

## Semiconductors

Book S4b

1986

High-voltage and switching

power transistors

# HIGH-VOLTAGE AND SWITCHING POWER TRANSISTORS (Book S4b)

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NOTE: For information on low-frequency power transistors and modules see Book S4a.



### DATA HANDBOOK SYSTEM

Our Data Handbook System comprises more than 60 books with specifications on electronic components, subassemblies and materials. It is made up of four series of handbooks:

**ELECTRON TUBES** 

BLUE

**SEMICONDUCTORS** 

RED

INTEGRATED CIRCUITS

PURPLE

COMPONENTS AND MATERIALS

GREEN

The contents of each series are listed on pages iv to viii.

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

When ratings or specifications differ from those published in the preceding edition they are indicated with arrows in the page margin. Where application information is given it is advisory and does not form part of the product specification.

Condensed data on the preferred products of Philips Electronic Components and Materials Division is given in our Preferred Type Range catalogue (issued annually).

Information on current Data Handbooks and on how to obtain a subscription for future issues is available from any of the Organizations listed on the back cover.

Product specialists are at your service and enquiries will be answered promptly.

## INTEGRATED CIRCUITS (PURPLE SERIES)

The purple series of data handbooks comprises:

EXIST	ING SERIES	Superseded by:
IC1	Bipolar ICs for radio and audio equipment	IC01N
IC2	Bipolar ICs for video equipment	IC02Na and IC02Nb
IC3	ICs for digital systems in radio, audio and video equipment	ICO1N, ICO2Na and ICO2Nb
IC4	Digital integrated circuits CMOS HE4000B family	
IC5	Digital integrated circuits — ECL ECL10 000 (GX family), ECL100 000 (HX family), dedicated	IC08N designs
IC6	Professional analogue integrated circuits	
IC7	Signetics bipolar memories	
IC8	Signetics analogue circuits	IC11N
IC9	Signetics TTL logic	IC09N and IC15N
IC10	Signetics Integrated Fuse Logic (IFL)	IC13N
IC11	Microprocessors, microcomputers and peripheral circuitry	IC14N

## SEMICONDUCTORS (RED SERIES)

The red series of data handbooks comprises:

S13

Semiconductor sensors

S1	Diodes Small-signal silicon diodes, voltage regulator diodes ( $<$ 1,5 W), voltage reference diodes, tuner diodes, rectifier diodes
S2a	Power diodes
S2b	Thyristors and triacs
<b>S3</b>	Small-signal transistors
S4a	Low-frequency power transistors and hybrid modules
S4b	High-voltage and switching power transistors
S5	Field-effect transistors
S6	R.F. power transistors and modules
<b>S7</b>	Surface mounted semiconductors
<b>S8</b>	Devices for optoelectronics Photosensitive diodes and transistors, light-emitting diodes, displays, photocouplers, infrared sensitive devices, photoconductive devices.
S9	Power MOS transistors
S10	Wideband transistors and wideband hybrid IC modules
S11	Microwave transistors
S12	Surface acoustic wave devices

## **ELECTRON TUBES (BLUE SERIES)**

The blue series of data handbooks comprises:

T1	Tubes for r.f. heating
T2a	Transmitting tubes for communications, glass types
T2b	Transmitting tubes for communications, ceramic types
Т3	Klystrons
T4	Magnetrons for microwave heating
T5	Cathode-ray tubes Instrument tubes, monitor and display tubes, C.R. tubes for special applications
T6	Geiger-Müller tubes
T7	Gas-filled tubes (will not be reprinted)
T8	Colour display systems Colour TV picture tubes, colour data graphic display tube assemblies, deflection units
Т9	Photo and electron multipliers
T10	Plumbicon camera tubes and accessories
T11	Microwave semiconductors and components
T12	Vidicon and Newvicon camera tubes
T13	Image intensifiers
T14	Infrared detectors  Data collations on these subjects are available now. Data Handbooks will be published in 1985.
T15	Dry reed switches

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

Monochrome tubes and deflection units

T16

NEW SERIE	

IC01N	Radio, audio and associated systems Bipolar, MOS	(published 1985)
IC02Na	Video and associated systems Bipolar, MOS Types MAB8031AH to TDA1524A	(published 1985)
IC02Nb	Video and associated systems Bipolar, MOS Types TDA2501 to TEA1002	(published 1985)
IC03N	Integrated circuits for telephony	(published 1985)
IC04N	HE4000B logic family CMOS	
IC05N	HE4000B logic family — uncased ICs CMOS	(published 1984)
IC06N	High-speed CMOS; PC54/74HC/HCT/HCU Logic family	(published 1985)
Suppleme to IC06N	nt High-speed CMOS; PC74HC/HCT/HCU Logic family	(published 1985)
IC07N	High-speed CMOS; PC54/74HC/HCT/HCU — uncased ICs Logic family	
IC08N	ECL 10K and 100K logic families	(published 1984)
IC09N	TTL logic series	(published 1984)
IC10N	Memories MOS, TTL, ECL	
IC11N	Linear LSI	(published 1985)
IC12N	Semi-custom gate arrays & cell libraries ISL, ECL, CMOS	
IC13N	Semi-custom Integrated Fuse Logic	(published 1985)
IC14N	Microprocessors, microcontrollers & peripherals Bipolar, MOS	(published 1985)
IC15N	FAST TTL logic series	(published 1984)
Note		
Books ava	ilable in the new series are shown with their date of publication.	

October 1985

## COMPONENTS AND MATERIALS (GREEN SERIES)

The green series of data handbooks comprises: Programmable controller modules

C1

	PLC modules, PC20 modules
C2	Television tuners, coaxial aerial input assemblies, surface acoustic wave filters
C3	Loudspeakers
C4	Ferroxcube potcores, square cores and cross cores
C5	Ferroxcube for power, audio/video and accelerators
C6	Synchronous motors and gearboxes
C7	Variable capacitors
C8	Variable mains transformers
C9	Piezoelectric quartz devices
C10	Connectors
C11	Varistors, thermistors and sensors
C12	Potentiometers, encoders and switches
C13	Fixed resistors
C14	Electrolytic and solid capacitors
C15	Ceramic capacitors
C16	Permanent magnet materials
C17	Stepping motors and associated electronics
C18	Direct current motors
C19	Piezoelectric ceramics
C20	Wire-wound components for TVs and monitors

HNIL FZ/30 series, NORbits 60-, 61-, 90-series, input devices

C22

C21\* Assemblies for industrial use

Film capacitors

<sup>\*</sup> To be issued shortly.

### **GENERAL PURPOSE DARLINGTON TRANSISTORS**

lc	pol.		collector-emitter voltage (open base) V <sub>CEO</sub> (V)									P <sub>tot</sub>	case
Α		45	60	80	100	120	130	150	200	375	400	W	
0,5	N									BU824		2	TO-20
1	N P	BDX42* BDX45*	BDX43* BDX46*	BDX44* BDX47*								5	TO-12
4	N P	BD675 BD676	BD677 BD678	BD679 BD680	BD681 BD682	BD683 BD684						40	TO-12
	N P		BDT61 BDT60	BDT61A BDT60A	BDT61B BDT60B	BDT61C BDT60C						50	TO-22
	N P		TIP110 TIP115	TIP111 TIP116	TIP112 TIP117	BDTGCC						50	TO-22
5	N P		TIP120 TIP125	TIP121 TIP126	TIP122 TIP127							65	TO-22
6	N N P		BD331 BD332	BD333 BD334	BD335 BD336	BD337 BD338				BU826		125 60	SOT-9
8 ~	N P		BD645 BD646	BD647 BD648	BD649 BD650	BD651 BD652	-					62,5	TO-22
	N N P						BDT21 BDT20	BU807	BU806			60 62,5	TO-22 TO-22
	N P		BDX63 BDX62	BDX63A BDX62A	BDX63B BDX62B	BDX63C BDX62C						90	TO-3
	N P		TIP130 TIP135	TIP131 TIP136	TIP132 TIP137							70	TO-22
0	N P		BDT63 BDT62	BDT63A BDT62A	BDT63B BDT62B	BDT63C BDT62C						90	TO-22
	N P		TIP140 TIP145	TIP141 TIP146	TIP142 TIP147					-		125	SOT-9

<sup>\*</sup> VCER-

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I <sub>C</sub>	pol.				collector-e	mitter volt	age (oper	n base) VCI	EO (V)			P <sub>tot</sub>	case
		45	60	80	100	120	130	150	200	375	400	w	
12	N		BDT65	BDT65A	BDT65B	BDT65C						125	TO-220
	P		BDT64	BDT64A	BDT64B	BDT64C							1000
	N		BDV65	BDV65A	BDV65B	BDV65C					BUV90; A	125	SOT-9
	P		BDV64	BDV64A	BDV64B	BDV64C							501
	N	Ì	BDX65	BDX65A	BDX65B	BDX65C						117	TO-3
	P		BDX64	BDX64A	BDX64B	BDX64C		1					
	N						l				BUX90	125	TO-3
16	N		BDV67	BDV67A	BDV67B	BDV67C						200	SOT-9
	P		BDV66	BDV66A	BDV66B	BDV66C							501
	N		BDX67	BDX67A	BDX67B	BDX67C						150	TO-3
	P		BDX66	BDX66A	BDX66B	BDX66C							
25	N		BDX69	BDX69A	BDX69B	BDX69C						200	TO-3
	P		BDX68	BDX68A	BDX68B	BDX68C			-				

### **GENERAL PURPOSE POWER TRANSISTORS**

IC	pol.				collector-	emitter vo	Itage (open	base) V <sub>CE</sub>	O (V)			P <sub>tot</sub>	case
Α		20	22	32	40	45	60	80	100	120	140	W	
1	N P					BD135 BD136	BD137 BD138	BD139 BD140				8	TO-126
	N P					BD825 BD826	BD827 BD828	BD829 BD830					TO-202
	N P					BDW55 BDW56	BDW57 BDW58	BDW59 BDW60					TO-126
	N P				BDT29 BDT30		BDT29A BDT30A	BDT29B BDT30B	BDT29C BDT30C			30	TO-220
	N P				TIP29 TIP30		TIP29A TIP30A	TIP29B TIP30B	TIP29C TIP30C			30	TO-220
1,5	N P					BD226 BD227	BD228 BD229	BD230 BD231				12,5	TO-126
	N P					BD839 BD840	BD841 BD842	BD843 BD844	BD845 BD846	BD847 BD848	BD849 BD850	10	TO-202

### **GENERAL PURPOSE POWER TRANSISTORS** (continued)

Ic	pol.				collector-	emitter vo	Itage (open	base) V <sub>CE</sub>	O (V)			P <sub>tot</sub>	case
A		20	22	32	40	45	60	80	100	120	140	W	
2	N P					BD233 BD234	BD235 BD236	BD237 BD238				25	TO-126
	N P				7	BD813 BD814	BD815 BD816	BD817 BD818				12,5	TO-202
3	N P					BD239 BD240	BD239A BD240A	BD239B BD240B	BD239C BD240C			30	TO-220
	N P					BD131 BD132						15	TO-126
	N P	BD329 BD330											
	N P N				BDT31	BD933 BD934	BD935 BD936 BDT31A	BD937 BD938 BDT31B	BD939 BD940 BDT31C	BD941 BD942		30	TO-220
	P N P				BDT32 TIP31 TIP32		BDT32A TIP31A TIP32A	BDT32B TIP31B TIP32B	BDT32C TIP31C TIP32C			40	TO-220
4	N P		BD433 BD434	BD435 BD436	BD437 BD438		IIFJZA	111726	117520			36	TO-126
5	N P					BD241 BD242	BD241A BD242A	BD241B BD242B	BD241C BD242C			40	то-220
	N N			ija rija i ji i Vatera isti ji i			BDX35 BDX36	BDX37				15	TO-126
	N P		BD943 BD944	BD945 BD946		BD947 BD948	BD949 BD950	BD951 BD952	BD953 BD954	BD955 BD956		40	TO-220
6	N P					BD243 BD244	BD243A BD244A	BD243B BD244B	BD243C BD244C			65	TO-220
	N P				BDT41 BDT42		BDT41A BDT42A	BDT41B BDT42B	BDT41C BDT42C			65	TO-220
	N P				TIP41 TIP42		TIP41A TIP42A	TIP41B TIP42B	TIP41C TIP42C			80	SOT-93

IC	pol.				collector-e	mitter vol	tage (open b	pase) V <sub>CE</sub> (	0 (V)			P <sub>tot</sub>	case
Α		20	22	32	40	45	60	80	100	120	140	W	
8	N P					BD201 BD202	BD203 BD204	BDX77 BDX78				60	TO-220
	N P						BDX91 BDX92	BDX93 BDX94	BDX95 BDX96			90	то-3
10	N P	,			A COMMISSION OF THE PARTY OF TH		PH3055T PH2955T					75	TO-220
	N P				7000		BDT91 BDT92	BDT93 BDT94	BDT95 BDT96			90	TO-220
	N P						BDV91 BDV92	BDV93 BDV94	BDV95 BDV96			100	SOT-93
	N P				TIP33 TIP34		TIP33A TIP34A	TIP33B TIP34B	TIP33C TIP34C			80	SOT-93
15	N P						BDT51 BDT52	BDT53 BDT54	BDT55 BDT56	BDT57 BDT58		90	TO-220
	N P						BDT81 BDT82	BDT83 BDT84	BDT85 BDT86	BDT87 BDT88		125	TO-220
	N P						TIP3055					100	SOT-93

Special: TIP47; 48; 49; 50 with  $V_{CEO}$  of 250, 300, 350, 400 V respectively at  $I_C$  = 1 A and  $P_{tot}$  = 40 W in TO-220.

### LOW-VOLTAGE SWITCHING TRANSISTORS

IC	pol.		collector-emitter voltage (open base) V <sub>CEO</sub> (V)						P <sub>tot</sub>	case	
Α						60	80	100		W	
10	N					BDY92	BDY91	BDY90		40	TO-3
12	N							BDY90A		40	· TO-3

HIGH-VOLTAGE TRANSISTORS video output - deflection - SMPS - motor control

lc	pol.				collector-	emitter vo	Itage (open	base) V <sub>CE</sub>	O (V)	7	<u> </u>	P <sub>tot</sub>	case
Α		160	250	300	350	375	400	450	700	800		] W	
0,05	N		BF469	BF471*								1,8	TO-12
	P		BF470	BF472*									
	N		BF583 BF869	BF585 BF871*	BF587							1,6	TO-20
	N P		BF870	BF872*								3	TO-20
0,1	N		BF419									6	TO-12
- •	N	BF457	BF458	BF459							-		
	N		BF819			-						6	TO-20
	N	BF857	BF858	BF859									
0,15	N	BF591	BF593									1,3	TO-20
0,5	N						BUX86	BUX87				20	TO-12
1,5	N			BUX99						:		28	TO-12
				PH13002			PH13003						
2	N						BUW84	BUW85				50	SOT-8
	N						BUX84	BUX85				40	TO-22
	N						BUX84F	BUX85F				18	SOT-1
2,5	N				-				BU705			75	SOT-93
3,5	N						BUX46	BUX46A				85	TO-3
5	N						BUT11	BUT11A	BU506;D			100	TO-220
	N						BUT11F	BUT 11AF				20	SOT-1
	N N						BUW11 BUS11	BUW11A BUS11A	BU706;D			100 100	SOT-9
	N			BUS21	BUS21A		BUS21B	BUS21C				100	10-3
6	N					BU426	BU426A					70	SOT-9
-	N		-			BU433						70	SOT-9
	N						BUX82	BUX83				60	TO-3
	N						BUV82	BUV83		Duno		70	SOT-9
	N							1 1 1 1		BUY89	ŀ	80	TO-3

<sup>\*</sup> V<sub>CER</sub>.

lc	pol.				collector-e	mitter v	oltage (open	base) V <sub>CE</sub>	O (V)		P <sub>tot</sub>	case
Α		160	250	300	350	375	400	450	700	800	W	
8	N N N N			BUS22 BUP22	BUS22A BUP22A		BUW12 BUS12 BUS22B BUP22B	BUW12A BUS12A BUS22C BUP22C	BU508A	BUV89	125 125 125 125	SOT-93 SOT-93 TO-3
9	N						BUX47	BUX47A			125	то-3
10	N						BUX80	BUX81			100	TO-3
12	N								BU808	BUX88	160	TO-3
15	N N N N			BUP23 BUS23	BUP23A BUS23A		BUW13 BUS13 BUX48 BUP23B BUS23B	BUW13A BUS13A BUX48A BUP23C BUS23C			175 175 175 175 175	SOT-93 TO-3 TO-3 SOT-93 TO-3
30	N N						BUS14 BUX98	BUS14A · BUX98A			250 250	TO-3 TO-3

7

## **ACCESSORIES**

### **CLIP MOUNTING**

	direct mounting	insulated	mounting
envelope	clip	mica alumina	clip
TO-126 (SOT-32)	56353	56354	56353
SOT-82	56353	56354	56353
TO-220 (SOT-78)	56363	56369 or 56367	56364
SOT-93	56379	56378	56379

### **SCREW MOUNTING**

	direct mo	ounting	insulated mounting					
envelope	metal washer	mounting material	mica washer	insul. bush	metal washer	mounting material		
TO-126 (SOT-32)	56326	мз						
up to 300 V			56387a	56387ъ	56326	M2,5		
то-220			1 1 2 2					
(SOT-78)	56360a	м3						
up to 800 V			56359ъ	56359c	56360a	м3		
up to 1000 V			56359ъ	56359d	56360a	м3		
SOT-93	,	м4	56368a	56368ъ		м3		
то-3	_	M4				1		
(SOT-3)								
up to 500 V			56201d	56201j or 56261a		м3		
up to 2000 V			56339	56352		м3		

The accessories mentioned can be supplied on request.

See also chapter Mounting Instructions.



## TO-126 (SOT-32)



SOT-186 (TO-220F)

type n	umber	P <sub>tot</sub>	V <sub>CEO</sub>
NPN	PNP	W	V
BF469 BF471	BF470 BF472	1,8	250 300*
BDX42 BDX43 BDX44	BDX45 BDX46 BDX47	5	45 <sup>*</sup> 60 <sup>*</sup> 80 <sup>*</sup>
BF419 BF457 BF458 BF459		6	250 160 250 300
BD135 BD137 BD139 BDW55 BDW57 BDW59	BD136 BD138 BD140 BDW56 BDW58 BDW60	8	45 60 80 45 60
BD226 BD228 BD230	BD227 BD229 BD231	12,5	45 60 80
BD131 BD329 BDX35 BDX36 BDX37	BD132 BD330	15	45 20 60 60 80
BUX86 BUX87		20	400 450
BD233 BD235 BD237	BD234 BD236 BD238	25	45 60 80
BUX99 PH13002 PH13003		28	300 300 400
BD433 BD435 BD437	BD434 BD436 BD438	36	22 32 45
BD675 BD677 BD679 BD681 BD683	BD676 BD678 BD680 BD682 BD684	40	45 60 80 100 120

type ni	umber	P <sub>tot</sub>	VCEO	
NPN	PNP	] W	V	
BUX84F BUX85F		18	400 450	
BUT11F BUT11AF		20	400 450	



TO-202 (SOT-128)

type ni	umber	P <sub>tot</sub>	VÇEO
NPN	PNP	W	V
BF583 BF585 BF587 BF869 BF871	BF870 BF872	5(1,6)	250 300 350 250 300*
BF591 BF593		(1,3)	170 210
BF819		6(1,2)	250
BF857 BF858 BF859		6(2)	160 250 300
BD825 BD827 BD829	BD826 BD828 BD830	8(2)	45 60 80
BD839 BD841 BD843 BD845 BD847 BD849	BD840 BD842 BD844 BD846 BD848 BD850	10(2)	45 60 80 100 120 140
BD813 BD815 BD817	BD814 BD816 BD818	12,5	45 60 80

<sup>\*</sup> VCER-

<sup>\*</sup> V<sub>CER</sub>.
() free air dissipation.



TO-220 (SOT-78)

type n	umber	P <sub>tot</sub>	V <sub>CEO</sub>
NPN	PNP	W	<b>V</b> .
BD239 BD239A BD239B BD239C BD933 BD935 BD937 BD939 BD941 BDT29 BDT29A BDT29A BDT29B BDT29C TIP29	BD240 BD240A BD240B BD240C BD934 BD936 BD938 BD940 BD942 BDT30 BDT30A BDT30A BDT30C TIP30	30	45 60 80 100 45 60 80 100 120 40 60 80 100
TIP29A TIP29B TIP29C	TIP3OA TIP3OB TIP3OC		60 80 100
BD241A BD241A BD241B BD241C TIP47 TIP48 TIP49	BD242 BD242A BD242B BD242C	40	45 60 80 100 250 300 350
TIP50 BD943 BD945 BD947 BD949 BD951 BD953 BD955 BDT31 BDT31A BDT31A BDT31C BUX84 BUX85	BD944 BD946 BD948 BD950 BD952 BD954 BD956 BDT32 BDT32A BDT32B		400 22 32 45 60 80 100 45 60 80 100 400 450
TIP31 TIP31A TIP31B TIP31C	TIP32 TIP32A TIP32B TIP32C		40 60 80 100

type nu	mber	P <sub>tot</sub>	VÇEO
NPN	PNP	w	V
BDT61 BDT61A BDT61B BDT61C TIP110 TIP111 TIP112 BD201 BD203 BDX77 BU807 BU806	BDT60 BDT60A BDT60B BDT60C TIP115 TIP116 TIP117 BD202 BD204 BDX78	50 60	60 80 100 120 60 80 100 45 60 80 150 200
BD645 BD647 BD649 BD651 BDT21	BD646 BD648 BD650 BD652 BDT20	62,5	60 80 100 120 130
BD243 BD243A BD243B BD243C BDT41A BDT41A BDT41C TIP41C TIP41A TIP41A TIP41C TIP120 TIP121	BD244 BD244A BD244B BD244C BDT42 BDT42A BDT42B BDT42C TIP42 TIP42A TIP42B TIP42B TIP42C TIP125 TIP126	65	45 60 80 100 40 60 80 100 60 80 100
TIP130 TIP131 TIP132	TIP135 TIP136 TIP137	70	60 80 100
PH3055T	PH2955T	75	60
BDT51 BDT53 BDT55 BDT57 BDT63 BDT63A BDT63B BDT63C BDT91 BDT93 BDT95	BDT52 BDT54 BDT56 BDT58 BDT62 BDT62B BDT62B BDT62C BDT92 BDT94 BDT96	90	60 80 100 120 60 80 100 120 60 80

type n	umber	P <sub>tot</sub>	VCEO
NPN	PNP	W	V
BUT11 BUT11A BU506 BU506D		100	400 450 700 700
BDT65 BDT65A BDT65B BDT65C BDT81 BDT83 BDT85 BDT87	BDT64 BDT64A BDT64B BDT64C BDT82 BDT84 BDT86 BDT86 BDT88	125	60 80 100 120 60 80 100 120



## SOT-93 (SOT-93)

type n	umber	P <sub>tot</sub>	VÇEO
NPN	PNP	W	V
BU426 BU426A BU433 BUV82 BUV83		70	375 400 375 400 450
BU705		75	700
TIP33 TIP33A TIP33B TIP33C	TIP34 TIP34A TIP34B TIP34C	80	40 60 80 100
BDV91 BDV93 BDV95 BUW11 BUW11A BU706 BU706D TIP3055	BDV92 BDV94 BDV96 TIP2955	100	60 80 100 400 450 700 700 60

type nu	mber	P <sub>tot</sub>	VCEO
NPN	PNP	W	V
BDV65A BDV65A BDV65B BDV65C TIP140 TIP141 TIP142 BUP22 BUP22A BUP22B	BDV64 BDV64A BDV64B BDV64C TIP145 TIP146 TIP147	125	60 80 100 120 60 80 100 300 350 400
BUP22B BUP22C BUV9O BUV9OA BUW12 BUW12A BU508A BU508D BUV89			450 400 400 400 450 700 700 800
BUP23 BUP23A BUP23B BUP23C BUW13 BUW13A		175	300 350 400 450 400 450
BDV67A BDV67A BDV67B BDV67C	BDV66A BDV66B BDV66C	200	60 80 100 120



## TO-3 (SOT-3)

type n	umber	P <sub>tot</sub>	VCEO
NPN	PNP	W	V
BDY90 BDY90A BDY91 BDY92		40	100 100 80 60
BUX82 BUX83		60	400 450
BUY89		80	800
BUX46 BUX46A		85	400 450
BDX63 BDX91 BDX63A BDX93 BDX63B BDX95 BDX63C	BDX62 BDX92 BDX62A BDX94 BDX62B BDX96 BDX96	90	60 60 80 80 100 100
BUS11 BUS11A BUS21 BUS21A BUS21B BUS21C BUX80 BUX81		100	400 450 300 350 400 450 400 450
BDX65 BDX65A BDX65B BDX65C	BDX64A BDX64A BDX64B BDX64C	117	60 80 100 120
BUS12A BUS12A BUS22 BUS22A BUS22B BUS22C		125	400 450 300 350 400 450
BUX47 BUX47A			400 450
BDX67 BDX67A BDX67B BDX67C	BDX66A BDX66B BDX66C	150	60 80 100 120
BU808			700
BUX88		160	800

type n	type number		
NPN	PNP	W	V
BUS13 BUS13A BUS23 BUS23A BUS23B BUS23C BUX48 BUX48A		175	400 450 300 350 400 450 400 450
BDX69 BDX69A BDX69B BDX69C	BDX68 BDX68A BDX68B BDX68C	200	60 80 100 120
BUS14 BUS14A BUX98 BUX98A		250	400 450 400 450



## **SOT-82**

(SOT-82)

type n	umber	P <sub>tot</sub>	V <sub>CEO</sub>
NPN	PNP	W	V
BUW84 BUW85		50	400 450
BD331	BD332	60	60
BD333	BD334		80
BD335	BD336		100
BD337	BD338		120

## TYPE NUMBER SURVEY POWER TRANSISTORS

type n	umber		P <sub>tot</sub>	type nu	mber		P <sub>tot</sub>
IPN	PNP	envelope	W	NPN	PNP	envelope	w
D131	BD132	TO-126	15	BD651	BD652	TO-220	62,5
D135	BD136	TO-126	8	BD675	BD676	TO-126	40
D137	BD138	TO-126	8	BD677	BD678	TO-126	40
D139	BD140	TO-126	8	BD679	BD680	TO-126	40
D201	BD202	TO-220	60	BD681	BD682	TO-126	40
D203	BD204	TO-220	60	BD683	BD684	TO-126	40
D226	BD227	TO-126	12,5	BD813	BD814	TO-202	2
D228	BD229	TO-126	12,5	BD815	BD816	TO-202	2
D230	BD231	TO-126	12,5	BD817	BD818	TO-202	2
D233	BD234	TO-126	25	BD825	BD826	TO-202	2
D235	BD236	TO-126	25	BD827	BD828	TO-202	2
D237	BD238	TO-126	25	BD829	BD830	TO-202	2
D239	BD240	TO-220	30	BD839	BD840	TO-202	2
D239A	BD240A	TO-220	30	BD841	BD842	TO-202	2
3D239B	BD240B	TO-220	30	BD843	BD844	TO-202	2
D239C	BD240C	TO-220	30	BD845	BD846	TO-202	2
D241	BD242	TO-220	40	BD847	BD848	TO-202	2
D241A	BD242A	TO-220	40	BD849	BD850	TO-202	2
D241B	BD242B	TO-220	40	BD933	BD934	TO-220	30
D241C	BD242C	TO-220	40	BD835	BD936	TO-220	30
D243	BD244	TO-220	65	BD937	BD938	TO-220	30
D243A	BD244A	TO-220	65	BD939	BD940	TO-220	30
D243B	BD244B	TO-220	65	BD941	BD942	TO-220	30
D243C	BD244C	TO-220	65	BD943	BD944	TO-220	40
D329	BD330	TO-126	15	BD945	BD946	TO-220	40
D331	BD332	SOT-82	60	BD947	BD948	TO-220	40
D333	BD334	SOT-82	60	BD949	BD950	TO-220	40
D335	BD336	SOT-82	60	BD951	BD952	TO-220	40
D337	BD338	SOT-82	60	BD954	BD955	TO-220	40
D433	BD434	TO-126	36	BD956	BD957	TO-220	40
D435	BD436	TO- 126	36	BDT21	BDT20	TO-220	62,5
D437	BD438	TO-126	36	BDT29	BDT30	TO-220	30
D645	BD646	TO-220	62,5	BDT29A	BDT3OA	TO-220	30
D647	BD648	TO-220	62,5	BDT29B	BDT3OB	TO-220	30
D649	BD650	TO-220	62,5	BDT29C	BDT30C	TO-220	30

type n	umber	1 .	P <sub>tot</sub>	type n	umber		P <sub>tot</sub>
NPN	PNP	envelope	w	NPN	PNP	envelope	W
BDT31	BDT32	TO-220	40	BDV93	BDV94	SOT-93	100
BDT31A	BDT32A	TO-220	40	BDV95	BDV96	SOT-93	100
BDT31B	BDT32B	TO-220	40	BDW55	BDW56	TO-126	8
BDT31C	BDT32C	TO-220	40	BDW57	BDW58	TO-126	8
BDT41	BDT42	TO-220	65	BDW59	BDW60	TO-126	8
BDT41A	BDT42A	TO-220	65	BDX35		TO-126	15
BDT41B	BDT42B	TO-220	65	BDX36		TO-126	15
BDT41C	BDT42C	TO-220	65	BDX37		TO-126	15
BDT51	BDT52	TO-220	90	BDX42	BDX45	TO-126	5
BDT53	BDT54	TO-220	90	BDX43	BDX46	TO-126	5
BDT55	BDT56	TO-220	90	BDX44	BDX47	TO-126	5
BDT57	BDT58	TO-220	90	BDX63	BDX62	TO-3	90
BDT61	BDT60	TO-220	50	BDX63A	BDX62A	TO-3	90
BDT61A	BDT60A	TO-220	50	BDX63B	BDX62B	TO-3	90
BDT61B	BDT60B	TO-220	50	BDX63C	BDX62C	TO-3	90
BDT61C	BDT60C	TO-220	50	BCX65	BDX64	TO-3	117
BDT63	BDT62	TO-220	90	BDX65A	BDX64A	TO-3	117
BDT63A	BDT62A	TO-220	90	BCX65B	BDX64B	TO-3	117
BDT63B	BDT62B	TO-220	90	BDX65C	BDX64C	TO-3	117
BDT63C	BDT62C	TO-220	90	BDX67	BDX66	TO-3	150
BDT65	BDT64	TO-220	125	BDX67A	BDX66A	TO-3	150
BDT65A	BDT64A	TO-220	125	BDX67B	BDX66B	TO-3	150
BDT65B	BDT64B	TO-220	125	BDX67C	BDX66C	TO-3	150
BDT65C	BDT64C	TO-220	125	BDX69	BDX68	TO-3	200
BDT81	BDT82	TO 220	125	BDX69A	BDX68A	TO-3	200
BDT83	BDT84	TO-220	125	BDX69B	BDX68B	TO-3	200
BDT85	BDT86	TO-220	125	BDX69C	BDX68C	TO-3	200
BDT87	BDT88	TO-220	125	BDX77	BDX78	TO-220	60
BDT91	BDT92	TO-220	90	BDX91	BDX92	TO3	90
BDT93	BDT94	TO-220	90	BDX93	BDX94	TO-3	90
BDT95	BDT96	TO-220	90	BDX95	BDX96	TO-3	90
BDV65	BDV64	SOT-93	125	BDY90	:	TO-3	40
BDV65A	BDV64A	SOT-93	125	BDY9OA		TO-3	40
BDV65B	BDV64B	SOT-93	125	BDY91		TO-3	40
BDV65C	BDV64C	SOT-93	125	BDY92		TO-3	40
BDV67A	BDV66A	SOT-93	175	BF419		TO-126	6
BDV67B	BDV66B	SOT-93	175	BF457		TO-126	6
BDV67C	BDV66C	SOT-93	175	BF458		TO-126	6
BDV67D	BDV66D	SOT-93	175	BF459		TO-126	6
BDV91	BDV92	SOT-93	100	BF469	BF470	TO-126	1,

type n	umber	amuslana	P <sub>tot</sub>	type n	umber		P <sub>tot</sub>
NPN	PNP	envelope	w	NPN	PNP	envelope	w
BF471 BF583 BF585 BF587 BF591	BF472	T0-126 T0-202 T0-202 T0-202 T0-202	1,8 1,6 1,6 1,6	BUS21A BUS21B BUS21C BUS22 BUS22A		TO-3 TO-3 TO-3 TO-3 TO-3	100 100 100 125 125
BF593 BF819 BF857 BF858 BF859		TO-202 TO-202 TO-202 TO-202 TO-202	1,3 6 6 6 6	BUS22B BUS22C BUS23 BUS23A BUS23B		TO-3 TO-3 TO-3 TO-3	125 125 175 175 175
BF869 BF871 BU426; A BU433 BU505	BF870 BF872	TO-202 TO-202 SOT-93 SOT-93 TO-220	5 5 70 70 75	BUS23C BUT11; A BUT11F BUT11AF BUV82; 83		TO-3 TO-220 SOT-186 SOT-186 SOT-93	175 100 20 20 70
BU506 BU506D BU508A BU508D BU705		TO-220 TO-220 SOT-93A SOT-93A	100 100 125 125 75	BUV89 BUV90; A BUW11; A BUW12; A BUW13; A		SOT-93A SOT-93 SOT-92 SOT-93 SOT-93	125 125 100 125 175
BU706 BU706D BU806 BU807 BU808		SOT-93A SOT-93A TO-220 TO-220 TO-3	100 100 60 60 160	BUW84; 85 BUX46; A BUX47; A BUX48; A BUX80; 81		SOT-82 TO-3 TO-3 TO-3 TO-3	50 85 125 175 100
BU824 BU826 BUP22 BUP22A BUP22B		TO-202 SOT-93 SOT-93 SOT-93 SOT-93	2 125 125 125 125	BUX82; 83 BUX84; 85 BUX84F BUX85F BUX86; 87		TO-3 TO-220 SOT-186 SOT-186 TO-126	60 40 18 18 20
BUP22C BUP23 BUP23A BUP23B BUP23C		SOT-93 SOT-93 SOT-93 SOT-93 SOT-93	125 175 175 175 175	BUX88 BUX90 BUX98; A BUX99 BUY89		TO-3 TO-3 TO-3 TO-126 TO-3	160 125 250 28 80
BUS11; A BUS12; A BUS13; A BUS14; A BUS21		TO-3 TO-3 TO-3 TO-3	100 125 175 250 100	PH3055T PH13002 PH13003 TIP29 TIP29A	PH2955T TIP30 TIP30A	TO-220 TO-126 TO-126 TO-220 TO-220	75 28 28 30 30

type	number		P <sub>tot</sub> type number		umber	envelope	P <sub>tot</sub>
NPN	PNP	envelope	w	NPN	PNP	envelope	W
TIP29B TIP29C TIP31 TIP31A TIP31B	TIP30B TIP30C TIP32 TIP32A TIP32B	TO-220 TO-220 TO-220 TO-220 TO-220	30 30 40 40 40	TIP48 TIP49 TIP50 TIP110 TIP111	TIP115 TIP116	T0-220 T0-220 T0-220 T0-220 T0-220	40 40 40 50 50
TIP31C TIP33 TIP33A TIP33B TIP33C	TIP32C TIP34 TIP34A TIP34B TIP34C	TO-220 SOT-93 SOT-93 SOT-93 SOT-93	40 80 80 80 80	TIP112 TIP120 TIP121 TIP122 TIP130	TIP117 TIP125 TIP126 TIP127 TIP135	TO-220 TO-220 TO-220 TO-220 TO-220	50 65 65 65 70
TIP41 TIP41A TIP41B TIP41C TIP47	TIP42 TIP42A TIP42B TIP42C	TO-220 TO-220 TO-220 TO-220 TO-220	65 65 65 65 40	TIP131 TIP132 TIP140 TIP141 TIP142	TIP136 TIP137 TIP145 TIP146 TIP147	TO-220 TO-220 SOT-93 SOT-93	70 70 125 125 125
				TIP3055	TIP2955	SOT-93	100

## TYPE NUMBER SURVEY ACCESSORIES

type number	description	envelope
56201d	mica washer (up to 500 V)	TO-3
56201j	insulating bushes (up to 500 V)	TO-3
56261a	insulating bushes (up to 500 V)	TO-3
56326	metal washer	TO-126
56339	mica washer (500 to 2000 V)	TO-3
56352	insulating mounting support	TO-3
56353	spring clip	TO-126/SOT-82
56354	mica insulator	TO-126/SOT-82
56359b	mica washer (up to 1000 V)	TO-220
56359c	insulating bush (up to 800 V)	TO-220
56359d	rectangular insulating bush (up to 1000 V)	TO-220
56360a	rectangular washer (brass)	TO-220
56363	spring clip (direct mounting)	TO-220
56364	spring clip (insulated mounting)	TO-220
56367	alumina insulator (up to 2000 V)	TO-220
56368a	mica insulator (up to 800 V)	SOT-93
5 <b>636</b> 8b	insulating bush (up to 800 V)	SOT-93
56369	mica insulator (up to 2 kV)	TO-220
56378	mica insulator (up to 1500 V)	SOT-93
56379	spring clip	SOT-93
56387a	mica insulator (up to 300 V)	TO-126
56387b	insulating bush (up to 300 V)	TO-126



### **GENERAL**

Rating systems Transistor ratings Letter symbols SOAR curves



### 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

VCBmax The maximum permissible instantaneous voltage between collector and base

terminals. The collector voltage is negative with respect to base in PNP tran-

sistors and positive with respect to base in NPN types.

V<sub>CBmax</sub> (IE = 0) The maximum permissible instantaneous voltage between collector and base terminals, when the emitter terminal is open circuited.

Emitter to base voltage ratings

VEBmax 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

VCEmax 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<sub>CEmax</sub> (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  $\frac{R_B}{R_E}$  ,  $\leq$  y which are equivalent

conditions under which the device may be cut-off.

V<sub>CEmax</sub> (I<sub>C</sub> = 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<sub>CEmax</sub> (I<sub>B</sub> = 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).

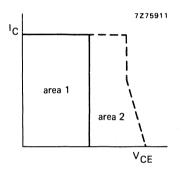
## TRANSISTOR RATINGS

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:

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



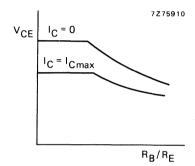


Fig. 1.

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

Cmax

The maximum permissible collector current. Without further qualification, the

d.c. value is implied.

IC(AV)max

The maximum permissible average value of the total collector current

I<sub>CM</sub>

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.

IE(AV)max

The maximum permissible average value of the total emitter current.

IER(AV)max

The maximum permissible average value of the total emitter current when

operating in the reverse emitter-base breakdown region.

IEM

The maximum permissible instantaneous value of the total emitter current.

FRM

The maximum permissible instantaneous value of the total reverse emitter

current allowable in the reverse breakdown region.

Base current ratings

IBmax The maximum permissible base current. Without further qualification, the d.c.

value is implied.

IB(AV)max The maximum permissible average value of the total base current.

IBR(AV)max The maximum permissible average value of the total reverse base current allow-

able in the reverse breakdown region.

IBM The maximum permissible instantaneous value of the total base current. The

rating also includes the switch off current.

IBRM The maximum permissible instantaneous value of the total reverse current

allowable in the reverse breakdown region.

### Transistor power ratings

P<sub>tot</sub> 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:

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.

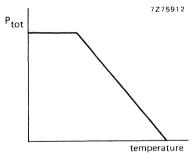


Fig. 3.

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 kelvin per watt (K/W). For mounting base rated devices, 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.

## TRANSISTOR **RATINGS**

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

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

where R<sub>th j-a</sub> is the thermal resistance from the transistor junction to the ambient. For case rated or mounting base rated devices, the thermal resistance R<sub>th i-a</sub> is made up of the thermal resistance junction to case or mounting base (R<sub>th i-mb</sub>), the contact thermal resistance (R<sub>th i</sub>) and the heatsink thermal resistance Rth h.

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

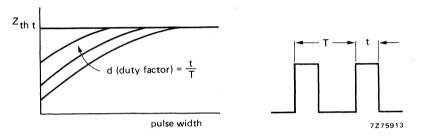


Fig. 4.

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

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

attached a clip-on cooling fin.

where Z<sub>th t</sub> and d are given in the above chart and R<sub>th c-a</sub> is the thermal resistance between case and ambient for case rated device. For mounting base rated device, it is equal to Rth h + Rth 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 Zth t.

> The maximum permissible junction temperature which is used as the basis for the calculation of power ratings. Unless otherwise stated, the continuous value

### Temperature ratings

T<sub>imax</sub>

	is implied.
T <sub>jmax</sub> (continous operation)	The maximum permissible continuous value.
T <sub>jmax</sub> (intermittent operation)	The maximum permissible instantaneous junction temperature usually allowed for a total duration of 200 hours.
T <sub>mb</sub>	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 <sub>case</sub>	The temperature of the envelope. This is confined to devices to which may be

24 March 1979

### 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 mominal 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.

### RATING SYSTEMS

#### **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.

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## 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), <b>(</b> av)	Average value
B, b	Base terminal, for MOS devices: Substrate
(BR)	Breakdown
С, с	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
	As first or second subscript: Source terminal (for FETS only)
S, s	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.

February 1974

### LETTER SYMBOLS

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

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

Example I<sub>B</sub>

b) instantaneous total values

Example iB

c) average total values

Example I<sub>B(AV)</sub>

d) peak total values

Example I<sub>BM</sub>

e) root-mean-square total values

Example I<sub>B(RMS)</sub>

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

a) instantaneous values

Example ib

b) root-mean-square values

Example Ib(rms)

c) peak values

Example I<sub>bm</sub>

d) average values

Example Ib(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: IB, iB, ib, Ibm

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<sub>F</sub>, I<sub>R</sub>, i<sub>F</sub>, I<sub>f(rms)</sub>

## 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.

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

Example: V<sub>CCE</sub>

## 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.

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

## Subscripts for multiple devices

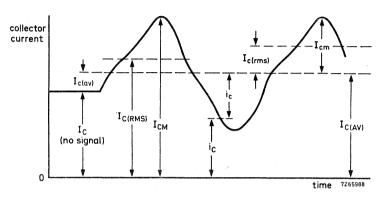
For multiple unit devices, the subscripts are modified by a number preceding the letter subscript; in the case of multiple subscripts, hyphens may be necessary to avoid misunderstanding.

Examples: I<sub>2C</sub> = continuous (d.c.) current flowing into the collector terminal of the second unit

V<sub>1C-2C</sub> = 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 fourpole 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:

 $\begin{array}{lll} F,\,f &=& \text{forward; forward transfer} \\ l,\,i\,(\text{or 1}) &=& \text{input} \\ L,\,1 &=& \text{load} \\ O,\,o\,(\text{or 2}) &=& \text{output} \\ R,\,r &=& \text{reverse; reverse transfer} \\ S,\,s &=& \text{source} \\ &=& \text{Examples: Z}_{C},\,h_{\epsilon},\,h_{\Gamma} \end{array}$ 

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

Examples:  $h_{\rm FE}$  = static value of forward current transfer ratio in common-emitter configuration (d.c. current gain)  $R_{\rm E}$  = 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  $Z_{o} = R_{o} + jX_{e} = \text{small-signal value of the external impedance}$ 

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

$$\begin{array}{c} \text{Examples: h} & \text{(or h}_{11}) \\ & \text{h}^{\text{i}} & \text{(or h}_{22}) \\ & \text{h}^{\text{o}} & \text{(or h}_{21}) \\ & \text{h}^{\text{f}} & \text{(or h}_{12}) \end{array}$$

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

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

## Distinction between real and imaginary parts

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

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

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

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

## TRANSISTOR SAFE OPERATING AREA

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

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

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

#### Collector current

Maximum collector current  $I_{Cmax}$  is specified in the data sheets for d.c. operation. For pulsed operation a higher collector current  $I_{Cmax}$  is permitted, for a defined maximum pulse length (max. 20 ms) and duty factor (usually 0,01).

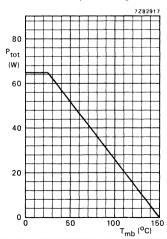
For power switching transistors I<sub>Csat</sub> is given; this is the value at which switching times and saturation voltage is measured.

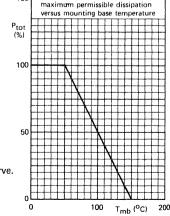
#### Collector-emitter voltage

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

#### Power dissipation

Maximum power dissipation P<sub>tot max</sub> is specified in the data sheets for a given mounting base temperature. This is usually 25 °C but may be any, much higher temperature. P<sub>tot max</sub> applies up to the stated temperature; above it derating must be applied. A power derating curve of the form shown in Fig. 1a and 1b is given in the data sheets. With it, maximum allowable power dissipation can be calculated for any mounting base temperature up to T<sub>i max</sub>.





150

Fig. 1 Power derating curve.

(a) (b)

7277038

Total power dissipation is given by

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

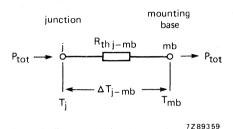


Fig. 2 Heat transport in a transistor with power dissipation constant with respect to time.

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

For pulsed operation a higher dissipation is permitted, because

- the junction does not have time to heat up fully unless the pulses are so long as to approximate steady-state conditions;
- -- the junction has time wholly or partly to cool down in the interval between pulses, except with very high duty factors.

Analogy with

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

yields

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

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

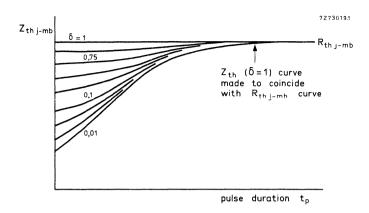


Fig. 3 A typical family of  $Z_{th\ j\text{-}mb}$  curves for a power transistor.

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

$$P_{tot\;max}\cdot t_p = \int\limits_{t_1}^{t_2} \ P \cdot t_p.$$

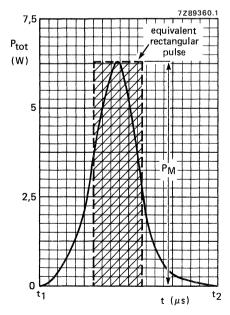


Fig. 4.

#### Second breakdown

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

#### THE SOAR BOUNDARIES

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

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

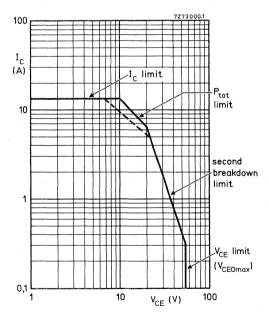


Fig. 5 A typical SOAR graph with boundaries named.

#### EXTENDING THE SOAR FOR SINGLE-SHOT AND REPETITIVE PULSED OPERATION

The data sheets for power transistors contain, apart from the d.c. SOAR, a set of curves that apply under specific pulse conditions. These will cover some 90% of applications. In addition to these, SOAR curves can be constructed by the circuit designer for specific operating conditions. The various extensions dealt with below will refer to Figs 5, 6 and 7.

#### **ICMmax**

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

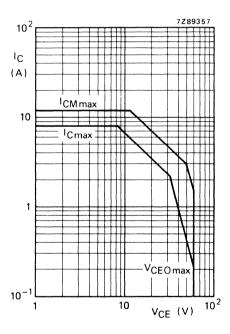


Fig. 6 Maximum collector current and collector-emitter voltage boundaries.

### P<sub>tot max</sub>

The Ptot max boundary given in the data sheet usually applies to:

$$T_{mb}$$
 = 25 °C;  $\delta$  = 0,01 and  $t_D$  = a range of values, say, 5  $\mu$ s to 2 ms.

For any deviations from these values a new P<sub>tot max</sub> boundary must be constructed.

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

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

$$T_{i \text{ max}} = 150 \text{ oC}$$
;  $T_{mb} = 80 \text{ oC}$ ;  $t_{p} = 0.2 \text{ ms}$  and  $\delta = 0.1$ .

From Fig. 7,  $Z_{th\ i\text{-mb}}$  = 0,5 K/W for the given values of  $t_D$  and  $\delta$ .

$$P_{\text{tot Mmax}} = \frac{150 - 80}{0.5} = 140 \text{ W}.$$

Thus from an arbitrary point (say 7 A, 20 V) we can draw a line parallel to the P<sub>tot max</sub> line (see Fig. 6).

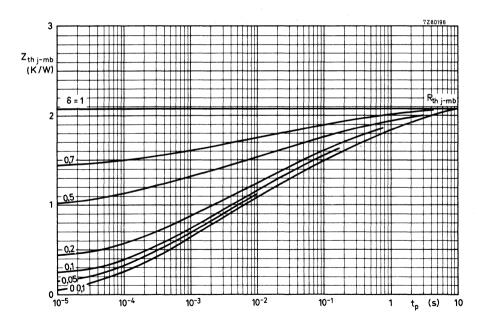


Fig. 7 Transient thermal impedance for example.

TRANSISTOR DATA

## 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.

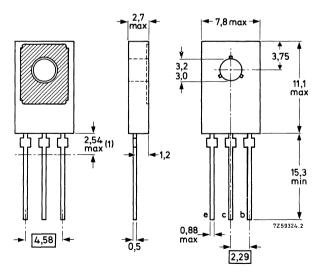
### QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V <sub>CBO</sub>	max.	300	V
Collector-emitter voltage (open base)	$v_{CEO}$	max.	250	V
Collector current (peak value)	ICM	max.	300	mΑ
Total power dissipation up to T <sub>mb</sub> = 90 °C	$P_{tot}$	max.	6	W
Junction temperature	Τį	max.	150	oC
D.C. current gain $I_C = 20 \text{ mA}$ ; $V_{CE} = 10 \text{ V}$	hFE	typ.	45	
Storage time	t <sub>s</sub>	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 <sub>CBO</sub>	max.	300	V .
Collector-emitter voltage (R <sub>BE</sub> $\leq$ 1 k $\Omega$ )	VCER	max.	300	٧
Collector-emitter voltage (open base)	VCEO	max.	250	V
Emitter-base voltage (open collector)	V <sub>EBO</sub>	max.	5	V
Collector current (continuous)	lc	max.	100	mA
Collector current (peak value) *	ICM	max.	300	mA
Total power dissipation up to T <sub>mb</sub> = 90 °C	P <sub>tot</sub>	max.	6	W
up to $T_{amb} = 70  {}^{\circ}C$	P <sub>tot</sub>	max.	0.8	W
Storage temperature	T <sub>stg</sub>	−65 to	+150	oC
Operating junction temperature	$T_{j}$	max.	150	oC
THERMAL RESISTANCE				
From junction to mounting base	R <sub>th j-mb</sub>	=	10	K/W
From junction to ambient	R <sub>th j-a</sub>		100	K/W

<sup>\*</sup> 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 <sub>j</sub> = 25 °C				
Collector cut-off current I <sub>E</sub> = 0; V <sub>CB</sub> = 250 V	I <sub>CBO</sub>	<	50	nΑ
Emitter cut-off current I <sub>C</sub> = 0; V <sub>EB</sub> = 3 V	I <sub>EBO</sub>	<	50	nA
D.C. current gain $I_C = 20 \text{ mA}$ ; $V_{CE} = 10 \text{ V}$	hFE	typ.	45	
Collector-emitter saturation voltage $I_C = 200 \text{ mA}$ ; $I_B = 20 \text{ mA}$ *	V <sub>CEsat</sub>	<	11	٧
Collector output capacitance at $f = 1 \text{ MHz}$ $I_E = 0$ ; $V_{CB} = 30 \text{ V}$	С <sub>Тс</sub>	<	4.5	pF
Storage time (in the typical circuit below)	t <sub>s</sub>	typ.	0.5	μs

\* The BF419 is controlled to  $V_{CEsat}$  max. 11.0 V and is thermally stable under all operating conditions where  $T_j$  max of 150 °C is not exceeded. For the typical circuit shown below, a heatsink is not required for operation with  $T_{amb} \le 70$  °C.

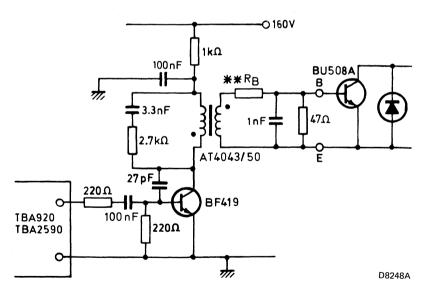


Fig.2 Typical circuit.

\*\* RB is chosen so that the end-of-scan base current for the BU508A is 1.4 A under nominal conditions. Typical value of RB is 0.5  $\Omega$  plus 0.1  $\Omega$  lead resistance.

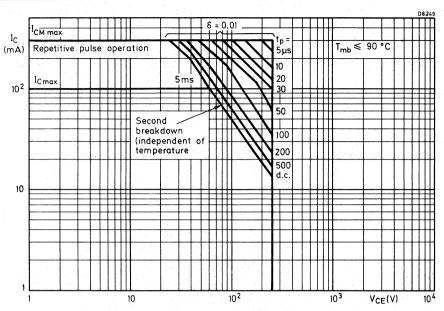
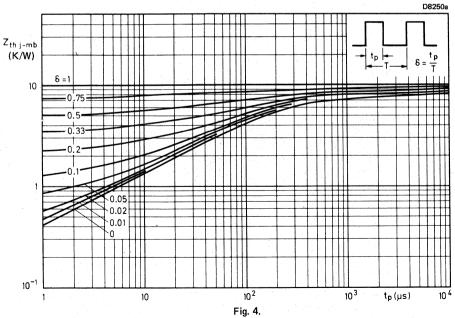
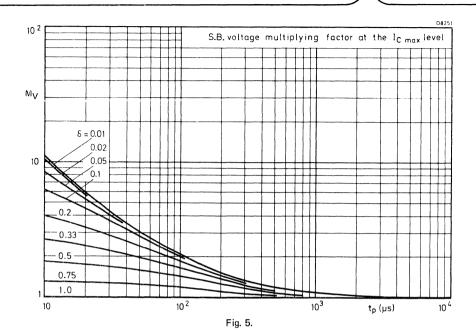
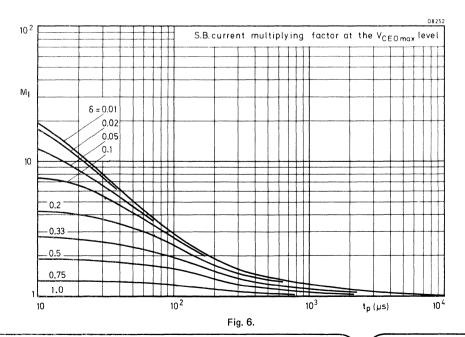
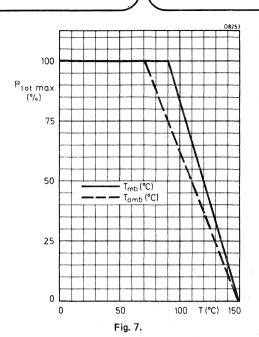


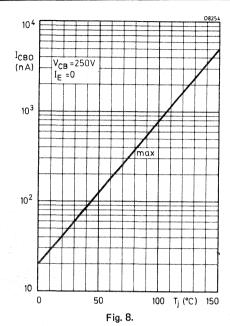
Fig.3 Safe Operating AReas with the transistor forward biased.

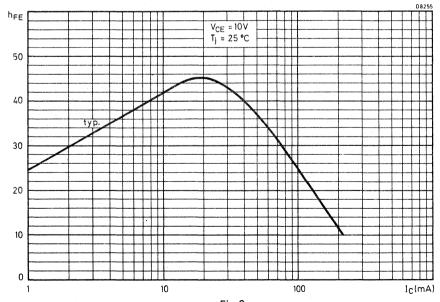












## SILICON PLANAR TRANSISTORS

for video output stages

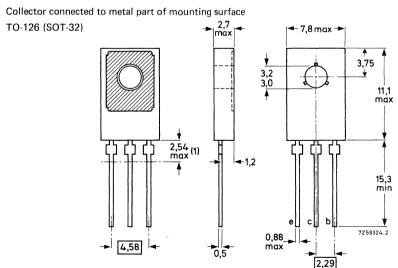
N-P-N transistors in a SOT-32 plastic envelope intended for video output stages in black-and-white and in colour television receivers.

### QUICK REFERENCE DATA

Feedback capacitance at f = 1 MHz I <sub>E</sub> = 0; V <sub>CB</sub> = 30 V	C <sub>re</sub>	<		3,5		pF
Transition frequency I <sub>C</sub> = 15 mA; V <sub>CE</sub> = 10 V	f <sub>T</sub>	typ.		90		MHz
D.C. current gain at $T_j = 25$ °C $I_C = 30$ mA; $V_{CE} = 10$ V	hFE	>		26		
Junction temperature	$T_{j}$	max.		150		oC
Total power dissipation up to T <sub>mb</sub> = 90 °C	$P_{tot}$	max.		6		W
Collector current (peak value)	1CM	max.		300		mΑ
Collector-emitter voltage (open base)	$v_{CEO}$	max.	160	250	300	٧
Collector-base voltage (open emitter)	$v_{CBO}$	max.	160	250	300	V
			BF457	BF458	BF459	

### **MECHANICAL DATA**

Dimensions in mm



(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 (IEC134)

KATINGS Limiting values in accordance	with the	ADSU	ute Maxii	num ,	system (	1150104)
			BF 457   B	F <b>4</b> 58	BF459	_
Collector-base voltage (open emitter)	$v_{CBO}$	max.	160	250	300	V
Collector-emitter voltage (open base)	$v_{\rm CEO}$	max.	160	250	300	V
Emitter-base voltage (open collector)	$v_{\rm EBO}$	max.	5	5	5	V
Collector current (d.c.)			$I_{\mathbf{C}}$	max.	100	mA
Collector current (peak value)			ICM	max.	300	mA
Base current (d.c.)			$I_B$	max.	. 50	m A
Total power dissipation up to $T_{mb}$ = 90 $^{o}C$	<b>.</b>		Ptot	max.	. 6	W
Storage temperature			$T_{stg}$	<b>-</b> 55	to +150	$^{\circ}\mathrm{C}$
Junction temperature			Tj	max.	. 150	°C
THERMAL RESISTANCE						
From junction to ambient			R <sub>th j-a</sub>	=	104	K/W
From junction to mounting base			R <sub>th j-mb</sub>	=	10	K/W

### CHARACTERISTICS

 $T_i = 25$  °C unless otherwise specified

Collector cut-off current

$$I_{\rm F} = 0$$
;  $V_{\rm CR} = 100 \text{ V for BF457}$ 

$$I_{\rm F} = 0$$
;  $V_{\rm CB} = 200 \text{ V for BF 458}$ 

$$I_{\rm E} = 0$$
;  $V_{\rm CB} = 250 \text{ V for BF459}$ 

$$I_{CBO}$$

Emitter cut-off current

$$I_{C} = 0$$
;  $V_{EB} = 3 \text{ V}$ 

$$I_{EBO}$$

D.C. current gain

$$I_{C} = 30 \text{ mA}; V_{CE} = 10 \text{ V}$$

$$h_{\rm EE}$$

Collector-emitter saturation voltage

$$I_C = 30 \text{ mA}; I_B = 6 \text{ mA}$$

$$V_{CEsat}$$

High frequency knee voltage at  $T_i = 150$  °C

$$I_C = 50 \text{ mA}$$

$$v_{CEK}$$

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  $V_{\hbox{\scriptsize CE}}=50~{\rm V}$ . 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

$$I_{C} = 15 \text{ mA}; V_{CE} = 10 \text{ V}$$

$$f_T$$

90

Feedback capacitance at f = 1 MHz

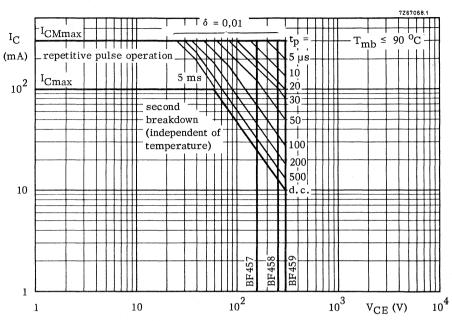
$$I_{\rm E} = 0$$
;  $V_{\rm CB} = 30 \ {\rm V}$ 

$$C_{re}$$

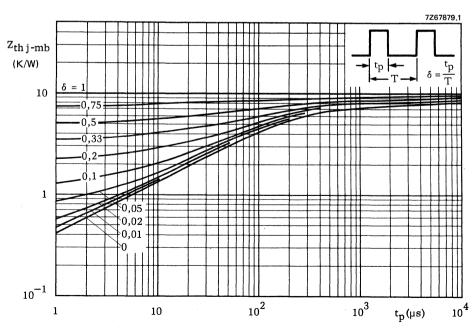
Output capacitance at f = 1 MHz

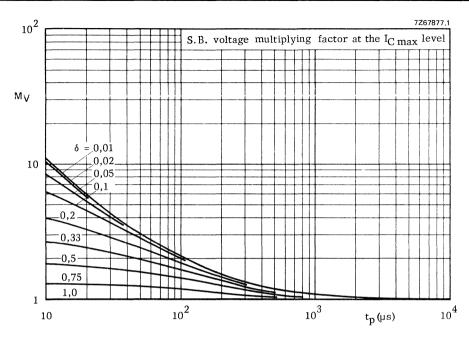
$$I_{E} = 0$$
;  $V_{CB} = 30 \text{ V}$ 

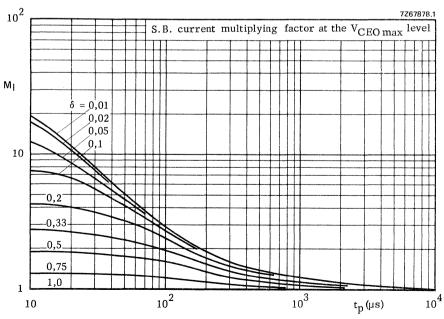
$$C_{oe}$$



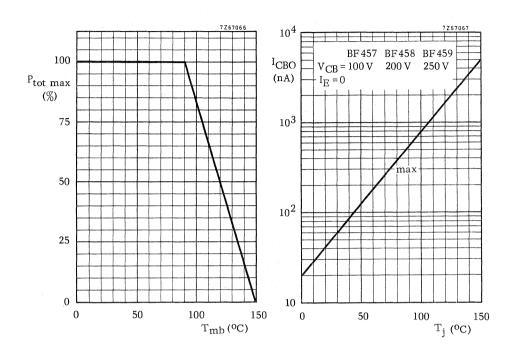
Safe Operating Area with the transistor forward biased







February 1974



# 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.

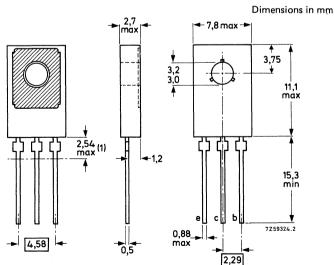
### QUICK REFERENCE DATA

		BF46	39  BF47	<u> 11                                  </u>
Collector-base voltage (open emitter)	$V_{CBO}$	max. 250	300	) V
Collector-emitter voltage open base	VCEO	max. 250	1	٧
$R_{BE} = 2.7 \text{ k}\Omega$	$v_{CER}$	max. —	300	) (
Collector current (peak value)	<sup>I</sup> CM	max.	100	mΑ
Total power dissipation up to $T_{mb} \le 114$ °C	P <sub>tot</sub>	max.	1,8	W
Junction temperature	Τį	max.	150	οС
D.C. current gain I <sub>C</sub> = 25 mA; V <sub>CE</sub> = 20 V	hFE	>	50	
Transition frequency $I_C = 10 \text{ mA}$ ; $V_{CE} = 10 \text{ V}$	f <sub>T</sub>	>	60	MHz
Feedback capacitance at $f = 0.5 \text{ MHz}$ $I_E = 0$ ; $V_{CB} = 30 \text{ V}$	C <sub>re</sub>	<	1,8	pF

#### **MECHANICAL DATA**

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

Collector connected to mounting base



See also chapters Mounting instructions and Accessories.

### **RATINGS**

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

			BF469   BF47	1
Collector-base voltage (open emitter)	$v_{CBO}$	max.	250 300	V
Collector-emitter voltage $R_{BE}$ = 2,7 k $\Omega$ open base	V <sub>CER</sub> V <sub>CEO</sub>	max. max.	- 300 250 -	V
Emitter-base voltage (open collector)	$v_{\sf EBO}$	max.	5	V
Collector current (d.c.)	<sup>1</sup> C	max.	50	mΑ
Collector current (peak value)	<sup>1</sup> CM	max.	100	mΑ
Total power dissipation up to $T_{mb}$ = 114 °C *	P <sub>tot</sub>	max.	1,8	W
Storage temperature	$T_{stg}$		-65 to + 150	oC .
Junction temperature	Tj	max.	150	oC
THERMAL RESISTANCE				
From junction to mounting base	R <sub>th j-mb</sub>	= ;	20	K/W
From junction to ambient in free air *	R <sub>th j-a</sub>	t <sub>a</sub> t <del>=</del>	100	K/W

<sup>\*</sup> 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 <sub>j</sub> = 25 °C unless otherwise specified				
Collector cut-off current $I_E = 0$ ; $V_{CB} = 200 \text{ V}$ $R_{BE} = 2.7 \text{ k}\Omega$ ; $V_{CE} = 200 \text{ V}$ ; $T_j = 150 \text{ °C}$	I <sub>CBO</sub> I <sub>CER</sub>	< <	10 10	nΑ μΑ
Emitter cut-off current I <sub>C</sub> = 0; V <sub>EB</sub> = 5 V	I <sub>EBO</sub>	<	10	μΑ
D.C. current gain $I_C = 25 \text{ mA}$ ; $V_{CE} = 20 \text{ V}$	hFE	>	50	
High-frequency knee voltage at $T_j = 150  {}^{\circ}\text{C}^*$ $I_C = 25  \text{mA}$	VCEK	typ.	20	V
Transistion frequency I <sub>C</sub> = 10 mA; V <sub>CE</sub> = 10 V	fŢ	>	60	MHz
Feedback capacitance at f = 0,5 MHz $I_E = 0$ ; $V_{CB} = 30 \text{ V}$	C <sub>re</sub>	<	1,8	pF

<sup>\*</sup> 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 VCE = 50 V.

