PHILIPS

Data handbook

PHILIPS

Electronic components and materials

Semiconductors and integrated circuits

Part 2 June 1979

Low-frequency power transistors

Low-frequency power hybrid modules

SEMICONDUCTORS AND INTEGRATED CIRCUITS

PART 2 - JUNE 1979

LOW-FREQUENCY POWER TRANSISTORS

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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 three series of handbooks each comprising several parts.

ELECTRON TUBES	BLUE
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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)

Part 1a	**December 1975**	**ET1a 12-75**	**Transmitting tubes for communication, tubes for r.f. heating** Types PE05/25 to TBW15/25
Part 1b	**August 1977**	**ET1b 08-77**	**Transmitting tubes for communication, tubes for r.f. heating, amplifier circuit assemblies**
Part 2a	**November 1977**	**ET2a 11-77**	**Microwave tubes** Communication magnetrons, magnetrons for microwave heating, klystrons, travelling-wave tubes, diodes, triodes T-R switches
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	**January 1975**	**ET3 01-75**	**Special Quality tubes, miscellaneous devices**
Part 4	**March 1975**	**ET4 03-75**	**Receiving tubes**
Part 5a	**March 1978**	**ET5a 03-78**	**Cathode-ray tubes** Instrument tubes, monitor and display tubes, C.R. tubes for special applications
Part 5b	**December 1978**	**ET5b 12-78**	**Camera tubes and accessories, image intensifiers**
Part 6	**January 1977**	**ET6 01-77**	**Products for nuclear technology** Channel electron multipliers, neutron tubes, 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	**May 1977**	**ET8 05-77**	**TV picture tubes**
Part 9	**March 1978**	**ET9 03-78**	**Photomultiplier tubes; phototubes**

SEMICONDUCTORS AND INTEGRATED CIRCUITS (RED SERIES)

Part 1a	**August 1978**	**SC1a 08-78**	**Rectifier diodes, thyristors, triacs** Rectifier diodes, voltage regulator diodes (> 1,5 W), transient suppressor diodes, rectifier stacks, thyristors, triacs
Part 1b	**May 1977**	**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
Part 2	**November 1977**	**SC2 11-77**	**Low-frequency and dual transistors***
Part 2	**June 1979**	**SC2 06-79**	**Low-frequency power transistors**
Part 3	**January 1978**	**SC3 01-78**	**High-frequency, switching and field-effect transistors**
Part 4a	**December 1978**	**SC4a 12-78**	**Transmitting transistors and modules**
Part 4b	**September 1978**	**SC4b 09-78**	**Devices for optoelectronics** Photosensitive diodes and transistors, light emitting diodes, photocouplers, infrared sensitive devices, photoconductive devices
Part 4c	**July 1978**	**SC4c 07-78**	**Discrete semiconductors for hybrid thick and thin-film circuits**
Part 5a	**November 1978**	**SC5a 11-76**	**Professional analogue integrated circuits**
Part 5b	**March 1977**	**SC5b 03-77**	**Consumer integrated circuits** Radio-audio, television
Part 6	**October 1977**	**SC6 10-77**	**Digital integrated circuits** LOCMOS HE4000B family
Signetics integrated circuits 1978			Bipolar and MOS memories Bipolar and MOS microprocessors Analogue circuits Logic - TTL

* Low-frequency general purpose transistors will be transferred to SC3 later in 1979. The old book SC2 11-77 should be kept until then.

COMPONENTS AND MATERIALS (GREEN SERIES)

Part 1	June 1977	CM1 06-77	**Assemblies for industrial use** High noise immunity logic FZ/30-series, counter modules 50-series, NORbits 60-series, 61-series, circuit blocks 90-series, circuit block CSA70(L), PLC modules, input/output devices, hybrid circuits, peripheral devices, ferrite core memory products
Part 2a	October 1977	CM2a 10-77	**Resistors** Fixed resistors, variable resistors, voltage dependent resistors (VDR), light dependent resistors (LDR), negative temperature coefficient thermistors (NTC), positive temperature coefficient thermistors (PTC), test switches
Part 2b	February 1978	CM2b 02-78	**Capacitors** Electrolytic and solid capacitors, film capacitors, ceramic capacitors, variable capacitors
Part 3	January 1977	CM3 01-77	**Radio, audio, television** Components for black and white television, components for colour television
Part 3a	September 1978	CM3a 09-78	**FM tuners, television tuners, surface acoustic wave filters**
Part 3b	October 1978	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, Ferrocube transformer cores
Part 4b	February 1979	CM4b 02-79	**Piezoelectric ceramics, permanent magnet materials**
Part 6	April 1977	CM6 04-77	**Electric motors and accessories** Small synchonous motors, stepper motors, miniature direct current motors
Part 7	September 1971	CM7 09-71	**Circuit blocks** Circuit blocks 100 kHz-series, circuit blocks 1-series, circuit blocks 10-series, circuit blocks for ferrite core memory drive
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	March 1976	CM9 03-76	**Piezoelectric quartz devices**
Part 10	April 1978	CM10 04-78	**Connectors**

INDEX

INDEX OF TYPE NUMBERS

Data Handbooks SC1a to SC4c

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

AD = Silicon alloyed diodes
GB = Germanium gold bonded diodes
HFSW = High-frequency and switching transistors
LF = Low-frequency transistors (SC2 11-77)
Mm = Discrete semiconductors for hybrid thick and thin-film circuits
PC = Germanium point contact diodes
R = Rectifier diodes
Sp = Special diodes
T = Tuner diodes
Vrg = Voltage regulator diodes
WD = Silicon whiskerless diodes

INDEX

DT = Dual transistors (SC2 11-77)
FET = Field-effect transistors
LF = Low-frequency transistors (SC2 11-77)
Mm = Discrete semiconductors for hybrid thick and thin-film circuits
P = Low-frequency power transistors (SC2 06-79)

HFSW = High-frequency and switching transistors
P = Low-frequency power transistors (SC2 06-79)

type no.	part	section
BF182	3	HFSW
BF183	3	HFSW
BF184	3	HFSW
BF185	3	HFSW
BF194	3	HFSW
BF195	3	HFSW
BF196	3	HFSW
BF197	3	HFSW
BF198	3	HFSW
BF199	3	HFSW
BF200	3	HFSW
BF240	3	HFSW
BF241	3	HFSW
BF245A	3	FET
BF245B	3	FET
BF245C	3	FET
BF256A	3	FET
BF256B	3	FET
BF256C	3	FET
BF324	3	HFSW
BF327	3	FET
BF336	3	HFSW
BF337	3	HFSW
BF338	3	HFSW
BF362	3	HFSW
BF363	3	HFSW
BF419	2	P
BF422	3	HFSW
BF423	3	HFSW
BF450	3	HFSW
BF451	3	HFSW
BF457	2	P
BF458	2	P
BF459	2	P
BF469	2	P
BF470	2	P
BF471	2	P
BF472	2	P
BF480	3	HFSW
BF494	3	HFSW
BF495	3	HFSW
BF550;R	4c	Mm
BF622	4c	Mm
BF623	4c	Mm
BFQ10	3	FET
BFQ11	3	FET
BFQ12	3	FET
BFQ13	3	FET
BFQ14	3	FET
BFQ15	3	FET
BFQ16	3	FET
BFQ17	4c	Mm
BFQ18A	4c	Mm
BFQ19	4c	Mm
BFQ23	3	HFSW
BFQ24	3	HFSW
BFQ32	3	HFSW
BFQ34	3	HFSW
BFQ42	4a	Tra
BFQ43	4a	Tra
BFR29	3	FET
BFR30	4c	Mm
BFR31	4c	Mm
BFR49	3	HFSW
BFR53;R	4c	Mm
BFR64	3	HFSW
BFR65	3	HFSW
BFR84	3	FET
BFR90	3	HFSW
BFR91	3	HFSW
BFR92;R	4c	Mm
BFR93;R	4c	Mm
BFR94	3	HFSW
BFR95	3	HFSW
BFR96	3	HFSW
BFS17;R	4c	Mm
BFS18;R	4c	Mm
BFS19;R	4c	Mm
BFS20;R	4c	Mm
BFS21	3	FET
BFS21A	3	FET
BFS22A	4a	Tra
BFS23A	4a	Tra
BFS28	3	FET
BFT24	3	HFSW
BFT25;R	4c	Mm
BFT44	3	HFSW
BFT45	3	HFSW
BFT46	4c	Mm
BFT92;R	4c	Mm
BFT93;R	4c	Mm
BFW10	3	FET
BFW11	3	FET
BFW12	3	FET
BFW13	3	FET
BFW16A	3	HFSW
BFW17A	3	HFSW
BFW30	3	HFSW
BFW45	3	HFSW
BFW61	3	FET
BFW92	3	HFSW
BFW93	3	HFSW
BFX34	3	HFSW
BFX89	3	HFSW
BFY50	3	HFSW
BFY51	3	HFSW
BFY52	3	HFSW
BFY55	3	HFSW
BFY90	3	HFSW
BG1895		
-541	1a	R
-641	1a	R
BG1897		
-541	1a	R
-542	1a	R
-641	1a	R
-642	1a	R
BG1898		
-541	1a	R
-641	1a	R

FET = Field-effect transistors
HFSW = High-frequency and switching transistors
Mm = Discrete semiconductors for hybrid thick and thin-film circuits
P = Low-frequency power transistors (SC2 06-79)
R = Rectifier diodes
Tra = Transmitting transistors and modules

FET = Field-effect transistors
HFSW = High-frequency and switching transistors
Mm = Discrete semiconductors for hybrid thick and thin-film circuits
PDT = Photodiodes or transistors
Th = Thyristors
Tra = Transmitting transistors and modules

HFSW = High-frequency and switching transistors
P = Low-frequency power transistors (SC2 06-79)
R = Rectifier diodes

Th = Thyristors
Tri = Triacs
Vrf = Voltage reference diodes

AD = Silicon alloyed diodes
GB = Germanium gold bonded diodes
I = Infrared devices
LED = Light-emitting diodes
Mm = Discrete semiconductors for hybrid thick and thin-film circuits
P = Low-frequency power transistors (SC2 06-79)
PC = Germanium point contact diodes
Ph = Photoconductive devices
PhC = Photocouplers
St = Rectifier stacks
TS = Transient suppressor diodes
Vrf = Voltage reference diodes
Vrg = Voltage regulator diodes
WD = Silicon whiskerless diodes

A = Accessories
FET = Field-effect transistors
HFSW = High-frequency and switching transistors
I = Infrared devices
LF = Low-frequency transistors (SC2 11-77)
P = Low-frequency power transistors (SC2 06-79)
R = Rectifier diodes
Tra = Transmitting transistors and modules
Vrg = Voltage regulator diodes
WD = Silicon whiskerless diodes

A = Accessories
DH = Diecast heatsinks
HE = Heatsink extrusions

MAINTENANCE TYPE LIST

The types listed below are included in this handbook only for the first page of the publication. Detailed information will be supplied on request.

BD133	BD232	BU133
BD181	BDY93/94	2N3055
BD182	BDY96/97	2N3442
BD183	BU126	2N4347

TYPE NUMBER SURVEY
SELECTION GUIDE

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

type number NPN	type number PNP	envelope	P_{tot} W	type number NPN	type number PNP	envelope	P_{tot} W
BD131	BD132	TO-126	15	BD681	BD682	TO-126	40
BD133		TO-126	15	BD683	BD684	TO-126	40
BD135	BD136	TO-126	8	BD933	BD934	TO-220	30
BD137	BD138	TO-126	8	BD935	BD936	TO-220	30
BD139	BD140	TO-126	8	BD937	BD938	TO-220	30
BD181		TO-3	78	BD939	BD940	TO-220	30
BD182		TO-3	117	BD941	BD942	TO-220	30
BD183		TO-3	117	BD943	BD944	TO-220	40
BD201	BD202	TO-220	60	BD945	BD946	TO-220	40
BD203	BD204	TO-220	60	BD947	BD948	TO-220	40
BD226	BD227	TO-126	12,5	BD949	BD950	TO-220	40
BD228	BD229	TO-126	12,5	BD951	BD952	TO-220	40
BD230	BD231	TO-126	12,5	BD953	BD954	TO-220	40
BD232		TO-126	15	BD955	BD956	TO-220	40
BD233	BD234	TO-126	25	BDT63	BDT62	TO-220	90
BD235	BD236	TO-126	25	BDT63A	BDT62A	TO-220	90
BD237	BD238	TO-126	25	BDT63B	BDT62B	TO-220	90
BD291	BD292	SOT-82	60	BDT63C	BDT62C	TO-220	90
BD293	BD294	SOT-82	60	BDT91	BDT92	TO-220	90
BD295	BD296	SOT-82	60	BDT93	BDT94	TO-220	90
BD329	BD330	TO-126	15	BDT95	BDT96	TO-220	90
BD331	BD332	SOT-82	60	BDV65	BDV64	SOT-93	125
BD333	BD334	SOT-82	60	BDV65A	BDV64A	SOT-93	125
BD335	BD336	SOT-82	60	BDV65B	BDV64B	SOT-93	125
BD337	BD338	SOT-82	60	BDX35		TO-126	15
BD433	BD434	TO-126	36	BDX36		TO-126	15
BD435	BD436	TO-126	36	BDX37		TO-126	15
BD437	BD438	TO-126	36	BDX42	BDX45	TO-126	5
BD645	BD646	TO-220	62,5	BDX43	BDX46	TO-126	5
BD647	BD648	TO-220	62,5	BDX44	BDX47	TO-126	5
BD649	BD650	TO-220	62,5	BDX63	BDX62	TO-3	90
BD651	BD652	TO-220	62,5	BDX63A	BDX62A	TO-3	90
BD675	BD676	TO-126	40	BDX63B	BDX62B	TO-3	90
BD677	BD678	TO-126	40	BDX63C	BDX62C	TO-3	90
BD679	BD680	TO-126	40	BDX65	BDX64	TO-3	117

type number NPN	PNP	envelope	P_{tot} W	type number NPN	PNP	envelope	P_{tot} W
BDX65A	BDX64A	TO-3	117	BU207A		TO-3	12,5
BDX65B	BDX64B	TO-3	117	BU208A		TO-3	80
BDX65C	BDX64C	TO-3	117	BU209A		TO-3	12,5
BDX67	BDX66	TO-3	150	BU326		TO-3	60
BDX67A	BDX66A	TO-3	150	BU326A		TO-3	60
BDX67B	BDX66B	TO-3	150	BU426		SOT-93	70
BDX67C	BDX66C	TO-3	150	BU426A		SOT-93	70
BDX77	BDX78	TO-220	60	BU433		SOT-93	70
BDX91	BDX92	TO-3	90	BUW84		SOT-82	50
BDX93	BDX94	TO-3	90	BUW85		SOT-82	50
BDX95	BDX96	TO-3	90	BUX80		TO-3	100
BDY20		TO-3	115	BUX81		TO-3	100
BDY90		TO-3	40	BUX82		TO-3	60
BDY91		TO-3	40	BUX83		TO-3	60
BDY92		TO-3	40	BUX84		TO-220	40
BDY93		TO-3	30	BUX85		TO-220	40
BDY94		TO-3	30	BUX86		TO-126	20
BDY96		TO-3	40	BUX87		TO-126	20
BDY97		TO-3	40	2N3055		TO-3	115
BF419		TO-126	6	2N3442		TO-3	117
BF457		TO-126	6	2N4347		TO-3	117
BF458		TO-126	6				
BF459		TO-126	6				
BF469	BF470	TO-126	1,8				
BF471	BF472	TO-126	1,8				
BU126		TO-3	30				
BU133		TO-3	30				
BU204		TO-3	10				
BU205		TO-3	10				
BU206		TO-3	10				

HIGH-VOLTAGE TRANSISTORS

video output - deflection - SMPS

I_C A	case	pol.	collector-emitter voltage (open base) = V_{CEO} (V)								
			160	250	300	375	400	450	600	700	800
10	TO-3	N					BUX80	BUX81			
6	TO-3	N				BU326	BU326A				
	SOT-93	N				BU426	BU426A				
	SOT-93	N				BU433					
	TO-3	N					BUX82	BUX83			
5	TO-3	N							BU207A	BU208A	
4	TO-3	N									BU209A
2,5	TO-3	N							BU204	BU205	BU206
2	SOT-82	N					BUW84	BUW85			
	TO-220	N					BUX84	BUX85			
0,5	TO-126	N					BUX86	BUX87			
0,1	TO-126	N		BF419							
	TO-126	N	BF457	BF458	BF459						
0,05	TO-126	N		BF469	BF471*						
	TO-126	P		BF470	BF472*						

* V_{CER}.

LOW-VOLTAGE TRANSISTORS

audio - general purpose - switching

I_C A	case	pol.	collector-emitter voltage (open base) V_{CEO} (V)								
			20	22	32	45	60	80	100	120 V	remarks
16	TO-3	N					BDX67	BDX67A	BDX67B	BDX67C	Darlington
							BDX66	BDX66A	BDX66B	BDX66C	Darlington
12	SOT-93	N					BDV65	BDV65A	BDV65B		Darlington
		P					BDV64	BDV64A	BDV64B		Darlington
	TO-3	N					BDX65	BDX65A	BDX65B	BDX65C	Darlington
		P					BDX64	BDX64A	BDX64B	BDX64C	Darlington
10	TO-220	N					BDT63	BDT63A	BDT63B	BDT63C	
		P					BDT62	BDT62A	BDT62B	BDT62C	
	TO-220	N					BDT91	BDT93	BDT95		
		P					BDT92	BDT94	BDT96		
	TO-3	N					BDY92	BDY91	BDY90		
8	TO-220	N				BD201	BD203	BDX77			
		P				BD202	BD204	BDX78			
	TO-220	N					BD645	BD647	BD649	BD651	Darlington
		P					BD646	BD648	BD650	BD652	Darlington
	TO-3	N					BDX63	BDX63A	BDX63B	BDX63C	Darlington
		P					BDX62	BDX62A	BDX62B	BDX62C	Darlington
	TO-3	N					BDX91	BDX93	BDX95		
		P					BDX92	BDX94	BDX96		
6	SOT-82	N				BD291	BD293	BD295			
		P				BD292	BD294	BD296			
	SOT-82	N					BD331	BD333	BD335	BD337	Darlington
		P					BD332	BD334	BD336	BD338	Darlington

LOW-VOLTAGE TRANSISTORS

audio - general purpose - switching

I_C A	case	pol.	collector-emitter voltage (open base) V_{CEO} (V)								remarks
			20	22	32	45	60	80	100	120 V	
5	TO-220	N		BD943	BD945	BD947	BD949	BD951	BD953	BD955	
		P		BD944	BD946	BD948	BD950	BD952	BD954	BD956	
	TO-126	N					BDX35	BDX37			
		N					BDX36				
4	TO-126	N		BD433	BD435	BD437					
		P		BD434	BD436	BD438					
	TO-126	N				BD675	BD677	BD679	BD681	BD683	Darlington
		P				BD676	BD678	BD680	BD682	BD684	Darlington
3	TO-126	N				BD131					
		P				BD132					
	TO-126	N	BD329								
		P	BD330								
	TO-220	N				BD933	BD935	BD937	BD939	BD941	
		P				BD934	BD936	BD938	BD940	BD942	
2	TO-126	N				BD233	BD235	BD237			
		P				BD234	BD236	BD238			
1,5	TO-126	N				BD226	BD228	BD230			
		P				BD227	BD229	BD231			
1	TO-126	N				BD135	BD137	BD139			
		P				BD136	BD138	BD140			
	TO-126	N				BDX42	BDX43	BDX44			
		P				BDX45	BDX46	BDX47			

TO-126 (SOT-32)

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

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
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	BD936		60
BD937	BD938		80
BD939	BD940		100
BD943	BD944	40	22
BD945	BD946		32
BD947	BD948		45
BD949	BD950		60
BD951	BD952		80
BD953	BD954		100
BUX84		40	400
BUX85			450
BD201	BD202	60	45
BD203	BD204		60
BDX77	BDX78		80
BD645	BD646	62,5	60
BD647	BD648		80
BD649	BD650		100
BD651	BD652		120

TO-220 (SOT-78) continued

type number NPN	type number PNP	P_{tot} W	V_{CEO} V
BDT91	BDT92	90	60
BDT93	BDT94		80
BDT95	BDT96		100
BDT63	BDT62	90	60
BDT63A	BDT62A		80
BDT63B	BDT62B		100
BDT63C	BDT62C		120

SOT-93

type number NPN	type number PNP	P_{tot} W	V_{CEO} V
BU426		70	375
BU426A			400
BU433			375
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
BU204		10	600
BU205			700
BU206			800
BU207A		12,5	600
BU209A			800
BDY90		40	100
BDY91			80
BDY92			60
BU326		60	375
BU326A			400
BUX82		60	400
BUX83			450
BU208A		80	700
BDX63	BDX62	90	60
BDX63A	BDX62A		80
BDX63B	BDX62B		100
BDX63C	BDX62C		120
BUX80		100	400
BUX81			450
BDX65	BDX64	117	60
BDX65A	BDX64A		80
BDX65B	BDX64B		100
BDX65C	BDX64C		120
BDX67	BDX66	150	60
BDX67A	BDX66A		80
BDX67B	BDX66B		100
BDX67C	BDX66C		120

TYPE NUMBER SURVEY ACCESSORIES

type number	description	envelope
56201c	insulating bushes (up to 500 V)	TO-3
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	SOT-32
56333	metal washer mica washer insulating bush	SOT-32
56339	mica washer (500 to 2000 V)	TO-3
56352	insulating mounting support	
56353	spring clip	SOT-32/SOT-82
56354	mica insulator	SOT-32/SOT-82
56359b	mica washer (up to 800 V)	TO-220
56359c	insulating bush (up to 800 V)	TO-220
56359d	rectangular insulating washer (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	TO-220
56368a	mica insulator	SOT-93
56368b	insulating bush	SOT-93
56369	mica insulator (up to 2 kV)	TO-220
56378	mica insulator	SOT-93
56379	spring clip	SOT-93

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	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	←	56333	→	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	56201c; 56201j or 56261a		M3
up to 2000 V			56339	56352		M3

The accessories mentioned can be supplied on request.

See also chapter Mounting Instructions.

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 ($R_{th\ j\text{-}mb} > 15\ ^oC/W$)
D. TRANSISTOR; power, audio frequency ($R_{th\ j\text{-}mb} \leqslant 15\ ^oC/W$)
E. DIODE; tunnel
F. TRANSISTOR; low power, high frequency ($R_{th\ j\text{-}mb} > 15\ ^oC/W$)
G. MULTIPLE OF DISSIMILAR DEVICES — MISCELLANEOUS; e.g. oscillator
H. DIODE; magnetic sensitive
L. TRANSISTOR; power, high frequency ($R_{th\ j\text{-}mb} \leqslant 15\ ^oC/W$)
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 ($R_{th\ j\text{-}mb} > 15\ ^oC/W$)
S. TRANSISTOR; low power, switching ($R_{th\ j\text{-}mb} > 15\ ^oC/W$)
T. CONTROL AND SWITCHING DEVICE; e.g. thyristor, power ($R_{th\ j\text{-}mb} \leqslant 15\ ^oC/W$)
U. TRANSISTOR; power, switching ($R_{th\ j\text{-}mb} \leqslant 15\ ^oC/W$)
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.

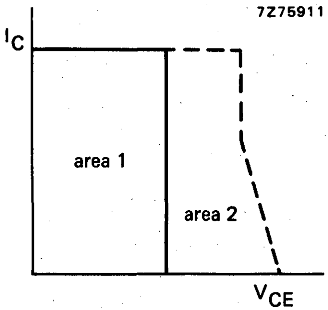


Fig. 1.

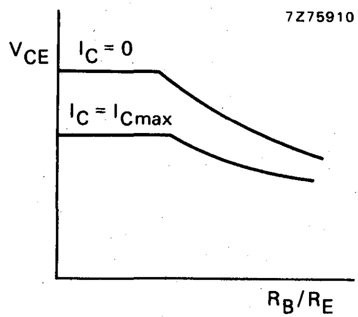


Fig. 2.

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.

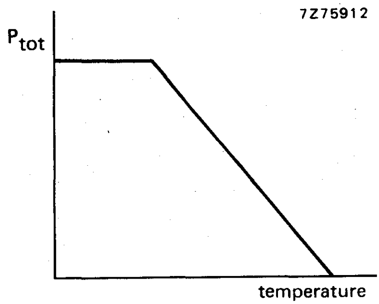


Fig. 3.

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.

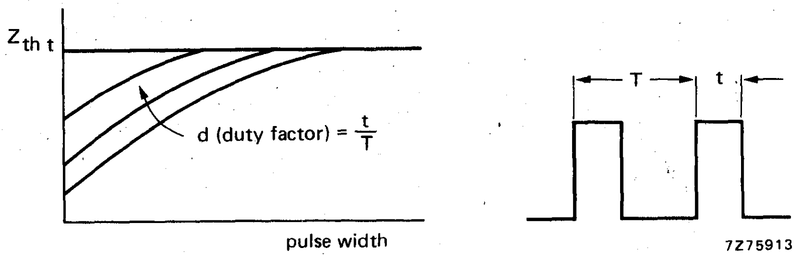


Fig. 4.

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.

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

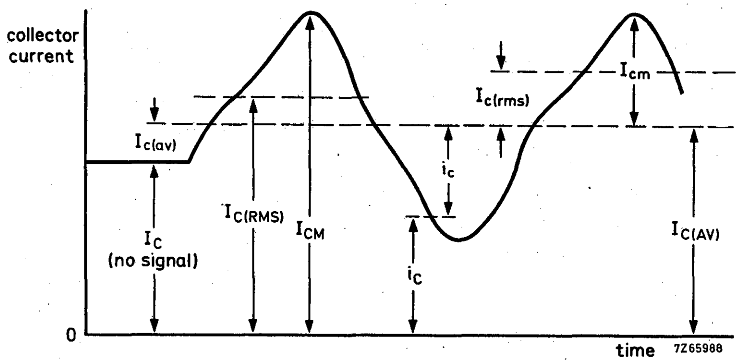
For multiple unit devices, the subscripts are modified by a number preceding the letter subscript; in the case of multiple subscripts, hyphens may be necessary to avoid misunderstanding.

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}

SAFE OPERATING AREA CURVES

1. D.C. SOAR

The d.c. safe operating area (SOAR) of a transistor is limited on the current axis by $I_{C\,max}$ and on the voltage axis by V_{CEOmax}. Intersecting these two is a third limit defined by $P_{tot\,max}$. These limits can be superimposed on the normal I_C-V_{CE} curve as in Fig. 1, but are better shown on a double logarithmic scale as in Fig. 2; the $P_{tot\,max}$ limit then appears as a straight line at 45° to the axes:

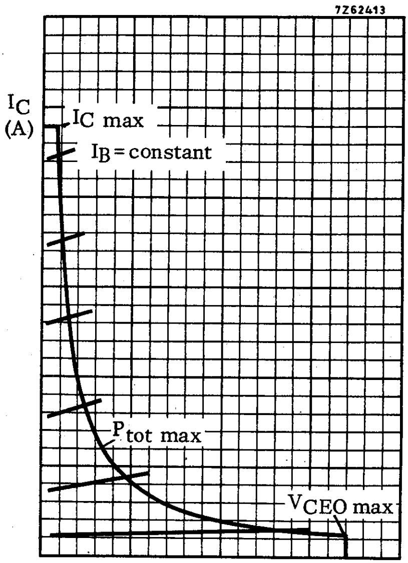


Fig. 1

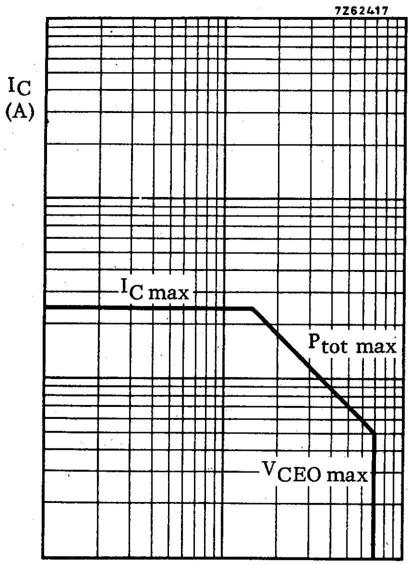


Fig. 2. D.C. SOAR curve

For steady state conditions there is a linear relation between the power dissipated at the junction and the temperature difference between junction and mounting base:

$$T_j - T_{mb} = C \cdot P_{tot},$$

where $C = R_{th\,j\text{-}mb}$, i.e. the thermal resistance from junction to mounting base.

$$T_j - T_{mb} = P_{tot} \cdot R_{th\,j\text{-}mb} \tag{1}$$

In terms of maximum allowable junction temperature eq. (1) can be written as:

$$T_{j\,max} - T_{mb} = P_{tot\,max} \cdot R_{th\,j\text{-}mb} \tag{1a}$$

The data sheets give an upper limit for $P_{tot\ max}$ which applies up to a temperature T_1. These relations are shown in Fig. 3 where the upper limit for $P_{tot\ max}$ has been chosen as 100%.

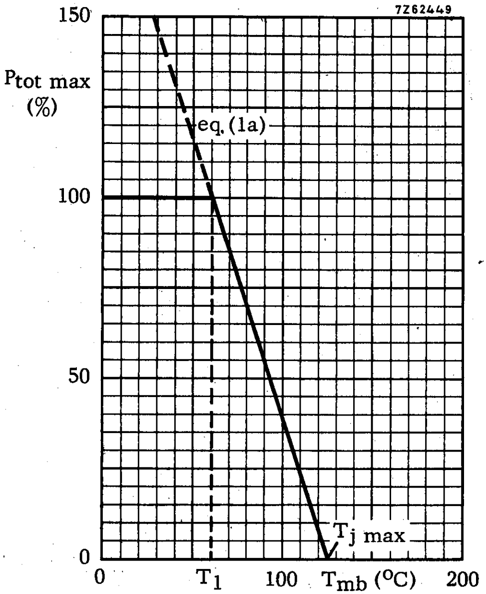


Fig. 3

So far we have discussed only d.c. conditions; it will be obvious that under pulse conditions a higher $P_{tot\ max}$ can be permitted.

2. Extension of the SOAR for pulse power

When pulse power is applied to a transistor the junction temperature will rise in a series of steps until a steady state condition is reached. See Fig. 4.
For this steady state, eq. (1) can be modified to:

$$T_{j\ peak} - T_{mb} = P_{peak} \cdot Z_{th\ j\text{-}mb} \tag{2}$$

where $Z_{th\ j\text{-}mb}$ is the transient thermal impedance from junction to mounting base and is dependent not only on $R_{th\ j\text{-}mb}$, but also on pulse width (t_p) and period (T). $Z_{th\ j\text{-}mb}$ is generally published in the form of Fig. 5.

In terms of maximum allowable junction temperature eq. (2) can be written as:

$$T_{j\ max} - T_{mb} = P_{peak\ max} \cdot Z_{th\ j\text{-}mb} \tag{2a}$$

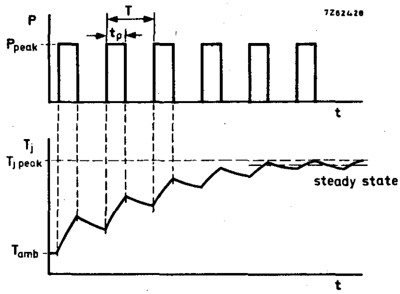


Fig. 4

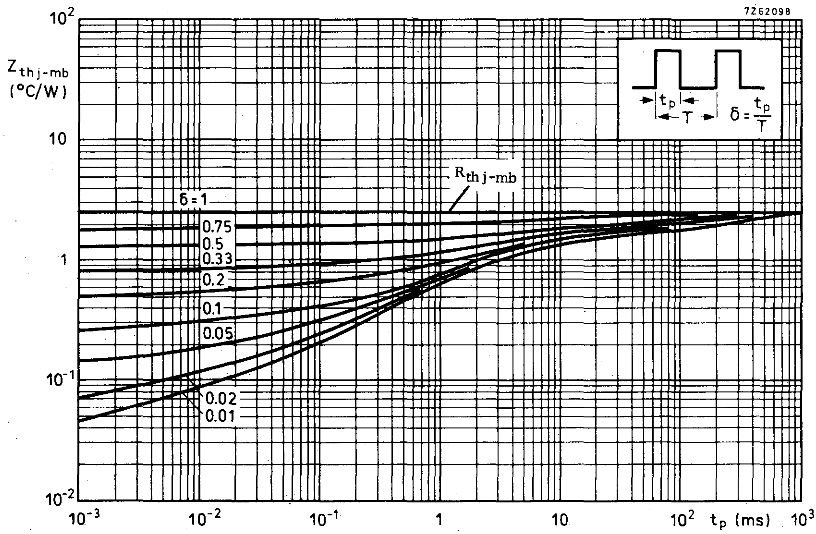


Fig. 5

Dividing eq. (2a) by eq. (1a), leads to:

$$P_{peak\ max} = P_{tot\ max} \frac{R_{th\ j\text{-}mb}}{Z_{th\ j\text{-}mb}} = P_{tot\ max} \cdot M_p. \tag{3}$$

This means that the $P_{tot\,max}$ curve can be shifted by the factor M_p, see the sloping part of the thick dashed line of Fig. 6. M_p is known as the 'power multiplying factor'.
The horizontal part of the dashed line of Fig. 6 is the rating I_{CMmax}; it is the upper limit of the SOAR for pulse conditions.
In addition to the limits set by the SOAR the average current $I_{C(AV)}$ with an averaging time t_{av} of 50 ms should not exceed the maximum permissible d.c. current I_{Cmax}.
Averaging is not necessary when SOAR limits lower than the rated I_{CMmax} are indicated for different pulse durations.

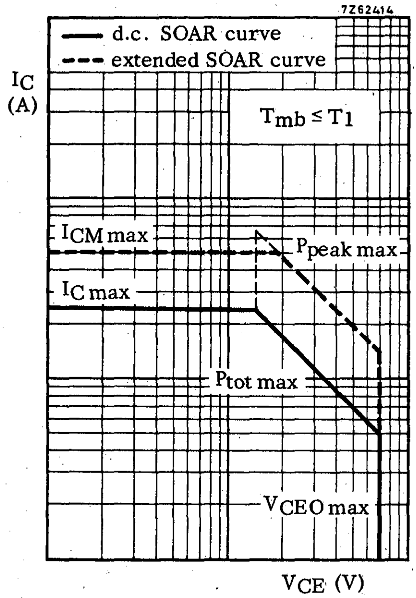


Fig. 6

3. Second Breakdown

3.1 The phenomenon

Primary breakdown is a sudden increase in I_C as a result of avalanche action within the crystal. If the collector current is increased further a critical condition can be reached at which the voltage across the crystal drops to a very low level. This phenomenon is known as second breakdown. It is initiated by a current concentration that leads to local heating within the crystal. The higher the voltage (before second breakdown) the lower the power at which the concentration occurs. If a single point on the crystal exceeds $T_{j\ max}$, the transistor characteristics may be permanently affected; further current concentration will lead to increased temperature and consequent second breakdown, which will destroy the transistor.

The SOAR curve must define an area that only precludes second breakdown but also the current concentration that precedes it.

3.2 Second breakdown and the d.c. SOAR

A transistor's susceptibility to second breakdown is investigated by d.c. loading up to current concentration. With different combinations of I_C and V_{CE}, points are plotted at which current concentration is observed. A limit is then defined that precludes current concentration. This line lowers the original SOAR curve (see Fig. 7). The final d.c. SOAR curve is that shown in Fig. 8. In general the second breakdown limit is independent of the mounting base temperature

The thermal resistance $R_{th\ j\text{-}mb}$ is guaranteed for all I_C-V_{CE} combinations within the d.c. SOAR.

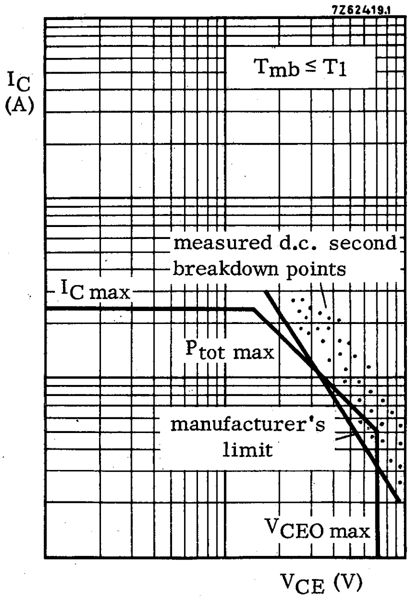


Fig. 7

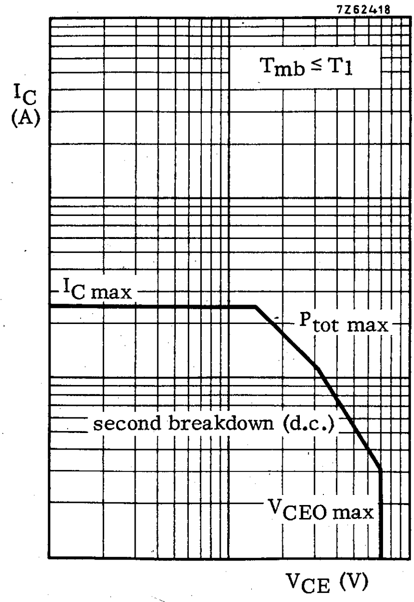


Fig. 8

3.3 Fixing the second breakdown line for pulses, in the SOAR curve

In section 3.1 it was suggested that second breakdown occurs when a single point of the junction (crystal) reaches a critical temperature. It is really the thermal conditions in the crystal itself that determine the point of second breakdown - the thermal resistance ($R_{th\ crystal}$) and the thermal impedance ($Z_{th\ crystal}$) between the hottest part of the crystal and the rest. $Z_{th\ crystal}$ is dependent on $R_{th\ crystal}$, δ, t_p, and the relation I_C-V_{CE}.

As with M_p, a multiplying factor M can be derived to fix the second breakdown line for pulse conditions. However, for second breakdown two multiplying factors are given; M_V is the voltage multiplying factor at the I_{Cmax} level: M_I is the current multiplying factor at the $V_{CEO\ max}$ level.*

Knowing δ and t_p, one can find M_V and M_I from two curves published in the data sheets, Figs 9a and 9b being examples. The voltage value at which the d.c. second breakdown line intersects the $I_{C\ max}$ line is then multiplied by M_V. In Fig. 10 the d.c. intersection is shown as point C, and a new intersection for specific pulse conditions as point C'. In the same way M_I is used to find D' from D, which is the point at which the d.c. second breakdown line intersects the $V_{CEO\ max}$ line. The line that passes through C' and D' defines the second breakdown limit for given values of δ and t_p.

* As decided in 1973, $M_{SB(V)}$ is now replaced by M_I and $M_{SB(I)}$ by M_V. The definitions are unaltered. Most of the graphs in the book have been changed, the remainder will be corrected at the first opportunity.

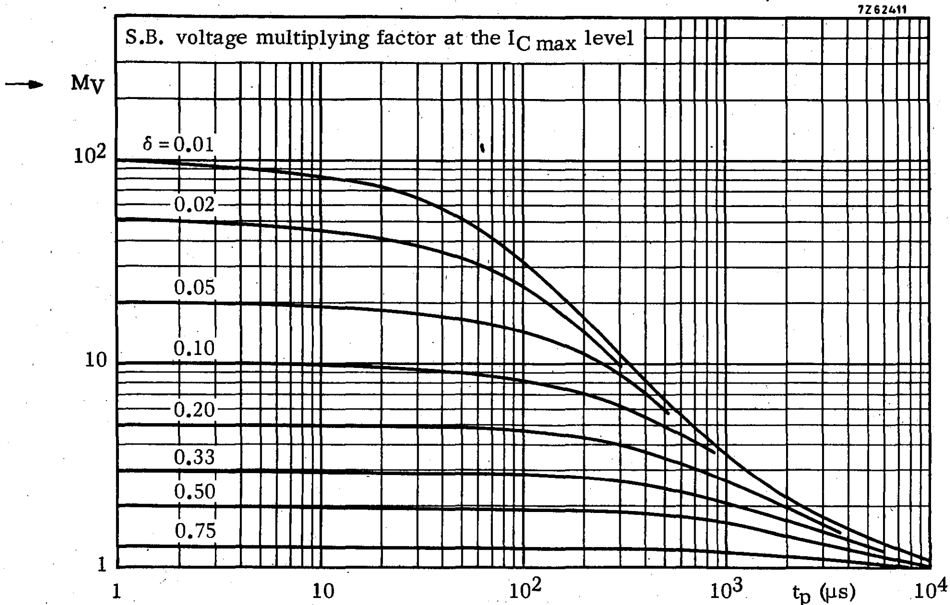

7Z62411
S.B. voltage multiplying factor at the $I_{C\,max}$ level
M_V
$\delta = 0.01$
0.02
0.05
0.10
0.20
0.33
0.50
0.75
10^2
10
1
1
10
10^2
10^3
t_p (μs)
10^4

Fig. 9a

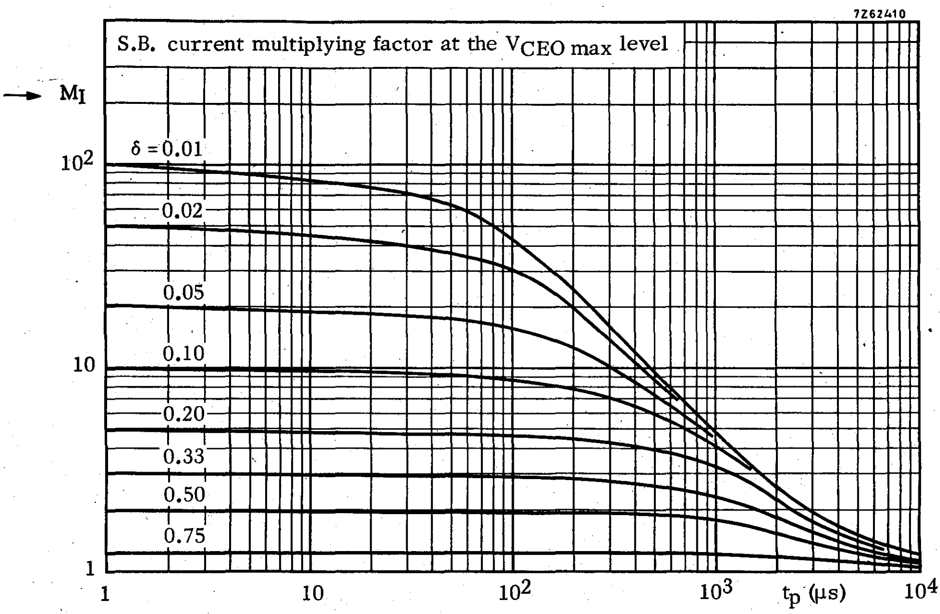

7Z62410
S.B. current multiplying factor at the $V_{CEO\,max}$ level
M_I
$\delta = 0.01$
0.02
0.05
0.10
0.20
0.33
0.50
0.75
10^2
10
1
1
10
10^2
10^3
t_p (μs)
10^4

Fig. 9b

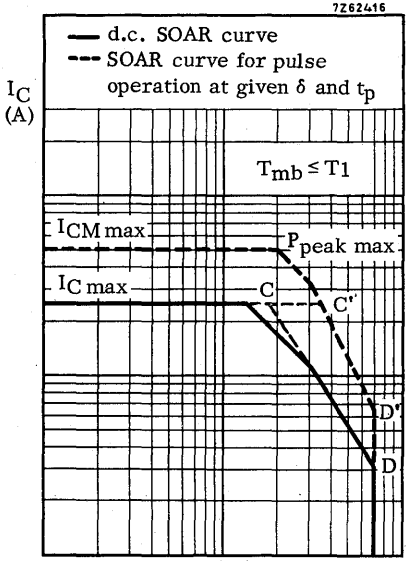


Fig. 10 V_{CE} (V)

A transistor can be safely operated under pulse conditions within the area bounded by I_{CMmax}, $P_{peak\,max}$, pulse SB limit, and V_{CEOmax}, provided the mounting base temperature does not exceed T_1. If the mounting base temperature does exceed T_1, M_p must be reduced by a factor derived from Fig. 3 (see section 1) but M need not be changed.

The SOAR curve for one specific duty cycle (δ) is given in the data sheets, but with the aid of curves Z_{th}, M_V, M_I and the d.c. SOAR, a pulse condition SOAR can be constructed for any duty factor.

4. Example of how to use the published SOAR information

4.1 Statement of the problem

The driver- and output-stage of an audio amplifier are given in Fig. 11. We shall investigate whether the driver transistor TR3 operates safely under worst case conditions.

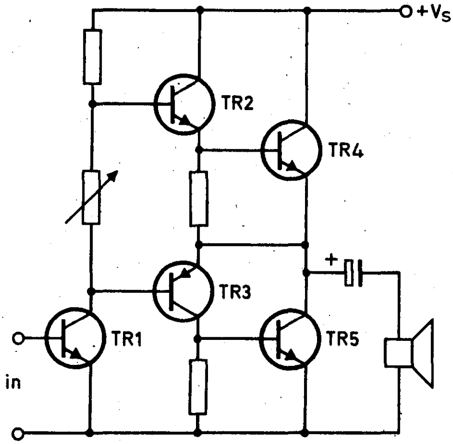


Fig. 11

The loudspeaker impedance is such that worst case conditions occur when the amplifier is overdriven by about 20 times the input signal necessary for full output power at a frequency of 750 Hz. Fig. 12 gives V_{CE} and I_C of TR3 under these conditions. The mounting base temperature of TR3 under these conditions is found to be 85 ^{o}C.

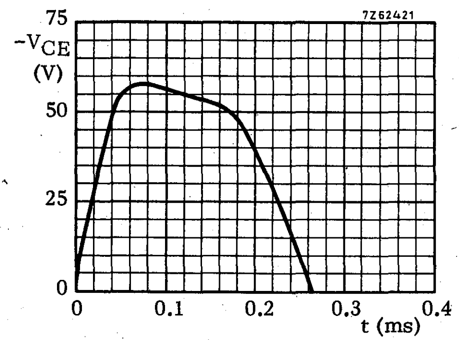


Fig. 12a

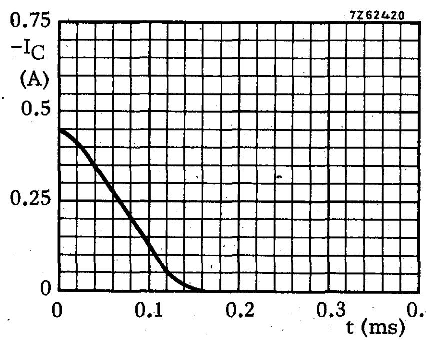


Fig. 12b

4.2 Information obtained from the published data of TR3

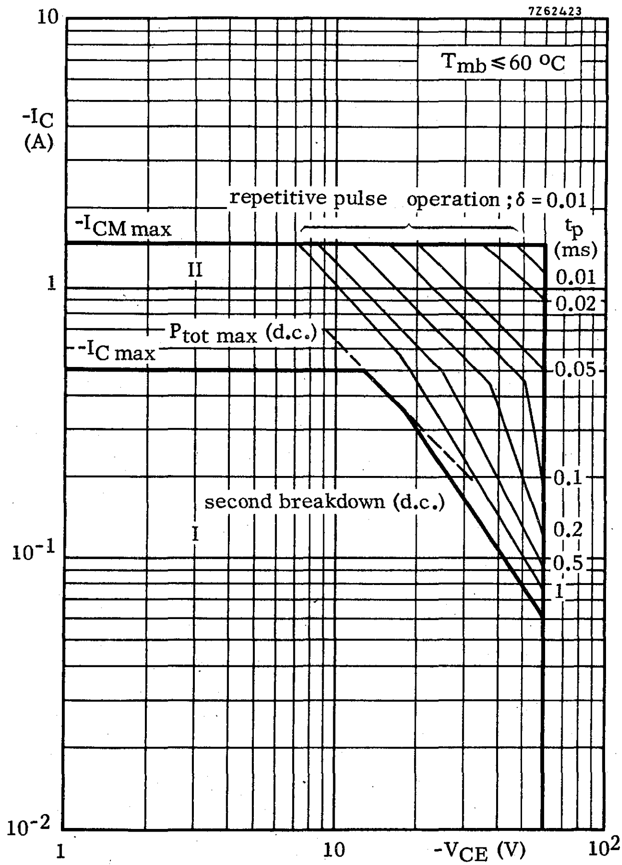


Fig. 13. Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation.

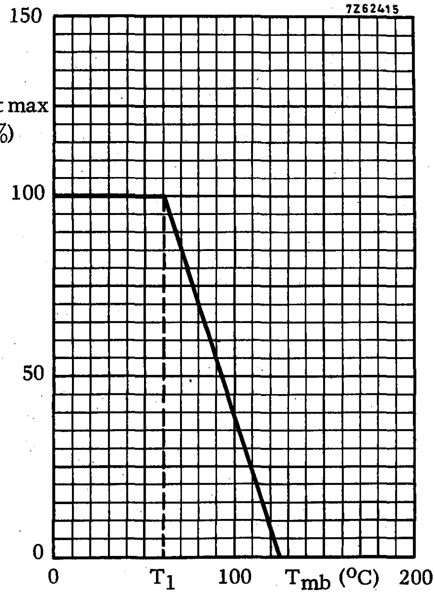


Fig. 14

$T_{j\,max}$ = 125 °C

$R_{th\,j\text{-}mb}$ = 10 °C/W

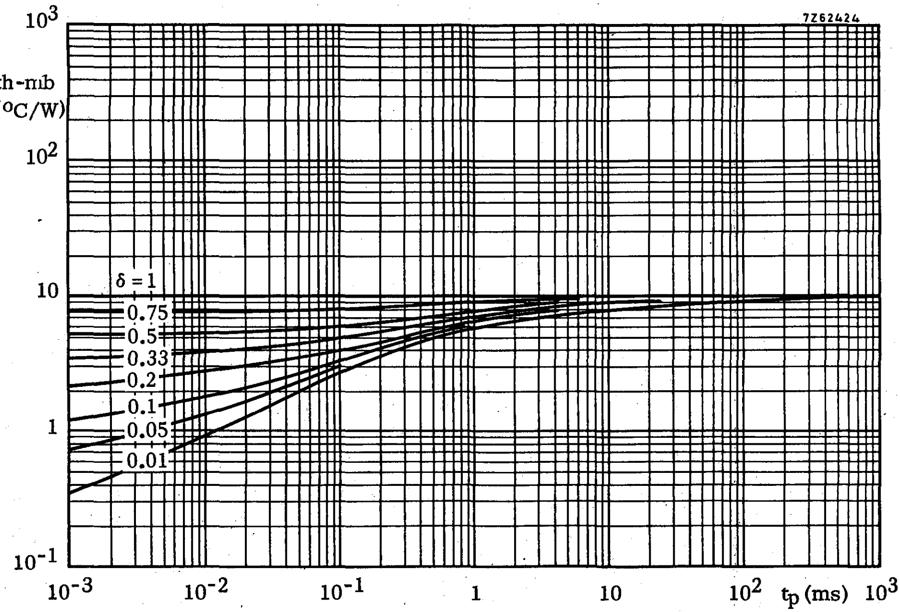


Fig. 15

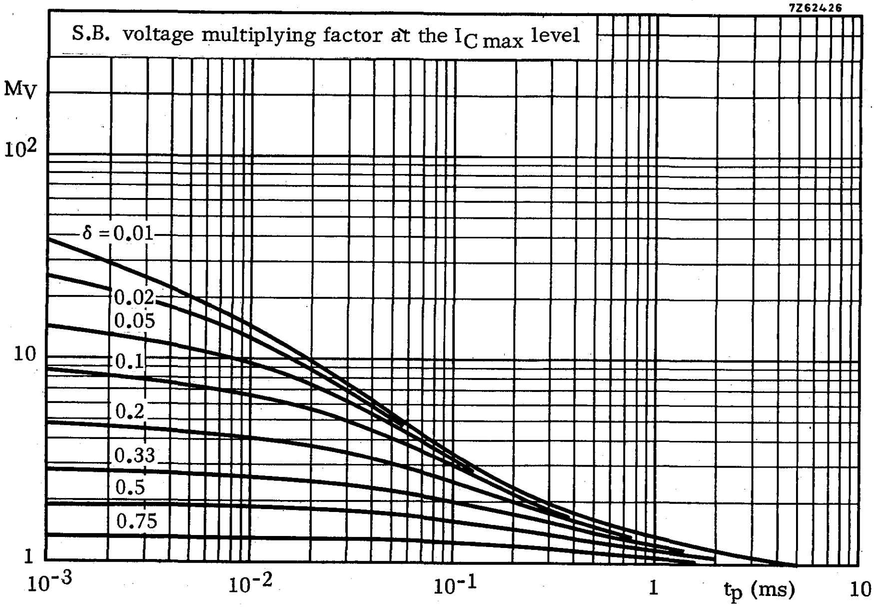

7Z62426
S.B. voltage multiplying factor at the $I_{C\,max}$ level
M_V
10^2
10
1
$\delta = 0.01$
0.02
0.05
0.1
0.2
0.33
0.5
0.75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10

Fig. 16

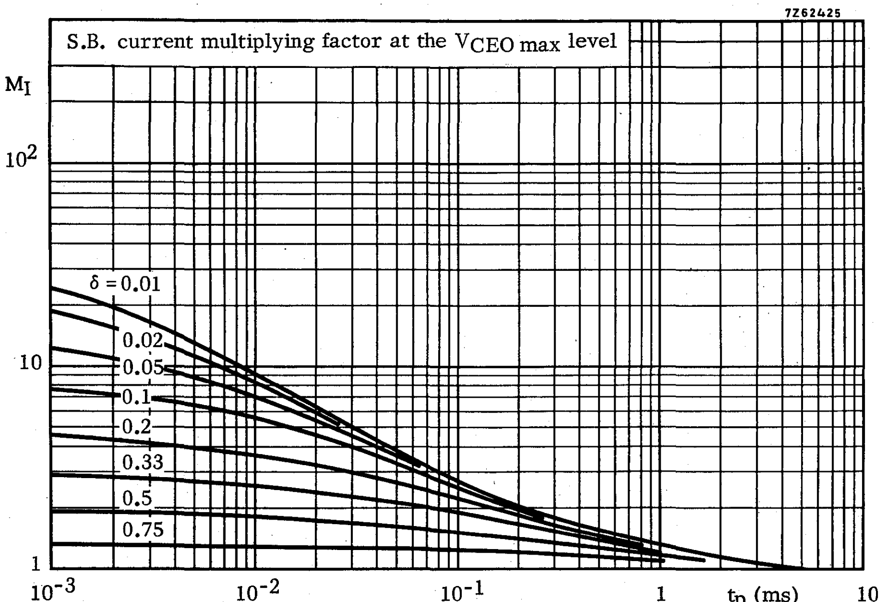

7Z62425
S.B. current multiplying factor at the $V_{CEO\,max}$ level
M_I
10^2
10
1
$\delta = 0.01$
0.02
0.05
0.1
0.2
0.33
0.5
0.75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10

Fig. 17

4.3 Construction of the pulse SOAR of TR3 in this application

4.3.1

Plot the power curve obtained by multiplying the two curves of Fig. 12 and construct an equivalent rectangular power pulse with the same peak value and area as the original pulse. The result is given in Fig. 18.

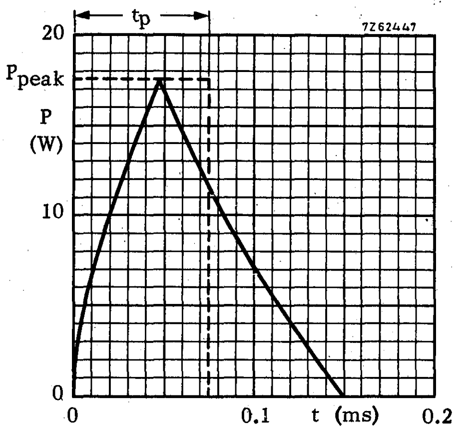


Fig. 18

4.3.2

Ascertain t_p, T, $\delta = t_p/T$ and P peak. The results are:

$t_p = 75\ \mu s$

$T = \frac{1}{750} = 1.33$ ms

$\delta = 0.056$

$P_{peak} = 17.5$ W

4.3.3

Refer to Fig. 14 and determine the derating factor for $P_{tot\ max}$ at 85 °C. The result is 0.6.

Refer to Fig. 15 and determine $M_p = \frac{R_{th\ j\text{-}mb}}{Z_{th\ j\text{-}mb}}$ for $t_p = 75\ \mu s$ and $\delta = 0.056$.

$R_{th\ j\text{-}mb} = 10\ ^oC/W$
$Z_{th\ j\text{-}mb} = 2.75\ ^oC/W$

$M_p = \frac{10}{2.75} = 3.64$

4.3.4

Refer to Fig. 16 and 17. and ascertain the M_{SB} factors for t_p = 75 μs and δ = 0.056. The results are:

$M_V = 3.6$

$M_I = 2.8$

4.3.5

Refer to Fig. 13. and construct the pulse extension of the d.c. SOAR for t_p = 75 μs and δ = 0.056 according to the following rules (see Fig. 19).

- Multiply the value of the voltage at point A by the derating factor obtained from Fig. 14 (0.6) and by M_p = 3.64 to obtain A'.
  $V_A = 13$ V

  $V_A' = 13 \text{ V} \times 0.6 \times 3.64 = 28.4$ V
- Through point A' construct a line of constant power (45°)

  $P_{peak\ max} = 28.4 \times I_{C\ max} = 14.2$ W.
- Multiply the value of V_{CE} at point C by M_V = 3.6 (see 4.3.4), to obtain C'.
- Multiply the value of I_C at point D by M_I = 2.8 (see 4.3.4), to obtain D'.
- Construct a new limit for second breakdown by drawing a line through point C' and D'.
- The SOAR for this particular case is formed by the $I_{CM\ max}$ line, the maximum peak dissipation line through A', the second breakdown limit line C'- D' and the V_{CEO} line.

4.3.6

Plot the I_C - V_{CE} excursion as found from Fig. 12a and b in Fig. 19 and check if every point of this excursion is inside the SOAR.
In this particular example the $P_{peak\ max}$ limit is exceeded, while the SB-limit is not exceeded. A solution for this case is to decrease the mounting base temperature, T_{mb}, by enlarging the heatsink.

4.3.7

The new permissible mounting base temperature, $T_{mb\ max}$, can be calculated as follows

$$T_{mb\ max} = T_{j\ max} - P_{peak} \cdot Z_{th\ j\text{-}mb}$$

$$P_{peak} = 17.5 \text{ W (see 4.3.2)}$$

$$Z_{th\ j\text{-}mb} = 2.75\ ^{o}\text{C/W}$$

Therefore:

$$T_{mb\ max} = 125 - 17.5 \times 2.75 = 77\ ^{o}\text{C}$$

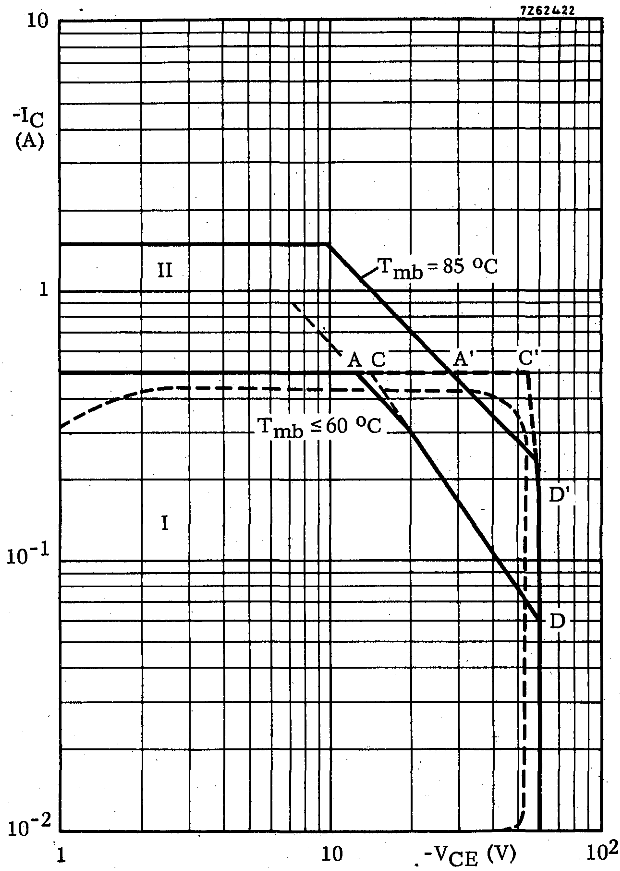


Fig. 19

I Region of permissible operation up to $T_{mb} = 60\ ^oC$

II Permissible extension for $t_p = 75\ \mu s$, $\delta = 0.056$ and $T_{mb} = 85\ ^oC$

4.3.8

For calculation of the heatsink the power may be averaged provided the period T does not exceed the thermal time constant of the transistor.

Then $T_{mb} - T_{amb} = \delta . P_{peak} . R_{th\ mb\text{-}a}$.

If $T_{mb\ max}$ and P_{peak} are known, the max. allowable $R_{th\ mb\text{-}a}$ may be calculated with

$$R_{th\ mb\text{-}a\ max} = \frac{T_{mb\ max} - T_{amb}}{\delta \ . \ P_{peak}}$$

In our example $R_{th\ mb\text{-}a\ max} = \dfrac{77 - 25}{0.056 \times 17.5} = 53\ ^{o}C/W$

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

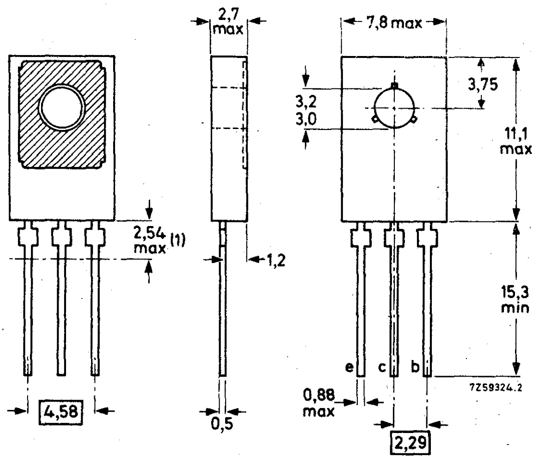
Collector-base voltage (open emitter)	V_{CBO}	max.	70	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	V
Collector current (peak value)	I_{CM}	max.	6	A
Total power dissipation up to T_{mb} = 60 °C	P_{tot}	max.	15	W
Junction temperature	T_j	max.	150	°C
D.C. current gain I_C = 0,5 A; V_{CE} = 12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

$T_j = 25\ ^oC$ 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; $T_j = 150\ ^oC$	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; $T_{amb} = 25\ ^oC$	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

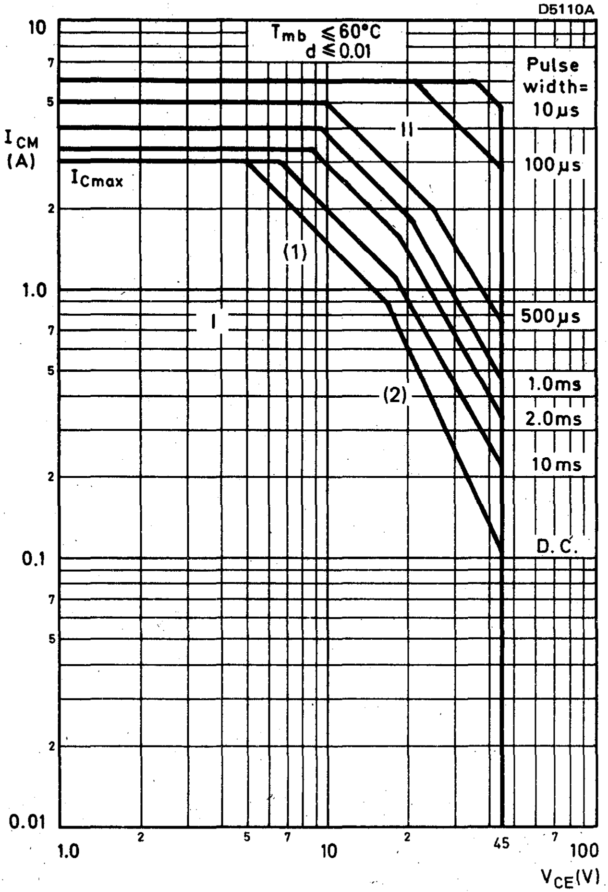


Fig. 2 Safe Operating ARea with the transistor forward biased.

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).

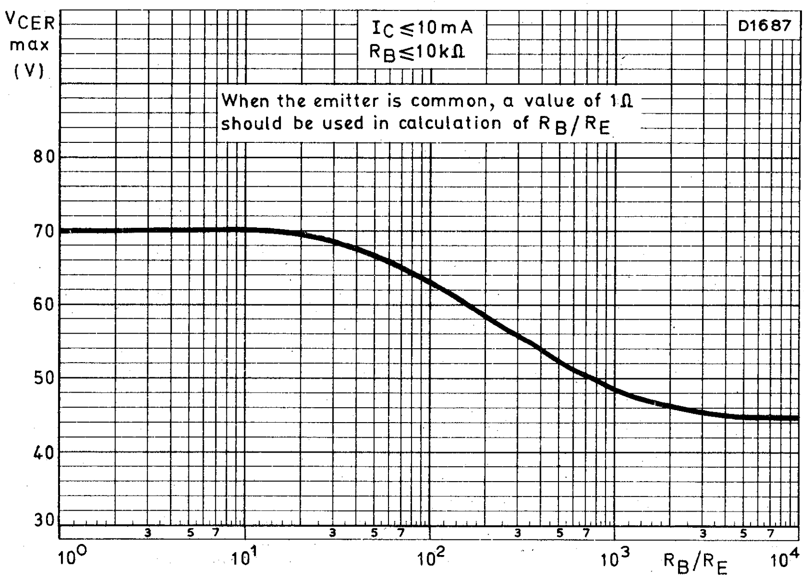


Fig. 3 Maximum allowable collector-emitter voltage as a function of base-emitter resistance.

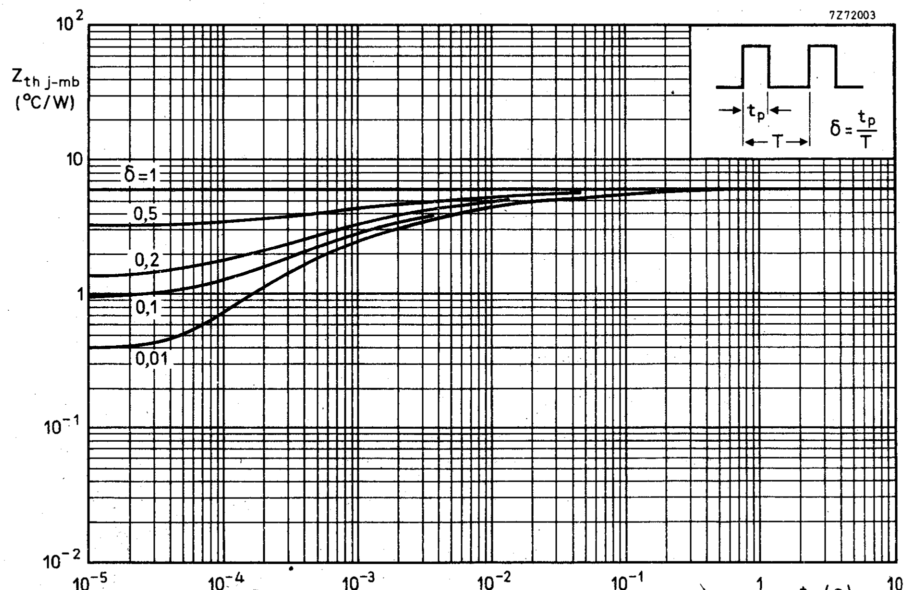


Fig. 4 Pulse power rating chart.

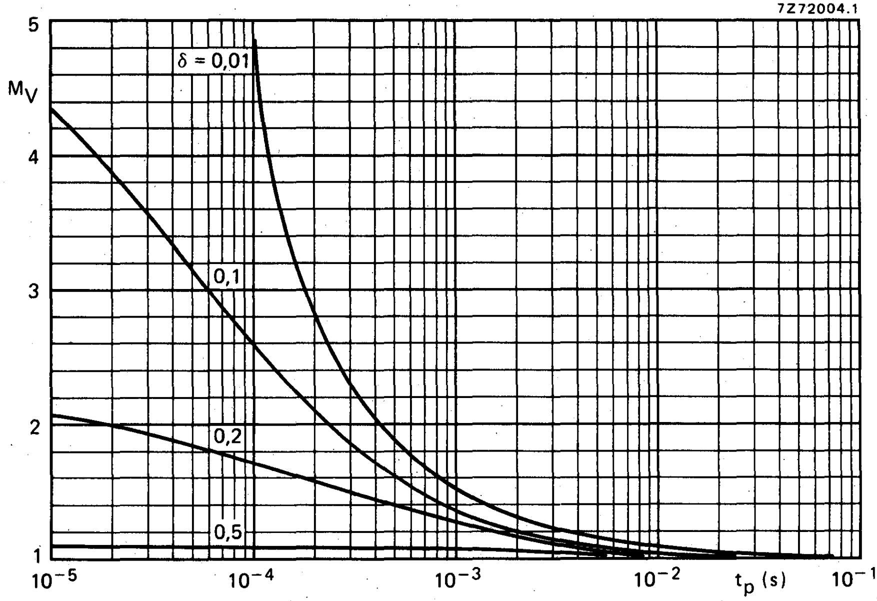


Fig. 5 S.B. voltage multiplying factor at the I_{Cmax} level.

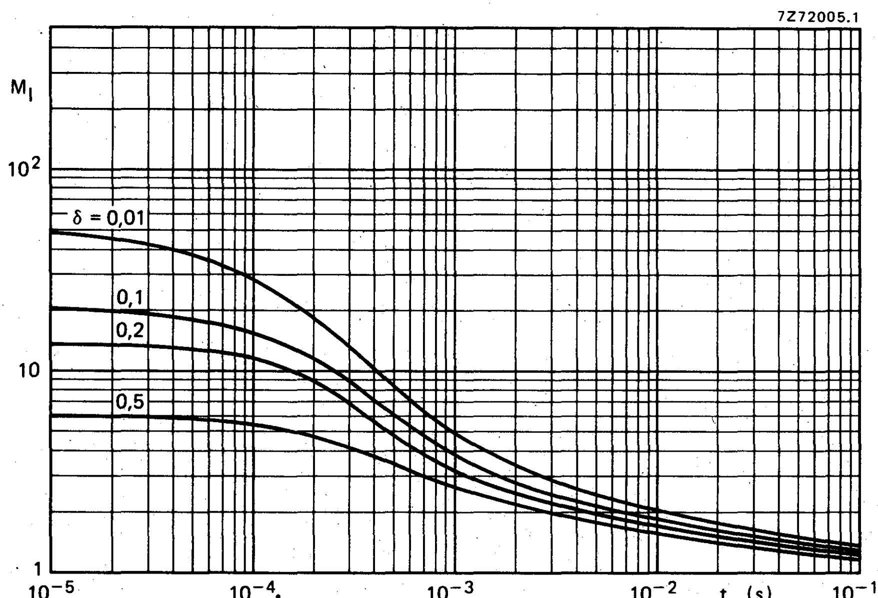


Fig. 6 S.B. current multiplying factor at the V_{CEOmax} level.

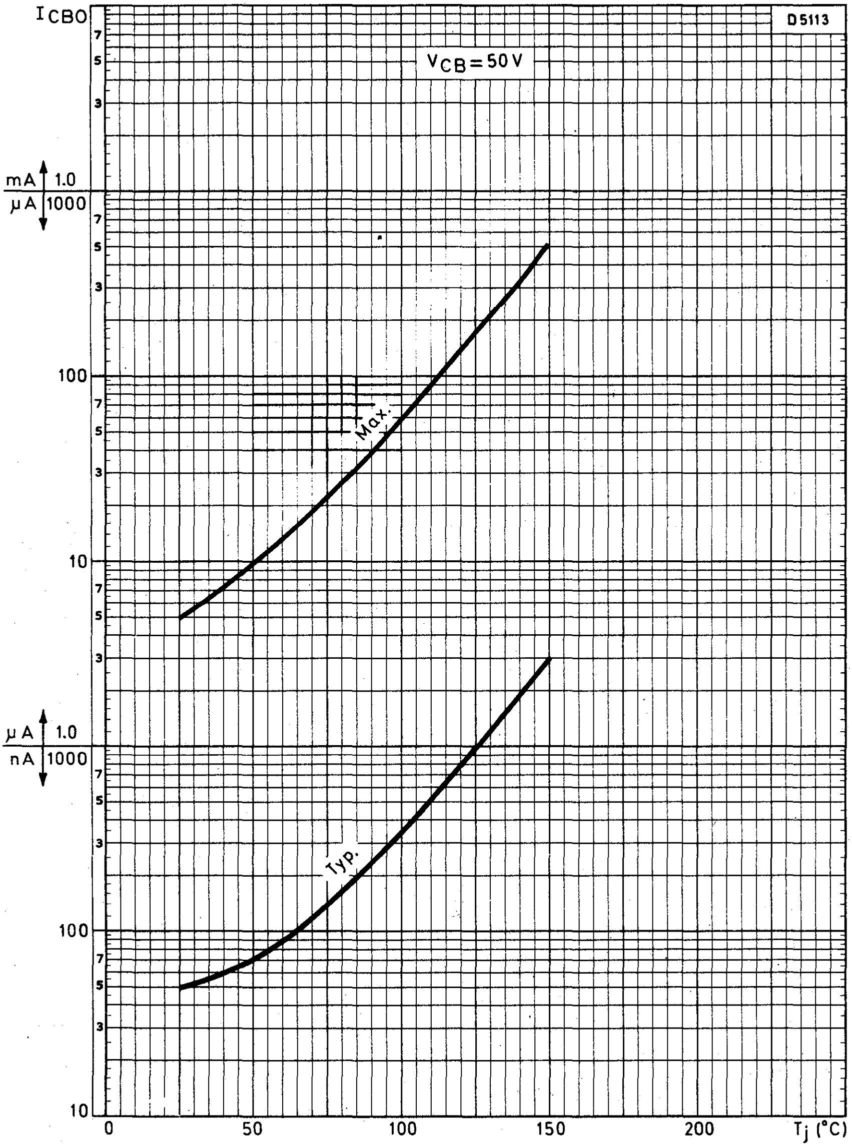


Fig. 7 Collector-base current (open emitter) as a function of the junction temperature.

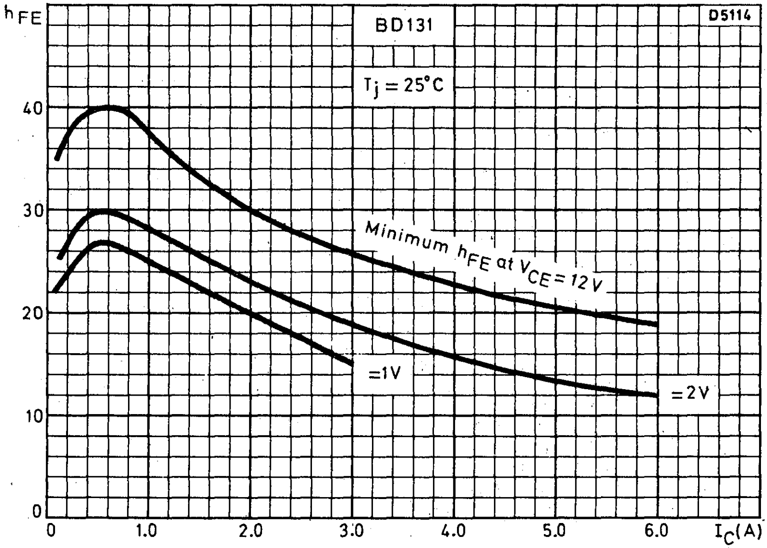

hFE
BD131
D5114
Tj = 25°C
40
30
20
10
0
Minimum hFE at VCE = 12 V
=1V
=2V
0
1.0
2.0
3.0
4.0
5.0
6.0
IC(A)

Fig. 8.

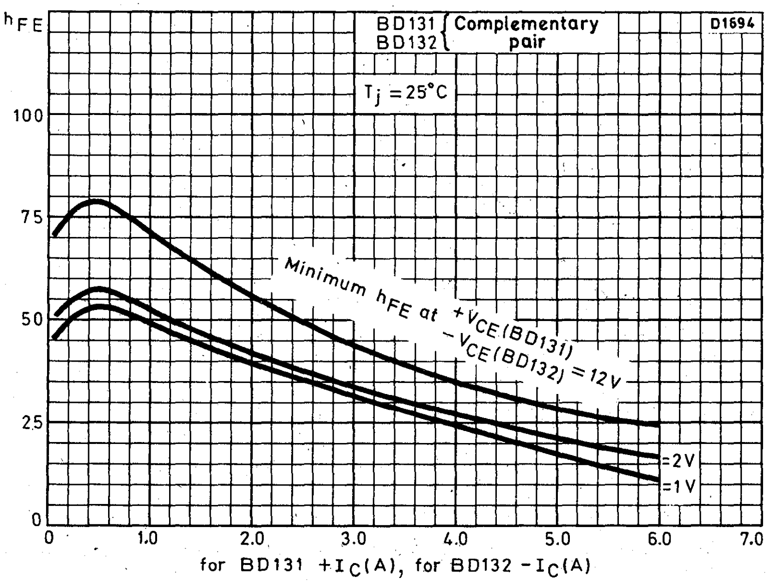

hFE
BD131 { Complementary
BD132 { pair
D1694
Tj = 25°C
100
75
50
25
0
Minimum hFE at +VCE(BD131)
−VCE(BD132) = 12 V
=2V
=1V
0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
for BD131 +IC(A), for BD132 −IC(A)

Fig. 9.

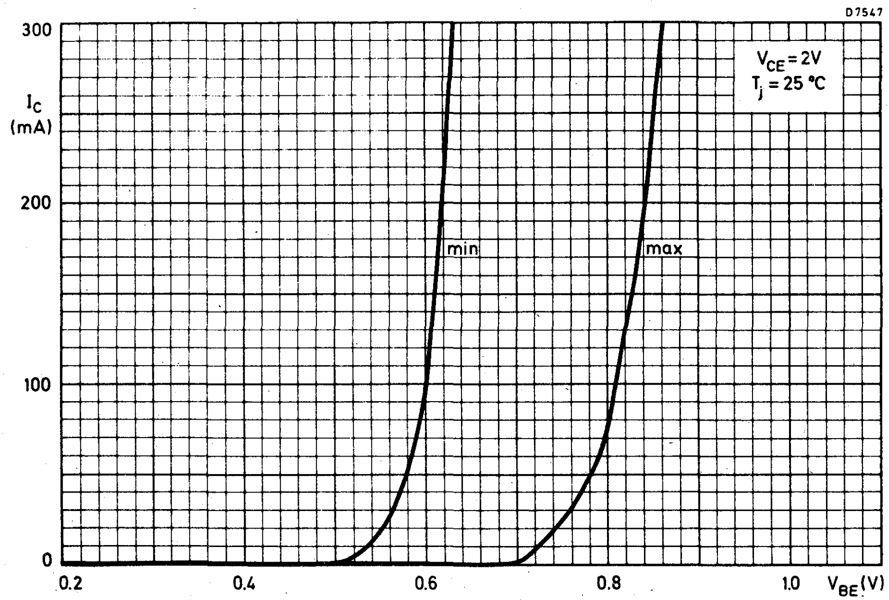

D7547
300
200
100
0
I_C (mA)
$V_{CE} = 2V$
$T_j = 25$ °C
min
max
0.2
0.4
0.6
0.8
1.0
V_{BE}(V)

Fig. 10.

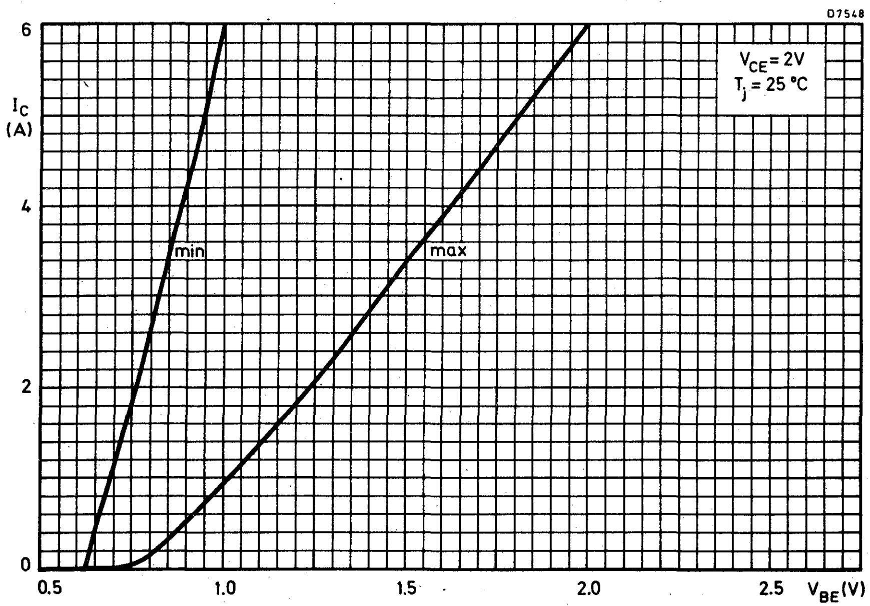

D7548
6
4
2
0
I_C (A)
$V_{CE} = 2V$
$T_j = 25$ °C
min
max
0.5
1.0
1.5
2.0
2.5
V_{BE}(V)

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

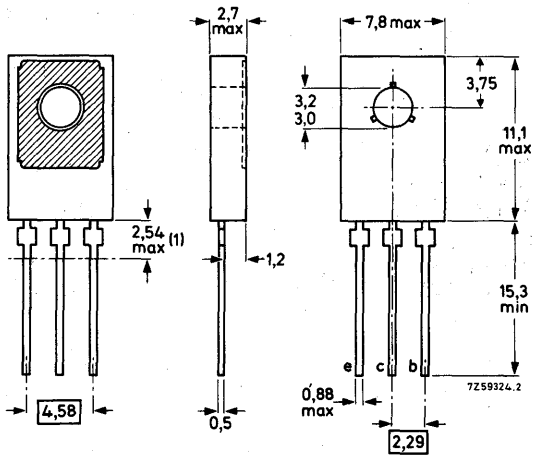
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	V
Collector current (peak value)	$-I_{CM}$	max.	6	A
Total power dissipation up to T_{mb} = 60 °C	P_{tot}	max.	15	W
Junction temperature	T_j	max.	150	°C
D.C. current gain $-I_C$ = 0,5 A;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

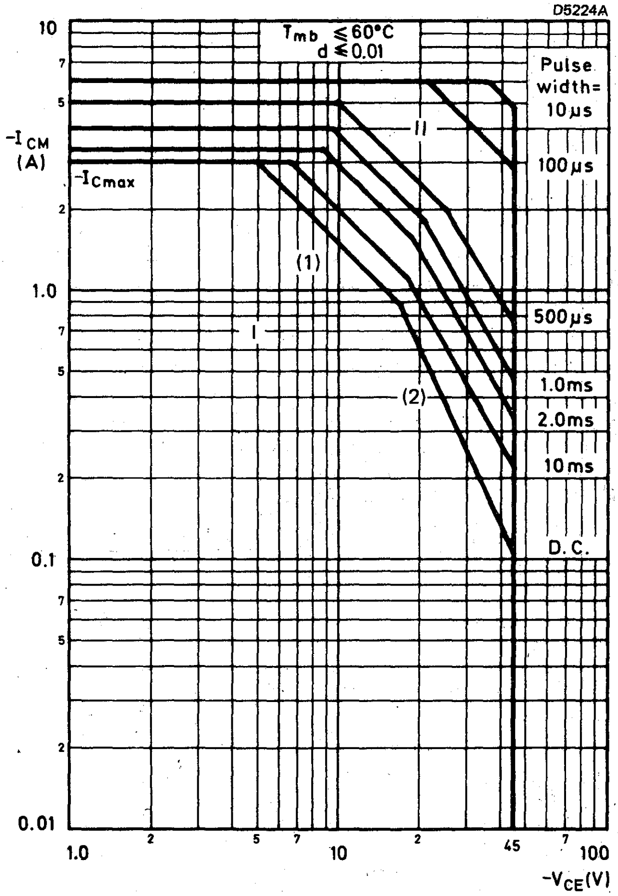


Fig. 2 Safe Operating ARea with the transistor forward biased.

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).

7Z72004.1

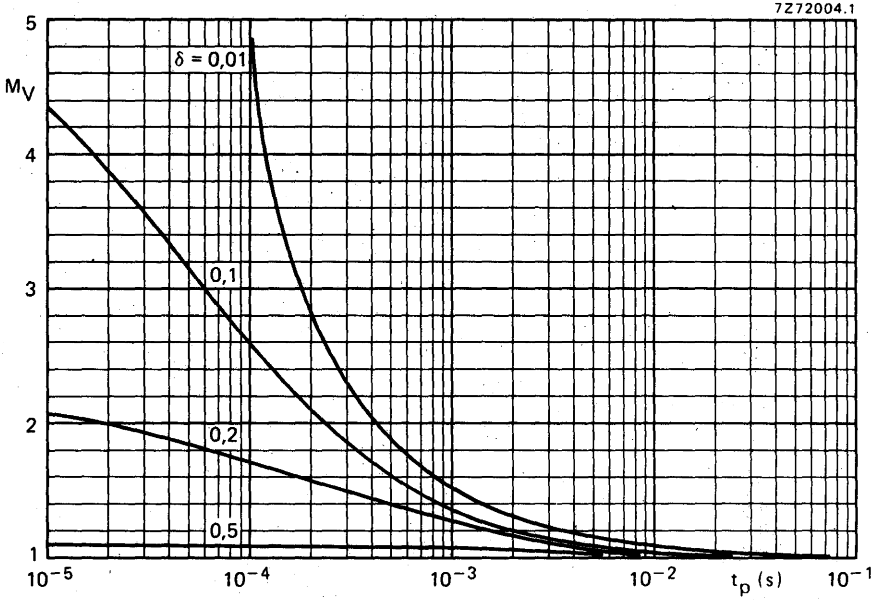


Fig. 3 S.B. voltage multiplying factor at the $-I_{Cmax}$ level.

7Z72005.1

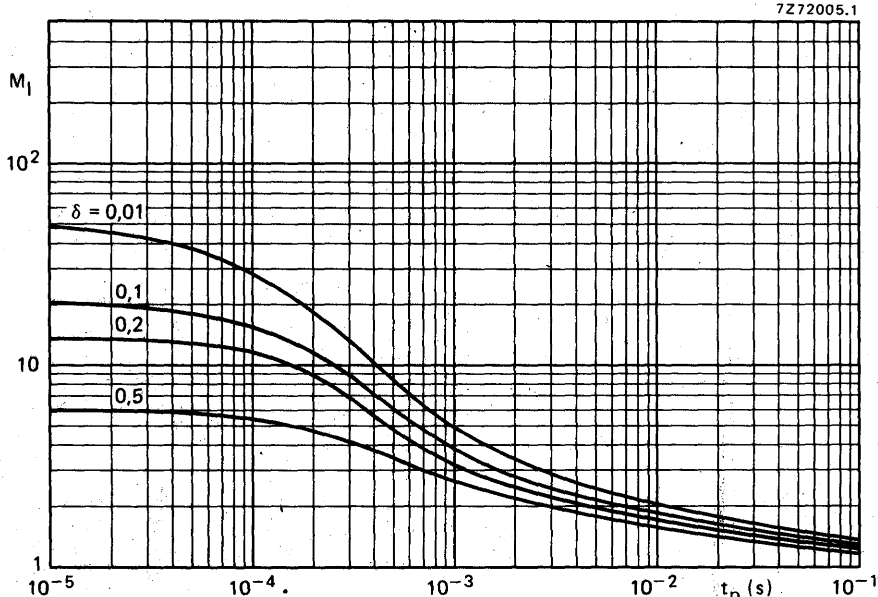


Fig. 4 S.B. current multiplying factor at the $-V_{CEOmax}$ level.

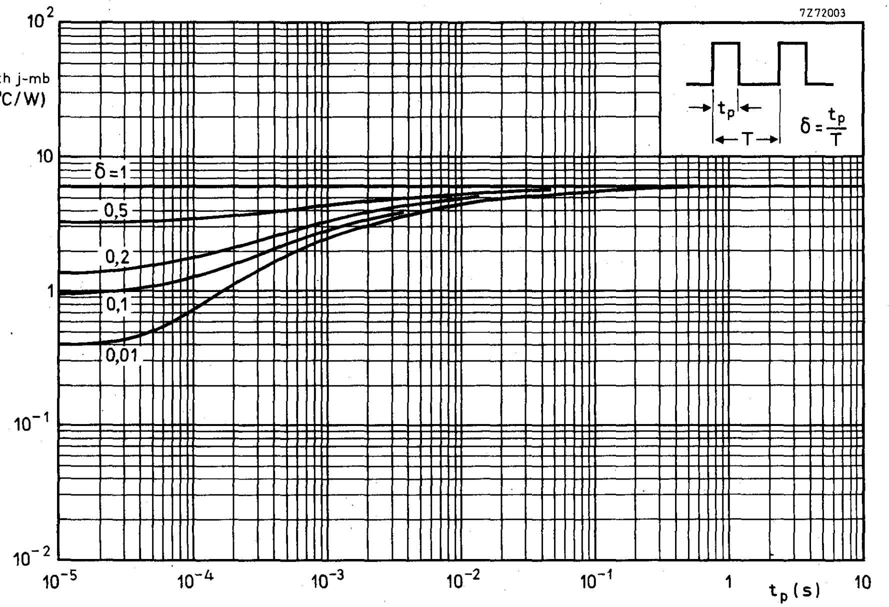


Fig. 5 Pulse power rating chart.

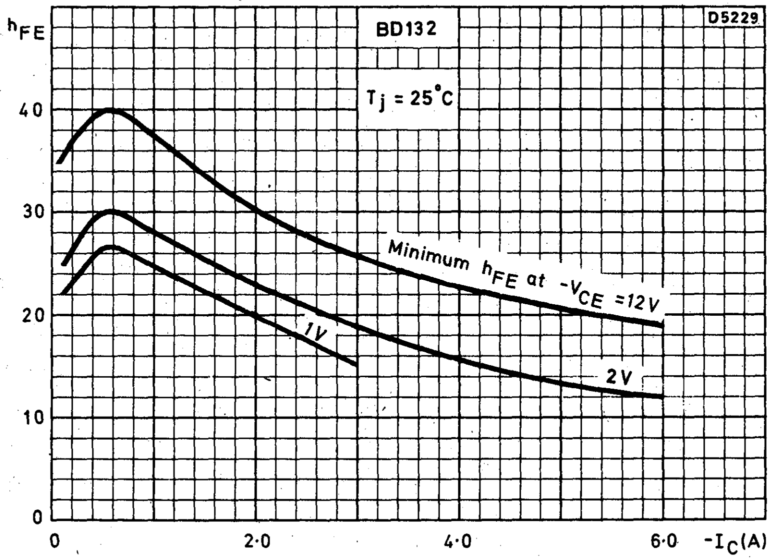


Fig. 6 D.C. current gain.

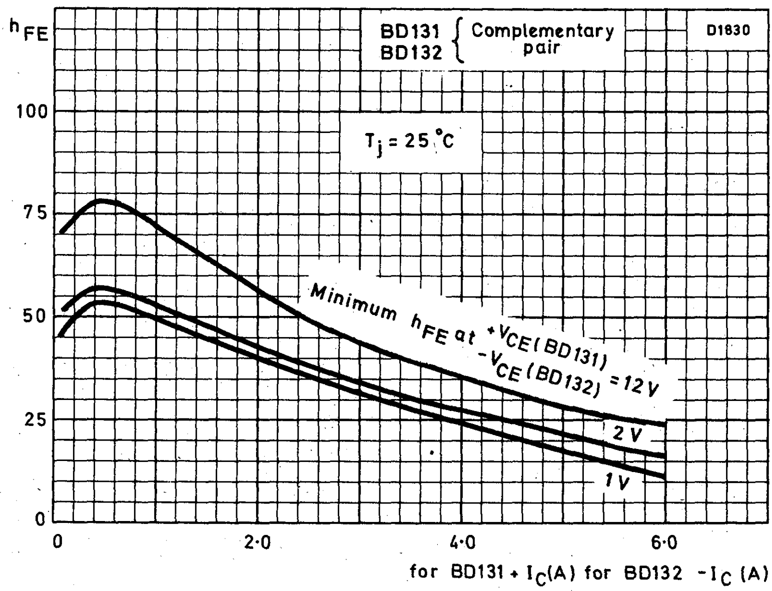


Fig. 7 D.C. current gain ratio.

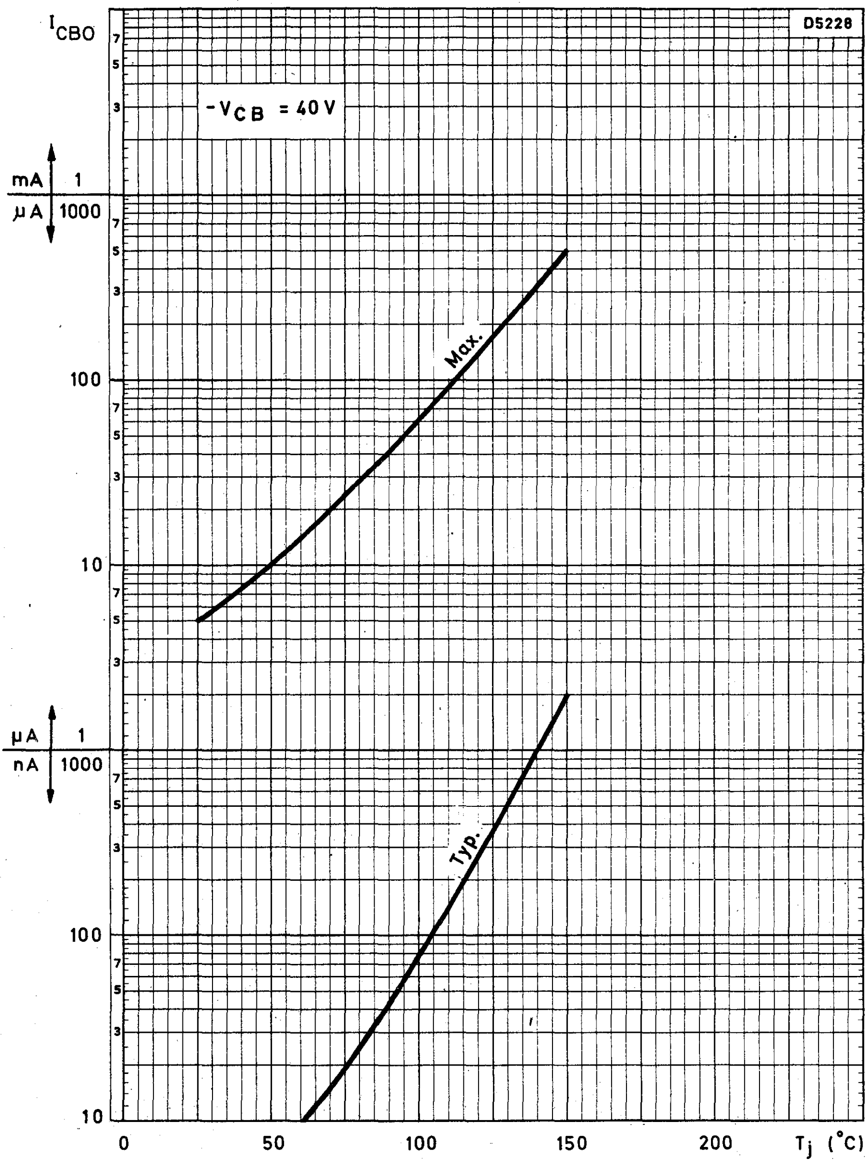


Fig. 8 Collector-base current (open emitter) as a function of the junction temperature.

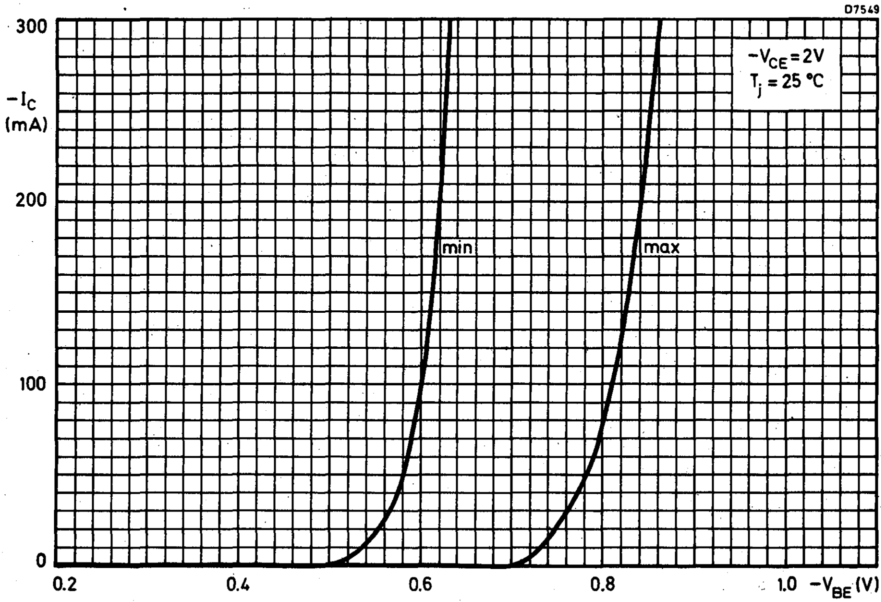

D7549
300
200
100
0
$-I_C$
(mA)
$-V_{CE} = 2V$
$T_j = 25$ °C
min
max
0.2
0.4
0.6
0.8
1.0
$-V_{BE}$ (V)

Fig. 9.

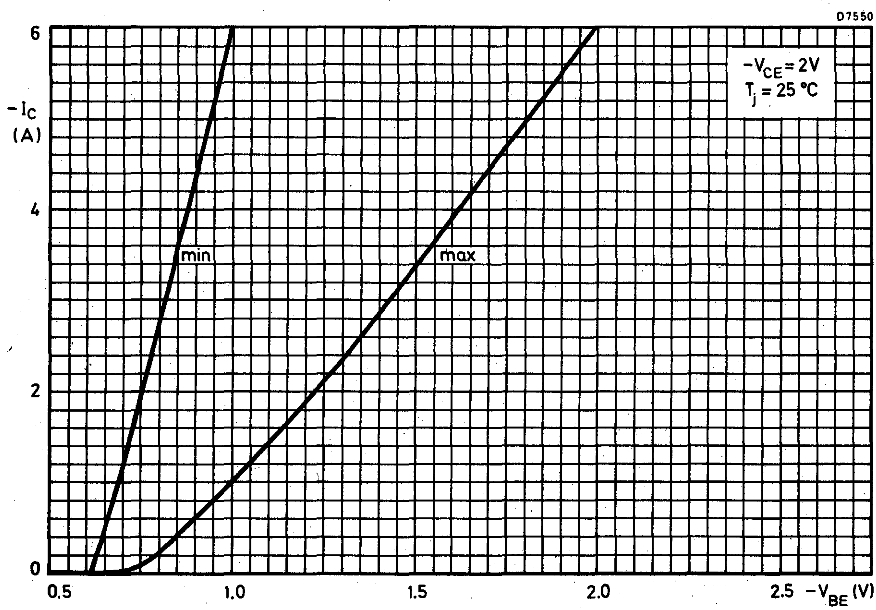

D7550
6
4
2
0
$-I_C$
(A)
$-V_{CE} = 2V$
$T_j = 25$ °C
min
max
0.5
1.0
1.5
2.0
2.5
$-V_{BE}$ (V)

Fig. 10.

SILICON PLANAR EPITAXIAL POWER TRANSISTOR

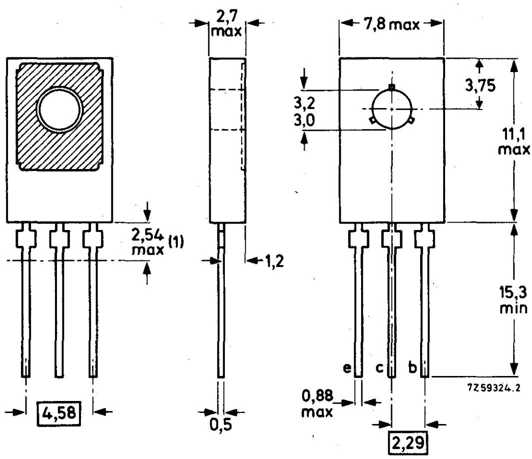
N-P-N transistor in a SOT-32 plastic envelope for general purpose, medium power applications.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	90	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	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

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.

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.

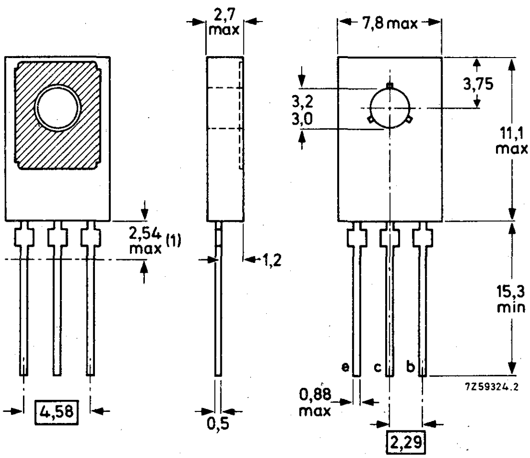
QUICK REFERENCE DATA

			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

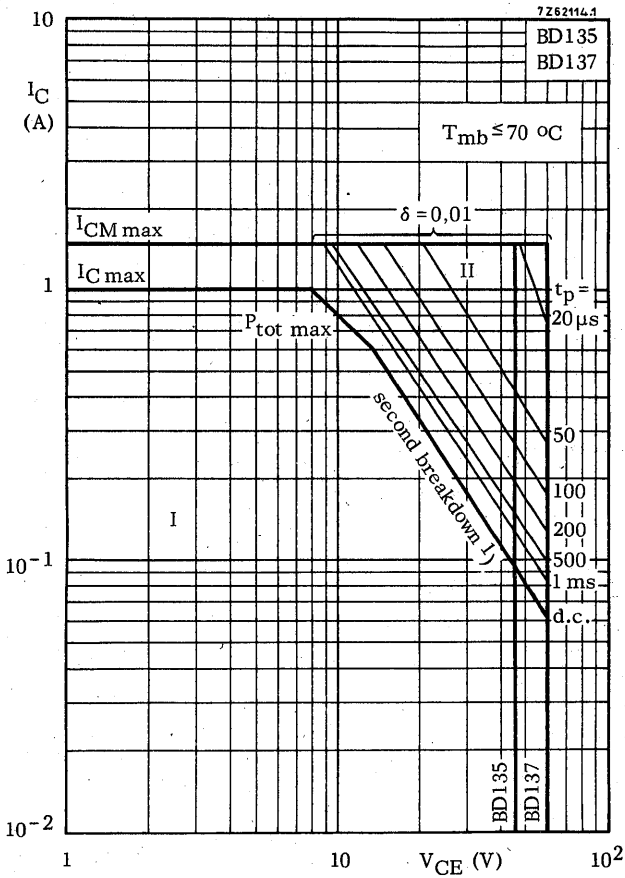
THERMAL RESISTANCE

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

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

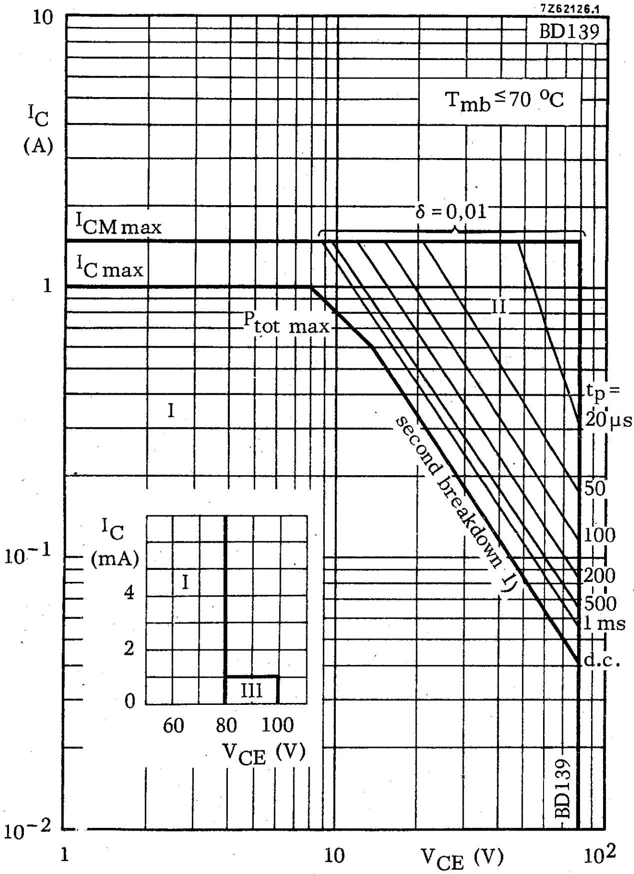
Collector cut-off current			
$I_E = 0$; $V_{CB} = 30$ V	I_{CBO}	<	100 nA
$I_E = 0$; $V_{CB} = 30$ V; $T_j = 125$ °C	I_{CBO}	<	10 μA
Emitter cut-off current			
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10 μA
Base-emitter voltage			
$I_C = 500$ mA; $V_{CE} = 2$ V	V_{BE}	<	1 V
Saturation voltage			
$I_C = 500$ 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			
$\lvert I_C \rvert = 150$ 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

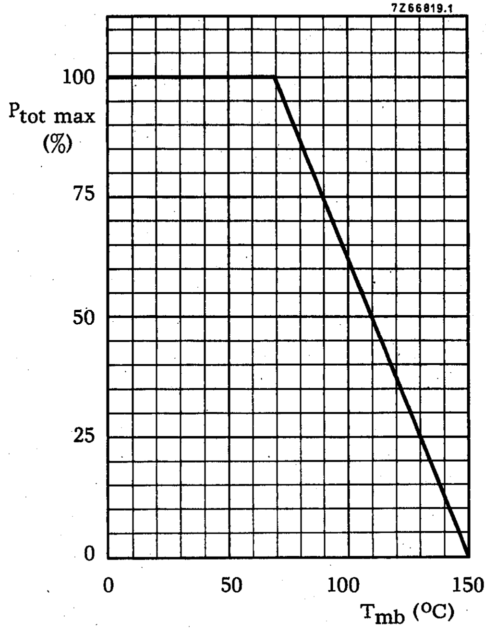


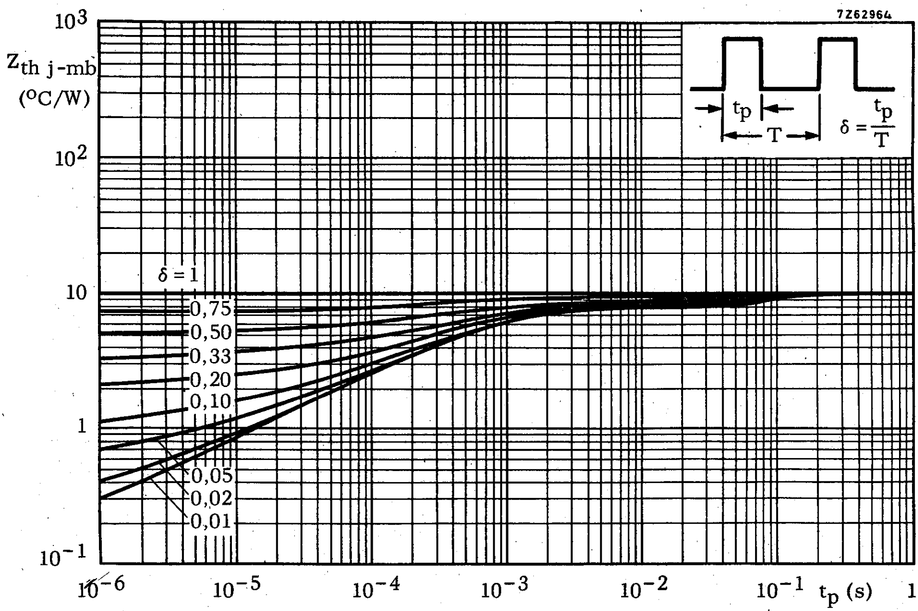
Safe Operating Area with the transistor forward biased

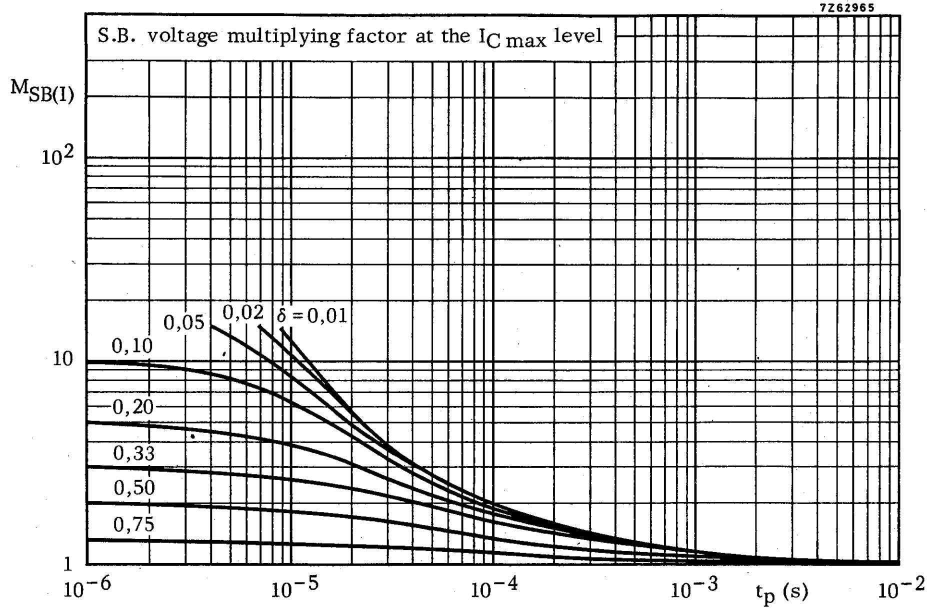
I Region of permissible d.c. operation
II Permissible extension for repetitive pulsed operation
III Repetitive pulse operation in this region is allowable, provided $R_{BE} \leq 1\ k\Omega$

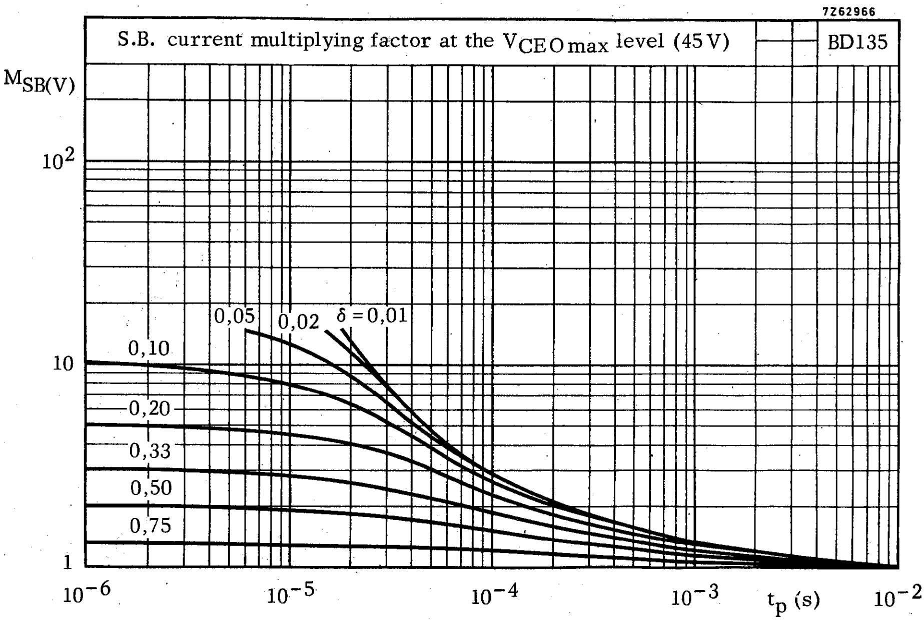
---

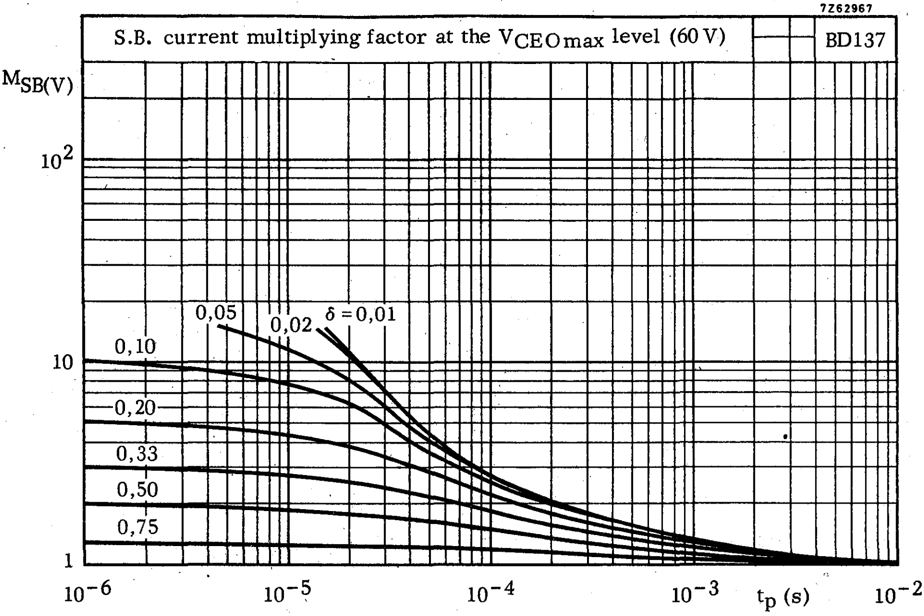
1) Independent of temperature

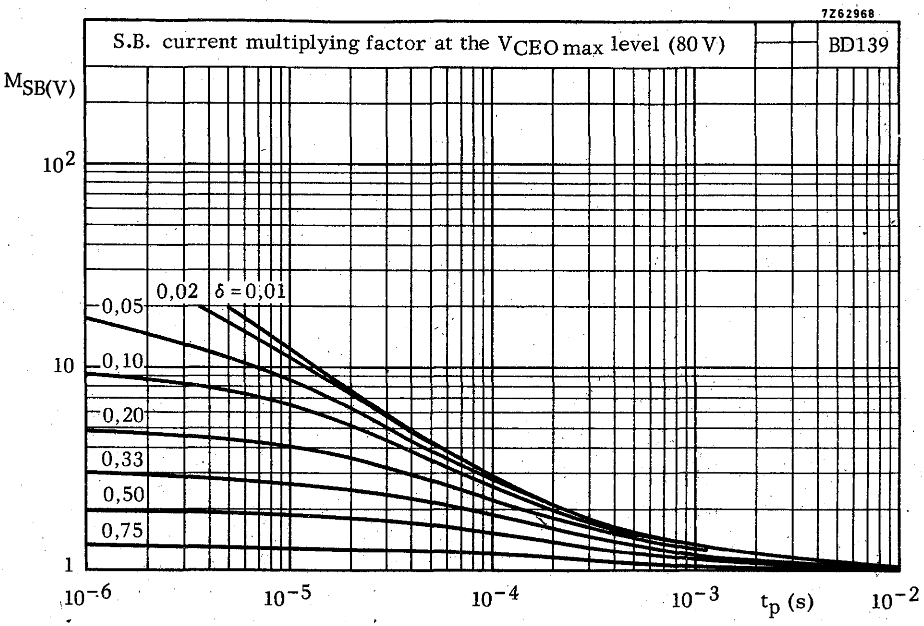

7Z66819.1
100
Ptot max
(%)
75
50
25
0
0
50
100
150
Tmb (°C)

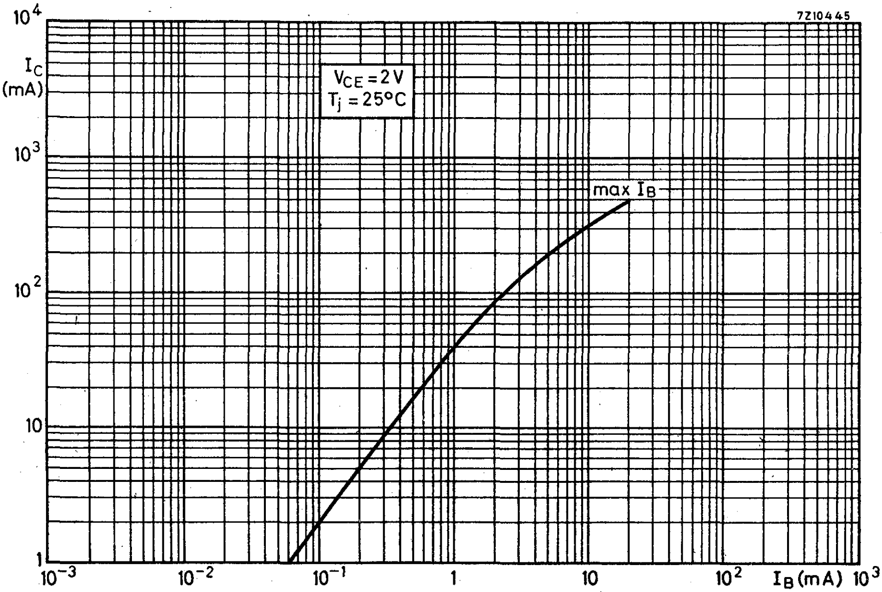

7Z62964
10^3
Zth j-mb
(°C/W)
10^2
10
1
10^{-1}
δ = 1
0,75
0,50
0,33
0,20
0,10
0,05
0,02
0,01
tp
T
δ = tp/T
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
tp (s)
1

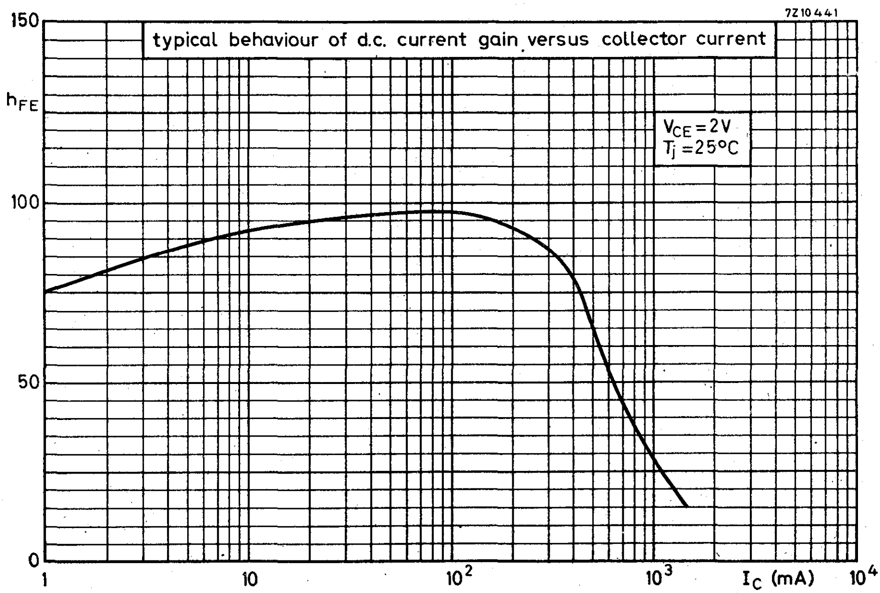

7Z62965
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

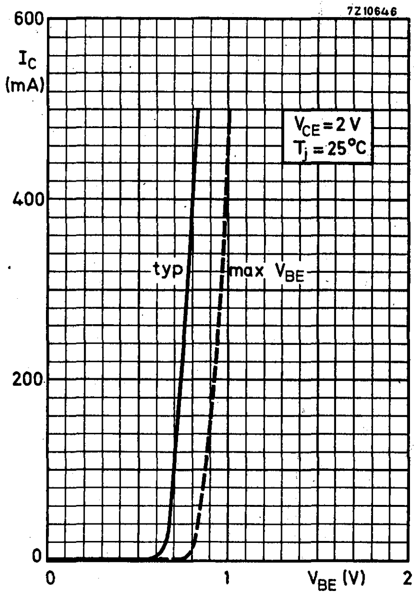

7Z62966
S.B. current multiplying factor at the $V_{CEO\,max}$ level (45 V)
BD135
$M_{SB(V)}$
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

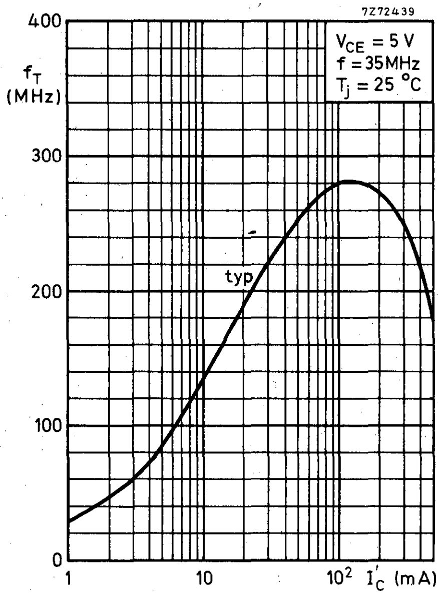

7Z62967
S.B. current multiplying factor at the $V_{CEO\,max}$ level (60 V)
BD137
$M_{SB(V)}$
10^2
10
1
0,05
0,02
$\delta = 0,01$
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

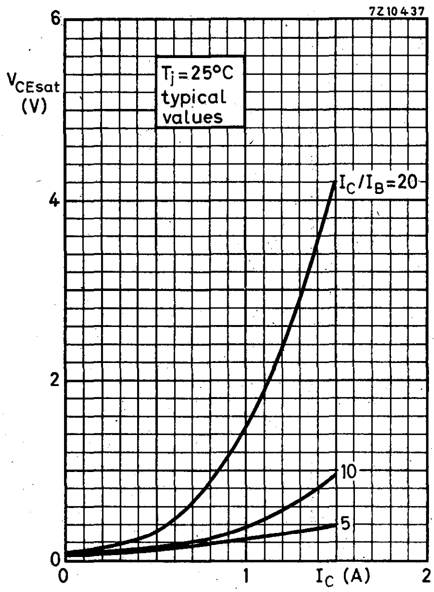

7Z62968
S.B. current multiplying factor at the $V_{CEO\,max}$ level (80 V)
BD139
$M_{SB(V)}$
10^2
10
1
0,02
$\delta = 0,01$
0,05
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

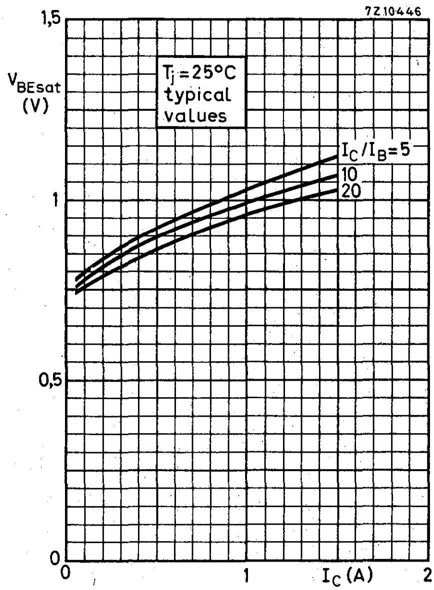

7Z10445
V_{CE} = 2 V
T_j = 25 °C
max I_B
I_C (mA)
10^4
10^3
10^2
10
1
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
I_B (mA)
10^3


7Z10441
typical behaviour of d.c. current gain versus collector current
V_{CE} = 2 V
T_j = 25 °C
h_{FE}
150
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 = 35MHz
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

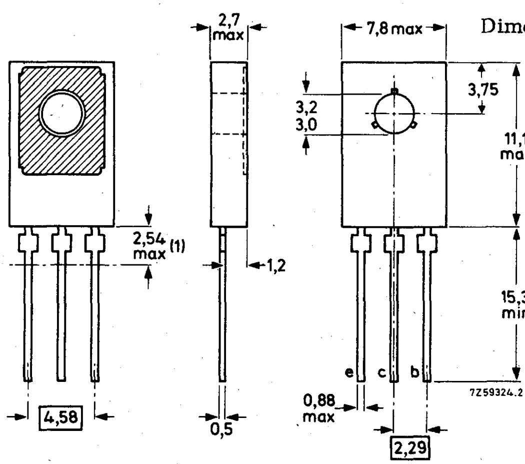
			BD136	BD138	BD140	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	$-V_{CER}$	max.	45	60	100	V
Collector current (peak value)	$-I_{CM}$	max.	1,5	1,5	1,5	A
Total power dissipation 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}	> <	40 250	40 250	40 250	
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

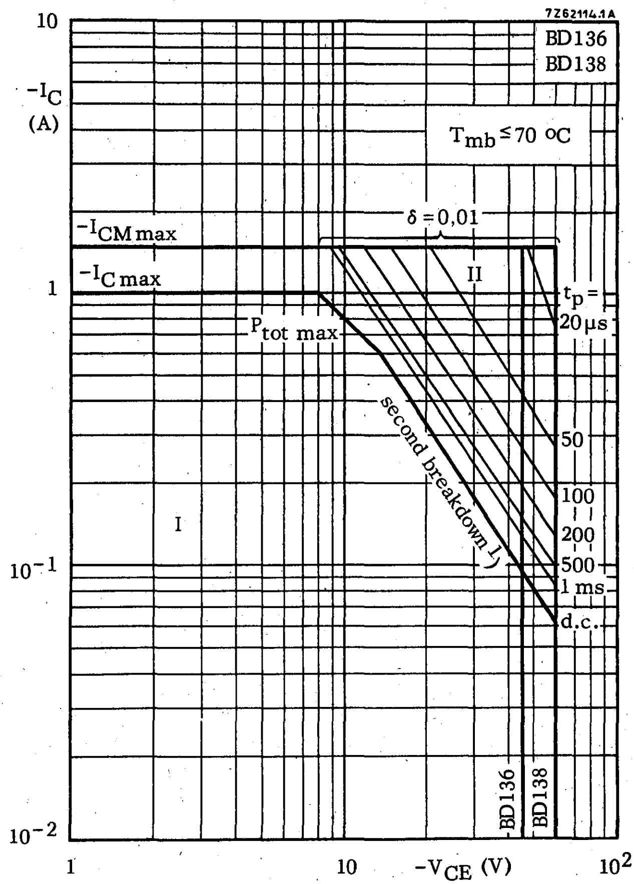
THERMAL RESISTANCE

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

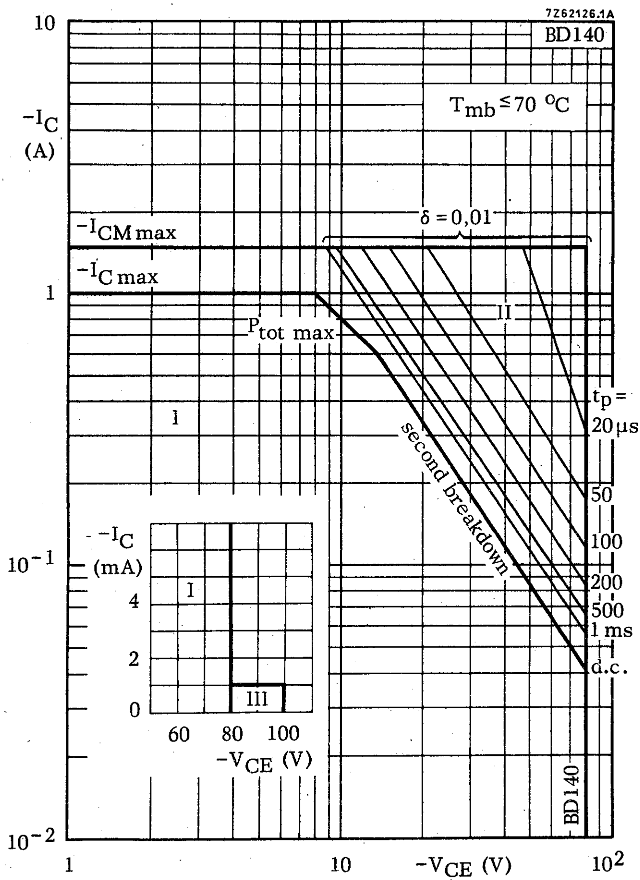


Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

1) Independent of temperature



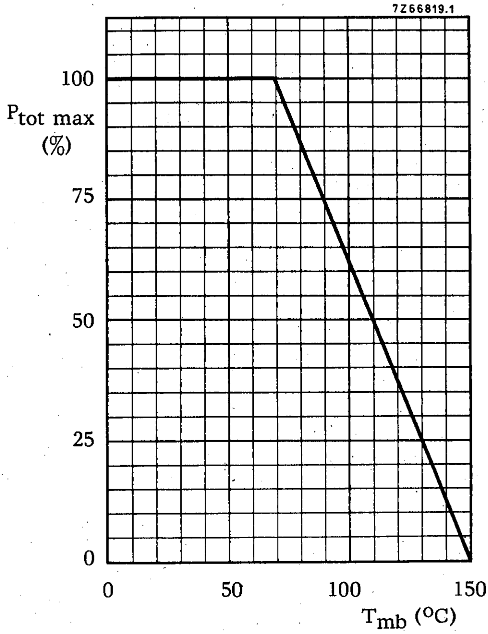
Safe Operating Area with the transistor forward biased

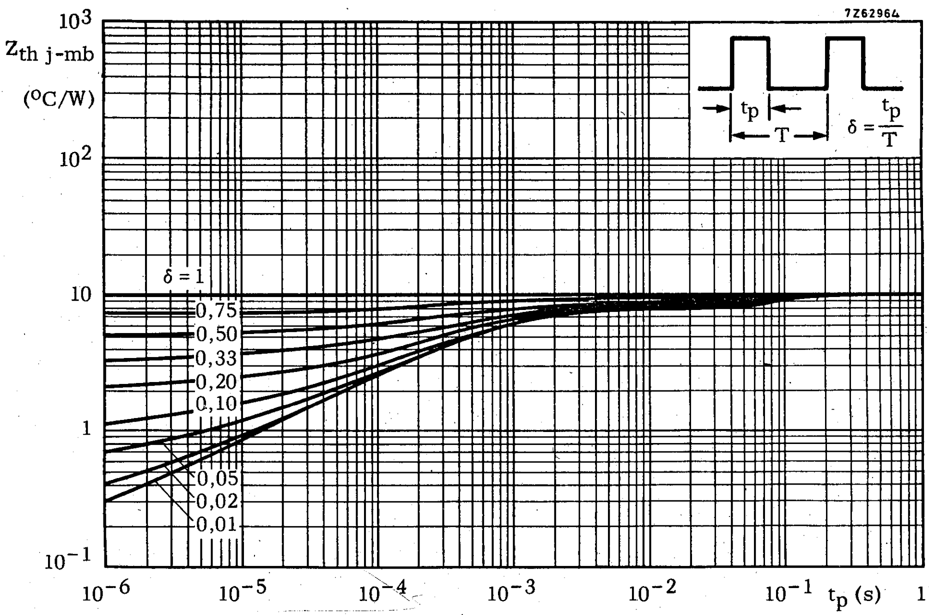
I Region of permissible d.c. operation

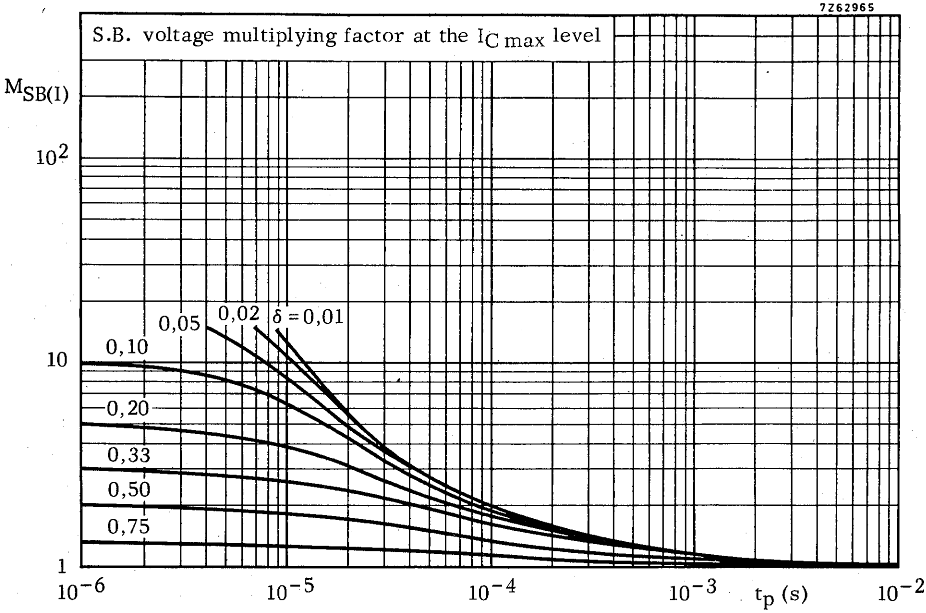
II Permissible extension for repetitive pulse operation

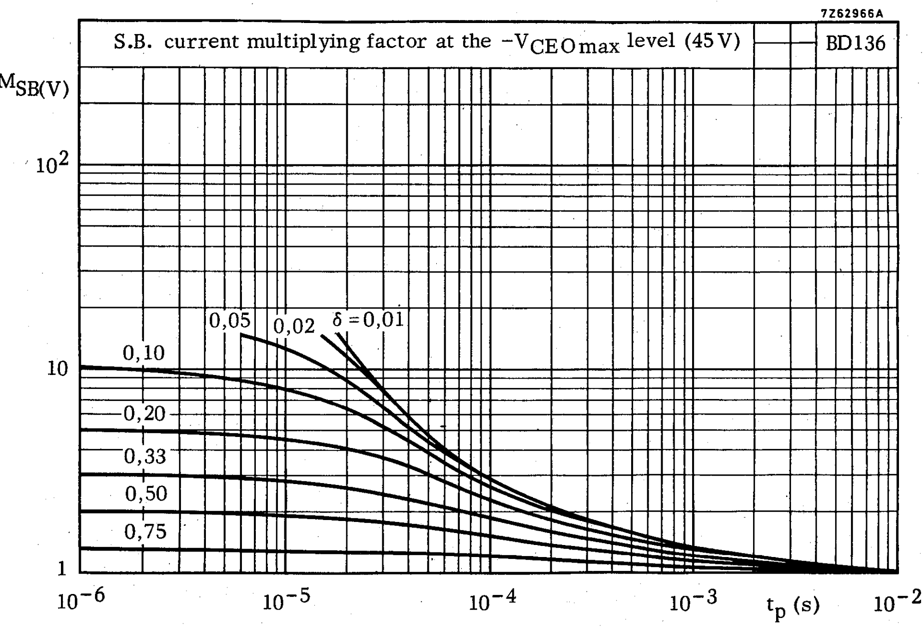
III Repetitive pulse operation in this region is allowable, provided $R_{BE} \leq 1$ kΩ.

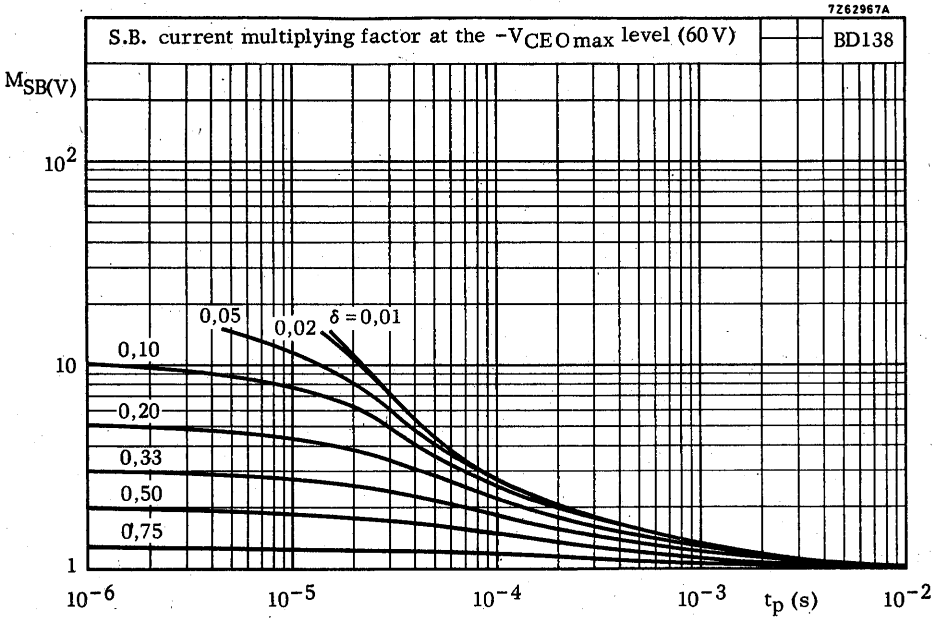
[1]) Independent of temperature

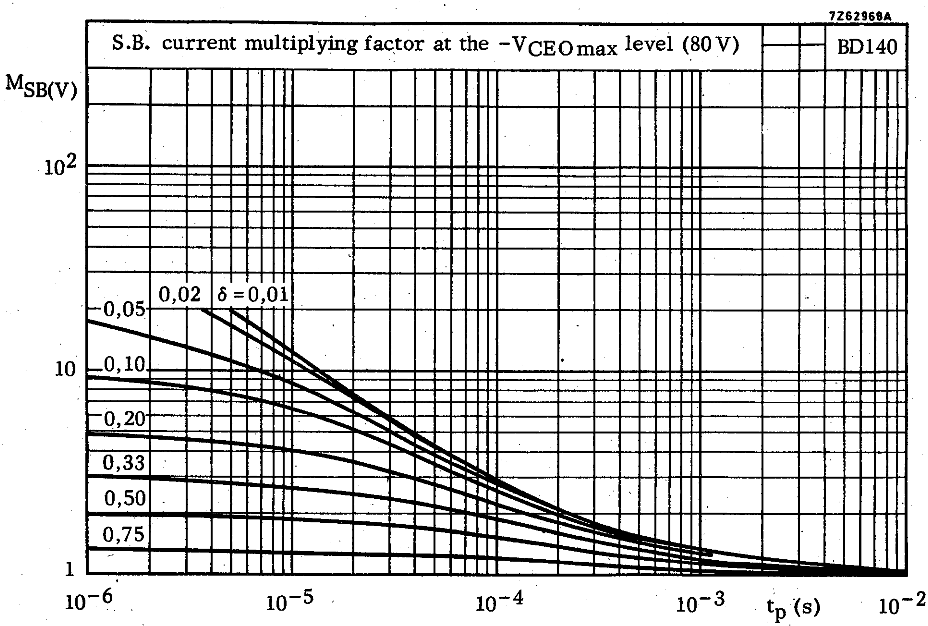

7Z66819.1
100
$P_{tot\ max}$
(%)
75
50
25
0
0
50
100
150
T_{mb} (°C)

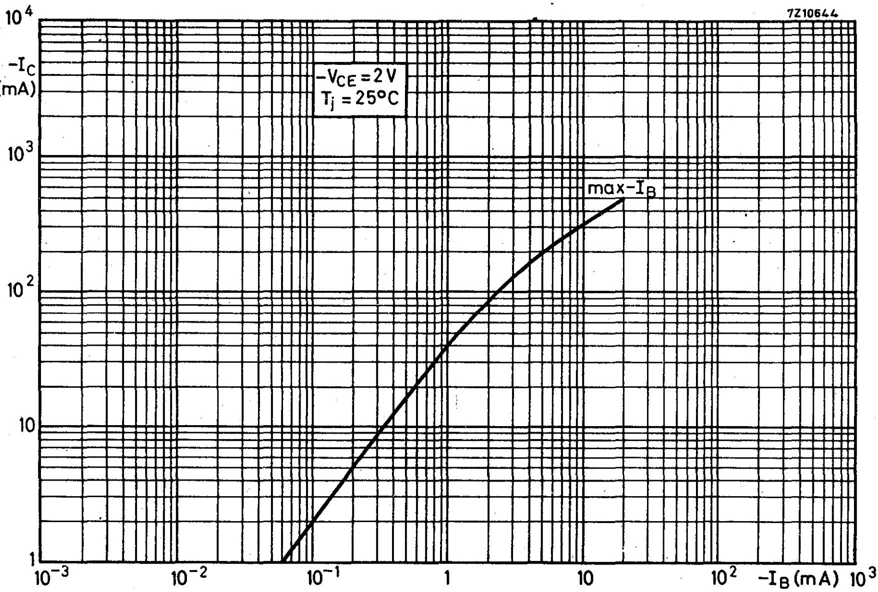

7Z62964
10^3
$Z_{th\ j\text{-}mb}$
(°C/W)
10^2
10
1
10^{-1}
δ = 1
0,75
0,50
0,33
0,20
0,10
0,05
0,02
0,01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
t_p (s)
1

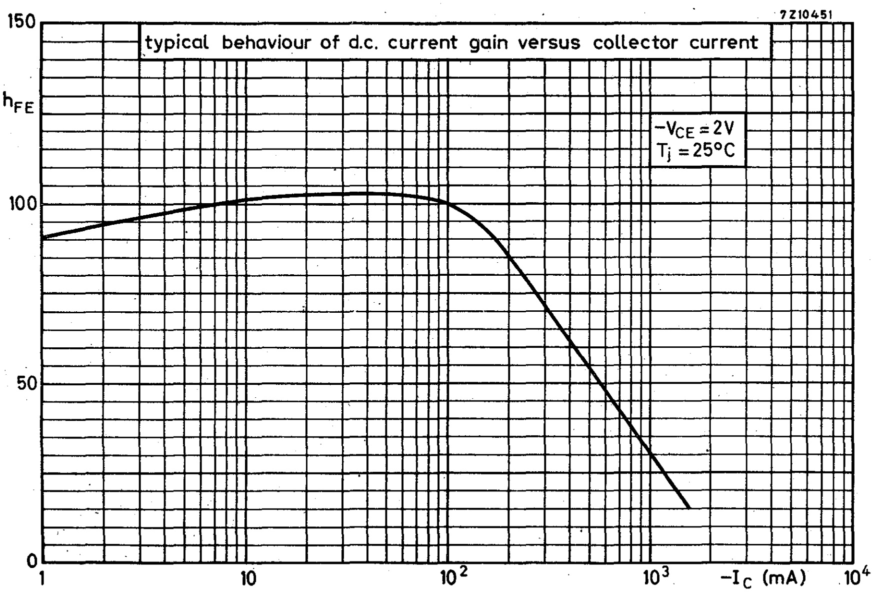

7Z62965
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

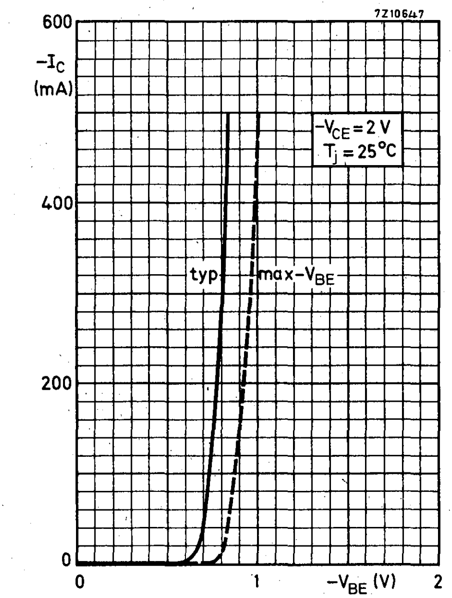

7Z62966A
S.B. current multiplying factor at the $-V_{CEO\,max}$ level (45 V)
BD136
$M_{SB(V)}$
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

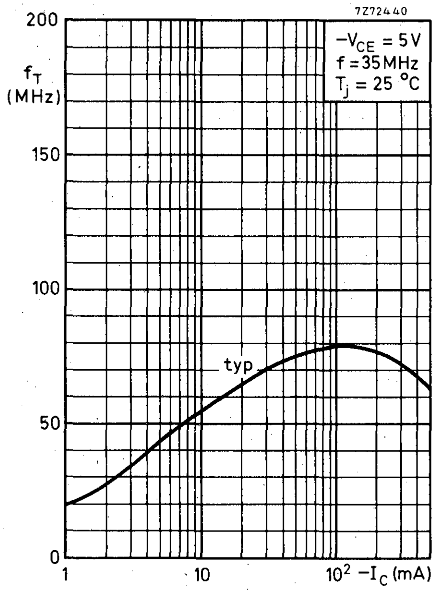

7Z62967A
S.B. current multiplying factor at the $-V_{CEO\,max}$ level (60 V)
BD138
$M_{SB(V)}$
10^2
10
1
0,05
0,02
$\delta = 0,01$
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

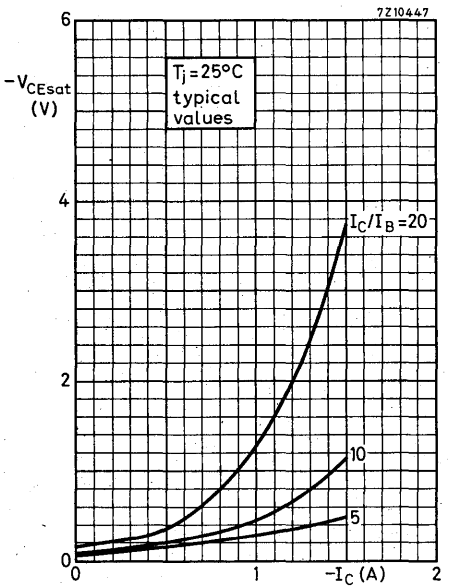

7Z62968A
S.B. current multiplying factor at the $-V_{CEO\,max}$ level (80 V)
BD140
$M_{SB(V)}$
10^2
10
1
0,02
$\delta = 0,01$
0,05
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

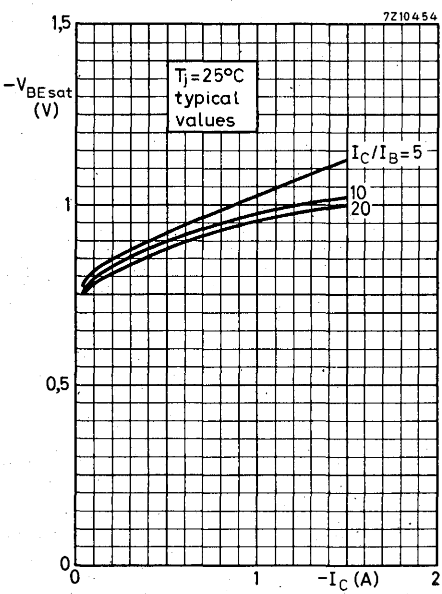

7Z10644
10^4
$-I_C$
(mA)
$-V_{CE} = 2$ V
$T_j = 25$°C
10^3
max-I_B
10^2
10
1
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
$-I_B$ (mA)
10^3


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


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


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


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

SILICON DIFFUSED POWER TRANSISTORS

N-P-N transistors in a TO-3 metal envelope for use in hi-fi audio equipment.
The BD181 is intended for 20 W into 4 Ω as well as 15 W into 8 Ω.
The BD182 is intended for 40 W into 4 Ω.
The BD183 is intended for 40 W into 8 Ω.
The transistors are also available as matched pairs under the type numbers 2-BD181, 2-BD182 and 2-BD183.

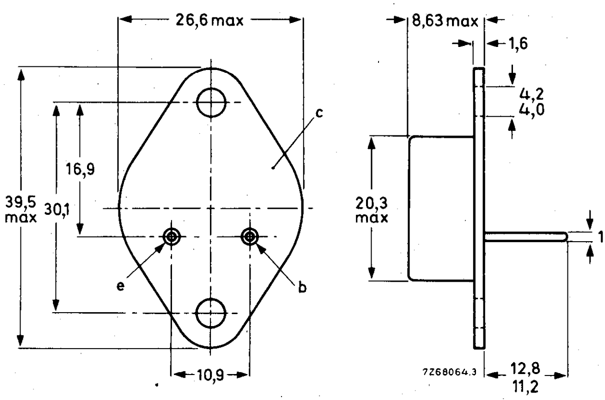
QUICK REFERENCE DATA

			BD181	BD182	BD183	
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 100 Ω)	V_{CER}	max.	55	70	85	V
Collector current (peak value)	I_{CM}	max.	15	15	15	A
Total power dissipation						
up to T_{mb} = 25 °C	P_{tot}	max.	–	117	117	W
up to T_{mb} = 83 °C	P_{tot}	max.	78	–	–	W
Junction temperature	T_j	max.	200	200	200	°C
D.C. current gain						
I_C = 3 A; V_{CE} = 4 V	h_{FE}		20 to 70	–	20 to 70	
I_C = 4 A; V_{CE} = 4 V	h_{FE}		–	20 to 70	–	
Cut-off frequency						
I_C = 0,3 A; V_{CE} = 4 V	f_{hfe}	>	15	15	15	kHz

MECHANICAL DATA Dimensions in mm

Collector connected to envelope

TO-3



For mounting instructions and accessories, see section Accessories.

SILICON EPITAXIAL-BASE POWER TRANSISTORS

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

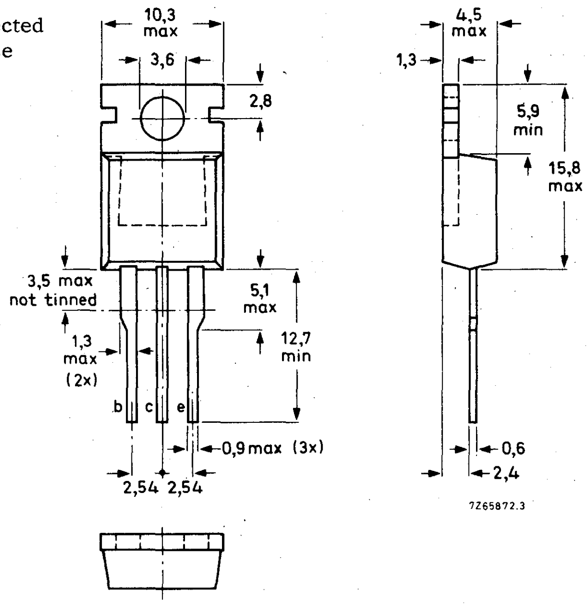
			BD201	BD203	
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	V
Collector current (d.c.)	I_C	max.	8	8	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	60	60	W
Cut-off frequency I_C = 0,3 A; V_{CE} = 3 V	f_{hfe}	>	25	25	kHz

MECHANICAL DATA

Dimensions in mm

TO-220

Collector connected to mounting base



For mounting instructions and accessories see section Accessories.

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

			BD201	BD203	
Voltages					
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

Currents				
Collector current (d.c.)	I_C	max.	8	A
Collector current (peak value, $t_p \leq 10$ ms)	I_{CM}	max.	12	A
Collector current (non-repetitive peak value, $t_p \leq 2$ ms)	I_{CSM}	max.	25	A
Power dissipation				
Total power dissipation up to $T_{mb} = 25\ ^{o}C$	P_{tot}	max.	60	W
Temperatures				
Storage temperature	T_{stg}		−65 to +150	^{o}C
Junction temperature	T_j	max.	150	^{o}C

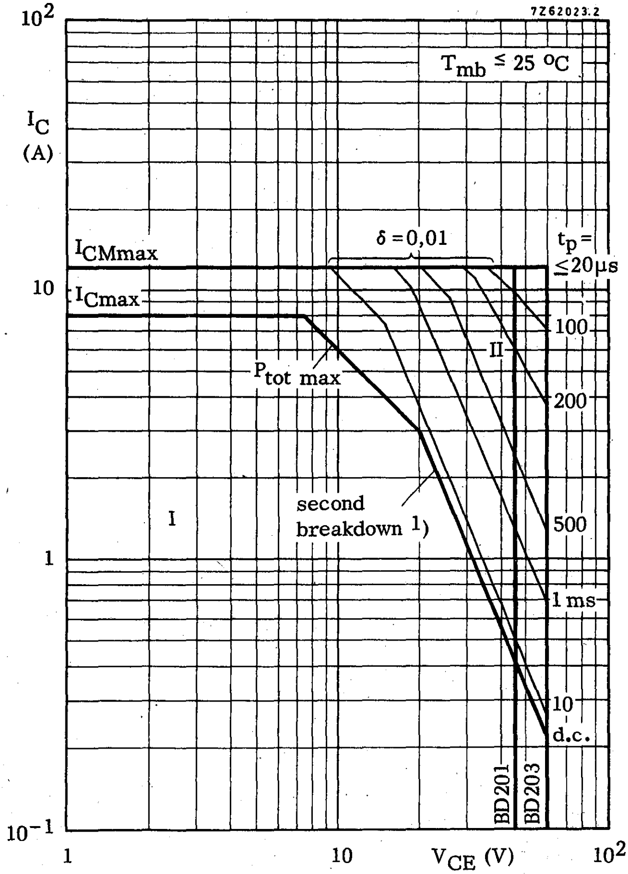
THERMAL RESISTANCE

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

CHARACTERISTICS $T_j = 25\ ^oC$ 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; $T_j = 150\ ^oC$	I_{CBO}	<	1	mA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	5	mA
Base-emitter voltage [1]				
$I_C = 3$ A; $V_{CE} = 2$ V	V_{BE}	<	1,5	V
Knee voltage [1]				
$I_C = 3$ A; I_B = value for which $I_C = 3,3$ A at $V_{CE} = 2$ V	V_{CEK}	typ.	1	V
Saturation voltage [1]				
$I_C = 3$ A; $I_B = 0,3$ A	V_{CEsat}	<	1	V
D.C. current gain [1]				
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
Transition frequency at f = 1 MHz				
$I_C = 0,3$ A; $V_{CE} = 3$ V	f_T	>	3	MHz

[1]) Measured under pulse conditions: $t_p < 300\ \mu s$, $\delta < 2\%$.

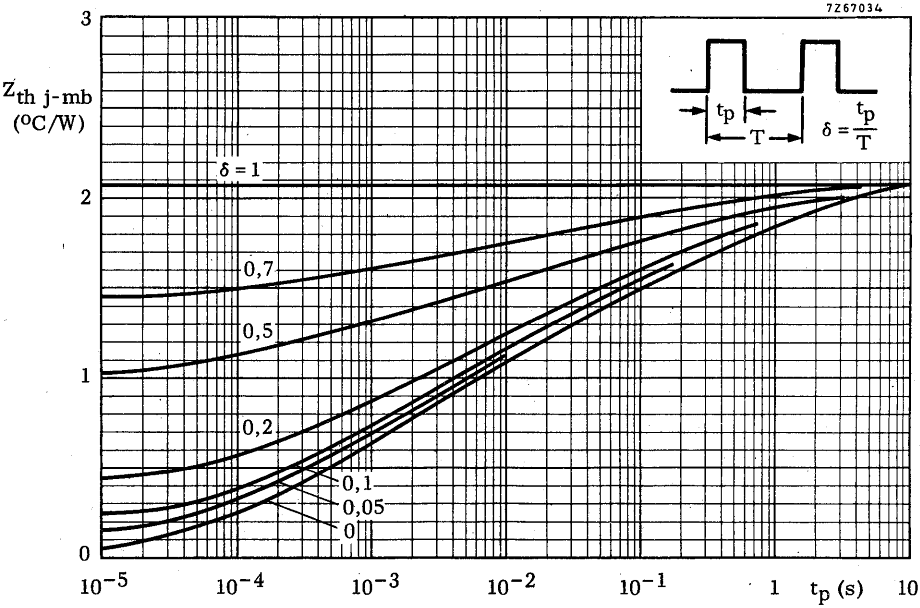


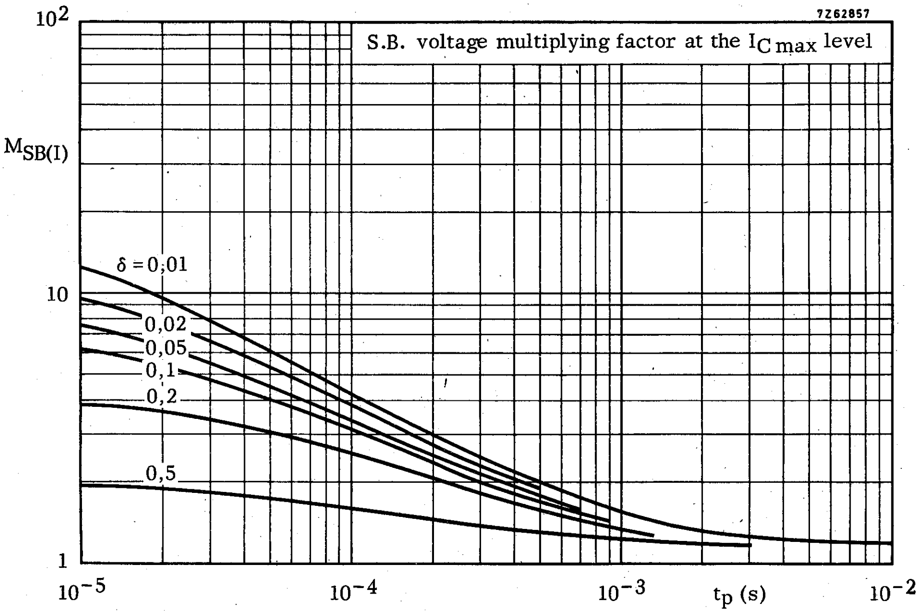
Safe Operating Area with the transistor forward biased

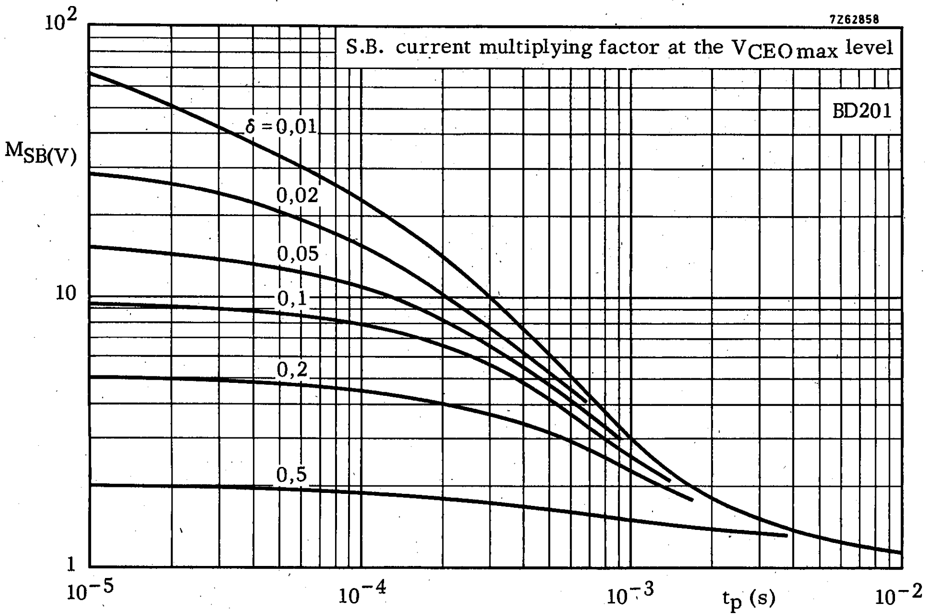
I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation

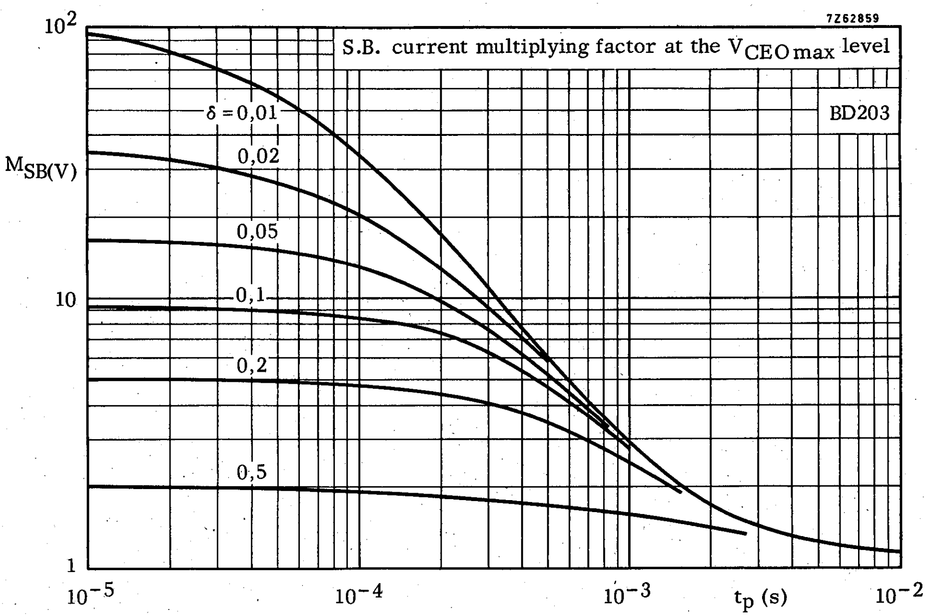
For $P_{tot\ max}$ versus T_{mb} see page 8.

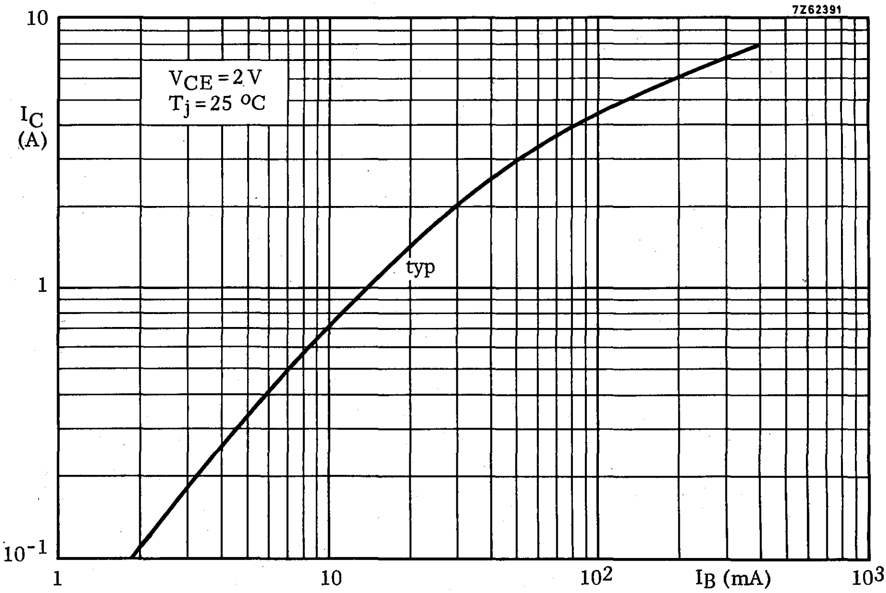
1) Independent of temperature.

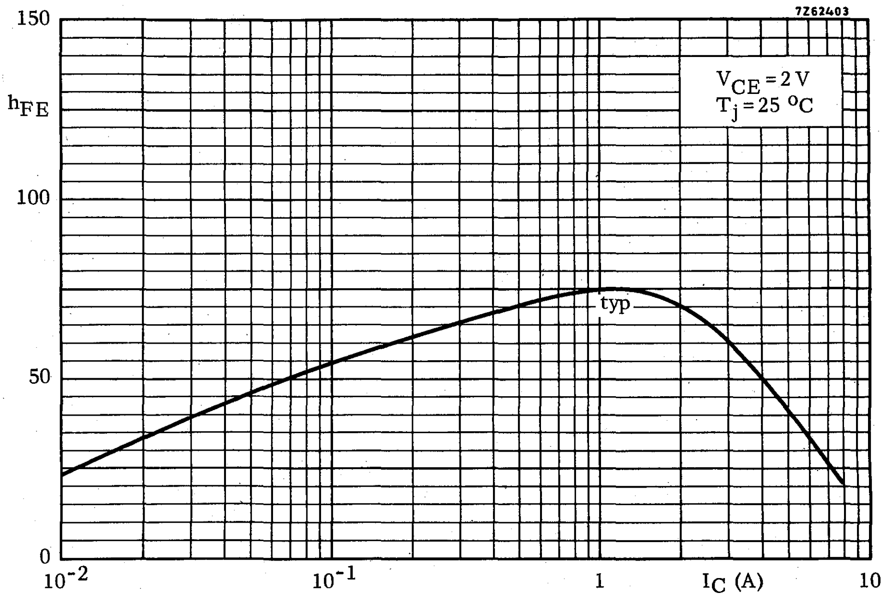

7Z67034
$Z_{th\ j\text{-}mb}$ (°C/W)
3
2
1
0
$\delta = 1$
0,7
0,5
0,2
0,1
0,05
0
t_p
T
$\delta = \frac{t_p}{T}$
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
t_p (s)
10

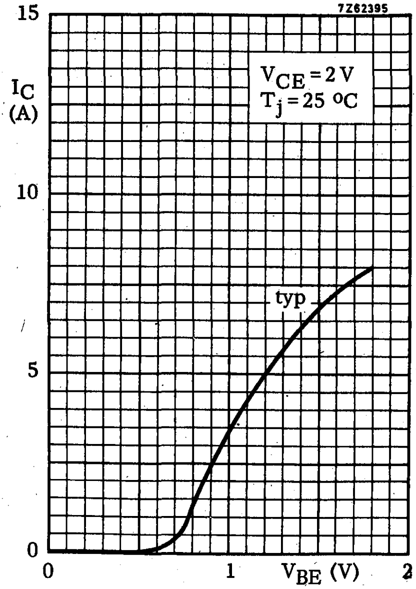

7Z62857
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
$\delta = 0{,}01$
0,02
0,05
0,1
0,2
0,5
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

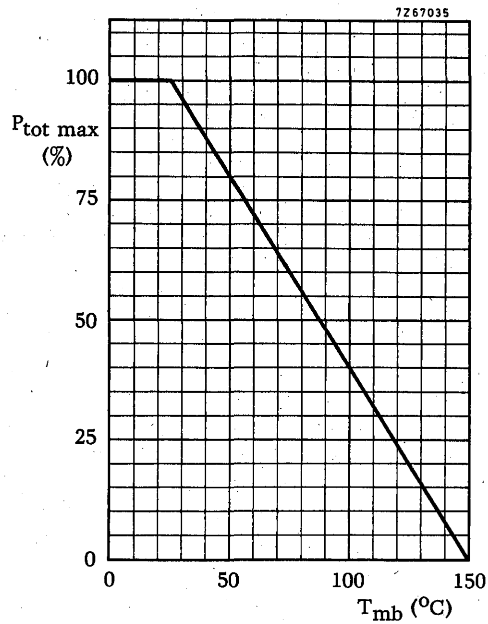

7Z62858
S.B. current multiplying factor at the $V_{CEO\,max}$ level
BD201
$M_{SB(V)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,5
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

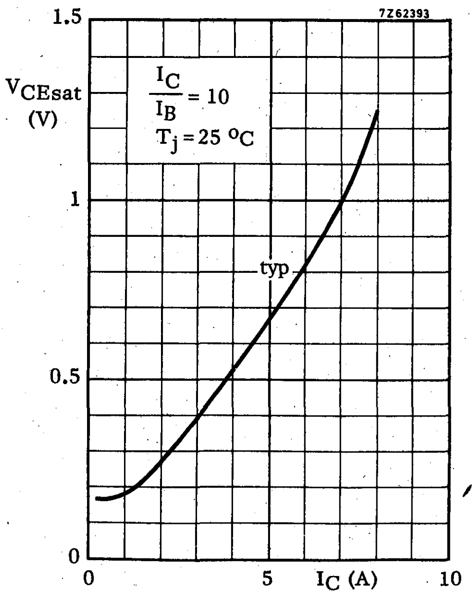

7Z62859
S.B. current multiplying factor at the $V_{CEO\,max}$ level
BD203
$M_{SB(V)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,5
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

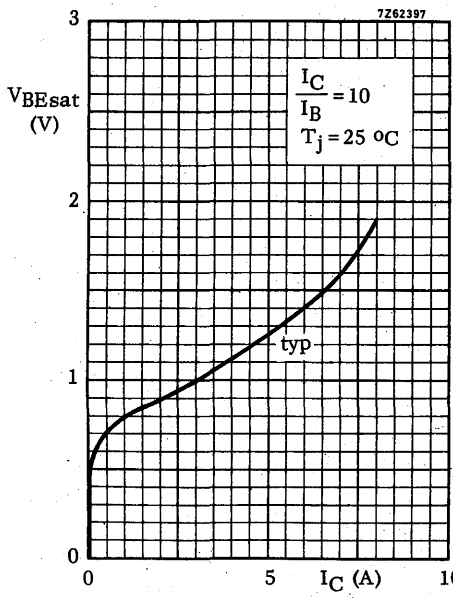

7Z62391
10
I_C
(A)
$V_{CE} = 2$ V
$T_j = 25$ °C
typ
1
10^{-1}
1
10
10^2
I_B (mA)
10^3

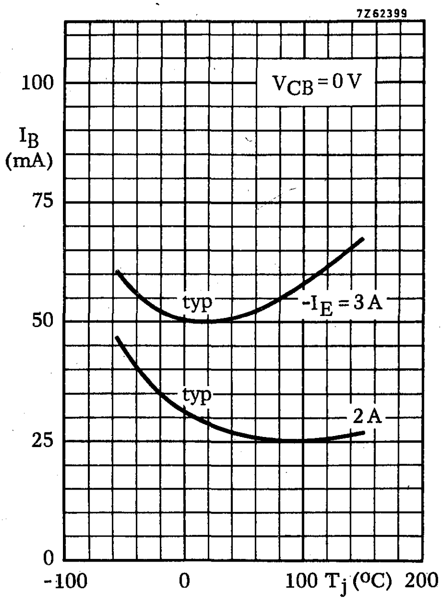

7Z62403
150
h_{FE}
$V_{CE} = 2$ V
$T_j = 25$ °C
100
typ
50
0
10^{-2}
10^{-1}
1
I_C (A)
10

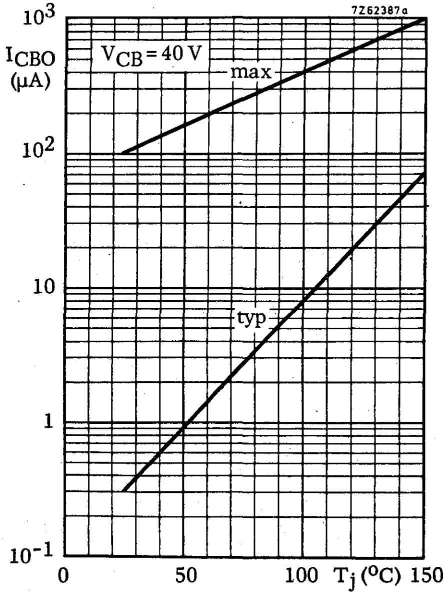

7Z62395
15
10
5
0
I_C (A)
$V_{CE} = 2$ V
$T_j = 25$ °C
typ
0
1
V_{BE} (V)
2

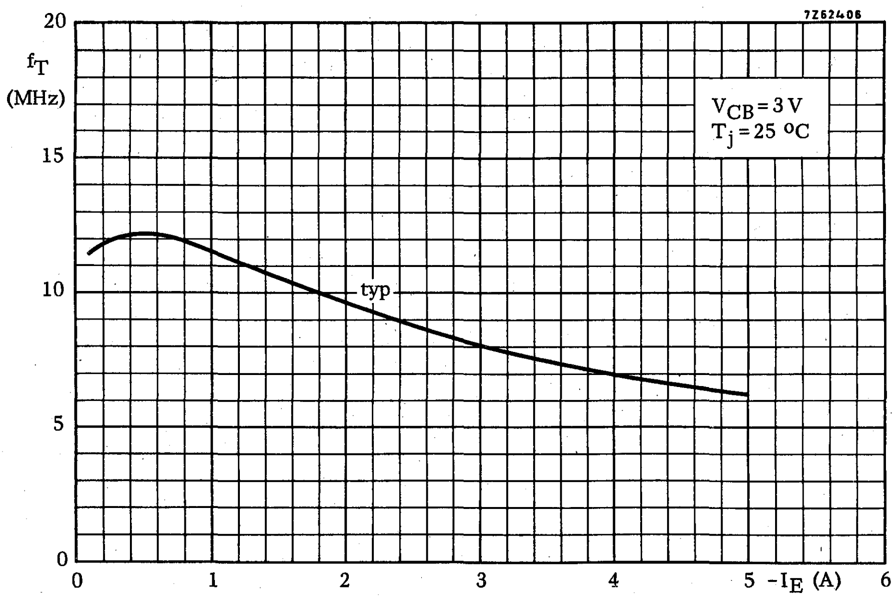

7Z67035
100
75
50
25
0
$P_{tot\ max}$ (%)
0
50
100
150
T_{mb} (°C)


7Z62393
1.5
1
0.5
0
V_{CEsat} (V)
$\frac{I_C}{I_B} = 10$
$T_j = 25$ °C
typ
0
5
I_C (A)
10


7Z62397
3
2
1
0
V_{BEsat} (V)
$\frac{I_C}{I_B} = 10$
$T_j = 25$ °C
typ
0
5
I_C (A)
10


7Z62399
$V_{CB} = 0\,V$
I_B (mA)
100
75
50
25
0
typ
$-I_E = 3\,A$
typ
2 A
-100
0
100
T_j (°C)
200


7Z62387a
I_{CBO} (μA)
10^3
$V_{CB} = 40\,V$
max
10^2
10
typ
1
10^{-1}
0
50
100
T_j (°C)
150


7Z62406
f_T (MHz)
20
15
10
5
0
$V_{CB} = 3\,V$
$T_j = 25\,°C$
typ
0
1
2
3
4
5
$-I_E$ (A)
6

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.

