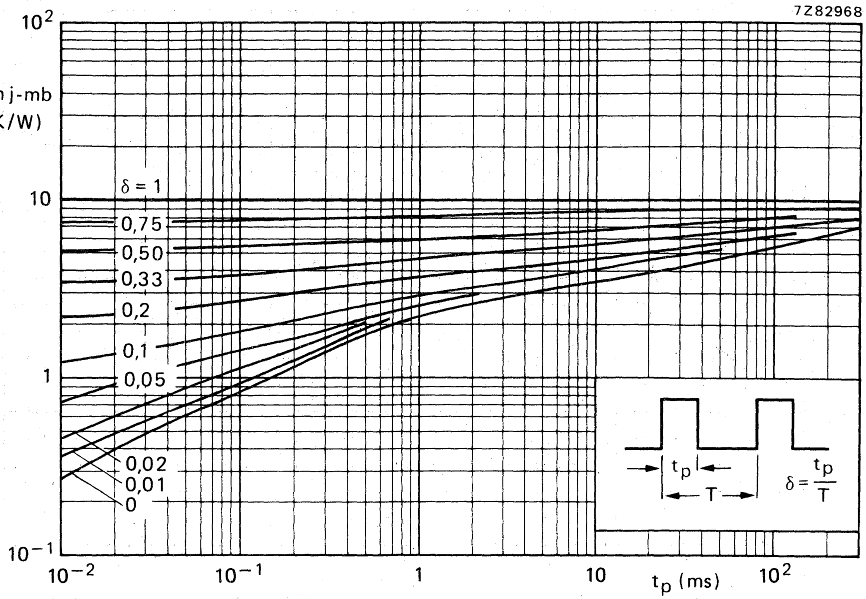


Fig. 5 Pulse power rating chart.

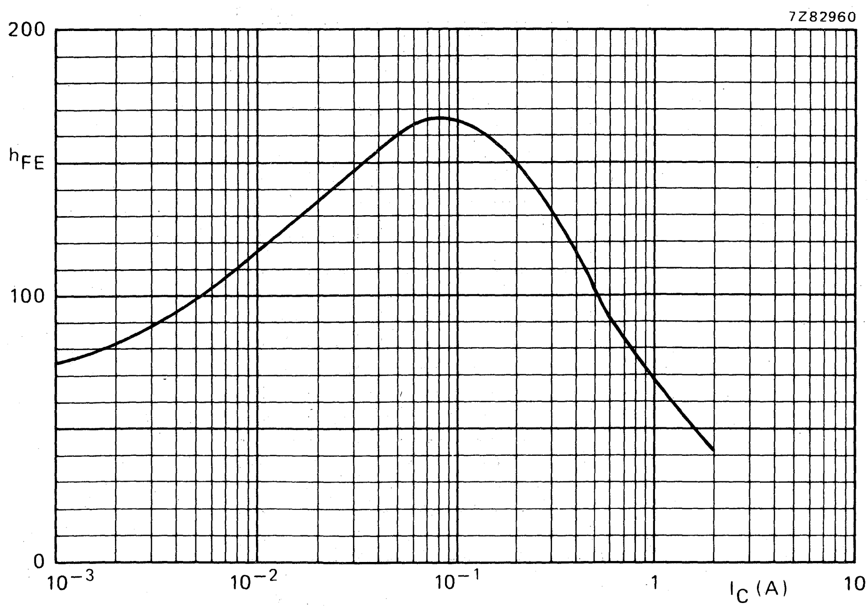


Fig. 6 Typical values d.c. current gain. V_{CE} = 2 V; T_{amb} = 25 °C.

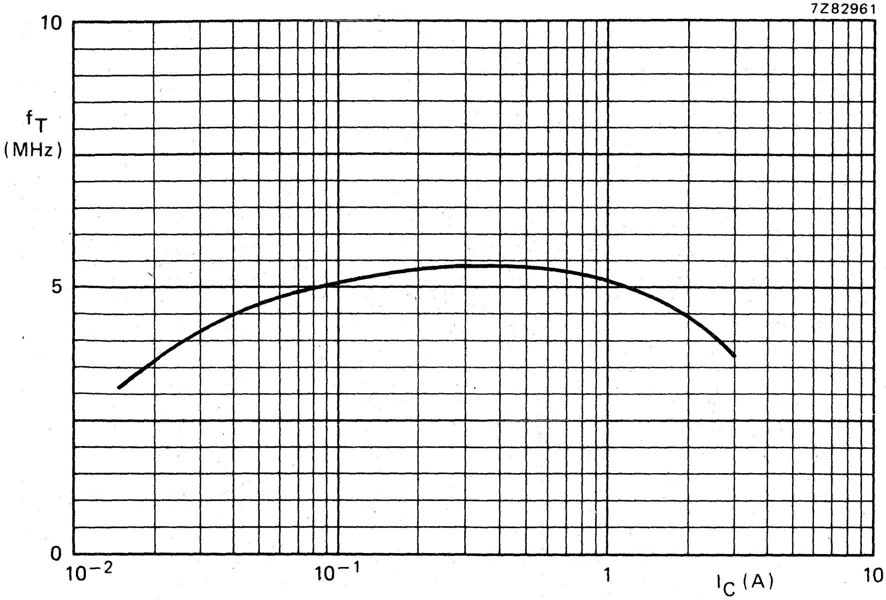


Fig. 7 Typical values transition frequency. V_{CE} = 10 V; f = 1 MHz; T_{amb} = 25 °C.

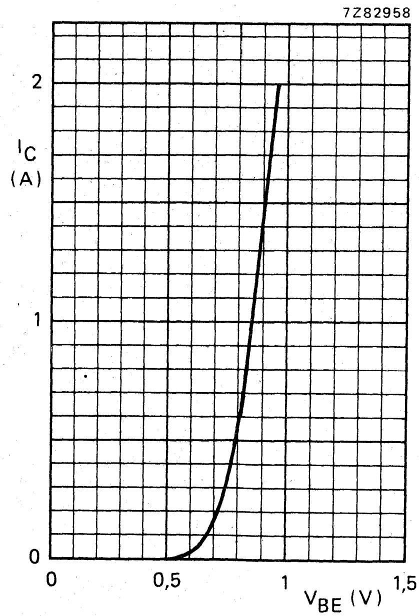


Fig. 8 Typical values V_{CE} = 2 V; T_{amb} = 25 °C.

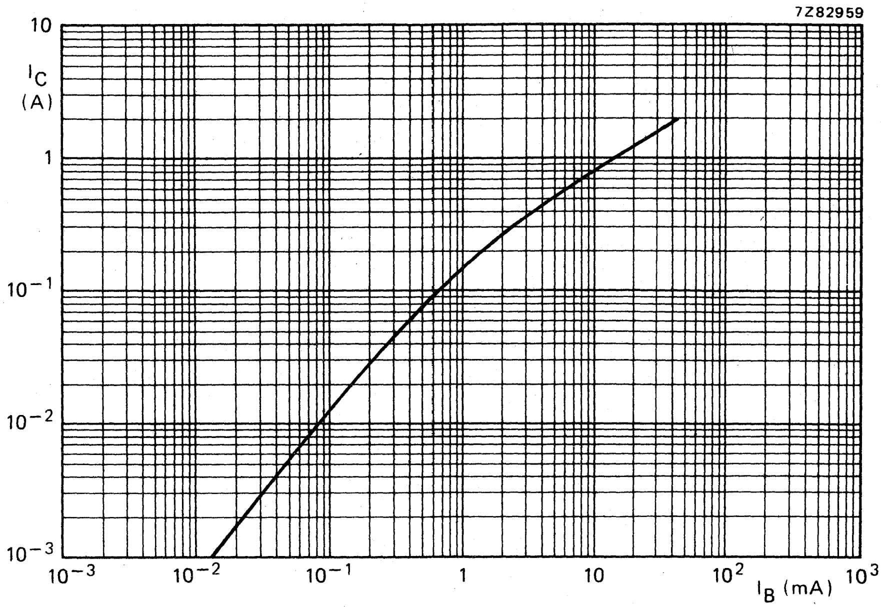


Fig. 9 Typical values at V_{CE} = 2 V; T_{amb} = 25 °C.

SILICON EPITAXIAL-BASE POWER TRANSISTORS

P-N-P transistors in a plastic TO-202 envelope intended for use in television and audio amplifier circuits where high peak powers can occur.

N-P-N complements are BD813, BD815 and BD817. Matched pairs can be supplied.

QUICK REFERENCE DATA

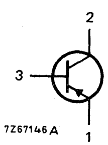
			BD814	BD816	BD818	
Collector-base voltage	$-V_{CBO}$	max.	45	60	100	V
Collector-emitter voltage	$-V_{CEO}$	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	$-V_{CER}$	max.	45	60	100	V
Collector current (peak value)	$-I_{CM}$	max.		6		A
Total power dissipation						
up to T_{amb} = 25 °C	P_{tot}	max.		2		W
up to T_{mb} = 25 °C	P_{tot}	max.		12,5		W
Junction temperature	T_j	max.		150		°C
D.C. current gain						
$-I_C$ = 1 A; $-V_{CE}$ = 2 V	h_{FE}	>		25		
Transition frequency						
$-I_C$ = 250 mA; $-V_{CE}$ = 10 V	f_T	>		3		MHz

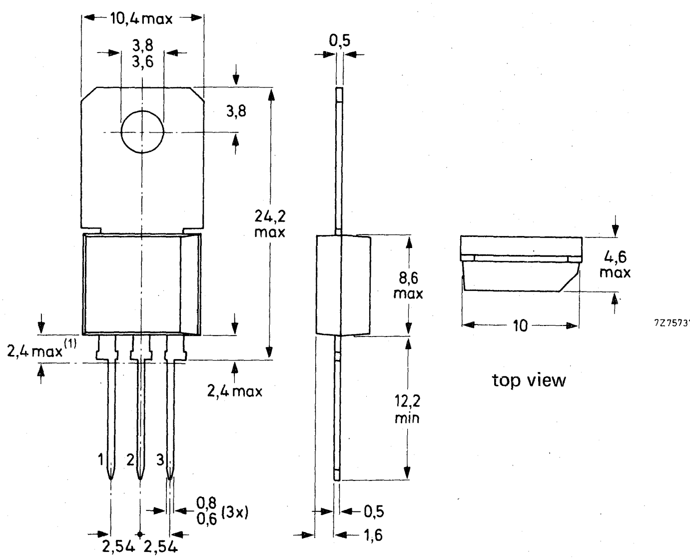
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-202.

Collector connected to mounting base.





(1) Plastic flash allowed within this zone.

RATINGS

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

			BD814	BD816	BD818	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	$-V_{CER}$	max.	45	60	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V

Collector current (d.c.)	$-I_C$	max.	2	A
Collector current (peak value)	$-I_{CM}$	max.	6	A
Total power dissipation				
at T_{amb} = 25 °C (free air)	P_{tot}	max.	2	W
at T_{mb} = 25 °C	P_{tot}	max.	12,5	W
Storage temperature	T_{stg}		−65 to + 150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	62,5	K/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	10	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0; -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	100	μA
$I_E = 0; -V_{CB} = -V_{CBOmax}; T_j = 150$ °C	$-I_{CBO}$	<	3	mA
Emitter cut-off current				
$I_C = 0; -V_{EB} = 5$ V	$-I_{EBO}$	<	1	mA
Base-emitter voltage				
$-I_C = 1$ A; $-V_{CE} = 2$ V	$-V_{BE}$	<	1,3	V
Collector-emitter saturation voltage				
$-I_C = 1$ A; $-I_B = 0,1$ A	$-V_{CEsat}$	<	0,6	V
D.C. current gain				
$-I_C = 150$ mA; $-V_{CE} = 2$ V	h_{FE}		40 to 250	
$-I_C = 1$ A; $-V_{CE} = 2$ V	h_{FE}	>	25	

Transition frequency at f = 1 MHz $-I_C$ = 250 mA; $-V_{CE}$ = 10 V	f_T	>	3 MHz
D.C. current gain ratio of matched pairs BD813/BD814; BD815/BD816; BD817/BD818 $\lvert I_C \rvert$ = 150 mA; $\lvert V_{CE} \rvert$ = 2 V	h_{FE1}/h_{FE2}	<	1,6
Switching times $-I_{Con}$ = 1 A; $-I_{Bon}$ = I_{Boff} = 0,1 A			
turn-on time	t_{on}	typ.	0,3 μs
turn-off time	t_{off}	typ.	0,7 μs

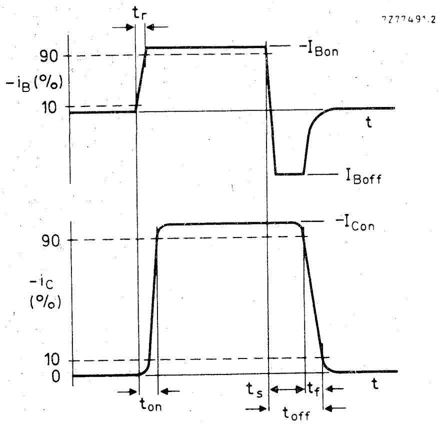


Fig. 2 Switching times waveforms.

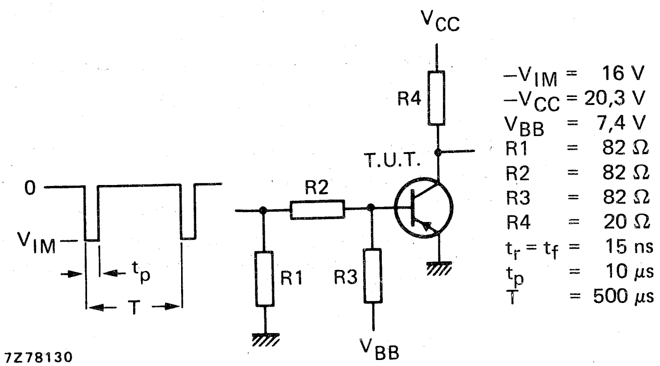


Fig. 3 Switching times test circuit.

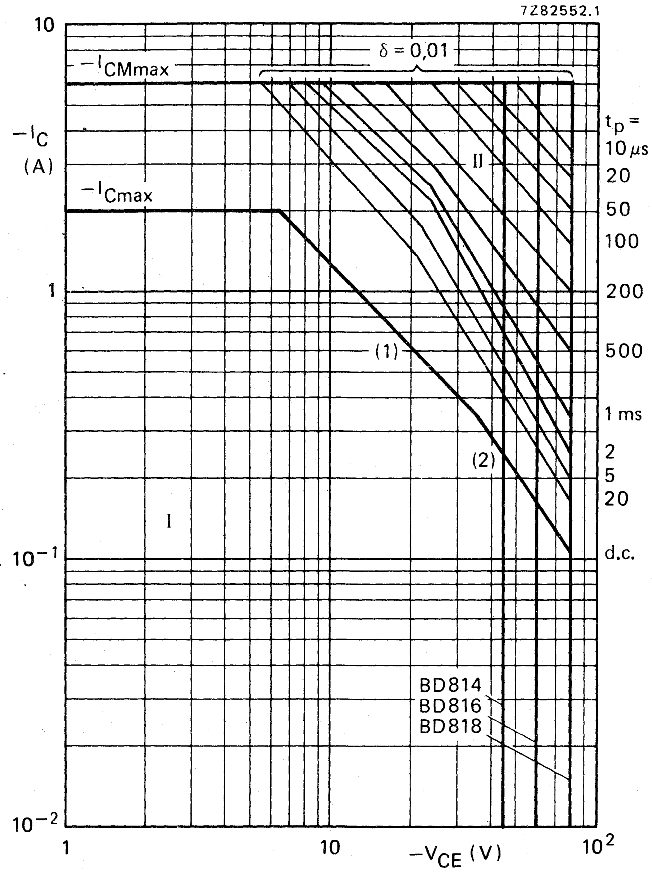


Fig. 4 Safe Operating ARea, $T_{mb} \leqslant 25\ ^oC$.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.

(2) Second-breakdown limits (independent of temperature).

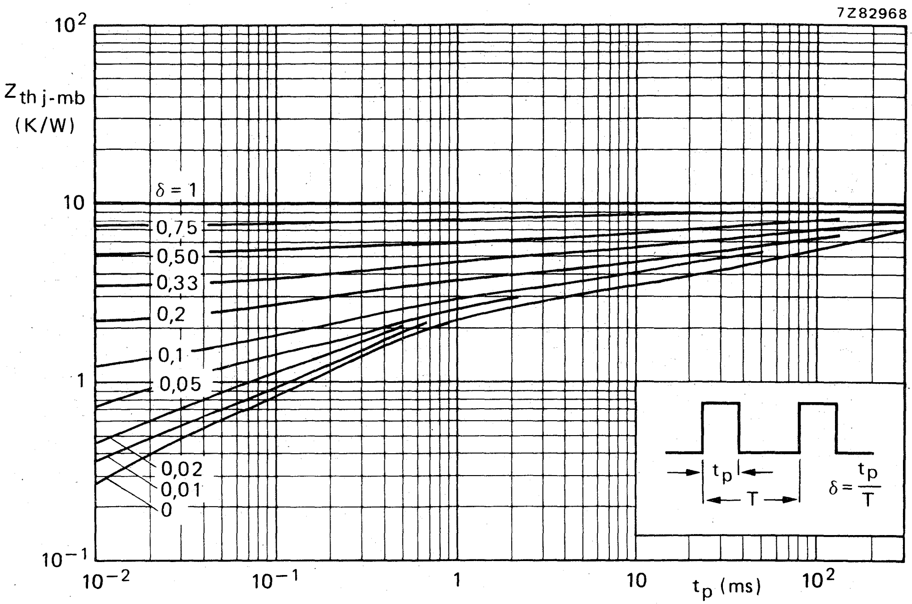


Fig. 5 Pulse power rating chart.

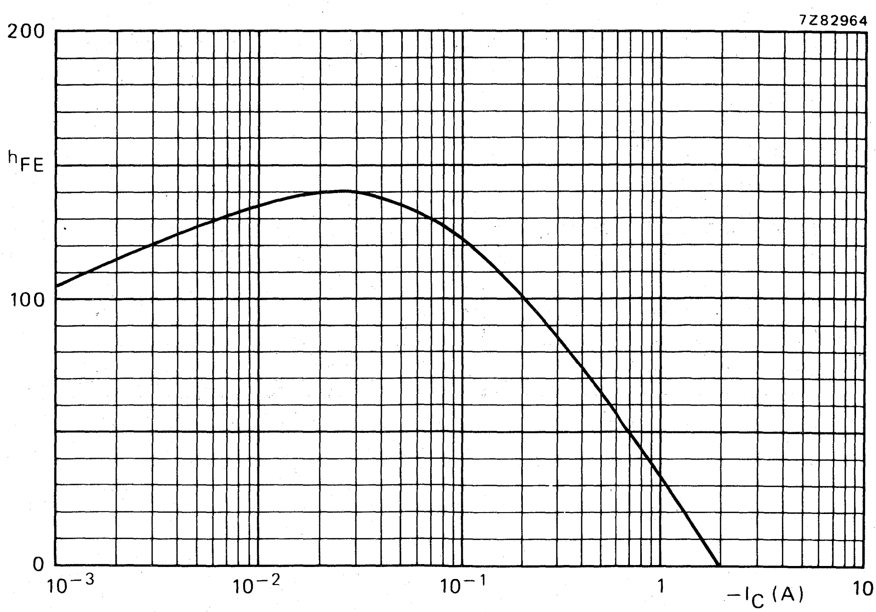


Fig. 6 Typical values d.c. current gain. $-V_{CE} = 2$ V; $T_{amb} = 25$ °C.

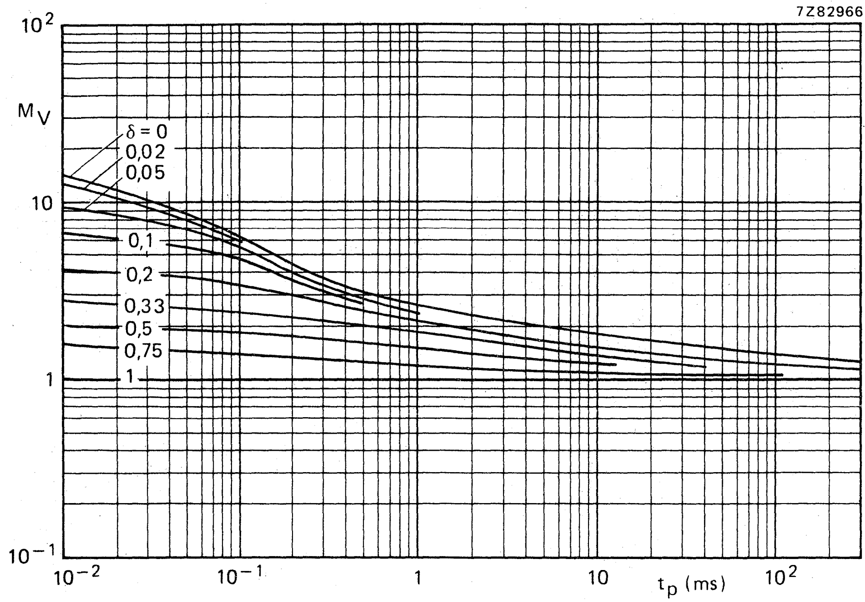


Fig. 7 S.B. voltage multiplying factor at I_{Cmax} level.

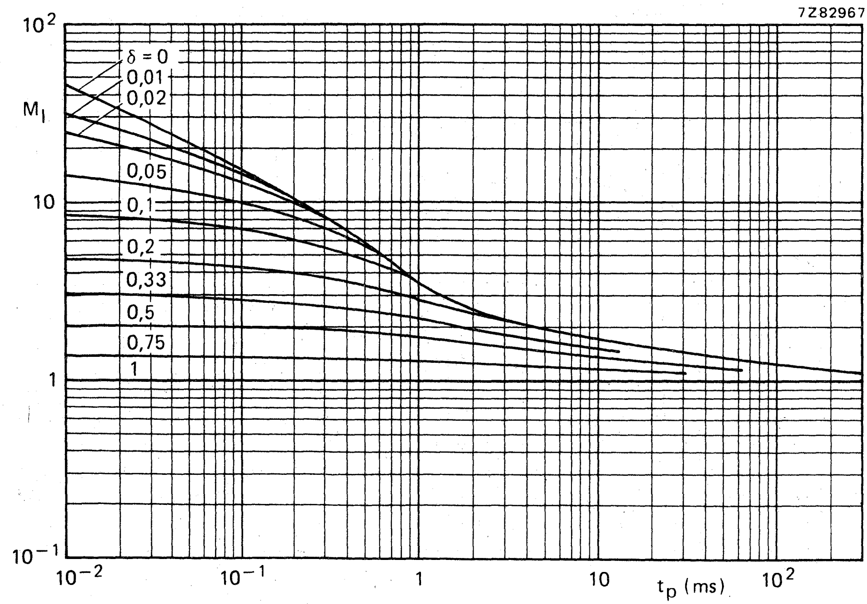


Fig. 8 S.B. current multiplying factor at V_{CEOmax} level.

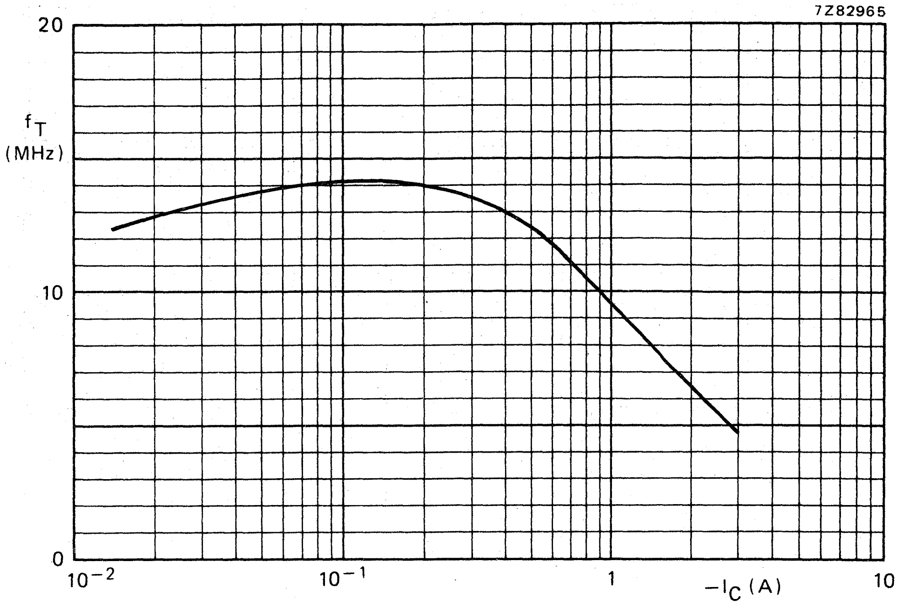


Fig. 9 Typical values transition frequency. $-V_{CE}$ = 10 V; f = 1 MHz; T_{amb} = 25 °C.

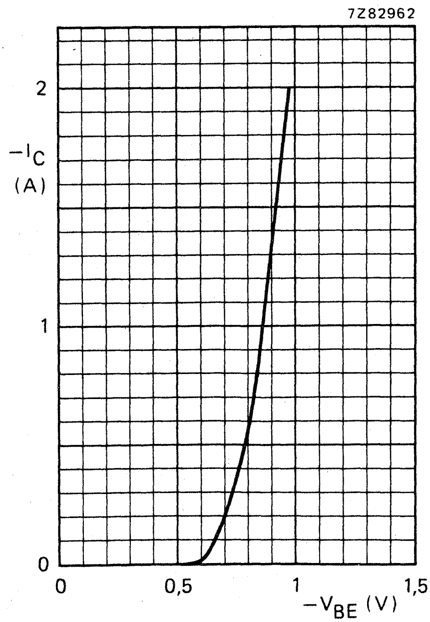


Fig. 10 Typical values. $-V_{CE}$ = 2 V; T_{amb} = 25 °C.

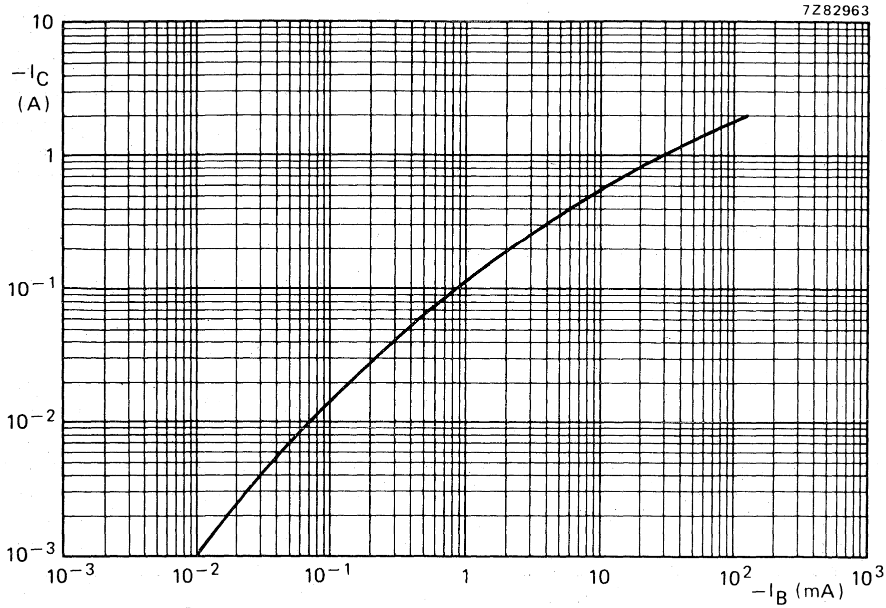


Fig. 11 Typical values at $-V_{CE}$ = 2 V; T_{amb} = 25 °C.

SILICON EPITAXIAL-BASE POWER TRANSISTORS

General purpose N-P-N transistors, in TO-202 plastic envelopes, recommended for driver-stages in hi-fi amplifiers and television circuits.

P-N-P complements are BD826, BD828 and BD830. Matched pairs can be supplied.

QUICK REFERENCE DATA

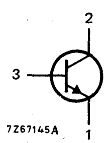
			BD825	BD827	BD829	
Collector-base voltage	V_{CBO}	max.	45	60	100	V
Collector-emitter voltage	V_{CEO}	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	V_{CER}	max.	45	60	100	V
Collector current (peak value)	I_{CM}	max.		1,5		A
Total power dissipation						
at T_{amb} = 25 °C (free air)	P_{tot}	max.		2		W
at T_{mb} = 50 °C	P_{tot}	max.		8		W
Junction temperature	T_j	max.		150		°C
D.C. current gain						
I_C = 150 mA; V_{CE} = 2 V	h_{FE}			40 to 250		
Transition frequency						
I_C = 50 mA; V_{CE} = 5 V	f_T	typ.		250		MHz

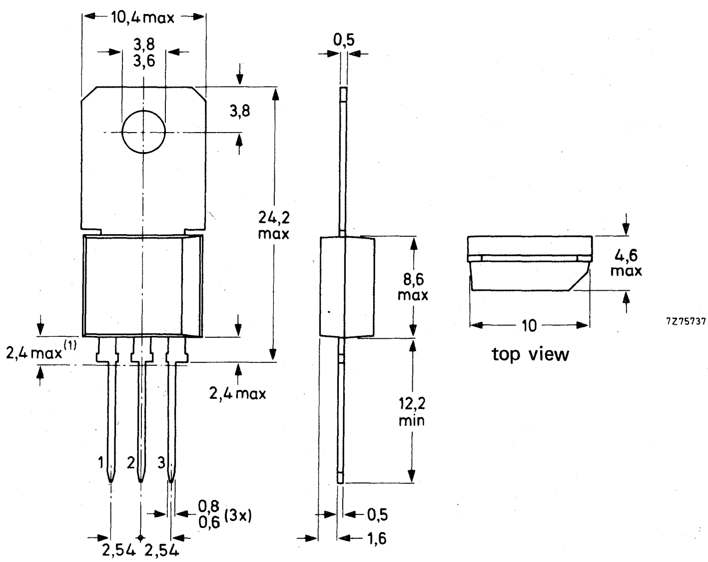
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-202.

Collector connected to mounting base





(1) Plastic flash allowed within this zone.

RATINGS

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

			BD825	BD827	BD829	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	V_{CER}	max.	45	60	100	V
Collector current (d.c.)	I_C	max.		1,0		A
Collector current (peak)	I_{CM}	max.		1,5		A
Total power dissipation						
T_{amb} = 25 °C (free air)	P_{tot}	max.		2		W
T_{mb} = 50 °C	P_{tot}	max.		8		W
Storage temperature	T_{stg}			−65 to + 150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	62,5	K/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	12,5	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off currents			
$I_E = 0$; $V_{CB} = 30$ V	I_{CBO}	<	100 nA
$I_E = 0$; $V_{CB} = 30$ V; $T_j = 125$ °C	I_{CBO}	<	10 µA
Emitter cut-off current			
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10 µA
D.C. current gain			
$I_C = 5$ mA; $V_{CE} = 2$ V	h_{FE}	>	25
$I_C = 150$ mA; $V_{CE} = 2$ V	h_{FE}		40 to 250
$I_C = 500$ mA; $V_{CE} = 2$ V	h_{FE}	>	25
Collector-emitter saturation voltage			
$I_C = 500$ mA; $I_B = 50$ mA	V_{CEsat}	<	0,5 V
Base-emitter voltage			
$I_C = 500$ mA; $V_{CE} = 2$ V	V_{BE}	<	1 V
Transition frequency at f = 35 MHz			
$I_C = 50$ mA; $V_{CE} = 5$ V	f_T	typ.	250 MHz
D.C. current gain ratio of matched complementary pairs			
$\|I_C\| = 150$ mA; $\|V_{CE}\| = 2$ V	h_{FE1}/h_{FE2}	typ.	1,3
		<	1,6

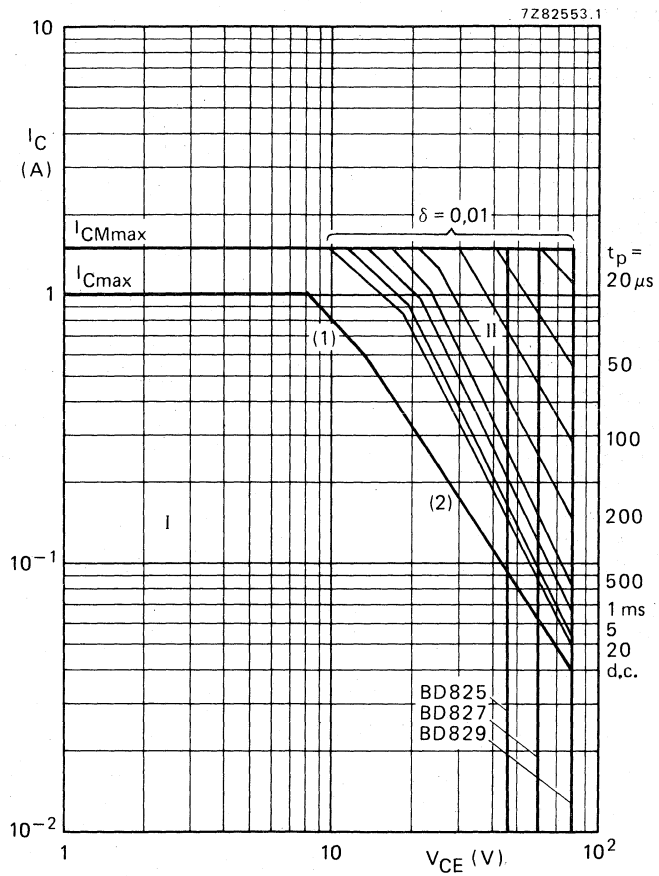


Fig. 2 Safe Operating ARea. $T_{mb} \leqslant 25\ ^oC$.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second-breakdown limits (independent of temperature).

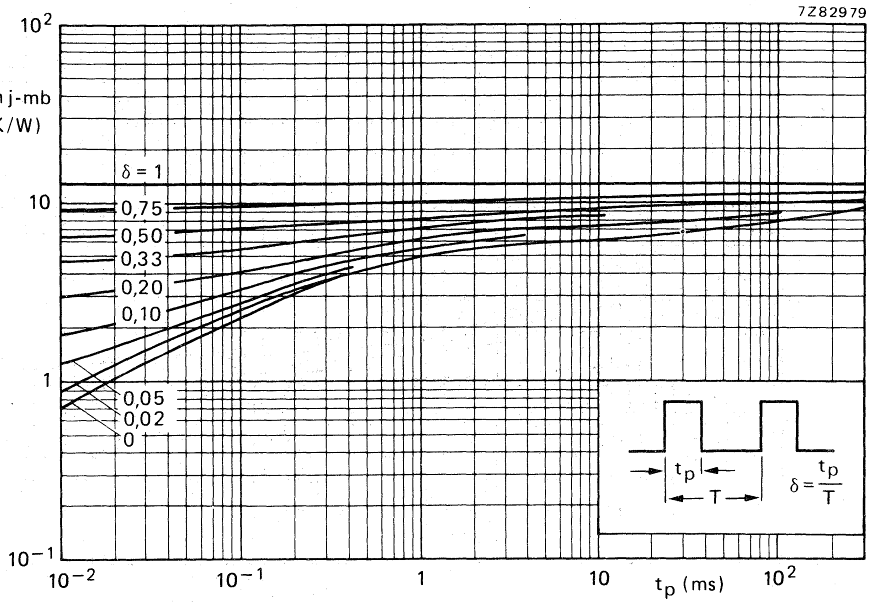


Fig. 3 Pulse power rating chart.

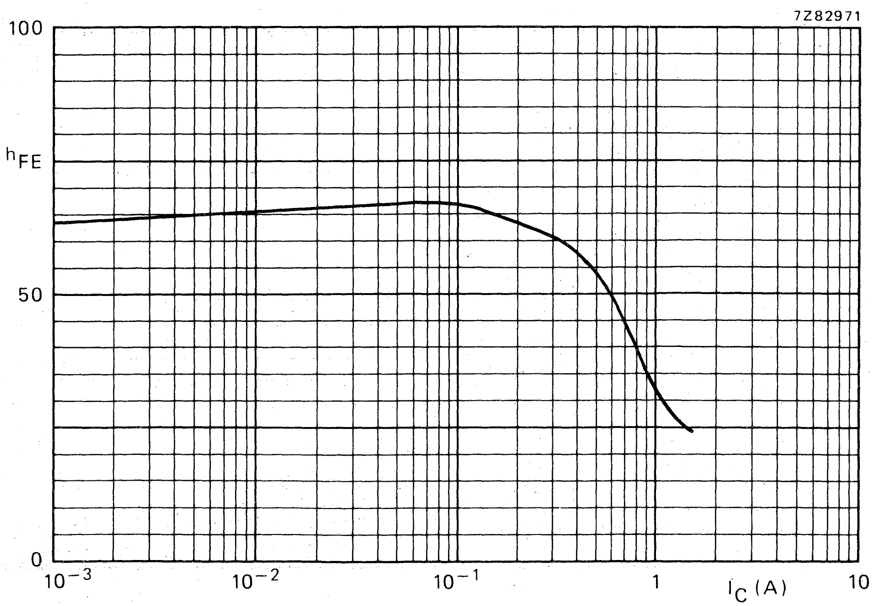


Fig. 4 Typical values d.c. current gain. V_{CE} = 2 V; T_{amb} = 25 °C.

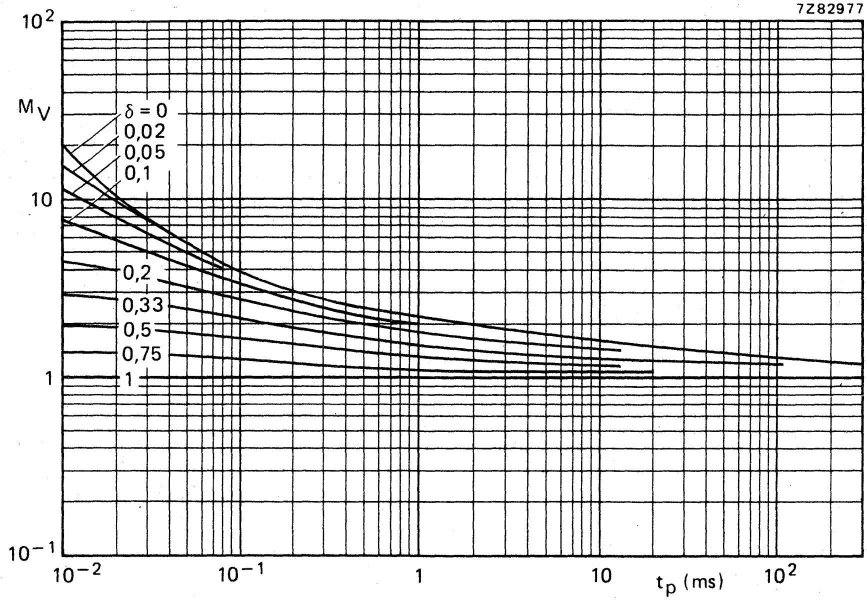


Fig. 5 S.B. voltage multiplying factor at I_{Cmax} level.

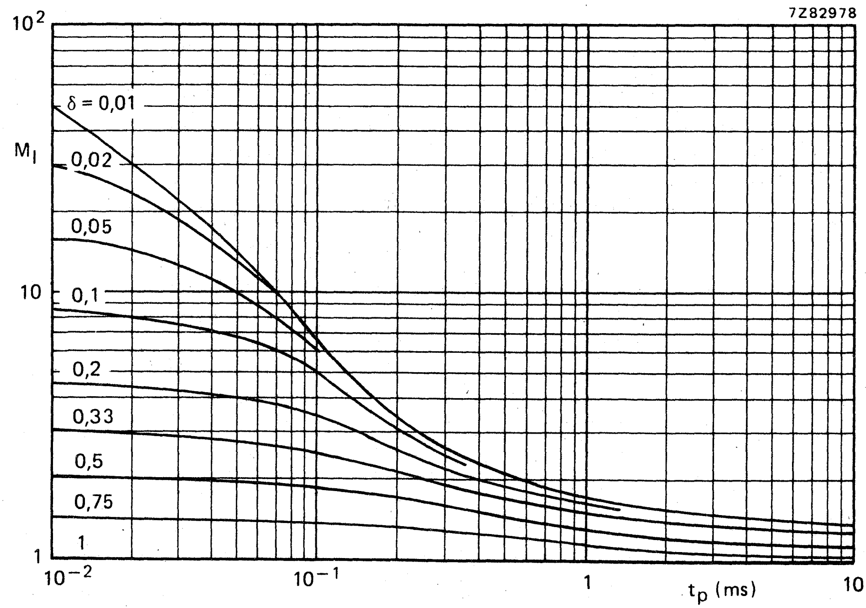


Fig. 6 S.B. current multiplying factor at V_{CEOmax} level.

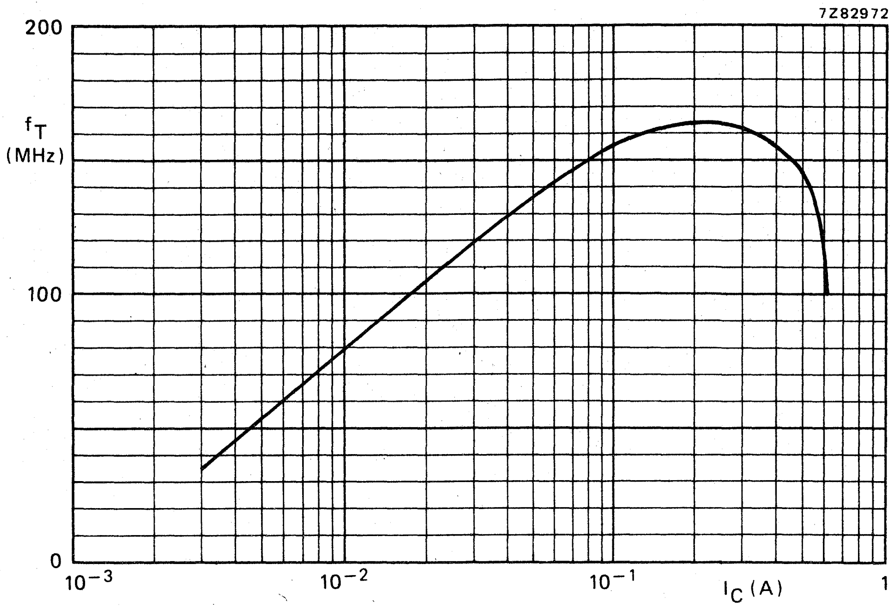


Fig. 7 Typical values transition frequency. V_{CE} = 5 V; f = 35 MHz; T_{amb} = 25 °C.

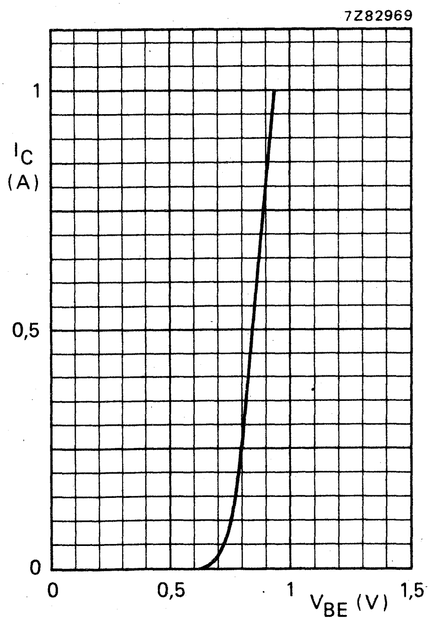


Fig. 8 Typical values. V_{CE} = 2 V; T_{amb} = 25 °C.

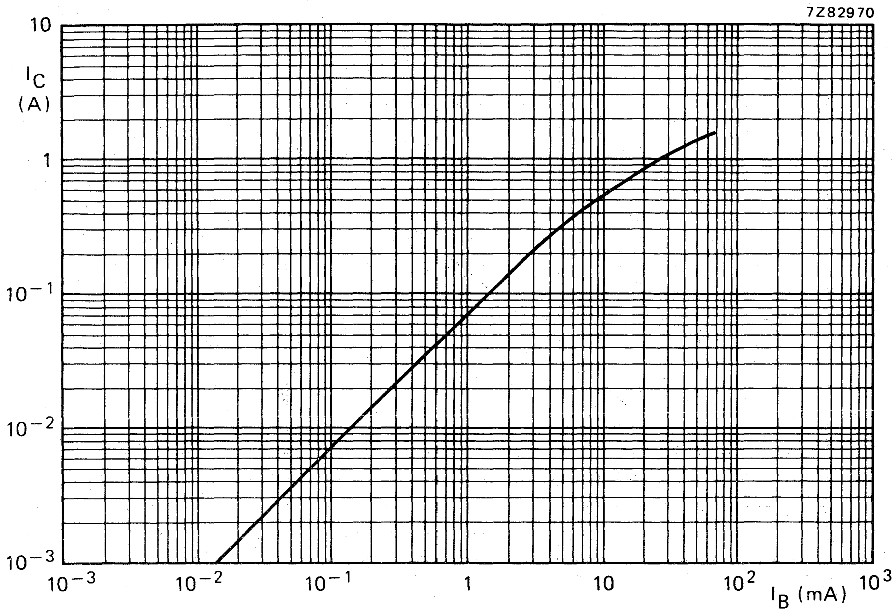


Fig. 9 Typical values at V_{CE} = 2 V; T_{amb} = 25 °C.

SILICON EPITAXIAL-BASE POWER TRANSISTORS

General purpose P-N-P transistors, in TO-202 plastic envelopes, recommended for driver stages in hi-fi amplifiers and television circuits.

N-P-N complements are BD825, BD827 and BD829. Matched pairs can be supplied.

QUICK REFERENCE DATA

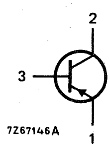
			BD826	BD828	BD830	
Collector-base voltage	$-V_{CBO}$	max.	45	60	100	V
Collector-emitter voltage	$-V_{CEO}$	max.	45	60	80	V
Collector-emitter voltage	$-V_{CER}$	max.	45	60	100	V
Collector current (peak value)	$-I_{CM}$	max.		1,5		A
Total power dissipation						
at T_{amb} = 25 °C (free air)	P_{tot}	max.		2		W
at T_{mb} = 50 °C	P_{tot}	max.		8		W
Junction temperature	T_j	max.		150		°C
D.C. current gain						
$-I_C$ = 150 mA; $-V_{CE}$ = 2 V	h_{FE}			40 to 250		
Transition frequency						
$-I_C$ = 50 mA; $-V_{CE}$ = 5 V	f_T	typ.		75		MHz

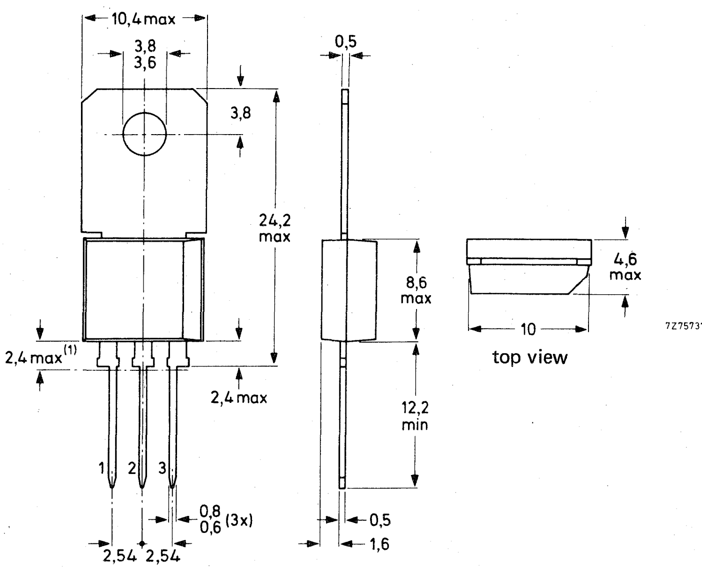
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-202.

Collector connected to mounting base.





(1) Plastic flash allowed within this zone.

RATINGS

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

			BD826	BD828	BD830	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	$-V_{CER}$	max.	45	60	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V
Collector current (d.c.)	$-I_C$	max.		1		A
Collector current (peak value)	$-I_{CM}$	max.		1,5		A
Total power dissipation						
T_{amb} = 25 °C (free air)	P_{tot}	max.		2		W
T_{mb} = 50 °C	P_{tot}	max.		8		W
Storage temperature	T_{stg}			−65 to + 150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	62,5	K/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	12,5	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current			
$I_E = 0$; $-V_{CB} = 30$ V	$-I_{CBO}$	<	100 nA
$I_E = 0$; $-V_{CB} = 30$ V; $T_j = 125$ °C	$-I_{CBO}$	<	10 μA
Emitter cut-off current			
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	10 μA
D.C. current gain			
$-I_C = 5$ mA; $-V_{CE} = 2$ V	h_{FE}	>	25
$-I_C = 150$ mA; $-V_{CE} = 2$ V	h_{FE}		40 to 250
$-I_C = 500$ mA; $-V_{CE} = 2$ V	h_{FE}	>	25
Collector-emitter saturation voltage			
$-I_C = 500$ mA; $-I_B = 50$ mA	$-V_{CEsat}$	<	0,5 V
Base-emitter voltage			
$-I_C = 500$ mA; $-V_{CE} = 2$ V	$-V_{BE}$	<	1 V
Transition frequency at f = 35 MHz			
$-I_C = 50$ mA; $-V_{CE} = 5$ V	f_T	typ.	75 MHz
D.C. current gain ratio of matched complementary pairs			
$\lvert I_C \rvert = 150$ mA; $\lvert V_{CE} \rvert = 2$ V	h_{FE1}/h_{FE2}	typ.	1,3
		<	1,6

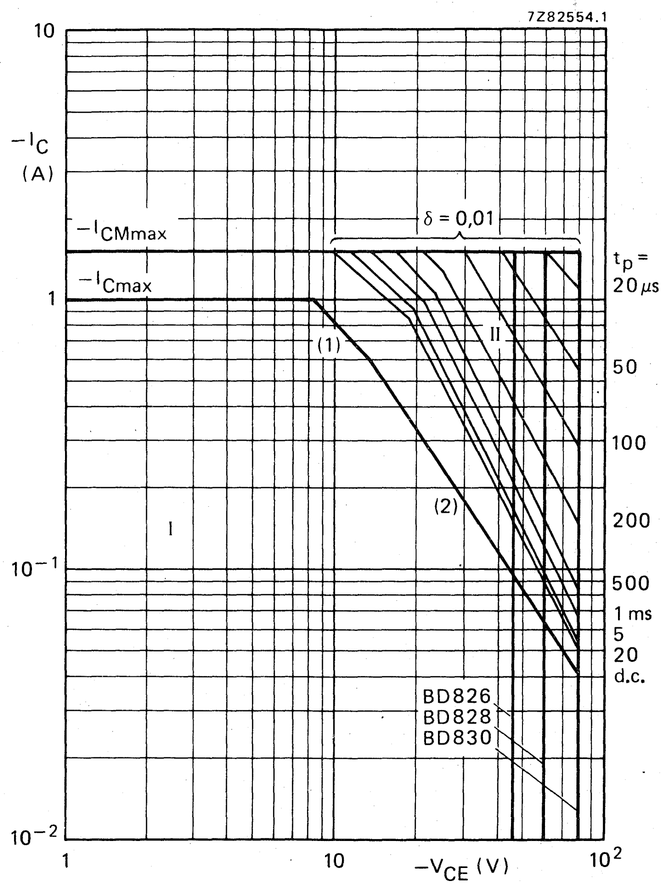


Fig. 2 Safe Operating ARea, $T_{mb} \leqslant 25\ ^oC$.

I Region of permissible d.c. operation.

II Permissible extension for repetition pulse operation.

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.

(2) Second-breakdown limits (independent of temperature).

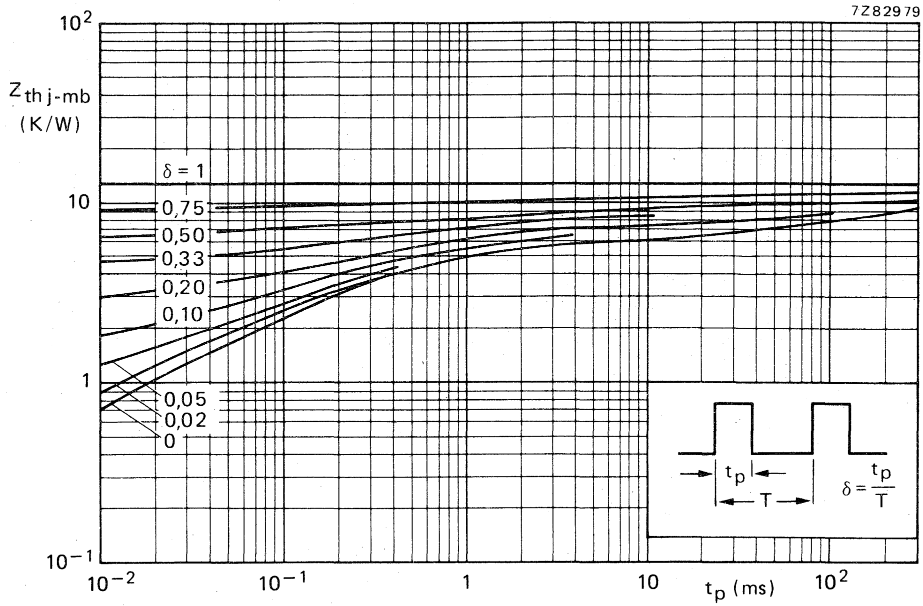


Fig. 3 Pulse power rating chart.

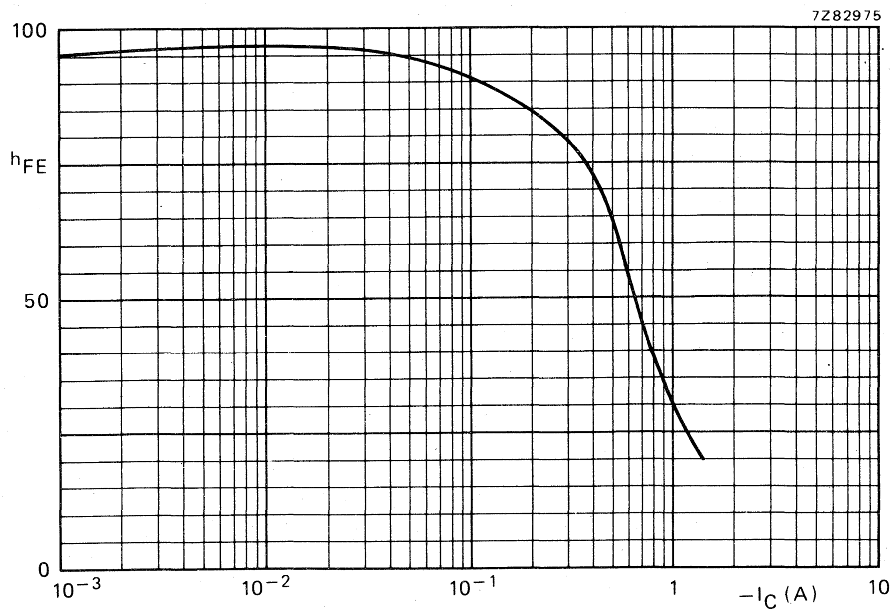


Fig. 4 Typical values d.c. current gain. $-V_{CE}$ = 2 V; T_{amb} = 25 °C.

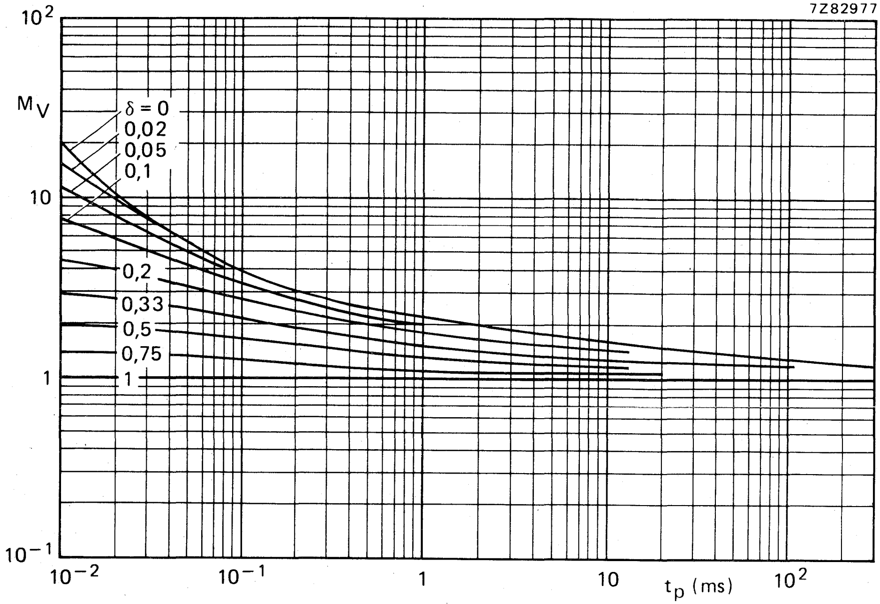


Fig. 5 S.B. voltage multiplying factor at I_{Cmax} level.

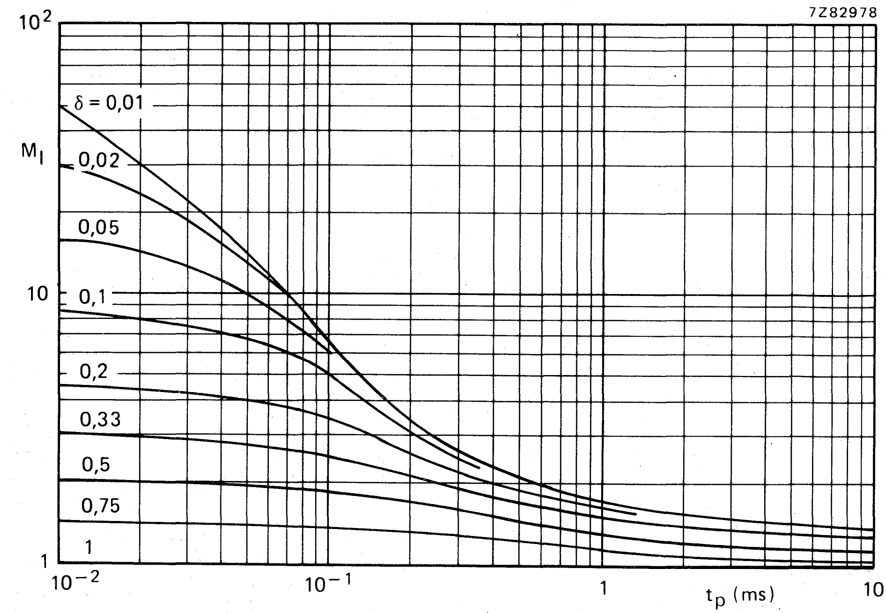


Fig. 6 S.B. current multiplying factor at V_{CEOmax} level.

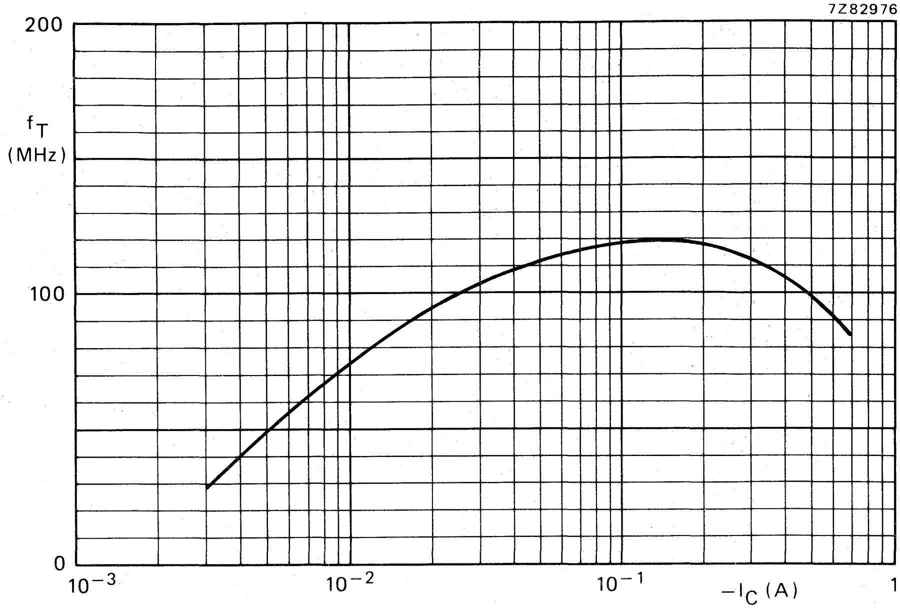


Fig. 7 Typical values transition frequency at $-V_{CE}$ = 5 V; f = 35 MHz; T_{amb} = 25 °C.

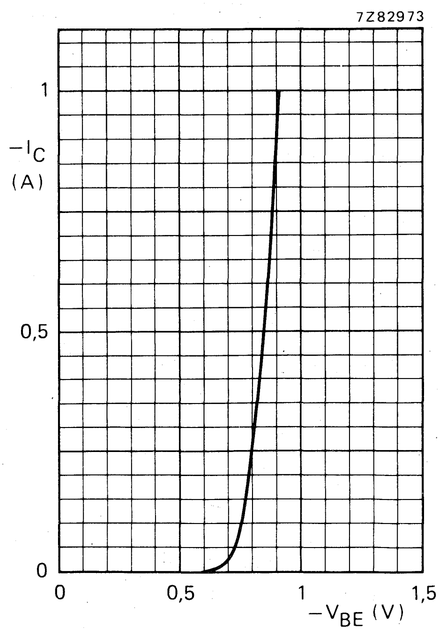


Fig. 8 Typical values. $-V_{CE}$ = 2 V; T_{amb} = 25 °C.

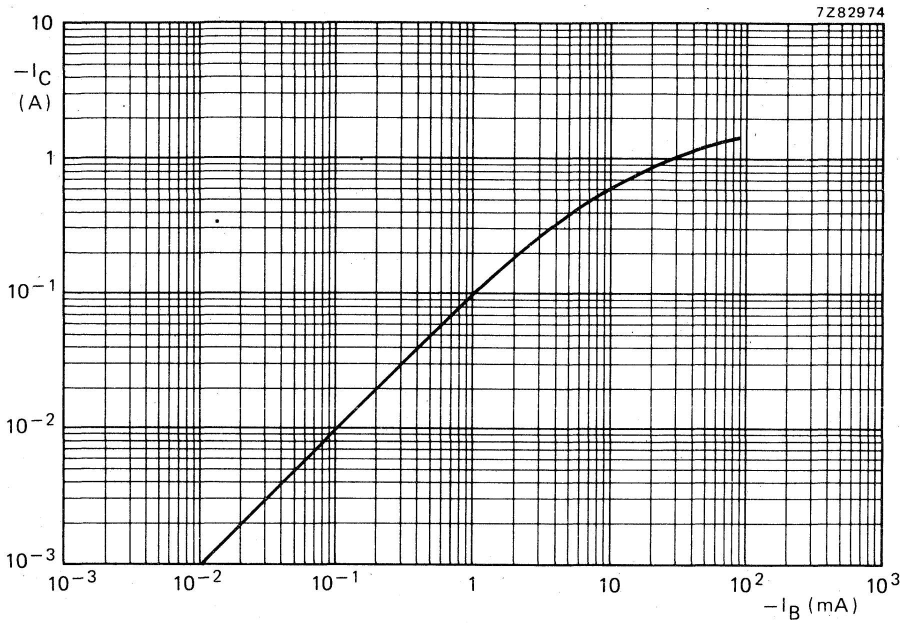


Fig. 9 Typical values at $-V_{CE} = 2$ V; $T_{amb} = 25$ °C.

SILICON PLANAR EPITAXIAL POWER TRANSISTORS

N-P-N silicon transistors, in a plastic TO-202 envelope, recommended for use in television circuits and audio applications.
P-N-P complements are BD840, BD842 and BD844.

QUICK REFERENCE DATA

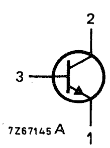
			BD839	BD841	BD843	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	V_{CER}	max.	45	60	100	V
Collector current (peak value)	I_{CM}	max.		3		A
Total power dissipation						
T_{amb} = 25 °C (free air)	P_{tot}	max.		2		W
T_{mb} = 25 °C	P_{tot}	max.		10		W
Junction temperature	T_j	max.		150		°C
D.C. current gain						
I_C = 1 A; V_{CE} = 2 V	h_{FE}	>		25		
Transition frequency at f = 35 MHz						
I_C = 50 mA; V_{CE} = 5 V	f_T	typ.		125		MHz

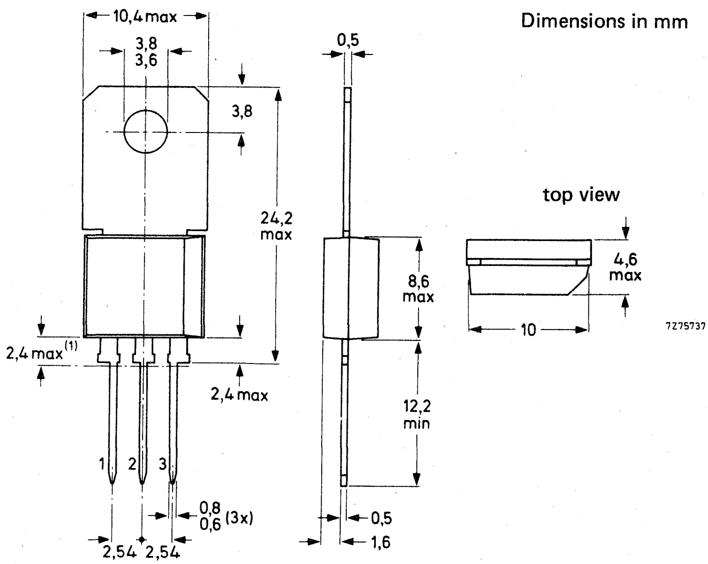
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-202.

Collector connected to mounting base.





(1) Plastic flash allowed within this zone.

RATINGS

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

			BD839	BD841	BD843	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	V_{CER}	max.	45	60	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V
Collector current (d.c.)	I_C	max.		1,5		A
Collector current (peak value)	I_{CM}	max.		3		A
Total power dissipation						
T_{amb} = 25 °C (free air)	P_{tot}	max.		2		W
T_{mb} = 25 °C	P_{tot}	max.		10		W
Storage temperature	T_{stg}			–65 to + 150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	62,5	K/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	12,5	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

Collector cut-off current			
$I_E = 0$; $V_{CB} = 30$ V	I_{CBO}	<	100 nA
$I_E = 0$; $V_{CB} = 30$ V; $T_j = 125$ °C	I_{CBO}	<	10 μA
Emitter cut-off current			
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10 μA
Base-emitter voltage*			
$I_C = 1$ A; $V_{CE} = 2$ V	V_{BE}	<	1,3 V
Collector-emitter saturation voltage			
$I_C = 1$ A; $I_B = 0{,}1$ A	V_{CEsat}	<	0,8 V
D.C. current gain			
$I_C = 5$ mA; $V_{CE} = 2$ V	h_{FE}	>	25
$I_C = 150$ mA; $V_{CE} = 2$ V BD839	h_{FE}		40 to 250
$I_C = 150$ mA; $V_{CE} = 2$ V BD841/BD843	h_{FE}		40 to 160
$I_C = 1$ A; $V_{CE} = 2$ V	h_{FE}	>	25
Transition frequency at f = 35 MHz			
$I_C = 50$ mA; $V_{CE} = 5$ V	f_T	typ.	125 MHz
D.C. current gain ratio of			
BD839/BD840, BD841/BD842, BD843/BD844		typ.	1,3
$\lvert I_C \rvert = 150$ mA; $\lvert V_{CE} \rvert = 2$ V	h_{FE1}/h_{FE2}	<	1,6

* V_{BE} decreases by about 2,3 mV/K with increasing temperature.

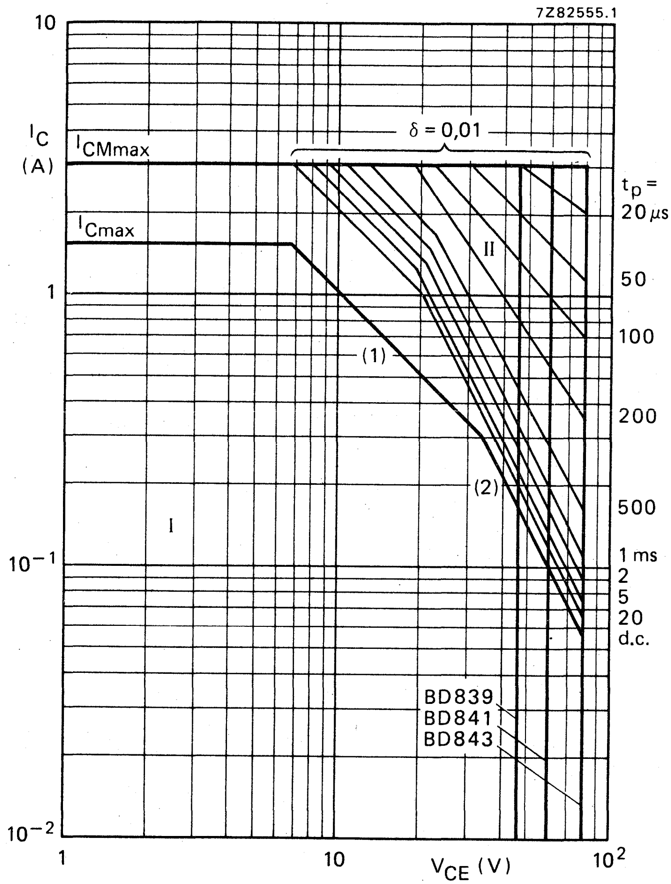


Fig. 2 Safe Operating ARea, $T_{mb} \leqslant 25\ ^oC$.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.
(2) Second-breakdown limits (independent of temperature).

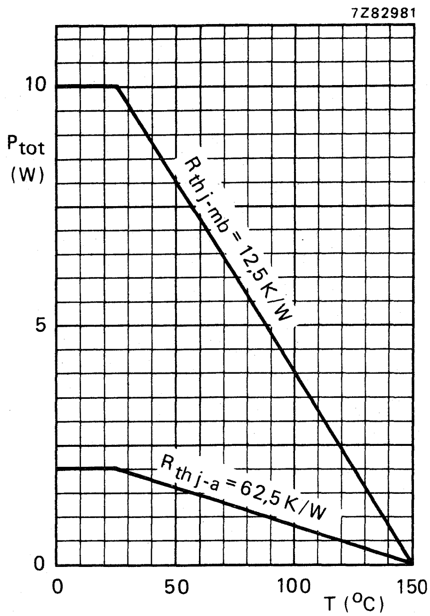


Fig. 3 Power derating curve.

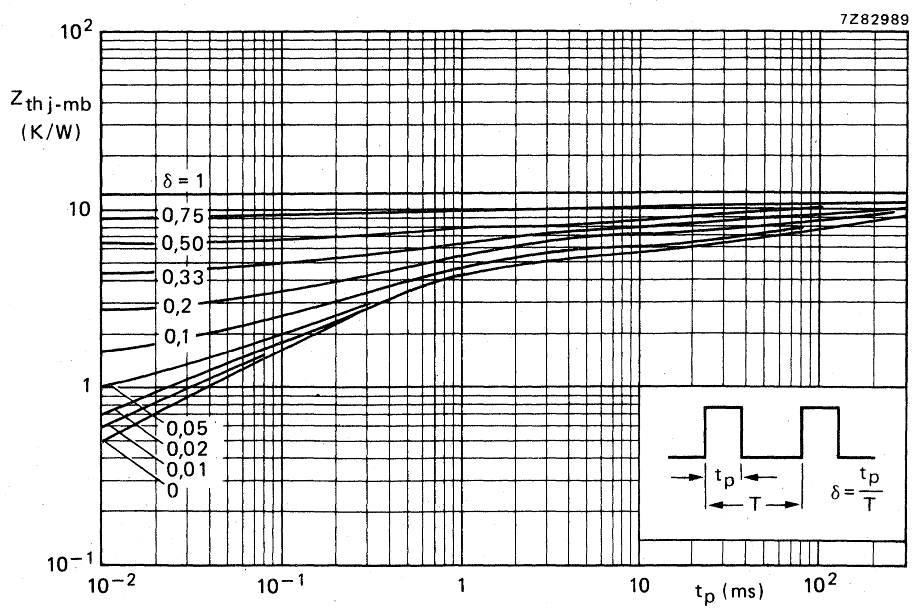


Fig. 4 Pulse power rating chart.

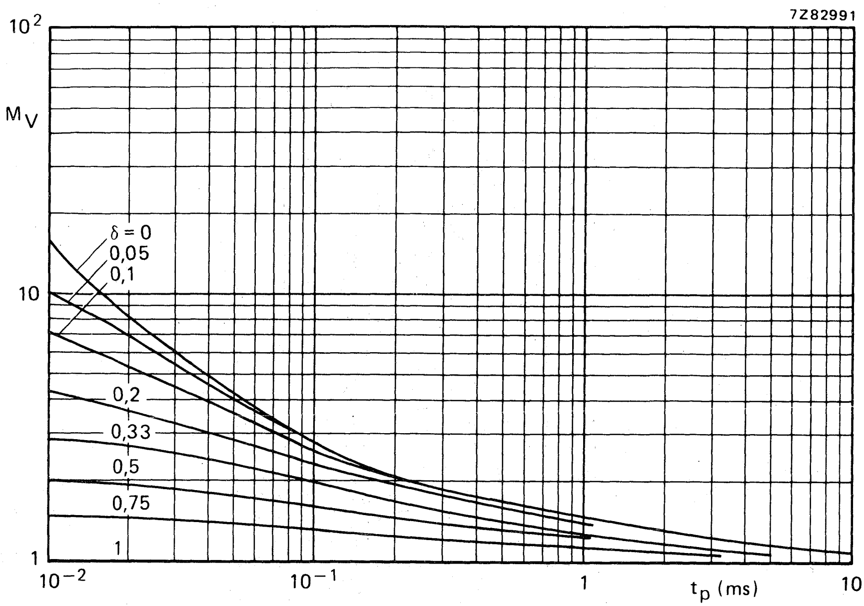


Fig. 5 S.B. voltage multiplying factor at the I_{Cmax} level.

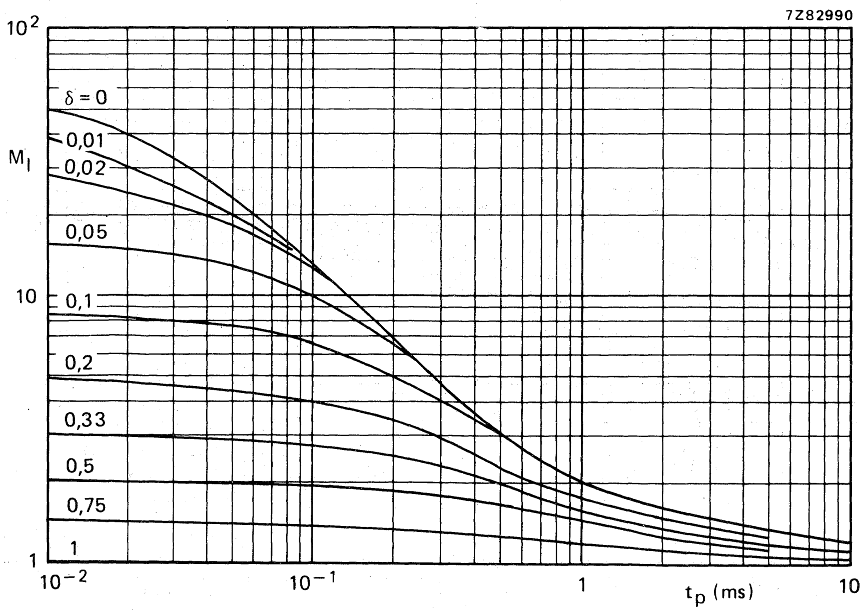


Fig. 6 S.B. current multiplying factor at the V_{CEOmax} level.

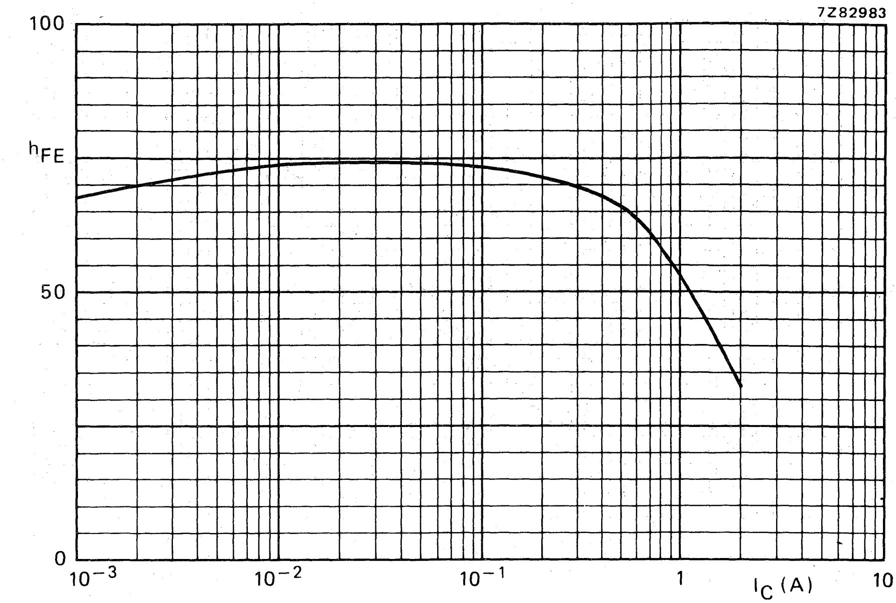


Fig. 7 Typical values d.c. current gain. V_{CE} = 2 V; T_{amb} = 25 °C.

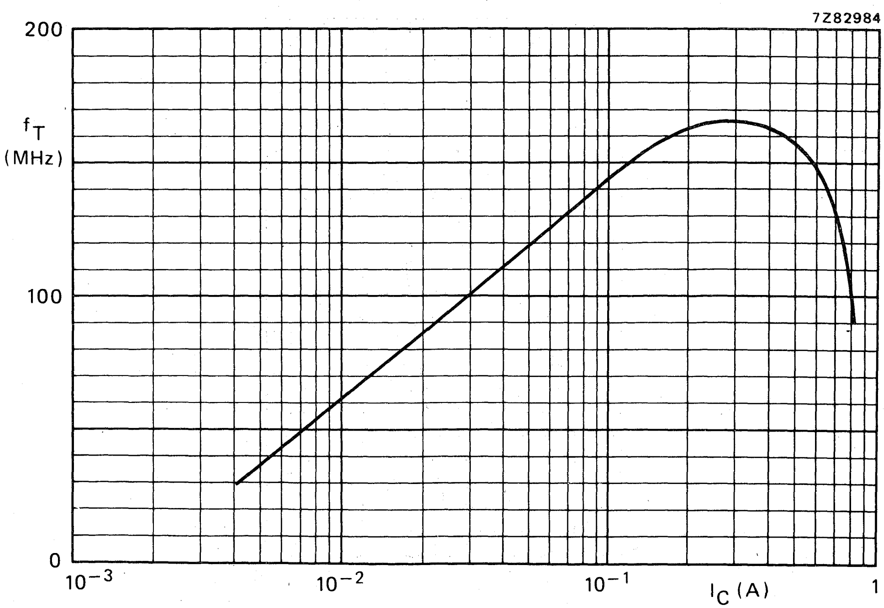


Fig. 8 Typical values transition frequency. V_{CE} = 5 V; T_{amb} = 25 °C; f = 35 MHz.

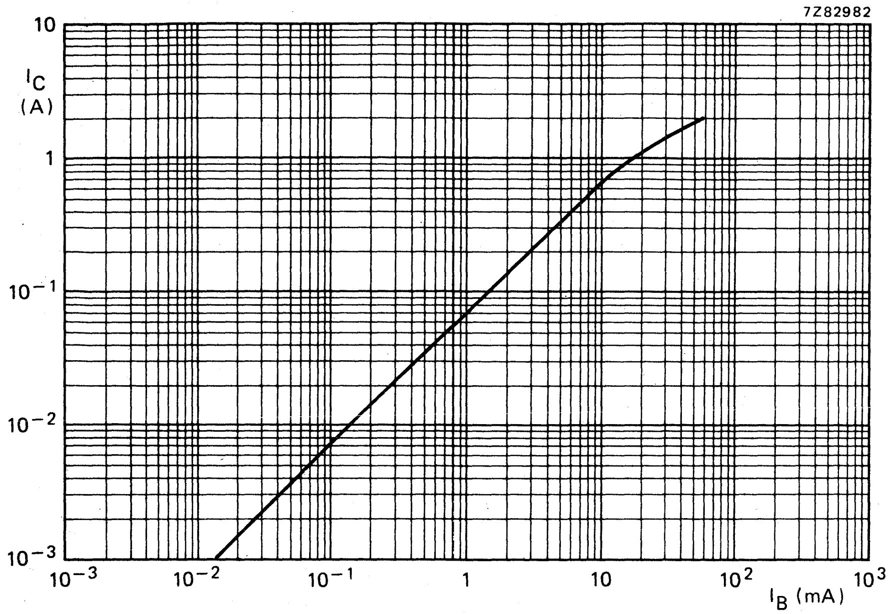


Fig. 9 Typical values at V_{CE} = 2 V; T_{amb} = 25 °C.

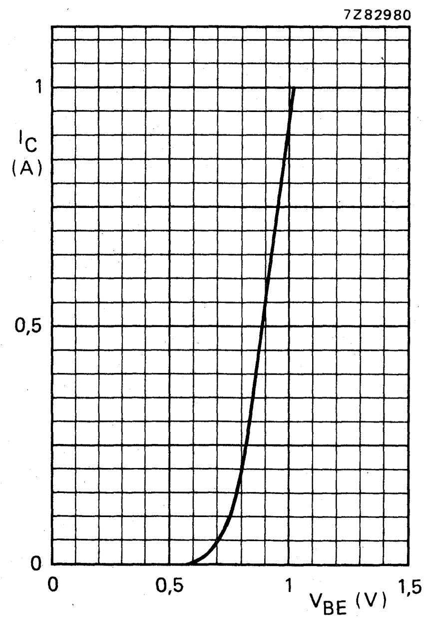


Fig. 10 Typical values. V_{CE} = 2 V; T_{amb} = 25 °C.

SILICON PLANAR EPITAXIAL POWER TRANSISTORS

P-N-P silicon transistors, in a plastic TO-202 envelope, recommended for use in television circuits and audio applications.
N-P-N complements are BD839, BD841 and BD843.

QUICK REFERENCE DATA

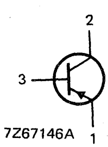
			BD840	BD842	BD844	
Collector-base voltage	$-V_{CBO}$	max.	45	60	100	V
Collector-emitter voltage	$-V_{CEO}$	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	$-V_{CER}$	max.	45	60	100	V
Emitter-base voltage	$-V_{EBO}$	max.	5	5	5	V
Collector current (peak value)	$-I_{CM}$	max.		3		A
Total power dissipation						
T_{amb} = 25 °C (free air)	P_{tot}	max.		2		W
T_{mb} = 25 °C	P_{tot}	max.		10		W
Junction temperature	T_j	max.		150		°C
D.C. current gain						
$-I_C$ = 1 A; $-V_{CE}$ = 2 V	h_{FE}	>		25		
Transition frequency at f = 35 MHz	f_T	typ.		50		MHz

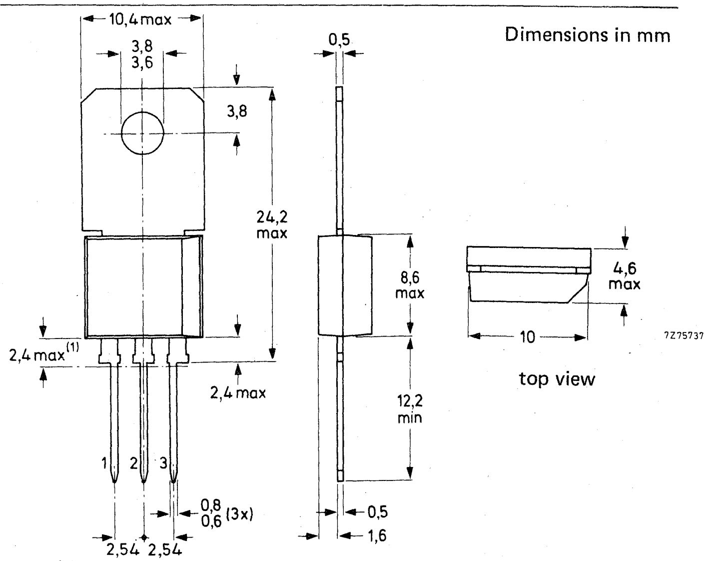
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-202.

Collector connected to mounting base.





(1) Plastic flash allowed within this zone.

RATINGS

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

			BD840	BD842	BD844	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	$-V_{CER}$	max.	45	60	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V
Collector current (d.c.)	$-I_C$	max.		1,5		A
Collector current (peak value)	$-I_{CM}$	max.		3		A
Total power dissipation						
T_{amb} = 25 °C (free air)	P_{tot}	max.		2		W
T_{mb} = 25 °C	P_{tot}	max.		10		W
Storage temperature	T_{stg}			−65 to + 150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	62,5	K/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	12,5	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current			
$I_E = 0$; $-V_{CB} = 30$ V	$-I_{CBO}$	<	100 nA
$I_E = 0$; $-V_{CB} = 30$ V; $T_j = 125$ °C	$-I_{CBO}$	<	10 μA
Emitter cut-off current			
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	10 μA
Base-emitter voltage*			
$-I_C = 1$ A; $-V_{CE} = 2$ V	$-V_{BE}$	<	1,3 V
Collector-emitter saturation voltage			
$-I_C = 1$ A; $-I_B = 0,1$ A	$-V_{CEsat}$	<	0,8 V
D.C. current gain			
$-I_C = 5$ mA; $-V_{CE} = 2$ V	h_{FE}	>	25
$-I_C = 150$ mA; $-V_{CE} = 2$ V BD840	h_{FE}		40 to 250
$-I_C = 150$ mA; $-V_{CE} = 2$ V BD842, BD844	h_{FE}		40 to 160
$-I_C = 1$ A; $-V_{CE} = 2$ V	h_{FE}	>	25
Transition frequency at f = 35 MHz			
$-I_C = 50$ mA; $-V_{CE} = 5$ V	f_T	typ.	50 MHz
D.C. current gain ratio of BD839/BD840, BD841/BD842, BD843/BD844		typ.	1,3
$\lvert I_C \rvert = 150$ mA; $\lvert V_{CE} \rvert = 2$ V	h_{FE1}/h_{FE2}	<	1,6

* V_{BE} decreases by about 2,3 mV/K with increasing temperature.

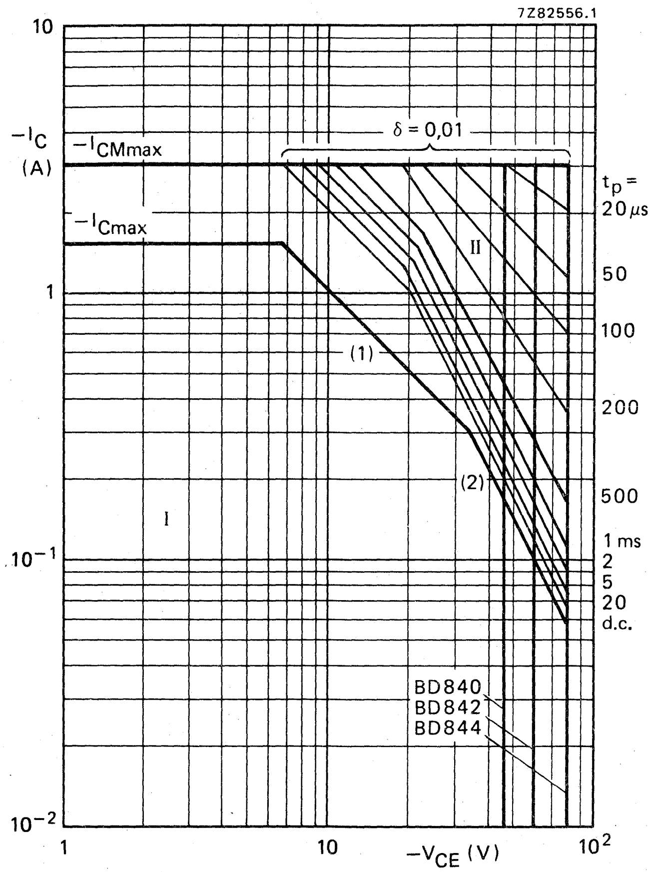


Fig. 2 Safe Operating ARea, $T_{mb} \leqslant 25\ ^oC$.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.

(2) Second-breakdown limits (independent of temperature).

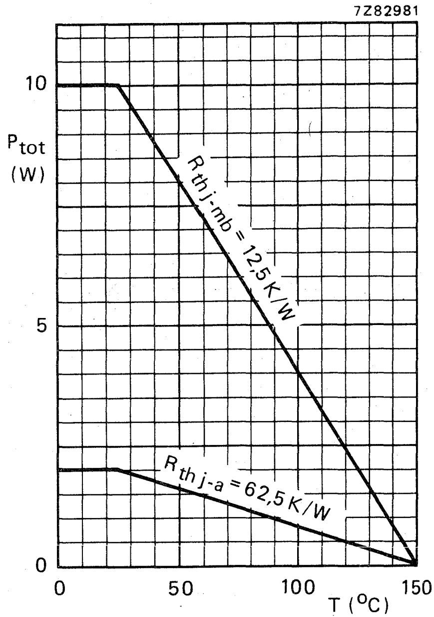


Fig. 3 Power derating curve.

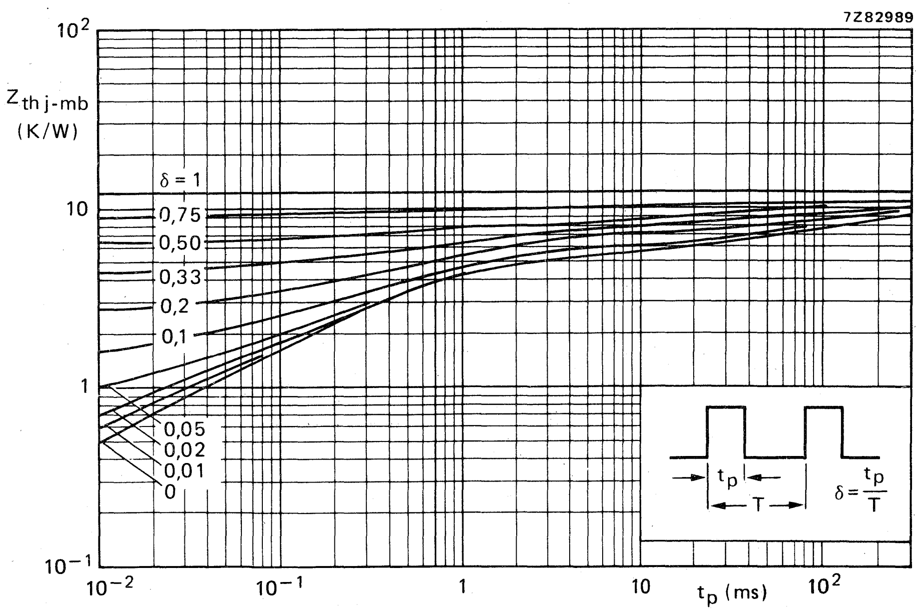


Fig. 4 Pulse power rating chart.

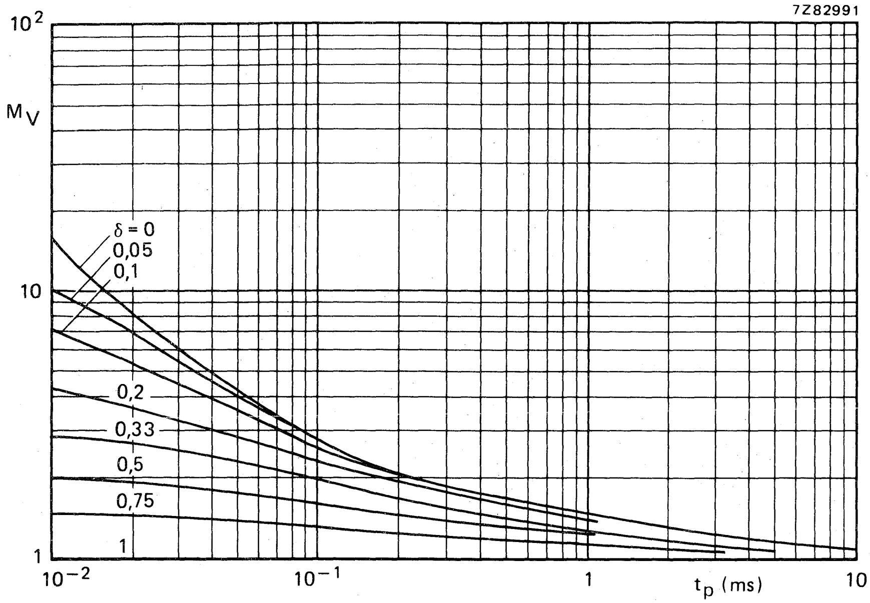


Fig. 5 S.B. voltage multiplying factor at the I_{Cmax} level.

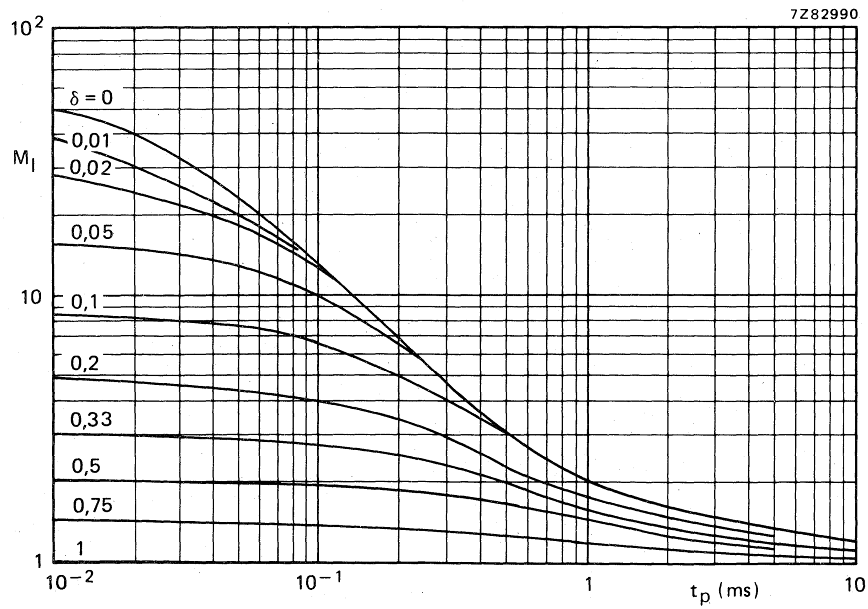


Fig. 6 S.B. current multiplying factor at the V_{CEOmax} level.

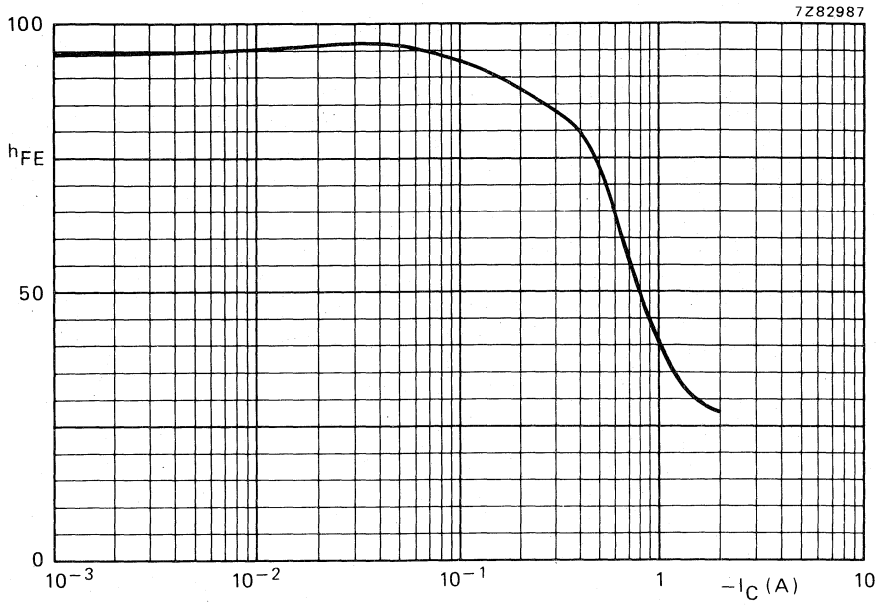


Fig. 7 Typical values d.c. current gain. $-V_{CE}$ = 2 V; T_{amb} = 25 °C.

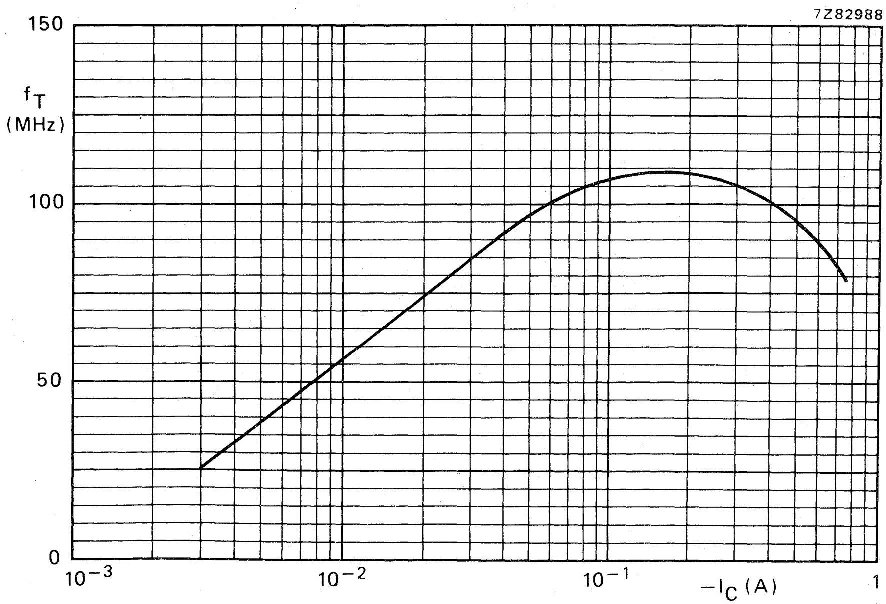


Fig. 8 Typical values transition frequency. $-V_{CE}$ = 5 V; f = 35 MHz; T_{amb} = 25 °C.

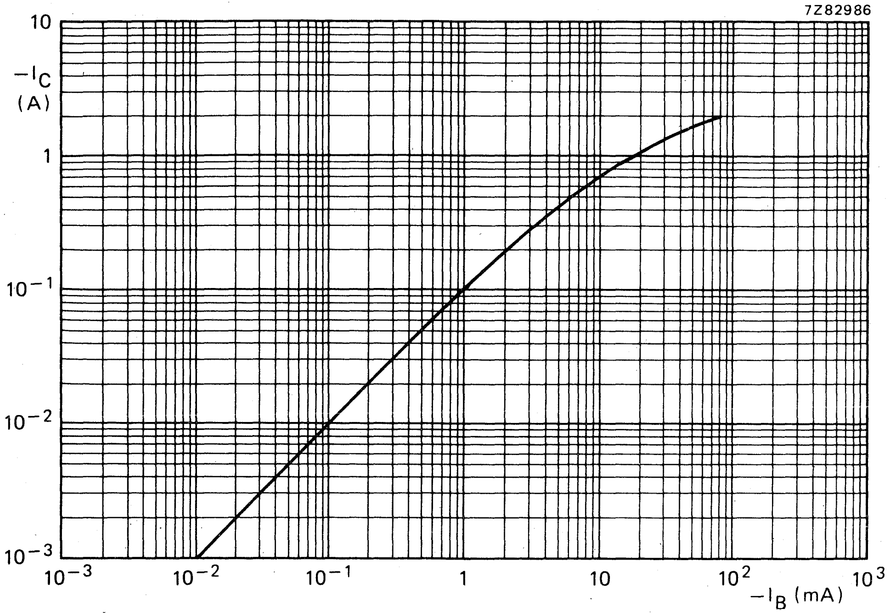


Fig. 9 Typical values at $-V_{CE}$ = 2 V; T_{amb} = 25 °C.

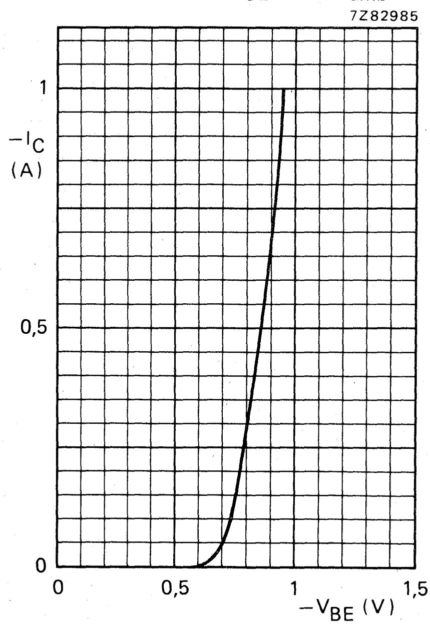


Fig. 10 Typical values. $-V_{CE}$ = 2 V; T_{amb} = 25 °C.

SILICON EPITAXIAL BASE POWER TRANSISTORS

N-P-N silicon transistors in a plastic envelope intended for use in output stages of audio and television amplifier circuits where high peak powers can occur.
P-N-P complements are BD934; 936; 938; 940 and 942.

QUICK REFERENCE DATA

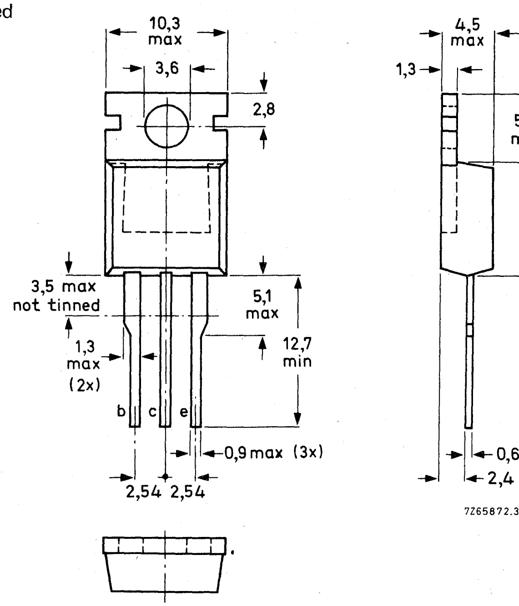
			BD933	935	937	939	941	
Collector-base voltage	V_{CBO}	max.	45	60	100	120	140	V
Collector-emitter voltage	V_{CEO}	max.	45	60	80	100	120	V
Collector current (d.c.)	I_C	max.			3			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.			30			W
Junction temperature	T_j	max.			150			°C
D.C. current gain								
I_C = 150 mA; V_{CE} = 2 V	h_{FE}				40 to 250			
I_C = 1 A; V_{CE} = 2 V	h_{FE}	>			25			
Transition frequency								
I_C = 250 mA; V_{CE} = 10 V	f_T	>			3			MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base.



See also chapters Mounting instructions and Accessories.

RATINGS

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

			BD933	935	937	939	941	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.			5			V
Collector current (d.c.)	I_C	max.			3			A
Collector current (peak value)	I_{CM}	max.			7			A
Base current (d.c.)	I_B	max.			0,5			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.			30			W
Storage temperature	T_{stg}				−65 to + 150			°C
Junction temperature	T_j	max.			150			°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	4,17	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	70	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	<	0,1	mA
$I_E = 0$; $V_{CB} = V_{CBOmax}$; T_j = 150 °C	I_{CBO}	<	3	mA
$I_E = 0$; $V_{CE} = V_{CEOmax}$	I_{CEO}	<	0,5	mA
Emitter cut-off current				
$I_C = 0$; V_{EB} = 5 V	I_{EBO}	<	1	mA
D.C. current gain *				
I_C = 150 mA; V_{CE} = 2 V	h_{FE}		40 to 250	
I_C = 1 A; V_{CE} = 2 V	h_{FE}	>	25	
Base-emitter voltage **				
I_C = 1 A; V_{CE} = 2 V	V_{BE}	<	1,3	V
Collector-emitter saturation voltage *				
I_C = 1 A; I_B = 0,1 A	V_{CEsat}	<	0,6	V
Transition frequency at f = 1 MHz				
I_C = 250 mA; V_{CE} = 10 V	f_T	>	3	MHz
→ Switching times				
I_{Con} = 1 A; $I_{Bon} = -I_{Boff}$ = 0,1 A				
turn-on time	t_{on}	typ	0,4	μs
		<	1	μs
Turn-off time	t_{off}	typ.	1,5	μs
		<	3	μs
→ Second-breakdown collector current				
V_{CE} = 40 V; t_p = 0,1 s; non-repetitive	$I_{(SB)}$	>	0,75	A

* Measured under pulse conditions: $t_p \leq 300\ \mu s$; $\delta < 2\%$.
** V_{BE} decreases by about 2,3 mV/°C with increasing temperature.

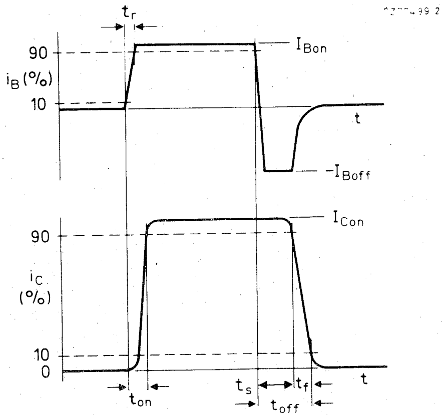


Fig. 2 Switching times waveforms.

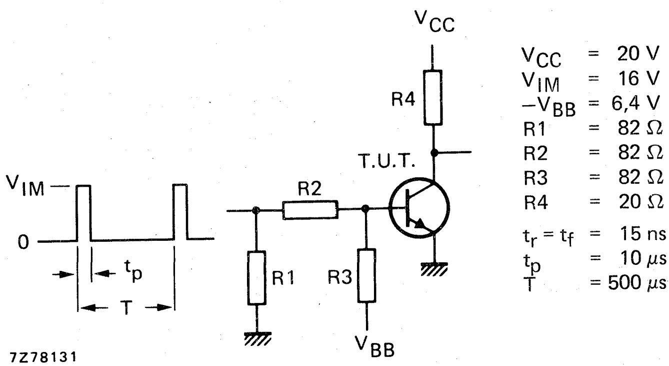


Fig. 3 Switching times test circuit.

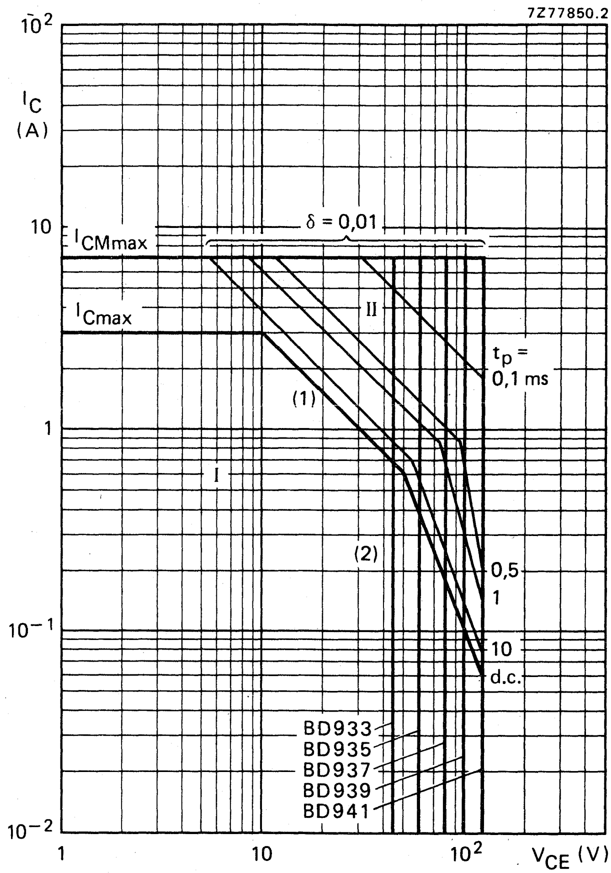


Fig. 4 Safe Operating ARea; T_{mb} = 25 °C.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second breakdown limits, independent of temperature.

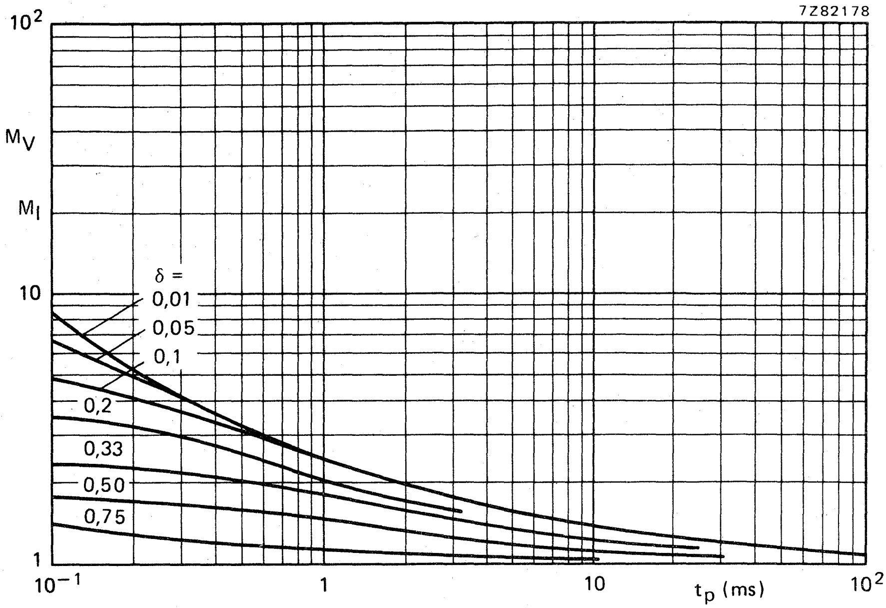


Fig. 5 Second-breakdown voltage multiplying factor at the I_{Cmax} level and second-breakdown current multiplying factor at the V_{CEOmax} level.

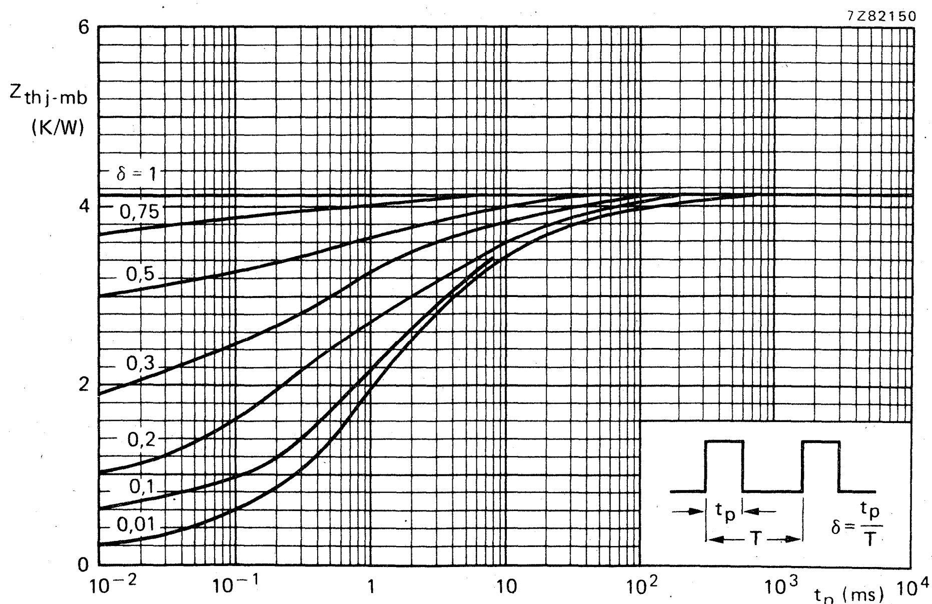


Fig. 6 Pulse power rating chart.

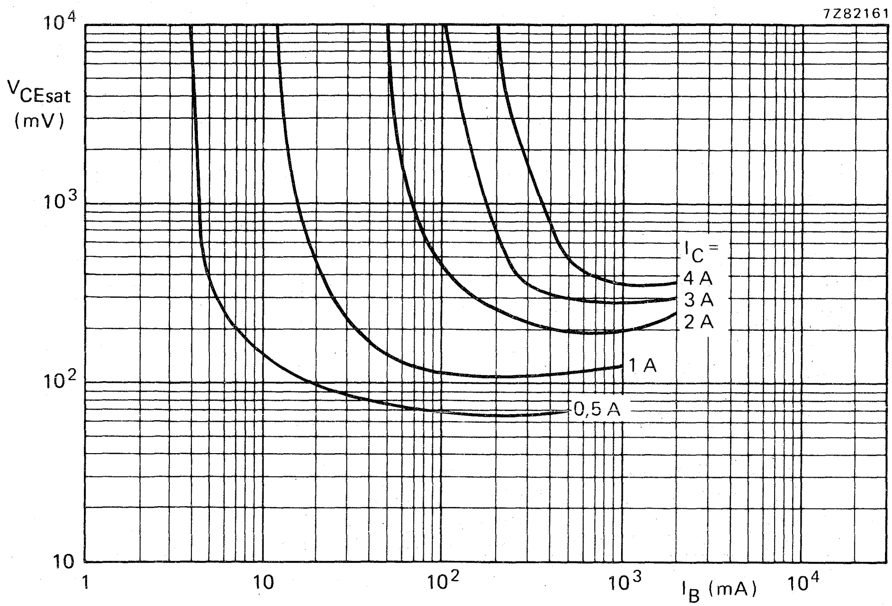


Fig. 7 Typical collector-emitter saturation voltage as a function of base current with collector current as a parameter.

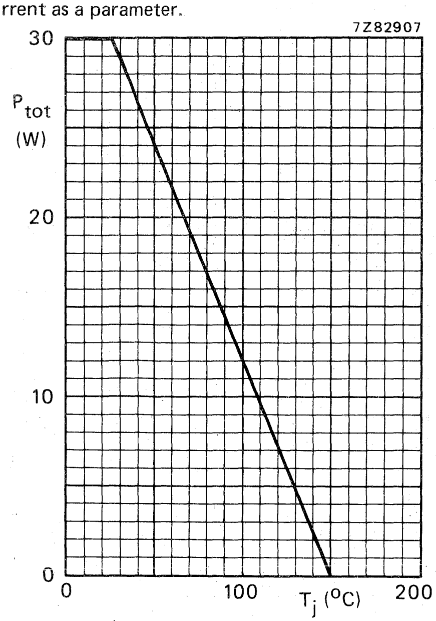


Fig. 8 Power derating curve.

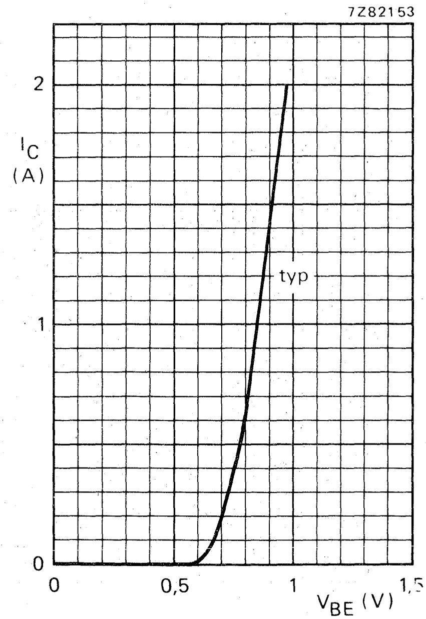


Fig. 9 $V_{CE} = 2$ V; $T_j = 25$ °C.

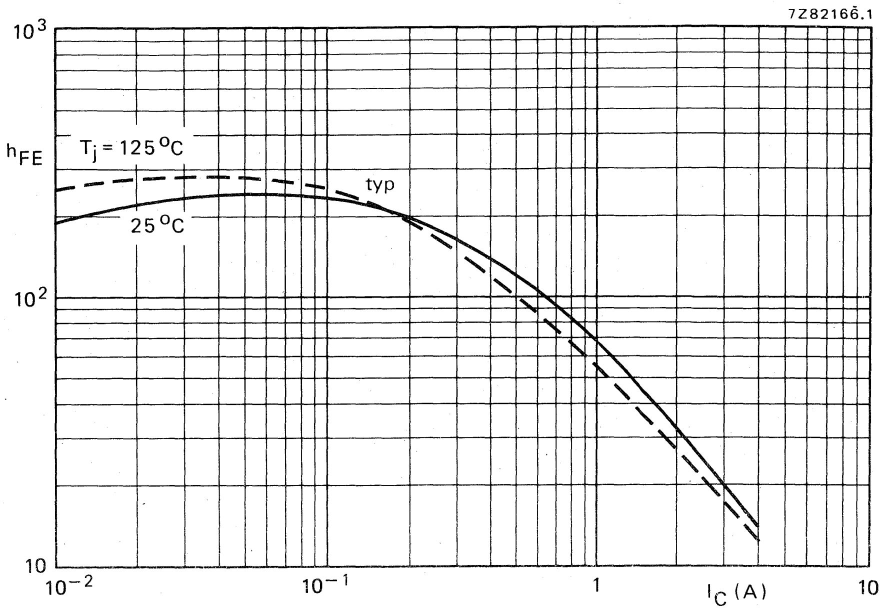


Fig. 10 Typical static forward current transfer ratio as a function of the collector current. V_{CE} = 2 V.

SILICON EPITAXIAL BASE POWER TRANSISTORS

P-N-P silicon transistors in a plastic envelope intended for use in output stages of audio and television amplifier circuits where high peak powers can occur.
N-P-N complements are BD933; 935; 937; 939 and 941.

QUICK REFERENCE DATA

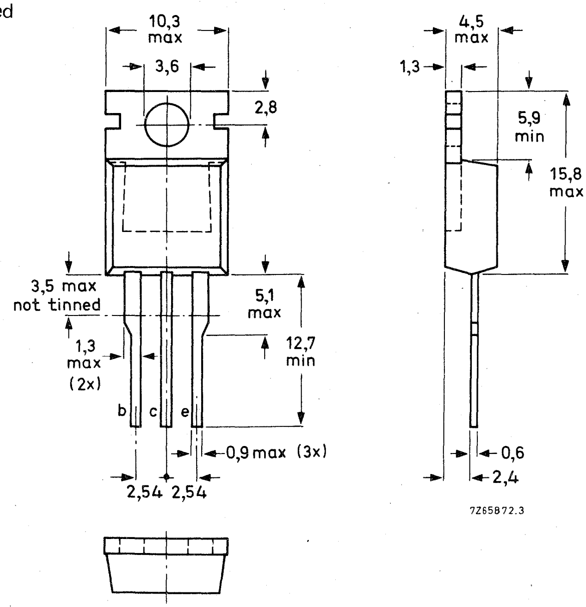
			BD934	936	938	940	942	
Collector-base voltage	$-V_{CBO}$	max.	45	60	100	120	140	V
Collector-emitter voltage	$-V_{CEO}$	max.	45	60	80	100	120	V
Collector current (d.c.)	$-I_C$	max.			3			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.			30			W
Junction temperature	T_j	max.			150			°C
D.C. current gain								
$-I_C$ = 150 mA; $-V_{CE}$ = 2 V	h_{FE}				40 to 250			
$-I_C$ = 1 A; $-V_{CE}$ = 2 V	h_{FE}	>			25			
Transition frequency								
$-I_C$ = 250 mA; $-V_{CE}$ = 10 V	f_T	>			3			MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base.



See also chapters Mounting instructions and Accessories.

RATINGS

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

			BD934	936	938	940	942	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	100	120	140	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	100	120	V

Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	V
Collector current (d.c.)	$-I_C$	max.	3	A
Collector current (peak value)	$-I_{CM}$	max.	7	A
Base current (d.c.)	$-I_B$	max.	0,5	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	30	W
Storage temperature	T_{stg}		−65 to + 150	°C
→ Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	4,17	°C/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	70	°C/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$-I_E = 0; -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	0,1	mA
$-I_E = 0; -V_{CB} = -V_{CBOmax}; T_j = 150$ °C	$-I_{CBO}$	<	3	mA
$I_B = 0; -V_{CE} = -V_{CEOmax}$	$-I_{CEO}$	<	0,5	mA
Emitter cut-off current				
$I_C = 0; -V_{EB} = 5$ V	$-I_{EBO}$	<	1	mA
D.C. current gain (note 1)				
$-I_C = 150$ mA; $-V_{CE} = 2$ V	h_{FE}		40 to 250	
$-I_C = 1$ A; $-V_{CE} = 2$ V	h_{FE}	>	25	
Base-emitter voltage (notes 1 and 2)				
$-I_C = 1$ A; $-V_{CE} = 2$ V	$-V_{BE}$	<	1,3	V
Collector-emitter saturation voltage (note 1)				
$-I_C = 1$ A; $-I_B = 0,1$ A	$-V_{CEsat}$	<	0,6	V
Transition frequency at f = 1 MHz				
$-I_C = 250$ mA; $-V_{CE} = 10$ V	f_T	>	3	MHz
Switching times				
$-I_{Con} = 1$ A; $-I_{Bon} = I_{Boff} = 0,1$ A				
turn-on time	t_{on}	typ.	0,3	µs
turn-off time	t_{off}	typ.	0,7	µs

Notes
1. Measured under pulse conditions: $t_p \leq 300$ µs; $\delta < 2\%$.
2. $-V_{BE}$ decreases by about 2,3 mV/°C with increasing temperature.

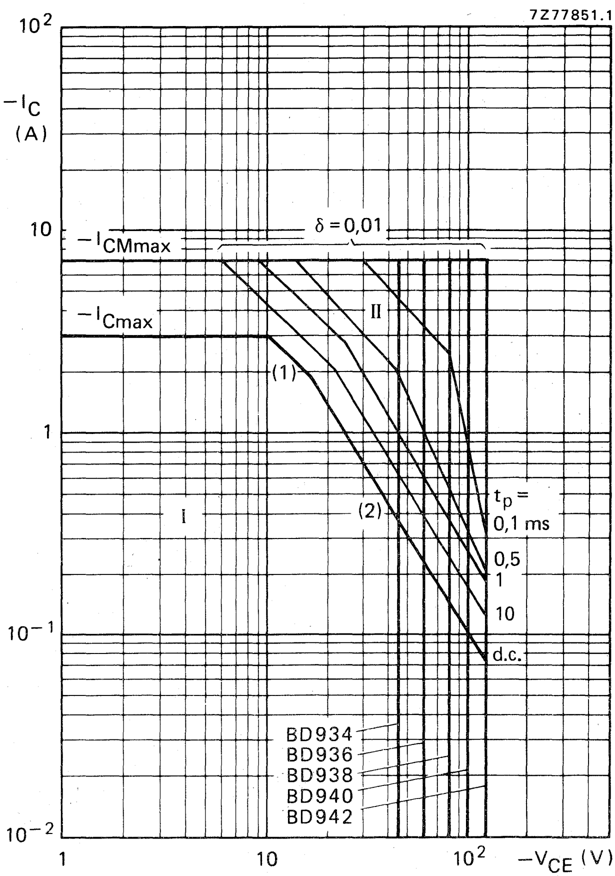


Fig. 2 Safe Operating ARea; T_{mb} = 25 °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.

(2) Second breakdown limits independent of temperature.

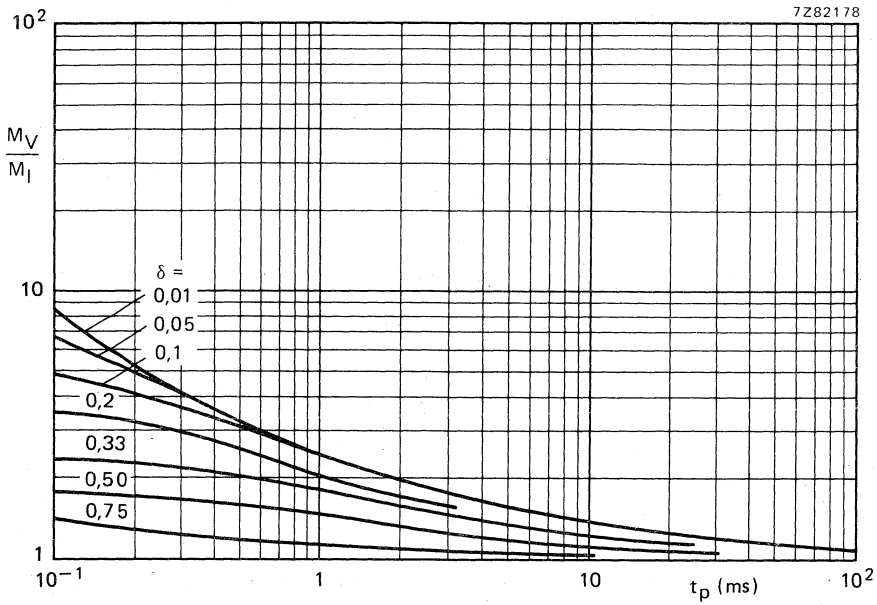


Fig. 3 Second breakdown voltage multiplying factor at the I_{Cmax} level and second breakdown current multiplying factor at the V_{CEOmax} level.

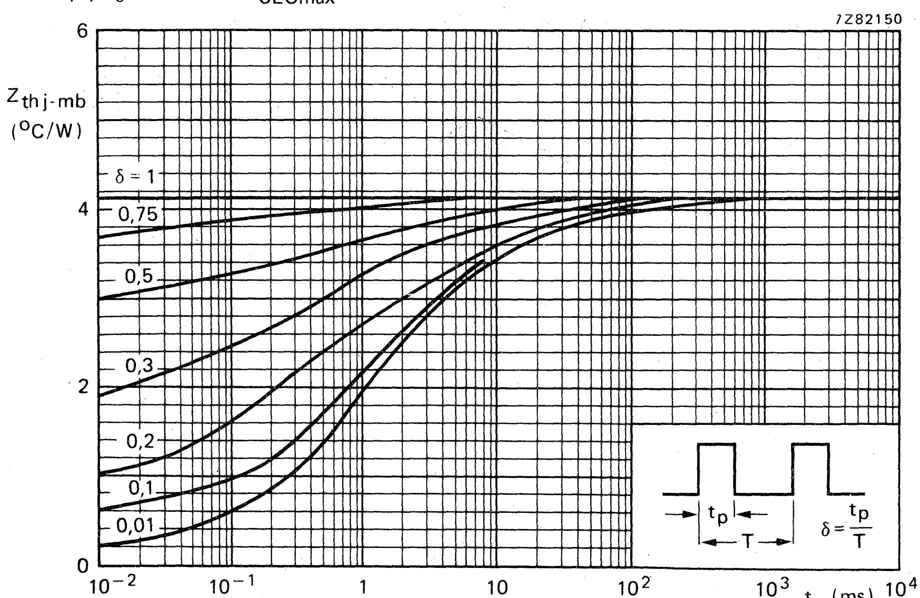


Fig. 4 Pulse power rating chart.

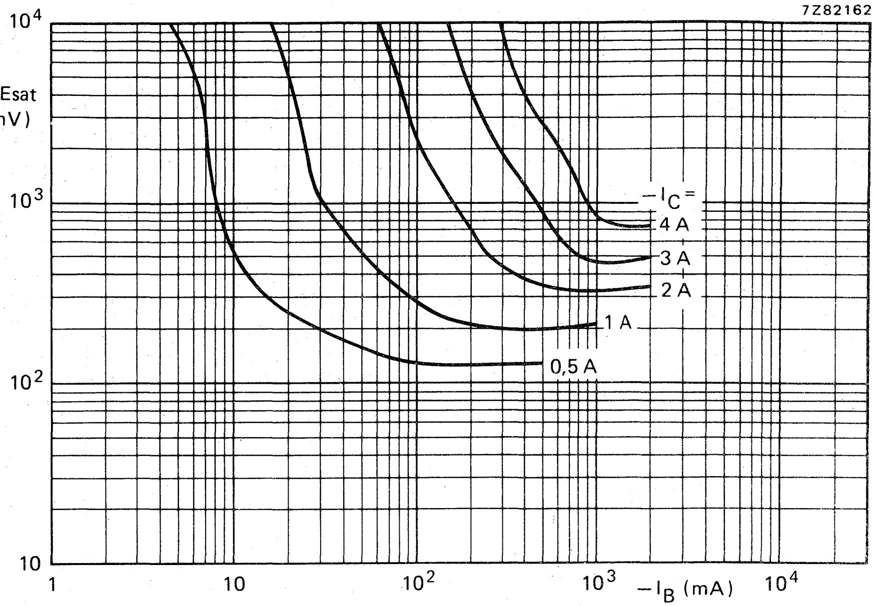


Fig. 5 Typical collector-emitter saturation voltage as a function of base current with collector current as a parameter.

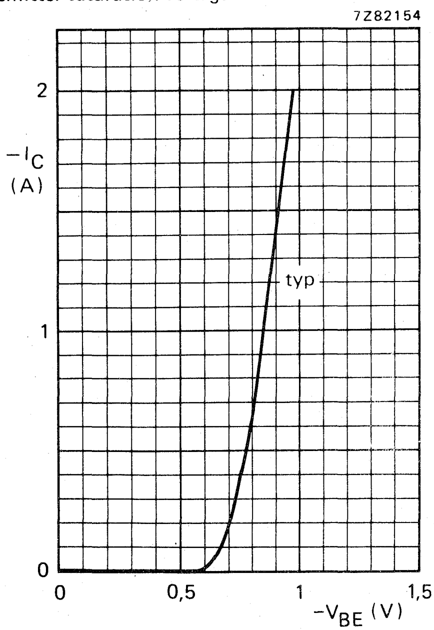


Fig. 6 Typical collector current as a function of base-emitter voltage. $-V_{CE}$ = 2 V; T_j = 25 °C.

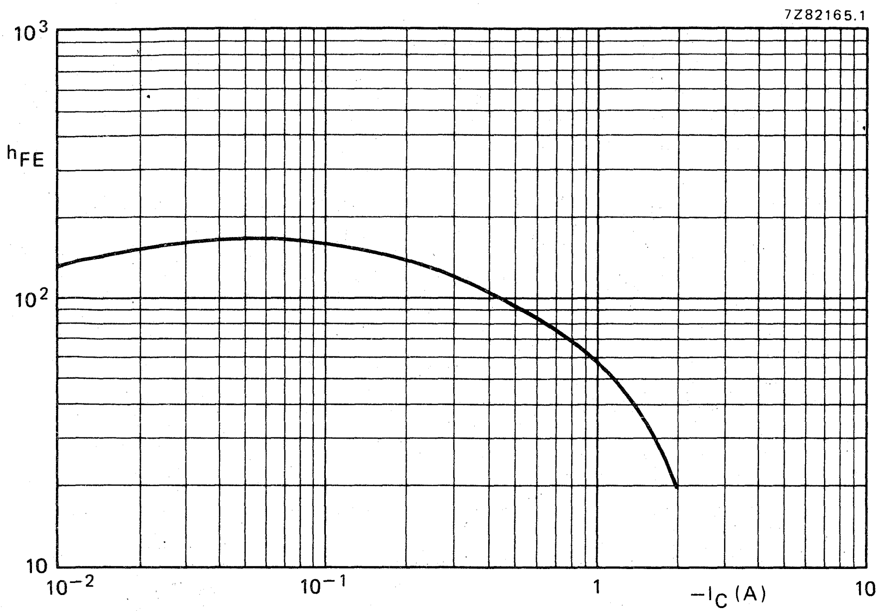


Fig. 7 Typical static forward current transfer ratio as a function of the collector current. $-V_{CE} = 2$ V; $T_j \leqslant 25\ ^{\circ}C$.

SILICON EPITAXIAL BASE POWER TRANSISTORS

N-P-N silicon transistors in a plastic envelope intended for use in audio output stages and general purpose amplifier applications. P-N-P complements are BD944; 946 and 948.

QUICK REFERENCE DATA

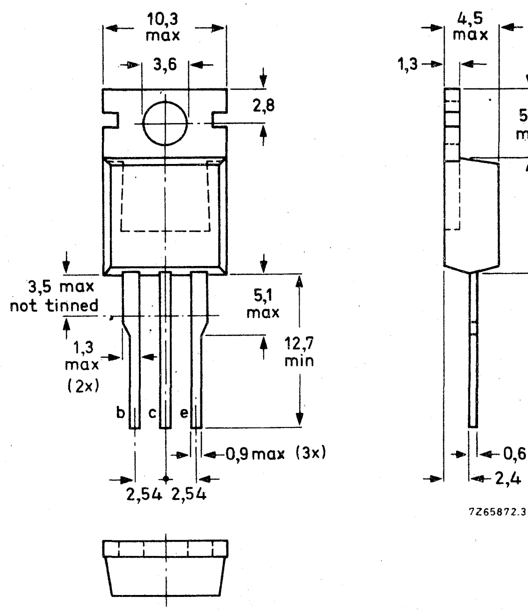
			BD943	945	947	
Collector-base voltage (open emitter)	V_{CBO}	max.	22	32	45	V
Collector-emitter voltage (open base)	V_{CEO}	max.	22	32	45	V
Collector current (d.c.)	I_C	max.		5		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		40		W
Junction temperature	T_j	max.		150		°C
D.C. current gain						
I_C = 10 mA; V_{CE} = 5 V	h_{FE}	>		25		
I_C = 500 mA; V_{CE} = 1 V	h_{FE}			85 to 475		
I_C = 2 A; V_{CE} = 1 V	h_{FE}	>	50	50	40	
Transition frequency at f = 1 MHz						
I_C = 250 mA; V_{CE} = 1 V	f_T	>		3		MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base.



See also chapters Mounting instructions and Accessories.

RATINGS

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

			BD943	945	947	
Collector-base voltage (open emitter)	V_{CBO}	max.	22	32	45	V
Collector-emitter voltage (open base)	V_{CEO}	max.	22	32	45	V
Emitter-base voltage (open collector)	V_{EBO}	max.		5		V
Collector current (d.c.)	I_C	max.		5		A
Collector current (peak value)	I_{CM}	max.		8		A
Base current (d.c.)	I_B	max.		1		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		40		W
Storage temperature	T_{stg}			−65 to + 150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	3,12	°C/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	70	°C/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			BD943	945	947	
Collector cut-off current						
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	<		0,1		mA
$I_E = 0$; $V_{CB} = V_{CBOmax}$; T_j = 150 °C	I_{CBO}	<		3		mA
$I_B = 0$; V_{CE} = 15 V; BD943 / 20 V; BD945 / 25 V; BD947	I_{CEO}	<		0,5		mA
Emitter cut-off current						
$I_C = 0$; V_{EB} = 5 V	I_{EBO}	<		1		mA
D.C. current gain (note 1)						
I_C = 10 mA; V_{CE} = 5 V	h_{FE}	>		25		
I_C = 500 mA; V_{CE} = 1 V	h_{FE}			85 to 475		
I_C = 2 A; V_{CE} = 1 V	h_{FE}	>	50	50	40	
I_C = 3 A; V_{CE} = 1 V	h_{FE}	>	–	–	30	
Base-emitter voltage (notes 1 and 2)						
I_C = 2 A; V_{CE} = 1 V	V_{BE}	<	1,1	1,1	–	V
I_C = 3 A; V_{CE} = 1 V	V_{BE}	<	–	–	1,3	V
Collector-emitter saturation voltage (note 1)						
I_C = 2 A; I_B = 0,2 A	V_{CEsat}	<	0,5	0,5	–	V
I_C = 3 A; I_B = 0,3 A	V_{CEsat}	<	–	–	0,7	V

Notes
1. Measured under pulse conditions; $t_p \leq 300\ \mu s$; $\delta < 2\%$.
2. V_{BE} decreases by about 2,3 mV/°C with increasing temperature.

Knee voltage*			
I_C = 2 A; I_B value for which			
I_C = 2,2 A and V_{CE} = 1 V	V_{CEK}	<	0,8 V
Transition frequency at f = 1 MHz			
I_C = 250 mA; V_{CE} = 1 V	f_T	>	3 MHz

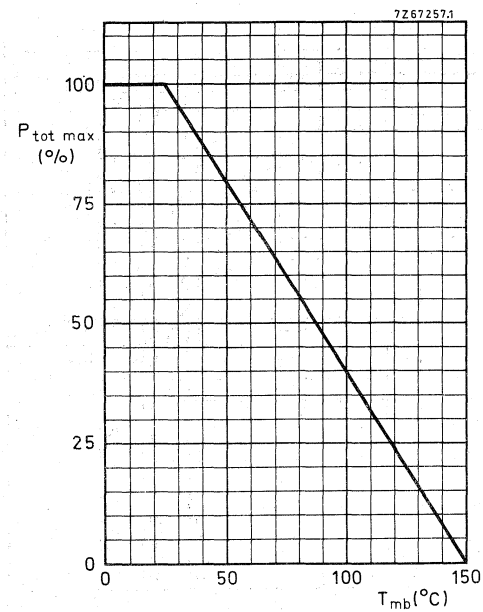


Fig. 2 Power derating curve.

* Measured under pulse conditions; $t_p \leqslant 300\ \mu s$; $\delta < 2\%$.

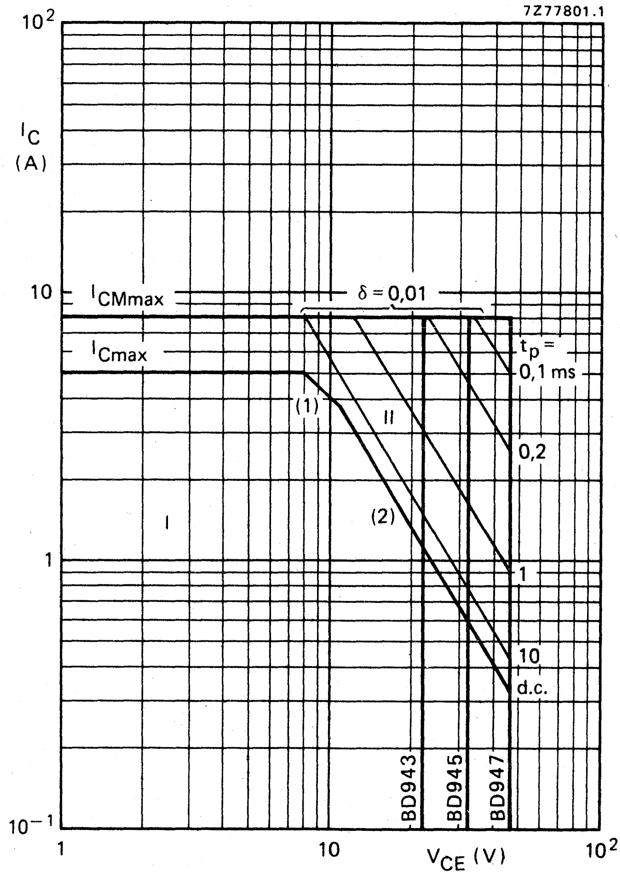


Fig. 3 Safe Operating ARea, $T_{mb} = 25\ ^oC$.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.

(2) Second-breakdown limits (independent of temperature).

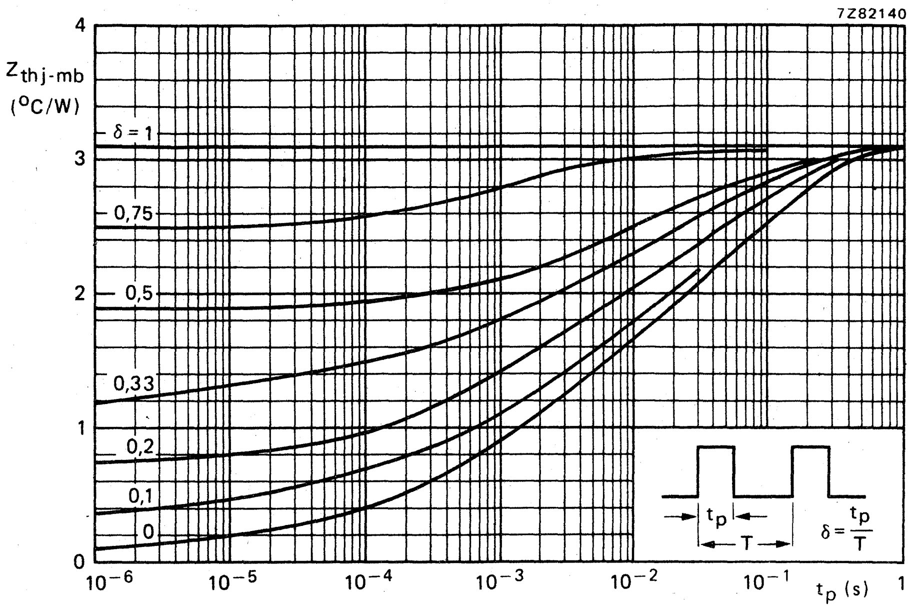


Fig. 4 Pulse power rating chart.

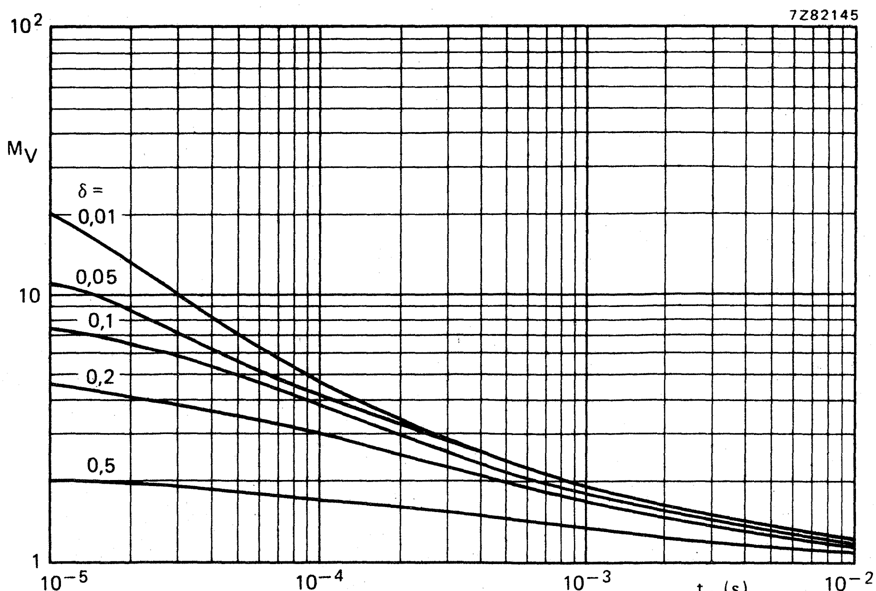


Fig. 5 S.B. voltage multiplying factor at the I_{Cmax} level.

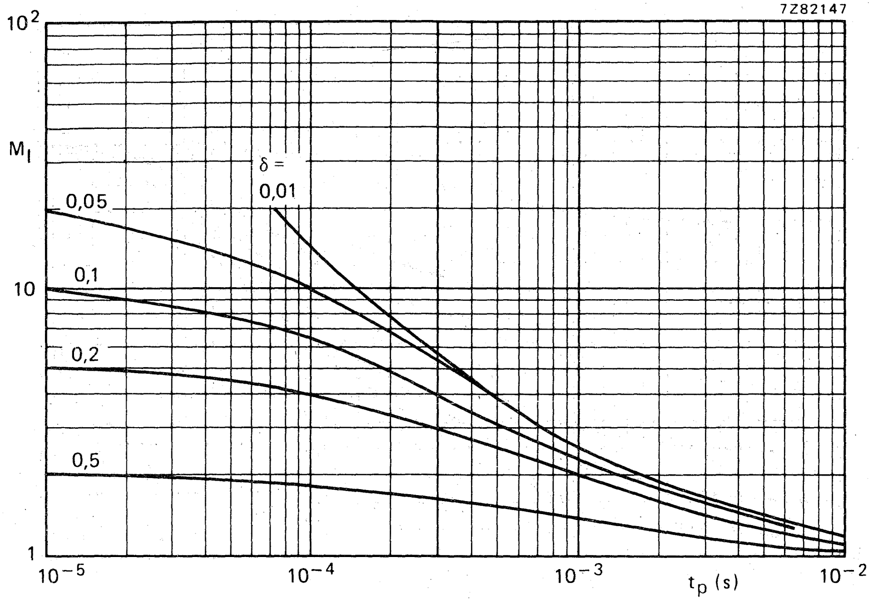


Fig. 6 S.B. current multiplying factor at the V_{CEOmax} level for BD943 and BD945.

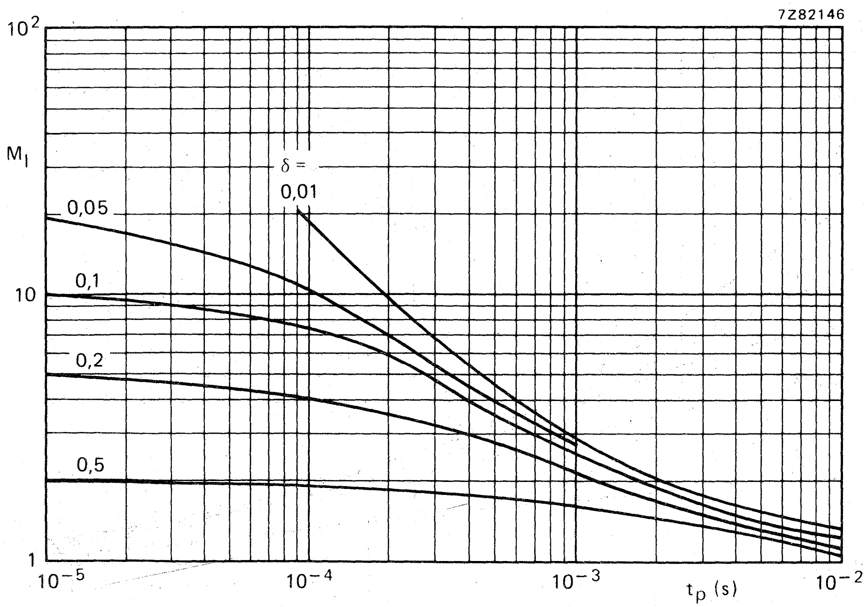


Fig. 7 S.B. current multiplying factor at the V_{CEOmax} level for BD947.

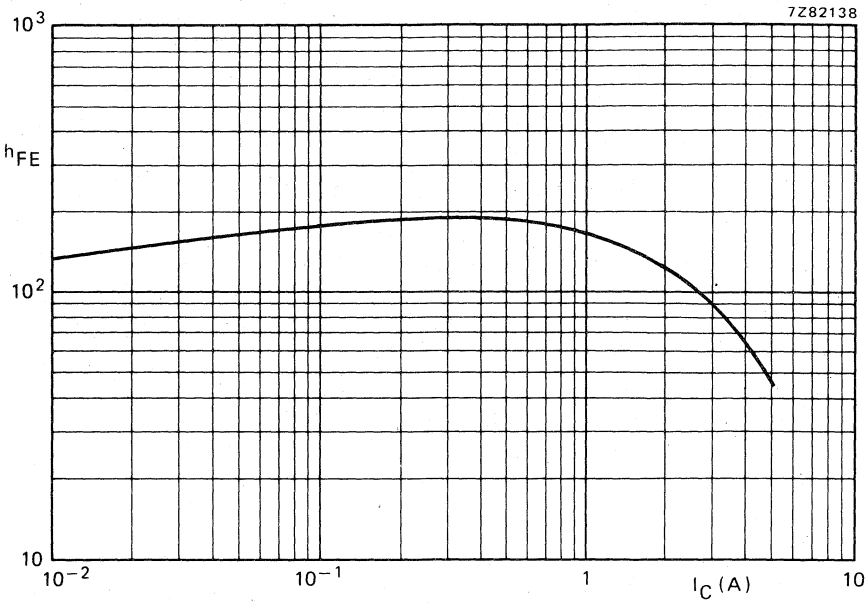


Fig. 8 Typical d.c. current gain at V_{CE} = 1 V; T_j = 25 °C.

SILICON EPITAXIAL BASE POWER TRANSISTORS

P-N-P silicon transistors in a plastic envelope intended for use in audio output stages and general purpose amplifiers. N-P-N complements are BD943; 945 and 947.

QUICK REFERENCE DATA

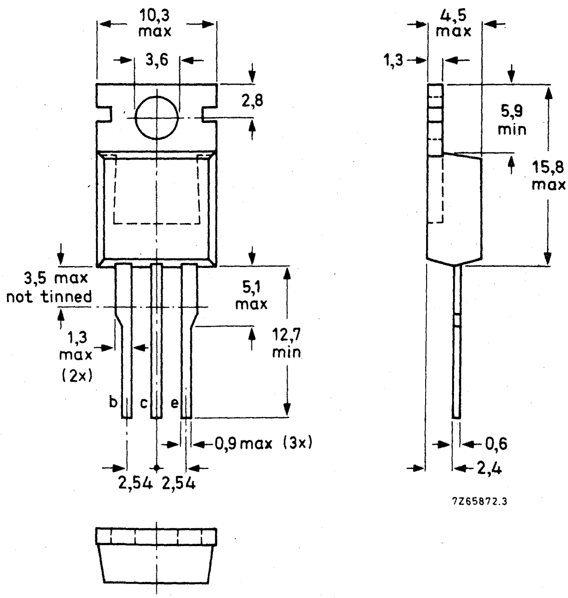
			BD944	946	948	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	22	32	45	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	22	32	45	V
Collector current (d.c.)	$-I_C$	max.		5		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		40		W
Junction temperature	T_j	max.		150		°C
D.C. current gain						
$-I_C$ = 10 mA; $-V_{CE}$ = 5 V	h_{FE}	>		25		
$-I_C$ = 500 mA; $-V_{CE}$ = 1 V	h_{FE}			85 to 475		
$-I_C$ = 2 A; $-V_{CE}$ = 1 V	h_{FE}	>	50	50	40	
Transition frequency at f = 1 MHz						
$-I_C$ = 250 mA; $-V_{CE}$ = 1 V	f_T	>		3		MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base.



See also chapters Mounting instructions and Accessories.

RATINGS

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

			BD944	946	948	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	22	32	45	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	22	32	45	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.		5		V
Collector current (d.c.)	$-I_C$	max.		5		A
Collector current (peak value)	$-I_{CM}$	max.		8		A
Base current (d.c.)	$-I_B$	max.		1		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		40		W
Storage temperature	T_{stg}			−65 to + 150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	3,12	°C/W
From junction to ambient (in free air)	$R_{th\ j\text{-}a}$	=	70	°C/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			BD944	946	948	
Collector cut-off current						
$I_E = 0; -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<		0,1		mA
$I_E = 0; -V_{CB} = -V_{CBOmax}; T_j$ = 150 °C	$-I_{CBO}$	<		3		mA
$I_B = 0; -V_{CE}$ = 15 V; BD944; $-V_{CE}$ = 20 V; BD946; $-V_{CE}$ = 25 V; BD948	$-I_{CEO}$	<		0,5		mA
Emitter cut-off current						
$-I_C = 0; -V_{EB}$ = 5 V	$-I_{EBO}$	<		1		mA
D.C. current gain (note 1)						
$-I_C$ = 10 mA; $-V_{CE}$ = 5 V	h_{FE}	>		25		
$-I_C$ = 500 mA; $-V_{CE}$ = 1 V	h_{FE}			85 to 475		
$-I_C$ = 2 A; $-V_{CE}$ = 1 V	h_{FE}	>	50	50	40	
$-I_C$ = 3 A; $-V_{CE}$ = 1 V	h_{FE}	>	–	–	30	
Base-emitter voltage (notes 1 and 2)						
$-I_C$ = 2 A; $-V_{CE}$ = 1 V	$-V_{BE}$	<	1,1	1,1	–	V
$-I_C$ = 3 A; $-V_{CE}$ = 1 V	$-V_{BE}$	<	–	–	1,3	V
Collector-emitter saturation voltage (note 1)						
$-I_C$ = 2 A; $-I_B$ = 0,2 A	$-V_{CEsat}$	<	0,5	0,5	–	V
$-I_C$ = 3 A; $-I_B$ = 0,3 V	$-V_{CEsat}$	<	–	–	0,7	V

Notes
1. Measured under pulse conditions; $t_p \leqslant 300\ \mu s$; $\delta < 2\%$.
2. V_{BE} decreases by about 2,3 mV/°C with increasing temperature.

Knee voltage *			
$-I_C = 2$ A; $-I_B$ = value for which			
$-I_C = 2{,}2$ A and $-V_{CE} = 1$ V	$-V_{CEK}$	<	0,8 V
Transition frequency at f = 1 MHz			
$-I_C = 250$ mA; $-V_{CE} = 1$ V	f_T	>	3 MHz

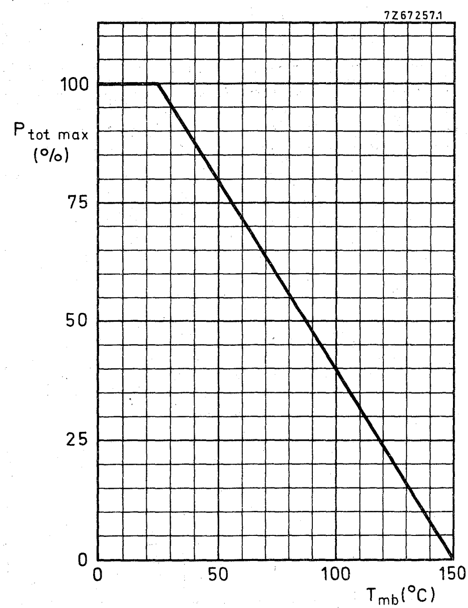


Fig. 2 Power derating curve.

* Measured under pulse conditions; $t_p \leqslant 300\ \mu s$; $\delta < 2\%$.

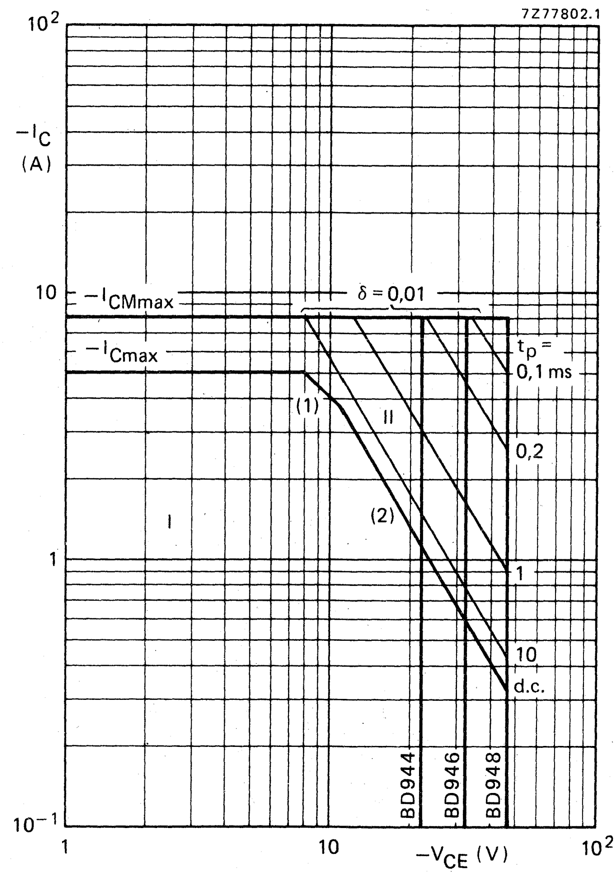


Fig. 3 Safe Operating ARea, $T_{mb} = 25\ ^oC$.

I Region of permissible d.c operation.

II Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.
(2) Second-breakdown limits (independent of temperature).

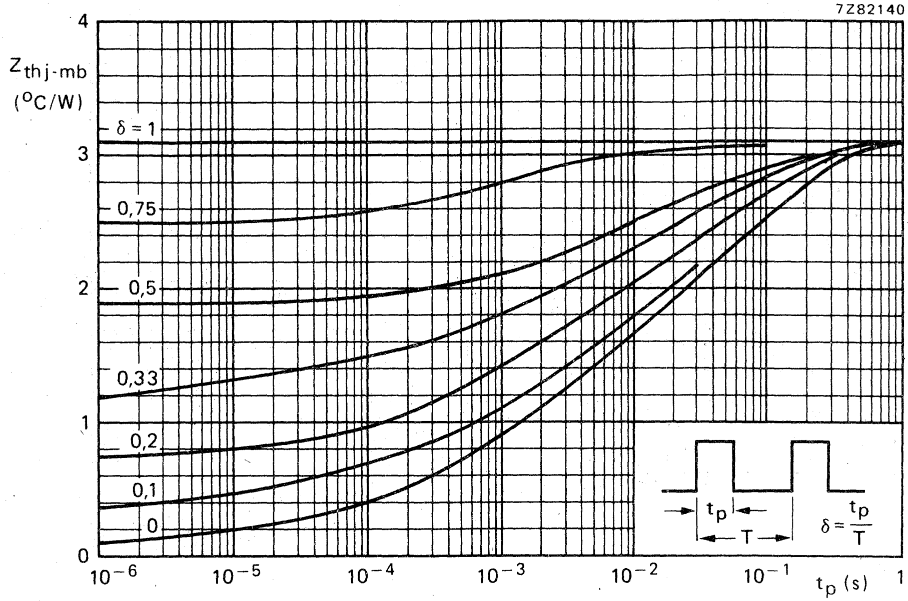


Fig. 4 Pulse power rating chart.

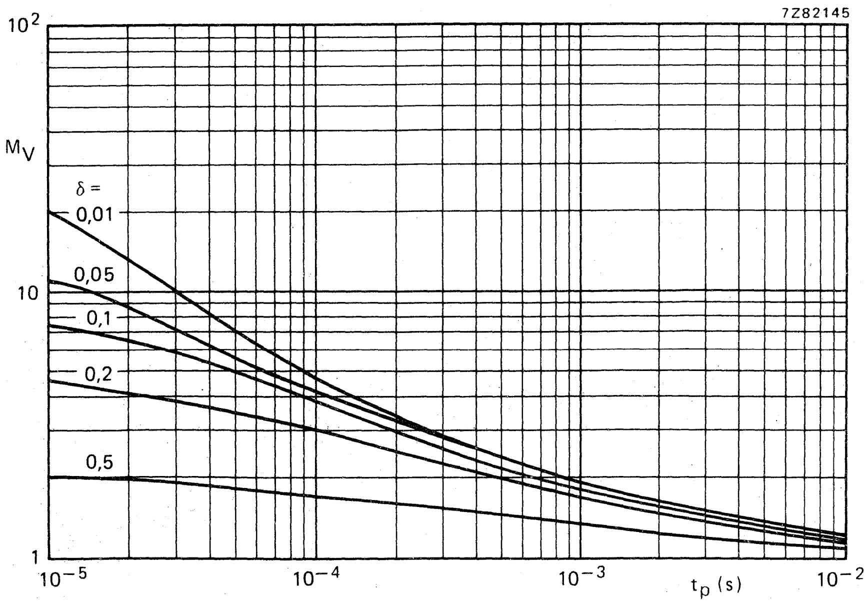


Fig. 5 S.B. voltage multiplying factor at the $-I_{Cmax}$ level.

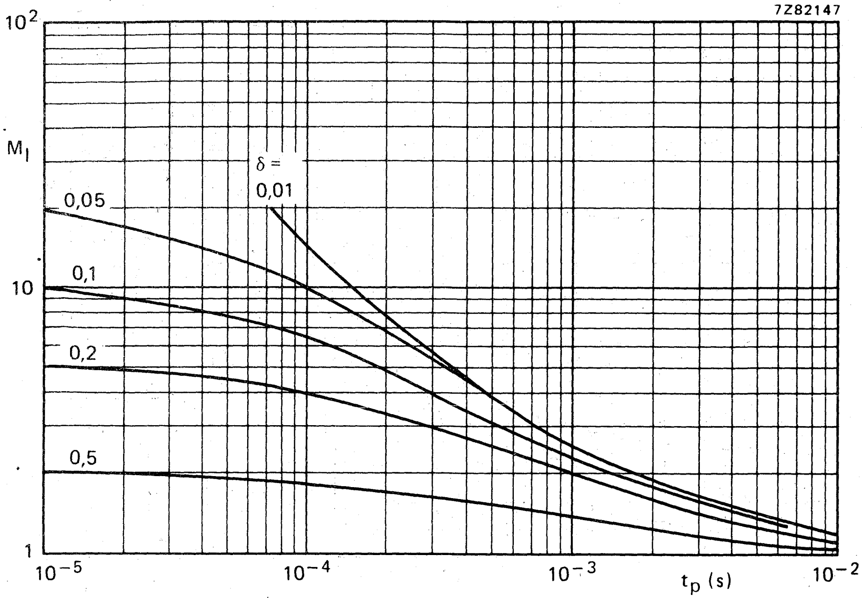


Fig. 6 S.B. current multiplying factor at the $-V_{CEOmax}$ level for BD944/946.

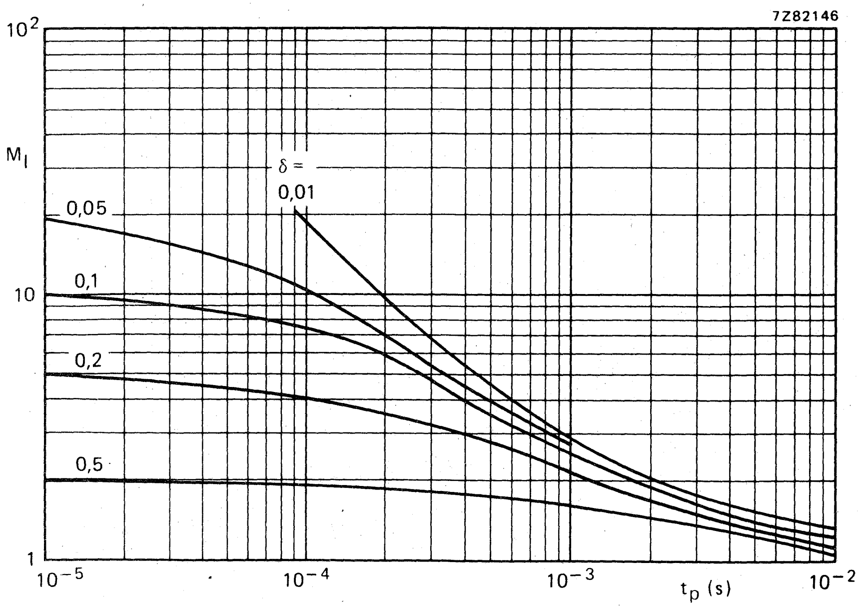


Fig. 7 S.B. current multiplying factor at the $-V_{CEOmax}$ level for BD948.

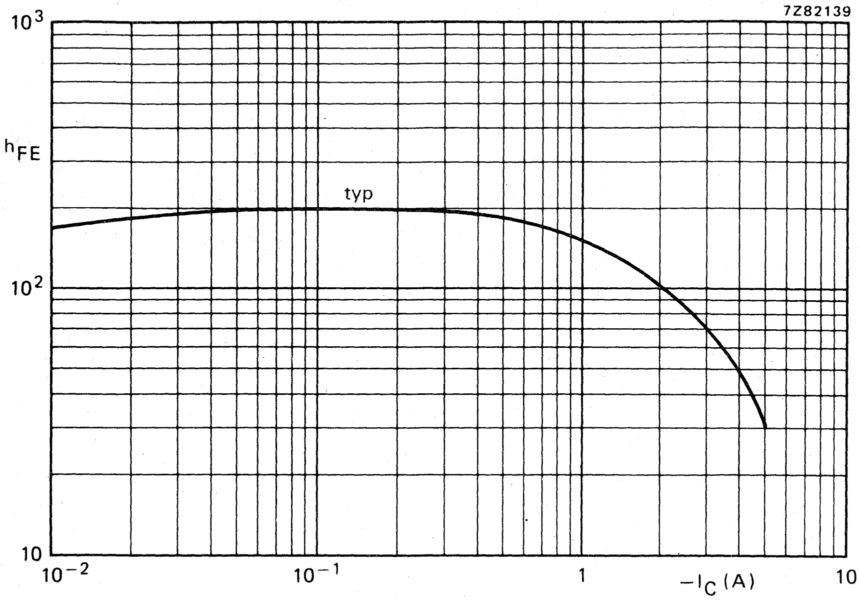


Fig. 8 Typical d.c. current gain at $-V_{CE}$ = 1 V; T_j = 25 °C.

SILICON EPITAXIAL BASE POWER TRANSISTORS

N-P-N transistors in a plastic TO-220 envelope. With their p-n-p complements BD950; 952; 954 and 956 they are intended for use in a wide range of power amplifiers and for switching applications.

QUICK REFERENCE DATA

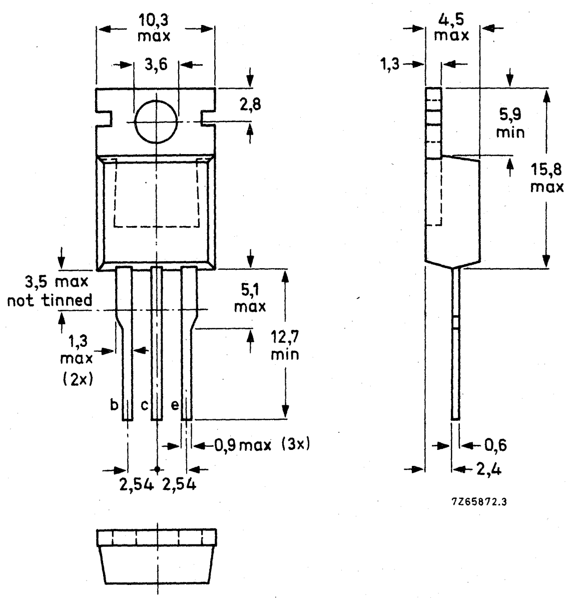
			BD949	BD951	BD953	BD955	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Collector current (d.c.)	I_C	max.		5			A
Collector current (peak value)	I_{CM}	max.		8			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		40			W
Junction temperature	T_j	max.		150			°C
D.C. current gain							
I_C = 0,5 A; V_{CE} = 4 V	h_{FE}	>		40			
I_C = 2 A; V_{CE} = 4 V	h_{FE}	>		20			

MECHANICAL DATA

Fig. 1 TO-220AB.

Dimensions in mm

Collector connected to mounting base.



See also chapters Mounting instructions and Accessories.

RATINGS

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

			BD949	951	953	955	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5				V
Collector current (d.c.)	I_C	max.	5				A
Collector current (peak value)	I_{CM}	max.	8				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	40				W
Storage temperature	T_{stg}		−65 to 150				°C
Junction temperature	T_j	max.	150				°C

THERMAL RESISTANCE

from junction to mounting base	$R_{th\ j\text{-}mb}$	=	3,12	°C/W
from junction to ambient (in free air)	$R_{th\ j\text{-}a}$	=	70	°C/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = V_{CBO\,max}$	I_{CBO}	<	0,1	mA
$I_E = 0$; $V_{CB} = ½\,V_{CBO\,max}$; T_j = 150 °C	I_{CBO}	<	2	mA
$I_B = 0$; $V_{CE} = ½\,V_{CEO\,max}$	I_{CEO}	<	0,5	mA
Emitter cut-off current				
$I_C = 0$; V_{EB} = 5 V	I_{EBO}	<	1	mA
D.C. current gain (note 1)				
I_C = 0,5 A; V_{CE} = 4 V	h_{FE}	>	40	
I_C = 2 A; V_{CE} = 4 V	h_{FE}	>	20	
Base-emitter voltage (notes 1 and 2)				
I_C = 2 A; V_{CE} = 4 V	V_{BE}	<	1,4	V
Collector-emitter saturation voltage (note 1)				
I_C = 2 A; I_B = 0,2 A	V_{CEsat}	<	1	V
Transition frequency at f = 1 MHz				
I_C = 0,5 A; V_{CE} = 4 V	f_T	>	3	MHz

(1) Measured under pulse conditions: $t_p \leqslant 300\ \mu s$, $\delta < 2\%$.
(2) V_{EB} decreases by about 2,3 mV/°C with increasing temperature.

CHARACTERISTICS (continued)

Switching times
(between 10% and 90% levels)
$I_{Con} = 1$ A; $I_{Bon} = -I_{Boff} = 0{,}1$ A

Turn-on time	t_{on}	typ.	0,3 μs
Turn-off time	t_{off}	typ.	1,5 μs

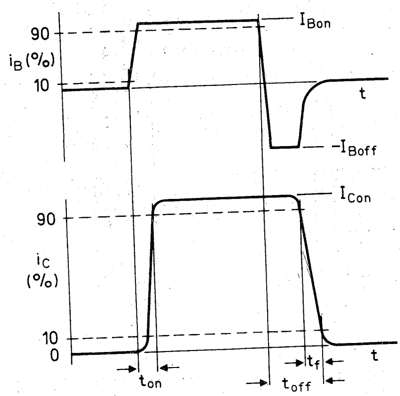
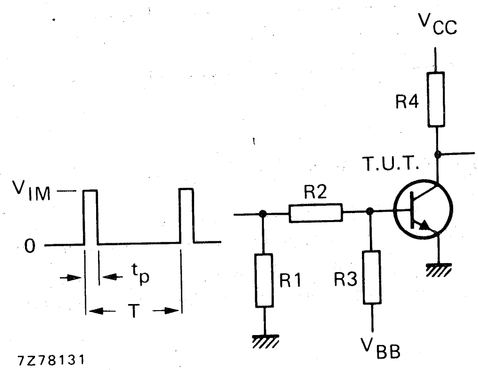


Fig. 2 Switching times waveforms.



V_{IM}	=	30 V
V_{CC}	=	20 V
V_{BB}	=	−3,5 V
R1	=	82 Ω
R2	=	150 Ω
R3	=	39 Ω
R4	=	20 Ω
$t_r = t_f$	≤	15 ns
t_p	=	10 μs
T	=	500 μs

Fig. 3 Switching times test circuit.

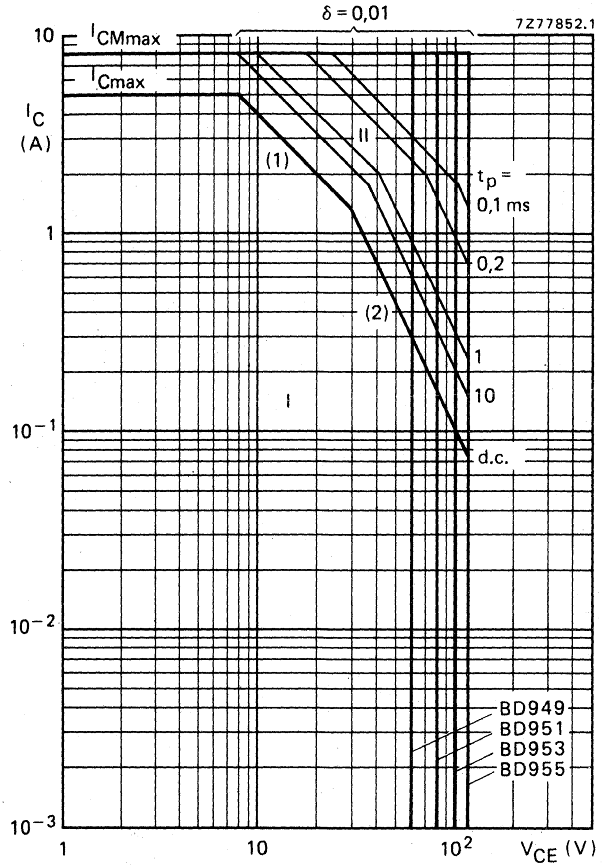


Fig. 4 Safe Operating ARea; $T_{mb} \leqslant 25$ °C.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second-breakdown limit (independent of temperature).

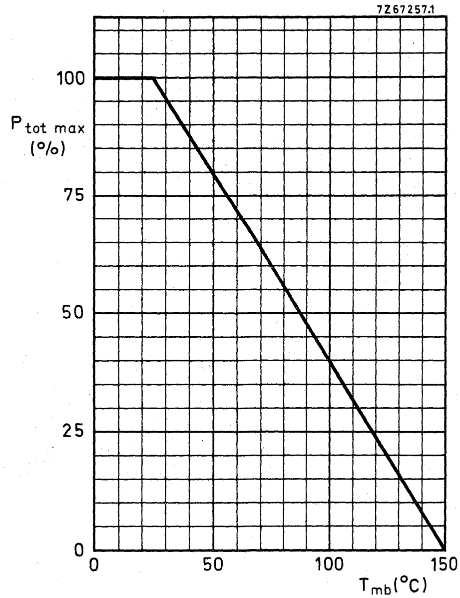


Fig. 5 Power derating curve.

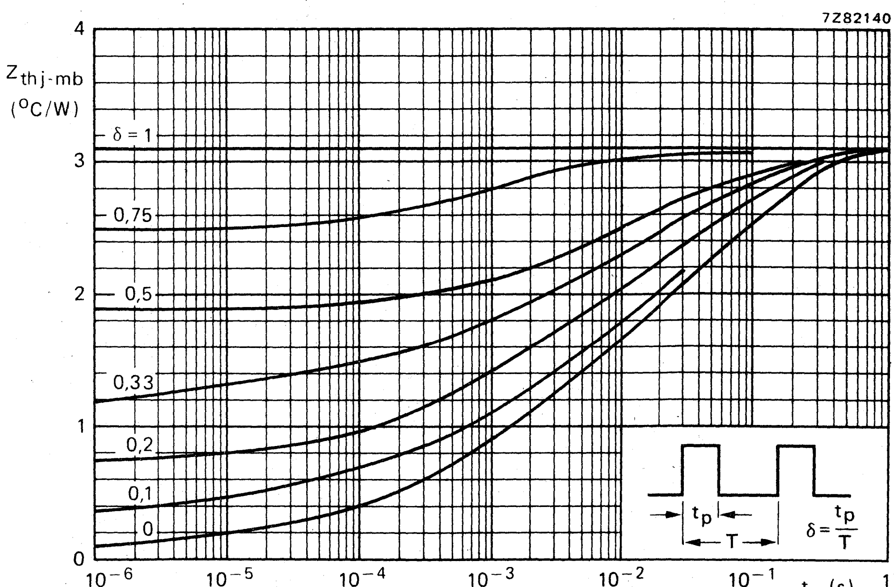


Fig. 6 Pulse power rating chart.

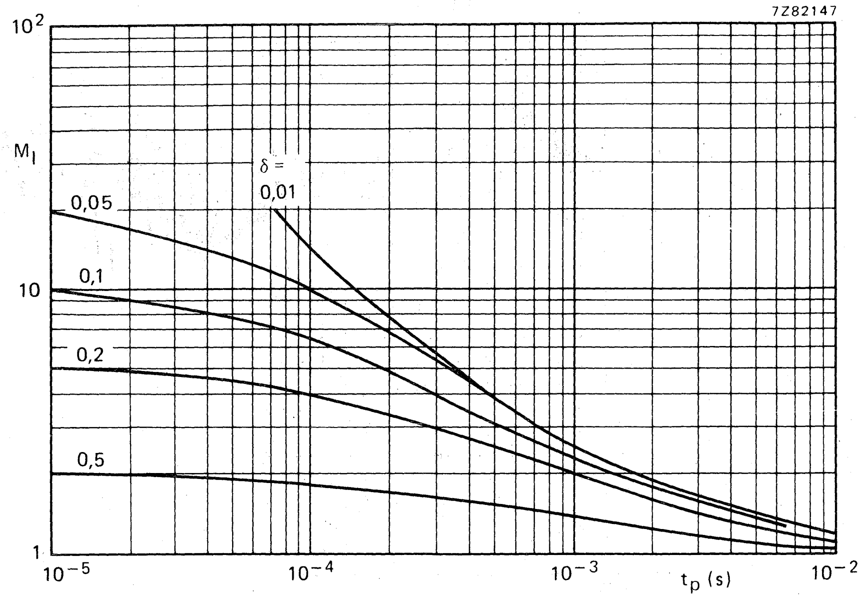


Fig. 7 S.B. current multiplying factor at the $V_{CEO\,max}$ level for BD949/951.

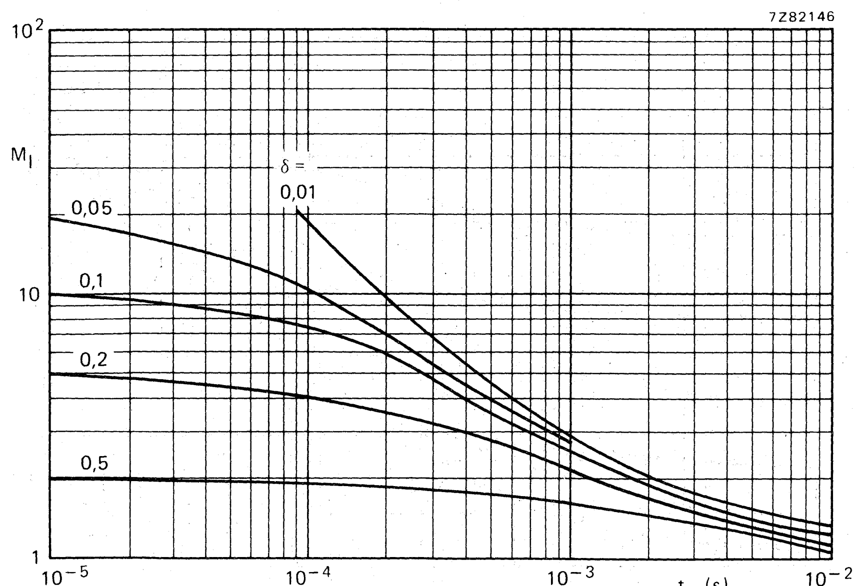


Fig. 8 S.B. current multiplying factor at the $V_{CEO\,max}$ level for BD953/955.

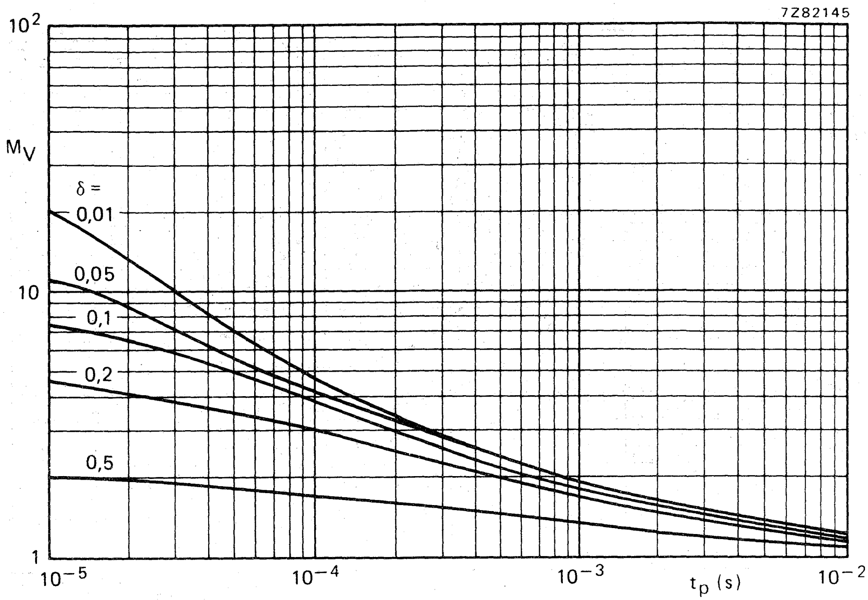


Fig. 9 S.B. voltage multiplying factor at the $I_{C\,max}$ level.