A further reduction of the collector-emitter voltage results in a rapid increase of the distortion of the signal.

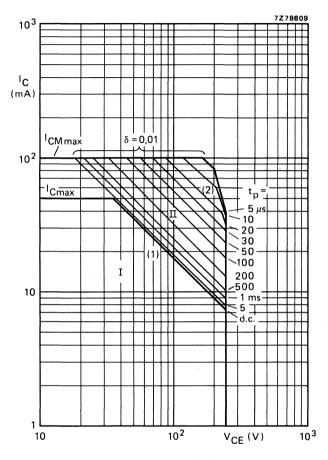
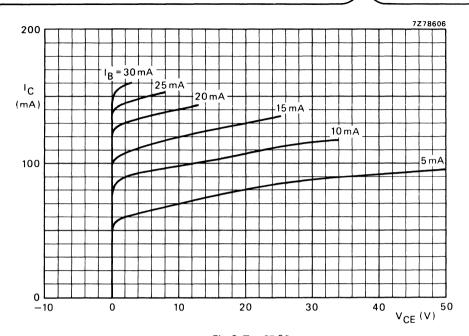
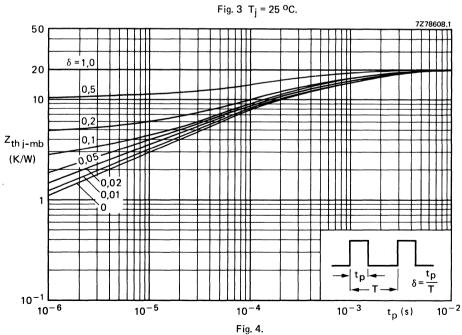


Fig. 2 Safe Operating ARea at T<sub>mb</sub> = 114 °C.

- I Region of permissible d.c. operation.
- II Permissible extension for repetitive pulse operation.
- (1) Ptot max and Ppeak max lines.
- (2) Second breakdown limits (independent of temperature).





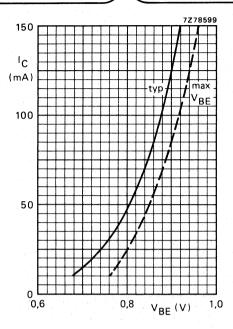
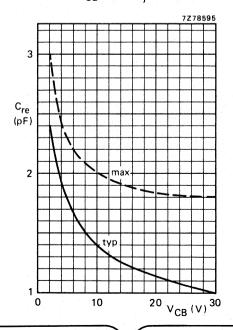


Fig. 5  $V_{CE}$  = 20 V;  $T_j$  = 25 °C.



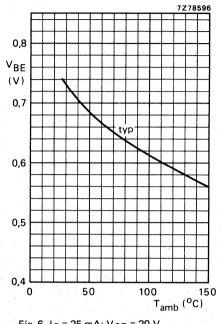


Fig. 6  $I_C$  = 25 mA;  $V_{CE}$  = 20 V.

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

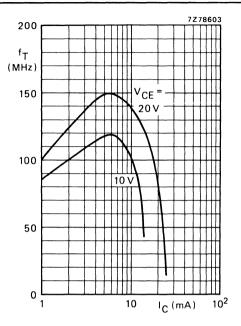
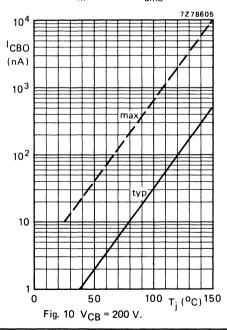


Fig. 8  $f_M = 35 \text{ MHz}$ ;  $T_{amb} = 25 \text{ }^{\circ}\text{C}$ .



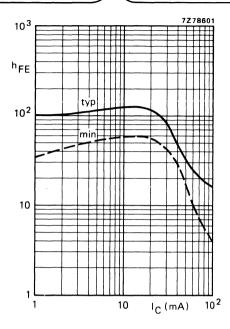
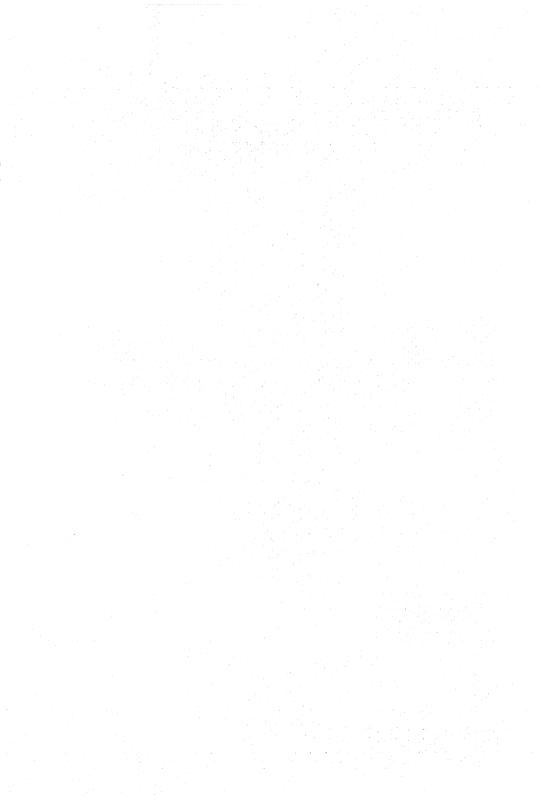


Fig. 9  $V_{CE} = 20 \text{ V}$ ;  $T_{amb} = 25 \text{ }^{\circ}\text{C}$ .



## 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.

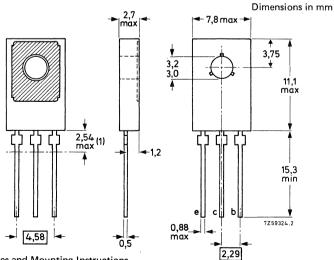
## QUICK REFERENCE DATA

		BF470	BF472	<u> </u>
Collector-base voltage (open emitter)	−V <sub>CBO</sub>	max. 250	300	V
Collector-emitter voltage open base	-Vceo	max. 250	_	V
$R_{BE} = 2.7 k\Omega$	-VCER	max. —	300	V
Collector current (peak value)	<sup>−1</sup> CM	max. 1	100	mΑ
Total power dissipation up to T <sub>mb</sub> = 114 °C	$P_{tot}$	max.	1,8	W
Junction temperature	Τį	max. 1	50	οС
D.C. current gain $-I_C = 25 \text{ mA}; -V_{CE} = 20 \text{ V}$	hFE	>	50	
Transition frequency $-I_C = 10 \text{ mA}; -V_{CE} = 10 \text{ V}$	fT	>	60	MHz
Feedback capacitance at $f = 0.5 \text{ MHz}$ $I_E = 0; -V_{CB} = 30 \text{ V}$	C <sub>re</sub>	<	1,8	pF

## MECHANICAL DATA

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

Collector connected to mounting base.



See also chapters Accessories and Mounting Instructions.

## **RATINGS**

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

			BF470	BF472	
Collector-base voltage (open emitter)	-V <sub>CBO</sub>	max.	250	300	٧
Collector-emitter voltage $R_{BE} = 2.7 \ k\Omega$ open base	-V <sub>CER</sub> -V <sub>CEO</sub>	max. max.	_ 250	300	V V
Emitter-base voltage (open collector)	-V <sub>EBO</sub>	max.		5	<b>V</b>
Collector current (d.c.)	-Ic	max.	5	0	mΑ
Collector current (peak value)	-ICM	max.	10	0	mΑ
Total power dissipation up to T <sub>mb</sub> = 114 °C *	P <sub>tot</sub>	max.	1,	.8	W
Storage temperature	$T_{stg}$		-65 to	+ 150	oC .
Junction temperature	Тj	max.	15	0	οС
→ THERMAL RESISTANCE					
From junction to mounting base From junction to ambient in free air *	R <sub>th j-mb</sub> R <sub>th j-a</sub>	=	10	0 0	K/W K/W

<sup>\*</sup> 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<sub>i</sub> = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0; -V_{CB} = 200 \text{ V}$	−lCBO	<	10	nA
$R_{BE} = 2.7 \text{ k}\Omega; -V_{CE} = 200 \text{ V}; T_j = 150 \text{ °C}$	<sup>−l</sup> CER	<	10	μΑ
Emitter cut-off current				
$I_{C} = 0; -V_{EB} = 5 V$	−lEBO	<	10	μΑ
D.C. current gain				
$-I_C = 25 \text{ mA}; -V_{CF} = 20 \text{ V}$	hFF	>	50	
High-frequency knee voltage at T <sub>i</sub> = 150 °C*	1.2			
-Ic = 25 mA	V	tun	20	V
0	−VCEK	typ.	20	V
Transition frequency				
$-I_C = 10 \text{ mA; } -V_{CE} = 10 \text{ V}$	fΤ	>	60	MHz
Feedback capacitance at f = 0,5 MHz				
$I_E = 0; -V_{CB} = 30 \text{ V}$	$C_{re}$	<	1,8	рF
_ <del>-</del> -	. •			

<sup>\*</sup> 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<sub>CE</sub> = 50 V. A further reduction of the collector-emitter voltage results in a rapid increase of the distortion of the signal.

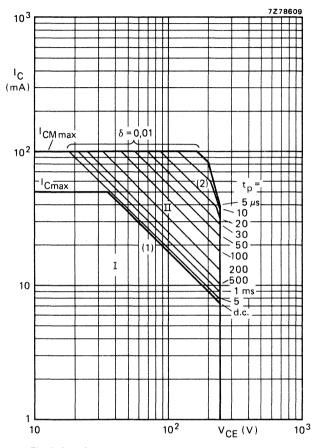
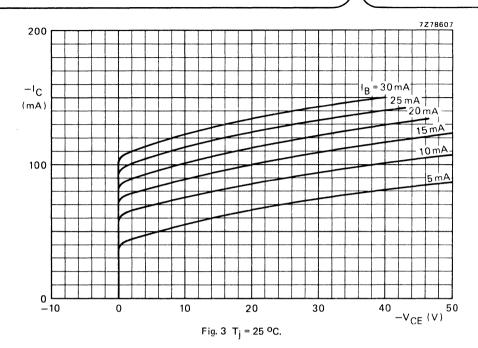


Fig. 2 Safe Operating ARea at  $T_{mb}$  = 114 °C.

- Region of permissible d.c. operation.
- II Permissible extension for repetitive pulse operation.
- (1) Ptot max and Ptot peak max lines.
- (2) Second breakdown limits (independent of temperature).



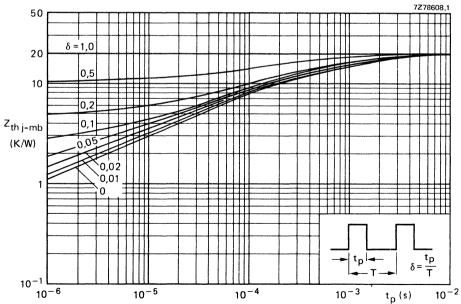


Fig. 4.

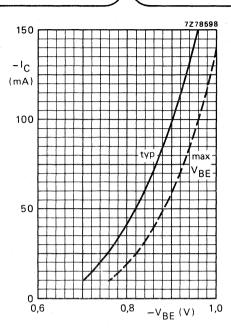
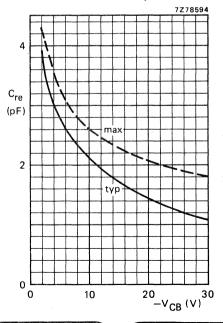


Fig. 5  $-V_{CE} = 20 \text{ V}$ ;  $T_i = 25 \text{ }^{\circ}\text{C}$ .



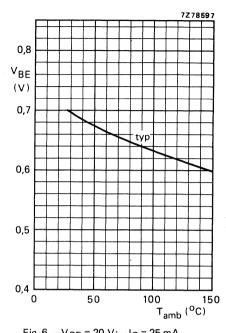


Fig. 6  $-V_{CE} = 20 \text{ V}$ ;  $-I_{C} = 25 \text{ mA}$ .

Fig. 7  $I_E = 0$ ; f = 1 MHz;  $T_j = 25 \text{ °C}$ .

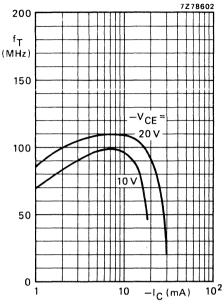
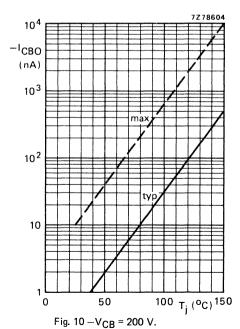


Fig. 8  $f_M = 35 \text{ MHz}$ ;  $T_{amb} = 25 \text{ }^{\circ}\text{C}$ .



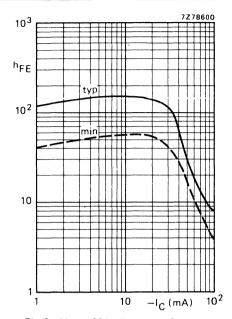


Fig. 9  $-V_{CE}$  = 20 V;  $T_{amb}$  = 25 °C.



# SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in TO-202 plastic envelope, intended for use in video output stages in black-and-white and in colour television receivers.

### QUICK REFERENCE DATA

			BF583	BF585	BF587	
Collector-base voltage (open emitter)	$v_{CBO}$	max.	300	350	400	V
Collector-emitter voltage (open base)	VCEO	max.	250	300	350	V
Collector current (peak value)	I <sub>СМ</sub>	max.		100		mΑ
Total power dissipation (free air)	$P_{tot}$	max.		1,6		W
D.C. current gain $I_C = 25 \text{ mA}$ ; $V_{CE} = 20 \text{ V}$	hFE	min.		50		
Transition frequency $-I_E = 10 \text{ mA; } V_{CB} = 10 \text{ V}$	fT		7	0 to 110		MHz
Junction temperature	$T_{j}$	max.		150		оС

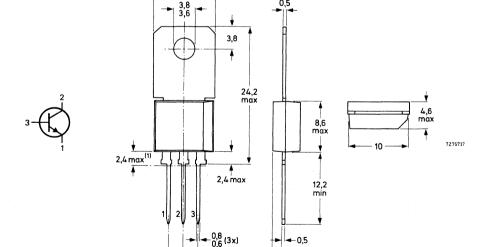
10,4 max

2,54 2,54

### **MECHANICAL DATA**

Fig. 1 TO-202.

Dimensions in mm



(1) Plastic flash allowed within this zone.

		,	BF583	BF585	BF587	
Collector-base voltage (open emitter)	$V_{CBO}$	max.	300	350	400	V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	250	300	350	٧
Emitter-base voltage (open collector)	V <sub>EBO</sub>	max.		5		V
Collector current						
d.c.	!c	max.		50		mΑ
peak value	ICM	max.		100		mΑ
Total power dissipation in free air up to T <sub>amb</sub> = 25 °C	P <sub>tot</sub>	max.		1,6		w
Total power dissipation						
up to T <sub>mb</sub> = 25 °C	P <sub>tot</sub>	max.		5,0		W
Storage temperature	T <sub>stg</sub>		-65	to + 150		oC
Junction temperature	Тj	max.		150		оС
THERMAL RESISTANCE						
From junction to ambient	R <sub>th j-a</sub>	max.		78		K/W
From junction to mounting base	R <sub>th j-mb</sub>	max.		25		K/W
CHARACTERISTICS						
T <sub>i</sub> = 25 °C unless otherwise specified						
Collector cut-off current						
I <sub>E</sub> = 0; V <sub>CB</sub> = 300 V	ГСВО	$\leq$		20		nA
Collector-emitter cut-off current						
$V_{CE}$ = 250 V; $R_{BE}$ = 2,7 k $\Omega$ ; $T_i$ = 150 $^{o}$ C	ICER	€		20		μΑ
Emitter cut-off current	CER	_		20		μ., ι
I <sub>C</sub> = 0; V <sub>EB</sub> = 5 V	I <sub>EBO</sub>	<		10		μΑ
High-frequency knee voltage	200					
$I_C = 25 \text{ mA}; T_j = 150 \text{ °C}$	VCEK	=		20		٧
D.C. current gain						
I <sub>C</sub> = 25 mA; V <sub>CE</sub> = 20 V	hFE	<b>≥</b>		50 20		
$I_C = 40 \text{ mA}; V_{CE} = 20 \text{ V}$				20		
Transition frequency -IE = 10 mA; V <sub>CB</sub> = 10 V	f⊤		7	0 to 110		MHz
Feedback capacitance at f = 1 MHz	- 1		_			
I <sub>E</sub> = 0; V <sub>CB</sub> = 30 V	Cre	$\leq$		1,8		pF
Collector capacitance at f = 1 MHz						
I <sub>E</sub> = 0; V <sub>CB</sub> = 30 V	Cc	<		2,5		рF

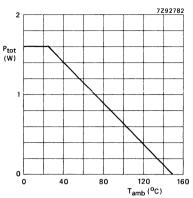


Fig. 2 Maximum permissible power dissipation.

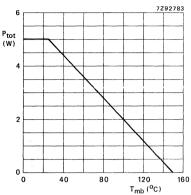


Fig. 3 Typical values.

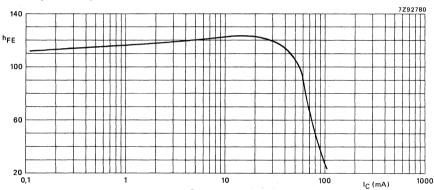


Fig. 4  $T_i$  = 25 °C;  $V_{CE}$  = 20 V; typical values.

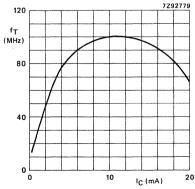


Fig. 5  $V_{CE}$  = 10 V; f = 100 MHz; typical values.

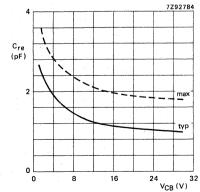


Fig. 6 I<sub>E</sub> = 0; f = 1 MHz.



# SWITCHING TRANSISTORS FOR TELEPHONY APPLICATIONS

Silicon n-p-n transistors in a TO-202 outline, intended for use in PABX and similar telephone systems.

### QUICK REFERENCE DATA

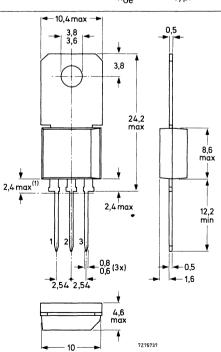
			BF591	BF593	
Collector-emitter voltage (open base)	$V_{CEO}$	max.	170	210	٧
Collector-base voltage (open emitter)	$V_{CBO}$	max.	210	250	٧
Collector current	lc	max.	19	50	mΑ
Total power dissipation up to $T_{amb} = 55$ °C	P <sub>tot</sub>	max.	1	,3	w
Current gain					
$I_C = 20 \text{ mA}; V_{CE} = 5 \text{ V}$	hFE = hfe	min.	;	30	
$I_C = 100 \text{ mA}; V_{CE} = 6 \text{ V}$	$h_{FE}(h_{fe})$	min.	;	30(20)	
Output admittance at f = 1 kHz $I_C = 100 \text{ mA}$ ; $V_{CE} = 5 \text{ V}$	h <sub>oe</sub>	typ.		7	mS

# MECHANICAL DATA

Fig. 1 TO-202.



(1) Plastic flash allowed within this zone.



Dimensions in mm

			BF591	BF	593	
Collector-emitter voltage (open base)	V <sub>CEO</sub>	max.	170		210	V
Collector-base voltage (open emitter)	V <sub>CBO</sub>	max.	210		250	V ,
Emitter-base voltage (open collector)	V <sub>EBO</sub>	max.		5		V
Collector current (d.c.)	l <sub>C</sub>	max.	15	50		mΑ
Total power dissipation up to T <sub>amb</sub> = 55 °C	P <sub>tot</sub>	max.	1	1,3		w
Storage temperature	$T_{sta}$		-65 to	o + 15	50	оС
Junction temperature	Tj	max.	1!	50		οС
THERMAL RESISTANCE						
From junction to ambient in free air	R <sub>th j-a</sub>	max.		73		K/W
CHARACTERISTICS						
T <sub>j</sub> = 25 °C unless otherwise specified			BF591	BF	593	
Collector-emitter breakdown voltage open base; I <sub>C</sub> = 10 mA	V(BR)CEO	≥	170	******	210	V
Collector-base breakdown voltage open emitter; $I_C = 0.1 \text{ mA}$	V <sub>(BR)</sub> CBO	$\geqslant$	210		250	V
Emitter-base breakdown voltage open collector; I <sub>E</sub> = 0,1 mA	V <sub>(BR)EBO</sub>	≥		5		v ,
Base-emitter voltage $I_C = 25 \text{ mA}$ ; $V_{CE} = 5 \text{ V}$	V <sub>BE</sub>	<b>&gt;</b>	•	65 85		V V
Collector cut-off current	1	<		50		nΑ
open emitter; V <sub>CB</sub> = 60 V	CBO	<		1,0		μА
$V_{BE} = 0$ ; $V_{CE} = 60 \text{ V}$ ; $T_j = 140 \text{ °C}$	CES		,	,,0		μπ
D.C. current gain* IC = 20 mA; VCF = 5 V	hFE			30		
I <sub>C</sub> = 100 mA; V <sub>CE</sub> = 6 V	hFE	≥		30		
I <sub>C</sub> = 150 mA; V <sub>CF</sub> = 7 V	hFE	$\geqslant$		20		
Small-signal current gain						
$I_C = 20 \text{ mA}; V_{CE} = 5 \text{ V}$	h <sub>fe</sub>	$\geq$		30		
$I_C = 100 \text{ mA}; V_{CE} = 6 \text{ V}$	h <sub>fe</sub>	$\geqslant$		20		
Output admittance at f = 1 kHz $I_C = 100 \text{ mA}$ ; $V_{CE} = 5 \text{ V}$	h <sub>oe</sub>	typ.		7		mS

<sup>\*</sup> Measured under pulse conditions;  $t_p = 300 \ \mu s$ ;  $\delta = 0.01$ .

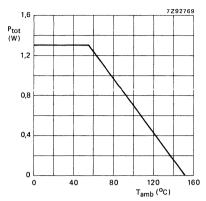


Fig. 2 Maximum permissible power dissipation.

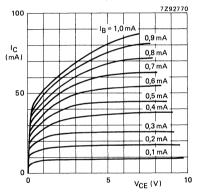


Fig. 3  $T_j = 25$  °C.

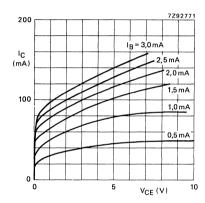


Fig. 4  $T_i = 25$  °C.

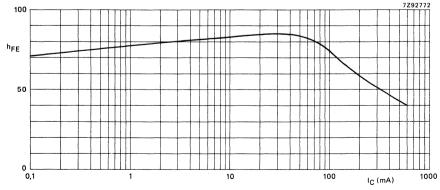


Fig. 5  $T_j = 25$  °C;  $V_{CE} = 5$  V; typical values.



# SILICON PLANAR TRANSISTOR

N-P-N transistor in TO-202 plastic envelope intended for use as a driver for line output transistors in colour television receivers.

### **QUICK REFERENCE DATA**

Collector-base voltage (open emitter)	V <sub>CBO</sub>	max.	300 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	250 V
Collector current (peak value)	<sup>I</sup> CM	max.	300 mA
Total power dissipation up to T <sub>mb</sub> = 75 °C	$P_{tot}$	max.	6 W
Junction temperature	Τį	max.	150 °C
D.C. current gain			
$I_C = 20 \text{ mA}, V_{CE} = 10 \text{ V}$	hFE	typ.	45
Storage time	t <sub>s</sub>	typ.	0,5 μs

### **MECHANICAL DATA**

Fig. 1 TO-202.

Collector connected to mounting base.

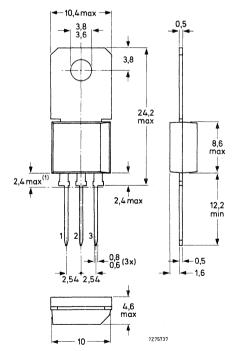
(1) Plastic flash allowed within this zone.

BF819



BF819A





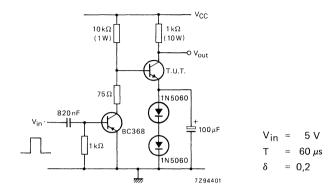
BF819A is available on request. It has ebc pinning instead of ecb.

Dimensions in mm

Limiting values in accordance with the Absolute Maximum System (IEC 134) 300 V Collector-base voltage (open emitter) max. VCRO 250 V Collector-emitter voltage (open base) VCEO max. 5 V Emitter-base voltage (open collector) VERO max. Collector current (d.c.) max. 100 mA lc. Collector current (peak value)\* 300 mA max. I<sub>CM</sub> 50 mA Base current (d.c.) l<sub>R</sub> max. Total power dissipation up to Tamb = 75 °C 1.2 W Ptot max. 6 W Total power dissipation up to Tmb = 75 °C Ptot max. Storage temperature  $T_{sta}$ -65 to +150 °C 150 °C Junction temperature  $T_i$ max. THERMAL RESISTANCE From junction to ambient in free air 62.5 K/W Rth i-a From junction to mounting base 12.5 K/W R<sub>th i-mb</sub> CHARACTERISTICS Ti = 25 °C Collector cut-off current < 50 nA  $I_F = 0$ ;  $V_{CB} = 250 \text{ V}$ ICBO Emitter cut-off current < 50 nA  $I_C = 0$ ;  $V_{EB} = 3 V$ **IEBO** D.C. current dain 45  $I_C = 20 \text{ mA}$ ;  $V_{CF} = 10 \text{ V}$ hFF typ. Collector-emitter saturation voltage  $I_C = 200 \text{ mA}$ ;  $I_R = 20 \text{ mA}$ \*\* 11 V VCEsat < Collector output capacitance at f = 1 MHz < IF = 0; VCB = 30 V  $C_{nh}$ 4,5 pF Storage time (see Fig. 2) Icon = 100 mA; IBon = 10 mA; -IBoff = 20 mA ts < 1,4 µs

Precautions should be taken during switch-on of the BF819 where an overshoot of current is likely to occur. The amplitude of the overshoot depends on the relative magnitude of stray external capacities to the transistor collector capacity. It is desirable to keep the stray capacities to a minimum by short lead lengths etc. so as to minimize the area of the switching path.

<sup>\*\*</sup> The BF819 is controlled to V<sub>CEsat</sub> max. 11,0 V and is thermally stable under all operating conditions where T<sub>j max</sub> of 150 °C is not exceeded. For the typical circuit shown in Fig. 2, a heatsink is not required for operation with T<sub>amb</sub> ≤ 75 °C.



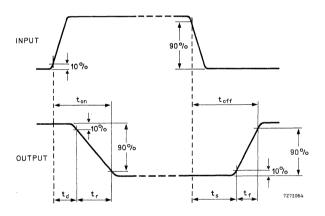


Fig. 2 Test circuit and switching waveforms.

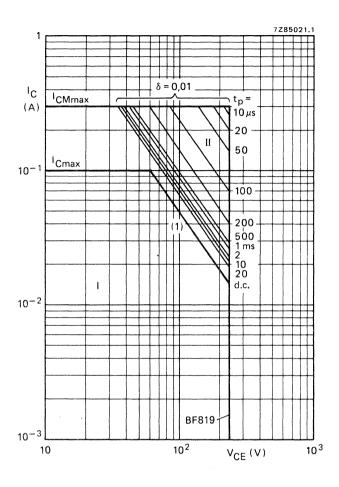


Fig. 3 Safe Operating ARea;  $T_{mb} = 25$  °C.

- I Region of permissible d.c. operation.
- II Permissible extension for repetitive pulse operation.
- (1) Second breakdown limits (independent of temperature).

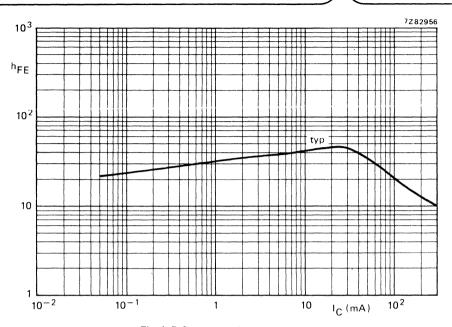


Fig. 4 D.C. current gain.  $V_{CB} = 10 \text{ V}$ .

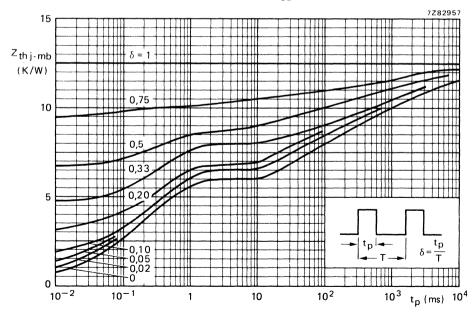


Fig. 5 Pulse power rating chart.

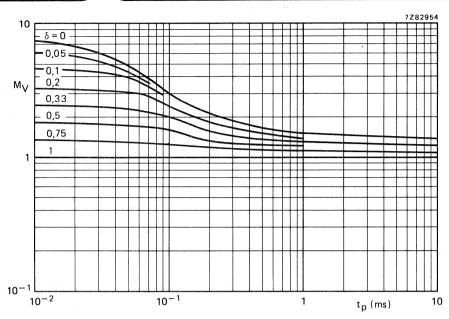


Fig. 6 S.B. voltage multiplying factor at the  $I_{\mbox{Cmax}}$  level.

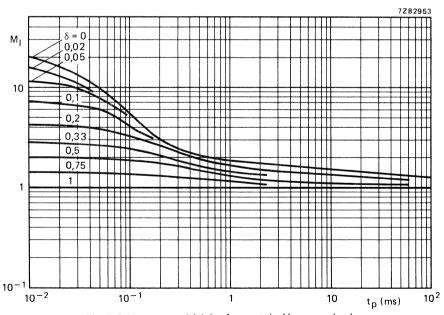


Fig. 7 S.B. current multiplying factor at the  $V_{\mbox{CEOmax}}$  level.

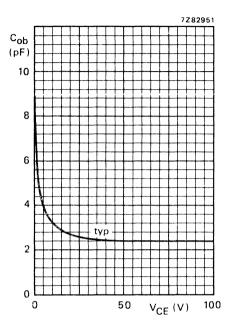


Fig. 8 Collector output capacitance f = 1 MHz;  $I_E = 0$ .



# SILICON PLANAR VIDEO OUTPUT TRANSISTORS

N-P-N transistors in TO-202 plastic envelopes intended for video output stages in black-and-white and in colour television receivers.

#### QUICK REFERENCE DATA

		BF857	BF858	BF859
Collector-base voltage (open emitter)	$v_{CBO}$	max. 160	250	300 V
Collector-emitter voltage (open base)	$v_{CEO}$	max. 160	250	300 V
Collector current (peak value)	<sup>I</sup> CM	max.	300	mA
Total power dissipation up to T <sub>mb</sub> = 75 °C	$P_{tot}$	max.	6	W
Junction temperature	Τj	max.	150	оС
D.C. current gain $I_C = 30 \text{ mA}$ ; $V_{CE} = 10 \text{ V}$	hFE	>	26	
Transition frequency at f = 35 MHz $I_C$ = 15 mA; $V_{CE}$ = 10 V	fΤ	typ.	90	MHz
Feedback capacitance at f = 1 MHz I <sub>E</sub> = 0; V <sub>CB</sub> = 30 V	C <sub>re</sub>	<	3	pF

### **MECHANICAL DATA**

Fig. 1 TO-202.

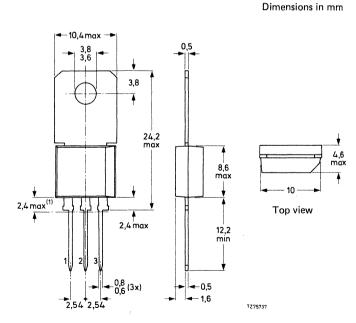
Collector connected to mounting base.

(1) Plastic flash allowed within this zone.



A-version





An A-version is available on request. It has ebc pinning instead of ecb.

		BF857	BF858	BF859	)
Collector-base voltage (open emitter)	$V_{CBO}$	max. 160	250	300	٧
Collector-emitter voltage (open base)	VCEO	max. 160	250	300	V
Emitter-base voltage (open collector)	$V_{EBO}$	max. 5	5	5	٧
Collector current (d.c.)	I <sub>C</sub>	max.	100		mΑ
Collector current (peak value)	I <sub>CM</sub>	max.	300		mΑ
Base current (d.c.)	IB	max.	50		mΑ
Total power dissipation up to T <sub>amb</sub> = 25 °C	$P_{tot}$	max.	2		W
Total power dissipation up to $T_{mb} = 75$ °C	P <sub>tot</sub>	max.	6		W
Storage temperature	$T_{stg}$		-65 to + 15	0	оС
Junction temperature	т <sub>ј</sub>	max.	150		oC
THERMAL RESISTANCE					
from junction to ambient in free air	R <sub>th j-a</sub>	= "	62,5		K/W
from junction to mounting base	R <sub>th j-mb</sub>	= .	12,5		K/W
CHARACTERISTICS					
T <sub>j</sub> = 25 °C unless otherwise specified					
Collector cut-off current					
$I_E = 0$ ; $V_{CB} = 100 \text{ V for BF857}$	Ісво	<	0,1		μΑ
I <sub>E</sub> = 0; V <sub>CB</sub> = 200 V for BF858 I <sub>F</sub> = 0; V <sub>CB</sub> = 250 V for BF859	СВО	< < <	0,1 0,1		μA μA
Emitter cut-off current	СВО		0,1		μΛ
I <sub>C</sub> = 0; V <sub>FB</sub> = 5 V	I <sub>EBO</sub>	<	100		μΑ
D.C. current gain	LBO				•
$I_C = 30 \text{ mÅ}; V_{CE} = 10 \text{ V}$	hFE	>	26		
Collector-emitter saturation voltage					
$I_C = 30 \text{ mA}; I_B = 6 \text{ mA}$	V <sub>CEsat</sub>	<	1		V
Transition frequency at f = 35 MHz			00		NAL 1-
I <sub>C</sub> = 15 mA; V <sub>CE</sub> = 10 V	fT	typ.	90		MHz
Feedback capacitance at f = 1 MHz I <sub>E</sub> = 0; V <sub>CB</sub> = 30 V	C <sub>re</sub>	<	3		рF
L -/ - CD	-16		J		1

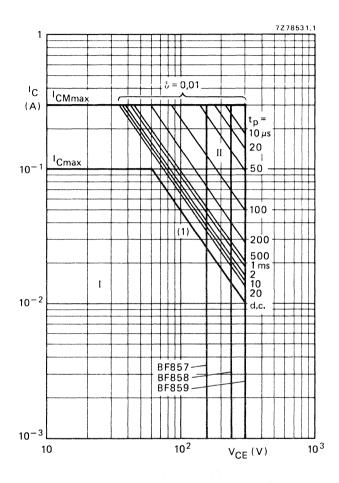


Fig. 2 Safe Operating ARea;  $T_{mb} = 75$  °C.

- I Region of permissible d.c. operation.
- II Permissible extension for repetitive pulse operation.
- (1) Second-breakdown limits (independent of temperature).

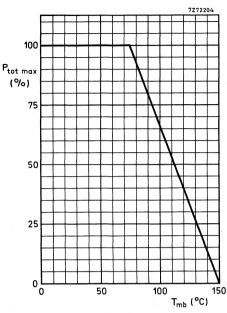


Fig. 3 Power derating curve.

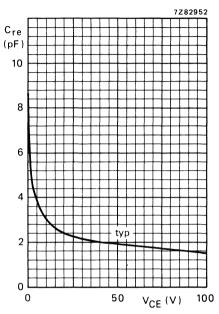


Fig. 4 Feedback capacitance f = 1 MHz.

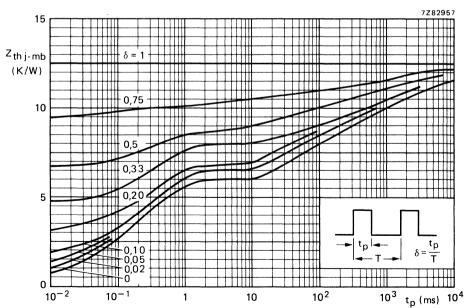


Fig. 5 Pulse power rating chart.

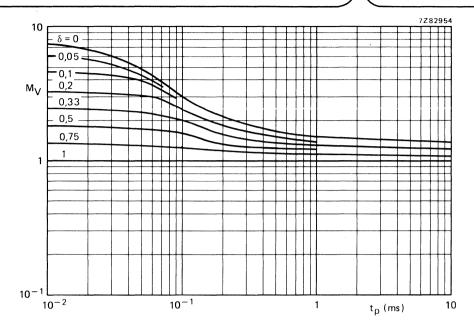


Fig. 6 S.B. voltage multiplying factor at the  $I_{\mbox{Cmax}}$  level.

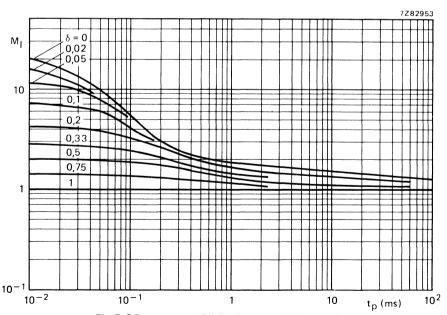


Fig. 7 S.B. current multiplying factor at the  $\rm V_{\mbox{\scriptsize CEmax}}$  level.

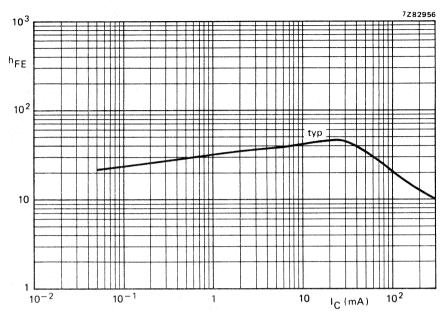


Fig. 8 D.C. current gain.  $V_{CE} = 10 \text{ V}$ .

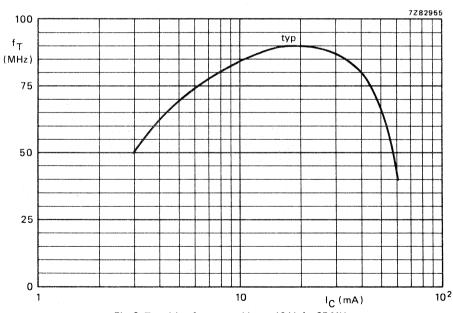


Fig. 9 Transition frequency.  $V_{CE} = 10 \text{ V}$ ; f = 35 MHz.

# SILICON PLANAR VIDEO OUTPUT TRANSISTORS

N-P-N transistors in a TO-202 plastic envelope intended for class-B video output stages in colour television receivers. P-N-P complements are BF870 and BF872.

### QUICK REFERENCE DATA

			BF869	BF871	
Collector-base voltage (open emitter)	$v_{CBO}$	max.	250	300	٧
Collector-emitter voltage (open base)	$v_{CEO}$	max.	250	_	V
Collector-emitter voltage ( $R_{BE} = 2.7 \text{ k}\Omega$ )	$v_{CER}$	max.	-	300	V
Collector current (peak value)	<sup>I</sup> CM	max.	10	0	mΑ
Total power dissipation up to $T_{mb} = 25$ °C	$P_{tot}$	max.		5	W
Junction temperature	Тj	max.	15	0	οС
D.C. current gain $I_C = 25 \text{ mA}$ ; $V_{CE} = 20 \text{ V}$ ; $T_j = 25 \text{ °C}$	hFE	>	5	0	
Transition frequency $-I_E = 10 \text{ mA; } V_{CB} = 10 \text{ V}$	f <sub>T</sub>	>	6	0	MHz
Feedback capacitance at f = 1 MHz $I_E = 0$ ; $V_{CB} = 30 \text{ V}$	C <sub>re</sub>	<		2	pF

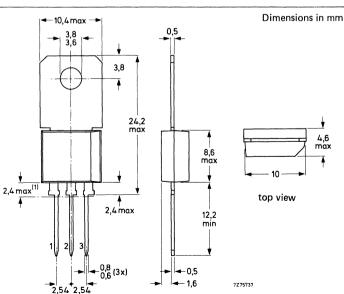
### MECHANICAL DATA

Fig. 1 TO-202.

Collector connected to mounting base.



Plastic flash allowed within this zone.



RATINGS

			BF869	BF871	
Collector-base voltage (open emitter)	V <sub>CBO</sub>	max.	250	300	 V
Collector-emitter voltage (open base)	VCEO	max.	250	- 1 - 1 - 1	V
Collector-emitter voltage ( $R_{BE} = 2.7 \text{ k}\Omega$ )	VCER	max.	_	300	٧
Emitter-base voltage (open collector)	V <sub>EBO</sub>	max.		5	V
Collector current (d.c.)	I <sub>C</sub>	max.	5	0	mΑ
Collector current (peak value)	I <sub>CM</sub>	max.	10	0	mA
Total power dissipation up to Tamb = 25 °C	P <sub>tot</sub>	max.	1,	6	W
Total power dissipation up to T <sub>mb</sub> = 25 °C	P <sub>tot</sub>	max.		5	W
Storage temperature	T <sub>stq</sub>		-65 to	+150	oC
Junction temperature	Ti	max.	15	0	оС
THERMAL RESISTANCE					
From junction to ambient	R <sub>th j-a</sub>	= '.'		8	K/W
From junction to mounting base	R <sub>th j-mb</sub>	=	2	5	K/W
CHARACTERISTICS					
T <sub>i</sub> = 25 °C unless otherwise specified			BF869	BF871	
Collector cut-off current					_
$I_E = 0$ ; $V_{CB} = 200 \text{ V}$	<sup>I</sup> CBO	<	10	10	nA
$R_{BE} = 2.7 \text{ k}\Omega; V_{CE} = 300 \text{ V}$	ICER	<	_	1	μΑ
$R_{BE} = 2.7 \text{ k}\Omega; V_{CE} = 200 \text{ V}; T_j = 150 \text{ °C}$	ICER	<	1	0	μΑ
Emitter cut-off current IC = 0; VEB = 5 V	I <sub>EBO</sub>	<	1	0	μΑ
D.C. current gain $I_C = 25 \text{ mA}$ ; $V_{CE} = 20 \text{ V}$	hFE	> 1	5	0	
Base-emitter voltage $I_C = 25 \text{ mA}$ ; $V_{CE} = 20 \text{ V}$	V <sub>BE</sub>	typ.	0,7	5	V
High frequency knee voltage $I_C = 25 \text{ mA}$ ; $T_j = 150  ^{\circ}\text{C}$	VCEK	typ.	2	0	٧
Transition frequency -IE = 10 mA; VCB = 10 V	f⊤	> ,	6	0	MHz
Feedback capacitance at f = 1 MHz $I_E = 0$ ; $V_{CB} = 30 V$	C <sub>re</sub>	<		2	pF

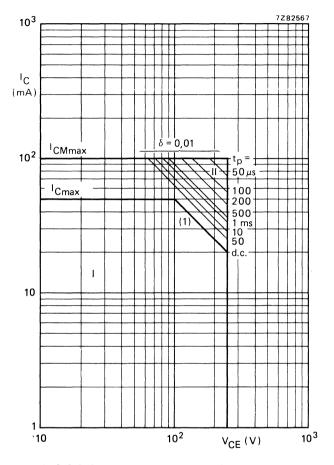


Fig. 2 Safe Operating ARea at  $T_{mb}$  = 25 °C.

- I Region of permissible d.c. operation.
- II Permissible extension for repetitive pulse operation.
- (1) Ptot max and Ptot peak max lines.

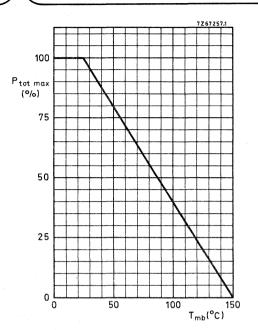


Fig. 3 Power derating curve.

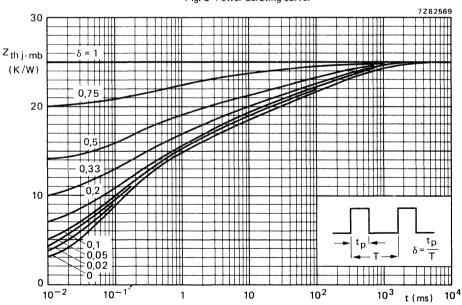
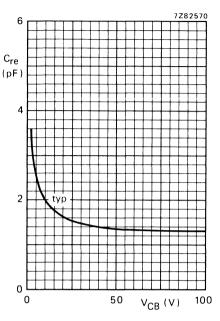


Fig. 4 Pulse power rating chart.



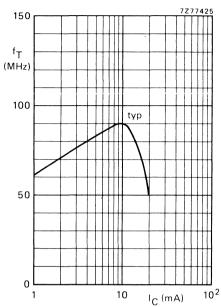


Fig. 5  $I_E = 0$ ; f = 1 MHz;  $T_j = 25 \text{ }^{\circ}\text{C}$ .

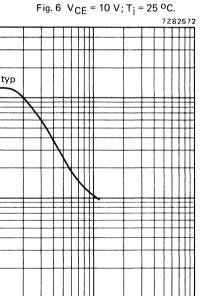
1

h<sub>FE</sub>

10<sup>2</sup>

10

10-1



10<sup>2</sup>

10 Fig. 7 D.C. current gain at  $V_{CE}$  = 20 V;  $T_{amb}$  = 25 °C.

Ic (mA)

10<sup>3</sup>



# SILICON PLANAR VIDEO OUTPUT TRANSISTORS

P-N-P transistors in a TO-202 plastic envelope intended for class-B video output stages in colour television receivers. N-P-N complements are BF869 and BF871.

#### QUICK REFERENCE DATA

			BF870	BF872	
Collector-base voltage (open emitter)	-V <sub>CBO</sub>	max.	250	300	V
Collector-emitter voltage (open base)	-V <sub>CEO</sub>	max.	250	_	V
Collector-emitter voltage ( $R_{BE} = 2.7 \text{ k}\Omega$ )	$-V_{CER}$	max.	-	300	V
Collector current (peak value)	-I <sub>CM</sub>	max.	10	00	mA
Total power dissipation up to $T_{mb} = 25$ °C	P <sub>tot</sub>	max.		5	W
Junction temperature	Τj	max.	15	60	oC
D.C. current gain $-I_C = 25 \text{ mA}; -V_{CE} = 20 \text{ V}; T_j = 25 ^{\circ}\text{C}$	hFE	>	5	60	
Transition frequency $I_E = 10 \text{ mA;} -V_{CB} = 10 \text{ V}$	f <sub>T</sub>	>	6	60	MHz
Feedback capacitance at f = 1 MHz I <sub>E</sub> = 0; -V <sub>CB</sub> = 30 V	C <sub>re</sub>	<	2,	.2	pF

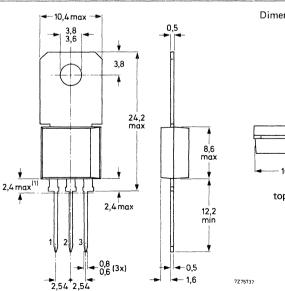
### MECHANICAL DATA

Fig. 1 TO-202.

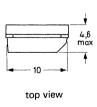
Collector connected to mounting base.



Plastic flash allowed within this zone.



Dimensions in mm



			BF870	BF872	
Collector-base voltage (open emitter)	-V <sub>CBO</sub>	max.	250	300	- V
Collector-emitter voltage (open base)	-V <sub>CEO</sub>	max.	250	_	V
Collector-emitter voltage ( $R_{BF} = 2.7 \text{ k}\Omega$ )	-V <sub>CER</sub>	max.	· -	300	٧
Emitter-base voltage (open collector)	-V <sub>EBO</sub>	max.		5	٧
Collector current (d.c.)	-Ic	max.		50	mΑ
Collector current (peak value)	-I <sub>CM</sub>	max.	10	00	mΑ
Total power dissipation up to Tamb = 25 °C	$P_{tot}$	max.	1	,6	W
Total power dissipation up to T <sub>mb</sub> = 25 °C	$P_{tot}$	max.		5	W
Storage temperature	T <sub>stg</sub>		−65 t	o +150	оС
Junction temperature	Tj	max.	19	50	оС
THERMAL RESISTANCE					
From junction to ambient	R <sub>th j-a</sub>	= 1,1		78	K/W
From junction to mounting base	R <sub>th j-mb</sub>	=		25	K/W
	til jillib				
CHARACTERISTICS					
T <sub>j</sub> = 25 °C unless otherwise specified			BF870	BF872	- · ·
T <sub>j</sub> = 25 °C unless otherwise specified Collector cut-off current					- - ^
T <sub>j</sub> = 25 °C unless otherwise specified Collector cut-off current I <sub>E</sub> = 0; -V <sub>CB</sub> = 200 V	—IСВО	<	BF870 10	10	- пА ^
$T_j$ = 25 °C unless otherwise specified Collector cut-off current $I_E$ = 0; $-V_{CB}$ = 200 V $R_{BE}$ = 2,7 k $\Omega$ ; $-V_{CE}$ = 300 V	-ICER	<	10	10	μΑ
$T_j$ = 25 °C unless otherwise specified Collector cut-off current I <sub>E</sub> = 0; $-V_{CB}$ = 200 V R <sub>BE</sub> = 2,7 k $\Omega$ ; $-V_{CE}$ = 300 V R <sub>BE</sub> = 2,7 k $\Omega$ ; $-V_{CE}$ = 200 V; $T_j$ = 150 °C			10	10	
$T_{j}$ = 25 °C unless otherwise specified Collector cut-off current $I_{E}$ = 0; $-V_{CB}$ = 200 V $R_{BE}$ = 2,7 k $\Omega$ ; $-V_{CE}$ = 300 V $R_{BE}$ = 2,7 k $\Omega$ ; $-V_{CE}$ = 200 V; $T_{j}$ = 150 °C Emitter cut-off current	-ICER	<	10	10	μΑ
$T_j$ = 25 °C unless otherwise specified Collector cut-off current I <sub>E</sub> = 0; $-V_{CB}$ = 200 V R <sub>BE</sub> = 2,7 k $\Omega$ ; $-V_{CE}$ = 300 V R <sub>BE</sub> = 2,7 k $\Omega$ ; $-V_{CE}$ = 200 V; $T_j$ = 150 °C	-ICER	< <	10	10 1	μΑ μΑ
$T_{j}$ = 25 °C unless otherwise specified Collector cut-off current $I_{E}$ = 0; $-V_{CB}$ = 200 V $R_{BE}$ = 2,7 k $\Omega$ ; $-V_{CE}$ = 300 V $R_{BE}$ = 2,7 k $\Omega$ ; $-V_{CE}$ = 200 V; $T_{j}$ = 150 °C Emitter cut-off current $I_{C}$ = 0; $-V_{EB}$ = 5 V	-ICER	< <	10	10 1	μΑ μΑ
$T_j$ = 25 °C unless otherwise specified Collector cut-off current $I_E$ = 0; $-V_{CB}$ = 200 V $R_{BE}$ = 2,7 k $\Omega$ ; $-V_{CE}$ = 300 V $R_{BE}$ = 2,7 k $\Omega$ ; $-V_{CE}$ = 200 V; $T_j$ = 150 °C Emitter cut-off current $I_C$ = 0; $-V_{EB}$ = 5 V D.C. current gain $-I_C$ = 25 mA; $-V_{CE}$ = 20 V Base emitter voltage	-ICER -ICER -IEBO	< < <	10	10 1 10 10	μΑ μΑ μΑ
$\begin{split} &T_j=25^{\circ}\text{C unless otherwise specified} \\ &\text{Collector cut-off current} \\ &I_E=0; -V_{CB}=200\text{V} \\ &R_{BE}=2,7k\Omega; -V_{CE}=300\text{V} \\ &R_{BE}=2,7k\Omega; -V_{CE}=200\text{V}; T_j=150^{\circ}\text{C} \\ &\text{Emitter cut-off current} \\ &I_C=0; -V_{EB}=5\text{V} \\ &D.C.\text{ current gain} \\ &-I_C=25\text{mA}; -V_{CE}=20\text{V} \\ &\text{Base emitter voltage} \\ &-I_C=25\text{mA}; -V_{CE}=20\text{V} \end{split}$	-ICER -ICER -IEBO	< < <	10	10 1 10 10	μΑ μΑ
$T_j$ = 25 °C unless otherwise specified Collector cut-off current $I_E$ = 0; $-V_{CB}$ = 200 V $R_{BE}$ = 2,7 k $\Omega$ ; $-V_{CE}$ = 300 V $R_{BE}$ = 2,7 k $\Omega$ ; $-V_{CE}$ = 200 V; $T_j$ = 150 °C Emitter cut-off current $I_C$ = 0; $-V_{EB}$ = 5 V D.C. current gain $-I_C$ = 25 mA; $-V_{CE}$ = 20 V Base emitter voltage $-I_C$ = 25 mA; $-V_{CE}$ = 20 V High-frequency knee voltage	-ICER -ICER -IEBO hFE -VBE	< < < < < < typ.	10 -	10 1 10 10	μΑ μΑ μΑ
$\begin{split} &T_j=25^{\circ}\text{C unless otherwise specified} \\ &\text{Collector cut-off current} \\ &I_E=0; -V_{CB}=200\text{V} \\ &R_{BE}=2,7k\Omega; -V_{CE}=300\text{V} \\ &R_{BE}=2,7k\Omega; -V_{CE}=200\text{V}; T_j=150^{\circ}\text{C} \\ &\text{Emitter cut-off current} \\ &I_C=0; -V_{EB}=5\text{V} \\ &D.C.\text{ current gain} \\ &-I_C=25\text{mA}; -V_{CE}=20\text{V} \\ &\text{Base emitter voltage} \\ &-I_C=25\text{mA}; -V_{CE}=20\text{V} \end{split}$	-ICER -ICER -IEBO	< < < < < < < < < < < < < > >	10 -	10 1 10 10 50	μΑ μΑ μΑ
$\begin{split} &T_j=25^{\circ}\text{C unless otherwise specified} \\ &\text{Collector cut-off current} \\ &I_E=0; -V_{CB}=200\text{V} \\ &R_{BE}=2,7k\Omega; -V_{CE}=300\text{V} \\ &R_{BE}=2,7k\Omega; -V_{CE}=200\text{V}; T_j=150^{\circ}\text{C} \\ &\text{Emitter cut-off current} \\ &I_C=0; -V_{EB}=5\text{V} \\ &D.C.\text{ current gain} \\ &-I_C=25\text{mA;} -V_{CE}=20\text{V} \\ &\text{Base emitter voltage} \\ &-I_C=25\text{mA;} -V_{CE}=20\text{V} \\ &\text{High-frequency knee voltage} \\ &-I_C=25\text{mA;} T_j=150^{\circ}\text{C} \end{split}$	-ICER -ICER -IEBO hFE -VBE	< < < < < < typ.	10 -	10 1 10 10 50	μΑ μΑ μΑ
$\begin{split} &T_j=25^{\circ}\text{C unless otherwise specified} \\ &\text{Collector cut-off current} \\ &I_E=0; -V_{CB}=200\text{V} \\ &R_{BE}=2,7k\Omega; -V_{CE}=300\text{V} \\ &R_{BE}=2,7k\Omega; -V_{CE}=200\text{V}; T_j=150^{\circ}\text{C} \\ &\text{Emitter cut-off current} \\ &I_C=0; -V_{EB}=5\text{V} \\ &D.C.\text{ current gain} \\ &-I_C=25\text{mA}; -V_{CE}=20\text{V} \\ &\text{Base emitter voltage} \\ &-I_C=25\text{mA}; -V_{CE}=20\text{V} \\ &\text{High-frequency knee voltage} \\ &-I_C=25\text{mA}; T_j=150^{\circ}\text{C} \\ &\text{Transition frequency} \end{split}$	-ICER -ICER -IEBO hFE -VBE -VCEK	<	10 -	10 1 10 10 50 75	μΑ μΑ μΑ V

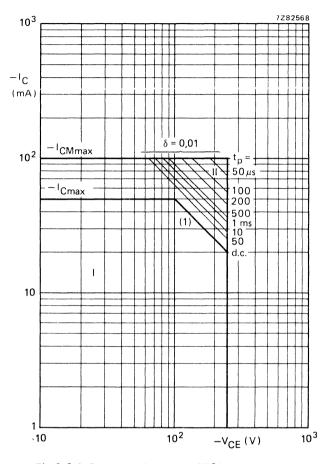


Fig. 2 Safe Operating ARea;  $T_{mb} = 25$  °C.

- I Region of permissible d.c. operation.
- II Permissible extension for repetitive pulse operation.
- (1) Ptot max and Ptot peak max lines.

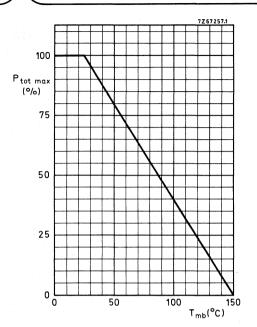


Fig. 3 Power derating curve.

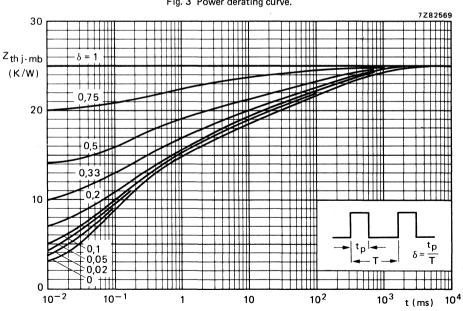
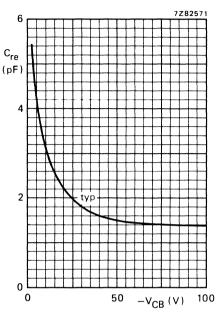


Fig. 4 Pulse power rating chart.



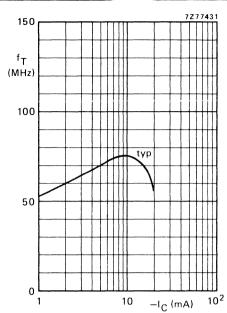
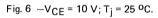


Fig. 5  $I_E = 0$ ; f = 1 MHz;  $T_{amb} = 25 \text{ }^{\circ}\text{C}$ .



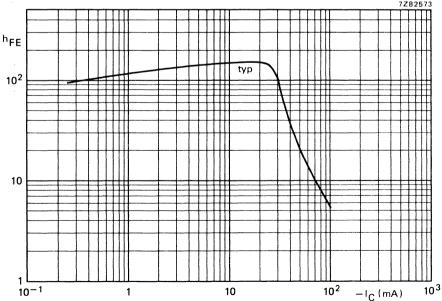


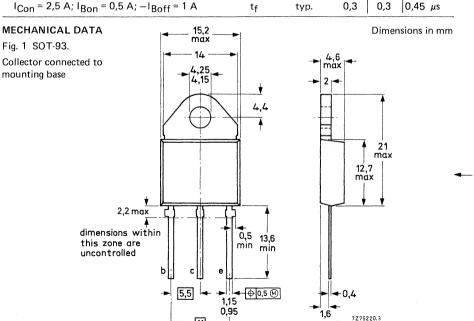
Fig. 7 D.C. current gain at  $-V_{CE} = 20 \text{ V}$ ;  $T_{amb} = 25 \text{ }^{\circ}\text{C}$ .

## 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  $90^{\circ}$  and  $110^{\circ}$  colour television receivers.

#### QUICK REFERENCE DATA

			BU426	426A	433
Collector-emitter voltage (V <sub>BE</sub> = 0; peak value)	V <sub>CESM</sub>	max.	800	900	800 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	375	400	375 V
Collector current (d.c.)	l <sub>C</sub>	max.		6	Α
Collector current (peak value) t <sub>p</sub> = 2 ms	I <sub>CM</sub>	max.		10	Α
Total power dissipation up to $T_{mb} = 73  {}^{\circ}\text{C}$	P <sub>tot</sub>	max.		70	W
Collector-emitter saturation voltage $I_C = 2.5 \text{ A}$ ; $I_B = 0.5 \text{ A}$	V <sub>CEsat</sub>	<		1,5	V
Fall time $I_{Con} = 2.5 \text{ A}$ ; $I_{Bon} = 0.5 \text{ A}$ ; $-I_{Boff} = 1 \text{ A}$	tf	typ.	0,3	0,3	0,45 μs



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 <sub>BE</sub> = 0, peak value)	VCESM	max.	800	900	800	٧	
Collector-emitter voltage (open base)	$v_{CEO}$	max.	375	400	375	V	
Collector current (d.c.)	l <sub>C</sub>	max.		6		Α	
Collector current (peak value)							
$t_p < 2 ms$	ICM	max.		10		Α	
Base current (d.c.)	۱ <sub>B</sub>	max.		2		Α	
Base current (peak value)	I <sub>BM</sub>	max.		3		Α	
Reverse base current (d.c. or average							
over any 20 ms period)	−¹B(AV)	max.		100		mΑ	
Reverse base current (peak value)*	−¹BM	max.		3		Α	
Total power dissipation up to T <sub>mb</sub> = 73 °C	$P_{tot}$	max.		70		W	
Storage temperature	$T_{stg}$		-65 to	+ 150		οС	
Junction temperature	$T_{j}$	max.		150		°C	
THERMAL RESISTANCE							
From junction to mounting base	R <sub>th j-mb</sub>	= ;		1,1		K/W	
CHARACTERISTICS							
T <sub>j</sub> = 25 °C unless otherwise specified							
Collector cut-off current **							
$V_{CEM} = 900 V; V_{BE} = 0$	ICES	<		1		mΑ	
$V_{CEM} = 900 \text{ V}; V_{BE} = 0; T_j = 125 ^{\circ}\text{C}$	<sup>I</sup> CES	<		2		mΑ	
D.C. current gain	1.	typ.		30			
I <sub>C</sub> = 0,6 A; V <sub>CE</sub> = 5 V; BU426; BU426A	hFE	<		60			
I <sub>C</sub> = 0,6 A; V <sub>CE</sub> = 5 V; BU433	hFE	typ.		40			
Transition frequency at f = 1 MHz							
$I_C = 0.2 \text{ A}; V_{CE} = 10 \text{ V}$	fΤ	typ.		6		MHz	

<sup>\*</sup> Turn-off current.

<sup>\*\*</sup> Measured with a half sine-wave voltage (curve tracer).

### CHARACTERISTICS (continued)

T <sub>j</sub> = 25 °C unless otherwise specified			
Emitter cut-off current			
$I_C = 0$ ; $V_{EB} = 10 \text{ V}$	I <sub>EBO</sub>	<	10 mA
Saturation voltages			
$I_C = 2.5 \text{ A}; I_B = 0.5 \text{ A}$	$v_{CEsat}$	<	1,5 V
	$V_{BEsat}$	<	1,4 V
$I_C = 4 \text{ A}; I_B = 1,25 \text{ A}$	$v_{CEsat}$	<	3 V
	$V_{BEsat}$	<	1,6 V
Collector-emitter sustaining voltage			
$I_C = 100 \text{ mA}$ ; $I_{Boff} = 0$ ; $L = 25 \text{ mH}$ ; $BU426$ ; $BU433$	<b>VCEOsust</b>	>	375 V
$I_C = 100 \text{ mA}$ ; $I_{Boff} = 0$ ; $L = 25 \text{ mH}$ ; $BU426A$	V <sub>CEOsust</sub>	>	400 V

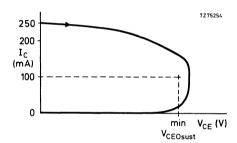


Fig. 2 Oscilloscope display for V<sub>CEOsust</sub>.

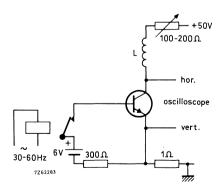


Fig. 3 Test circuit for V<sub>CEOsust</sub>.

### CHARACTERISTICS (continued)

Switching times (between 10% and 90% levels)

I<sub>Con</sub> = 2,5 A; V<sub>CC</sub> = 250 V

 $I_{Bon} = 0.5 A; -I_{Boff} = 1 A$ 

Turn-on time

0,6 µs typ. 2 μs Storage time < 3,5 µs BU426; 426A typ. 0,3 µs tf typ. 0,45 µs Turn-off time  $(t_{off} = t_s + t_f)$ BU433 0,7 µs < 0,7 μs typ. < 1,0 µs BU426; 426A < 0,75 μs

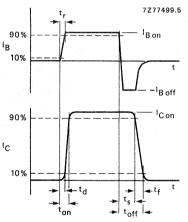


Fig. 4 Waveforms.

0,5 µs

typ.

ton

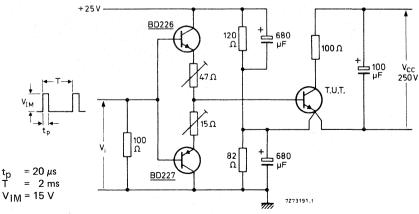


Fig. 5 Test circuit.

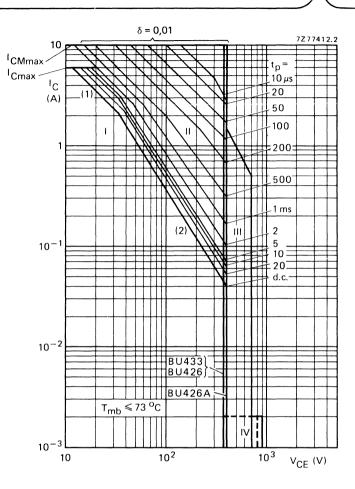
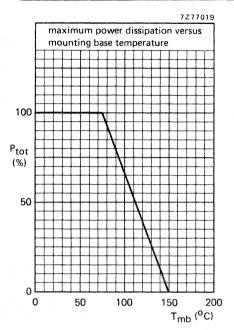
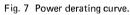


Fig. 6 Safe Operating ARea.