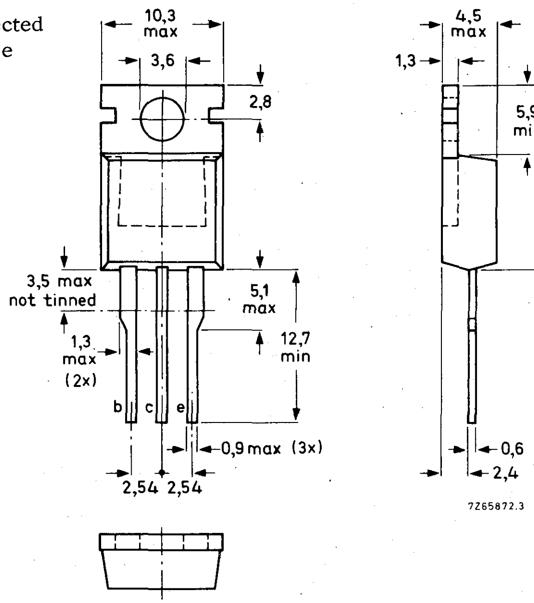
QUICK REFERENCE DATA					
			BD202	BD204	
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	V
Collector current (d.c.)	$-I_C$	max.	8	8	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	60	60	W
Cut-off frequency					
$-I_C$ = 0,3 A; $-V_{CE}$ = 3 V	f_{hfe}	>	25	25	kHz

MECHANICAL DATA

Dimensions in mm

TO-220

Collector connected to mounting base



For mounting instructions and accessories see section Accessories.

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

Voltages

			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

Currents

Collector current (d.c.)	$-I_C$	max.	8	A
Collector current (peak value, $t_p \leq 10$ ms)	$-I_{CM}$	max.	12	A
Collector current (non-repetitive peak value, $t_p \leq 2$ ms)	$-I_{CSM}$	max.	25	A

Power dissipation

Total power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.	60	W

Temperatures

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

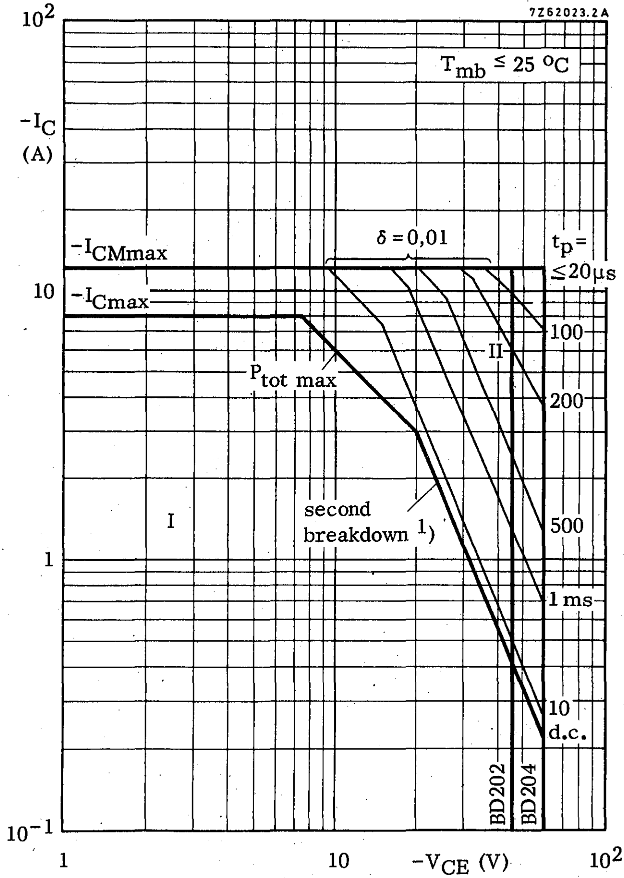
THERMAL RESISTANCE

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

CHARACTERISTICS $T_j = 25\ ^oC$ 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; $T_j = 150\ ^oC$	$-I_{CBO}$	<	1	mA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	5	mA
Base-emitter voltage [1]				
$-I_C = 3$ A; $-V_{CE} = 2$ V	$-V_{BE}$	<	1,5	V
Knee voltage [1]				
$-I_C = 3$ A; $-I_B$ = value at which $-I_C = 3,3$ A at $-V_{CE} = 2$ V	$-V_{CEK}$	typ.	1	V
Saturation voltage [1]				
$-I_C = 3$ A; $-I_B = 0,3$ A	$-V_{CEsat}$	<	1	V
D.C. current gain [1]				
BD202; $-I_C = 3$ A; $-V_{CE} = 2$ V	h_{FE}	>	30	
BD204; $-I_C = 2$ 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
Transition frequency at f = 1 MHz				
$-I_C = 0,3$ A; $-V_{CE} = 3$ V	f_T	>	3	MHz

[1]) Measured under pulse conditions: $t_p < 300\ \mu s$, $\delta < 2\%$.

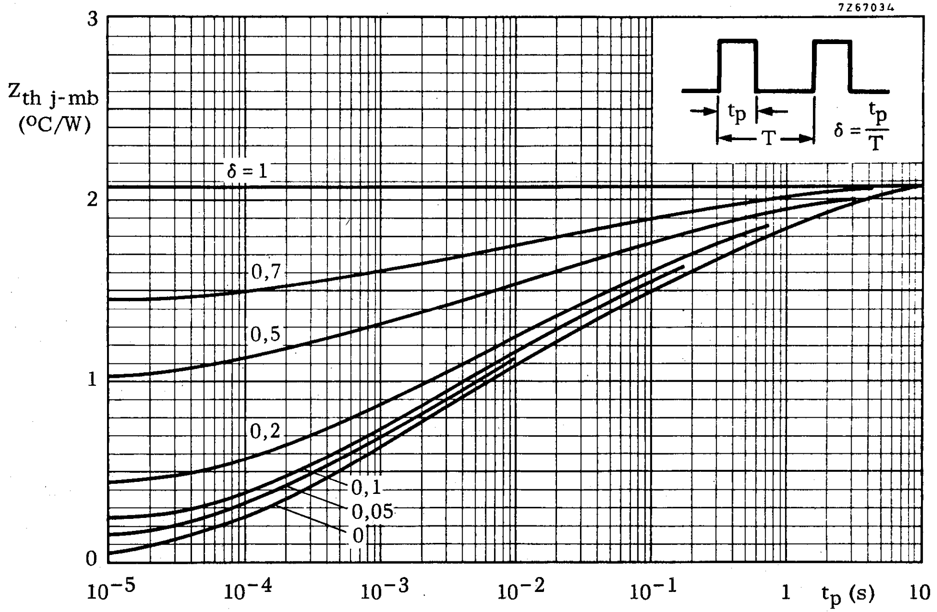


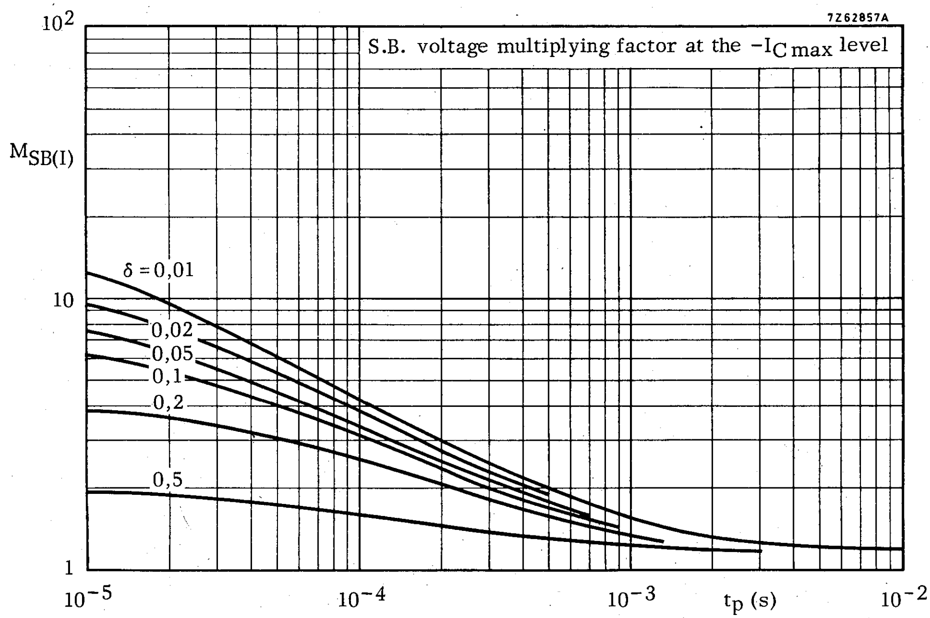
Safe Operating Area with the transistor forward biased

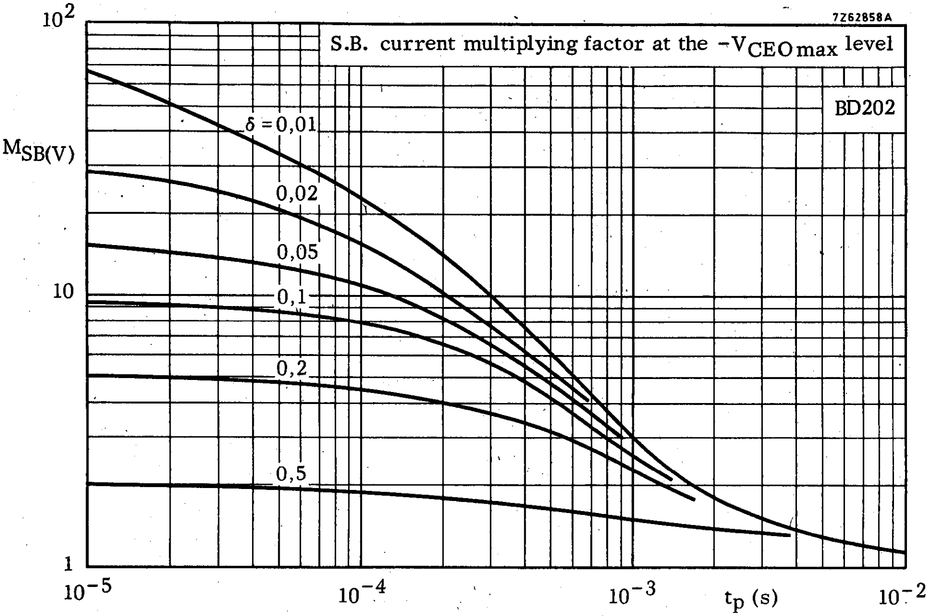
I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation

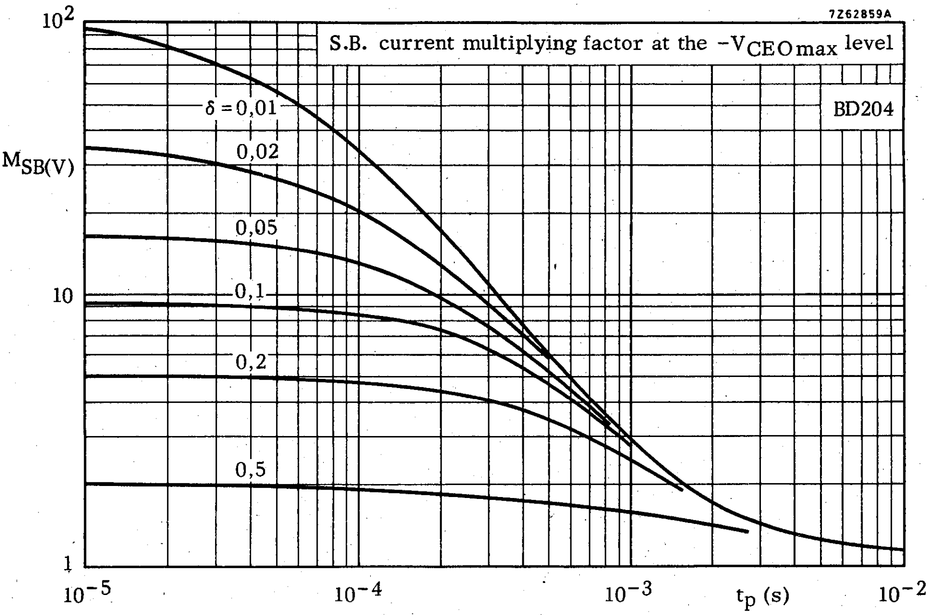
For $P_{tot\ max}$ versus T_{mb} see page 8.

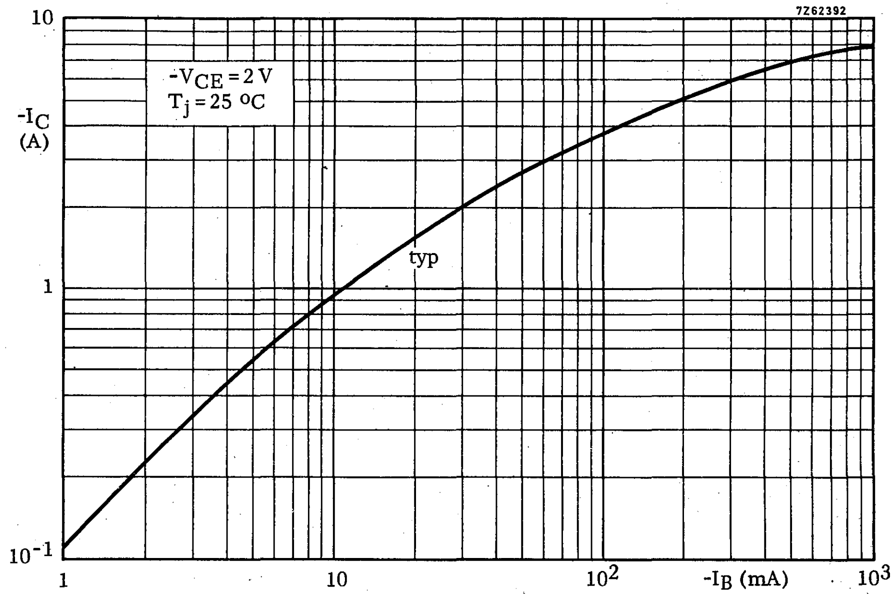
1) Independent of temperature.

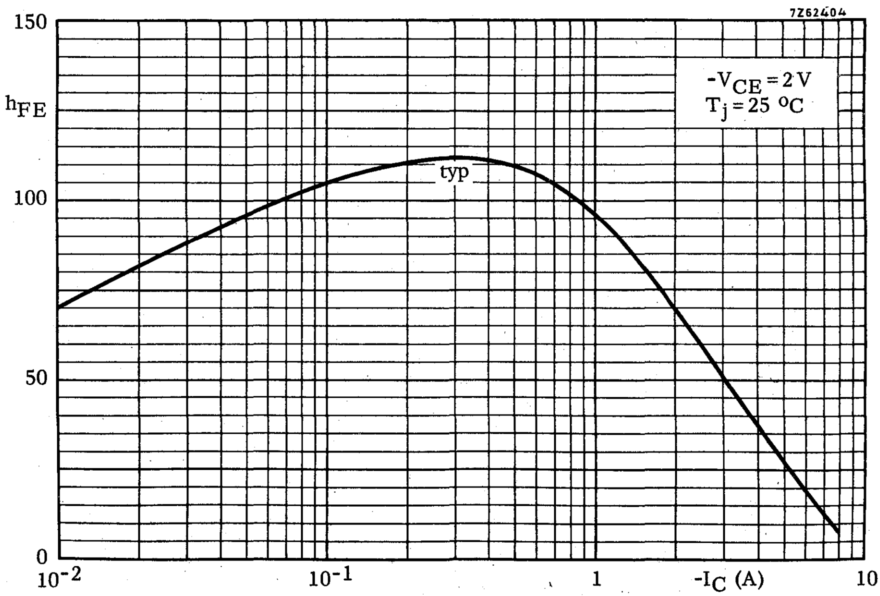

7Z67034
$Z_{th\ j\text{-}mb}$ (°C/W)
t_p
T
$\delta = \frac{t_p}{T}$
$\delta = 1$
0,7
0,5
0,2
0,1
0,05
0
t_p (s)

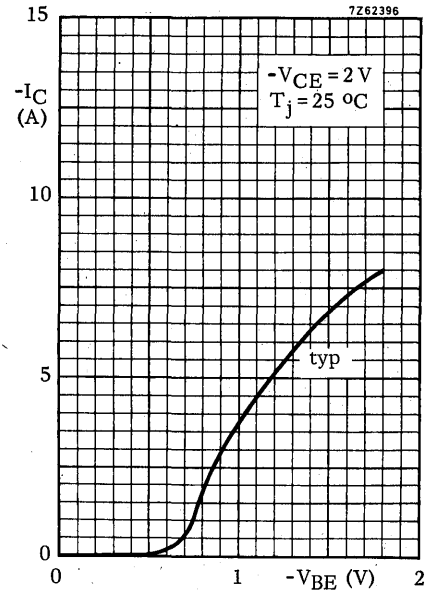

7Z62857A
S.B. voltage multiplying factor at the $-I_{C\,max}$ level
$M_{SB(I)}$
$\delta = 0{,}01$
0,02
0,05
0,1
0,2
0,5
t_p (s)

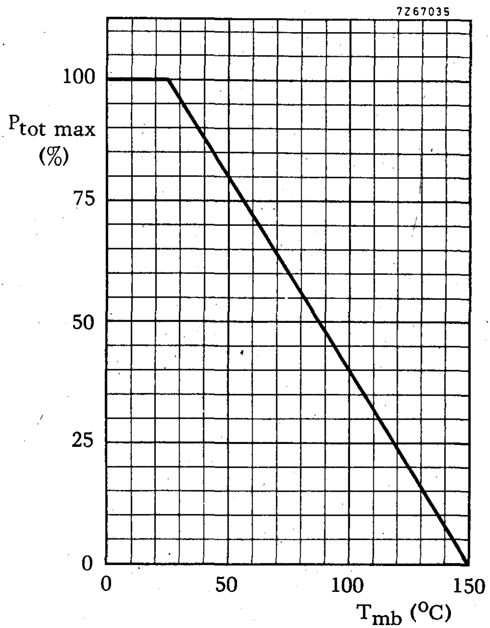

7Z62858A
S.B. current multiplying factor at the $-V_{CEO\,max}$ level
BD202
$M_{SB(V)}$
$\delta = 0{,}01$
0,02
0,05
0,1
0,2
0,5
10^2
10
1
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

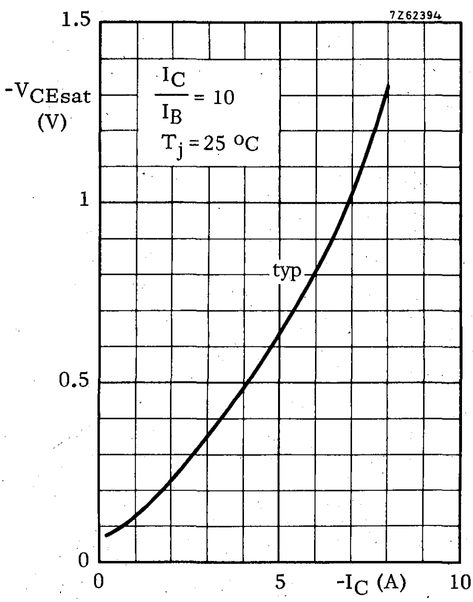

7Z62859A
S.B. current multiplying factor at the $-V_{CEO\,max}$ level
BD204
$M_{SB(V)}$
$\delta = 0{,}01$
0,02
0,05
0,1
0,2
0,5
10^2
10
1
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

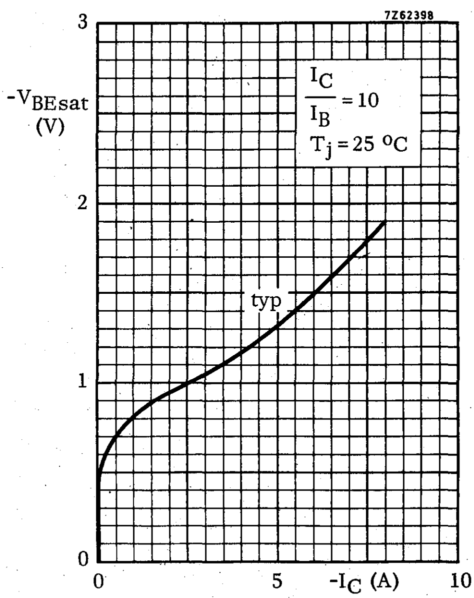

7Z62392
$-V_{CE} = 2$ V
$T_j = 25$ °C
$-I_C$ (A)
10
1
10^{-1}
typ
1
10
10^2
$-I_B$ (mA)
10^3

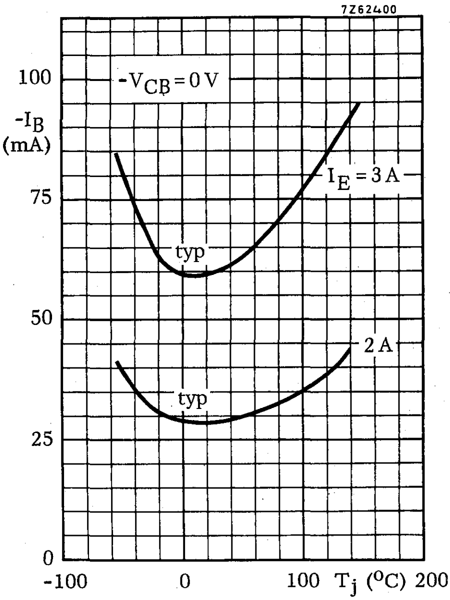

7Z62404
$-V_{CE} = 2$ V
$T_j = 25$ °C
h_{FE}
150
100
50
0
typ
10^{-2}
10^{-1}
1
$-I_C$ (A)
10

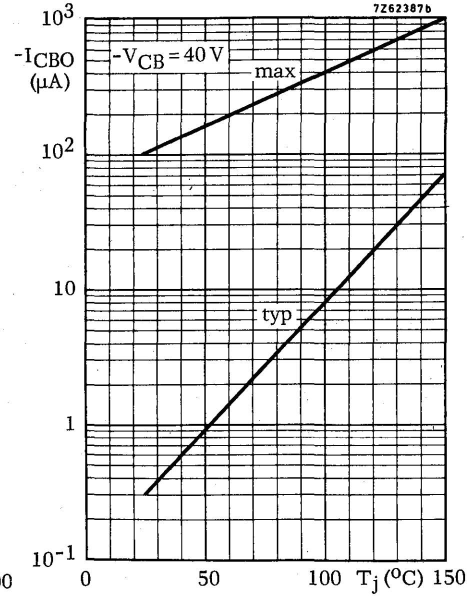

7Z62396
15
-I_C
(A)
10
5
0
0
1
-V_{BE} (V)
2
-V_{CE} = 2 V
T_j = 25 °C
typ

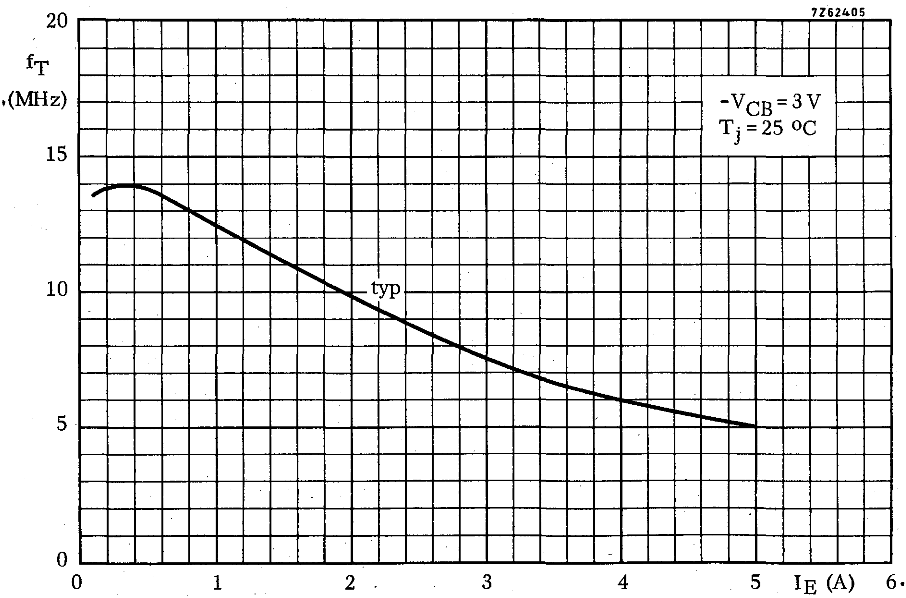

7Z67035
100
$P_{tot\ max}$
(%)
75
50
25
0
0
50
100
150
T_{mb} (°C)


7Z62394
1.5
-V_{CEsat}
(V)
1
0.5
0
0
5
-I_C (A)
10
$\frac{I_C}{I_B}$ = 10
T_j = 25 °C
typ


7Z62398
3
-V_{BEsat}
(V)
2
1
0
0
5
-I_C (A)
10
$\frac{I_C}{I_B}$ = 10
T_j = 25 °C
typ


7Z62400
-V_CB = 0 V
-I_B (mA)
100
75
50
25
0
I_E = 3 A
typ
2 A
typ
-100
0
100
T_j (°C)
200


7Z62387b
10^3
-I_CBO (μA)
-V_CB = 40 V
max
10^2
10
typ
1
10^-1
0
50
100
T_j (°C)
150


7Z62405
20
f_T (MHz)
-V_CB = 3 V
T_j = 25 °C
15
10
typ
5
0
0
1
2
3
4
5
I_E (A)
6

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.

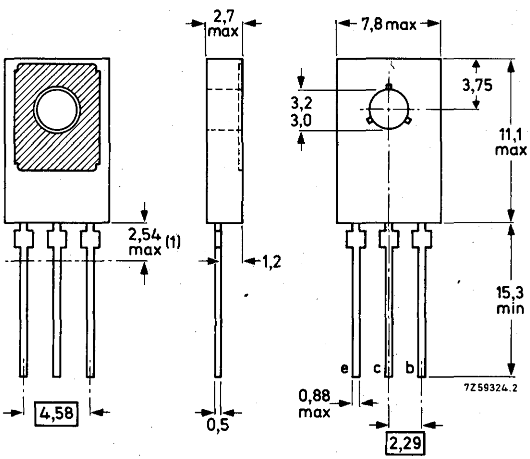
QUICK REFERENCE DATA

			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)

Voltages

			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
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 $T_j = 25\ ^oC$ 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; $T_j = 125\ ^oC$	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

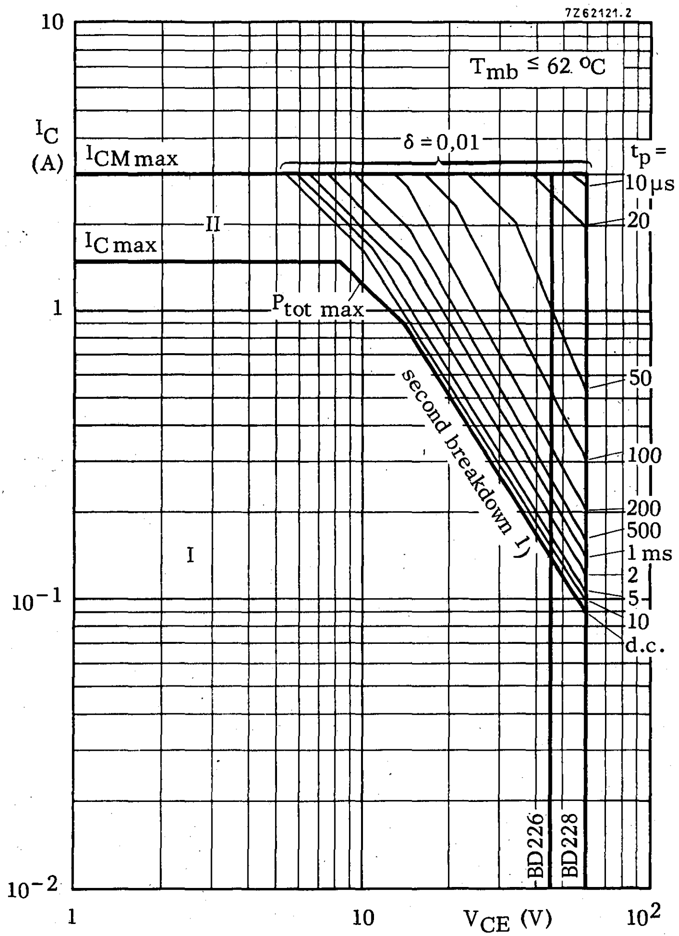
D.C. current gain ratio of matched pairs

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/^oC with increasing temperature.

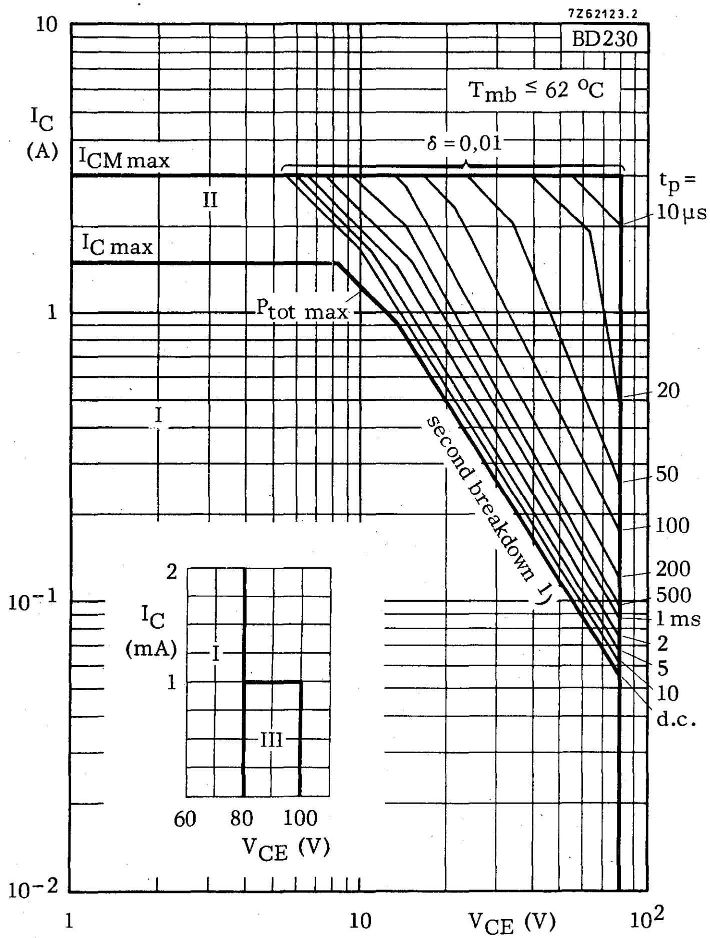


Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

1) Independent of temperature



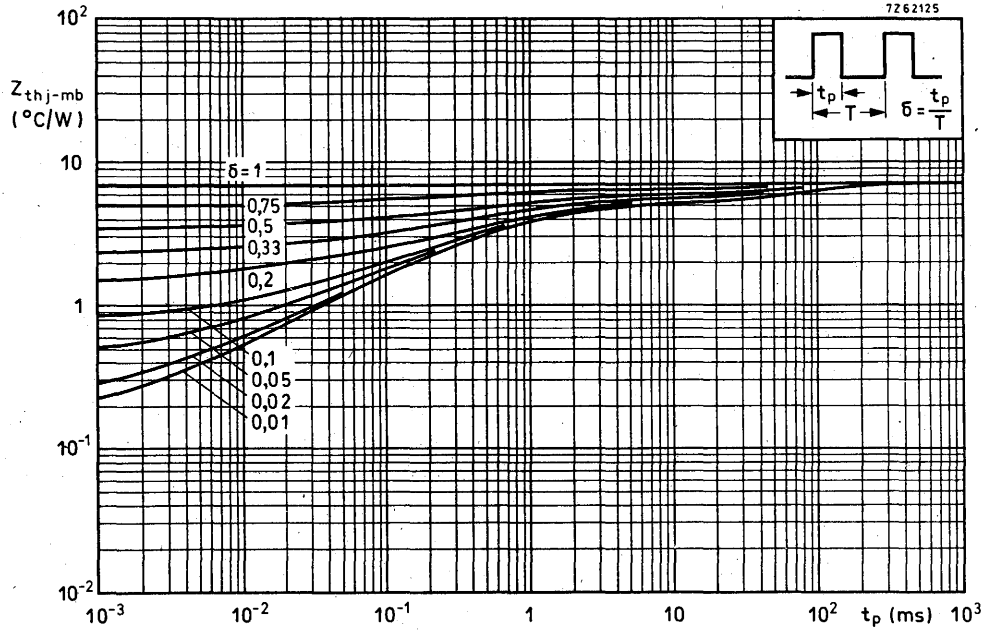
Safe Operating Area with the transistor forward biased

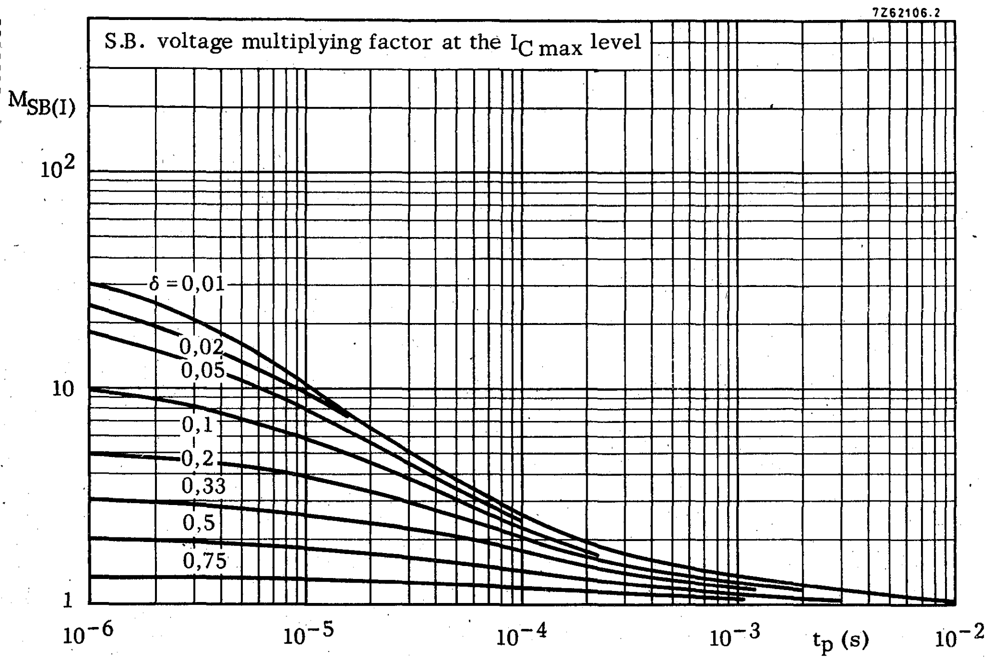
I Region of permissible d.c. operation

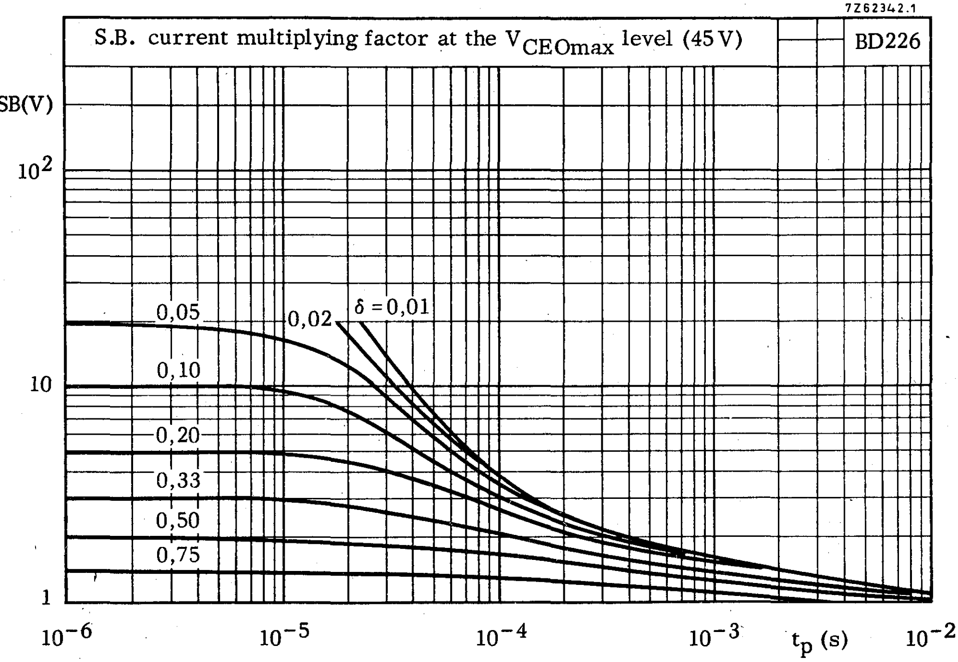
II Permissible extension for repetitive pulse operation

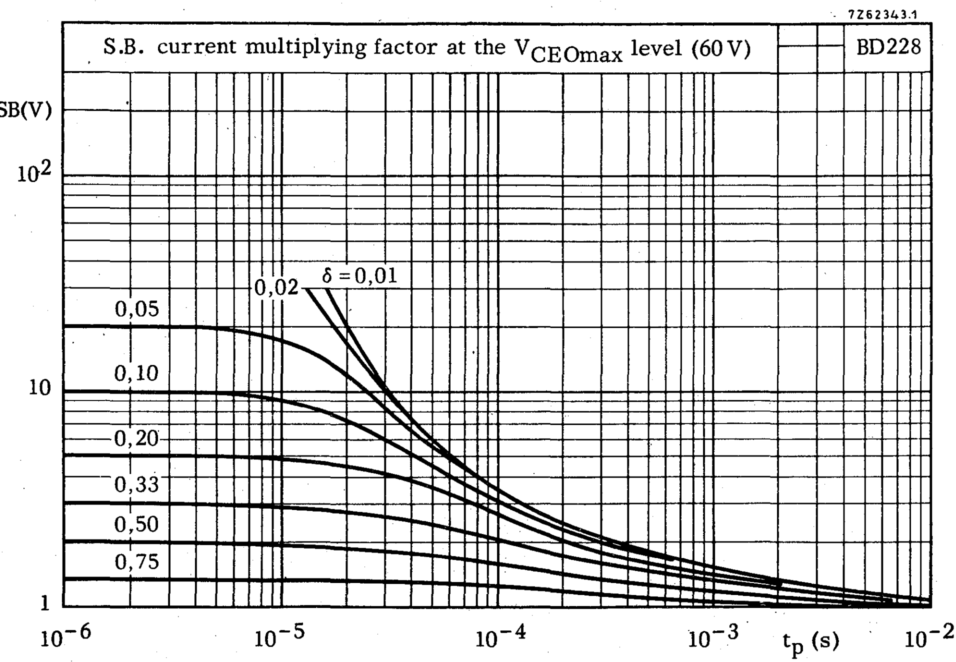
III Repetitive pulse operation in this region is allowable, provided $R_{BE} \leq 1$ kΩ

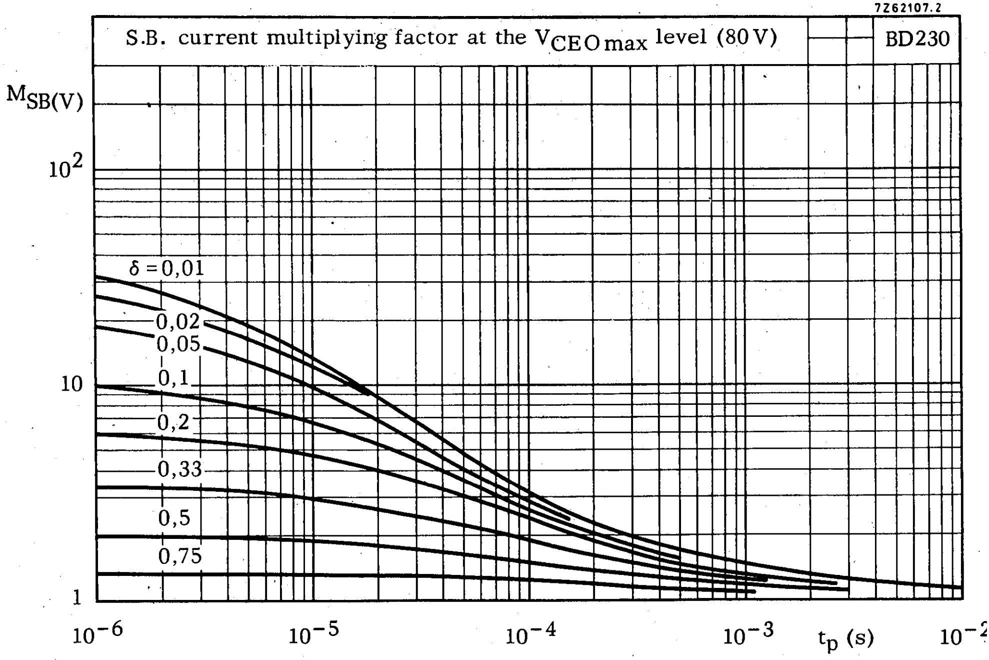
1) Independent of temperature

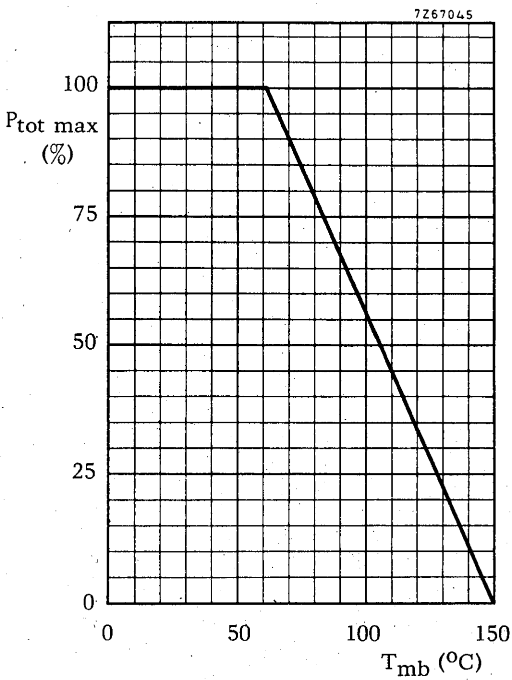

7Z62125
$Z_{th\,j\text{-}mb}$ (°C/W)
10^2
10
1
10^{-1}
10^{-2}
$\delta = 1$
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3

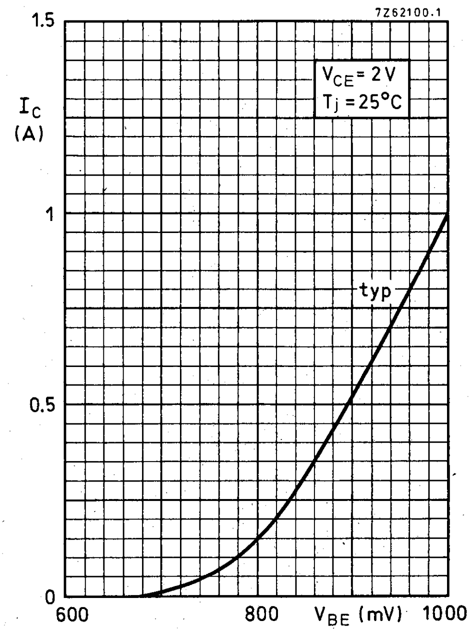

7Z62106.2
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
$\delta = 0,01$
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

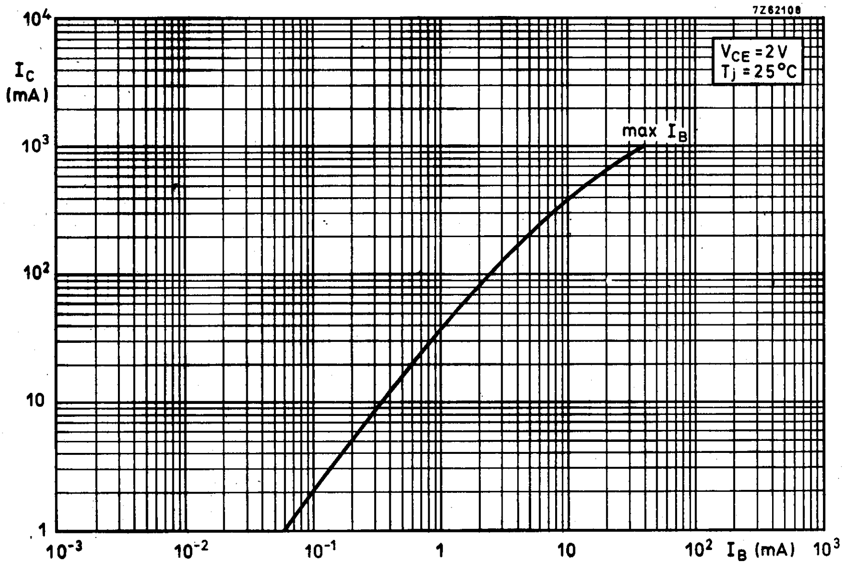

7Z62342.1
S.B. current multiplying factor at the V_{CEOmax} level (45 V)
BD226
SB(V)
10^2
10
1
0,05
0,02
$\delta = 0,01$
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

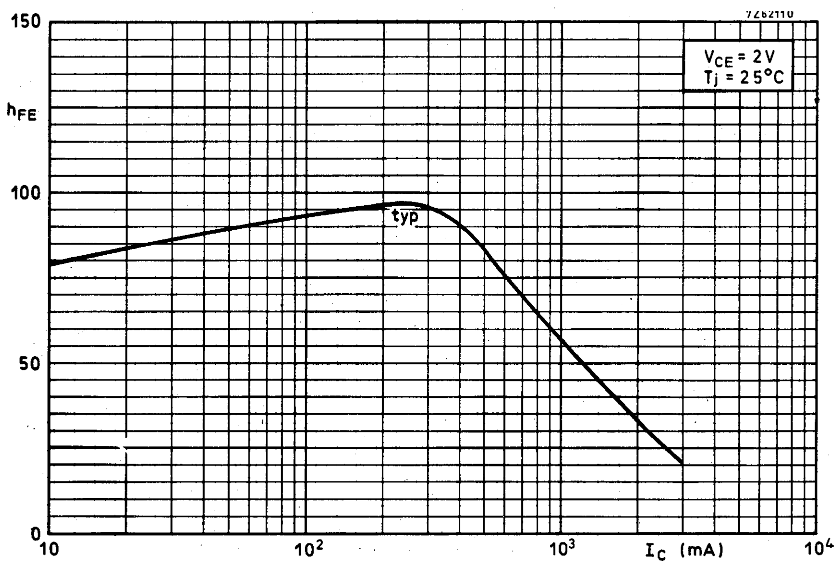

7Z62343.1
S.B. current multiplying factor at the V_{CEOmax} level (60 V)
BD228
SB(V)
10^2
10
1
0,02
$\delta = 0,01$
0,05
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

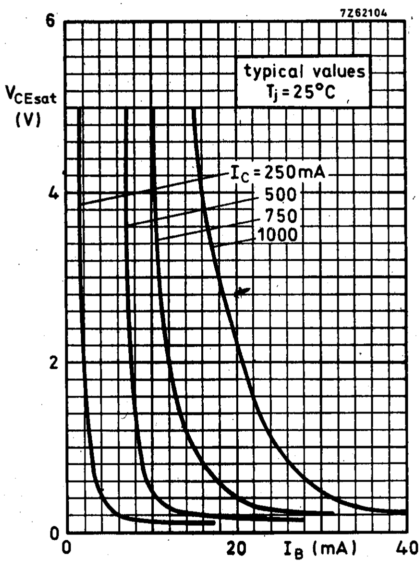

7Z62107.2
S.B. current multiplying factor at the $V_{CEO max}$ level (80 V)
BD230
$M_{SB(V)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

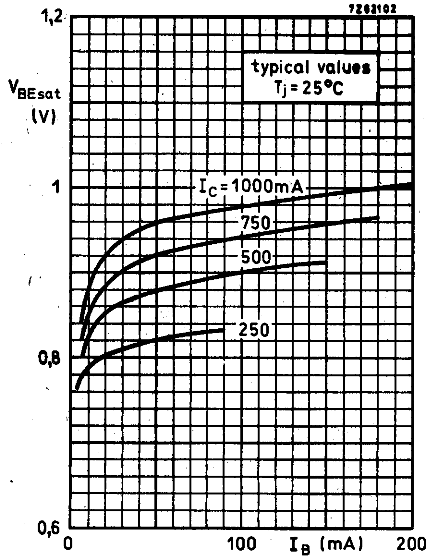

7Z67045
$P_{tot\ max}$ (%)
100
75
50
25
0
0
50
100
150
T_{mb} (°C)

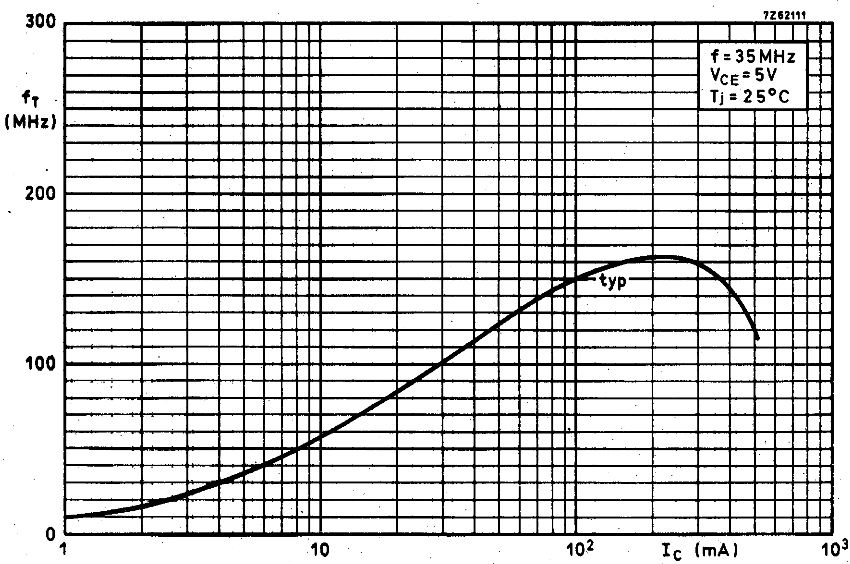

7Z62100.1
I_C (A)
1.5
1
0.5
0
V_{CE} = 2 V
T_j = 25°C
typ
600
800
V_{BE} (mV)
1000


7Z62108
$V_{CE} = 2 V$
$T_j = 25 °C$
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


7Z62110
$V_{CE} = 2 V$
$T_j = 25 °C$
h_{FE}
150
100
50
0
typ
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

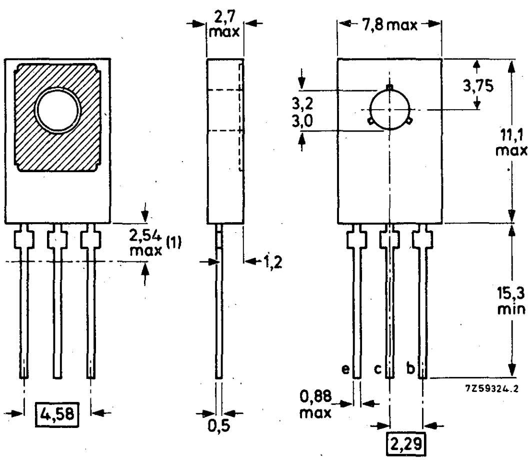
			BD227	BD229	BD231	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	$-V_{CER}$	max.	45	60	100	V
Collector current (peak value)	$-I_{CM}$	max.	3	3	3	A
Total power dissipation up 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

D.C. current gain

			BD227	BD229	BD231
$-I_C = 5$ 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

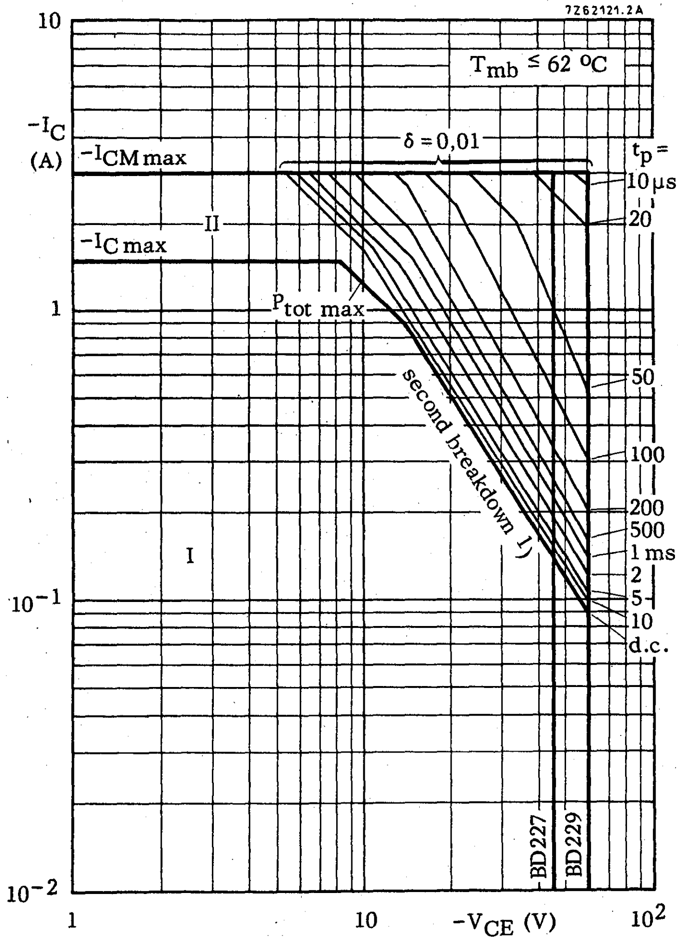
D.C. current gain ratio of matched pairs

BD226/BD227; BD228/BD229;

BD230/BD231

$\lvert I_C\rvert = 150$ 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.

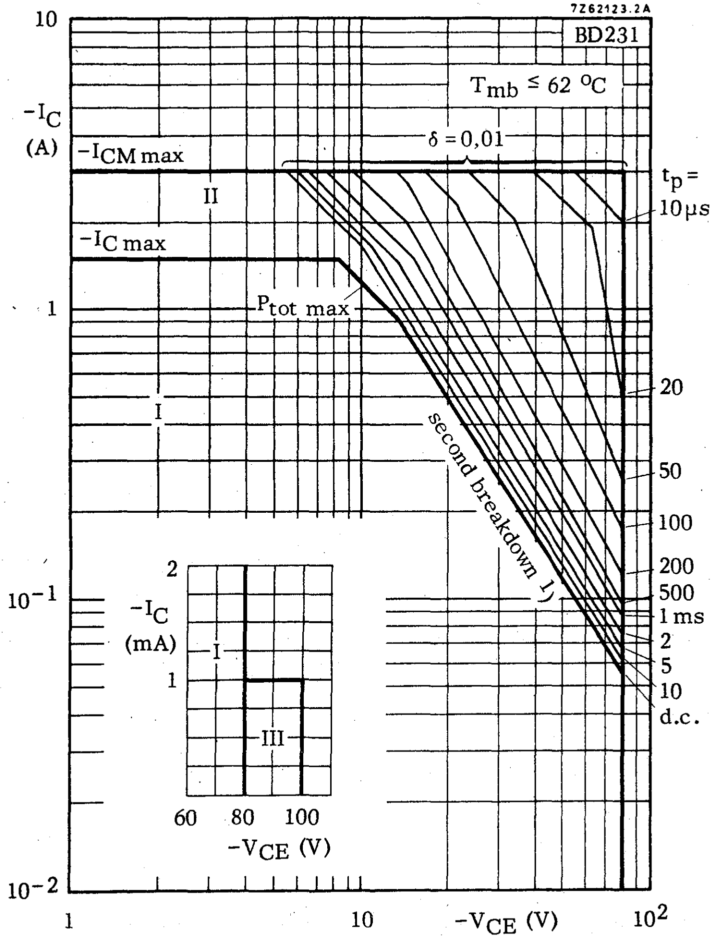


Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

1) Independent of temperature



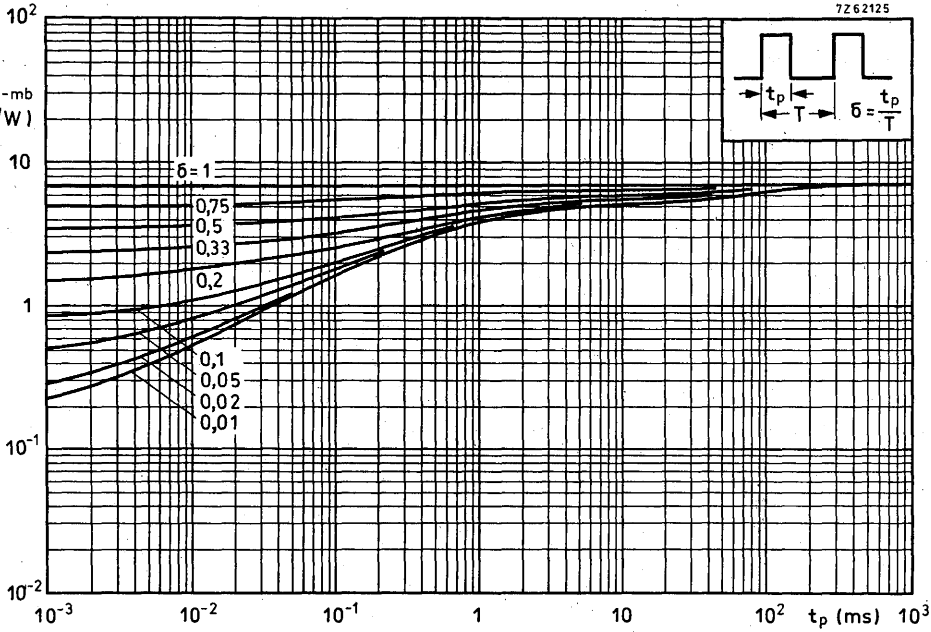
Safe Operating Area with the transistor forward biased

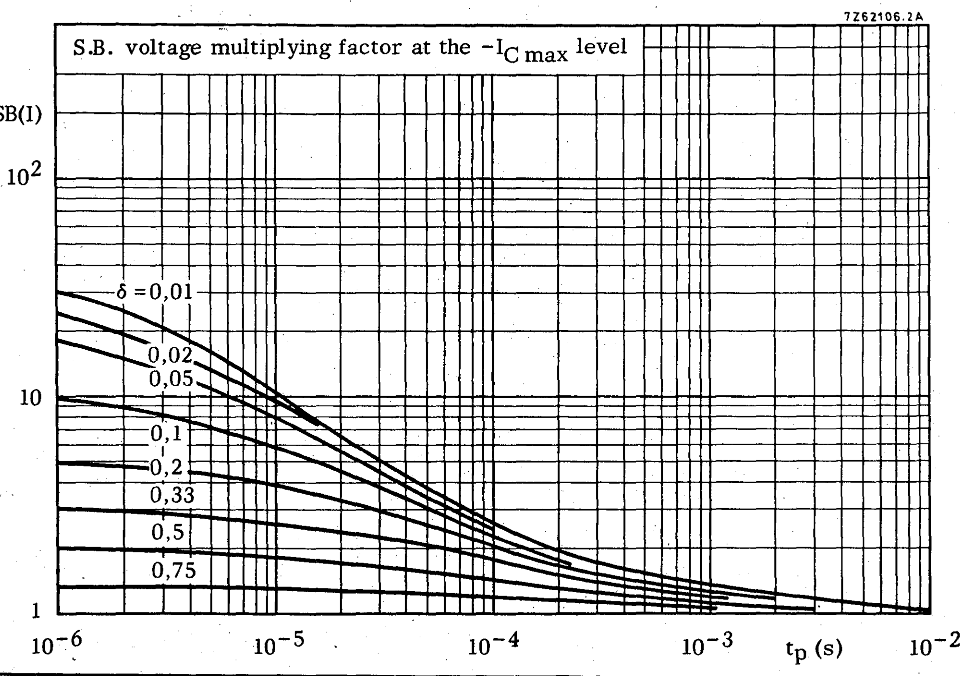
I Region of permissible d.c. operation

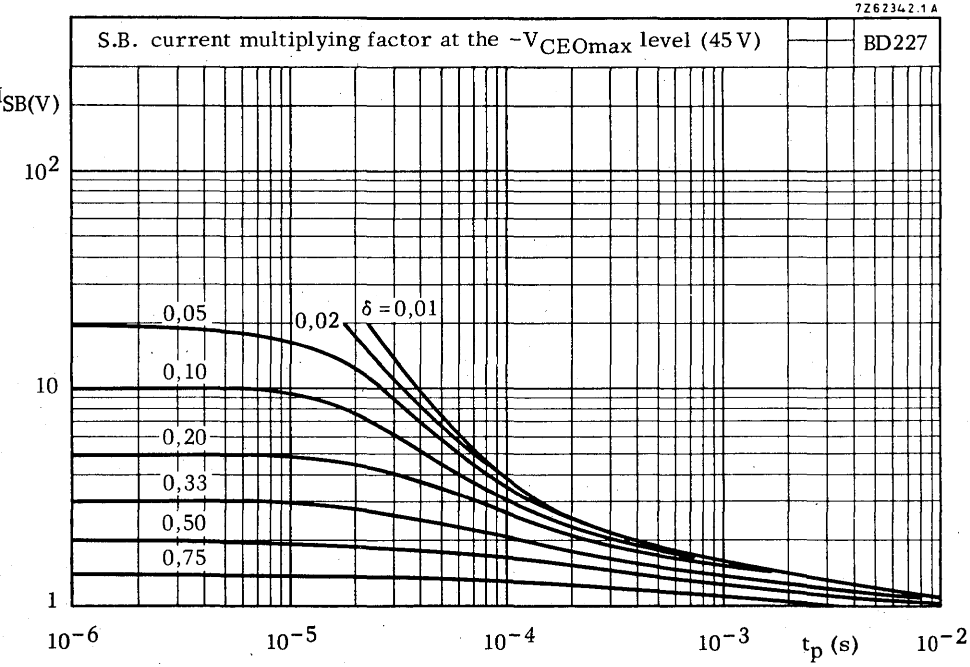
II Permissible extension for repetitive pulse operation

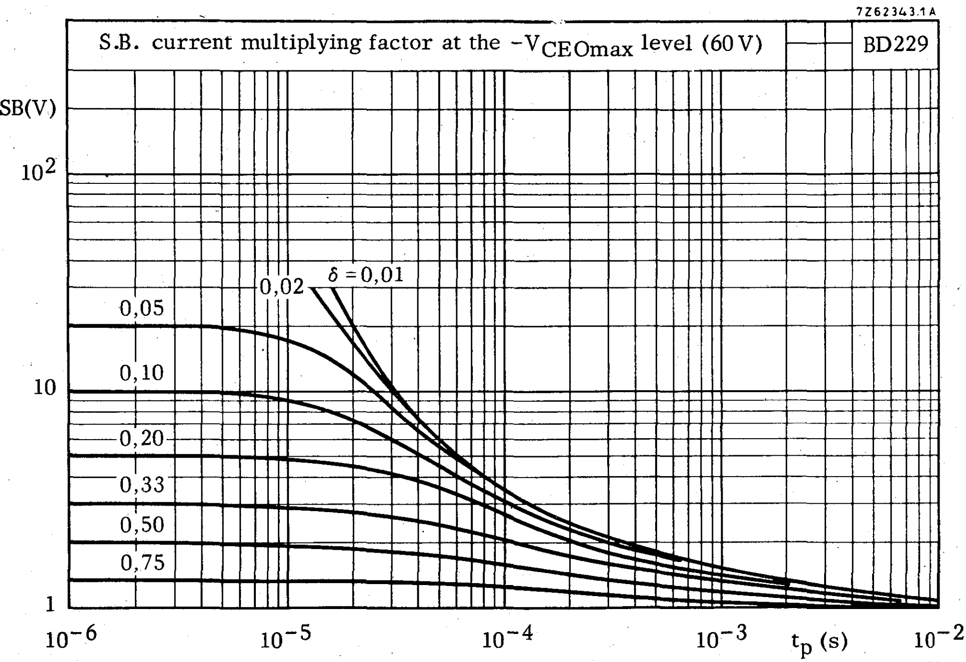
III Repetitive pulse operation in this region is allowable, provided $R_{BE} \leq 1\ k\Omega$

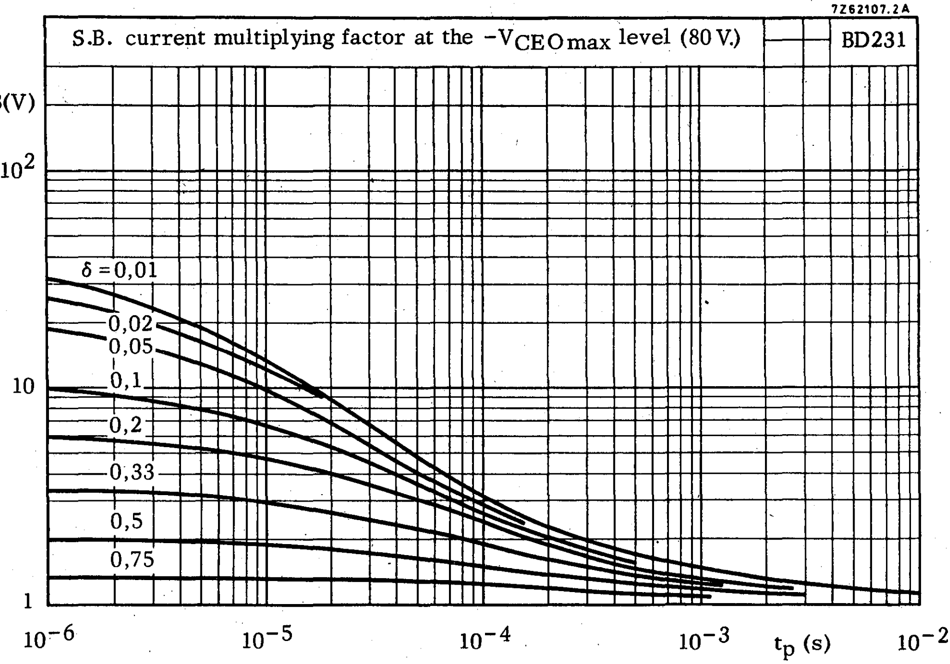
1) Independent of temperature

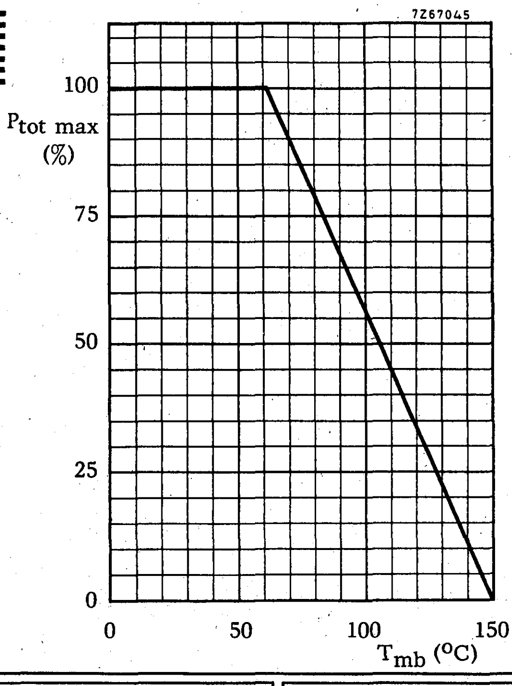

7Z62125
$Z_{th\,j\text{-}mb}$ (°C/W)
10^2
10
1
10^{-1}
10^{-2}
t_p
T
$\delta = \frac{t_p}{T}$
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3

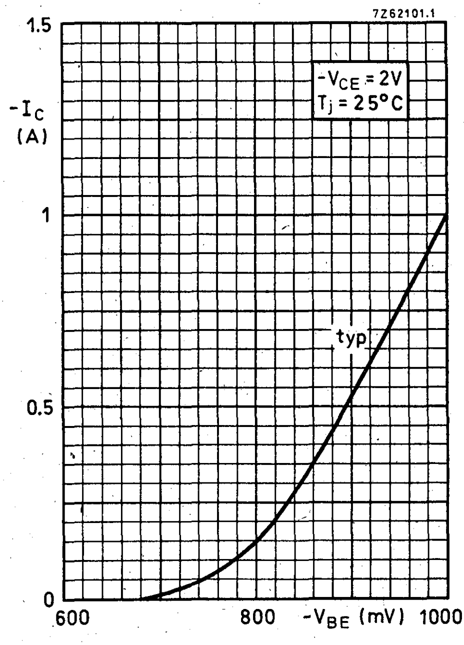

7Z62106.2A
S.B. voltage multiplying factor at the $-I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

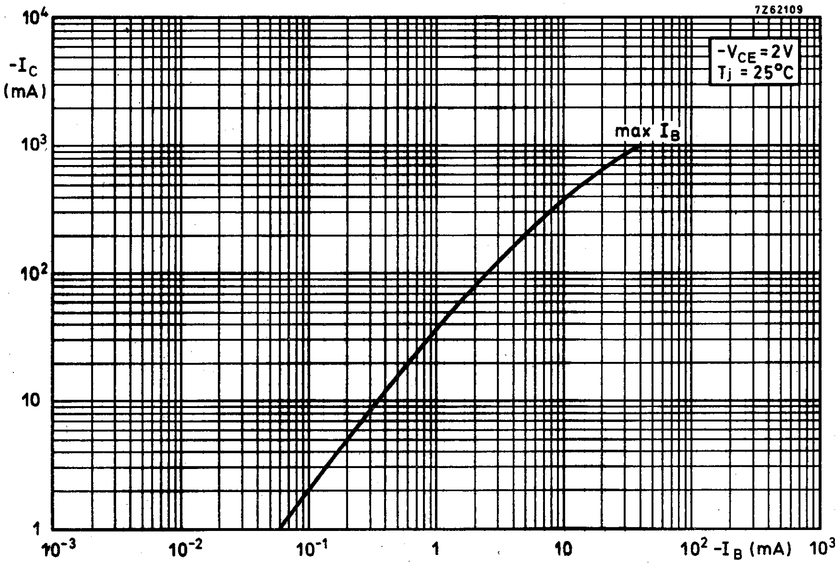

7Z62342.1 A
S.B. current multiplying factor at the $-V_{CEOmax}$ level (45 V)
BD227
$I_{SB(V)}$
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

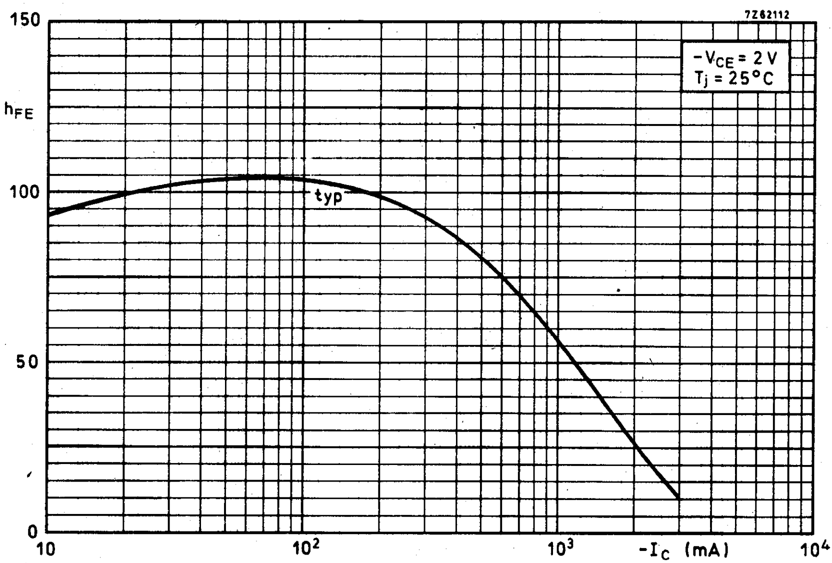

7Z62343.1 A
S.B. current multiplying factor at the $-V_{CEOmax}$ level (60 V)
BD229
$I_{SB(V)}$
10^2
10
1
0,02
δ = 0,01
0,05
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

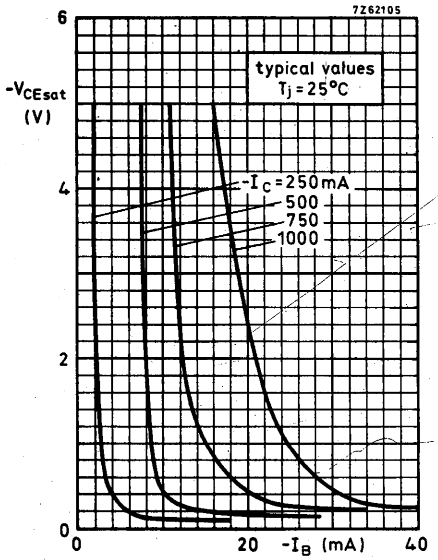

7Z62107.2A
S.B. current multiplying factor at the $-V_{CEO\,max}$ level (80 V.)
BD231
$M_{SB(V)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

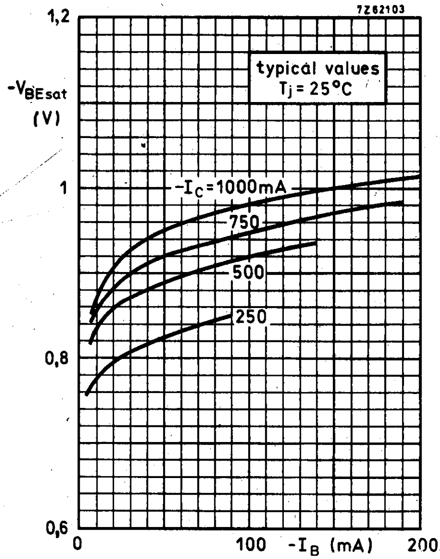

7Z67045
100
$P_{tot\,max}$ (%)
75
50
25
0
0
50
100
150
T_{mb} (°C)

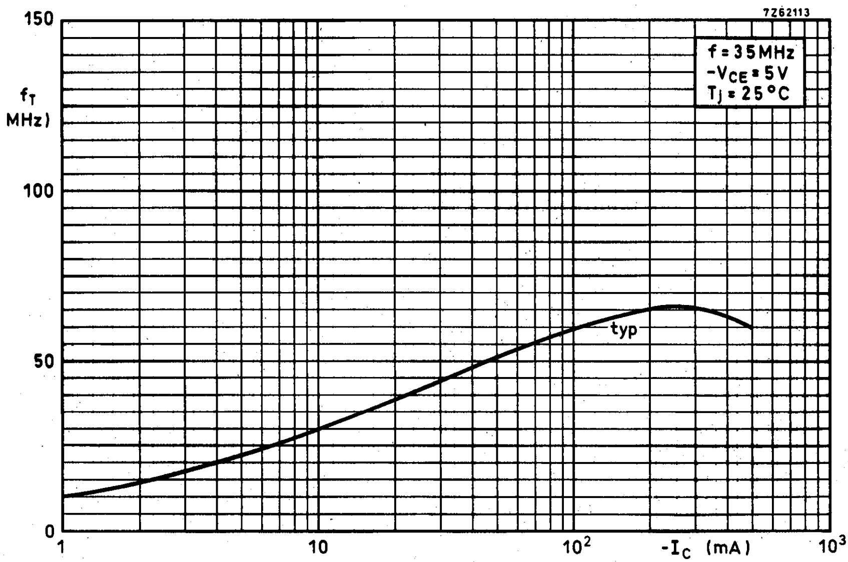

7Z62101.1
1.5
$-I_C$ (A)
1
0.5
0
$-V_{CE} = 2V$
$T_j = 25°C$
typ
600
800
$-V_{BE}$ (mV)
1000


7Z62109
$-V_{CE} = 2 V$
$T_j = 25 °C$
$-I_C$ (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


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


7Z62105
typical values
$T_j = 25°C$
$-V_{CEsat}$
(V)
$-I_C = 250 mA$
500
750
1000
6
4
2
0
0
20
40
$-I_B$ (mA)


7Z62103
typical values
$T_j = 25°C$
$-V_{BEsat}$
(V)
$-I_C = 1000 mA$
750
500
250
1,2
1
0,8
0,6
0
100
200
$-I_B$ (mA)


7Z62113
f = 35 MHz
$-V_{CE} = 5 V$
$T_j = 25°C$
f_T
MHz)
typ
150
100
50
0
1
10
10^2
10^3
$-I_C$ (mA)

SILICON DIFFUSED POWER TRANSISTOR

High-voltage n-p-n transistor in a SOT-32 plastic envelope intended for use as line driver in television receivers.

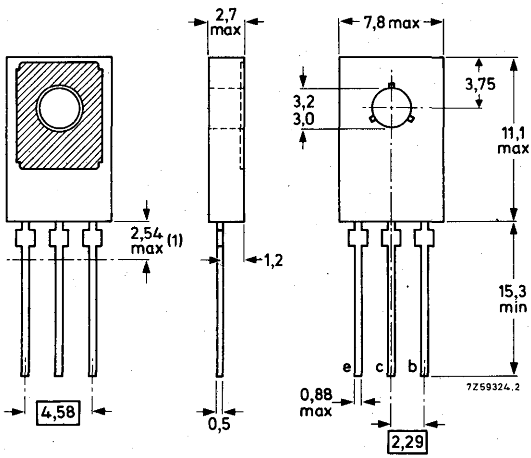
QUICK REFERENCE DATA				
Collector-emitter voltage ($R_{BE} \leq 1$ kΩ) peak value	V_{CERM}	max.	500	V
Collector-emitter voltage (open base)	V_{CEO}	max.	300	V
Collector current (d.c.)	I_C	max.	0,25	A
Collector current (peak value, $t_p \leq 1$ ms)	I_{CM}	max.	1	A
Total power dissipation up to T_{mb} = 57,5 °C	P_{tot}	max.	15	W
Junction temperature	T_j	max.	125	°C
D.C. current gain I_C = 150 mA; V_{CE} = 5 V	h_{FE}	>	20	
Transition frequency I_C = 50 mA; V_{CE} = 10 V	f_T	typ.	20	MHz

MECHANICAL DATA

Dimensions in mm

TO-126 (SOT-32)

Collector connected to metal part of mounting surface



For mounting instructions see section Accessories in handbook SC2, set 56333 for insulated mounting and type 56326 for non-insulated mounting.

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

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

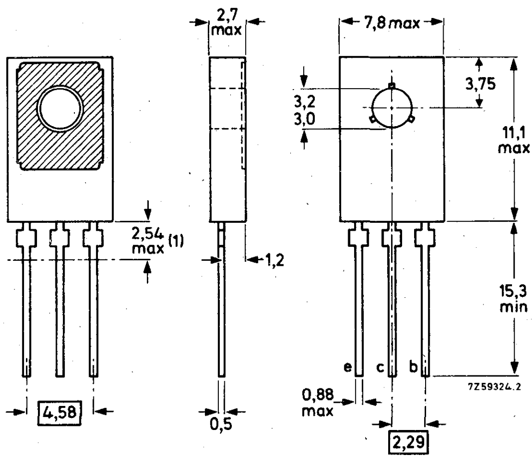
			BD233	BD235	BD237	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	V_{CER}	max.	45	60	100	V
Collector current (peak value)	I_{CM}	max.		6		A
Total power dissipation up to T_{mb} = 25 °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

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

			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

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

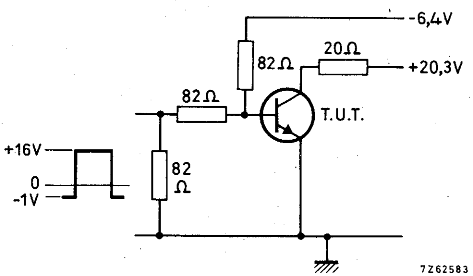
$I_C = 0$; V_{EB} = 5 V	I_{EBO}	<	1	mA

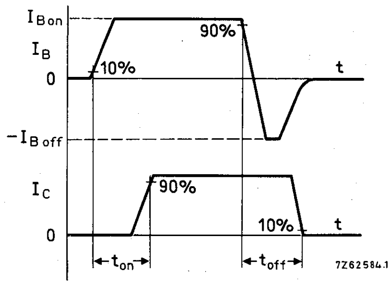
CHARACTERISTICS (continued)

$T_j = 25\ ^oC$

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			
$\lvert I_C \rvert = 150$ 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	1,1 μs

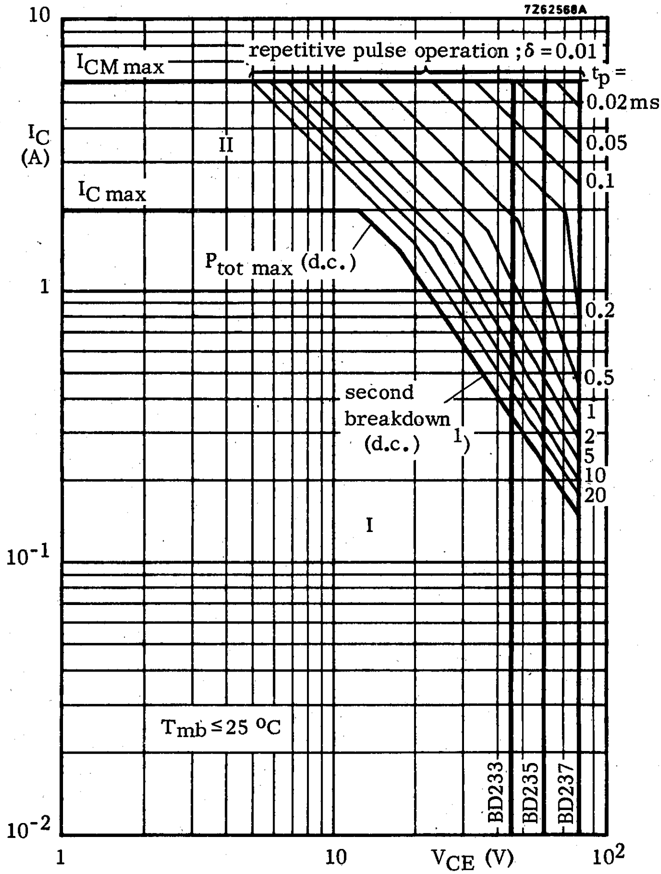
Test circuit





Input pulse:

$t_r = t_f = 15$ ns
$t_p = 10$ μs
$T = 500$ μs

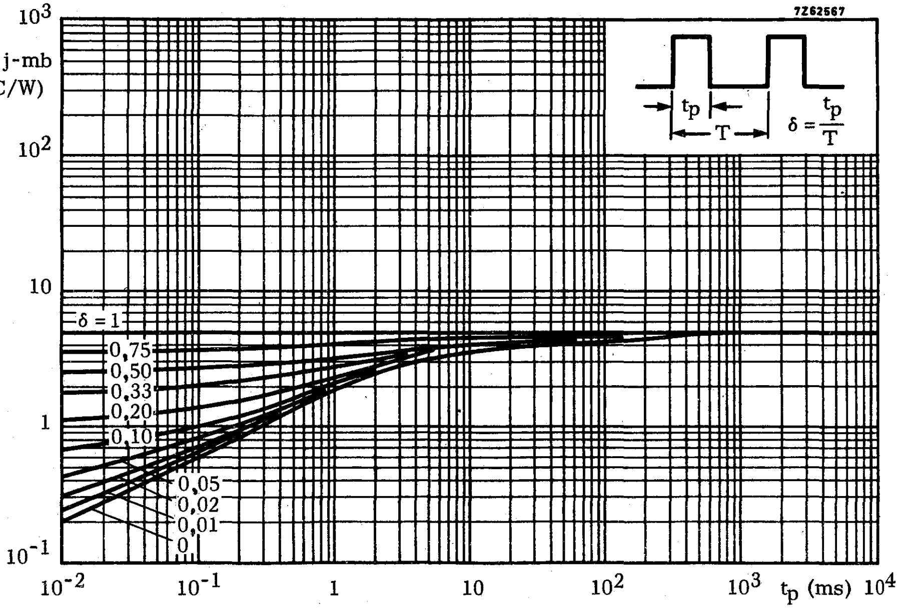


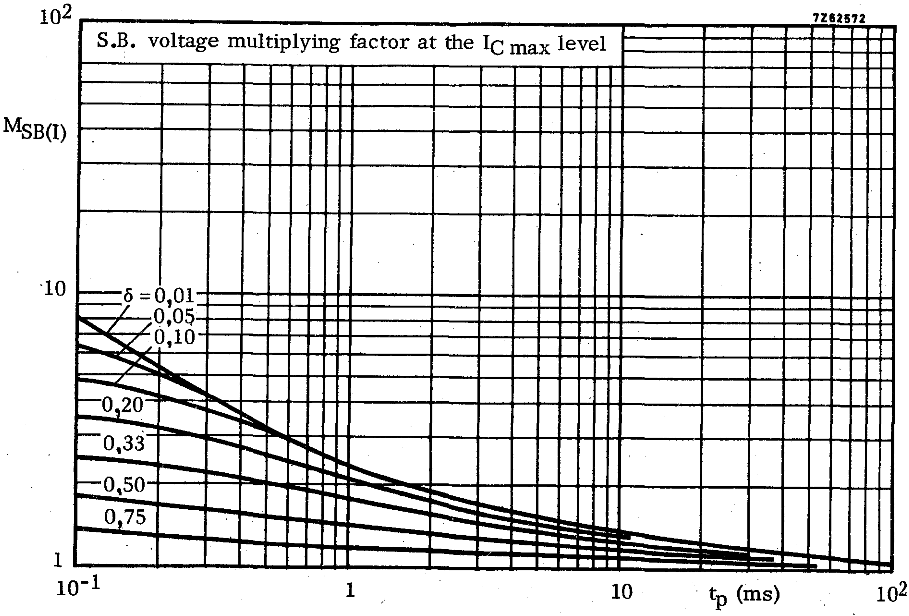
Safe Operating Area with the transistor forward biased

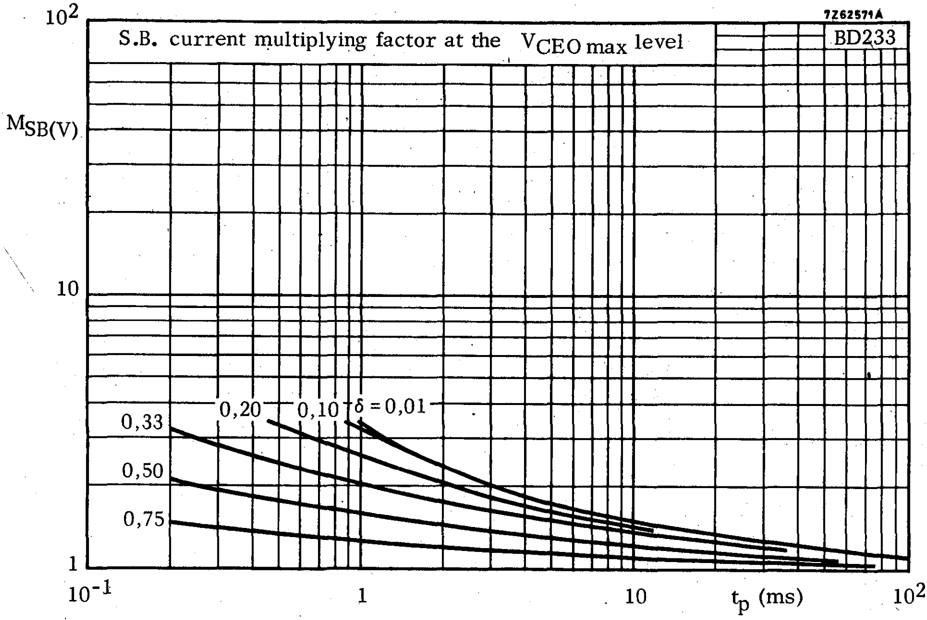
I Region of permissible d.c. operation

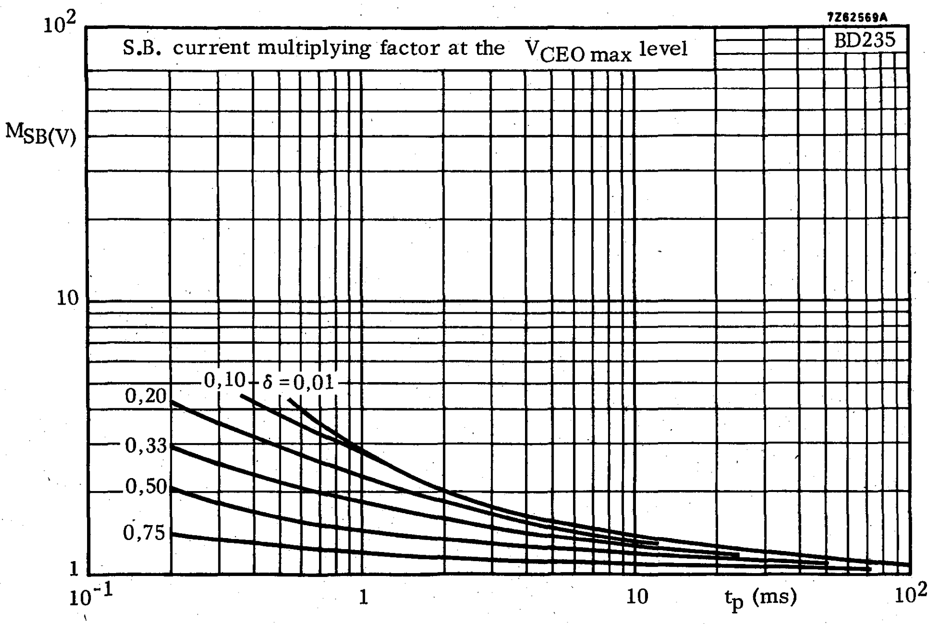
II Permissible extension for repetitive pulse operation

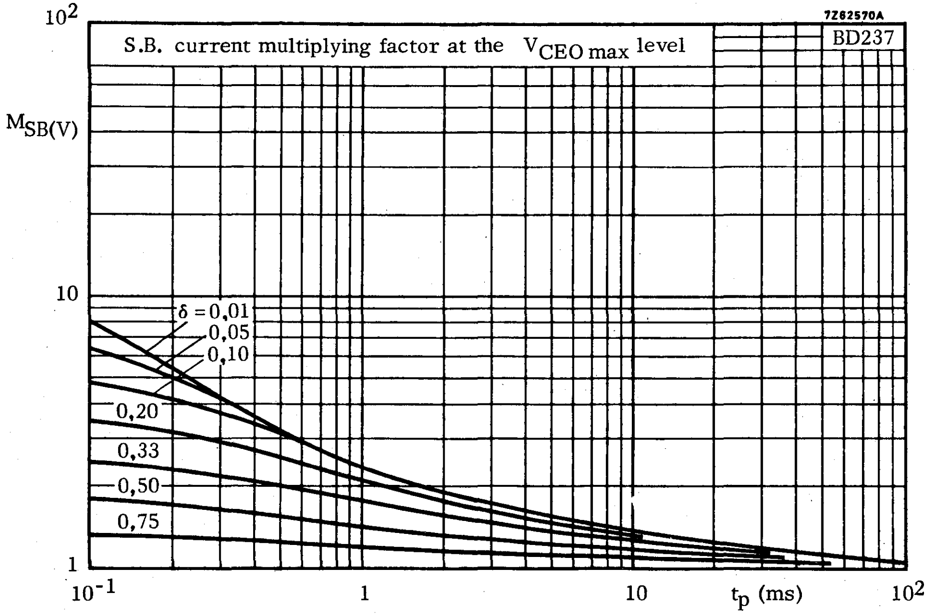
1) Independent of temperature

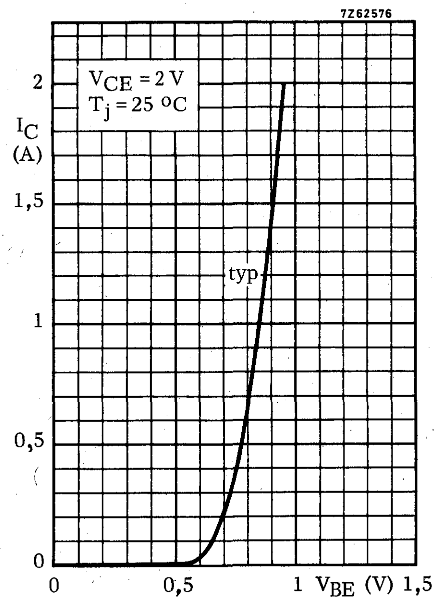

7Z62567
$Z_{th\ j-mb}$ ($^oC/W$)
10^3
10^2
10
1
10^{-1}
t_p
T
$\delta = \frac{t_p}{T}$
$\delta = 1$
0,75
0,50
0,33
0,20
0,10
0,05
0,02
0,01
0
10^{-2}
10^{-1}
1
10
10^2
10^3
t_p (ms)
10^4

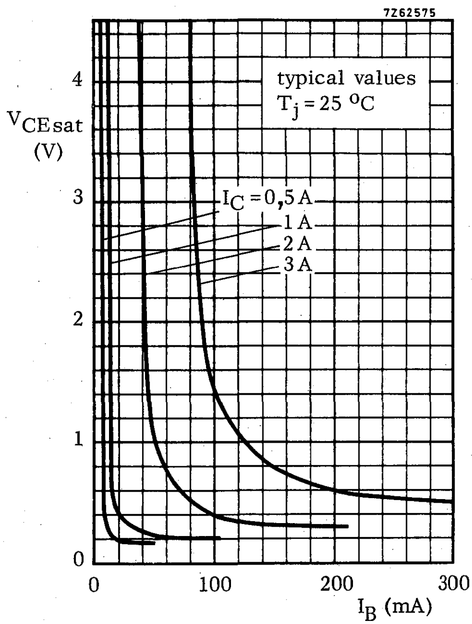

7Z62572
S.B. voltage multiplying factor at the $I_{C\ max}$ level
$M_{SB(I)}$
10^2
10
1
$\delta = 0,01$
0,05
0,10
0,20
0,33
0,50
0,75
10^{-1}
1
10
t_p (ms)
10^2

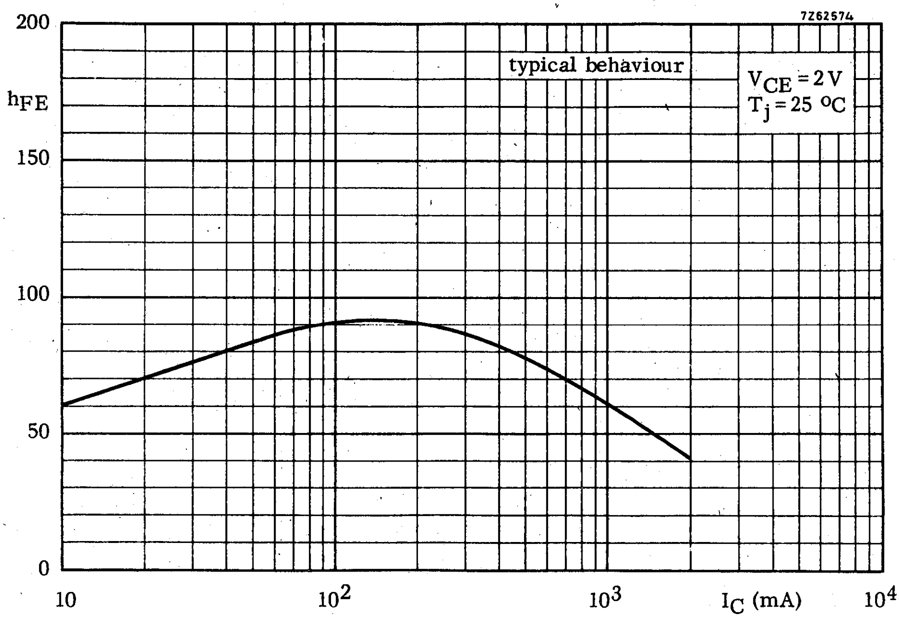

7Z62571A
S.B. current multiplying factor at the $V_{CEO\,max}$ level
BD233
$M_{SB(V)}$
10^2
10
1
0,33
0,20
0,10
$\delta = 0,01$
0,50
0,75
10^{-1}
1
10
t_p (ms)
10^2


7Z62569A
S.B. current multiplying factor at the $V_{CEO\,max}$ level
BD235
$M_{SB(V)}$
10^2
10
1
0,20
0,10
$\delta = 0,01$
0,33
0,50
0,75
10^{-1}
1
10
t_p (ms)
10^2


7Z62570A
S.B. current multiplying factor at the $V_{CEO\,max}$ level
BD237
10^2
$M_{SB(V)}$
10
1
$\delta = 0{,}01$
0,05
0,10
0,20
0,33
0,50
0,75
10^{-1}
1
10
t_p (ms)
10^2


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


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)


7Z62574
typical behaviour
$V_{CE} = 2\,V$
$T_j = 25\,^{\circ}C$
h_{FE}
200
150
100
50
0
10
10^2
10^3
I_C (mA)
10^4

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

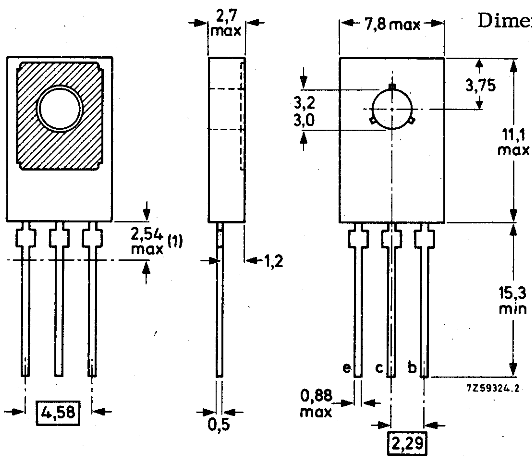
			BD234	BD236	BD238	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	$-V_{CER}$	max.	45	60	100	V
Collector current (peak value)	$-I_{CM}$	max.		6		A
Total power dissipation up to 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

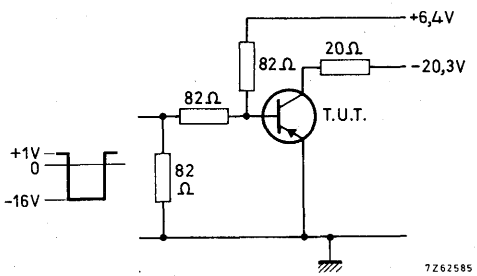
$I_C = 0;\ -V_{EB} = 5$ V	$-I_{EBO}$	<	1	mA

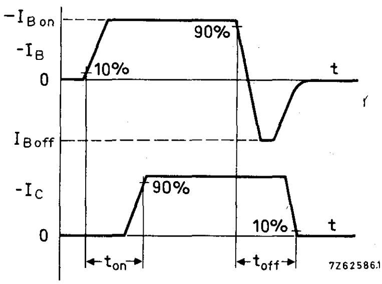
CHARACTERISTICS (continued)

$T_j = 25\ ^oC$

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			
$\lvert I_C \rvert = 150$ 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

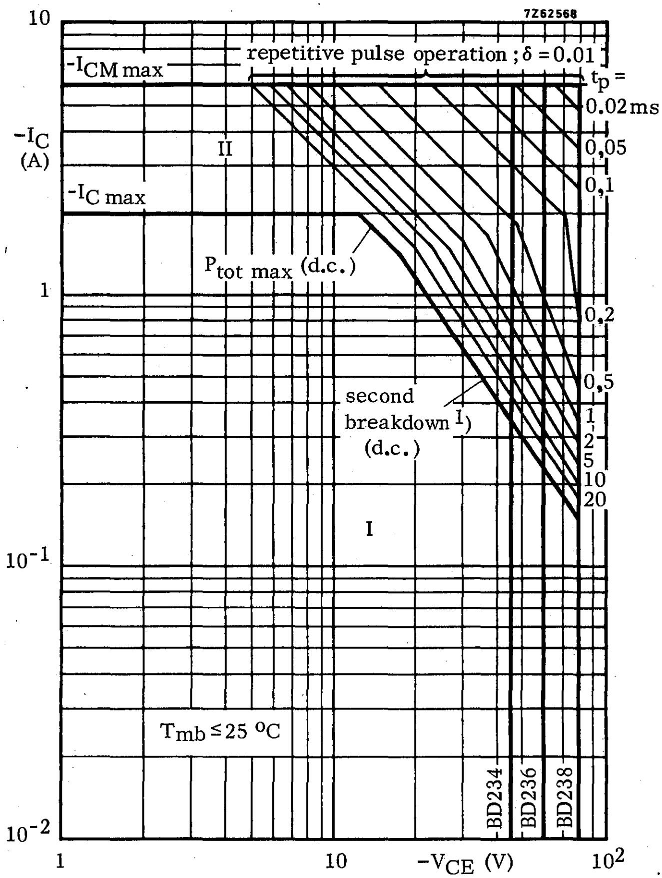
Test circuit





Input pulse:

$t_r = t_f = 15$ ns
$t_p = 10$ µs
$T = 500$ µs

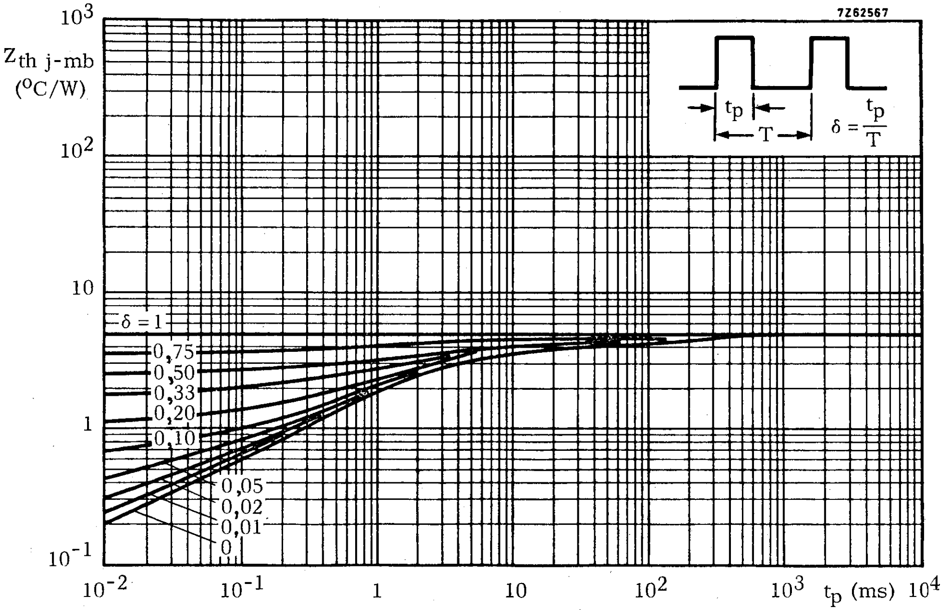


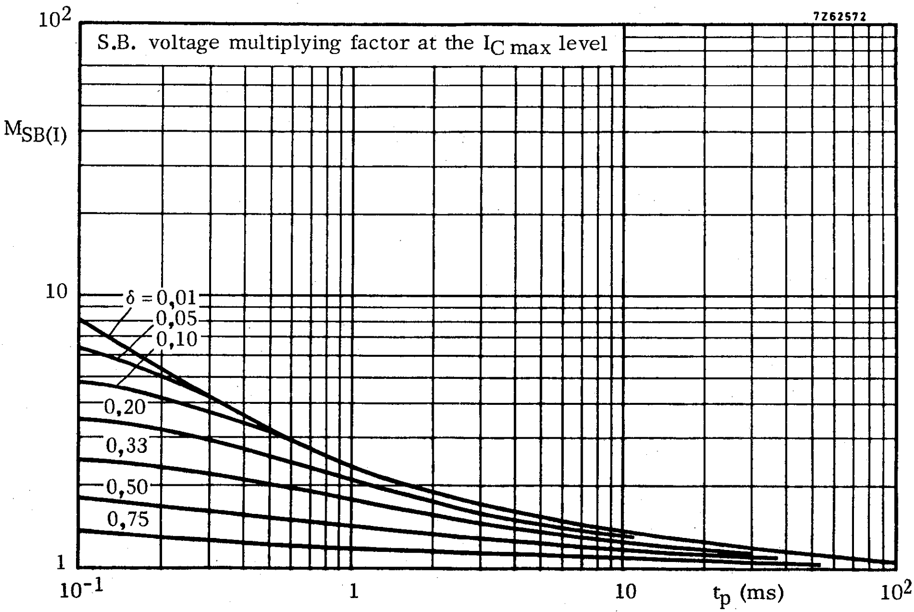
Safe Operating Area with the transistor forward biased

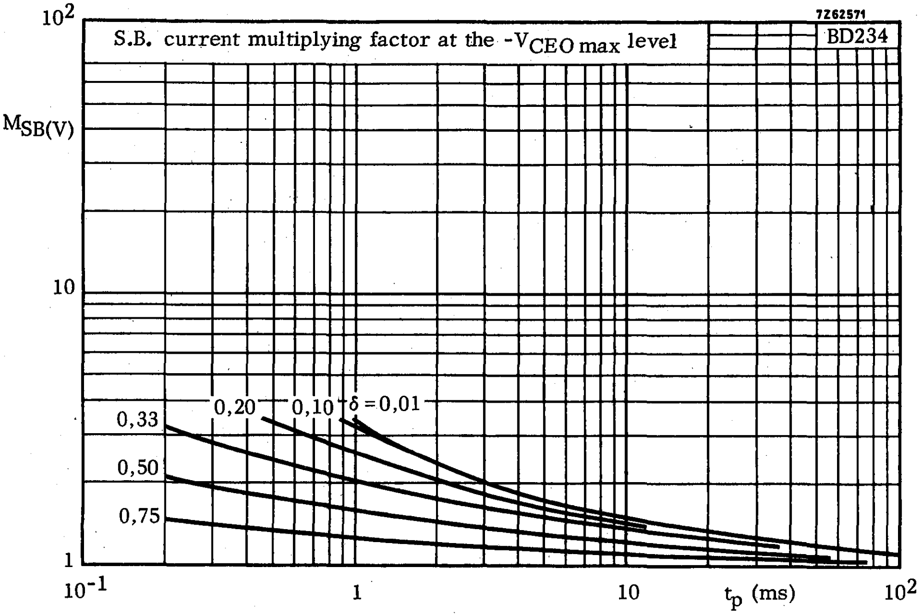
I Region of permissible d.c. operation

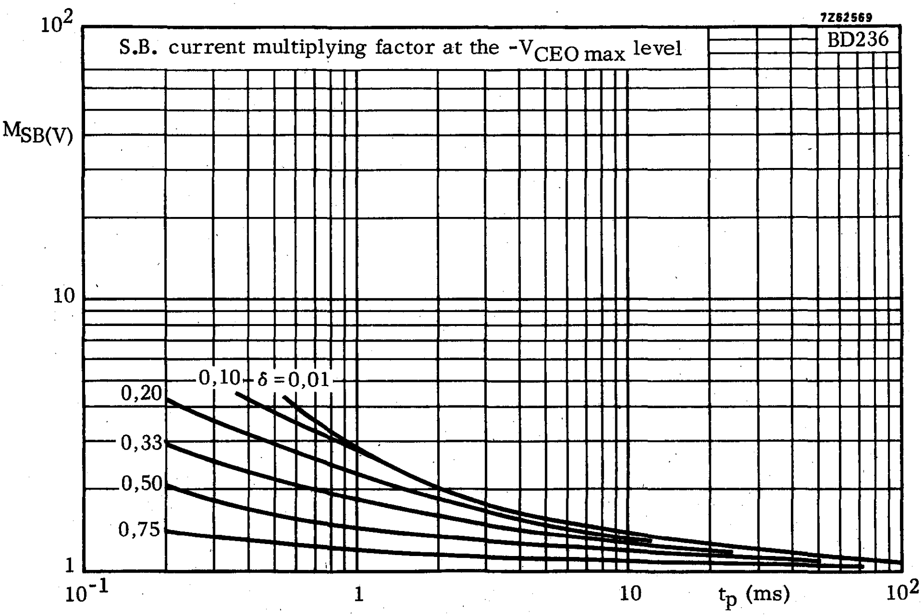
II Permissible extension for repetitive pulse operation

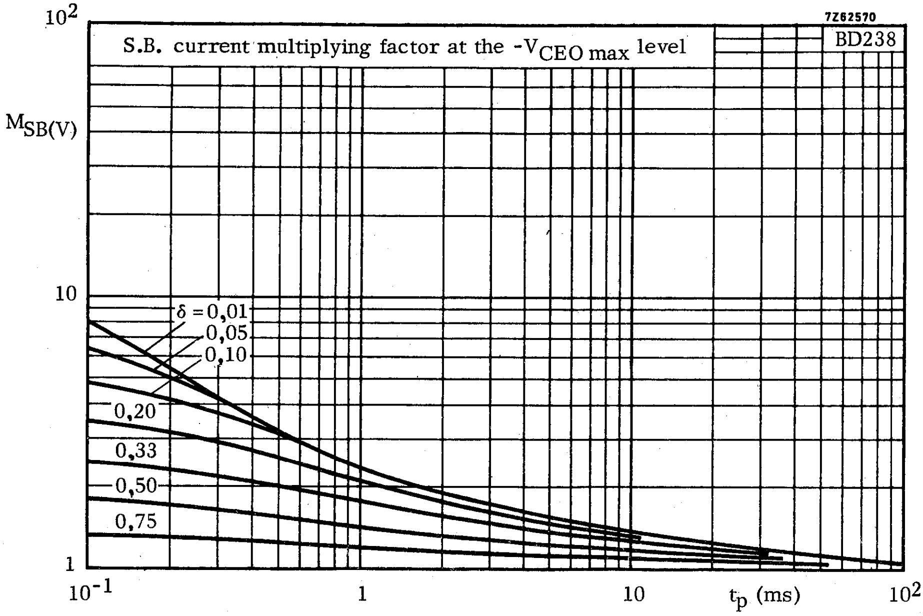
1) Independent of temperature.

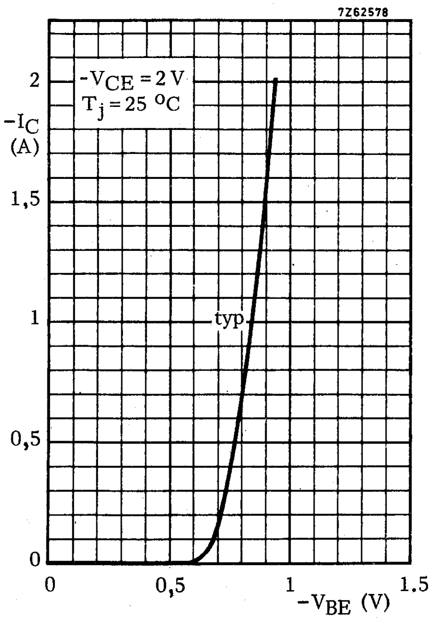

7Z62567
$Z_{th\ j\text{-}mb}$ ($^{o}C/W$)
10^3
10^2
10
1
10^{-1}
$\delta = 1$
0,75
0,50
0,33
0,20
0,10
0,05
0,02
0,01
0
t_p
T
$\delta = \frac{t_p}{T}$
10^{-2}
10^{-1}
1
10
10^2
10^3
t_p (ms)
10^4

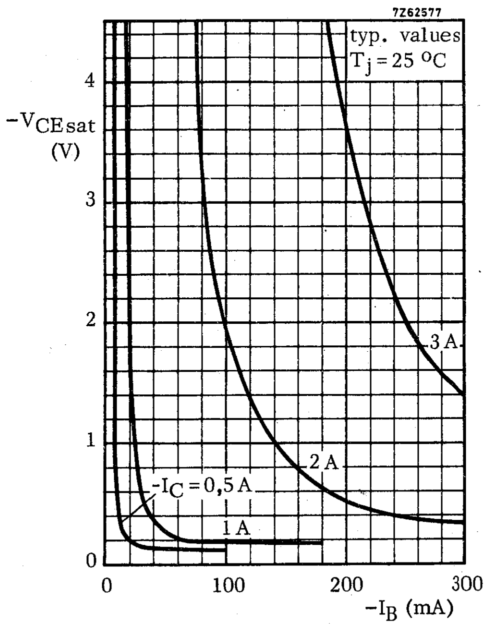

7Z62572
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
$\delta = 0,01$
0,05
0,10
0,20
0,33
0,50
0,75
10^{-1}
1
10
t_p (ms)
10^2

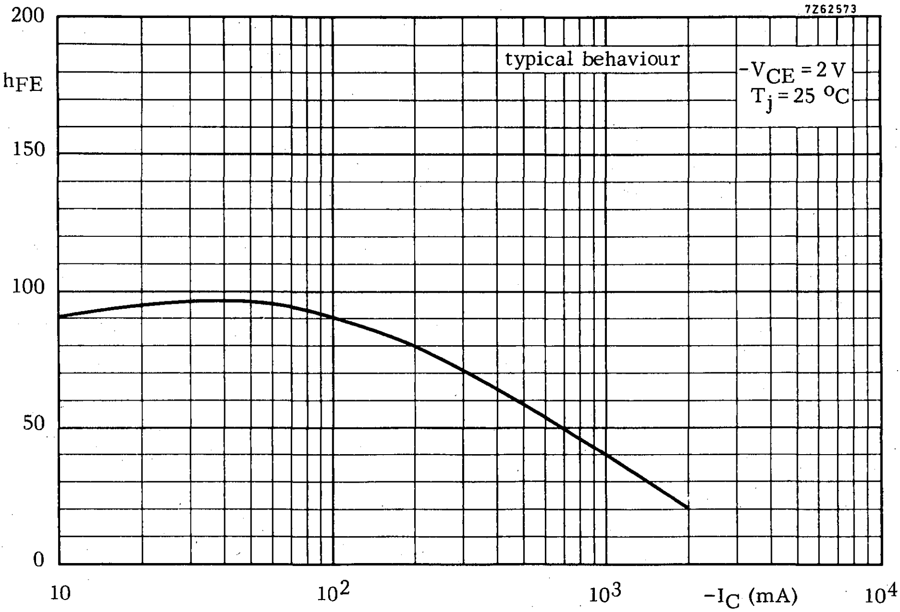

7Z62571
S.B. current multiplying factor at the $-V_{CEO\,max}$ level
BD234
10^2
$M_{SB(V)}$
10
1
0,33
0,50
0,75
0,20
0,10
δ = 0,01
10^{-1}
1
10
t_p (ms)
10^2


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


7Z62570
S.B. current multiplying factor at the $-V_{CEO\,max}$ level
BD238
10^2
$M_{SB(V)}$
10
1
$\delta = 0,01$
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)


7Z62573
typical behaviour
$-V_{CE} = 2$ V
$T_j = 25$ °C
h_{FE}
200
150
100
50
0
10
10^2
10^3
$-I_C$ (mA)
10^4

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

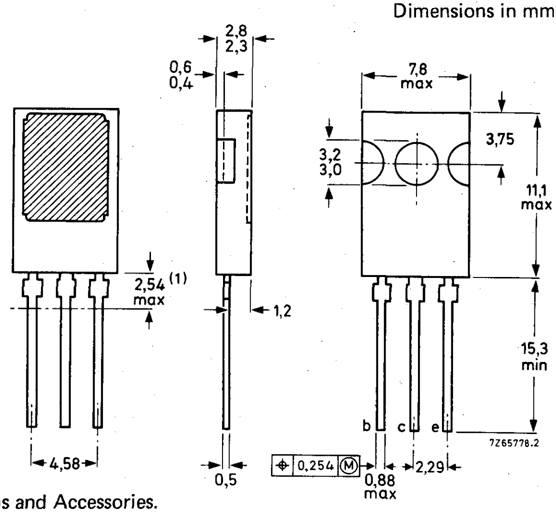
			BD291	BD293	BD295	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	80	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Collector-current (d.c.)	I_C	max.		6		A
Collector-current (peak) $t_p < 10$ ms; $\delta < 0,1$	I_{CM}	max.		10		A
Base current (d.c.)	I_B	max.		2,5		A
Total power dissipation up to $T_{mb} = 25\ ^oC$	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



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)

			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 °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; $V_{CE} = 3$ 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		typ.	1,3
$I_C = 1$ A; $V_{CE} = 2$ V	h_{FE1}/h_{FE2}	<	2,5

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

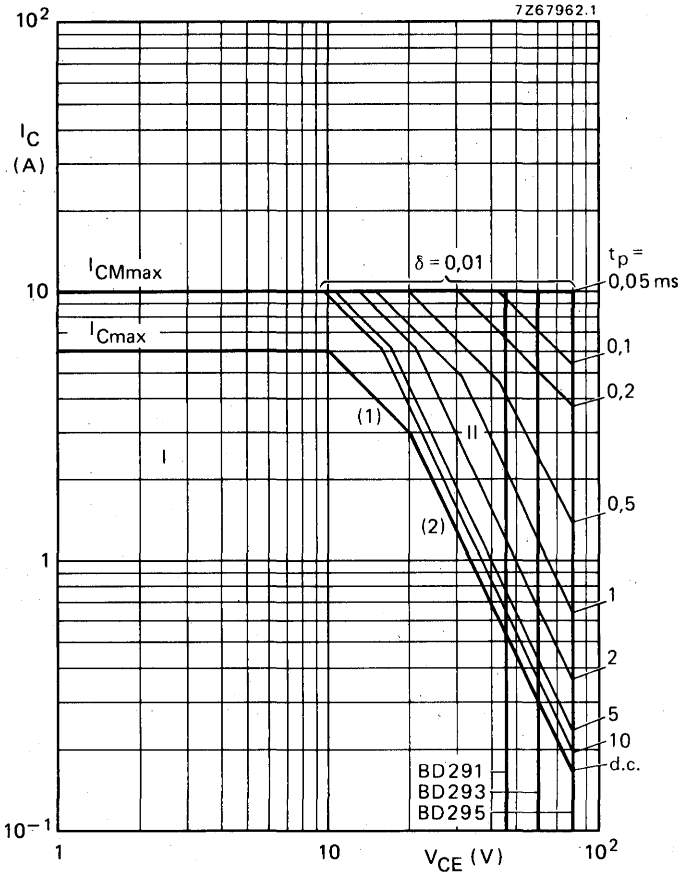


Fig. 2 Safe Operating Area with the transistor forward biased, $T_{mb} \leq 25\ ^{o}C$.

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

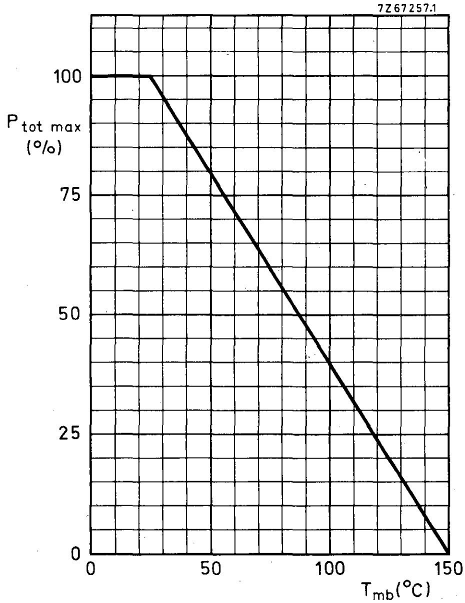


Fig. 3 Power derating curve.

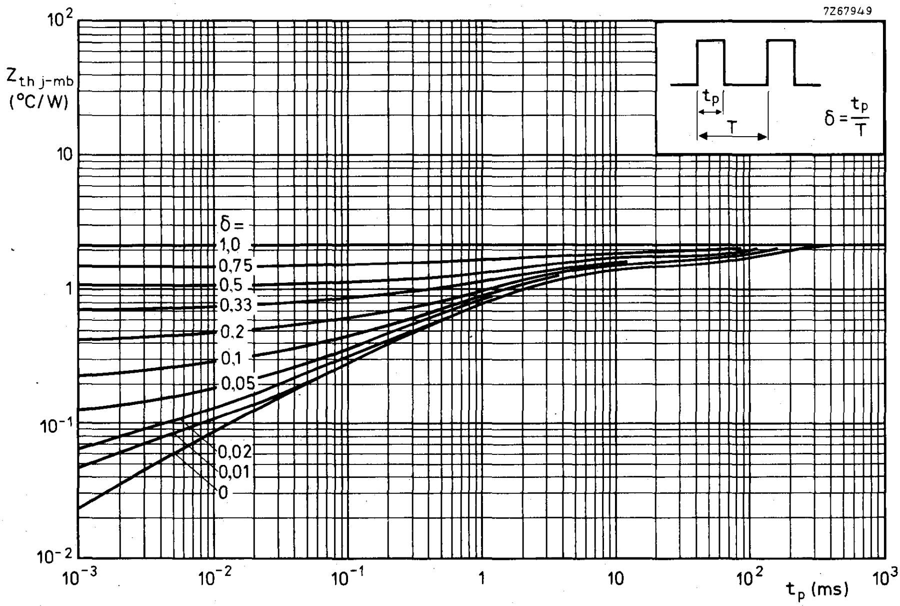


Fig. 4 Pulse power rating chart.

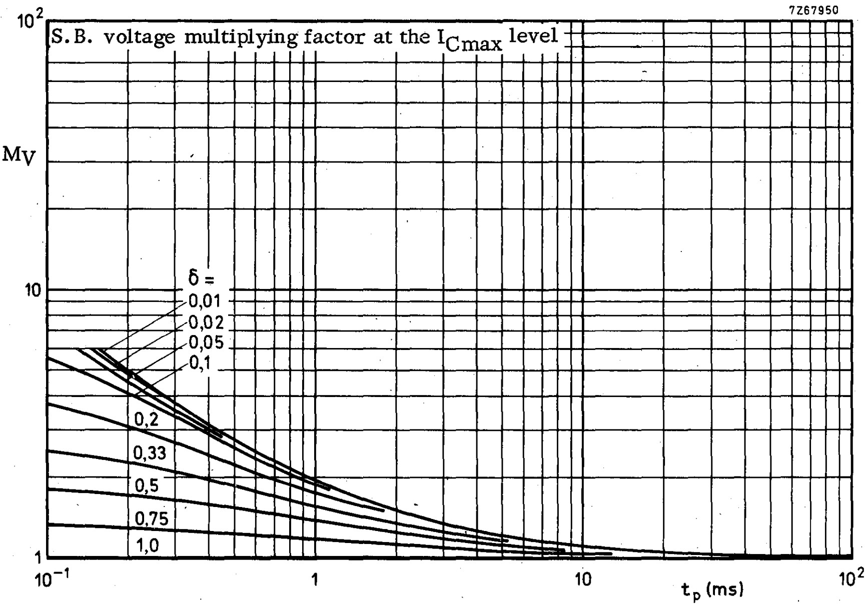


Fig. 5 Second breakdown voltage multiplying factor at the $I_{C\,max}$ level.

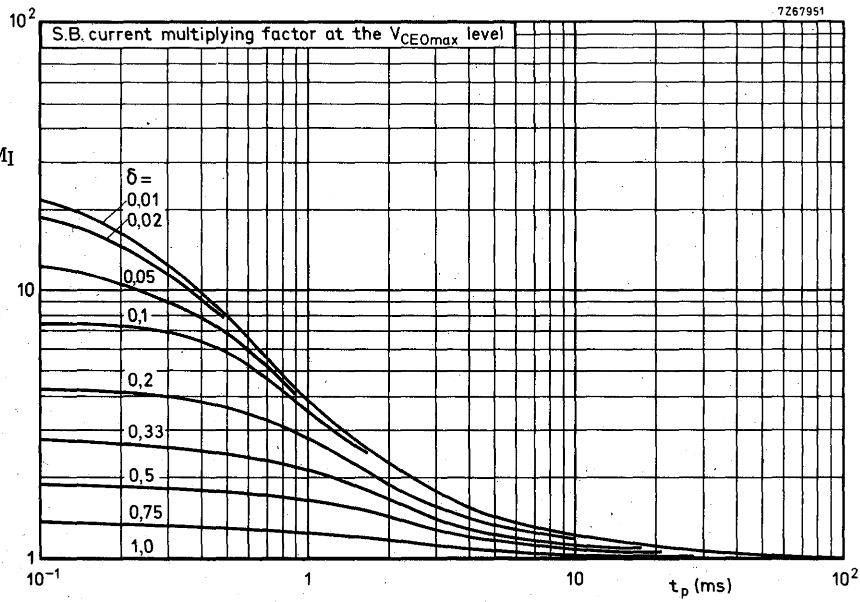


Fig. 6 Second breakdown current multiplying factor at the $V_{CEO\,max}$ level.

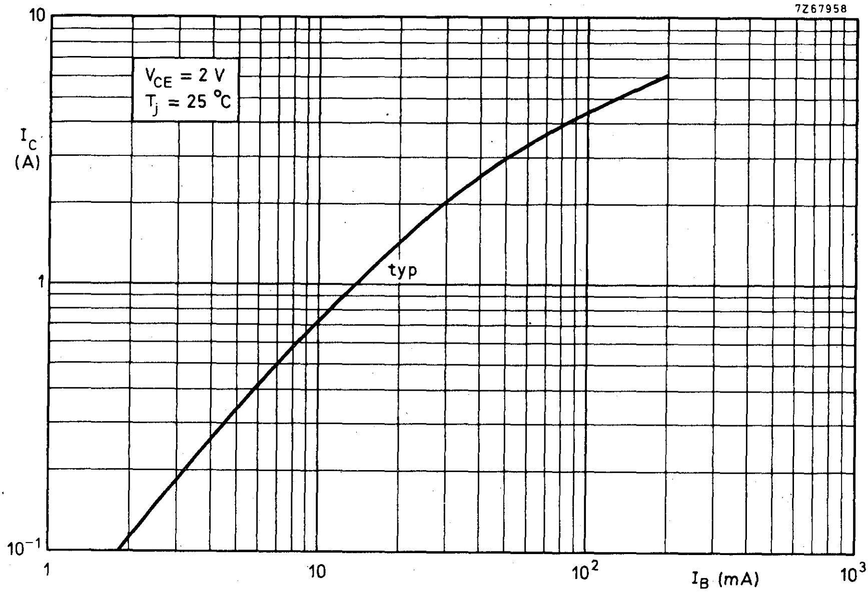


Fig. 7 Typical collector current.

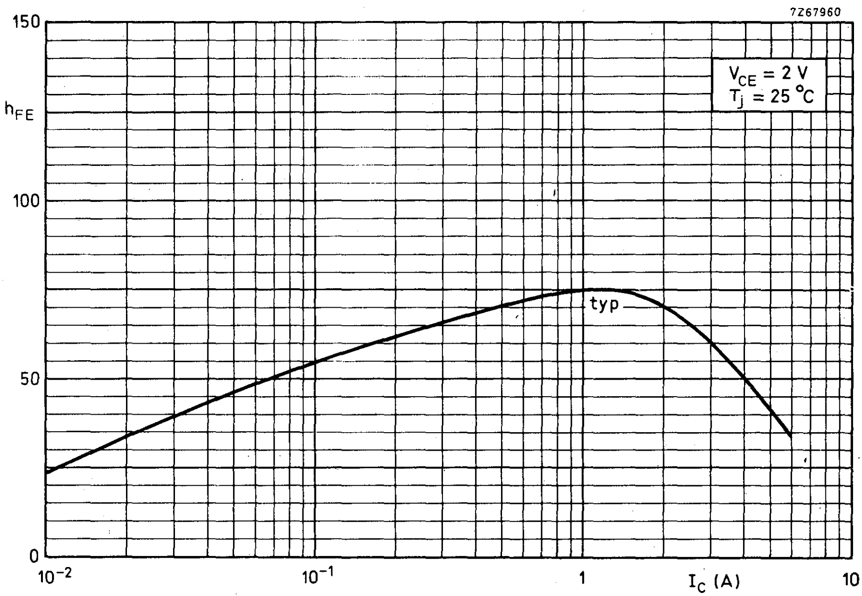


Fig. 8 Typical d.c. current gain.

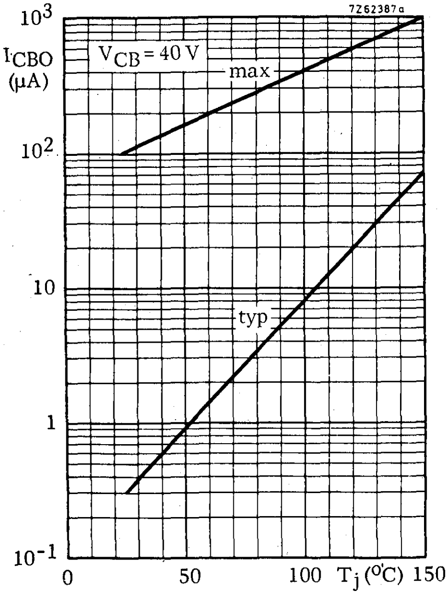


Fig. 9 Collector-base current.

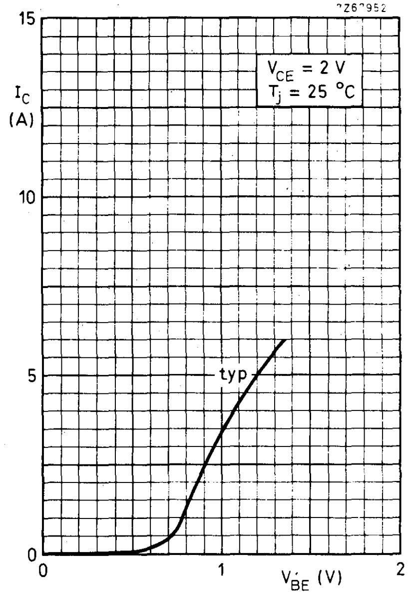


Fig. 10 Collector current.

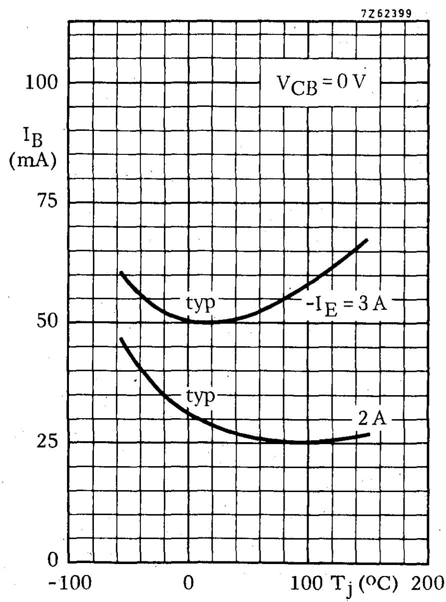


Fig. 11 Base current.

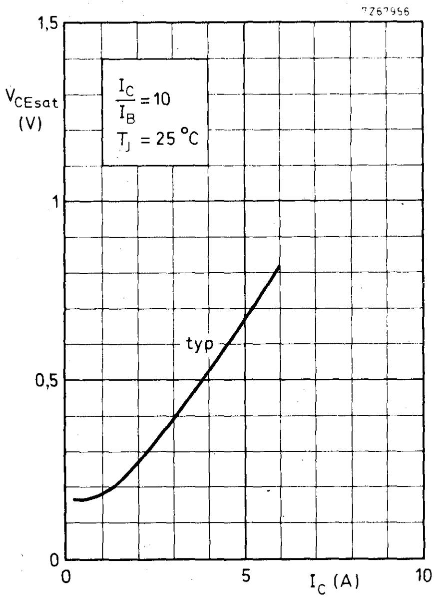


Fig. 12 Collector-emitter saturation voltage.

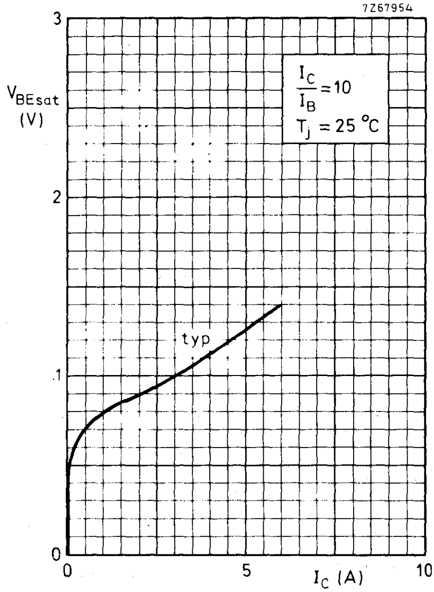


Fig. 13 Base-emitter saturation voltage.

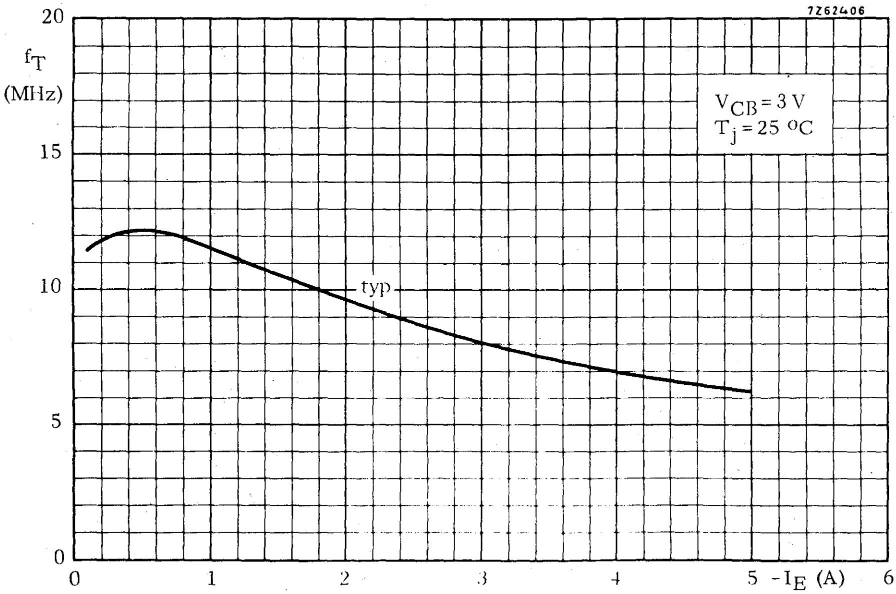


Fig. 14 Transition frequency.

APPLICATION INFORMATION

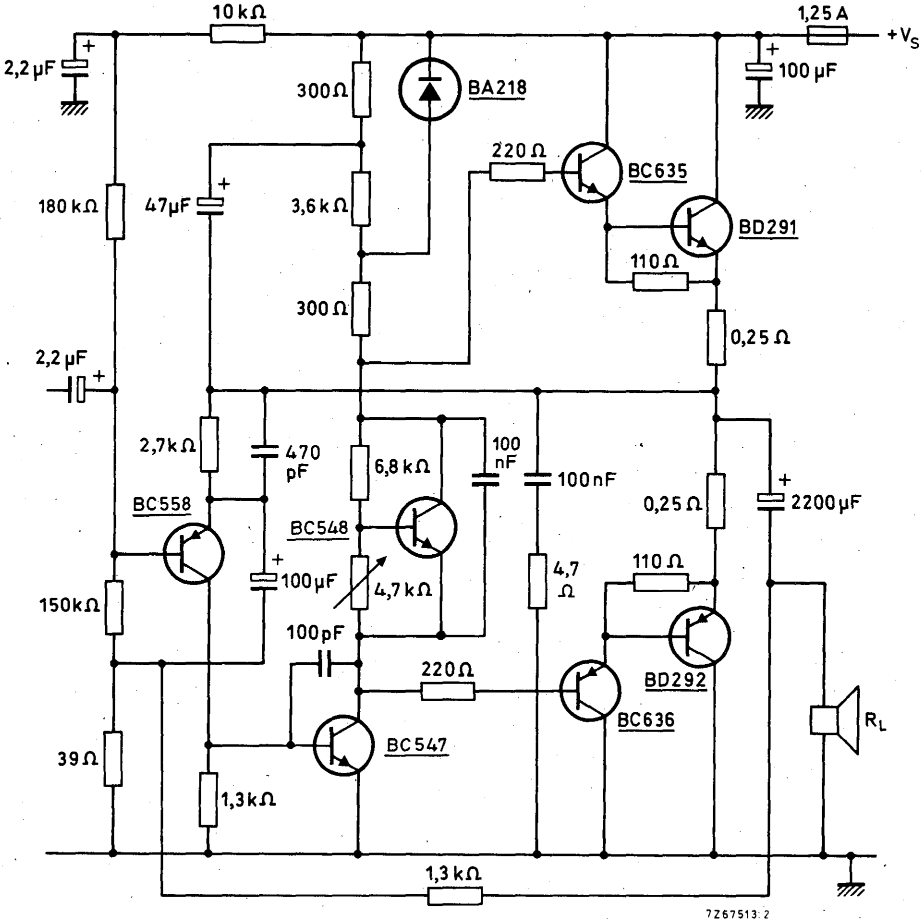


Fig. 15 Basic circuit diagram of a 20 W hi-fi amplifier.

Performance at V_S = 32,4 V; R_L = 4 Ω (unloaded supply voltage = 38 V)

Collector quiescent current of BD291 and BD292	$\lvert I_{CQ} \rvert$	typ.	20	mA
Total current drain at P_o = 20 W; f = 1 kHz	I_S	typ.	1	A
Input impedance	z_i	typ.	175	kΩ
Output impedance	z_o	typ.	50	mΩ
Output power at f = 1 kHz; d_{tot} = 1%	P_o	typ.	24	W
Input voltage for P_o = 20 W; f = 1 kHz	$V_{i(rms)}$	typ.	375	mV

Total harmonic distortion at P_o = 20 W	d_{tot}	typ.	0,06 %
Intermodulation distortion at P_o = 20 W	d_{im}	typ.	0,5 %
Voltage feedback factor		typ.	52 dB
Unweighted signal to noise ratio, (ref. to P_o = 50 mW)		typ.	75 dB
Frequency response (−1 dB)		typ. 20 Hz to	75 kHz
Thermal resistance required per output transistor	$R_{th\ j\text{-}a}$	$\leqslant$	8,65 °C/W

Stable continuous operation is ensured up to an ambient temperature of 50 °C.

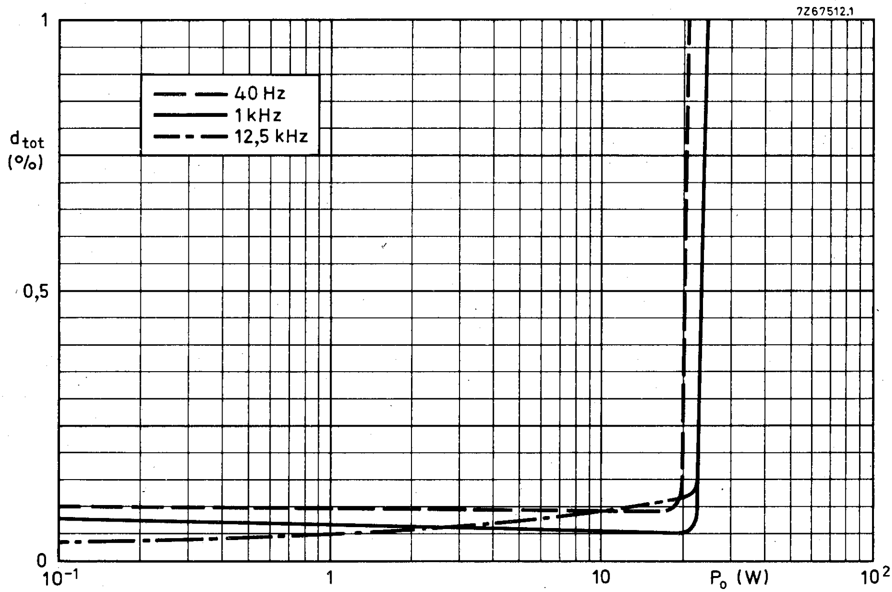


Fig. 16 Total harmonic distortion.

APPLICATION INFORMATION (continued)

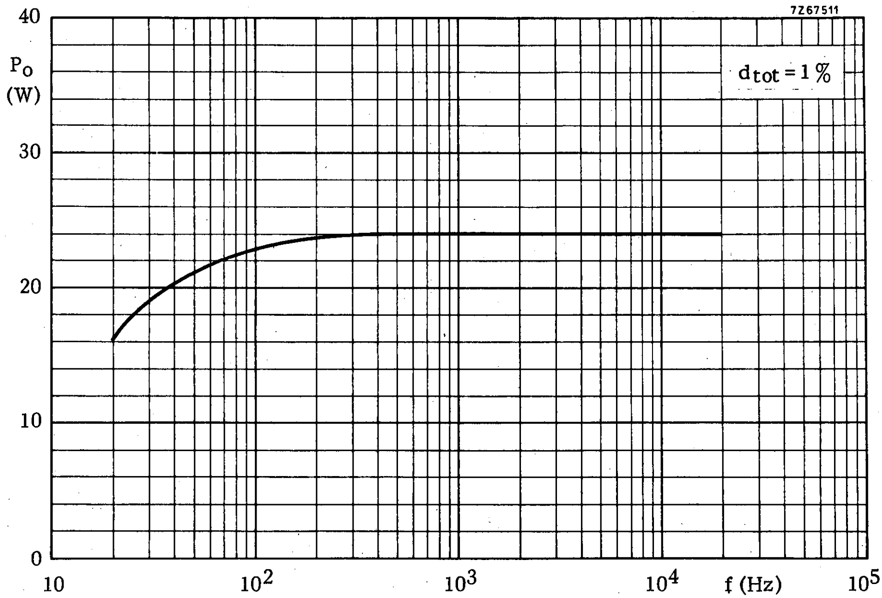


Fig. 17 Typical value of output power as a function of the frequency.

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

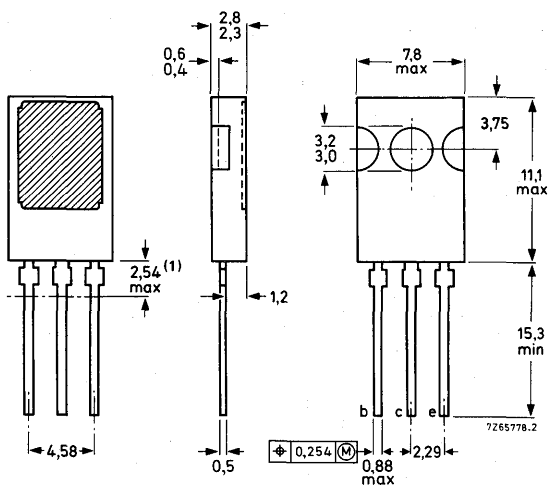
			BD292	BD294	BD296	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	80	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	V
Collector-current (d.c.)	$-I_C$	max.		6		A
Collector-current (peak) $t_p < 10$ ms; $\delta < 0,1$	$-I_{CM}$	max.		10		A
Base current (d.c.)	$-I_B$	max.		2,5		A
Total power dissipation up to $T_{mb} = 25\ ^{o}C$	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.



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)

			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 $T_{mb} = 25\ ^oC$	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 °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; $t_p < 300\ \mu s$, $\delta < 2\%$.

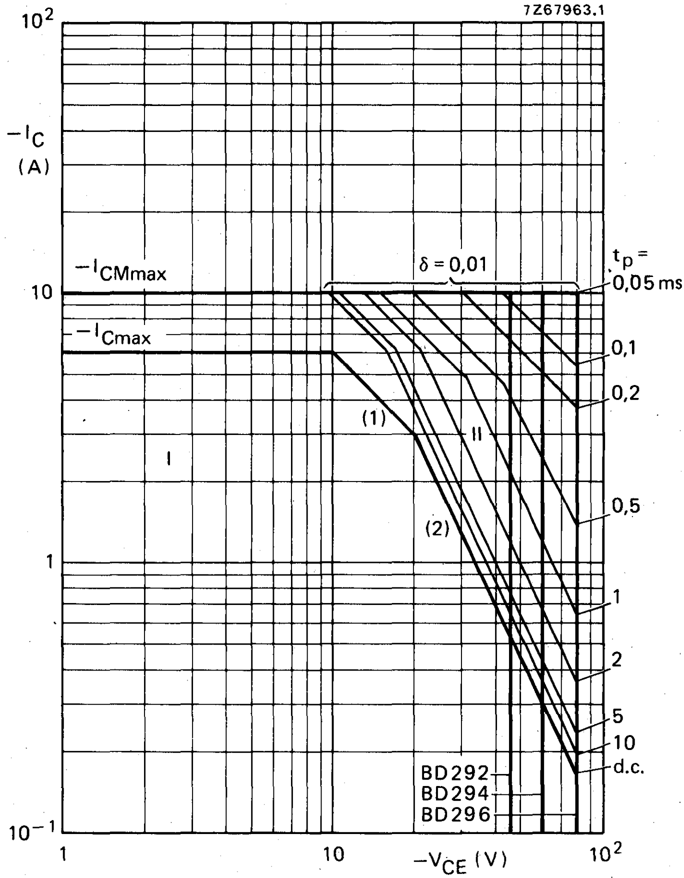


Fig. 2 Safe Operating Area with the transistor forward biased; $T_{mb} \leqslant 25\ ^oC$.

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).

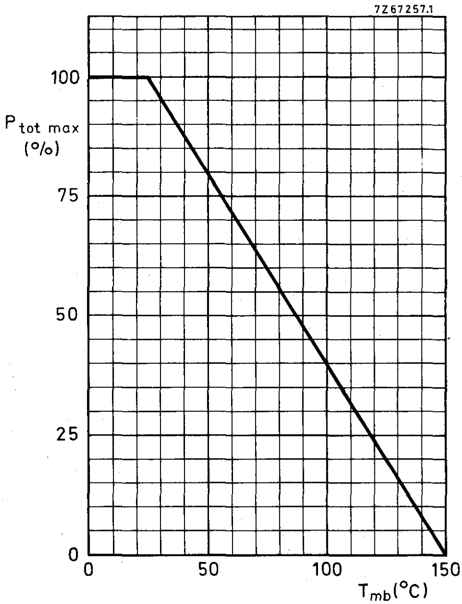


Fig. 3 Power derating curve.

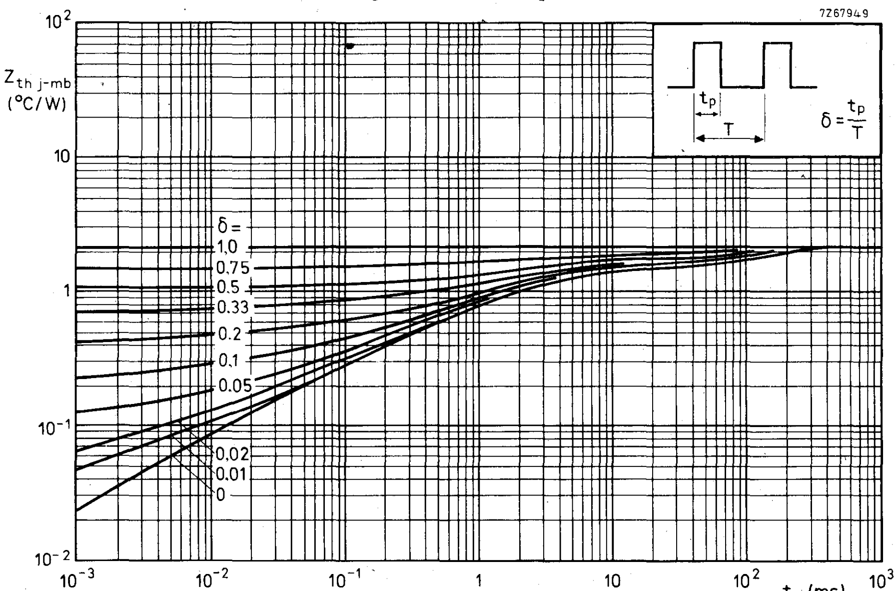


Fig. 4 Pulse power rating chart.

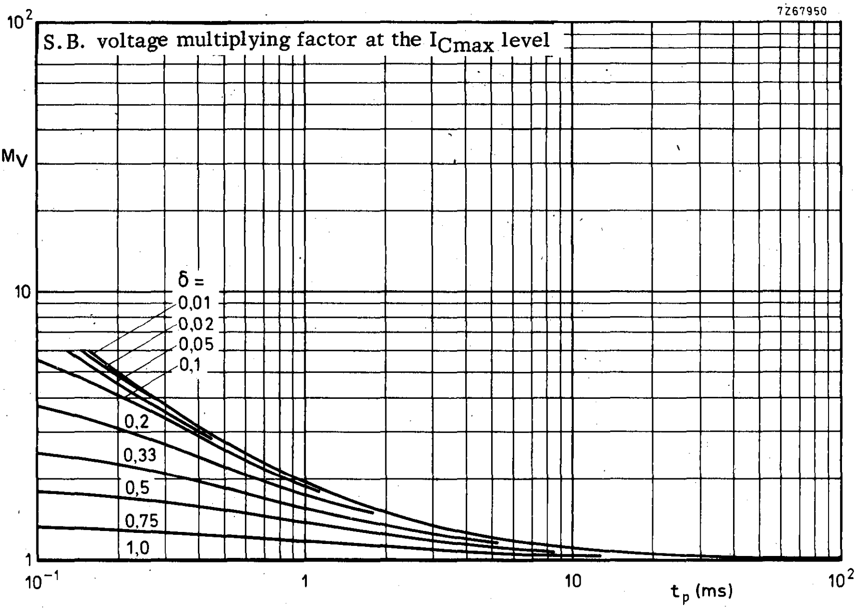


Fig. 5 Second breakdown voltage multiplying factor at the I_{Cmax} level.

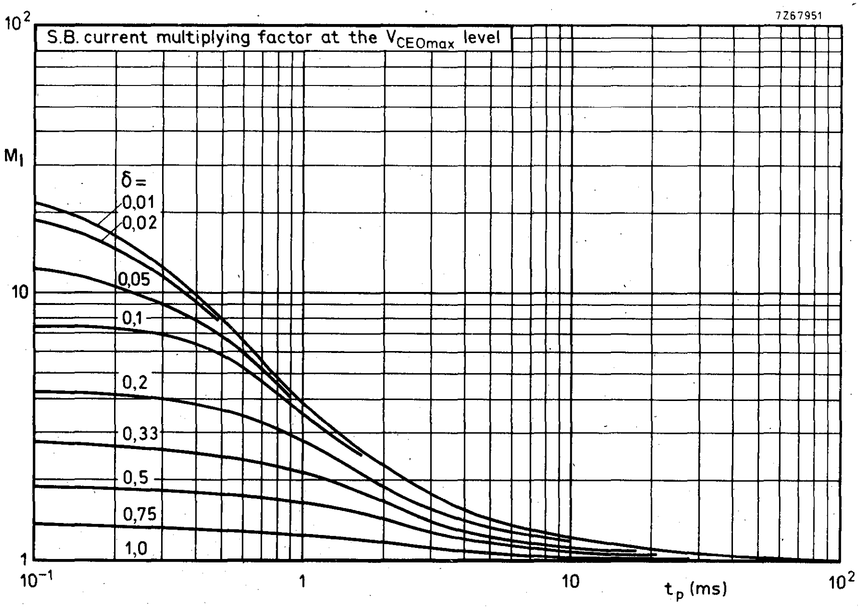


Fig. 6 Second breakdown current multiplying factor at the V_{CEOmax} level.

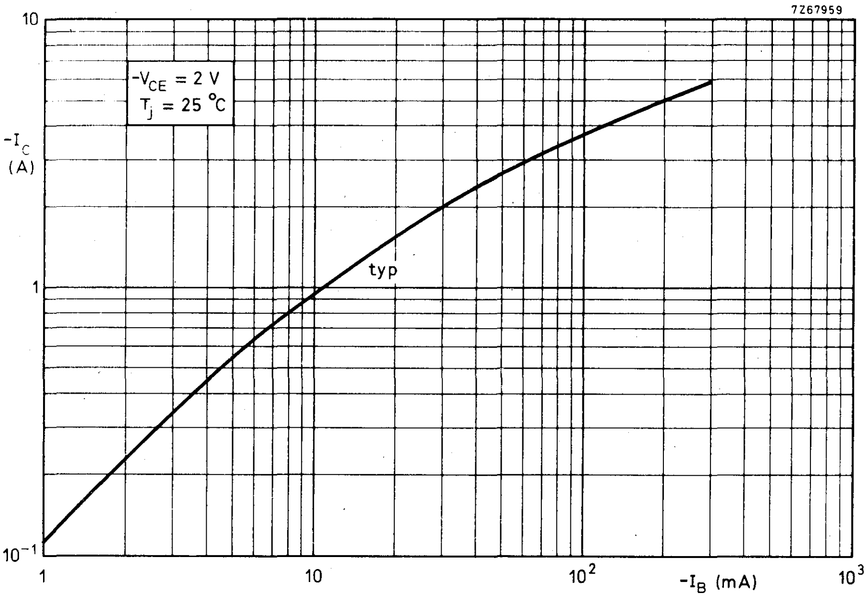


Fig. 7 Typical collector current.

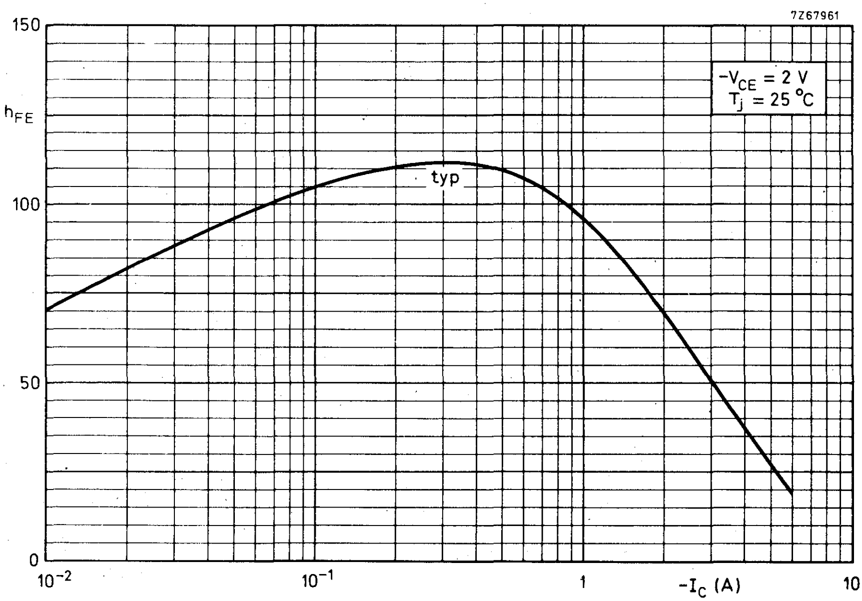


Fig. 8 Typical d.c. current gain.

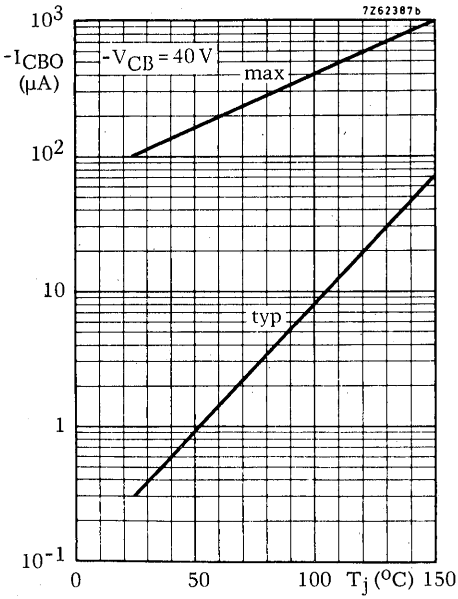


Fig. 9 Collector-base current.

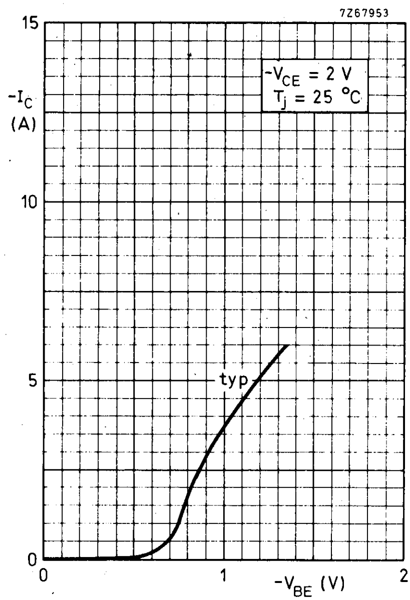


Fig. 10 Collector current.

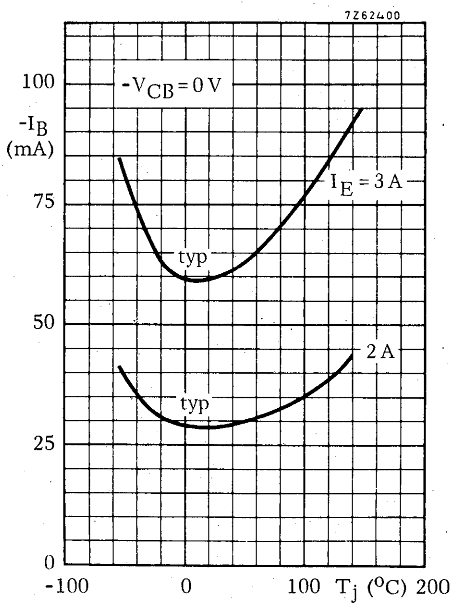


Fig. 11 Base current.

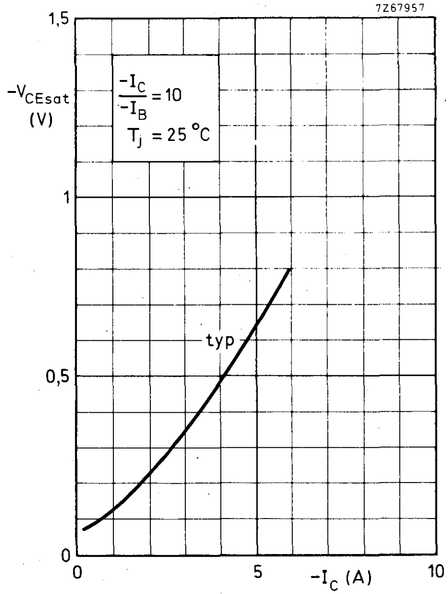


Fig. 12 Collector-emitter saturation voltage.

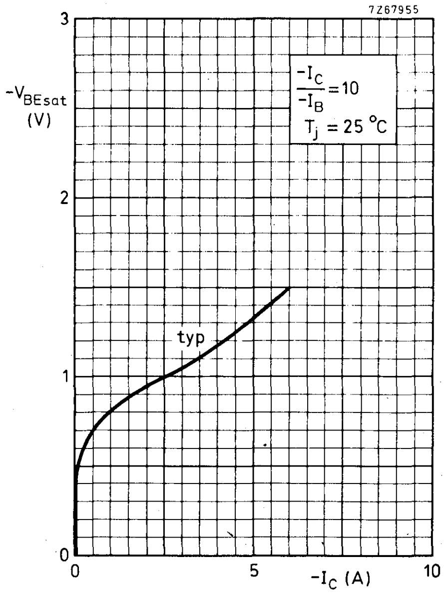


Fig. 13 Base-emitter saturation voltage.

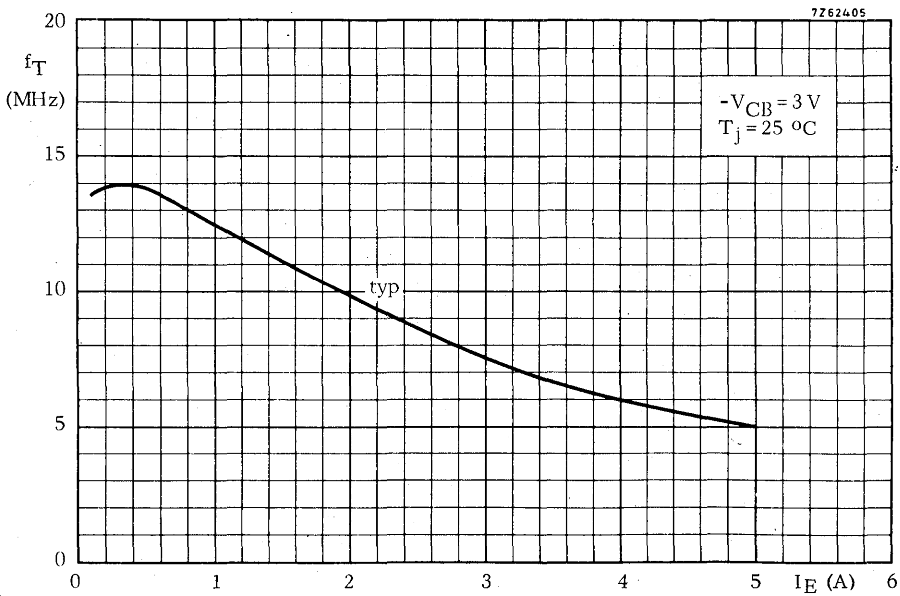


Fig. 14 Transition frequency as a function of emitter current.

FOR APPLICATION INFORMATION SEE BD291, BD293 AND BD295.

SILICON PLANAR EPITAXIAL POWER TRANSISTOR

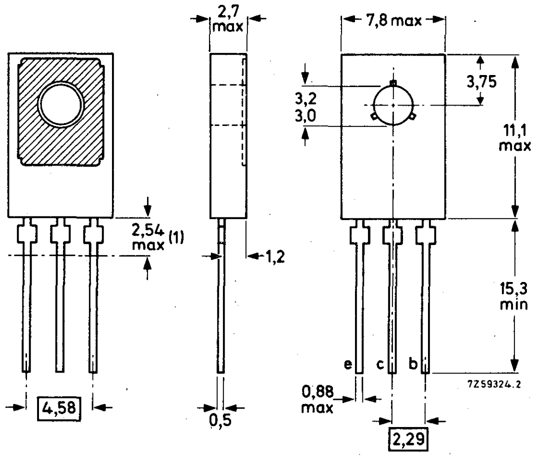
N-P-N transistor in a SOT-32 plastic envelope intended for car-radio output stages. P-N-P complement is BD330. Matched pairs can be supplied.