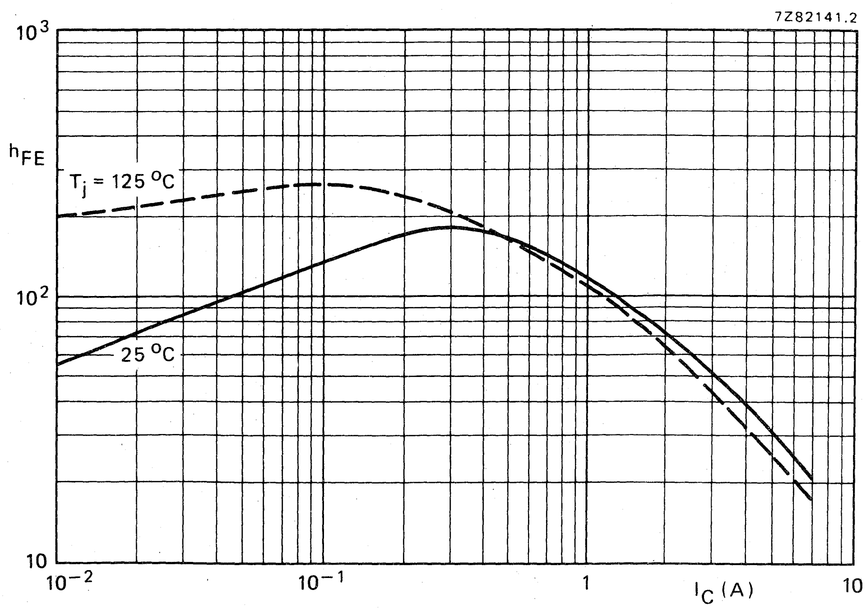


Fig. 10 Typical d.c. current gain at V_{CE} = 4 V.

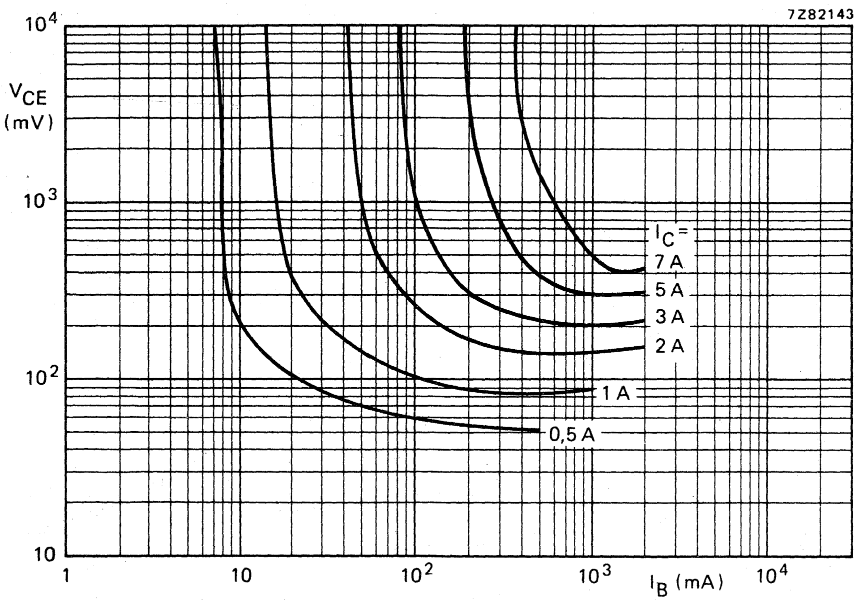


Fig. 11 Collector-emitter voltage as a function of base current.

SILICON EPITAXIAL BASE POWER TRANSISTORS

P-N-P transistors in a plastic TO-220 envelope. With their n-p-n complements BD949; 951; 953 and 955 they are intended for use in a wide range of power amplifiers and for switching applications.

QUICK REFERENCE DATA

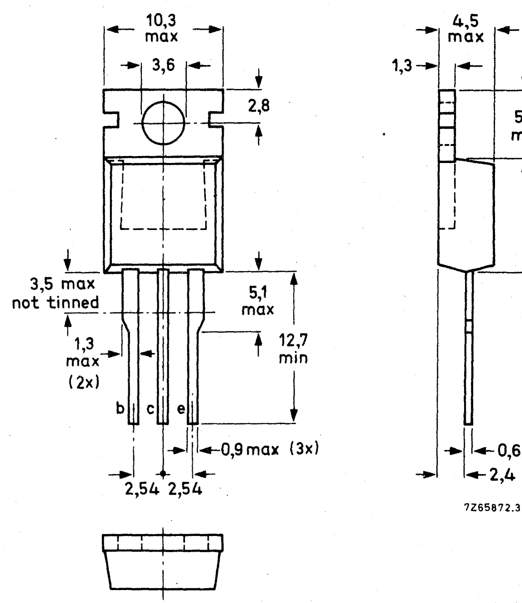
			BD950	952	954	956	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Collector current (d.c.)	$-I_C$	max.		5			A
Collector current (peak value)	$-I_{CM}$	max.		8			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		40			W
Junction temperature	T_j	max.		150			°C
D.C. current gain							
$-I_C$ = 0,5 A; $-V_{CE}$ = 4 V	h_{FE}	>		40			
$-I_C$ = 2 A; $-V_{CE}$ = 4 V	h_{FE}	>		20			

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base.



See also chapters Mounting instructions and Accessories.

RATINGS

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

			BD950	952	954	956	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.		5			V
Collector current (d.c.)	$-I_C$	max.		5			A
Collector current (peak value)	$-I_{CM}$	max.		8			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		40			W
Storage temperature	T_{stg}			−65 to 150			°C
Junction temperature	T_j	max.		150			°C

THERMAL RESISTANCE

from junction to mounting base	$R_{th\ j\text{-}mb}$	=	3,12	°C/W
from junction to ambient (in free air)	$R_{th\ j\text{-}a}$	=	70	°C/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $-V_{CB} = -V_{CBO\,max}$	$-I_{CBO}$	<	0,1	mA
$I_E = 0$; $-V_{CB} = -½\,V_{CBO\,max}$; T_j = 150 °C	$-I_{CBO}$	<	2	mA
$I_B = 0$; $-V_{CE} = -½\,V_{CEO\,max}$	$-I_{CEO}$	<	0,5	mA
Emitter cut-off current				
$I_C = 0$; $-V_{EB}$ = 5 V	$-I_{EBO}$	<	1	mA
D.C. current gain (note 1)				
$-I_C$ = 0,5 A; $-V_{CE}$ = 4 V	h_{FE}	>	40	
$-I_C$ = 2 A; $-V_{CE}$ = 4 V	h_{FE}	>	20	
Base-emitter voltage (notes 1 and 2)				
$-I_C$ = 2 A; $-V_{CE}$ = 4 V	$-V_{BE}$	<	1,4	V
Collector-emitter saturation voltage (note 1)				
$-I_C$ = 2 A; $-I_B$ = 0,2 A	$-V_{CEsat}$	<	1	V
Transition frequency at f = 1 MHz				
$-I_C$ = 0,5 A; $-V_{CE}$ = 4 V	f_T	>	3	MHz

(1) Measured under pulse conditions: $t_p \leq 300\ \mu s$, $\delta < 2\%$.
(2) V_{EB} decreases by about 2,3 mV/°C with increasing temperature.

CHARACTERISTICS (continued)

Switching times
(between 10% and 90% levels)
I_{Con} = 1 A; $-I_{Bon}$ = I_{Boff} = 0,1 A

Turn-on time	t_{on}	typ.	0,1 μs
Turn-off time	t_{off}	typ.	0,4 μs

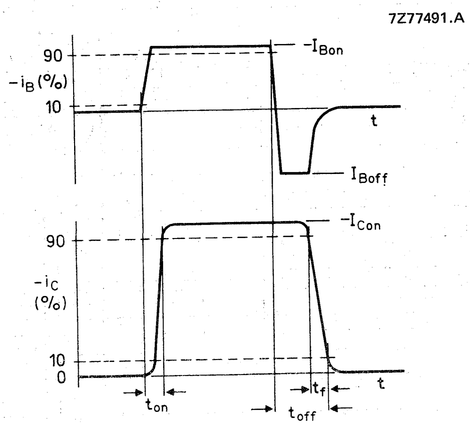


Fig. 2 Switching times waveforms.

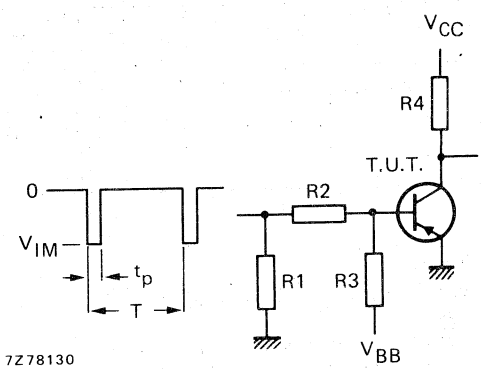


Fig. 3 Switching times test circuit.

$-V_{IM}$ = 30 V
$-V_{CC}$ = 20 V
V_{BB} = 3,5 V
R1 = 82 Ω
R2 = 150 Ω
R3 = 39 Ω
R4 = 20 Ω
$t_r = t_f \leq 15$ ns
t_p = 10 μs
T = 500 μs

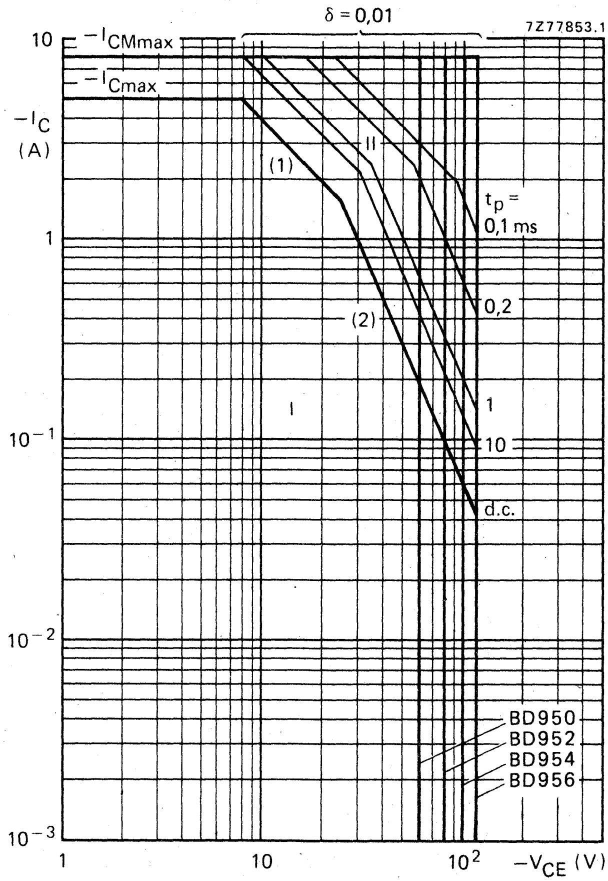


Fig. 4 Safe Operating ARea; $T_{mb} \leqslant 25$ °C.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.
(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second-breakdown limit (independent of temperature).

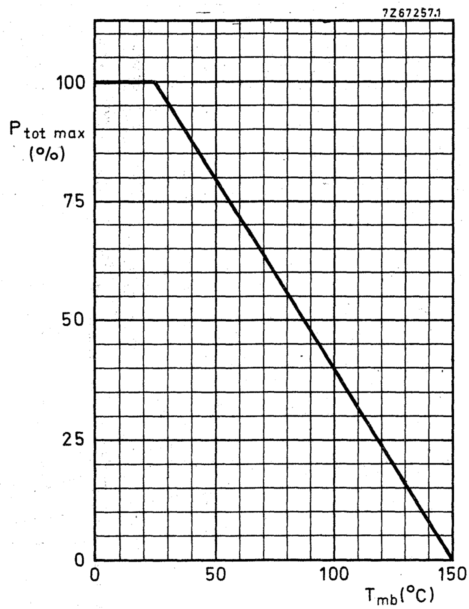


Fig. 5 Power derating curve.

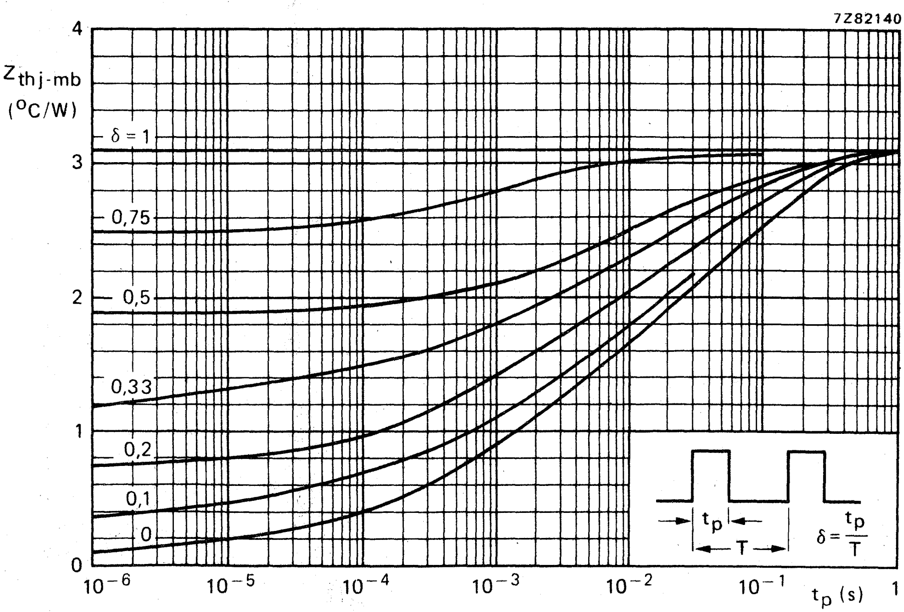


Fig. 6 Pulse power rating chart.

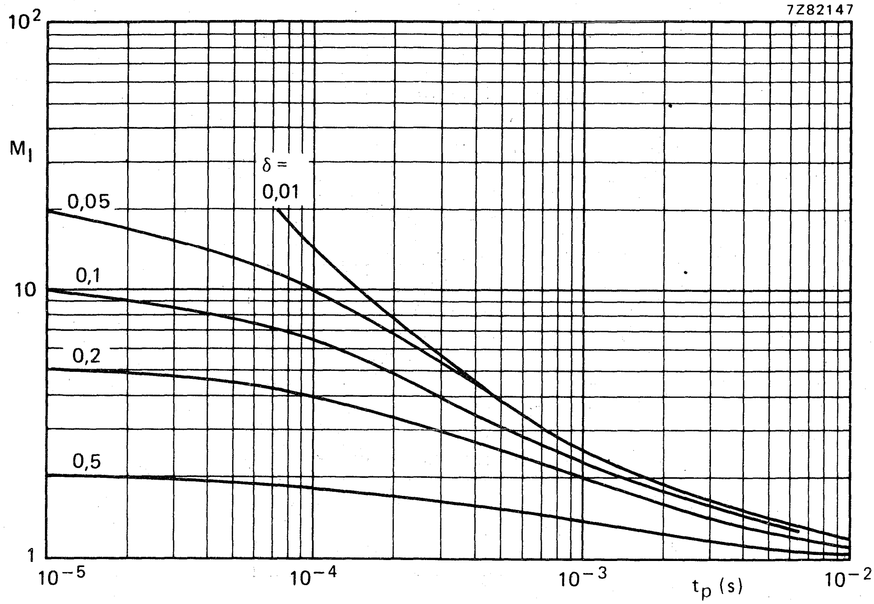


Fig. 7 S.B. current multiplying factor at the $-V_{CEO\,max}$ level for BD950 and BD952.

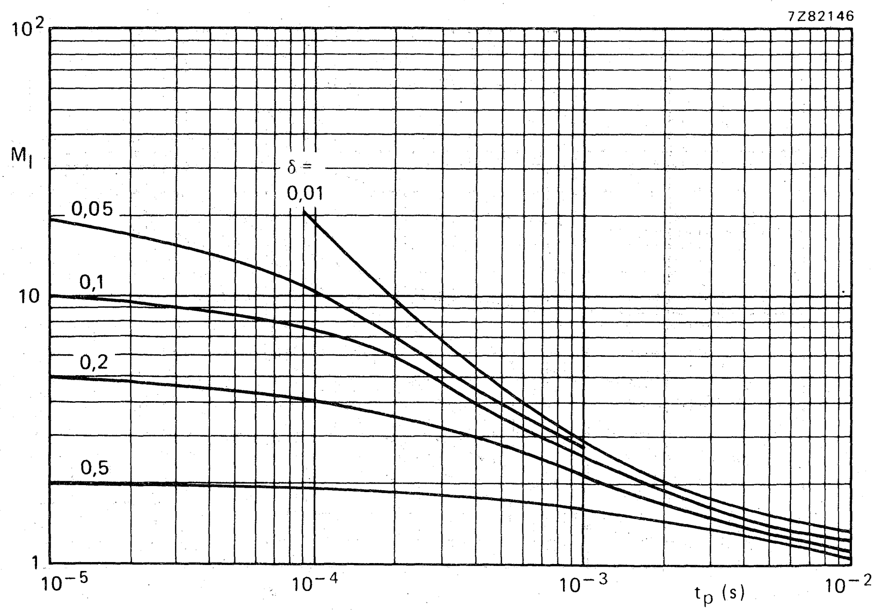


Fig. 8 S.B. current multiplying factor at the $-V_{CEO\,max}$ level for BD954 and BD956.

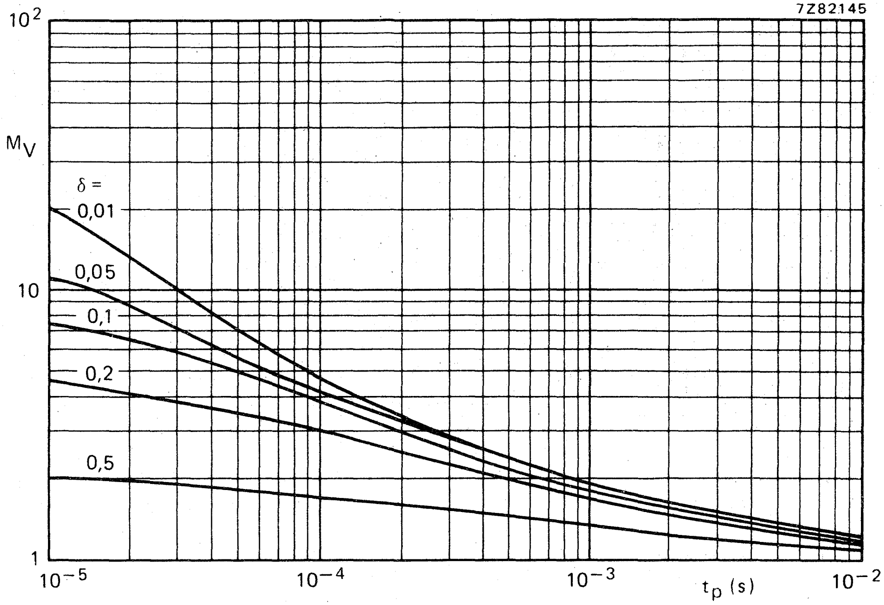


Fig. 9 S.B. voltage multiplying factor at the $-I_{C\,max}$ level.

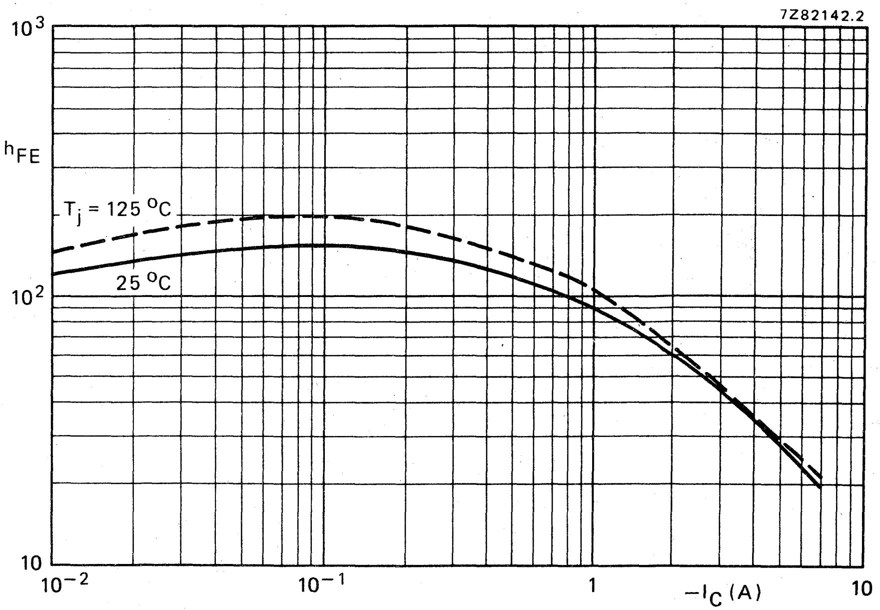


Fig. 10 Typical d.c. current gain at $-V_{CE}$ = 4 V.

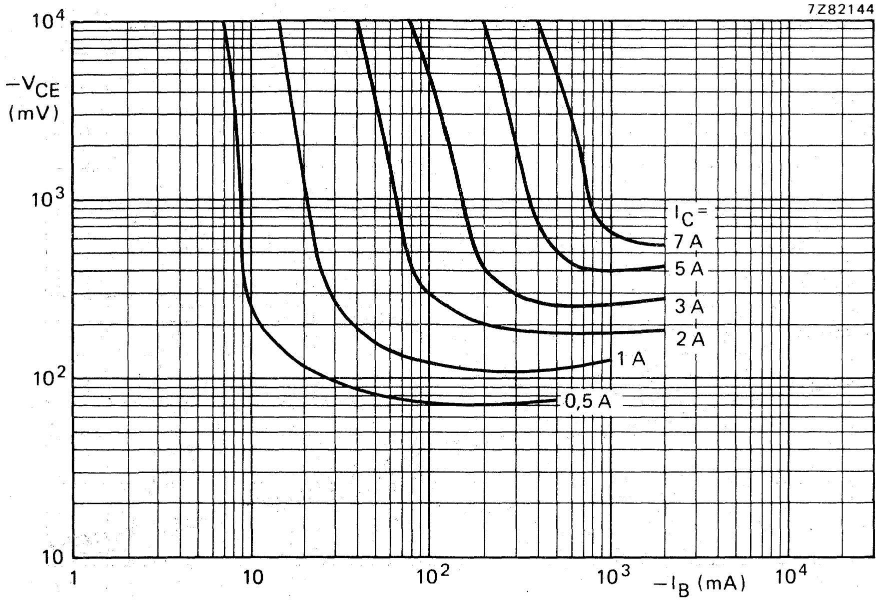


Fig. 11 Collector-emitter voltage as a function of base current.

SILICON EPITAXIAL BASE POWER TRANSISTORS

N-P-N silicon transistors in a plastic envelope intended for use in output stages of audio and television amplifier circuits where high peak powers can occur.

QUICK REFERENCE DATA

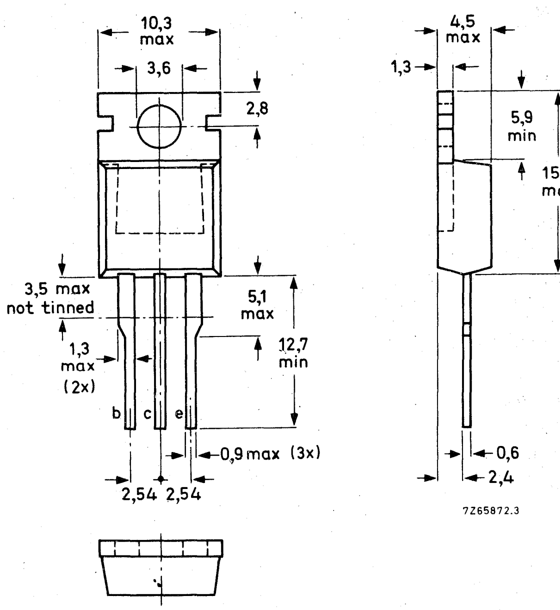
			BDT29	A	B	C	
Collector-base voltage	V_{CBO}	max.	40	60	80	100	V
Collector-emitter voltage	V_{CEO}	max.	40	60	80	100	V
Collector current (peak value)	I_{CM}	max.	3				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	30				W
Junction temperature	T_j	max.	150				°C
D.C. current gain							
I_C = 200 mA; V_{CE} = 4 V	h_{FE}	>	40				
I_C = 1 A; V_{CE} = 4 V	h_{FE}		15 to 75				
Transition frequency at f = 1 MHz							
I_C = 200 mA; V_{CE} = 10 V	f_T	>	3				MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base.



See also chapters Mounting Instructions and Accessories.

RATINGS

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

			BDT29	A	B	C	
Collector-base voltage (open emitter)	V_{CBO}	max.	40	60	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	60	80	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5				V
Collector current (d.c.)	I_C	max.	1				A
Collector current (peak value)	I_{CM}	max.	3				A
Base current (d.c.)	I_B	max.	0,4				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	30				W
Storage temperature	T_{stg}		−65 to + 150				°C
Junction temperature	T_j	max.	150				°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	4,17	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	70	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			BDT29; A	BDT29B; C	
Collector cut-off current					
$I_B = 0$; V_{CE} = 30 V	I_{CEO}	<	0,3	—	mA
$I_B = 0$; V_{CE} = 60 V	I_{CEO}	<	—	0,3	mA
$V_{BE} = 0$; $V_{CE} = V_{CEOmax}$	I_{CES}	<	0,2		mA
Emitter cut-off current					
$I_C = 0$; V_{EB} = 5 V	I_{EBO}	<	1		mA
D.C. current gain*					
I_C = 200 mA; V_{CE} = 4 V	h_{FE}	>	40		
I_C = 1 A; V_{CE} = 4 V	h_{FE}		15 to 75		
Base-emitter voltage**					
I_C = 1 A; V_{CE} = 4 V	V_{BE}	<	1,3		V
Collector-emitter saturation voltage*					
I_C = 1 A; I_B = 0,125 A	V_{CEsat}	<	0,7		V

			BDT29	A	B	C	
Collector-emitter breakdown voltage*							
$I_B = 0$; I_C = 30 mA	$V_{(BR)CEO}$	>	40	60	80	100	V
Small-signal current gain							
I_C = 0,2 A; V_{CE} = 10 V; f = 1 kHz	$\|h_{fe}\|$	>	20				
Turn off breakdown energy							
L = 20 mH; I_{CC} = 1,8 A	$E_{(BR)}$	>	32				mJ

* Measured under pulse conditions: $t_p \leq 300\ \mu s$; $\delta < 2\%$.
** V_{BE} decreases by about 2,3 mV/°C with increasing temperature.

Transition frequency at f = 1 MHz I_C = 0,2 A; V_{CE} = 10 V	f_T	>	3 MHz
Switching times (between 10% and 90% levels) I_{Con} = 1 A; I_{Bon} = $-I_{Boff}$ = 0,1 A			
Turn-on time	t_{on}	typ.	0,3 μs
Turn-off time	t_{off}	typ.	1 μs

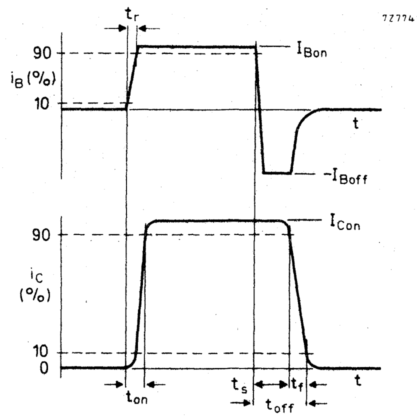
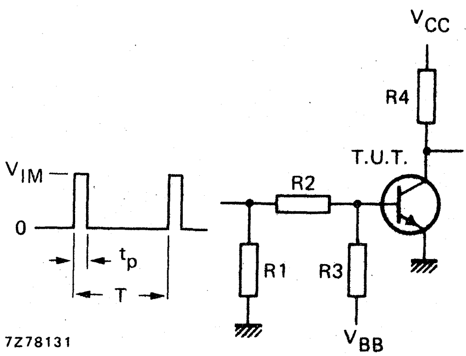


Fig. 2 Switching times waveforms.



V_{IM}	=	16 V
V_{CC}	=	20 V
$-V_{BB}$	=	6,4 V
R1	=	82 Ω
R2	=	82 Ω
R3	=	82 Ω
R4	=	20 Ω
$t_r = t_f$	⩽	15 ns
t_p	=	20 μs
T	=	500 μs

Fig. 3 Switching times test circuit.

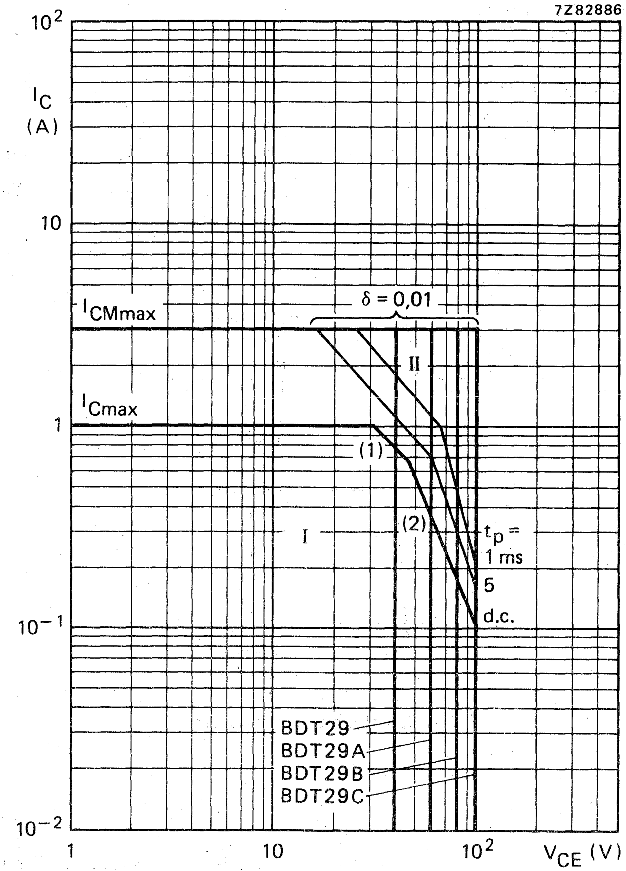


Fig. 4 Safe Operating ARea; T_{mb} = 25 °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.

(2) Second breakdown limits, independent of temperature.

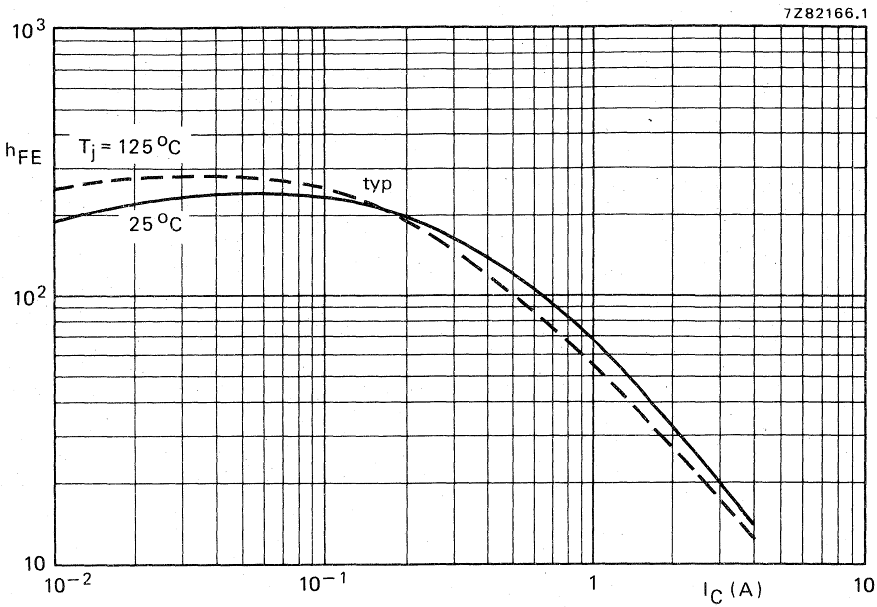


Fig. 5 Typical static forward current transfer ratio as a function of the collector current. $V_{CE} = 4$ V.

SILICON EPITAXIAL BASE POWER TRANSISTORS

P-N-P silicon transistors in a plastic envelope intended for use in output stages of audio and television amplifier circuits where high peak powers can occur.

QUICK REFERENCE DATA

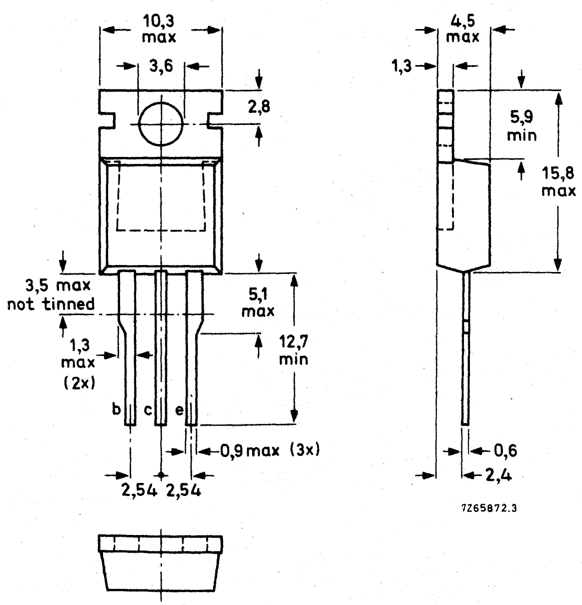
			BDT30	A	B	C	
Collector-base voltage	$-V_{CBO}$	max.	40	60	80	100	V
Collector-emitter voltage	$-V_{CEO}$	max.	40	60	80	100	V
Collector current (d.c.)	$-I_{CM}$	max.	3				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	30				W
Junction temperature	T_j	max.	150				°C
D.C. current gain $-I_C$ = 1 A; $-V_{CE}$ = V	h_{FE}	>	15 to 75				
Transition frequency $-I_C$ = 200 mA; $-V_{CE}$ = 10 V	f_T	>	3				MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base.



See also chapters Mounting Instructions and Accessories.

RATINGS

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

			BDT30	A	B	C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	40	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	80	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5				V
Collector current (d.c.)	$-I_C$	max.	1				A
Collector current (peak value)	$-I_{CM}$	max.	3				A
Base current (d.c.)	$-I_B$	max.	0,4				A
Total power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.	30				W
Storage temperature	T_{stg}		−65 to +150				^oC
Junction temperature	T_j	max.	150				^oC

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	4,17	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	70	K/W

CHARACTERISTICS

$T_j = 25\ ^oC$ unless otherwise specified

			BDT30;A	BDT30B;C	
Collector cut-off current					
$-I_B = 0; -V_{CE} = 30$ V	$-I_{CEO}$	<	0,3	–	mA
$-I_B = 0; -V_{CE} = 60$ V	$-I_{CEO}$	<	–	0,3	mA
$-V_{BE} = 0; -V_{CE} = -V_{CEOmax}$	$-I_{CES}$	<	0,2		mA
Emitter cut-off current					
$I_C = 0; -V_{EB} = 5V$	$-I_{EBO}$	<	1		mA
D.C. current gain*					
$-I_C = 200$ mA; $-V_{CE} = 4$ V	h_{FE}	>	40		
$-I_C = 1$ A; $-V_{CE} = 4$ V	h_{FE}		15 to 75		
Base-emitter voltage*					
$-I_C = 1$ A; $-V_{CE} = 4$ V	$-V_{BE}$	<	1,3		V
Collector-emitter saturation voltage*					
$-I_C = 1$ A; $-I_B = 0{,}125$ A	$-V_{CEsat}$	<	0,7		V

			BDT30	A	B	C	
Collector-emitter breakdown voltage*							
$I_B = 0; -I_C = 30$ mA	$-V_{(BR)CEO}$	>	40	60	80	100	
Small-signal current gain							
$-I_C = 0{,}2$ A; $-V_{CE} = 10$ V; f = 1 kHz	$\|h_{fe}\|$	>	20				
Turn off breakdown energy							
L = 20 mH; $I_{CC} = 1{,}22$ A	$E_{(BR)}$	>	15				mJ

* Measured under pulse conditions: $t_p \leqslant 300\ \mu s$; $\delta < 2\%$.

Transition frequency at f = 1 MHz			
$-I_C$ = 200 mA; $-V_{CE}$ = 10 V	f_T	>	3 MHz
Switching times			
$-I_{Con}$ = 1 A; $-I_{Bon}$ = I_{Boff} = 0,1 A			
turn-on time	t_{on}	typ.	0,3 μs
turn-off time	t_{off}	typ.	1 μs

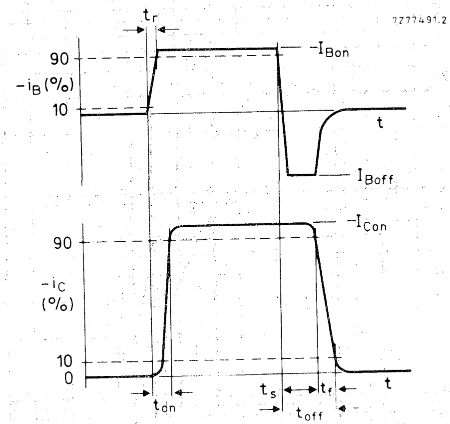
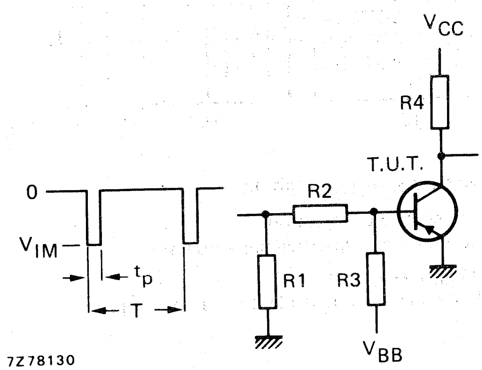


Fig. 2 Switching times waveforms.



$-V_{IM}$	=	16 V
$-V_{CC}$	=	20 V
$+V_{BB}$	=	6,4 V
R1	=	82 Ω
R2	=	82 Ω
R3	=	82 Ω
R4	=	20 Ω
$t_r = t_f$	=	15 ns
t_p	=	20 μs
T	=	500 μs

Fig. 3 Switching times test circuit.

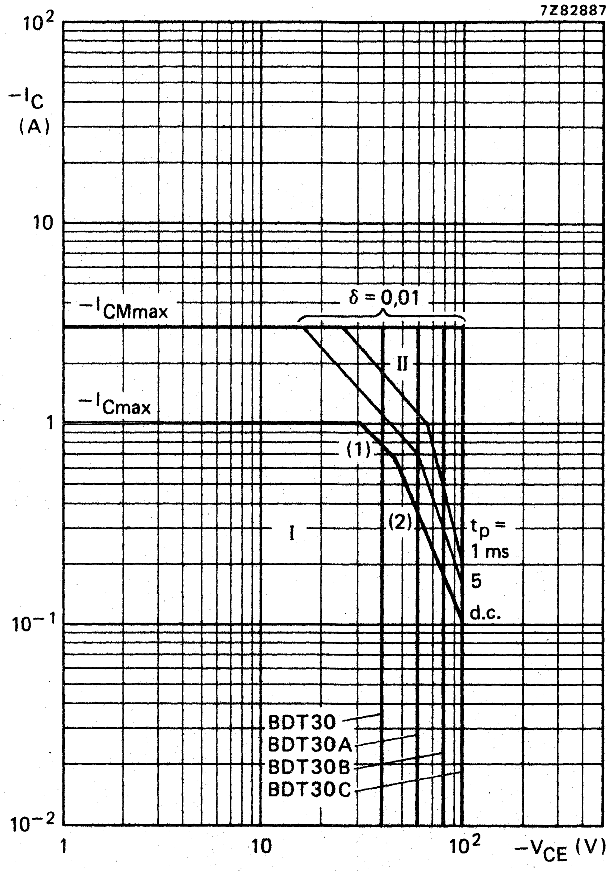


Fig. 4 Safe Operating ARea; T_{mb} = 25 °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.

(2) Second breakdown limits independent of temperature.

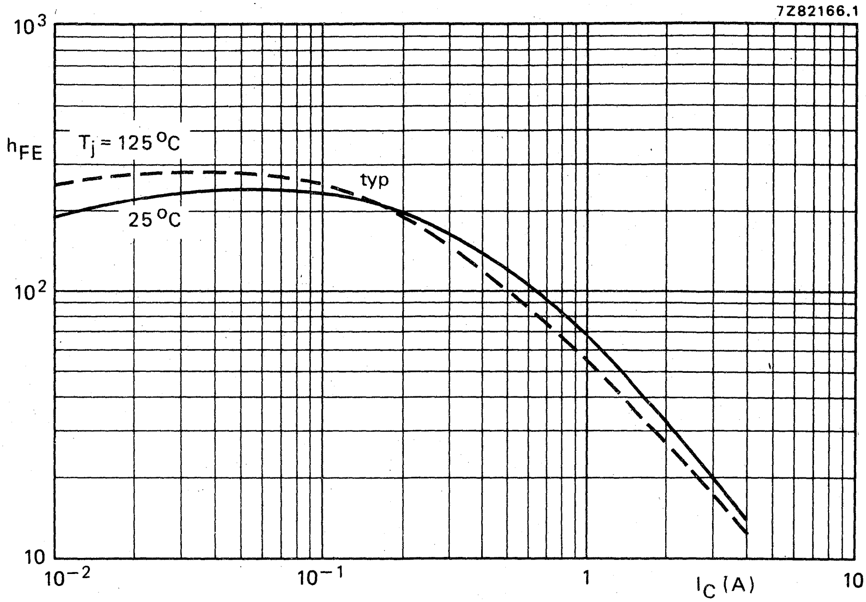


Fig. 5 Typical static forward current transfer ratio as a function of the collector current. $-V_{CE} = 4$ V.

SILICON EPITAXIAL BASE POWER TRANSISTORS

N-P-N transistors in a plastic envelope intended for use in audio output stages and general amplifier and switching applications.

QUICK REFERENCE DATA

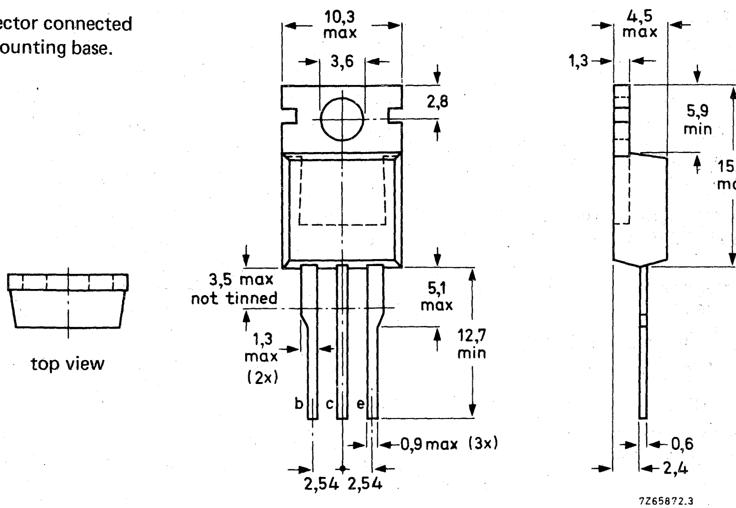
			BDT31	A	B	C	
Collector-base voltage (open emitter)	V_{CBO}	max.	40	60	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	60	80	100	V
Collector current (d.c.)	I_C	max.			3		A
Collector current (peak value)	I_{CM}	max.			5		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.			40		W
Junction temperature	T_j	max.			150		°C
D.C. current gain							
I_C = 1 A; V_{CE} = 4 V	h_{FE}	>			25		
I_C = 3 A; V_{CE} = 4 V	h_{FE}				10 to 50		

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base.



See also chapters Mounting Instructions and Accessories.

RATINGS

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

			BDT31	A	B	C	
Collector-base voltage (open emitter)	V_{CBO}	max.	40	60	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	60	80	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.		5			V
Collector current (d.c.)	I_C	max.		3			A
Collector current (peak value)	I_{CM}	max.		5			A
Base current (d.c.)	I_B	max.		1			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		40			W
Storage temperature	T_{stg}			−65 to +150			°C
Junction temperature	T_j	max.		150			°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$ =	3,12	K/W
From junction to ambient (in free air)	$R_{th\ j\text{-}a}$ =	70	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			BDT31; A	BDT31B; C	
Collector cut-off current					
I_B = 0; V_{CE} = 30 V	I_{CEO}	<	0,3	–	mA
I_B = 0; V_{CE} = 60 V	I_{CEO}	<	–	0,3	mA
V_{BE} = 0; V_{CE} = V_{CEOmax}	I_{CES}	<	0,2		mA
Emitter cut-off current					
I_C = 0; V_{EB} = 5 V	I_{EBO}	<	1		mA
D.C. current gain *					
I_C = 1 A; V_{CE} = 4 V	h_{FE}	>	25		
I_C = 3 A; V_{CE} = 4 V	h_{FE}		10 to 50		
Base-emitter voltage * **					
I_C = 3 A; V_{CE} = 4 V	V_{BE}	<	1,8		V
Collector-emitter saturation voltage *					
I_C = 3 A; I_B = 0,375 A	V_{CEsat}	<	1,2		V

			BDT31	A	B	C	
Collector-emitter breakdown voltage *							
I_B = 0; I_C = 30 mA	$V_{(BR)CEO}$	>	40	60	80	100	V

Small-signal current transfer ratio				
I_C = 0,5 A; V_{CE} = 10 V; f = 1 kHz	$\|h_{fe}\|$	>	20	
I_C = 0,5 A; V_{CE} = 10 V; f = 1 MHz	$\|h_{fe}\|$	>	3	
Turn-off breakdown energy				
L = 20 mH; I_{CC} = 1,8 A	$E_{(BR)}$	>	32	mJ

* Measured under pulse conditions: $t_p \leqslant 300\ \mu s$; $\delta \leqslant 2\%$.
** V_{BE} decreases by about 2,3 mV/°C with increasing temperature.

Switching times
(between 10% and 90% levels)
$I_{Con} = 1$ A; $I_{Bon} = -I_{Boff} = 0,1$ A

Turn-on time	t_{on}	typ.	0,3 μs
Turn-off time	t_{off}	typ.	1 μs

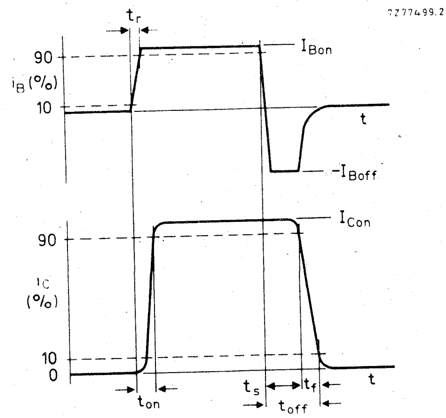


Fig. 2 Switching times waveforms.

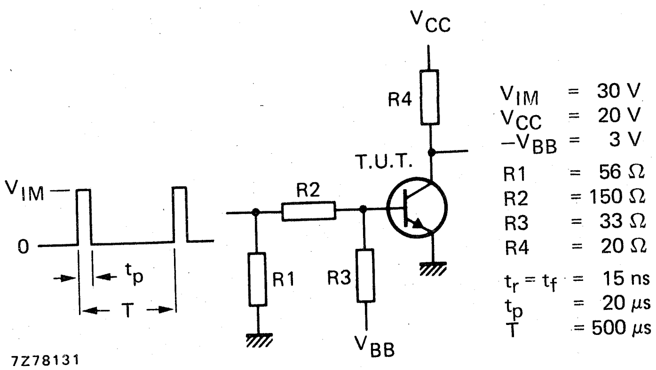


Fig. 3 Switching times test circuit.

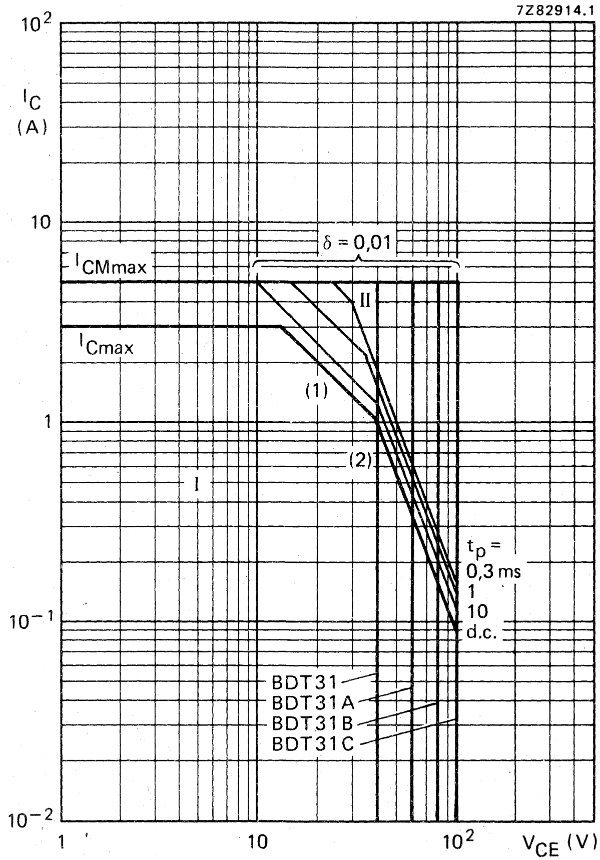


Fig. 4 Safe Operating ARea; T_{mb} = 25 °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.

(2) Second-breakdown limits (independent of temperature).

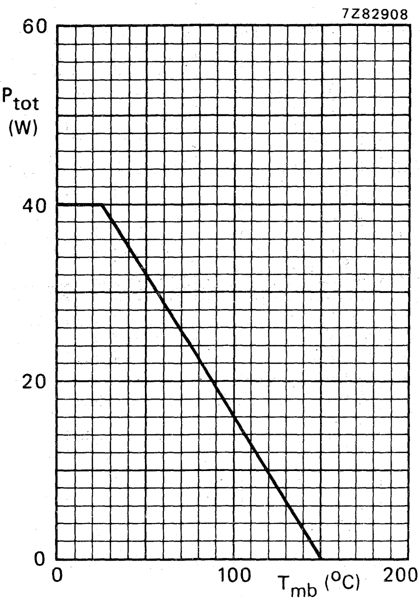


Fig. 5 Power derating curve.

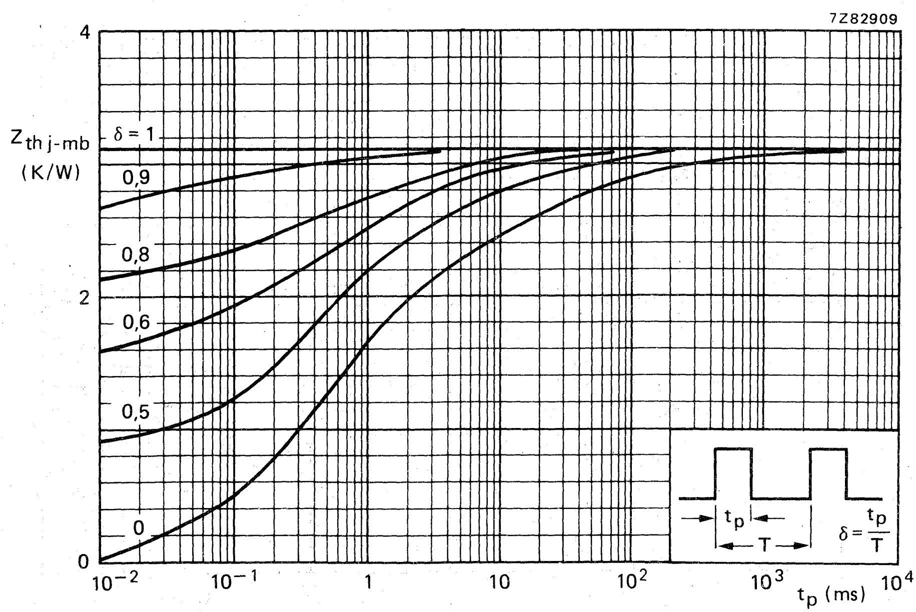


Fig. 6 Pulse power rating chart.

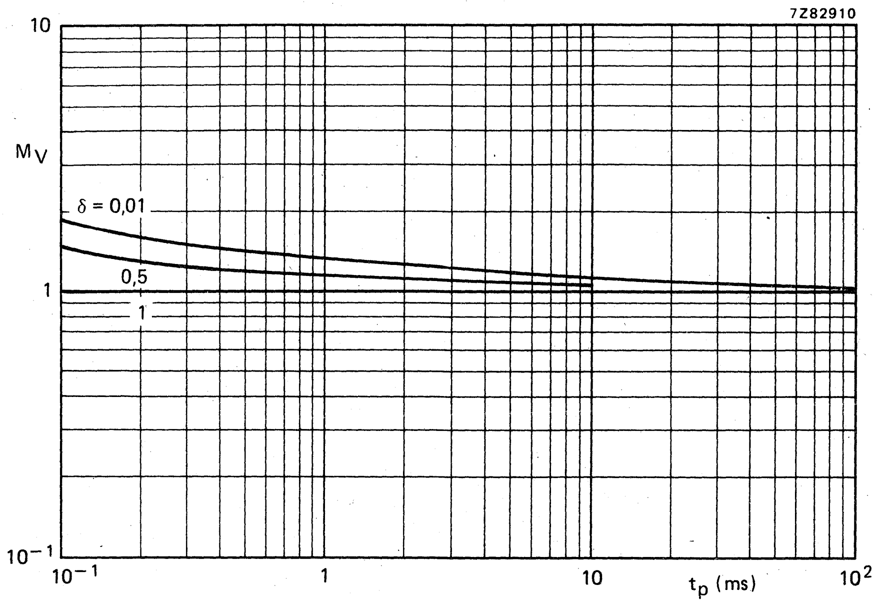


Fig. 7 S.B. voltage multiplying factor at the I_{Cmax} level.

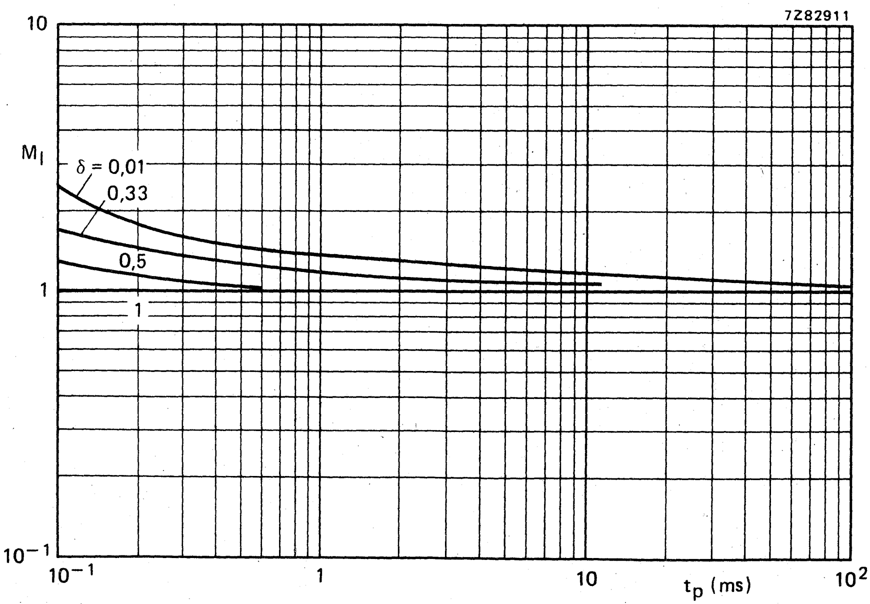


Fig. 8 S.B. current multiplying factor at the V_{CEOmax} level.

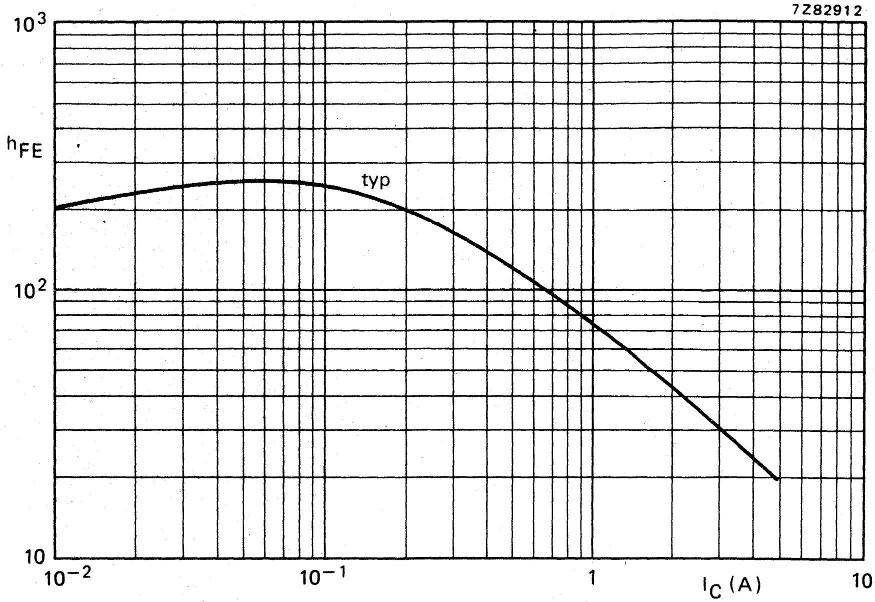


Fig. 9 Typical values d.c. current gain at V_{CE} = 4 V.

SILICON EPITAXIAL BASE POWER TRANSISTORS

P-N-P transistors in a plastic TO-220 envelope. They are intended for use in a wide range of power amplifiers and for switching applications.

QUICK REFERENCE DATA

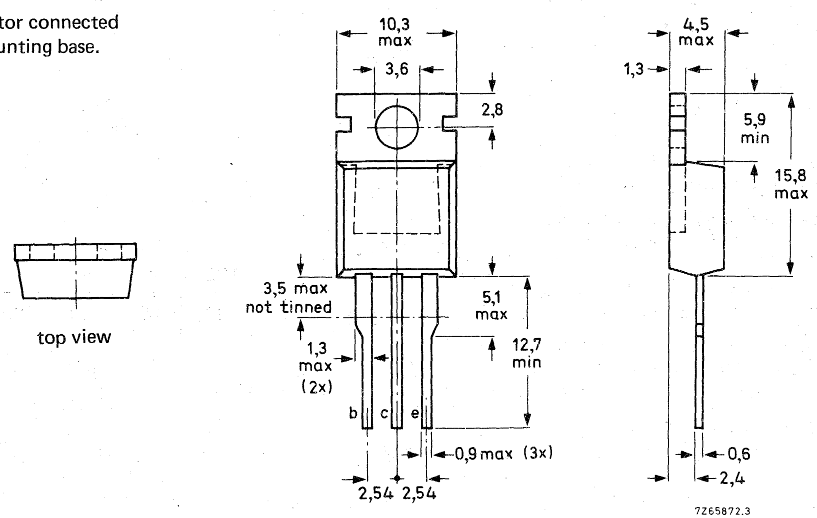
			BDT32	A	B	C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	40	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	80	100	V
Collector current (d.c.)	$-I_C$	max.		3			A
Collector current (peak value)	$-I_{CM}$	max.		5			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		40			W
Junction temperature	T_j	max.		150			°C
D.C. current gain							
$-I_C$ = 1 A; $-V_{CE}$ = 4 V	h_{FE}	>		25			
$-I_C$ = 3 A; $-V_{CE}$ = 4 V	h_{FE}			10 to 50			

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base.



See also chapters Mounting Instructions and Accessories.

RATINGS

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

			BDT32	A	B	C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	40	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	80	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5				V
Collector current (d.c.)	$-I_C$	max.	3				A
Collector current (peak value)	$-I_{CM}$	max.	5				A
Base current	$-I_B$	max.	1				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	40				W
Storage temperature	T_{stg}		−65 to 150				°C
Junction temperature	T_j	max.	150				°C

THERMAL RESISTANCE

from junction to mounting base	$R_{th\ j\text{-}mb}$	=	3,12	K/W
from junction to ambient (in free air)	$R_{th\ j\text{-}a}$	=	70	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			BDT32; A	B; C	
Collector cut-off current					
$I_B = 0$; $-V_{CE} = 30$ V	$-I_{CEO}$	<	0,3		mA
$I_B = 0$; $-V_{CE} = 60$ V	$-I_{CEO}$	<		0,3	mA
$V_{EB} = 0$; $-V_{CE} = -V_{CEO}$	$-I_{CES}$	<	0,2		mA
Emitter cut-off current					
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	1		mA
D.C. current gain *					
$-I_C = 1$ A; $-V_{CE} = 4$ V	h_{FE}	>	25		
$-I_C = 3$ A; $-V_{CE} = 4$ V	h_{FE}		10 to 50		
Base-emitter voltage * **					
$-I_C = 3$ A; $-V_{CE} = 4$ V	$-V_{BE}$	<	1,8		V
Collector-emitter saturation voltage					
$-I_C = 3$ A; $-I_B = 0,375$ A	$-V_{CEsat}$	<	1,2		V

			BDT32	A	B	C	
Collector-emitter breakdown voltage *							
$I_B = 0$; $-I_C = 30$ mA	$-V_{(BR)CEO}$	>	40	60	80	100	V
Small signal current transfer ratio							
$-I_C = 0,5$ A; $-V_{CE} = 10$ V; f = 1 kHz	$\|h_{fe}\|$	>	20				
$-I_C = 0,5$ A; $-V_{CE} = 10$ V; f = 1 MHz	$\|h_{fe}\|$	>	3				
Turn-off breakdown energy							
L = 20 mH; $I_{CC} = 1,22$ A	$E_{(BR)}$	>	15				mJ

* Measured under pulse conditions: $t_p \leqslant 300\ \mu s$, $\delta < 2\%$.
** V_{EB} decreases by about 2,3 mV/°C with increasing temperature.

Switching times
(between 10% and 90% levels)
$-I_{Con} = 1$ A; $-I_{Bon} = I_{Boff} = 0,1$ A

Turn-on time	t_{on}	typ.	0,3 μs
Turn-off time	t_{off}	typ.	1 μs

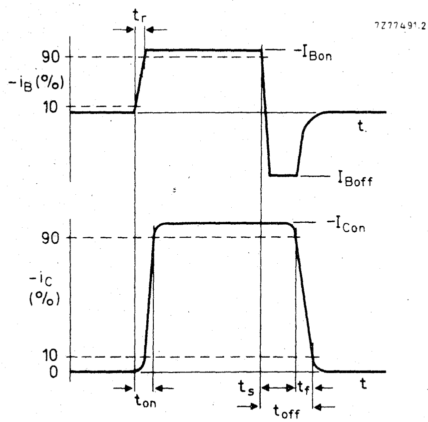
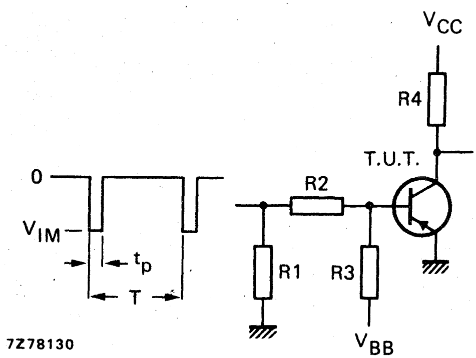


Fig. 2 Switching times waveforms.



$-V_{IM}$	=	30 V
$-V_{CC}$	=	20 V
V_{BB}	=	3 V
R_1	=	56 Ω
R2	=	150 Ω
R3	=	33 Ω
R4	=	20 Ω
$t_r = t_f$	⩽	15 ns
t_p	=	20 μs
T	=	500 μs

Fig. 3 Switching times test circuit.

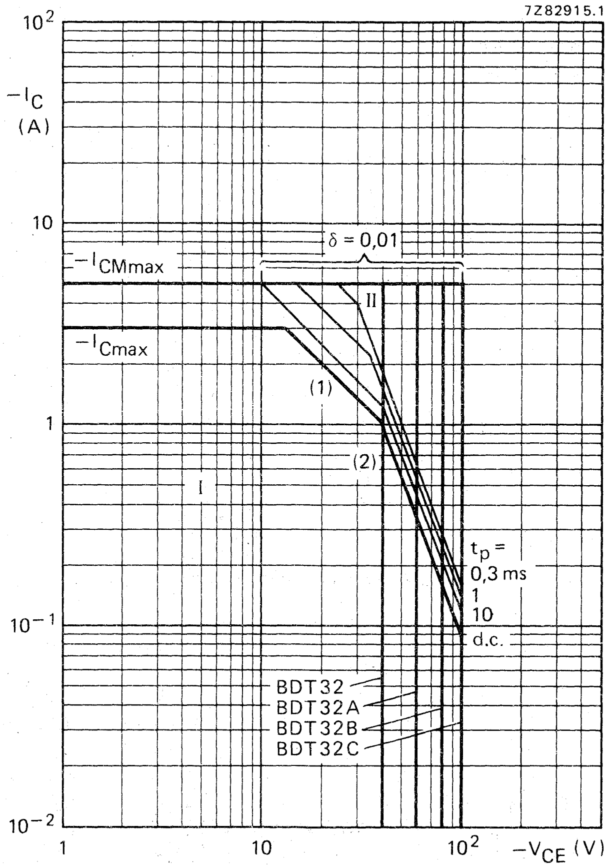


Fig. 4 Safe Operating ARea; $T_{mb} \leqslant 25\ ^oC$.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second-breakdown limit (independent of temperature).

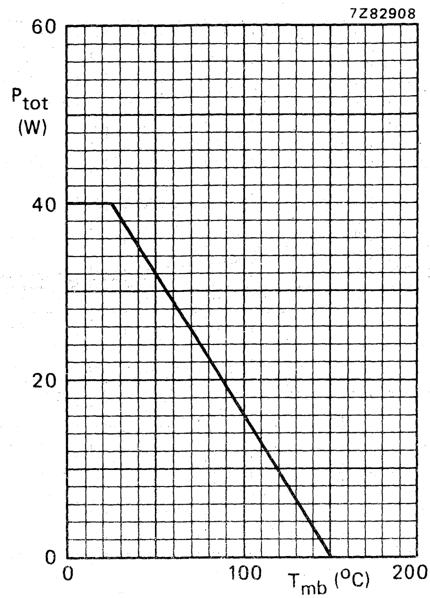


Fig. 5 Power derating curve.

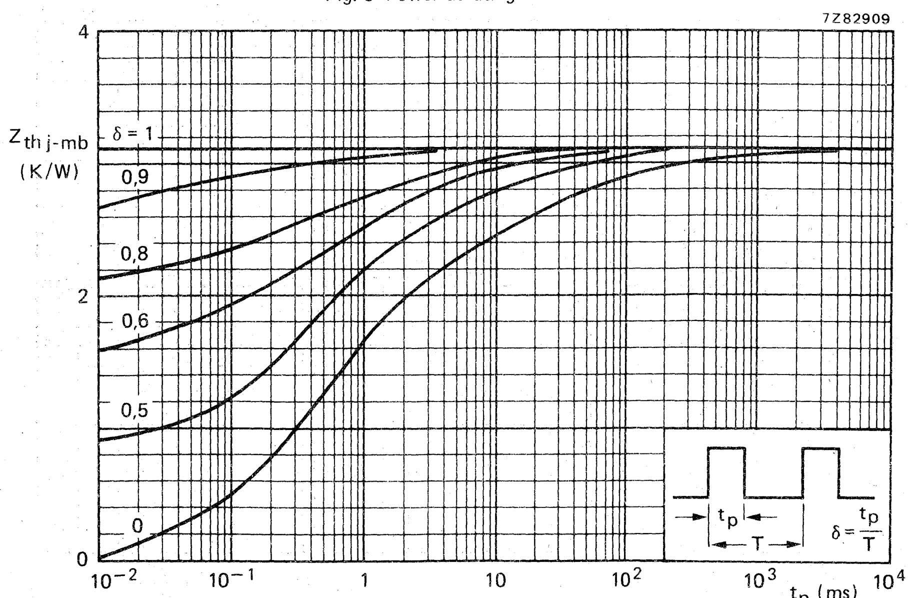


Fig. 6 Pulse power rating chart.

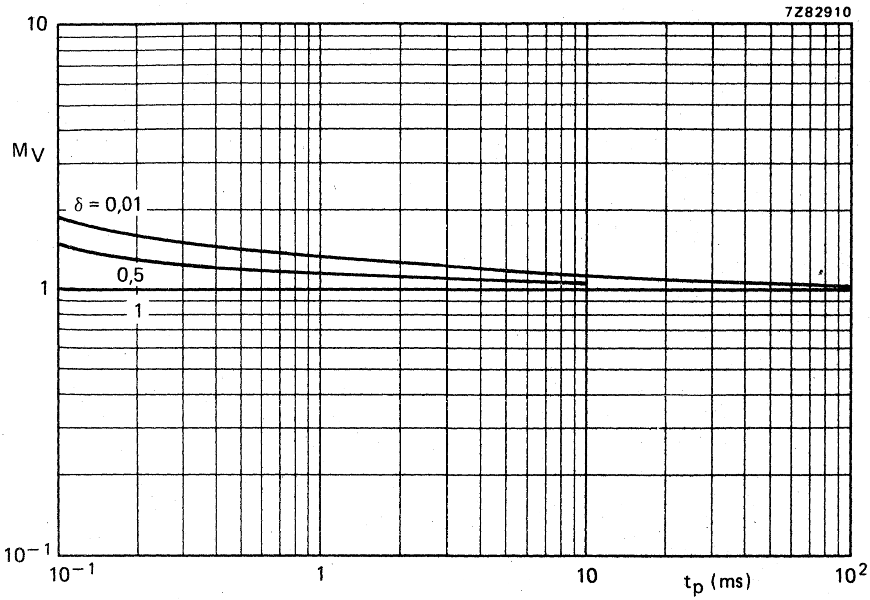


Fig. 7 S.B. voltage multiplying factor at the $-I_{Cmax}$ level.

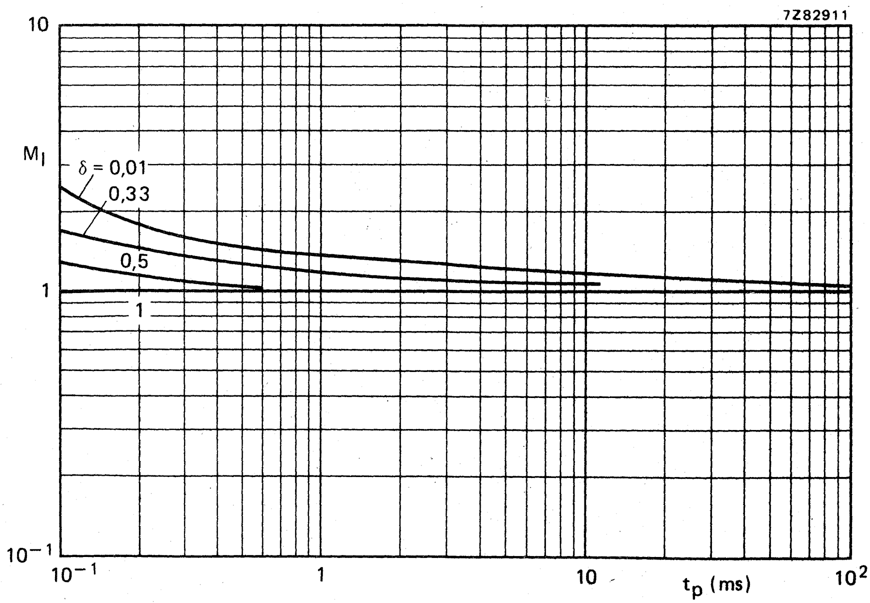


Fig. 8 S.B. current multiplying factor at the $-V_{CEOmax}$ level.

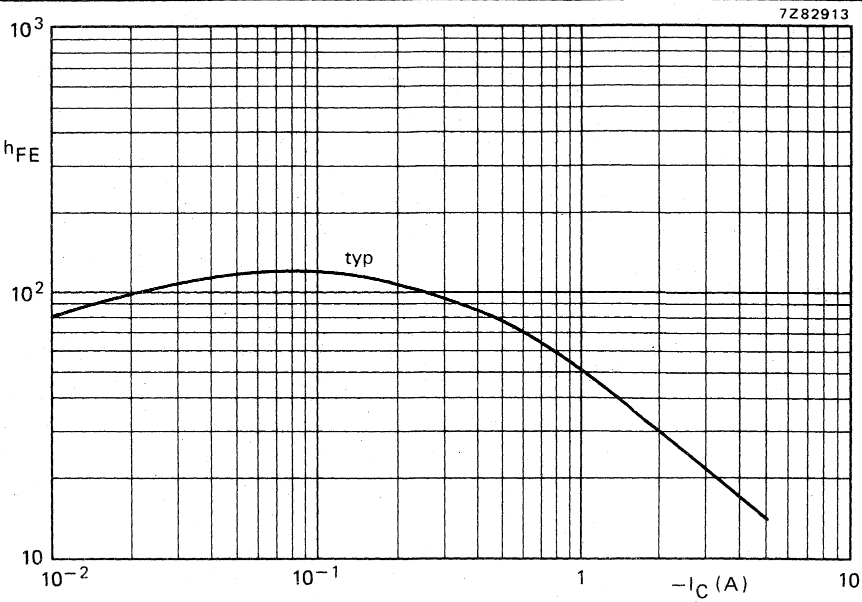


Fig. 9 Typical d.c. current gain at $-V_{CE} = 4$ V; $T_j = 25$ °C.

SILICON EPITAXIAL BASE POWER TRANSISTORS

N-P-N silicon transistors in a plastic envelope intended for use in general purpose amplifier and switching applications.

QUICK REFERENCE DATA

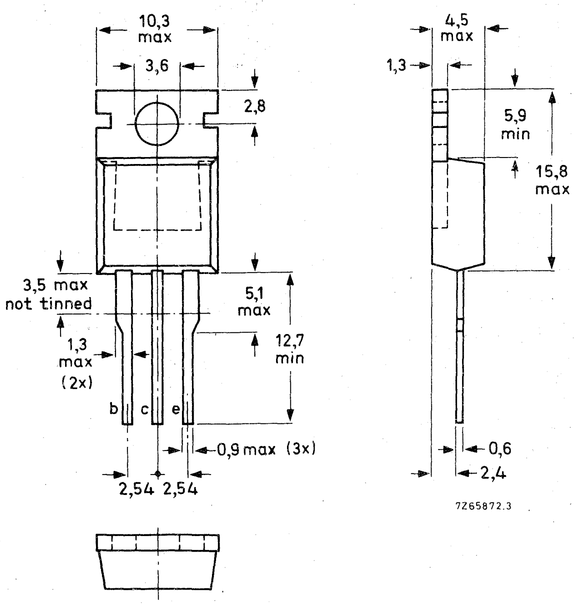
			BDT41	A	B	C	
Collector-base voltage (open emitter)	V_{CBO}	max.	40	60	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	60	80	100	V
Collector current (d.c.)	I_C	max.		6			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		65			W
Junction temperature	T_j	max.		150			°C
D.C. current gain I_C = 3 A; V_{CE} = 4 V	h_{FE}			15 to 75			

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base.



See also chapters Mounting Instructions and Accessories.

RATINGS

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

			BDT41	A	B	C	
Collector-base voltage (open emitter)	V_{CBO}	max.	40	60	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	60	80	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5				V
Collector current (d.c.)	I_C	max.	6				A
Collector current (peak value)	I_{CM}	max.	10				A
Base current (d.c.)	I_B	max.	3				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	65				W
Storage temperature	T_{stg}		−65 to + 150				°C
Junction temperature	T_j	max.	150				°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,92	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	70	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			BDT41;A	B;C	
Collector cut-off current					
$I_B = 0$; $V_{CE} = 30$ V	I_{CEO}	<	0,7	—	mA
$I_B = 0$; $V_{CE} = 60$ V	I_{CEO}	<	—	0,7	mA
$V_{BE} = 0$; $V_{CE} = V_{CEOmax}$	I_{CES}	<	0,4		mA
Emitter cut-off current					
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	1		mA
D.C. current gain*					
$I_C = 0,3$ A; $V_{CE} = 4$ V	h_{FE}	>	30		
$I_C = 3$ A; $V_{CE} = 4$ V	h_{FE}		15 to 75		
Base-emitter voltage**					
$I_C = 6$ A; $V_{CE} = 4$ V	V_{BE}	<	2		V
Collector-emitter saturation voltage*					
$I_C = 6$ A; $I_B = 0,6$ A	V_{CEsat}	<	1,5		V

			BDT41	A	B	C	
Collector-emitter breakdown voltage*							
$I_B = 0$; $I_C = 30$ mA	$V_{(BR)CEO}$	>	40	60	80	100	V
Small-signal current transfer ratio							
$I_C = 0,5$ A; $V_{CE} = 10$ V; f = 1 kHz	$\|h_{fe}\|$	>	20				
Transition frequency at f = 1 MHz							
$I_C = 0,5$ A; $V_{CE} = 10$ V	f_T	>	3				MHz

* Measured under pulse conditions: $t_p \leqslant 300\ \mu s$, $\delta < 2\%$.
** V_{EB} decreases by about 2,3 mV/°C with increasing temperature.

Turn-off breakdown energy with inductive load (Fig. 4) $-I_{Boff} = 0$; $I_{CC} = 2,5$ A	$E_{(BR)}$	>	62,5 mJ
Switching times (between 10% and 90% levels) $I_{Con} = 6$ A; $I_{Bon} = -I_{Boff} = 0,6$ A			
Turn-on time	t_{on}	typ.	0,6 μs
Turn-off time	t_{off}	typ.	1 μs

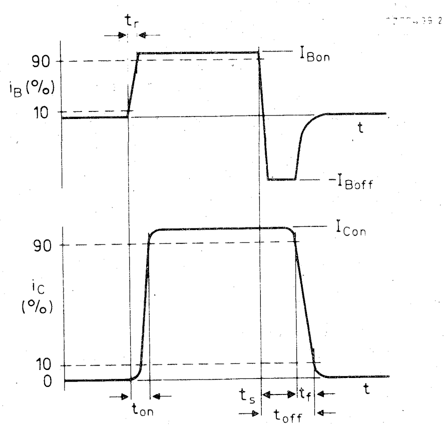
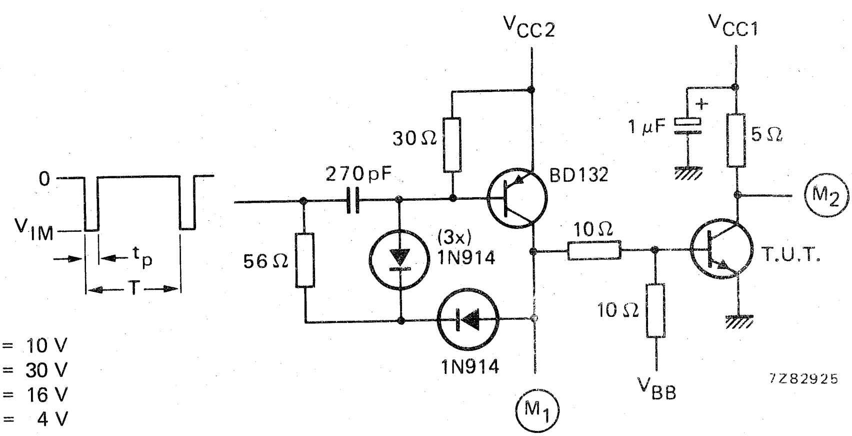


Fig. 2 Switching times waveforms.



$-V_{IM}$ = 10 V
V_{CC1} = 30 V
V_{CC2} = 16 V
$-V_{BB}$ = 4 V
$t_r = t_f$ = 15 ns
t_p = 20 μs
δ ⩽ 2 %

Fig. 3 Switching times test circuit.
Adjust V_{CC2} so that the input to M_1 = 14 V.

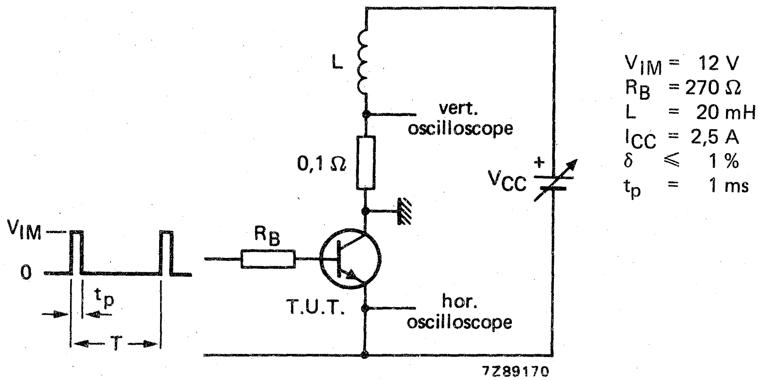


Fig. 4 Test circuit for turn-off breakdown energy.

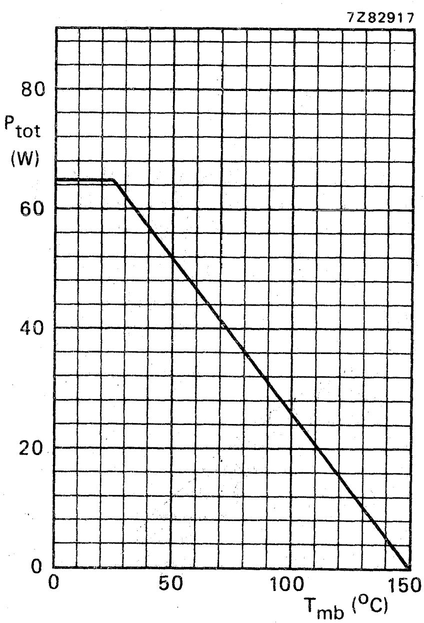


Fig. 5 Power derating curve.

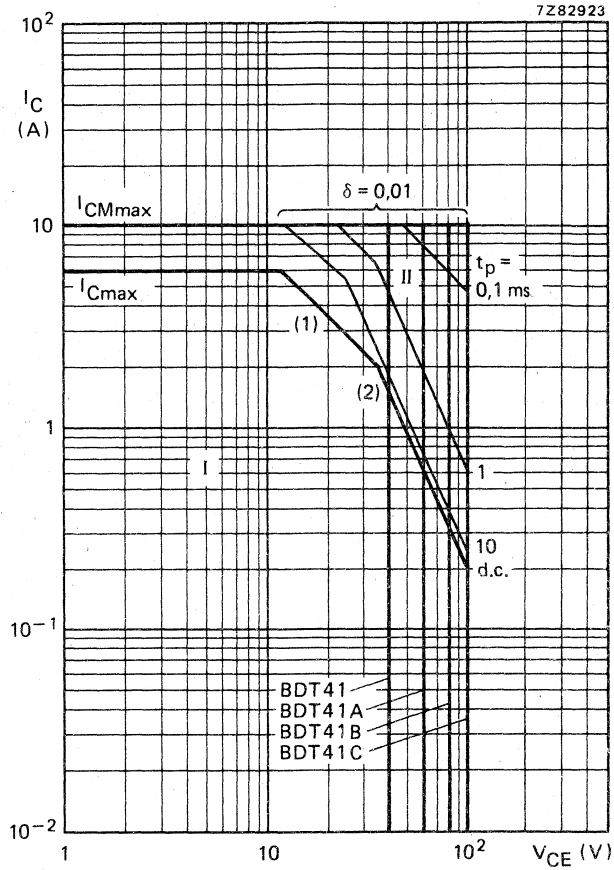


Fig. 6 Safe Operating ARea, T_{mb} = 25 °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.

(2) Second-breakdown limits (independent of temperature).

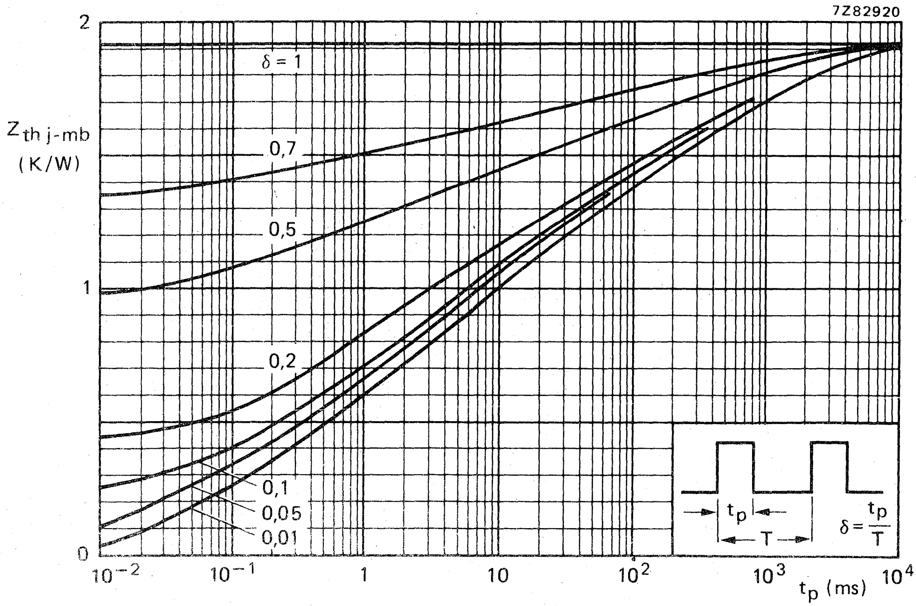


Fig. 7 Pulse power rating chart.

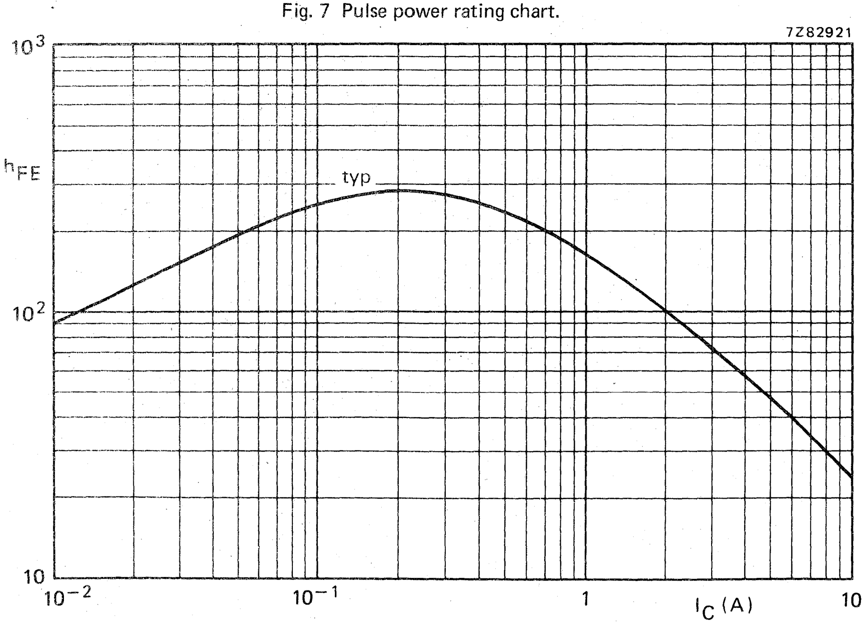


Fig. 8 D.C. current gain at V_{CE} = 4 V; T_j = 25 °C.

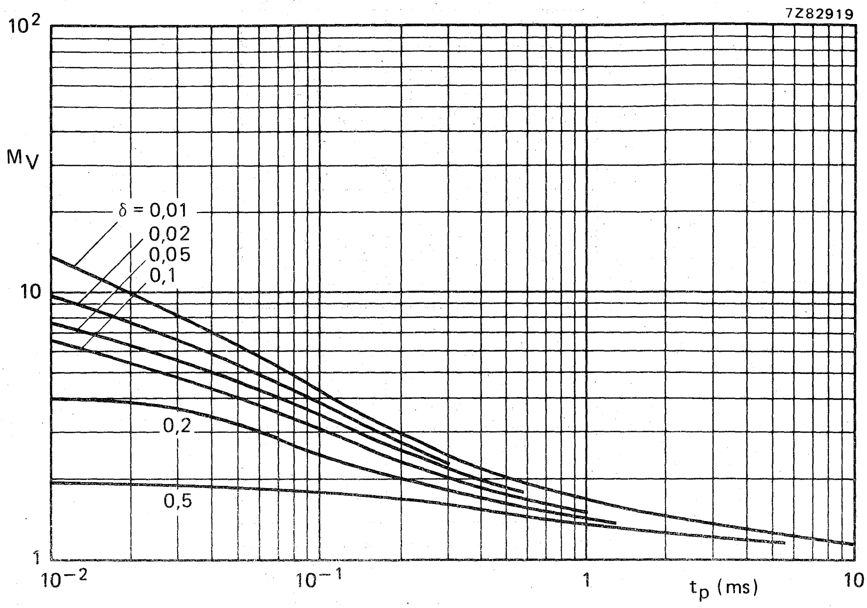


Fig. 9 S.B. voltage multiplying factor at the I_{Cmax} level.

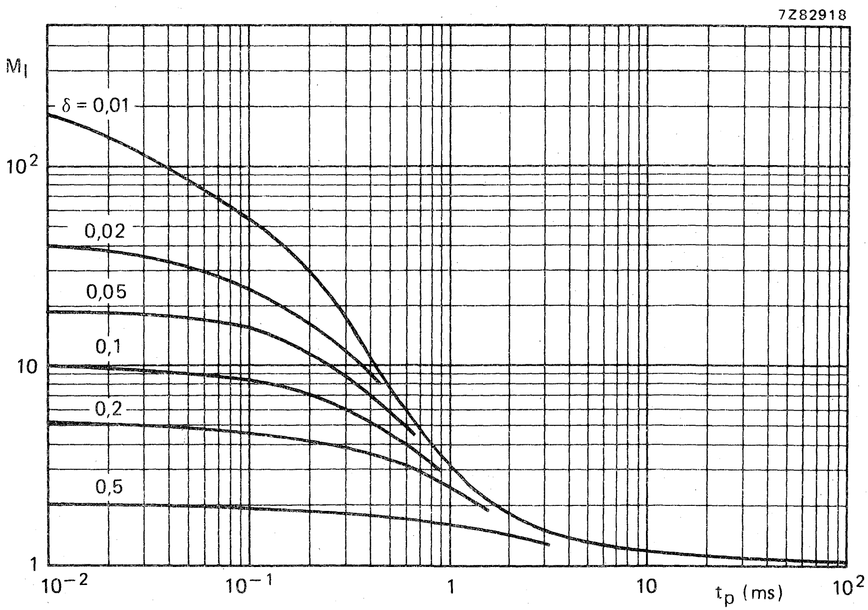


Fig. 10 S.B. current multiplying factor at the V_{CEOmax} level.

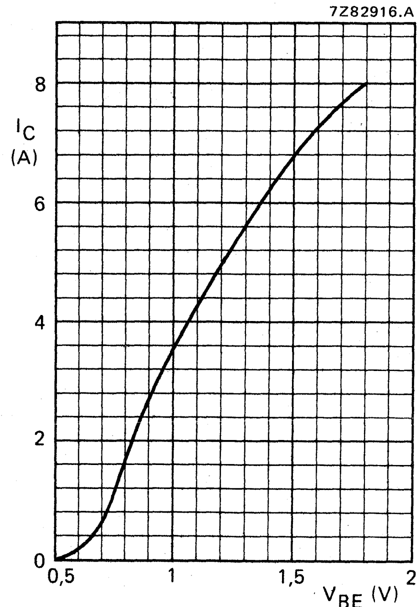


Fig. 11 Typical collector current.
$V_{CE} = 4$ V; $T_j = 25$ °C.

SILICON EPITAXIAL BASE POWER TRANSISTORS

P-N-P silicon transistors in a plastic envelope intended for use in general output stages of amplifier circuits and switching applications.

QUICK REFERENCE DATA

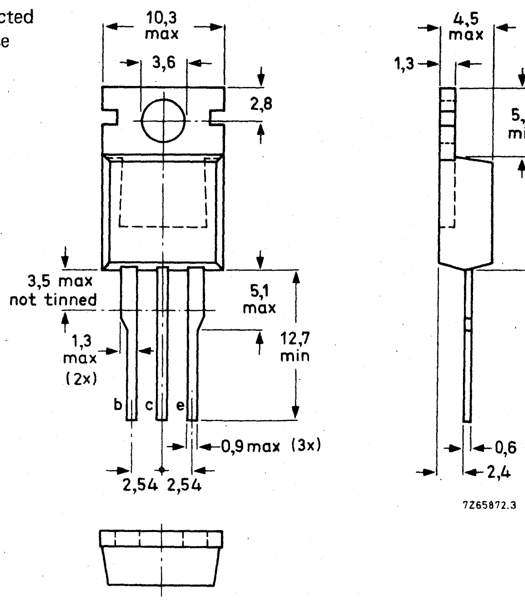
			BDT42	A	B	C	
Collector-base voltage	$-V_{CBO}$	max.	40	60	80	100	V
Collector-emitter voltage	$-V_{CEO}$	max.	40	60	80	100	V
Collector current (d.c.)	$-I_C$	max.	6				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	65				W
Junction temperature	T_j	max.	150				°C
D.C. current gain $-I_C$ = 3 A; $-V_{CE}$ = 4 V	h_{FE}		15 to 75				

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base



See also chapters Mounting Instructions and Accessories.

RATINGS

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

			BDT42	A	B	C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	40	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	80	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5				V
Collector current (d.c.)	$-I_C$	max.	6				A
Collector current (peak value)	$-I_{CM}$	max.	10				A
Base current (d.c.)	$-I_B$	max.	3				A
Total power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.	65				W
Storage temperature	T_{stg}		−65 to + 150				^oC
Junction temperature	T_j	max.	150				^oC

THERMAL RESISTANCE

From junction to mouting base	$R_{th\ j\text{-}mb}$	=	1,92	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	70	K/W

CHARACTERISTICS

$T_j = 25\ ^oC$ unless otherwise specified

			BDT42;A	B;C	
Collector cut-off current					
$I_B = 0$; $-V_{CE} = 30$ V	$-I_{CEO}$	<	0,7	–	mA
$I_B = 0$; $-V_{CE} = 60$ V	$-I_{CEO}$	<	–	0,7	mA
$V_{BE} = 0$; $-V_{CE} = -V_{CEOmax}$	$-I_{CES}$	<	0,4		mA
Emitter cut-off current					
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	1		mA
D.C. current gain*					
$-I_C = 300$ mA; $-V_{CE} = 4$ V	h_{FE}	>	30		
$-I_C = 3$ A; $-V_{CE} = 4$ V	h_{FE}		15 to 75		
Base-emitter voltage**					
$-I_C = 6$ A; $-V_{CE} = 4$ V	$-V_{BE}$	<	2		V
Collector-emitter saturation voltage*					
$-I_C = 6$ A; $-I_B = 0,6$ A	$-V_{CEsat}$	<	1,5		V

			BDT42	A	B	C	
Collector-emitter breakdown voltage* $I_B = 0$; $-I_C = 30$ mA	$-V_{(BR)CEO}$	>	40	60	80	100	V
Transition frequency at f = 1 MHz $-I_C = 500$ mA; $-V_{CE} = 10$ V	f_T	>	3				MHz
Small signal current transfer ratio $-I_C = 0,5$ A; $-V_{CE} = 10$ V; f = 1 kHz	$\|h_{fe}\|$	>	20				

* Measured under pulse conditions: $t_p \leq 300\ \mu s$; $\delta < 2\%$.
** V_{EB} decreases by about 2,3 mV/^oC with increasing temperature.

Turn-off breakdown energy with inductive load (Fig. 5) $I_{Boff} = 0; -I_{CC} = 2,5$ A	$E_{(BR)}$	>	62,5 mJ
Switching times $-I_{Con} = 6$ A; $-I_{Bon} = I_{Boff} = 0,6$ A			
turn-on time	t_{on}	typ.	0,4 μs
turn-off time	t_{off}	typ.	0,7 μs

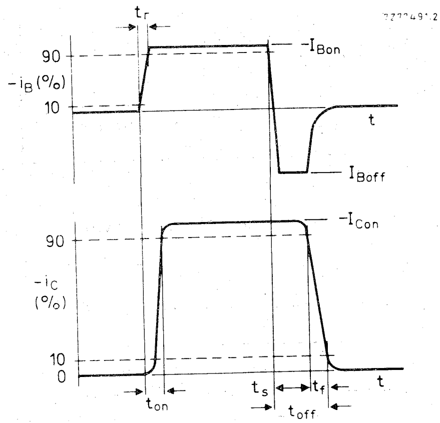
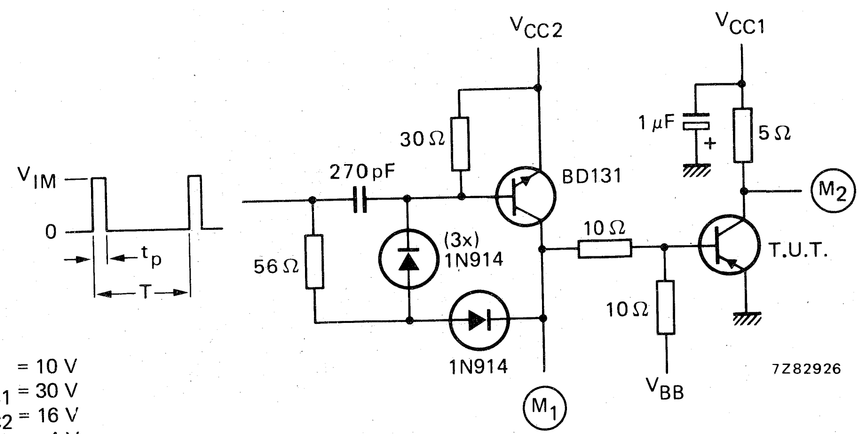


Fig. 2 Switching times waveforms.



V_{IM} = 10 V
$-V_{CC1}$ = 30 V
$-V_{CC2}$ = 16 V
V_{BB} = 4 V
$t_r = t_f$ = 15 ns
t_p = 20 μs
δ ⩽ 2 %

Fig. 3 Switching times test circuit.
Adjust V_{CC2} so that the input to M1 = 14 V.

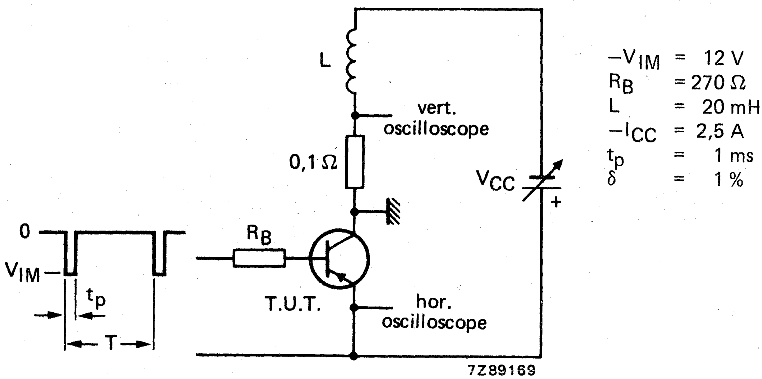


Fig. 4 Test circuit for turn-off breakdown energy.

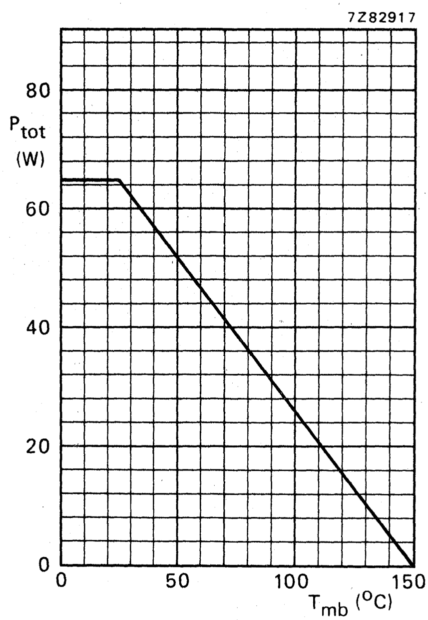


Fig. 5 Power derating curve.

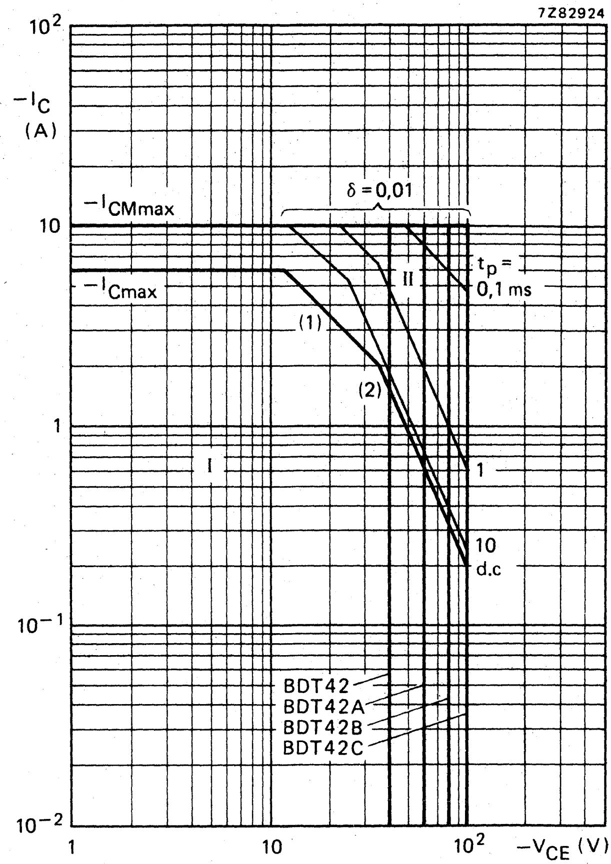


Fig. 6 Safe Operating ARea; $T_{mb} = 25\ ^oC$.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(2) $P_{tot\,max}$ and $P_{peak\,max}$ lines.

(3) Second breakdown limits independent of temperature.

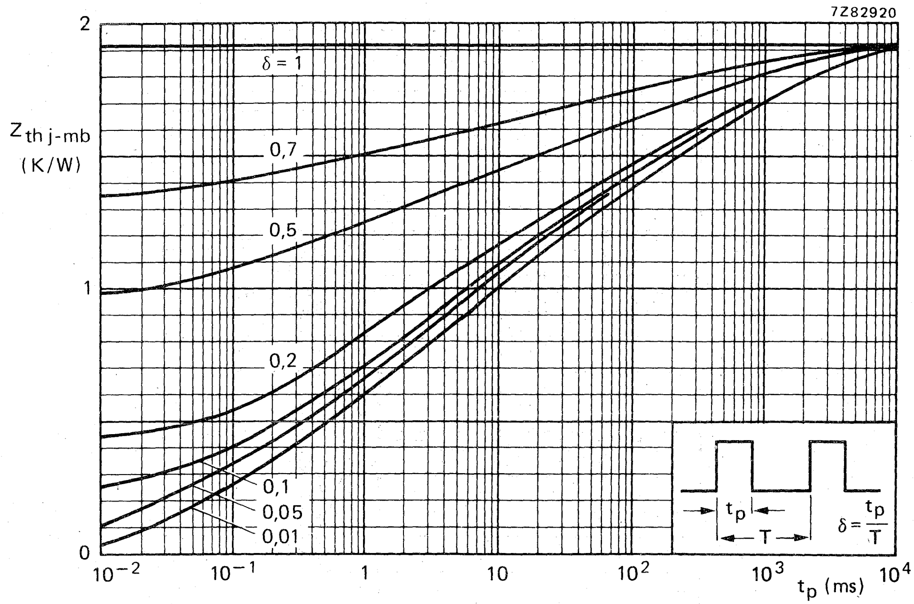


Fig. 7 Pulse power rating chart.

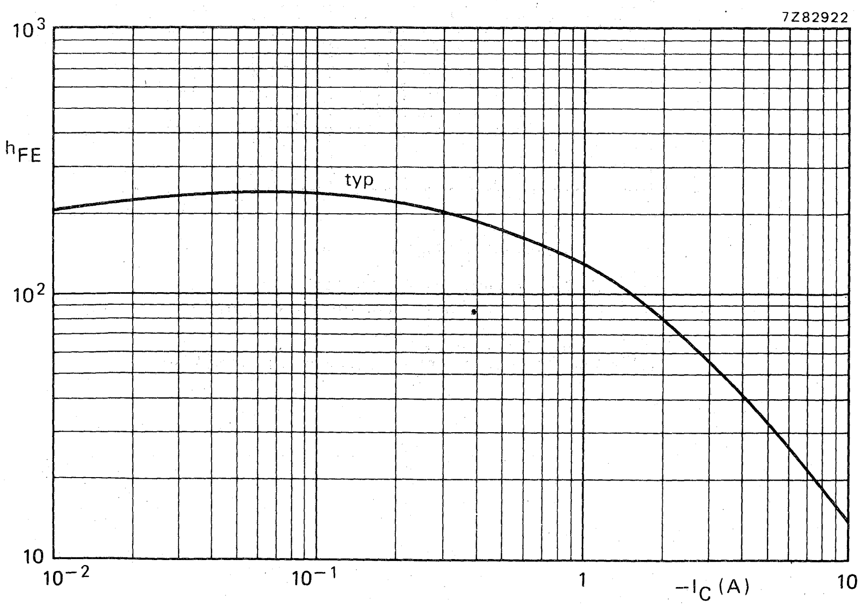


Fig. 8 Typical values d.c. current gain. $-V_{CE}$ = 4 V; T_j = 25 °C.

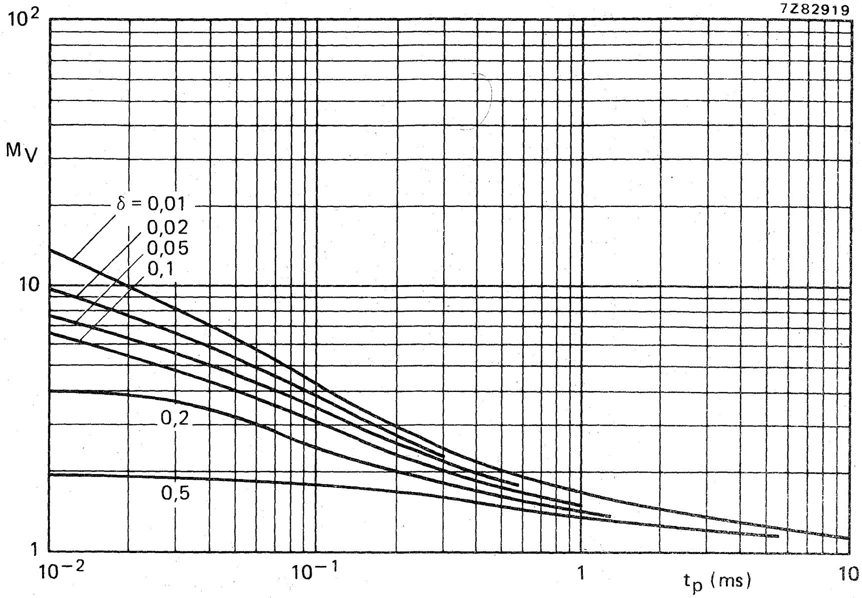


Fig. 9 Second breakdown voltage multiplying factor at the I_{Cmax} level.

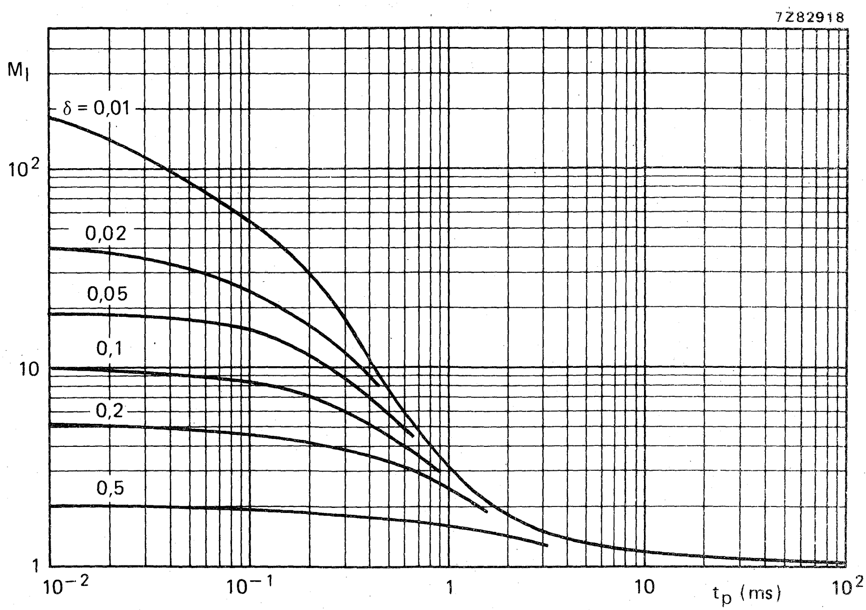


Fig. 10 Second breakdown current multiplying factor at the V_{CEOmax} level.

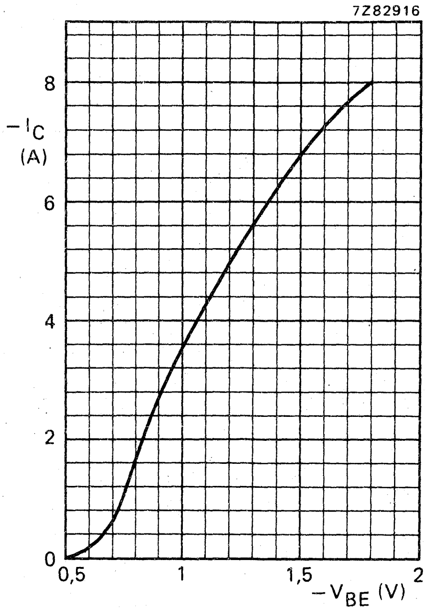


Fig. 11 Typical collector current.
$-V_{CE}$ = 4 V; T_j = 25 °C.

SILICON DARLINGTON POWER TRANSISTORS

P-N-P silicon power transistors in monolithic Darlington circuit for audio output stages and general purpose amplifier applications.
N-P-N complements are BDT61, BDT61A, BDT61B and BDT61C.

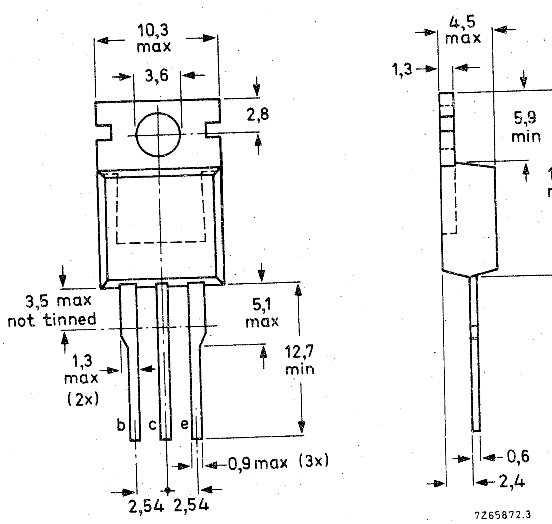
QUICK REFERENCE DATA

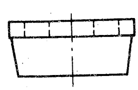
			BDT60	A	B	C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Collector current (d.c.)	$-I_C$	max.		4			A
Collector current (peak value)	$-I_{CM}$	max.		6			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		50			W
Junction temperature	T_j	max.		150			°C
D.C. current gain $-I_C$ = 0,5 A; $-V_{CE}$ = 3 V	h_{FE}	typ.		1000			

MECHANICAL DATA

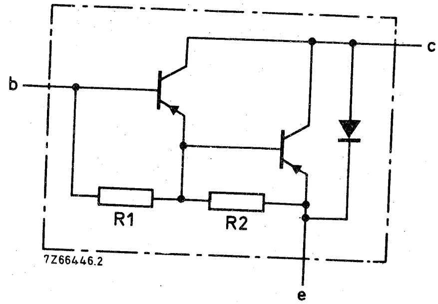
Fig. 1 TO-220AB.

Collector connected to mounting base.





See also chapters Mounting instructions and Accessories



R1 typ. 6 kΩ
R2 typ. 100 Ω

Fig. 2 Circuit diagram.

RATINGS

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

			BDT60	A	B	C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.		5			V
Collector current (d.c.)	$-I_C$	max.		4			A
Collector current (peak value)	$-I_{CM}$	max.		6			A
Reverse diode current	$I_R = I_C$	max.		4			A
Base current (d.c.)	$-I_B$	max.		100			mA
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		50			W
Storage temperature	T_{stg}			−65 to + 150			°C
Junction temperature*	T_j	max.		150			°C

THERMAL RESISTANCE*

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2,5	K/W
From junction to ambient (in free air)	$R_{th\ j\text{-}a}$	=	70	K/W

* Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

Collector cut-off current			
$I_E = 0$; $-V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	0,2 mA
$I_E = 0$; $-V_{CB} = -\frac{1}{2}V_{CBOmax}$; T_j = 150 °C	$-I_{CBO}$	<	2 mA
$I_B = 0$; $-V_{CE} = -\frac{1}{2}V_{CEOmax}$	$-I_{CEO}$	<	1 mA
Emitter cut-off current			
$I_C = 0$; $-V_{EB}$ = 5 V	$-I_{EBO}$	<	5 mA
Forward bias second-breakdown collector current			
$-V_{CE}$ = 20 V; t = 0,1 s; non-repetitive (without heatsink); T_{amb} = 25 °C	$-I_{(SB)}$	<	2,5 A
D.C. current gain*			
$-I_C$ = 0,5 A; $-V_{CE}$ = 3 V	h_{FE}	typ.	1000
$-I_C$ = 1,5 A; $-V_{CE}$ = 3 V	h_{FE}	>	750
$-I_C$ = 4 A; $-V_{CE}$ = 3 V	h_{FE}	typ.	500
Base-emitter voltage			
$-I_C$ = 1,5 A; $-V_{CE}$ = 3 V	$-V_{BE}$	<	2,5 V
Collector-emitter saturation voltage*			
$-I_C$ = 1,5 A; $-I_B$ = 6 mA	$-V_{CEsat}$	<	2,5 V
Cut-off frequency			
$-I_C$ = 1,5 A; $-V_{CE}$ = 3 V	f_{hfe}	>	25 kHz
Small-signal current gain at f = 1 MHz			
$-I_C$ = 1,5 A; $-V_{CE}$ = 3 V	h_{fe}	>	10

* Measured under pulse conditions; $t_p < 300\ \mu s$; $\delta < 2\%$.

CHARACTERISTICS (continued)

Diode, forward voltage			
I_F = 1,5 A	V_F	<	2 V
I_F = 4 A	V_F	typ.	2,1 V
Switching times (between 10% and 90% levels)			
$-I_{Con}$ = 1,5 A; $-I_{Bon}$ = I_{Boff} = 6 mA; $-V_{CC}$ = 30 V			
turn-on time	t_{on}	typ.	0,3 μs
turn-off time	t_{off}	typ.	1,5 μs

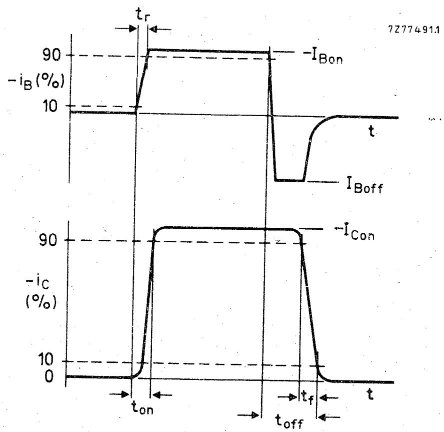
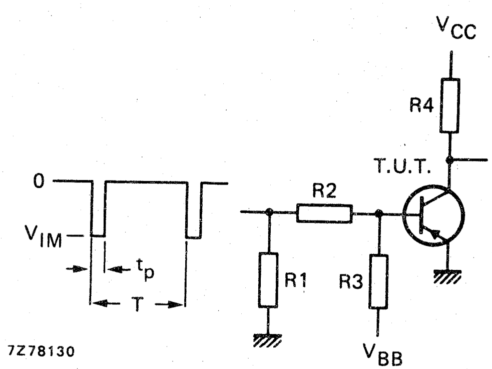


Fig. 3 Switching times waveforms.



$-V_{IM}$	=	12 V
$-V_{CC}$	=	30 V
$+V_{BB}$	=	3 V
R1	=	56 Ω
R2	=	1 kΩ
R3	=	680 Ω
R4	=	22 Ω
$t_r = t_f$	=	15 ns
t_p	=	10 μs
T	=	500 μs

Fig. 4 Switching times test circuit.

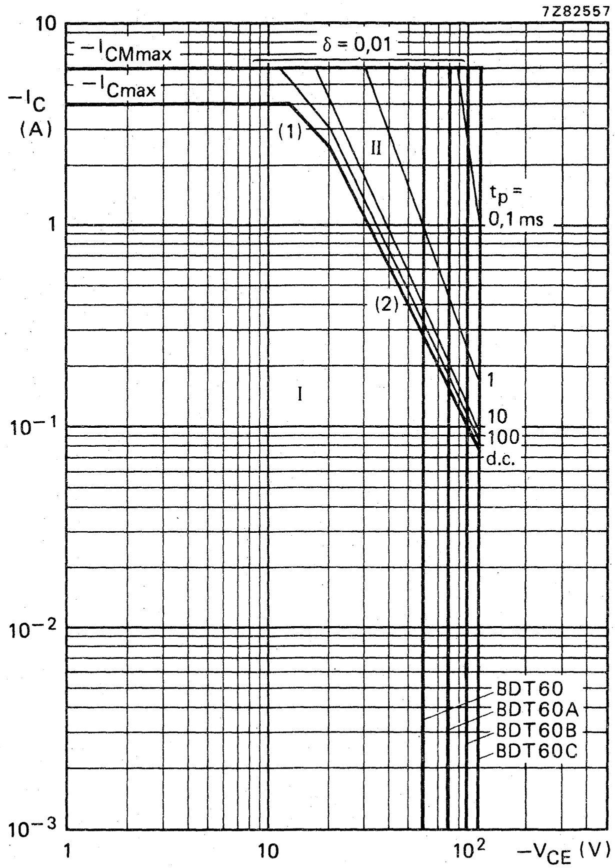


Fig. 5 Safe Operating ARea; T_{mb} = 25 °C.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.
(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second-breakdown limits (independent of temperature).

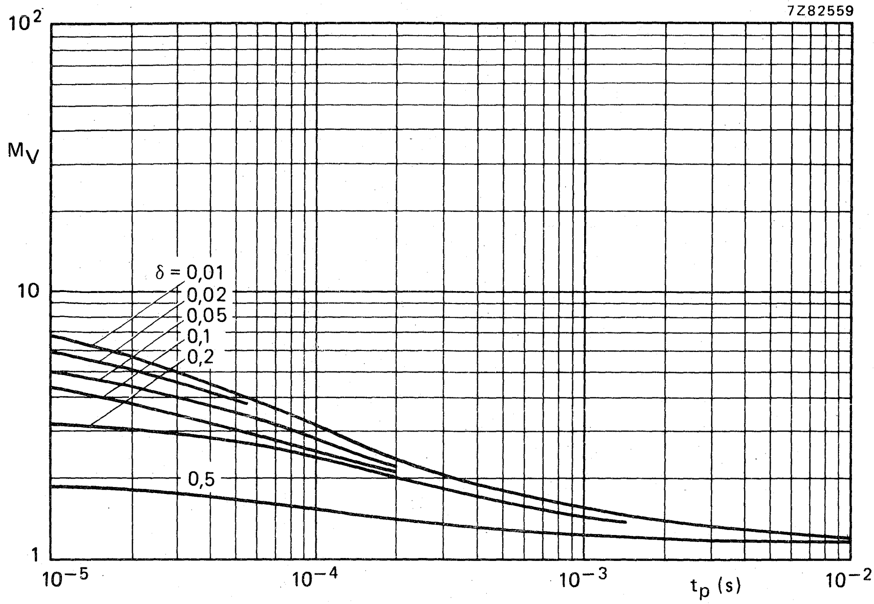


Fig. 6 Second-breakdown voltage multiplying factor at the $I_{C\,max}$ level.

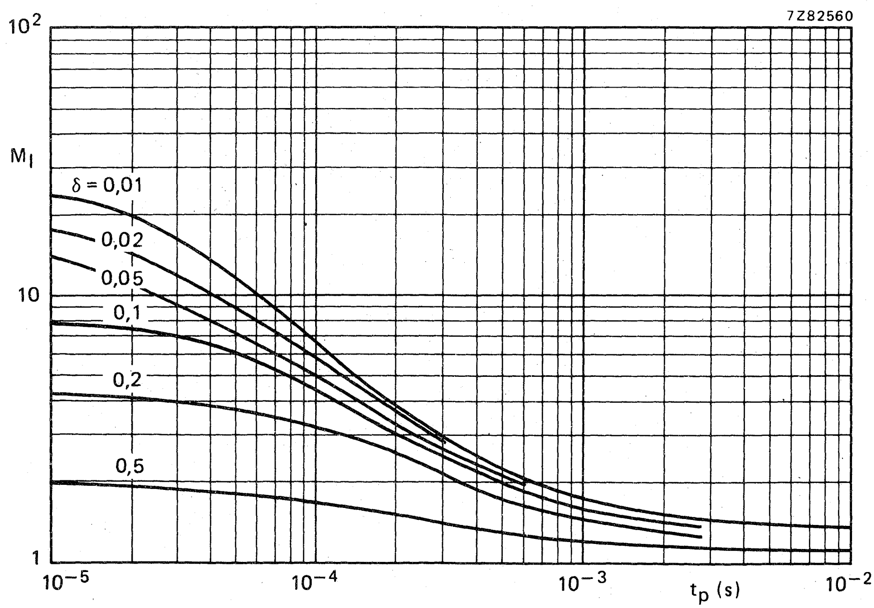


Fig. 7 Second-breakdown current multiplying factor at the $V_{CEO\,max}$ level.

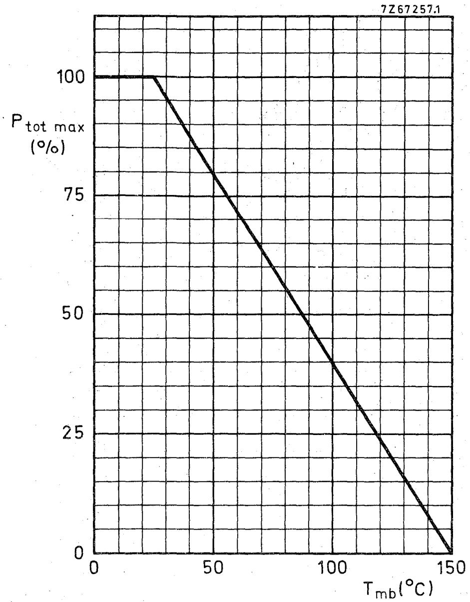


Fig. 8 Power derating curve.

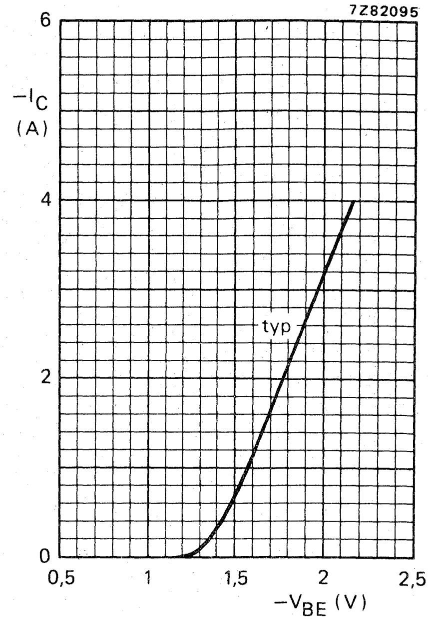


Fig. 9 $-V_{CE} = 3$ V; $T_j = 25$ °C.

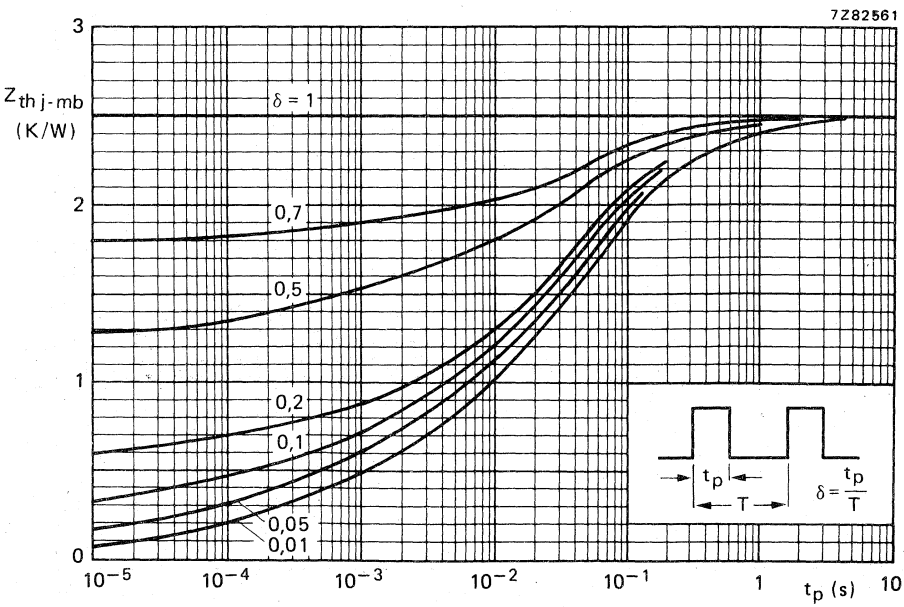


Fig. 10 Pulse power rating chart.

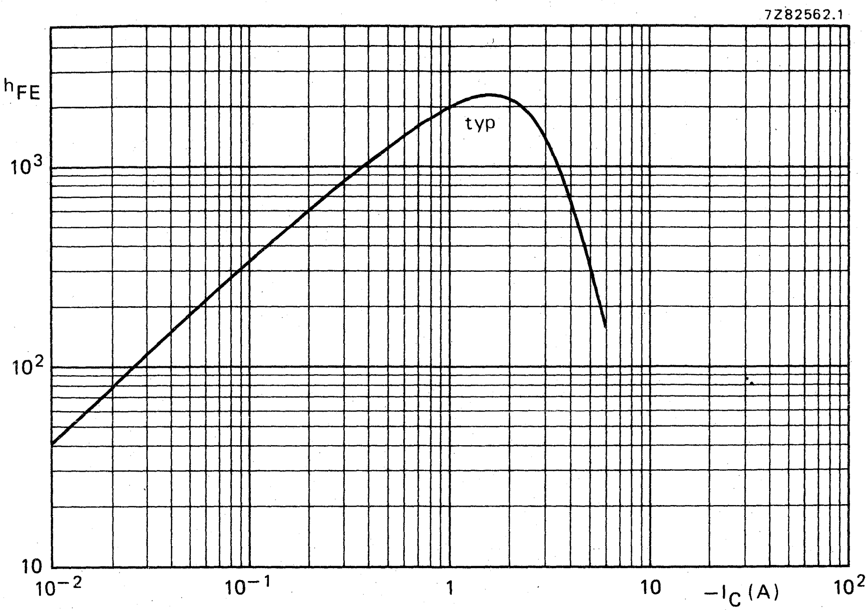


Fig. 11 Typical d.c. current gain. $-V_{CE}$ = 3 V; T_{mb} = 25 °C.

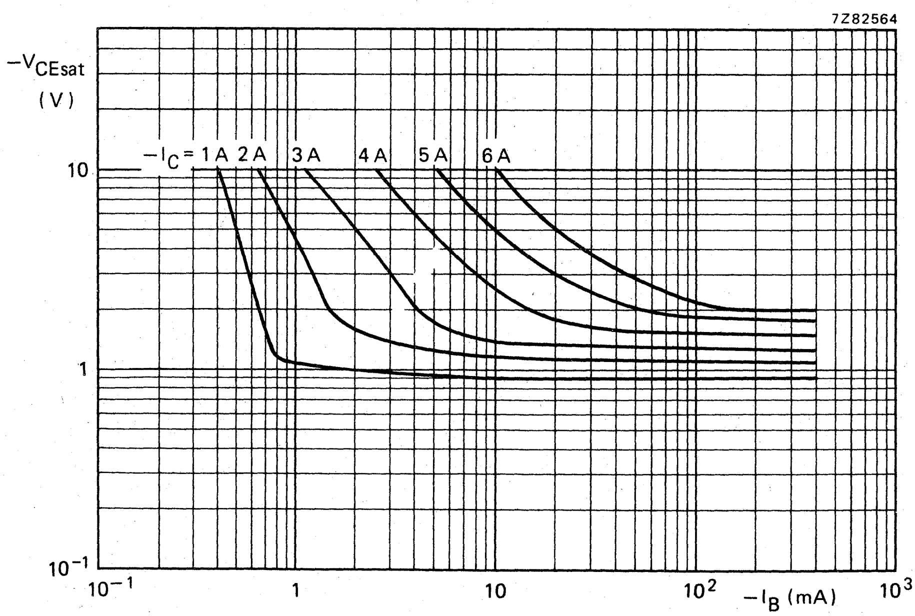


Fig. 12 Typical values collector-emitter saturation voltage at T_{mb} = 25 °C.

SILICON DARLINGTON POWER TRANSISTORS

N-P-N silicon power transistors in monolithic Darlington circuit for audio output stages and general purpose amplifier applications.

P-N-P complements are BDT60, 60A, 60B and 60C.

QUICK REFERENCE DATA

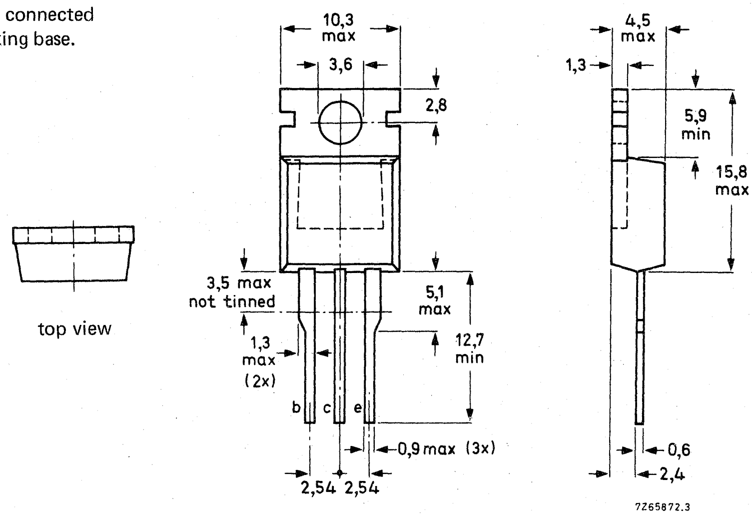
			BDT61	A	B	C	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Collector current (d.c.)	I_C	max.		4			A
Collector current (peak value)	I_{CM}	max.		6			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		50			W
Junction temperature	T_j	max.		150			°C
D.C. current gain I_C = 0,5 A; V_{CE} = 3 V	h_{FE}	typ.		2200			

MECHANICAL DATA

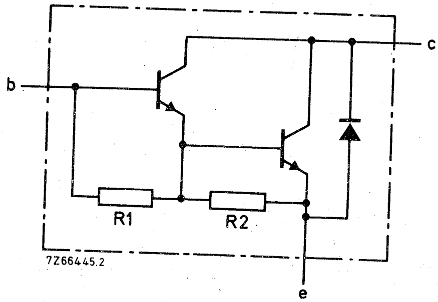
Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base.



See also chapters Mounting Instructions and Accessories.



R1 typ. 6 kΩ
R2 typ. 100 Ω

Fig. 2 Circuit diagram.

RATINGS

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

			BDT61	A	B	C	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.		5			V
Collector current (d.c.)	I_C	max.		4			A
Collector current (peak value)	I_{CM}	max.		6			A
Reverse diode current	$I_R = -I_C$	max.		4			A
Base current (d.c.)	I_B	max.		100			mA
Total power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.		50			W
Storage temperature	T_{stg}			−65 to + 150			^oC
Junction temperature *	T_j	max.		150			^oC

THERMAL RESISTANCE *

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2,5	K/W
From junction to ambient (in free air)	$R_{th\ j\text{-}a}$	=	70	K/W

* Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

CHARACTERISTICS

$T_j = 25\ ^oC$ unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	<	0,2	mA
$I_E = 0$; $V_{CB} = ½V_{CBOmax}$; $T_j = 150\ ^oC$	I_{CBO}	<	2	mA
$I_B = 0$; $V_{CE} = ½V_{CEOmax}$	I_{CEO}	<	1	mA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	5	mA
Forward-bias second-breakdown collector current				
$V_{CE} = 50$ V; t = 0,1 s; non-repetitive (without heatsink); $T_{amb} = 25\ ^oC$	$I_{(SB)}$	>	1	A
D.C. current gain *				
$I_C = 0,5$ A; $V_{CE} = 3$ V	h_{FE}	typ.	2200	←
$I_C = 1,5$ A; $V_{CE} = 3$ V	h_{FE}	>	750	
$I_C = 4$ A; $V_{CE} = 3$ V	h_{FE}	typ.	1500	←
Base-emitter voltage *				
$I_C = 1,5$ A; $V_{CE} = 3$ V	V_{BE}	<	2,5	V
Collector-emitter saturation voltage *				
$I_C = 1,5$ A; $I_B = 6$ mA	V_{CEsat}	<	2,5	V
Turn-off breakdown energy with inductive load (Fig. 3)				
$-I_{Boff} = 0$; L = 5 mH; $I_{CC} = 3,2$ A	$E_{(BR)}$	>	25	mJ ←
Small-signal current gain at f = 1 MHz				
$I_C = 1,5$ A; $V_{CE} = 3$ V	h_{fe}	>	10	
Cut-off frequency				
$I_C = 1,5$ A; $V_{CE} = 3$ V	f_{hfe}	typ.	25	kHz

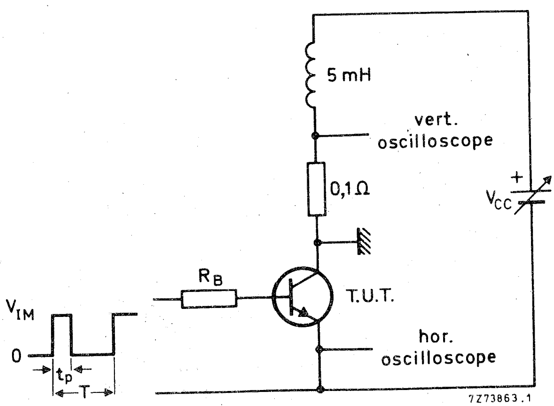


Fig. 3 Turn-off breakdown energy with inductive load.

$V_{IM} = 12$ V; $R_B = 270\ \Omega$; $\delta = \frac{t_p}{T} \times 100\% = 1\%$; $I_{CC} = 3,2$ A.

* Measured under pulse conditions; $t_p < 300\ \mu s$; $\delta < 2\%$.

CHARACTERISTICS (continued)

Diode, forward voltage			
I_F = 1,5 A	V_F	<	2 V
I_F = 4 A	V_F	typ.	2,1 V
Switching times (between 10% and 90% levels) I_{Con} = 1,5 A; $I_{Bon} = -I_{Boff}$ = 6 mA			
turn-on time	t_{on}	typ.	0,8 μs
		<	2 μs
→ turn-off time	t_{off}	typ.	4,5 μs
		<	8 μs

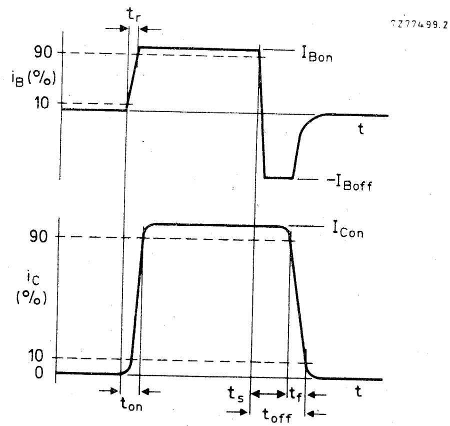


Fig. 4 Switching times waveforms.

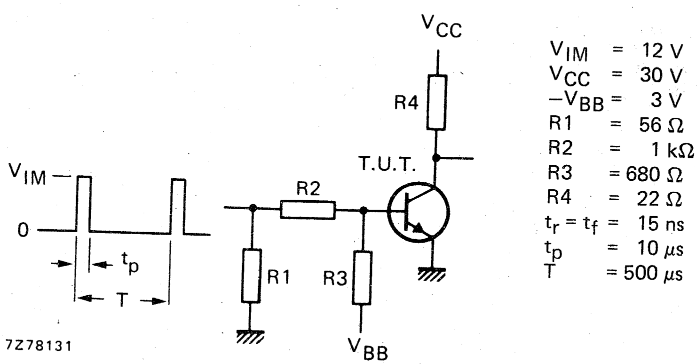


Fig. 5 Switching times test circuit.

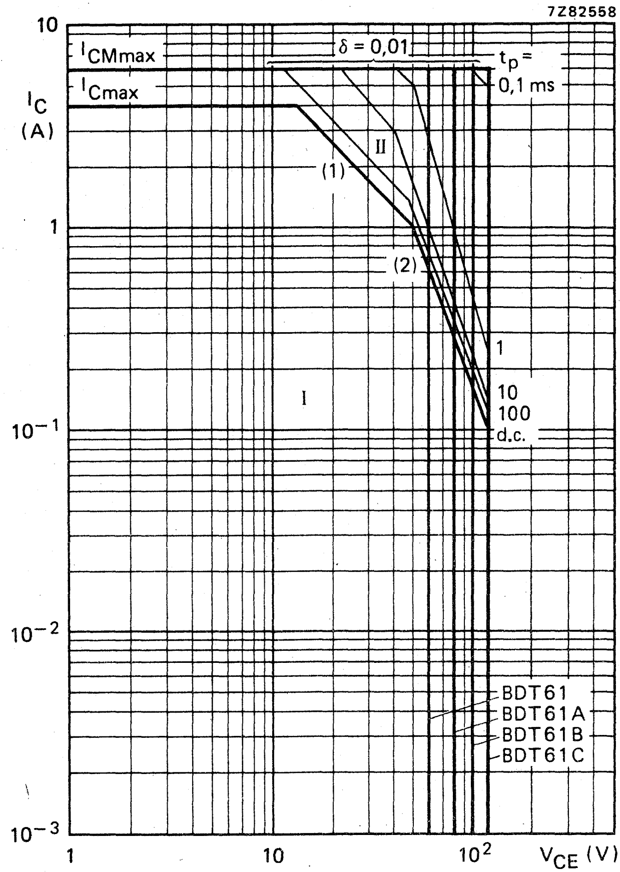


Fig. 6 Safe Operating ARea; T_{mb} = 25 °C.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.
(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second-breakdown limits (independent of temperature).

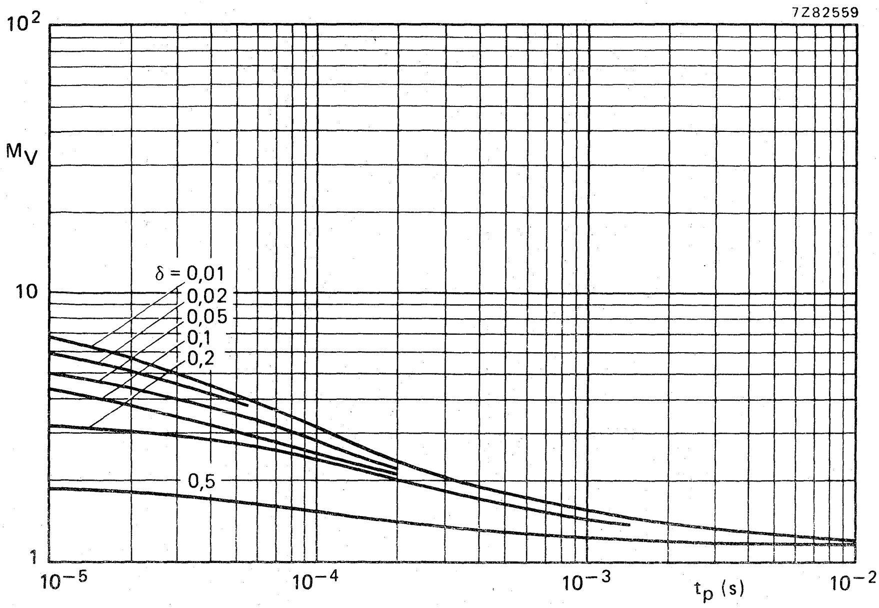


Fig. 7 Second breakdown voltage multiplying factor at the I_{Cmax} level.

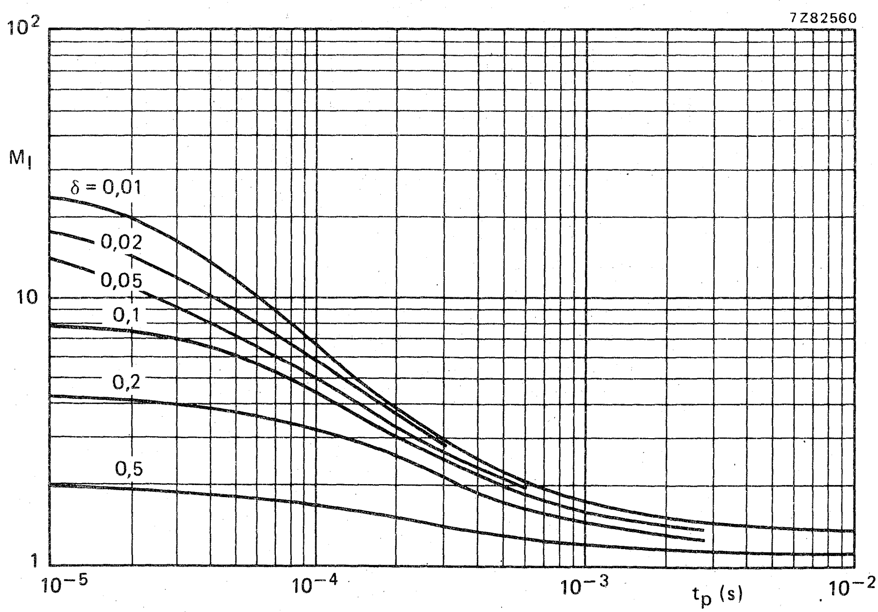


Fig. 8 Second breakdown current multiplying factor at the V_{CEOmax} level.

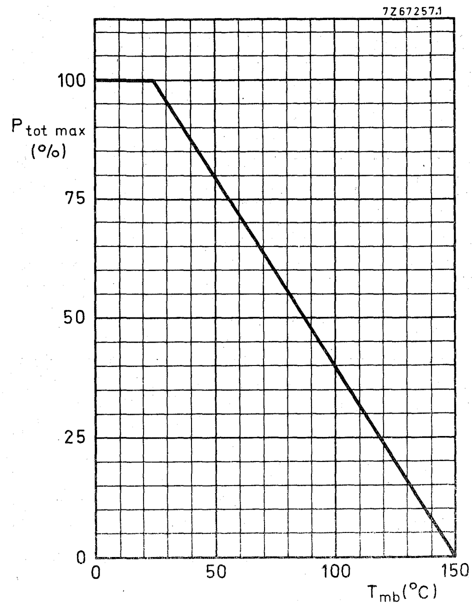


Fig. 9 Power derating curve.

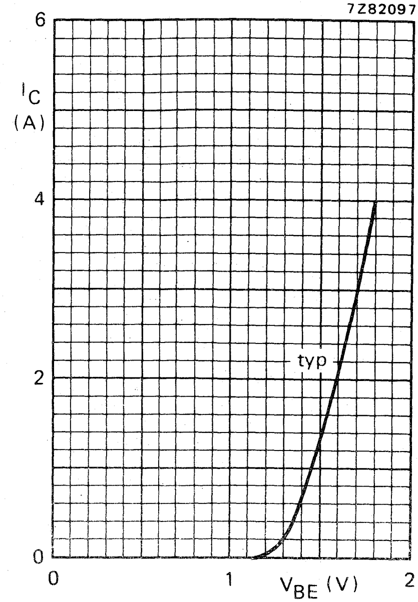


Fig. 10 V_{CE} = 3 V; T_j = 25 °C.

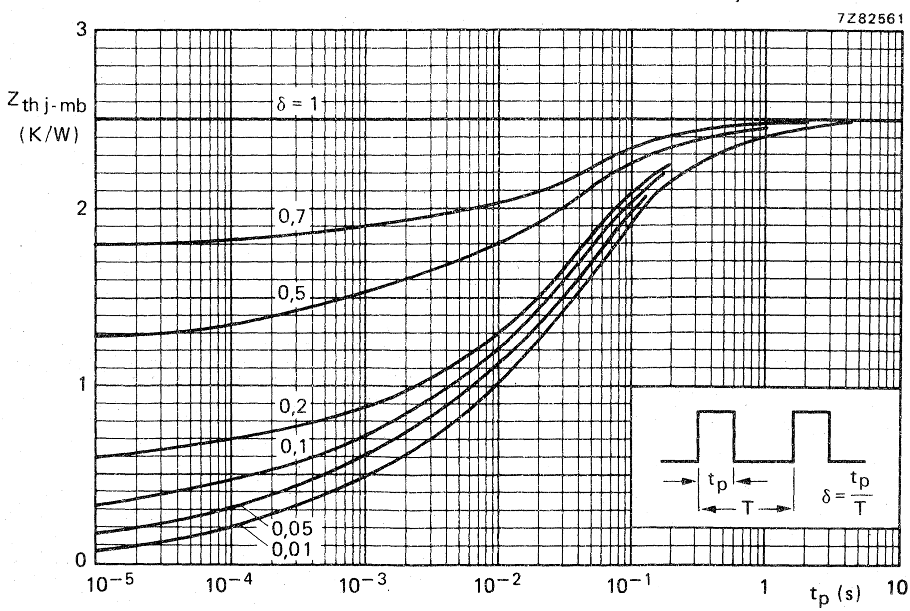


Fig. 11 Pulse power rating chart.

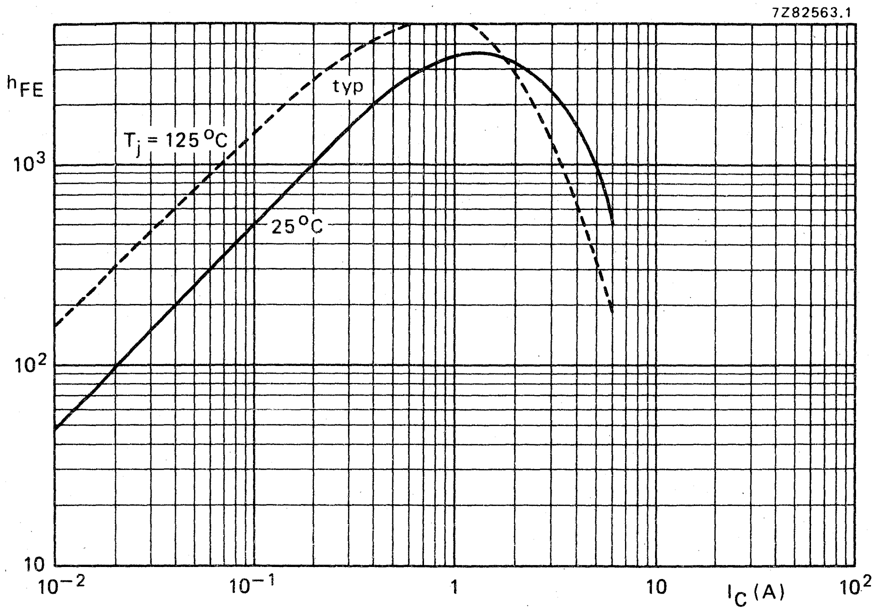


Fig. 12 Typical d.c. current gain. V_{CE} = 3 V.

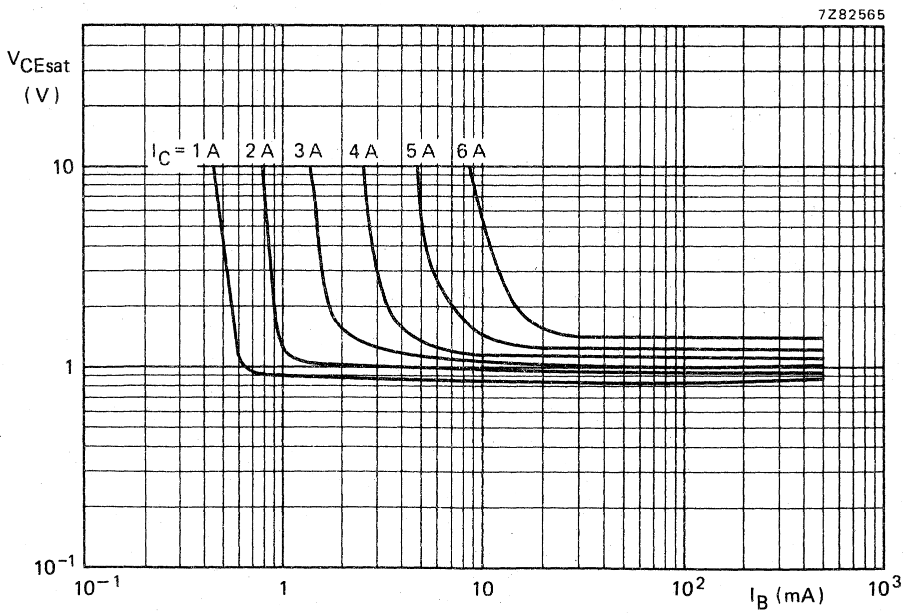


Fig. 13 Typical values collector-emitter saturation voltage at T_{mb} = 25 °C.

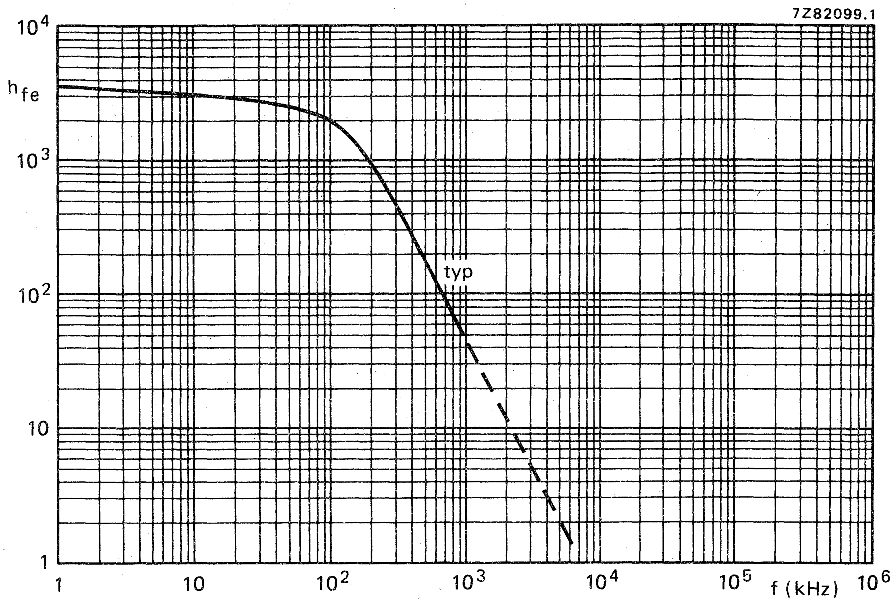


Fig. 14 Small signal current gain. I_C = 1,5 A; V_{CE} = 3 V; T_j = 25 °C.

SILICON DARLINGTON POWER TRANSISTORS

P-N-P epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications. TO-220 plastic envelope. N-P-N complements are BDT63, BDT63A, BDT63B and BDT63C.

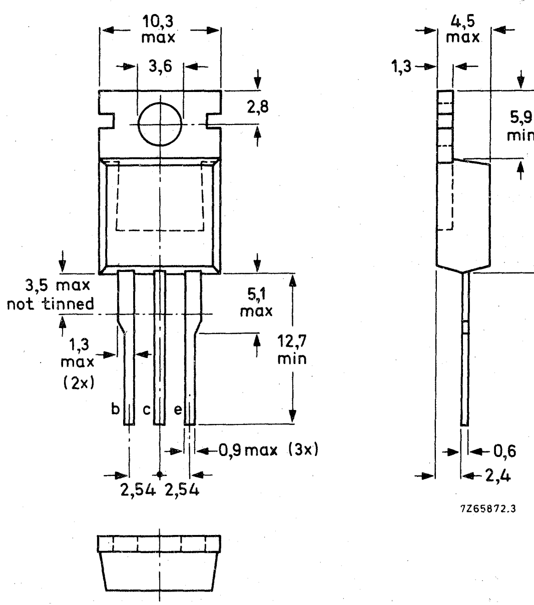
QUICK REFERENCE DATA

			BDT62	A	B	C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Collector current (d.c.)	$-I_C$	max.		10			A
Collector current (peak value) t_p = 0,3 ms; δ = 10%	$-I_{CM}$	max.		15			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		90			W
Junction temperature	T_j	max.		150			°C
D.C. current gain $-I_C$ = 3 A; $-V_{CE}$ = 3 V	h_{FE}	>		1000			

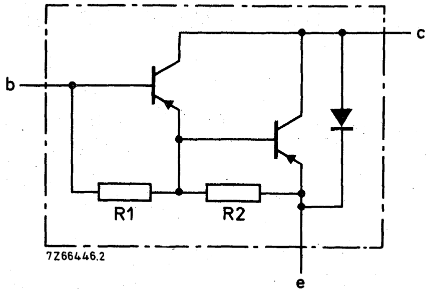
MECHANICAL DATA

Fig. 1 TO-220AB.

Collector connected to mounting base.



See also chapters Mounting instructions and Accessories.



R1 typ. 4 kΩ
R2 typ. 60 Ω

Fig. 2 Circuit diagram.

RATINGS

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

			BDT62	A	B	C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.		5			V
Collector current (d.c.)	$-I_C$	max.		10			A
Collector current (peak value) t_p = 0,3 ms; δ = 10%	$-I_{CM}$	max.		15			A
Base current (d.c.)	$-I_B$	max.		250			mA
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		90			W
Storage temperature	T_{stg}			–65 to + 150			°C
Junction temperature*	T_j	max.		150			°C

THERMAL RESISTANCE*

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,39	°C/W
From junction to ambient (in free air)	$R_{th\ j\text{-}a}$	=	70	°C/W

* Base on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

Collector cut-off current				
$I_E = 0$; $-V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	0,2	mA
$I_E = 0$; $-V_{CB} = -½V_{CBOmax}$; T_j = 150 °C	$-I_{CBO}$	<	2	mA
$I_B = 0$; $-V_{CE} = -½V_{CEOmax}$	$-I_{CEO}$	<	0,5	mA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	5	mA
Forward bias second-breakdown collector current				
$-V_{CE} = 40$ V; t = 0,1 s; non-repetitive (without heatsink)				
BDT62	$I_{(SB)}$	>	0,45	A
BDT62A, B and C	$I_{(SB)}$	>	1,4	A
D.C. current gain*				
$-I_C = 3$ A; $-V_{CE} = 3$ V	h_{FE}	>	1000	
$-I_C = 10$ A; $-V_{CE} = 3$ V	h_{FE}	typ.	200	
Base-emitter voltage*				
$-I_C = 3$ A; $-V_{CE} = 3$ V	$-V_{BE}$	<	2,5	V
Collector-emitter saturation voltage*				
$-I_C = 3$ A; $-I_B = 12$ mA	$-V_{CEsat}$	<	2	V
$-I_C = 8$ A; $-I_B = 80$ mA	$-V_{CEsat}$	<	2,5	V
Cut-off frequency				
$-I_C = 3$ A; $-V_{CE} = 3$ V	f_{hfe}	typ.	100	kHz
Collector capacitance				
$-V_{CB} = 10$ V; f = 1 MHz	C_{ob}	typ.	100	pF
D.C. current gain ratio of matched complementary pairs				
$-I_C = 3$ A; $-V_{CE} = 3$ V	h_{FE1}/h_{FE2}	<	2,5	
Small-signal current gain at f = 1 MHz				
$-I_C = 3$ A; $-V_{CE} = 3$ V	h_{fe}	>	25	

* Measured under pulse conditions; $t_p < 300$ µs; $\delta < 2\%$.

CHARACTERISTICS (continued)

Diode, forward voltage $I_F = 3$ A	V_F	<	2 V
Switching times (between 10% and 90% levels) $-I_{Con} = 3$ A; $-I_{Bon} = I_{Boff} = 12$ mA			
turn-on time	t_{on}	typ.	0,5 μs
turn-off time	t_{off}	typ.	2,5 μs

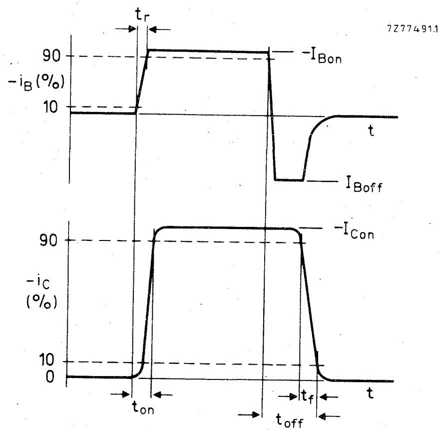
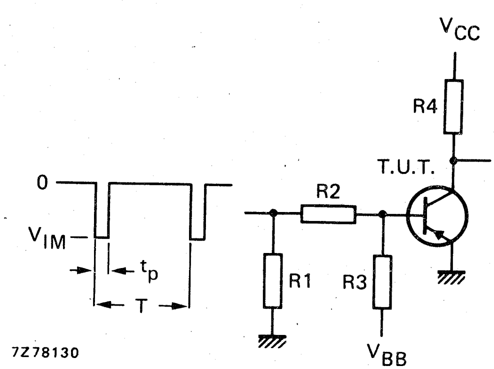


Fig. 3 Switching times waveforms.



$-V_{IM}$	=	10 V
$-V_{CC}$	=	10 V
$+V_{BB}$	=	4 V
R1	=	56 Ω
R2	=	410 Ω
R3	=	560 Ω
R4	=	3 Ω
$t_r = t_f$	=	15 ns
t_p	=	10 μs
T	=	500 μs

Fig. 4 Switching times test circuit.

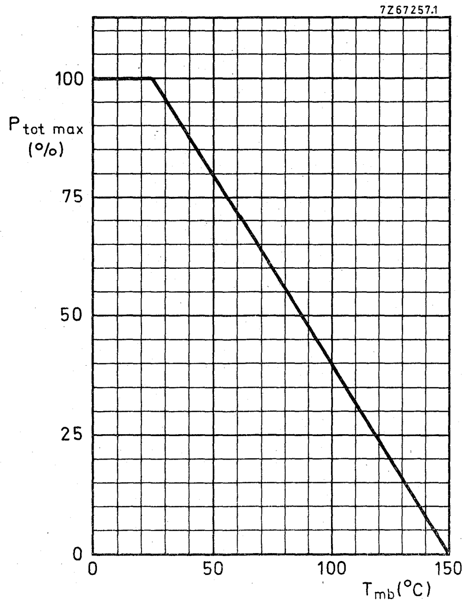


Fig. 5 Power derating curve.

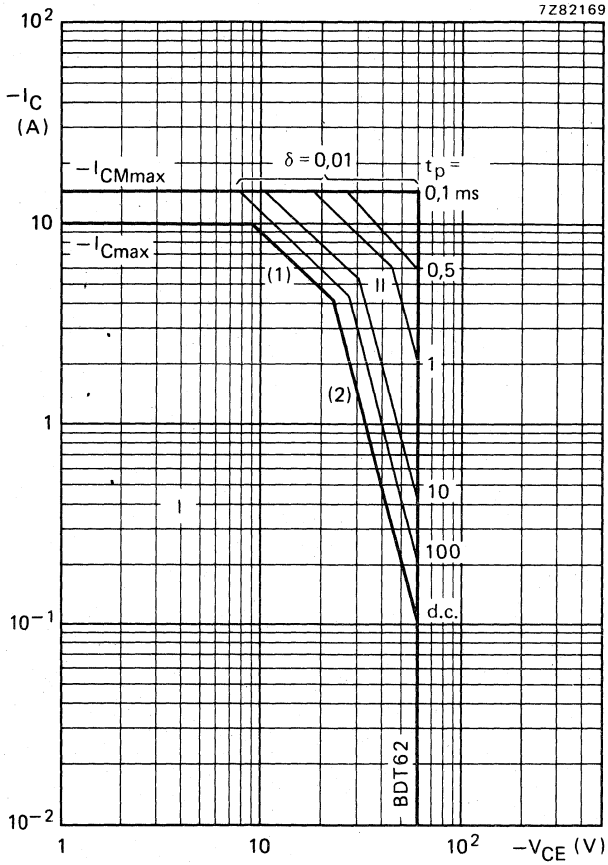


Fig. 6 Safe Operating ARea BDT62; T_{mb} = 25 °C.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.
(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second-breakdown limits (independent of temperature).

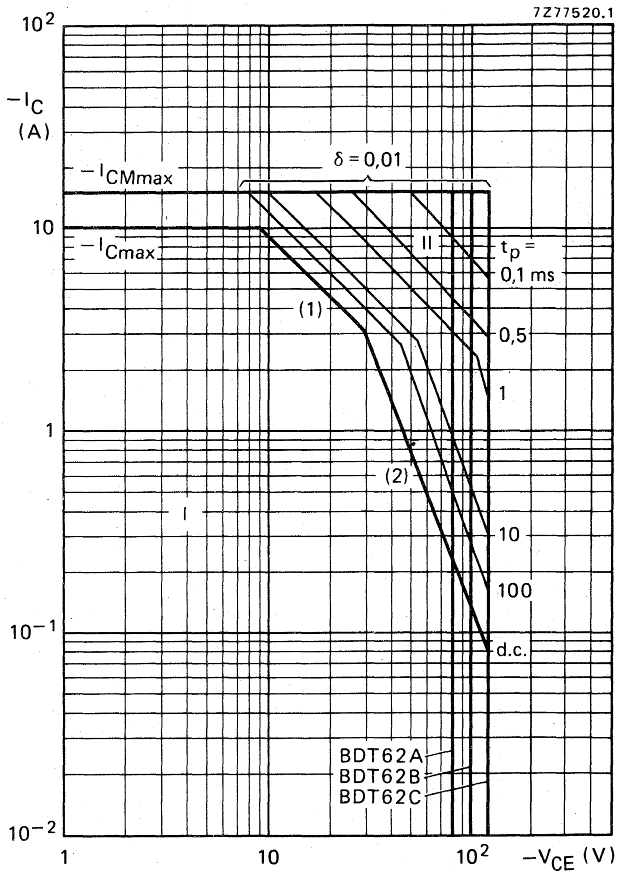


Fig. 7 Safe Operating ARea BDT62A; 62B and 62C; T_{mb} = 25 °C.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.
(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second-breakdown limits (independent of temperature).

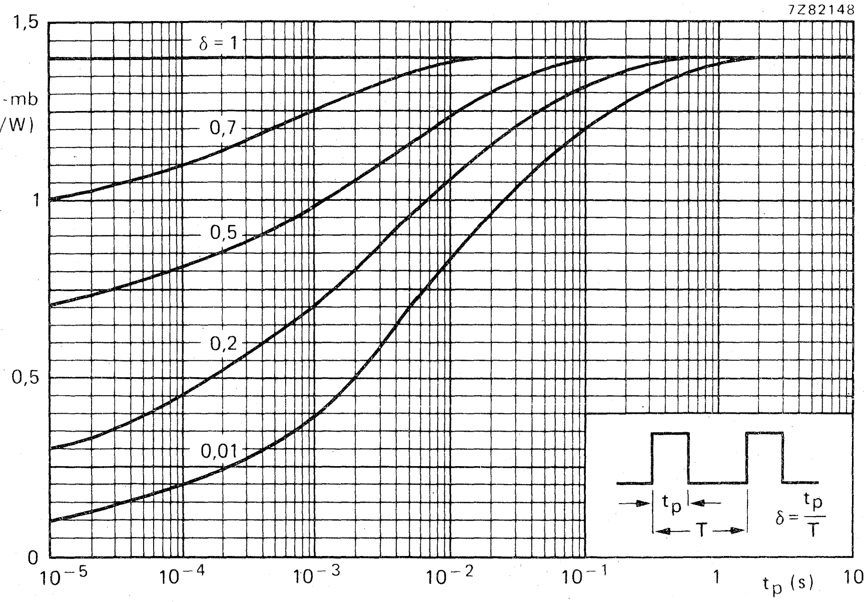


Fig. 8 Pulse power rating chart.

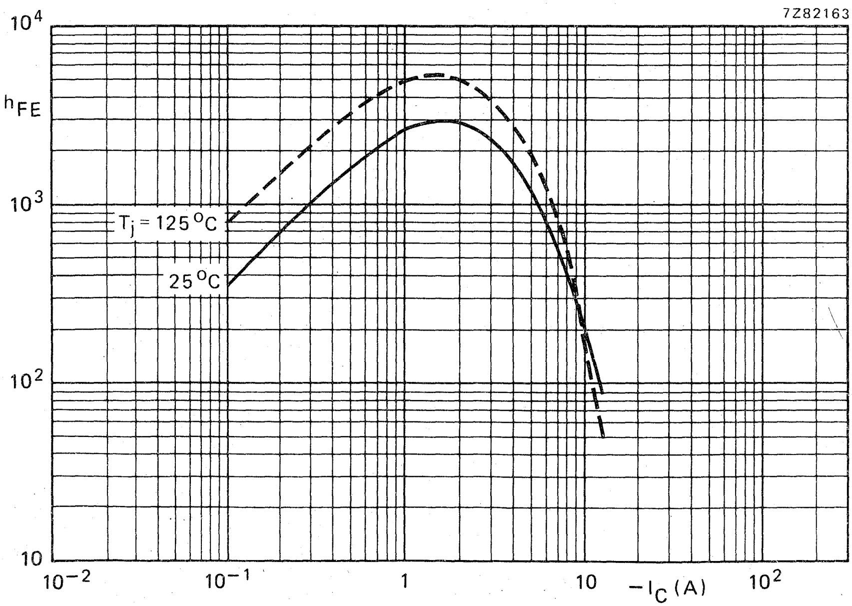


Fig. 9 Typical d.c. current gain at $-V_{CE} = 3$ V.

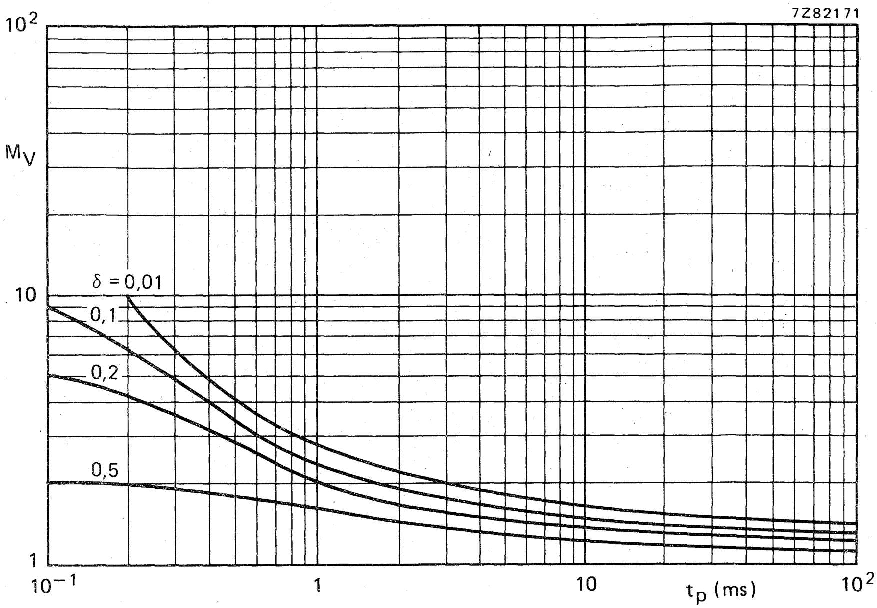


Fig. 10 S.B. voltage multiplying factor at the IC_{max} level.

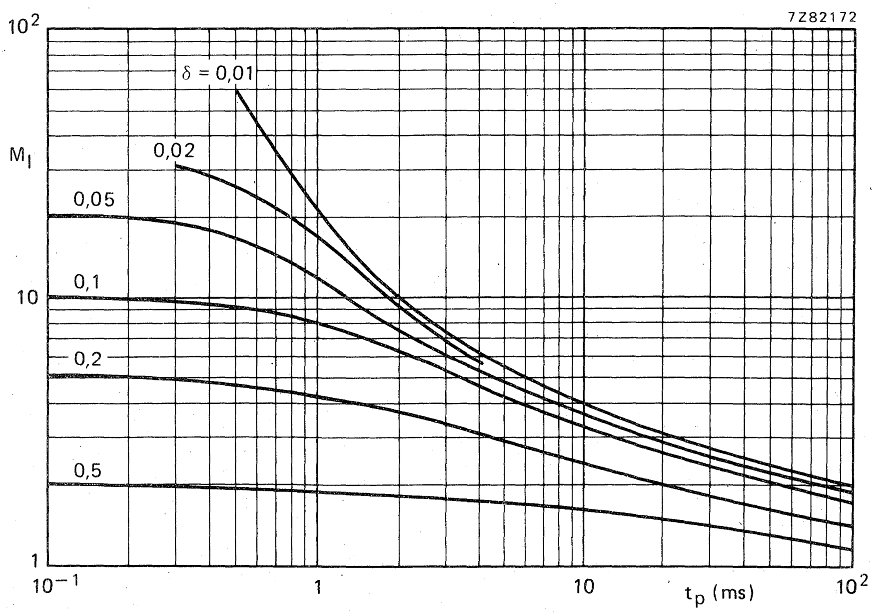


Fig. 11 S.B. current multiplying factor at the $V_{CEO\,max}$ level.

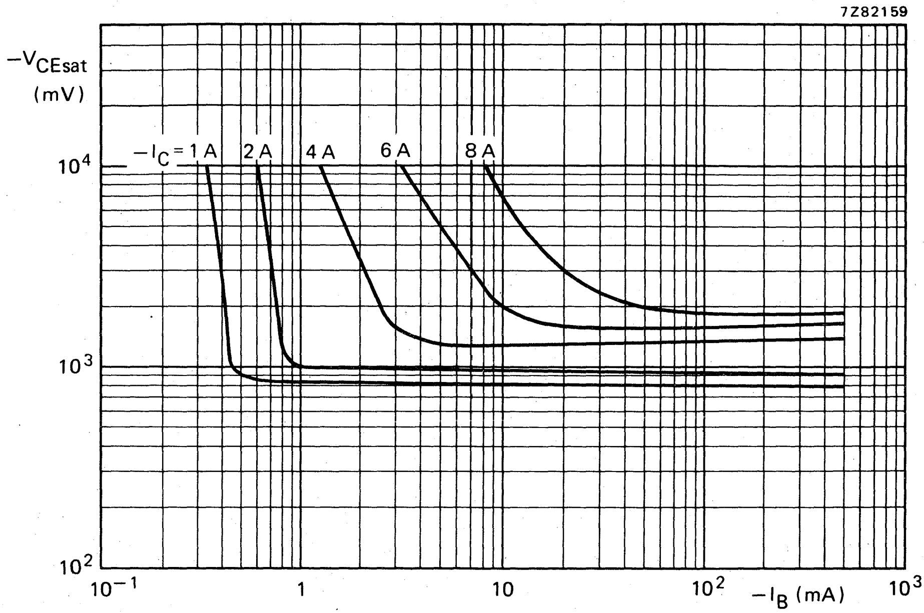


Fig. 12 Typical collector-emitter saturation voltage.

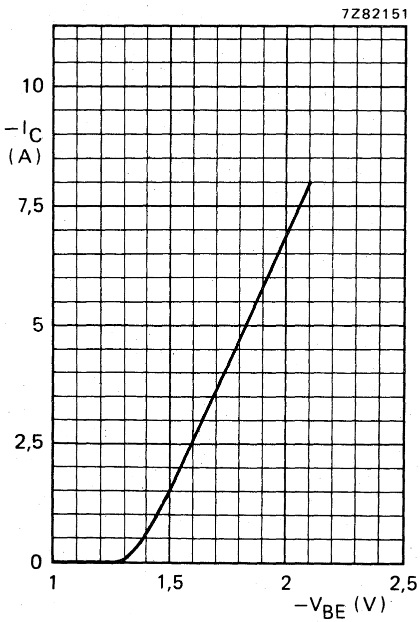


Fig. 13 Typical base emitter voltage as a function of the collector current.

SILICON DARLINGTON POWER TRANSISTORS

N-P-N epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications; TO-220 plastic envelope. P-N-P complements are BDT62, BDT62A; BDT62B and BDT62C.

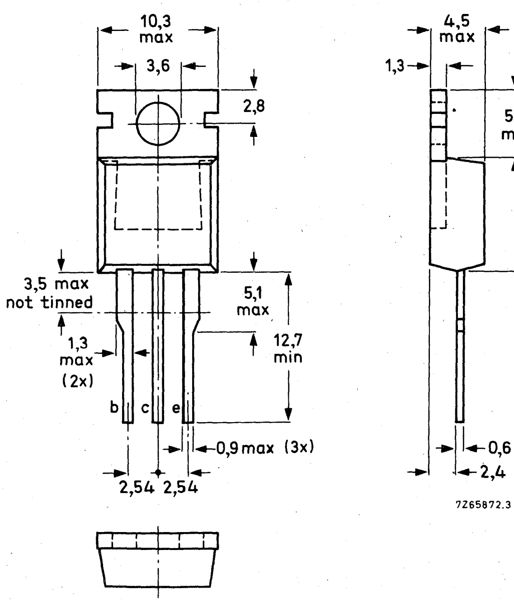
QUICK REFERENCE DATA

			BDT63	A	B	C	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Collector current (d.c.)	I_C	max.	10				A
Collector current (peak value) t_p = 0,3 ms; δ = 10%	I_{CM}	max.	15				A
Total power dissipation up to T_{mb} = 25 ^oC	P_{tot}	max.	90				W
Junction temperature	T_j	max.	150				^oC
D.C. current gain I_C = 3 A; V_{CE} = 3 V	h_{FE}	>	1000				

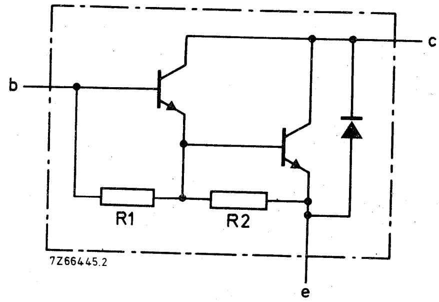
MECHANICAL DATA

Fig. 1 TO-220AB.

Collector connected to mounting base.



See also chapters Mounting instructions and Accessories.



R1 typ. 8 kΩ
R2 typ. 100 Ω

Fig. 2 Circuit diagram.

RATINGS

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

			BDT63	A	B	C	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5				V
Collector current (d.c.)	I_C	max.	10				A
Collector current (peak value) t_p = 0,3 ms; δ = 10%	I_{CM}	max.	15				A
Base current (d.c.)	I_B	max.	250				mA
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	90				W
Storage temperature	T_{stg}		−65 to + 150				°C
Junction temperature*	T_j	max.	150				°C

THERMAL RESISTANCE *

From junction to mounting base	$R_{th\ j\text{-}mb}$ =	1,39	°C/W
From junction to ambient (in free air)	$R_{th\ j\text{-}a}$ =	70	°C/W

* Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

Collector cut-off current			
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	<	0,2 mA
$I_E = 0$; $V_{CB} = ½V_{CBOmax}$; T_j = 150 °C	I_{CBO}	<	2 mA
$I_B = 0$; $V_{CE} = ½V_{CEOmax}$	I_{CEO}	<	0,5 mA
Emitter cut-off current			
$I_C = 0$; V_{EB} = 5 V	I_{EBO}	<	5 mA
Forward-bias second-breakdown collector current			
V_{CE} = 40 V; t = 0,1 s; non-repetitive (without heatsink)	$I_{(SB)}$	>	2,25 A
D.C. current gain*			
I_C = 3 A; V_{CE} = 3 V	h_{FE}	>	1000
I_C = 10 A; V_{CE} = 3 V	h_{FE}	typ.	3000
Base-emitter voltage*			
I_C = 3 A; V_{CE} = 3 V	V_{BE}	<	2,5 V
Collector-emitter saturation voltage*			
I_C = 3 A; I_B = 12 mA	V_{CEsat}	<	2 V
I_C = 8 A; I_B = 80 mA	V_{CEsat}	<	2,5 V
Diode, forward voltage			
I_F = 3 A	V_F	<	2 V
Turn-off breakdown energy with inductive load (Fig. 6)			
$-I_{Boff} = 0$; L = 5 mH	$E_{(BR)}$	>	100 mJ
Small-signal current gain at f = 1 MHz			
I_C = 3 A; V_{CE} = 3 V	h_{fe}	>	25
Cut-off frequency			
I_C = 3 A; V_{CE} = 3 V	f_{hfe}	typ.	50 kHz
Collector capacitance			
V_{CB} = 10 V; f = 1 MHz	C_{ob}	typ.	100 pF
D.C. current gain ratio of matched complementary pairs			
I_C = 3 A; V_{CE} = 3 V	h_{FE1}/h_{FE2}	<	2,5

* Measured under pulse conditions; $t_p < 300$ µs; $\delta < 2\%$.

CHARACTERISTICS (continued)

Switching times
(between 10% and 90% levels)
$I_{Con} = 3$ A; $I_{Bon} = -I_{Boff} = 12$ mA

turn-on time	t_{on}	typ.	1 μs
		<	2,5 μs
turn-off time	t_{off}	typ.	5 μs
		<	10 μs

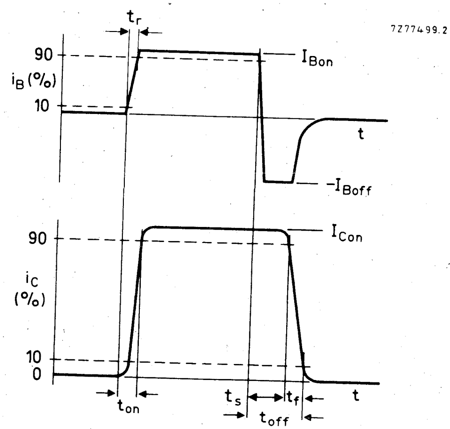
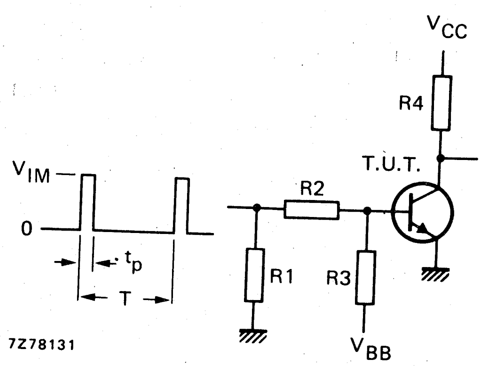


Fig. 3 Switching times waveforms.



V_{IM}	=	10 V
V_{CC}	=	10 V
$-V_{BB}$	=	4 V
R1	=	56 Ω
R2	=	410 Ω
R3	=	560 Ω
R4	=	3 Ω
$t_r = t_f$	=	15 ns
t_p	=	10 μs
T	=	500 μs

Fig. 4 Switching times test circuit.