- I Region of permissible d.c. operation.
- II Permissible extension for repetitive pulse operation.
- III Area of permissible operation during turn-on in single-transistor converters, provided R  $_{BE} \leqslant$  100  $\Omega$  and  $t_p \leqslant$  0,6  $\mu s.$
- IV Repetitive pulse operation in this region is permissible, provided  $V_{BE} \le 0$  and  $t_{D} \le 2$  ms.
- (1) Ptot max and Ppeak max lines.
- (2) Second-breakdown limits (independent of temperature).





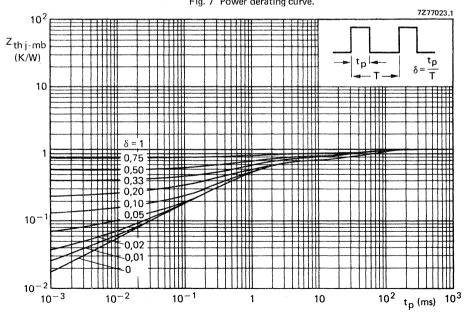


Fig. 8 Pulse power rating chart.

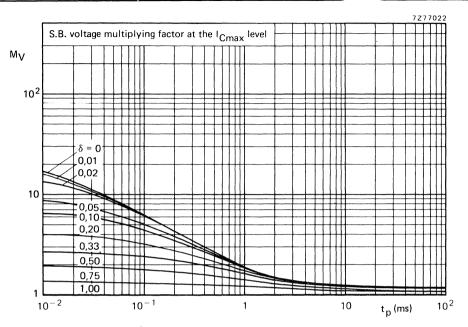


Fig. 9 S.B. voltage multiplying factor at the  $I_{\mbox{Cmax}}$  level.

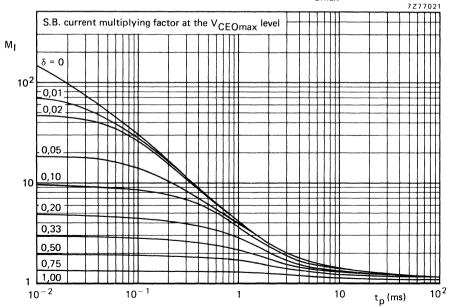


Fig. 10 S.B. current multiplying factor at the  $V_{\mbox{CEOmax}}$  level.

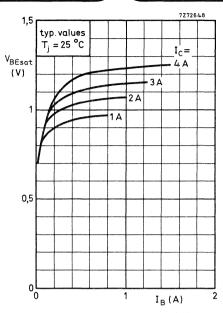


Fig. 11 Typical values. Base-emitter saturation voltage for BU426 and BU426A.

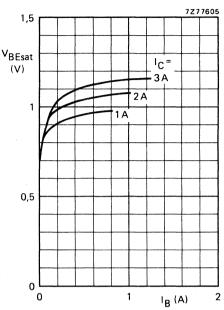
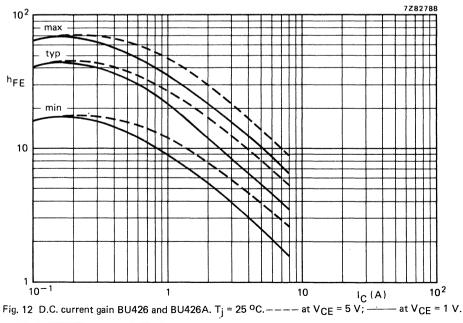


Fig. 11A. Typical values. Base-emitter saturation voltage for BU433; T<sub>i</sub> = 25 °C.



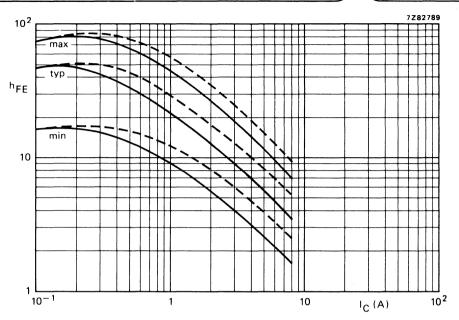


Fig. 13 D.C. current gain BU433;  $T_j = 25$  °C; ——— at  $V_{CE} = 5$  V; ——— at  $V_{CE} = 1$  V.

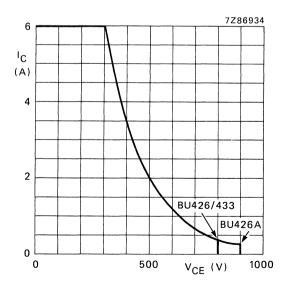


Fig. 14 Reverse bias SOAR.  $-V_{drive}$  = 2 to 6 V; L<sub>B</sub> = 0 to 4,7  $\mu$ H; T<sub>mb</sub> = 100 °C.

#### APPLICATION INFORMATION (detailed information on request)

Important factors in the design of SMPS circuits are the power losses and heatsink requirements of the supply output transistor and the base drive conditions during turn-off. In SMPS circuits for CTV receivers the duty factor of the collector current generally varies between 0,35 and 0,6.

The operating frequency lies between 15 kHz and 35 kHz and the shape of the collector current varies from rectangular in a forward converter to a sawtooth in a flyback circuit.

All these variables influence the collector dissipation, so that a simple presentation of the design information is only possible if the information is restricted to the main application area of the relevant transistor type. Therefore, as the BU426 or BU426A will mainly be used in flyback converters and the BU433 in forward SMPS, the information of Figs 17 up to 22 is based on these applications:

The total power dissipation for a limit-case transistor BU426 or BU433 is given in Figs 19 and 22, which apply for a mounting base temperature of 100 °C. The required thermal resistance for the heatsink can be calculated from:

$$R_{th mb-a max}^* = \frac{T_{mb max} - T_{amb max}}{P_{tot}}$$

\* 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 ( $\approx$  300-350 V). The rate-of-rise of the voltage during turn-off must be below 1000 V/ $\mu$ s. Application of this transistor in low-power flyback converters is also possible, provided that the rate-of-rise is limited to 500 V/ $\mu$ s. For the BU426(A) a rate-of-rise of 1000 V/ $\mu$ s is permissible. Practical SMPS output circuits for an output power in the order of 180 W are given in Figs 17 and 20. At a collector current of 2,5 A and a base current of 0,25 A in these circuits the following turn-off times can be expected.

		T <sub>m</sub>	b
		25 °C	100 °C
BU426 (426A)	Storage time t <sub>s</sub>	typ. 1,4	< 2,0 μs
	Fall time t <sub>f</sub>	0,15	< 0,5 μs
BU433	Storage time t <sub>s</sub>	typ. 1,4	< 2,0 μs
	Fall time t <sub>f</sub>	0,18	< 0,6 μs

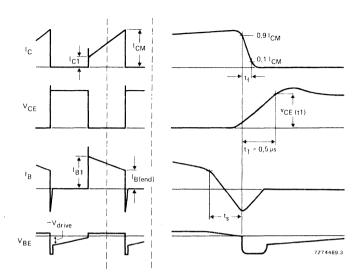


Fig. 15 Relevant waveforms of switching transistor.

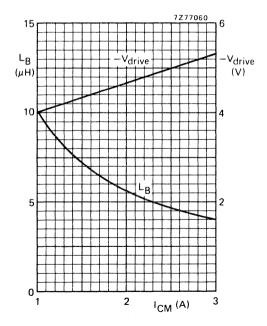


Fig. 16 Minimum required base inductance and recommended negative drive voltage versus maximum peak collector current.

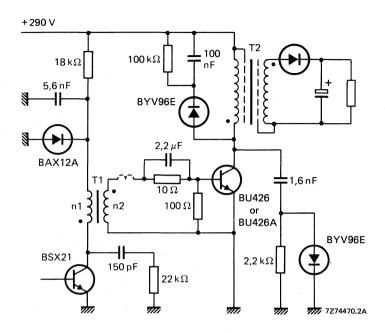


Fig. 17 Practical output circuit of a flyback SMPS of BU426 or BU426A.

```
T1 (driver transformer) core U20; n1 = 400 turns n2 = 25 turns L_{Btot} \approx 4.5 \, \mu\text{H} T2 (output transformer) L_p = 6 \, \text{mH} V_{CE(t1)} < 500 \, \text{V (see Fig. 15)}
```

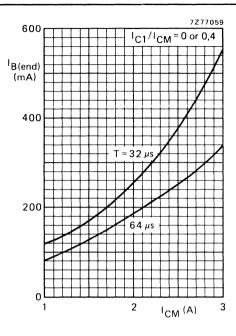


Fig. 18 Recommended nominal "end" value of the base current versus maximum peak collector current.

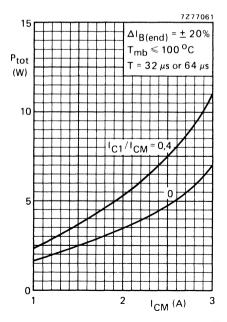


Fig. 19 Maximum total power dissipation of a limit-case transistor of the base current is chosen in accordance with Fig. 18.

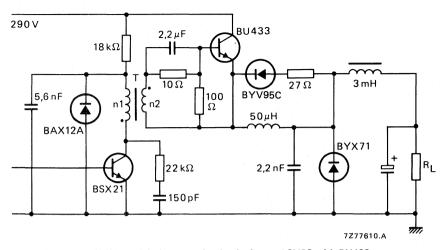


Fig. 20 Practical output circuit of a forward SMPS with BU433.

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

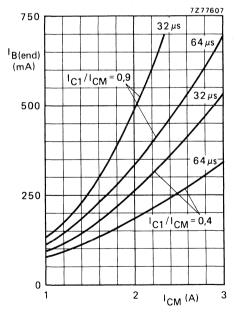


Fig. 21 Recommended nominal "end" value of the base current versus maximum peak collector current.

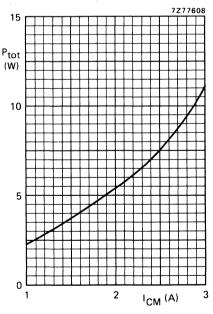


Fig. 22 Maximum total power dissipation of a limit-case transistor if the base current is chosen in accordance with Fig. 21.

## **DEVELOPMENT DATA**

This data sheet contains advance information and specifications are subject to change without notice.

# SILICON POWER TRANSISTOR

High-voltage, high-speed switching, glass passivated n-p-n power transistor in a TO-220 envelope, intended for use in horizontal deflection circuits of television receivers.

### QUICK REFERENCE DATA

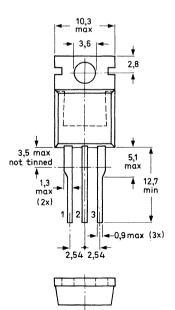
$v_{CESM}$	max.	1500 V
VCEO	max.	700 V
IC	max.	2,5 A
ICM	max.	4 A
$P_{tot}$	max.	75 W
V <sub>CEsat</sub>	<	5 V
t <sub>f</sub>	typ.	0,7 μs
	VCEO IC ICM Ptot VCEsat	VCEO max. IC max. ICM max. Ptot max. VCEsat <

#### **MECHANICAL DATA**

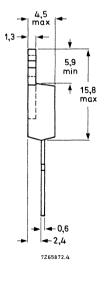
Fig. 1 TO-220.

Collector connected to mounting base









See also chapters Mounting instructions and Accessories.

### **RATINGS**

Limiting values in accordance with the Absolute Maximum System (IEC 134)					
Collector-emitter voltage (peak value; V <sub>BE</sub> = 0)	$V_{CESM}$	max.	1500	٧	
Collector-emitter voltage (open base)	$v_{CEO}$	max.	700	٧	
Collector current (d.c.)	Ic	max.	2,5	Α	
Collector current (peak value); t <sub>p</sub> < 2 ms	ICM	max.	4	Α	
Base current (d.c.)	I <sub>B</sub>	max.	2	Α	
Base current (peak value); $t_p < 2 \text{ ms}$	I <sub>BM</sub>	max.	4	Α	
Total power dissipation up to $T_{mb} = 25$ °C	P <sub>tot</sub>	max.	75	W	
Storage temperature	T <sub>stg</sub>	-65 to	+150	oC	
Junction temperature	Тj	max.	150	oC	
THERMAL RESISTANCE					
From junction to mounting base	R <sub>th j-mb</sub>	= '	1,67	K/W	
CHARACTERISTICS					
T <sub>j</sub> = 25 °C unless otherwise specified					
Collector cut off current*					
V <sub>CE</sub> = V <sub>CESMmax</sub> ; V <sub>BE</sub> = 0	CES	<	0,15	mΑ	
$V_{CE} = V_{CESMmax}$ ; $V_{BE} = 0$ ; $T_j = 125  {}^{\circ}C$	ICES	<	1	mΑ	
Emitter cut-off current I <sub>C</sub> = 0; V <sub>EB</sub> = 5 V	<sup>I</sup> EBO	<	1	mA	
Saturation voltages	V		5	V	
$I_C = 2 \text{ A}; I_B = 0.9 \text{ A}$	V <sub>CEsat</sub> V <sub>BEsat</sub>	<	1,3		
Collector-emitter sustaining voltage I <sub>C</sub> = 100 mA; I <sub>B</sub> = 0; L = 50 mH		. >	700	V	
D.C. current gain	VCEOsus	t	700	٧	
I <sub>C</sub> = 2 A; V <sub>CE</sub> = 5 V	hFE	>	2,22		

<sup>\*</sup> Measured with a half sine-wave voltage (curve tracer).

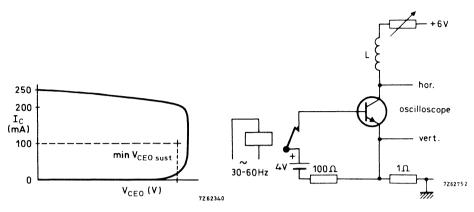
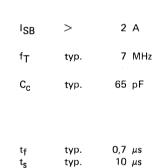


Fig. 2 Oscilloscope display for sustaining voltage.

Fig. 3 Test circuit for V<sub>CEOsust</sub>

 $V_{CE}=120$  V; T=200  $\mu s$  Transition frequency at f=5 MHz  $I_{C}=0,1$  A;  $V_{CE}=5$  V Collector capacitance at f=1 MHz  $I_{E}=I_{e}=0$ ;  $V_{CB}=10$  V Switching times in horizontal deflection circuit  $-V_{IM}=4$  V;  $L_{B}=25$   $\mu H$ ;  $I_{CM}=2$  A;  $I_{B}(end)=0,9$  A fall time storage time

Second-breakdown current



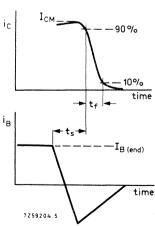


Fig. 4 Switching times waveforms.

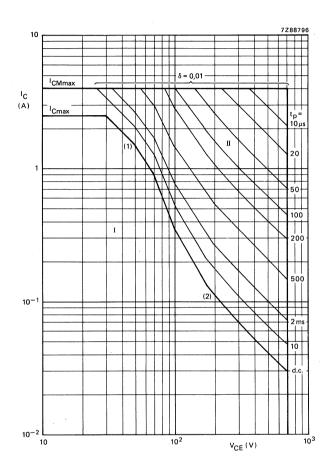


Fig. 5 Safe Operating ARea at  $T_{mb} \le 25$  °C.

- Region of permissible d.c. operation.
- Permissible extension for repetitive pulse operation.
- (1)
- P<sub>tot max</sub> and P<sub>tot peak max</sub> lines. Second-breakdown limits (independent of temperature).

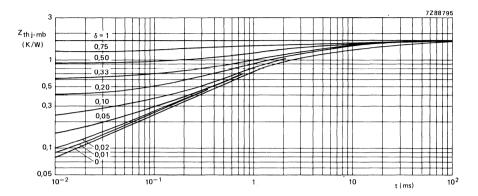


Fig. 6 Pulse power rating chart.

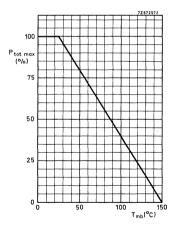


Fig. 7 Power derating curve.



# **DEVELOPMENT DATA**

This data sheet contains advance information and specifications are subject to change without notice.

### SILICON DIFFUSED POWER TRANSISTOR

High-voltage, high-speed switching n-p-n transistor in plastic envelope (TO-220) and intended for use in horizontal deflection circuits of colour television receivers and in line-operated switch-mode applications.

### QUICK REFERENCE DATA

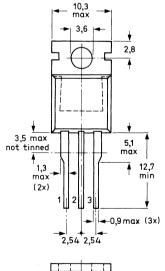
Collector-emitter voltage (V <sub>BE</sub> = 0, peak value)	V <sub>CESM</sub>	max.	1500 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	700 V
Collector saturation current	I <sub>Csat</sub>	=	3 A
Collector current	<sup>I</sup> C	max.	5 A
Total power dissipation up to T <sub>mb</sub> = 25 °C	$P_{tot}$	max.	100 W
Collector-emitter saturation voltage $I_C = 3 A$ ; $I_B = 1,33 A$	V <sub>CEsat</sub>	<	5 V
Fall time $I_C = 3 \text{ A}; I_{B(end)} = 1 \text{ A}; L_B = 12 \mu\text{H}$	tf	typ.	0,7 μs

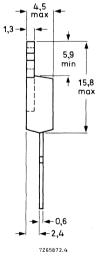
### **MECHANICAL DATA**

Dimensions in mm

Fig. 1 TO-220. Collector connected to case.







For Accesories and Mounting instructions refer to Handbook high-voltage and switching power transistors.

## RATINGS

11.1.1.1.00				
Limiting values in accordance with the Absolute Maximum System (	(IEC 134)			
Collector-emitter voltage (V <sub>BE</sub> = 0, peak value)	VCESM	max.	1500	<b>V</b>
Collector-emitter voltage (open base)	V <sub>CEO</sub>	max.	700	٧
Collector current (d.c.)	Ic	max.	5	Α
Collector current (peak value)	ICM	max.	8	Α
Base current (d.c.)	I <sub>B</sub>	max.	3	Α
Base current (peak value)	ВМ	max.	5	Α
Total power dissipation up to T <sub>mb</sub> = 25 °C	P <sub>tot</sub>	max.	100	W
Storage temperature	$T_{stg}$	-65 to +	150	oC
Junction temperature	Tj	max.	150	оС
THERMAL RESISTANCE				
From junction to mounting base	R <sub>th j-mb</sub>	=	1,25	K/W
CHARACTERISTICS				
T <sub>j</sub> = 25 °C unless otherwise specified				
Collector cut-off current*				
V <sub>CE</sub> = V <sub>CESMmax</sub> ; V <sub>BE</sub> = 0 V <sub>CE</sub> = V <sub>CESMmax</sub> ; V <sub>BE</sub> = 0; T <sub>j</sub> = 125 °C	ICES	< <		mA mA
Emitter cut-off current V <sub>EB</sub> = 6 V; I <sub>C</sub> = 0	Irno	<	10	mA
Second breakdown current	IEBO		, 10	mA.
$V_{CE} = 300 \text{ V}; t_p = 200 \mu\text{s}$	I <sub>SB</sub>	>	1	A
Saturation voltages			_	.,
I <sub>C</sub> = 3 A; I <sub>B</sub> = 1,33 A	V <sub>CEsat</sub> V <sub>BEsat</sub>	<	1,3	V
Collector-emitter sustaining voltage	DESGL		,.,-	·
I <sub>C</sub> = 0,1 A; I <sub>B</sub> = 0; L = 25 mH	V <sub>CEOsust</sub>	>	700	<b>V</b>
Switching times (in line deflection circuit)				
$I_{CM} = 3 \text{ A; } I_{B(end)} = 1 \text{ A; } L_{B} = 12 \mu\text{H}$			0 7	
storage time	t <sub>f</sub> t <sub>s</sub>	typ. typ.	0,7 6,5	•
	-3	-, -,	-,-	

<sup>\*</sup> Measured with a half sine-wave voltage (curve tracer).

### DEVELOPMENT DATA

This data sheet contains advance information and specifications are subject to change without notice.

## SILICON DIFFUSED POWER TRANSISTOR

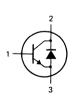
High-voltage, high-speed switching n-p-n transistor with integrated efficiency diode in plastic envelope and intended for use in horizontal deflection circuits of colour television receivers and in line-operated switch-mode applications.

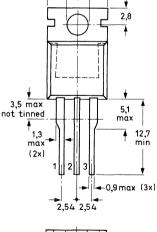
#### QUICK REFERENCE DATA

Collector-emitter voltage (V <sub>BE</sub> = 0, peak value)	V <sub>CESM</sub>	max.	1500 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	700 V
Collector saturation current	I <sub>Csat</sub>	=	3 A
Collector current	<sup>I</sup> C	max.	5 A
Total power dissipation up to $T_{mb} = 25$ °C	$P_{tot}$	max.	100 W
Collector-emitter saturation voltage $I_C = 3 A$ ; $I_B = 1,33 A$	V <sub>CEsat</sub>	<	5 V
Diode forward voltage at $I_F = 3 A$	$V_{F}$	typ.	1,5 V
Fall time $I_C = 3 \text{ A}; I_{B(end)} = 1 \text{ A}; L_B = 12 \mu\text{H}$	t <sub>f</sub>	typ.	0,7 μs

# MECHANICAL DATA Fig. 1 TO-220.

Collector connected to case.

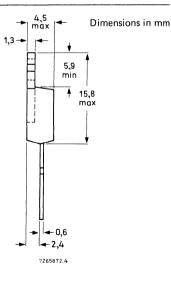




10,3

máx

3,6



For Accessories and Mounting instructions refer to Handbook high-voltage and switching power transistors.

RATINGS			
Limiting values in accordance with the Absolute Maximum	System (IEC 134	)	
Collector-emitter voltage (V <sub>BE</sub> = 0, peak value)	VCESN	n max.	1500 V
Collector-emitter voltage (open base)	V <sub>CEO</sub>	max.	700 V
Collector current (d.c.)	lc	max.	5 A
Collector current (peak value)	ICM	max.	8 A
Base current (d.c.)	IB	max.	3 A
Base current (peak value)	<sup>I</sup> BM	max.	5 A
Total power dissipation up to T <sub>mb</sub> = 25 °C	P <sub>tot</sub>	max.	100 W
Storage temperature	$T_{stg}$	65 to	+ 150 °C
Junction temperature	$T_{j}$	max.	150 °C
THERMAL RESISTANCE			
From junction to mounting base	R <sub>th j-m</sub>	nb =	1,25 K/W
CHARACTERISTICS			
T <sub>j</sub> = 25 °C unless otherwise specified			
Collector cut-off current*			
$V_{CE} = V_{CESMmax}$ ; $V_{BE} = 0$ $V_{CE} = V_{CESMmax}$ ; $V_{BE} = 0$ ; $T_j = 125$ °C	ICES	< <	0,5 mA 1,0 mA
Emitter cut-off current			
$V_{EB} = 6 \text{ V; } I_C = 0$	IEBO	<	10 mA
Second breakdown current $V_{CE} = 300 \text{ V; } t_p = 200 \mu\text{s}$	I <sub>SB</sub>	>	1 A
Saturation voltages			
I <sub>C</sub> = 3 A; I <sub>B</sub> = 1,33 A	V <sub>CEsa</sub> V <sub>BEsa</sub>	t < t <	5 V 1,3 V
Collector-emitter sustaining voltage			
I <sub>C</sub> = 0,1 A; I <sub>B</sub> = 0; L = 25 mH	VCEO	sust >	700 V
Diode forward voltage I <sub>F</sub> = 3 A	V <sub>F</sub>	typ.	1,5 V 2,2 V

0,7 μs

6,5 µs

typ.

typ.

 $\mathsf{t}_\mathsf{f}$ 

Switching times (in line deflection circuit) I<sub>CM</sub> = 3 A; I<sub>B(end)</sub> = 1 A; L<sub>B</sub> = 12  $\mu$ H fall time

storage time

<sup>\*</sup> Measured with a half sine-wave voltage (curve tracer).

## SILICON DIFFUSED POWER TRANSISTOR

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

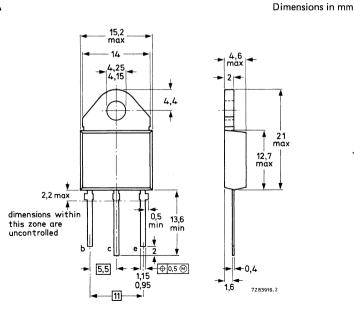
### QUICK REFERENCE DATA

Collector-emitter voltage (V <sub>BE</sub> = 0, peak value)	V <sub>CESM</sub>	max.	1500 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	700 V
Collector current (d.c.)	Ic	max.	8 A
Collector current (peak value)	ICM	max.	15 A
Total power dissipation up to T <sub>mb</sub> = 25 °C	$P_{tot}$	max.	125 W
Collector-emitter saturation voltage $I_C = 4,5 A; I_B = 2 A$	V <sub>CEsat</sub>	<	1 V
Saturation collector current	Csat	typ.	4,5 A
Fall time $I_{CM} = 4.5 \text{ A}$ ; $I_{B(end)} = 1.4 \text{ A}$	t <sub>f</sub>	typ.	0,7 μs

### **MECHANICAL DATA**

Fig. 1 SOT-93A.

Collector connected to mounting base.



See also chapters Mounting instructions and Accessories.

# **BU508A**

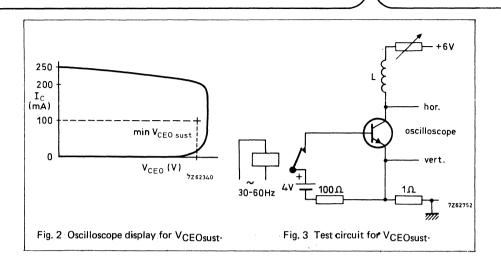
### **RATINGS**

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

Limiting values in accordance with the Absolute Maximum System (1)	_0 134/		
Collector-emitter voltage (VBF = 0, peak value)	V <sub>CESM</sub>	max.	1500 V
Collector-emitter voltage (open base)	V <sub>CEO</sub>	max.	700 V
Collector current (d.c.)	lc	max.	8 A
Collector current (peak value)	ICM	max.	15 A
Base current (d.c.)	IB	max.	4 A
Base current (peak value)	I <sub>BM</sub>	max.	6 A
Reverse base current (d.c. or average over any 20 ms period)	-I <sub>B</sub> (AV)	max.	100 mA
Reverse base current * (peak value)	$-I_{BM}$	max.	5 A
Total power dissipation up to T <sub>mb</sub> = 25 °C	P <sub>tot</sub>	max.	125 W
Storage temperature	T <sub>stg</sub>	-65 to	+150 °C
Junction temperature	$T_{j}$	max.	150 °C
THERMAL RESISTANCE			
From junction to mounting base	R <sub>th j-mb</sub>	-	1 K/W
CHARACTERISTICS			
T <sub>j</sub> = 25 °C unless otherwise specified			
Collector cut-off current *			1.0 1
V <sub>BE</sub> = 0; V <sub>CE</sub> = V <sub>CESMmax</sub>	CES	<	1,0 mA
$V_{BE} = 0$ ; $V_{CE} = V_{CESMmax}$ ; $T_j = 125$ °C	CES	<	2,0 mA
Emitter cut-off current $V_{FB} = 6 \text{ V; } I_{C} = 0$	leno	<	10 mA
Saturation collector current	<sup>I</sup> EBO		IO IIIA
V <sub>CEsat</sub> < 1 V	Csat	typ.	4,5 A
Collector-emitter sustaining voltage	V		700 \
I <sub>B</sub> = 0; I <sub>C</sub> = 100 mA; L = 25 mH	V <sub>CEOsust</sub>	<i>&gt;</i>	700 V
Saturation voltage $I_C = 4,5 A; I_B = 2 A$	V <sub>CEsat</sub>	<	1 V
I <sub>C</sub> = 4,5 A; I <sub>B</sub> = 2 A	V <sub>BEsat</sub>	<	1,3 V
Transition frequency at f = 5 MHz IC = 0,1 A; VCF = 5 V	fT	typ.	7 MHz
Collector capacitance at f = 1 MHz	• • •	typ.	7 141112
I <sub>E</sub> = I <sub>e</sub> = 0; V <sub>CB</sub> = 10 V	$c_c$	typ.	125 pF
Second-breakdown current			
V <sub>CE</sub> = 120 V; t = 200 μs	I(SB)	>	11 A

<sup>\*</sup> Turn-off current.

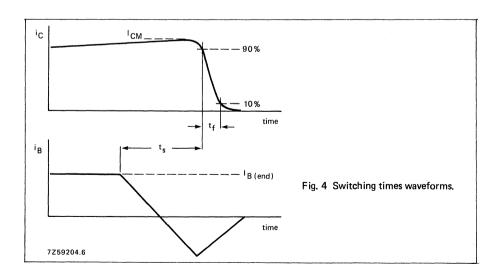
<sup>\*\*</sup> Measured with a half-sinewave voltage (curve tracer).



Switching times (in line deflection circuit)

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

 $0.7 \mu s$ tf typ. typ. 6,5 µs



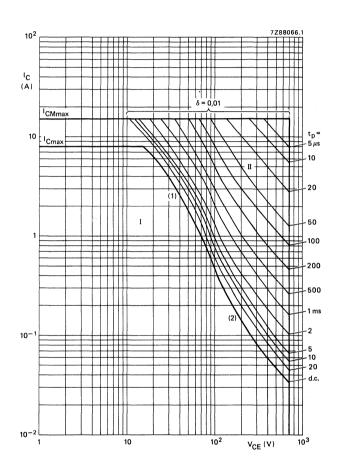


Fig. 5 Safe Operating Area;  $T_{mb} \le 25$  °C.

- 1. Ptot max line.
- 2. Second-breakdown limits (independent of temperature)
- Region of permissible d.c.operation.
- Permissible extension for repetitive pulse operation. П

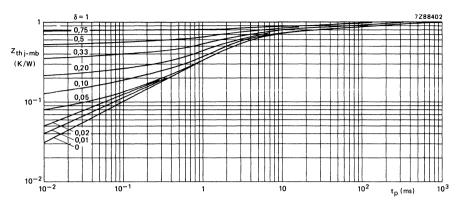


Fig. 6 Pulse power rating chart.

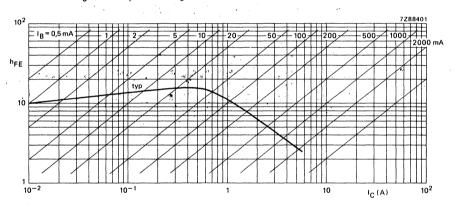


Fig. 7 Typical values d.c. current gain at  $V_{CE}$  = 5 V;  $T_{mb}$  = 25 °C.

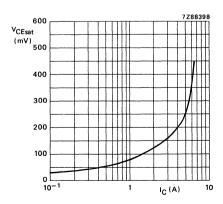


Fig. 8 Typical values  $I_C/I_B = 2$ ;  $T_j = 25$  °C.

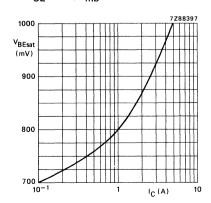


Fig. 9 Typical values  $I_C/I_B = 2$ ;  $T_j = 25$  °C.

### APPLICATION INFORMATION - HORIZONTAL DEFLECTION CIRCUIT WITH BU508A

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 15%, 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  $\pm$  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 —dlg/dt, see Fig. 12.

The maximum transistor dissipation largely depends on the tolerances in the drive conditions. The dissipation given in Fig. 13 allows for base current and  $-dl_B/dt$  tolerances of  $\pm$  15%. The curve applies for a limit-case transistor at a mounting base temperature of 85 °C.

 $T_{amb\ max}$  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.

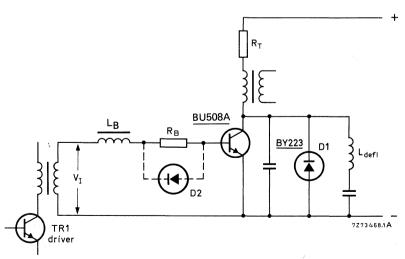


Fig. 10 Simplified horizontal deflection circuit.

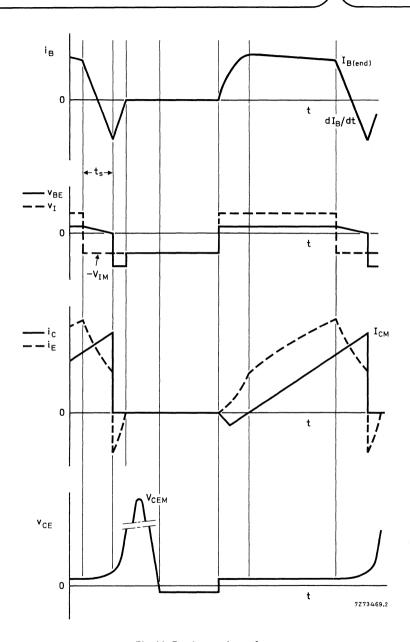


Fig. 11 Fundamental waveforms.

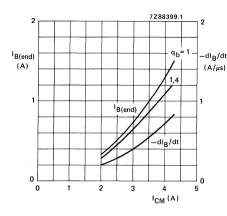


Fig. 12 Nominal end value of the base current and its rate of fall during turn-off as a function of nominal peak collector current.

A 15% spread allowance is included on these nominal values. QB is defined as  $I_{B\,1}/I_{B\,(end)}$  (see Fig. 11). The reverse drive voltage during the storage and fall time  $(-V_{IM})$  must be > 2 V).

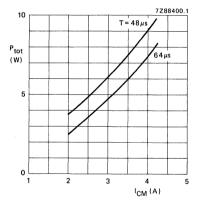


Fig. 13 Worst-case dissipation of BU508A under limited operational conditions according to Fig. 12.  $T_{mb}$  = 85 °C.

## SILICON DIFFUSED POWER TRANSISTOR

High-voltage, high-speed switching n-p-n power transistor with integrated efficiency diode in a SOT-93A envelope intended for use in horizontal deflection circuits of colour television receivers.

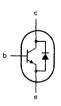
### QUICK REFERENCE DATA

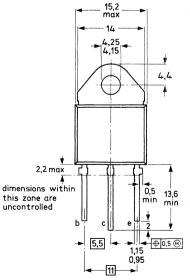
Collector-emitter voltage (V <sub>BE</sub> = 0, peak value)	V <sub>CESM</sub>	max.	1500 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	700 V
Collector current (d.c.)	<sup>I</sup> C	max.	8 A
Collector current (peak value)	ICM	max.	15 A
Total power dissipation up to T <sub>mb</sub> = 25 °C	P <sub>tot</sub>	max.	125 W
Collector-emitter saturation voltage $I_C = 4,5 A; I_B = 2 A$	V <sub>CEsat</sub>	<	1 V
Saturation collector current	Csat	typ.	4,5 A
Diode forward voltage (I <sub>F</sub> = 4,5 A)	VF	typ.	1,6 V
Fall time $I_{CM} = 4.5 \text{ A}$ ; $I_{B(end)} = 1.4 \text{ A}$	tf	typ.	0,7 · μs

#### **MECHANICAL DATA**

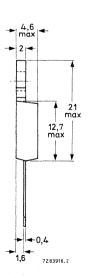
Fig. 1 SOT-93A.

Collector connected to case.





Dimensions in mm

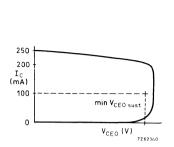


For Accessories and Mounting instructions see handbook high-voltage and switching power transistors.

#### RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134) Collector-emitter voltage 1500 V (V<sub>RF</sub> = 0, peak value) VCESM max. 700 V Collector-emitter voltage (open base) VCEO max. Collector current (d.c.) 1c max. 8 A Collector current (peak value) max. 15 A CM 4 A Base current (d.c.) l<sub>R</sub> max. 6 A Base current (peak value) max. I<sub>BM</sub> 125 W Total power dissipation up to Tmb = 25 °C Ptot max. -65 to + 150 °C Storage temperature  $T_{sta}$ 150 °C Junction temperature Τį max. THERMAL RESISTANCE From junction to mounting base 1 K/W Rth j-mb CHARACTERISTICS T<sub>i</sub> = 25 °C unless otherwise specified Collector cut-off current\* 1,0 mA V<sub>BE</sub> = 0; V<sub>CE</sub> = V<sub>CESMmax</sub> ICES < <  $V_{BE} = 0$ ;  $V_{CE} = V_{CESMmax}$ ;  $T_i = 125 \, {}^{\circ}C$ **ICES** 2,0 mA Emitter cut-off current 10 mA  $V_{EB} = 6 V; I_{C} = 0$ < 1<sub>EBO</sub> Collector-emitter sustaining voltage  $I_B = 0$ ;  $I_C = 100 \text{ mA}$ ; L = 25 mH> 700 V VCEOsust Saturation voltages  $I_C = 4,5 A; I_B = 2 A$ VCEsat < 1 V VRFsat < 1.3 V Diode forward voltage < 2 V  $I_F = 4.5 A$ ٧F 1,6 V typ. Transition frequency at f = 5 MHz 7 MHz  $I_C = 0.1 A; V_{CE} = 5 V$ fΤ typ. Collector capacitance at f = 1 MHz  $I_E = I_e = 0; V_{CB} = 10 \text{ V}$  $C_c$ 125 pF typ. Second-breakdown current 11 A  $V_{CF} = 120 \text{ V}$ ; t = 200  $\mu$ s I(SB) >

<sup>\*</sup> Measured with a half-sinewave voltage (curve tracer).



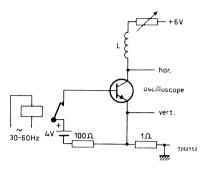


Fig. 2 Oscilloscope display for V<sub>CEOsust</sub>.

Fig. 3 Test circuit for V<sub>CEOsust</sub>.

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  $\mu$ s  $t_s$  typ. 6,5  $\mu$ s

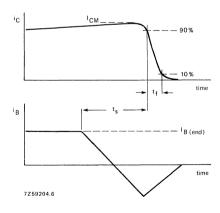


Fig. 4 Switching times waveforms.

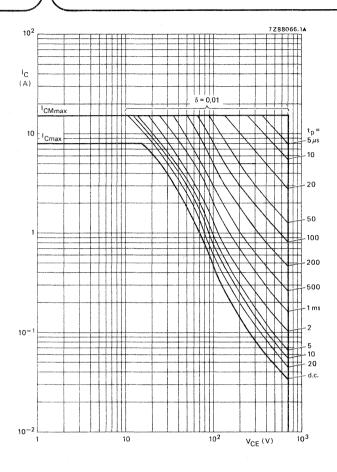


Fig. 5 Safe Operating Area;  $T_{mb} \le 25$  °C.

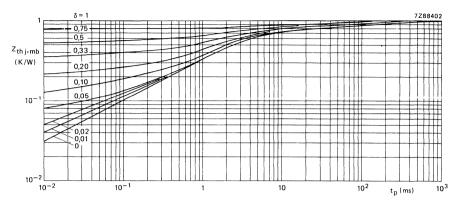


Fig. 6 Pulse power rating chart.

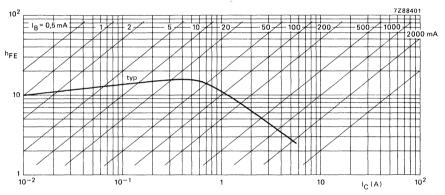


Fig. 7 Typical values d.c. current gain at  $V_{CE}$  = 5 V;  $T_{mb}$  = 25 °C.

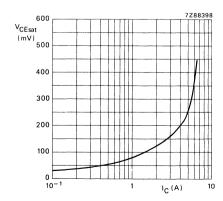


Fig. 8 Typical values  $I_C/I_B = 2$ ;  $T_j = 25$  °C.

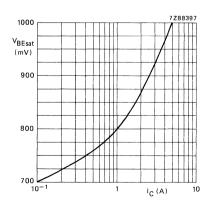


Fig. 9 Typical values  $I_C/I_B = 2$ ;  $T_i = 25$  °C.

#### APPLICATION INFORMATION - HORIZONTAL DEFLECTION CIRCUIT WITH BU508D

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 15%, 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  $\pm$  10%.

The BU508D is essentially a BU508A with an integrated speed-up diode without parasitic base-emitter resistor. A circuit, optimized for BU508A, thus can be used with a BU508D without alterations. It should be remarked that the total device dissipation increases due to losses in the diode.

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 —dlg/dt, see Fig. 12.

The maximum transistor dissipation largely depends on the tolerances in the drive conditions. The dissipation given in Fig. 13 allows for base current and  $-dl_B/dt$  tolerances of  $\pm$  15%. The curve applies for a limit-case transistor at a mounting base temperature of 85 °C.

The thermal resistance for the heatsink can be calculated from  $R_{th mb-a} = \frac{85 - T_{amb max}}{P_{tot max}}$  in which

T<sub>amb max</sub> 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<sub>amb</sub> in the above equation is 45 °C.

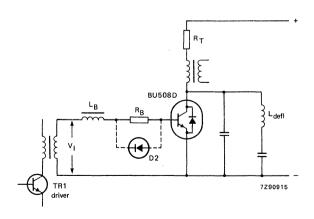


Fig. 10 Simplified horizontal deflection circuit.

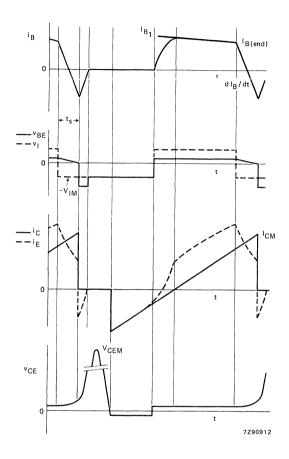


Fig. 11 Fundamental waveforms.

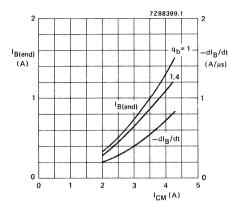


Fig. 12 Nominal end value of the base current and its rate of fall during turn-off as a function of nominal peak collector current. A 15% spread allowance is included on these nominal values.  $Q_B$  is defined as  $I_B1/I_B(end)$  (see Fig.11). The reverse drive voltage during the storage and fall time ( $-V_{IM}$ ) must be > 2 V).

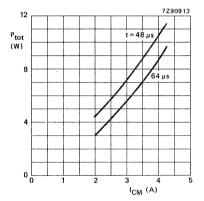


Fig. 13 Worst-case dissipation of BU508D under limited operational conditions according to Fig. 12.  $T_{mb}$  = 85  $^{o}$ C.

# SILICON DIFFUSED POWER TRANSISTOR

High-voltage, high-speed switching, glass passivated n-p-n power transistor in a SOT-93A envelope, intended for use in horizontal deflection circuits of television receivers.

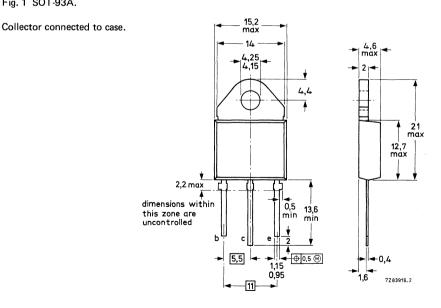
#### QUICK REFERENCE DATA

Collector-emitter voltage (V <sub>BE</sub> = 0; peak value)	V <sub>CESM</sub>	max.	1500 \	V
Collector-emitter voltage (open base)	VCEO	max.	700	٧
Collector current (d.c.)	IC	max.	2,5	Α
Collector current (peak value, $t_p < 2 \text{ ms}$ )	I <sub>СМ</sub>	max.	4 /	Α
Total power dissipation up to $T_{mb} = 25  {}^{\circ}C$	$P_{tot}$	max.	75 \	W
Collector-emitter saturation voltage $I_C = 2 A$ ; $I_B = 0.9 A$	V <sub>CEsat</sub>	<	5 '	V
Fall time				
$I_{Con} = 2 A; I_{B(end)} = 0.9 A$	t <sub>f</sub>	typ.	0,9	μs

### MECHANICAL DATA

Fig. 1 SOT-93A.

Dimensions in mm

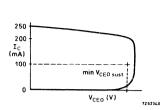


See also chapters Mounting instructions and Accessories.

## **RATINGS**

NATINGS			
Limiting values in accordance with the Absolute Maximum	System (IEC 134).		
Collector-emitter voltage (peak value; V <sub>BE</sub> = 0)	<b>VCESM</b>	max.	1500 V
Collector-emitter voltage (open base)	VCEO	max.	700 V
Collector current (d.c.)	I <sub>C</sub>	max.	2,5 A
Collector current (peak value; tp < 2 ms)	I <sub>CM</sub>	max.	4 A
Base current	I <sub>B</sub>	max.	2 A
Base current (peak value; tp < 2 ms)	<sup>i</sup> BM	max.	4 A
Total power dissipation up to T <sub>mb</sub> = 25 °C	P <sub>tot</sub>	max.	75 W
Storage temperature	T <sub>stg</sub>	-65 to	+ 150 °C
Junction temperature	Tj	max.	150 °C
THERMAL RESISTANCE			
From junction to mounting base	R <sub>th j-mb</sub>	=	1,67 K/W
CHARACTERISTICS			
T <sub>j</sub> = 25 °C unless otherwise specified			
Collector cut-off current*			
VCE = VCESMmax; VBE = 0	CES	<	0,15 mA
$V_{CE} = V_{CESMmax}$ ; $V_{BE} = 0$ ; $T_j = 125$ °C	ICES	-	1 mA
Emitter cut-off current I <sub>C</sub> = 0; V <sub>EB</sub> = 5 V	<sup>I</sup> EBO	<	1 mA
Emitter-base voltage	,EBO		,,
I <sub>C</sub> = 0; I <sub>E</sub> = 10 mA	$V_{EBO}$	>	6 V
Saturation voltage			
$I_C = 2 A; I_B = 0.9 A$	V <sub>CEsat</sub>	<	5 V
	$V_{BEsat}$	<	1,3 V
Collector-emitter sustaining voltage $I_C = 100 \text{ mA}$ ; $I_B = 0$ ; $L = 25 \text{ mH}$	VCEOsust	>	700 V
Collector saturation current	CEOsusi	·	
V <sub>CE</sub> = 5 V	I <sub>Csat</sub>	=	2 A
D.C. current gain			
$I_C = 2 A; V_{CE} = 5 V$	hFE	>	2,2
Second breakdown current			
$V_{CE} = 120 \text{ V}; t = 200 \mu \text{s}$	I(SB)	>	2,0 A
Transition frequency at f = 5 MHz	f	tvn	7 MHz
I <sub>C</sub> = 0,1 A; V <sub>CE</sub> = 5 V Collector capacitance at f = 1 MHz	fT	typ.	/ IVII7Z
I <sub>E</sub> = I <sub>e</sub> = 0; V <sub>CB</sub> = 10 V	C <sub>c</sub>	typ.	65 pF
E C C C C C C C C C C C C C C C C C C C	C		•

<sup>\*</sup> Measured with a half-sinewave voltage (curve tracer).



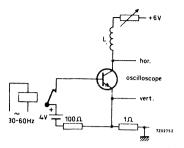


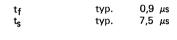
Fig. 2 Oscilloscope display for sustaining voltage.

Fig. 3 Test circuit for sustaining voltage.

Switching times (in horizontal deflection circuit)

 $-V_{IM}$  = 4 V;  $L_{B}$  = 15  $\mu$ H;  $I_{CM}$  = 2 A  $I_{B(end)}$  = 0,9 A;  $-dI_{B}/dt$  = 0,24 A/ $\mu$ s fall time

fall time storage time



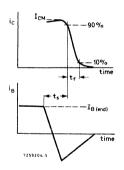


Fig. 4 Switching times waveform.

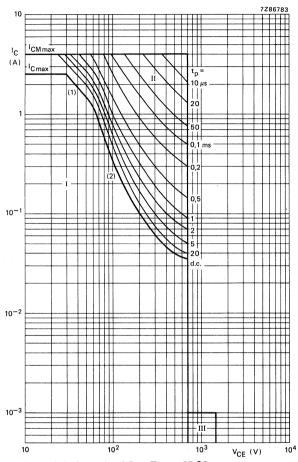


Fig. 5 Safe Operating ARea; T<sub>mb</sub> = 25 °C.

- (1) P<sub>tot max</sub> and P<sub>peak max</sub> lines.
   (2) Second breakdown limits (independent of temperature). Region of permissible d.c. operation.
- 11 Permissible extension for repetitive pulse operation.
- 111 Repetitive pulse operation in this region is allowable, provided R<sub>BE</sub> < 100  $\Omega$ , t<sub>p</sub> = 20  $\mu$ s, d = 0,25.

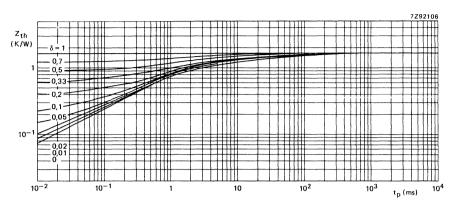


Fig. 6 Pulse power rating chart.  $R_{th j\text{-}mb}$  = 1,67 K/W;  $I_C$  = 1 A;  $V_{CE}$  = 25 V;  $d = \frac{t_p}{T}$ .

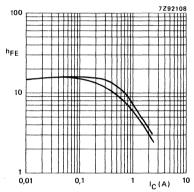


Fig. 7 Typical d.c. current gain.

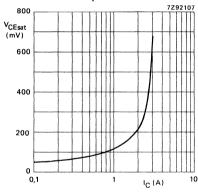


Fig. 8 Typical values  $V_{CEsat}$   $I_c/I_B = 2$ ;  $T_j = 25$  °C.

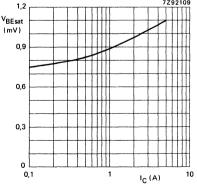


Fig. 9 Typical values  $V_{BEsat}$ ;  $I_{C}/I_{B} = 2$ ;  $T_{j} = 25 \, ^{O}C$ .



# DEVELOPMENT DATA

This data sheet contains advance information and specifications are subject to change without notice.

# SILICON DIFFUSED POWER TRANSISTOR

High-voltage, high-speed switching n-p-n transistor in plastic envelope SOT-93A, and intended for use in horizontal deflection circuits of colour television receivers and in line-operated switch-mode applications.

#### QUICK REFERENCE DATA

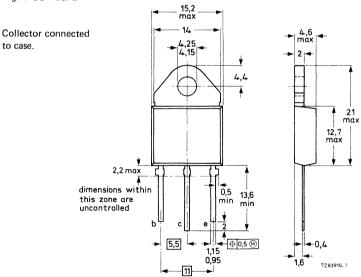
Collector-emitter voltage (V <sub>BE</sub> = 0, peak value)	V <sub>CESM</sub>	max.	1500	٧
Collector-emitter voltage (open base)	$V_{CEO}$	max.	700	٧
Collector saturation current	I <sub>Csat</sub>	=	3	Α
Collector current	<sup>I</sup> C	max.	5	Α
Total power dissipation up to T <sub>mb</sub> = 25 °C	P <sub>tot</sub>	max.	100	W
Collector-emiter saturation voltage $I_C = 3 A$ ; $I_B = 1,33 A$	V <sub>CEsat</sub>	<	5	v
Fall time $I_C = 3 \text{ A}; I_{B \text{ (end)}} = 1 \text{ A}; L_B = 12 \mu\text{H}$	t <sub>f</sub>	typ.	0,7	μs

#### **MECHANICAL DATA**

Dimensions in mm

Fig. 1 SOT-93A.

to case.



For Accessories and Mounting instructions refer to Handbook high-voltage and switching power transistors.

LIMITING VALUES (in accordance with the Absolute Maximum	System IEC 13	34)		
Collector-emitter voltage (V <sub>BE</sub> = 0, peak value)	$V_{CESM}$	max.	1500	V
Collector-emitter voltage (open base)	VCEO	max.	700	V
Collector current (d.c.)	I <sub>C</sub>	max.	5	Α
Collector current (peak value)	ICM	max.	8	Α
Base current (d.c.)	I <sub>B</sub>	max.	3	Α
Base current (peak value)	<sup>I</sup> BM	max.	- 5	Α
Total power dissipation up to T <sub>mb</sub> = 25 °C	$P_{tot}$	max.	100	W
Storage temperature	$T_{stg}$	-65 to	+ 150	οС
Junction temperature	Tj	max.	150	оС
THERMAL RESISTANCE				
From junction to mounting base	R <sub>th j-mb</sub>	= ,	1,25	K/W
CHARACTERISTICS				
T <sub>j</sub> = 25 °C unless otherwise specified				
Collector cut-off current*				
$V_{CE} = V_{CESM max}$ ; $V_{BE} = 0$ $V_{CE} = V_{CESM max}$ ; $V_{BE} = 0$ ; $T_j = 125  {}^{\circ}C$	ICES	< <	•	mA mA
Emitter cut-off current				
$V_{EB} = 6 \text{ V}; I_{C} = 0$	<sup>I</sup> EBO	<	10	mΑ
Second-breakdown current $V_{CE} = 300 \text{ V}; t_p = 200 \mu \text{s}$	I <sub>SB</sub>	>	1	Α
Saturation voltages				
I <sub>C</sub> = 3 A; I <sub>B</sub> = 1,33 A	V <sub>CEsat</sub> V <sub>BEsat</sub>	< <	5 1,3	V V
Collector-emitter sustaining voltage				
I <sub>C</sub> = 0,1 A; I <sub>B</sub> = 0; L = 25 mH	$V_{CEOsus}$	>	700	V
Switching times (in line deflection circuit) $I_{CM} = 3 A; I_{B(end)} = 1 A; L_{B} = 12 \mu H$				
fall time	t <sub>f</sub>	typ.	0,7	•
storage time	t <sub>S</sub>	typ.	6,5	μs

<sup>\*</sup> Measured with a half sine-wave voltage (curve tracer).

This data sheet contains advance information and specifications are subject to change without notice.

## SILICON DIFFUSED POWER TRANSISTOR

High-voltage, high-speed switching n-p-n transistor with integrated efficiency diode in plastic envelope and intended for use in horizontal deflection circuits of colour television receivers and in line-operated switch-mode applications.

## QUICK REFERENCE DATA

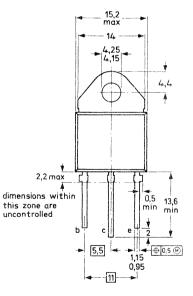
Collector-emitter voltage (V <sub>BE</sub> = 0, peak value)	VCESM	max.	1500 V
Collector-emitter voltage (open base)	$v_{CEO}$	max.	700 V
Collector saturation current	Csat	=	3 A
Collector current	I <sub>C</sub>	max.	5 A
Total power dissipation up to T <sub>mb</sub> = 25 °C	$P_{tot}$	max.	100 W
Collector-emitter saturation voltage $I_C = 3 A$ ; $I_B = 1,33 A$	V <sub>CEsat</sub>	<	5 V
Diode forward voltage at $I_F = 3 A$	٧F	typ.	1,5 V
Fall time $I_C = 3 \text{ A}; I_{B(end)} = 1 \text{ A}; L_B = 12 \mu\text{H}$	t <sub>f</sub>	typ.	0,7 μs

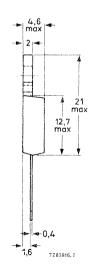
## **MECHANICAL DATA**

Fig. 1 SOT-93A.

Collector connected to case.







Dimensions in mm

For Accessories and Mounting instruction refer to Handbook high-voltage and switching power transistors.

LIMITING VALUES (in accordance with the Absolute Maximum S	System IEC 13	4)		
Collector-emitter voltage (V <sub>BE</sub> = 0, peak value)	<b>VCESM</b>	max.	1500	V
Collector-emitter voltage (open base)	VCEO	max.	700	٧
Collector current (d.c.)	<sup>I</sup> C	max.	5	Α
Collector current (peak value)	<sup>I</sup> CM	max.	8	Α
Base current (d.c.)	<sup>I</sup> B	max.	3	A
Base current (peak value)	I <sub>BM</sub>	max.	5	Α
Total power dissipation up to T <sub>mb</sub> = 25 °C	P <sub>tot</sub>	max.	100	W
Storage temperature	T <sub>stg</sub>	-65 to	+ 100	оС
Junction temperature	Тj	max.	150	οС
THERMAL RESISTANCE				
From junction to mounting base	$R_{th j-mb}$	=	1,25	K/W
CHARACTERISTICS				
T <sub>j</sub> = 25 °C unless otherwise specified				
Collector cut-off current*				
VCE = VCESM max; VBE = 0 $VCE = VCESM max; VBE = 0; T_j = 125 °C$	ICES	<		mA mA
Emitter cut-off current	_			
$V_{EB} = 6 \text{ V}; I_{C} = 0$	<sup>I</sup> EBO	<	10	mΑ
Second-breakdown current V <sub>CE</sub> = 300 V; t <sub>D</sub> = 200 μs	I <sub>SB</sub>	>	1	Α
Saturation voltages	'58		,	^
I <sub>C</sub> = 3 A; I <sub>B</sub> = 1,33 A	V <sub>CEsat</sub> V <sub>BEsat</sub>	< <	5 1,3	V V
Collector-emitter sustaining voltage $I_C = 0.1 \text{ A}; I_B = 0; L = 25 \text{ mH}$	V <sub>CEOsus</sub>	>	700	<b>V</b>
Diode forward voltage	V <sub>F</sub>	typ.	1,5 2,2	
Switching times (in line deflection circuit) $I_{CM} = 3 \text{ A}; I_{B(end)} = 1 \text{ A}; L_{B} = 12 \mu\text{H}$			-,-	
fall time	t <sub>f</sub>	typ.	0,7	μs
storage time	ts	typ.	6,5	μs

<sup>\*</sup> Measured with a half sine-wave voltage (curve tracer).

# SILICON DARLINGTON POWER TRANSISTORS

High voltage n-p-n Darlington circuit with integrated speed-up diode in a plastic TO-220 envelope for industrial fast switching applications and horizontal deflection circuits of monitors and b/w television receivers.

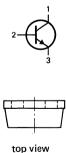
#### QUICK REFERENCE DATA

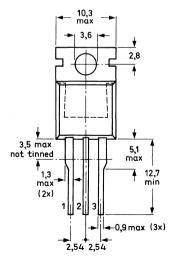
		В	U806	BU807	
Collector-base voltage (open emitter)	V <sub>CBO</sub>	max.	400	330	٧
Collector-emitter voltage (V <sub>EB</sub> = 6 V)	$v_{CEX}$	max.	400	330	٧
Collector-emitter voltage (open base)	$v_{CEO}$	max.	200	150	٧
Collector current (d.c.)	<sup>I</sup> C	max.	•	8	Α
Collector current (peak value) $t_p = 0.3 \text{ ms}; \delta = 10\%$	<sup>I</sup> CM	max.	1	15	Α
Total power dissipation up to T <sub>mb</sub> = 25 °C	$P_{tot}$	max.	6	30	W
Junction temperature	Тj	max.	15	50	oC .
Fall time $I_{Con} = 5 \text{ A}$ ; $I_{Bon} = 50 \text{ mA}$ ; $-I_{Boff} = 500 \text{ mA}$	t <sub>f</sub>	typ.	0	,2	μs

#### **MECHANICAL DATA**

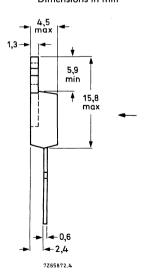
Fig. 1 TO-220AB.

Collector connected to mounting base.





Dimensions in mm



See also chapters Mounting instructions and Accessories.

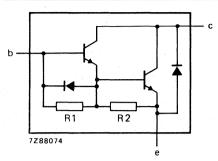


Fig. 2 Circuit diagram.

#### **RATINGS**

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

		В	U806	BU807	
Collector-base voltage (open emitter)	V <sub>CBO</sub>	max.	400	330	V
Collector-emitter voltage (V <sub>EB</sub> = 6 V)	V <sub>CEX</sub>	max.	400	330	٧
Collector-emitter voltage (open base)	V <sub>CEO</sub>	max.	200	150	٧ '
Emitter-base voltage (open collector)	V <sub>EBO</sub>	max.		6	٧
Collector current (d.c.)	lc	max.		8	Α
Collector current (peak value) $t_p = 0.3 \text{ ms}; \delta = 0.1$	ICM	max.		15	A
Base current (d.c.)	I <sub>B</sub>	max.	10	00	mΑ
Total power dissipation up to T <sub>mb</sub> = 25 °C	P <sub>tot</sub>	max.		60 ·	W
Storage temperature	T <sub>stg</sub>		65 to	o + 150	оС
Junction temperature*	$T_{j}$	max.	1!	50	оС
THERMAL RESISTANCE*					
From junction to mounting base	R <sub>th j-mb</sub>	=	2,0	08	K/W
CHARACTERISTICS T <sub>j</sub> = 25 °C unless otherwise specified					
Collector cut-off current**					
$V_{CE} = V_{CESmax}; V_{BE} = 0$	CES	<	- 1	00	μΑ
$V_{CE} = V_{CEXmax}$ ; $V_{EB} = 6 V$	ICEX	<	1	00	μΑ
Emitter cut-off current					
I <sub>C</sub> = 0; V <sub>EB</sub> = 6 V	<sup>I</sup> EBO	<		3	mA
Collector-emitter sustaining voltage		В	U806	BU807	-
I <sub>C</sub> = 100 mA; I <sub>Boff</sub> = 0; L = 25 mH	$V_{CEOsust}$	>	200	150	٧

<sup>\*</sup> 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.

<sup>\*\*</sup> Measured with a half sine wave voltage (curve tracer).

Saturation voltages

$$I_C = 5 A; I_B = 50 mA$$

Diode, forward voltage

1F = 4 A

V<sub>CEsat</sub> < 1,5 V V<sub>BEsat</sub> < 2,8 V V<sub>F</sub> < 2 V

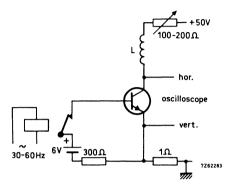


Fig. 3 Test circuit for V<sub>CEOsust</sub>.

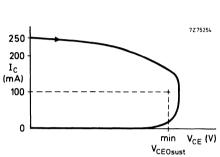


Fig. 4 Oscilloscope display for V<sub>CEOsust</sub>.

Switching times (between 10% and 90% levels)

 $I_{Con} = 5 A; V_{CC} = 100 V$ 

 $I_{Bon} = 50 \text{ mA}$ ;  $-I_{Boff} = 500 \text{ mA}$ 

Turn-on time

Turn-off time: Storage time

Fall time

 $t_{OR}$  typ. 0,35  $\mu$ s  $t_{S}$  typ. 0,55  $\mu$ s  $t_{f}$  typ. 0,2  $\mu$ s

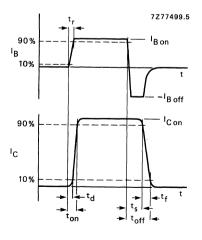


Fig. 5 Waveforms.

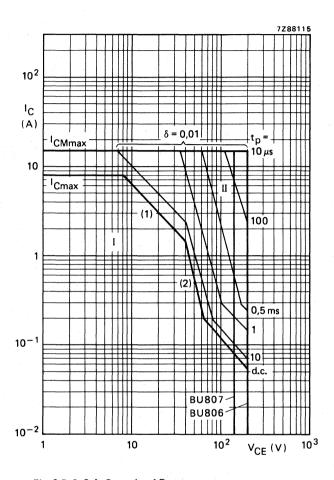


Fig. 6 D.C. Safe Operating ARea.

- I Region of permissible d.c. operation.
- II Permissible extension for repetitive pulse operation.
- (1) P<sub>tot max</sub> and P<sub>tot peak max</sub> lines.(2) Second breakdown limits (independent of temperature).

# SILICON DIFFUSED POWER TRANSISTOR

High-voltage, high-speed, glass-passivated n-p-n switching transistor in a TO-3 envelope, intended for use in three-phase a.c. motor control systems.

## QUICK REFERENCE DATA

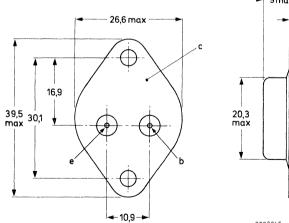
Collector-emitter voltage (peak value; VBE = 0)	VCESM	max.	1500	V
Collector-emitter voltage (open base)	$v_{CEO}$	max.	700	V
Collector current (d.c.)	<sup>I</sup> C	max.	12	Α
Collector current (peak value) $t_p < 2 \text{ ms}$	<sup>I</sup> CM	max.	20	Α
Total power dissipation up to T <sub>mb</sub> = 25 °C	$P_{tot}$	max.	160	W
Collector-emitter saturation voltage $I_C = 9 A; I_B = 4 A$	V <sub>CEsat</sub>	<	1	V
Collector saturation current	Csat	=	9	Α
Fall time ICon = 9 A; IBon = -IBoff = 4 A	t <sub>f</sub>	typ.	0,5	μs

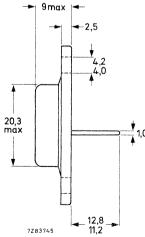
#### **MECHANICAL DATA**

Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.





See also chapters Mounting instructions and Accessories.