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

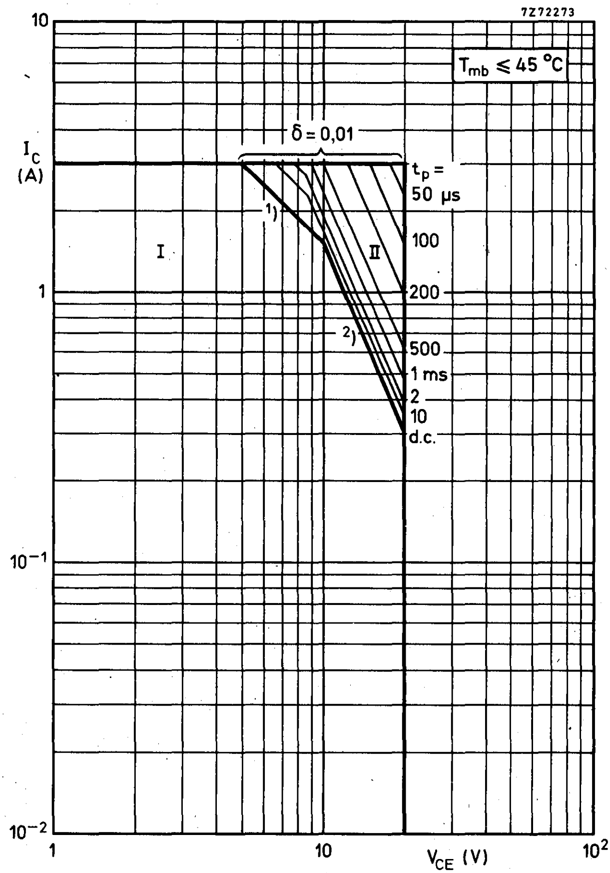
THERMAL RESISTANCE

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

$T_j = 25\ ^{o}C$ unless otherwise specified

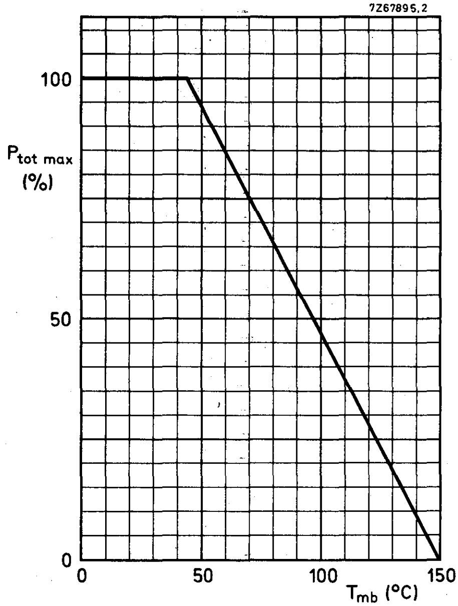
Collector cut-off current				
$I_E = 0;\ V_{CB} = 32\ V$	I_{CBO}	<	10	μA
$I_E = 0;\ V_{CB} = 32\ V;\ T_j = 150\ ^{o}C$	I_{CBO}	<	1	mA
Emitter cut-off current				
$I_C = 0;\ V_{EB} = 5\ V$	I_{EBO}	<	10	μA
Base-emitter voltage				
$I_C = 5\ mA;\ V_{CE} = 10\ V$	V_{BE}	typ.	0,6	V
$I_C = 2\ A;\ V_{CE} = 1\ V$	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	

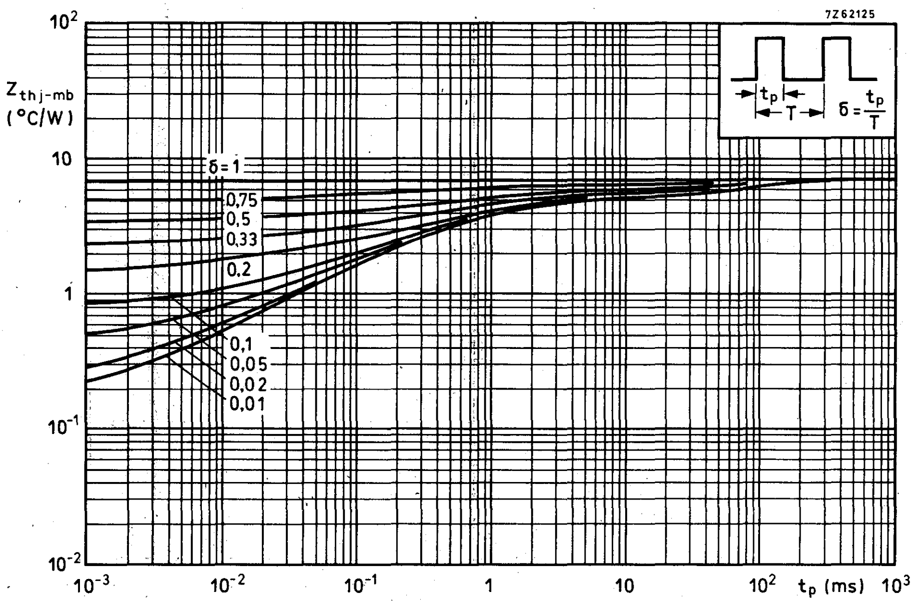


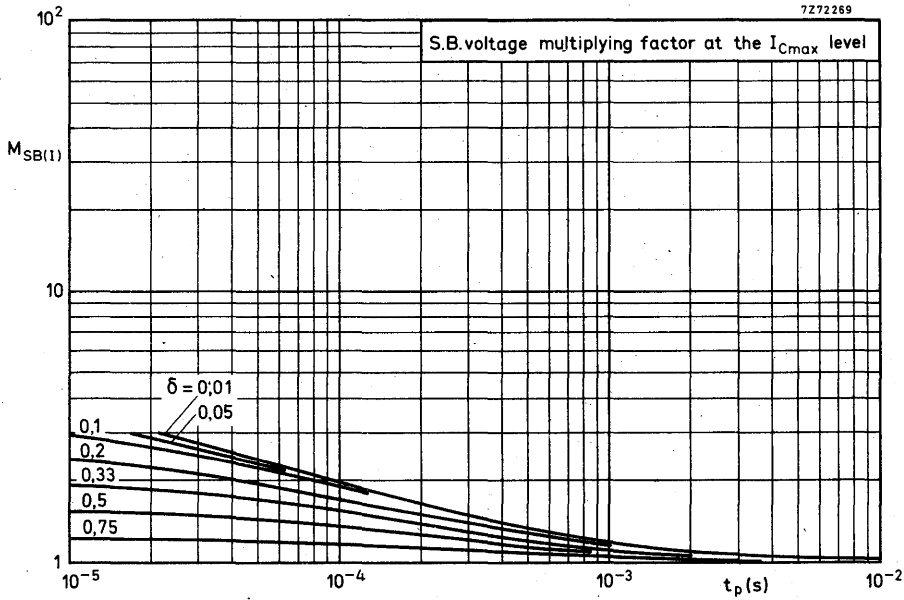
Safe Operating ARea with the transistor forward biased

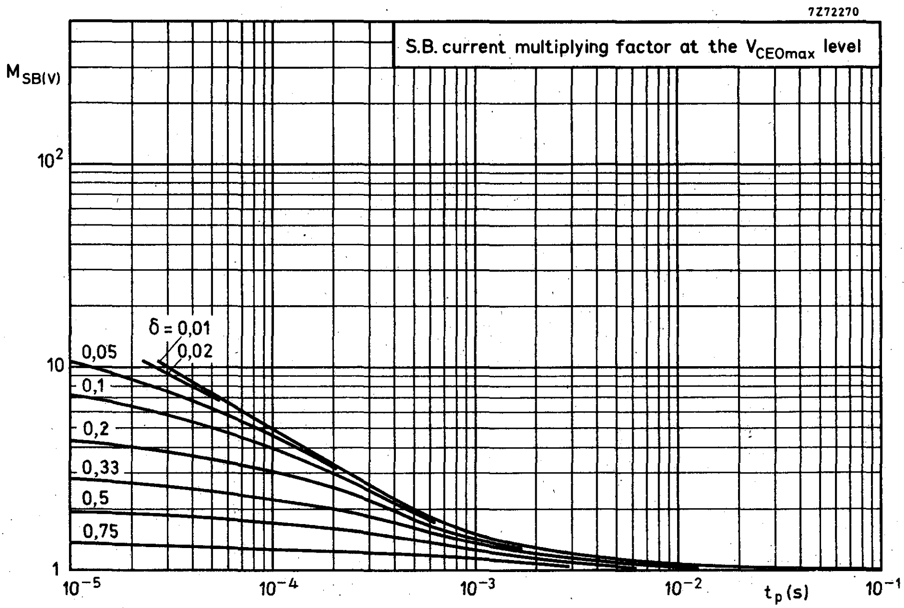
I Region of permissible d.c. operation
II Permissible extension for repetive pulse operation

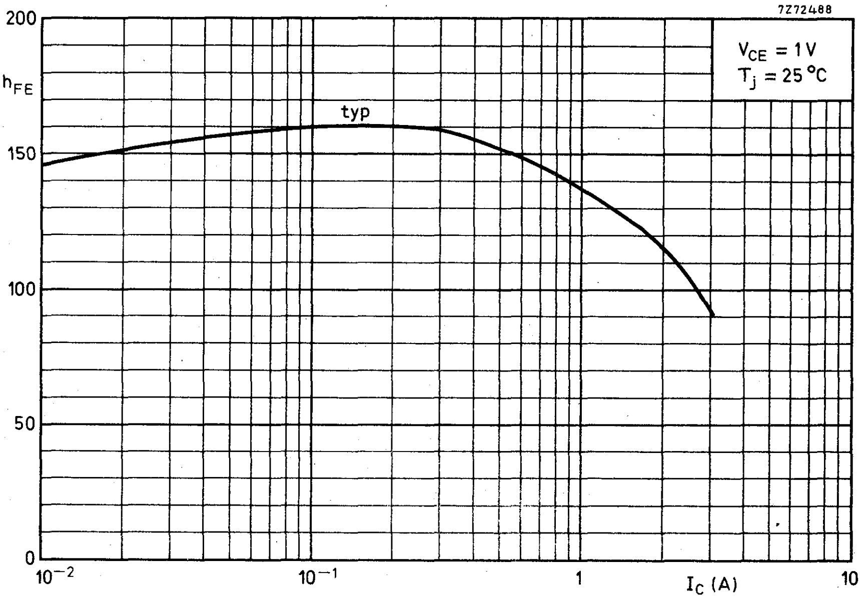
[1]) $P_{tot\ max}$ and $P_{peak\ max}$ lines.
[2]) Second-breakdown limits (independent of temperature).

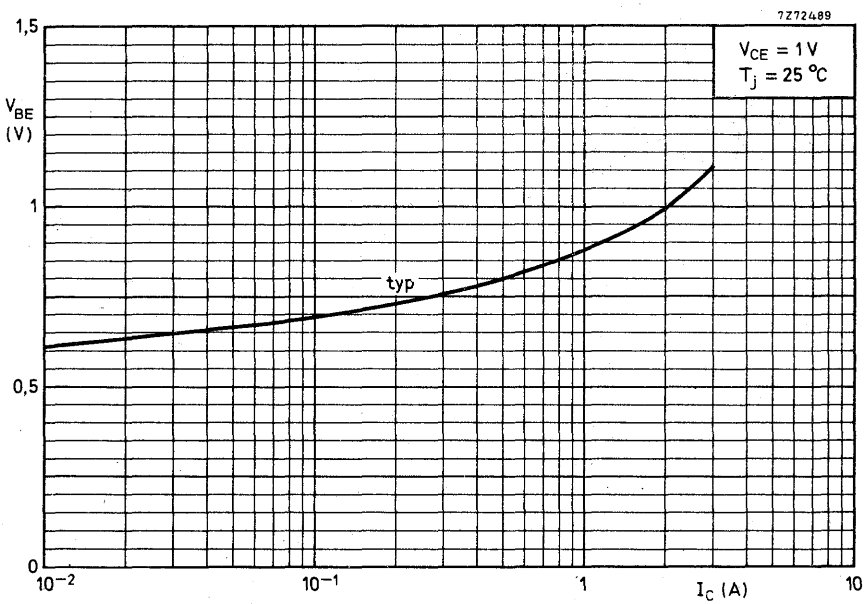

7Z67895.2
100
$P_{tot\ max}$
(%)
50
0
0
50
100
150
T_{mb} (°C)

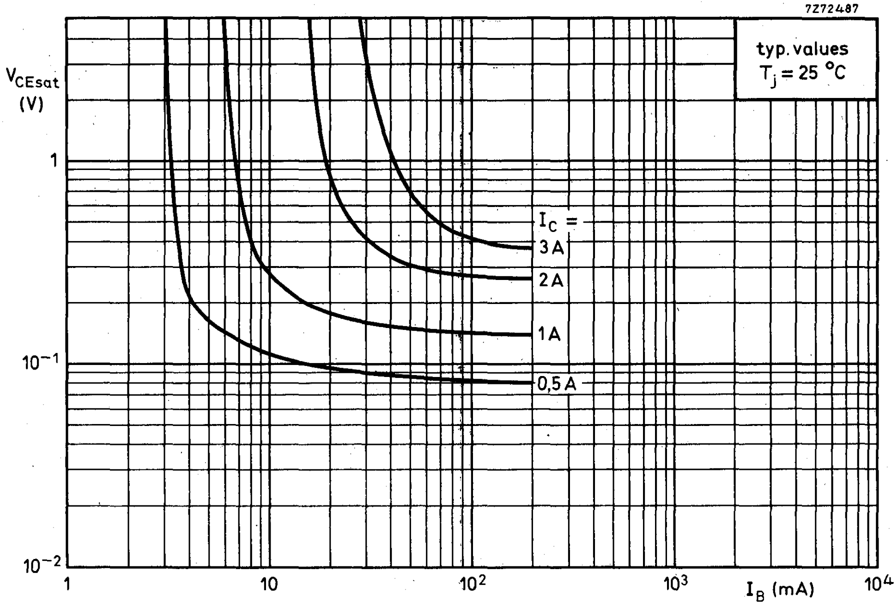

7Z62125
10^2
$Z_{th\ j-mb}$
(°C/W)
10
1
10^{-1}
10^{-2}
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3


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}


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

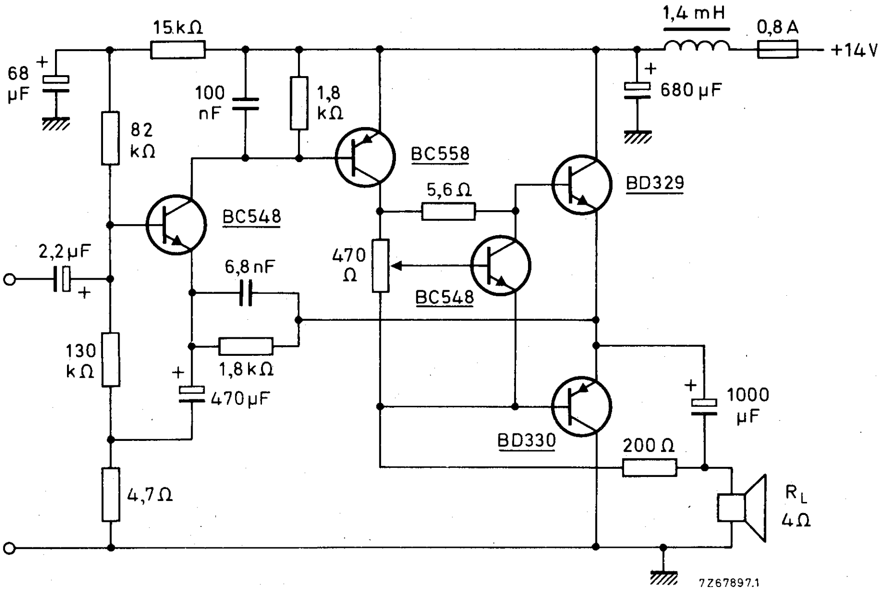

7Z72489
1,5
1
0,5
0
V_{BE}
(V)
typ
V_{CE} = 1 V
T_j = 25 °C
10^{-2}
10^{-1}
1
10
I_C (A)



APPLICATION INFORMATION See next page.

APPLICATION INFORMATION

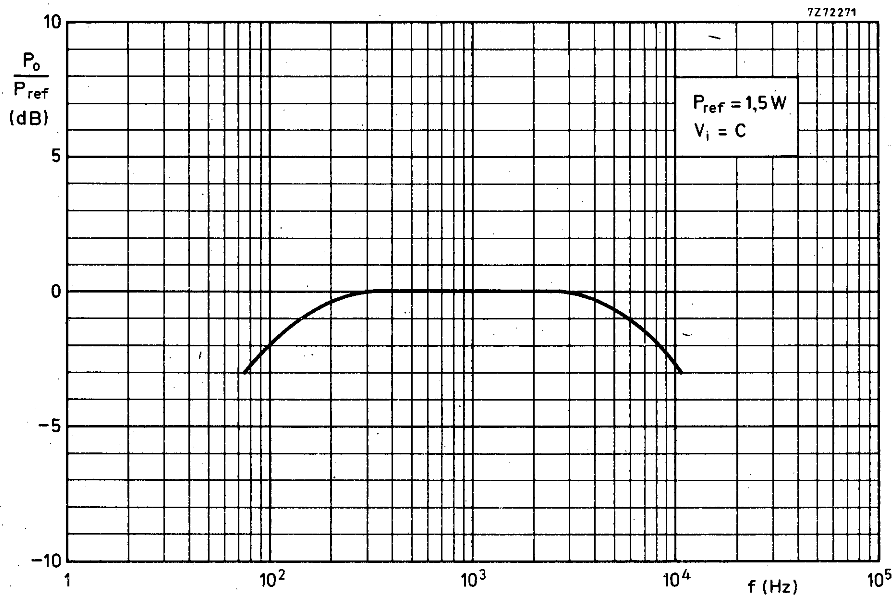
Basic circuit diagram of a 5,5 W car-radio audio amplifier.

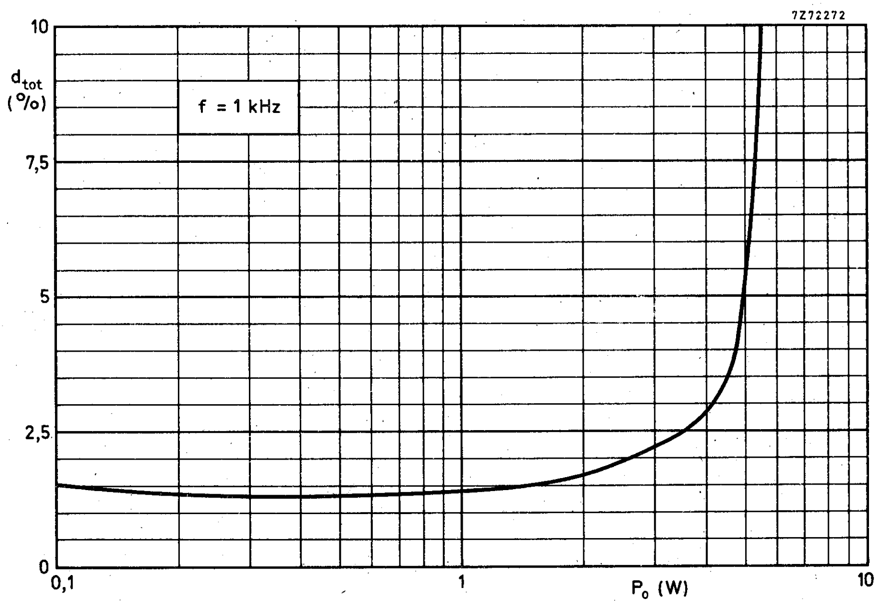


Performance at f = 1 kHz unless otherwise specified

Output power at d_{tot} = 10%	P_o	typ.	5,5	W
Input voltage for P_o = 5,5 W	$V_{i(rms)}$	typ.	20	mV
Input impedance	z_i	typ.	20	kΩ
Collector quiescent current of output transistors	$\lvert I_{CQ} \rvert$	typ.	10	mA
Collector current of BC558	$-I_C$	typ.	28	mA
Collector current of BC548 (pre-amplifier)	I_C	typ.	0,5	mA
Total current drain at P_o = 5,5 W	I_B	typ.	540	mA
Frequency range (−3 dB)	f		75 Hz to 11	kHz

With a heatsink thermal resistance for each output transistor of 40 °C/W the maximum permissible ambient temperature is 60 °C.


7Z72271
$\frac{P_o}{P_{ref}}$ (dB)
P_{ref} = 1,5 W
V_i = C
10
5
0
−5
−10
1
10^2
10^3
10^4
f (Hz)
10^5


7Z72272
d_{tot} (%)
f = 1 kHz
10
7,5
5
2,5
0
0,1
1
P_o (W)
10

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.

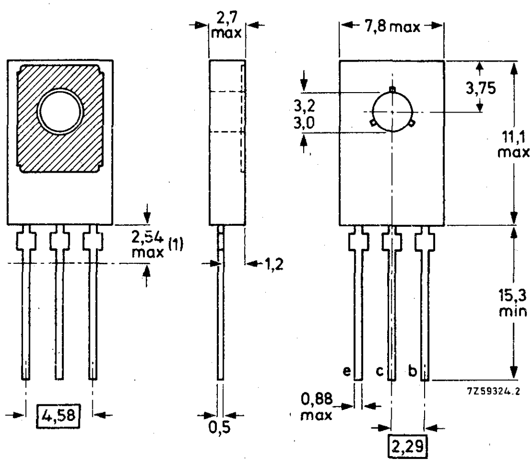
QUICK REFERENCE DATA				
Collector-emitter voltage (V_{BE} = 0)	$-V_{CES}$	max.	32	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20	V
Collector current (peak value)	$-I_{CM}$	max.	3	A
Total power dissipation up to T_{mb} = 45 °C	P_{tot}	max.	15	W
Junction temperature	T_j	max.	150	°C
D.C. current 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

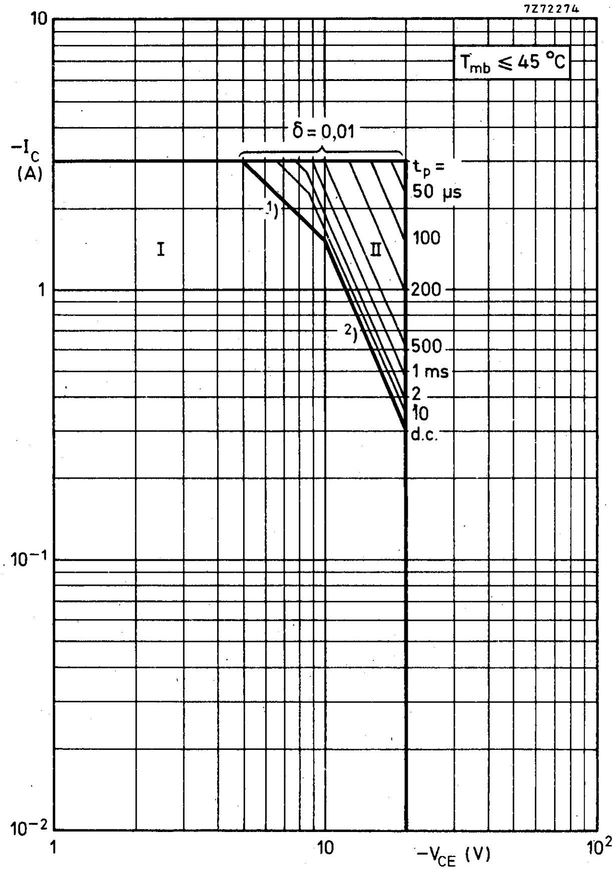
THERMAL RESISTANCE

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				
$\lvert I_C \rvert = 0,5$ A; $\lvert V_{CE} \rvert = 1$ V	h_{FE1}/h_{FE2}	<	1,6	



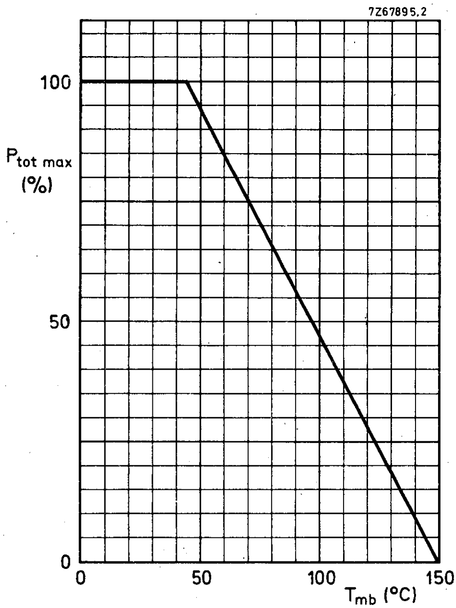
Safe Operating ARea with the transistor forward biased

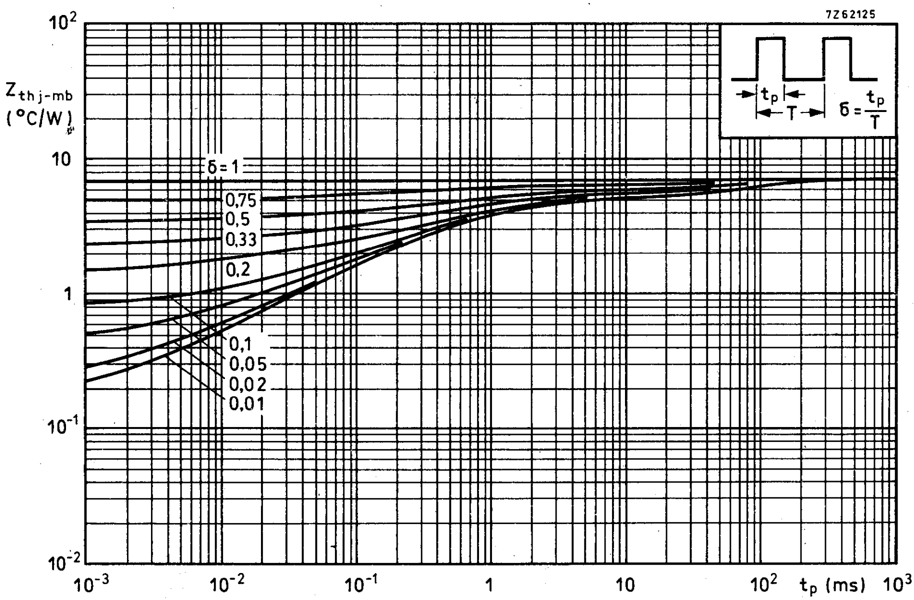
I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation

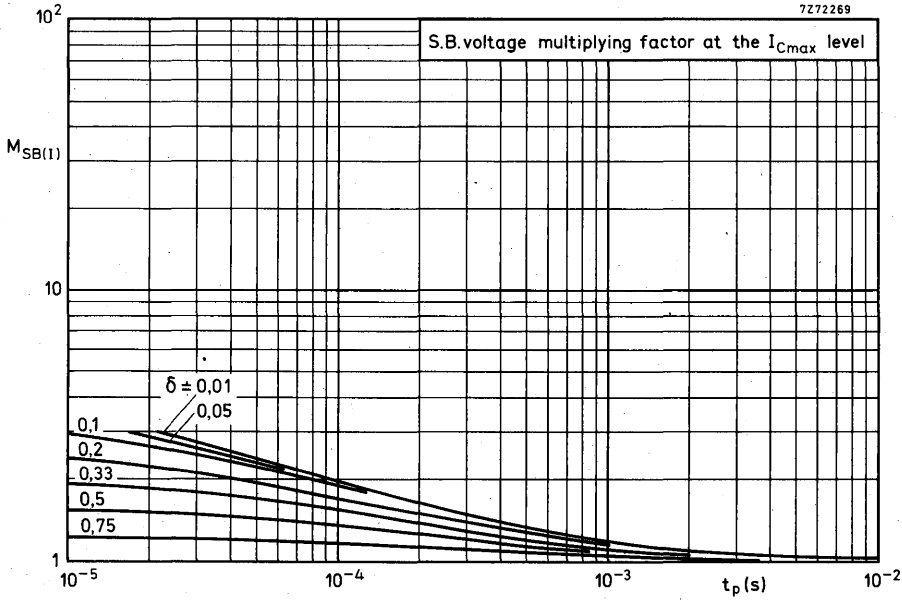
---

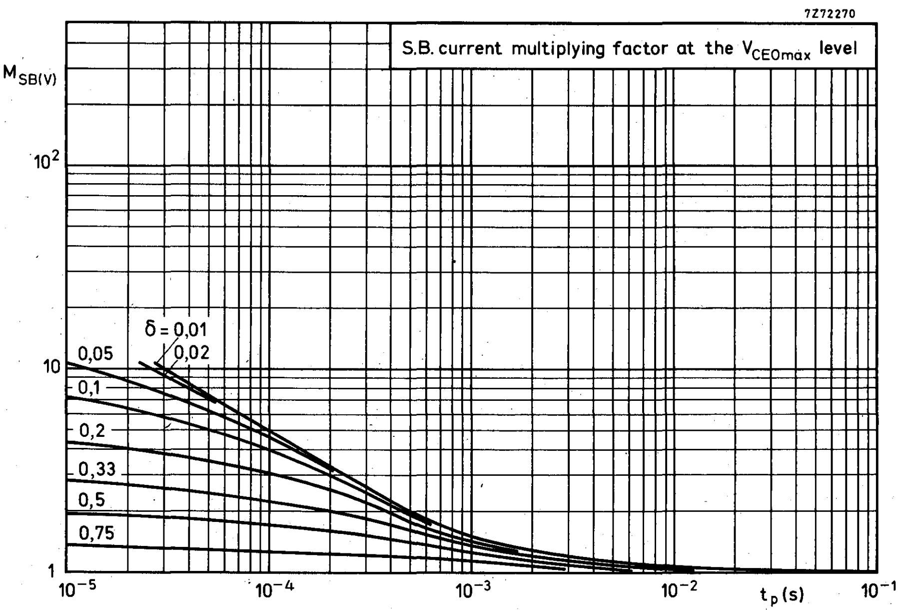
1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.

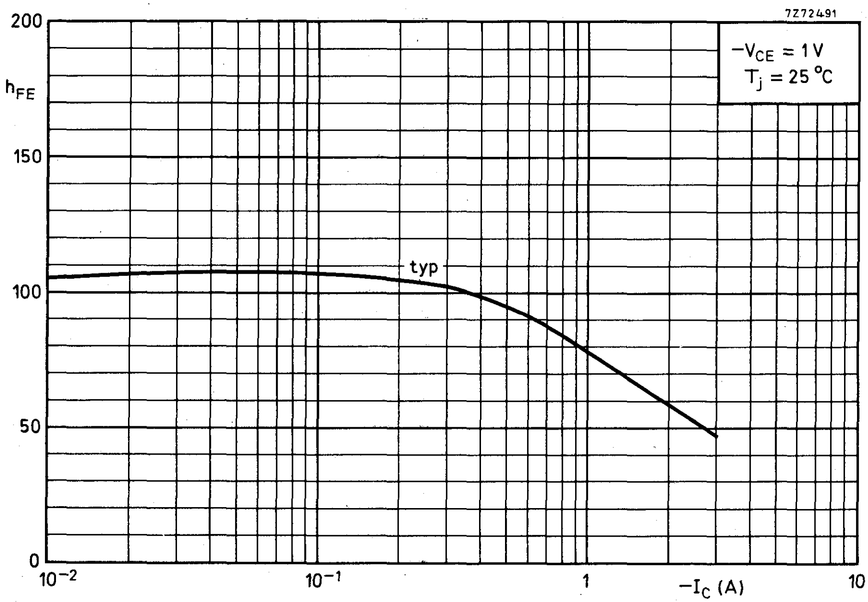
2) Second-breakdown limits (independent of temperature).

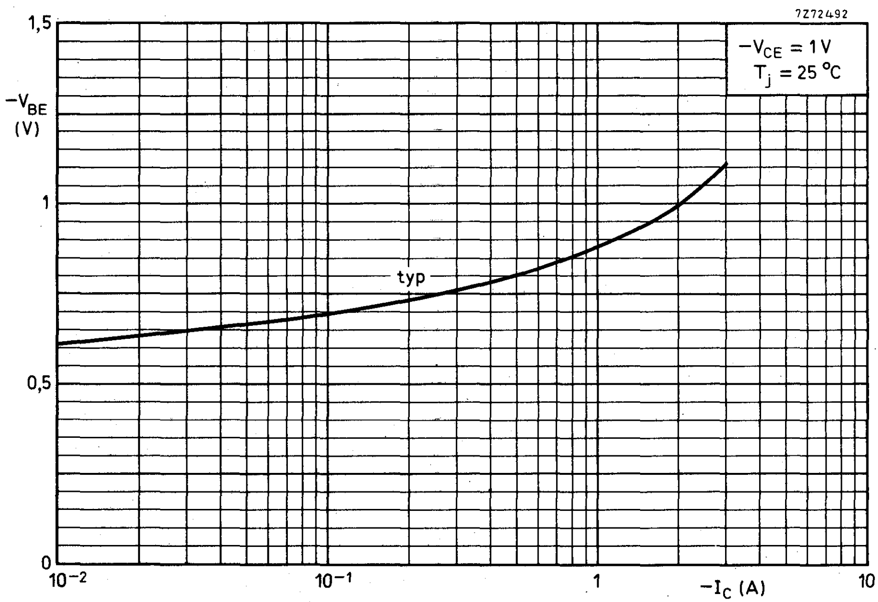

7Z67895.2
100
50
0
$P_{tot\ max}$ (%)
0
50
100
150
T_{mb} (°C)

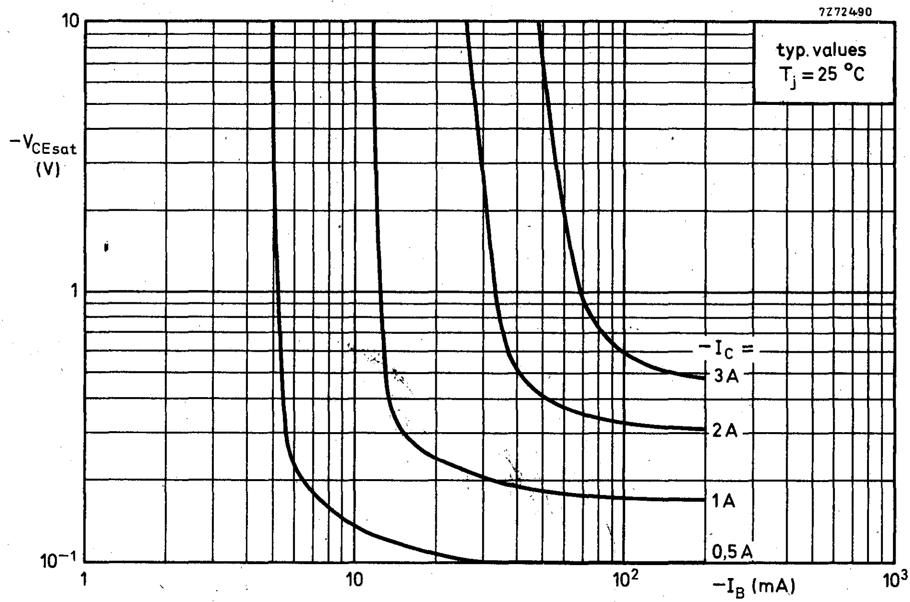

7Z62125
10^2
10
1
10^{-1}
10^{-2}
$Z_{th\ j\text{-}mb}$ (°C/W)
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3


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}


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


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



FOR APPLICATION INFORMATION SEE BD329.

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

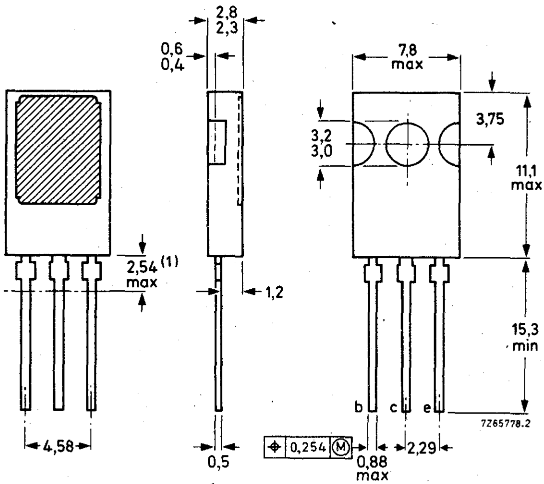
			BD331	333	335	337	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Collector-current (d.c.)	I_C	max.		6			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		60			W
Junction temperature	T_j	max.		150			°C
D.C. current gain I_C = 0,5 A; V_{CE} = 3 V	h_{FE}	typ.		1500			
I_C = 3,0 A; V_{CE} = 3 V	h_{FE}	>		750			
Transition frequency I_C = 3 A; V_{CE} = 3 V	f_T	typ.		7			MHz

MECHANICAL DATA

Dimensions in mm

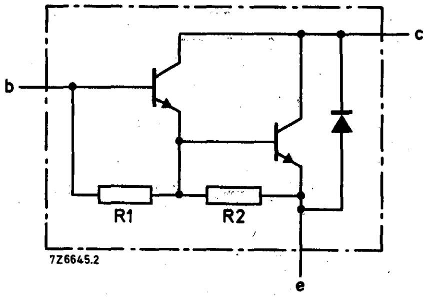
Fig. 1 SOT-82.

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.



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) $t_p \leqslant 10$ ms; $\delta \leqslant 0,1$	I_{CM}	max.	10				A
Base current (d.c.)	I_B	max.	150				mA
Total power dissipation up to $T_{mb} = 25\ ^oC$	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 °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
$I_B = 0$; $V_{CE} = ½\ V_{CEOmax}$	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.	1500	
I_C = 3 A; V_{CE} = 3 V	h_{FE}	>	750	
I_C = 6 A; V_{CE} = 3 V	h_{FE}	typ.	1500	
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
Transition frequency				
I_C = 3 A; V_{CE} = 3 V	f_T	typ.	7	MHz
Cut-off frequency				
I_C = 3 A; V_{CE} = 3 V	f_{hfe}	typ.	60	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	

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

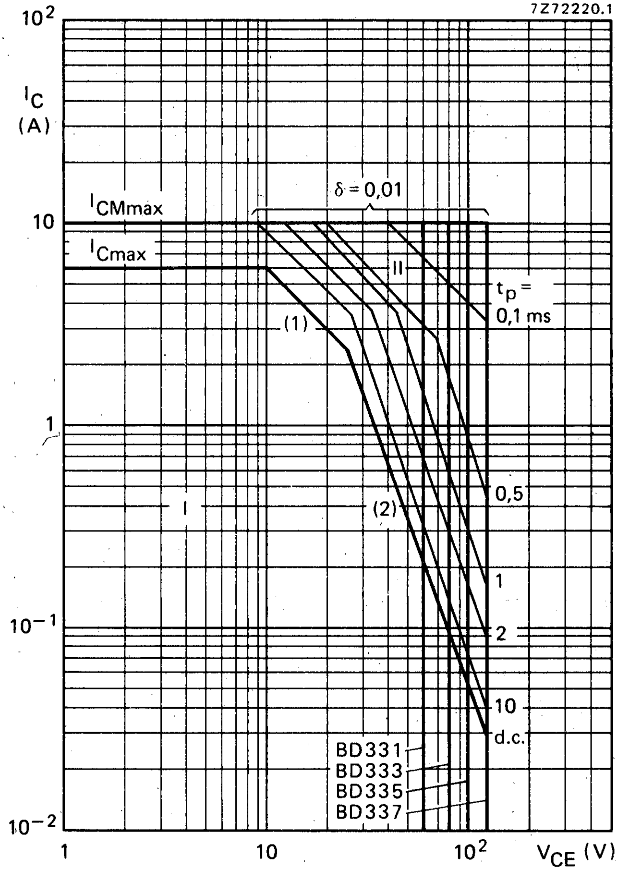


Fig. 3 Safe Operating Area with the transistor forward biased; $T_{mb} \leqslant 25$ °C.

I Region of permissible d.c operation

II Permissible extension for repetitive pulse operation

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

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

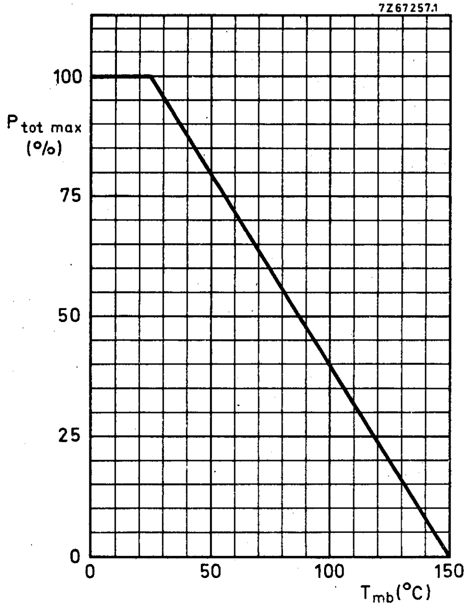


Fig. 4 Power derating curve.

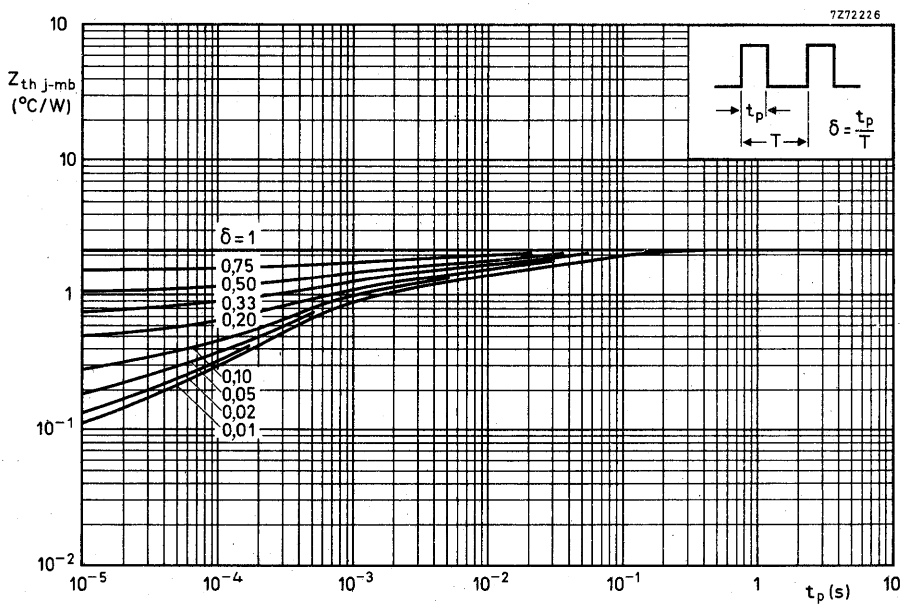


Fig. 5 Pulse power rating chart.

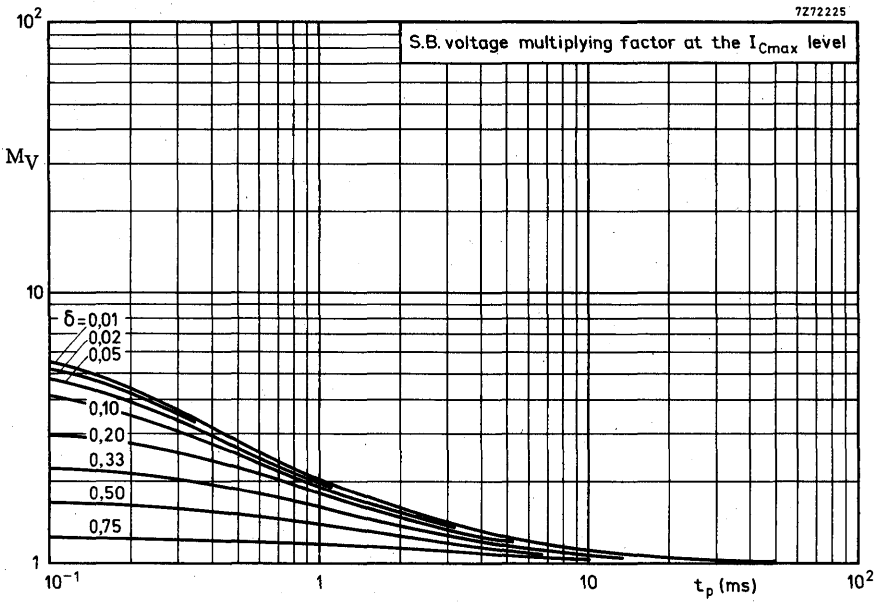


Fig. 6 Second breakdown voltage multiplying factor at I_{Cmax} level.

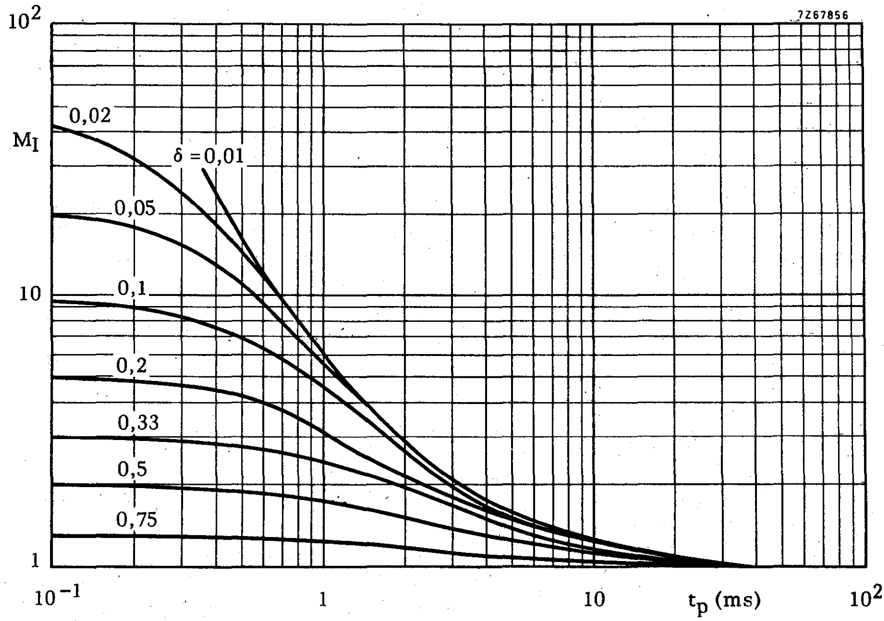


Fig. 7 Second breakdown current multiplying factor at V_{CEOmax} level.

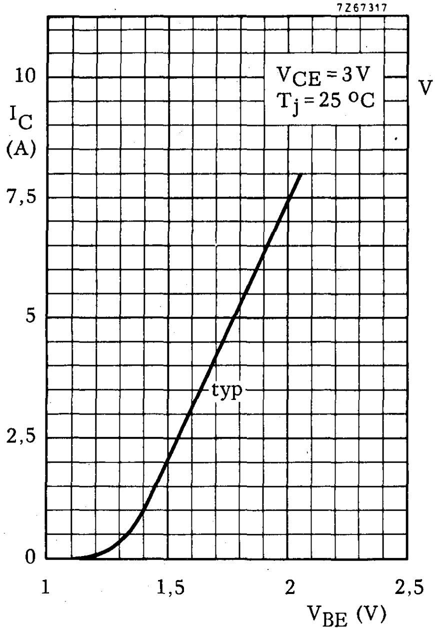


Fig. 8 Collector current.

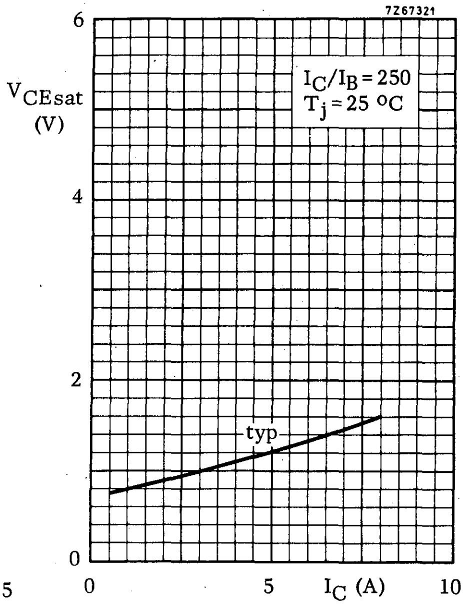


Fig. 9 Collector-emitter saturation voltage.

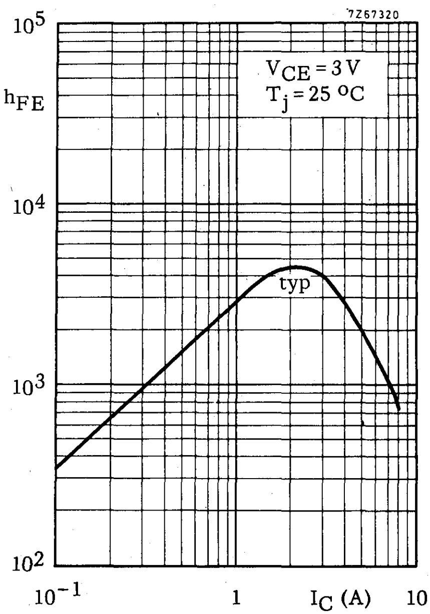


Fig. 10 D.C. current gain.

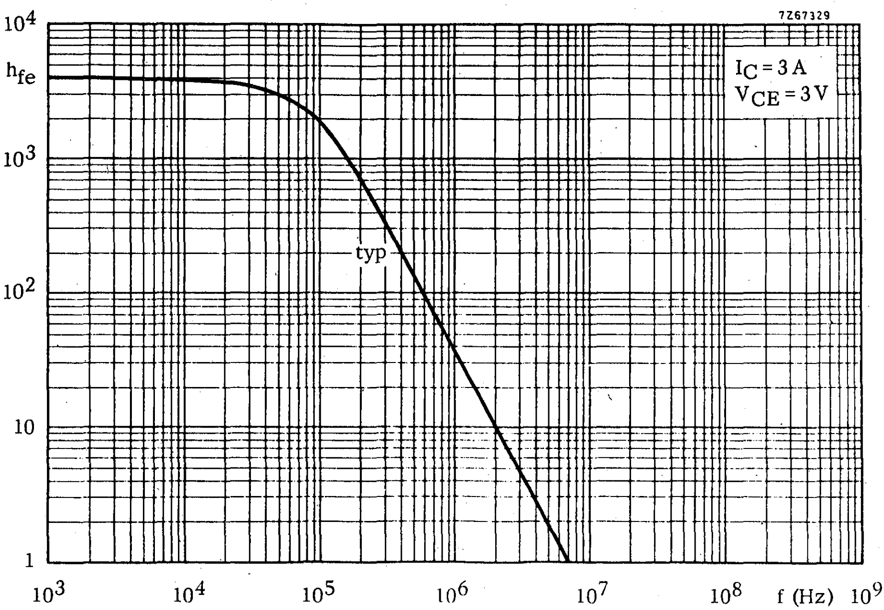


Fig. 11 Small signal current gain at $I_C = 3$ A; $V_{CE} = 3$ V.

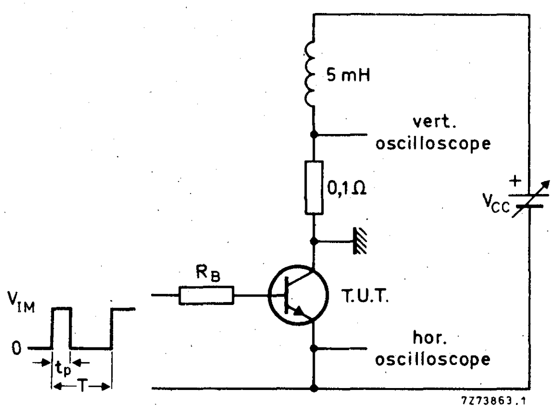


Fig. 12 Test circuit for turn-off breakdown energy. $V_{IM} = 12$ V; $R_B = 270\ \Omega$.

APPLICATION INFORMATION

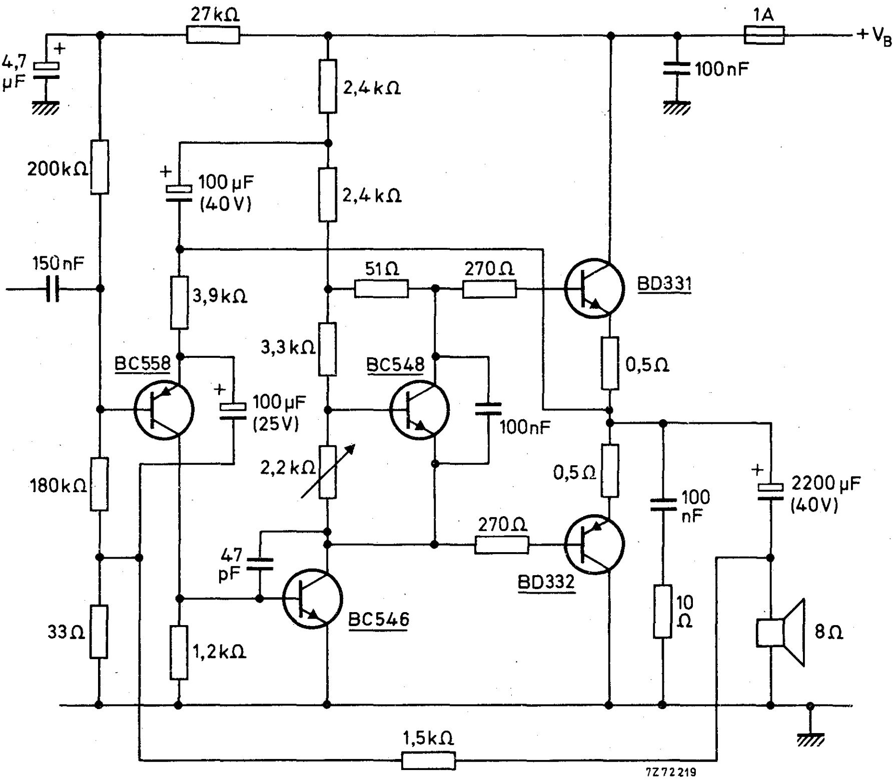


Fig. 13 Basic circuit diagram of a 20 W hi-fi amplifier.

Performance at V_B = 43 V (unloaded supply voltage = 51 V):

Collector quiescent current of BD331 and BD332	$\lvert I_{CQ} \rvert$	typ.	20	mA
Total current drain at P_o = 20 W; f = 1 kHz	I_B	typ.	710	mA
Input impedance	z_i	typ.	180	kΩ
Output impedance	z_o	typ.	80	mΩ
Output power at f = 1 kHz; d_{tot} = 1%	P_o	typ.	24	W
Input voltage for P_o = 20 W; f = 1 kHz	$V_{i(rms)}$	typ.	375	mV
Total harmonic distortion at P_o = 20 W	d_{tot}	typ.	0,08	%
Intermodulation distortion at P_o = 20 W	d_{im}	typ.	0,2	%
Heatsink thermal resistance per output transistor	$R_{th\ h\text{-}a}$	≤	6,4	°C/W

Stable continuous operation is ensured up to an ambient temperature of 50 °C.

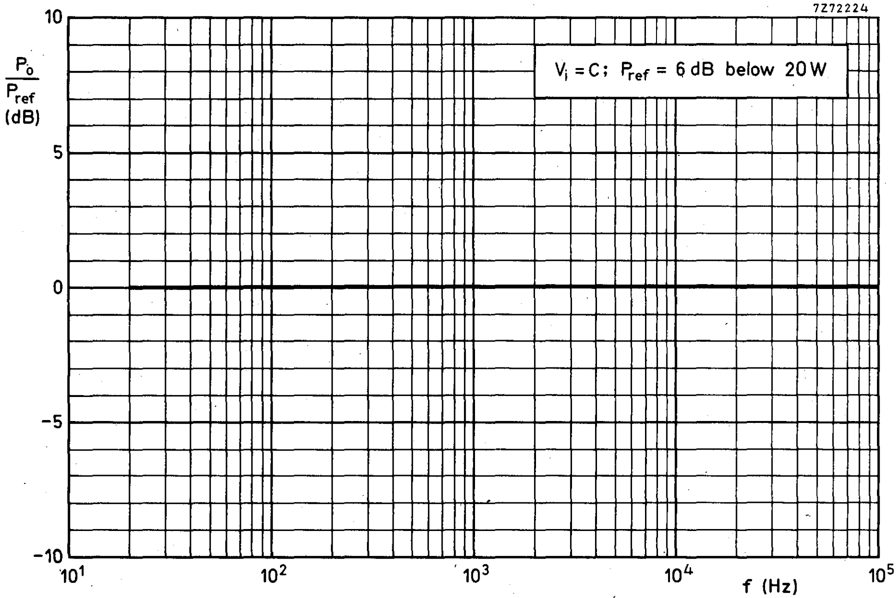


Fig. 14 Output power in relation to reference power.

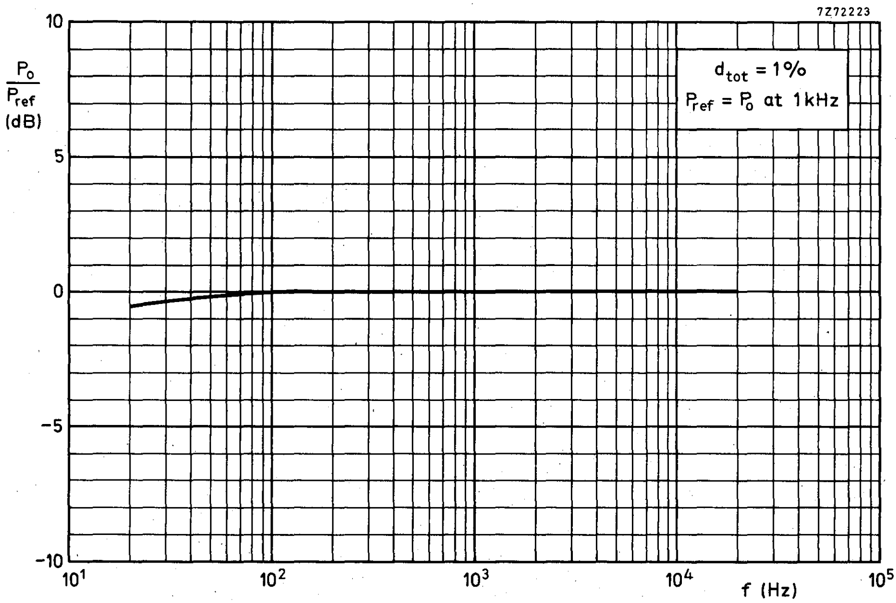


Fig. 15 Output power in relation to reference power.

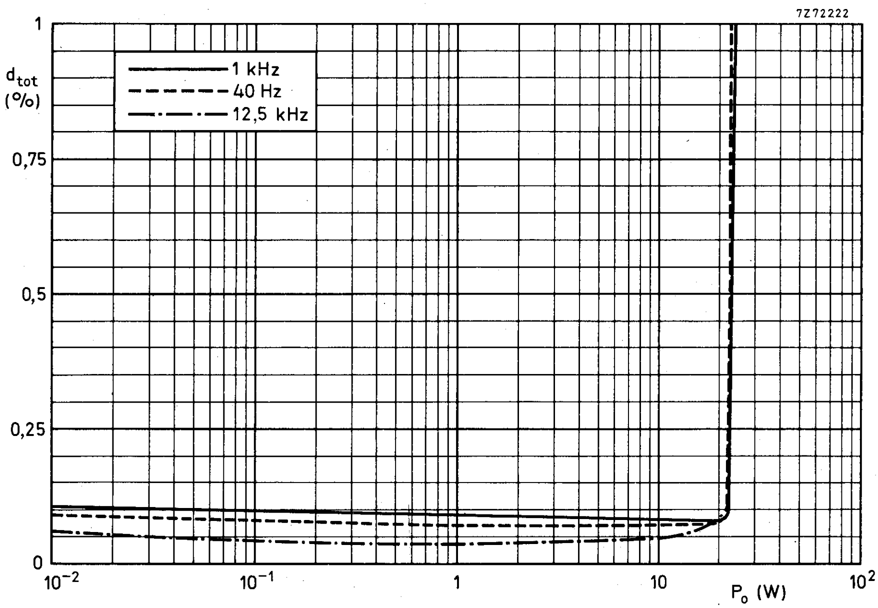


Fig. 16 Total harmonic distortion.

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

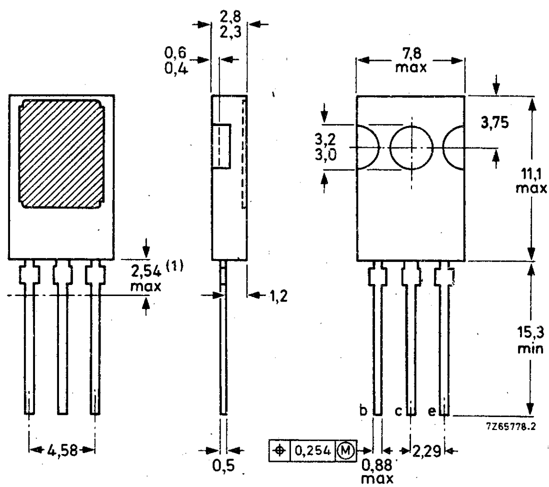
			BD332	334	336	338	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Collector-current (d.c.)	$-I_C$	max.		6			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		60			W
Junction temperature	T_j	max.		150			°C
D.C. current gain $-I_C$ = 0,5 A; $-V_{CE}$ = 3 V	h_{FE}	typ.		1500			
$-I_C$ = 3,0 A; $-V_{CE}$ = 3 V	h_{FE}	>		750			
Transition frequency $-I_C$ = 3 A; $-V_{CE}$ = 3 V	f_T	typ.		7			MHz

MECHANICAL DATA

Dimensions in mm

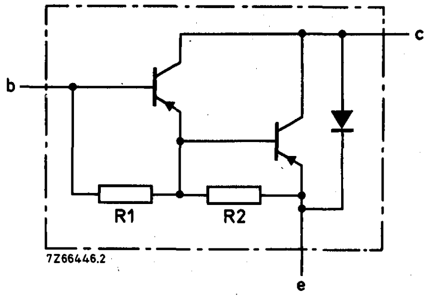
Fig. 1 SOT-82.

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.



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 $T_{mb} = 25\ ^{o}C$	P_{tot}	max.	60				W
Storage temperature	T_{stg}		−65 to + 150				^{o}C
Junction temperature *	T_j	max.	150				^{o}C

THERMAL RESISTANCE *

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

* 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
$I_E = 0; -V_{CB} = -V_{CBOmax}; T_j = 150\ ^{o}C$	$-I_{CBO}$	<	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.	1500	
$-I_C = 3$ A; $-V_{CE} = 3$ V	h_{FE}	>	750	
$-I_C = 6$ A; $-V_{CE} = 3$ V	h_{FE}	typ.	1500	
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
Transition frequency				
$-I_C = 3$ A; $-V_{CE} = 3$ V	f_T	typ.	7	MHz
Cut-off frequency				
$-I_C = 3$ A; $-V_{CE} = 3$ V	f_{hfe}	typ.	60	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	

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

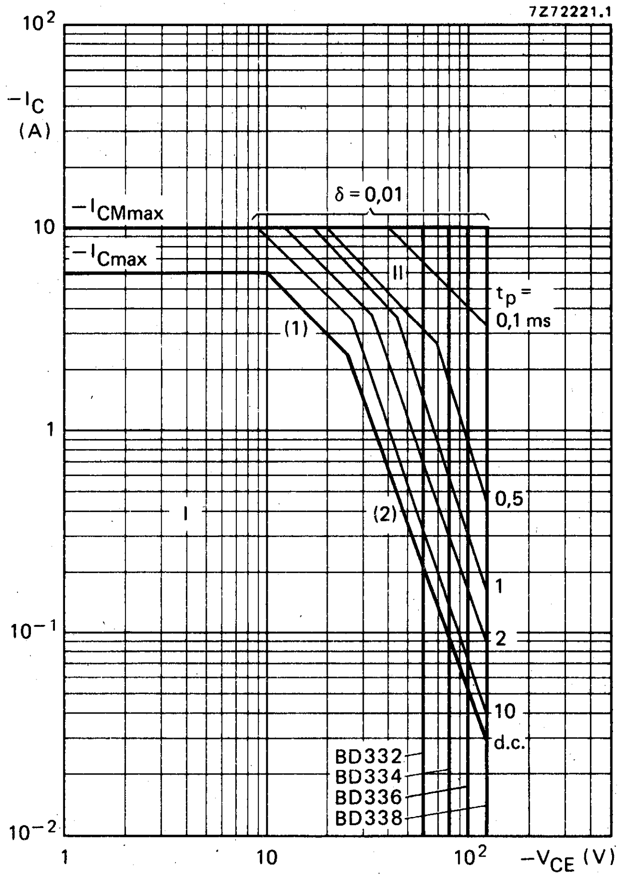


Fig. 3 Safe Operating Area with the transistor forward biased; $T_{mb} = 25\ ^oC$.

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).

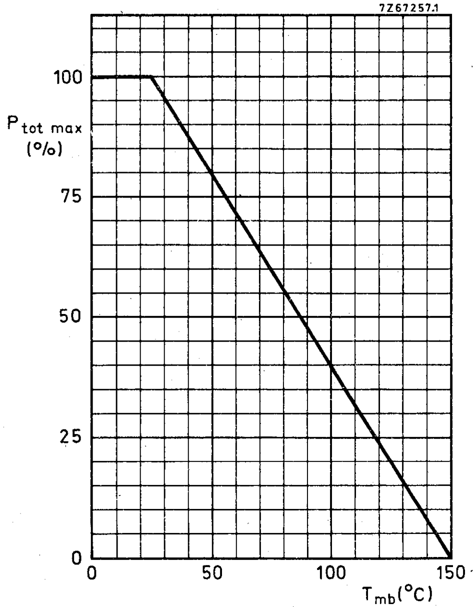


Fig. 4 Power derating curve.

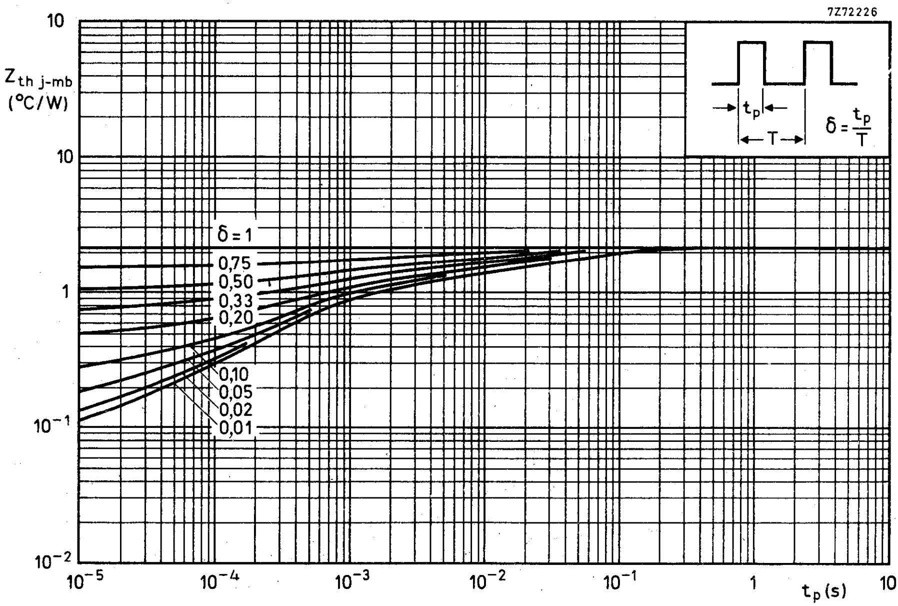


Fig. 5 Pulse power rating chart.

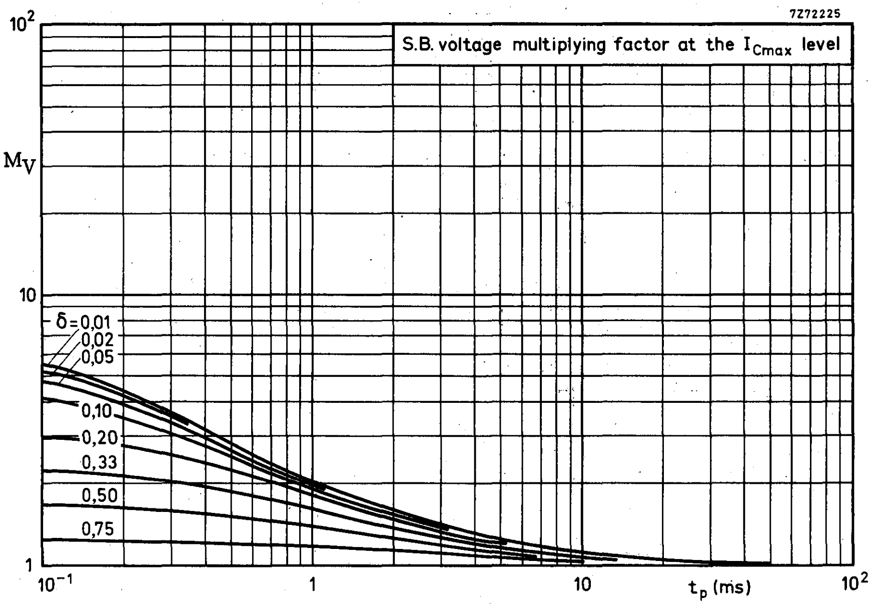


Fig. 6 Second breakdown voltage multiplying factor at the I_{Cmax} level.

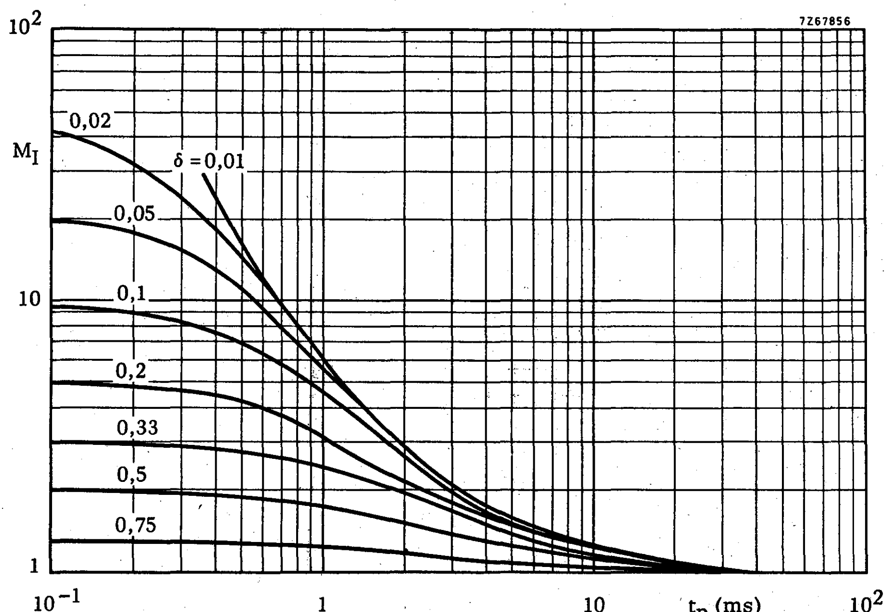


Fig. 7 Second breakdown current multiplying factor at the V_{CEOmax} level.

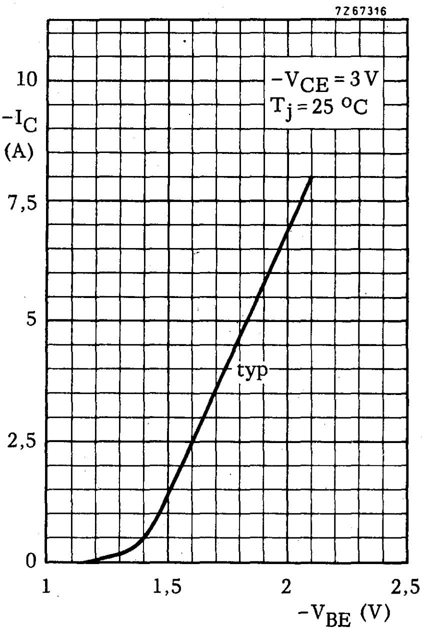


Fig. 8 Collector current.

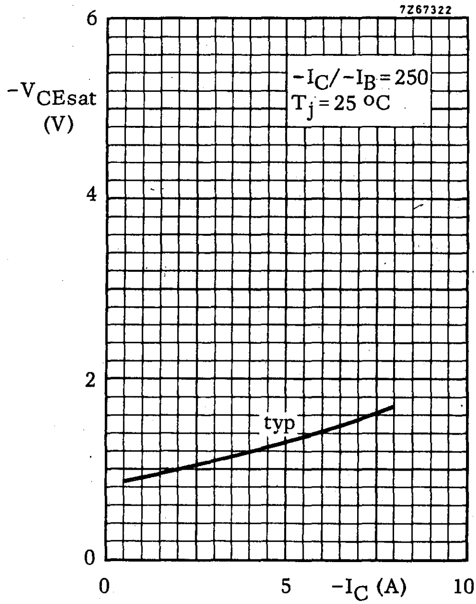


Fig. 9 Collector-emitter saturation voltage.

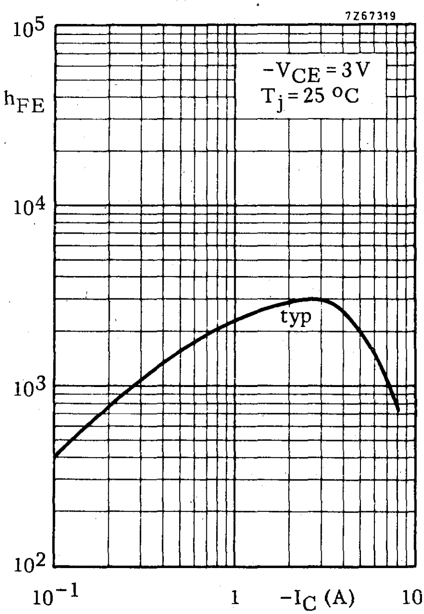


Fig. 10 D.C. current gain.

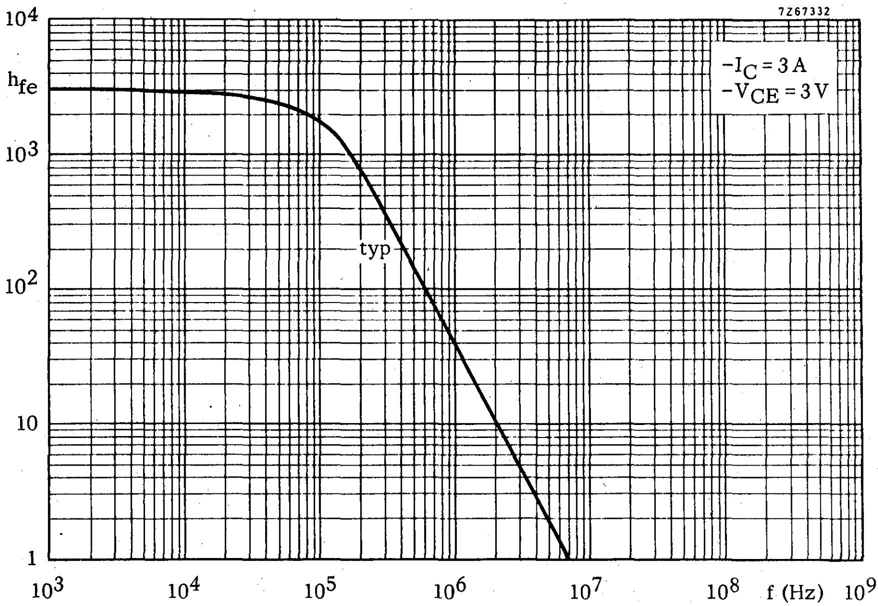


Fig. 11 Small signal current gain.

FOR APPLICATION INFORMATION SEE BD331, BD333, BD335 AND BD337.

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.

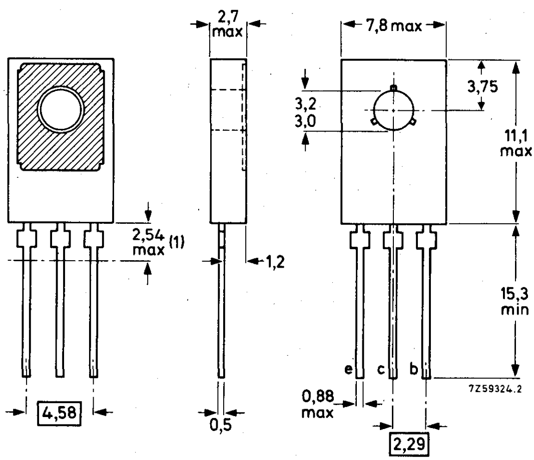
QUICK REFERENCE DATA

			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

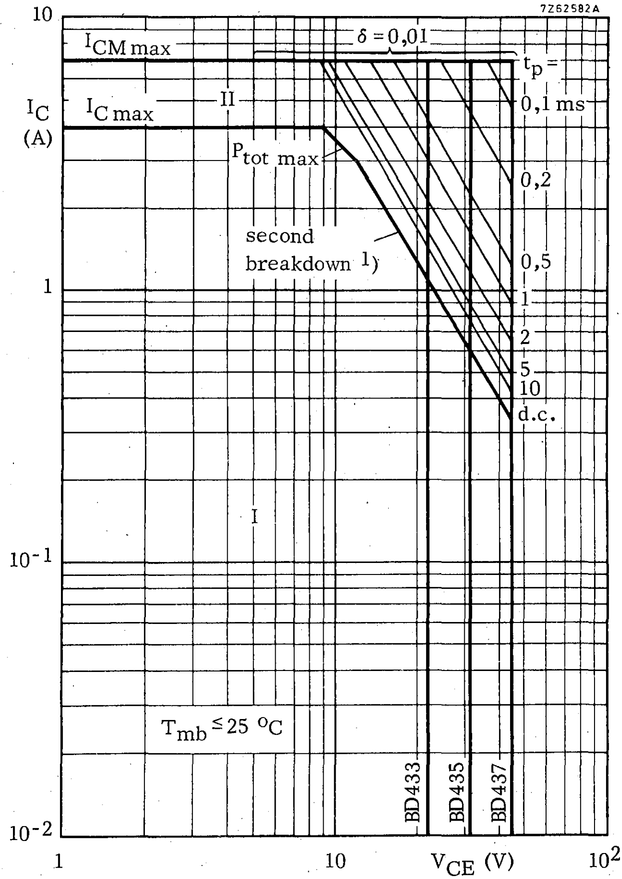
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	3,5	°C/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	100	°C/W

CHARACTERISTICS

$T_j = 25\ ^oC$ 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; $T_j = 150\ ^oC$	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
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	–	–	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						
$\lvert I_C \rvert = 500$ mA; $\lvert V_{CE} \rvert = 1$ V						
BD433/BD434 and BD435/BD436	h_{FE1}/h_{FE2}	<		1,4		
BD437/BD438	h_{FE1}/h_{FE2}	<		1,8		

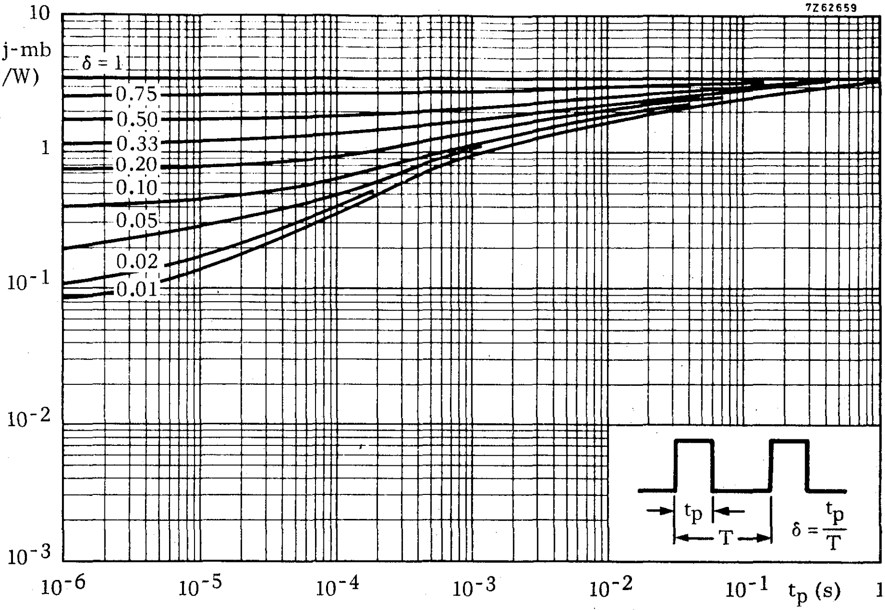
[1]) V_{BE} decreases by typ. 2,3 mV/^oC with increasing temperature.

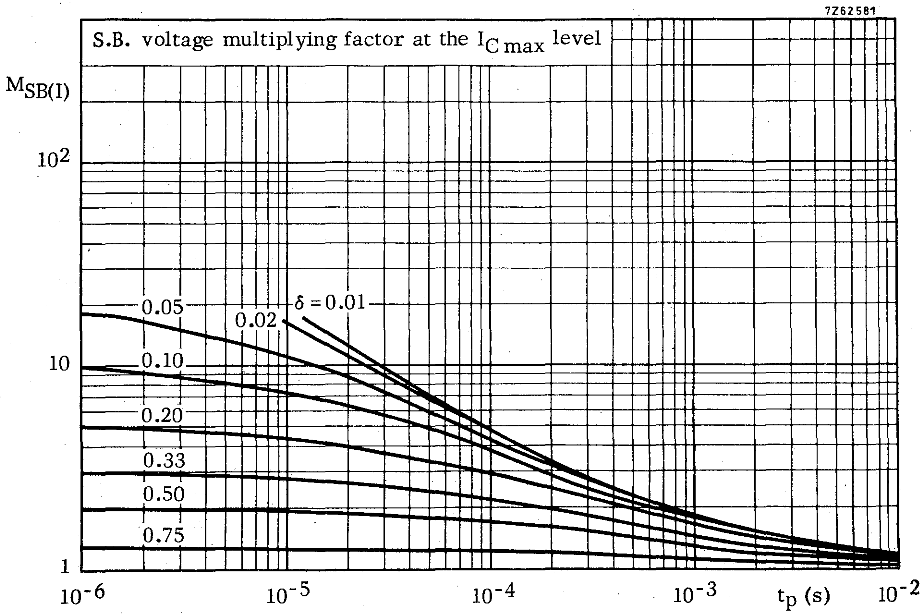


Safe Operating ARea with the transistor forward biased

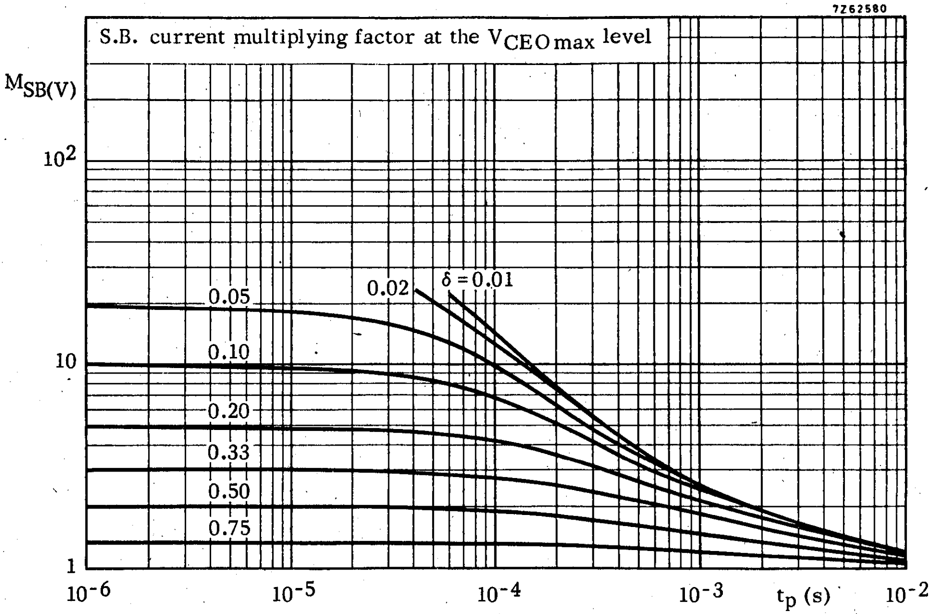
I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation

1) Independent of temperature.

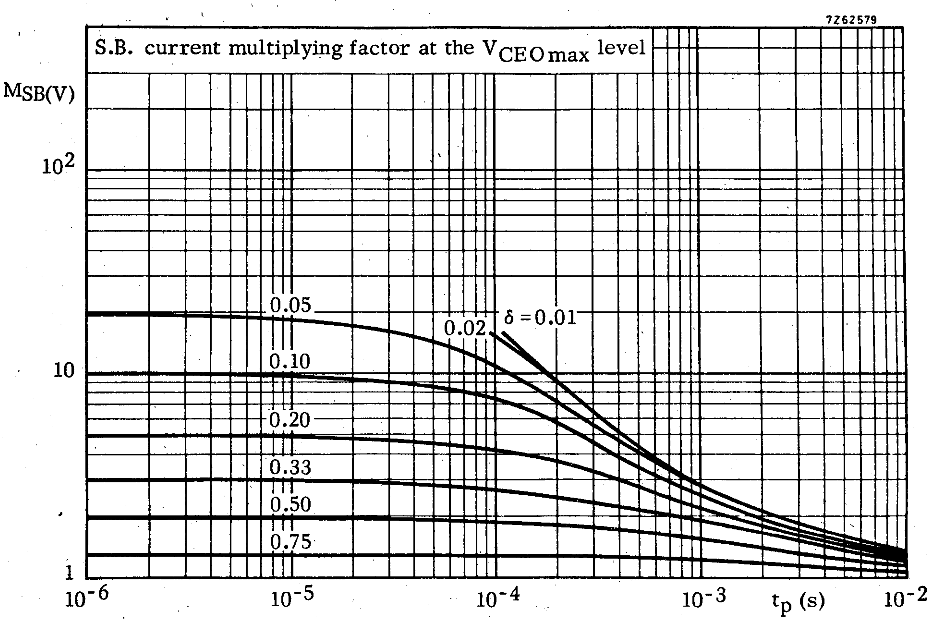

7Z62659
10
Zth j-mb
(°C/W)
δ = 1
0.75
0.50
0.33
1
0.20
0.10
0.05
0.02
10⁻¹
0.01
10⁻²
10⁻³
10⁻⁶
10⁻⁵
10⁻⁴
10⁻³
10⁻²
10⁻¹
tp (s)
1
tp
T
δ = tp/T

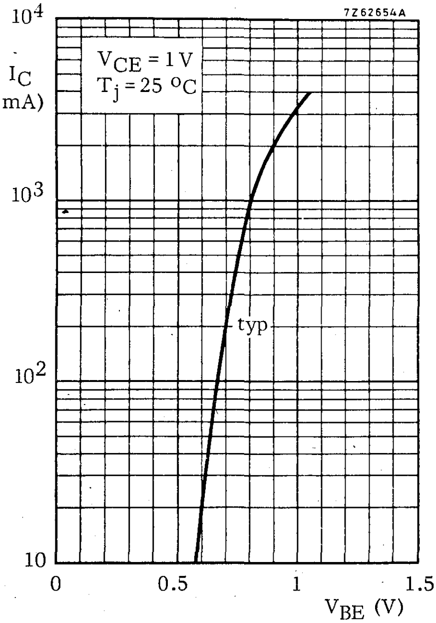

7Z62581
S.B. voltage multiplying factor at the IC max level
MSB(I)
10²
0.05
δ = 0.01
0.02
10
0.10
0.20
0.33
0.50
0.75
1
10⁻⁶
10⁻⁵
10⁻⁴
10⁻³
tp (s)
10⁻²

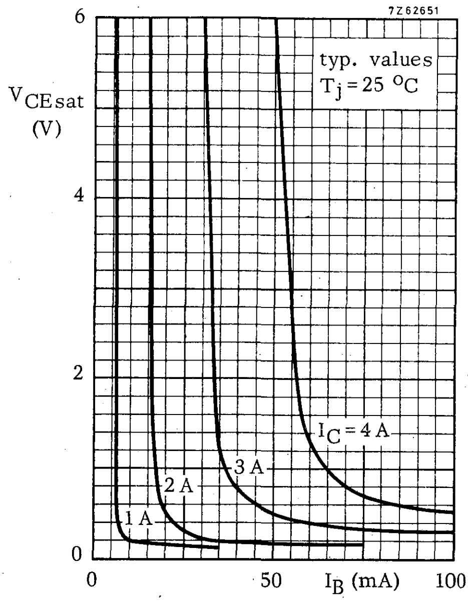
BD433; BD435

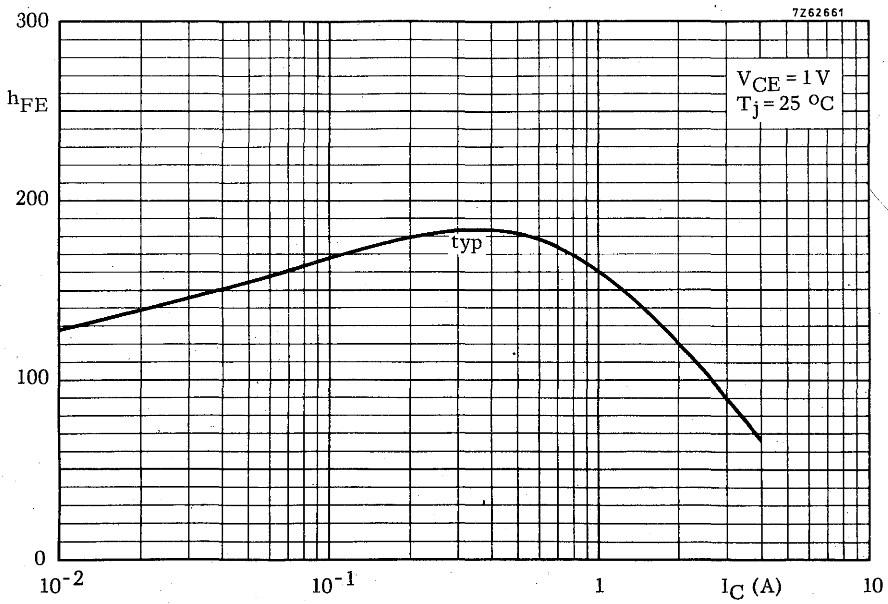


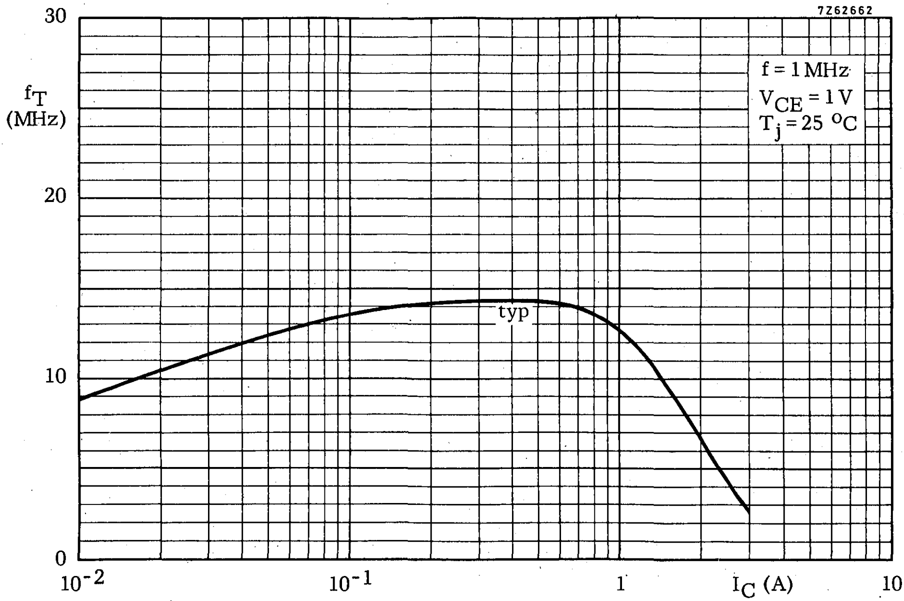
BD437

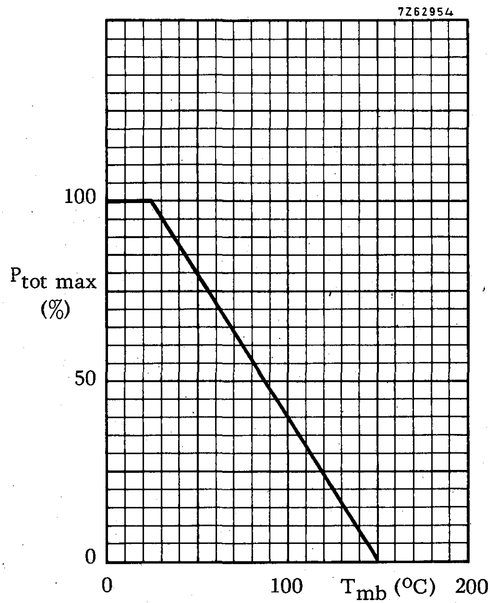



7Z62654A
10^4
I_C
mA)
$V_{CE} = 1\ V$
$T_j = 25\ ^oC$
10^3
typ
10^2
10
0
0.5
1
1.5
V_{BE} (V)


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

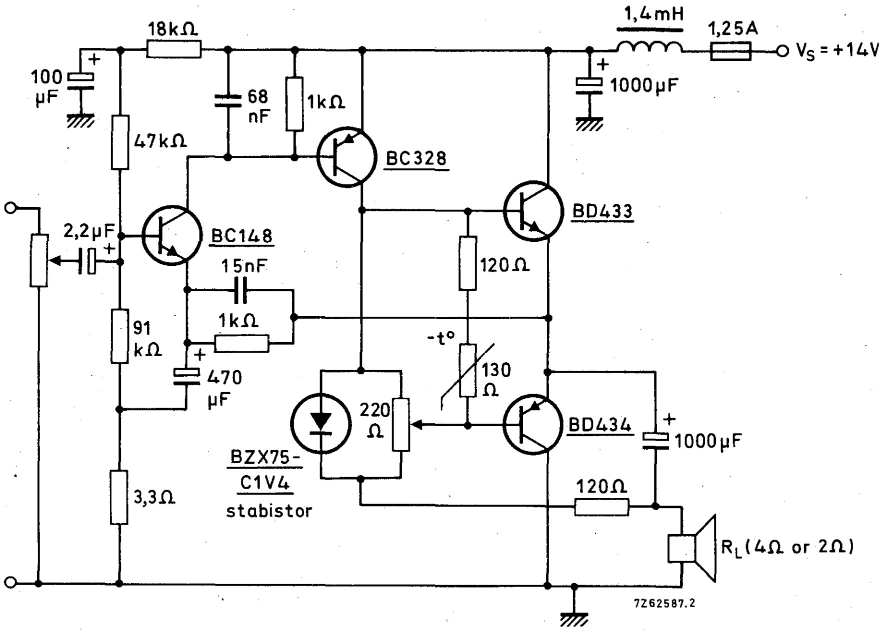

7Z62661
300
h_{FE}
$V_{CE} = 1\ V$
$T_j = 25\ ^oC$
200
typ
100
0
10^{-2}
10^{-1}
1
I_C (A)
10


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

APPLICATION INFORMATION

Basic circuit diagram of a 6 W car-radio audio amplifier.



Typical performance:

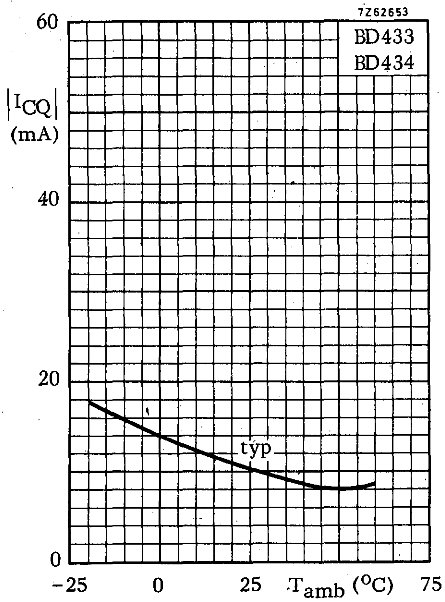
Output power at d_{tot} = 10% and R_L = 4 Ω	P_o	≥	6	W
Output power at d_{tot} = 10% and R_L = 2 Ω	P_o		8	W
Input voltage for P_o = 5 W; R_L = 4 Ω	$V_{i(rms)}$		20	mV
P_o = 5 W; R_L = 2 Ω	$V_{i(rms)}$		15	mV
Input impedance	z_i		20	kΩ
Collector quiescent current of output transistors	$\lvert I_{CQ} \rvert$		10	mA
Collector current of BC328 [1]	$-I_C$		50	mA
Total current consumption at P_o = 6 W	I_{tot}		580	mA
Frequency response (−3 dB)			0,1 to 12	kHz
Total thermal resistance per output transistor	$R_{th\ j\text{-}a}$	max.	26,5	°C/W

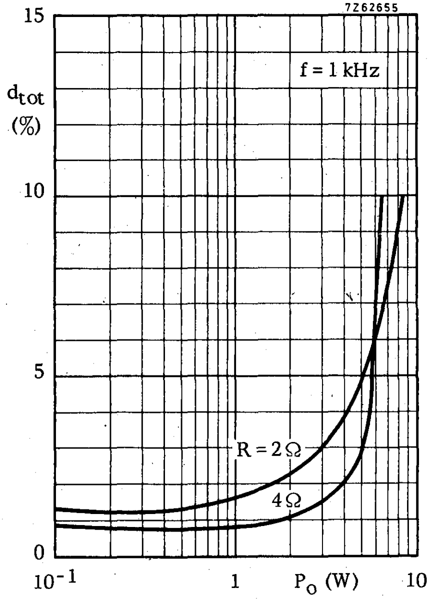
Stable continuous operation is ensured up to an ambient temperature of 60 °C

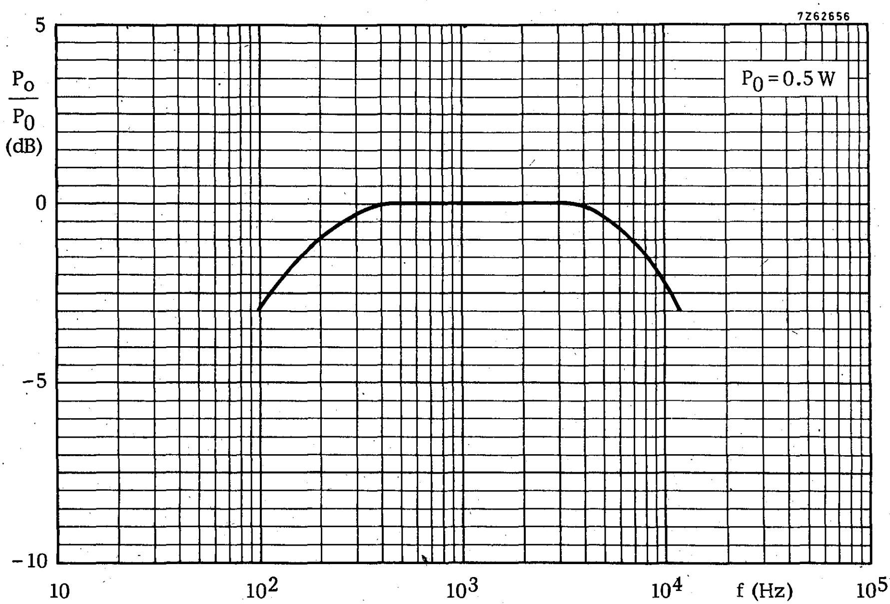
The amplifier is overdrive proof and short circuit proof.

1) Area of printed wiring copper around collector lead ≈ 1 cm^2.

APPLICATION INFORMATION (continued)

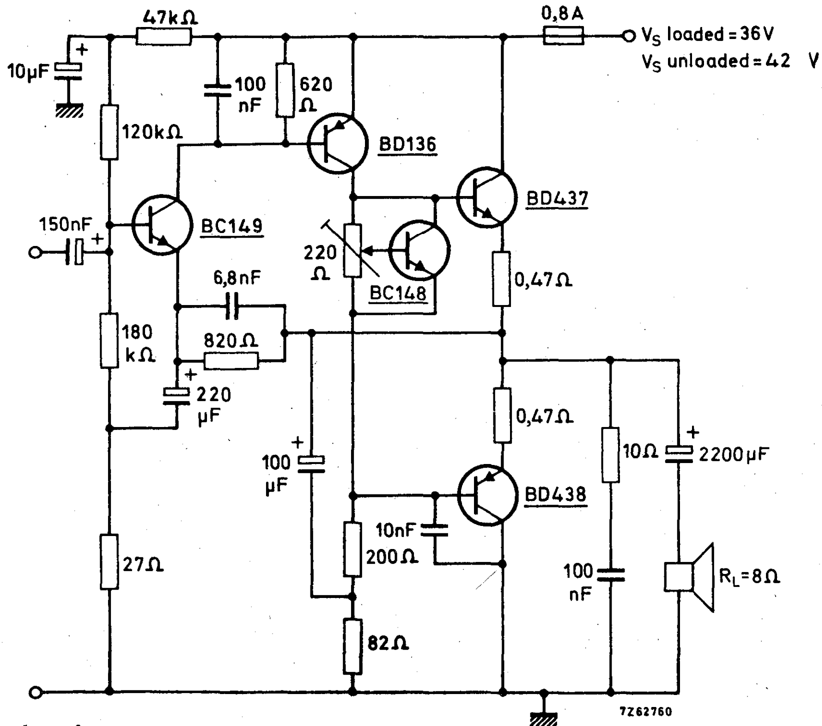






APPLICATION INFORMATION (continued)

Basic circuit diagram of a 15 W high quality amplifier.

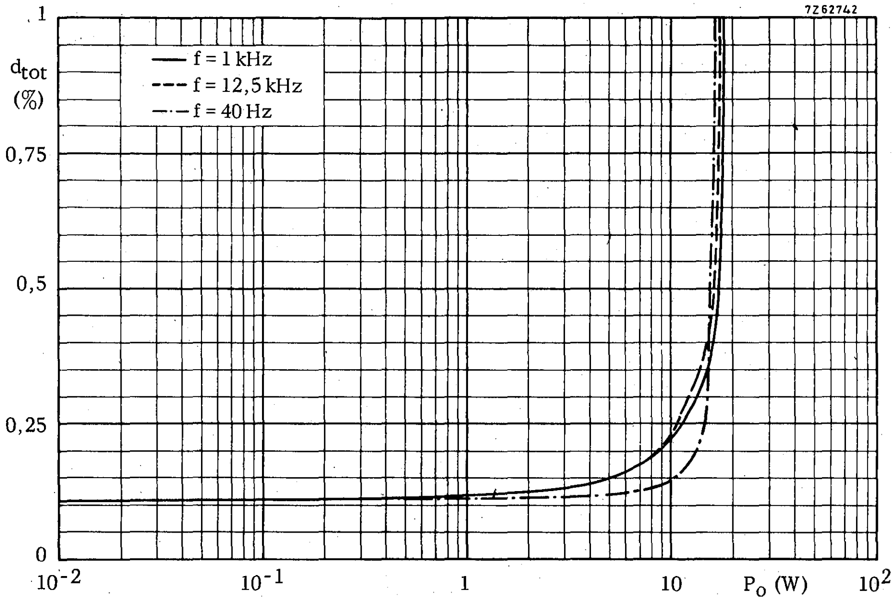


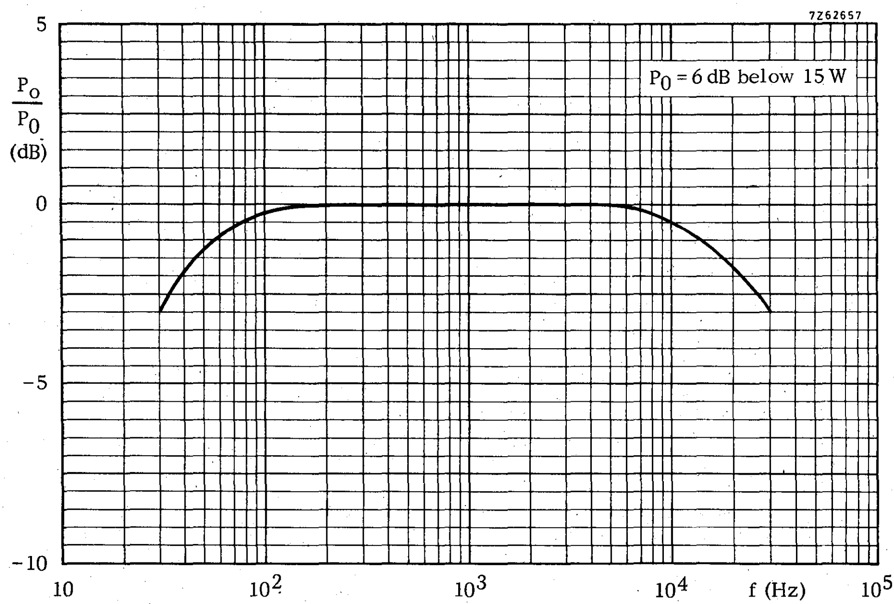
Typical performance:

Output power at d_{tot} = 1%	P_o	≥	15	W
Input voltage for P_o = 10 W	$V_{i(rms)}$		360	mV
Input impedance	z_i		100	kΩ
Output impedance	z_o		0, 15	Ω
Collector quiescent current of output transistors	$\lvert I_{CQ}\rvert$		10	mA
Collector current of BD136	$-I_C$		72	mA
Collector current of BC149	I_C		1, 6	mA
Total current consumption at P_o = 15 W	I_{tot}		710	mA
Frequency response (−3 dB)		30 Hz to	30	kHz
Total thermal resistance per output transistor	$R_{th\ j\text{-}a}$	max.	18	$^oC/W$
Total thermal resistance of the BD136	$R_{th\ j\text{-}a}$	max.	44	$^oC/W$

Stable continuous operation is ensured up to an ambient temperature of 45 ^oC.

APPLICATION INFORMATION (continued)





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

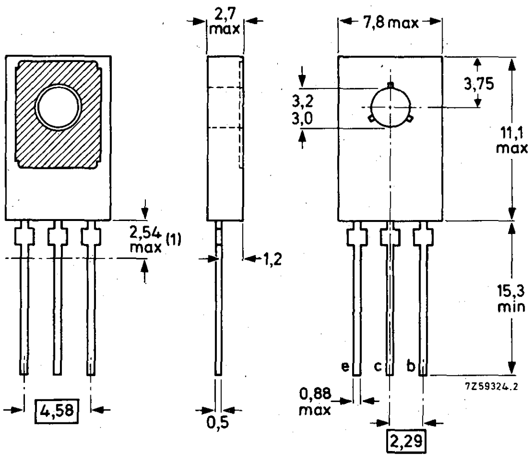
			BD434	BD436	BD438	
Collector-emitter voltage ($-V_{BE} = 0$)	$-V_{CES}$	max.	22	32	45	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	22	32	45	V
Collector current (peak value)	$-I_{CM}$	max.	7	7	7	A
Total power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.	36	36	36	W
D.C. current gain $-I_C = 2$ 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)

			BD434	BD436	BD438	
Voltages						
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

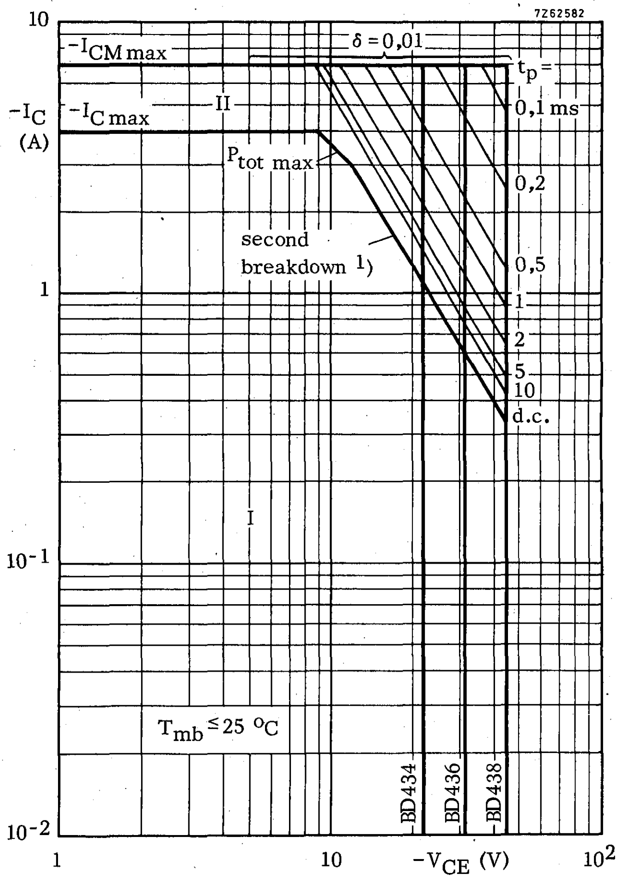
THERMAL RESISTANCE

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

CHARACTERISTICS T_j = 25 °C unless otherwise specified

			BD434	BD436	BD438	
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	–	–	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						
$\lvert I_C \rvert = 500$ mA; $\lvert V_{CE} \rvert = 1$ 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/°C with increasing temperature.

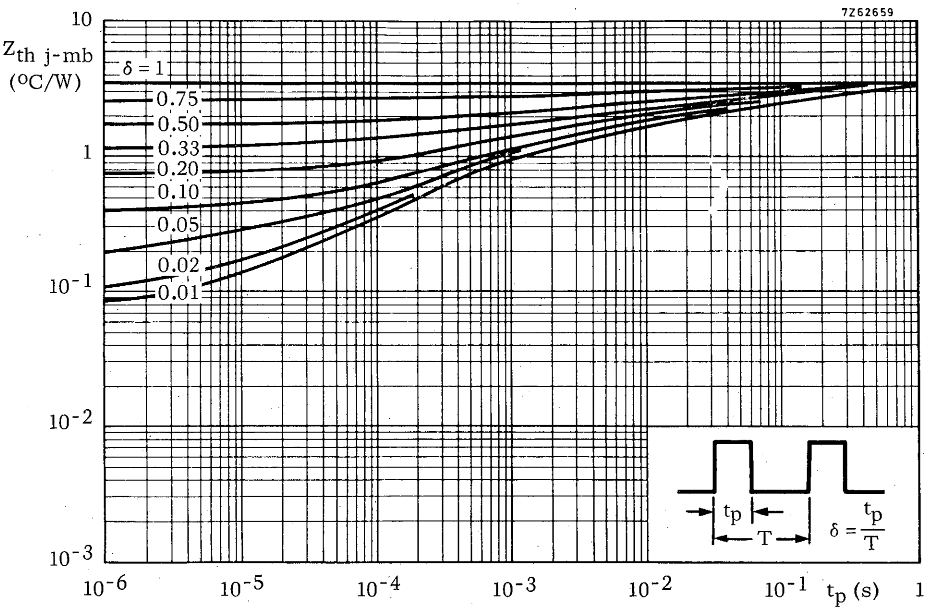


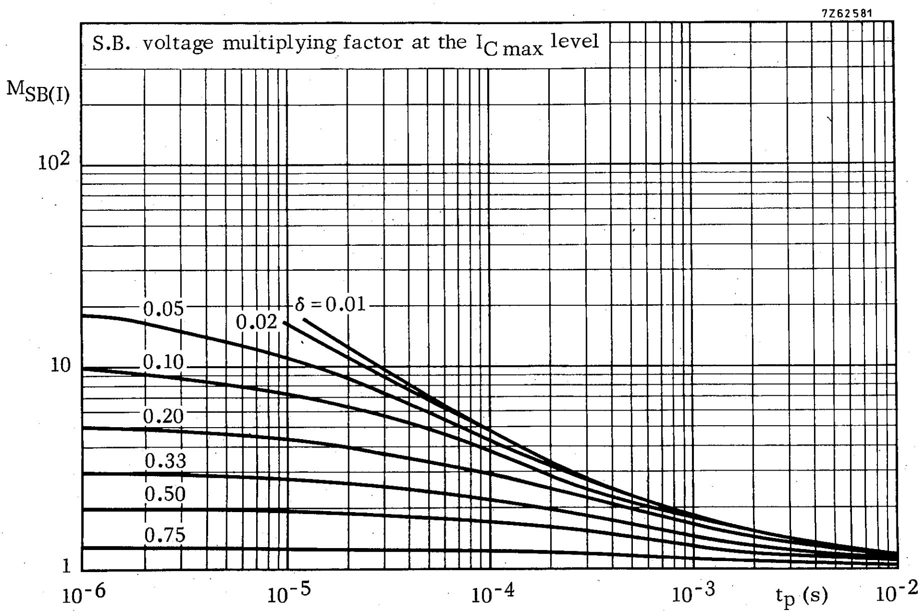
Safe Operating ARea with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

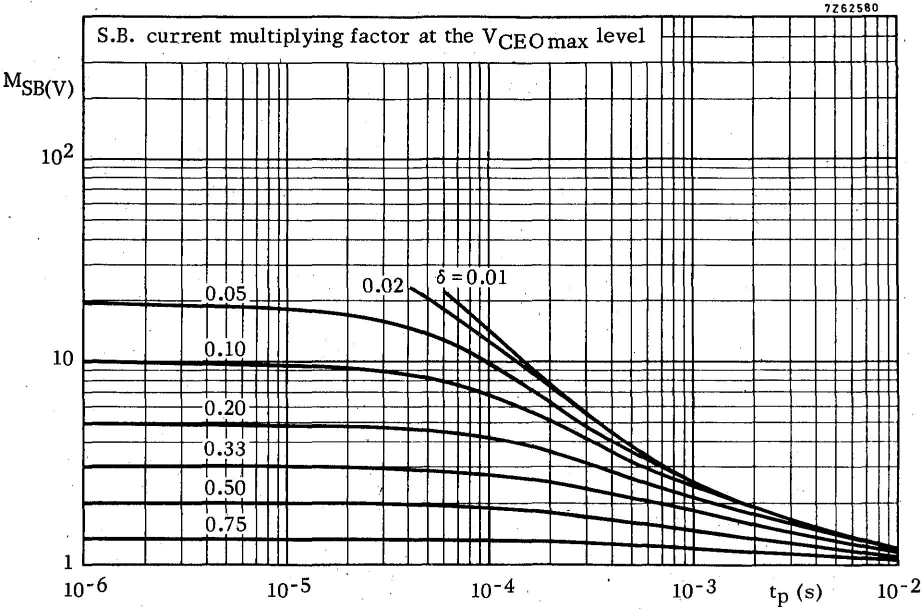
1) Independent of temperature.


7Z62659
$Z_{th\ j\text{-}mb}$ (°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
t_p
T
$\delta = \frac{t_p}{T}$
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
t_p (s)
1


7Z62581
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}

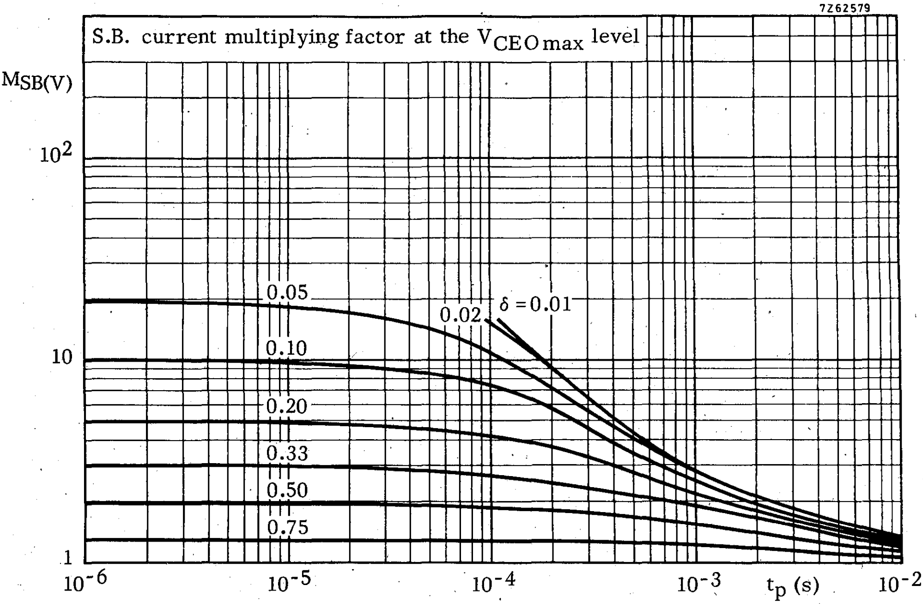
BD434; BD436

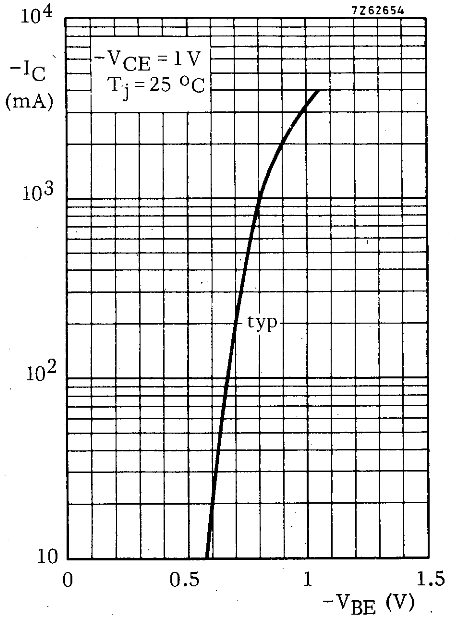
7Z62580

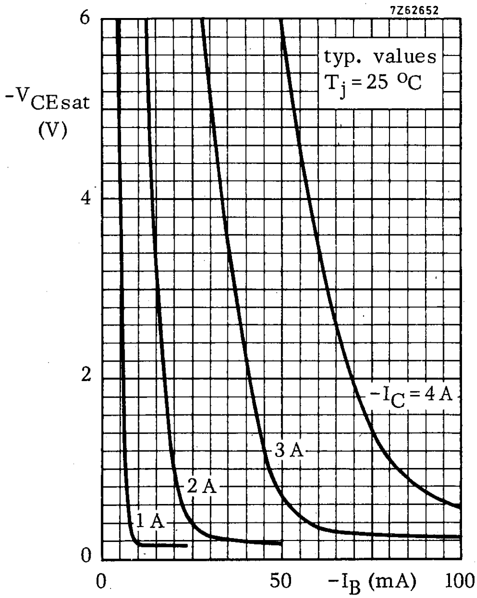


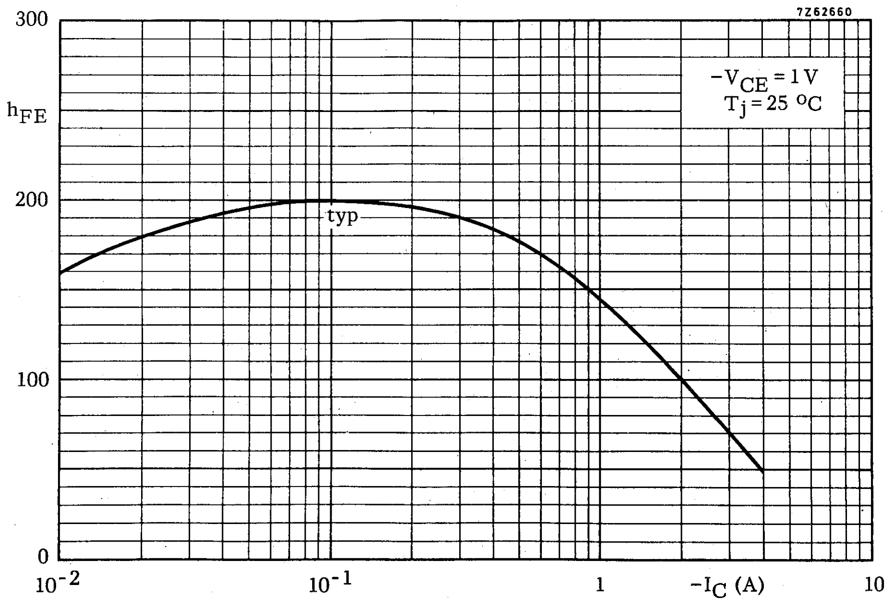
BD438

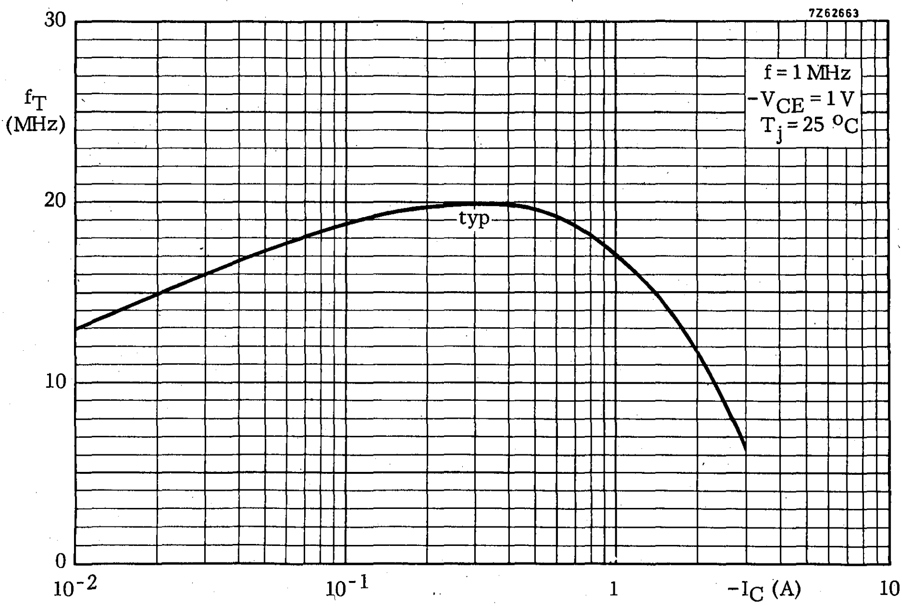
7Z62579

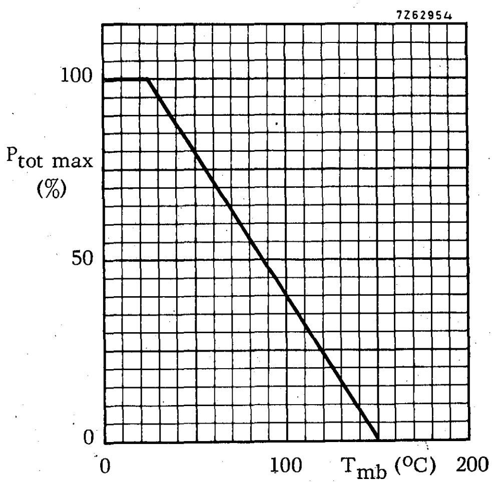



7Z62654
$-V_{CE} = 1$ V
$T_j = 25$ °C
$-I_C$ (mA)
10^4
10^3
10^2
10
typ
0
0.5
1
1.5
$-V_{BE}$ (V)


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


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





APPLICATION INFORMATION

For information on a 6 W car-radio amplifier and on a 15 W high quality amplifier see BD433; BD435; BD437.

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

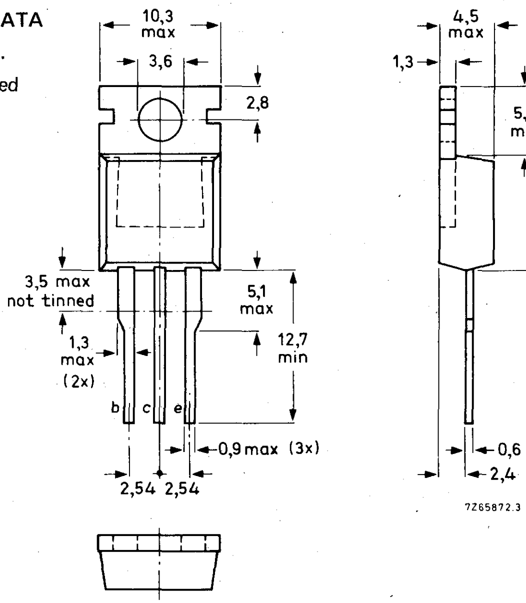
			BD645	647	649	651	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Collector current (peak value)	I_{CM}	max.		12			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		62,5			W
Junction temperature	T_j	max.		150			°C
D.C. current gain:							
I_C = 0,5 A; V_{CE} = 3 V	h_{FE}	typ.		1500			
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

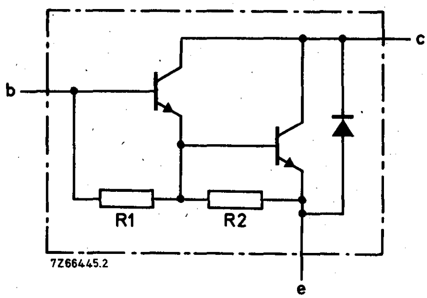


Fig. 2
R_1 typ. 4 kΩ
R_2 typ. 100 Ω

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	°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				
$I_E = 0$; $V_{CBO} = V_{CEOmax}$	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.	1500	
$I_C = 3$ A; $V_{CE} = 3$ V	h_{FE}	>	750	
$I_C = 8$ A; $V_{CE} = 3$ V	h_{FE}	typ.	500	
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.	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. 4	$E_{(BR)}$	>	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	←

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

T_j = 25 °C unless otherwise specified

Switching times (between 10% and 90% levels)

I_{Con} = 3 A; I_{Bon} = $-I_{Boff}$ = 12 mA; V_{CC} = 10 V

Turn-on time	t_{on}	typ.	0,5 μs
Turn-off time	t_{off}	typ.	2,5 μs

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

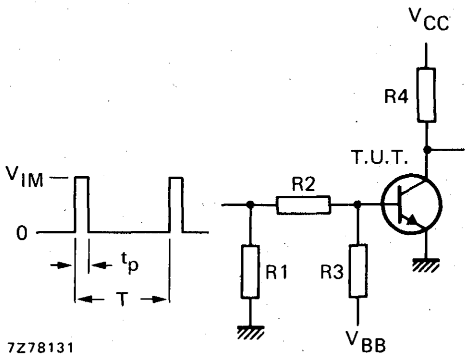


Fig. 3 Test circuit switching times.

Diode, forward voltage

I_F = 3 A | V_F typ. 1,2 V

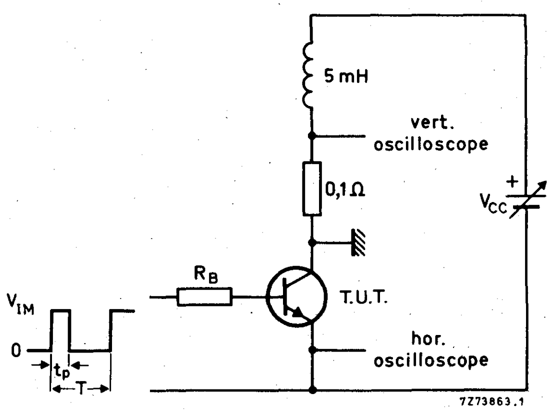


Fig. 4 Test circuit for turn-off breakdown energy. V_{IM} = 12 V; R_B = 270 Ω; T = 100 ms; t_p = 1 ms.

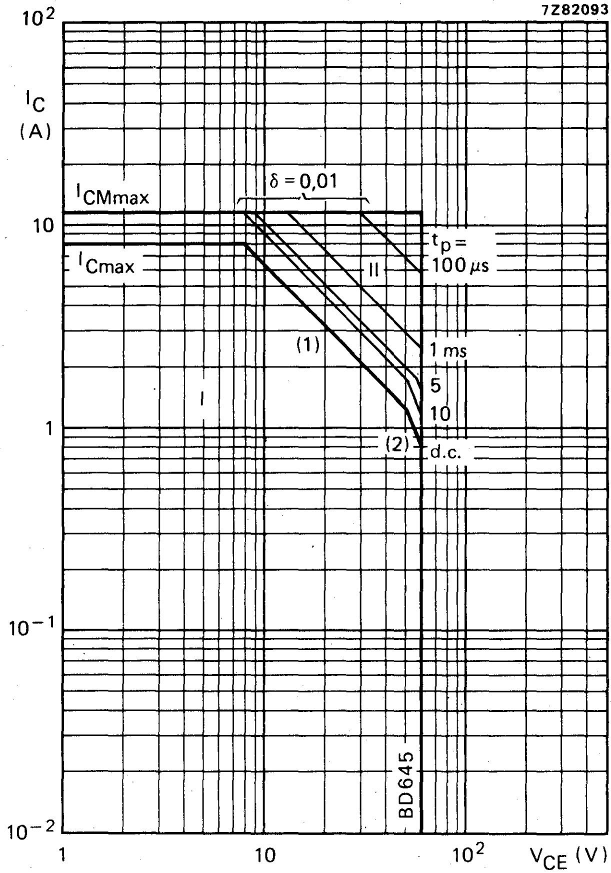


Fig. 5 Safe Operating ARea; $T_{mb} = 25\ ^{o}C$

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).

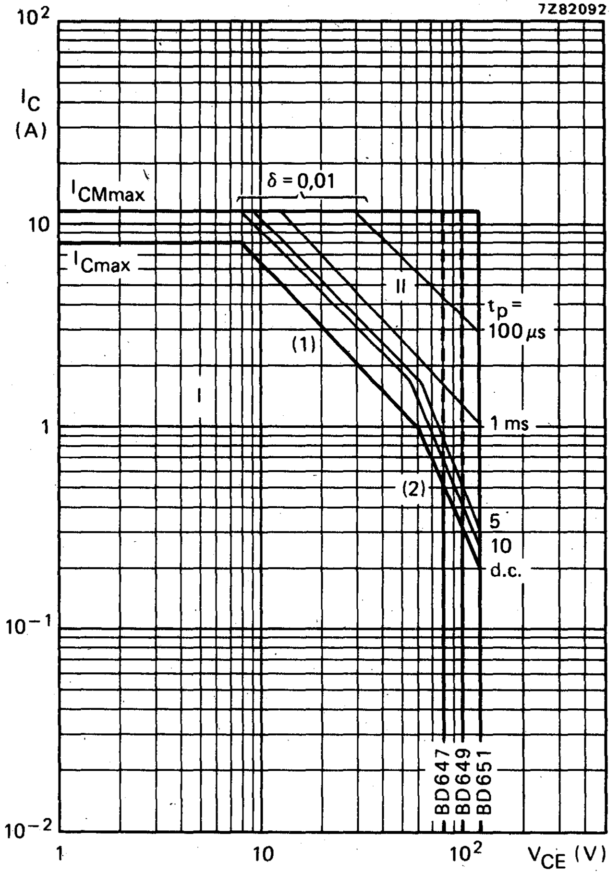


Fig. 6 Safe Operating ARea; $T_{mb} = 25\ ^oC$.

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).

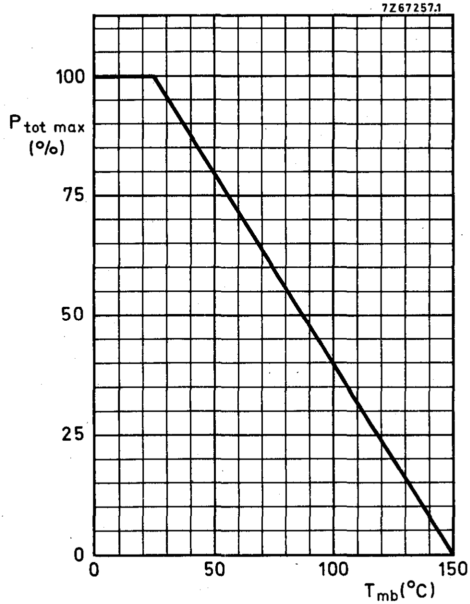


Fig. 7.

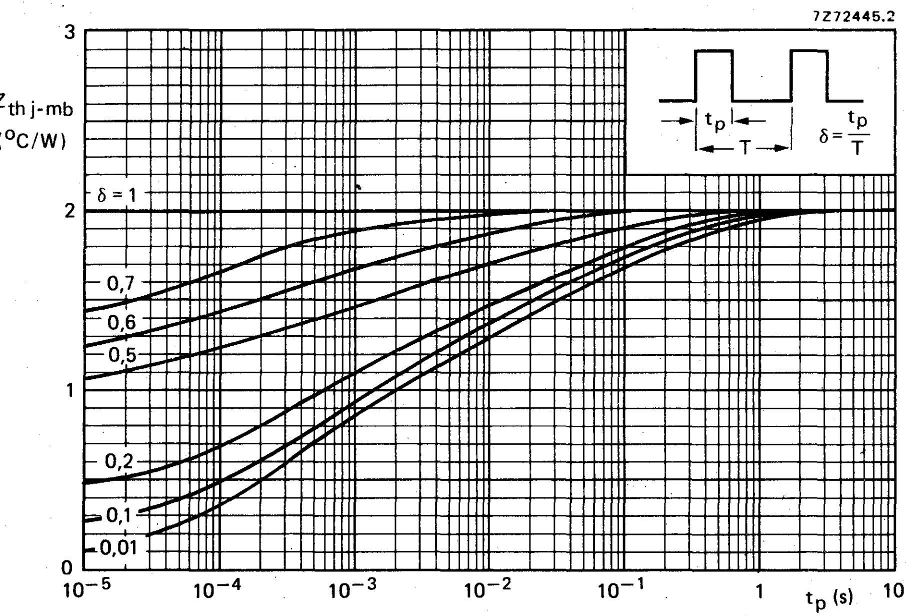


Fig. 8 Pulse power rating chart.

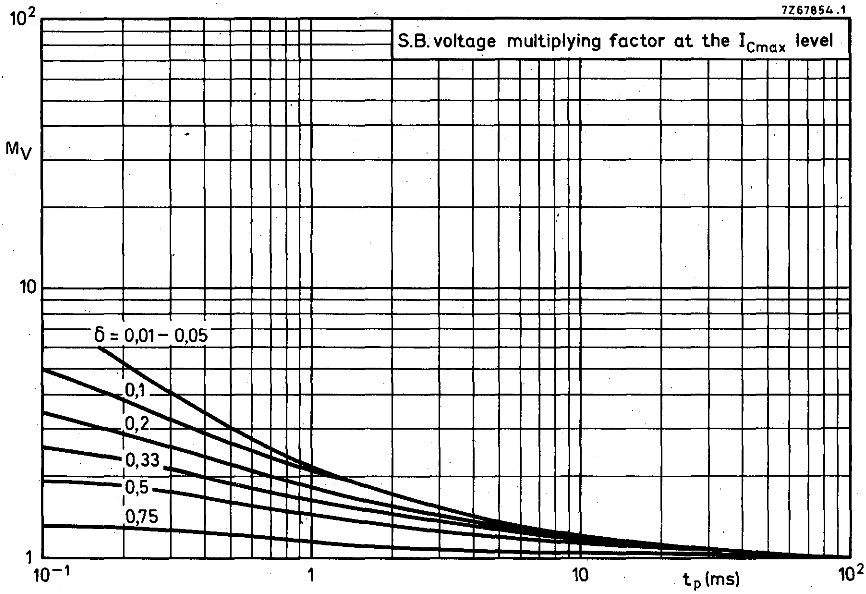

7Z67854.1
S.B. voltage multiplying factor at the I_{Cmax} level
10^2
M_V
10
1
δ = 0,01 – 0,05
0,1
0,2
0,33
0,5
0,75
10^{-1}
1
10
t_p (ms)
10^2

Fig. 9.

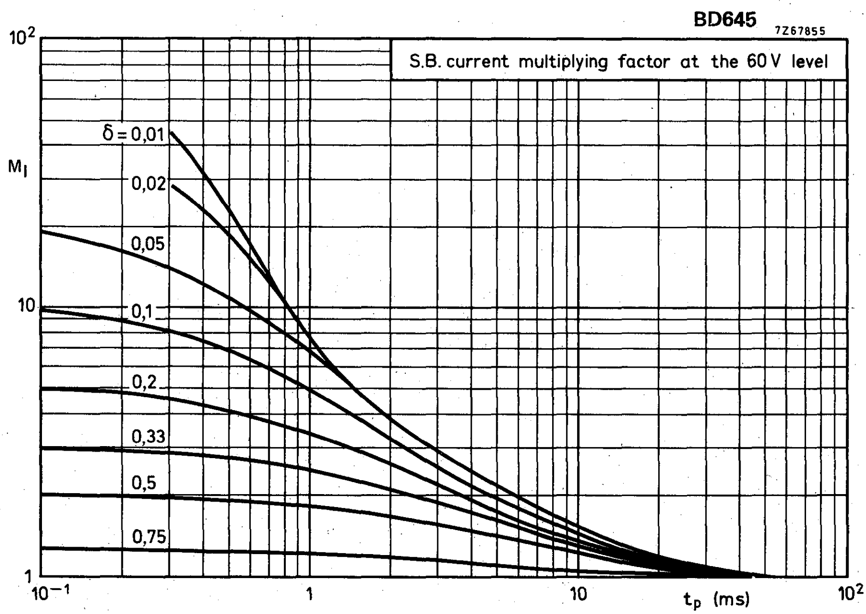

BD645
7Z67855
S.B. current multiplying factor at the 60 V level
10^2
M_I
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-1}
1
10
t_p (ms)
10^2

Fig. 10.

BD647; BD649

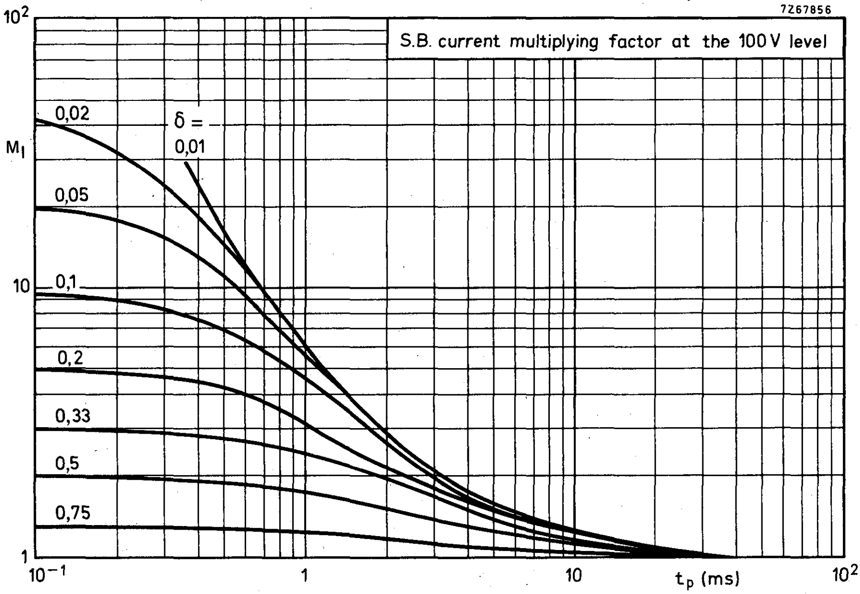


Fig. 11 Second breakdown current multiplying factor at the 100 V level.

BD651

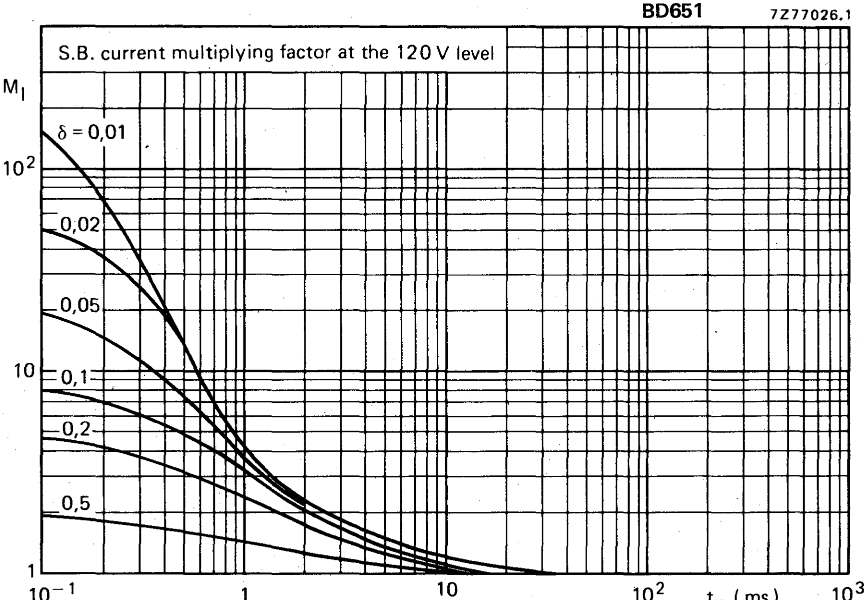


Fig. 12 Second breakdown current multiplying factor at the 120 V level.

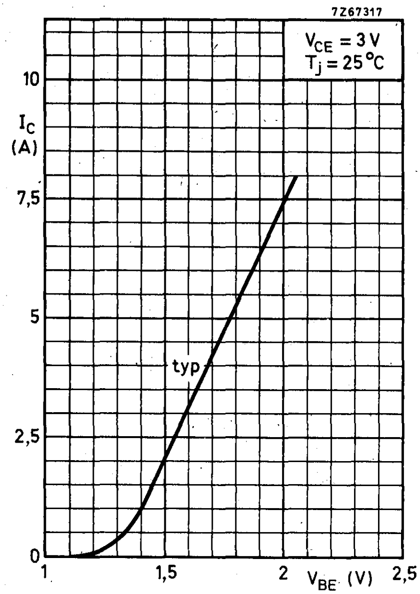


Fig. 13.

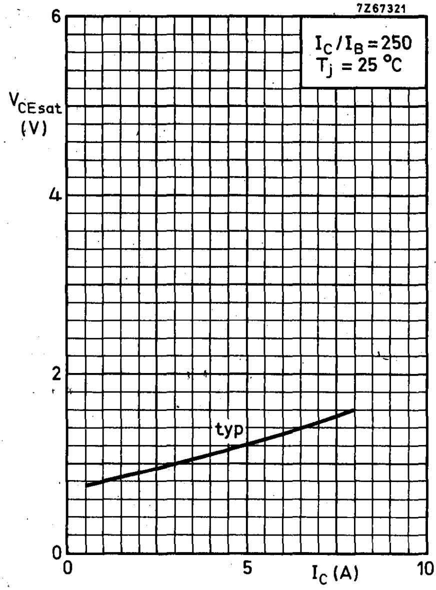


Fig. 14.

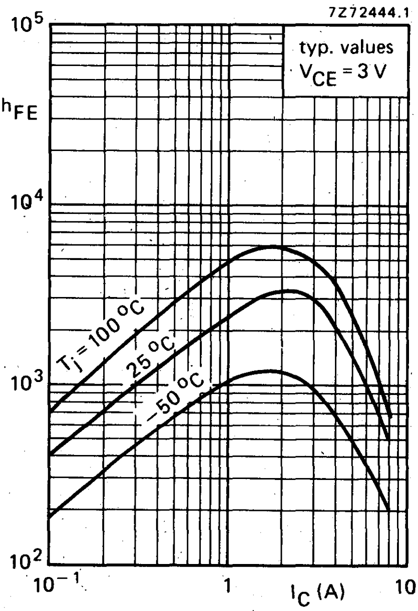


Fig. 15.

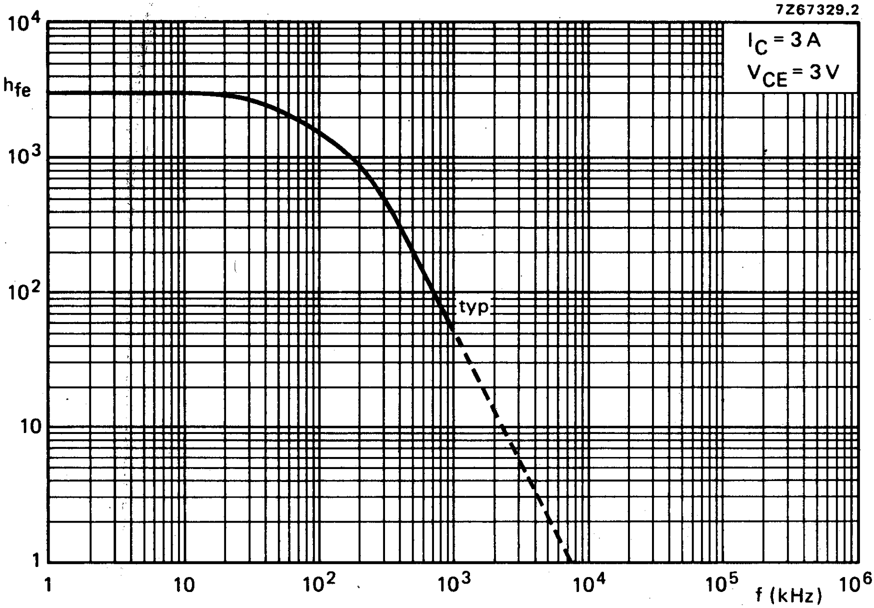

7Z67329.2
$I_C = 3$ A
$V_{CE} = 3$ V
h_{fe}
10^4
10^3
10^2
10
1
typ
1
10
10^2
10^3
10^4
10^5
f (kHz)
10^6

Fig. 16.

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

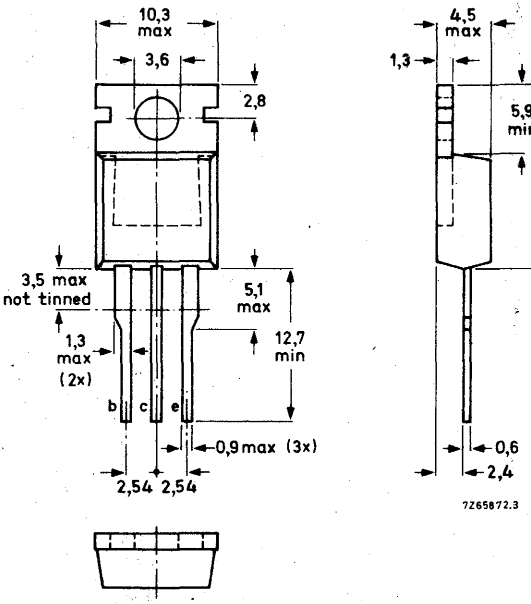
			BD646	648	650	652	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Collector current (peak value)	$-I_{CM}$	max.		12			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		62,5			W
Junction temperature	T_j	max.		150			°C
D.C. current gain:							
$-I_C$ = 0,5 A; $-V_{CE}$ = 3 V	h_{FE}	typ.		1500			
$-I_C$ = 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

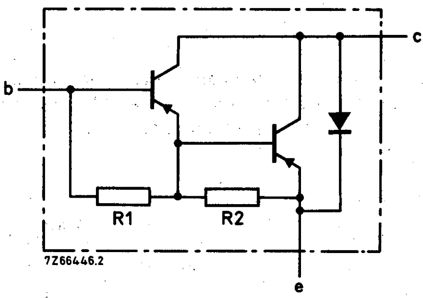
Dimensions in mm

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	°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
$I_E = 0$; 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
$I_B = 0$; $-V_{CE} = \frac{1}{2} V_{CEOmax}$	$-I_{CEO}$	<	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.	1500	
$-I_C = 3$ A; $-V_{CE} = 3$ V	h_{FE}	>	750	
$-I_C = 8$ A; $-V_{CE} = 3$ V	h_{FE}	typ.	500	
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.	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	$\lvert h_{fe} \rvert$	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	

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)

T_j = 25 °C unless otherwise specified

Switching times (between 10% and 90% levels)

$-I_{Con}$ = 3 A; $-I_{Bon} = I_{Boff}$ = 12 mA; V_{CC} = −10 V

Turn-on time	t_{on}	typ.	0,2 μs
Turn-off time	t_{off}	typ.	1,5 μs

$-V_{IM}$ = 10 V
$t_r = t_f$ = 15 ns
t_p = 10 μs
T = 500 μs

R1 = 56 Ω
R2 = 410 Ω
R3 = 560 Ω
R4 = 3 Ω

V_{BB} = 4 V

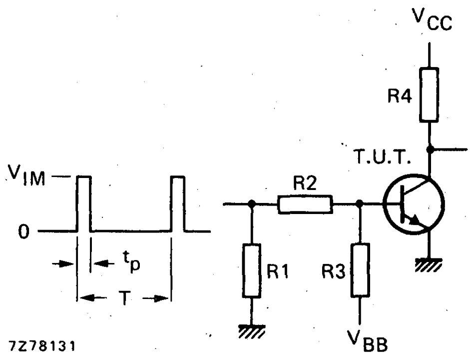


Fig. 3 Test circuit.

Diode, forward voltage

I_F = 3 A	V_F	typ.	1,8 V

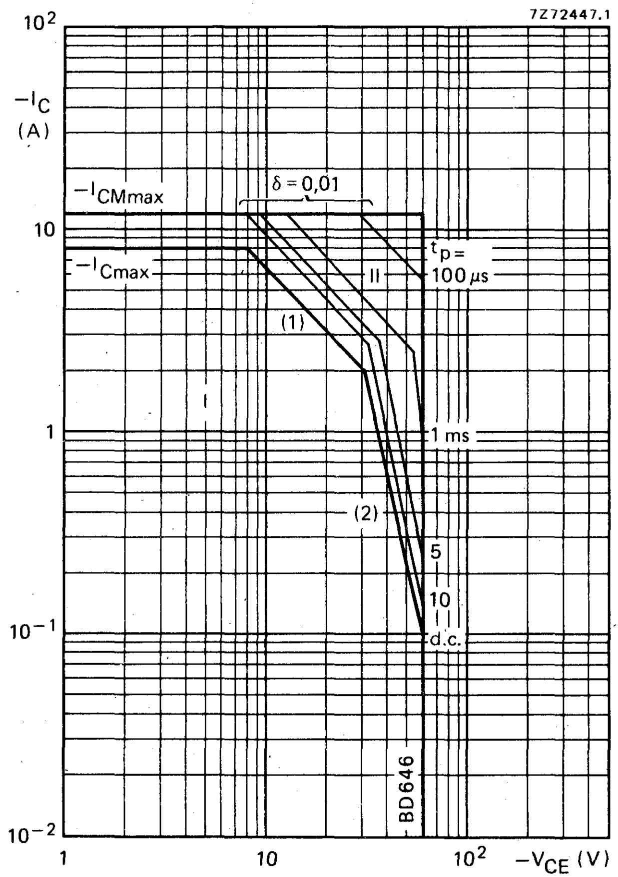


Fig. 4 Safe Operating ARea. $T_{mb} = 25\ ^oC$.

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).

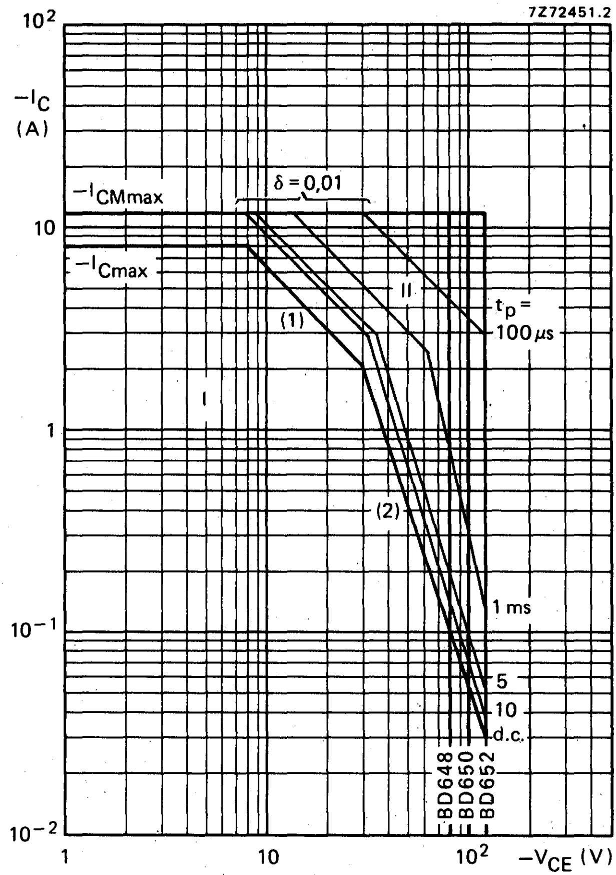


Fig. 5 Safe Operating ARea. T_{mb} = 25 °C

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).

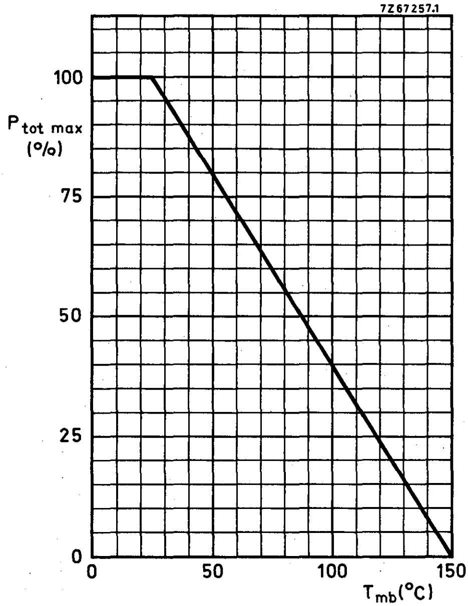


Fig. 6.

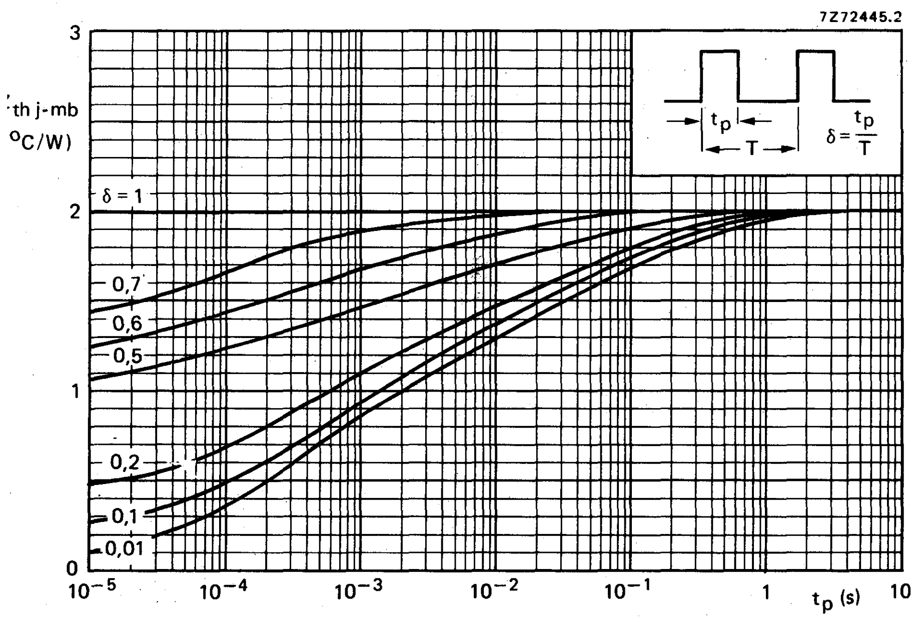


Fig. 7 Pulse power rating chart.

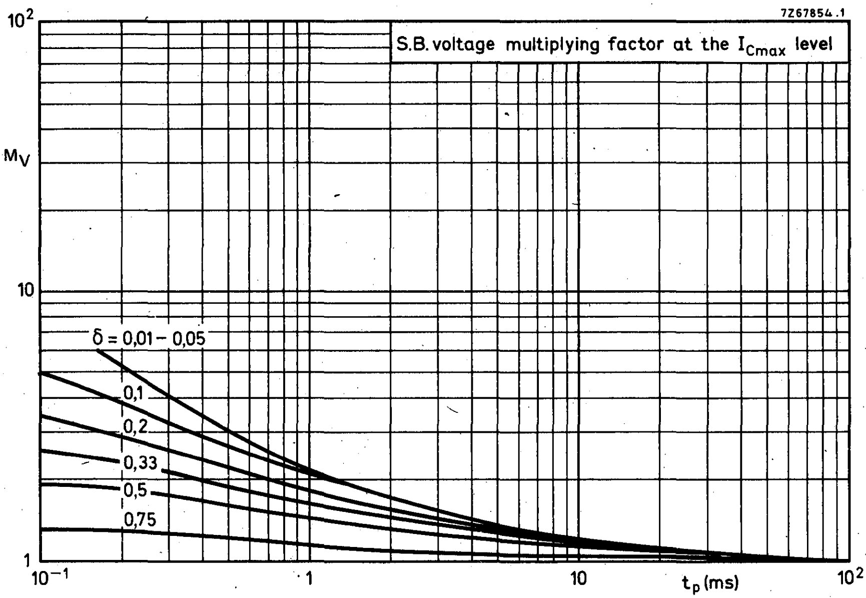


Fig. 8.

BD646

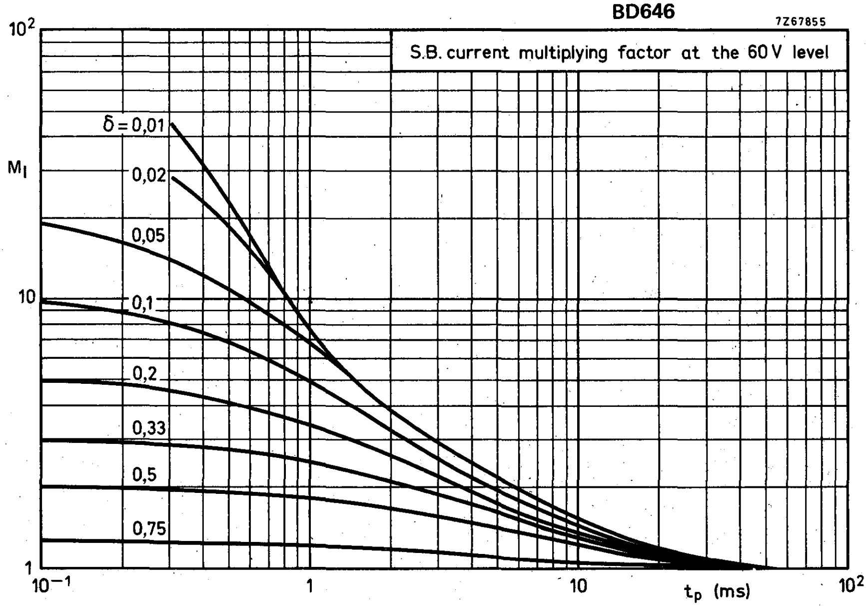


Fig. 9.

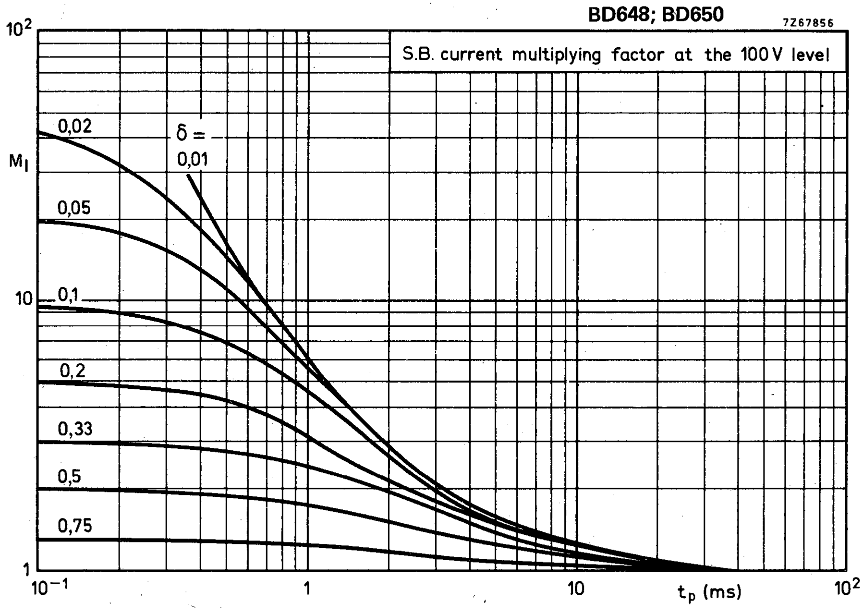

BD648; BD650
7Z67856
S.B. current multiplying factor at the 100 V level
M_I
10^2
10
1
0,02
δ =
0,01
0,05
0,1
0,2
0,33
0,5
0,75
10^{-1}
1
10
t_p (ms)
10^2

Fig. 10.

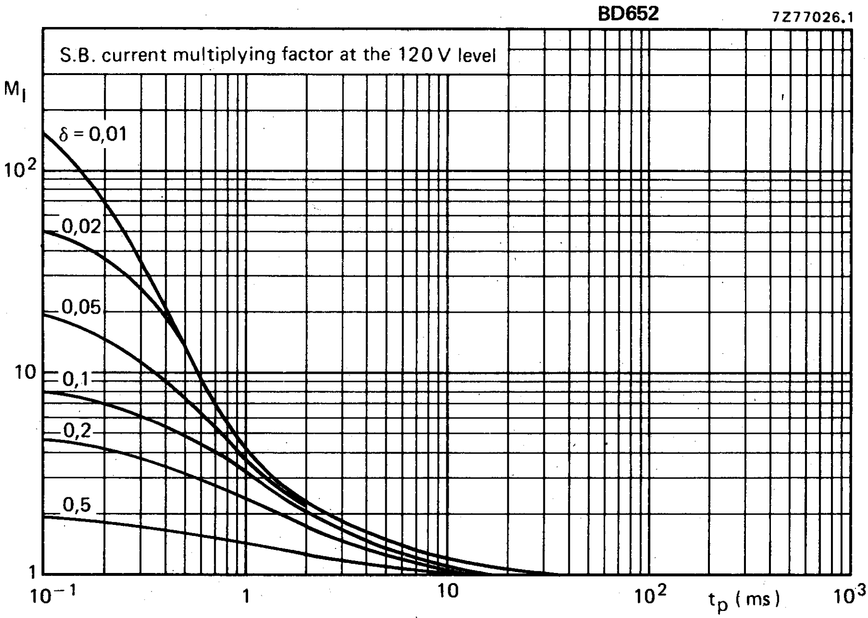

BD652
7Z77026.1
S.B. current multiplying factor at the 120 V level
M_I
δ = 0,01
10^2
0,02
0,05
10
0,1
0,2
0,5
1
10^{-1}
1
10
10^2
t_p (ms)
10^3

Fig. 11.

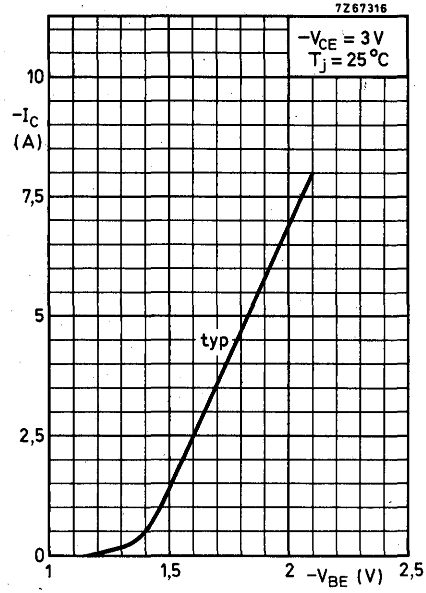


Fig. 12.

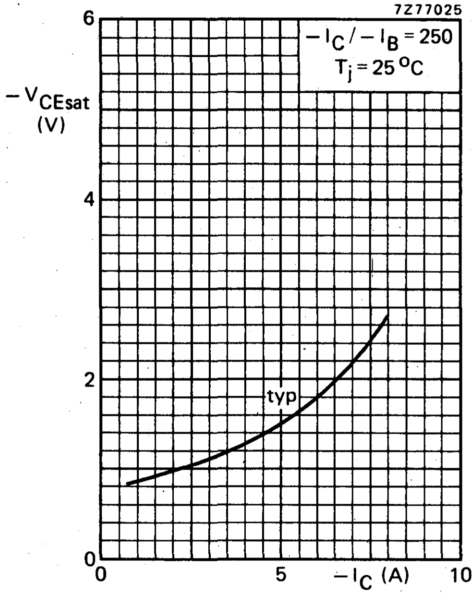


Fig. 13.

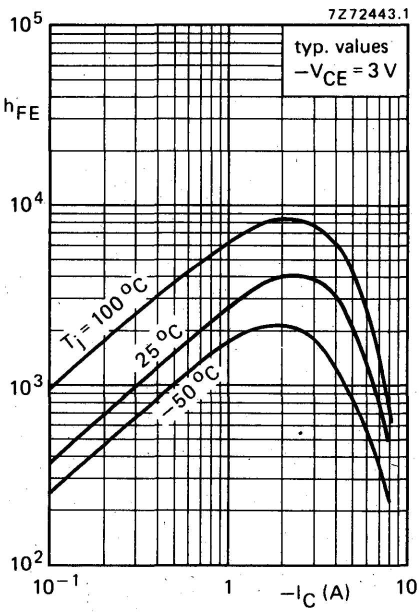


Fig. 14.

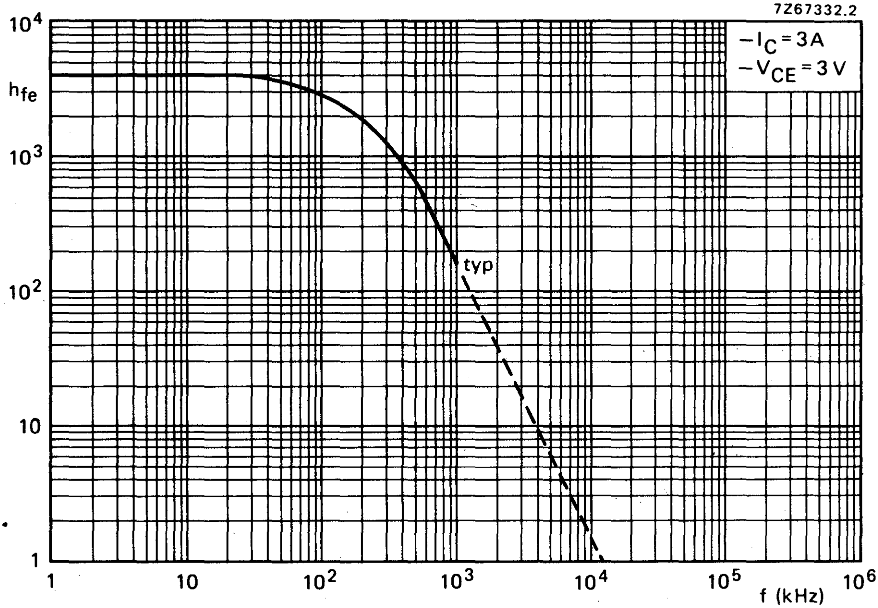

7Z67332.2
$-I_C = 3 A$
$-V_{CE} = 3 V$
h_{fe}
10^4
10^3
10^2
10
1
1
10
10^2
10^3
10^4
10^5
10^6
f (kHz)
typ

Fig. 15.

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

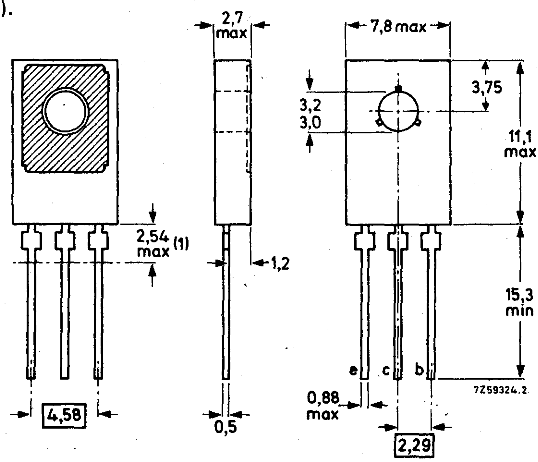
			BD675	677	679	681	683	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	100	120	V
Collector current (peak value)	I_{CM}	max.			6			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.			40			W
Junction temperature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

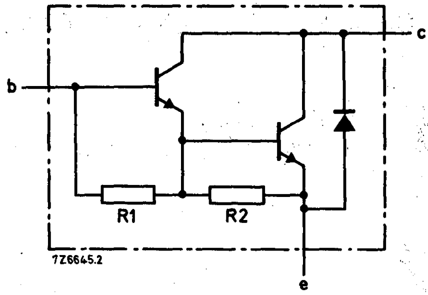
Collector connected to mounting base.



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

Accessories: 56326 (washer) or 56353 (clip) for direct mounting.
56333 (washer + mica) or 56353 + 56354 (clip + mica) for insulated mounting.

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	°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 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.	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	$\lvert h_{fe} \rvert$	typ.	50	←
Cut-off frequency				
I_C = 1,5 A; V_{CE} = 3 V	f_{hfe}	typ.	60 kHz	←
Turn-off breakdown energy with inductive load				
$-I_{Boff} = 0$; I_{CM} = 3,5 A; L = 5 mH; see 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	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.

CHARACTERISTICS (continued)

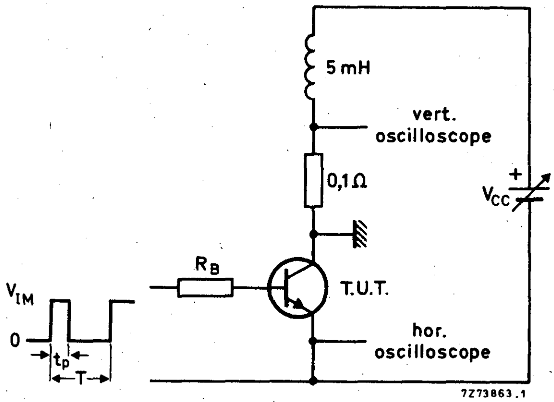


Fig. 3 Test circuit for turn-off breakdown energy. V_{IM} = 12 V; R_B = 270 Ω.

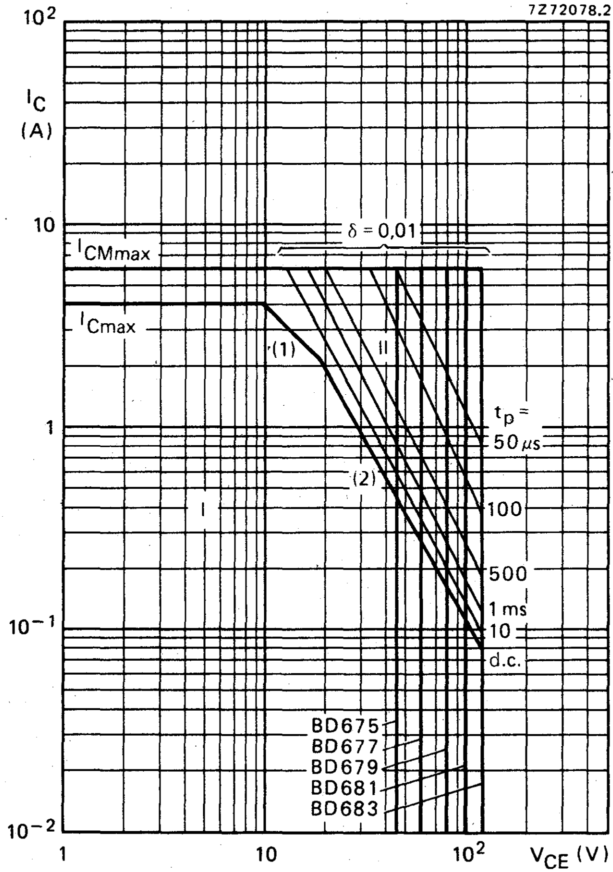


Fig. 4 Safe Operating ARea. T_{mb} = 25 °C.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

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

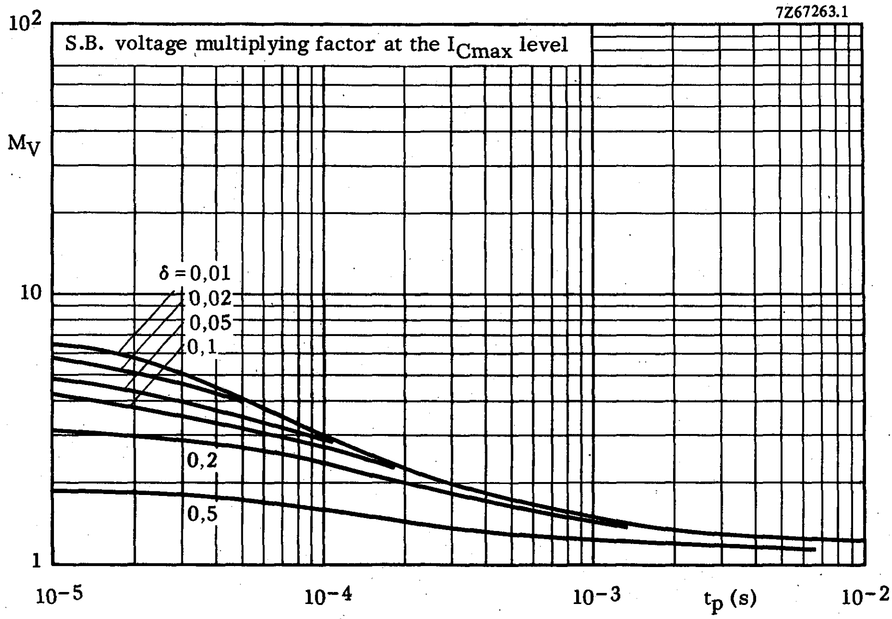


Fig. 5 S.B. voltage multiplying factor at the I_{Cmax} level.