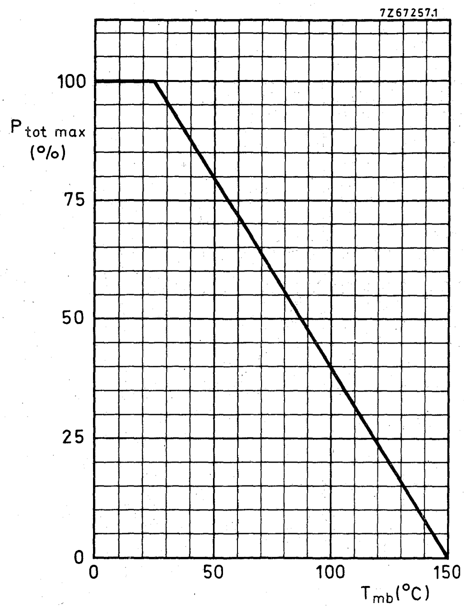


Fig. 5 Power derating curve.

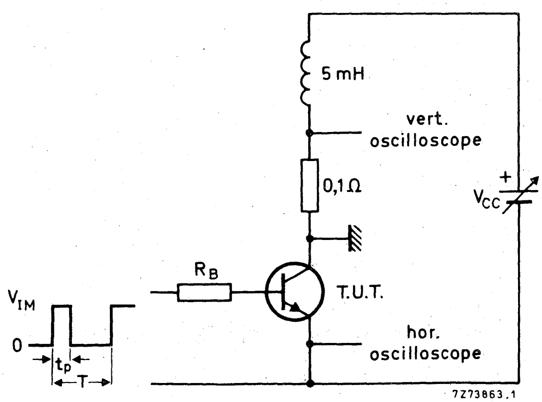


Fig. 6 Turn-off breakdown energy with inductive load.
V_{IM} = 12 V; R_B = 270 Ω; $\delta = \frac{t_p}{T} \times 100\% = 1\%$; I_{CC} = 6,3 A.

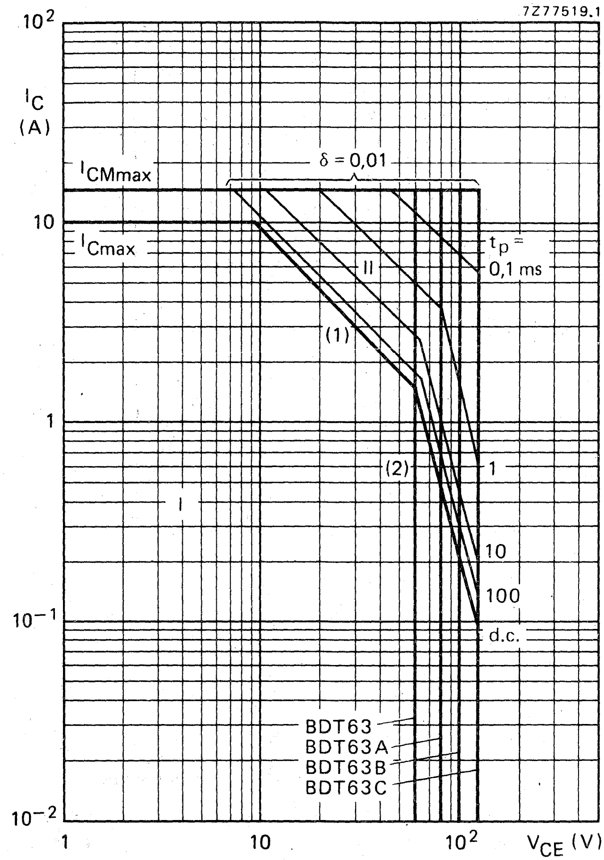


Fig. 7 Safe Operating ARea; T_{mb} = 25 °C.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.
(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second-breakdown limits (independent of temperature).

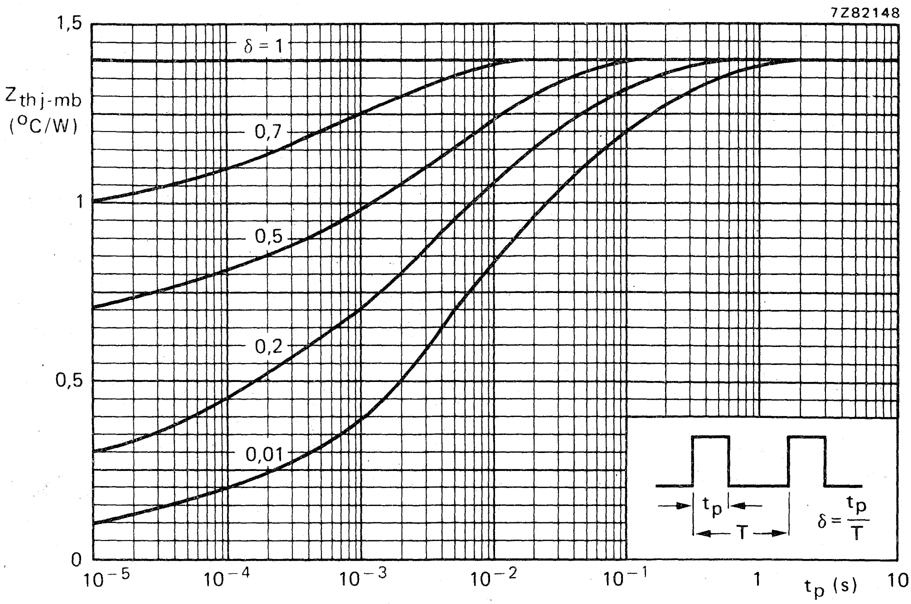


Fig. 8 Pulse power rating chart.

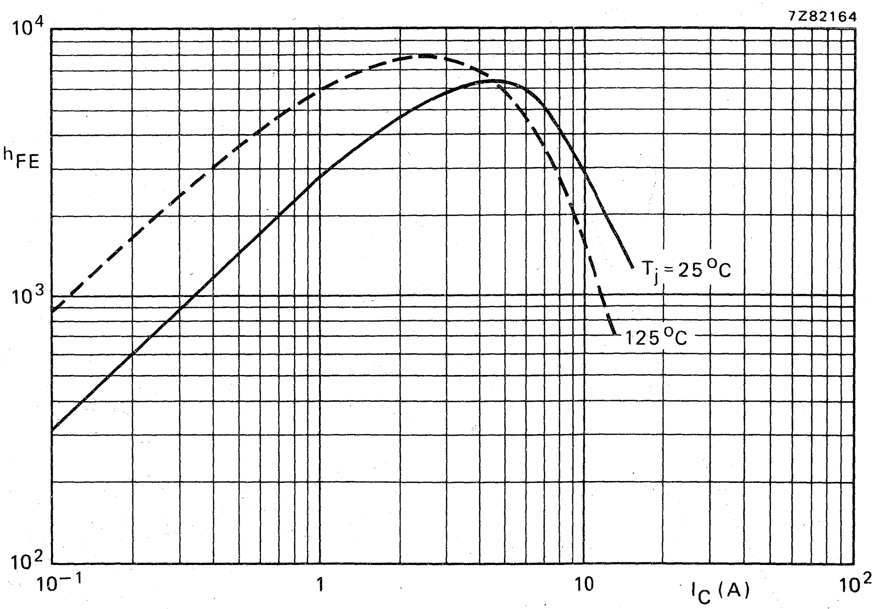


Fig. 9 Typical d.c. current gain at V_{CE} = 3 V.

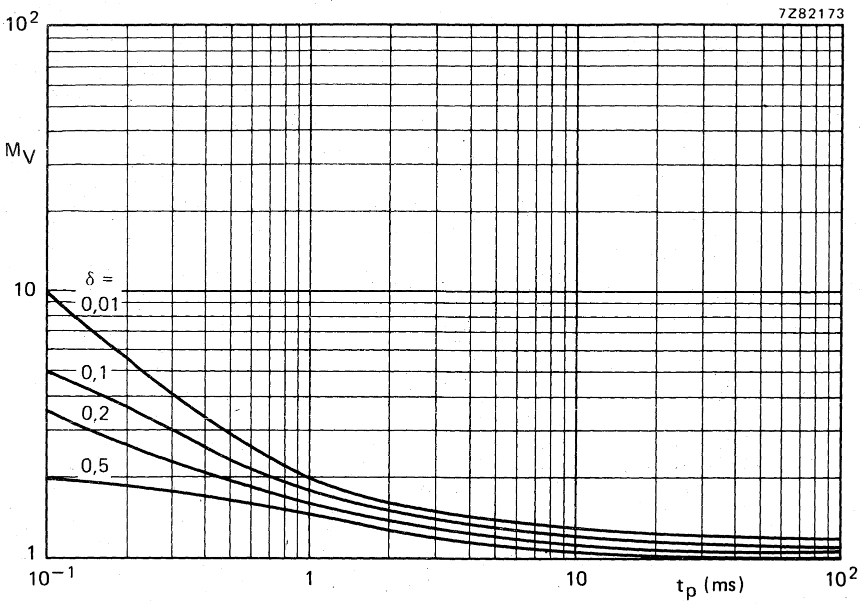


Fig. 10 S.B. voltage multiplying factor at the $I_{C\,max}$ level.

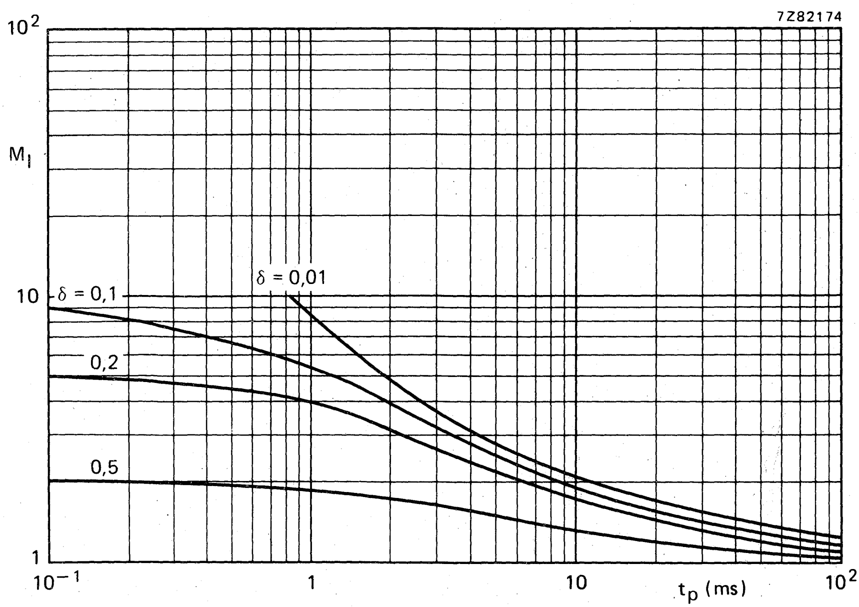


Fig. 11 S.B. current multiplying factor at V_{CEO} level = 60 V and 100 V.

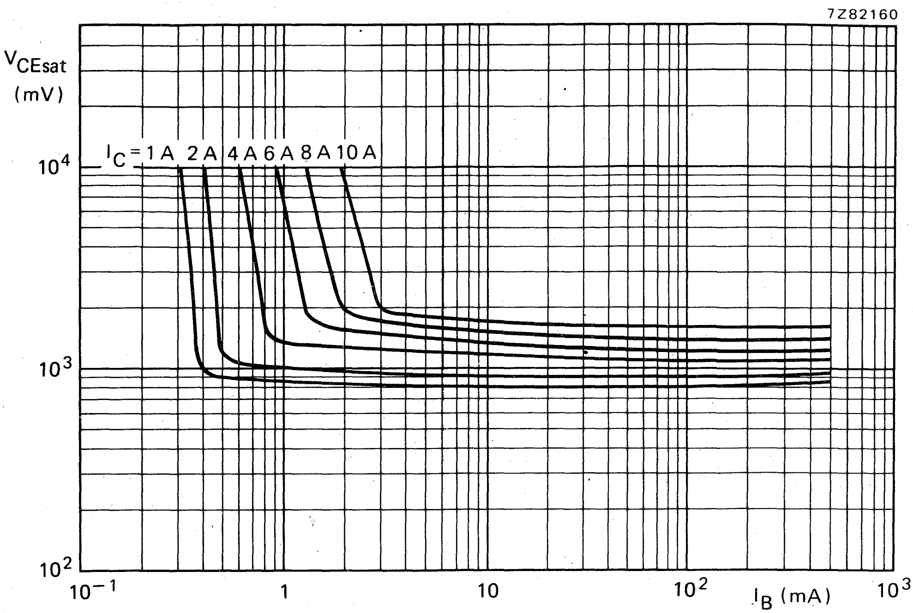


Fig. 12 Typical collector-emitter saturation voltage.

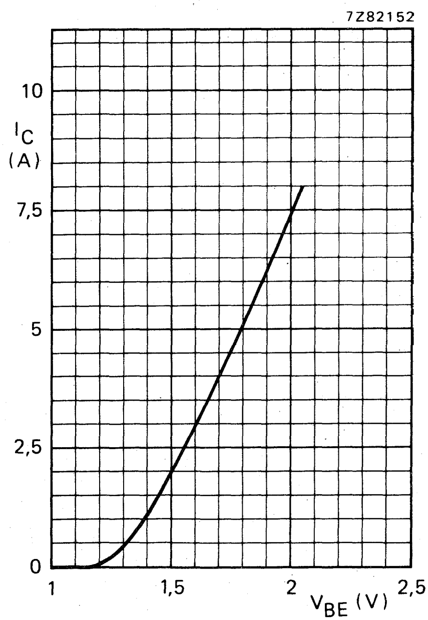


Fig. 13 Typical base-emitter voltage as a function of the collector current.

SILICON DARLINGTON POWER TRANSISTORS

P-N-P epitaxial base transistors in monolithic Darlington circuit for audio output stages and general purpose amplifier and switching applications. TO-220 plastic envelope. N-P-N complements are BDT65, BDT65A, BDT65B and BDT65C.

QUICK REFERENCE DATA

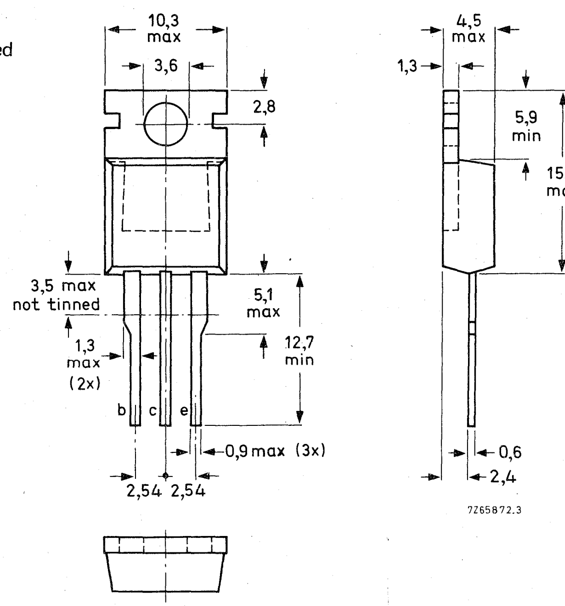
			BDT64	64A	64B	64C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	5	V
Collector current (peak value)	$-I_{CM}$	max.	20				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	125				W
Junction temperature	T_j	max.	150				°C
D.C. current gain $-I_C$ = 5 A; $-V_{CE}$ = 4 V	h_{FE}	>	1000				

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base.



See also chapters Mounting instructions and Accessories.

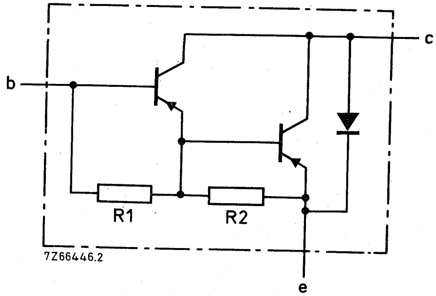


Fig. 2 Circuit diagram. R1 typ. 3 kΩ; R2 typ. 45 Ω.

RATINGS

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

			BDT64	64A	64B	64C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	5	V
Collector current (d.c.)	$-I_C$	max.	12				A
Collector current (peak value)	$-I_{CM}$	max.	20				A
Base current (d.c.)	$-I_B$	max.	500				mA
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	125				W
Storage temperature	T_{stg}		−65 to + 150				°C
Junction temperature	T_j	max.	150				°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1	K/W

CHARACTERISTICS

$T_j = 25\ ^oC$ unless otherwise specified.

Collector cut-off current			
$-V_{CB} = -V_{CBOmax}$; $I_E = 0$	$-I_{CBO}$	<	0,4 mA
$I_E = 0$; $-V_{CB} = -½\ V_{CBOmax}$; $T_j = 150\ ^oC$	$-I_{CBO}$	<	2 mA
$I_B = 0$; $-V_{CE} = -½\ V_{CEOmax}$	$-I_{CEO}$	<	1 mA
Emitter cut-off current			
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	5 mA
D.C. current gain*			
$-I_C = 1$ A; $-V_{CE} = 4$ V	h_{FE}	typ.	1500
$-I_C = 5$ A; $-V_{CE} = 4$ V	h_{FE}	>	1000
$-I_C = 12$ A; $-V_{CE} = 4$ V	h_{FE}	typ.	750
Base-emitter voltage			
$-I_C = 5$ A; $-V_{CE} = 4$ V	$-V_{BE}$	<	2,5 V
Collector-emitter saturation voltage*			
$-I_C = 5$ A; $-I_B = 20$ mA	$-V_{CEsat}$	<	2 V
$-I_C = 10$ A; $-I_B = 100$ mA	$-V_{CEsat}$	<	3 V
Diode, forward voltage			
$I_F = 5$ A	V_F	<	2 V
$I_F = 12$ A	V_F	typ.	2 V
Collector capacitance at f = 1 MHz			
$-V_{CB} = 10$ V; $I_E = I_e = 0$	C_c	typ.	200 pF
Second breakdown collector current			
non-repetitive; without heatsink			
$-V_{CE} = 60$ V; $t_p = 0,1$ s	$-I_{SB}$	>	2 A
Switching times (see Figs 3 and 4)			
$-I_{Con} = 5$ A; $-I_{Bon} = I_{Boff} = 20$ mA			
$-V_{CC} = 30$ V			
turn-on time	t_{on}	typ.	0,5 μs
		<	2 μs ←
turn-off time	t_{off}	typ.	2,5 μs
		<	5 μs
Small-signal current gain			
$-I_C = 5$ A; $-V_{CE} = 3$ V; f = 1 MHz	$\|h_{fe}\|$	typ.	40

* Measured under pulse conditions: $t_p < 300\ \mu s$; $\delta < 2\%$.

CHARACTERISTICS (continued)

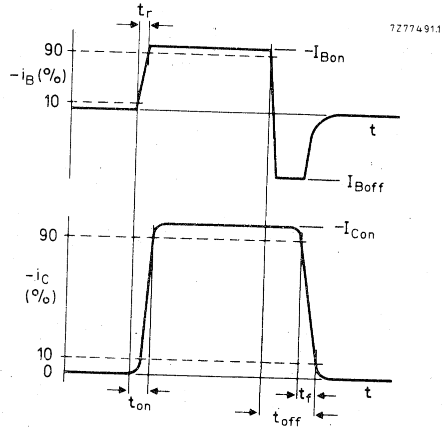
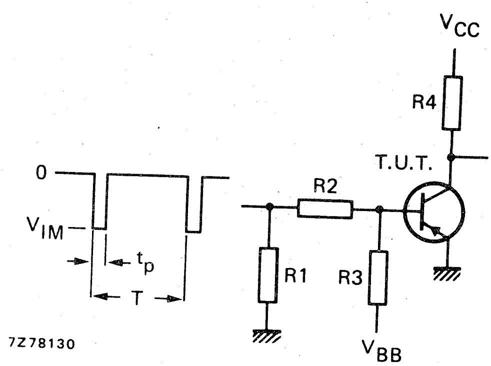


Fig. 3 Switching times waveforms.



$-V_{IM}$	=	15	V
$-V_{CC}$	=	30	V
V_{BB}	=	4	V
R1	=	56	Ω
R2	=	410	Ω
R3	=	560	Ω
R4	=	6	Ω
$t_r = t_f$	=	15	ns
t_p	=	10	μs
T	=	500	μs

Fig. 4 Switching times test circuit.

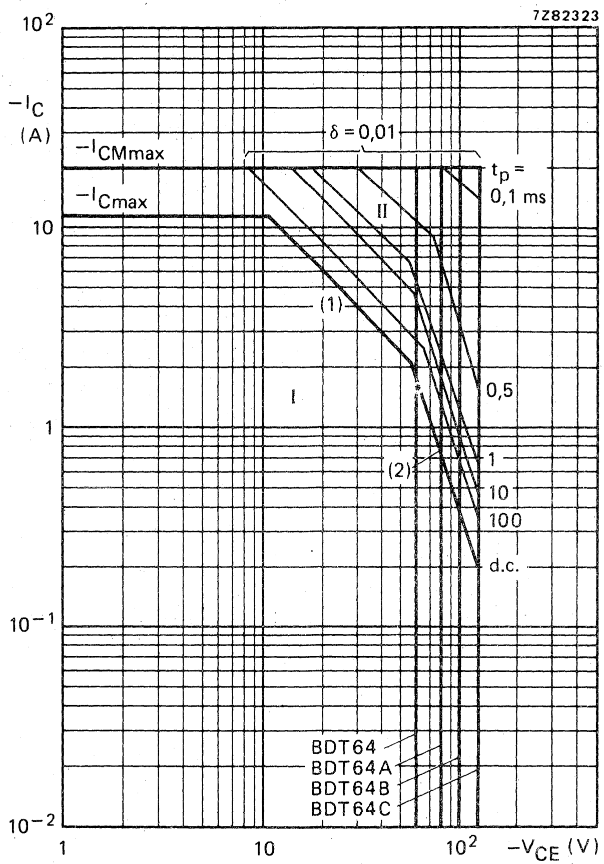


Fig. 5 Safe Operating ARea; T_{mb} = 25 °C.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.
(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second-breakdown limits (independent of temperature).

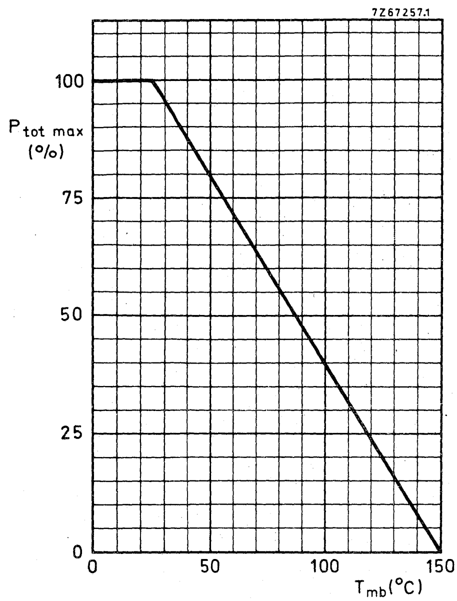


Fig. 6 Power derating curve.

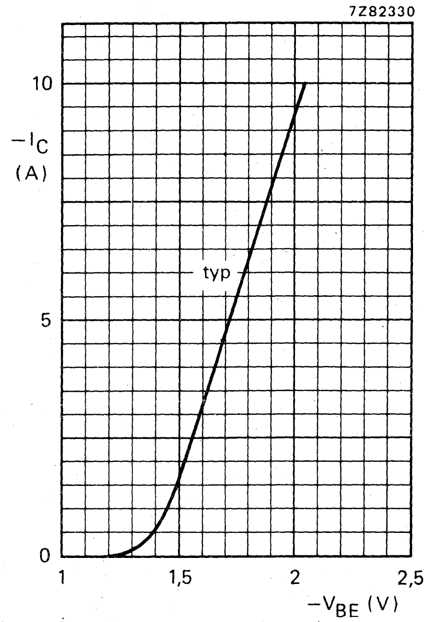


Fig. 7 $-V_{CE} = 3$ V; $T_{amb} = 25$ °C.

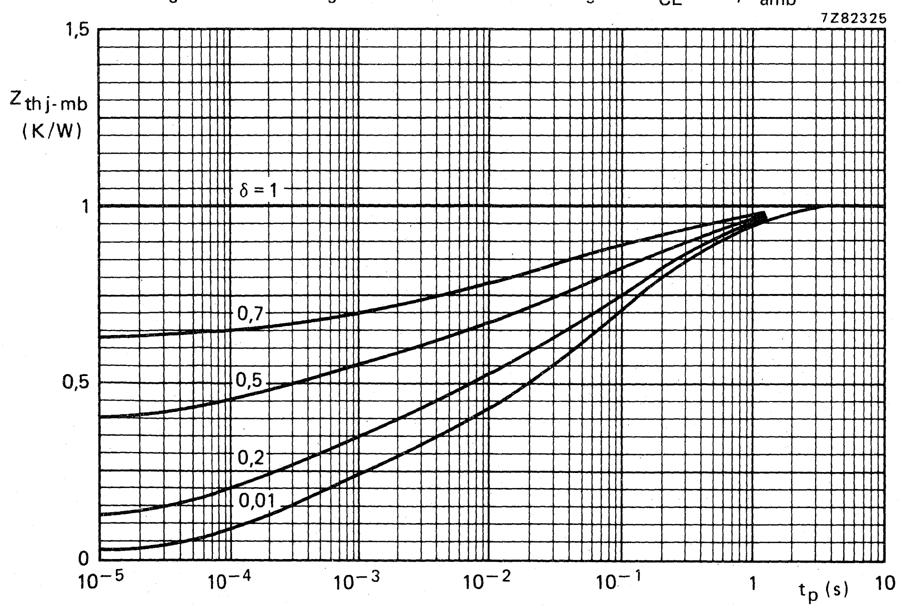


Fig. 8 Pulse power rating chart.

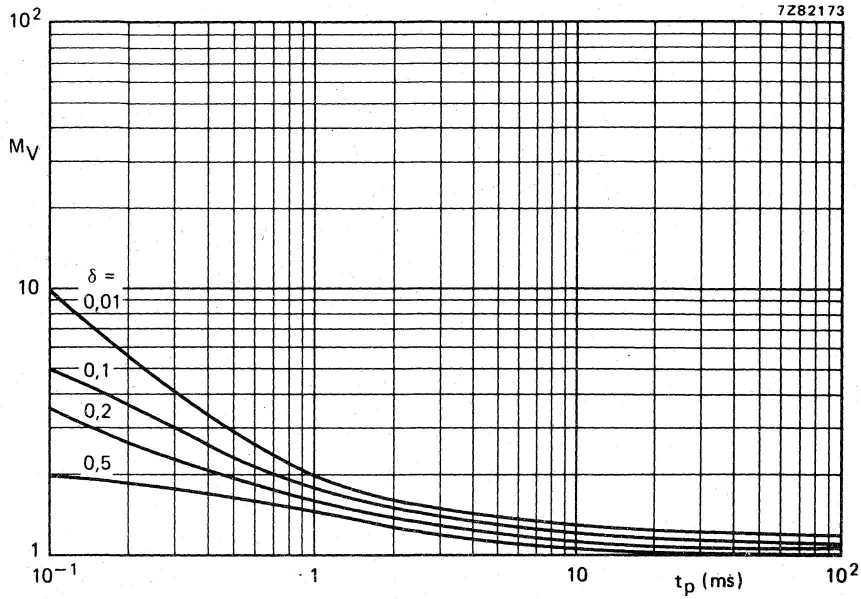


Fig. 9 S.B. voltage multiplying factor at the I_{Cmax} level.

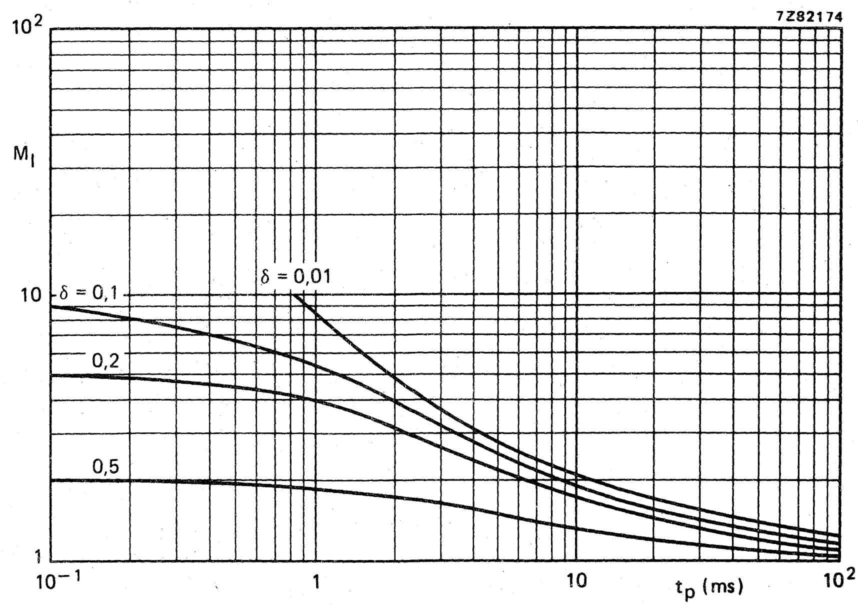


Fig. 10 S.B. current multiplying factor at the V_{CEOmax} level.

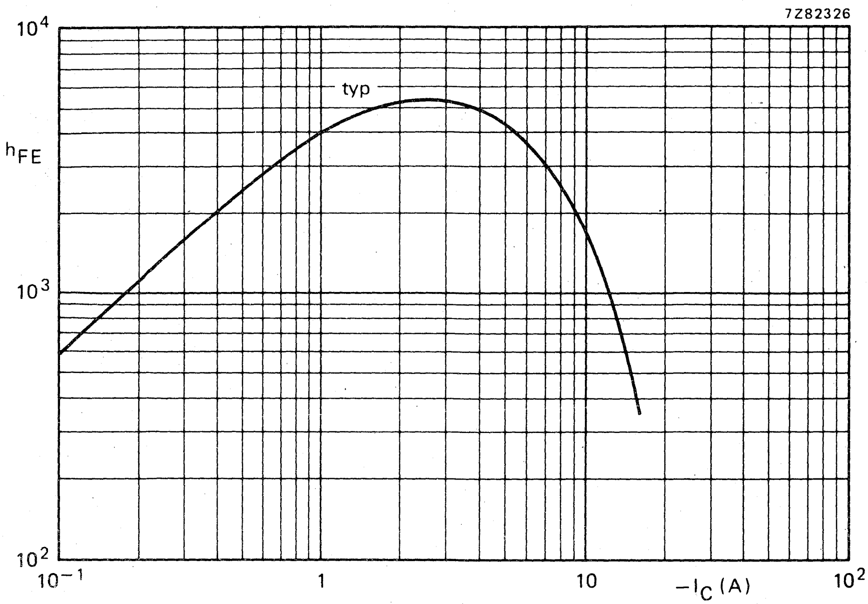


Fig. 11 D.C. current gain. $-V_{CE} = 3$ V; $T_j = 25$ °C.

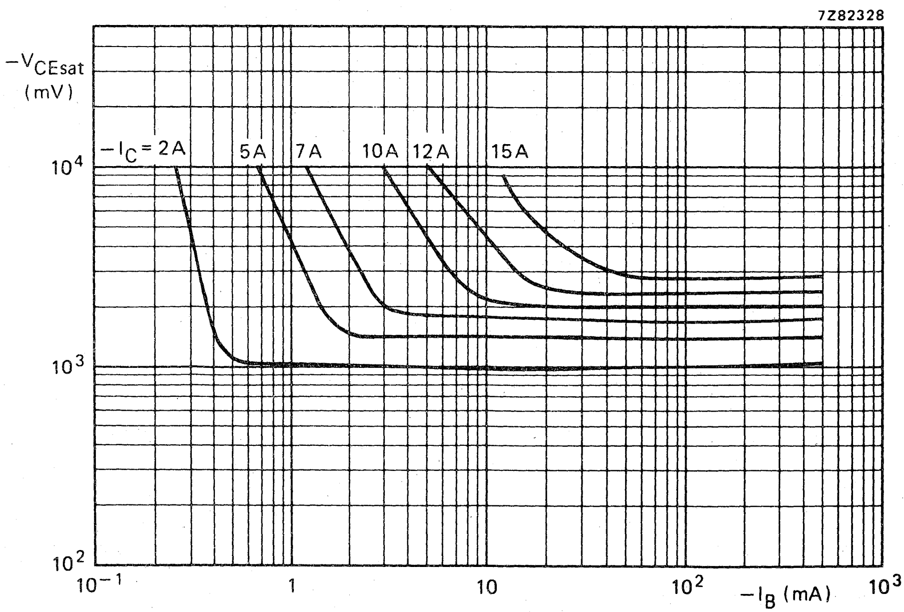


Fig. 12 Typical collector-emitter saturation voltages.

SILICON DARLINGTON POWER TRANSISTORS

N-P-N epitaxial base transistors in monolithic Darlington circuit for audio output stages and general purpose amplifier and switching applications. TO-220 plastic envelope. P-N-P complements are BDT64; BDT64A; BDT64B and BDT64C.

QUICK REFERENCE DATA

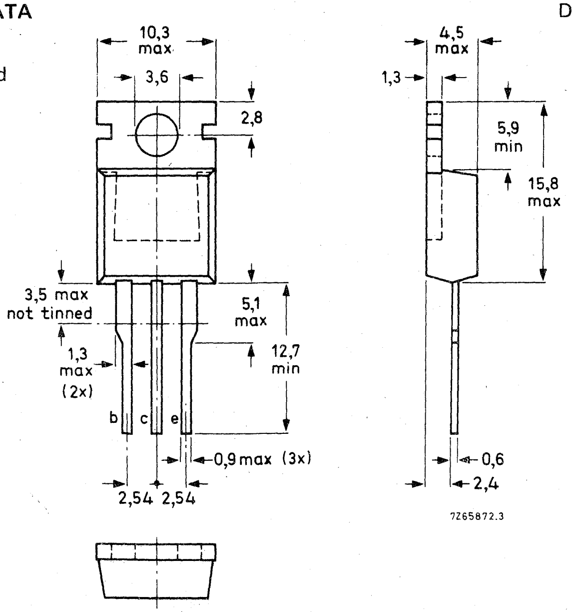
			BDT65	65A	65B	65C	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	5	V
Collector current (peak value)	I_{CM}	max.	20				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	125				W
Junction temperature	T_j	max.	150				°C
D.C. current gain I_C = 5 A; V_{CE} = 4 V	h_{FE}	>	1000				

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base.



See also chapters Mounting instructions and Accessories

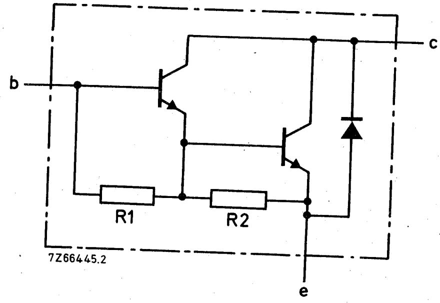


Fig. 2 Circuit diagram. R1 typ. 5 kΩ; R2 typ. 80 Ω.

RATINGS

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

			BDT65	65A	65B	65C	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	5	V

Collector current (d.c.)	I_C	max.	12	A
Collector current (peak value)	I_{CM}	max.	20	A
Base current (d.c.)	I_B	max.	500	mA
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	125	W
Storage temperature	T_{stg}		−65 to + 150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$ =	1	K/W

CHARACTERISTICS

T_j = 25 °C, unless otherwise specified

Collector cut-off current			
$V_{CB} = V_{CBOmax}$; I_E = o	I_{CBO}	<	0,4 mA
$V_{CB} = ½V_{CBOmax}$; I_E = 0; T_j = 150 °C	I_{CBO}	<	2 mA
I_B = 0; $V_{CE} = ½V_{CEOmax}$	I_{CEO}	<	1 mA
Emitter cut-off current			
I_C = 0; V_{EB} = 5 V	I_{EBO}	<	5 mA
D.C. current gain*			
I_C = 1 A; V_{CE} = 4 V	h_{FE}	typ.	1500
I_C = 5 A; V_{CE} = 4 V	h_{FE}	>	1000
I_C = 12 A; V_{CE} = 4 V	h_{FE}	typ.	1000
Base-emitter voltage			
I_C = 5 A; V_{CE} = 4 V	V_{BE}	<	2,5 V
Collector-emitter saturation voltage*			
I_C = 5 A; I_B = 20 mA	V_{CEsat}	<	2 V
I_C = 10 A; I_B = 100 mA	V_{CEsat}	<	3 V
Diode, forward voltage			
I_F = 5 A	V_F	<	2 V
I_F = 12 A	V_F	typ.	2 V
Collector capacitance at f = 1 MHz			
V_{CB} = 10 V; $I_E = I_e$ = 0	C_c	typ.	200 pF
Second-breakdown collector current non-repetitive; without heatsink			
V_{CE} = 60 V; t_p = 0,1 s	I_{SB}	>	2 A ←
Turn-off breakdown energy with inductive load;			
$-I_{Boff}$ = 0; I_{CM} = 6,3 A; L = 5 mH (see Fig. 3)	$E_{(BR)}$	>	100 mJ
Switching times (see Figs 4 and 5)			
I_{Con} = 5 A; $I_{Bon} = -I_{Boff}$ = 20 mA			←
turn-on time	t_{on}	typ.	1 μs
		<	2,5 μs
turn-off time	t_{off}	typ.	6,0 μs
		<	10 μs
Small-signal current gain			
I_C = 5 A; V_{CE} = 3 V; f = 1 MHz	$\|h_{fe}\|$	typ.	20 ←

* Measured under pulse conditions $t_p \leq 300$ μs; $\delta < 2\%$.

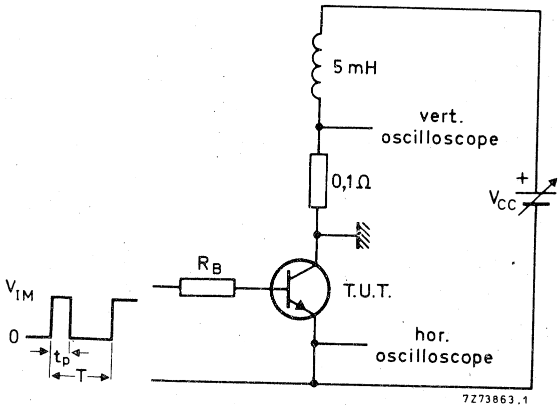


Fig. 3 Test circuit for turn-off breakdown energy.
V_{IM} = 12 V; R_B = 270 Ω;
t_p = 1 ms; δ = 1%.

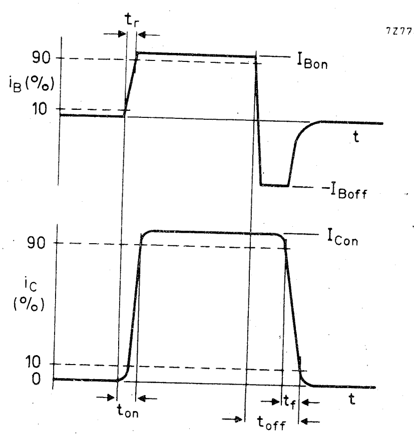
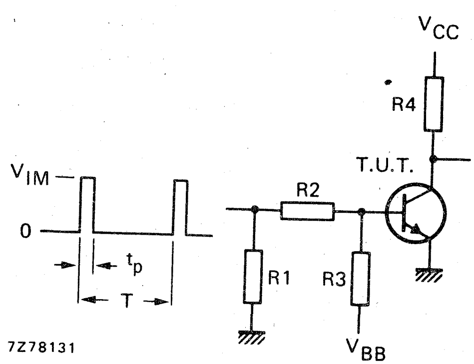


Fig. 4 Switching times waveforms.



V_{CC} = 30 V
V_{IM} = 15 V
$-V_{BB}$ = 4 V
R1 = 56 Ω
R2 = 410 Ω
R3 = 560 Ω
R4 = 6 Ω
$t_r = t_f$ = 15 ns
t_p = 10 μs
T = 500 μs

Fig. 5 Switching times test circuit.

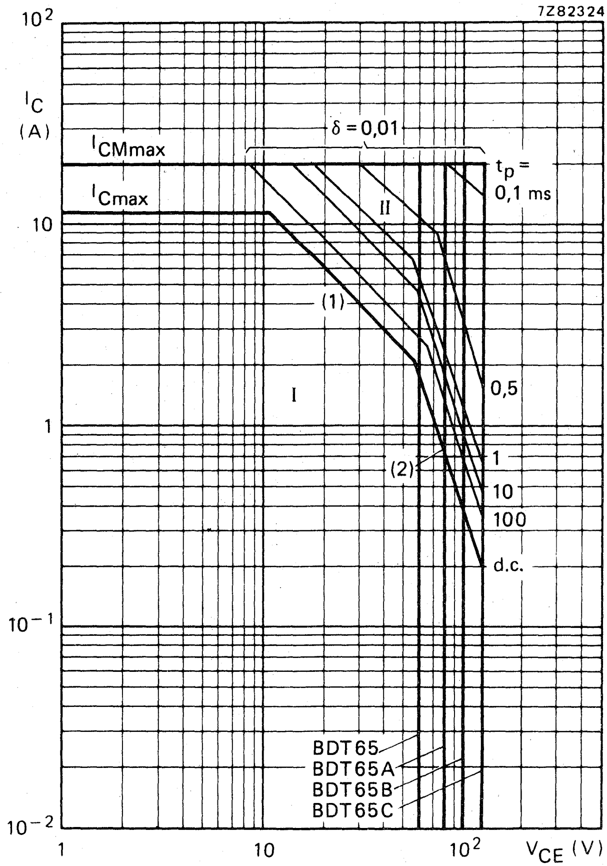


Fig. 6 Safe Operating ARea; T_{mb} = 25 °C.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.
(2) Second-breakdown limits (independent of temperature).

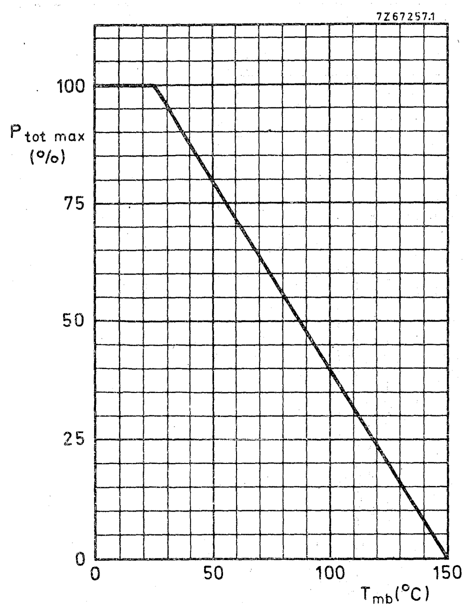


Fig. 7 Power derating curve.

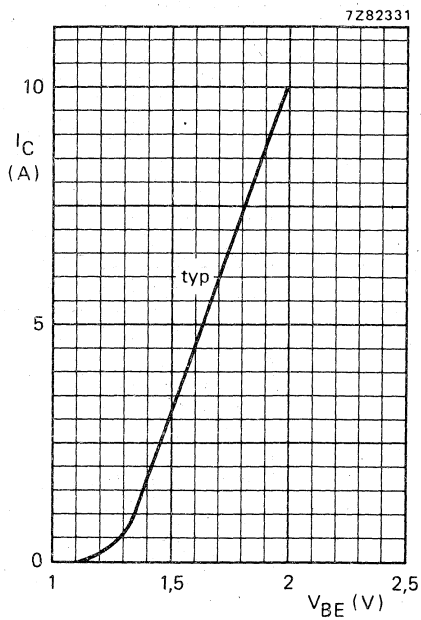


Fig. 8 Base-emitter voltage as a function of collector current. V_{CE} = 3 V; T_{amb} = 25 °C.

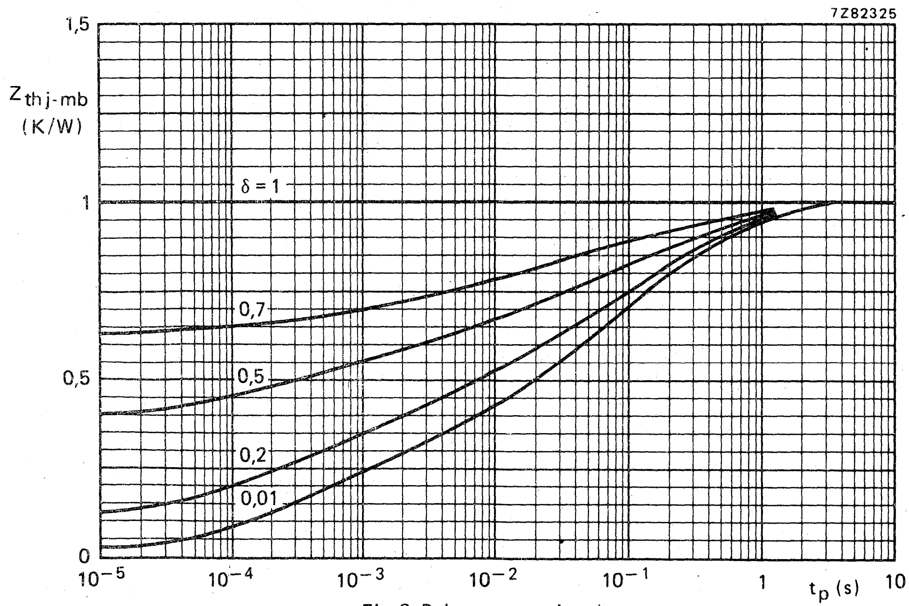


Fig. 9 Pulse power rating chart.

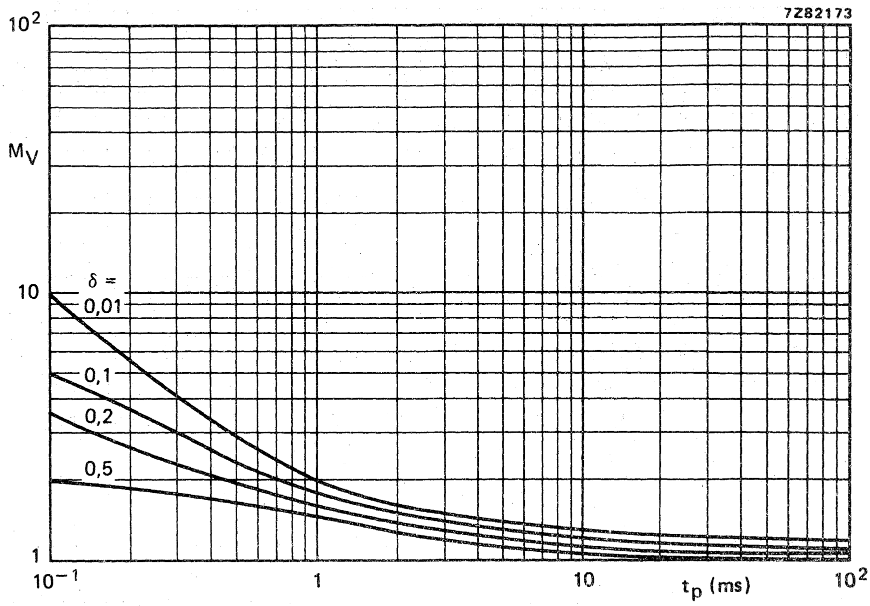


Fig. 10 S.B. voltage multiplying factor at the I_{Cmax} level.

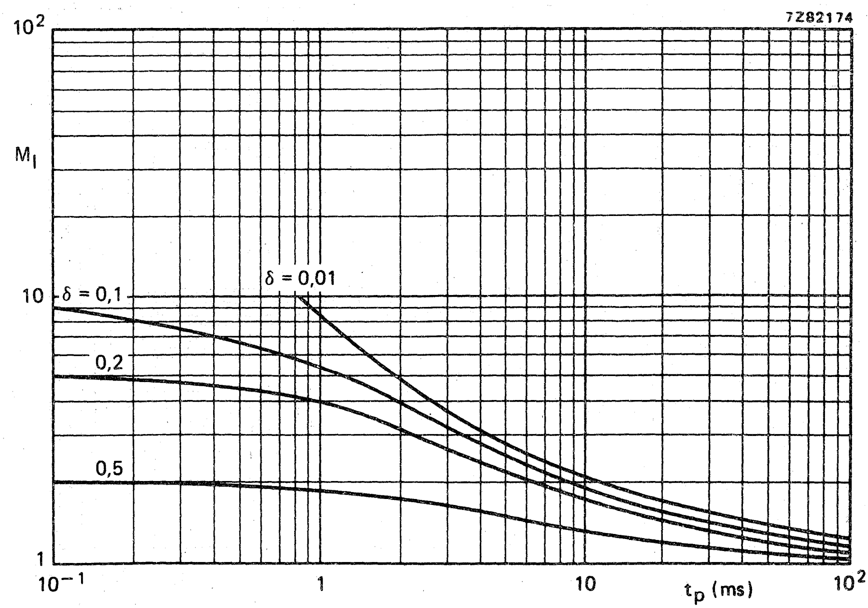


Fig. 11 S.B. current multiplying factor at the V_{CEOmax} level.

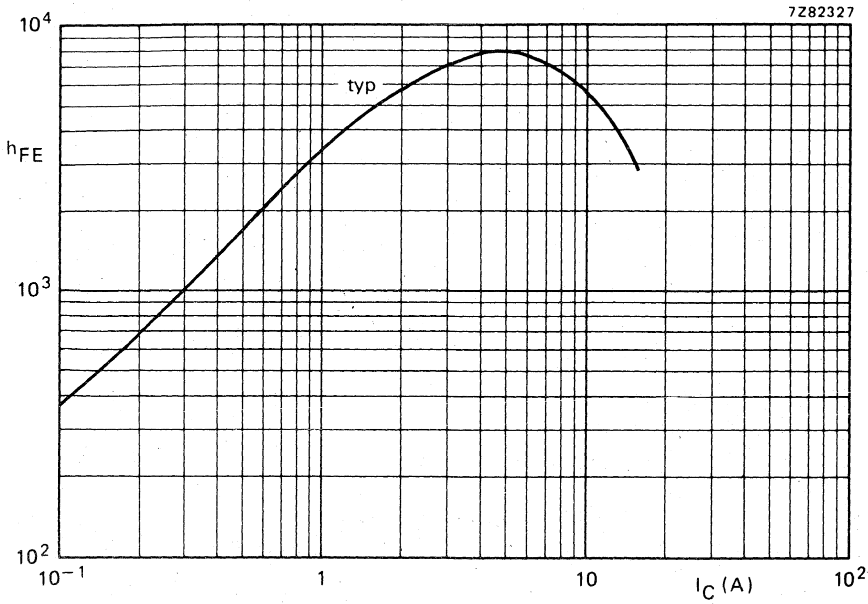


Fig. 12 Typical d.c. current gain as a function of collector current; V_{CE} = 3 V; T_j = 25 °C.

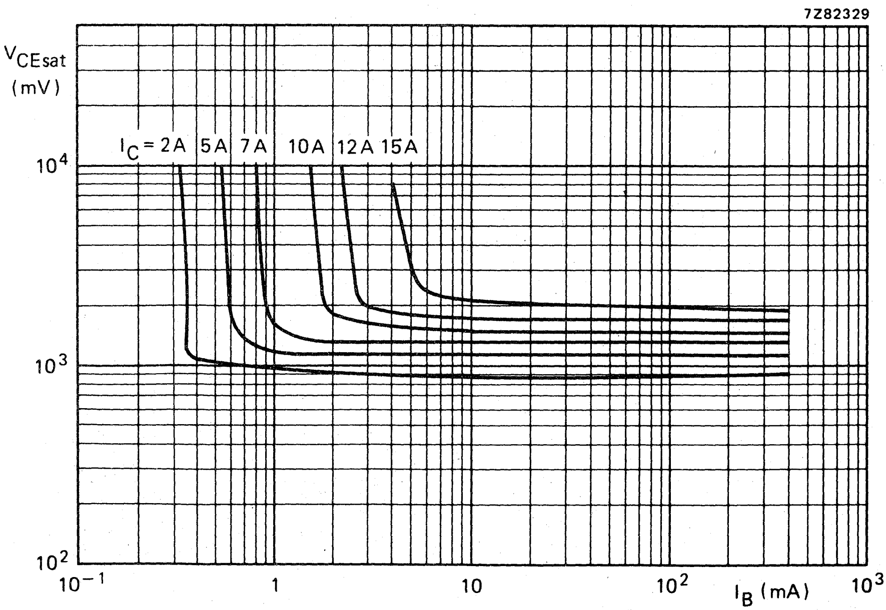


Fig. 13 Typical collector-emitter saturation voltages.

SILICON EPITAXIAL BASE POWER TRANSISTORS

N-P-N transistors in a plastic envelope intended for use in audio output stages and general amplifier and switching applications.
P-N-P complements are BDT92, BDT94 and BDT96.

QUICK REFERENCE DATA

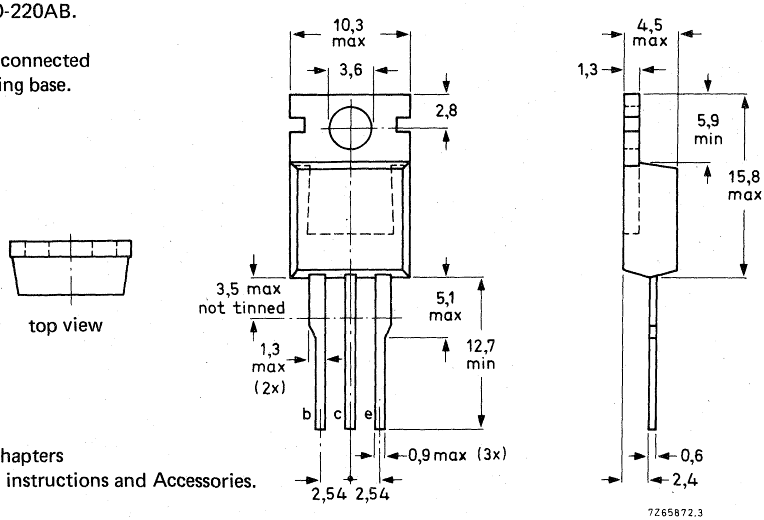
			BDT91	BDT93	BDT95	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	V
Collector current (d.c.)	I_C	max.		10		A
Collector current (peak value)	I_{CM}	max.		20		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		90		W
Junction temperature	T_j	max.		150		°C
D.C. current gain						
I_C = 4 A; V_{CE} = 4 V	h_{FE}			20 to 200		
I_C = 10 A; V_{CE} = 4 V	h_{FE}	>		5		
Transition frequency						
I_C = 0,5 A; V_{CE} = 10 V	f_T	>		4		MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.

Collector connected to mounting base.



See also chapters
Mounting instructions and Accessories.

RATINGS

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

			BDT91	BDT93	BDT95	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.		7		V
Collector current (d.c.)	I_C	max.		10		A
Collector current (peak value)	I_{CM}	max.		20		A
Base current (d.c.)	I_B	max.		4		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		90		W
Storage temperature	T_{stg}			−65 to +150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,39	°C/W
From junction to ambient (in free air)	$R_{th\ j\text{-}a}$	=	70	°C/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	<	0,1	mA
$I_E = 0$; $V_{CB} = ½V_{CBOmax}$; T_j = 150 °V	I_{CBO}	<	5	mA
$I_B = 0$; $V_{CE} = V_{CEOmax}$	I_{CEO}	<	1	mA
Emitter cut-off current				
$I_C = 0$; V_{EB} = 7 V	I_{EBO}	<	1	mA
D.C. current gain (note 1)				
I_C = 4 A; V_{CE} = 4 V	h_{FE}		20 to 200	
I_C = 10 A; V_{CE} = 4 V	h_{FE}	>	5	
Base-emitter voltage (notes 1 and 2)				
I_C = 4 A; V_{CE} = 4 V	V_{BE}	<	1,6	V
Collector-emitter saturation voltage (note 1)				
I_C = 4 A; I_B = 0,4 A	V_{CEsat}	<	1	V
I_C = 10 A; I_B = 3,3 A	V_{CEsat}	<	3	V
Transition frequency at f = 1 MHz				
I_C = 0,5 A; V_{CE} = 10 V	f_T	>	4	MHz
Cut-off frequency				
I_C = 0,5 A; V_{CE} = 10 V	f_{hfe}	>	20	kHz

Notes
1. Measured under pulse conditions: $t_p \leq 300\ \mu s$; $\delta \leq 2\%$.
2. V_{BE} decreases by about 2,3 mV/°C with increasing temperature.

Second-breakdown collector current V_{CE} = 60 V; t_p = 0,1 s	$I_{(SB)}$	>	1,5 A
Switching times (between 10% and 90% levels) I_{Con} = 4 A; I_{Bon} = $-I_{Boff}$ = 0,4 A			
Turn-on time	t_{on}	typ.	0,5 μs
		<	1 μs
Turn-off time	t_{off}	typ.	2 μs
		<	4 μs

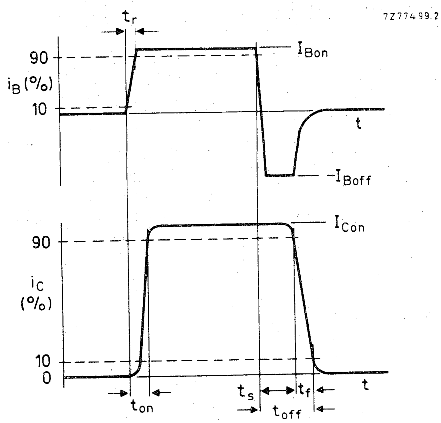


Fig. 2 Switching times waveforms.

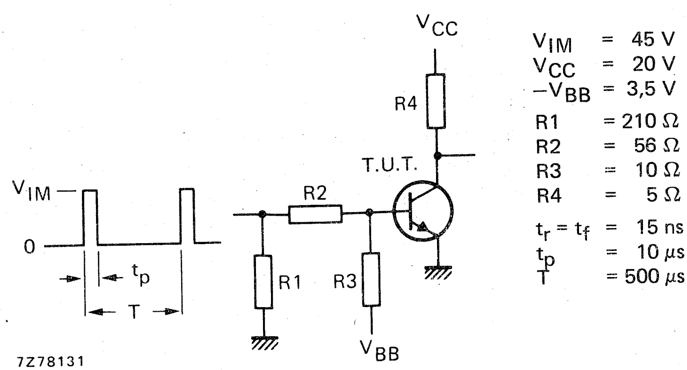


Fig. 3 Switching times test circuit.

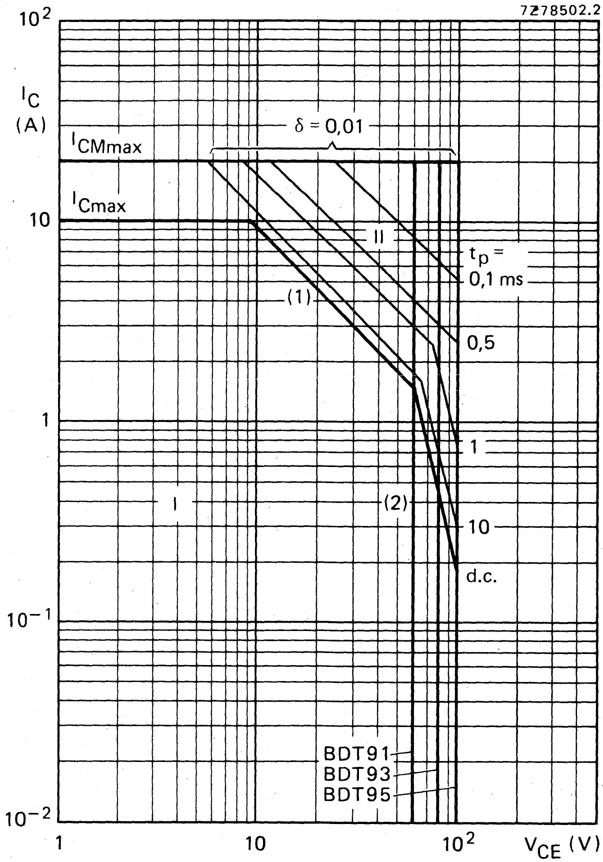


Fig. 4 Safe Operating ARea; T_{mb} = 25 °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.

(2) Second-breakdown limits (independent of temperature).

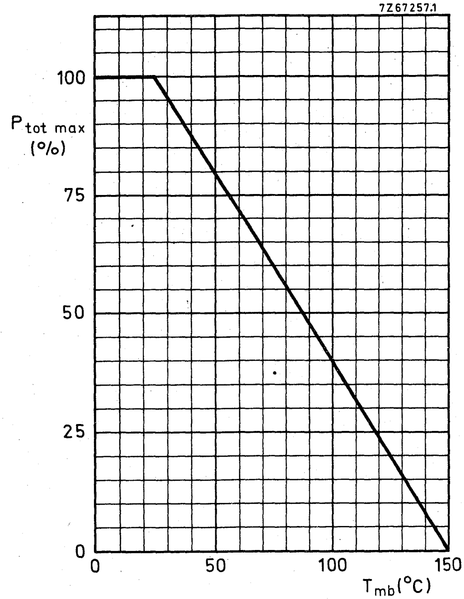


Fig. 5 Power derating curve.

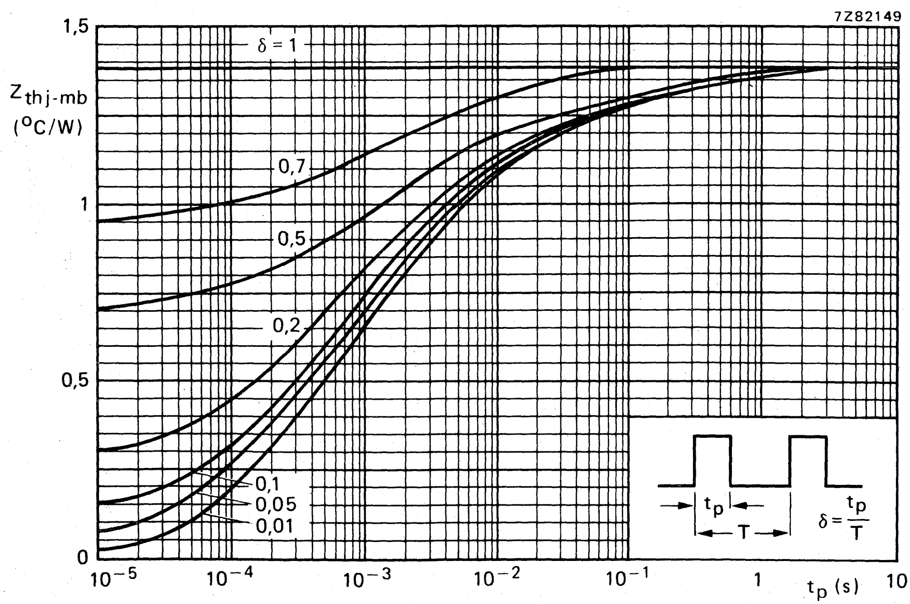


Fig. 6 Pulse power rating chart.

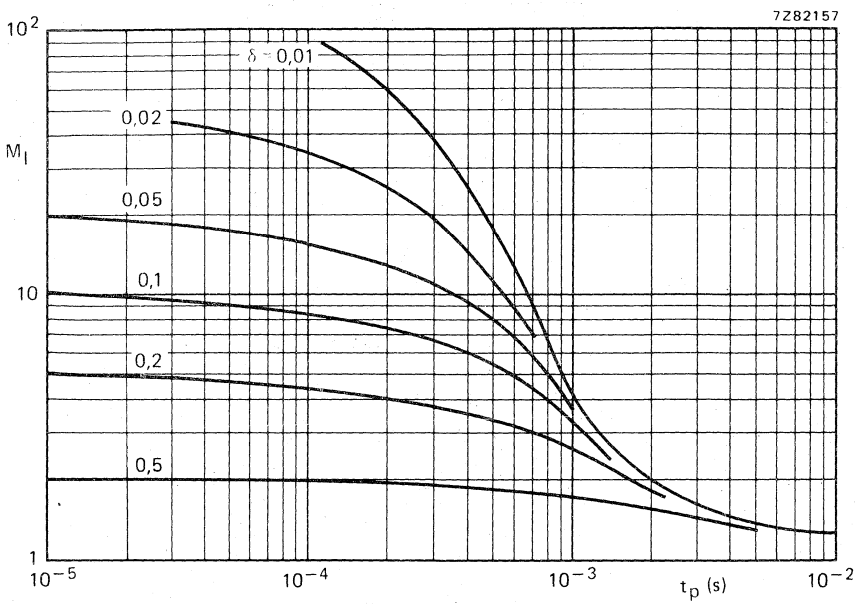


Fig. 7 S.B. current multiplying factor at the V_{CEOmax} level.

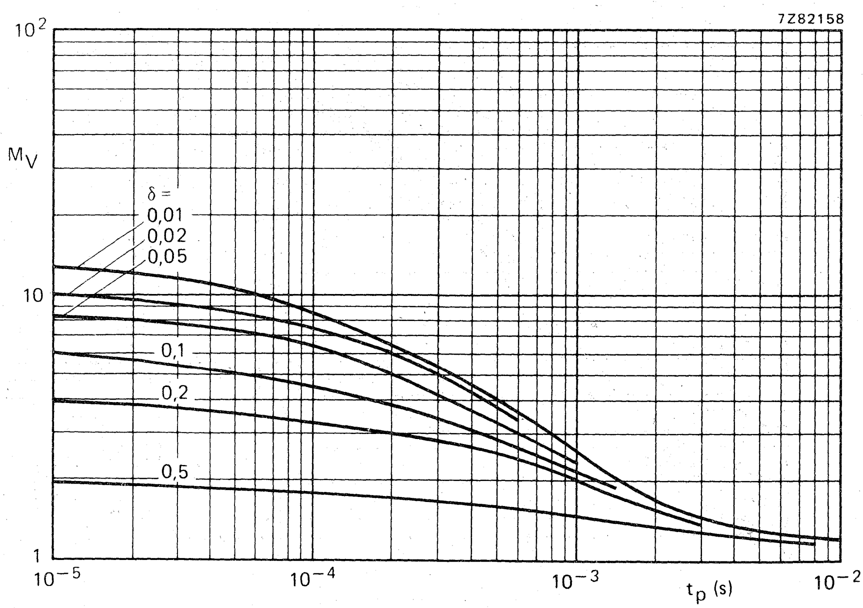


Fig. 8 S.B. voltage multiplying factor at the I_{Cmax} level.

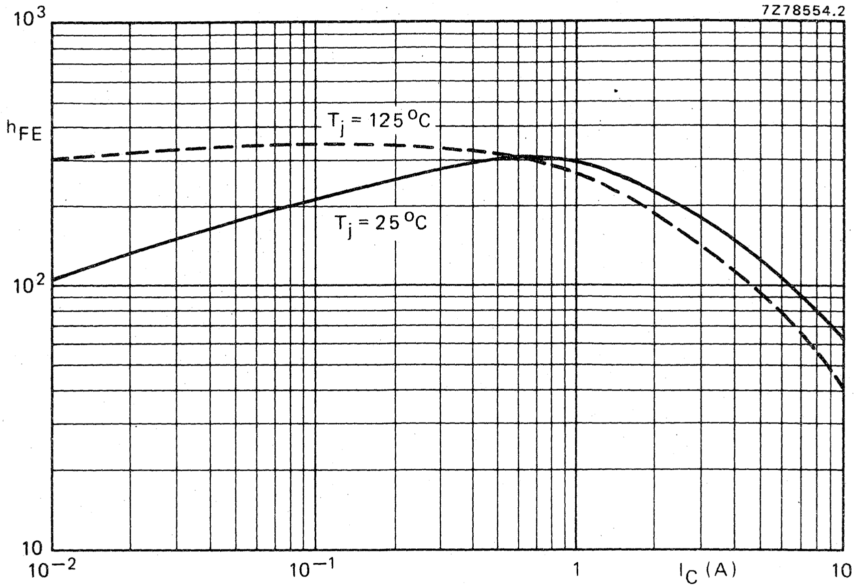


Fig. 9 Typical d.c. current gain at $V_{CE} = 4$ V.

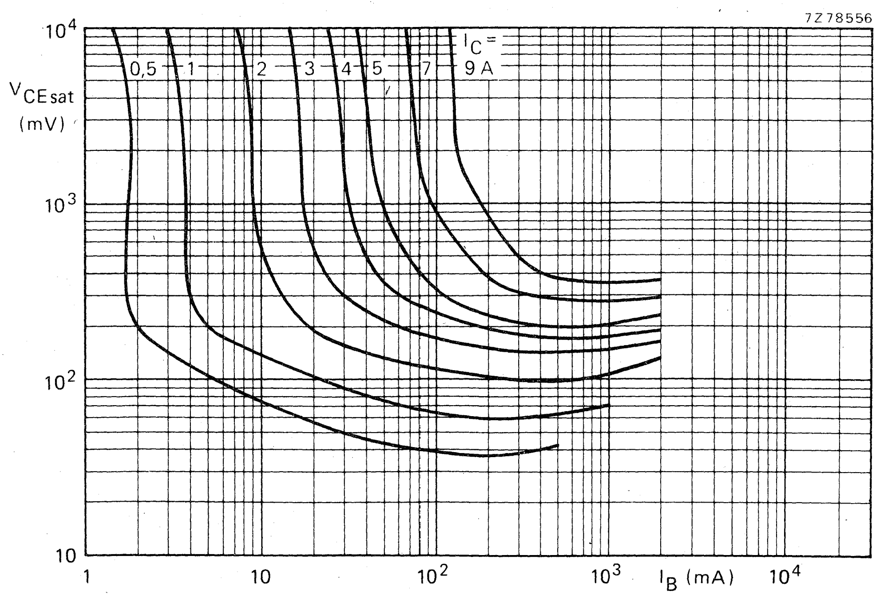


Fig. 10 Typical collector-emitter saturation voltage. $T_{mb} = 25\,^oC$.

SILICON EPITAXIAL BASE POWER TRANSISTORS

P-N-P transistors in a plastic envelope intended for use in audio output stages and general amplifier and switching applications.
N-P-N complements are BDT91, BDT93 and BDT95.

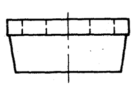
QUICK REFERENCE DATA

			BDT92	BDT94	BDT96	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	V
Collector current (d.c.)	$-I_C$	max.		10		A
Collector current (peak value)	$-I_{CM}$	max.		20		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		90		W
Junction temperature	T_j	max.		150		°C
D.C. current gain						
$-I_C$ = 4 A; $-V_{CE}$ = 4 V	h_{FE}			20 to 200		
$-I_C$ = 10 A; $-V_{CE}$ = 4 V	h_{FE}	>		5		
Transition frequency						
$-I_C$ = 0,5 A; $-V_{CE}$ = 10 V	f_T	>		4		MHz

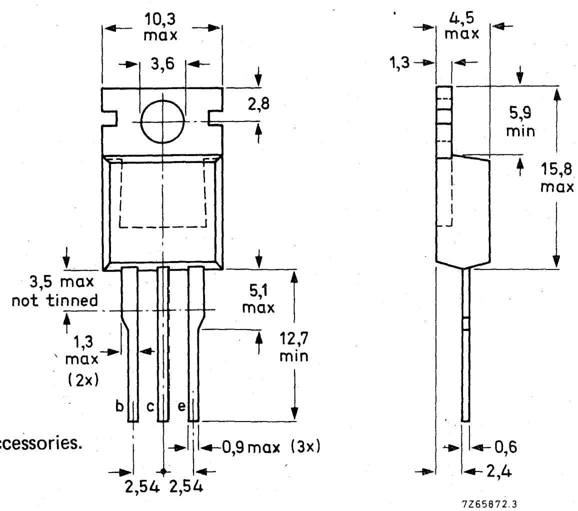
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220AB.



top view



See also chapters
Mounting instructions and Accessories.

RATINGS

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

			BDT92	BDT94	BDT96	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.		7		V
Collector current (d.c.)	$-I_C$	max.		10		A
Collector current (peak value)	$-I_{CM}$	max.		20		A
Base current (d.c.)	$-I_B$	max.		4		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		90		W
Storage temperature	T_{stg}			−65 to +150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,39	°C/W
From junction to ambient (in free air)	$R_{th\ j\text{-}a}$	=	70	°C/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0; -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	0,1	mA
$I_E = 0; -V_{CB} = -½V_{CBOmax}$; T_j = 150 °C	$-I_{CBO}$	<	5	mA
$I_B = 0; -V_{CE} = -V_{CEOmax}$	$-I_{CEO}$	<	1	mA
Emitter cut-off current				
$I_C = 0; -V_{EB} = 7$ V	$-I_{EBO}$	<	1	mA
D.C. current gain (note 1)				
$-I_C = 4$ A; $-V_{CE} = 4$ V	h_{FE}		20 to 200	
$-I_C = 10$ A; $-V_{CE} = 4$ V	h_{FE}	>	5	
Base-emitter voltage (notes 1 and 2)				
$-I_C = 4$ A; $-V_{CE} = 4$ V	$-V_{BE}$	<	1,6	V
Collector-emitter saturation voltage (note 1)				
$-I_C = 4$ A; $-I_B = 0,4$ A	$-V_{CEsat}$	<	1	V
$-I_C = 10$ A; $-I_B = 3,3$ A	$-V_{CEsat}$	<	3	V
Transition frequency at f = 1 MHz				
$-I_C = 0,5$ A; $-V_{CE} = 10$ V	f_T	>	4	MHz
Cut-off frequency				
$-I_C = 0,5$ A; $-V_{CE} = 10$ V	f_{hfe}	>	20	kHz

Notes
1. Measured under pulse conditions: $t_p \leq 300\ \mu s$; $\delta \leq 2\%$.
2. V_{BE} decreases by about 2,3 mV/°C with increasing temperature.

Second-breakdown collector current $-V_{CE}$ = 60 V; t_p = 0,1 s	$-I_{(SB)}$	<	0,6 A
Switching times (between 10% and 90% levels) $-I_{Con}$ = 4 A; $-I_{Bon}$ = $+I_{Boff}$ = 0,4 A			
Turn-on time	t_{on}	typ.	0,3 µs
Turn-off time	t_{off}	typ.	1,5 µs

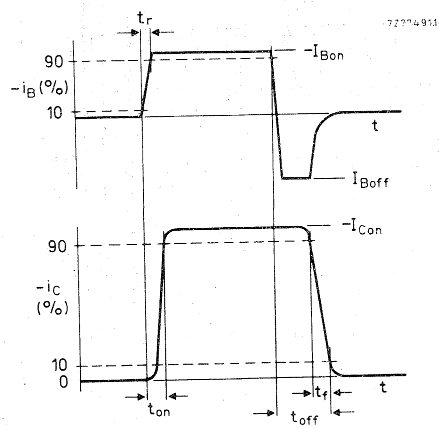


Fig. 2 Switching times waveforms.

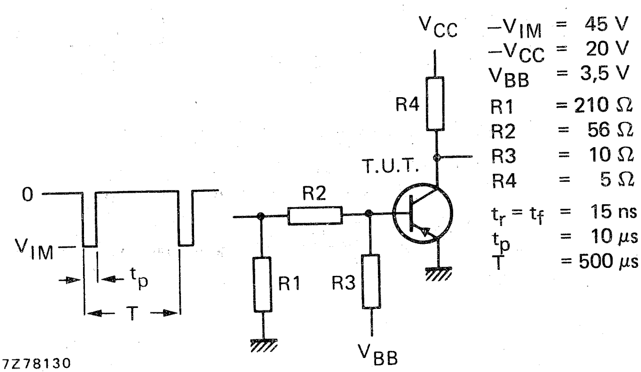


Fig. 3 Switching times test circuit.

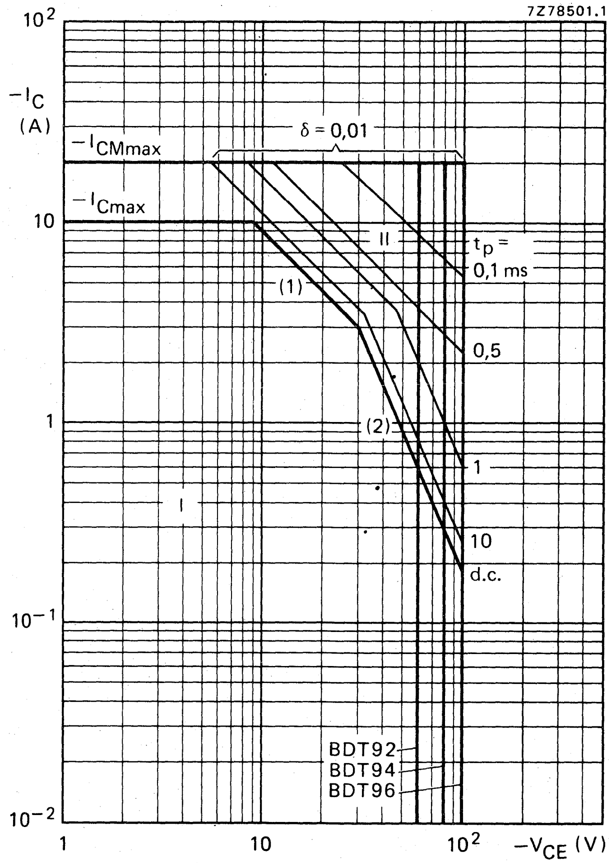


Fig. 4 Safe Operating ARea; T_{mb} = 25 °C.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second-breakdown limits (independent of temperature).

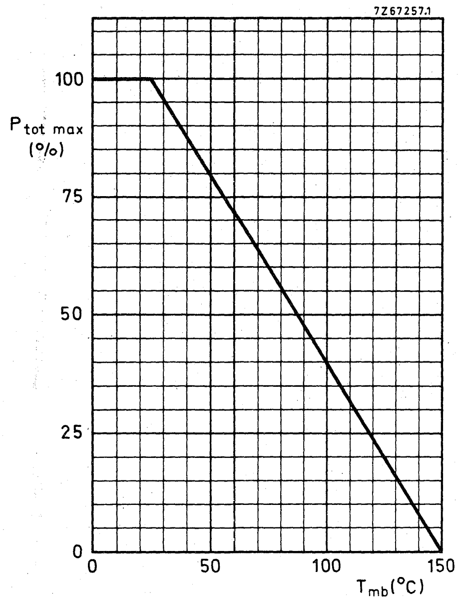


Fig. 5 Power derating curve.

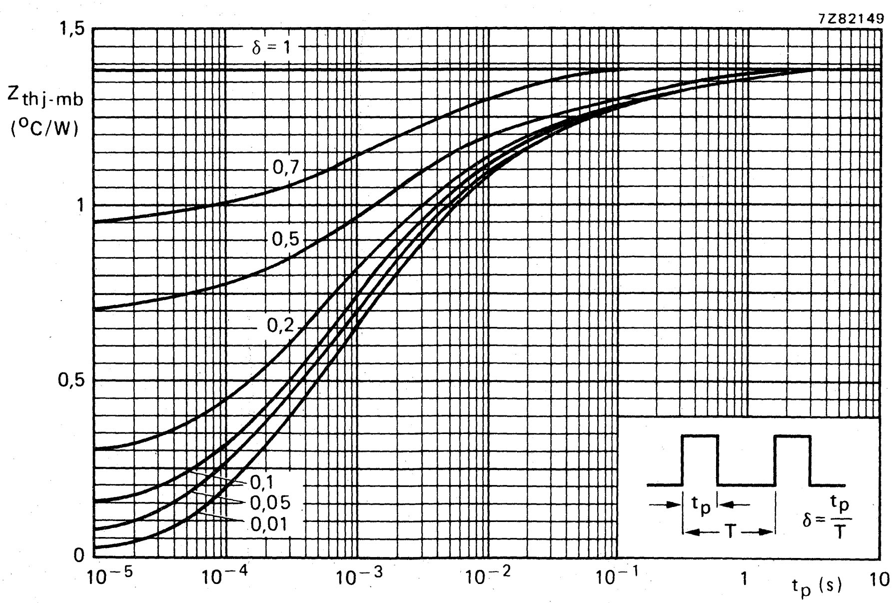


Fig. 6 Pulse power rating chart.

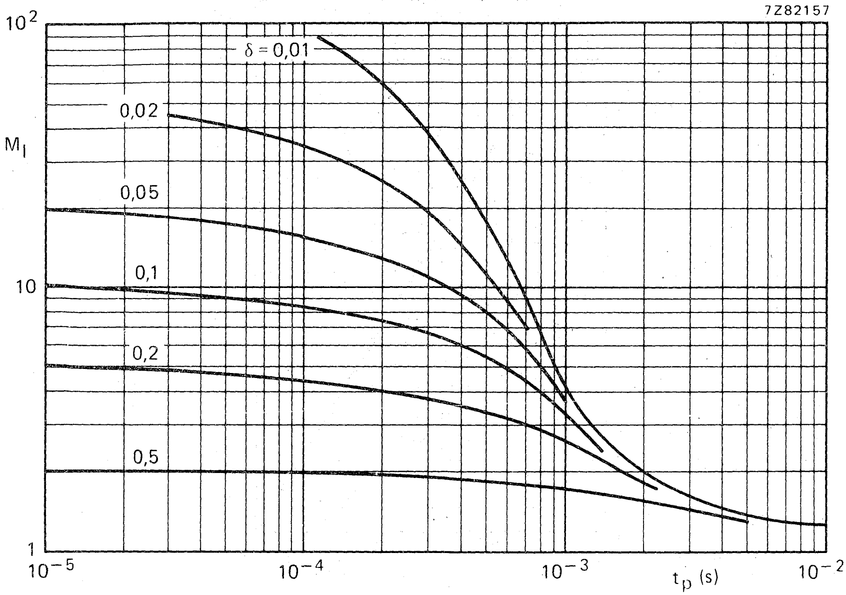


Fig. 7 S.B. current multiplying factor at the V_{CEOmax} level.

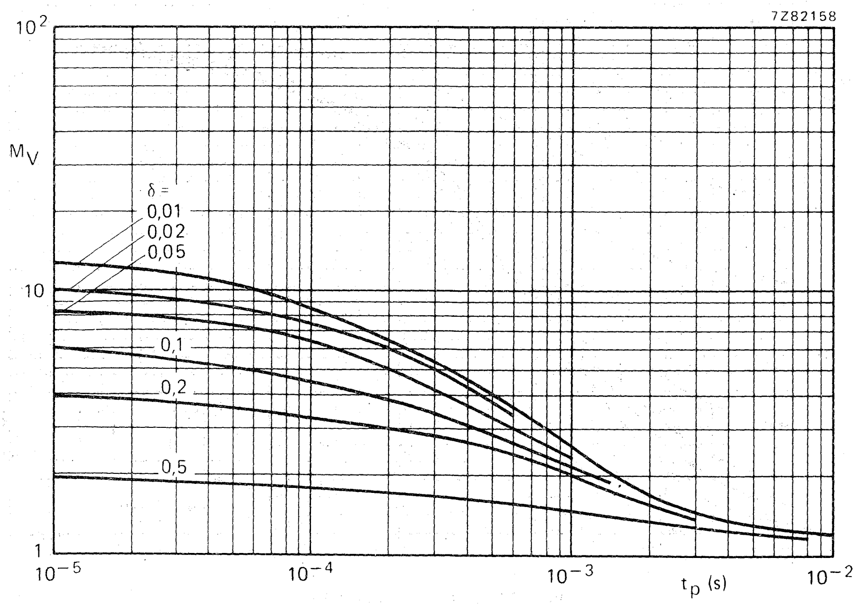


Fig. 8 S.B. voltage multiplying factor at the I_{Cmax} level.

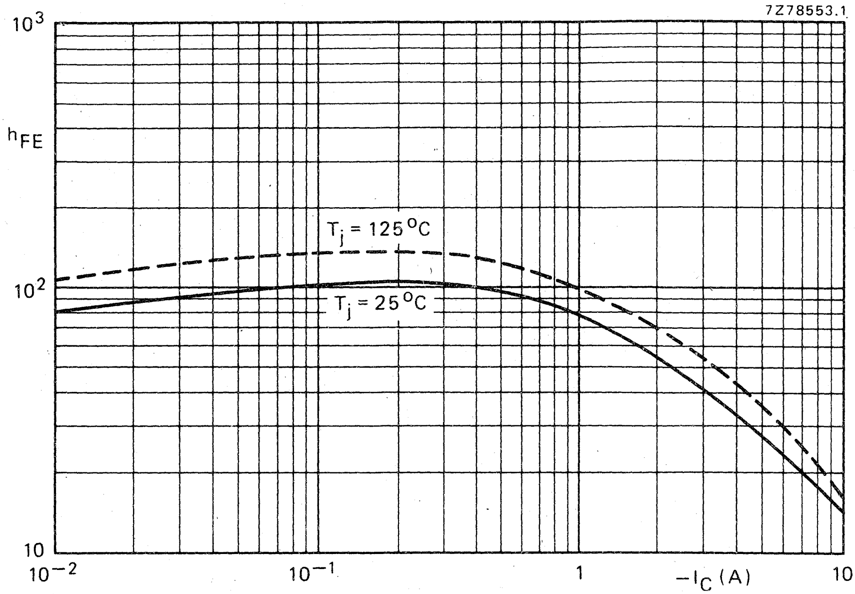


Fig. 9 Typical d.c. current gain at $-V_{CE} = 4$ V.

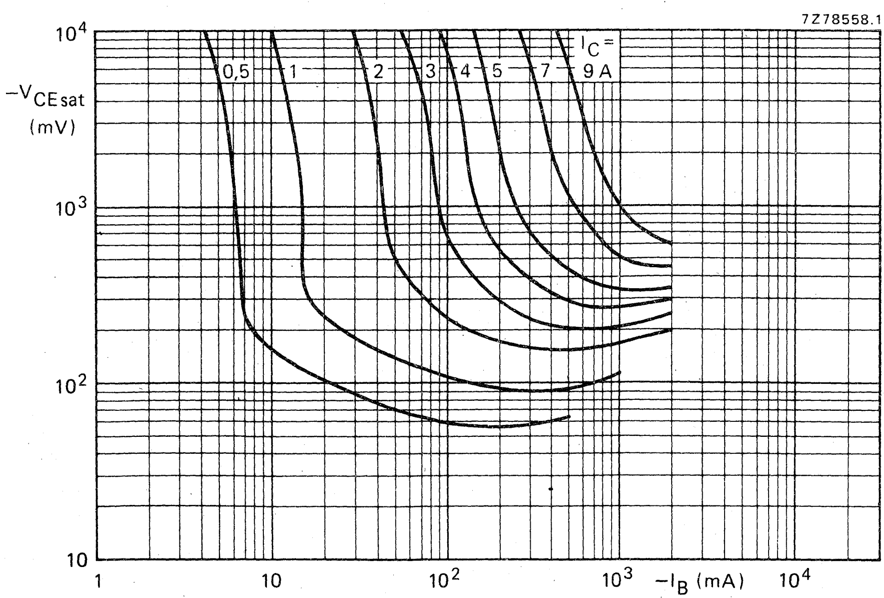


Fig. 10 Typical collector-emitter saturation voltage. $T_{mb} = 25\,^oC$.

SILICON DARLINGTON POWER TRANSISTORS

P-N-P epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications. N-P-N complements are BDV65, 65A, 65B and 65C. Matched complementary pairs can be supplied.

QUICK REFERENCE DATA

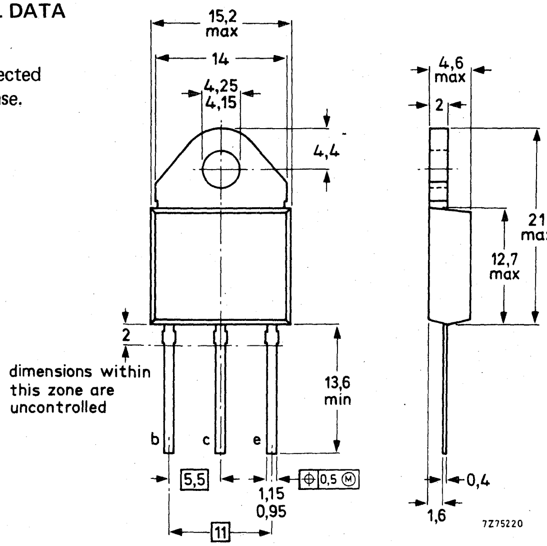
			BDV64	A	B	C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Collector current (peak value)	$-I_{CM}$	max.		20			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		125			W
Junction temperature	T_j	max.		150			°C
D.C. current gain							
$-I_C$ = 1 A; $-V_{CE}$ = 4 V	h_{FE}	typ.		1500			
$-I_C$ = 5 A; $-V_{CE}$ = 4 V	h_{FE}	>		1000			
Cut-off frequency							
$-I_C$ = 5 A; $-V_{CE}$ = 4 V	f_{hfe}	typ.		100			kHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT-93.

Collector connected to mounting base.



See also chapters Mounting instructions and Accessories

CIRCUIT DIAGRAM

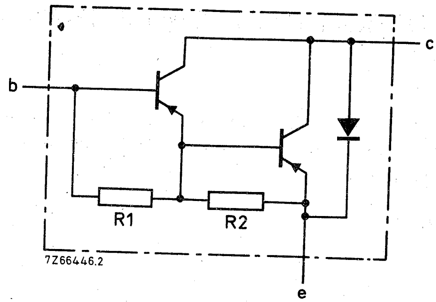


Fig. 2.
R1 typical 5 kΩ
R2 typical 80 Ω.

RATINGS

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

			BDV64	A	B	C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	5	V

Collector current (d.c.)	$-I_C$	max.	12	A
Collector current (peak value)	$-I_{CM}$	max.	20	A
Base current (d.c.)	$-I_B$	max.	0,5	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	125	W
Storage temperature	T_{stg}		−65 to + 150	°C
Junction temperature	T_j	max.	150	°C*

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1	K/W*

CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

Collector cut-off currents				
$I_E = 0; -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	400	μA
$I_E = 0; -V_{CB} = -½V_{CBOmax}$; T_j = 150 °C	$-I_{CBO}$	<	2	mA
$I_B = 0; -V_{CE} = -½V_{CEOmax}$	$-I_{CEO}$	<	1	mA
Emitter cut-off current				
$I_C = 0; -V_{EB} = 5$ V	$-I_{EBO}$	<	5	mA

* Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

D.C. current gain*			
$-I_C$ = 1 A; $-V_{CE}$ = 4 V	h_{FE}	typ.	1500
$-I_C$ = 5 A; $-V_{CE}$ = 4 V	h_{FE}	>	1000
$-I_C$ = 10 A; $-V_{CE}$ = 4 V	h_{FE}	typ.	1000
Base-emitter voltage*			
$-I_C$ = 5 A; $-V_{CE}$ = 4 V	$-V_{BE}$	<	2,5 V**
Collector-emitter saturation voltage*			
$-I_C$ = 5 A; $-I_B$ = 20 mA	$-V_{CEsat}$	<	2 V
Collector capacitance at f = 1 MHz			
$I_E = I_e = 0$; $-V_{CB}$ = 10 V	C_c	typ.	200 pF
Cut-off frequency			
$-I_C$ = 5 A; $-V_{CE}$ = 4 V	f_{hfe}	typ.	100 kHz
Diode, forward voltage			
I_F = 5 A	V_F	typ.	1,8 V
I_F = 12 A	V_F	typ.	2 V
D.C. current gain ratio of matched complementary pairs			
$-I_C$ = 5 A; $-V_{CE}$ = 3 V	h_{FE1}/h_{FE2}	max.	2,5
Switching times (see also Fig. 4)			
$-I_{Con}$ = 5 A; $-I_{Bon}$ = I_{Boff} = 20 mA; V_{CC} = −16 V			
Turn-on time	t_{on}	typ.	0,5 µs
Fall time	t_f	typ.	1,0 µs
Turn-off time	t_{off}	typ.	2,0 µs

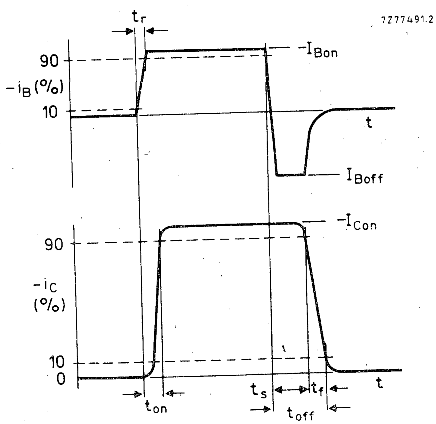
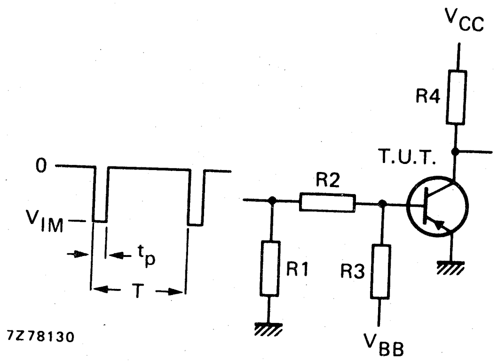


Fig. 3 Waveforms.

* Measured under pulse conditions: t_p < 300 µs; δ < 2%.
** $-V_{BE}$ decreases by about 3,6 mV/°C with increasing temperature.



$-V_{IM}$ = 16,5 V
$-V_{CC}$ = 16 V
V_{BB} = 6,5 V
R1 = 56 Ω
R2 = 410 Ω
R3 = 560 Ω
R4 = 3 Ω
$t_r = t_f$ = 15 ns
t_p = 10 μs
T = 500 μs

Fig. 4 Switching times test circuit.

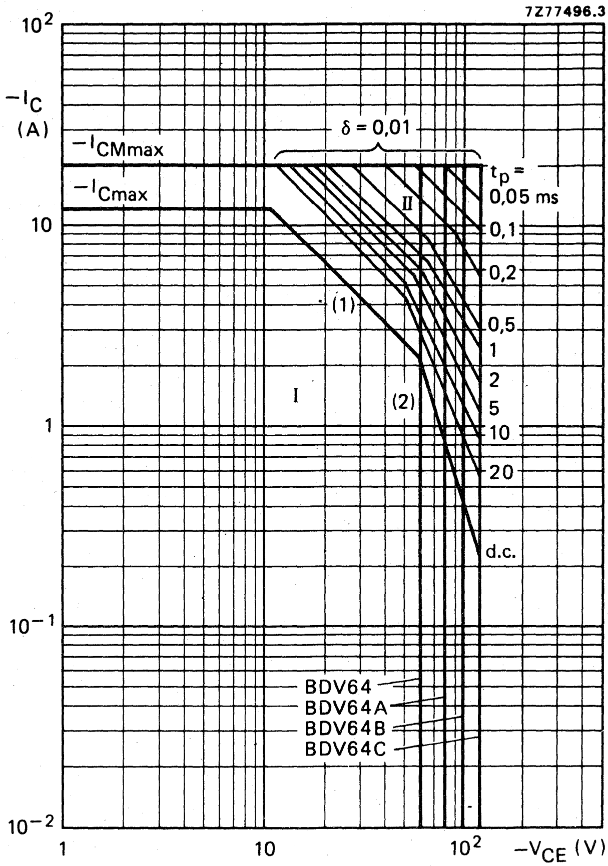


Fig. 5 Safe Operating ARea; $T_{mb} \leqslant 25$ °C.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second breakdown limits (independent of temperature).

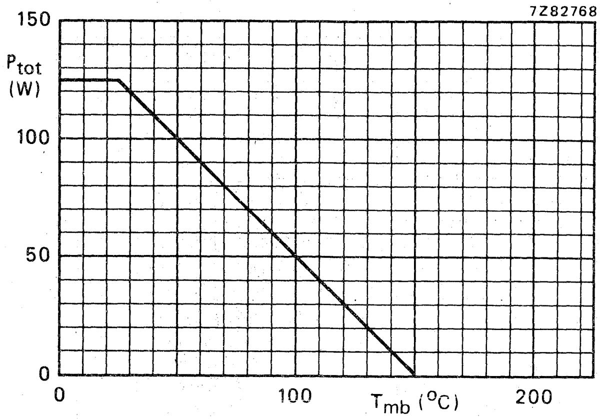


Fig. 6 Power derating curve.

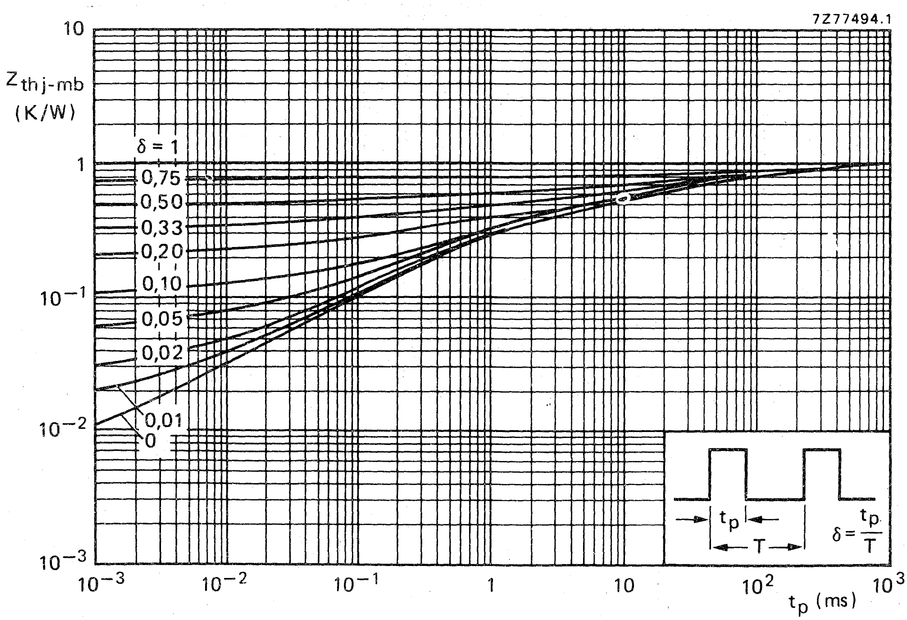


Fig. 7 Pulse power rating chart.

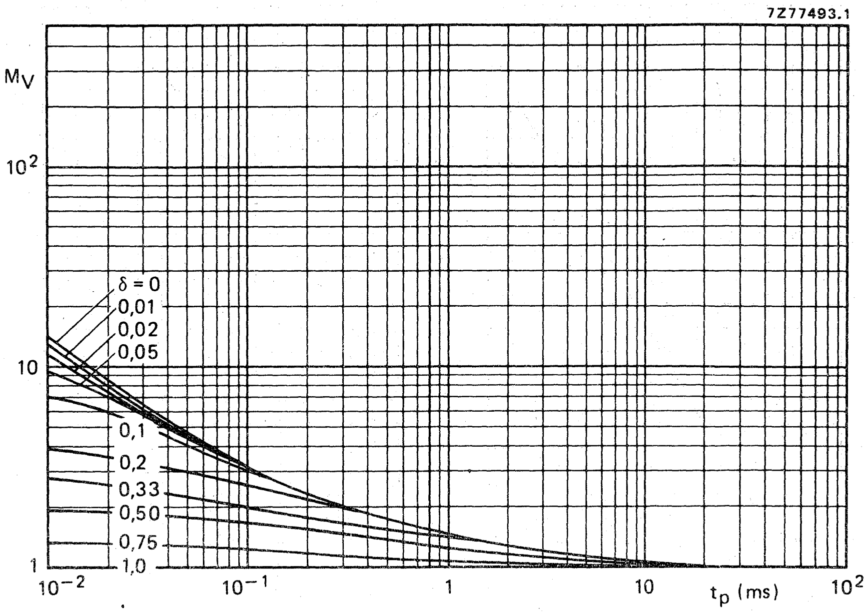


Fig. 8 S.B. voltage multiplying factor at the $-I_{Cmax}$ level.

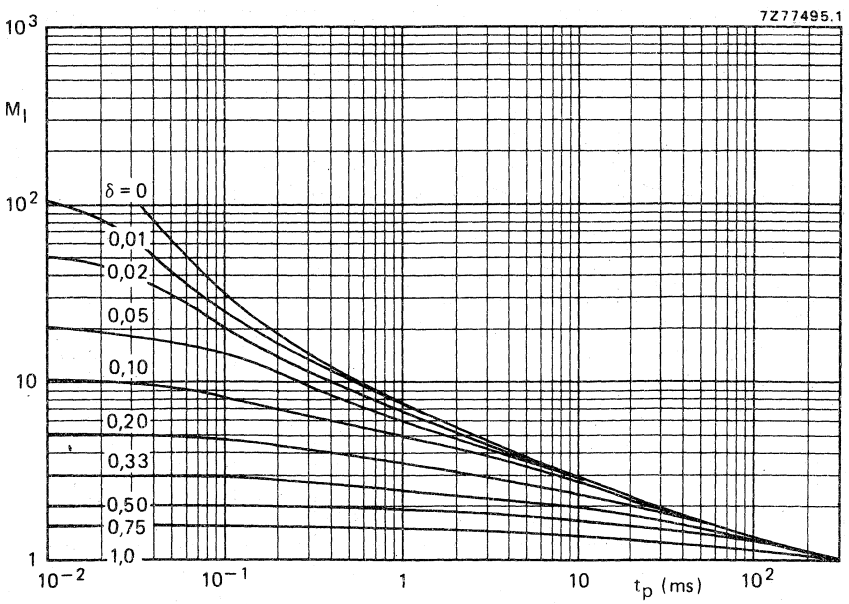


Fig. 9 S.B. current multiplying factor at the $-V_{CEOmax}$ level (100 V).

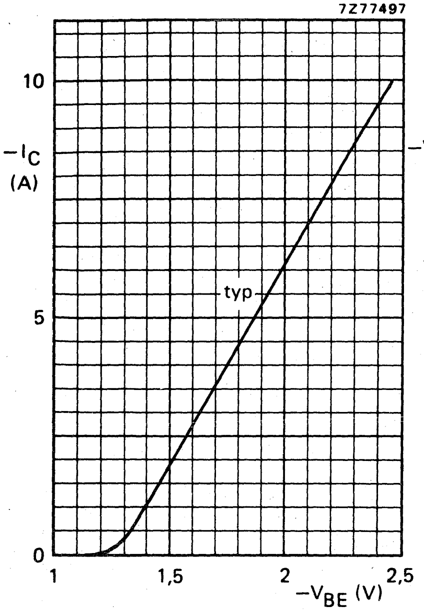


Fig. 10 $-V_{CE} = 4$ V; $T_j = 25$ °C.

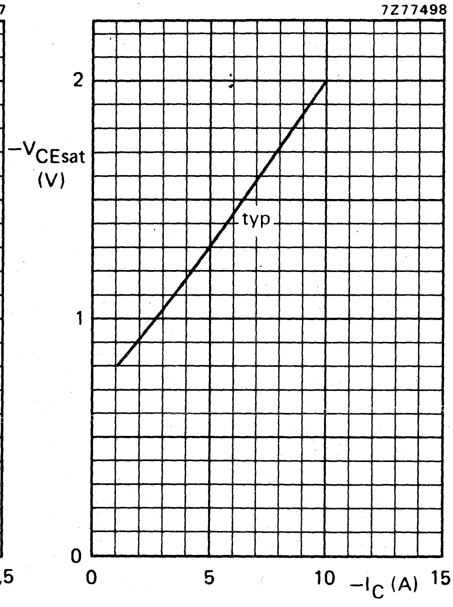


Fig. 11 $-I_C/I_B = 250$; $T_j = 25$ °C.

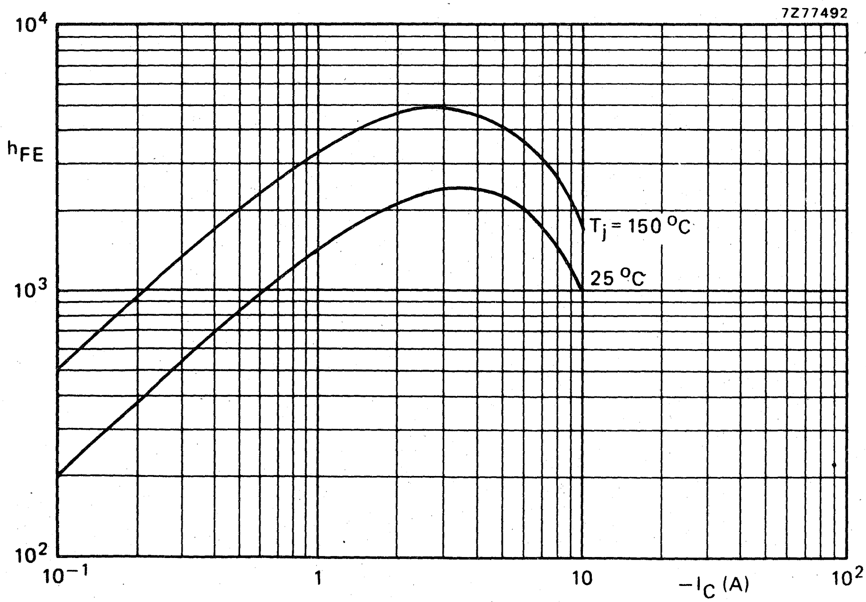


Fig. 12 Typical values; $-V_{CE} = 4$ V.

SILICON DARLINGTON POWER TRANSISTORS

N-P-N epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications. P-N-P complements are BDV64, 64B and 64C. Matched complementary pairs can be supplied.

QUICK REFERENCE DATA

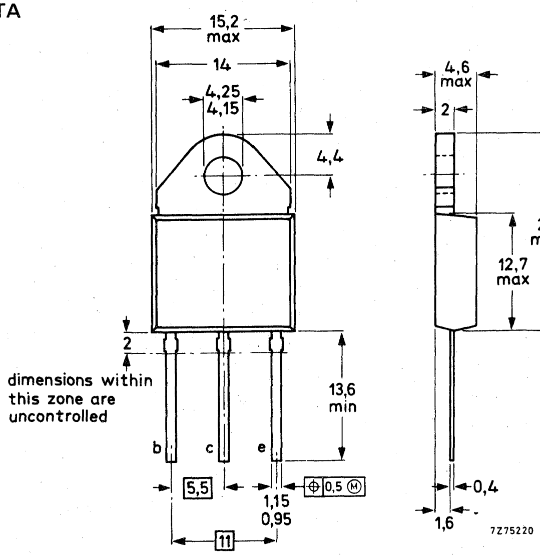
			BDV65	A	B	C	
Collector-base voltage (open emitter	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Collector current (peak value)	I_{CM}	max.	20				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	125				W
Junction temperature	T_j	max.	150				°C
D.C. current gain							
I_C = 1 A; V_{CE} = 4 V	h_{FE}	typ.	1500				
I_C = 5 A; V_{CE} = 4 V	h_{FE}	>	1000				
Cut-off frequency							
I_C = 5 A; V_{CE} = 4 V	f_{hfe}	typ.	70				kHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT-93.

Collector connected to mounting-base.



See also chapters Mounting instructions and Accessories in Handbook l.f. power transistors.

CIRCUIT DIAGRAM

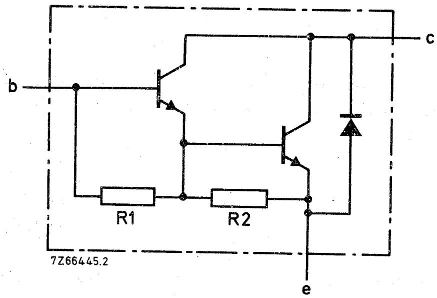


Fig. 2.
R1 typical 5 kΩ
R2 typical 80 Ω.

RATINGS

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

			BDV65	A	B	C	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	5	V

Collector current (d.c.)	I_C	max.	12	A
Collector current (peak value)	I_{CM}	max.	20	A
Base current (d.c.)	I_B	max.	0,5	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	125	W
Storage temperature	T_{stg}		−65 to + 150	°C
Junction temperature	T_j	max.	150	°C*

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1	K/W*

CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

Collector cut-off currents				
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	<	400	µA
$I_E = 0$; $V_{CB} = ½V_{CBOmax}$; T_j = 150 °C	I_{CBO}	<	2	mA
$I_B = 0$; $V_{CE} = ½V_{CEOmax}$	I_{CEO}	<	1	mA
Emitter cut-off current				
$I_C = 0$; V_{EB} = 5 V	I_{EBO}	<	5	mA

* Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

D.C. current gain*			
I_C = 1 A; V_{CE} = 4 V	h_{FE}	typ.	1500
I_C = 5 A; V_{CE} = 4 V	h_{FE}	>	1000
I_C = 10 A; V_{CE} = 4 V	h_{FE}	typ.	1750
Base-emitter voltage*			
I_C = 5 A; V_{CE} = 4 V	V_{BE}	<	2,5 V**
Collector-emitter saturation voltage*			
I_C = 5 A; I_B = 20 mA	V_{CEsat}	<	2 V
Collector capacitance at f = 1 MHz			
$I_E = I_e = 0$; V_{CB} = 10 V	C_c	typ.	150 pF
Cut-off frequency			
I_C = 5 A; V_{CE} = 4 V	f_{hfe}	typ.	70 kHz
Diode, forward voltage			
I_F = 5 A	V_F	typ.	1,2 V
I_F = 12 A	V_F	typ.	2 V ←
D.C. current gain ratio of matched complementary pairs			
I_C = 5 A; V_{CE} = 3 V	h_{FE1}/h_{FE2}	<	2,5
Switching times (see also Fig. 4)			
I_{Con} = 5 A; $I_{Bon} = -I_{Boff}$ = 20 mA; V_{CC} = 16 V			
Turn-on time	t_{on}	typ.	1 μs
Fall time	t_f	typ.	3 μs
Turn-off time	t_{off}	typ.	6 μs

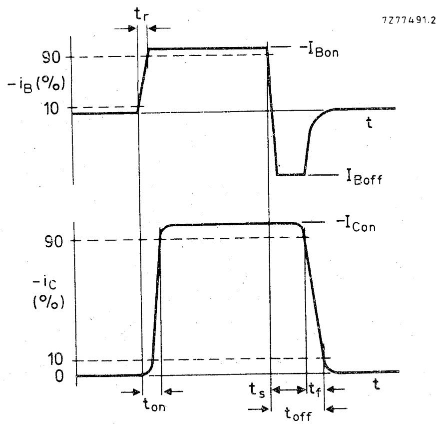
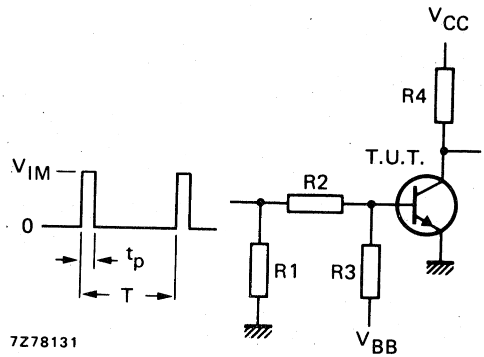


Fig. 3 Waveforms showing t_{on}; $t_s + t_f = t_{off}$.

* Measured under pulse conditions: $t_p < 300$ μs; $\delta < 2\%$.
** V_{BE} decreases by about 3,6 mV/°C with increasing temperature.



V_{1M} = 16,5 V
V_{CC} = 16 V
V_{BB} −6,5 V
R1 = 56 Ω
R2 = 410 Ω
R3 = 560 Ω
R4 = 3 Ω
$t_r = t_f$ = 15 ns
t_p = 10 μs
T = 500 μs

Fig. 4 Switching times test circuit.

Turn-off breakdown energy with inductive load (see also Fig. 5).

I_{Con} = 6,3 A; $-I_{Boff}$ = 0; t_p = 1 ms; T = 100 ms $\qquad E_{(BR)} > 100$ mJ

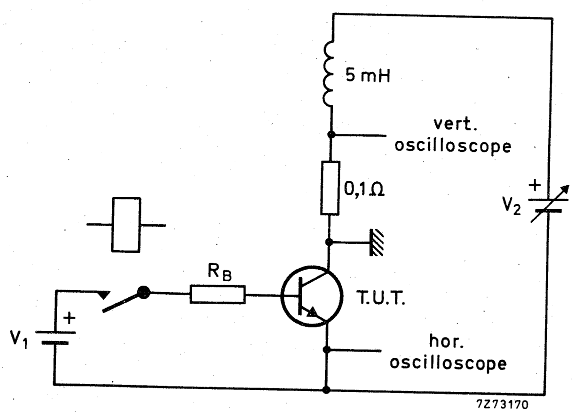


Fig. 5 Test circuit; V_1 = 12 V; R_B = 270 Ω.

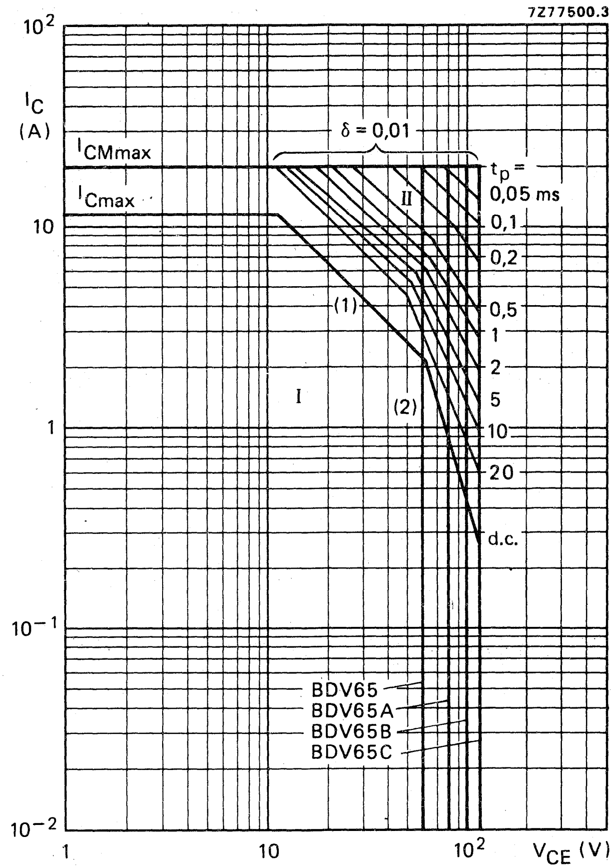


Fig. 6 Safe Operating ARea; $T_{mb} \leqslant 25\ ^oC$.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.
(2) Second breakdown limits (independent of temperature).

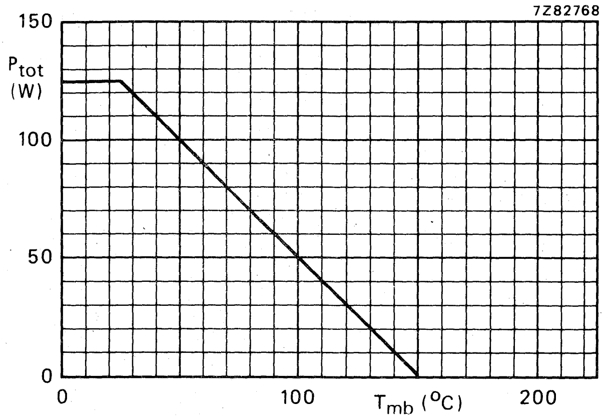


Fig. 7 Power derating curve.

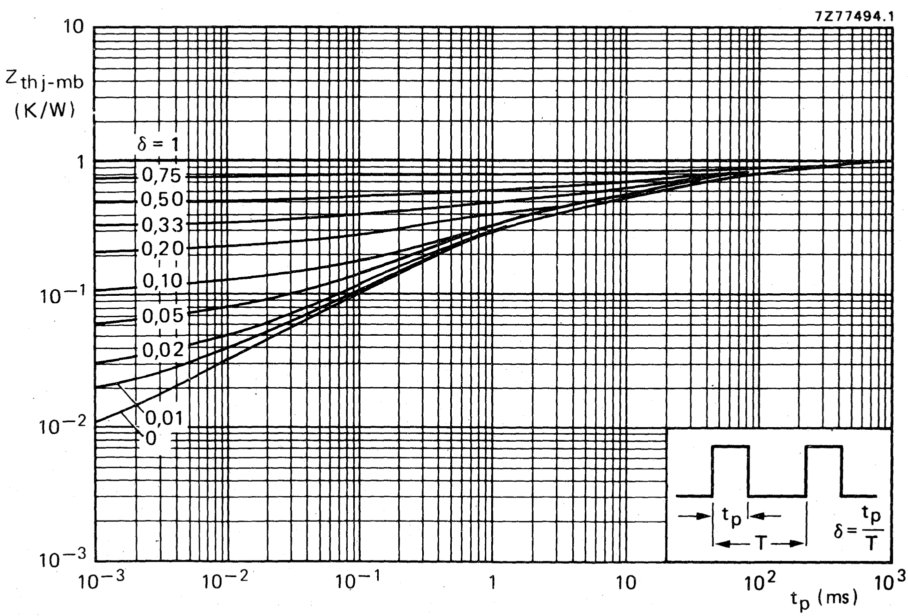


Fig. 8 Pulse power rating chart.

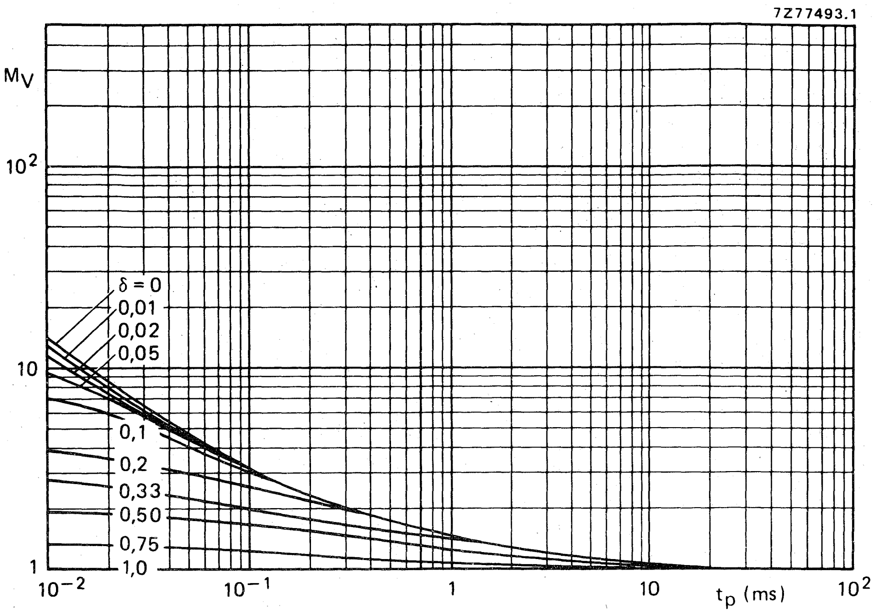


Fig. 9 S.B. voltage multiplying factor at the I_{Cmax} level.

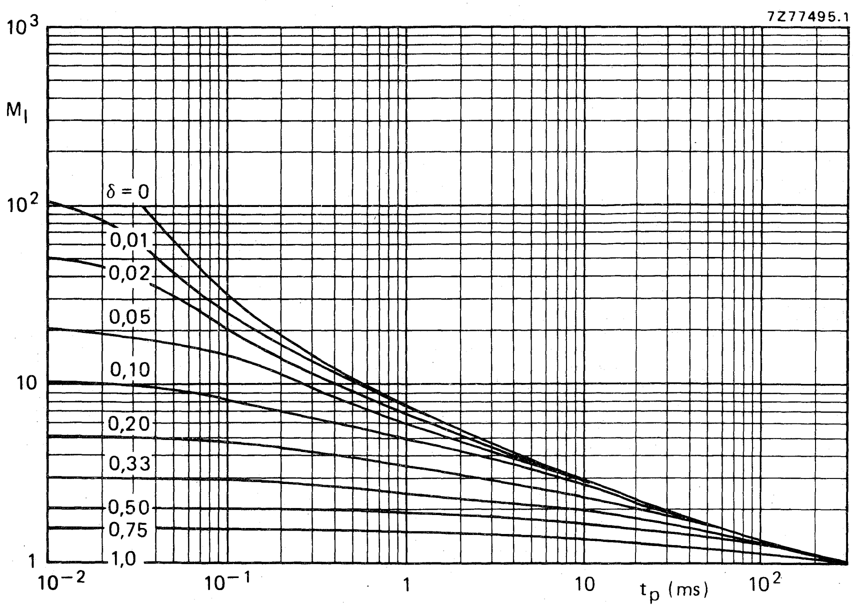


Fig. 10 S.B. current multiplying factor at the V_{CEOmax} level (100 V).

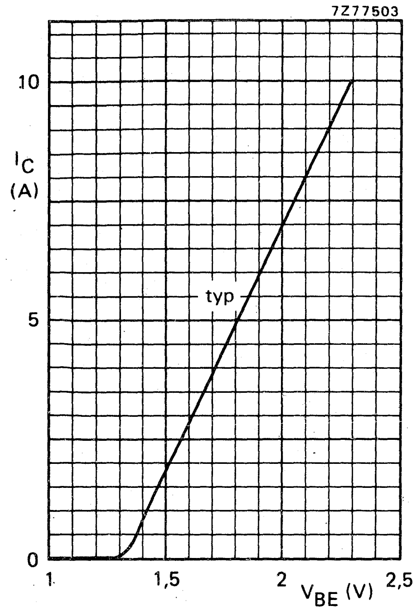


Fig. 11 V_{CE} = 4 V; T_j = 25 °C.

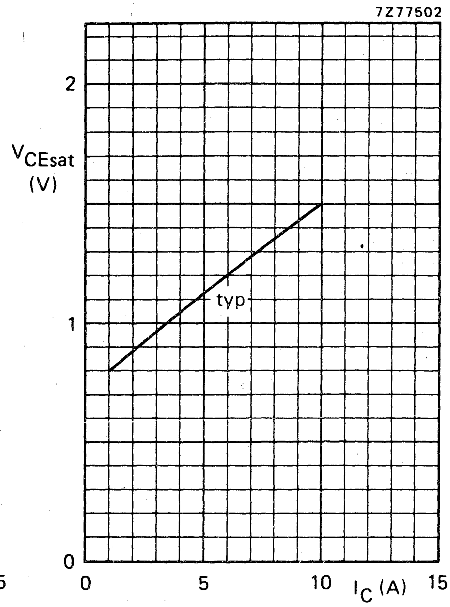


Fig. 12 I_C/I_B = 250; T_j = 25 °C.

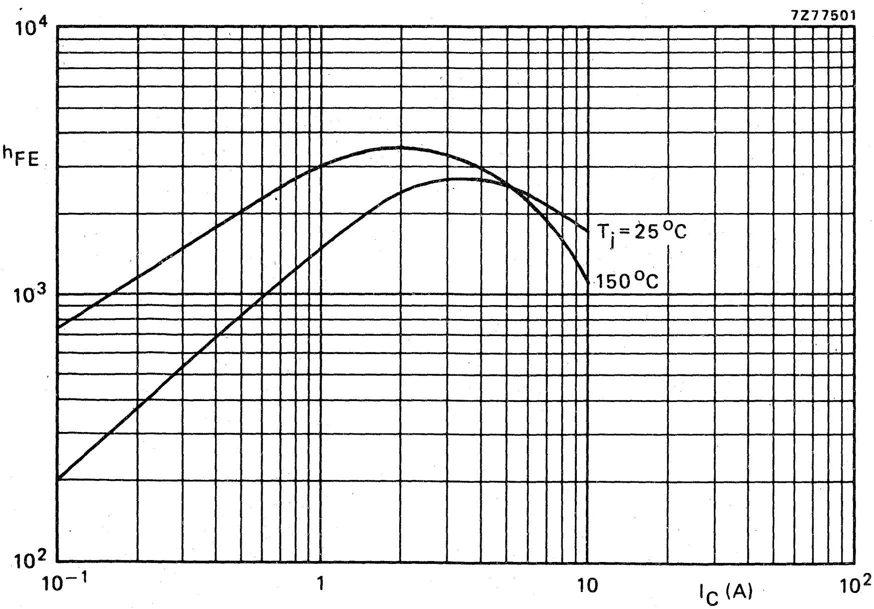


Fig. 13 Typical values; V_{CE} = 4 V.

SILICON POWER TRANSISTORS

N-P-N epitaxial base power transistors in the plastic SOT-93 envelope. These transistors are intended for use in audio output stages and general amplifier and switching applications.

P-N-P complements are BDV92, BDV94 and BDV96.

QUICK REFERENCE DATA

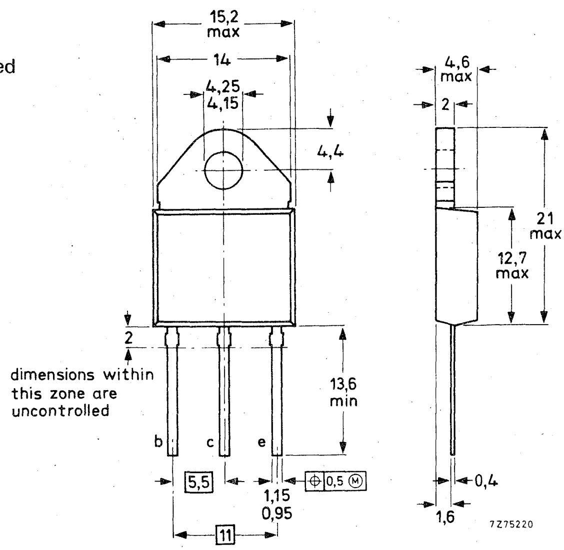
			BDV91	BDV93	BDV95	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	V
Collector current (peak value)	I_{CM}	max.		20		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		100		W
Junction temperature	T_j	max.		150		°C
D.C. current gain I_C = 4 A; V_{CE} = 4 V	h_{FE}	>		20		
Transition frequency I_C = 0,5 A; V_{CE} = 10 V	f_T	>		3		MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT-93.

Collector connected to mounting base.



See chapters Mounting Instructions SOT-93 and Accessories.

RATINGS

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

			BDV91	BDV93	BDV95	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.	7	7	7	V
Collector current (d.c.)	I_C	max.		10		A
Collector current (peak value)	I_{CM}	max.		20		A
Base current (d.c.)	I_B	max.		7		A
Emitter current (d.c.)	I_E	max.		14		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		100		W
Storage temperature	T_{stg}			−65 to +150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,25	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off currents				
$I_E = 0$; $V_{CB} = V_{CBO\,max}$	I_{CBO}	<	0,1	mA
$I_E = 0$; $V_{CB} = ½V_{CBO\,max}$; T_j = 150 °C	I_{CBO}	<	1	mA
$I_B = 0$; $V_{CE} = V_{CEO\,max}$	I_{CEO}	<	1	mA
Emitter cut-off current				
$I_C = 0$; V_{EB} = 7 V	I_{EBO}	<	1	mA
D.C. current gain				
I_C = 4 A; V_{CE} = 4 V	h_{FE}	>	20	
I_C = 10 A; V_{CE} = 4 V	h_{FE}	>	5	
Collector-emitter saturation voltage				
I_C = 4 A; I_B = 0,4 A	$V_{CE\,sat}$	<	1	V
I_C = 10 A; I_B = 3,3 A	$V_{CE\,sat}$	<	3	V
Base-emitter saturation voltage				
I_C = 4 A; I_B = 0,4 A	$V_{BE\,sat}$	<	1,6	V
Base-emitter voltage				
I_C = 4 A; V_{CE} = 4 V	V_{BE}	<	1,6	V

CHARACTERISTICS (continued)

Transition frequency			
I_C = 0,5 A; V_{CE} = 10 V	f_T	>	3 MHz
Switching times (between 10% and 90% levels)			
I_{Con} = 4 A; I_{Bon} = $-I_{Boff}$ = 0,4 A; V_{CC} = 30 V			
Turn-on time	t_{on}	typ.	0,5 μs
Turn-off time	t_{off}	typ.	2,0 μs
Fall time	t_f	typ.	0,7 μs

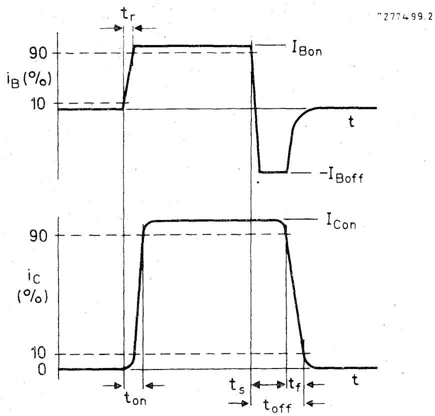
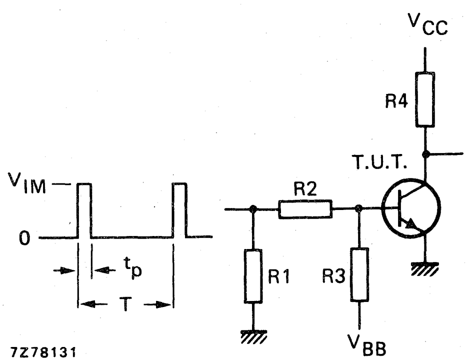


Fig. 2 Switching times waveforms.



V_{IM}	=	55 V
V_{CC}	=	30 V
$-V_{BB}$	=	7 V
R1	=	150 Ω
R2	=	60 Ω
R3	=	20 Ω
R4	=	7,5 Ω
$t_r = t_f$	=	15 ns
t_p	=	10 μs
T	=	500 μs

Fig. 3 Switching times test circuit.

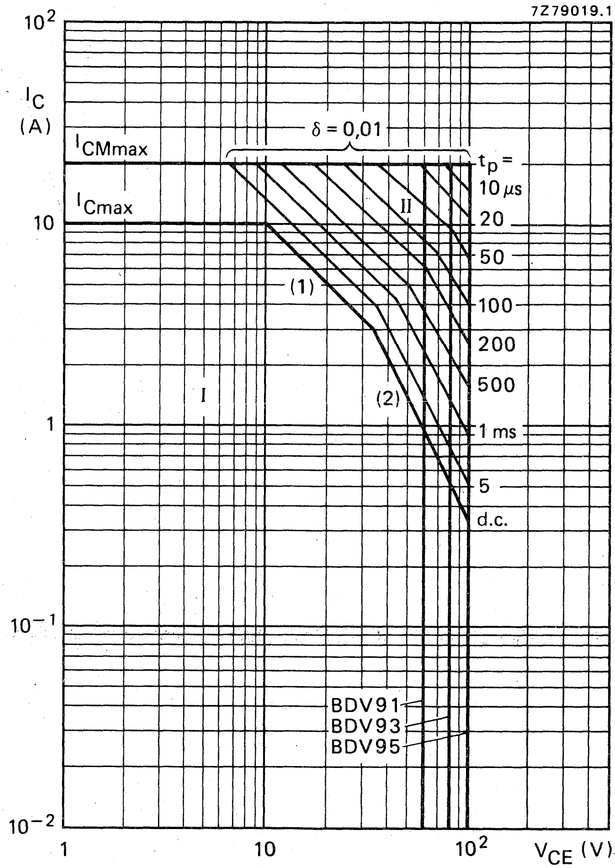


Fig. 4 Safe Operating ARea; $T_{mb} = 25$ °C.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.
(2) Second breakdown limits independent of temperature.

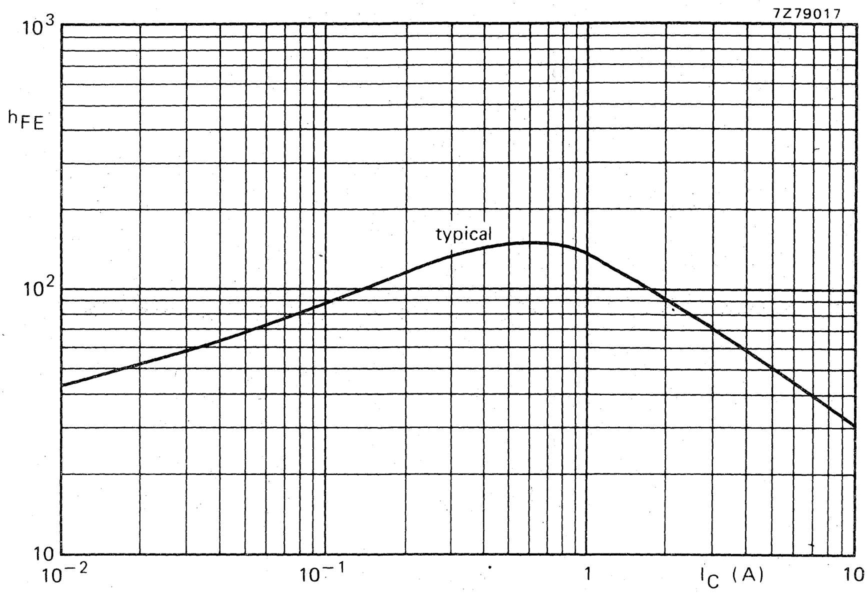


Fig. 5 $V_{CE} = 4$ V; $T_j = 25$ °C.

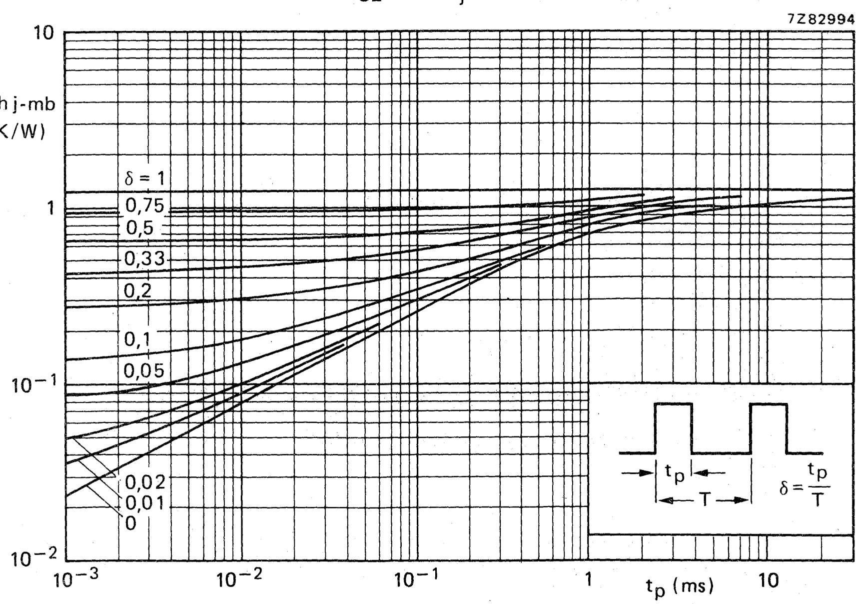


Fig. 6 Pulse power rating chart.

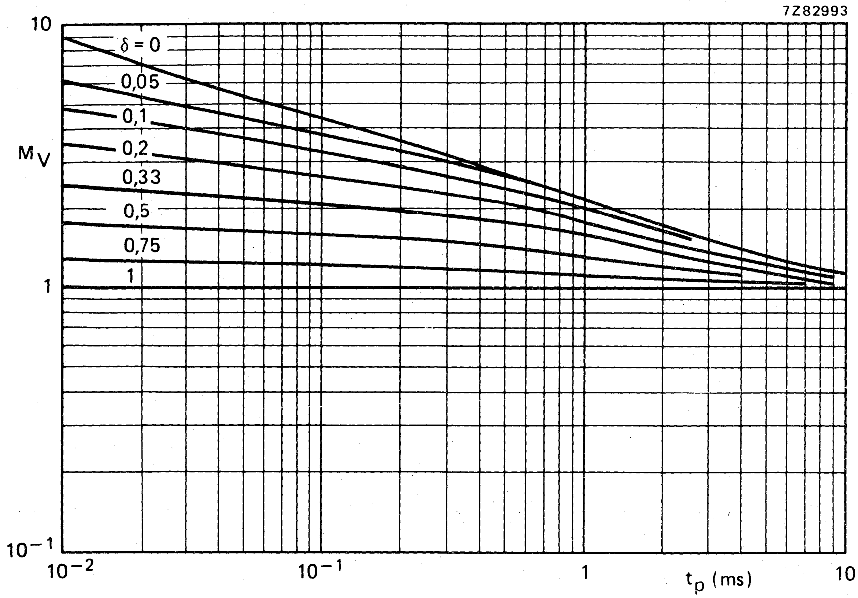


Fig. 7 Second-breakdown voltage multiplying factor at the I_{Cmax} level.

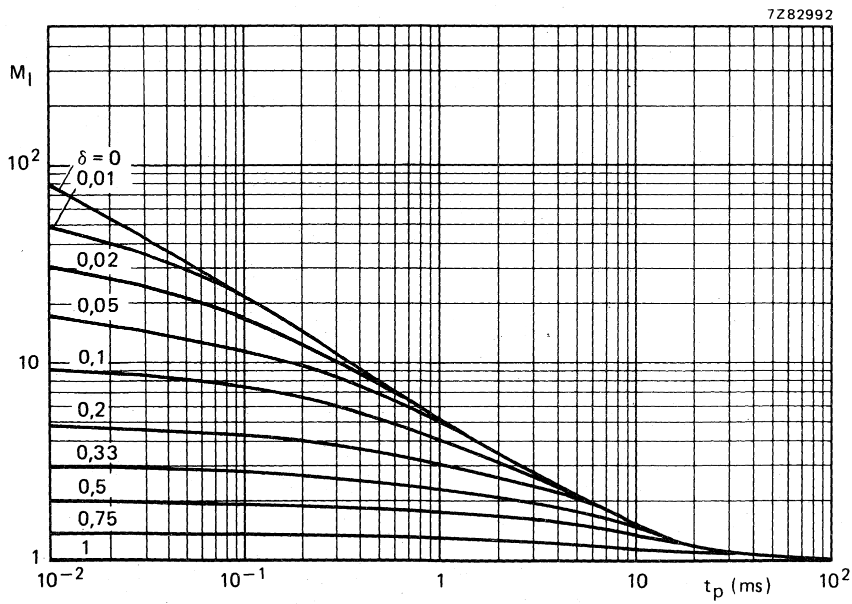


Fig. 8 Second-breakdown current multiplying factor at the V_{CEOmax} level.

SILICON POWER TRANSISTORS

P-N-P epitaxial base power transistors in the plastic SOT-93 envelope. These transistors are intended for use in audio output stages and general amplifier and switching applications.

N-P-N complements are BDV91, BDV93 and BDV95.

QUICK REFERENCE DATA

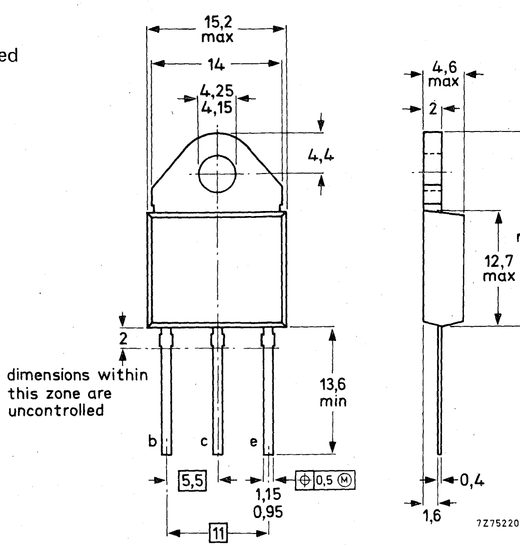
			BDV92	BDV94	BDV96	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	V
Collector current (peak value)	$-I_{CM}$	max.		20		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		100		W
Junction temperature	T_j	max.		150		°C
D.C. current gain $-I_C$ = 4 A; $-V_{CE}$ = 4 V	h_{FE}	>		20		
Transition frequency $-I_C$ = 0,5 A; $-V_{CE}$ = 10 V	f_T	>		4		MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT-93.

Collector connected to mounting base.



See chapters Mounting Instructions SOT-93 and Accessories.

RATINGS

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

			BDV92	BDV94	BDV96	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	7	7	7	V
Collector current (d.c.)	$-I_C$	max.		10		A
Collector current (peak value)	$-I_{CM}$	max.		20		A
Base current (d.c.)	$-I_B$	max.		7		A
Emitter current (d.c.)	$-I_E$	max.		14		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		100		W
Storage temperature	T_{stg}			−65 to +150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$ =	1,25	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

Collector cut-off currents				
$I_E = 0$; $-V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	0,1	mA
$I_E = 0$; $-V_{CB} = -\frac{1}{2}V_{CBOmax}$; T_j = 150 °C	$-I_{CBO}$	<	1	mA
$I_B = 0$; $-V_{CE} = -V_{CEO\,max}$	$-I_{CEO}$	<	1	mA
Emitter cut-off current				
$I_C = 0$; $-V_{EB}$ = 7 V	$-I_{EBO}$	<	1	mA
D.C. current gain				
$-I_C$ = 4 A; $-V_{CE}$ = 4 V	h_{FE}	>	20	
$-I_C$ = 10 A; $-V_{CE}$ = 4 V	h_{FE}	>	5	
Collector-emitter saturation voltage				
$-I_C$ = 4 A; $-I_B$ = 0,4 A	$-V_{CEsat}$	<	1	V
$-I_C$ = 10 A; $-I_B$ = 3,3 A	$-V_{CEsat}$	<	3	V
Base-emitter saturation voltage				
$-I_C$ = 4 A; $-I_B$ = 0,4 A	$-V_{BEsat}$	<	1,6	V
Base-emitter voltage				
$-I_C$ = 4 A; $-V_{CE}$ = 4 V	$-V_{BE}$	<	1,6	V

CHARACTERISTICS (continued)

Transition frequency			
$-I_C$ = 0,5 A; $-V_{CE}$ = 10 V	f_T	>	4 MHz
Switching times (between 10% and 90% levels)			
$-I_{Con}$ = 4 A; $-I_{Bon}$ = I_{Boff} = 0,4 A; $-V_{CC}$ = 30 V			
Turn-on time	t_{on}	typ.	0,3 µs
Turn-off time	t_{off}	typ.	0,7 µs
Fall time	t_f	typ.	0,3 µs

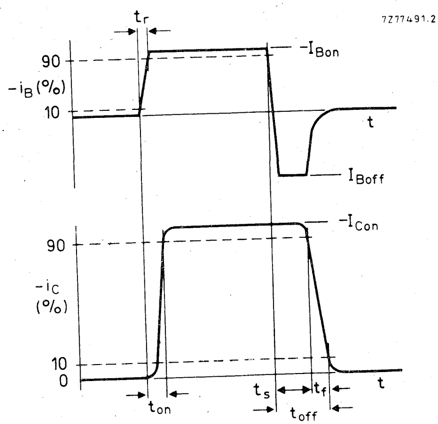
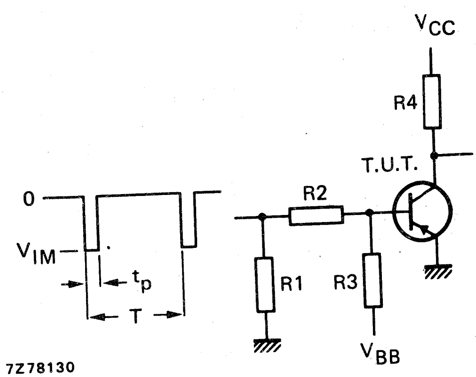


Fig. 2 Switching times waveforms.



$-V_{IM}$	=	55 V
$-V_{CC}$	=	30 V
V_{BB}	=	7 V
R1	=	150 Ω
R2	=	60 Ω
R3	=	20 Ω
R4	=	7,5 Ω
$t_r = t_f$	=	15 ns
t_p	=	10 µs
T	=	500 µs

Fig. 3 Switching times test circuit.

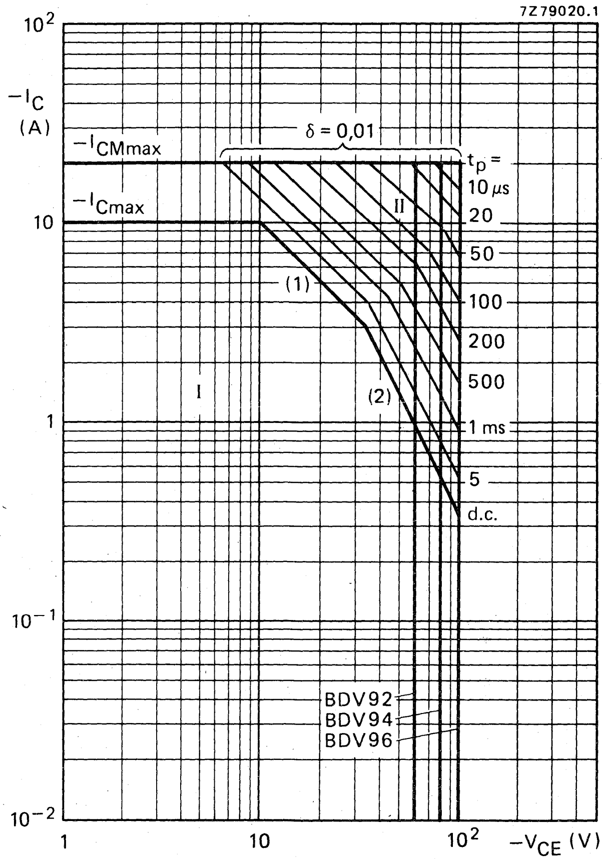


Fig. 4 Safe Operating ARea; T_{mb} = 25 °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.

(2) Second breakdown limits independent of temperature.

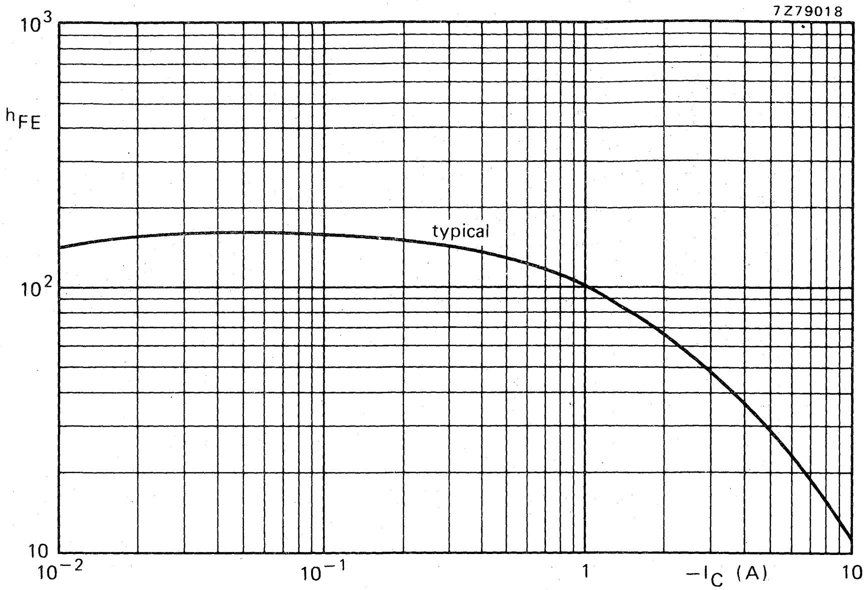


Fig. 5 $-V_{CE}$ = 4 V; T_j = 25 °C.

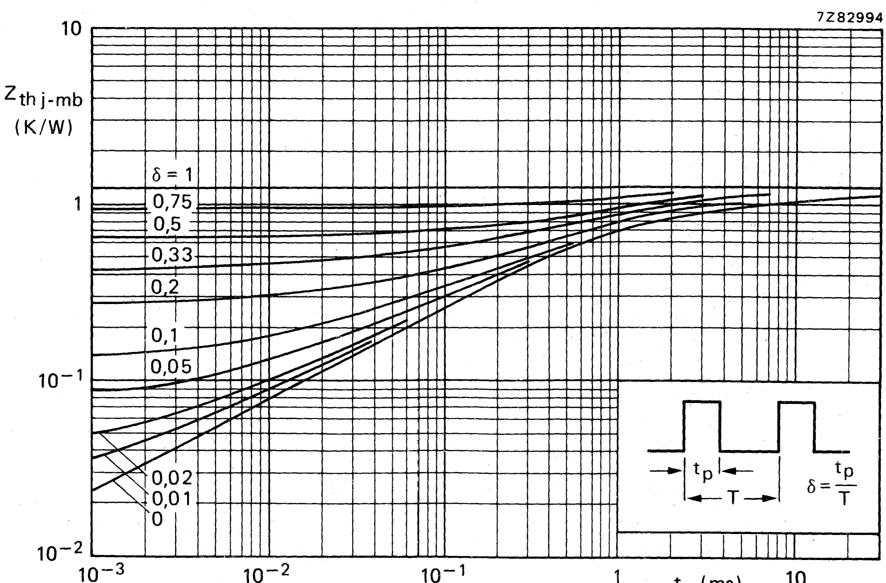


Fig. 6 Pulse power rating chart.

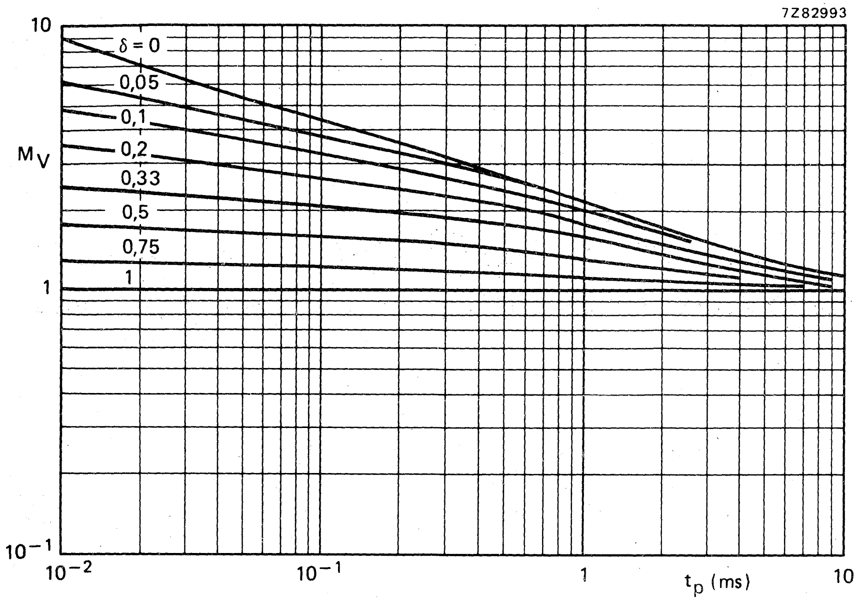


Fig. 7 Second-breakdown voltage multiplying factor at the I_{Cmax} level.

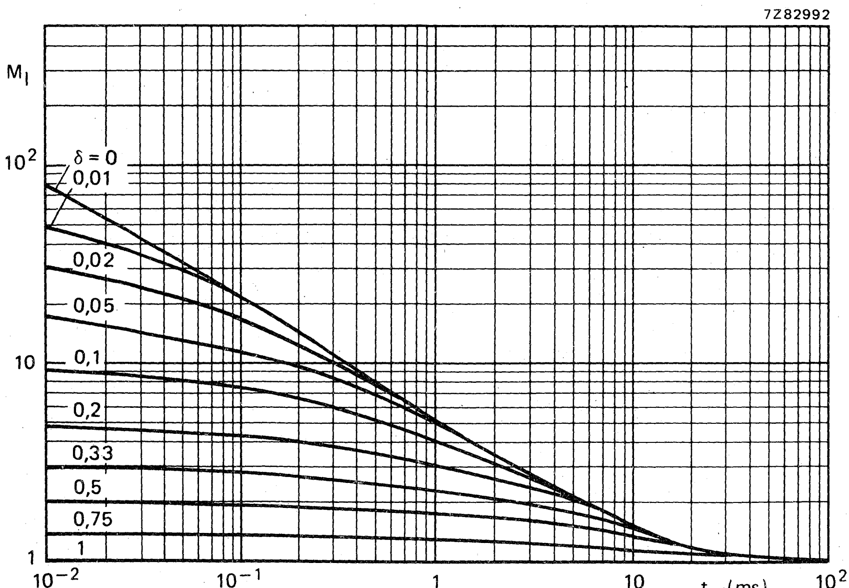


Fig. 8 Second-breakdown current multiplying factor at the V_{CEOmax} level.

SILICON PLANAR EPITAXIAL POWER TRANSISTORS

N-P-N medium-power transistors in SOT-32 plastic envelopes specially intended for use in professional equipment (i.e. telecommunication). The high degree of reliability has been achieved by using process steps and materials which have been proved to be highly reliable.

Features of this product:
- unimetal (gold-to-gold) ultrasonic wire bounding;
- gold silicon eutectic chip bond;
- glass-passivated chip;
- silicone plastic

P-N-P complements are BDW56, BDW58 and BDW60.

QUICK REFERENCE DATA

			BDW55	BDW57	BDW59	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	100	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	V_{CER}	max.	45	60	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Collector current (peak value)	I_{CM}	max.		1,5		A
Total power dissipation up to T_{mb} = 95 °C	P_{tot}	max.		8		W
Junction temperature	T_j	max.		175		°C
D.C. current gain I_C = 150 mA; V_{CE} = 2 V	h_{FE}	>		40 to 250		
Transition frequency I_C = 50 mA; V_{CE} = 5 V	f_T	typ.		250		MHz

MECHANICAL DATA

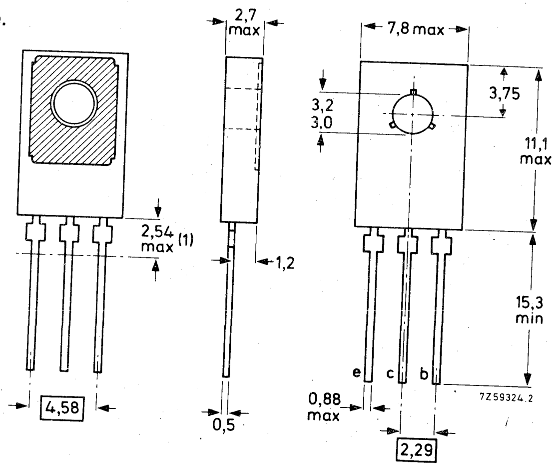
TO-126 (SOT-32) see page 2.

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-126 (SOT-32).

Collector connected to metal part of mounting surface.



(1) Within this region the cross-section of the leads is uncontrolled.

See also chapters Mounting Instructions and Accessories.

RATINGS

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

			BDW55	BDW57	BDW59	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	100	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	V_{CER}	max.	45	60	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V
Collector current (d.c.)	I_C	max.		1		A
Collector current (peak value)	I_{CM}	max.		1,5		A
Total power dissipation up to T_{mb} = 95 °C	P_{tot}	max.		8		W
Storage temperature	T_{stg}			−65 to +175		°C
Junction temperature	T_j	max.		175		°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	100	K/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	10	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

Collector cut-off current			
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	<	100 nA
$I_E = 0$; V_{CB} = 30, 45, 70 V (resp.); T_j = 150 °C	I_{CBO}	<	10 μA
Emitter cut-off current			
$I_C = 0$; V_{EB} = 5 V	I_{EBO}	<	10 μA
Base-emitter voltage			
I_C = 500 mA; V_{CE} = 2 V	V_{BE}	<	1 V
Collector-emitter saturation voltage			
I_C = 500 mA; I_B = 50 mA	V_{CEsat}	<	0,5 V
D.C. current gain			
I_C = 5 mA; V_{CE} = 2 V	h_{FE}	>	25
I_C = 150 mA; V_{CE} = 2 V	h_{FE}		40 to 250
I_C = 500 mA; V_{CE} = 2 V	h_{FE}	>	25
Transition frequency at f = 35 MHz			
I_C = 50 mA; V_{CE} = 5 V	f_T	typ.	250 MHz
Switching times (see also Figs 2 and 3)			
I_{Con} = 150 mA; $I_{Bon} = -I_{Boff}$ = 15 mA;			
V_{CC} = 10,2 V			
Turn-on delay time	t_d	typ.	30 ns
Turn-on rise time	t_r	typ.	30 ns
Turn-off storage time	t_s	typ.	500 ns
Turn-off fall time	t_f	typ.	80 ns

CHARACTERISTICS (continued)

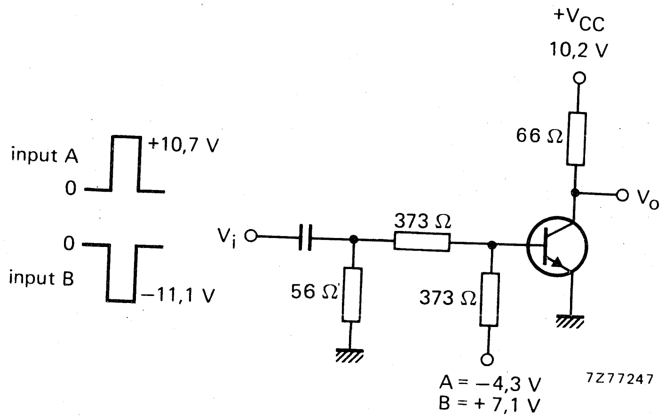


Fig. 2 Test circuit for measuring switching times.

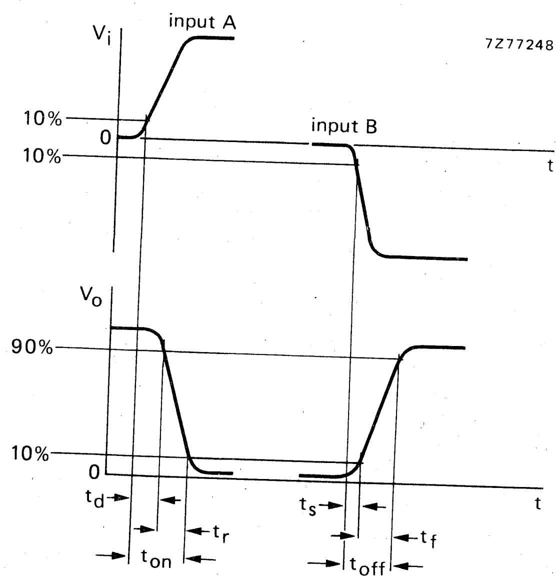


Fig. 3 Switching times waveforms.

Equipment

pulse generator; rise time = 1 ns.
double-beam or dual-trace oscilloscope; rise time < 5 ns.

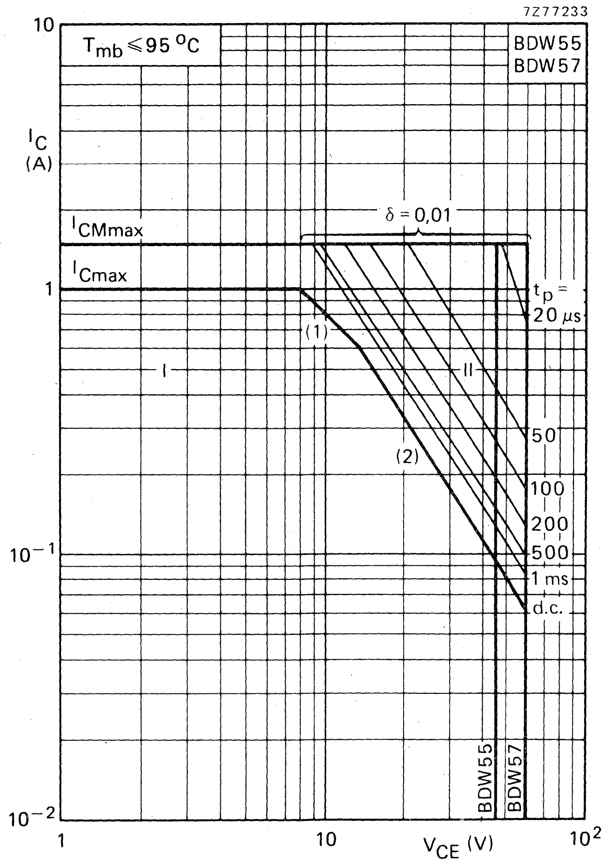


Fig. 4 Safe Operating ARea.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.
(1) $P_{tot\,max}$ and $P_{tot\,peak\,max}$ lines.
(2) Second-breakdown limits (independent of temperature).

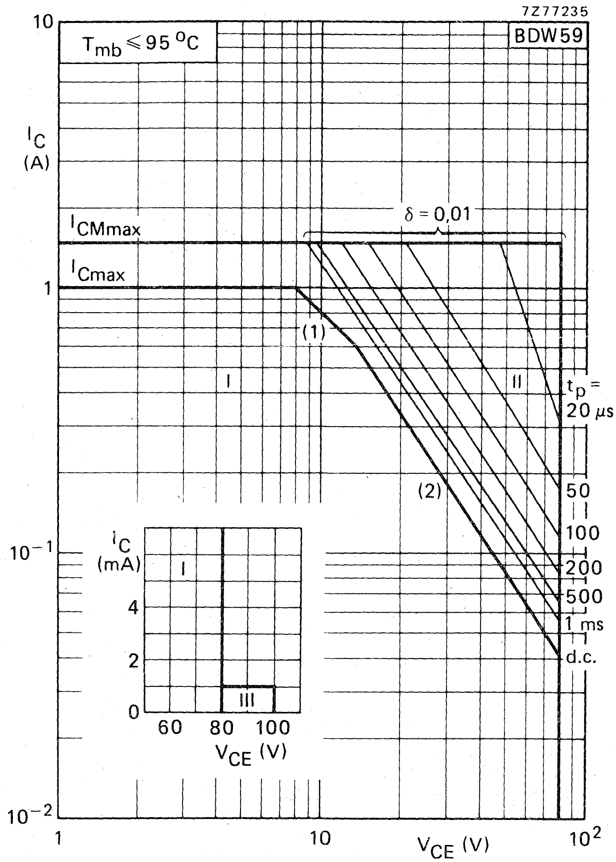


Fig. 5 Safe Operating ARea.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.
III Repetitive pulse operation in this region is permissible, provided $R_{BE} \leqslant 1\ k\Omega$.

(1) $P_{tot\,max}$ and $P_{tot\,peak\,max}$ lines.
(2) Second-breakdown limits (independent of temperature).

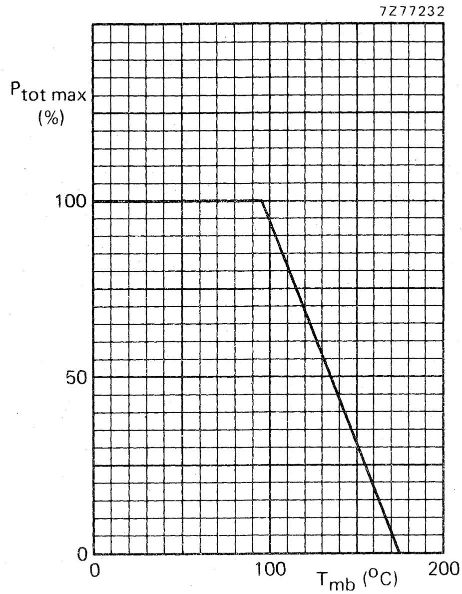

7Z77232
$P_{tot\ max}$ (%)
100
50
0
0
100
200
T_{mb} (^oC)

Fig. 6.

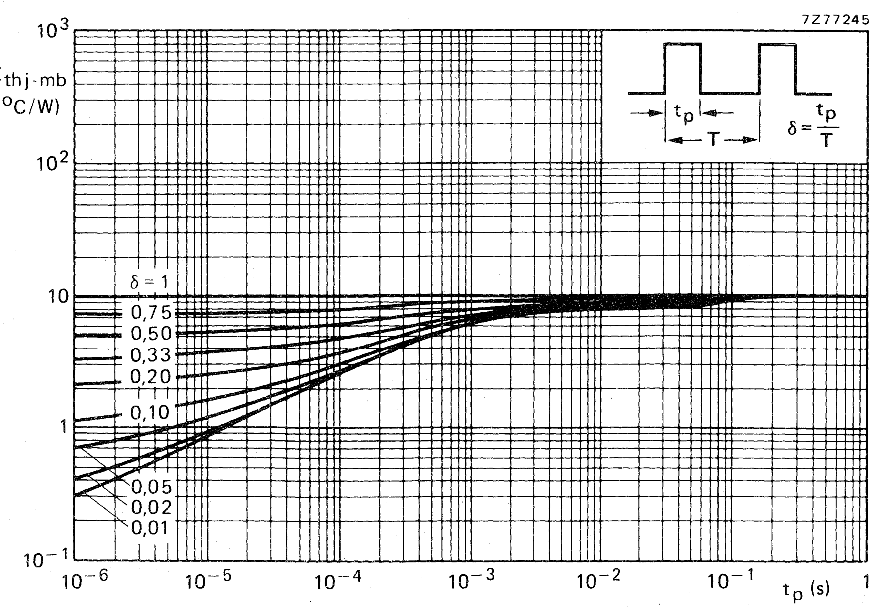

7Z77245
$Z_{th\ j\text{-}mb}$ ($^oC/W$)
10^3
10^2
10
1
10^{-1}
$\delta = 1$
0,75
0,50
0,33
0,20
0,10
0,05
0,02
0,01
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
t_p (s)
t_p
T
$\delta = \frac{t_p}{T}$

Fig. 7.

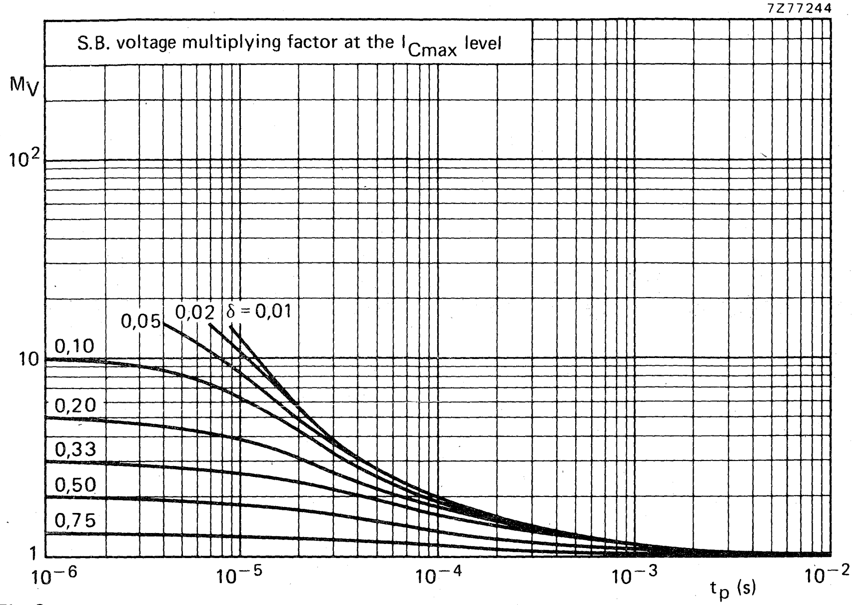

7Z77244
S.B. voltage multiplying factor at the I_{Cmax} level
M_V
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

Fig. 8.

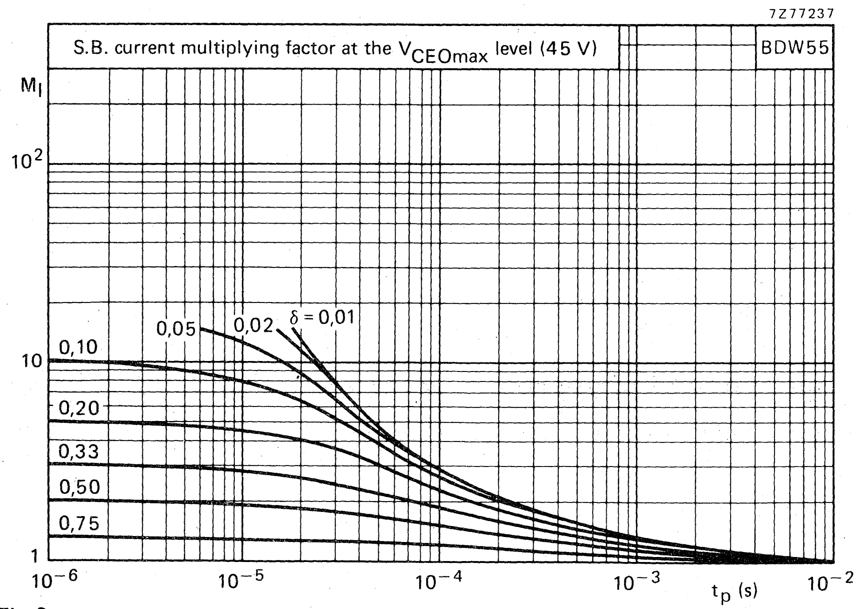

7Z77237
S.B. current multiplying factor at the V_{CEOmax} level (45 V)
BDW55
M_I
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

Fig. 9.

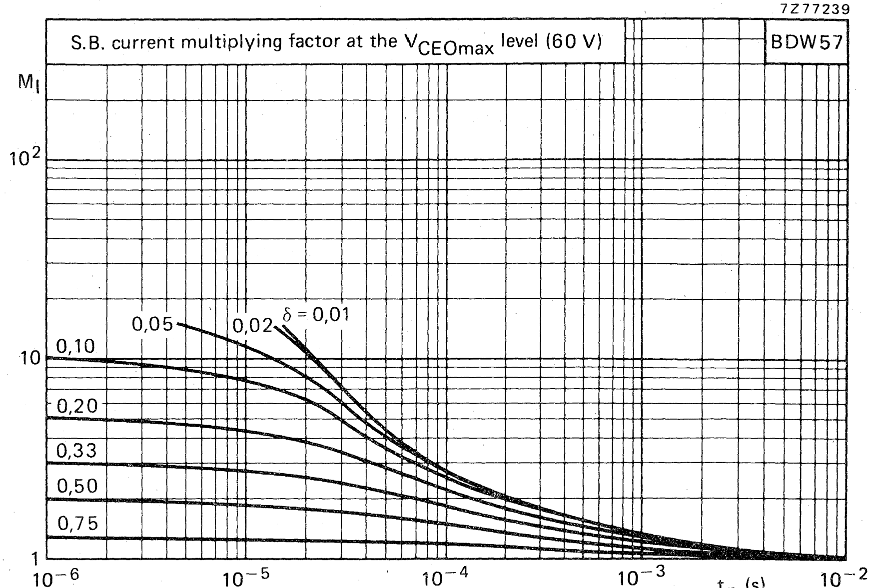

7Z77239
S.B. current multiplying factor at the V_{CEOmax} level (60 V)
BDW57
M_I
10^2
10
1
$\delta = 0,01$
0,02
0,05
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

Fig. 10.

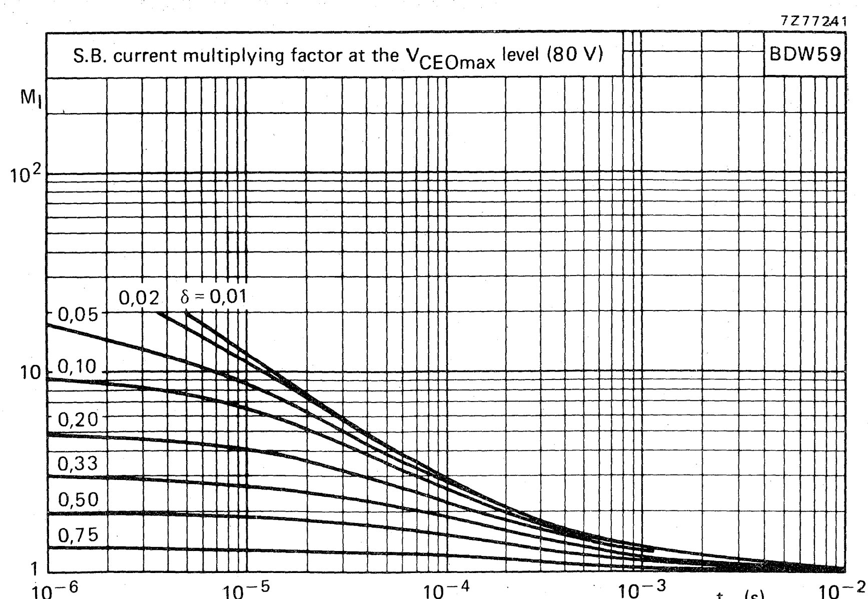

7Z77241
S.B. current multiplying factor at the V_{CEOmax} level (80 V)
BDW59
M_I
10^2
10
1
0,02
$\delta = 0,01$
0,05
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

Fig. 11.

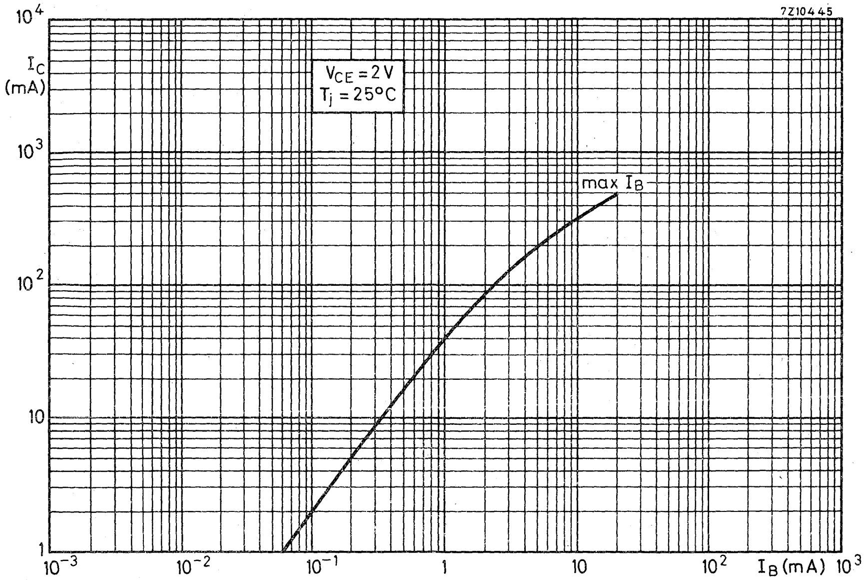

7Z10445
10^4
I_C (mA)
$V_{CE} = 2$ V
$T_j = 25$°C
10^3
max I_B
10^2
10
1
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
I_B (mA)
10^3

Fig. 12.

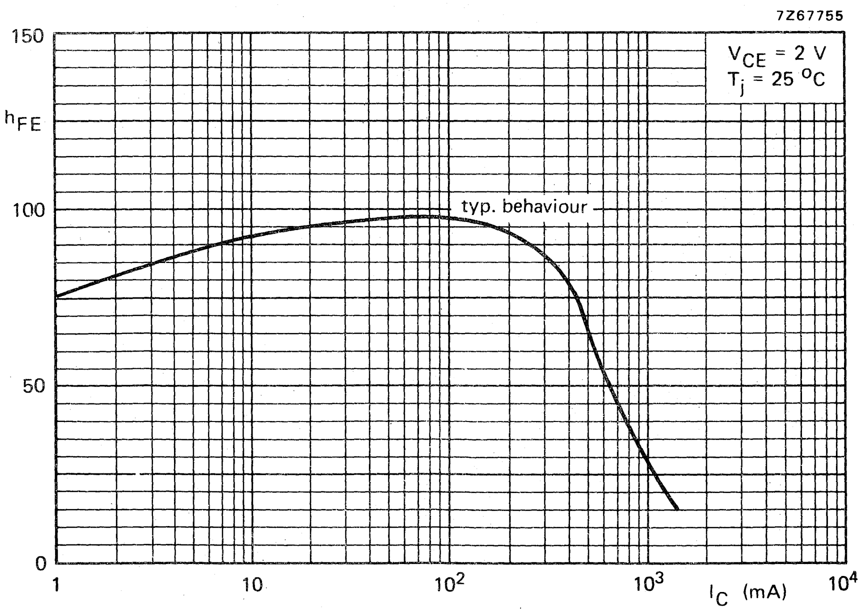

7Z67755
150
h_{FE}
$V_{CE} = 2$ V
$T_j = 25$ °C
100
typ. behaviour
50
0
1
10
10^2
10^3
I_C (mA)
10^4

Fig. 13.

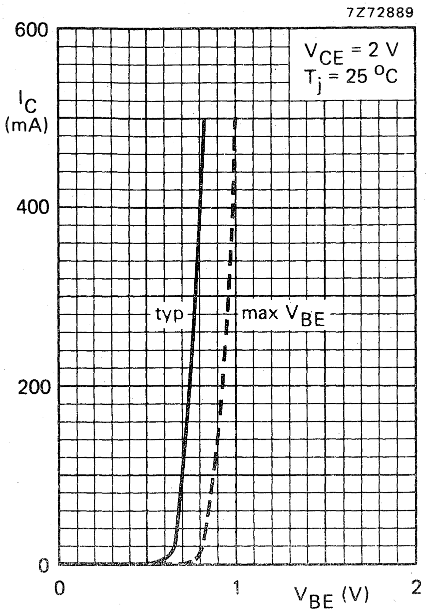


Fig. 14.

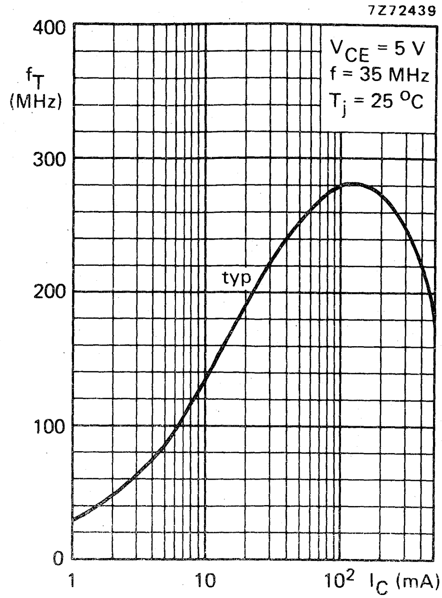


Fig. 15.

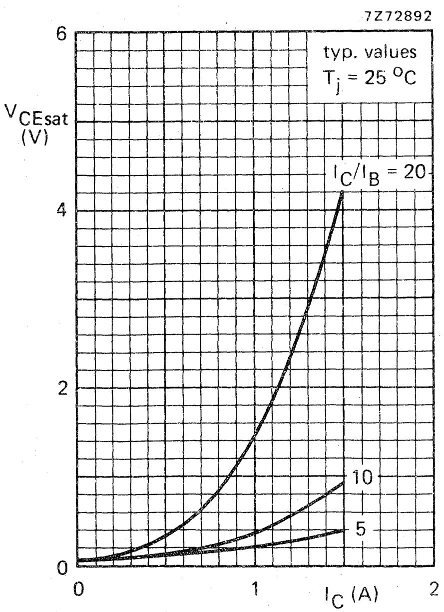


Fig. 16.

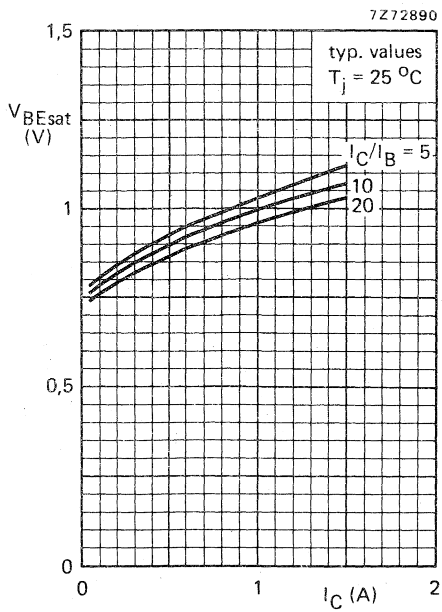


Fig. 17.

SILICON PLANAR EPITAXIAL POWER TRANSISTORS

P-N-P medium-power transistors in SOT-32 plastic envelopes specially intended for use in professional equipment (i.e. telecommunication). The high degree of reliability has been achieved by using process steps and materials which have been proved to be highly reliable.

Features of this product:
- unimetal (gold-to-gold) ultrasonic wire bounding;
- gold silicon eutectic chip bond;
- glass-passivated chip;
- silicone plastic.