## **RATINGS**

RATINGS				
Limiting values in accordance with the Absolute Maximum System	(IEC 134)			
Collector-emitter voltage (peak value; V <sub>BE</sub> = 0)	$v_{CESM}$	max,	1500	V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	700	V
Collector current (d.c.)	IC	max.	12	Α
Collector current (peak value); t <sub>p</sub> < 2 ms	ICM	max.	20	Α
Base current (d.c.)	I <sub>B</sub>	max.	8	Α
Base current (peak value); t <sub>p</sub> < 2 ms	I <sub>BM</sub>	max.	12	Α
Total power dissipation up to T <sub>mb</sub> = 25 °C	P <sub>tot</sub>	max.	160	W
Storage temperature	T <sub>stq</sub>	-65 to	+ 150	οС
Junction temperature	Tj	max.	150	оС
THERMAL RESISTANCE				
From junction to mounting base	R <sub>th j-mb</sub>	=	0,78	K/W
CHARACTERISTICS				
T <sub>i</sub> = 25 <sup>o</sup> C unless otherwise specified				
Collector cut-off current*				
V <sub>CE</sub> = V <sub>CESMmax</sub> ; V <sub>BE</sub> = 0	<sup>I</sup> CES	<	1	mΑ
$V_{CE} = V_{CESMmax}$ ; $V_{BE} = 0$ ; $T_j = 125$ °C	CES	<	4	mΑ
Emitter cut-off current				
$I_C = 0; V_{EB} = 5 V$	IEBO	<	10	mΑ
Saturation voltages				
$I_C = 9 A; I_B = 4 A$	VCEsat	< <		V
I <sub>C</sub> = 12 V; I <sub>B</sub> = 6 A	V <sub>BEsat</sub>	<	1,5	
	V <sub>CEsat</sub>	_	3	٧
Collector-emitter sustaining voltage I <sub>C</sub> = 200 mA; I <sub>B</sub> = 0; L = 25 mH	V <sub>CEOsust</sub>	>	700	٧
Second breakdown collector current				
$V_{CE} = 100 \text{ V; } t_p = 1 \text{ s}$	I(SB)C	>	0,4	Α
Fransition frequency at f = 5 MHz				
$I_C = 0,1 A; V_{CE} = 5 V$	fΤ	typ.	7	MHz
Collector capacitance at f = 1 MHz			000	_
$I_E = I_e = 0$ ; $V_{CB} = 10 \text{ V}$	$c_{C}$	typ.	200	рF

<sup>\*</sup> Measured with a half sine-wave voltage (curve tracer).

Switching times resistive load (Figs 2 and 3)

 $I_{Con} = 9 A$ ;  $I_{Bon} = -I_{Boff} = 4 A$ 

Turn-on time

Turn-off: Storage time

Fall time

 $t_{OR}$  typ. 1,5  $\mu$ s  $t_{S}$  typ. 4,5  $\mu$ s  $t_{f}$  typ. 0,5  $\mu$ s

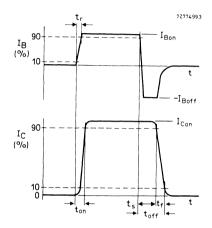


Fig. 2 Switching times waveforms with resistive load.

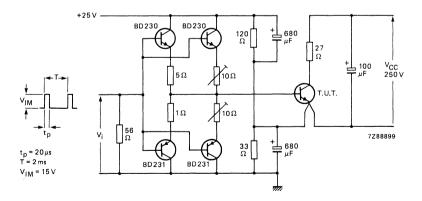


Fig. 3 Test circuit resistive load.

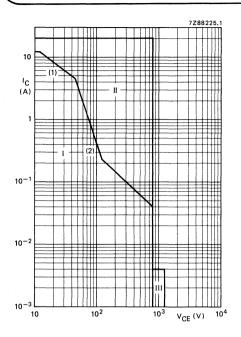


Fig. 4 Safe Operating ARea at  $T_{mb} \le 25$  °C.

- (1) P<sub>tot max</sub> line.
- (2) Second-breakdown limits (independent of temperature).
- I Region of permissible d.c. operation.
- II Permissible extension for repetitive pulse operation.
- III Repetitive pulse operation in this region is permissible, provided  $V_{BE} \le 0$  and  $t_D \le 5$  ms.

# DEVELOPMENT DATA

This data sheet contains advance information and specifications are subject to change without notice.

## SILICON N-P-N DARLINGTON TRANSISTOR

Monolithic high voltage n-p-n Darlington transistor with integrated speed-up diode in a TO-202 envelope intended for fast switching applications such as small motor control and switch-mode power supplies.

#### QUICK REFERENCE DATA

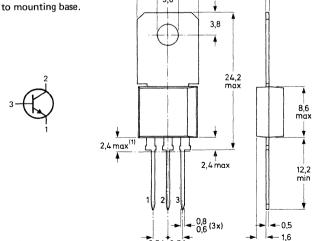
Collector-emitter voltage VRF = 0; peak value	Vcesm	max.	650 V
Collector-emitter voltage (open base)	$v_{CEO}$	max.	375 V
Collector current (d.c.)	<sup>I</sup> C	max.	0,5 A
Collector current (peak value)	ICM	max.	1 A
Total power dissipation up to T <sub>amb</sub> = 25 °C up to T <sub>mb</sub> = 25 °C	P <sub>tot</sub> P <sub>tot</sub>	max. max.	2 W 12,5 W
Collector-emitter saturation voltage $I_C = 200 \text{ mA}$ ; $I_B = 600 \mu A$	V <sub>CEsat</sub>	<	5 V
Collector saturation current	I <sub>Csat</sub>		0,2 A

## **MECHANICAL DATA**

Dimensions in mm

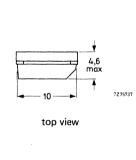


Fig. 1 TO-202.

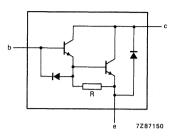


2,54 2,54

10,4 max 3,8 3,6



See also chapters Mounting instructions and Accessories.



R typ.  $600 \Omega$ 

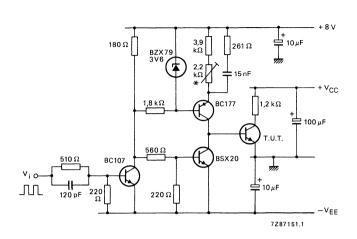
Fig. 2 Circuit diagram.

## **RATINGS**

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

Eliming values in accordance with the Absolute Maxi	mam bystem (120 10-1)			
Collector-emitter voltage				
V <sub>BE</sub> = 0; peak value	VCESM	max.	650 V	
Collector-emitter voltage (open base)	VCEO	max.	375 V	
Collector current (d.c.)	l <sub>C</sub>	max.	0,5 A	
Collector current (peak value)	ICM	max.	1 A	٠.
Base current (d.c.)	I <sub>B</sub>	max.	0,2 A	
Base current	I <sub>BM</sub>	max.	1 A	
Total power dissipation				
up to T <sub>amb</sub> = 25 °C	P <sub>tot</sub>	max.	2 W	
up to $T_{mb} = 25$ °C	P <sub>tot</sub>	max.	12,5 W	1
Storage temperature	$T_{stg}$	65 to	+ 150 °C	С
Junction temperature	Тj	max.	150 °	С
THERMAL RESISTANCE				
From junction to mounting base	R <sub>th j-mb</sub>	=	10 K	/W
From junction to ambient	R <sub>th j-amb</sub>	=	62,5 K	./W
CHARACTERISTICS				
T <sub>j</sub> = 25 °C unless otherwise specified				
Collector cut-off current*				
$V_{CE} = V_{CESMmax}; V_{BE} = 0$	CES	< <	0,1 m	
$V_{CE} = V_{CESMmax}$ ; $V_{BE} = 0$ ; $T_j = 125  {}^{\circ}C$	<sup>I</sup> CES	<	0,2 m	ıΑ
Emitter cut-off current	•			
$I_C = 0; V_{EB} = 5 V$	<sup>I</sup> EBO	3,	3 to 20 m	ıΑ
Collector-emitter sustaining voltage $I_B = 0$ ; $I_C = 250$ mA; $L = 25$ mH**	V <sub>CEOsust</sub>	>	375 V	,
Saturation voltages				
$I_C = 200 \text{ mA}; I_B = 600 \mu A$	$v_{CEsat}$	< <	5 V 2 V	

- \* Measured with a half-sinewave voltage (curve tracer).
- \*\* Clamped at rated VCEOsust



\* For adjustment of IB = 0,9 mA, VEE = 0 V.

Fig. 3 Switching times test circuit.

Switching times

 $I_{Con}$  = 200 mA;  $V_{CC}$  = 250 V;  $T_j$  = 100 °C;  $I_{BM}$  = 5 mA;  $I_B$  = 0,9 mA;  $V_{EE}$  = 1 V

rise time

storage time

fall time

1 μs 1,5 µs

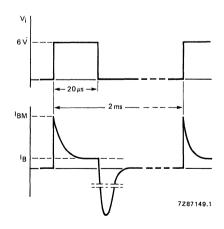


Fig. 4 Input current and base current waveforms.

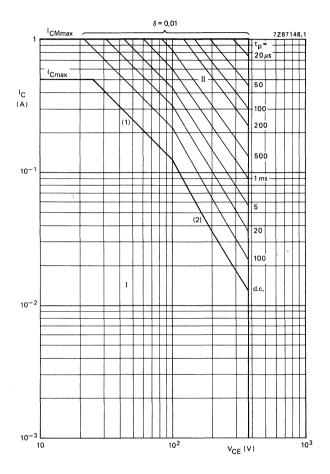


Fig. 5 Safe Operating ARea,  $T_{mb} \le 25$  °C.

- Region of permissible d.c. operation.
- II Permissible extension for repetitive pulse operation.
- (1) P<sub>tot max</sub> and P<sub>peak max</sub> lines.
   (2) Second-breakdown limits (independent of temperature).

# SILICON DARLINGTON POWER TRANSISTOR

Monolithic high voltage n-p-n Darlington circuit with integrated speed-up diode in a plastic SOT-93 envelope, intended for fast switching application.

#### QUICK REFERENCE DATA

Collector-emitter voltage (V <sub>BE</sub> = 0; peak value)	$V_{CESM}$	max.	800 V
Collector-emitter voltage (open base)	$v_{CEO}$	max.	375 V
Collector current (d.c.)	<sup>1</sup> C	max.	6 A
Collector current (peak value)			
$t_p$ < 2 ms	ICM	max.	8 A
Total power dissipation up to T <sub>mb</sub> = 25 °C	$P_{tot}$	max.	125 W
Collector-emitter saturation voltage			
$I_C = 2,5 \text{ A}; I_B = 55 \text{ mA}$	$v_{CEsat}$	<	2,0 V
$I_C = 4 \text{ A}; I_B = 200 \text{ mA}$	$v_{CEsat}$	<	2,5 V
Collector saturation current	Csat	=	2,5 A
Fall time			
I <sub>Con</sub> = 2,5A; I <sub>Bon</sub> = 55 mA; -I <sub>Boff</sub> = 1 A	t <sub>f</sub>	typ.	0,2 μs

## **MECHANICAL DATA** 15,2 Fig. 1 SOT-93. max Collector connected to max mounting base. 4,15 12,7 máx 2,2 max dimensions within 0,5 13.6 this zone are min uncontrolled b ⊕ 0,5 ⊛ 1,15 1,6 7Z75220.3

Dimensions in mm

See also chapters Mounting instructions and Accessories in Data Handbook S4b.

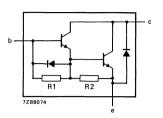


Fig. 2 Circuit diagram.

R1 typ. 200  $\Omega$  R2 typ. 100  $\Omega$ 

## **RATINGS**

Collector-emitter voltage (V <sub>BE</sub> = 0, peak value)	V <sub>CESM</sub>	max.	800	٧	
Collector-emitter voltage (open base)	V <sub>CEO</sub>	max.	375	٧	
Collector current (d.c.)	IC .	max.	6	Α	
Collector current (peak value)					
$t_p < 2 \text{ ms}$	<sup>I</sup> CM	max.	8	Α	
Base current (d.c.)	I <sub>B</sub>	max.	2	Α	
Base current (peak value)	I <sub>BM</sub>	max.	3	Α	
Total power dissipation up to T <sub>mb</sub> = 25 °C	$P_{tot}$	max.	125	W	
Storage temperature	$T_{stg}$	-65 to +	150	οС	
Junction temperature*	T <sub>i</sub>	max.	150	οС	
	•				

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

THERMAL RESISTANCE\*

From junction to mounting base  $R_{th j-mb} = 1,0 \text{ K/W}$ 

<sup>\*</sup> 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.

1 mA

2 mA

150 mA

50 mA

375 V

2,0 V

2,2 V

2,5 V

2,5 A

#### CHARACTERISTICS

$T_i$	=	25	oC	unless	otherwise	specified
-------	---	----	----	--------	-----------	-----------

Collector	cut-off	current*

VCE - VCESMmax, VBE - 0	
$V_{CE} = V_{CESMmax}$ ; $V_{BE} = 0$ ; $T_j = 125  {}^{\circ}C$	
mitter cut-off current	

Emitter cut-off current  $I_C = 0$ ;  $V_{EB} = 8 V$ 

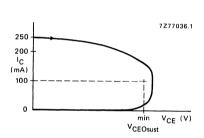
Saturation voltages

$$I_C = 2.5 \text{ A}; I_B = 55 \text{ mA}$$

$$I_C = 4 A$$
;  $I_B = 200 \text{ mA}$ 

+50 V
L { vert.
oscilloscope
hor. oscilloscope
1Ω

Fig. 3 Test circuit for VCEOsust-



ICES

<sup>I</sup>CES

IFRO

**VCEOsust** 

V<sub>CEsat</sub> V<sub>BEsat</sub>

**V**CEsat

Csat

<

<

<

<

Fig. 4 Oscilloscope display for VCEOsust-

<sup>\*</sup> Measured with a half sine wave voltage (curve tracer).

#### CHARACTERISTICS (continued)

Switching times (between 10% and 90% levels)

 $I_{Con}$  = 2,5 A;  $V_{CC}$  = 250 V  $I_{Bon}$  = 55 mA;  $-I_{Boff}$  = 1 A

Turn-on time

Turn-off time: Storage time

Fall time

Fall time;  $T_{mb} = 100 \text{ }^{\circ}\text{C}$ 

ton	< .	1,3 μs
		0.0

 $t_s$  < 2,0  $\mu s$ 

 $t_f$  typ. 0,2  $\mu$ s

 $t_f$  < 0,6  $\mu$ s

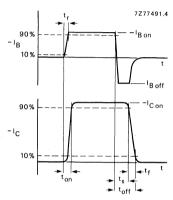


Fig. 5 Waveforms.

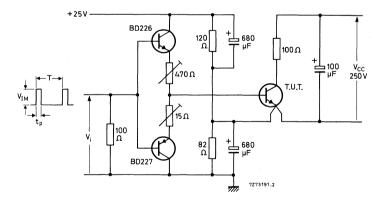


Fig. 6 Test circuit. T = 2 ms;  $t_p$  = 20  $\mu$ s;  $V_{1M}$  = 15 V.

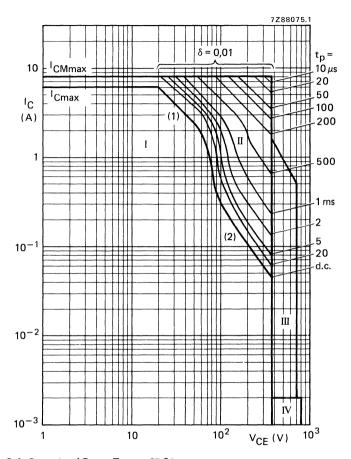


Fig. 7 Safe Operating ARea at  $T_{amb}$  = 25 °C.

- 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  $t_p < 1.3 \,\mu s.$
- IV Repetitive pulse operation in this region is permissible, provided VBE  $\leqslant$  0 and  $t_p \leqslant$  2 ms.
- (1) P<sub>tot max</sub> and P<sub>peak max</sub> lines.(2) Second-breakdown limits (independent of temperature).

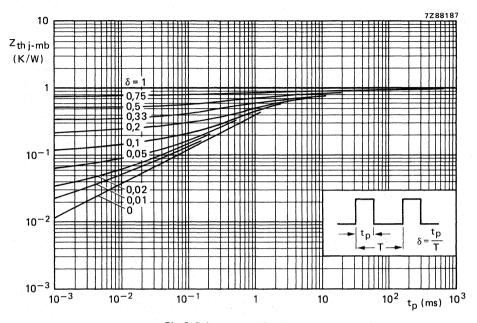


Fig. 8 Pulse power rating chart.

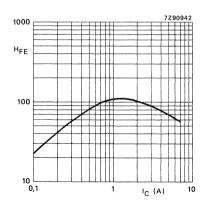


Fig. 9 D.C. current gain.

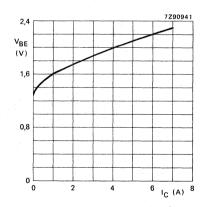


Fig. 10  $V_{BEsat}$  curve;  $T_j = 25^{\circ}$  C; typical values.

# **DEVELOPMENT DATA**

This data sheet contains advance information and specifications are subject to change without notice.

# SILICON DIFFUSED POWER TRANSISTORS

High-voltage, high-speed, glass-passivated n-p-n power transistors in a SOT-93 envelope, intended for use in converters, inverters, switching regulators, motor control systems etc.

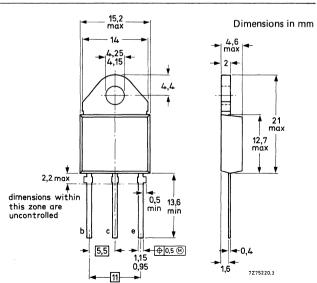
## QUICK REFERENCE DATA

			BUP22	Α	В	С	
Collector-emitter voltage $V_{BE} = 0$ ; peak value	V <sub>CESM</sub>	max.	550	650	750	850 V	
Collector-emitter voltage open base	V <sub>CEO</sub>	max.	300	350	400	450 V	
Collector saturation current	<sup>I</sup> Csat		6	6	6	6 A	
Collector current (d.c.)	l <sub>C</sub>	max.	8	8	8	8 A	
Collector current (peak value)	ICM	max.	20	20	20	20 A	
Total power dissipation up to T <sub>mb</sub> = 25 °C	P <sub>tot</sub>	max.	125	125	125	125 W	
Collector-emitter saturation voltage $I_C = 6 A$	V <sub>CEsat</sub>	<	1,5	1,5	1,5	1,5 V	
D.C. current gain $I_C = 1 A$ ; $V_{CE} = 5 V$ $I_C = 6 A$ ; $V_{CE} = 1,5 V$	hFE hFE	typ.	25 10	25 9	25 7,5	25 6	

#### **MECHANICAL DATA**

Fig. 1 SOT-93.

Collector connected to case.



For accessories and mounting instructions see Handbook I.f. power transistors.

# **BUP22 SERIES**

### RATINGS

			,		• •			
				BUP22	Α	В	C	
	Collector-emitter voltage							
	V <sub>BE</sub> = 0; peak value	VCESM	max.	550	650	750	850	V
	Collector-emitter voltage							
	open base	VCEO	max.	300	350	400	450	V
	Collector current (d.c.)	Ic	max.			8		Α
	Collector current (peak value)	ICM	max.		2	0		Α
	Base current (d.c.)	I <sub>B</sub>	max.			4		Α
	Total power dissipation							
	up to T <sub>mb</sub> = 25 °C	P <sub>tot</sub>	max.		12	5		W
	Storage temperature	$T_{stg}$		65	to + 15	0		oC
	Junction temperature	Τį	max.		. 15	0		oC
	THERMAL RESISTANCE							
	From junction to mounting base	R.L.	_ :			1		K/W
	Trom junction to mounting base	R <sub>th j-mb</sub>				•		10/ 11
	CHARACTERISTICS							
	T <sub>j</sub> = 25 °C unless otherwise specified							
	Collector cut-off current*							
	$V_{CE} = V_{CESMmax}$ ; $V_{BE} = 0$	<sup>I</sup> CES	<b>/</b>			1		mA
-	$V_{CE} = V_{CESMmax}; V_{BE} = 0;$							
	T <sub>j</sub> = 125 °C	CES	<			2		mΑ
	Emitter cut-off current							
	$I_C = 0$ ; $V_{EB} = 9 V$	IEBO	<		1	0		mA
	D.C. current gain							
	$I_C = 1 A; V_{CE} = 5 V$	hFE	typ.		. 2	5		
				BUP22	Α	В	С	
	Collector-emitter sustaining voltage							
•	I <sub>B</sub> = 0; I <sub>C</sub> = 0,1 A; L = 25 mH	VCEOsust	>	300	350	400	450	V
	Saturation voltages			4.5				.,
	I <sub>C</sub> = 6 A; I <sub>B</sub> = 0,6 A	V <sub>CEsat</sub> V <sub>BEsat</sub>	<	1,5 1,5	· —	_	- <del>-</del>	V V
	I <sub>C</sub> = 6 A; I <sub>B</sub> = 0,67 A			1,5	1.5			V
	10 0 A, 18 0,07 A	V <sub>CEsat</sub> V <sub>BEsat</sub>	< <		1,5 1,5			V
	I <sub>C</sub> = 6 A; I <sub>B</sub> = 0,8 A	VCEsat	<	_		1,5	_	V
		VBEsat	<		- 1	1,5	-	Ň
	I <sub>C</sub> = 6 A; I <sub>B</sub> = 1 A	V <sub>CEsat</sub>	<	,—	_		1,5	
		VBEsat	<	,	-	-	1,5	V

<sup>\*</sup> Measured with half sine-wave voltage (curve tracer).

# DEVELOPMENT DATA

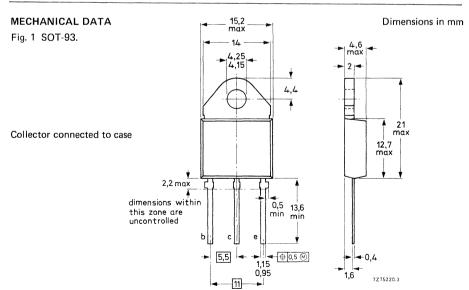
This data sheet contains advance information and specifications are subject to change without notice.

# SILICON DIFFUSED POWER TRANSISTORS

High-voltage, high-speed, glass-passivated n-p-n power transistors in a SOT-93 envelope, intended for use in converters, switching regulators, motor control systems etc.

#### QUICK REFERENCE DATA

Collector-emitter voltage			BUP23	А	В	С
V <sub>BE</sub> = 0; peak value	$v_{CESM}$	max.	550	650	750	850 V
Collector-emitter voltage						
open base	$v_{CEO}$	max.	300	350	400	450 V
Collector saturation current	I <sub>Csat</sub>	=	10	10	10	10 A
Collector current (d.c.)	<sup>I</sup> C	max.	15	15	15	15 A
Collector current (peak value)	<sup>I</sup> CM	max.	30	30	30	30 A
Total power dissipation	D	ma.a	175	175	175	175 W
up to T <sub>mb</sub> = 25 <sup>o</sup> C	$P_{tot}$	max.	175	175	1/5	1/5 W
Collector-emitter saturation voltage $I_C = 10 \text{ A}$	V <sub>CEsat</sub>	<	1,5	1,5	1,5	1,5 V
D.C. current gain						
$I_C = 1,5 A; V_{CE} = 5 V$	hee	typ.	25	25	25	25
$I_C = 10 \text{ A}; V_{CE} = 1.5 \text{ V}$	hFE	>	10	9	7,5	6



For accessories and mounting instructions see Handbook I.f. power transistors.

# **BUP23 SERIES**

### **RATINGS**

Limiting values in accordance with the Absc	Jule Maximul	ii Oyste		1	1	١ ۵	
Collector-emitter voltage			BUP23	Α	В	С	
V <sub>BE</sub> = 0; peak value	VCESM	max.	550	650	750	850	٧
Collector-emitter voltage							
open base	VCEO	max.	300	350	400	450	V
Collector current (d.c.)	IC .	max.			15		Α
Collector current (peak value)	<sup>I</sup> CM	max.		;	30		Α
Base current (d.c.)	I <sub>B</sub>	max.			6		Α
Base current (peak value)	<sup>I</sup> BM	max.			9		Α
Total power dissipation							
up to $T_{mb} = 25$ °C	$P_{tot}$	max.		1	75		W
Storage temperature	$T_{stg}$			-65 t	to + 150	)	оС
Junction temperature	T <sub>j</sub>	max.		1	50		оС
THERMAL RESISTANCE							
From junction to mounting base	R <sub>th j-mb</sub>	=		. (	0,7		K/W
CHARACTERISTICS							
T <sub>j</sub> = 25 °C unless otherwise specified							
Collector cut-off current*							
$V_{CE} = V_{CESMmax}$ ; $V_{BE} = 0$	ICES	<			1		mΑ
Emitter cut-off current					10		A
I <sub>C</sub> = 0; V <sub>EB</sub> = 9 V	<sup>I</sup> EBO	<			10		mΑ
D.C. current gain	h=-	typ.			25		
I <sub>C</sub> = 1,5 A; V <sub>CE</sub> = 5 V	hFE	typ.	BUP23	A	23	l c	
Collector-emitter sustaining voltage							-
$I_B = 0$ ; $I_C = 0.1 A$ ; $L = 25 \text{ mH}$	V <sub>CEOsust</sub>	>	300	350	400	450	V
Saturation voltages							
I <sub>C</sub> = 10 A; I <sub>B</sub> = 1 A	VCEsat	<	1,5 1,5	-	_	_	V V
	VBEsat		·	1.5		-	V
I <sub>C</sub> = 10 A; I <sub>B</sub> = 1,11 A	V <sub>CEsat</sub> V <sub>BEsat</sub>	< <	_	1,5 1,5	_	_	V
I <sub>C</sub> = 10 A; I <sub>B</sub> = 1,33 A	V <sub>CEsat</sub>	<		_	1,5	-	V
	$V_{BEsat}$	<	_	_	1,5	-	V
$I_C = 10 \text{ A}; I_B = 1,67 \text{ A}$	V <sub>CEsat</sub> V <sub>BEsat</sub>	< <	_	-	_ _	1,5 1,5	5 V 5 V

<sup>\*</sup> Measured with half sine-wave voltage (curve tracer).

# SILICON DIFFUSED POWER TRANSISTORS



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

### QUICK REFERENCE DATA

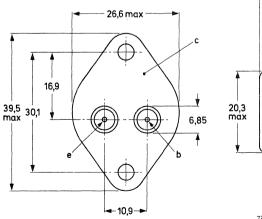
		_	BUS11	BUS11A
Collector-emitter voltage ( $V_{BE} = 0$ , peak value)	V <sub>CESM</sub>	max.	850	1000 V
Collector-emitter voltage (open base)	$v_{CEO}$	max.	400	450 V
Collector current (d.c.)	1 <sub>C</sub>	max.		5 A
Collector current (peak value) $t_p \le 2$ ms	ICM	max.		10 A
Total power dissipation up to $T_{mb} = 25$ °C	$P_{tot}$	max.	1	00 W
Collector-emitter saturation voltage $I_C = 3 A; I_B = 0.6 A$ $I_C = 2.5 A; I_B = 0.5 A$	V <sub>CEsat</sub> V <sub>CEsat</sub>	< <	1,5 -	– V 1,5 V
Fall time (resistive load) $I_{Con} = 3 \text{ A; } I_{Bon} = -I_{Boff} = 0,6 \text{ A}$ $I_{Con} = 2,5 \text{ A; } I_{Bon} = -I_{Boff} = 0,5 \text{ A}$	t <sub>f</sub> t <sub>f</sub>	< <	0,8	— μs 0,8 μs

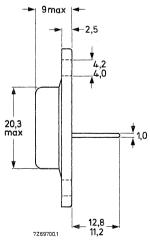
### **MECHANICAL DATA**

Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.





Products approved to CECC 50 004-124 available on request.

See also chapters Mounting instructions and Accessories.

# BUS11 BUS11A

## **RATINGS**

			BUS11	BUS11	Α
Collector-emitter voltage (V <sub>BE</sub> = 0, peak value)	V <sub>CESM</sub>	max.	850	1000	٧
Collector-emitter voltage (open base)	$V_{CEO}$	max.	400	450	V
Collector current (d.c.)	1 <sub>C</sub>	max.		5	Α
Collector current (peak value) tp < 2 ms	ICM	max.	1	0	Α
Base current (d.c.)	l <sub>B</sub>	max.		2	Α
Base current (peak value); $t_p < 2$ ms	I <sub>BM</sub>	max.		3	Α
Total power dissipation up to T <sub>mb</sub> = 25 °C	$P_{tot}$	max.	10	00	W
Storage temperature	T <sub>stg</sub>		-65 to +20	00	оС
Junction temperature	Tj	max.	20	00	oC
THERMAL RESISTANCE					
From junction to mounting base	R <sub>th j-mb</sub>	=	1,7	75	K/W
CHARACTERISTICS					
T <sub>j</sub> = 25 °C unless otherwise specified					
Collector cut-off current *					
$V_{CE} = V_{CESMmax}; V_{BE} = 0$	ICES	<		1	mΑ
$V_{CE} = V_{CESMmax}$ ; $V_{BE} = 0$ ; $T_j = 125  {}^{\circ}C$	<sup>I</sup> CES	<		2	mΑ
Emitter cut-off current		_			
$I_C = 0; V_{EB} = 9 V$	IEBO	<		10	mΑ
Saturation voltages			BUS11	BUS11	Α
Ic = 3 A; I <sub>B</sub> = 0,6 A	$v_{CEsat}$	<	1,5	_	٧
I <sub>C</sub> = 2,5 A; I <sub>B</sub> = 0,5 A	VCEsat	<		1,5	V
$I_C = 3 A; I_B = 0.6 A$	<b>VBEsat</b>	<	1,4	_	٧
$I_C = 2,5 \text{ A}; I_B = 0,5 \text{ A}$	$V_{BEsat}$	<		1,4	V
Collector-emitter sustaining voltage	M		400	450	v
$I_C = 100 \text{ mA}; I_{Boff} = 0; L = 25 \text{ mH}$	VCEOsus	t^	400	450	V

<sup>\*</sup> Measured with a half sine-wave voltage (curve tracer).

### CHARACTERISTICS (continued)

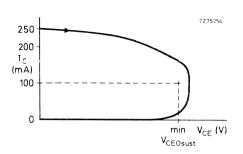


Fig. 2 Oscilloscope display for sustaining voltage.

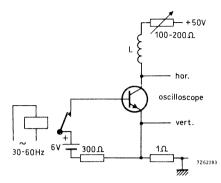


Fig. 3 Test circuit for VCEOsust-

Switching times resistive load (Figs 4 and 5) ICon = 3 A; IBon = IBoff = 0,6 A Turn-on time
Turn-off: Storage time Fall time
$I_{Con} = 2.5 \text{ A}$ ; $I_{Bon} = -I_{Boff} = 0.5 \text{ A}$ Turn-on time
Turn-off: Storage time Fall time
Switching times inductive load (Figs 6 and 7) $I_{Con} = 3 \text{ A}$ ; $I_{B} = 0.6 \text{ A}$ Turn-off: Storage time
Fall time
$I_{Con} = 3 \text{ A}$ ; $I_{B} = 0.6 \text{ A}$ ; $T_{j} = 100 ^{\circ}\text{C}$ Turn-off: Storage time
Fall time
Switching times inductive load (Figs 6 and 7) $I_{Con} = 2.5 \text{ A}$ ; $I_{B} = 0.5 \text{ A}$ Turn-off: Storage time
Fall time
$I_{Con}$ = 2,5 A; $I_{B}$ = 0,5 A; $T_{j}$ = 100 °C Turn-off: Storage time
Fall time

		BUS11	BUS11A	
ton	<	1	-	μs
ts	< < <	4		μs
t <sub>f</sub>	<	0,8		μs
·				
ton	<		1	μs
ts	< < <		4	μs
tf	<		0,8	μs
	tun	1,1		
$t_{S}$	typ.	1,4		μs μs
	typ.	80	_	ns
tf	<	150	_	ns
ts	typ.	1,2		μs
-5	<	1,5		μs
tf	typ.	140 300		ns
		300		ns
+	typ.		1,1	$\mu$ s
t <sub>s</sub>	<		1,4	$\mu$ s
t <sub>f</sub>	typ.		80	ns
-1	<		150	ns
	typ.		1,2	μs
ts	<		1,5	μs
	typ.		140	ns
tf	<		300	ns

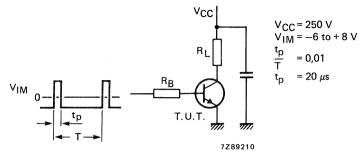


Fig. 4 Test circuit resistive load.

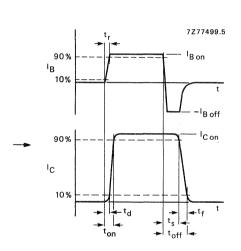


Fig. 5 Switching times waveforms with resistive load.

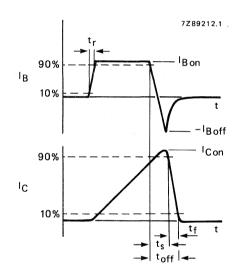


Fig. 6 Switching times waveforms with inductive load.

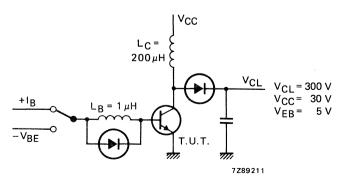
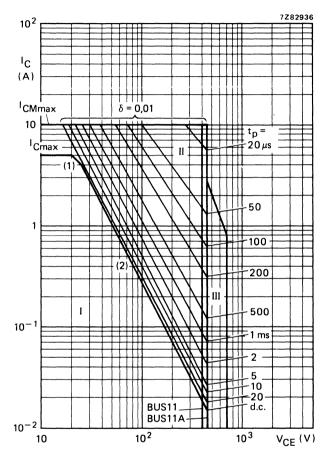


Fig. 7 Test circuit inductive load.



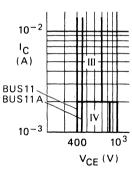


Fig. 8 Safe Operating ARea at  $T_{mb} \le 25$  °C.

- (1) P<sub>tot max</sub> and P<sub>tot peak</sub> max. lines.(2) Second-breakdown limits.
- 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 RBE  $\leq$  100  $\Omega$  and tp  $\leq$  0,6  $\mu$ s.
- IV Repetitive pulse operation in this region is permissible provided  $V_{BE} \le 0$  and  $t_p \le 2$  ms.

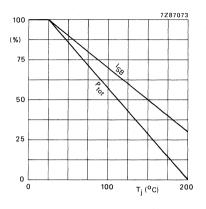


Fig. 9 Total power dissipation and second-breakdown current derating curve.

Fig. 10 Reverse bias SOAR.

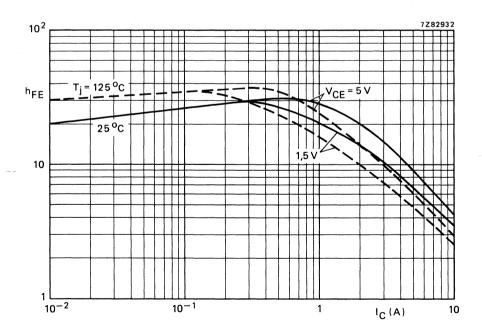


Fig. 11 D.C. current gain.

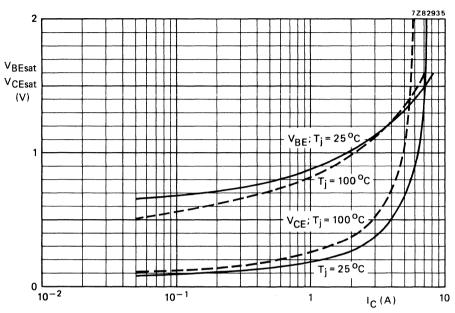


Fig. 12 Typical values base-emitter and collector-emitter voltage,  $I_C/I_B = 5$ .

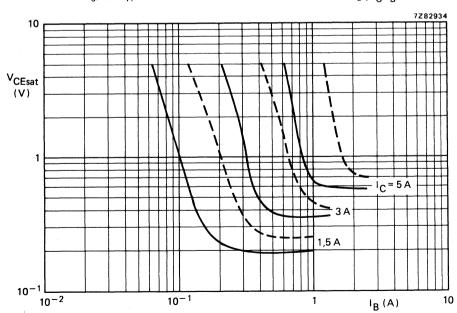


Fig. 13 Typ. (——) and max. (---) values collector-emitter saturation voltage at  $T_j = 25$  °C.

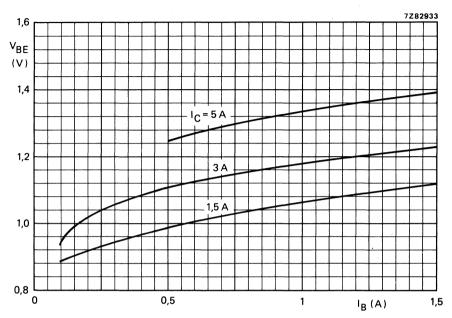


Fig. 14 Typical values at  $T_j = 25$  °C.

#### APPLICATION INFORMATION

Important design factors of SMPS circuits are the maximum power losses, heatsink requirements and base drive conditions of the switching transistor. The power losses are very dependent on the operating frequency, the maximum collector current amplitude and shape.

The operating frequency is mostly set between 15 and 50 kHz. The collector current shape varies from rectangular in a forward converter to sawtooth in a flyback converter.

Information on nominal base drive, optimum base inductance and maximum transistor dissipation applied in a forward converter is given in Figs 15, 16 and 17. In these figures I<sub>CM</sub> represents the maximum repetitive peak collector current, which occurs during overload. The information is derived from limit-case transistors at a mounting base temperature of 100 °C under the following conditions (see also Fig. 15):

- collector current shape I<sub>C1</sub>/I<sub>CM</sub> = 0,9
- duty factor  $t_p/T = 0.45$
- rate of rise of I<sub>C</sub> during turn-on =  $4 \text{ A}/\mu\text{s}$
- rate of rise of  $V_{CF}$  during turn-off = 1 kV/ $\mu$ s
- reverse drive voltage during turn-off = 5 V
- base current shape  $I_{B1}/I_{Be} = 1,5$

The required thermal resistance of the heatsink can be calculated from

$$R_{th mb-a} < \frac{100 - T_{amb}}{P_{tot}} K/W$$

To ensure thermal stability the value of the ambient temperature  $T_{amb} > 40$  °C.

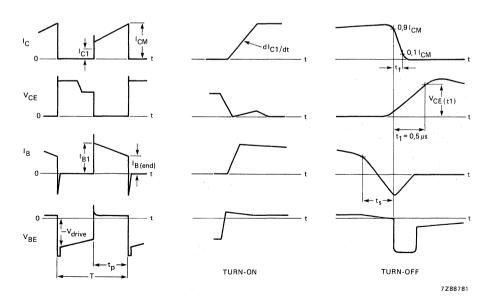


Fig. 15 Relevant waveforms of the switching transistor in a forward SMPS.

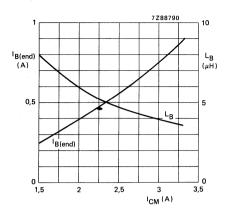


Fig. 16 Recommended nominal "end" value of the base current ( $I_{Be}$ ) and optimum base inductance ( $I_{Be}$ ) at  $-V_{drive} = 5 V$  versus maximum peak collector current.  $I_{Bend} = \pm 20\%$ .

For other values of  $-V_{drive}$  (3 V to 7 V) the related L<sub>B</sub> is:

$$L_{Bnom} \frac{(-V_{drive}) + 1}{6}$$

LBnom is the value given in this graph.

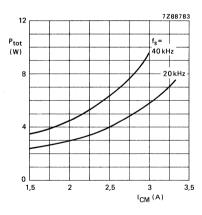


Fig. 17 Maximum transistor dissipation under worse-case operating condition versus maximum peak collector current.  $T_{mb} = 100$   $^{o}$ C;  $dI_{B(end)} = \pm 20\%$ .

# SILICON DIFFUSED POWER TRANSISTORS



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

## QUICK REFERENCE DATA

		BUS12		BUS12A	
Collector-emitter voltage (V <sub>BE</sub> = 0, peak value)	V <sub>CESM</sub>	max.	850		1000 V
Collector-emitter voltage (open base)	$v_{CEO}$	max.	400		450 V
Collector current (d.c.)	l <sub>C</sub>	max.		8	Α
Collector current (peak value) $t_p \le 2 \text{ ms}$	<sup>I</sup> CM	max.		20	Α
Total power dissipation up to T <sub>mb</sub> = 25 °C	$P_{tot}$	max.		125	W
Collector-emitter saturation voltage $I_C = 6 A$ ; $I_B = 1,2 A$ $I_C = 5 A$ ; $I_B = 1 A$	V <sub>CEsat</sub> V <sub>CEsat</sub>	< <	1,5 —		– V 1,5 V
Fall time (resistive load) $ C_{On} = 6 \text{ A};  B_{On} = - B_{Off} = 1,2 \text{ A}$ $ C_{On} = 5 \text{ A};  B_{On} = - B_{Off} = 1 \text{ A}$	t <sub>f</sub> t <sub>f</sub>	< <	0,8 -		— μs 0,8 μs

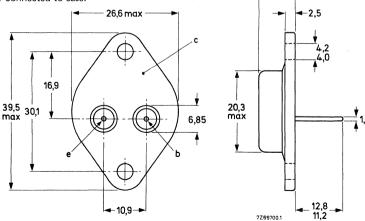
#### MECHANICAL DATA

Dimensions in mm

9max

Fig. 1 TO-3.

Collector connected to case.



See also chapters Mounting instructions and Accessories.

Products approved to CECC50 004-106 available on request.

# BUS12 BUS12A

**RATINGS** 

			BUS12		BUS12	Α
Collector-emitter voltage (V <sub>BE</sub> = 0, peak value)	VCESM	max	x. 850		1000	V
Collector-emitter voltage (open base)	V <sub>CEO</sub>	max	x. 400		450	V
Collector current (d.c.)	l <sub>C</sub>	max	x.	. 8	}	Α
Collector current (peak value); tp < 2 ms	ICM	max	x.	20	) .	Α
Base current (d.c.)	l <sub>B</sub>	max	x.	4	1	Α
Base current (peak value); t <sub>p</sub> ≤ 2 ms	IBM	max	x	6	;	Α
Total power dissipation up to T <sub>mb</sub> = 25 °C	P <sub>tot</sub>	max	x.	125	,	W
Storage temperature	$T_{stg}$		-65 to	+200	)	oC
Junction temperature	т <sub>ј</sub>	max	×.	200	)	оС
THERMAL RESISTANCE						
From junction to mounting base	R <sub>th j-mb</sub>	,		1,4		K/W
CHARACTERISTICS						
T <sub>i</sub> = 25 °C unless otherwise specified						
Collector cut-off current *						
$V_{CE} = V_{CESMmax}; V_{BE} = 0$	CES	<		1		mA mA
$VCE = VCESMmax; VBE = 0; T_j = 125 °C$	CES	,		3		mA
Emitter cut-off current I <sub>C</sub> = 0; V <sub>FR</sub> = 9 V	I <sub>EBO</sub>	<		10	)	mΑ
C 3, 1EB 3 1	LEBO					
			BUS12		BUS12	Α
Saturation voltages						
I <sub>C</sub> = 6 A; I <sub>B</sub> = 1,2 A	V <sub>CEsat</sub>	<	1,5		1.5	V
I <sub>C</sub> = 5 A; I <sub>B</sub> = 1 A I <sub>C</sub> = 6 A; I <sub>B</sub> = 1,2 A	V <sub>CEsat</sub>	< <	 1,5		1,5	V
IC = 5 A; IB = 1,2 A	V <sub>BEsat</sub>	2	- 1,0		1,5	-
3	V <sub>BEsat</sub>	- 7			1,0	•
Collector-emitter sustaining voltage I <sub>C</sub> = 100 mA; I <sub>Boff</sub> = 0; L = 25 mH	V <sub>CEOsust</sub>	>	400		450	V
				•		

<sup>\*</sup> Measured with a half sine-wave voltage (curve tracer).

## CHARACTERISTICS (continued)

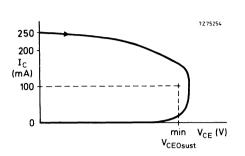


Fig. 2 Oscilloscope display for sustaining voltage.

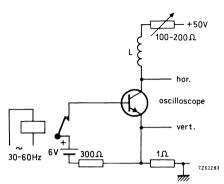


Fig. 3 Test circuit for V<sub>CEOsust</sub>.

Switching times resistive load (Figs 4 and 5)				
I <sub>Con</sub> = 6 A; I <sub>Bon</sub> = -I <sub>Boff</sub> = 1,2 A			BUS12	BUS12A
Turn-on time	ton	<	1	— μs
Turn-off: Storage time Fall time	t <sub>s</sub> t <sub>f</sub>	< <	4 0,8	— μs — μs
$I_{Con} = 5 \text{ A}; I_{Bon} = -I_{Boff} = 1 \text{ A}$				
Turn-on time	ton	<	manus.	1 μs
Turn-off: Storage time Fall time	t <sub>s</sub> t <sub>f</sub>	< <	_	4 μs 0,8 μs
Switching times inductive load (Figs 6 and 7) $I_{Con} = 6 \text{ A}$ ; $I_{B} = 1.2 \text{ A}$				
Turn-off: Storage time	t <sub>s</sub>	typ.	1,6 2,1	— μs — μs
Fall time	t <sub>f</sub>	typ.	80 150	- ns - ns
$I_{Con} = 6 \text{ A}; I_{B} = 1.2 \text{ A}; T_{j} = 100  {}^{\circ}\text{C}$				
Turn-off: Storage time	t <sub>s</sub>	typ.	1,8 2,3	— μs — μs
Fall time	t <sub>f</sub>	typ.	140 300	- ns - ns
Switching times inductive load (Figs 6 and 7) $I_{Con} = 5 \text{ A}$ ; $I_{B} = 1 \text{ A}$				
Turn-off: Storage time	t <sub>S</sub>	typ.	_	1,6 μs 2,1 μs
Fall time	t <sub>f</sub>	typ.	_	80 ns 150 ns
$I_{Con} = 5 \text{ A}; I_{B} = 1 \text{ A}; T_{j} = 100 ^{\circ}\text{C}$				
Turn-off: Storage time	t <sub>s</sub>	typ.	_	1,8 μs 2,3 μs
Fall time			_	140 ns
raii time	t <sub>f</sub>	typ.	<u> </u>	300 ns

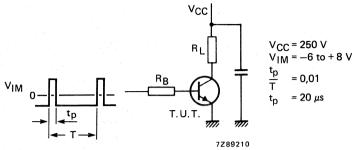


Fig. 4 Test circuit resistive load.

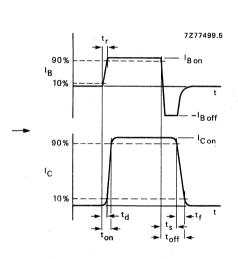


Fig. 5 Switching times waveforms with resistive load.

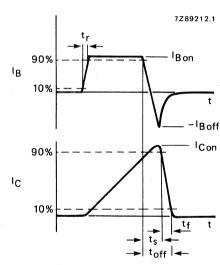


Fig. 6 Switching times waveforms with inductive load.

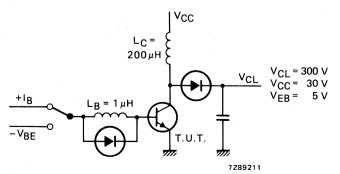
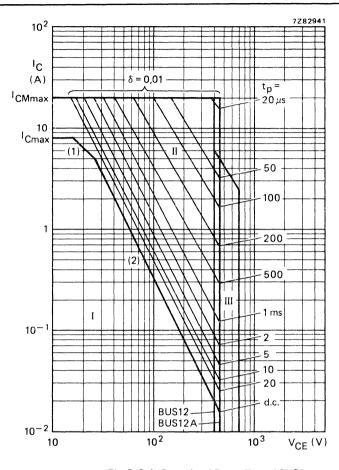


Fig. 7 Test circuit inductive load.



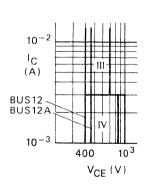


Fig. 8 Safe Operating ARea at  $T_{mb} \le 25$  °C.

- (1) P<sub>tot max</sub> and P<sub>tot peak max</sub> lines.
   (2) Second-breakdown limits (independent of temperature).
- 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<sub>BE</sub>  $\leq$  0 and t<sub>D</sub>  $\leq$  2 ms.

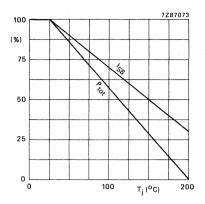


Fig. 9 Total power dissipation and secondbreakdown current derating curve.

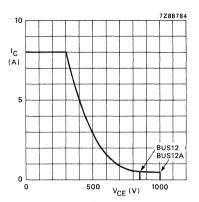


Fig. 10 Reverse bias SOAR.

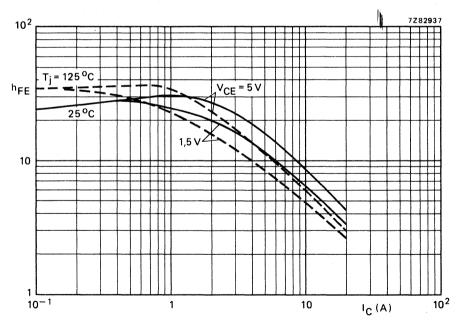


Fig. 11 Typical values d.c. current gain.

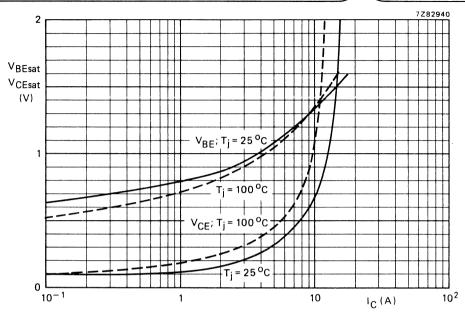


Fig. 12 Typical values base and collector voltage at  $I_C/I_B = 5$ .

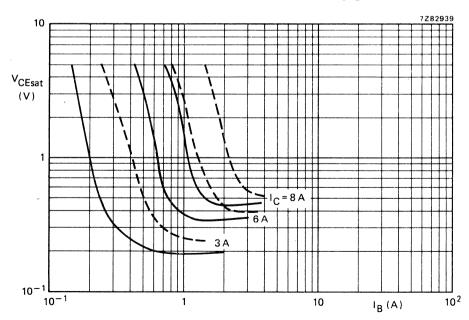


Fig. 13 Typ. (——) and max. (— —) values collector-emitter saturation voltage at  $T_j$  = 25 °C.

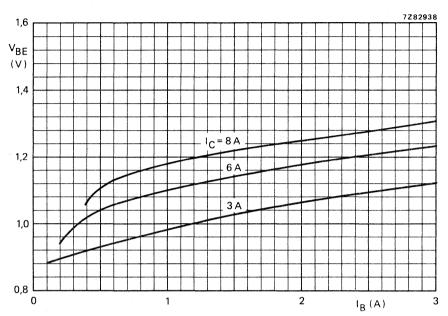


Fig. 14 Typical values base-emitter voltage at  $T_j = 25$  °C.

#### APPLICATION INFORMATION

Important design factors of SMPS circuits are the maximum power losses, heatsink requirements and base drive conditions of the switching transistor. The power losses are very dependent on the operating frequency, the maximum collector current amplitude and shape.

The operating frequency is mostly set between 15 and 50 kHz. The collector current shape varies from rectangular in a forward converter to sawtooth in a flyback converter.

Information on nominal base drive, optimum base inductance and maximum transistor dissipation applied in a forward converter is given in Figs 15, 16 and 17. In these figures ICM represents the maximum repetitive peak collector current, which occurs during overload. The information is derived from limit-case transistors at a mounting base temperature of 100 °C under the following conditions (see also Fig. 15):

- collector current shape I<sub>C1</sub>/I<sub>CM</sub> = 0,9
- duty factor  $t_p/T = 0.45$  rate of rise of I<sub>C</sub> during turn-on = 8 A/ $\mu$ s
- rate of rise of  $V_{CE}$  during turn-off = 1 kV/ $\mu$ s
- reverse drive voltage during turn-off = 5 V
- base current shape IB1/IBe = 1,5

The required thermal resistance of the heatsink can be calculated from

$$R_{th mb-a} < \frac{100 - T_{amb}}{P_{tot}} K/W$$

To ensure thermal stability the value of the ambient temperature  $T_{amb} > 40$  °C.

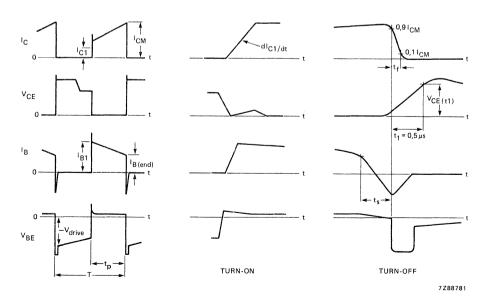


Fig. 15 Relevant waveforms of the switching transistor in a forward SMPS.

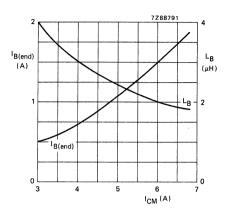


Fig. 16 Recommended nominal "end" value of the base current ( $I_{Be}$ ) and optimum base inductance ( $I_{Be}$ ) at  $-V_{drive} = 5$  V versus maximum peak collector current.  $dI_{B(end)} = \pm 20\%$ .

For other values of  $-V_{drive}$  (3 V to 7 V) the related L<sub>B</sub> is:

$$L_{Bnom} \frac{(-V_{drive}) + 1}{6}$$

LBnom is the value given in this graph.

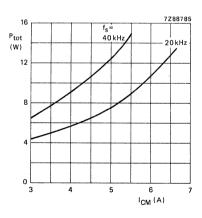


Fig. 17 Maximum transistor dissipation under worse-case operating condition versus maximum peak collector current.  $T_{mb} = 100$   $^{\circ}$ C;  $dI_{B(end)} = \pm 20\%$ .

# SILICON DIFFUSED POWER TRANSISTORS



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

### QUICK REFERENCE DATA

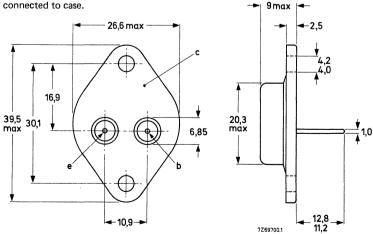
		BUS13		В	US13A
Collector-emitter voltage ( $V_{BE} = 0$ , peak value)	$v_{CESM}$	max.	850		1000 V
Collector-emitter voltage (open base)	$v_{CEO}$	max.	400		450 V
Collector current (d.c.)	1 <sub>C</sub>	max.		15	Α
Collector current (peak value) $t_p < 2 \text{ ms}$	ICM	max.		30	Α
Total power dissipation up to T <sub>mb</sub> = 25 °C	$P_{tot}$	max.		175	W
Collector-emitter saturation voltage  I C = 10 A; I B = 2 A  I C = 8 A; I B = 1,6 A	V <sub>CEsat</sub> V <sub>CEsat</sub>	< <	1,5 		– V 1,5 V
Fall time (resistive load) $I_{Con} = 10 \text{ A}; I_{Bon} = -I_{Boff} = 2 \text{ A}$ $I_{Con} = 8 \text{ A}; I_{Bon} = -I_{Boff} = 1,6 \text{ A}$	<sup>t</sup> f t <sub>f</sub>	< <	0,8		— μs 0,8 μs

## **MECHANICAL DATA**

Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.



Products approved to CECC 50 004–125 available on request. See also chapters Mounting instructions and Accessories.

# BUS13 BUS13A

**RATINGS** 

		_	BUS13	BUS1	3A
Collector-emitter voltage (V <sub>BE</sub> = 0, peak value)	VCESM	max.	850	100	0 V
Collector-emitter voltage (open base)	V <sub>CEO</sub>	max.	400	45	60 V
Collector current (d.c.)	IC	max.		15	Α
Collector current (peak value); tp < 2 ms	CM	max.	;	30	Α
Base current (d.c.)	l <sub>B</sub>	max.		6	Α
Base current (peak value); t <sub>p</sub> < 2 ms	I <sub>BM</sub>	max.		9	Α
Total power dissipation up to T <sub>mb</sub> = 25 °C	$P_{tot}$	max.	1	75	W
Storage temperature	T <sub>stg</sub>		65 to +20	00	оС
Junction temperature	Tj	max.	20	00	οС
THERMAL RESISTANCE					
From junction to mounting base	R <sub>th j-mb</sub>	==	1	,0	K/W
CHARACTERISTICS					
T <sub>j</sub> = 25 °C unless otherwise specified					
Collector cut-off current *					
V <sub>CE</sub> = V <sub>CESMmax</sub> ; V <sub>BE</sub> = 0	CES	< <		1	mA
$V_{CE} = V_{CESMmax}$ ; $V_{BE} = 0$ ; $T_j = 125$ °C	CES			4	mΑ
Emitter cut-off current IC = 0; VFB = 9 V	less	<		10	mΑ
IC - 0, VEB - 9 A	<sup>I</sup> EBO				ША
			BUS13	BUS1	3A
Saturation voltages I <sub>C</sub> = 10 A; I <sub>B</sub> = 2 A	V <sub>CEsat</sub>	<	1,5		· V
I <sub>C</sub> = 8 A; I <sub>B</sub> = 1,6 A	VCEsat	< < <	_	1,	,5 V
I <sub>C</sub> = 10 A; I <sub>B</sub> = 2 A	VBEsat	<	1,6	_	V
I <sub>C</sub> = 8 A, I <sub>B</sub> = 1,6 A	<b>VBEsat</b>	<		1	,6 V
Collector-emitter sustaining voltage I <sub>C</sub> = 100 mA; I <sub>Boff</sub> = 0; L = 25 mH	Voca	>	400	ΛF	50 V
1C - 100 IIIA, 1Bott - 0, L - 25 IIII	VCEOsust		400	1	. v

<sup>\*</sup> Measured with a half sine-wave voltage (curve tracer).

## CHARACTERISTICS (continued)

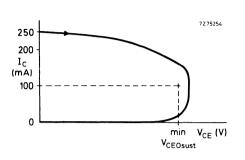


Fig. 2 Oscilloscope display for sustaining voltage.

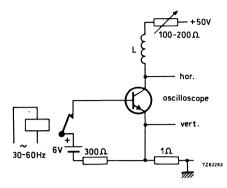


Fig. 3 Test circuit for V<sub>CEOsust</sub>.

Switching times resistive load (Figs 4 and 5) $I_{Con} = 10 \text{ A; } I_{Bon} = -I_{Boff} = 2 \text{ A}$ Turn-on time
Turn-off: Storage time Fall time
$I_{Con} = 8 \text{ A}$ ; $I_{Bon} = -I_{Boff} = 1,6 \text{ A}$ Turn-on time
Turn-off: Storage time Fall time
Switching times inductive load (Figs 6 and 7) $I_{Con} = 10 \text{ A}$ ; $I_{B} = 2 \text{ A}$
Turn-off: Storage time
Fall time
$I_{Con} = 10 \text{ A}$ ; $I_B = 2 \text{ A}$ ; $T_j = 100 ^{\circ}\text{C}$
Turn-off: Storage time
Fall time
Switching times inductive load (Figs 6 and 7) $I_{Con} = 8 \text{ A}$ ; $I_{B} = 1,6 \text{ A}$ Turn-off: Storage time
Fall time
$I_{Con} = 8 \text{ A}$ ; $I_{B} = 1,6 \text{ A}$ ; $T_{j} = 100 ^{\circ}\text{C}$ Turn-off: Storage time
Fall time

		BUS13	BUS13A	
ton	<	1	_	μs
ts	< < <	4	_	μs
tf	<	0,8	_	μs
ton	<		1	μs
ts	< < <	_	4	μs
tf	<	_	0,8	μs
		2.2		
ts	typ.	2,3 3,0	_	μs μs
_	typ.	80	, _	ns
tf	<	150	_	ns
	typ.	2,5	_	μs
t <sub>S</sub>	<	3,2	_	μs
t <sub>f</sub>	typ.	140	_	ns
-1	<	300	_	ns
	typ.		2,3	μs
ts	< '		3,0	μs
	typ.	_	80	ns
tf	<		150	ns
			0.5	
ts	typ.	- <del>-</del> 1	2,5	μs
•	typ.	_	3,2 140	μs ns
tf	τyμ. <	_	300	ns
	7		, 555	

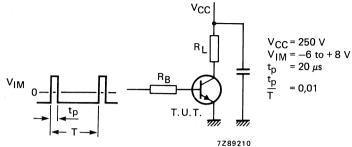


Fig. 4 Test circuit resistive load.

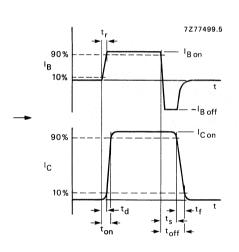


Fig. 5 Switching times waveforms with resistive load.

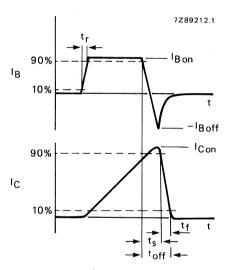


Fig. 6 Switching times waveforms with inductive load.

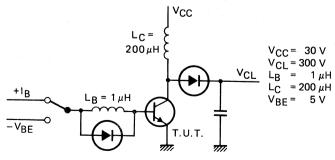
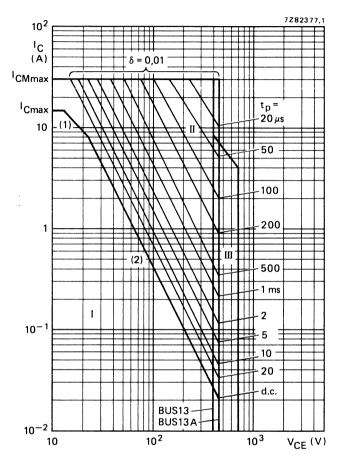


Fig. 7 Test circuit inductive load.



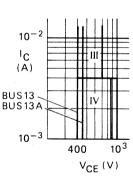


Fig. 8 Safe Operating ARea at  $T_{mb} \le 25$  °C.

- (1) Ptot max and Ptot peak max lines.(2) Second-breakdown limits (independent of temperature).
- 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 RBE  $\leqslant$  100  $\Omega$  and  $t_p \leqslant$  0,6  $\mu s.$
- IV Repetitive pulse operation in this region is permissible provided  $V_{BE} \le 0$  and  $t_p \le 2$  ms.

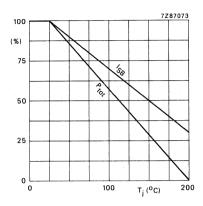


Fig. 9 Total power dissipation and second-breakdown current derating curve.

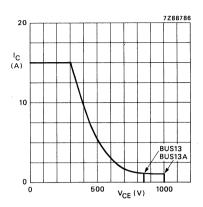


Fig. 10 Reverse bias SOAR.

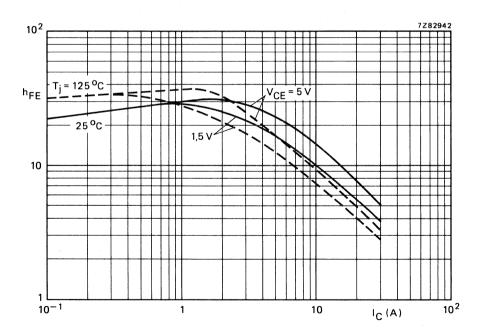


Fig. 11 Typical values d.c. current gain.

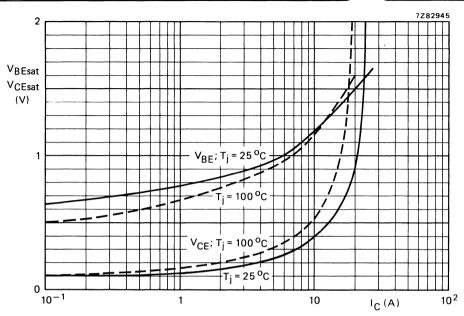


Fig. 12 Typical values base and collector voltage at  $I_C/I_B = 5$ .

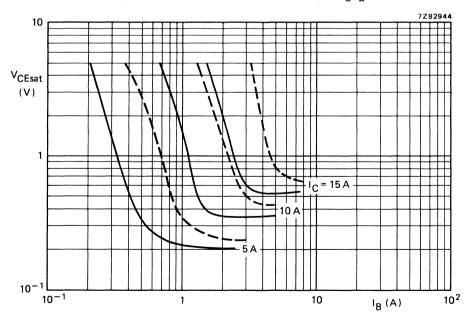


Fig. 13 Typical (——) and maximum (— —) values saturation voltage.  $T_i = 25$  °C.

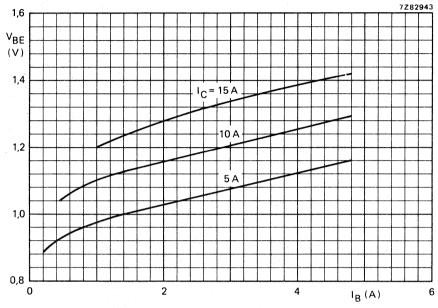


Fig. 14 Typical values base-emitter voltage at  $T_j = 25$  °C.

#### APPLICATION INFORMATION

Important design factors of SMPS circuits are the maximum power losses, heatsink requirements and base drive conditions of the switching transistor. The power losses are very dependent on the operating frequency, the maximum collector current amplitude and shape.

The operating frequency is mostly set between 15 and 50 kHz. The collector current shape varies from rectangular in a forward converter to sawtooth in a flyback converter.

Information on nominal base drive, optimum base inductance and maximum transistor dissipation applied in a forward converter is given in Figs 15, 16 and 17. In these figures I<sub>CM</sub> represents the maximum repetitive peak collector current, which occurs during overload. The information is derived from limit-case transistors at a mounting base temperature of 100 °C under the following conditions (see also Fig. 15):

- collector current shape I<sub>C1</sub>/I<sub>CM</sub> = 0,9
- duty factor  $t_D/T = 0.45$
- rate of rise of IC during turn-on = 10 A/ $\mu$ s
- rate of rise of  $V_{CF}$  during turn-off = 1 kV/ $\mu$ s
- reverse drive voltage during turn-off = 5 V
- base current shape IB1/IBe = 1,5

The required thermal resistance of the heatsink can be calculated from

$$R_{th\ mb-a} < \frac{100 - T_{amb}}{P_{tot}} \ K/W$$

To ensure thermal stability the value of the ambient temperature  $T_{amb} > 40$  °C.