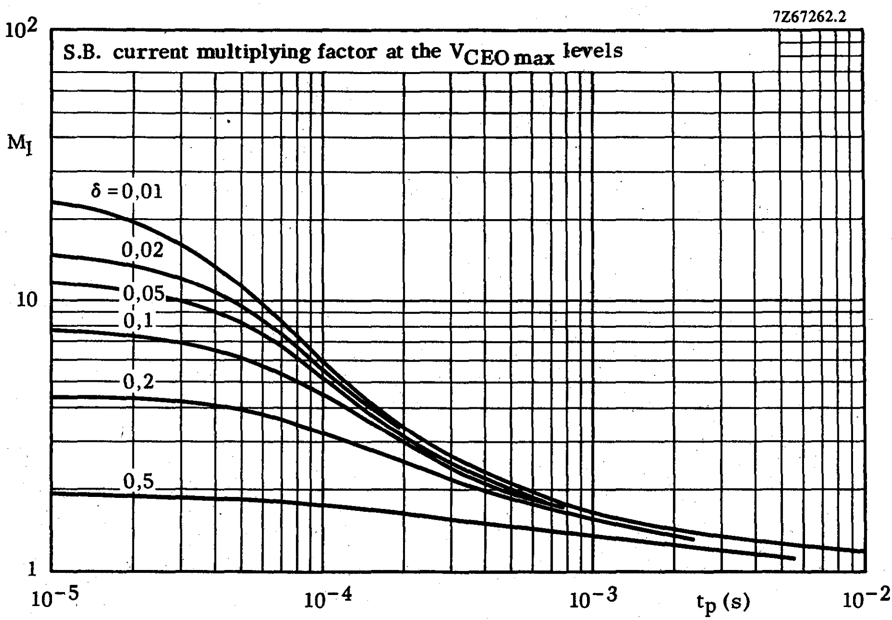


Fig. 6 S.B. current multiplying factor at the V_{CEOmax} levels.

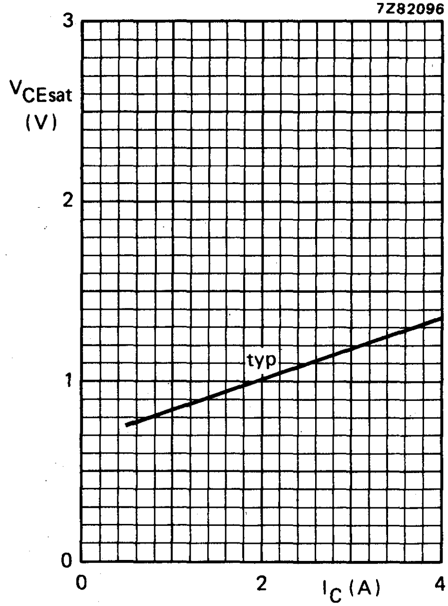


Fig. 7.

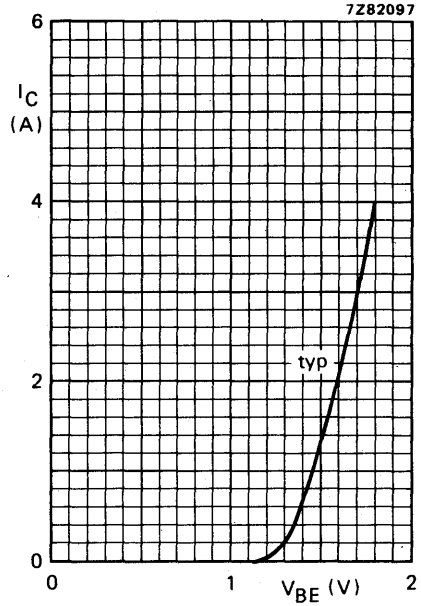


Fig. 8.

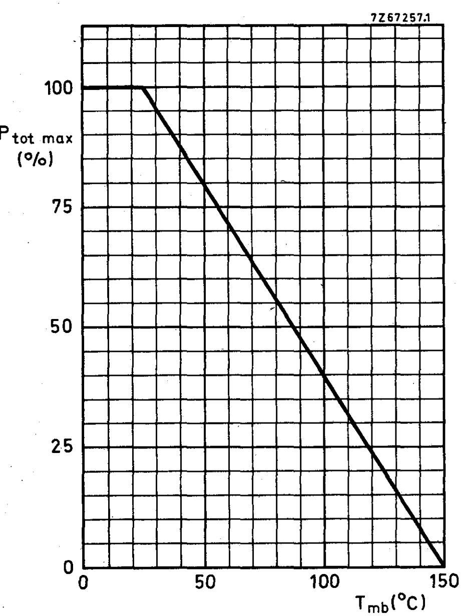


Fig. 9.

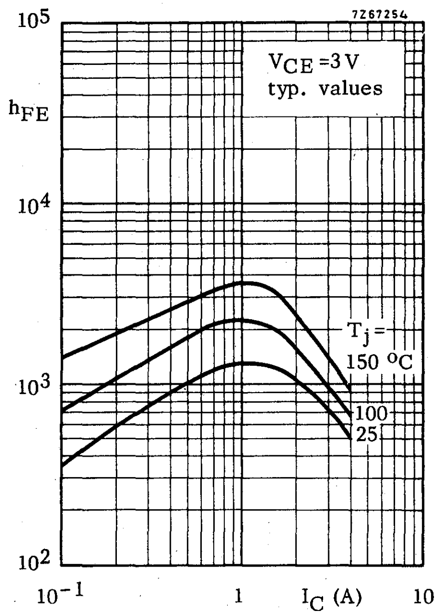


Fig. 10.

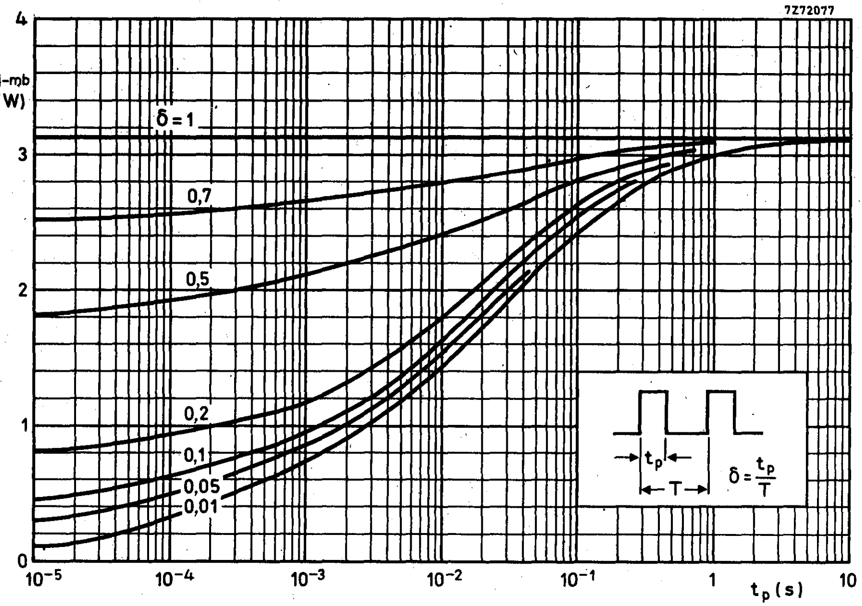


Fig. 11 Pulse power rating chart.

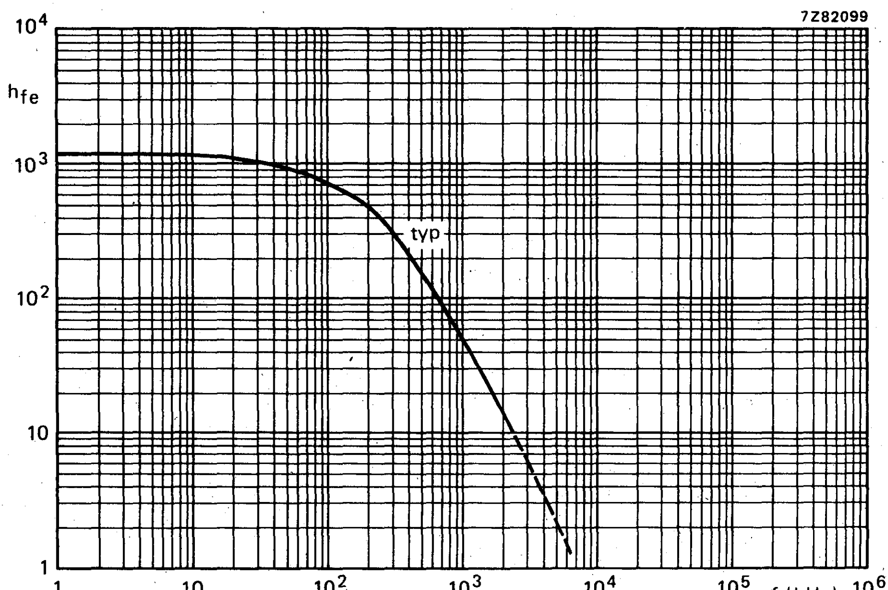


Fig. 12 Small signal current gain. $I_C = 1,5$ A; $V_{CE} = 3$ V.

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

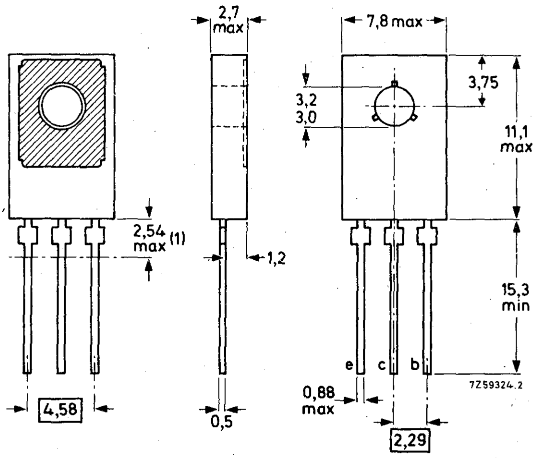
			BD676	678	680	682	684	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	100	120	V
Collector-current (peak value)	$-I_{CM}$	max.			6			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.			40			W
Junction temperature	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

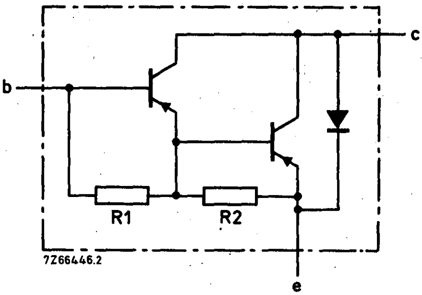
Fig. 1 TO-126 (SOT-32).

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	$\lvert h_{fe} \rvert$	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.

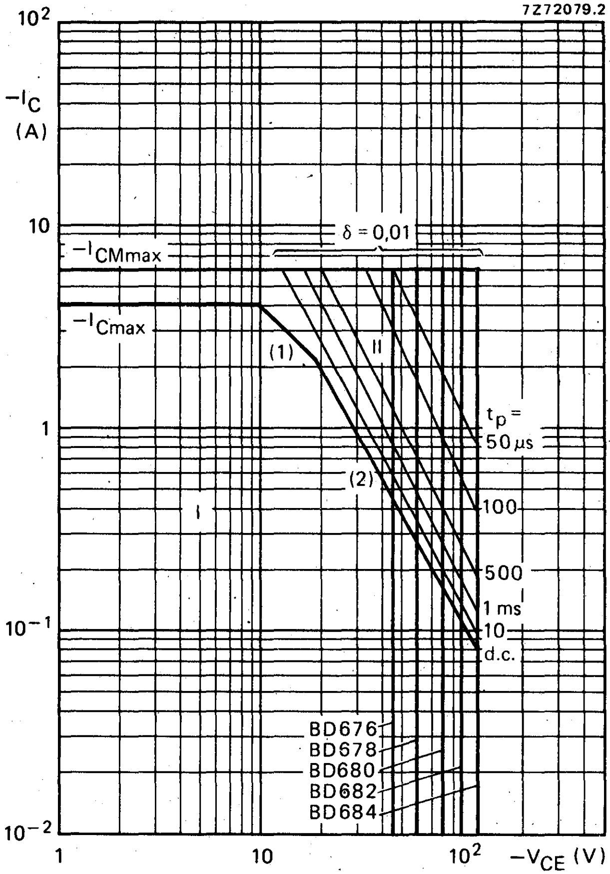


Fig. 3 Safe Operating ARea. $T_{mb} = 25\ ^oC$.

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).

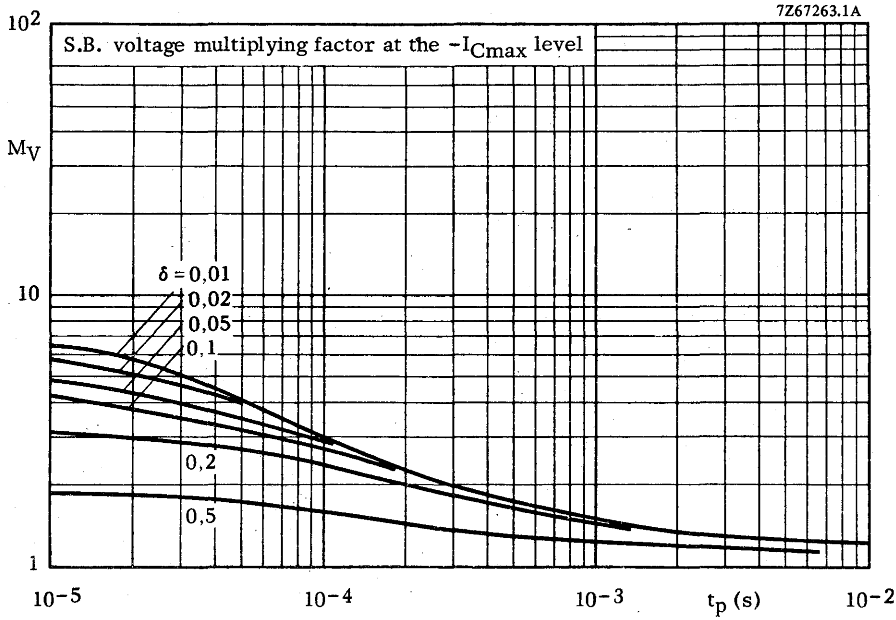


Fig. 4 S.B. voltage multiplying factor at the $-I_{Cmax}$ level.

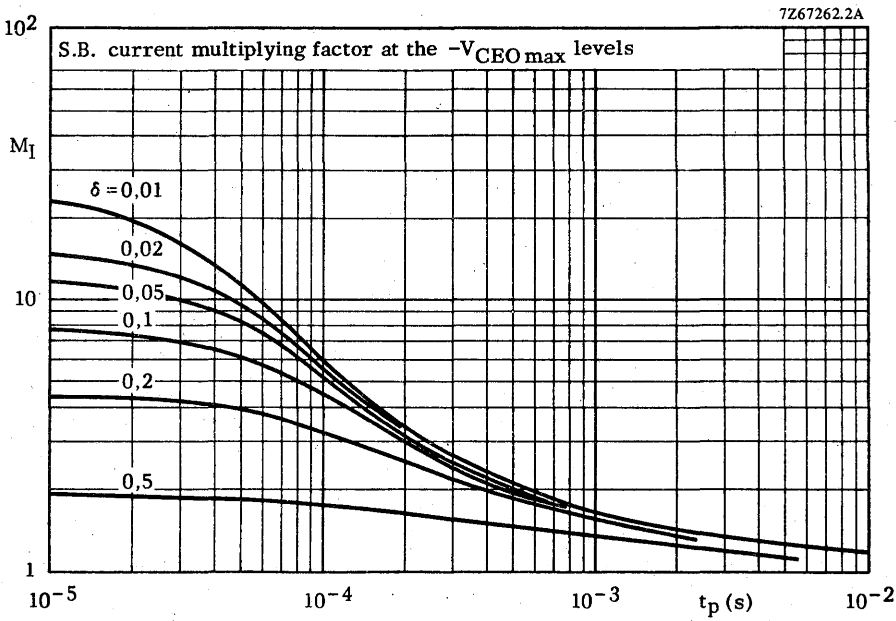


Fig. 5 S.B. current multiplying factor at the $-V_{CEOmax}$ levels.

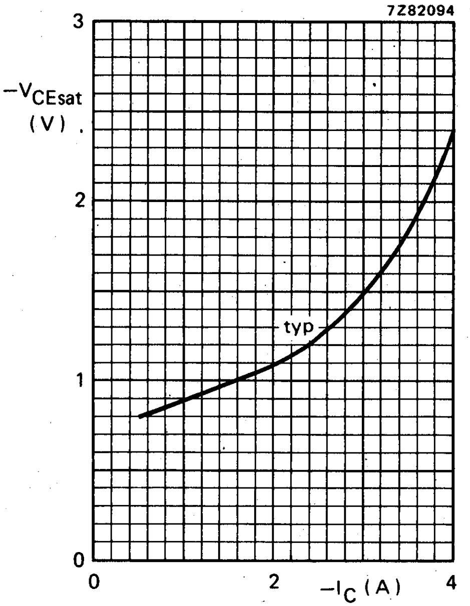


Fig. 6.

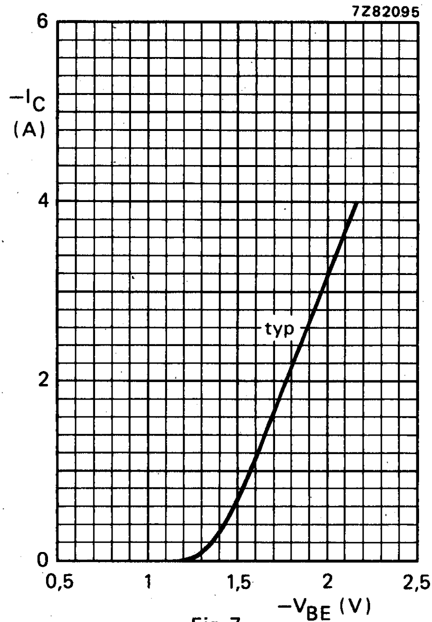


Fig. 7.

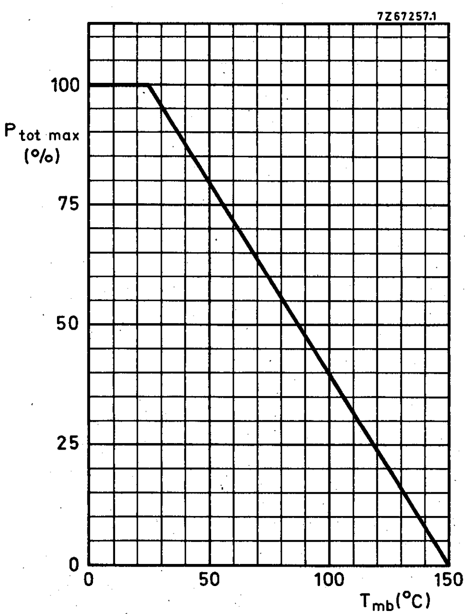


Fig. 8.

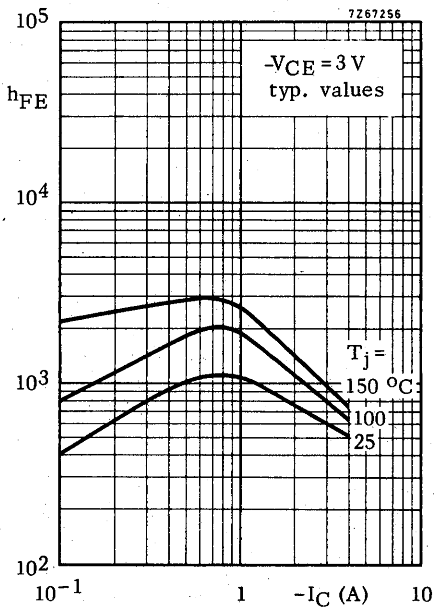


Fig. 9.

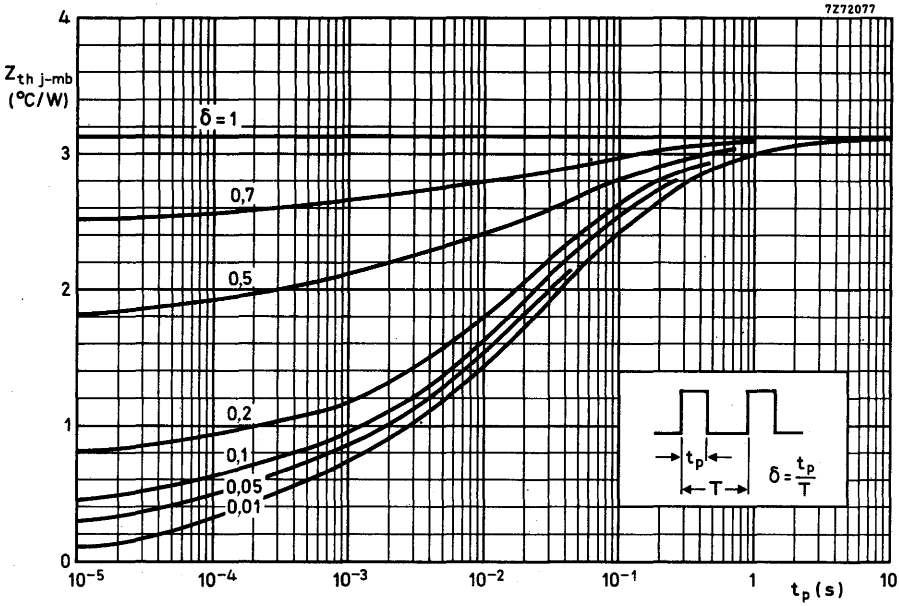


Fig. 10 Pulse power rating chart.

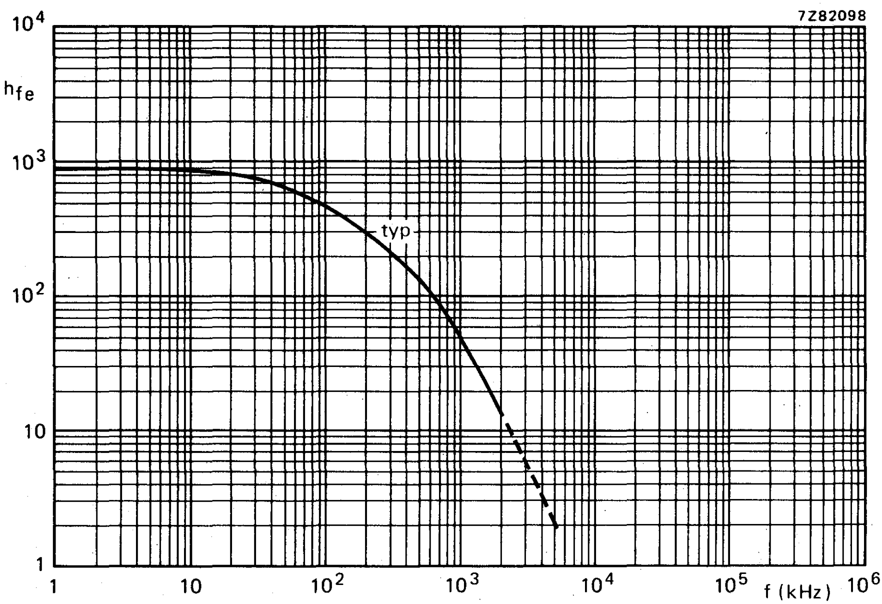


Fig. 11 Small signal current gain. $-I_C$ = 1,5 A; $-V_{CE}$ = 3 V.

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

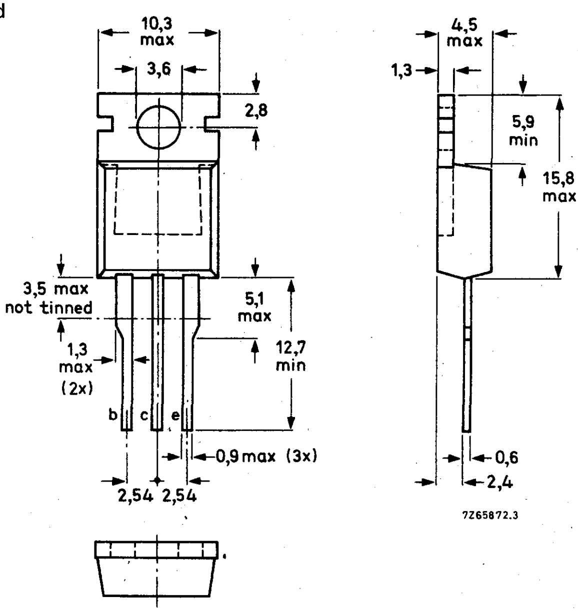
			BD933	935	937	939	941	
Collector-base voltage	V_{CBO}	max.	45	60	100	120	140	V
Collector-emitter voltage	V_{CEO}	max.	45	60	80	100	120	V
Collector current (d.c.)	I_C	max.			3			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.			30			W
Junction temperature	T_j	max.			150			°C
D.C. current gain								
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	°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
$I_E = 0$; $V_{CE} = V_{CEOmax}$	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.	0,3	µs
Turn-off time	t_{off}	typ.	1	µs

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

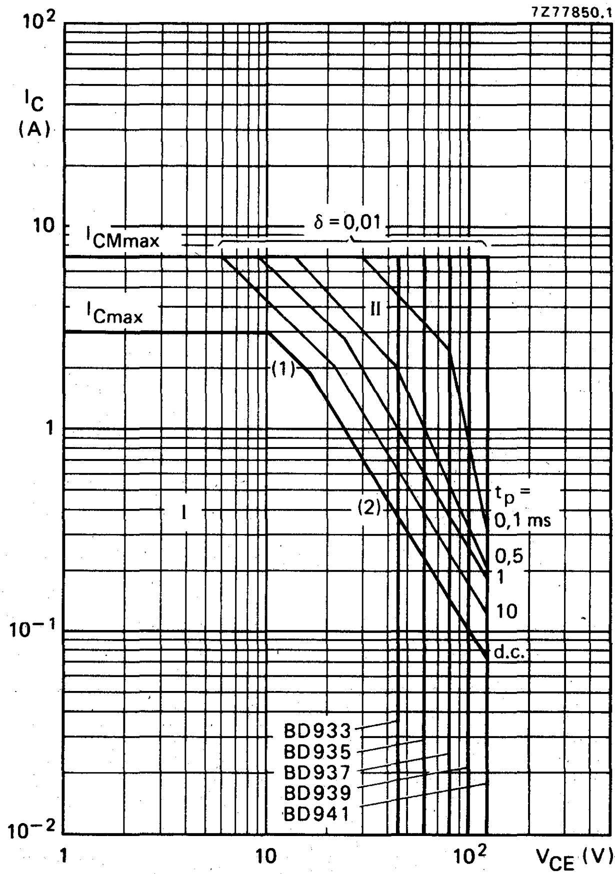


Fig. 2 Safe Operating ARea; T_{mb} = 25 °C.

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.

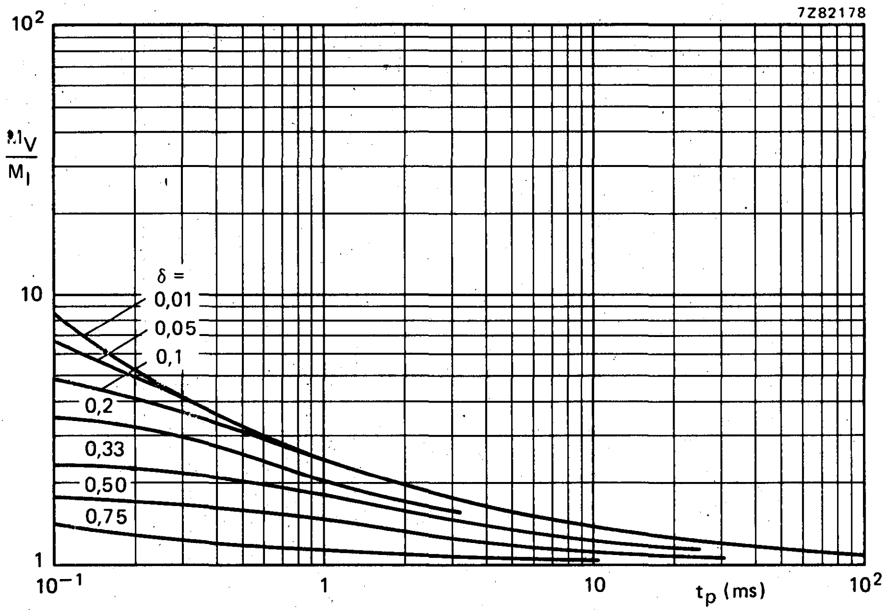


Fig. 3 Second breakdown voltage multiplying factor at the I_{Cmax} level and second breakdown current multiplying factor at the V_{CEOmax} level.

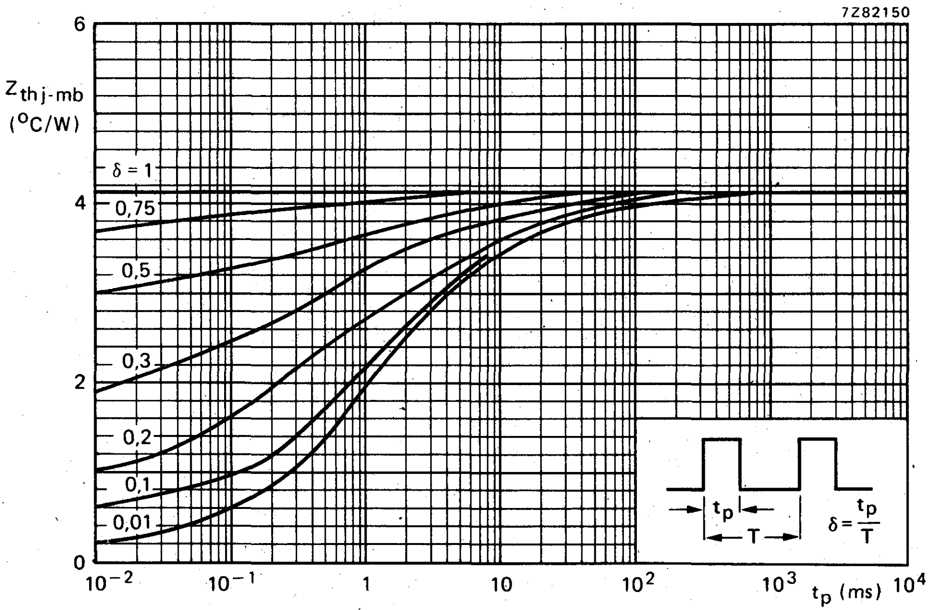


Fig. 4 Pulse power rating chart.

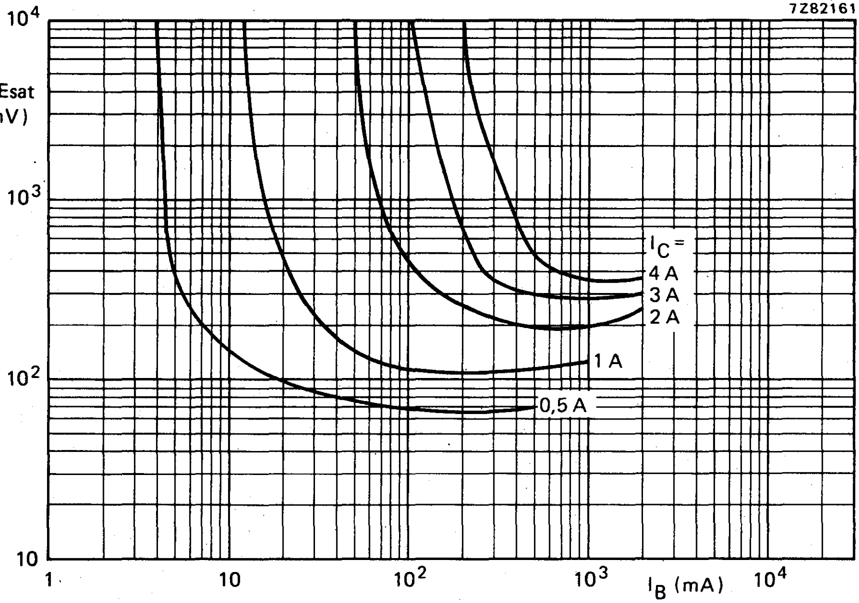


Fig. 5 Typical collector-emitter saturation voltage as a function of base current with collector current as a parameter.

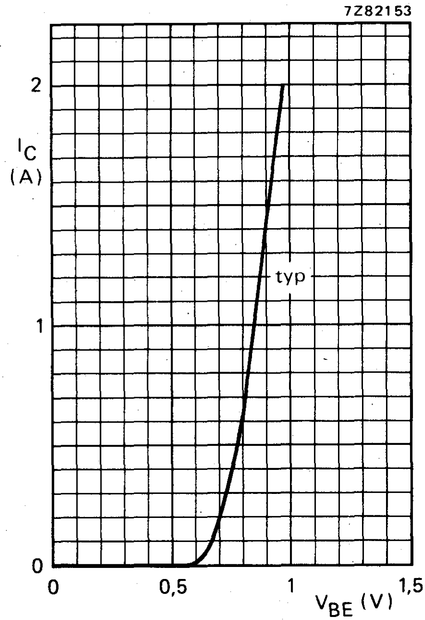


Fig. 6 Typical collector current as a function of base-emitter voltage. V_{CE} = 2 V; T_j = 25 °C.

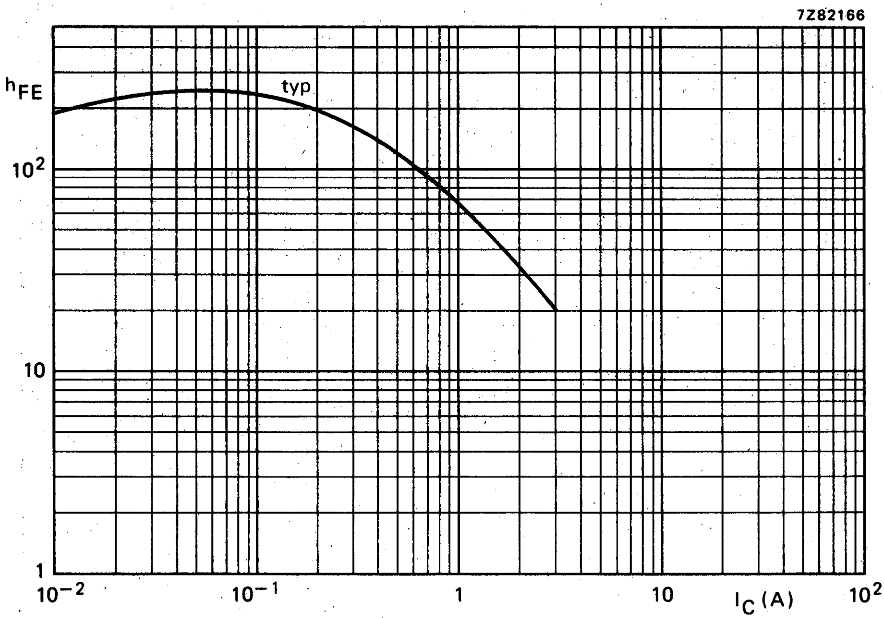


Fig. 7 Typical static forward current transfer ratio as a function of the collector current. $V_{CE} = 2$ V; $T_j = 25$ °C.

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

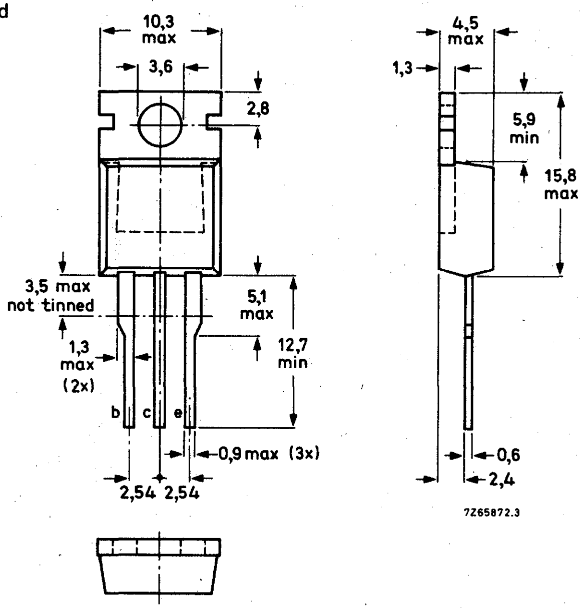
			BD934	936	938	940	942	
Collector-base voltage	$-V_{CBO}$	max.	45	60	100	120	140	V
Collector-emitter voltage	$-V_{CEO}$	max.	45	60	80	100	120	V
Collector current (d.c.)	$-I_C$	max.			3			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.			30			W
Junction temperature	T_j	max.			150			°C
D.C. 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 $T_{mb} = 25\ ^oC$	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	$^oC/W$
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	70	$^oC/W$

CHARACTERISTICS

$T_j = 25\ ^oC$ unless otherwise specified

Collector cut-off current				
$-I_E = 0; -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	0,1	mA
$-I_E = 0; -V_{CB} = -V_{CBOmax}; T_j = 150\ ^oC$	$-I_{CBO}$	<	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: $t_p \leqslant 300\ \mu s$; $\delta < 2\%$.
2. $-V_{BE}$ decreases by about 2,3 mV/^oC with increasing temperature.

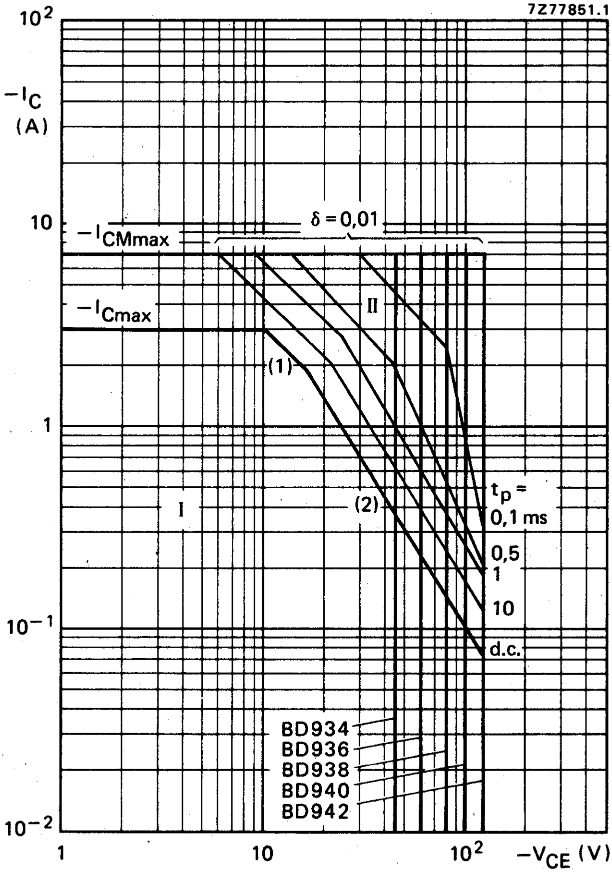


Fig. 2 Safe Operating ARea; T_{mb} = 25 °C.

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.

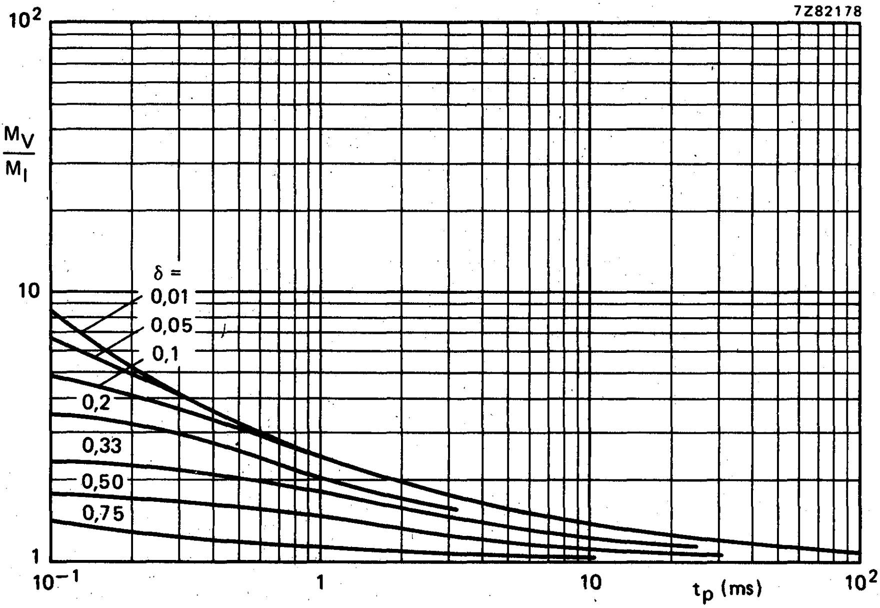


Fig. 3 Second breakdown voltage multiplying factor at the I_{Cmax} level and second breakdown current multiplying factor at the V_{CEOmax} level.

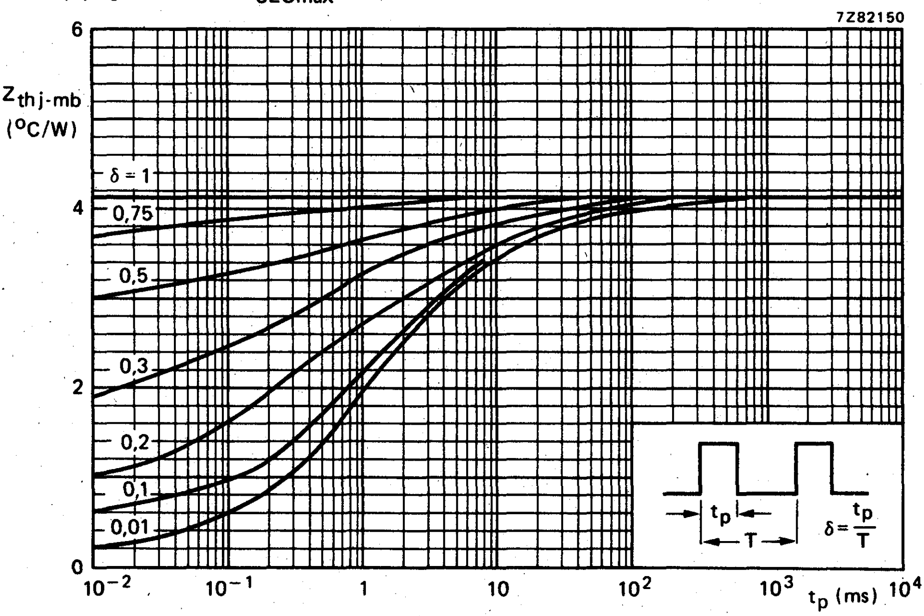


Fig. 4 Pulse power rating chart.

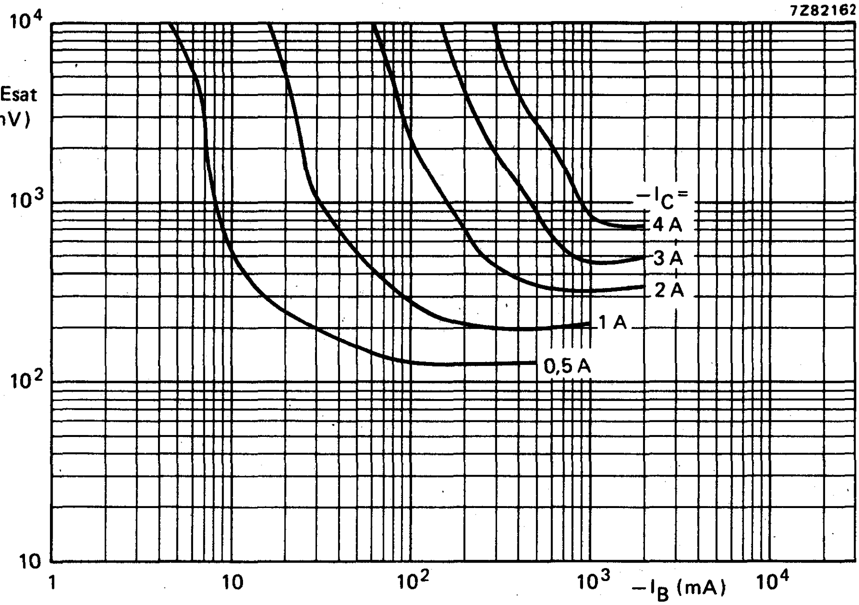


Fig. 5 Typical collector-emitter saturation voltage as a function of base current with collector current as a parameter.

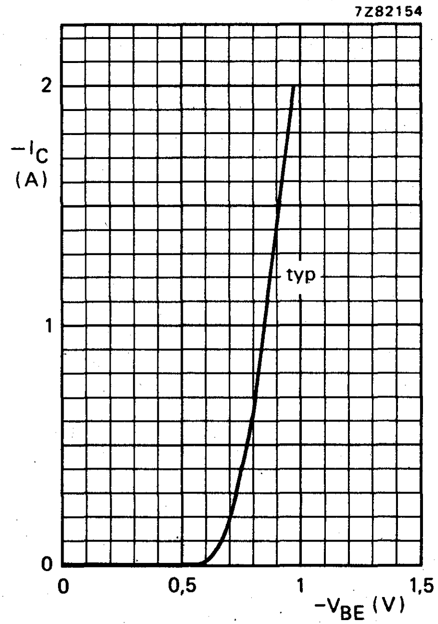


Fig. 6 Typical collector current as a function of base-emitter voltage. $-V_{CE}$ = 2 V; T_j = 25 °C.

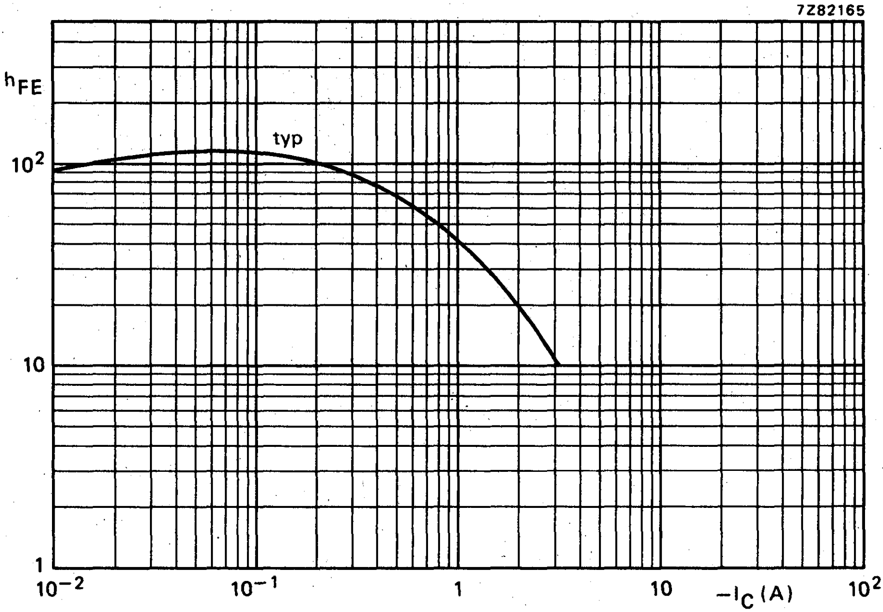


Fig. 7 Typical static forward current transfer ratio as a function of the collector current. $-V_{CE} = 2$ V; $T_j \leqslant 25$ °C.

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

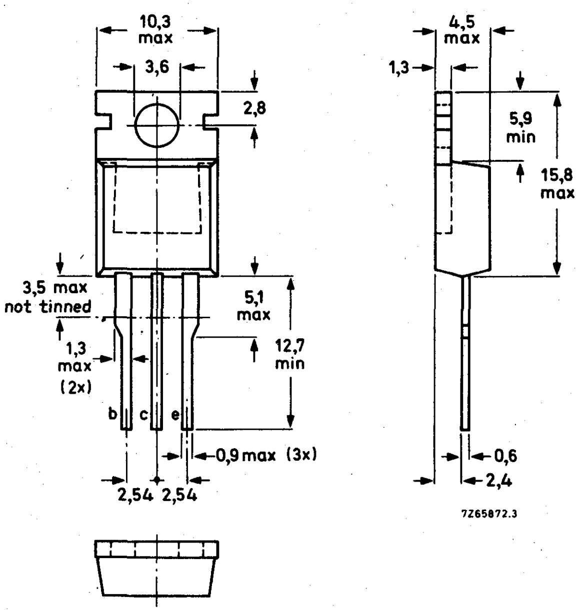
			BD943	945	947	
Collector-base voltage (open emitter)	V_{CBO}	max.	22	32	45	V
Collector-emitter voltage (open base)	V_{CEO}	max.	22	32	45	V
Collector current (d.c.)	I_C	max.		5		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		40		W
Junction temperature	T_j	max.		150		°C
D.C. current gain						
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.

			BD943	945	947	
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 af f = 1 MHz						
I_C = 250 mA; V_{CE} = 1 V	f_T	>	3	3	3	MHz

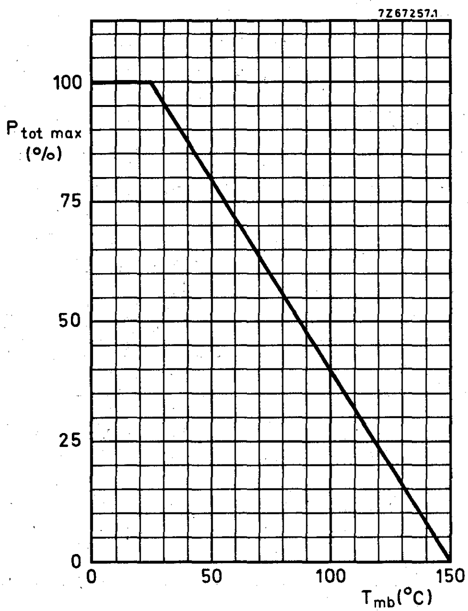


Fig. 2 Power derating curve.

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

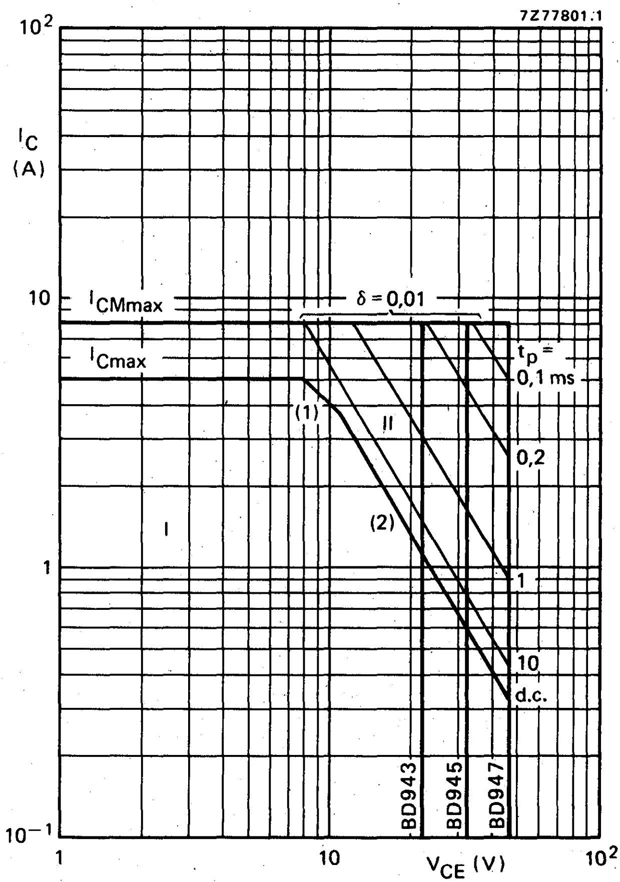


Fig. 3 Safe Operating ARea, $T_{mb} = 25\ ^oC$.

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).

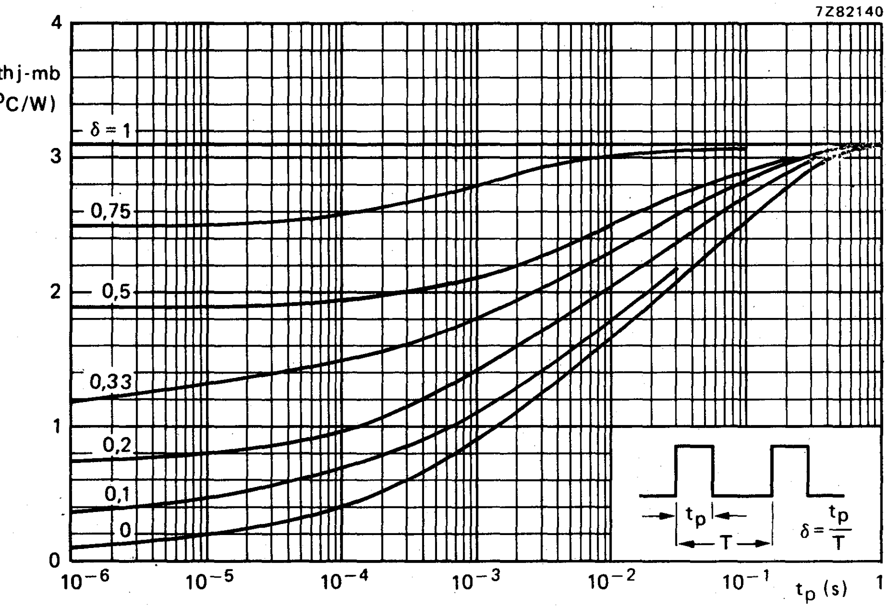


Fig. 4 Pulse power rating chart.

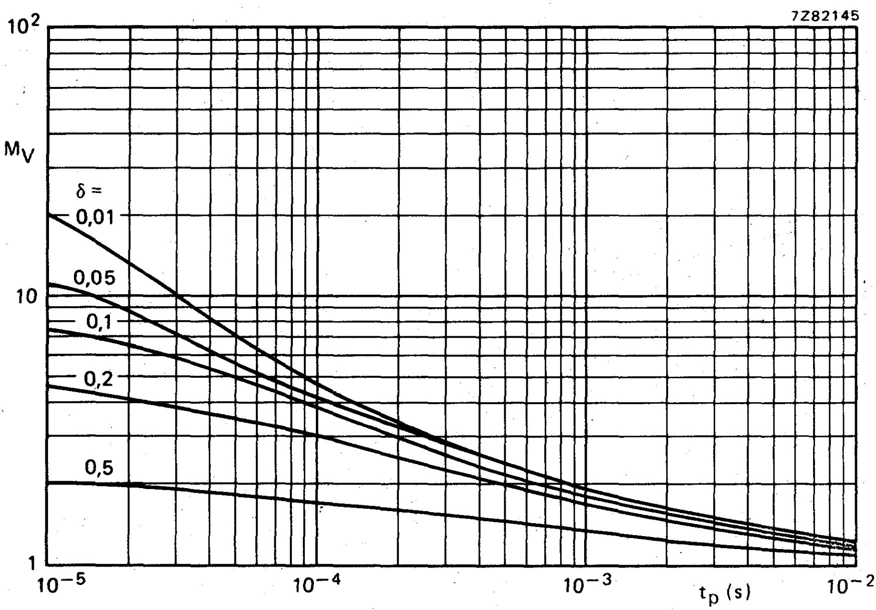


Fig. 5 S.B. voltage multiplying factor at the I_{Cmax} level.

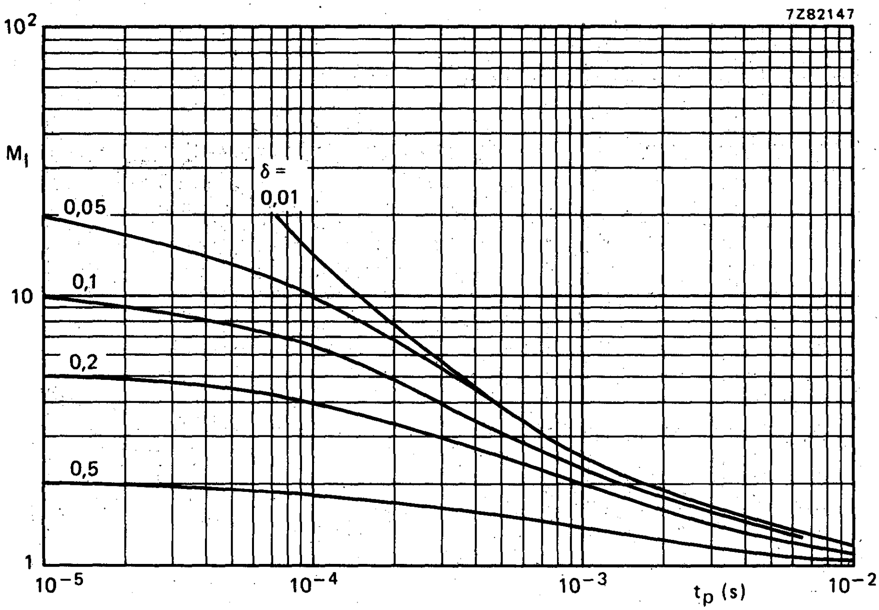


Fig. 6 S.B. current multiplying factor at the V_{CEOmax} level for BD943 and BD945.

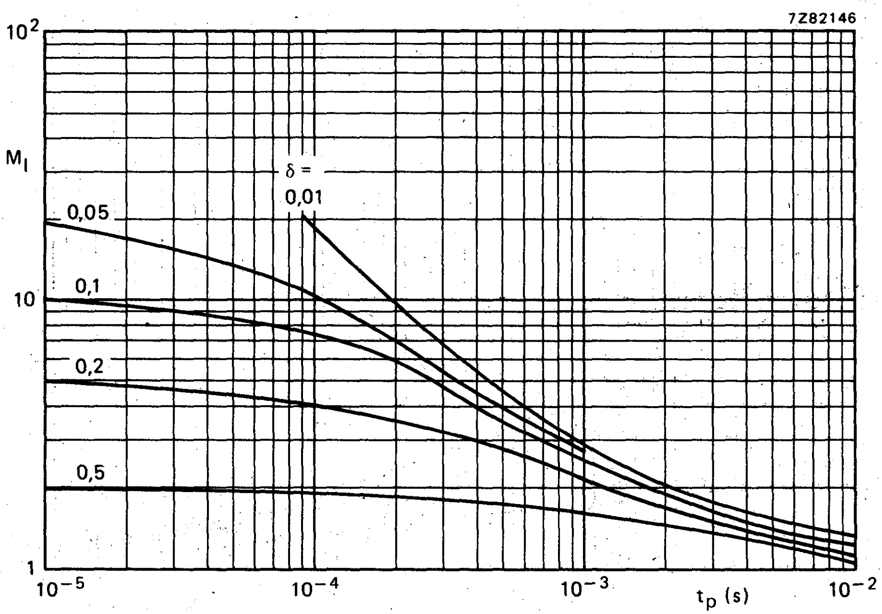


Fig. 7 S.B. current multiplying factor at the V_{CEOmax} level for BD947.

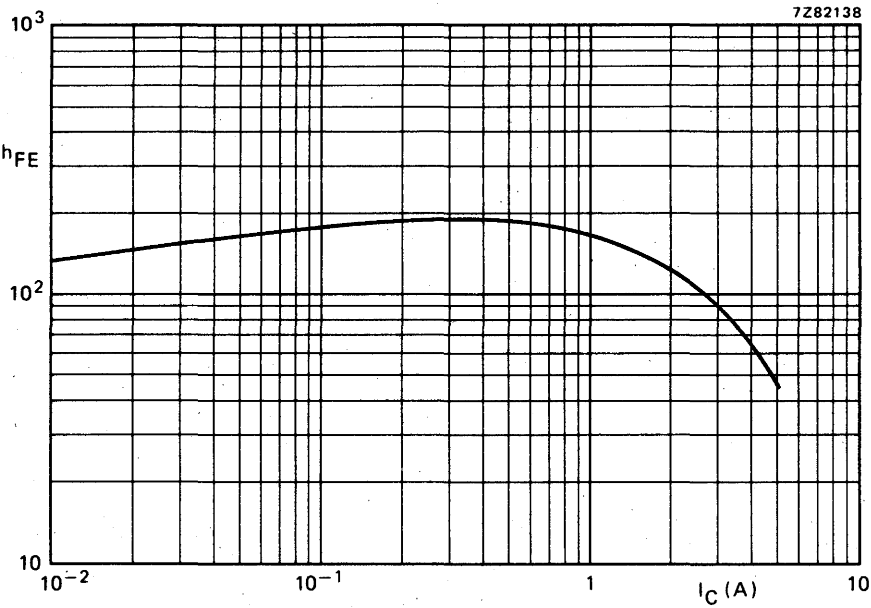


Fig. 8 Typical d.c. current gain at $V_{CE} = 1$ V; $T_j = 25$ °C.

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

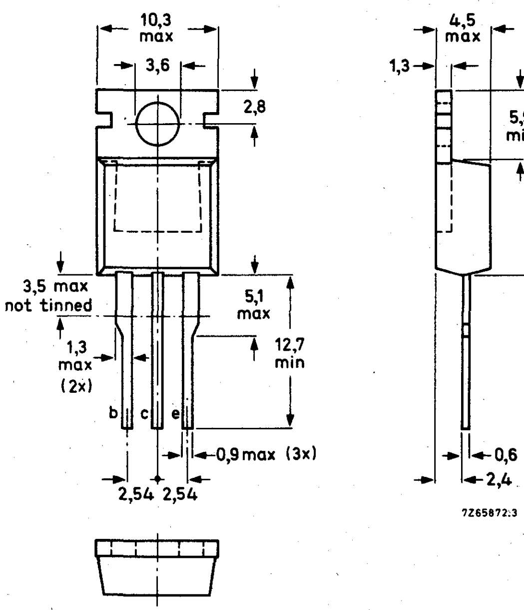
			BD944	946	948	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	22	32	45	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	22	32	45	V
Collector current (d.c.)	$-I_C$	max.		5		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		40		W
Junction temperature	T_j	max.		150		°C
D.C. current 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; $t_p \leq 300\ \mu s$; $\delta < 2\%$.
2. V_{BE} decreases by about 2,3 mV/°C with increasing temperature.

			BD944	946	948	
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	3	3	MHz

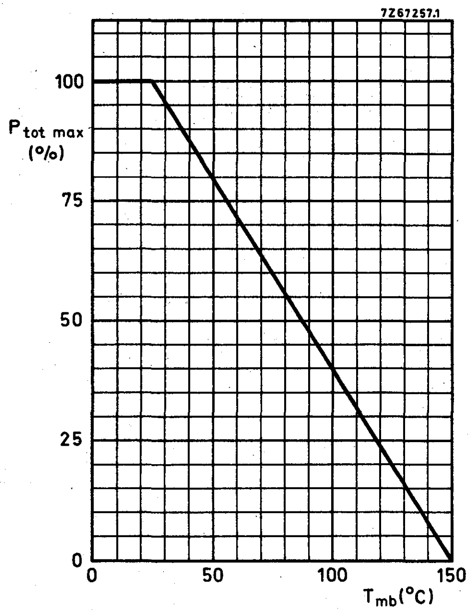


Fig. 2 Power derating curve.

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

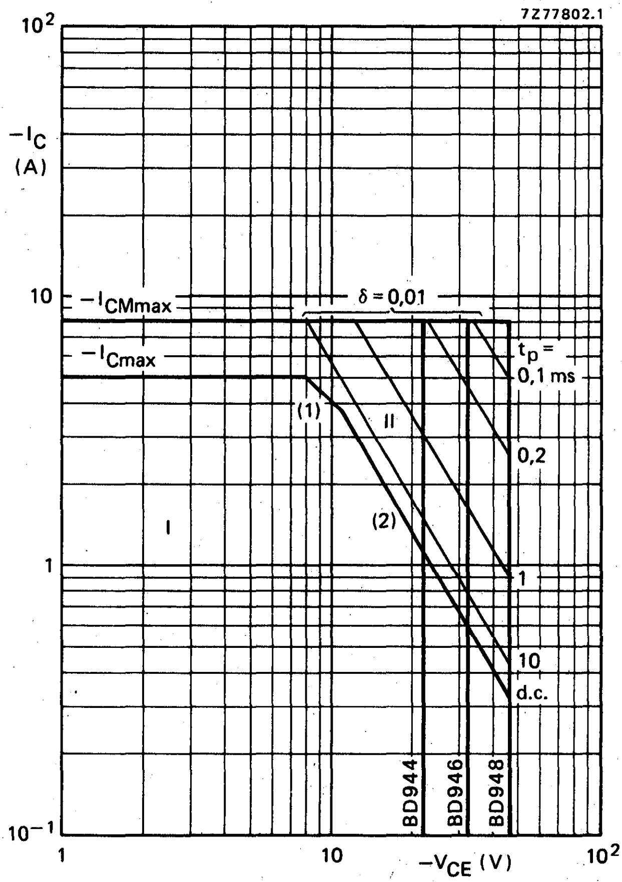


Fig. 3 Safe Operating ARea, $T_{mb} = 25\ ^{o}C$.

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).

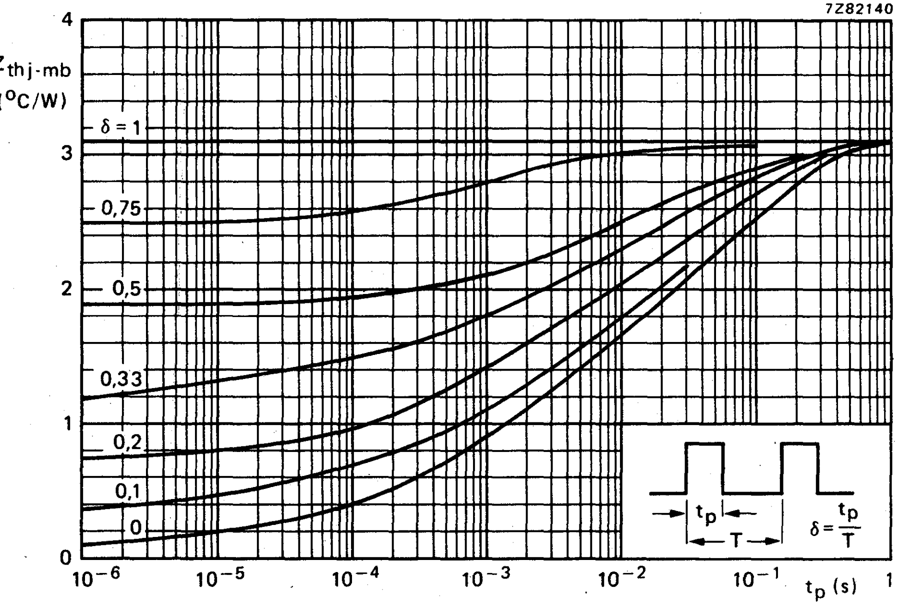


Fig. 4 Pulse power rating chart.

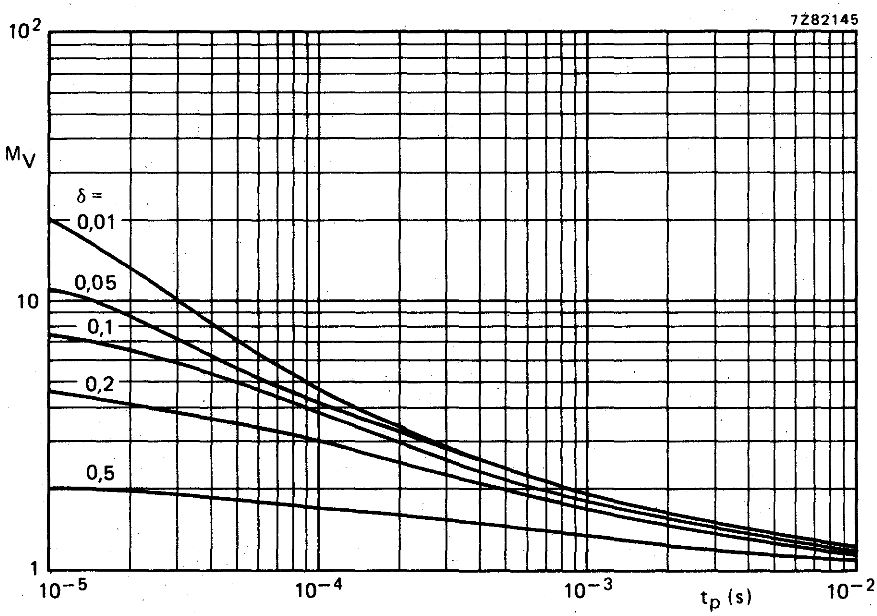


Fig. 5 S.B. voltage multiplying factor at the $-I_{Cmax}$ level.

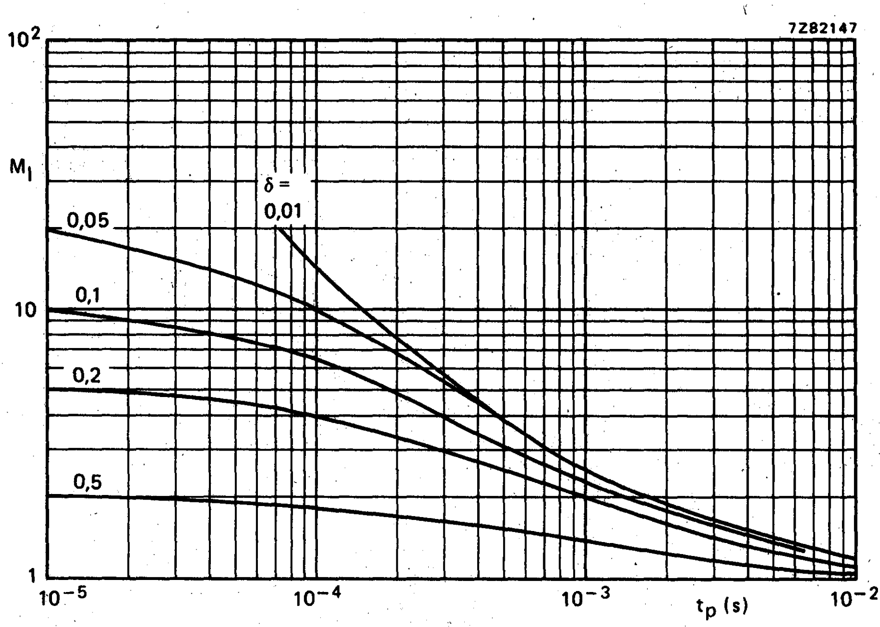


Fig. 6 S.B. current multiplying factor at the $-V_{CEOmax}$ level for BD944/946.

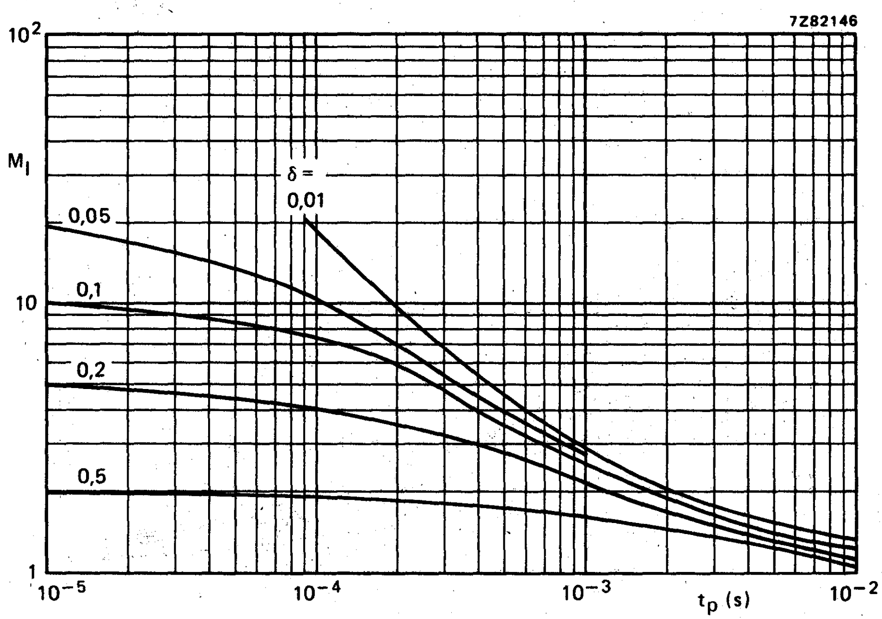


Fig. 7 S.B. current multiplying factor at the $-V_{CEOmax}$ level for BD948.

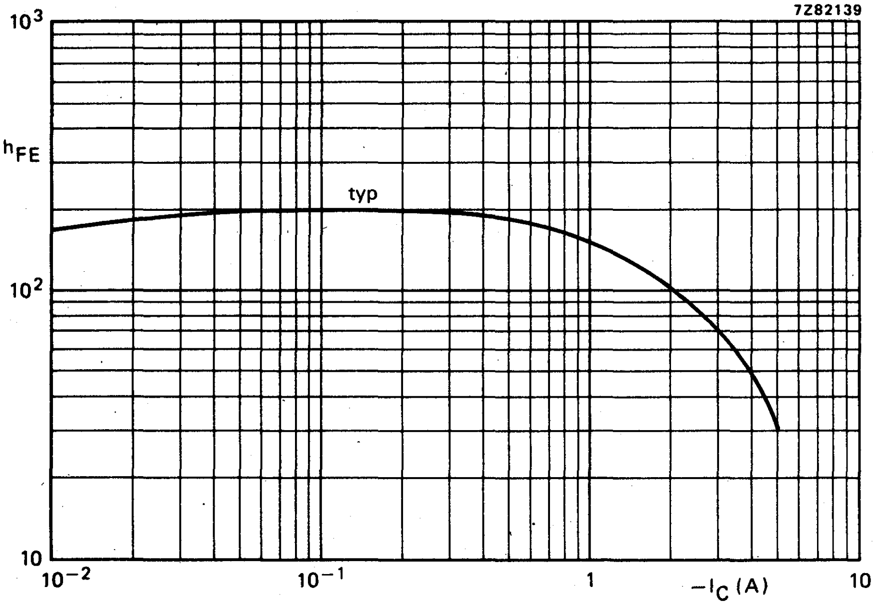


Fig. 8 Typical d.c. current gain at $-V_{CE} = 1$ V; $T_j = 25$ °C.

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

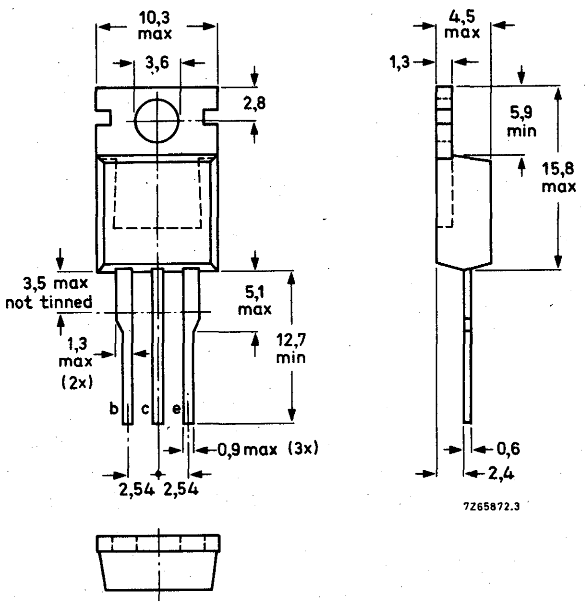
			BD949	BD951	BD953	BD955	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Collector current (d.c.)	I_C	max.		5			A
Collector current (peak value)	I_{CM}	max.		8			A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	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: $t_p \leq 300\ \mu s$, $\delta < 2\%$.
(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.	0,3 μs
Turn-off time	t_{off}	typ.	1,5 μs

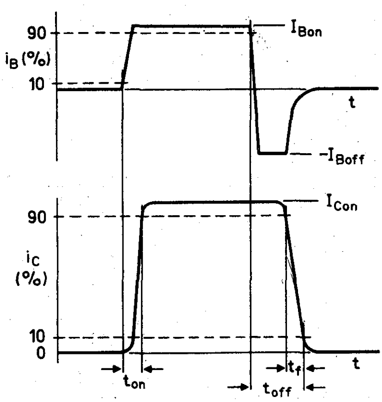
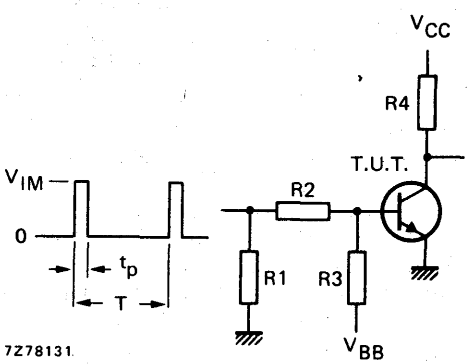


Fig. 2 Switching times waveforms.



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
$t_r = t_f$	$\leqslant$	15 ns
t_p	=	10 μs
T	=	500 μs

Fig. 3 Switching times test circuit.

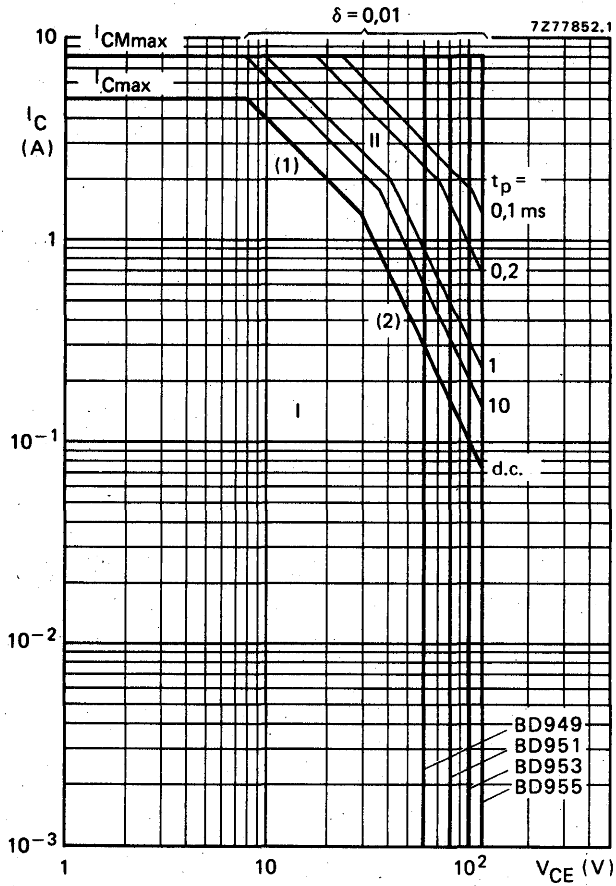


Fig. 4 Safe Operating ARea; $T_{mb} \leqslant 25\ ^oC$.

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 limit (independent of temperature).

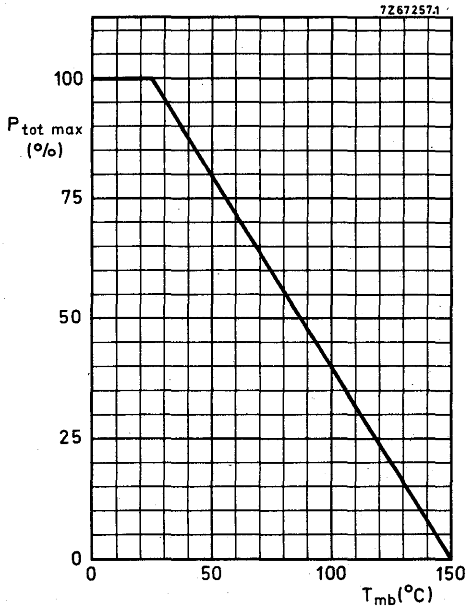


Fig. 5 Power derating curve.

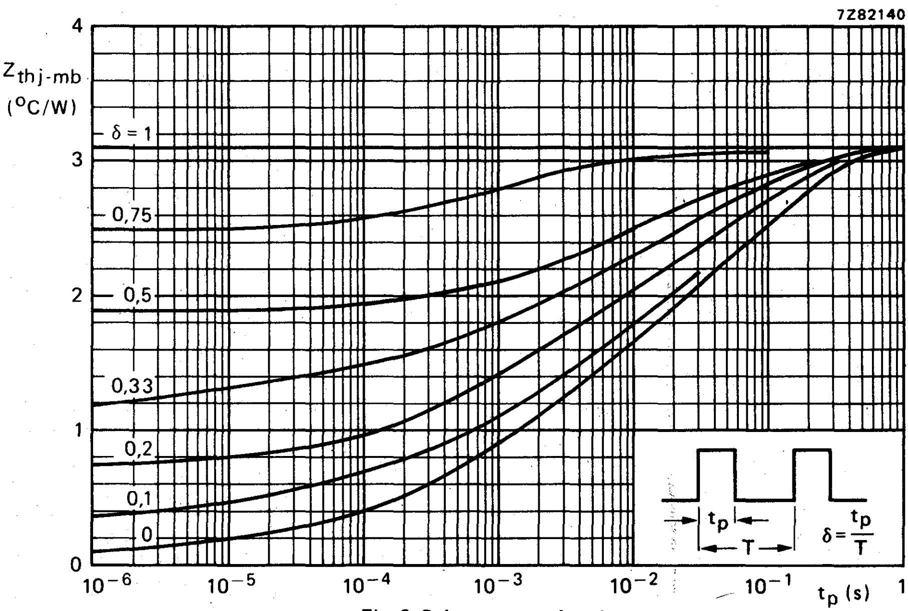


Fig. 6 Pulse power rating chart.

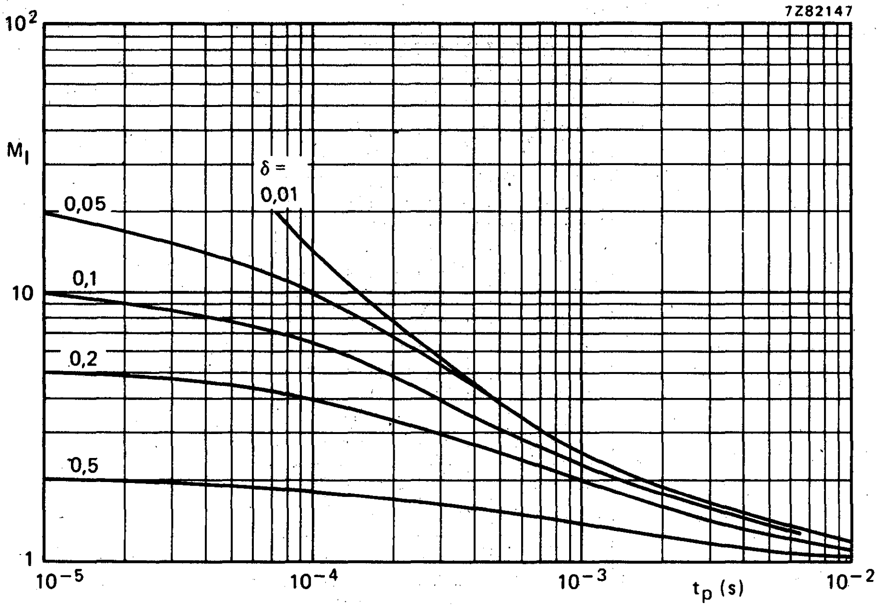


Fig. 7 S.B. current multiplying factor at the $V_{CEO\,max}$ level for BD949/951.

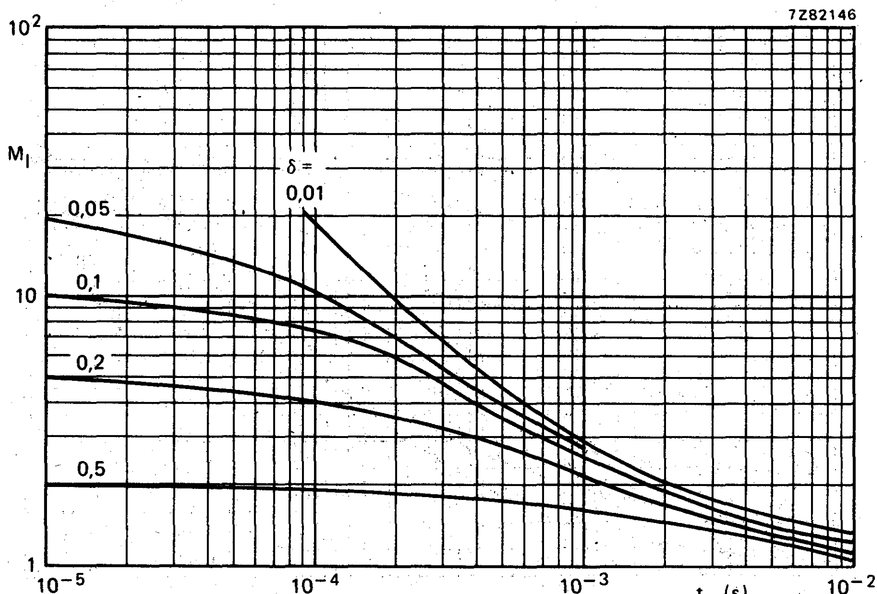


Fig. 8 S.B. current multiplying factor at the $V_{CEO\,max}$ level for BD953/955.

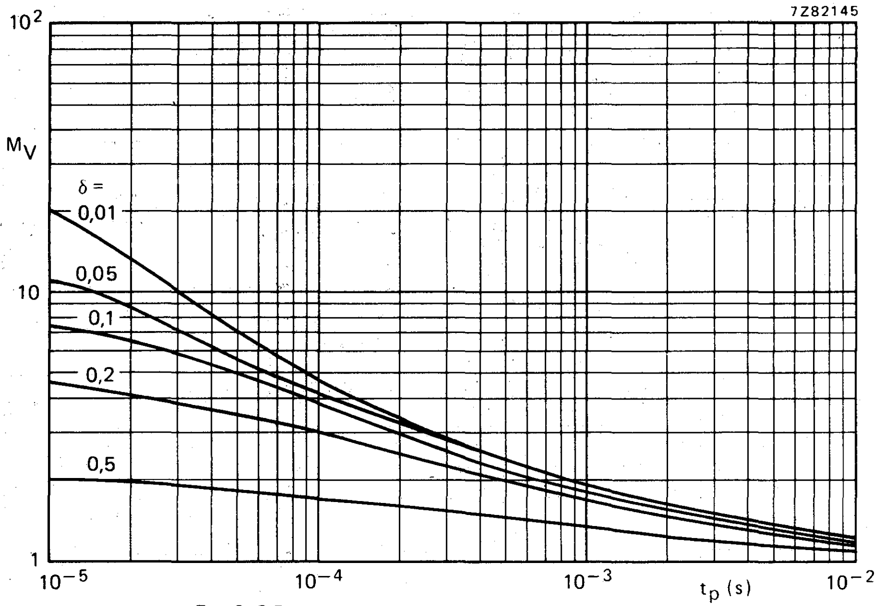


Fig. 9 S.B. voltage multiplying factor at the $I_{C\,max}$ level.

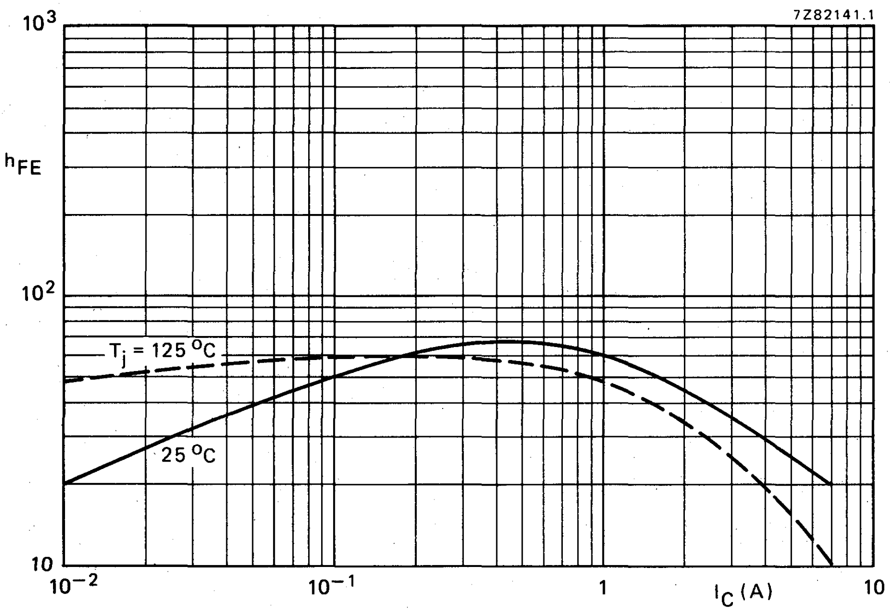


Fig. 10 Typical d.c. current gain at V_{CE} = 4 V.

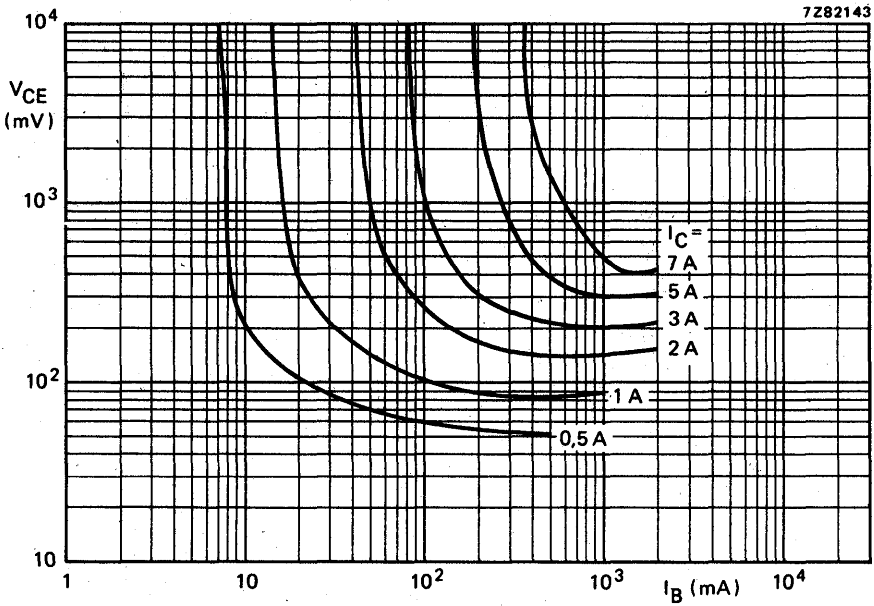


Fig. 11 Collector-emitter voltage as a function of base current.

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

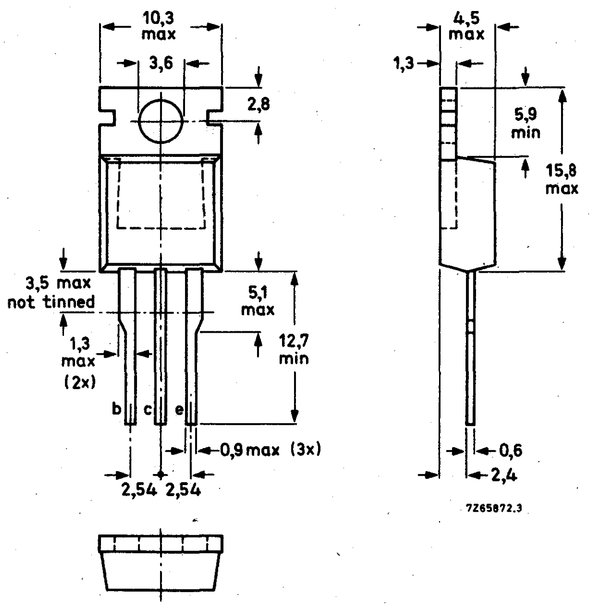
			BD950	952	954	956	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Collector current (d.c.)	$-I_C$	max.		5			A
Collector current (peak value)	$-I_{CM}$	max.		8			A
Total power dissipation up to T_{mb} = 25 °C	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
$I_E = 0$; $-V_{CB} = -\frac{1}{2} V_{CBO\,max}$; T_j = 150 °C	$-I_{CBO}$	<	2	mA
$I_B = 0$; $-V_{CE} = -\frac{1}{2} V_{CEO\,max}$	$-I_{CEO}$	<	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.	0,1 μs
Turn-off time	t_{off}	typ.	0,4 μs

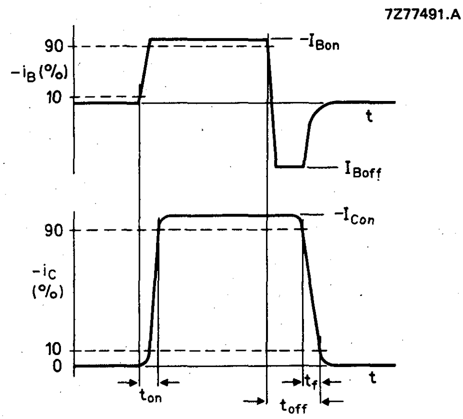
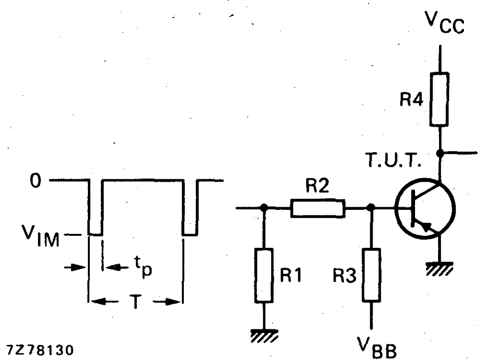


Fig. 2 Switching times waveforms.



$-V_{IM}$ = 30 V
$-V_{CC}$ = 20 V
V_{BB} = 3,5 V
R1 = 82 Ω
R2 = 150 Ω
R3 = 39 Ω
R4 = 20 Ω
$t_r = t_f \leqslant 15$ ns
t_p = 10 μs
T = 500 μs

Fig. 3 Switching times test circuit.

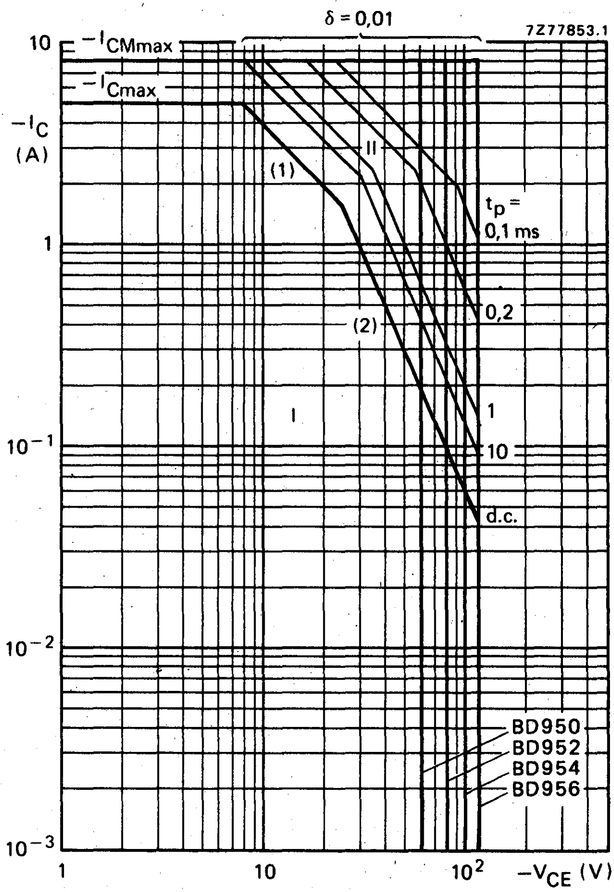


Fig. 4 Safe Operating ARea; $T_{mb} \leqslant 25\ ^oC$.

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 limit (independent of temperature).

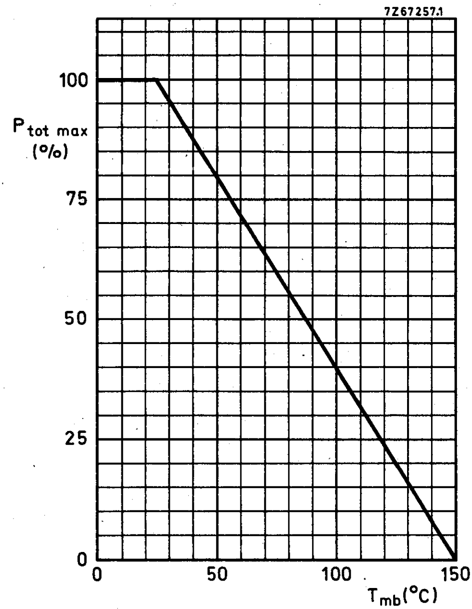


Fig. 5 Power derating curve.

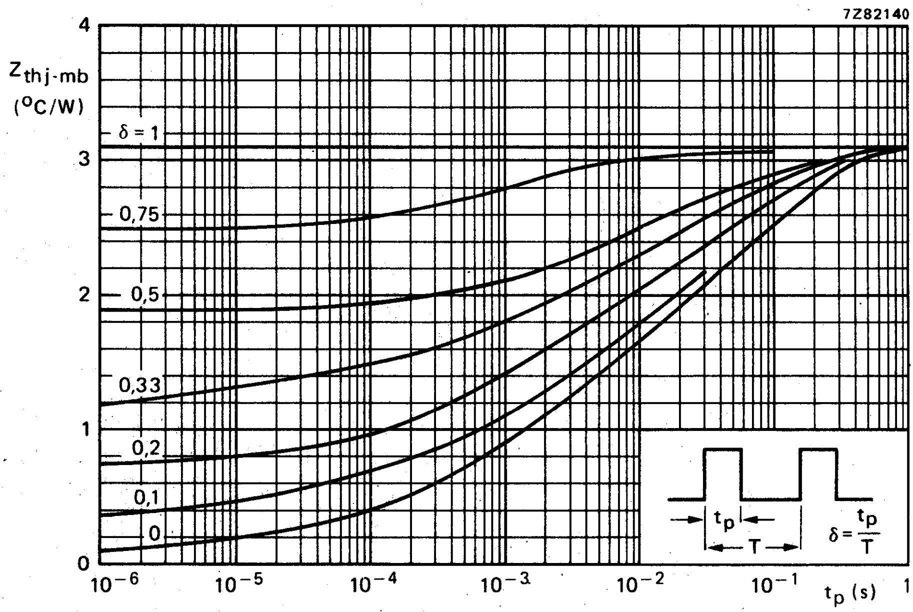


Fig. 6 Pulse power rating chart.

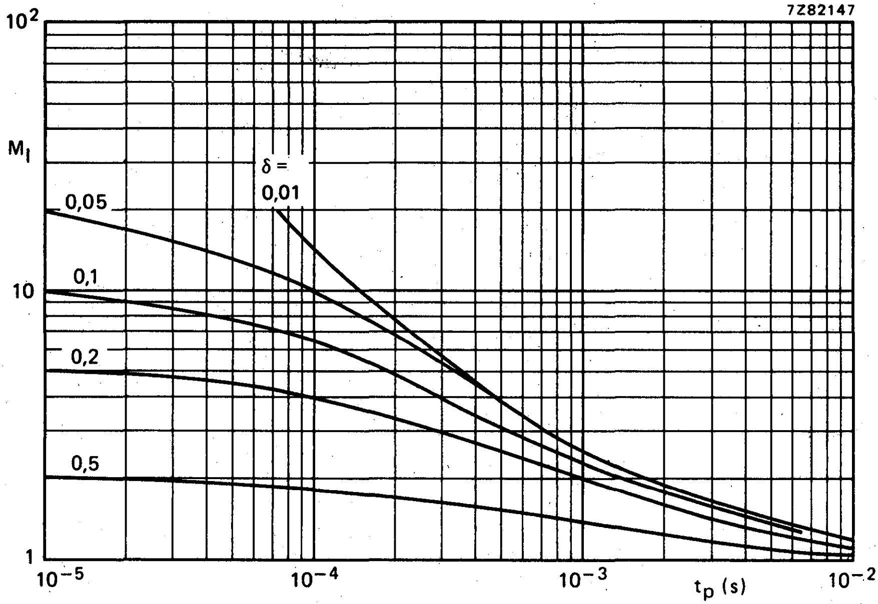


Fig. 7 S.B. current multiplying factor at the $-V_{CEO\,max}$ level for BD950 and BD952.

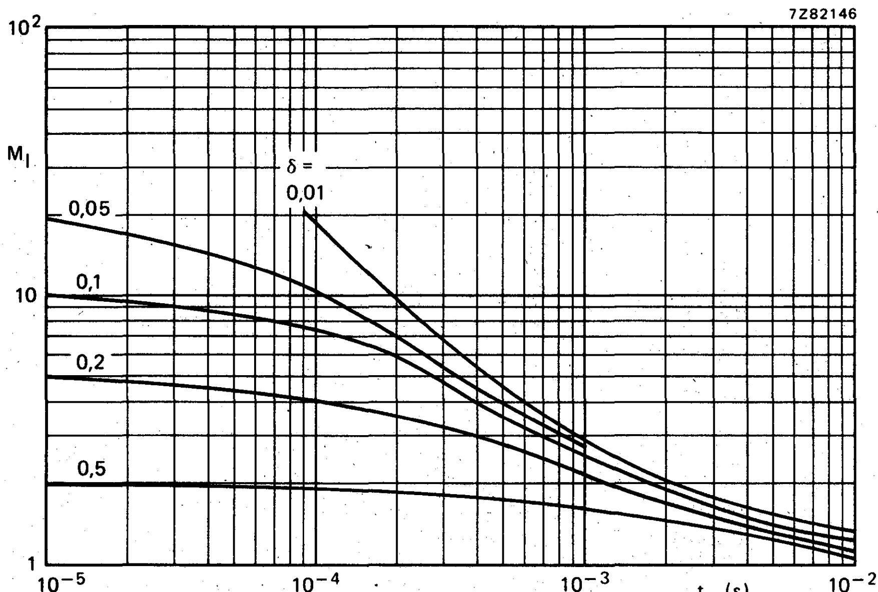


Fig. 8 S.B. current multiplying factor at the $-V_{CEO\,max}$ level for BD954 and BD956.

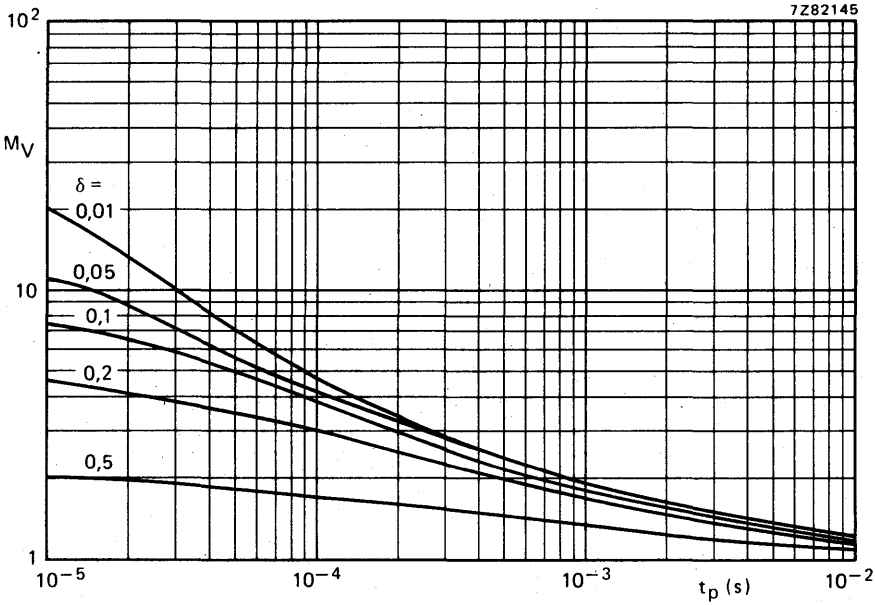


Fig. 9 S.B. voltage multiplying factor at the $-I_{C\,max}$ level.

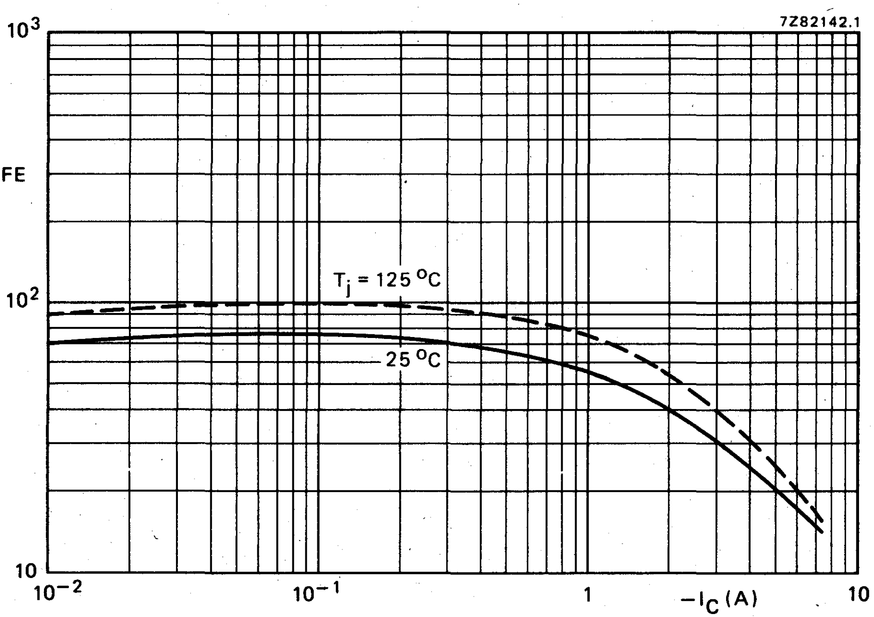


Fig. 10 Typical d.c. current gain at $-V_{CE}$ = 4 V.

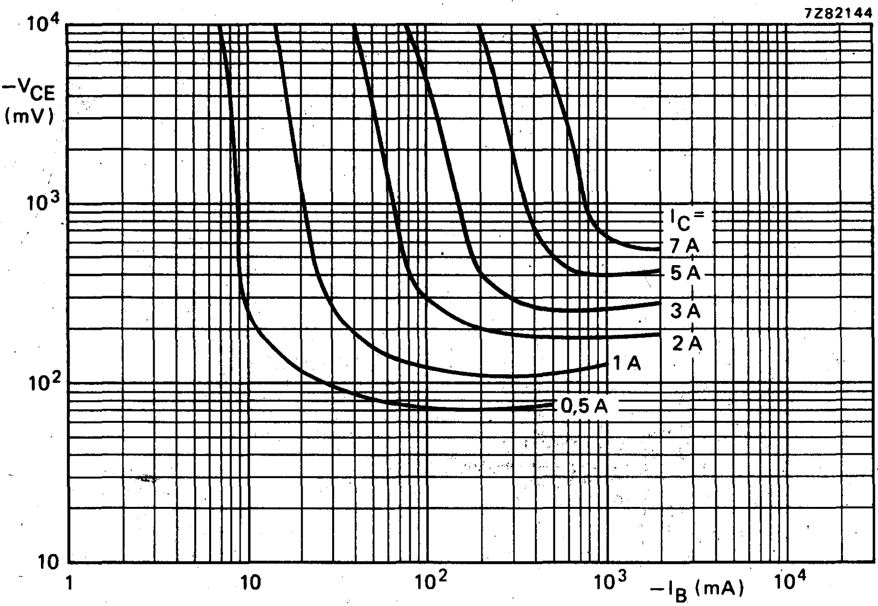


Fig. 11 Collector-emitter voltage as a function of base current.

SILICON 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.

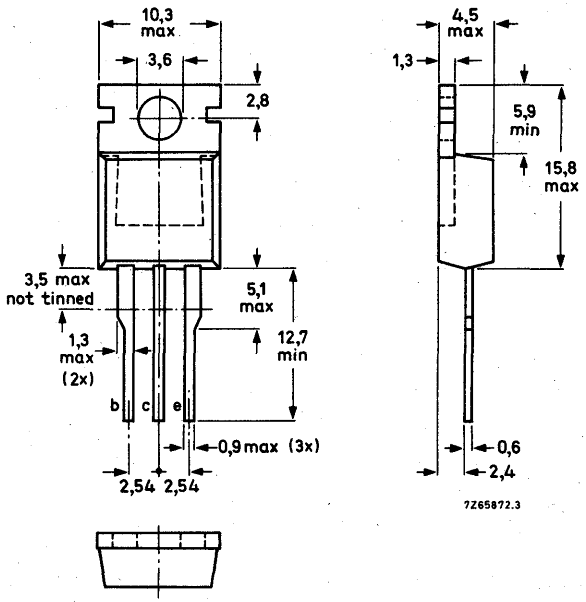
QUICK REFERENCE DATA

			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				

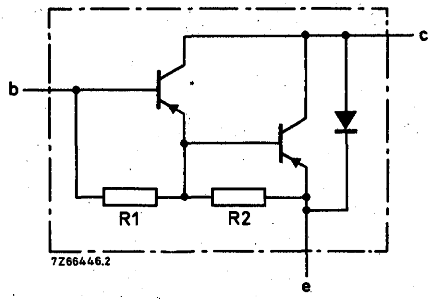
MECHANICAL DATA

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; $t_p < 300\ \mu s$; $\delta < 2\%$.

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

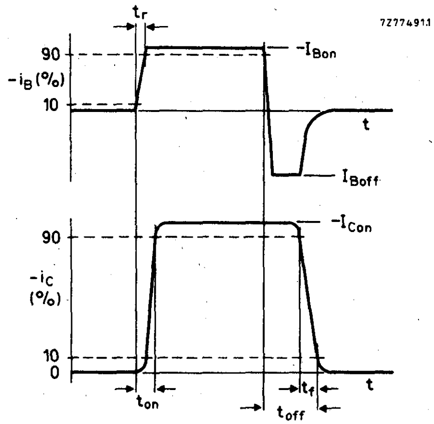
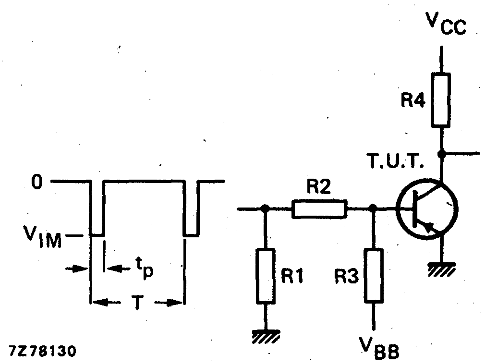


Fig. 3 Switching times waveforms.



$-V_{IM}$	=	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.

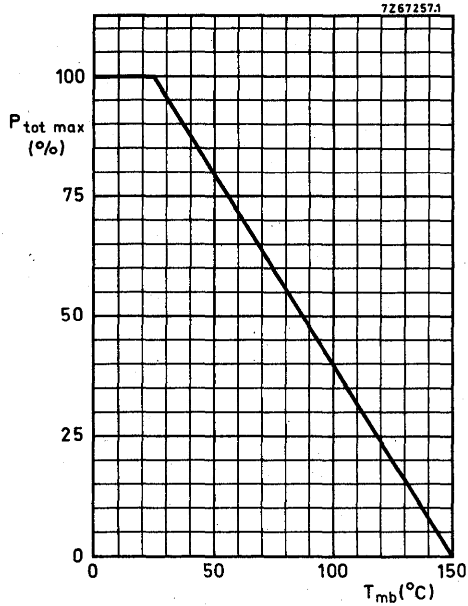


Fig. 5 Power derating curve.

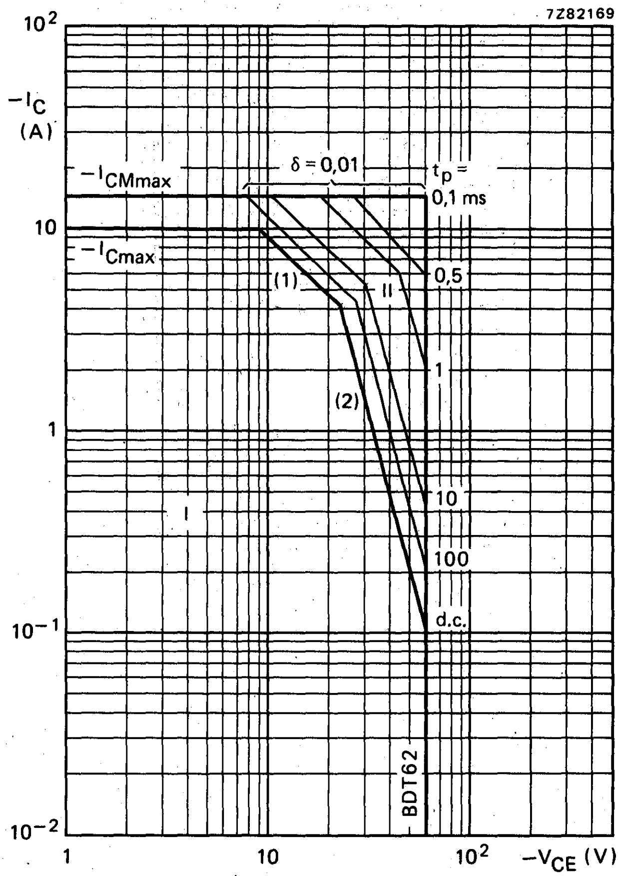


Fig. 6 Safe Operating ARea BDT62; T_{mb} = 25 °C.

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).

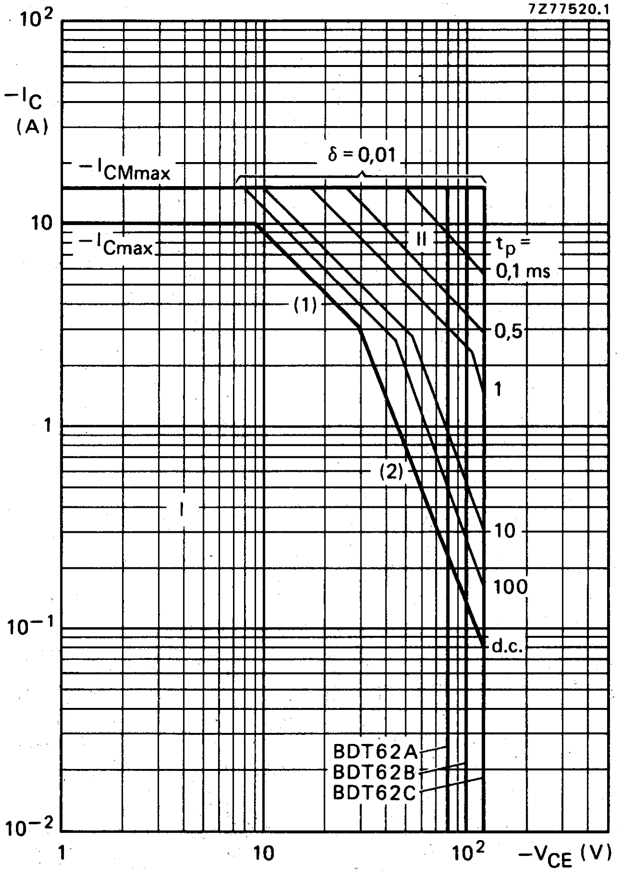


Fig. 7 Safe Operating ARea BDT62A; 62B and 62C; T_{mb} = 25 °C.

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).

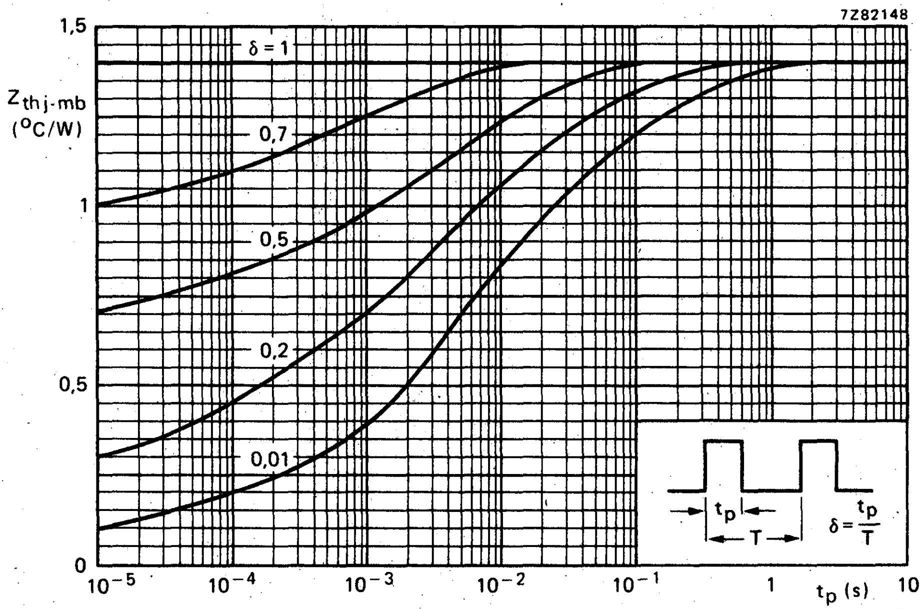


Fig. 8 Pulse power rating chart.

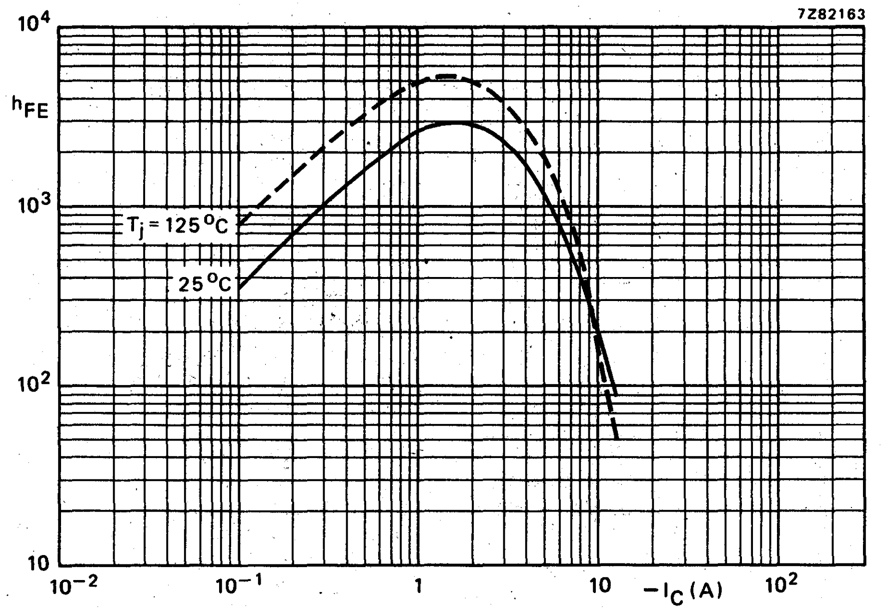


Fig. 9 Typical d.c. current gain at $-V_{CE} = 3$ V.

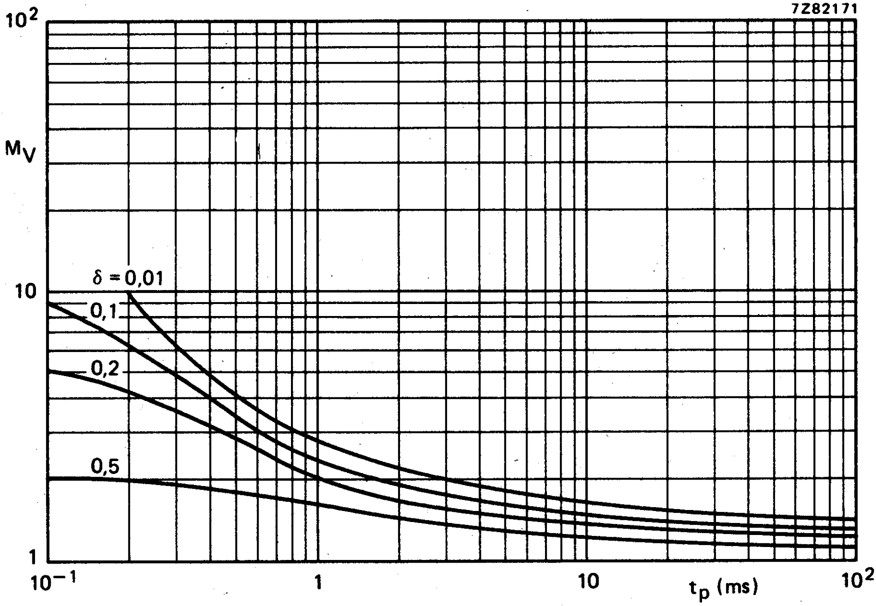


Fig. 10 S.B. voltage multiplying factor at the IC_{max} level.

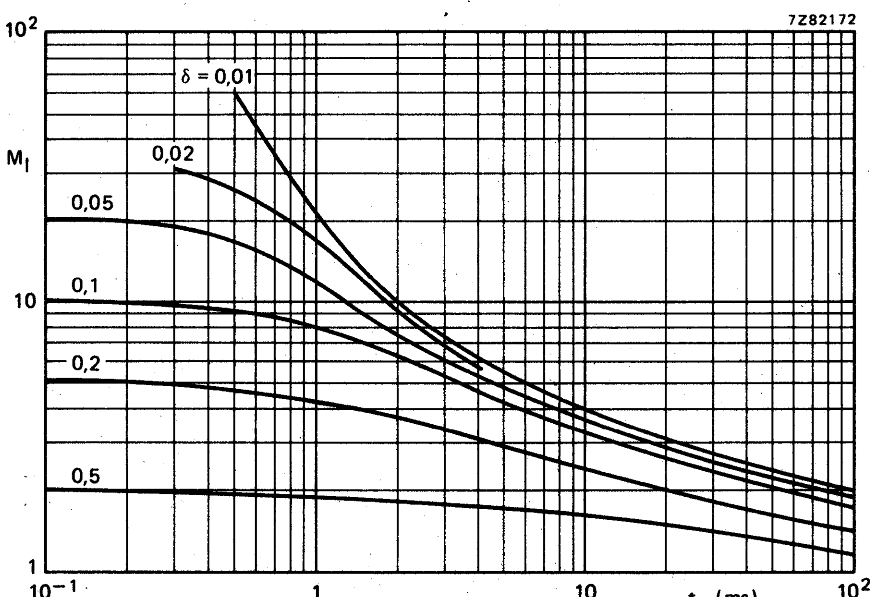


Fig. 11 S.B. current multiplying factor at the $V_{CEO\,max}$ level.

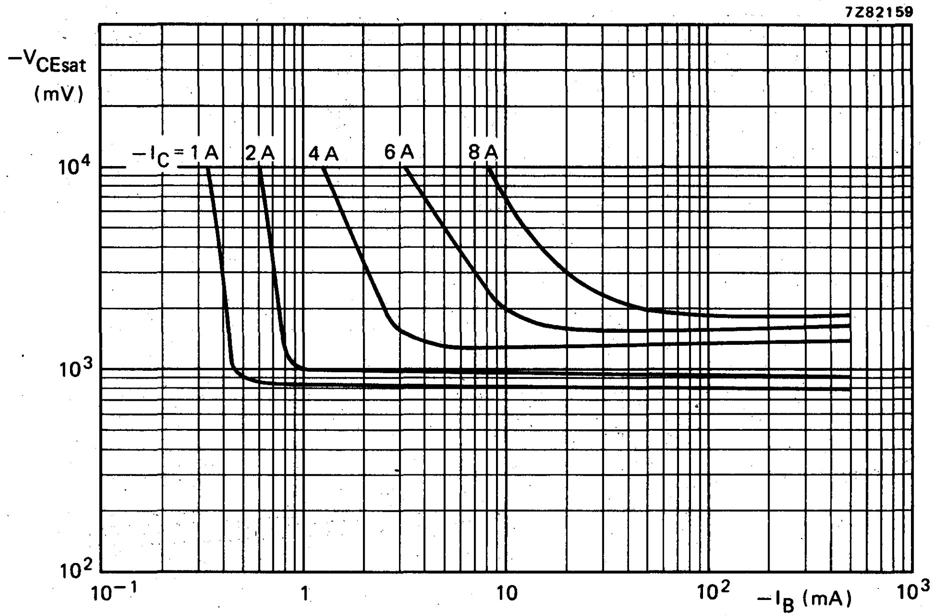


Fig. 12 Typical collector-emitter saturation voltage.

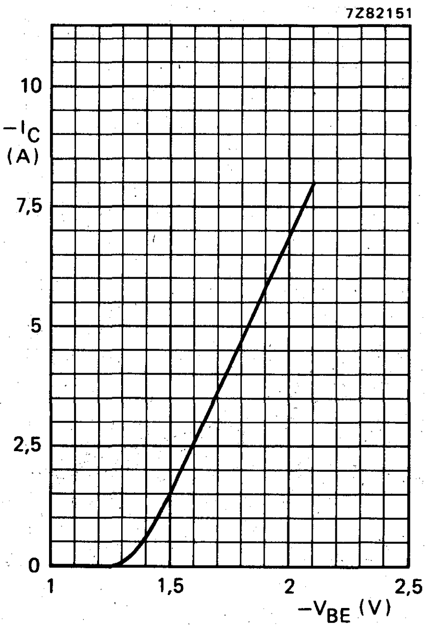


Fig. 13 Typical base emitter voltage as a function of the collector current.

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.

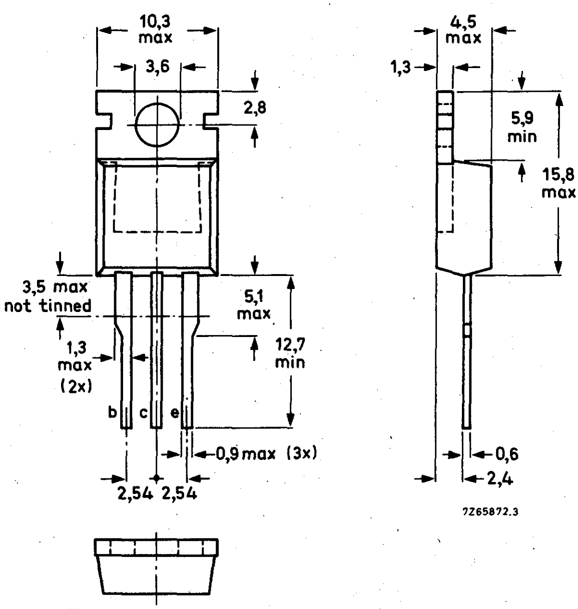
QUICK REFERENCE DATA

			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 °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			

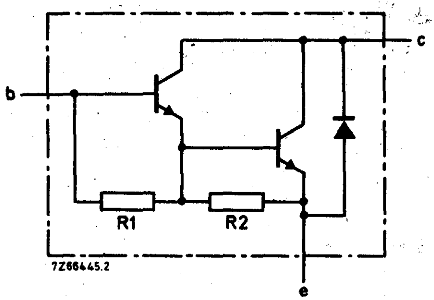
MECHANICAL DATA

Fig. 1 TO-220AB.

Collector connected to mounting base.



See also chapters Mounting instructions and Accessories.



R1 typ. 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

$T_j = 25\ ^oC$ 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}	<	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; $t_p < 300\ \mu s$; $\delta < 2\%$.

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.	0,5 μs
turn-off time	t_{off}	typ.	2,5 μs

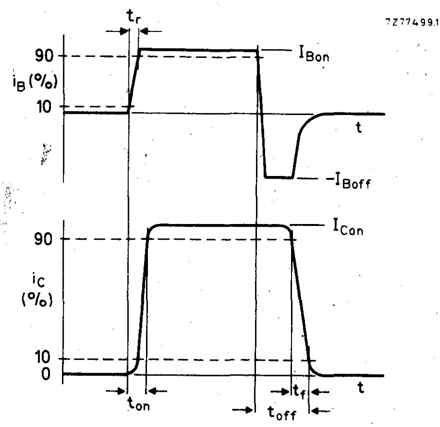
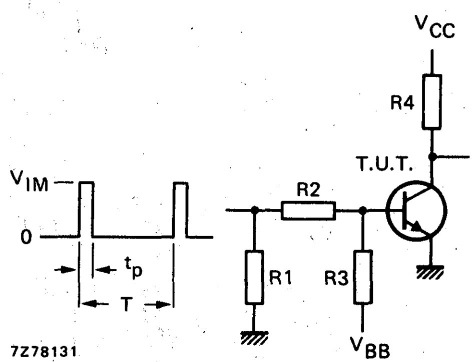


Fig. 3 Switching times waveforms.



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.

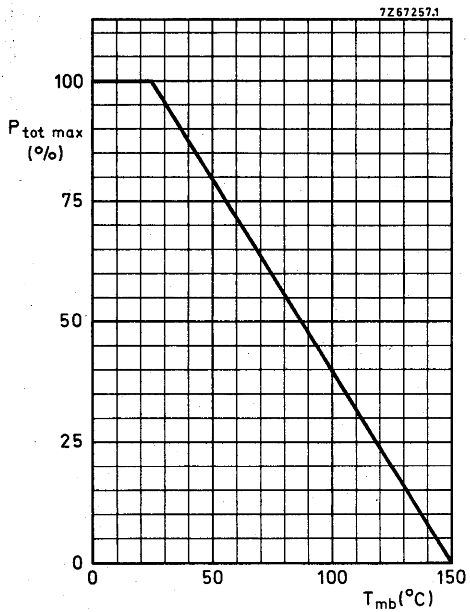


Fig. 5 Power derating curve.

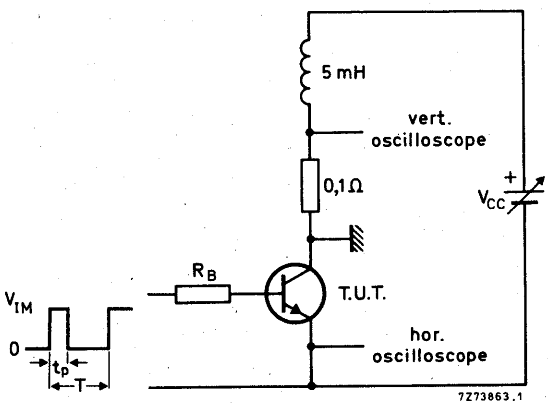


Fig. 6 Turn-off breakdown energy with inductive load.
$V_{IM} = 12$ V; $R_B = 270\ \Omega$; $\delta = \frac{t_p}{T} \times 100\% = 1\%$; $I_{CC} = 6{,}3$ A.

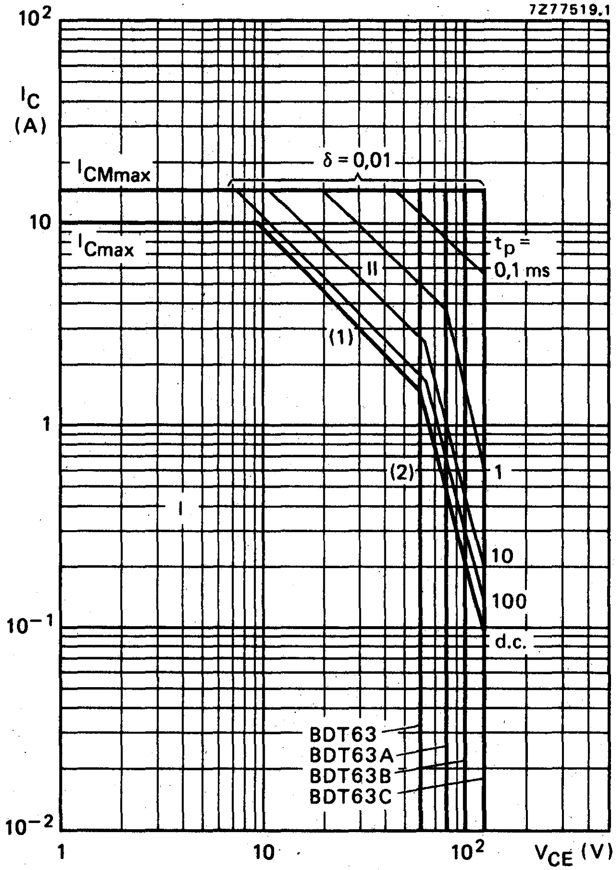


Fig. 7 Safe Operating ARea; $T_{mb} = 25\ ^oC$.

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).

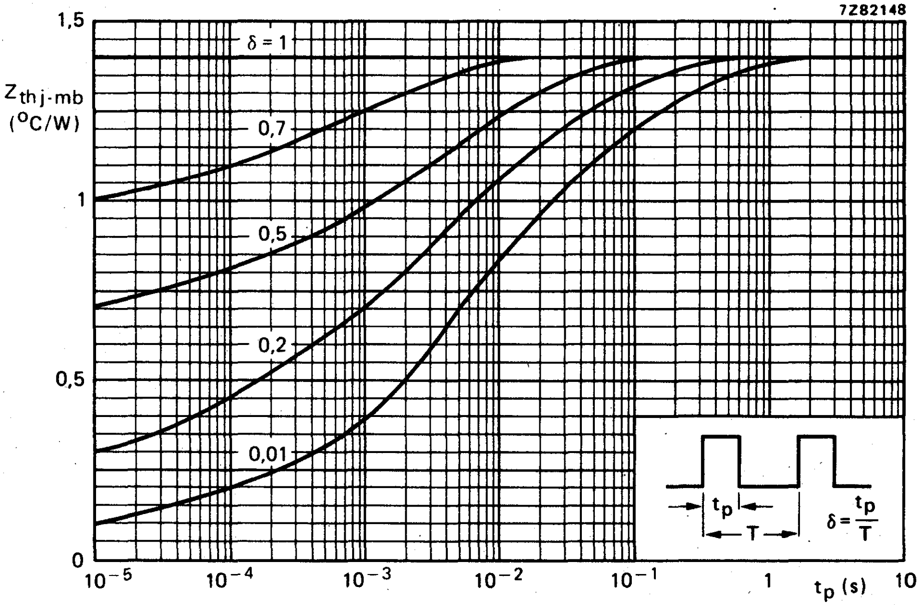


Fig. 8 Pulse power rating chart.

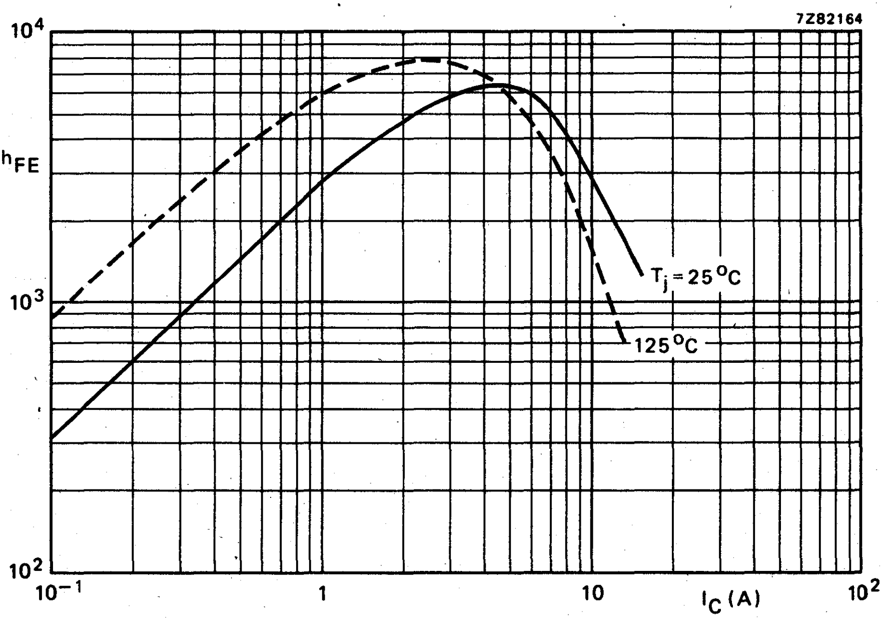


Fig. 9 Typical d.c. current gain at $V_{CE} = 3$ V.

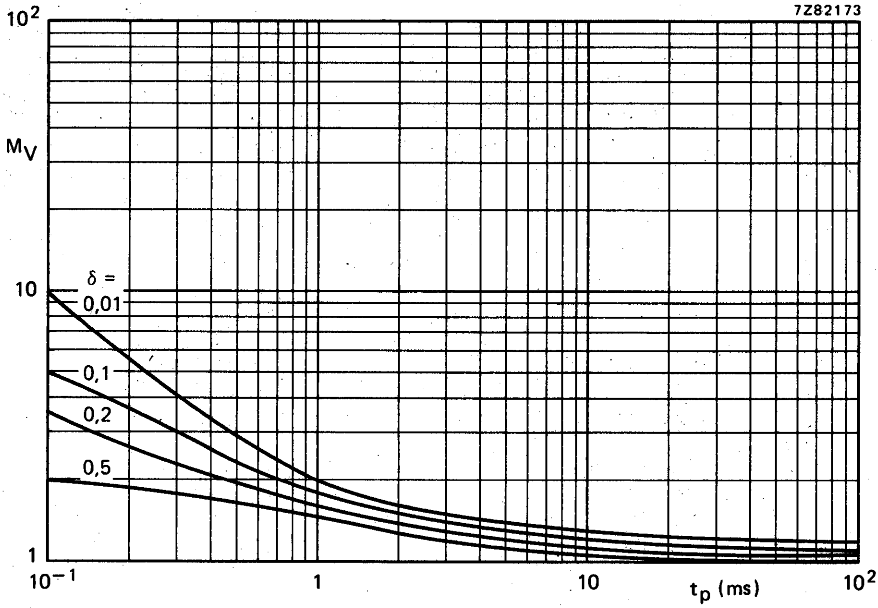


Fig. 10 S.B. voltage multiplying factor at the $I_{C\,max}$ level.

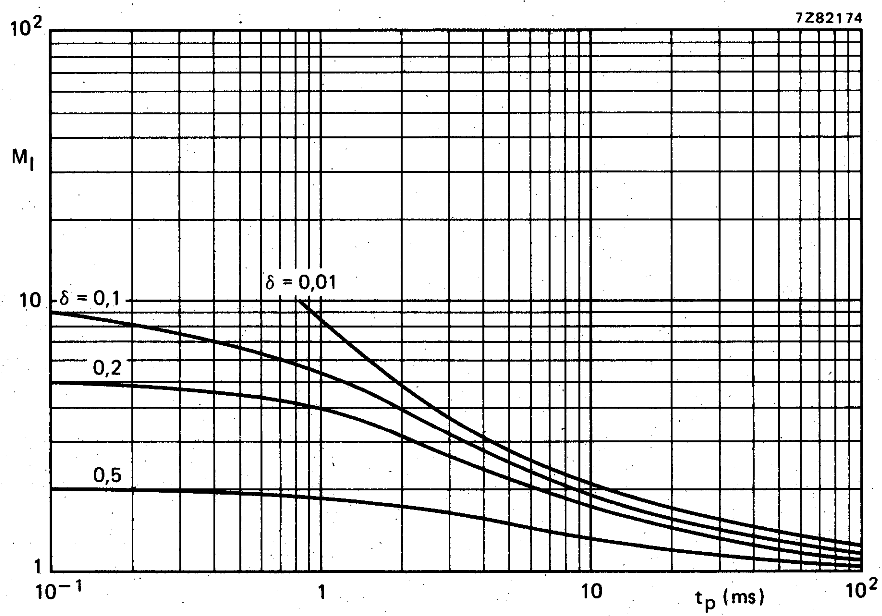


Fig. 11 S.B. current multiplying factor at V_{CEO} level = 60 V and 100 V.

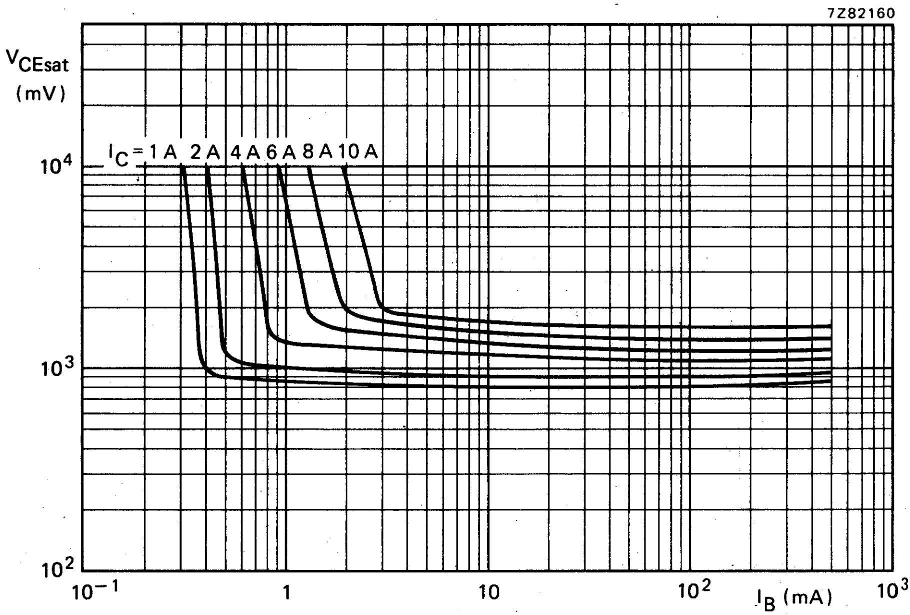


Fig. 12 Typical collector-emitter saturation voltage.

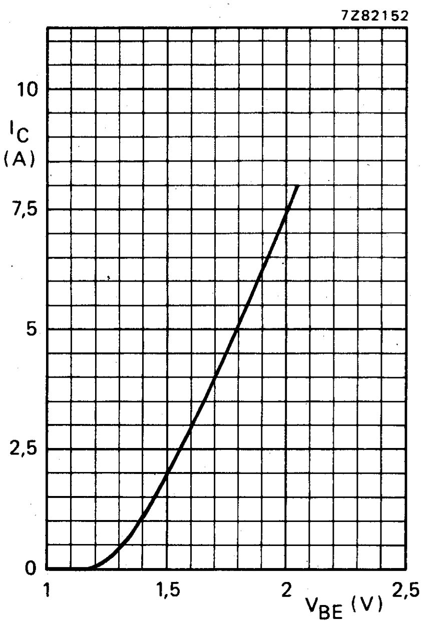


Fig. 13 Typical base-emitter voltage as a function of the collector current.

SILICON 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

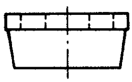
			BDT91	BDT93	BDT95	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	V
Collector current (d.c.)	I_C	max.		10		A
Collector current (peak value)	I_{CM}	max.		20		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		90		W
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

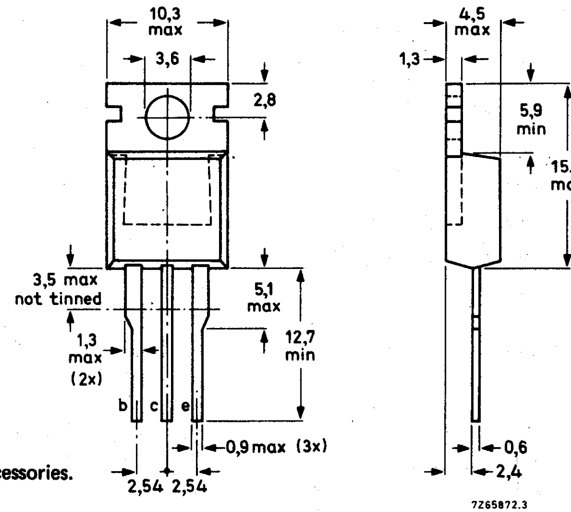
MECHANICAL DATA

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: $t_p \leqslant 300\ \mu s$; $\delta \leqslant 2\%$.
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.	0,3 μs
Turn-off time	t_{off}	typ.	1,5 μs

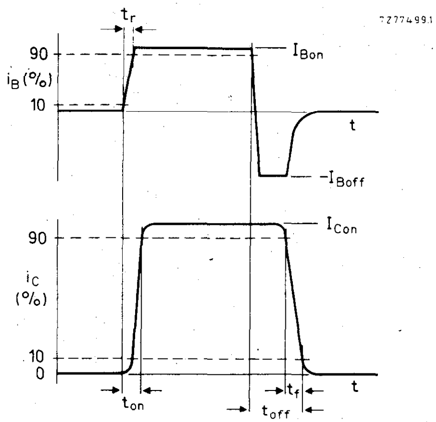


Fig. 2 Switching times waveforms.

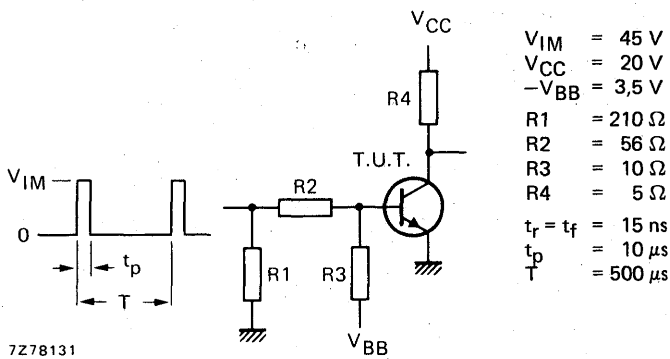


Fig. 3 Switching times test circuit.

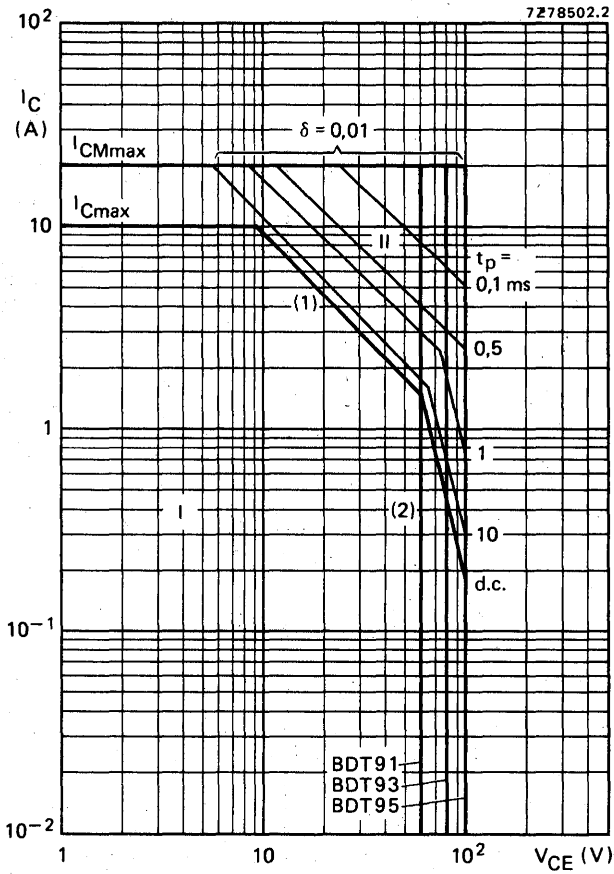


Fig. 4 Safe Operating ARea; T_{mb} = 25 °C.

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).

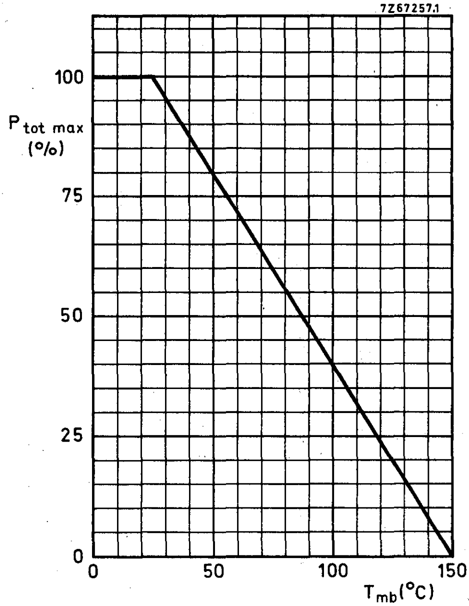


Fig. 5 Power derating curve.

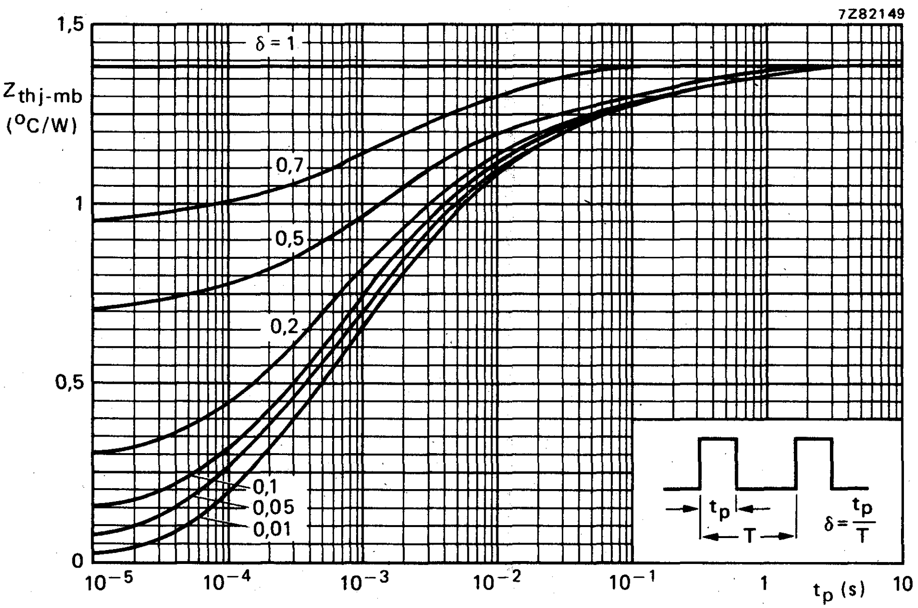


Fig. 6 Pulse power rating chart.

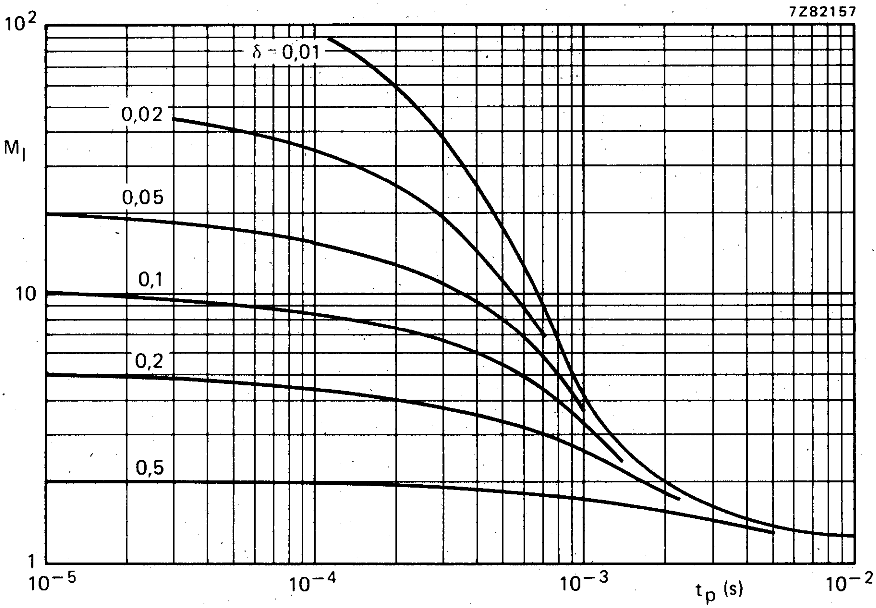


Fig. 7 S.B. current multiplying factor at the V_{CEOmax} level.

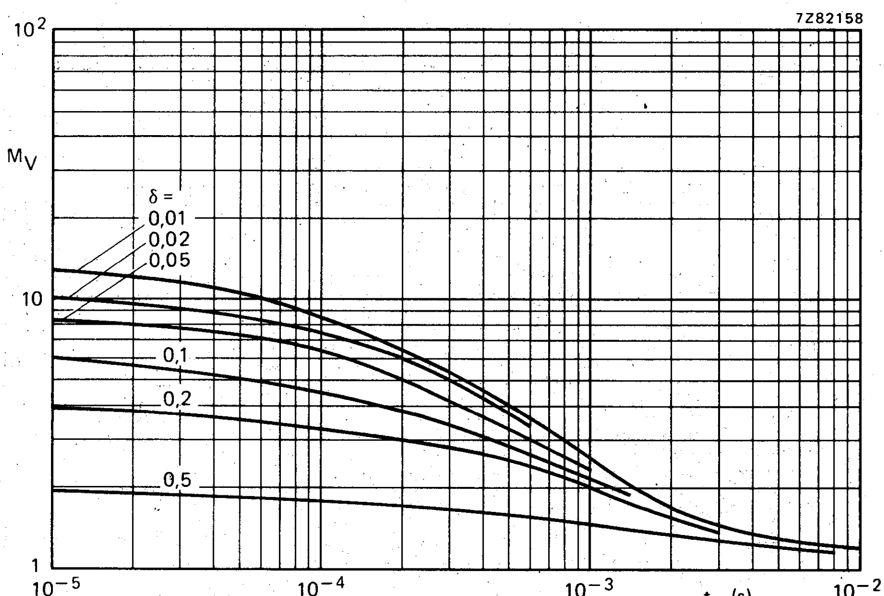


Fig. 8 S.B. voltage multiplying factor at the I_{Cmax} level.

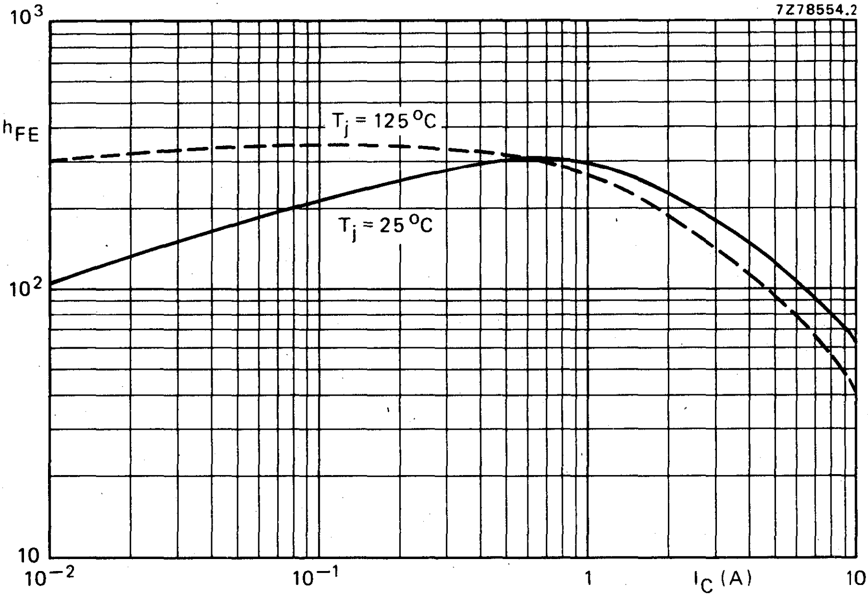


Fig. 9 Typical d.c. current gain at V_{CE} = 4 V.

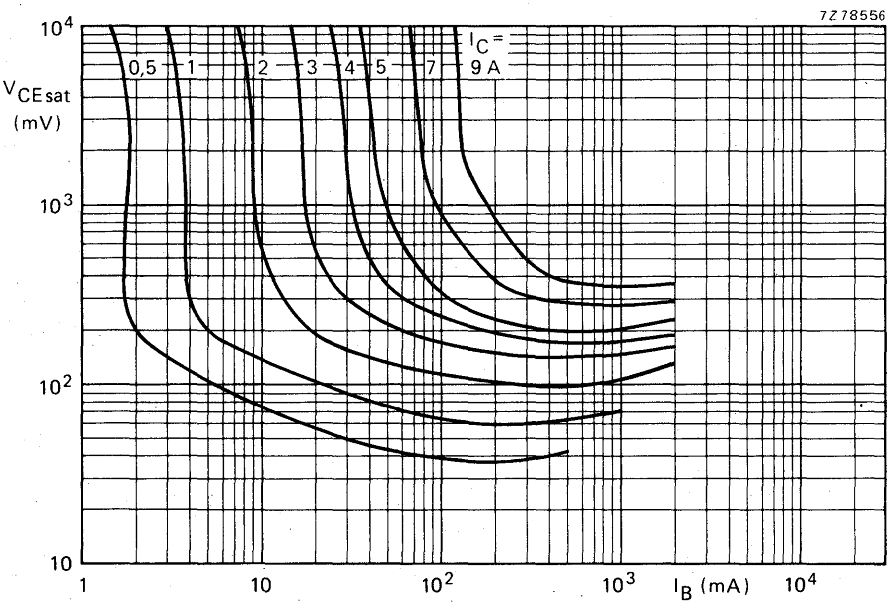


Fig. 10 Typical collector-emitter saturation voltage. T_{mb} = 25 ^oC.

SILICON 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.

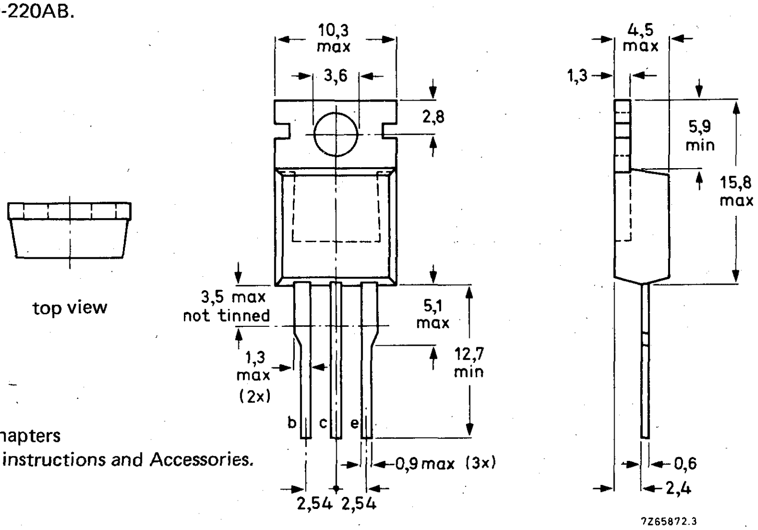
QUICK REFERENCE DATA

			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.



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: $t_p \leqslant 300\ \mu s$; $\delta \leqslant 2\%$.
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

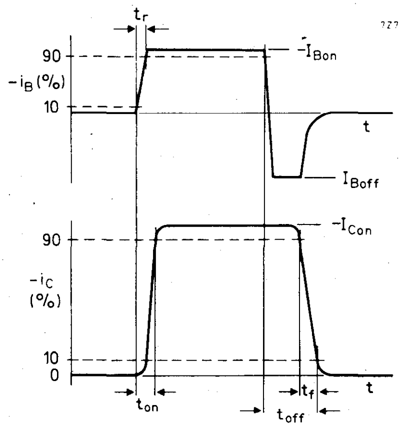


Fig. 2 Switching times waveforms.

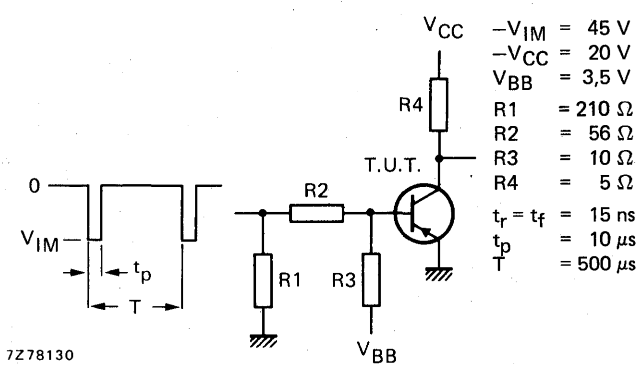


Fig. 3 Switching times test circuit.

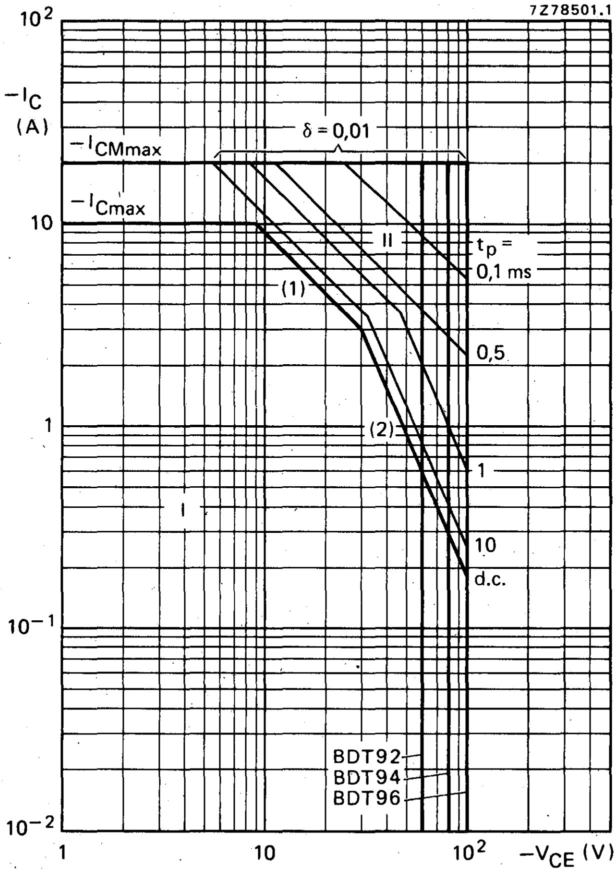


Fig. 4 Safe Operating ARea; T_{mb} = 25 °C.

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).

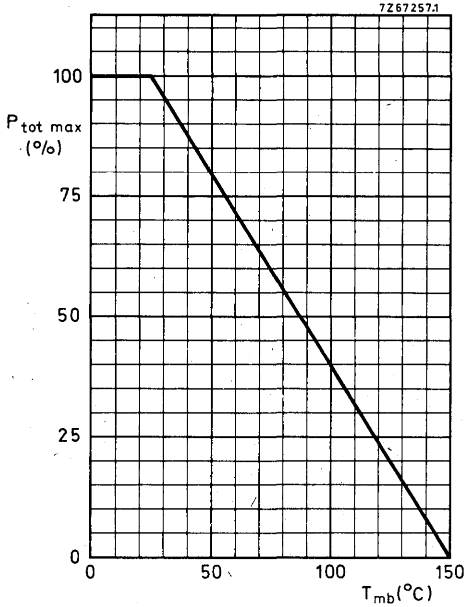


Fig. 5 Power derating curve.

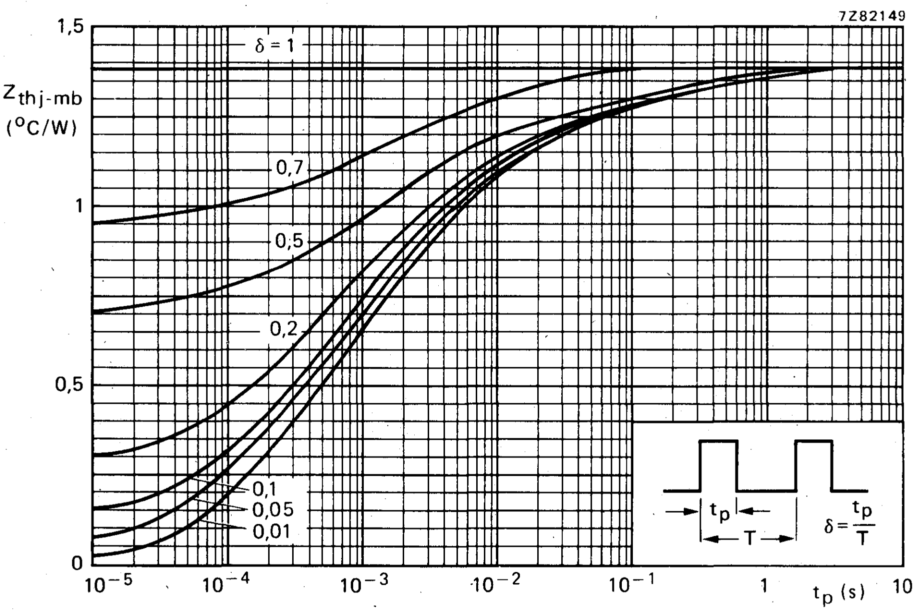


Fig. 6 Pulse power rating chart.

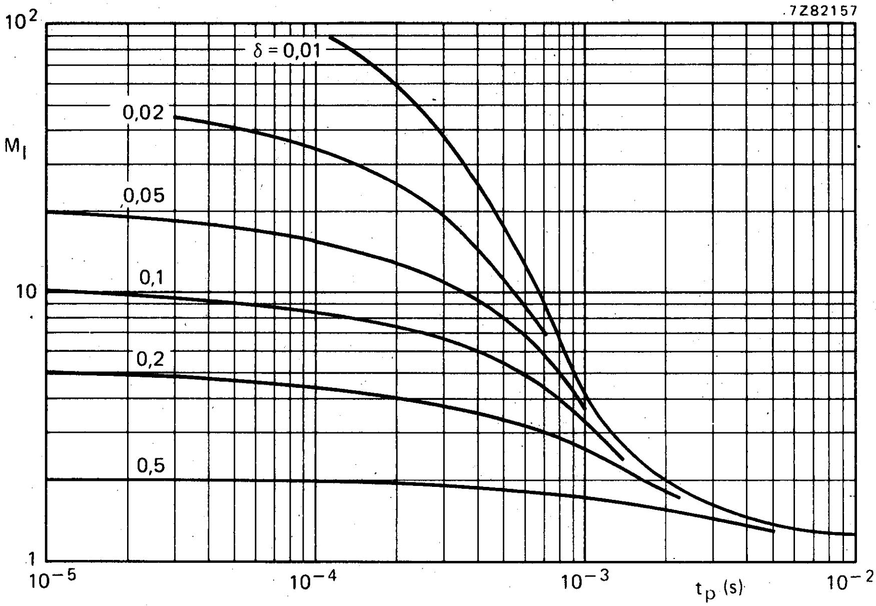


Fig. 7 S.B. current multiplying factor at the V_{CEOmax} level.

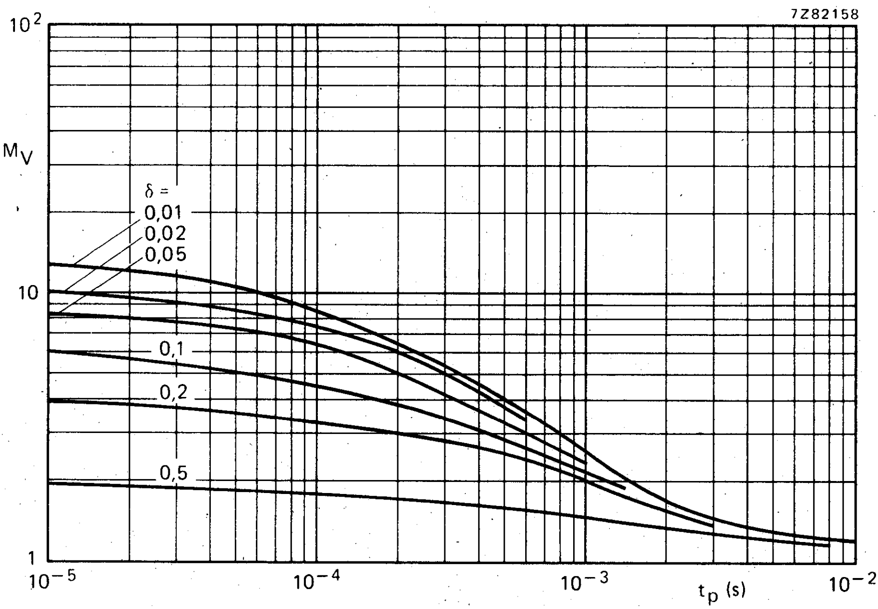


Fig. 8 S.B. voltage multiplying factor at the I_{Cmax} level.

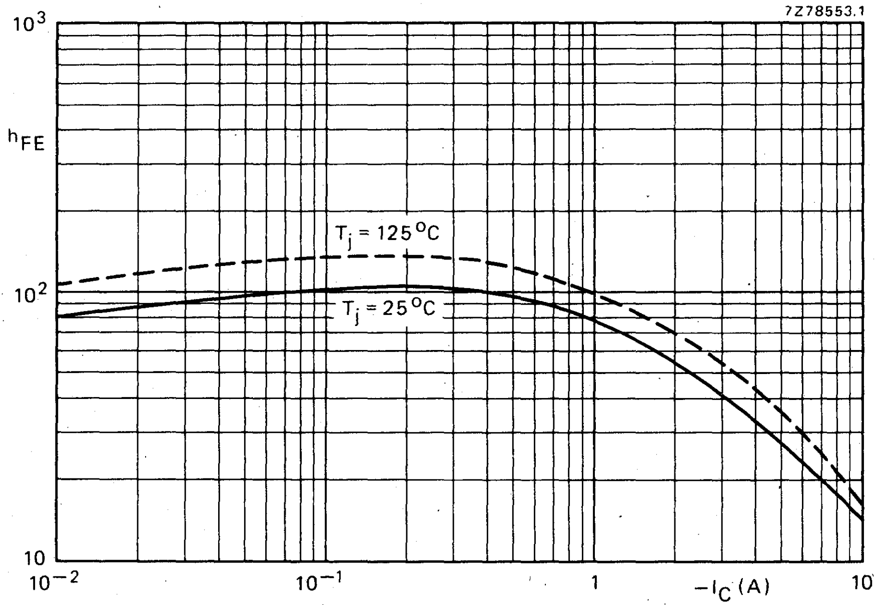


Fig. 9 Typical d.c. current gain at $-V_{CE} = 4$ V.

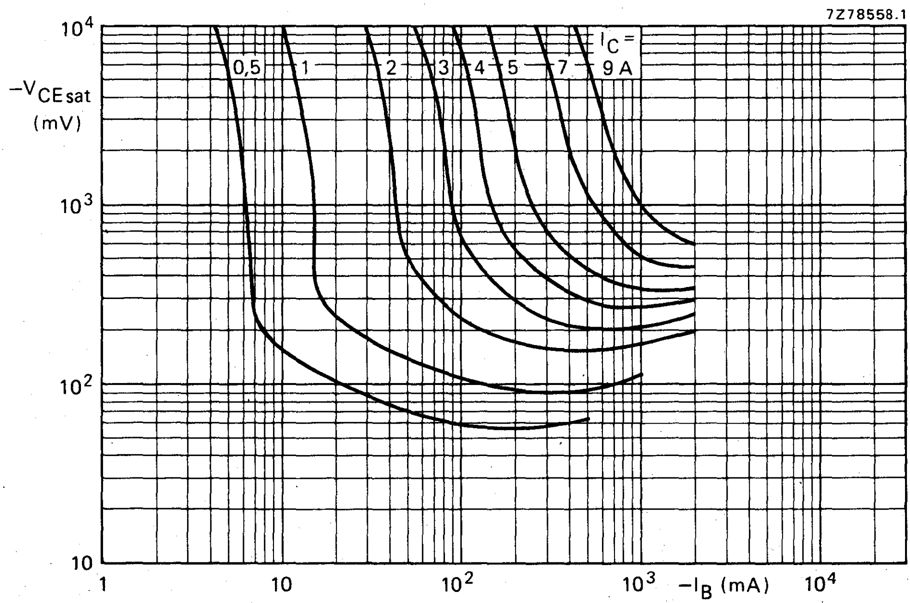


Fig. 10 Typical collector-emitter saturation voltage. $T_{mb} = 25\,^oC$.