N-P-N complements are BDW55, BDW57 and BDW59.

QUICK REFERENCE DATA

			BDW56	BDW58	BDW60	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	100	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	$-V_{CER}$	max.	45	60	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	V
Collector current (peak value)	$-I_{CM}$	max.		1,5		A
Total power dissipation up to T_{mb} = 95 °C	P_{tot}	max.		8		W
Junction temperature	T_j	max.		175		°C
D.C. current gain $-I_C$ = 150 mA; $-V_{CE}$ = 2 V	h_{FE}	>		40 to 250		
Transition frequency $-I_C$ = 50 mA; $-V_{CE}$ = 5 V	f_T	typ.		75		MHz

MECHANICAL DATA

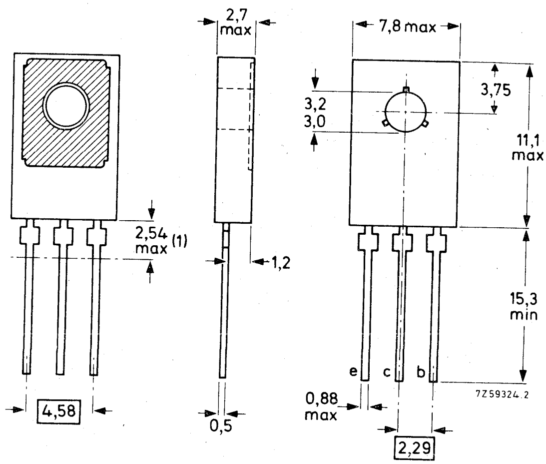
TO-126 (SOT-32) see page 2.

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-126 (SOT-32).

Collector connected to metal part of mounting surface.



(1) Within this region the cross-section of the leads is uncontrolled.

See also chapters Mounting Instructions and Accessories.

RATINGS

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

			BDW56	BDW58	BDW60	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	100	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	$-V_{CER}$	max.	45	60	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V
Collector current (d.c.)	$-I_C$	max.		1		A
Collector current (peak value)	$-I_{CM}$	max.		1,5		A
Total power dissipation up to T_{mb} = 95 °C	P_{tot}	max.		8		W
Storage temperature	T_{stg}			−65 to +175		°C
Junction temperature	T_j	max.		175		°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	100	K/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	10	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

Collector cut-off current			
$I_E = 0$; $-V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	100 nA
$I_E = 0$; $-V_{CB}$ = 30, 45, 70 V (resp.); T_j = 150 °C	$-I_{CBO}$	<	10 μA
Emitter cut-off current			
$I_C = 0$; $-V_{EB}$ = 5 V	$-I_{EBO}$	<	10 μA
Base-emitter voltage			
$-I_C$ = 500 mA; $-V_{CE}$ = 2 V	$-V_{BE}$	<	1 V
Collector-emitter saturation voltage			
$-I_C$ = 500 mA; $-I_B$ = 50 mA	$-V_{CEsat}$	<	0,5 V
D.C. current gain			
$-I_C$ = 5 mA; $-V_{CE}$ = 2 V	h_{FE}	>	25
$-I_C$ = 150 mA; $-V_{CE}$ = 2 V	h_{FE}		40 to 250
$-I_C$ = 500 mA; $-V_{CE}$ = 2 V	h_{FE}	>	25
Transition frequency at f = 35 MHz;			
$-I_C$ = 50 mA; $-V_{CE}$ = 5 V	f_T	typ.	75 MHz
Switching times (see also Figs 2 and 3)			
$-I_{Con}$ = 150 mA; $-I_{Bon}$ = I_{Boff} = 15 mA; $-V_{CC}$ = 10,2 V			
Turn-on delay time	t_d	typ.	30 ns
Turn-on rise time	t_r	typ.	40 ns
Turn-off storage time	t_s	typ.	500 ns
Turn-off fall time	t_f	typ.	80 ns

CHARACTERISTICS (continued)

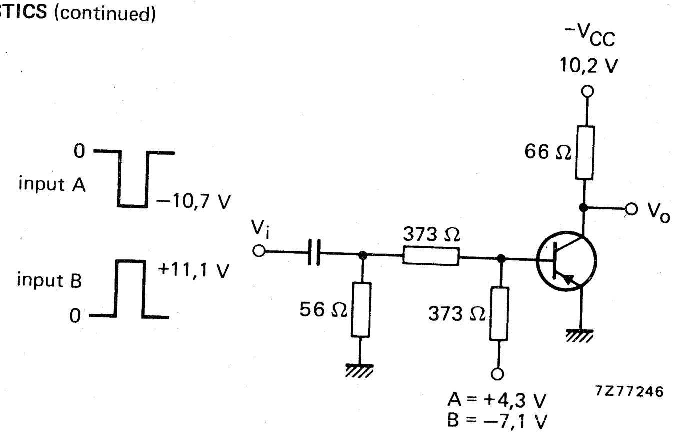


Fig. 2 Test circuit for measuring switching times.

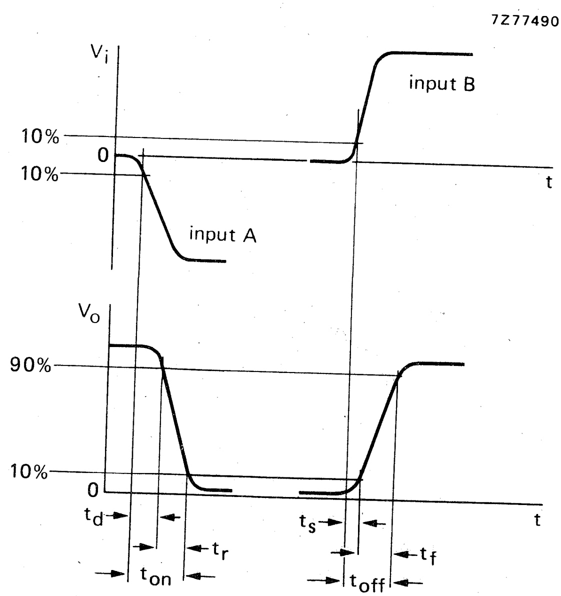


Fig. 3 Switching time waveforms.

Equipment

pulse generator; rise time = 1 ns.
double-beam or dual-trace oscilloscope; rise time < 5 ns.

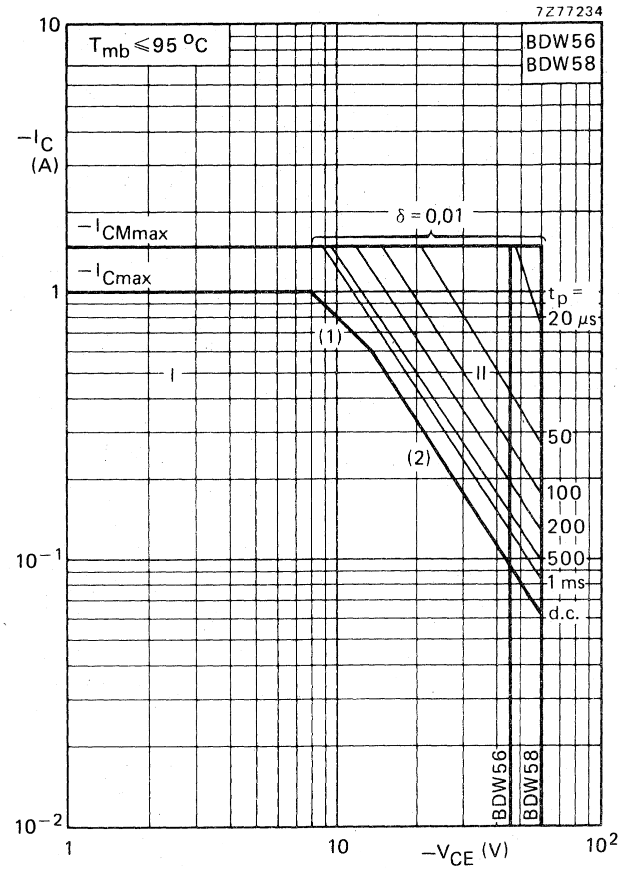


Fig. 4 Safe Operating ARea.

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

(1) $P_{tot\,max}$ and $P_{tot\,peak\,max}$ lines.

(2) Second-breakdown limits (independent of temperature).

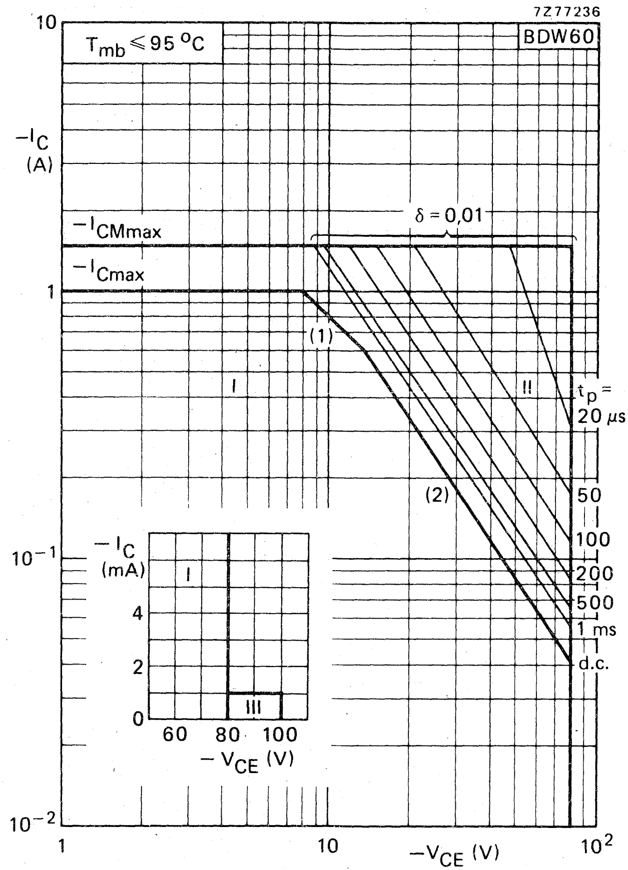


Fig. 5 Safe Operating ARea.

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

III Repetitive pulse operation in this region is permissible provided $R_{BE} \leq 1$ kΩ

(1) $P_{tot\,max}$ and $P_{tot\,peak\,max}$ lines

(2) Second-breakdown limits (independent of temperature).

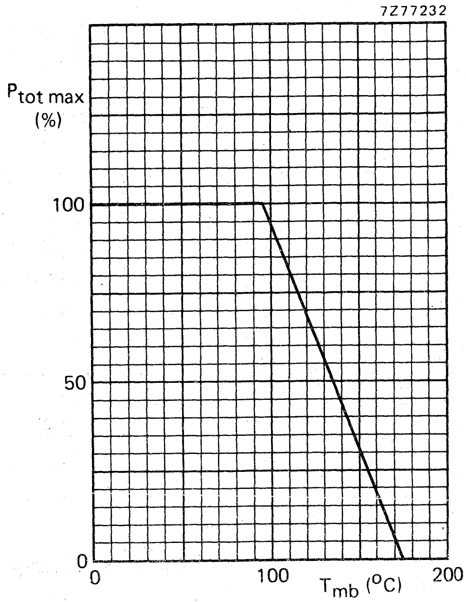

7Z77232
$P_{tot\,max}$
(%)
100
50
0
0
100
T_{mb} (°C)
200

Fig. 6.

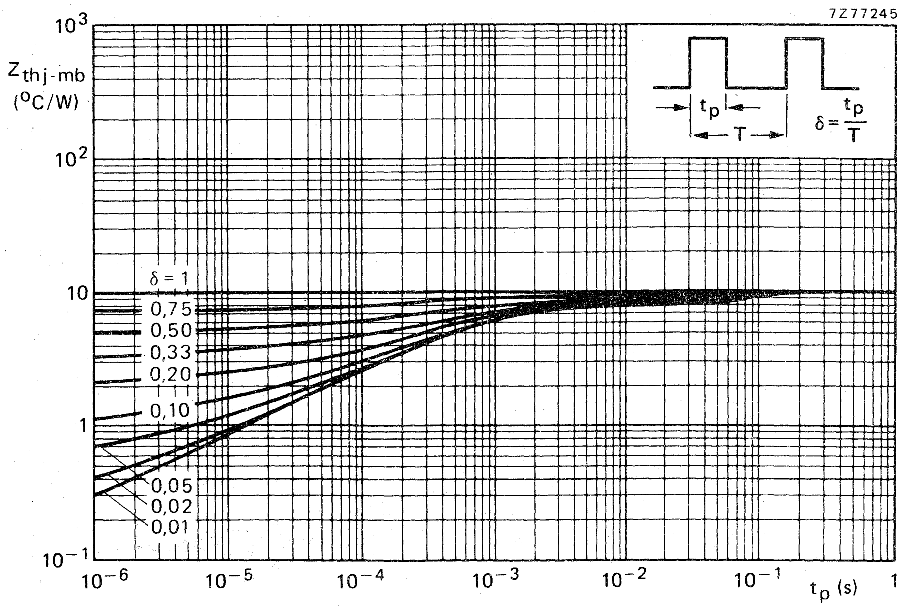

7Z77245
10^3
$Z_{th\,j\text{-}mb}$
(°C/W)
10^2
10
1
10^{-1}
δ = 1
0,75
0,50
0,33
0,20
0,10
0,05
0,02
0,01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
t_p (s)
1

Fig. 7.

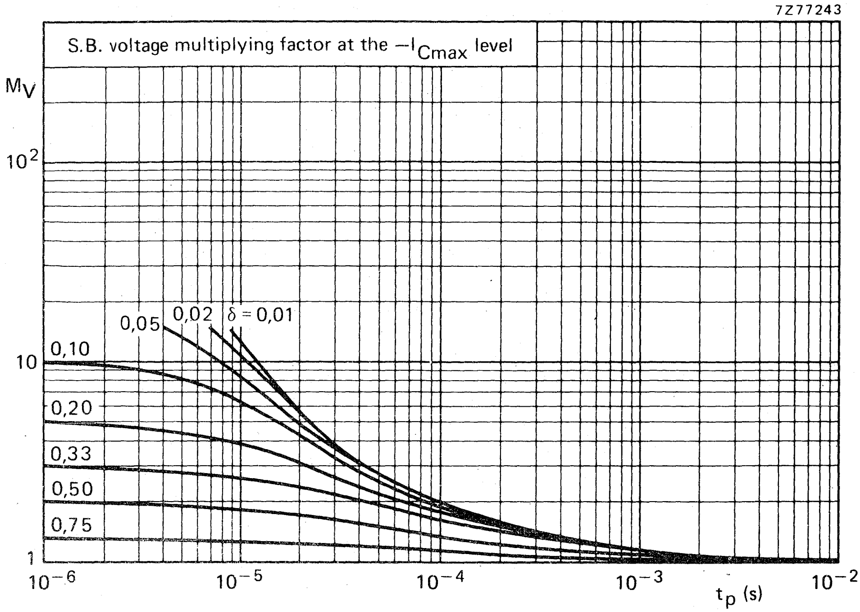

7Z77243
S.B. voltage multiplying factor at the $-I_{Cmax}$ level
M_V
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

Fig. 8.

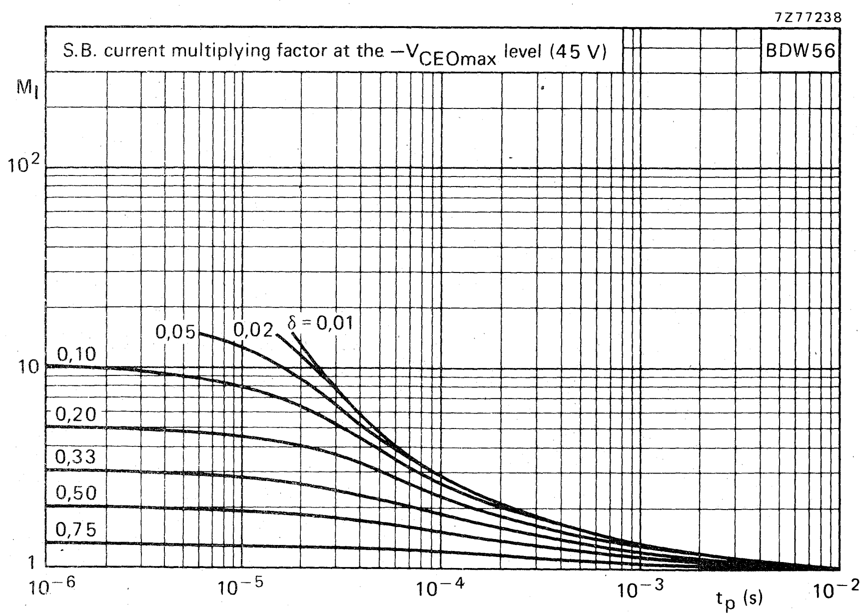

7Z77238
S.B. current multiplying factor at the $-V_{CEOmax}$ level (45 V)
BDW56
M_I
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

Fig. 9.

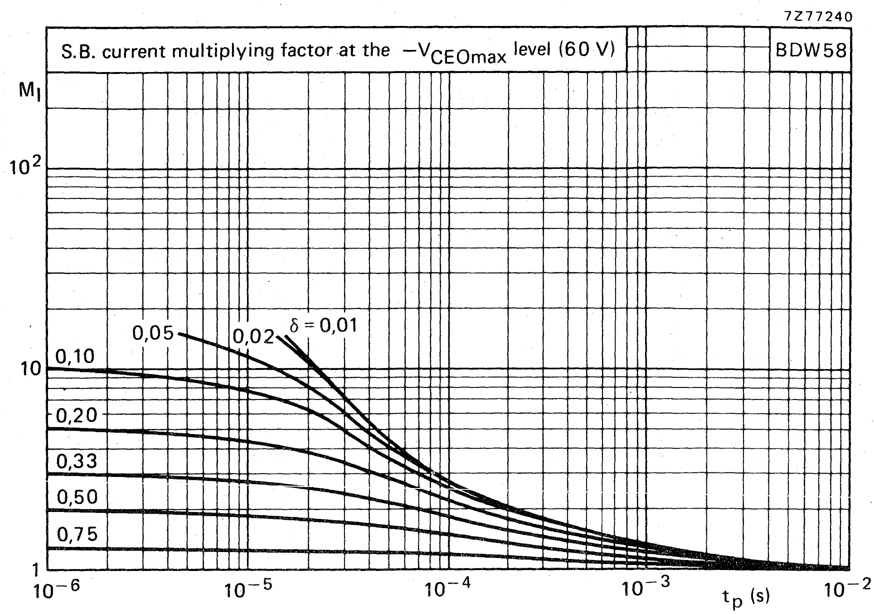

7Z77240
S.B. current multiplying factor at the $-V_{CEOmax}$ level (60 V)
BDW58
M_I
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

Fig. 10.

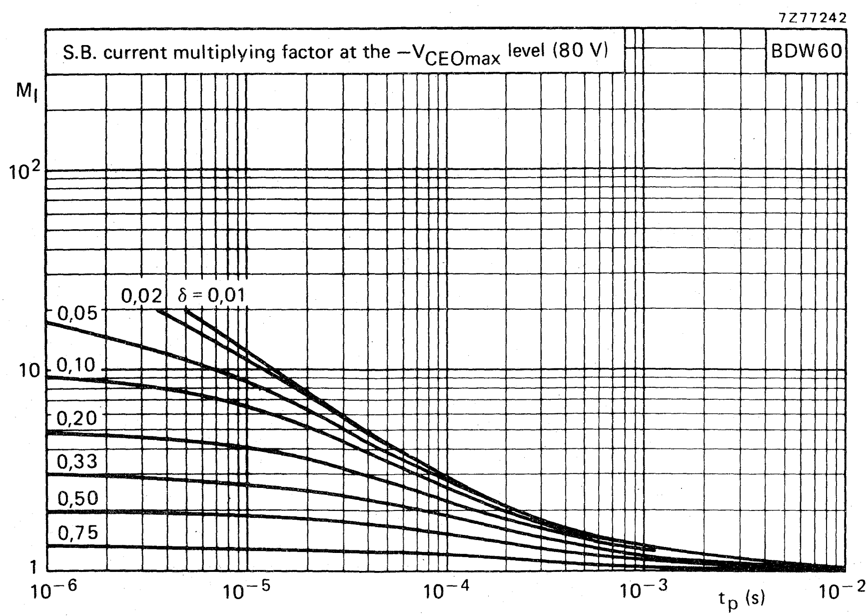

7Z77242
S.B. current multiplying factor at the $-V_{CEOmax}$ level (80 V)
BDW60
M_I
10^2
10
1
0,02
δ = 0,01
0,05
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

Fig. 11.

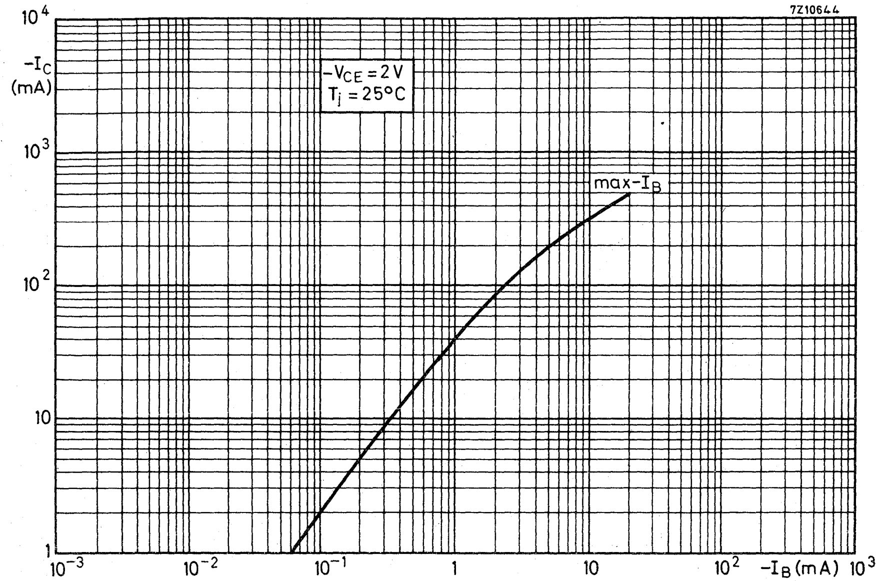

7Z10644
$-V_{CE} = 2$ V
$T_j = 25$ °C
$-I_C$ (mA)
10^4
10^3
10^2
10
1
max-I_B
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
$-I_B$ (mA)
10^3

Fig. 12.

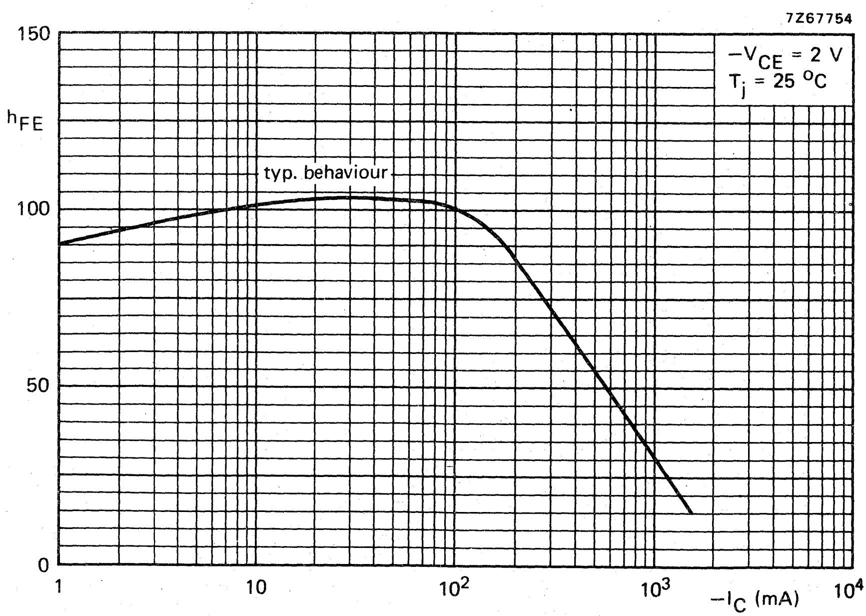

7Z67754
$-V_{CE} = 2$ V
$T_j = 25$ °C
h_{FE}
150
100
50
0
typ. behaviour
1
10
10^2
10^3
$-I_C$ (mA)
10^4

Fig. 13.

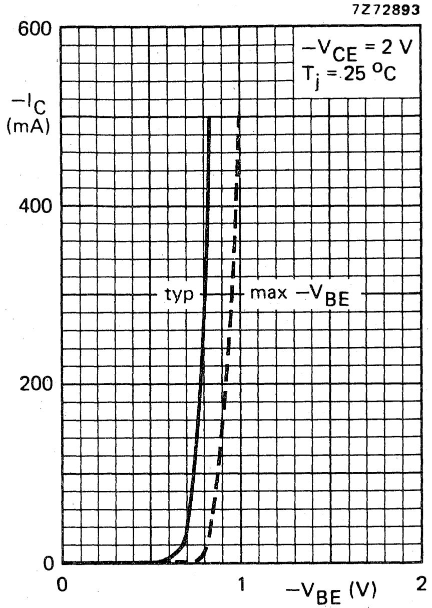


Fig. 14.

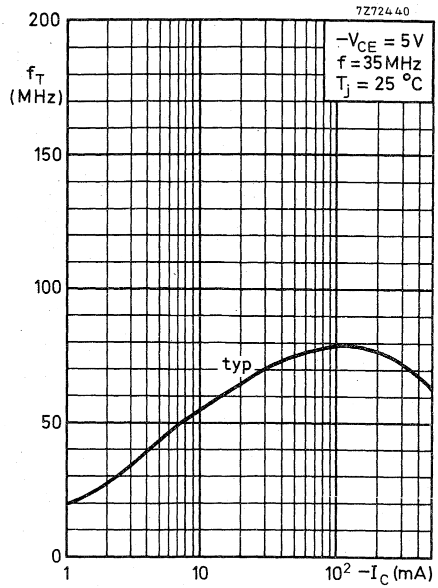


Fig. 15.

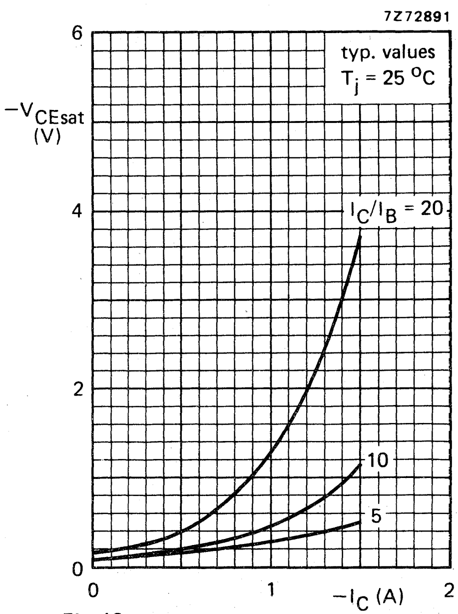


Fig. 16.

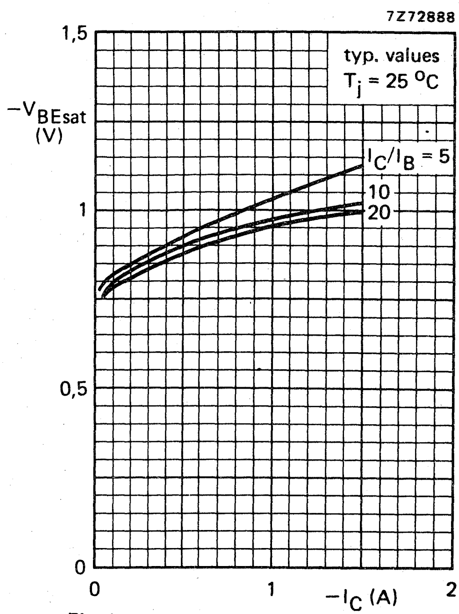


Fig. 17.

SILICON PLANAR EPITAXIAL POWER TRANSISTORS

N-P-N transistors in TO-126 plastic envelopes intended for high current switching applications, e.g. inverters, and switching regulator circuits.

QUICK REFERENCE DATA

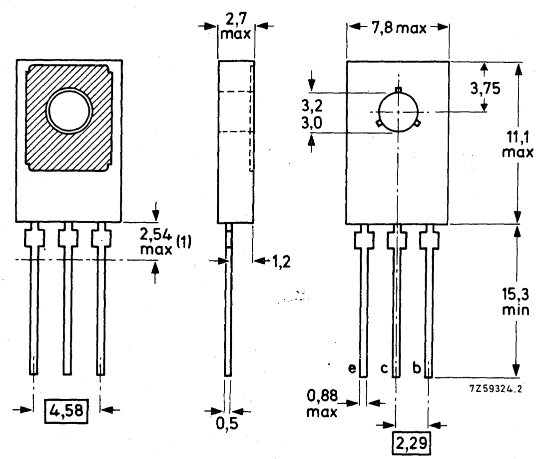
			BDX35	BDX36	BDX37	
Collector-base voltage (open emitter)	V_{CBO}	max.	100	120	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	60	80	V
Collector current (peak value)	I_{CM}	max.	10	10	10	A
Total power dissipation up to T_{mb} = 75 °C	P_{tot}	max.	15	15	15	W
D.C. current gain I_C = 0,5 A; V_{CE} = 10 V	h_{FE}	>	45	45	45	
Collector-emitter saturation voltage I_C = 5 A; I_B = 0,5 A	V_{CEsat}	<	0,9	0,7	0,9	V
Turn-off time I_{Con} = 5 A; I_{Bon} = $-I_{Boff}$ = 0,5 A	t_{off}	typ.	350	350	350	ns

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-126 (SOT-32)

Collector connected to the metal part of the mounting surface



(1) Within this region the cross-section of the leads is uncontrolled.
See also chapters Mounting instructions and Accessories.

RATINGS

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

Voltages

			BDX35	BDX36	BDX37	
Collector-base voltage (open emitter)	V_{CBO}	max.	100	120	120	V
Collector-emitter voltage ($V_{BE} = 0$)	V_{CES}	max.	100	120	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	60	80	V
Emitter-base voltage (open collector)	V_{EBO}	max.		5		V
Collector current (d.c.)	I_C	max.		5		A
Collector current (peak value)	I_{CM}	max.		10		A
Base current (d.c.)	I_B	max.		1		A
Base current (peak value)	I_{BM}	max.		2		A
Reverse base current (peak value)	$-I_{BM}$	max.		2		A
Total power dissipation						
up to $T_{mb} = 75\ ^oC$	P_{tot}	max.		15		W
up to $T_{amb} = 25\ ^oC$	P_{tot}	max.		1,25		W
Storage temperature	T_{stg}			−65 to + 150		^oC
Junction temperature	T_j	max.		150		^oC

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	5	$^oC/W$
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	100	$^oC/W$

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 80$ V	BDX35	I_{CBO}	<	10 µA
$I_E = 0$; $V_{CB} = 80$ V; $T_j = 100$ °C	BDX35	I_{CBO}	<	50 µA
$I_E = 0$; $V_{CB} = 100$ V	BDX36/37	I_{CBO}	<	10 µA
$I_E = 0$; $V_{CB} = 100$ V; $T_j = 100$ °C	BDX36/37	I_{CBO}	<	50 µA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 4$ V		I_{EBO}	typ.	5 nA
			<	10 µA
$I_C = 0$; $V_{EB} = 5$ V		I_{EBO}	<	1 mA
D.C. current gain		h_{FE}		45 to 450
$I_C = 0{,}5$ A; $V_{CE} = 10$ V	BDX35/36	h_{FE}	typ.	130
	BDX37	h_{FE}	typ.	80
Collector-emitter saturation voltage				
$I_C = 5$ A; $I_B = 0{,}5$ A	BDX35/37	V_{CEsat}	<	0,9 V
	BDX36	V_{CEsat}	<	0,7 V
$I_C = 7$ A; $I_B = 0{,}7$ A	BDX35/37	V_{CEsat}	<	1,2 V
$I_C = 10$ A; $I_B = 1$ A	BDX36	V_{CEsat}	<	1,5 V
Base-emitter saturation voltage				
$I_C = 5$ A; $I_B = 0{,}5$ A		V_{BEsat}	<	1,6 V
$I_C = 7$ A; $I_B = 0{,}7$ A	BDX35/37	V_{BEsat}	<	1,8 V
$I_C = 10$ A; $I_B = 1$ A	BDX36	V_{BEsat}	<	2,2 V
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 10$ V		C_c	typ.	40 pF
			<	60 pF
Transition frequency at f = 35 MHz				
$I_C = 0{,}5$ A; $V_{CE} = 5$ V; $T_{amb} = 25$ °C		f_T	typ.	100 MHz
Switching times (between 10% and 90% levels)				
$I_{Con} = 1$ A; $I_{Bon} = -I_{Boff} = 0{,}1$ A				
turn-on time		t_{on}	typ.	0,06 µs
			<	0,1 µs
turn-off time		t_{off}	typ.	0,6 µs
			<	0,8 µs
$I_{Con} = 2$ A; $I_{Bon} = -I_{Boff} = 0{,}2$ A				
turn-on time		t_{on}	<	80 ns
turn-off time		t_{off}	typ.	0,45 µs
			<	0,7 µs
$I_{Con} = 5$ A; $I_{Bon} = -I_{Boff} = 0{,}5$ A				
turn-on time		t_{on}	typ.	180 ns
			<	300 ns
turn-off time		t_{off}	typ.	320 ns
			<	500 ns

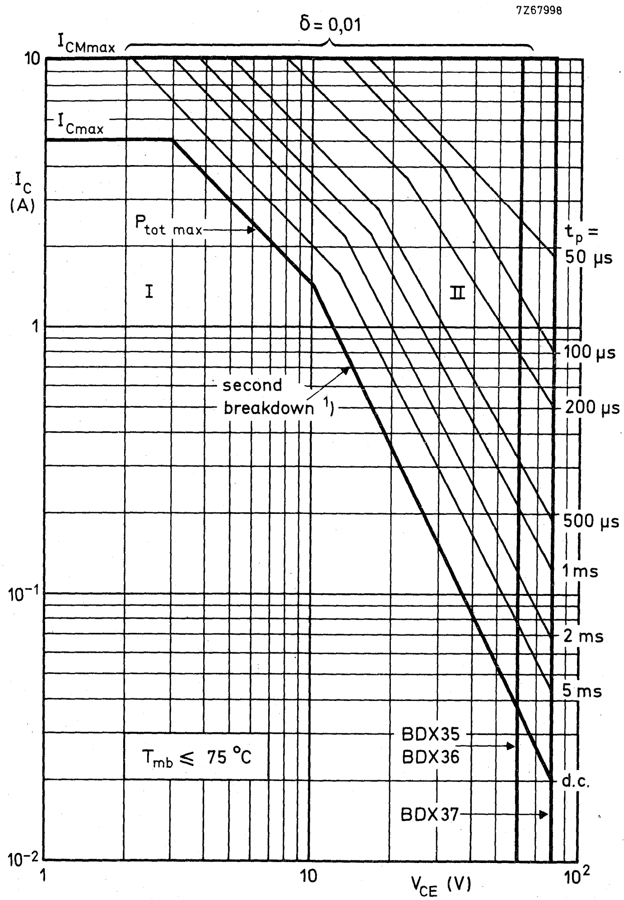


Fig. 2 Safe Operating Area with the transistor forward biased.

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation.

[1]) Independent of temperature.

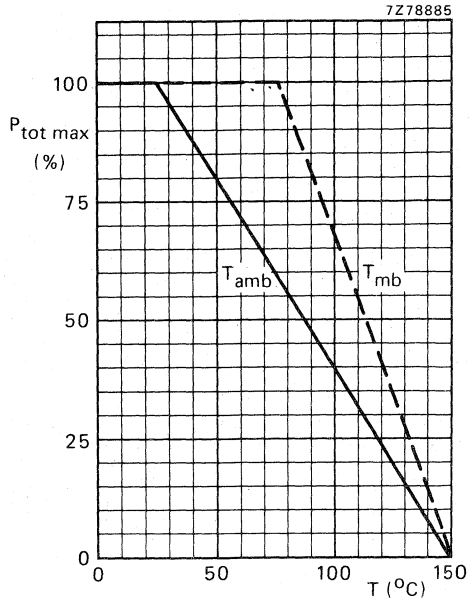


Fig. 3 Power derating curve.

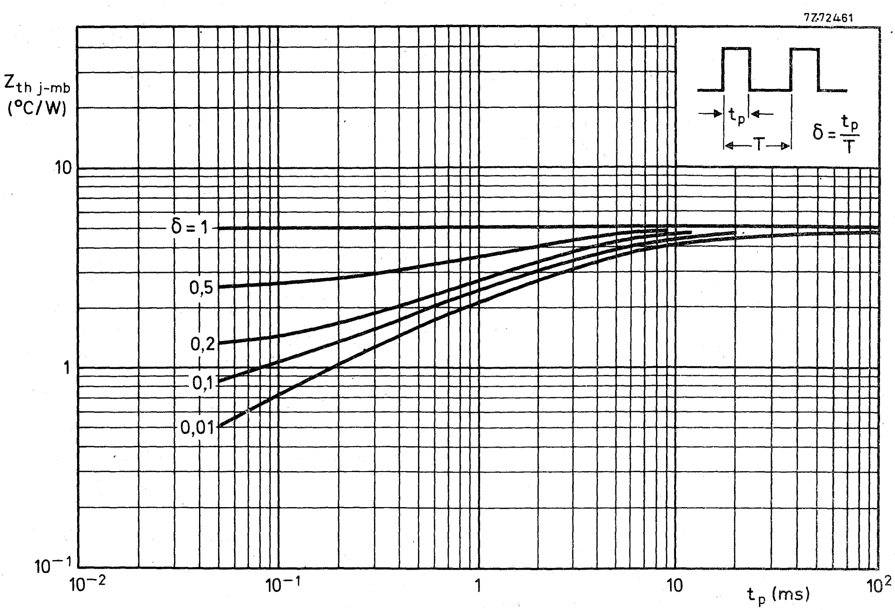


Fig. 4 Pulse power rating chart.

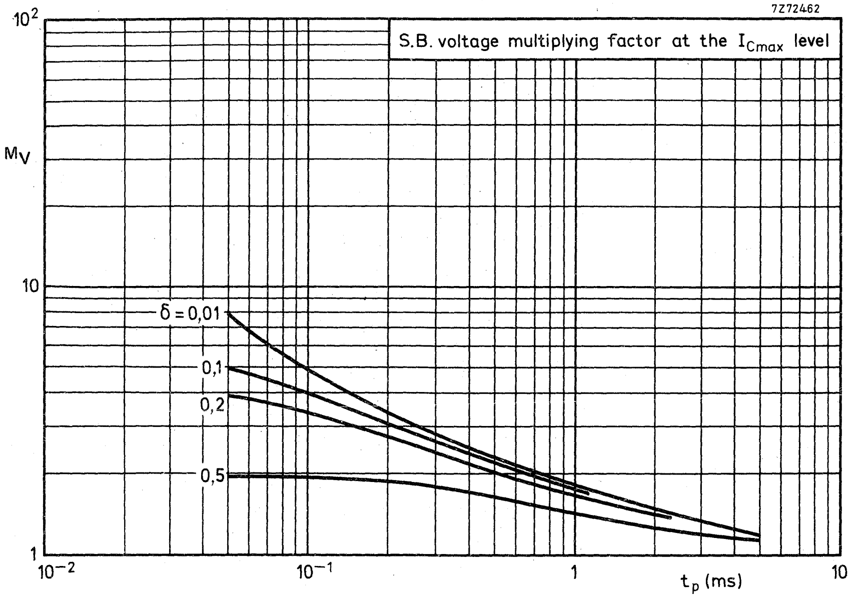


Fig. 5 S.B. voltage multiplying factor at the I_{Cmax} level.

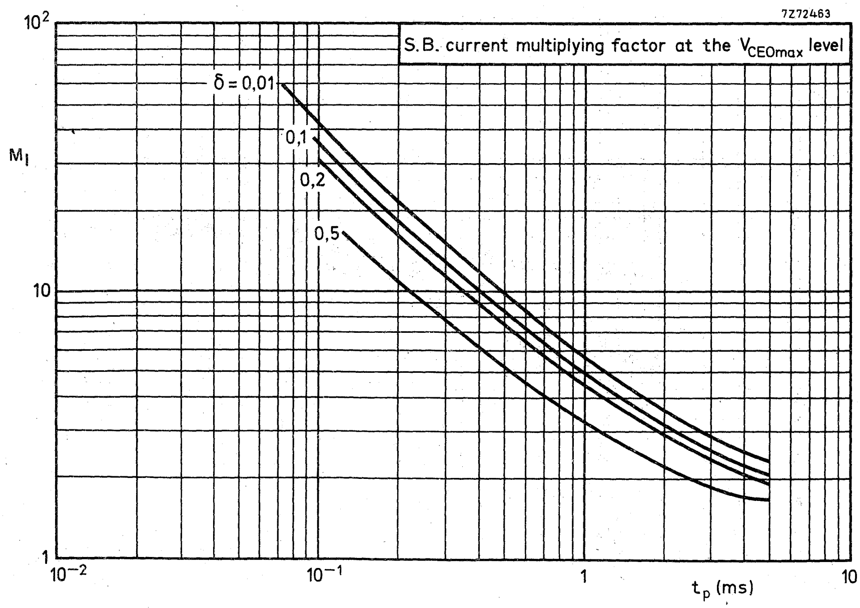


Fig. 6 S.B. current multiplying factor at the V_{CEOmax} level.

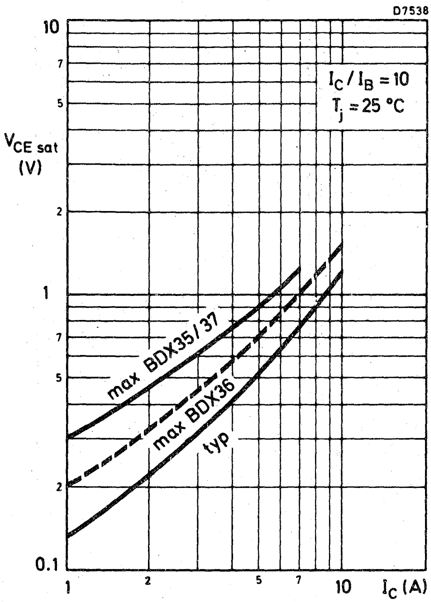


Fig. 7 Collector-emitter saturation voltage as a function of the collector current.

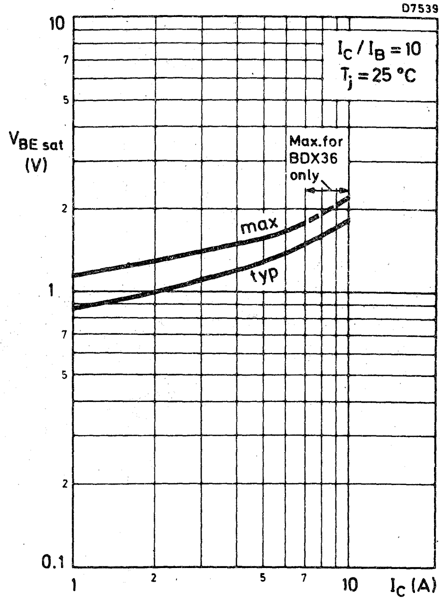


Fig. 8 Base-emitter saturation voltage as a function of the collector current.

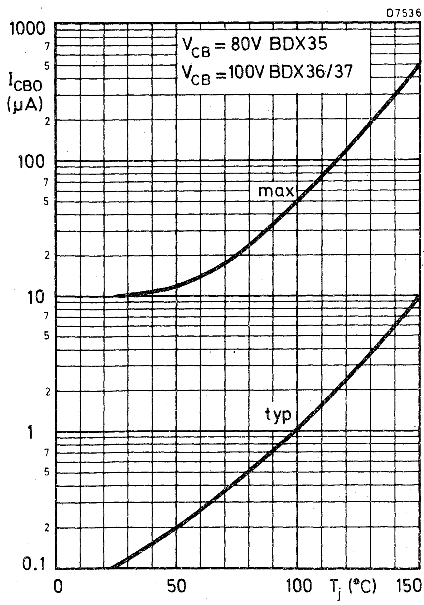


Fig. 9 Collector-base current with an open emitter as a function of junction temperature.

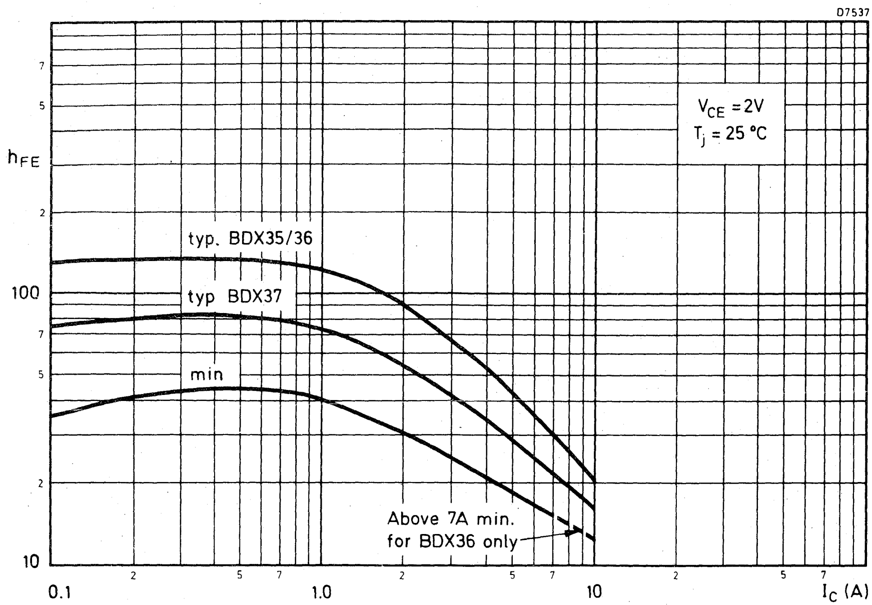


Fig. 10 D.C. current gain as a function of collector current.

N-P-N SILICON PLANAR DARLINGTON TRANSISTORS

Silicon n-p-n planar Darlington transistors for industrial switching applications, e.g. print hammer, solenoid, relay and lamp driving. Encapsulated in a TO-126 plastic envelope with collector connected to the heatsink.
P-N-P complements are BDX45, BDX46 and BDX47 respectively.

QUICK REFERENCE DATA

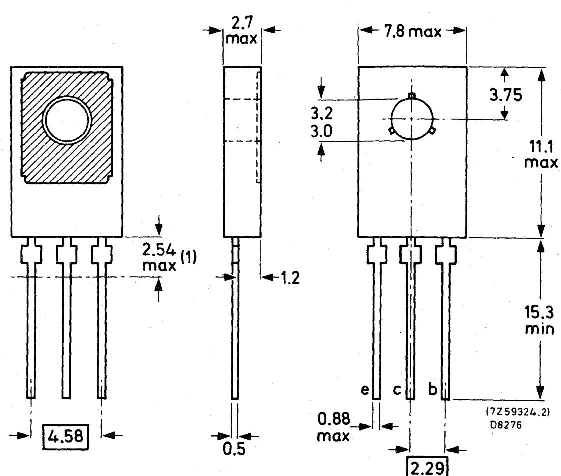
			BDX42	BDX43	BDX44	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	V
Collector-emitter voltage	V_{CER}	max.	45	60	80	V
Collector current	I_C	max.	1	1	1	A
Total power dissipation						
up to T_{amb} = 25 °C	P_{tot}	max.	1,25	1,25	1,25	W
up to T_{mb} = 100 °C	P_{tot}	max.	5	5	5	W
D.C. current gain						
I_C = 500 mA; V_{CE} = 10 V	h_{FE}	>	2000	2000	2000	
Collector-emitter saturation voltage						
I_C = 1 A; I_B = 1 mA	V_{CEsat}	<	–	1,6	–	V
I_C = 1 A; I_B = 4 mA	V_{CEsat}	<	1,6	–	1,6	V
Turn-off time						
I_C = 500 mA; $I_{Bon} = -I_{Boff}$ = 0,5 mA	t_{off}	typ.	1500	1500	1500	ns

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-126.

Collector connected to the metal part of mounting surface.



(1) Dimensions within this zone are uncontrolled.

See also chapters Mounting Instructions and Accessories.

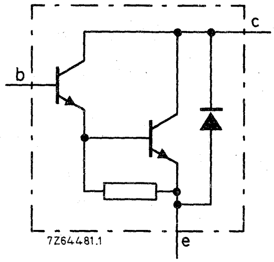


Fig. 2 Circuit diagram.

RATINGS

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

			BDX42	BDX43	BDX44	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	V
Collector-emitter voltage *	V_{CER}	max.	45	60	80	V
Emitter-base voltage (open collector)	V_{EBO}	max.		5		V
Collector current (d.c.)	I_C	max.		1		A
Collector current (peak)	I_{CM}	max.		2		A
Base current (d.c.)	I_B	max.		0,1		A
Total power dissipation						
up to T_{amb} = 25 °C	P_{tot}	max.		1,25		W
up to T_{mb} = 100 °C	P_{tot}	max.		5		W
Storage temperature	T_{stg}			−65 to + 150		°C
Junction temperature **	T_j	max.		150		°C

THERMAL RESISTANCE **

From junction to ambient	$R_{th\ j\text{-}a}$	=	100	°C/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	10	°C/W

* External R_{BE} not to exceed value shown in Fig. 12.

** Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
V_{BE} = 0; V_{CE} = 45 V	BDX42	I_{CES}	<	10 μA
V_{BE} = 0; V_{CE} = 60 V	BDX43	I_{CES}	<	10 μA
V_{BE} = 0; V_{CE} = 80 V	BDX44	I_{CES}	<	10 μA
Emitter cut-off current				
I_C = 0; V_{EB} = 4 V		I_{EBO}	<	10 μA
D.C. current gain				
I_C = 150 mA; V_{CE} = 10 V		h_{FE}	>	1000
I_C = 500 mA; V_{CE} = 10 V		h_{FE}	>	2000
Collector-emitter saturation voltage				
I_C = 500 mA; I_B = 0,5 mA		V_{CEsat}	<	1,3 V
I_C = 1 A; I_B = 1 mA	BDX43	V_{CEsat}	<	1,6 V
I_C = 1 A; I_B = 4 mA	BDX42, 44	V_{CEsat}	<	1,6 V
I_C = 500 mA; I_B = 0,5 mA; T_j = 150 °C		V_{CEsat}	<	1,3 V
I_C = 1 A; I_B = 1 mA; T_j = 150 °C	BDX43	V_{CEsat}	<	1,8 V
I_C = 1 A; I_B = 4 mA; T_j = 150 °C	BDX42, 44	V_{CEsat}	<	1,6 V
Base-emitter saturation voltage				
I_C = 500 mA; I_B = 0,5 mA		V_{BEsat}	<	1,9 V
I_C = 1 A; I_B = 1 mA	BDX43	V_{BEsat}	<	2,2 V
I_C = 1 A; I_B = 4 mA	BDX42, 44	V_{BEsat}	<	2,2 V
Small signal current gain				
I_C = 500 mA; V_{CE} = 5 V; f = 35 MHz		h_{fe}	typ.	10
Switching times (see also Fig. 3 and Fig. 4)				
I_C = 500 mA; I_{Bon} = $-I_{Boff}$ = 0,5 mA				
Turn-on time		t_{on}	typ.	400 ns
Turn-off time		t_{off}	typ.	1500 ns
I_C = 1 A; I_{Bon} = $-I_{Boff}$ = 1 mA				
Turn-on time		t_{on}	typ.	400 ns
Turn-off time		t_{off}	typ.	1500 ns

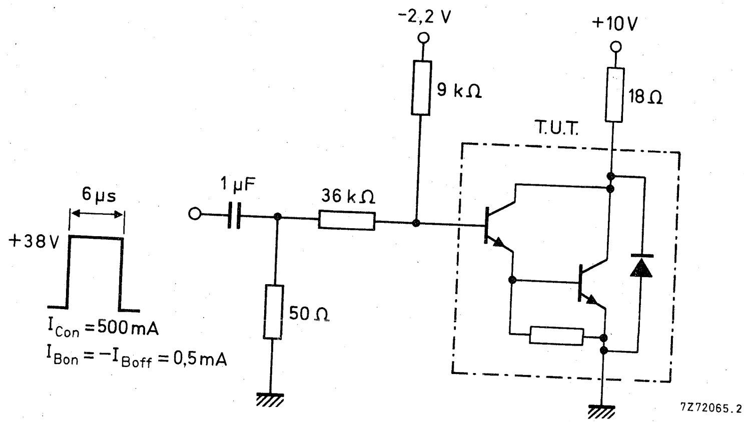


Fig. 3 Test circuit for 500 mA switching.

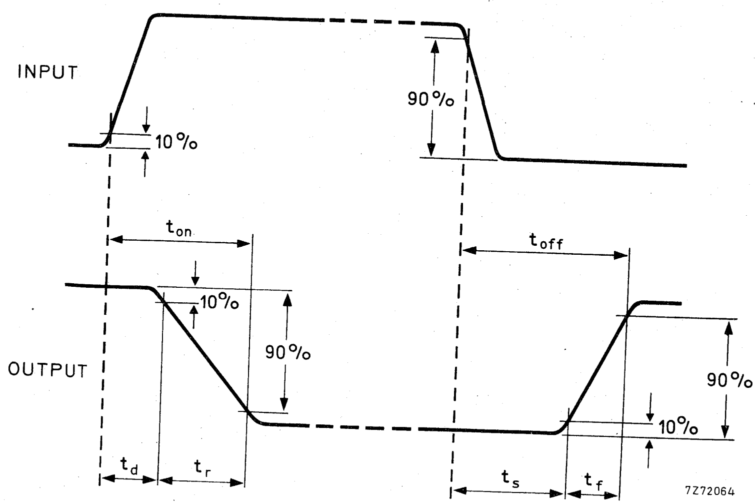


Fig. 4 Switching waveforms.

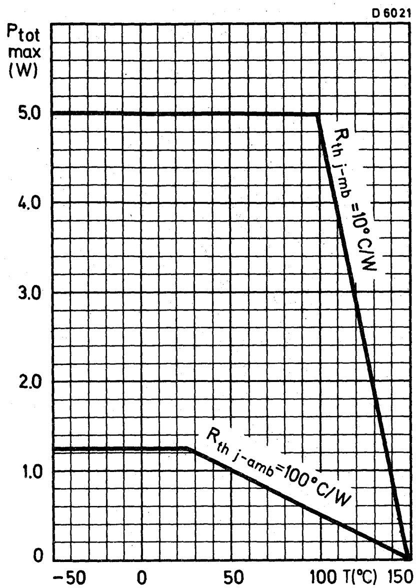


Fig. 5.

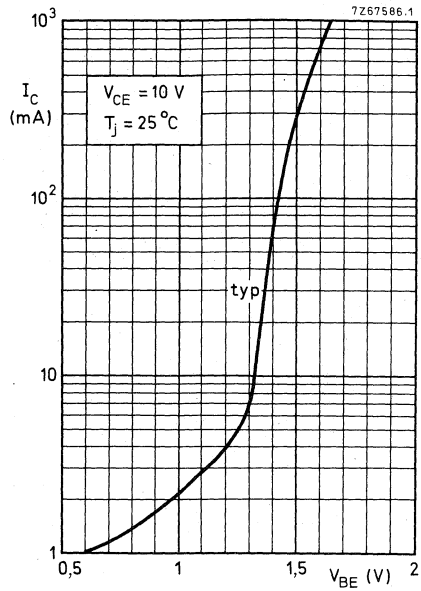


Fig. 6.

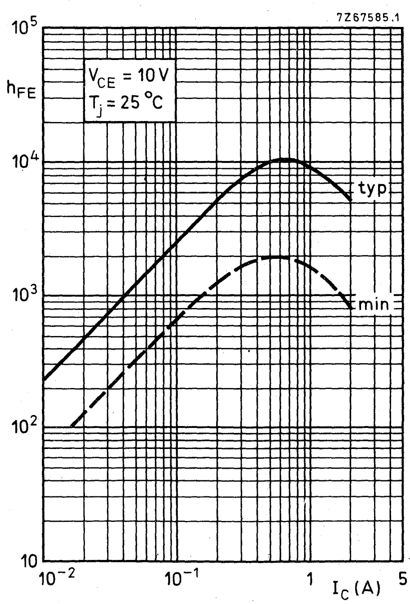


Fig. 7.

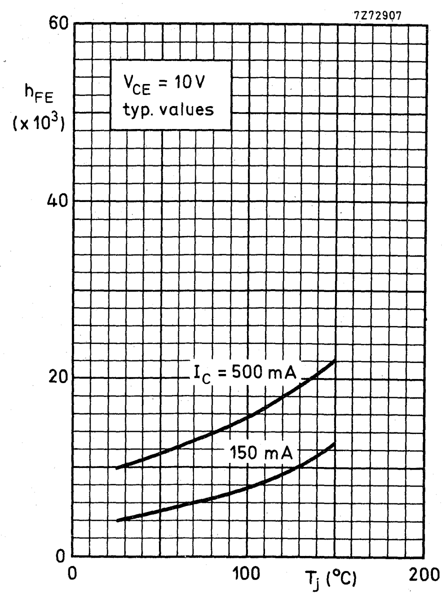


Fig. 8.

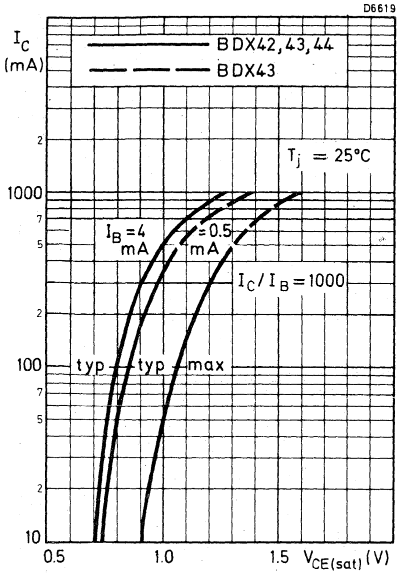


Fig. 9.

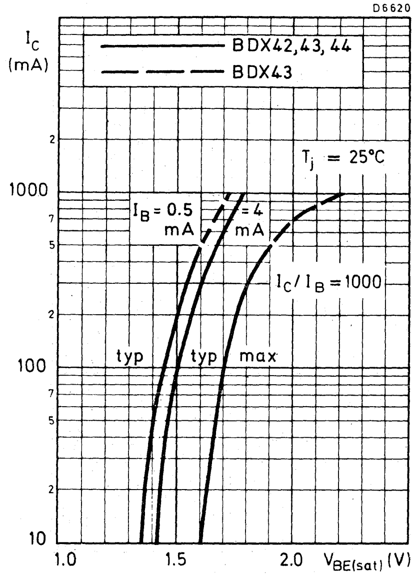


Fig. 10.

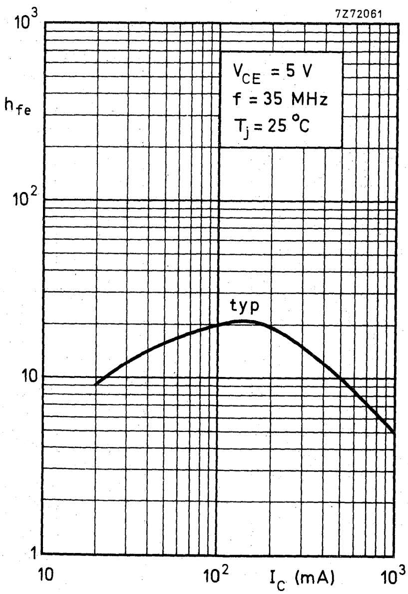


Fig. 11.

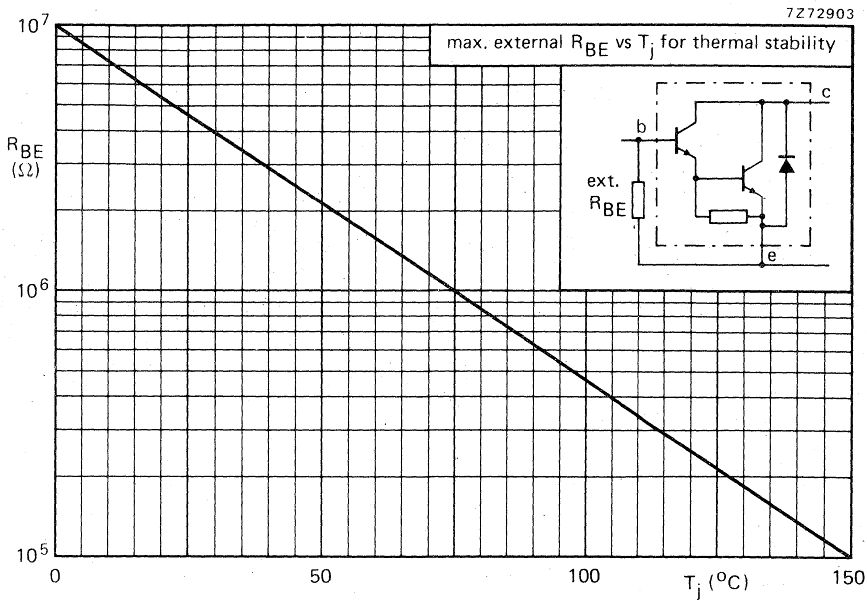

7Z72903
max. external R_{BE} vs T_j for thermal stability
10^7
R_{BE}
(Ω)
10^6
10^5
0
50
100
T_j (°C)
150
c
b
ext.
R_{BE}
e

Fig. 12.

P-N-P SILICON PLANAR DARLINGTON TRANSISTORS

Silicon p-n-p planar Darlington transistors for industrial switching applications, e.g. print hammer, solenoid, relay and lamp driving. Encapsulated in a TO-126 plastic envelope with collector connected to the heatsink.
N-P-N complements are BDX42, BDX43 and BDX44 respectively.

QUICK REFERENCE DATA

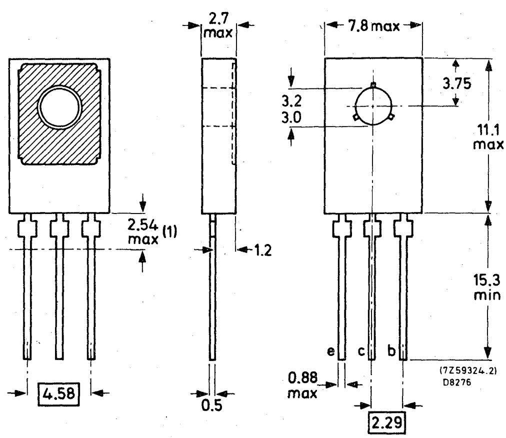
			BDX45	BDX46	BDX47	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage	$-V_{CER}$	max.	45	60	80	V
Collector current	$-I_C$	max.	1	1	1	A
Total power dissipation						
up to T_{amb} = 25 °C	P_{tot}	max.	1,25	1,25	1,25	W
up to T_{mb} = 100 °C	P_{tot}	max.	5	5	5	W
D.C. current gain						
$-I_C$ = 500 mA; $-V_{CE}$ = 10 V	h_{FE}	>	2000	2000	2000	
Collector-emitter saturation voltage						
$-I_C$ = 1 A; $-I_B$ = 1 mA	$-V_{CEsat}$	<	–	1,6	–	V
$-I_C$ = 1 A; $-I_B$ = 4 mA	$-V_{CEsat}$	<	1,6	–	1,6	V
Turn-off time						
$-I_C$ = 500 mA; $-I_{Bon}$ = I_{Boff} = 0,5 mA	t_{off}	typ.	1500	1500	1500	ns

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-126.

Collector connected to the metal part of mounting surface.



(1) Dimensions within this zone are uncontrolled

See also chapters Mounting Instructions and Accessories.

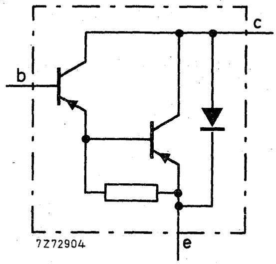


Fig. 2 Circuit diagram.

RATINGS

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

			BDX45	BDX46	BDX47	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage *	$-V_{CER}$	max.	45	60	80	V

Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	V
Collector current (d.c.)	$-I_C$	max.	1	A
Collector current (peak)	$-I_{CM}$	max.	2	A
Base current (d.c.)	$-I_B$	max.	0,1	A
Total power dissipation				
up to T_{amb} = 25 °C	P_{tot}	max.	1,25	W
up to T_{mb} = 100 °C	P_{tot}	max.	5	W
Storage temperature	T_{stg}		−65 to + 150	°C
Junction temperature**	T_j	max.	150	°C

THERMAL RESISTANCE **

From junction to ambient	$R_{th\ j\text{-}a}$	=	100	°C/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	10	°C/W

* External R_{BE} not to exceed value shown in Fig. 12.
** Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$V_{BE} = 0$; $-V_{CE} = 45$ V	BDX45	$-I_{CES}$	<	10 μA
$V_{BE} = 0$; $-V_{CE} = 60$ V	BDX46	$-I_{CES}$	<	10 μA
$V_{BE} = 0$; $-V_{CE} = 80$ V	BDX47	$-I_{CES}$	<	10 μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 4$ V		$-I_{EBO}$	<	10 μA
D.C. current gain				
$-I_C = 150$ mA; $-V_{CE} = 10$ V		h_{FE}	>	1000
$-I_C = 500$ mA; $-V_{CE} = 10$ V		h_{FE}	>	2000
Collector-emitter saturation voltage				
$-I_C = 500$ mA; $-I_B = 0,5$ mA		$-V_{CEsat}$	<	1,3 V
$-I_C = 1$ A; $-I_B = 1$ mA	BDX46	$-V_{CEsat}$	<	1,6 V
$-I_C = 1$ A; $-I_B = 4$ mA	BDX45, 47	$-V_{CEsat}$	<	1,6 V
$-I_C = 500$ mA; $-I_B = 0,5$ mA; $T_j = 150$ °C		$-V_{CEsat}$	<	1,3 V
$-I_C = 1$ A; $-I_B = 1$ mA; $T_j = 150$ °C	BDX46	$-V_{CEsat}$	<	1,8 V
$-I_C = 1$ A; $-I_B = 4$ mA; $T_j = 150$ °C	BDX45, 47	$-V_{CEsat}$	<	1,6 V
Base-emitter saturation voltage				
$-I_C = 500$ mA; $-I_B = 0,5$ mA		$-V_{BEsat}$	<	1,9 V
$-I_C = 1$ A; $-I_B = 1$ mA	BDX46	$-V_{BEsat}$	<	2,2 V
$-I_C = 1$ A; $-I_B = 4$ mA	BDX45, 47	$-V_{BEsat}$	<	2,2 V
Small signal current gain				
$-I_C = 500$ mA; $-V_{CE} = 5$ V, f = 35 MHz		h_{fe}	typ.	10
Switching times (see also Fig. 3 and Fig. 4)				
$-I_C = 500$ mA; $-I_{Bon} = I_{Boff} = 0,5$ mA				
Turn-on time		t_{on}	typ.	400 ns
Turn-off time		t_{off}	typ.	1500 ns
$-I_C = 1$ A; $-I_{Bon} = I_{Boff} = 1$ mA				
Turn-on time		t_{on}	typ.	400 ns
Turn-off time		t_{off}	typ.	1500 ns

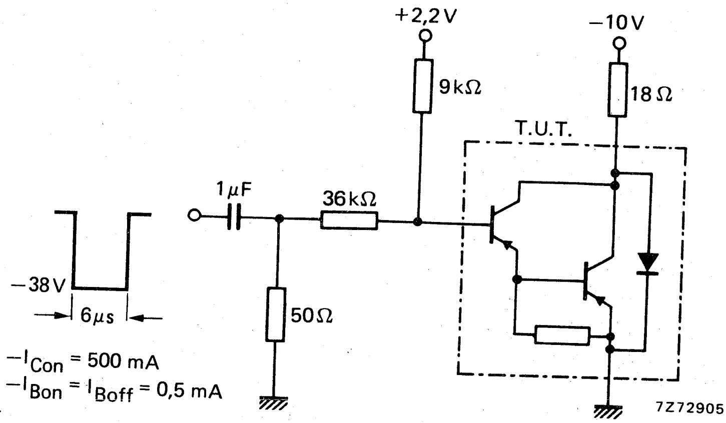


Fig. 3 Test circuit for 500 mA switching.

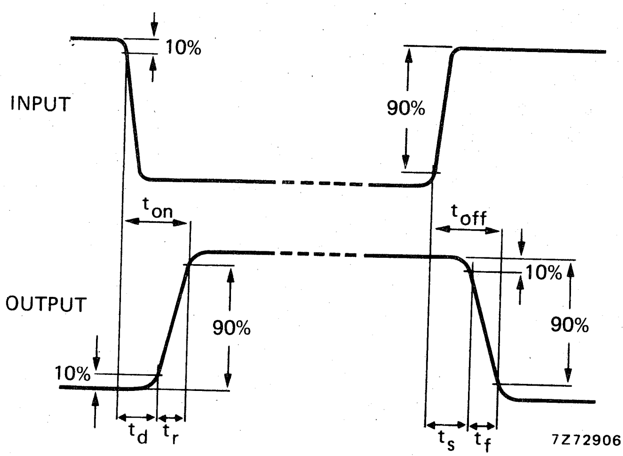


Fig. 4 Switching waveforms.

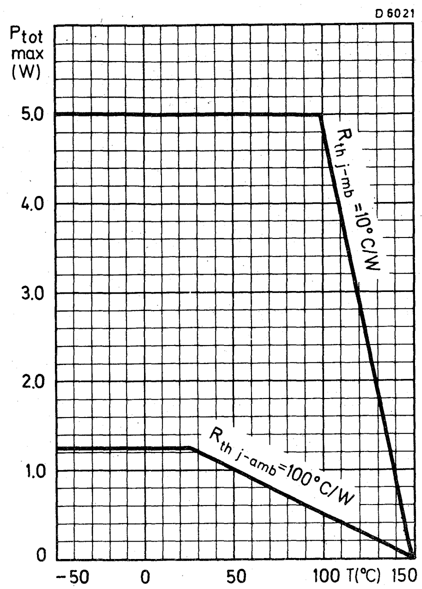


Fig. 5.

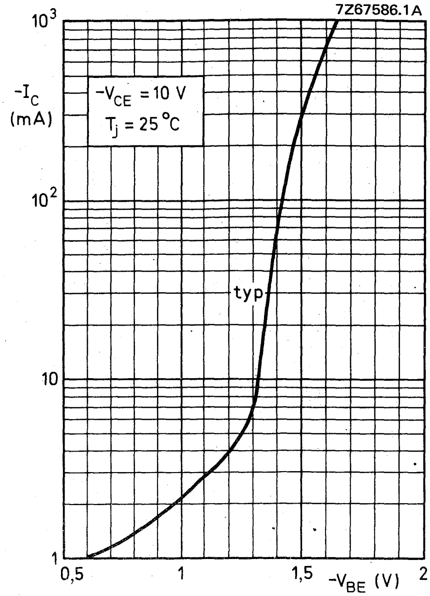


Fig. 6.

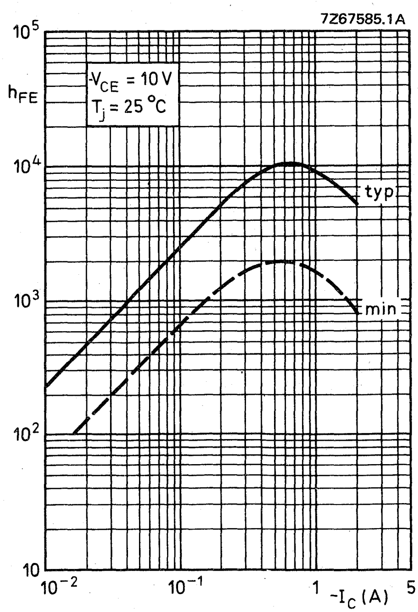


Fig. 7.

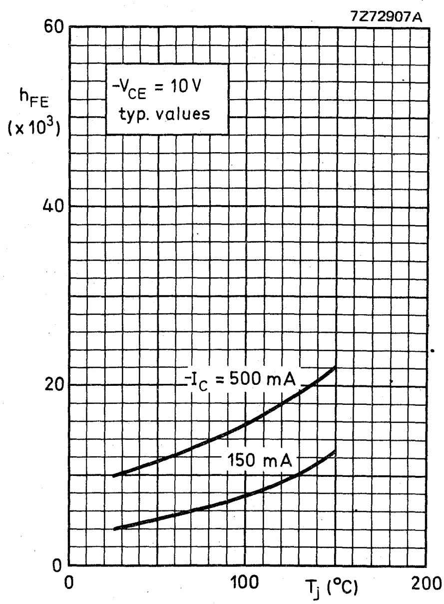


Fig. 8.

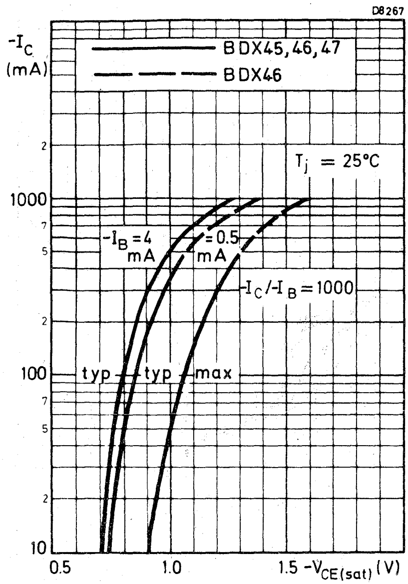


Fig. 9.

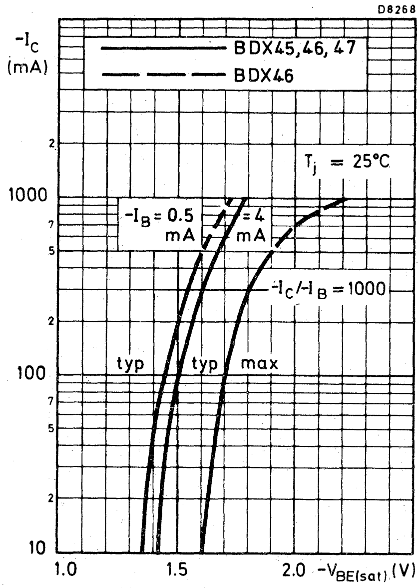


Fig. 10.

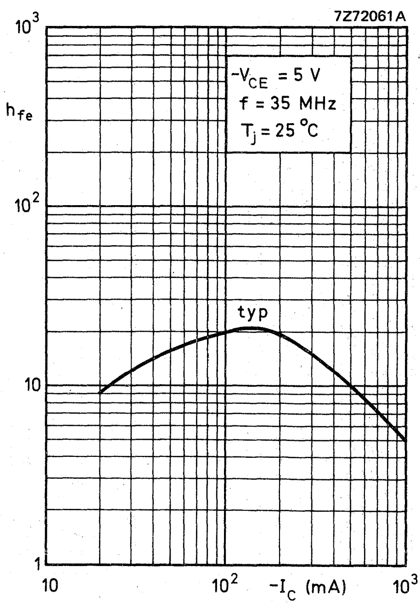


Fig. 11.

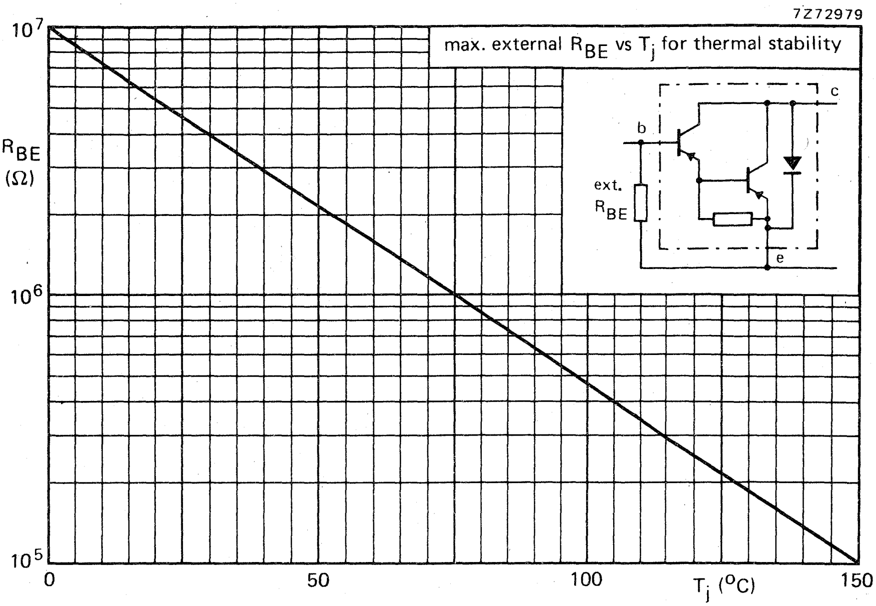

7Z72979
max. external R_{BE} vs T_j for thermal stability
10^7
R_{BE}
(Ω)
10^6
10^5
0
50
100
T_j (^oC)
150
b
c
e
ext.
R_{BE}

Fig. 12.

SILICON DARLINGTON POWER TRANSISTORS

P-N-P epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications: TO-3 envelope, N-P-N complements are BDX63, BDX63A, BDX63B and BDX63C. Matched complementary pairs can be supplied.

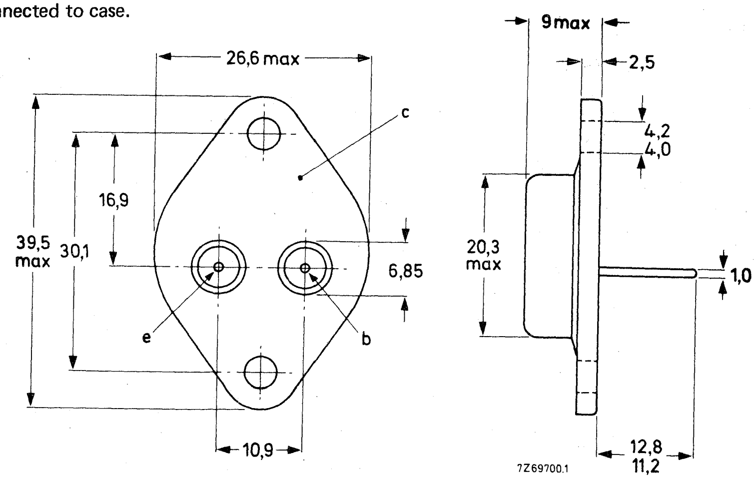
QUICK REFERENCE DATA

			BDX62	62A	62B	62C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Collector current (peak value)	$-I_{CM}$	max.	12				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	90				W
Junction temperature	T_j	max.	200				°C
D.C. current gain							
$-I_C$ = 0,5 A; $-V_{CE}$ = 3 V	h_{FE}	typ.	1500				
$-I_C$ = 3,0 A; $-V_{CE}$ = 3 V	h_{FE}	>	1000				
Cut-off frequency							
$-I_C$ = 3 A; $-V_{CE}$ = 3 V	f_{hfe}	typ.	100				kHz

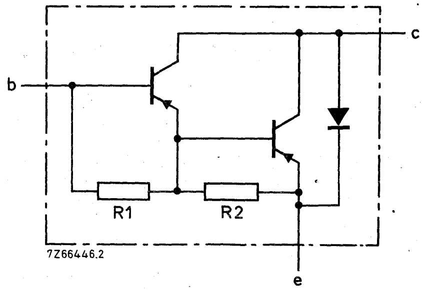
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-3.
Collector connected to case.



See also chapters Mounting instructions and Accessories.



R_1 typ. 6 kΩ
R_2 typ. 80 Ω

Fig. 2 Circuit diagram.

RATINGS

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

			BDX62	62A	62B	62C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	5	V
Collector current (d.c.)	$-I_C$	max.		8			A
Collector current (peak value)	$-I_{CM}$	max.		12			A
Base current (d.c.)	$-I_B$	max.		150			mA
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		90			W
Storage temperature	T_{stg}			−65 to +200			°C
Junction temperature*	T_j	max.		200			°C

THERMAL RESISTANCE*

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,94 °C/W

* Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

Collector cut-off current			
$I_E = 0; -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	0,2 mA
$I_E = 0; -V_{CB} = 40$ V; $T_j = 200$ °C; BDX62 $I_E = 0; -V_{CB} = 50$ V; $T_j = 200$ °C; BDX62A $I_E = 0; -V_{CB} = 60$ V; $T_j = 200$ °C; BDX62B $I_E = 0; -V_{CB} = 70$ V; $T_j = 200$ °C; BDX62C	$-I_{CBO}$	<	2 mA
$I_B = 0; -V_{CE} = -½V_{CEO}$	$-I_{CEO}$	<	0,5 mA
Emitter cut-off current $I_C = 0; -V_{EB} = 5$ V	$-I_{EBO}$	<	5 mA
D.C. current gain (note 1)			
$-I_C = 0,5$ A; $-V_{CE} = 3$ V	h_{FE}	typ.	1500
$-I_C = 3$ A; $-V_{CE} = 3$ V	h_{FE}	>	1000
$-I_C = 8$ A; $-V_{CE} = 3$ V	h_{FE}	typ.	750
Base-emitter voltage (notes 1 and 2) $-I_C = 3$ A; $-V_{CE} = 3$ V	$-V_{BE}$	<	2,5 V
Collector-emitter saturation voltage (note 1) $-I_C = 3$ A; $-I_B = 12$ mA	$-V_{CEsat}$	<	2 V
Collector capacitance at f = 1 MHz $I_E = I_e = 0; -V_{CB} = 10$ V	C_c	typ.	100 pF
Cut-off frequency $-I_C = 3$ A; $-V_{CE} = 3$ V	f_{hfe}	typ.	100 kHz
Small-signal current gain $-I_C = 3$ A; $-V_{CE} = 3$ V; f = 1 MHz	h_{fe}	typ.	100
D.C. current gain ratio of complementary matched pairs $-I_C = 3$ A; $-V_{CE} = 3$ V	h_{FE1}/h_{FE2}	<	2,5

Notes
1. Measured under pulse conditions: $t_p < 300$ µs, $\delta < 2\%$.
2. $-V_{BE}$ decreases by about 3,6 mV/°C with increasing temperature.

CHARACTERISTICS (continued)

Switching times (between 10% and 90% levels)		
$-I_{Con} = 3$ A; $-I_{Bon} = I_{Boff} = 12$ mA		
turn-on time	t_{on}	typ. 0,5 μs
turn-off time	t_{off}	typ. 2,5 μs

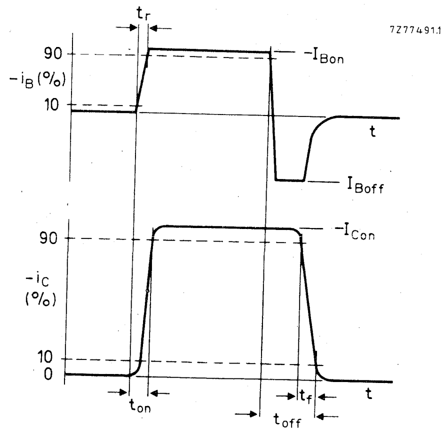
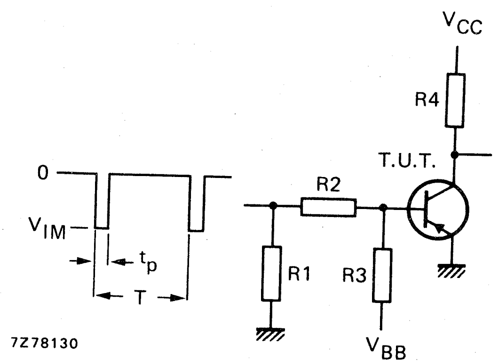


Fig. 3 Switching times waveforms.



$-V_{IM}$	=	10 V
$-V_{CC}$	=	10 V
$+V_{BB}$	=	2,2 V
R1	=	56 Ω
R2	=	410 Ω
R3	=	560 Ω
R4	=	3 Ω
$t_r = t_f$	=	15 ns
t_p	=	10 μs
T	=	500 μs

Fig. 4 Switching times test circuit.

Diode forward voltage		
$I_F = 3$ A	V_F	typ. 1,8 V

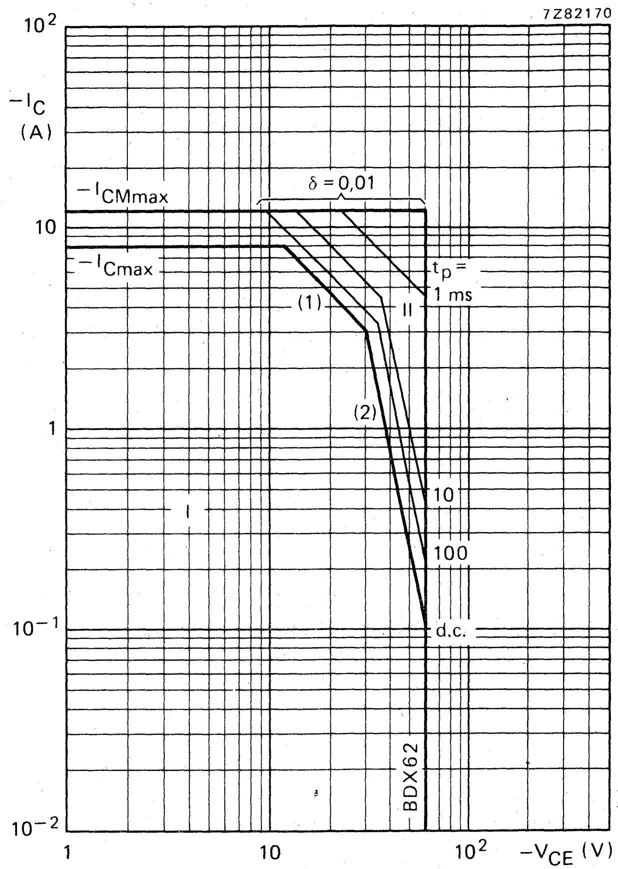


Fig. 5 Safe Operating ARea; T_{mb} = 25 °C.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second-breakdown limits (independent of temperature).

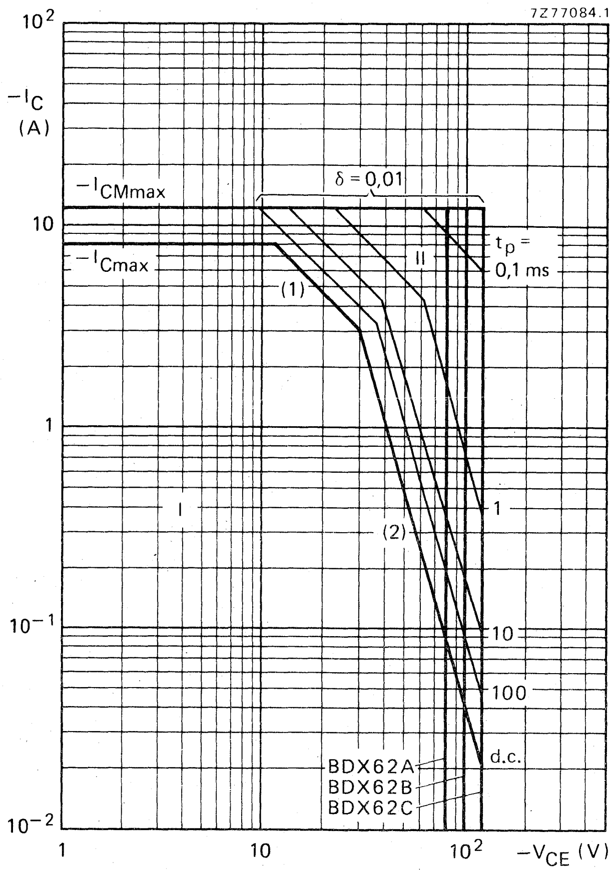


Fig. 6 Safe Operating ARea; T_{mb} = 25 °C.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second-breakdown limits (independent of temperature).

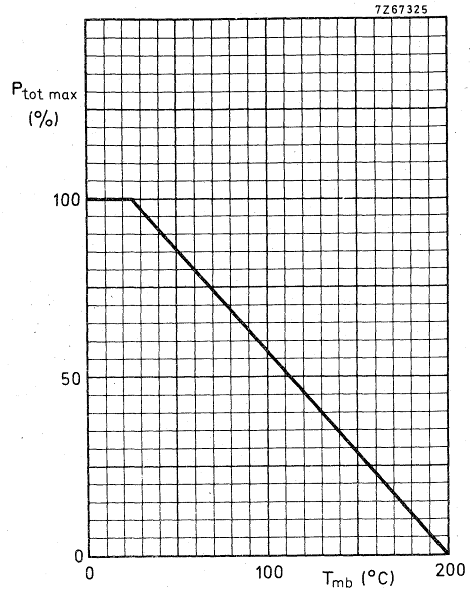


Fig. 7 Power derating curve.

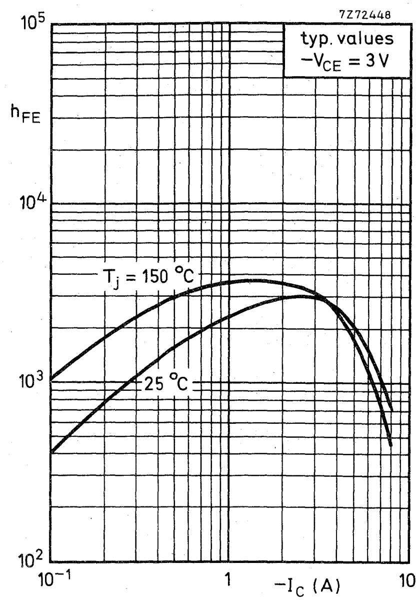


Fig. 8 D.C. current gain.

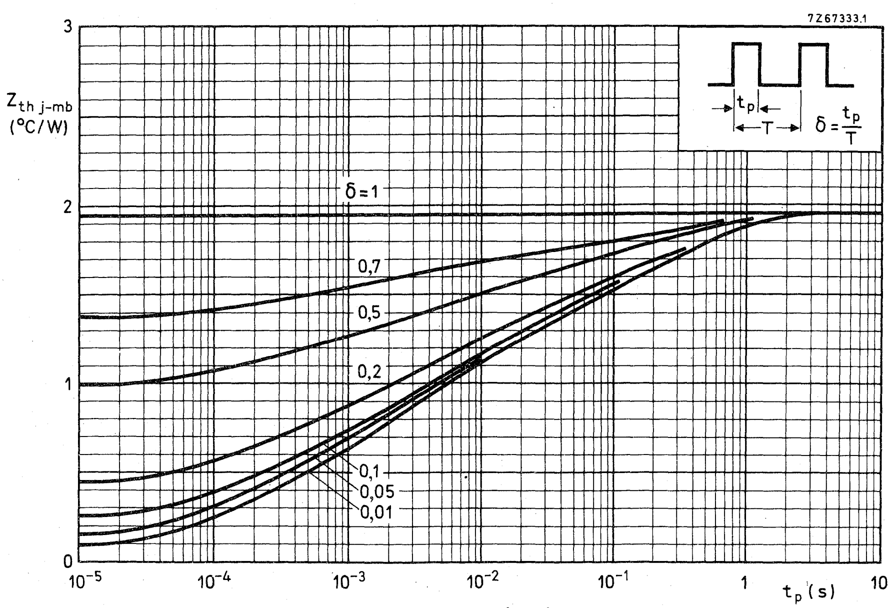


Fig. 9 Pulse power rating chart.

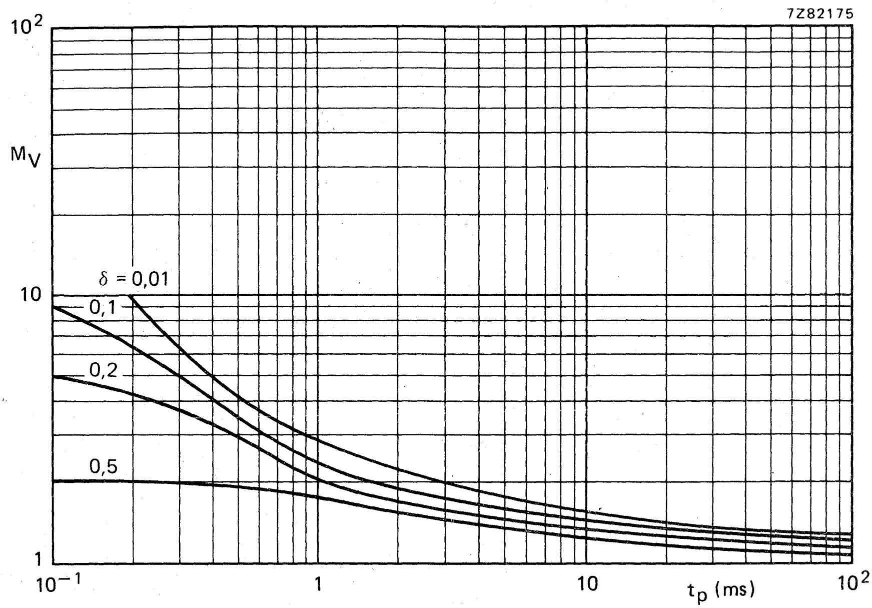


Fig. 10 S.B. voltage multiplying factor at the I_{Cmax} level.

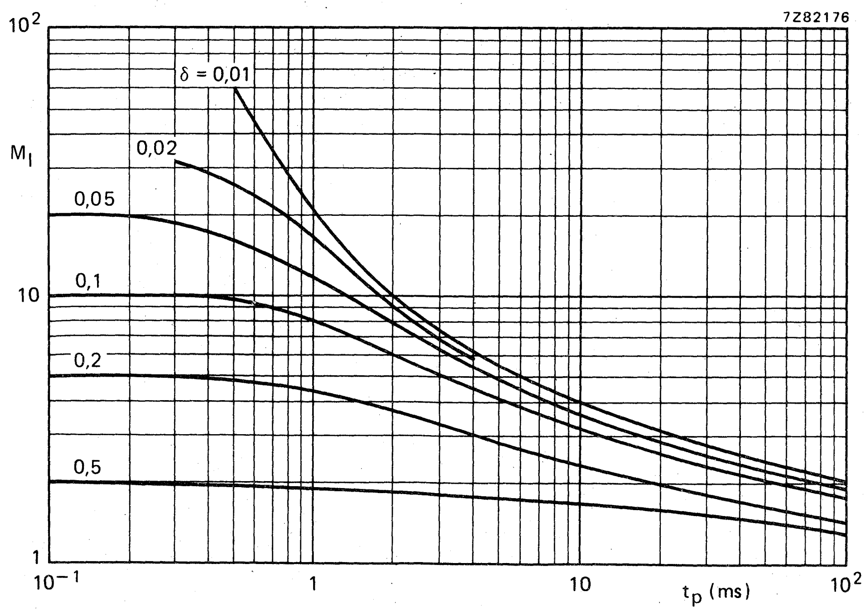


Fig. 11 S.B. current multiplying factor at the V_{CEO} 100 V and 60 V level.

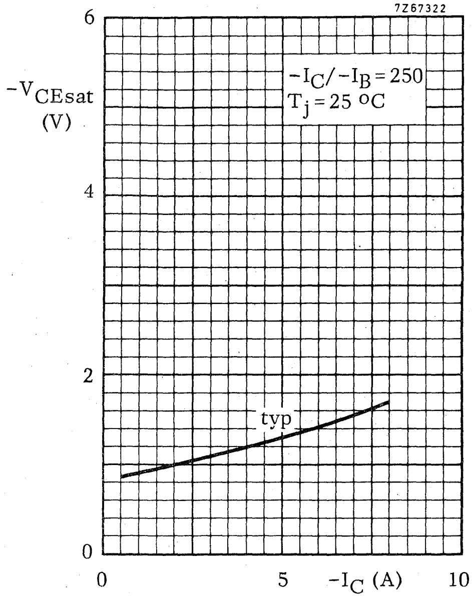


Fig. 12.

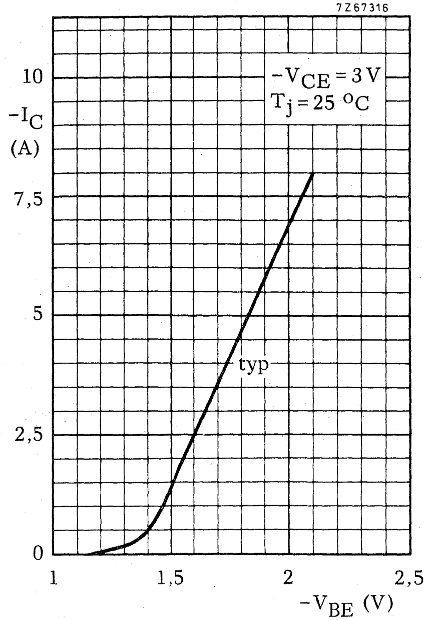


Fig. 13.

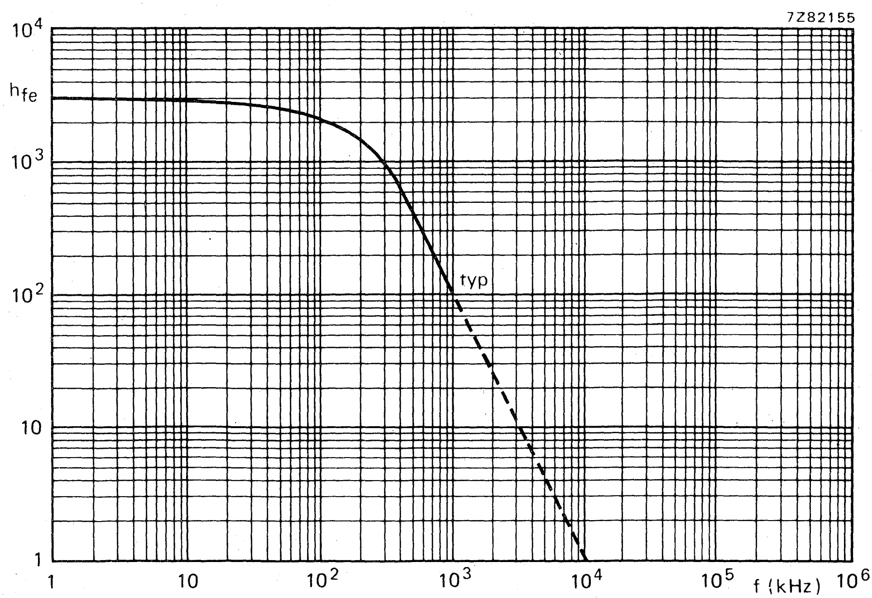


Fig. 14 Small signal current gain at $-I_C = 3$ A; $-V_{CE} = 3$ V.

SILICON DARLINGTON POWER TRANSISTORS

N-P-N epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications; TO-3 envelope, P-N-P complements are BDX62, BDX62A, BDX62B and BDX62C. Matched complementary pairs can be supplied.

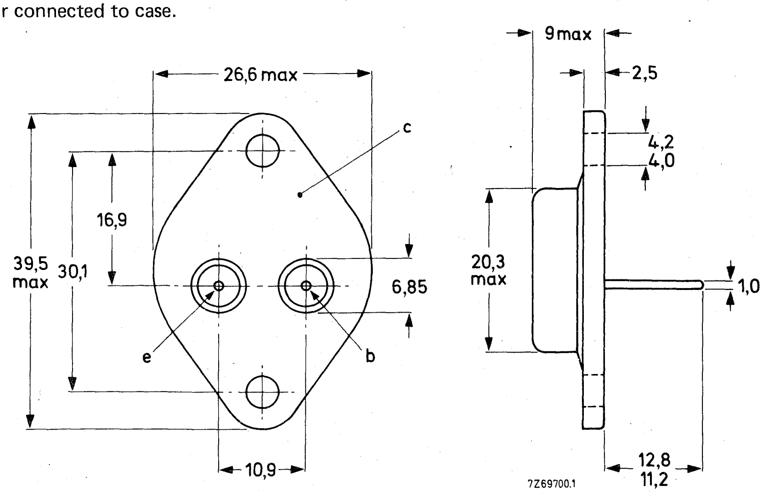
QUICK REFERENCE DATA

			BDX63	63A	63B	63C	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Collector current (peak value)	I_{CM}	max.	12				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	90				W
Junction temperature	T_j	max.	200				°C
D.C. current gain							
I_C = 0,5 A; V_{CE} = 3 V	h_{FE}	typ.	2500				
I_C = 3,0 A; V_{CE} = 3 V	h_{FE}	>	1000				
Cut-off frequency							
I_C = 3 A; V_{CE} = 3 V	f_{hfe}	typ.	100				kHz

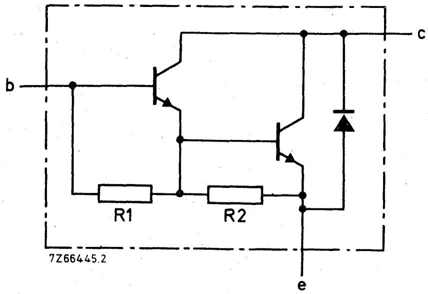
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-3.
Collector connected to case.



See also chapters Mounting Instructions and Accessories.



R1 typ. 8 kΩ
R2 typ. 100 Ω

Fig. 2 Circuit diagram.

RATINGS

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

			BDX63	63A	63B	63C	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	140	V
Collector-emitter voltage (open-base)	V_{CEO}	max.	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	5	V
Collector current (d.c.)	I_C	max.	8				A
Collector current (peak value)	I_{CM}	max.	12				A
Base current (d.c.)	I_B	max.	150				mA
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	90				W
Storage temperature	T_{stg}		−65 to +200				°C
Junction temperature*	T_j	max.	200				°C

THERMAL RESISTANCE *

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,94	K/W

* Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current			
$I_E = 0$; $V_{CB} = V_{CEOmax}$	I_{CBO}	<	0,2 mA
$I_E = 0$; $V_{CB} = ½V_{CBOmax}$; T_j = 200 °C	I_{CBO}	<	2 mA
$I_B = 0$; $V_{CE} = ½V_{CEOmax}$	I_{CEO}	<	0,5 mA
Emitter cut-off current			
$I_C = 0$; V_{EB} = 5 V	I_{EBO}	<	5 mA
D.C. current gain (note 1)			
I_C = 0,5 A; V_{CE} = 3 V	h_{FE}	typ.	2500 ←
I_C = 3 A; V_{CE} = 3 V	h_{FE}	>	1000
I_C = 8 A; V_{CE} = 3 V	h_{FE}	typ.	2600
Base-emitter voltage (notes 1 and 2)			
I_C = 3 A; V_{CE} = 3 V	V_{BE}	<	2,5 V
Collector-emitter saturation voltage (note 1)			
I_C = 3 A; I_B = 12 mA	V_{CEsat}	<	2 V
Collector capacitance at f = 1 MHz			
$I_E = I_e = 0$; V_{CB} = 10 V	C_c	typ.	100 pF
Cut-off frequency			
I_C = 3 A; V_{CE} = 3 V	f_{hfe}	typ.	100 kHz
Turn-off breakdown energy with inductive load (Fig. 4)			
$-I_{Boff} = 0$; I_{Con} = 4,5 A; t_p = 1 ms; T = 100 ms	$E_{(BR)}$	>	50 mJ
D.C. current gain ratio of complementary matched pairs			
I_C = 3 A; V_{CE} = 3 V	h_{FE1}/h_{FE2}	<	2,5
Small signal current gain			
I_C = 3 A; V_{CE} = 3 V; f = 1 MHz	$\|h_{fe}\|$	typ.	100 ←
Diode, forward voltage			
I_F = 3 A	V_F	typ.	1,2 V ←

Notes
1. Measured under pulse conditions: $t_p < 300\ \mu s$, $\delta < 2\%$.
2. V_{BE} decreases by about 3,6 mV/°C with increasing temperature.

CHARACTERISTICS (continued)

Switching times
(between 10% and 90% levels)
I_{Con} = 3 A; I_{Bon} = $-I_{Boff}$ = 12 mA

turn-on time	t_{on}	typ.	0,5 μs
turn-off time	t_{off}	typ.	5 μs

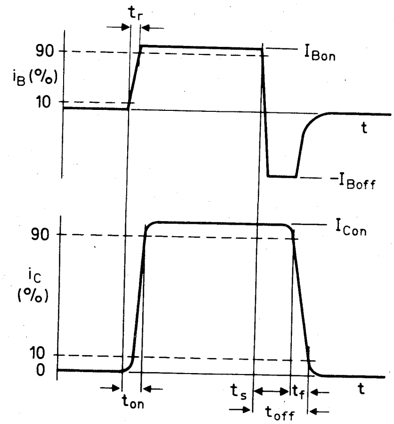
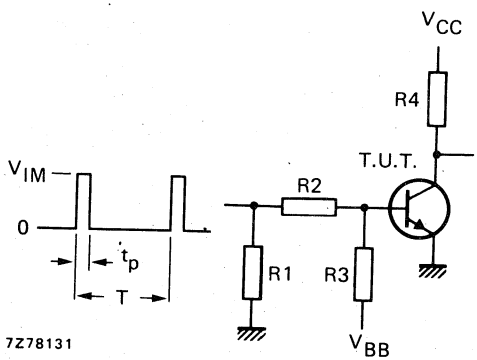


Fig. 3 Switching time waveforms.



V_{IM}	=	10 V
V_{CC}	=	10 V
V_{BB}	=	−4 V
R1	=	56 Ω
R2	=	410 Ω
R3	=	560 Ω
R4	=	3 Ω
$t_r = t_f$	⩽	15 ns
t_p	=	10 μs
T	=	500 μs

Fig. 4 Switching times test circuit.

Diode, forward voltage
$I_F = 3$ A $\quad V_F \quad$ typ. 1,2 V

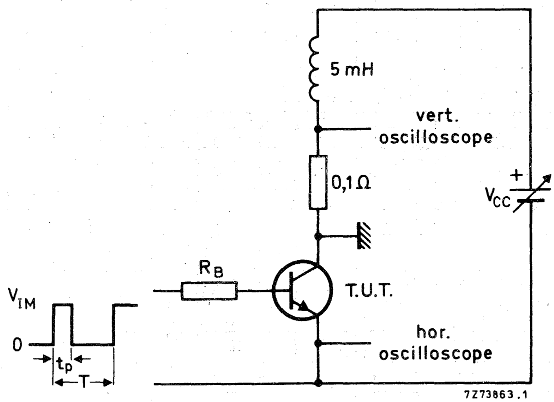


Fig. 5 Test circuit for turn-off breakdown energy.
$V_{IM} = 12$ V; $R_B = 270\ \Omega$; $I_{CC} = 4,5$ A; $t_p = 1$ ms; $\delta = 1\%$.

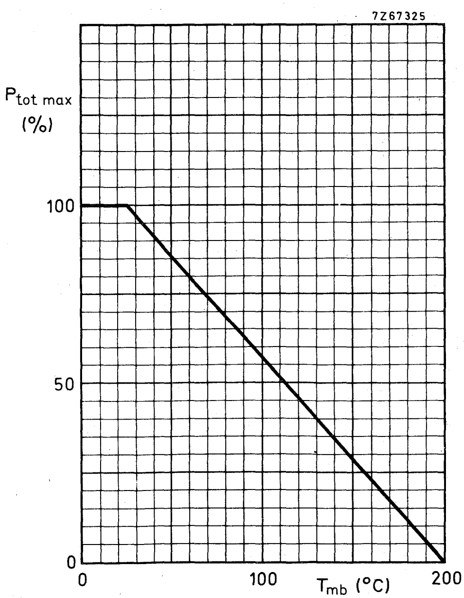


Fig. 6 Power derating curve.

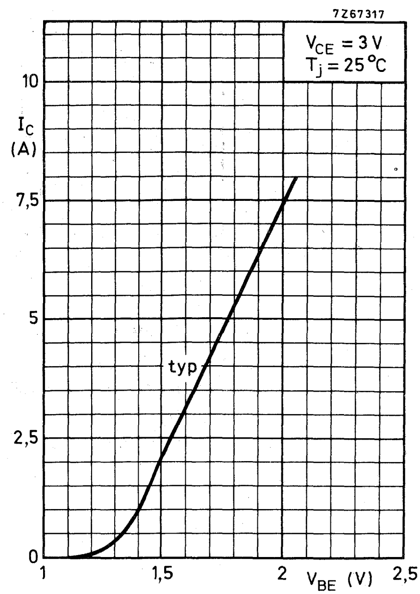


Fig. 7.

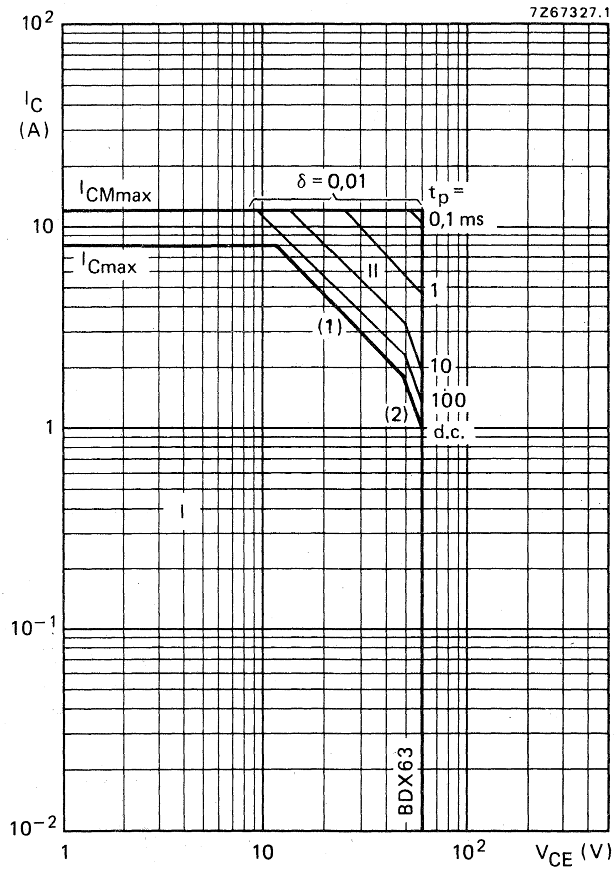


Fig. 8 Safe Operating ARea, $T_{mb} \leqslant 25$ °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.

(2) Second-breakdown limits (independent of temperature).

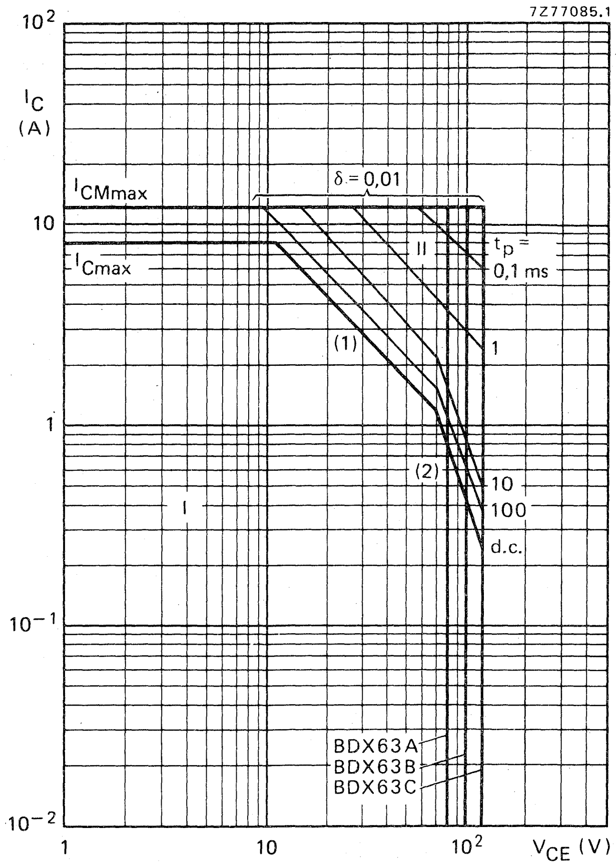


Fig. 9 Safe Operating ARea, $T_{mb} \leqslant 25\ ^oC$.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.
(2) Second-breakdown limits (independent of temperature).

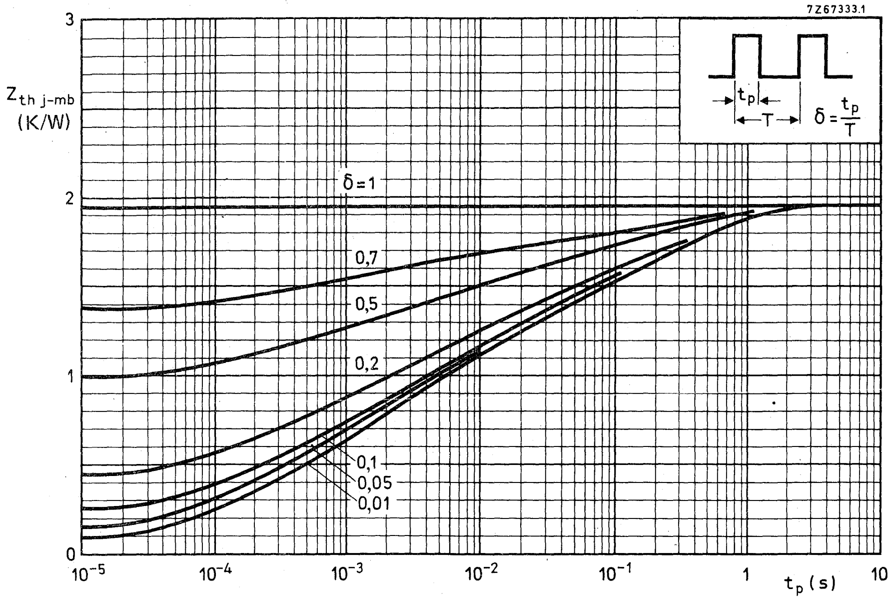


Fig. 10 Pulse power rating chart.

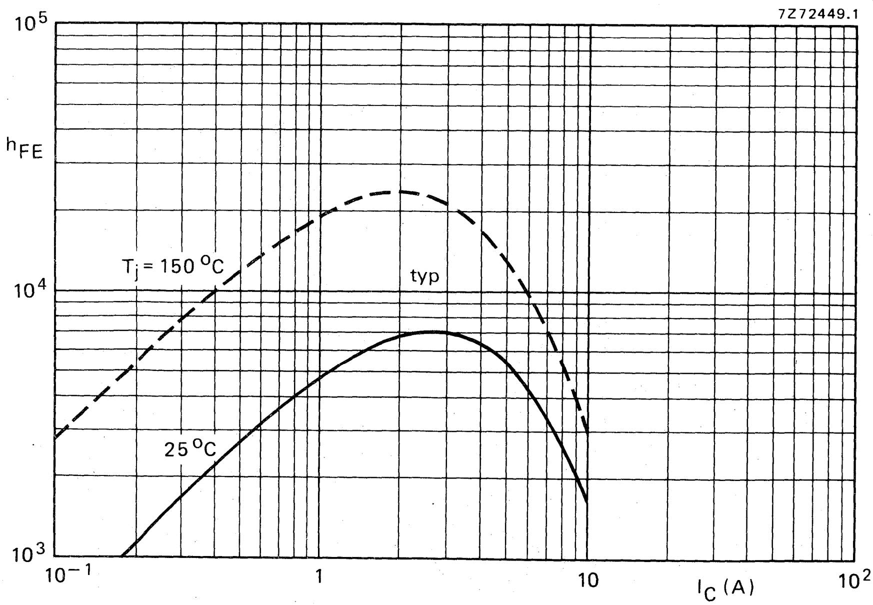


Fig. 11 Typical values d.c. current gain at V_{CE} = 3 V.

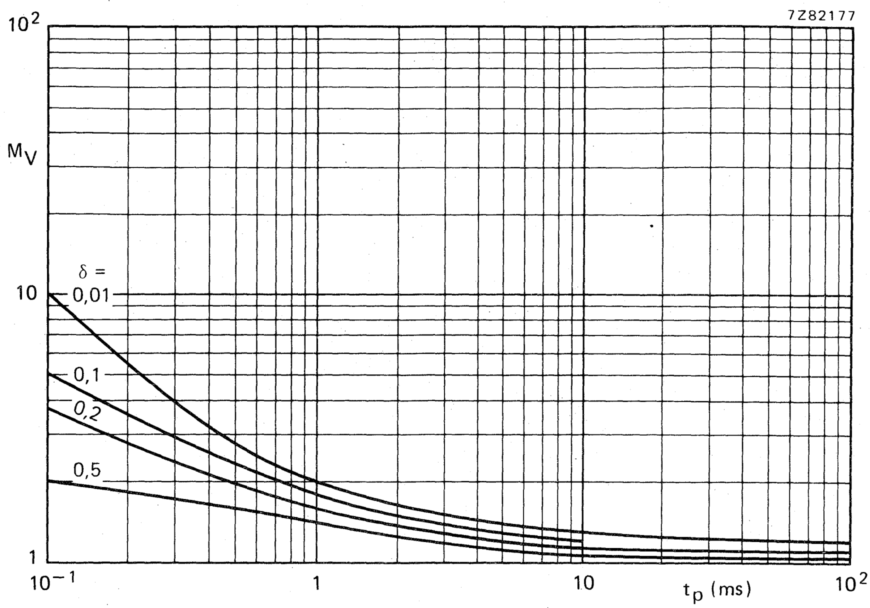


Fig. 12 S.B. voltage multiplying factor at the I_{Cmax} level.

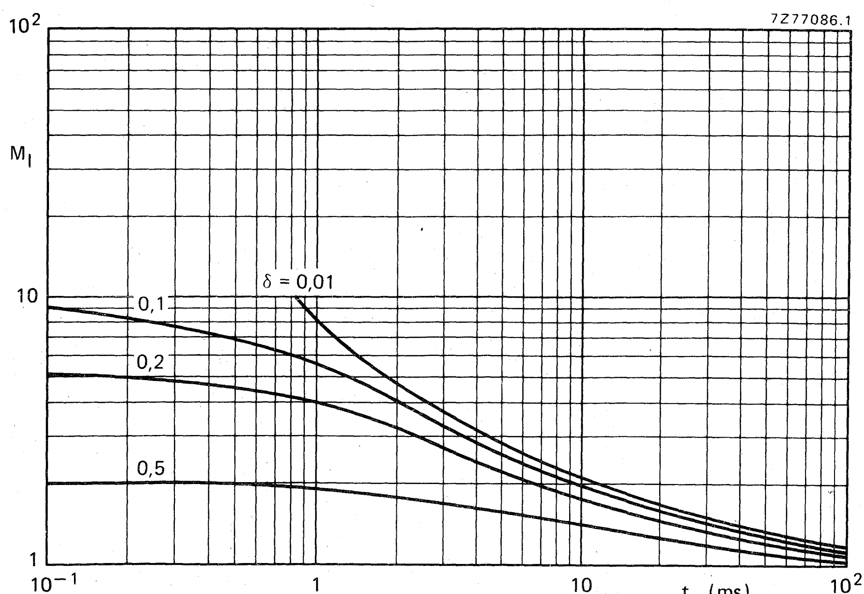


Fig. 13 S.B. current multiplying factor at the V_{CEO} 100 V and 60 V level.

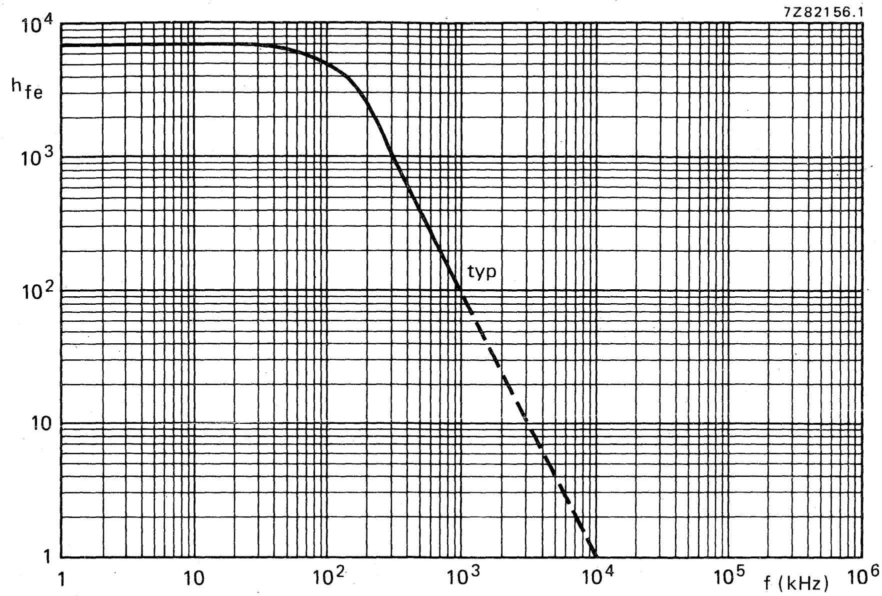


Fig. 14 Small-signal current gain at I_C = 3 A; V_{CE} = 3 V.

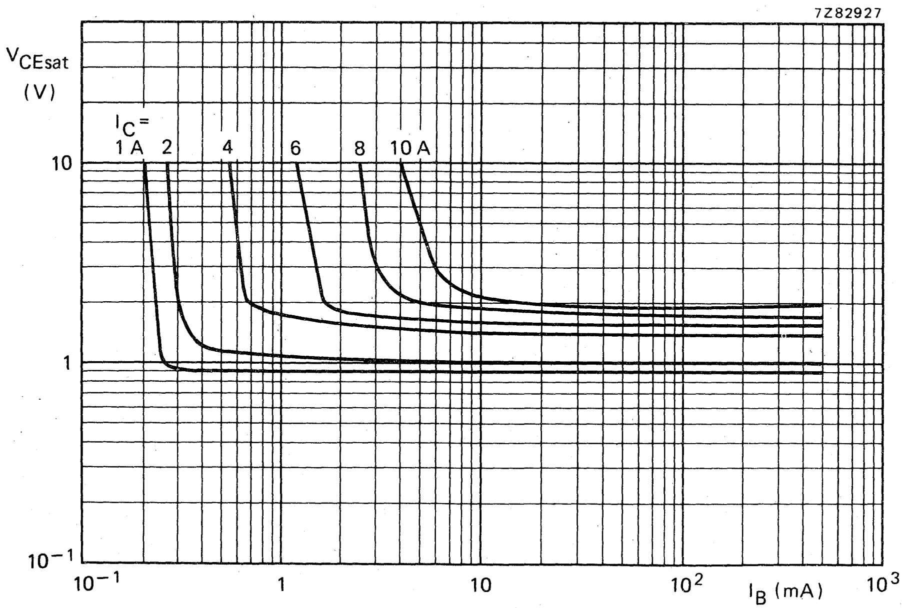


Fig. 15 Typical values collector-emitter saturation voltage at T_j = 25 °C.

SILICON DARLINGTON POWER TRANSISTORS

P-N-P epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications; TO-3 envelope. N-P-N complements are BDX65, BDX65A, BDX65B and BDX65C. Matched complementary pairs can be supplied.

QUICK REFERENCE DATA

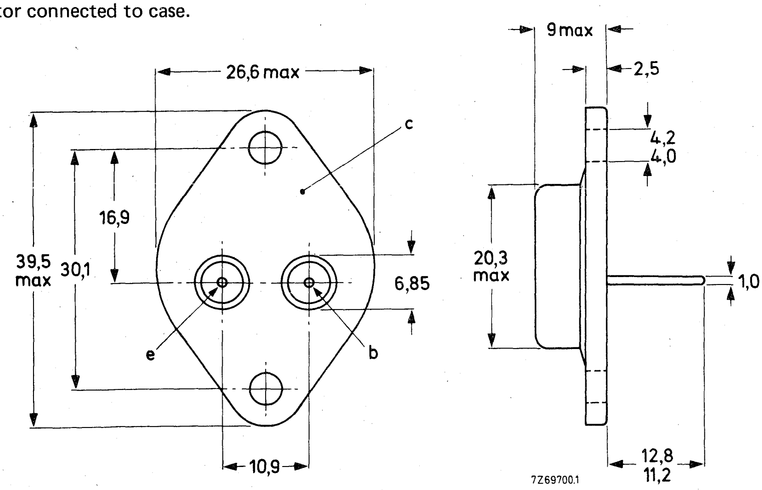
			BDX64	64A	64B	64C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Collector current (peak value)	$-I_{CM}$	max.	16				A
Total power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.	117				W
Junction temperature	T_j	max.	200				^oC
D.C. current gain $-I_C = 1$ A; $-V_{CE} = 3$ V	h_{FE}	typ.	1500				
$-I_C = 5$ A; $-V_{CE} = 3$ V	h_{FE}	>	1000				
Cut-off frequency $-I_C = 5$ A; $-V_{CE} = 3$ V	f_{hfe}	typ.	80				kHz

MECHANICAL DATA

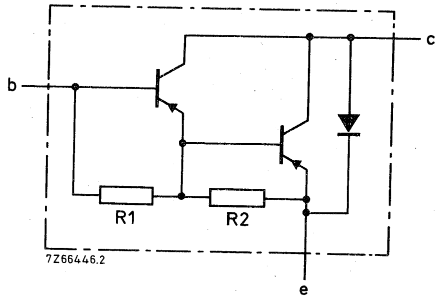
Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.



See also chapters Mounting instructions and Accessories.



R1 typ. 5 kΩ
R2 typ. 80 Ω

Fig. 2 Circuit diagram.

RATINGS

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

			BDX64	64A	64B	64C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	5	V
Collector current (d.c.)	$-I_C$	max.	12				A
Collector current (peak value)	$-I_{CM}$	max.	16				A
Base current (d.c.)	$-I_B$	max.	200				mA
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	117				W
Storage temperature	T_{stg}		−65 to + 200				°C
Junction temperature*	T_j	max.	200				°C

THERMAL RESISTANCE*

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,5	°C/W

* Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current			
$I_E = 0; -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	0,4 mA
$I_E = 0; -V_{CB} = 40$ V; $T_j = 200$ °C: BDX64 $I_E = 0; -V_{CB} = 50$ V; $T_j = 200$ °C: BDX64A $I_E = 0; -V_{CB} = 60$ V; $T_j = 200$ °C: BDX64B $I_E = 0; -V_{CB} = 70$ V; $T_j = 200$ °C: BDX64C	$-I_{CBO}$	<	3 mA
$I_B = 0; -V_{CE} = -½ V_{CEOmax}$	$-I_{CEO}$	<	1 mA
Emitter cut-off current			
$I_C = 0; -V_{EB} = 5$ V	$-I_{EBO}$	<	5 mA
D.C. current gain (note 1)			
$-I_C = 1$ A; $-V_{CE} = 3$ V	h_{FE}	typ.	1500
$-I_C = 5$ A; $-V_{CE} = 3$ V	h_{FE}	>	1000
$-I_C = 12$ A; $-V_{CE} = 3$ V	h_{FE}	typ.	750
Base-emitter voltage (notes 1 and 2)			
$-I_C = 5$ A; $-V_{CE} = 3$ V	$-V_{BE}$	<	2,5 V
Collector-emitter saturation voltage (note 1)			
$-I_C = 5$ A; $-I_B = 20$ mA	$-V_{CEsat}$	<	2 V
Collector capacitance at f = 1 MHz			
$I_E = I_e = 0; -V_{CB} = 10$ V	C_c	typ.	200 pF
Cut-off frequency			
$-I_C = 5$ A; $-V_{CE} = 3$ V	f_{hfe}	typ.	80 kHz
Small-signal current gain			
$-I_C = 5$ A; $-V_{CE} = 3$ V; f = 1 MHz	h_{fe}	typ.	30
D.C. current gain ratio of complementary matched pairs			
$-I_C = 5$ A; $-V_{CE} = 3$ V	h_{FE1}/h_{FE2}	<	2,5

Notes

1. Measured under pulse conditions: $t_p < 300\ \mu s$, $\delta < 2\%$.
2. $-V_{BE}$ decreases by about 3,6 mV/°C with increasing temperature.

CHARACTERISTICS (continued)

Diode, forward voltage $I_F = 5$ A	V_F	<	1,8 V
Switching times (between 10% and 90% levels) $-I_{Con} = 5$ A; $-I_{Bon} = I_{Boff} = 20$ mA			
turn-on time	t_{on}	typ.	1 μs
turn-off time	t_{off}	typ.	2,5 μs

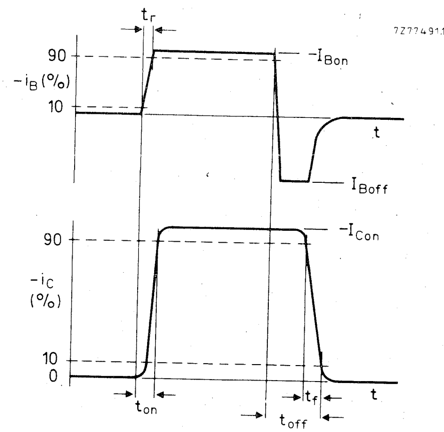
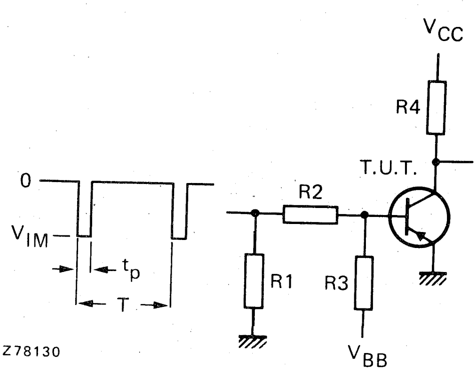


Fig. 3 Switching times waveforms.



$-V_{IM}$	=	16,5 V
$-V_{CC}$	=	16 V
$+V_{BB}$	=	6,5 V
R1	=	56 Ω
R2	=	410 Ω
R3	=	560 Ω
R4	=	3 Ω
$t_r = t_f$	⩽	15 ns
t_p	=	10 μs
T	=	500 μs

Fig. 4 Switching times test circuit.

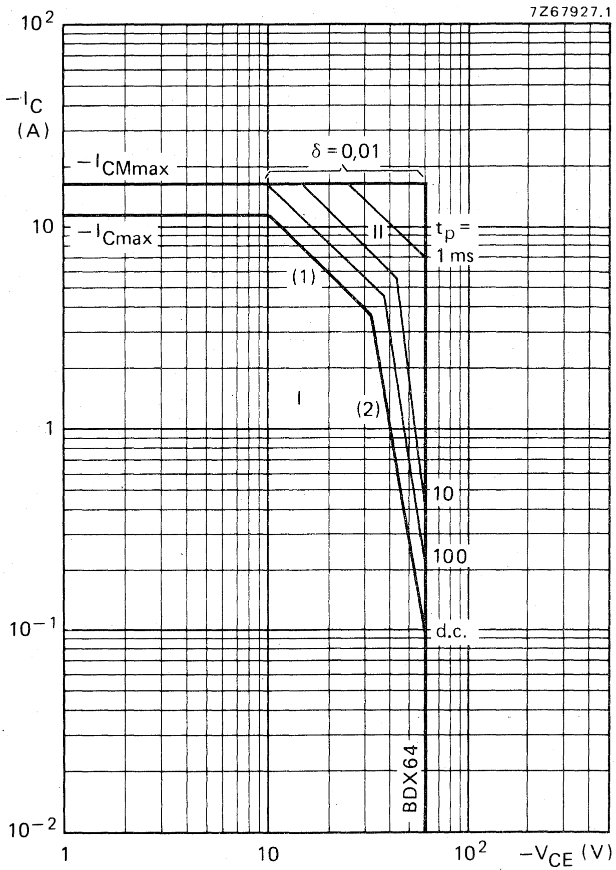


Fig. 5 Safe Operating ARea; $T_{mb} \leqslant 25\ ^oC$.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.
(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.
(2) Second-breakdown limits (independent of temperature).

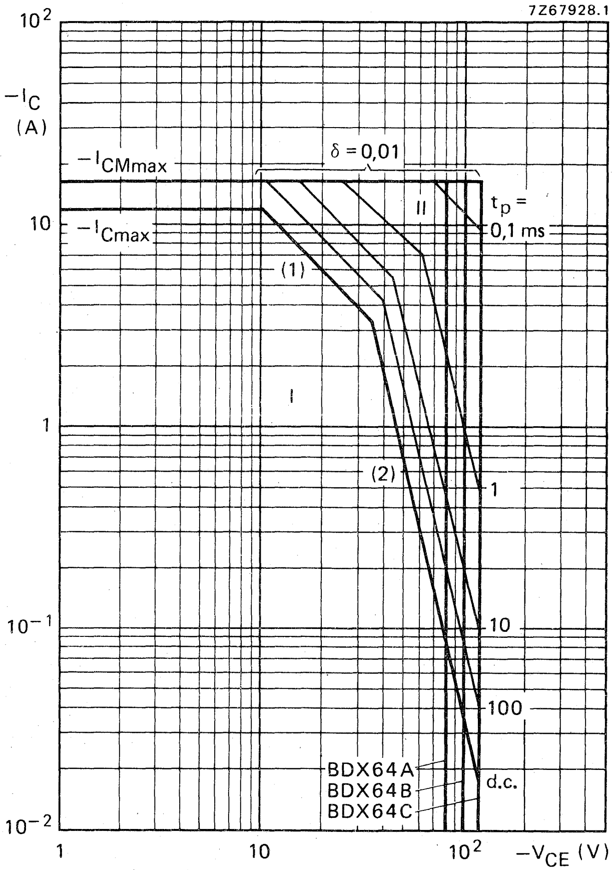


Fig. 6 Safe Operating ARea; $T_{mb} \leqslant 25$ °C.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.
(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second-breakdown limits (indepenedent of temperature).

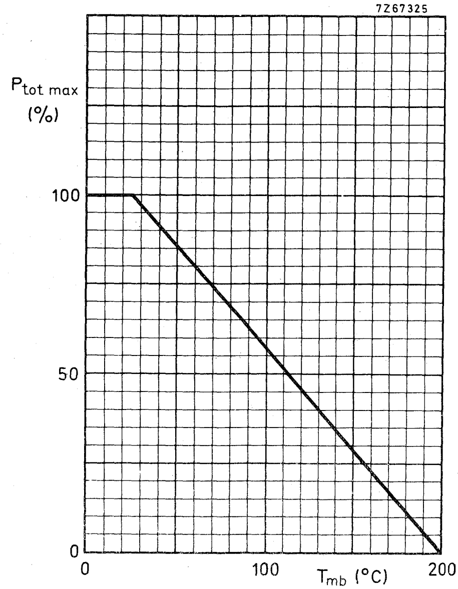


Fig. 7 Power derating curve.

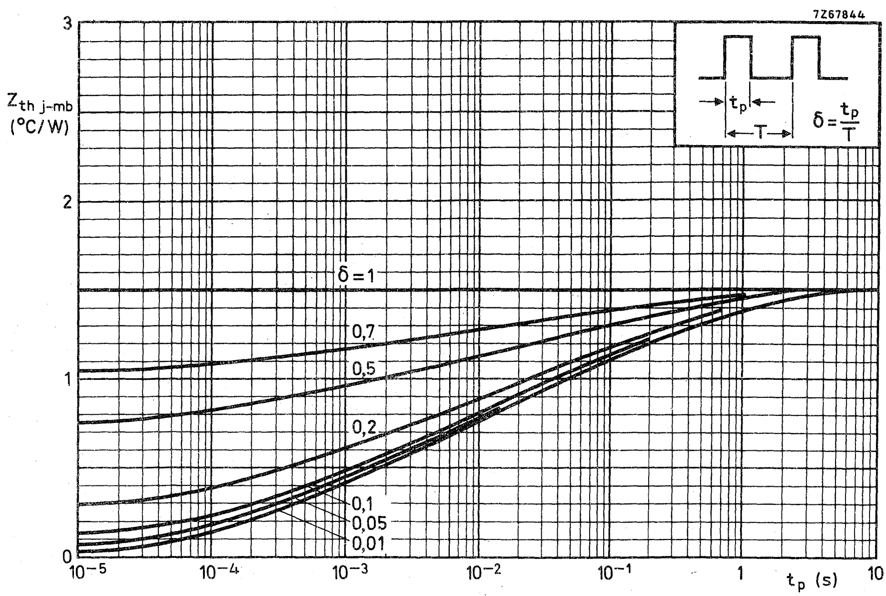


Fig. 8 Pulse power rating chart.

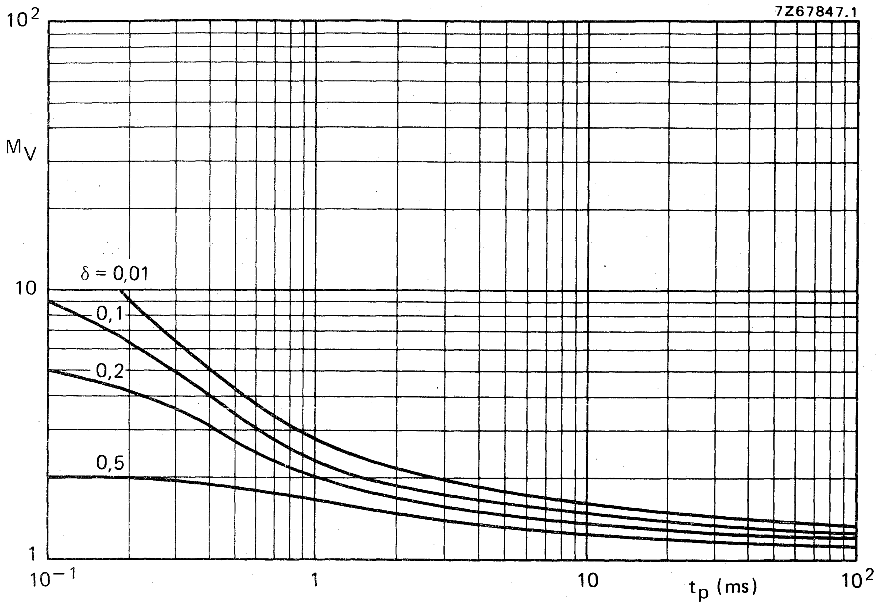


Fig. 9 S.B. voltage multiplying factor at the $-I_{C\,max}$ level.

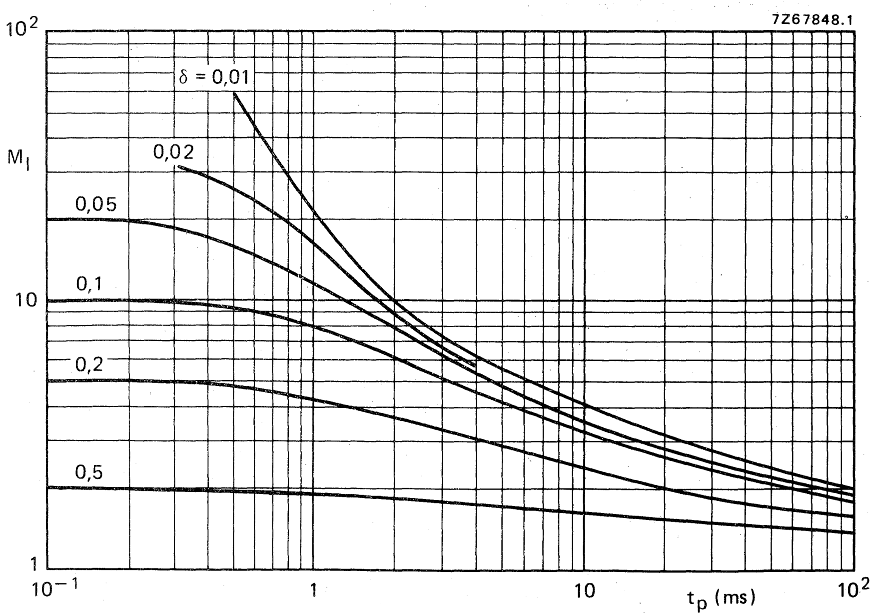


Fig. 10 S.B. current multiplying factor at $-V_{CEO}$ 100 V and 60 V level.

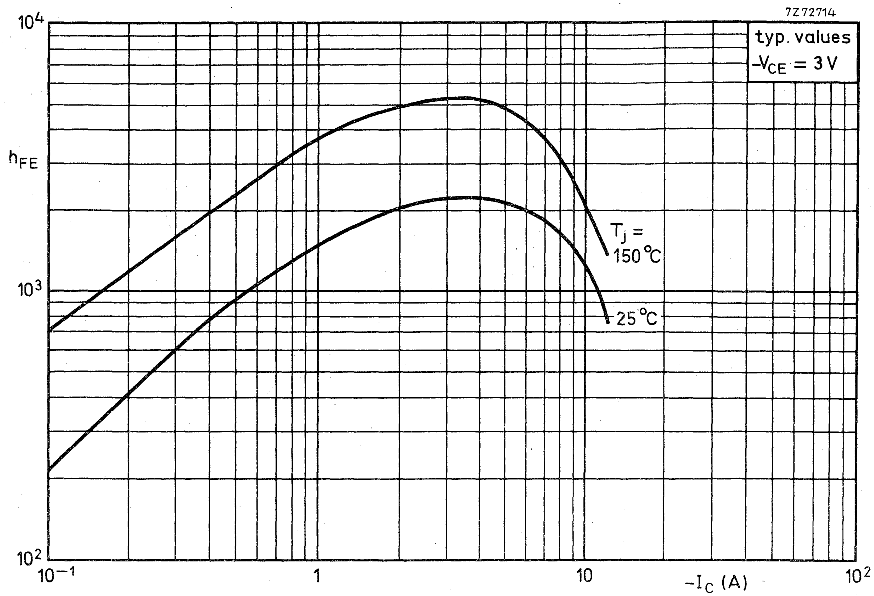


Fig. 11 D.C. current gain.

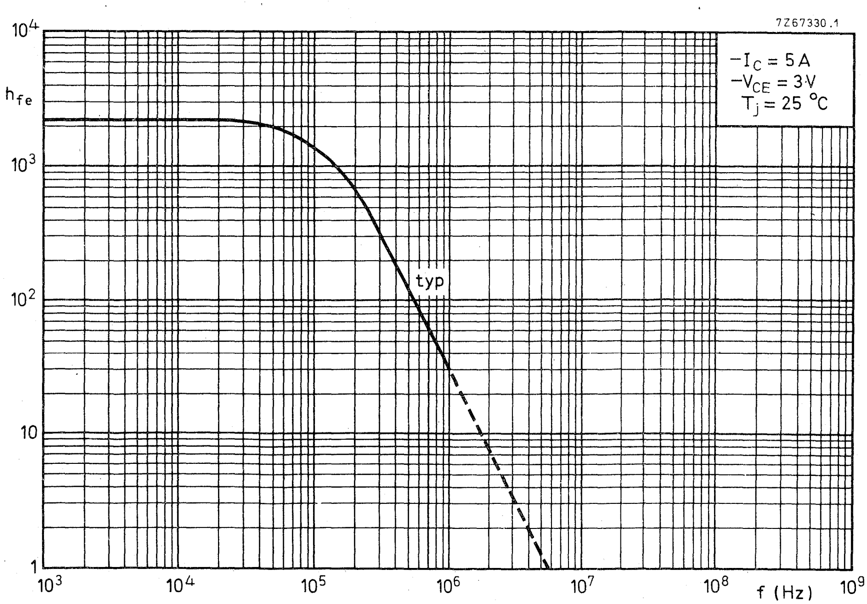


Fig. 12 Small-signal current gain.

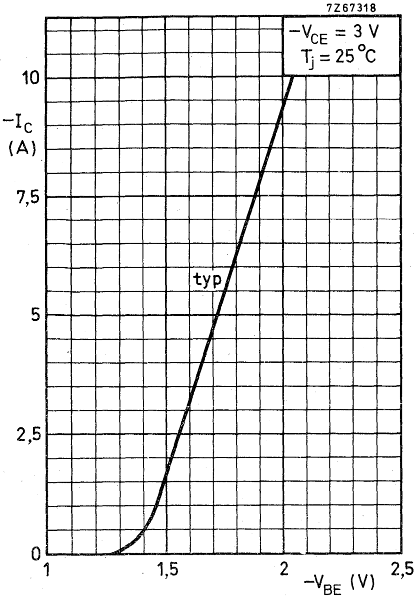


Fig. 13 Typical collector current.

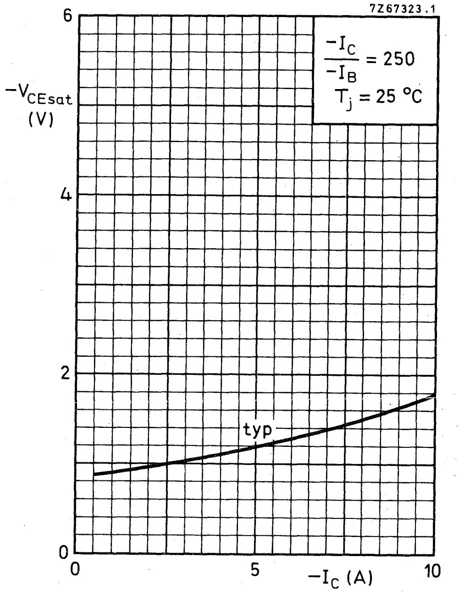


Fig. 14 Typical collector-emitter saturation voltage.

SILICON DARLINGTON POWER TRANSISTORS

N-P-N epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications; TO-3 envelope. P-N-P complements are BDX64, BDX64A, BDX64B and BDX64C. Matched complementary pairs can be supplied.

QUICK REFERENCE DATA

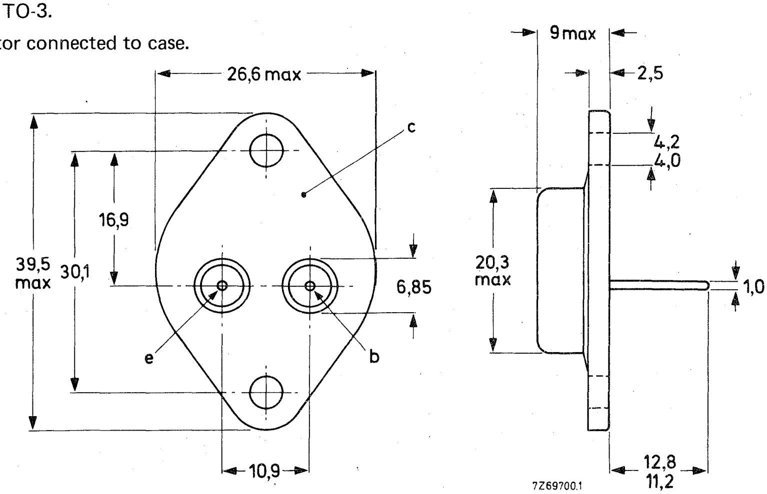
			BDX65	65A	65B	65C	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Collector current (peak value)	I_{CM}	max.		16			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		117			W
Junction temperature	T_j	max.		200			°C
D.C. current gain I_C = 1 A; V_{CE} = 3 V	h_{FE}	typ.		3300			
I_C = 5 A; V_{CE} = 3 V	h_{FE}	>		1000			
Cut-off frequency I_C = 5 A; V_{CE} = 3 V	f_{hfe}	typ.		50			kHz

MECHANICAL DATA

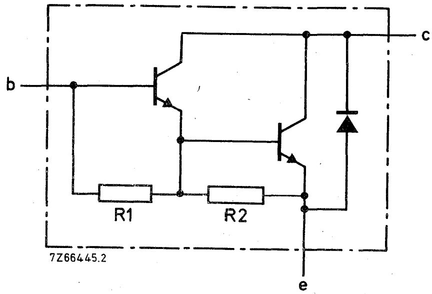
Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.



See also chapters Mounting instructions and Accessories.



R1 typ. 5 kΩ
R2 typ. 80 Ω

Fig. 2 Circuit diagram.

RATINGS

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

			BDX65	65A	65B	65C	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	5	V
Collector current (d.c.)	I_C	max.		12			A
Collector current (peak value)	I_{CM}	max.		16			A
Base current (d.c.)	I_B	max.		200			mA
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		117			W
Storage temperature	T_{stg}			−65 to + 200			°C
Junction temperature*	T_j	max.		200			°C

THERMAL RESISTANCE *

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,5	K/W

* Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current			
$I_E = 0$; $V_{CB} = V_{CEOmax}$	I_{CBO}	<	0,4 mA
$I_E = 0$; $V_{CB} = ½ V_{CBOmax}$; T_j = 200 °C	I_{CBO}	<	3 mA
$I_B = 0$; $V_{CE} = ½ V_{CEOmax}$	I_{CEO}	<	1 mA
Emitter cut-off current			
$I_C = 0$; V_{EB} = 5 V	I_{EBO}	<	5 mA
D.C. current gain (note 1)			
I_C = 1 A; V_{CE} = 3 V	h_{FE}	typ.	3300 ←
I_C = 5 A; V_{CE} = 3 V	h_{FE}	>	1000
I_C = 12 A; V_{CE} = 3 V	h_{FE}	typ.	3700 ←
Base-emitter voltage (notes 1 and 2)			
I_C = 5 A; V_{CE} = 3 V	V_{BE}	<	2,5 V
Collector-emitter saturation voltage (note 1)			
I_C = 5 A; I_B = 20 mA	V_{CEsat}	<	2 V
Collector capacitance at f = 1 MHz			
$I_E = I_e = 0$; V_{CB} = 10 V	C_c	typ.	200 pF
Cut-off frequency			
I_C = 5 A; V_{CE} = 3 V	f_{hfe}	typ.	50 kHz
Turn-off breakdown energy with inductive load (Fig. 5)			
$-I_{Boff} = 0$; I_{CC} = 6,3 A	$E_{(BR)}$	>	100 mJ ←
D.C. current gain ratio of complementary matched pairs			
I_C = 5 A; V_{CE} = 3 V	h_{FE1}/h_{FE2}	<	2,5

Notes
1. Measured under pulse conditions: $t_p < 300$ µs, $\delta < 2\%$.
2. V_{BE} decreases by about 3,6 mV/°C with increasing temperature.

CHARACTERISTICS (continued)

Diode, forward voltage $I_F = 5$ A	V_F	typ.	1,2 V
Switching times (between 10% and 90% levels) $I_{Con} = 5$ A; $I_{Bon} = -I_{Boff} = 20$ mA			
Turn-on time	t_{on}	typ.	1 μs
→ Turn-off time	t_{off}	typ.	6 μs

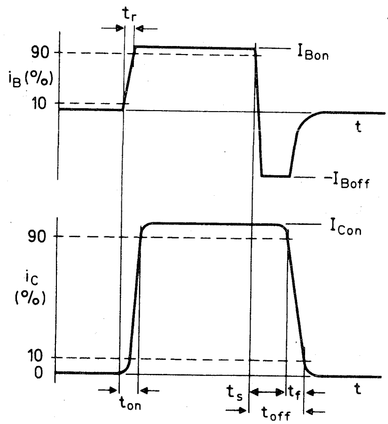
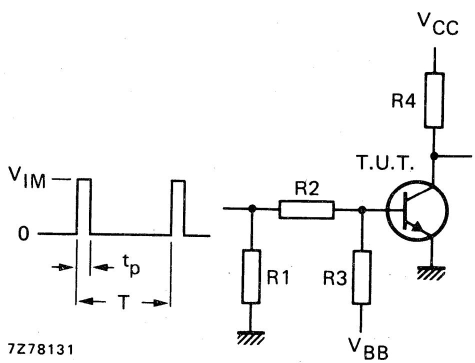


Fig. 3 Switching times waveforms.



V_{IM}	=	15	V
V_{CC}	=	15	V
$-V_{BB}$	=	4	V
R1	=	56	Ω
R2	=	410	Ω
R3	=	560	Ω
R4	=	3	Ω
$t_r = t_f \leqslant$		15	ns
t_p	=	10	μs
T	=	500	μs

Fig. 4 Switching times test circuit.

CHARACTERISTICS (continued)

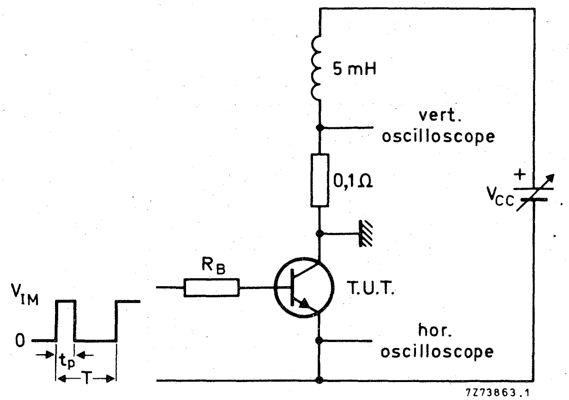


Fig. 5 Test circuit for turn-off breakdown energy. V_{IM} = 12 V; R_B = 270 Ω; I_{CC} = 6,3 A; δ = 1%.

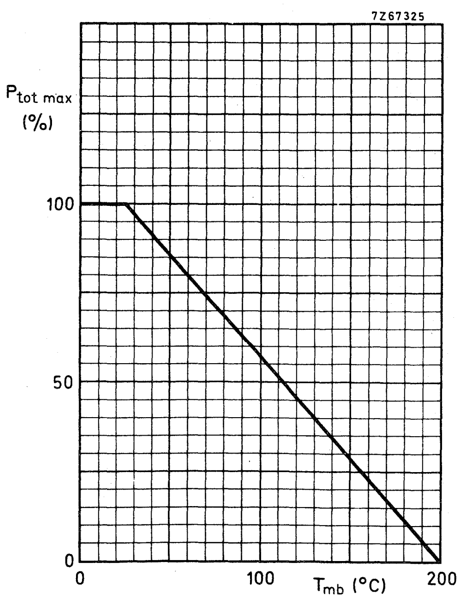


Fig. 6 Power derating curve.

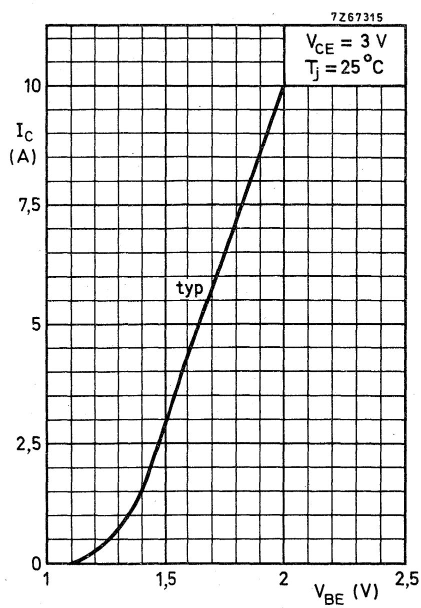


Fig. 7 Typical collector current.

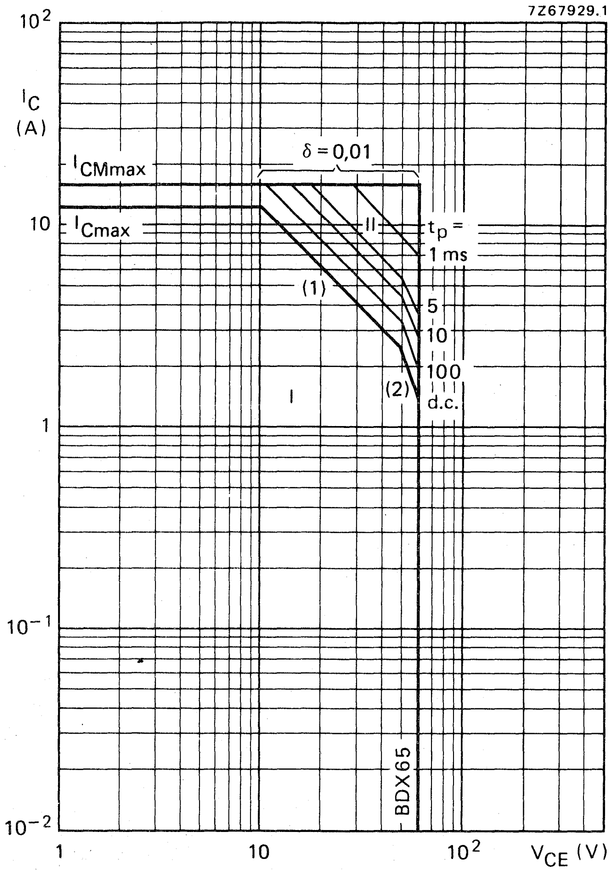


Fig. 8 Safe Operating ARea at $T_{mb} \leqslant 25\ ^oC$ of BDX65.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ and $P_{tot\ peak\ max}$ lines.

(2) Second-breakdown limits (independent of temperature).

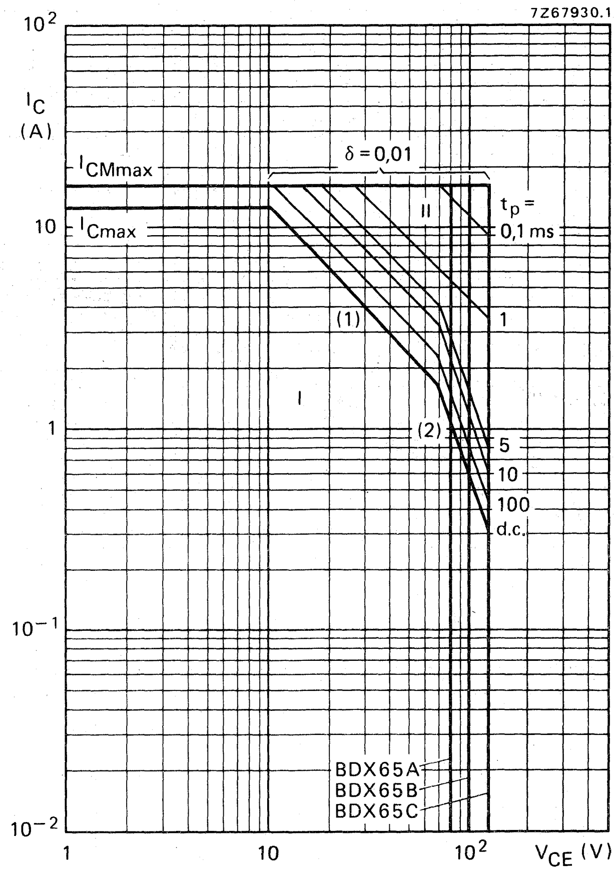


Fig. 9 Safe Operating ARea at $T_{mb} \leqslant 25\ ^oC$.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ and $P_{tot\ peak\ max}$ lines.

(2) Second-breakdown limits (independent of temperature).

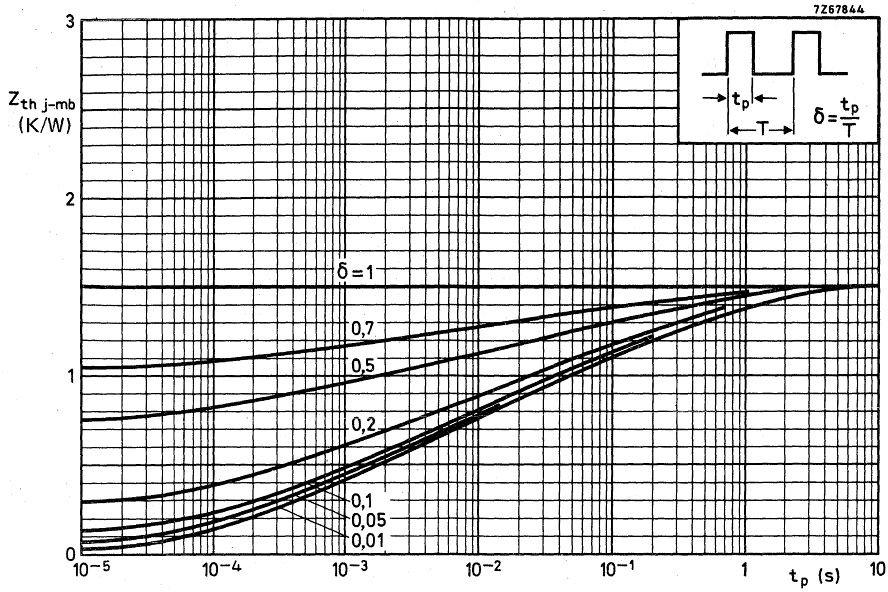


Fig. 10 Pulse power rating chart.

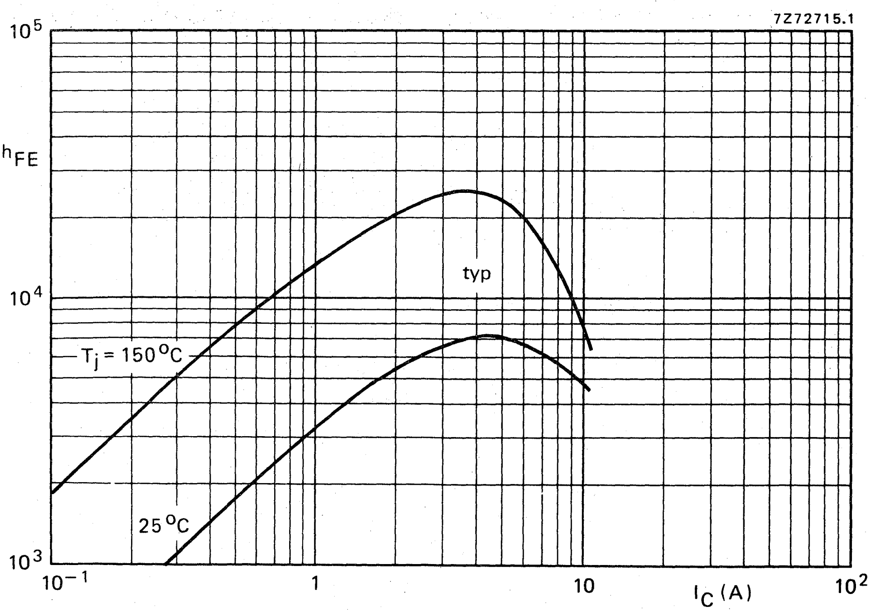


Fig. 11 Typical d.c. current gain at $V_{CE} = 3$ V.

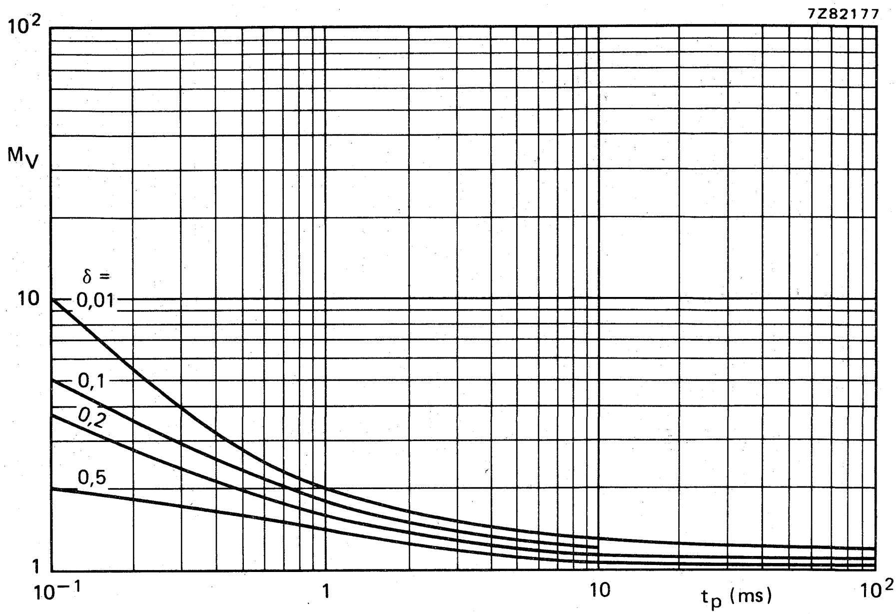


Fig. 12 S.B. voltage multiplying factor at the I_{Cmax} level.

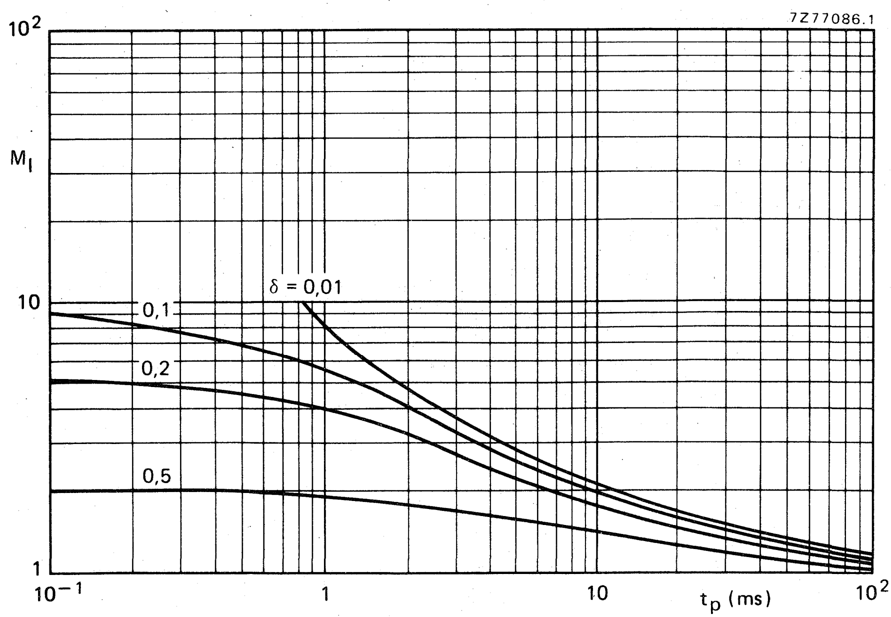


Fig. 13 S.B. current multiplying factor at V_{CEO} 100 V and 60 V level.

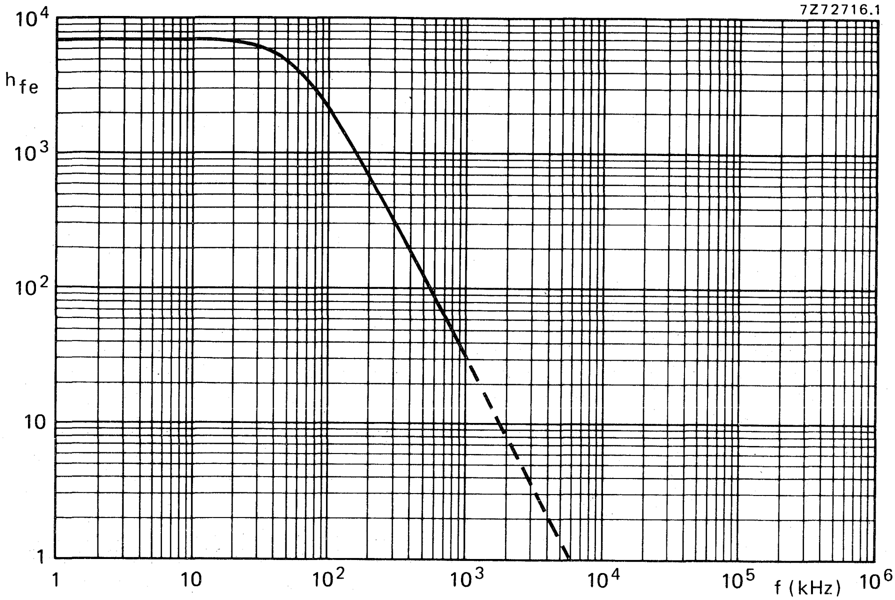


Fig. 14 Typical small-signal current gain, $I_C = 5$ A; $V_{CE} = 3$ V; $T_j = 25$ °C.

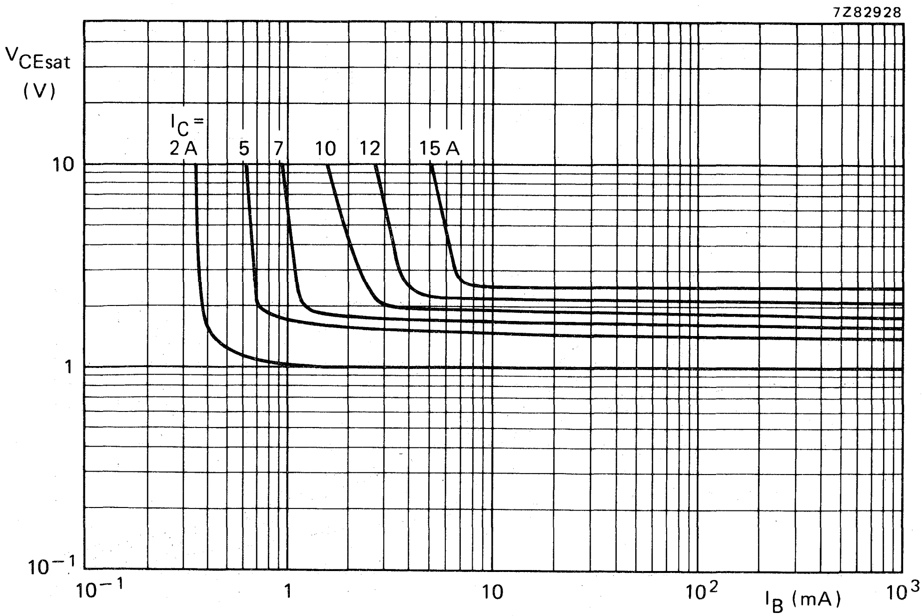


Fig. 15 Typical values collector-emitter saturation voltage. $T_{amb} = 25$ °C.

SILICON DARLINGTON POWER TRANSISTORS

P-N-P epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications; TO-3 envelope. N-P-N complements are BDX67, BDX67A, BDX67B and BDX67C. Matched complementary pairs can be supplied.

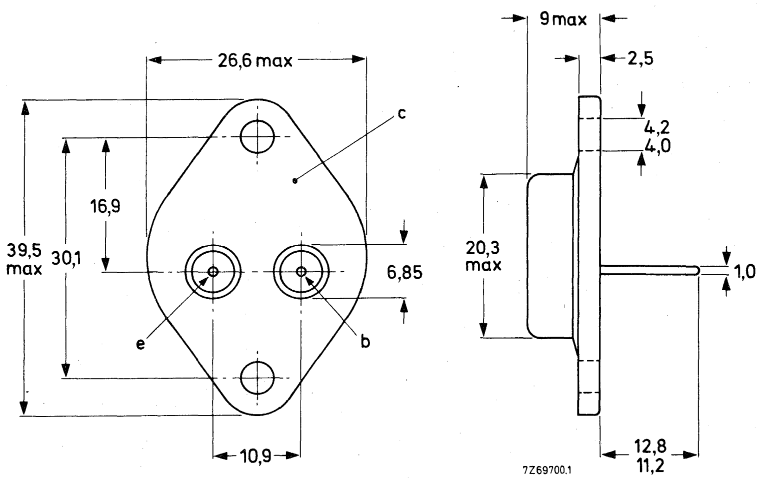
QUICK REFERENCE DATA

			BDX66	66A	66B	66C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Collector current (peak value)	$-I_{CM}$	max.	20				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	150				W
Junction temperature	T_j	max.	200				°C
D.C. current gain $-I_C$ = 1 A; $-V_{CE}$ = 3 V	h_{FE}	typ.	2000				
$-I_C$ = 10 A; $-V_{CE}$ = 3 V	h_{FE}	>	1000				
Cut-off frequency $-I_C$ = 5 A; $-V_{CE}$ = 3 V	f_{hfe}	typ.	60				kHz

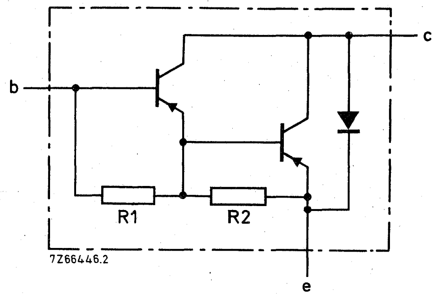
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-3.



See also chapters Mounting instructions and Accessories.



R1 typ. 3 kΩ
R2 typ. 80 Ω

Fig. 2 Circuit diagram.

RATINGS

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

			BDX66	66A	66B	66C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open-base)	$-V_{CEO}$	max.	60	80	100	120	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	5	V
Collector current (d.c.)	$-I_C$	max.	16				A
Collector current (peak value)	$-I_{CM}$	max.	20				A
Base current	$-I_B$	max.	250				mA
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	150				W
Storage temperature	T_{stg}		−65 to +200				°C
Junction temperature*	T_j	max.	200				°C

THERMAL RESISTANCE *

From junction to mounting base $R_{th\ j\text{-}mb}$ = 1,17 °C/W

* Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

Collector cut-off current				
$I_E = 0; -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	1	mA
$I_E = 0; -V_{CB} = 40$ V; $T_j = 200$ °C; BDX66 $I_E = 0; -V_{CB} = 50$ V; $T_j = 200$ °C; BDX66A $I_E = 0; -V_{CB} = 60$ V; $T_j = 200$ °C; BDX66B $I_E = 0; -V_{CB} = 70$ V; $T_j = 20$ °C; BDX66C	$-I_{CBO}$	<	5	mA
$I_B = 0; -V_{CE} = -½V_{CEOmax}$	$-I_{CEO}$	<	3	mA
Emitter cut-off current				
$I_C = 0; -V_{EB} = 5$ V	$-I_{EBO}$	<	5	mA
D.C. current gain *				
$-I_C = 1$ A; $-V_{CE} = 3$ V	h_{FE}	typ.	2000	
$-I_C = 10$ A; $-V_{CE} = 3$ V	h_{FE}	>	1000	
$-I_C = 16$ A; $-V_{CE} = 3$ V	h_{FE}	typ.	1000	
Base-emitter voltage *				
$-I_C = 10$ A; $-V_{CE} = 3$ V	$-V_{BE}$	<	2,5	V
Collector-emitter saturation voltage *				
$-I_C = 10$ A; $-I_B = 40$ mA	$-V_{CEsat}$	<	2	V
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0; -V_{CB} = 10$ V	C_c	typ.	300	pF
Cut-off frequency				
$-I_C = 5$ A; $-V_{CE} = 3$ V	f_{hfe}	typ.	60	kHz
Small-signal current gain				
$-I_C = 5$ A; $-V_{CE} = 3$ V; f = 1 MHz	h_{fe}	typ.	50	
D.C. current gain ratio of complementary matched pairs				
$-I_C = 10$ A; $-V_{CE} = 3$ V	h_{FE1}/h_{FE2}	<	2,5	
Diode, forward voltage				
$I_F = 10$ A	V_F	typ.	2	V

* Measured under pulse conditions: $t_p < 300\ \mu s$, $\delta < 2\%$.

CHARACTERISTICS (continued)

$T_j = 25\ ^oC$ unless otherwise specified

Switching times
(between 10% and 90% levels)

$-I_{Con} = 10$ A; $-I_{Bon} = I_{Boff} = 40$ mA

turn-on time	t_{on}	typ.	1 µs
turn-off time	t_{off}	typ.	3,5 µs

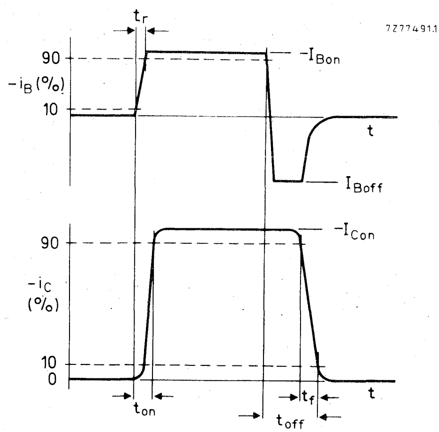
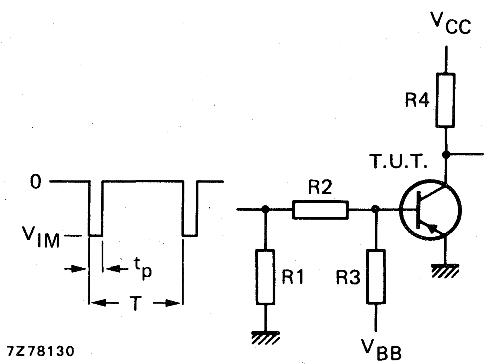


Fig. 3 Switching times waveforms.



$-V_{IM}$	=	18 V
$-V_{CC}$	=	12 V
$+V_{BB}$	=	3 V
R1	=	56 Ω
R2	=	220 Ω
R3	=	180 Ω
R4	=	1 Ω
$t_r = t_f$	=	15 ns
t_p	=	10 µs
T	=	500 µs

Fig. 4 Switching times test circuit.

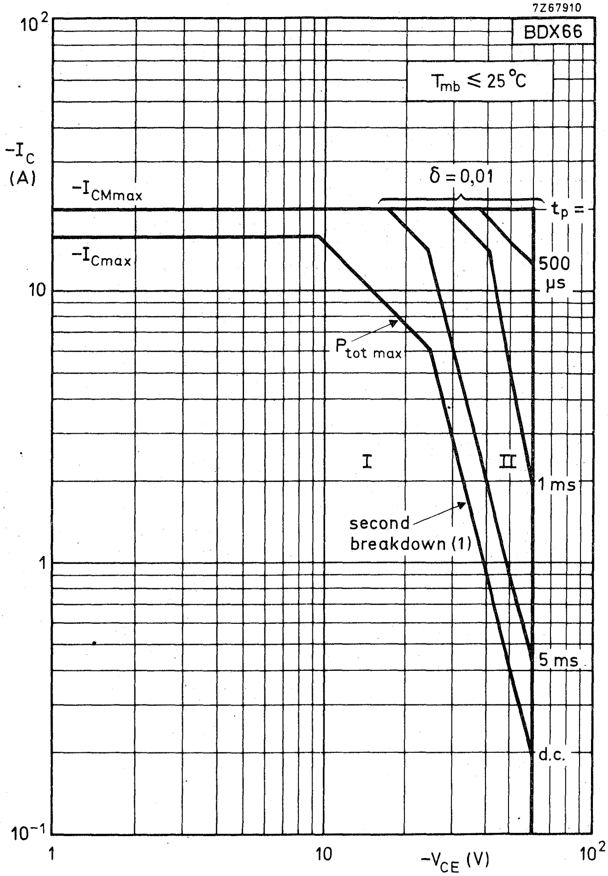


Fig. 5 Safe Operating ARea with the transistor forward biased.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(1) Independent of temperature.

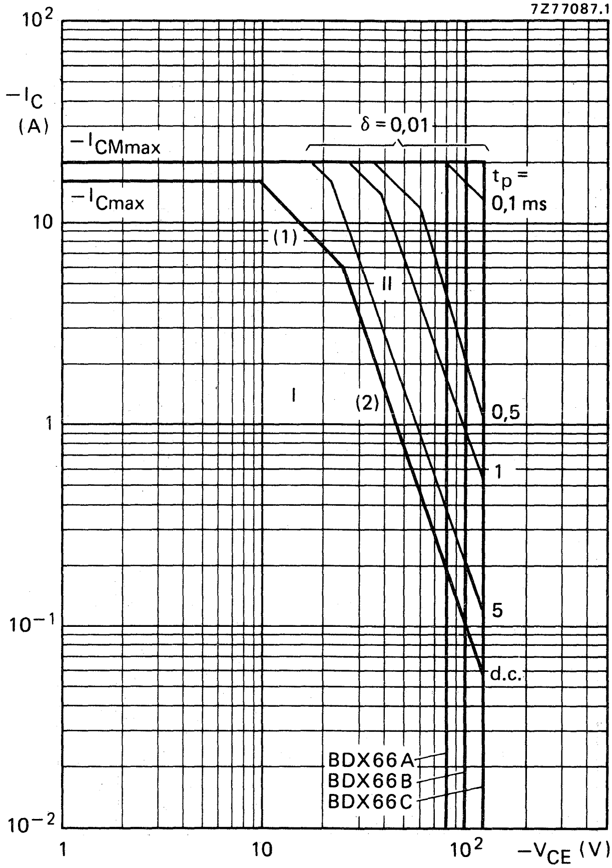


Fig. 6 Safe Operating ARea.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(1) $P_{tot\,max}$ and $P_{tot\,peak\,max}$ lines.