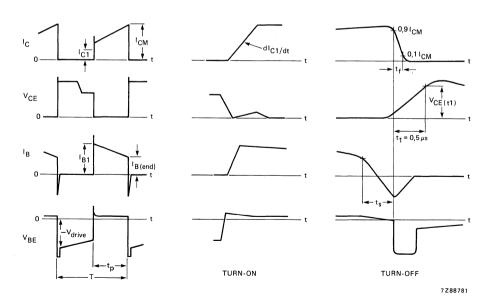


Fig. 15 Relevant waveforms of the switching transistor in a forward SMPS.

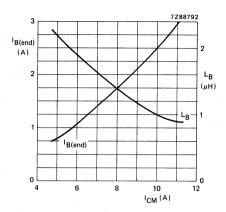


Fig. 16 Recommended nominal "end" value of the base current ( $I_{Be}$ ) and optimum base inductance ( $I_{Be}$ ) at  $-V_{drive} = 5$  V versus maximum peak collector current.  $I_{Bend} = \pm 20\%$ .

For other values of  $-V_{drive}$  (3 V to 7 V) the related L<sub>B</sub> is:

$$L_{Bnom} \frac{(-V_{drive}) + 1}{6}$$

LBnom is the value given in this graph.

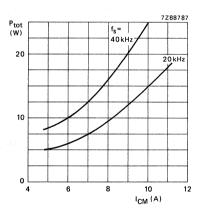


Fig. 17 Maximum transistor dissipation under worse-case operating condition versus maximum peak collector current.  $T_{mb} = 100$   $^{o}$ C;  $dI_{B(end)} = \pm 20\%$ .

# SILICON DIFFUSED POWER TRANSISTORS

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

### QUICK REFERENCE DATA

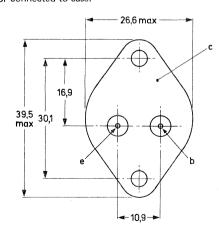
		В	US14	E	BUS14A
Collector-emitter voltage (V <sub>BE</sub> = 0, peak value)	$v_{CESM}$	max.	850		1000 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	400		450 V
Collector current (d.c.)	I <sub>C</sub>	max.		30	Α
Collector current (peak value) $t_p \le 2$ ms	I <sub>CM</sub>	max.		50	Α
Total power dissipation up to T <sub>mb</sub> = 25 °C	P <sub>tot</sub>	max.		250	W
Collector-emitter saturation voltage $I_C = 20 \text{ A}$ ; $I_B = 4 \text{ A}$ $I_C = 16 \text{ A}$ ; $I_B = 3,2 \text{ A}$	V <sub>CEsat</sub> V <sub>CEsat</sub>	< <	1,5 		– V 1,5 V
Fall time (resistive load) $I_{Con} = 20 \text{ A; } I_{Bon} = -I_{Boff} = 4 \text{ A}$ $I_{Con} = 16 \text{ A; } I_{Bon} = -I_{Boff} = 3,2 \text{ A}$	t <sub>f</sub> t <sub>f</sub>	< <	0,8 -		— μ <b>s</b> 0,8 μs

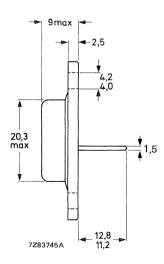
### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.





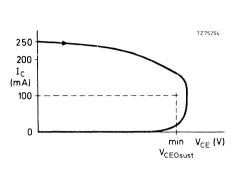
See also chapters Mounting instructions and Accessories.

**RATINGS** 

		Вι	JS14	BUS14A
Collector-emitter voltage (V <sub>BE</sub> = 0, peak value)	V <sub>CESM</sub>	max.	850	1000 V
Collector-emitter voltage (open base)	VCEO	max.	400	450 V
Collector current (d.c.)	Ic	max.	3	80 A
Collector current (peak value); t <sub>p</sub> < 2 ms	I <sub>CM</sub>	max.	5	60 A
Base current (d.c.)	I <sub>B</sub>	max.		6 A
Base current (peak value); $t_p < 2$ ms	I <sub>BM</sub>	max.	1	0 A
Total power dissipation up to T <sub>mb</sub> = 25 °C	P <sub>tot</sub>	max.	25	0 W
Storage temperature	$T_{stg}$	-	65 to +20	00 °C
Junction temperature	т <sub>ј</sub>	max.	20	00 °C
THERMAL RESISTANCE				
From junction to mounting base	R <sub>th j-mb</sub>	= -	0	,7 K/W
CHARACTERISTICS				
T <sub>j</sub> = 25 °C unless otherwise specified				
Collector cut-off current *				_
VCE = VCESMmax; VBE = 0 VCE = VCESMmax; VBE = 0; T <sub>i</sub> = 125 °C	CES	<		1 mA 5 mA
Emitter cut-off current	.CE2			
I <sub>C</sub> = 0; V <sub>EB</sub> = 9 V	I <sub>EBO</sub>	<	1	0 mA
Catalanaian unla		В	JS14	BUS14A
Saturation voltages	V <sub>CEsat</sub>	<	1,5	– v
I <sub>C</sub> = 16 A; I <sub>B</sub> = 3,2 A	VCEsat	< < <		1,5 V
I <sub>C</sub> = 20 A; I <sub>B</sub> = 4 A	VBEsat	<	1,7	– V
$I_C = 16 \text{ A}; I_B = 3.2 \text{ A}$	VBEsat	<		1,7 ∨
Collector-emitter sustaining voltage				
$I_C = 100 \text{ mA}; I_{Boff} = 0; L = 25 \text{ mH}$	V <sub>CEOsust</sub>	>	400	450 V

<sup>\*</sup> Measured with a half sine-wave voltage (curve tracer).

### **CHARACTERISTICS** (continued)



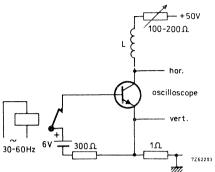


Fig. 2 Oscilloscope display for sustaining voltage.

Fig. 3 Test circuit for V<sub>CEOsust</sub>.

Switching times resistive load (Figs 4 and 5) $\frac{1}{100} = \frac{20.0 \text{ Mpc}}{100} = \frac{1}{100} \text{ (res. 4.0)}$			BUS14	BUS14A	
$I_{\text{Con}} = 20 \text{ A}; I_{\text{Bon}} = -I_{\text{Boff}} = 4 \text{ A}$					-
Turn-on time	t <sub>on</sub>	<	1 '	_	μs
Turn-off: Storage time	t <sub>s</sub>	<	4		$\mu$ s
Fall time	tf	<	0,8		$\mu$ s
$I_{Con} = 16 \text{ A}; I_{Bon} = -I_{Boff} = 3.2 \text{ A}$					
Turn-on time	t <sub>on</sub>	<		1	$\mu$ s
Turn-off: Storage time	t <sub>s</sub>	< <	******	4	$\mu$ s
Fall time	tf	<	_	0,8	$\mu$ s
Switching times inductive load (Figs 6 and 7)					
$I_{Con} = 20 \text{ A}; I_{B} = 4 \text{ A}$		typ.	2,8		μs
Turn-off: Storage time	t <sub>s</sub>	<	3,6		μs
		typ.	80		ns
Fall time	t <sub>f</sub>	<	150		ns
$I_{Con} = 20 \text{ A}; I_{B} = 4 \text{ A}; T_{i} = 100 ^{\circ}\text{C}$					
Turn-off: Storage time	t <sub>s</sub>	typ.	3,1	_	μs
	3	<	4,0 140		μs
Fall time	t <sub>f</sub>	typ.	300		ns ns
			300		115
Switching times inductive load (Figs 6 and 7) $I_{Con} = 16 \text{ A}; I_B = 3,2 \text{ A}$					
		typ.		28	μs
Turn-off: Storage time	t <sub>s</sub>	<		3,6	μs
Fall time	+ -	typ.		80	ns
i an time	tf	<		150	ns
$I_{Con} = 16 \text{ A}; I_{B} = 3.2 \text{ A}; T_{j} = 100 ^{\circ}\text{C}$				0.1	
Turn-off: Storage time	t <sub>s</sub>	typ.		3,1	μs
ŭ	3	< tvn		4,0 140	μs ns
Fall time	tf	typ.		300	ns
		_		, 500	113

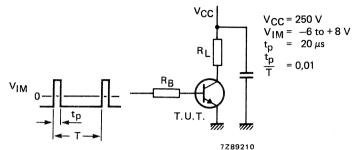


Fig. 4 Test circuit resistive load.

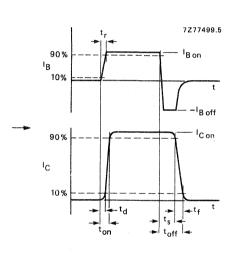


Fig. 5 Switching times waveforms with resistive load.

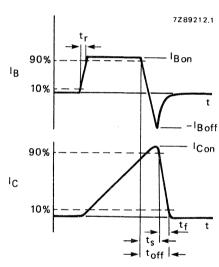


Fig. 6 Switching times waveforms with inductive load.

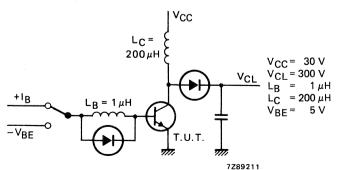


Fig. 7 Test circuit inductive load.

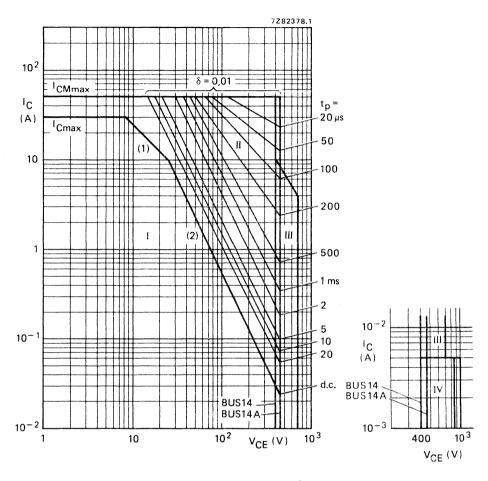


Fig. 8 Safe Operating ARea at  $T_{mb} \le 25$  °C.

- (1)
- $P_{tot\,max}$  and  $P_{peak\,max}$  lines. Second-breakdown limits (independent of temperature).
- Region of permissible d.c. operation
- Permissible extension for repetitive pulse operation 11
- Area of permissible operation during turn-on in single transistor converters, provided RBE  $\leq$  100  $\Omega$  and  $t_{\rm p} \leq$  0,6  $\mu{\rm s}$
- Repetitive pulse operation in this region is permissible IV provided VBE  $\leq$  0 and t<sub>D</sub>  $\leq$  2 ms.

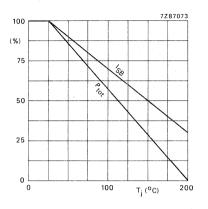


Fig. 9 Total power dissipation and second-breakdown current derating curve.

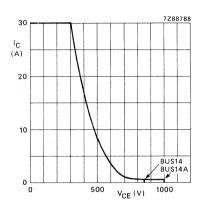


Fig. 10 Reverse bias SOAR.

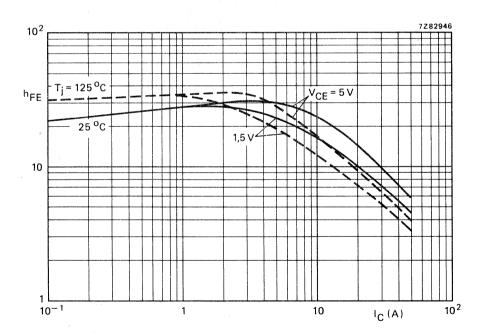


Fig. 11 Typical values d.c. current gain.

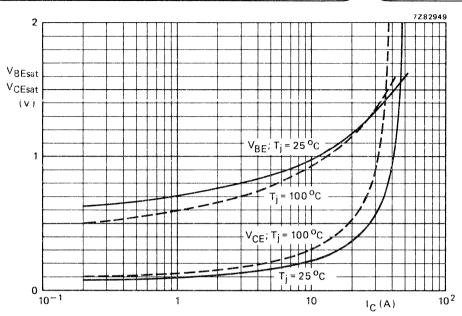


Fig. 12 Typical values base and collector voltage.  $I_C/I_B = 5$ .

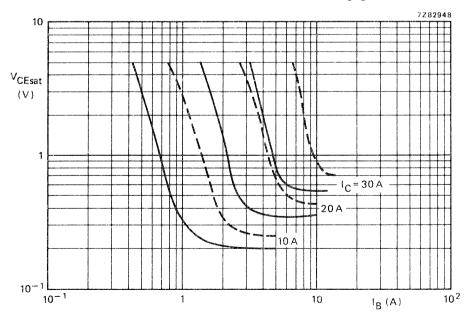


Fig. 13 Typical (——) and maximum (— —) values saturation voltage.  $T_j = 25$  °C.

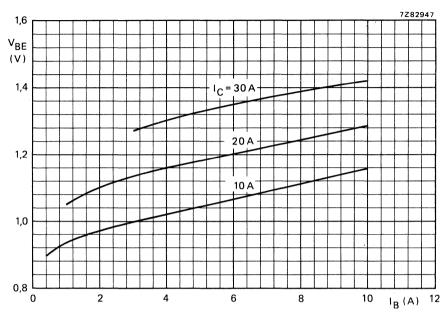


Fig. 14 Typical values at  $T_j = 25$  °C.

#### APPLICATION INFORMATION

Important design factors of SMPS circuits are the maximum power losses, heatsink requirements and base drive conditions of the switching transistor. The power losses are very dependent on the operating frequency, the maximum collector current amplitude and shape.

The operating frequency is mostly set between 15 and 50 kHz. The collector current shape varies from rectangular in a forward converter to sawtooth in a flyback converter.

Information on nominal base drive, optimum base inductance and maximum transistor dissipation applied in a forward converter is given in Figs 15, 16 and 17. In these figures I<sub>CM</sub> represents the maximum repetitive peak collector current, which occurs during overload. The information is derived from limit-case transistors at a mounting base temperature of 100 °C under the following conditions (see also Fig. 15):

- collector current shape I<sub>C1</sub>/I<sub>CM</sub> = 0,9
- duty factor  $t_D/T = 0.45$
- rate of rise of I<sub>C</sub> during turn-on = 20 A/ $\mu$ s
- rate of rise of  $V_{CE}$  during turn-off = 1 kV/ $\mu$ s
- reverse drive voltage during turn-off = 5 V
- base current shape IB1/IBe = 1,5

The required thermal resistance of the heatsink can be calculated from

$$R_{th\ mb\text{-a}} < \frac{100 - T_{amb}}{P_{tot}} \text{ K/W}$$

To ensure thermal stability the value of the ambient temperature  $T_{amb} > 40$  °C.

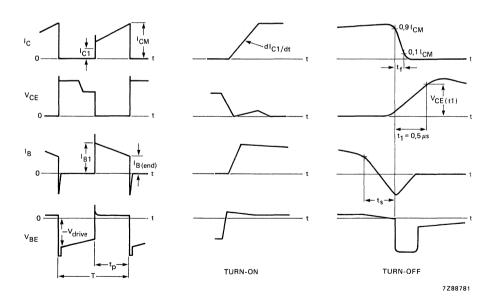


Fig. 15 Relevant waveforms of the switching transistor in a forward SMPS.

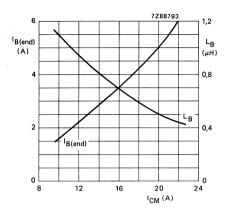


Fig. 16 Recommended nominal "end" value of the base current ( $I_{Be}$ ) and optimum base inductance ( $I_{Be}$ ) at  $-V_{drive} = 5 V$  versus maximum peak collector current.  $dI_{B(end)} = \pm 20\%$ .

For other values of  $-V_{drive}$  (3 V to 7 V) the related L<sub>B</sub> is:

$$L_{Bnom} \frac{(-V_{drive}) + 1}{6}$$

LBnom is the value given in this graph.

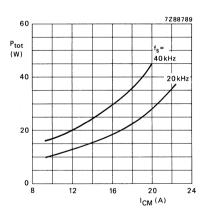


Fig. 17 Maximum transistor dissipation under worse-case operating condition versus maximum peak collector current.  $T_{mb} = 100$  °C;  $dI_{B(end)} = \pm 20\%$ .

### DEVELOPMENT DATA

This data sheet contains advance information and specifications are subject to change without notice.

# SILICON DIFFUSED POWER TRANSISTORS

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

### QUICK REFERENCE DATA

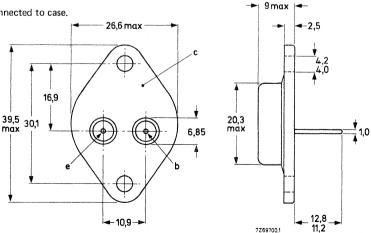
Collector-emitter voltage			BUS21	Α	В	С
V <sub>BE</sub> = 0; peak value	$v_{CESM}$	max.	550	650	750	850 V
Collector-emitter voltage open base	V <sub>CEO</sub>	max.	300	350	400	450 V
Collector saturation current	<sup>I</sup> Csat	=	3	3	3	3 A
Collector current (d.c.)	1 <sub>C</sub>	max.	5	5	5	5 A
Collector current (peak value)	ICM	max.	10	10	10	10 A
Total power dissipation up to T <sub>mb</sub> = 25 °C	P <sub>tot</sub>	max.	100	100	100	100 W
Collector-emitter saturation voltage $I_C = 3 A$	V <sub>CEsat</sub>	<	1,5	1,5	1,5	1,5 V
D.C. current gain $I_C = 0.5 A$ ; $V_{CE} = 10 V$ $I_C = 3 A$ ; $V_{CE} = 1.5 V$	hFE	typ.	25 10	25 9	25 7,5	25 6

### **MECHANICAL DATA**

Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.



For accessories and mounting instructions see Handbook high-voltage and switching power transistors.

# **BUS21 SERIES**

### RATINGS

			D11004				
Collector-emitter voltage			BUS21	A	В	С	
V <sub>BE</sub> = 0; peak value	VCESM	max.	550	650	750	850	V
Collector-emitter voltage open base	V <sub>CEO</sub>	max.	300	350	400	450	٧
Collector current (d.c.)	I <sub>C</sub>	max.			5		Α
Collector current (peak value)	ICM	max.		, 1	10		Α
Base current (d.c.)	I <sub>B</sub>	max.			2		Α
Base current (peak value)	I <sub>ВМ</sub>	max.			4		Α
Total power dissipation up to T <sub>mb</sub> = 25 °C	P <sub>tot</sub>	max.		10	00		w
Storage temperature	$T_{stg}$		<b>65</b> 1	to + 20	00		οС
Junction temperature	Tj	max.		20	00		οС
THERMAL RESISTANCE							
From junction to mounting base	R <sub>th j-mb</sub>	=		1,2	25		K/W
CHARACTERISTICS							
T <sub>j</sub> = 25 °C unless otherwise specified							
Collector cut-off current*							
$V_{CE} = V_{CESMmax}; V_{BE} = 0$	ICES	<			1		mΑ
Emitter cut-off current I <sub>C</sub> = 0; V <sub>FB</sub> = 9 V	less	<		1	10		mA
IC - 0, vEB - a v	ГЕВО		BUS21	l a i	В	l C	шА
D.C. current gain							
I <sub>C</sub> = 0,5 A; V <sub>CE</sub> = 10 V I <sub>C</sub> = 3 A; V <sub>CE</sub> = 1,5 V	hFE	typ.	25 10	25 9	25 7,5	25 6	
Collector-emitter sustaining voltage							
I <sub>B</sub> = 0; I <sub>C</sub> = 0,1 A; L = 25 mH	V <sub>CEOsust</sub>	>	300	350	400	450	V
Saturation voltages	17		4.5				.,
I <sub>C</sub> = 3 A; I <sub>B</sub> = 0,3 A	V <sub>CEsat</sub> V <sub>BEsat</sub>	< <	1,5 1,5	_ :	_	_	V V
I <sub>C</sub> = 3 A; I <sub>B</sub> = 0,34 A	VCEsat	<	_	1,5	-	_	v
·C 374, ·B 3,377	V <sub>BEsat</sub>	<		1,5	_	_	v
I <sub>C</sub> = 3 A; I <sub>B</sub> = 0,4 A	V <sub>CEsat</sub>	<		_	1,5	-	V
	V <sub>BEsat</sub>	<	-	-	1,5	-	V
I <sub>C</sub> = 3 A; I <sub>B</sub> = 0,5 A	VCEsat	< <	_	-	_	1,5	٧
	V <sub>BEsat</sub>	<		ı —	-	1,5	V

<sup>\*</sup> Measured with half sine-wave voltage (curve tracer).

# **DEVELOPMENT DATA**

This data sheet contains advance information and specifications are subject to change without notice.

## SILICON DIFFUSED POWER TRANSISTORS

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

#### QUICK REFERENCE DATA

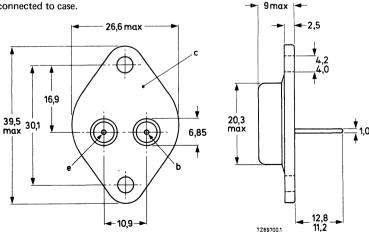
Collector-emitter voltage		В	US22	Α	В	С
V <sub>BE</sub> = 0; peak value	V <sub>CESM</sub>	max.	550	650	750	850 V
Collector-emitter voltage; open base	$V_{CEO}$	max.	300	350	400	450 V
Collector saturation current	I <sub>Csat</sub>	=	6	6	6	6 A
Collector current (d.c.)	l <sub>C</sub>	max.	8	8	8	8 A
Collector current (peak value)	<sup>I</sup> CM	max.	20	20	20	20 A
Total power dissipation up to $T_{mb} = 25$ °C	P <sub>tot</sub>	max.	125	125	125	125 W
Collector-emitter saturation voltage $I_C = 6 A$	V <sub>CEsat</sub>	<	1,5	1,5	1,5	1,5 V
D.C. current gain $I_C = 1 A$ ; $V_{CE} = 5 V$ $I_C = 6 A$ ; $V_{CE} = 1,5 V$	hFE	typ.	18 10	18 9	18 7,5	18 6

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.



For accessories and mounting instructions see Handbook high-voltage and switching power transistors.

# **BUS22 SERIES**

### **RATINGS**

					1 1	1 -	
Collector-emitter voltage		B	US22	Α	В	C	_
V <sub>BE</sub> = 0; peak value	VCESM	max.	550	650	750	850	V
Collector-emitter voltage; open base	V <sub>CEO</sub>	max.	300	350	400	450	<b>V</b>
Collector current (d.c.)	I <sub>C</sub>	max.			8		Α
Collector current (peak value)	ICM	max.		2	20		Α.
Base current (d.c.)	1 <sub>B</sub>	max.			4 ;		Α
Base current (peak value)	I <sub>BM</sub>	max.			6		Α
Total power dissipation up to T <sub>mb</sub> = 25 °C	P <sub>tot</sub>	max.		12	25		w
Storage temperature	T <sub>stg</sub>			−65 t	o + 200		оС
Junction temperature	τ <sub>j</sub>	max.		20	00		οС
THERMAL RESISTANCE							
From junction to mounting base	R <sub>th j-mb</sub>	- A		- 1	,4		K/W
CHARACTERISTICS							
T <sub>i</sub> = 25 °C unless otherwise specified							
Collector cut-off current*							
$V_{CE} = V_{CESMmax}; V_{BE} = 0$	CES	< 1			1		mΑ
Emitter cut-off current							
$I_C = 0; V_{EB} = 9 V$	IEBO	<			10		mΑ
D.C. current gain I <sub>C</sub> = 1 A; V <sub>CF</sub> = 5 V	hFE	typ.		1	8		
3 32			US22	A	В	l c	
Collector-emitter sustaining voltage	v		300	350	400	450	
$I_B = 0$ ; $I_C = 0.1$ A; L = 25 mH Saturation voltages	VCEOsust	>	300	350	400	450	V
I <sub>C</sub> = 6 A; I <sub>B</sub> = 0,6 A	$v_{\sf CEsat}$	<	1,5	·		_	V
	VBEsat	<	1,5		-	-	V
$I_C = 6 A$ ; $I_B = 0.67 A$	V <sub>CEsat</sub>	<	-	1,5	-		V
	V <sub>BEsat</sub>	$1 < 1 \leq 1$		1,5	-	-	٧
$I_C = 6 \text{ A}; I_B = 0.8 \text{ A}$	VCEsat VBEsat	< <	_	_	1,5 1,5		V V
I <sub>C</sub> = 6 A; I <sub>B</sub> = 1 A	V <sub>CEsat</sub>	<	_	_	_	1,5	
	$V_{BEsat}$	<		_	-	1,5	V
				l	1	1	

<sup>\*</sup> Measured with half sine-wave voltage (curve tracer).

# **DEVELOPMENT DATA**

This data sheet contains advance information and specifications are subject to change without notice.

## SILICON DIFFUSED POWER TRANSISTORS

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

#### QUICK REFERENCE DATA

Collector-emitter voltage			BUS23	Α	В	С
V <sub>BE</sub> = 0; peak value	$v_{CESM}$	max.	550	650	750	850 V
Collector-emitter voltage open base	V <sub>CEO</sub>	max.	300	350	400	450 V
Collector saturation current	I <sub>Csat</sub>	=	10	10	10	10 A
Collector current (d.c.)	I <sub>C</sub>	max.	15	15	15	15 A
Collector current (peak value)	ICM	max,	30	30	30	30 A
Total power dissipation up to $T_{mb} = 25$ °C	P <sub>tot</sub>	max.	175	175	175	175 W
Collector-emitter saturation voltage $I_C = 10 \text{ A}$	V <sub>CEsat</sub>	<	1,5	1,5	1,5	1,5 V
D.C. current gain I <sub>C</sub> = 1,5 A; V <sub>CE</sub> = 5 V I <sub>C</sub> = 10 A; V <sub>CE</sub> = 1,5 V	hFE	typ.	25 10	25 9	25 7,5	25 6

#### **MECHANICAL DATA**

Dimensions in mm

Fig. 1 TO-3.

Collector connected to case

26,6 max

20,3

16,9

10,9

10,9

11,2

For accessories and mounting instructions see Handbook I.f. power transistors.

# **BUS23 SERIES**

### RATINGS

			BUS23	Α	В	С	
Collector-emitter voltage VBE = 0; peak value	V <sub>CESM</sub>	max.	550	650	750	850	V
Collector-emitter voltage open base	V <sub>CEO</sub>	max.	300	350	400	450	V
Collector current (d.c.)	l <sub>C</sub>	max.		l	15		Α
Collector current (peak value)	ICM	max.			30		Α
Base current (d.c.)	I <sub>B</sub>	max.			6		Α
Base current (peak value)	I <sub>BM</sub>	max.			9		Α
Total power dissipation up to T <sub>mb</sub> = 25 °C	P <sub>tot</sub>	max.		1	75		W
Storage temperature	T <sub>stg</sub>			65	to + 150	) .	οС
Junction temperature	Tj	max.		1	50		oC
THERMAL RESISTANCE							
From junction to mounting base	R <sub>th j-mb</sub>	=		C	),7		K/W
CHARACTERISTICS							
T <sub>i</sub> = 25 °C unless otherwise specified							
Collector cut-off current*							
$V_{CE} = V_{CESMmax}$ ; $V_{BE} = 0$	CES	<			1		mΑ
Emitter cut-off current					40		
I <sub>C</sub> = 0; V <sub>EB</sub> = 9 V	IEBO	<			10		mA
D.C. current gain I <sub>C</sub> = 1,5 A; V <sub>CF</sub> = 5 V	hFE	typ.			25		
IC - 1,5 A, VCE - 5 V	"FE	typ.	BUS23	Α	В	С	
Collector-emitter sustaining voltage			50020				
$I_B = 0$ ; $I_C = 0.1 A$ ; $L = 25 \text{ mH}$	V <sub>CEOsust</sub>	, >	300	350	400	450	٧
Saturation voltages							
I <sub>C</sub> = 10 A; I <sub>B</sub> = 1 A	V <sub>CEsat</sub> V <sub>BEsat</sub>	>	1,5 1,5	=,	_	-	V V
$I_C = 10 \text{ A}; I_B = 1,11 \text{ A}$	V <sub>CEsat</sub> V <sub>BEsat</sub>	< < <	- -	1,5 1,5	 	_	V V
$I_C = 10 \text{ A}; I_B = 1,33 \text{ A}$	V <sub>CEsat</sub> V <sub>BEsat</sub>	< <	- -	_ _	1,5 1,5	_	V V
I <sub>C</sub> = 10 A; I <sub>B</sub> = 1,67 A	V <sub>CEsat</sub> V <sub>BEsat</sub>	< <	_	_	_ _	1,5 1,5	

<sup>\*</sup> Measured with half sine-wave voltage (curve tracer).

# SILICON DIFFUSED POWER TRANSISTORS

High-voltage, high-speed, glass-passivated n-p-n power transistors in a TO-220 envelope, intended for use in converters, inverters, switching regulators, motor control systems etc.

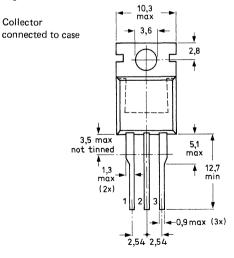
### QUICK REFERENCE DATA

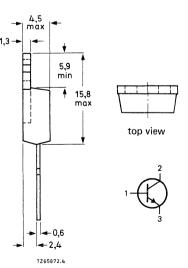
			BUT11	BUT11A	
Collector-emitter voltage (V <sub>BE</sub> = 0, peak value)	$v_{CESM}$	max.	850	1000 \	<b>V</b>
Collector-emitter voltage (open base)	$v_{CEO}$	max.	400	450 \	V
Collector current (d.c.)	1 <sub>C</sub>	max.		5	Д
Collector current (peak value) $t_p \le 2 \text{ ms}$	ICM	max.		10	Д
Total power dissipation up to $T_{mb} = 25  {}^{\circ}\text{C}$	$P_{tot}$	max.	10	00 V	N
Collector-emitter saturation voltage				ı	
$I_C = 3 \text{ A}; I_B = 0.6 \text{ A}$	$v_{CEsat}$	<	1,5	- \	V
$I_C = 2.5 \text{ A}; I_B = 0.5 \text{ A}$	V <sub>CEsat</sub>	<		1,5 \	<b>V</b>
Fall time					
$I_{Con} = 3 \text{ A}; I_{Bon} = -I_{Boff} = 0.6 \text{ A}$	t <sub>f</sub>	<	0,8	- <i>μ</i>	ıs
$I_{Con} = 2.5 \text{ A}; I_{Bon} = -I_{Boff} = 0.5 \text{ A}$	t <sub>f</sub>	<	_	0,8 μ	ıs

### **MECHANICAL DATA**

Dimensions in mm

Fig. 1 TO-220





See also chapters Mounting instructions and Accessories.

# BUT11 **BUT11A**

### **RATINGS**

			BUT11	BUT11A	
Collector-emitter voltage (peak value, V <sub>BE</sub> = 0)	VCESM	max.	850	1000	٧
Collector-emitter voltage (open base)	VCEO	max.	400	450	V
Collector current (d.c.)	lc	max.	·	5	Α
Collector current (peak value) t <sub>p</sub> < 2 ms	ICM	max.	1	0	Α
Base current (d.c.)	l <sub>B</sub>	max.		2	Α
Base current (peak value); t <sub>p</sub> < 2 ms	I <sub>BM</sub>	max.		4	Α
Total power dissipation up to T <sub>mb</sub> = 25 °C	P <sub>tot</sub>	max.	10	00	W
Storage temperature	T <sub>stg</sub>		65 to + 15	50	оС
Junction temperature	Tj	max.	15	60	оС
THERMAL RESISTANCE					
From junction to mounting base	R <sub>th j-mb</sub>	=	1,2	25	K/W
CHARACTERISTICS					
T <sub>i</sub> = 25 °C unless otherwise specified					
Collector cut-off current *					
$V_{CE} = V_{CESMmax}; V_{BE} = 0$	CES	<		1	mΑ
$V_{CE} = V_{CESMmax}$ ; $V_{BE} = 0$ ; $T_j = 125  {}^{\circ}\text{C}$	<sup>I</sup> CES	<		2	mΑ
Emitter cut-off current					
$I_C = 0; V_{EB} = 9 V$	<sup>I</sup> EBO	<	1	10	mΑ
Saturation voltages					
$I_C = 3 \text{ A}; I_B = 0.6 \text{ A}$	V <sub>CEsat</sub>	<	1,5	-	٧
L - 25 A. L - 05 A	VBEsat	<	1,3		•
I <sub>C</sub> = 2,5 A; I <sub>B</sub> = 0,5 A	V <sub>CEsat</sub> V <sub>BEsat</sub>	<	_	1,5 1,3	
Collector-emitter sustaining voltage	DESGL				
IC = 100 mA; I <sub>Boff</sub> = 0; L = 25 mA	V <sub>CEOsus</sub>	st>	400	450	٧

<sup>\*</sup> Measured with a half sine-wave voltage (curve tracer).

### CHARACTERISTICS (continued)

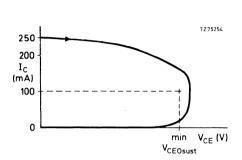


Fig. 2 Oscilloscope display for sustaining voltage.

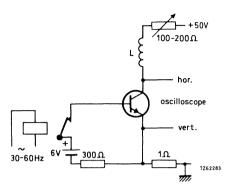


Fig. 3 Test circuit for V<sub>CEOsust</sub>.

Switching times resistive load (Figs 4 and 5)				
I <sub>Con</sub> = 3 A; I <sub>Bon</sub> = -I <sub>Boff</sub> = 0,6 A			BUT11	BUT11A
Turn-on time	ton	<	1	— μs
Turn-off: Storage time	t <sub>s</sub>	<	4	— μs
Fall time	t <sub>f</sub>	<	0,8	— μs
$I_{Con} = 2.5 \text{ A}; I_{Bon} = -I_{Boff} = 0.5 \text{ A}$				
Turn-on time	ton	<		1 μs
Turn-off: Storage time	t <sub>s</sub>	<		4 μs
Fall time	t <sub>f</sub>	<	_	0,8 μs
Switching times inductive load (Figs 6 and 7) $I_{Con} = 3 \text{ A}$ ; $I_{B} = 0.6 \text{ A}$				
Turn-off: Storage time	t <sub>s</sub>	typ.	1,1 1,4	— μs — μs
Fall time	t <sub>f</sub>	typ.	80 150	- ns - ns
$I_{Con} = 3 \text{ A}; I_{B} = 0.6 \text{ A}; T_{j} = 100 ^{\circ}\text{C}$				
Turn-off: Storage time	$t_{S}$	typ.	1,2 1,5	— μs — μs
Fall time	t <sub>f</sub>	typ.	140 300	- ns - ns
Switching times inductive load (Figs 6 and 7) $I_{Con} = 2,5 \text{ A}; I_{B} = 0,5 \text{ A}$				
Turn-off: Storage time	t <sub>S</sub>	typ.	_	1,1 μs 1,4 μs
Fall time	tf	typ.	_	80 ns
$I_{Con}$ = 2,5 A; $I_{B}$ = 0,5 A; $T_{j}$ = 100 °C		<	_	150 ns
Turn-off: Storage time	t <sub>s</sub>	typ.	_	1,2 μs
<u> </u>		< ,	-	1,5 μs
Fall time	t <sub>f</sub>	typ.	_	140 ns
		<		300 ns

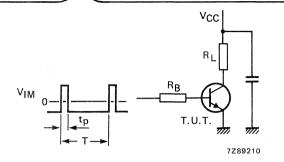


Fig. 4 Test circuit resistive load.



The values of RB and RL are selected in accordance with  $I_{Con}$  and  $I_{B}$  requirements.

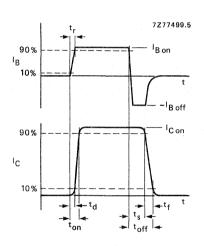


Fig. 5 Switching times waveforms with resistive load.

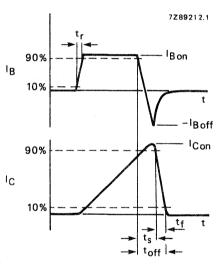


Fig. 6 Switching times waveforms with inductive load.

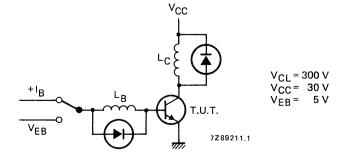


Fig. 7 Test circuit inductive load.

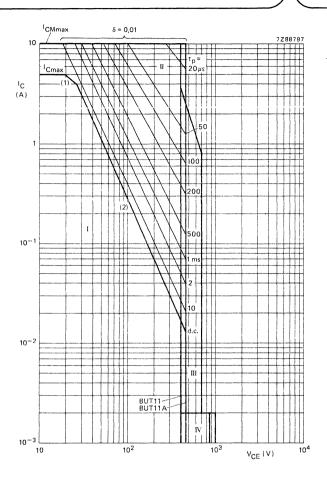


Fig. 8 Safe Operating ARea at  $T_{mb} \le 25$  °C.

- (1) P<sub>tot max</sub> and P<sub>tot peak</sub> max. lines.
   (2) Second-breakdown limits (independent of temperature).
- Region of permissible d.c. operation
- 11 Permissible extension for repetitive pulse operation
- III Area of permissible operation during turn-on in single transistor converters, provided RBE  $\leq$  100  $\Omega$  and tp  $\leq$  0,6  $\mu$ s.
- IV Repetitive pulse operation in this region is permissible provided  $V_{BE} \le 0$  and  $t_0 \le 5$  ms.

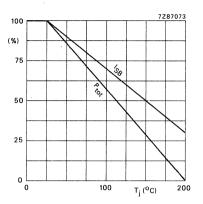


Fig. 9 Total power dissipation and second-breakdown current derating curve.

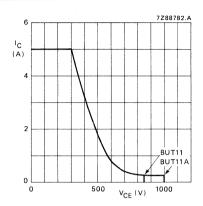


Fig. 10 Reverse bias SOAR.

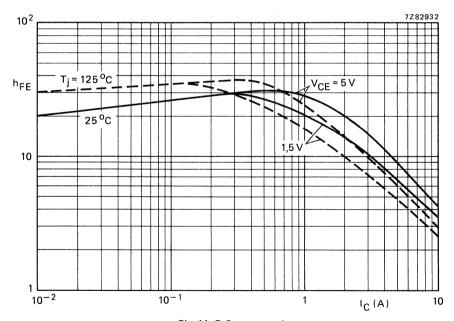


Fig. 11 D.C. current gain.

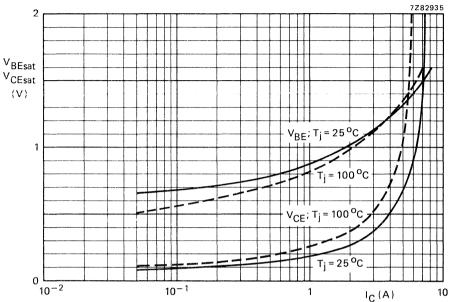


Fig. 12 Typical values base-emitter and collector-emitter voltage,  $I_C/I_B = 5$ .

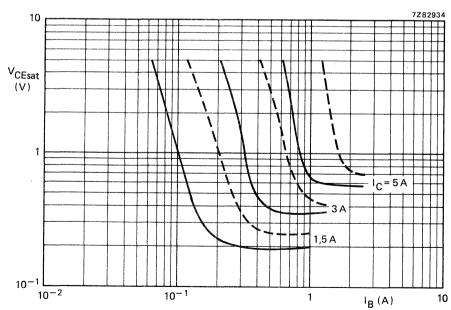


Fig. 13 Typ. (----) and max. (---) values collector-emitter saturation voltage at  $T_j = 25$  °C.

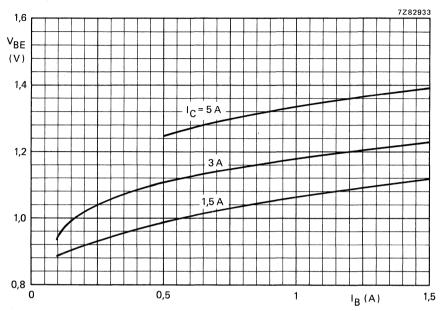


Fig. 14 Typical values at  $T_i = 25$  °C.

#### APPLICATION INFORMATION

Important design factors of SMPS circuits are the maximum power losses, heatsink requirements and base drive conditions of the switching transistor. The power losses are very dependent on the operating frequency, the maximum collector current amplitude and shape.

The operating frequency is mostly set between 15 and 50 kHz. The collector current shape varies from rectangular in a forward converter to sawtooth in a flyback converter.

Information on nominal base drive, optimum base inductance and maximum transistor dissipation applied in a forward converter is given in Figs 15, 16 and 17. In these figures I<sub>CM</sub> represents the maximum repetitive peak collector current, which occurs during overload. The information is derived from limit-case transistors at a mounting base temperature of 100 °C under the following conditions (see also Fig. 15):

- collector current shape I<sub>C1</sub>/I<sub>CM</sub> = 0,9
- duty factor  $(t_p/T) = 0.45$
- rate of rise of  $^{1}$ C during turn-on = 4 A/ $\mu$ s
- rate of rise of  $V_{CF}$  during turn-off = 1 kV/ $\mu$ s
- reverse drive voltage during turn-off = 5 V
- base current shape IB1/IBe = 1,5

The required thermal resistance of the heatsink can be calculated from

$$R_{th mb-a} < \frac{100 - T_{amb}}{P_{tot}} K/W$$

To ensure thermal stability the value of the ambient temperature  $T_{amb} > 40$  °C.

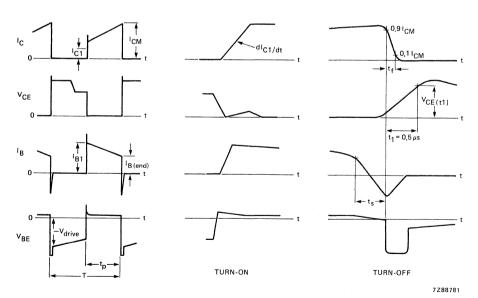


Fig. 15 Relevant waveforms of the switching transistor in a forward SMPS.

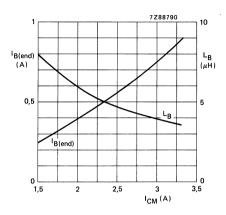


Fig. 16 Recommended nominal "end" value of the base current ( $I_{Be}$ ) and optimum base inductance ( $L_{B}$ ) at  $-V_{drive} = 5 \text{ V}$  versus maximum peak collector current.  $dI_{B(end)} = \pm 20\%$ .

For other values of  $-V_{drive}$  (3 V to 7 V) the related LB is:

$$L_{\text{Bnom}} \frac{(-V_{\text{drive}}) + 1}{6}$$

LBnom is the value given in this graph.

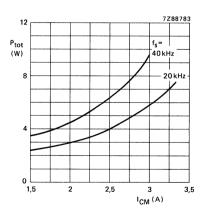


Fig. 17 Maximum transistor dissipation under worse-case operating condition versus maximum peak collector current.  $T_{mb}$  = 100 °C;  $dI_{B(end)}$  =  $\pm$  20%.

### SILICON DIFFUSED POWER TRANSISTOR

High-voltage, high-speed, glass-passivated n-p-n power transistor in a SOT-186 envelope with an electrically insulated seating plane. The device is intended for use in converters, inverters, switching regulators motor control systems, etc.

### QUICK REFERENCE DATA

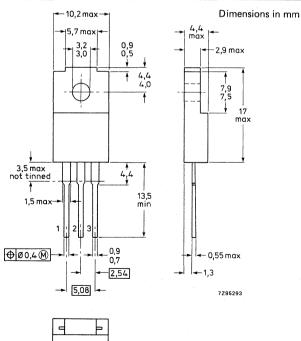
Collector-emitter voltage		E	UT11F	BUT11A	F
open base	$V_{CEO}$	max.	400	450	V
V <sub>BE</sub> = 0, peak value	VCESM	max.	850	1000	V
Collector saturation current	<sup>I</sup> Csat	=	3	2,5	Α
Collector current					
d.c.	IC	max.		5	Α
peak value	<sup>I</sup> CM	max.	1	0	Α
Total power dissipation up to $T_h = 25$ °C	$P_{tot}$	max.	2	0	W
Collector-emitter saturation voltage $I_C = 3 \text{ A}; I_B = 0.6 \text{ A}$ $I_C = 2.5 \text{ A}; I_B = 0.5 \text{ A}$	V <sub>CEsat</sub>	< <sup>1</sup>	1,5 	_ 1,5	V
Fall time					
$I_{Con} = 3 \text{ A}; I_{Bon} = I_{Boff} = 0.6 \text{ A}$	+.	<	0,8	_	μs
$I_{\text{Con}} = 2,5 \text{ A}; I_{\text{Bon}} = I_{\text{Boff}} = 0,5 \text{ A}$	t <sub>f</sub>	<	_	0,8	μs

### MECHANICAL DATA

Fig. 1 SOT-186 (TO-220F).



Seating plane is electrically insulated from all terminals.



## BUT11F BUT11AF

### **RATINGS**

Collector-emitter voltage		<u>E</u>	BUT11F   BUT	11AF
open base	$v_{CEO}$	max.	400	450 V
$V_{BE} = 0$ ; peak value	VCESM	max.	850 10	000 V
Collector current			•	
d.c.	lc	max.	5	Α
peak value	ГСМ	max.	10	Α
Base current			_	
d.c. peak value	<sup>I</sup> B	max.	2 4	A
·	<sup>I</sup> BM	max.	4	Α
Total power dissipation up to $T_h = 25  {}^{\circ}\text{C}^*$	D	mav	20	w
•	P <sub>tot</sub>	max.		
Storage temperature	$T_{stg}$		-65 to + 150	•
Junction temperature	т <sub>ј</sub>	max.	150	oC
THERMAL RESISTANCE				
From junction to internal heatsink	R <sub>th j-mb</sub>		1,45	K/W
From junction to external heatsink*	R <sub>th j-h</sub>		6,45	K/W
From junction to external heatsink**	R <sub>th j-h</sub>		3.95	K/W
From junction to ambient	R <sub>th j-a</sub>		55	K/W
·	ur j-a			
INSULATION				
Voltage allowed between al terminals				
and external heatsink, peak value	$V_{insul}$	max.	1500	V
Insulation capacitance between				
collector and external heatsink	C <sub>c-h</sub>	typ.	12	pF
CHARACTERISTICS				
T <sub>i</sub> = 25 <sup>o</sup> C unless otherwise specified				
Collector cut-off currents				
V <sub>CE</sub> = V <sub>CESmax</sub> ; V <sub>BE</sub> = 0		max.	1	mA
$V_{CE} = V_{CESmax}$ ; $V_{BE} = 0$ ; $T_i = 125$ °C	CES	max.	2	mA
Emitter cut-off current				
$V_{EB} = 9 V; I_{C} = 0$	<sup>I</sup> EBO	max.	10	mA
D.C. current gain				
$I_C = 0.5 A; V_{CE} = 5 V$	hFE	typ.	25	

<sup>\*</sup> Mounted without heatsink compound and 30  $\pm$  5 Newton pressure on centre of envelope.

<sup>\*\*</sup> Mounted with heatsink compound and 30  $\pm$  5 Newton pressure on centre of envelope.

Collector-emitter sustaining voltage	•		BUT11A	BUT11A	\F
$I_C = 0,1 \text{ A}; I_B = 0; L = 25 \mu\text{H}$ (see Figs 2 and 3)	V <sub>CEOsus</sub>	min.	400	450	V
Saturation voltages					
$I_C = 3 \text{ A}; I_B = 0.6 \text{ A}$	V <sub>CEsat</sub> V <sub>BEsat</sub>	max. max.	1,5 1,3	_	V V
$I_C = 2,5 \text{ A}; I_B = 0,5 \text{ A}$	V <sub>CEsat</sub> V <sub>BEsat</sub>	max. max.	_	1,5 1,5	V V
Switching times resistive load (Figs 4 and 5)	DESGL			.,,	•
$I_{Con} = 3 \text{ A}; I_{Bon} = I_{Boff} = 0.6 \text{ A}$	t <sub>on</sub> t <sub>s</sub>	max.	1 4	_	μs μs
In = 25 A.I. = I == 0.5 A	t <sub>f</sub>	max.	8,0	_	μs
$I_{Con} = 2,5 \text{ A}; I_{Bon} = I_{Boff} = 0,5 \text{ A}$	t <sub>on</sub> t <sub>s</sub> t <sub>f</sub>	max. max. max.		1 4 0,8	μs μs μs
Switching times inductive load (Figs 6 and 7)					
I <sub>Con</sub> = 3 A; I <sub>B</sub> = 0,6 A	t <sub>s</sub>	typ. max.	1,1 1,4	_	μs μs
	t <sub>f</sub>	typ. max.	80 150	-	ns ns
$I_{Con} = 3 \text{ A}; I_B = 0.6 \text{ A}; T_j = 100 ^{\circ}\text{C}$	t <sub>s</sub>	typ. max.	1,2 1,5	_	μs μs
	t <sub>f</sub>	typ. max.	140 300	_	ns ns
$I_{Con} = 2.5 \text{ A}; I_{B} = 0.5 \text{ A}$	t <sub>s</sub>	typ. max.	_	1,1 1,4	μs μs
	t <sub>f</sub>	typ. max.		80 150	ns ns
$I_{Con} = 2.5 \text{ A}; I_{B} = 0.5 \text{ A}; T_{j} = 100 ^{\circ}\text{C}$	t <sub>S</sub>	typ. max.		1,2 1,5	μs μs
	t <sub>f</sub>	typ. max.	_	140 300	ns ns

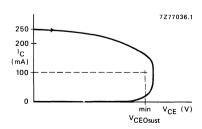


Fig. 2 Oscilloscope display for sustaining voltage.

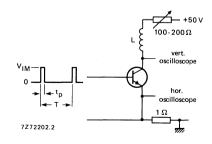


Fig. 3 Test circuit for V<sub>CEOsus</sub>.

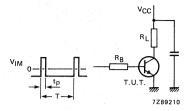


Fig. 4 Test circuit resistive load.

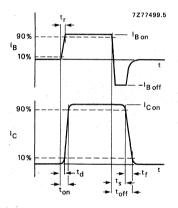


Fig. 5 Switching times waveforms with resistive load.

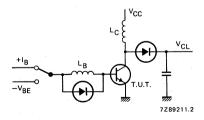


Fig. 7 Test circuit inductive load.

$$V_{CC} = 250 \text{ V}$$
 $V_{IM} = -6 \text{ to} + 8 \text{ V}$ 
 $t_{p} = 20 \mu \text{s}$ 
 $\frac{t_{p}}{T} = 0.01$ 

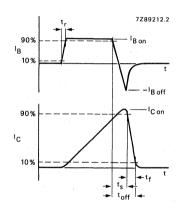


Fig. 6 Switching times waveforms with inductive load.

$$\begin{array}{l} {\rm V_{CL}} \ = 300 \ {\rm V} \\ {\rm V_{CC}} \ = \ 30 \ {\rm V} \\ {\rm V_{EB}} \ = \ 5 \ {\rm V} \\ {\rm L_{B}} \ = \ 1 \ \mu {\rm H} \\ {\rm L_{C}} \ = 200 \ \mu {\rm H} \end{array}$$

## SILICON DIFFUSED POWER TRANSISTORS

High voltage, high speed switching n-p-n power transistor in plastic SOT-93 envelope, intended for use in converters, inverters, switching regulators, motor control systems and switching applications.

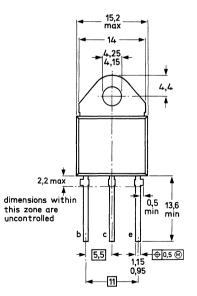
#### QUICK REFERENCE DATA

			BUV82	BUV83	
Collector-emitter voltage (V <sub>BE</sub> = 0, peak value)	VCESM	max.	850	1000	V
Collector-emitter voltage ( $R_{BE}$ = 100 $\Omega$ )	$v_{CER}$	max.	500	500	V
Collector-emitter voltage (open base)	$v_{CEO}$	max.	400	450	V
Collector current (d.c.)	Ic	max.		6	Α
Collector current (peak value) $t_p = 2 \text{ ms}$	<sup>I</sup> CM	max.	1	0	Α
Total power dissipation up to T <sub>mb</sub> = 73 °C	P <sub>tot</sub>	max.	7	0	W
Collector-emitter saturation voltage $I_C = 2,5 \text{ A}; I_B = 0,5 \text{ A}$	V <sub>CEsat</sub>	<	1,	5	V
Fall time .1 <sub>Con</sub> = 2,5 A; 1 <sub>Bon</sub> = 0,5 A; -1 <sub>Boff</sub> = 1 A	t <sub>f</sub>	typ.	0,	3	μs

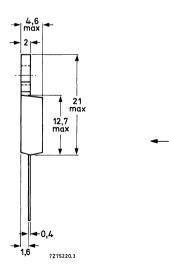
### **MECHANICAL DATA**

Fig. 1 SOT-93.

Collector connected to mounting base



Dimensions in mm



See also chapters Mounting instructions and Accessories.

# BUV82 BUV83

### RATINGS

			BUV82	BUV83		
Collector-emitter voltage (V <sub>BE</sub> = 0; peak value)	VCESM	max.	850	1000	V	
Collector-emitter voltage					4.	
$(R_{BE} = 100 \Omega)$	VCER	max.	500	500	٧	
Collector-emitter voltage (open base)	VCEO	max.	400	450	٧	
Collector current (d.c.)	l <sub>C</sub>	max.		6	Α	
Collector current (peak value)						
t <sub>p</sub> = 2 ms	<sup>I</sup> CM	max.	•	10	Α	
Base current (d.c.)	I <sub>B</sub>	max.		2	Α	
Base current (peak value)	<sup>I</sup> BM	max.		3	Α	
Reverse base current (d.c. or average over any 20 ms period)	<sup>−l</sup> B(AV)	max.	1	00	mA	
Reverse base current (peak value)*	-I <sub>BM</sub>	max.		3	Α	
Total power dissipation up to $T_{mb} = 73$ °C	P <sub>tot</sub>	max.		70	W	
Storage temperature	T <sub>stg</sub>	-	-65 to + 1	50	оС	
Junction temperature	Tj	max.	1!	50	°C	
THERMAL RESISTANCE						
From junction to mounting base	R <sub>th j-mb</sub>	=	1	,1	K/W	
CHARACTERISTICS						
T <sub>i</sub> = 25 °C unless otherwise specified						
Collector cut-off current**						
$V_{CEM} = V_{CESMmax}; V_{BE} = 0$	<sup>I</sup> CES	<		1	mΑ	
$V_{CEM} = V_{CESMmax}$ ; $V_{BE} = 0$ ; $T_j = 125$ °C	ICES	< ,		2	mΑ	
D.C. current gain						
I <sub>C</sub> = 0,6 A; V <sub>CE</sub> = 5 V	hFE	typ.	:	22		

<sup>\*</sup> Turn-off current.

<sup>\*\*</sup> Measured with a half sine wave voltage (curve tracer).

### CHARACTERISTICS (continued)

T;	= 25	oC	unless	otherwise	specified
----	------	----	--------	-----------	-----------

1 = 25 °C unless otherwise specified					
Emitter cut-off current I <sub>C</sub> = 0; V <sub>EB</sub> = 10 V	I <sub>EBO</sub>	<	1	0	mA
Saturation voltages					
$I_C = 2.5 \text{ A}; I_B = 0.5 \text{ A}$	$v_{CEsat}$	<	1,	5	٧
	$V_{BEsat}$	<	1,	4	V
$I_C = 4 A; I_B = 1,25 A$	$v_{CEsat}$	<		3	V
	$V_{BEsat}$	<	1,	6	V
Collector-emitter sustaining voltages			BUV82	BUV83	
I <sub>C</sub> = 100 mA; I <sub>Boff</sub> = 0; L = 25 mH	VCEOsust	>	400	450	V
$I_C$ = 100 mA; $R_{BE}$ = 100 $\Omega$ ; L = 15 mH	$V_{CERsust}$	>	500	500	V

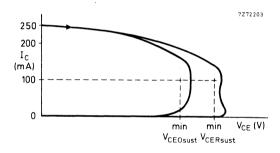


Fig. 2 Oscilloscope display for sustaining voltages.

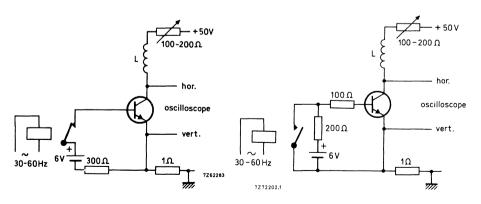


Fig. 3 Test circuit for V<sub>CEOsust</sub>.

Fig. 4 Test circuit for V<sub>CERsust</sub>.

#### CHARACTERISTICS (continued)

 $T_j = 25$  °C unless otherwise specified

Transition frequency	at f =	1 M	lHz
I <sub>C</sub> = 0,2 A; V <sub>CE</sub> =	10 V		

Switching times

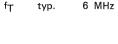
 $I_{Con} = 2.5 \text{ A}; V_{CC} = 250 \text{ V}$  $I_{Bon} = 0.5 \text{ A}; -I_{Boff} = 1 \text{ A}$ 

Turn-on time

Turn-off: Storage time

Fall time

Fall time, T<sub>mb</sub> = 95 °C



ton  $\stackrel{\text{typ.}}{<}$  0,3  $\mu$ s  $\stackrel{\text{typ.}}{<}$  0,6  $\mu$ s

t<sub>s</sub> typ. 2 μs < 3,5 μs

t<sub>f</sub> typ. 0,3 μs

0.75 µs

<

tf

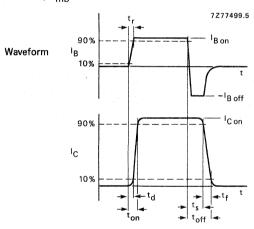


Fig. 5 Switching times waveform.

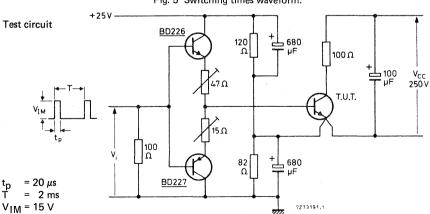


Fig. 6 Switching times test circuit.

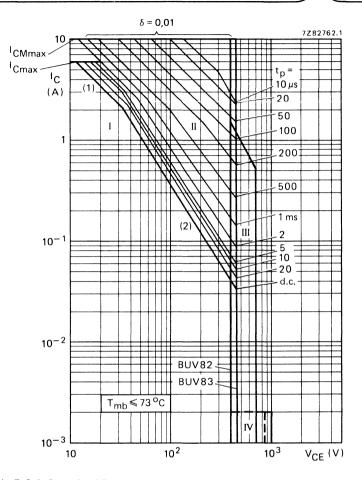


Fig. 7 Safe Operating ARea.

- I Region of permissible d.c. operation.
- II Permissible extension for repetitive pulse operation.
- III Area of permissible operation during turn-on in single-transistor converters, provided R  $_{BE} \leqslant 100~\Omega$  and  $t_p \leqslant 0.6~\mu s.$
- IV Repetitive pulse operation in this region is permissible, provided  $V_{BE} \le 0$  and  $t_p \le 2$  ms.
- (1) Ptot max and Ppeak max lines.
- (2) Second-breakdown limits (independent of temperature).

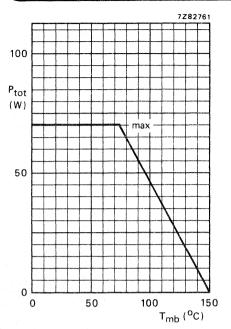


Fig. 8 Power derating curve.

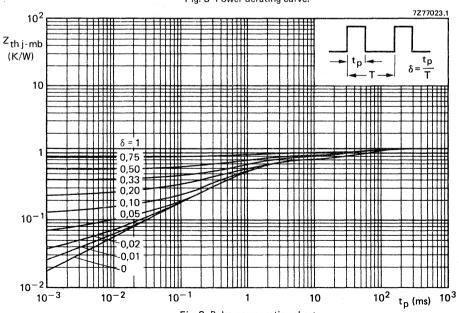


Fig. 9 Pulse power rating chart.

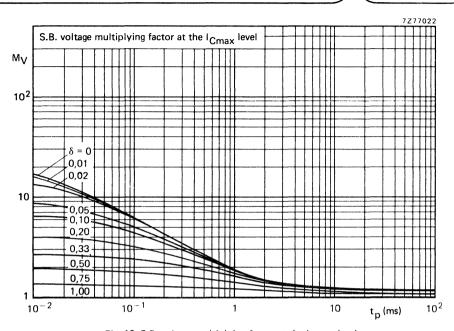


Fig. 10 S.B. voltage multiplying factor at the  $I_{\mbox{Cmax}}$  level.

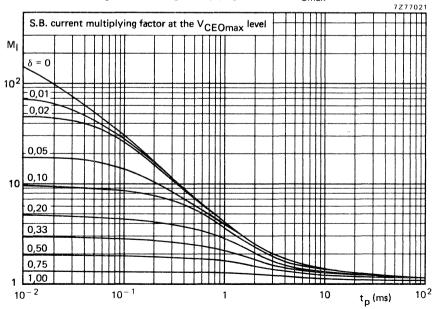


Fig. 11 S.B. current multiplying factor at the V<sub>CEOmax</sub> level.

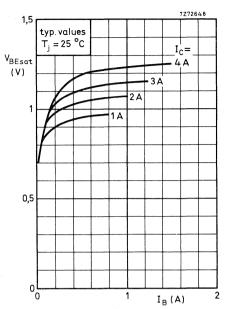


Fig. 12 Base-emitter saturation voltage.

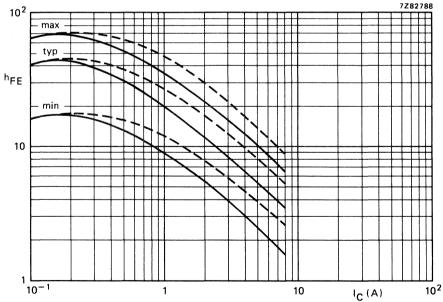


Fig. 13 D.C. current gain.  $T_j = 25$  °C; -- at  $V_{CE} = 5$  V; -- at  $V_{CE} = 1$  V.

### **DEVELOPMENT DATA**

This data sheet contains advance information and specifications are subject to change without notice,

### SILICON DIFFUSED POWER TRANSISTOR

High-voltage, high-speed switching n-p-n transistor in a plastic SOT-93 envelope especially intended for use in a.c. motor control systems from three-phase mains.

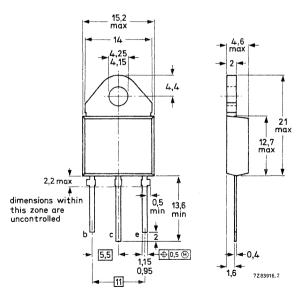
### QUICK REFERENCE DATA

Collector-emitter voltage (V <sub>BE</sub> = 0, peak value)	$V_{CESM}$	max.	1200 V
Collector-emitter voltage (open base)	$v_{CEO}$	max.	800 V
Collector current (d.c.)	1 <sub>C</sub>	max.	8 A
Collector current (peak value)	l <sub>CM</sub>	max.	15 A
Total power dissipation up to $T_{mb}$ = 25 ${}^{o}C$	$P_{tot}$	max.	125 W
Collector-emitter saturation voltage $I_C = 4,5 A$ ; $I_B = 2 A$	V <sub>CEsat</sub>	<	1 V
Turn-on fall time	t <sub>f</sub>	typ.	0,5 μs

### MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT93A Collector connected to mounting base.



See also chapters Mounting instructions and Accessories in handbook I.f. power transistors.

# RATINGS

Limiting values in accordance with the Absolute Maximum System (IE	C 134)			
Collector-emitter voltage (peak value; V <sub>BE</sub> = 0)	$v_{CESM}$	max.	1200	V
Collector-emitter voltage (open base)	$v_{CEO}$	max.	800	V
Collector current (d.c.)	l <sub>C</sub>	max.	8	Α
Collector current (peak value)	<sup>I</sup> CM	max.	15	A
Base current (d.c.)	I <sub>B</sub>	max.	4	Α
Base current (peak value)	I <sub>BM</sub>	max.	6	Α
Total power dissipation up to T <sub>mb</sub> = 25 °C	$P_{tot}$	max.	125	W
Storage temperature	T <sub>stg</sub>	65 to +	150	оС
Junction temperature	Tj	max.	150	oC
THERMAL RESISTANCE				
From junction to mounting base	R <sub>th j-mb</sub>	=	1,0	K/W
CHARACTERISTICS				
T <sub>j</sub> = 25 °C unless otherwise specified				
Collector cut-off current*				
$V_{BE} = 0$ ; $V_{CE} = V_{CESMmax}$	CES	<	•	mΑ
$V_{BE} = 0$ ; $V_{CE} = V_{CESMmax}$ ; $T_j = 125$ °C	ICES	<	2,0	mΑ
Emitter cut-off current			10	A
$V_{EB} = 5 \text{ V}; I_C = 0$	IEBO	<	10	mA
Collector-emitter sustaining voltage $I_R = 0$ ; $I_C = 100 \text{ mA}$ ; $L = 25 \text{ mH}$	VCEOsus	>	800	V
Saturation voltage	* CEOsus	ST-	000	•
I <sub>C</sub> = 4,5 A; I <sub>B</sub> = 2 A	$V_{CEsat}$	<	1	٧
I <sub>C</sub> = 6 A; I <sub>B</sub> = 3 A	$V_{BEsat}$	<	1,3	
	V <sub>CEsat</sub>	typ.	1	V
Transition frequency at f = 5 MHz IC = 0,1 A; VCF = 5 V	fT	typ.	7	MHz
Collector capacitance at f = 1 MHz	'1	typ.	,	IVIIIZ
$I_E = I_e = 0$ ; $V_{CB} = 10 \text{ V}$	C <sub>c</sub>	typ.	125	pF
Switching times in resistive switching circuit (Fig. 5)	Ü			
$I_{Con} = 4,5 \text{ A}; I_{Bon} = -I_{Boff} = 2 \text{ A}$				
Turn-on time	ton	typ.	0,2	μs
Storage time	t <sub>S</sub>	typ.	3,5	μs
Fall time	t <sub>f</sub>	typ.	0,5	μs
Second-breakdown current				
$V_{CE} = 100 \text{ V; } t_p = 1 \text{ s}$	l(SB)	>	0,3	Α

<sup>\*</sup> Measured with a half-sinewave voltage (curve tracer).