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, BDV65A and BDV65B. Matched complementary pairs can be supplied.

QUICK REFERENCE DATA

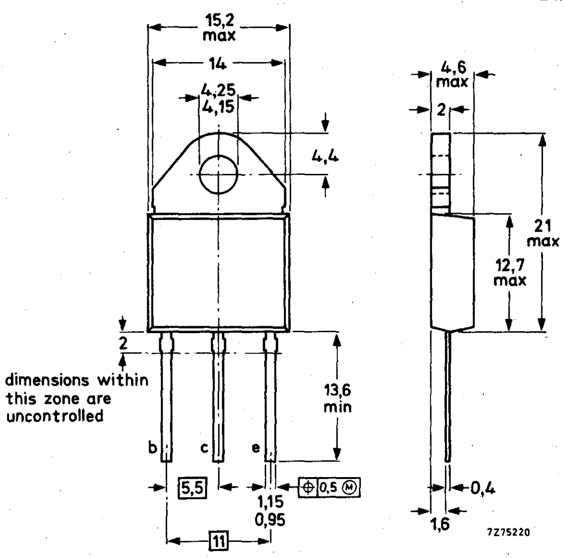
			BDV64	BDV64A	BDV64B
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100 V
Collector current (peak value)	$-I_{CM}$	max.		20	A
Total power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.		125	W
Junction temperature	T_j	max.		150	^oC
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.



Accessories supplied on request: 56368 (see also data sheet *Mounting instructions SOT-93).*

CIRCUIT DIAGRAM

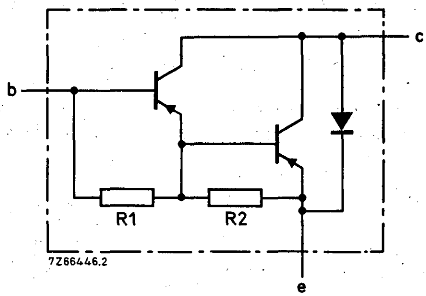


Fig. 2
R1 typical 5 kΩ
R2 typical 80 Ω.

RATINGS

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

			BDV64	BDV64A	BDV64B	
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.		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	°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 currents			
$I_E = 0; -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	400 µA
$I_E = 0; -V_{CB} = -½\,V_{CBOmax}; T_j = 150$ °C	$-I_{CBO}$	<	2 mA
$I_B = 0; -V_{CE} = -½\,V_{CEOmax}$	$-I_{CEO}$	<	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
$-I_C = 10$ 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
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

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

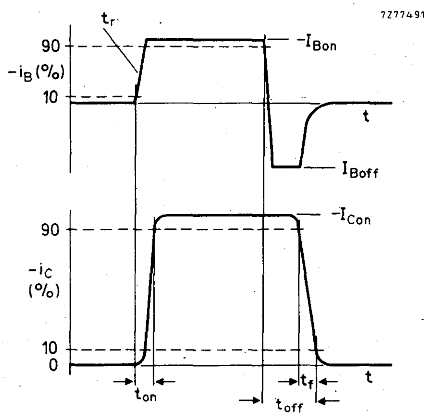


Fig. 3 Waveforms showing t_{on}; $t_s + t_f = t_{off}$.

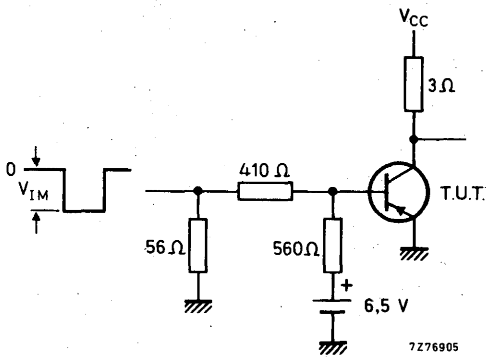


Fig. 4 Switching times test circuit; $V_{CC} = -16$ V;
$V_{IM} = 16{,}5$ V; $t_r = t_f = 15$ ns; $t_p = 10$ μs; T = 500 μs.

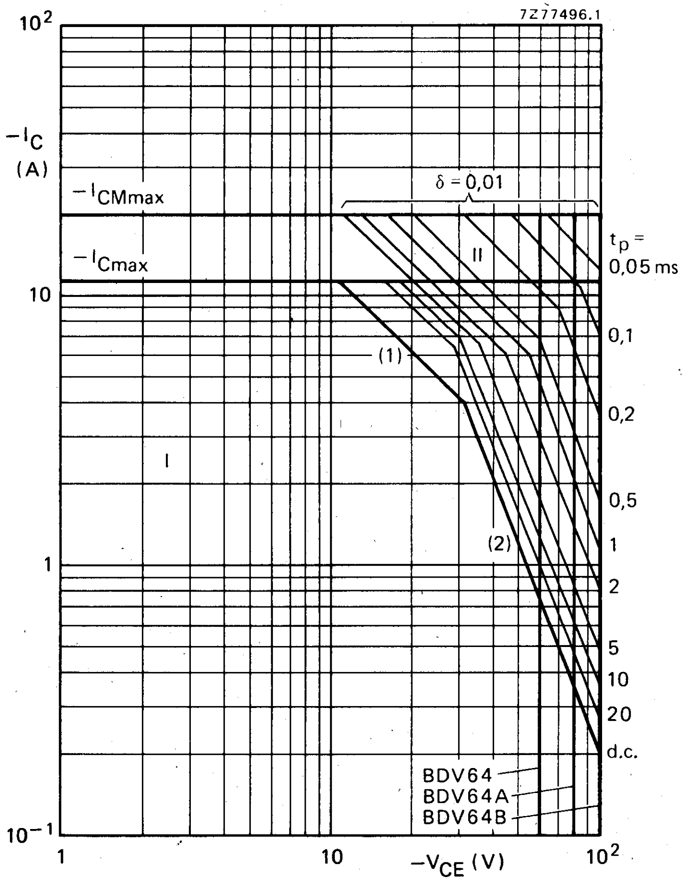


Fig. 5 Safe Operating ARea; $T_{mb} \leqslant 25$ °C.

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).

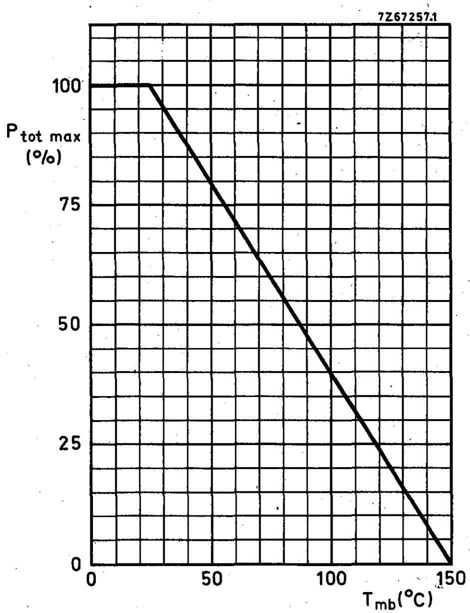


Fig. 6.

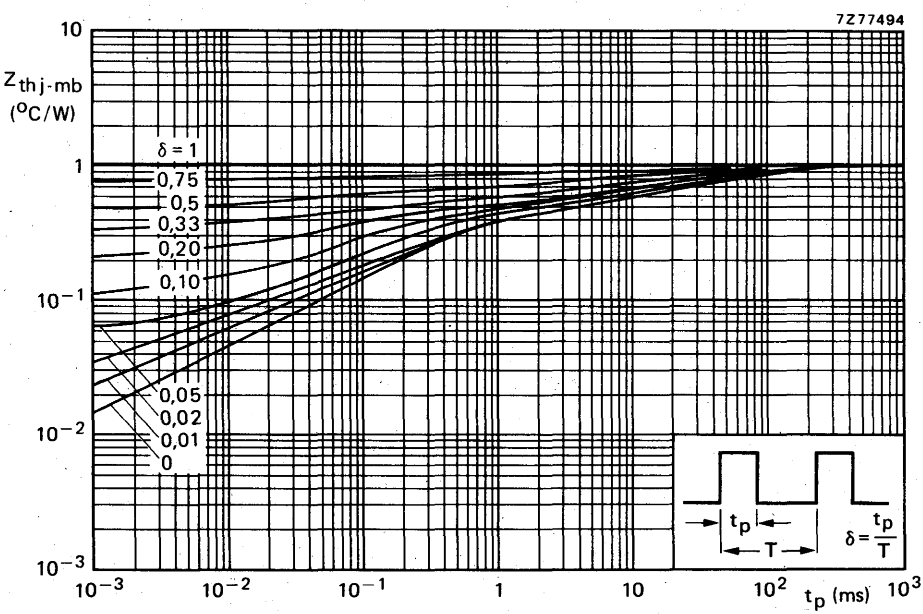


Fig. 7 Heating-up curve.

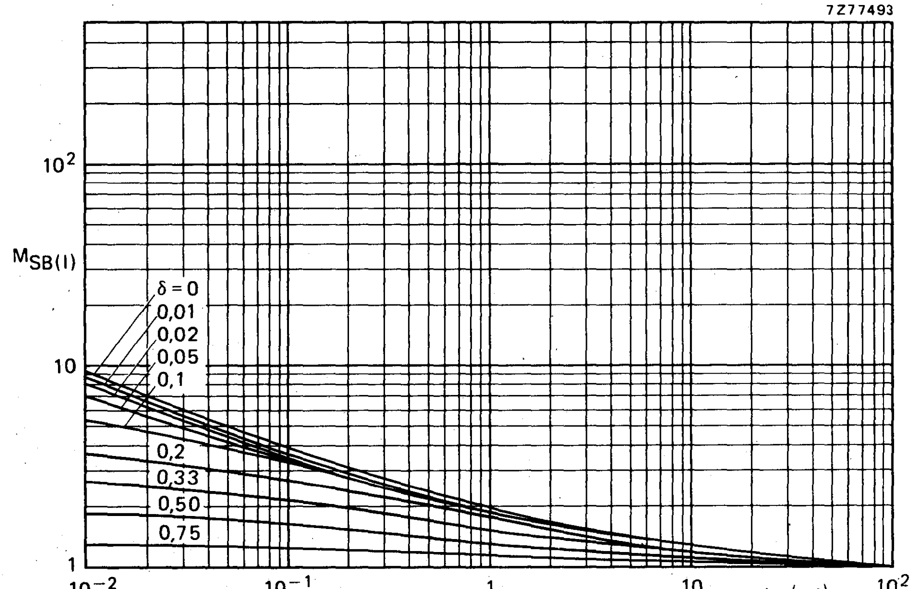


Fig. 8 S.B. voltage multiplying factor at the $-I_{Cmax}$ level.

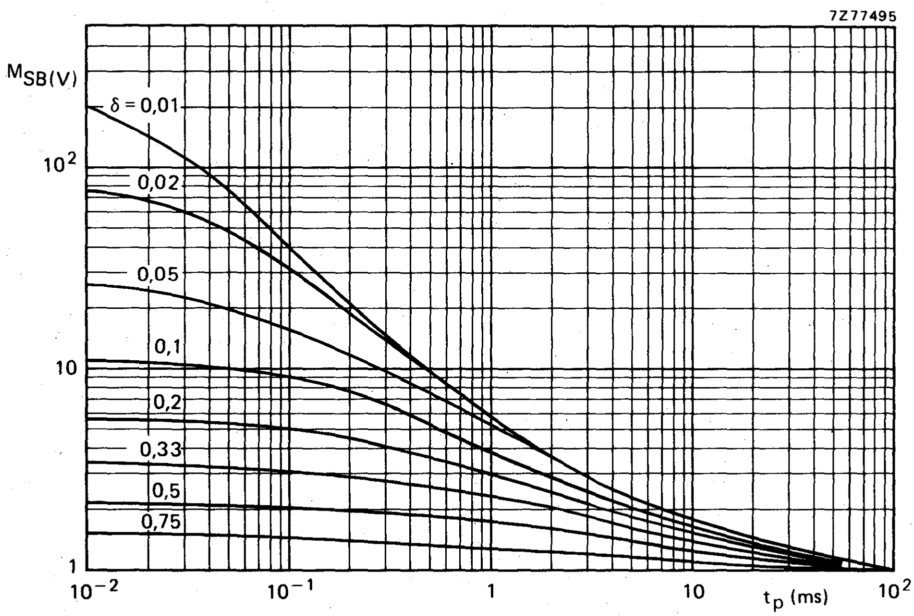


Fig. 9 S.B. current multiplying factor at the $-V_{CEOmax}$ level (100 V).

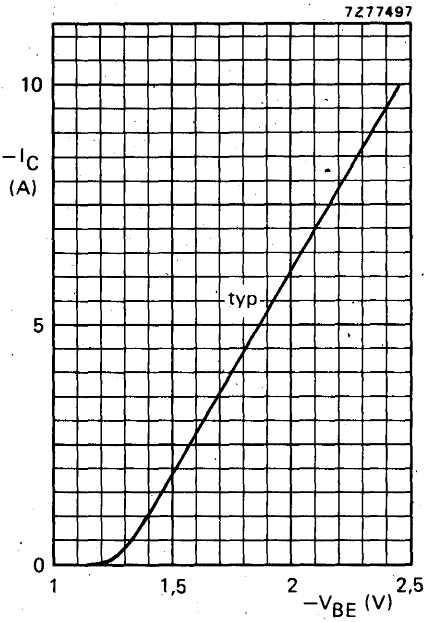


Fig. 10 – V_{CE} = 4 V; T_j = 25 °C.

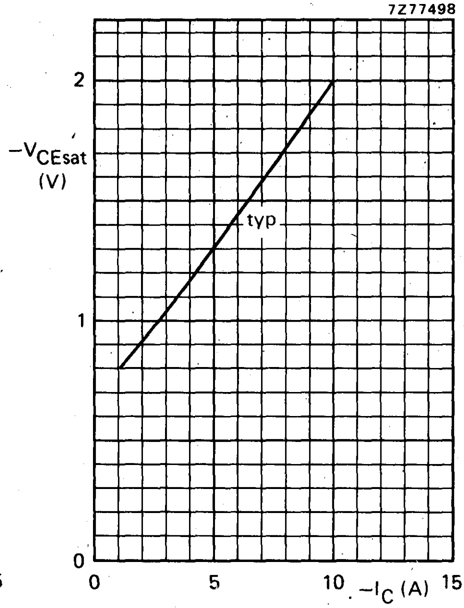


Fig. 11 $-I_C/-I_B$ = 250; T_j = 25 °C.

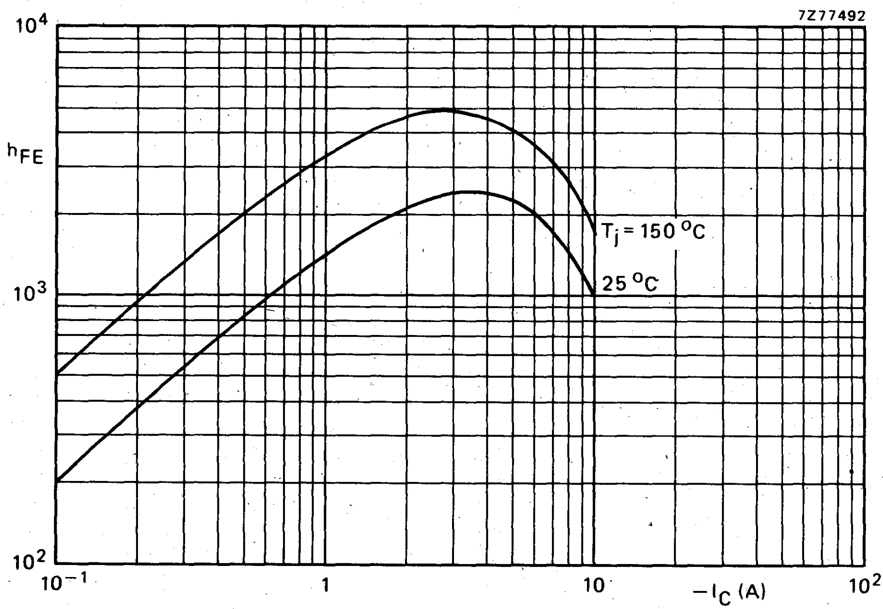


Fig. 12 Typical values; $-V_{CE}$ = 4 V.

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, BDV64A and BDV64B. Matched complementary pairs can be supplied.

QUICK REFERENCE DATA

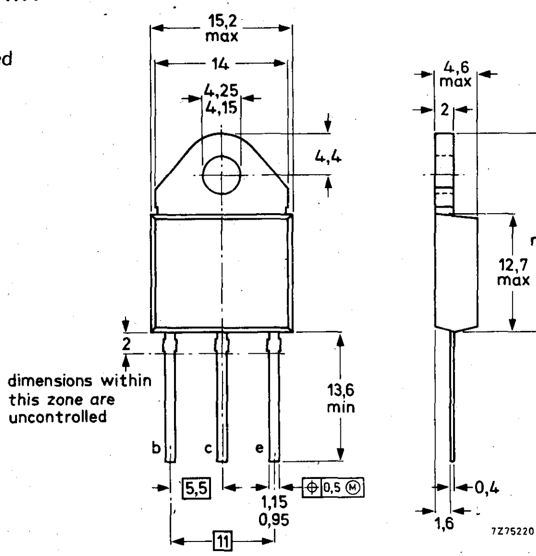
			BDV65	BDV65A	BDV65B	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	V
Collector current (peak value)	I_{CM}	max.		20		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		125		W
Junction temperature	T_j	max.		150		°C
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.



Accessories supplied on request: 56368 (see also data sheet *Mounting instructions SOT-93).*

CIRCUIT DIAGRAM

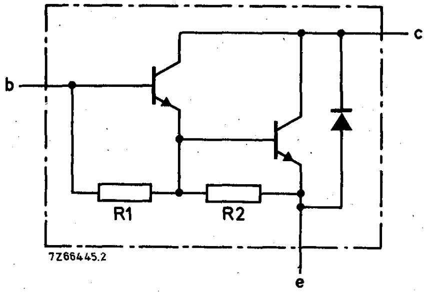


Fig. 2.
R1 typical 5 kΩ
R2 typical 80 Ω.

RATINGS

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

			BDV65	BDV65A	BDV65B	
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.		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	°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 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
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
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.	1,5 μs
Turn-off time	t_{off}	typ.	2,5 μs

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

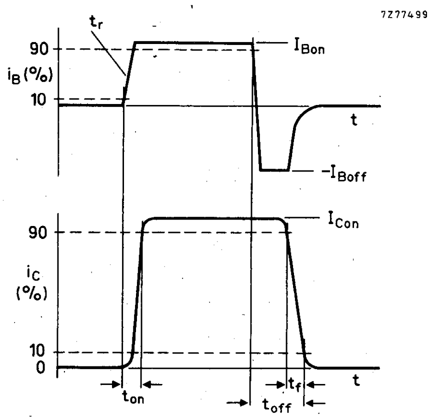


Fig. 3 Waveforms showing t_{on}; $t_s + t_f = t_{off}$.

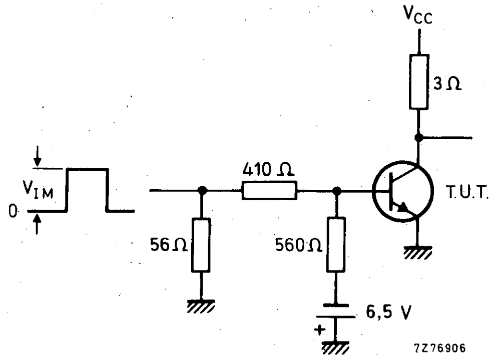


Fig. 4 Switching times test circuit; V_{CC} = 16 V;
V_{IM} = 16,5 V; $t_r = t_f$ = 15 ns; t_p = 10 μs; T = 500 μs.

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

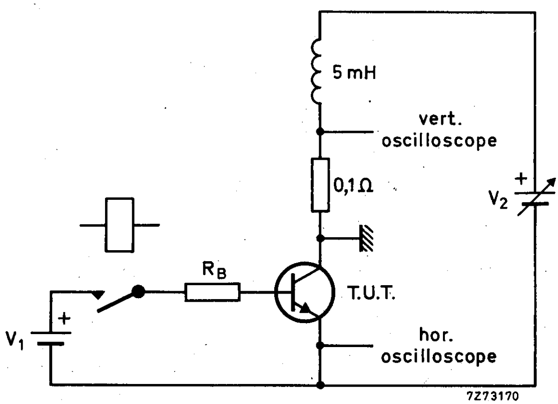


Fig. 5 Test circuit; V_1 = 12 V; R_B = 270 Ω.

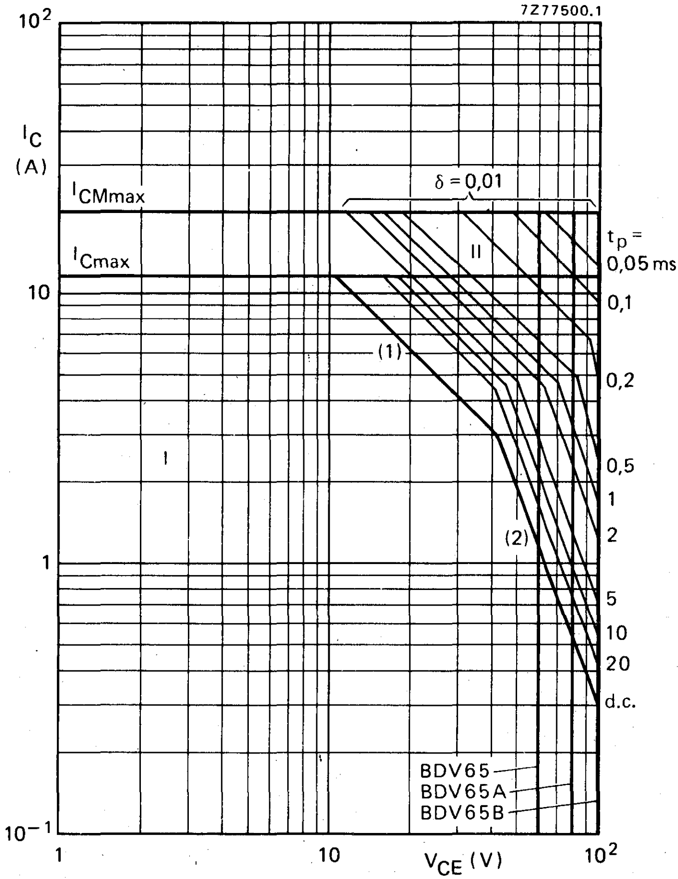


Fig. 6 Safe Operating ARea; $T_{mb} \leqslant 25$ °C.

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).

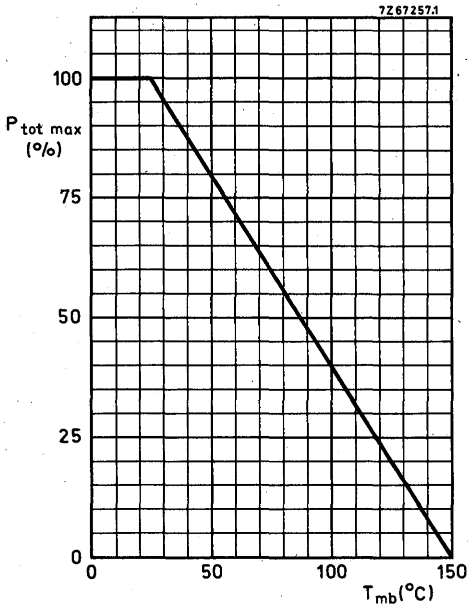


Fig. 7.

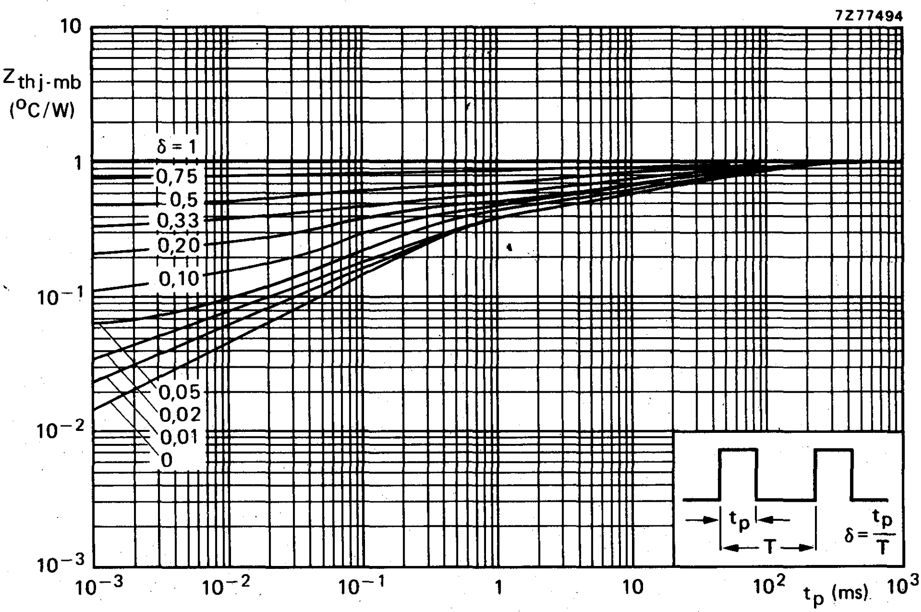


Fig. 8 Heating-up curve.

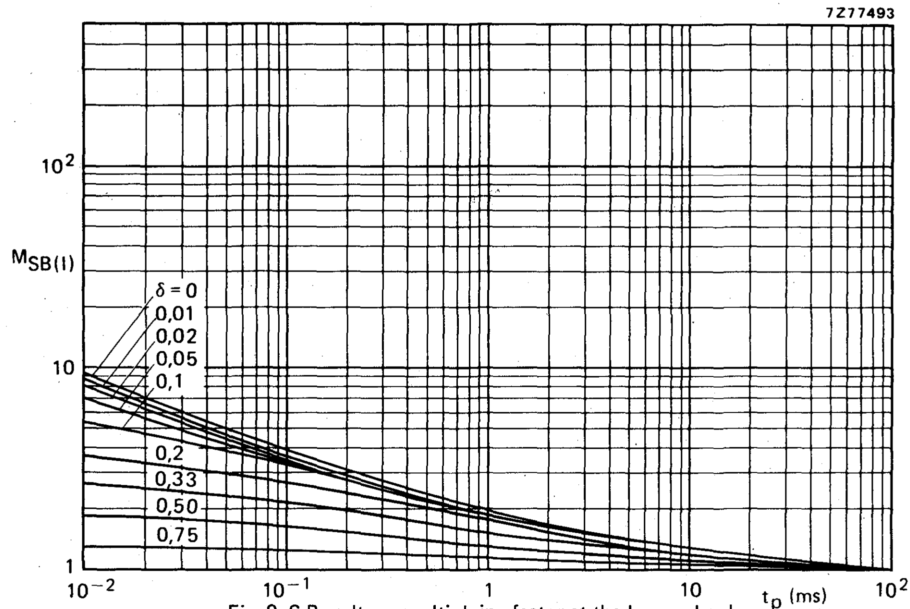


Fig. 9 S.B. voltage multiplying factor at the $I_{C\,max}$ level.

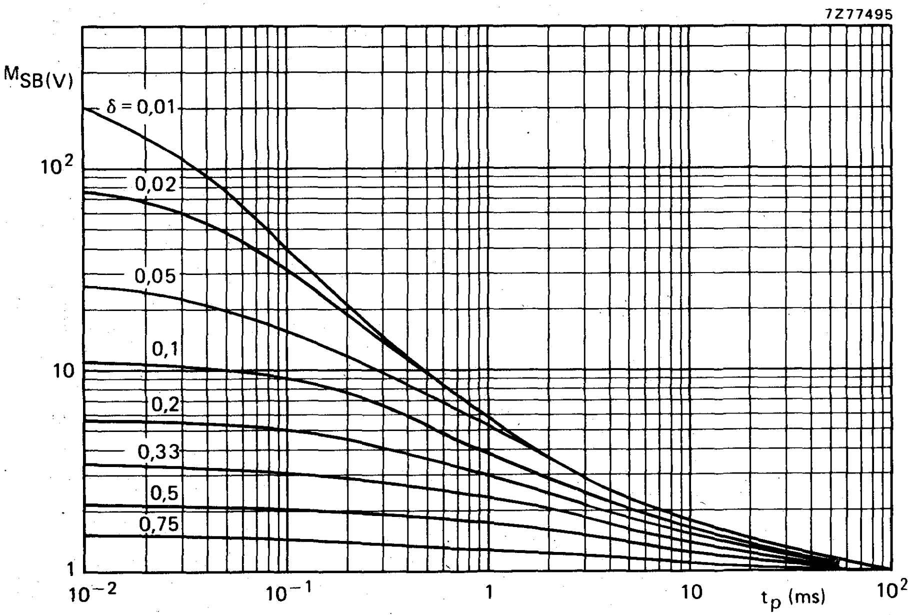


Fig. 10 S.B. current multiplying factor at the V_{CEOmax} level (100 V).

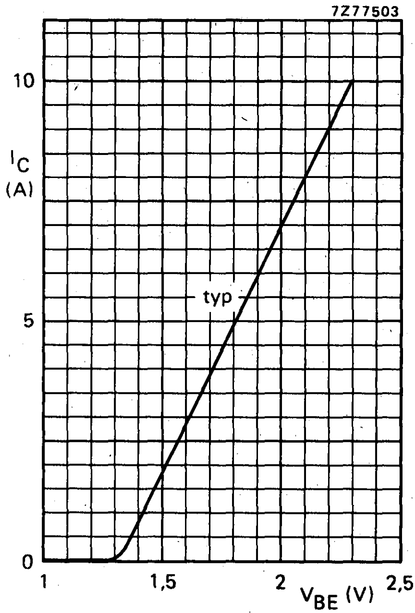


Fig. 11 V_{CE} = 4 V; T_j = 25 °C.

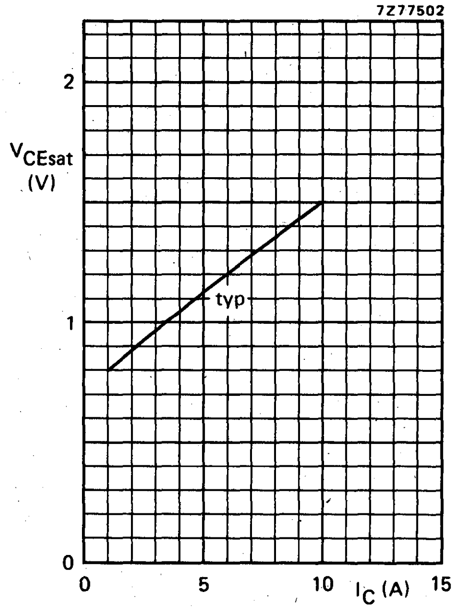


Fig. 12 I_C/I_B = 250; T_j = 25 °C.

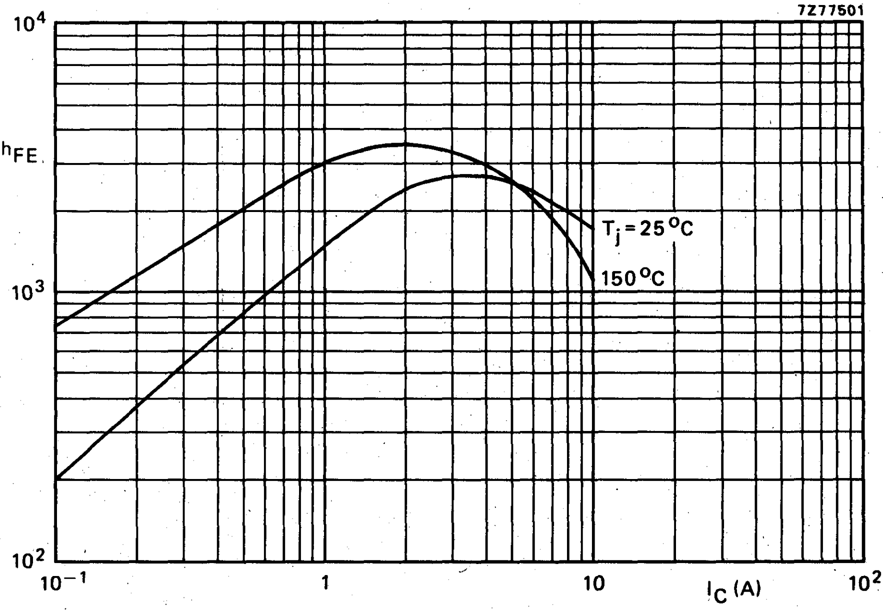


Fig. 13 Typical values; V_{CE} = 4 V.

SILICON 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

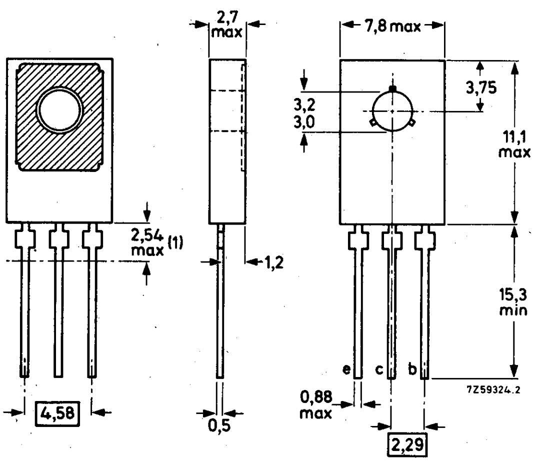
			BDX35	BDX36	BDX37	
Collector-base voltage (open emitter)	V_{CBO}	max.	100	120	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	60	80	V
Collector current (peak value)	I_{CM}	max.	10	10	10	A
Total power dissipation up to T_{mb} = 75 °C	P_{tot}	max.	15	15	15	W
D.C. current gain I_C = 0,5 A; V_{CE} = 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
Turn-off time				
$I_C = 5$ A; $I_{Bon} = -I_{Boff} = 0{,}5$ A		t_{off}	typ.	350 ns
			<	800 ns

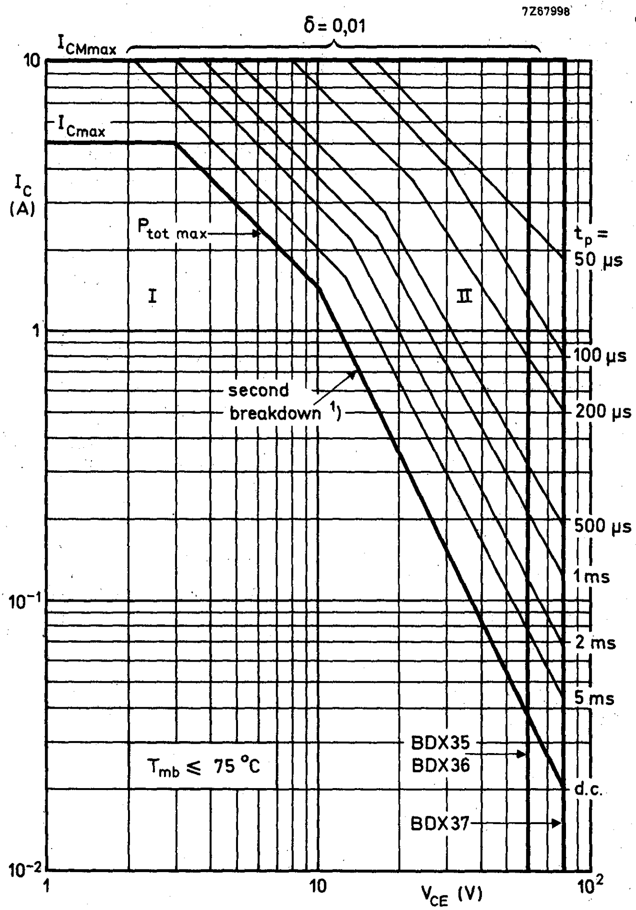


Fig. 2 Safe Operating Area with the transistor forward biased.
I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation.

1) Independent of temperature.

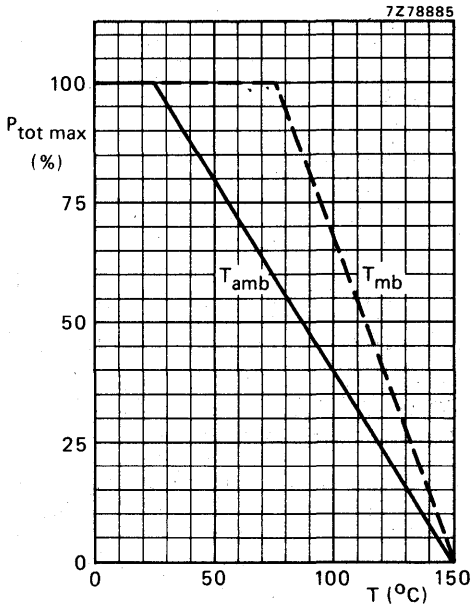


Fig. 3 Power derating curve.

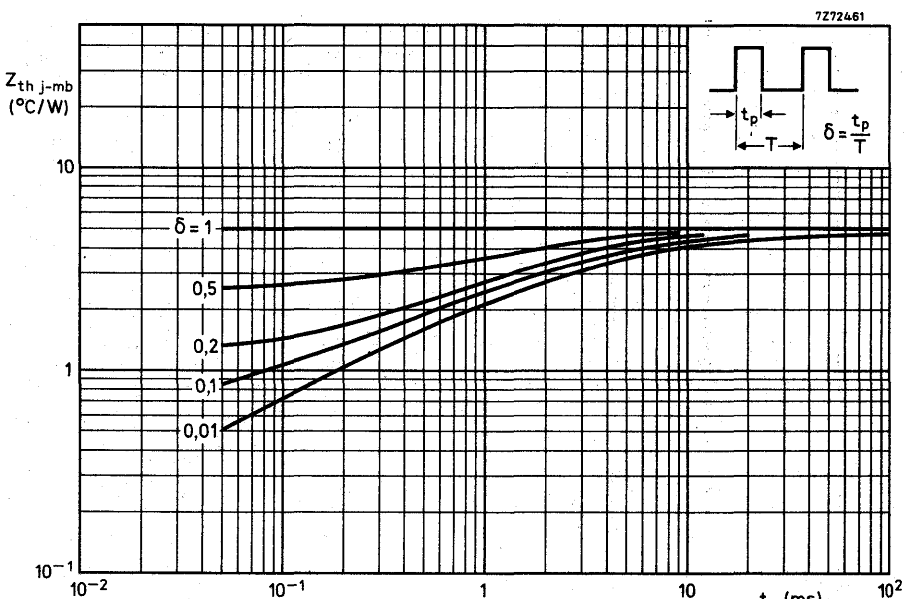


Fig. 4 Pulse power rating chart.

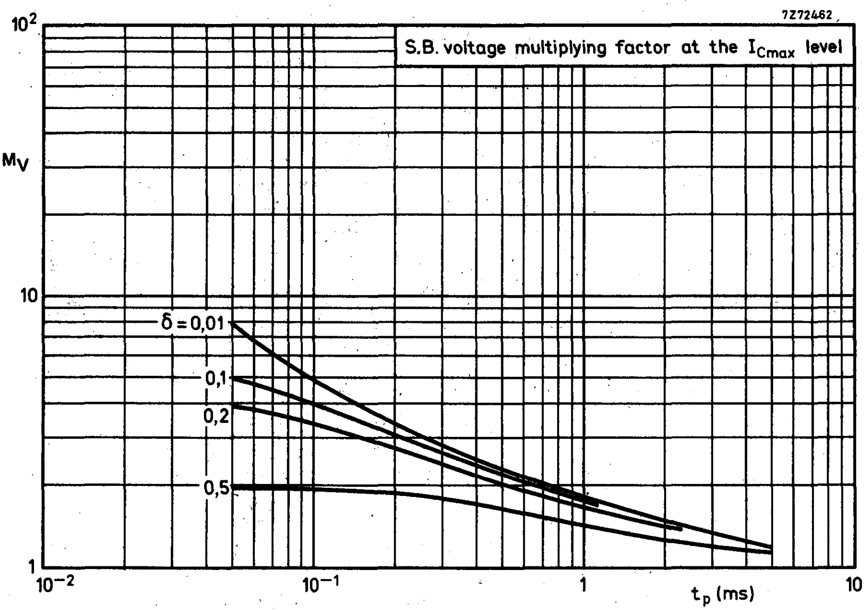


Fig. 5 S.B. voltage multiplying factor at the I_{Cmax} level.

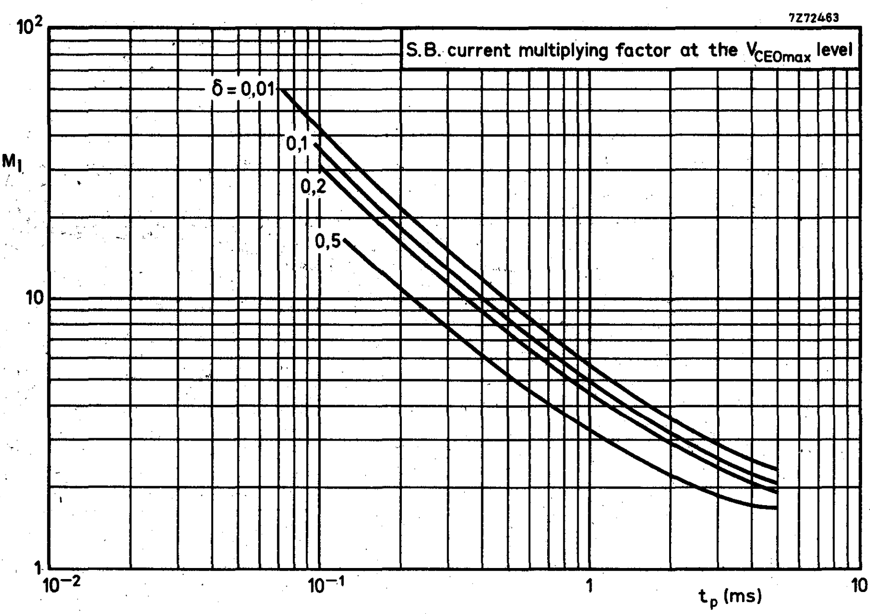


Fig. 6 S.B. current multiplying factor at the V_{CEOmax} level.

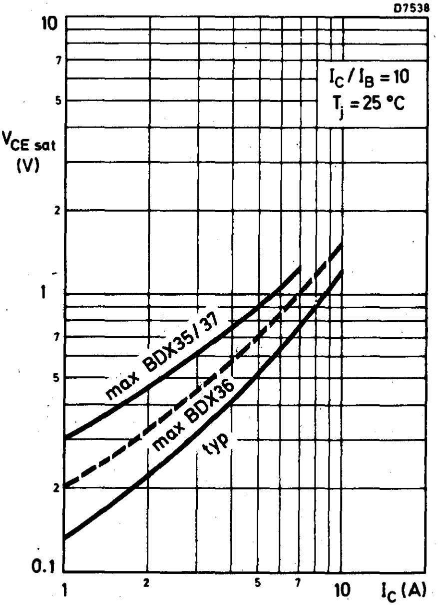


Fig. 7 Collector-emitter saturation voltage as a function of the collector current.

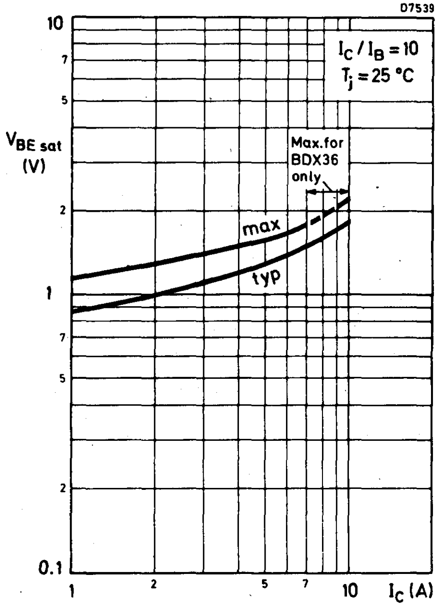


Fig. 8 Base-emitter saturation voltage as a function of the collector current.

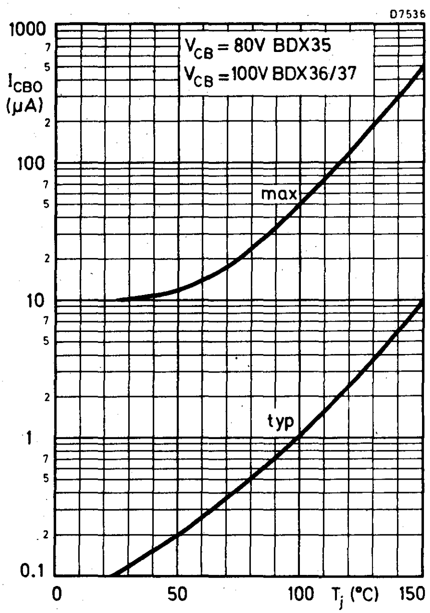


Fig. 9 Collector-base current with an open emitter as a function of junction temperature.

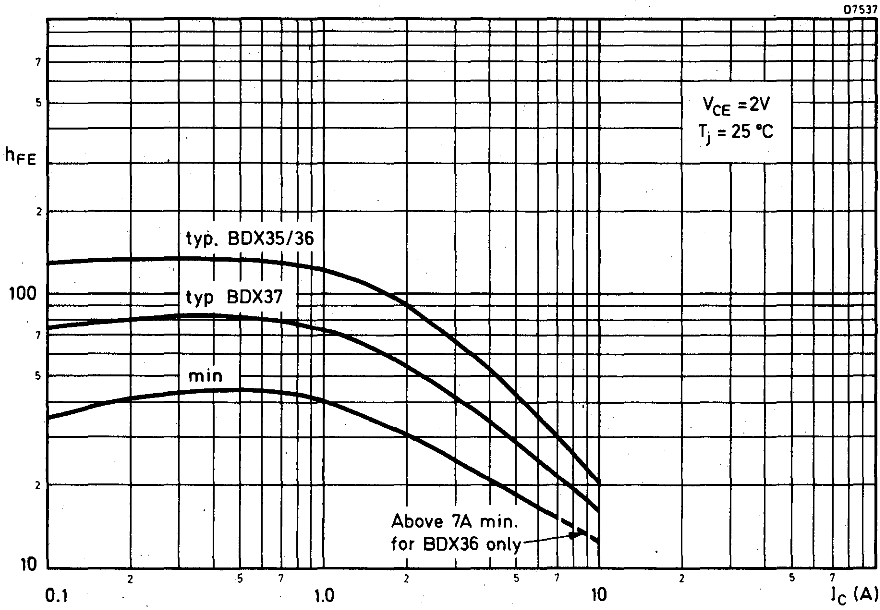


Fig. 10 D.C. current gain as a function of collector current.

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

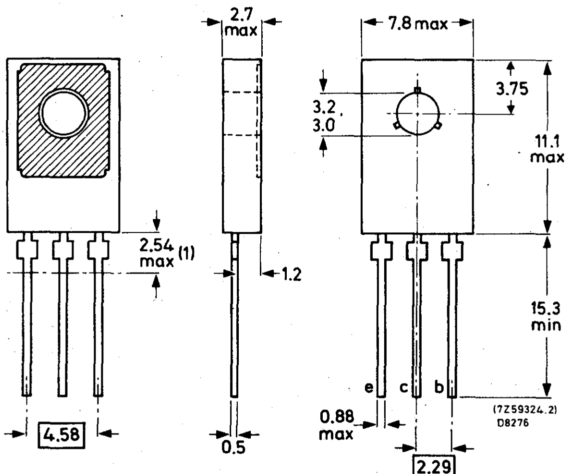
			BDX42	BDX43	BDX44	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	V
Collector-emitter voltage	V_{CER}	max.	45	60	80	V
Collector current	I_C	max.	1	1	1	A
Total power dissipation						
up to T_{amb} = 25 °C	P_{tot}	max.	1,25	1,25	1,25	W
up to T_{mb} = 100 °C	P_{tot}	max.	5	5	5	W
D.C. current 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.

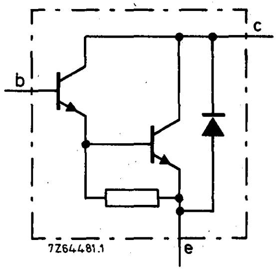


Fig. 2 Circuit diagram.

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

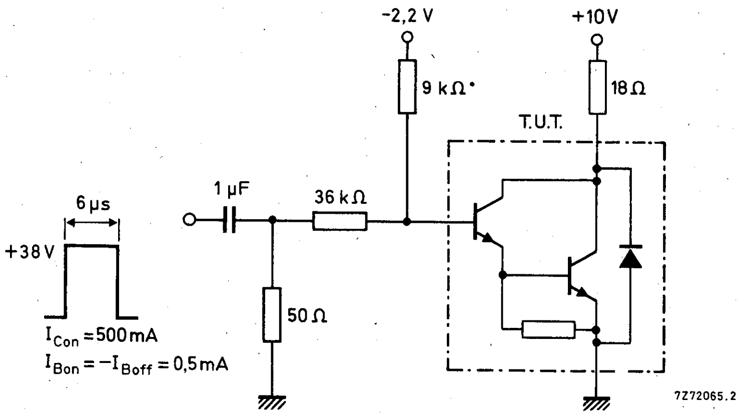


Fig. 3 Test circuit for 500 mA switching.

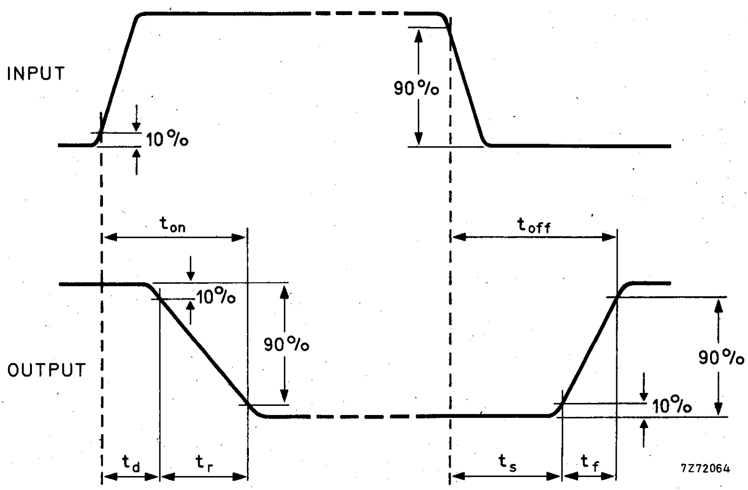


Fig. 4 Switching waveforms.

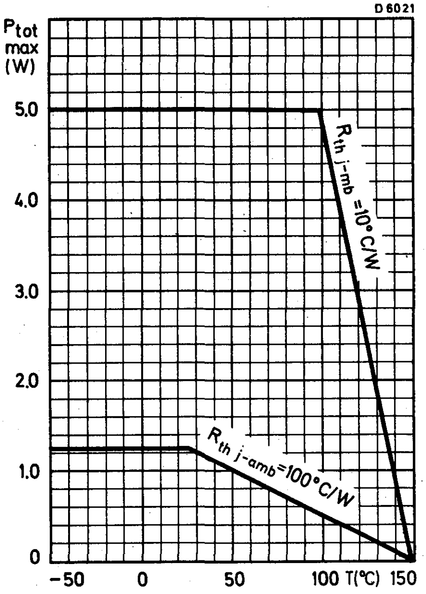


Fig. 5.

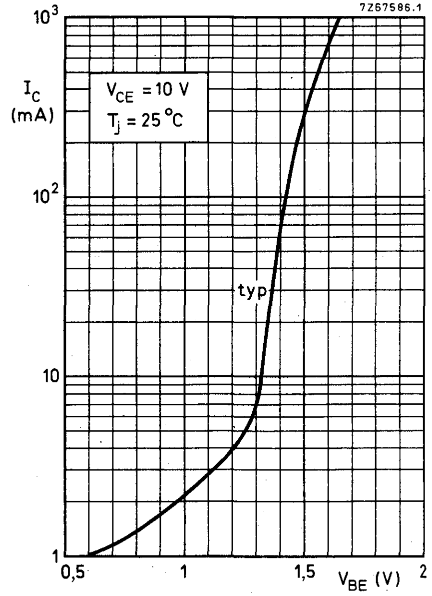


Fig. 6.

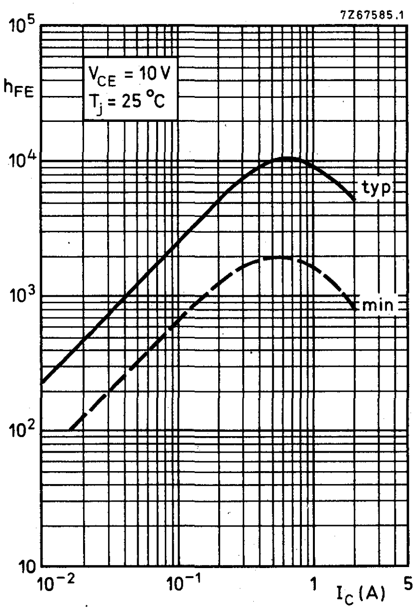


Fig. 7.

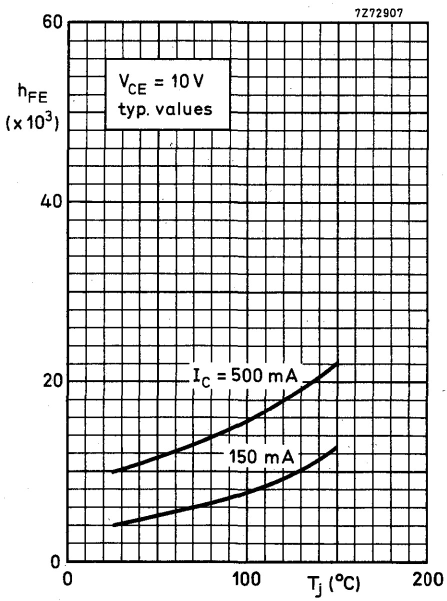


Fig. 8.

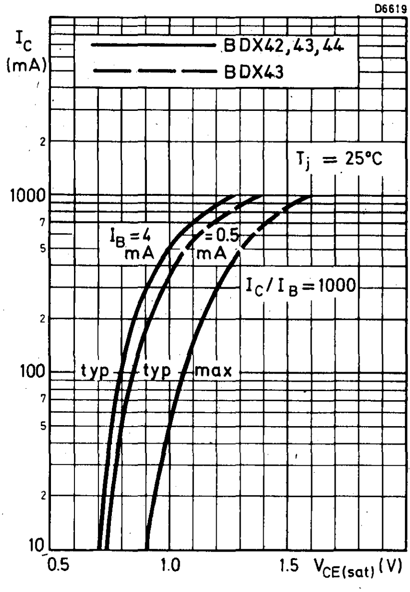


Fig. 9.

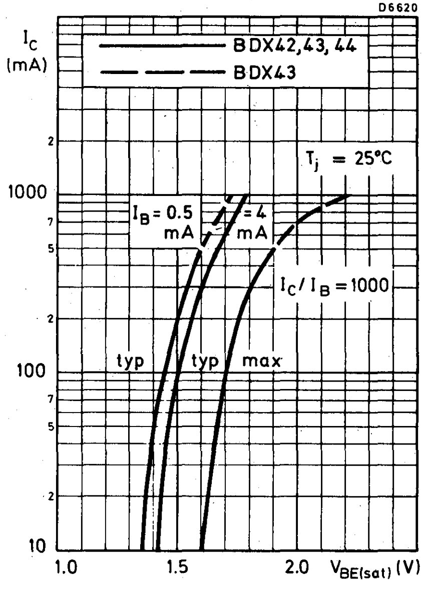


Fig. 10.

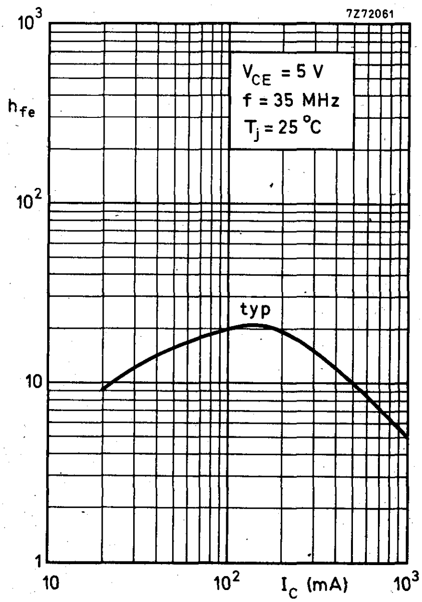


Fig. 11.

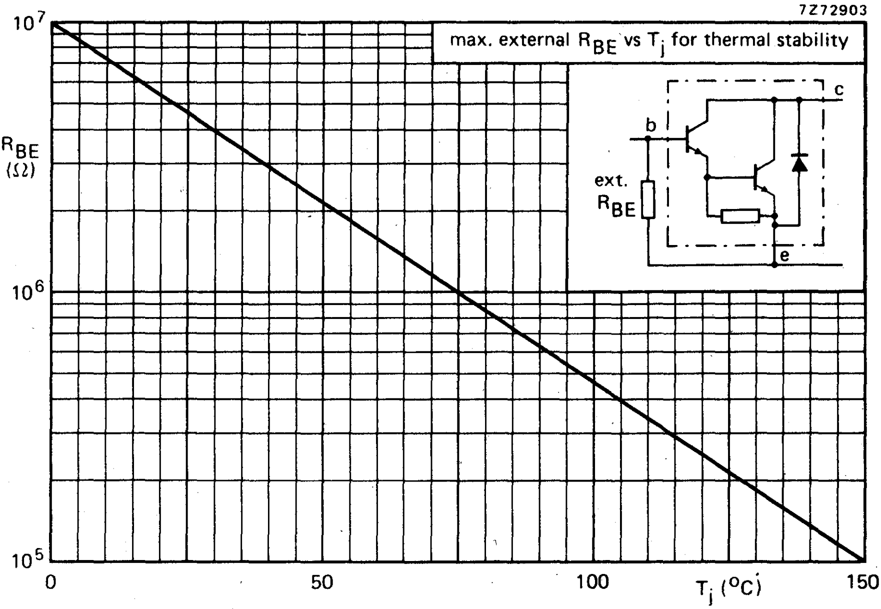

7Z72903
max. external R_{BE} vs T_j for thermal stability
R_{BE} (Ω)
10^7
10^6
10^5
0
50
100
150
T_j (°C)
ext. R_{BE}
b
c
e

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

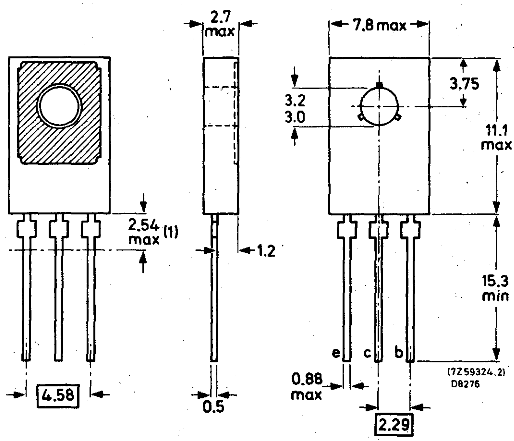
			BDX45	BDX46	BDX47	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage	$-V_{CER}$	max.	45	60	80	V
Collector current	$-I_C$	max.	1	1	1	A
Total power dissipation						
up to T_{amb} = 25 °C	P_{tot}	max.	1,25	1,25	1,25	W
up to T_{mb} = 100 °C	P_{tot}	max.	5	5	5	W
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.

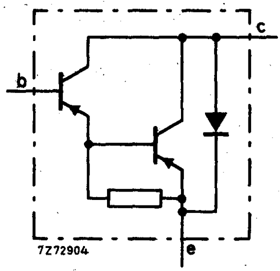


Fig. 2 Circuit diagram.

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

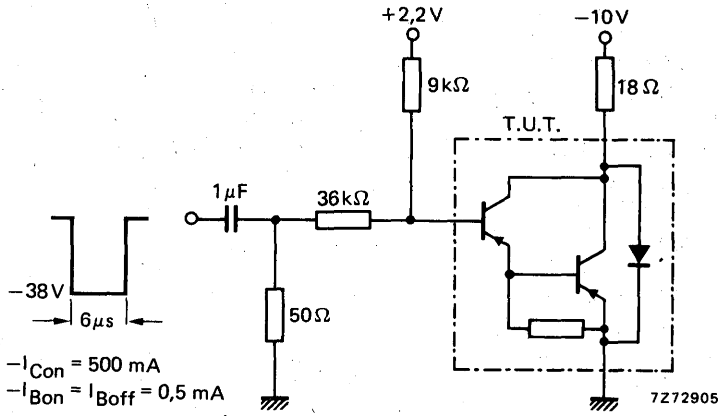


Fig. 3 Test circuit for 500 mA switching.

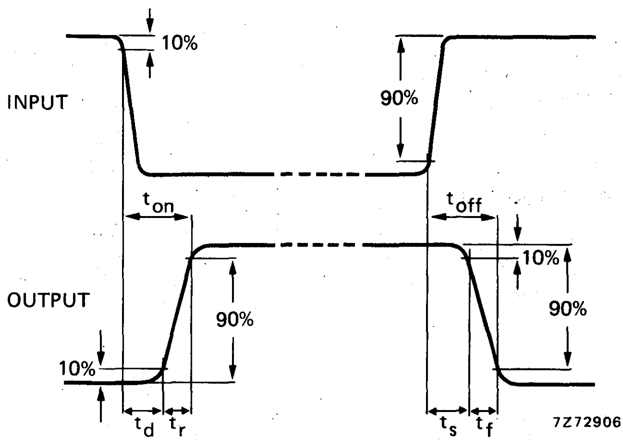


Fig. 4 Switching waveforms.

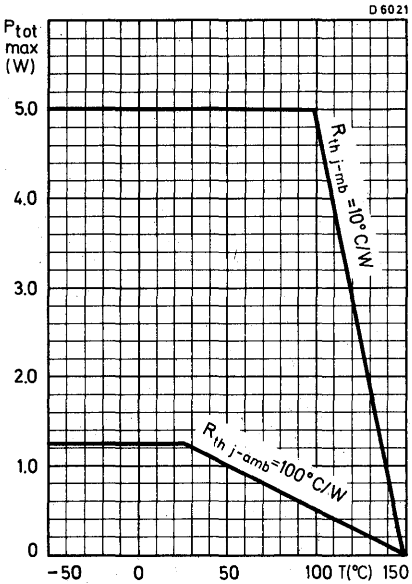


Fig. 5.

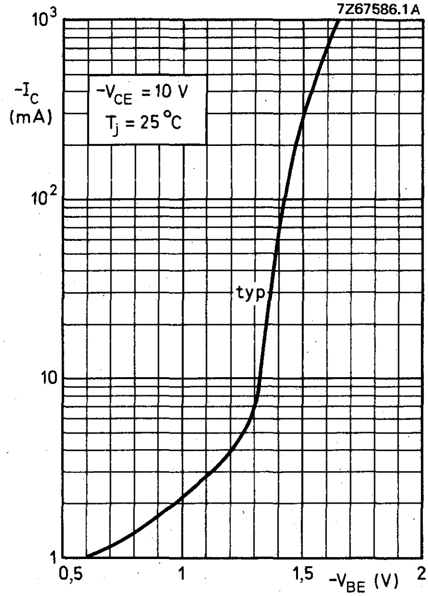


Fig. 6.

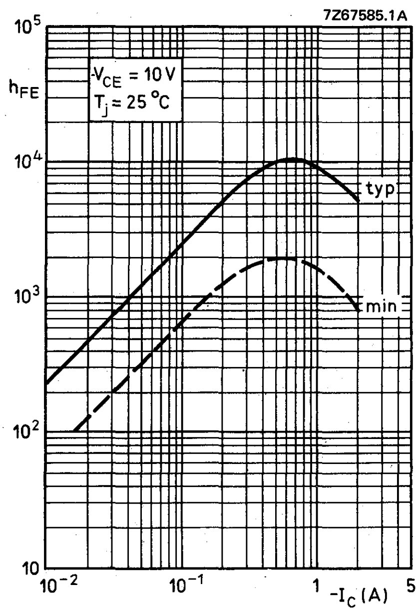


Fig. 7.

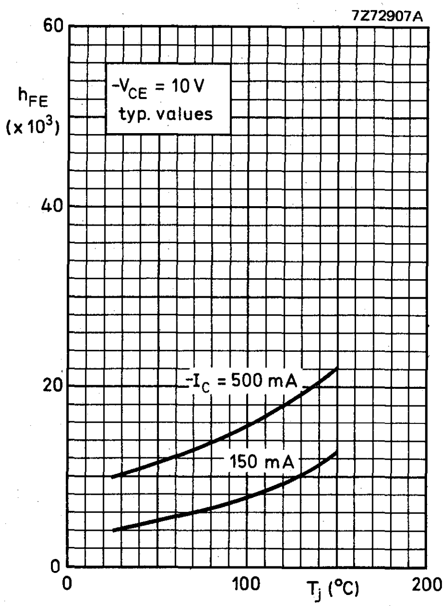


Fig. 8.

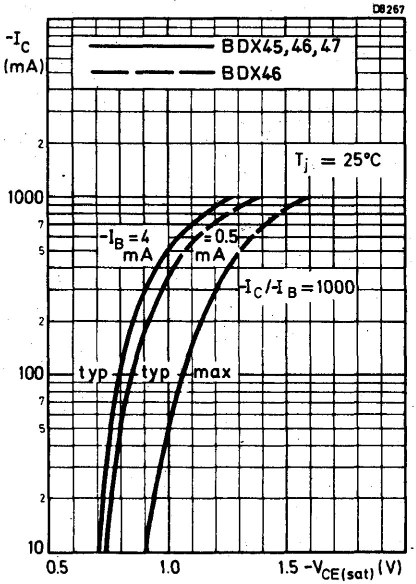


Fig. 9.

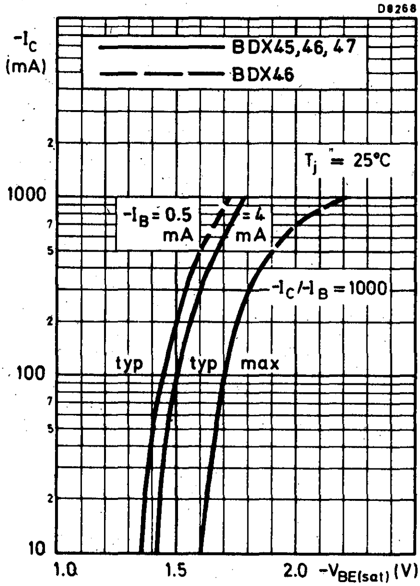


Fig. 10.

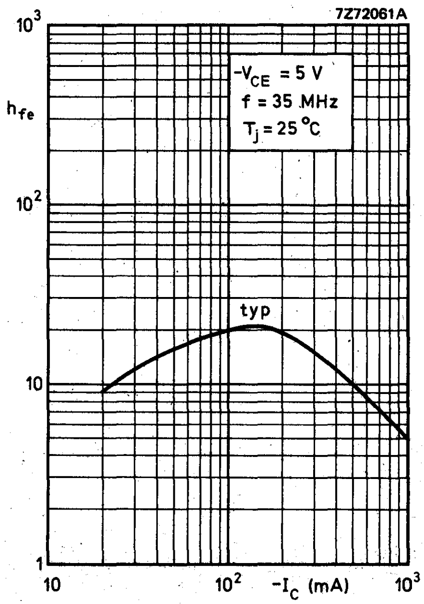


Fig. 11.

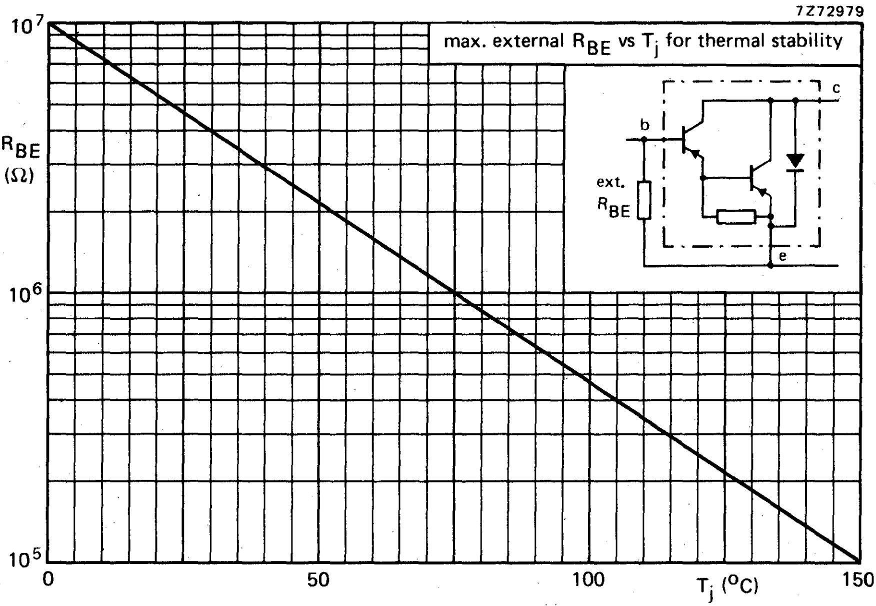

7Z72979
max. external R_{BE} vs T_j for thermal stability
10^7
R_{BE}
(Ω)
10^6
10^5
0
50
100
T_j (°C)
150
c
b
ext.
R_{BE}
e

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.

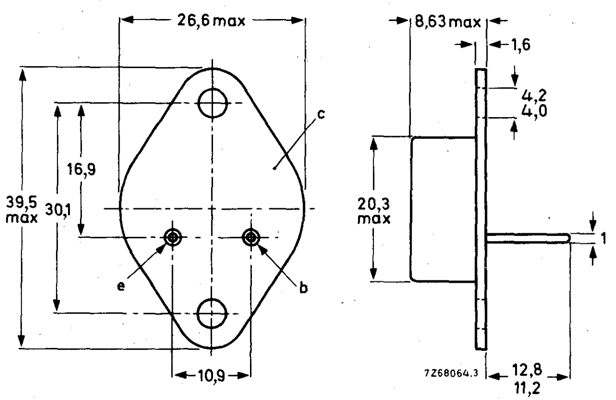
QUICK REFERENCE DATA

			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

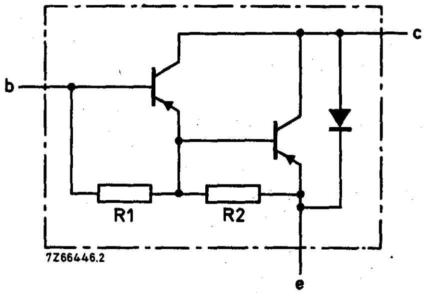
MECHANICAL DATA

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 $T_{mb} = 25\ ^oC$	P_{tot}	max.	90				W
Storage temperature	T_{stg}		−65 to +200				^oC
Junction temperature*	T_j	max.	200				^oC

THERMAL RESISTANCE*

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,94	$^oC/W$

* 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 °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
$I_B = 0; -V_{CE} = -\frac{1}{2}V_{CEO}$	$-I_{CEO}$	<	0,5 mA
Emitter cut-off current			
$I_C = 0; -V_{EB} = 5$ V	$-I_{EBO}$	<	5 mA
D.C. current gain (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: $t_p < 300\ \mu s$, $\delta < 2\%$.
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. 2,5 μs

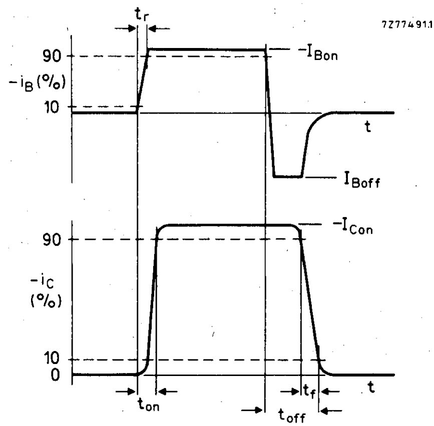
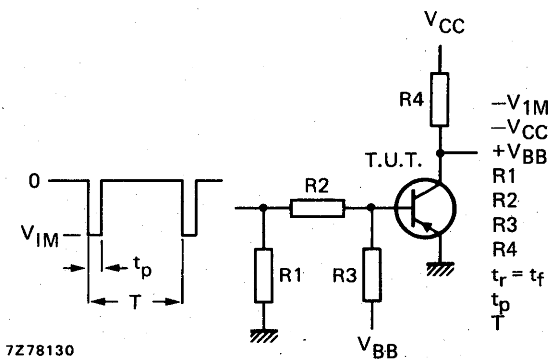


Fig. 3 Switching times waveforms.



$-V_{1M}$ = 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

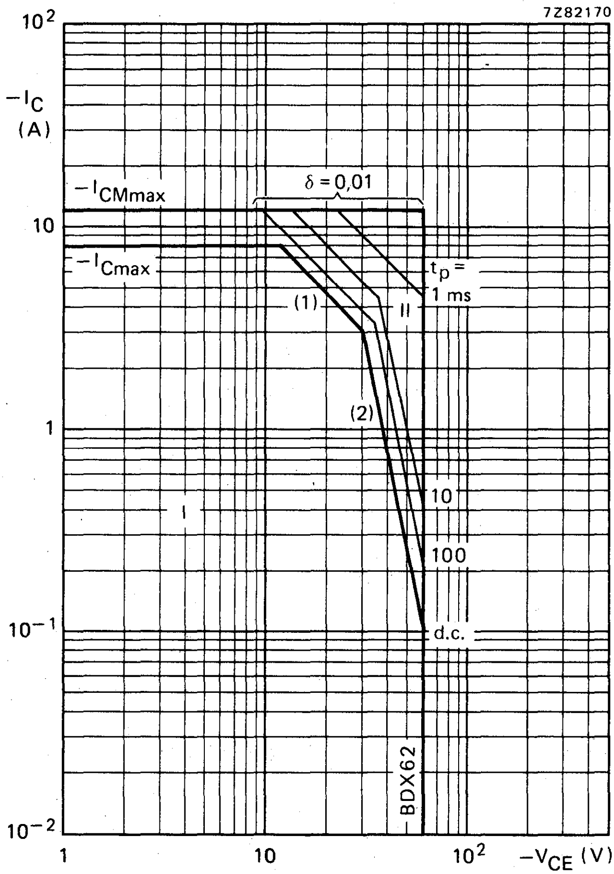


Fig. 5 Safe Operating ARea; $T_{mb} = 25\ ^{o}C$.

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).

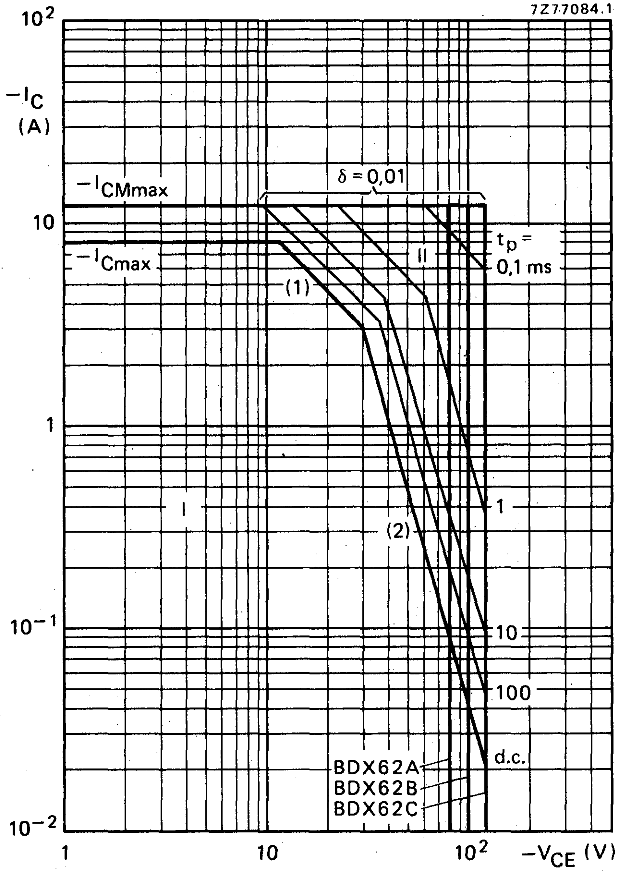


Fig. 6 Safe Operating ARea; T_{mb} = 25 °C.

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).

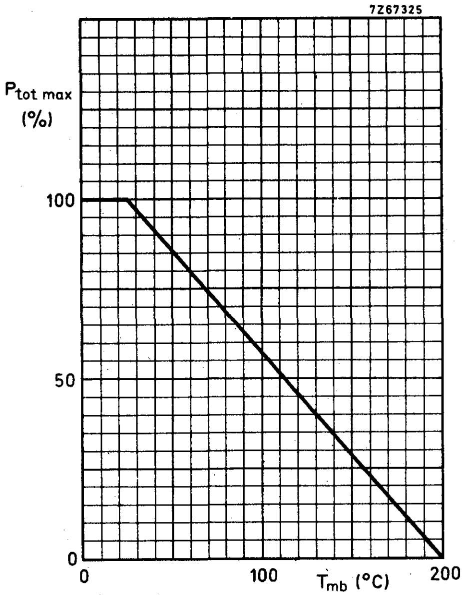


Fig. 7 Power derating curve.

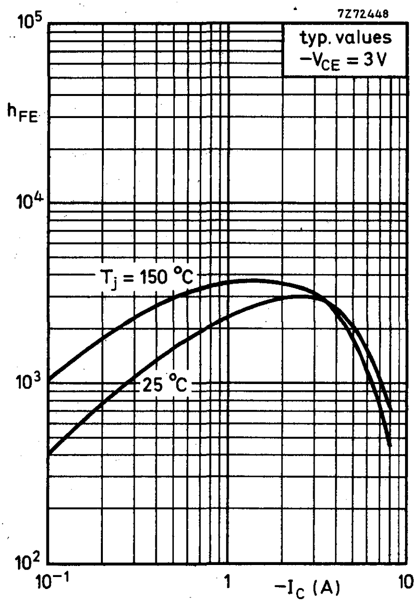


Fig. 8 D.C. current gain.

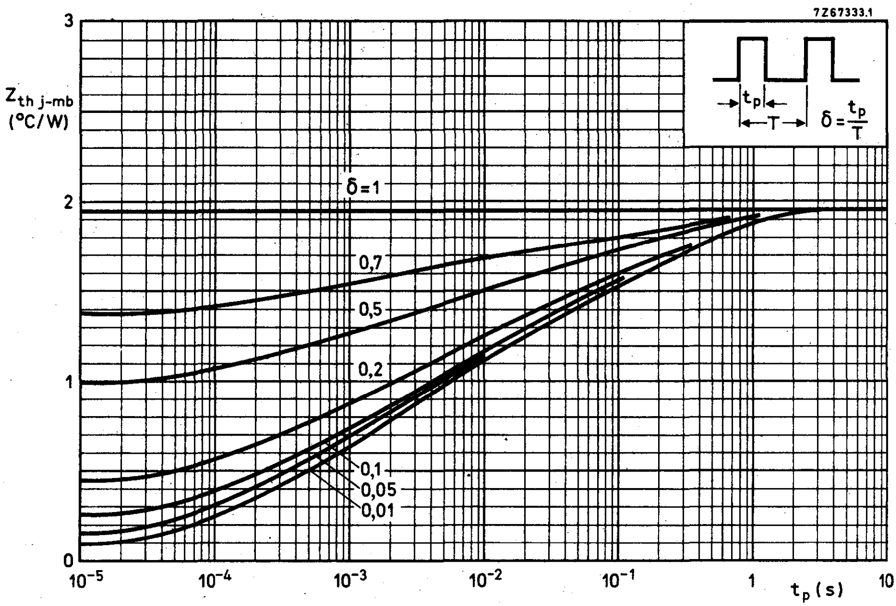


Fig. 9 Pulse power rating chart.

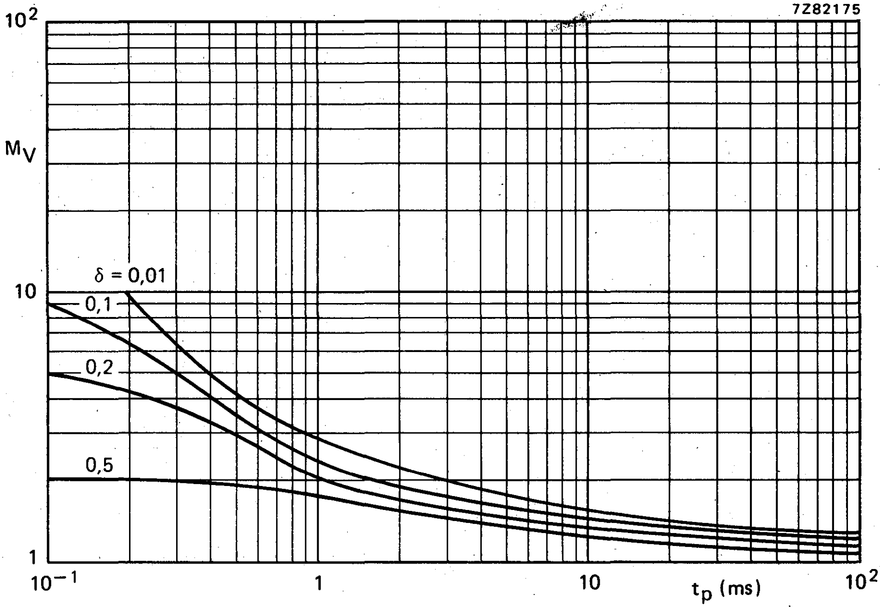


Fig. 10 S.B. voltage multiplying factor at the I_{Cmax} level.

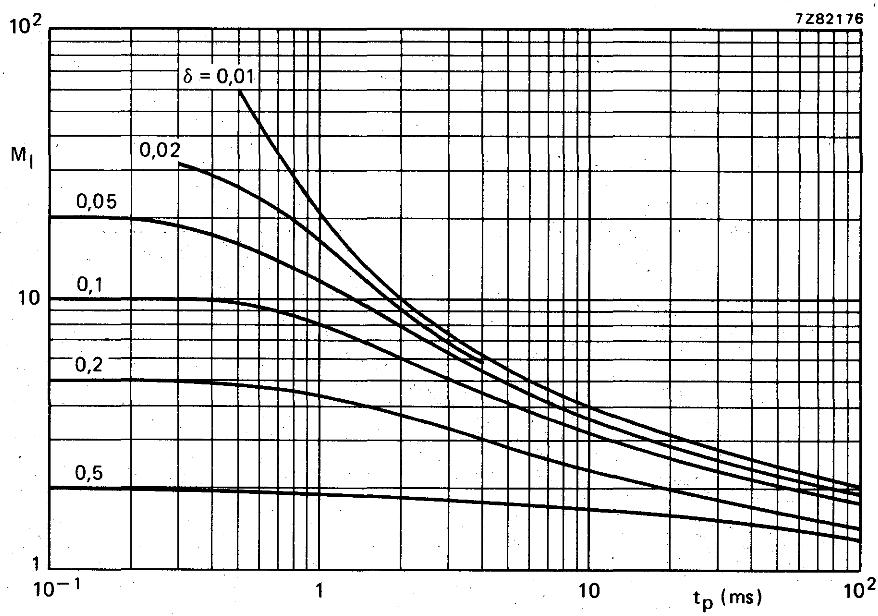


Fig. 11 S.B. current multiplying factor at the V_{CEO} 100 V and 60 V level.

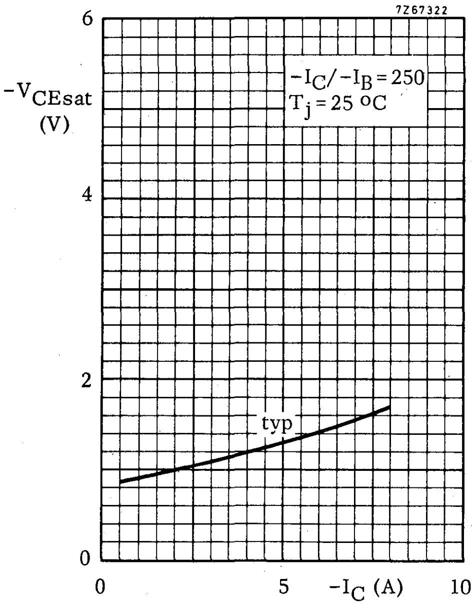


Fig. 12.

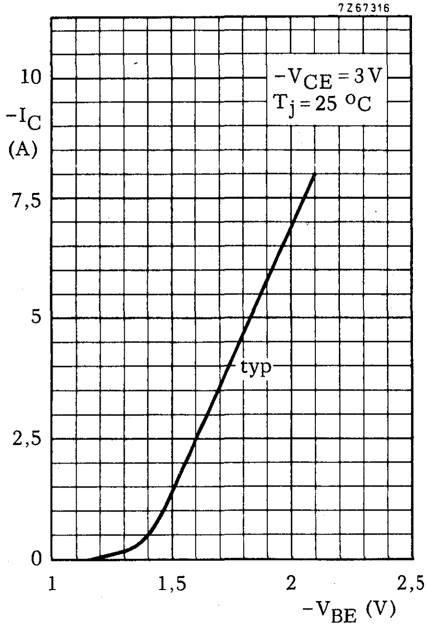


Fig. 13.

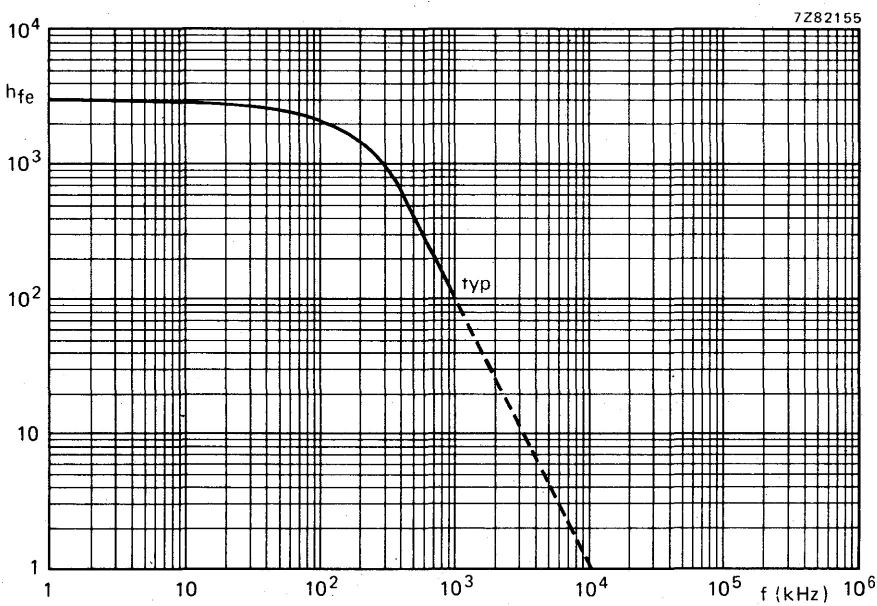


Fig. 14 Small signal current gain at $-I_C = 3$ A; $-V_{CE} = 3$ V.

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.

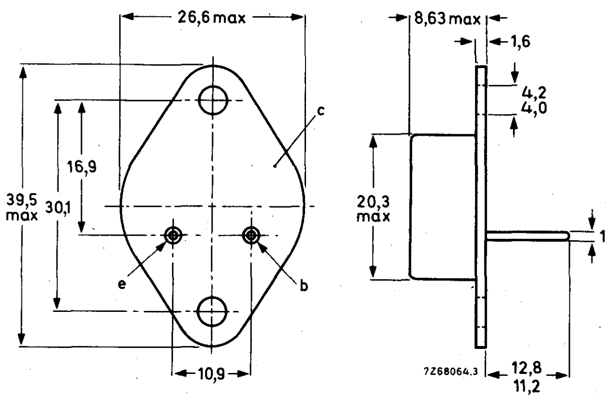
QUICK REFERENCE DATA

			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.	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

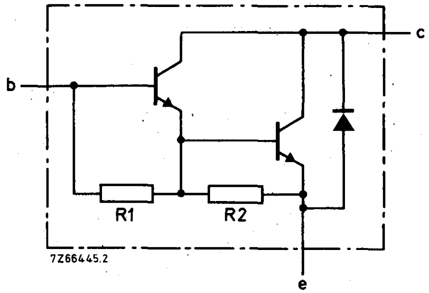
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-3.
Collector connected to case.



See also chapters Mounting instructions and Accessories.



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	°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			
$I_E = 0$; $V_{CB} = V_{CEOmax}$	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.	1500
$I_C = 3$ A; $V_{CE} = 3$ V	h_{FE}	>	1000
$I_C = 8$ A; $V_{CE} = 3$ V	h_{FE}	typ.	2000
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

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.	2,5 µs

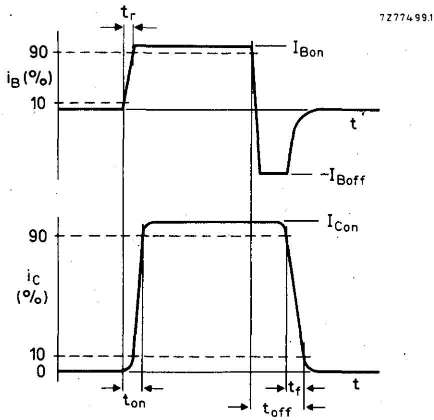
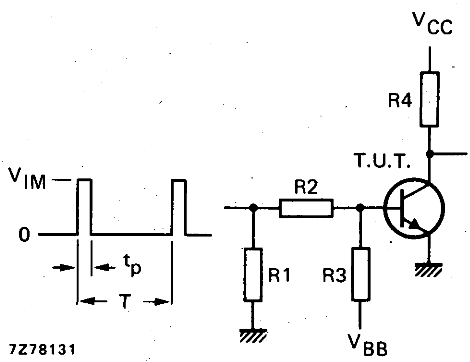


Fig. 3 Switching time waveforms.



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. | 1,2 V

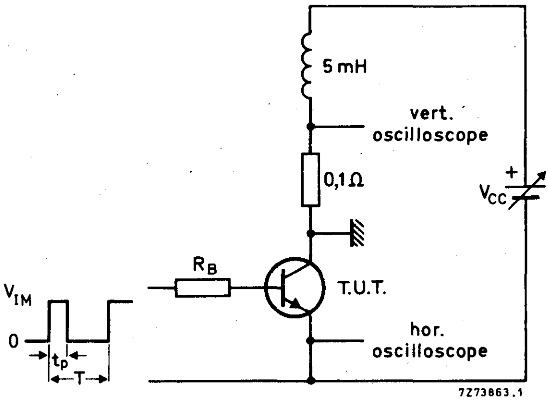


Fig. 5 Test circuit for turn-off breakdown energy.
$V_{IM} = 12$ V; $R_B = 270\ \Omega$; $I_C = 4{,}5$ A; $t_p = 1$ ms; $\delta = 1\%$.

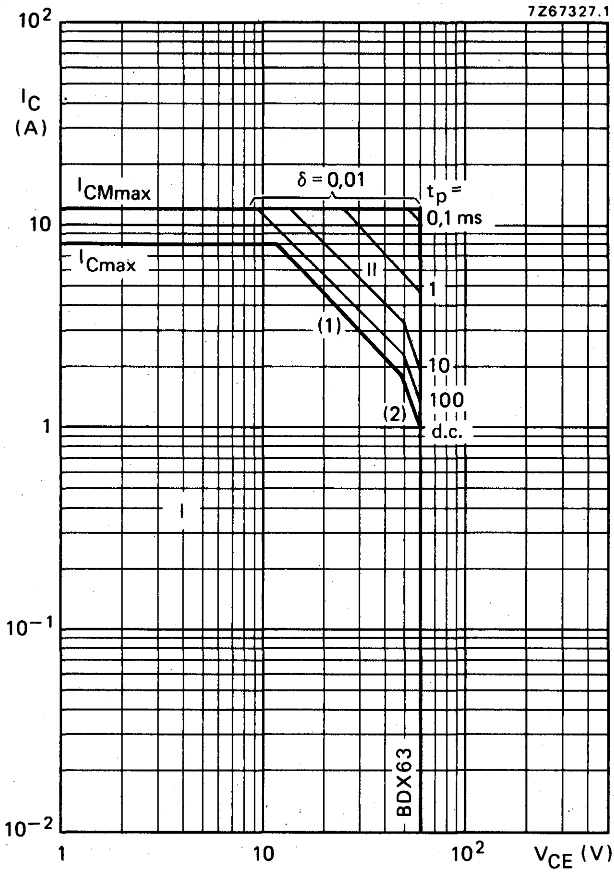


Fig. 6 Safe Operating ARea, $T_{mb} \leqslant 25\ ^{o}C$.

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).

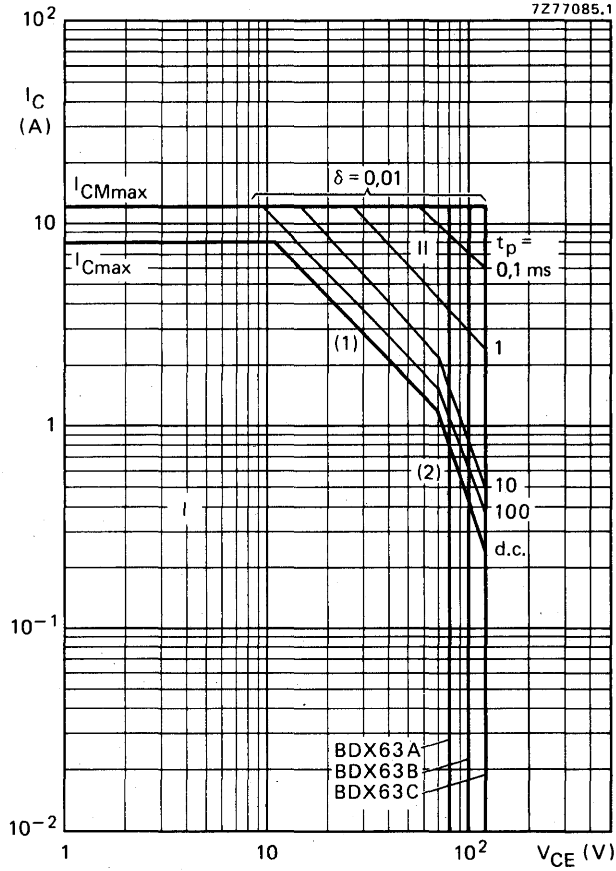


Fig. 7 Safe Operating ARea, $T_{mb} \leqslant 25\ ^{o}C$.

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).

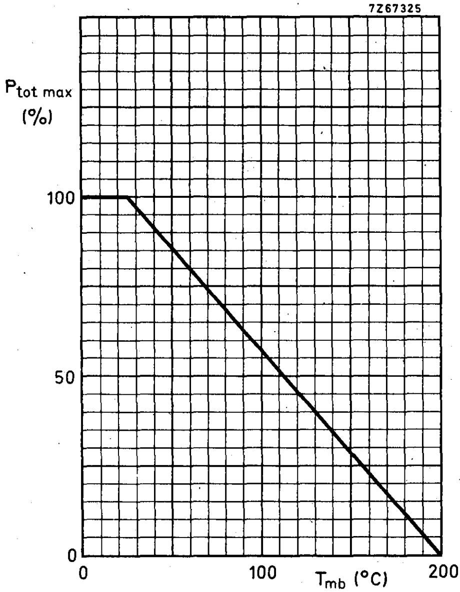


Fig. 8 Power derating curve.

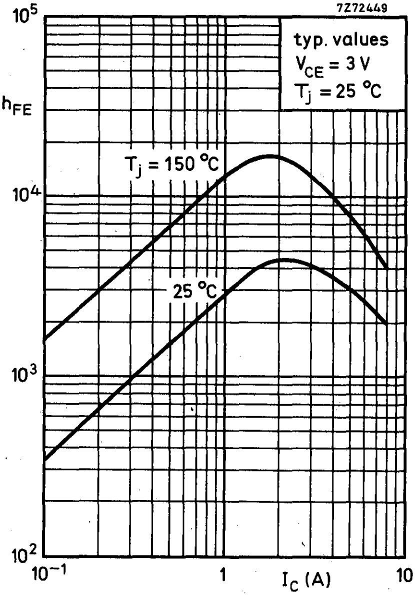


Fig. 9 D.C. current gain.

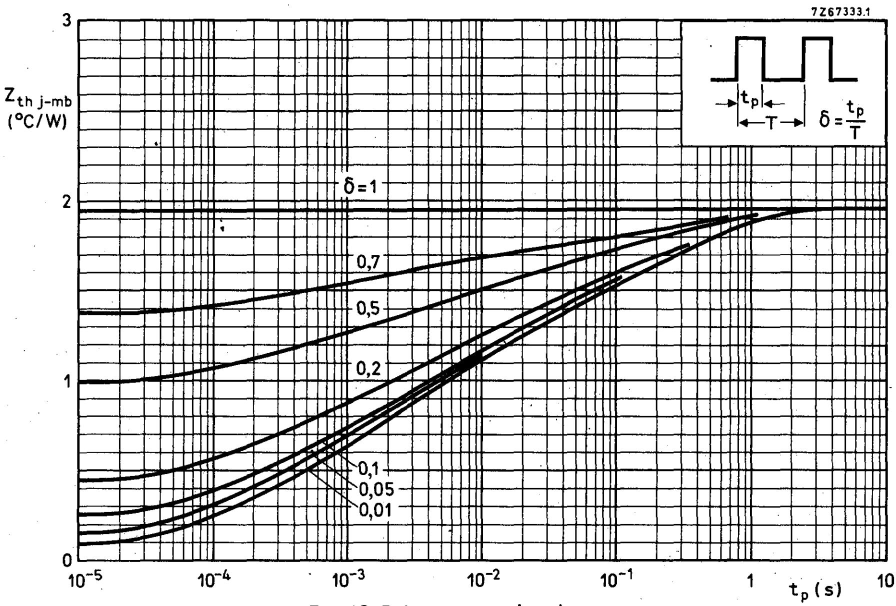


Fig. 10 Pulse power rating chart.

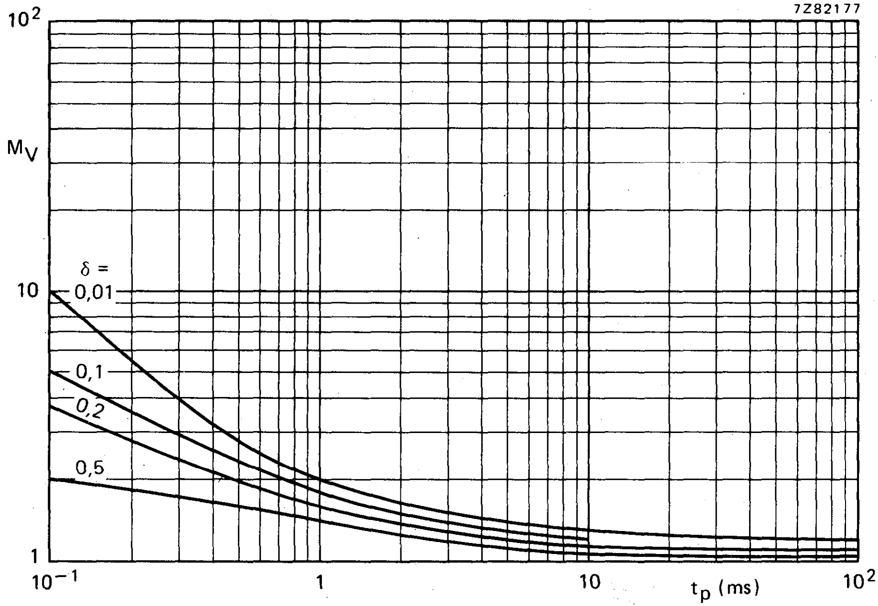


Fig. 11 S.B. voltage multiplying factor at the I_{Cmax} level.

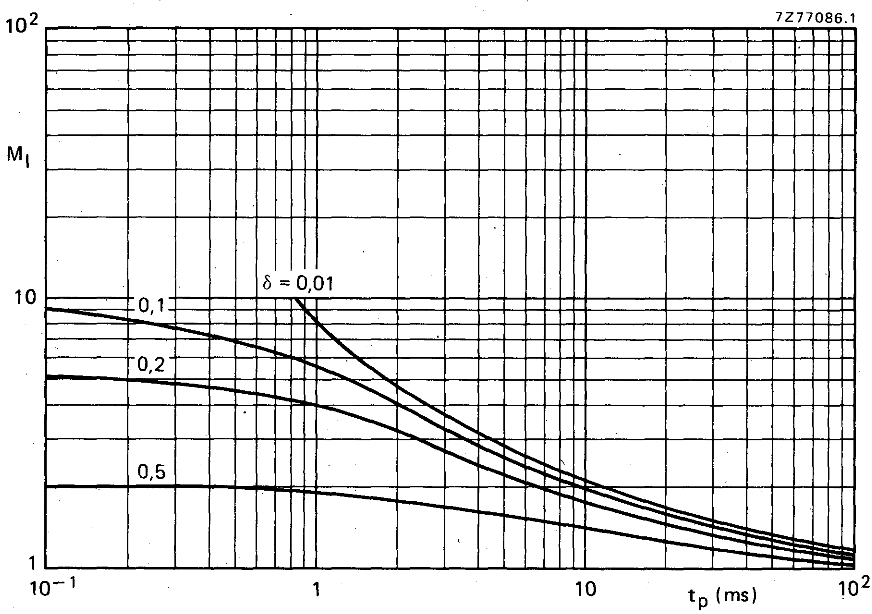


Fig. 12 S.B. current multiplying factor at the V_{CEO} 100 V and 60 V level.

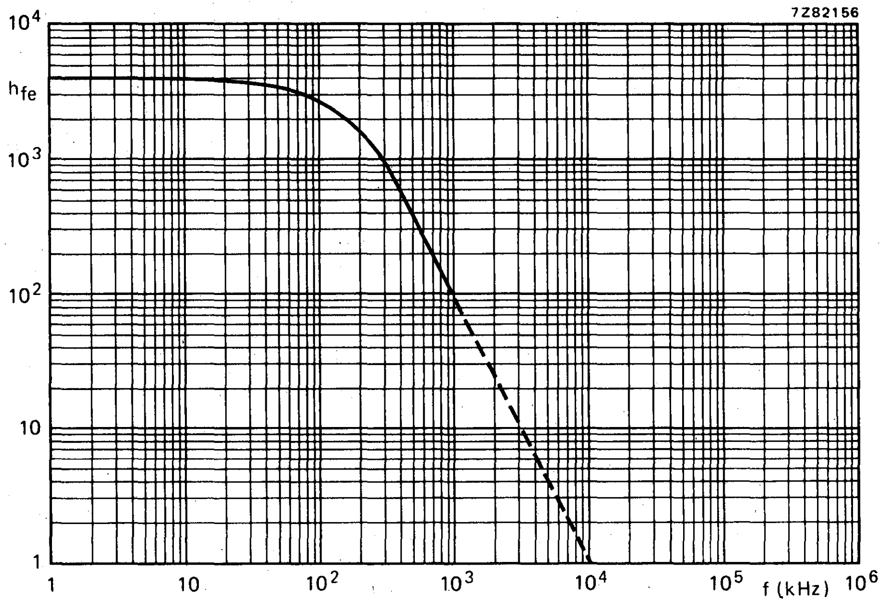


Fig. 13 Small-signal current gain at I_C = 3 A; V_{CE} = 3 V.

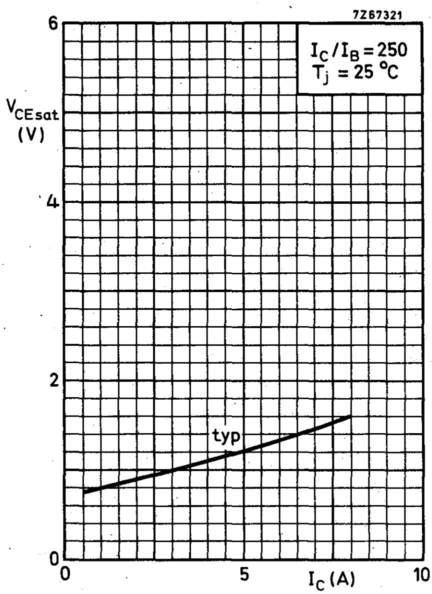


Fig. 14.

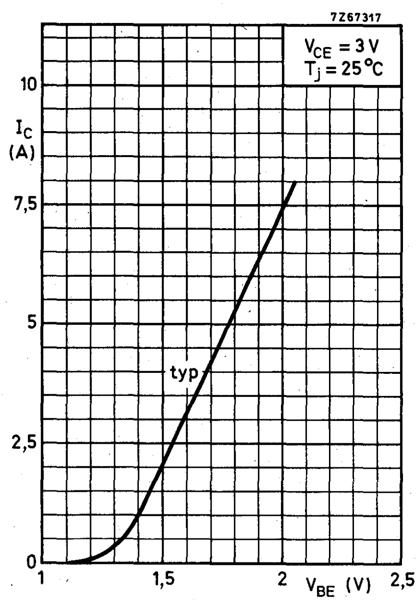


Fig. 15.

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

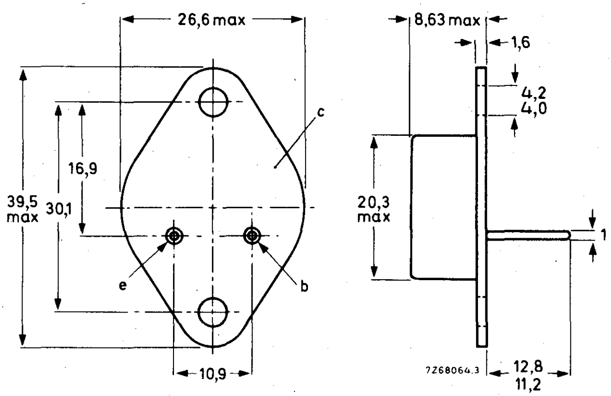
			BDX64	64A	64B	64C	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	120	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	120	V
Collector current (peak value)	$-I_{CM}$	max.		16			A
Total power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.		117			W
Junction temperature	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

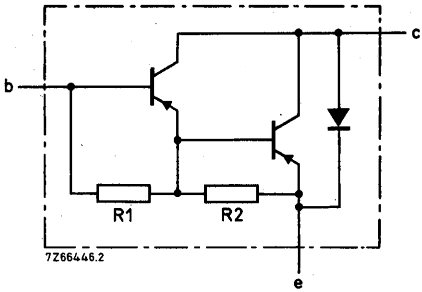
Dimensions in mm

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 $T_{mb} = 25\ ^oC$	P_{tot}	max.		117			W
Storage temperature	T_{stg}			−65 to + 200			^oC
Junction temperature*	T_j	max.		200			^oC

THERMAL RESISTANCE*

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,5	$^oC/W$

* 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 °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: $t_p < 300$ 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	<	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

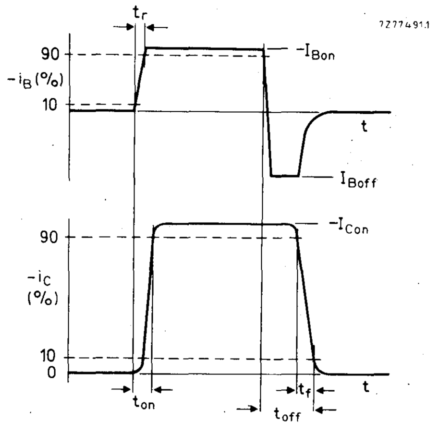
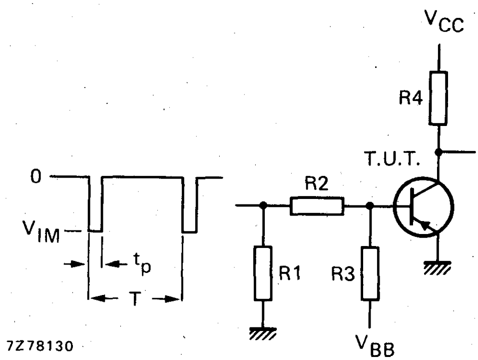


Fig. 3 Switching times waveforms.



$-V_{IM}$	=	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.

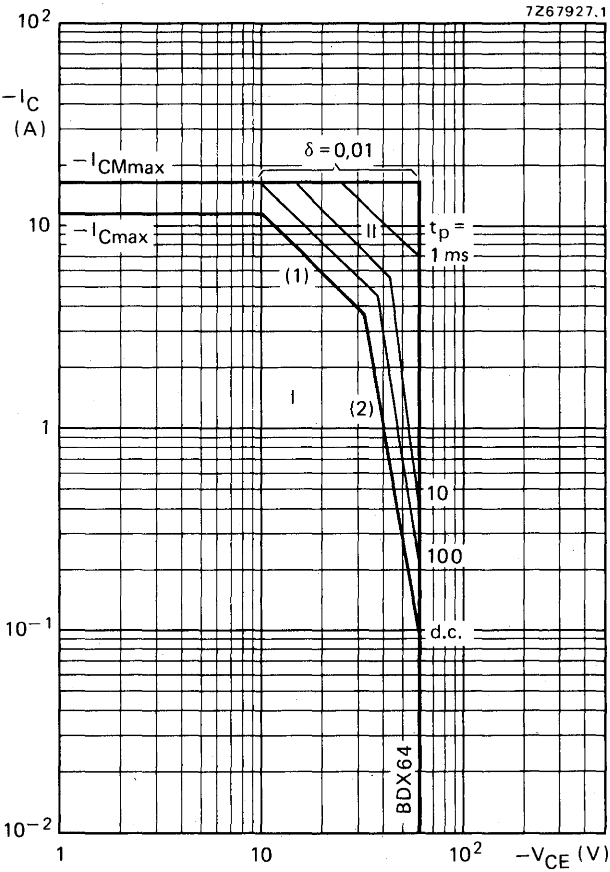


Fig. 5 Safe Operating ARea; $T_{mb} \leqslant 25\ ^oC$.

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).

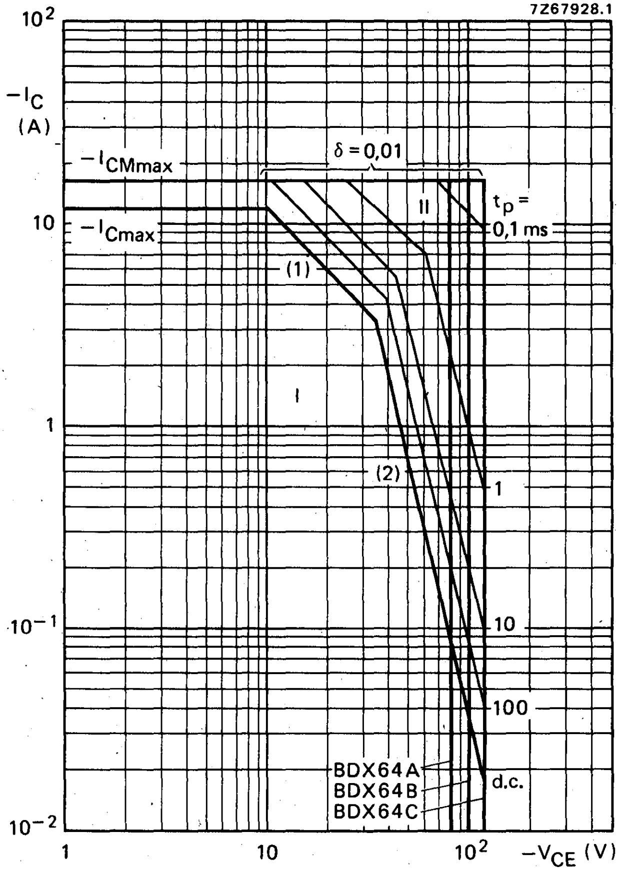


Fig. 6 Safe Operating ARea; $T_{mb} \leqslant 25\ ^{o}C$.

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).

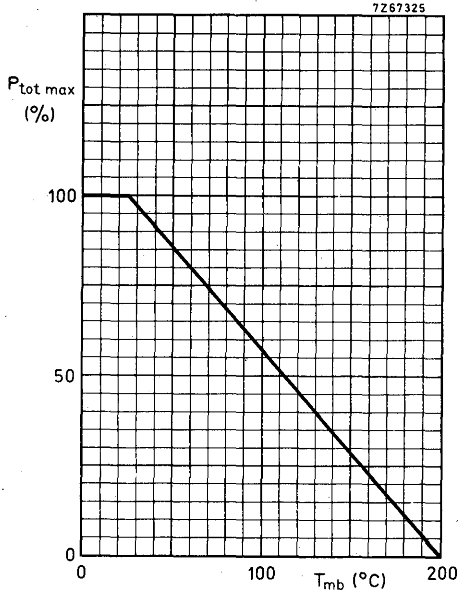


Fig. 7 Power derating curve.

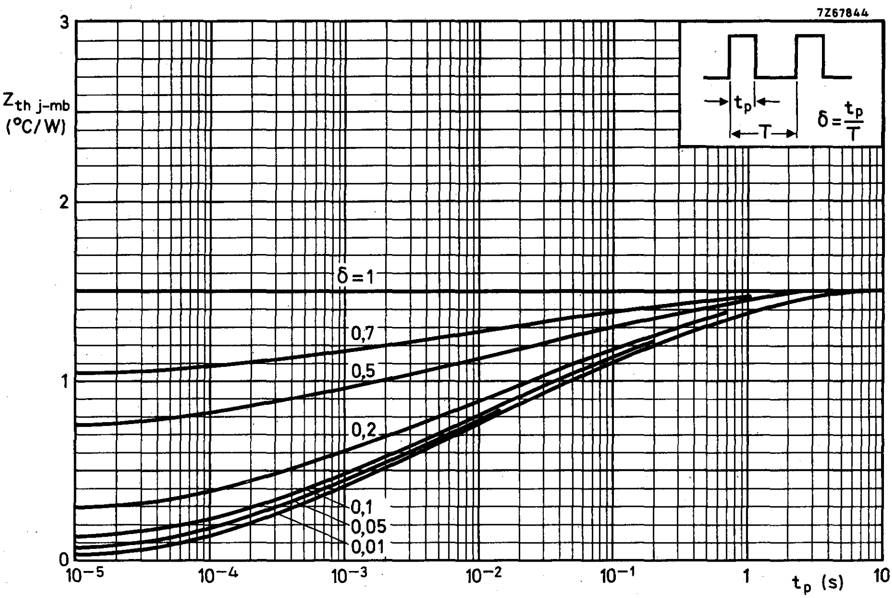


Fig. 8 Pulse power rating chart.

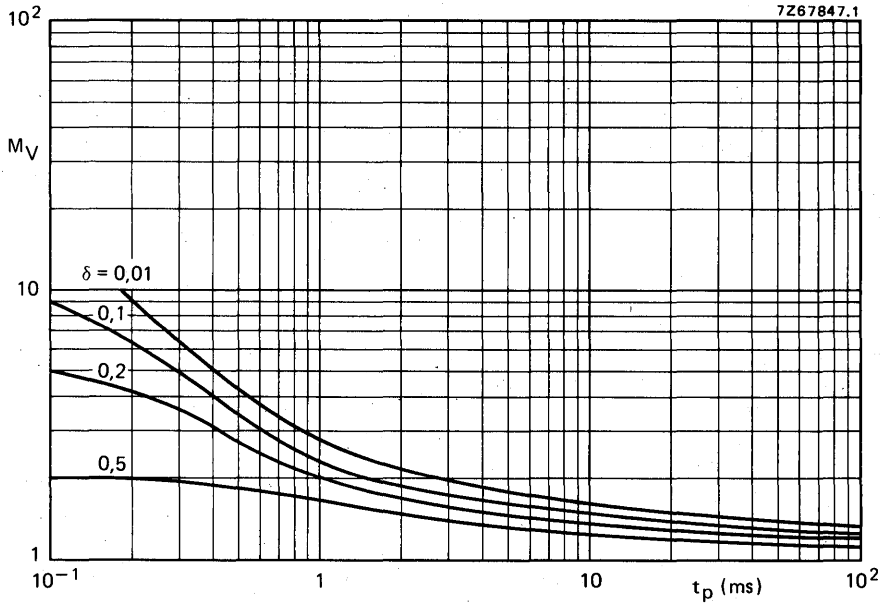


Fig. 9 S.B. voltage multiplying factor at the $-I_{C\,max}$ level.

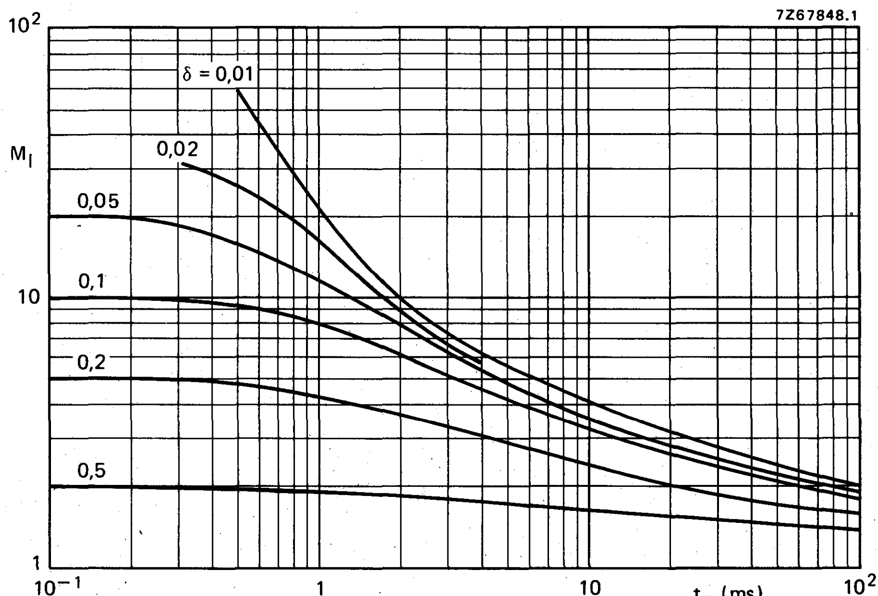


Fig. 10 S.B. current multiplying factor at $-V_{CEO}$ 100 V and 60 V level.

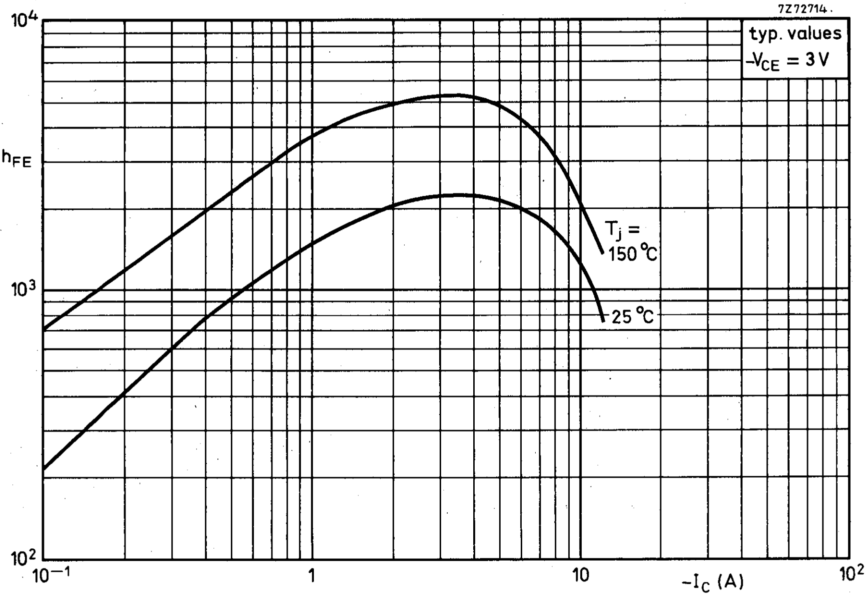


Fig. 11 D.C. current gain.

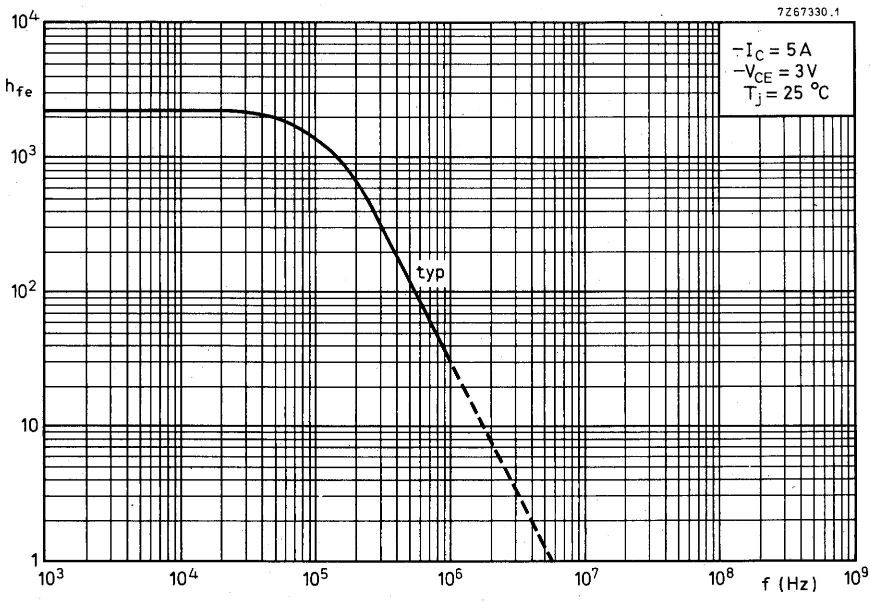


Fig. 12 Small-signal current gain.

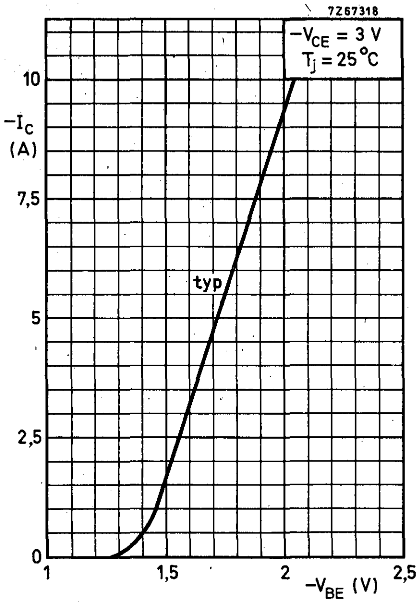


Fig. 13 Typical collector current.

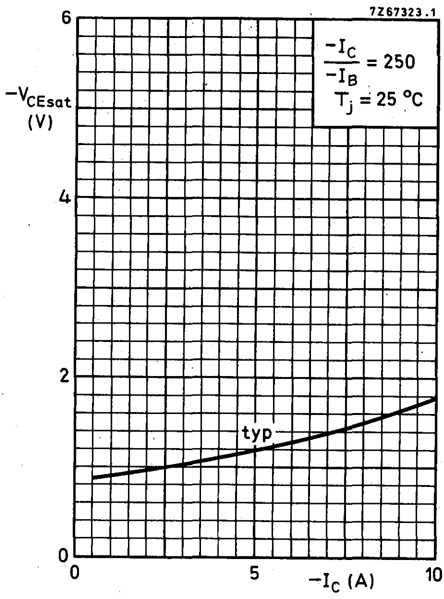


Fig. 14 Typical collector-emitter saturation voltage.

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

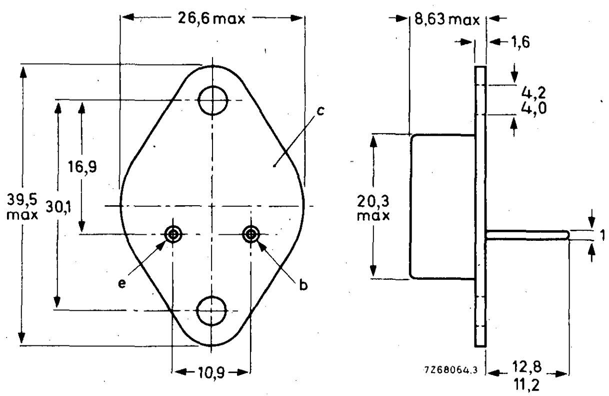
			BDX65	65A	65B	65C	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Collector current (peak value)	I_{CM}	max.	16				A
Total power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.	117				W
Junction temperature	T_j	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.	50				kHz

MECHANICAL DATA

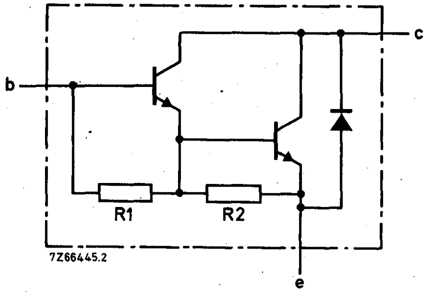
Dimensions in mm

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	°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				
$I_E = 0$; $V_{CB} = V_{CEOmax}$		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	BDX65; 65A; 65B	h_{FE}	typ.	1500
	BDX65C	h_{FE}	typ.	1250
I_C = 5 A; V_{CE} = 3 V		h_{FE}	>	1000
I_C = 12 A; V_{CE} = 3 V	BDX65; 65A; 65B	h_{FE}	typ.	1250
	BDX65C	h_{FE}	typ.	600
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_{Con} = 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: $t_p < 300\ \mu s$, $\delta < 2\%$.
2. V_{BE} decreases by about 3,6 mV/°C with increasing temperature.

CHARACTERISTICS (continued)

Diode, forward voltage			
$I_F = 5$ A	V_F	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.	2,5 μs

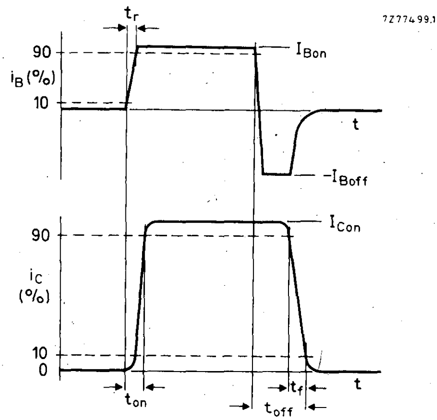
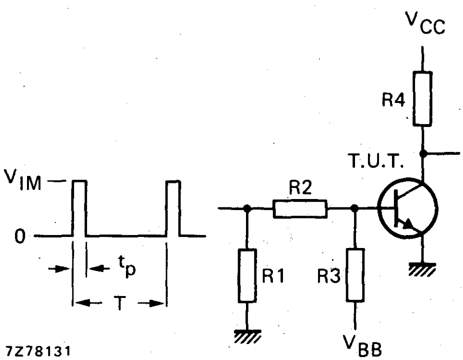


Fig. 3 Switching times waveforms.



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
$t_r = t_f \leqslant$ 15 ns
t_p = 10 μs
T = 500 μs

Fig. 4 Switching times test circuit.

CHARACTERISTICS (continued)

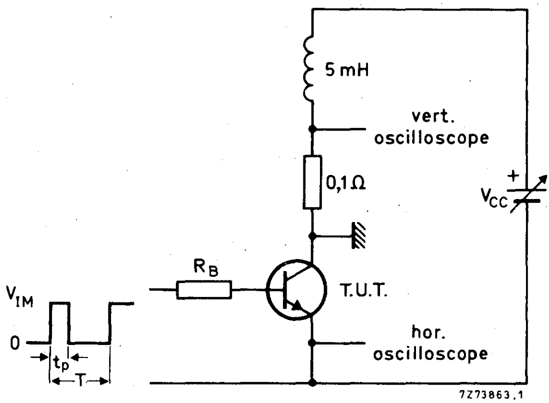


Fig. 5 Test circuit for turn-off breakdown energy. V_{IM} = 12 V; R_B = 270 Ω; I_C = 6,3 A; δ = 1%.

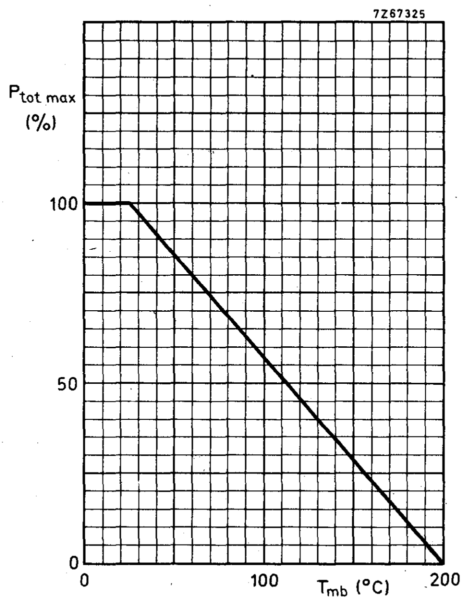


Fig. 6 Power derating curve.

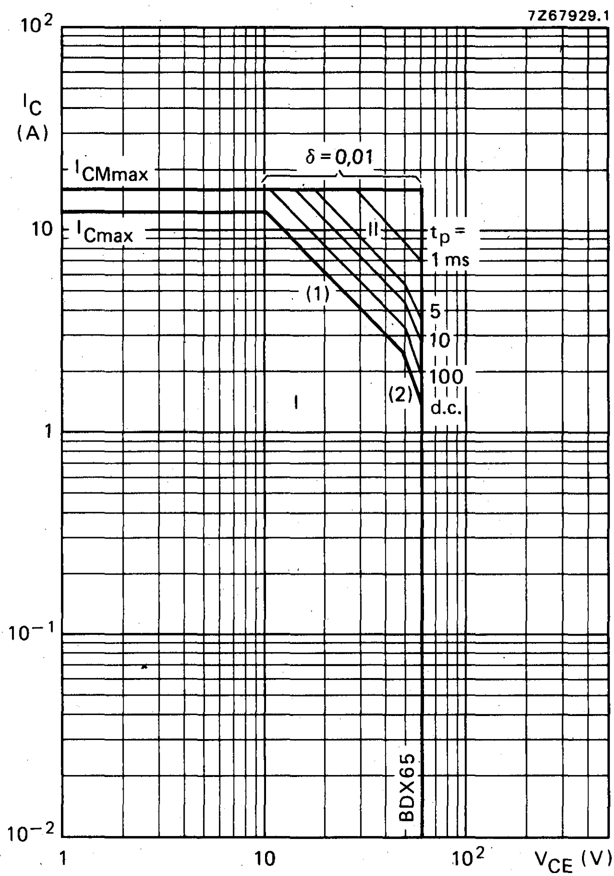


Fig. 7 Safe Operating ARea at $T_{mb} \leqslant 25$ °C of BDX65.

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).

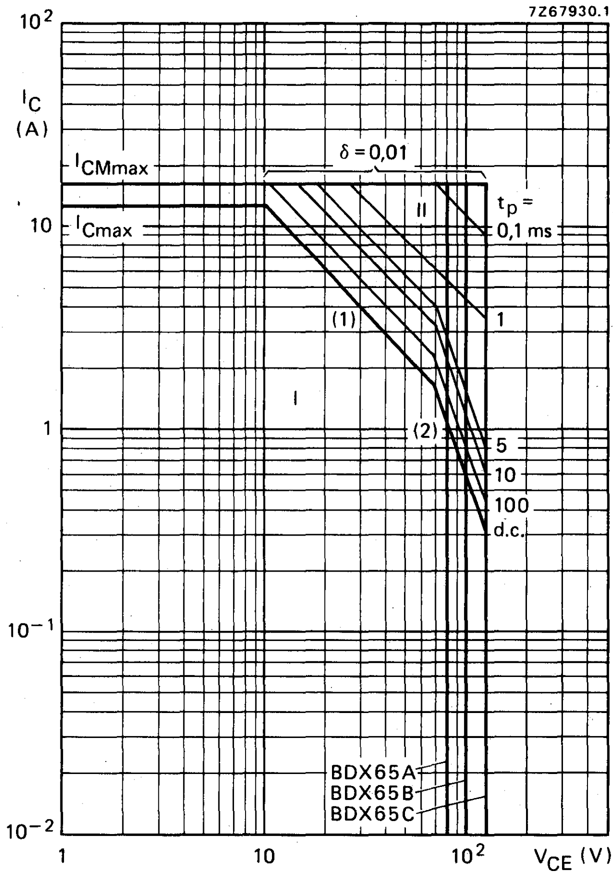


Fig. 8 Safe Operating ARea at $T_{mb} \leqslant 25\ ^{o}C$.

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).

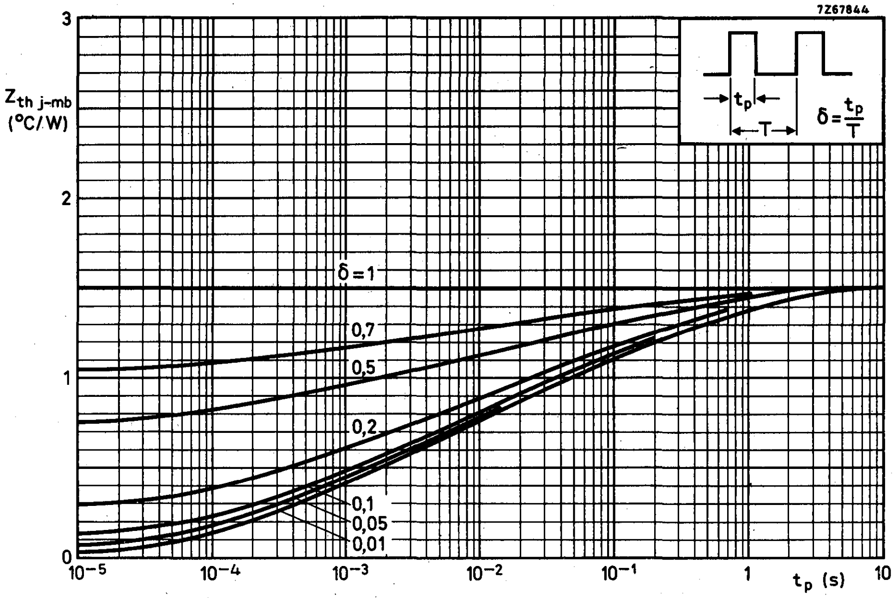


Fig. 9 Pulse power rating chart.

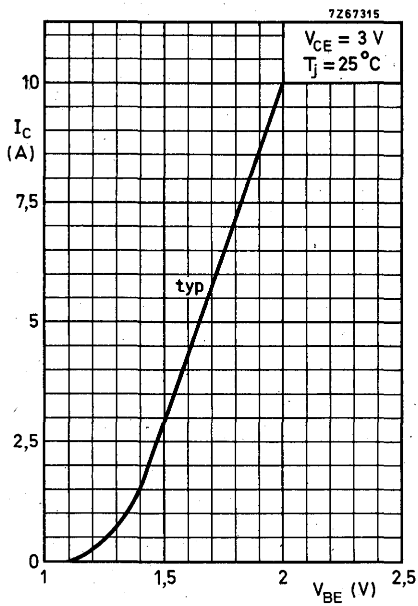


Fig. 10 Typical collector current.

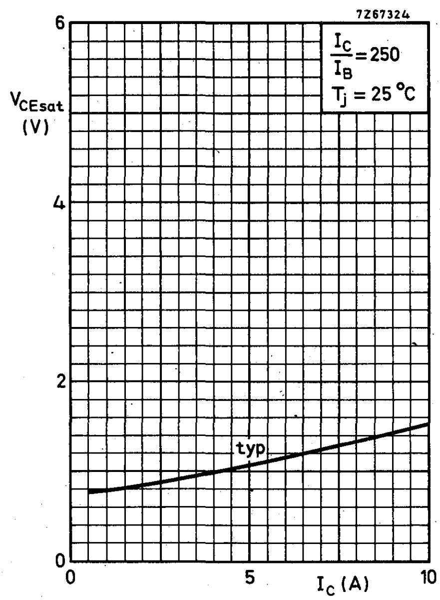


Fig. 11 Typical collector-emitter saturation voltage.

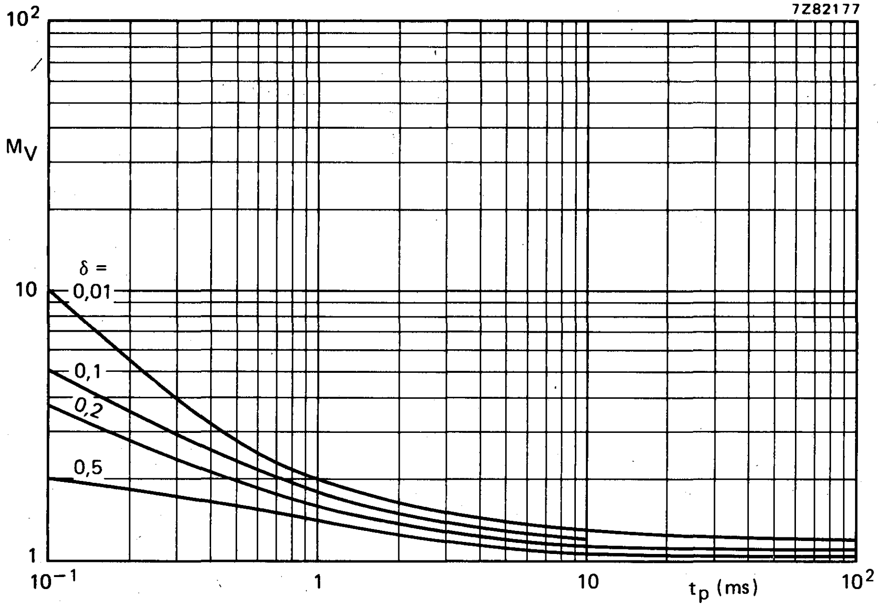


Fig. 12 S.B. voltage multiplying factor at the I_{Cmax} level.

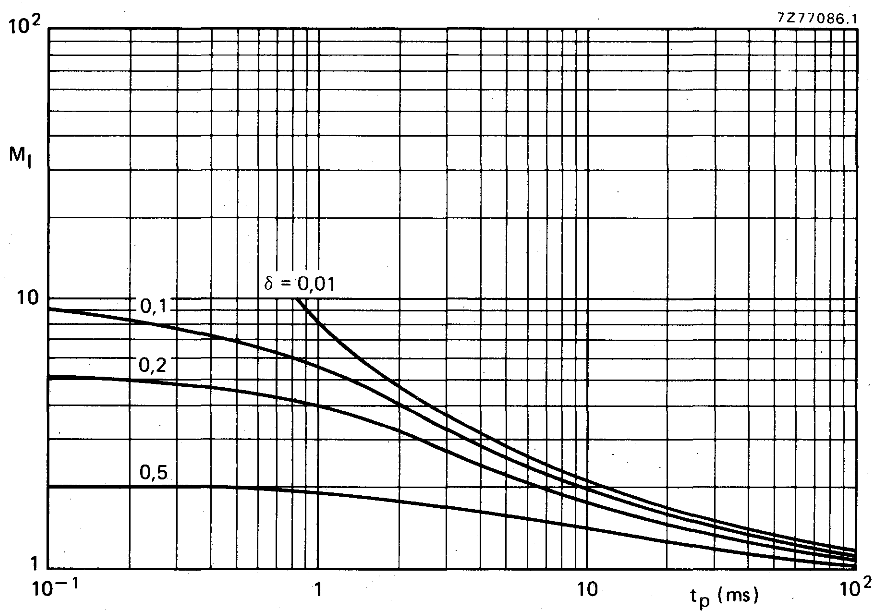


Fig. 13 S.B. current multiplying factor at V_{CEO} 100 V and 60 V level.

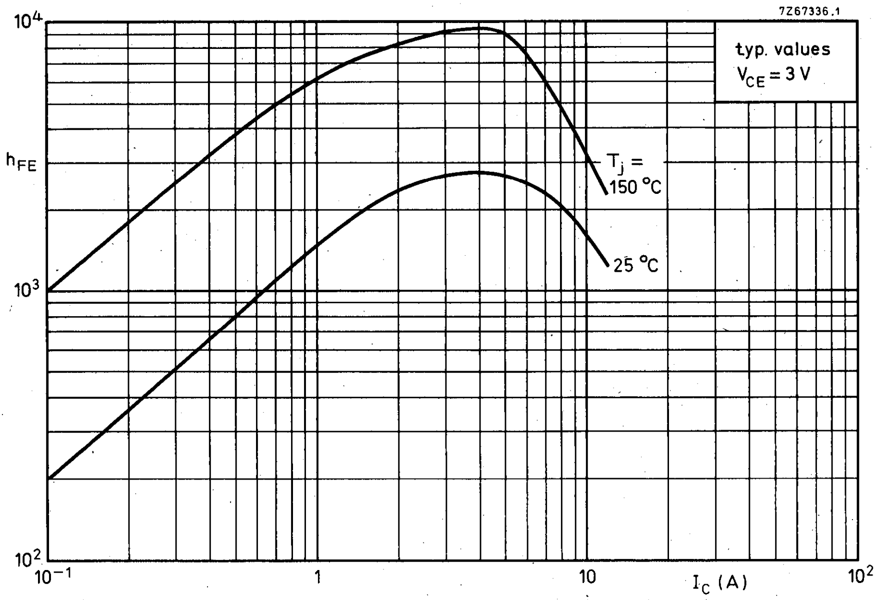


Fig. 14 Typical d.c. current gain BDX65; 65A and 65B.

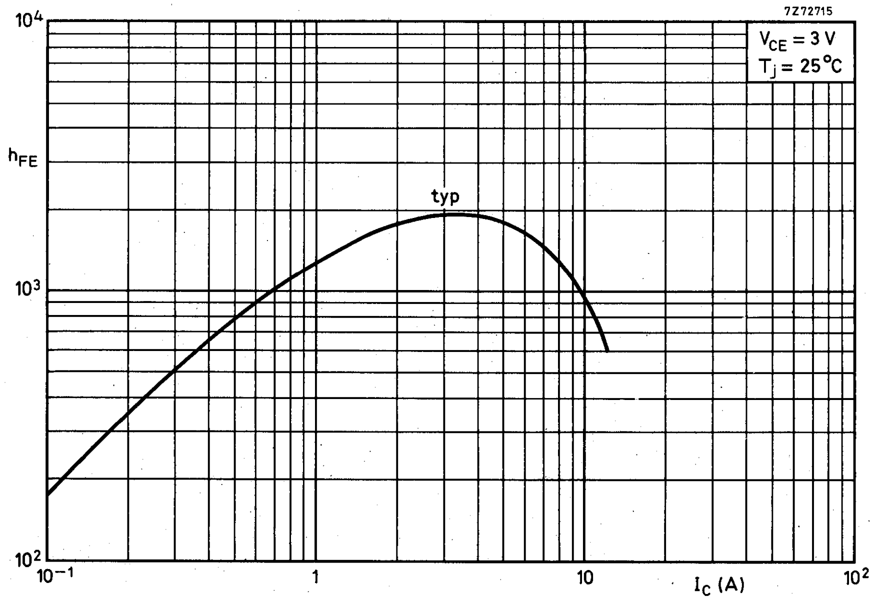


Fig. 15 Typical d.c. current gain for BDX65C.

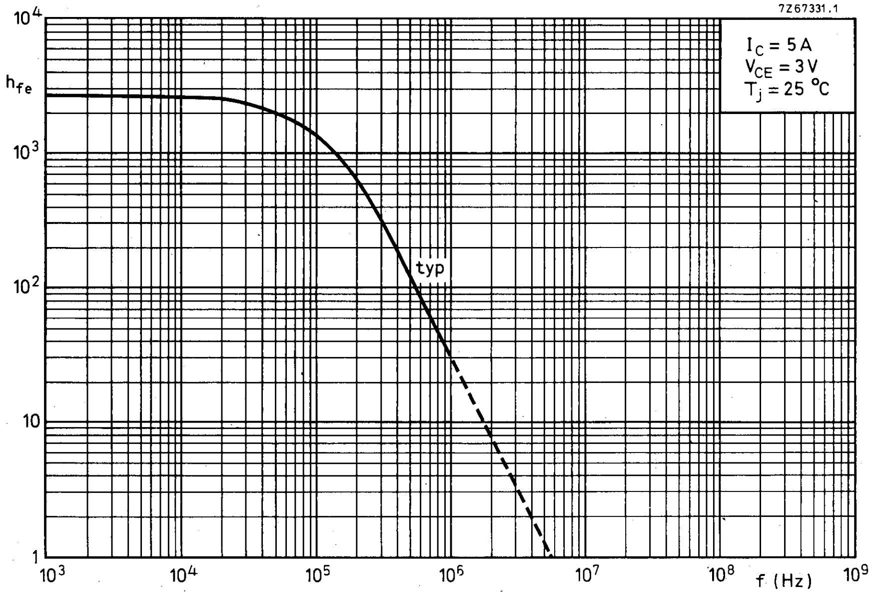


Fig. 16 Typical small-signal current gain for BDX65; 65A and 65B.

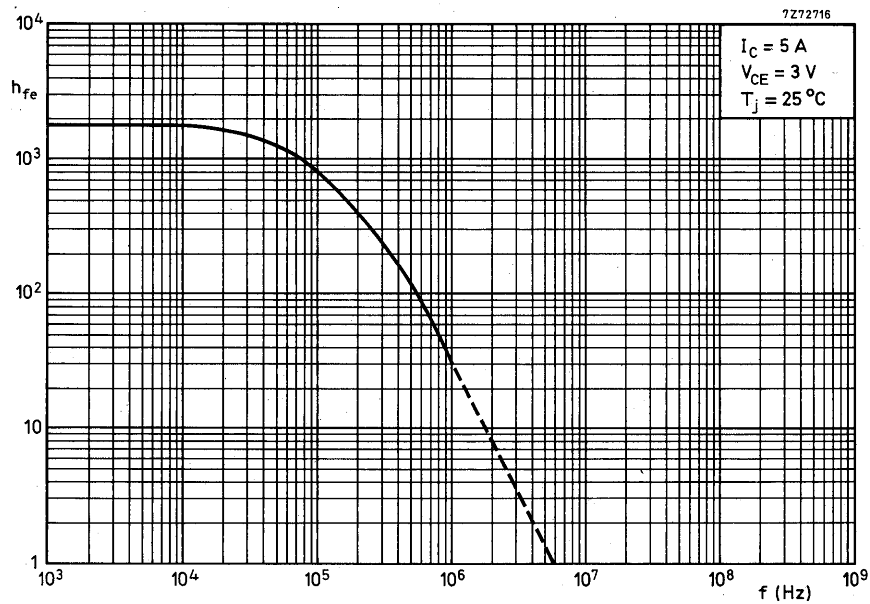


Fig. 17 Typical small-signal current gain for BDX65C.

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.

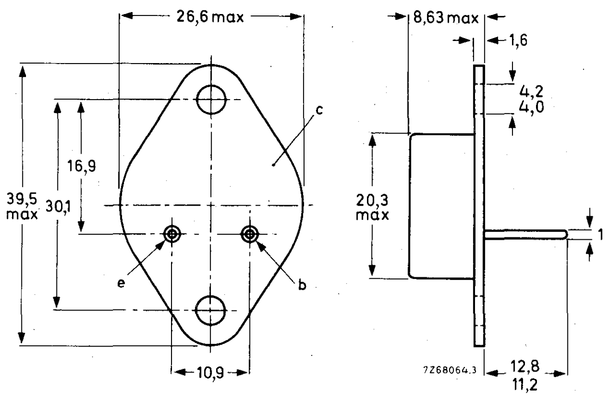
QUICK REFERENCE DATA

			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 $T_{mb} = 25\ ^oC$	P_{tot}	max.	150				W
Junction temperature	T_j	max.	200				^oC
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

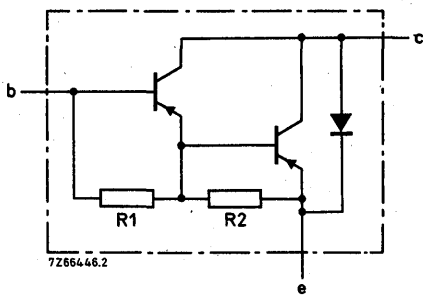
MECHANICAL DATA

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 °C unless otherwise specified
(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

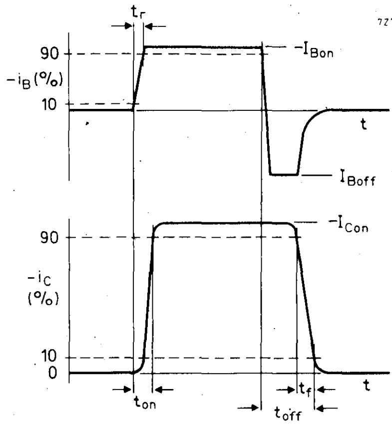
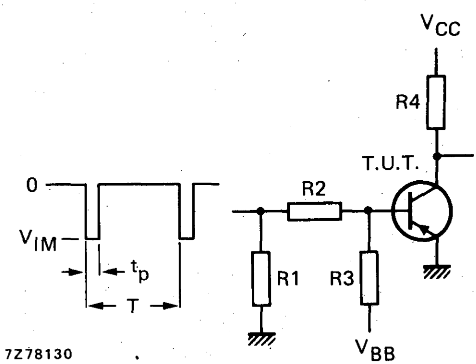


Fig. 3 Switching times waveforms.



$-V_{IM}$ = 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.

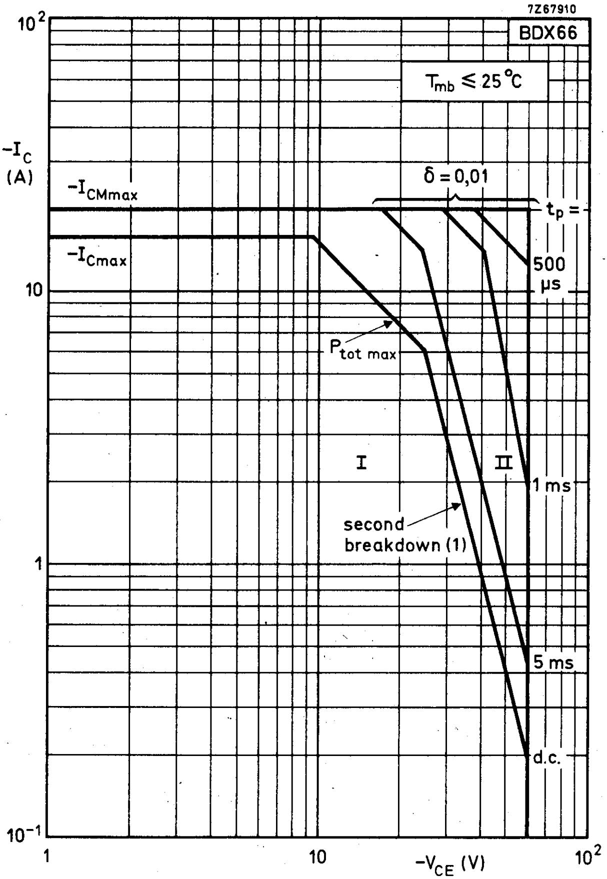


Fig. 5 Safe Operating ARea with the transistor forward biased.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

(1) Independent of temperature.

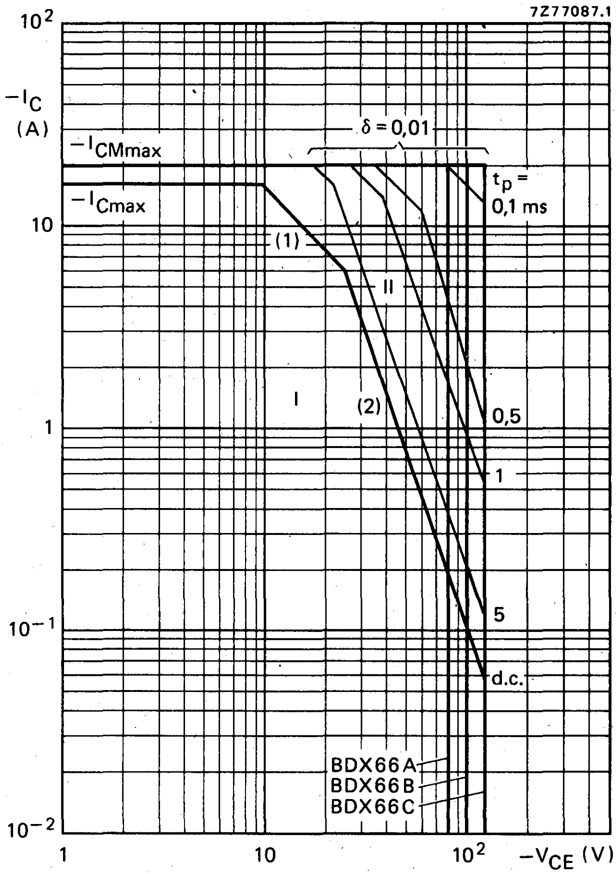


Fig. 6 Safe Operating ARea.

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).

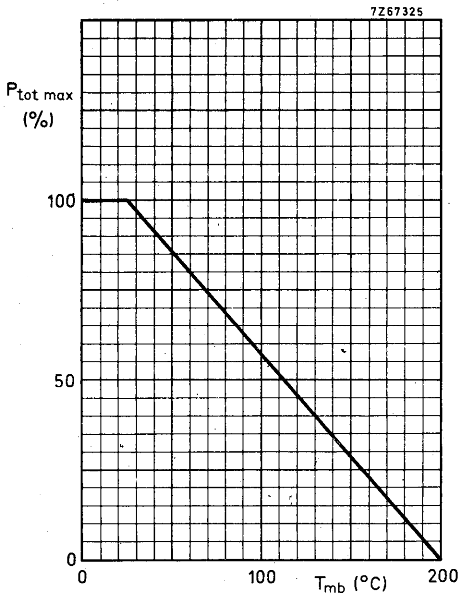


Fig. 7 Power derating curve.

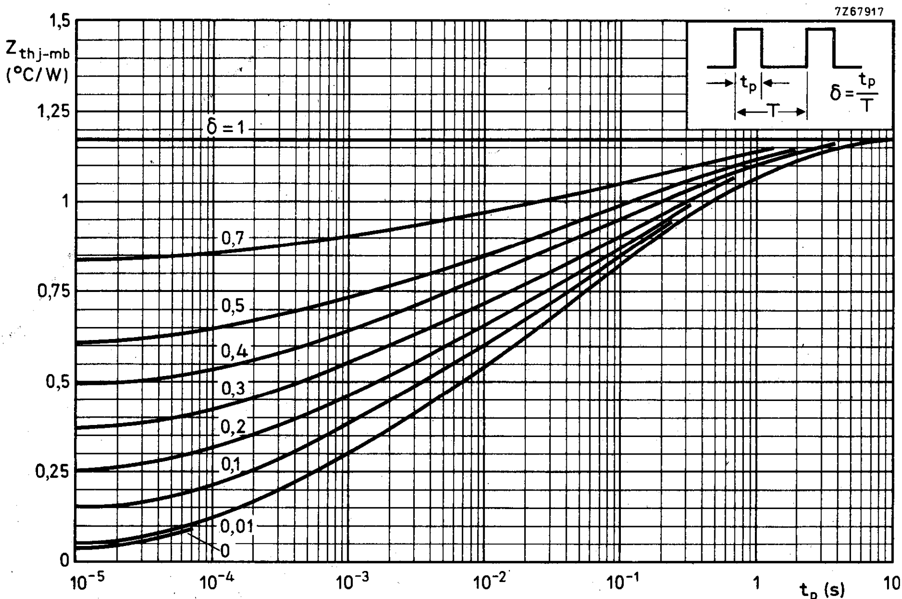


Fig. 8 Pulse power rating chart.

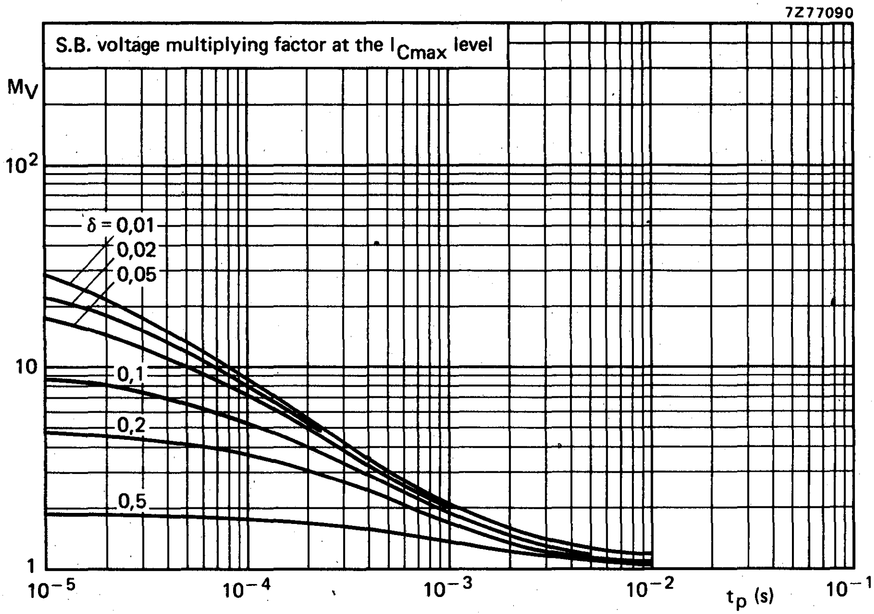


Fig. 9 S.B. voltage multiplying factor at the I_{Cmax} level.

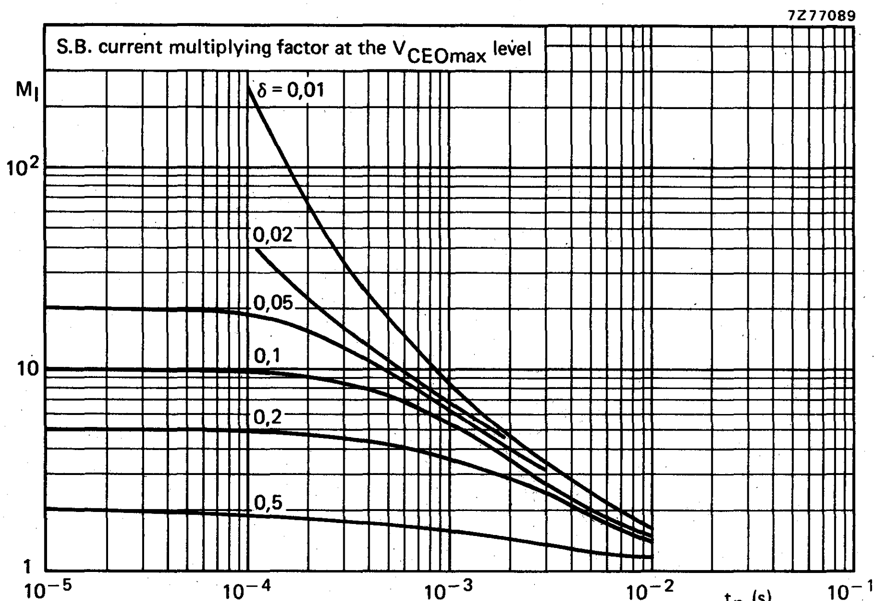


Fig. 10 S.B. current multiplying factor at the V_{CEOmax} level.

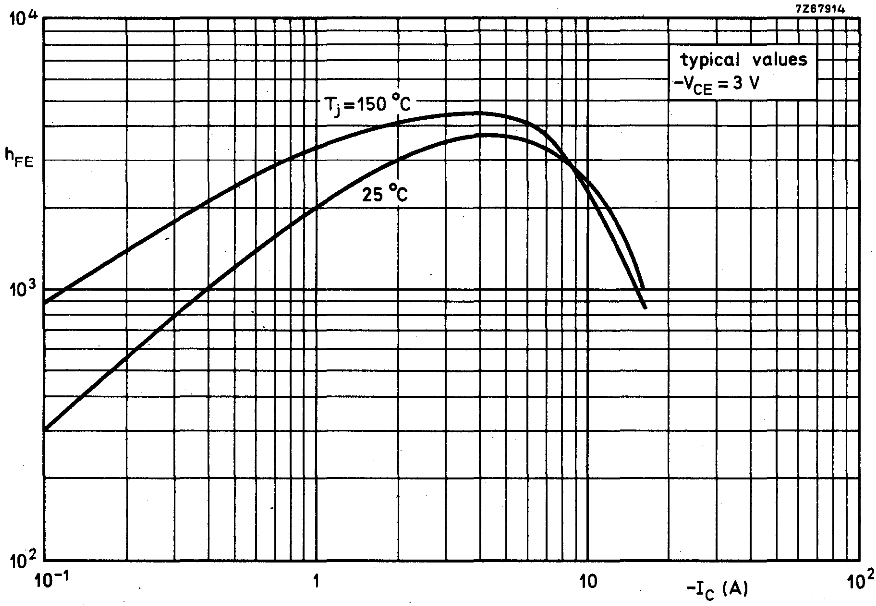


Fig. 11 D.C. current gain.

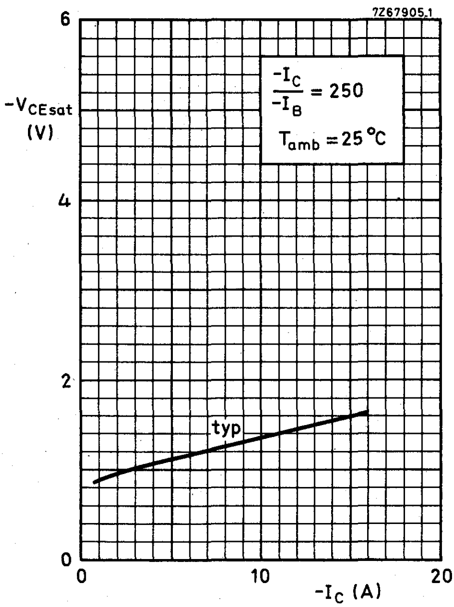


Fig. 12 Collector-emitter saturation voltage.

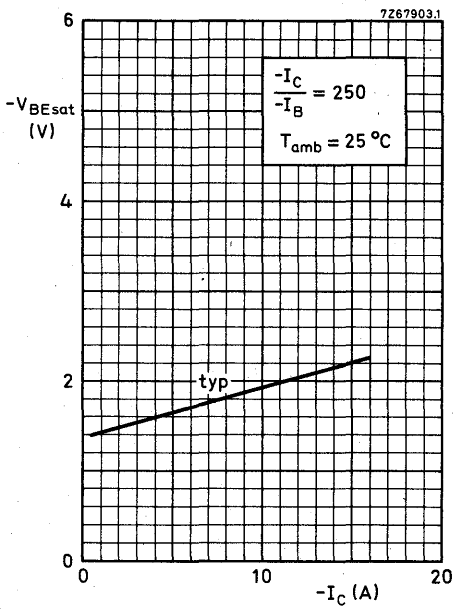


Fig. 13 Base-emitter saturation voltage.

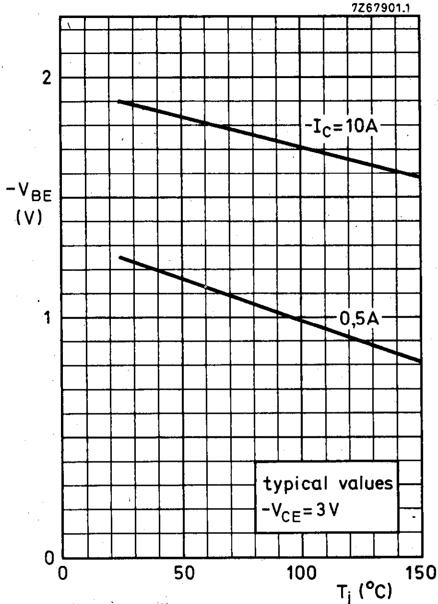


Fig. 14 Typical base-emitter voltage.

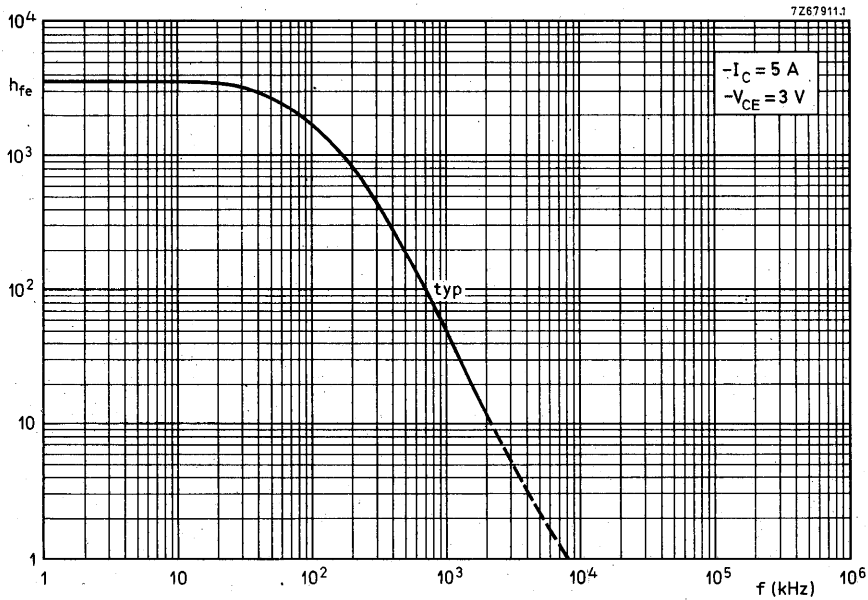


Fig. 15 Small-signal current gain.

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

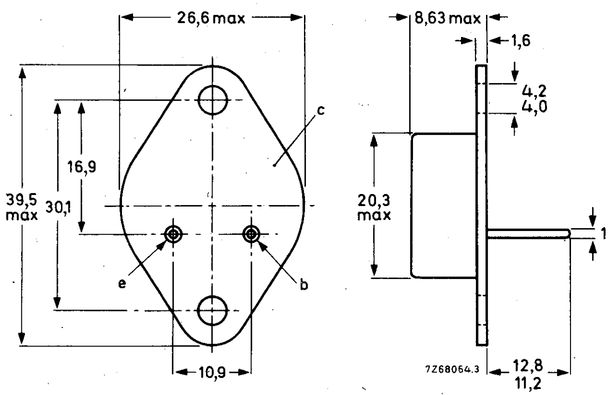
			BDX67	67A	67B	67C	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	120	V
Collector current (peak value)	I_{CM}	max.	20				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	150				W
Junction temperature	T_j	max.	200				°C
D.C. current gain I_C = 1 A; V_{CE} = 3 V	h_{FE}	typ.	1350				
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

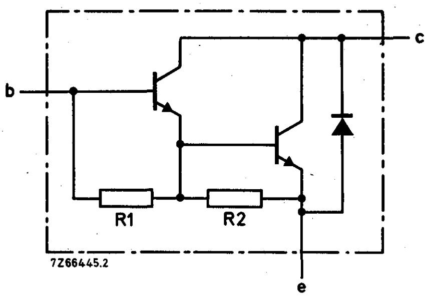
Dimensions in mm

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	°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				
$I_E = 0$; $V_{CB} = V_{CEOmax}$	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.	1350	
$I_C = 10$ A; $V_{CE} = 3$ V	h_{FE}	>	1000	
$I_C = 16$ A; $V_{CE} = 3$ V	h_{FE}	typ.	850	
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				
$-I_{Boff} = 0$; $I_{Con} = 7,8$ 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: $t_p < 300$ μs, $\delta < 2$%.

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

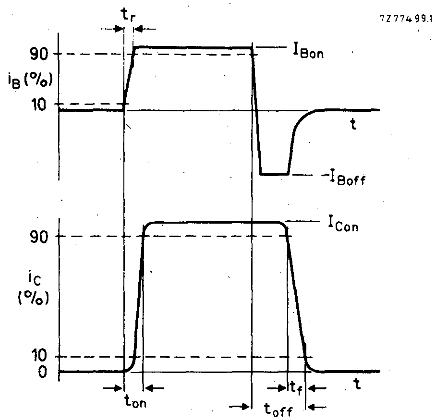
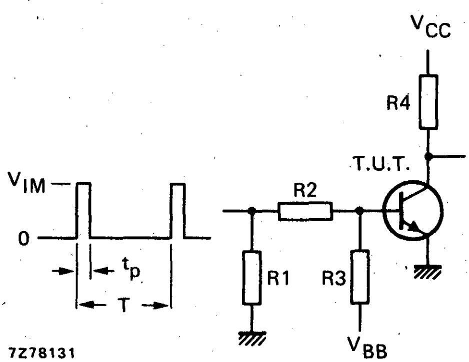


Fig. 3 Switching times waveforms.



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)

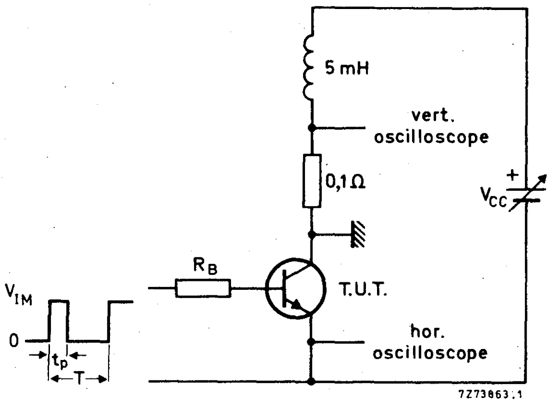


Fig. 5 Test circuit for turn-off breakdown energy. V_{IM} = 12 V; R_B = 270 Ω; I_C = 7,8 A; t_p = 1 ms; δ = 1%.