(2) Second breakdown limits (independent of temperature).

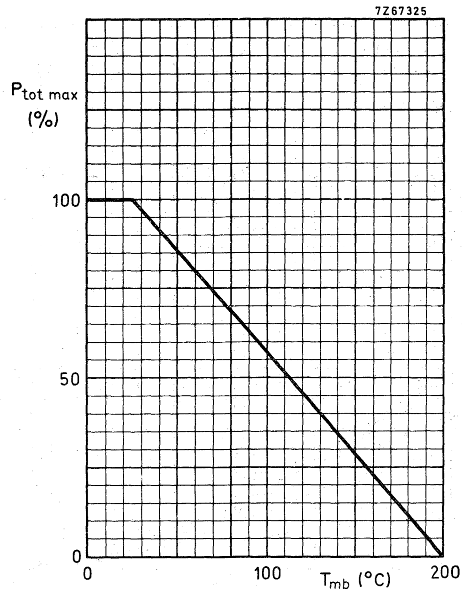


Fig. 7 Power derating curve.

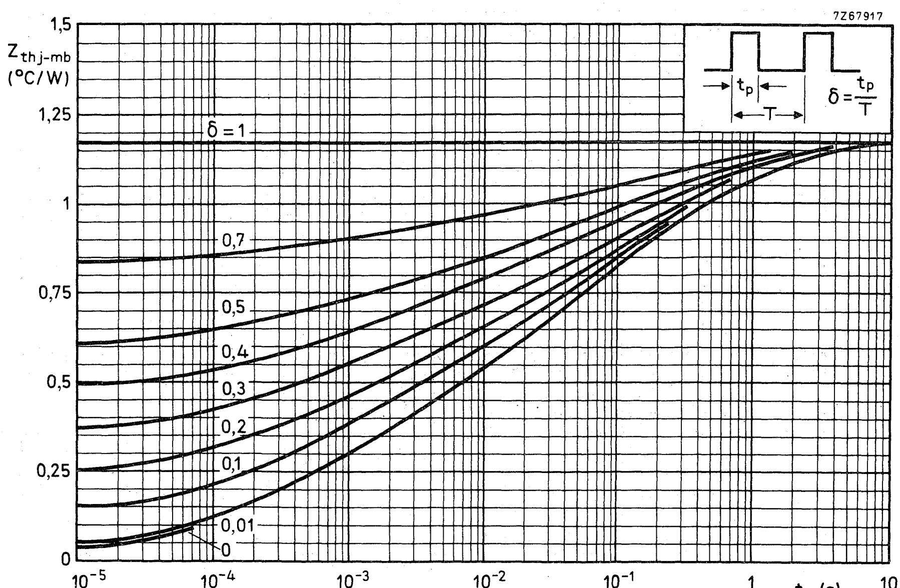


Fig. 8 Pulse power rating chart.

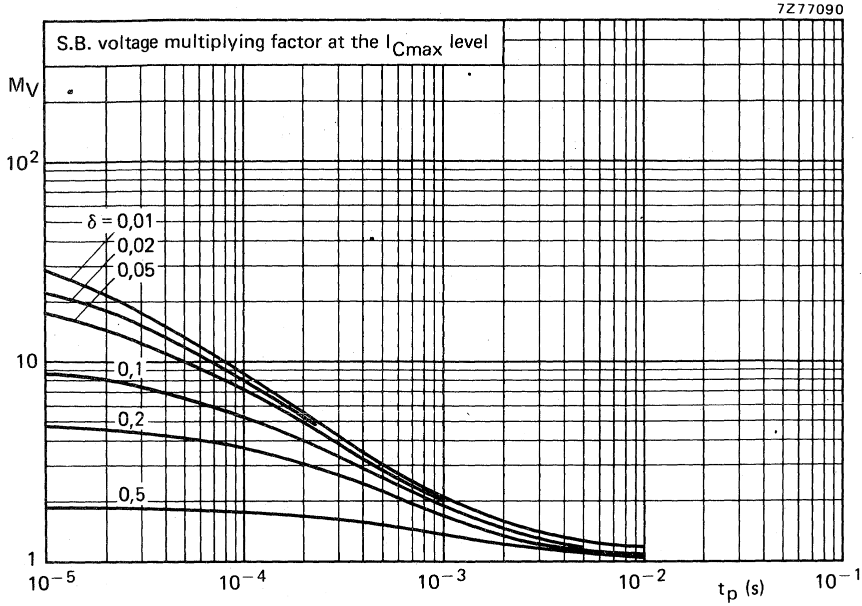


Fig. 9 S.B. voltage multiplying factor at the I_{Cmax} level.

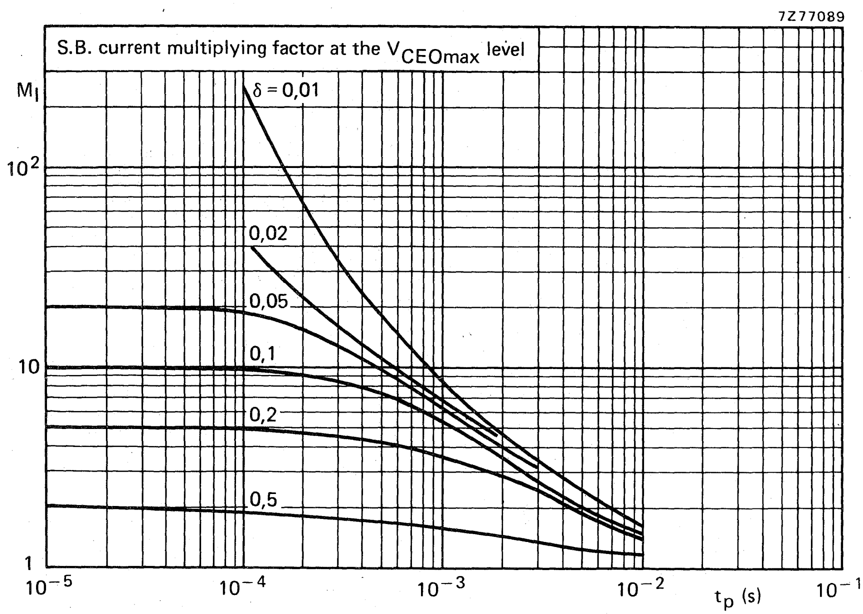


Fig. 10 S.B. current multiplying factor at the V_{CEOmax} level.

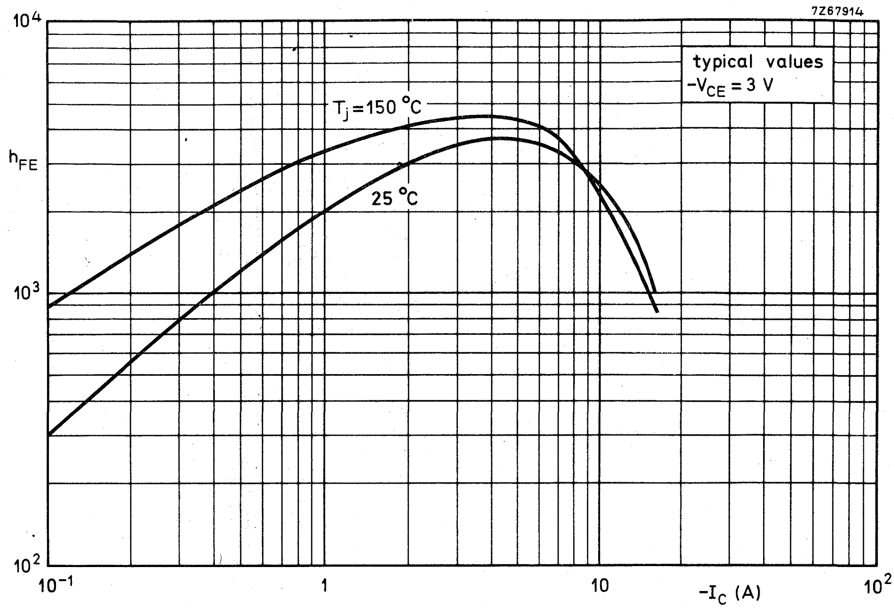


Fig. 11 D.C. current gain.

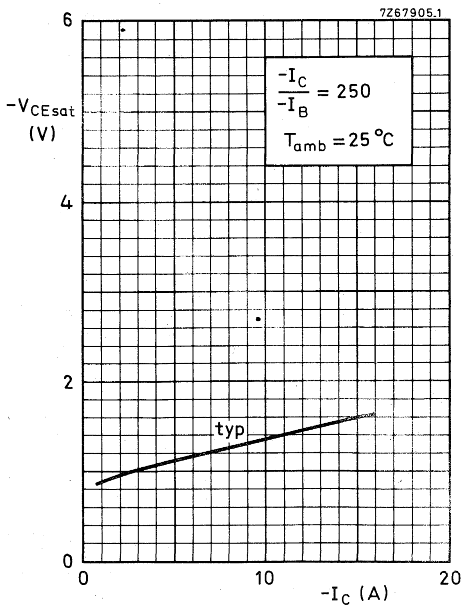


Fig. 12 Collector-emitter saturation voltage.

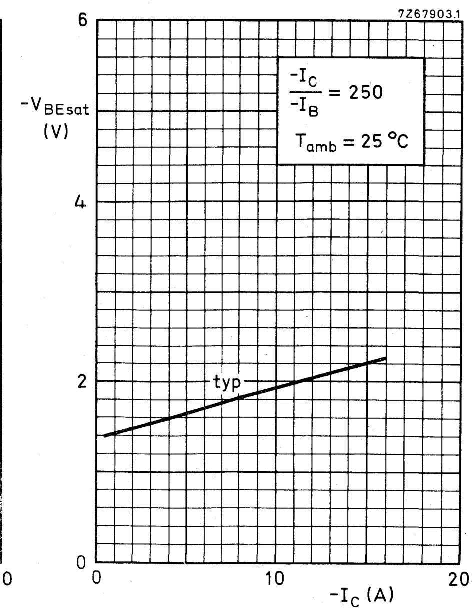


Fig. 13 Base-emitter saturation voltage.

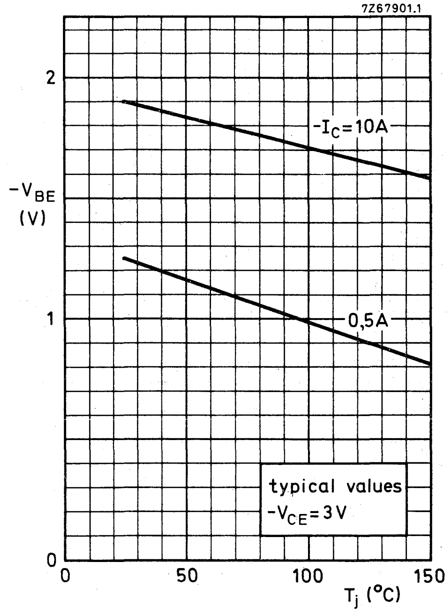


Fig. 14 Typical base-emitter voltage.

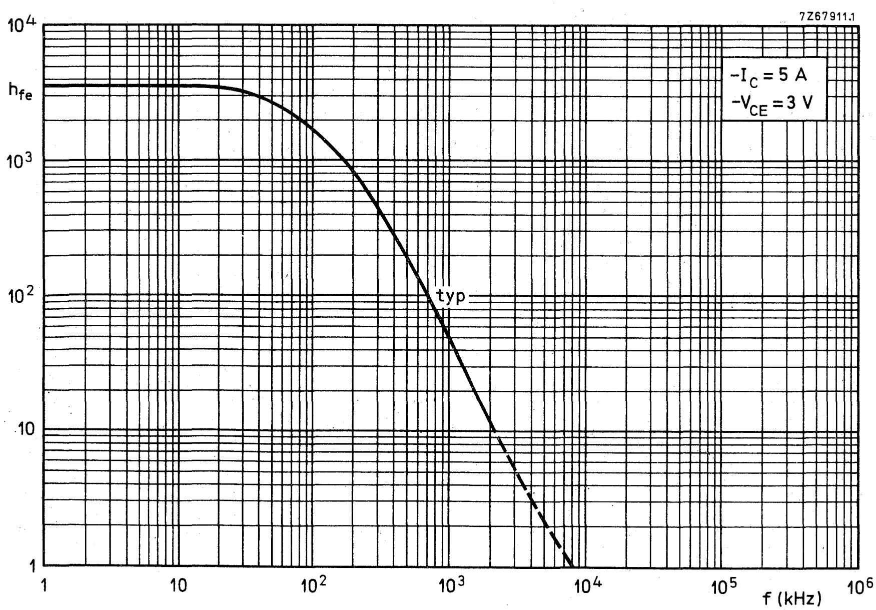


Fig. 15 Small-signal current gain.

SILICON DARLINGTON POWER TRANSISTORS

N-P-N epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications; TO-3 envelope. P-N-P complements are BDX66, BDX66A, BDX66B and BDX66C. Matched complementary pairs can be supplied.

QUICK REFERENCE DATA

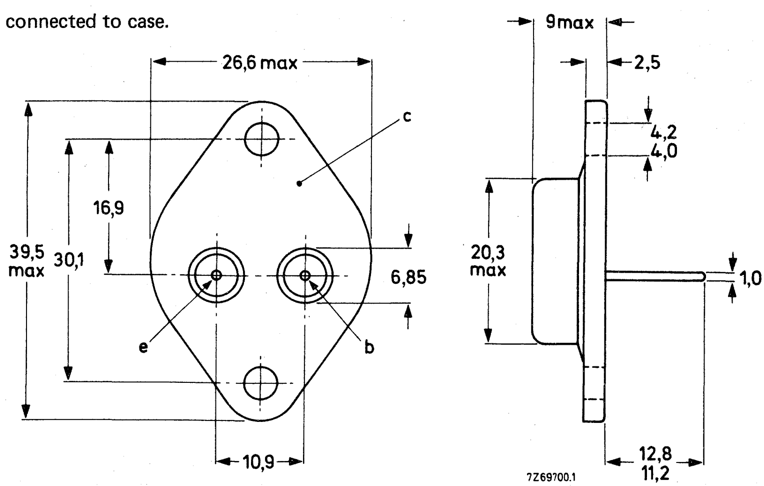
			BDX67	67A	67B	67C	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Collector current (peak value)	I_{CM}	max.		20			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		150			W
Junction temperature	T_j	max.		200			°C
D.C. current gain I_C = 1 A; V_{CE} = 3 V	h_{FE}	typ.		5200			
I_C = 10 A; V_{CE} = 3 V	h_{FE}	>		1000			
Cut-off frequency I_C = 5 A; V_{CE} = 3 V	f_{hfe}	typ.		50			kHz

MECHANICAL DATA

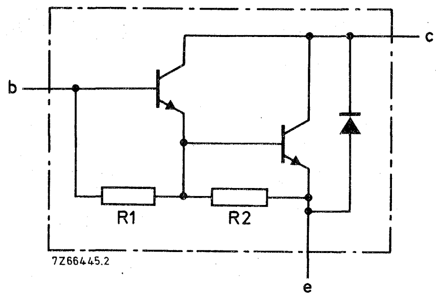
Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.



See also chapters Mounting Instructions and Accessories.



R1 typ. 3 kΩ
R2 typ. 80 Ω

Fig. 2 Circuit diagram.

RATINGS

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

			BDX67	67A	67B	67C	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	5	V

Collector current (d.c.)	I_C	max.	16	A
Collector current (peak value)	I_{CM}	max.	20	A
Base current (d.c.)	I_B	max.	250	mA
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	150	W
Storage temperature	T_{stg}		−65 to + 200	°C
Junction temperature *	T_j	max.	200	°C

THERMAL RESISTANCE *

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,17	K/W

* Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = V_{CEOmax}$	I_{CBO}	<	1	mA
$I_E = 0$; $V_{CB} = ½ V_{CBOmax}$; T_j = 200 °C	I_{CBO}	<	5	mA
$I_B = 0$; $V_{CE} = ½ V_{CEOmax}$	I_{CEO}	<	3	mA
Emitter-cut-off current				
$I_C = 0$; V_{EB} = 5 V	I_{EBO}	<	5	mA
D.C. current gain *				
I_C = 1 A; V_{CE} = 3 V	h_{FE}	typ.	5200 ←	
I_C = 10 A; V_{CE} = 3 V	h_{FE}	>	1000	
I_C = 16 A; V_{CE} = 3 V	h_{FE}	typ.	4000 ←	
Base-emitter voltage *				
I_C = 10 A; V_{CE} = 3 V	V_{BE}	<	2,5	V
Collector-emitter saturation voltage *				
I_C = 10 A; I_B = 40 mA	V_{CEsat}	<	2	V
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; V_{CB} = 10 V	C_c	typ.	300	pF
Cut-off frequency				
I_C = 5 A; V_{CE} = 3 V	f_{hfe}	typ.	50	kHz
Turn-off breakdown energy with inductive load				
$-I_{Boff} = 0$; I_{CC} = 7,8 A; see Fig. 5	$E_{(BR)}$	>	150	mJ
Small-signal current gain				
I_C = 5 A; V_{CE} = 3 V; f = 1 MHz	h_{fe}	typ.	20	
D.C. current gain ratio of complementary matched pairs				
I_C = 10 A; V_{CE} = 3 V	h_{FE1}/h_{FE2}	<	2,5	
Diode, forward voltage				
I_F = 10 A	V_F	typ.	2,5	V

* Measured under pulse conditions: $t_p < 300\ \mu s$, $\delta < 2\%$.

CHARACTERISTICS (continued)

T_j = 25 °C unless otherwise specified

Switching times
(between 10% and 90% levels)
I_{Con} = 10 A; I_{Bon} = $-I_{Boff}$ = 40 mA;

turn-on time	t_{on}	typ.	1 μs
turn-off time	t_{off}	typ.	3,5 μs

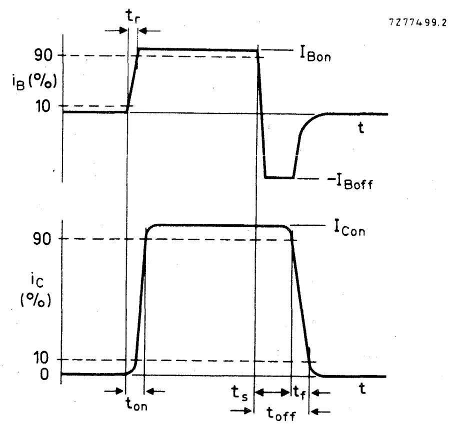
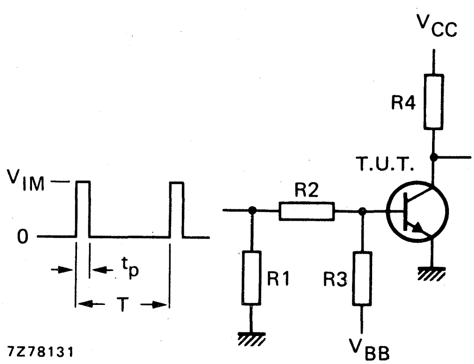


Fig. 3 Switching times waveforms.



V_{IM}	=	18 V
V_{CC}	=	12 V
V_{BB}	=	−3 V
R1	=	56 Ω
R2	=	220 Ω
R3	=	180 Ω
R4	=	1 Ω
$t_r = t_f$	≤	15 ns
t_p	=	10 μs
T	=	500 μs

Fig. 4 Switching times test circuit.

CHARACTERISTICS (continued)

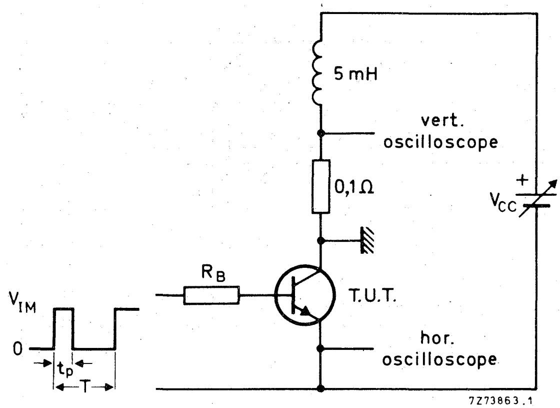


Fig. 5 Test circuit for turn-off breakdown energy. V_{IM} = 12 V; R_B = 270 Ω; I_{CC} = 7,8 A; t_p = 1 ms; δ = 1%.

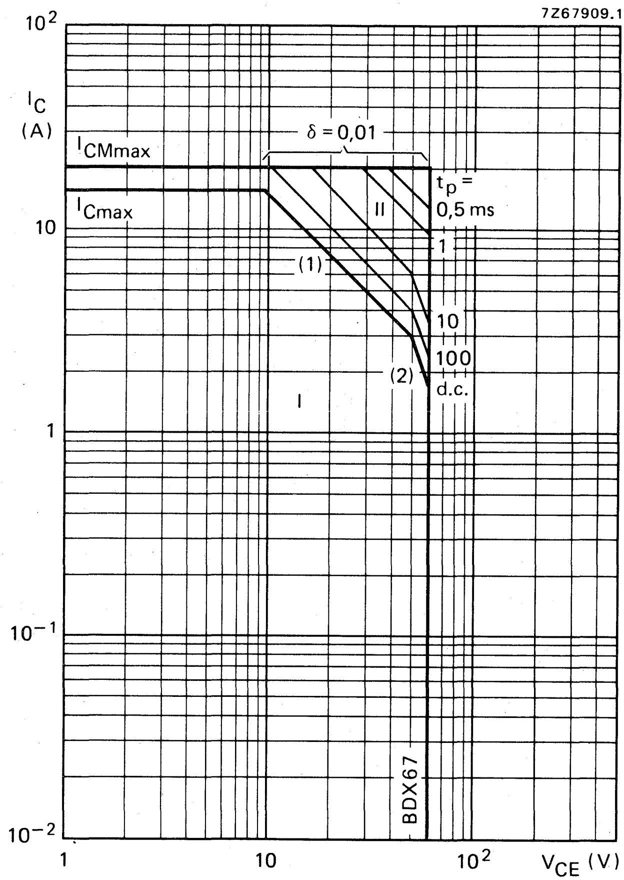


Fig. 6 Safe Operating ARea at T_{mb} = 25 °C of BDX67.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ and $P_{tot\ peak\ max}$ lines.

(2) Second breakdown limits (independent of temperature).

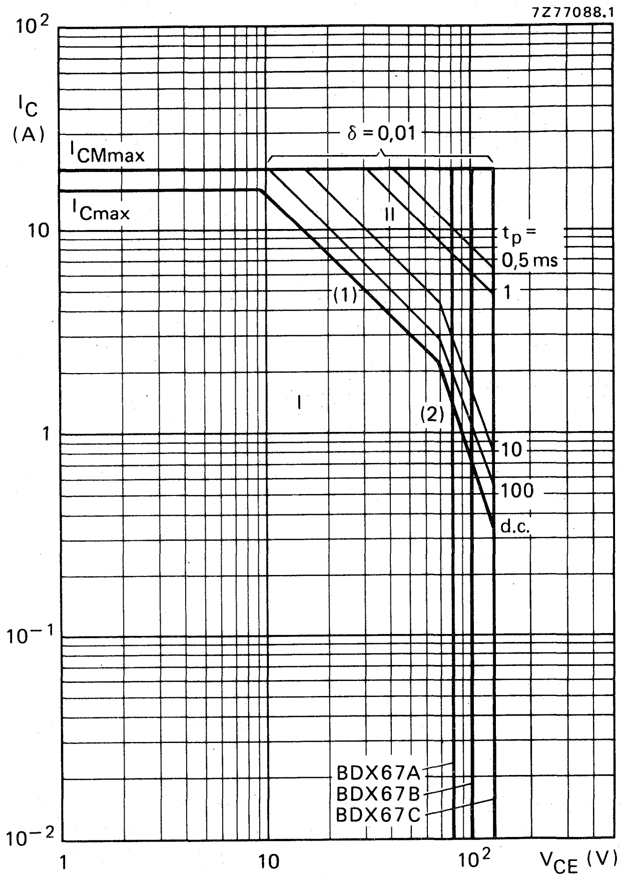


Fig. 7 Safe Operating ARea at T_{mb} = 25 °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(1) $P_{tot\ max}$ and $P_{tot\ peak\ max}$ lines.

(2) Second breakdown limits (independent of temperature).

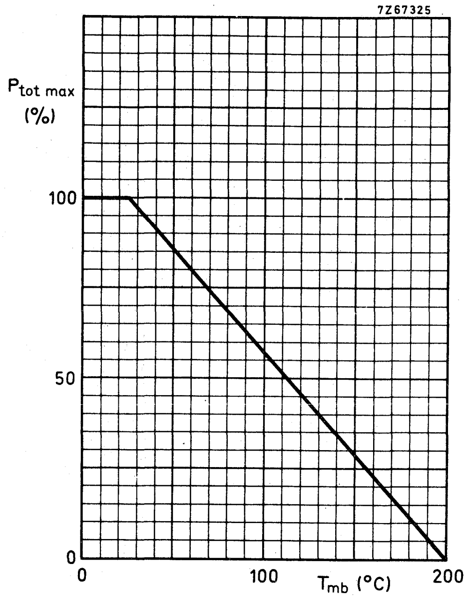


Fig. 8 Power derating curve.

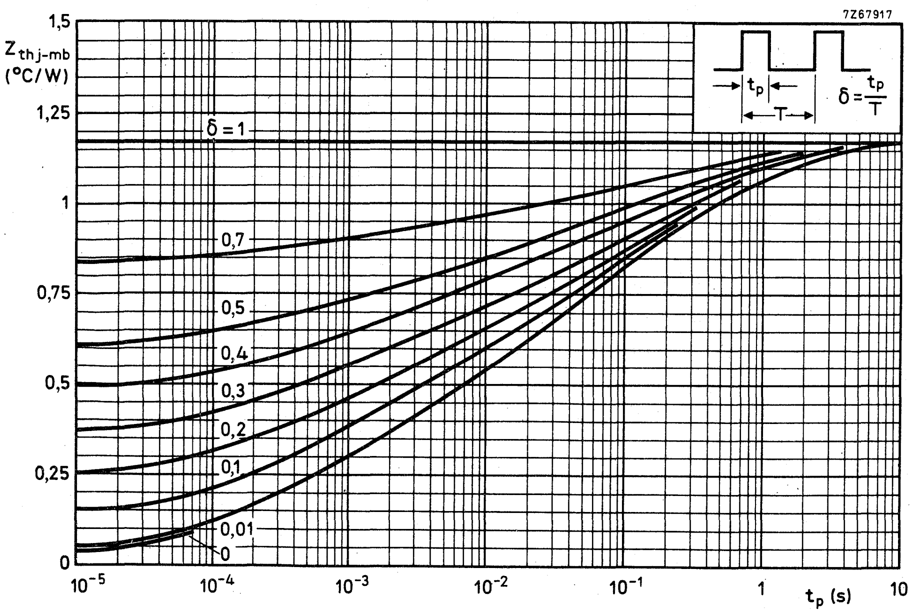


Fig. 9 Pulse power rating chart.

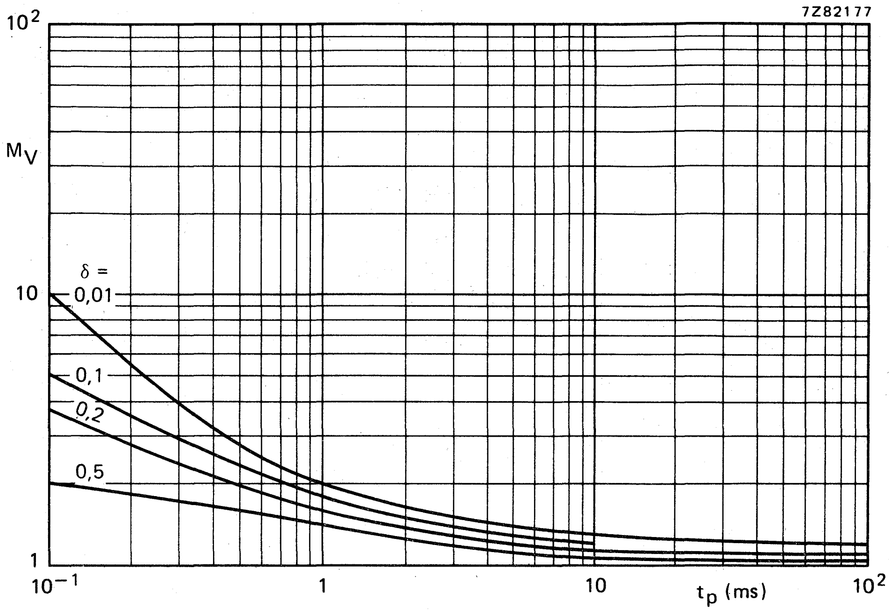


Fig. 10 S.B. voltage multiplying factor at the I_{Cmax} level.

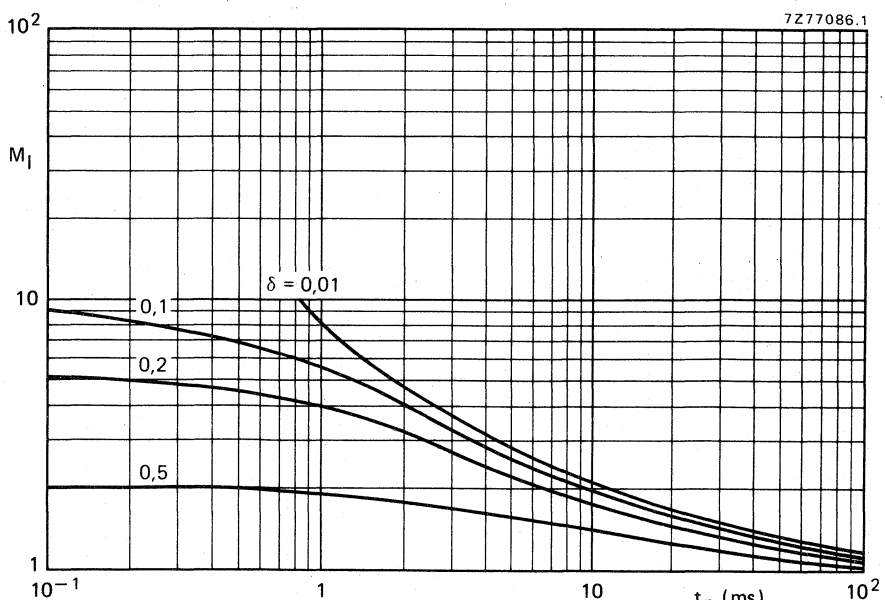


Fig. 11 S.B. current multiplying factor at the V_{CEOmax} level.

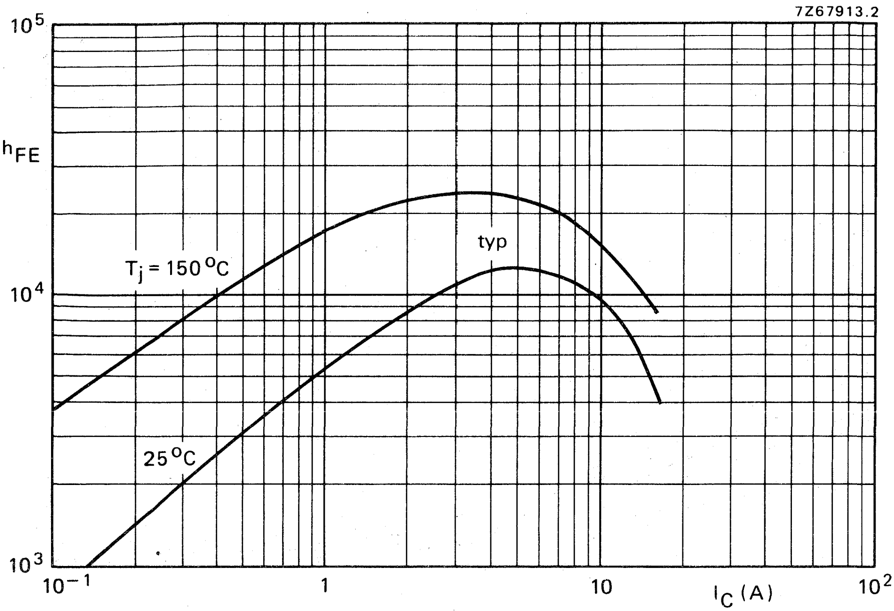


Fig. 12 D.C. current gain.

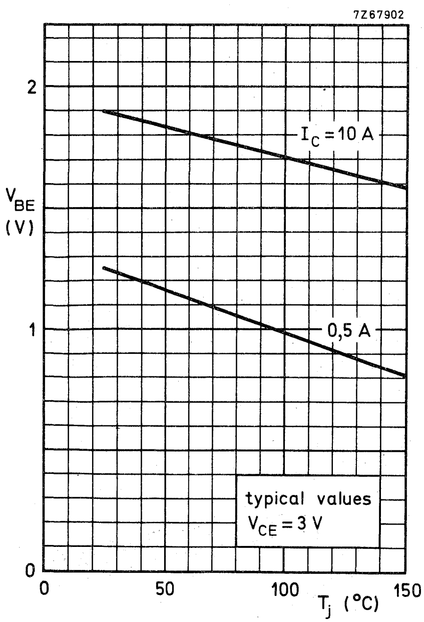


Fig. 13 Typical base-emitter voltage.

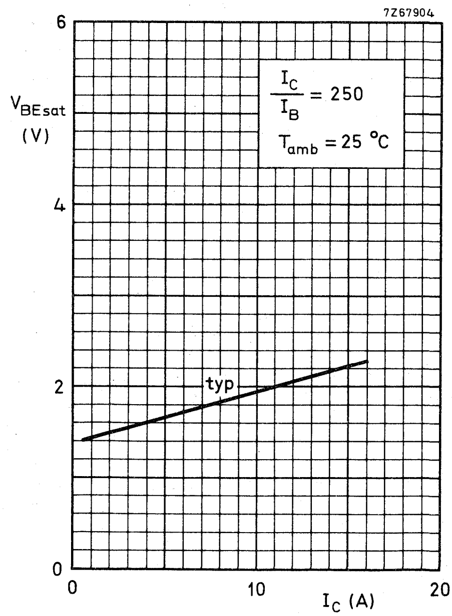


Fig. 14 Base-emitter saturation voltage.

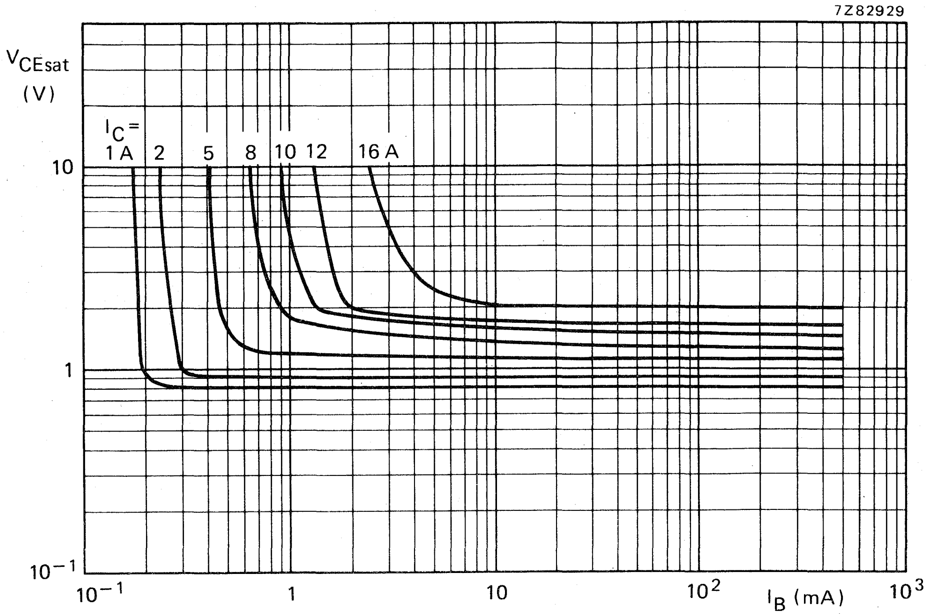


Fig. 15 Typical values collector-emitter saturation voltage at T_j = 25 °C.

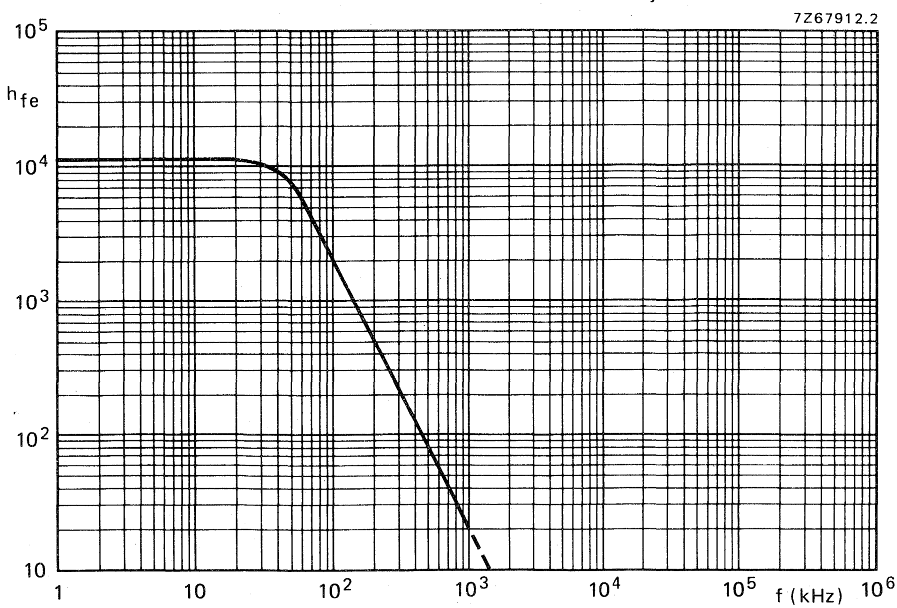


Fig. 16 Small-signal current gain, I_C = 5 A; V_{CE} = 3 V.

SILICON EPITAXIAL-BASE POWER TRANSISTOR

N-P-N transistor in a plastic envelope, intended for industrial amplifier and switching applications.
P-N-P complement is BDX78.

QUICK REFERENCE DATA

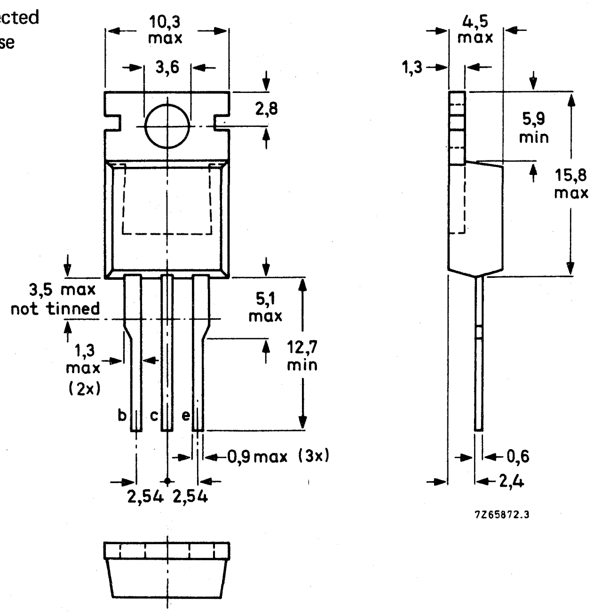
Collector-emitter voltage (open base)	V_{CEO}	max.	80 V
Collector-base voltage (open emitter)	V_{CBO}	max.	100 V
Collector current (d.c.)	I_C	max.	8 A
Total power dissipation up to T_{mb} = 25 ^oC	P_{tot}	max.	60 W
D.C. current gain I_C = 2 A; V_{CE} = 2 V	h_{FE}	>	30
Cut-off frequency I_C = 0,3 A; V_{CE} = 3 V	f_{hfe}	>	25 kHz

MECHANICAL DATA

Dimensions in mm

TO-220

Collector connected to mounting base



See also chapters Mounting Instructions and Accessories.

RATINGS

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

Collector-base voltage (open emitter)	V_{CBO}	max.	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	80	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V
Collector current (d.c.)	I_C	max.	8	A
Collector current (peak value, $t_p \leqslant 10$ ms)	I_{CM}	max.	12	A
Collector current (surge) ($t_p \leqslant 2$ ms)	I_{CS}	max.	25	A
Base current (d.c.)	I_B	max.	3	A
Storage temperature	T_{stg}	−65 to	+150	°C
Junction temperature	T_j	max.	150	°C
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	60	W

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2,08	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	70	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_B = 0$; $V_{CE} = 30$ V	I_{CEO}	<	1	mA
$I_E = 0$; $V_{CB} = 70$ V; $T_j = 150$ °C	I_{CBO}	<	2	mA
$I_E = 0$; $V_{CB} = 100$ V	I_{CBO}	<	0,1	mA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	2	mA
Base-emitter voltage*				
$I_C = 3$ A; $V_{CE} = 2$ V	V_{BE}	<	1,5	V
Knee voltage*				
$I_C = 3$ A; I_B = value for which $I_C = 3{,}3$ A at $V_{CE} = 2$ V	V_{CEK}	typ.	1	V
Saturation voltages				
$I_C = 2$ A; $I_B = 0{,}2$ A	V_{CEsat}	<	0,6	V
$I_C = 3$ A; $I_B = 0{,}3$ A	V_{CEsat}	<	1	V
$I_C = 6$ A; $I_B = 0{,}6$ A	V_{CEsat}	<	1,5	V
$I_C = 6$ A; $I_B = 0{,}6$ A	V_{BEsat}	<	2	V
D.C. current gain*				
$I_C = 2$ A; $V_{CE} = 2$ V	h_{FE}	>	30	
Cut-off frequency				
$I_C = 0{,}3$ A; $V_{CE} = 3$ V	f_{hfe}	>	25	kHz

* Measured under pulse conditions; $t_p \leqslant 300\ \mu s$; $\delta \leqslant 2\%$.

Transition frequency at f = 1 MHz $-I_E$ = 0,3 A; V_{CB} = 3 V	f_T	>	3 MHz
Collector-emitter breakdown voltage * I_C = 0,2 A; I_B = 0	$V_{(BR)CEO}$	>	80 V
Forward bias second-breakdown collector current V_{CE} = 50 V; t_p = 0,1 s T_{amb} = 25 °C without heatsink	$I_{(SB)}$	>	1,2 A
Collector capacitance at f = 1 MHz V_{CB} = 10 V; I_E = 0	C_c	<	200 pF
Switching times (between 10% and 90% levels) I_{Con} = 2 A; I_{Bon} = $-I_{Boff}$ = 0,2 A			
Turn-on time	t_{on}	typ.	1 μs
Turn-off time	t_{off}	typ.	4 μs

* Measured under pulse conditions: $t_p < 300$ μs, $\delta < 2\%$.

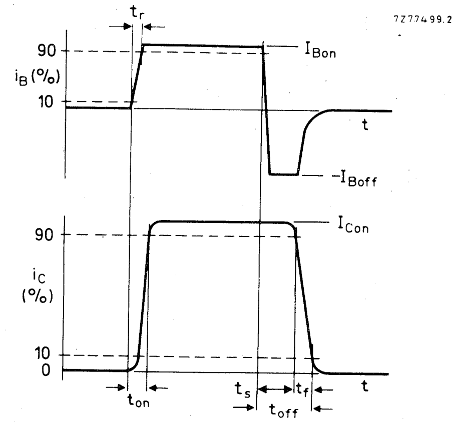
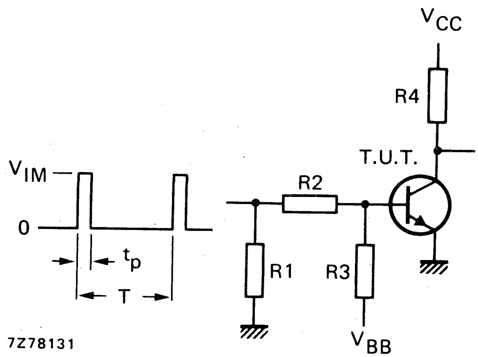


Fig. 2 Switching times waveforms.



V_{IM}	=	15 V
V_{CC}	=	20 V
$-V_{BB}$	=	4 V
R1	=	– Ω
R2	=	33 Ω
R3	=	22 Ω
R4	=	10 Ω
$t_r = t_f$	⩽	15 ns
t_p	=	20 μs
T	=	500 μs

Fig. 3 Switching times test circuit.

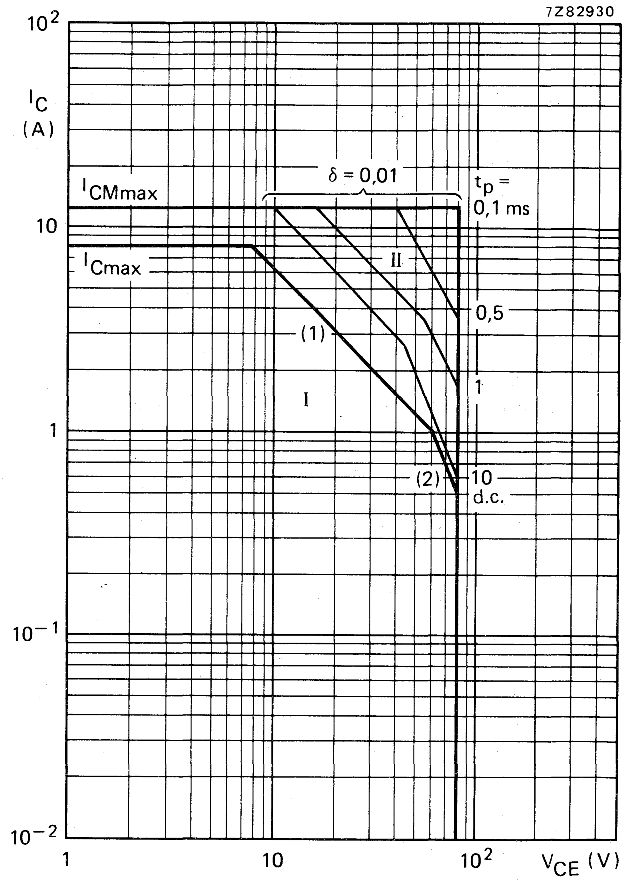


Fig. 4 Safe Operating ARea at $T_{mb} \leqslant 25\ ^oC$.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(1) $P_{tot\,max}$ and $P_{tot\,peak\,max}$ lines.

(2) Second-breakdown limits (independent of temperature).

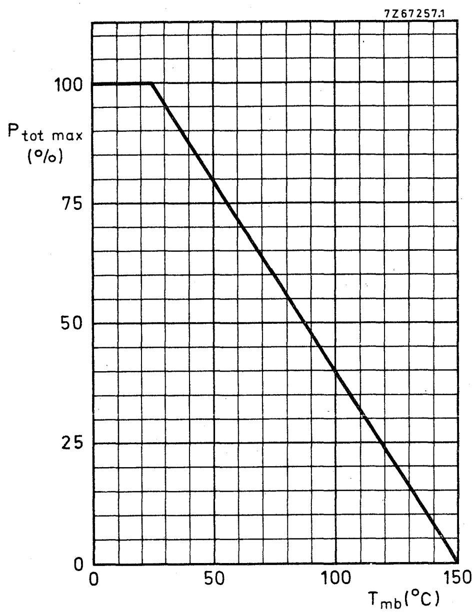


Fig. 5 Power derating curve.

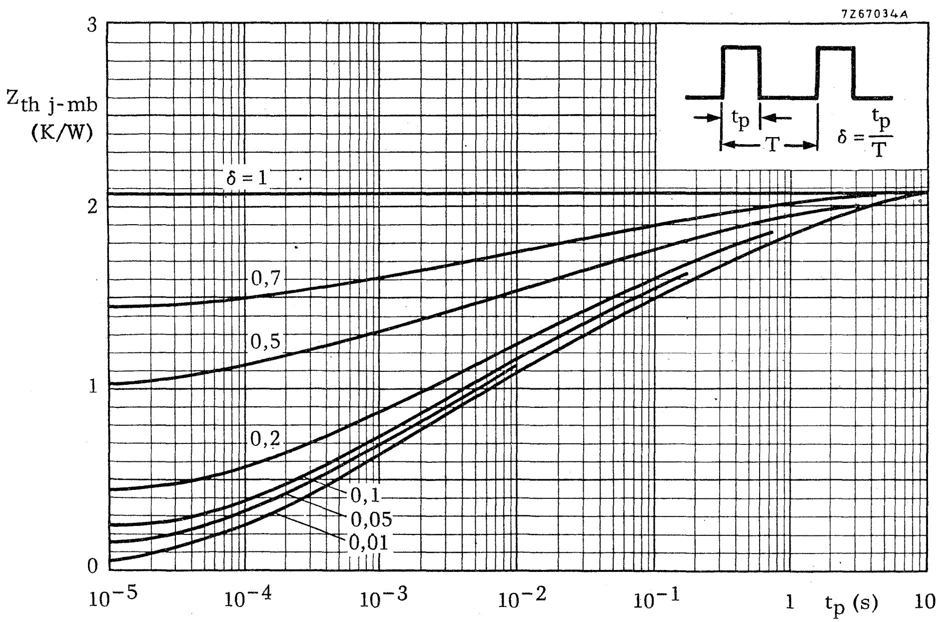


Fig. 6 Pulse power rating chart.

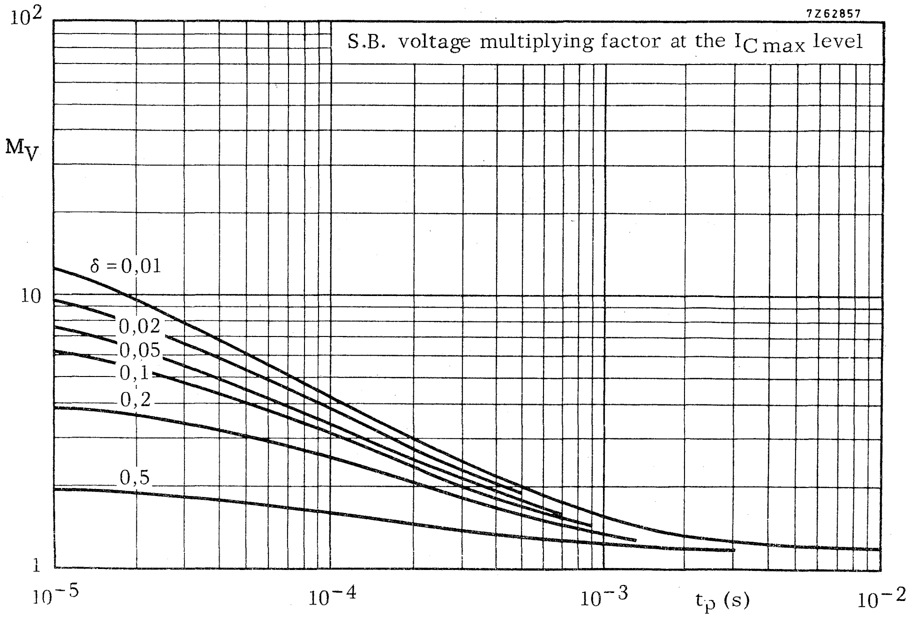


Fig. 7 S.B. voltage multiplying factor at the I_{Cmax} level.

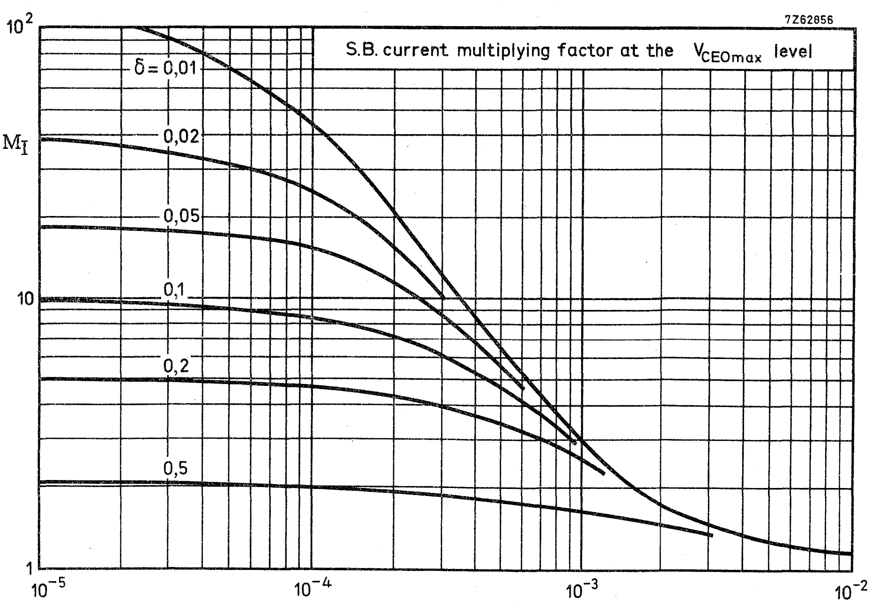


Fig. 8 S.B. current multiplying factor at the V_{CEOmax} level.

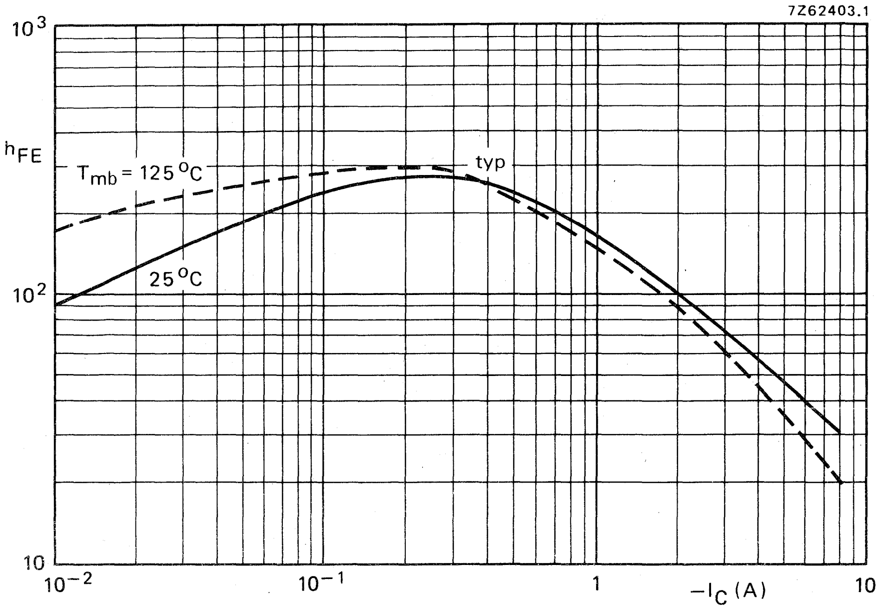


Fig. 9 D.C. current gain at V_{CE} = 2 V.

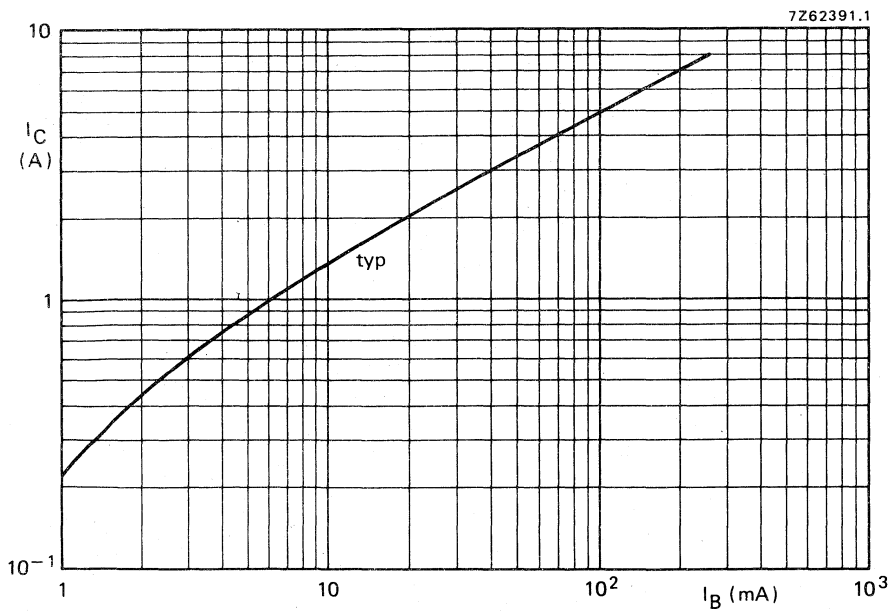


Fig. 10 Typical collector current. T_j = 25 °C; V_{CE} = 2 V.

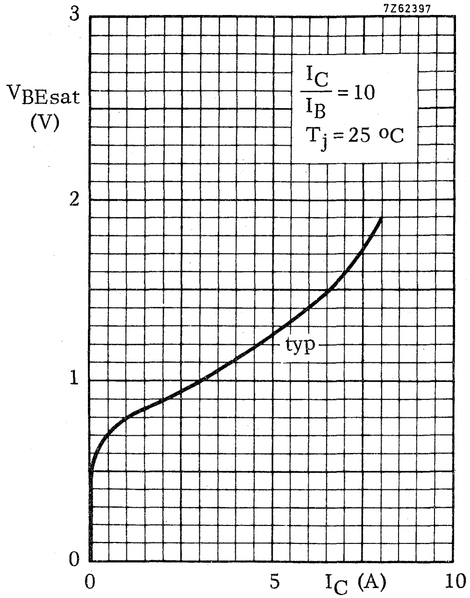


Fig. 11 Base-emitter saturation voltage.

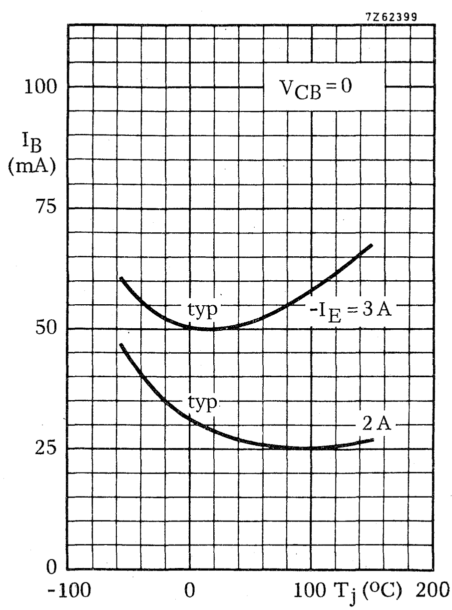


Fig. 12 Base current.

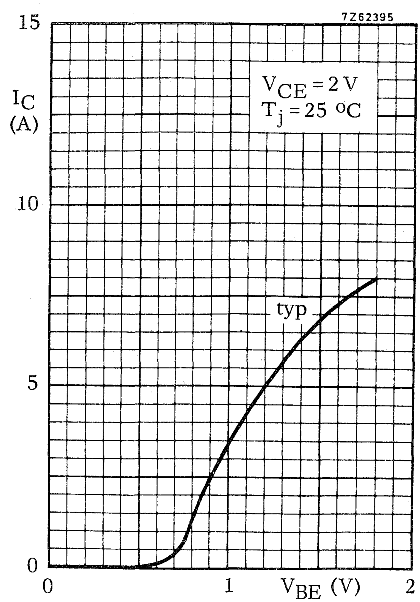


Fig. 13 Collector current.

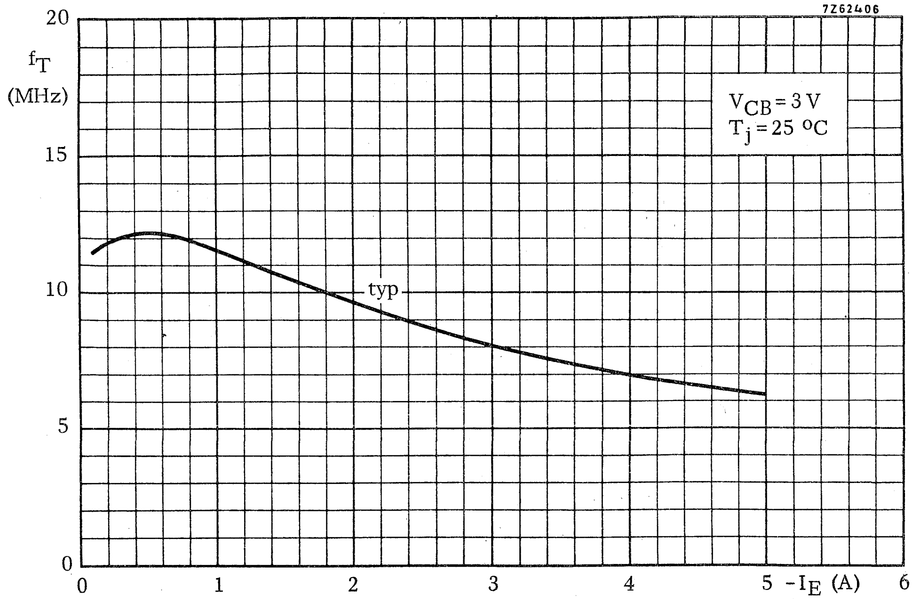


Fig. 14 Typical values transition frequency at V_{CB} = 3 V; T_j = 25 °C.

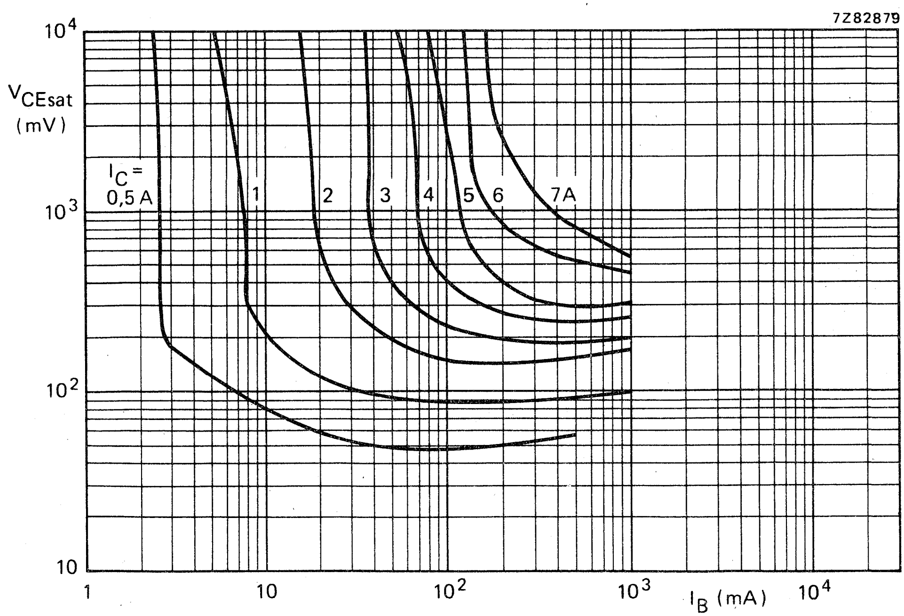


Fig. 15 Typical values collector-emitter saturation voltage at T_j = 25 °C.

SILICON EPITAXIAL-BASE POWER TRANSISTOR

P-N-P transistor in a plastic envelope, intended for industrial amplifier and switching applications. N-P-N complement BDX77.

QUICK REFERENCE DATA

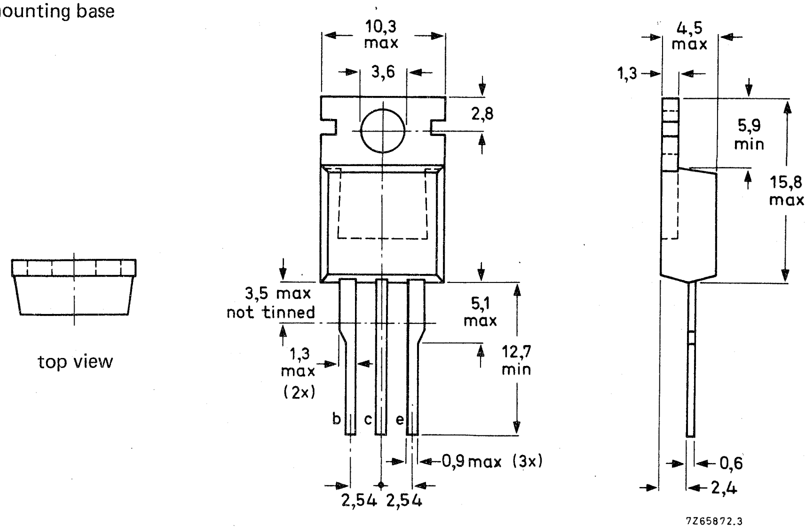
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	80 V
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	80 V
Collector current (d.c.)	$-I_C$	max.	8 A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	60 W
D.C. current gain $-I_C$ = 2 A; $-V_{CE}$ = 2 V	h_{FE}	>	30
Cut-off frequency $-I_C$ = 0,3 A; $-V_{CE}$ = 3 V	f_{hfe}	>	25 kHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220

Collector connected to mounting base



See also chapters Mounting Instructions and Accessories.

RATINGS

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

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	80 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	80 V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5 V
Collector current (d.c.)	$-I_C$	max.	8 A
Collector current (peak value, $t_p \leqslant 10$ ms)	$-I_{CM}$	max.	12 A
Collector current (surge) $t_p \leqslant 2$ ms	$-I_{CS}$	max.	25 A
Base current (d.c.)	$-I_B$	max.	3 A
Storage temperature	T_{stg}	−65 to + 150	°C
Junction temperature	T_j	max.	150 °C
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	60 W

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2,08 K/W
From junction to mounting base in free air	$R_{th\ j\text{-}a}$	=	70 K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current			
$I_B = 0$; $-V_{CE} = 30$ V	$-I_{CEO}$	<	1 mA
$I_E = 0$; $-V_{CB} = 70$ V; $T_j = 150$ °C	$-I_{CBO}$	<	2 mA
$I_E = 0$; $-V_{CB} = 100$ V	$-I_{CBO}$	<	0,1 mA
Emitter cut-off current			
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	2 mA
Base-emitter voltage*			
$-I_C = 3$ A; $-V_{CE} = 2$ V	$-V_{BE}$	<	1,5 V
Knee voltage*			
$-I_C = 3$ A; $-I_B$ = value at which $-I_C = 3,3$ A at $-V_{CE} = 2$ V	$-V_{CEK}$	typ.	1 V
Saturation voltages*			
$-I_C = 3$ A; $-I_B = 0,3$ A	$-V_{CEsat}$	<	1 V
$-I_C = 2$ A; $-I_B = 0,2$ A	$-V_{CEsat}$	<	0,6 V
$-I_C = 6$ A; $-I_B = 0,6$ A	$-V_{CEsat}$	<	1,5 V
$-I_C = 6$ A; $-I_B = 0,6$ A	$-V_{BEsat}$	<	2 V

* Measured under pulse conditions: $t_p < 300\ \mu s$, $\delta < 2\%$.

Collector-emitter breakdown voltage* $-I_C = 0,2$ A; $I_B = 0$	$V_{(BR)CEO}$	>	80 V
D.C. current gain* $-I_C = 2$ A; $-V_{CE} = 2$ V	h_{FE}	>	30
Cut-off frequency $-I_C = 0,3$ A; $-V_{CE} = 3$ V	f_{hfe}	>	25 kHz
Transition frequency at f = 1 MHz $-I_E = 0,3$ A; $-V_{CB} = 3$ V	f_T	>	3 MHz
Forward bias second-breakdown collector current $-V_{CE} = 50$ V; $t_p = 0,1$ s; $T_{amb} = 25$ °C	$I_{(SB)}$	>	1,2 A
Collector capacitance at f = 1 MHz $-V_{CB} = 10$ V; $I_E = 0$	C_c	<	200 pF
Switching times (between 10% and 90% levels) $-I_{Con} = 2$ A; $-I_{Bon} = I_{Boff} = 0,2$ A;			
turn-on time	t_{on}	typ.	1 μs
turn-off time	t_{off}	typ.	2 μs

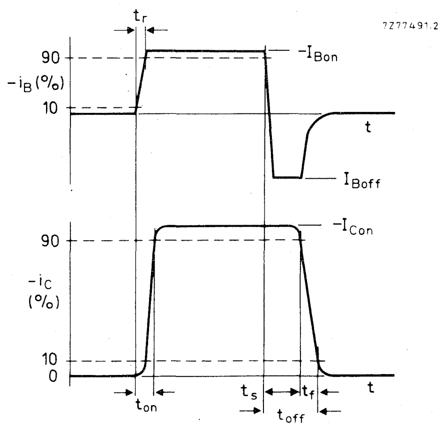


Fig. 2 Switching times waveforms.

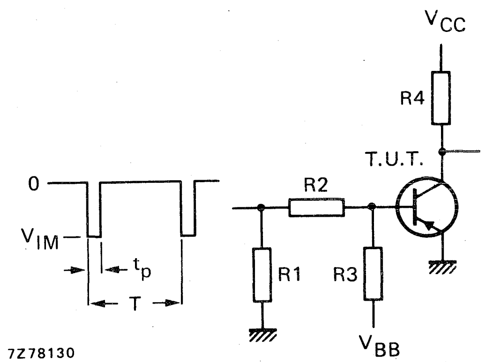


Fig. 3 Switching times test circuit.

$-V_{IM} = 15$ V	R1 = 56 Ω	$t_r = t_f = 15$ ns
$-V_{CC} = 20$ V	R2 = 33 Ω	$t_p = 10$ μs
$+V_{BB} = 4$ V	R3 = 22 Ω	T = 500 μs
	R4 = 10 Ω	

* Measured under pulse conditions $t_p \leqslant 300$ μs; $\delta \leqslant 2\%$.

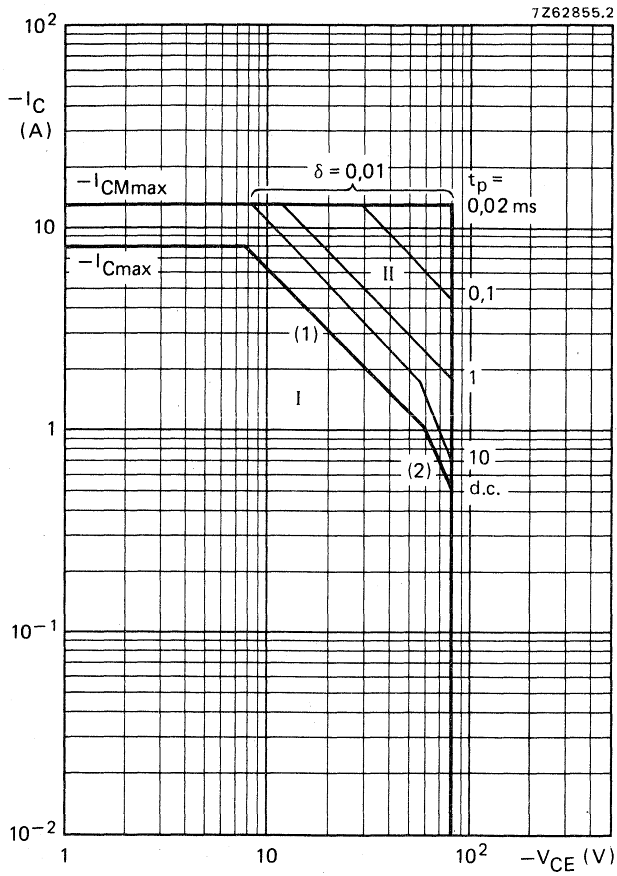


Fig. 4 Safe Operating ARea at $T_{mb} \leq 25\ ^{o}C$.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(1) $P_{tot\,max}$ and $P_{tot\,peak\,max}$ lines.

(2) Second-breakdown limits (independent of temperature).

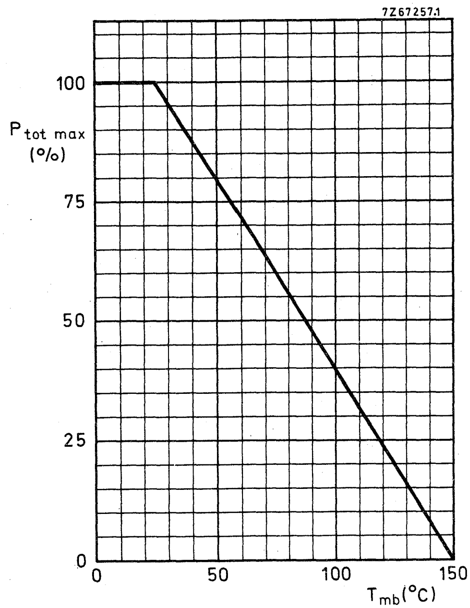


Fig. 5 Power derating curve.

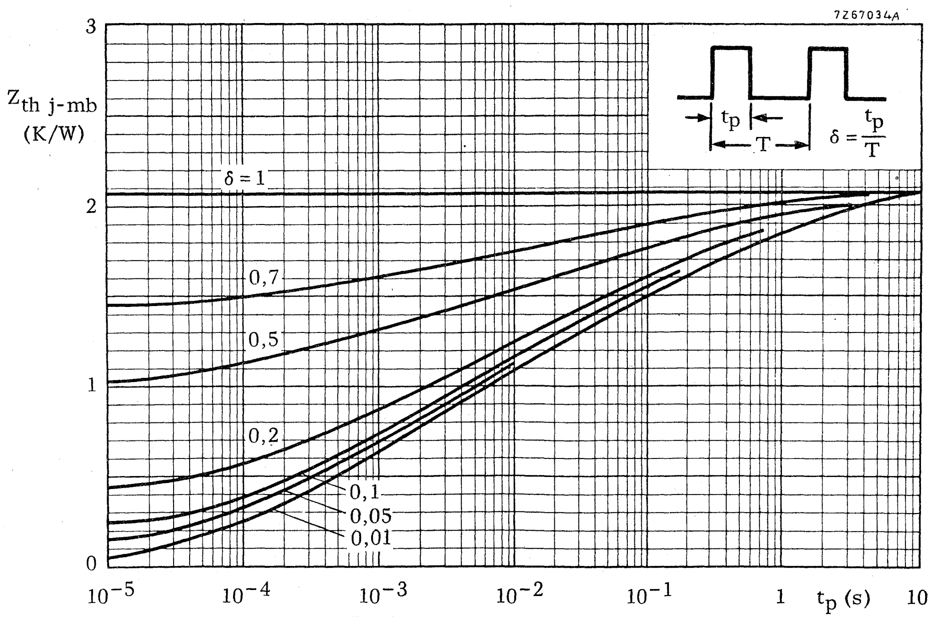


Fig. 6 Pulse power rating chart.

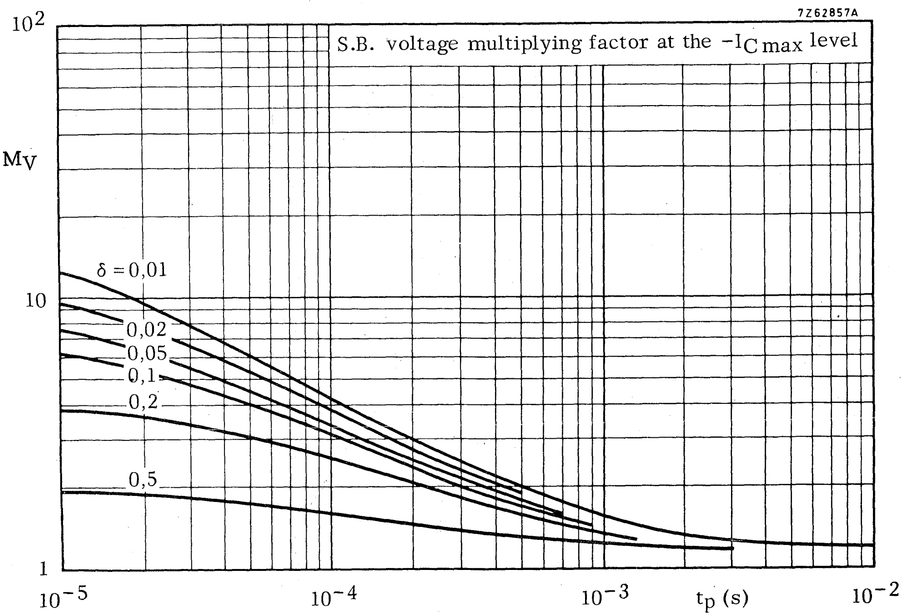


Fig. 7 S.B. voltage multiplying factor at the $-I_{C\,max}$ level.

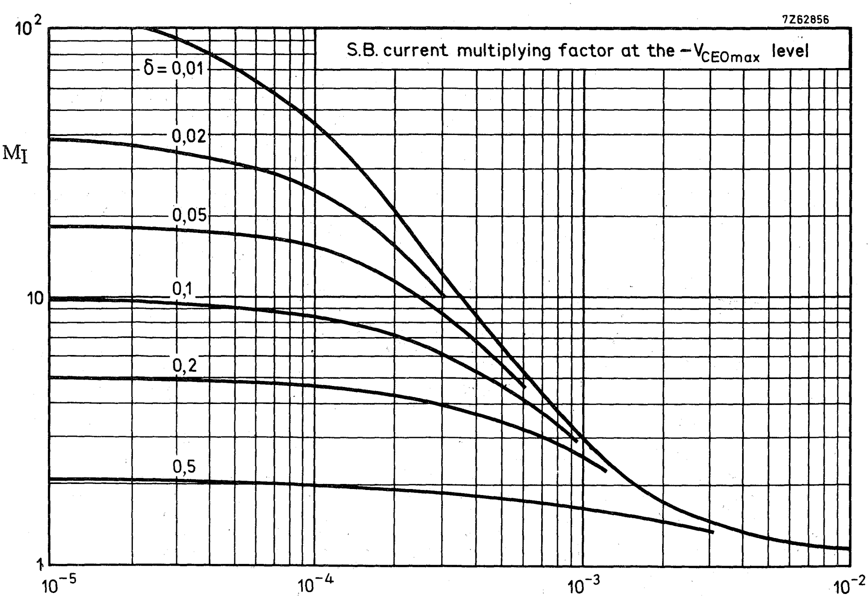


Fig. 8 S.B. current multiplying factor at the $-V_{CEO\,max}$ level.

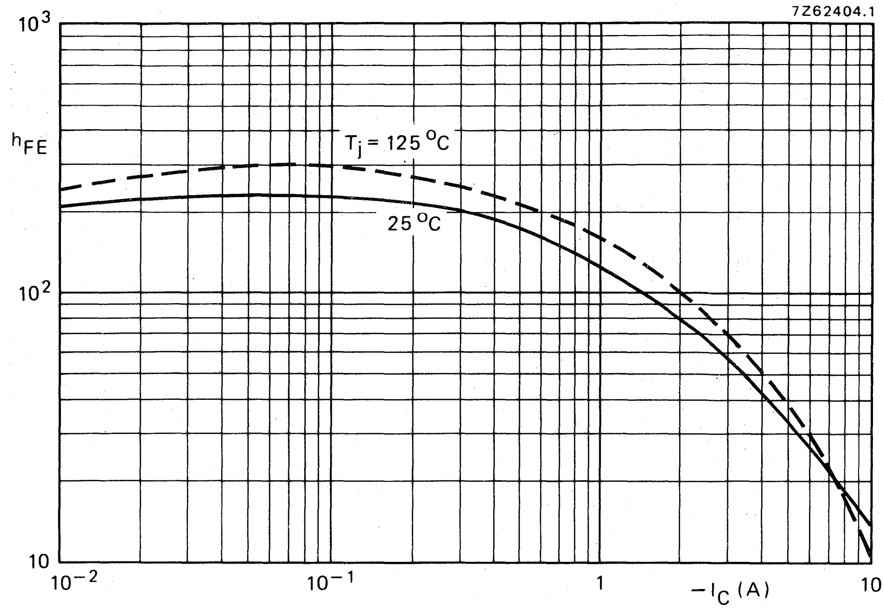


Fig. 9 D.C. current gain at $-V_{CE}$ = 2 V.

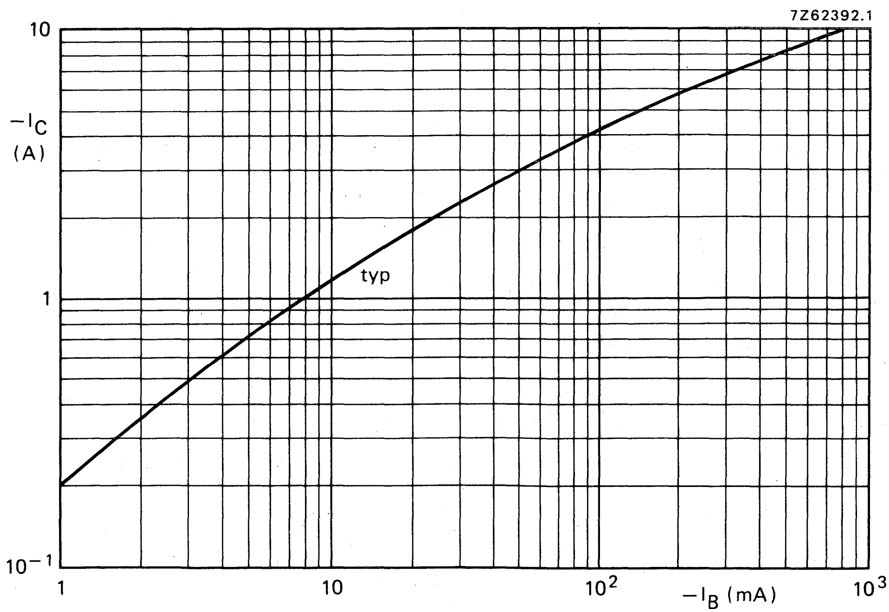


Fig. 10 Typical values collector current. $-V_{CE}$ = 2 V; T_j = 25 °C.

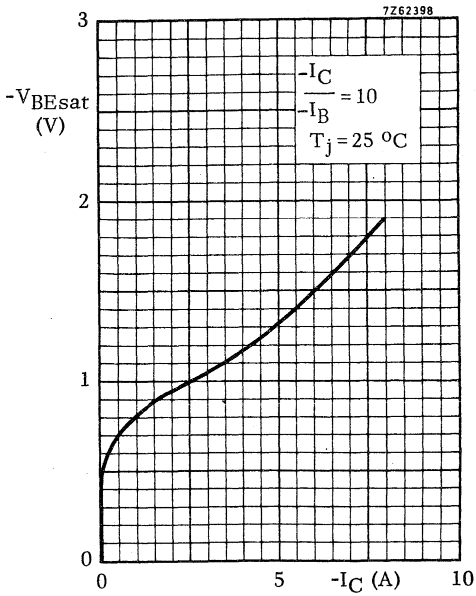


Fig. 11 Base-emitter saturation voltage.

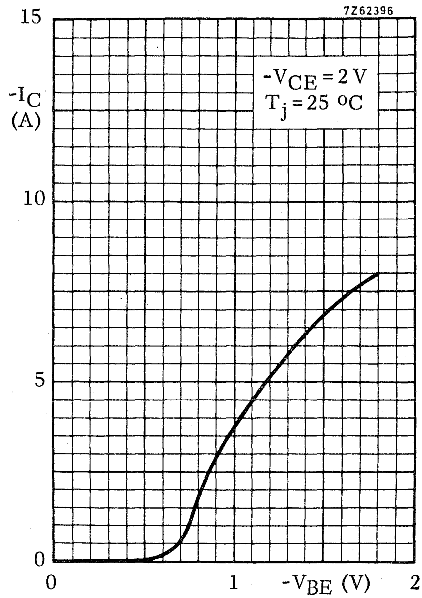


Fig. 12 Collector current.

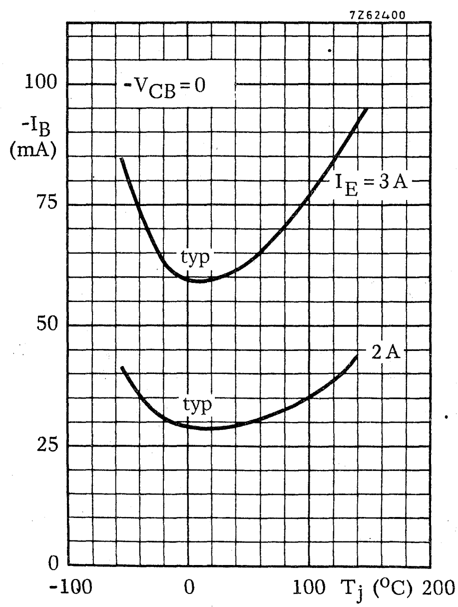


Fig. 13.

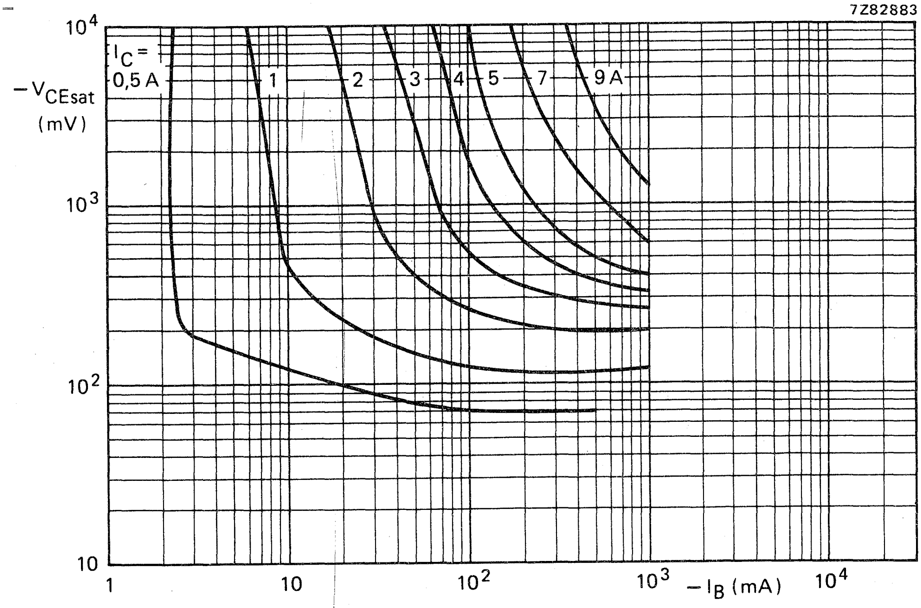


Fig. 14 Typical values collector-emitter saturation voltage at T_j = 25 °C.

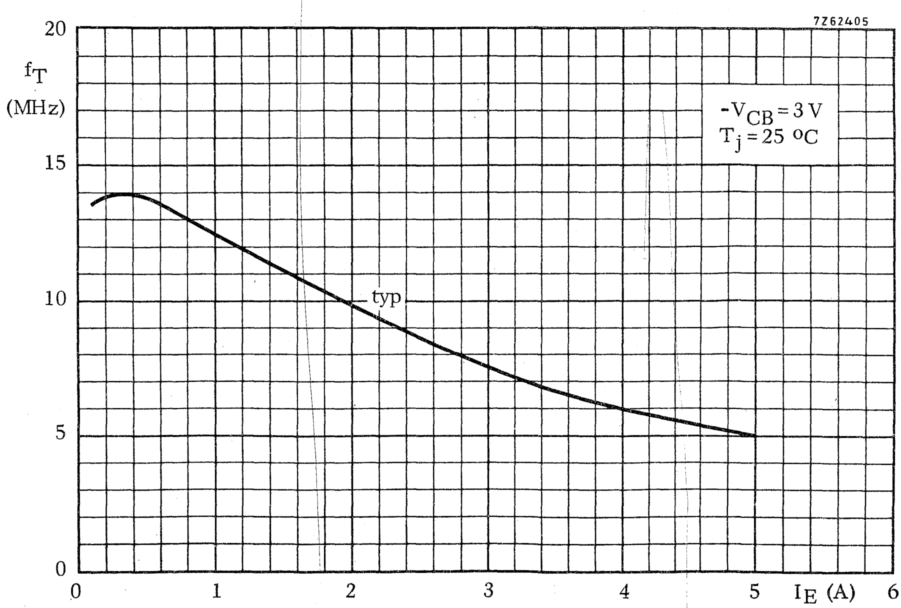


Fig. 15.

SILICON POWER TRANSISTORS

N-P-N transistors in TO-3 envelope for audio output stages and general amplifier and switching applications. P-N-P complements are BDX92, BDX94 and BDX96.

QUICK REFERENCE DATA

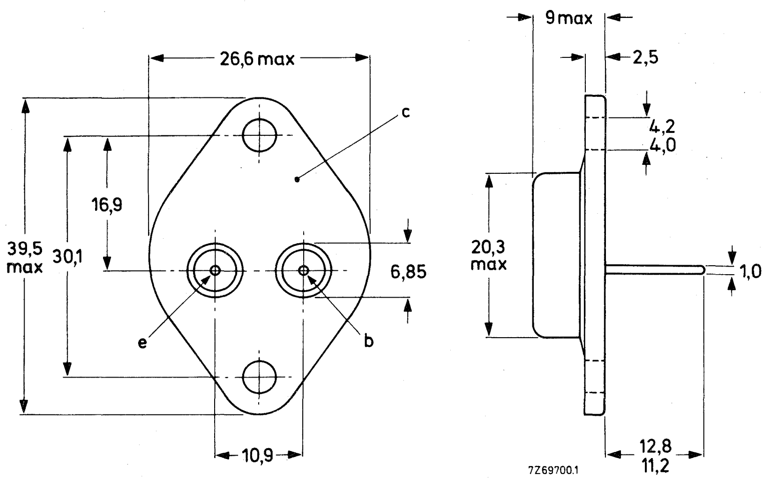
			BDX91	BDX93	BDX95	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	V
Collector current (peak value)	I_{CM}	max.		12		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		90		W
Junction temperature	T_j	max.		200		°C
D.C. current gain I_C = 3 A; V_{CE} = 2 V	h_{FE}	>		20		
Transition frequency I_C = 1 A; V_{CE} = 10 V	f_T	>		4		MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-3.

Collector connected to envelope.



See also chapters Mounting Instructions and Accessories.

RATINGS

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

			BDX91	BDX93	BDX95	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V
Collector current (d.c.)	I_C	max.		8		A
Collector current (peak value)	I_{CM}	max.		12		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		90		W
Storage temperature	T_{stg}			−65 to +200		°C
Junction temperature	T_j	max.		200		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,94	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	<	0,1	mA
$I_E = 0$; $V_{CB} = ½V_{CBOmax}$; T_j = 200 °C	I_{CBO}	<	2	mA
$I_B = 0$; $V_{CE} = V_{CEOmax}$	I_{CEO}	<	1	mA
Emitter cut-off current				
$I_C = 0$; V_{EB} = 5 V	I_{EBO}	<	1	mA
D.C. current gain*				
I_C = 3 A; V_{CE} = 2 V	h_{FE}	>	20	
I_C = 5 A; V_{CE} = 2 V	h_{FE}	>	10	
Base-emitter voltage*				
I_C = 3 A; V_{CE} = 2 V	V_{BE}	<	1,4	V
Collector-emitter saturation voltage*				
I_C = 3 A; I_B = 0,3 A	V_{CEsat}	<	0,8	V
I_C = 5 A; I_B = 1 A	V_{CEsat}	<	1	V
Base-emitter saturation voltage*				
I_C = 3 A; I_B = 0,3 A	V_{BEsat}	<	1,5	V
I_C = 5 A; I_B = 1 A	V_{BEsat}	<	2	V

* Measured under pulse conditions: $t_p < 300\ \mu s$, $\delta < 2\%$.

Small-signal current gain at f = 1 kHz I_C = 0,5 A; V_{CE} = 10 V	h_{fe}	>		40		
Transition frequency I_C = 1 A; V_{CE} = 10 V	f_T	>		4		MHz
			BDX91	BDX93	BDX95	
Collector-emitter breakdown voltage* I_C = 100 mA	$V_{(BR)CEO}$	>	60	80	100	V
Switching times (between 10% and 90% levels) I_{Con} = 3 A; I_{Bon} = $-I_{Boff}$ = 0,3 A						
Turn-on time	t_{on}	typ.		0,2		μs
		<		1		μs
Turn-off time	t_{off}	typ.		1,2		μs
		<		2		μs

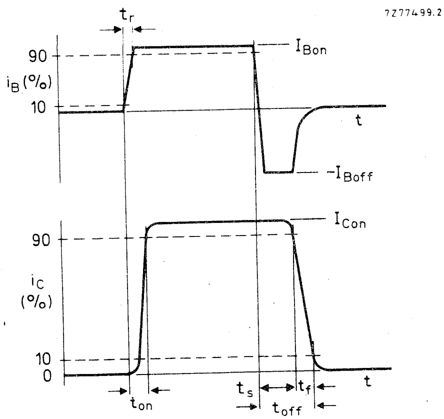
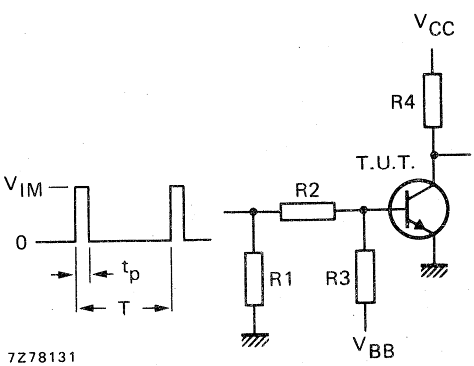


Fig. 2 Switching times waveforms.



V_{IM} = 55 V
V_{CC} = 30 V
$-V_{BB}$ = 5 V
R1 = 150 Ω
R2 = 82 Ω
R3 = 20 Ω
R4 = 10 Ω
$t_r = t_f \leqslant$ 15 ns
t_p = 10 μs
T = 500 μs

Fig. 3 Switching times test circuit.

* Measured under pulse conditions: $t_p < 300$ μs, $\delta < 2\%$.

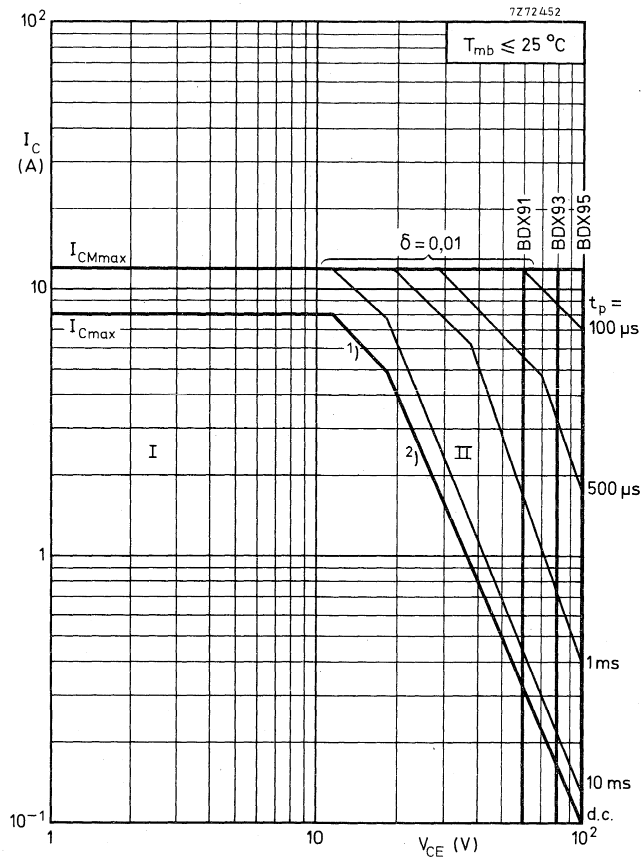


Fig. 4 Safe Operating ARea at $T_{mb} \leqslant 25$ °C.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.

(1) $P_{tot\,max}$ and $P_{tot\,peak\,max}$ lines.
(2) Second-breakdown limits (independent of temperature).

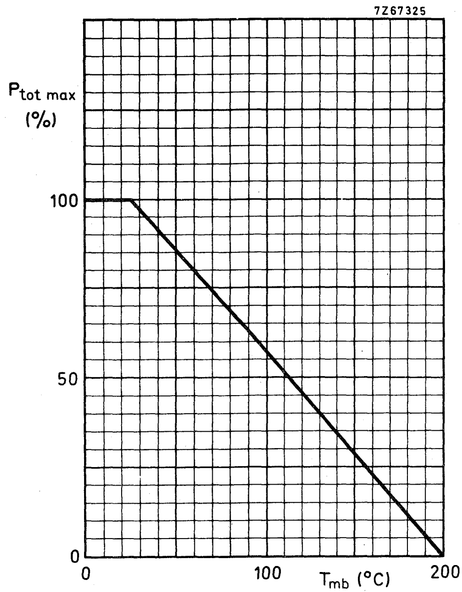


Fig. 5 Power derating curve

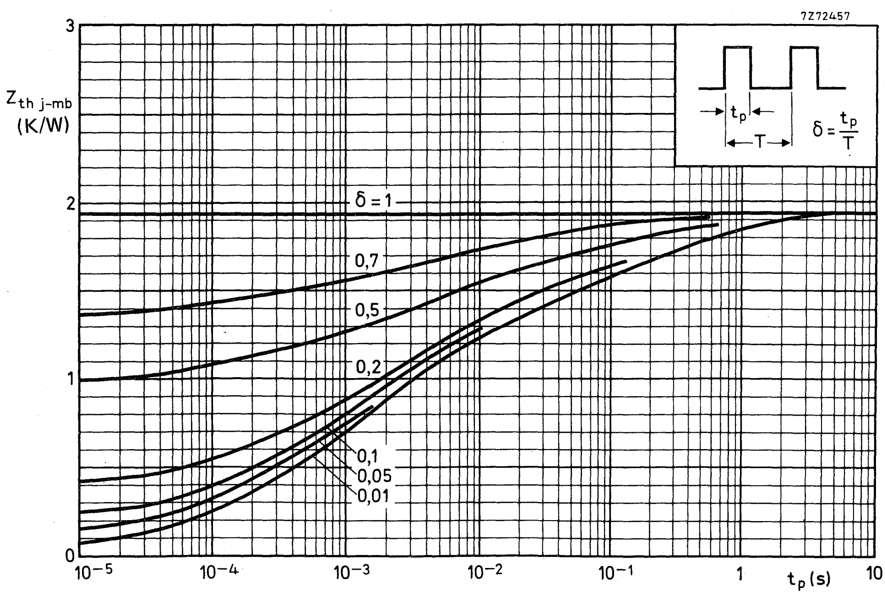


Fig. 6 Pulse power rating chart.

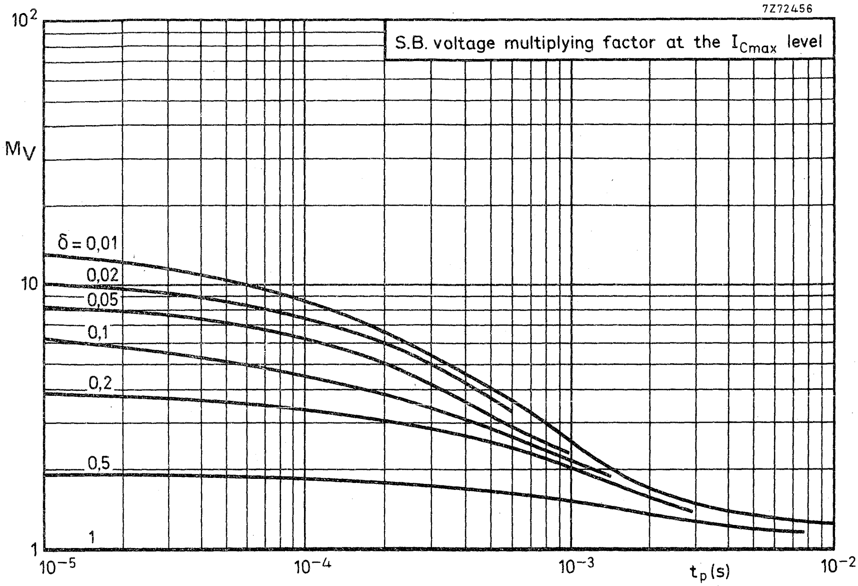


Fig. 7 S.B. voltage multiplying factor at the I_{Cmax} level.

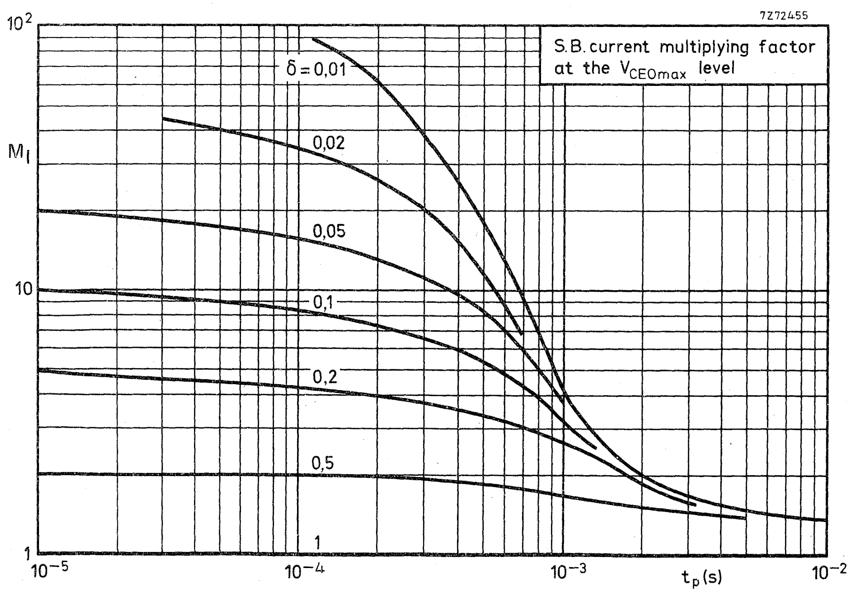


Fig. 8 S.B. current multiplying factor at the V_{CEOmax} level.

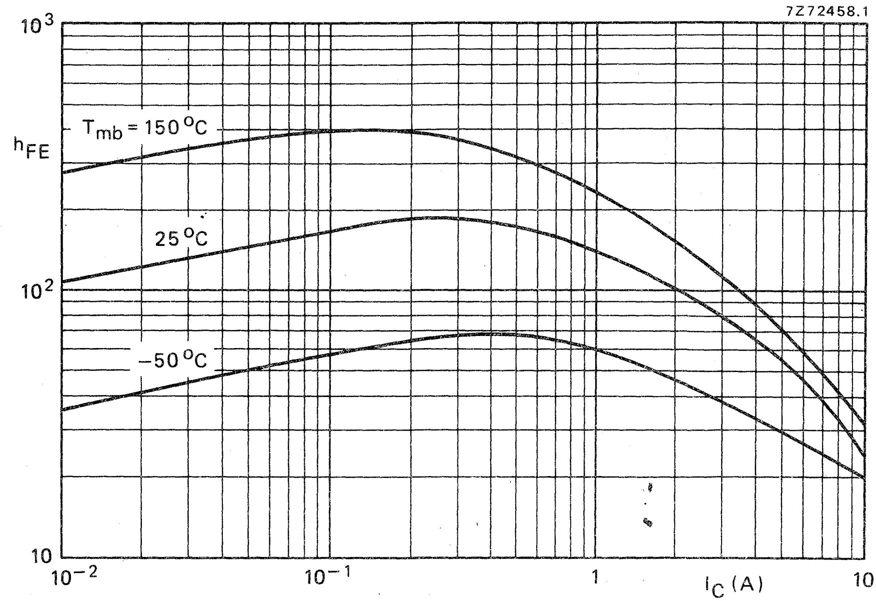


Fig. 9 D.C. current gain at V_{CE} = 2 V; T_j = 25 °C.

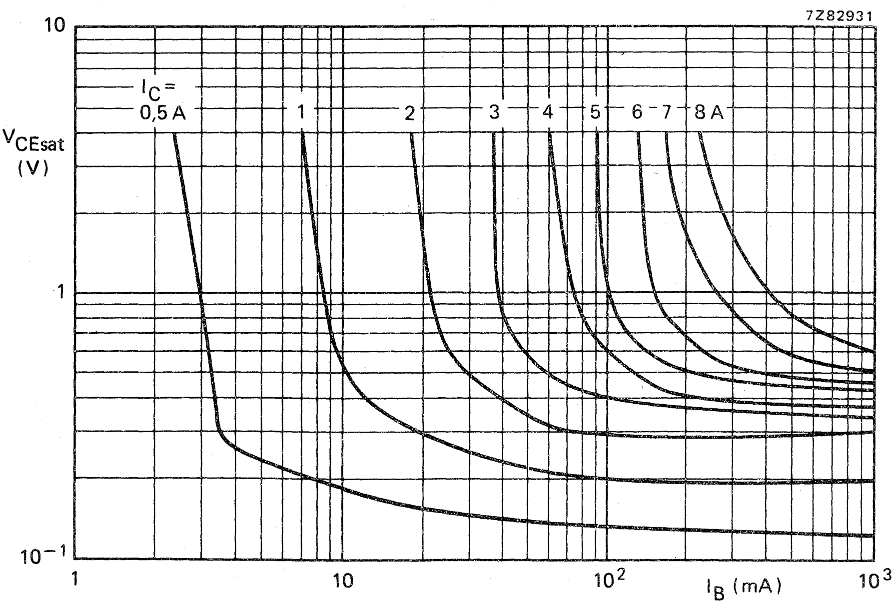


Fig. 10 Typical values collector-emitter saturation voltage.

SILICON POWER TRANSISTORS

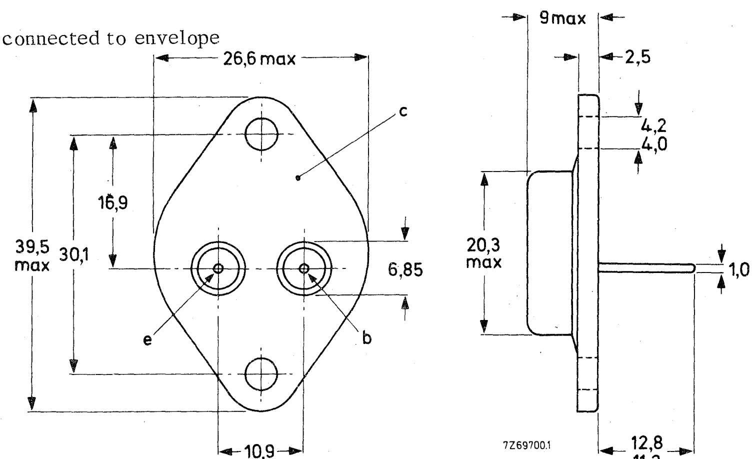
P-N-P transistors in TO-3 envelope for audio output stages and general amplifier and switching applications. N-P-N complements are BDX91, BDX93 and BDX95.

QUICK REFERENCE DATA

			BDX92	BDX94	BDX96	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	V
Collector current (peak value)	$-I_{CM}$	max.		12		A
Total power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.		90		W
Junction temperature	T_j	max.		200		^oC
D.C. current gain $-I_C = 3$ A; $-V_{CE} = 2$ V	h_{FE}	>		20		
Transition frequency $-I_C = 1$ A; $-V_{CE} = 10$ V	f_T	>		4		MHz

MECHANICAL DATA Dimensions in mm

TO-3
Collector connected to envelope



For mounting instructions and accessories see section Accessories.

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

			BDX92	BDX94	BDX96	
Voltages						
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V
Currents						
Collector current (d.c.)	$-I_C$	max.		8		A
Collector current (peak value)	$-I_{CM}$	max.		12		A
Power dissipation						
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		90		W
Temperatures						
Storage temperature	T_{stg}			−65 to +200		°C
Junction temperature	T_j	max.		200		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	1,94	°C/W

CHARACTERISTICS $T_j = 25\ ^oC$ unless otherwise specified

Collector cut-off current				
$I_E = 0;\ -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	0, 1	mA
$I_E = 0;\ -V_{CB} = 30$ V; $T_j = 200\ ^oC$: BDX92				
$I_E = 0;\ -V_{CB} = 40$ V; $T_j = 200\ ^oC$: BDX94	$-I_{CBO}$	<	2	mA
$I_E = 0;\ -V_{CB} = 50$ V; $T_j = 200\ ^oC$: BDX96				
$I_B = 0;\ -V_{CE} = -V_{CEOmax}$	$-I_{CEO}$	<	1	mA
Emitter cut-off current				
$I_C = 0;\ -V_{EB} = 5$ V	$-I_{EBO}$	<	1	mA
D.C. current gain [1]				
$-I_C = 3$ A; $-V_{CE} = 2$ V	h_{FE}	>	20	
$-I_C = 5$ A; $-V_{CE} = 2$ V	h_{FE}	>	10	
Base-emitter voltage [1]				
$-I_C = 3$ A; $-V_{CE} = 2$ V	$-V_{BE}$	<	1, 4	V
Collector-emitter saturation voltage [1]				
$-I_C = 3$ A; $-I_B = 0,3$ A	$-V_{CEsat}$	<	0, 8	V
$-I_C = 5$ A; $-I_B = 1$ A	$-V_{CEsat}$	<	1	V
Base-emitter saturation voltage [1]				
$-I_C = 3$ A; $-I_B = 0,3$ A	$-V_{BEsat}$	<	1, 5	V
$-I_C = 5$ A; $-I_B = 1$ A	$-V_{BEsat}$	<	2	V
Small-signal current gain at f = 1 kHz				
$-I_C = 0,5$ A; $-V_{CE} = 10$ V	h_{fe}	>	40	
Transition frequency				
$-I_C = 1$ A; $-V_{CE} = 10$ V	f_T	>	4	MHz

[1]) Measured under pulse conditions: $t_p < 300\ \mu s$, $\delta < 2\%$.

CHARACTERISTICS (continued) $T_j = 25\ ^oC$ unless otherwise specified

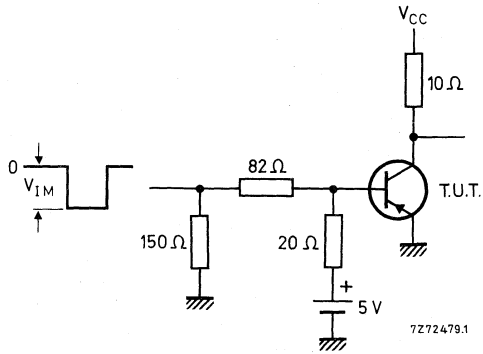
Switching times (between 10% and 90% levels)

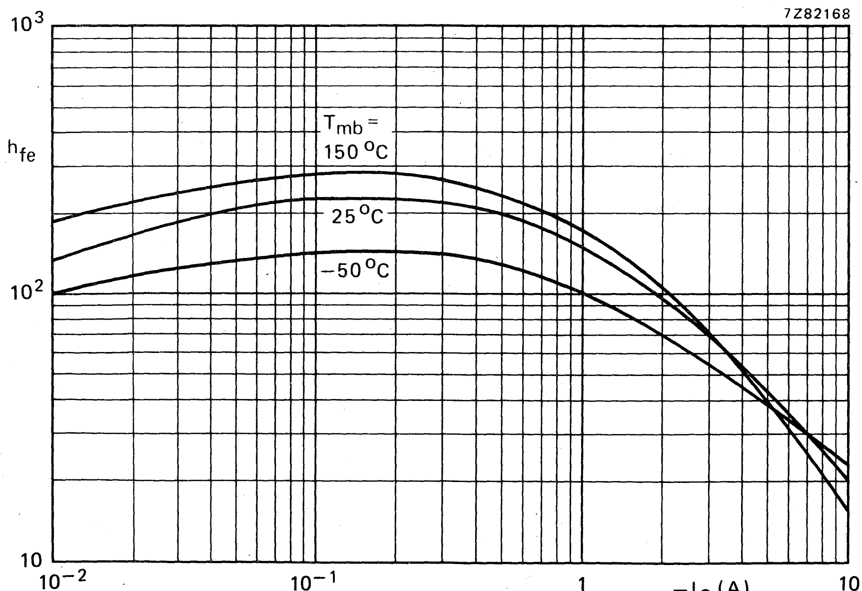
$-I_{Con} = 3\ A$; $-I_{Bon} = I_{Boff} = 0,3\ A$; $V_{CC} = -30\ V$

Turn-on time	t_{on}	typ.	0,2 μs
		<	1 μs
Turn-off time	t_{off}	typ.	1 μs
		<	2 μs

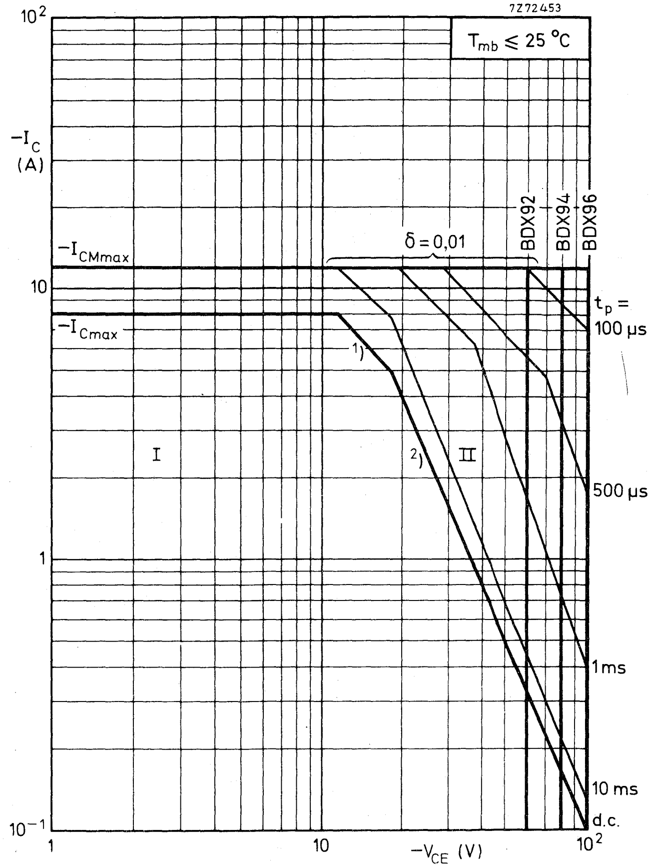
Test circuit

V_{IM} = 55 V
$t_r = t_f$ = 15 ns
t_p = 10 μs
T = 500 μs





Typical small-signal current gain as a function of collector current; $-V_{CE} = 2\ V$.

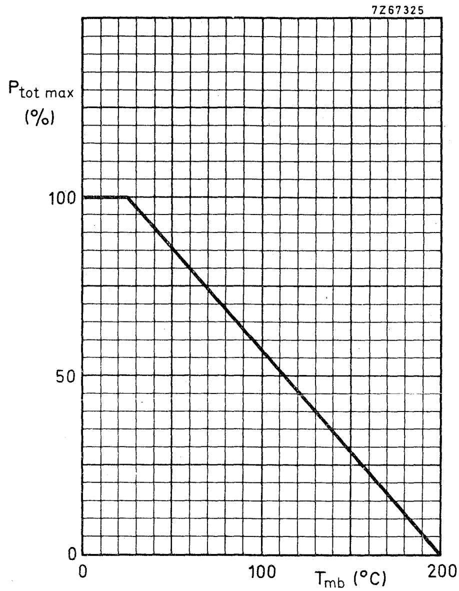


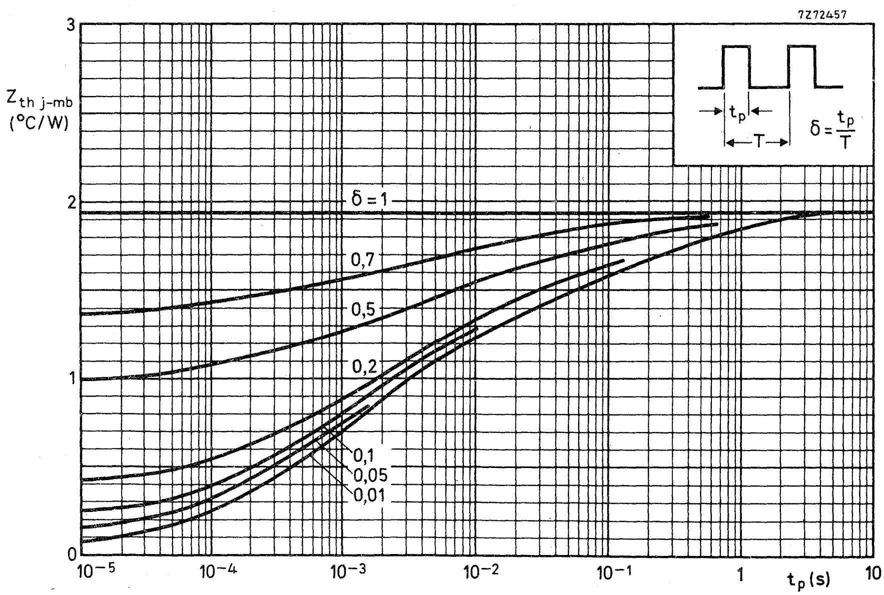
Safe Operating ARea with the transistor forward biased

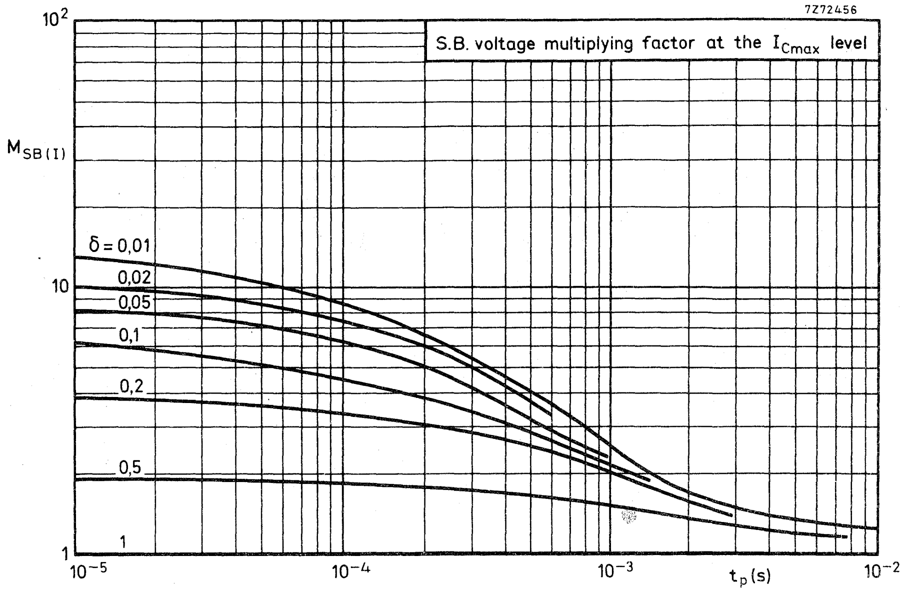
I Region of permissible d.c. operation

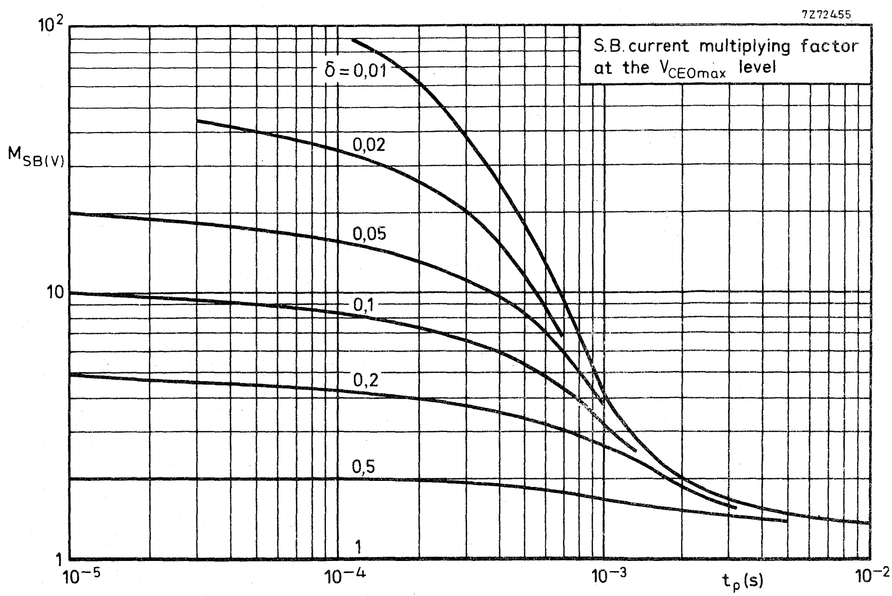
II Permissible extension for repetitive pulse operation

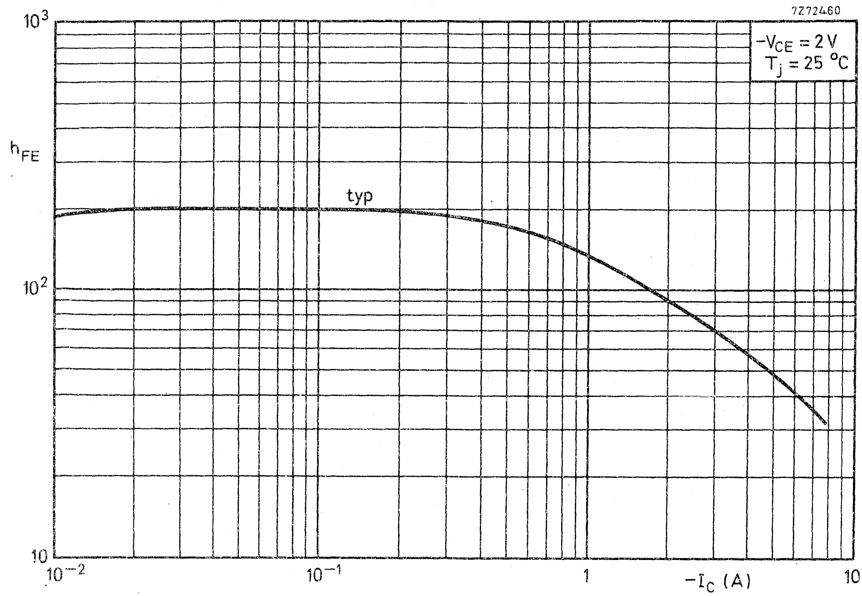
1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.
2) Second-breakdown limits (independent of temperature).

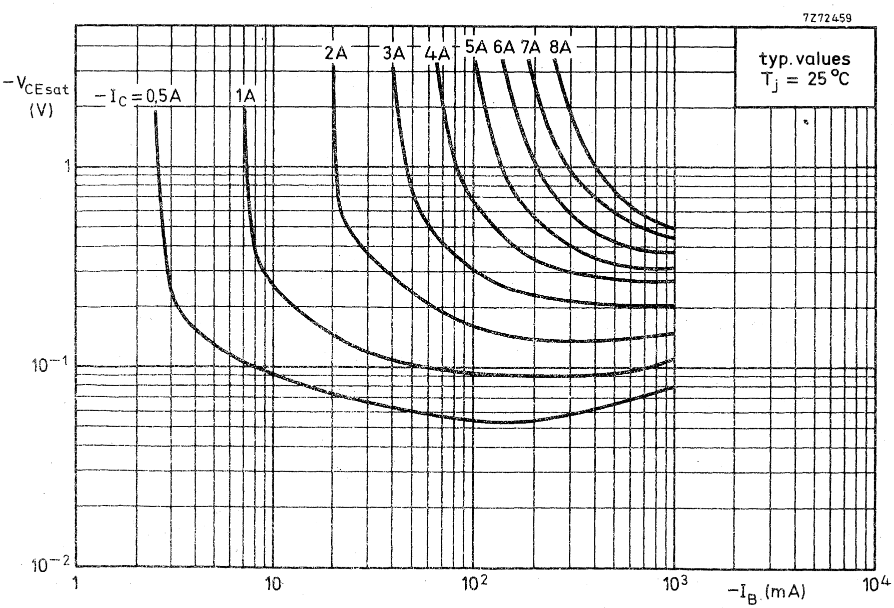

7Z67325
$P_{tot\ max}$
(%)
100
50
0
0
100
T_{mb} (°C)
200


7Z72457
$Z_{th\ j\text{-}mb}$
(°C/W)
3
2
1
0
t_p
T
$\delta = \frac{t_p}{T}$
δ = 1
0,7
0,5
0,2
0,1
0,05
0,01
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
t_p (s)
10


7Z72456
S.B. voltage multiplying factor at the I_{Cmax} level
10^2
$M_{SB(I)}$
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,5
1
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}


7Z72455
S.B. current multiplying factor at the V_{CEOmax} level
10^2
$M_{SB(V)}$
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,5
1
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}


7Z72460
$-V_{CE} = 2$ V
$T_j = 25$ °C
h_{FE}
typ
10^3
10^2
10
10^{-2}
10^{-1}
1
$-I_C$ (A)
10


7Z72459
typ. values
$T_j = 25$ °C
$-V_{CEsat}$ (V)
$-I_C = 0{,}5$ A
1A
2A
3A
4A
5A
6A
7A
8A
1
10^{-1}
10^{-2}
1
10
10^2
10^3
$-I_B$ (mA)
10^4

SILICON DIFFUSED POWER TRANSISTORS

High-speed switching n-p-n transistors in a metal envelope intended for use in converters, inverters, switching regulators and switching control amplifiers.

QUICK REFERENCE DATA

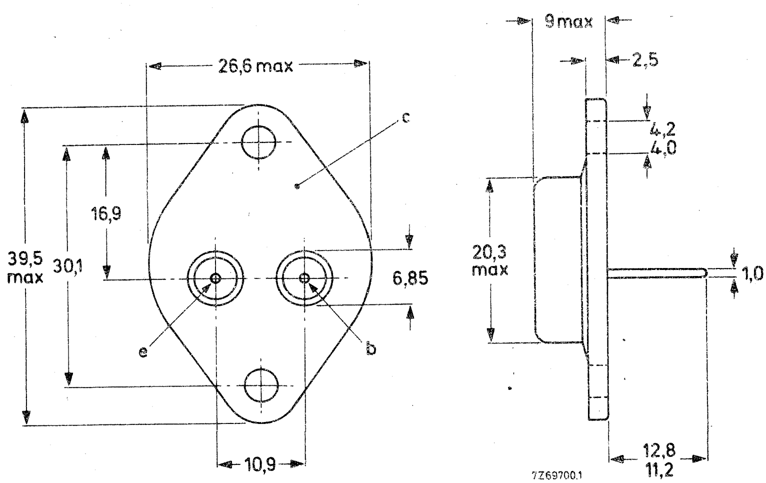
			BDY90	BDY91	BDY92	
Collector-base voltage (open emitter)	V_{CBO}	max.	120	100	80	V
Collector-emitter voltage (open base)	V_{CEO}	max.	100	80	60	V
Collector current (peak value)	I_{CM}	max.		15		A
Total power dissipation up to T_{mb} = 70 °C	P_{tot}	max.		40		W
Collector-emitter saturation voltage I_C = 10 A; I_B = 1 A	V_{CEsat}	<		1		V
Fall time I_C = 5 A; $I_B = -I_{BM}$ = 0,5 A; V_{CC} = 30 V	t_f	<		0,2		μs
Transition frequency at f = 5 MHz I_C = 0,5 A; V_{CE} = 5 V	f_T	typ.		70		MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.



For Mounting instructions and Accessories see handbook l.f. power transistors.

RATINGS

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

			BDY90	BDY91	BDY92	
Collector-base voltage (open emitter)	V_{CBO}	max.	120	100	80	V
Collector-emitter voltage (V_{EB} = 1,5 V)	V_{CEX}	max.	120	100	80	V
Collector-emitter voltage (open base)	V_{CEO}	max.	100	80	60	V
Emitter-base voltage (open collector)	V_{EBO}	max.	6	6	6	V
Collector current (d.c.)	I_C	max.		10		A
Collector current (peak value)	I_{CM}	max.		15		A
Base current (d.c.)	I_B	max.		2		A
Base current (peak value)	I_{BM}	max.		3		A
Emitter current (d.c.)	$-I_E$	max.		11		A
Emitter current (peak value)	$-I_{EM}$	max.		15		A
→ Total power dissipation up to T_{mb} = 70 °C	P_{tot}	max.		40		W
Storage temperature	T_{stg}			−65 to + 150		°C
→ Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

→ From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2,0	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
V_{EB} = 1,5 V; V_{CE} = V_{CEXmax};	I_{CEX}	<	1	mA
V_{EB} = 1,5 V; V_{CE} = V_{CEXmax}; T_{mb} = 150 °C	I_{CEX}	<	3	mA
Saturation voltages				
I_C = 5 A; I_B = 0,5 A	V_{CEsat}	<	0,5	V
	V_{BEsat}	<	1,2	V
→ I_C = 10 A; I_B = 1 A	V_{CEsat}	<	1,0	V
	V_{BEsat}	<	1,5	V

CHARACTERISTICS

D.C. current gain			
I_C = 1 A; V_{CE} = 2 V	h_{FE}	>	35
I_C = 5 A; V_{CE} = 5 V	h_{FE}		30 to 120
I_C = 10 A; V_{CE} = 5 V	h_{FE}	>	20
Transition frequency at f = 5 MHz			
I_C = 0,5 A; V_{CE} = 5 V	f_T	typ.	70 MHz
Switching times			
Turn on time			
I_C = 5 A; I_B = $-I_{BM}$ = 0,5 A V_{CC} = 30 V	t_{on}	<	0,35 μs
Turn off time			
I_C = 5 A; I_B = $-I_{BM}$ = 0,5 A			
V_{CC} = 30 V storage time	t_s	<	1,3 μs
fall time	t_f	<	0,2 μs

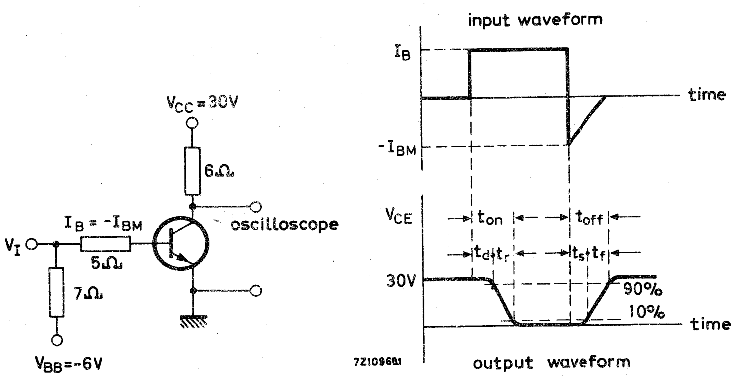


Fig. 2 Test circuit and waveforms.

Pulse generator:				Pulse duration	t_p	= 20 μs
Rise time	t_r	<	50 ns	Duty cycle	δ	= 0,02
Fall time	t_f	<	50 ns			

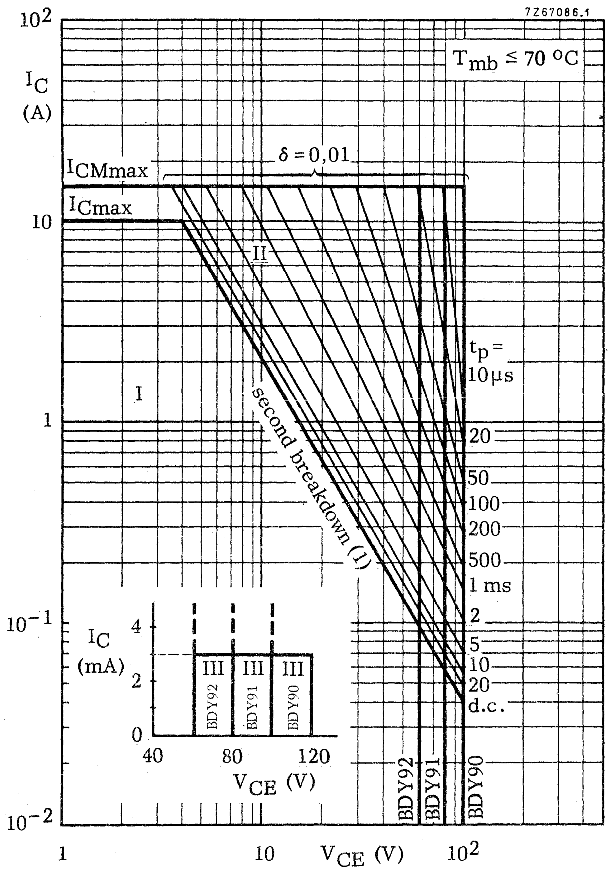


Fig. 3 Safe Operating ARea (Regions I and II forward biased).

I Region of permissible d.c. operation

II Permissible extension for repetitve pulse operation

III Repetitive pulse operation in this region is allowable, provided $-V_{BE} \geqslant 1{,}5$ V

(1) Independent of temperature

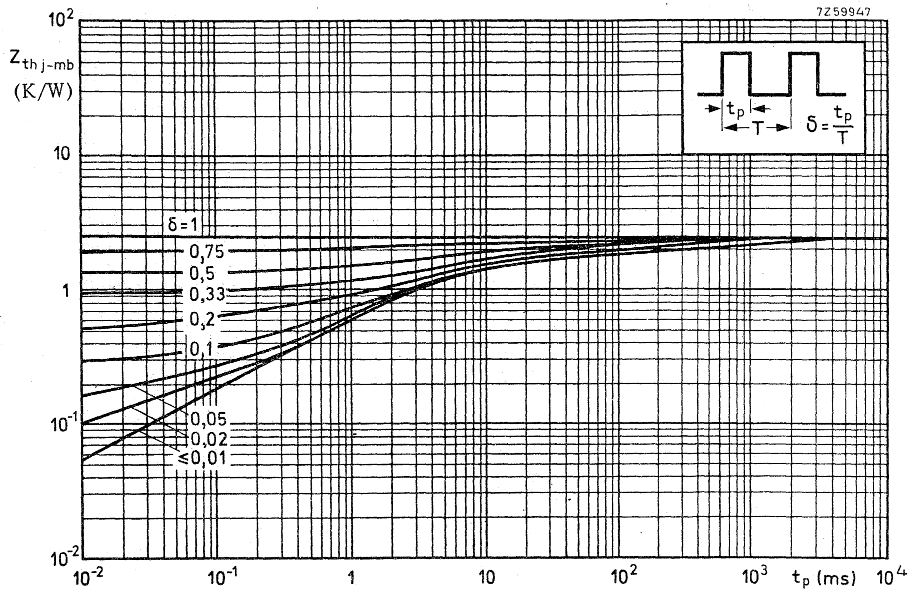


Fig. 4 Pulse power rating chart.

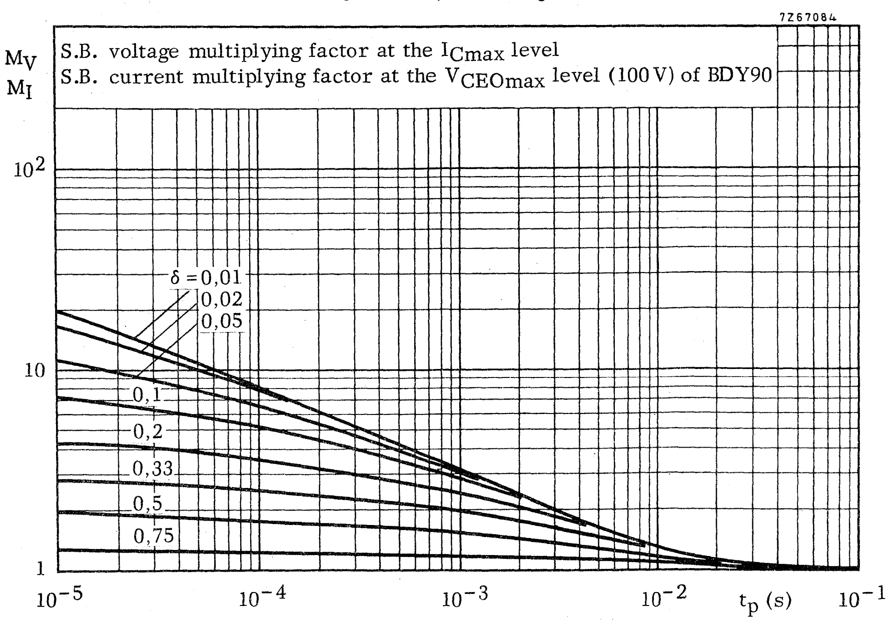


Fig. 5 S.B. voltage multiplying factor at the I_C max level.
S.B. current multiplying factor at the BDY90 V_{CEOmax} level (100 V).

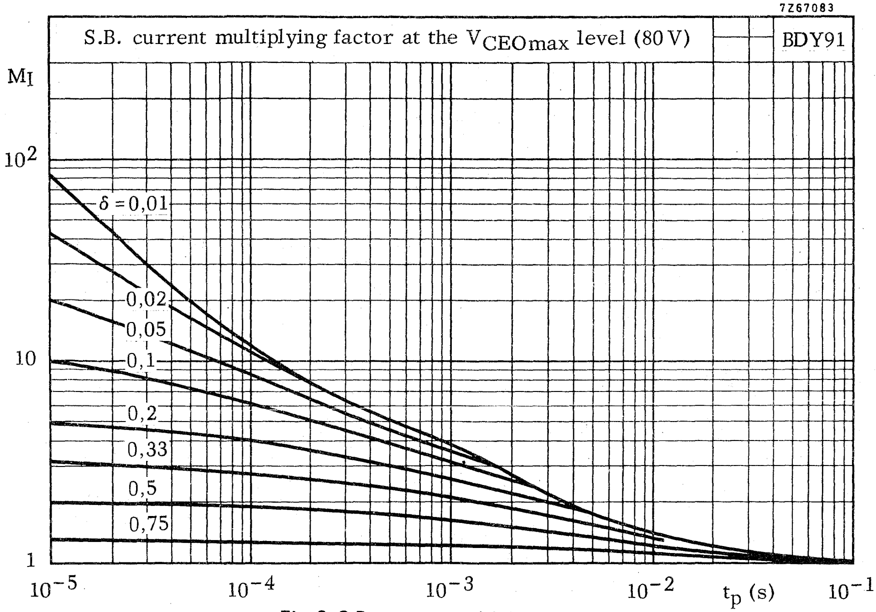


Fig. 6 S.B. current multiplying factor.

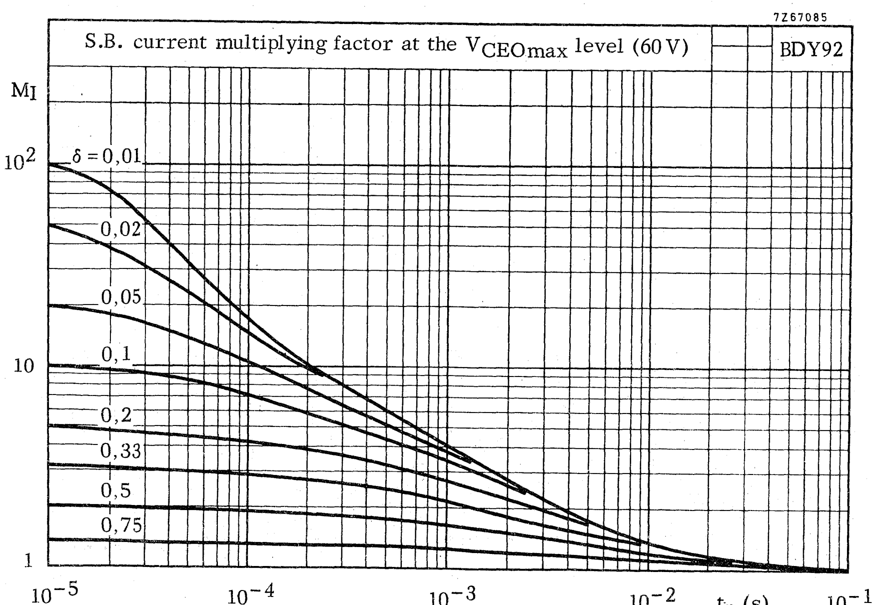


Fig. 7 S.B. current multiplying factor.

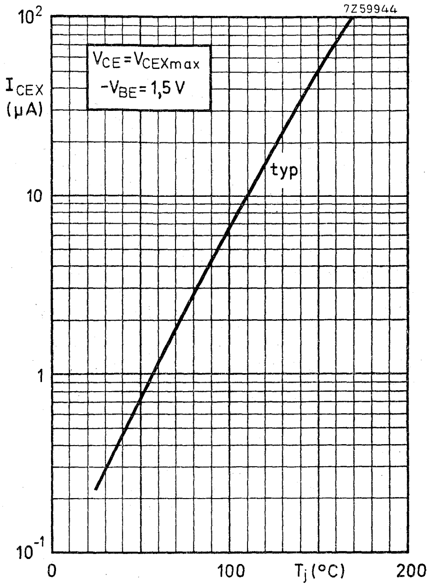


Fig. 8 Collector-emitter current.

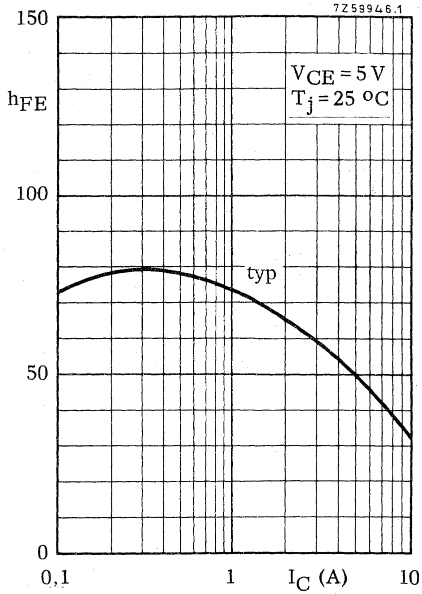


Fig. 9 D.C. current gain.

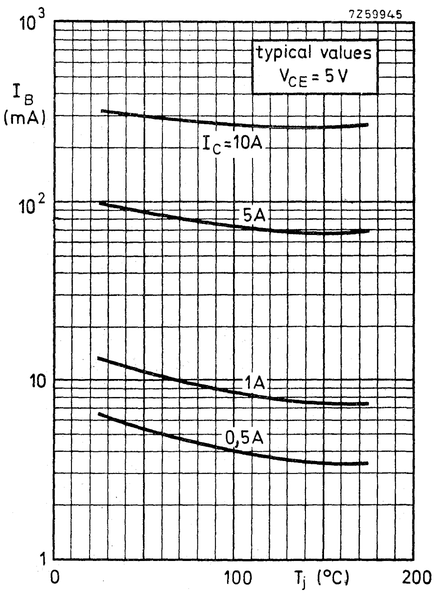


Fig. 10 Typical base current.

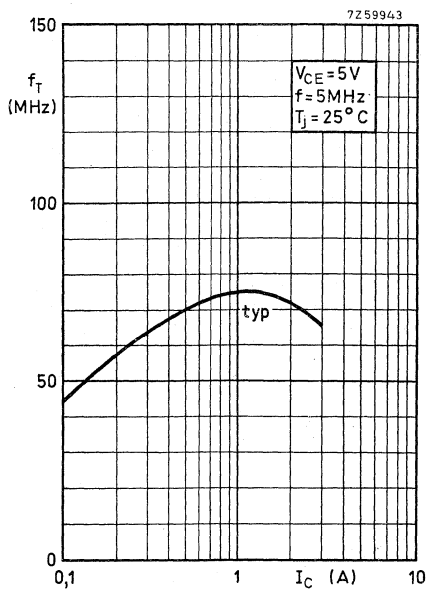


Fig. 11 Transition frequency.

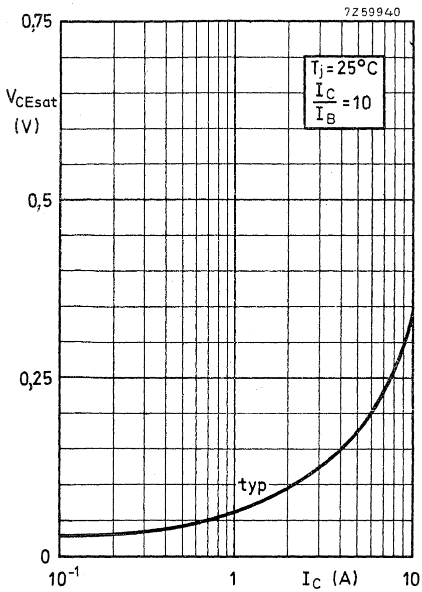


Fig. 12 Collector-emitter saturation voltage as a function of collector current.

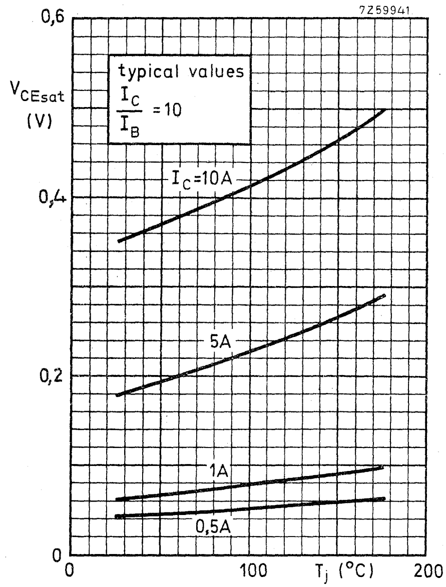


Fig. 13 Collector-emitter saturation voltage as a function of junction temperature.

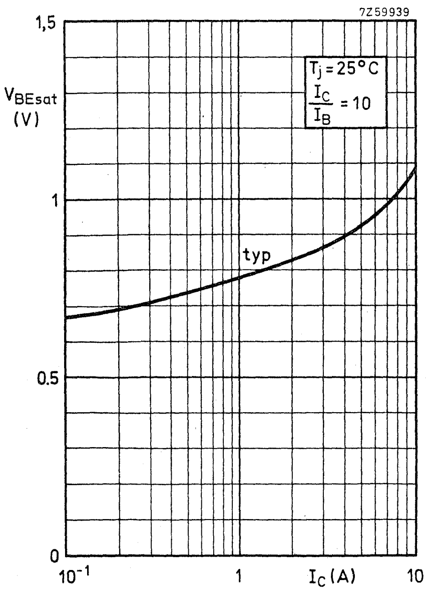


Fig. 14 Typical base-emitter saturation voltage.

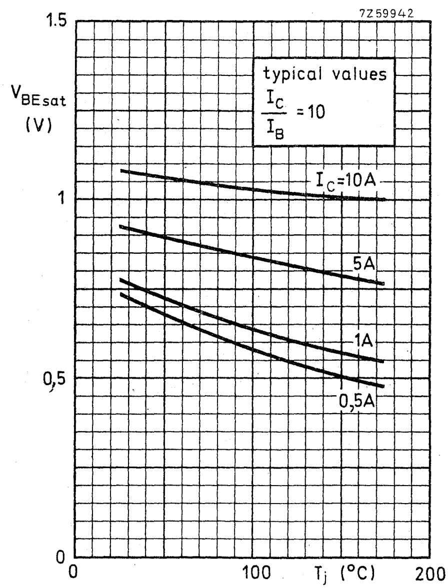


Fig. 15 Typical base-emitter saturation voltage.

SILICON DIFFUSED POWER TRANSISTOR

High-speed switching n-p-n transistor in a metal envelope intended for use in converters, inverters, switching regulators and switching control amplifiers.

QUICK REFERENCE DATA

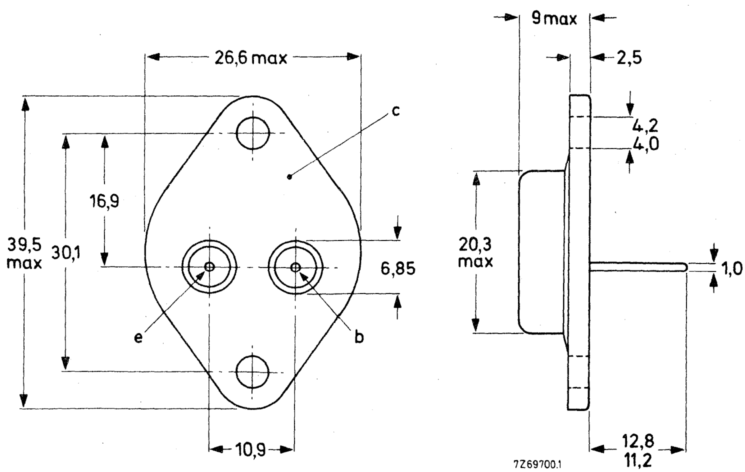
Collector-base voltage (open emitter)	V_{CBO}	max.	120 V
Collector-emitter voltage (open base)	V_{CEO}	max.	100 V
Collector current (peak value)	I_{CM}	max.	15 A
Total power dissipation up to T_{mb} = 70 °C	P_{tot}	max.	40 W
Collector-emitter saturation voltage I_C = 12 A; I_B = 1,2 A	V_{CEsat}	$<$	1,0 V
Fall time I_C = 5,0 A; $I_B = -I_{BM}$ = 0,5 A; V_{CC} = 30 V	t_f	$<$	0,2 μs
Transition frequency at f = 5 MHz I_C = 0,5 A; V_{CE} = 5 V	f_T	typ.	70 MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.



See also chapters Mounting instructions and Accessories.

RATINGS

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

Collector-base voltage (open emitter)	V_{CBO}	max.	120 V
Collector-emitter voltage (V_{EB} = 1,5 V)	V_{CEX}	max.	120 V
Collector-emitter voltage (open base)	V_{CEO}	max.	100 V
Emitter-base voltage (open collector)	V_{EBO}	max.	6 V
Collector current (d.c.)	I_C	max.	12 A
Collector current (peak value)	I_{CM}	max.	15 A
Base current (d.c.)	I_B	max.	2 A
Base current (peak value)	I_{BM}	max.	3 A
Emitter current (d.c.)	$-I_E$	max.	15 A
Emitter current (peak value)	$-I_{EM}$	max.	15 A
Total power dissipation up to T_{mb} = 70 °C	P_{tot}	max.	40 W
Storage temperature	T_{stg}		−65 to + 150 °C
Junction temperature	T_j	max.	150 °C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2,0 K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current			
V_{EB} = 1,5 V; $V_{CE} = V_{CEXmax}$; T_{mb} = 150 °C	I_{CEX}	<	3 mA
Saturation voltages			
I_C = 5 A; I_B = 0,5 A	V_{CEsat}	<	0,5 V
	V_{BEsat}	<	1,2 V
I_C = 12 A; I_B = 1,2 A	V_{CEsat}	<	1,0 V
	V_{BEsat}	<	1,5 V
D.C. current gain			
I_C = 1 A; V_{CE} = 2 V	h_{FE}	>	35
I_C = 5 A; V_{CE} = 5 V	h_{FE}		30 to 120
I_C = 12 A; V_{CE} = 5 V	h_{FE}	>	20
Transition frequency at f = 5 MHz			
I_C = 0,5 A; V_{CE} = 5 V	f_T	typ.	70 MHz

Switching times

Turn on time $I_C = 5$ A; $I_B = -I_{BM} = 0,5$ A; $V_{CC} = 30$ V	t_{on}	<	0,35 µs
Turn off time $I_C = 5$ A; $I_B = -I_{BM} = 0,5$ A; $V_{CC} = 30$ V			
storage time	t_s	<	1,3 µs
fall time	t_f	<	0,2 µs

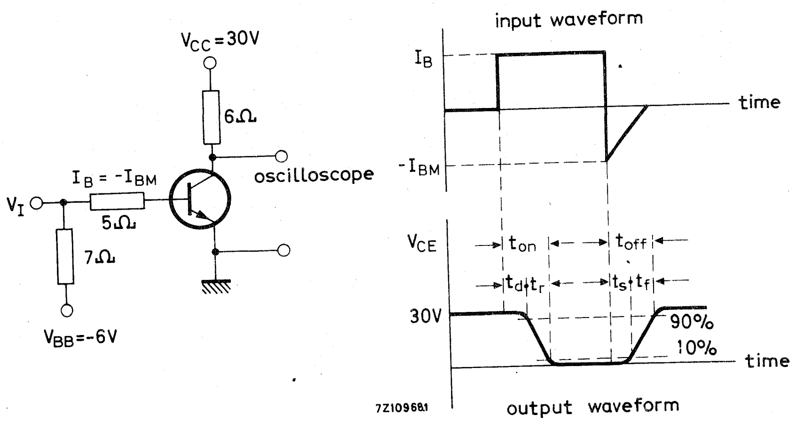


Fig. 2 Test circuit and waveforms.

Pulse generator:

Rise time	t_r	<	50	ns	Pulse duration	t_p	=	20 µs
Fall time	t_f	<	50	ns	Duty factor	δ	=	0,02

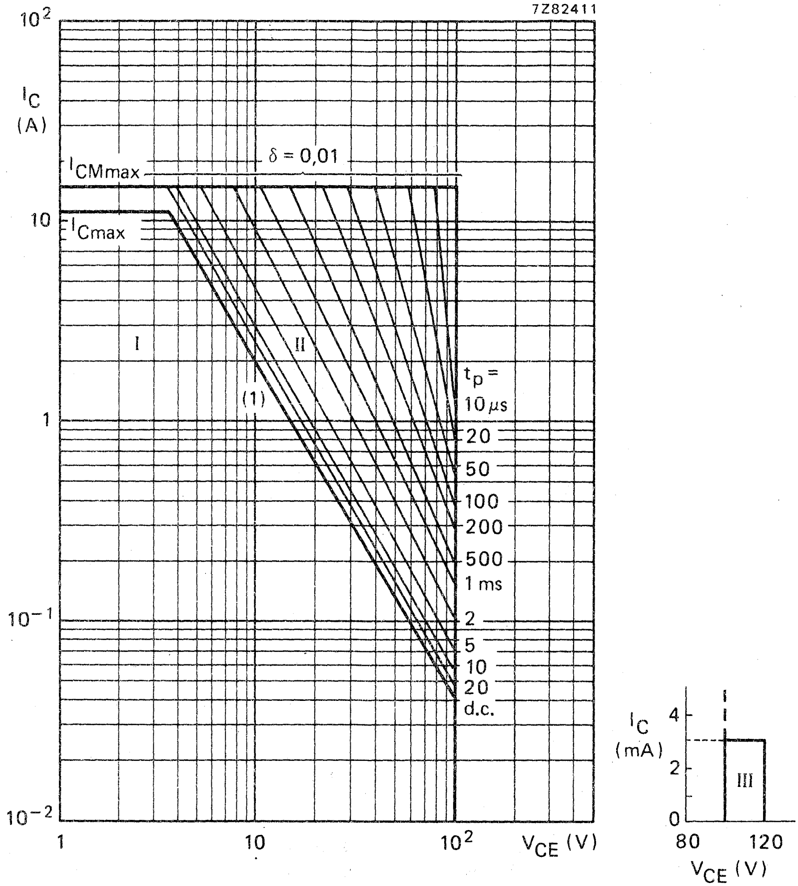


Fig. 3 Safe Operating ARea (regions I and II forward biased). $T_{mb} \leqslant 70\ ^oC$.

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

III Repetitive pulse operation in this region is permissible, provided $-V_{BE} \geqslant 1,5$ V

(1) Second breakdown limits (independent of temperature)

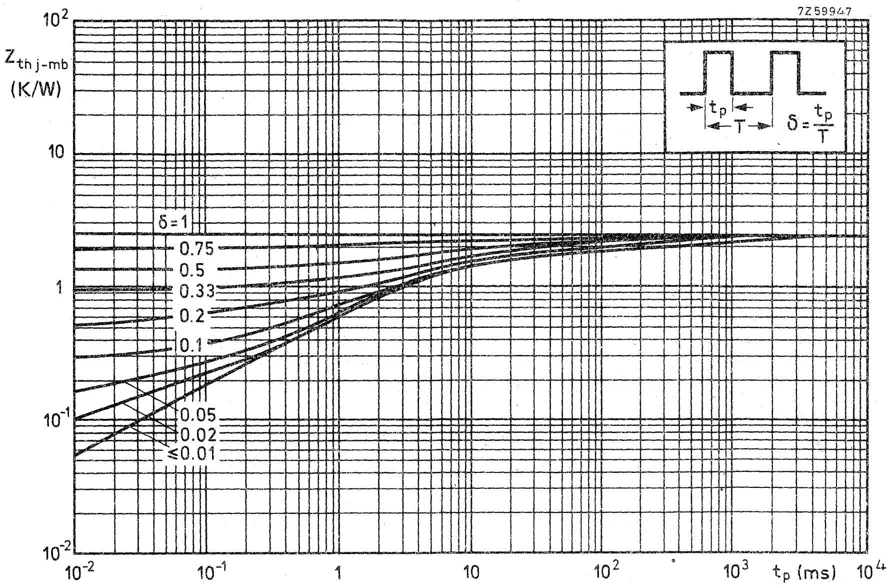


Fig. 4.

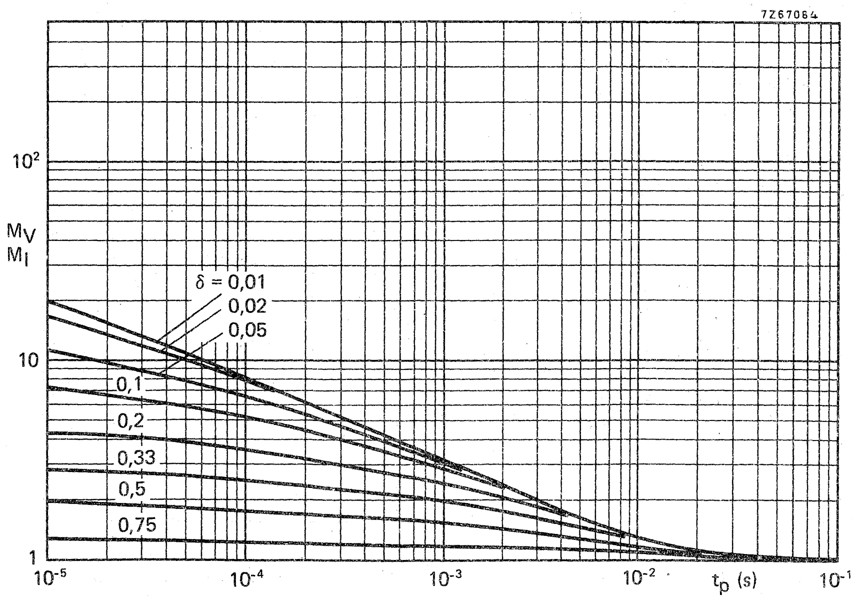


Fig. 5 SB voltage multiplying factor at I_{Cmax} level and SB current multiplying factor at V_{CEOmax} level.

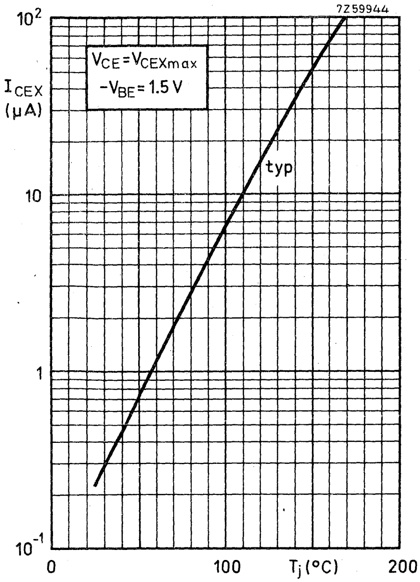


Fig. 6 Collector-emitter current as a function of junction temperature.

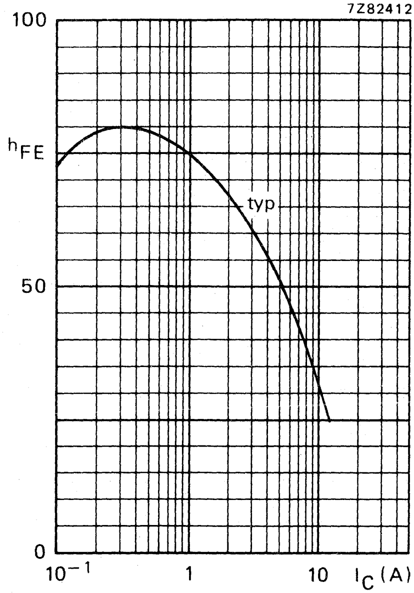


Fig. 7 D.C. current gain at $V_{CE} = 5$ V and $T_j = 25$ °C.

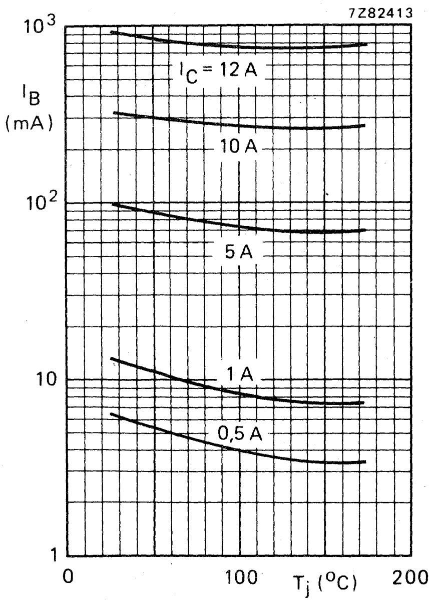


Fig. 8 Typical base current at $V_{CE} = 5$ V.

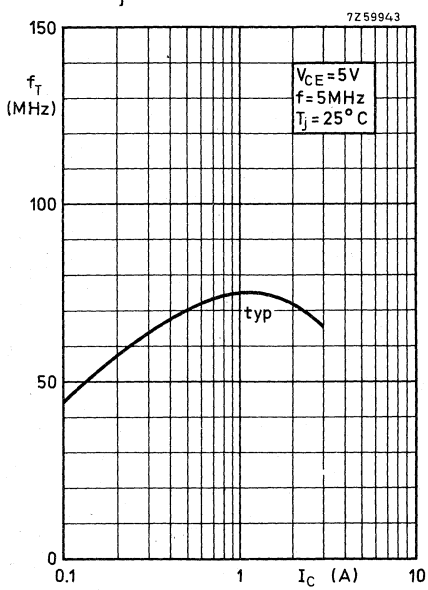


Fig. 9 Transition frequency as a function of the collector current.

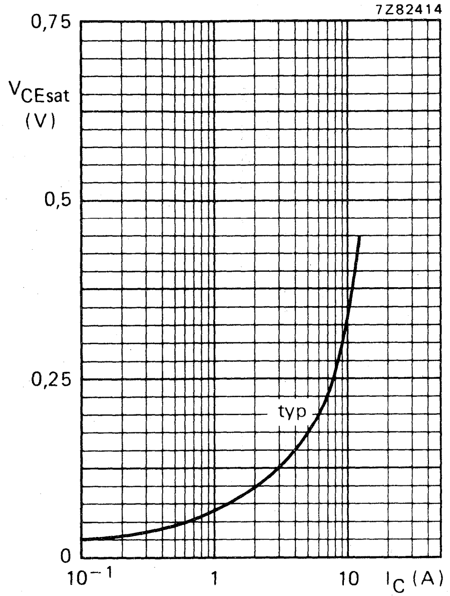


Fig. 10 Collector-emitter saturation voltage at $I_C/I_B = 10$; $T_j = 25\ ^oC$.

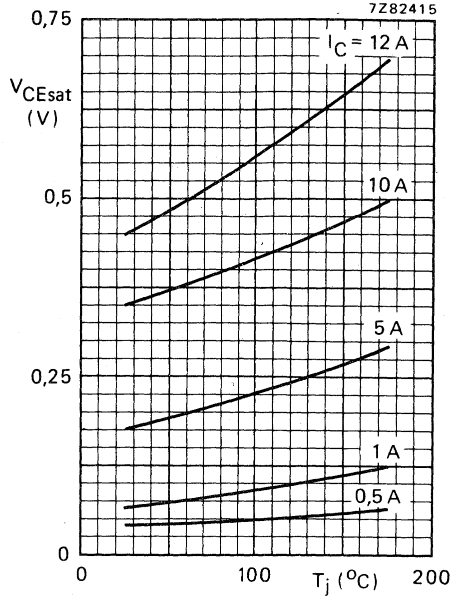


Fig. 11 Typical collector-emitter saturation voltage at $I_C/I_B = 10$.

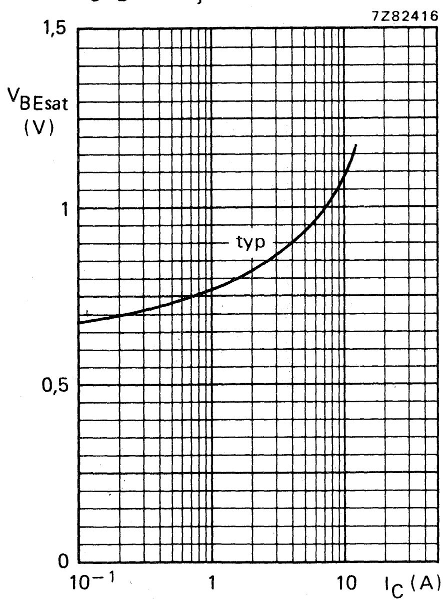


Fig. 12 Typical base-emitter saturation voltage at $I_C/I_B = 10$ and $T_j = 25\ ^oC$.

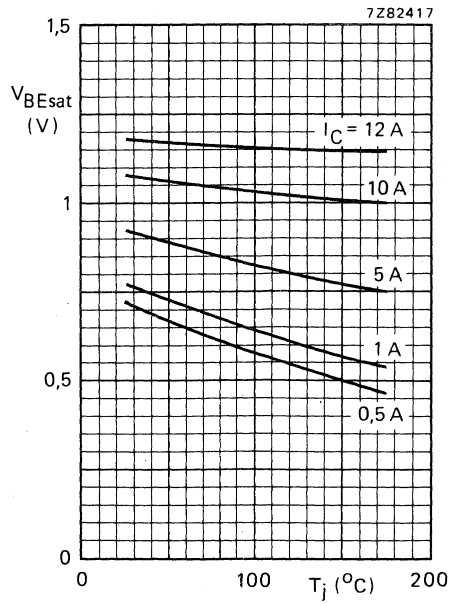


Fig. 13 Typical base-emitter saturation voltage at $I_C/I_B = 10$.

HIGH–VOLTAGE TRANSISTOR

Silicon n-p-n transistor in TO-126 plastic envelope intended for use as a driver for line output transistors in colour tv receivers.

QUICK REFERENCE DATA

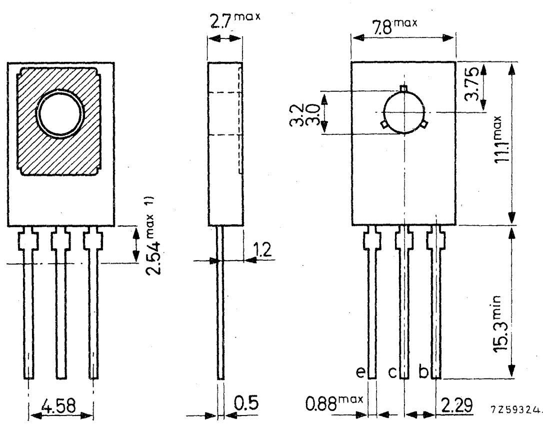
Collector-base voltage (open emitter)	V_{CBO}	max.	300	V
Collector-emitter voltage (open base)	V_{CEO}	max.	250	V
Collector current (peak value)	I_{CM}	max.	300	mA
Total power dissipation up to T_{mb} = 90 °C	P_{tot}	max.	6	W
Junction temperature	T_j	max.	150	°C
D.C. current gain I_C = 20 mA; V_{CE} = 10 V	h_{FE}	typ.	45	
Storage time	t_s	typ.	0.5	μs

MECHANICAL DATA

Dimensions in mm

Fig.1 TO-126 (SOT-32)

Collector connected to mounting base



(1) Within this region the cross-section of the leads is uncontrolled

See also chapters Mounting Instructions and Accessories.

RATINGS

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

Collector-base voltage (open emitter)	V_{CBO}	max.	300	V
Collector-emitter voltage ($R_{BE} \leqslant 1\ k\Omega$)	V_{CER}	max.	300	V
Collector-emitter voltage (open base)	V_{CEO}	max.	250	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V
Collector current (continuous)	I_C	max.	100	mA
Collector current (peak value) *	I_{CM}	max.	300	mA
Total power dissipation up to T_{mb} = 90 °C	P_{tot}	max.	6	W
up to T_{amb} = 70 °C	P_{tot}	max.	0.8	W
Storage temperature	T_{stg}		−65 to +150	°C
Operating junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	10	°C/W
From junction to ambient	$R_{th\ j\text{-}a}$	=	100	°C/W

* Precautions should be taken during switch-on of the BF419 where an overshoot of current is likely to occur. The amplitude of the overshoot depends on the relative magnitude of stray external capacities to the transistor collector capacity. It is desirable to keep the stray capacities to a minimum by short lead lengths etc. so as to minimise the area of the switching path.

CHARACTERISTICS

T_j = 25 °C

Collector cut-off current				
$I_E = 0$; $V_{CB} = 250$ V	I_{CBO}	<	50	nA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 3$ V	I_{EBO}	<	50	nA
D.C. current gain				
$I_C = 20$ mA; $V_{CE} = 10$ V	h_{FE}	typ.	45	
Collector-emitter saturation voltage				
$I_C = 200$ mA; $I_B = 20$ mA *	V_{CEsat}	<	11	V
Collector output capacitance at f = 1 MHz				
$I_E = 0$; $V_{CB} = 30$ V	C_{Tc}	<	4.5	pF
Storage time				
(in the typical circuit below)	t_s	typ.	0.5	µs

* The BF419 is controlled to V_{CEsat} max. 11.0 V and is thermally stable under all operating conditions where T_j max of 150 °C is not exceeded. For the typical circuit shown below, a heatsink is not required for operation with $T_{amb} \leqslant 70$ °C.

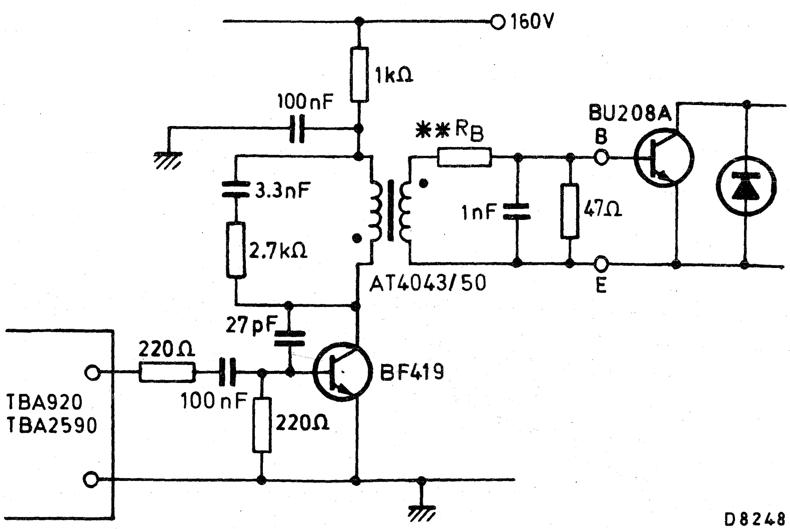


Fig.2 Typical circuit.

** R_B is chosen so that the end-of-scan base current for the BU208A is 1.4 A under nominal conditions. Typical value of R_B is 0.5 Ω plus 0.1 Ω lead resistance.

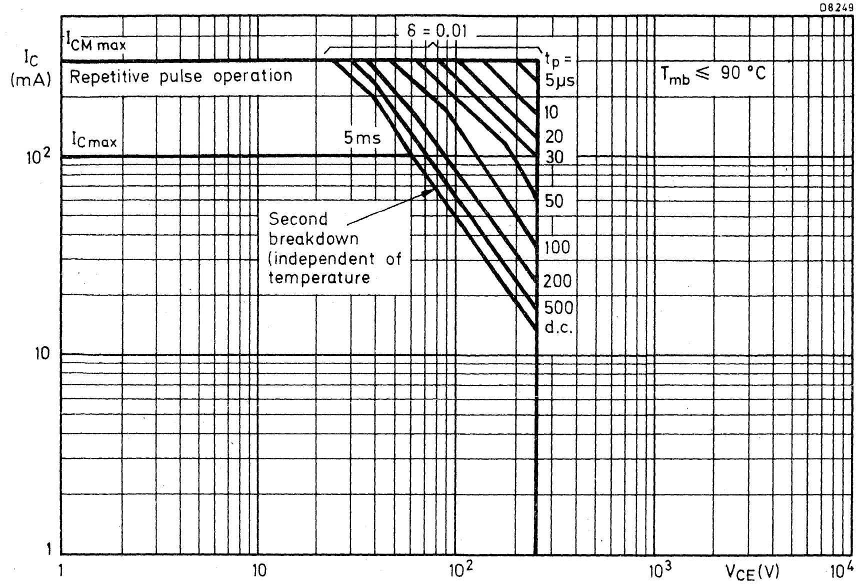


Fig.3 Safe Operating AReas with the transistor forward biased.

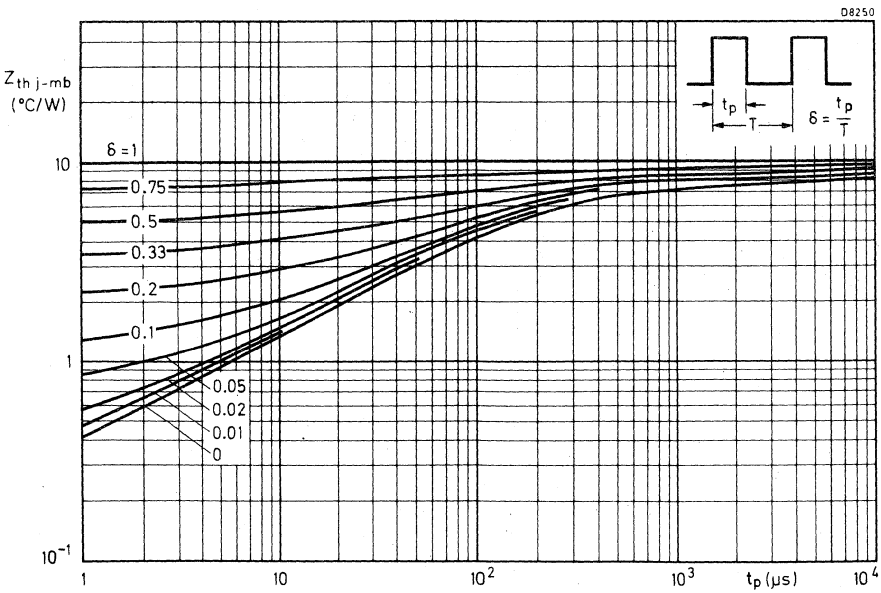


Fig. 4.

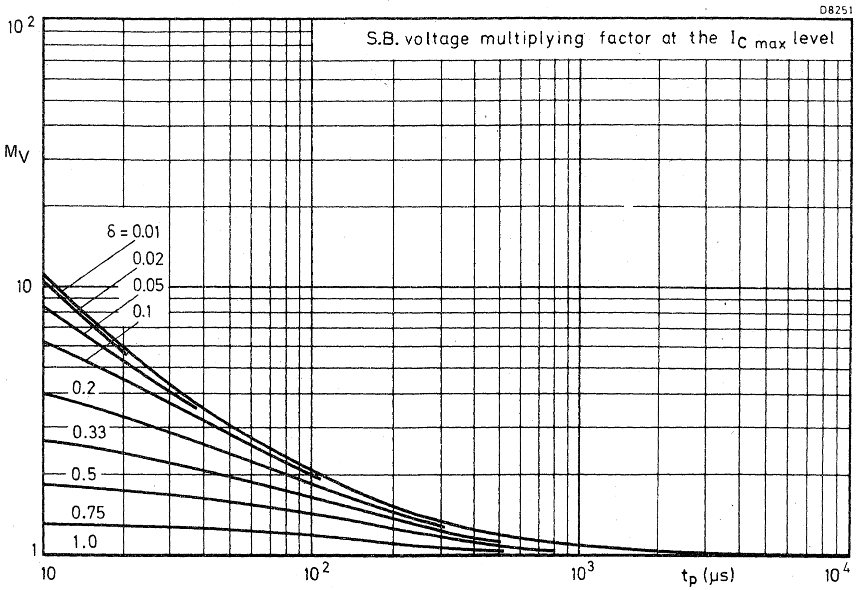

D8251
S.B. voltage multiplying factor at the $I_{C\,max}$ level
10^2
M_V
δ = 0.01
0.02
0.05
0.1
10
0.2
0.33
0.5
0.75
1.0
1
10
10^2
10^3
t_p (μs)
10^4

Fig. 5.

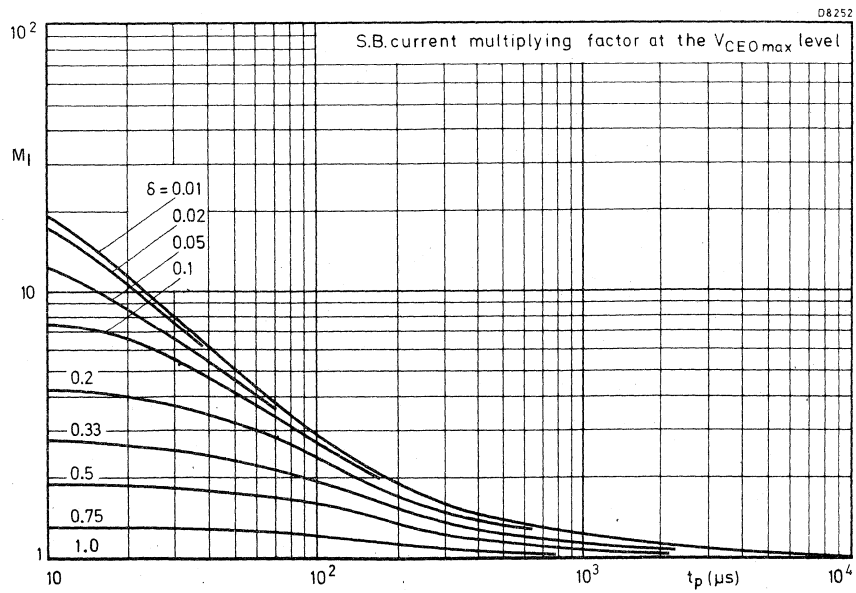

D8252
S.B. current multiplying factor at the $V_{CEO\,max}$ level
10^2
M_I
δ = 0.01
0.02
0.05
0.1
10
0.2
0.33
0.5
0.75
1.0
1
10
10^2
10^3
t_p (μs)
10^4

Fig. 6.

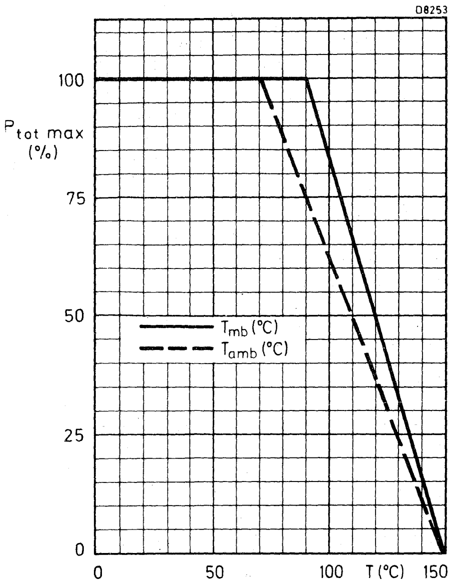


Fig. 7.

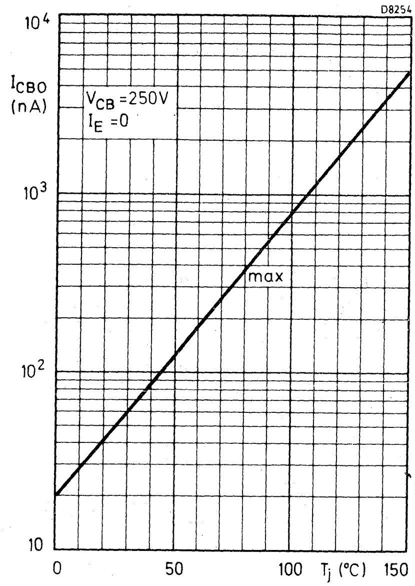


Fig. 8.