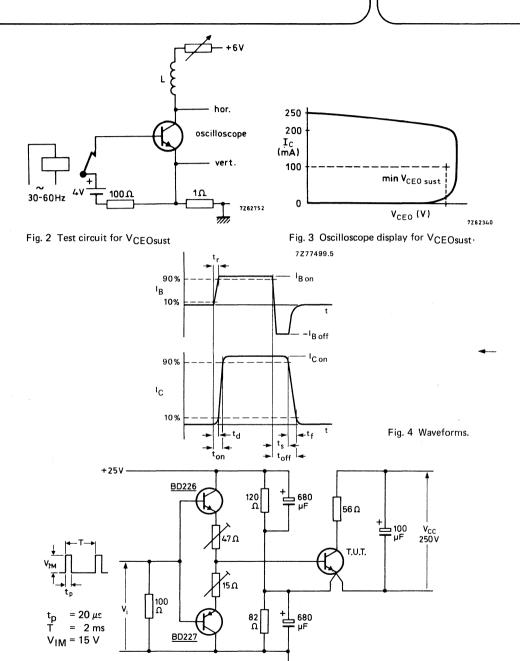


Fig. 5 Switching times test circuit.

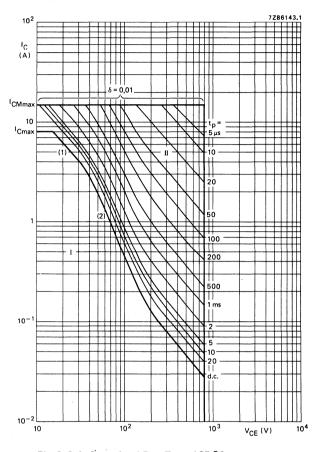


Fig. 6 Safe Operating ARea;  $T_{mb} \le 25$  °C.

- 1.
- P<sub>tot max</sub> and P<sub>tot peak</sub> max. lines. Second-breakdown limits (independent of temperature) 2.
- Region of permissible d.c. operation.
- П Permissible extension for repetitive pulse operation.

# **DEVELOPMENT DATA**

This data sheet contains advance information and specifications are subject to change without notice.

# SILICON DIFFUSED DARLINGTON POWER TRANSISTORS

High-voltage, monolithic n-p-n power Darlington transistors in an SOT-93 envelope intended for use in car ignition systems, d.c. and a.c. motor controls, solenoid drivers, etc.

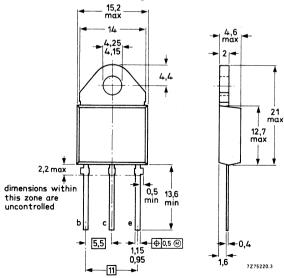
### QUICK REFERENCE DATA

			BUV90   BUV90A	
Collector-emitter voltage (V <sub>BE</sub> = 0, peak value)	$v_{CESM}$	max.	650	V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	400	V
Collector saturation current	<sup>I</sup> Csat		10	Α
Collector current (d.c.)	Ic	max.	12	Α
Collector current (peak value)	<sup>I</sup> CM	max.	30	Α
Total power dissipation up to T <sub>mb</sub> = 25 °C	$P_{tot}$	max.	125	W
Collector-emitter saturation voltage $I_C = 5 A$ ; $I_B = 0.05 A$	V <sub>CEsat</sub>	<	1.5	V
I <sub>C</sub> = 10 A; I <sub>B</sub> = 0.3 A	V <sub>CEsat</sub>	<	. 2	V
Fall time (inductive switching)				
$I_{Con} = 5 \text{ A}; I_{Bon} = 50 \text{ mA}; L_{C} = 200 \mu \text{H}$	tf	typ.	0.7	μs
I <sub>Con</sub> = 10 A; I <sub>Bon</sub> = 300 mA; L <sub>C</sub> = 200 μH	t <sub>f</sub>	typ.	1	μs

### **MECHANICAL DATA**

Dimensions in mm

Fig.1 SOT-93; Collector connected to mounting base



For Accessories and Mounting instructions see handbook: L.F. power transistors and modules.

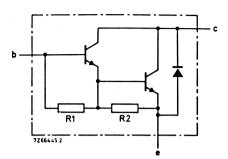


Fig. 2 Darlington circuit diagram R1 typical 500  $\Omega$  R2 typical 300  $\Omega$ 

## **RATINGS**

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

Collector-emitter voltage (V <sub>BE</sub> = 0, peak value)	V <sub>CESM</sub>	max.	650	V
Collector-emitter voltage (open base)	$v_{CEO}$	max.	400	$\mathbf{V}^{-}$
Collector current (d.c.)	<sup>I</sup> C	max.	12	Α
Collector current (peak value)	<sup>I</sup> CM	max.	30	Α
Base current (d.c.)	I <sub>B</sub>	max.	4	Α
Base current (peak value)	I <sub>BM</sub>	max.	6	Α
Total power dissipation up to $T_{mb} = 25$ °C	$P_{tot}$	max.	125	W
Storage temperature	T <sub>stg</sub>		-65 to +150	οС
Junction temperature	Tj	max.	150	οС
THERMAL RESISTANCE				
From junction to mounting base	R <sub>th j-mb</sub>	=	1	K/W
CHARACTERISTICS				
T <sub>j</sub> = 25 °C unless otherwise specified				
Collector cut-off current*				
$V_{CE} = V_{CESMmax}; V_{BE} = 0$	ICES	<	1	mΑ
$V_{CE} = V_{CESMmax}$ ; $V_{BE} = 0$ ; $T_j = 125  {}^{\circ}C$	<sup>I</sup> CES	<	3	mΑ
Emitter cut-off current				
$I_C = 0$ ; $V_{EB} = 6 V$	<sup>I</sup> EBO	<	20	mΑ
Collector-emitter sustaining voltage	\/		400	V
$I_C = 5 A; I_B = 0; L = 8 \text{ mH}$ Diode forward voltage	VCEOsust	>	400	V
IF = 8 A; IB = 0	VF	<	3	٧

<sup>\*</sup>Measured with a half sine-wave voltage (curve tracer).

CHARACTERISTICS (continued)					
			BUV90	BUV90A	
Saturation voltages					
$I_C = 5 A; I_B = 0.05 A$	$v_{CEsat}$	<	1.5	1.7	V
	$V_{BEsat}$	<		2	V
$I_C = 5 \text{ A}$ ; $I_B = 0.06 \text{ A}$ ; $T_i = -40 ^{\circ}\text{C}$	$v_{CEsat}$	<.	1.5	1.8	V
	$V_{BEsat}$	<		2	V
$I_C = 6 \text{ A}; I_B = 0.1 \text{ A}; T_i = 150 ^{\circ}\text{C}$	$V_{CEsat}$	<	1.5	1.7	V
*	$V_{BEsat}$	<	'	2	V
$I_C = 10 \text{ A}; I_B = 0.3 \text{ A}$	$V_{CEsat}$	<		2	V
	$V_{BEsat}$	<	2	2.5	V
Turn-off breakdown energy, with inductive load (Fig.3) I <sub>C</sub> = 10 A; I <sub>B</sub> = 0.3 A					
$L_C = 8 \text{ mH}; V_{CL} = 400 \text{ V}$	E <sub>(BR)</sub>	>	4	00	mJ
Turn-on test (Fig.4)	$V_{CEon}$	>	4	00	V
Fall time; inductive switching (Fig.5)					
$I_{Con} = 5 \text{ A}; I_{Bon} = 50 \text{ mA}; L_{C} = 200 \mu \text{H}$	tf	typ.	. (	0.7	μs
$I_{Con} = 10 \text{ A}$ ; $I_{Ron} = 300 \text{ mA}$ ; $I_{Con} = 200 \mu \text{H}$	tf	typ.		1	μs

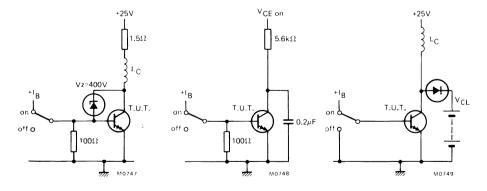


Fig.3: Energy test

Fig.4: Turn-on test

Fig.5: Inductive switching

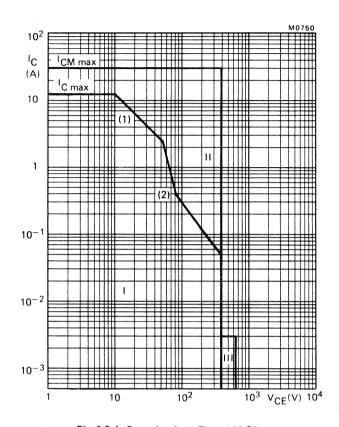


Fig. 6 Safe Operating Area;  $T_{mb} \leqslant$  25  $^{o}\text{C}$ 

- Region of permissible d.c. operation
- 11 Permissible extension for repetitive pulse operation
- III Repetitive pulse operation in this region is permissible, provided  $\rm V_{BE}\,{<}\,0$  and  $\rm t_p\,{<}\,5$  ms.
- (1) Ptot max line.
- (2) Second-breakdown limits (independent of temperature).

# SILICON DIFFUSED POWER TRANSISTORS

High-voltage, high-speed, glass-passivated n-p-n power transistors in a SOT-93 envelope, intended for use in converters, inverters, switching regulators, motor control systems etc.

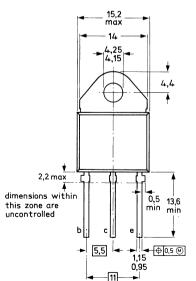
### QUICK REFERENCE DATA

			BUW11	BUW11A	4
Collector-emitter voltage (V <sub>BE</sub> = 0, peak value)	<b>V</b> CESM	max.	850	1000	٧
Collector-emitter voltage (open base)	$v_{CEO}$	max.	400	450	٧
Collector current (d.c.)	Ic	max.		5	Α
Collector current (peak value) $t_p \le 2$ ms	ICM	max.	1	10	Α
Total power dissipation up to T <sub>mb</sub> = 25 °C	$P_{tot}$	max.	10	00	W
Collector-emitter saturation voltage					
$I_C = 3 A; I_B = 0.6 A$	$v_{CEsat}$	<	1,5	-	V
$I_C = 2.5 \text{ A}; I_B = 0.5 \text{ A}$	V <sub>CEsat</sub>	<	_	1,5	V
Fall time (resistive load)					
$I_{Con} = 3 \text{ A}; I_{Bon} = -I_{Boff} = 0.6 \text{ A}$	tf	<	0,8		μs
$I_{\text{Con}} = 2,5 \text{ A}; I_{\text{Bon}} = -I_{\text{Boff}} = 0,5 \text{ A}$	tf	<	-	0,8	μs

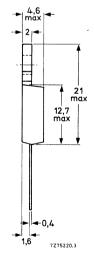
### **MECHANICAL DATA**

Fig. 1 SOT-93.

Collector connected to mounting base,



Dimensions in mm



See also chapters Mounting instructions and Accessories.

# BUW11 BUW11A

## **RATINGS**

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

			BUW11	BUW11A	
Collector-emitter voltage (V <sub>BE</sub> = 0, peak value)	<sup>V</sup> CESM	max.	850	1000	V
Collector-emitter voltage (open base)	VCEO	max.	400	450	V
Collector current (d.c.)	I <sub>C</sub>	max.		5	Α
Collector current (peak value) tp < 2 ms	ICM	max.	1	0	Α
Base current (d.c.)	I <sub>B</sub>	max.		2	Α
Base current (peak value); tp < 2 ms	<sup>I</sup> BM	max.		4	Α
Total power dissipation up to T <sub>mb</sub> = 25 °C	P <sub>tot</sub>	max.	10	0	W
Storage temperature	T <sub>stg</sub>		65 to + 15	0	οС
Junction temperature	тj	max.	15	0	oC
THERMAL RESISTANCE					
From junction to mounting base	R <sub>th j-mb</sub>	=	1,2	5	K/W
CHARACTERISTICS				4	
T <sub>j</sub> = 25 °C unless otherwise specified					
Collector cut-off current*					
VCE = VCESMmax; VBE = 0	CES	< '		1	mΑ
$V_{CE} = V_{CESMmax}$ ; $V_{BE} = 0$ ; $T_j = 125$ °C	CES	<		2	mA
Emitter cut-off current IC = 0; V <sub>EB</sub> = 9 V	IFRO	<	1	0	mA
	IEBO		BUW11	BUW11A	
Saturation voltages IC = 3 A; IB = 0,6 A	Vor	<	1,5	DOWN	<u>.</u>
1C = 3 A, 1B = 0,0 A	V <sub>CEsat</sub> V <sub>BEsat</sub>	<	1,3		v
I <sub>C</sub> = 2,5 A; I <sub>B</sub> = 0,5 A	VCEsat	<		1,5	v
	<b>V</b> BEsat	<	_	1,4	٧
Collector-emitter sustaining voltage					
$I_C = 100 \text{ mA}; I_{Boff} = 0; L = 25 \text{ mH}$	V <sub>CEOsust</sub>	>	400	450	V
Collector saturation current			1.0		
V <sub>CE</sub> = 1,5 V	Csat	<	3	2,5	Α

<sup>\*</sup> Measured with a half sine-wave voltage (curve tracer).

## CHARACTERISTICS (continued)

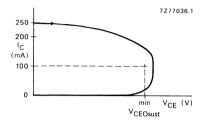


Fig. 2 Oscilloscope display for sustaining voltage.

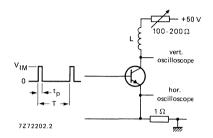


Fig. 3 Test circuit for V<sub>CEOsust</sub>.

Switching times resistive load (Figs 4 and 5)  ICon = 3 A; IBon = IBoff = 0,6 A  Turn-on time
Turn-off: Storage time Fall time
l <sub>Con</sub> = 2,5 A; l <sub>Bon</sub> = -I <sub>Boff</sub> = 0,5 A Turn-on time
Turn-off: Storage time Fall time
Switching times inductive load (Figs 6 and 7) $I_{Con} = 3 \text{ A}$ ; $I_{B} = 0.6 \text{ A}$ Turn-off: Storage time
Fall time
$I_{Con}$ = 3 A; $I_{B}$ = 0,6 A; $T_{j}$ = 100 °C Turn-off: Storage time
Fall time
Switching times inductive load (Figs 6 and 7) $I_{Con} = 2.5 \text{ A}$ ; $I_{B} = 0.5 \text{ A}$ Turn-off: Storage time
Fall time
$I_{Con}$ = 2,5 A; $I_{B}$ = 0,5 A; $T_{j}$ = 100 °C Turn-off: Storage time
Fall time

		BUW11	BUW11A	
ton	<	1	_	μs
ts	< < <	4	_	μs
tf	<	0,8		μs
t <sub>on</sub>	< < <	_	1	μs
$t_{s}$	<	-	4	μs
tf	<	_	0,8	μs
	typ.	1,1		μs
t <sub>S</sub>	<	1,4	_	$\mu$ s
tf	typ.	80	_	ns
'	<	150	_	ns
	typ.	1,2	_	μs
t <sub>S</sub>	<	1,5	-	$\mu$ s
t <sub>f</sub>	typ.	140	_	ns
		300	_	ns
t <sub>s</sub>	typ.		1,1	μs
-5	<	_	1,4 80	μs
tf	typ.	_	150	ns ns
	`	_	130	113
ts	typ.	_	1,2	μs
٠S	<		1,5	μs
	typ.	_	140 300	ns
	_		300	ns

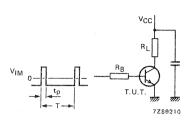


Fig. 4 Test circuit resistive load.

 $V_{CC} = 250 \text{ V}$   $V_{IM} = -6 \text{ to} + 8 \text{ V}$   $\frac{t_p}{T} = 0.01$   $t_p = 20 \,\mu\text{s}$ The values of R<sub>B</sub> and R<sub>L</sub> are selected in accordance with I<sub>Con</sub> and I<sub>B</sub> requirements.

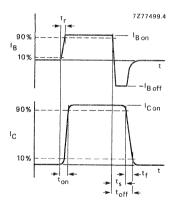


Fig. 5 Switching times waveforms with resistive load,

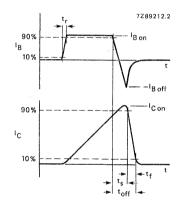


Fig. 6 Switching times waveforms with inductive load.

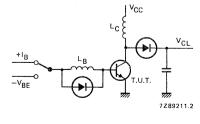
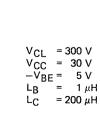


Fig. 7 Test circuit inductive load.



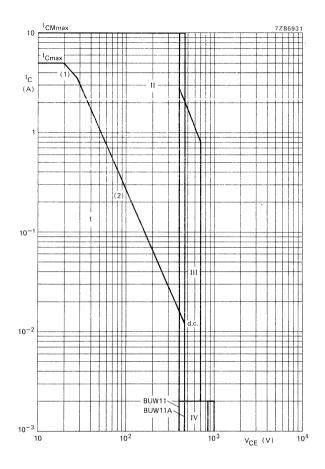


Fig. 8 Safe Operating ARea at  $T_{mb} \le 25$  °C.

- (1) Ptot max line.
- (2) Second-breakdown limits.
- I Region of permissible d.c. operation
- 11 Permissible extension for repetitive pulse operation
- III Area of permissible operation during turn-on in single transistor converters, provided RBE  $\leqslant$  100  $\Omega$  and tp  $\leqslant$  0,6  $\mu s.$
- IV Repetitive pulse operation in this region is permissible provided  $V_{BE} \le 0$  and  $t_p \le 5$  ms.

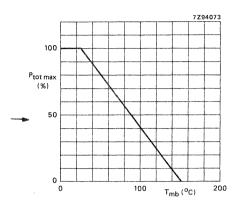


Fig. 9 Total power dissipation derating curve.

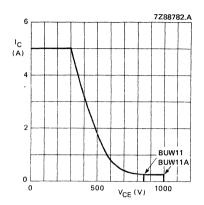


Fig. 10 Reverse bias SOAR.

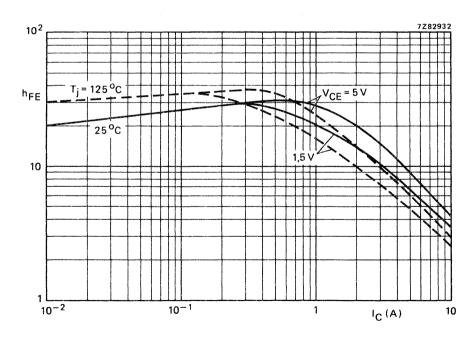


Fig. 11 Typical values d.c. current gain.

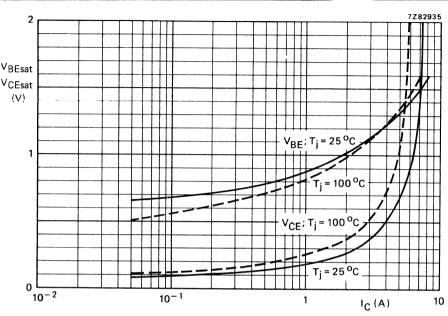


Fig. 12 Typical values base-emitter and collector-emitter voltage,  $I_C/I_B = 5$ .

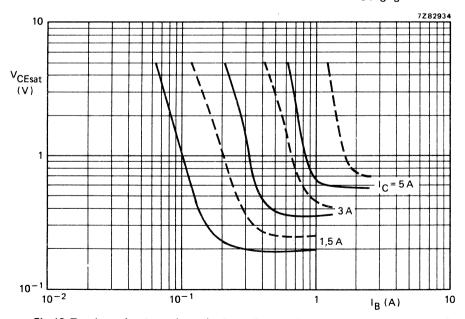


Fig. 13 Typ. (——) and max. (---) values collector-emitter saturation voltage at  $T_j = 25$  °C.

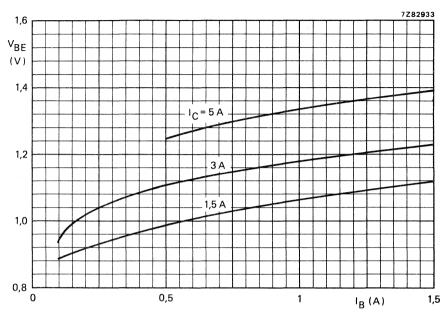


Fig. 14 Typical values at  $T_j = 25$  °C.

#### APPLICATION INFORMATION

Important design factors of SMPS circuits are the maximum power losses, heatsink requirements and base drive conditions of the switching transistor. The power losses are very dependent on the operating frequency, the maximum collector current amplitude and shape.

The operating frequency is mostly set between 15 and 50 kHz. The collector current shape varies from rectangular in a forward converter to sawtooth in a flyback converter.

information on nominal base drive, optimum base inductance and maximum transistor dissipation applied in a forward converter is given in Figs 15, 16 and 17. In these figures I<sub>CM</sub> represents the maximum repetitive peak collector current, which occurs during overload. The information is derived from limit-case transistors at a mounting base temperature of 100 °C under the following conditions (see also Fig. 15):

- collector current shape I<sub>C1</sub>/I<sub>CM</sub> = 0,9
- duty factor t<sub>D</sub>/T = 0,45
- rate of rise of I<sub>C</sub> during turn-on =  $4 A/\mu s$
- rate of rise of  $V_{CE}$  during turn-off = 1 kV/ $\mu$ s
- reverse drive voltage during turn-off = 5 V
- base current shape IB1/IBe = 1,5

The required thermal resistance of the heatsink can be calculated from

$$R_{th\;mb\text{-}a} < \frac{100 - T_{amb}}{P_{tot}} \; \text{K/W}$$

To ensure thermal stability the value of the ambient temperature  $T_{amb} > 40$  °C.

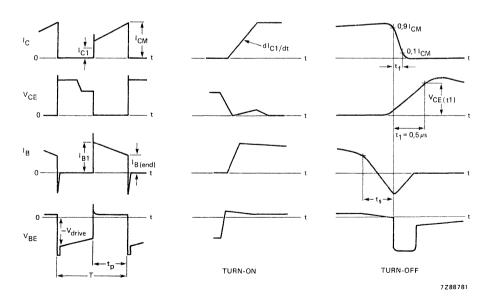


Fig. 15 Relevant waveforms of the switching transistor in a forward SMPS.

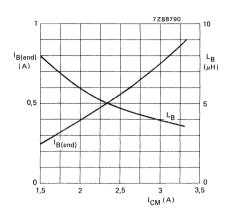


Fig. 16 Recommended nominal "end" value of the base current ( $I_{Be}$ ) and optimum base inductance ( $I_{Be}$ ) at  $-V_{drive} = 5$  V versus maximum peak collector current.  $I_{Be} = \pm 20\%$ .

For other values of  $-V_{drive}$  (3 V to 7 V) the related L<sub>B</sub> is:

$$L_{Bnom} \frac{(-V_{drive}) + 1}{6}$$

LBnom is the value given in this graph.

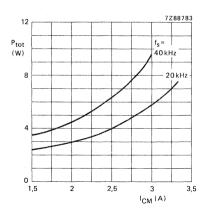


Fig. 17 Maximum transistor dissipation under worse-case operating condition versus maximum peak collector current.  $T_{mb} = 100$  °C;  $dI_{B(end)} = \pm 20\%$ .

# SILICON DIFFUSED POWER TRANSISTORS

High-voltage, high-speed, glass-passivated n-p-n power transistors in a SOT-93 envelope, intended for use in converters, inverters, switching regulators, motor control systems etc.

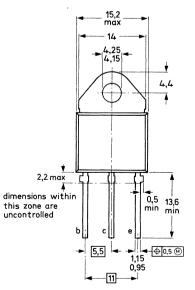
### QUICK REFERENCE DATA

			BUW12	BUW12A	<u>\</u>
Collector-emitter voltage (V <sub>BE</sub> = 0, peak value)	$v_{CESM}$	max.	850	1000	V
Collector-emitter voltage (open base)	$v_{CEO}$	max.	400	450	V
Collector current (d.c.)	I <sub>C</sub>	max.		8	Α
Collector current (peak value) $t_p \le 2$ ms	<sup>1</sup> CM	max.	2	20	Α
Total power dissipation up to $T_{mb} = 25$ °C	P <sub>tot</sub>	max.	12	25	W
Collector-emitter saturation voltage  I C = 6 A; IB = 1,2 A	VCEsat	<	1,5	_	V V
$I_C = 5 A$ ; $I_B = 1 A$ Fall time (resistive load)	V <sub>CEsat</sub>		_	1,5	V
I <sub>Con</sub> = 6 A; I <sub>Bon</sub> = -I <sub>Boff</sub> = 1,2 A I <sub>Con</sub> = 5 A; I <sub>Bon</sub> = -I <sub>Boff</sub> = 1 A	t <sub>f</sub>	< <	0,8 -	_ 0,8	μs μs

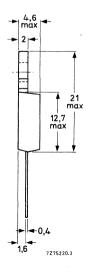
### **MECHANICAL DATA**

Fig. 1 SOT-93.

Collector connected to mounting base.



Dimensions in mm



See also chapters Mounting instructions and Accessories.

# BUW12 BUW12A

## RATINGS

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

		(,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	BUW12	BUW12A	
Collector-emitter voltage (peak value; V <sub>BE</sub> = 0)	VCESM	max.	850	1000	v
Collector-emitter voltage (open base)	VCEO	max.	400	450	· V
Collector current (d.c.)	I <sub>C</sub>	max.		8	Α
Collector current (peak value); tp < 2 ms	ICM	max.	1 2	20	Α
Base current (d.c.)	1 <sub>B</sub>	max.		4	Α
Base current (peak value); t <sub>p</sub> ≤ 2 ms	I <sub>BM</sub>	max.		6	Α
Total power dissipation up to T <sub>mb</sub> = 25 °C	P <sub>tot</sub>	max.	12	25	W
Storage temperature	T <sub>stg</sub>	_	-65 to + 15	50	οС
Junction temperature	Тj	max.	15	50	оС
THERMAL RESISTANCE					
From junction to mounting base	R <sub>th j-mb</sub>	=	1	,0	K/W
CHARACTERISTICS					
T <sub>j</sub> = 25 °C unless otherwise specified					
Collector cut-off current*					
VCE = VCESMmax; VBE = 0	ICES	< <		1	mΑ
V <sub>CE</sub> = V <sub>CESMmax</sub> ; V <sub>BE</sub> = 0; T <sub>j</sub> = 125 °C Emitter cut-off current	ICES	< ,		3	mΑ
I <sub>C</sub> = 0; V <sub>EB</sub> = 9 V	I <sub>EBO</sub>	<	1	10	mΑ
Saturation voltages	·EBO	•	BUW12	BUW12A	
I <sub>C</sub> = 6 A; I <sub>R</sub> = 1,2 A	V <sub>CEsat</sub>	<	1,5	_	· V
	VBEsat	<	1,5	· —	V
$I_C = 5 A$ ; $I_B = 1,0 A$	V <sub>CEsat</sub>	<	_	1,5	٧
	V <sub>BEsat</sub>	<	_	1,5	V
Collector-emitter sustaining voltage	V		400	450	.,
I <sub>C</sub> = 100 mA; I <sub>Boff</sub> = 0; L = 25 mH	VCEOsust	>	400	450	V

<sup>\*</sup> Measured with a half sine-wave voltage (curve tracer).

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μs ns ns μs μs ns

## CHARACTERISTICS (continued)

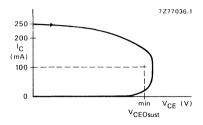


Fig. 2 Oscilloscope display for sustaining voltage.

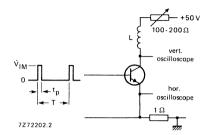
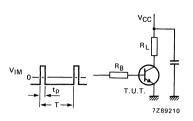


Fig. 3 Test circuit for V<sub>CEOsust</sub>.

Switching times resistive load (Figs 4 and 5)			BUW12	BUW12A
$I_{\text{Con}} = 6 \text{ A}; I_{\text{Bon}} = -I_{\text{Boff}} = 1,2 \text{ A}$				BOWIZA
Turn-on time	<sup>t</sup> on	<	1	_
Turn-off: Storage time	t <sub>s</sub>	<	4	_
Fall time	tf	<	0,8	_
$I_{Con} = 5 A; I_{Bon} = -I_{Boff} = 1 A$				
Turn-on time	ton	<		1
Turn-off: Storage time	t <sub>s</sub>	<		4
Fall time	tf	<	_	0,8
Switching times inductive load (Figs 6 and 7)				
I <sub>Con</sub> = 6 A; I <sub>B</sub> = 1,2 A		4	1.0	
Turn-off: Storage time	t <sub>s</sub>	typ.	1,6 2,1	_
		typ.	80	_
Fall time	t <sub>f</sub>	< p.	150	_
I <sub>Con</sub> = 6 A; I <sub>B</sub> = 1,2 A; T <sub>i</sub> = 100 °C		•		
Turn-off: Storage time	+	typ.	1,8	-
ram on. Storage time	t <sub>S</sub>	<	2,3	· -
Fall time	t <sub>f</sub>	typ.	140	_
	-1	<	300	_
Switching times inductive load (Figs 6 and 7)				
$I_{Con} = 5 A; I_{B} = 1 A$		typ.		1,6
Turn-off: Storage time	t <sub>s</sub>	<		2,1
Fall Aires		typ.		80
Fall time	t <sub>f</sub>	<	_	150
I <sub>Con</sub> = 5 A; I <sub>B</sub> = 1 A; T <sub>j</sub> = 100 °C				4.0
Turn-off: Storage time	t <sub>s</sub>	typ.	-	1,8
		•	_	2,3 140
Fall time	t <sub>f</sub>	typ.		300
		`	_	300



 $V_{CC}$  = 250 V  $V_{IM}$  = -6 to +8 V  $\frac{t_p}{T}$  = 0,01  $t_p$  = 20  $\mu$ s The values of R<sub>B</sub> and R<sub>L</sub> are selected in accordance with I Con and I<sub>B</sub> requirements.

Fig. 4 Test circuit resistive load.

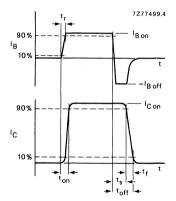


Fig. 5 Switching times waveforms, with resistive load.

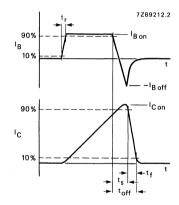


Fig. 6 Switching times waveforms with inductive load.

= 300 V

= 5 V = 1 μH = 200 μH

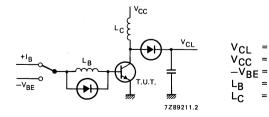


Fig. 7 Test circuit inductive load.

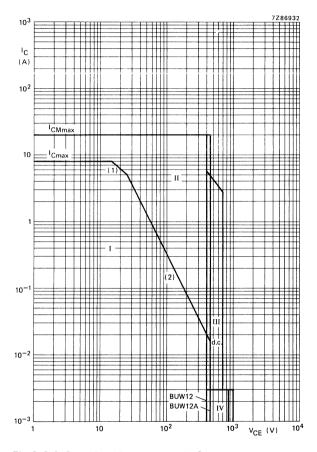


Fig. 8 Safe Operating ARea at  $T_{\mbox{mb}} \leqslant$  25 °C.

- (1) Ptot max line.
- (2) Second-breakdown limits.
- 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<sub>BE</sub>  $\leq$  100  $\Omega$  and t<sub>p</sub>  $\leq$  0,6  $\mu$ s. IV Repetitive pulse operation in this region is permissible
- provided  $V_{\mbox{\footnotesize{BE}}}\!\leqslant\!0$  and  $t_{\mbox{\footnotesize{p}}}\!\leqslant\!2$  ms.

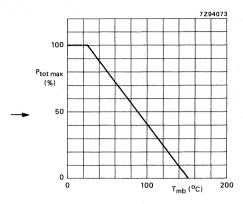


Fig. 9 Total power dissipation derating curve.

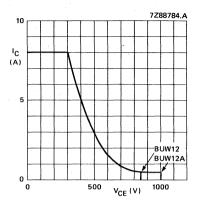


Fig. 10 Reverse bias SOAR.

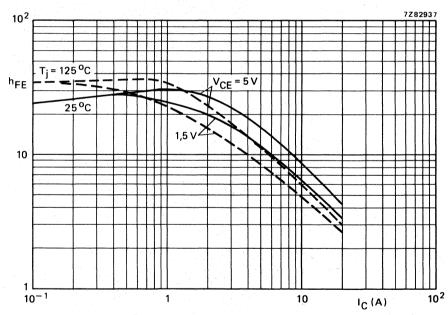


Fig. 11 Typical values d.c. current gain.

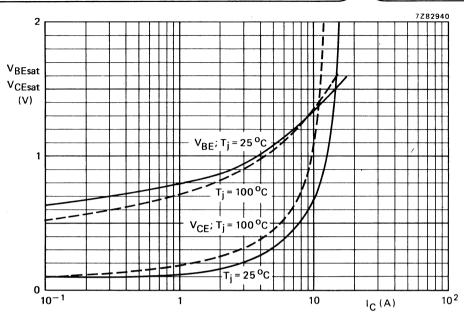


Fig. 12 Typical values base and collector voltage at  $I_C/I_B = 5$ .

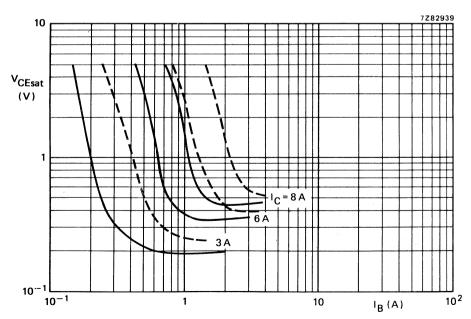


Fig. 13 Typ. (——) and max. (— —) values collector-emitter saturation voltage at T  $_{\rm j}$  = 25 °C.

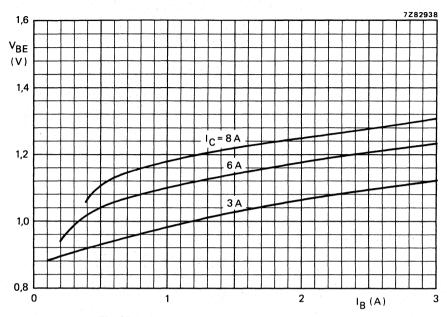


Fig. 14 Typical values base-emitter voltage at  $T_j = 25$  °C.

#### APPLICATION INFORMATION

Important design factors of SMPS circuits are the maximum power losses, heatsink requirements and base drive conditions of the switching transistor. The power losses are very dependent on the operating frequency, the maximum collector current amplitude and shape.

The operating frequency is mostly set between 15 and 50 kHz. The collector current shape varies from rectangular in a forward converter to sawtooth in a flyback converter.

Information on nominal base drive, optimum base inductance and maximum transistor dissipation applied in a forward converter is given in Figs 15, 16 and 17. In these figures I<sub>CM</sub> represents the maximum repetitive peak collector current, which occurs during overload. The information is derived from limit-case transistors at a mounting base temperature of 100 °C under the following conditions (see also Fig. 15):

- collector current shape I<sub>C1</sub>/I<sub>CM</sub> = 0,9
- duty factor  $t_p/T = 0.45$
- rate of rise of IC during turn-on =  $8 A/\mu s$
- rate of rise of V<sub>CF</sub> during turn-off = 1 kV/μs
- reverse drive voltage during turn-off = 5 V
- base current shape  $I_{B1}/I_{Be} = 1.5$

The required thermal resistance of the heatsink can be calculated from

$$R_{th mb-a} < \frac{100 - T_{amb}}{P_{tot}} K/W.$$

To ensure thermal stability the value of the ambient temperature  $T_{amb} > 40$  °C.

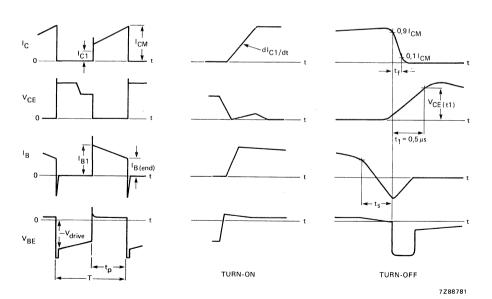


Fig. 15 Relevant waveforms of the switching transistor in a forward SMPS.

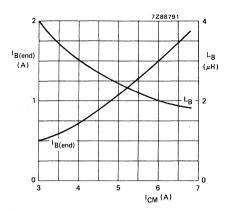


Fig. 16 Recommended nominal "end" value of the base current ( $I_{Be}$ ) and optimum base inductance ( $L_B$ ) at  $-V_{drive} = 5 V$  versus maximum peak collector current.  $dI_{B(end)} = \pm 20\%$ .

For other values of  $-V_{\mbox{drive}}$  (3 V to 7 V) the related LB is:

$$L_{Bnom} \frac{(-V_{drive}) + 1}{6}$$

LBnom is the value given in this graph.

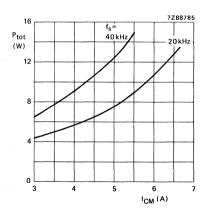


Fig. 17 Maximum transistor dissipation under worse-case operating condition versus maximum peak collector current.  $T_{mb}$  = 100  $^{\rm O}$ C;  ${\rm dI}_{\rm B(end)}$  =  $\pm$  20%.

# SILICON DIFFUSED POWER TRANSISTORS

High-voltage, high-speed, glass-passivated n-p-n power transistors in a SOT-93 envelope, intended for use in converters, inverters, switching regulators, motor control systems etc.

### QUICK REFERENCE DATA

			BUW13	BUW13A	4
Collector-emitter voltage (V <sub>BE</sub> = 0, peak value)	$V_{CESM}$	max.	850	1000	V
Collector-emitter voltage (open base)	$v_{CEO}$	max.	400	450	V
Collector current (d.c.)	l <sub>C</sub>	max.	1	5	Α
Collector current (peak value) $t_p < 2 \text{ ms}$	ICM	max.	3	0	Α
Total power dissipation up to $T_{mb} = 25$ °C	$P_{tot}$	max.	17	5	W
Collector-emitter saturation voltage					
$I_C = 10 \text{ A}; I_B = 2 \text{ A}$	$v_{CEsat}$	<	1,5		V
I <sub>C</sub> = 8 A; I <sub>B</sub> = 1,6 A	$v_{CEsat}$	<	- ]	1,5	V
Fall time					
$I_{Con} = 10 \text{ A}; I_{Bon} = -I_{Boff} = 2 \text{ A}$	tf	<	0,8		μs
$I_{Con} = 8 A; I_{Bon} = -I_{Boff} = 1,6 A$	tf	<	-	0,8	μs

## **MECHANICAL DATA**

Fig. 1 SOT-93.

Collector connected to mounting base

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dimensions within this zone are uncontrolled

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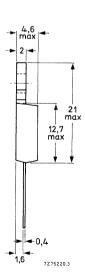
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Dimensions in mm



See also chapters Mounting instructions and Accessories.

# BUW13 BUW13A

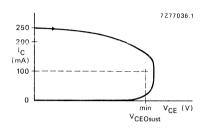
## **RATINGS**

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

Elimenia valdos in docordanco wien eno ricocideo Maxii	nam oystom	(	.,		
			BUW13	BUW1	3 <u>A</u>
Collector-emitter voltage (peak value, V <sub>BE</sub> = 0)	<sup>V</sup> CESM	max.	850	100	0 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	400	45	0 V
Collector current (d.c.)	lc	max.	15		A
Collector current (peak value); tp < 2 ms	<sup>1</sup> CM	max.	30		Α
Base current (d.c.)	i <sub>B</sub>	max.	6		Α
Base current (peak value); tp < 2 ms	IBM	max.	9		Α
Total power dissipation up to T <sub>mb</sub> = 25 °C	$P_{tot}$	max.	175		W
Storage temperature	$T_{stg}$	-	-65 to + 15	oC	
Junction temperature	Тј	max.	15	50	oC
THERMAL RESISTANCE					
From junction to mounting base	R <sub>th j-mb</sub>	==	0	,7	K/W
CHARACTERISTICS					
T <sub>j</sub> = 25 °C unless otherwise specified					
Collector cut-off current*					
V <sub>CE</sub> = V <sub>CESMmax</sub> ; V <sub>BE</sub> = 0	CES	<	1		mA
$V_{CE} = V_{CESMmax}; V_{BE} = 0; T_j = 125  {}^{\circ}C$	CES	<		4	mA
Emitter cut-off current	IEBO	<		10	mA
Saturation voltages			BUW13	BUW1	3A
$I_C = 10 \text{ A}; I_B = 2 \text{ A}$	V <sub>CEsat</sub>	<	1,5	_	V
I <sub>C</sub> = 8 A; I <sub>B</sub> = 1,6 A	V <sub>BEsat</sub>	>	1,6	1,	V 5 V
1C - 0 A, 1B - 1,0 A	V <sub>CEsat</sub> V <sub>BEsat</sub>	< < <	_	1,	
Collector-emitter sustaining voltage	DESCR				
I <sub>C</sub> = 100 mA; I <sub>Boff</sub> = 0; L = 25 mH	V <sub>CEOsust</sub>	>	400	45	0 V

<sup>\*</sup> Measured with a half sine-wave voltage (curve tracer).

## CHARACTERISTICS (continued)



V<sub>IM</sub> t<sub>p</sub> hor. oscilloscope

Fig. 2 Oscilloscope display for sustaining voltage.

Fig. 3 Test circuit for V<sub>CEOsust</sub>.

rig. 2 Oscilloscope display for sustaining voltage.	Fig. 3 Test circuit for VCEOsust.						
Switching times resistive load (Figs 4 and 5)  ICon = 10 A; IBon = -IBoff = 2 A		,	BUW13	BUW13			
Turn-on time	<sup>t</sup> on	<	1		μs		
Turn-off: Storage time	t <sub>s</sub>	<	4	_	μs		
Fall time	tf	<	0,8	-	μs		
$I_{Con} = 8 A$ ; $I_{Bon} = -I_{Boff} = 1,6 A$ Turn-on time	t <sub>on</sub>	<		1	μs		
Turn-off: Storage time	t <sub>s</sub>	<	_	4	μs		
Fall time	t <sub>f</sub>	<		0,8	μs		
Switching times inductive load (Figs 6 and 7)  I Con = 10 A; I <sub>B</sub> = 2 A	•						
Turn-off: Storage time	+	typ.	2,3		μs		
Turrorr. Storage time	t <sub>s</sub>	<	3,0	_	$\mu$ s		
Fall time	t <sub>f</sub>	typ.	80		ns		
t an time	٠,	<	150		ns		
I <sub>Con</sub> = 10 A; I <sub>B</sub> = 2 A; T <sub>j</sub> = 100 °C Turn-off: Storage time	t <sub>s</sub>	typ.	2,5	_	μs		
Tan on Storage time	-5	<	3,2		μs		
Fall time	t <sub>f</sub>	typ.	140		ns		
	-1	<	300		ns		
Switching times inductive load (Figs 6 and 7)							
I <sub>Con</sub> = 8 A; I <sub>B</sub> = 1,6 A		typ.	_	2,3	μs		
Turn-off: Storage time	t <sub>S</sub>	<	-	3,0	μs		
Fall time		typ.	_	80	ns		
raii time	t <sub>f</sub>	<	_	150	ns		
I <sub>Con</sub> = 8 A; I <sub>B</sub> = 1,6 A; T <sub>i</sub> = 100 °C		tu (n		2,5			
Turn-off: Storage time	t <sub>s</sub>	typ.		3,2	μs		
	_		_	140	μs ns		
Fall time	t <sub>f</sub>	typ.	_	300	ns		
		_	- 1	300	113		

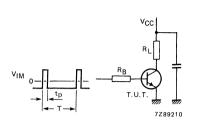


Fig. 4 Test circuit resistive load.

$$V_{CC}$$
 = 250 V  
 $V_{IM}$  = -6 to +8 V  
 $t_p$  = 20  $\mu$ s  
 $\frac{t_p}{T}$  = 0,01  
The values of R<sub>B</sub> and R<sub>L</sub>  
are selected in accordance  
with I<sub>Con</sub> and I<sub>B</sub>  
requirements.

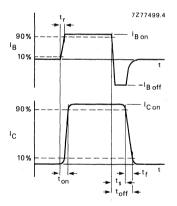


Fig. 5 Switching times waveforms with resistive load.

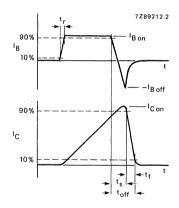


Fig. 6 Switching times waveforms with inductive load.

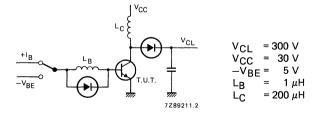


Fig. 7 Test circuit inductive load.

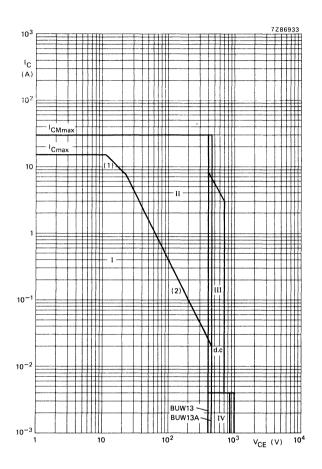
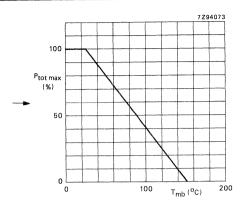


Fig. 8 Safe Operating ARea at  $T_{mb} \le 25$  °C.

- (1) Ptot max line.
- (2) Second-breakdown limits.
- 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 RBE  $\leqslant$  100  $\Omega$  and  $t_p \leqslant$  0,6  $\mu s.$
- IV Repetitive pulse operation in this region is permissible provided VBE  $\le$  0 and t<sub>p</sub>  $\le$  5 ms.



7Z98786.A

10

10

BUW13

BUW13A

0

0

500

V<sub>CE</sub> (V)

1000

Fig. 9 Total power dissipation derating curve.

Fig. 10 Reverse bias SOAR.

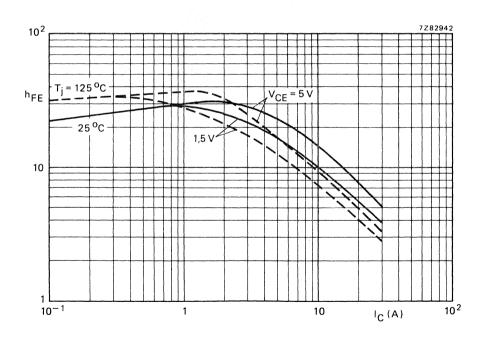


Fig. 11 Typical values d.c. current gain.

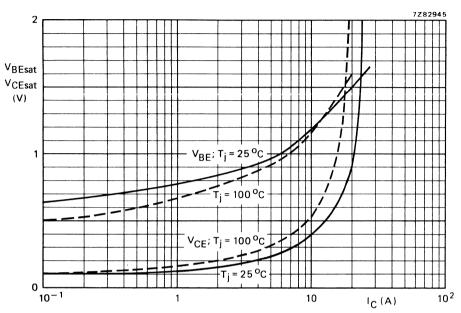


Fig. 12 Typical values base and collector voltage at  $I_C/I_B = 5$ .

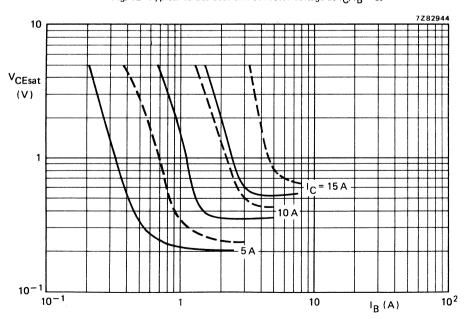


Fig. 13 Typical (——) and maximum (— —) values saturation voltage.  $T_j = 25$  °C.

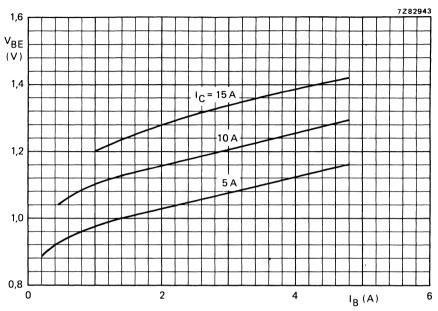


Fig. 14 Typical values base-emitter voltage at  $T_j = 25$  °C.

#### APPLICATION INFORMATION

Important design factors of SMPS circuits are the maximum power losses, heatsink requirements and base drive conditions of the switching transistor. The power losses are very dependent on the operating frequency, the maximum collector current amplitude and shape.

The operating frequency is mostly set between 15 and 50 kHz. The collector current shape varies from rectangular in a forward converter to sawtooth in a flyback converter.

Information on nominal base drive, optimum base inductance and maximum transistor dissipation applied in a forward converter is given in Figs 15, 16 and 17. In these figures I<sub>CM</sub> represents the maximum repetitive peak collector current, which occurs during overload. The information is derived from limit-case transistors at a mounting base temperature of 100 °C under the following conditions (see also Fig. 15):

- collector current shape IC1/ICM = 0,9
- duty factor  $t_D/T = 0.45$
- rate of rise of I<sub>C</sub> during turn-on = 10 A/ $\mu$ s
- rate of rise of  $V_{CF}$  during turn-off = 1 kV/ $\mu$ s
- reverse drive voltage during turn-off = 5 V
- base current shape I<sub>B1</sub>/I<sub>Be</sub> = 1,5

The required thermal resistance of the heatsink can be calculated from

$$R_{th\ mb-a} < \frac{100 - T_{amb}}{P_{tot}} \ K/W$$

To ensure thermal stability the value of the ambient temperature  $T_{amb} > 40$  °C.

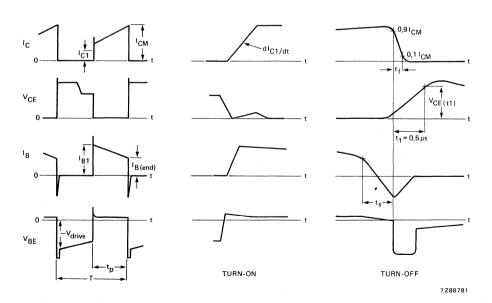


Fig. 15 Relevant waveforms of the switching transistor in a forward SMPS.

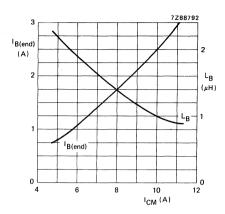


Fig. 16 Recommended nominal "end" value of the base current ( $I_{Be}$ ) and optimum base inductance ( $I_{Be}$ ) at  $-V_{drive} = 5 V$  versus maximum peak collector current.  $dI_{B(end)} = \pm 20\%$ .

For other values of  $-V_{drive}$  (3 V to 7 V) the related L<sub>B</sub> is:

$$L_{\text{Bnom}} \frac{(-V_{\text{drive}}) + 1}{6}$$

LBnom is the value given in this graph.

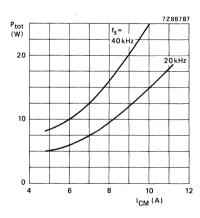


Fig. 17 Maximum transistor dissipation under worse-case operating condition versus maximum peak collector current.  $T_{mb}$  = 100  $^{o}$ C;  $dI_{B(end)}$  =  $\pm$  20%.

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

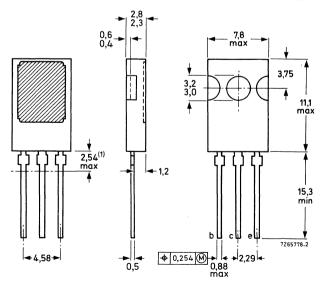
			BUW84	BUW85	
Collector-emitter voltage (V <sub>BE</sub> = 0, peak value)	$v_{CESM}$	max.	800	1000	V
Collector-emitter voltage (open base)	$v_{CEO}$	max.	400	450	V
Collector current (d.c.)	l <sub>C</sub>	max.	2		Α
Collector current (peak value) $t_p = 2 \text{ ms}$	ГСМ	max.	3		Α
Total power dissipation up to $T_{mb}$ = 45 ${}^{o}C$	$P_{tot}$	max.	50		W
Collector-emitter saturation voltage $I_C = 1 A$ ; $I_B = 0.2 A$	$V_{CEsat}$	<	1		V
Fall time	+.	tvn	0.4		
I <sub>Con</sub> = 1 A; I <sub>Bon</sub> = 0,2 A; —I <sub>Boff</sub> = 0,4 A	t <sub>f</sub>	typ.	0,4		μs

#### MECHANICAL DATA

Dimensions in mm

Collector connected to mounting base.

Fig. 1 SOT-82.



(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)

	* *					
		BU	N84	В	UW85	
Collector-emitter voltage (VBE = 0, peak value)	VCESM	max.	800		1000	V
Collector-emitter voltage (open base)	VCEO	max.	400		450	V
Emitter-base voltage (open collector)	VEBO	max.	5		5	<b>V</b> , ,
Collector current (d.c.)	I <sub>C</sub>	max.		2		A
Collector current (peak value)				-		
t <sub>p</sub> = 2 ms	ICM	max.		3		Α
Base current (d.c.)	IB	max.	0,7	<b>7</b> 5		Α
Base current (peak value)	<sup>I</sup> BM	max.		1		Α
Reverse base current (peak value) *	-I <sub>BM</sub>	max.		1		Α
Total power dissipation up to T <sub>mb</sub> = 45 °C	P <sub>tot</sub>	max.	5	50		W
Storage tamperature	T <sub>stg</sub>	-65	to +15	50		оС
Junction temperature	Tj	max.	15	50		оС
THERMAL RESISTANCE						
From junction to mounting base	R <sub>th j-mb</sub>	. = ' - '	2	,1		K/W
From junction to ambient in free air	R <sub>th j-a</sub>	= '	10	)0		K/W
CHARACTERISTICS						
T <sub>i</sub> = 25 °C unless otherwise specified						
Collector cut-off current **						
$V_{CEM} = V_{CESMmax}; V_{BE} = 0$	ICES	<	20	00		μΑ
V <sub>CEM</sub> = V <sub>CESMmax</sub> ; V <sub>BE</sub> = 0; T <sub>i</sub> = 125 °C	CES	< .	1	,5		mΑ
D.C. current gain						
I <sub>C</sub> = 0,1 A; V <sub>CE</sub> = 5 V	hFE	typ.	. 5	50		

<sup>\*</sup> Turn-off current.

<sup>\*\*</sup> Measured with a half sine-wave voltage (curve tracer).

 $T_i = 25$  °C unless otherwise specified

Emitter cut-off current I <sub>C</sub> = 0; V <sub>EB</sub> = 5 V
Saturation voltages
$I_C = 0.3 \text{ A}; I_B = 30 \text{ mA}$
I <sub>C</sub> = 1 A; I <sub>B</sub> = 0,2 A
I <sub>C</sub> = 1 A; I <sub>B</sub> = 0,2 A
Collector-emitter sustaining voltage
$I_C = 100 \text{ mA}$ ; $I_{Boff} = 0$ ; L = 25 mH

I <sub>EBO</sub>	<		1	mΑ
V <sub>CEsat</sub> V <sub>CEsat</sub> V <sub>BEsat</sub>	< < <	0,1	1	V V V
V <sub>CEOsu</sub>	-	8UW84 400	BUW85	į V

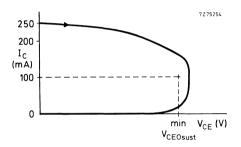


Fig. 2 Oscilloscope display for sustaining voltage.

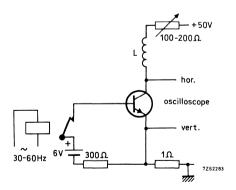


Fig. 3 Test circuit for V<sub>CEOsust</sub>.

T<sub>i</sub> = 25 °C unless otherwise specified

Transition frequency at f = 1 MHz

IC = 0,2 A; VCE = 10 V

 $I_{Con} = 1 A; V_{CC} = 250 V$ 

I<sub>Bon</sub> = 0,2 A; -I<sub>Boff</sub> = 0,4 A Turn-on time

Switching times

Turn-off: Storage time

Fall time

Fall time, T<sub>mb</sub> = 95 °C

fΤ typ. 20 MHz

typ.  $0,2 \mu s$ ton 0,5 μs

2 μs typ.  $t_s$ 3,5 µs <

tf typ.  $0,4 \mu s$ < 1,4 µs tf

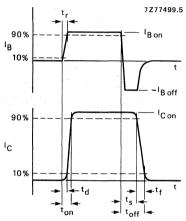


Fig. 4 Waveforms.

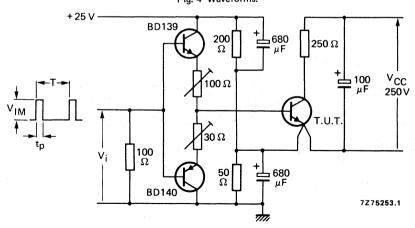


Fig. 5 Test circuit.

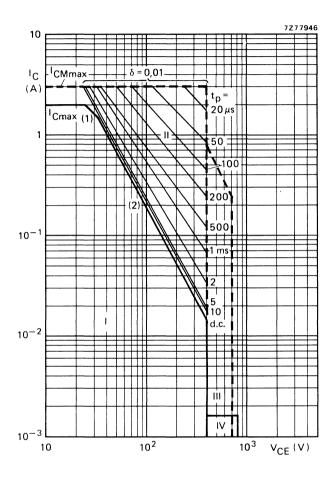


Fig. 6 Safe Operating ARea at  $T_{mb} \le 25$  °C of BUW84.

- 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 RBE  $\leqslant$  100  $\Omega$  and tp  $\leqslant$  0,6  $\mu s$
- IV Repetitive pulse operation in this region is permissible, provided VBE  $\leqslant$  0 and  $t_p \leqslant$  2 ms
- (1) Ptot max line.
- (2) Second-breakdown limits (independent of temperature).

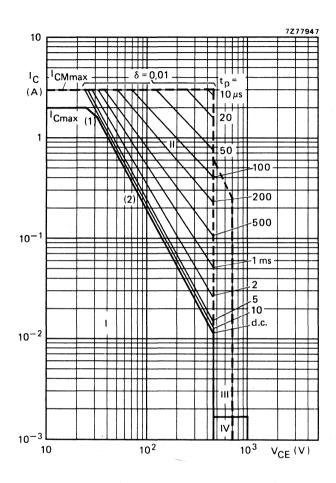
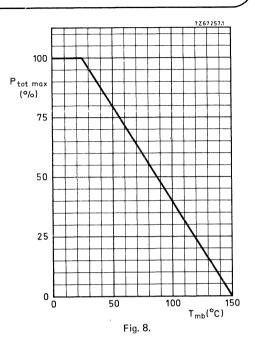


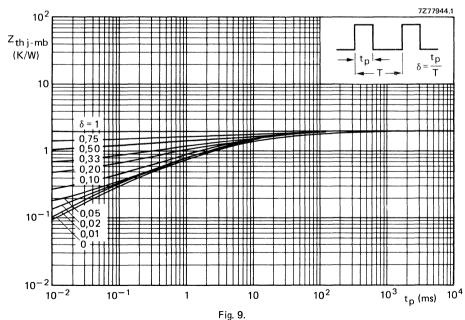
Fig. 7 Safe Operating ARea at  $T_{mb} \le 25$  °C of BUW85.

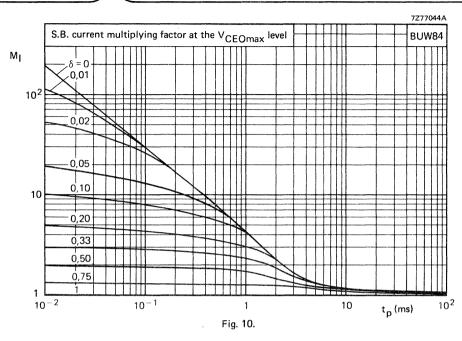
- I Region of permissible d.c. operation
- II Permissible extension for repetitive pulse operation
- III Area of permissible operation during turn-on in single transistor converters, provided RBE  $\le$  100  $\Omega$  and tp  $\le$  0,6  $\mu s$
- IV Repetitive pulse operation in this region is permissible, provided  $V_{BE} \le 0$  and  $t_{D} \le 2$  ms

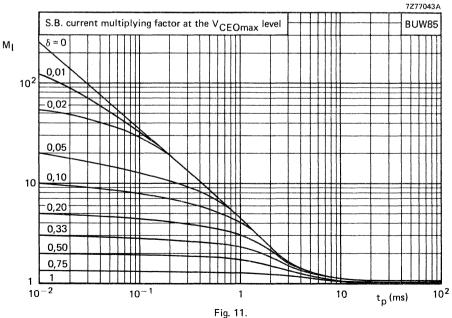
<sup>(1)</sup> Ptot max line.

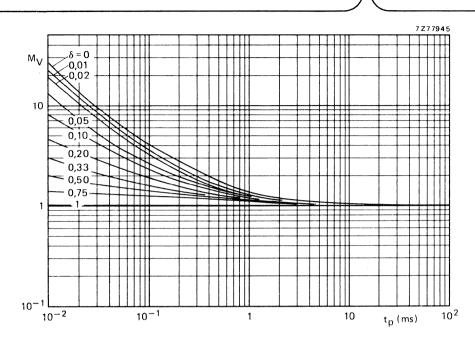
<sup>(2)</sup> Second-breakdown limits (independent of temperature).



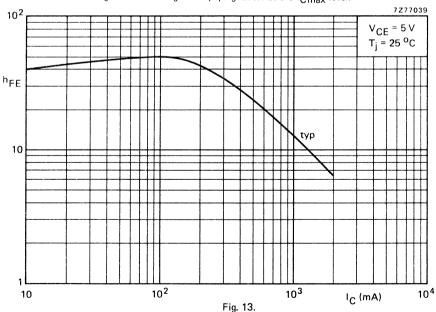


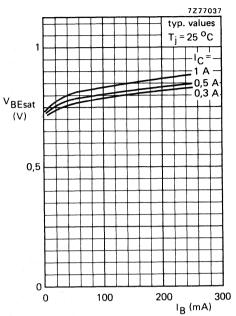


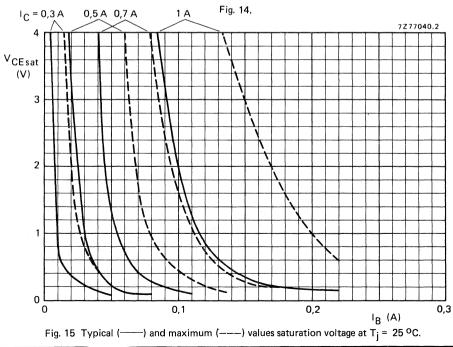












High-voltage, high-speed, glass-passivated n-p-n power transistors in a TO-3 envelope, intended for use in converters, inverters, switching regulators, motor control systems etc.

### QUICK REFERENCE DATA

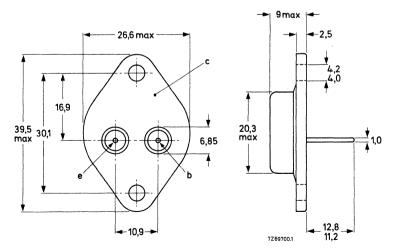
			BUX46	BUX46A	
Collector-emitter voltage (V <sub>EB</sub> = 2,5 V)	$V_{CEX}$	max.	850	1000	٧
Collector-emitter voltage (R <sub>BE</sub> $\leq$ 10 $\Omega$ )	$v_{CER}$	max.	850	1000	٧
Collector-emitter voltage (open base)	$v_{CEO}$	max.	400	450	٧
Collector current (d.c.)	I <sub>C</sub>	max.	3,	5	Α
Collector current (peak value) $t_p \le 2 \text{ ms}$	<sup>I</sup> CM	max.		5	Α
Total power dissipation up to T <sub>mb</sub> = 25 °C	P <sub>tot</sub>	max.	8	5	W
Collector-emitter saturation voltage $I_C = 2.5 \text{ A}$ ; $I_B = 0.5 \text{ A}$	V <sub>CEsat</sub>	<	1,	5	V
Fall time (resistive load) $I_{Con} = 2.5 \text{ A}; I_{Bon} = -I_{Boff} = 0.5 \text{ A}$	t <sub>f</sub>	<	0,	8	μs

### **MECHANICAL DATA**

Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.



See also chapters Mounting instructions and Accessories.