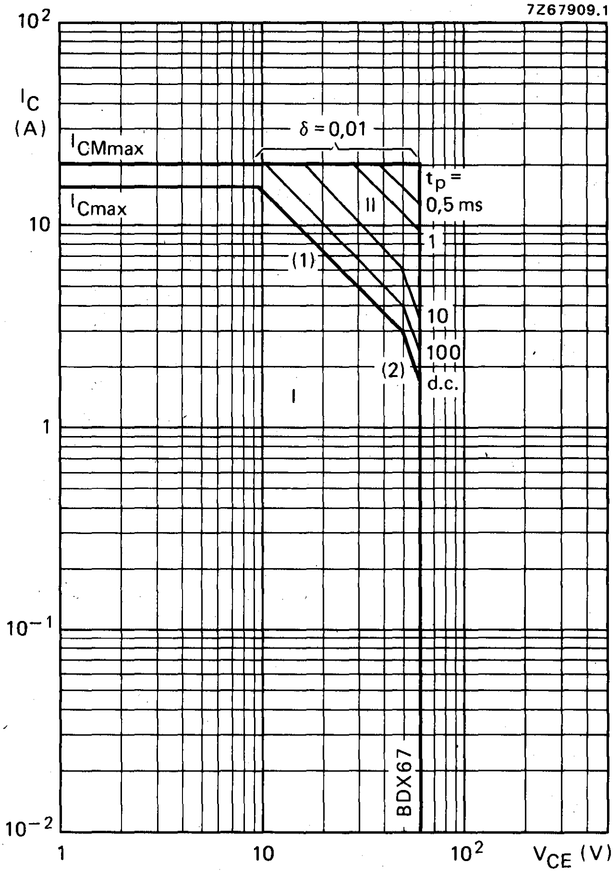


Fig. 6 Safe Operating ARea at T_{mb} = 25 °C of BDX67.

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).

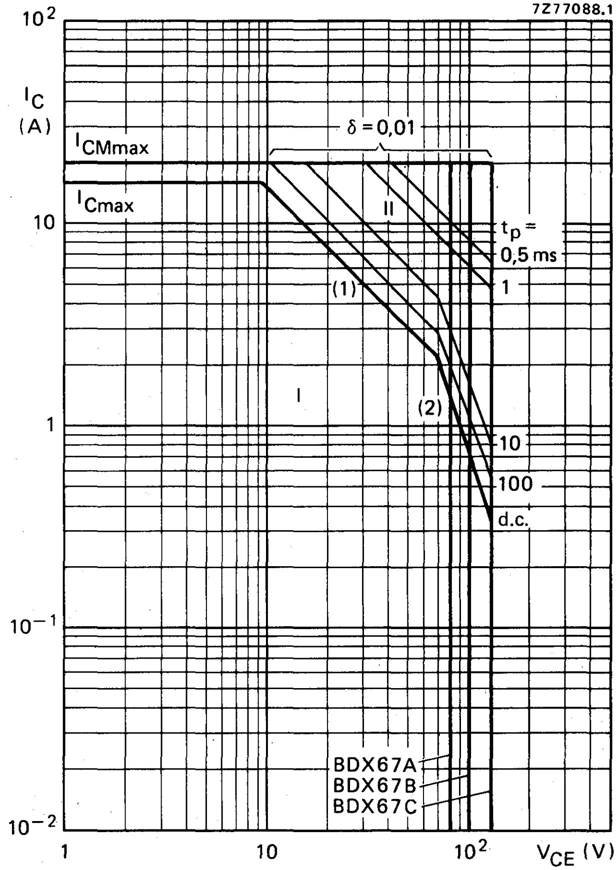


Fig. 7 Safe Operating ARea at T_{mb} = 25 °C.

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).

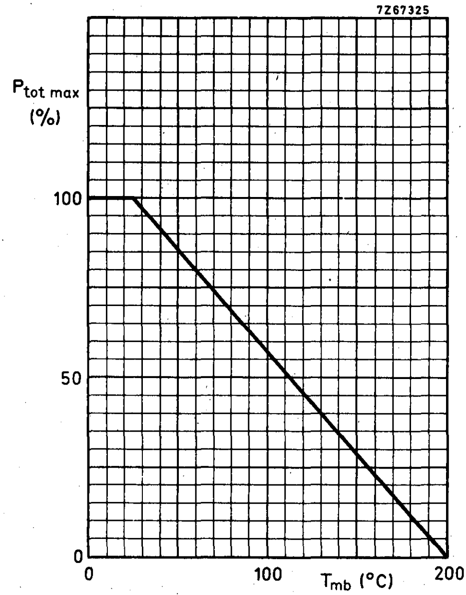


Fig. 8 Power derating curve.

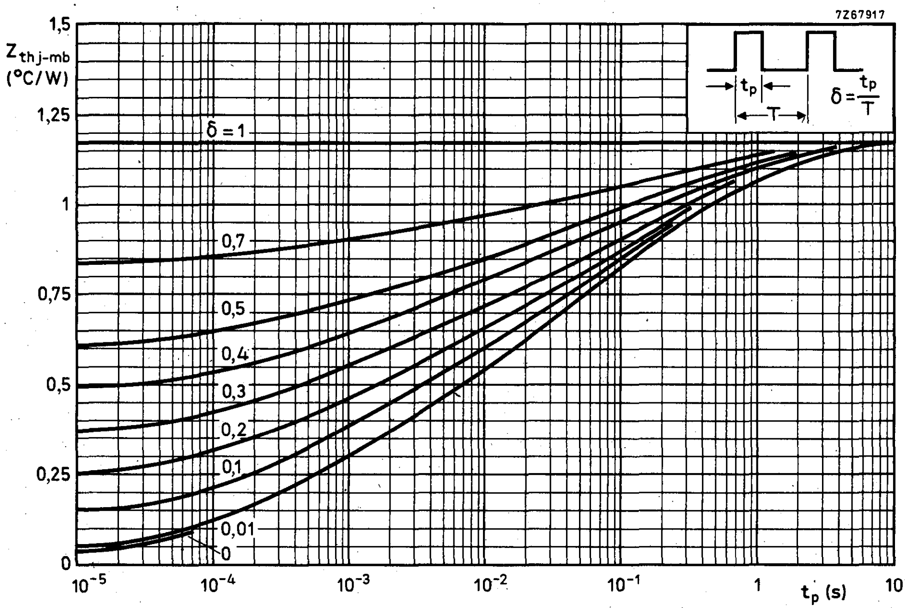


Fig. 9 Pulse power rating chart.

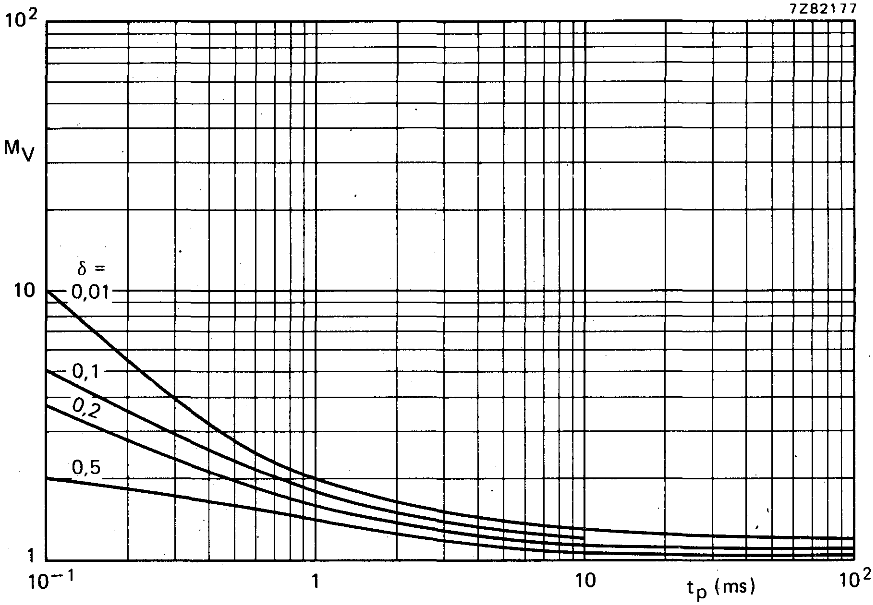


Fig. 10 S.B. voltage multiplying factor at the I_{Cmax} level.

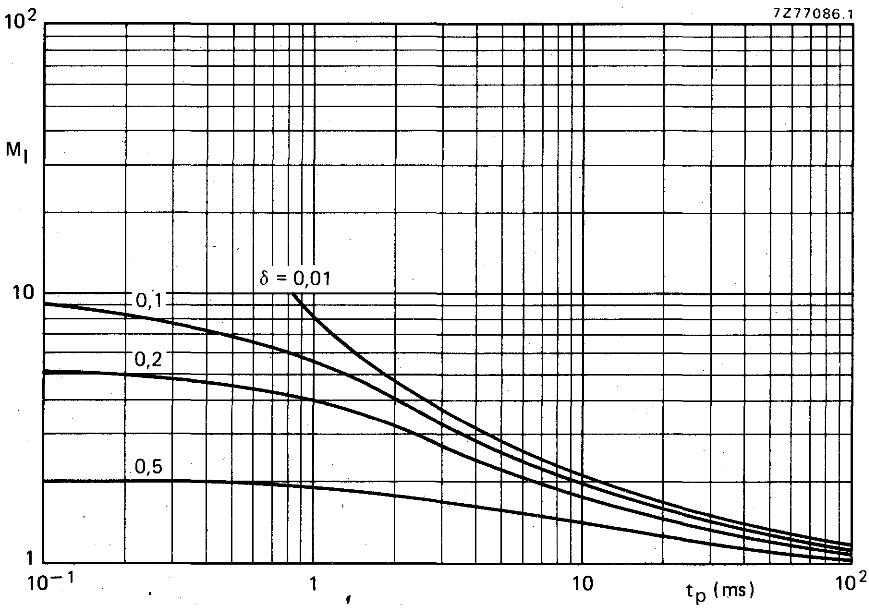


Fig. 11 S.B. current multiplying factor at the V_{CEOmax} level.

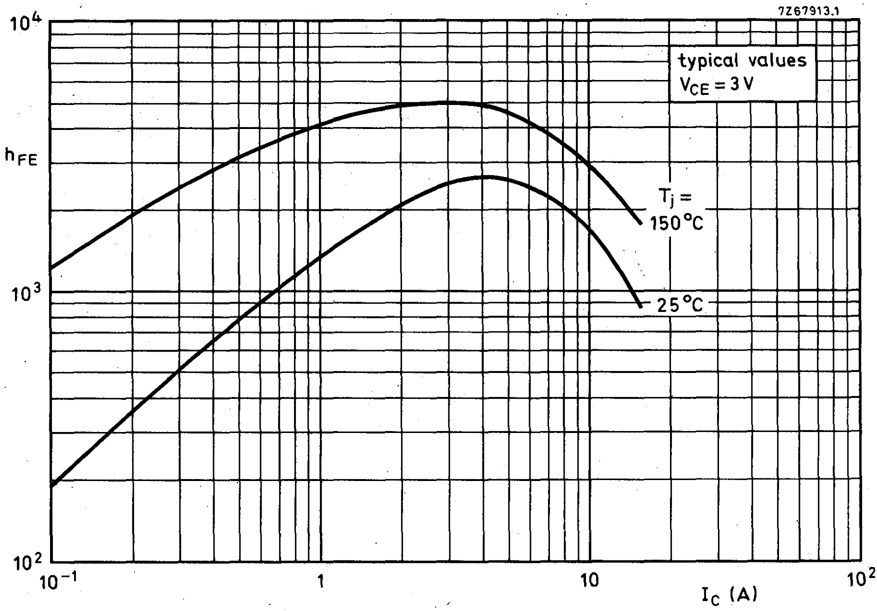


Fig. 12 D.C. current gain.

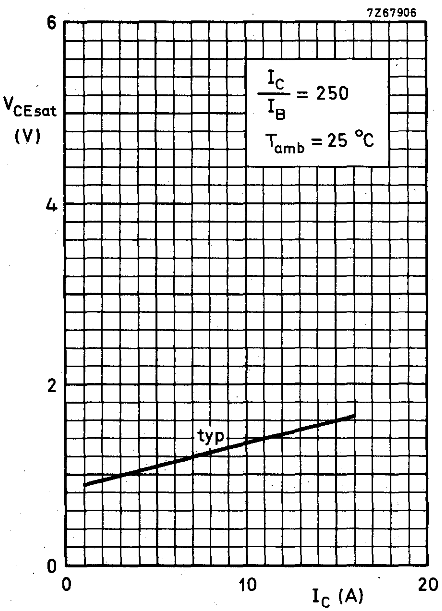


Fig. 13 Collector-emitter saturation voltage.

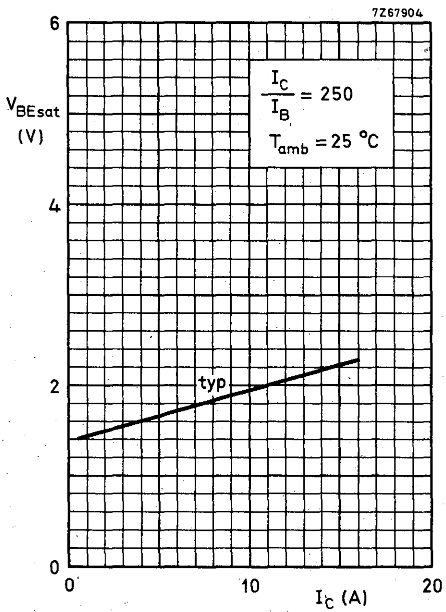


Fig. 14 Base-emitter saturation voltage.

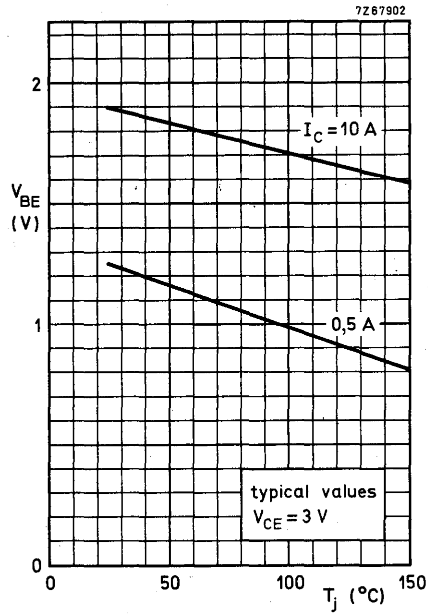


Fig. 15 Typical base-emitter voltage at I_C = 10 A and I_C = 0,5 A.

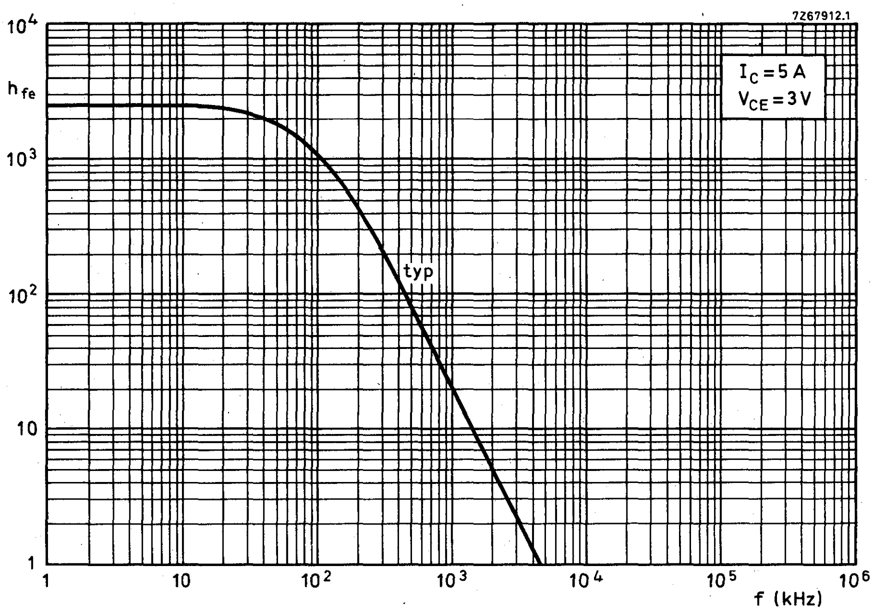


Fig. 16 Small-signal current gain.

SILICON EPITAXIAL-BASE POWER TRANSISTOR

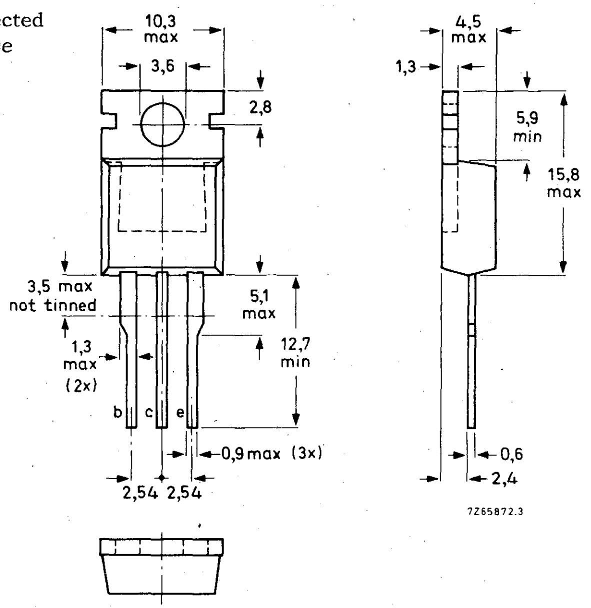
N-P-N transistor in a plastic envelope, intended for industrial amplifier and switching applications. P-N-P complement is BDX78.

QUICK REFERENCE DATA				
Collector-emitter voltage (open base)	V_{CEO}	max.	80	V
Collector 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

TO-220

Collector connected to mounting base



For mounting instructions and accessories see section Accessories.

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

Voltage

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

Current

Collector current (d.c.)	I_C	max.	8	A
Collector current (peak value, $t_p \leq 10$ ms)	I_{CM}	max.	12	A
Collector current (non-repetitive peak value, $t_p \leq 2$ ms)	I_{CSM}	max.	25	A

Temperature

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

Power dissipation

Total power dissipation up to $T_{mb} = 25$ °C	P_{tot}	max.	60	W

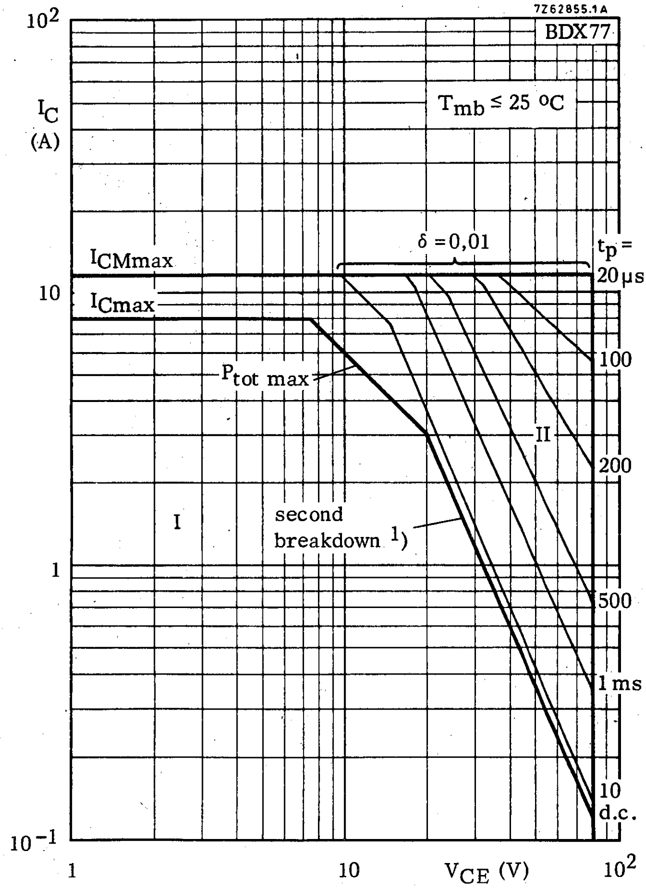
THERMAL RESISTANCE

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

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

Collector cut-off current				
$I_B = 0;\ V_{CE} = 30\ V$	I_{CEO}	<	1	mA
$I_E = 0;\ V_{CB} = 40\ V;\ T_j = 150\ ^oC$	I_{CBO}	<	1	mA
Emitter cut-off current				
$I_C = 0;\ V_{EB} = 5\ V$	I_{EBO}	<	5	mA
Base-emitter voltage [1]				
$I_C = 3\ A;\ V_{CE} = 2\ V$	V_{BE}	<	1,5	V
Knee voltage [1]				
$I_C = 3\ A$; I_B = value for which				
$I_C = 3,3\ A$ at $V_{CE} = 2\ V$	V_{CEK}	typ.	1	V
Saturation voltage [1]				
$I_C = 3\ A;\ I_B = 0,3\ A$	V_{CEsat}	<	1	V
D.C. current gain [1]				
$I_C = 2\ A;\ V_{CE} = 2\ V$	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

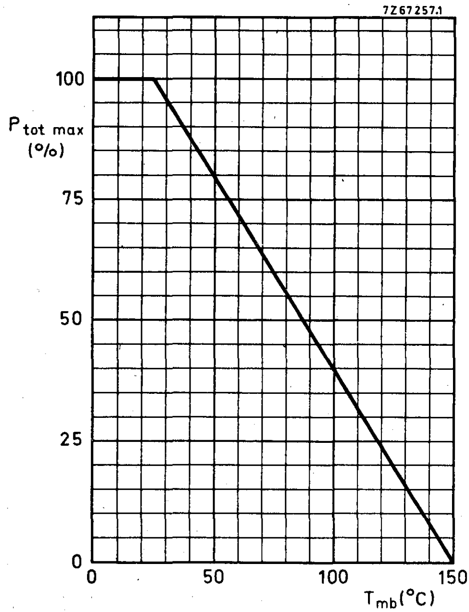
[1]) Measured under pulse conditions: $t_p < 300\ \mu s$, $\delta < 2\%$.

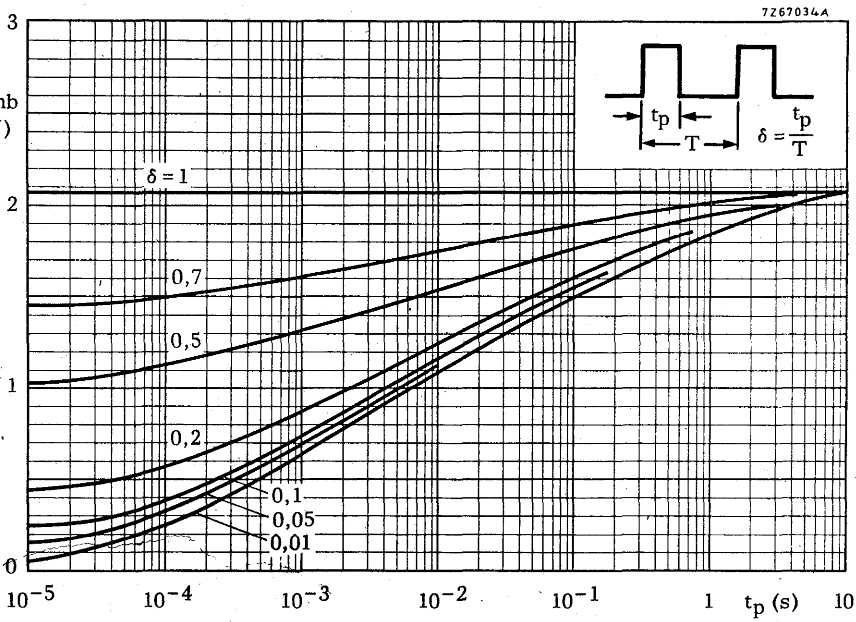


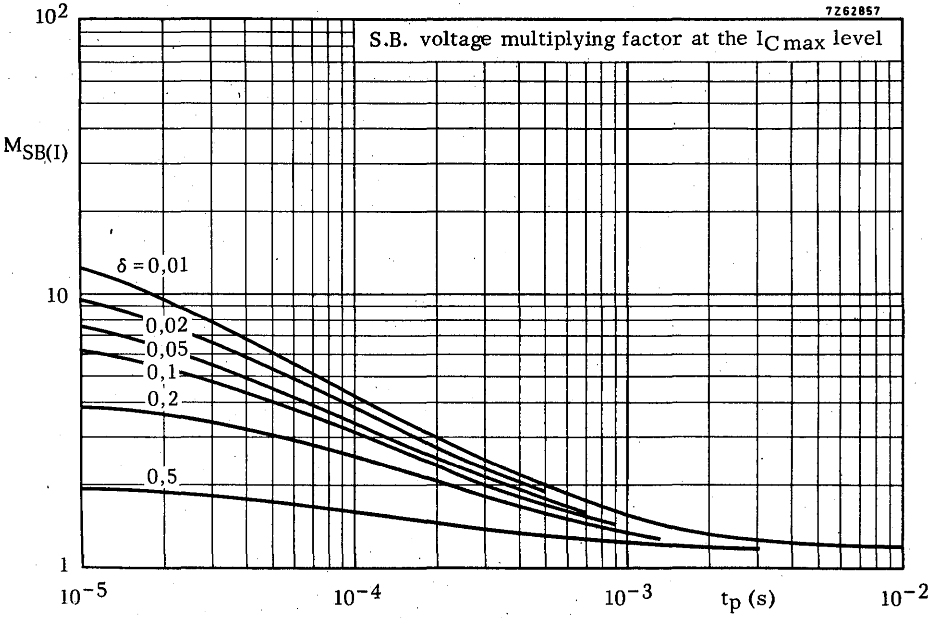
Safe Operating Area with the transistor forward biased

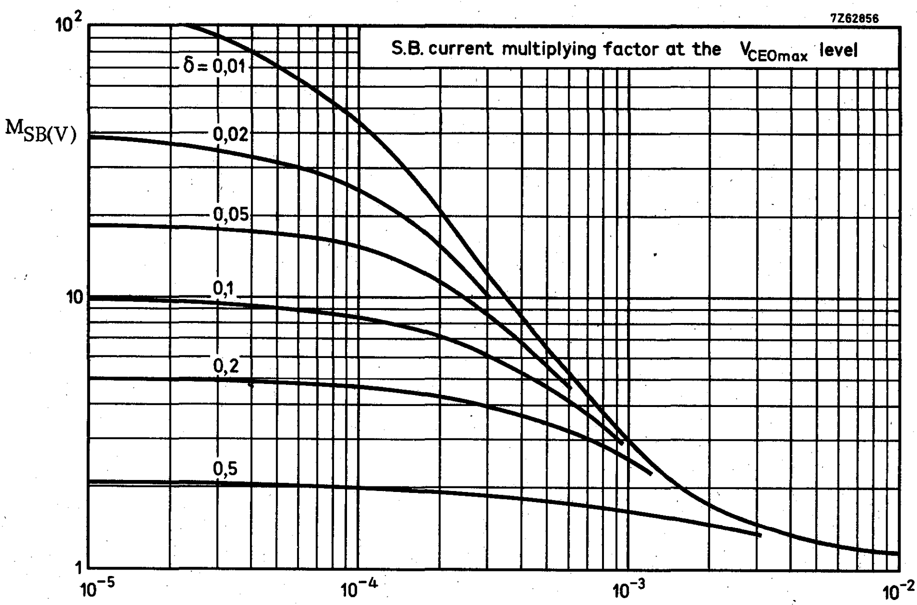
I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation

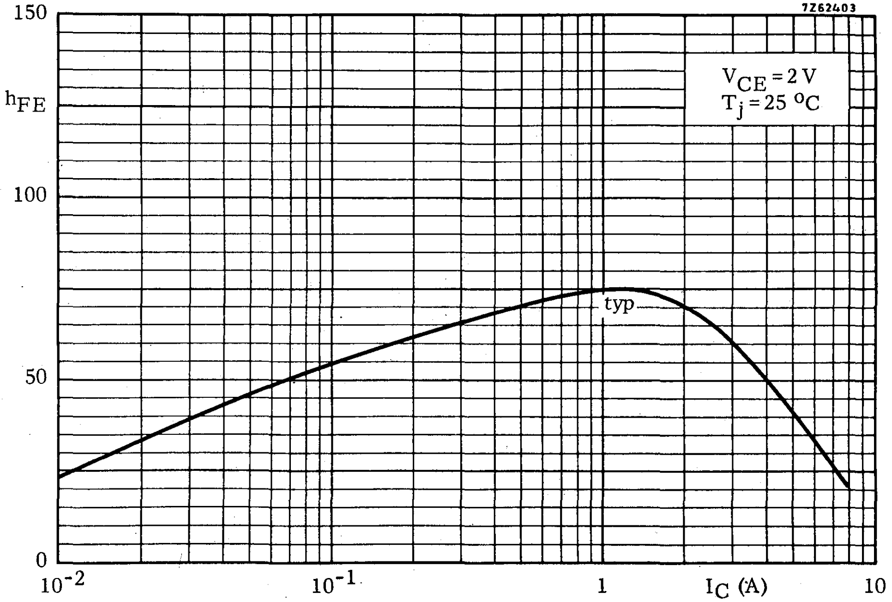
1) Independent of temperature.

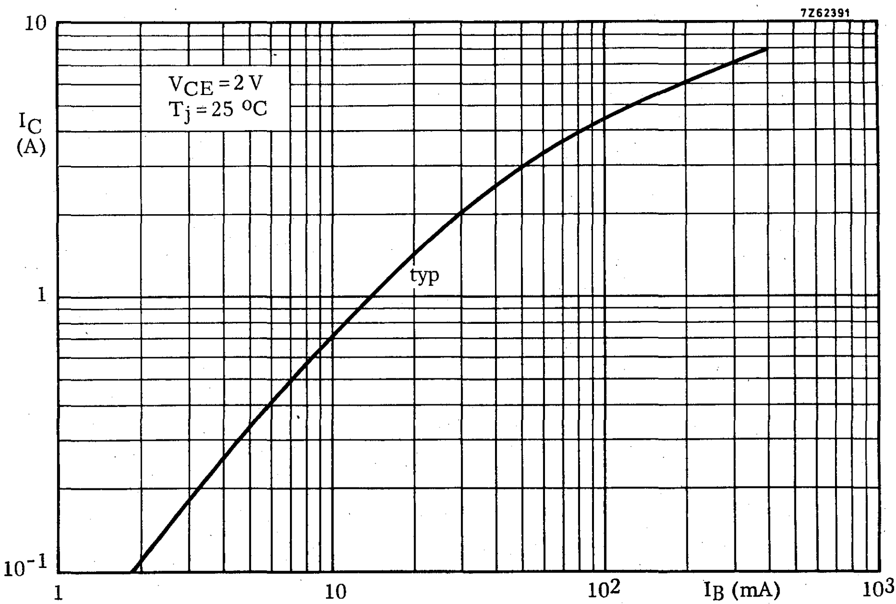

7Z67257.1
100
$P_{tot\ max}$
(%)
75
50
25
0
0
50
100
150
T_{mb}(°C)

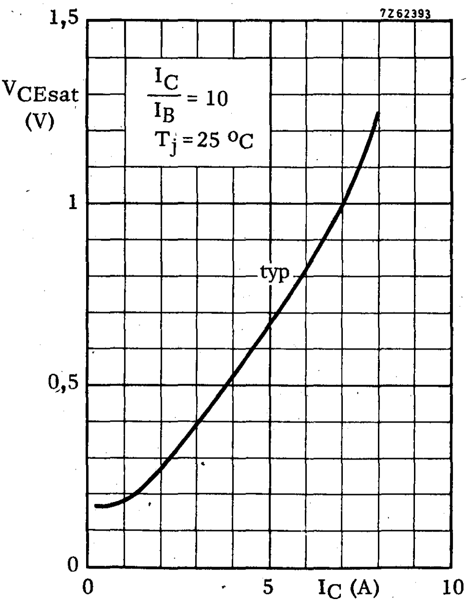

7Z67034A
3
$Z_{th\ j\text{-}mb}$
(°C/W)
$\delta = 1$
2
0,7
0,5
1
0,2
0,1
0,05
0,01
0
t_p
T
$\delta = \frac{t_p}{T}$
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
t_p (s)
10

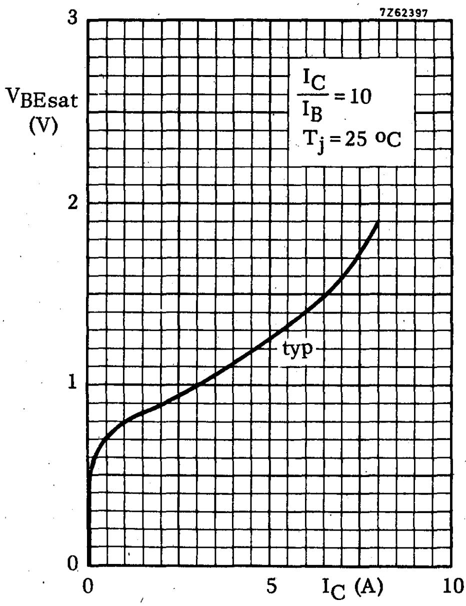

7Z62857
S.B. voltage multiplying factor at the $I_{C max}$ level
$M_{SB(I)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,5
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

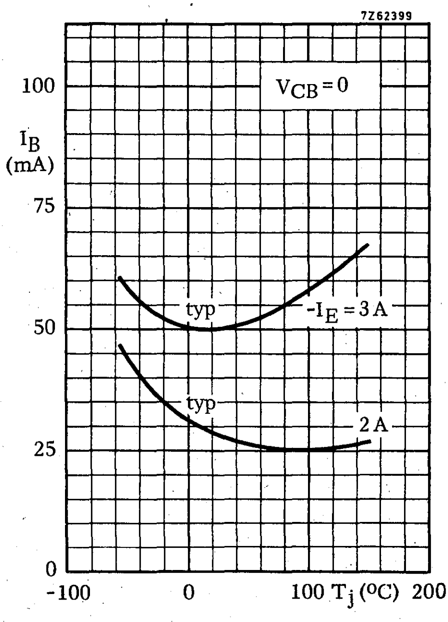

7Z62856
S.B. current multiplying factor at the V_{CEOmax} level
$M_{SB(V)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,5
10^{-5}
10^{-4}
10^{-3}
10^{-2}

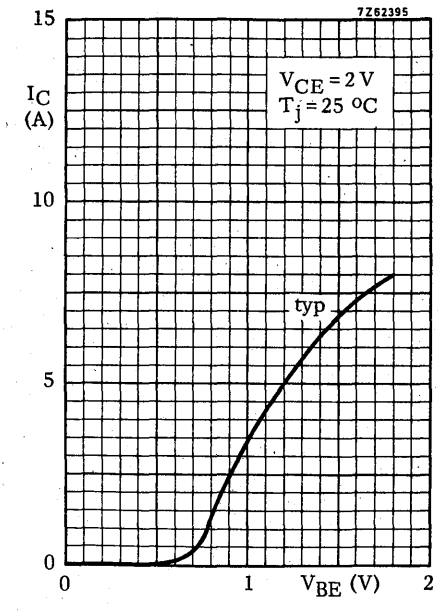

7Z62403
150
h_{FE}
100
50
0
$V_{CE} = 2$ V
$T_j = 25$ °C
typ
10^{-2}
10^{-1}
1
I_C (A)
10

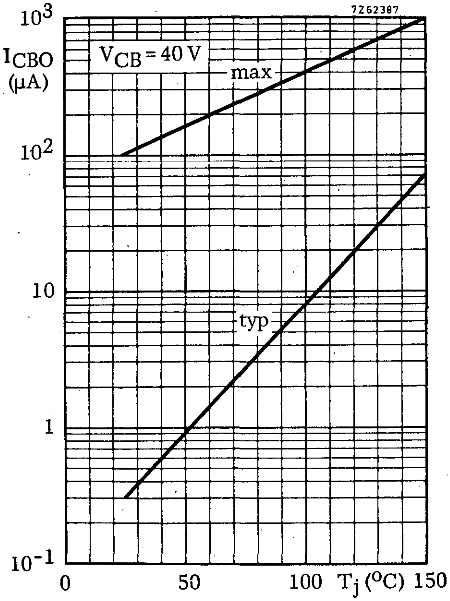

7Z62391
10
I_C
(A)
1
10^{-1}
$V_{CE} = 2$ V
$T_j = 25$ °C
typ
1
10
10^2
I_B (mA)
10^3

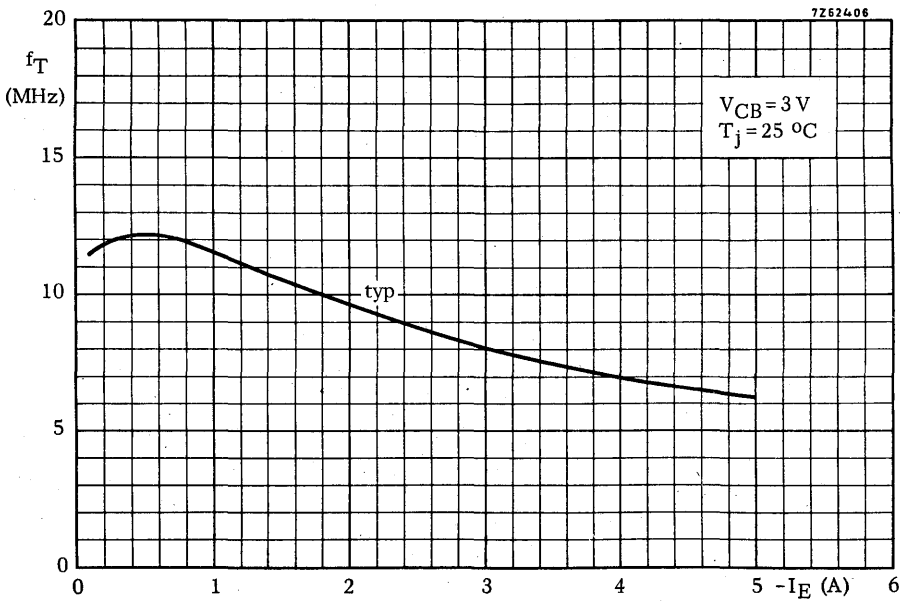

7Z62393
1,5
V_{CEsat}
(V)
$\frac{I_C}{I_B} = 10$
$T_j = 25\ ^oC$
1
typ
0,5
0
0
5
I_C (A)
10


7Z62397
3
V_{BEsat}
(V)
$\frac{I_C}{I_B} = 10$
$T_j = 25\ ^oC$
2
typ
1
0
0
5
I_C (A)
10


7Z62399
100
I_B
(mA)
$V_{CB} = 0$
75
typ
$-I_E = 3$ A
50
typ
2 A
25
0
-100
0
100
T_j (^oC)
200


7Z62395
15
I_C
(A)
$V_{CE} = 2$ V
$T_j = 25\ ^oC$
10
typ
5
0
0
1
V_{BE} (V)
2


7Z62387
I_{CBO} (μA)
10^3
10^2
10
1
10^{-1}
$V_{CB} = 40$ V
max
typ
0
50
100
T_j (°C)
150


7Z62406
f_T (MHz)
20
15
10
5
0
$V_{CB} = 3$ V
$T_j = 25$ °C
typ
0
1
2
3
4
5
$-I_E$ (A)
6

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.

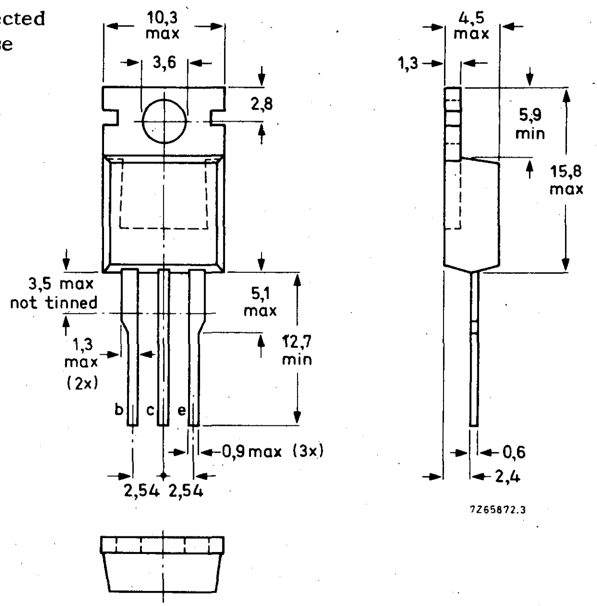
QUICK REFERENCE DATA				
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	80	V
Collector current (d.c.)	$-I_C$	max.	8	A
Total power dissipation up to T_{mb} = 25 ^oC	P_{tot}	max.	60	W
D.C. current gain $-I_C$ = 2 A; $-V_{CE}$ = 2 V	h_{FE}	>	30	
Cut-off frequency $-I_C$ = 0,3 A; $-V_{CE}$ = 3 V	f_{hfe}	>	25	kHz

MECHANICAL DATA

Dimensions in mm

TO-220

Collector connected to mounting base



For mounting instructions and accessories see section Accessories.

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

Voltage

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

Current

Collector current (d.c.)	$-I_C$	max.	8	A
Collector current (peak value, $t_p \leq 10$ ms)	$-I_{CM}$	max.	12	A
Collector current (non-repetitive peak value, $t_p \leq 2$ ms)	$-I_{CSM}$	max.	25	A

Temperature

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

Power dissipation

Total power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.	60	W

THERMAL RESISTANCE

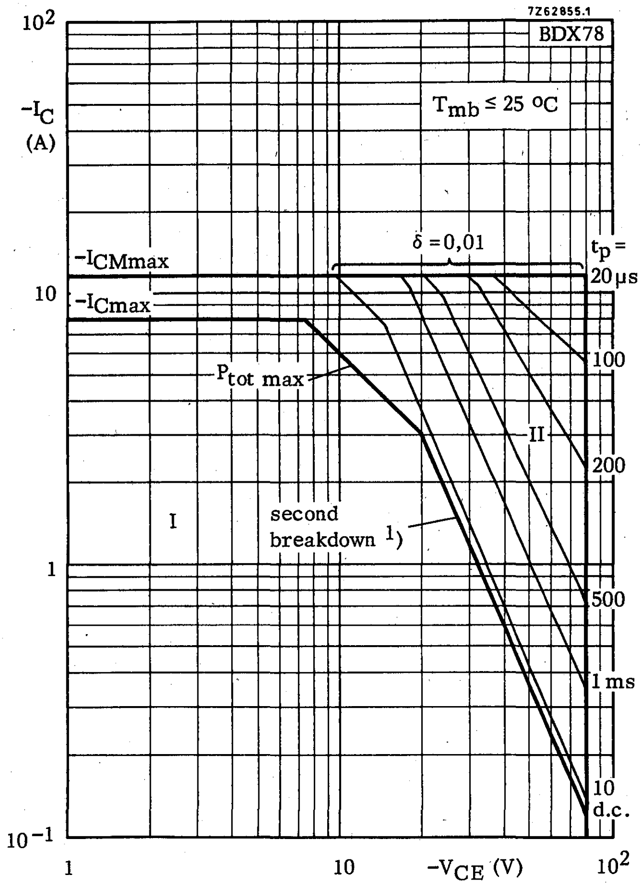
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2,08	$^oC/W$
From junction to mounting base in free air	$R_{th\ j\text{-}a}$	=	70	$^oC/W$

CHARACTERISTICS

$T_j = 25\ ^oC$ 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; $T_j = 150\ ^oC$	$-I_{CBO}$	<	1	mA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	5	mA
Base-emitter voltage [1]				
$-I_C = 3$ A; $-V_{CE} = 2$ V	$-V_{BE}$	<	1,5	V
Knee voltage [1]				
$-I_C = 3$ A; $-I_B$ = value at which $-I_C = 3,3$ A at $-V_{CE} = 2$ V	$-V_{CEK}$	typ.	1	V
Saturation voltage [1]				
$-I_C = 3$ A; $-I_B = 0,3$ A	$-V_{CEsat}$	<	1	V
D.C. current gain [1]				
$-I_C = 2$ 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

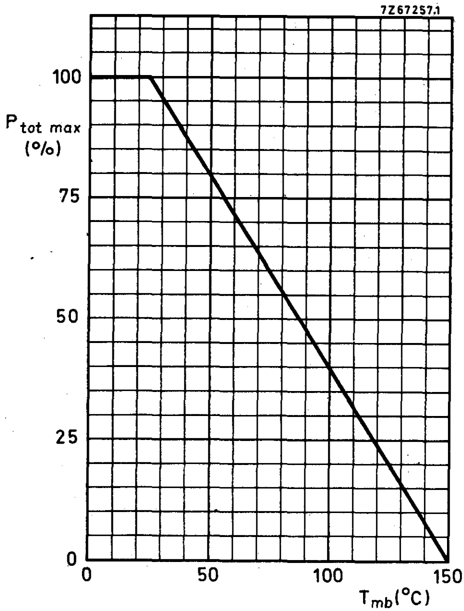
[1]) Measured under pulse conditions: $t_p < 300\ \mu s$, $\delta < 2\%$.

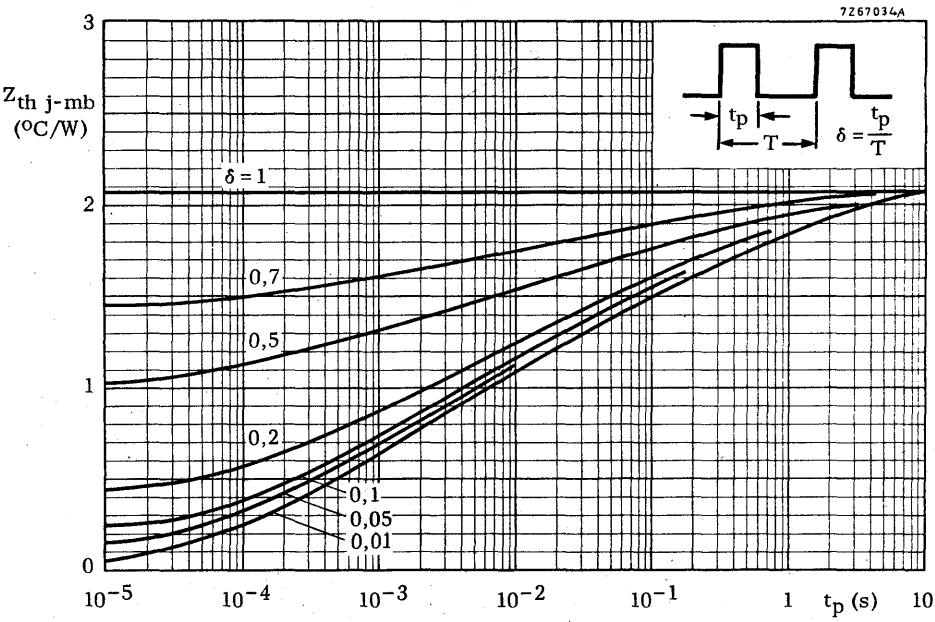


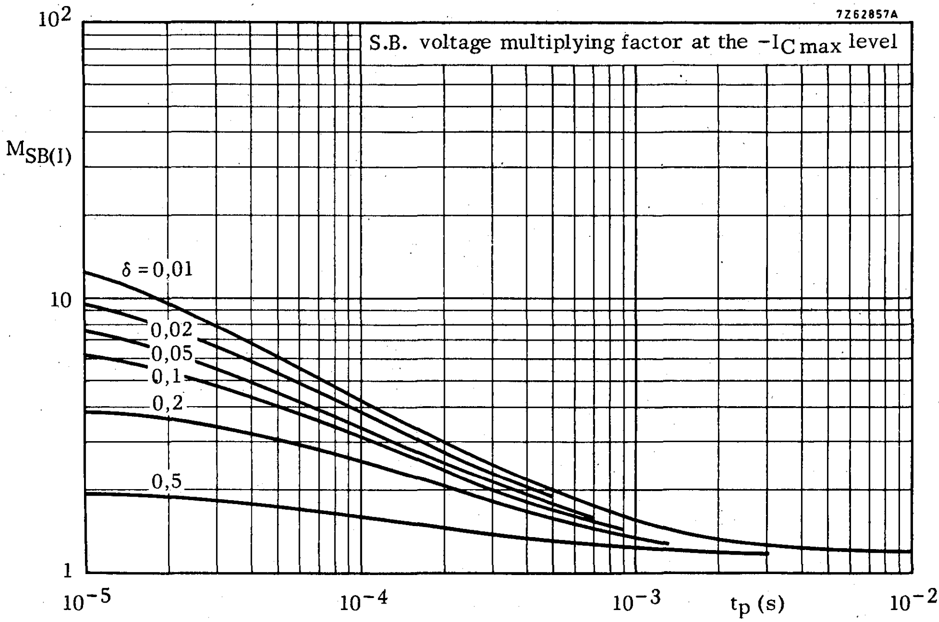
Safe Operating Area with the transistor forward biased

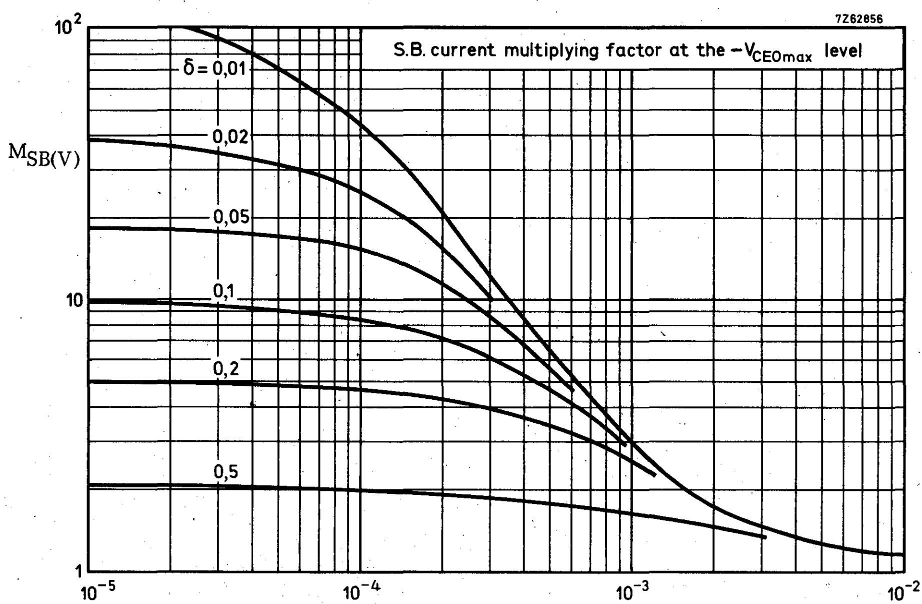
I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation

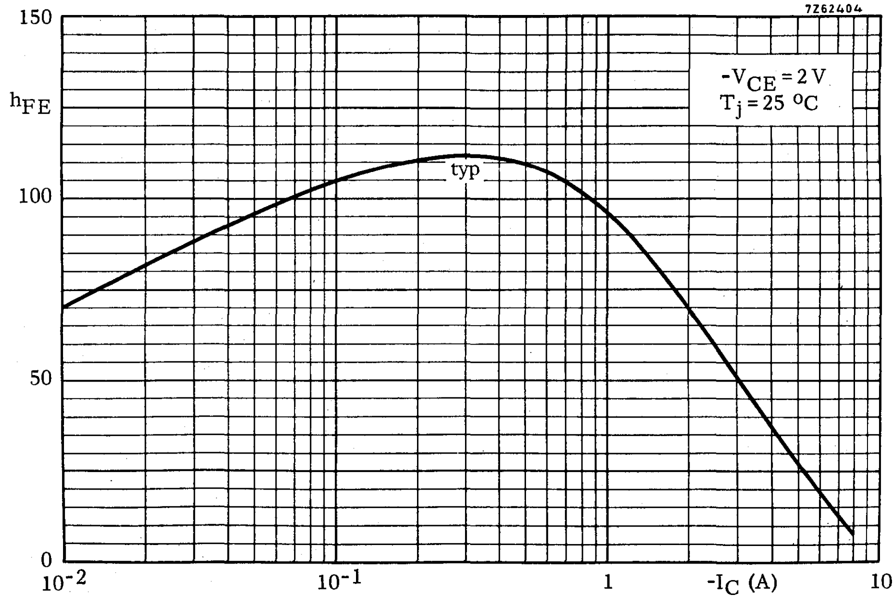
[1]) Independent of temperature.

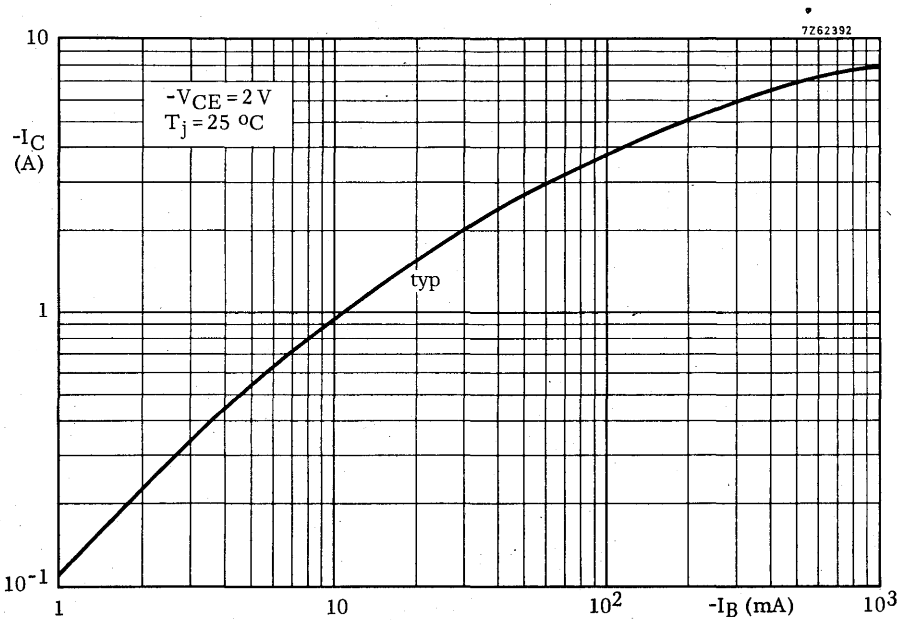

7Z67257.1
100
Ptot max
(%)
75
50
25
0
0
50
100
150
Tmb(°C)

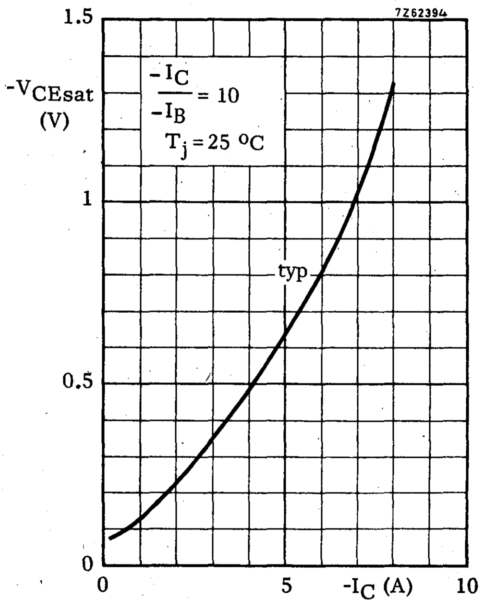

7Z67034A
3
Zth j-mb
(°C/W)
2
1
0
δ = 1
0,7
0,5
0,2
0,1
0,05
0,01
tp
T
δ = tp/T
10−5
10−4
10−3
10−2
10−1
1
tp (s)
10

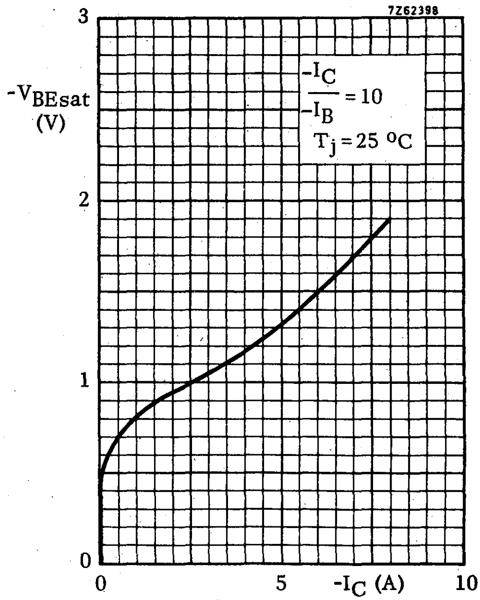

7Z62857A
S.B. voltage multiplying factor at the $-I_{C\,max}$ level
10^2
$M_{SB(I)}$
$\delta = 0{,}01$
10
0,02
0,05
0,1
0,2
0,5
1
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

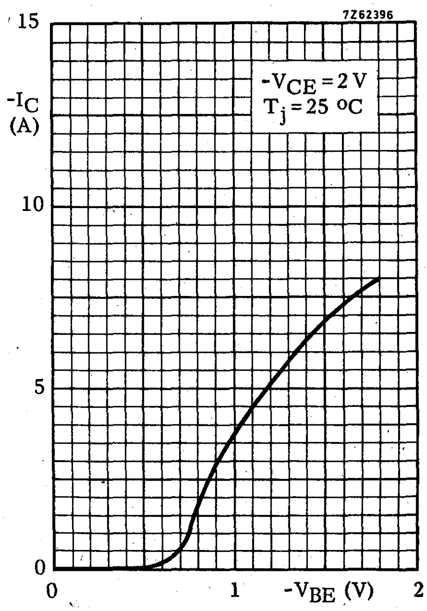

7Z62856
S.B. current multiplying factor at the $-V_{CEOmax}$ level
10^2
$M_{SB(V)}$
$\delta = 0{,}01$
0,02
0,05
10
0,1
0,2
0,5
1
10^{-5}
10^{-4}
10^{-3}
10^{-2}

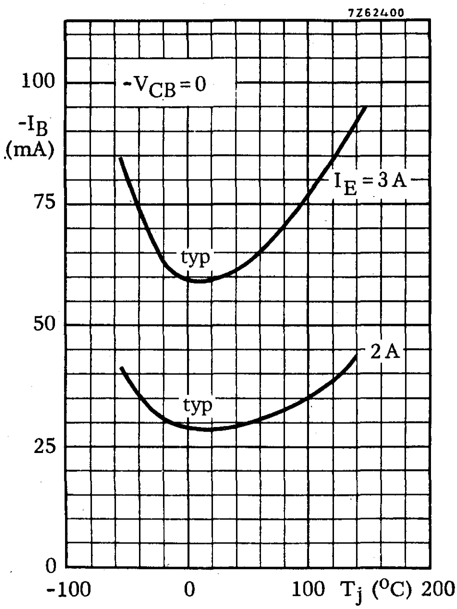

7Z62404
150
h_{FE}
100
50
0
$-V_{CE} = 2$ V
$T_j = 25$ °C
typ
10^{-2}
10^{-1}
1
$-I_C$ (A)
10

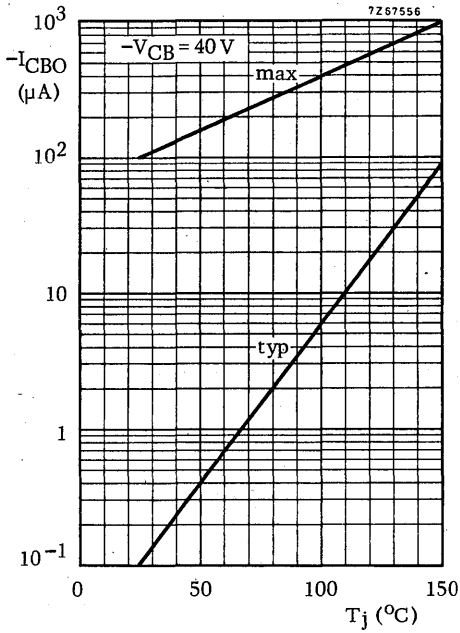

7Z62392
10
$-I_C$
(A)
1
10^{-1}
$-V_{CE} = 2$ V
$T_j = 25$ °C
typ
1
10
10^2
$-I_B$ (mA)
10^3

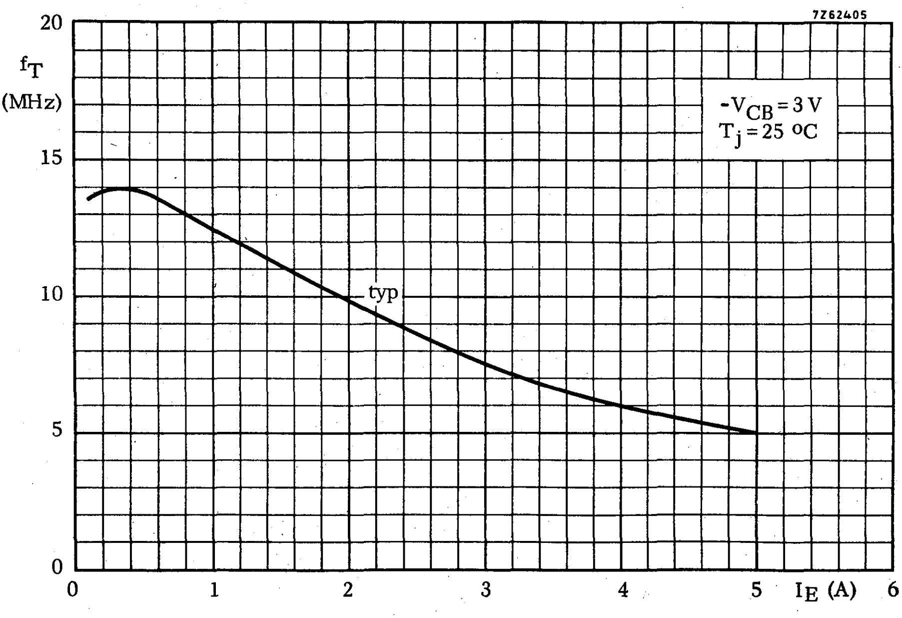

7Z62394
1.5
$-V_{CEsat}$
(V)
$\frac{-I_C}{-I_B} = 10$
$T_j = 25\ ^oC$
1
typ
0.5
0
0
5
$-I_C$ (A)
10


7Z62398
3
$-V_{BEsat}$
(V)
$\frac{-I_C}{-I_B} = 10$
$T_j = 25\ ^oC$
2
1
0
0
5
$-I_C$ (A)
10


7Z62396
15
$-I_C$
(A)
$-V_{CE} = 2$ V
$T_j = 25\ ^oC$
10
5
0
0
1
$-V_{BE}$ (V)
2


7Z62400
-V_{CB} = 0
-I_B
(mA)
100
75
50
25
0
I_E = 3 A
typ
2 A
typ
-100
0
100
T_j (°C)
200


7Z67556
10^3
$-I_{CBO}$
(μA)
$-V_{CB}$ = 40 V
max
10^2
10
typ
1
10^{-1}
0
50
100
150
T_j (°C)


7Z62405
20
f_T
(MHz)
15
10
5
0
-V_{CB} = 3 V
T_j = 25 °C
typ
0
1
2
3
4
5
I_E (A)
6

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.

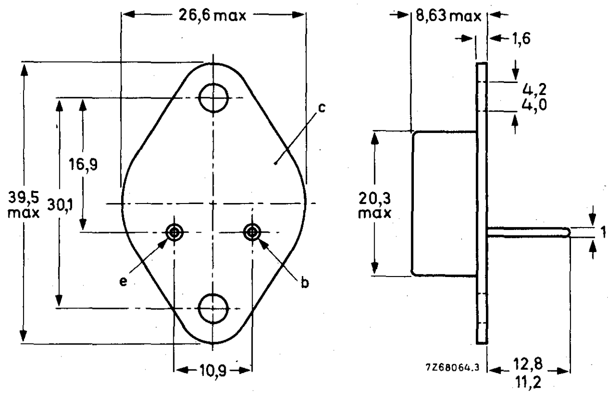
QUICK REFERENCE DATA

			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

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)

Voltages

			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

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 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	<	0,1	mA
$I_E = 0$; $V_{CB} = 30$ V; $T_j = 200$ °C: BDX91 $I_E = 0$; $V_{CB} = 40$ V; $T_j = 200$ °C: BDX93 $I_E = 0$; $V_{CB} = 50$ V; $T_j = 200$ °C: BDX95	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 [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: $t_p < 300$ µs, $\delta < 2\%$.

CHARACTERISTICS (continued) T_j = 25 °C 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.	1,2 μs
		<	2 μs

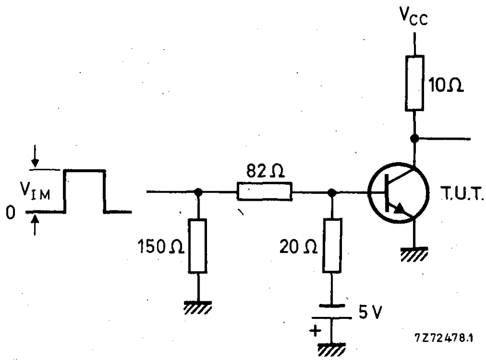
Test circuit

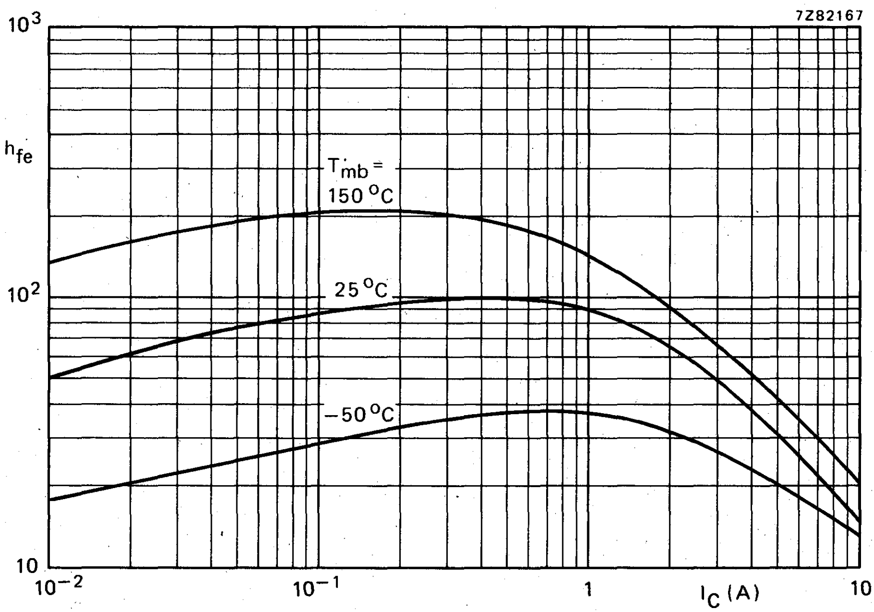
V_{IM} = 55 V

$t_r = t_f$ = 15 ns

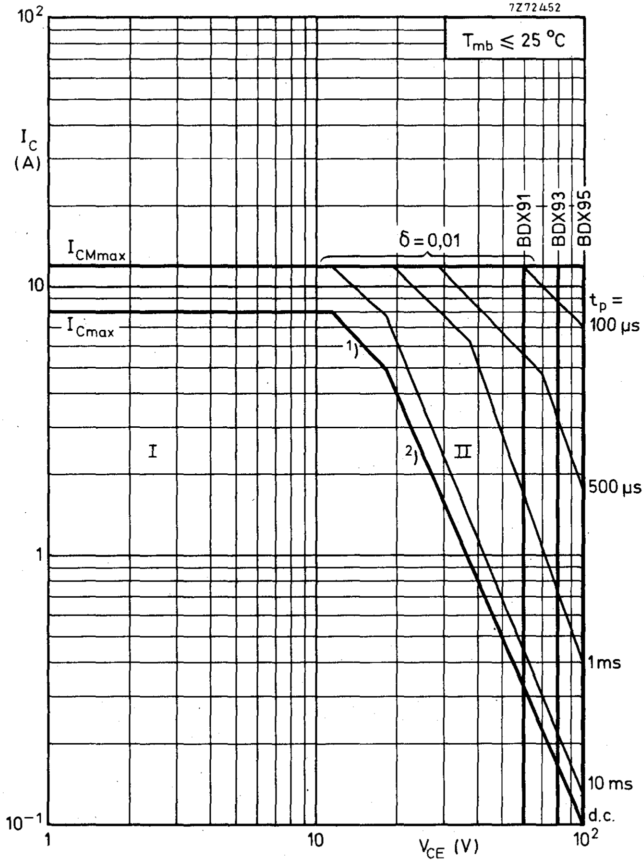
t_p = 10 μs

T = 500 μs





Typical small-signal current gain as a function of collector current; V_{CE} = 2 V.



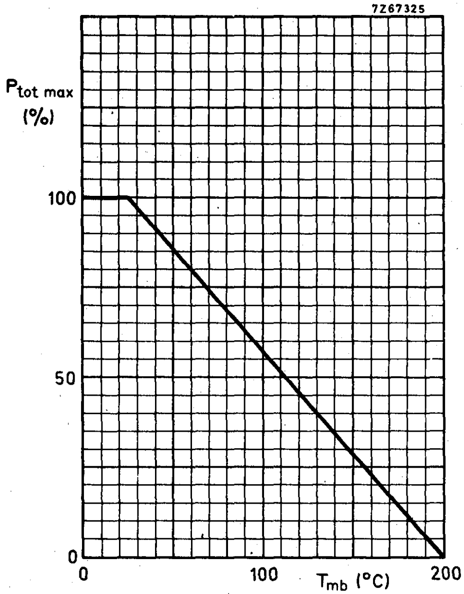
Safe Operating ARea with the transistor forward biased

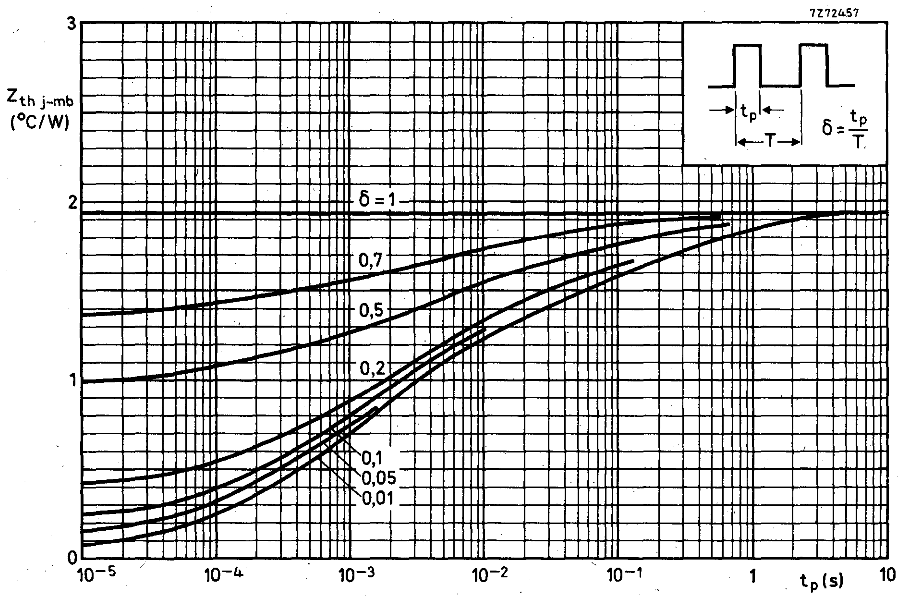
I Region of permissible d.c. operation

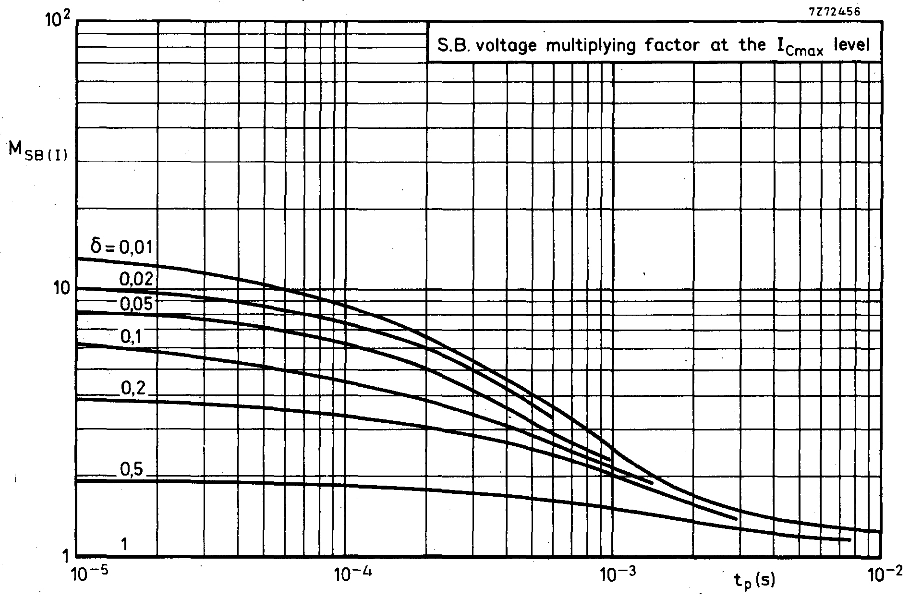
II Permissible extension for repetitive pulse operation

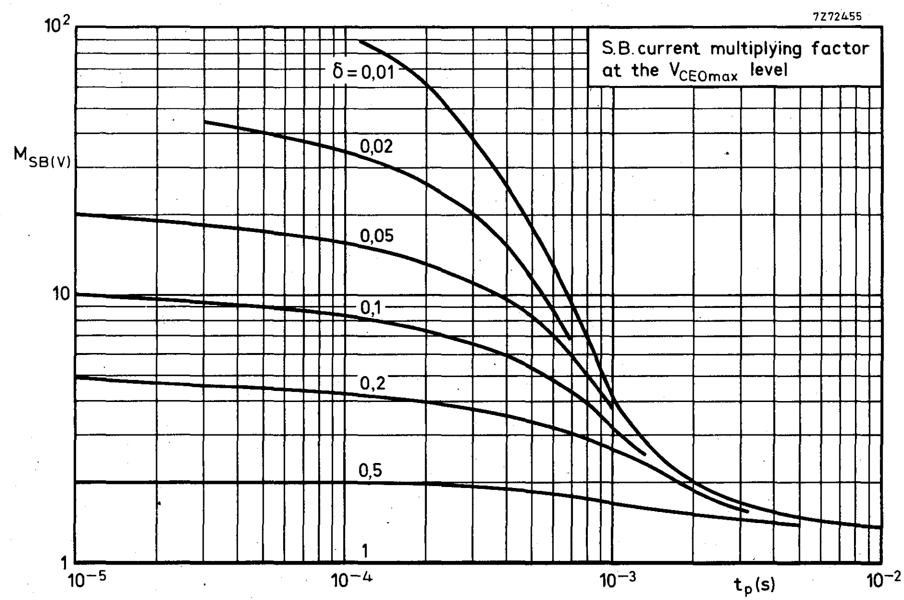
1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.

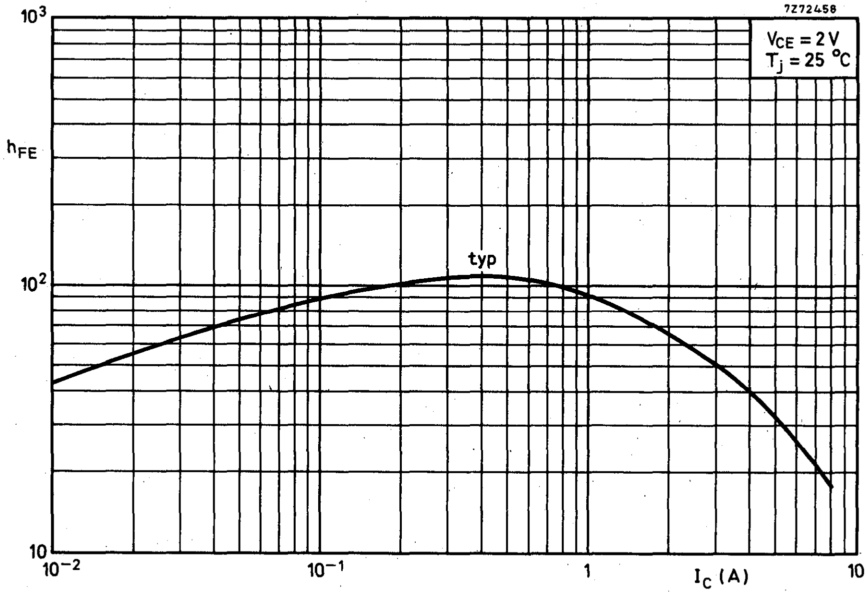
2) Second-breakdown limits (independent of temperature).

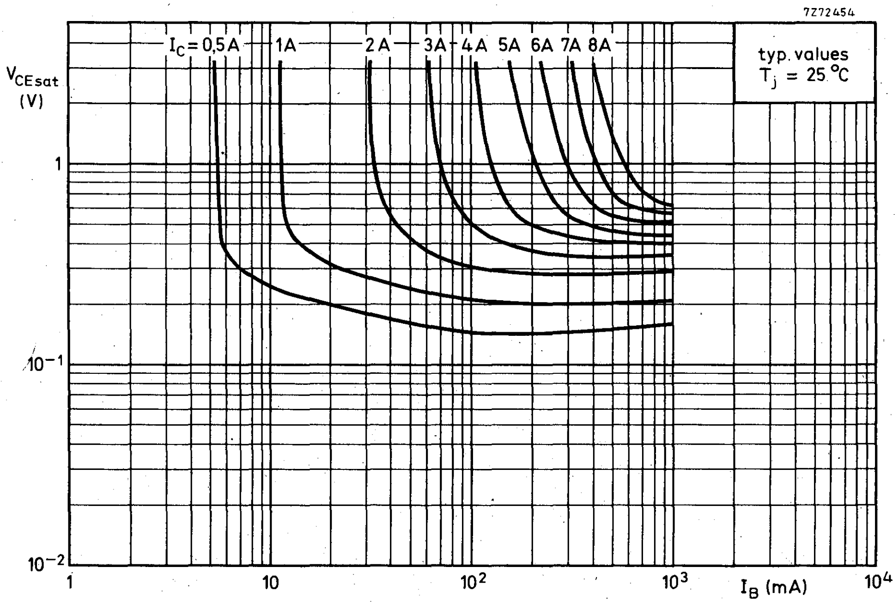

7Z67325
$P_{tot\ max}$
(%)
100
50
0
0
100
T_{mb} (°C)
200


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
M_SB(I)
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,5
1
10^−5
10^−4
10^−3
10^−2
t_p (s)


7Z72455
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
0,5
1
10^−5
10^−4
10^−3
10^−2
t_p (s)


7Z72458
$V_{CE} = 2$ V
$T_j = 25$ °C
h_{FE}
typ
10^3
10^2
10
10^{-2}
10^{-1}
1
I_C (A)
10


7Z72454
$I_C = 0{,}5$ A
1A
2 A
3A
4 A
5A
6A
7A
8A
typ. values
$T_j = 25$ °C
V_{CEsat}
(V)
1
10^{-1}
10^{-2}
1
10
10^2
10^3
I_B (mA)
10^4

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.

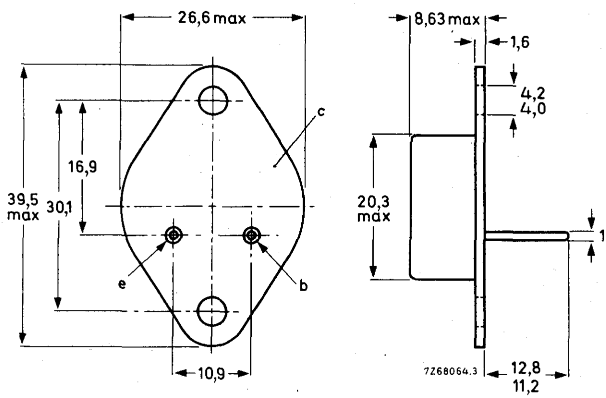
QUICK REFERENCE DATA

			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)

Voltages

			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
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 $T_{mb} = 25\ ^{o}C$	P_{tot}	max.	90	W

Temperatures

Storage temperature	T_{stg}		−65 to +200	^{o}C
Junction temperature	T_j	max.	200	^{o}C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	1,94	$^{o}C/W$

CHARACTERISTICS $T_j = 25\ ^{o}C$ unless otherwise specified

Collector cut-off current				
$I_E = 0;\ -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	0, 1	mA
$I_E = 0;\ -V_{CB} = 30\ V;\ T_j = 200\ ^{o}C$: BDX92 $I_E = 0;\ -V_{CB} = 40\ V;\ T_j = 200\ ^{o}C$: BDX94 $I_E = 0;\ -V_{CB} = 50\ V;\ T_j = 200\ ^{o}C$: BDX96	$-I_{CBO}$	<	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 [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

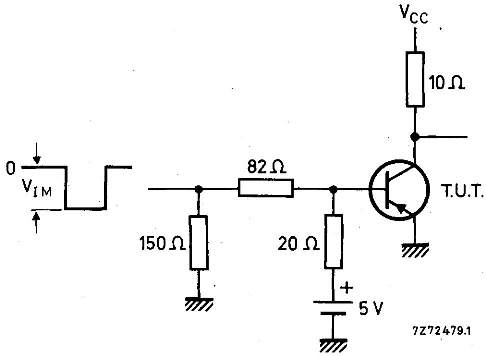
Switching times (between 10% and 90% levels)

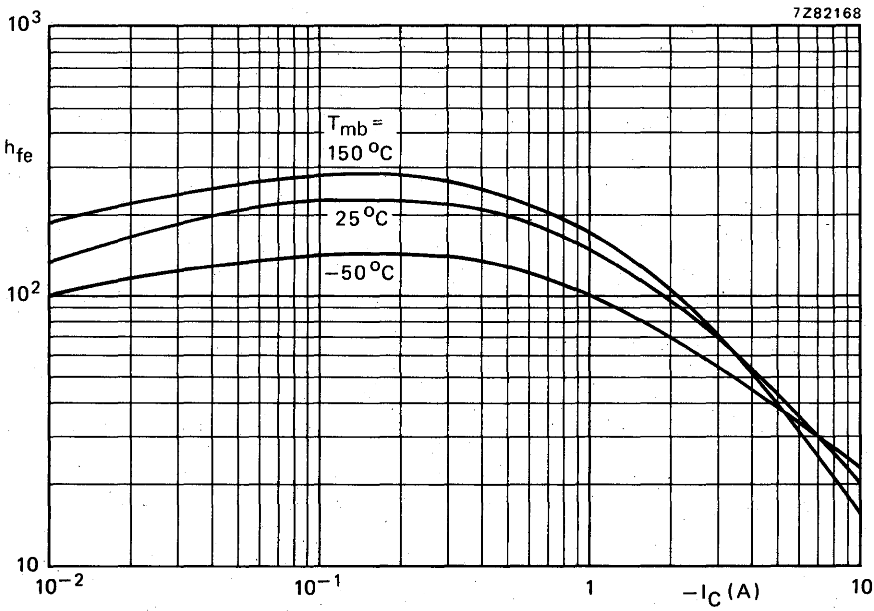
$-I_{Con} = 3$ A; $-I_{Bon} = I_{Boff} = 0,3$ A; $V_{CC} = -30$ V

Turn-on time	t_{on}	typ.	0,2 μs
		<	1 μs
Turn-off time	t_{off}	typ.	1 μs
		<	2 μs

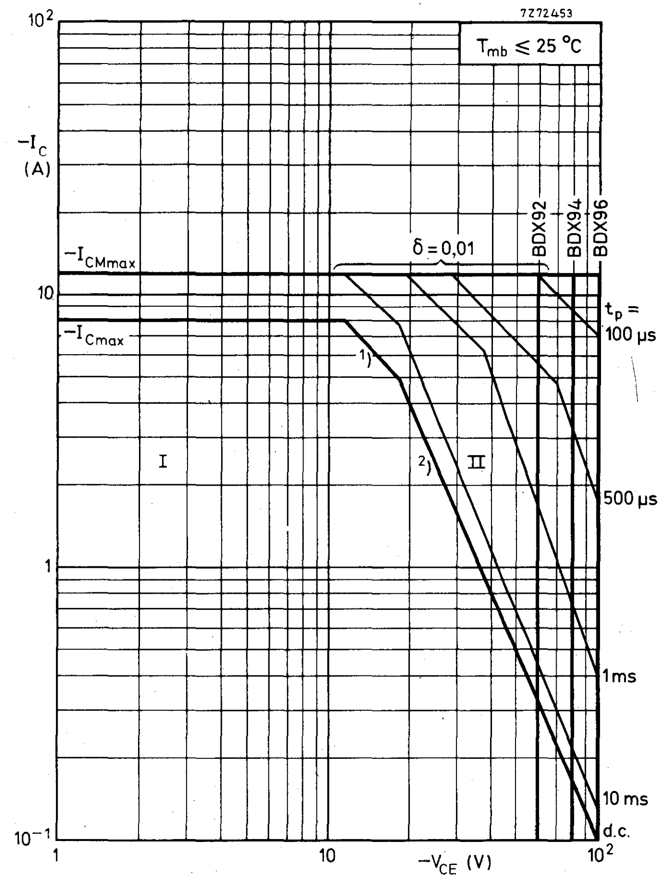
Test circuit

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

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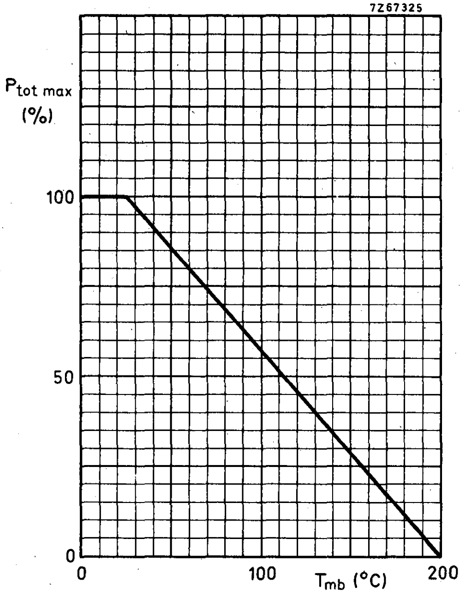
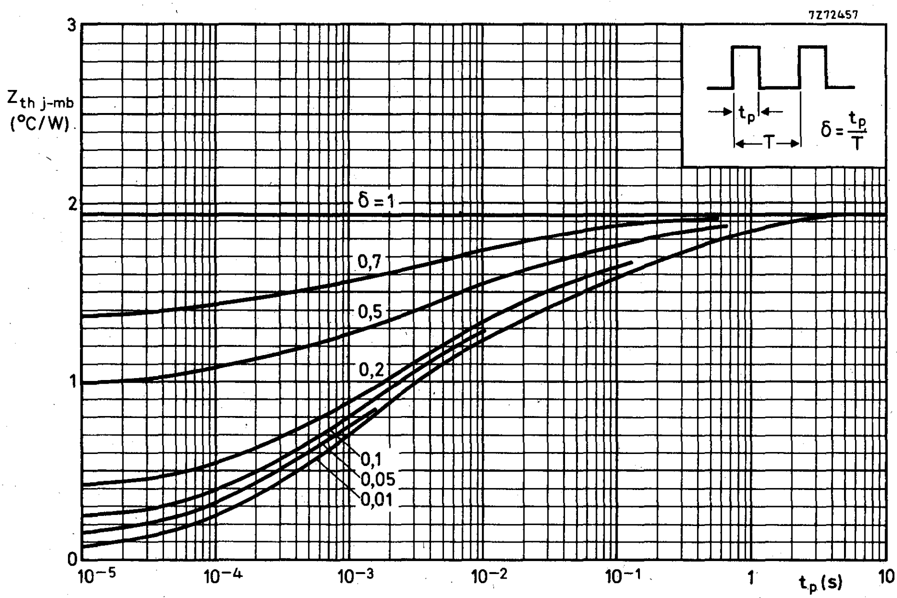
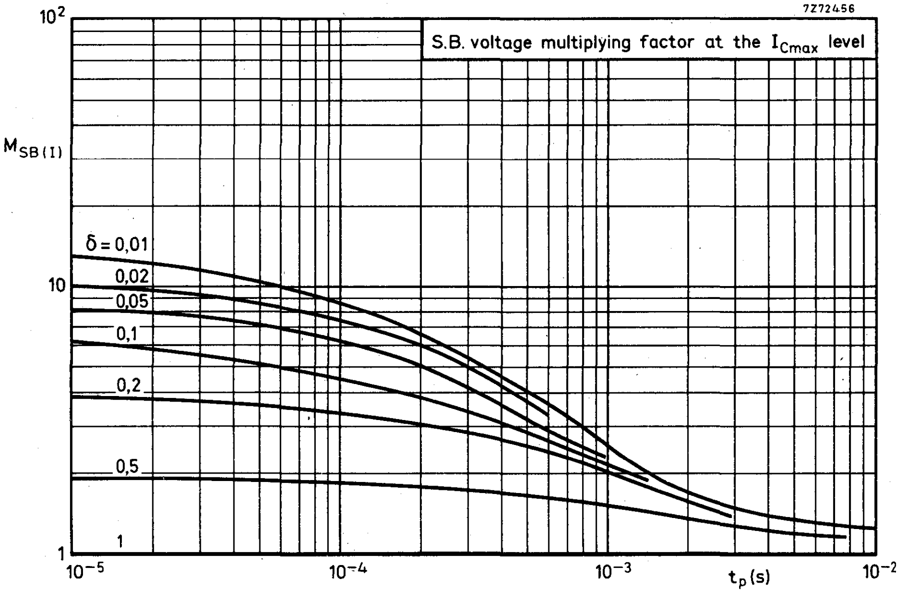
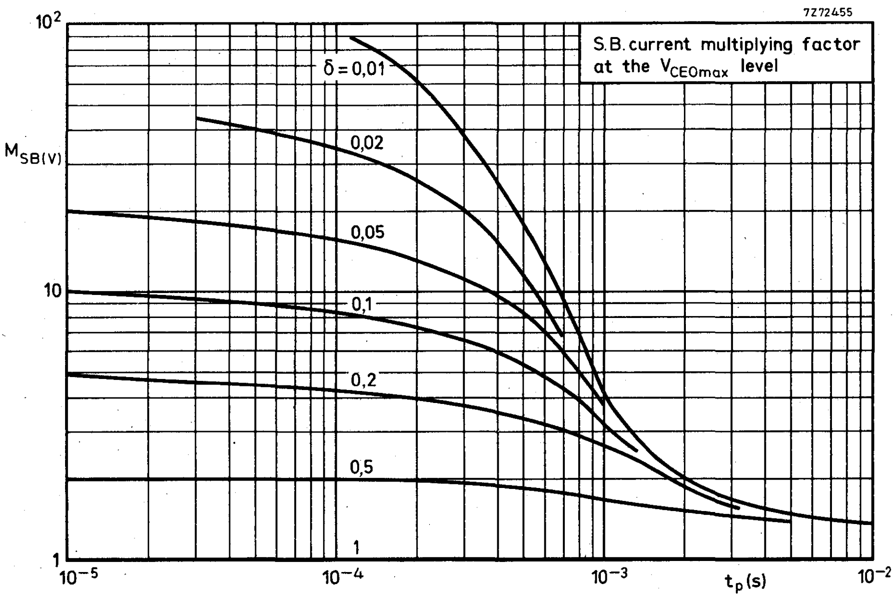
[1]) $P_{tot\ max}$ and $P_{peak\ max}$ lines.

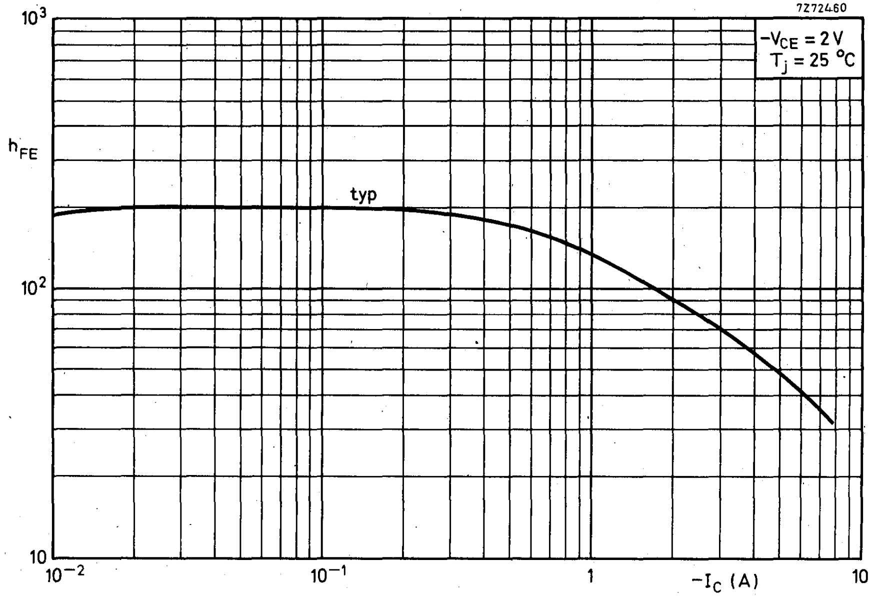
[2]) Second-breakdown limits (independent of temperature).

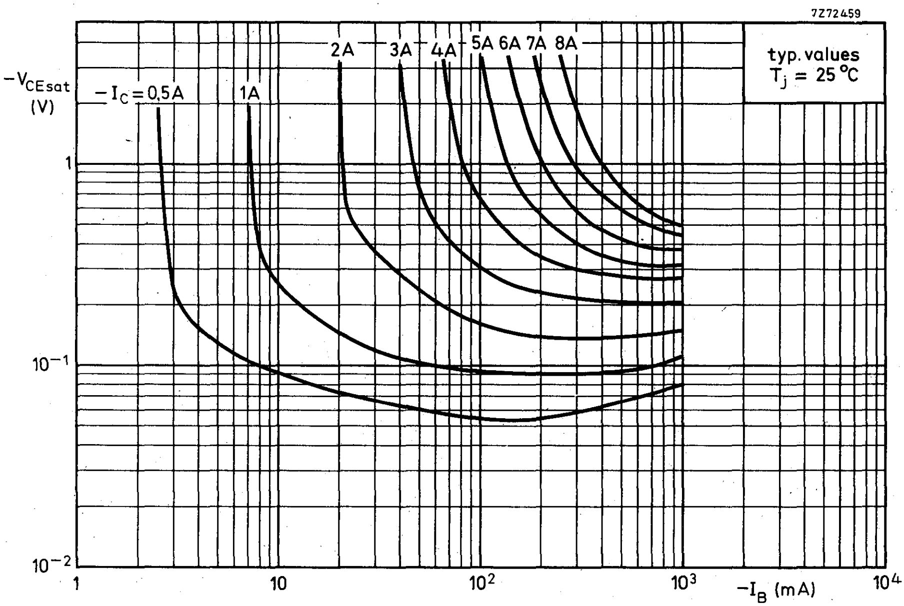

7Z67325
$P_{tot\ max}$ (%)
100
50
0
0
100
T_{mb} (°C)
200


7Z72457
$Z_{th\ j\text{-}mb}$ (°C/W)
3
2
1
0
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
t_p
T
$\delta = \frac{t_p}{T}$


7Z72456
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
0,5
1
10^{-5}
10^{-4}
10^{-3}
10^{-2}
t_p (s)


7Z72455
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
0,5
1
10^{-5}
10^{-4}
10^{-3}
10^{-2}
t_p (s)


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
10^4
$-I_B$ (mA)

SILICON DIFFUSED POWER TRANSISTORS

N-P-N transistor in a TO-3 metal envelope, intended for use in linear applications such as hi-fi amplifiers and signal processing circuits.

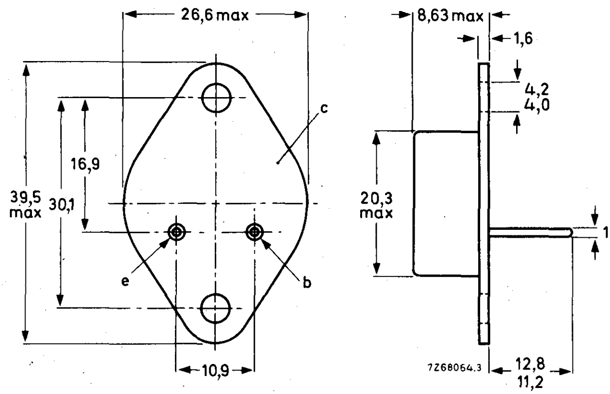
QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	V
Collector current (peak value)	I_{CM}	max.	15	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	115	W
Junction temperature	T_j	max.	200	°C
D.C. current gain I_C = 4 A; V_{CE} = 4 V	h_{FE}	20 to	70	
Transition frequency at f = 1 MHz I_C = 1 A; V_{CE} = 4 V	f_T	typ.	1	MHz

MECHANICAL DATA

Dimensions in mm

Collector connected to envelope

TO-3



For mounting instructions and accessories, see section Accessories.

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

Voltages				
Collector-base voltage (open emitter)	V_{CBO}	max.	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	V [1]
Collector-emitter voltage (R_{BE} = 100 Ω)	V_{CER}	max.	70	V [1]
Emitter-base voltage (open collector)	V_{EBO}	max.	7	V
Currents				
Collector current (d.c.)	I_C	max.	15	A
Collector current (peak value)	I_{CM}	max.	15	A
Emitter current (peak value)	$-I_{EM}$	max.	15	A
Power dissipation				
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	115	W
Temperatures				
Storage temperature	T_{stg}		-65 to +200	°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	40	°C/W
From junction to mounting base	$R_{th\ j-mb}$	=	1,5	°C/W

[1] I_C = 0.2 A

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

Collector cut-off currents		
$I_E = 0$; $V_{CB} = 100$ V	I_{CBO}	typ. 3 μA < 5 mA
$-V_{BE} = 1.5$ V; $V_{CE} = 100$ V	I_{CEX}	typ. 4 μA < 5 mA
$-V_{BE} = 1.5$ V; $V_{CE} = 100$ V; $T_j = 150\ ^oC$	I_{CEX}	typ. 0.3 mA < 10 mA
Emitter cut-off current		
$I_C = 0$; $V_{EB} = 7$ V	I_{EBO}	typ. 1 nA < 5 mA
Base-emitter voltage		
$I_C = 4$ A; $V_{CE} = 4$ V	V_{BE}	typ. 1.1 V < 1.8 V
Collector-emitter saturation voltage		
$I_C = 4$ A; $I_B = 0.4$ A	V_{CEsat}	typ. 0.4 V < 1.1 V
Knee voltage		
$I_C = 10$ A; I_B = value for which $I_C = 11$ A at $V_{CE} = 5$ V	V_{CEK}	< 3.0 V
D.C. current gain		
$I_C = 4$ A; $V_{CE} = 4$ V	h_{FE}	20 to 70
Collector capacitance at f = 1 MHz		
$I_E = I_e = 0$; $V_{CB} = 20$ V	C_c	typ. 250 pF
Transition frequency at f = 1 MHz		
$I_C = 1$ A; $V_{CE} = 4$ V	f_T	typ. 1 MHz
Cut-off frequency		
$I_C = 1$ A; $V_{CE} = 4$ V	f_{hfe}	typ. 9 kHz

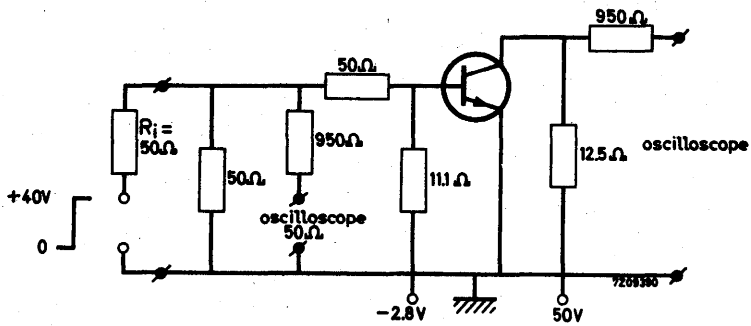
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Switching times

I_C = 4 A; I_B = $-I_{BM}$ = 400 mA

Delay time	t_d	typ. 0.4	μs
Rise time	t_r	typ. 2	μs
Storage time	t_s	typ. 2	μs
Fall time	t_f	typ. 2.5	μs

Test circuit:

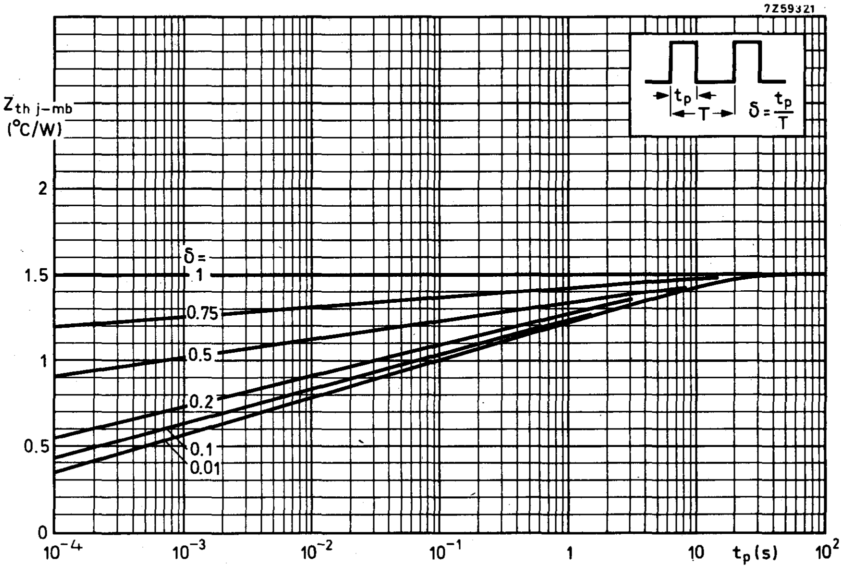


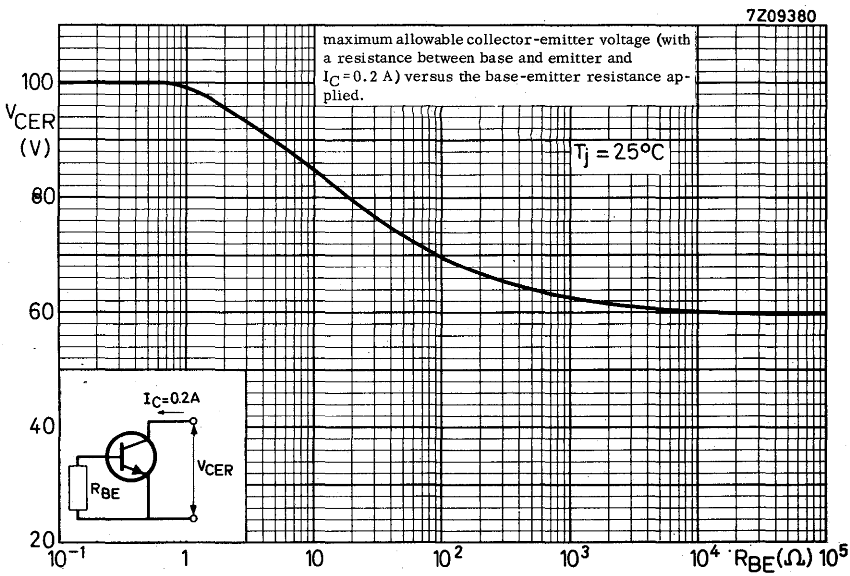
Pulse generator:

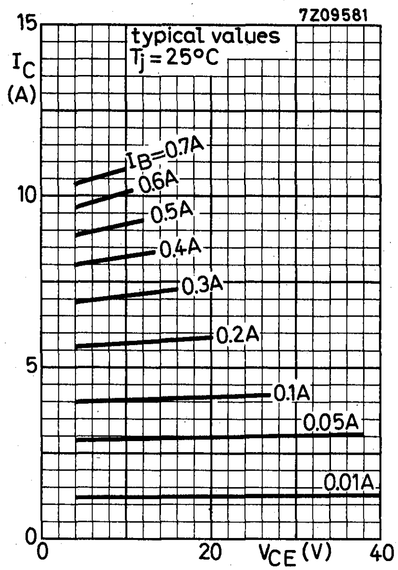
Pulse duration	t	>	10	μs
Rise time	t_r	≤	10	ns

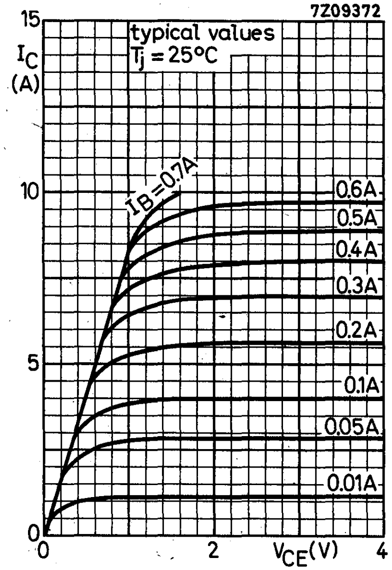
Oscilloscope:

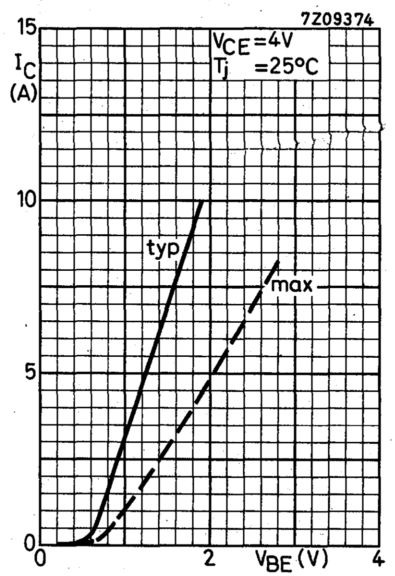
Rise time	t_r	≤	10	ns
Input resistance	R_i	=	50	Ω

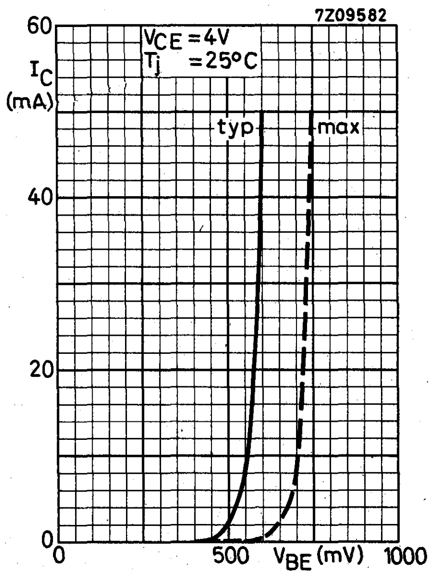

7Z59321
$Z_{th\ j-mb}$ (°C/W)
t_p T $\delta = \frac{t_p}{T}$
δ =
1
0.75
0.5
0.2
0.1
0.01
t_p (s)
0
0.5
1
1.5
2
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2

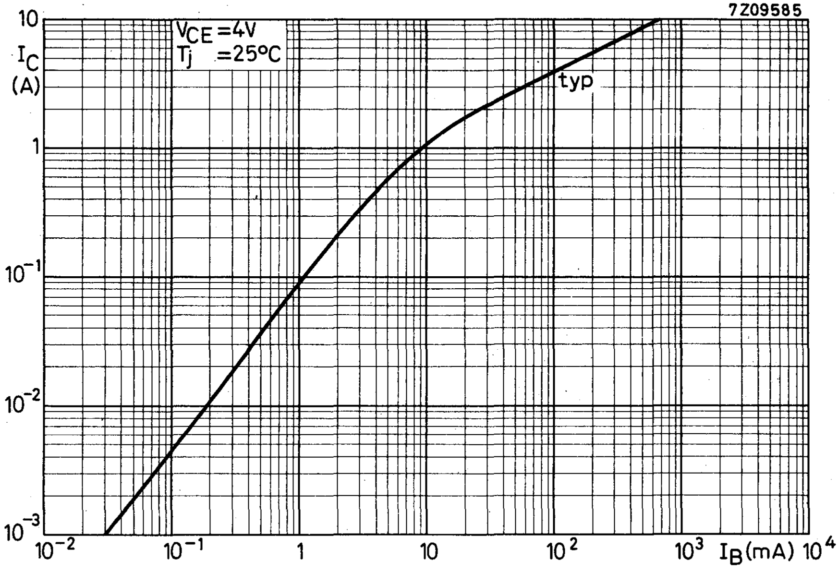

7Z09380
maximum allowable collector-emitter voltage (with a resistance between base and emitter and $I_C = 0.2$ A) versus the base-emitter resistance applied.
$T_j = 25$°C
V_{CER} (V)
I_C=0.2A
R_{BE}
V_{CER}
20
40
60
80
100
10^{-1}
1
10
10^2
10^3
10^4
R_{BE} (Ω)
10^5

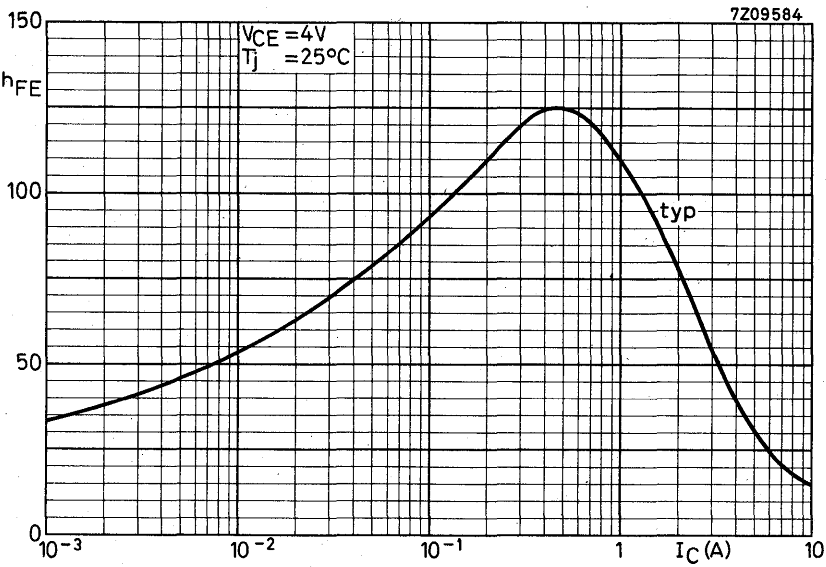

7Z09581
typical values
$T_j = 25°C$
I_C
(A)
I_B=0.7A
0.6A
0.5A
0.4A
0.3A
0.2A
0.1A
0.05A
0.01A
V_{CE} (V)
15
10
5
0
0
20
40

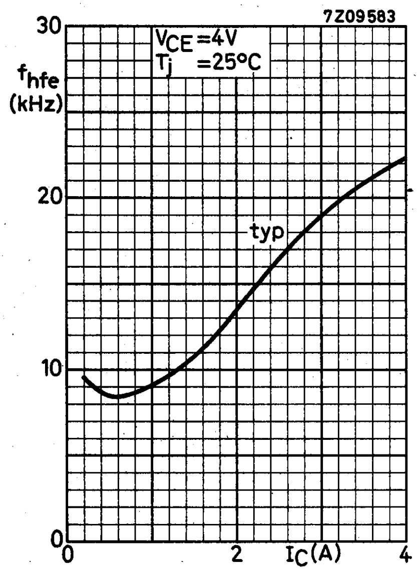

7Z09372
typical values
$T_j = 25°C$
I_C
(A)
I_B=0.7A
0.6A
0.5A
0.4A
0.3A
0.2A
0.1A
0.05A
0.01A
V_{CE}(V)
15
10
5
0
0
2
4

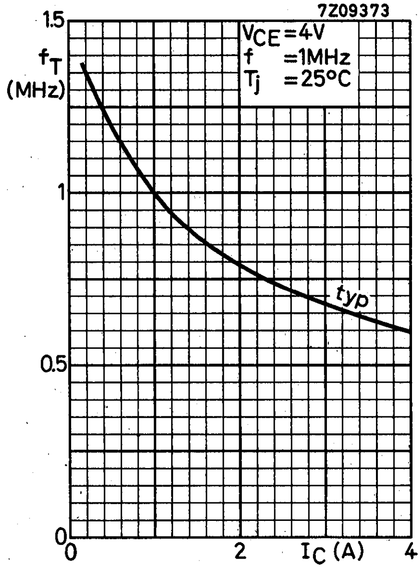

7Z09374
V_{CE}=4V
T_j =25°C
I_C
(A)
typ
max
V_{BE} (V)
15
10
5
0
0
2
4

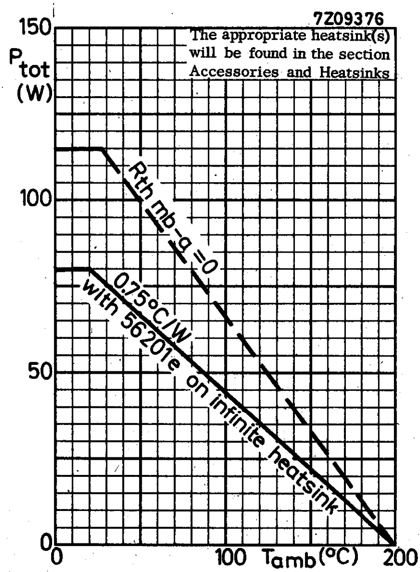

7Z09582
V_{CE} =4V
T_j =25°C
I_C
(mA)
typ
max
V_{BE} (mV)
60
40
20
0
0
500
1000

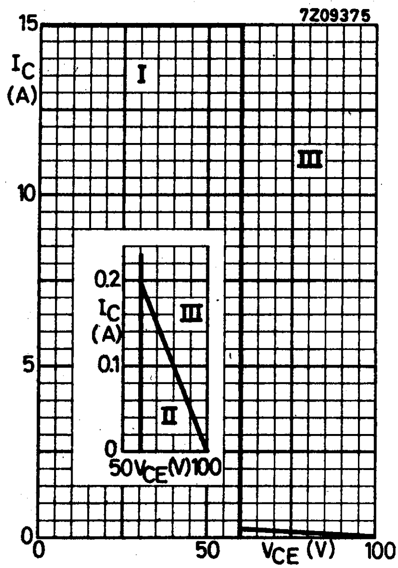

7Z09585
V_{CE} = 4V
T_j = 25°C
I_C (A)
10
1
10^{-1}
10^{-2}
10^{-3}
typ
10^{-2}
10^{-1}
1
10
10^2
10^3
I_B (mA)
10^4


7Z09584
V_{CE} = 4V
T_j = 25°C
h_{FE}
150
100
50
0
typ
10^{-3}
10^{-2}
10^{-1}
1
I_C (A)
10


7Z09583
V_{CE} = 4V
T_j = 25°C
f_{hfe} (kHz)
typ
I_C (A)
30
20
10
0
0
2
4


7Z09373
V_{CE} = 4V
f = 1MHz
T_j = 25°C
f_T (MHz)
typ
I_C (A)
1.5
1
0.5
0
0
2
4

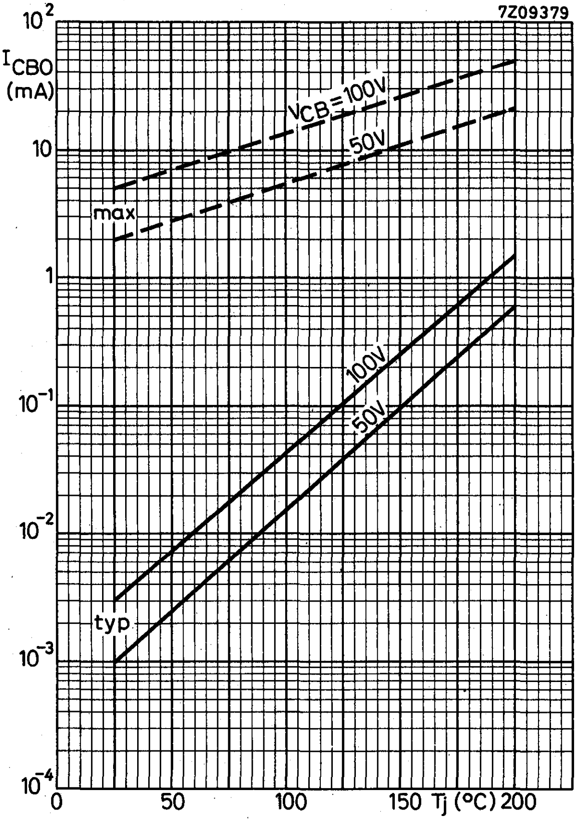

7Z09376
The appropriate heatsink(s) will be found in the section Accessories and Heatsinks
P_{tot} (W)
Rth mb-a = 0
0.75°C/W
with 56201e on infinite heatsink
T_{amb} (°C)
150
100
50
0
0
100
200



I Region of permissible operation under all base-emitter conditions provided no limiting values are exceeded.

II Additional region of operation when the transistor is cut-off with $-V_{BE} \leq 1.5$ V.

III Operation during switching off is allowed, provided the transistor is cut-off with $-V_{BE} \leq 1.5$ V and the transient energy does not exceed 75 mWs.


7Z09379
I_{CBO} (mA)
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
V_{CB}=100V
50V
max
100V
50V
typ
0
50
100
150
200
T_j (°C)

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

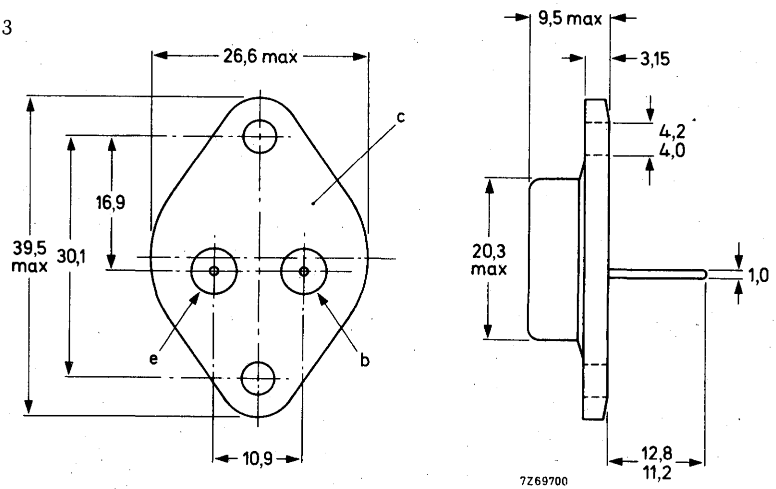
			BDY90	BDY91	BDY92
Collector-base voltage (open emitter)	V_{CBO}	max.	120	100	80 V
Collector-emitter voltage (open base)	V_{CEO}	max.	100	80	60 V
Collector current (peak value)	I_{CM}	max.	15	15	15 A
Total power dissipation up to T_{mb}=75°C	P_{tot}	max.	40	40	40 W
Collector-emitter saturation voltage I_C = 10 A; I_B = 1 A	V_{CEsat}	<	1.5	1.5	1.0 V
Fall time I_C = 5.0 A; I_B = $-I_{BM}$ = 0.5A V_{CC} = 30 V	t_f	<	0.2	0.2	0.2 μs
Transition frequency at f = 5 MHz I_C = 0.5 A; V_{CE} = 5 V	f_T	typ.	70	70	70 MHz

MECHANICAL DATA

Collector connected to case

Dimensions in mm

TO-3



For mounting instructions and accessories, see section Accessories.

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

Voltages (See also pages 4, 5 and 6)			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

Currents			
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
Power dissipation			
Total power dissipation up to T_{mb}=75°C	P_{tot}	max.	40 W
Temperatures			
Storage temperature	T_{stg}		−65 to + 175 °C
Junction temperature	T_j	max.	175 °C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2.5 °C/W

CHARACTERISTICS — Tj = 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 = 10 A; I_B = 1 A	BDY90 BDY91	V_{CEsat}	<	1.5 V
	BDY92	V_{CEsat}	<	1.0 V
	BDY90 to 92	V_{BEsat}	<	1.5 V

CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

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

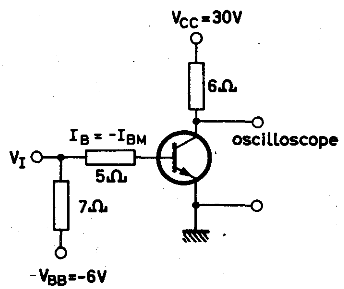
Turn on time

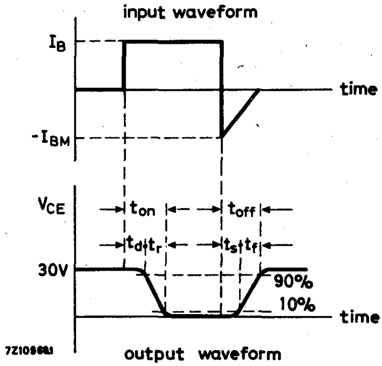
I_C = 5 A; $I_B = -I_{BM}$ = 0.5 A				
V_{CC} = 30 V	t_{on}	<	0.35	µs

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

Test circuit

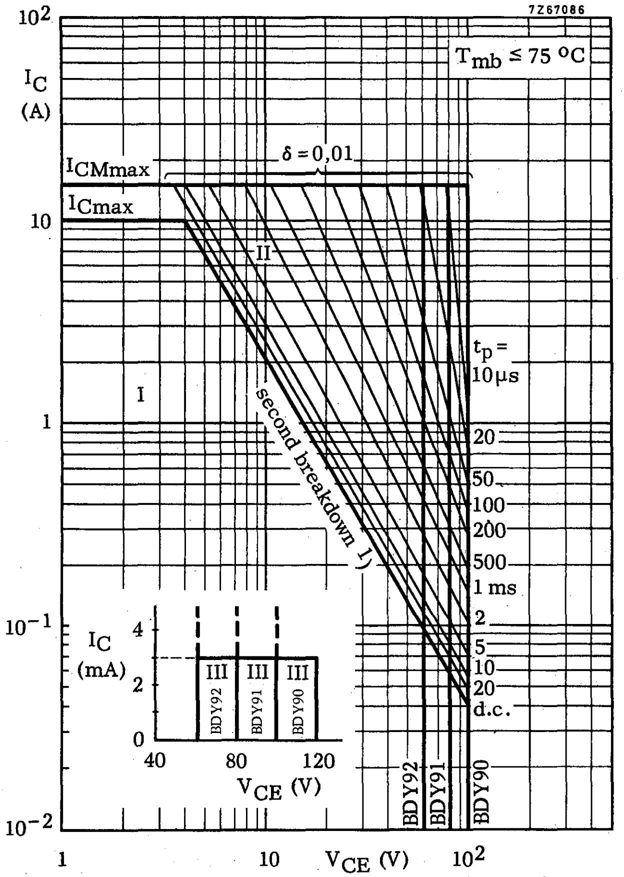




Pulse generator:

Rise time	t_r	<	50	ns
Fall time	t_f	<	50	ns

Pulse duration	t_p	=	20	µs
Duty cycle	δ	=	0.02	

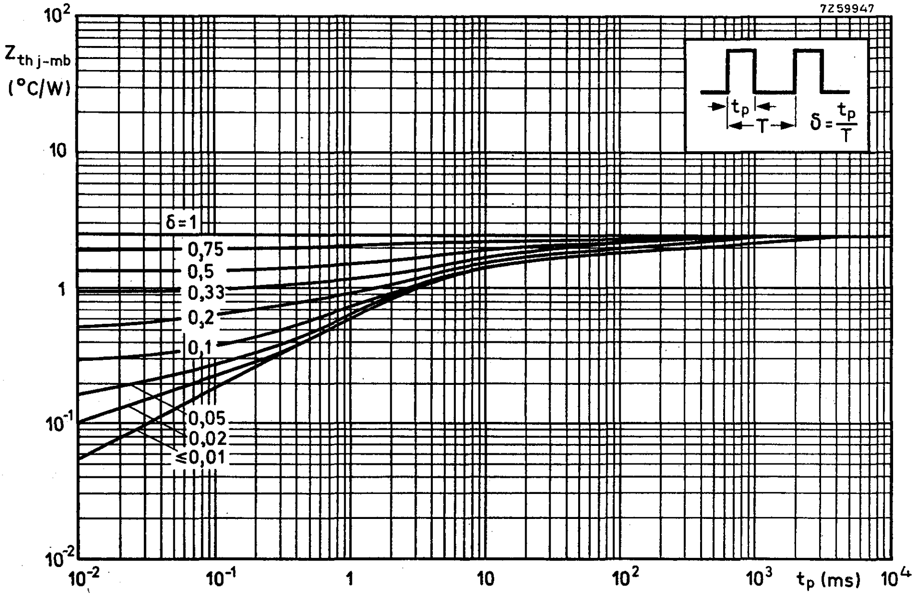


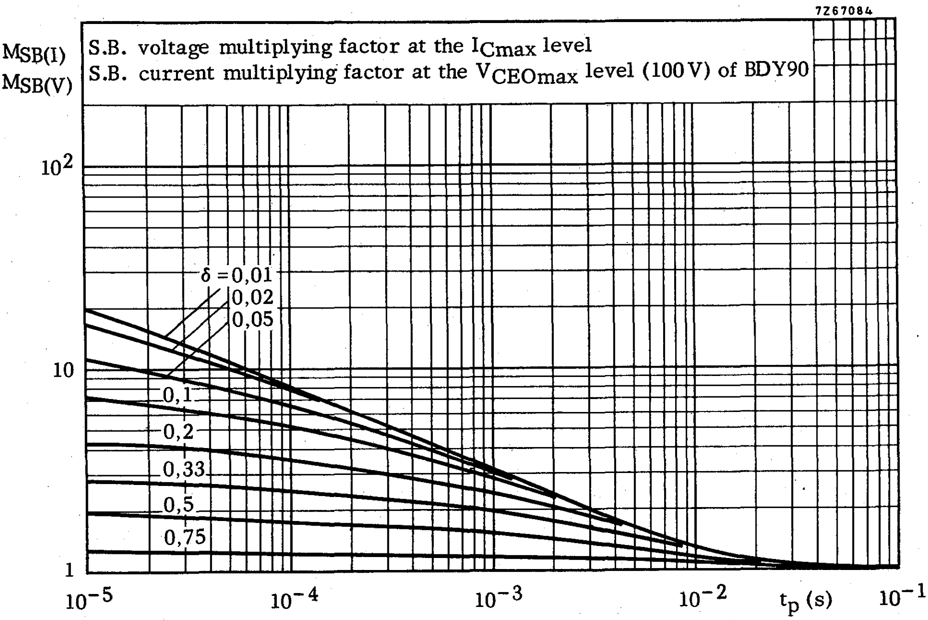
Safe Operating Area (Regions I and II forward biased)

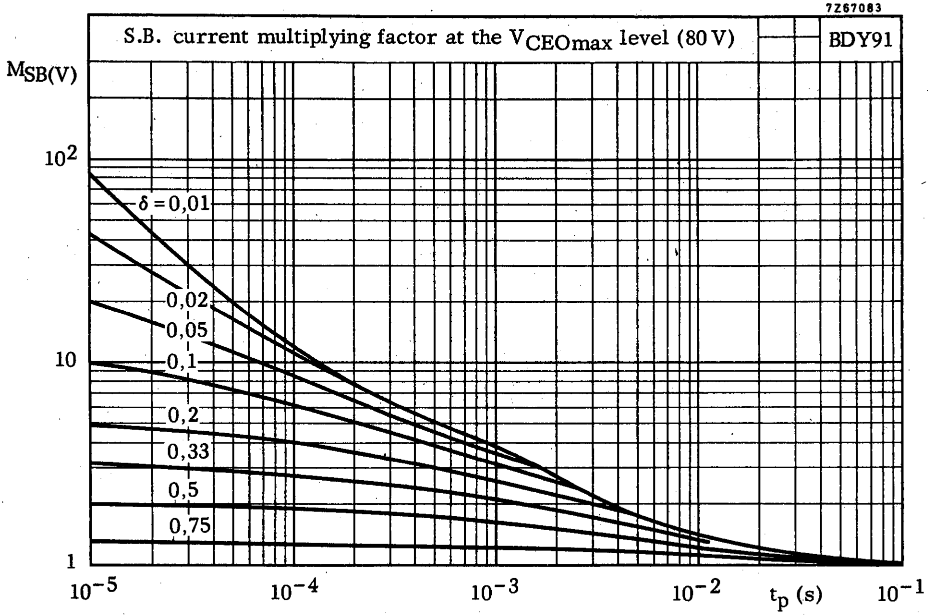
I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation
III Repetitive pulse operation in this region is allowable, provided $-V_{BE} \geq 1{,}5$ V

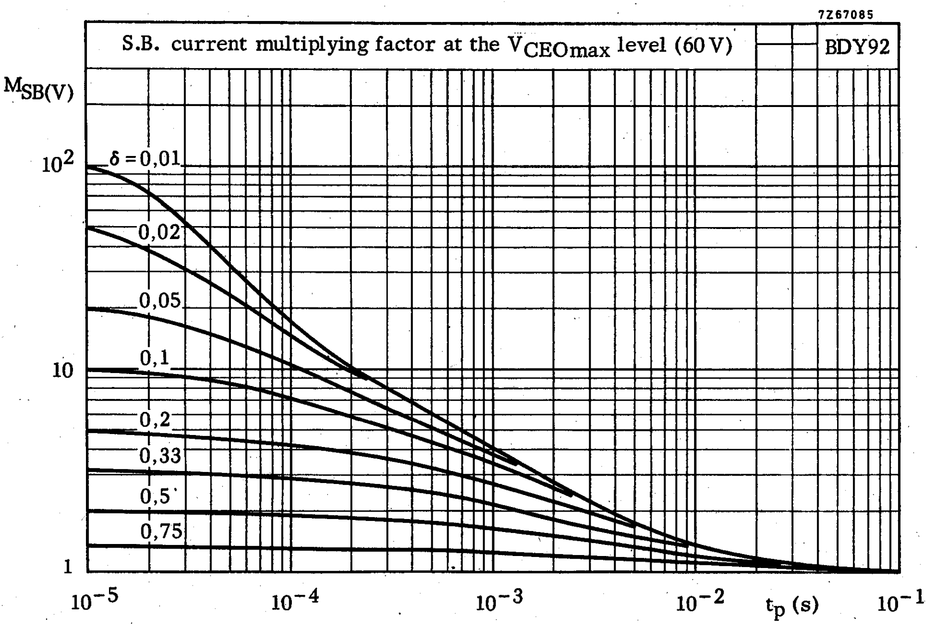
For $P_{tot\ max}$ versus T_{mb} see page 10.

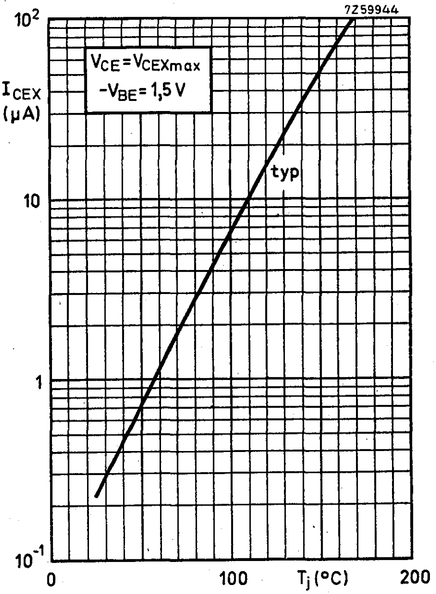
1) Independent of temperature

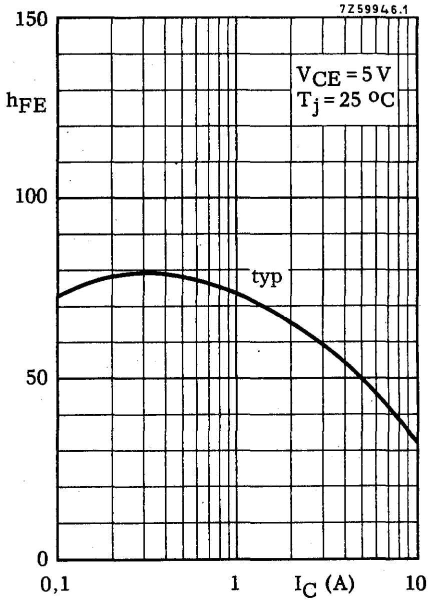

7Z59947
$Z_{th\ j\text{-}mb}$ (°C/W)
$\delta = \frac{t_p}{T}$
δ=1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
≤0,01
t_p (ms)

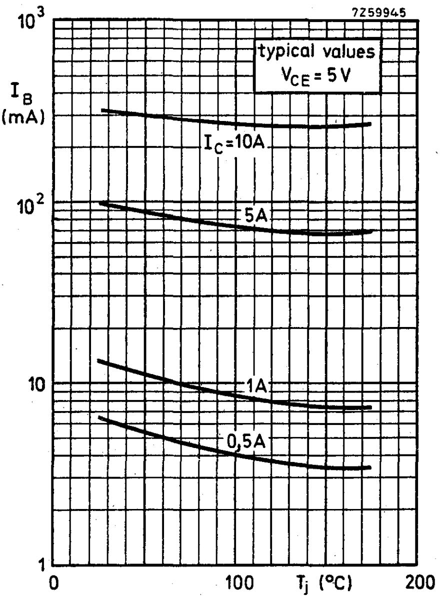

7Z67084
$M_{SB(I)}$ S.B. voltage multiplying factor at the I_{Cmax} level
$M_{SB(V)}$ S.B. current multiplying factor at the V_{CEOmax} level (100 V) of BDY90
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
t_p (s)

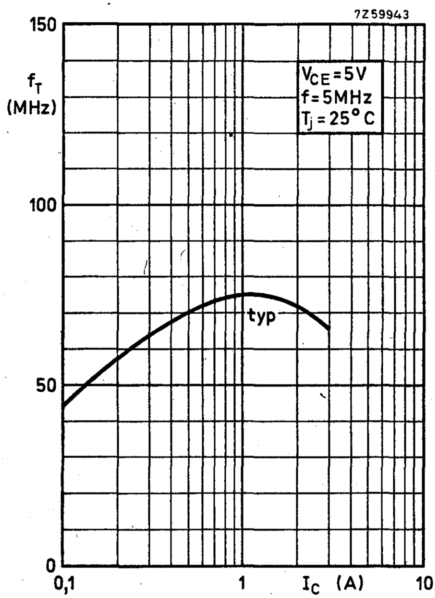

7Z67083
S.B. current multiplying factor at the V_{CEOmax} level (80 V)
BDY91
$M_{SB(V)}$
10^2
10
1
$\delta = 0,01$
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-5}
10^{-4}
10^{-3}
10^{-2}
t_p (s)
10^{-1}

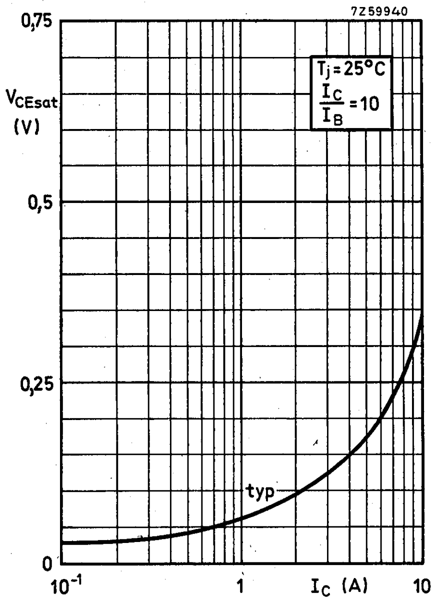

7Z67085
S.B. current multiplying factor at the V_{CEOmax} level (60 V)
BDY92
$M_{SB(V)}$
10^2
10
1
$\delta = 0,01$
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-5}
10^{-4}
10^{-3}
10^{-2}
t_p (s)
10^{-1}

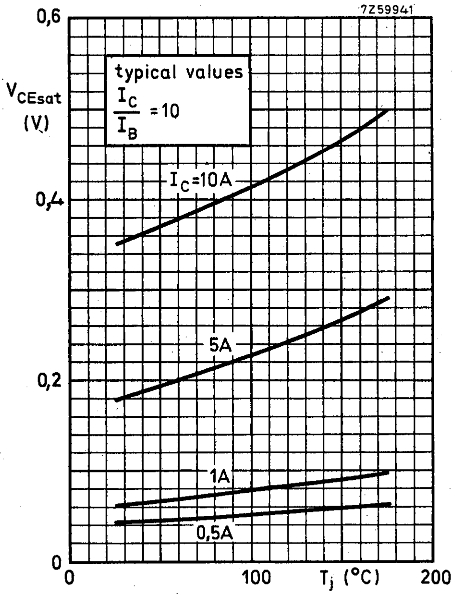

7Z59944
$V_{CE} = V_{CEXmax}$
$-V_{BE} = 1{,}5$ V
I_{CEX} (μA)
typ
10^2
10
1
10^{-1}
0
100
T_j (°C)
200

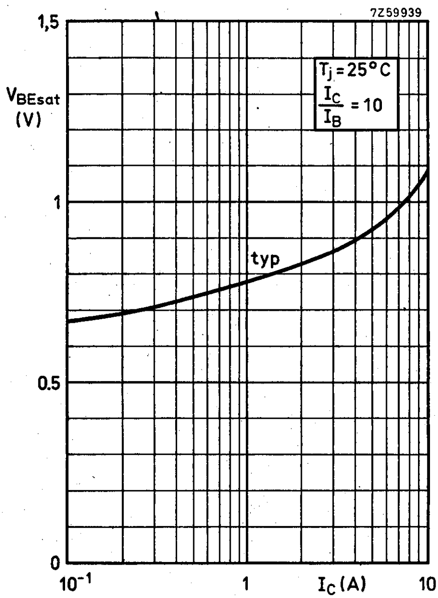

7Z59946.1
$V_{CE} = 5$ V
$T_j = 25$ °C
h_{FE}
typ
150
100
50
0
0,1
1
I_C (A)
10

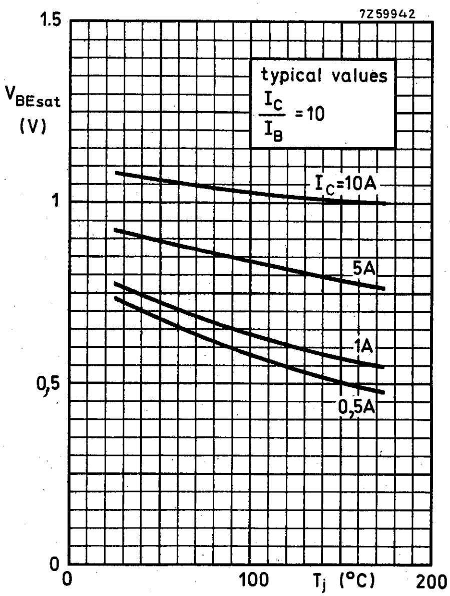

7Z59945
typical values
$V_{CE} = 5$ V
I_B (mA)
$I_C = 10$A
5A
1A
0,5A
10^3
10^2
10
1
0
100
T_j (°C)
200


7Z59943
$V_{CE} = 5$ V
f = 5 MHz
$T_j = 25$ °C
f_T (MHz)
typ
150
100
50
0
0,1
1
I_C (A)
10


7Z59940
0,75
V_{CEsat}
(V)
0,5
0,25
0
$T_j = 25°C$
$\frac{I_C}{I_B} = 10$
typ
10^{-1}
1
I_C (A)
10

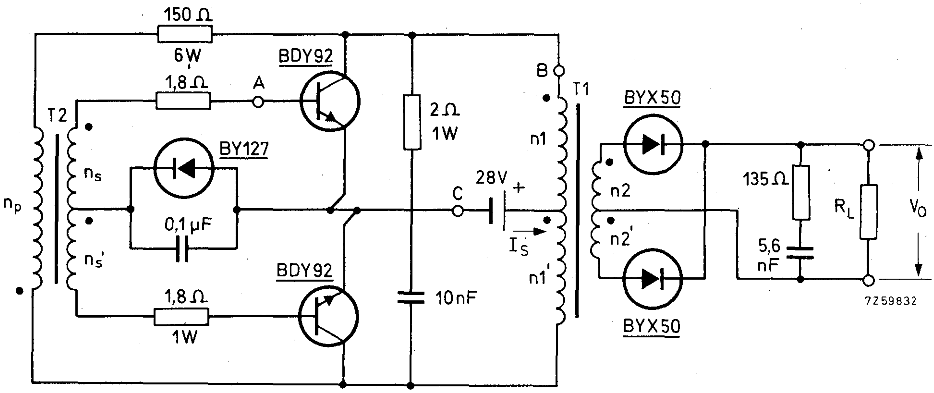

7Z59941
0,6
V_{CEsat}
(V)
0,4
0,2
0
typical values
$\frac{I_C}{I_B} = 10$
I_C=10A
5A
1A
0,5A
0
100
T_j (°C)
200


7Z59939
1,5
V_{BEsat}
(V)
1
0.5
0
$T_j = 25°C$
$\frac{I_C}{I_B} = 10$
typ
10^{-1}
1
I_C (A)
10


7Z59942
1.5
V_{BEsat}
(V)
1
0,5
0
typical values
$\frac{I_C}{I_B} = 10$
I_C=10A
5A
1A
0,5A
0
100
T_j (°C)
200

APPLICATION INFORMATION

Typical operation in a 250 W d.c. to d.c. converter with two BDY92 transistors



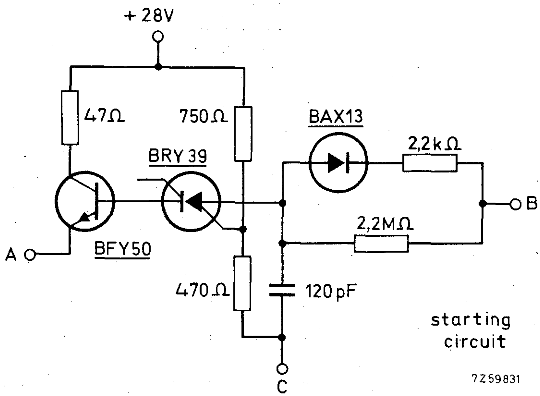
Each transistor is mounted on a heatsink of $R_{th\ h\text{-}a}$ = 15 °C/W

Performance at T_{amb} = 55 °C

I_S = 10,5 A
V_O = 240 V
P_O = 250 W
η = 84 %
f = 28,5 kHz

Losses at P_O = 250 W

In transistors	2 x 6 W
In diodes	2 x 2 W
In transformers	8 W
Circuit losses	14 W



Transformer data

T_1 = Ferroxcube core E55 material 3E1
Cat. No. 4332 020 34900

$n_1 + n_1'$ is bifilarly wound

$n_1 = n_1'$ = 9 turns, ϕ 1,4 mm

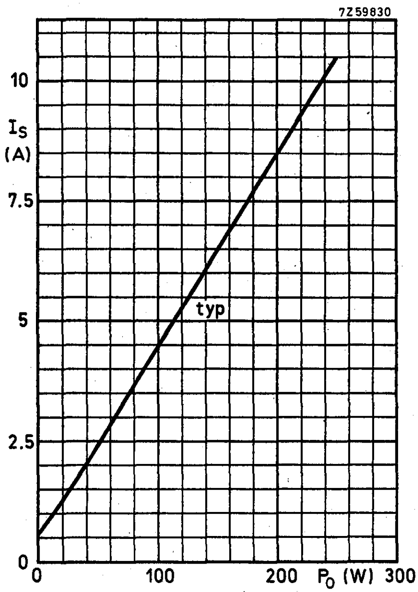
$n_2 = n_2'$ = 85 turns, ϕ 0,5 mm

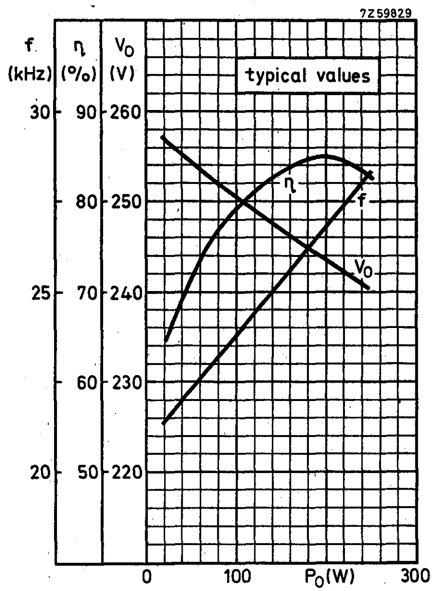
T_2 = Ferroxcube core H16 material 3E2
Cat. No. 4322 020 33030

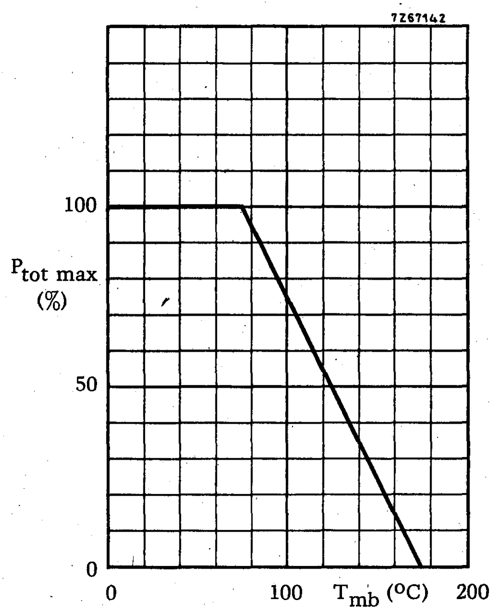
$n_s + n_s'$ is bifilarly wound

$n_s = n_s'$ = 4 turns, ϕ 0,7 mm

n_p = 24 turns, ϕ 0,3 mm


7Z59830
10
I_S
(A)
7.5
5
2.5
0
typ
0
100
200
P_o (W)
300


7Z59829
f
(kHz)
η
(%)
V_o
(V)
typical values
30
90
260
80
250
25
70
240
60
230
20
50
220
η
f
V_o
0
100
P_o(W)
300


7Z67142
100
$P_{tot\ max}$
(%)
50
0
0
100
T_{mb} (°C)
200

SILICON DIFFUSED POWER TRANSISTORS

High voltage, high speed switching n-p-n power transistors in a TO-3 envelope, intended for use in converters, inverters, switching regulators and motor control systems.

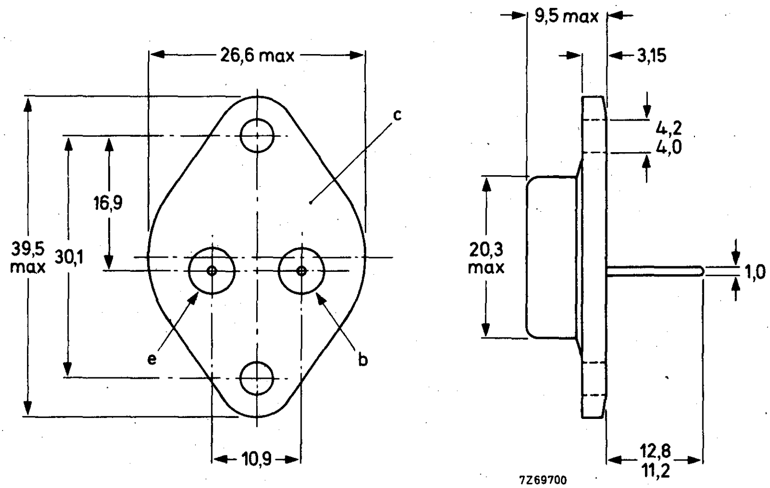
QUICK REFERENCE DATA

			BDY93	BDY94	
Collector-emitter peak voltage (V_{BE} = 0)	V_{CESM}	max.	750	750	V
Collector-emitter voltage (R_{BE} = 100 Ω)	V_{CER}	max.	450	400	V
Collector-emitter voltage (open base)	V_{CEO}	max.	350	300	V
Collector current (d.c.)	I_C	max.	4	4	A
Collector current (peak value)	I_{CM}	max.	7	7	A
Total power dissipation up to T_{mb} = 75 °C	P_{tot}	max.	30	30	W
Collector-emitter saturation voltage I_C = 2,5 A; I_B = 0,5 A	V_{CEsat}	<	1,5	1,5	V
Fall time I_C = 2,5 A; I_{B1} = 0,5 A; $-I_{B2}$ = 1 A	t_f	typ.	0,4	0,5	μs

MECHANICAL DATA Dimensions in mm

Collector connected to case

TO-3



For mounting instructions and accessories, see section Accessories.

SILICON DIFFUSED POWER TRANSISTORS

High voltage, high speed switching n-p-n power transistors in a TO-3 envelope, intended for use in converters, inverters, switching regulators and motor control systems.

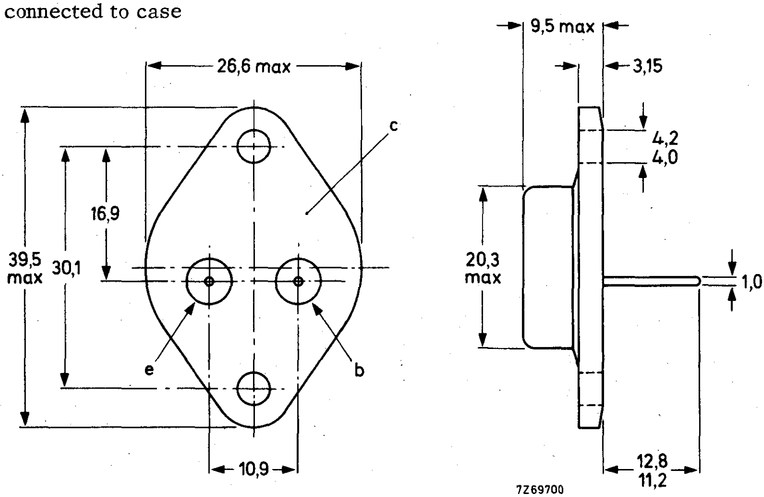
QUICK REFERENCE DATA

			BDY96	BDY97	
Collector-emitter peak voltage (V_{BE} = 0)	V_{CESM}	max.	750	750	V
Collector-emitter voltage (R_{BE} = 100 Ω)	V_{CER}	max.	450	400	V
Collector-emitter voltage (open base)	V_{CEO}	max.	350	300	V
Collector current (d.c.)	I_C	max.	10	10	A
Collector current (peak value)	I_{CM}	max.	15	15	A
Total power dissipation up to T_{mb} = 90 °C	P_{tot}	max.	40	40	W
Collector-emitter saturation voltage I_C = 5 A; I_B = 1 A	V_{CEsat}	<	1,5	1,5	V
Fall time I_C = 5 A; I_{B1} = 1 A; $-I_{B2}$ = 2 A	t_f	typ.	0,3	0,4	μs

MECHANICAL DATA Dimensions in mm

TO-3

Collector connected to case



For mounting instructions and accessories, see section Accessories

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

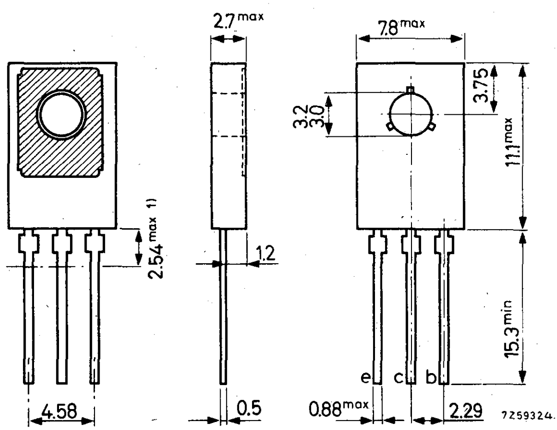
Collector-base voltage (open emitter)	V_{CBO}	max.	300	V
Collector-emitter voltage (open base)	V_{CEO}	max.	250	V
Collector current (peak value)	I_{CM}	max.	300	mA
Total power dissipation up to T_{mb} = 90 °C	P_{tot}	max.	6	W
Junction temperature	T_j	max.	150	°C
D.C. current gain I_C = 20 mA; V_{CE} = 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

$T_j = 25\ ^oC$

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_{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 ^oC is not exceeded. For the typical circuit shown below, a heatsink is not required for operation with $T_{amb} \leqslant 70\ ^oC$.

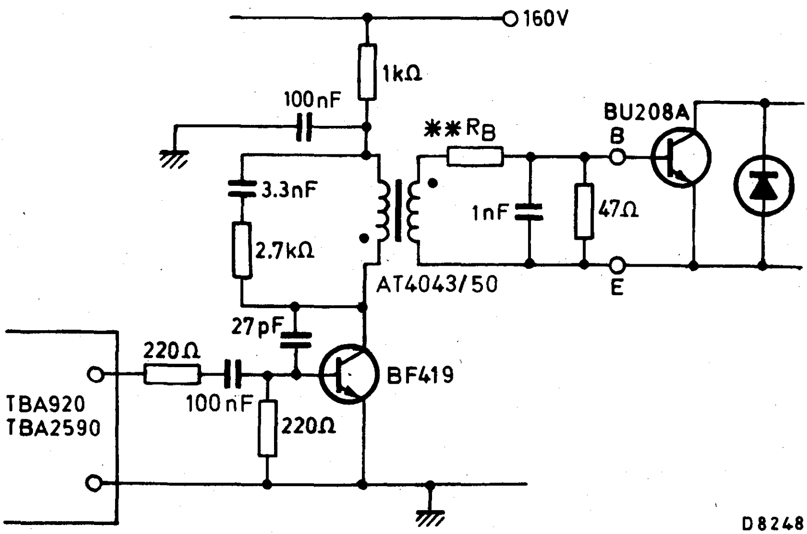


Fig.2 Typical circuit.

** 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.

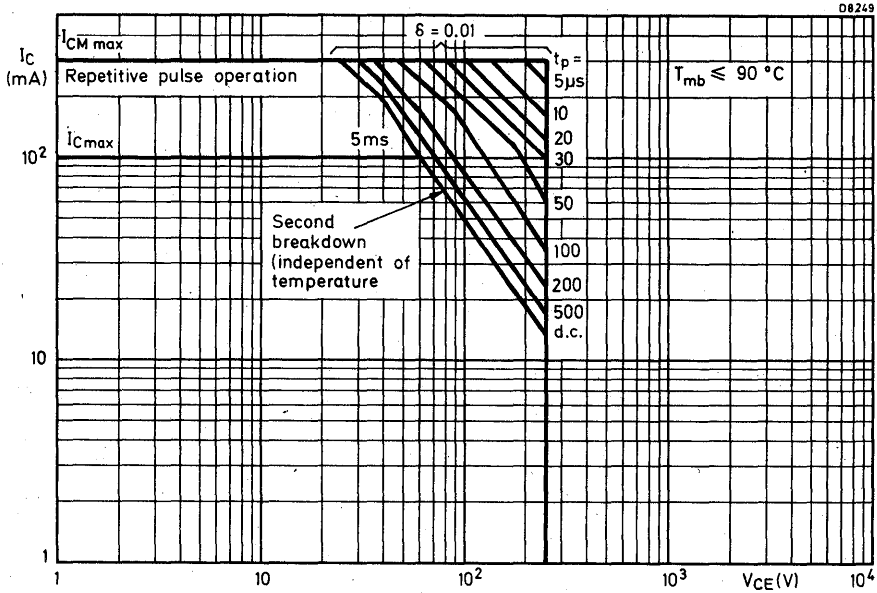


Fig.3 Safe Operating AReas with the transistor forward biased.

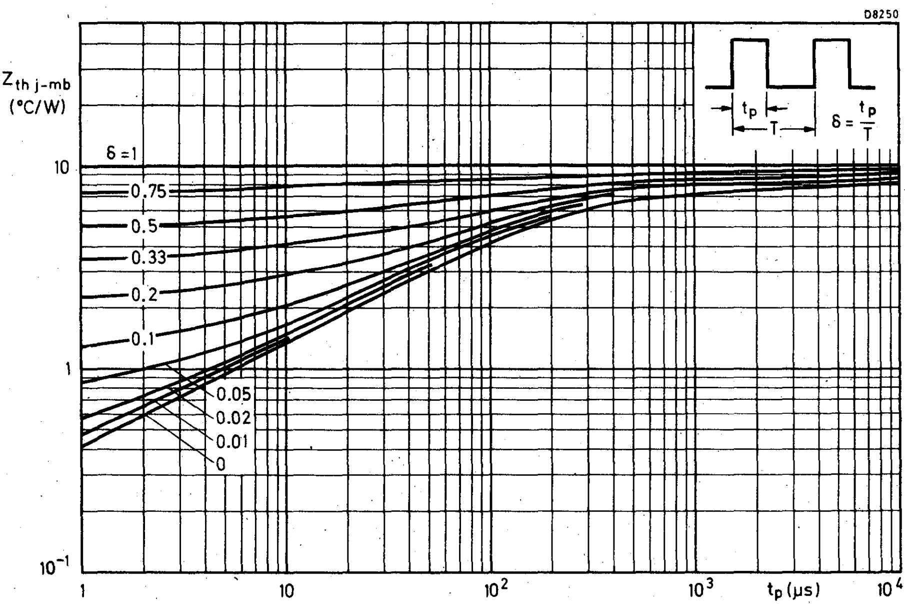


Fig. 4.

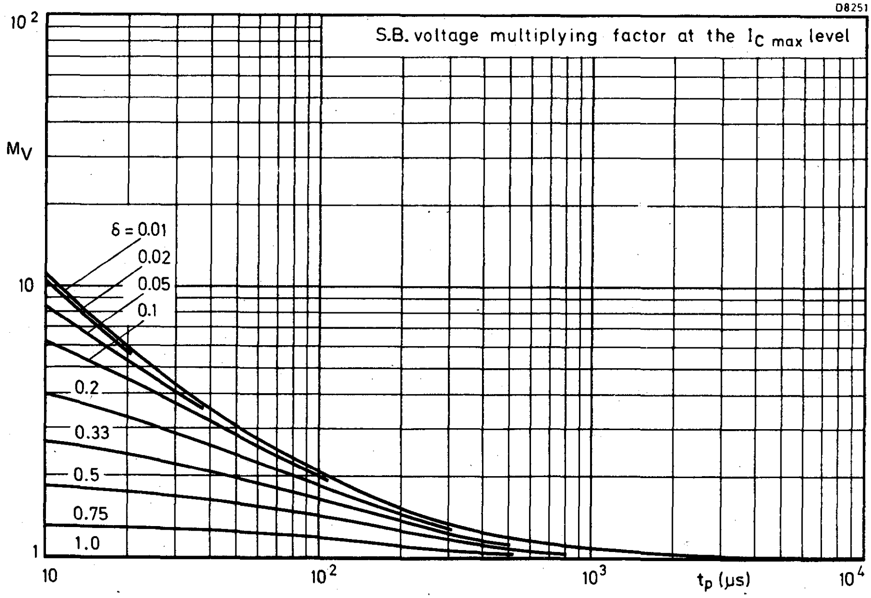

D8251
S.B. voltage multiplying factor at the $I_{C\,max}$ level
10^2
M_V
δ = 0.01
0.02
0.05
0.1
10
0.2
0.33
0.5
0.75
1.0
1
10
10^2
10^3
t_p (μs)
10^4

Fig. 5.

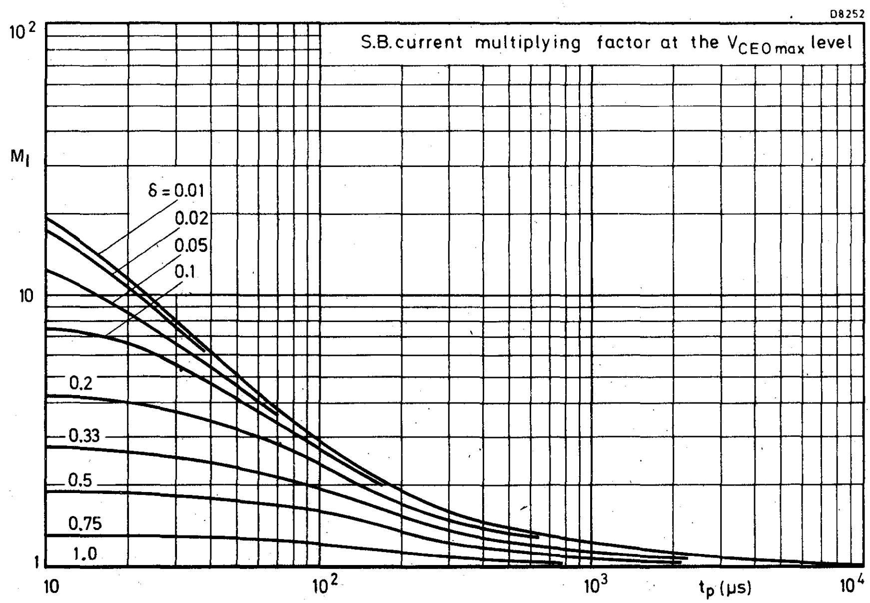

D8252
S.B. current multiplying factor at the $V_{CEO\,max}$ level
10^2
M_I
δ = 0.01
0.02
0.05
0.1
10
0.2
0.33
0.5
0.75
1.0
1
10
10^2
10^3
t_p (μs)
10^4

Fig. 6.

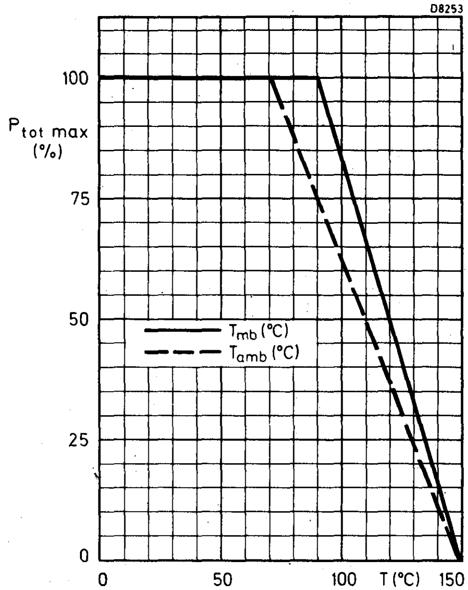


Fig. 7.

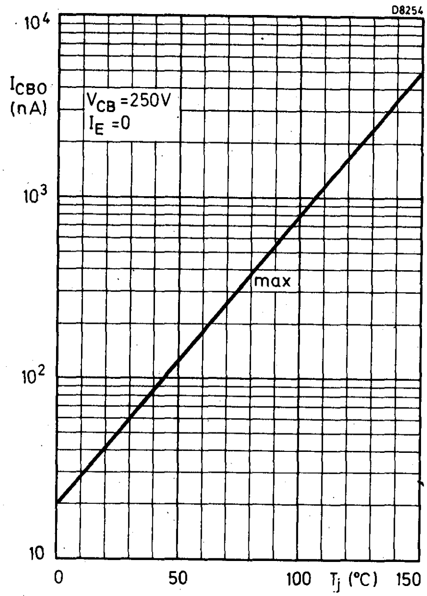


Fig. 8.

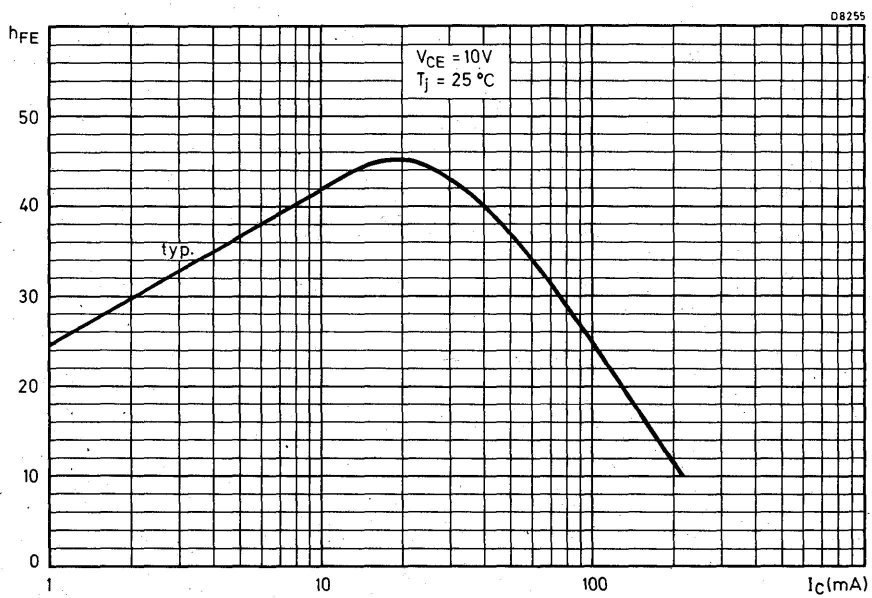


Fig. 9.

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

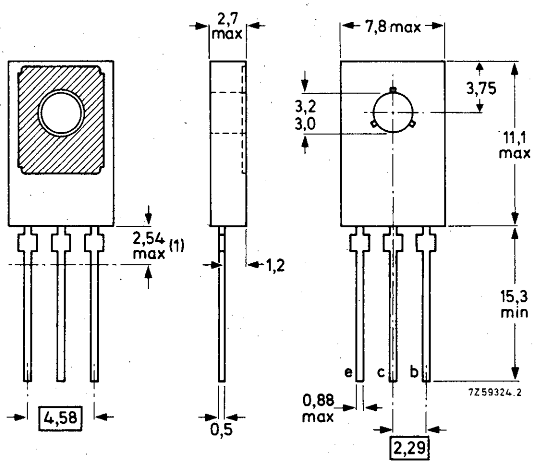
			BF457	BF458	BF459	
Collector-base voltage (open emitter)	V_{CBO}	max.	160	250	300	V
Collector-emitter voltage (open base)	V_{CEO}	max.	160	250	300	V
Collector current (peak value)	I_{CM}	max.		300		mA
Total power dissipation up to T_{mb} = 90 °C	P_{tot}	max.		6		W
Junction temperature	T_j	max.		150		°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 °C	P_{tot}	max.	6	W

Temperature

Storage temperature	T_{stg}		−55 to +150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

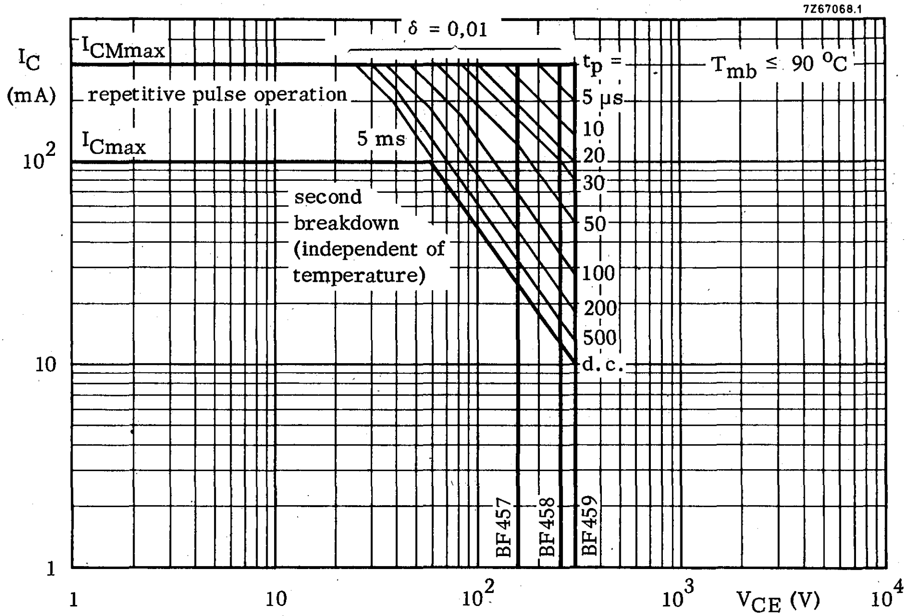
From junction to ambient	$R_{th\ j\text{-}a}$	=	104	°C/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	10	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

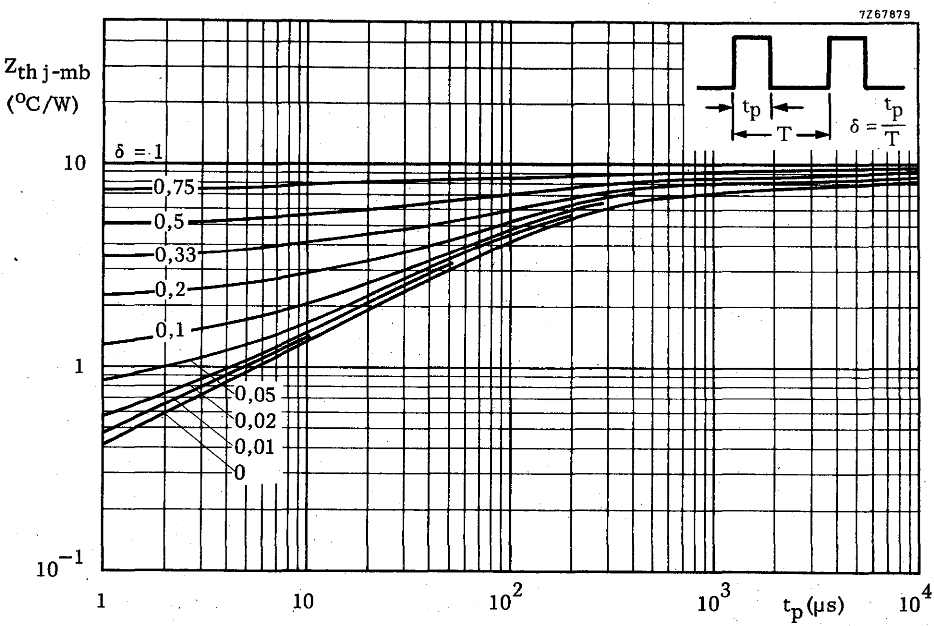
Collector cut-off current				
$I_E = 0$; $V_{CB} = 100$ V for BF457				
$I_E = 0$; $V_{CB} = 200$ V for BF458	I_{CBO}	<	50	nA
$I_E = 0$; $V_{CB} = 250$ V for BF459				
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 3$ V	I_{EBO}	<	50	nA
D.C. current gain				
$I_C = 30$ mA; $V_{CE} = 10$ V	h_{FE}	>	26	
Collector-emitter saturation voltage				
$I_C = 30$ mA; $I_B = 6$ mA	V_{CEsat}	<	1	V
High frequency knee voltage at $T_j = 150$ °C				
$I_C = 50$ mA	V_{CEK}	typ.	15	V

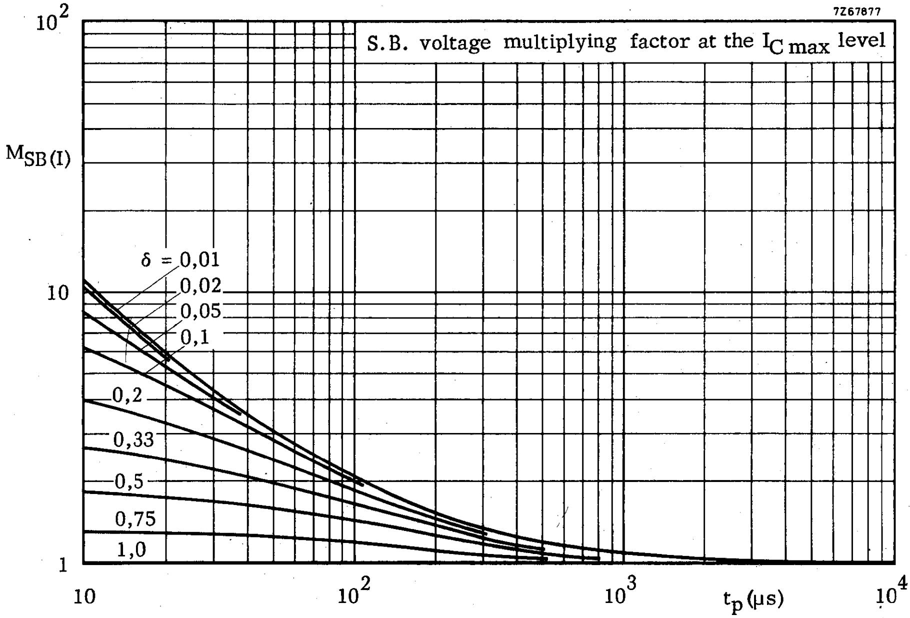
The high frequency knee voltage of a transistor is that value of the collector-emitter voltage at which the small signal gain, measured in a practical circuit, has dropped to 80% of the gain at $V_{CE} = 50$ V. A further reduction of the collector-emitter voltage results in a rapid increase of the distortion of the signal.