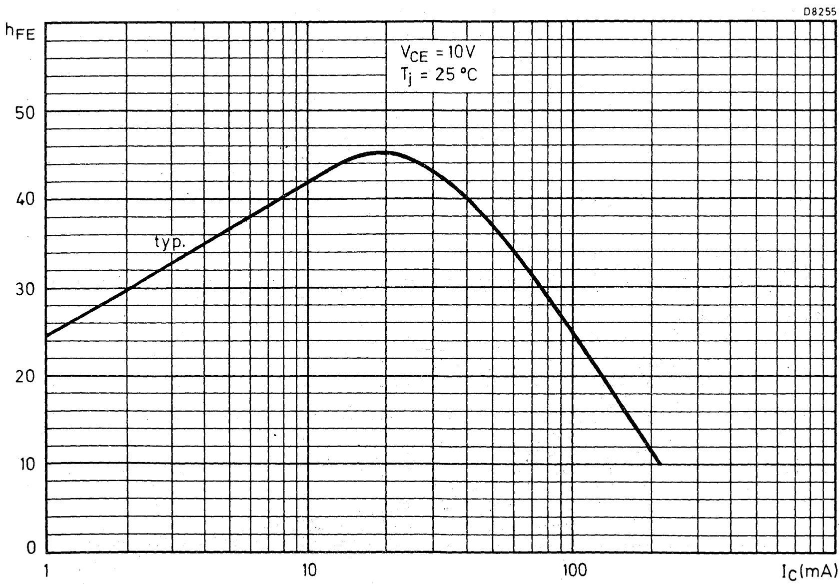


Fig. 9.

SILICON PLANAR TRANSISTORS

for video output stages

N-P-N transistors in a SOT-32 plastic envelope intended for video output stages in black-and-white and in colour television receivers.

QUICK REFERENCE DATA

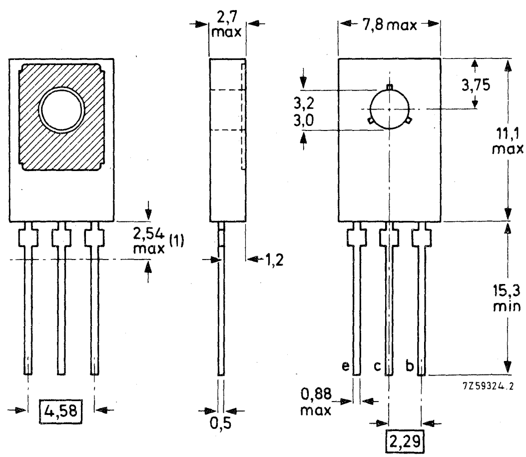
			BF457	BF458	BF459	
Collector-base voltage (open emitter)	V_{CBO}	max.	160	250	300	V
Collector-emitter voltage (open base)	V_{CEO}	max.	160	250	300	V
Collector current (peak value)	I_{CM}	max.		300		mA
Total power dissipation up to T_{mb} = 90 °C	P_{tot}	max.		6		W
Junction temperature	T_j	max.		150		°C
D.C. current gain at T_j = 25 °C I_C = 30 mA; V_{CE} = 10 V	h_{FE}	>		26		
Transition frequency I_C = 15 mA; V_{CE} = 10 V	f_T	typ.		90		MHz
Feedback capacitance at f = 1 MHz I_E = 0; V_{CB} = 30 V	C_{re}	<		3,5		pF

MECHANICAL DATA

Dimensions in mm

Collector connected to metal part of mounting surface

TO-126 (SOT-32)



(1) Within this region the cross-section of the leads is uncontrolled.

For mounting instructions see section Accessories type 56326 for non-insulated mounting and type 56333 for insulated mounting.

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

Voltage			BF457	BF458	BF459	
Collector-base voltage (open emitter)	V_{CBO}	max.	160	250	300	V
Collector-emitter voltage (open base)	V_{CEO}	max.	160	250	300	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V

Current

Collector current (d.c.)	I_C	max.	100	mA
Collector current (peak value)	I_{CM}	max.	300	mA
Base current (d.c.)	I_B	max.	50	mA

Power dissipation

Total power dissipation up to $T_{mb} = 90\ ^oC$	P_{tot}	max.	6	W

Temperature

Storage temperature	T_{stg}		-55 to +150	^oC
Junction temperature	T_j	max.	150	^oC

THERMAL RESISTANCE

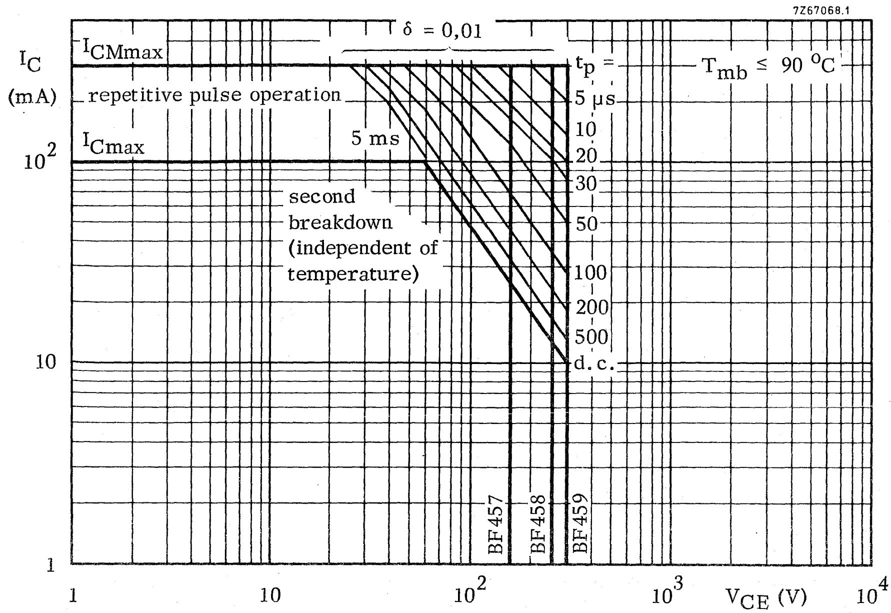
From junction to ambient	$R_{th\ j-a}$	=	104	$^oC/W$
From junction to mounting base	$R_{th\ j-mb}$	=	10	$^oC/W$

CHARACTERISTICS $T_j = 25\ ^{o}C$ unless otherwise specified

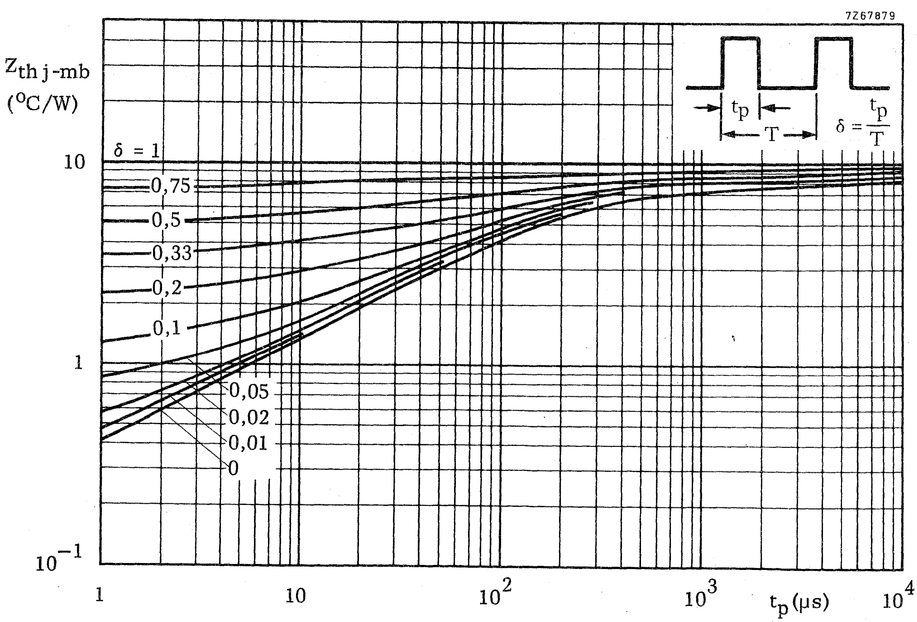
Collector cut-off current				
$I_E = 0$; $V_{CB} = 100$ V for BF457				
$I_E = 0$; $V_{CB} = 200$ V for BF458	I_{CBO}	<	50	nA
$I_E = 0$; $V_{CB} = 250$ V for BF459				
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 3$ V	I_{EBO}	<	50	nA
D.C. current gain				
$I_C = 30$ mA; $V_{CE} = 10$ V	h_{FE}	>	26	
Collector-emitter saturation voltage				
$I_C = 30$ mA; $I_B = 6$ mA	V_{CEsat}	<	1	V
High frequency knee voltage at $T_j = 150\ ^{o}C$				
$I_C = 50$ mA	V_{CEK}	typ.	15	V

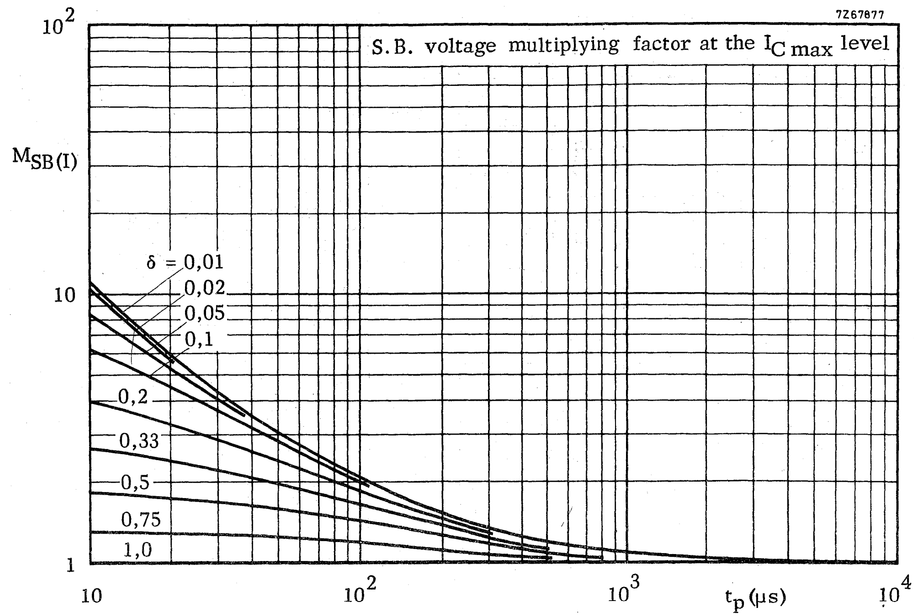
The high frequency knee voltage of a transistor is that value of the collector-emitter voltage at which the small signal gain, measured in a practical circuit, has dropped to 80% of the gain at $V_{CE} = 50$ V. A further reduction of the collector-emitter voltage results in a rapid increase of the distortion of the signal.

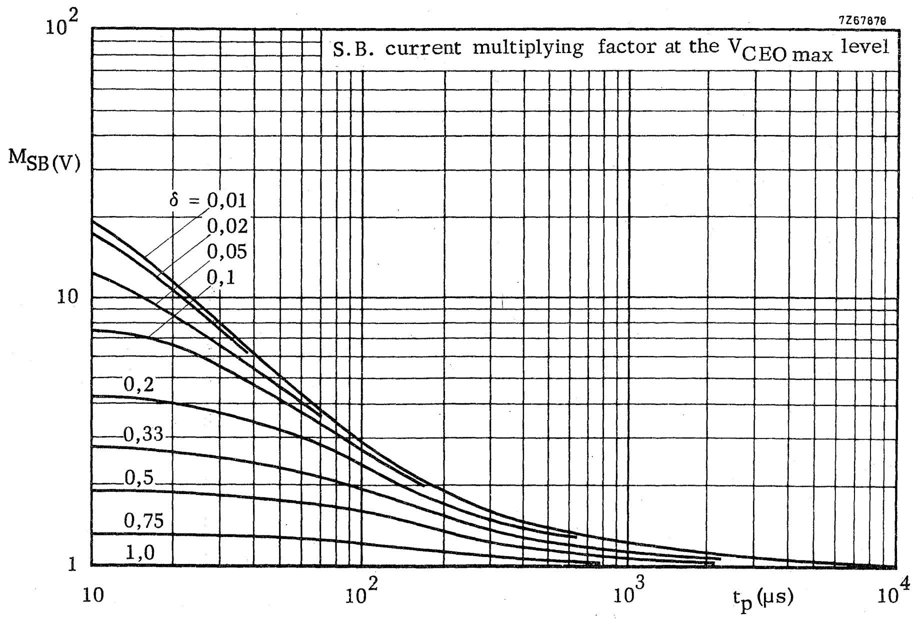
Transition frequency at f = 100 MHz				
$I_C = 15$ mA; $V_{CE} = 10$ V	f_T	typ.	90	MHz
Feedback capacitance at f = 1 MHz				
$I_E = 0$; $V_{CB} = 30$ V	C_{re}	<	3,5	pF
Output capacitance at f = 1 MHz				
$I_E = 0$; $V_{CB} = 30$ V	C_{oe}	<	4,5	pF

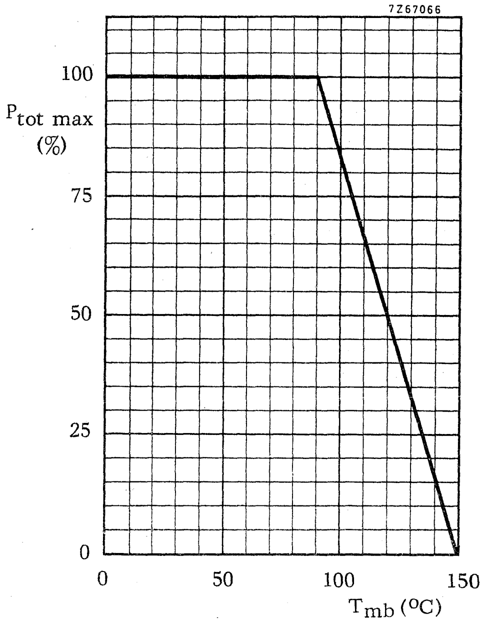


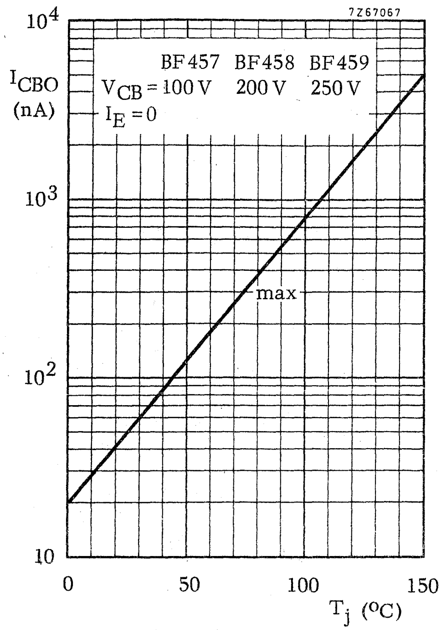
Safe Operating Area with the transistor forward biased




7Z67877
S.B. voltage multiplying factor at the $I_{C\,max}$ level
10^2
$M_{SB(I)}$
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
1,0
10
10^2
10^3
t_p (μs)
10^4


7Z67878
S.B. current multiplying factor at the $V_{CEO\,max}$ level
10^2
$M_{SB(V)}$
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
1,0
10
10^2
10^3
t_p (μs)
10^4


7Z67066
100
75
50
25
0
$P_{tot\ max}$ (%)
0
50
100
150
T_{mb} (°C)


7Z67067
10^4
10^3
10^2
10
I_{CBO} (nA)
BF457 BF458 BF459
V_{CB} = 100 V 200 V 250 V
I_E = 0
max
0
50
100
150
T_j (°C)

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in plastic envelope intended for class-B video output stages in television receivers and for high-voltage i.f. output stages.
P-N-P complements are BF470 and BF472 respectively.

QUICK REFERENCE DATA

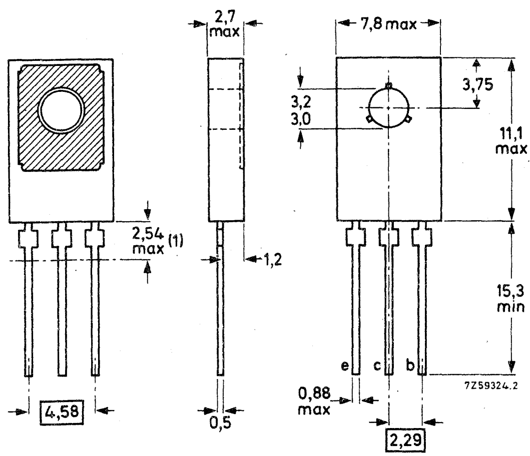
			BF469	BF471	
Collector-base voltage (open emitter)	V_{CBO}	max.	250	300	V
Collector-emitter voltage					
open base	V_{CEO}	max.	250	–	V
R_{BE} = 2,7 kΩ	V_{CER}	max.	–	300	V
Collector current (peak value)	I_{CM}	max.	100	100	mA
Total power dissipation up to $T_{mb} \leqslant 114\,^oC$	P_{tot}	max.	1,8	1,8	W
Junction temperature	T_j	max.	150	150	^oC
D.C. current gain I_C = 25 mA; V_{CE} = 20 V	h_{FE}	>	50	50	
Transition frequency I_C = 10 mA; V_{CE} = 10 V	f_T	>	60	60	MHz
Feedback capacitance at f = 0,5 MHz I_E = 0; V_{CB} = 30 V	C_{re}	<	1,8	1,8	pF

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-126 (SOT-32).

Collector connected to mounting base



For mounting instructions
see Handbook section Accessories
type 56326 for direct mounting
type 56333 for insulated mounting
types 56353 and 56354 for direct and insulated clip mounting.

RATINGS

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

			BF469	BF471	
Collector-base voltage (open emitter)	V_{CBO}	max.	250	300	V
Collector-emitter voltage					
R_{BE} = 2,7 kΩ	V_{CER}	max.	–	300	V
open base	V_{CEO}	max.	250	–	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5		V
Collector current (d.c.)	I_C	max.	50		mA
Collector current (peak value)	I_{CM}	max.	100		mA
Total power dissipation up to T_{mb} = 114 °C *	P_{tot}	max.	1,8		W
Storage temperature	T_{stg}		−65 to + 150		°C
Junction temperature	T_j	max.	150		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	20	°C/W
From junction to ambient in free air *	$R_{th\ j\text{-}a}$	=	100	°C/W

* Transistor mounted on a printed-circuit board, maximum lead length 4 mm, mounting pad for collector lead minimum 10 mm x 10 mm.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 200$ V	I_{CBO}	<	10	nA
$R_{BE} = 2{,}7$ kΩ; $V_{CE} = 200$ V; $T_j = 150$ °C	I_{CER}	<	10	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10	μA
D.C. current gain				
$I_C = 25$ mA; $V_{CE} = 20$ V	h_{FE}	>	50	
High-frequency knee voltage at $T_j = 150$ °C*				
$I_C = 25$ mA	V_{CEK}	typ.	20	V
Transistion frequency				
$I_C = 10$ mA; $V_{CE} = 10$ V	f_T	>	60	MHz
Feedback capacitance at f = 0,5 MHz				
$I_E = 0$; $V_{CB} = 30$ V	C_{re}	<	1,8	pF
Feedback time constant at f = 10,7 MHz**				
$-I_E = 10$ mA; $V_{CB} = 20$ V	$r_{bb'}C_{b'c}$	<	90	ps

* The high-frequency knee voltage of a transistor is that value of the collector-emitter voltage at which the small-signal gain, measured in a practical circuit, has dropped to 80% of the gain at $V_{CE} = 50$ V.
A further reduction of the collector-emitter voltage results in a rapid increase of the distortion of the signal.

** $r_{bb'}C_{b'c} = \frac{|h_{rb}|}{\omega}$.

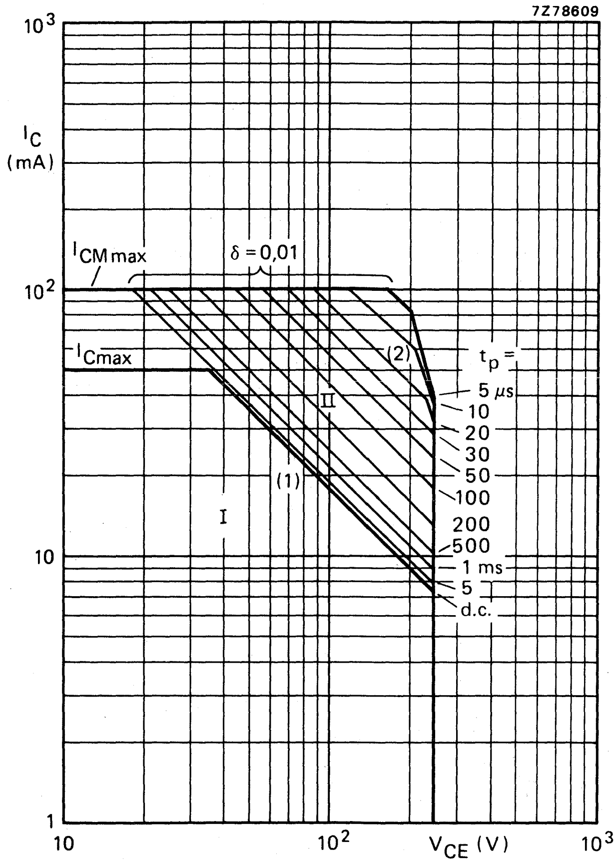


Fig. 2 Safe Operating ARea at T_{mb} = 114 °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.

(2) Second breakdown limits (independent of temperature).

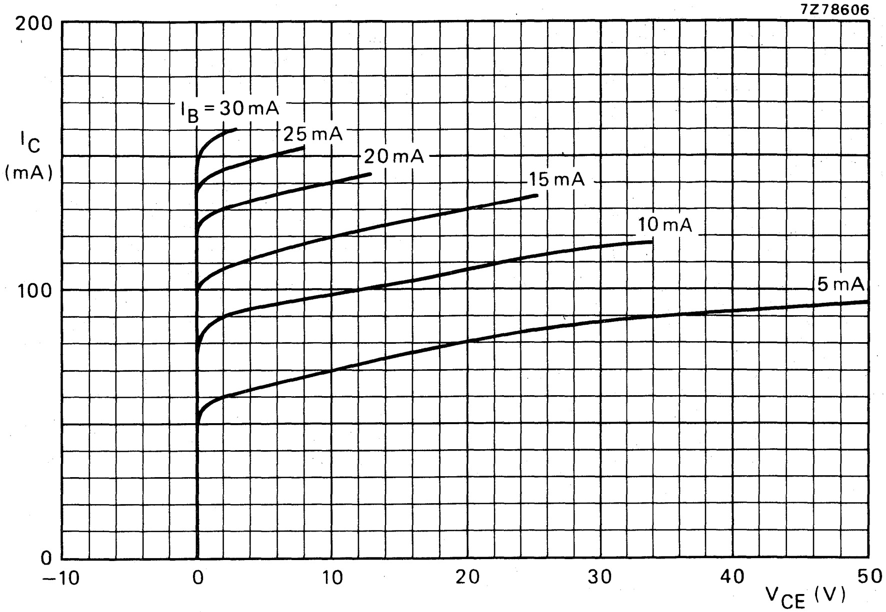


Fig. 3 $T_j = 25\ ^oC$.

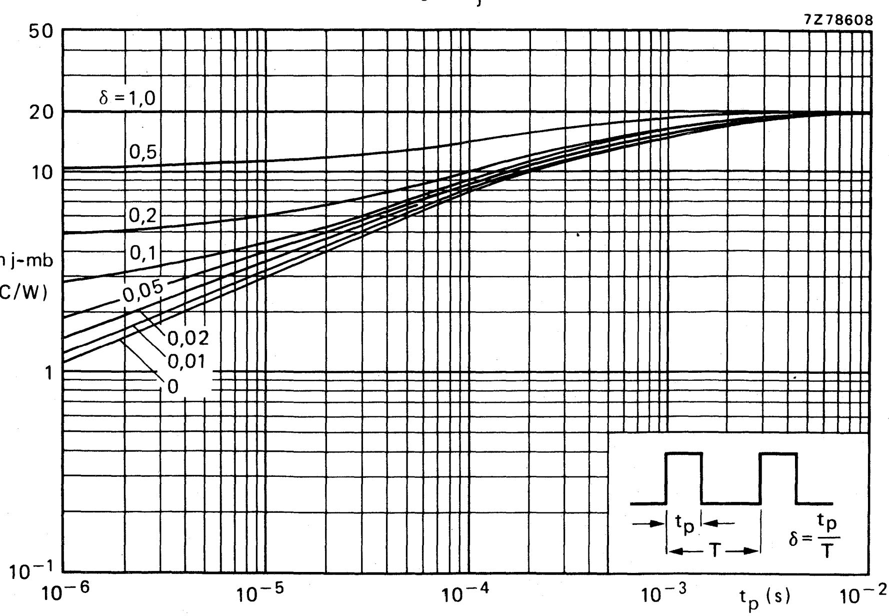


Fig. 4.

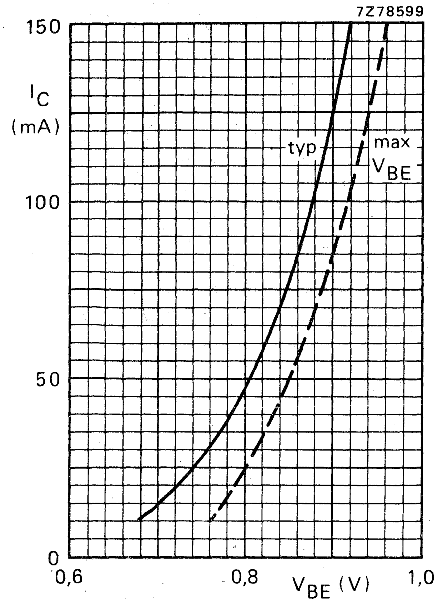


Fig. 5 V_{CE} = 20 V; T_j = 25 °C.

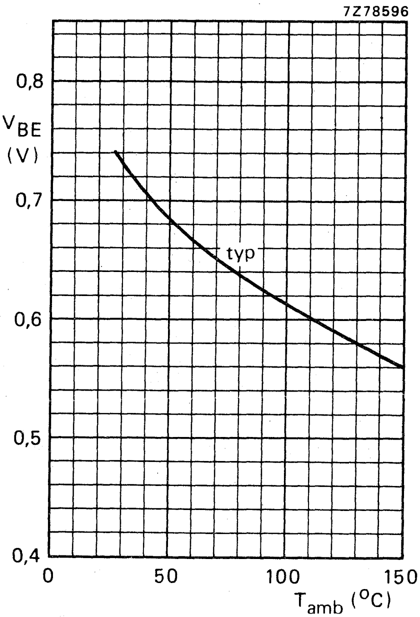


Fig. 6 I_C = 25 mA; V_{CE} = 20 V.

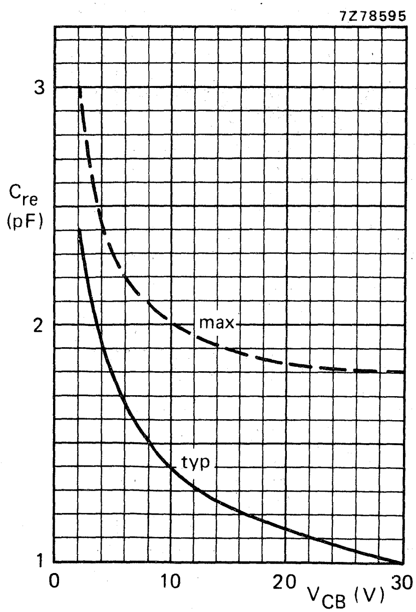


Fig. 7 I_E = 0; f = 1 MHz; T_j = 25 °C.

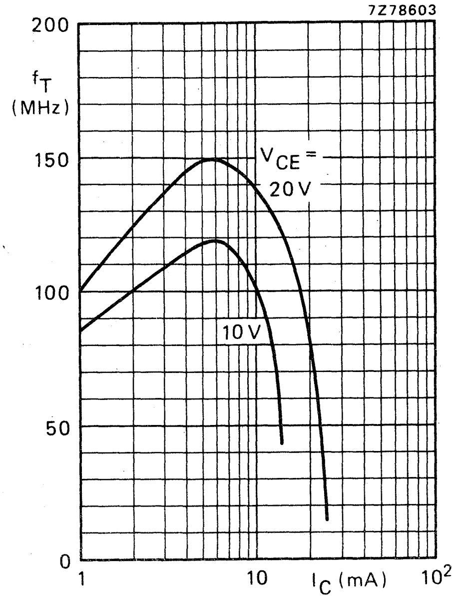


Fig. 8 f_M = 35 MHz; T_{amb} = 25 °C.

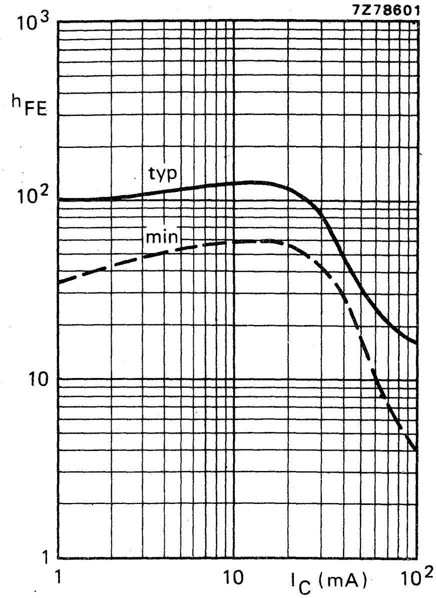


Fig. 9 V_{CE} = 20 V; T_{amb} = 25 °C.

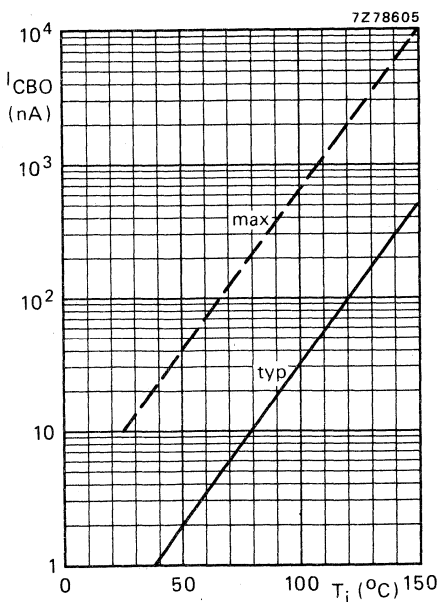


Fig. 10 V_{CB} = 200 V.

SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in a plastic envelope intended for class-B video output stages in television receivers and for high-voltage i.f. output stages.
N-P-N complements are BF469 and BF471 respectively.

QUICK REFERENCE DATA

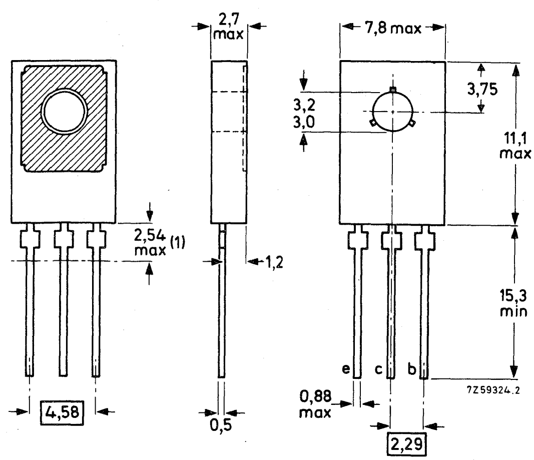
			BF470	BF472	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	250	300	V
Collector-emitter voltage					
open base	$-V_{CEO}$	max.	250	–	V
R_{BE} = 2,7 kΩ	$-V_{CER}$	max.	–	300	V
Collector current (peak value)	$-I_{CM}$	max.	100		mA
Total power dissipation up to T_{mb} = 114 °C	P_{tot}	max.	1,8		W
Junction temperature	T_j	max.	150		°C
D.C. current gain					
$-I_C$ = 25 mA; $-V_{CE}$ = 20 V	h_{FE}	>	50		
Transition frequency					
$-I_C$ = 10 mA; $-V_{CE}$ = 10 V	f_T	>	60		MHz
Feedback capacitance at f = 0,5 MHz					
I_E = 0; $-V_{CB}$ = 30 V	C_{re}	<	1,8		pF

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-126 (SOT-32).

Collector connected to mounting base.



For mounting instructions
see Handbook section Accessories
type 56326 for direct mounting
type 56333 for insulated mounting
types 56353 and 56354 for direct and insulated clip mounting.

RATINGS

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

			BF470	BF472	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	250	300	V
Collector-emitter voltage					
R_{BE} = 2,7 kΩ	$-V_{CER}$	max.	–	300	V
open base	$-V_{CEO}$	max.	250	–	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5		V
Collector current (d.c.)	$-I_C$	max.	50		mA
Collector current (peak value)	$-I_{CM}$	max.	100		mA
Total power dissipation up to T_{mb} = 114 °C *	P_{tot}	max.	1,8		W
Storage temperature	T_{stg}		–65 to + 150		°C
Junction temperature	T_j	max.	150		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	20	°C/W
From junction to ambient in free air *	$R_{th\ j\text{-}a}$	=	100	°C/W

* Transistor mounted on a printed-circuit board, maximum lead length 4 mm; mounting pad for collector lead minimum 10 mm x 10 mm.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $-V_{CB} = 200$ V	$-I_{CBO}$	<	10	nA
$R_{BE} = 2{,}7$ kΩ; $-V_{CE} = 200$ V; $T_j = 150$ °C	$-I_{CER}$	<	10	μA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	10	μA
D.C. current gain				
$-I_C = 25$ mA; $-V_{CE} = 20$ V	h_{FE}	>	50	
High-frequency knee voltage at $T_j = 150$ °C*				
$-I_C = 25$ mA	$-V_{CEK}$	typ.	20	V
Transition frequency				
$-I_C = 10$ mA; $-V_{CE} = 10$ V	f_T	>	60	MHz
Feedback capacitance at f = 0,5 MHz				
$I_E = 0$; $-V_{CB} = 30$ V	C_{re}	<	1,8	pF
Feedback time constant at f = 10,7 MHz**				
$I_E = 10$ mA; $-V_{CB} = 20$ V	$r_{bb'}C_{b'c}$	<	90	ps

* The high-frequency knee voltage of a transistor is that value of the collector-emitter voltage at which the small-signal gain, measured in a practical circuit, has dropped to 80% of the gain at $-V_{CE} = 50$ V. A further reduction of the collector-emitter voltage results in a rapid increase of the distortion of the signal.

** $r_{bb'}C_{b'c} = \frac{|h_{rb}|}{\omega}$.

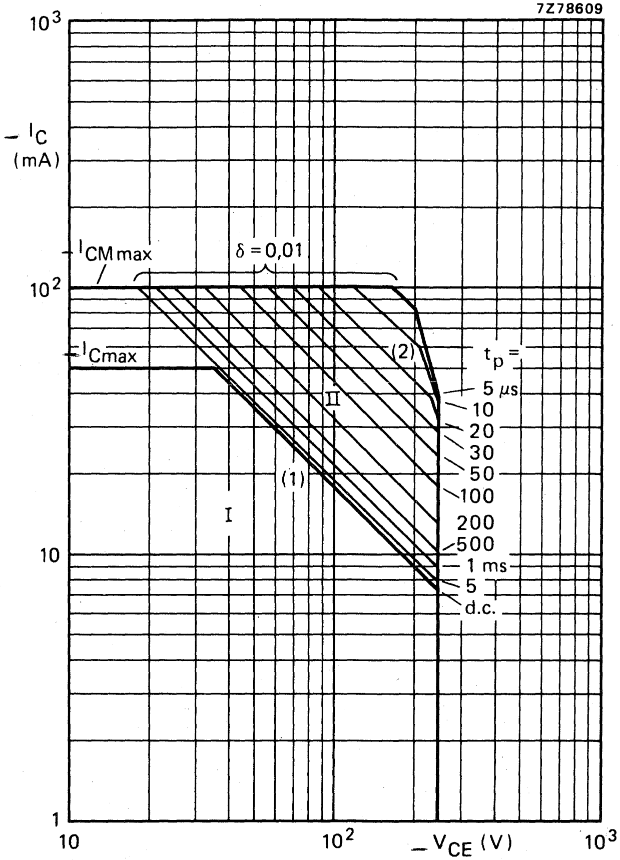


Fig. 2 Safe Operating ARea at T_{mb} = 114 °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(1) $P_{tot\,max}$ and $P_{tot\,peak\,max}$ lines.

(2) Second breakdown limits (independent of temperature).

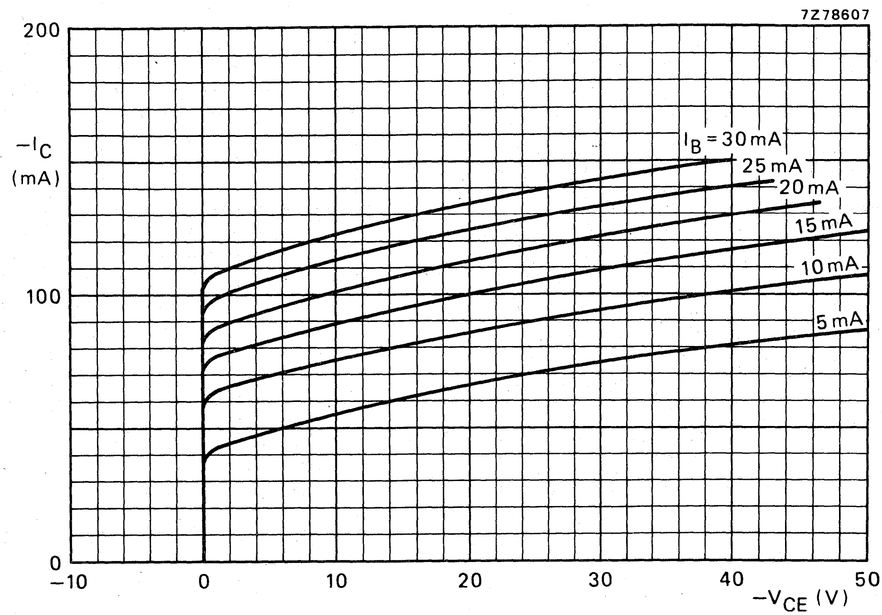


Fig. 3 T_j = 25 °C.

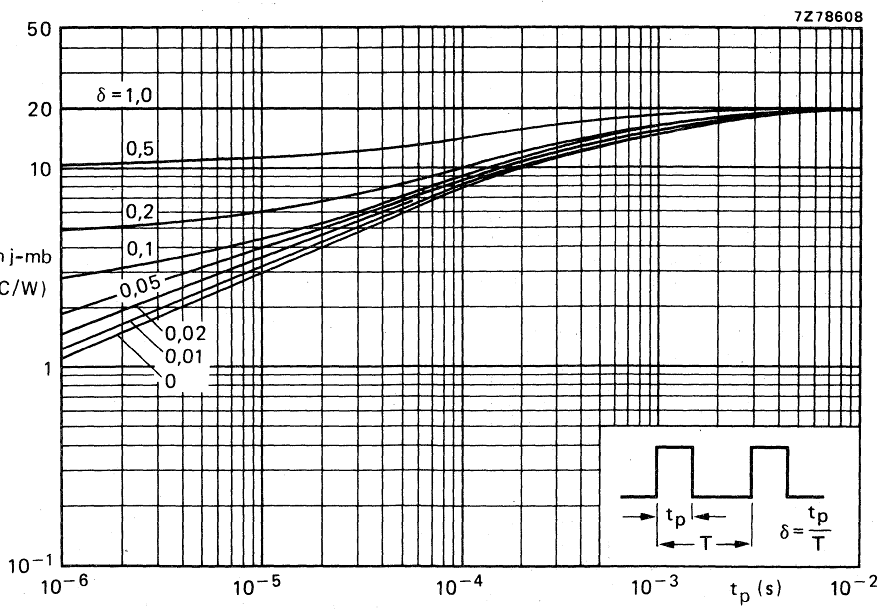


Fig. 4.

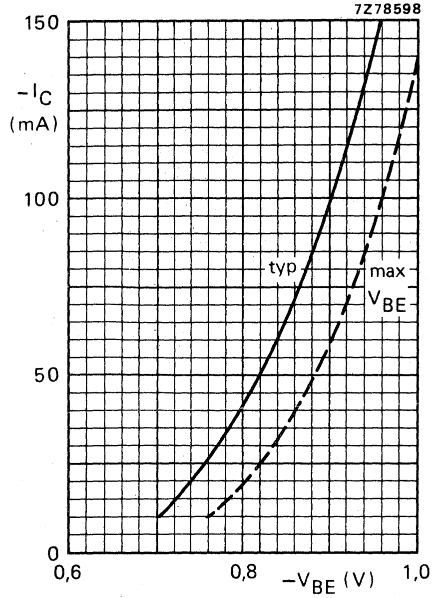


Fig. 5 $-V_{CE}$ = 20 V; T_j = 25 °C.

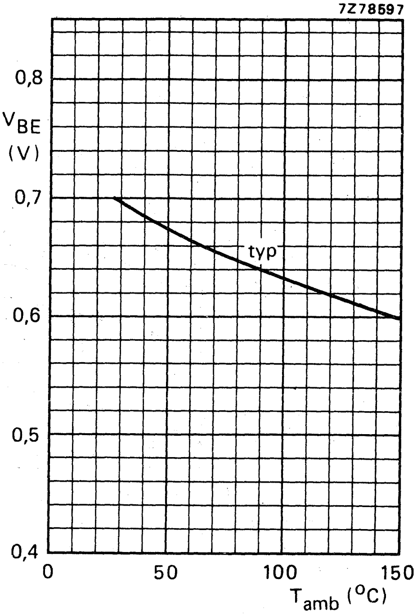


Fig. 6 $-V_{CE}$ = 20 V; $-I_C$ = 25 mA.

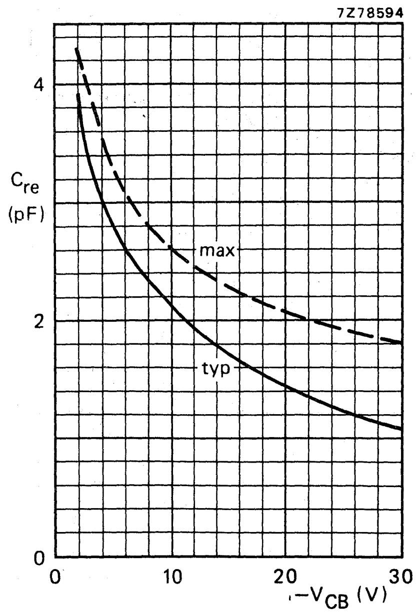


Fig. 7 I_E = 0; f = 1 MHz; T_j = 25 °C.

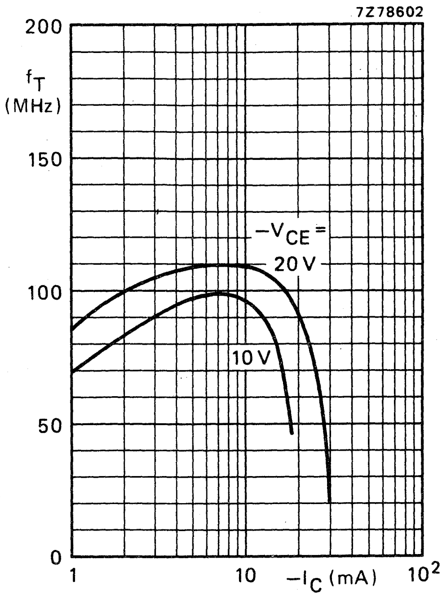


Fig. 8 f_M = 35 MHz; T_{amb} = 25 °C.

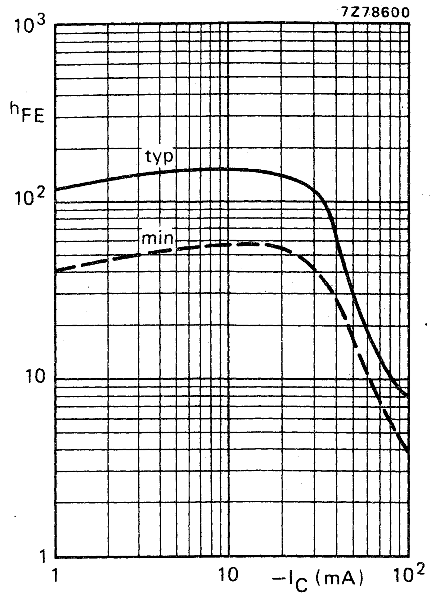


Fig. 9 $-V_{CE}$ = 20 V; T_{amb} = 25 °C.

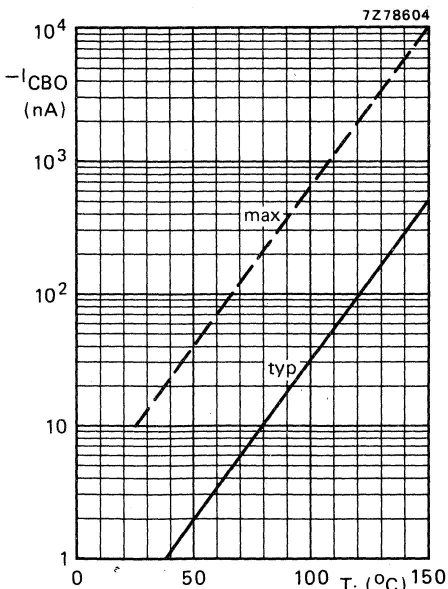


Fig. 10 $-V_{CB}$ = 200 V.

SILICON PLANAR TRANSISTOR

N-P-N transistor in TO-202 plastic envelope intended for use as a driver for line output transistors in colour television receivers.

QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.	300	V
Collector-emitter voltage (open base)	V_{CEO}	max.	250	V
Collector current (peak value)	I_{CM}	max.	300	mA
Total power dissipation up to T_{mb} = 75 °C	P_{tot}	max.	6	W
Junction temperature	T_j	max.	150	°C
D.C. current gain I_C = 20 mA, V_{CE} = 10 V	h_{FE}	typ.	45	
Storage time	t_s	typ.	0,5	μs

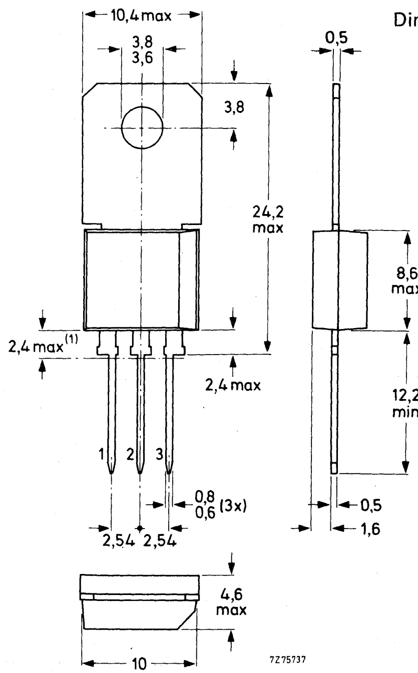
MECHANICAL DATA

Fig. 1 TO-202.

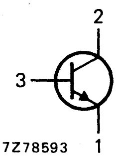
Dimensions in mm

Collector connected to mounting base.

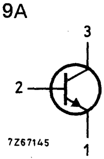
(1) Plastic flash allowed within this zone.



BF819



BF819A



BF819A is available on request. It has ebc pinning instead of ecb.

RATINGS

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

Collector-base voltage (open emitter)	V_{CBO}	max.	300	V
Collector-emitter voltage (open base)	V_{CEO}	max.	250	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V
Collector current (d.c.)	I_C	max.	100	mA
Collector current (peak value)*	I_{CM}	max.	300	mA
Base current (d.c.)	I_B	max.	50	mA
Total power dissipation up to T_{amb} = 75 °C	P_{tot}	max.	1,2	W
Total power dissipation up to T_{mb} = 75 °C	P_{tot}	max.	6	W
Storage temperature	T_{stg}	−65 to +150		°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	62,5	K/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	12,5	K/W

* Precautions should be taken during switch-on of the BF819 where an overshoot of current is likely to occur. The amplitude of the overshoot depends on the relative magnitude of stray external capacities to the transistor collector capacity. It is desirable to keep the stray capacities to a minimum by short lead lengths etc. so as to minimise the area of the switching path.

CHARACTERISTICS

$T_j = 25\ ^oC$

Collector cut-off current $I_E = 0$; $V_{CB} = 250$ V	I_{CBO}	<	50 nA
Emitter cut-off current $I_C = 0$; $V_{EB} = 3$ V	I_{EBO}	<	50 nA
D.C. current gain $I_C = 20$ mA; $V_{CE} = 10$ V	h_{FE}	typ.	45
Collector-emitter saturation voltage $I_C = 200$ mA; $I_B = 20$ mA*	$V_{CE\,sat}$	<	11 V
Collector output capacitance at f = 1 MHz $I_E = 0$; $V_{CB} = 30$ V	C_{ob}	<	4,5 pF
Storage time (in the typical circuit below)	t_s	typ.	0,5 μs

* The BF819 is controlled to V_{CEsat} max. 11,0 V and is thermally stable under all operating conditions where $T_{j\,max}$ of 150 ^oC is not exceeded. For the typical circuit shown below, a heatsink is not required for operation with $T_{amb} \leq 75\ ^oC$.

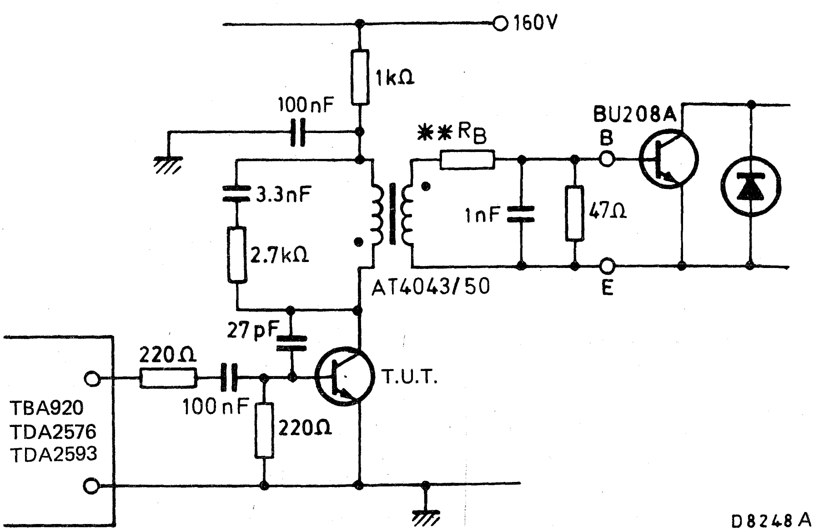


Fig. 2 Typical circuit.

** R_B is chosen so that the end-of-scan base current for the BU208A is 1,4 A under nominal conditions. Typical value of R_B is 0,5 Ω plus 0,1 Ω lead resistance.

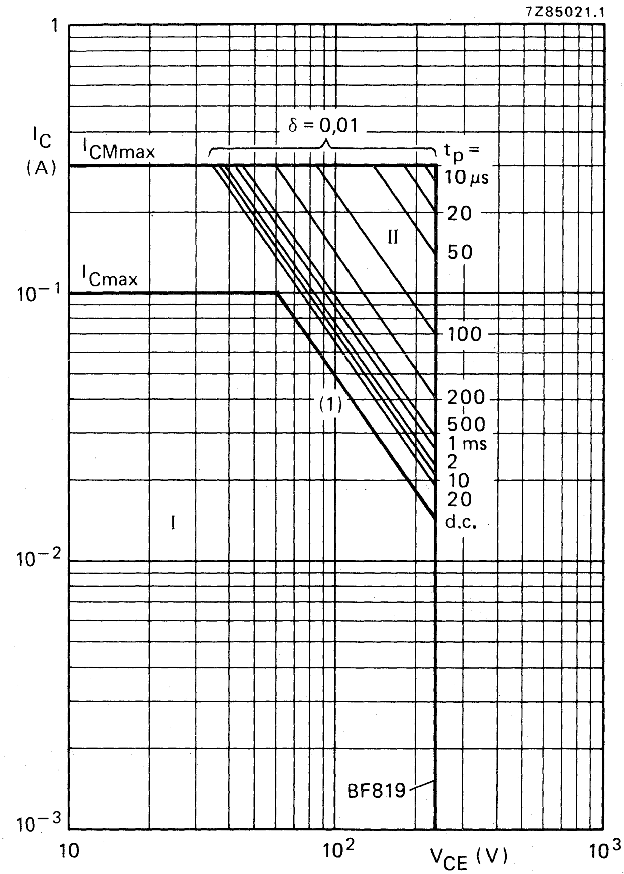


Fig. 3 Safe Operating ARea; T_{mb} = 25 °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(1) Second breakdown limits (independent of temperature).

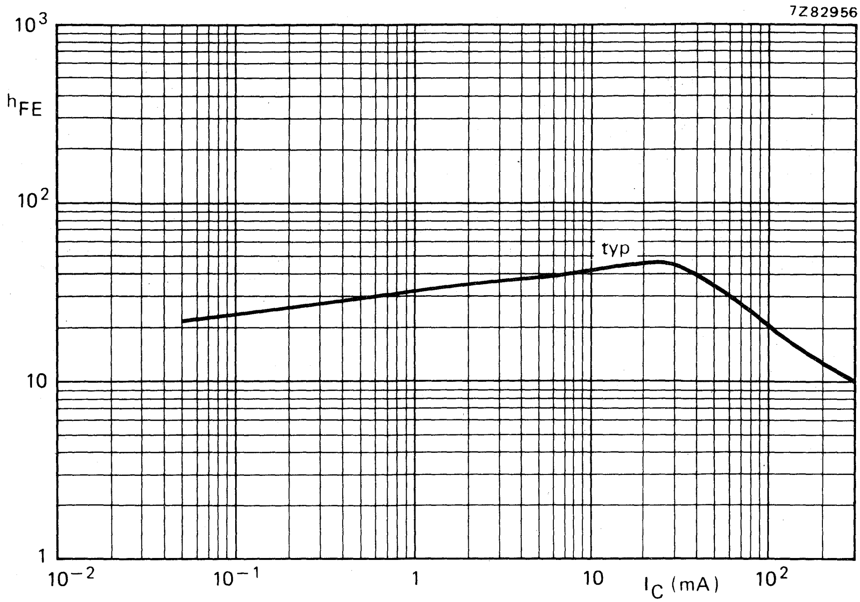


Fig. 4 D.C. current gain. V_{CB} = 10 V.

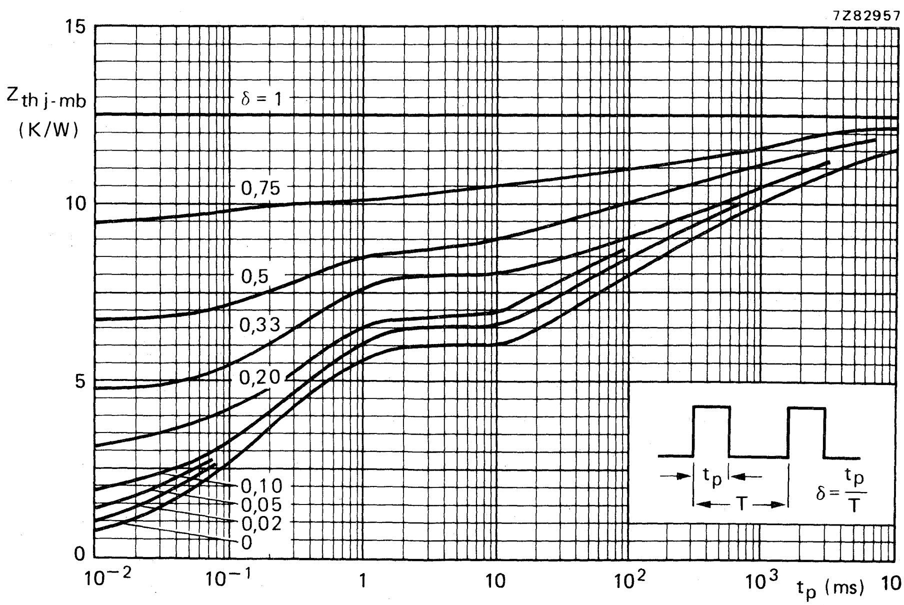


Fig. 5 Pulse power rating chart.

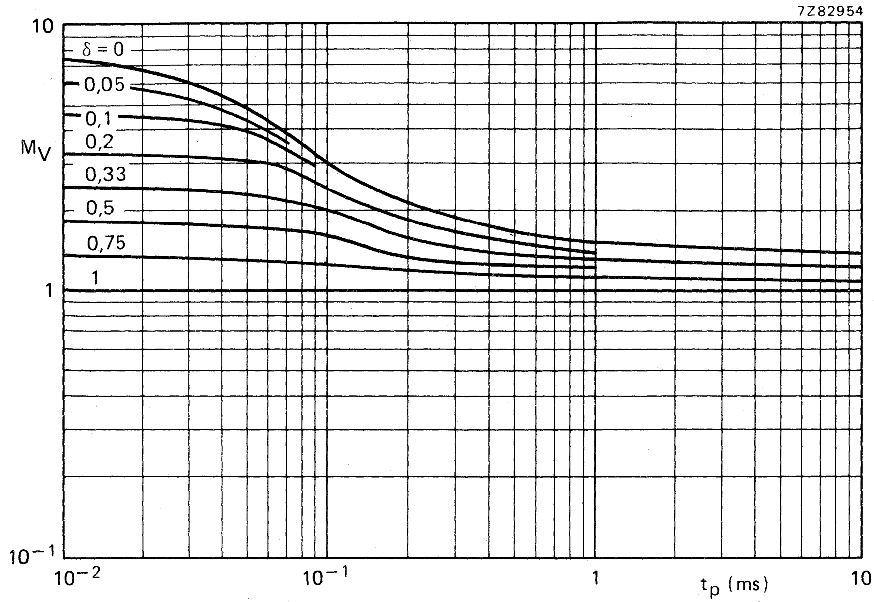


Fig. 6 S.B. Voltage multiplying factor at the I_{Cmax} level.

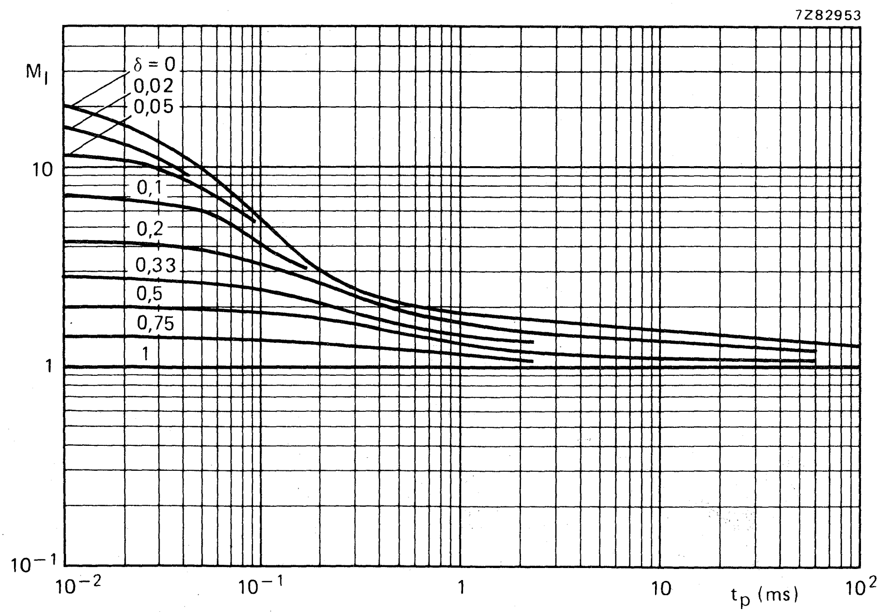


Fig. 7 S.B. current multiplying factor at the V_{CEOmax} level.

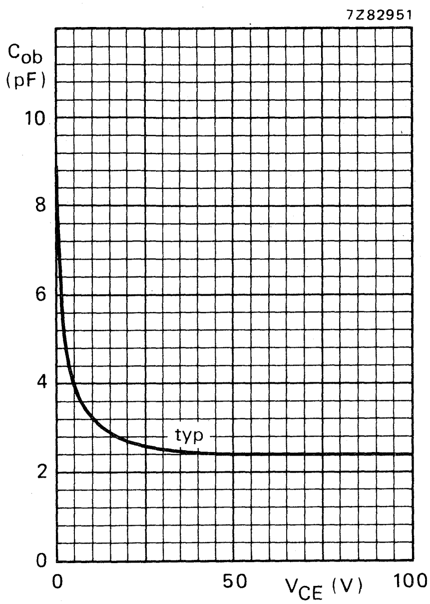


Fig. 8 Collector output capacitance
f = 1 MHz; I_E = 0.

SILICON PLANAR VIDEO OUTPUT TRANSISTORS

N-P-N transistors in TO-202 plastic envelopes intended for video output stages in black-and-white and in colour television receivers.

QUICK REFERENCE DATA

			BF857	BF858	BF859	
Collector-base voltage (open emitter)	V_{CBO}	max.	160	250	300	V
Collector-emitter voltage (open base)	V_{CEO}	max.	160	250	300	V
Collector current (peak value)	I_{CM}	max.		300		mA
Total power dissipation up to T_{mb} = 75 °C	P_{tot}	max.		6		W
Junction temperature	T_j	max.		150		°C
D.C. current gain I_C = 30 mA; V_{CE} = 10 V	h_{FE}	>		26		
Transition frequency at f = 35 MHz I_C = 15 mA; V_{CE} = 10 V	f_T	typ.		90		MHz
Feedback capacitance at f = 1 MHz I_E = 0; V_{CB} = 30 V	C_{re}	<		3		pF

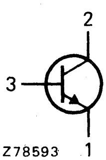
MECHANICAL DATA

Dimensions in mm

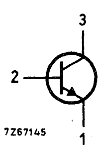
Fig. 1 TO-202.

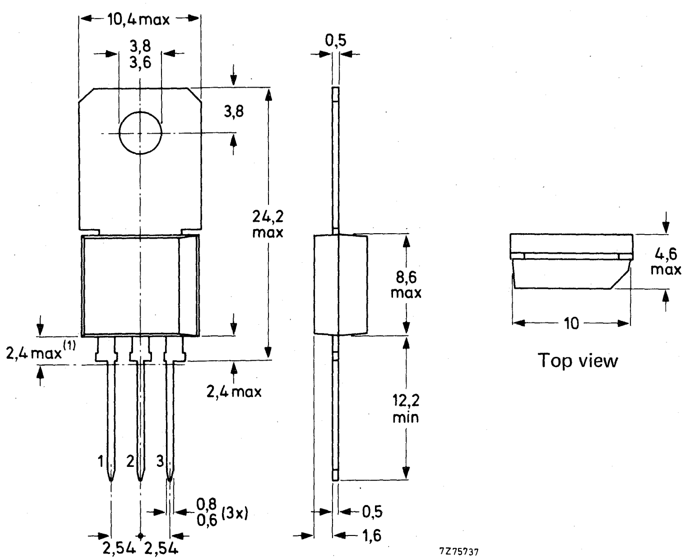
Collector connected to mounting base.

(1) Plastic flash allowed within this zone.



A-version





An A-version is available on request. It has ebc pinning instead of ecb.

RATINGS

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

			BF857	BF858	BF859	
Collector-base voltage (open emitter)	V_{CBO}	max.	160	250	300	V
Collector-emitter voltage (open base)	V_{CEO}	max.	160	250	300	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V
Collector current (d.c.)	I_C	max.		100		mA
Collector current (peak value)	I_{CM}	max.		300		mA
Base current (d.c.)	I_B	max.		50		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.		2		W
Total power dissipation up to T_{mb} = 75 °C	P_{tot}	max.		6		W
Storage temperature	T_{stg}			−65 to + 150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

from junction to ambient in free air	$R_{th\ j\text{-}a}$	=	62,5	K/W
from junction to mounting base	$R_{th\ j\text{-}mb}$	=	12,5	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
I_E = 0; V_{CB} = 100 V for BF857	I_{CBO}	<	0,1	μA
I_E = 0; V_{CB} = 200 V for BF858	I_{CBO}	<	0,1	μA
I_E = 0; V_{CB} = 250 V for BF859	I_{CBO}	<	0,1	μA
Emitter cut-off current				
I_C = 0; V_{EB} = 5 V	I_{EBO}	<	100	μA
D.C. current gain				
I_C = 30 mA; V_{CE} = 10 V	h_{FE}	>	26	
Collector-emitter saturation voltage				
I_C = 30 mA; I_B = 6 mA	V_{CEsat}	<	1	V
Transition frequency at f = 35 MHz				
I_C = 15 mA; V_{CE} = 10 V	f_T	typ.	90	MHz
Feedback capacitance at f = 1 MHz				
I_E = 0; V_{CB} = 30 V	C_{re}	<	3	pF

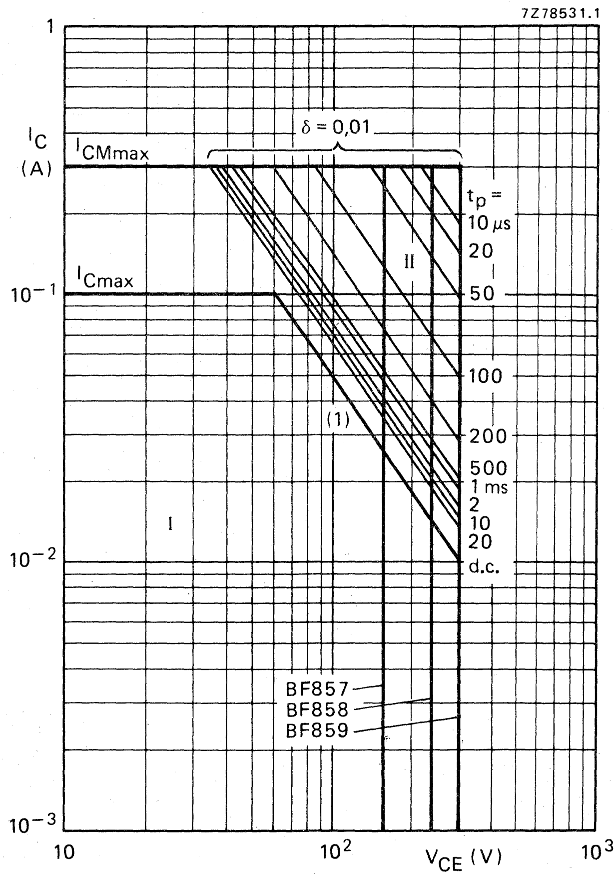


Fig. 2 Safe Operating ARea; T_{mb} = 75 °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(1) Second-breakdown limits (independent of temperature).

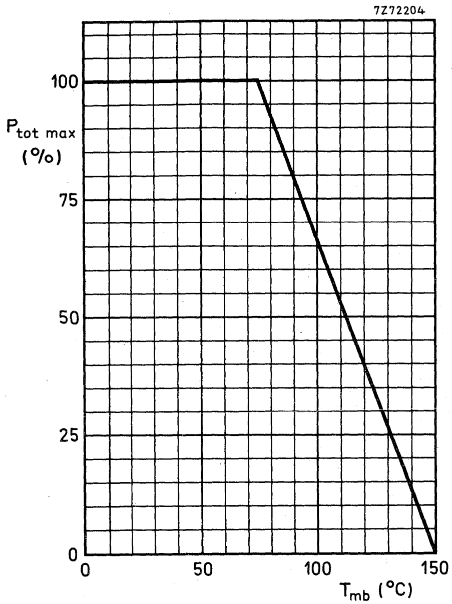


Fig. 3 Power derating curve.

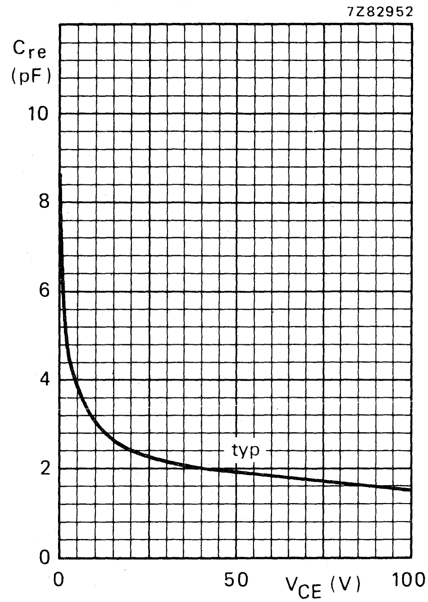


Fig. 4 Feedback capacitance f = 1 MHz.

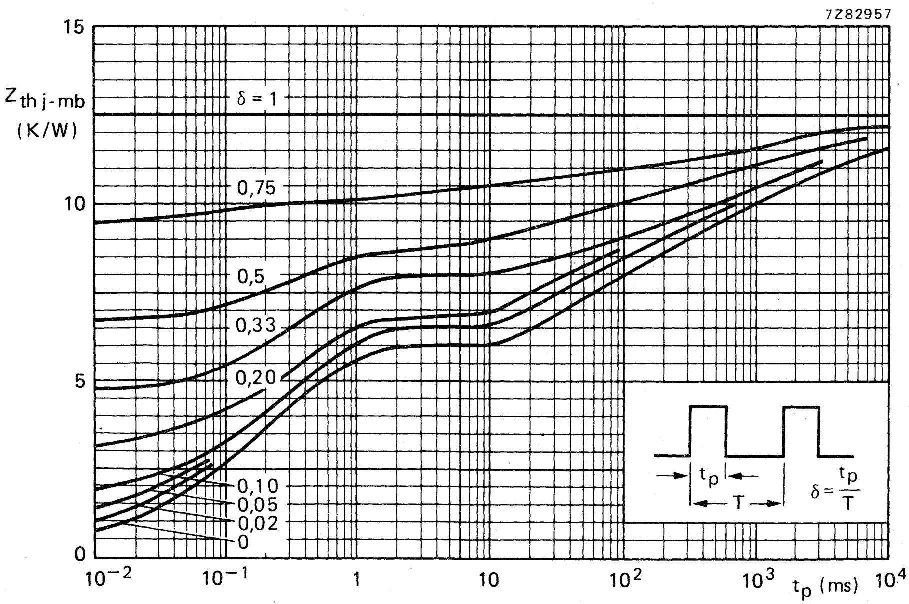


Fig. 5 Pulse power rating chart.

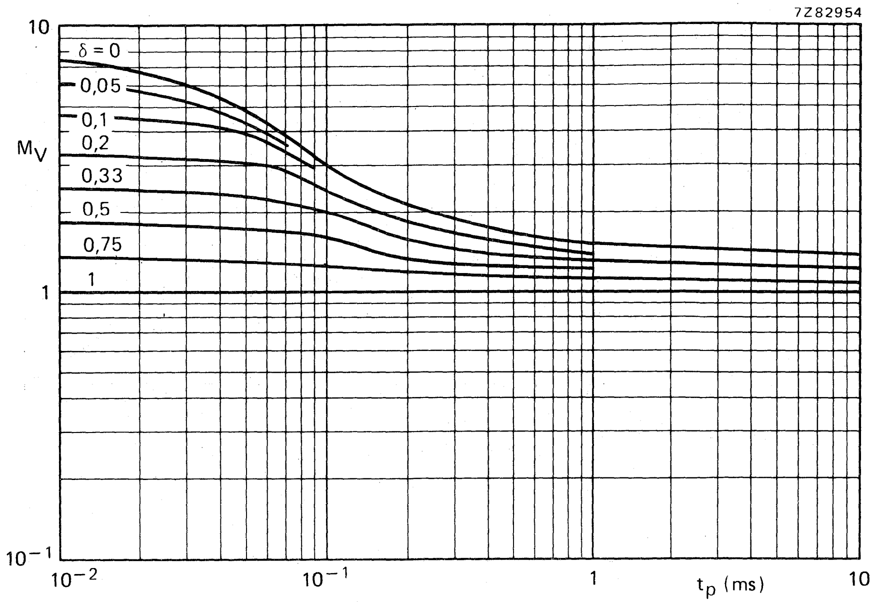


Fig. 6 S.B. voltage multiplying factor at the I_{Cmax} level.

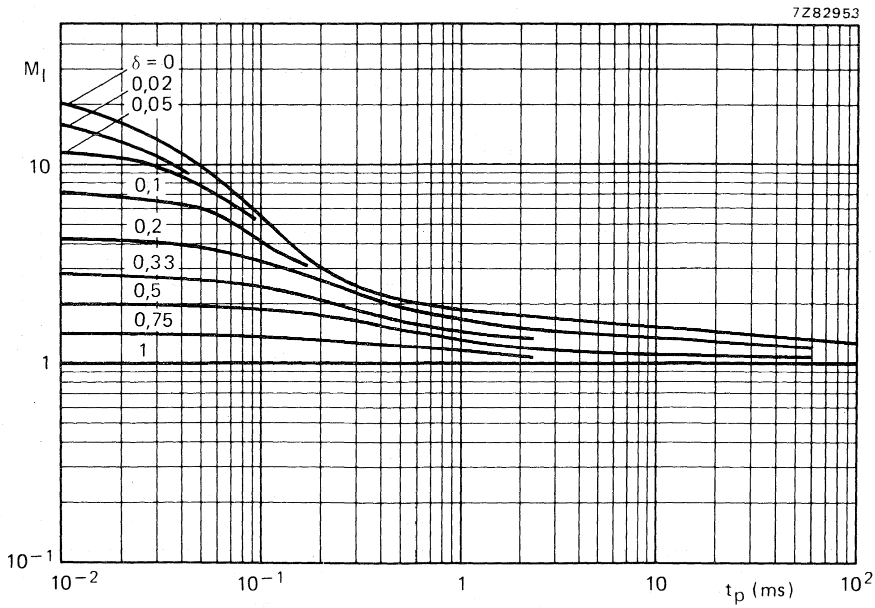


Fig. 7 S.B. current multiplying factor at the V_{CEmax} level.

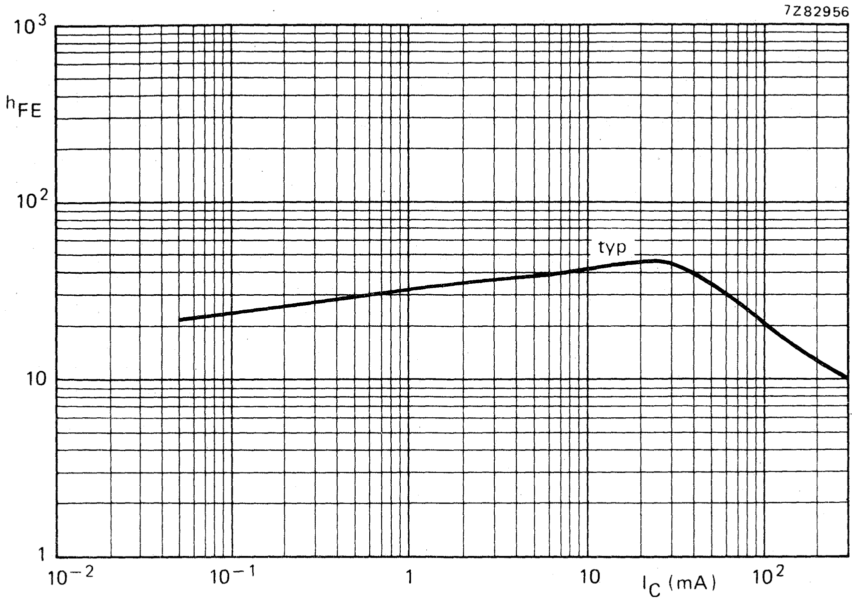


Fig. 8 D.C. current gain. V_{CE} = 10 V.

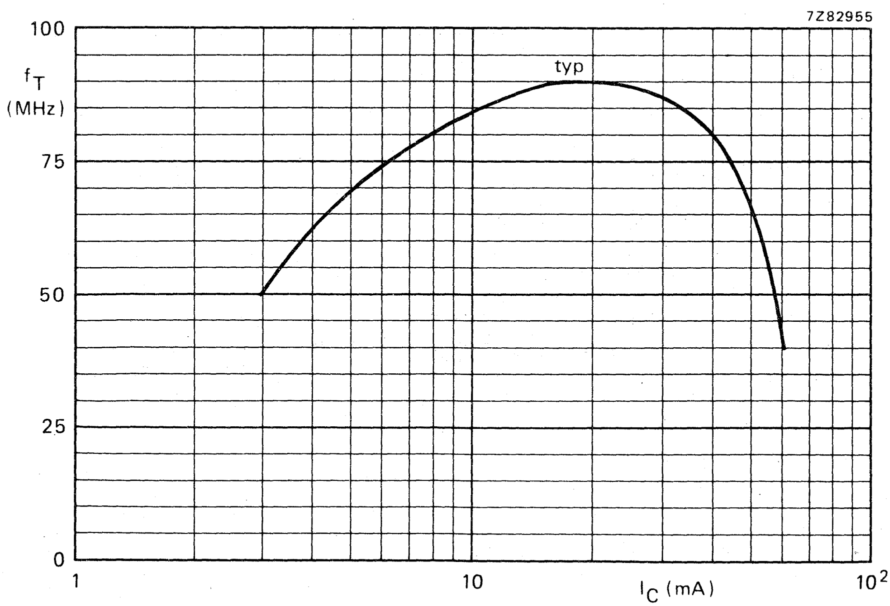


Fig. 9 Transition frequency. V_{CE} = 10 V; f = 35 MHz.

SILICON PLANAR VIDEO OUTPUT TRANSISTORS

N-P-N transistors in a TO-202 plastic envelope intended for class-B video output stages in colour television receivers. P-N-P complements are BF870 and BF872.

QUICK REFERENCE DATA

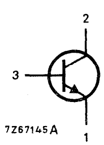
			BF869	BF871	
Collector-base voltage (open emitter)	V_{CBO}	max.	250	300	V
Collector-emitter voltage (open base)	V_{CEO}	max.	250	−	V
Collector-emitter voltage (R_{BE} = 2,7 kΩ)	V_{CER}	max.	−	300	V
Collector current (peak value)	I_{CM}	max.	100		mA
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	5		W
Junction temperature	T_j	max.	150		°C
D.C. current gain I_C = 25 mA; V_{CE} = 20 V; T_j = 25 °C	h_{FE}	>	50		
Transition frequency $-I_E$ = 10 mA; V_{CB} = 10 V	f_T	>	60		MHz
Feedback capacitance at f = 1 MHz I_E = 0; V_{CB} = 30 V	C_{re}	<	2		pF

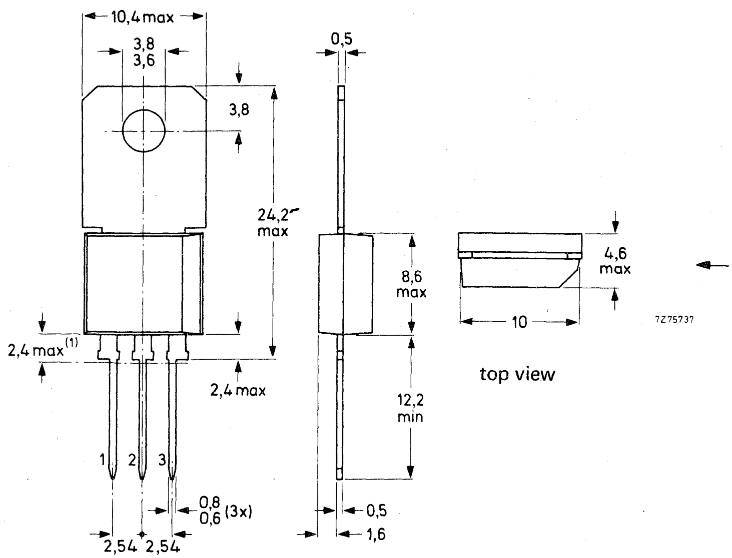
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-202.

Collector connected to mounting base.





top view

(1) Plastic flash allowed within this zone.

RATINGS

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

			BF869	BF871	
Collector-base voltage (open emitter)	V_{CBO}	max.	250	300	V
Collector-emitter voltage (open base)	V_{CEO}	max.	250	–	V
Collector-emitter voltage (R_{BE} = 2,7 kΩ)	V_{CER}	max.	–	300	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5		V
Collector current (d.c.)	I_C	max.	50		mA
Collector current (peak value)	I_{CM}	max.	100		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	1,6		W
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	5		W
Storage temperature	T_{stg}		–65 to +150		°C
Junction temperature	T_j	max.	150		°C

THERMAL RESISTANCE

From junction to ambient	$R_{th\ j\text{-}a}$	=	78	K/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	25	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			BF869	BF871	
Collector cut-off current					
I_E = 0; V_{CB} = 200 V	I_{CBO}	<	10	10	nA
R_{BE} = 2,7 kΩ; V_{CE} = 300 V	I_{CER}	<	–	1	μA
R_{BE} = 2,7 kΩ; V_{CE} = 200 V; T_j = 150 °C	I_{CER}	<	10		μA
Emitter cut-off current					
I_C = 0; V_{EB} = 5 V	I_{EBO}	<	10		μA
D.C. current gain					
I_C = 25 mA; V_{CE} = 20 V	h_{FE}	>	50		
Base-emitter voltage					
I_C = 25 mA; V_{CE} = 20 V	V_{BE}	typ.	0,75		V
High frequency knee voltage					
I_C = 25 mA; T_j = 150 °C	V_{CEK}	typ.	20		V
Transition frequency					
$-I_E$ = 10 mA; V_{CB} = 10 V	f_T	>	60		MHz
Feedback capacitance at f = 1 MHz					
I_E = 0; V_{CB} = 30 V	C_{re}	<	2		pF

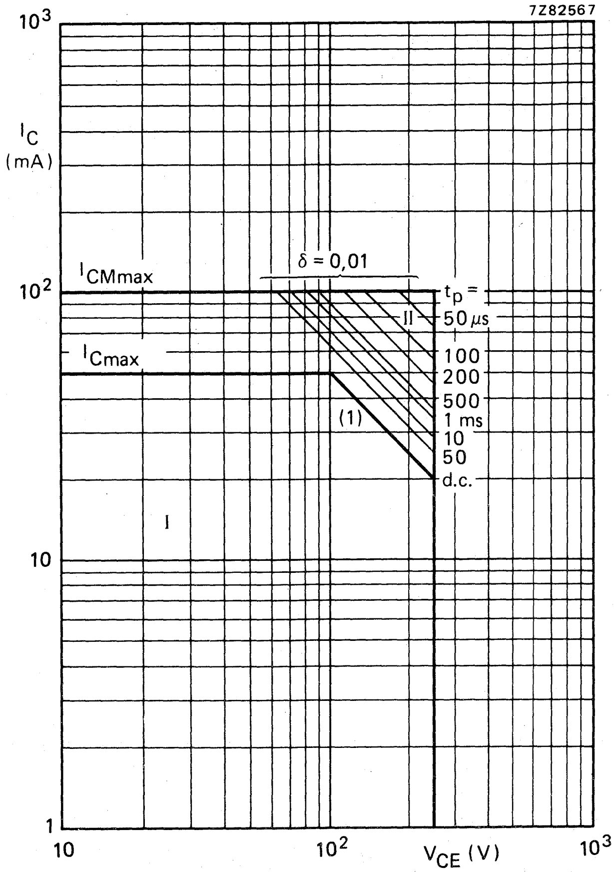


Fig. 2 Safe Operating ARea at T_{mb} = 25 °C.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.
(1) $P_{tot\ max}$ and $P_{tot\ peak\ max}$ lines.

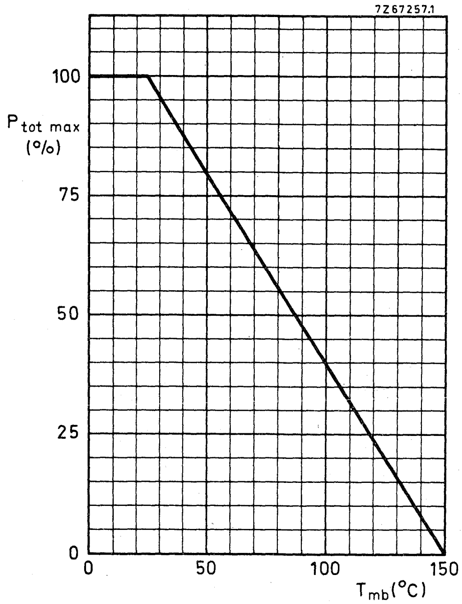


Fig. 3 Power derating curve.

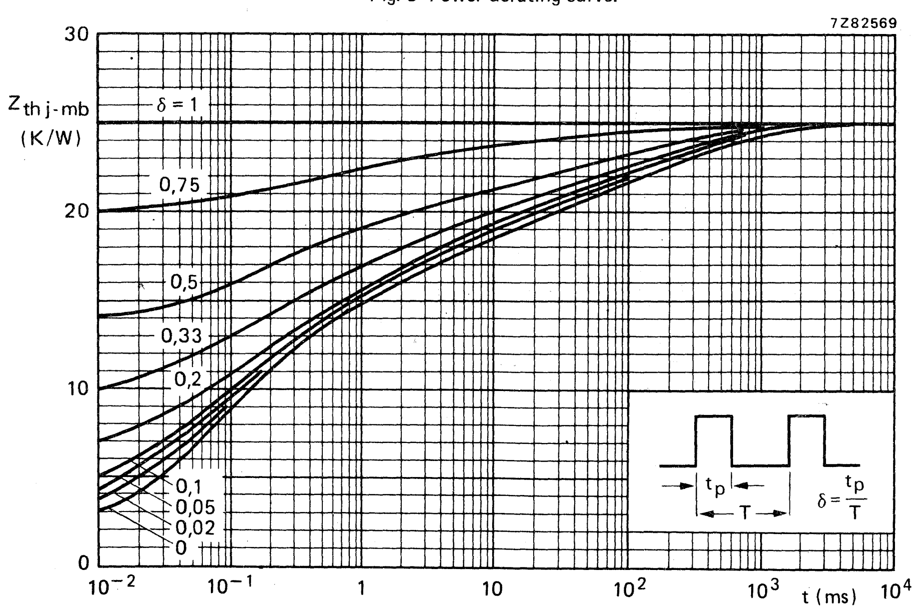


Fig. 4 Pulse power rating chart.

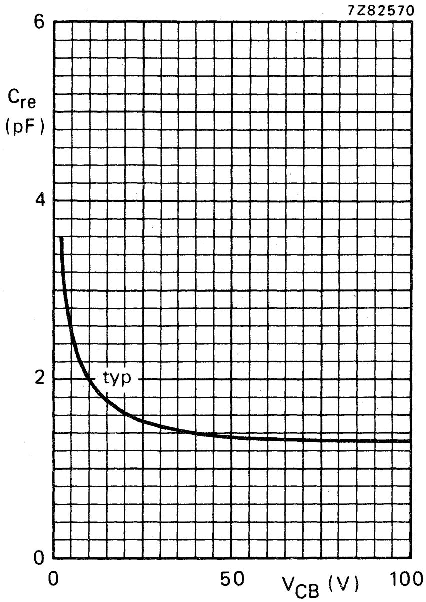


Fig. 5 $I_E = 0$; f = 1 MHz; $T_j = 25\ ^oC$.

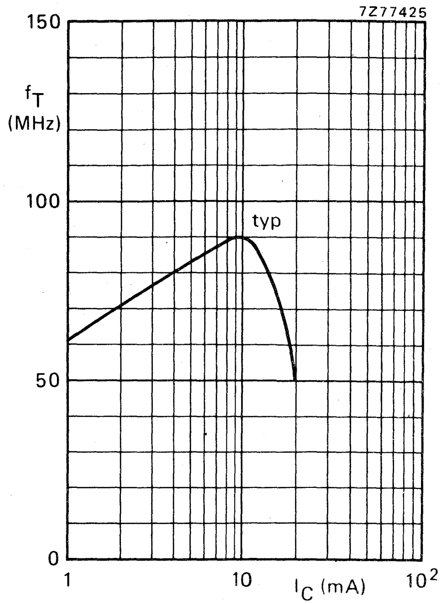


Fig. 6 $V_{CE} = 10$ V; $T_j = 25\ ^oC$.

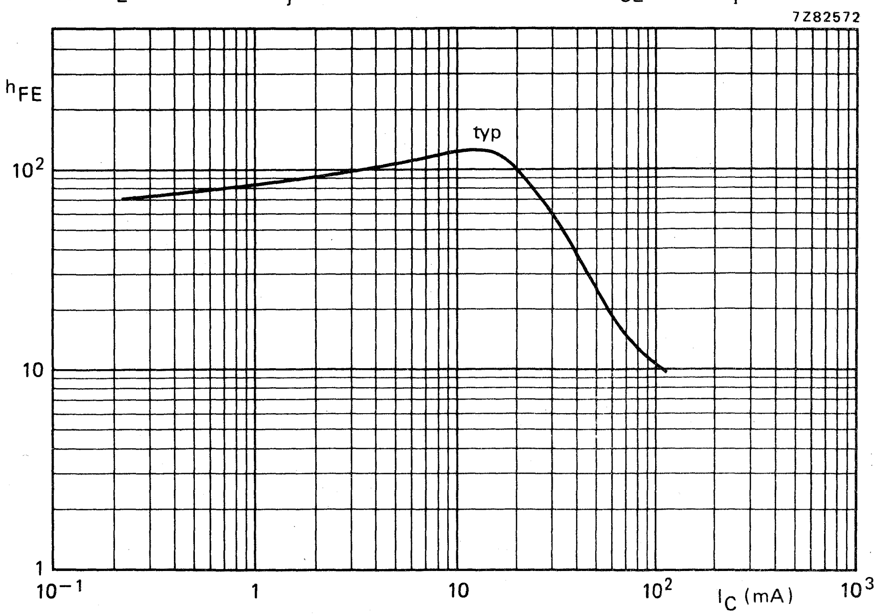


Fig. 7 D.C. current gain at $V_{CE} = 20$ V; $T_{amb} = 25\ ^oC$.

SILICON PLANAR VIDEO OUTPUT TRANSISTORS

P-N-P transistors in a TO-202 plastic envelope intended for class-B video output stages in colour television receivers. N-P-N complements are BF869 and BF871.

QUICK REFERENCE DATA

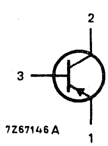
			BF870	BF872	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	250	300	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	250	–	V
Collector-emitter voltage (R_{BE} = 2,7 kΩ)	$-V_{CER}$	max.	–	300	V
Collector current (peak value)	$-I_{CM}$	max.	100		mA
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	5		W
Junction temperature	T_j	max.	150		°C
D.C. current gain $-I_C$ = 25 mA; $-V_{CE}$ = 20 V; T_j = 25 °C	h_{FE}	>	50		
Transition frequency I_E = 10 mA; $-V_{CB}$ = 10 V	f_T	>	60		MHz
Feedback capacitance at f = 1 MHz I_E = 0; $-V_{CB}$ = 30 V	C_{re}	<	2,2		pF

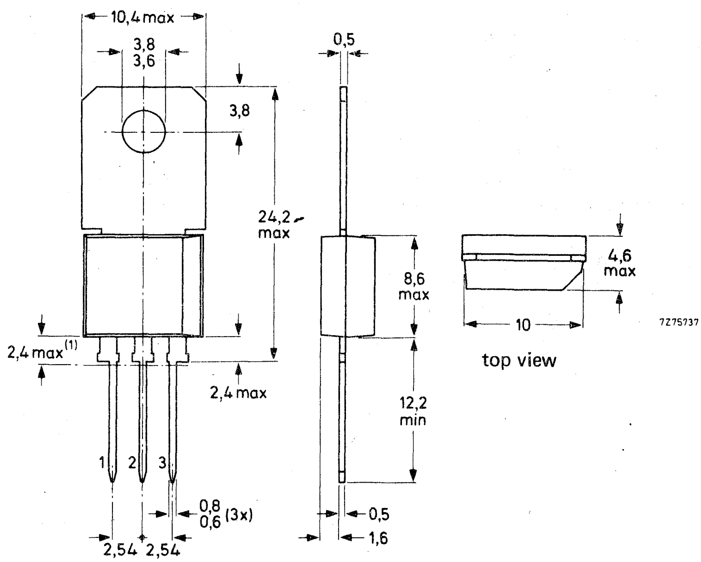
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-202.

Collector connected to mounting base.





(1) Plastic flash allowed within this zone.

RATINGS

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

			BF870	BF872	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	250	300	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	250	–	V
Collector-emitter voltage (R_{BE} = 2,7 kΩ)	$-V_{CER}$	max.	–	300	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5		V
Collector current (d.c.)	$-I_C$	max.	50		mA
Collector current (peak value)	$-I_{CM}$	max.	100		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	1,6		W
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	5		W
Storage temperature	T_{stg}		−65 to +150		°C
Junction temperature	T_j	max.	150		°C

THERMAL RESISTANCE

From junction to ambient	$R_{th\ j\text{-}a}$	=	78	K/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	25	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			BF870	BF872	
Collector cut-off current					
$I_E = 0$; $-V_{CB}$ = 200 V	$-I_{CBO}$	<	10	10	nA
R_{BE} = 2,7 kΩ; $-V_{CE}$ = 300 V	$-I_{CER}$	<	–	1	μA
R_{BE} = 2,7 kΩ; $-V_{CE}$ = 200 V; T_j = 150 °C	$-I_{CER}$	<	10		μA
Emitter cut-off current					
$I_C = 0$; $-V_{EB}$ = 5 V	$-I_{EBO}$	<	10		μA
D.C. current gain					
$-I_C$ = 25 mA; $-V_{CE}$ = 20 V	h_{FE}	>	50		
Base emitter voltage					
$-I_C$ = 25 mA; $-V_{CE}$ = 20 V	$-V_{BE}$	typ.	0,75		V
High-frequency knee voltage					
$-I_C$ = 25 mA; T_j = 150 °C	$-V_{CEK}$	typ.	20		V
Transition frequency					
I_E = 10 mA; $-V_{CB}$ = 10 V	f_T	>	60		MHz
Feedback capacitance at f = 1 MHz					
$I_E = 0$; $-V_{CB}$ = 30 V	C_{re}	<	2,2		pF

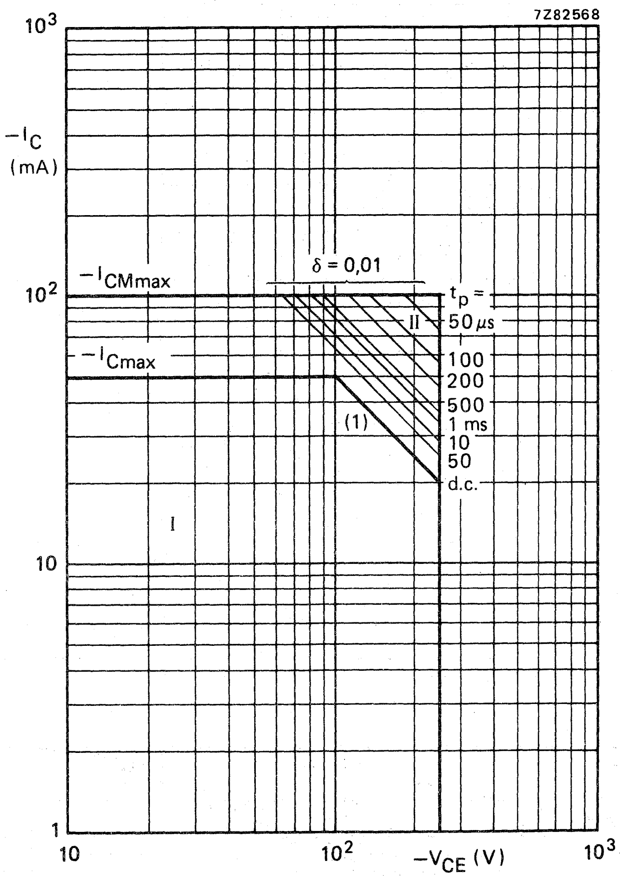


Fig. 2 Safe Operating ARea; T_{mb} = 25 °C.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.
(1) $P_{tot\ max}$ and $P_{tot\ peak\ max}$ lines.

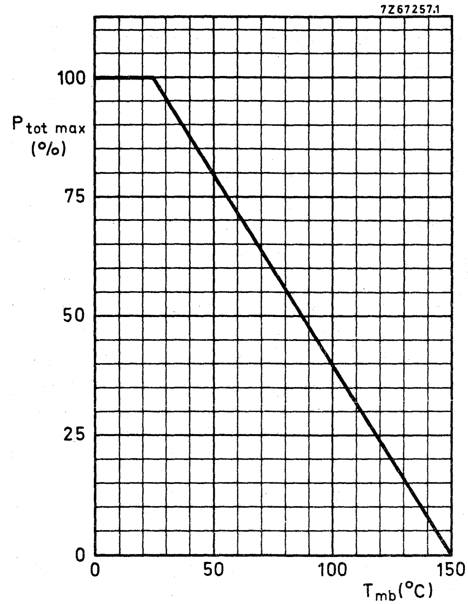


Fig. 3 Power derating curve.

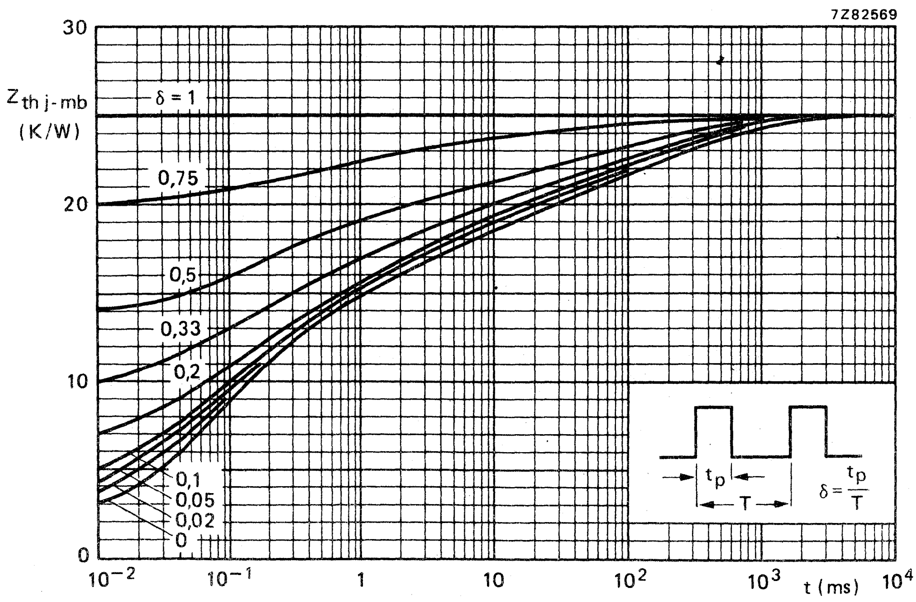


Fig. 4 Pulse power rating chart.

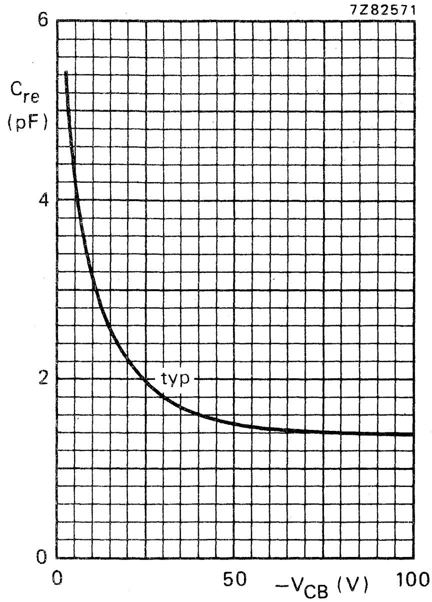


Fig. 5 $I_E = 0$; f = 1 MHz; $T_{amb} = 25$ °C.

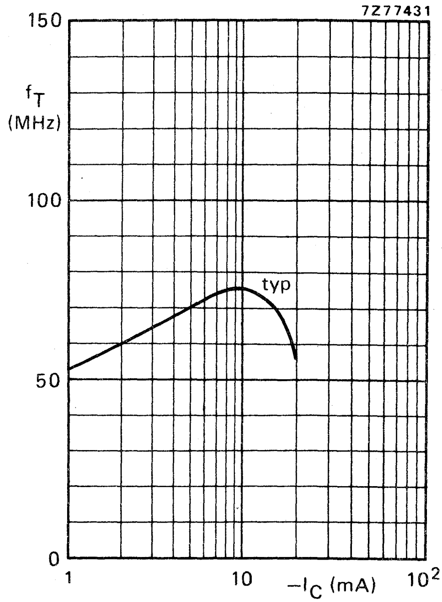


Fig. 6 $-V_{CE} = 10$ V; $T_j = 25$ °C.

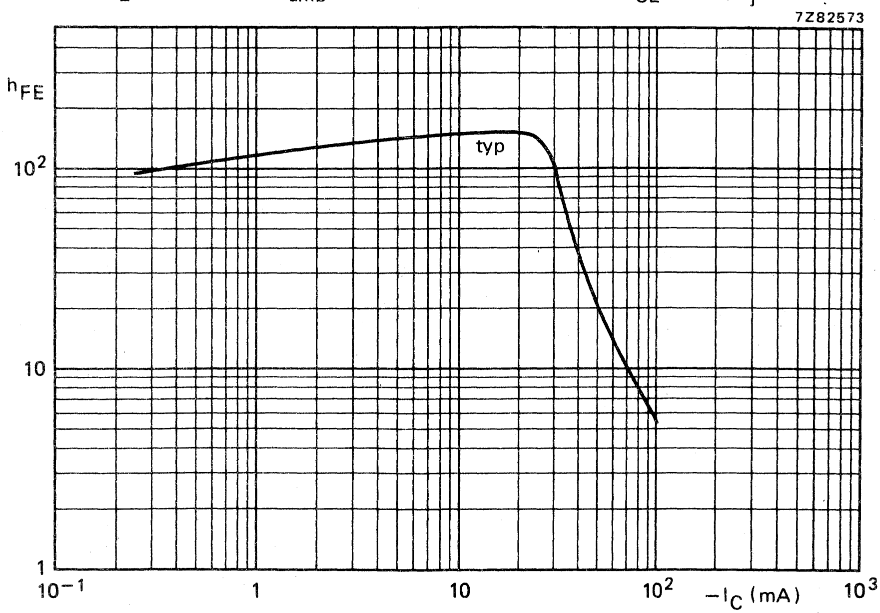


Fig. 7 D.C. current gain at $-V_{CE} = 20$ V; $T_{amb} = 25$ °C.

SILICON DIFFUSED POWER TRANSISTOR

High-voltage, high-speed switching n-p-n transistor in a metal envelope intended for use in horizontal deflection circuits of colour television receivers.

QUICK REFERENCE DATA

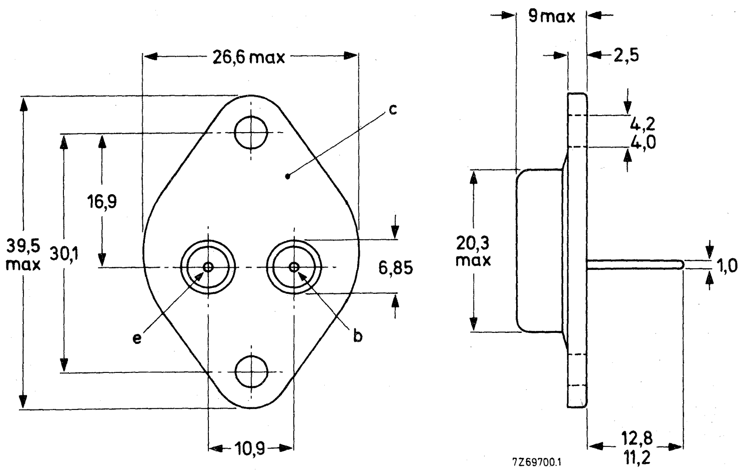
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max.	1500	V
Collector current (d.c.)	I_C	max.	5	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	80	W
Collector-emitter saturation voltage I_C = 4,5 A; I_B = 2 A	V_{CEsat}	<	1	V
Fall time I_{CM} = 4,5 A; $I_{B(end)}$ = 1,4 A	t_f	typ.	0,7	μs

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.



See also chapters Mounting Instructions and Accessories.

RATINGS

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

Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max.	1500	V
Collector-emitter voltage (open base)	V_{CEO}	max.	700	V
Collector current (d.c.)	I_C	max.	5	A
Collector current (peak value)	I_{CM}	max.	7,5	A
Collector current (non-repetitive peak)	I_{CSM}	max.	15	A
Base current (peak value)	I_{BM}	max.	4	A
Reverse base current (d.c. or average over any 20 ms period)	$-I_{B(AV)}$	max.	100	mA
Reverse base current (peak value) *	$-I_{BM}$	max.	4	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	80	W
Storage temperature	T_{stg}	−65 to + 115		°C
Junction temperature	T_j	max.	115	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	max.	1,12	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current V_{BE} = 0; V_{CE} = $V_{CESMmax}$	I_{CES}	<	1,0	mA
D.C. current gain I_C = 4,5 A; V_{CE} = 5 V	h_{FE}	>	2,5	
Emitter-base voltage I_C = 0; I_E = 10 mA	$+V_{EBO}$	>	5	V
I_C = 0; I_E = 100 mA	$+V_{EBO}$	typ.	7	V
Saturation voltage I_C = 4,5 A; I_B = 2 A	V_{CEsat}	<	1	V
I_C = 4,5 A; I_B = 2 A	V_{BEsat}	<	1,5	V
Collector-emitter sustaining voltage I_B = 0; I_C = 100 mA; L = 25 mH	$V_{CEOsust}$	>	700	V
Transition frequency at f = 5 MHz I_C = 0,1 A; V_{CE} = 5 V	f_T	typ.	7	MHz
Collector capacitance at f = 1 MHz I_E = I_e = 0; V_{CB} = 10 V	C_c	typ.	125	pF
Switching times (in line deflection circuit) L_B = 6 µH; $-V_{IM}$ = 4 V; I_{CM} = 4,5 A; $I_{B(end)}$ = 1,4 A ($-dI_B/dt$ = 0,6 A/µs)	t_f	typ.	0,7	µs
	t_s	typ.	6,5	µs

* Turn-off current.

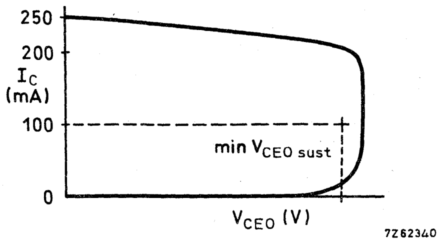


Fig. 2 Oscilloscope display for $V_{CEOsust}$.

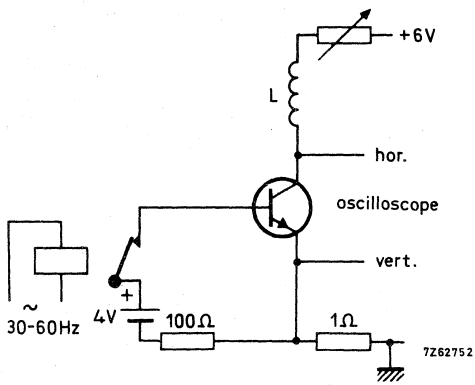


Fig. 3 Test circuit for $V_{CEOsust}$.

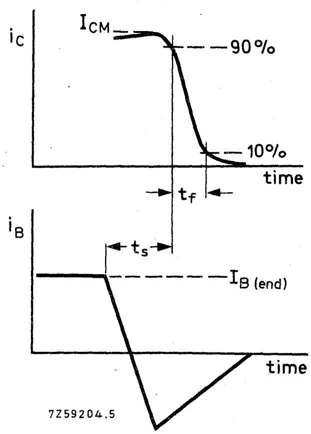


Fig. 4 Switching times waveforms.

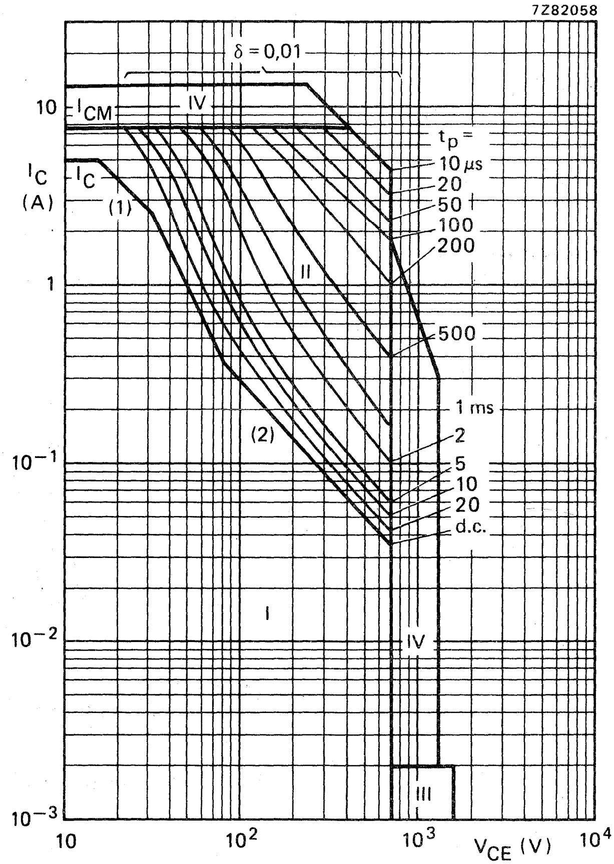


Fig. 5 Safe Operating ARea with the transistor forward biased. $T_{mb} \leqslant 25$ °C.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.
III Repetitive pulse operation in this region is permissible, provided $V_{BE} \leqslant 0$ V; $t_p \leqslant 20$ μs; $\delta \leqslant 0,25$.
IV Transient I_C/V_{CE} limit, e.g. during picture tube flashover (less than 10 line periods);
for V_{CE} less than 700 V then t_p less than or equal to 25 μs
for V_{CE} greater than 700 V then t_p less than 5 μs.

Notes
1. $P_{tot\,max}$ and $P_{peak\,max}$ lines.
2. Second-breakdown limits (independent of temperature).

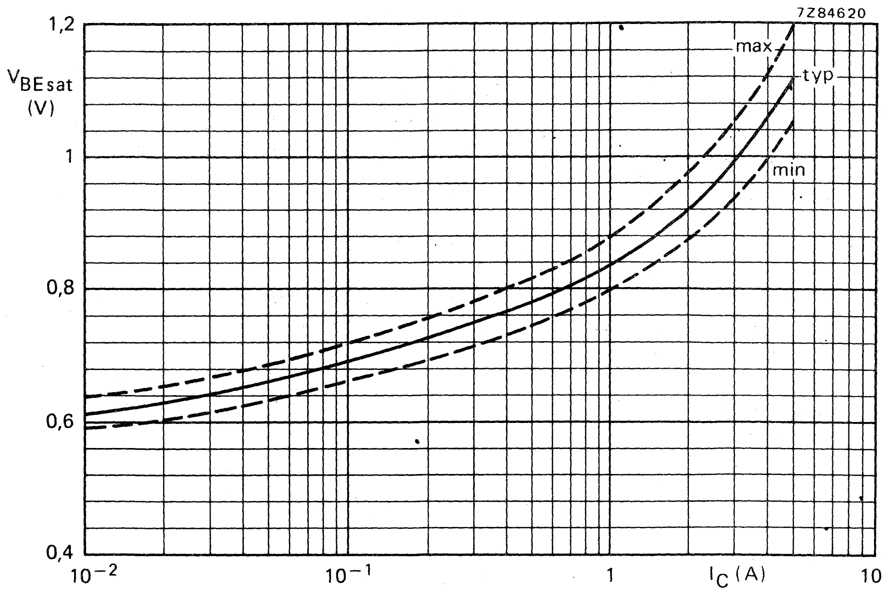


Fig. 6a Base-emitter saturation voltage. $I_C/I_B = 2$; $T_j = 25\ ^oC$.

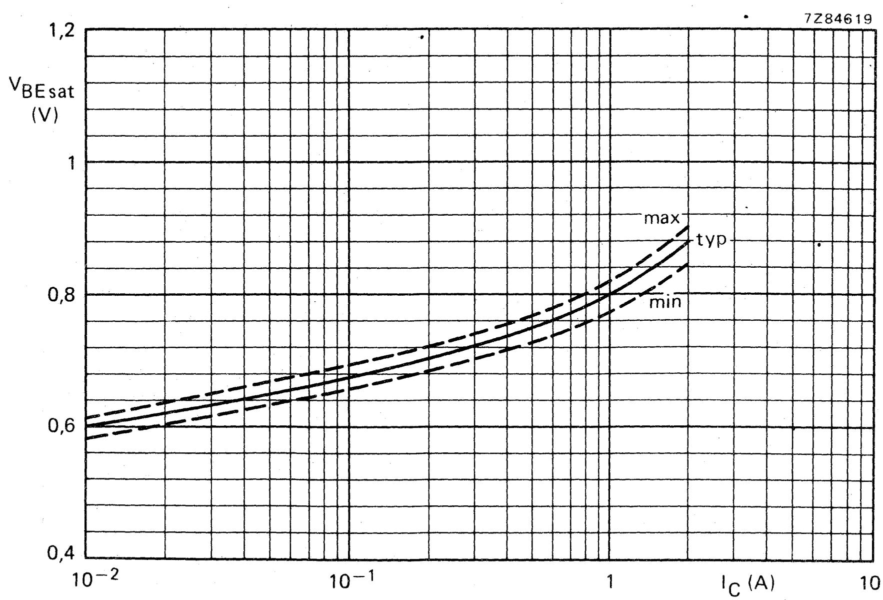


Fig. 6b Base-emitter saturation voltage $I_C/I_B = 4$; $T_j = 25\ ^oC$.

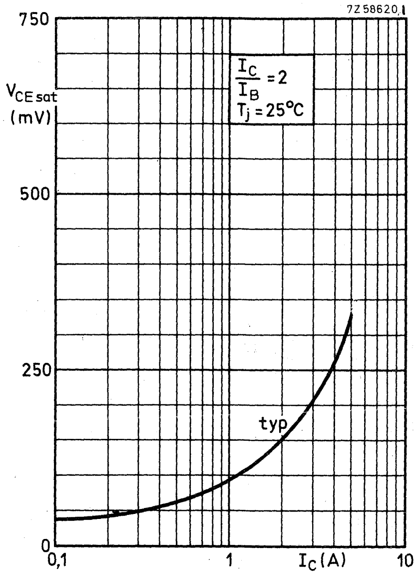


Fig. 7 Collector-emitter saturation voltage.

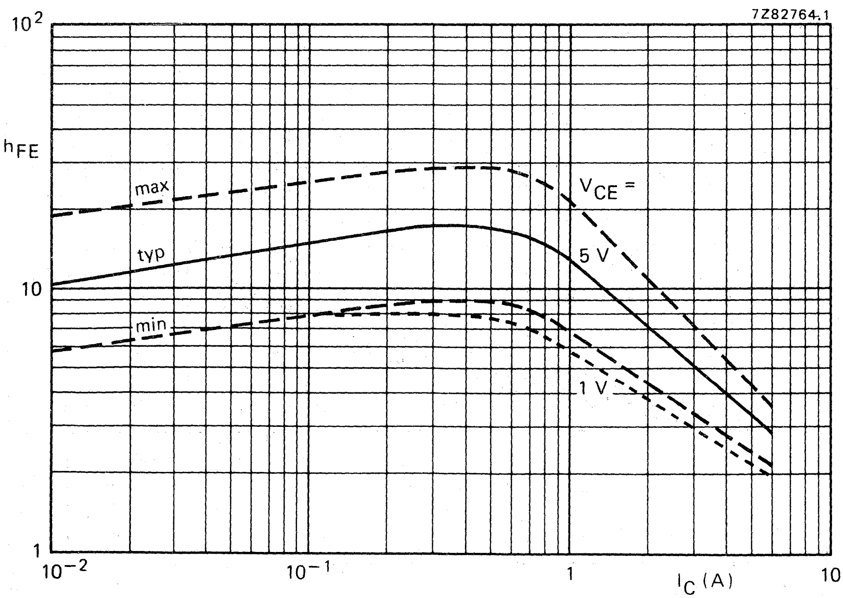


Fig. 8 D.C. current gain at V_{CE} = 5 V; T_j = 25 °C; ---- at V_{CE} = 1 V.

APPLICATION INFORMATION - HORIZONTAL DEFLECTION CIRCUIT WITH BU208A *

In designing horizontal deflection circuits, allowance has to be made for component and operating spreads in order not to exceed any Absolute Maximum Rating. Extensive analysis has shown that, for the peak collector current and the collector-emitter voltage of the output transistor, the total allowance need not be higher than 25%, and the following recommended base-drive and heatsink conditions are based on this figure.

To simplify the presentation, the design curves given refer to nominal conditions. Where the collector current will be modulated by the E-W correction circuit, the average value of the peak collector current applies provided the modulation is less than ± 10%.

To obtain a short fall time and minimum turn-off dissipation with a high-voltage transistor, the storage time must be sufficiently long and, during turn-off, the negative base-emitter voltage must be sufficiently high. Both requirements can easily be realized by including a small coil in series with the base of the output transistor. However, to reduce base current variations, a series base resistor is also added to most designs. This has the disadvantage of reducing the energy in the base inductance during turn-off, which in turn reduces the negative base-emitter voltage and with large resistor values may lead to an insufficient negative voltage for correct device turn-off. This can be improved by shunting the base resistor by a diode and/or a capacitor. Instead of giving various detailed base circuits based on these considerations, it is a more direct approach to specify the recommended $-di_B/dt$, see Fig. 11.

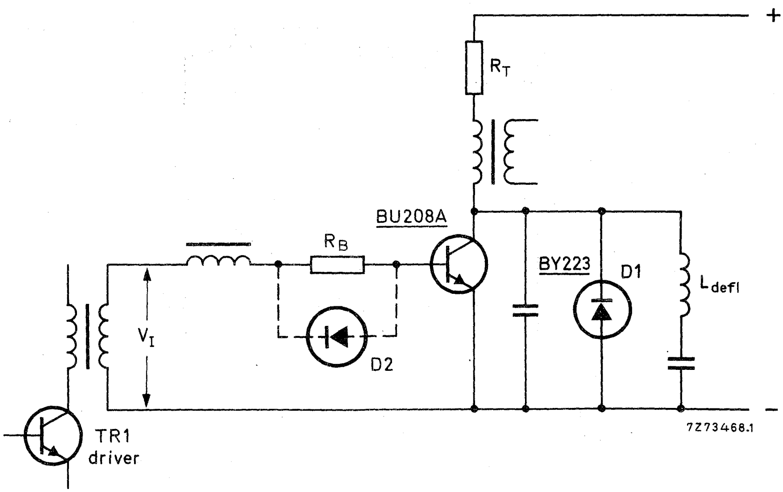


Fig. 9 Simplified horizontal deflection circuit.

* Detailed Application Information is available.

APPLICATION INFORMATION (continued)

The maximum transistor dissipation largely depends on the tolerances in the drive conditions. The dissipation given in Fig. 12 allows for base current and $-dI_B/dt$ tolerances in the order of ± 20%. The curve applies for a limit-case transistor at a mounting base temperature of 100 °C.

The thermal resistance for the heatsink can be calculated from $R_{th\ mb\text{-}a} = \frac{100 - T_{amb\ max}}{P_{tot\ max}}$ in which $T_{amb\ max}$ is the maximum ambient temperature of the transistor. In order to assure a value of thermal resistance at which thermal stability is ascertained, the minimum value for T_{amb} in the above equation is 45 °C.

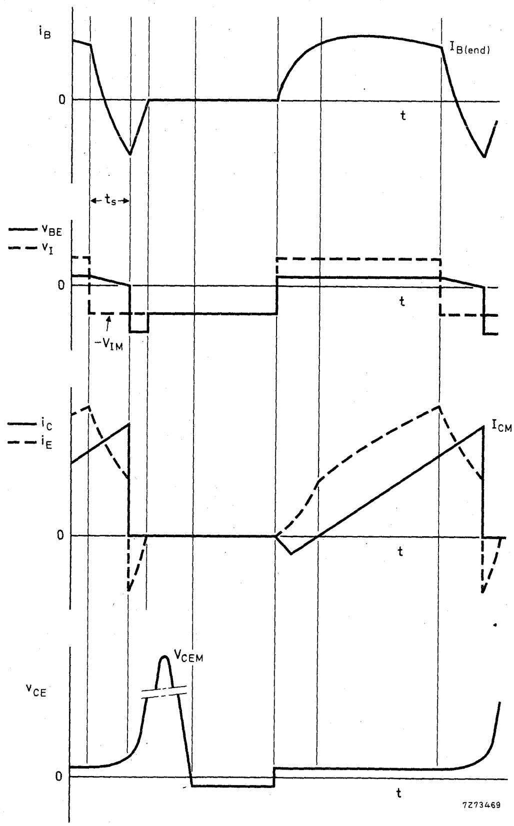


Fig. 10 Fundamental waveforms.

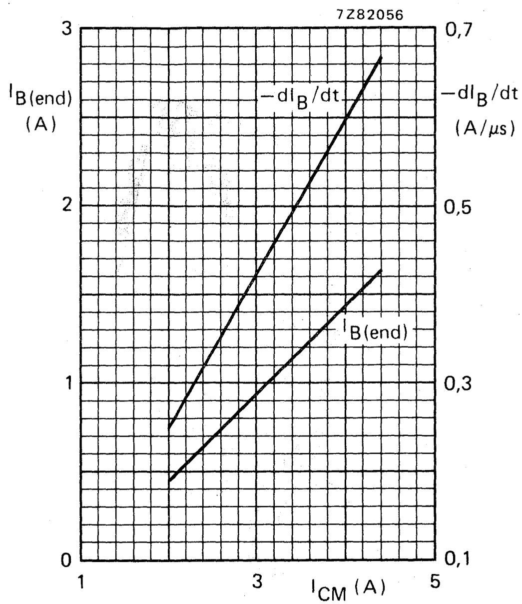


Fig. 11
Nominal end value of the base current and its rate of fall during turn-off as a function of nominal peak collector current to obtain, for a typical transistor, the recommended storage time of 6,5 µs. (During the storage time and the decay time of the collector current the negative turn-off drive voltage ($-V_{IM}$) must be > 4 V.)

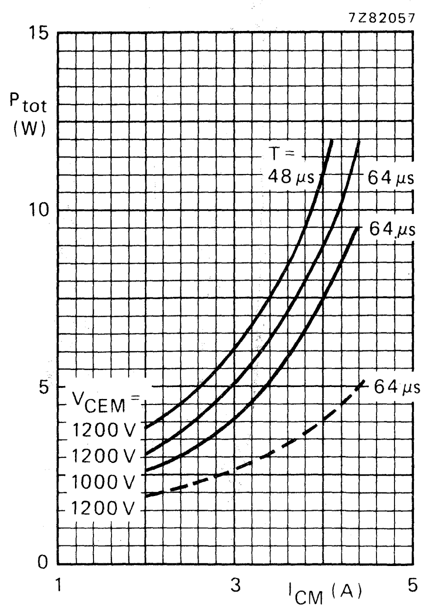


Fig. 12
Continuous lines are maximum values; T_{mb} = 100 °C; δ = 0,18; base tolerances ± 20%.
Total dissipation of a limit-case transistor under maximum operating conditions for 625 and 819 lines (T_{mb} = 100 °C).

The dashed line gives the total dissipation of a typical transistor under nominal conditions (T_{mb} = 50 °C).

SILICON DIFFUSED POWER TRANSISTORS

High-voltage, high-speed switching n-p-n power transistors in TO-3 envelopes, intended for use in the switched-mode power supply of 90° and 110° colour television receivers.

QUICK REFERENCE DATA

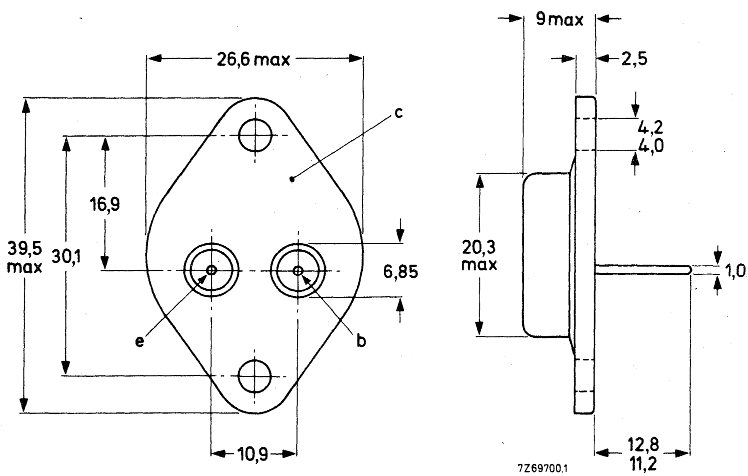
			BU326	BU326A	
Collector-emitter voltage (V_{BE} = 0; peak value)	V_{CESM}	max.	800	900	V
Collector-emitter voltage (open base)	V_{CEO}	max.	375	400	V
Collector current (d.c.)	I_C	max.	6		A
Collector current (peak value; $t_p < 2$ ms)	I_{CM}	max.	8		A
Total power dissipation up to T_{mb} = 50 °C	P_{tot}	max.	60		W
Collector-emitter saturation voltage I_C = 2,5 A; I_B = 0,5 A	V_{CEsat}	<	1,5		V
Fall time I_{Con} = 2,5 A; I_{Bon} = 0,5 A; $-I_{Boff}$ = 1 A	t_f	typ.	0,3		µs

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.



See also chapters Mounting instructions and Accessories.

RATINGS

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

			BU326	BU326A	
Collector-emitter voltage (V_{BE} = 0; peak value)	V_{CESM}	max.	800	900	V
Collector-emitter voltage (open base)	V_{CEO}	max.	375	400	V
Collector current (d.c.)	I_C	max.	6		A
Collector current (peak value; $t_p < 2$ ms)	I_{CM}	max.	8		A
Base current (d.c.)	I_B	max.	2		A
Base current (peak value)	I_{BM}	max.	3		A
Reverse base current (d.c. or average over any 20 ms period)	$-I_{B(AV)}$	max.	0,1		A
Reverse base current (peak value; turn-off current)	$-I_{BM}$	max.	3		A
Total power dissipation up to T_{mb} = 50 °C	P_{tot}	max.	60		W
Storage temperature	T_{stg}		−65 to + 150		°C
Junction temperature	T_j	max.	150		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,65	°C/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current *				
$V_{BE} = 0$; $V_{CEM} = V_{CESMmax}$	I_{CES}	<	1	mA
$V_{BE} = 0$; $V_{CEM} = V_{CESMmax}$; T_j = 125 °C	I_{CES}	<	2	mA
Emitter cut-off current				
$I_C = 0$; V_{EB} = 10 V	I_{EBO}	<	10	mA
Saturation voltages				
I_C = 2,5 A; I_B = 0,5	V_{CEsat}	<	1,5	V
	V_{BEsat}	<	1,4	V
I_C = 4 A; I_B = 1,25 A	V_{CEsat}	<	3	V
	V_{BEsat}	<	1,6	V
Collector-emitter sustaining voltage (see Figs 2 and 3)				
$I_{Boff} = 0$; I_C = 0,1 A; L = 25 mH BU326	$V_{CEOsust}$	>	375	V
BU326A	$V_{CEOsust}$	>	400	V
D.C. current gain				
I_C = 0,6 A; V_{CE} = 5 V	h_{FE}	typ.	30	
Transition frequency at f = 1 MHz				
I_C = 0,2 A; V_{CE} = 10 V	f_T	typ.	6	MHz

* Measured with a half sine-wave voltage (curve tracer).

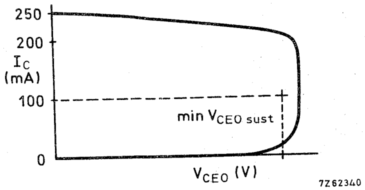


Fig. 2 Oscilloscope display for $V_{CEOsust}$.

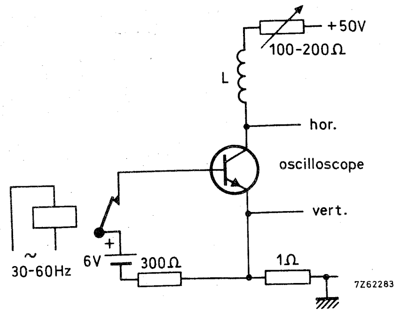


Fig. 3 Test circuit for $V_{CEOsust}$.

Switching times (see Figs 4 and 5)
I_{Con} = 2,5 A; V_{CC} = 250 V;
I_{Bon} = 0,5 A; $-I_{Boff}$ = 1 A

Turn-on time	t_{on}	typ.	0,3 μs
		<	0,5 μs
Turn-off time ($t_{off} = t_s + t_f$)			
Storage time	t_s	typ.	2 μs
		<	3,5 μs
Fall time	t_f	typ.	0,3 μs
Fall time at T_{mb} = 95 °C	t_f	<	1 μs

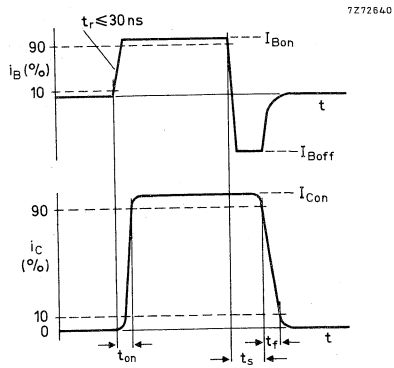
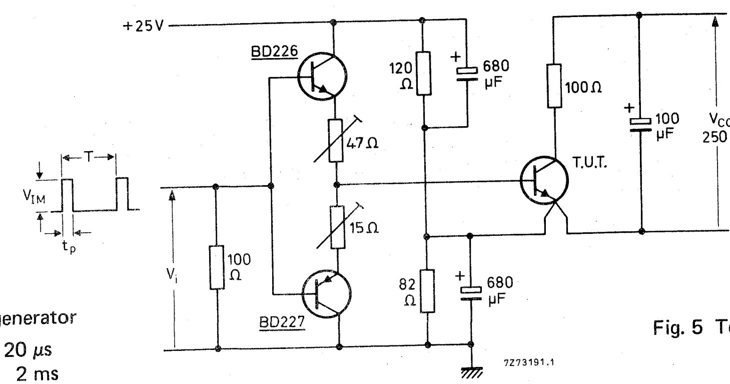


Fig. 4 Waveforms.



Pulse generator
t_p = 20 μs
T = 2 ms
V_{IM} = 15 V

Fig. 5 Test circuit.

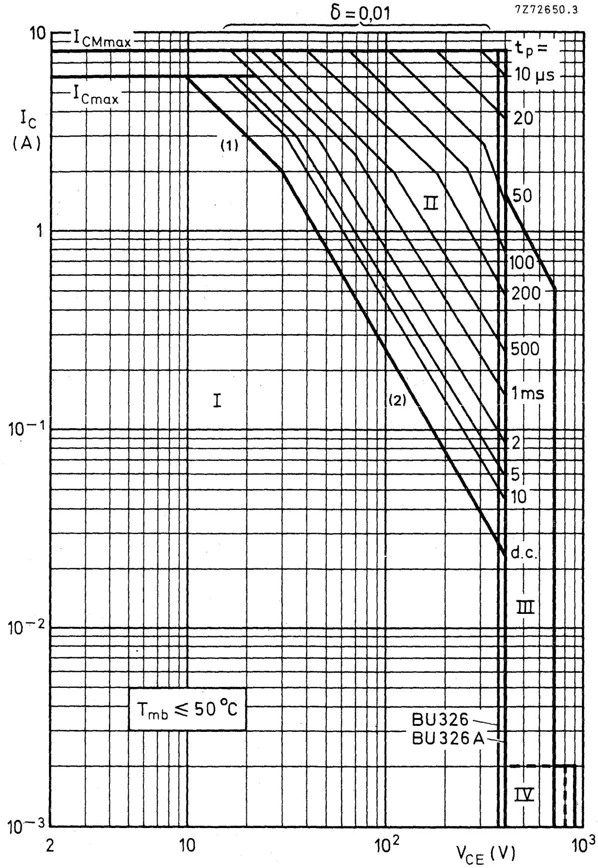


Fig. 6 Safe Operating ARea.

I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation
III Area of permissible operation during turn-on in single-transistor converters, provided $R_{BE} \leqslant 100\ \Omega$ and $t_p \leqslant 0{,}6\ \mu s$
IV Repetitive pulse operation in this region is permissible, provided $V_{BE} \leqslant 0$ and $t_p \leqslant 2$ ms

(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.
(2) Second-breakdown limits (independent of temperature).

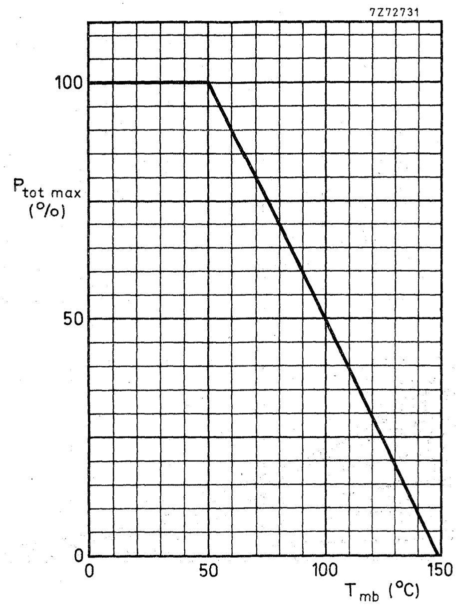


Fig. 7 Power derating curve.

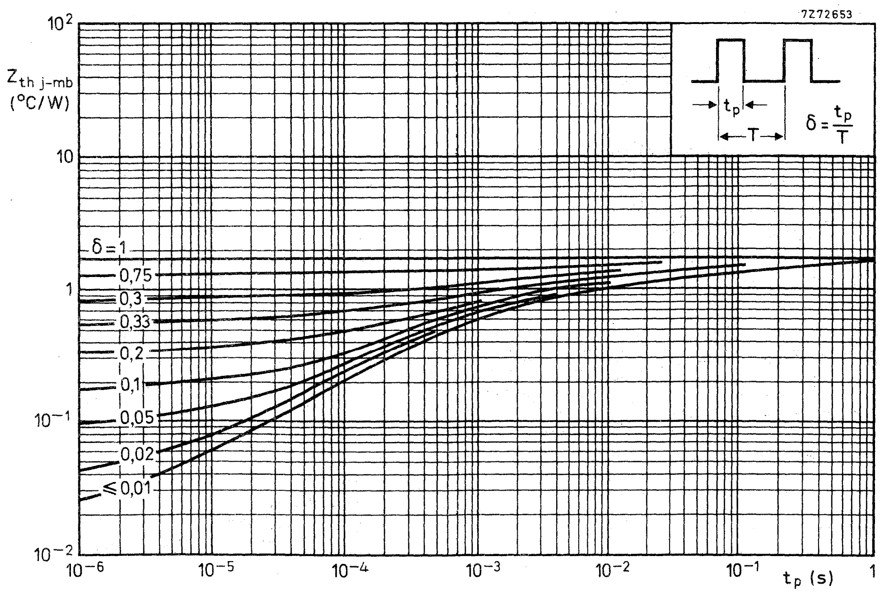


Fig. 8 Pulse power rating chart.

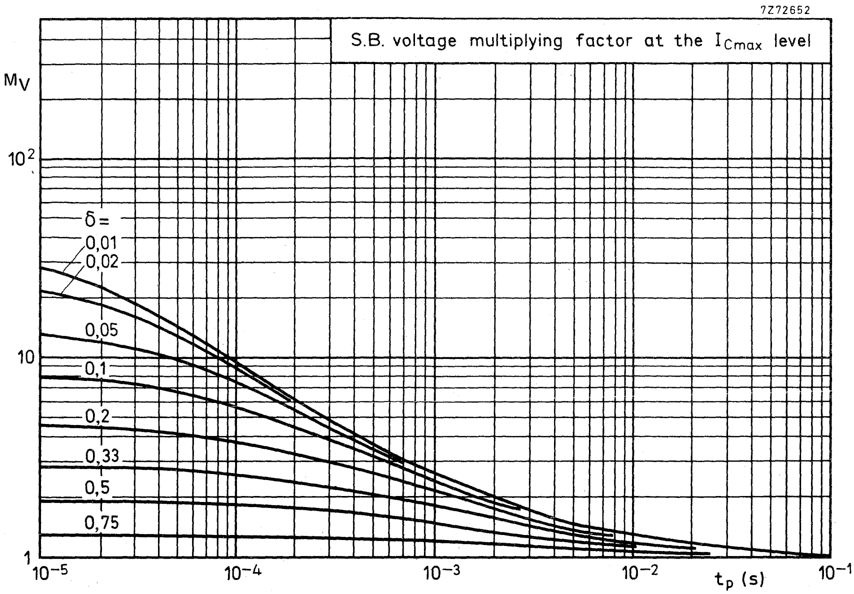


Fig. 9 S.B. voltage multiplying factor at the I_{Cmax} level.

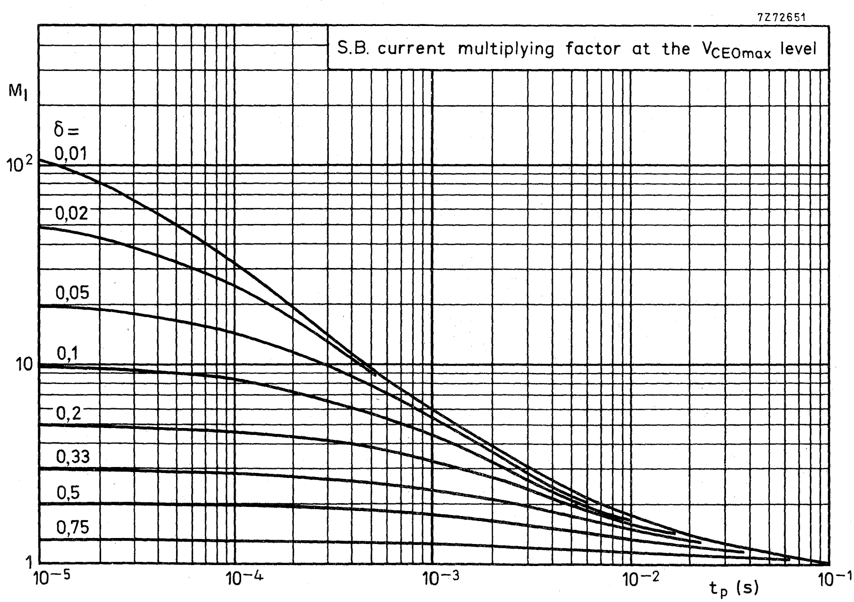


Fig. 10 S.B. current multiplying factor at the V_{CEOmax} level.

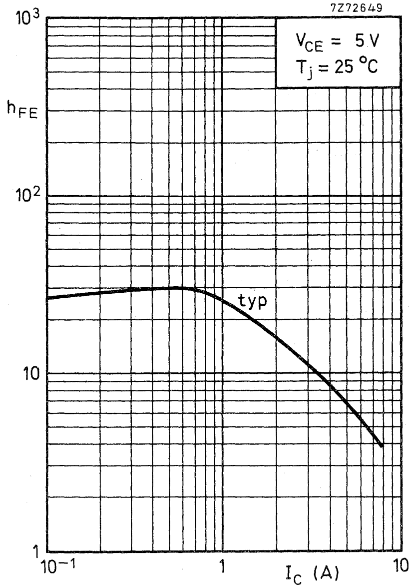


Fig. 11 D.C. current gain.

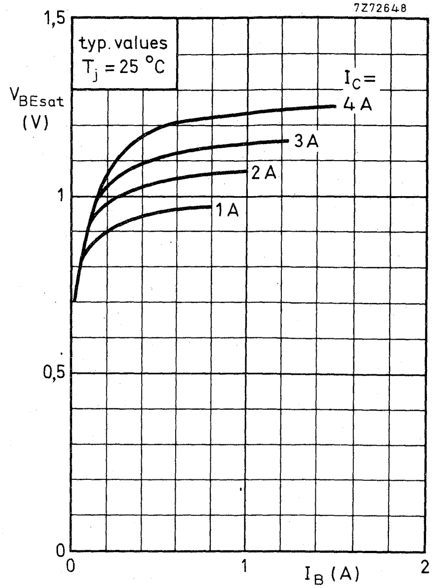


Fig. 12 Base-emitter saturation voltage.

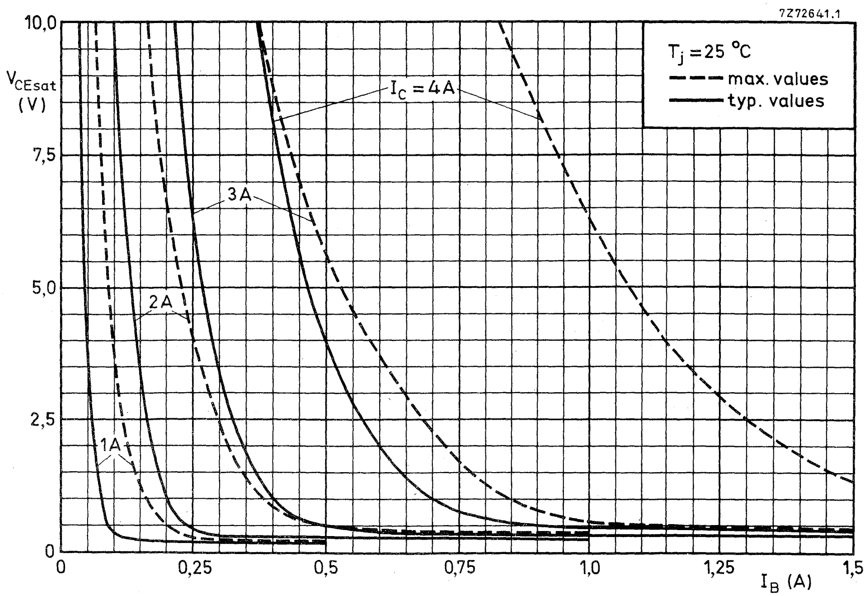


Fig. 13 Collector-emitter saturation voltage.

APPLICATION INFORMATION BU326A (detailed information on request)

Important factors in the design of SMPS circuits are the power losses and heatsink requirements of the supply output transistor and the base drive conditions during turn-off. In SMPS circuits for CTV receivers the duty factor of the collector current generally varies between 0,35 and 0,6.

The operating frequency lies between 15 kHz and 35 kHz and the shape of the collector current varies from rectangular in a forward converter to a sawtooth in a flyback circuit.

As the BU326A will mainly be used in flyback converters the information on optimum base drive and device dissipation given in the graphs on page 10 is concentrated on this application. In these figures I_{CM} represents the highest repetitive peak collector current that can occur in the given circuit, e.g. during overload.

The total power dissipation for a limit-case transistor is given in Fig. 18 which applies for a mounting base temperature of 100 °C. The required thermal resistance for the heatsink can be calculated from

$$R_{th\ mb\text{-}a\ max}{}^{*} = \frac{T_{mb\ max} - T_{amb\ max}}{P_{tot}}$$

* Including additional thermal resistances resulting from mounting hardware.

To ensure thermal stability the thermal resistance of the heatsink used must not exceed the values plotted in Fig. 19.

A practical SMPS output circuit for an output power in the order of 180 W is given in Fig. 15.

At a collector current of 2,5 A and a base current of 0,25 A in this circuit the following turn-off times can be expected.

			T_{mb} = 25 °C		= 100 °C	
Storage time	t_s	typ.	1,4	<	20	μs
Fall time	t_f	typ.	0,15	<	0,5	μs

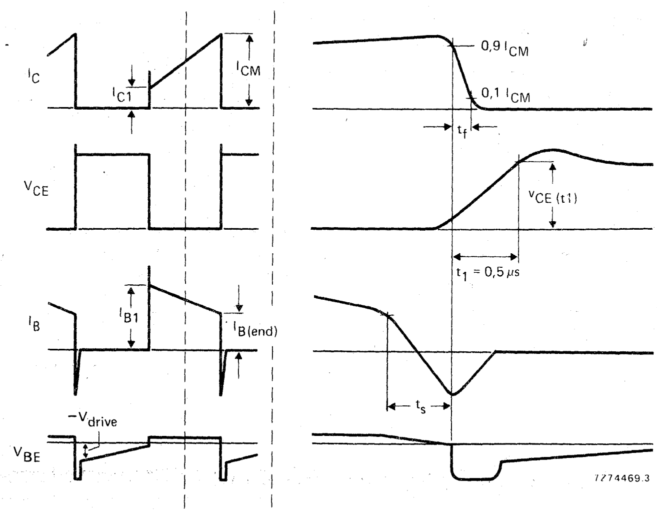


Fig. 14 Relevant waveforms of switching transistor.

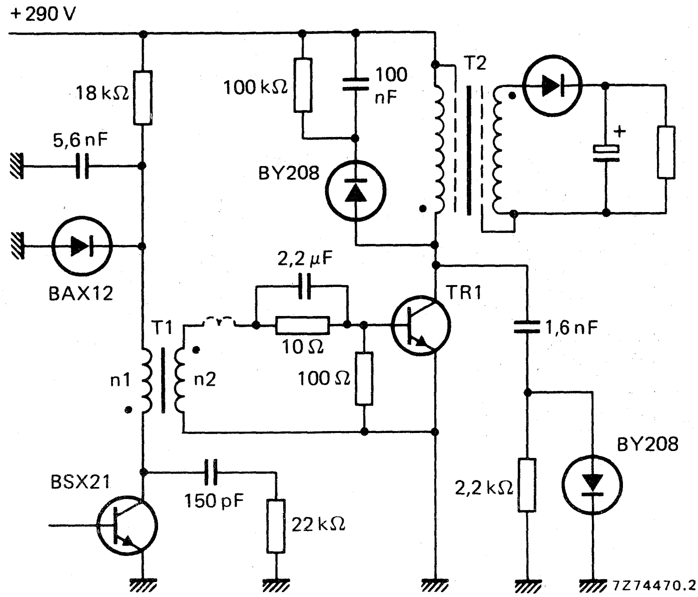


Fig. 15 Practical SMPS output circuit.

TR1 = BU326A
T1 (driver transformer): Core U20; n1 = 400 turns; n2 = 25 turns
total inductance in base circuit ≈ 4,5 μH
T2 (output transformer): L_p = 6 mH
$v_{CE(t1)} < 500$ V (see Fig. 14)

Next page:

Fig. 16 Recommended nominal "end" value of the base current versus maximum peak collector current.

Fig. 17 Minimum required base inductance and recommended negative drive voltage versus maximum peak collector current.

Fig. 18 Maximum total power dissipation of a limit-case transistor if the base current is chosen in accordance with Fig. 16.

Fig. 19 Maximum permissible thermal resistance of the heatsink versus maximum peak collector current to ensure thermal stability.

Note: For all curves the duty factor δ = 0,5, as shown in Fig. 14.

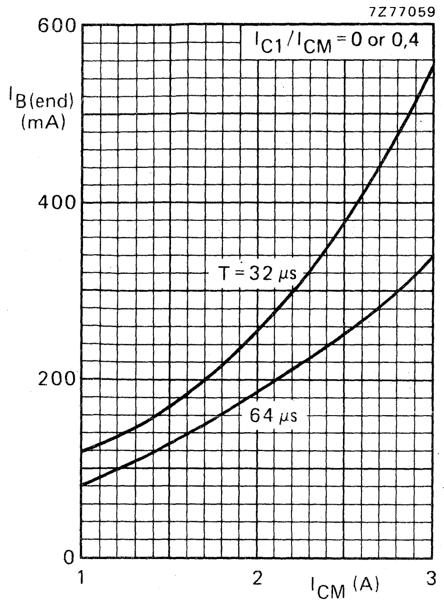


Fig. 16.

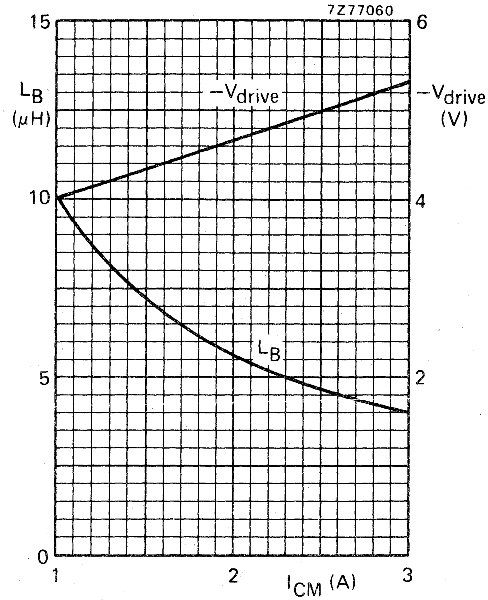


Fig. 17.

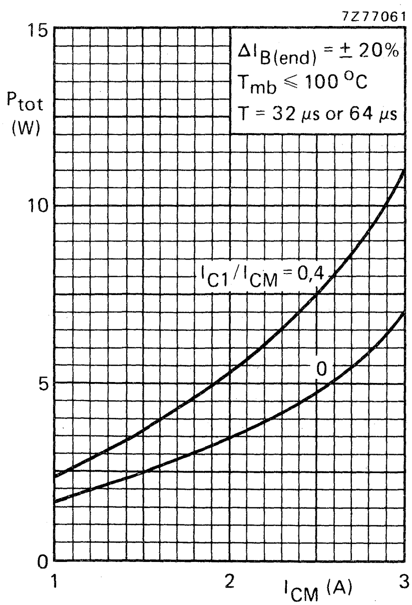


Fig. 18.

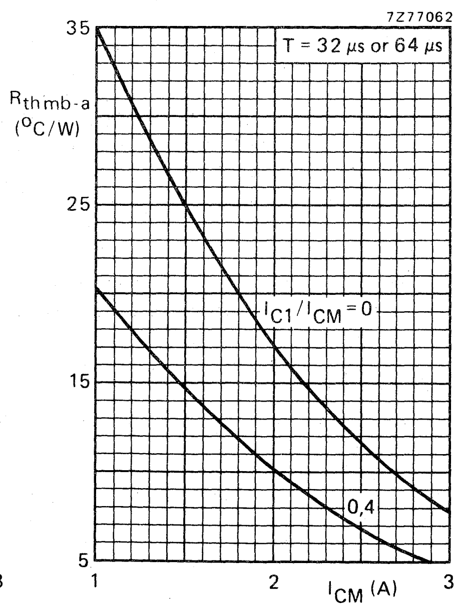


Fig. 19.

SILICON DIFFUSED POWER TRANSISTORS

High voltage, high speed switching n-p-n power transistor in plastic SOT-93 envelope, intended for use in the switched-mode power supply of 90° and 110° colour television receivers.

QUICK REFERENCE DATA

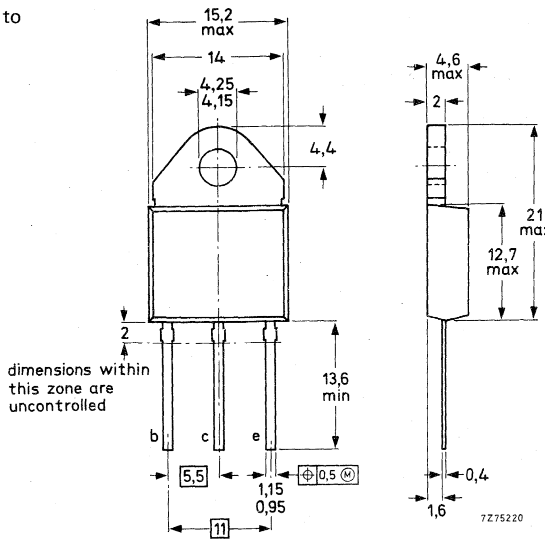
			BU426	426A	433	
Collector-emitter voltage (V_{BE} = 0; peak value)	V_{CESM}	max.	800	900	800	V
Collector-emitter voltage (open base)	V_{CEO}	max.	375	400	375	V
Collector current (d.c.)	I_C	max.		6		A
Collector current (peak value) t_p = 2 ms	I_{CM}	max.		10		A
Total power dissipation up to T_{mb} = 73 °C	P_{tot}	max.		70		W
Collector-emitter saturation voltage I_C = 2,5 A; I_B = 0,5 A	V_{CEsat}	<		1,5		V
Fall time I_{Con} = 2,5 A; I_{Bon} = 0,5 A; $-I_{Boff}$ = 1 A	t_f	typ.	0,3	0,3	0,45	μs

MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT-93.

Collector connected to mounting base



See also chapters Mounting instructions and Accessories.

RATINGS

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

			BU426	426A	433	
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max.	800	900	800	V
Collector-emitter voltage (open base)	V_{CEO}	max.	375	400	375	V
Collector current (d.c.)	I_C	max.		6		A
Collector current (peak value) $t_p < 2$ ms	I_{CM}	max.		10		A
Base current (d.c.)	I_B	max.		2		A
Base current (peak value)	I_{BM}	max.		3		A
Reverse base current (d.c. or average over any 20 ms period)	$-I_{B(AV)}$	max.		100		mA
Reverse base current (peak value)*	$-I_{BM}$	max.		3		A
Total power dissipation up to T_{mb} = 73 °C	P_{tot}	max.		70		W
Storage temperature	T_{stg}			−65 to + 150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,1	°C/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current **				
V_{CEM} = 900 V; V_{BE} = 0	I_{CES}	<	1	mA
V_{CEM} = 900 V; V_{BE} = 0; T_j = 125 °C	I_{CES}	<	2	mA
D.C. current gain				
I_C = 0,6 A; V_{CE} = 5 V; BU426; BU426A	h_{FE}	typ.	30	
		<	60	
I_C = 0,6 A; V_{CE} = 5 V; BU433	h_{FE}	typ.	40	
Transition frequency at f = 1 MHz				
I_C = 0,2 A; V_{CE} = 10 V	f_T	typ.	6	MHz

* Turn-off current.
** Measured with a half sine-wave voltage (curve tracer).

CHARACTERISTICS (continued)

T_j = 25 °C unless otherwise specified

Emitter cut-off current			
I_C = 0; V_{EB} = 10 V	I_{EBO}	<	10 mA
Saturation voltages			
I_C = 2,5 A; I_B = 0,5 A	V_{CEsat}	<	1,5 V
	V_{BEsat}	<	1,4 V
I_C = 4 A; I_B = 1,25 A	V_{CEsat}	<	3 V
	V_{BEsat}	<	1,6 V
Collector-emitter sustaining voltage			
I_C = 100 mA; I_{Boff} = 0; L = 25 mH; BU426; BU433	$V_{CEOsust}$	>	375 V
I_C = 100 mA; I_{Boff} = 0; L = 25 mH; BU426A	$V_{CEOsust}$	>	400 V

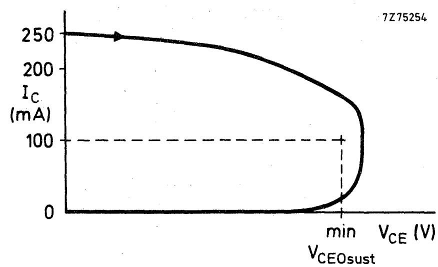


Fig. 2 Oscilloscope display for $V_{CEOsust}$.

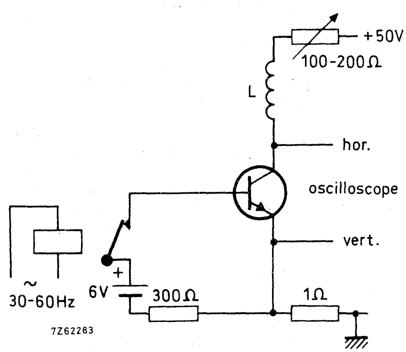


Fig. 3 Test circuit for $V_{CEOsust}$.

CHARACTERISTICS (continued)

Switching times (between 10% and 90% levels)

I_{Con} = 2,5 A; V_{CC} = 250 V

I_{Bon} = 0,5 A; $-I_{Boff}$ = 1 A

Turn-on time			t_{on}	typ.	0,5 μs
				<	0,6 μs
Turn-off time ($t_{off} = t_s + t_f$)	Storage time		t_s	typ.	2 μs
				<	3,5 μs
	Fall time	BU426; 426A	t_f	typ.	0,3 μs
		BU433	t_f	typ.	0,45 μs
				<	0,7 μs
	Fall time, T_{mb} = 95 °C	BU433	t_f	typ.	0,7 μs
				<	1,0 μs
		BU426; 426A	t_f	<	0,75 μs

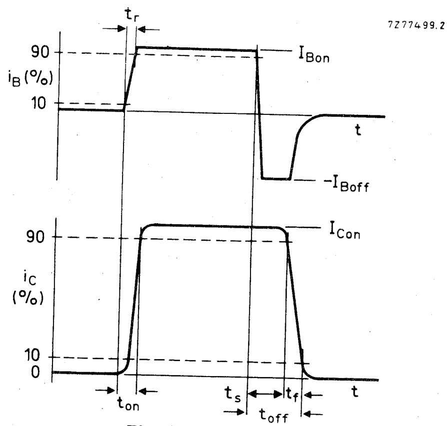


Fig. 4 Waveforms.

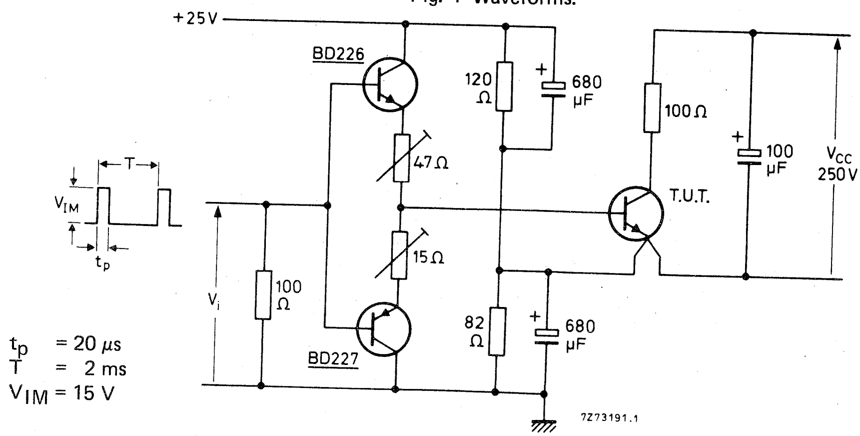


Fig. 5 Test circuit.

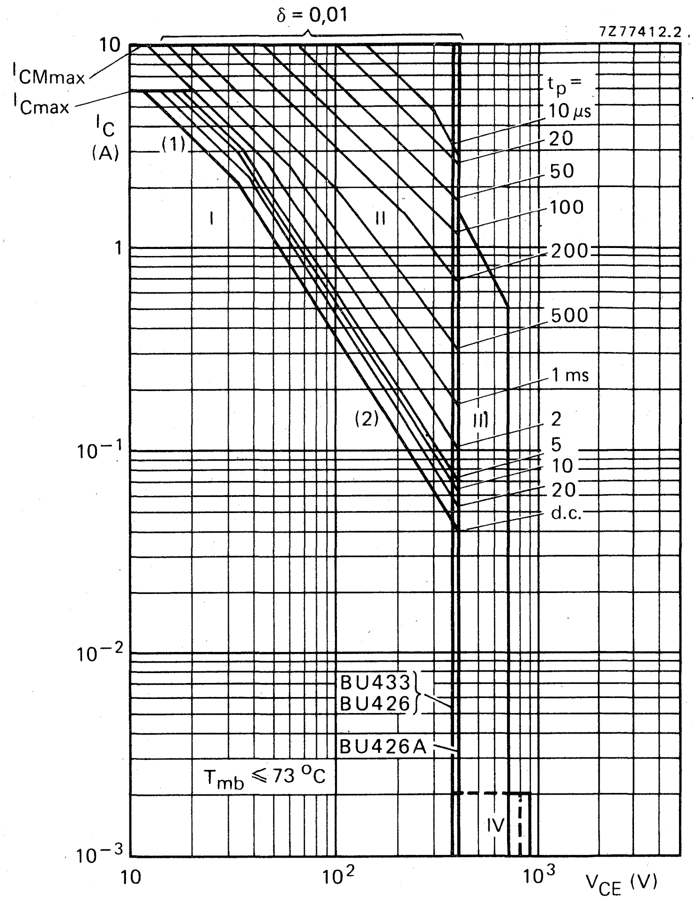


Fig. 6 Safe Operating ARea.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

III Area of permissible operation during turn-on in single-transistor converters, provided $R_{BE} \leqslant 100\ \Omega$ and $t_p \leqslant 0,6\ \mu s$.

IV Repetitive pulse operation in this region is permissible, provided $V_{BE} \leqslant 0$ and $t_p \leqslant 2$ ms.

(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.

(2) Second-breakdown limits (independent of temperature).

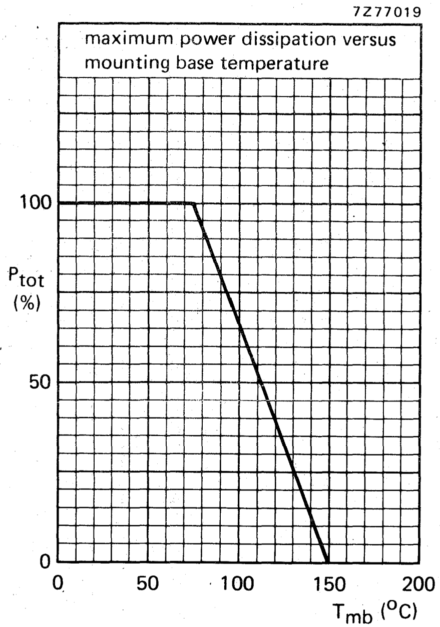


Fig. 7 Power derating curve.

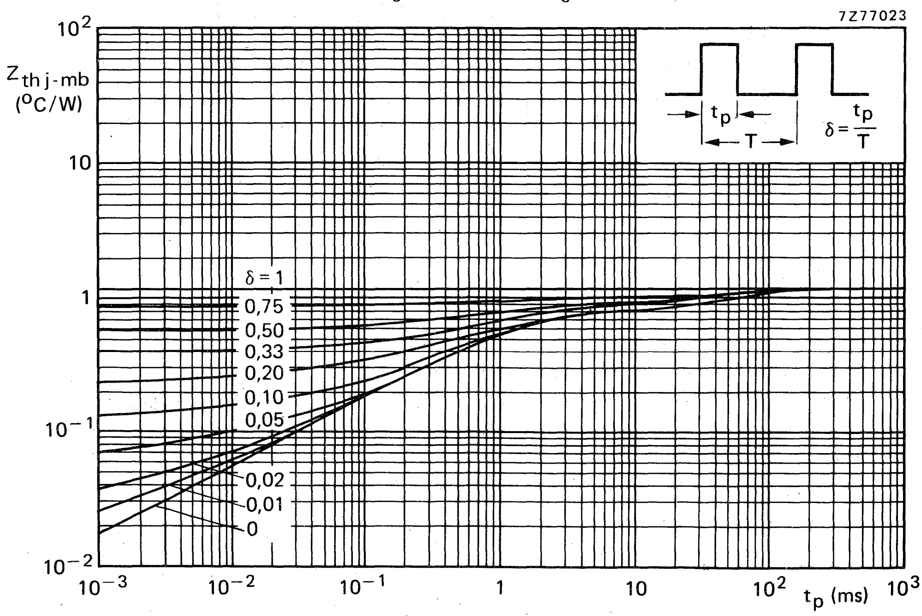


Fig. 8 Pulse power rating chart.

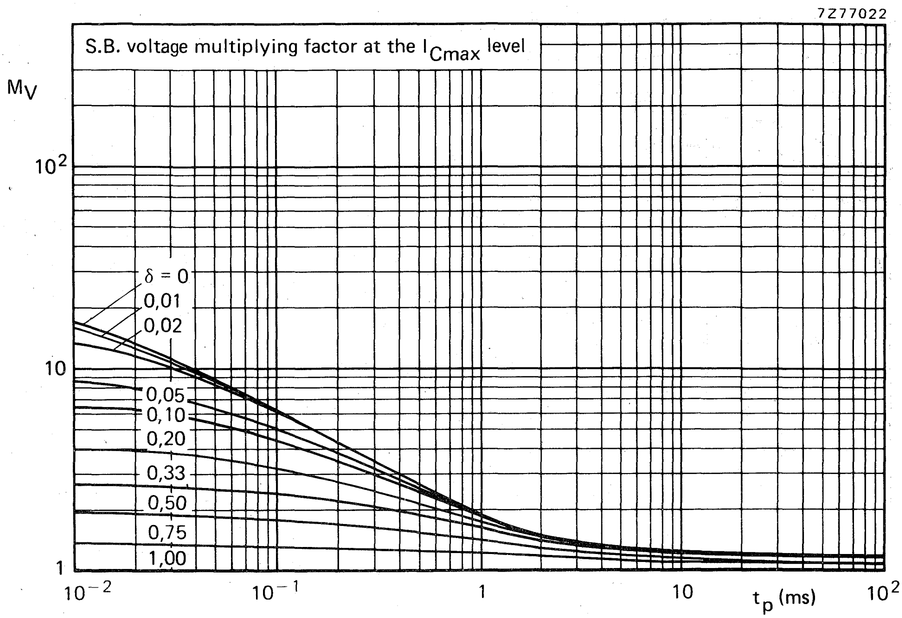


Fig. 9 S.B. voltage multiplying factor at the I_{Cmax} level.

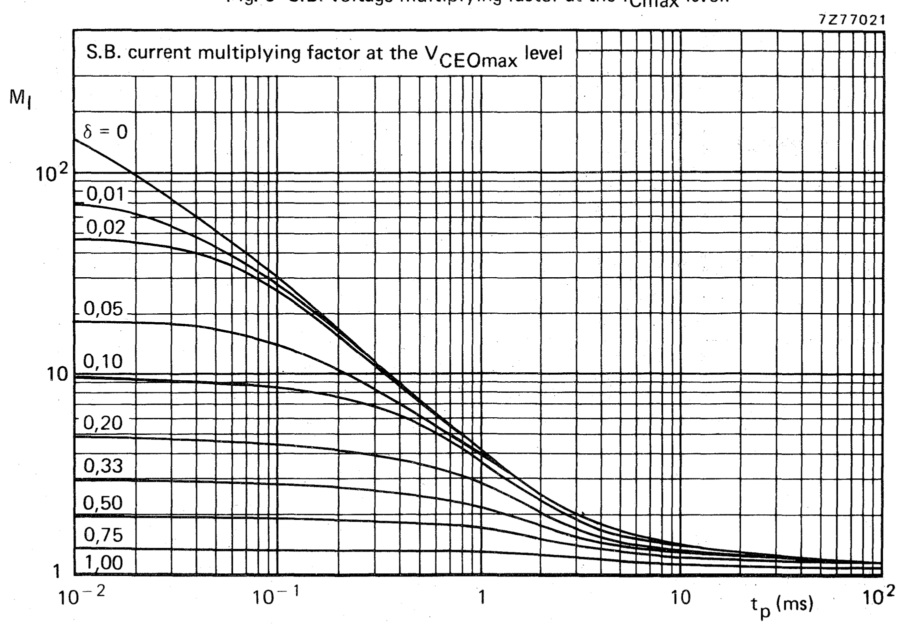


Fig. 10 S.B. current multiplying factor at the V_{CEOmax} level.

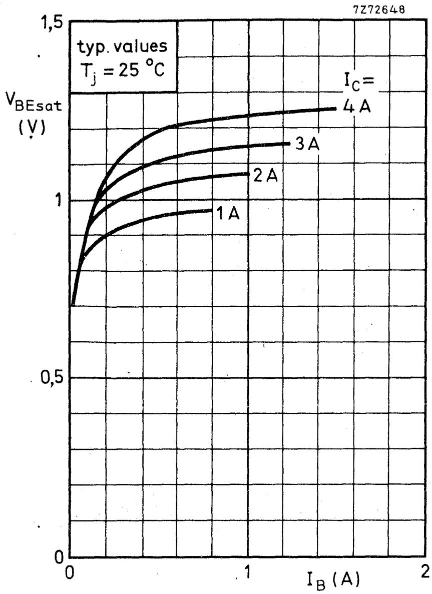


Fig. 11.

Fig. 11 Typical values. Base-emitter saturation voltage for BU426 and BU426A.

Fig. 12 D.C. current gain BU426 and BU426A.
T_j = 25 °C;
– – – – at V_{CE} = 5 V;
——— at V_{CE} = 1 V.

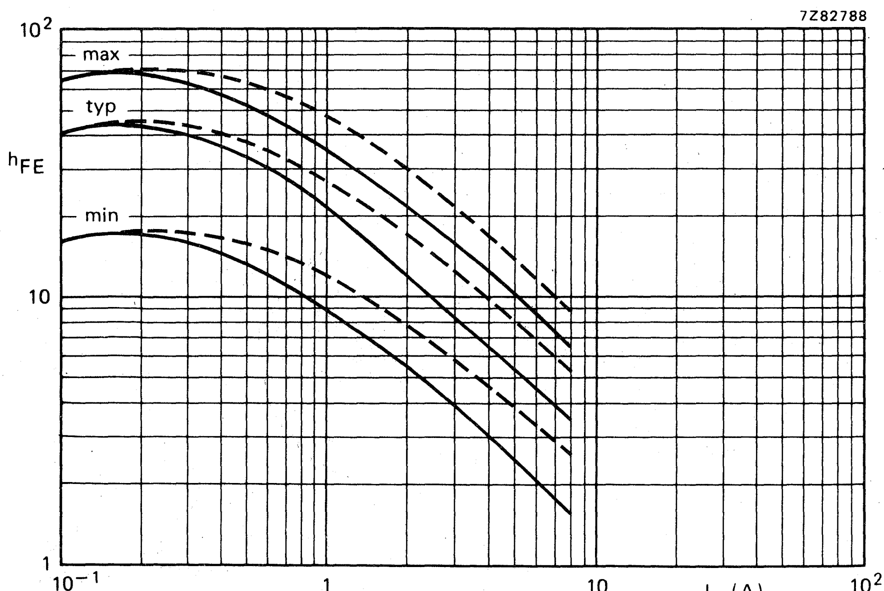


Fig. 12.

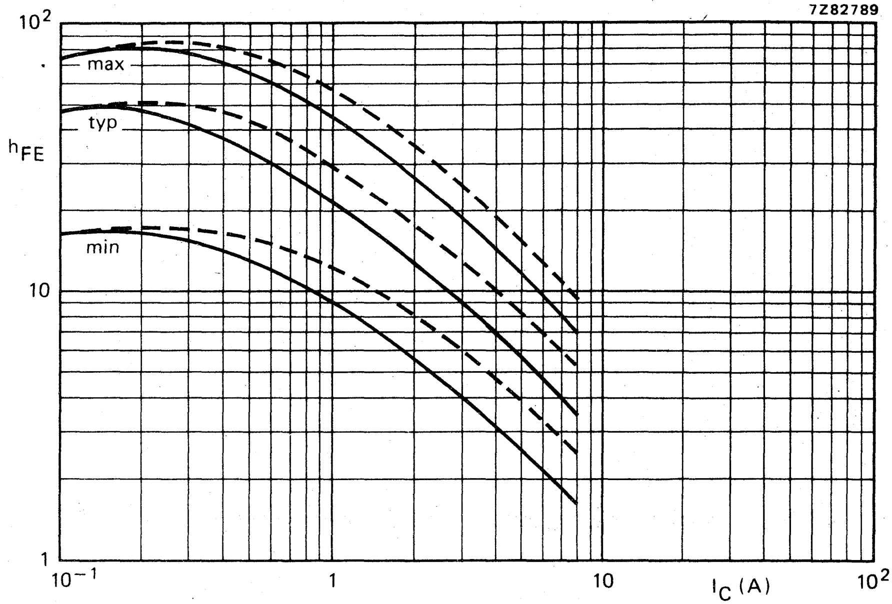


Fig. 13.

Fig. 13 D.C. current gain BU433;
T_j = 25 °C;
– – – – at V_{CE} = 5 V;
——— at V_{CE} = 1 V.

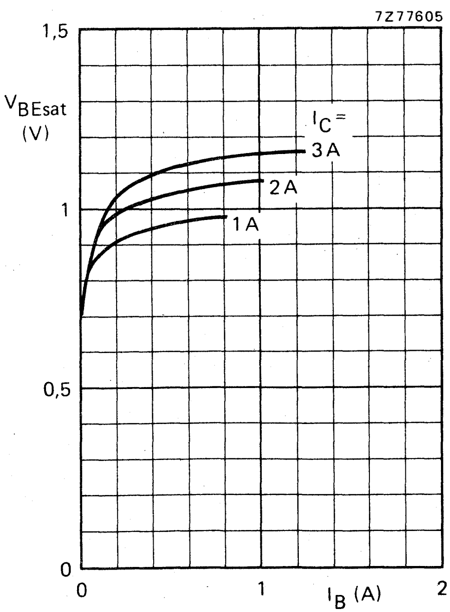


Fig. 14.

Fig. 14 Typical values. Base-emitter saturation voltage for BU433;
T_j = 25 °C.

APPLICATION INFORMATION (detailed information on request)

Important factors in the design of SMPS circuits are the power losses and heatsink requirements of the supply output transistor and the base drive conditions during turn-off. In SMPS circuits for CTV receivers the duty factor of the collector current generally varies between 0,35 and 0,6.

The operating frequency lies between 15 kHz and 35 kHz and the shape of the collector current varies from rectangular in a forward converter to a sawtooth in a flyback circuit.

All these variables influence the collector dissipation, so that a simple presentation of the design information is only possible if the information is restricted to the main application area of the relevant transistor type. Therefore, as the BU426 or BU426A will mainly be used in flyback converters and the BU433 in forward SMPS, the information of Figs 17 up to 22 is based on these applications:

The total power dissipation for a limit-case transistor BU426 or BU433 is given in Figs 19 and 22, which apply for a mounting base temperature of 100 °C. The required thermal resistance for the heatsink can be calculated from:

$$R_{th\ mb\text{-}a\ max}{}^{*} = \frac{T_{mb\ max} - T_{amb\ max}}{P_{tot}}$$

* Including additional thermal resistances resulting from mounting hardware.

To ensure thermal stability minimum value of T_{amb} in this equation is 40 °C. As indicated, the BU433 will mainly be used in (non-isolated) forward converters, where the turn-off losses are limited by the maximum collector emitter voltage (≈ 300-350 V). The rate-of-rise of the voltage during turn-off must be below 1000 V/μs. Application of this transistor in low-power flyback converters is also possible, provided that the rate-of-rise is limited to 500 V/μs. For the BU426(A) a rate-of-rise of 1000 V/μs is permissible. Practical SMPS output circuits for an output power in the order of 180 W are given in Figs 17 and 20. At a collector current of 2,5 A and a base current of 0,25 A in these circuits the following turn-off times can be expected.

		T_{mb} 25 °C	T_{mb} 100 °C
BU426 (426A)	Storage time t_s	typ. 1,4	< 2,0 μs
	Fall time t_f	0,15	< 0,5 μs
BU433	Storage time t_s	typ. 1,4	< 2,0 μs
	Fall time t_f	0,18	< 0,6 μs

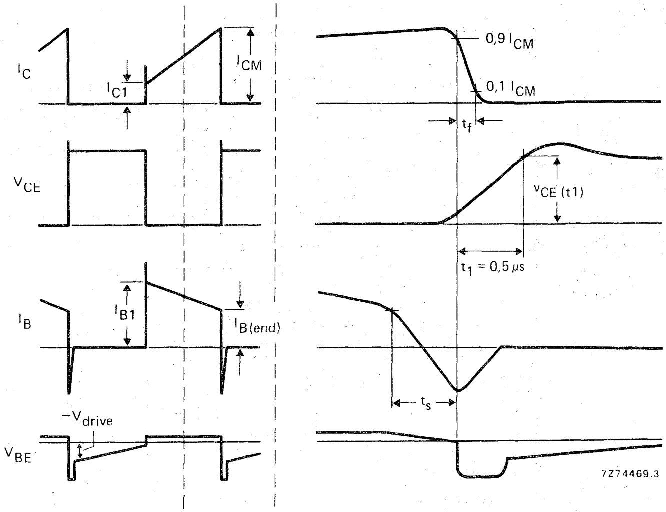


Fig. 15 Relevant waveforms of switching transistor.

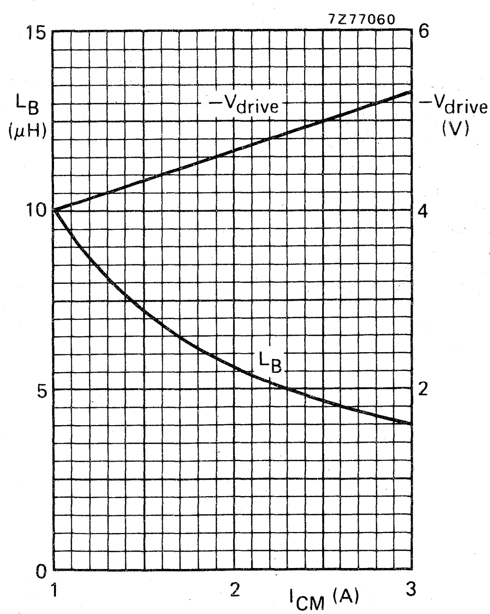


Fig. 16 Minimum required base inductance and recommended negative drive voltage versus maximum peak collector current.

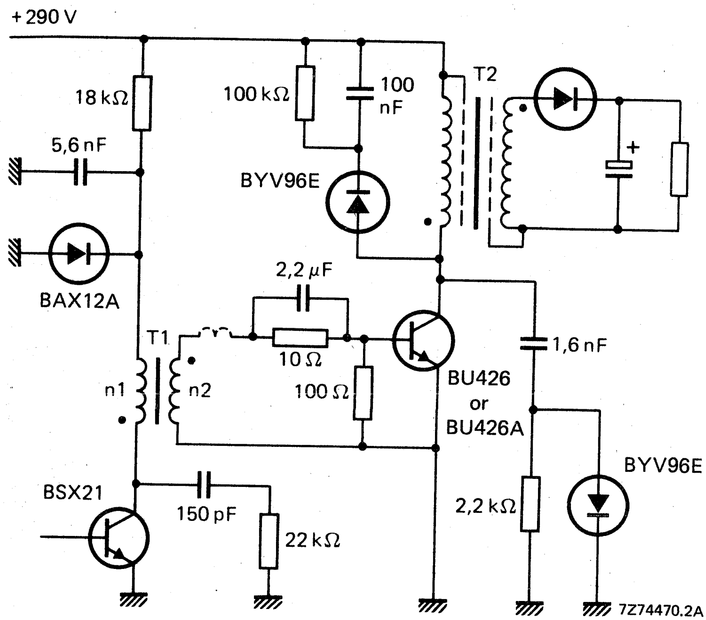


Fig. 17 Practical output circuit of a flyback SMPS of BU426 or BU426A.