# BUX46 BUX46A

## **RATINGS**

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

			BUX46	В	UX46A	
Collector-emitter voltage (V <sub>EB</sub> = 2,5 V)	VCEX	max.	850		1000	٧
Collector-emitter voltage (R <sub>BE</sub> $\leq$ 10 $\Omega$ )	VCER	max.	850		1000	V
Collector-emitter voltage (open base)	VCEO	max.	400		450	V
Collector current (d.c.)	IC	max.	. 3	,5		Α
Collector current (peak value) $t_p < 2 \text{ ms}$	I <sub>CM</sub>	max.		5		Α
Base current (d.c.)	1 <sub>B</sub>	max.	1,	,5		Α
Base current (peak value); $t_p < 2$ ms	<sup>I</sup> BM	max.		3		Α
Total power dissipation up to T <sub>mb</sub> = 25 °C	P <sub>tot</sub>	max.	8	35		W
Storage temperature	$T_{stg}$	-(	65 to + 1 <b>7</b>	5		οС
Junction temperature	Tj	max.	17	5		οС
THERMAL RESISTANCE						
From junction to mounting base	R <sub>th j-mb</sub>	=	1,7	75		K/W
CHARACTERISTICS						
T <sub>j</sub> = 25 °C unless otherwise specified						
Collector cut-off current *						
VCE = VCER <sub>max</sub> ; R <sub>BE</sub> ≤ 10 Ω VCE = VCER <sub>max</sub> ; R <sub>BE</sub> ≤ 10 Ω; T <sub>j</sub> = 125 °C	ICER ICER	< -	0,	,3 2		mA mA
Emitter cut-off current						
$I_C = 0; V_{EB} = 5 V$	IEBO	<		1		mA
Saturation voltages $I_C = 3.5 \text{ A}$ ; $I_B = 0.7 \text{ A}$	Vo= .	<		5		V
I <sub>C</sub> = 2,5 A, I <sub>B</sub> = 0,7 A I <sub>C</sub> = 2,5 A; I <sub>B</sub> = 0,5 A	V <sub>CEsat</sub> V <sub>CEsat</sub>	< '	1	,5		v
	V <sub>BEsat</sub>	<	1	,3		V
Collector-emitter sustaining voltage I <sub>C</sub> = 200 mA; I <sub>B</sub> = 0; L = 25 mH	V <sub>CEOsust</sub>	>	400		450	V
Collector-emitter cut-off current			_			
V <sub>CE</sub> = V <sub>CEXmax</sub> ; V <sub>BE</sub> = -2,5 V V <sub>CE</sub> = V <sub>CEXmax</sub> ; V <sub>BE</sub> = -2,5 V; T <sub>j</sub> = 125 °C	CEX	< <	0	,1 1		mA mA
Emitter-base breakdown voltage $I_C = 0$ ; $I_E = 0,5$ A	V <sub>(BR)EBO</sub>	<	3	30		V
Second breakdown collector current	(511)250			,		
$V_{CE} = 70 \text{ V; } t = 1 \text{ sec.}$	(SB)C	>	0	,5		Α

<sup>\*</sup> Measured with a half sine-wave voltage (curve tracer).

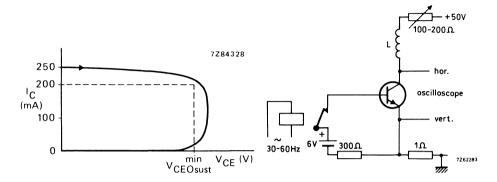


Fig. 2 Oscilloscope display for sustaining voltage.

Fig. 3 Test circuit for V<sub>CEOsust</sub>.

Switching times	resistive load	(Figs 4 and 5)
lo = 25 Δ·lo	= -ln ((:	Λ 5 Δ

$I_{Con} = 2.5 \text{ A}; I_{Bon} = -I_{Boff} = 0.5 \text{ A}$	
Turn-on time	

$$I_{Con} = 2.5 \text{ A}$$
;  $I_{B} = 0.5 \text{ A}$ 
Fall time

typ.

 $t_{f}$ 

 $0.2 \mu s$ 

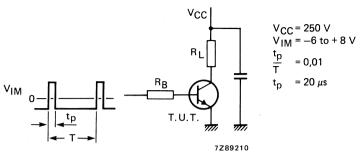


Fig. 4 Test circuit resistive load.

The values of  $R_{\mbox{\footnotesize{B}}}$  and  $R_{\mbox{\footnotesize{L}}}$  are selected in accordance with  $I_{\mbox{\footnotesize{Con}}}$  and  $I_{\mbox{\footnotesize{B}}}$  requirements.

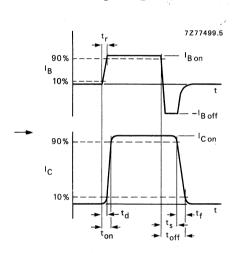


Fig. 5 Switching times waveforms with resistive load.

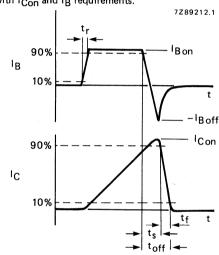


Fig. 6 Switching times waveforms with inductive load.

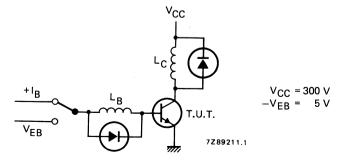


Fig. 7 Test circuit inductive load.  $L_C = 1$  mH;  $L_B = 3 \mu H$ .

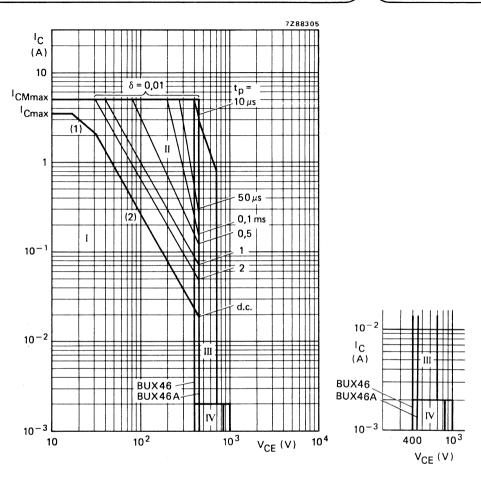


Fig. 8 Safe Operating ARea at  $T_{mb} \le 60$  °C.

- (1) P<sub>tot max</sub> and P<sub>tot peak</sub> max. lines.(2) Second-breakdown limits.
- 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 RBE  $\leqslant$  100  $\Omega$  and  $t_p \leqslant$  0,6  $\mu s.$
- IV Repetitive pulse operation in this region is permissible, provided  $V_{BE} \le 0$  and  $t_p \le 2$  ms.

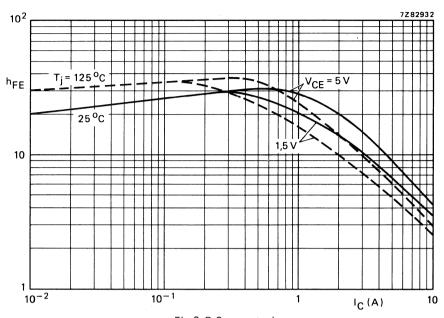


Fig. 9 D.C. current gain.

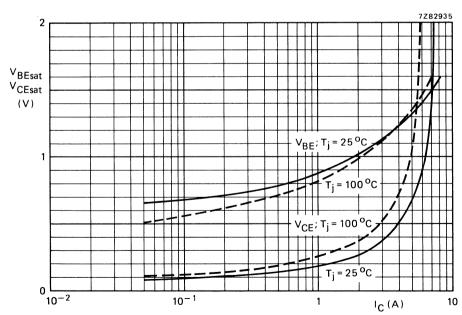


Fig. 10 Typical values base-emitter and collector-emitter voltage,  $I_C/I_B = 5$ .

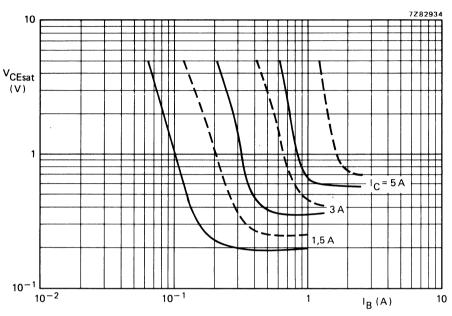


Fig. 11 Typ. (——) and max. (---) values collector-emitter saturation voltage at  $T_i = 25$  °C.

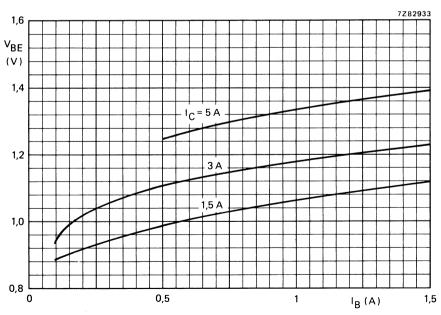
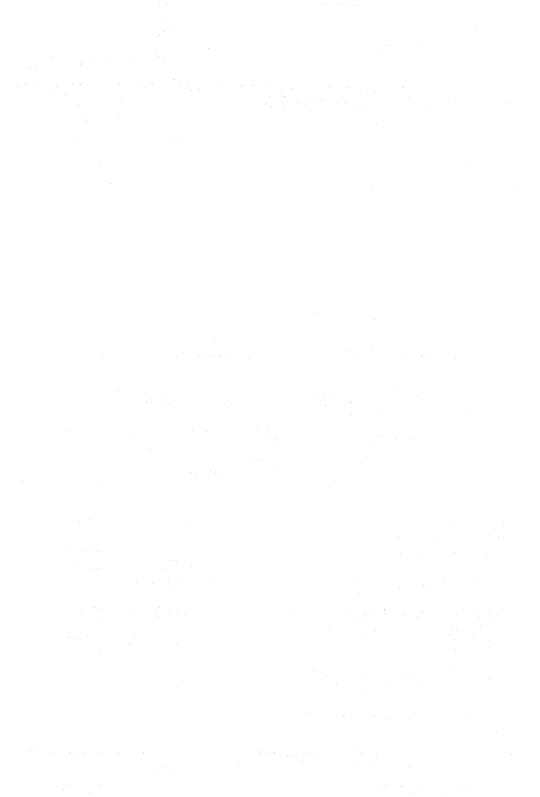


Fig. 12 Typical values at  $T_j = 25$  °C.



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

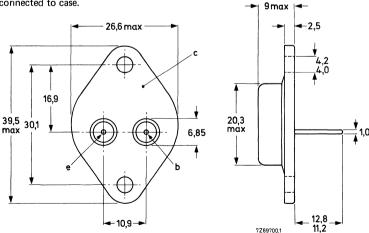
### QUICK REFERENCE DATA

			BUX47	BUX47A	<u>.</u>
Collector-emitter voltage (V <sub>EB</sub> = 2,5 V)	$v_{CEX}$	max.	850	1000	V
Collector-emitter voltage (R <sub>BE</sub> $\leq$ 10 $\Omega$ )	$v_{CER}$	max.	850	1000	V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	400	450	V
Collector current (d.c.)	I <sub>C</sub>	max.		9	Α
Collector current (peak value) $t_p \le 5$ ms	<sup>I</sup> CM	max.	1	15	Α
Total power dissipation up to T <sub>mb</sub> = 25 °C	P <sub>tot</sub>	max.	. 12	25	W
Collector-emitter saturation voltage $I_C = 6 A$ ; $I_B = 1,2 A$ $I_C = 5 A$ ; $I_B = 1 A$	V <sub>CEsat</sub> V <sub>CEsat</sub>	< <	1,5 -	_ 1,5	V V
Fall time (resistive load)  I <sub>Con</sub> = 6 A; I <sub>Bon</sub> = -I <sub>Boff</sub> = 1,2 A  I <sub>Con</sub> = 5 A; I <sub>Bon</sub> = -I <sub>Boff</sub> = 1 A	t <sub>f</sub> t <sub>f</sub>	< <	0,8 -	_ 0,8	μs μs

### MECHANICAL DATA

Fig. 1 TO-3.

Collector connected to case.



See also chapters Mounting instructions and Accessories.

Dimensions in mm

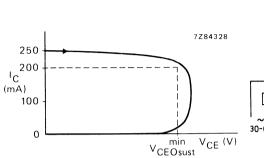
# BUX47 BUX47A

## **RATINGS**

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

			BUX47	BUX47A	
Collector-emitter voltage (V <sub>EB</sub> = 2,5 V)	VCEX	max.	850	1000	V
Collector-emitter voltage ( $R_{BE} \le 10 \Omega$ )	V <sub>CER</sub>	max.	850	1000	٧
Collector-emitter voltage (open base)	VCEO	max.	400	450	٧
Collector current (d.c.)	Ic	max.		9	Α
Collector current (peak value); t <sub>p</sub> < 5 ms	<sup>1</sup> CM	max.	•	15	Α
Base current (d.c.)	I <sub>B</sub>	max.		3	Α
Base current (peak value); $t_p \le 5 \text{ ms}$	I <sub>BM</sub>	max.		6	Α
Total power dissipation up to T <sub>mb</sub> = 25 °C	P <sub>tot</sub>	max.	12	25	W
Storage temperature	T <sub>stq</sub>		65 to + 20	00	οС
Junction temperature	Tj	max.	20	00	оС
THERMAL RESISTANCE					
From junction to mounting base	R <sub>th j-mb</sub>	=	. 1	,4	K/W
CHARACTERISTICS					
T <sub>j</sub> = 25 <sup>o</sup> C unless otherwise specified					
Collector cut-off current*					
$V_{CE} = V_{CERmax}$ ; $R_{BE} \le 10 \Omega$ $V_{CE} = V_{CERmax}$ ; $R_{BE} \le 10 \Omega$ ; $T_j = 125 \degree C$	ICER ICER	< <	Ó	,4 3	mA mA
Emitter cut-off current					
$I_C = 0; V_{EB} = 5 V$	I <sub>EBO</sub>	<		1	mΑ
Saturation voltages				1	
$I_C = 6 \text{ A}; I_B = 1,2 \text{ A}$	VCEsat	< '	1,5		V V
I <sub>C</sub> = 9 A; I <sub>B</sub> = 1,8 A	V <sub>CEsat</sub>	< < <	5	1,5	V
I <sub>C</sub> = 5 A; I <sub>B</sub> = 1 A	V <sub>CEsat</sub>	>	_	5	V
I <sub>C</sub> = 8 A; I <sub>B</sub> = 1,6 A I <sub>C</sub> = 6 A; I <sub>B</sub> = 1,2 A	V <sub>CEsat</sub>	2	1,6		v
I <sub>C</sub> = 5 A; I <sub>B</sub> = 1 A	V <sub>BEsat</sub> V <sub>BEsat</sub>	2		1,6	v
Collector-emitter sustaining voltage	• DESat	`			
I <sub>C</sub> = 200 mA; I <sub>B</sub> = 0; L = 25 mH	V <sub>CEOsust</sub>	>	400	450	V
Emitter-base breakdown voltage				•	
$I_C = 0; I_B = 0.5 A$	V <sub>(BR)EBO</sub>		7 to	30	V
Collector cut-off current					
$V_{CE} = V_{CEXmax}$ ; $V_{BE} = -2.5 \text{ V}$	CEX	<	0,1	15 ,5	mA mA
$V_{CE} = V_{CEXmax}; V_{BE} = -2,5 \text{ V}; T_j = 125 \text{ °C}$	CEX			,:	illA

<sup>\*</sup> Measured with a half sine-wave voltage (curve tracer).



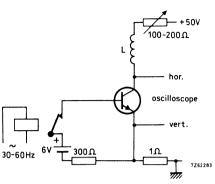


Fig. 2 Oscilloscope display for sustaining voltage.

Fig. 3 Test circuit for V<sub>CEOsust</sub>.

Switching times resistive load (Figs 4 and 5) BUX47: ICon = 6 A; IBon = -IBoff = 1,2 A BUX47A: ICon = 5 A; IBon = -IBoff = 1 A Turn-on time	<sup>t</sup> on	typ.	0,6 μs 1,0 μs
Turn-off: Storage time	$t_{S}$	typ.	2,8 μs 3,0 μs
Fall time	t <sub>f</sub>	typ.	0,45 μs 0,8 μs
Switching times inductive load (Figs 6 and 7) BUX47: $I_{Con} = 6 \text{ A}$ ; $I_{B} = 1,2 \text{ A}$ BUX47A: $I_{Con} = 5 \text{ A}$ ; $I_{B} = 1 \text{ A}$			
Turn-off: Storage time	t <sub>s</sub>	typ.	2,5 μs
Storage time; T <sub>j</sub> = 100 °C	t <sub>s</sub>	<	4 μs
Fall time	tf	typ.	80 ns
Fall time; T <sub>j</sub> = 100 °C	t <sub>f</sub>	<	400 ns

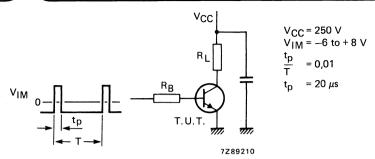


Fig. 4 Test circuit resistive load.

The values of RB and RL are selected in accordance with ICon and IB requirements.

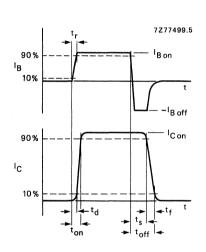


Fig. 5 Switching times waveforms with resistive load.

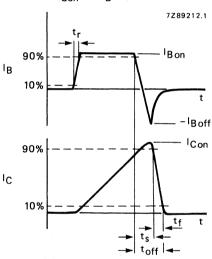


Fig. 6 Switching times waveforms with inductive load.

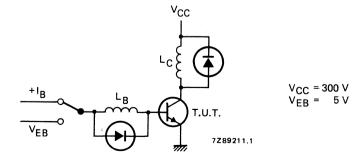


Fig. 7 Test circuit inductive load.  $L_C$  = 1,5 mH;  $L_B$  = 3  $\mu$ H.

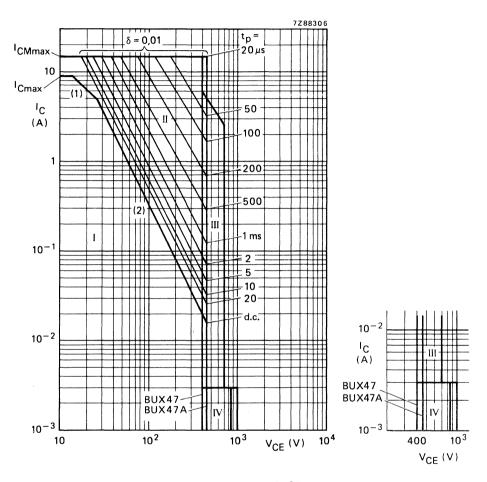


Fig. 8 Safe Operating ARea at  $T_{mb}\!\leqslant\!25$  °C.

- (1) P<sub>tot max</sub> and P<sub>tot peak max</sub> lines.(2) Second-breakdown limits.
- 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 RBE  $\leqslant$  100  $\Omega$  and  $t_p \leqslant$  0,6  $\mu s.$
- IV Repetitive pulse operation in this region is permissible, provided  $V_{\mbox{\footnotesize{BE}}}\leqslant 0$  and  $t_{\mbox{\footnotesize{p}}}\leqslant 2$  ms.

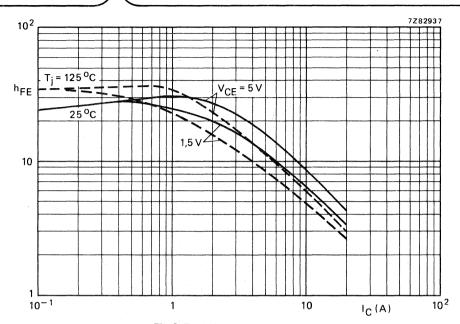


Fig. 9 Typical values d.c. current gain.

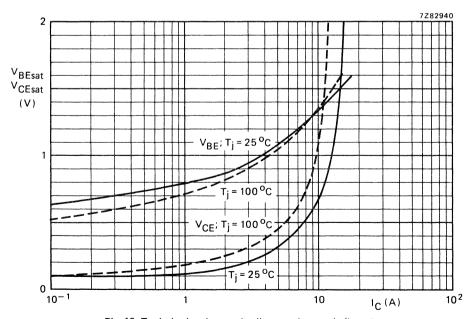


Fig. 10 Typical values base and collector voltage at  $I_C/I_B = 5$ .

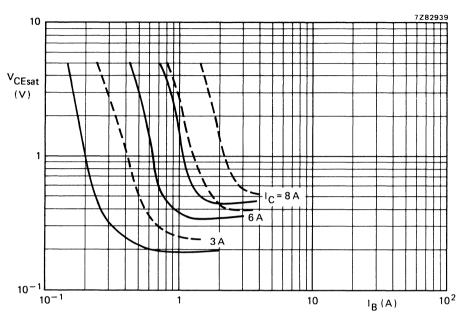


Fig. 11 Typ. (——) and max. (---) values collector-emitter saturation voltage at  $T_i = 25$  °C.

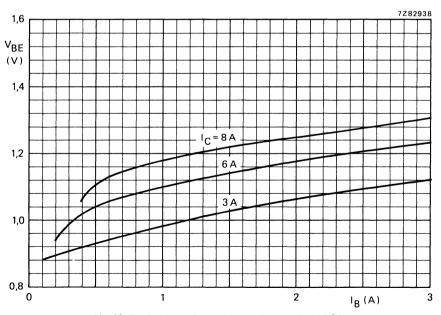


Fig. 12 Typical values base-emitter voltage at  $T_i = 25$  °C.

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

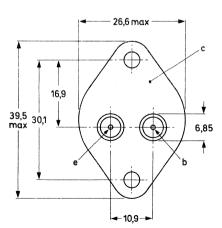
### QUICK REFERENCE DATA

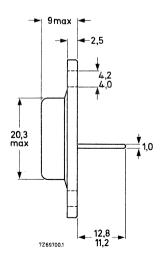
			BUX48	BUX48A	\ -
Collector-emitter voltage (peak value; V <sub>BF</sub> = 0)	V <sub>CESM</sub>	max.	850	1000	V
Collector-emitter voltage (open base)	VCEO	max.	400	450	V
Collector current (d.c.)	lc	max.	•	15	Α
Collector current (peak value; $t_p < 2 \text{ ms}$ )	<sup>I</sup> CM	max.	:	30	Α
Total power dissipation up to T <sub>mb</sub> = 25 °C	$P_{tot}$	max.	17	75	W
Collector-emitter saturation voltage  I <sub>C</sub> = 10 A; I <sub>B</sub> = 2 A  I <sub>C</sub> = 8 A; I <sub>B</sub> = 1,6 A	V <sub>CEsat</sub> V <sub>CEsat</sub>	< <	1,5 —	_ 1,5	V V
Fall time (resistive load) $I_{Con} = 10 \text{ A}; I_{Bon} = -I_{Boff} = 2 \text{ A}$ $I_{Con} = 8 \text{ A}; I_{Bon} = -I_{Boff} = 1,6 \text{ A}$	t <sub>f</sub> t <sub>f</sub>	< <	800 	_ 800	ns ns

### **MECHANICAL DATA**

Fig. 1 TO-3.

Collector connected to case.





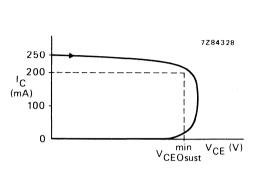
See also chapters Mounting instructions and Accessories.

Dimensions in mm

## **RATINGS**

101111130					
Limiting values in accordance with the Absolute Maxin	num System	(IEC 13		DUVA	0.4
			BUX48	BUX4	
Collector-emitter voltage (peak value; V <sub>BE</sub> = 0)	VCESM	max.	850	1000	) V
Collector-emitter voltage (peak value; $V_{BE} = -2.5 \text{ V}$ )	$V_{CEX}$	max.	850	1000	) V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	400	450	) V
Collector current (d.c.)	<sup>I</sup> C	max.	•	15	Α
Collector current (peak value)	<sup>I</sup> CM	max.	3	30	Α
Base current (d.c.)	I <sub>B</sub>	max.		4	Α
Base current (peak value)	I <sub>BM</sub>	max.	2	20	Α
Total power dissipation up to $T_{mb} = 25$ °C	P <sub>tot</sub>	max.	17	75	W
Storage temperature	T <sub>stg</sub>		-65 to +20	00	οС
Junction temperature	T <sub>j</sub>	max.	20		oC
THERMAL RESISTANCE					
From junction to mounting base	R <sub>th j-mb</sub>	=	1	,0	K/W
CHARACTERISTICS					
T <sub>i</sub> = 25 °C unless otherwise specified					
Collector-emitter current					
$V_{CE} = V_{CEX}$ ; $R_{BE} \le 10 \Omega$ ;	ICER	<	0	,5	mΑ
$V_{CE} = V_{CEX}$ ; $R_{BE} \le 10 \Omega$ ; $T_j = 125  {}^{\circ}C$	<sup>I</sup> CER	<		4	mΑ
Collector-emitter current					
$V_{CE} = V_{CEX}$ ; $V_{BE} = -2.5 V$	ICEX	<	0	,2	mΑ
$V_{CE} = V_{CEX}; V_{BE} = -2.5 V; T_j = 125 °C$	ICEX	<		2	mΑ
Emitter cut-off current					
$I_C = 0; V_{EB} = 5 V$	<sup>I</sup> EBO	<		1	mΑ
Saturation voltages				1	
I <sub>C</sub> = 10 A; I <sub>B</sub> = 2 A	V <sub>CEsat</sub>	<	1,5 1,6	-	V V
IC = 8 A; I <sub>B</sub> = 1,6 A	V <sub>BEsat</sub>		1,0	-	
IC - 0 A, IB - 1,0 A	VCEsat VBEsat	< <	_		5 V 5 V
I <sub>C</sub> = 15 A; I <sub>B</sub> = 3 A	VCEsat	<	5	_	V
I <sub>C</sub> = 12 A; I <sub>B</sub> = 2,4 A	V <sub>CEsat</sub>	<	_		5 V
Collector-emitter sustaining voltage	CESat	•		`	•
IC = 200 mA; IBoff = 0; L = 25 mH	V <sub>CEOsust</sub>	>	400	450	) V
Emitter-base breakdown voltage	OL OSUST				
$I_C = 0$ ; $I_B = 50 \text{ mA}$ ;	V <sub>(BR)EBO</sub>		7 to	o <b>30</b>	٧

<sup>\*</sup> Measured with a half sine-wave voltage (curve tracer).



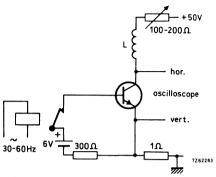


Fig. 2 Oscilloscope display for sustaining voltage.

Fig. 3 Test circuit for V<sub>CEOsust</sub>.

Switching times resistive load (Fig. 4 and 5)					
I <sub>Con</sub> = 10 A; I <sub>Bon</sub> = -I <sub>Boff</sub> = 2 A			BUX48	BUX48A	
Turn-on time	t <sub>on</sub>	<	1	-	μs
Turn-off: Storage time Fall time	t <sub>s</sub> t <sub>f</sub>	< <	3 0,8	_ _	μs μs
$I_{Con} = 8 \text{ A}; I_{Bon} = -I_{Boff} = 1,6 \text{ A}$					
Turn-on time	ton	<	_	1	μs
Turn-off: Storage time Fall time	t <sub>s</sub> t <sub>f</sub>	< <	_	3 0,8	μs μs
Switching times inductive load (Fig. 6 and 7) $I_{Con} = 10 \text{ A}$ ; $I_{Bon} = 2 \text{ A}$ ; $I_{mb} = 25  {}^{o}\text{C}$					
Turn-off: Storage time Fall time	t <sub>s</sub> t <sub>f</sub>	typ. typ.	3 80	<u> </u>	μs ns
$I_{Con} = 10 \text{ A}; I_{Bon} = 2 \text{ A}; T_{mb} = 100  {}^{\circ}\text{C}$					
Turn-off: Storage time Fall time	t <sub>s</sub>	< <	5 0,4	_	μs μs
$I_{Con} = 8 \text{ A}; I_{Bon} = 1,6 \text{ A}; T_{mb} = 25  {}^{o}\text{C}$					
Turn-off: Storage time Fall time	t <sub>s</sub> t <sub>f</sub>	typ. typ.	_	3 80	μs ns
I <sub>Con</sub> = 8 A; I <sub>Bon</sub> = 1,6 A; T <sub>mb</sub> = 100 °C					
Turn-off: Storage time Fall time	t <sub>s</sub>	< <		5 0,4	μs μs

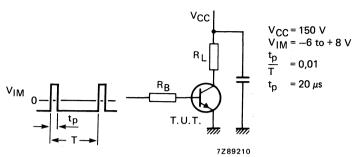


Fig. 4 Test circuit resistive load.

The values of  $R_{\mbox{\footnotesize{B}}}$  and  $R_{\mbox{\footnotesize{L}}}$  are selected in accordance with  $I_{\mbox{\footnotesize{Con}}}$  and  $I_{\mbox{\footnotesize{B}}}$  requirements.

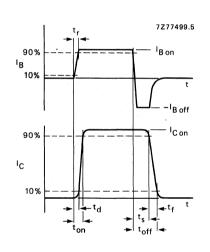


Fig. 5 Switching times waveforms with resistive load.

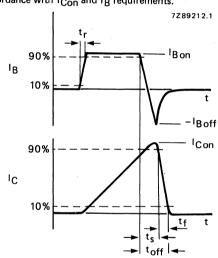


Fig. 6 Switching times waveforms with inductive load.

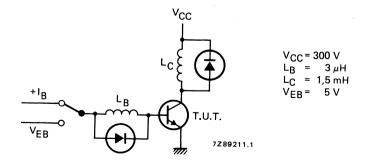
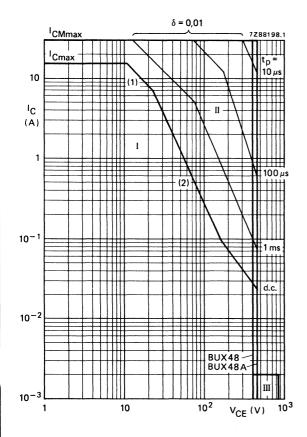


Fig. 7 Test circuit inductive load.



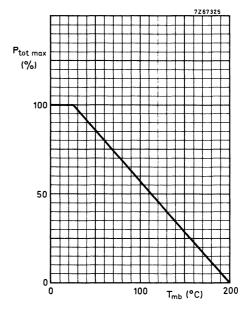


Fig. 8a Derating curve.

Fig. 8 Safe Operating ARea at  $T_{mb} \le 25$  °C.

- (1) P<sub>tot max</sub> and P<sub>tot peak max</sub> lines.
   (2) Second-breakdown limits.
- I Region of permissible d.c. operation.
- II Permissible extension for repetitive pulse operation.
- III Repetitive pulse operation in this region is permissible, provided  $V_{BE} \leq 0$  and  $t_p \leq 5$  ms.

Fig. 9 Forward bias safe operation area,  $T_i \le 125$  °C.

- I Safe operation area during turn-off and during turn-on.
  For BUX48A the right-hand limit is 450 V.
- II Safe operation are during turn-on only provided  $t_r < 0.2 \ \mu s.$
- III Safe operation area during turn-on only provided  $\rm t_r\!<\!0.5~\mu s$  and  $\rm R_{BE}\!<\!100~\Omega.$

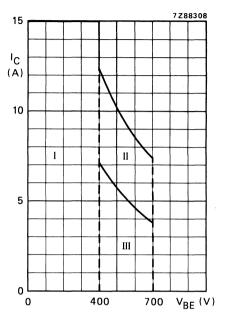
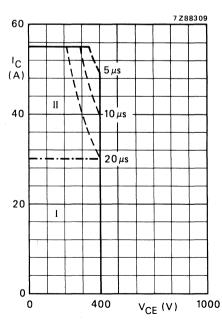


Fig. 10 Forward bias accidental overload area,  $T_{\rm j} \leqslant 125$  °C.

- I Safe operation provided normal forward bias conditions are respected (I<sub>S/B</sub>, T<sub>i max</sub>).
- II Safe operation area for non-repetitive pulses. During component life the number of pulses in area II should not exceed 3000 times.



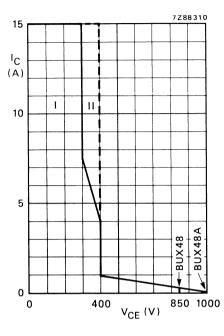


Fig. 11 Reverse bias safe operation area,  $I_{Cend}/I_{Bend} \ge 5$ ;  $-V_{BE} = 3 \text{ V}$ .

- Normal reverse bias safe operation area,  $V_{BF} < 0 \text{ V}$ .
- II Extension of the reverse bias safe operation area provided a desaturation network (Baker clamp) is used.

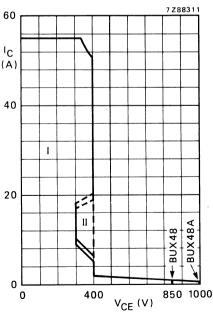


Fig. 12 Reverse bias accidental overload area,  $-V_{BE} = 3 \text{ V}; \text{ T}_i \leq 125 \text{ °C}.$ 

- I Operation at high currents (I<sub>C</sub> > I<sub>CM</sub>) is permitted, provided the pulses are non repetitive and  $V_{BE}$  < 0.
- II This area may be entered only through the broken line. Crossing the continuous line is not permitted.

During component life the number of surge pulses in area I and II should not exceed 3000 times.

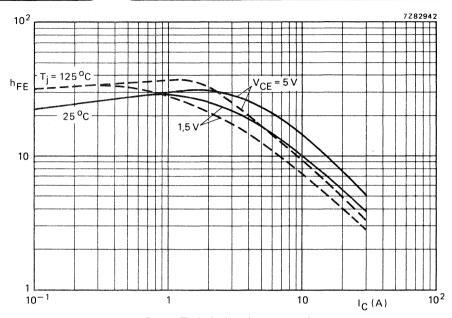


Fig. 13 Typical values d.c. current gain.

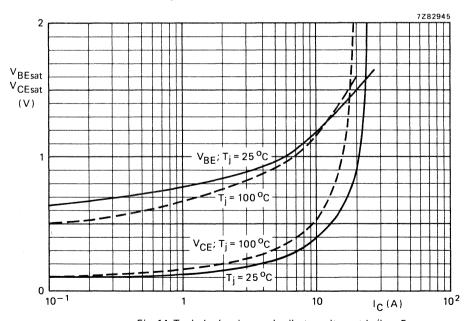


Fig. 14 Typical values base and collector voltage at  $I_C/I_B = 5$ .

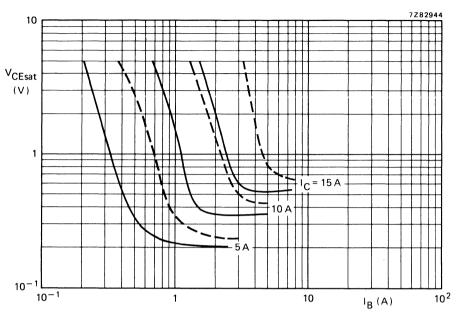


Fig. 15 Typical (——) and maximum (— —) values saturation voltage.  $T_i = 25$  °C.

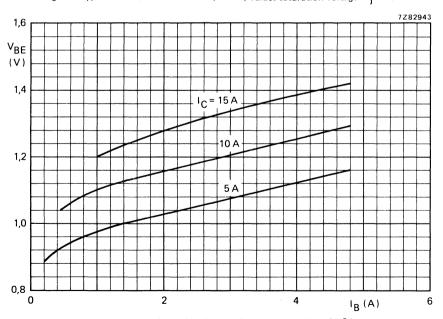


Fig. 16 Typical values base-emitter voltage at  $T_j$  = 25  $^{o}$ C.

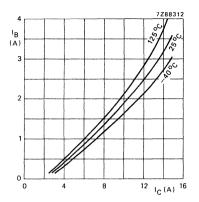


Fig. 17 Minimum base current to saturate the transistor as a function of the collector current.

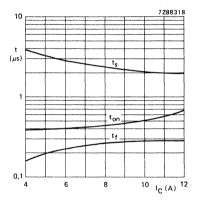


Fig. 19 Typical values switching times resistive circuits as a function of collector current.

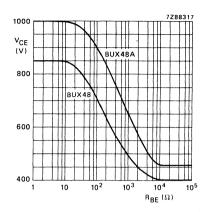


Fig. 18 Typical values collector-emitter voltage as a function of the base-emitter resistance.

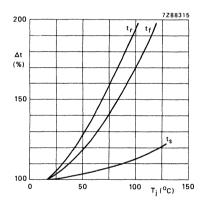


Fig. 20 Increase of switching times as a function of temperature. To read in connection with Fig. 19.

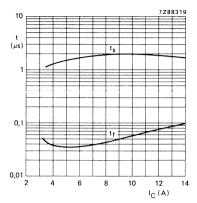


Fig. 21 Typical values switching times inductive circuits as a function of collector current.

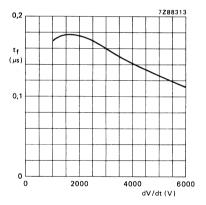


Fig. 23 Typical values fall time as a function of  $dV_{CE}/dt$  at  $T_{mb}$  = 25 °C and  $I_{C}$  = 10 A.

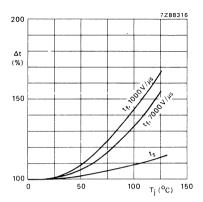


Fig. 22 Increase of storage and fall times to read in connection with Fig. 21 as a function of junction temperature.

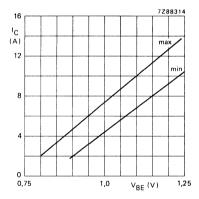


Fig. 24 Base-emitter voltage as a function of collector current at  $V_{CE}$  = 1,5 V;  $T_{mb}$  = 25 °C and 90% confidence.



# SILICON DIFFUSED POWER TRANSISTORS

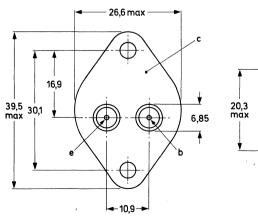
High-voltage, high-speed switching n-p-n power transistors in TO-3 envelopes, intended for use in converters, inverters, switching regulators and motor control systems.

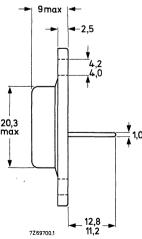
QUICK REFERENCE DATA						
			BUX80	BUX 81		
Collector-emitter voltage (V <sub>BE</sub> = 0, peak value)	$v_{CESM}$	max.	800	1000	V	
Collector-emitter voltage ( $R_{BE} = 50 \Omega$ )	$v_{CER}$	max.	500	500	V	
Collector-emitter voltage (open base)	$v_{\rm CEO}$	max.	400	450	V	
Collector current (d.c.)	$I_{\mathbf{C}}$	max.	1	0	A	
Collector current (peak value) tp = 2 ms	$I_{\text{CM}}$	max.	1	5	Α	
Total power dissipation up to T <sub>mb</sub> = 40 °C	$P_{tot}$	max.	10	0	W	
Collector-emitter saturation voltage I <sub>C</sub> = 5 A; I <sub>B</sub> = 1 A	V <sub>CEsat</sub>	<	1,	5	V	
Fall time $I_{Con} = 5 A$ ; $I_{Bon} = 1 A$ ; $-I_{Boff} = 2 A$	$t_{\mathbf{f}}$	typ.	0,	3	μs	

#### MECHANICAL DATA

Dimensions in mm

TO-3 Collector connected to case





See also chapters Mounting instructions and Accessories.

 ${f RATINGS}$  Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-emitter voltage			BUX 80	BUX 81	
(V <sub>BE</sub> = 0, peak value)	$v_{CESM}$	max.	800	1000	V
Callector emitted valters					
Collector-emitter voltage (R <sub>BE</sub> = $50 \Omega$ )	$v_{CER}$	max.	500	500	V
Collector-emitter voltage (open base)	$v_{CEO}$	max.	400	450	V
Collector current (d.c.)	$^{\mathrm{I}}\mathrm{_{C}}$	max.	10	)	Α
Collector current (peak value)				_	
$t_p = 2 \text{ ms}$	$^{\mathrm{I}}\mathrm{CM}$	max.	15		A
Base current (d.c.)	$I_{B}$	max.	. 4	1	A
Base current (peak value)	$I_{BM}$	max.	(	5 .	A
Reverse base current (d.c. or average over any 20 ms period)	-I <sub>B</sub> (AV)	max.	100	)	mA
Reverse base current (peak value) 1)	-I <sub>BM</sub>	max.	6	5	A
Total power dissipation up to $T_{mb}$ = 40 $^{o}C$	P <sub>tot</sub>	max.	100	)	w
Storage temperature	$T_{\rm stg}$	-65	to +150	)	$^{\mathrm{o}\mathrm{C}}$
Junction temperature	$T_{\mathbf{j}}$	max.	150	)	$^{\mathrm{o}\mathrm{C}}$
THERMAL RESISTANCE					
From junction to mounting base	R <sub>th j-mb</sub>	==	1, 1	l	K/W
CHARACTERISTICS	$T_{j} = 25  \circ 0$	unless	otherwi	se spe	cified
Collector cut-off current <sup>2</sup> )					
$V_{CEM} = V_{CESMmax}$ ; $V_{BE} = 0$	$I_{CES}$	<	j	l	mA
$V_{CEM} = V_{CESMmax}$ ; $V_{BE} = 0$ ; $T_j = 125$ °C	ICES	<	3	3	mA
D.C. current gain					
$I_C = 1,2 A; V_{CE} = 5 V$	$h_{ m FE}$	typ.	30	)	

<sup>1)</sup> Turn-off current.

 $<sup>^{2}</sup>$ ) Measured with a half sine wave voltage (curve tracer).

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## CHARACTERISTICS (continued)

Emitter cut-off current

$$I_{C} = 0; V_{EB} = 10 \text{ V}$$

Saturation voltages

$$I_C = 5 A$$
;  $I_B = 1 A$ 

$$I_{C} = 8 \text{ A}; I_{B} = 2,5 \text{ A}$$

Collector-emitter sustaining voltages

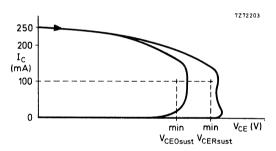
$$I_{\rm C}$$
 = 100 mA;  $I_{\rm Boff}$  = 0; L = 25 mH

$$I_{C} = 100 \text{ mA}; R_{BE} = 50 \Omega; L = 15 \text{ mH}$$

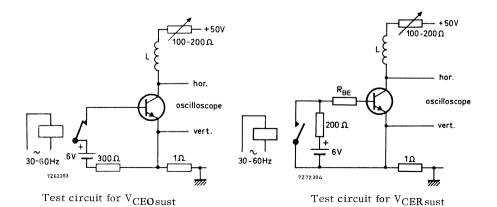
 $T_{ij} = 25$  °C unless otherwise specified

$$V_{
m BE\ sat}$$
 < 1,4  $V$   $V_{
m CE\ sat}$  < 3  $V$ 

		BUX 80	BUX81	
$v_{CEOsust}$	>	400	450	V
$v_{CERsust}$	>	500	500	V



Oscilloscope display for sustaining voltages



## CHARACTERISTICS (continued)

 $T_i = 25$  °C unless otherwise specified

Transition frequency at f = 1 MHz

$$I_C = 0.2 A$$
;  $V_{CE} = 10 V$ 

fΤ typ. MHz

Switching times

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

Turn-on time

$$t_{\rm on}$$
 typ. 0,35 µs  $<$  0,5 µs

Turn-off: Storage time

typ. 2,5 μs  $t_s$ 3,5 μs

Fall time

 $t_f$ 

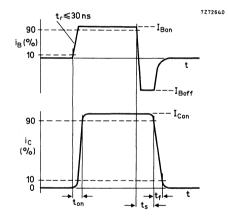
0,3 typ. μs

Fall time,  $T_{mb} = 95$  °C

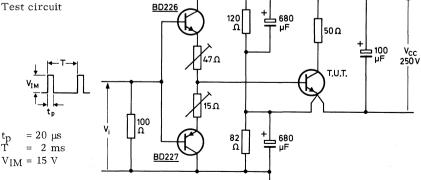




+25V

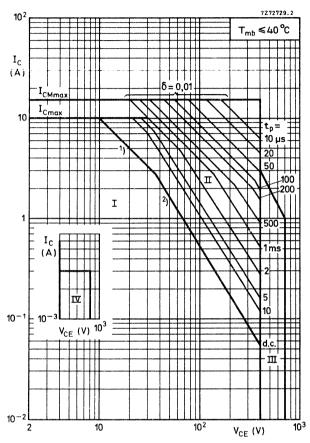


Test circuit



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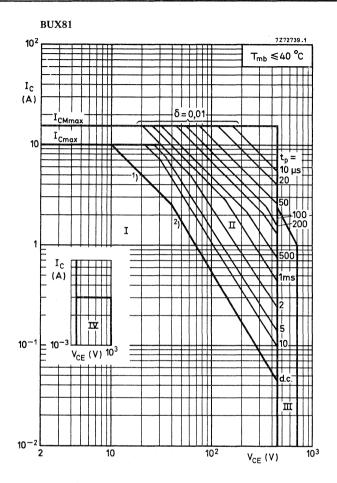




- I Region of permissible d.c. operation
- II Permissible extension for repetitive pulse operation
- III Area of permissible operation during turn-on in single-transistor converters, provided  $R_{BE} \le 100~\Omega$  and  $t_p \le 0.6~\mu s$
- IV Repetitive pulse operation in this region is permissible, provided  $V_{\rm BE} \le 0$  and  $t_{\rm p} \le 2$  ms

 $<sup>^{</sup>l})\;P_{tot\;max}$  and  $P_{peak\;max}$  lines.

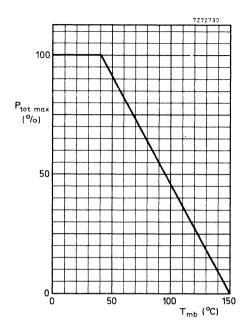
<sup>2)</sup> Second-breakdown limits (independent of temperature).

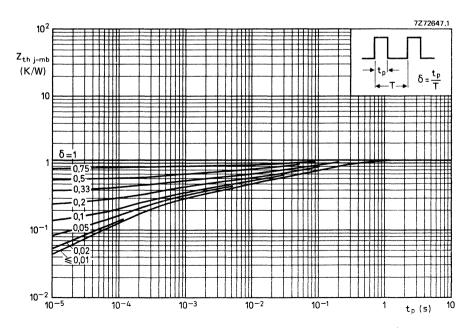


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- IV Repetitive pulse operation in this region is permissible, provided  $V_{\rm BE} \le 0$  and  $t_{\rm D} \le 2$  ms

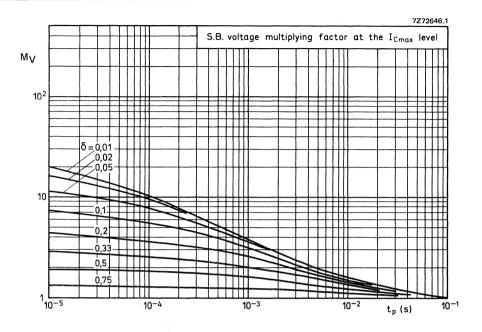
<sup>1)</sup>  $P_{tot \ max}$  and  $P_{peak \ max}$  lines.

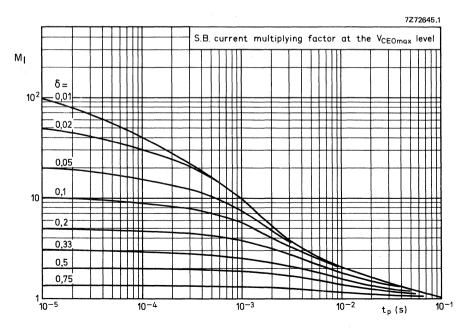
<sup>2)</sup> Second-breakdown limits (independent of temperature).

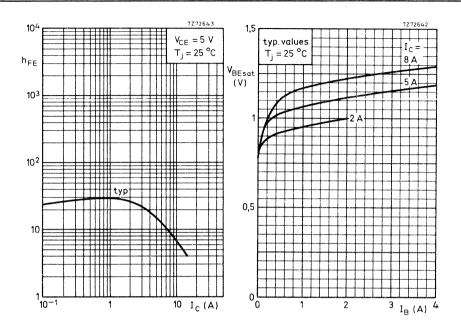


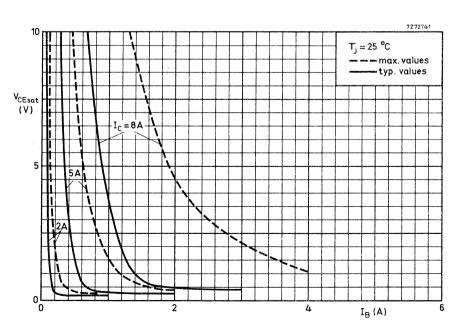


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#### APPLICATION INFORMATION ON BUX80 (detailed information on request)

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<sub>CM</sub> 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

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

To ensure thermal stability the minimum value of T<sub>amb</sub> 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.

Storage time Fall time

	$T_{mb}$	= 25 °C	100 °C	
ts	typ	2	2,7	μs
tf	typ	0,18	0,5	μs

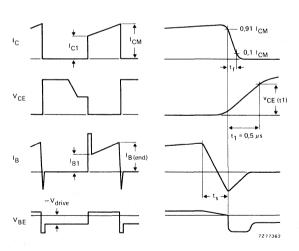


Fig. 1 Relevant waveforms of switching transistor.

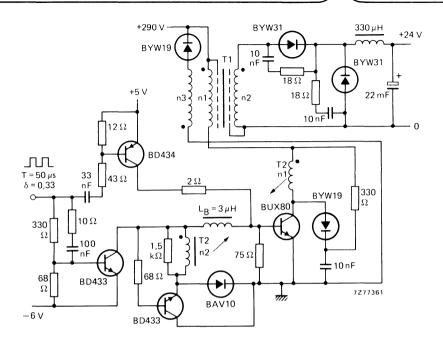


Fig. 2 Practical SMPS output circuit. T1 (output transformer): Core U64: n

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)

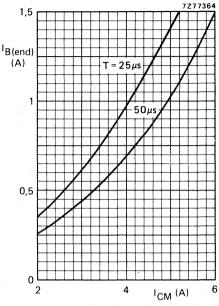
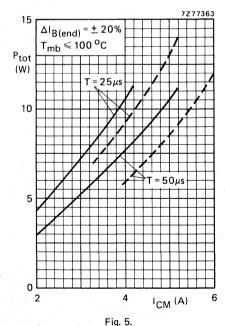


Fig. 3.



8 6  $L_{\mathsf{B}}$ -V<sub>drive</sub>  $(\mu H)$ (V) Vdrive 4 6 2 0 2 6 I<sub>CM</sub> (A) Fig. 4.

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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

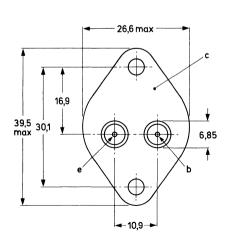
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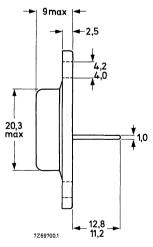
QUICK REFERENCE DATA						
			BUX82	BUX83		
Collector-emitter voltage (V <sub>BE</sub> = 0, peak value)	$v_{CESM}$	max.	800	1000	V	
Collector-emitter voltage (RBE = $100 \Omega$ )	$v_{\text{CER}}$	max.	500	500	V	
Collector-emitter voltage (open base)	$v_{CEO}$	max.	400	450	V	
Collector current (d.c.)	$I_{\mathbf{C}}$	max.		6	A	
Collector current (peak value) t <sub>p</sub> = 2 ms	$^{\mathrm{I}}\mathrm{CM}$	max.		8	A	
Total power dissipation up to $T_{mb}$ = 50 $^{o}C$	$P_{tot}$	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 <sub>f</sub>	typ.	0	, 3	μs	

## MECHANICAL DATA

Dimensions in mm

TO-3 Collector connected to case





See also chapters Mounting instructions and Accessories.

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

Collector-emitter voltage		I	3UX82	BUX8	3
(V <sub>BE</sub> = 0, peak value)	$v_{\rm CESM}$	max.	800	1000	v
Collector-emitter voltage ( $R_{BE} = 100 \Omega$ )	$v_{\rm CER}$	max.	500	500	V
Collector-emitter voltage (open base)	$v_{\rm CEO}$	max.	400	450	V
Collector current (d.c.)	$I_{\mathbf{C}}$	max.		5	A
Collector current (peak value)					
$t_p = 2 \text{ ms}$	$^{\mathrm{I}}\mathrm{CM}$	max.		8	AO
Base current (d.c.)	$I_{B}$	max.		2	Α
Base current (peak value)	$I_{ extbf{BM}}$	max.		3	A
Reverse base current (d.c. or average over any 20 ms period)	-I <sub>B</sub> (AV)	max.	100	)	mA
Reverse base current (peak value) 1)	$-I_{BM}$	max.	,	3	A
Total power dissipation up to $T_{mb}$ = 50 $^{o}C$	P <sub>tot</sub>	max.	60	)	W
Storage temperature	${ m T_{stg}}$	-65	to +150	) )	o <sub>C</sub>
Junction temperature	$T_{\mathbf{j}}$	max.	150	)	°С
THERMAL RESISTANCE					
From junction to mounting base	R <sub>th j-mb</sub>	=	1,6	5	K/W
CHARACTERISTICS	$T_j = 25$ °C 1	unless	otherwis	se spe	cified
Collector cut-off current <sup>2</sup> )					
$V_{CEM} = V_{CESMmax}; V_{BE} = 0$	ICES	<		1	mA
$V_{CEM} = V_{CESMmax}$ ; $V_{BE} = 0$ ; $T_j = 125$ $^{\circ}C$	$I_{\rm CES}$	<		2	mA
D.C. current gain					
$I_{C} = 0, 6 A; V_{CE} = 5 V$	$h_{\mathrm{FE}}$	typ.	3	0 , ,	

<sup>1)</sup> Turn-off current.

<sup>2)</sup> Measured with a half sine wave voltage (curve tracer).

## CHARACTERISTICS (continued)

Emitter cut-off current

$I_{C} = 0$ ; $V_{EB} = 10 \text{ V}$	I

Saturation voltages

$$I_C = 2,5 \text{ A}; I_B = 0,5 \text{ A}$$

$$I_C = 4 \text{ A}; I_B = 1,25 \text{ A}$$

$$I_{\rm C} = 4 \text{ A}; I_{\rm B} = 1,25 \text{ A}$$

# Collector-emitter sustaining voltages

$$I_{C}$$
 = 100 mA;  $I_{Boff}$  = 0; L = 25 mH  
 $I_{C}$  = 100 mA;  $R_{BE}$  = 100  $\Omega$ ; L = 15 mH

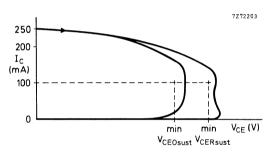
$$I_{EBO}$$

VBE sat

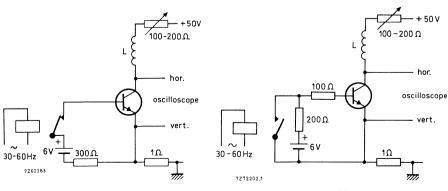
$$v_{CEsat}$$
 < 1,5  $v$ 

 $T_i = 25$  °C unless otherwise specified

BUX 82 BUX 83 450 VCEOsust 400



Oscilloscope display for sustaining voltages



Test circuit for VCEOsust

Test circuit for  $V_{\mbox{ERsust}}$ 

## CHARACTERISTICS (continued)

 $T_i$  = 25  $^{\rm O}$ C unless otherwise specified

Transition frequency at f = 1 MHz

$$l_C = 0, 2 A; V_{CE} = 10 V$$

fTtyp.

typ.

typ.

typ.

<

MHz

Switching times

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

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

0,3  $\mu s$ 0,5  $\mu s$ 

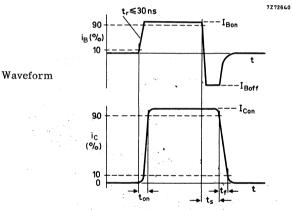
$$t_s$$

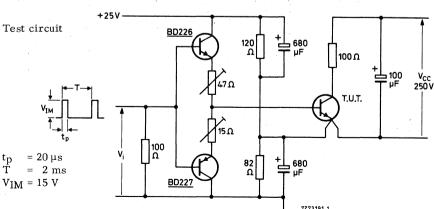
 $\mu s$ 

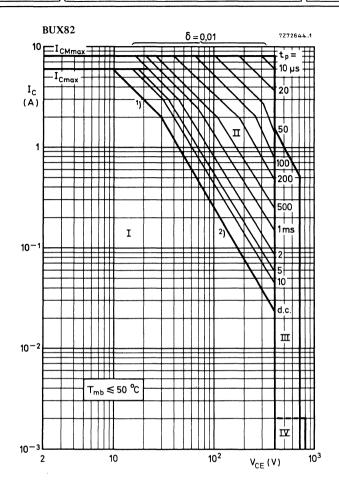
3, 5

Fall time, 
$$T_{mb} = 95$$
 °C

$$\mathsf{t_f}$$





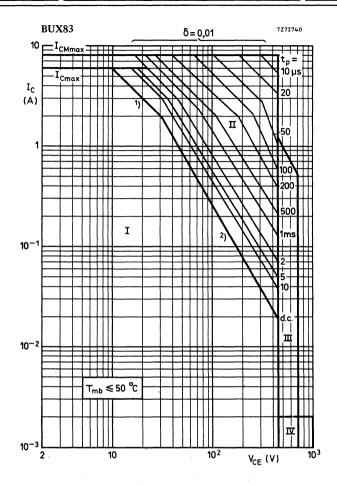


- I Region of permissible d.c. operation
- II Permissible extension for repetitive pulse operation
- III Area of permissible operation during turn-on in single-transistor converters, provided  $R_{BE} \leq 100~\Omega$  and  $t_D \leq 0,6~\mu s$
- IV Repetitive pulse operation in this region is permissible, provided  $V_{\rm BE} \le 0$  and  $t_{\rm p} \le 2~{\rm ms}$

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 $<sup>^{1}\</sup>text{)}\text{ }P_{\text{tot}\;\text{max}}\text{ and }P_{\text{peak}\;\text{max}}\text{ lines.}$ 

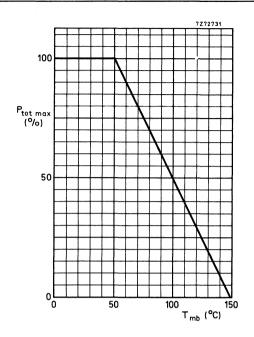
 $<sup>^{2}</sup>$ ) Second-breakdown limits (independent of temperature).

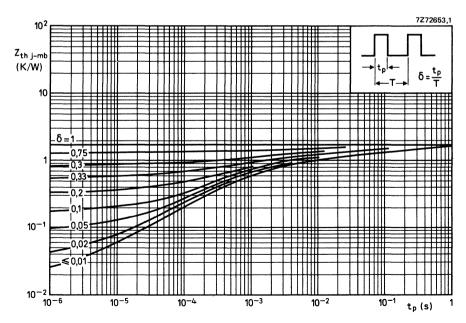


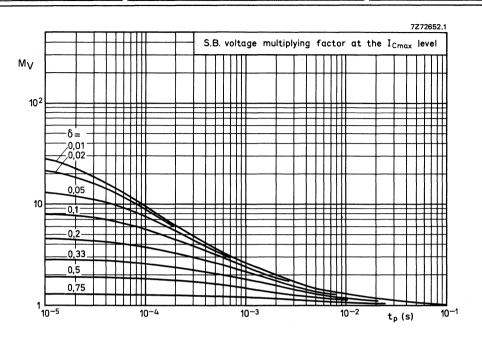
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- IV Repetitive pulse operation in this region is permissible, provided  $V_{\rm BE} \le 0$  and  $t_{\rm p} \le 2$  ms

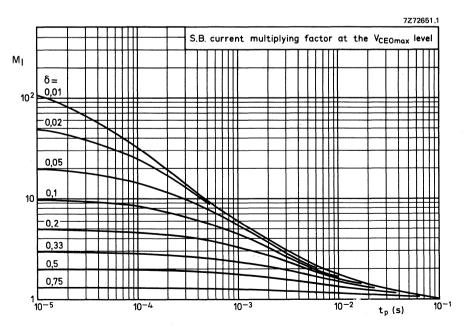
 $<sup>^{</sup>l})\;P_{tot\;max}$  and  $P_{peak\;max}$  lines.

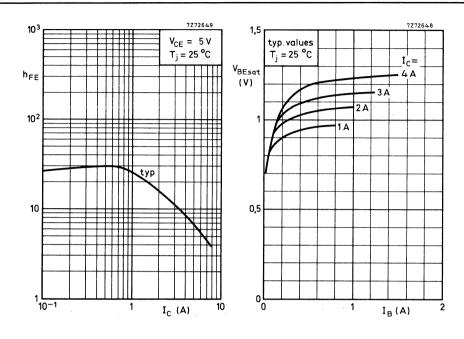
 $<sup>^{2}</sup>$ ) Second-breakdown limits (independent of temperature).

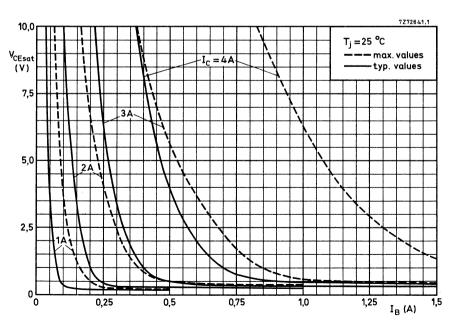












#### APPLICATION INFORMATION ON BUX82 (detailed information on request)

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

$$R_{th\ mb-a} = \frac{100 - T_{amb\ max}}{P_{tot}}$$

To ensure thermal stability the minimum value of T<sub>amb</sub> 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.

Storage time Fall time

$$\begin{array}{c|cccc} & T_{mb} = 25 \text{ °C} & 100 \text{ °C} \\ \hline t_s & typ & 1,9 & 2,7 & \mu s \\ t_f & typ & 0,17 & 0,7 & \mu s \\ \end{array}$$

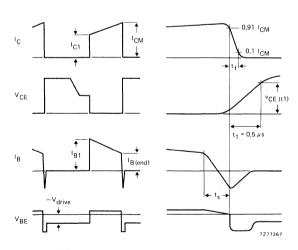


Fig. 1 Relevant waveforms of switching transistor.

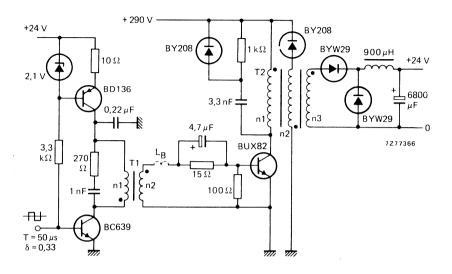
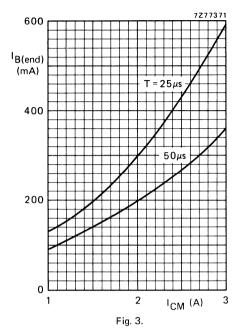


Fig. 2 Practical forward converter SMPS output circuit. T1 (driver transformer): Core U20; n1 = 75 turns; n2 = 20 turns T2 (output transformer): Core E55; n1 = n2 = 72 turns; n3 = 19 turns  $v_{CE(t1)} < 300 \text{ V}$  (see Fig. 1)



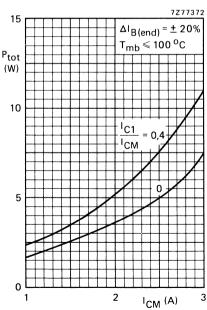


Fig. 5.

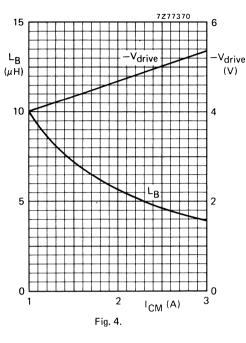
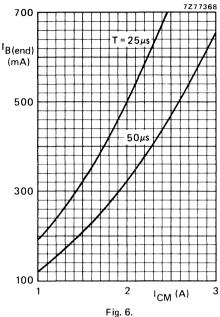


Fig. 3 Recommended nominal "end" value of the base current versus maximum peak collector current in a **flyback** converter.

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.

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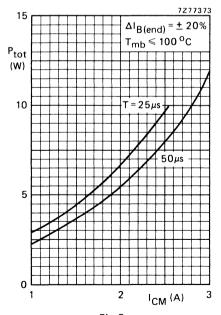


Fig. 8.

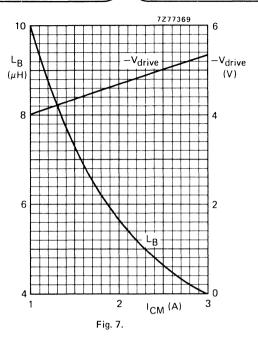


Fig. 6 Recommended nominal "end" value of the base current versus maximum peak collector current in a forward converter.

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

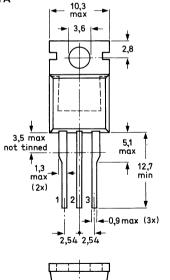
			BUX84	BUX85	
Collector-emitter voltage (V <sub>BE</sub> = 0, peak value)	V <sub>CESM</sub>	max	800	1000	٧
Collector-emitter voltage (open base)	$v_{CEO}$	max	400	450	٧
Collector current (d.c.)	I <sub>C</sub>	max	:	2	Α
Collector current (peak value) t <sub>p</sub> = 2 ms	<sup>I</sup> CM	max	;	3	Α
Total power dissipation up to T <sub>mb</sub> = 50 °C	$P_{tot}$	max	40	)	W
Collector-emitter saturation voltage $I_C = 1 A$ ; $I_B = 0.2 A$	V <sub>CEsat</sub>	<		1	v
Fall time $I_{Con} = 1 \text{ A}; I_{Bon} = 0.2 \text{ A}; -I_{Boff} = 0.4 \text{ A}$	tf	typ	0,4	1	μs

## **MECHANICAL DATA**

TO-220

Collector connected to mounting base





See also chapters Mounting Instructions and Accessories.

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

Collector-emitter voltage		В	UX84   BUX85	
(V <sub>BE</sub> = 0, peak value)	VCESM	max	800 1000	V
Collector-emitter voltage (open base)	$V_{CEO}$	max	400 450	V
Collector current (d.c.)	I <sub>C</sub>	max	2	Α
Collector current (peak value)				
$t_p = 2 \text{ ms}$	ICM	max	3	Α
Base current (d.c.)	ΙB	max	0,75	Α
Base current (peak value)	<sup>I</sup> BM	max	1	Α
Reverse base current (peak value) *	-I <sub>BM</sub>	max	1	Α
Total power dissipation up to T <sub>mb</sub> = 50 °C	P <sub>tot</sub>	max	40	W
Storage temperature	T <sub>stg</sub>	<b>–65</b>	to +150	°C
Junction temperature	T <sub>i</sub>	max	150	оС
	.1			<u> </u>
THERMAL RESISTANCE				
From junction to mounting base	R <sub>th j-mb</sub>	=	2,5	K/W
From junction to ambient in free air	R <sub>th j-a</sub>	. =	70	K/W
CHARACTERISTICS	$T_j = 2$	25 °C u	nless otherwise	specified
Collector cut-off current **				
V <sub>CEM</sub> = V <sub>CESMmax</sub> ; V <sub>BE</sub> = 0	ICES	<	200	μΑ
$V_{CEM} = V_{CESMmax}$ ; $V_{BE} = 0$ ; $T_j = 125$ °C	ICES	<	1,5	mA
D.C. current gain				
I <sub>C</sub> = 0,1 A; V <sub>CE</sub> = 5 V	hFE	typ	50	

<sup>\*</sup> Turn-off current.