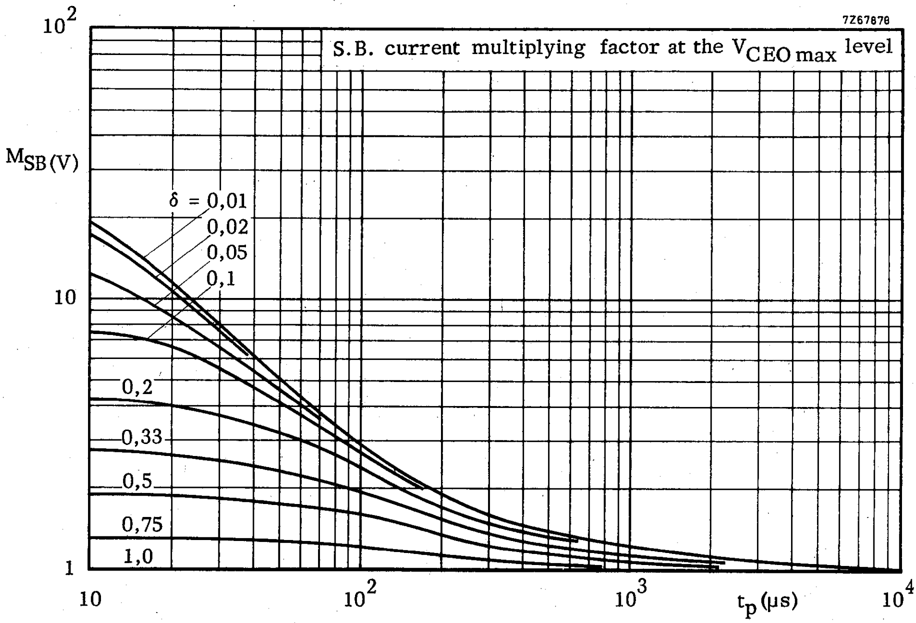
Transition frequency at f = 100 MHz				
$I_C = 15$ mA; $V_{CE} = 10$ V	f_T	typ.	90	MHz
Feedback capacitance at f = 1 MHz				
$I_E = 0$; $V_{CB} = 30$ V	C_{re}	<	3,5	pF
Output capacitance at f = 1 MHz				
$I_E = 0$; $V_{CB} = 30$ V	C_{oe}	<	4,5	pF

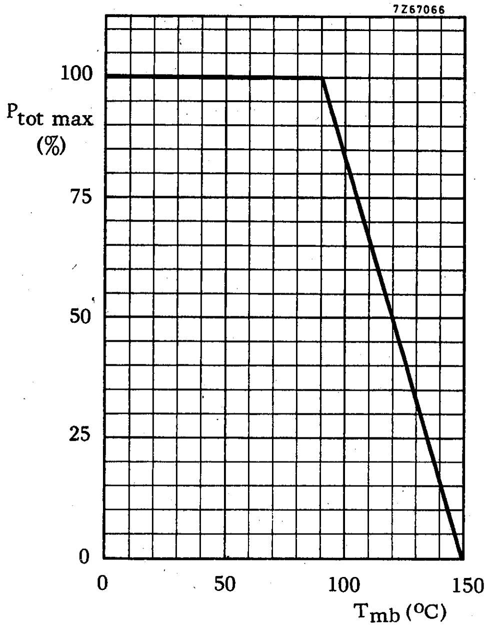


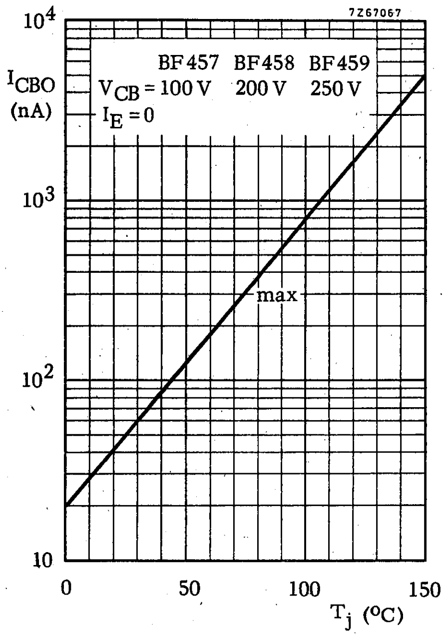
Safe Operating Area with the transistor forward biased




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

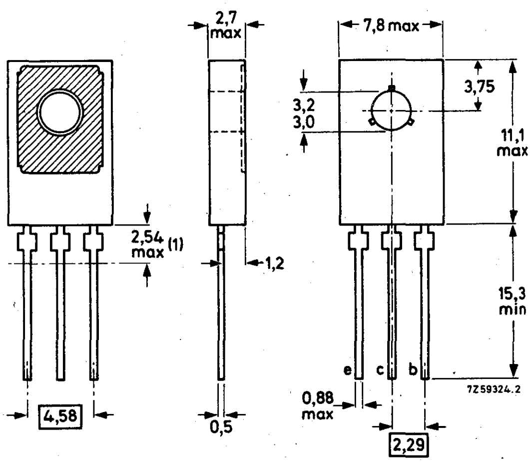
			BF469	BF471	
Collector-base voltage (open emitter)	V_{CBO}	max.	250	300	V
Collector-emitter voltage					
open base	V_{CEO}	max.	250	–	V
R_{BE} = 2,7 kΩ	V_{CER}	max.	–	300	V
Collector current (peak value)	I_{CM}	max.	100		mA
Total power dissipation up to $T_{mb} \leq 114$ °C	P_{tot}	max.	1,8		W
Junction 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)

			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

$T_j = 25\ ^oC$ unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 200$ V	I_{CBO}	<	10	nA
$R_{BE} = 2,7\ k\Omega$; $V_{CE} = 200$ V; $T_j = 150\ ^oC$	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 $T_j = 150\ ^oC$*				
$I_C = 25$ 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.

** $r_{bb'}C_{b'c} = \frac{|h_{rb}|}{\omega}$.

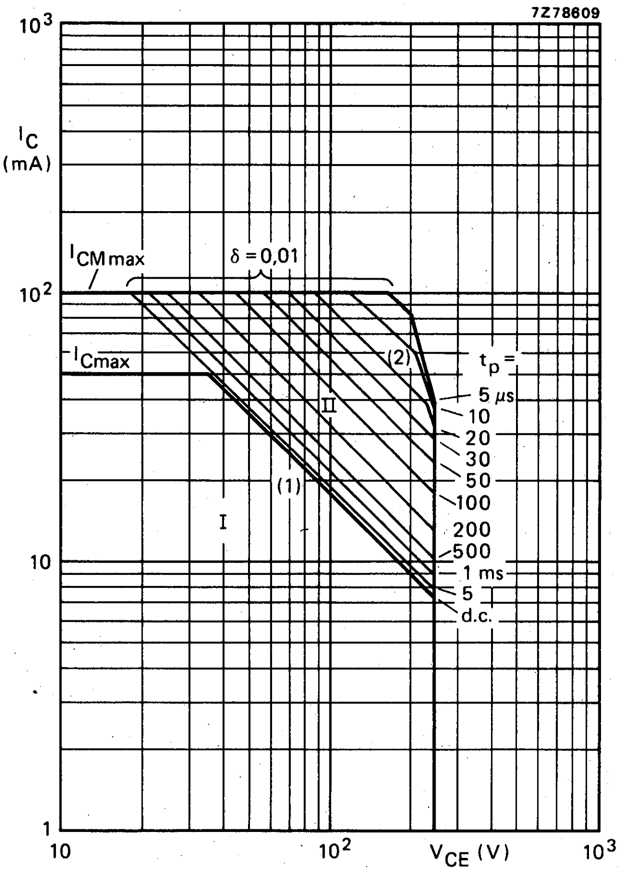


Fig. 2 Safe Operating ARea at T_{mb} = 114 °C.

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).

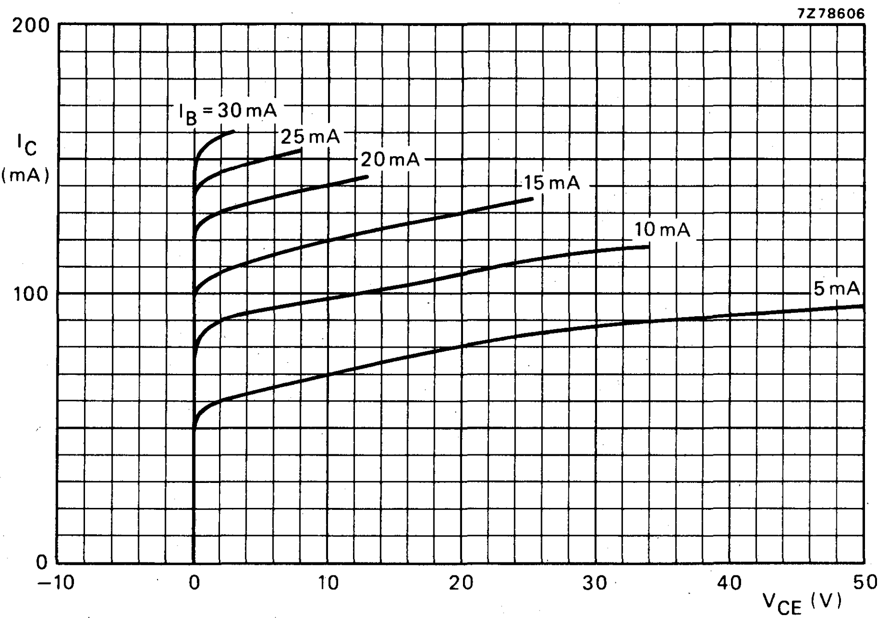


Fig. 3 $T_j = 25\ ^oC$.

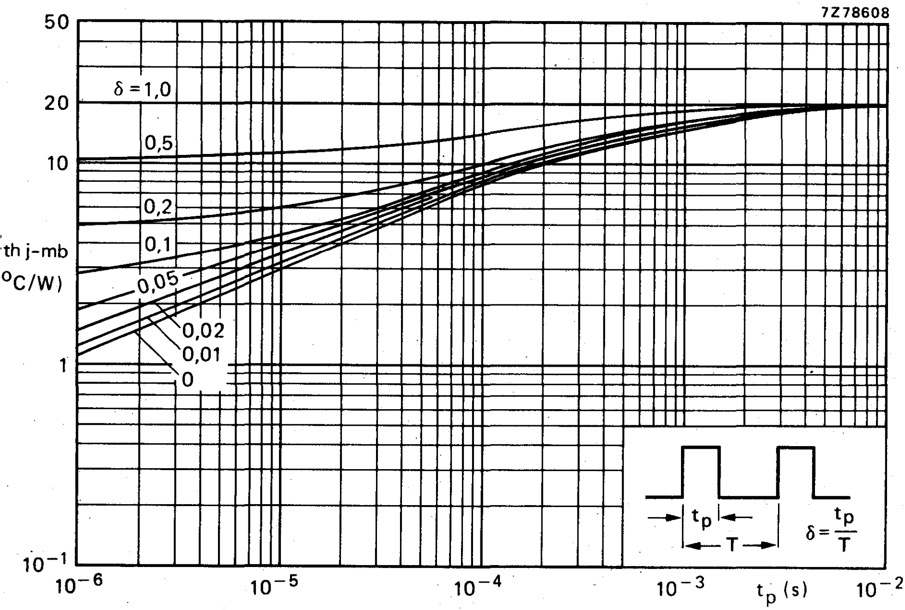


Fig. 4.

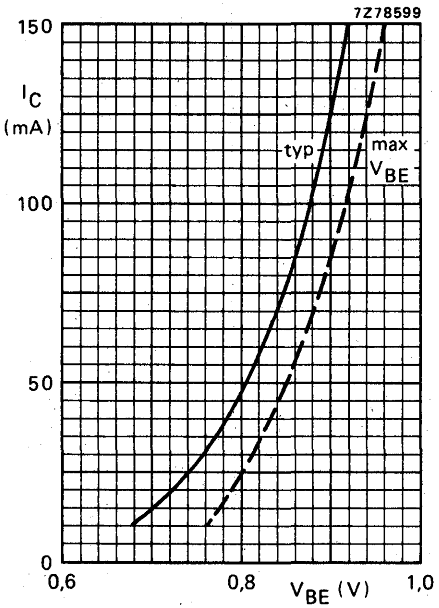


Fig. 5 $V_{CE} = 20$ V; $T_j = 25$ °C.

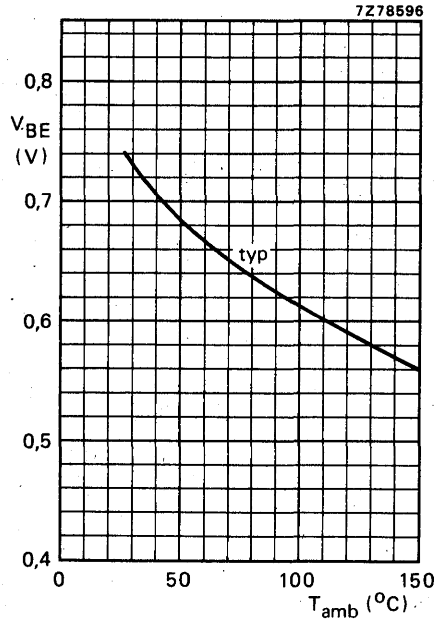


Fig. 6 $I_C = 25$ mA; $V_{CE} = 20$ V.

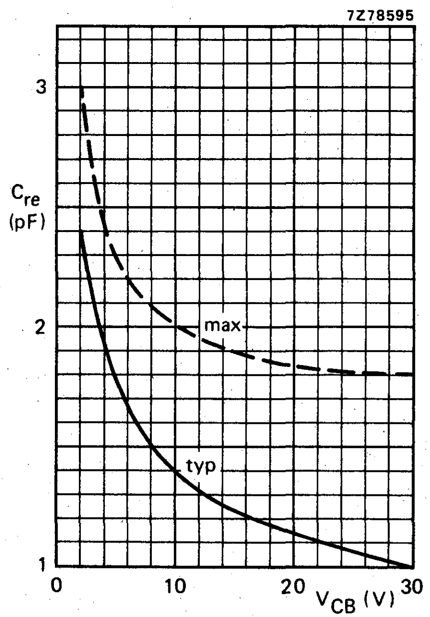


Fig. 7 $I_E = 0$; f = 1 MHz; $T_j = 25$ °C.

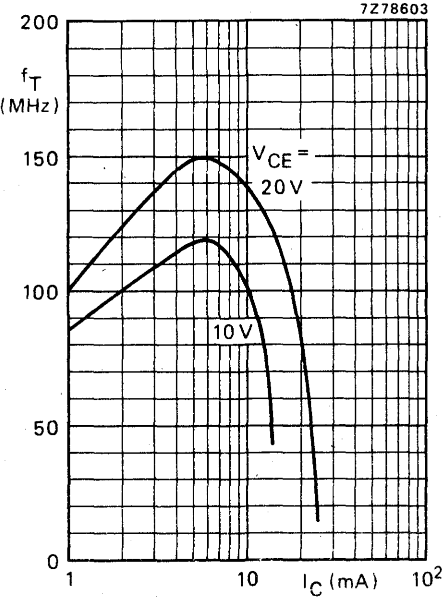


Fig. 8 f_M = 35 MHz; T_{amb} = 25 °C.

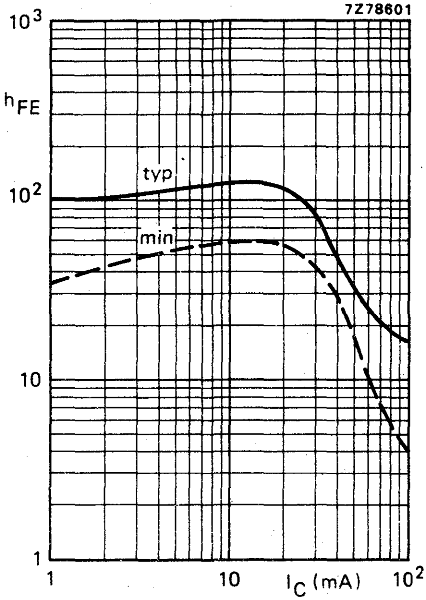


Fig. 9 V_{CE} = 20 V; T_{amb} = 25 °C.

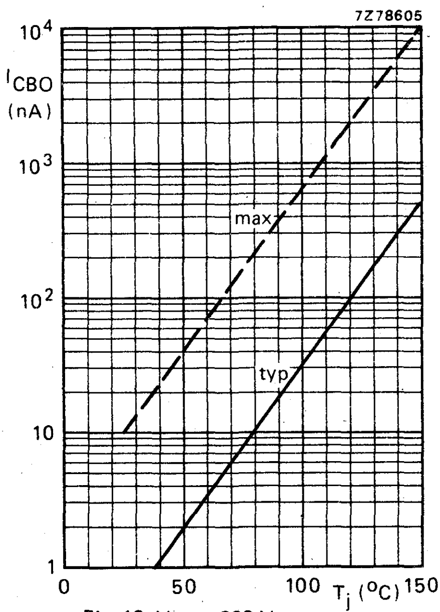


Fig. 10 V_{CB} = 200 V.

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

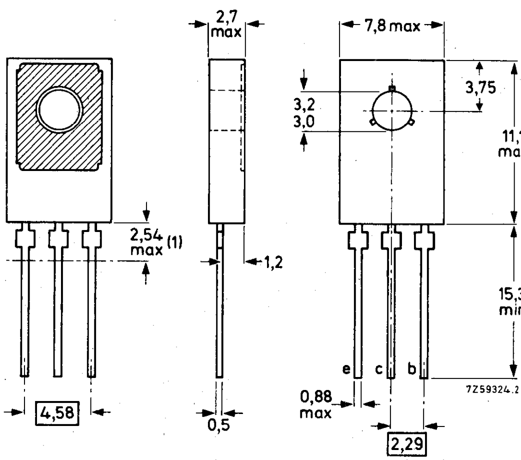
			BF470	BF472	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	250	300	V
Collector-emitter voltage					
open base	$-V_{CEO}$	max.	250	–	V
R_{BE} = 2,7 kΩ	$-V_{CER}$	max.	–	300	V
Collector current (peak value)	$-I_{CM}$	max.	100		mA
Total power dissipation up to T_{mb} = 114 °C	P_{tot}	max.	1,8		W
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.

** $r_{bb'}C_{b'c} = \frac{|h_{rb}|}{\omega}$.

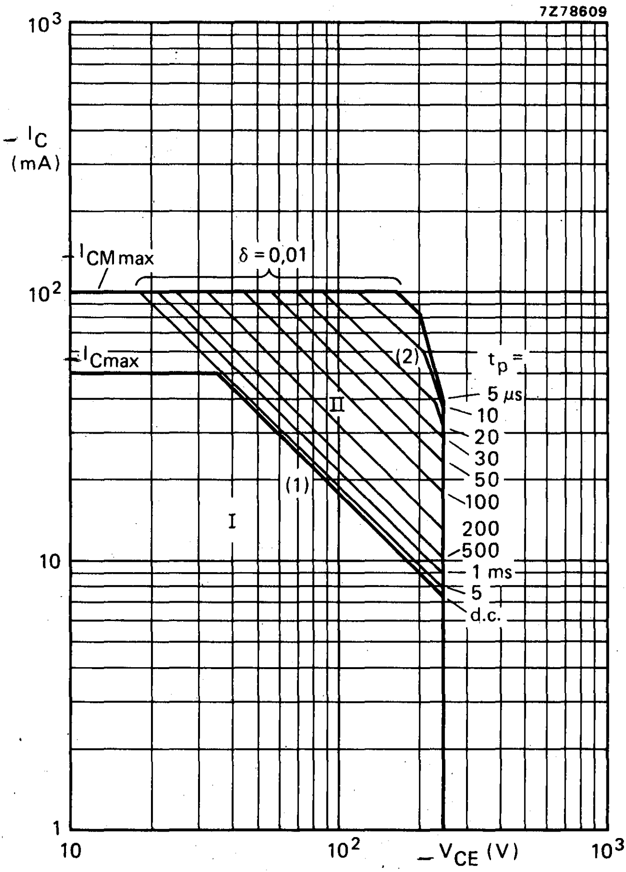


Fig. 2 Safe Operating ARea at T_{mb} = 114 °C.

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).

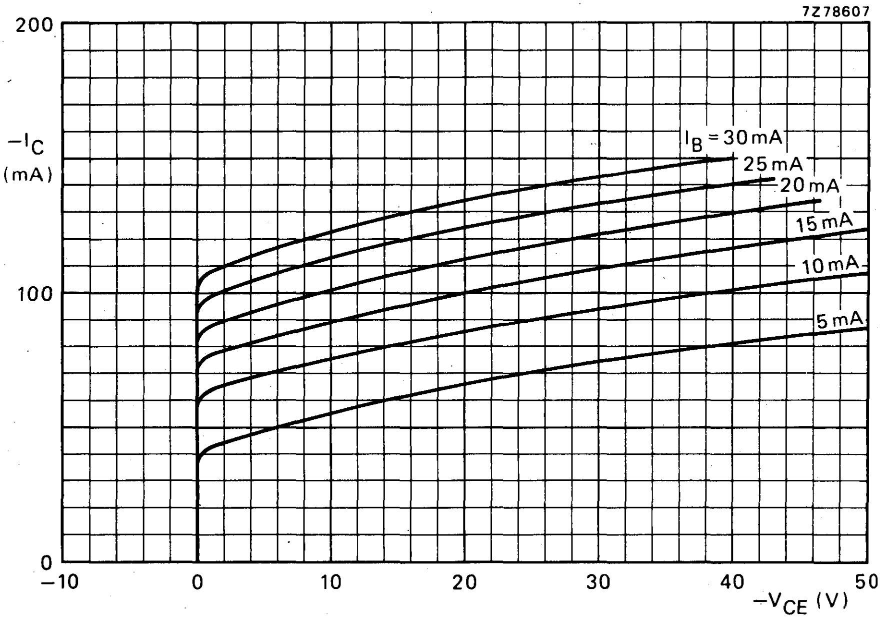


Fig. 3 $T_j = 25\ ^oC$.

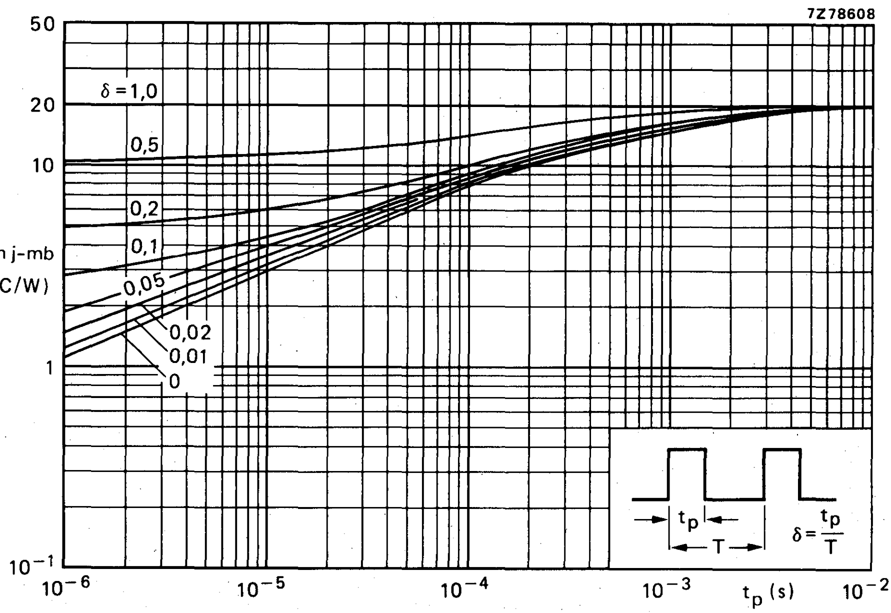


Fig. 4.

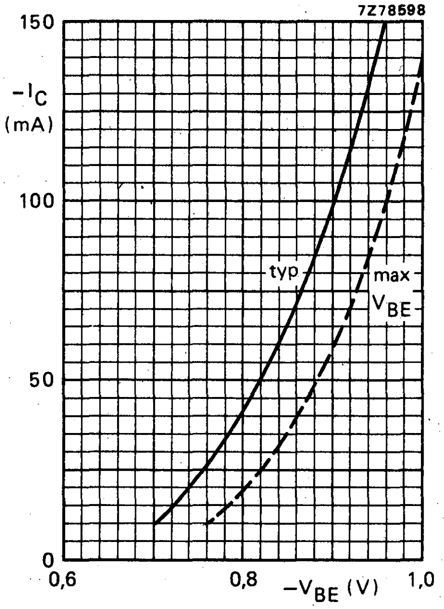


Fig. 5 $-V_{CE} = 20$ V; $T_j = 25$ °C.

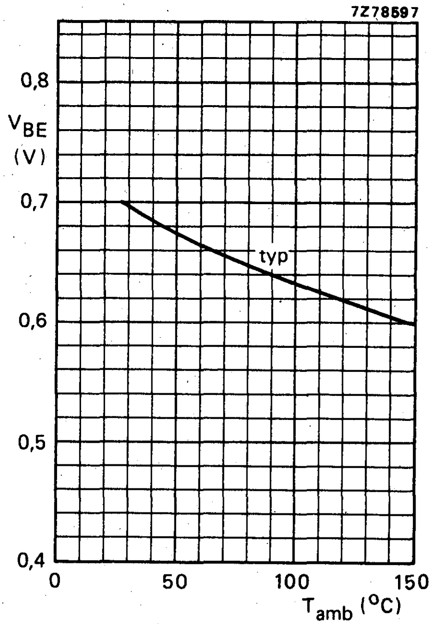


Fig. 6 $-V_{CE} = 20$ V; $-I_C = 25$ mA.

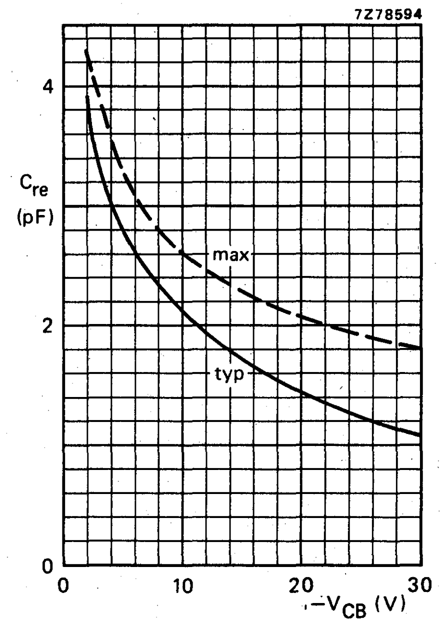


Fig. 7 $I_E = 0$; f = 1 MHz; $T_j = 25$ °C.

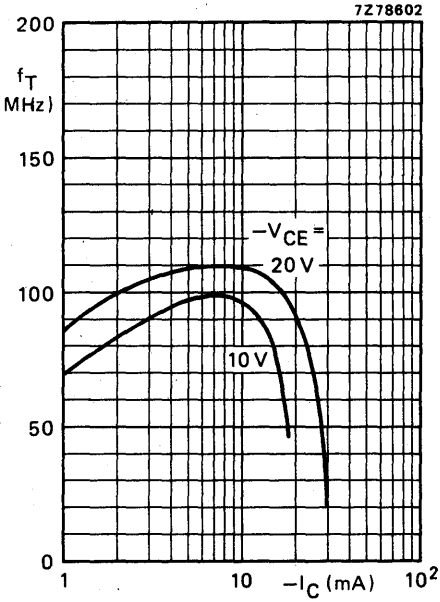


Fig. 8 f_M = 35 MHz; T_{amb} = 25 °C.

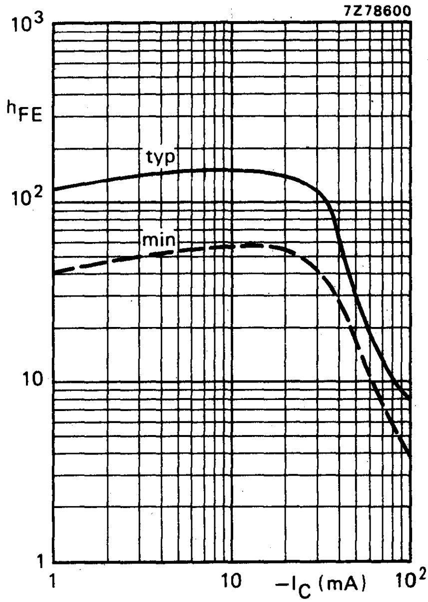


Fig. 9 $-V_{CE}$ = 20 V; T_{amb} = 25 °C.

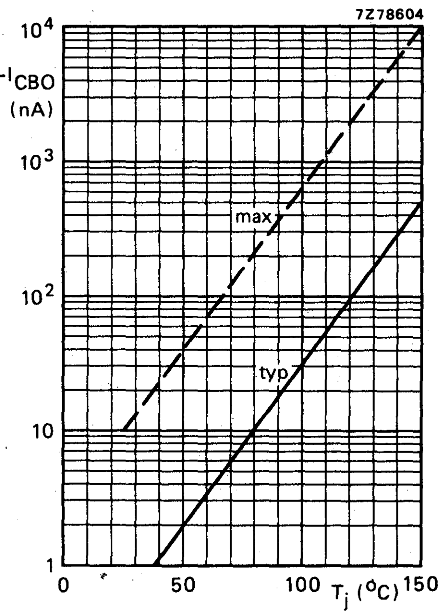


Fig. 10 $-V_{CB}$ = 200 V.

SILICON DIFFUSED POWER TRANSISTOR

High voltage, high speed switching n-p-n power transistor intended for use in the switched mode power supply of 90° and 110° colour television receivers.

QUICK REFERENCE DATA

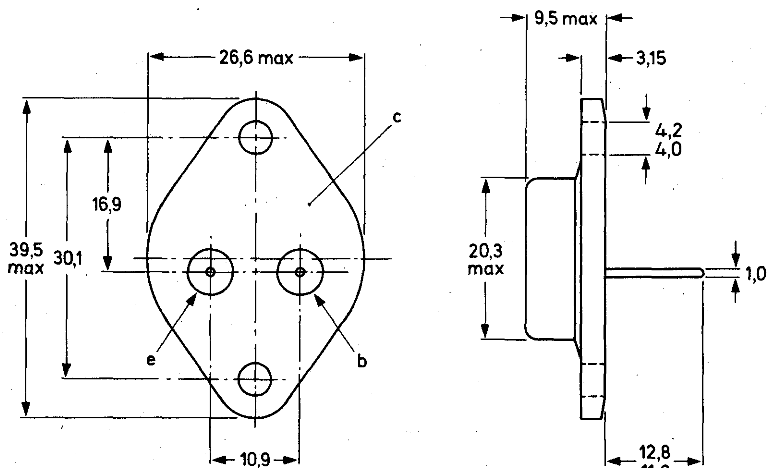
Collector-emitter voltage (V_{BE} = 0) (peak value)	V_{CESM}	max.	750	V
Collector current (peak value)	I_{CM}	max.	6	A
Total power dissipation up to T_{mb} = 50 °C	P_{tot}	max.	30	W
Collector-emitter saturation voltage I_C = 2,5 A; I_B = 0,25 A	V_{CEsat}	<	10	V
Fall time I_{CM} = 2,5 A; $I_{B(end)}$ = 0,25 A	t_f	typ.	0,15	μs

MECHANICAL DATA

Dimensions in mm

Collector connected to case.

TO-3



For mounting instructions and accessories, see section Accessories.

SILICON DIFFUSED POWER TRANSISTOR

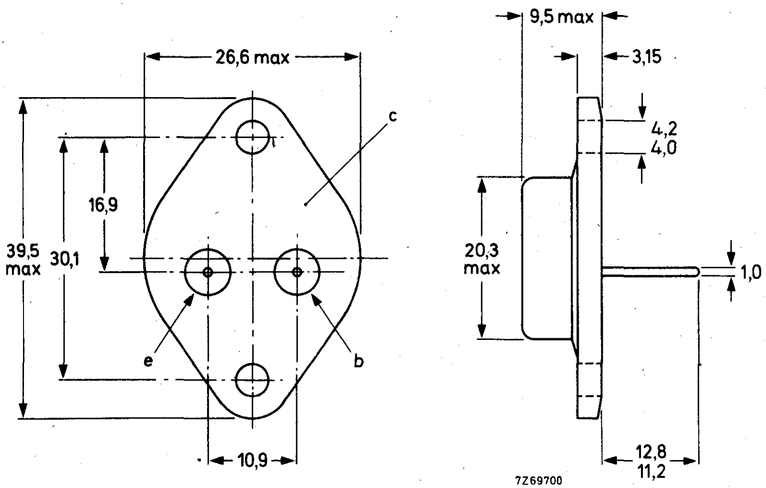
High voltage n-p-n power transistor intended for general purpose applications.

QUICK REFERENCE DATA				
Collector-emitter voltage ($V_{BE} = 0$) (peak value)	V_{CESM}	max.	750	V
Collector current (peak value)	I_{CM}	max.	6	A
Total power dissipation up to $T_{mb} = 50\ ^oC$	P_{tot}	max.	30	W
Collector-emitter saturation voltage $I_C = 2.5$ A; $I_B = 0.25$ A	$V_{CE\,sat}$	<	10	V
Fall time $I_{CM} = 2.5$ A; $I_{B1} = -I_{B2} = 0.5$ A; $V_{CC} = 125$ V	t_f	typ.	0.5	μs

MECHANICAL DATA Dimensions in mm

Collector connected to case

TO-3



For mounting instructions and accessories, see section Accessories.

SILICON DIFFUSED POWER TRANSISTORS

High-voltage, high-speed switching n-p-n transistors in a metal envelope intended for use in horizontal deflection circuits of television receivers.

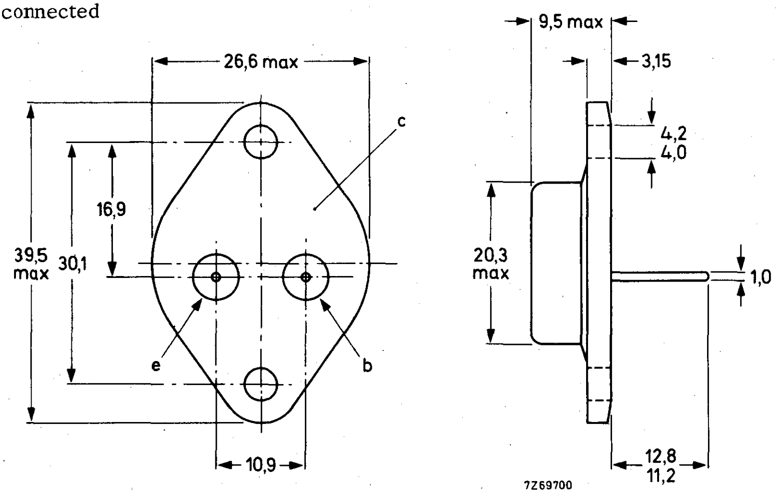
QUICK REFERENCE DATA

			BU204	BU205	BU206	
Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM}	max.	1300	1500	1700	V
Collector current (d.c.)	I_C	max.	2,5	2,5	2,5	A
Total power dissipation up to $T_{mb} = 90\ ^oC$	P_{tot}	max.	10	10	10	W
D.C. current gain $I_C = 2$ A; $V_{CE} = 5$ V	h_{FE}	>	2	2	1,8	
Fall time $I_{CM} = 2$ A; $I_{B(end)} = 1$ A	t_f	typ.	0,75	0,75	0,75	µs

MECHANICAL DATA

TO-3

Collector connected to case



For mounting instructions and accessories see section Accessories.

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

Voltage			BU204	BU205	BU206	
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max.	1300	1500	1700	V
Collector-emitter voltage ($R_{BE} \leq 100\ \Omega$, peak value)	V_{CERM}	max.	1300	1500	1700	V
Collector-emitter voltage (open base)	V_{CEO}	max.	600	700	800	V

Current				
Collector current (d.c.)	I_C	max.	2,5	A
Collector current (peak value)	I_{CM}	max.	3	A
Base current (peak value)	I_{BM}	max.	2,5	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.	1,5	A

Power dissipation				
Total power dissipation up to T_{mb} = 90 °C	P_{tot}	max.	10	W

Temperature				
Storage temperature	T_{stg}		−65 to +115	°C
Junction temperature	T_j	max.	115	°C

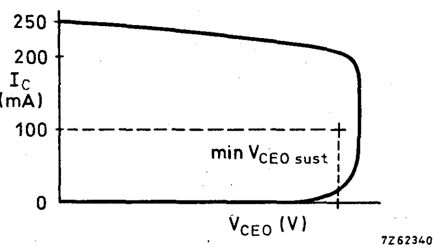
THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	max.	2,5	°C/W

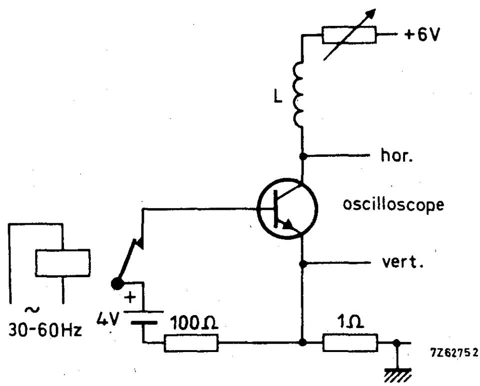
1) Turn-off current.

CHARACTERISTICS T_j = 25 ^oC unless otherwise specified

			BU204	BU205	BU206	
Collector cut-off current						
V_{BE} = 0; V_{CE} = $V_{CESMmax}$	I_{CES}	<		1		mA
D.C. current gain			BU204	BU205	BU206	
I_C = 2 A; V_{CE} = 5 V	h_{FE}	>	2	2	1,8	
Emitter-base voltage						
I_C = 0; I_E = 10 mA	$+V_{EBO}$	>	5	5	5	V
I_C = 0; I_E = 100 mA	$+V_{EBO}$	typ.	7	7	7	V
Saturation voltage						
I_C = 2 A; I_B = 1 A	V_{CEsat}	<	5	5	-	V
I_C = 2 A; I_B = 1,1 A	V_{CEsat}	<	-	-	5	V
I_C = 2 A; I_B = 1 A	V_{BEsat}	<	1,5	1,5	-	
I_C = 2 A; I_B = 1,1 A	V_{BEsat}	<	-	-	1,5	V
Collector-emitter sustaining voltage						
I_B = 0; I_C = 100 mA; L = 25 mH	$V_{CEOsust}$	>	600	700	800	V



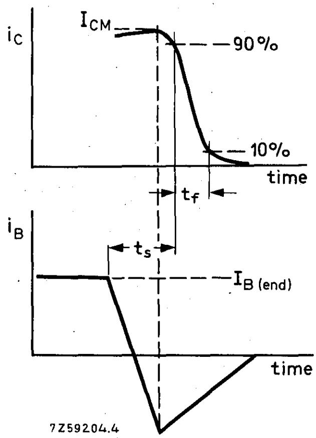
Oscilloscope display for $V_{CEOsust}$

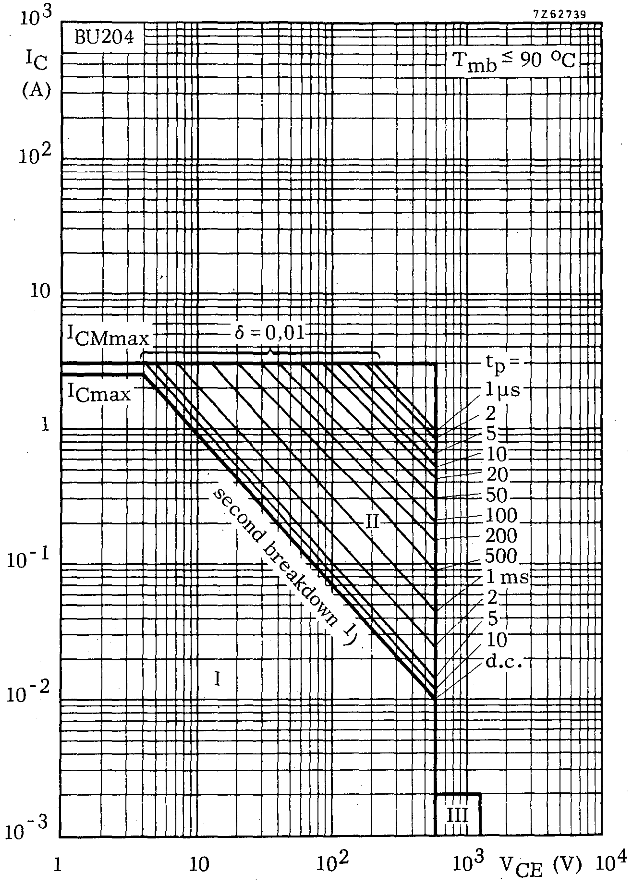


Test circuit for $V_{CEOsust}$

CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Transition frequency at f = 5 MHz				
I_C = 0,1 A; V_{CE} = 5 V	f_T	typ.	7,5	MHz
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; V_{CB} = 10 V	C_c	typ.	65	pF
Switching times (in horizontal deflection circuit)				
I_{CM} = 2 A; $I_{B(end)}$ = 1 A; L_B = 25 μH				
Fall time	t_f	typ.	0,75	μs
Storage time	t_s	typ.	10	μs





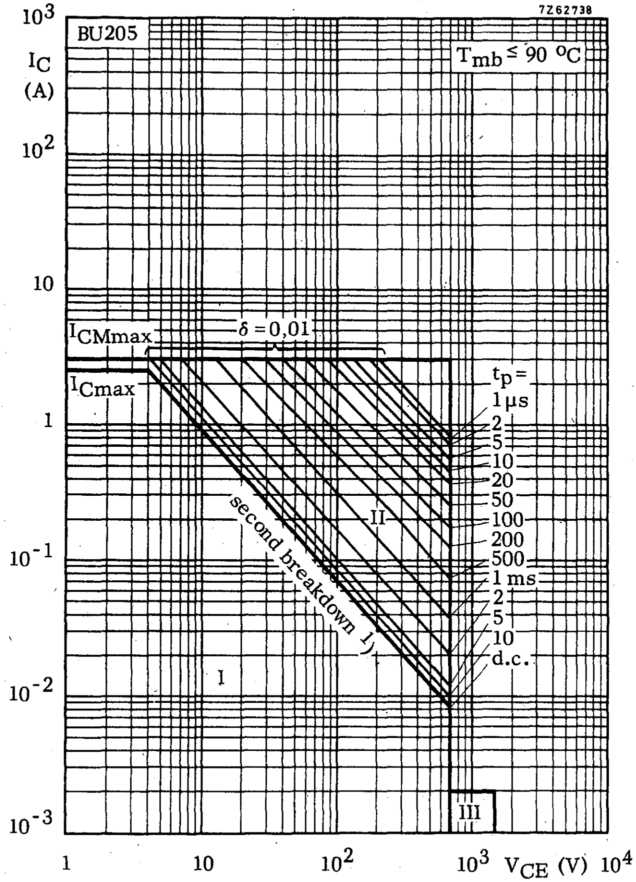
Safe Operation Area with the transistor forward biased.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.
III Repetitive pulse operation in this region is allowable, provided $R_{BE} \leq 100\ \Omega$; $t_p \leq 20$ µs; $\delta \leq 0,25$.

Note

Information on picture tube arcing is available.

1) Independent of temperature.



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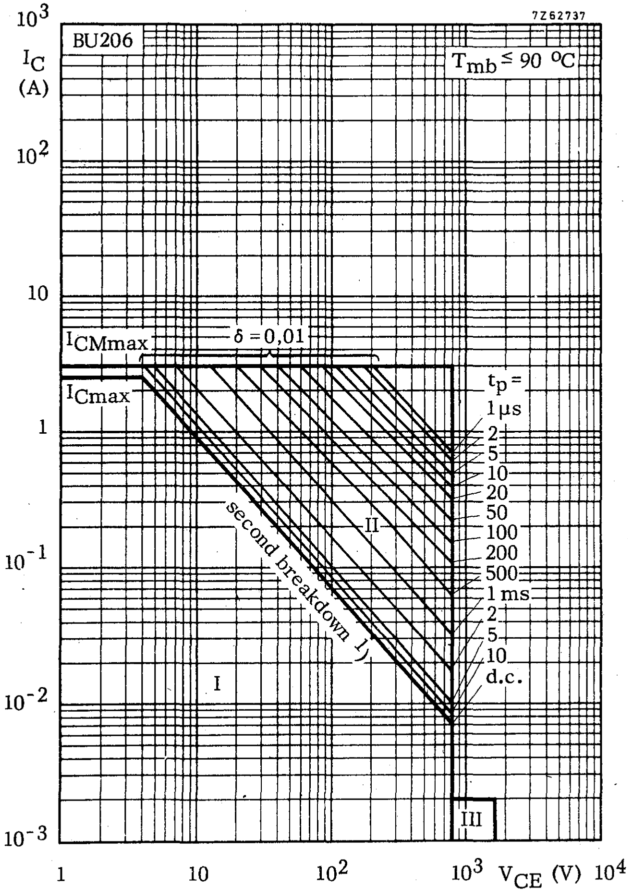

Safe Operating Area with the transistor forward biased.

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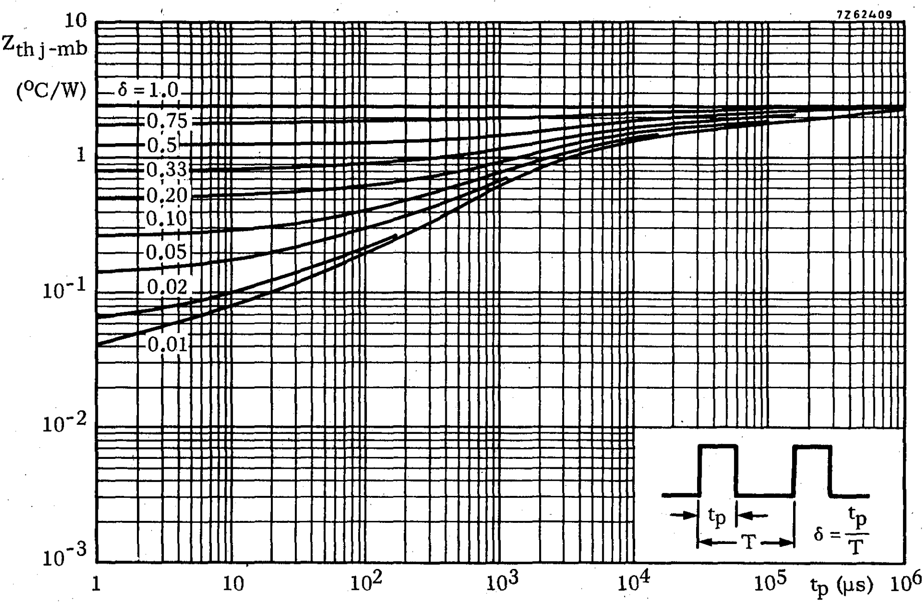
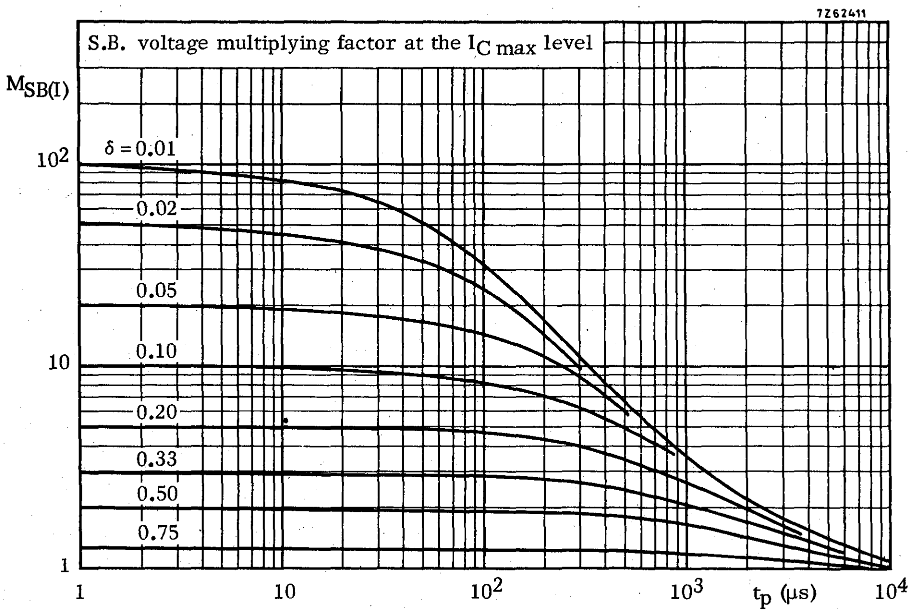
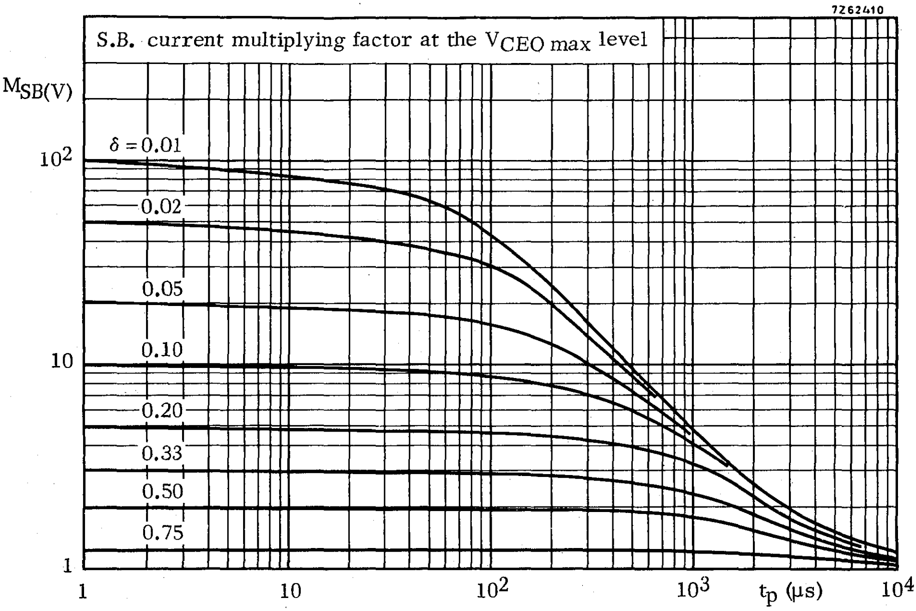
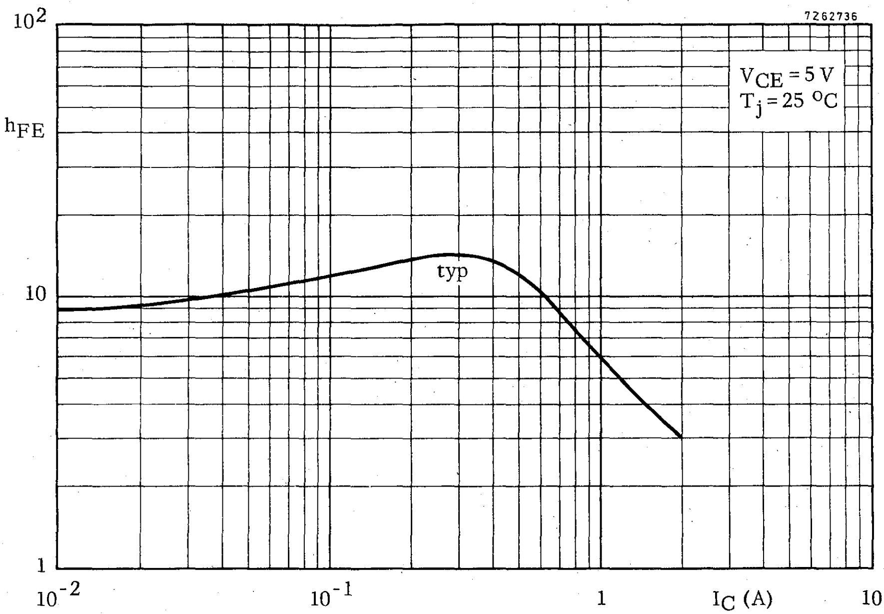
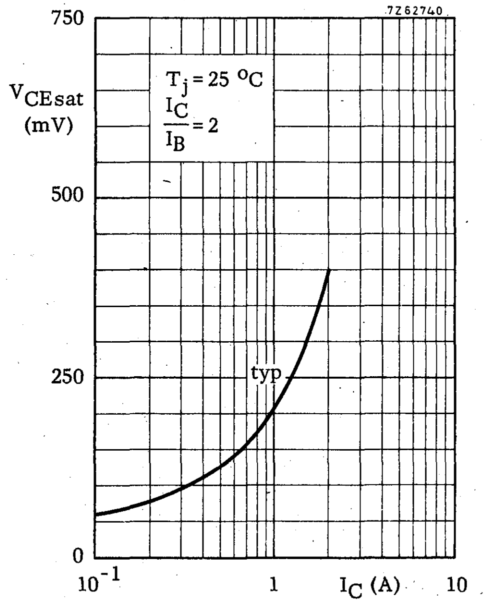
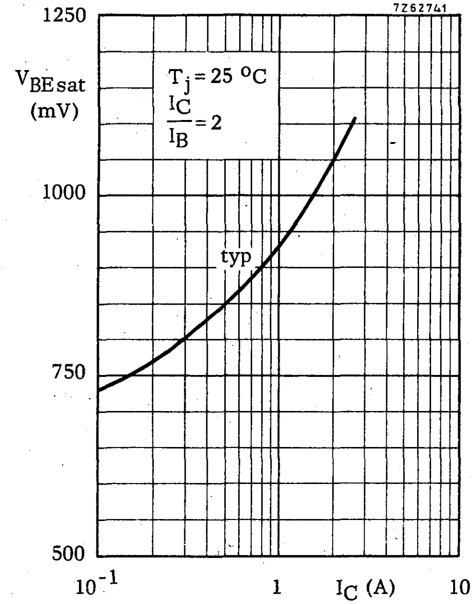

7Z62409
10
$Z_{th\,j\text{-}mb}$
($^oC/W$)
1
10^{-1}
10^{-2}
10^{-3}
$\delta = 1.0$
0.75
0.5
0.33
0.20
0.10
0.05
0.02
0.01
t_p
T
$\delta = \frac{t_p}{T}$
1
10
10^2
10^3
10^4
10^5
t_p (µs)
10^6


7Z62411
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
$\delta = 0.01$
0.02
0.05
0.10
0.20
0.33
0.50
0.75
1
10
10^2
10^3
t_p (µs)
10^4


7Z62410
S.B. current multiplying factor at the $V_{CEO\,max}$ level
$M_{SB(V)}$
$\delta = 0.01$
0.02
0.05
0.10
0.20
0.33
0.50
0.75
10^2
10
1
1
10
10^2
10^3
t_p (μs)
10^4


7Z62736
h_{FE}
$V_{CE} = 5$ V
$T_j = 25$ °C
typ
10^2
10
1
10^{-2}
10^{-1}
1
I_C (A)
10


7Z62740
750
500
250
0
V_{CEsat} (mV)
$T_j = 25\ ^oC$
$\frac{I_C}{I_B} = 2$
typ
10^{-1}
1
I_C (A)
10


7Z62741
1250
1000
750
500
V_{BEsat} (mV)
$T_j = 25\ ^oC$
$\frac{I_C}{I_B} = 2$
typ
10^{-1}
1
I_C (A)
10

SILICON DIFFUSED POWER TRANSISTORS

High-voltage, high-speed switching n-p-n transistors in a metal envelope intended for use in horizontal deflection circuits of colour television receivers.

QUICK REFERENCE DATA

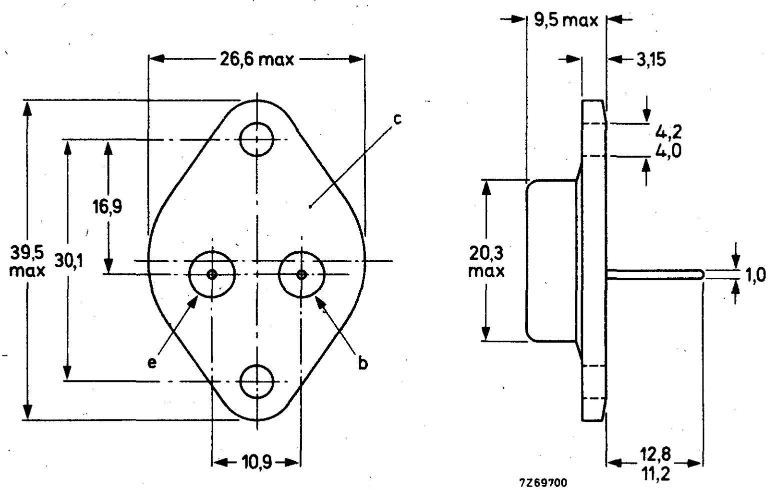
			BU207A	BU209A	
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max.	1500	1700	V
Collector current (d.c.)	I_C	max.	5	4	A
Total power dissipation up to T_{mb} = 95 ^oC	P_{tot}	max.	12,5	12,5	W
Collector-emitter saturation voltage					
I_C = 4,5 A; I_B = 2 A	V_{CEsat}	<	5	–	V
I_C = 3 A; I_B = 1,3 A	V_{CEsat}	<	–	5	V
Fall time					
I_{CM} = 4,5 A; $I_{B(end)}$ = 1,8 A	t_f	typ.	0,9	–	μs
I_{CM} = 3 A; $I_{B(end)}$ = 1,3 A	t_f	typ.	–	0,7	μs

MECHANICAL DATA

Dimensions in mm

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)

			BU207A	BU209A	
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max.	1500	1700	V
Collector-emitter voltage ($R_{BE} \leqslant 100\ \Omega$, peak value)	V_{CERM}	max.	1500	1700	V
Collector-emitter voltage (open base)	V_{CEO}	max.	600	800	V
Collector current (d.c.)	I_C	max.	5	4	A
Collector current (peak value)	I_{CM}	max.	7,5	6	A
Base current (peak value)	I_{BM}	max.	4	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.	3,5		A
Total power dissipation up to T_{mb} = 95 °C	P_{tot}	max.	12,5		W
Storage temperature	T_{stg}		–65 to + 115		°C
Junction temperature	T_j	max.	115		°C

THERMAL RESISTANCE

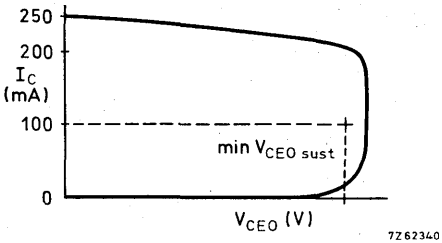
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,6	°C/W

* Turn-off current.

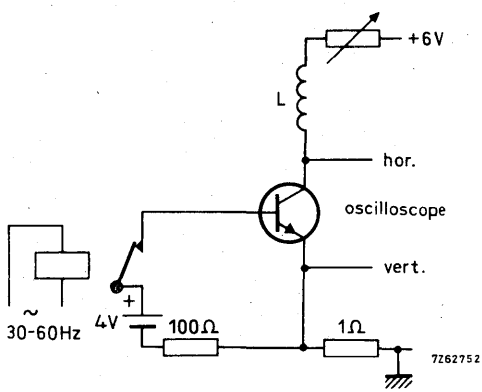
CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			BU207A	BU209A	
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}	>	2,25	–	
I_C = 3,0 A; V_{CE} = 5 V	h_{FE}	>	–	2,25	
Emitter-base voltage					
I_C = 0; I_E = 10 mA	$+V_{EBO}$	>	5	5	V
I_C = 0; I_E = 100 mA	$+V_{EBO}$	typ.	7	7	V
Saturation voltage					
I_C = 4,5 A; I_B = 2 A	V_{CEsat}	<	5	–	V
I_C = 3,0 A; I_B = 1,3 A	V_{CEsat}	<	–	5	V
I_C = 4,5 A; I_B = 2 A	V_{BEsat}	<	1,5	–	
I_C = 3,0 A; I_B = 1,3 A	V_{BEsat}	<	–	1,5	V
Collector-emitter sustaining voltage					
I_B = 0; I_C = 100 mA; L = 25 mH	$V_{CEOsust}$	>	600	800	V



Oscilloscope display for $V_{CEOsust}$.

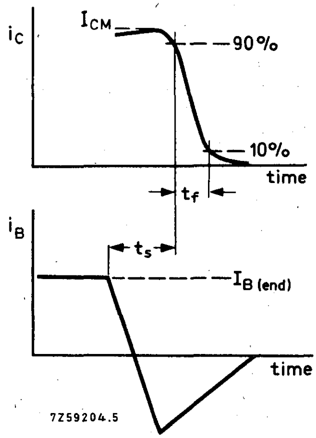


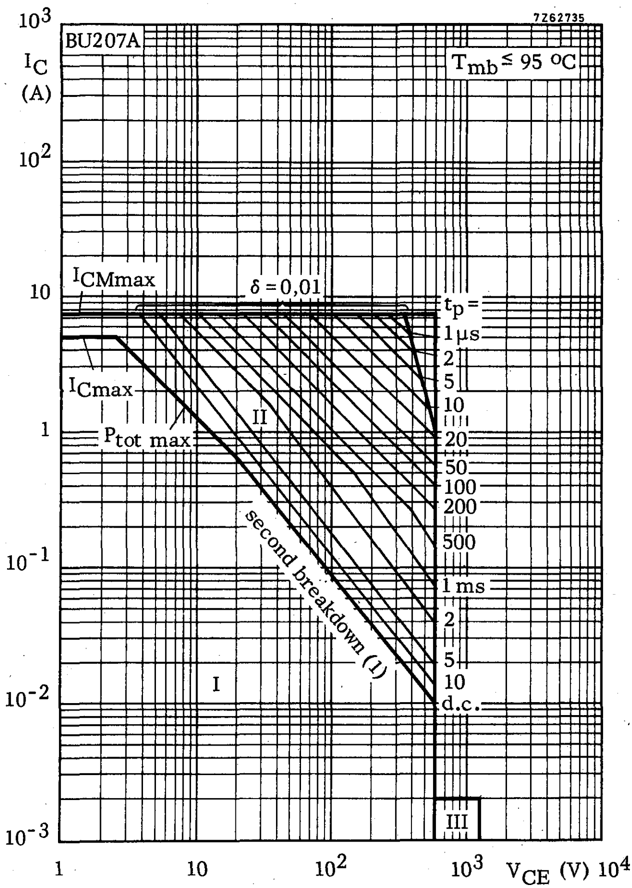
Test circuit for $V_{CEOsust}$.

CHARACTERISTICS (continued)

$T_j = 25\ ^oC$ unless otherwise specified

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)					
$L_B = 10\ \mu H$			BU207A	BU209A	
$I_{CM} = 4,5\ A$; $I_{B(end)} = 1,8\ A$	t_f	typ.	0,9	–	μs
$I_{CM} = 3,0\ A$; $I_{B(end)} = 1,3\ A$	t_f	typ.	–	0,7	μs
$I_{CM} = 4,5\ A$; $I_{B(end)} = 1,8\ A$	t_s	typ.	10	–	μs
$I_{CM} = 3,0\ A$; $I_{B(end)} = 1,3\ A$	t_s	typ.	–	10	μs

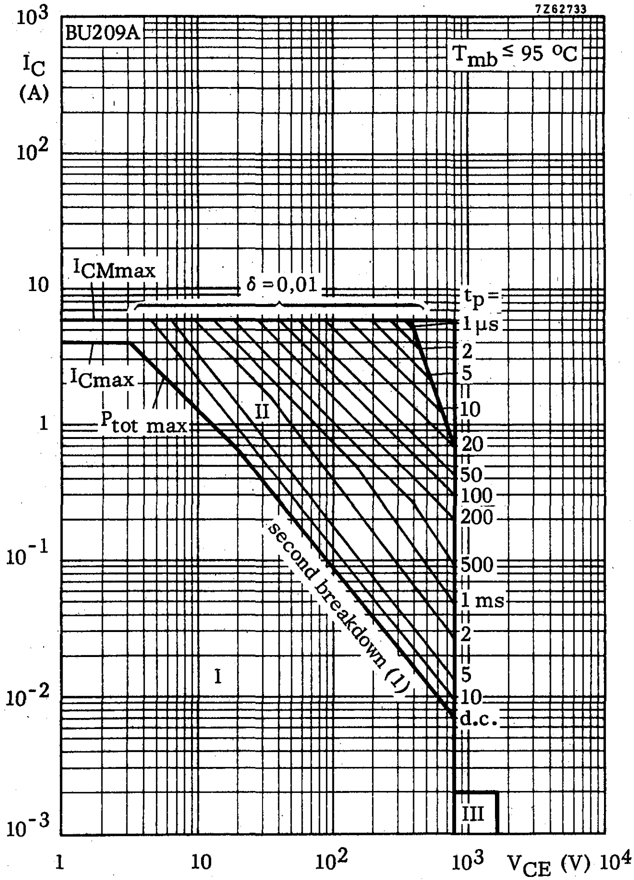




Safe Operating ARea with the transistor forward biased.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.
III Repetitive pulse operation in this region is permissible, provided $R_{BE} \leqslant 100\ \Omega$; $t_p \leqslant 20\ \mu s$; $\delta \leqslant 0{,}25$.

Notes
Information on picture tube arcing is available.
(1) Independent of temperature.



Safe Operating ARea with the transistor forward biased.

I Region of permissible d.c. operation.

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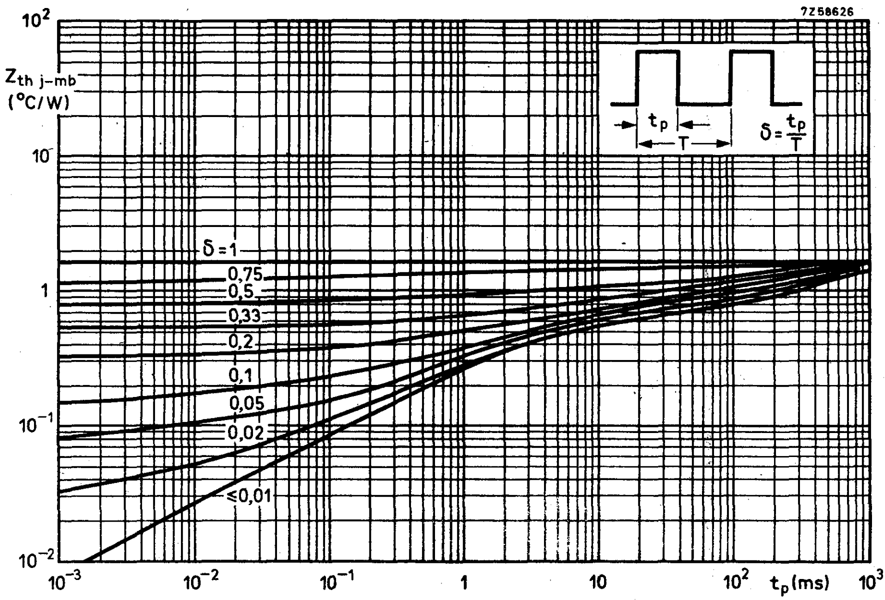
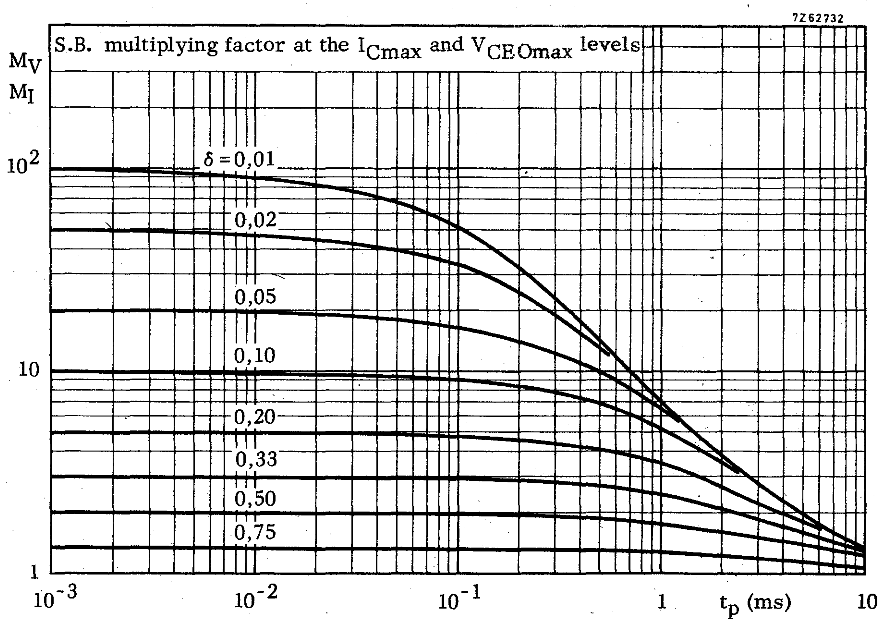
III Repetitive pulse operation in this region is permissible, provided $R_{BE} \leq 100\ \Omega$; $t_p \leq 20\ \mu s$; $\delta \leq 0{,}25$.

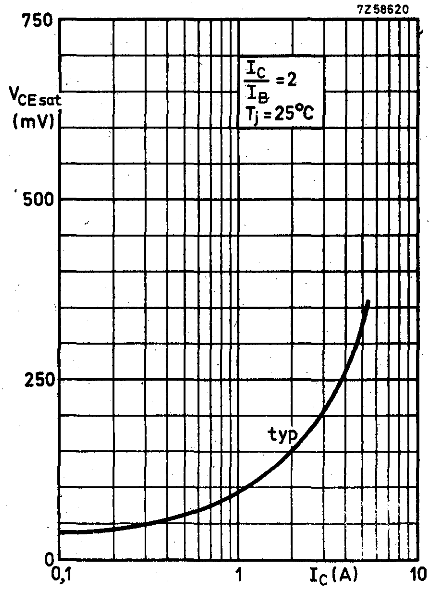
Notes

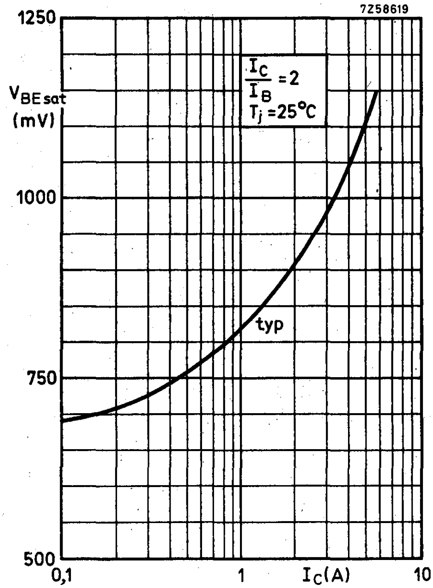
Information on picture tube arcing is available.

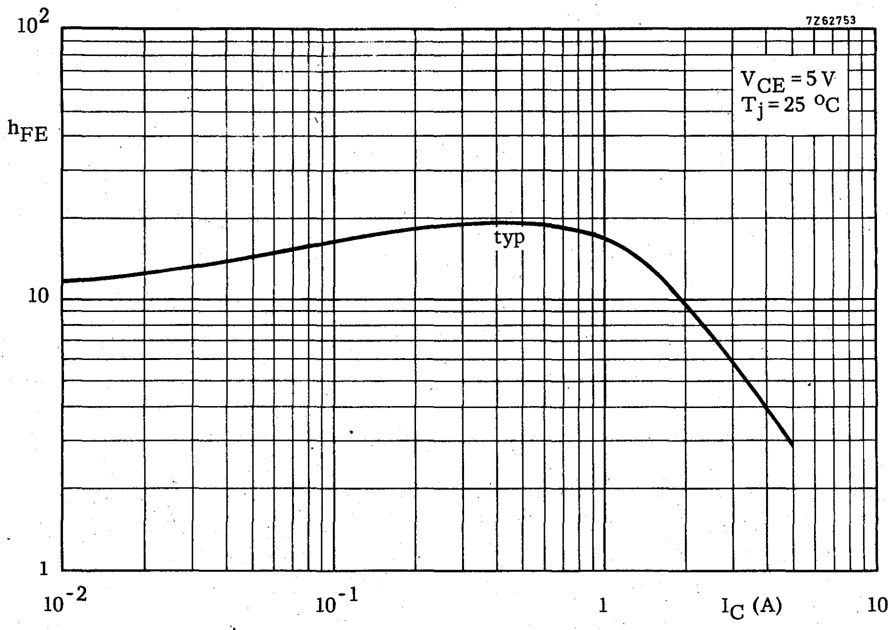
(1) Independent of temperature.


7Z58626
$Z_{th\ j-mb}$ (°C/W)
10^2
10
1
10^{-1}
10^{-2}
$\delta = 1$
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


7Z62732
S.B. multiplying factor at the I_{Cmax} and V_{CEOmax} levels
M_V
M_I
10^2
10
1
$\delta = 0{,}01$
0,02
0,05
0,10
0,20
0,33
0,50
0,75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10


7Z58620
750
500
250
0
V_{CEsat}
(mV)
$\frac{I_C}{I_B}=2$
$T_j=25^\circ C$
typ
0,1
1
I_C (A)
10


7Z58619
1250
1000
750
500
V_{BEsat}
(mV)
$\frac{I_C}{I_B}=2$
$T_j=25^\circ C$
typ
0,1
1
I_C (A)
10


7Z62753
10^2
h_{FE}
10
1
$V_{CE}=5$ V
$T_j=25$ °C
typ
10^{-2}
10^{-1}
1
I_C (A)
10

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.

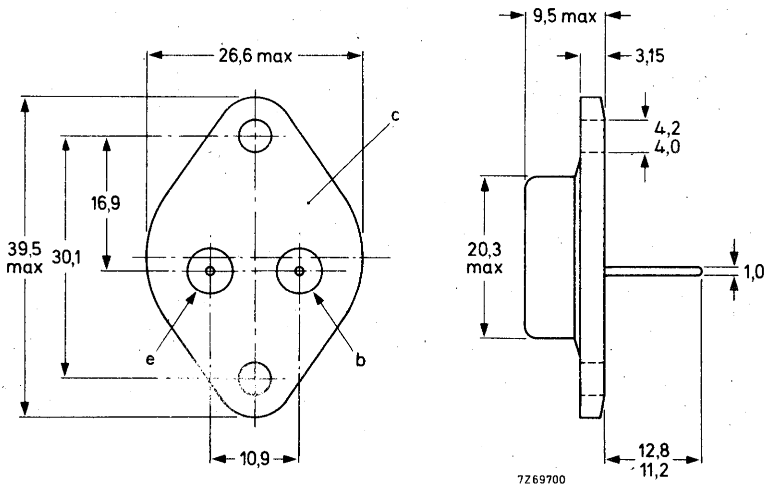
QUICK REFERENCE DATA

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

Fig. 1 TO-3.

Collector connected to case.



For mounting instructions and accessories see Handbook section 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 ($R_{BE} \leqslant 100\ \Omega$, peak value)	V_{CERM}	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	°C/W

* Turn-off current.

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

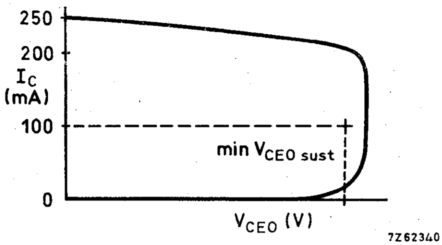


Fig. 2 Oscilloscope display for $V_{CEOsust}$.

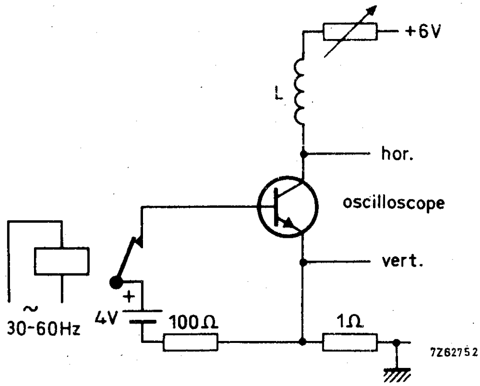


Fig. 3 Test circuit for $V_{CEOsust}$.

CHARACTERISTICS (continued)

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)			
$L_B = 6\ \mu H$; $-V_{IM} = 4$ V;			
$I_{CM} = 4,5$ A; $I_{B(end)} = 1,4$ A			
$(-dI_B/dt = 0,6\ A/\mu s)$	t_f	typ.	0,7 μs
	t_s	typ.	6,5 μs

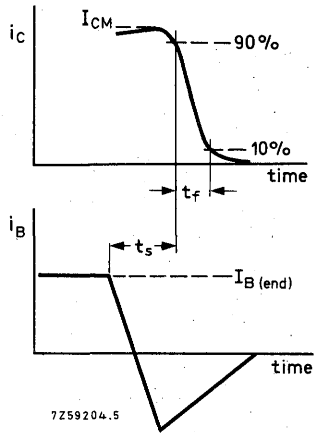


Fig. 4 Switching times.

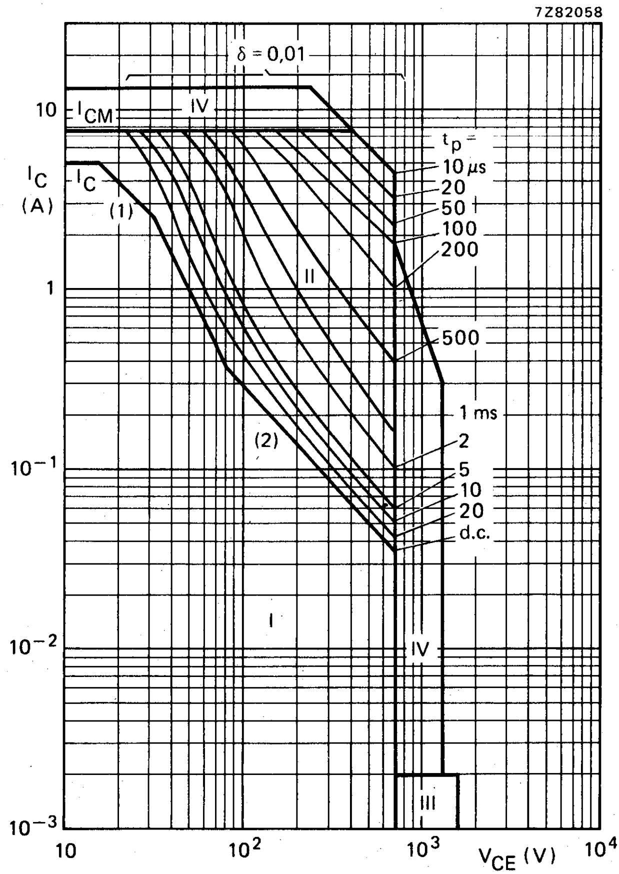


Fig. 5 Safe Operating ARea with the transistor forward biased. $T_{mb} \leqslant 25$ °C.

- I Region of permissible d.c. operation.
- II Permissible extension for repetitive pulse operation.
- III Repetitive pulse operation in this region is permissible, provided $R_{BE} \leqslant 100\ \Omega$; $t_p \leqslant 20\ \mu s$; $\delta \leqslant 0,25$.
- 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).

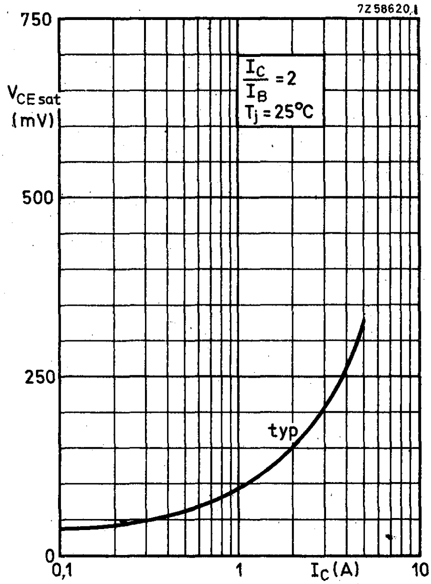


Fig. 6 Collector-emitter saturation voltage.

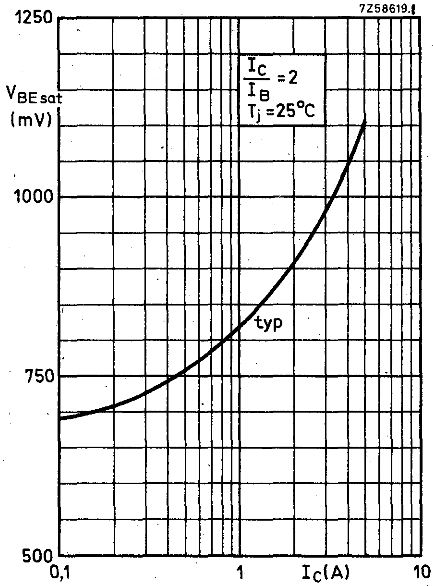


Fig. 7 Base-emitter saturation voltage.

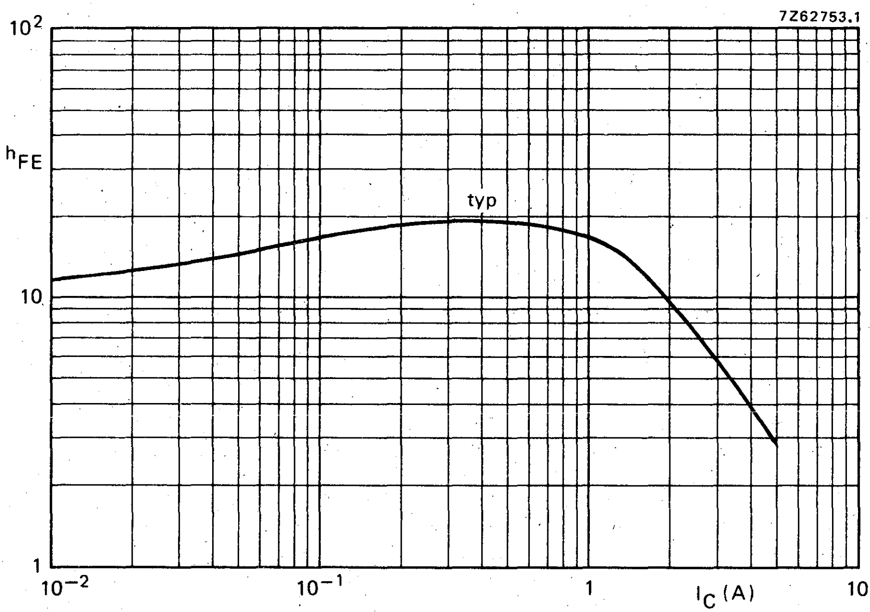


Fig. 8 D.C. current gain. $V_{CE} = 5$ V; $T_j = 25\,^\circ C$.

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.

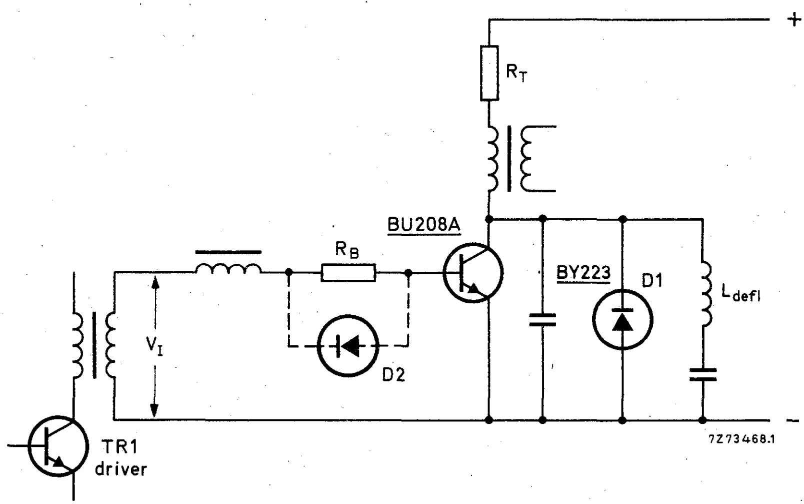


Fig. 9 Simplified horizontal deflection circuit.

* 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 $R_{th\ mb\text{-}a} = \dfrac{100 - T_{amb\ max}}{P_{tot\ max}}$ 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.

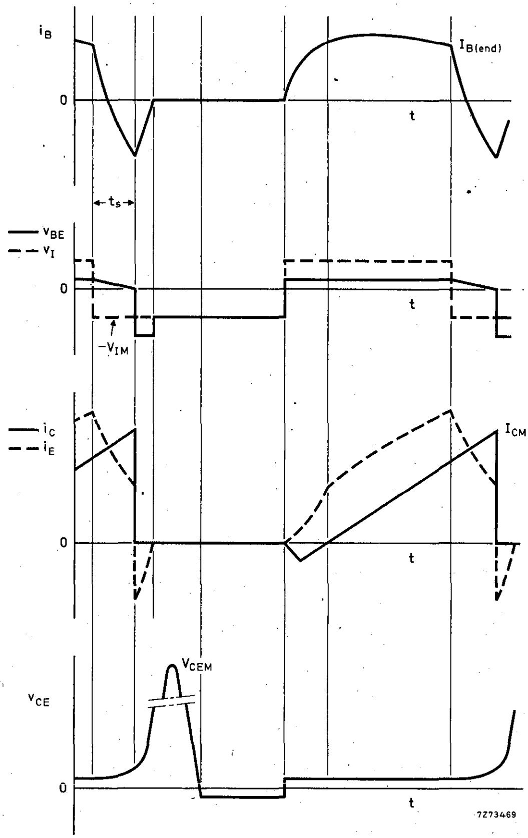


Fig. 10 Fundamental waveforms.

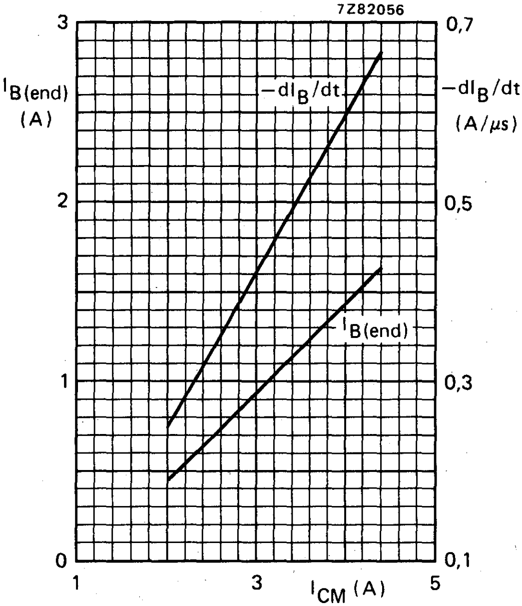


Fig. 11
Nominal end value of the base current and its rate of fall during turn-off as a function of nominal peak collector current to obtain, for a typical transistor, the recommended storage time of 6,5 μs. (During the storage time and the decay time of the collector current the negative turn-off drive voltage ($-V_{IM}$) must be > 4 V.)

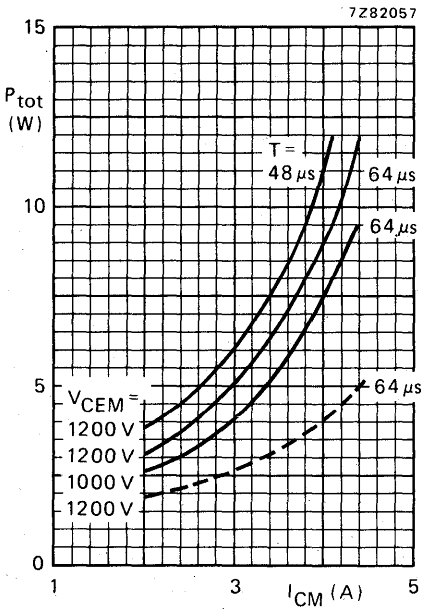


Fig. 12
Continuous lines are maximum values; T_{mb} = 100 °C; δ = 0,18; base tolerances ± 20%.
Total dissipation of a limit-case transistor under maximum operating conditions for 625 and 819 lines (T_{mb} = 100 °C).

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

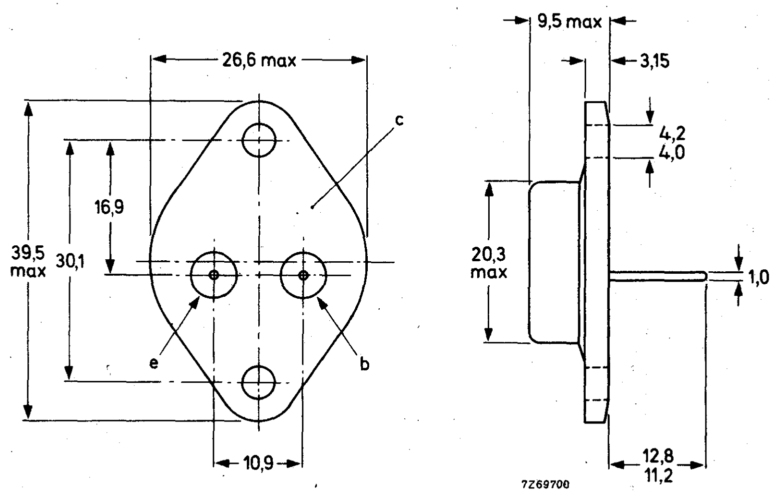
			BU326	BU326A	
Collector-emitter voltage ($V_{BE} = 0$; peak value)	V_{CESM}	max.	800	900	V
Collector-emitter voltage (open base)	V_{CEO}	max.	375	400	V
Collector current (d.c.)	I_C	max.	6		A
Collector current (peak value; $t_p < 2$ ms)	I_{CM}	max.	8		A
Total power dissipation up to $T_{mb} = 50$ °C	P_{tot}	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).

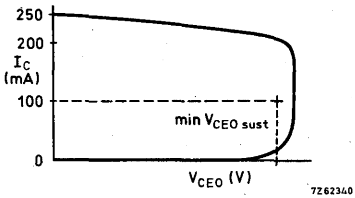


Fig. 2 Oscilloscope display for $V_{CEOsust}$.

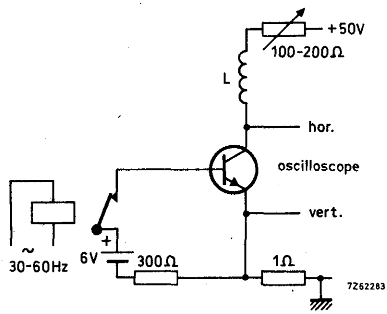


Fig. 3 Test circuit for $V_{CEOsust}$.

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.

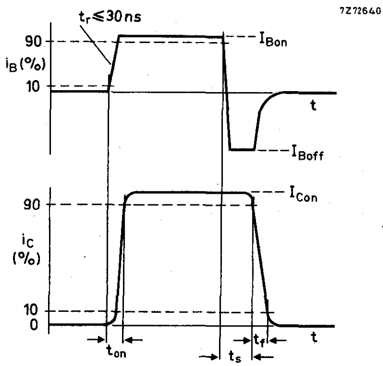
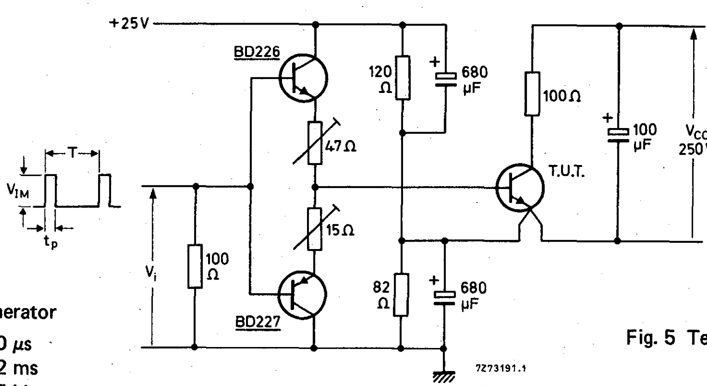


Fig. 4 Waveforms.



Pulse generator
t_p = 20 μs
T = 2 ms
V_{IM} = 15 V

Fig. 5 Test circuit.

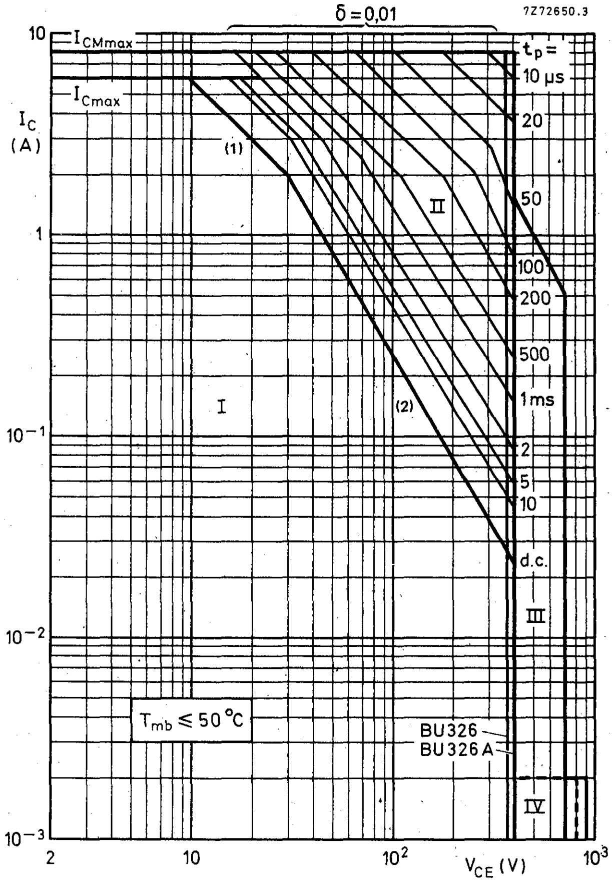


Fig. 6 Safe Operating ARea.

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 $R_{BE} \leq 100\ \Omega$ 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).

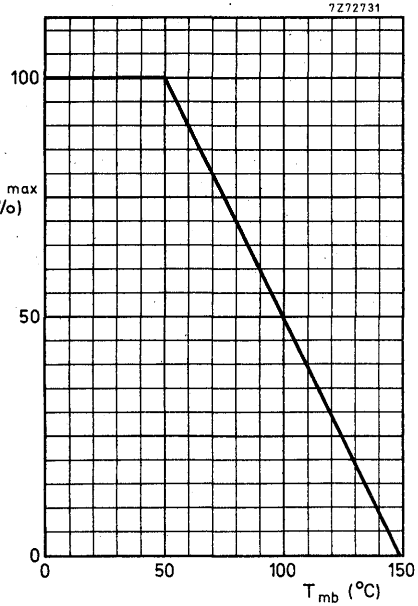


Fig. 7 Power derating curve.

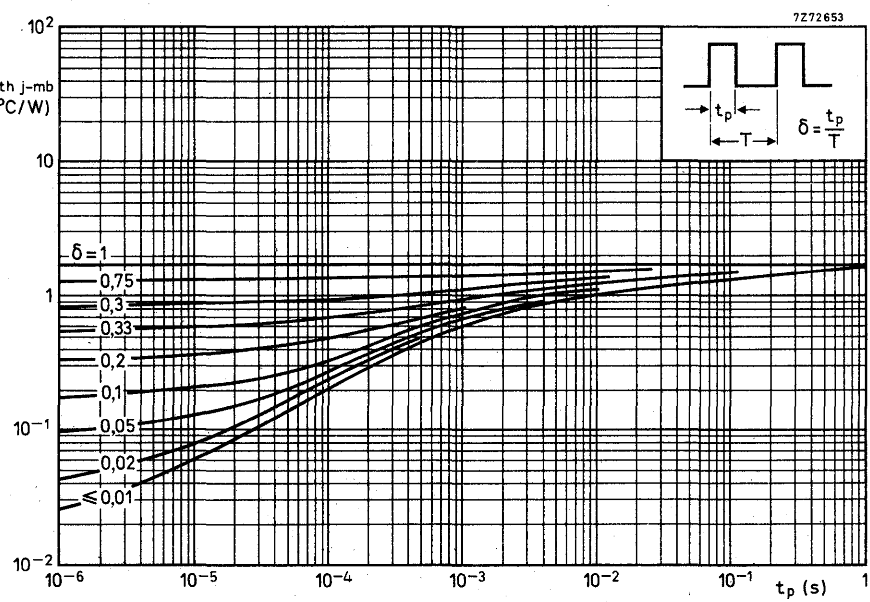


Fig. 8 Pulse power rating chart.

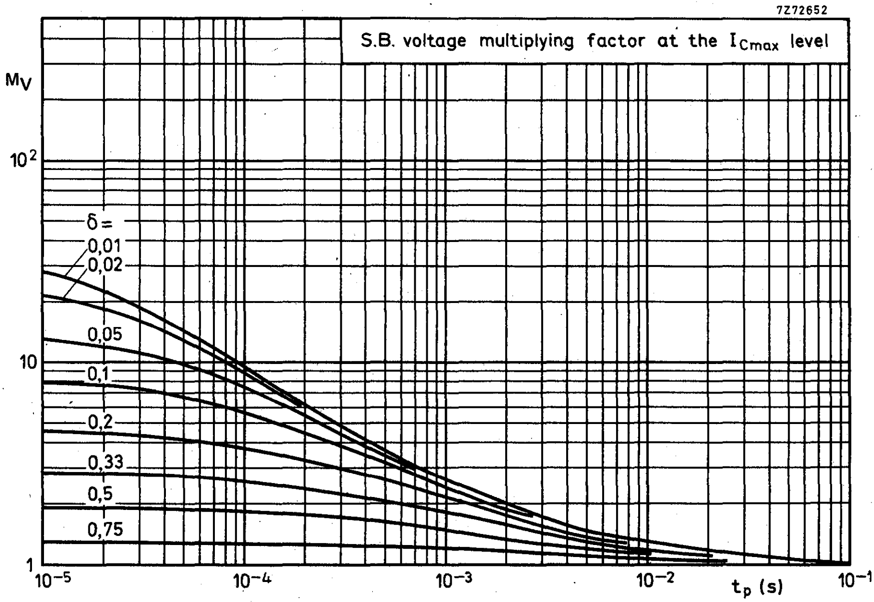


Fig. 9 S.B. voltage multiplying factor at the I_{Cmax} level.

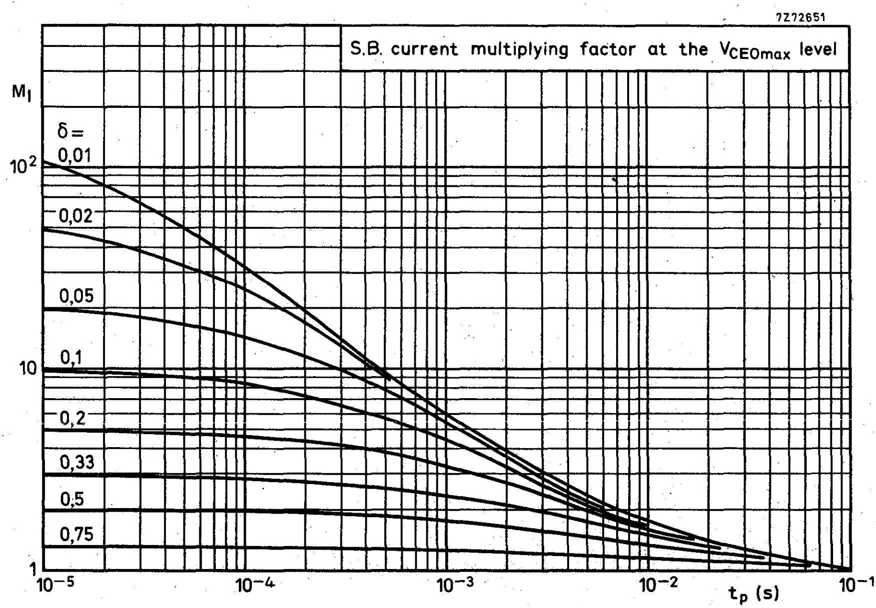


Fig. 10 S.B. current multiplying factor at the V_{CEOmax} level.

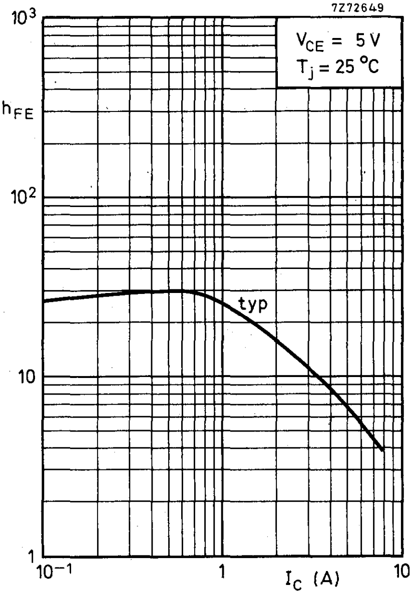


Fig. 11 D.C. current gain.

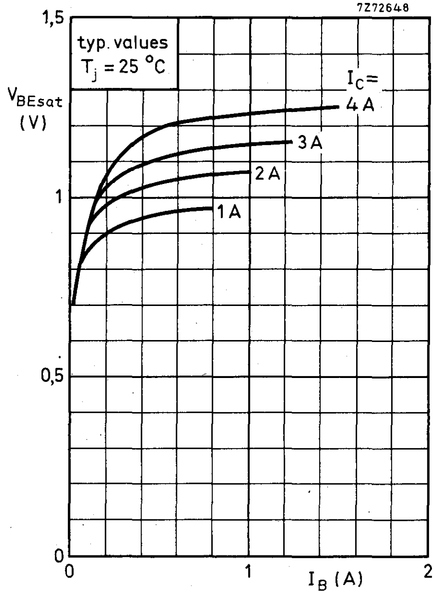


Fig. 12 Base-emitter saturation voltage.

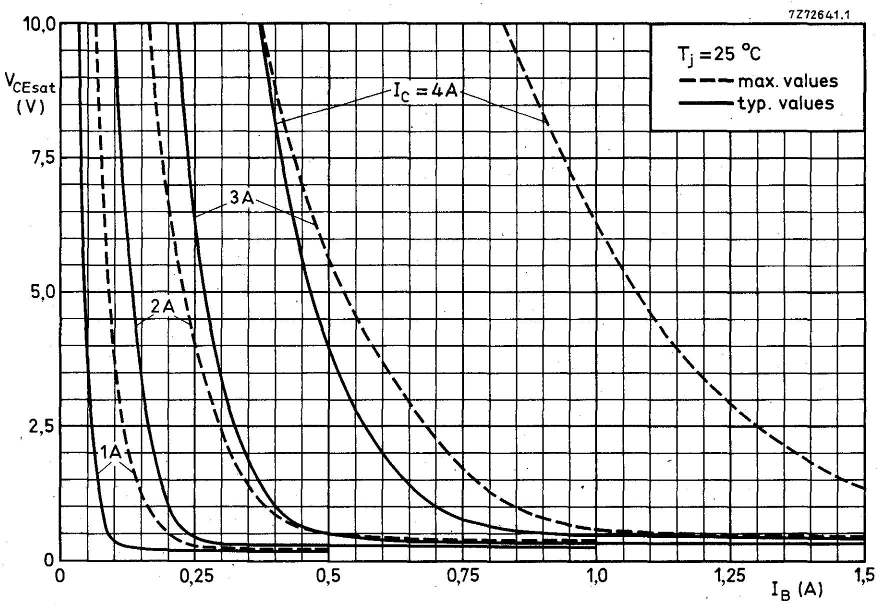


Fig. 13 Collector-emitter saturation voltage.

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

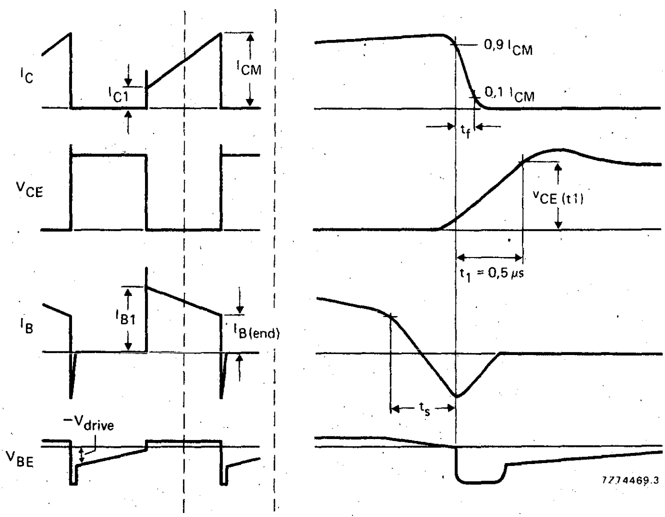


Fig. 14 Relevant waveforms of switching transistor.

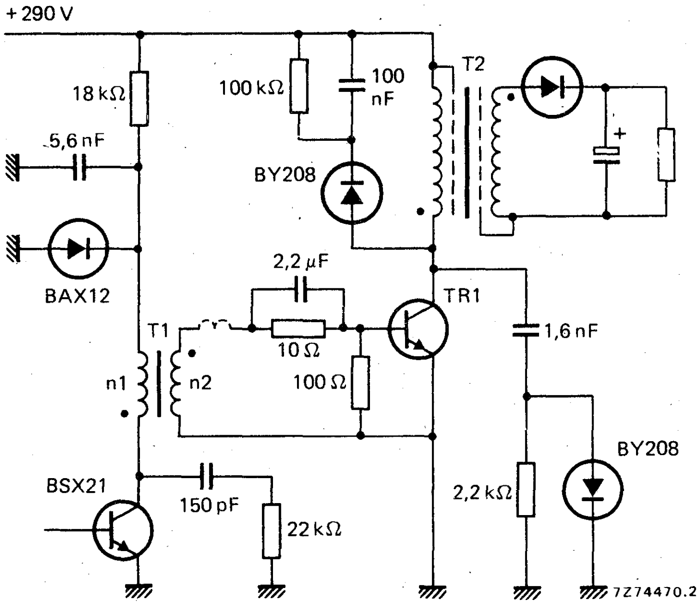


Fig. 15 Practical SMPS output circuit.

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.

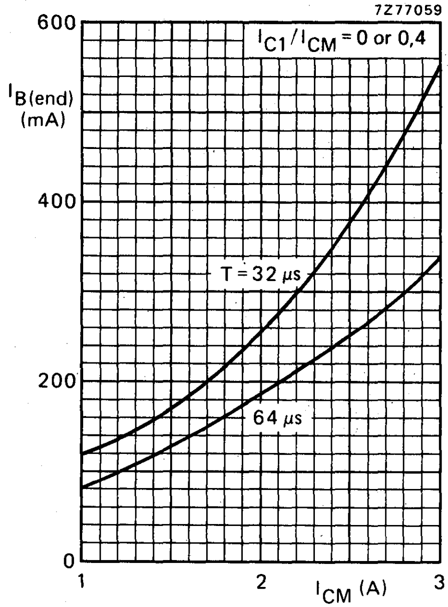


Fig. 16.

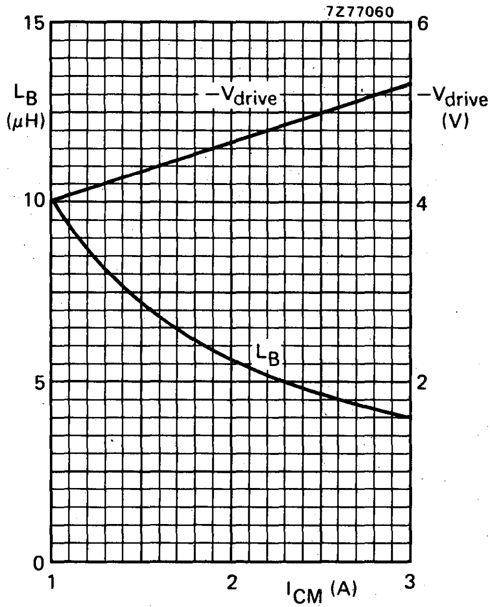


Fig. 17.

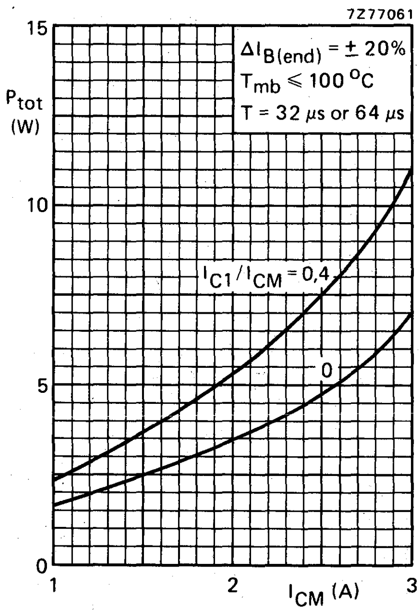


Fig. 18.

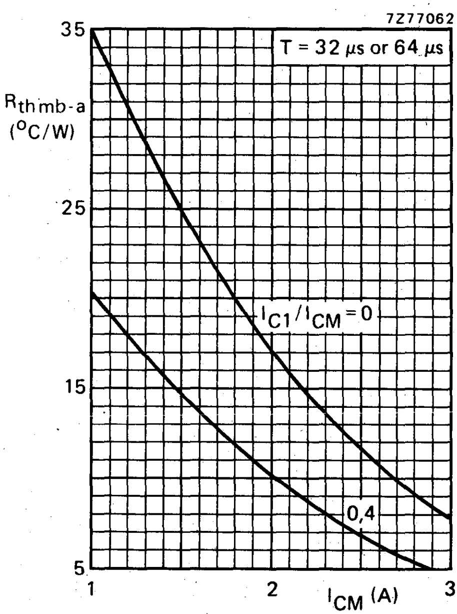


Fig. 19.

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

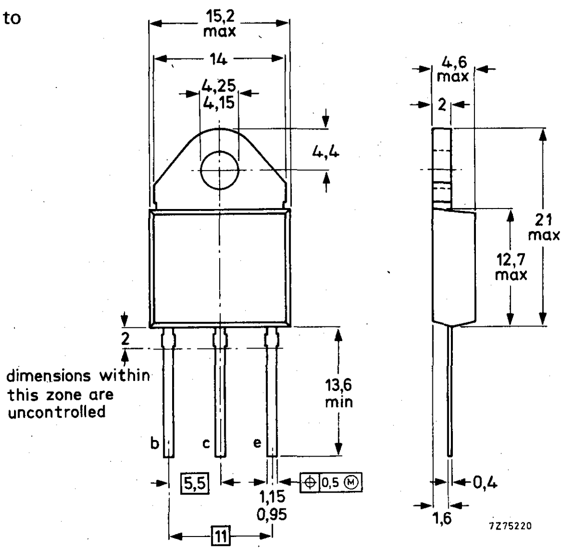
			BU426	426A	433	
Collector-emitter voltage (V_{BE} = 0; peak value)	V_{CESM}	max.	800	900	800	V
Collector-emitter voltage (open base)	V_{CEO}	max.	375	400	375	V
Collector current (d.c.)	I_C	max.		6		A
Collector current (peak value) t_p = 2 ms	I_{CM}	max.		8		A
Total power dissipation up to T_{mb} = 73 °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.		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)*	$-I_{BM}$	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	
Emitter cut-off current				
I_C = 0; V_{EB} = 10 V	I_{EBO}	<	10	mA
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)

$T_j = 25\ ^oC$ 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

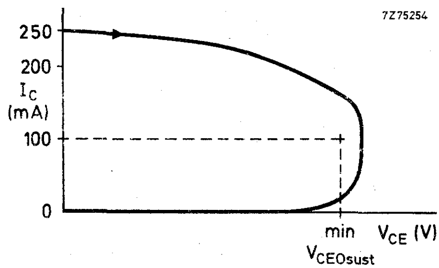


Fig. 2 Oscilloscope display for $V_{CEOsust}$.

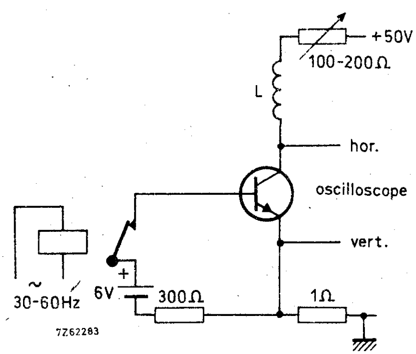


Fig. 3 Test circuit for $V_{CEOsust}$.

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

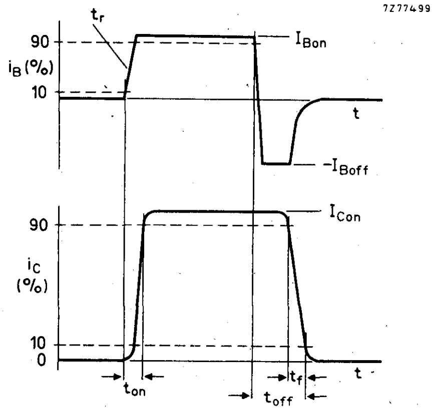


Fig. 4 Waveforms.

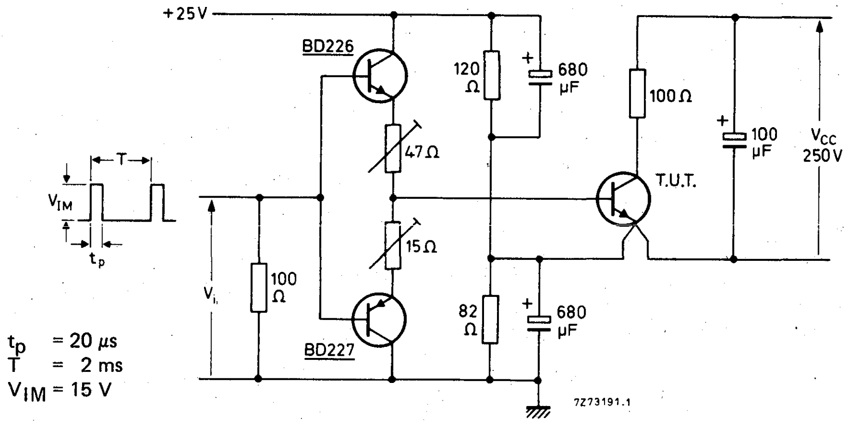


Fig. 5 Test circuit.

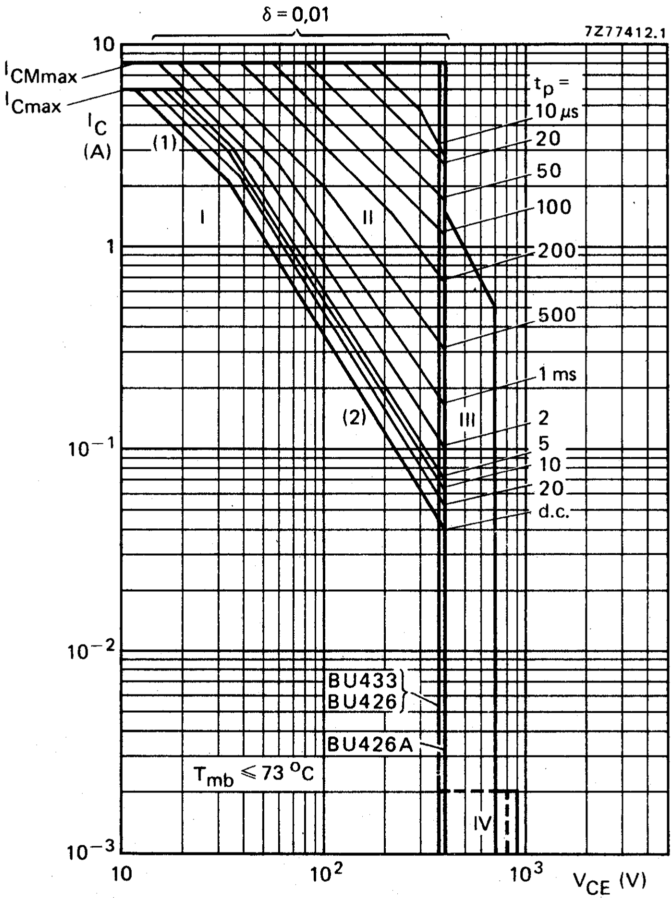


Fig. 6 Safe Operating ARea.

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 $R_{BE} \leq 100\ \Omega$ 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).

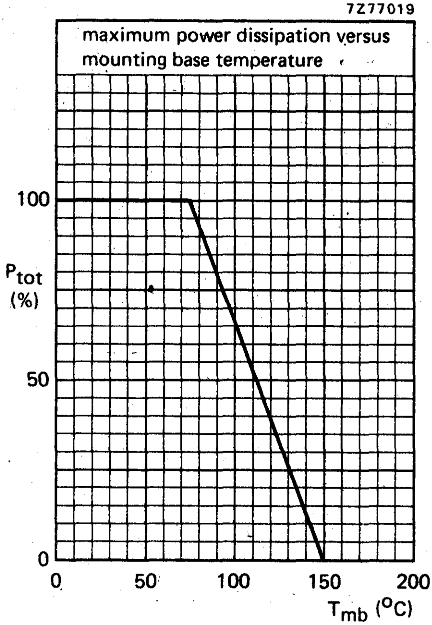


Fig. 7 Power derating curve.

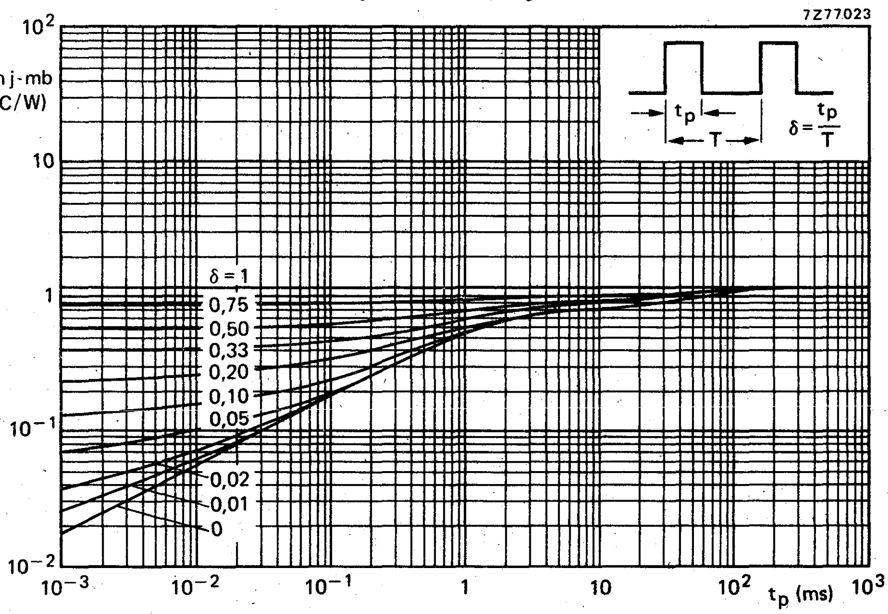


Fig. 8 Pulse power rating chart.

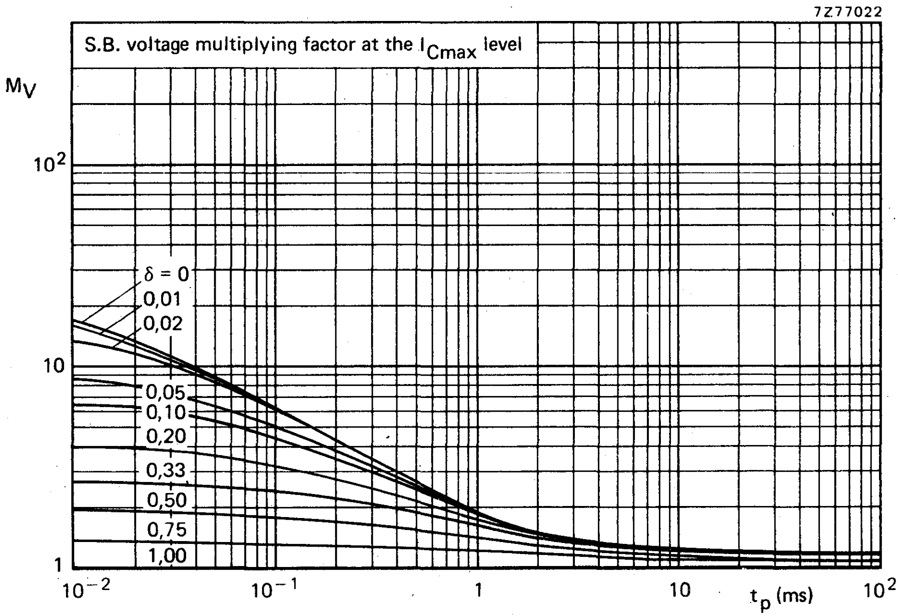


Fig. 9 S.B. voltage multiplying factor at the I_{Cmax} level.

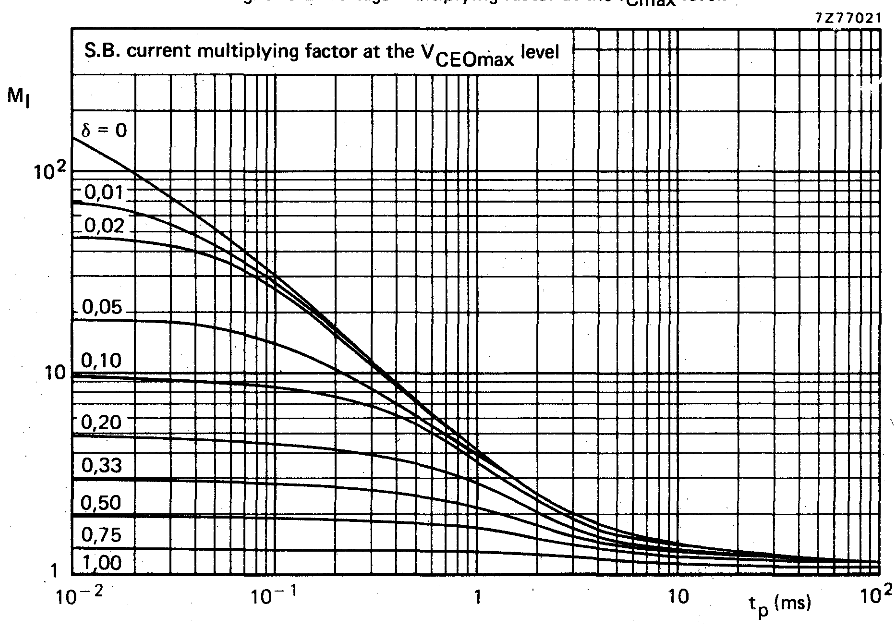


Fig. 10 S.B. current multiplying factor at the V_{CEOmax} level.

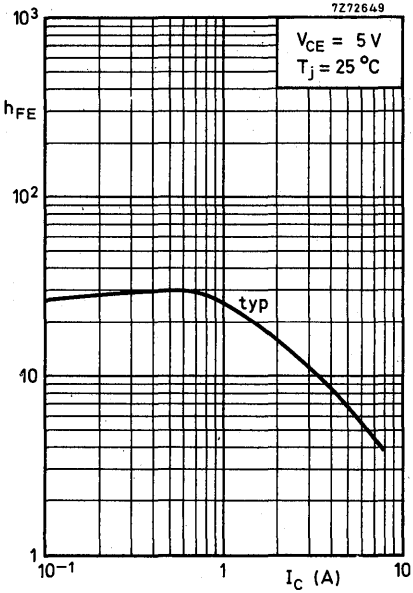


Fig. 11 D.C. current gain BU426 and BU426A.

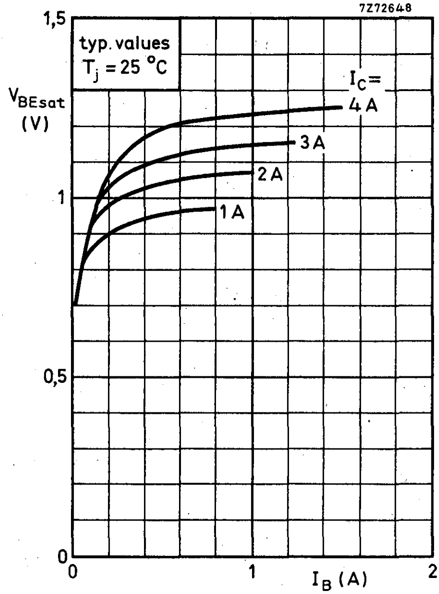


Fig. 12 Base-emitter saturation voltage for BU426 and BU426A.

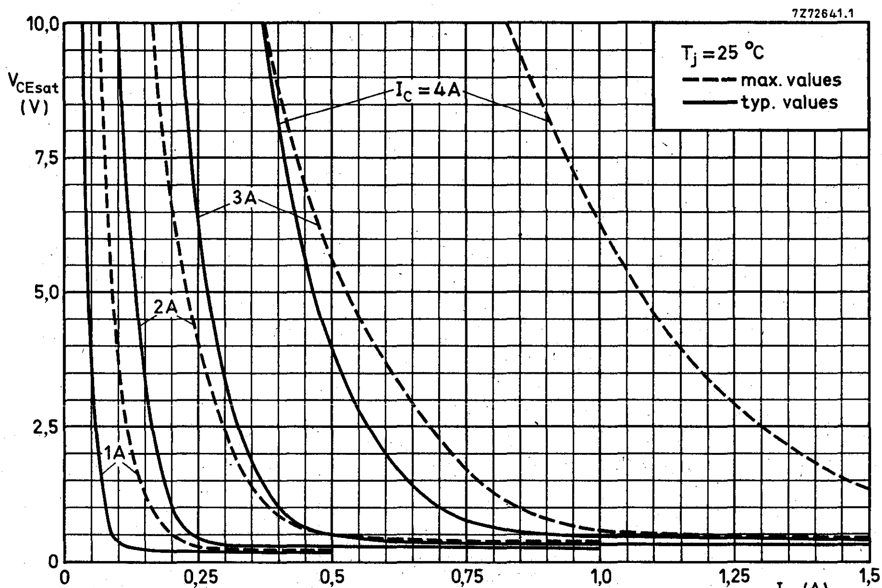


Fig. 13 Collector-emitter saturation voltage for BU426 and BU426A.

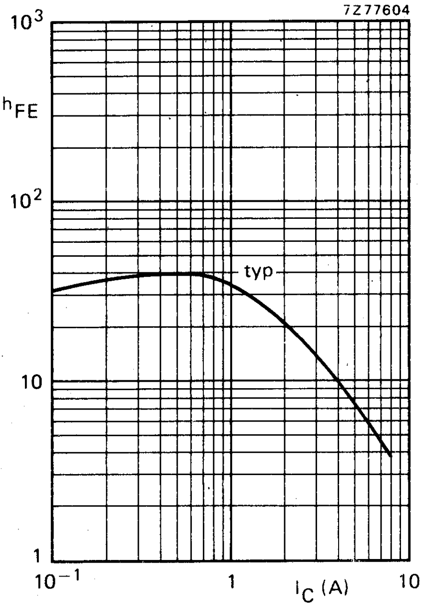


Fig. 14 D.C. current gain for BU433; V_{CE} = 5 V; T_j = 25 °C.

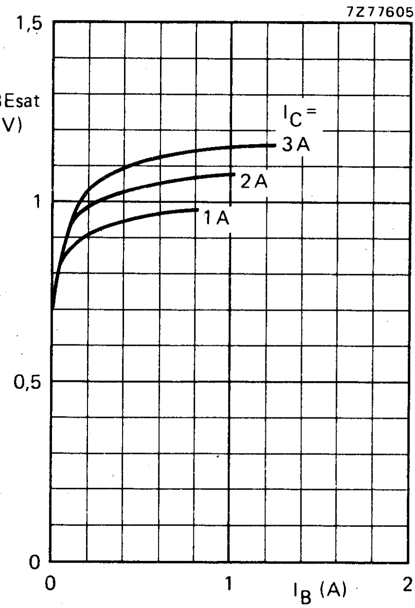


Fig. 15 Base-emitter saturation voltage for BU433; T_j = 25 °C.

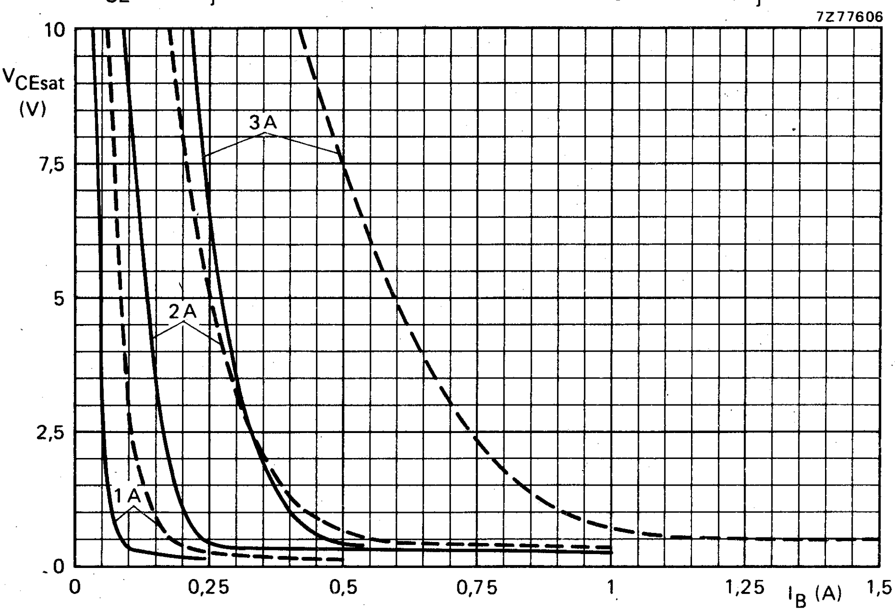


Fig. 16 Typical (——) and maximum (– – –) values collector-emitter saturation voltage for BU433; T_j = 25 °C.

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 19, 20, 21 and 22, 23, 24 is based on these applications:

The total power dissipation for a limit-case transistor BU426 or BU433 is given in Figs 21 and 24, 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 19 and 22. 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	100 °C
BU426 (426A)	Storage time t_s Fall time t_f	typ. 1,4 0,15	< 2,0 μs < 0,5 μs
BU433	Storage time t_s Fall time t_f	typ. 1,4 0,18	< 2,0 μs < 0,6 μs

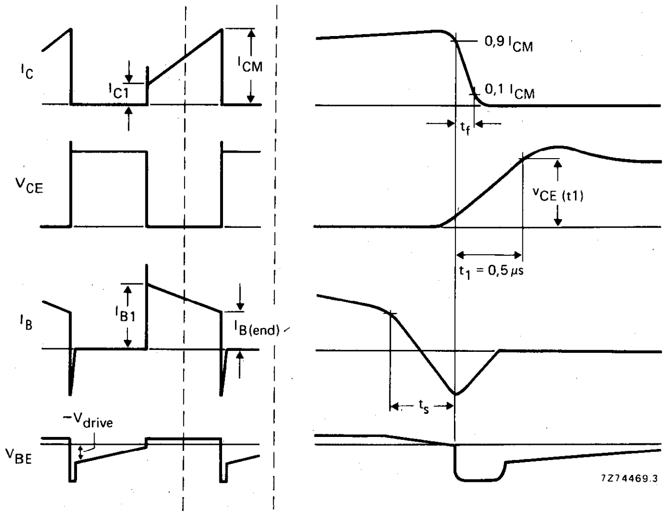


Fig. 17 Relevant waveforms of switching transistor.

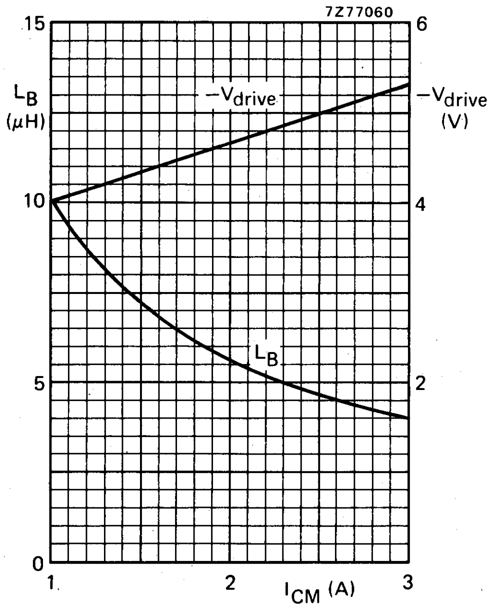


Fig. 18 Minimum required base inductance and recommended negative drive voltage versus maximum peak collector current.

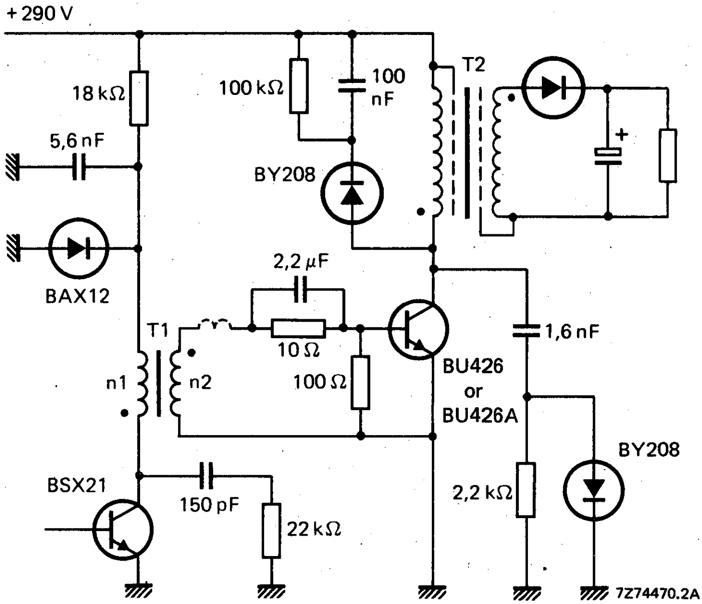


Fig. 19 Practical output circuit of a flyback SMPS of BU426 or BU426A.

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. 17)

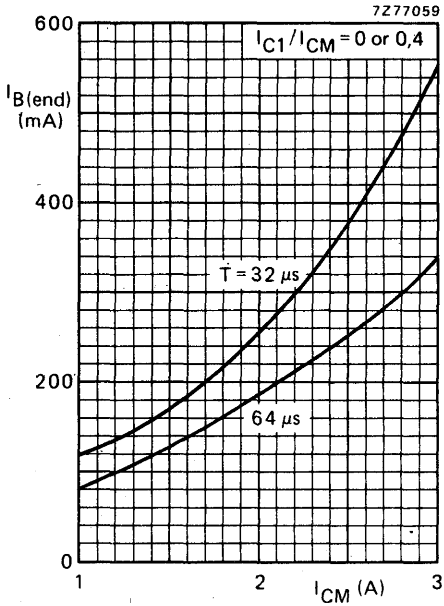


Fig. 20 Recommended nominal "end" value of the base current versus maximum peak collector current.

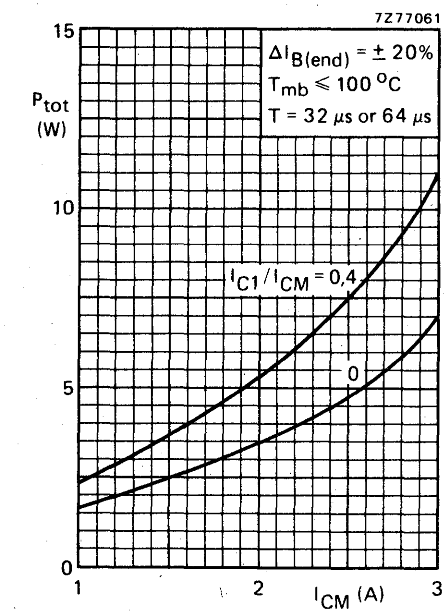


Fig. 21 Maximum total power dissipation of a limit-case transistor of the base current is chosen in accordance with Fig. 20.

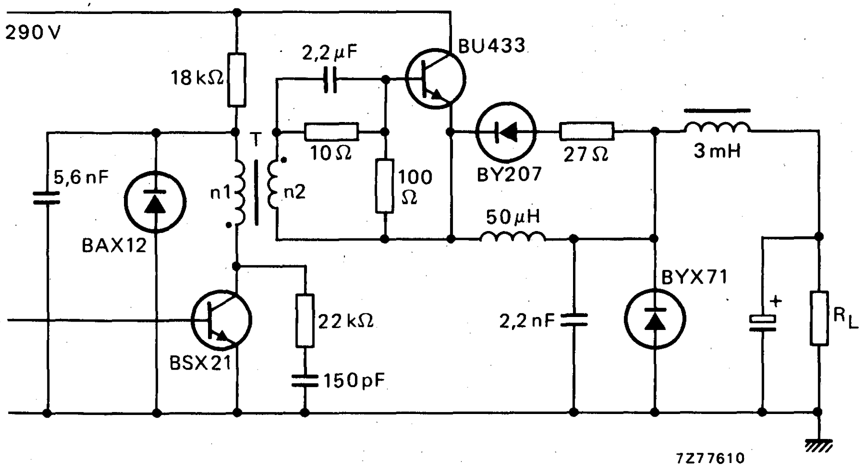


Fig. 22 Practical output circuit of a forward SMPS with BU433.

T (driver transformer): Core U20
n1 = 400 turns; n2 = 25 turns
$L_{Btot} \approx 4,5\ \mu H$

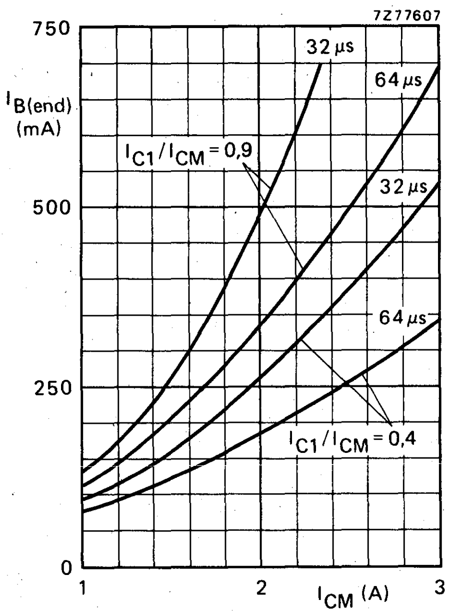


Fig. 23 Recommended nominal "end" value of the base current versus maximum peak collector current.

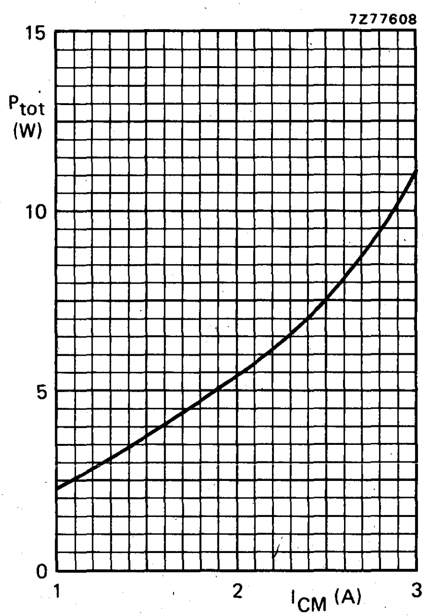


Fig. 24 Maximum total power dissipation of a limit-case transistor if the base current is chosen in accordance with Fig. 23.

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

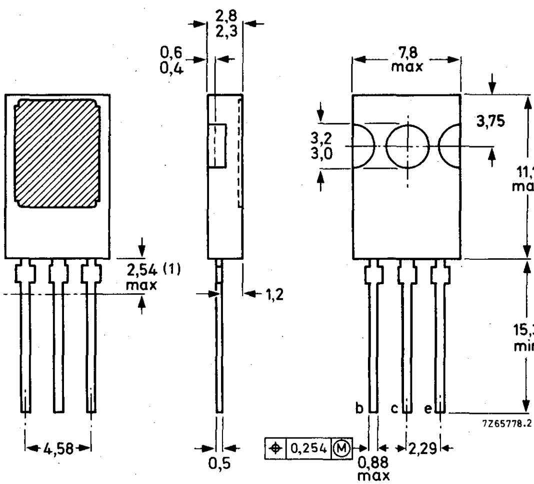
			BUW84	BUW85	
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max.	800	1000	V
Collector-emitter voltage (open base)	V_{CEO}	max.	400	450	V
Collector current (d.c.)	I_C	max.	2		A
Collector current (peak value) t_p = 2 ms	I_{CM}	max.	3		A
Total power dissipation up to T_{mb} = 45 °C	P_{tot}	max.	50		W
Collector-emitter saturation voltage I_C = 1 A; I_B = 0,2 A	V_{CEsat}	<	3		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.



For mounting instructions see Handbook section Accessories.

Accessories: 56353 and 56354.

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

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}	<	1,5		V
$I_C = 1$ A; $I_B = 0,2$ A	V_{CEsat}	<	3		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

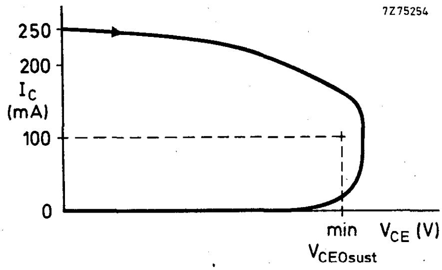


Fig. 2 Oscilloscope display for sustaining voltage.

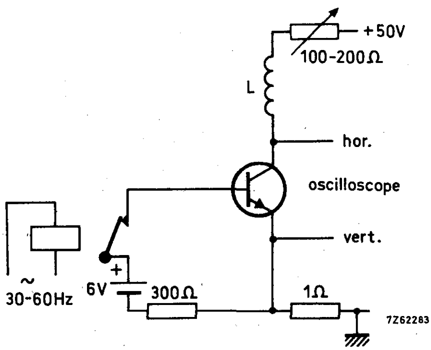


Fig. 3 Test circuit for $V_{CEOsust}$.

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

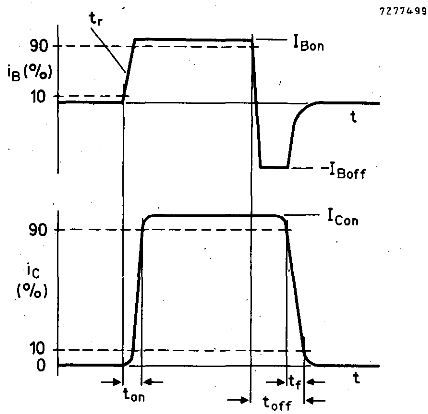


Fig. 4 Waveforms.

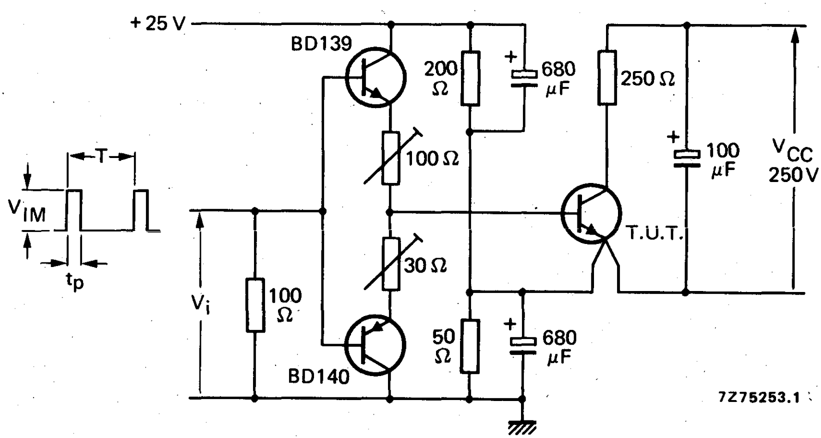


Fig. 5 Test circuit.

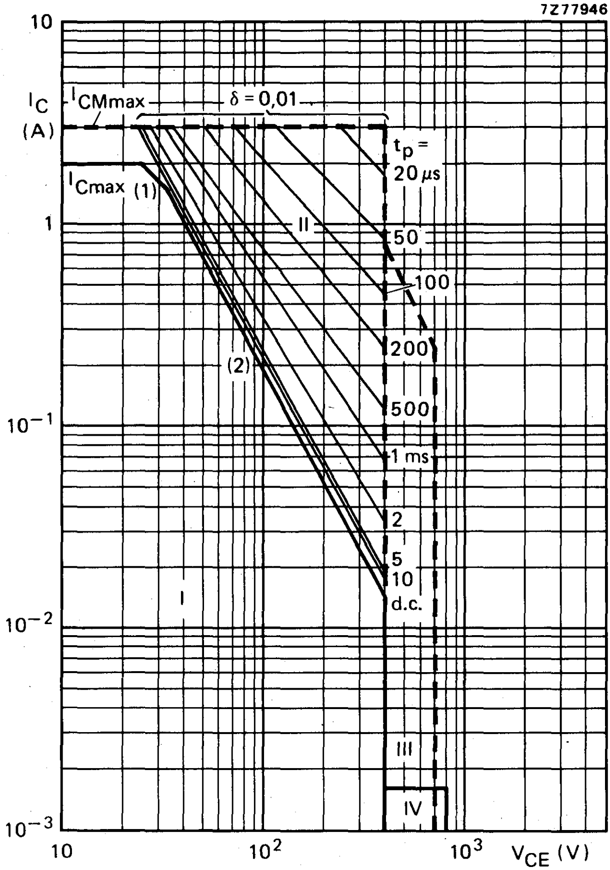


Fig. 6 Safe Operating ARea at $T_{mb} \leqslant 25$ °C of BUW84.

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).

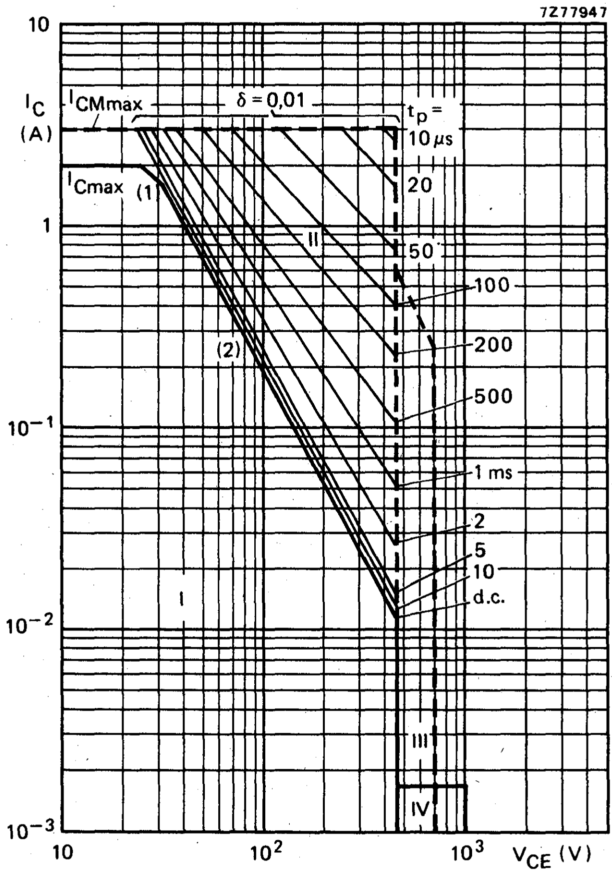


Fig. 7 Safe Operating ARea at $T_{mb} \leqslant 25\ ^oC$ of BUW85.

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).

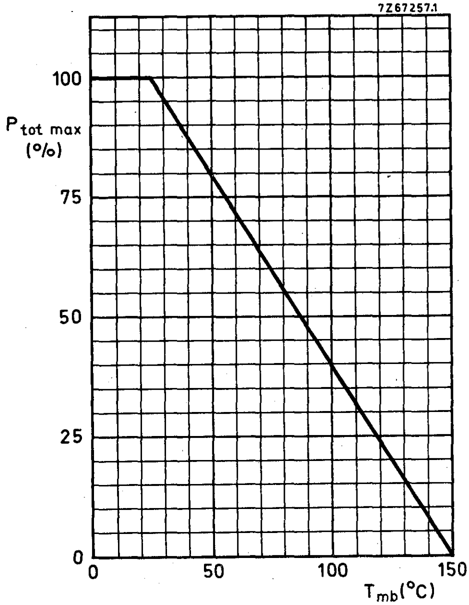

7Z67257.1
100
P tot max
(%)
75
50
25
0
0
50
100
150
T mb (°C)

Fig. 8.

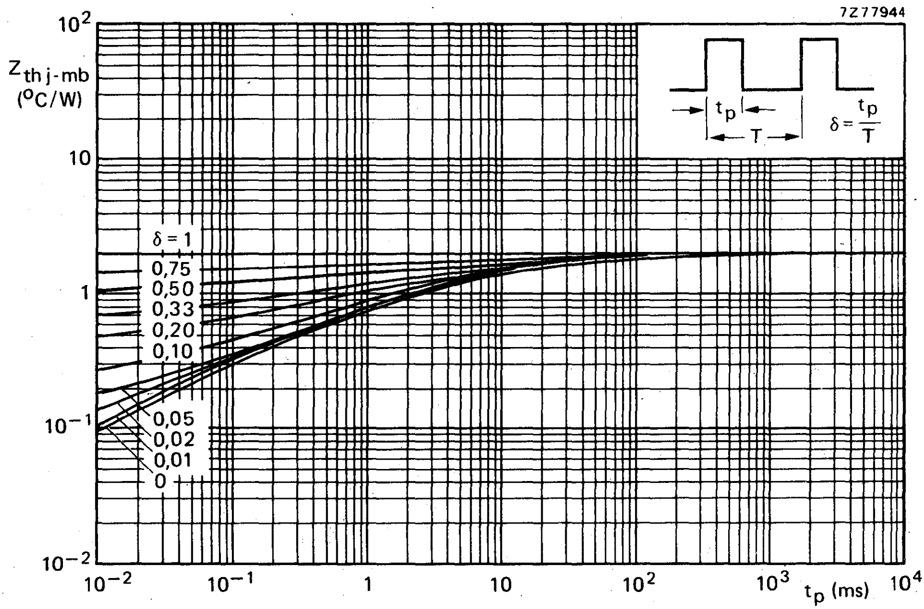

7Z77944
10^2
Z th j-mb
(°C/W)
10
1
10^{-1}
10^{-2}
δ = 1
0,75
0,50
0,33
0,20
0,10
0,05
0,02
0,01
0
t p
T
δ = t p / T
10^{-2}
10^{-1}
1
10
10^2
10^3
t p (ms)
10^4

Fig. 9.

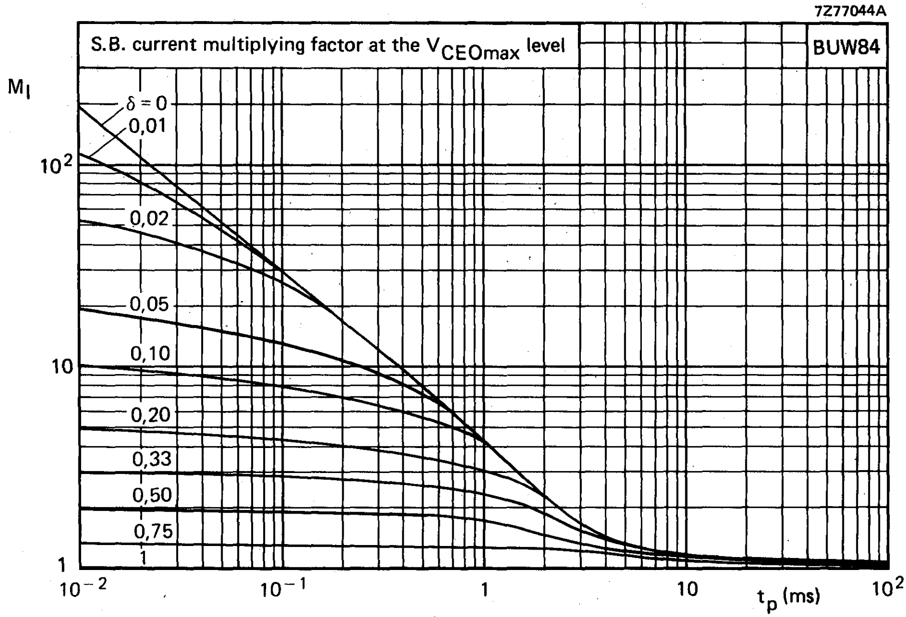

7Z77044A
S.B. current multiplying factor at the V_{CEOmax} level
BUW84
M_I
$\delta = 0$
0,01
0,02
0,05
0,10
0,20
0,33
0,50
0,75
1
10^2
10
1
10^{-2}
10^{-1}
1
10
t_p (ms)
10^2

Fig. 10.

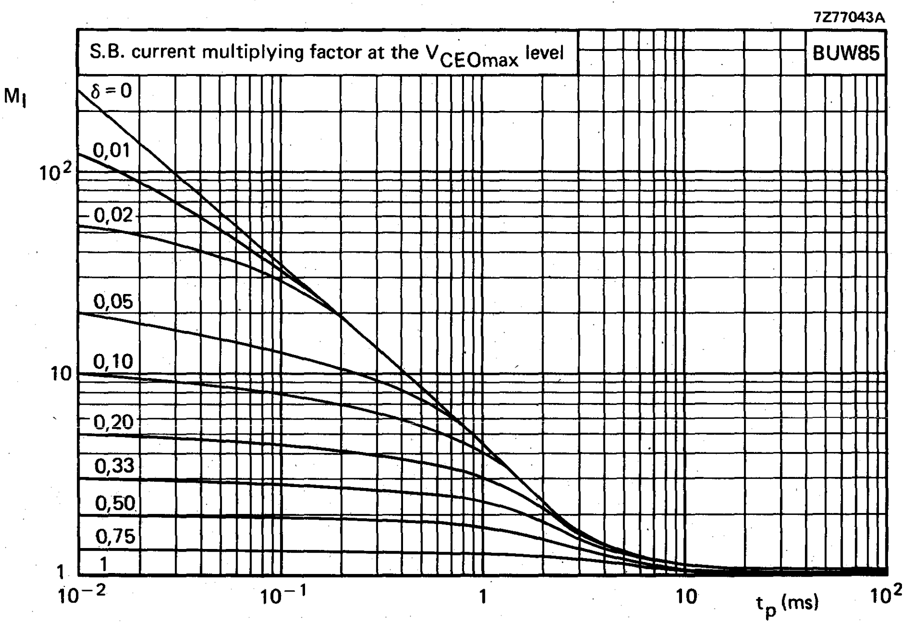

7Z77043A
S.B. current multiplying factor at the V_{CEOmax} level
BUW85
M_I
$\delta = 0$
0,01
0,02
0,05
0,10
0,20
0,33
0,50
0,75
1
10^2
10
1
10^{-2}
10^{-1}
1
10
t_p (ms)
10^2

Fig. 11.

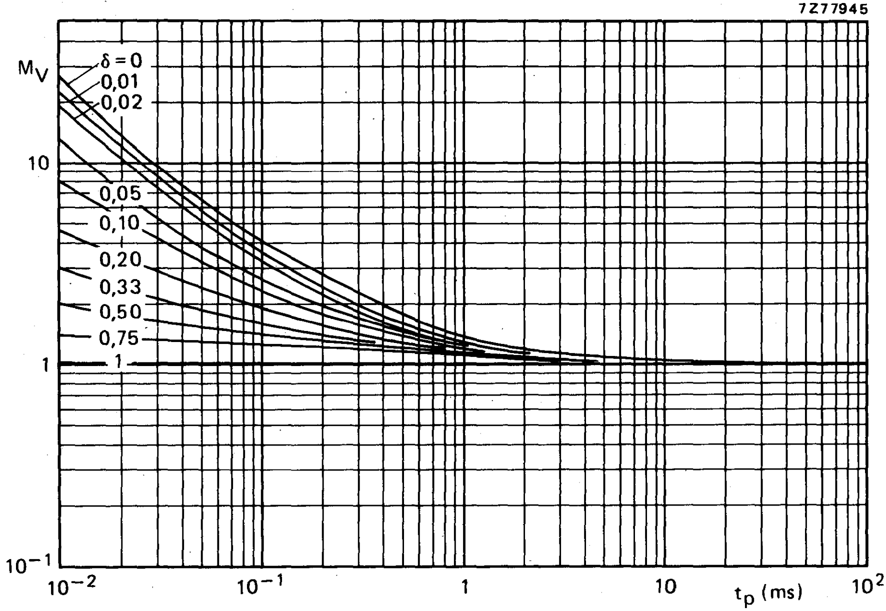


Fig. 12 S.B. voltage multiplying factor at the I_{Cmax} level.

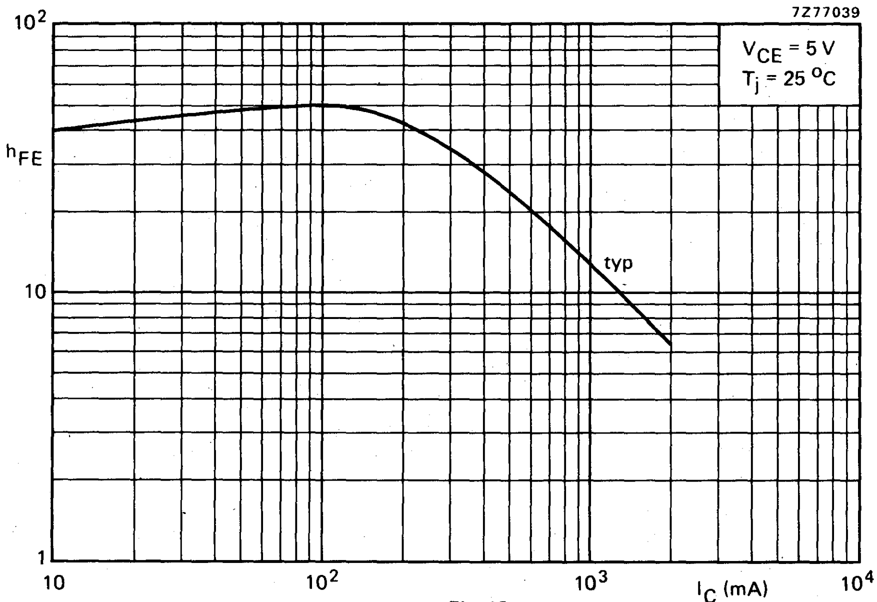


Fig. 13.

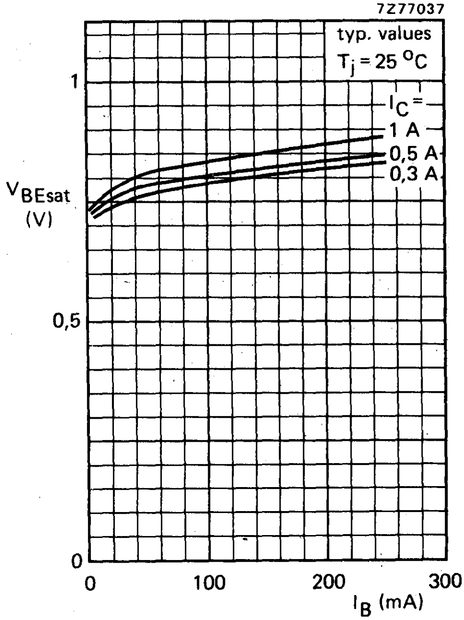

7Z77037
typ. values
$T_j = 25\ ^oC$
$I_C =$
1 A
0,5 A
0,3 A
V_{BEsat}
(V)
1
0,5
0
0
100
200
300
I_B (mA)

Fig. 14.

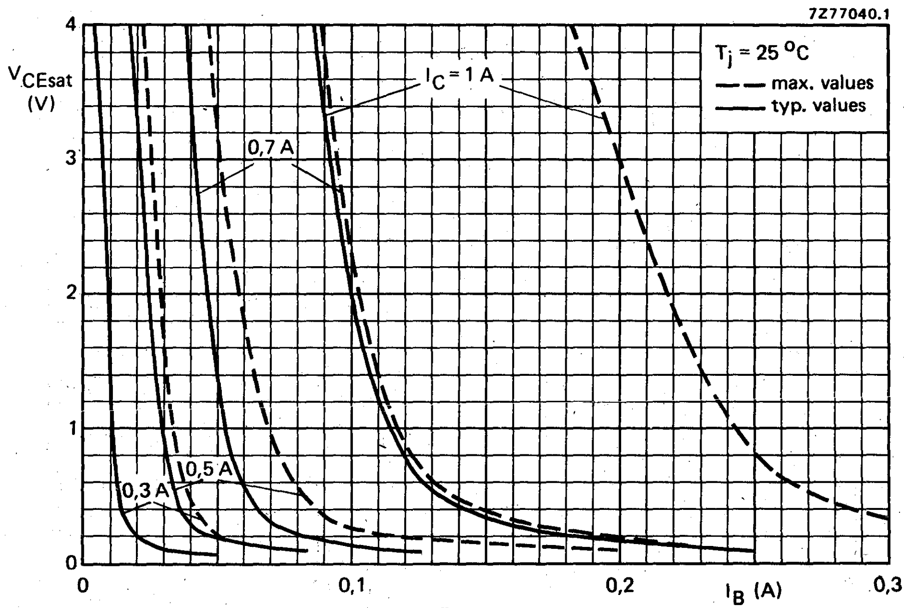

7Z77040.1
$T_j = 25\ ^oC$
max. values
typ. values
$I_C = 1$ A
0,7 A
0,5 A
0,3 A
V_{CEsat}
(V)
4
3
2
1
0
0
0,1
0,2
0,3
I_B (A)

Fig. 15.

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.

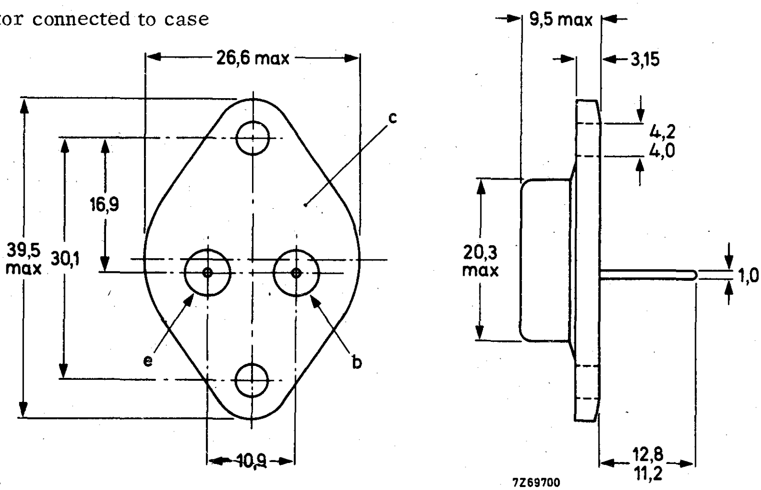
QUICK REFERENCE DATA

			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

MECHANICAL DATA Dimensions in mm

TO-3

Collector connected to case



For mounting instructions and accessories see section Accessories in handbook SC2.