T1 (driver transformer)
core U20; n1 = 400 turns
n2 = 25 turns

$L_{Btot} \approx 4,5\ \mu H$

T2 (output transformer)

$L_p = 6$ mH

$V_{CE(t1)} < 500$ V (see Fig. 15)

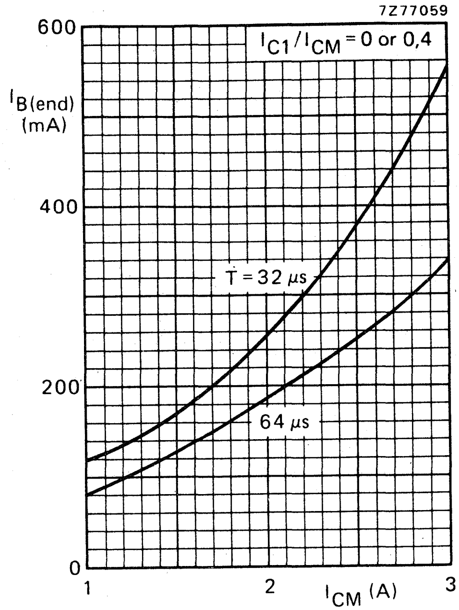


Fig. 18 Recommended nominal "end" value of the base current versus maximum peak collector current.

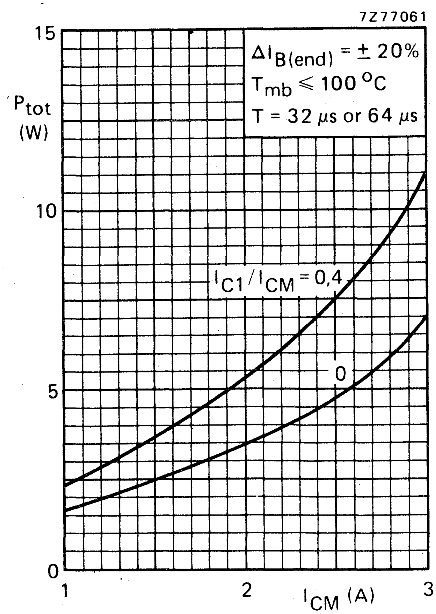


Fig. 19 Maximum total power dissipation of a limit-case transistor of the base current is chosen in accordance with Fig. 18.

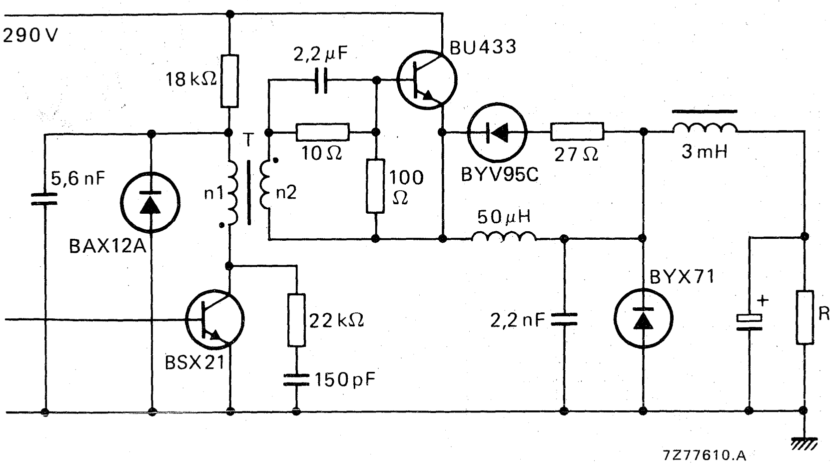


Fig. 20 Practical output circuit of a forward SMPS with BU433.

T (driver transformer): Core U20
n1 = 400 turns; n2 = 25 turns
$L_{Btot} \approx 4,5\ \mu H$

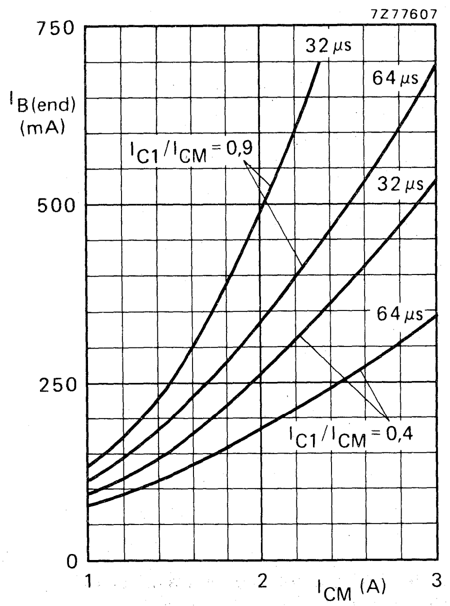


Fig. 21 Recommended nominal "end" value of the base current versus maximum peak collector current.

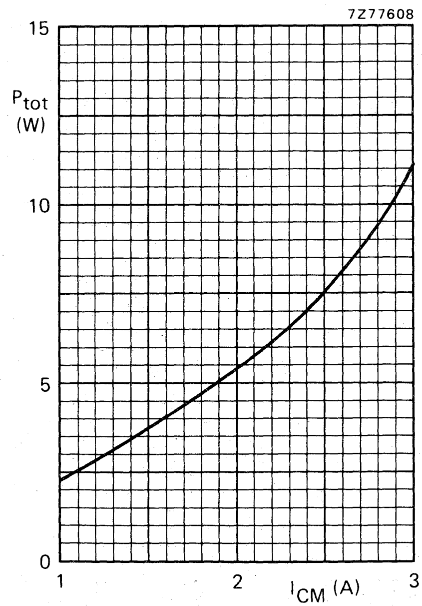


Fig. 22 Maximum total power dissipation of a limit-case transistor if the base current is chosen in accordance with Fig. 21.

SILICON DIFFUSED POWER TRANSISTORS

High-voltage, high-speed, glass-passivated n-p-n power transistors in a TO-3 envelope, intended for use in converters, inverters, switching regulators, motor control systems etc.

QUICK REFERENCE DATA

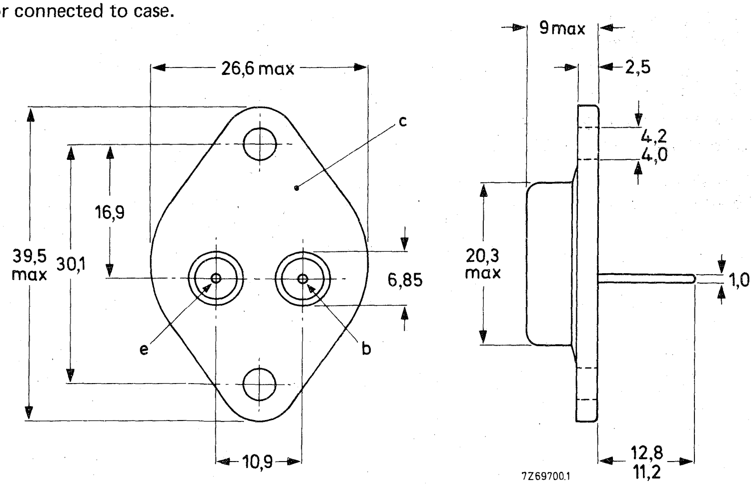
			BUS11	BUS11A	
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max.	850	1000	V
Collector-emitter voltage (open base)	V_{CEO}	max.	400	450	V
Collector current (d.c.)	I_C	max.	5	5	A
Collector current (peak value) $t_p \leq 2$ ms	I_{CM}	max.	10	10	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	100	100	W
Collector-emitter saturation voltage					
I_C = 3 A; I_B = 0,6 A	V_{CEsat}	<	1,5	–	V
I_C = 2,5 A; I_B = 0,5 A	V_{CEsat}	<	–	1,5	V
Fall time					
I_{Con} = 3 A; I_{Bon} = $-I_{Boff}$ = 0,6 A	t_f	<	0,8	–	μs
I_{Con} = 2,5 A; I_{Bon} = $-I_{Boff}$ = 0,5 A	t_f	<	–	0,8	μs

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.



See also chapters Accessories and Mounting instructions.

RATINGS

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

			BUS11	BUS11A	
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max.	850	1000	V
Collector-emitter voltage (open base)	V_{CEO}	max.	400	450	V
Collector current (d.c.)	I_C	max.	5		A
Collector current (peak value) $t_p < 2$ ms	I_{CM}	max.	10		A
Base current (d.c.)	I_B	max.	2		A
Base current (peak value); $t_p < 2$ ms	I_{BM}	max.	3		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	100		W
Storage temperature	T_{stg}		−65 to +200		°C
Junction temperature	T_j	max.	200		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,75	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			BUS11	BUS11A	
Collector cut-off current *					
$V_{CE} = V_{CESMmax}$; $V_{BE} = 0$	I_{CES}	<	1		mA
$V_{CE} = V_{CESMmax}$; $V_{BE} = 0$; T_j = 125 °C	I_{CES}	<	2		mA
Emitter cut-off current					
$I_C = 0$; $V_{EB} = 9$ V	I_{EBO}	<	10		mA
Saturation voltages					
I_C = 3 A; I_B = 0,6 A	V_{CEsat}	<	1,5	–	V
I_C = 2,5 A; I_B = 0,5 A	V_{CEsat}	<	–	1,5	V
I_C = 3 A; I_B = 0,6 A	V_{BEsat}	<	1,4	–	V
I_C = 2,5 A; I_B = 0,5 A	V_{BEsat}	<	–	1,4	V
Collector-emitter sustaining voltage					
I_C = 100 mA; I_{Boff} = 0; L = 25 mH	$V_{CEOsust}$	>	400	450	V
D.C. current gain					
I_C = 0,5 A; V_{CE} = 5 V	h_{FE}	typ.	30		

* Measured with a half sine-wave voltage (curve tracer).

CHARACTERISTICS (continued)

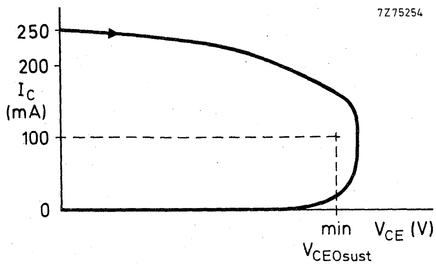


Fig. 2 Oscilloscope display for sustaining voltage.

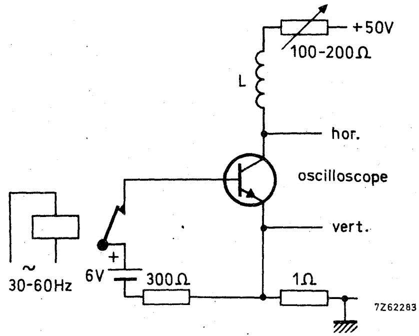


Fig. 3 Test circuit for $V_{CEOsust}$.

			BUS11	BUS11A	
Switching times resistive load (Fig. 4 and 5)					
I_{Con} = 3 A; I_{Bon} = $-I_{Boff}$ = 0,6 A					
Turn-on time	t_{on}	<	1	–	µs
Turn-off: Storage time	t_s	<	4	–	µs
Fall time	t_f	<	0,8	–	µs
I_{Con} = 2,5 A; I_{Bon} = $-I_{Boff}$ = 0,5 A					
Turn-on time	t_{on}	<	–	1	µs
Turn-off: Storage time	t_s	<	–	4	µs
Fall time	t_f	<	–	0,8	µs
Switching times inductive load (Fig. 6 and 7)					
I_{Con} = 3 A; I_B = 0,6 A					
Turn-off: Storage time	t_s	typ.	1,1	–	µs
Fall time	t_f	typ.	80	–	ns
I_{Con} = 2,5 A; I_B = 0,5 A					
Turn-off: Storage time	t_s	typ.	–	1,1	µs
Fall time	t_f	typ.	–	80	ns

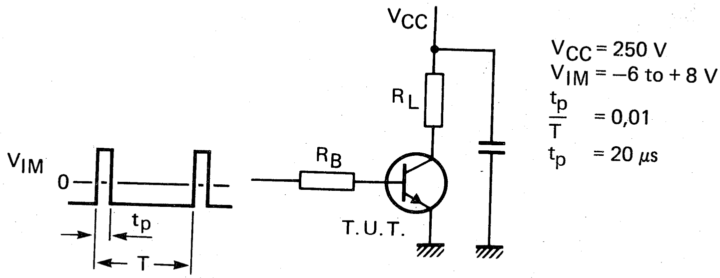


Fig. 4 Test circuit resistive load.

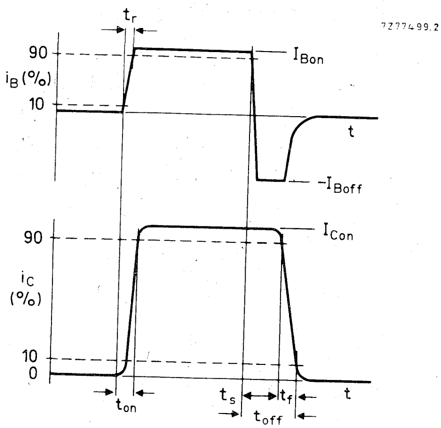


Fig. 5 Switching times waveforms with resistive load.

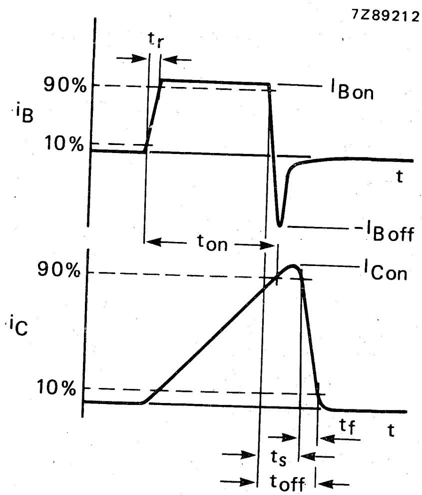


Fig. 6 Switching times waveforms with inductive load.

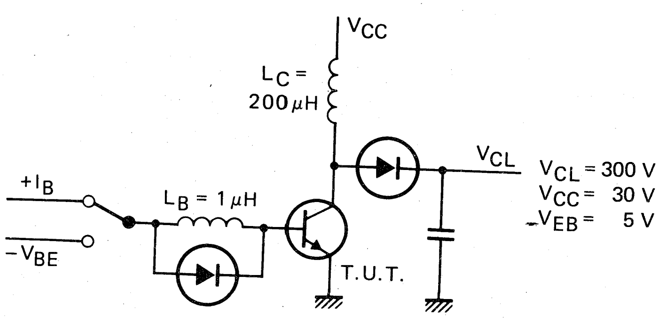


Fig. 7 Test circuit inductive load.

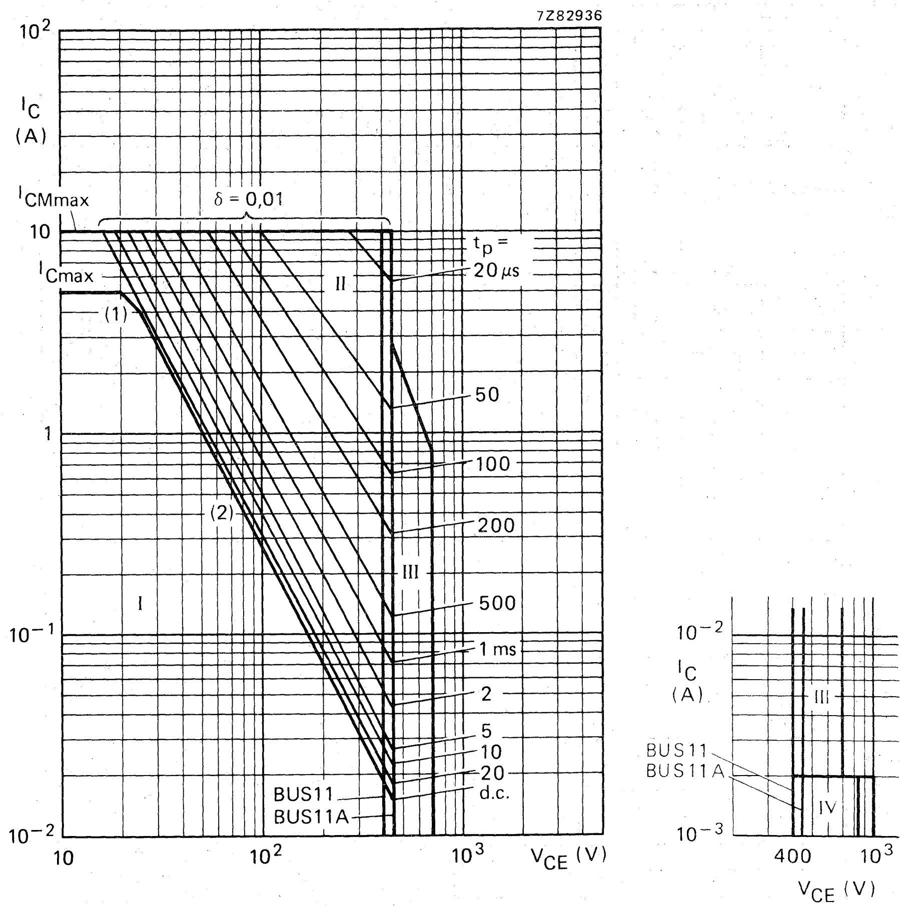


Fig. 8 Safe Operating ARea at $T_{mb} \leqslant 25\ ^{o}C$.

(1) $P_{tot\ max}$ and $P_{tot\ peak}$ max. lines.
(2) Second-breakdown limits (independent of temperature).

I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation
III Area of permissible operation during turn-on in single transistor converters, provided $R_{BE} \leqslant 100\ \Omega$ and $t_p \leqslant 0{,}6\ \mu s$.
IV Repetitive pulse operation in this region is permissible provided $V_{BE} \leqslant 0$ and $t_p \leqslant 2$ ms.

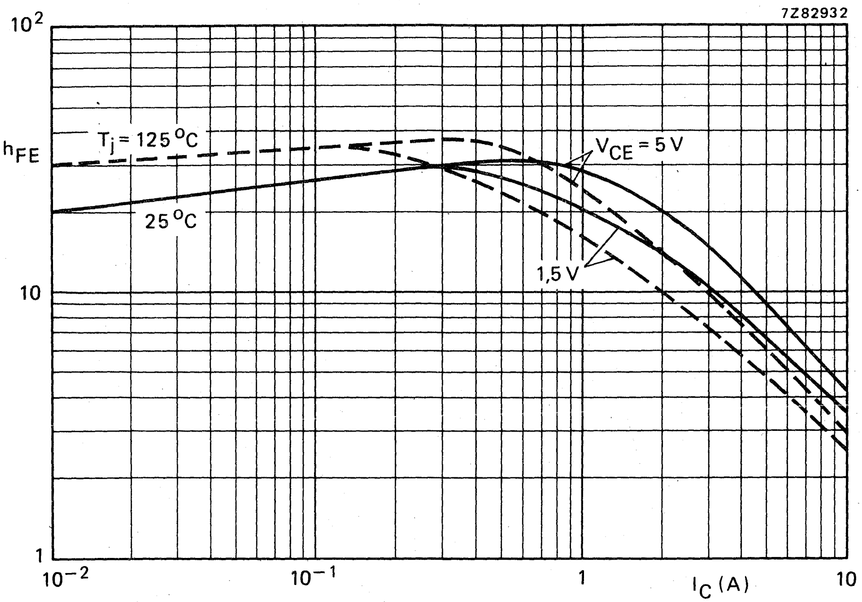


Fig. 9 D.C. current gain.

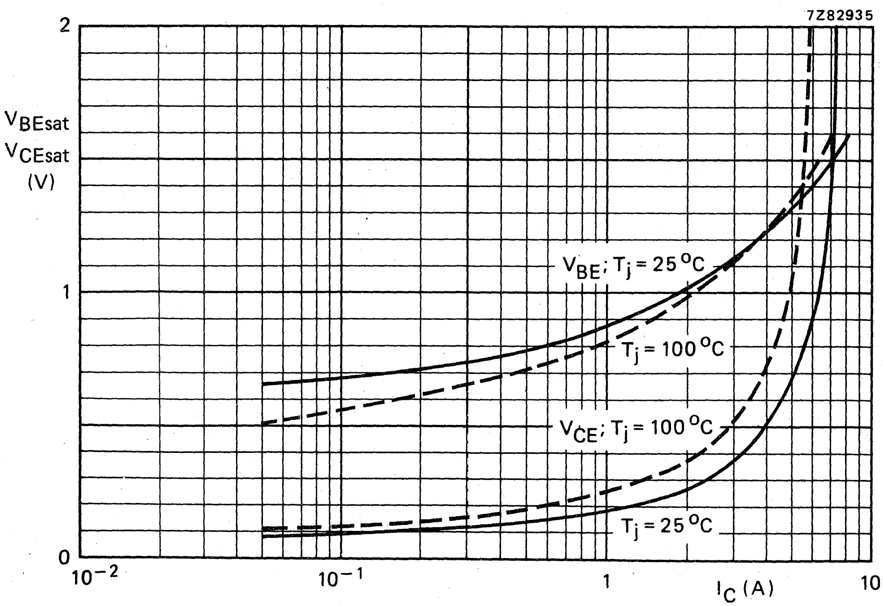


Fig. 10 Typical values base-emitter and collector-emitter voltage, $I_C/I_B = 5$.

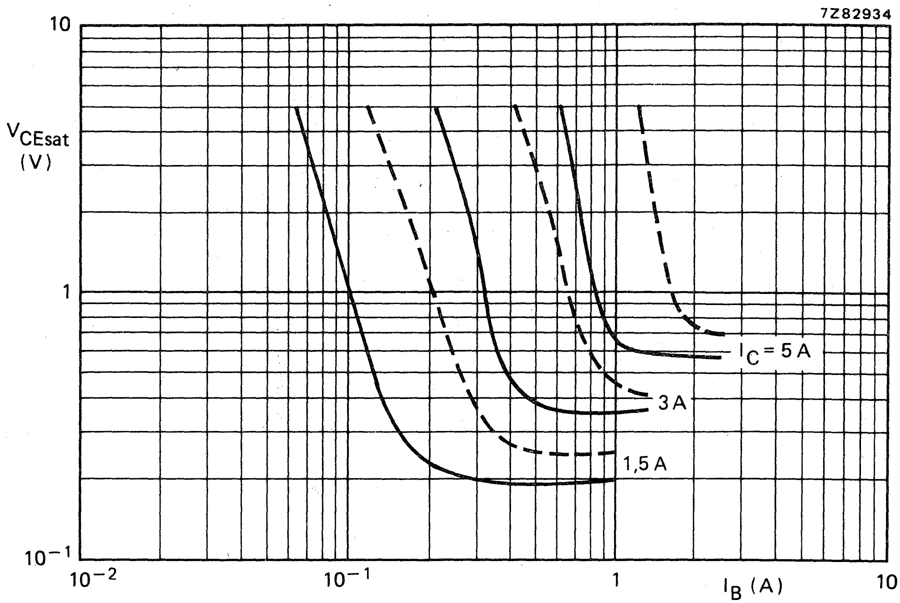


Fig. 11 Typ. (——) and max. (– – –) values collector-emitter saturation voltage at T_j = 25 °C.

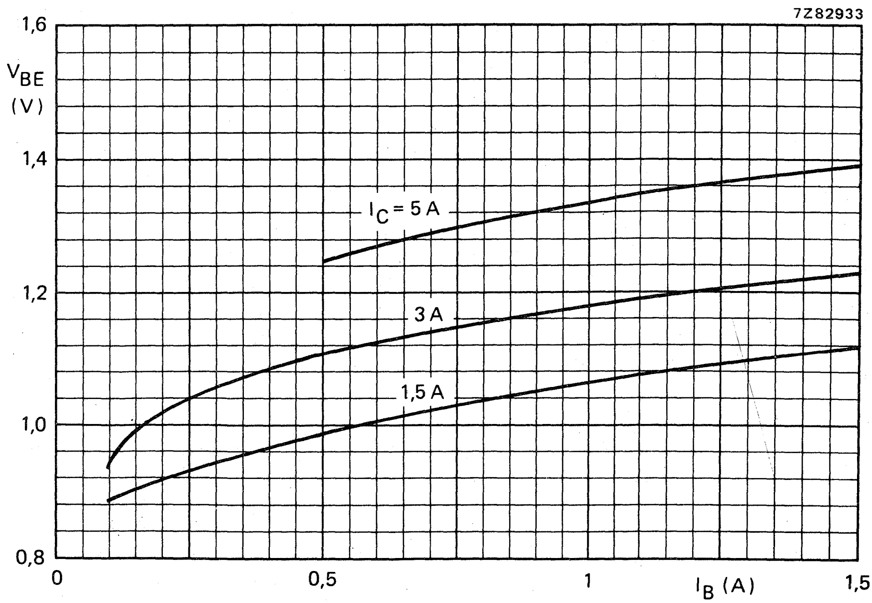


Fig. 12 Typical values at T_j = 25 °C.

SILICON DIFFUSED POWER TRANSISTORS

High-voltage, high-speed, glass-passivated n-p-n power transistors in a TO-3 envelope, intended for use in converters, inverters, switching regulators, motor control systems etc.

QUICK REFERENCE DATA

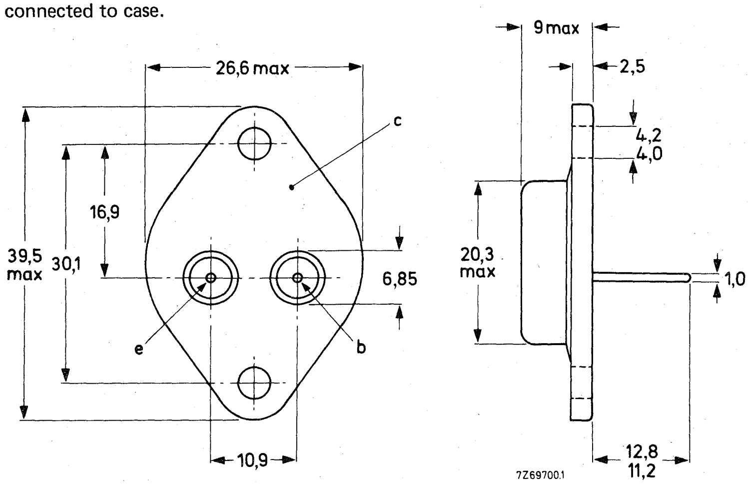
			BUS12	BUS12A	
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max.	850	1000	V
Collector-emitter voltage (open base)	V_{CEO}	max.	400	450	V
Collector current (d.c.)	I_C	max.	8	8	A
Collector current (peak value) $t_p \leq 2$ ms	I_{CM}	max.	20	20	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	125	125	W
Collector-emitter saturation voltage					
I_C = 6 A; I_B = 1,2 A	V_{CEsat}	<	1,5	–	V
I_C = 5 A; I_B = 1 A	V_{CEsat}	<	–	1,5	V
Fall time					
I_{Con} = 6 A; I_{Bon} = $-I_{Boff}$ = 1,2 A	t_f	<	0,8	–	µs
I_{Con} = 5 A; I_{Bon} = $-I_{Boff}$ = 1 A	t_f	<	–	0,8	µs

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.



See also chapters Accessories and Mounting Instructions.

RATINGS

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

			BUS12	BUS12A	
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max.	850	1000	V
Collector-emitter voltage (open base)	V_{CEO}	max.	400	450	V
Collector current (d.c.)	I_C	max.	8		A
Collector current (peak value); $t_p < 2$ ms	I_{CM}	max.	20		A
Base current (d.c.)	I_B	max.	4		A
Base current (peak value); $t_p \leqslant 2$ ms	I_{BM}	max.	6		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	125		W
Storage temperature	T_{stg}		−65 to +200		°C
Junction temperature	T_j	max.	200		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\,j\text{-}mb}$	=	1,4	K/W

CHARACTERISTICS

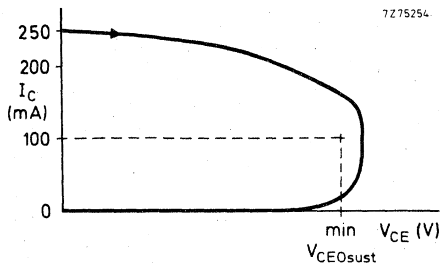
T_j = 25 °C unless otherwise specified

Collector cut-off current *				
$V_{CE} = V_{CESMmax}$; $V_{BE} = 0$	I_{CES}	<	1	mA
$V_{CE} = V_{CESMmax}$; $V_{BE} = 0$; T_j = 125 °C	I_{CES}	<	3	mA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 9$ V	I_{EBO}	<	10	mA

			BUS12	BUS12A	
Saturation voltages					
I_C = 6 A; I_B = 1,2 A	V_{CEsat}	<	1,5	—	V
I_C = 5 A; I_B = 1 A	V_{CEsat}	<	—	1,5	V
I_C = 6 A; I_B = 1,2 A	V_{BEsat}	<	1,5	—	V
I_C = 5 A; I_B = 1 A	V_{BEsat}	<	—	1,5	V
Collector-emitter sustaining voltage					
I_C = 100 mA; I_{Boff} = 0; L = 25 mH	$V_{CEOsust}$	>	400	450	V

* Measured with a half sine-wave voltage (curve tracer).

CHARACTERISTICS (continued)



Fif. 2 Oscilloscope display for sustaining voltage.

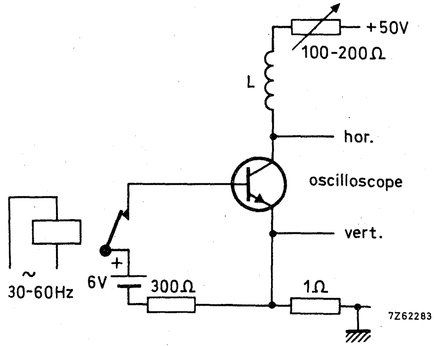


Fig. 3 Test circuit for $V_{CEOsust}$.

			BUS12	BUS12A	
Switching times resistive load (Fig. 4 and 5)					
I_{Con} = 6 A; I_{Bon} = $-I_{Boff}$ = 1,2 A					
Turn-on time	t_{on}	<	1	–	μs
Turn-off: Storage time	t_s	<	4	–	μs
Fall time	t_f	<	0,8	–	μs
I_{Con} = 5 A; I_{Bon} = $-I_{Boff}$ = 1 A					
Turn-on time	t_{on}	<	–	1	μs
Turn-off: Storage time	t_s	<	–	4	μs
Fall time	t_f	<	–	0,8	μs
Switching times inductive load (Fig. 6 and 7)					
I_{Con} = 6 A; I_B = 1,2 A					
Turn-off: Storage time	t_s	typ.	1,6	–	μs
Fall time	t_f	typ.	80	–	ns
I_{Con} = 5 A; I_B = 1 A					
Turn-off: Storage time	t_s	typ.	–	1,6	μs
Fall time	t_f	typ.	–	80	ns

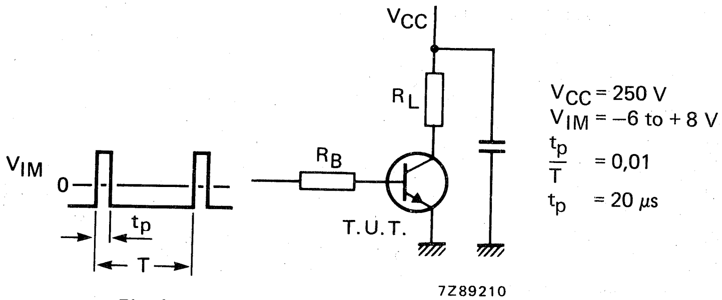


Fig. 4 Test circuit resistive load.

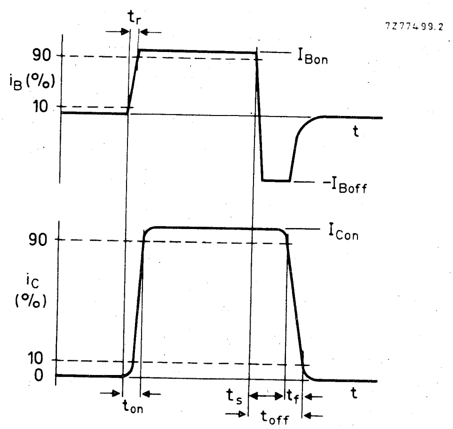


Fig. 5 Switching times waveforms with resistive load.

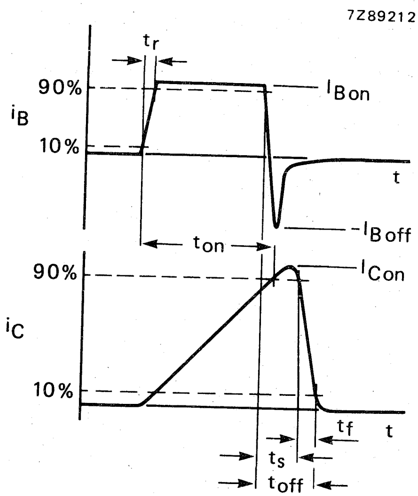


Fig. 6 Switching times waveforms with inductive load.

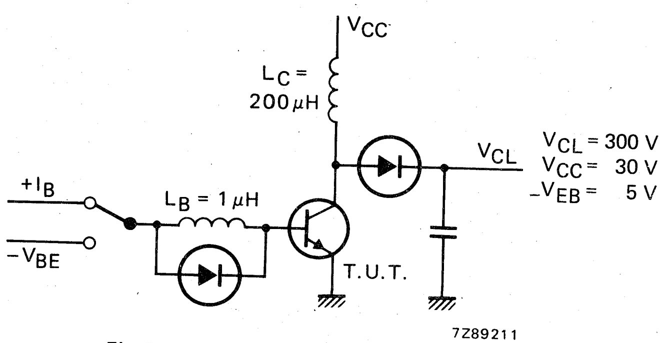
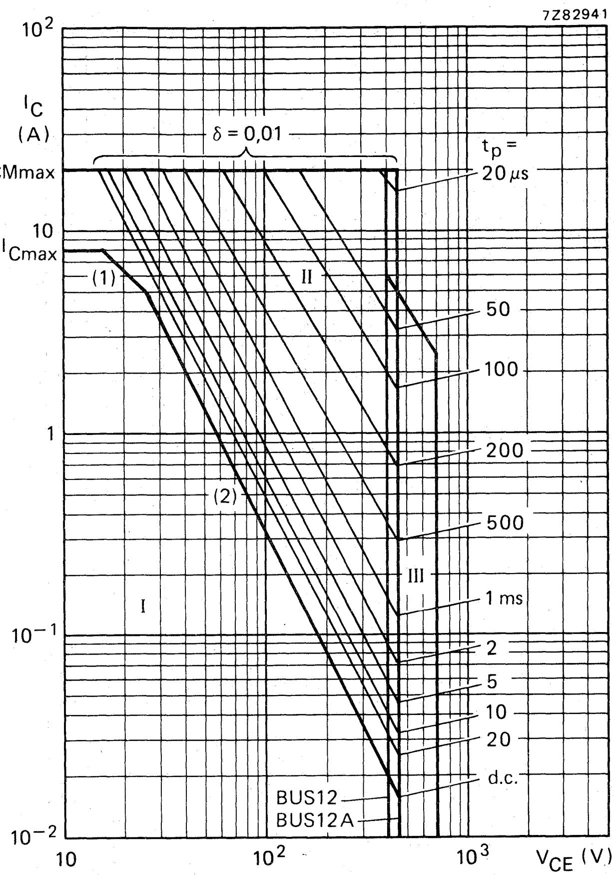


Fig. 7 Test circuit inductive load.



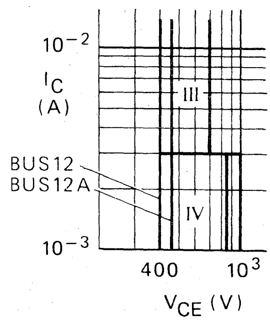


Fig. 8 Safe Operating ARea at $T_{mb} \leq 25\ ^oC$.

(1) $P_{tot\ max}$ and $P_{tot\ peak\ max}$ lines.
(2) Second-breakdown limits (independent of temperature).

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation
III Area of permissible operation during turn-on in single transistor converters, provided $R_{BE} \leq 100\ \Omega$ and $t_p \leq 0{,}6\ \mu s$.
IV Repetitive pulse operation in this region is permissible provided $V_{BE} \leq 0$ and $t_p \leq 2$ ms.

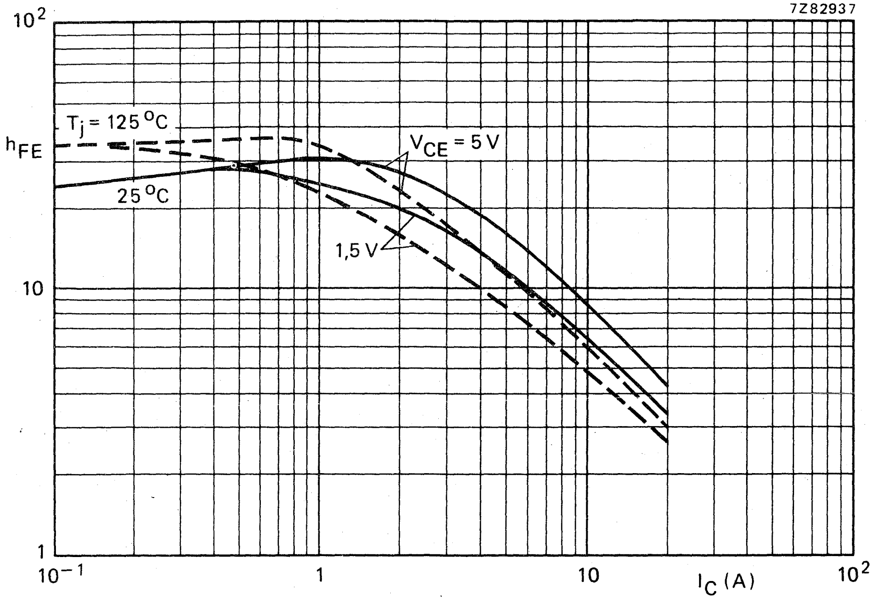


Fig. 9 Typical values d.c. current gain.

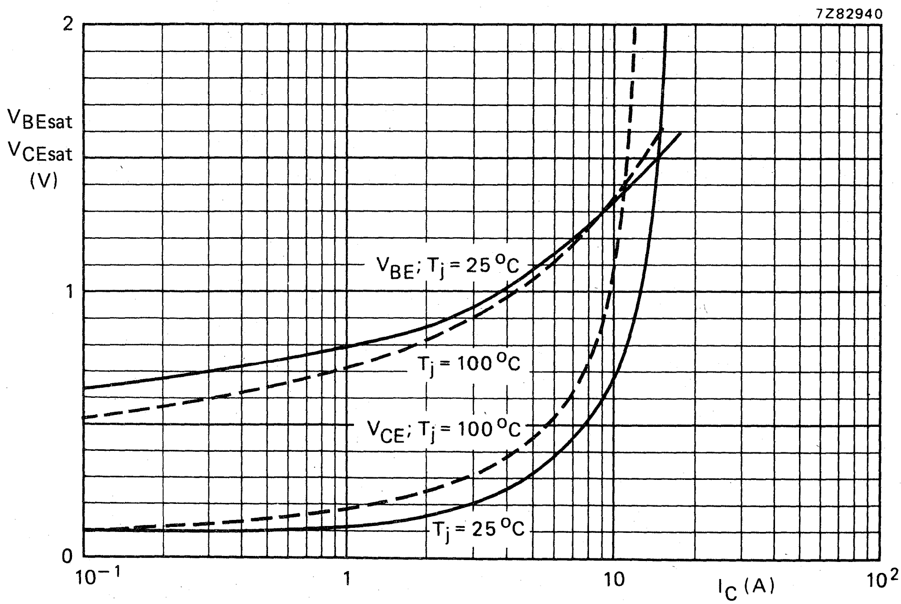


Fig. 10 Typical values base and collector voltage at $I_C/I_B = 5$.

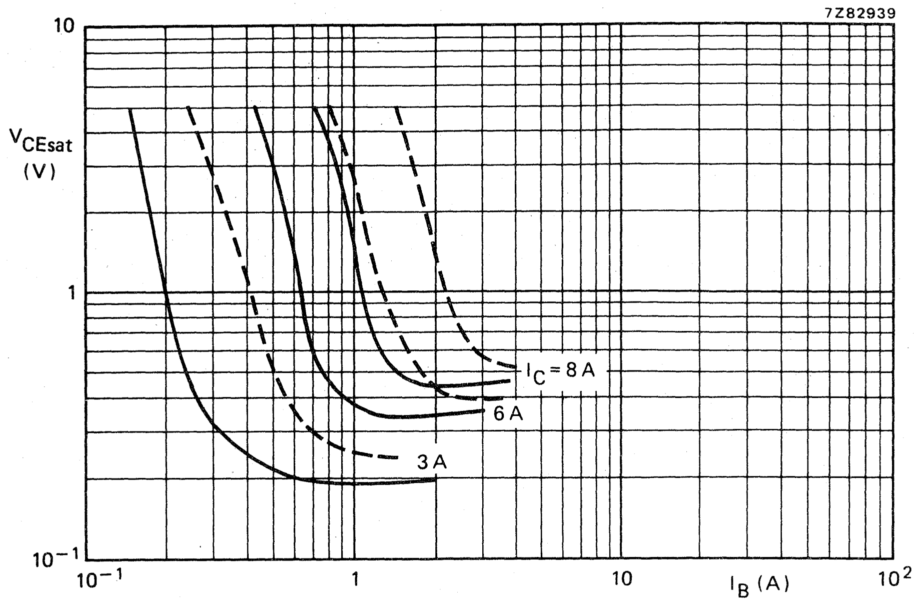


Fig. 11 Typ. (——) and max. (– – –) values collector-emitter saturation voltage at T_j = 25 °C.

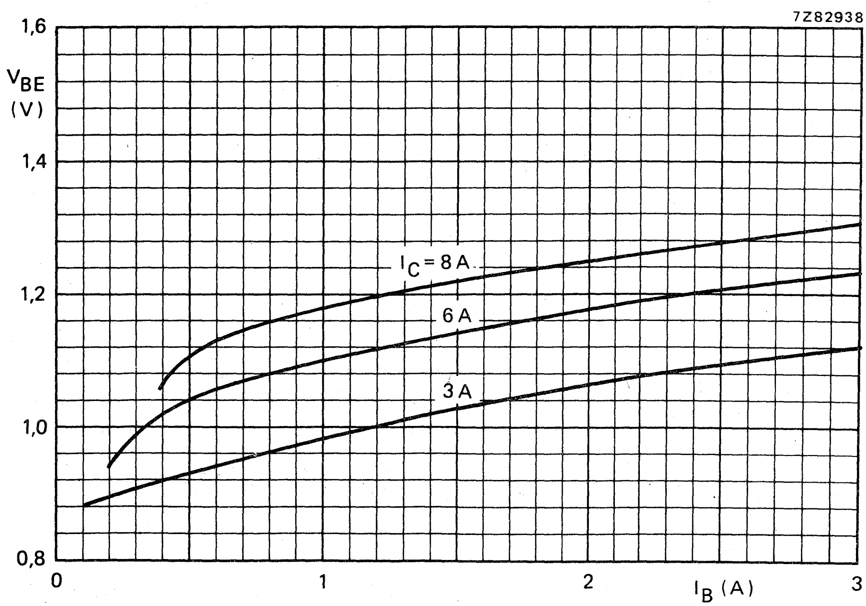


Fig. 12 Typical values base-emitter voltage at T_j = 25 °C.

SILICON DIFFUSED POWER TRANSISTORS

High-voltage, high-speed, glass-passivated n-p-n power transistors in a TO-3 envelope, intended for use in converters, inverters, switching regulators, motor control systems etc.

QUICK REFERENCE DATA

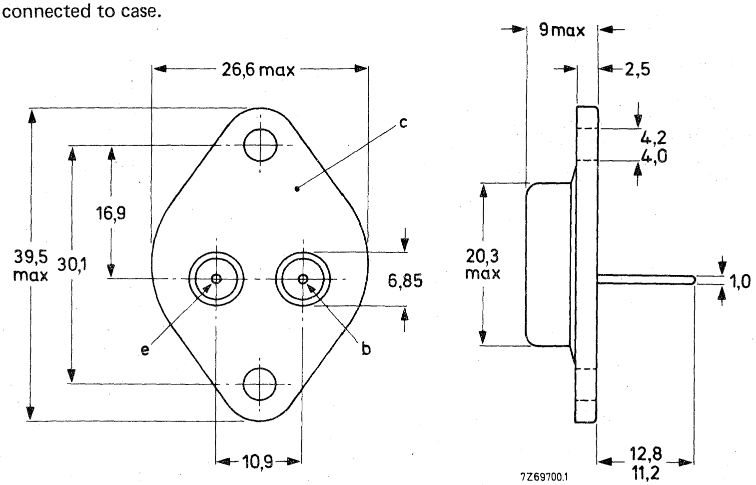
			BUS13	BUS13A	
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max.	850	1000	V
Collector-emitter voltage (open base)	V_{CEO}	max.	400	450	V
Collector current (d.c.)	I_C	max.	15	15	A
Collector current (peak value) $t_p < 2$ ms	I_{CM}	max.	30	30	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	175	175	W
Collector-emitter saturation voltage					
I_C = 10 A; I_B = 2 A	V_{CEsat}	<	1,5	—	V
I_C = 8 A; I_B = 1,6 A	V_{CEsat}	<	—	1,5	V
Fall time					
I_{Con} = 10 A; I_{Bon} = $-I_{Boff}$ = 2 A	t_f	<	0,8	—	µs
I_{Con} = 8 A; I_{Bon} = $-I_{Boff}$ = 1,6 A	t_f	<	—	0,8	µs

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.



See also chapters Accessories and Mounting Instructions.

RATINGS

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

			BUS13	BUS13A	
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max.	850	1000	V
Collector-emitter voltage (open base)	V_{CEO}	max.	400	450	V
Collector current (d.c.)	I_C	max.	15		A
Collector current (peak value); $t_p < 2$ ms	I_{CM}	max.	30		A
Base current (d.c.)	I_B	max.	6		A
Base current (peak value); $t_p < 2$ ms	I_{BM}	max.	9		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	175		W
Storage temperature	T_{stg}		−65 to +200		°C
Junction temperature	T_j	max.	200		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,0	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current *				
$V_{CE} = V_{CESMmax}$; $V_{BE} = 0$	I_{CES}	<	1	mA
$V_{CE} = V_{CESMmax}$; $V_{BE} = 0$; T_j = 125 °C	I_{CES}	<	4	mA
Emitter cut-off current				
$I_C = 0$; V_{EB} = 9 V	I_{EBO}	<	10	mA

			BUS13	BUS13A	
Saturation voltages					
I_C = 10 A; I_B = 2 A	V_{CEsat}	<	1,5	—	V
I_C = 8 A; I_B = 1,6 A	V_{CEsat}	<	—	1,5	V
I_C = 10 A; I_B = 2 A	V_{BEsat}	<	1,6	—	V
I_C = 8 A; I_B = 1,6 A	V_{BEsat}	<	—	1,6	V
Collector-emitter sustaining voltage					
I_C = 100 mA; I_{Boff} = 0; L = 25 mH	$V_{CEOsust}$	>	400	450	V

* Measured with a half sine-wave voltage (curve tracer).

CHARACTERISTICS (continued)

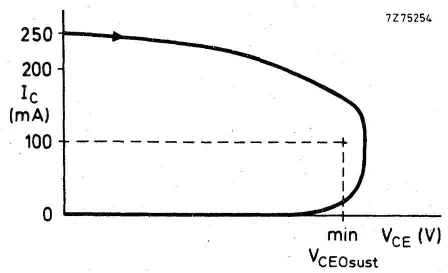


Fig. 2 Oscilloscope display for sustaining voltage.

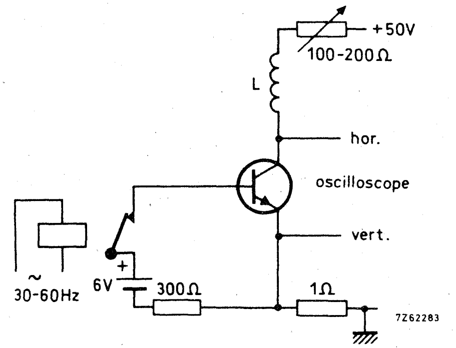


Fig. 3 Test circuit for $V_{CEOsust}$.

			BUS13	BUS13A	
Switching times resistive load (Fig. 4 and 5)					
I_{Con} = 10 A; I_{Bon} = $-I_{Boff}$ = 2 A					
Turn-on time	t_{on}	<	1	–	μs
Turn-off: Storage time	t_s	<	4	–	μs
Fall time	t_f	<	0,8	–	μs
I_{Con} = 8 A; I_{Bon} = $-I_{Boff}$ = 1,6 A					
Turn-on time	t_{on}	<	–	1	μs
Turn-off: Storage time	t_s	<	–	4	μs
Fall time	t_f	<	–	0,8	μs
Switching times inductive load (Fig. 6 and 7)					
I_{Con} = 10 A; I_{Bon} = 2 A					
Turn-off: Storage time	t_s	typ.	2,3	–	μs
Fall time	t_f	typ.	80	–	ns
I_{Con} = 8 A; I_{Bon} = 1,6 A					
Turn-off: Storage time	t_s	typ.	–	2,3	μs
Fall time	t_f	typ.	–	80	ns

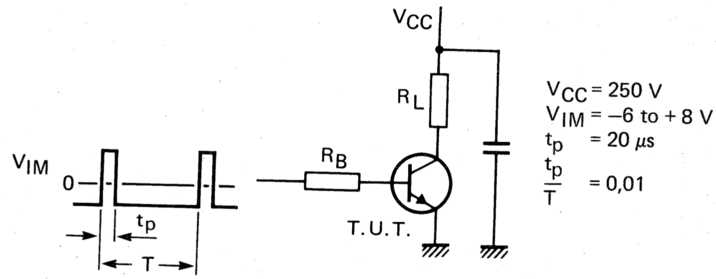


Fig. 4 Test circuit resistive load.

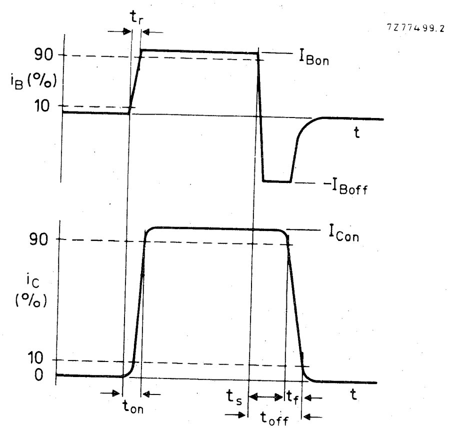


Fig. 5 Switching times waveforms with resistive load.

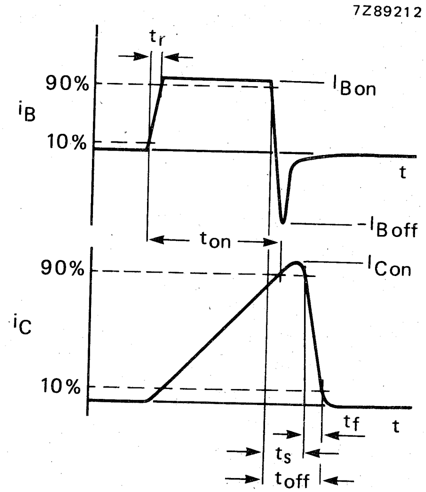


Fig. 6 Switching times waveforms with inductive load.

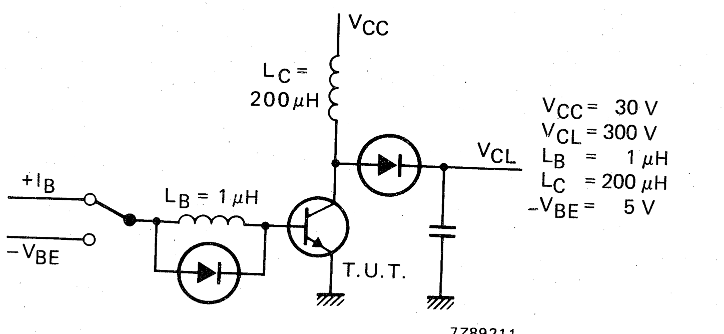


Fig. 7 Test circuit inductive load.

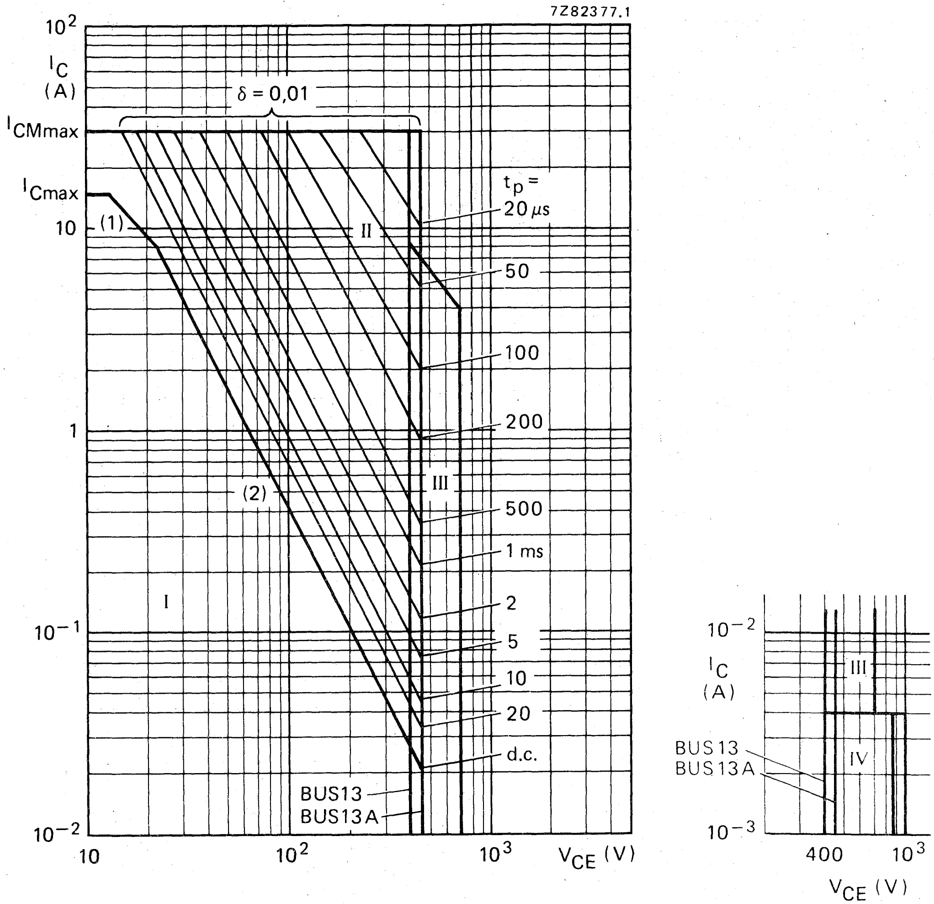


Fig. 8 Safe Operating ARea at $T_{mb} \leqslant 25$ °C.

(1) $P_{tot\ max}$ and $P_{tot\ peak\ max}$ lines.
(2) Second-breakdown limits (independent of temperature).

I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation
III Area of permissible operation during turn-on in single transistor converters, provided $R_{BE} \leqslant 100\ \Omega$ and $t_p \leqslant 0,6$ µs.
IV Repetitive pulse operation in this region is permissible provided $V_{BE} \leqslant 0$ and $t_p \leqslant 2$ ms.

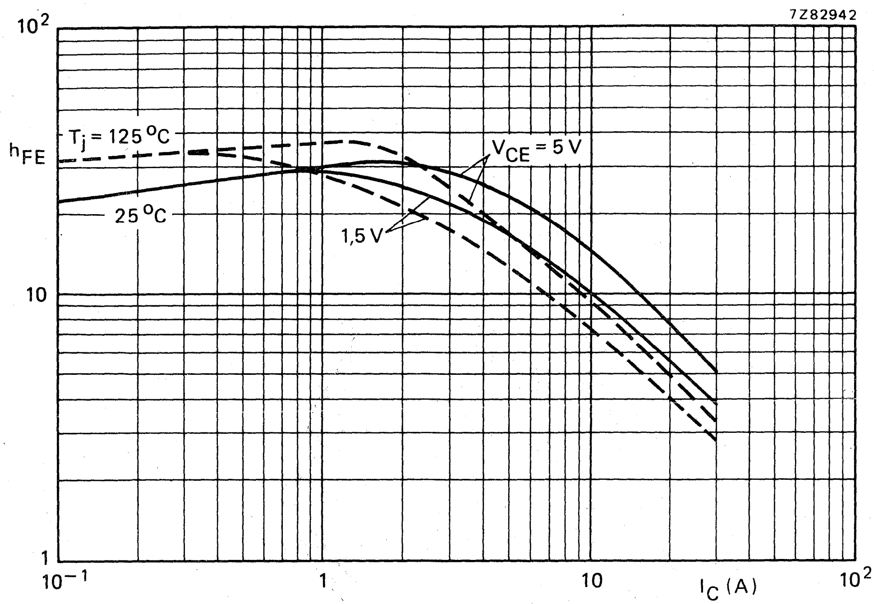


Fig. 9 Typical values d.c. current gain.

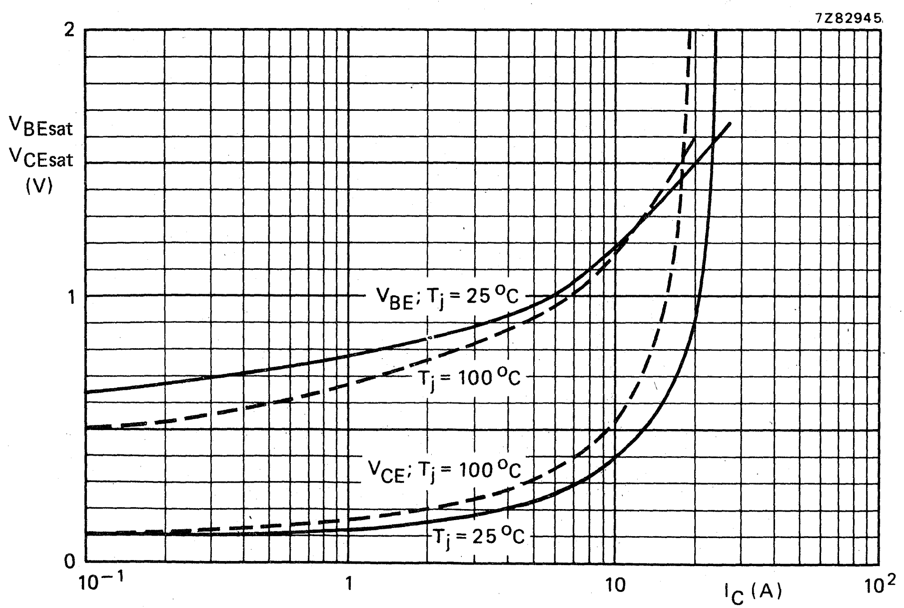


Fig. 10 Typical values base and collector voltage at $I_C/I_B = 5$.

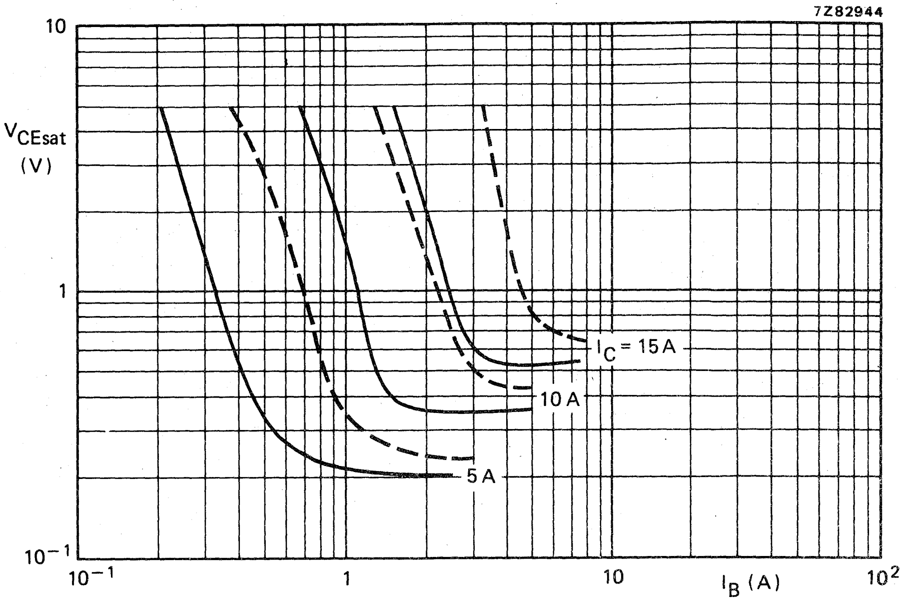


Fig. 11 Typical (——) and maximum (– – –) values saturation voltage. T_j = 25 °C.

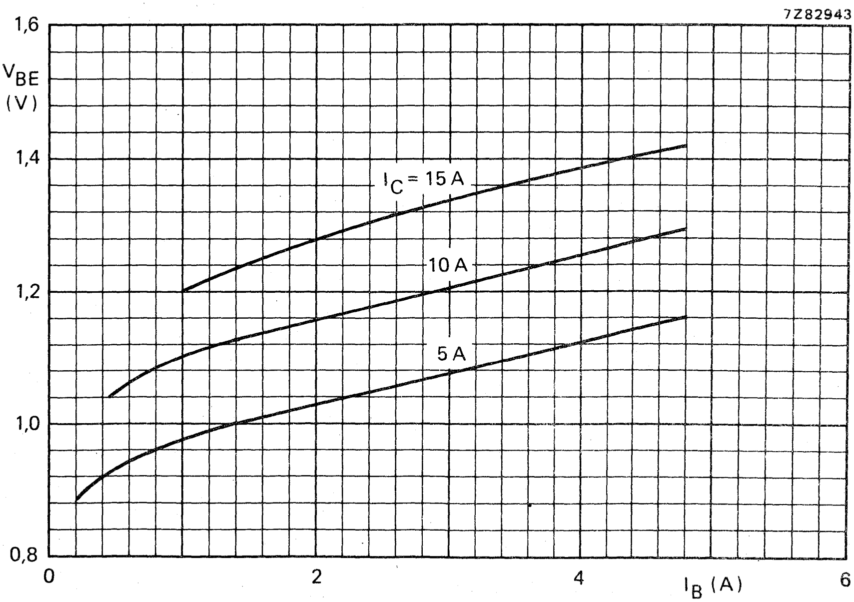


Fig. 12 Typical values base-emitter voltage at T_j = 25 °C.

SILICON DIFFUSED POWER TRANSISTORS

High-voltage, high-speed, glass-passivated n-p-n power transistors in a TO-3 envelope, indended for use in converters, inverters, switching regulators, motor control systems etc.

QUICK REFERENCE DATA

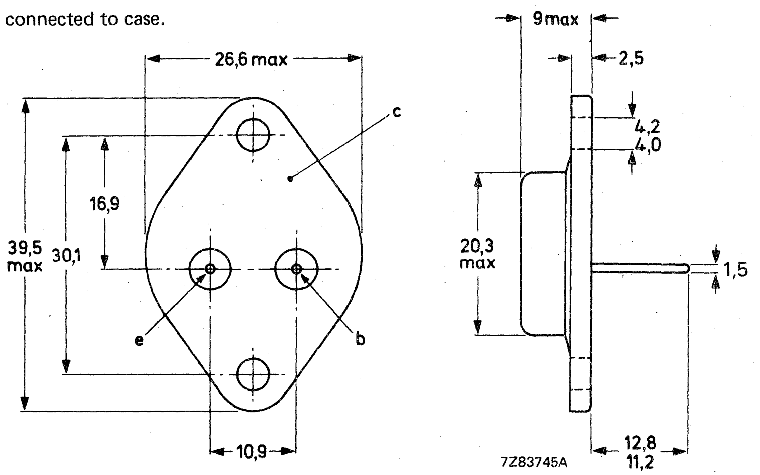
			BUS14	BUS14A	
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max.	850	1000	V
Collector-emitter voltage (open base)	V_{CEO}	max.	400	450	V
Collector current (d.c.)	I_C	max.	30	30	A
Collector current (peak value) $t_p \leq 2$ ms	I_{CM}	max.	50	50	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	250	250	W
Collector-emitter saturation voltage					
I_C = 20 A; I_B = 4 A	V_{CEsat}	<	1,5	–	V
I_C = 16 A; I_B = 3,2 A	V_{CEsat}	<	–	1,5	V
Fall time					
I_{Con} = 20 A; I_{Bon} = $-I_{Boff}$ = 4 A	t_f	<	0,8	–	μs
I_{Con} = 16 A; I_{Bon} = $-I_{Boff}$ = 3,2 A	t_f	<	–	0,8	μs

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.



See also chapters Accessories and Mounting Instructions.

RATINGS

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

			BUS14	BUS14A	
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max.	850	1000	V
Collector-emitter voltage (open base)	V_{CEO}	max.	400	450	V
Collector current (d.c.)	I_C	max.	30		A
Collector current (peak value); $t_p < 2$ ms	I_{CM}	max.	50		A
Base current (d.c.)	I_B	max.	6		A
Base current (peak value); $t_p < 2$ ms	I_{BM}	max.	10		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	250		W
Storage temperature	T_{stg}		−65 to +200		°C
Junction temperature	T_j	max.	200		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	0,7	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current *				
$V_{CE} = V_{CESMmax}$; $V_{BE} = 0$	I_{CES}	<	1	mA
$V_{CE} = V_{CESMmax}$; $V_{BE} = 0$; T_j = 125 °C	I_{CES}	<	5	mA
Emitter cut-off current				
$I_C = 0$; V_{EB} = 9 V	I_{EBO}	<	10	mA

			BUS14	BUS14A	
Saturation voltages					
I_C = 20 A; I_B = 4 A	V_{CEsat}	<	1,5	—	V
I_C = 16 A; I_B = 3,2 A	V_{CEsat}	<	—	1,5	V
I_C = 20 A; I_B = 4 A	V_{BEsat}	<	1,7	—	V
I_C = 16 A; I_B = 3,2 A	V_{BEsat}	<	—	1,7	V
Collector-emitter sustaining voltage					
I_C = 100 mA; I_{Boff} = 0; L = 25 mH	$V_{CEOsust}$	>	400	450	V

* Measured with a half sine-wave voltage (curve tracer).

CHARACTERISTICS (continued)

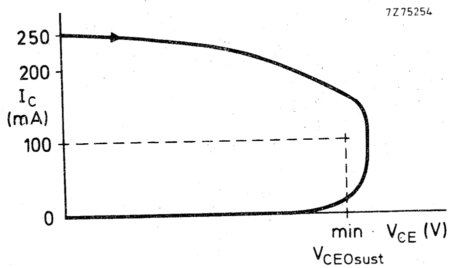


Fig. 2 Oscilloscope display for sustaining voltage.

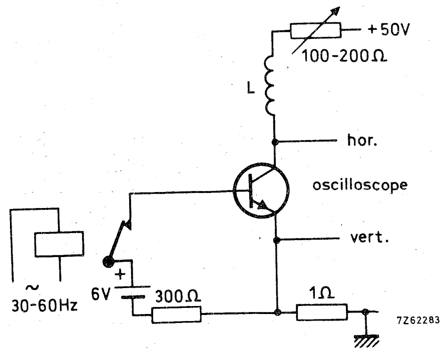


Fig. 3 Test circuit for $V_{CEOsust}$.

			BUS14	BUS14A	
Switching times resistive load					
I_{Con} = 20 A; I_{Bon} = $-I_{Boff}$ = 4 A					
Turn-on time	t_{on}	<	1	—	μs
Turn-off: Storage time	t_s	<	4	—	μs
Fall time	t_f	<	0,8	—	μs
I_{Con} = 16 A; I_{Bon} = $-I_{Boff}$ = 3,2 A					
Turn-on time	t_{on}	<	—	1	μs
Turn-off: Storage time	t_s	<	—	4	μs
Fall time	t_f	<	—	0,8	μs
Switching times inductive load					
I_{Con} = 20 A; I_B = 4 A					
Turn-off: Storage time	t_s	typ.	2,8	—	μs
Fall time	t_f	typ.	80	—	ns
I_{Con} = 16 A; I_B = 3,2 A					
Turn-off: Storage time	t_s	typ.	—	2,8	μs
Fall time	t_f	typ.	—	80	ns

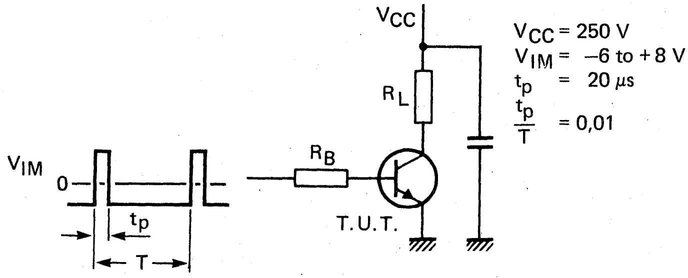


Fig. 4 Test circuit resistive load.

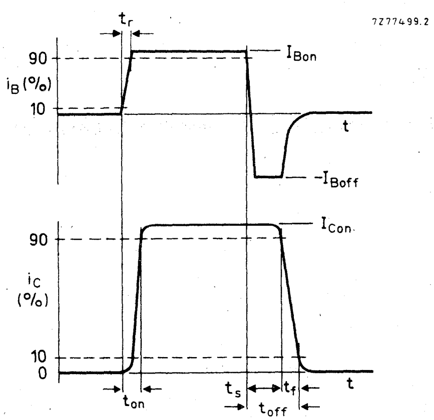


Fig. 5 Switching times waveforms with resistive load.

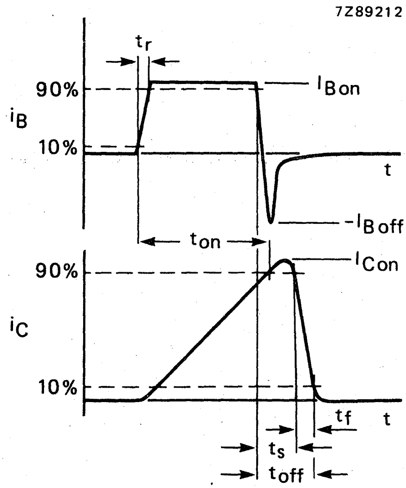


Fig. 6 Switching times waveforms with inductive load.

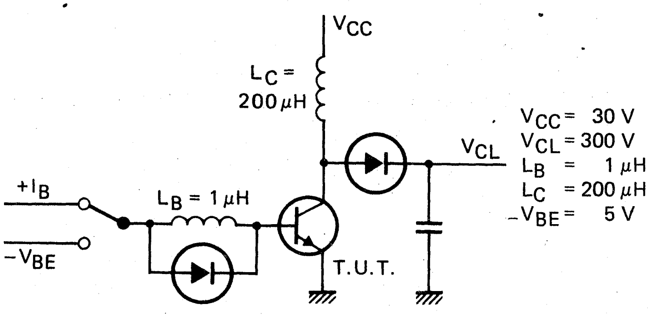
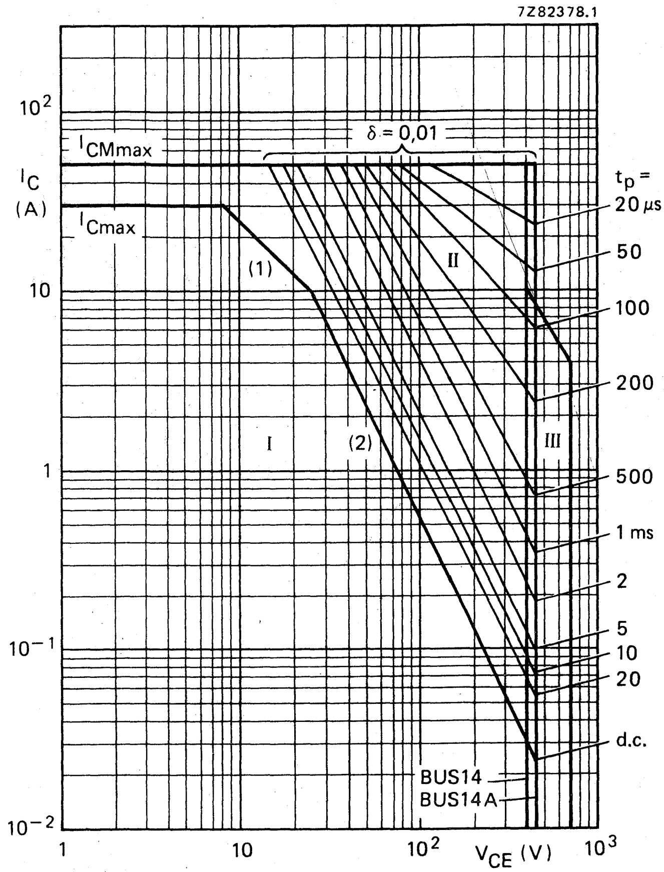


Fig. 7 Test circuit inductive load.



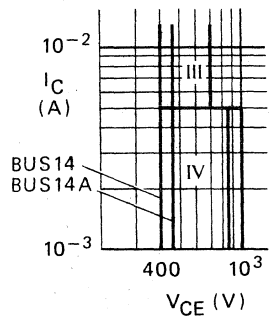


Fig. 8 Safe Operating ARea at $T_{mb} \leqslant 25$ °C.

(1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.
(2) Second-breakdown limits (independent of temperature).
I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation
III Area of permissible operation during turn-on in single transistor converters, provided $R_{BE} \leqslant 100\ \Omega$ and $t_p \leqslant 0,6\ \mu s$
IV Repetitive pulse operation in this region is permissible provided $V_{BE} \leqslant 0$ and $t_p \leqslant 2$ ms.

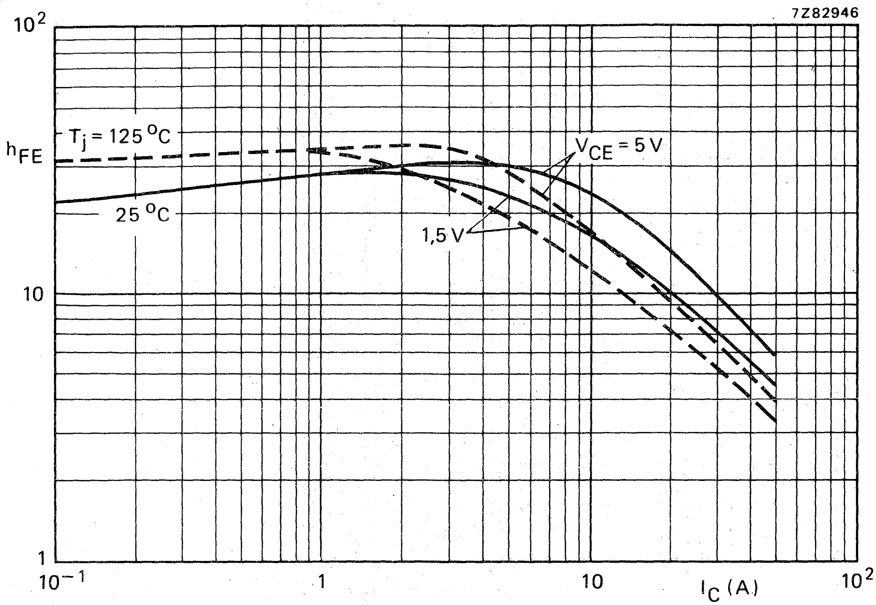


Fig. 9 Typical values d.c. current gain.

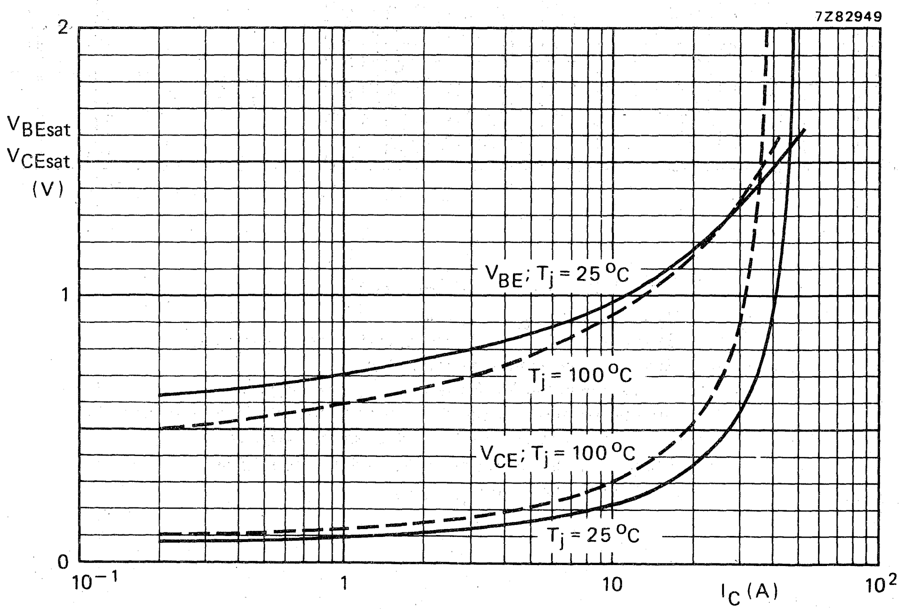


Fig. 10 Typical values base and collector voltage. $I_C/I_B = 5$.

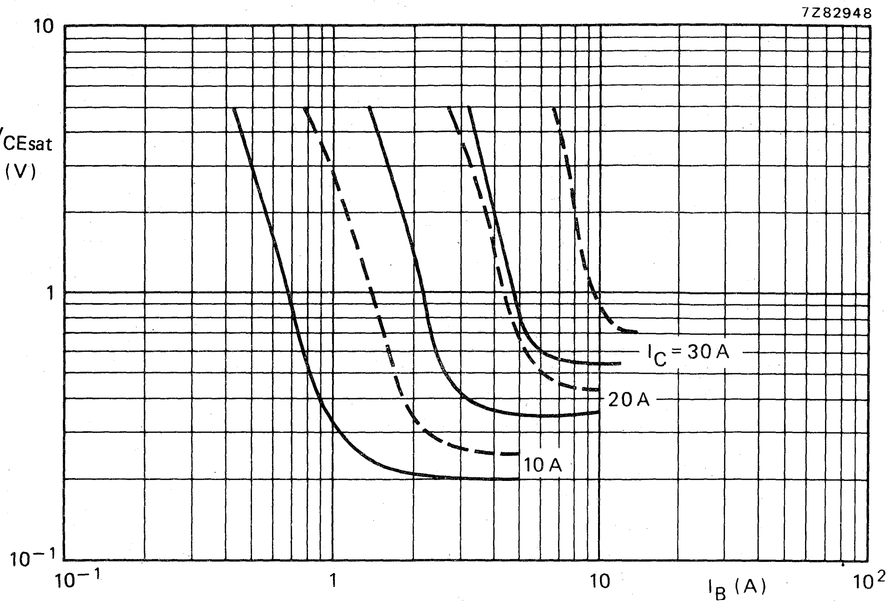


Fig. 11 Typical (——) and maximum (– – –) values saturation voltage. T_j = 25 °C.

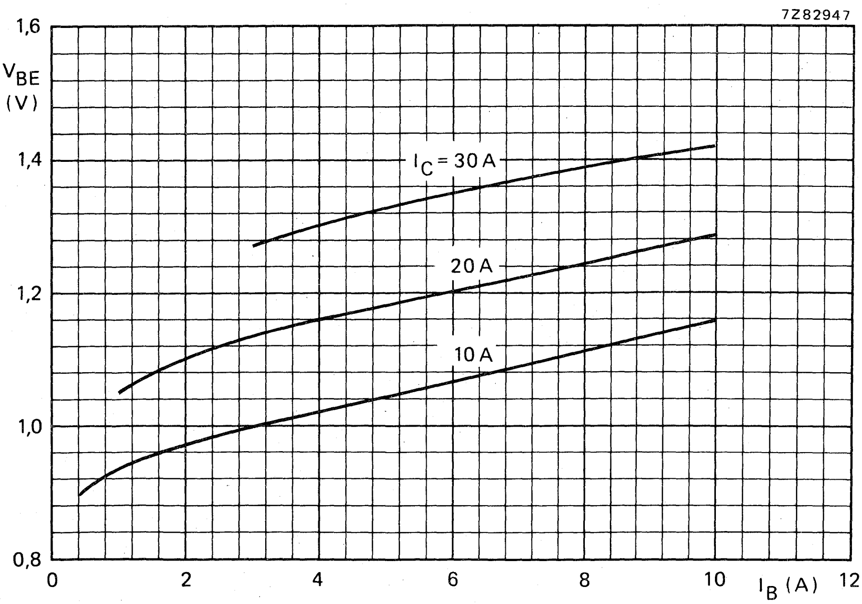


Fig. 12 Typical values at T_j = 25 °C.

SILICON DIFFUSED POWER TRANSISTORS

High voltage, high speed switching n-p-n power transistor in plastic SOT-93 envelope, intended for use in converters, inverters, switching regulators, motor control systems and switching applications.

QUICK REFERENCE DATA

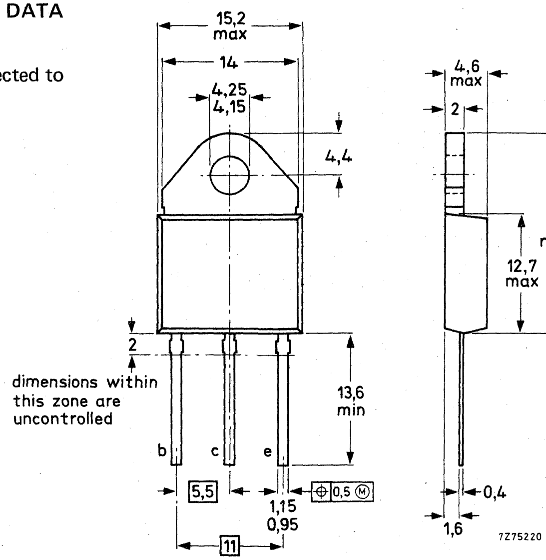
			BUV82	BUV83	
Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM}	max.	850	1000	V
Collector-emitter voltage ($R_{BE} = 100\ \Omega$)	V_{CER}	max.	500	500	V
Collector-emitter voltage (open base)	V_{CEO}	max.	400	450	V
Collector current (d.c.)	I_C	max.	6		A
Collector current (peak value) $t_p = 2$ ms	I_{CM}	max.	10		A ←
Total power dissipation up to $T_{mb} = 73\ ^oC$	P_{tot}	max.	70		W
Collector-emitter saturation voltage $I_C = 2,5$ A; $I_B = 0,5$ A	V_{CEsat}	$<$	1,5		V
Fall time $I_{Con} = 2,5$ A; $I_{Bon} = 0,5$ A; $-I_{Boff} = 1$ A	t_f	typ.	0,3		μs

MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT-93.

Collector connected to mounting base



See also chapters Mounting instructions and Accessories in handbook l.f. power transistors.

RATINGS

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

			BUV82	BUV83	
Collector-emitter voltage (V_{BE} = 0; peak value)	V_{CESM}	max.	850	1000	V
Collector-emitter voltage (R_{BE} = 100 Ω)	V_{CER}	max.	500	500	V
Collector-emitter voltage (open base)	V_{CEO}	max.	400	450	V
Collector current (d.c.)	I_C	max.	6		A
Collector current (peak value) t_p = 2 ms	I_{CM}	max.	10		A
Base current (d.c.)	I_B	max.	2		A
Base current (peak value)	I_{BM}	max.	3		A
Reverse base current (d.c. or average over any 20 ms period)	$-I_{B(AV)}$	max.	100		mA
Reverse base current (peak value)*	$-I_{BM}$	max.	3		A
Total power dissipation up to T_{mb} = 73 °C	P_{tot}	max.	70		W
Storage temperature	T_{stg}		−65 to + 150		°C
Junction temperature	T_j	max.	150		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,1	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current**				
$V_{CEM} = V_{CESMmax}$; $V_{BE} = 0$	I_{CES}	<	1	mA
$V_{CEM} = V_{CESMmax}$; $V_{BE} = 0$; T_j = 125 °C	I_{CES}	<	2	mA
D.C. current gain				
I_C = 0,6 A; V_{CE} = 5 V	h_{FE}	typ.	35	

* Turn-off current.
** Measured with a half sine wave voltage (curve tracer).

CHARACTERISTICS (continued)

T_j = 25 °C unless otherwise specified

			BUV82	BUV83	
Emitter cut-off current					
$I_C = 0$; $V_{EB} = 10$ V	I_{EBO}	<	10		mA
Saturation voltages					
$I_C = 2{,}5$ A; $I_B = 0{,}5$ A	V_{CEsat}	<	1,5		V
	V_{BEsat}	<	1,4		V
$I_C = 4$ A; $I_B = 1{,}25$ A	V_{CEsat}	<	3		V
	V_{BEsat}	<	1,6		V
Collector-emitter sustaining voltages			BUV82	BUV83	
$I_C = 100$ mA; $I_{Boff} = 0$; L = 25 mH	$V_{CEOsust}$	>	400	450	V
$I_C = 100$ mA; $R_{BE} = 100\ \Omega$; L = 15 mH	$V_{CERsust}$	>	500	500	V

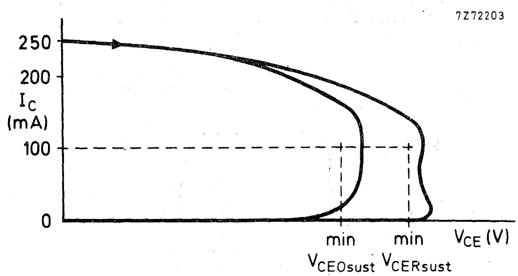


Fig. 2 Oscilloscope display for sustaining voltages.

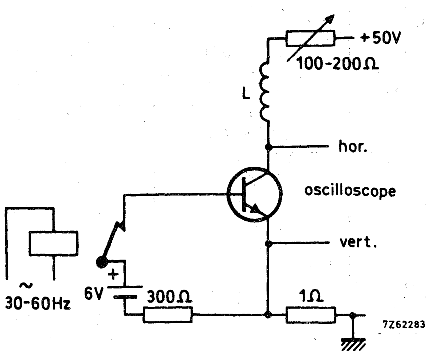


Fig. 3 Test circuit for $V_{CEOsust}$.

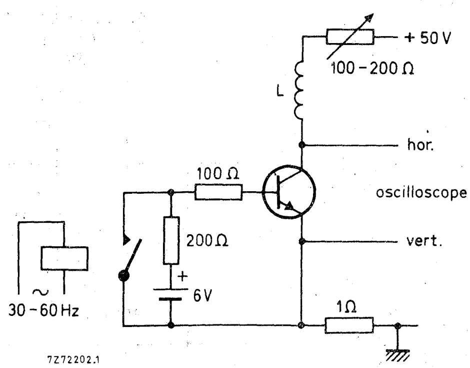


Fig. 4 Test circuit for $V_{CERsust}$.

CHARACTERISTICS (continued)

T_j = 25 °C unless otherwise specified

Transition frequency at f = 1 MHz; I_C = 0,2 A; V_{CE} = 10 V	f_T	typ.	6 MHz
Switching times; I_{Con} = 2,5 A; V_{CC} = 250 V; I_{Bon} = 0,5 A; $-I_{Boff}$ = 1 A; Turn-on time	t_{on}	typ.	0,3 μs
		<	0,6 μs
Turn-off: Storage time	t_s	typ.	2 μs
		<	3,5 μs
Fall time	t_f	typ.	0,3 μs
Fall time, T_{mb} = 95 °C	t_f	<	0,75 μs

Waveform

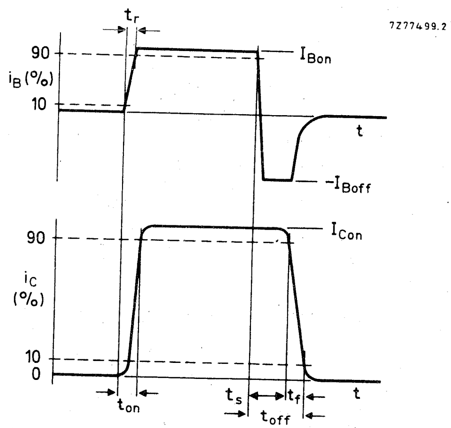
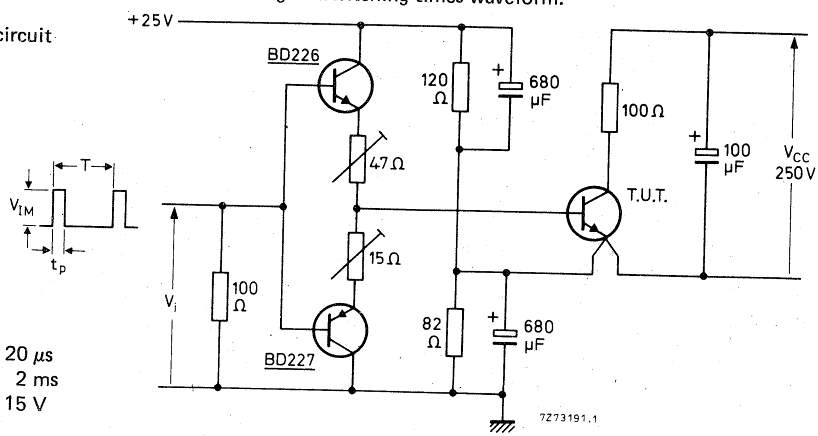


Fig. 5 Switching times waveform.

Test circuit



t_p = 20 μs
T = 2 ms
V_{IM} = 15 V

Fig. 6 Switching times test circuit.

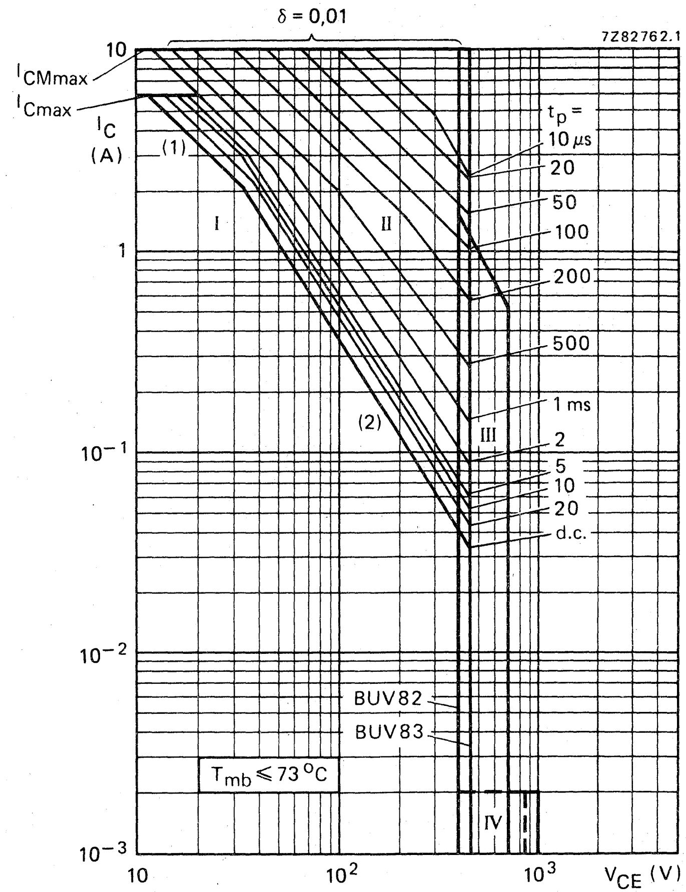


Fig. 7 Safe Operating ARea.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

III Area of permissible operation during turn-on in single-transistor converters, provided $R_{BE} \leqslant 100\ \Omega$ and $t_p \leqslant 0,6\ \mu s$.

IV Repetitive pulse operation in this region is permissible, provided $V_{BE} \leqslant 0$ and $t_p \leqslant 2$ ms.

(1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.

(2) Second-breakdown limits (independent of temperature).

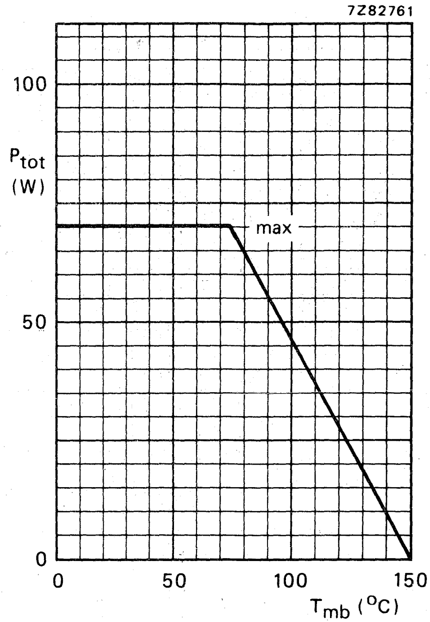


Fig. 8 Power derating curve.

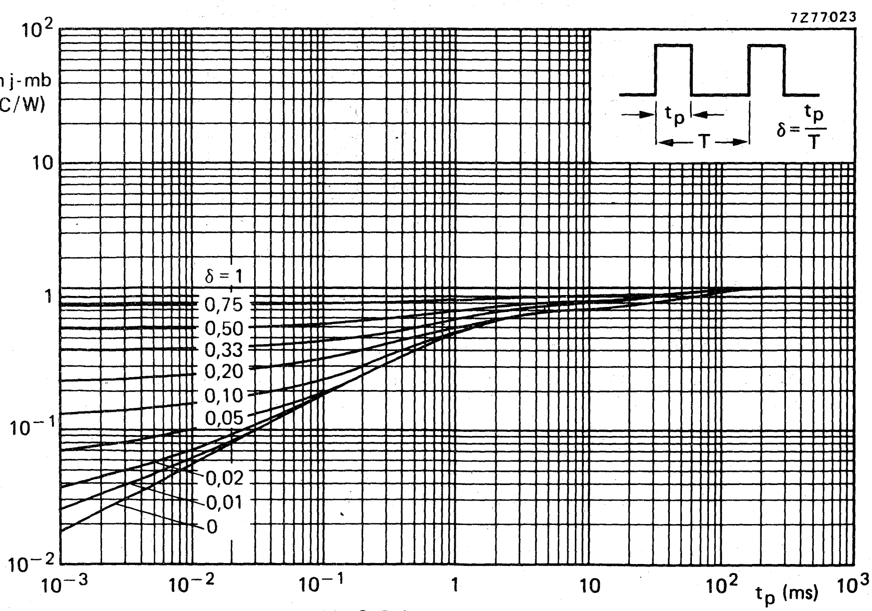


Fig. 9 Pulse power rating chart.

7Z77022

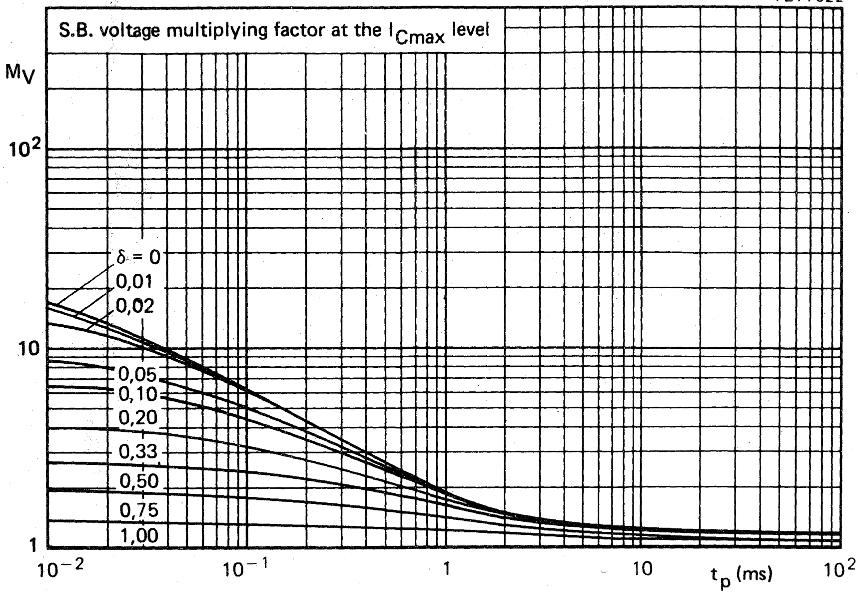


Fig. 10 S.B. voltage multiplying factor at the I_{Cmax} level.

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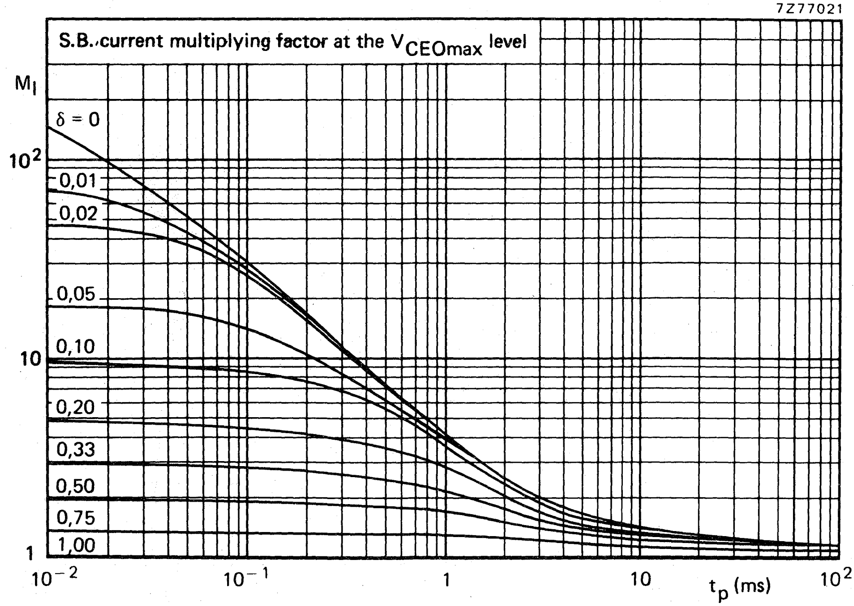


Fig. 11 S.B. current multiplying factor at the V_{CEOmax} level.

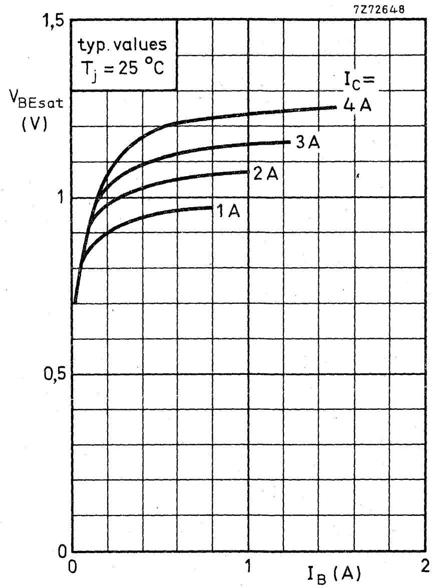


Fig. 12 Base-emitter saturation voltage.

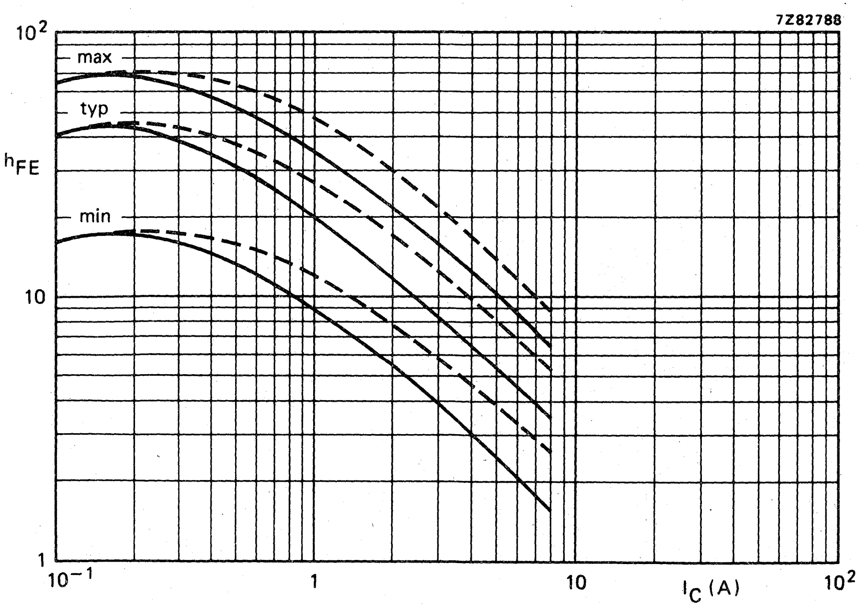


Fig. 13 D.C. current gain. $T_j = 25\ ^oC$; — — — at $V_{CE} = 5$ V; —— at $V_{CE} = 1$ V.

SILICON DIFFUSED POWER TRANSISTORS

High-voltage, high-speed, glass-passivated n-p-n power transistors in SOT-82 envelopes, intended for use in converters, inverters, switching regulators, motor control systems and switching applications.

QUICK REFERENCE DATA

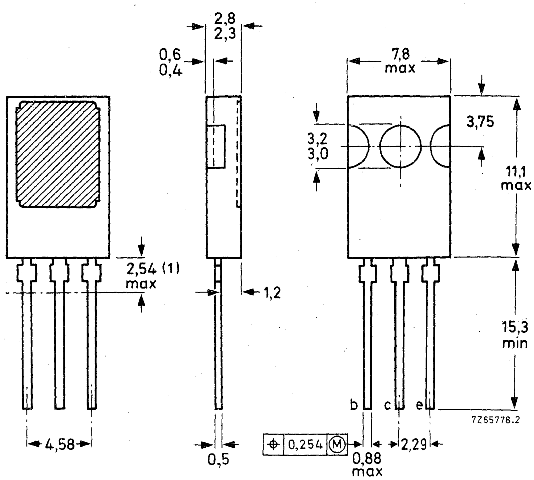
			BUW84	BUW85	
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max.	800	1000	V
Collector-emitter voltage (open base)	V_{CEO}	max.	400	450	V
Collector current (d.c.)	I_C	max.	2		A
Collector current (peak value) t_p = 2 ms	I_{CM}	max.	3		A
Total power dissipation up to T_{mb} = 45 °C	P_{tot}	max.	50		W
Collector-emitter saturation voltage I_C = 1 A; I_B = 0,2 A	V_{CEsat}	<	1		V
Fall time I_{Con} = 1 A; I_{Bon} = 0,2 A; $-I_{Boff}$ = 0,4 A	t_f	typ.	0,4		μs

MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT-82.

Collector connected to mounting base.



(1) Within this region the cross-section of the leads is uncontrolled.

See also chapters Mounting Instructions and Accessories.

RATINGS

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

			BUW84	BUW85	
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max.	800	1000	V
Collector-emitter voltage (open base)	V_{CEO}	max.	400	450	V
Collector current (d.c.)	I_C	max.	2		A
Collector current (peak value) t_p = 2 ms	I_{CM}	max.	3		A
Base current (d.c.)	I_B	max.	0,75		A
Base current (peak value)	I_{BM}	max.	1		A
Reverse base current (peak value) *	$-I_{BM}$	max.	1		A
Total power dissipation up to T_{mb} = 45 °C	P_{tot}	max.	50		W
Storage tamperature	T_{stg}		−65 to +150		°C
Junction temperature	T_j	max.	150		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2,1	°C/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	100	°C/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current **				
$V_{CEM} = V_{CESMmax}$; V_{BE} = 0	I_{CES}	<	200	µA
$V_{CEM} = V_{CESMmax}$; V_{BE} = 0; T_j = 125 °C	I_{CES}	<	1,5	mA
D.C. current gain				
I_C = 0,1 A; V_{CE} = 5 V	h_{FE}	typ.	50	

* Turn-off current.
** Measured with a half sine-wave voltage (curve tracer).

CHARACTERISTICS (continued)

T_j = 25 °C unless otherwise specified

Emitter cut-off current					
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	1		mA
Saturation voltages					
$I_C = 0{,}3$ A; $I_B = 30$ mA	V_{CEsat}	<	0,8		V
$I_C = 1$ A; $I_B = 0{,}2$ A	V_{CEsat}	<	1		V
$I_C = 1$ A; $I_B = 0{,}2$ A	V_{BEsat}	<	1,1		V
Collector-emitter sustaining voltage			BUW84	BUW85	
$I_C = 100$ mA; $I_{Boff} = 0$; L = 25 mH	$V_{CEOsust}$	>	400	450	V

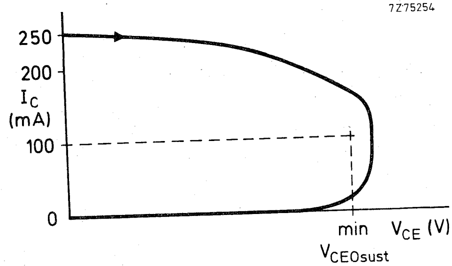


Fig. 2 Oscilloscope display for sustaining voltage.

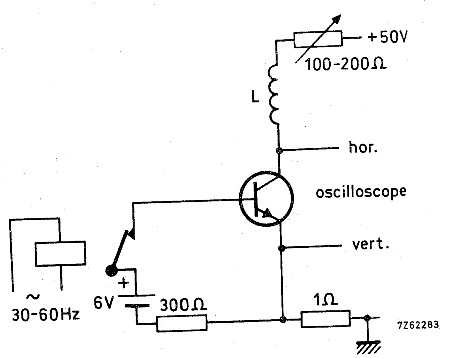


Fig. 3 Test circuit for $V_{CEOsust}$.

CHARACTERISTICS (continued)

T_j = 25 °C unless otherwise specified

Transition frequency at f = 1 MHz I_C = 0,2 A; V_{CE} = 10 V	f_T	typ.	20 MHz
Switching times I_{Con} = 1 A; V_{CC} = 250 V I_{Bon} = 0,2 A; $-I_{Boff}$ = 0,4 A			
Turn-on time	t_{on}	typ.	0,2 μs
		<	0,5 μs
Turn-off: Storage time	t_s	typ.	2 μs
		<	3,5 μs
Fall time	t_f	typ.	0,4 μs
Fall time, T_{mb} = 95 °C	t_f	<	1,4 μs

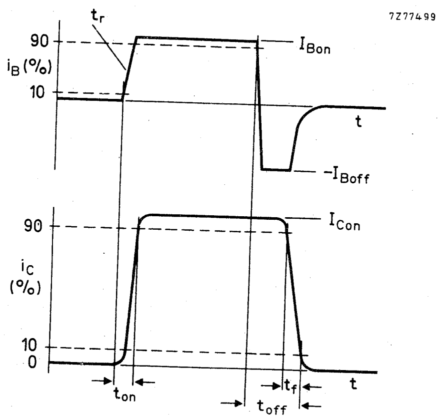


Fig. 4 Waveforms.

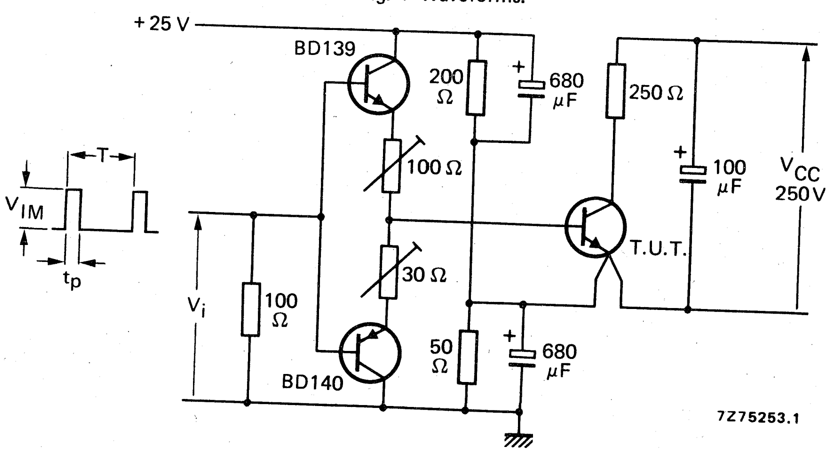


Fig. 5 Test circuit.

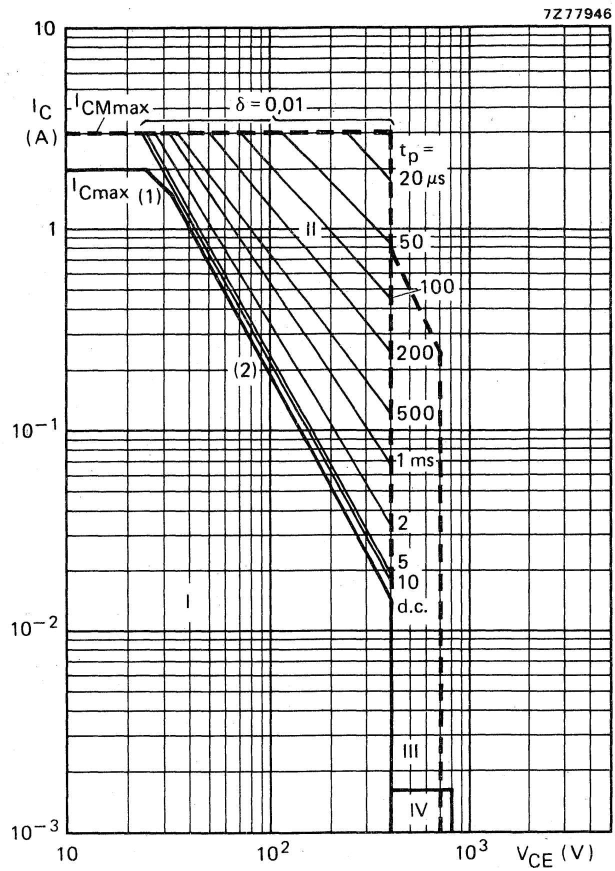


Fig. 6 Safe Operating ARea at $T_{mb} \leqslant 25$ °C of BUW84.

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

III Area of permissible operation during turn-on in single transistor converters, provided $R_{BE} \leqslant 100\ \Omega$ and $t_p \leqslant 0{,}6\ \mu s$

IV Repetitive pulse operation in this region is permissible, provided $V_{BE} \leqslant 0$ and $t_p \leqslant 2$ ms

(1) $P_{tot\,max}$ line.

(2) Second-breakdown limits (independent of temperature).

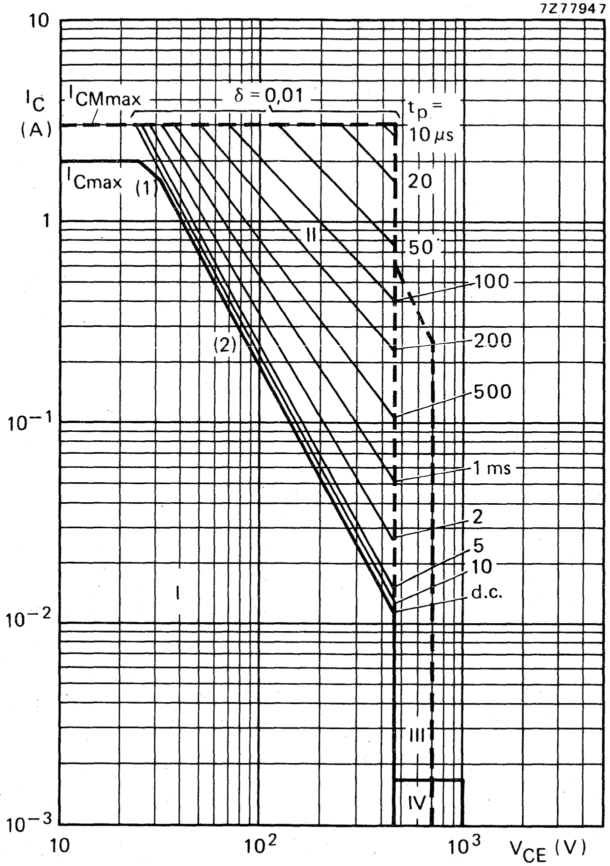


Fig. 7 Safe Operating ARea at $T_{mb} \leqslant 25$ °C of BUW85.

I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation
III Area of permissible operation during turn-on in single transistor converters, provided $R_{BE} \leqslant 100\ \Omega$ and $t_p \leqslant 0{,}6\ \mu s$
IV Repetitive pulse operation in this region is permissible, provided $V_{BE} \leqslant 0$ and $t_p \leqslant 2$ ms

(1) $P_{tot\ max}$ line.
(2) Second-breakdown limits (independent of temperature).

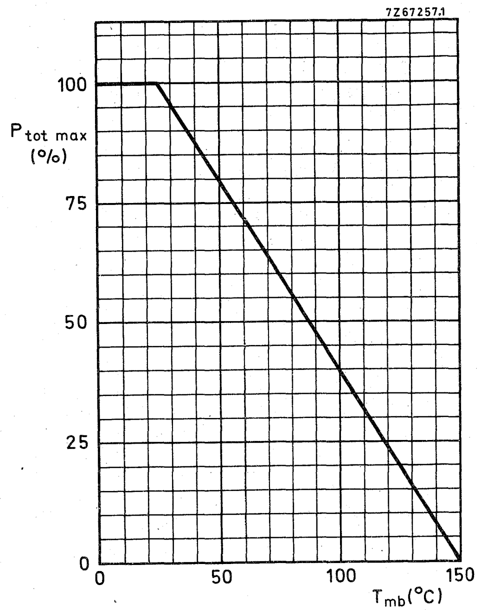

7Z67257.1
100
$P_{tot\ max}$
(%)
75
50
25
0
0
50
100
150
T_{mb}(°C)

Fig. 8.

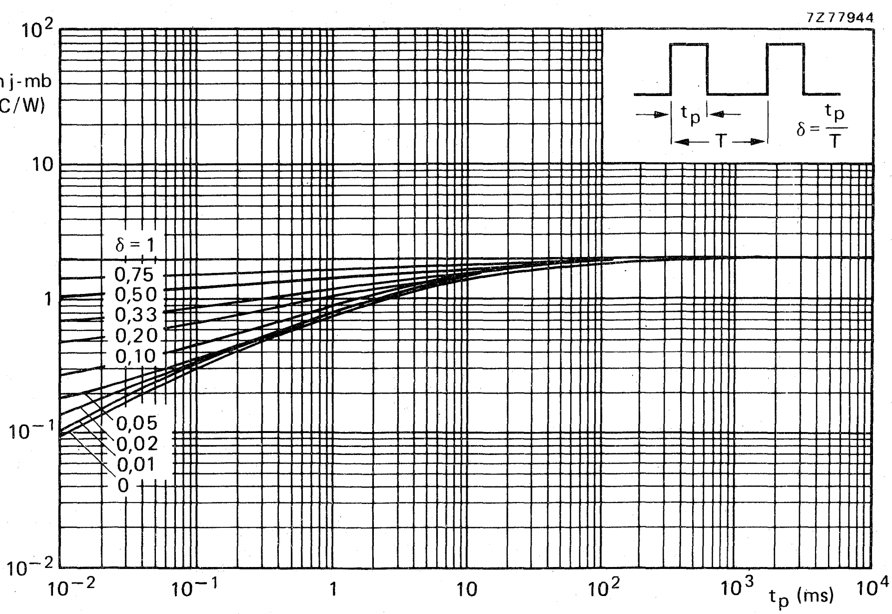

7Z77944
10^2
$Z_{th\ j\text{-}mb}$
(°C/W)
10
1
10^{-1}
10^{-2}
δ = 1
0,75
0,50
0,33
0,20
0,10
0,05
0,02
0,01
0
t_p
T
$\delta = \frac{t_p}{T}$
10^{-2}
10^{-1}
1
10
10^2
10^3
t_p (ms)
10^4

Fig. 9.

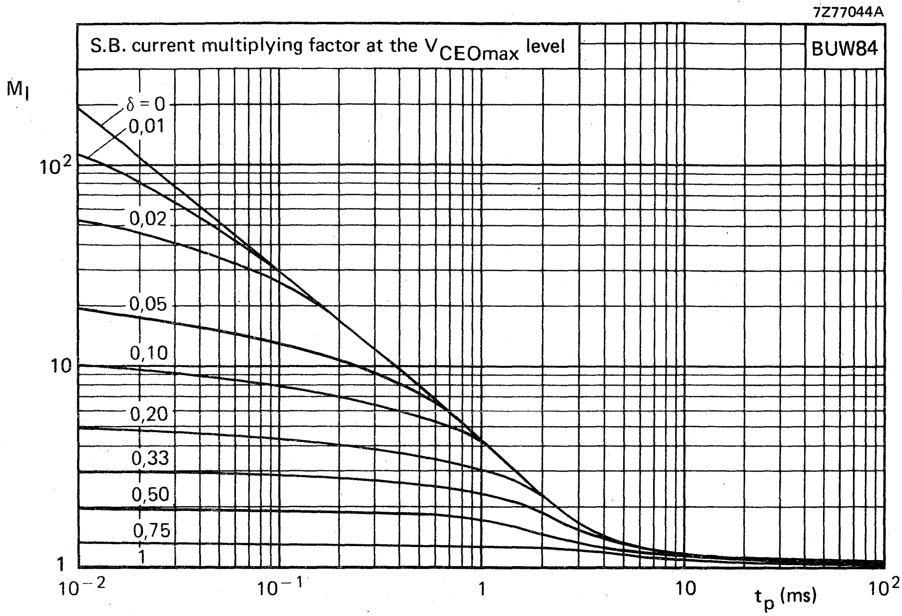

7Z77044A
S.B. current multiplying factor at the V_{CEOmax} level
BUW84
M_I
δ = 0
0,01
0,02
0,05
0,10
0,20
0,33
0,50
0,75
1
10^2
10
1
10^{-2}
10^{-1}
1
10
t_p (ms)
10^2

Fig. 10.

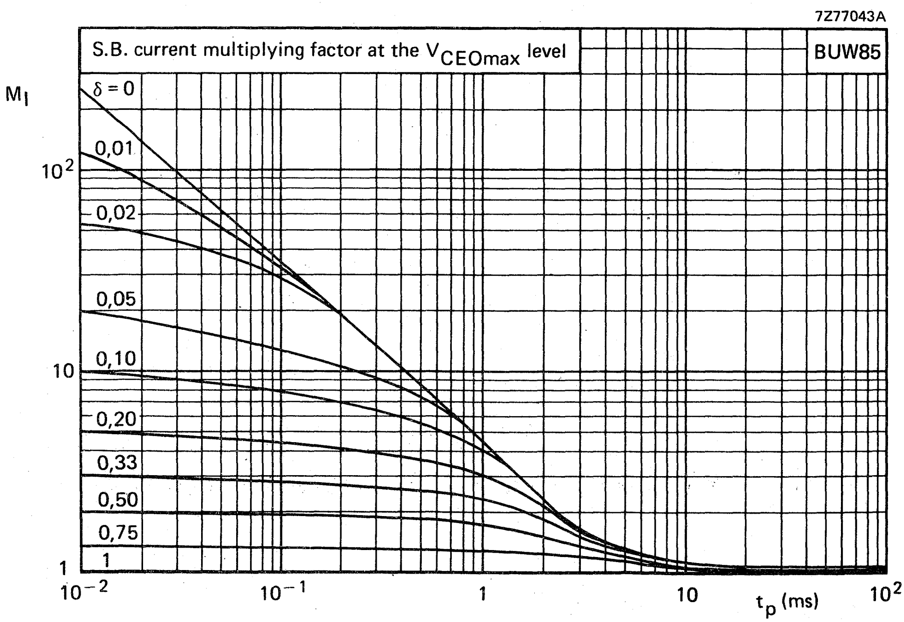

7Z77043A
S.B. current multiplying factor at the V_{CEOmax} level
BUW85
M_I
δ = 0
0,01
0,02
0,05
0,10
0,20
0,33
0,50
0,75
1
10^2
10
1
10^{-2}
10^{-1}
1
10
t_p (ms)
10^2

Fig. 11.

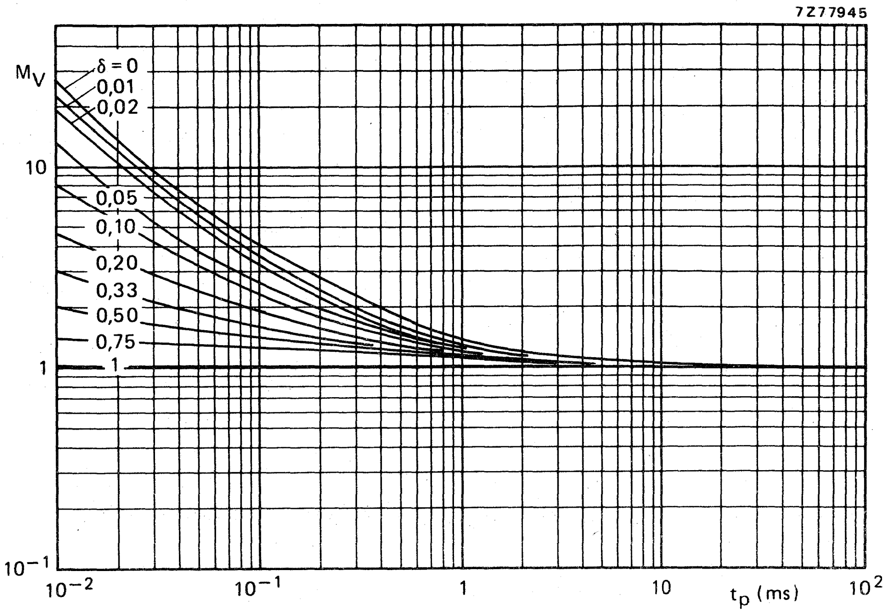


Fig. 12 S.B. voltage multiplying factor at the I_{Cmax} level.

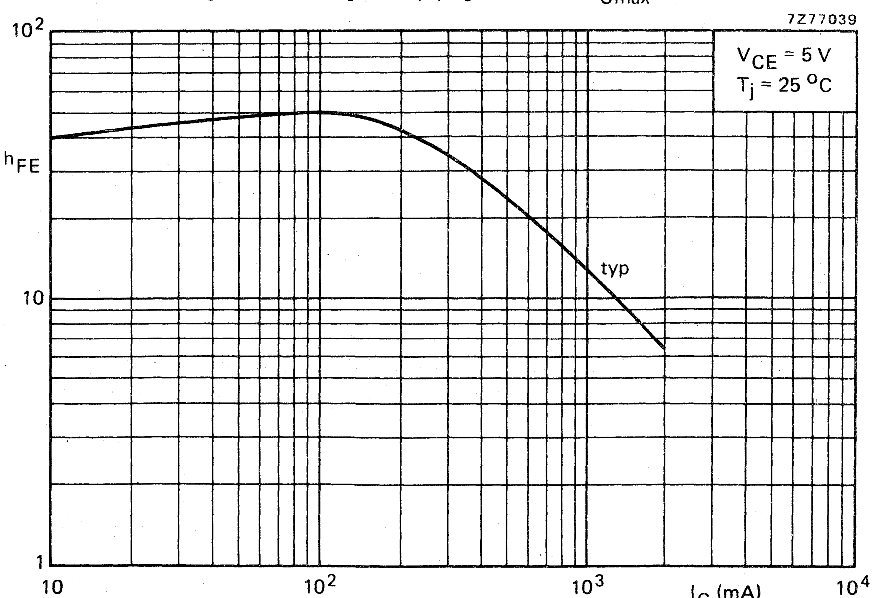


Fig. 13.

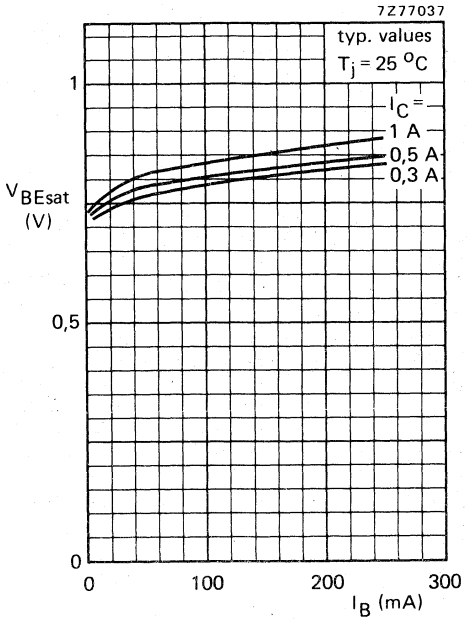


Fig. 14.

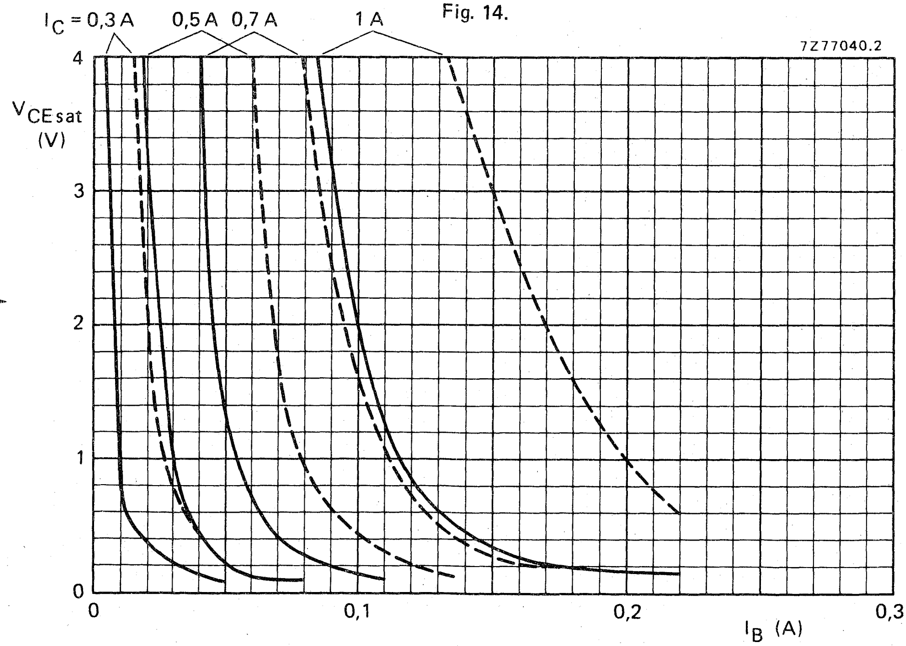


Fig. 15 Typical (——) and maximum (– – –) values saturation voltage at T_j = 25 °C.

SILICON DIFFUSED POWER TRANSISTORS

High-voltage, high-speed switching n-p-n power transistors in TO-3 envelopes, intended for use in converters, inverters, switching regulators and motor control systems.

QUICK REFERENCE DATA

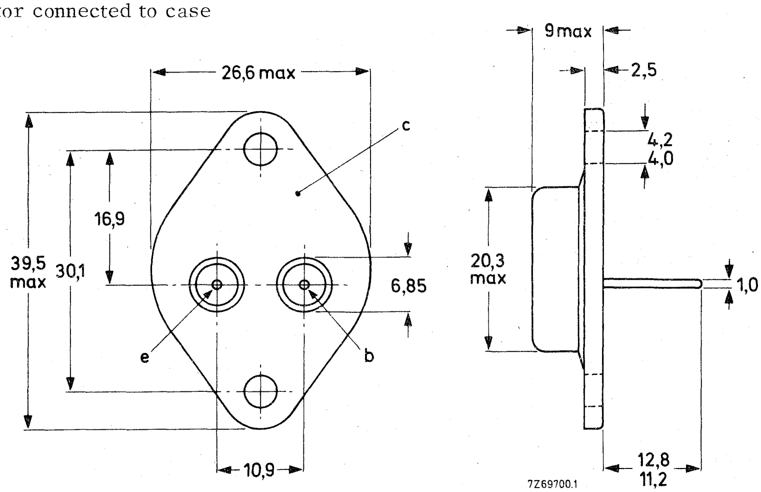
			BUX80	BUX81	
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max.	800	1000	V
Collector-emitter voltage (R_{BE} = 50 Ω)	V_{CER}	max.	500	500	V
Collector-emitter voltage (open base)	V_{CEO}	max.	400	450	V
Collector current (d.c.)	I_C	max.	10		A
Collector current (peak value) t_p = 2 ms	I_{CM}	max.	15		A
Total power dissipation up to T_{mb} = 40 °C	P_{tot}	max.	100		W
Collector-emitter saturation voltage I_C = 5 A; I_B = 1 A	V_{CEsat}	<	1,5		V
Fall time I_{Con} = 5 A; I_{Bon} = 1 A; $-I_{Boff}$ = 2 A	t_f	typ.	0,3		μs

Red Binder, Tab 5

MECHANICAL DATA

Dimensions in mm

TO-3
Collector connected to case



For mounting instructions and accessories see section Accessories.

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

Voltages

			BUX80	BUX81	
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max.	800	1000	V
Collector-emitter voltage (R_{BE} = 50 Ω)	V_{CER}	max.	500	500	V
Collector-emitter voltage (open base)	V_{CEO}	max.	400	450	V

Currents

Collector current (d.c.)	I_C	max.	10	A
Collector current (peak value) t_p = 2 ms	I_{CM}	max.	15	A
Base current (d.c.)	I_B	max.	4	A
Base current (peak value)	I_{BM}	max.	6	A
Reverse base current (d.c. or average over any 20 ms period)	$-I_{B(AV)}$	max.	100	mA
Reverse base current (peak value) [1]	$-I_{BM}$	max.	6	A

Power dissipation

Total power dissipation up to T_{mb} = 40 °C	P_{tot}	max.	100	W

Temperatures

Storage temperature	T_{stg}		−65 to +150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,1	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current [2]

$V_{CEM} = V_{CESMmax}$; $V_{BE} = 0$	I_{CES}	<	1	mA
$V_{CEM} = V_{CESMmax}$; $V_{BE} = 0$; T_j = 125 °C	I_{CES}	<	3	mA

D.C. current gain

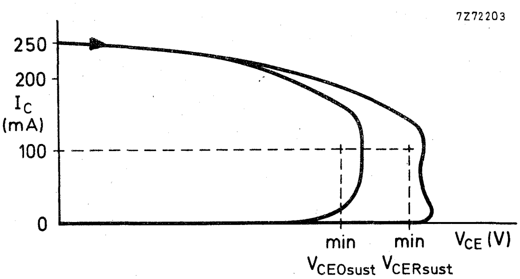
I_C = 1,2 A; V_{CE} = 5 V	h_{FE}	typ.	30	

[1]) Turn-off current.

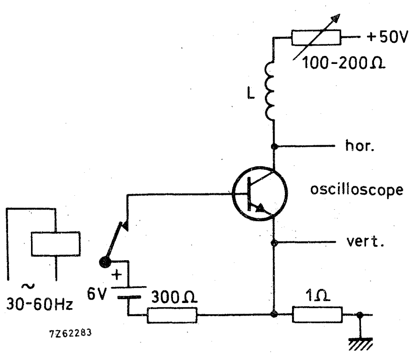
[2]) Measured with a half sine wave voltage (curve tracer).

CHARACTERISTICS (continued) $T_j = 25\ ^oC$ unless otherwise specified

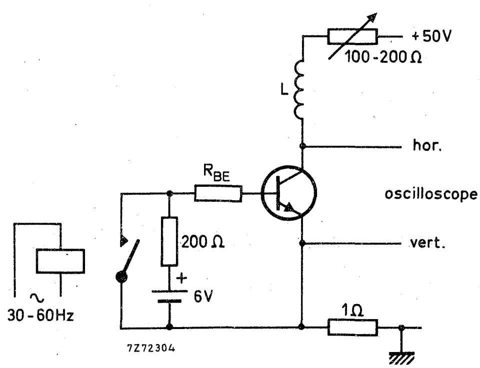
Emitter cut-off current					
$I_C = 0$; $V_{EB} = 10$ V	I_{EBO}	<	10		mA
Saturation voltages					
$I_C = 5$ A; $I_B = 1$ A	V_{CEsat}	<	1,5		V
	V_{BEsat}	<	1,4		V
$I_C = 8$ A; $I_B = 2,5$ A	V_{CEsat}	<	3		V
	V_{BEsat}	<	1,8		V
Collector-emitter sustaining voltages			BUX80	BUX81	
$I_C = 100$ mA; $I_{Boff} = 0$; $L = 25$ mH	$V_{CEOsust}$	>	400	450	V
$I_C = 100$ mA; $R_{BE} = 50\ \Omega$; $L = 15$ mH	$V_{CERsust}$	>	500	500	V



Oscilloscope display for sustaining voltages



Test circuit for $V_{CEOsust}$



Test circuit for $V_{CERsust}$

CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Transition frequency at f = 1 MHz

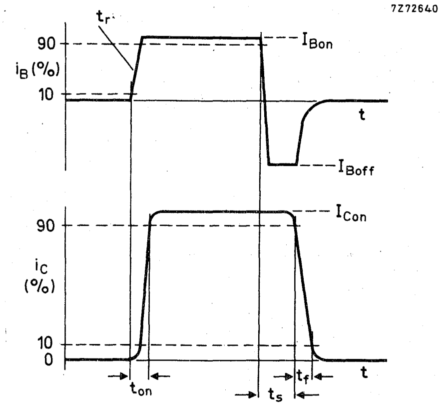
I_C = 0,2 A; V_{CE} = 10 V	f_T	typ.	6	MHz

Switching times

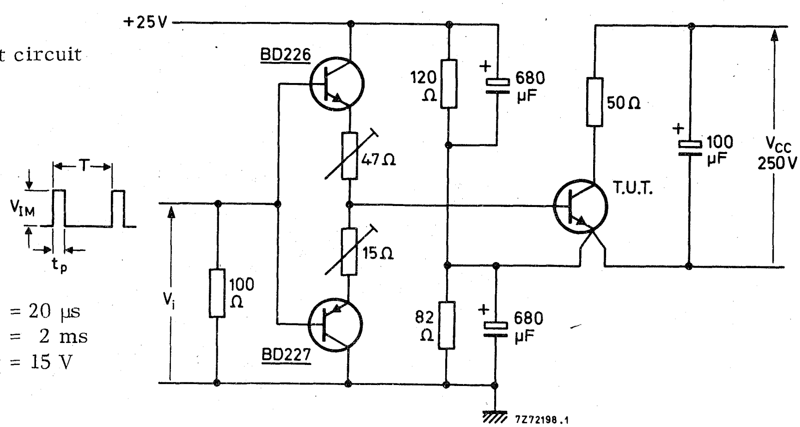
I_{Con} = 5 A; V_{CC} = 250 V
I_{Bon} = 1 A; $-I_{Boff}$ = 2 A

Turn-on time	t_{on}	typ.	0,35	µs
		<	0,5	µs
Turn-off: Storage time	t_s	typ.	2,5	µs
		<	3,5	µs
Fall time	t_f	typ.	0,3	µs
Fall time, T_{mb} = 95 °C	t_f	<	0,8	µs

Waveform

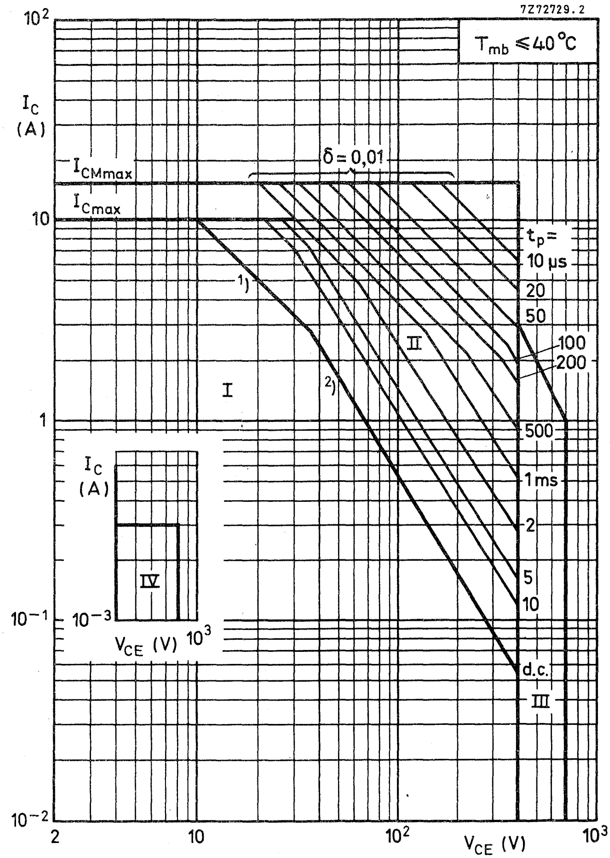


Test circuit



t_p = 20 µs
T = 2 ms
V_{IM} = 15 V

BUX80



Safe Operating ARea

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

III Area of permissible operation during turn-on in single-transistor converters, provided $R_{BE} \leq 100\ \Omega$ and $t_p \leq 0,6\ \mu s$

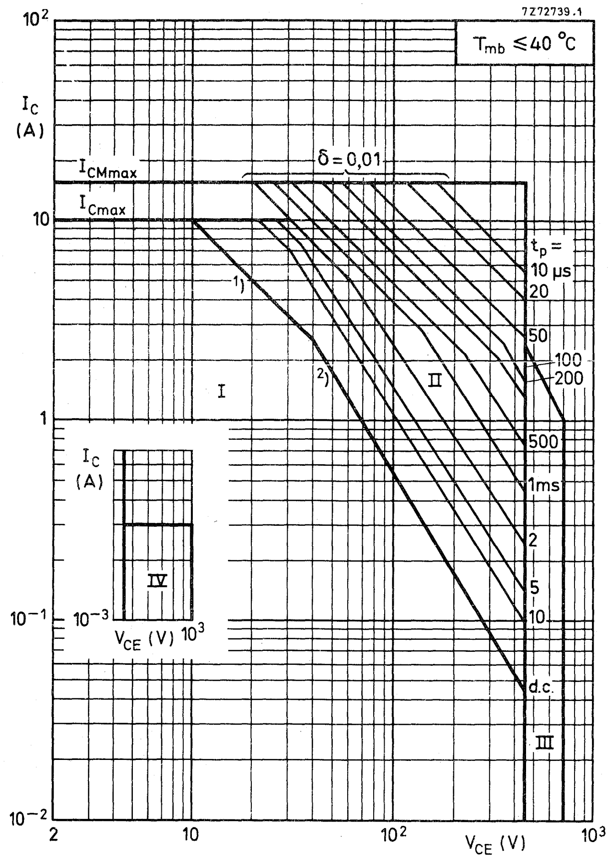
IV Repetitive pulse operation in this region is permissible, provided $V_{BE} \leq 0$ and $t_p \leq 2$ ms

---

1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.

2) Second-breakdown limits (independent of temperature).

BUX81



Safe Operating ARea

I Region of permissible d.c. operation

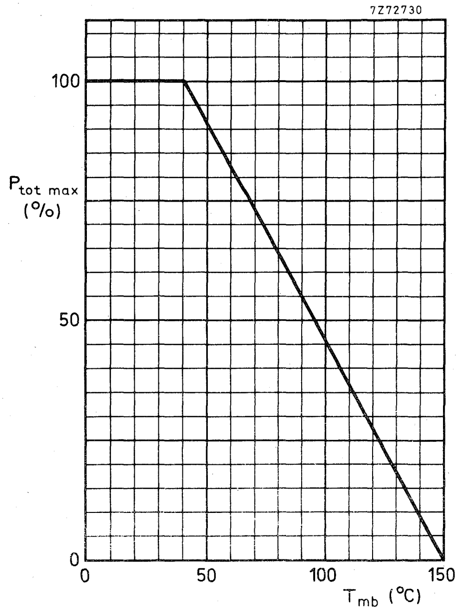
II Permissible extension for repetitive pulse operation

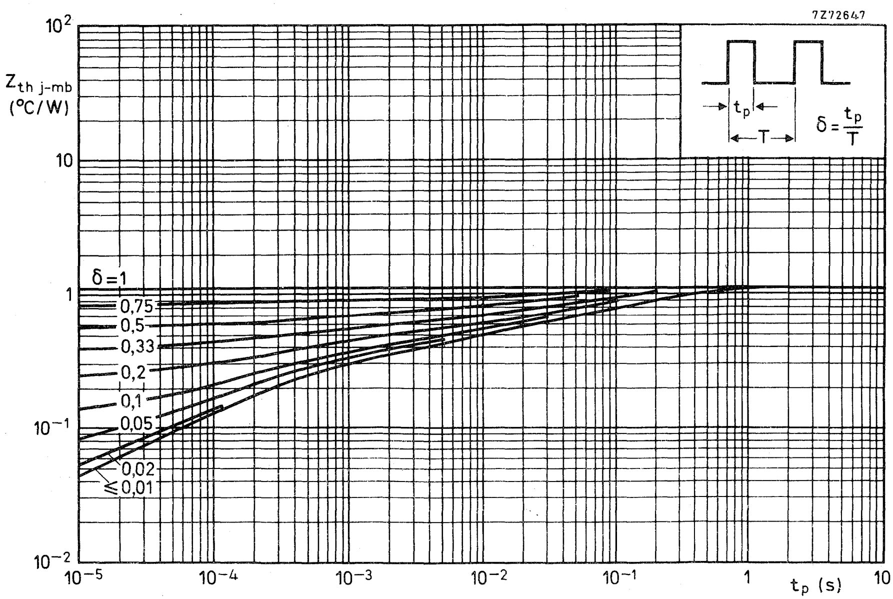
III Area of permissible operation during turn-on in single-transistor converters, provided $R_{BE} \leq 100\ \Omega$ and $t_p \leq 0,6\ \mu s$

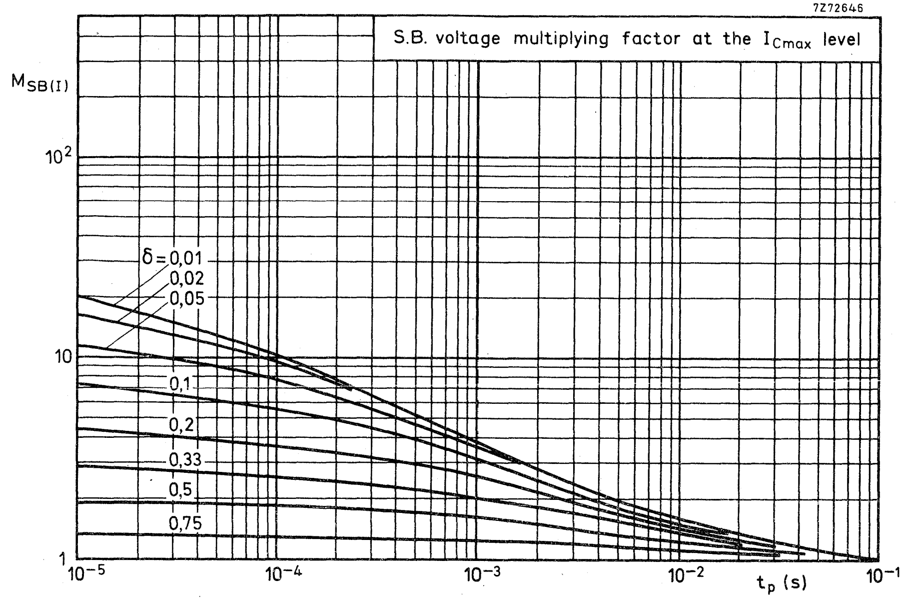
IV Repetitive pulse operation in this region is permissible, provided $V_{BE} \leq 0$ and $t_p \leq 2$ ms

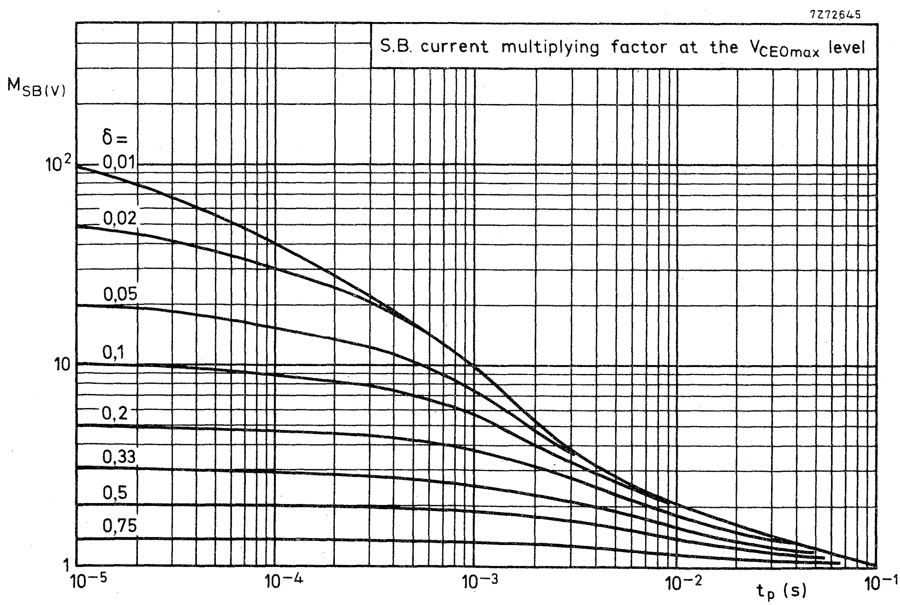
1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.

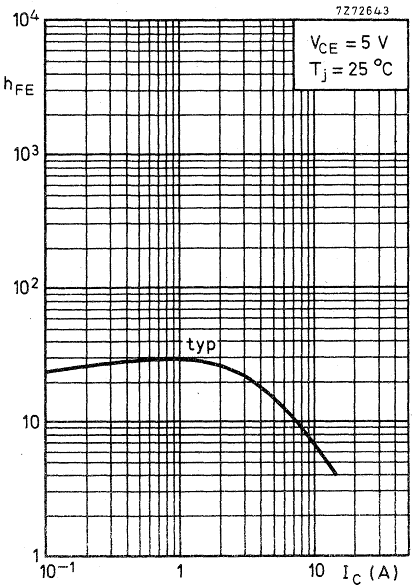
2) Second-breakdown limits (independent of temperature).

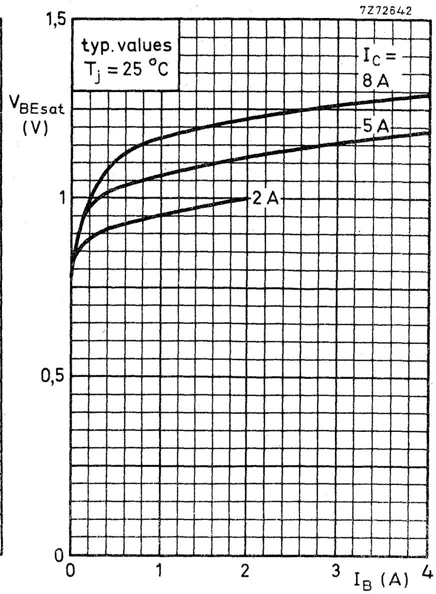

7Z72730
100
50
0
$P_{tot\ max}$ (%)
0
50
100
150
T_{mb} (°C)

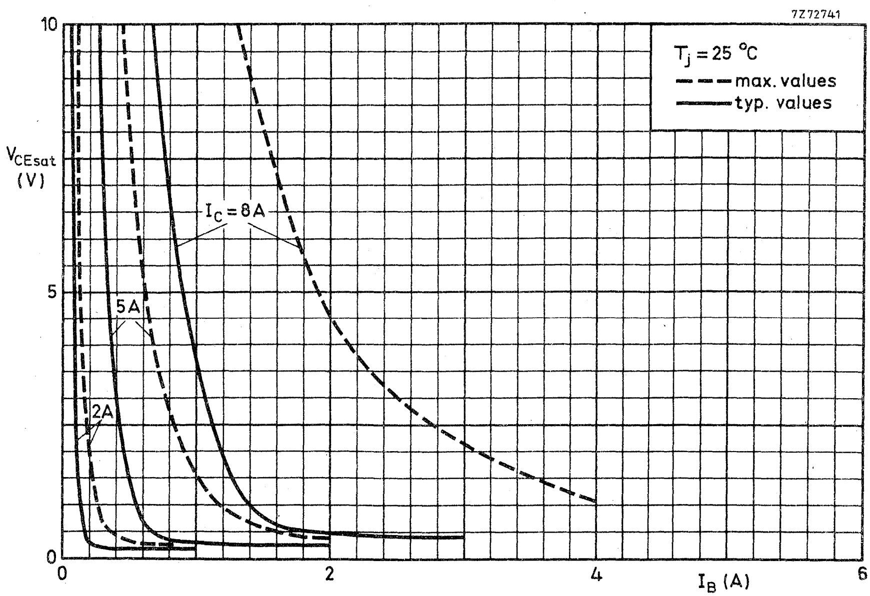

7Z72647
10^2
$Z_{th\ j\text{-}mb}$ (°C/W)
10
1
10^{-1}
10^{-2}
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
≤ 0,01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
t_p (s)
10


7Z72646
S.B. voltage multiplying factor at the I_Cmax level
M_SB(I)
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^-5
10^-4
10^-3
10^-2
10^-1
t_p (s)


7Z72645
S.B. current multiplying factor at the V_CEOmax level
M_SB(V)
10^2
10
1
δ =
0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^-5
10^-4
10^-3
10^-2
10^-1
t_p (s)


7Z72643
V_{CE} = 5 V
T_j = 25 °C
h_{FE}
10^4
10^3
10^2
10
1
typ
10^{-1}
1
10
I_C (A)


7Z72642
typ. values
T_j = 25 °C
I_C =
8 A
5 A
2 A
V_{BEsat}
(V)
1,5
1
0,5
0
0
1
2
3
4
I_B (A)


7Z72741
T_j = 25 °C
max. values
typ. values
V_{CEsat}
(V)
10
5
0
I_C = 8 A
5 A
2A
0
2
4
6
I_B (A)

APPLICATION INFORMATION ON BUX80 (detailed information on request)

Important factors in the design of SMPS circuits are the power losses and heatsink requirements of the supply output transistor and the base drive conditions during turn-off. In SMPS circuits with mains isolation the duty factor of the collector current generally varies between 0,25 and 0,5.

The operating frequency lies between 15 kHz and 50 kHz and the shape of the collector current varies from rectangular in a forward converter to a sawtooth in a flyback circuit.

As the BUX80 will mainly be used in forward or push-pull converters the information on optimum base drive and device dissipation given in the graphs on page 12 is concentrated on this application. In these figures I_{CM} represents the highest repetitive peak collector current that can occur in the given circuit, e.g. during overload.

The total power dissipation for a limit-case transistor is given in Fig. 5 which applies for a mounting base temperature of 100 °C. The required thermal resistance for the heatsink can be calculated from

$$R_{th\ mb\text{-}a} = \frac{100 - T_{amb\ max}}{P_{tot}}$$

To ensure thermal stability the minimum value of T_{amb} in the above equation is 40 °C.

A practical SMPS output circuit for an output power in the order of 400 W is given in Fig. 2.

At a collector current of 5 A and a base current of 1 A in this circuit the following turn-off times can be expected.

			T_{mb} = 25 °C	100 °C	
Storage time	t_s	typ	2	2,7	μs
Fall time	t_f	typ	0,18	0,5	μs

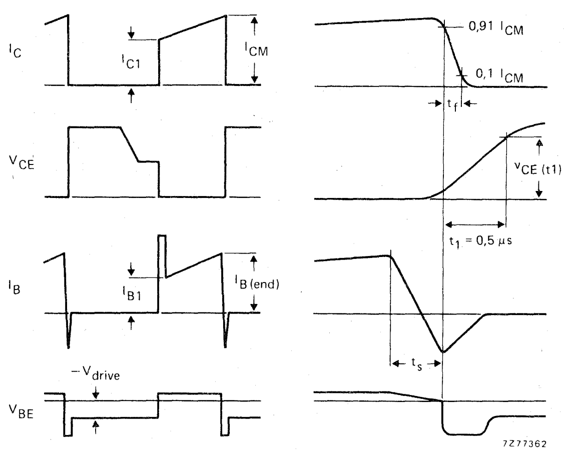


Fig. 1 Relevant waveforms of switching transistor.

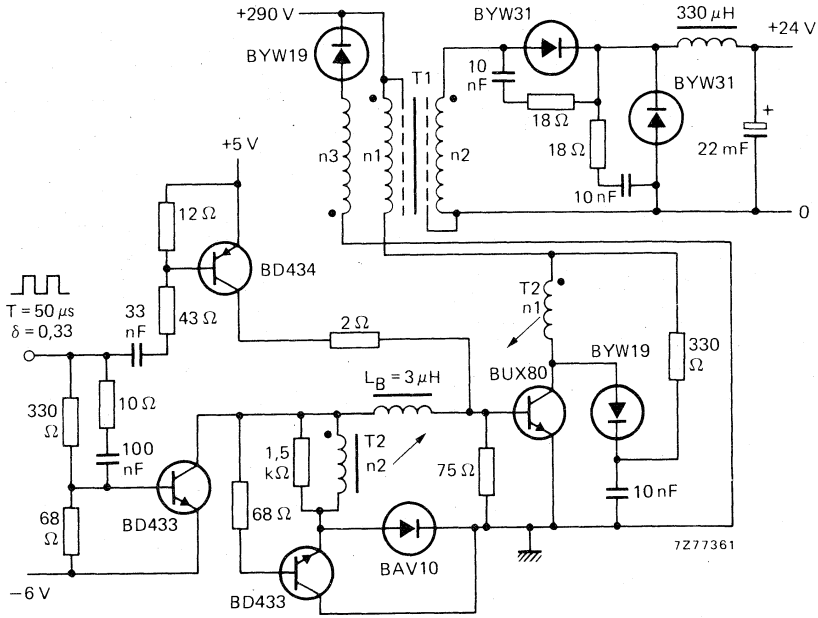


Fig. 2 Practical SMPS output circuit.

T1 (output transformer): Core U64; n1 = n3 = 56 turns; n2 = 17 turns

T2 (base current transformer): Core U20; n1 = 5 turns; n2 = 25 turns

$v_{CE(t1)} < 300$ V (see Fig. 1)

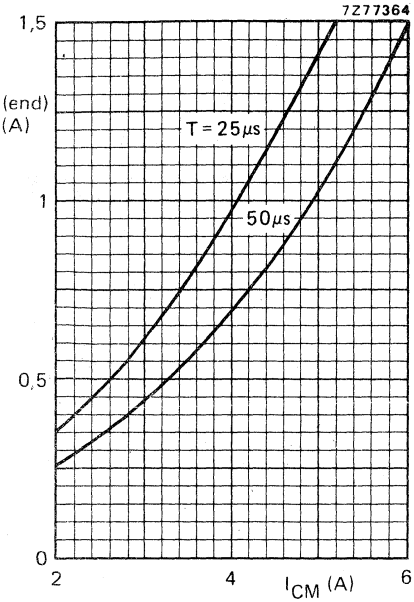


Fig. 3.

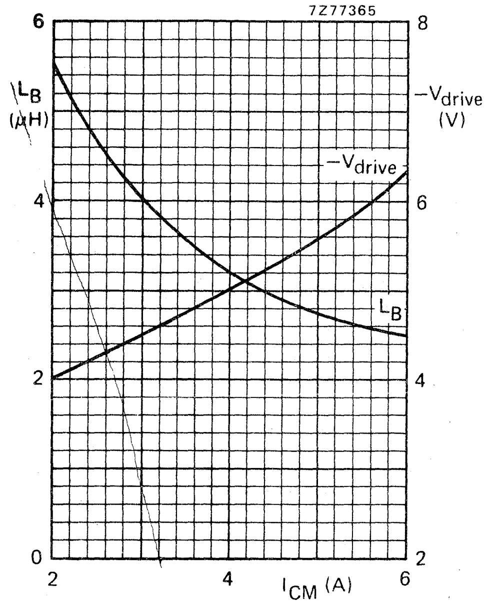


Fig. 4.

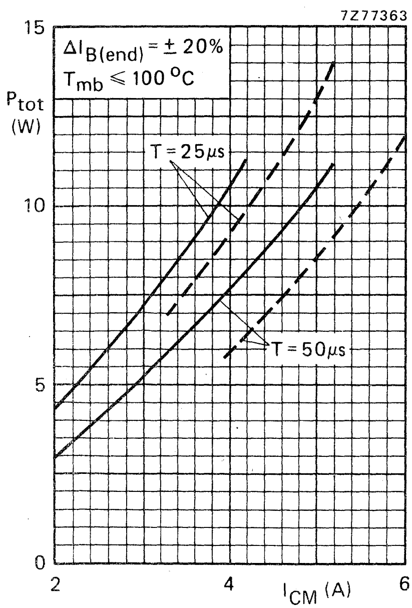


Fig. 5.

Fig. 3 Recommended nominal "end" value of the base current versus maximum peak collector current.

Fig. 4 Minimum required base inductance and recommended negative drive voltage versus maximum peak collector current.

Fig. 5 Maximum total power dissipation of a limit-case transistor if the base current is chosen in accordance with Fig. 3. Solid lines for transformer drive and dotted lines for collector-coupled current drive.

SILICON DIFFUSED POWER TRANSISTORS

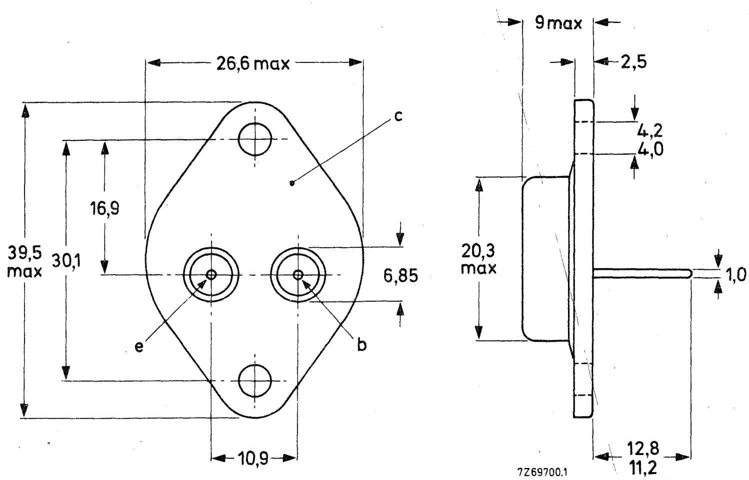
High-voltage, high-speed switching n-p-n power transistors in TO-3 envelopes, intended for use in converters, inverters, switching regulators and motor control systems.

QUICK REFERENCE DATA

			BUX82	BUX83	
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max.	800	1000	V
Collector-emitter voltage (R_{BE} = 100 Ω)	V_{CER}	max.	500	500	V
Collector-emitter voltage (open base)	V_{CEO}	max.	400	450	V
Collector current (d.c.)	I_C	max.	6		A
Collector current (peak value) t_p = 2 ms	I_{CM}	max.	8		A
Total power dissipation up to T_{mb} = 50 °C	P_{tot}	max.	60		W
Collector-emitter saturation voltage I_C = 2,5 A; I_B = 0,5 A	V_{CEsat}	<	1,5		V
Fall time I_{Con} = 2,5 A; I_{Bon} = 0,5 A; $-I_{Boff}$ = 1 A	t_f	typ.	0,3		μs

MECHANICAL DATA Dimensions in mm

TO-3
Collector connected to case



For mounting instructions and accessories see section Accessories.

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

Voltages

			BUX82	BUX83	
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max.	800	1000	V
Collector-emitter voltage (R_{BE} = 100 Ω)	V_{CER}	max.	500	500	V
Collector-emitter voltage (open base)	V_{CEO}	max.	400	450	V

Currents

Collector current (d.c.)	I_C	max.	6	A
Collector current (peak value) t_p = 2 ms	I_{CM}	max.	8	A
Base current (d.c.)	I_B	max.	2	A
Base current (peak value)	I_{BM}	max.	3	A
Reverse base current (d.c. or average over any 20 ms period)	$-I_{B(AV)}$	max.	100	mA
Reverse base current (peak value) [1]	$-I_{BM}$	max.	3	A

Power dissipation

Total power dissipation up to T_{mb} = 50 °C	P_{tot}	max.	60	W

Temperatures

Storage temperature	T_{stg}		−65 to +150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,65	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current [2]

$V_{CEM} = V_{CESMmax}$; $V_{BE} = 0$	I_{CES}	<	1	mA
$V_{CEM} = V_{CESMmax}$; $V_{BE} = 0$; T_j = 125 °C	I_{CES}	<	2	mA

D.C. current gain

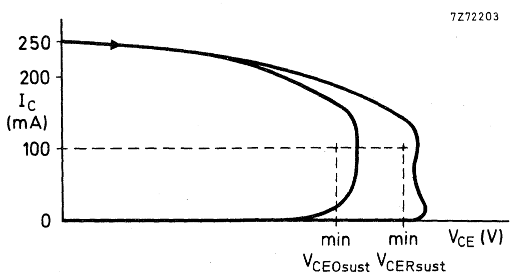
I_C = 0,6 A; V_{CE} = 5 V	h_{FE}	typ.	30

1) Turn-off current.

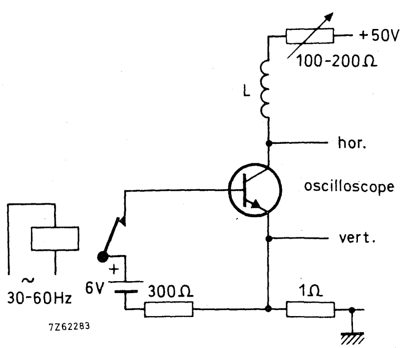
2) Measured with a half sine wave voltage (curve tracer).

CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

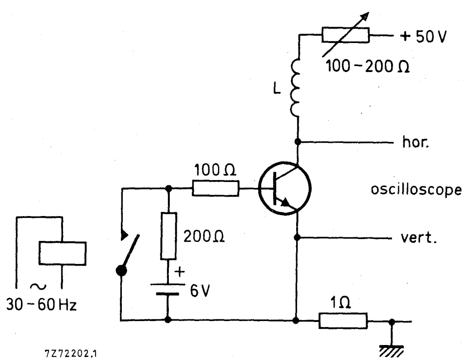
Emitter cut-off current					
I_C = 0; V_{EB} = 10 V	I_{EBO}	<	10		mA
Saturation voltages					
I_C = 2,5 A; I_B = 0,5 A	V_{CEsat}	<	1,5		V
	$V_{BE\,sat}$	<	1,4		V
I_C = 4 A; I_B = 1,25 A	V_{CEsat}	<	3		V
	$V_{BE\,sat}$	<	1,6		V
Collector-emitter sustaining voltages			BUX82	BUX83	
I_C = 100 mA; I_{Boff} = 0; L = 25 mH	$V_{CEOsust}$	>	400	450	V
I_C = 100 mA; R_{BE} = 100 Ω; L = 15 mH	$V_{CERsust}$	>	500	500	V



Oscilloscope display for sustaining voltages



Test circuit for $V_{CEOsust}$

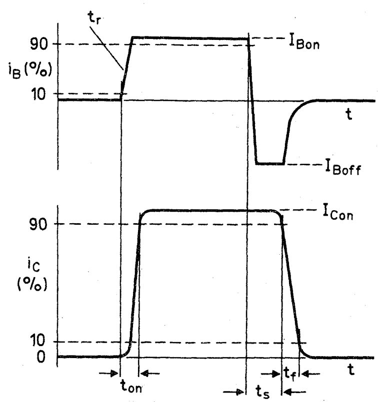


Test circuit for V_{ERsust}

CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

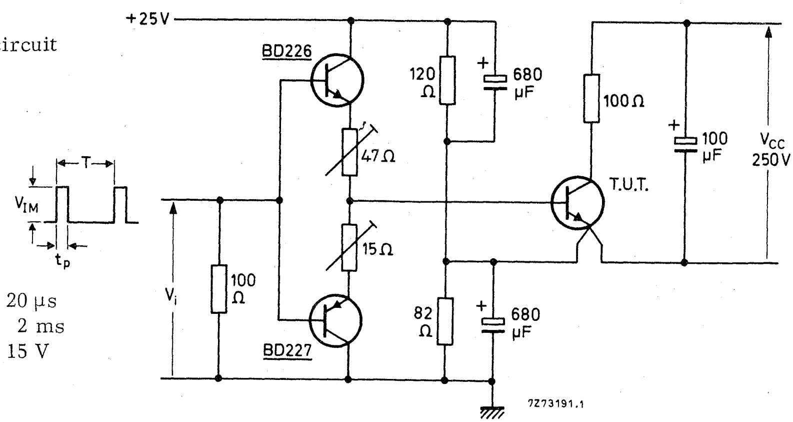
Transition frequency at f = 1 MHz				
I_C = 0,2 A; V_{CE} = 10 V	f_T	typ.	6	MHz
Switching times				
I_{Con} = 2,5 A; V_{CC} = 250 V				
I_{Bon} = 0,5 A; $-I_{Boff}$ = 1 A				
Turn-on time	t_{on}	typ.	0,3	μs
		<	0,5	μs
Turn-off: Storage time	t_s	typ.	2	μs
		<	3,5	μs
Fall time	t_f	typ.	0,3	μs
Fall time, T_{mb} = 95 °C	t_f	<	1	μs

Waveform

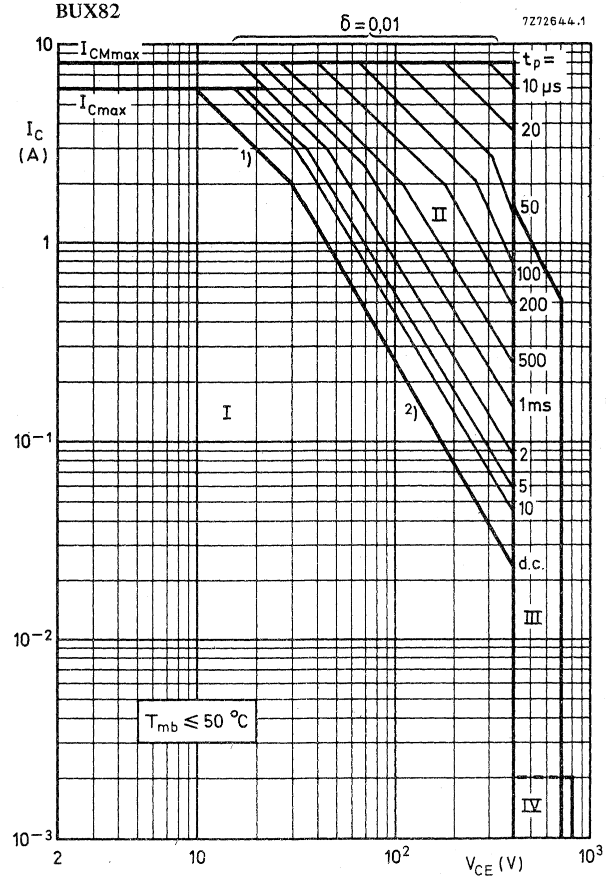


Test circuit

t_p = 20 μs
T = 2 ms
V_{IM} = 15 V



BUX82



Safe Operating ARea

I Region of permissible d.c. operation

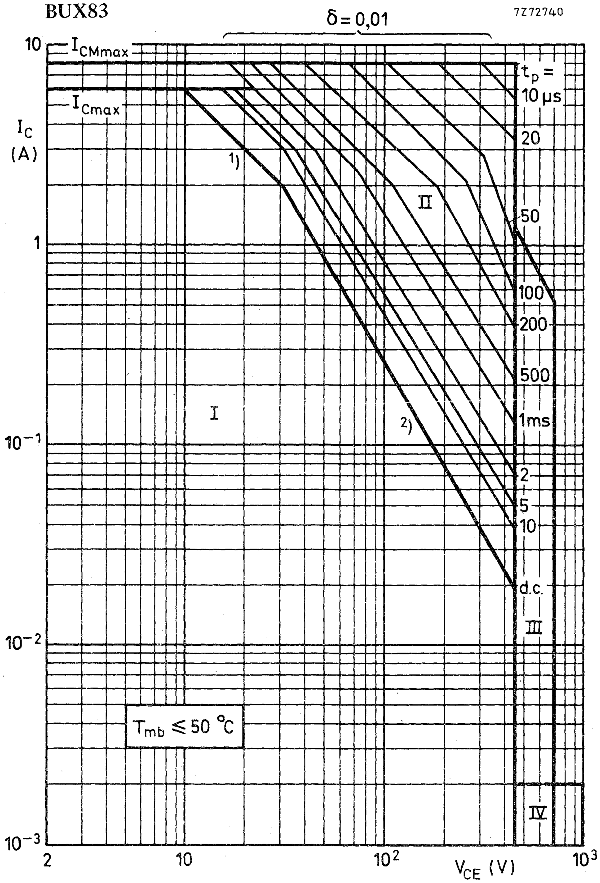
II Permissible extension for repetitive pulse operation

III Area of permissible operation during turn-on in single-transistor converters, provided $R_{BE} \leq 100\ \Omega$ and $t_p \leq 0,6\ \mu s$

IV Repetitive pulse operation in this region is permissible, provided $V_{BE} \leq 0$ and $t_p \leq 2$ ms

1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.

2) Second-breakdown limits (independent of temperature).



Safe Operating ARea

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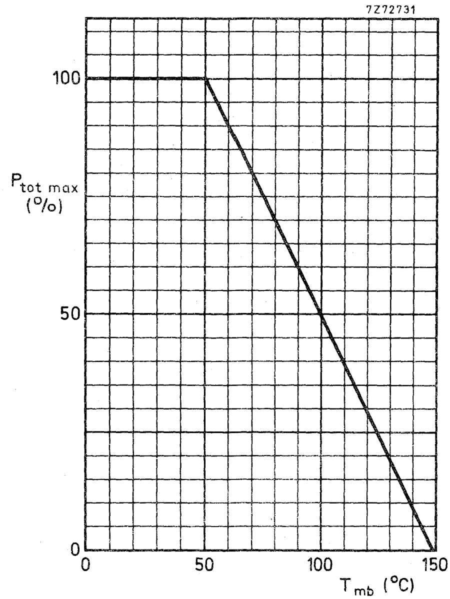
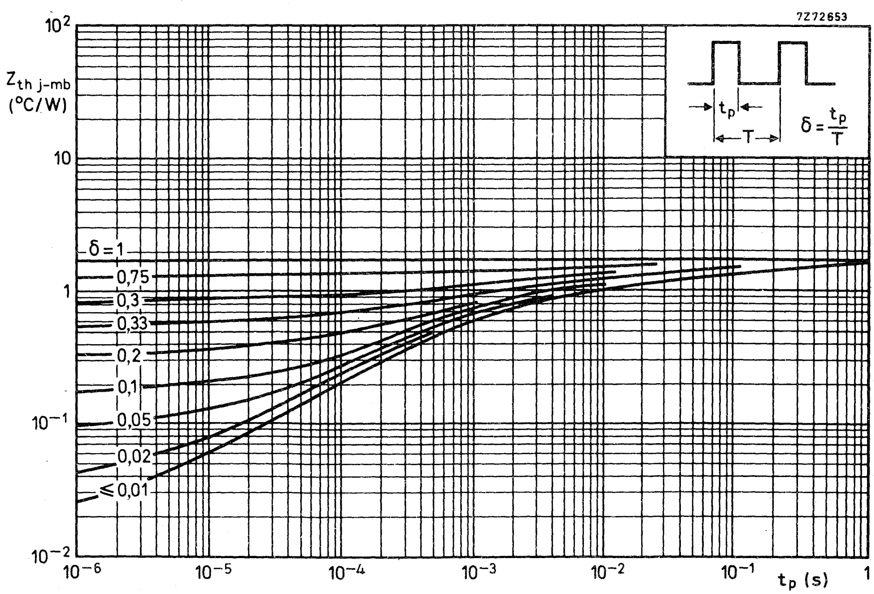
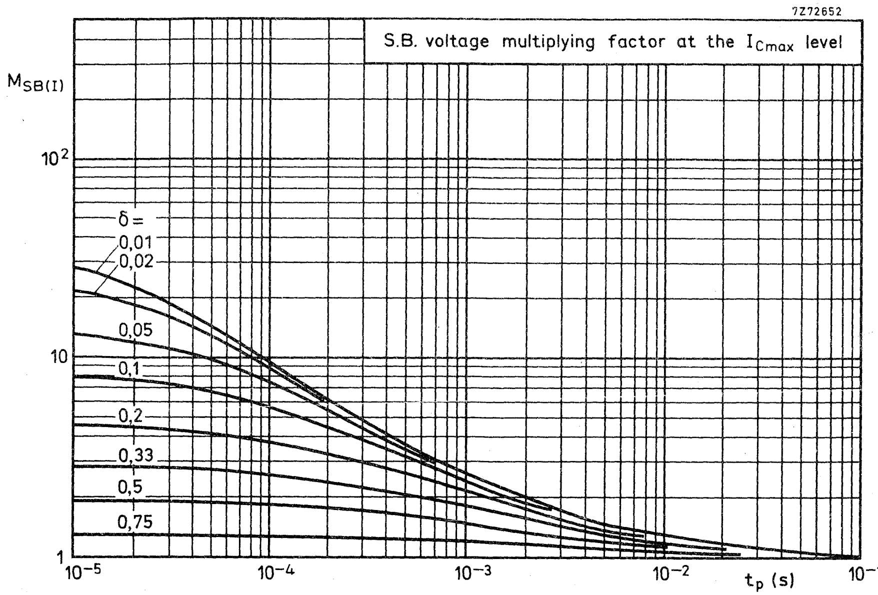
IV Repetitive pulse operation in this region is permissible, provided $V_{BE} \leq 0$ and $t_p \leq 2$ ms

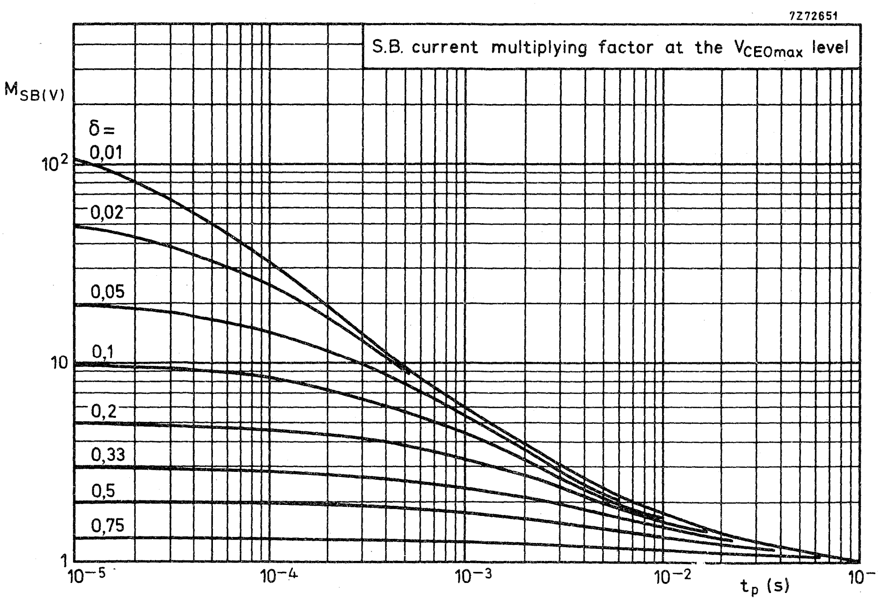
1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.

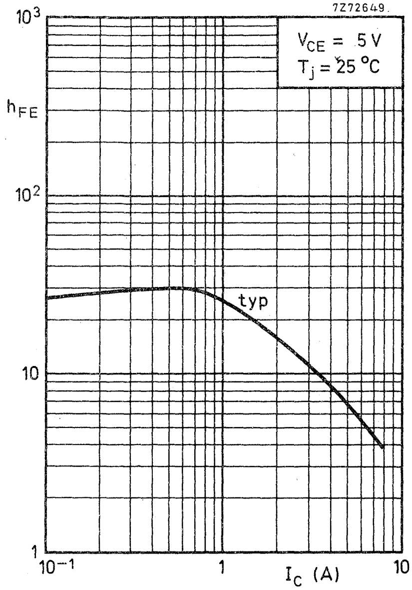
2) Second-breakdown limits (independent of temperature).

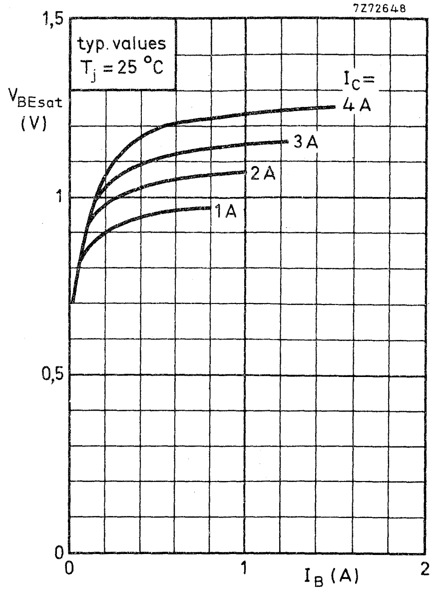

7Z72731
100
$P_{tot\ max}$ (%)
50
0
0
50
100
150
T_{mb} (°C)

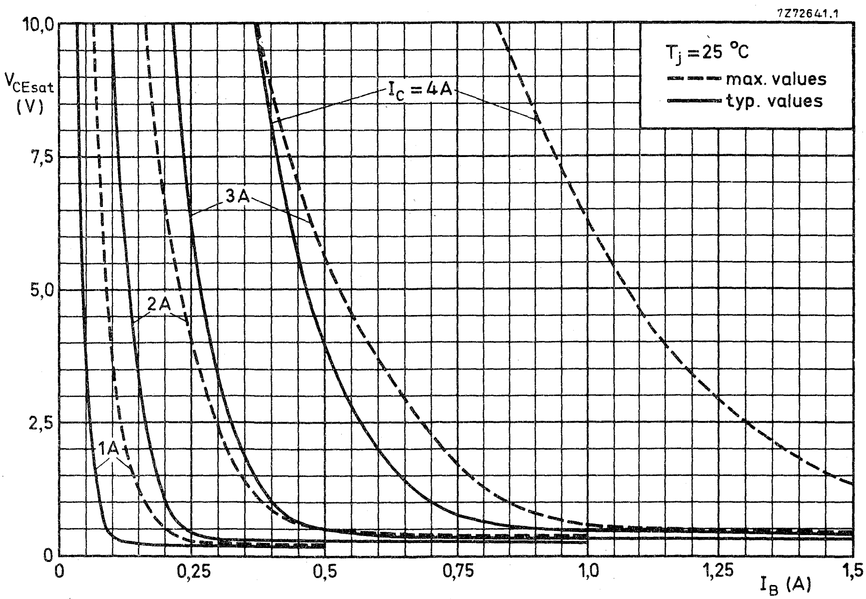

7Z72653
10^2
$Z_{th\ j\text{-}mb}$ (°C/W)
10
1
10^{-1}
10^{-2}
t_p
T
$\delta = \frac{t_p}{T}$
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
≤ 0,01
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
t_p (s)


7Z72652
S.B. voltage multiplying factor at the I_{Cmax} level
$M_{SB(I)}$
10^2
10
1
δ =
0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-5}
10^{-4}
10^{-3}
10^{-2}
t_p (s)
10^{-1}


7Z72651
S.B. current multiplying factor at the V_{CEOmax} level
$M_{SB(V)}$
10^2
10
1
δ =
0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-5}
10^{-4}
10^{-3}
10^{-2}
t_p (s)
10^{-1}


7Z72649
V_{CE} = 5 V
T_j = 25 °C
h_{FE}
typ
I_C (A)


7Z72648
typ. values
T_j = 25 °C
V_{BEsat} (V)
I_C =
4 A
3 A
2 A
1 A
I_B (A)


7Z72641.1
T_j = 25 °C
max. values
typ. values
V_{CEsat} (V)
I_C = 4A
3A
2A
1A
I_B (A)

APPLICATION INFORMATION ON BUX82 (detailed information on request)

Important factors in the design of SMPS circuits are the power losses and heatsink requirements of the supply output transistor and the base drive conditions during turn-off. In SMPS circuits with mains isolation the duty factor of the collector current generally varies between 0,25 and 0,5.

The operating frequency lies between 15 kHz and 50 kHz and the shape of the collector current varies from rectangular in a forward converter to a sawtooth in a flyback circuit.