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

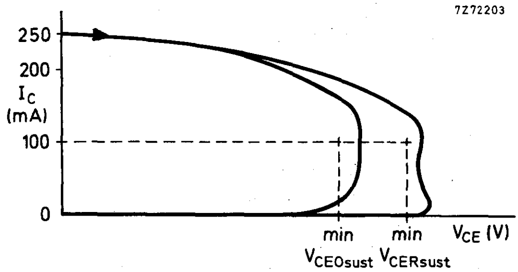
$I_C = 0$; $V_{EB} = 10\ V$	I_{EBO}	<	10	mA

Saturation voltages

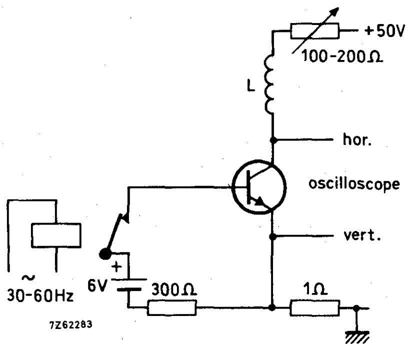
$I_C = 5\ A$; $I_B = 1\ A$	V_{CEsat}	<	1,5	V
	$V_{BE\ sat}$	<	1,4	V
$I_C = 8\ A$; $I_B = 2,5\ A$	V_{CEsat}	<	3	V
	$V_{BE\ sat}$	<	1,8	V

Collector-emitter sustaining voltages

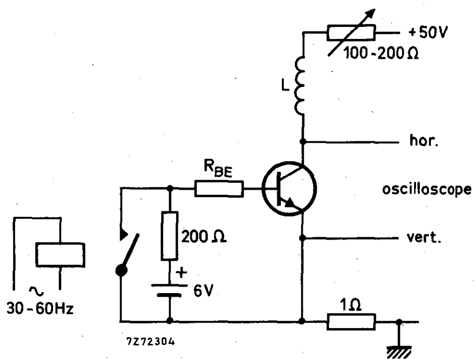
			BUX80	BUX81	
$I_C = 100\ mA$; $I_{Boff} = 0$; $L = 25\ mH$	$V_{CEOsust}$	>	400	450	V
$I_C = 100\ mA$; $R_{BE} = 50\ \Omega$; $L = 15\ mH$	$V_{CERsust}$	>	500	500	V



Oscilloscope display for sustaining voltages



Test circuit for $V_{CEOsust}$



Test circuit for $V_{CERsust}$

CHARACTERISTICS (continued) $T_j = 25\ ^oC$ unless otherwise specified

Transition frequency at f = 1 MHz

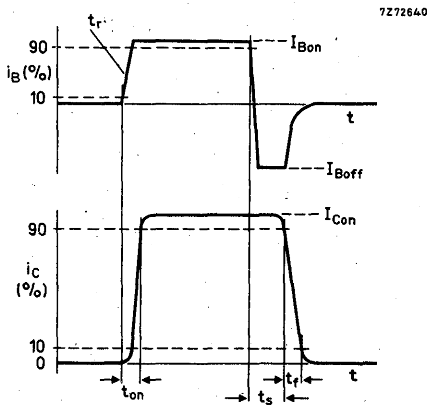
$I_C = 0,2\ A$; $V_{CE} = 10\ V$	f_T	typ.	6	MHz

Switching times

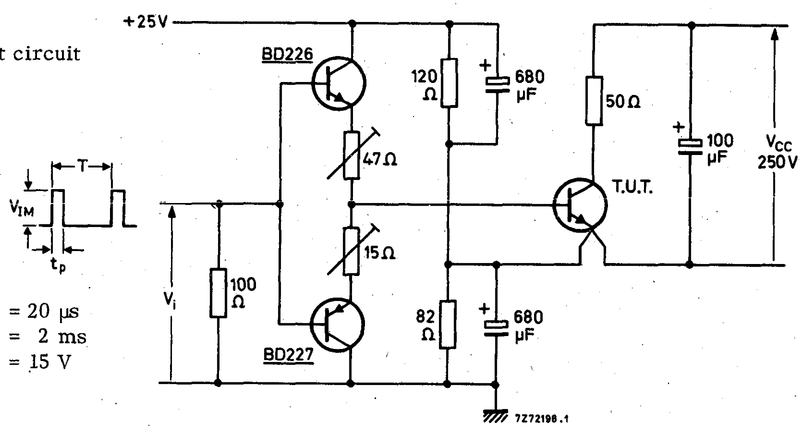
$I_{Con} = 5\ A$; $V_{CC} = 250\ V$
$I_{Bon} = 1\ A$; $-I_{Boff} = 2\ A$

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, $T_{mb} = 95\ ^oC$	t_f	<	0, 8	μs

Waveform

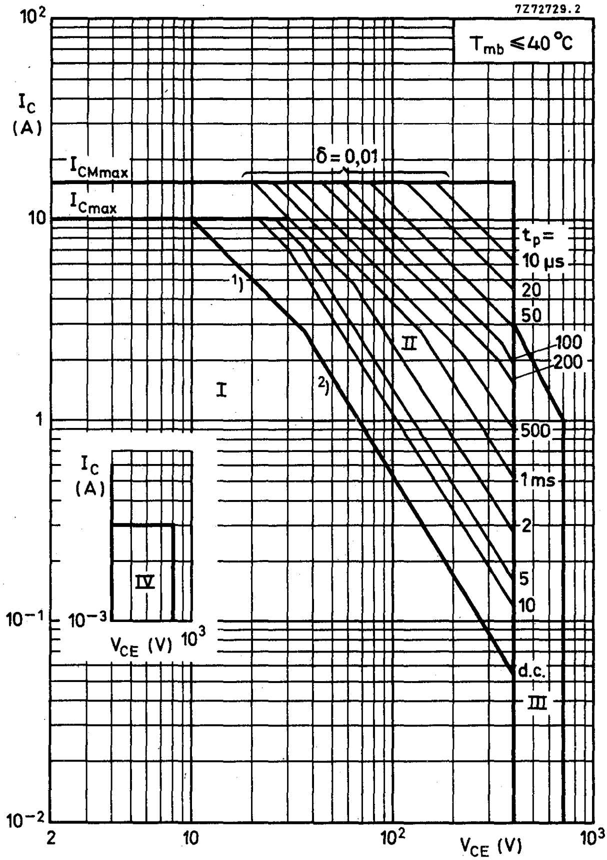


Test circuit



$t_p = 20\ \mu s$
$T = 2\ ms$
$V_{IM} = 15\ V$

BUX80



Safe Operating ARea

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

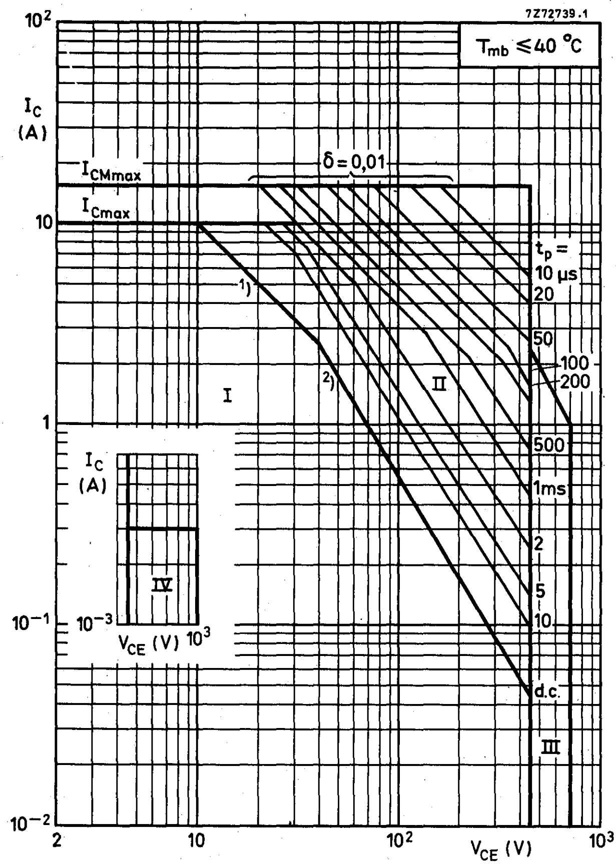
III Area of permissible operation during turn-on in single-transistor converters, provided $R_{BE} \leq 100\ \Omega$ and $t_p \leq 0,6\ \mu s$

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

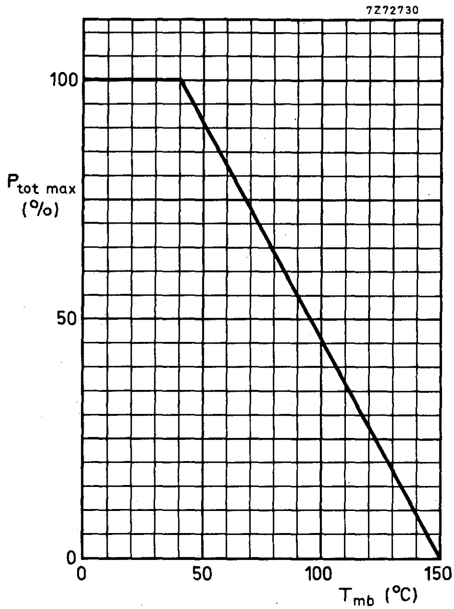
II Permissible extension for repetitive pulse operation

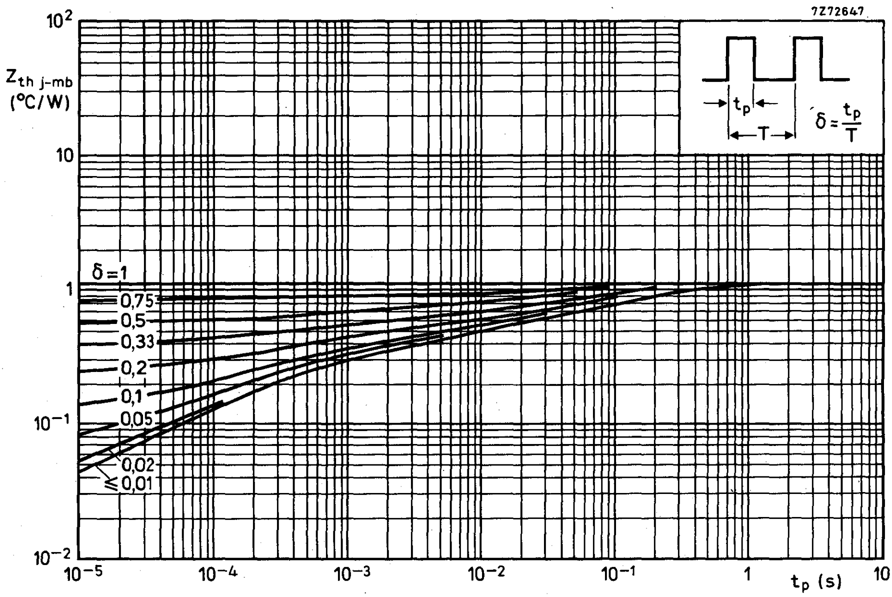
III Area of permissible operation during turn-on in single-transistor converters, provided $R_{BE} \leq 100\,\Omega$ and $t_p \leq 0{,}6\ \mu s$

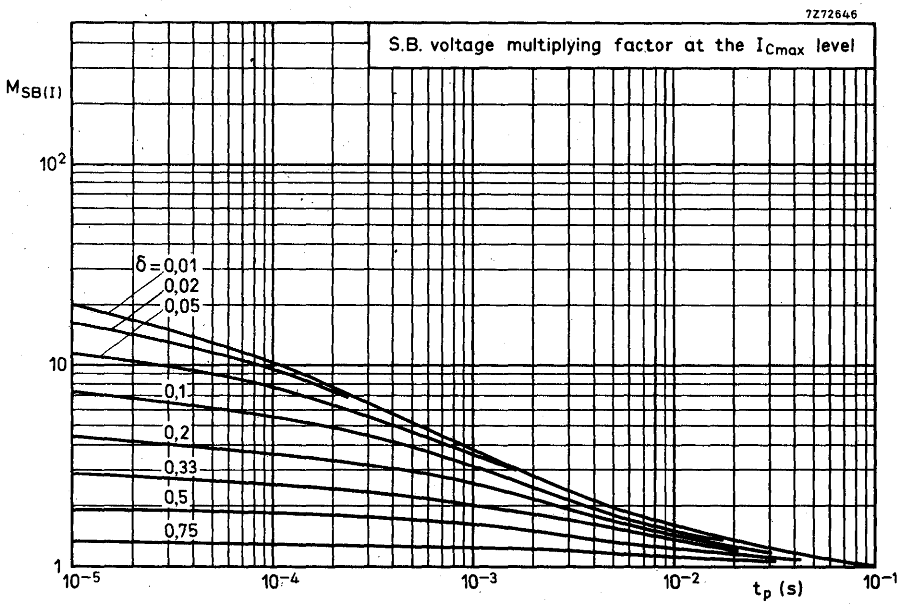
IV Repetitive pulse operation in this region is permissible, provided $V_{BE} \leq 0$ and $t_p \leq 2$ ms

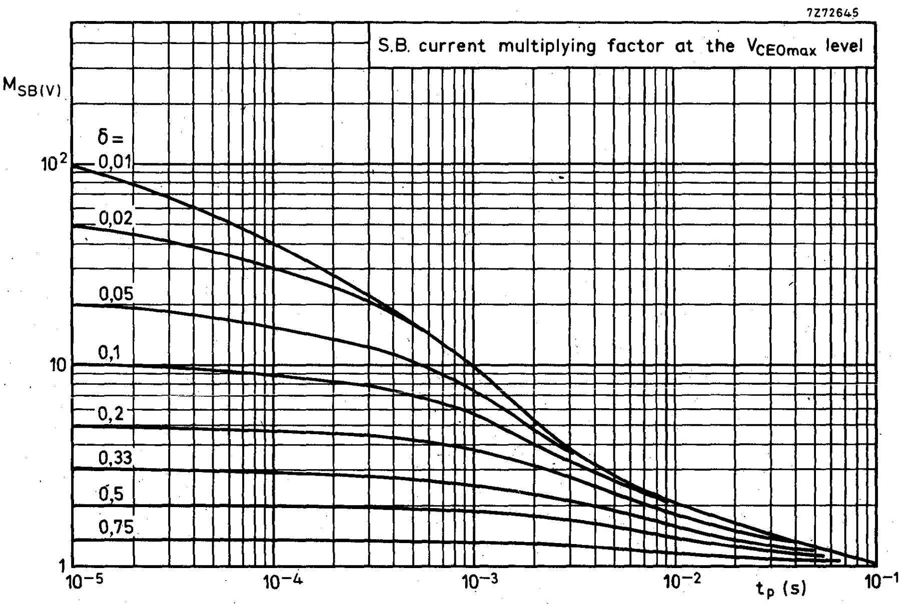
1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.

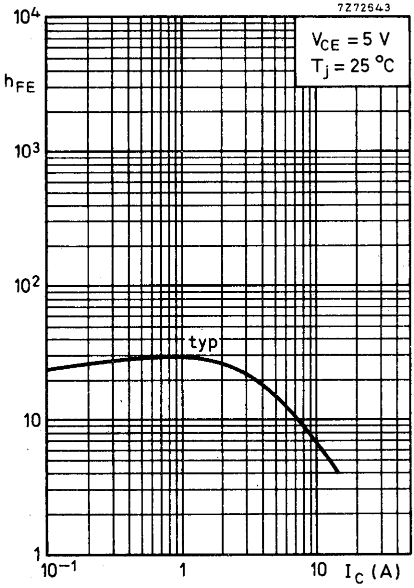
2) Second-breakdown limits (independent of temperature).

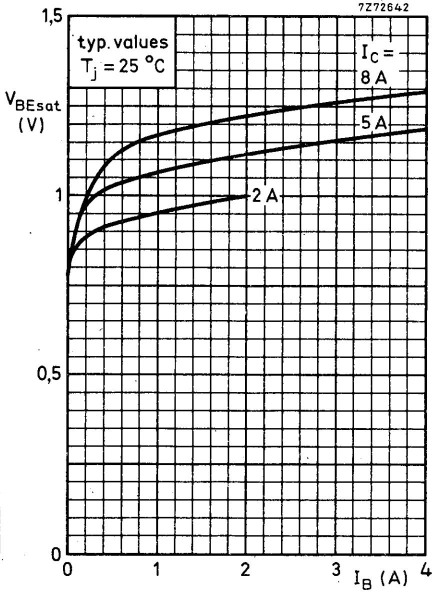

7Z72730
$P_{tot\ max}$ (%)
100
50
0
0
50
100
150
T_{mb} (°C)

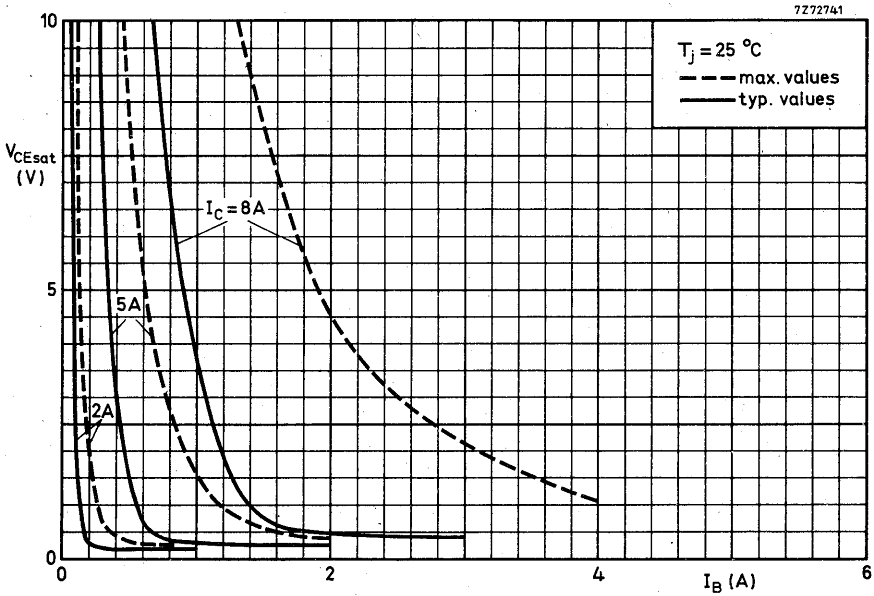

7Z72647
$Z_{th\ j\text{-}mb}$ (°C/W)
10^2
10
1
10^{-1}
10^{-2}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
t_p (s)
$\delta = 1$
0,75
0,5
0,33
0,2
0,1
0,05
0,02
≤ 0,01
t_p
T
$\delta = \frac{t_p}{T}$


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}
t_p (s)
10^{-1}


7Z72645
S.B. current multiplying factor at the V_{CEOmax} level
$M_{SB(V)}$
δ =
10^2
0,01
0,02
0,05
10
0,1
0,2
0,33
0,5
0,75
1
10^{-5}
10^{-4}
10^{-3}
10^{-2}
t_p (s)
10^{-1}


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
V_{BEsat} (V)
$I_C =$ 8 A
5 A
2 A
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)
$I_C = 8$ A
5A
2A
10
5
0
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

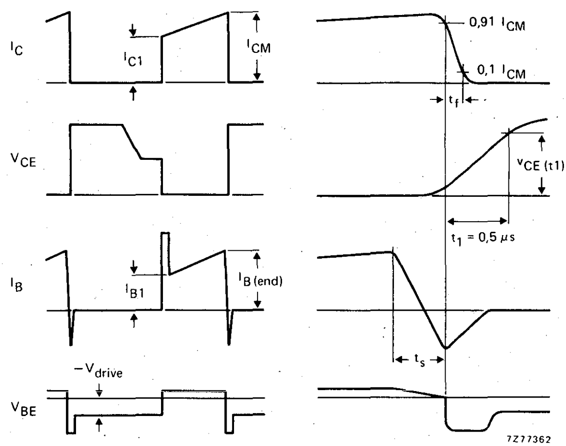


Fig. 1 Relevant waveforms of switching transistor.

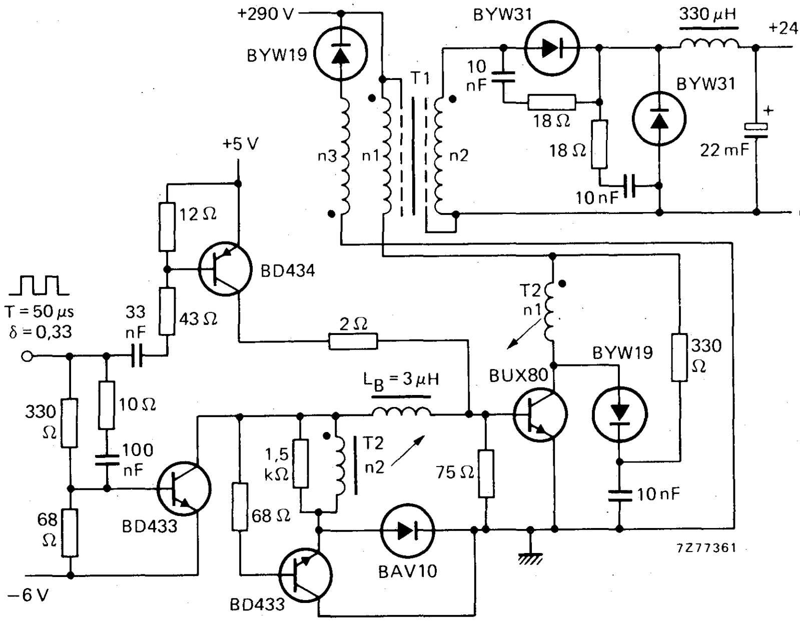


Fig. 2 Practical SMPS output circuit.

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)

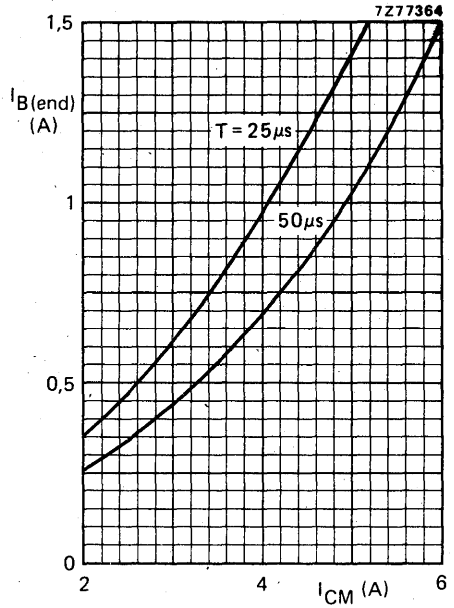


Fig. 3.

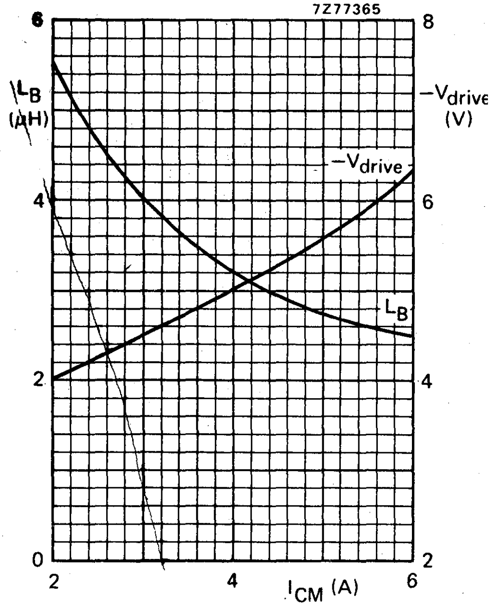


Fig. 4.

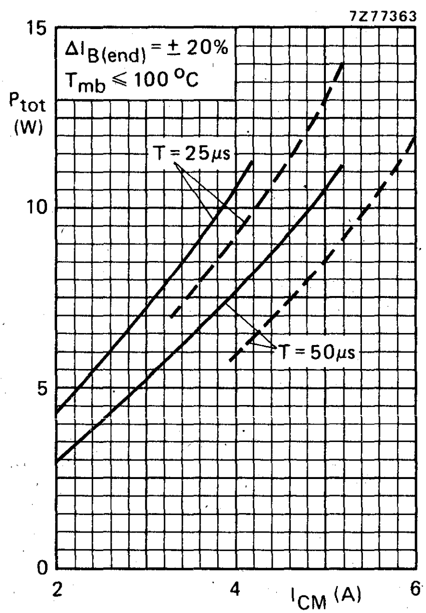


Fig. 5.

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

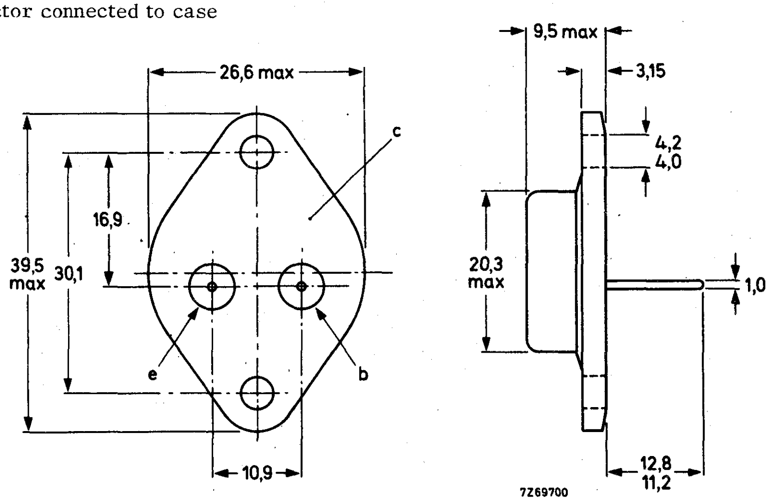
High-voltage, high-speed switching n-p-n power transistors in TO-3 envelopes, intended for use in converters, inverters, switching regulators and motor control systems.

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 in handbook SC2.

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

			BUX82	BUX83	
Voltages					
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

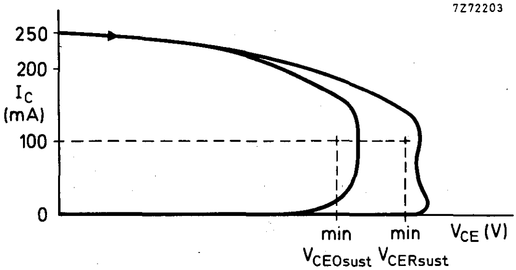
$I_C = 0$; $V_{EB} = 10$ V	I_{EBO}	<	10	mA

Saturation voltages

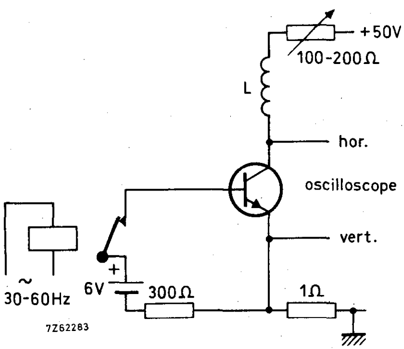
$I_C = 2,5$ A; $I_B = 0,5$ A	V_{CEsat}	<	1,5	V
	$V_{BE\,sat}$	<	1,4	V
$I_C = 4$ A; $I_B = 1,25$ A	V_{CEsat}	<	3	V
	$V_{BE\,sat}$	<	1,6	V

Collector-emitter sustaining voltages

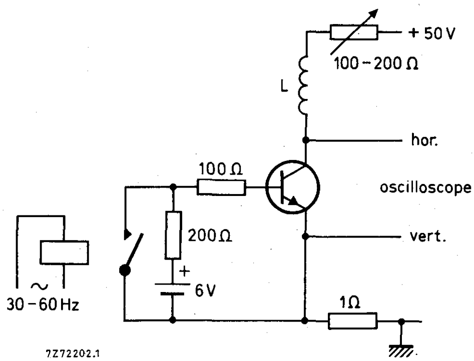
			BUX82	BUX83	
$I_C = 100$ mA; $I_{Boff} = 0$; $L = 25$ mH	$V_{CEOsust}$	>	400	450	V
$I_C = 100$ mA; $R_{BE} = 100\,\Omega$; $L = 15$ mH	$V_{CERsust}$	>	500	500	V



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

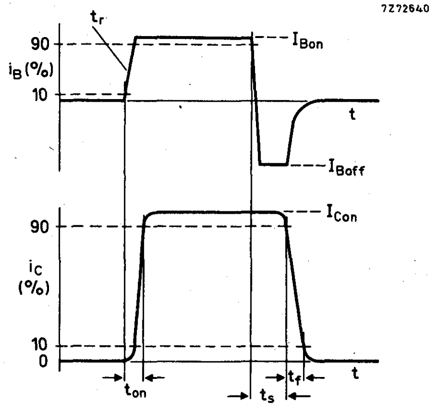
Switching times

I_{Con} = 2,5 A; V_{CC} = 250 V

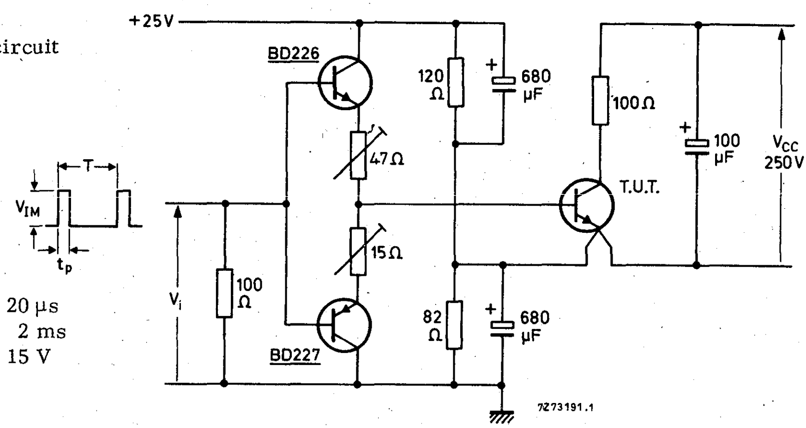
I_{Bon} = 0,5 A; $-I_{Boff}$ = 1 A

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

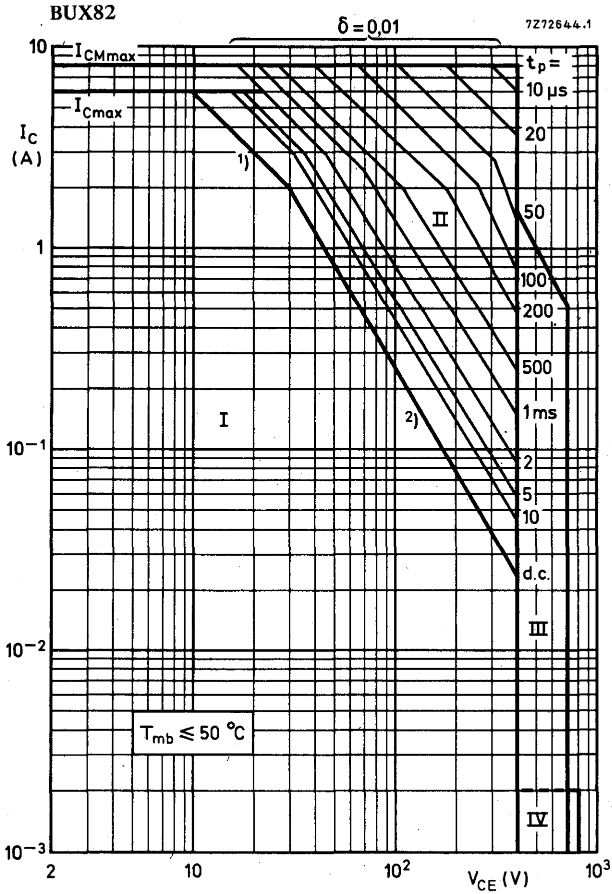
Waveform



Test circuit



t_p = 20 μs
T = 2 ms
V_{IM} = 15 V



Safe Operating ARea

I Region of permissible d.c. operation

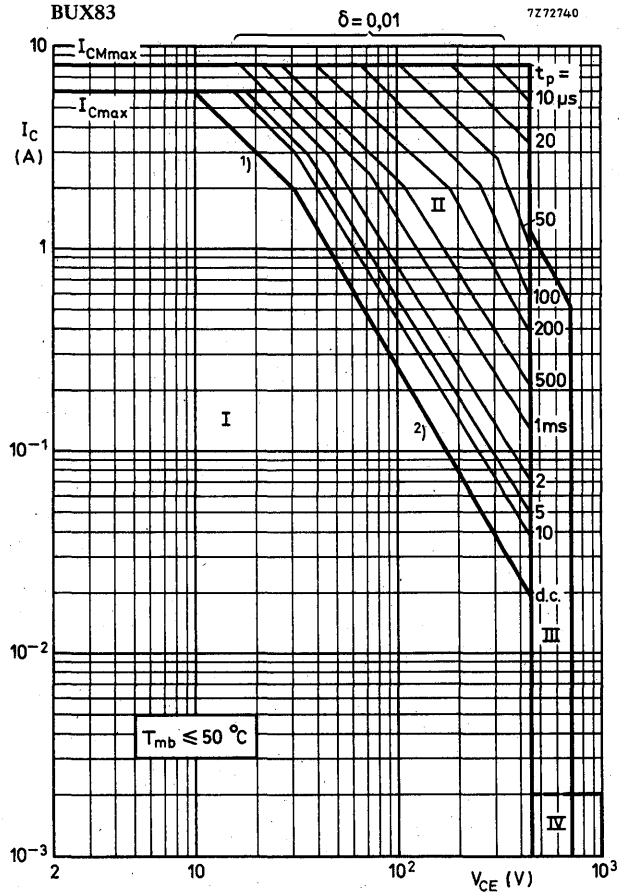
II Permissible extension for repetitive pulse operation

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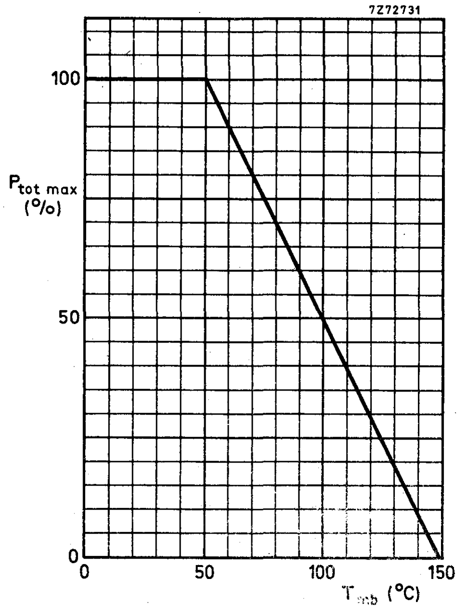
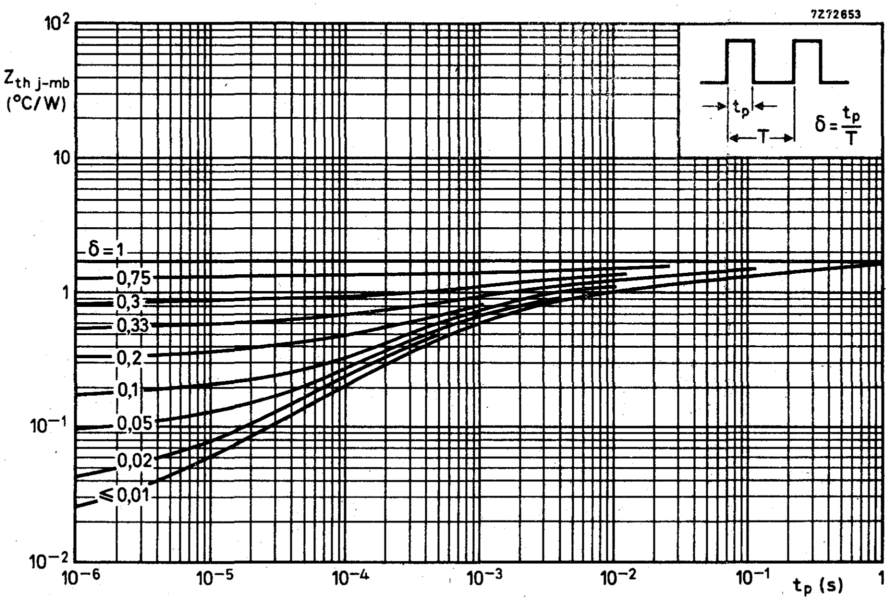
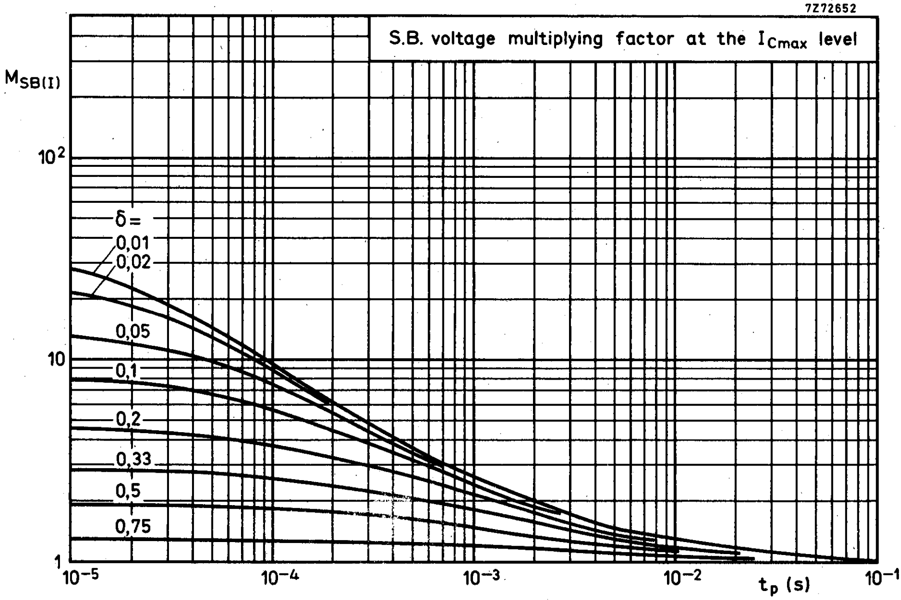
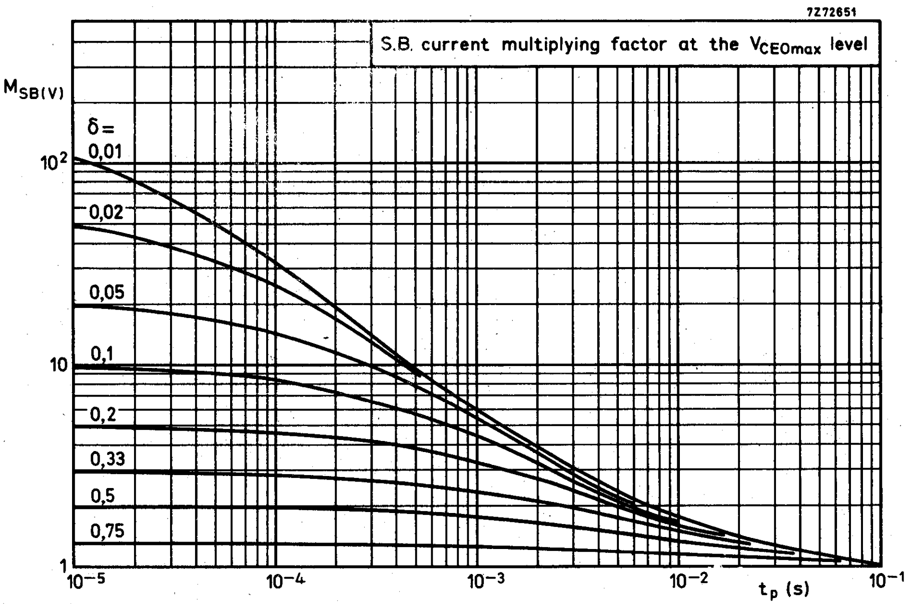
1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.

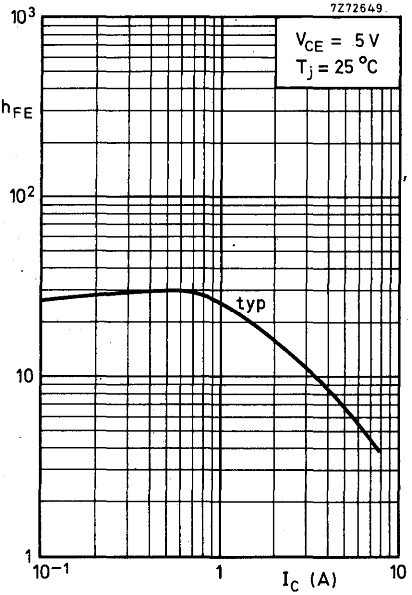
2) Second-breakdown limits (independent of temperature).

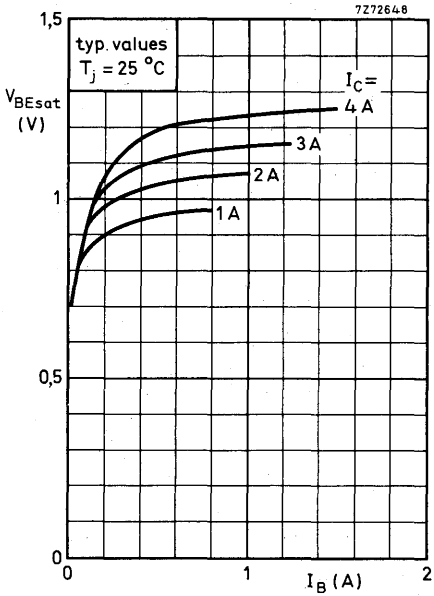

7Z72731
100
50
0
$P_{tot\,max}$ (%)
0
50
100
150
T_{mb} (°C)

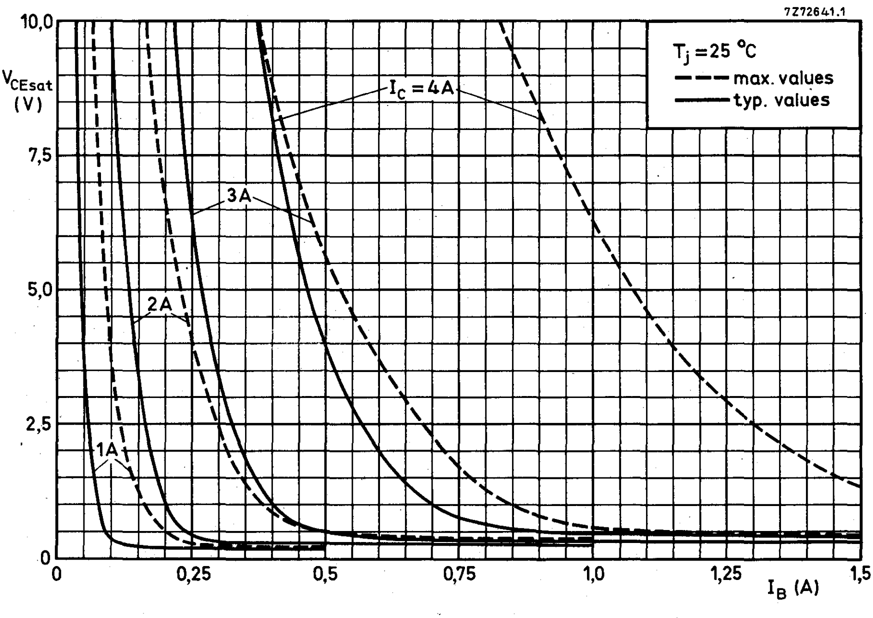

7Z72653
10^2
$Z_{th\ j\text{-}mb}$ (°C/W)
10
1
10^{-1}
10^{-2}
$\delta = 1$
0,75
0,5
0,33
0,2
0,1
0,05
0,02
≤ 0,01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
t_p (s)


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
$M_{SB(V)}$
δ =
0,01
10^2
0,02
0,05
0,1
10
0,2
0,33
0,5
0,75
1
10^{-5}
10^{-4}
10^{-3}
10^{-2}
t_p (s)
10^{-1}


7Z72649
V_{CE} = 5 V
T_j = 25 °C
h_{FE}
10^3
10^2
10
1
typ
10^{-1}
1
10
I_C (A)


7Z72648
typ. values
T_j = 25 °C
V_{BEsat}
(V)
1,5
1
0,5
0
I_C =
4 A
3 A
2 A
1 A
0
1
2
I_B (A)


7Z72641.1
T_j =25 °C
max. values
typ. values
V_{CEsat}
(V)
10,0
7,5
5,0
2,5
0
I_C =4A
3A
2A
1A
0
0,25
0,5
0,75
1,0
1,25
1,5
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

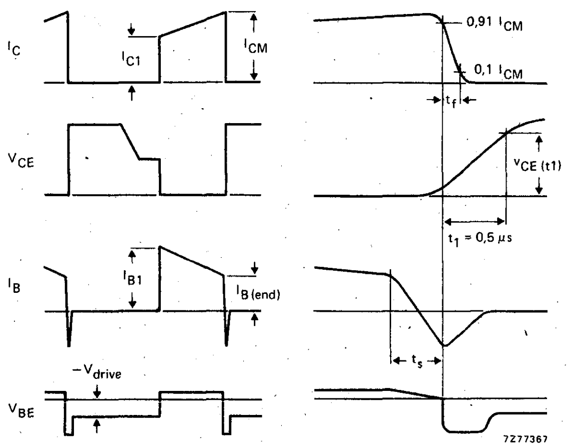


Fig. 1 Relevant waveforms of switching transistor.

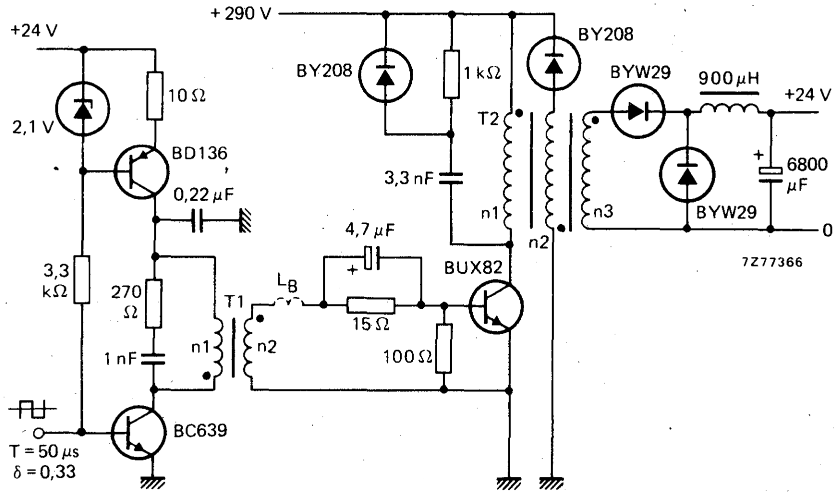


Fig. 2 Practical forward converter SMPS output circuit.

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)

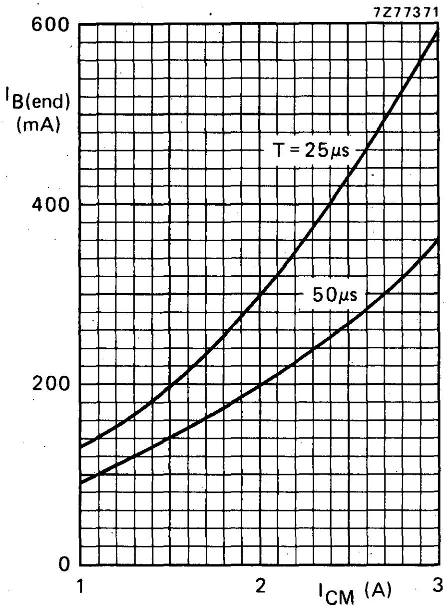


Fig. 3.

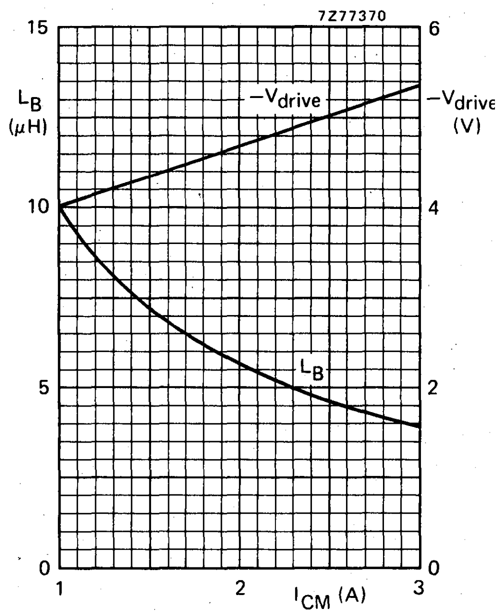


Fig. 4.

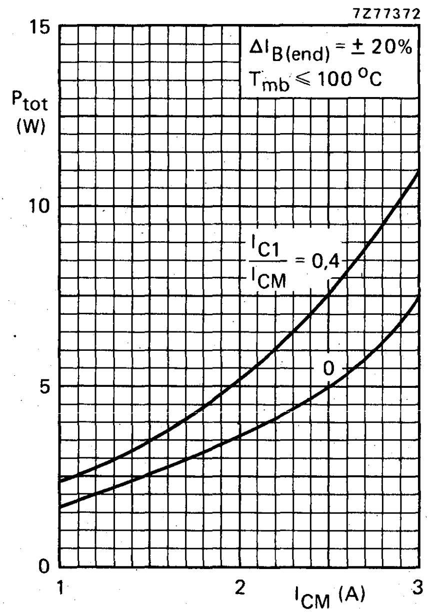


Fig. 5.

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.

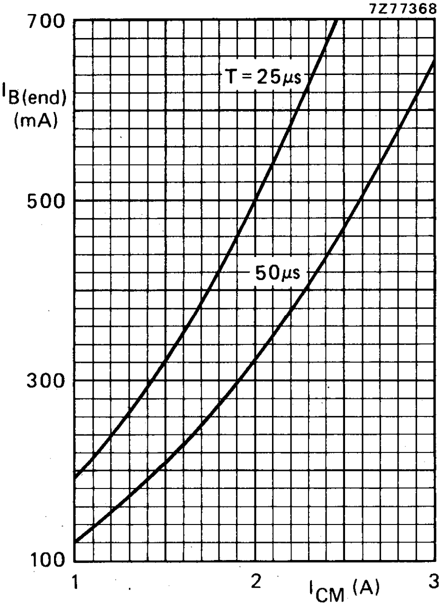


Fig. 6.

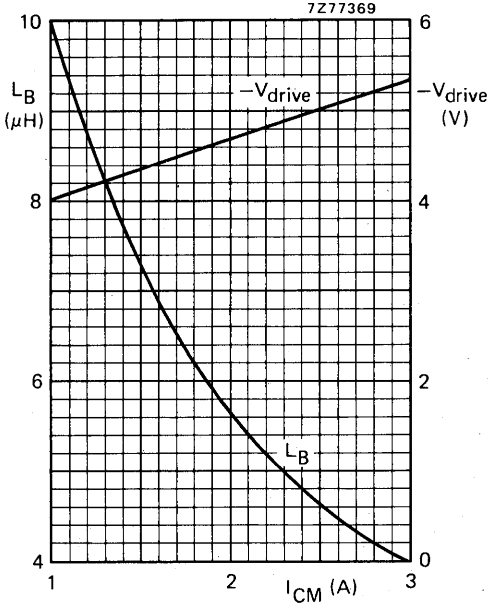


Fig. 7.

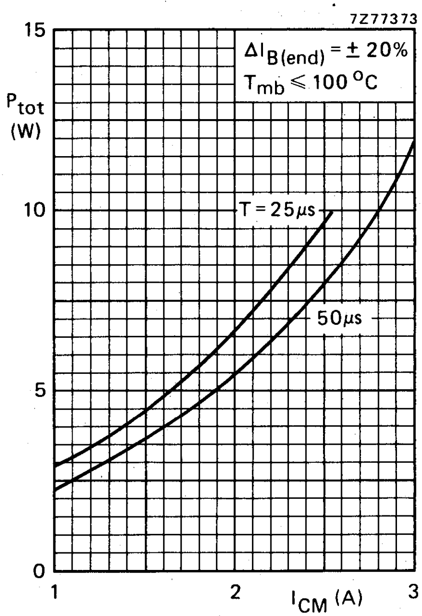


Fig. 8.

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.

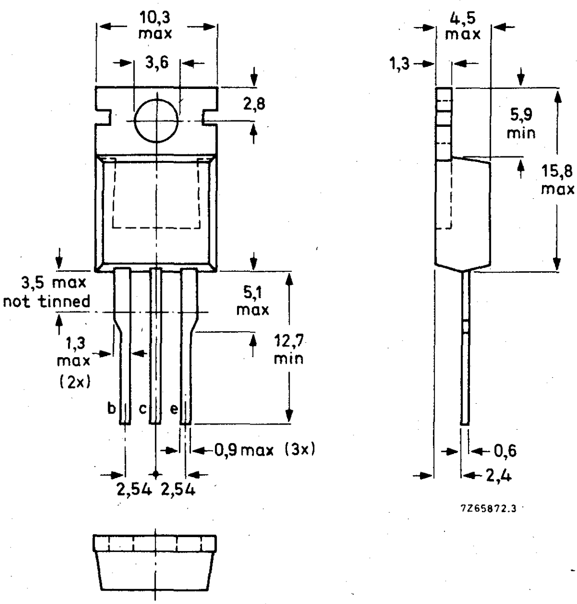
QUICK REFERENCE DATA

			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}	<	3		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



For mounting instructions and accessories see section Accessories (Handbook SC2).

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

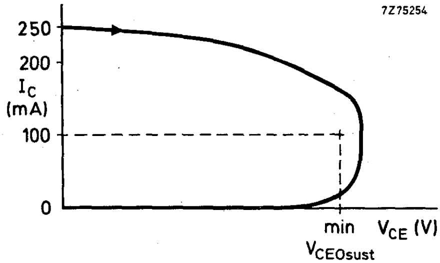
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	1	mA

Saturation voltages

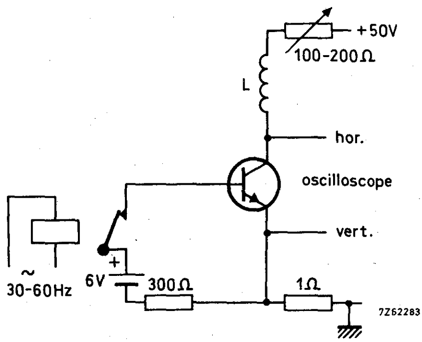
$I_C = 0{,}3$ A; $I_B = 30$ mA	V_{CEsat}	<	0,8	V
$I_C = 1$ A; $I_B = 0{,}2$ A	V_{CEsat}	<	1,0	V
$I_C = 1$ A; $I_B = 0{,}2$ A	V_{BEsat}	<	1,1	V

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

Transition frequency at f = 1 MHz

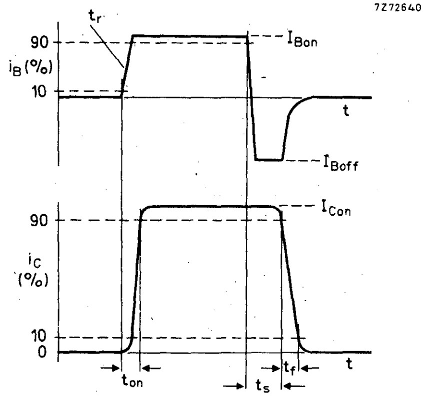
$I_C = 0{,}2$ A; $V_{CE} = 10$ V	f_T	typ	20	MHz

Switching times

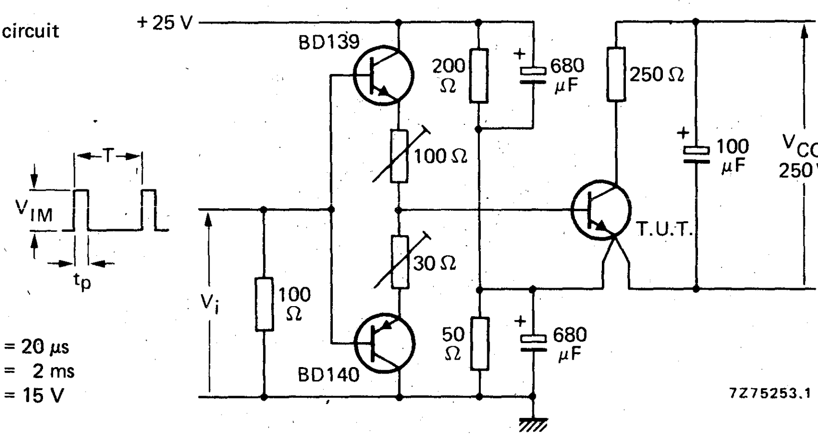
$I_{Con} = 1$ A; $V_{CC} = 250$ V
$I_{Bon} = 0{,}2$ A; $-I_{Boff} = 0{,}4$ A

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, $T_{mb} = 95\ ^oC$	t_f	<	1,4	µs

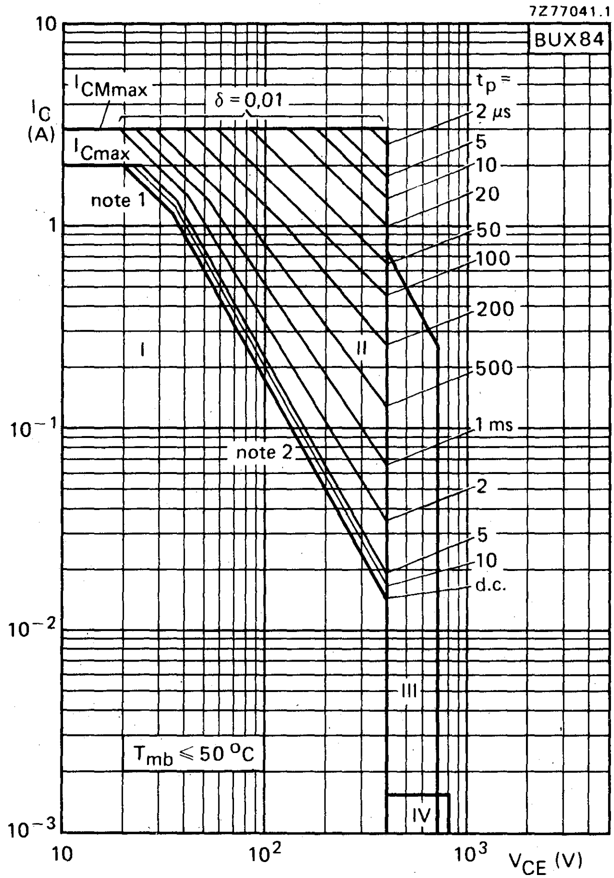
Waveform



Test circuit



$t_p = 20\ \mu s$
$T = 2$ ms
$V_{IM} = 15$ V



Safe Operating ARea

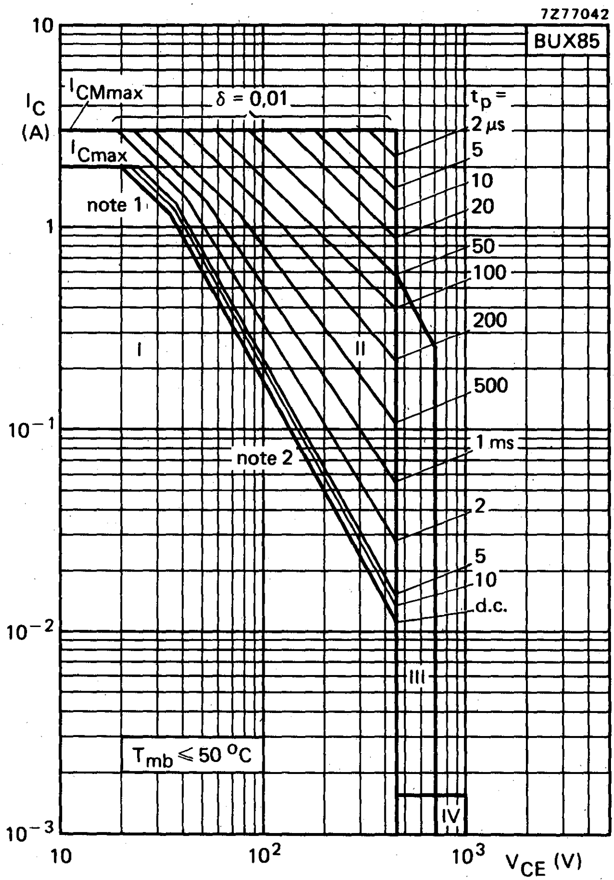
I Region of permissible d.c. operation

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

I Region of permissible d.c. operation

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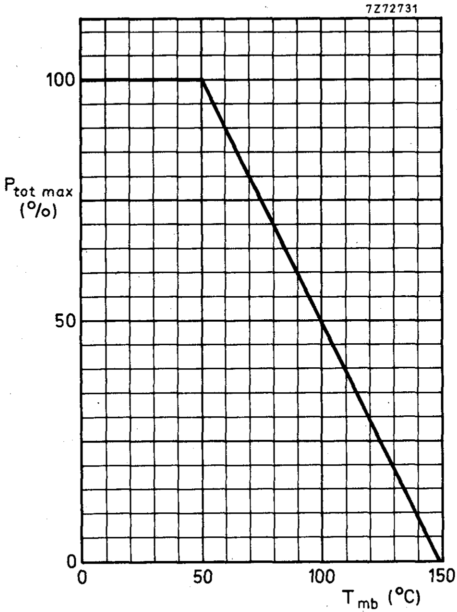
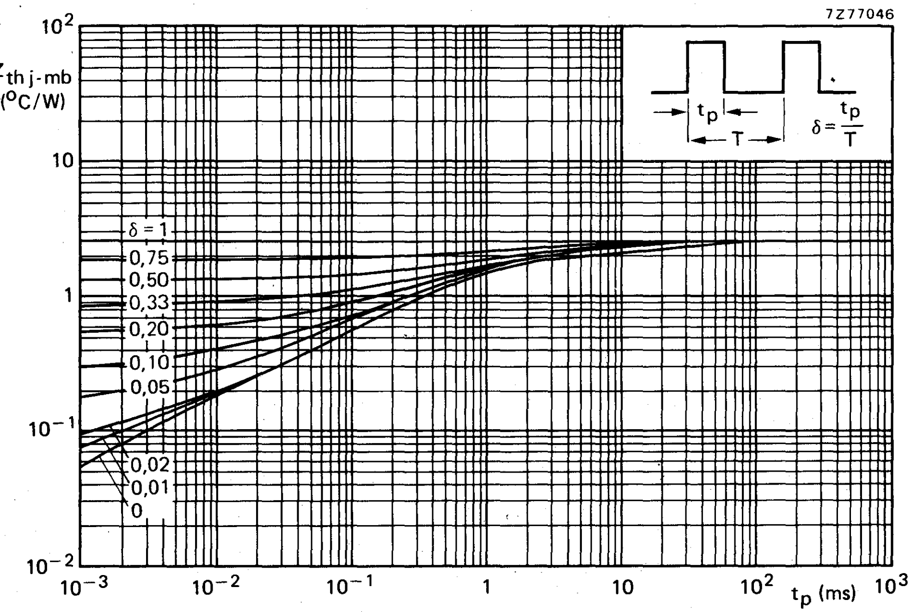
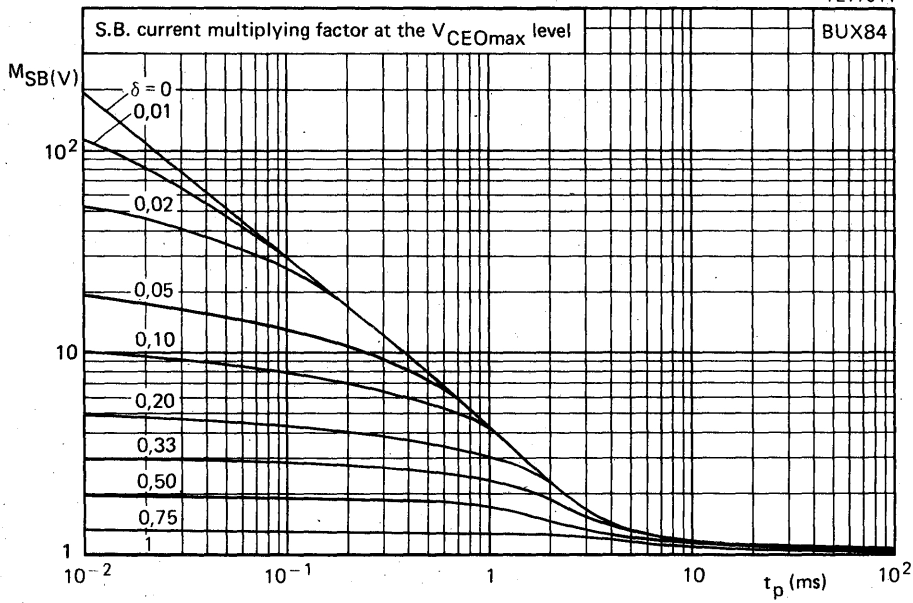
2. Second-breakdown limits (independent of temperature).

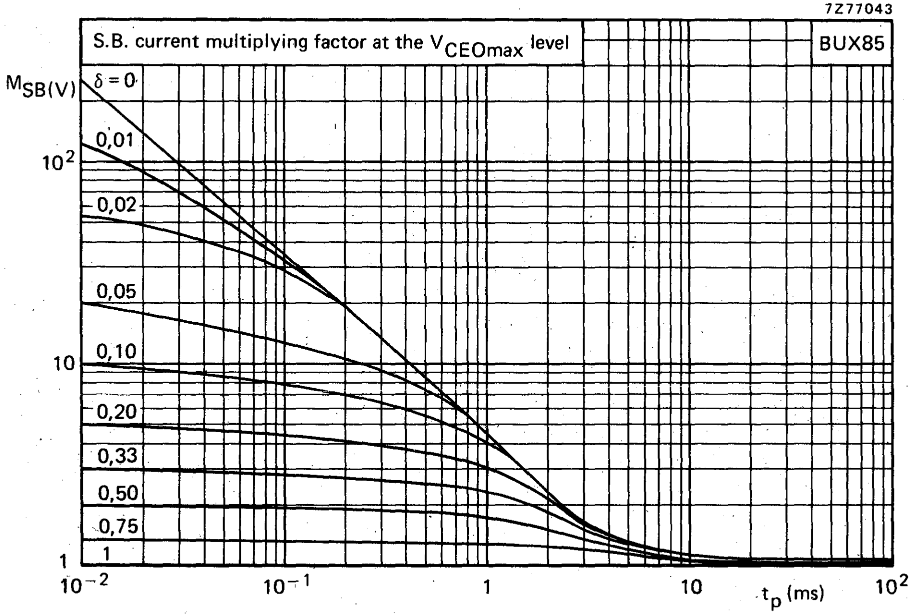

7Z72731
100
$P_{tot\ max}$
(%)
50
0
0
50
100
150
T_{mb} (°C)

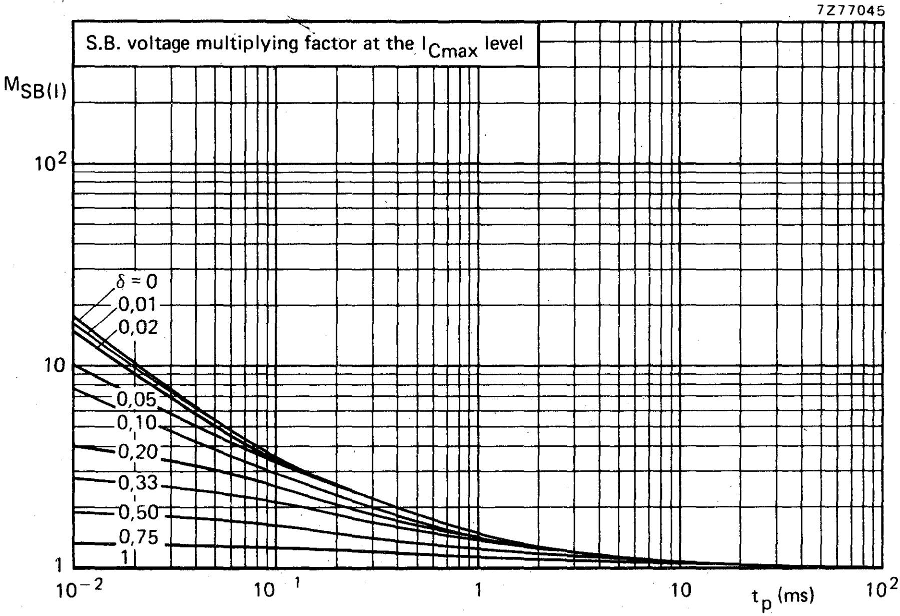

7Z77046
10^2
$Z_{th\ j\text{-}mb}$
(°C/W)
10
1
10^{-1}
10^{-2}
t_p
T
$\delta = \frac{t_p}{T}$
$\delta = 1$
0,75
0,50
0,33
0,20
0,10
0,05
0,02
0,01
0
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3

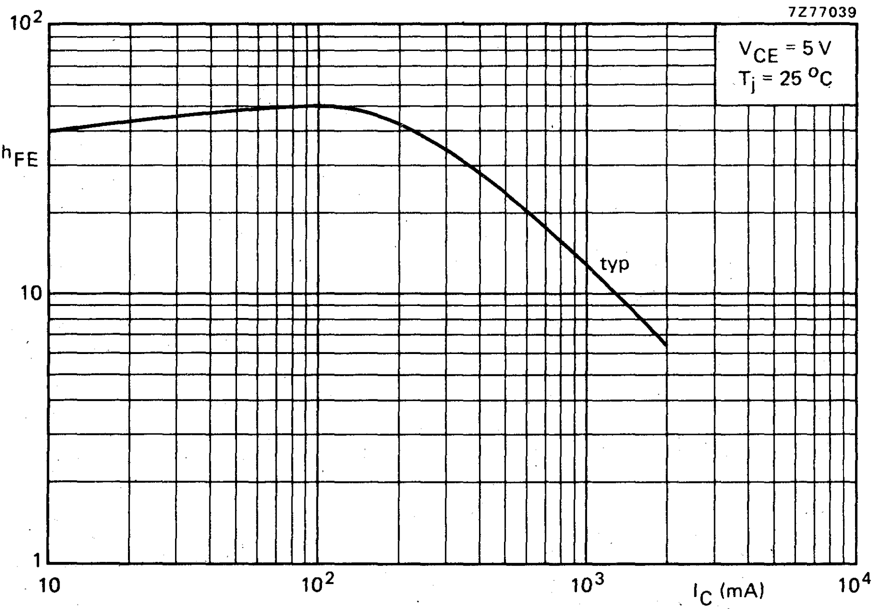
7Z77044

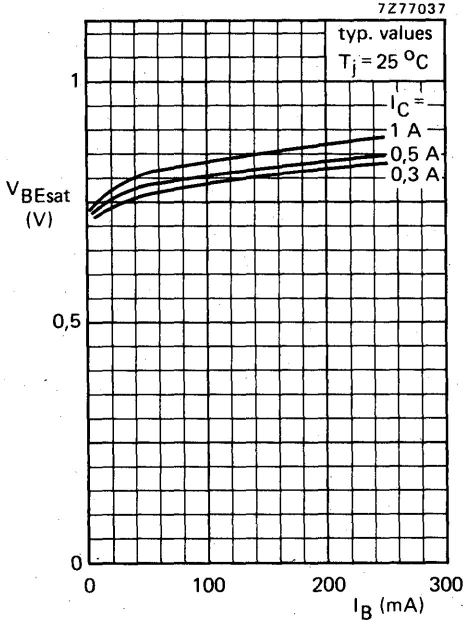


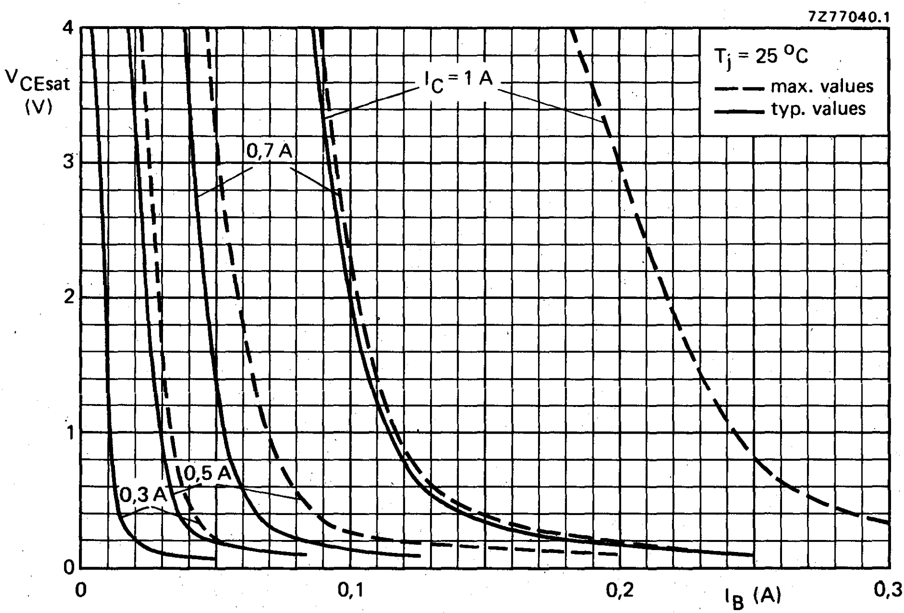
7Z77043




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


7Z77037
typ. values
T_j = 25 °C
I_C =
1 A
0,5 A
0,3 A
V_{BEsat} (V)
1
0,5
0
0
100
200
300
I_B (mA)


7Z77040.1
T_j = 25 °C
max. values
typ. values
I_C = 1 A
0,7 A
0,5 A
0,3 A
V_{CEsat} (V)
4
3
2
1
0
0
0,1
0,2
0,3
I_B (A)

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

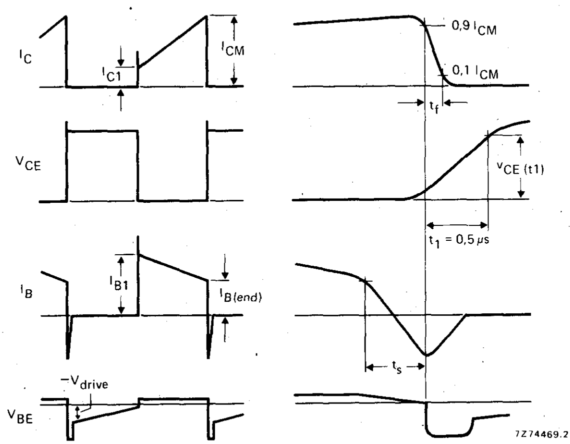


Fig. 1 Relevant waveforms of switching transistor.

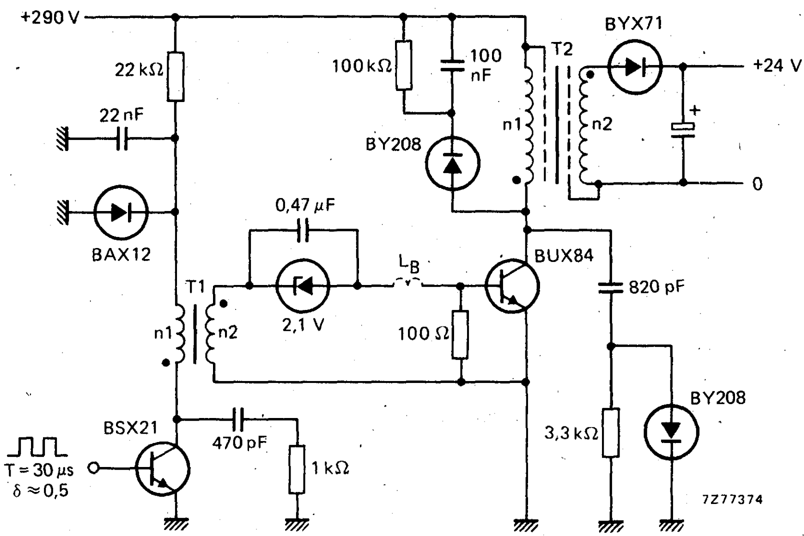


Fig. 2 Practical SMPS output circuit.

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)

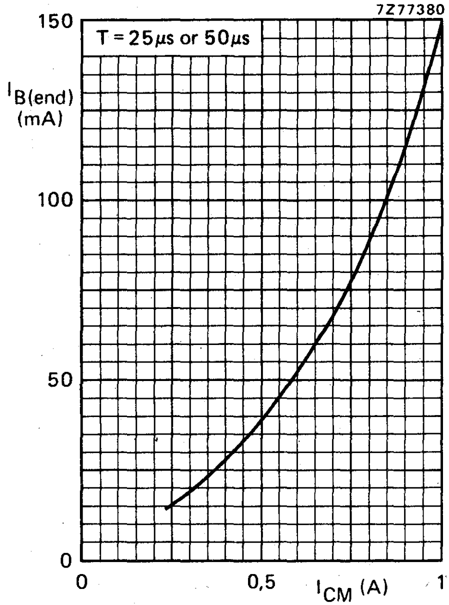


Fig. 3.

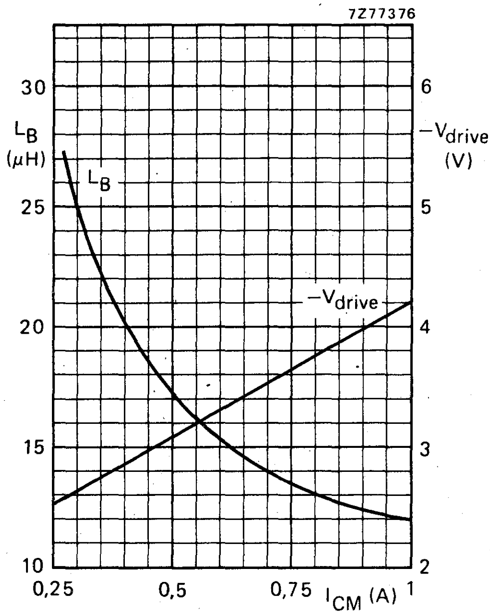


Fig. 4.

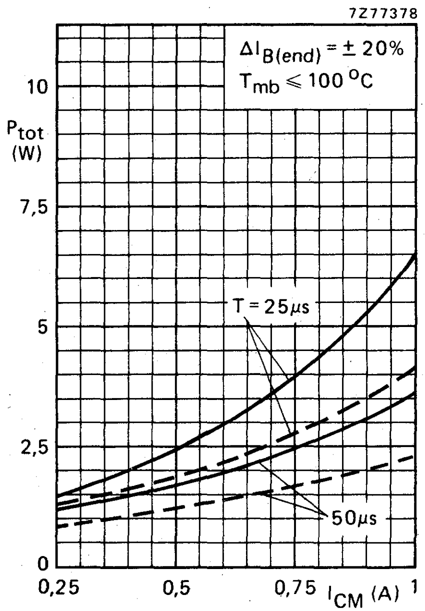


Fig. 5.

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 $I_{C1}/I_{CM} = 0$.

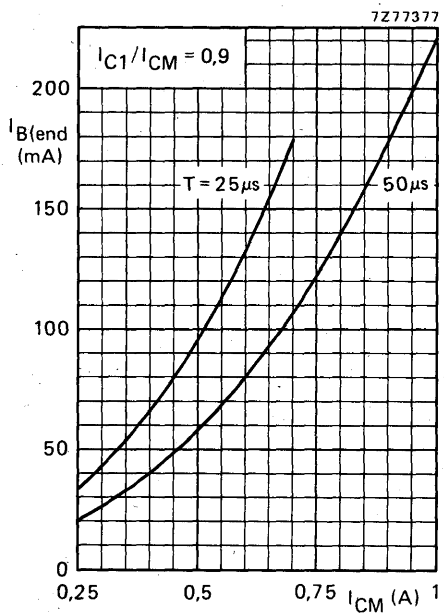


Fig. 6.

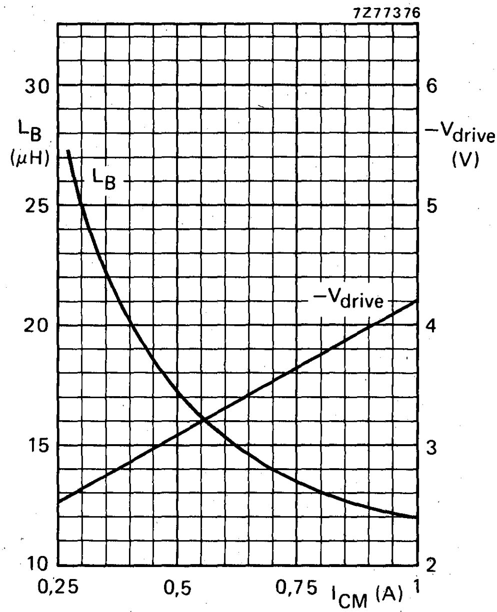


Fig. 7.

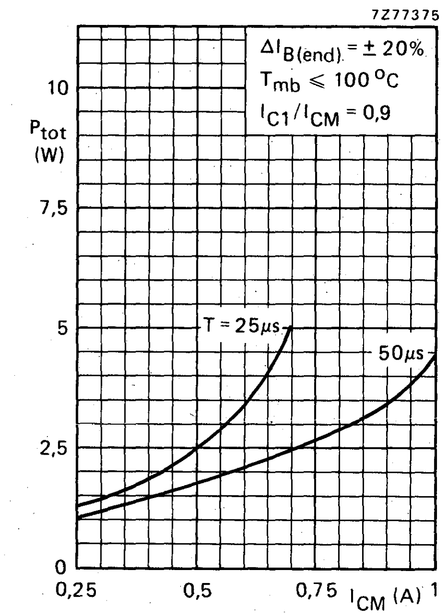


Fig. 8.

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

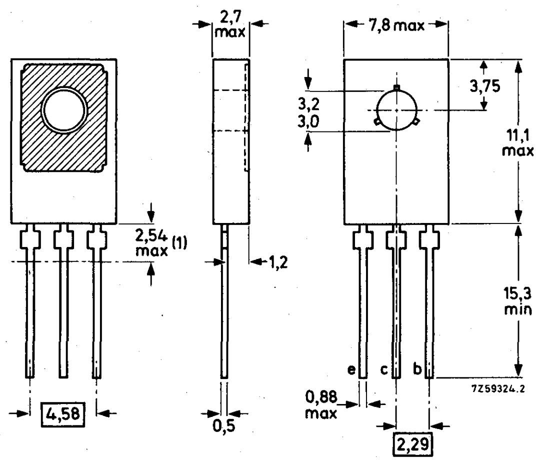
			BUX86	BUX87	
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max	800	1000	V
Collector-emitter voltage (open base)	V_{CEO}	max	400	450	V
Collector current (d.c.)	I_C	max	0,5		A
Collector current (peak value): t_p = 2 ms	I_{CM}	max	1		A
Total power dissipation up to T_{mb} = 60 °C	P_{tot}	max	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 ^oC	P_{tot}	max	20	W
Temperatures				
Storage temperature	T_{stg}		−65 to +150	^oC
Junction temperature	T_j	max	150	^oC

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	4,5	$^oC/W$
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	100	$^oC/W$

CHARACTERISTICS T_j = 25 ^oC unless otherwise specified

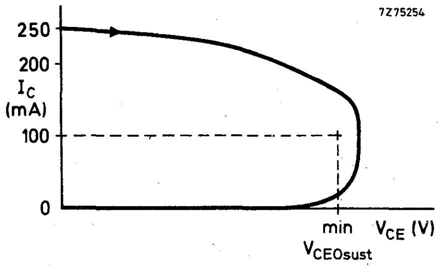
Collector cut-off current (note 2)				
$V_{CEM} = V_{CESMmax}$; $V_{BE} = 0$	I_{CES}	<	100	µA
$V_{CEM} = V_{CESMmax}$; $V_{BE} = 0$; T_j = 125 ^oC	I_{CES}	<	1	mA
D.C. current gain				
I_C = 50 mA; V_{CE} = 5 V	h_{FE}	typ	50	

Notes
1. Turn-off current
2. Measured with a half sine-wave voltage (curve tracer).

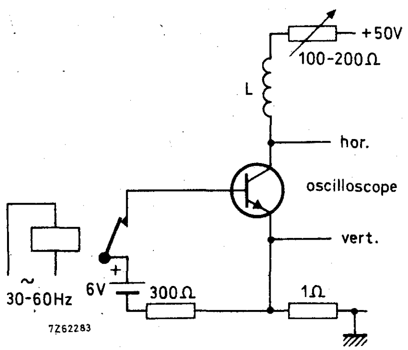
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

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

		BUX86	BUX87	
Collector-emitter sustaining voltages				
$I_C = 100$ mA; $I_{Boff} = 0$; $L = 25$ mH	$V_{CEOsust}$	400	450	V



Oscilloscope display for sustaining voltage



Test circuit for $V_{CEOsust}$

CHARACTERISTICS (continued) $T_j = 25\ ^oC$ unless otherwise specified

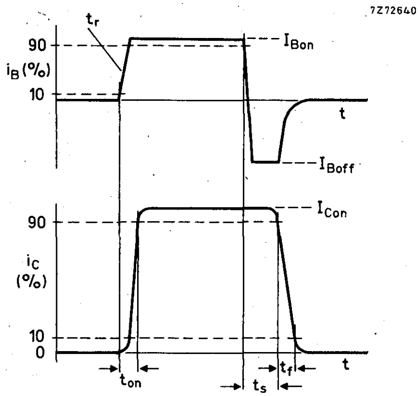
Transition frequency at f = 1 MHz

$I_C = 50$ mA; $V_{CE} = 10$ V	f_T	typ	20	MHz

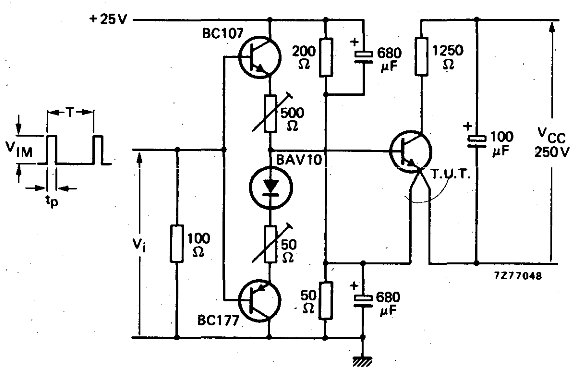
Switching times

$I_{Con} = 0{,}2$ 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, $T_{mb} = 95\ ^oC$	t_f	<	1,3	μs

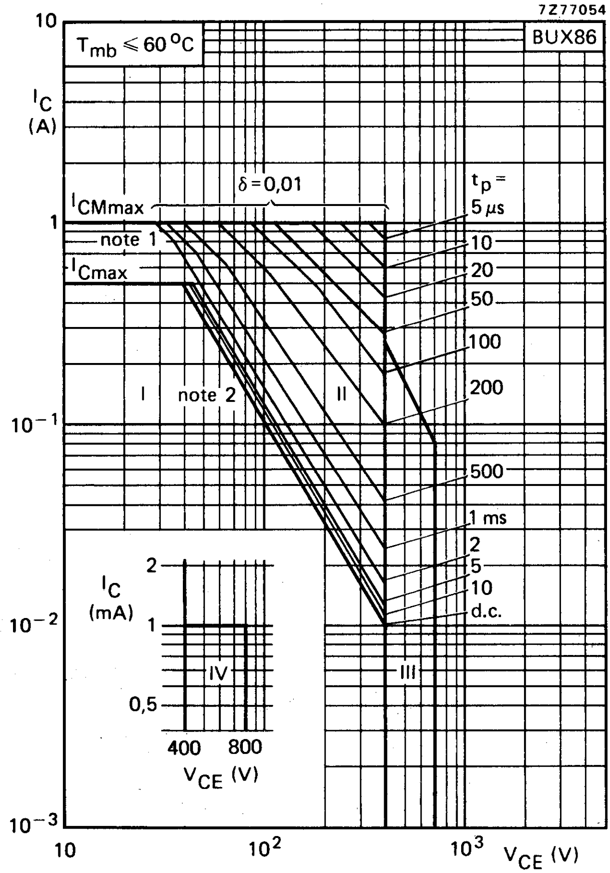
Waveform



Test circuit



t_p = 20 μs
T = 2 ms
V_{IM} = 15 V



Safe Operating ARea

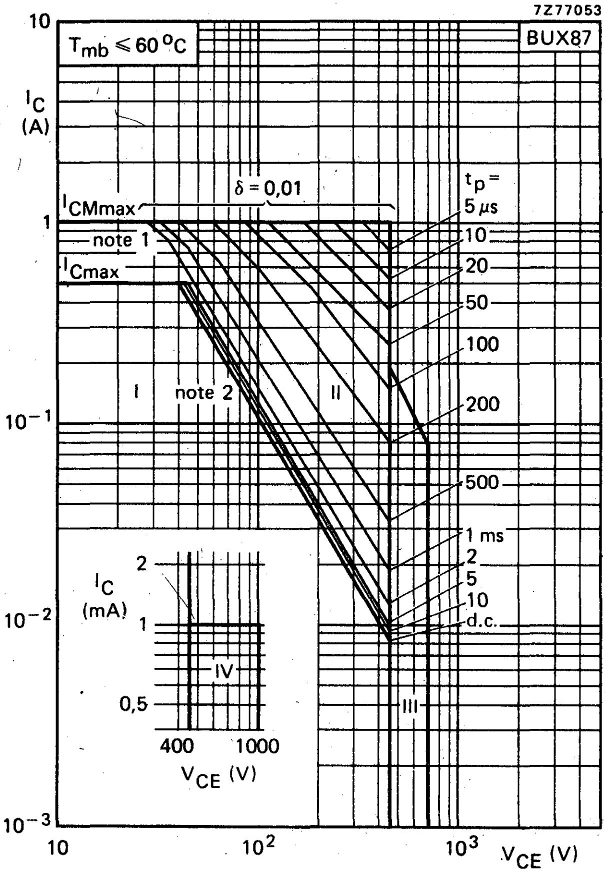
I Region of permissible d.c. operation

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

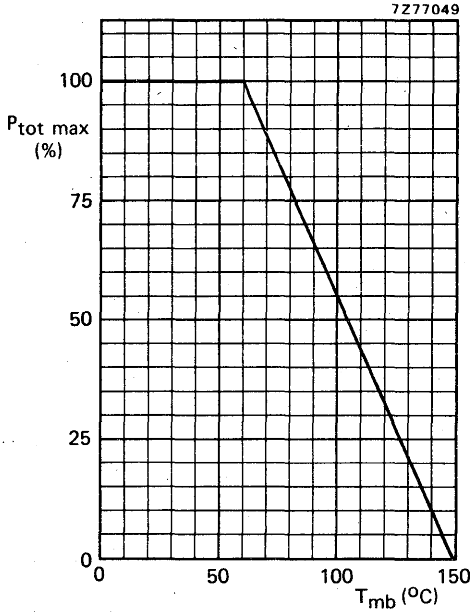
I Region of permissible d.c. operation

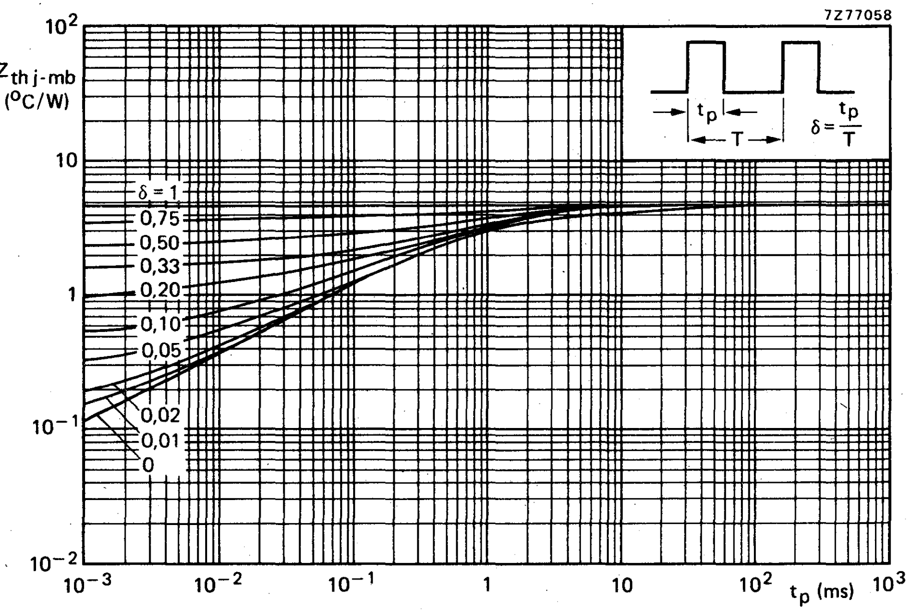
II Permissible extension for repetitive pulse operation

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

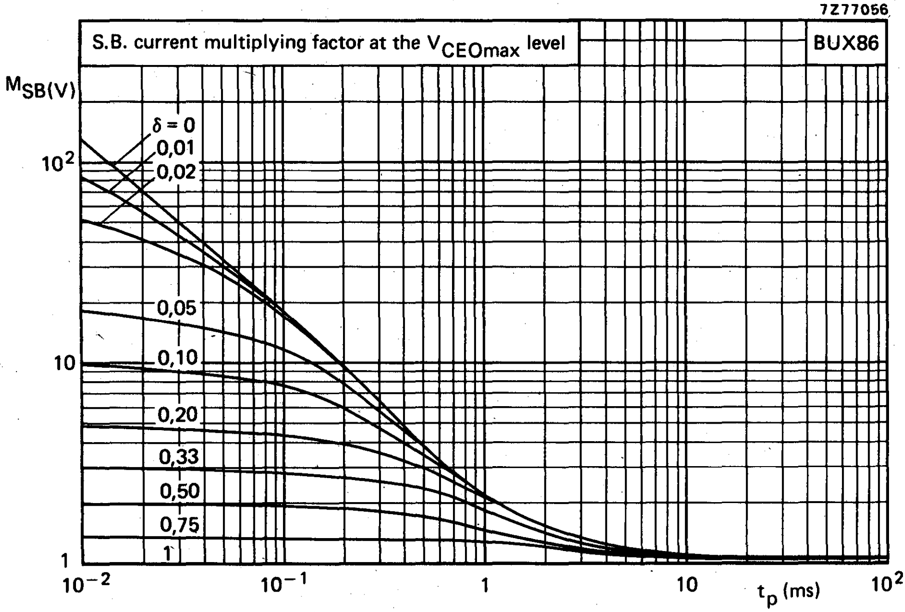
IV Repetitive pulse operation in this region is permissible, provided $V_{BE} \leqslant 0$ and $t_p \leqslant 2$ ms

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

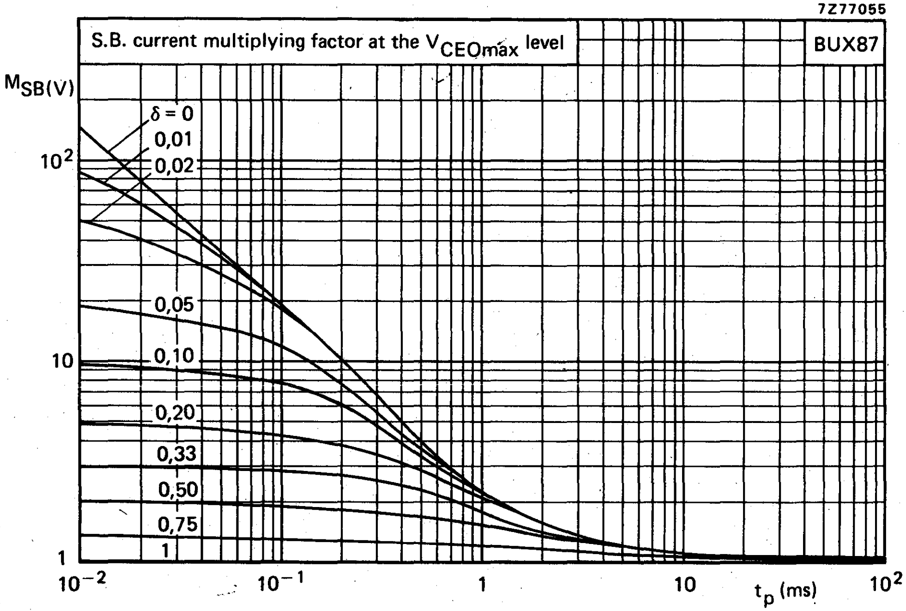

7Z77049
100
$P_{tot\ max}$ (%)
75
50
25
0
0
50
100
150
T_{mb} (°C)

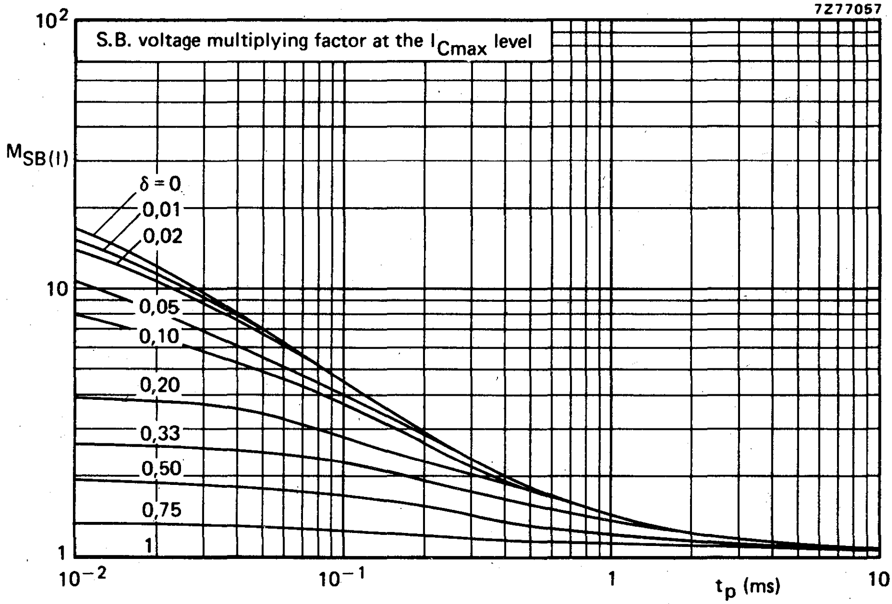

7Z77058
10^2
$Z_{th\ j\text{-}mb}$ (°C/W)
10
1
10^{-1}
10^{-2}
$\delta = 1$
0,75
0,50
0,33
0,20
0,10
0,05
0,02
0,01
0
t_p
T
$\delta = \frac{t_p}{T}$
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3

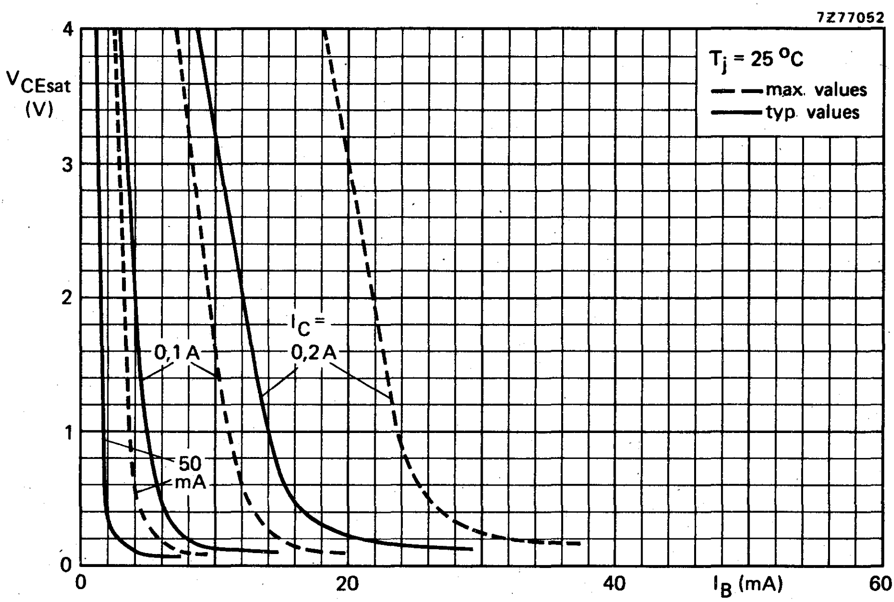
7Z77056

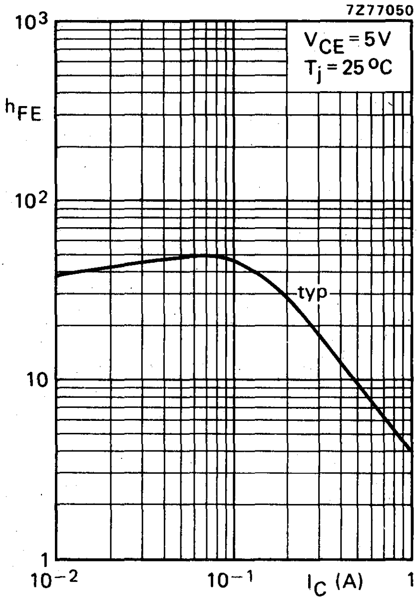


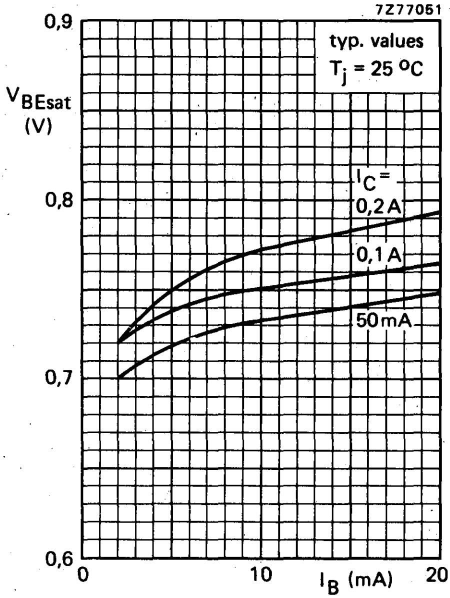
7Z77055




7Z77057
S.B. voltage multiplying factor at the I_{Cmax} level
10^2
$M_{SB(I)}$
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
t_p (ms)
10


7Z77052
T_j = 25 °C
max. values
typ. values
V_{CEsat}
(V)
4
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

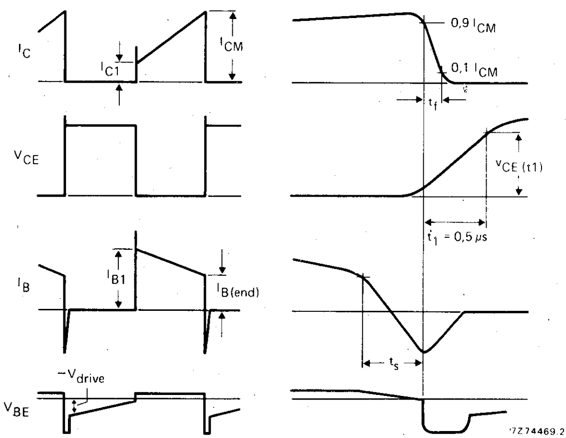


Fig. 1 Relevant waveforms of switching transistor.

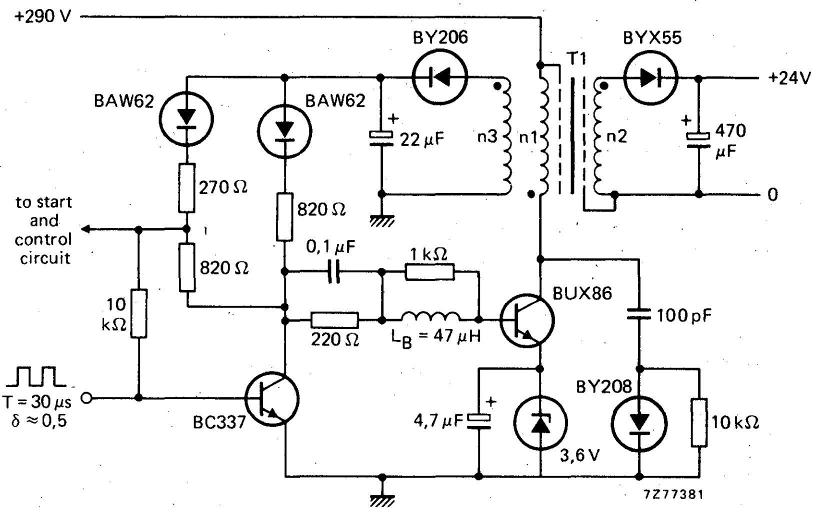


Fig. 2 Practical SMPS output circuit.

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)

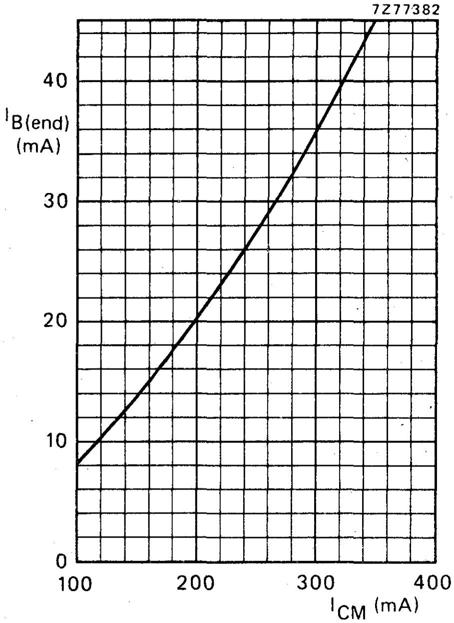


Fig. 3.

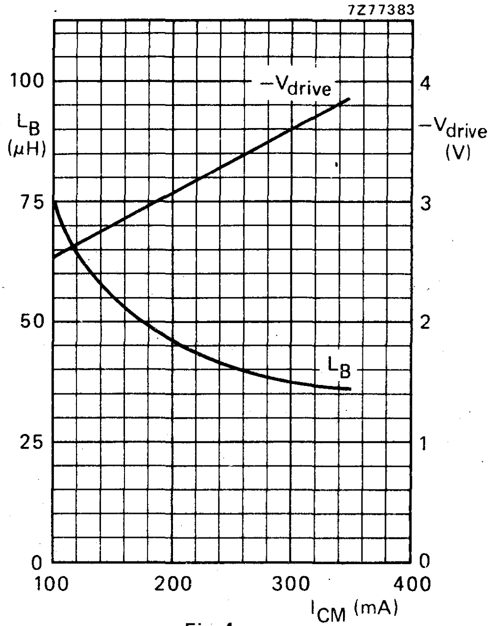


Fig. 4.

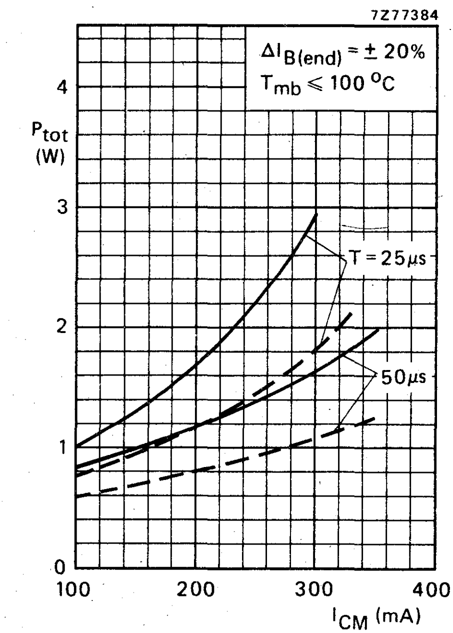


Fig. 5.

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

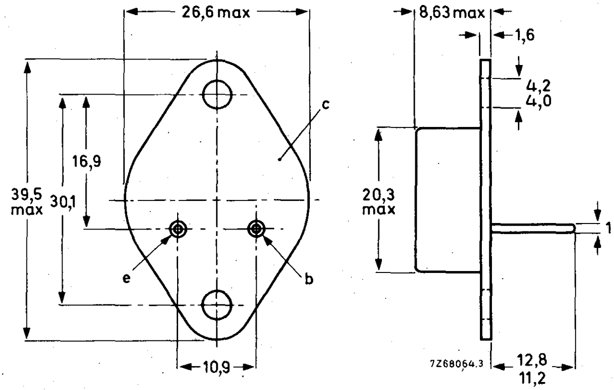
N-P-N transistor in a TO-3 metal envelope, intended for use in linear applications such as hi-fi amplifiers and signal processing circuits.
Matched pairs are available.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	100	V
Collector-emitter voltage (R_{BE} = 100 Ω)	V_{CER}	max.	70	V
Collector current (d.c.)	I_C	max.	15	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	115	W
Junction temperature	T_j	max.	200	°C
D.C. current gain I_C = 4 A; V_{CE} = 4 V	h_{FE}	20 to	70	
Transition frequency at f = 1 MHz I_C = 1 A; V_{CE} = 4 V	f_T	>	0.8	MHz

MECHANICAL DATA

Dimensions in mm

Collector connected to envelope
TO-3



For mounting instructions and accessories, see section Accessories.

SILICON DIFFUSED POWER TRANSISTORS

N-P-N transistors in a TO-3 metal envelope, intended for use in a wide variety of linear power applications in audio amplifiers, converters, voltage regulators, power supplies, etc.

QUICK REFERENCE DATA

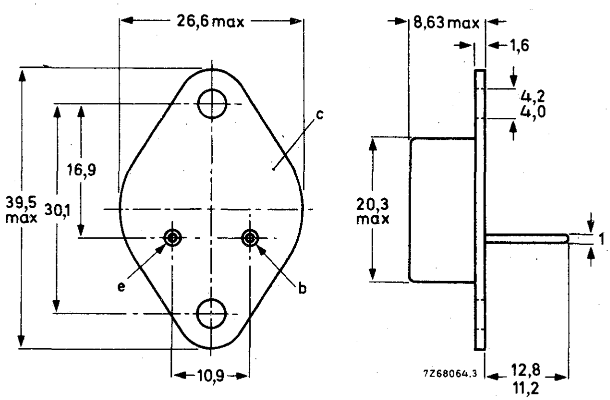
			2N3442	2N4347	
Collector-base voltage (open emitter)	V_{CBO}	max.	160	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	140	120	V
Collector current (d.c.)	I_C	max.	10		A
Total power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.	117		W
Junction temperature	T_j	max.	200		^oC
D.C. current gain $I_C = 3$ A; $V_{CE} = 4$ V : 2N3442 $I_C = 2$ A; $V_{CE} = 4$ V : 2N4347	h_{FE}		20 to 70		

MECHANICAL DATA

Dimensions in mm

Collector connected to envelope

TO-3



For mounting instructions and accessories, see section Accessories.

MOUNTING INSTRUCTIONS

GENERAL NOTE ON FLAT HEATSINKS

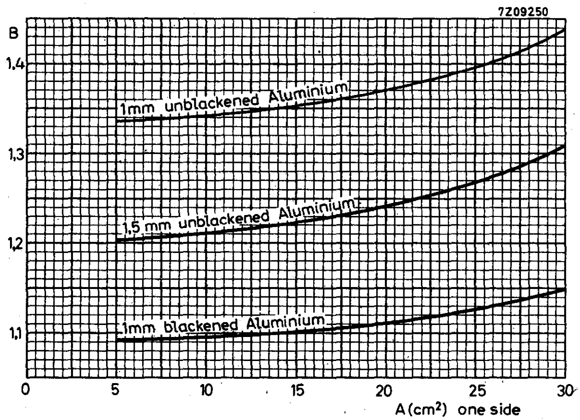
All information on thermal resistances of the accessories combined with flat heatsinks is valid for square heatsinks of 1,5 mm blackened aluminium.
For a few variations the thermal resistance may be derived as follows:

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 SOT-32 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° tolerance for M2,5 thread and within 2° 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 (SOT-32 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. (SOT-32 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.

Pre-heating

For good soldering and avoiding damage to the SOT-82 device pre-heating is recommended to a temperature $\leqslant$ 165 °C at a duration $\leqslant$ 10 s.

Soldering

Recommended metal-alloy of solder paste (85% metal weight)
a. 62 Sn/36 Pb/2 Ag or b. 60 Sn/40 Pb.
Maximum soldering temperature $\leqslant$ 250 °C (soldering plate)
Soldering cycle duration: a without pre-heating $\leqslant$ 14 s.
b with pre-heating $\leqslant$ 22 s.

Thermal data from mounting base to heatsink

	$R_{th\ mb\text{-}h}$ (°C/W)			
	clip mounting		screw mounting	
	direct	insulated	direct	insulated
SOT-32, with heatsink compound	1,0	3,0	0,5	3,0
SOT-32, 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 $\leqslant$ 150 °C.

a. Dip or wave soldering
Temperature $\leqslant$ 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.

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).

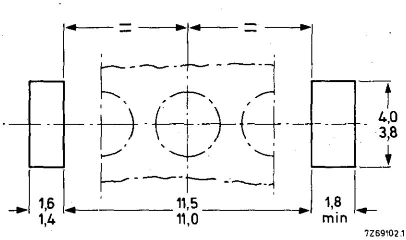


Fig. 1 Heatsink requirements.

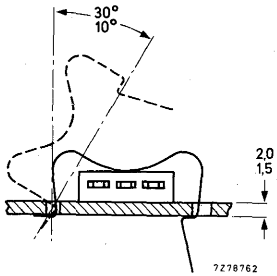


Fig. 2 Mounting spring clip.

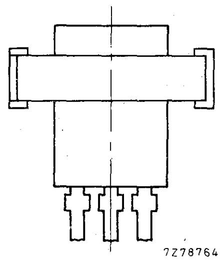


Fig. 3 Position of transistor (top view).

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). There should be minimum 3 mm distance between the device and the edge of the insulator for adequate creepage.

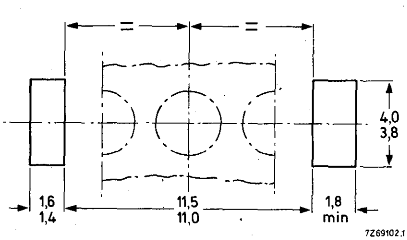


Fig. 4 Heatsink requirements.

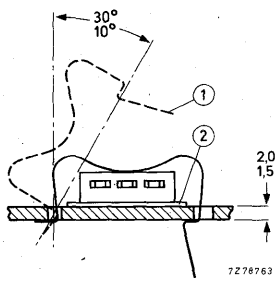


Fig. 5 Mounting.
(1) spring clip 56353.
(2) insulator 56354.

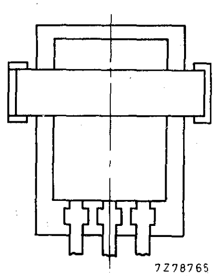


Fig. 6 Position of transistor (top view).

INSTRUCTIONS FOR SCREW MOUNTING

Dimensions in mm

Direct mounting with screw and spacing washer

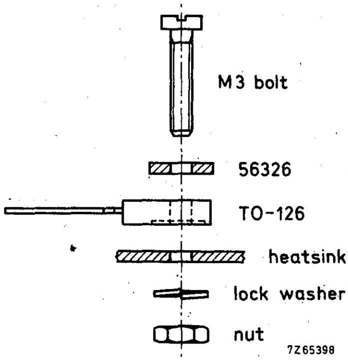


Fig. 7 Assembly through heatsink with nut.

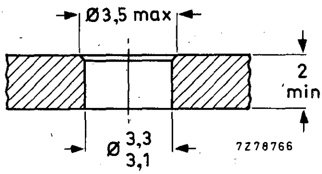


Fig. 8 Heatsink requirements.

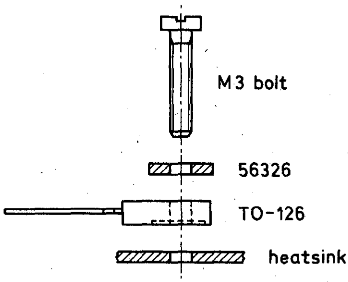


Fig. 9 Assembly into tapped heatsink.

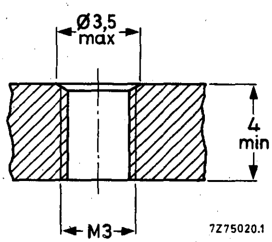


Fig. 10 Heatsink requirements.

INSTRUCTIONS FOR SCREW MOUNTING

Insulated mounting with 56333 (up to 250 V)

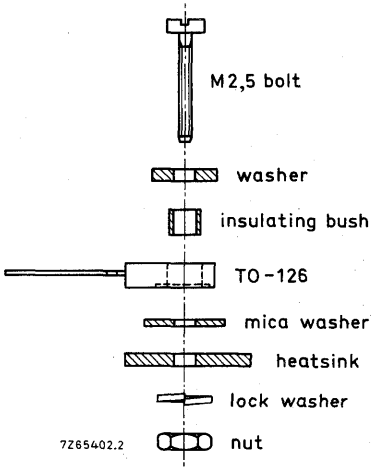


Fig. 11 Assembly through heatsink with nut.

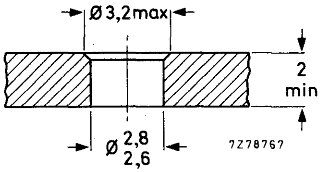


Fig. 12 Heatsink requirements.

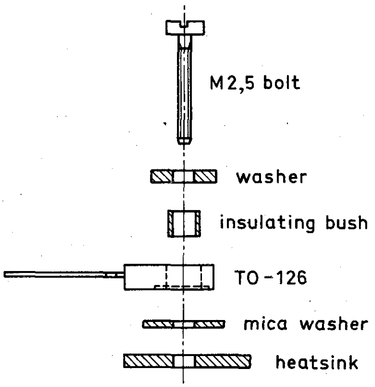


Fig. 13 Assembly with tapped heatsink.

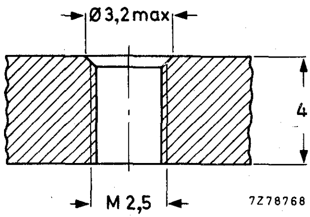


Fig. 14 Heatsink requirements.

MOUNTING INSTRUCTIONS FOR TO-220 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.
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 by means of spring clip offers:

   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	^{o}C/W
without heatsink compound, direct mounting	$R_{th\ mb\text{-}h}$	=	1,4	1,4	^{o}C/W
with heatsink compound and 0,1 mm maximum mica washer	$R_{th\ mb\text{-}h}$	=	2,2	–	^{o}C/W
with heatsink compound and 0,25 mm maximum alumina insulator	$R_{th\ mb\text{-}h}$	=	0,8	–	^{o}C/W
with heatsink compound and 0,05 mm mica washer					
insulated up to 500 V	$R_{th\ mb\text{-}h}$	=	–	1,4	^{o}C/W
insulated up to 800 V/1000 V	$R_{th\ mb\text{-}h}$	=	–	1,6	^{o}C/W
without heatsink compound and 0,05 mm mica washer					
insulated up to 500 V	$R_{th\ mb\text{-}h}$	=	–	3,0	^{o}C/W
insulated up to 800 V/1000 V	$R_{th\ mb\text{-}h}$	=	–	4,5	^{o}C/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^{o} maximum, twisted or straightened. To keep forces within the abovementioned limits, the leads are generally clamped near the body, using pliers. The leads should neither be bent nor twisted less than 2,4 mm from the body.

Soldering

Lead soldering temperature at > 3 mm from the body; $t_{sld} < 5$ s:

Devices with $T_{j\ max} \leqslant 175$ ^{o}C, soldering temperature $T_{sld\ max} = 275$ ^{o}C.
Devices with $T_{j\ max} \leqslant 110$ ^{o}C, soldering temperature $T_{sld\ max} = 240$ ^{o}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.

INSTRUCTIONS FOR CLIP MOUNTING

Direct mounting with clip 56363

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, not on the tab (see Fig. 2a).

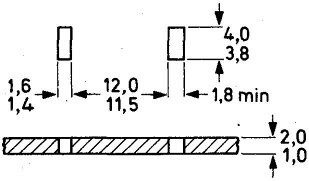


Fig. 1 Heatsink requirements.

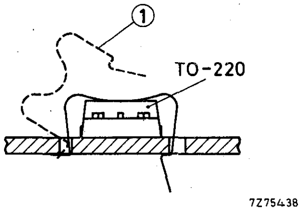


Fig. 2 Mounting.
(1) spring clip.

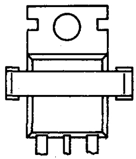


Fig. 2a Position of transistor (top view).

Insulated mounting with clip 56364

With the insulators 56367 or 56369 insulation up to 2 kV is obtained.

1. 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 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. There should be minimum 3 mm distance between the device and the edge of the insulator for adequate creepage.

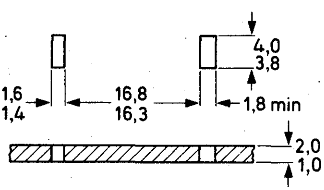


Fig. 3 Heatsink requirements.

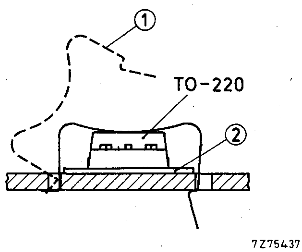


Fig. 4 Mounting.
(1) spring clip.
(2) insulator 56369 or 56367.

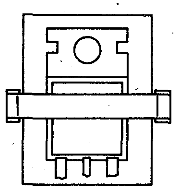


Fig. 4a Position of transistor (top view).

INSTRUCTIONS FOR SCREW MOUNTING

Dimensions in mm

Direct mounting with screw and spacing washer

- *through heatsink with nut*

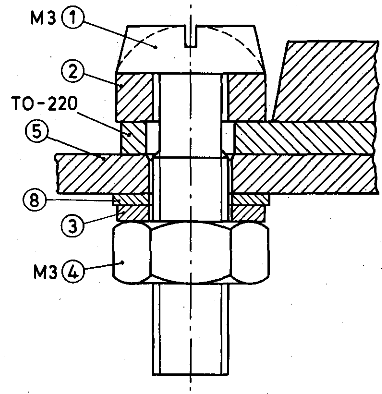


Fig. 5 Assembly.

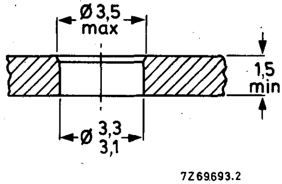


Fig. 6 Heatsink requirements.

(1) M3 screw.
(2) rectangular washer (56360a).
(3) toothed lock washer.
(4) M3 nut.
(5) heatsink.
(6) plain washer.

- *into tapped heatsink*

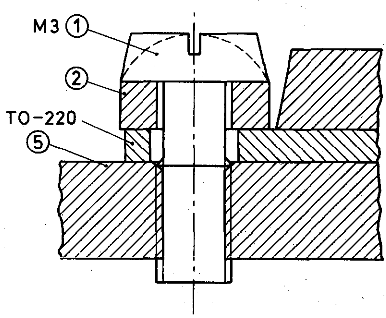


Fig. 7 Assembly.

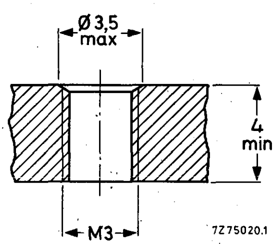


Fig. 8 Heatsink requirements.

(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)

- *through heatsink with nut* Dimensions in mm

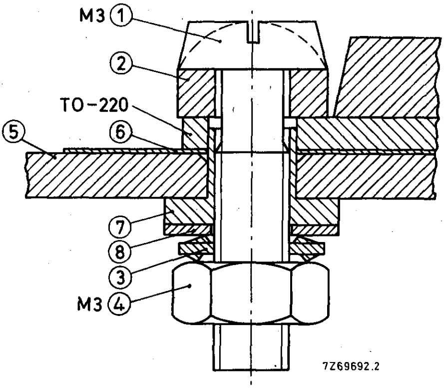


Fig. 9 Assembly.

(1) M3 screw.
(2) rectangular washer 56360a.
(3) toothed lock washer.
(4) M3 nut.
(5) heatsink.
(6) mica insulator 56359b.
(7) insulating bush 56359c.
(8) plain washer.

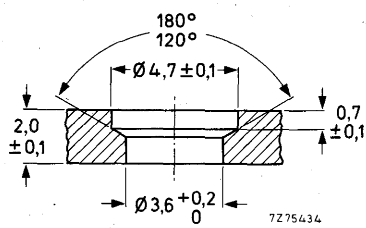


Fig. 10 Heatsink requirements for 500 V insulation.

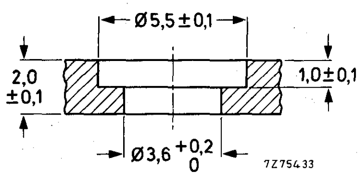


Fig. 11 Heatsink requirements for 800 V insulation.

- *into tapped heatsink*

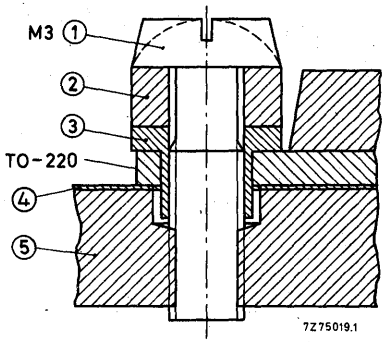


Fig. 12 Assembly.

(1) M3 screw.
(2) rectangular washer 56360a.
(3) rectangular insulation bush 56359d.
(4) mica insulator 56359b.
(5) heatsink.

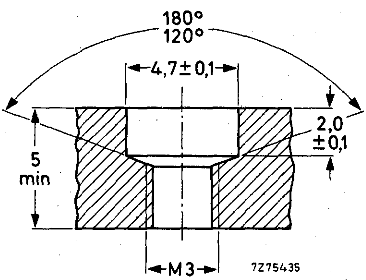


Fig. 13 Heatsink requirements for 500 V insulation.

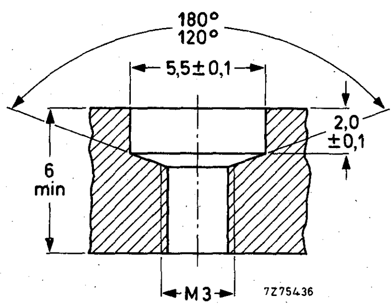


Fig. 14 Heatsink requirements for 1000 V insulation.

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.

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 ($R_{th\ mb\text{-}h}$) 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 separate data sheets.

Soldering

Recommendations for devices with a maximum junction temperature rating ≤ 175 °C:

a. Dip or wave soldering

Maximum permissible solder temperature is 260 °C at a distance from the body of > 5 mm and for a total contact time with soldering bath or waves of < 7 s.

b. Hand soldering

Maximum permissible temperature is 275 °C at a distance from the body of > 3 mm and for a total contact time with the soldering iron of < 5 s.

The body of the device must not touch anything with a temperature > 200 °C.

It is not permitted to solder the metal tab of the device to a heatsink, otherwise the junction temperature rating will be exceeded.

Avoid any force on body and leads during or after soldering; do not correct the position of the device or of its leads after soldering.

Thermal data

			clip mounting	screw mounting
Thermal resistance from mounting base to heatsink				
direct mounting				
with heatsink compound	$R_{th\ mb\text{-}h}$	=	0,3	0,3 °C/W
without heatsink compound	$R_{th\ mb\text{-}h}$	=	1,5	0,8 °C/W
with 0,05 mm mica washer				
with heatsink compound	$R_{th\ mb\text{-}h}$	=	0,8	0,8 °C/W
without heatsink compound	$R_{th\ mb\text{-}h}$	=	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)).

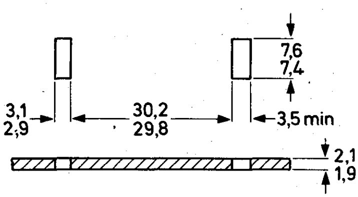


Fig. 1a Heatsink requirements.

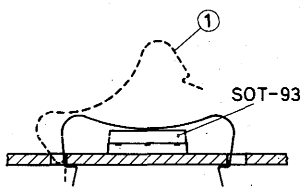


Fig. 1b Mounting.
(1) = spring clip 56379.

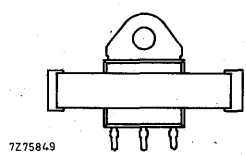


Fig. 1c Position of the device.

Insulated mounting with clip 56379

With the mica of package 56368 insulation up to 1 kV 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.

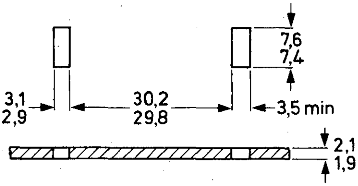


Fig. 2a Heatsink requirements.

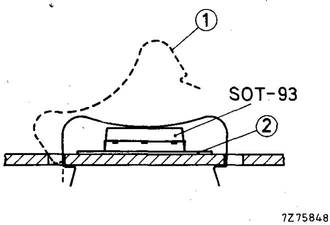


Fig. 2b Mounting.
(1) = spring clip 56379
(2) = insulator 56378

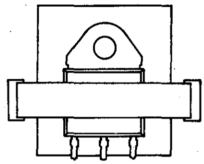


Fig. 2c Position of the device.

INSTRUCTIONS FOR SCREW MOUNTING

Direct mounting

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.

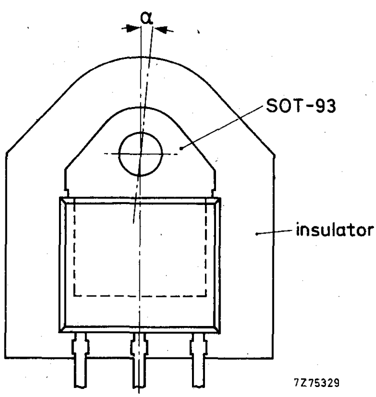


Fig. 3 Mica insulator.
The axial deviation (α) between SOT-93 and mica should not exceed 5°.

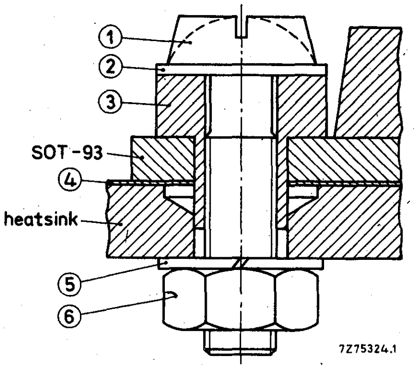


Fig. 4 Assembly.
See also Fig. 3.

(1) M3 screw
(2) plain washer
(3) insulating bush (56368b)
(4) mica insulator (56368a)
(5) lock washer
(6) M3 nut

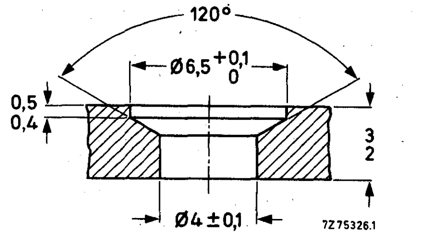


Fig. 5 Heatsink requirements up to 800 V insulation.

Insulated screw mounting with tapped hole; up to 800 V.

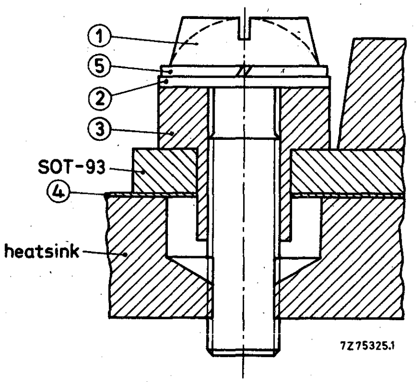


Fig. 6 Assembly.
See also Fig. 3.

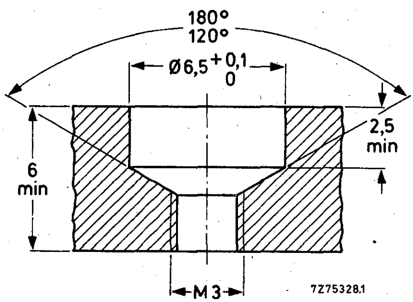


Fig. 7 Heatsink requirements up to 800 V insulation.

(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

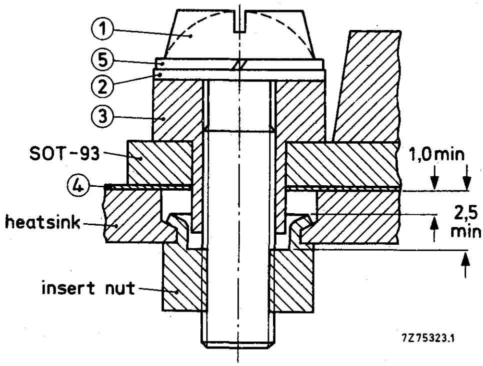


Fig. 8 Assembly and heatsink requirements for 500 V insulation. See also Fig. 3.

(1) M3 screw
(2) plain washer
(3) insulating bush (56368b)
(4) mica insulator (56368a)
(5) lock washer

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 56201c and mica washer 56201d.
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)

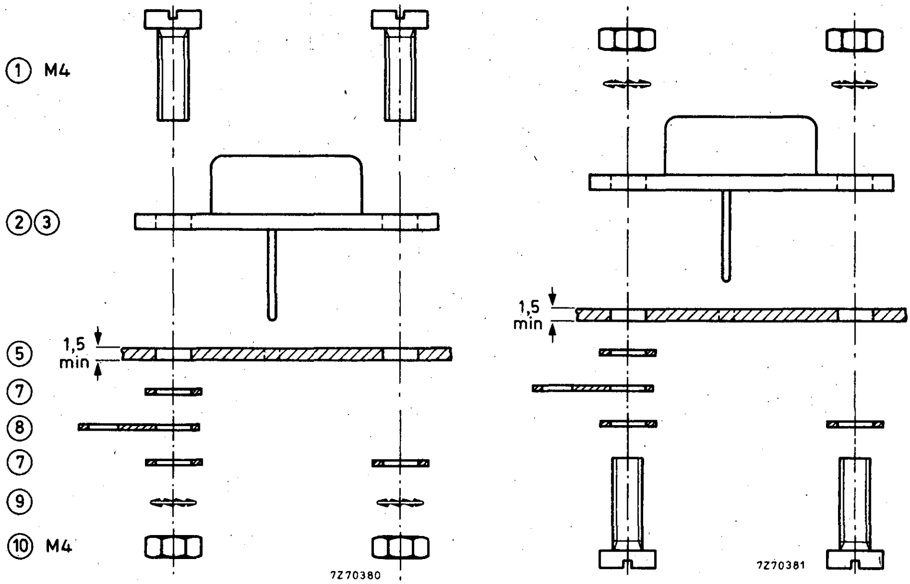
Thermal data

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	$^{o}C/W$
with heatsink compound	$R_{th\ mb-h}$	0,1	0,3	0,5	$^{o}C/W$

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 for all figures:

- (1) = screw
- (2) = TO-3 thick base (3, 15 mm)
- (2)(3) = TO-3 thick or thin base
- (3) = TO-3 thin base (1, 6 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

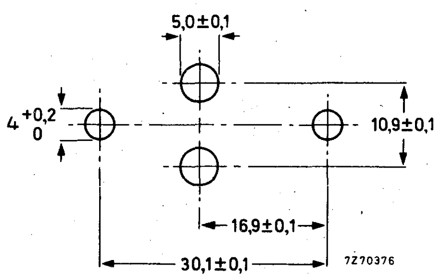


Fig. 3. Hole pattern for direct mounting with nuts

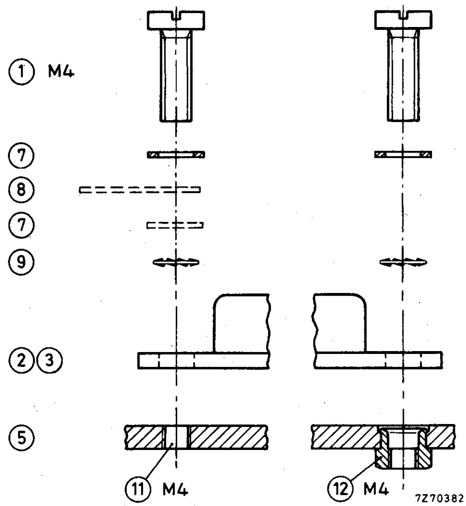


Fig. 4 Direct mounting with tapped holes or insert nuts.

MOUNTING INSTRUCTIONS FOR UP TO 500 V INSULATION

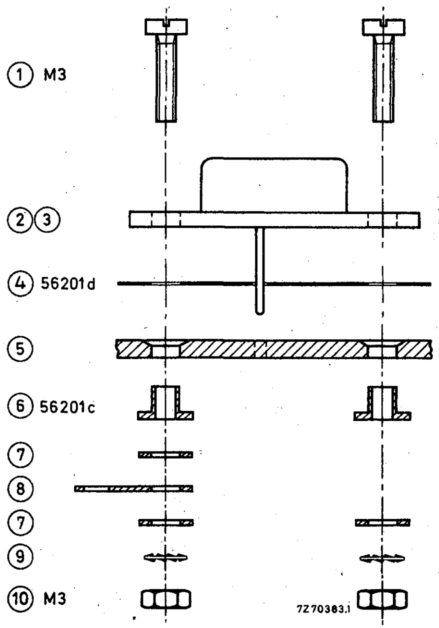
Using insulating bushes 56201c and mica washer 56201d

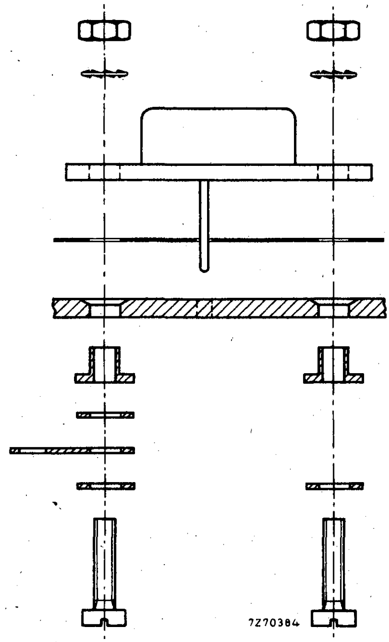
For the component arrangement with minimum heatsink thickness see Figs 5 and 6. For hole pattern and shape of holes see Figs 7 and 8.
The accessories can also be used for thinbase transistors on a 2,5 mm heatsink provided with M3 insert nuts in an arrangement like Figs 10 and 12.

Using insulating bushes 56201j or 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.

MOUNTING INSTRUCTIONS FOR UP TO 500 V INSULATION (continued)





Figs 5 and 6. Insulated mounting (500 V) with 56201c and 56201d

Heatsink thickness: 1,5 to 2,5 mm for thick-base TO-3
2 to 2,5 mm for thin-base TO-3

For legend see page 2.

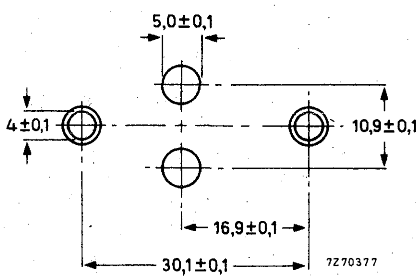


Fig. 7. Hole pattern for 500 V insulation, nut fastening

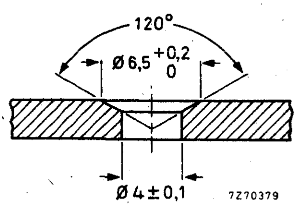


Fig. 8. Shape of hole for 500 V insulation, nut fastening

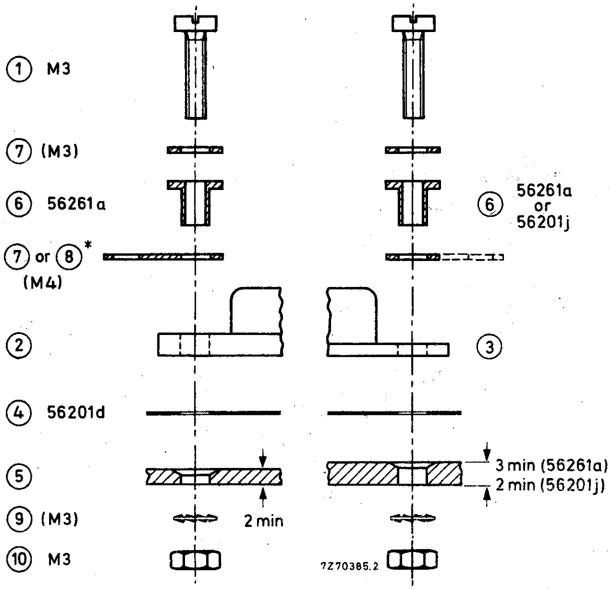


Fig. 9 Insulated mounting (500 V) with nuts.

For legend see page 2.

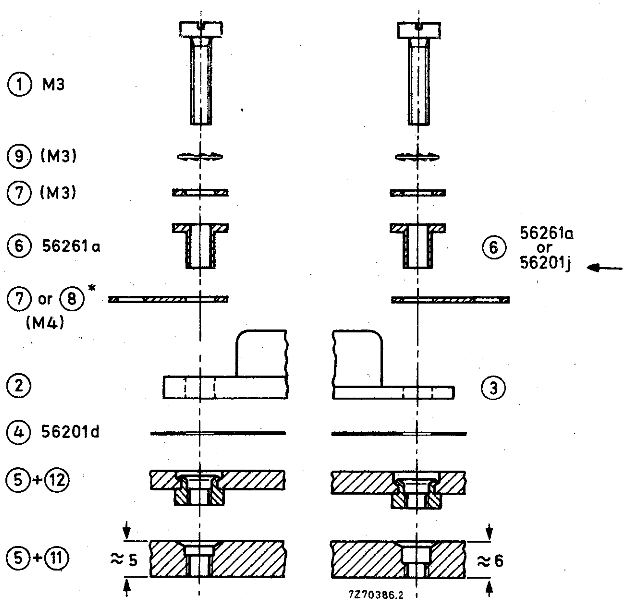


Fig. 10 Insulated mounting (500 V) with tapped holes or insert nuts.

* Thickness approximately 0,6 mm, outer diameter 7,5 mm.

MOUNTING INSTRUCTIONS FOR UP TO 500 V INSULATION (continued)

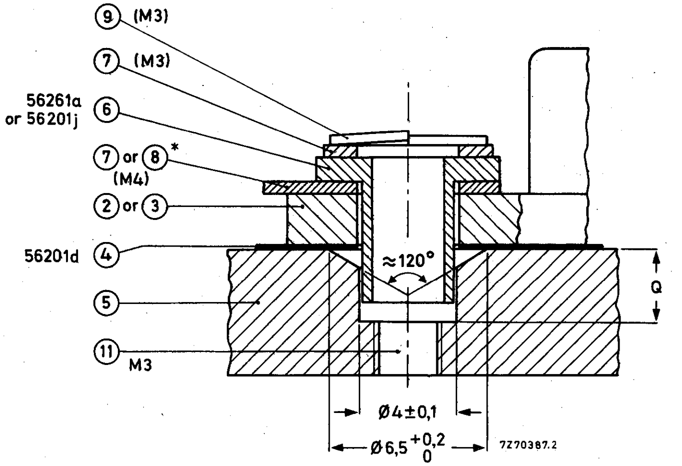


Fig. 11 Assembly (partial) for Fig. 10 – tapped holes.

Q minimum 2 mm for thick-base TO-3 (with **56261a**).
Q minimum 3 mm for thin-base TO-3 (with **56261a**).
Q minimum 2 mm for thin-base TO-3 (with **56201j**).

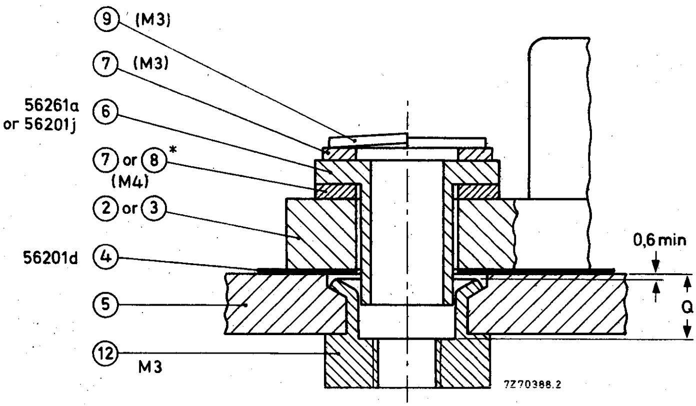


Fig. 12 Assembly (partial) for Fig. 10 – insert nuts and thick-base TO-3.

Q minimum 2 mm for thick-base TO-3 (with **56261a**).
Q minimum 3 mm for thin-base TO-3 (with **56261a**).
Q minimum 2 mm for thin-base TO-3 (with **56201j**).

* Thickness approximately 0,6 mm, outer diameter 7,5 mm.

Legend for all figures:

(1)	screw.
(2)	TO-3 thick base (3,15 mm).
(2) (3)	TO-3 thick or thin base.
(3)	TO-3 thin base (1,6 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.

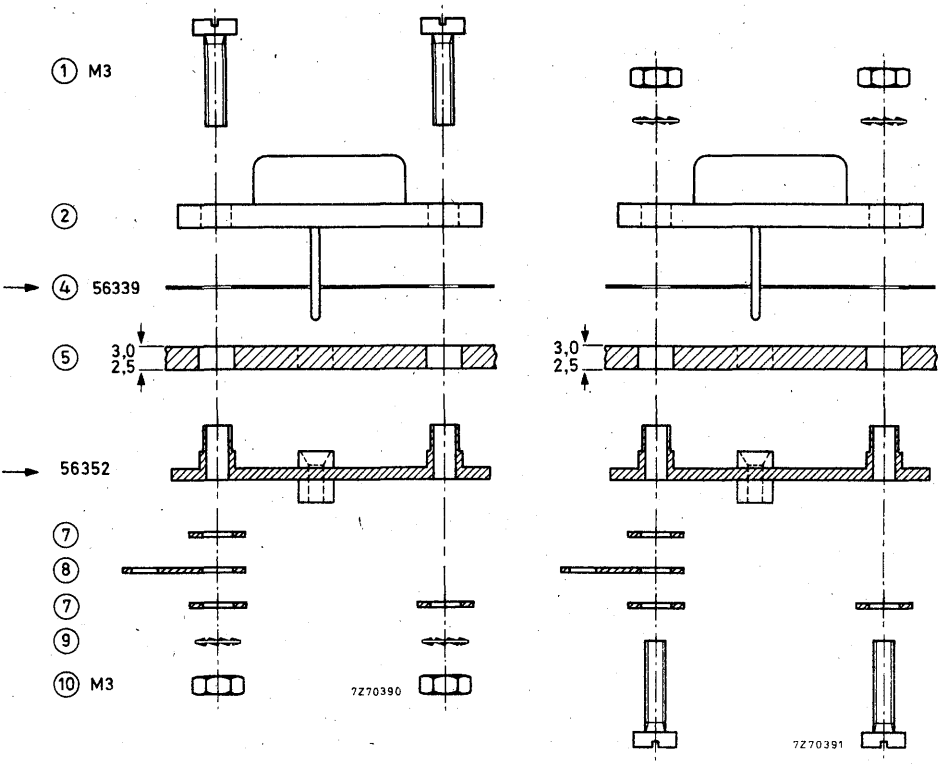
Dimensions in mm

MOUNTING INSTRUCTIONS FOR 500 V TO 2000 V INSULATION (Thick-base TO-3 only)

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.

MOUNTING INSTRUCTIONS FOR 500 V TO 2000 V INSULATION (continued)



Figs 13 and 14 Insulated mounting (500 V – 2000 V, thick-base TO-3) with mica **56339** and mounting support **56352**.

For legend see page 2 or 7.

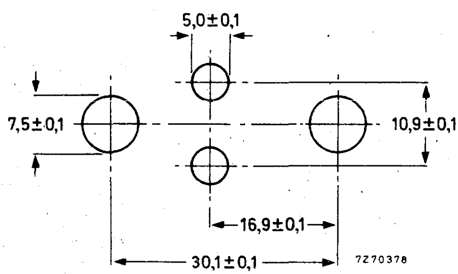


Fig. 15 Hole pattern for Figs 13 and 14.

ACCESSORIES

TYPE NUMBER SURVEY ACCESSORIES

type number	description	envelope
56201c	insulating bushes (up to 500 V)	TO-3
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	SOT-32
56333	metal washer mica washer insulating bush	SOT-32
56339	mica washer (500 to 2000 V)	TO-3
56352	insulating mounting support	
56353	spring clip	SOT-32/SOT-82
56354	mica insulator	SOT-32/SOT-82
56359b	mica washer (up to 800 V)	TO-220
56359c	insulating bush (up to 800 V)	TO-220
56359d	rectangular insulating washer (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	TO-220
56368a	mica insulator	SOT-93
56368b	insulating bush	SOT-93
56369	mica insulator (up to 2 kV)	TO-220
56378	mica insulator	SOT-93
56379	spring clip	SOT-93

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	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	←	56333	→	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	56201c; 56201j or 56261a		M3
up to 2000 V			56339	56352		M3

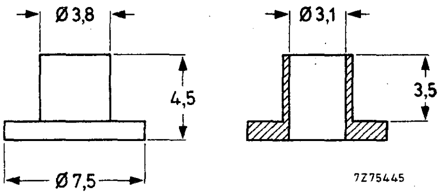
The accessories mentioned can be supplied on request.

See also chapter Mounting Instructions.

56201c 2 INSULATING BUSHES

Two insulating bushes for up to 500 V insulation of TO-3 envelopes.

MECHANICAL DATA Dimensions in mm



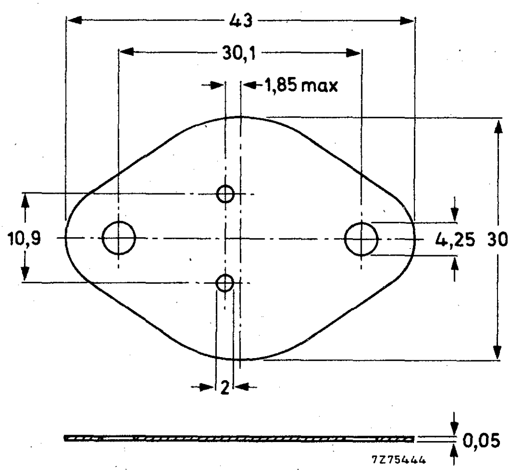
TEMPERATURE

Maximum permissible temperature T_{max} 150 °C

56201d MICA WASHER

Mica washer for up to 500 V insulation of TO-3 envelopes.

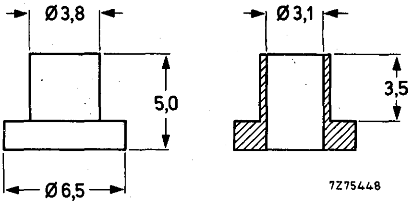
MECHANICAL DATA Dimensions in mm



56201j 2 INSULATING BUSHES

Two insulating bushes for up to 500 V insulation of **TO-3** envelopes.

MECHANICAL DATA Dimensions in mm



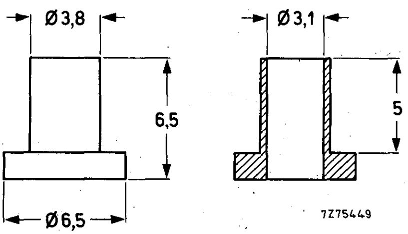
TEMPERATURE

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

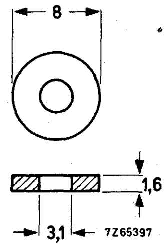
Maximum permissible temperature T_{max} 150 °C

56326 WASHER

Flat metal washer for direct mounting of envelope SOT-32 (TO-126).

MECHANICAL DATA

Dimensions in mm

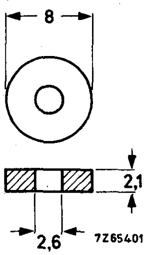


56333

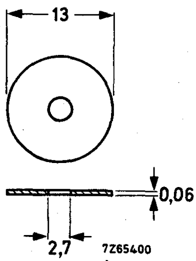
Mounting accessories for insulated mounting of envelope SOT-32 (TO-126); the set consists of a metal washer, a mica washer and an insulating bush.

MECHANICAL DATA

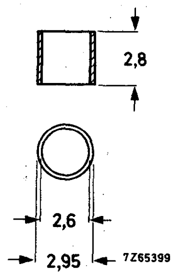
Dimensions in mm



Metal washer.



Mica washer.



Insulating bush.

TEMPERATURE

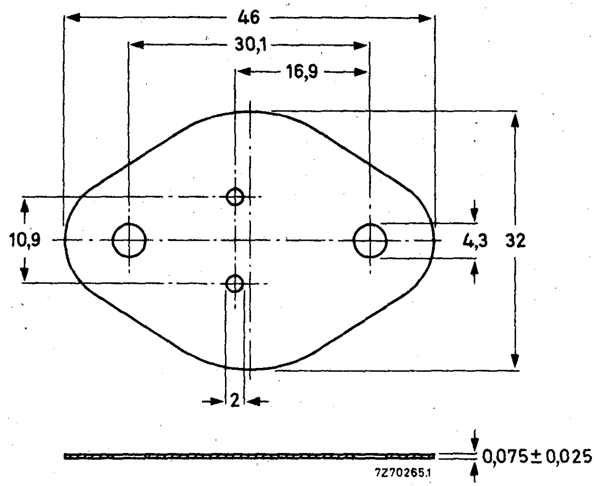
Maximum permissible temperature $T_{max} = 150\ ^{o}C$

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

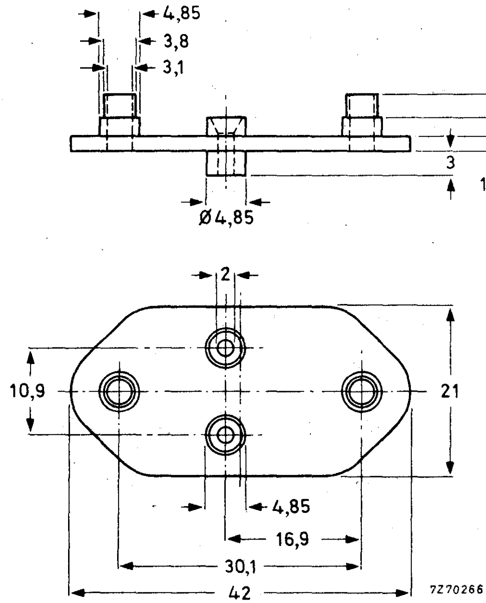


56352 MOUNTING SUPPORT

Mounting support for 500 to 2000 V insulation of thick-base TO-3 envelopes, for which it should be combined with mica washer 56339.

MECHANICAL DATA

Dimensions in mm



TEMPERATURE

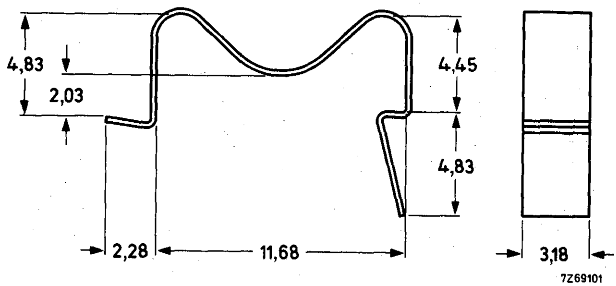
Maximum permissible temperature T_{max} 125 °C

56353 CLIP

for SOT-32 and SOT-82 envelopes

MECHANICAL DATA

Dimensions in mm



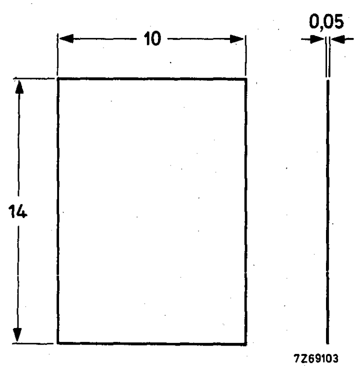
Spring clip suitable for heatsink of 1,5 to 2 mm.
See mounting instructions SOT-32/SOT-82 envelopes.

56354 MICA INSULATOR

for SOT-32 and SOT-82 envelopes

MECHANICAL DATA

Dimensions in mm



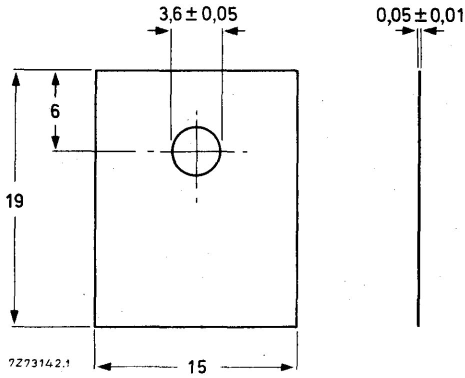
See also chapter Mounting Instructions.

56359b MICA WASHER

for TO-220 envelopes (up to 800 V)

MECHANICAL DATA

Dimensions in mm

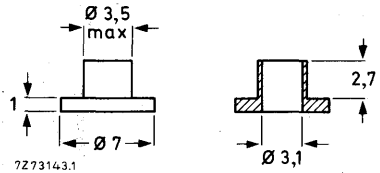


56359c INSULATING BUSH

for TO-220 envelopes (up to 800 V)

MECHANICAL DATA

Dimensions in mm



TEMPERATURE

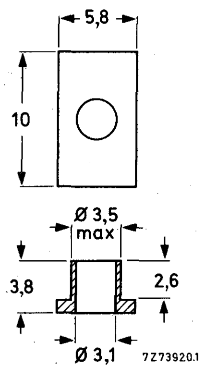
Maximum permissible temperature T_{max} = 150 °C

56359d RECTANGULAR INSULATING WASHER

for TO-220 envelopes (up to 1000 V)

MECHANICAL DATA

Dimensions in mm



TEMPERATURE

Maximum permissible temperature T_{max} = 150 °C

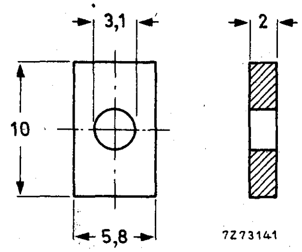
56360a RECTANGULAR WASHER

for direct and insulated mounting of TO-220 envelopes

MECHANICAL DATA

Dimensions in mm

material: brass.



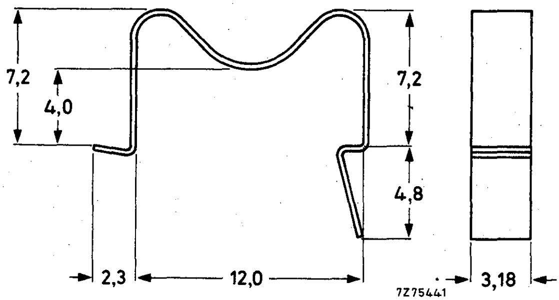
56363 SPRING CLIP

for direct mounting of TO-220 envelopes

MECHANICAL DATA

Dimensions in mm

material: steel, zinc-chromate passivated.



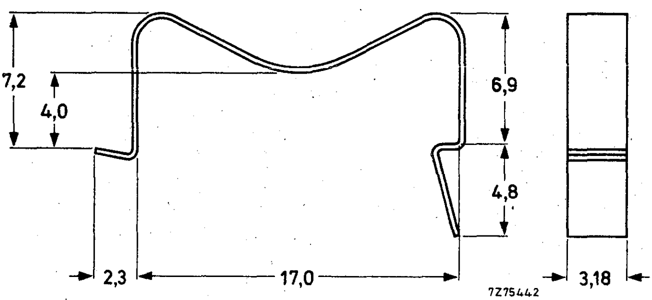
56364 SPRING CLIP

for insulated mounting of TO-220 envelopes

MECHANICAL DATA

Dimensions in mm

material: steel, sinc-chromate passivated.



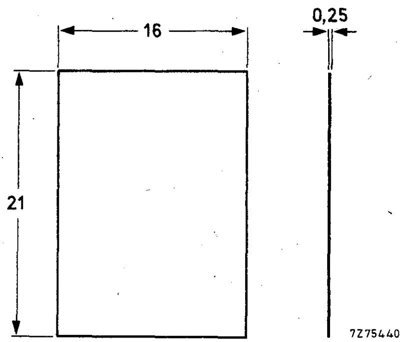
to be used in conjunction with **56367** or **56369.**

56367 ALUMINA INSULATOR

for insulating mounting of TO-220 envelopes

MECHANICAL DATA

Dimensions in mm



alumina insulator (up to 2 kV)
material: 96-alumina.*

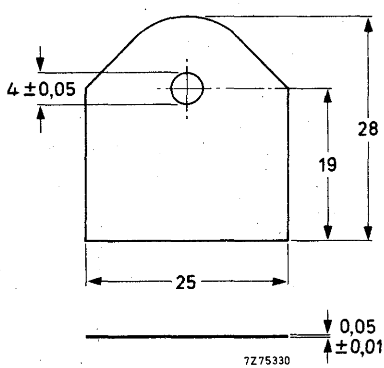
* Because alumina is brittle, extreme care must be taken when mounting devices not to crack the alumina, particularly when used without heatsink compound.

56368a MICA INSULATOR

for insulated screw mounting of SOT-93 envelopes

MECHANICAL DATA

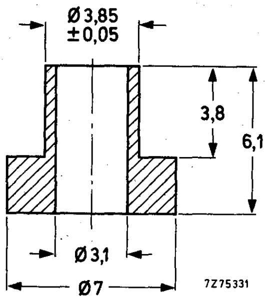
Dimensions in mm



56368b INSULATING BUSH

for insulated screw mounting of SOT-93 envelopes

MECHANICAL DATA Dimensions in mm



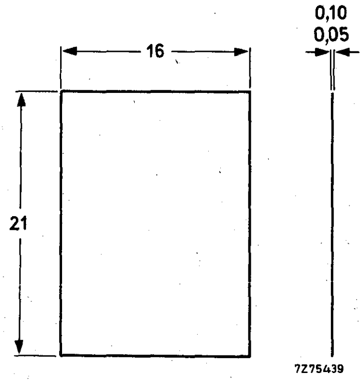
TEMPERATURE

Maximum permissible temperature T_{max} = 150 °C

56369 MICA INSULATOR

for insulated clip mounting of TO-220 envelopes (up to 2 kV)

MECHANICAL DATA Dimensions in mm

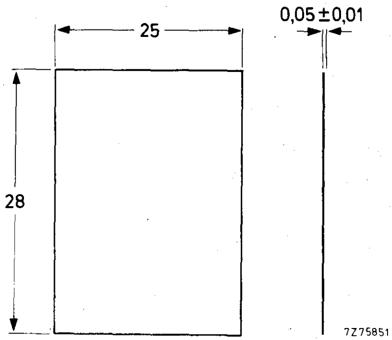


56378 MICA INSULATOR

for SOT-93 clip mounting

MECHANICAL DATA

Dimensions in mm

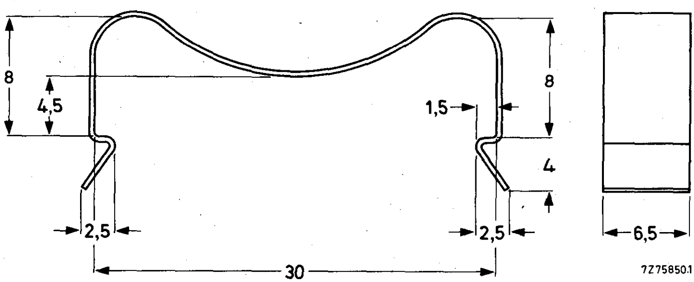


56379 SPRING CLIP

for direct and insulated mounting of SOT-93 envelopes

MECHANICAL DATA

Dimensions in mm



material: CrNi steel NLN-939; thickness 0,4 ± 0,04.

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 %

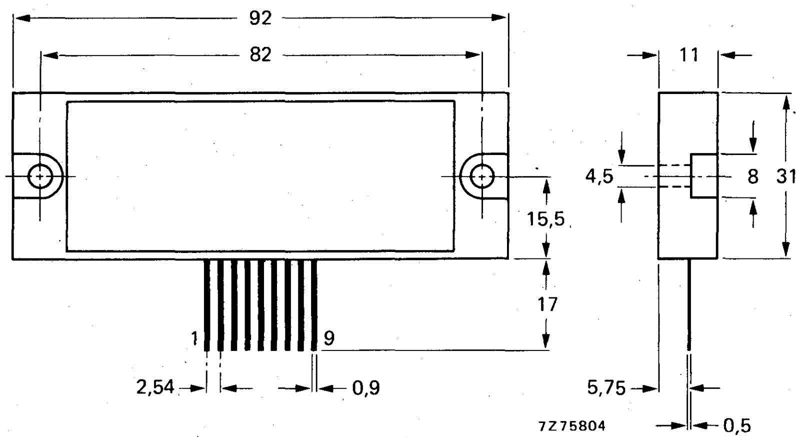


Fig. 1 Outline; dimensions in mm.

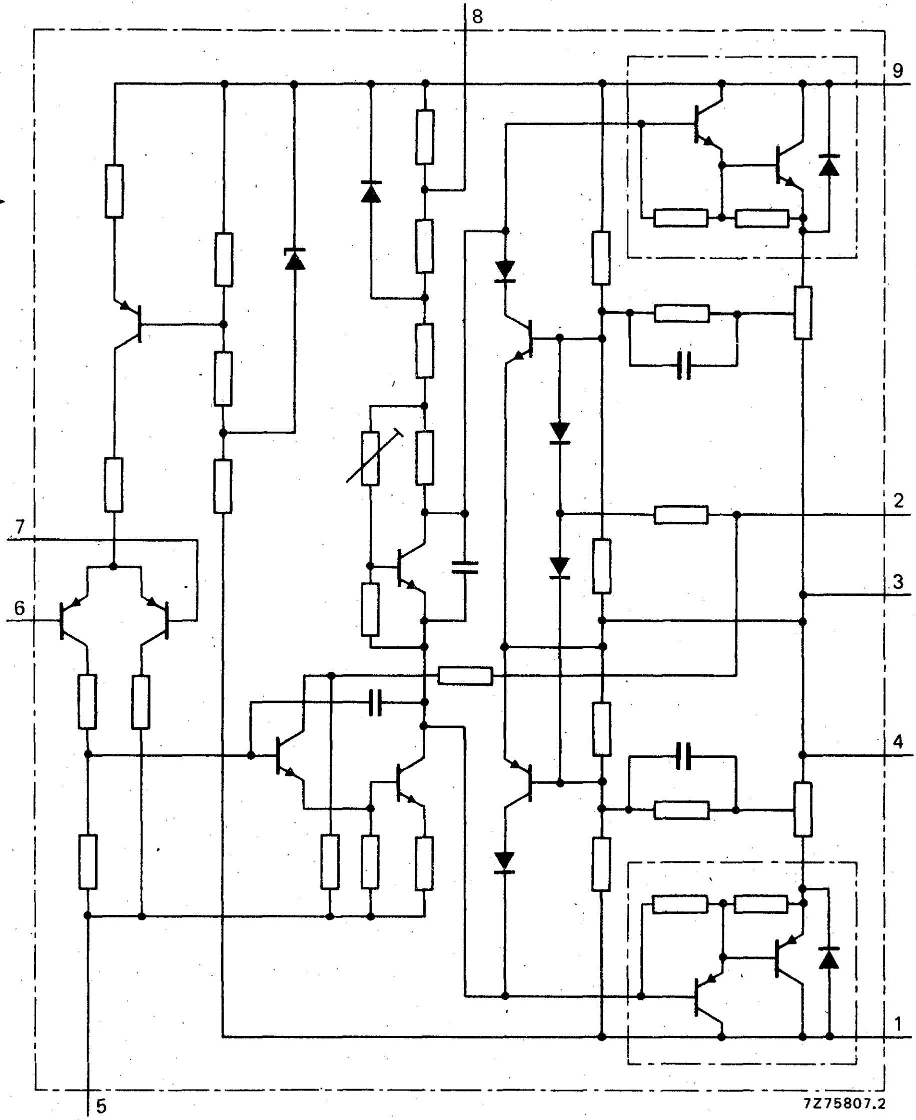


Fig. 2 Circuit diagram.

DEVELOPMENT SAMPLE DATA

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

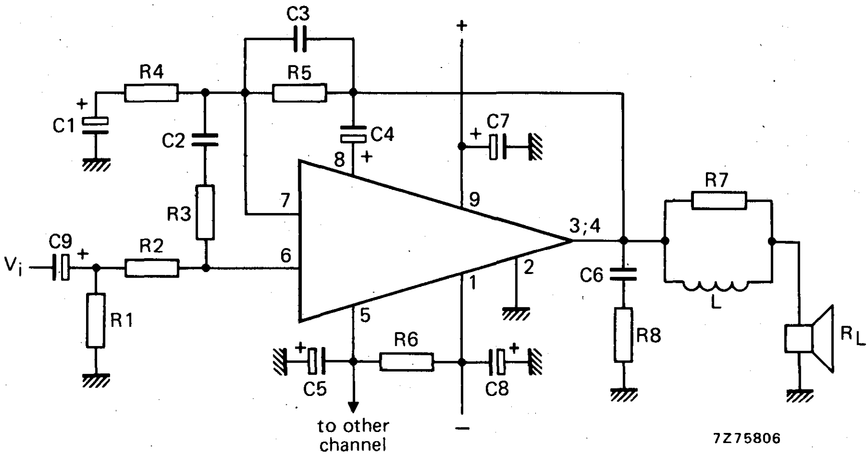


Fig. 3 Example of an amplifier with external components.

List of components:

R1 = 10 kΩ (0,25 W)	C1 = 47 μF (10 V)	L = 4 μH
R2 = 4,7 kΩ (0,25 W)	C2 = 270 pF (10%)	
R3 = 300 Ω (0,25 W)	C3 = 120 pF (10%)	R_L = 4 or 8 Ω
R4 = 680 Ω (0,25 W)	C4 = 100 μF	
R5 = 10 kΩ (0,25 W)	C5 = 470 μF	
R6 = 22 Ω (0,5 W)	C6 = 100 nF	
R7 = 2,2 Ω (0,25 W)	C7 = 10 μF (63 V)	
R8 = 10 Ω (0,5 W)	C8 = 10 μF (63 V)	
	C9 = 1 μF (63 V)	

MOUNTING RECOMMENDATIONS

The modules are delivered with leads in SIL (single in-line) but leads may also be bent to DIL (dual in-line).

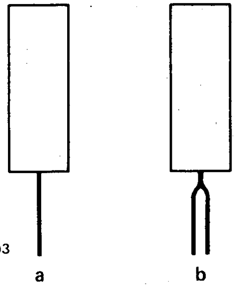
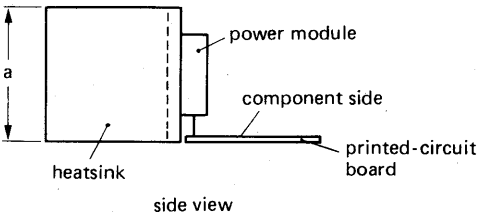


Fig. 4:
a. Single in-line (SIL) leads.
b. Dual in-line (DIL) leads.



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

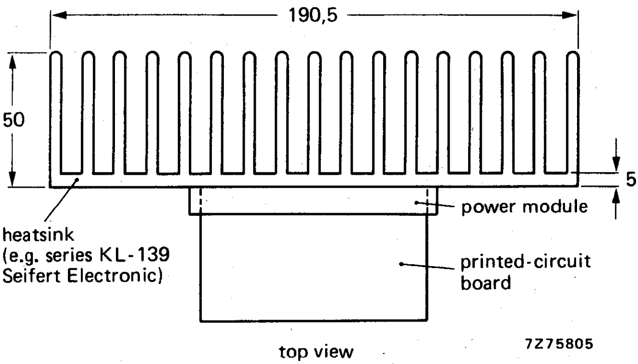


Fig. 5 Example of a heatsink to be used for the module; dimensions in mm.

PRINTED-CIRCUIT BOARDS for OM931 and OM961

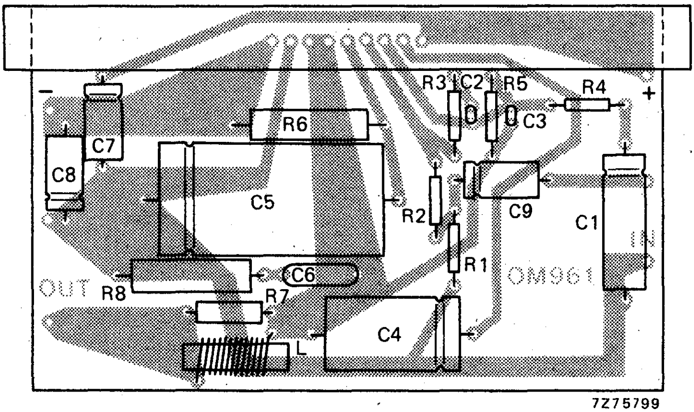


Fig. 6 Component side of SIL-version showing component layout.

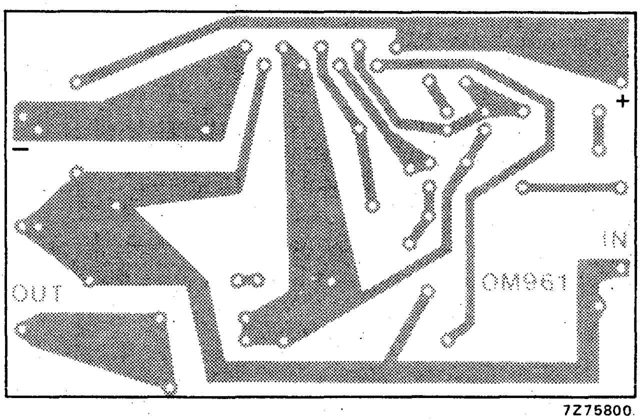


Fig. 7 Component side of DIL-version; for component layout see Fig. 6.

Dimensions in mm

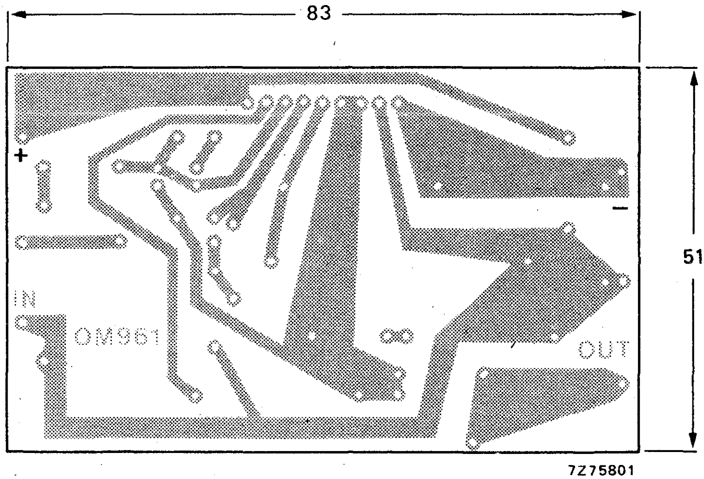


Fig. 8 Track side of SIL-version.

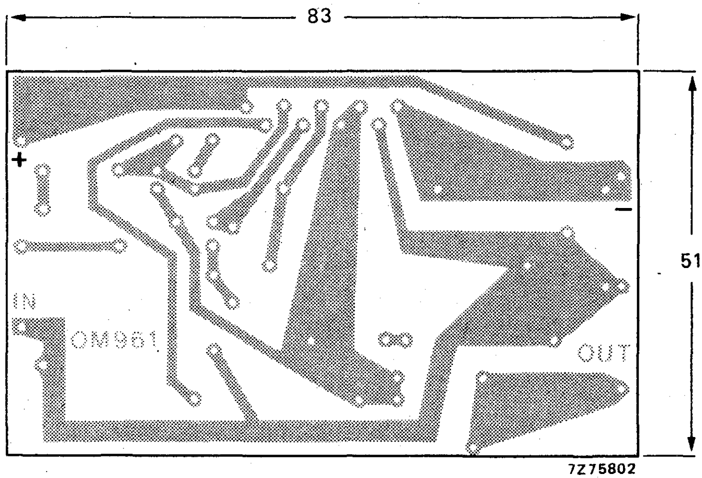


Fig. 9 Track side of DIL-version.

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