Information on optimum base drive and device dissipation of the BUX82 in a flyback converter is given in Figs 3 to 5. Figs 6 to 8 apply to a forward converter. In these figures I_{CM} represents the highest repetitive peak collector current that can occur in the given circuit, e.g. during overload.

The total power dissipation for a limit-case transistor is given in Figs 5 and 8 which applies for a mounting base temperature of 100 °C. The required thermal resistance for the heatsink can be calculated from

$$R_{th\ mb\text{-}a} = \frac{100 - T_{amb\ max}}{P_{tot}}.$$

To ensure thermal stability the minimum value of T_{amb} in the above equation is 40 °C.

A practical forward converter output circuit for an output power in the order of 200 W is given in Fig. 2.

At a collector current of 2,5 A and a base current of 0,5 A in this circuit the following turn-off times can be expected.

			T_{mb} = 25 °C	100 °C	
Storage time	t_s	typ	1,9	2,7	µs
Fall time	t_f	typ	0,17	0,7	µs

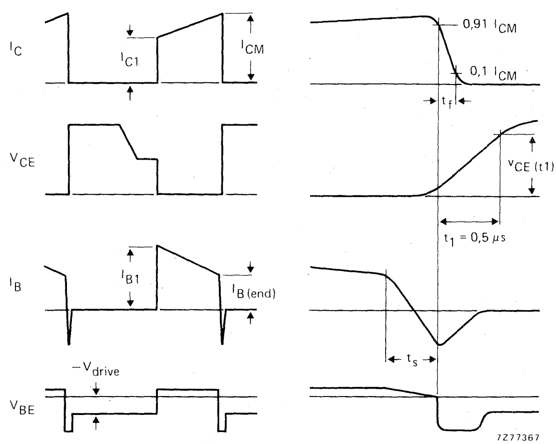


Fig. 1 Relevant waveforms of switching transistor.

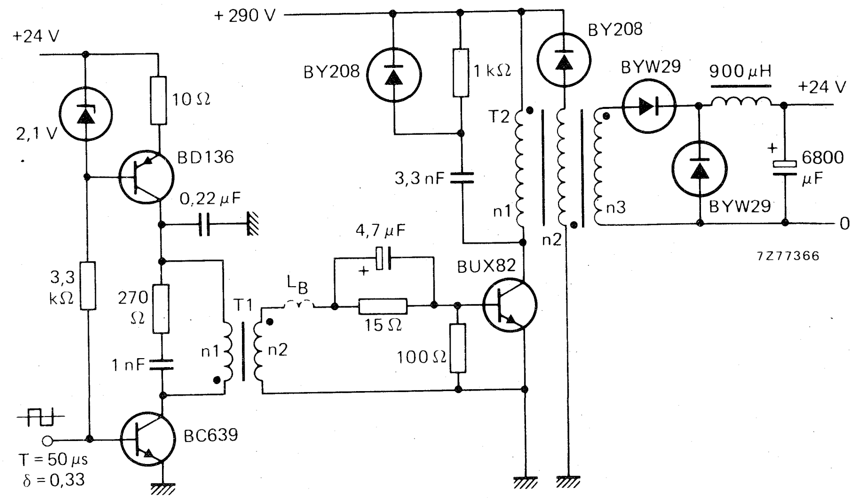


Fig. 2 Practical forward converter SMPS output circuit.
T1 (driver transformer): Core U20; n1 = 75 turns; n2 = 20 turns
T2 (output transformer): Core E55; n1 = n2 = 72 turns; n3 = 19 turns
$v_{CE(t1)} < 300$ V (see Fig. 1)

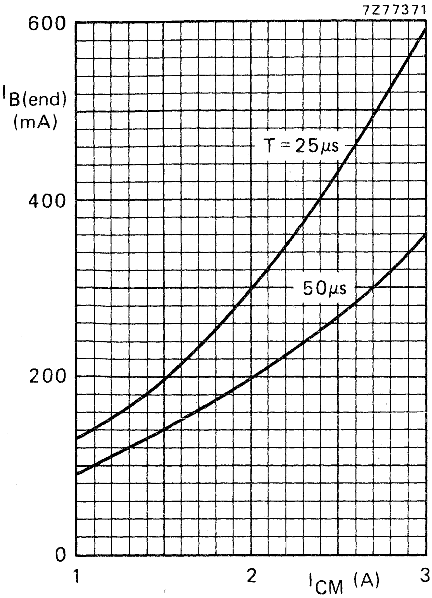


Fig. 3.

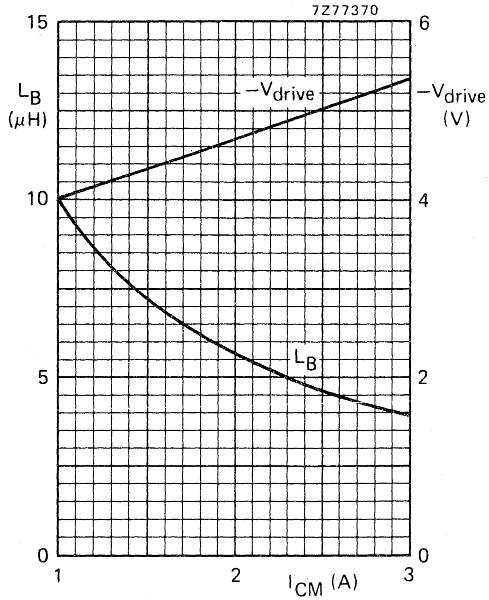


Fig. 4.

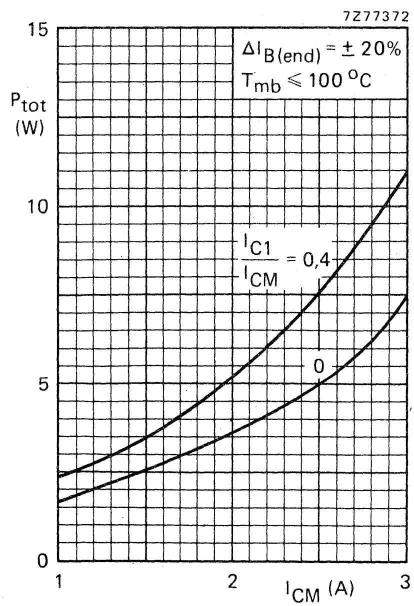


Fig. 5.

Fig. 3 Recommended nominal "end" value of the base current versus maximum peak collector current in a **flyback** converter.

Fig. 4 Minimum required base inductance and recommended negative drive voltage versus maximum peak collector current.

Fig. 5 Maximum total power dissipation of a limit-case transistor if the base current is chosen in accordance with Fig. 3.

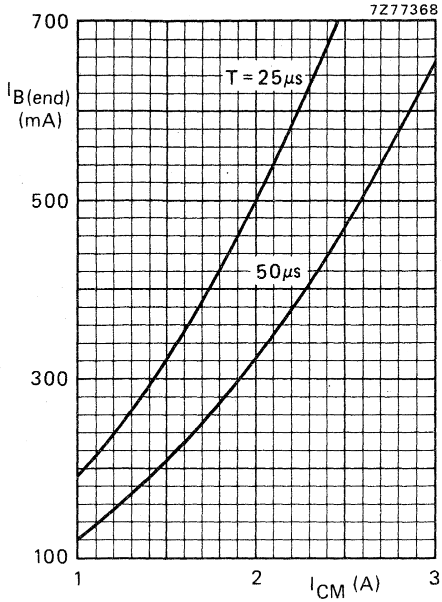


Fig. 6.

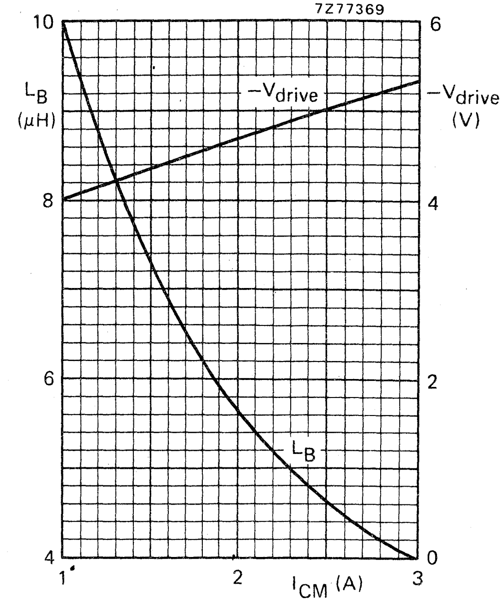


Fig. 7.

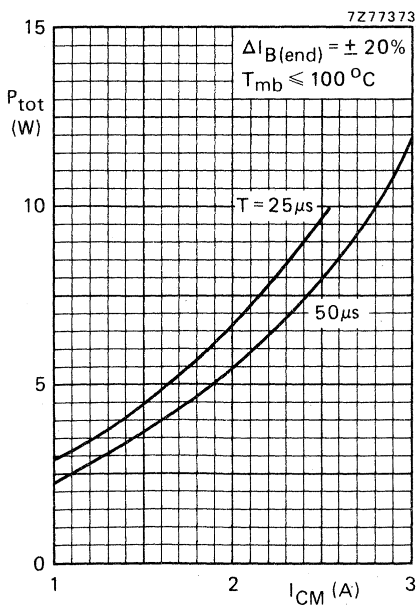


Fig. 8.

Fig. 6 Recommended nominal "end" value of the base current versus maximum peak collector current in a **forward** converter.

Fig. 7 Minimum required base inductance and recommended negative drive voltage versus maximum peak collector current.

Fig. 8 Maximum total power dissipation of a limit-case transistor if the base current is chosen in accordance with Fig. 6.

SILICON DIFFUSED POWER TRANSISTORS

High-voltage, high-speed, glass-passivated n-p-n power transistors in TO-220 envelopes, intended for use in converters, inverters, switching regulators, motor control systems and switching applications.

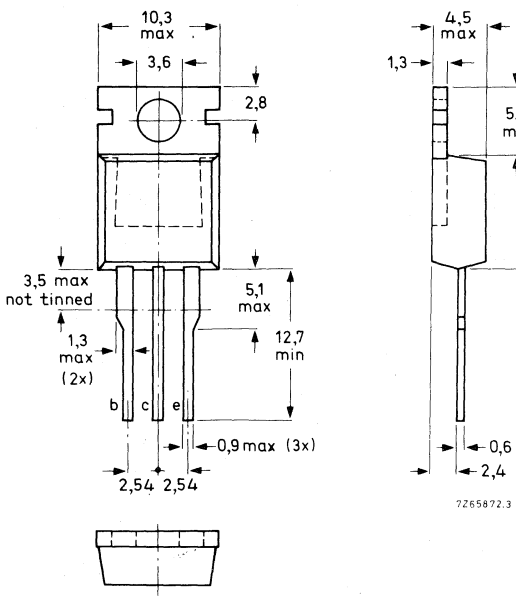
QUICK REFERENCE DATA

			BUX84	BUX85	
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max	800	1000	V
Collector-emitter voltage (open base)	V_{CEO}	max	400	450	V
Collector current (d.c.)	I_C	max	2		A
Collector current (peak value) t_p = 2 ms	I_{CM}	max	3		A
Total power dissipation up to T_{mb} = 50 °C	P_{tot}	max	40		W
Collector-emitter saturation voltage I_C = 1 A; I_B = 0,2 A	V_{CEsat}	<	1		V
Fall time I_{Con} = 1 A; I_{Bon} = 0,2 A; $-I_{Boff}$ = 0,4 A	t_f	typ	0,4		µs

MECHANICAL DATA

Dimensions in mm

TO-220
Collector connected to mounting base



See also chapters Mounting Instructions and Accessories.

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

Voltages

			BUX84	BUX85	
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max	800	1000	V
Collector-emitter voltage (open base)	V_{CEO}	max	400	450	V

Currents

Collector current (d.c.)	I_C	max	2	A
Collector current (peak value) t_p = 2 ms	I_{CM}	max	3	A
Base current (d.c.)	I_B	max	0,75	A
Base current (peak value)	I_{BM}	max	1	A
Reverse base current (peak value) *	$-I_{BM}$	max	1	A

Power dissipation

Total power dissipation up to T_{mb} = 50 °C	P_{tot}	max	40	W

Temperatures

Storage temperature	T_{stg}		−65 to +150	°C
Junction temperature	T_j	max	150	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2,5	°C/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	70	°C/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current **

$V_{CEM} = V_{CESMmax}$; $V_{BE} = 0$	I_{CES}	<	200	μA
$V_{CEM} = V_{CESMmax}$; $V_{BE} = 0$; T_j = 125 °C	I_{CES}	<	1,5	mA

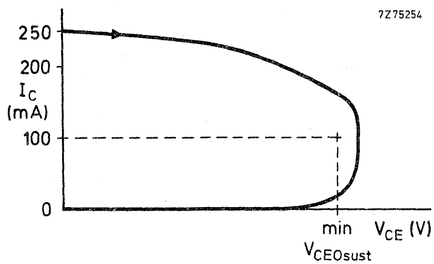
D.C. current gain

I_C = 0,1 A; V_{CE} = 5 V	h_{FE}	typ	50

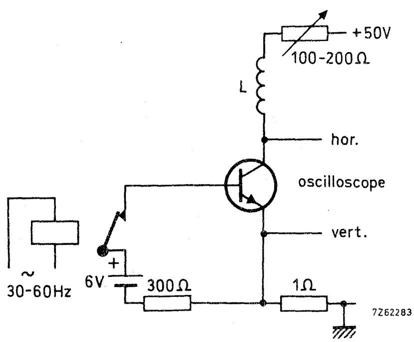
* Turn-off current.
** Measured with a half sine-wave voltage (curve tracer).

CHARACTERISTICS (continued) $T_j = 25\ ^oC$ unless otherwise specified

Emitter cut-off current					
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	1		mA
Saturation voltages					
$I_C = 0{,}3$ A; $I_B = 30$ mA	V_{CEsat}	<	0,8		V
$I_C = 1$ A; $I_B = 0{,}2$ A	V_{CEsat}	<	1,0		V
$I_C = 1$ A; $I_B = 0{,}2$ A	V_{BEsat}	<	1,1		V
Collector-emitter sustaining voltage			BUX84	BUX85	
$I_C = 100$ mA; $I_{Boff} = 0$; $L = 25$ mH	$V_{CEOsust}$	>	400	450	V



Oscilloscope display for sustaining voltage.



Test circuit for $V_{CEOsust}$.

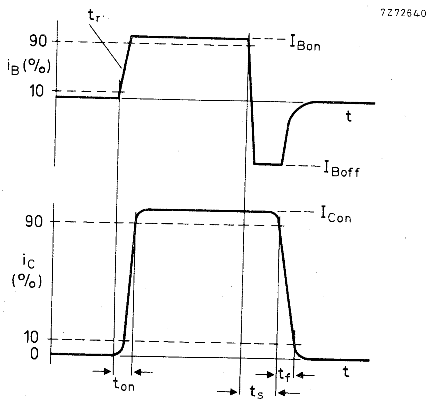
CHARACTERISTICS (continued)

T_j = 25 °C unless otherwise specified

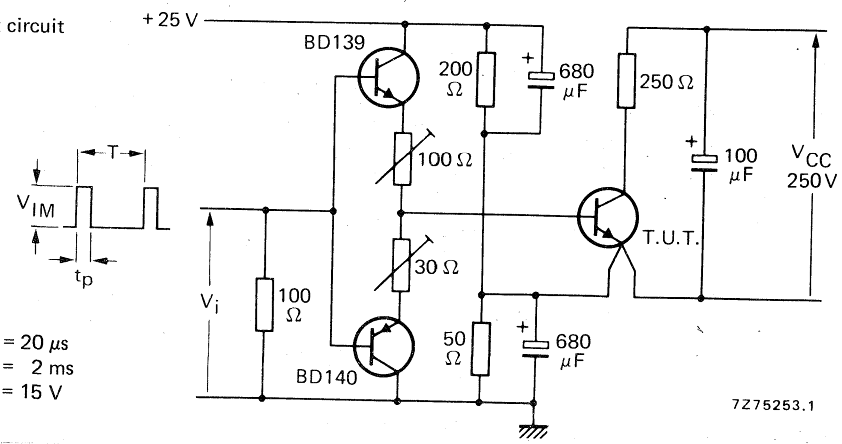
Transition frequency at f = 1 MHz

I_C = 0,2 A; V_{CE} = 10 V	f_T	typ	20	MHz
Switching times				
I_{Con} = 1 A; V_{CC} = 250 V				
I_{Bon} = 0,2 A; $-I_{Boff}$ = 0,4 A				
Turn-on time	t_{on}	typ	0,2	μs
		<	0,5	μs
Turn-off: Storage time	t_s	typ	2	μs
		<	3,5	μs
Fall time	t_f	typ	0,4	μs
Fall time, T_{mb} = 95 °C	t_f	<	1,4	μs

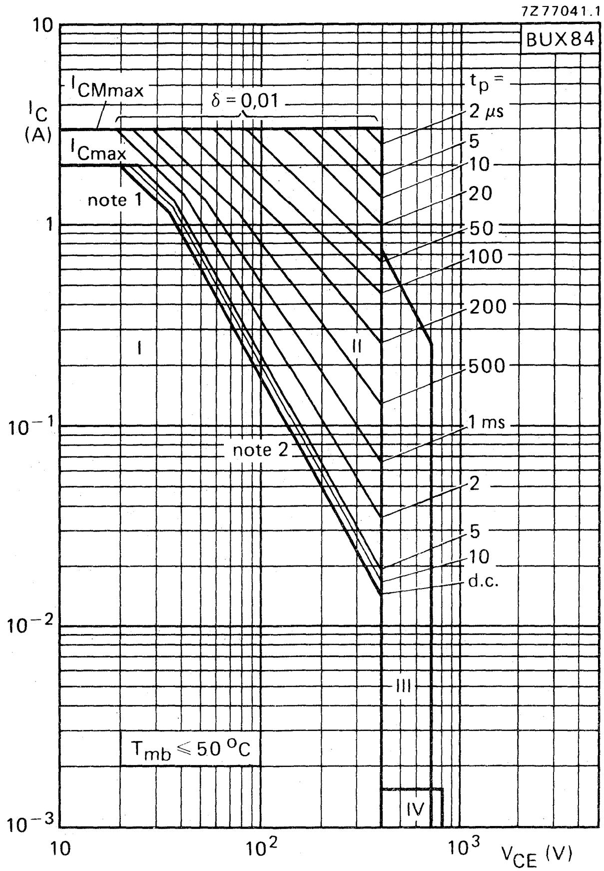
Waveform



Test circuit



t_p = 20 μs
T = 2 ms
V_{IM} = 15 V



Safe Operating ARea

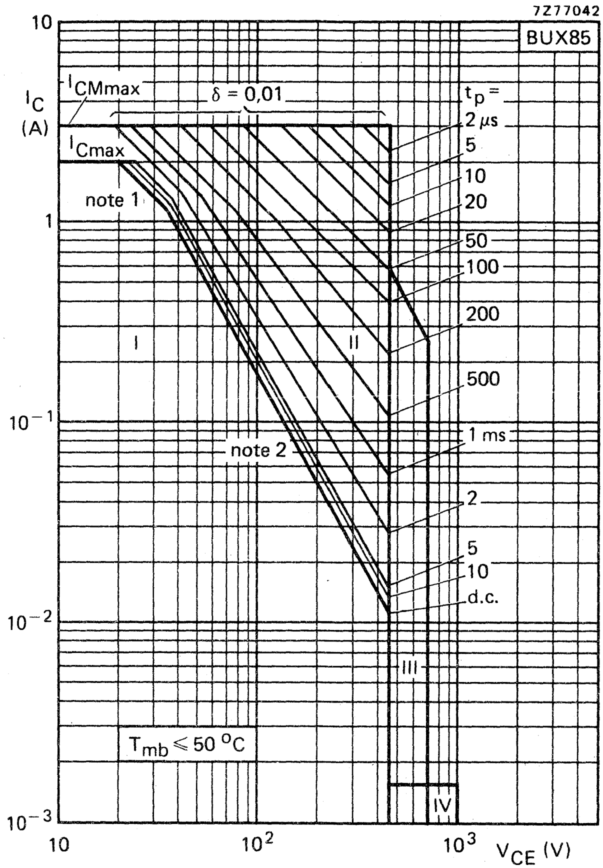
I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

III Area of permissible operation during turn-on in single transistor converters, provided $R_{BE} \leqslant 100\ \Omega$ and $t_p \leqslant 0{,}6\ \mu s$

IV Repetitive pulse operation in this region is permissible, provided $V_{BE} \leqslant 0$ and $t_p \leqslant 2$ ms

Notes
1. $P_{tot\ max}$ and $P_{peak\ max}$ lines.
2. Second-breakdown limits (independent of temperature).



Safe Operating ARea

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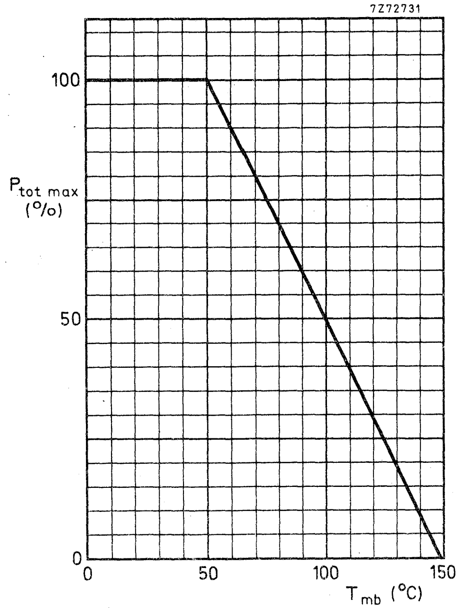
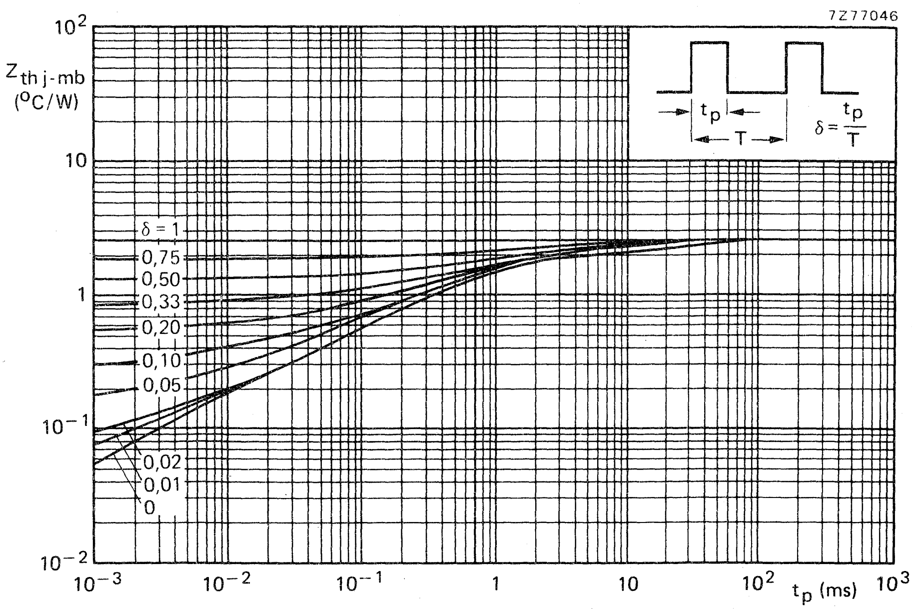
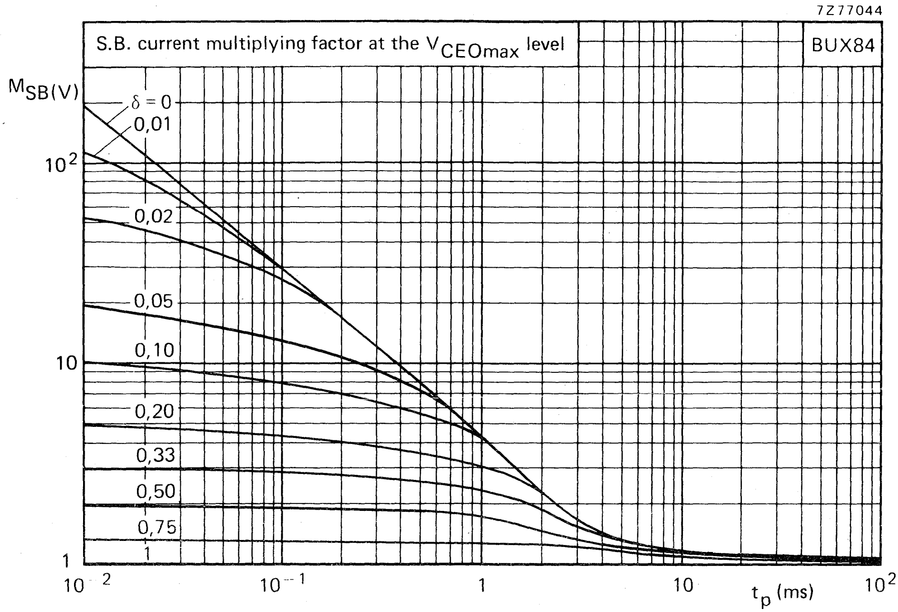
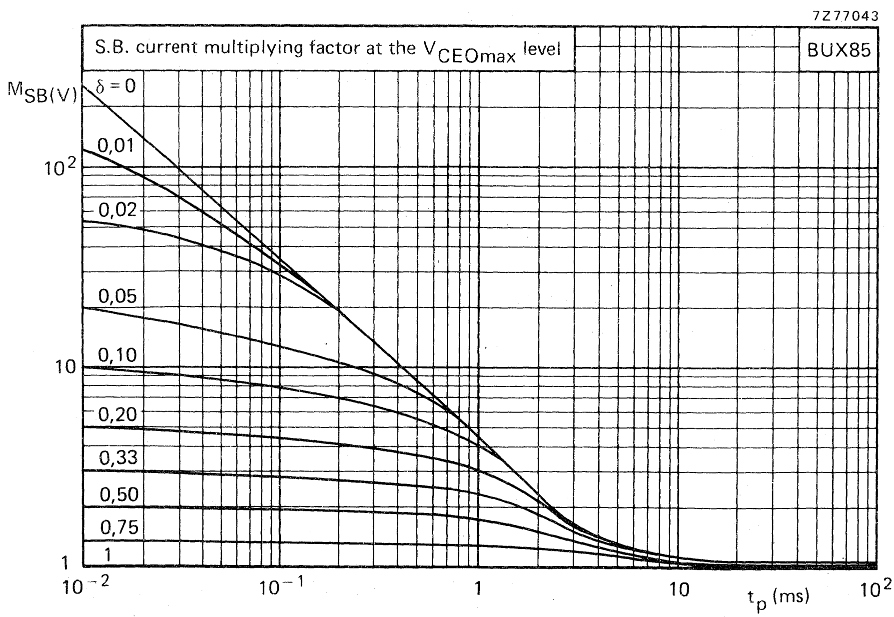
IV Repetitive pulse operation in this region is permissible, provided $V_{BE} \leqslant 0$ and $t_p \leqslant 2$ ms

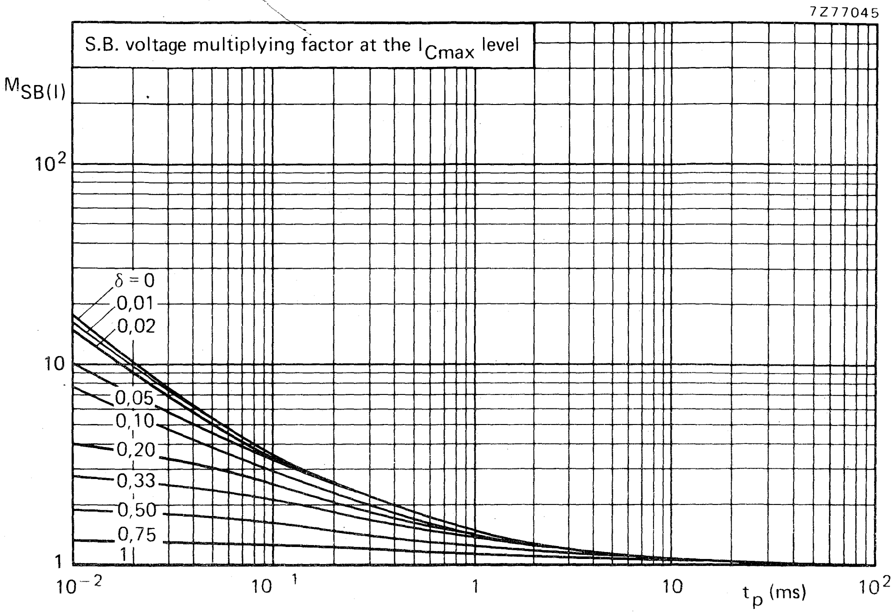
Notes
1. $P_{tot\ max}$ and $P_{peak\ max}$ lines.
2. Second-breakdown limits (independent of temperature).

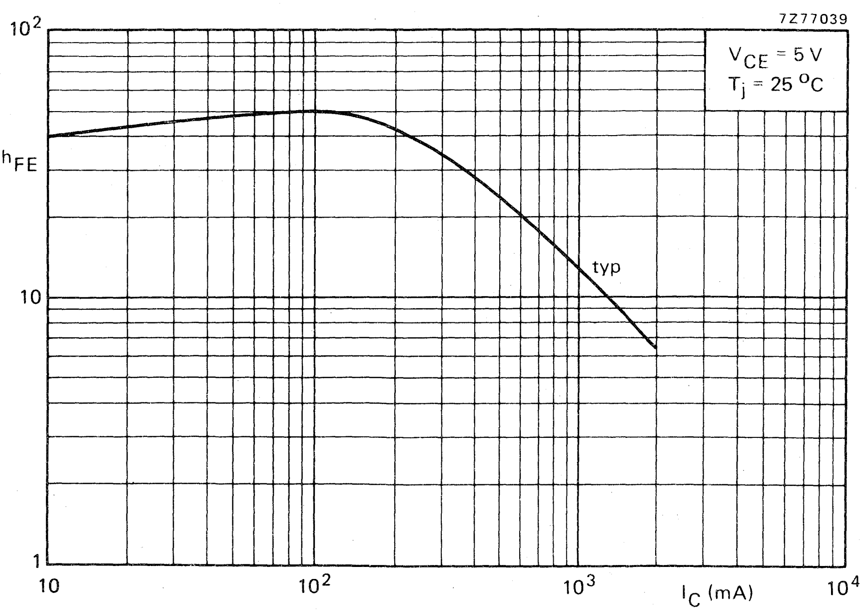

7Z72731
100
50
0
$P_{tot\ max}$ (%)
0
50
100
150
T_{mb} (°C)


7Z77046
10^2
$Z_{th\ j\text{-}mb}$ (°C/W)
10
1
10^{-1}
10^{-2}
δ = 1
0,75
0,50
0,33
0,20
0,10
0,05
0,02
0,01
0
t_p
T
$\delta = \frac{t_p}{T}$
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3


7Z77044
S.B. current multiplying factor at the V_{CEOmax} level
BUX84
$M_{SB(V)}$
δ = 0
0,01
0,02
0,05
0,10
0,20
0,33
0,50
0,75
1
10^2
10
1
10^{-2}
10^{-1}
1
10
t_p (ms)
10^2


7Z77043
S.B. current multiplying factor at the V_{CEOmax} level
BUX85
$M_{SB(V)}$
δ = 0
0,01
0,02
0,05
0,10
0,20
0,33
0,50
0,75
1
10^2
10
1
10^{-2}
10^{-1}
1
10
t_p (ms)
10^2


7Z77045
S.B. voltage multiplying factor at the I_{Cmax} level
$M_{SB(I)}$
10^2
10
1
δ = 0
0,01
0,02
0,05
0,10
0,20
0,33
0,50
0,75
1
10^{-2}
10^{-1}
1
10
t_p (ms)
10^2


7Z77039
V_{CE} = 5 V
T_j = 25 °C
h_{FE}
10^2
10
1
typ
10
10^2
10^3
I_C (mA)
10^4

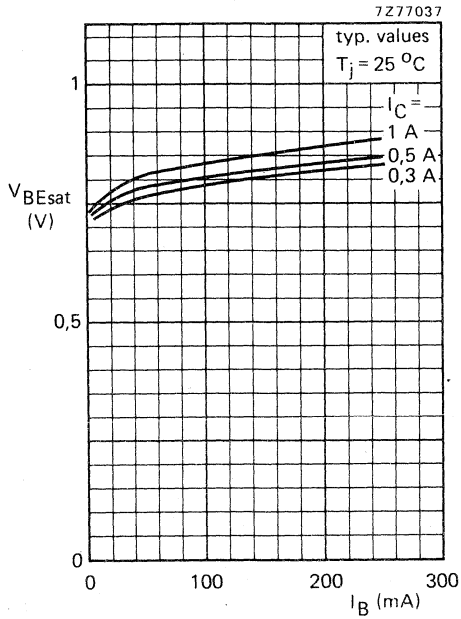


Fig. 14 Typical values saturation voltage, T_j = 25 °C.

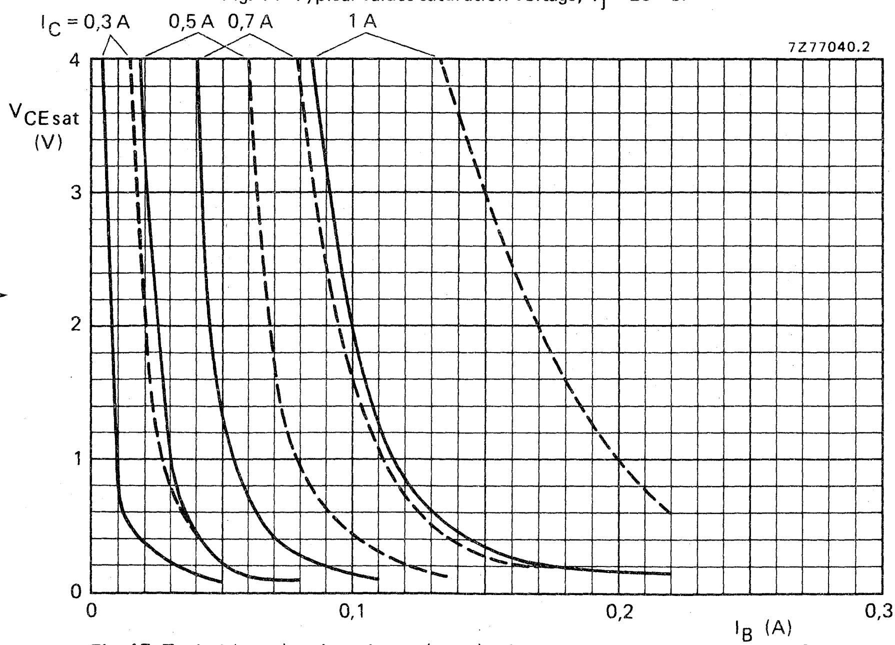


Fig. 15 Typical (——) and maximum (– – –) values saturation voltage at T_j = 25 °C.

APPLICATION INFORMATION ON BUX84 (detailed information on request)

Important factors in the design of SMPS circuits are the power losses and heatsink requirements of the supply output transistor and the base drive conditions during turn-off. In most SMPS circuits with mains isolation the duty factor of the collector current generally varies between 0,25 and 0,5.

The operating frequency lies between 15 kHz and 50 kHz and the shape of the collector current varies from rectangular in a forward converter to a sawtooth in a flyback circuit.

Information on optimum base drive and device dissipation of the BUX84 in a flyback converter is given in Figs 3 to 5. Figs 6 to 8 apply to a forward converter. In these figures I_{CM} represents the highest repetitive peak collector current that can occur in the given circuit, e.g. during overload.

The total power dissipation for a limit-case transistor is given in Figs 5 and 8 which apply for a mounting base temperature of 100 °C. The required thermal resistance for the heatsink can be calculated from

$$R_{th\ mb\text{-}a} = \frac{100 - T_{amb\ max}}{P_{tot}}.$$

To ensure thermal stability the minimum value of T_{amb} in the above equation is 40 °C.

A practical SMPS output circuit for an output power in the order of 50 W is given in Fig. 2.

At a collector current of 0,7 A and a base current of 70 mA in this circuit the following turn-off times can be expected.

			T_{mb} = 25 °C	100 °C	
Storage time	t_s	typ	2,2	2,8	μs
Fall time	t_f	typ	0,25	0,85	μs

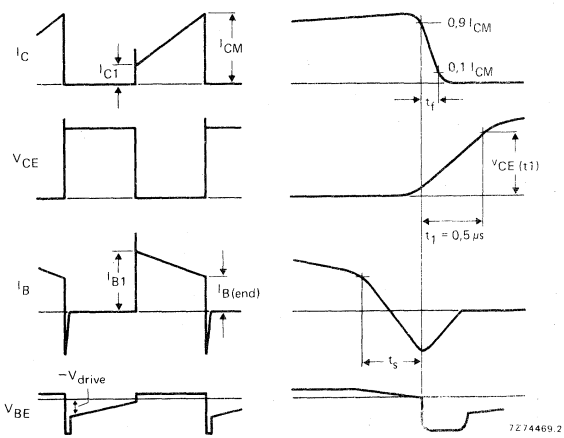


Fig. 1 Relevant waveforms of switching transistor.

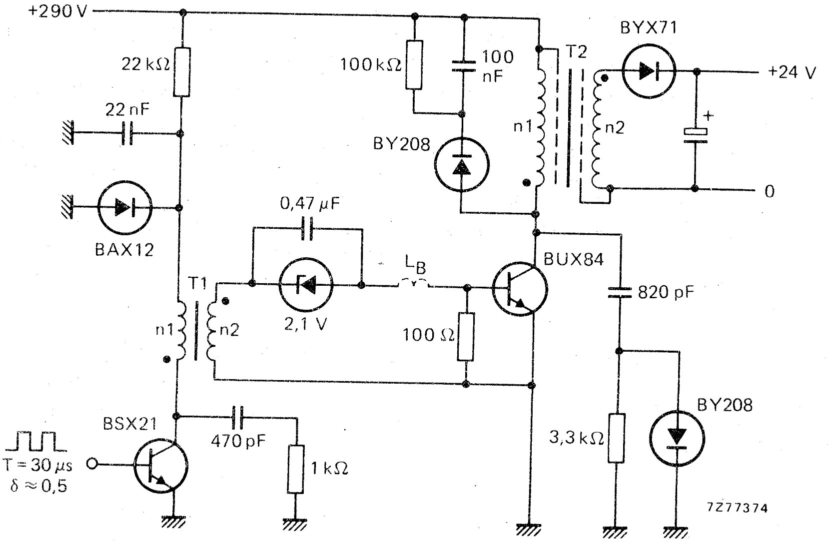


Fig. 2 Practical SMPS output circuit.

T1 (driver transformer): Core U15; $n1 = 360$ turns; $n2 = 60$ turns
total inductance in base circuit ≈ 15 μH

T2 (output transformer): Core E55; primary inductance $L_p = 16$ mH
$n1 = 116$ turns; $n2 = 12$ turns

$v_{CE(t1)} < 300$ V (see Fig. 1)

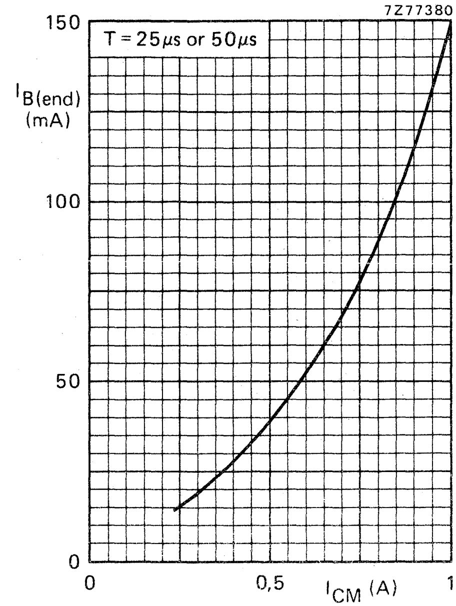


Fig. 3.

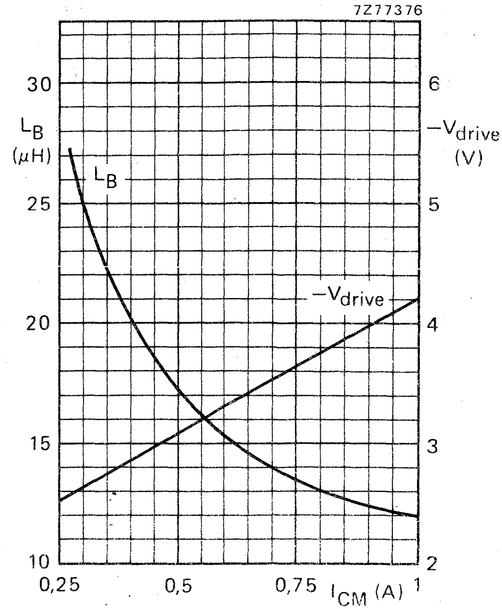


Fig. 4.

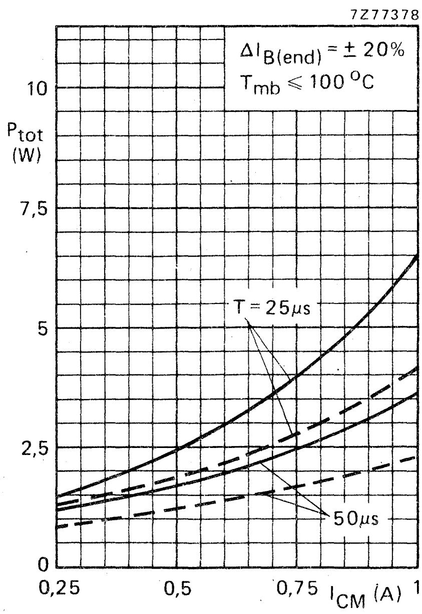


Fig. 5.

Fig. 3 Recommended nominal "end" value of the base current versus maximum peak collector current in a **flyback** converter.

Fig. 4 Minimum required base inductance and recommended negative drive voltage versus maximum peak collector current.

Fig. 5 Maximum total power dissipation of a limit-case transistor if the base current is chosen in accordance with Fig. 3. Solid lines for $I_{C1}/I_{CM} = 0,4$ and dotted lines for $I_{C1}/I_{CM} = 0$.

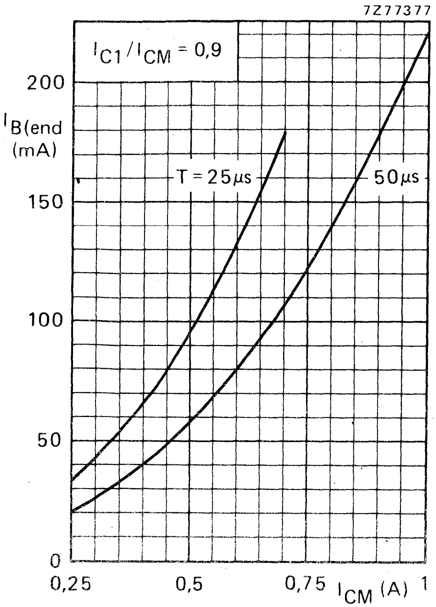


Fig. 6.

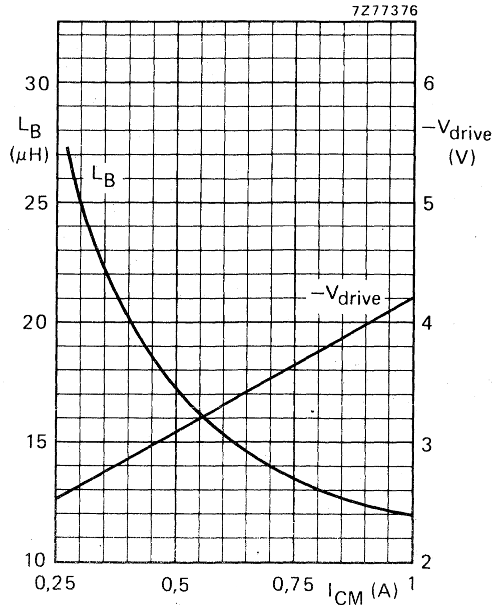


Fig. 7.

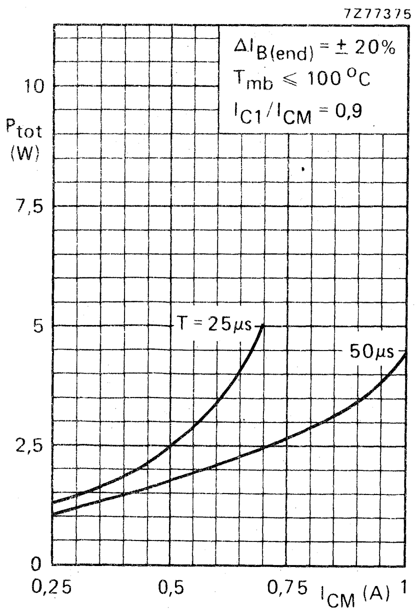


Fig. 8.

Fig. 6 Recommended nominal "end" value of the base current versus maximum peak collector current in a **forward** converter.

Fig. 7 Minimum required base inductance and recommended negative drive voltage versus maximum peak collector current.

Fig. 8 Maximum total power dissipation of a limit-case transistor if the base current is chosen in accordance with Fig. 6.

SILICON DIFFUSED POWER TRANSISTORS

High-voltage, high-speed, glass-passivated n-p-n power transistors in SOT-32 envelopes, for use in converters, inverters, switching regulators, motor control systems and switching applications.

QUICK REFERENCE DATA

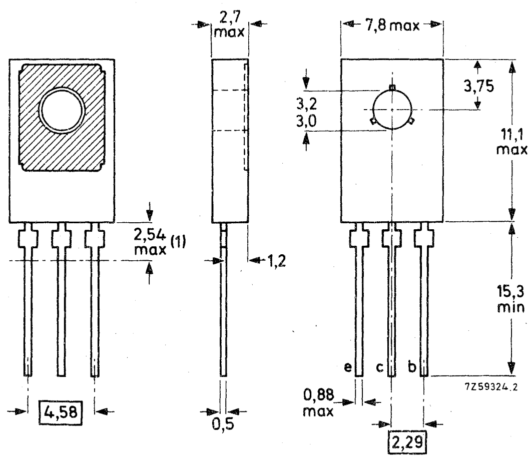
			BUX86	BUX87	
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max	800	1000	V
Collector-emitter voltage (open base)	V_{CEO}	max	400	450	V
Collector current (d.c.)	I_C	max	0,5		A
Collector current (peak value): t_p = 2 ms	I_{CM}	max	1		A
Total power dissipation up to T_{mb} = 60 °C	P_{tot}	max	20		W
Collector-emitter saturation voltage: I_C = 0,2 A; I_B = 20 mA	V_{CEsat}	$<$	3		V
Fall time: I_{Con} = 0,2 A; I_{Bon} = 20 mA; $-I_{Boff}$ = 40 mA	t_f	typ	0,4		μs

MECHANICAL DATA

Dimensions in mm

TO-126 (SOT-32)

Collector connected to metal part of mounting surface



Accessories: 56326 (washer) or 56353 (clip) for direct mounting and 56353 + 56354 (package) for insulated mounting.

* Within this region the cross-section of the leads is uncontrolled.

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

			BUX86	BUX87	
Voltages					
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max	800	1000	V
Collector-emitter voltage (open base)	V_{CEO}	max	400	450	V
Currents					
Collector current (d.c.)	I_C	max	0,5		A
Collector current (peak value): t_p = 2 ms	I_{CM}	max	1		A
Base current (d.c.)	I_B	max	0,2		A
Base current (peak value)	I_{BM}	max	0,3		A
Reverse base current (peak value) (note 1)	$-I_{BM}$	max	0,3		A
Power dissipation					
Total power dissipation up to T_{mb} = 60 °C	P_{tot}	max	20		W
Temperatures					
Storage temperature	T_{stg}		−65 to +150		°C
Junction temperature	T_j	max	150		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	4,5	°C/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	100	°C/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

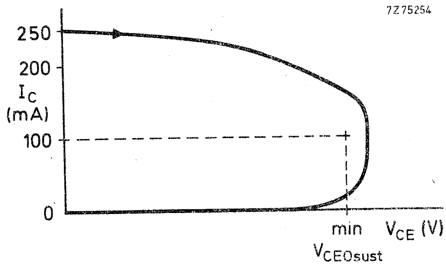
Collector cut-off current (note 2)				
$V_{CEM} = V_{CESMmax}$; $V_{BE} = 0$	I_{CES}	<	100	μA
$V_{CEM} = V_{CESMmax}$; $V_{BE} = 0$; T_j = 125 °C	I_{CES}	<	1	mA
D.C. current gain				
I_C = 50 mA; V_{CE} = 5 V	h_{FE}	typ	50	

Notes
1. Turn-off current
2. Measured with a half sine-wave voltage (curve tracer).

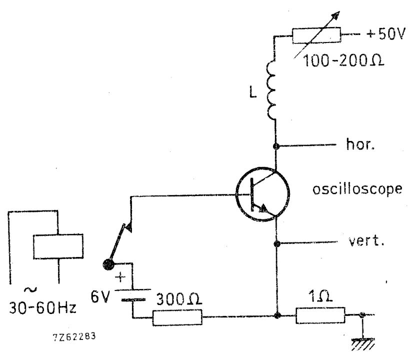
CHARACTERISTICS (continued)

$T_j = 25\ ^oC$ unless otherwise specified

Emitter cut-off current					
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	1		mA
Saturation voltage					
$I_C = 0,1$ A; $I_B = 10$ mA	V_{CEsat}	<	1,5		V
$I_C = 0,2$ A; $I_B = 20$ mA	V_{CEsat}	<	3		V
$I_C = 0,2$ A; $I_B = 20$ mA	V_{BEsat}	<	1,0		V
Collector-emitter sustaining voltages			BUX86	BUX87	
$I_C = 100$ mA; $I_{Boff} = 0$; L = 25 mH	$V_{CEOsust}$	>	400	450	V ←



Oscilloscope display for sustaining voltage



Test circuit for $V_{CEOsust}$

CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Transition frequency at f = 1 MHz

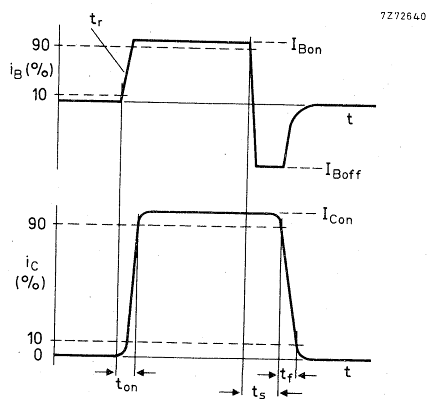
I_C = 50 mA; V_{CE} = 10 V	f_T	typ	20	MHz

Switching times

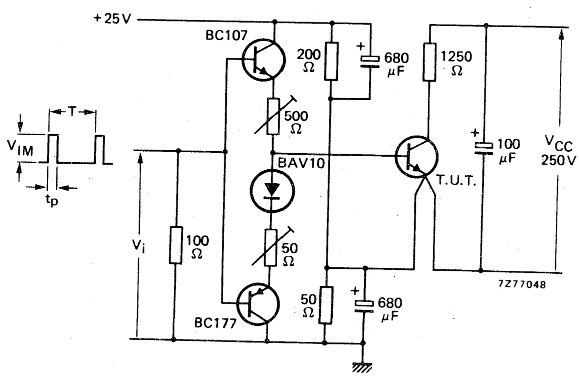
I_{Con} = 0,2 A; V_{CC} = 250 V
I_{Bon} = 20 mA; $-I_{Boff}$ = 40 mA

Turn-on time	t_{on}	typ	0,25	μs
		<	0,5	μs
Turn-off: Storage time	t_s	typ	2	μs
		<	3,5	μs
Fall time	t_f	typ	0,4	μs
Fall time, T_{mb} = 95 °C	t_f	<	1,3	μs

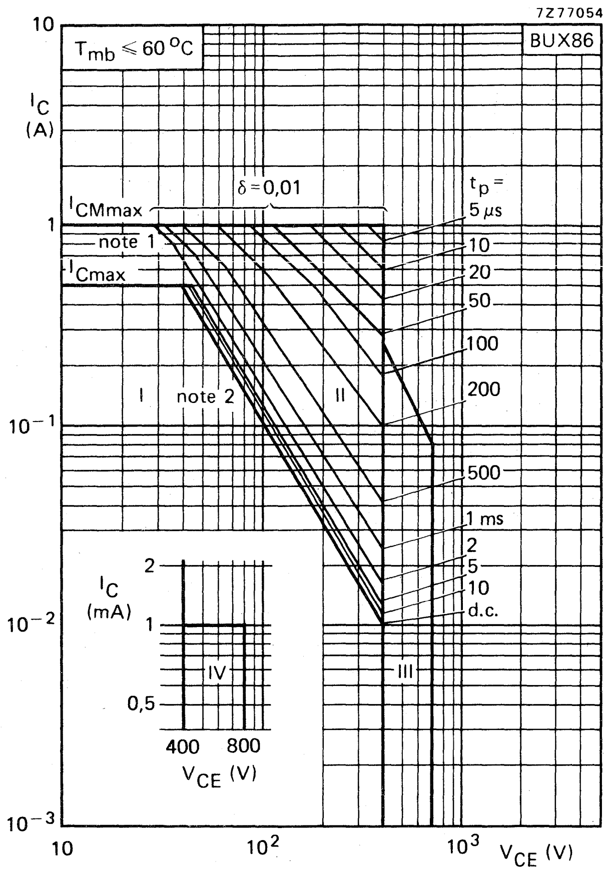
Waveform



Test circuit



t_p = 20 μs
T = 2 ms
V_{IM} = 15 V



Safe Operating ARea

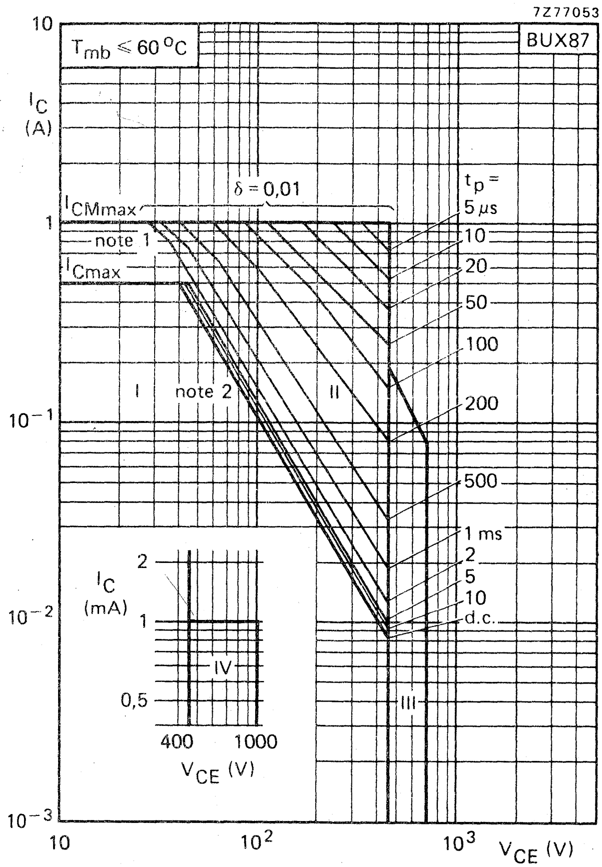
I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

III Area of permissible operation during turn-on in single-transistor converters, provided $R_{BE} \leqslant 100\ \Omega$ and $t_p \leqslant 0{,}6\ \mu s$

IV Repetitive pulse operation in this region is permissible, provided $V_{BE} \leqslant 0$ and $t_p \leqslant 2$ ms

Notes
1. $P_{peak\ max}$ lines.
2. Second-breakdown limits (independent of temperature).



Safe Operating ARea

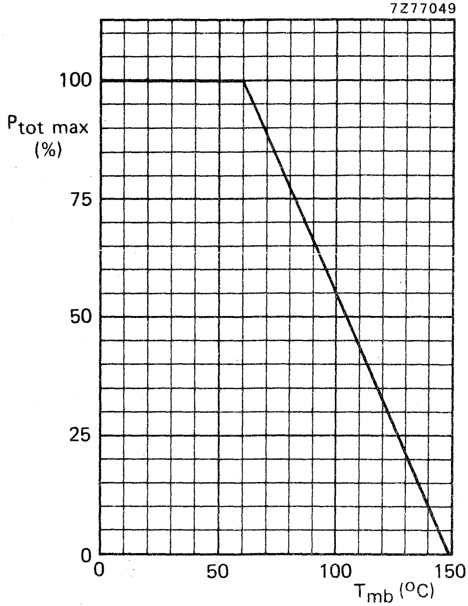
I Region of permissible d.c. operation

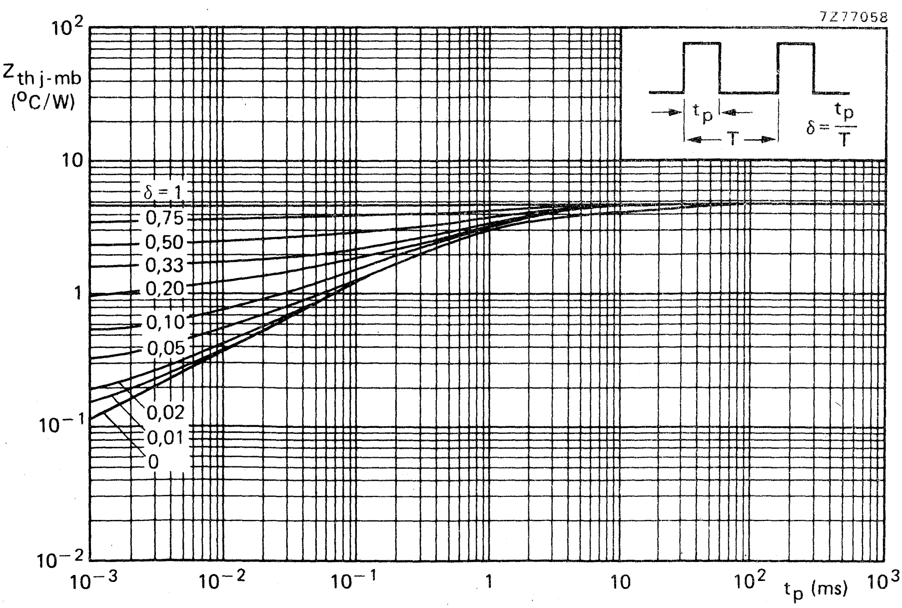
II Permissible extension for repetitive pulse operation

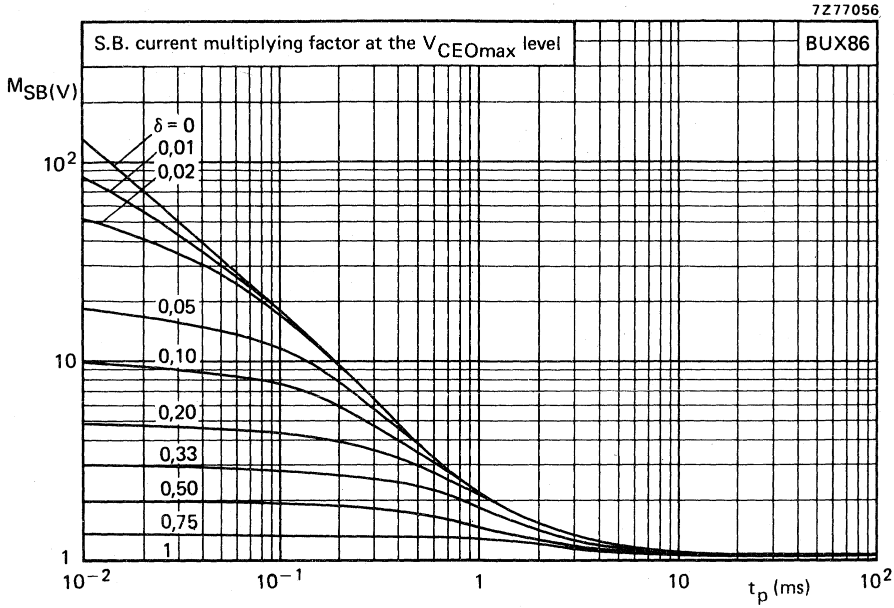
III Area of permissible operation during turn-on in single-transistor converters, provided $R_{BE} \leq 100\ \Omega$ an $t_p \leq 0{,}6\ \mu s$

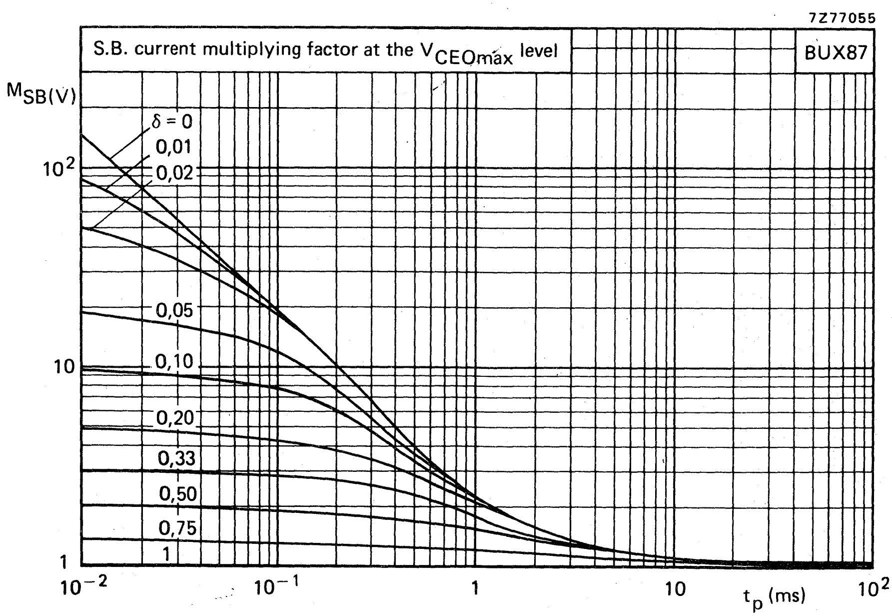
IV Repetitive pulse operation in this region is permissible, provided $V_{BE} \leq 0$ and $t_p \leq 2$ ms

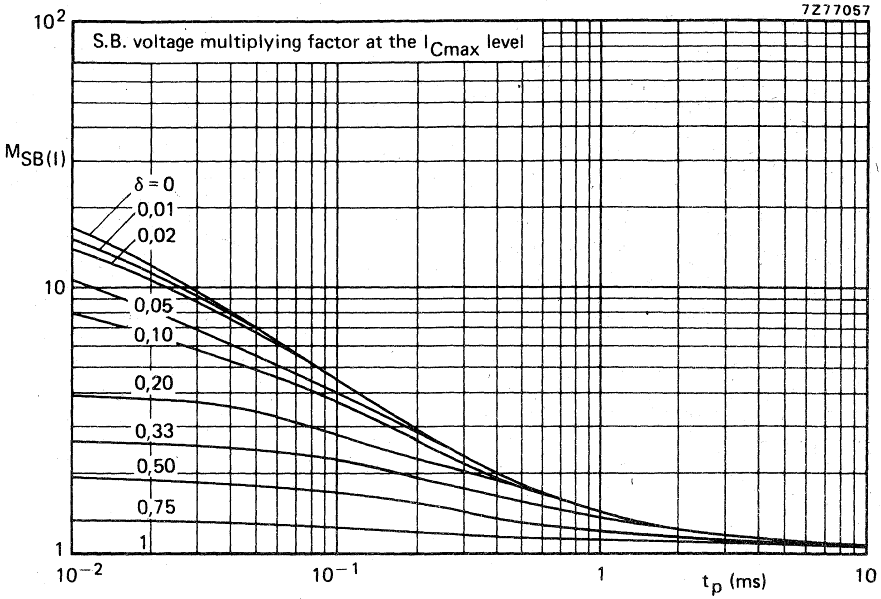
Notes
1. $P_{peak\ max}$ lines.
2. Second-breakdown limits (independent of temperature).

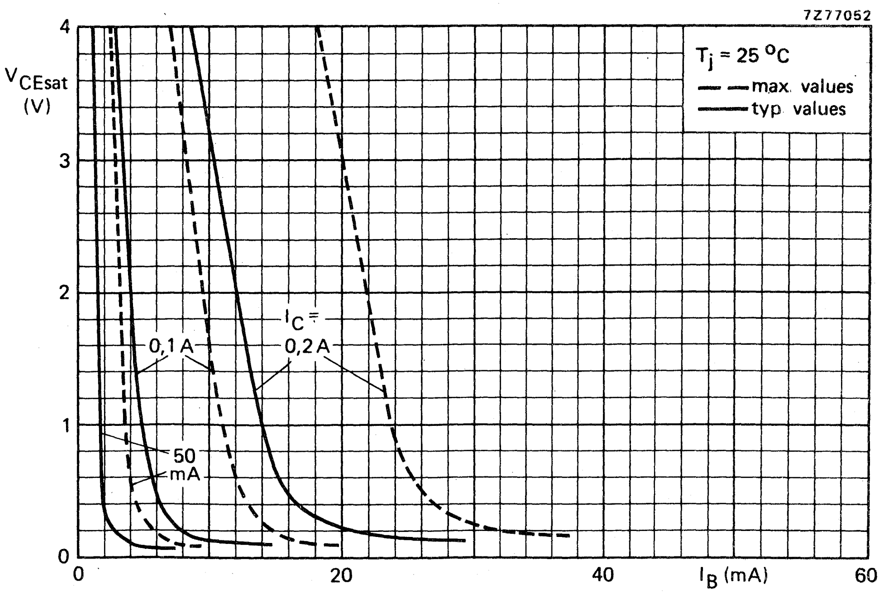

7Z77049
100
75
50
25
0
$P_{tot\ max}$ (%)
0
50
100
150
T_{mb} (°C)

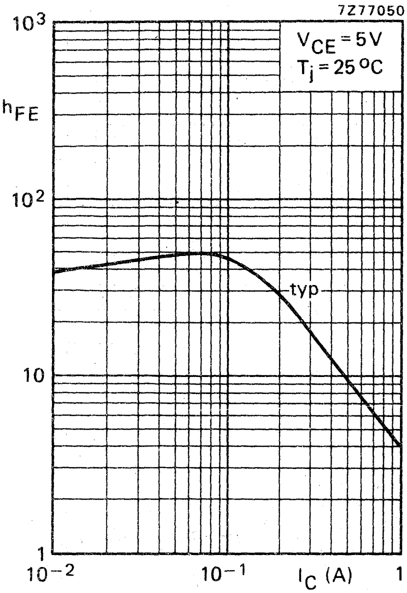

7Z77058
10^2
10
1
10^{-1}
10^{-2}
$Z_{th\ j\text{-}mb}$ (°C/W)
δ = 1
0,75
0,50
0,33
0,20
0,10
0,05
0,02
0,01
0
t_p
T
$\delta = \frac{t_p}{T}$
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3

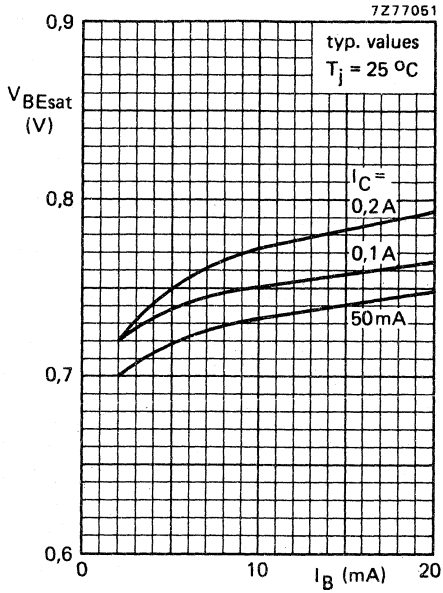

7Z77056
S.B. current multiplying factor at the V_{CEOmax} level
BUX86
$M_{SB(V)}$
δ = 0
0,01
0,02
0,05
0,10
0,20
0,33
0,50
0,75
1
10^2
10
1
10^{-2}
10^{-1}
1
10
t_p (ms)
10^2


7Z77055
S.B. current multiplying factor at the V_{CEOmax} level
BUX87
$M_{SB(V)}$
δ = 0
0,01
0,02
0,05
0,10
0,20
0,33
0,50
0,75
1
10^2
10
1
10^{-2}
10^{-1}
1
10
t_p (ms)
10^2


7Z77057
S.B. voltage multiplying factor at the I_{Cmax} level
10^2
$M_{SB(I)}$
δ = 0
0,01
0,02
10
0,05
0,10
0,20
0,33
0,50
0,75
1
1
10^{-2}
10^{-1}
1
t_p (ms)
10


7Z77052
T_j = 25 °C
max. values
typ. values
4
V_{CEsat}
(V)
3
2
1
0
I_C =
0,1 A
0,2 A
50
mA
0
20
40
I_B (mA)
60


7Z77050
V_{CE} = 5 V
T_j = 25 °C
h_{FE}
10^3
10^2
10
1
typ
10^{-2}
10^{-1}
I_C (A)
1


7Z77051
typ. values
T_j = 25 °C
V_{BEsat}
(V)
0,9
0,8
0,7
0,6
I_C =
0,2 A
0,1 A
50 mA
0
10
I_B (mA)
20

APPLICATION INFORMATION ON BUX86 (detailed information on request)

Important factors in the design of SMPS circuits are the power losses and heatsink requirements of the supply output transistor and the base drive conditions during turn-off. In SMPS circuits with mains isolation the duty factor of the collector current generally varies between 0,25 to 0,5.

The operating frequency lies between 15 kHz and 50 kHz and the shape of the collector current varies from rectangular in a forward converter to a sawtooth in a flyback circuit.

As the BUX86 will mainly be used in low-power flyback converters the information on optimum base drive and device dissipation given in the graphs on page 13 is concentrated on this application. In these figures I_{CM} represents the highest repetitive peak collector current that can occur in the given circuit, e.g. during overload.

The total power dissipation for a limit-case transistor is given in Fig. 5 which applies for a mounting base temperature of 100 °C. The required thermal resistance for the heatsink can be calculated from

$$R_{th\ mb\text{-}a} = \frac{100 - T_{amb\ max}}{P_{tot}}.$$

To ensure thermal stability the minimum value of T_{amb} in the above equation is 40 °C.

A practical SMPS output circuit for an output of power in the order of 15 W is given in Fig. 2.

At a collector current of 200 mA and a base current of 20 mA in this circuit the following turn-off times can be expected.

			T_{mb} = 25 °C	100 °C	
Storage time	t_s	typ	1,3	1,8	μs
Fall time	t_f	typ	0,2	0,8	μs

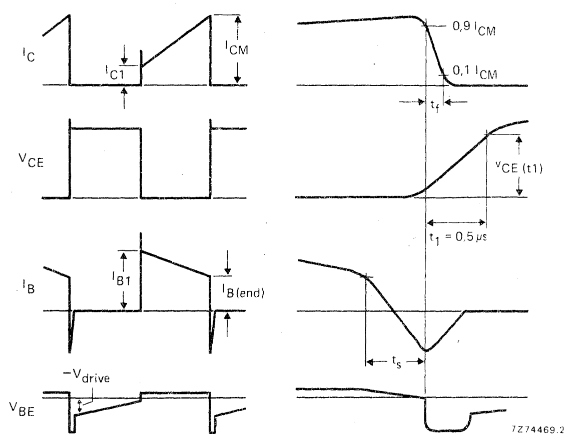


Fig. 1 Relevant waveforms of switching transistor.

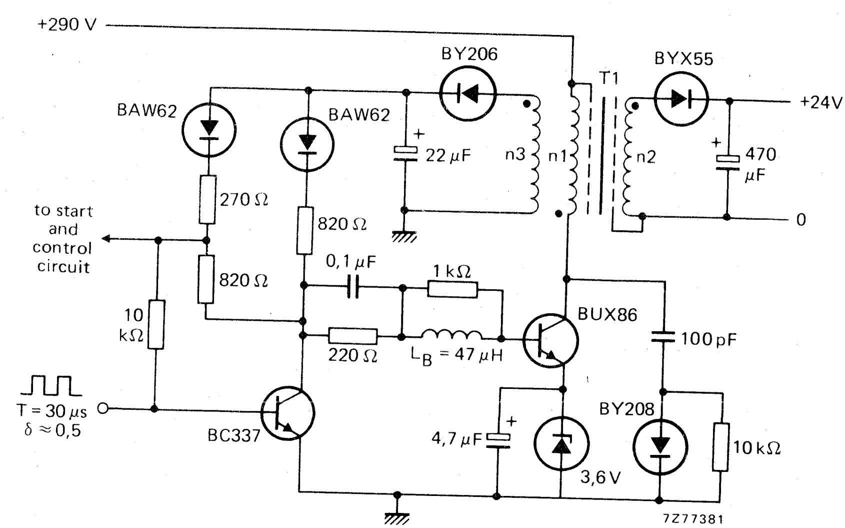


Fig. 2 Practical SMPS output circuit.

T1 (output transformer): Core U20; primary inductance L_p = 23 mH
n1 = 252 turns; n2 = 27 turns; n3 = 22 turns

$V_{CE(t1)} < 300$ V (see Fig. 1)

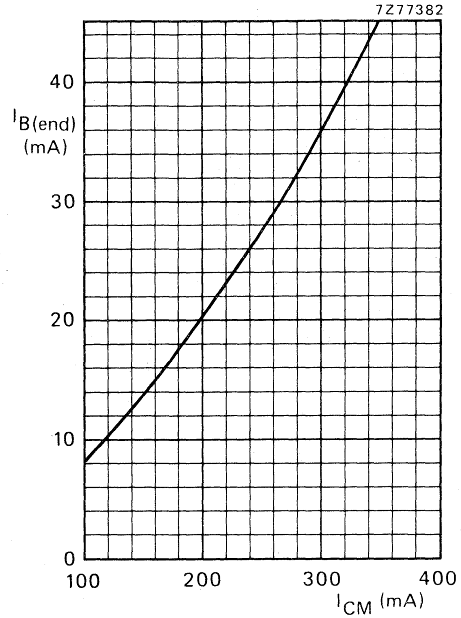


Fig. 3.

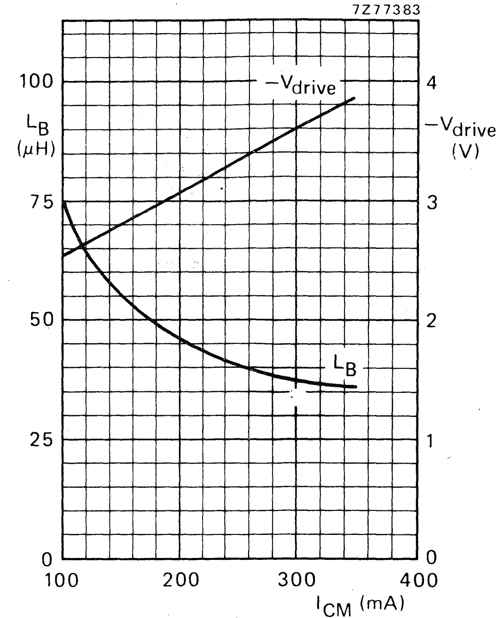


Fig. 4.

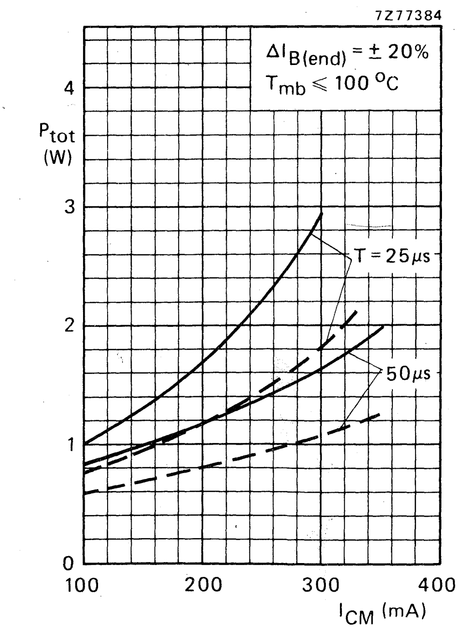


Fig. 5.

Fig. 3 Recommended nominal "end" value of the base current versus maximum peak collector current.

Fig. 4 Minimum required base inductance and recommended negative drive voltage versus maximum peak collector current.

Fig. 5 Maximum total power dissipation of a limit-case transistor if the base current is chosen in accordance with Fig. 3. Solid lines for I_{C1}/I_{CM} = 0,4 and dotted lines for I_{C1}/I_{CM} = 0.

SILICON DIFFUSED POWER TRANSISTOR

High-voltage, high-speed switching n-p-n transistor in a TO-3 envelope especially intended for use in a.c. motor control systems from three-phase mains.

QUICK REFERENCE DATA

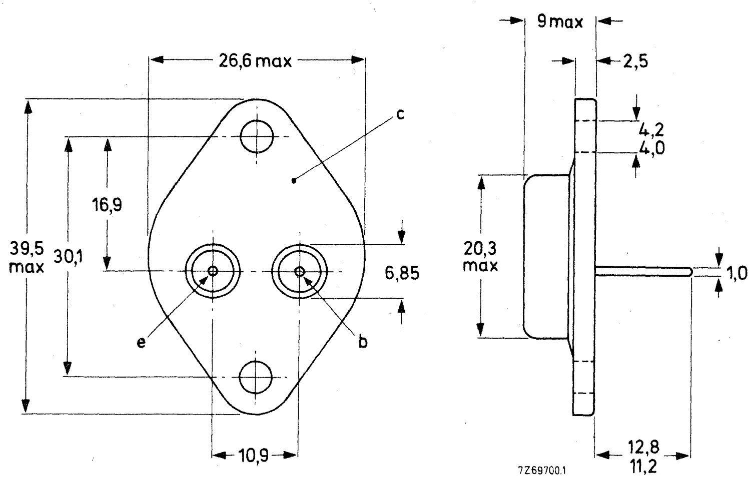
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max.	1500	V
Collector-emitter voltage (open base)	V_{CEO}	max.	800	V
Collector current (d.c.)	I_C	max.	6	A
Total power dissipation up to T_{mb} = 60 °C	P_{tot}	max.	80	W
Collector-emitter saturation voltage I_C = 4,5 A; I_B = 2 A	V_{CEsat}	<	1	V
D.C. current gain I_C = 4,5 A; V_{CE} = 5 V	h_{FE}	>	2,5	

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.



For Accessories and Mounting instructions see handbook l.f. power transistors.

RATINGS

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

Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max.	1500	V
Collector-emitter voltage (open base)	V_{CEO}	max.	800	V
Collector current (d.c.)	I_C	max.	6	A
Collector current (peak value)	I_{CM}	max.	10	A
Collector current (non-repetitive peak)	I_{CSM}	max.	15	A
Base current (d.c.)	I_B	max.	4	A
Base current (peak value)	I_{BM}	max.	6	A
Reverse base current (d.c. or average over any 20 ms period)	$-I_{B(AV)}$	max.	100	mA
Reverse base current (peak value) *	$-I_{BM}$	max.	4	A
Total power dissipation up to T_{mb} = 60 °C	P_{tot}	max.	80	W
Storage temperature	T_{stg}		−65 to + 150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	max.	1,12	K/W

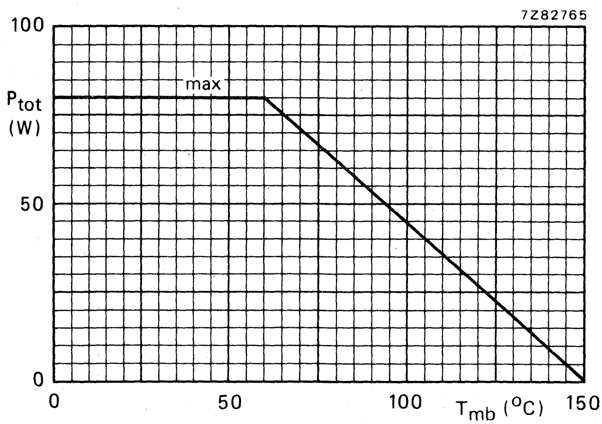


Fig. 2 Power derating curve.

* Turn-off current.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current			
V_{BE} = 0; V_{CE} = $V_{CESMmax}$; T_j = 125 °C	I_{CES}	<	1,0 mA
D.C. current gain			
I_C = 4,5 A; V_{CE} = 5 V	h_{FE}	>	2,5
Emitter cut-off current			
I_C = 0; V_{EB} = 5 V	I_{EBO}	<	10 mA
Saturation voltage			
I_C = 4,5 A; I_B = 2 A	V_{CEsat}	<	1 V
I_C = 4,5 A; I_B = 2 A	V_{BEsat}	<	1,5 V
Collector-emitter sustaining voltage			
I_B = 0; I_C = 100 mA; L = 25 mH	$V_{CEOsust}$	>	800 V

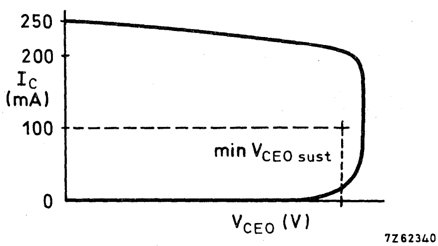


Fig. 3 Oscilloscope display for $V_{CEOsust}$.

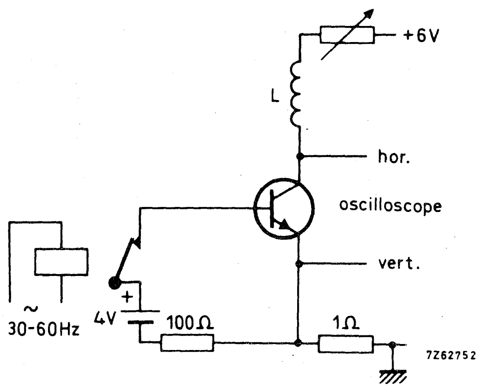


Fig. 4 Test circuit for $V_{CEOsust}$.

Second-breakdown collector current			
V_{CE} = 100 V; t_p = 1 s	$I_{(SB)}$	>	0,3 A
Transition frequency at f = 5 MHz			
I_C = 0,1 A; V_{CE} = 5 V	f_T	typ.	7 MHz
Collector capacitance at f = 1 MHz			
I_E = I_e = 0; V_{CB} = 10 V	C_c	typ.	125 pF

CHARACTERISTICS (continued)

Switching times (between 10% and 90% levels) in resistive switching circuit

I_{Con} = 4,5 A; V_{CC} = 250 V; R_L = 56 Ω

$I_{Bon} = -I_{Boff}$ = 2 A

Turn-on time	t_{on}	typ.	0,2 μs
Storage time ($t_s = t_{off} - t_f$)	t_s	typ.	3,5 μs
Fall time	t_f	typ.	0,5 μs

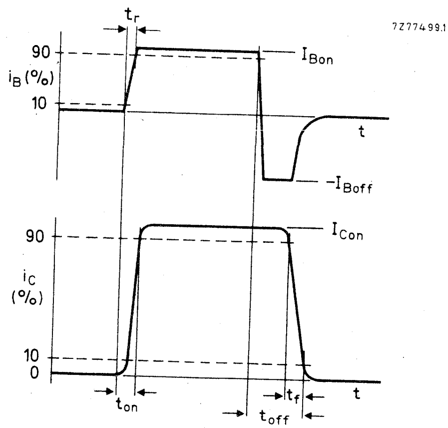


Fig. 5 Waveforms.

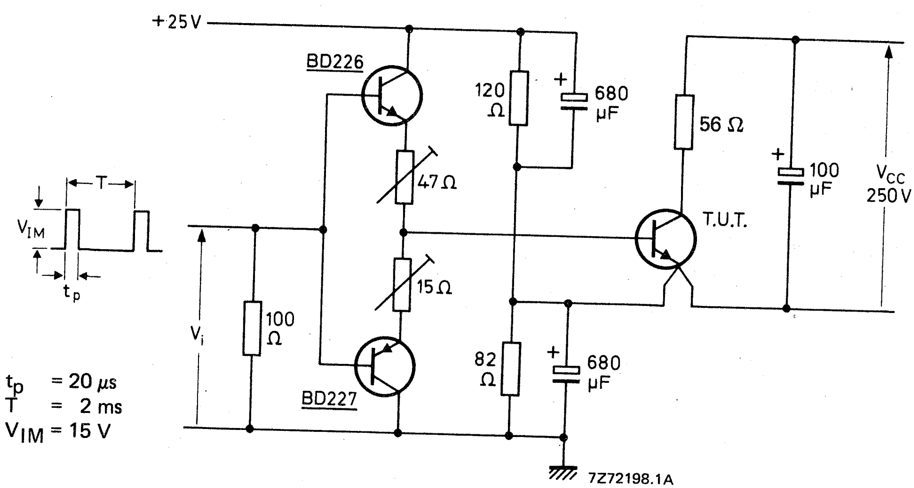


Fig. 6 Test circuit.

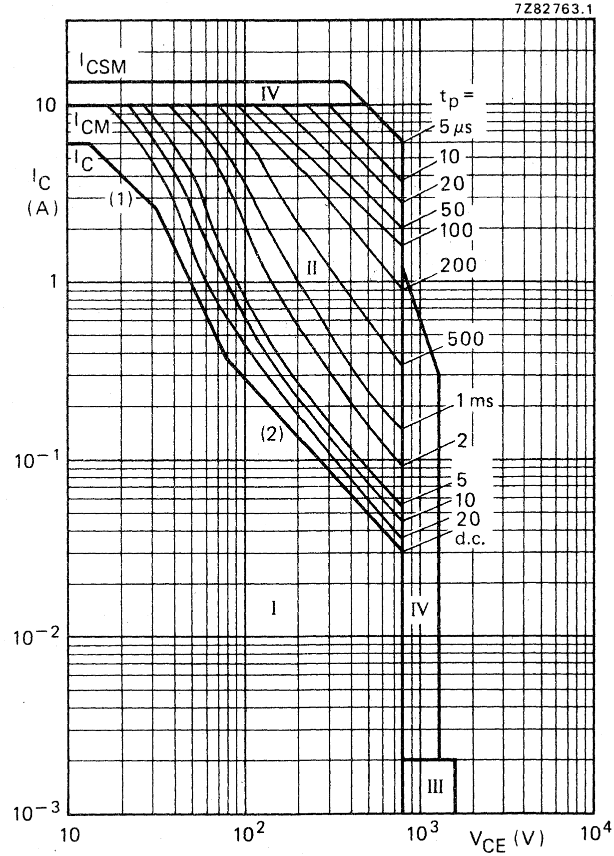


Fig. 7 Safe Operating ARea with the transistor forward biased.
$T_{mb} \leq 60$ °C; $\delta = 0{,}01$.

1. $P_{tot\ max}$ and $P_{peak\ max}$ lines.
2. Second-breakdown limits (independent of temperature).

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.
III Repetitive pulse operation in this region is permissible, provided $V_{BE} \leq 0$ V; $t_p \leq 20$ μs; $\delta \leq 0{,}25$.
IV Transient I_C/V_{CE} limit
for V_{CE} less than 700 V then t_p less than or equal to 25 μs
for V_{CE} greater than 700 V then t_p less than 5 μs.

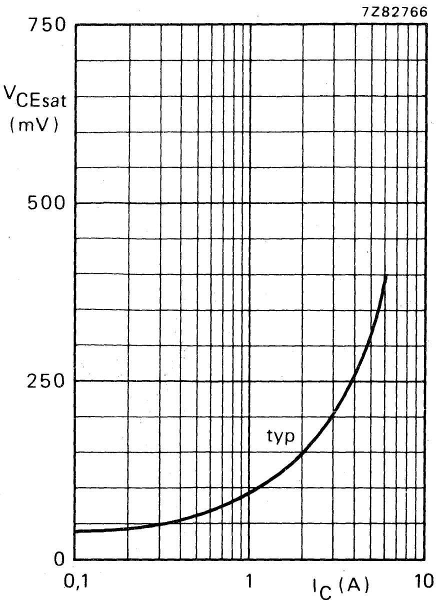


Fig. 8 Collector-emitter saturation voltage at $I_C/I_B = 2$; $T_j = 25\ ^oC$.

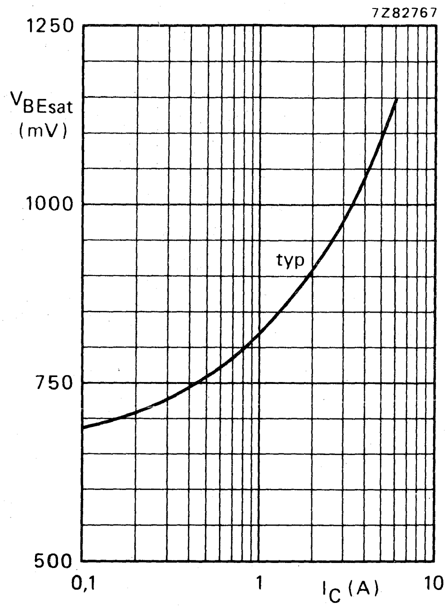


Fig. 9 Base-emitter saturation voltage at $I_C/I_B = 2$; $T_j = 25\ ^oC$.

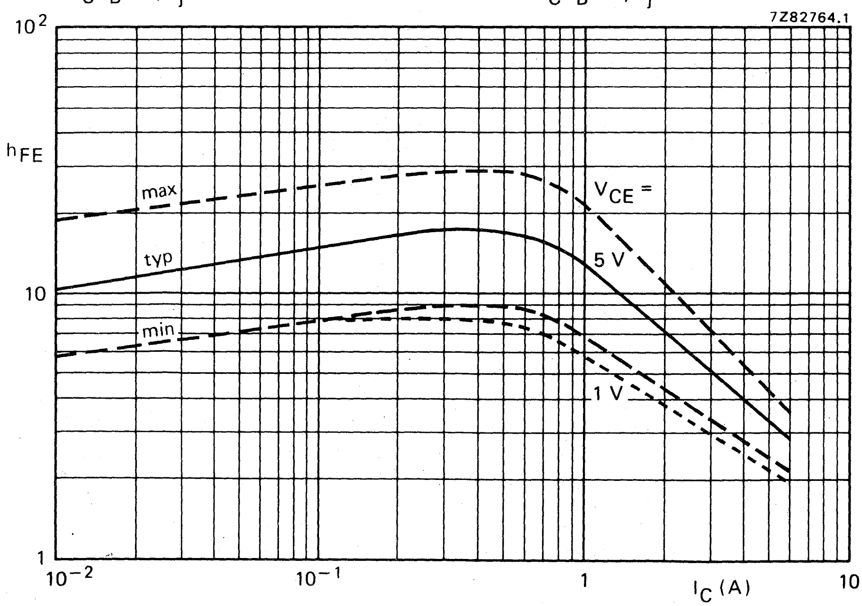


Fig. 10 D.C. current gain at $V_{CE} = 5$ V; $T_j = 25\ ^oC$; . . . . at $V_{CE} = 1$ V.

MOUNTING INSTRUCTIONS

GENERAL NOTE ON FLAT HEATSINKS

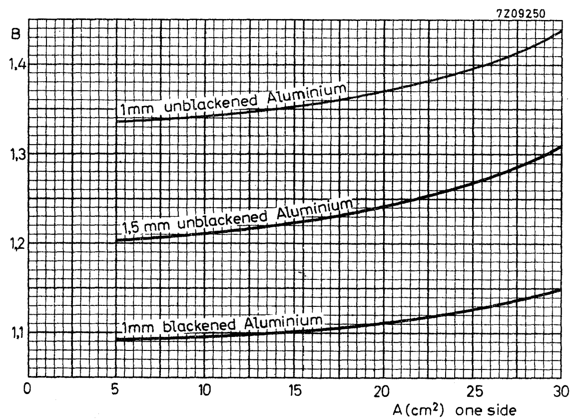
All information on thermal resistances of the accessories combined with flat heatsinks is valid for square heatsinks of 1,5 mm blackened aluminium.
For a few variations the thermal resistance may be derived as follows:

a. Rectangular heatsinks (sides a and 2a)

When mounted with long side horizontal, multiply by 0,95.
When mounted with short side horizontal, multiply by 1,10.

b. Unblackened or thinner heatsinks

Multiply by the factor B given below as a function of the heatsink size A.



MOUNTING INSTRUCTIONS
FOR TO-126 AND SOT-82 ENVELOPES

GENERAL DATA AND INSTRUCTIONS

General rules

1. First fasten the devices to the heatsink before soldering the leads.
2. Avoid axial stress to the leads.
3. Keep mounting tool (e.g. screwdriver) clear of the plastic body.

Heatsink requirements

Minimum thickness: 2 mm.
Flatness in the mounting area: 0,02 mm maximum per 10 mm.
Mounting holes must be deburred and should also be perpendicular to the plane of the heatsink, within 10^{o} tolerance for M2,5 thread and within 2^{o} tolerance for M3 thread. If the hole in the heatsink is threaded, it should be counter-sunk and free of burrs.

Heatsink compound

Values of the thermal resistance from mounting base to heatsink ($R_{th\ mb\text{-}h}$) given for mounting with heatsink compound refer to the use of a metallic oxide-loaded compound. Ordinary silicone grease is not recommended.

For insulated mounting, the compound should be applied to the bottom of both device and insulator.

Mounting methods for power transistors

1. Clip mounting (TO-126 and SOT-82)

   Mounting by means of spring clip offers:

   a. A good thermal contact under the crystal area.
   b. Safe insulation for mains and high voltage operation

2. M2,5 and M3 screw mounting. (TO-126 only).

   The spacing washer should be inserted between screw head and body.

   Mounting torque for screw mounting:

Minimum torque (for good heat transfer)	0,4 Nm (4 kgcm)
Maximum torque (to avoid damaging the device)	0,6 Nm (6 kgcm)

   N.B. when the driven nut or screw is in direct contact with a toothed lock washer the torques are as follows:

Minimum torque (for good heat transfer)	0,55 Nm (5,5 kgcm)
Maximum torque (to avoid damaging the device)	0,80 Nm (8,0 kgcm)

3. Body mounting (SOT-82).

   A SOT-82 envelope can be adhesive mounted or soldered into a hybrid circuit.
   For soldering a copper plate or an anodized aluminium plate with copper layer is recommended.
   When adhesive mounting is applied also a ceramic substrate may be used.

Thermal data

From mounting base to heatsink

	$R_{th\ mb\text{-}h}$ (K/W)			
	clip mounting		screw mounting	
	direct	insulated	direct	insulated
TO-126, with heatsink compound	1,0	3,0	0,5	3,0
TO-126, without heatsink compound	3,0	6,0	1,0	6,0
SOT-82, with heatsink compound	0,4	2,0	–	–
SOT-82, without heatsink compound	2,0	5,0	–	–

Lead bending

Maximum permissible tensile force on the body, for 5 seconds is 20 N (2 kgf).

The leads can be bent through 90° maximum, twisted or straightened. To keep forces within the above-mentioned limits, the leads are generally clamped near the body, using pliers. The leads should neither be bent nor twisted less than 2,4 mm from the body.

Lead soldering

For devices with a maximum junction temperature ⩽ 150 °C.

a. Dip or wave soldering
   Temperature ⩽ 260 °C at a distance from the body > 5 mm and for a total contact time with soldering bath or waves < 7 s.
b. Hand soldering
   Temperature at a distance from the body > 3 mm for a total contact time < 5 s is < 275 °C or < 250 °C for a total contact time of < 10 s.

The body of the device must be kept clear of anything with a temperature > 200 °C.
Avoid any force on body and leads during or after soldering; do not correct the position of the device or of its leads after soldering.

Mounting base soldering

Recommended metal-alloy of solder paste (85% metal weight)
62 Sm/36 Pb/2 Ag or 60 Sn/40 Pb.
Maximum soldering temperature ⩽ 200 °C (tab-temperature).
Soldering cycle duration including pre-heating ⩽ 30 sec.

For good soldering and avoiding damage to the encapsulation pre-heating is recommended to a temperature ⩽ 165 °C at a duration ⩽ 10 s.

INSTRUCTIONS FOR CLIP MOUNTING

Direct mounting with clip 56353

1. Place the device on the heatsink, applying heatsink compound to the mounting base.
2. Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10° to 30° to the vertical (see Figs 1 and 2).
3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body (see Fig. 3).

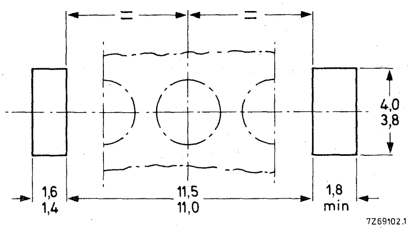


Fig. 1 Heatsink requirements.

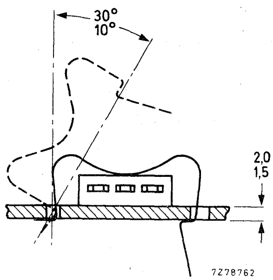


Fig. 2 Mounting spring clip.

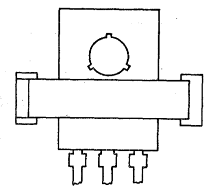


Fig. 3 Position of transistor (top view).

Insulated mounting with clip 56353 and mica 56354 (up to 1000 V insulation)

1. Place the device with the insulator on the heatsink, applying heatsink compound to the bottom of both device and insulator.
2. Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10° to 30° to the vertical (see Figs 4 and 5).
3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body (Fig. 6). Ensure that the device is centred on the mica insulator to prevent creepage.

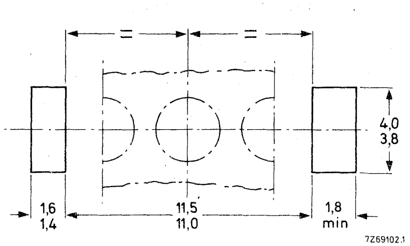


Fig. 4 Heatsink requirements.

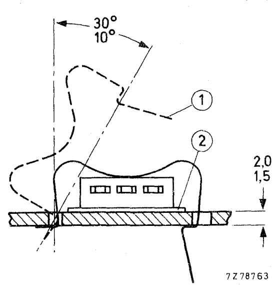


Fig. 5 Mounting.
(1) spring clip 56353.
(2) insulator 56354.

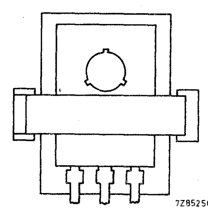


Fig. 6 Position of transistor (top view).

INSTRUCTIONS FOR SCREW MOUNTING

Direct mounting with screw and spacing washer

Dimensions in mm

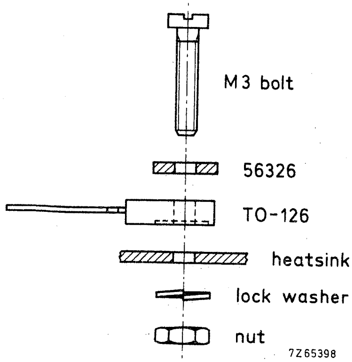


Fig. 7 Assembly through heatsink with nut.

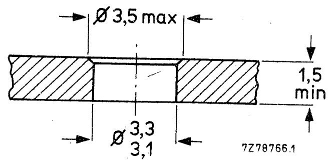


Fig. 8 Heatsink requirements.

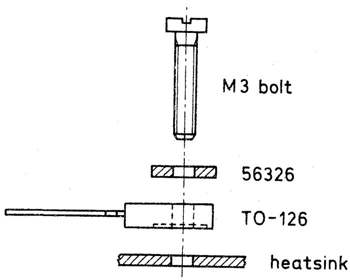


Fig. 9 Assembly into tapped heatsink.

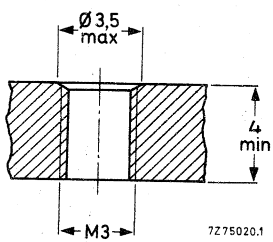


Fig. 10 Heatsink requirements.

INSTRUCTIONS FOR SCREW MOUNTING

Insulated mounting with 56333 (up to 250 V)

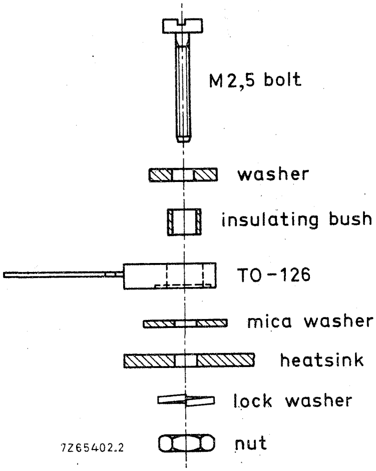


Fig. 11 Assembly through heatsink with nut.

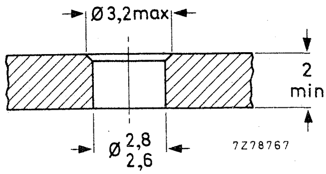


Fig. 12 Heatsink requirements.

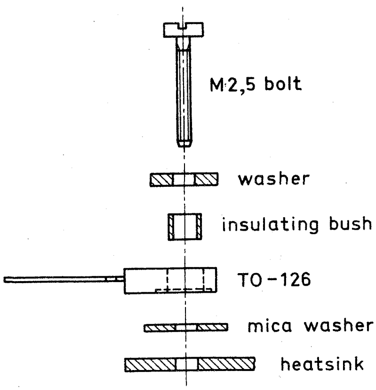


Fig. 13 Assembly with tapped heatsink.

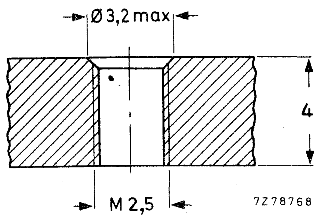


Fig. 14 Heatsink requirements.

INSTRUCTIONS FOR SCREW MOUNTING

Insulated mounting with 56326, 56387a and 56387b (up to 300 V)

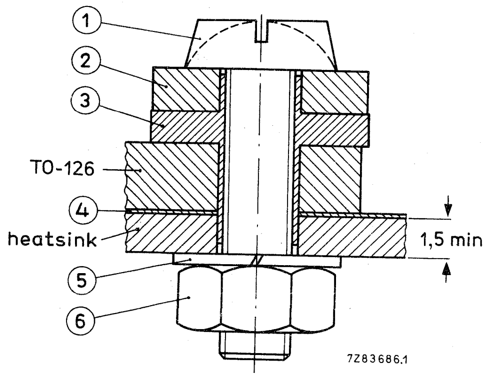


Fig. 15 Assembly through heatsink with nut.

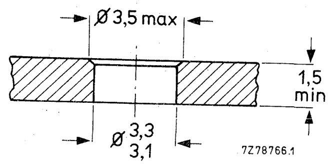


Fig. 16 Heatsink requirements.

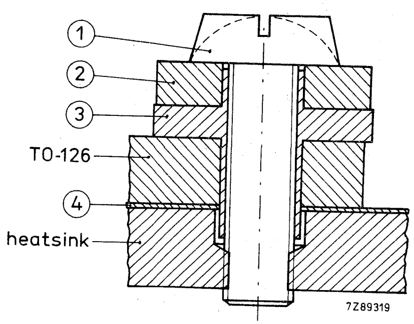


Fig. 17 Assembly with tapped heatsink.

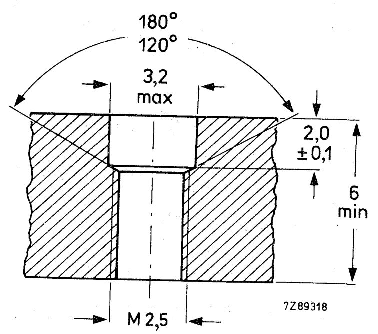


Fig. 18 Heatsink requirements.

Legend

1 M2,5 screw
2 metal washer 56326
3 insulating bush 56387b
4 mica washer 56387 a
5 lock washer
6 M2,5 nut

MOUNTING INSTRUCTIONS FOR TO-220 ENVELOPES

GENERAL DATA AND INSTRUCTIONS

General rules

1. First fasten the device to the heatsink before soldering the leads.
2. Avoid axial stress to the leads.
3. Keep mounting tool (e.g. screwdriver) clear of the plastic body.
4. The rectangular washer may only touch the plastic part of the body; it should not exert any force on that part (screw mounting).

Heatsink requirements

Flatness in the mounting area: 0,02 mm maximum per 10 mm.
Mounting holes must be deburred, see further mounting instructions.

Heatsink compound

Values of the thermal resistance from mounting base to heatsink ($R_{th\ mb\text{-}h}$) given for mounting with heatsink compound refer to the use of a metallic oxide-loaded compound. Ordinary silicone grease is not recommended.

For insulated mounting, the compound should be applied to the bottom of both device and insulator.

Mounting methods for power transistors

1. Clip mounting

   Mounting with a spring clip gives:

   a. A good thermal contact under the crystal area, and slightly lower $R_{th\ mb\text{-}h}$ values than screw mounting.
   b. Safe insulation for mains operation.

2. M3 screw mounting

   It is recommended that the rectangular spacing washer is inserted between screw head and mounting tab.

   Mounting torque for screw mounting:

   (For thread-forming screws these are final values. Do not use self-tapping screws.)

Minimum torque (for good heat transfer)	0,55 Nm (5,5 kgcm)
Maximum torque (to avoid damaging the device)	0,80 Nm (8,0 kgcm)

N.B.: When a nut or screw is not driven direct against a curved spring washer or lock washer (not for thread-forming screw), the torques are as follows:

Minimum torque (for good heat transfer)	0,4 Nm (4 kgcm)
Maximum torque (to avoid damaging the device)	0,6 Nm (6 kgcm)

N.B.: Data on accessories are given in separate data sheets.

3. Rivet mounting non-insulated

The device should not be pop-rivetted to the heatsink. However, it is permissible to press-rivet providing that eyelet rivets of soft material are used, and the press forces are slowly and carefully controlled so as to avoid shock and deformation of either heatsink or mounting tab.

Thermal data

			clip mounting	screw mounting	
From mounting base to heatsink					
with heatsink compound, direct mounting	$R_{th\ mb\text{-}h}$	=	0,3	0,5	K/W
without heatsink compound, direct mounting	$R_{th\ mb\text{-}h}$	=	1,4	1,4	K/W
with heatsink compound and 0,1 mm maximum mica washer	$R_{th\ mb\text{-}h}$	=	2,2	–	K/W
with heatsink compound and 0,25 mm maximum alumina insulator	$R_{th\ mb\text{-}h}$	=	0,8	–	K/W
with heatsink compound and 0,05 mm mica washer					
insulated up to 500 V	$R_{th\ mb\text{-}h}$	=	–	1,4	K/W
insulated up to 800 V/1000 V	$R_{th\ mb\text{-}h}$	=	–	1,6	K/W
without heatsink compound and 0,05 mm mica washer					
insulated up to 500 V	$R_{th\ mb\text{-}h}$	=	–	3,0	K/W
insulated up to 800 V/1000 V	$R_{th\ mb\text{-}h}$	=	–	4,5	K/W

Lead bending

Maximum permissible tensile force on the body, for 5 seconds is 20 N (2 kgf).

The leads can be bent through 90° maximum, twisted or straightened. To keep forces within the above-mentioned limits, the leads are generally clamped near the body, using pliers. The leads should neither be bent nor twisted less than 2,4 mm from the body.

Soldering

Lead soldering temperature at > 3 mm from the body; $t_{sld} < 5$ s:

Devices with $T_{j\ max} \leq 175$ °C, soldering temperature $T_{sld\ max} = 275$ °C.
Devices with $T_{j\ max} \leq 110$ °C, soldering temperature $T_{sld\ max} = 240$ °C.

Avoid any force on body and leads during or after soldering: do not correct the position of the device or of its leads after soldering.

It is not permitted to solder the metal tab of the device to a heatsink, otherwise its junction temperature rating will be exceeded.

Mounting base soldering

Recommended metal-alloy of solder paste (85% metal weight)
62 Sm/36 Pb/2 Ag or 60 Sn/40 Pb.
Maximum soldering temperature ≤ 200 °C (tab-temperature).
Soldering cycle duration including pre-heating ≤ 30 sec.

For good soldering and avoiding damage to the encapsulation pre-heating is recommended to a temperature ≤ 165 °C at a duration ≤ 10 s.

INSTRUCTIONS FOR CLIP MOUNTING

Direct mounting with clip 56363

1. Apply heatsink compound to the mounting base, then place the transistor on the heatsink.
2. Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10° to 30° to the vertical (see Figs 1 and 2).
3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body, not on the tab (see Fig. 2a).

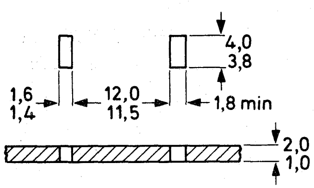


Fig. 1 Heatsink requirements.

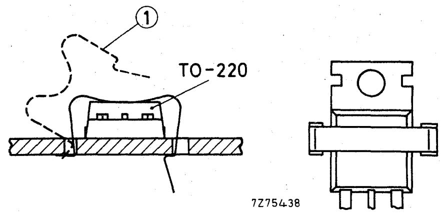


Fig. 2 Mounting.
(1) spring clip 56363.

Fig. 2a Position of transistor (top view).

Insulated mounting with clip 56364

With the insulators 56367 or 56369 insulation up to 2 kV is obtained.

1. Apply heatsink compound to the bottom of both transistor and insulator, then place the transistor with the insulator on the heatsink.
2. Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10° to 30° to the vertical (see Figs 3 and 4).
3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body, not on the tab. Ensure that the device is centred on the mica insulator to prevent creepage.

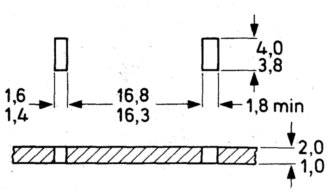


Fig. 3 Heatsink requirements.

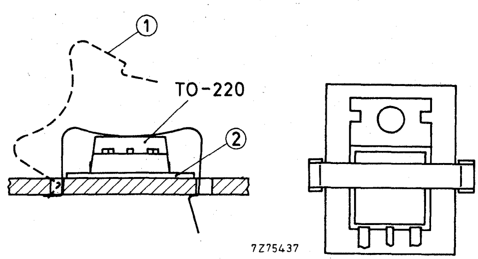


Fig. 4 Mounting.
(1) spring clip 56364.
(2) insulator 56369 or 56367.

Fig. 4a Position of transistor (top view).

INSTRUCTIONS FOR SCREW MOUNTING

Dimensions in mm

Direct mounting with screw and spacing washer

- *through heatsink with nut*

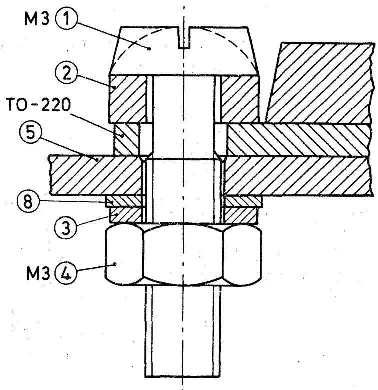


Fig. 5 Assembly.

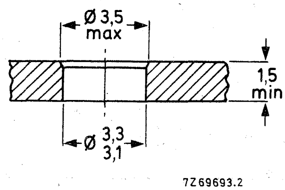


Fig. 6 Heatsink requirements.

(1) M3 screw.
(2) rectangular washer (56360a).
(3) lock washer.
(4) M3 nut.
(5) heatsink.
(8) plain washer.

- *into tapped heatsink*

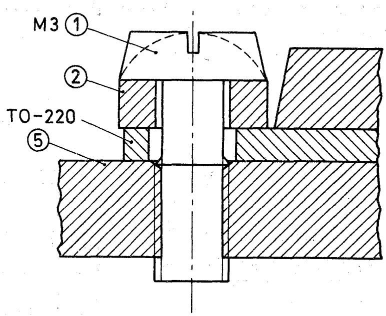


Fig. 7 Assembly.

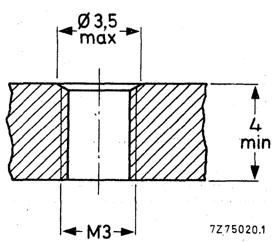


Fig. 8 Heatsink requirements.

(1) M3 screw.
(2) rectangular washer 56360a.
(5) heatsink.

Insulated mounting with screw and spacing washer
(not recommended where mounting tab is on mains voltage)

Dimensions in mm

- *through heatsink with nut*

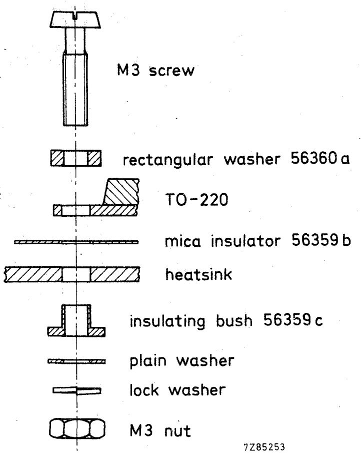


Fig. 9 Insulated screw mounting with rectangular washer. Known as a "bottom mounting".

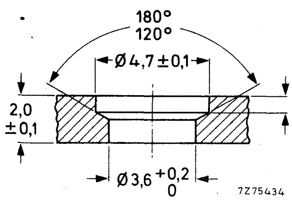


Fig. 10 Heatsink requirements for 500 V insulation.

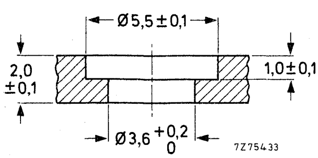


Fig. 11 Heatsink requirements for 800 V insulation.

- *into tapped heatsink*

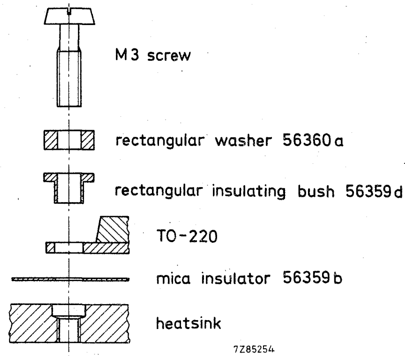


Fig. 12 Insulated screw mounting with rectangular washer into tapped heatsink. Known as a "top mounting".

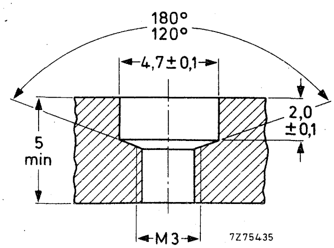


Fig. 13 Heatsink requirements for 500 V insulation.

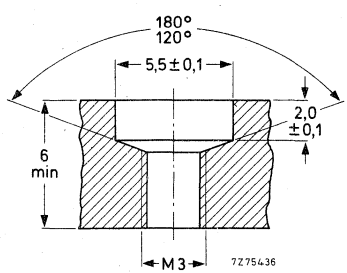


Fig. 14 Heatsink requirements for 1000 V insulation.

MOUNTING INSTRUCTIONS FOR SOT-93 ENVELOPES

GENERAL DATA AND INSTRUCTIONS

General rule

Avoid any sudden forces on leads and body; these forces, such as from falling on a hard surface, are easily underestimated. In the direct screw mounting an M4 screw must be used; an M3 screw in the insulating mounting.

Heatsink requirements

Flatness in the mounting area: 0,02 mm maximum per 10 mm.
The mounting hole must be deburred.

Heatsink compound

The thermal resistance from mounting base to heatsink ($R_{th\ mb-h}$) can be reduced by applying a metallic-oxide heatsink compound between the contact surfaces. For insulated mounting the compound should be applied to the bottom of both device and insulator.

Maximum play

The bush or the washer may only just touch the plastic part of the body, but should not exert any force on that part. Keep mounting tool (e.g. screwdriver) clear of the plastic body.

Mounting torques

For M3 screw (insulated mounting):	
Minimum torque (for good heat transfer)	0,4 Nm (4 kgcm)
Maximum torque (to avoid damaging the device)	0,6 Nm (6 kgcm)
For M4 screw (direct mounting only):	
Minimum torque (for good heat transfer)	0,4 Nm (4 kgcm)
Maximum torque (to avoid damaging the device)	1,0 Nm (10 kgcm)

Note: The M4 screw head should not touch the plastic part of the envelope.

Lead bending

Maximum permissible tensile force on the body for 5 s — 20 N (2 kgf)

No torsion is permitted at the emergence of the leads.

Bending or twisting is not permitted within a lead length of 0,3 mm.

The leads can be bent through 90° maximum, twisted or straightened; to keep forces within the above-mentioned limits, the leads are generally clamped near the body.

N.B.: Data on accessories are given in chapter Accessories.

Soldering

Recommendations for devices with a maximum junction temperature rating $\leq$ 175 °C:

a. Dip or wave soldering

Maximum permissible solder temperature is 260 °C at a distance from the body of > 5 mm and for a total contact time with soldering bath or waves of < 7 s.

b. Hand soldering

Maximum permissible temperature is 275 °C at a distance from the body of > 3 mm and for a total contact time with the soldering iron of < 5 s.

The body of the device must not touch anything with a temperature > 200 °C.

It is not permitted to solder the metal tab of the device to a heatsink, otherwise the junction temperature rating will be exceeded.

Avoid any force on body and leads during or after soldering; do not correct the position of the device or of its leads after soldering.

Thermal data

			clip mounting	screw mounting
Thermal resistance from mounting base to heatsink				
direct mounting				
with heatsink compound	$R_{th\ mb-h}$	=	0,3	0,3 °C/W
without heatsink compound	$R_{th\ mb-h}$	=	1,5	0,8 °C/W
with 0,05 mm mica washer				
with heatsink compound	$R_{th\ mb-h}$	=	0,8	0,8 °C/W
without heatsink compound	$R_{th\ mb-h}$	=	3,0	2,2 °C/W

INSTRUCTIONS FOR CLIP MOUNTING

Direct mounting with clip 56379

1. Place the device on the heatsink, applying heatsink compound to the mounting base.
2. Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10° to 20° to the vertical (see Fig. 1b).
3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body, not on the tab (see Fig. 1(c)).

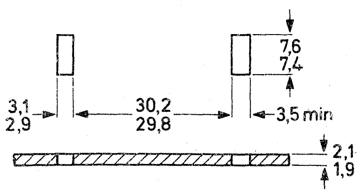


Fig. 1a Heatsink requirements.

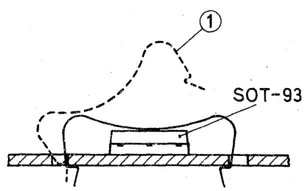


Fig. 1b Mounting.
(1) = spring clip 56379.

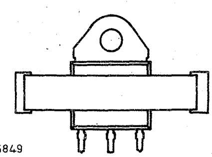


Fig. 1c Position of the device.

Insulated mounting with clip 56379

With the mica 56378 insulation up to 1500 V is obtained.

1. Place the device with the insulator on the heatsink, applying heatsink compound to the bottom of both device and insulator.
2. Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10° to 20° to the vertical (see Figs 2a and 2b).
3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body, not on the tab (see Fig. 2c). There should be minimum 3 mm distance between the device and the edge of the insulator for adequate creepage.

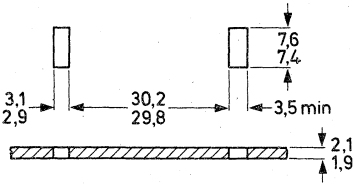


Fig. 2a Heatsink requirements.

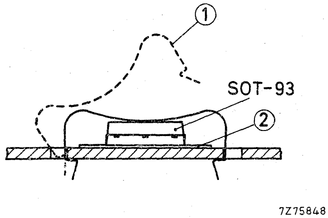


Fig. 2b Mounting.
(1) = spring clip 56379
(2) = insulator 56378

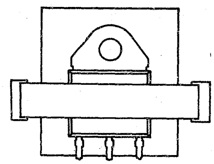


Fig. 2c Position of the device.

INSTRUCTIONS FOR SCREW MOUNTING

Direct mounting

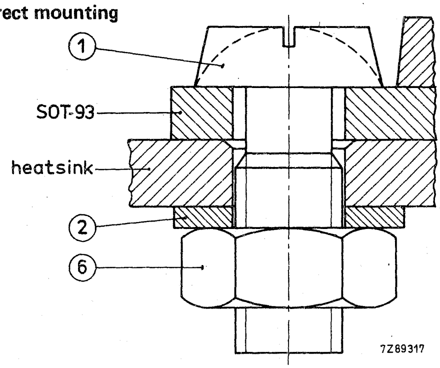


Fig. 3a Assembly through heatsink with nut.

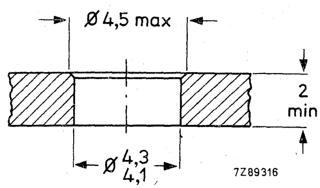


Fig. 3b Heatsink requirements.

When screw mounting the SOT-93 envelope, it is particularly important to apply a thin, even layer of heatsink compound to the mounting base, and to apply torque to the screw slowly so that the compound has time to flow and the mounting base is not deformed. Most SOT-93 envelopes contain a crystal larger than that in the other plastic envelopes, and it is more likely to crack if the mounting base is deformed.

Legend: (1) M4 screw; (2) plain washer; (6) M4 nut.
Where vibrations are to be expected the use of a lock washer or of a curved spring washer is recommended, with a plain washer between aluminium heatsink and spring washer.

Insulated screw mounting with nut; up to 800 V.

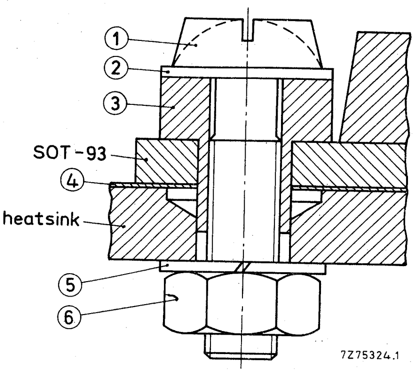


Fig. 4 Assembly.
See also Fig. 9.

(1) M3 screw
(2) plain washer
(3) insulating bush (56368b)
(4) mica insulator (56368a)
(5) lock washer
(6) M3 nut

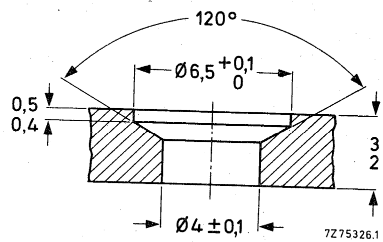


Fig. 5 Heatsink requirements up to 800 V insulation.

Insulated screw mounting with tapped hole; up to 800 V.

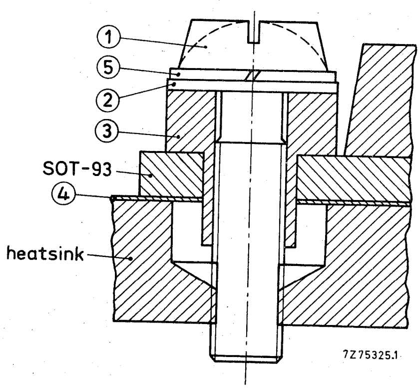


Fig. 6 Assembly.
See also Fig. 9.

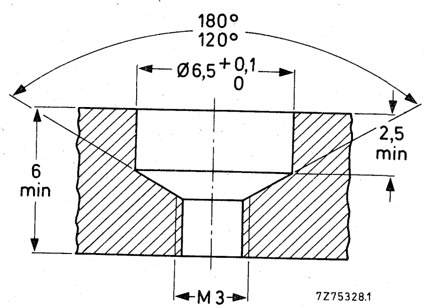


Fig. 7 Heatsink requirements up to 800 V insulation.

(1) M3 screw
(2) plain washer
(3) insulating bush (56368b)
(4) mica insulator (56368a)
(5) lock washer

Insulated screw mounting with insert nut; up to 500 V

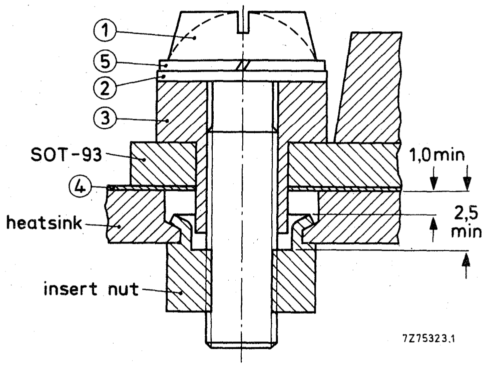


Fig. 8 Assembly and heatsink requirements for 500 V insulation. See also Fig. 3.

(1) M3 screw
(2) plain washer
(3) insulating bush (56368b)
(4) mica insulator (56368a)
(5) lock washer

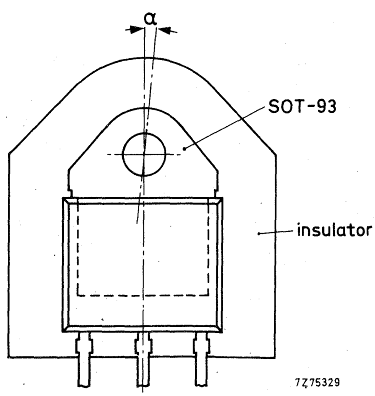


Fig. 9 Mica insulator.

The axial deviation (α) between SOT-93 and mica should not exceed 5°.

MOUNTING INSTRUCTIONS FOR TO-3 ENVELOPES

GENERAL DATA AND INSTRUCTIONS

Instructions for direct mounting.

Mounting instructions for up to 500 V insulation.
Using insulating bushes 56201j or 56261a and mica washer 56201d.

Mounting instructions for 500 to 2000 V insulation.
Using mounting support 56352 and mica washer 56339.

Heatsink requirements

Flatness in the mounting area: 0,05 mm per 40 mm

Mounting holes must be deburred.

Mounting torques

Minimum torque (for good heat transfer)	0,4 Nm (4 kgcm)
Maximum torque (to avoid damaging the transistor)	0,6 Nm (6 kgcm)

N.B.: When the driven nut or screw is in direct contact with a toothed lock washer (e.g. Fig. 10), the torques are as follows:

Minimum torque	0,55 Nm (5,5 kgcm)
Maximum torque	0,8 Nm (8 kgcm)

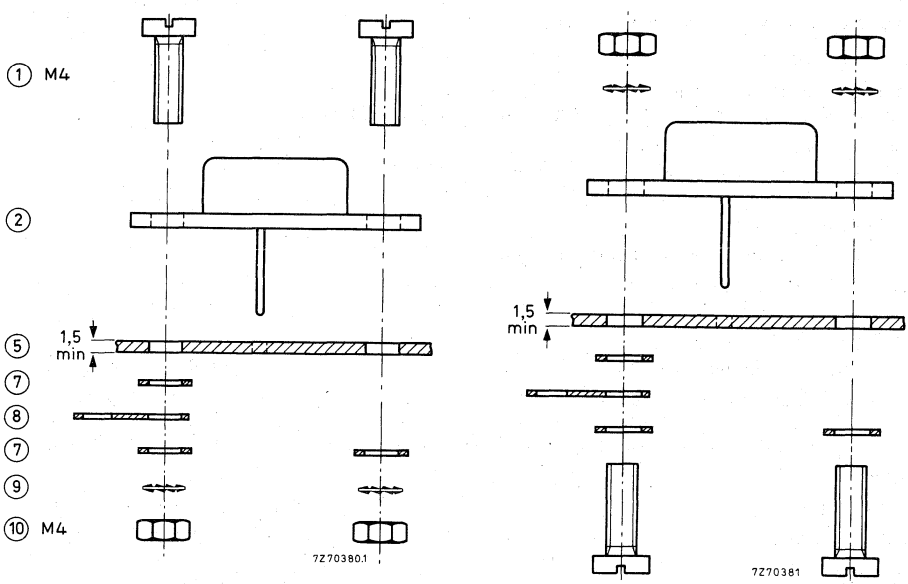
Thermal data

The thermal resistance from mounting base to heatsink ($R_{th\ mb-h}$) can be reduced by applying a heat conducting compound between transistor and heatsink. For insulated mounting the compound should be applied to the bottom of both device and insulator.

		Direct mounting	Insulated mounting 500 V mica	Insulated mounting 2000 V mica	
From mounting base to heatsink					
without heatsink compound	$R_{th\ mb-h}$	0,6	1,0	1,25	K/W
with heatsink compound	$R_{th\ mb-h}$	0,1	0,3	0,5	K/W

INSTRUCTIONS FOR DIRECT MOUNTING

The transistors should be mounted with M4 screws, see Figs 1 and 2. Minimum heatsink thickness (for good heat transfer) 1,5 mm. Hole pattern: Fig. 3.
A heatsink with tapped holes or insert nuts can also be used, but a torque washer is necessary between metal washer and transistor. See Fig. 4.



Figs 1 and 2. Direct mounting with nuts.

Legend
(1) = screw
(2) = TO-3
(4) = mica
(5) = heatsink
(6) = insulating bush
(7) = metal washer
(8) = soldering tag
(9) = lock washer
(10) = nut
(11) = tapped hole
(12) = insert nut
Dimensions in mm

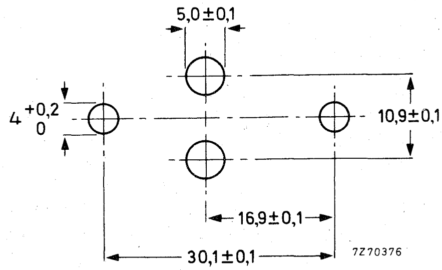


Fig. 3 Hole pattern for direct mounting with nuts.

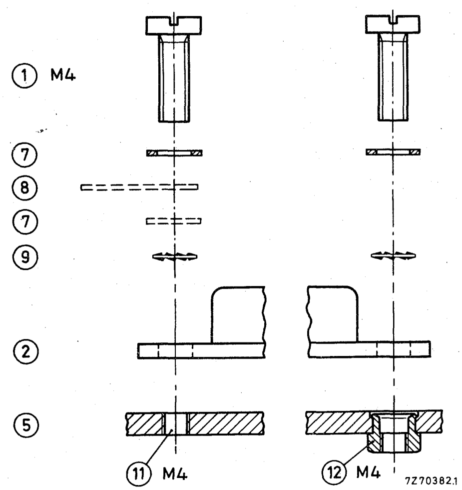


Fig. 4 Direct mounting with tapped holes or insert nuts.

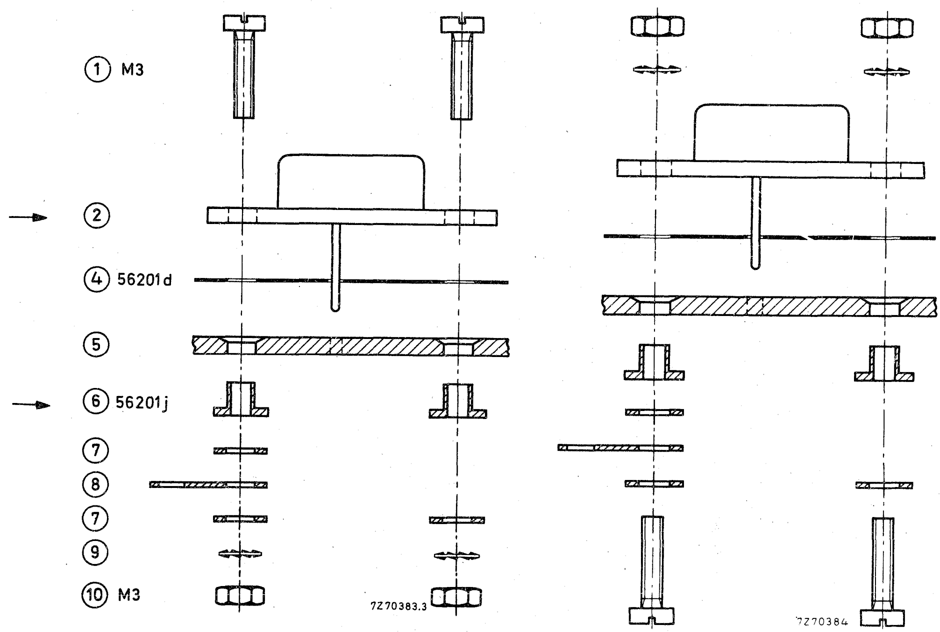
MOUNTING INSTRUCTIONS FOR UP TO 500 V INSULATION

Using insulating bushes 56201j and mica washer 56201d

For the component arrangement with minimum heatsink thickness see Figs 5 and 6. For hole pattern and shape of holes see Figs 7 and 8.

Using insulating bush 56261a and mica washer 56201d

For an arrangement with M3 screws and nuts see Fig. 9, mounting holes are given in Figs 7 and 8. The accessories can also be used in combination with M3 screws and heatsinks provided with tapped holes or insert nuts. Lock washers are necessary between screw-head and metal washer, see Fig. 10. For an assembly drawing with tapped holes see Fig. 11, with insert nuts see Fig. 12.



Figs 5 and 6. Insulated mounting (500 V) with 56201j and 56201d. Heatsink thickness: 1,5 to 2,5 mm.

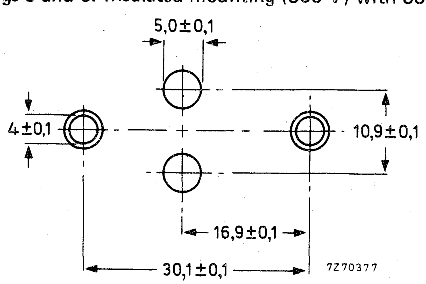


Fig. 7 Hole pattern for 500 V insulation, nut fastening.

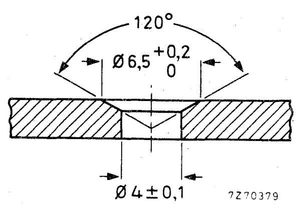


Fig. 8 Shape of hole for 500 V insulation, nut fastening.

For legend see page 2.

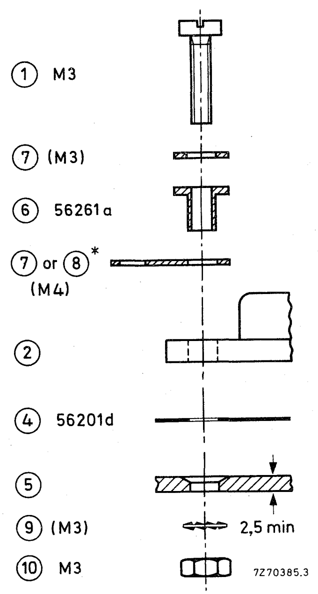


Fig. 9 Insulated mounting (500 V) with nuts.

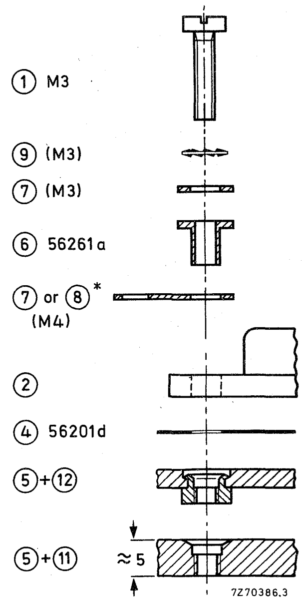


Fig. 10 Insulated mounting (500 V) with tapped holes or insert nuts.

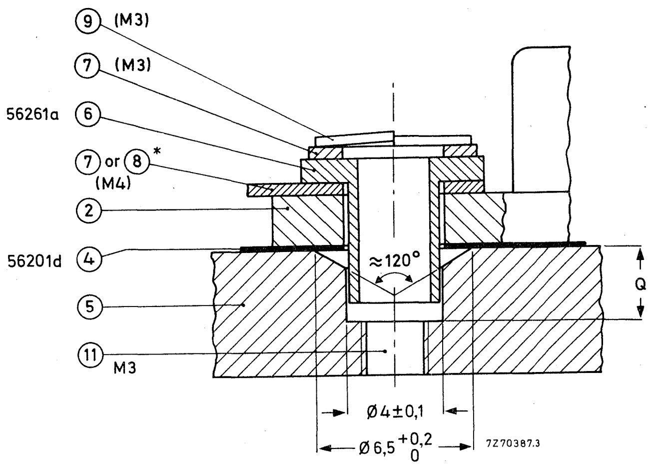


Fig. 11 Assembly (partial) for Fig. 10 - tapped holes.
Q minimum 2,5 mm.

For legend see page 2.

* Thickness approximately 0,6 mm, outer diameter 7,5 mm.

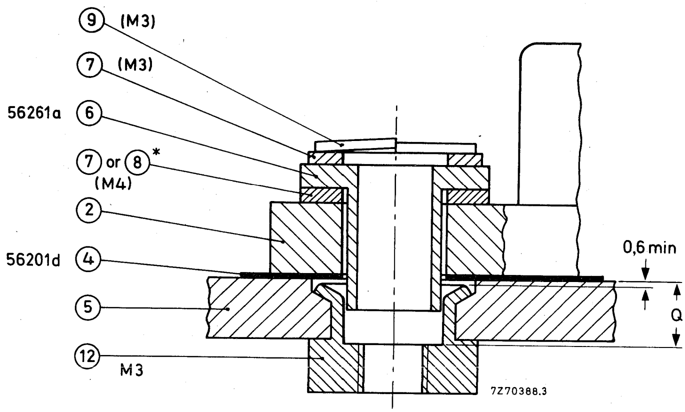


Fig. 12 Assembly (partial) for Fig. 10 - insert nuts Q minimum 2,5 mm.

Legend for all figures:

(1) screw.
(2) TO-3 thick base (3,15 mm).
(4) mica.
(5) heatsink.
(6) insulating bush.
(7) metal washer.
(8) soldering tag.
(9) lock washer.
(10) nut.
(11) tapped hole.
(12) insert nut.

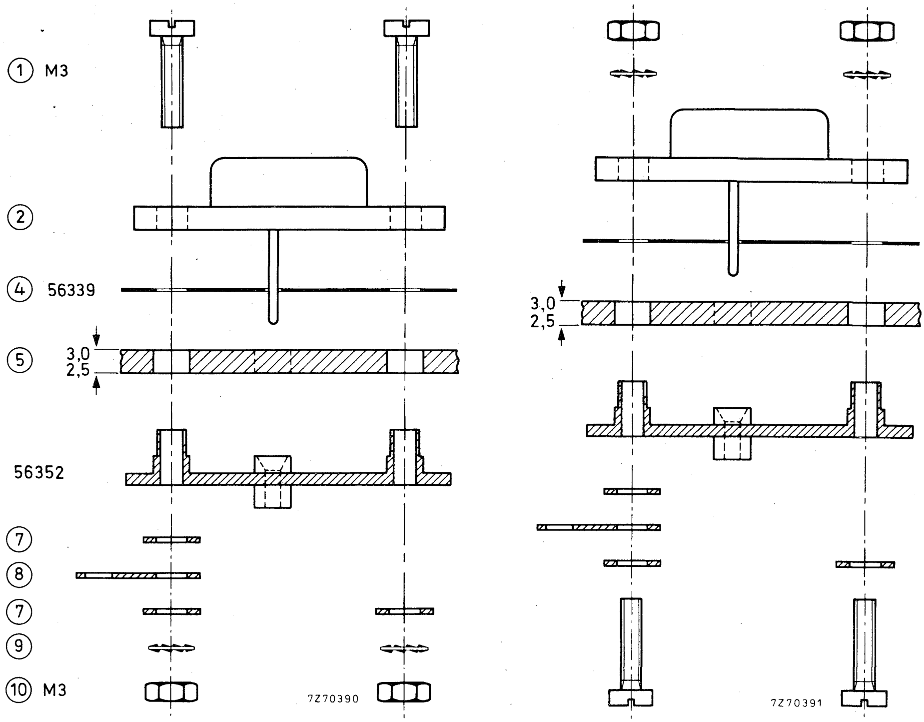
Dimensions in mm

* Thickness approximately 0,6 mm, outer diameter 7,5 mm.

MOUNTING INSTRUCTIONS FOR 500 V TO 2000 V INSULATION

Using mounting support 56352 and mica washer 56339

The transistor should be mounted with M3 screws. For component arrangement see Figs 13 and 14. For hole pattern see Fig. 15. Thickness of heatsink 2,5 mm to 3 mm.



Figs 13 and 14. Insulated mounting (500 V–2000 V).

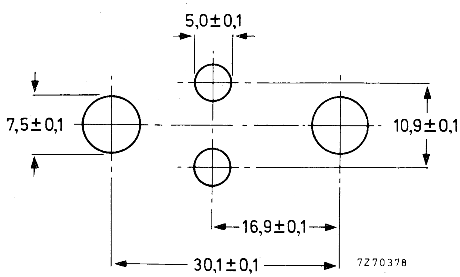


Fig. 15 Hole pattern for Figs 13 and 14.

For legend see page 6.

ACCESSORIES

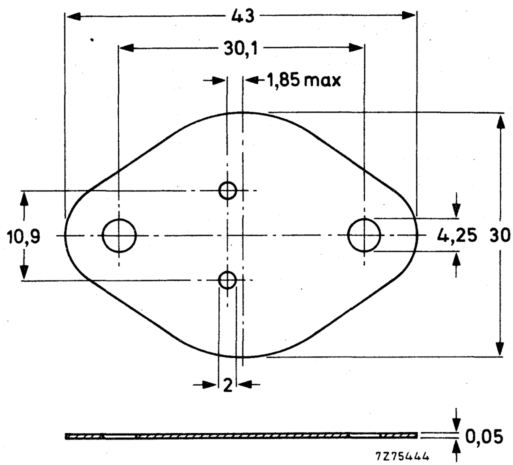
TYPE NUMBER SURVEY ACCESSORIES

type number	description	envelope
56201d	mica washer (up to 500 V)	TO-3
56201j	insulating bushes (up to 500 V)	TO-3
56261a	insulating bushes (up to 500 V)	TO-3
56326	metal washer	TO-126
56333	metal wahser mica washer } (up to 250 V) insulating bush	TO-126
56339	mica washer (500 to 2000 V)	TO-3
56352	insulating mounting support	
56353	spring clip	TO-126/SOT-82
56354	mica insulator	TO-126/SOT-82
56359b	mica washer (up to 1000 V)	TO-220
56359c	insulating bush (up to 800 V)	TO-220
56359d	rectangular insulating bush (up to 1000 V)	TO-220
56360a	rectangular washer (brass)	TO-220
56363	spring clip (direct mounting)	TO-220
56364	spring clip (insulated mounting)	TO-220
56367	alumina insulator (up to 2000 V)	TO-220
56368a	mica insulator (up to 800 V)	SOT-93
56368b	insulating bush (up to 800 V)	SOT-93
56369	mica insulator (up to 2 kV)	TO-220
56378	mica insulator (up to 1500 V)	SOT-93
56379	spring clip	SOT-93
56387a	mica insulator (up to 300 V)	TO-126
56387b	insulating bush (up to 300 V)	TO-126

56201d MICA WASHER

Mica washer for up to 500 V insulation of **TO-3** envelopes.

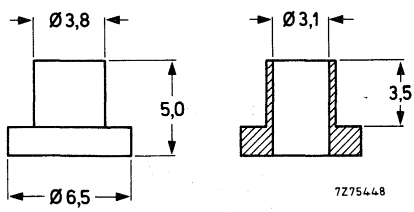
MECHANICAL DATA Dimensions in mm



56201j 2 INSULATING BUSHES

Two insulating bushes for up to 500 V insulation of **TO-3** envelopes.

MECHANICAL DATA Dimensions in mm



TEMPERATURE

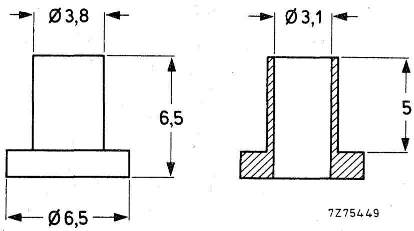
Maximum permissible temperature T_{max} 150 °C

56261a 2 INSULATING BUSHES

Two insulating bushes for up to 500 V insulation of **TO-3** envelopes.

MECHANICAL DATA

Dimensions in mm



TEMPERATURE

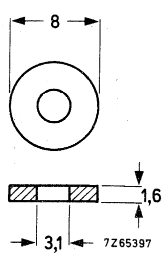
Maximum permissible temperature T_{max} 150 °C

56326 WASHER

Flat metal washer for direct mounting of envelope TO-126 (SOT-32).

MECHANICAL DATA

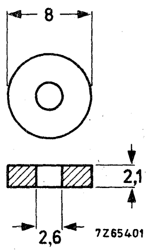
Dimensions in mm



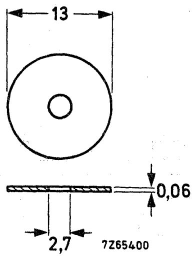
56333

Mounting accessories for insulated mounting of envelope TO-126 (SOT-32); the set consists of a metal washer, a mica washer and an insulating bush.

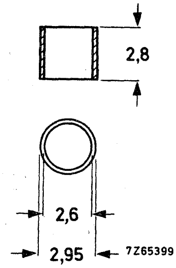
MECHANICAL DATA Dimensions in mm



Metal washer.



Mica washer.



Insulating bush.

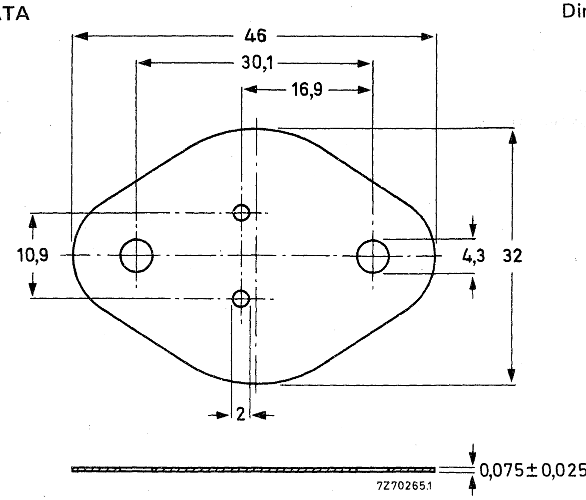
TEMPERATURE

Maximum permissible temperature T_{max} = 150 °C

56339 MICA WASHER

Mica washer for 500 to 2000 V insulation of TO-3 envelopes, for which it should be combined with mounting support 56352.

MECHANICAL DATA Dimensions in mm

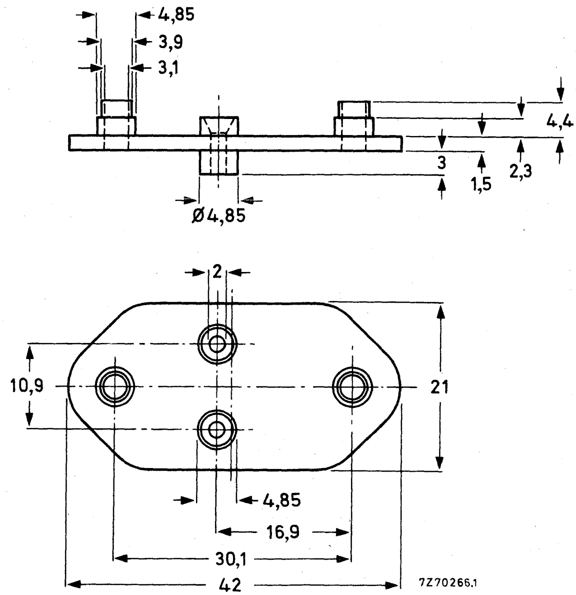


56352 MOUNTING SUPPORT

Mounting support for 500 to 2000 V insulation of TO-3 envelopes, for which it should be combined with mica washer 56339.

MECHANICAL DATA

Dimensions in mm



TEMPERATURE

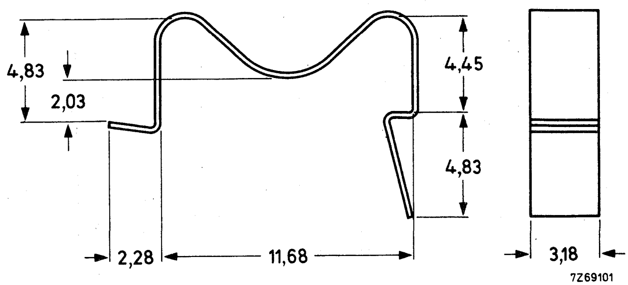
Maximum permissible temperature T_{max} 125 °C

56353 CLIP

for TO-126 and SOT-82 envelopes

MECHANICAL DATA

Dimensions in mm



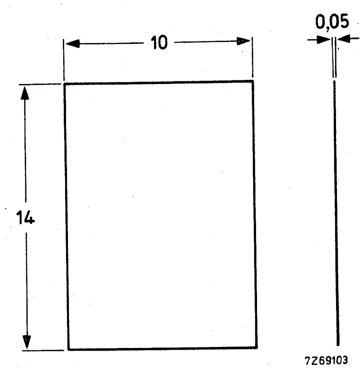
Spring clip suitable for heatsink of 1,5 to 2 mm.
See mounting instructions TO-126/SOT-82 envelopes.

56354 MICA INSULATOR

for TO-126 and SOT-82 envelopes

MECHANICAL DATA

Dimensions in mm



See also chapter Mounting Instructions TO-126 and SOT-82 envelopes.

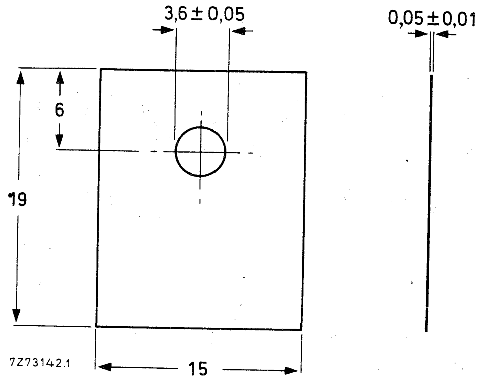
56359b

MICA WASHER

for TO-220 envelopes (up to 1000 V)

MECHANICAL DATA

Dimensions in mm



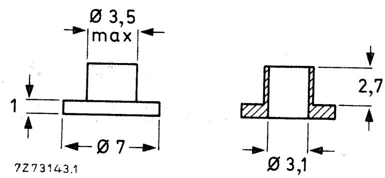
56359c

INSULATING BUSH

for TO-220 envelopes (up to 800 V)

MECHANICAL DATA

Dimensions in mm



TEMPERATURE

Maximum permissible temperature T_{max} = 150 °C

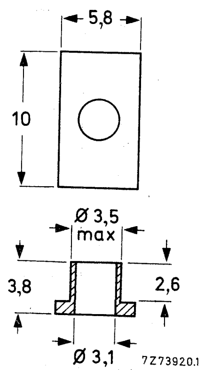
56359d

RECTANGULAR INSULATING BUSH

for TO-220 envelopes (up to 1000 V)

MECHANICAL DATA

Dimensions in mm



TEMPERATURE

Maximum permissible temperature T_{max} = 150 °C

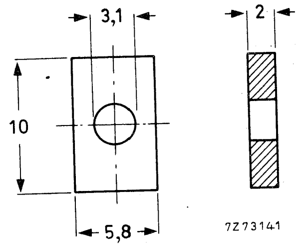
56360a RECTANGULAR WASHER

for direct and insulated mounting of TO-220 envelopes

Dimensions in mm

MECHANICAL DATA

material: brass.



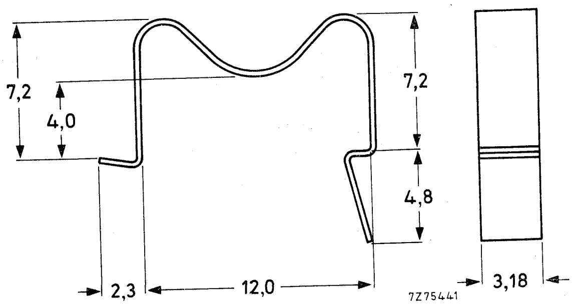
56363 SPRING CLIP

for direct mounting of TO-220 envelopes

Dimensions in mm

MECHANICAL DATA

material: steel, zinc-chromate passivated.



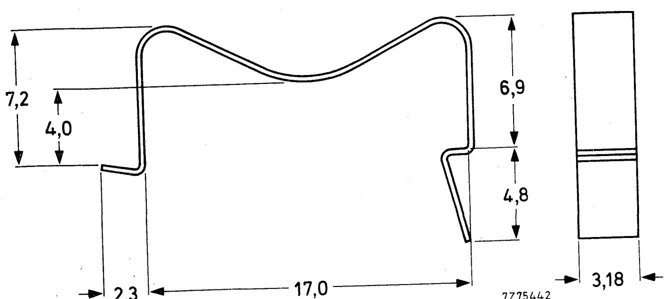
56364 SPRING CLIP

for insulated mounting of TO-220 envelopes

Dimensions in mm

MECHANICAL DATA

material: steel, zinc-chromate passivated.



to be used in conjunction with **56367** or **56369.**

56367

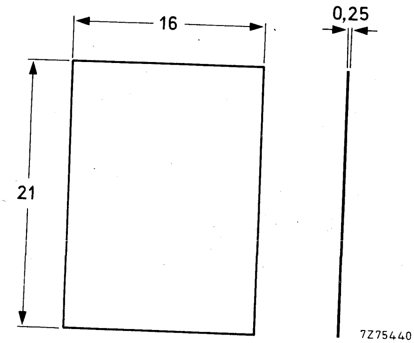
ALUMINA INSULATOR

for insulating mounting of TO-220 envelopes (up to 2 kV)

MECHANICAL DATA

material: 96-alumina.

Dimensions in mm



* Because alumina is brittle, extreme care must be taken when mounting devices not to crack the alumina, particularly when used without heatsink compound.

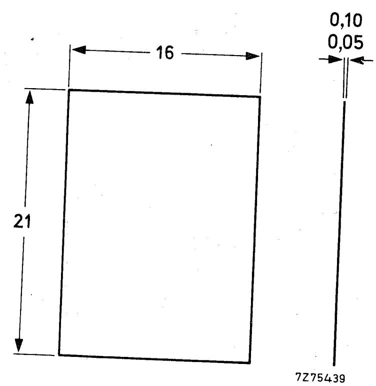
56369

MICA INSULATOR

for insulated clip mounting of TO-220 envelopes (up to 2 kV)

MECHANICAL DATA

Dimensions in mm

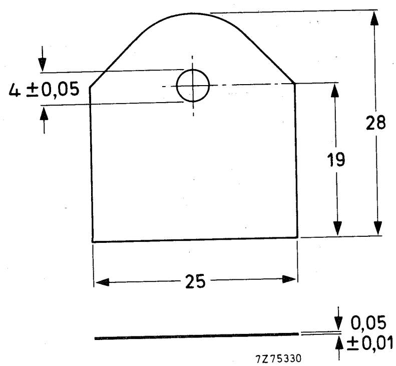


56368a MICA INSULATOR

for insulated screw mounting of SOT-93 envelopes (up to 800 V)

MECHANICAL DATA

Dimensions in mm

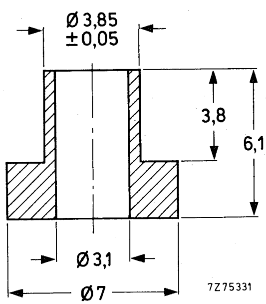


56368b INSULATING BUSH

for insulated screw mounting of SOT-93 envelopes (up to 800 V)

MECHANICAL DATA

Dimensions in mm



TEMPERATURE

Maximum permissible temperature T_{max} = 150 °C

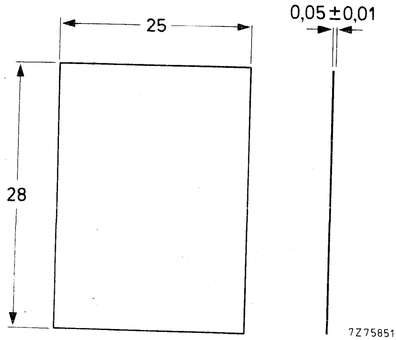
56369 see page 9.

56378 MICA INSULATOR

for SOT-93 clip mounting (up to 1500 V)

MECHANICAL DATA

Dimensions in mm



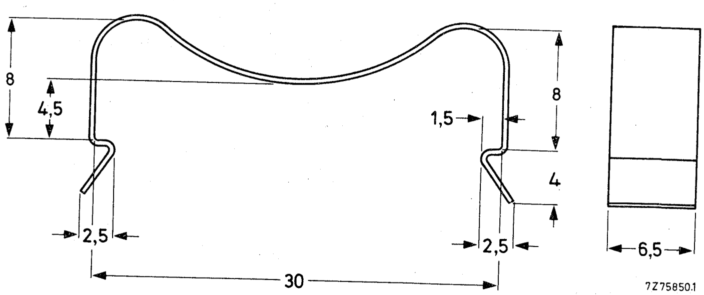
56379 SPRING CLIP

for direct and insulated mounting of SOT-93 envelopes

MECHANICAL DATA

Dimensions in mm

Material:
CrNi steel NLN-939;
thickness 0,4 ± 0,04.

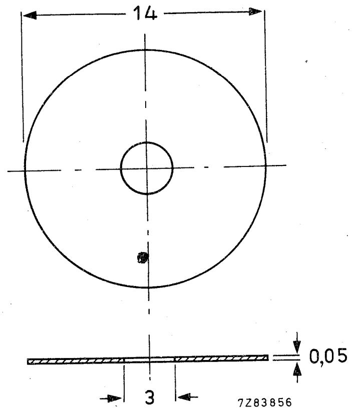


56387a MICA WASHER

for insulated screw mounting of TO-126 envelopes (up to 300 V)

MECHANICAL DATA

Dimensions in mm

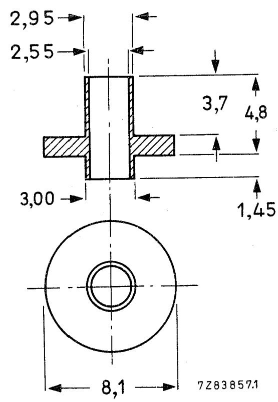


56387b INSULATING BUSH

for insulated screw mounting of TO-126 envelopes (up to 300 V)

MECHANICAL DATA

Dimensions in mm



TEMPERATURE

Maximum permissible temperature T_{max} 150 °C

CLIP MOUNTING

envelope	direct mounting		insulated mounting			
	clip		mica	alumina	clip	
TO-126 (SOT-32)	56353		56354		56353	
SOT-82	56353		56354		56353	
TO-220 (SOT-78)	56363		56369 or	56367	56364	
SOT-93	56379		56378		56379	

SCREW MOUNTING

envelope	direct mounting		insulated mounting			
	metal washer	mounting material	mica washer	insul. bush	metal washer	mounting material
TO-126						
(SOT-32)	56326	M3				
up to 250 V			←	56333	→	M2,5
up to 300 V			56387a	56387b	56326	M2,5
TO-220						
(SOT-78)	56360a	M3				
up to 800 V			56359b	56359c	56360a	M3
up to 1000 V			56359b	56359d	56360a	M3
SOT-93	–	M4	56368a	56368b		M3
TO-3	–	M4				
(SOT-3)						
up to 500 V			56201d	56201j or 56261a		M3
up to 2000 V			56339	56352		M3

The accessories mentioned can be supplied on request.

See also chapter Mounting Instructions.

HYBRID MODULES

HYBRID INTEGRATED CIRCUIT HI-FI AUDIO POWER AMPLIFIERS

The OM931 and OM961 are thin-film hybrid integrated circuit hi-fi audio amplifiers for sinusoidal output power up to 60 W. The modules offer maximum design possibilities regarding amplification, ripple rejection, stability for complex loads, etc. The amplifiers have built-in short-circuit protection (SOAR protected), and are especially designed for low transient and harmonic distortion. All built-in resistors are dynamically adjusted for optimum performance over a wide temperature range.

QUICK REFERENCE DATA

			OM931	OM961
Sinusoidal output power for $d_{tot} < 0,2$ %				
f = 20 Hz to 20 kHz				
$R_L = 4\ \Omega$	P_o		> 30 W at ± 23 V	> 60 W at ± 31 V
$R_L = 8\ \Omega$	P_o		> 30 W at ± 26 V	> 60 W at ± 35 V
Total harmonic distortion				
$P_o = 1$ W; f = 1 kHz	d_{tot}	typ.	0,02	0,02 %

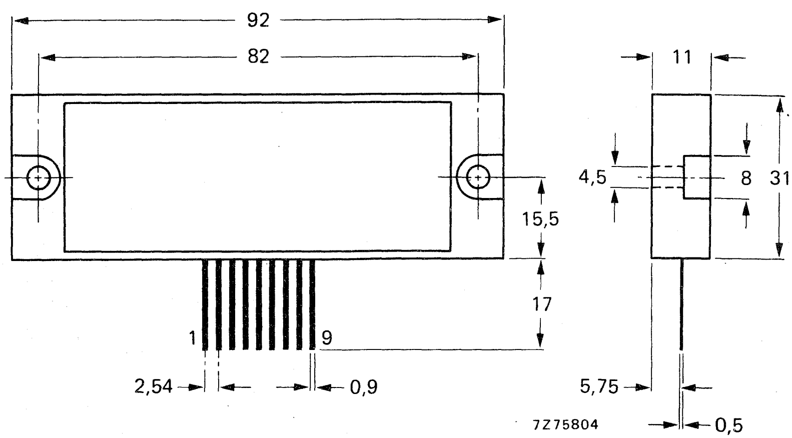


Fig. 1 Outline; dimensions in mm.

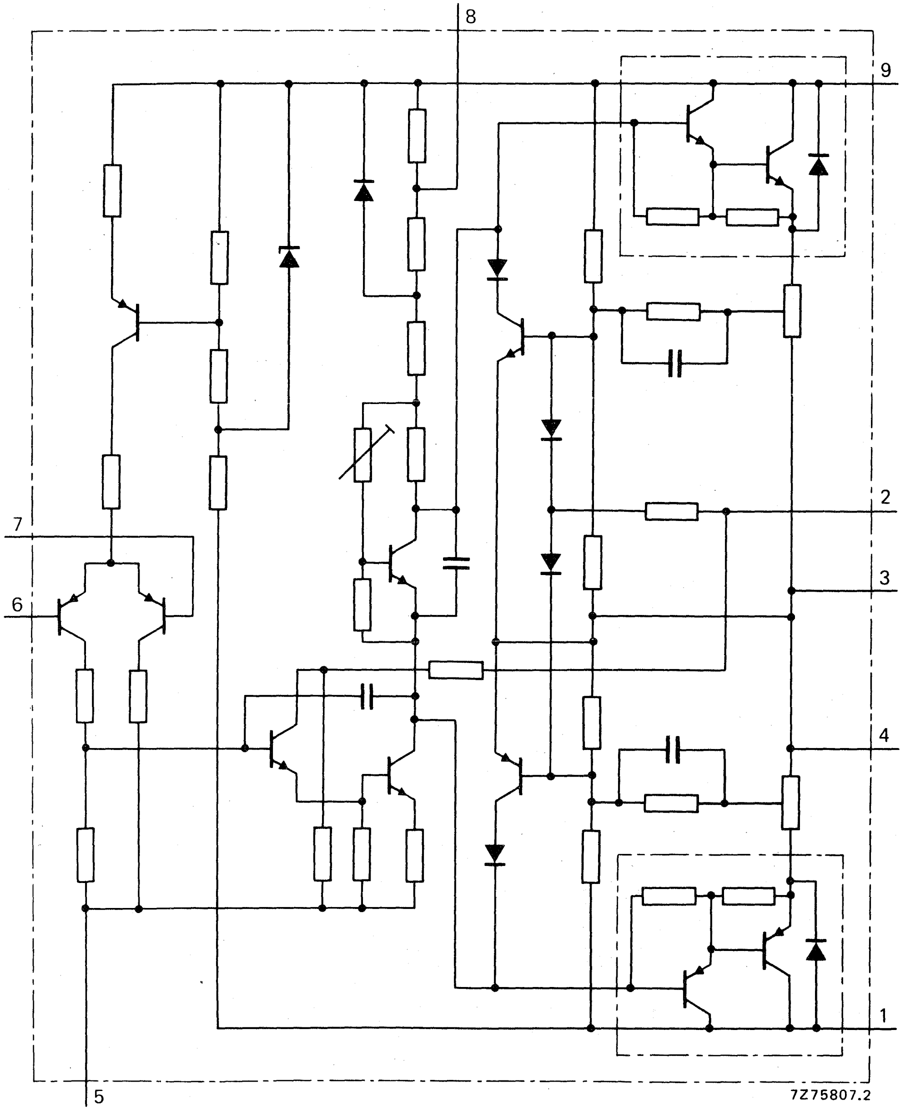


Fig. 2 Circuit diagram.

RATINGS

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

Symmetrical supply voltage	**OM931**	V_S	max.	±40 V
	OM961	V_S	max.	±45 V
Operating mounting base temperature		T_{mb}	max.	95 °C
Storage temperature		T_{stg}		−30 to +100 °C

CHARACTERISTICS

Mounted on a heatsink with $R_{th\ h\text{-}a}$ = 1,4 °C/W (OM931) and $R_{th\ h\text{-}a}$ = 0,8 °C/W (OM961); measured in the circuit of Fig. 3.

			OM931		OM961		
Symmetrical supply voltage	V_S	typ.	±23	±26	±31	±35	V
Total supply current (zero signal)	I_{tot}	typ.	80		100		mA
Sinusoidal output power for $d_{tot} < 0,2$ % f = 20 Hz to 20 kHz (Federal Trade Commission, U.S.A.)							
$R_L = 4\ \Omega$	P_o	>	30	–	60	–	W*
$R_L = 8\ \Omega$	P_o	>	–	30	–	60	W*
Clipping level at f = 1 kHz; $R_L = 4\ \Omega$; $d_{tot} = 0,7\%$	P_o	typ.	40		75		W
Total harmonic distortion P_o = 1 W; f = 1 kHz	d_{tot}	typ.	0,02		0,02		%
Intermodulation distortion at f_1 = 250 Hz and f_2 = 8 kHz; amplitude ratio V_{f1}/V_{f2} = 4/1							
P_o = 1 W	d_{im}	typ.	0,05		0,05		%
P_o = rated value	d_{im}	typ.	0,1		0,1		%
Input sensitivity for P_o = rated value	V_i	typ.	0,7	1	1	1,4	V

Input impedance determined by input circuitry	R_i	typ.	10 kΩ
Open loop gain	G_o	typ.	80 dB
Closed loop gain	G_c	typ.	24 dB
Frequency response P_o = rated value −10 dB (−1 dB)	f		30 Hz to 40 kHz
Power bandwidth (−3 dB)	f_p		20 Hz to 40 kHz
Signal-to-noise ratio (unweighted) P_o = 50 mW; wide band	S/N	typ.	75 dB
Signal-to-noise ratio (weighted) P_o = 50 mW; A-curve	S/N	typ.	87 dB
D.C. output offset voltage	V_{off}	typ.	±20 mV
Ripple rejection	RR	⩾	65 dB
Output impedance	R_o	typ.	0,05 Ω

* P_o is stated as rated value.

APPLICATION INFORMATION

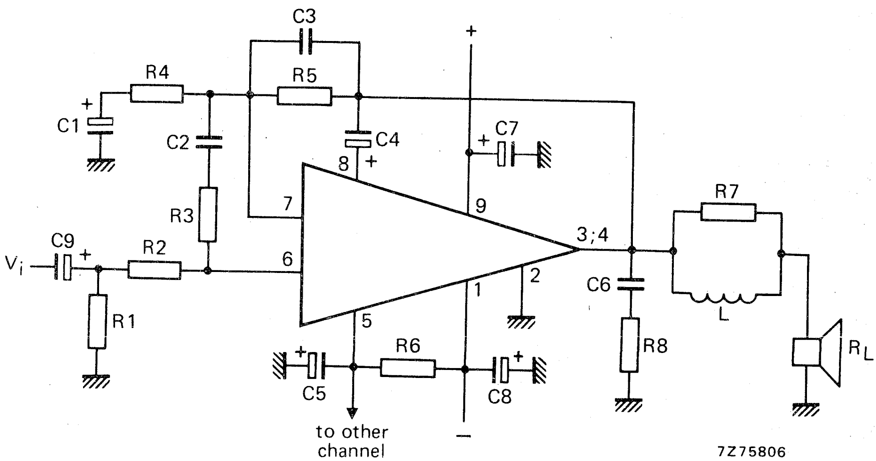


Fig. 3 Example of an amplifier with external components.

List of components:

R1 = 10 kΩ (0,25 W)
R2 = 4,7 kΩ (0,25 W)
R3 = 300 Ω (0,25 W)
R4 = 680 Ω (0,25 W)
R5 = 10 kΩ (0,25 W)
R6 = 22 Ω (0,5 W)
R7 = 2,2 Ω (0,25 W)
R8 = 10 Ω (0,5 W)

C1 = 47 μF (10 V)
C2 = 270 pF (10%)
C3 = 120 pF (10%)
C4 = 100 μF
C5 = 470 μF
C6 = 100 nF
C7 = 10 μF (63 V)
C8 = 10 μF (63 V)
C9 = 1 μF (63 V)

L = 4 μH

R_L = 4 or 8 Ω

MOUNTING RECOMMENDATIONS

The modules are delivered with leads in SIL (single in-line) but leads may also be bent to DIL (dual in-line).

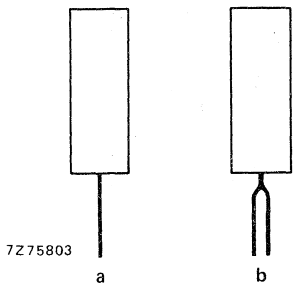
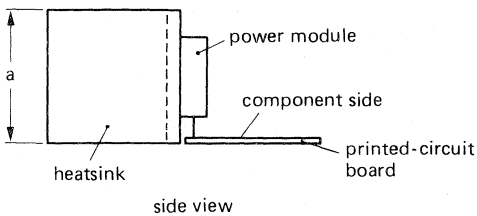


Fig. 4:
a. Single in-line (SIL) leads.
b. Dual in-line (DIL) leads.



Thermal resistance values from heatsink to ambient for various heatsink lengths (a):

$R_{th\ h\text{-}a}$ = 1,4 °C/W: a = 50 mm
$R_{th\ h\text{-}a}$ = 1,0 °C/W: a = 75 mm
$R_{th\ h\text{-}a}$ = 0,8 °C/W: a = 90 mm

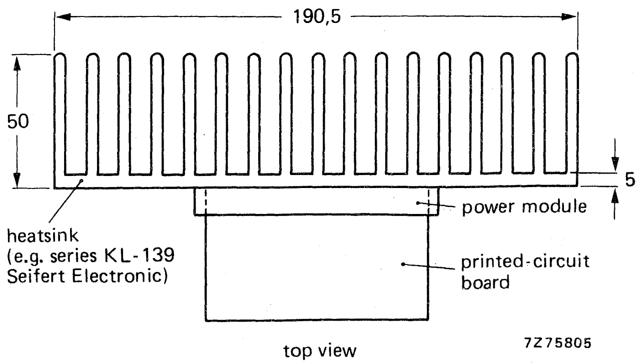


Fig. 5 Example of a heatsink to be used for the module; dimensions in mm.

PRINTED-CIRCUIT BOARDS for OM931 and OM961

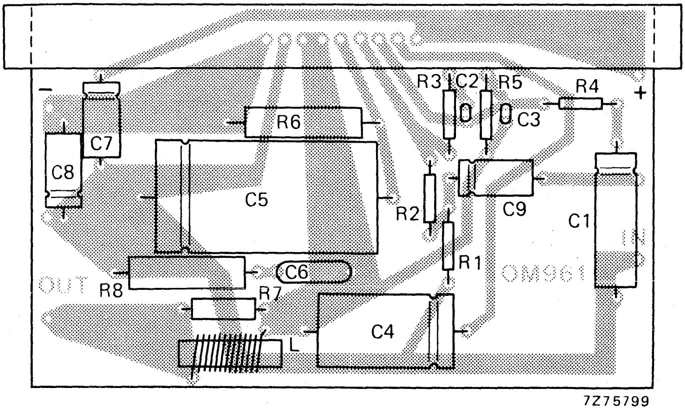


Fig. 6 Component side of SIL-version showing component layout.

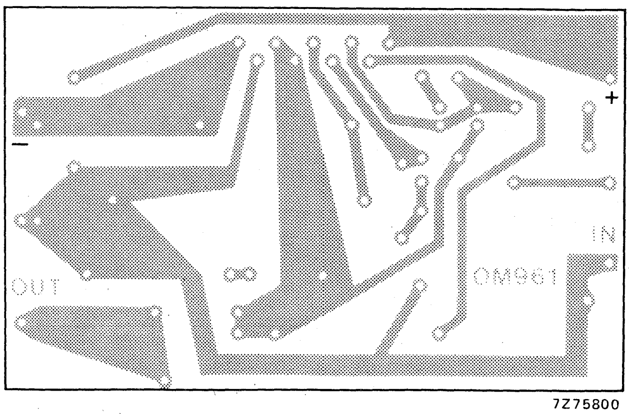


Fig. 7 Component side of DIL-version; for component layout see Fig. 6.

Dimensions in mm

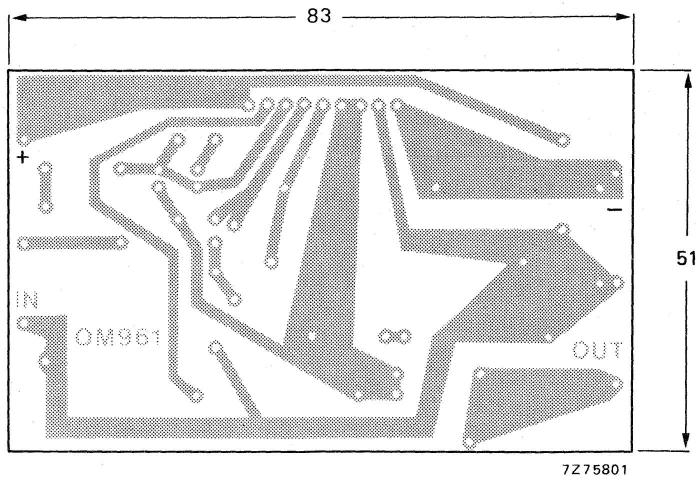


Fig. 8 Track side of SIL-version.

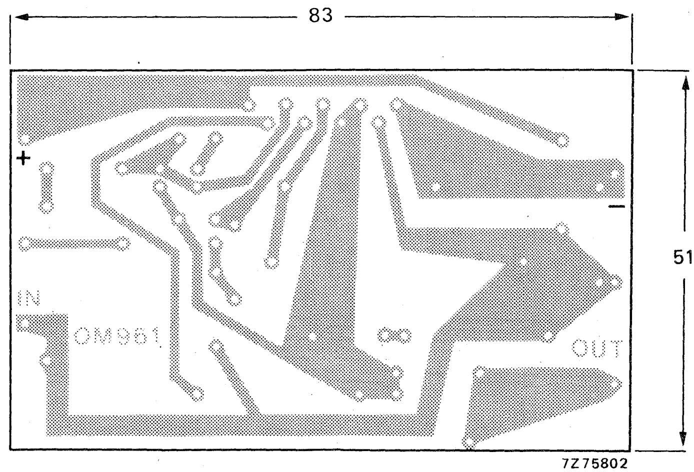


Fig. 9 Track side of DIL-version.

NOTES

NOTES

LOW-FREQUENCY POWER TRANSISTORS

Electronic components and materials for professional, industrial and consumer uses from the world-wide Philips Group of Companies

Argentina: FAPESA, Av. Crovara 2550, Tablada, Prov. de BUENOS AIRES, Tel. 652-7438/7478.
Australia: PHILIPS INDUSTRIES HOLDINGS LTD., Elcoma Division, 67 Mars Road, LANE COVE, 2066, N.S.W., Tel. 427 08 88.
Austria: ÖSTERREICHISCHE PHILIPS BAUELEMENTE Industrie G.m.b.H., Triester Str. 64, A-1101 WIEN, Tel. 62 91 11.
Belgium: M.B.L.E., 7, rue du Pavillon, B-1030 BRUXELLES, Tel. (02) 242 7400.
Brazil: IBRAPE, Caixa Postal 7383, Av. Brigadeiro Faria Lima, 1735 SAO PAULO, SP, Tel. (011) 211-2600.
Canada: PHILIPS ELECTRONICS LTD., Electron Devices Div., 601 Milner Ave., SCARBOROUGH, Ontario, M1B 1M8, Tel. 292-5161.
Chile: PHILIPS CHILENA S.A., Av. Santa Maria 0760, SANTIAGO, Tel. 39-40 01.
Colombia: SADAPE S.A., P.O. Box 9805, Calle 13, No. 51 + 39, BOGOTA D.E. 1., Tel. 600 600.
Denmark: MINIWATT A/S, Emdrupvej 115A, DK-2400 KØBENHAVN NV., Tel. (01) 69 16 22.
Finland: OY PHILIPS AB, Elcoma Division, Kaivokatu 8, SF-00100 HELSINKI 10, Tel. 1 72 71.
France: R.T.C. LA RADIOTECHNIQUE-COMPELEC, 130 Avenue Ledru Rollin, F-75540 PARIS 11, Tel. 355-44-99.
Germany: VALVO, UB Bauelemente der Philips G.m.b.H., Valvo Haus, Burchardstrasse 19, D-2 HAMBURG 1, Tel. (040) 3296-1.
Greece: PHILIPS S.A. HELLENIQUE, Elcoma Division, 52, Av. Syngrou, ATHENS, Tel. 915 311.
Hong Kong: PHILIPS HONG KONG LTD., Elcoma Div., 15/F Philips Ind. Bldg., 24-28 Kung Yip St., KWAI CHUNG, Tel. 12-24 51 21.
India: PEICO ELECTRONICS & ELECTRICALS LTD., Ramon House, 169 Backbay Reclamation, BOMBAY 400020, Tel. 295144.
Indonesia: P.T. PHILIPS-RALIN ELECTRONICS, Elcoma Div., Panim Bank Building, 2nd Fl., Jl. Jend. Sudirman, P.O. Box 223, JAKARTA, Tel. 716 131.
Ireland: PHILIPS ELECTRICAL (IRELAND) LTD., Newstead, Clonskeagh, DUBLIN 14, Tel. 69 33 55.
Italy: PHILIPS S.p.A., Sezione Elcoma, Piazza IV Novembre 3, I-20124 MILANO, Tel. 2-6994.
Japan: NIHON PHILIPS CORP., Shuwa Shinagawa Bldg., 26-33 Takanawa 3-chome, Minato-ku, TOKYO (108), Tel. 448-5611.
(IC Products) SIGNETICS JAPAN, LTD, TOKYO, Tel. (03)230-1521.
Korea: PHILIPS ELECTRONICS (KOREA) LTD., Elcoma Div., Philips House, 260-199 Itaewon-dong, Yongsan-ku, C.P.O. Box 3680, SEOUL, Tel. 794-4202.
Malaysia: PHILIPS MALAYSIA SDN. BERHAD, Lot 2, Jalan 222, Section 14, Petaling Jaya, P.O.B. 2163, KUALA LUMPUR, Selangor, Tel. 77 44 11.
Mexico: ELECTRONICA S.A. de C.V., Varsovia No. 36, MEXICO 6, D.F., Tel. 533-11-80.
Netherlands: PHILIPS NEDERLAND B.V., Afd. Elonco, Boschdijk 525, 5600 PB EINDHOVEN, Tel. (040) 79 33 33.
New Zealand: PHILIPS ELECTRICAL IND. LTD., Elcoma Division, 2 Wagener Place, St. Lukes, AUCKLAND, Tel. 894-160.
Norway: NORSK A/S PHILIPS, Electronica, Sørkedalsveien 6, OSLO 3, Tel. 46 38 90.
Peru: CADESA, Rocca de Vergallo 247, LIMA 17, Tel. 62 85 99.
Philippines: PHILIPS INDUSTRIAL DEV. INC., 2246 Pasong Tamo, P.O. Box 911, Makati Comm. Centre, MAKATI-RIZAL 3116, Tel. 86-89-51 to 59.
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