<sup>\*\*</sup> Measured with a half sine-wave voltage (curve tracer).

## CHARACTERISTICS (continued)

Collector-emitter sustaining voltage

 $I_C = 100 \text{ mA}$ ;  $I_{Boff} = 0$ ; L = 25 mH

T<sub>i</sub> = 25 °C unless otherwise specified

1,0

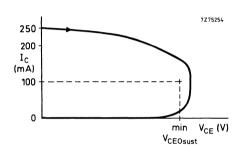
## Emitter cut-off current

$I_C = 0; V_{EB} = 5 V$	<sup>I</sup> EBO	<	1	mA
Saturation voltages				
$I_C = 0.3 \text{ A}; I_B = 30 \text{ mA}$	$v_{CEsat}$	<	0,8	V

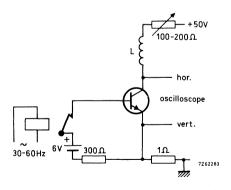
# $V_{CEOsust} > \frac{BUX84 \mid BUX85}{400 \mid 450}$

**V**CEsat

 $V_{\mathsf{BEsat}}$ 



Oscilloscope display for sustaining voltage.



Test circuit for V<sub>CEOsust</sub>.

## CHARACTERISTICS (continued)

# T<sub>i</sub> = 25 °C unless otherwise specified

# Transition frequency at f = 1 MHz

$$I_C = 0.2 A; V_{CE} = 10 V$$

f<sub>T</sub> typ 20 MHz

## Switching times

$$I_{Bon} = 0.2 A; -I_{Boff} = 0.4 A$$

Turn-on time

 $t_{on}$   $\stackrel{typ}{<}$  0,2  $\mu s$  0,5  $\mu s$ 

## Turn-off: Storage time

t<sub>s</sub> typ 2 μs < 3,5 μs

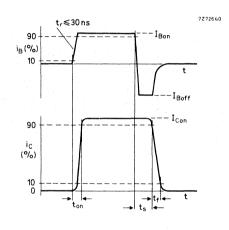
Fall time

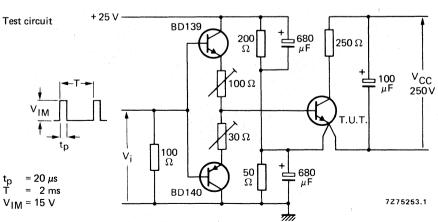
t<sub>f</sub> typ 0,4 μs

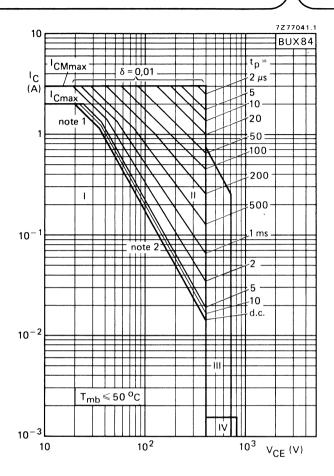
Fall time, T<sub>mb</sub> = 95 °C

 $t_f$  < 1,4  $\mu$ s





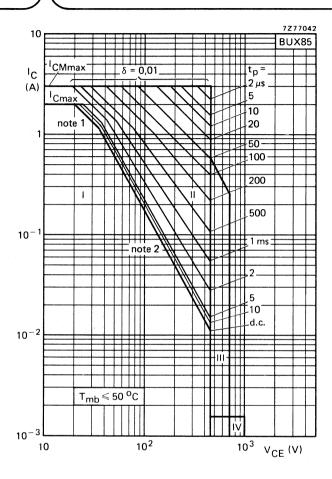




- I Region of permissible d.c. operation
- II Permissible extension for repetitive pulse operation
- III Area of permissible operation during turn-on in single transistor converters, provided RBE  $\leqslant$  100  $\Omega$  and tp  $\leqslant$  0,6  $\mu s$
- IV Repetitive pulse operation in this region is permissible, provided VBE  $\leqslant$  0 and  $t_p \leqslant$  2 ms

#### Notes

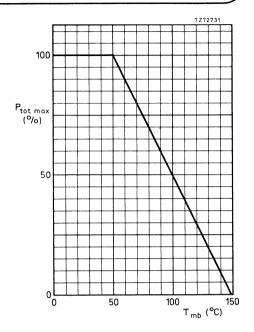
- 1. Ptot max and Ppeak max lines.
- 2. Second-breakdown limits (independent of temperature).

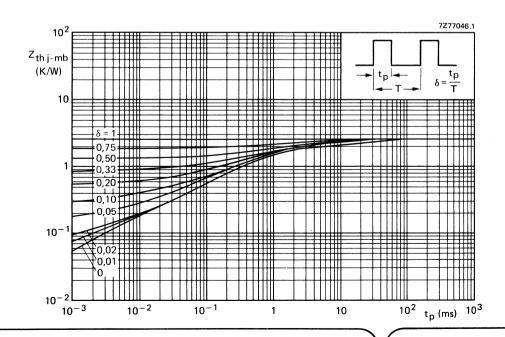


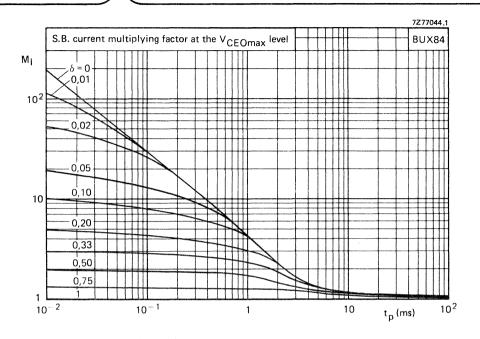
- I Region of permissible d.c. operation
- II Permissible extension for repetitive pulse operation
- III Area of permissible operation during turn-on in single transistor converters, provided RBE  $\le$  100  $\Omega$  and tp  $\le$  0,6  $\mu s$
- IV Repetitive pulse operation in this region is permissible, provided V  $_{BE} \leqslant 0$  and  $t_p \leqslant 2$  ms

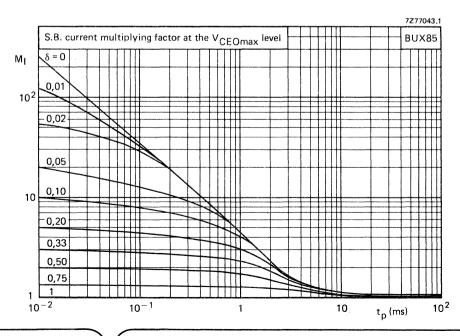
#### Notes

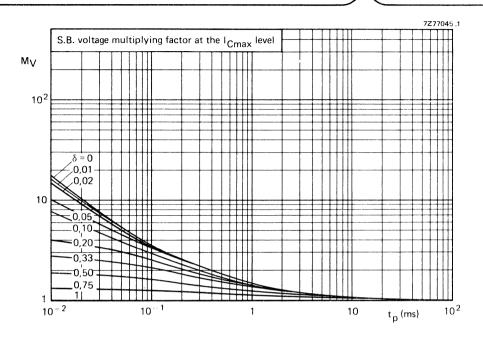
- 1. Ptot max and Ppeak max lines.
- 2. Second-breakdown limits (independent of temperature).

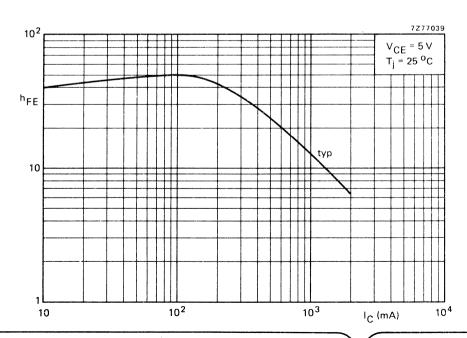












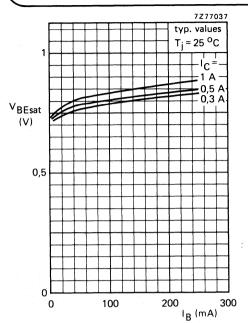
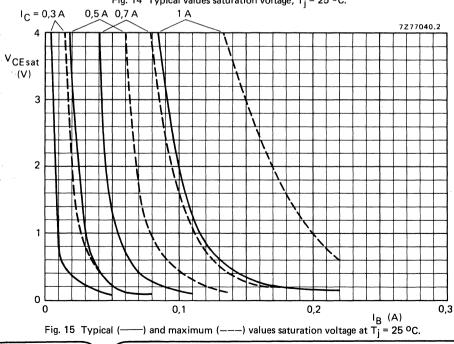


Fig. 14 Typical values saturation voltage,  $T_{\hat{i}} = 25$  °C.



#### APPLICATION INFORMATION ON BUX84 (detailed information on request)

Important factors in the design of SMPS circuits are the power losses and heatsink requirements of the supply output transistor and the base drive conditions during turn-off. In most SMPS circuits with mains isolation the duty factor of the collector current generally varies between 0,25 and 0,5.

The operating frequency lies between 15 kHz and 50 kHz and the shape of the collector current varies from rectangular in a forward converter to a sawtooth in a flyback circuit.

Information on optimum base drive and device dissipation of the BUX84 in a flyback converter is given in Figs 3 to 5. Figs 6 to 8 apply to a forward converter. In these figures I<sub>CM</sub> 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

$$R_{th\ mb-a} = \frac{100 - T_{amb\ max}}{P_{tot}}$$

To ensure thermal stability the minimum value of Tamb 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.

Storage time Fall time

$$T_{mb} = 25$$
 °C | 100 °C  
 $t_s$  | typ | 2,2 | 2,8 |  $\mu s$   
 $t_f$  | typ | 0,25 | 0,85 |  $\mu s$ 

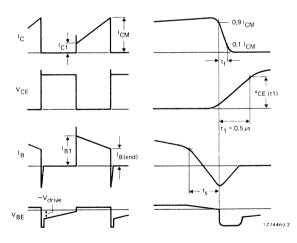


Fig. 1 Relevant waveforms of switching transistor.

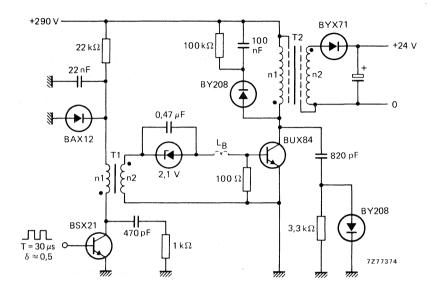


Fig. 2 Practical SMPS output circuit.

T1 (driver transformer): Core U15; n1 = 360 turns; n2 = 60 turns total inductance in base circuit  $\approx 15~\mu\text{H}$  T2 (output transformer): Core E55; primary inductance  $L_D$  = 16 mH

n1 = 116 turns; n2 = 12 turns

 $v_{CE(t1)} < 300 \text{ V (see Fig. 1)}$ 

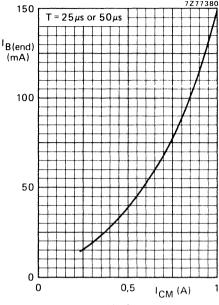


Fig. 3.

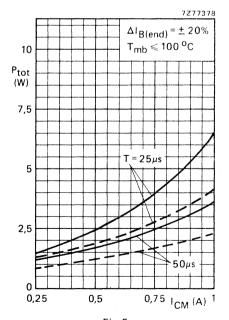


Fig. 5.

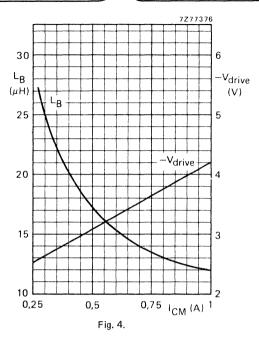
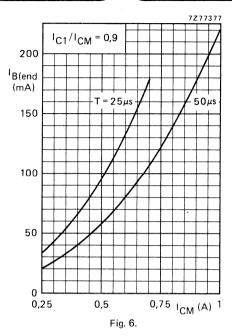
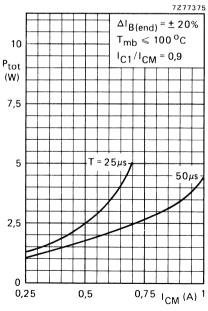


Fig. 3 Recommended nominal "end" value of the base current versus maximum peak collector current in a flyback converter.

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  $I_{C1}/I_{CM} = 0$ .





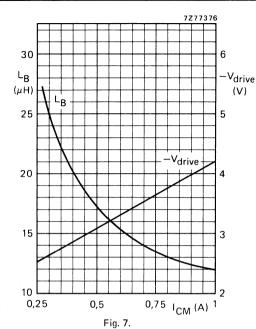


Fig. 6 Recommended nominal "end" value of the base current versus maximum peak collector current in a forward converter.

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.

Fig. 8.

specifications are subject to change without notice.

# SILICON DIFFUSED POWER TRANSISTORS

High-voltage, high-speed, glass-passivated n-p-n power transistor in a SOT-186 envelope with an electrically isolated seating plane. The device is intended for use in converters, inverters, switching regulators, motor control systems, etc.

## QUICK REFERENCE DATA

			BUX84F	BUX85F	
Collector-emitter voltage			400	450	.,
open base VBF = 0, peak value	VCEO	max. max.	400 800	450 1000	
52	VCESM	IIIdX.	800	1000	v
Collector saturation current	l Csat	=	•	l	Α
Collector current					
d.c.	IC	max.	:	2	Α
peak value	ICM	max.	;	3	Α
Total power dissipation up to T <sub>h</sub> = 25 °C	Ptot	max.	18	3	W
Collector-emitter saturation voltage $I_C = 1 A$ ; $I_B = 0.2 A$	VCEsat	< 1	1,0	)	٧
Fall time					
I <sub>Con</sub> = 1 A; I <sub>Bon</sub> = 0,2 A; I <sub>Boff</sub> = 0,4 A	tf	typ.	0,4	1	μs

#### **MECHANICAL DATA**

See Fig. 1.

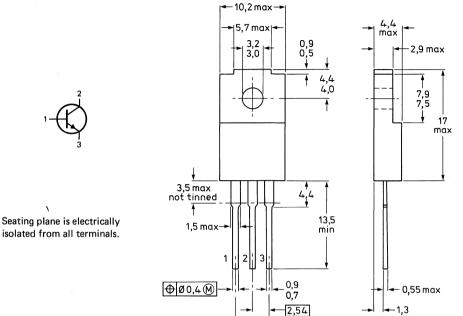
## **MECHANICAL DATA**

Fig. 1 SOT-186 (TO-220F).

Dimensions in mm

7Z95293

| BUX85F



4

5,08

BUX84F

## **RATINGS**

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

Collector-emitter voltage					
open base	VCEO	max.	400	450	V
V <sub>BE</sub> = 0; peak value	VCESM	max.	800	1000	٧
Collector current, d.c.	IC	max.		2	Α
Collector current, peak value	ICM	max.		3	Α
Base current, d.c.	IB	max.	0,7	5	Α
peak value	IBM	max.		1	Α
Total power dissipation					
up to $T_h = 25$ °C (note 1)	P <sub>tot</sub>	max.	1	8	W
Storage temperature	$T_{stg}$			-65 to +150	oC
Junction temperature	Tj	max.	15	0	oC

THERMAL RESISTANCE				
			BUX84F   BUX	X85F
From junction to internal heatsink	R <sub>th j-ih</sub>		2,2	K/W
From junction to external heatsink (note 1)	R <sub>th j-h</sub>		7,2	K/W
From junction to external heatsink (note 2)	R <sub>th j-h</sub>		4,7	K/W
From junction to ambient	R <sub>th j-a</sub>		55	K/W
INSULATION				
Voltage allowed between all terminals and external heatsink, peak value	V <sub>insul</sub>	max.	1500	V
Insulation capacitance between collector and external heatsink	C <sub>c-h</sub>	typ.	12	pF
CHARACTERISTICS				
T <sub>j</sub> = 25 °C unless otherwise specified				
Collector cut-off currents  VCE = VCESmax; VBE = 0  VCE = VCESmax; VBE = 0; T <sub>j</sub> = 125 °C	ICES	max. max.	0,2 1,5	mA mA
VEB = 5 V; IC = 0	IEBO	max.	1	mA
D.C. current gain $I_C = 0.1 A$ ; $V_{CE} = 5 V$	hFE	typ.	50	
Transition frequency at $f = 1 \text{ MHz}$ $I_C = 0.2 \text{ A}$ ; $V_{CE} = 10 \text{ V}$	fŢ	typ.	20	MHz

<sup>(1)</sup> Mounted without heatsink compound and 30  $\pm$  5 N pressure on centre of envelope.

<sup>(2)</sup> Mounted with heatsink compound and 30  $\pm$  5 N pressure on centre of envelope.



## 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

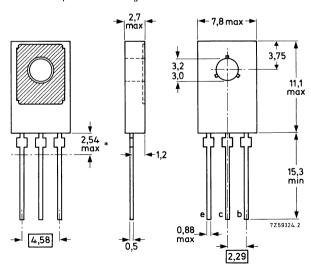
			BUX86	BUX87	
Collector-emitter voltage ( $V_{BE} = 0$ , peak value)	$V_{CESM}$	max	800	1000	V
Collector-emitter voltage (open base)	$V_{CEO}$	max	400	450	V
Collector current (d.c.)	<sup>I</sup> C	max	0,5	5	Α
Collector current (peak value): $t_p = 2 \text{ ms}$	<sup>I</sup> CM	max	1	İ	Α
Total power dissipation up to $T_{mb} = 60  {}^{\circ}\text{C}$	P <sub>tot</sub>	max	20	)	W
Collector-emitter saturation voltage: $I_C = 0.2 A$ ; $I_B = 20 mA$	<b>V</b> CEsat	<	1		V
Fall time: $I_{Con} = 0.2 \text{ A}$ ; $I_{Bon} = 20 \text{ mA}$ ; $-I_{Boff} = 40 \text{ mA}$	t <sub>f</sub>	typ	0,4	ļ	μs

#### MECHANICAL DATA

Dimensions in mm

TO-126 (SOT-32)

Collector connected to metal part of mounting surface



<sup>\*</sup> Within this region the cross-section of the leads is uncontrolled. See chapters Mounting Instructions and Accessories.

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

		В	JX86	BUX87	_
Collector-emitter voltage (V <sub>BE</sub> = 0, peak value)	VCESM	max.	800	1000	٧
Collector-emitter voltage (open base)	VCEO	max.	400	450	V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	5	5	V
Collector current (d.c.)	l <sub>C</sub>	max.	0,	5	Α
Collector current (peak value) t <sub>p</sub> = 2 ms	ICM	max.	0,	1	A
Base current (d.c.)	•		0,		A
Base current (peak value)	l <sub>B</sub>	max.	0,		A
Reverse base current (peak value) (note 1)	<sup>I</sup> BM	max.			
neverse base current (peak value) (note 1)	<sup>−1</sup> BM	max.	0,	,3	Α
Total power dissipation up to T <sub>mb</sub> = 60 °C	P <sub>tot</sub>	max.	2	0	W
Ctorono tomo oraturo	_	65	15	•	°C
Storage temperature	T <sub>stg</sub>		to + 15		_
Junction temperature	Tj	max.	15		oC.
THERMAL RESISTANCE					
From junction to mounting base	R <sub>th j-mb</sub>	=	4,	.5	K/W
From junction to ambient in free air	R <sub>th j-a</sub>	=	10	0	K/W
CHARACTERISTICS	-	O	46		
CHARACTERISTICS	$T_j = 25^{\circ}$	Cunie	ss otnei	wise spec	птеа
Collector-cut-off current (note 2)					
V <sub>CEM</sub> = V <sub>CESMmax</sub> ; V <sub>BE</sub> = 0	ICES	<	10	0	μΑ
$V_{CEM} = V_{CESMmax}$ ; $V_{BE} = 0$ ; $T_j = 125$ °C	ICES	<		1	mA .
D.C. current gain					
I <sub>C</sub> = 50 mA; V <sub>CF</sub> = 5 V	hFE	typ.	5	0	
O A STATE OF THE S	r E	.,	, •	-	

## Notes

<sup>1.</sup> Turn-off current.

<sup>2.</sup> Measured with a half sine-wave voltage (curve tracer).

mΑ

## CHARACTERISTICS (continued)

 $T_i = 25$  OC unless otherwise specified

Emitter cut-off current	t
$I_C = 0; V_{EB} = 5 V$	

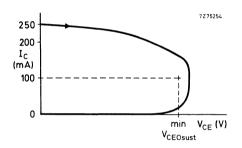
Saturation voltage				
$I_C = 0.1 \text{ A}; I_B = 10 \text{ mA}$	$v_{CEsat}$	<	0,8	V
$I_C = 0.2 \text{ A}; I_B = 20 \text{ mA}$	$v_{CEsat}$	<	1,0	V
$I_C = 0.2 \text{ A}; I_B = 20 \text{ mA}$	$v_{BEsat}$	<	1,0	V

**IEBO** 

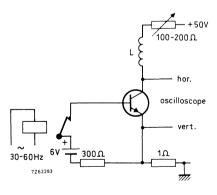
## Collector-emitter sustaining voltages

$$I_C = 100 \text{ mA}$$
;  $I_{Boff} = 0$ ;  $L = 25 \text{ mH}$ 

		BUX86	BUX87	
V <sub>CEOsust</sub>	>	400	450	٧



## Oscilloscope display for sustaining voltage



Test circuit for VCEOsust

## BUX86 BUX87

## CHARACTERISTICS (continued)

## T<sub>i</sub> = 25 °C unless otherwise specified

Transition frequency at f = 1 MHz

$$I_C = 50 \text{ mA}; V_{CE} = 10 \text{ V}$$

f<sub>T</sub> typ 20 MHz

0,25 μs

Switching times

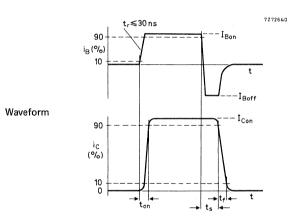
 $I_{Con}$  = 0,2 A;  $V_{CC}$  = 250 V  $I_{Bon}$  = 20 mA;  $-I_{Boff}$  = 40 mA Turn-on time

Turn-off: Storage time

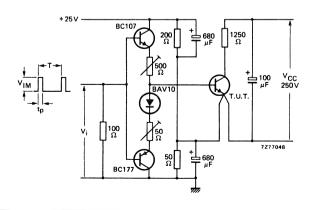
Fall time

Fall time, T<sub>mb</sub> = 95 °C

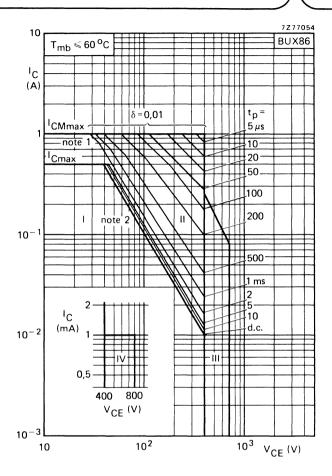
typ



Test circuit



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

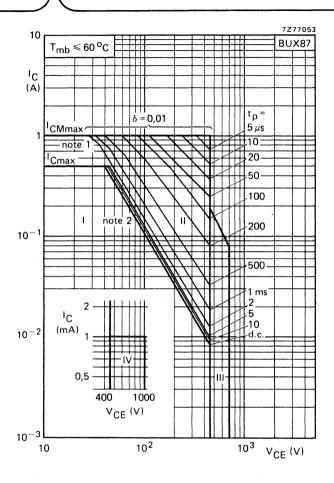


## Safe Operating ARea

- 1 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 RBE  $\leqslant$  100  $\Omega$  and tp  $\leqslant$  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

- Ppeak max lines.
- 2. Second-breakdown limits (independent of temperature).

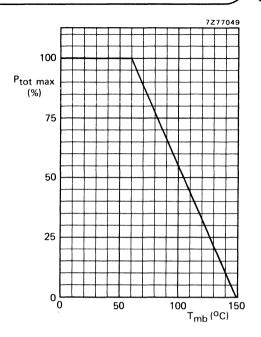


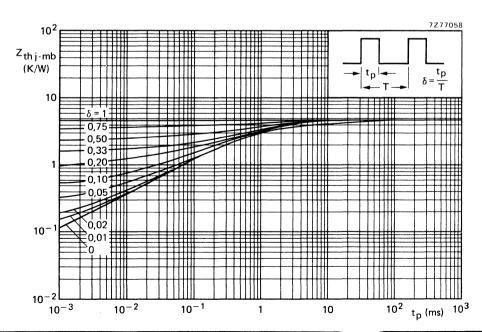
## Safe Operating ARea

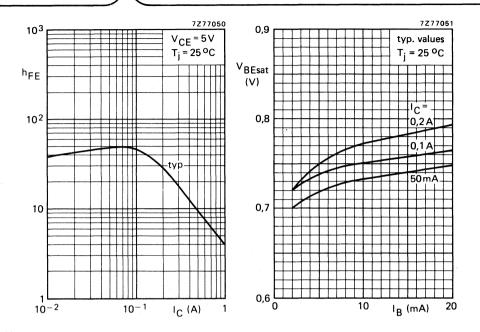
- Region of permissible d.c. operation
- II Permissible extension for repetitive pulse operation
- III Area of permissible operation during turn-on in single-transistor converters, provided R<sub>BE</sub>  $\leq$  100  $\Omega$  an t<sub>D</sub>  $\leq$  0,6  $\mu$ s
- IV Repetitive pulse operation in this region is permissible, provided  $V_{\mbox{\footnotesize{BE}}}\leqslant 0$  and  $t_{\mbox{\footnotesize{p}}}\leqslant 2$  ms

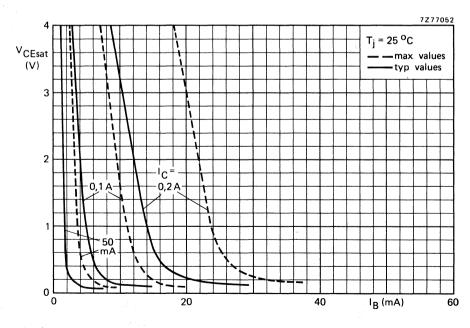
#### Notes

- P<sub>peak max</sub> lines.
   Second-breakdown limits (independent of temperature).









#### 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<sub>CM</sub> 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

$$R_{th mb-a} = \frac{100 - T_{amb max}}{P_{tot}}$$

To ensure thermal stability the minimum value of Tamb 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.

Storage time Fall time

	T <sub>mb</sub>	= 25 °C	100 °C	
ts	typ	1,3	1,8	μs
$t_f$	typ	0,2	0,8	μs

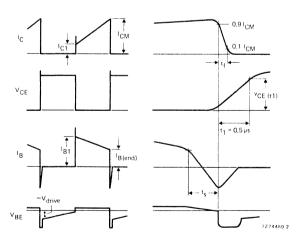


Fig. 1 Relevant waveforms of switching transistor.

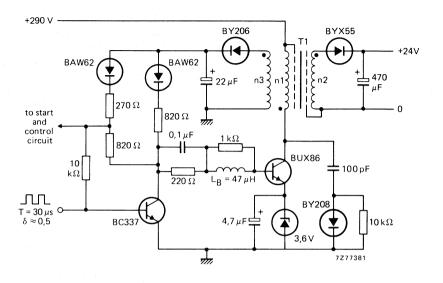
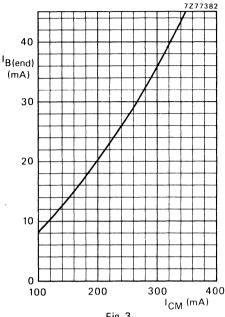
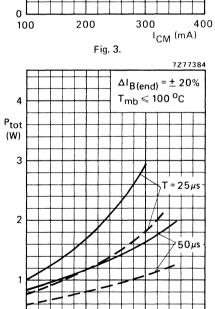


Fig. 2 Practical SMPS output circuit.

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)





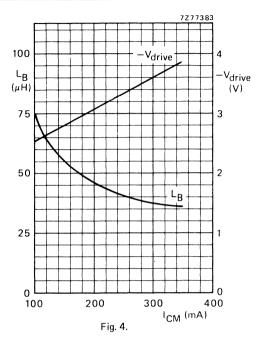


Fig. 3 Recommended nominal "end" value of the base current versus maximum peak collector current.

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  $I_{C1}/I_{CM} = 0$ .

300

400

I<sub>CM</sub> (mA)

200

0

100

## SILICON DIFFUSED POWER TRANSISTOR

High-voltage, high-speed, glass-passivated n-p-n switching transistor in a TO-3 envelope, intended for use in three-phase a.c. motor control systems.

## QUICK REFERENCE DATA

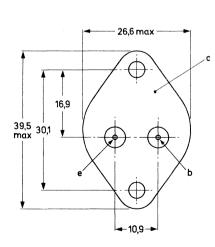
Collector-emitter voltage (peak value; V <sub>BE</sub> = 0)	VCESM	max.	1200	٧
Collector-emitter voltage (open base)	$v_{CEO}$	max.	800	V
Collector current (d.c.)	lc .	max.	12	Α
Collector current (peak value) $t_p < 2$ ms	ICM	max.	20	Α
Total power dissipation up to $T_{mb} = 25$ °C	$P_{tot}$	max.	160	W
Collector-emitter saturation voltage $I_C = 9 A$ ; $I_B = 4 A$	V <sub>CEsat</sub>	<	1	٧
Collector saturation current	Csat	=	9	Α
Fall time I <sub>Con</sub> = 9 A; I <sub>Bon</sub> = -I <sub>Boff</sub> = 4 A	tf	typ.	0,5	μs

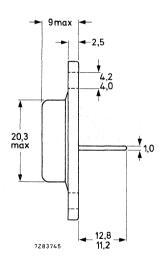
## **MECHANICAL DATA**

Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.





See also chapters Mounting instructions and Accessories.

## **RATINGS**

Limiting values in accordance with the Absolute Maximum System (	IEC 134)			
Collector-emitter voltage (peak value; V <sub>BE</sub> = 0)	V <sub>CESM</sub>	max.	1200	٧
Collector-emitter voltage (open base)	$V_{CEO}$	max.	800	٧
Collector current (d.c.)	Ic	max.	12	Α
Collector current (peak value); tp < 2 ms	ICM	max.	20	Α
Base current (d.c.)	I <sub>B</sub>	max.	8	Α
Base current (peak value); t <sub>p</sub> < 2 ms	I <sub>BM</sub>	max.	12	Α
Total power dissipation up to T <sub>mb</sub> = 25 °C	P <sub>tot</sub>	max.	160	W
Storage temperature	$T_{stg}$	-65 to	+ 150	οС
Junction temperature	Tj	max.	150	oC
THERMAL RESISTANCE				
From junction to mounting base	R <sub>th j-mb</sub>	= ,	0,78	K/W
CHARACTERISTICS				
T <sub>i</sub> = 25 °C unless otherwise specified				
Collector cut-off current*				
$V_{CE} = V_{CESMmax}$ ; $V_{BE} = 0$	ICES	<	1	mΑ
$V_{CE} = V_{CESMmax}$ ; $V_{BE} = 0$ ; $T_j = 125  {}^{\circ}C$	ICES	<	4	mΑ
Emitter cut-off current				
$I_C = 0$ ; $V_{EB} = 5 V$	IEBO	<	10	mΑ
Saturation voltages	V		1	V
I <sub>C</sub> = 9 A; I <sub>B</sub> = 4 A	V <sub>CEsat</sub> V <sub>BEsat</sub>	<	1,5	-
I <sub>C</sub> = 12 V; I <sub>B</sub> = 6 A	VCEsat	<		V
Collector-emitter sustaining voltage	CLSat			
I <sub>C</sub> = 200 mA; I <sub>B</sub> = 0; L = 25 mH	V <sub>CEOsust</sub>	>	800	٧
Second breakdown collector current				
$V_{CE} = 100 \text{ V; } t_p = 1 \text{ s}$	I(SB)C	>	0,4	Α
Transition frequency at f = 5 MHz			7	8411
$I_C = 0.1 \text{ A}$ ; $V_{CE} = 5 \text{ V}$	fΤ	typ.	,	MHz
Collector capacitance at f = 1 MHz I <sub>F</sub> = I <sub>P</sub> = 0; V <sub>CB</sub> = 10 V	CC	typ.	200	пF
L G -1 OB	-0	- 7 12 1		ı-·

<sup>\*</sup> Measured with a half sine-wave voltage (curve tracer).

μs

Switching times resistive load (Figs 2 and 3)

 $I_{Con} = 9 A$ ;  $I_{Bon} = -I_{Boff} = 4 A$ 

Turn-on time

Turn-off: Storage time Fall time t<sub>on</sub>

typ. typ.

typ.

1,5

4,5 μs 0,5 μs

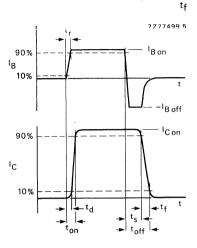


Fig. 2 Switching times waveforms with resistive load.

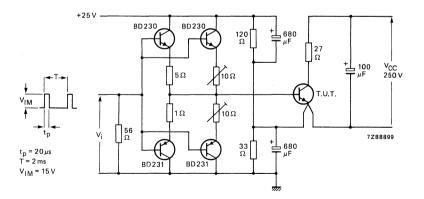


Fig. 3 Test circuit resistive load.

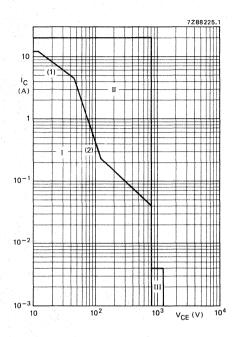


Fig. 4 Safe Operating ARea at  $T_{mb} \le 25$  °C.

- (1) P<sub>tot max</sub> line.
  (2) Second-breakdown limits (independent of temperature).
- Region of permissible d.c. operation.
- II Permissible extension for repetitive pulse operation.
- III Repetitive pulse operation in this region is permissible, provided  $V_{BE} \leqslant 0$  and  $t_p \leqslant 5$  ms.

## DARLINGTON POWER TRANSISTOR

High voltage, N-P-N monolithic Darlington power transistor, primarily intended for use in car ignition systems.

## QUICK REFERENCE DATA

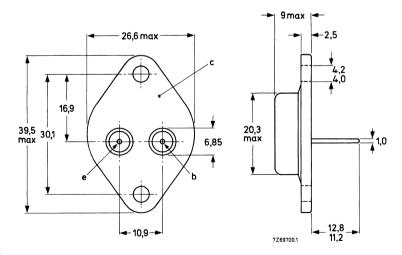
Collector-emitter voltage (V <sub>BE</sub> = 0; peak value)	V <sub>CESM</sub>	max.	650 V
Collector-emitter voltage (open base)	$v_{CEO}$	max.	400 V
Collector current (d.c.)	I <sub>C</sub>	max.	12 A
Collector current (peak value) $t_p \le 5$ ms	I <sub>CM</sub>	max.	30 A
Total power dissipation up to $T_{mb} = 25$ °C	$P_{tot}$	max.	125 W
Junction temperature	Τį	max.	200 °C
Collector-emitter saturation voltage	•		
$I_C = 5 \text{ A}; I_B = 50 \text{ mA}$	V <sub>CEsat</sub>	<	1,5 V
$I_C = 10 \text{ A}; I_B = 300 \text{ mA}$	V <sub>CEsat</sub>	<	2,0 V
Collector saturation current	I <sub>Csat</sub>	typ.	10 A

## **MECHANICAL DATA**

Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.



See also chapters Mounting instructions and Accessories.

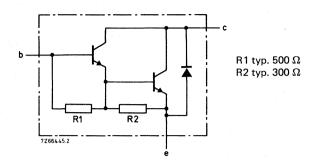


Fig. 2 Circuit diagram.

## RATINGS

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

Collector-emitter voltage (V <sub>EB</sub> = 0); peak value	$v_{CESM}$	max.	650	V
Collector-emitter voltage (open base)	V <sub>CEO</sub>	max.	400	V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	6	V
Collector current (d.c.)	l <sub>C</sub>	max.	12	Α
Collector current (peak value); t <sub>p</sub> < 5 ms	ICM	max.	30	Α
Base current (d.c.)	I <sub>B</sub>	max.	4	A
Base current (peak value); $t_p \le 5$ ms	I <sub>BM</sub>	max.	6	Α
Total power dissipation up to $T_{mb} = 25$ °C	P <sub>tot</sub>	max.	125	W
Storage temperature	$T_{stg}$	65 to +	200	оС
Junction temperature*	$T_{j}$	max.	200	οС
THERMAL RESISTANCE*				
From junction to mounting base	R <sub>th j-mb</sub>	=	1,4	K/W

<sup>\*</sup> 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 <sub>j</sub> = 25 °C unless otherwise specified			
Collector cut-off current*			
$V_{BE} = 0$ ; $V_{CE} = V_{CESMmax}$	<sup>1</sup> CES	<	1 mA
$V_{BE} = 0$ ; $V_{CE} = V_{CESMmax}$ ; $T_j = 125  ^{O}C$	CES	<	3 mA
Emitter cut-off current			
$I_C = 0; V_{EB} = 6 V$	<sup>I</sup> EBO	<	20 mA
Collector-emitter sustaining voltage			
$I_C = 5 A$ ; $I_{Boff} = 0$ ; $L = 8 mH$	$v_{CEOsust}$	>	400 V
Saturation voltages			
$I_C = 5 A; I_B = 50 mA$	V <sub>CEsat</sub>	<	1,5 V
	$v_{BEsat}$		2,0 V
$I_C = 5 \text{ A}; I_B = 60 \text{ mA}; T_j = -40 ^{\circ}\text{C}$	V <sub>CEsat</sub>	< <	1,5 V
	V <sub>BEsat</sub>		2,0 V
$I_C = 6 \text{ A}; I_B = 100 \text{ mA}; T_j = 150 \text{ °C}$	V <sub>CEsat</sub>	<	1,5 V
	$V_{BEsat}$	<	2,0 V
$I_C = 10 \text{ A}; I_B = 300 \text{ mA}$	VCEsat	<	2,0 V
	$V_{BEsat}$	<	2,5 V
Turn-off breakdown energy with inductive load (Fig. 3)			
$-I_{Boff} = 0$ ; $I_{CC} = 10 \text{ A}$ ; $L = 8 \text{ mH}$ ; $I_{Bon} = 300 \text{ mA}$ ;	F .	_	400 1
$V_{CL} = 400 V$	E <sub>(BR)</sub>	>	400 mJ
Collector-emitter diode, forward voltage	V		20.1/
$I_F = 8 A; I_B = 0$	٧ <sub>F</sub>	<	3,0 V

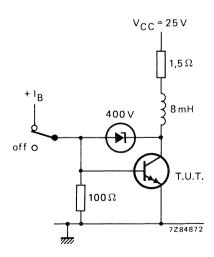


Fig. 3 Energy test circuit.

<sup>\*</sup> Measured with a half sine-wave voltage (curve tracer).

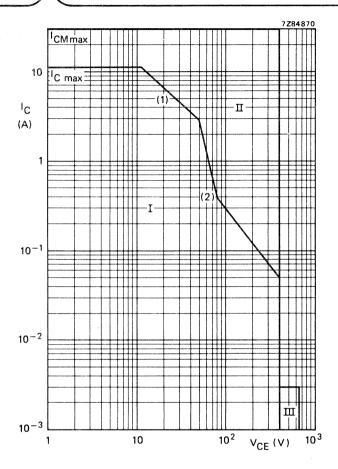


Fig. 4 Safe Operating ARea at  $T_{mb} \le 25$  °C.

- (1) P<sub>tot max</sub> and P<sub>tot peak max</sub> lines.(2) Second-breakdown limits (independent of temperature).
- Region of permissible d.c. operation
- II Permissible extension for repetitive pulse operation
- III Repetitive pulse operation in this region is permissible, provided  $V_{BE} \le 0$  and  $t_p \le 5$  ms.

## SILICON DIFFUSED POWER TRANSISTORS

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

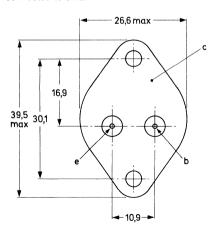
#### QUICK REFERENCE DATA

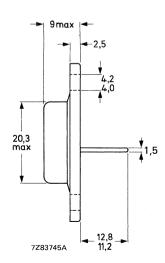
			BUX98	BUX98A	4
Collector-emitter voltage (V <sub>EB</sub> = 3 V)	$v_{CEX}$	max.	850	1000	V
Collector-emitter voltage (RBE $<$ 5 $\Omega$ )	$v_{CER}$	max.	850	1000	V
Collector-emitter voltage (open base)	$v_{CEO}$	max.	400	450	V
Collector current (d.c.)	Ic	max.	;	30	Α
Collector current (peak value) $t_p \le 5$ ms	<sup>I</sup> CM	max.	(	60	Α
Total power dissipation up to T <sub>mb</sub> = 25 °C	$P_{tot}$	max.	250		W
Collector-emitter saturation voltage $I_C = 20 \text{ A}$ ; $I_B = 4 \text{ A}$ $I_C = 16 \text{ A}$ ; $I_B = 3,2 \text{ A}$	V <sub>CEsat</sub> V <sub>CEsat</sub>	< <	1,5 —	_ 1,5	V V
Fall time (resistive load) $I_{Con} = 20 \text{ A}; I_{Bon} = -I_{Boff} = 4 \text{ A}$ $I_{Con} = 16 \text{ A}; I_{Bon} = -I_{Boff} = 3,2 \text{ A}$	t <sub>f</sub> t <sub>f</sub>	< <	0,8 —	_ 0,8	μs μs

## MECHANICAL DATA

Fig. 1 TO-3.

Collector connected to case.





See also chapters Mounting instructions and Accessories.

Dimensions in mm

## BUX98 BUX98A

## RATINGS

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

Limiting values in accordance with the Absolute Ma.	Aiiiiuiii Systeiii	(120 13				
			BUX98	BU:	X98A	_
Collector-emitter voltage (V <sub>EB</sub> = 3 V)	VCEX	max.	850	10	000	V
Collector-emitter voltage (R <sub>BE</sub> $\leq$ 5 $\Omega$ )	$v_{CER}$	max.	850	10	000	V
Collector-emitter voltage (open base)	VCEO	max.	400	4	450	V
Collector current (d.c.)	l <sub>C</sub>	max.	30			Α
Collector current (peak value); t <sub>p</sub> < 5 ms	ICM	max.	60			Α
Base current (d.c.)	I <sub>B</sub>	max.		8		Α
Base current (peak value); t <sub>p</sub> < 5 ms	<sup>I</sup> BM	max.	30			Α
Total power dissipation up to T <sub>mb</sub> = 25 °C	P <sub>tot</sub>	max.	250			W
Storage temperature	T <sub>stq</sub>	_	-65 to + 20	00		οС
Junction temperature	Tj	max.	200			οС
THERMAL RESISTANCE						
From junction to mounting base	$R_{th}$ j-mb	==	Ç	),7		K/W
CHARACTERISTICS						
T <sub>i</sub> = 25 <sup>o</sup> C unless otherwise specified						
Collector cut-off current*						
$V_{CE} = V_{CERmax}$ ; $R_{BE} \le 5 \Omega$	CER	< <	1			mΑ
$V_{CE} = V_{CERmax}$ ; $R_{BE} \le 5 \Omega$ ; $T_j = 125  {}^{\circ}C$	CER	<	8			mΑ
Collector cut-off current			•			
$V_{CE} = V_{CEXmax}$ ; $V_{EB} = 2.5 V$	CEX	<	0,4			mΑ
$V_{CE} = V_{CEXmax}; V_{EB} = 2,5 \text{ V}; T_j = 125 \text{ °C}$	ICEX	<		4		mΑ
Emitter cut-off current !C = 0; V <sub>ER</sub> = 5 V	Inno	<		2		mΑ
Saturation voltages	<sup>1</sup> EBO			2		шА
I <sub>C</sub> = 20 A; I <sub>B</sub> = 4 A	V <sub>CEsat</sub>	<	1,5			V
	VBEsat	<	1,6			v
I <sub>C</sub> = 30 A; I <sub>B</sub> = 8 A	V <sub>CEsat</sub>	<	3,5			V
I <sub>C</sub> = 16 A; I <sub>B</sub> = 3,2 A	V <sub>CEsat</sub>	<	_		1,5	V
	VBEsat	<			1,6	V
$I_C = 24 \text{ A}; I_B = 5 \text{ A}$	$v_{CEsat}$	<	_		5	V
Collector-emitter sustaining voltage						
$I_C = 200 \text{ mA}; I_{Boff} = 0; L = 25 \text{ mH}$	V <sub>CEOsust</sub>	>	400		450	V
Transition frequency at f = 1 MHz	_					
I <sub>C</sub> = 1 A; V <sub>CE</sub> = 10 V	fŢ	typ.		5		MHz
Emitter-base breakdown voltage	V		<b>-</b> .	- 20		.,
$I_C = 0$ ; $I_B = 0.1 \text{ A}$	V <sub>(BR)EBO</sub>		7 to 30		V	
Collector capacitance at f = 1 MHz V <sub>CE</sub> = 10 V	c <sub>C</sub>	typ.	500			рF
-CE 10 V	C)	Lyp.	51	00		ρı.

 $<sup>\</sup>ensuremath{^{*}}$  Measured with a half sine-wave voltage (curve tracer).

## CHARACTERISTICS (continued)

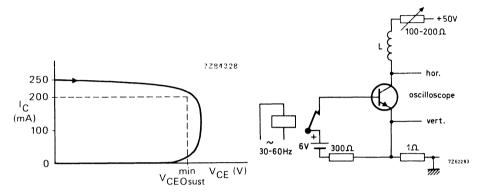


Fig. 2 Oscilloscope display for sustaining voltage.

Fig. 3 Test circuit for V<sub>CEOsust</sub>.

Switching times resistive load			BUX98	BUX98A
$I_{Con} = 20 \text{ A}; I_{Bon} = -I_{Boff} = 4 \text{ A}$			0.55	
Turn-on time	t <sub>on</sub>	typ.	0,55 1	— μs — μs
Turn-off: Storage time	$t_{S}$	typ.	1,5 3	— μs — μs
Fall time	t <sub>f</sub>	typ.	0,3 0,8	— μs — μs
$I_{Con} = 16 \text{ A}; I_{Bon} = -I_{Boff} = 3.2 \text{ A}$				0.55
Turn-on time	t <sub>on</sub>	typ.	_	0,55 μs 1 μs
Turn-off: Storage time	t <sub>S</sub>	typ.	_	1,5 μs 3 μs
Fall time	t <sub>f</sub>	typ.		0,3 μs 0,8 μs
Switching times inductive load $I_{Con} = 20 \text{ A}$ ; $I_{B} = 4 \text{ A}$				
Turn-off: Storage time	t <sub>S</sub>	typ.	3,5	— μs
Fall time	t <sub>f</sub>	typ.	80	- ns
$I_{Con} = 20 \text{ A}$ ; $I_B = 4 \text{ A}$ ; $T_j = 100  ^{\circ}\text{C}$ Storage time	t <sub>s</sub>	<	5	_ μs
Fall time	t <sub>f</sub>	<	400	– ns
I <sub>Con</sub> = 16 A; I <sub>B</sub> = 3,2 A	٠,			
Turn-off: Storage time	t <sub>s</sub>	typ.		3,5 μs
Fall time	ū	typ.		80 ns
	t <sub>f</sub>	typ.		00 113
$I_{Con} = 16 \text{ A}; I_B = 3.2 \text{ A}; T_j = 100  {}^{\circ}\text{C}$	t	_		-
Turn-off: Storage time	t <sub>s</sub>	<		5 μs
Fall time	t <sub>f</sub>	<	_	400 ns

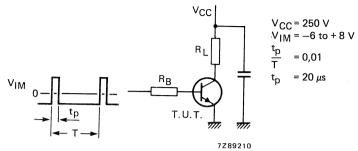


Fig. 4 Test circuit resistive load.

The values of  $\rm R_B$  and  $\rm R_L$  are selected in accordance with ICon and IB requirements.

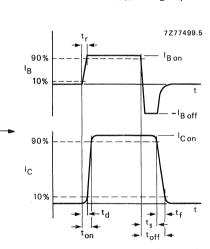


Fig. 5 Switching times waveforms with resistive load.

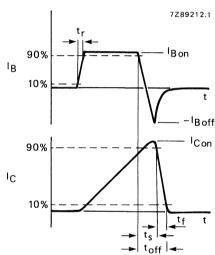


Fig. 6 Switching times waveforms with inductive load.

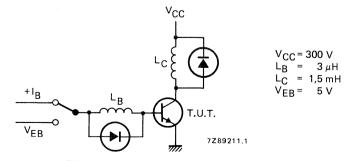


Fig. 7 Test circuit inductive load.

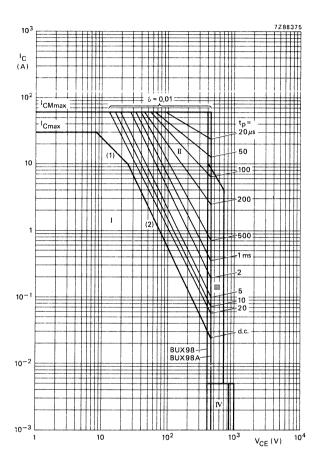
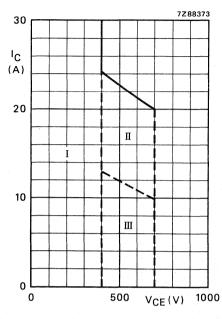


Fig. 8 Safe Operating ARea at  $T_{mb} \le 25$  °C.

- (1) Ptot max and Ppeak max lines.
- (2) Second-breakdown limits.
- 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 RBE  $\leqslant$  100  $\Omega$  and t $_p \leqslant$  0,6  $\mu s.$
- IV Repetitive pulse operation in this region is permissible, provided VBE  $\leqslant$  0 and  $t_p \leqslant$  2 ms.



- Fig. 9 Forward bias safe operation area, T  $_{j} \le$  125 °C. I Safe operation area during turn-off and during turn-on.
  - For BUX98A the right-hand limit is 450 V.
- II Safe operation are during turn-on only provided  $t_r < 0.2 \,\mu s.$
- III Safe operation area during turn-on only; provided  $t_r < 0.5 \mu s$  and  $R_{BF} < 50 \Omega$ .

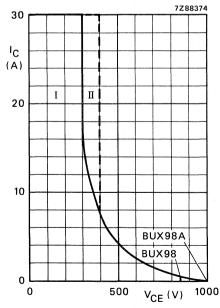


Fig. 10 Reverse bias safe operation area,  $I_{Cend}/I_{Bend} \ge 5$ ;  $-V_{BE} = 3 V$ .

- I Normal reverse bias safe operation area  $V_{BE} < 0 V$ .
- Il Extension of the reverse bias safe operation area provided a desaturation network (Baker clamp) is used.

For BUX98A VCE limit = 450 V.

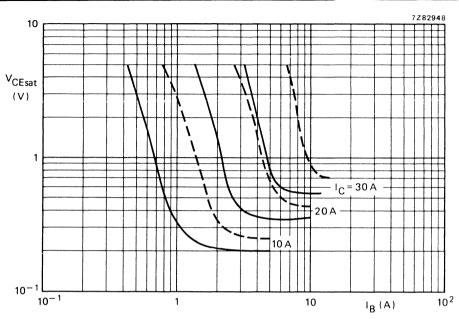


Fig. 11 Typical (——) and maximum (— —) values saturation voltage.  $T_i = 25$  °C.

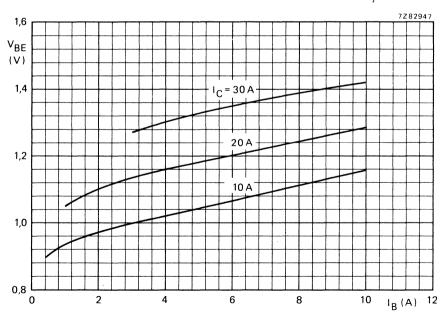


Fig. 12 Typical values at  $T_j = 25$  °C.

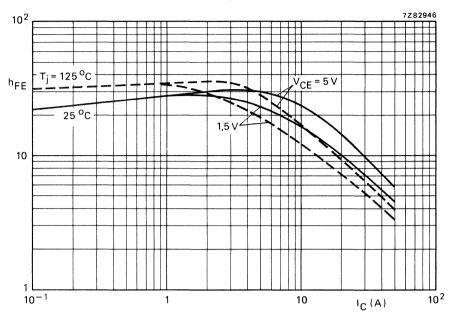


Fig. 13 Typical values d.c. current gain.

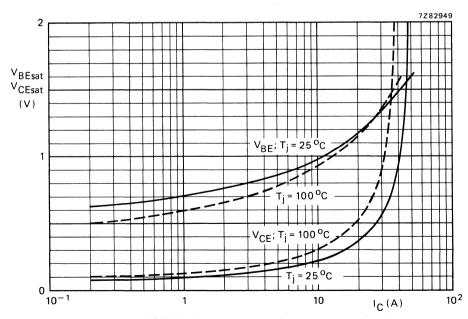


Fig. 14 Typical values base and collector voltage.  $I_C/I_B = 5$ .

## DEVELOPMENT DATA

This data sheet contains advance information and specifications are subject to change without notice.

# SILICON TRIPLE DIFFUSED POWER TRANSISTOR

High-voltage, high-speed, glass-passivated n-p-n power transistor in a TO-126 envelope, intended for use in fast switching applications.

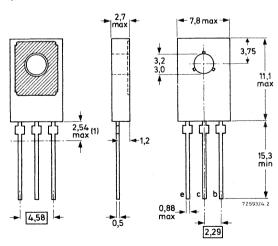
#### QUICK REFERENCE DATA

Collector-emitter voltage			
-V <sub>BE</sub> = 1,5 V; peak value	<sup>∨</sup> CEVM	max.	730 V
Collector-emitter voltage, open base	$v_{CEO}$	max.	300 V
Collector current (d.c.)	<sup>1</sup> C	max.	1,5 A
Total power dissipation up to $T_{mb} = 25$ °C	$P_{tot}$	max.	28 W
Collector-emitter saturation voltage $I_C = 0.2 \text{ A}$ ; $I_B = 20 \text{ mA}$	$v_{CEsat}$	max.	2 V
D.C. current gain $I_C = 10 \text{ mA}$ ; $V_{CF} = 2 \text{ V}$	hee	min.	10
	hFE	111111.	
Fall time; $I_C = 0.2 \text{ A}$ ; $I_B = 20 \text{ mA}$	t <sub>f</sub>	max.	0,8 μs

#### MECHANICAL DATA

Dimensions in mm

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



For accessories and mounting instructions see Handbook high-voltage and switching power transistors.

## **RATINGS**

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

Collector-emitter voltage V <sub>RF</sub> = 0; peak value	Vocas	max.	730	V
	VCESM	IIIax.	/30	V
Collector-emitter voltage V <sub>BE</sub> = -1,5 V; peak value	V <sub>CEVM</sub>	max.	730	V
Collector-emitter voltage, open base	V <sub>CEO</sub>	max,	300	٧
Emitter-base voltage, open collector	V <sub>EBO</sub>	max.	12	V
Collector current (d.c.)	lC .	max.	1,5	Α
Collector current (peak value)	ICM	max.	3	Α
Base current (d.c.)	I <sub>B</sub>	max.	0,75	Α
Base current (peak value)	<sup>I</sup> вм	max.	1,5	Α
Emitter current (d.c.)	I <sub>E</sub>	max.	2,25	Α
Emitter current (peak value)	<sup>I</sup> EM	max.	4,5	Α
Total power dissipation up to T <sub>mb</sub> = 25 °C	P <sub>tot</sub>	max.	28	W
Storage temperature	$T_{stg}$	-65 to	+150	οС
Junction temperature	Tj	max.	150	οС
THERMAL RESISTANCE				
From junction to mounting base	R <sub>th j-mb</sub>		4.5	K/W
From junction to ambient	R <sub>th j-a</sub>		•	K/W
CHARACTERISTICS				
T <sub>i</sub> = 25 °C unless otherwise specified				
Collector cut-off current				
$V_{CE} = 400 \text{ V}; V_{BE} = 0$	ICES	≼	5	μΑ
$V_{CE} = 730 \text{ V}; V_{BE} = -1.5 \text{ V}$	CEV	≤	50	μΑ
$V_{CE} = 730 \text{ V}; V_{BE} = -1,5 \text{ V}; T_j = 100 \text{ °C}$	CEV	€	250	μΑ
Emitter cut-off current				
I <sub>C</sub> = 0; V <sub>EB</sub> = 12 V	<sup>I</sup> EBO	€	1	mΑ
Collector-emitter sustaining voltage  IB = 0; IC = 0,1 A; L = 25 mH	V <sub>CEOsust</sub>	≽	300	V
D.C. current gain	*CEOsust		000	•
I <sub>C</sub> = 10 mA; V <sub>CE</sub> = 2 V	hFE	≽	10	
I <sub>C</sub> = 50 mA; V <sub>CE</sub> = 5 V		≥	16	
	hFE	≤	42	

# SILICON DIFFUSED POWER TRANSISTOR

High-voltage, high-speed switching n-p-n transistor in a TO-3 envelope especially intended for use in a.c. motor control systems from three-phase mains.

#### QUICK REFERENCE DATA

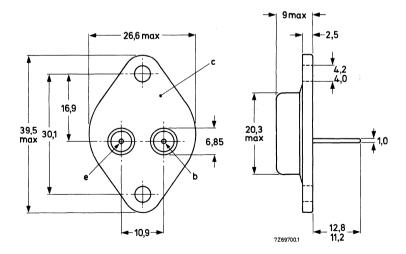
Collector-emitter voltage (V <sub>BE</sub> = 0, peak value)	VCESM	max.	1500 V
Collector-emitter voltage (open base)	$v_{CEO}$	max.	800 V
Collector current (d.c.)	I <sub>C</sub> .	max.	6 A
Total power dissipation up to T <sub>mb</sub> = 60 °C	P <sub>tot</sub>	max.	80 W
Collector-emitter saturation voltage $I_C = 4,5 A; I_B = 2 A$	V <sub>CEsat</sub>	<	1 V
D.C. current gain I <sub>C</sub> = 4,5 A; V <sub>CE</sub> = 5 V	hFE	>	2,5

#### **MECHANICAL DATA**

Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.

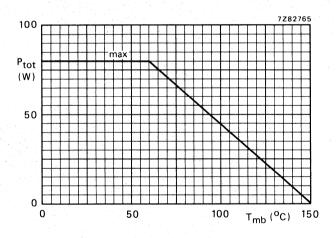


See also chapters Mounting instructions and Accessories.

## **RATINGS**

From junction to mounting base

Limiting values in accordance with the Absolute Maximum System (	IEC 134)			
Collector-emitter voltage (V <sub>BE</sub> = 0, peak value)	VCESM	max.	1500	٧
Collector-emitter voltage (open base)	V <sub>CEO</sub>	max.	800	٧
Collector current (d.c.)	Ic	max.	6	Α
Collector current (peak value)	<sup>I</sup> CM	max.	10	Α
Collector current (non-repetitive peak)	ICSM	max.	15	Α
Base current (d.c.)	I <sub>B</sub>	max.	4	Α
Base current (peak value)	Івм	max.	6	A
Reverse base current (d.c. or average over any 20 ms period)	−l <sub>B</sub> (AV)	max.	100	mA
Reverse base current (peak value) *	-I <sub>BM</sub>	max.	4	Α
Total power dissipation up to T <sub>mb</sub> = 60 °C	P <sub>tot</sub>	max.	80	W
Storage temperature	T <sub>stg</sub>	-65 to	+ 150	oC
Junction temperature	Τ <sub>j</sub>	max.	150	οС
THERMAL RESISTANCE				



R<sub>th j-mb</sub>

max.

1,12 K/W

Fig. 2 Power derating curve.

<sup>\*</sup> Turn-off current.

#### CHARACTERISTICS

T<sub>i</sub> = 25 °C unless otherwise specified

Collector cut-off current

$$V_{BE}$$
 = 0;  $V_{CE}$  =  $V_{CESMmax}$ ;  $T_j$  = 125 °C D.C. current gain

 $I_C = 4.5 A; V_{CF} = 5 V$ 

Emitter cut-off current

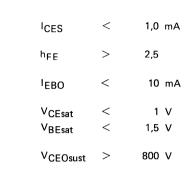
 $I_C = 0; V_{FB} = 5 V$ 

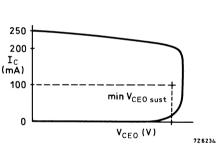
Saturation voltage  $I_C = 4.5 A; I_B = 2 A$ 

 $I_C = 4.5 A; I_B = 2 A$ 

Collector-emitter sustaining voltage

 $I_B = 0$ ;  $I_C = 100 \text{ mA}$ ; L = 25 mH





7Z62340

Fig. 3 Oscilloscope display for V<sub>CEOsust</sub>.

hor. oscilloscope 30-60Hz Fig. 4 Test circuit for VCEOsust-

Second-breakdown collector current 
$$V_{CE} = 100 \text{ V}$$
;  $t_p = 1 \text{ s}$  Transition frequency at  $f = 5 \text{ MHz}$   $I_C = 0,1 \text{ A}$ ;  $V_{CE} = 5 \text{ V}$  Collector capacitance at  $f = 1 \text{ MHz}$   $I_E = I_e = 0$ ;  $V_{CB} = 10 \text{ V}$ 

$$I_{(SB)}$$
 > 0,3 A  $f_T$  typ. 7 MHz  $C_c$  typ. 125 pF

#### CHARACTERISTICS (continued)

Switching times (between 10% and 90% levels)

in resistive switching circuit

 $I_{Con}$  = 4,5 A;  $V_{CC}$  = 250 V;  $R_L$  = 56  $\Omega$ 

 $I_{Bon} = -I_{Boff} = 2 A$ 

Turn-on time

Storage time  $(t_s = t_{off} - t_f)$ 

Fall time

t<sub>on</sub> typ. 1,5 μs t<sub>s</sub> typ. 4,5 μs t<sub>f</sub> typ. 0,5 μs

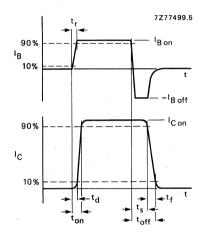


Fig. 5 Waveforms.

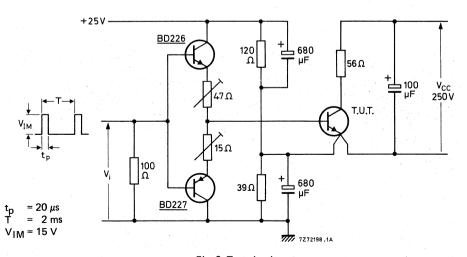


Fig. 6 Test circuit.

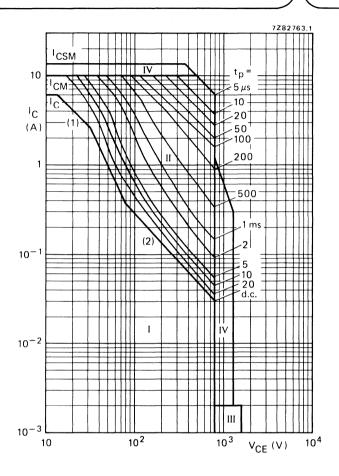


Fig. 7 Safe Operating ARea with the transistor forward biased.  $T_{mb} \le 60 \text{ °C}; \delta = 0.01.$ 

- P<sub>tot max</sub> and P<sub>peak max</sub> lines.
   Second-breakdown limits.
- Region of permissible d.c. operation.
- II Permissible extension for repetitive pulse operation.
- III Repetitive pulse operation in this region is permissible,
- provided V  $_{BE}$   $\leqslant$  0 V; t  $_{p}$   $\leqslant$  20  $\mu s;$   $\delta$   $\leqslant$  0,25. IV Transient I  $_{C}/v_{CE}$  limit for VCE less than 700 V then  $t_p$  less than or equal to 25  $\mu$ s for VCE greater than 700 V then  $t_p$  less than 5  $\mu$ s.

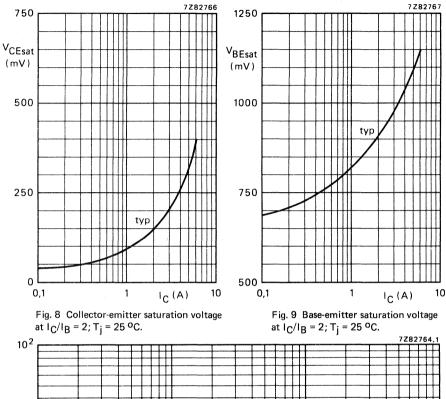


Fig. 10 D.C. current gain at  $V_{CE} = 5 \text{ V}$ ;  $T_j = 25 \text{ °C}$ ; ....... at  $V_{CE} = 1 \text{ V}$ .

## **DEVELOPMENT DATA**

This data sheet contains advance information and specifications are subject to change without notice.

# SILICON DIFFUSED POWER TRANSISTORS

High-voltage, high-speed, glass-passivated n-p-n power transistors in a TO-126 envelope, intended for use in switching regulators, inverters, motor control, solenoid/relay drivers and deflection circuits.

#### QUICK REFERENCE DATA

			PH1300	2 PH	13003
Collector-emitter voltage $V_{BF} = -1.5 \text{ V}$	V0=14	may	60	0	700 V
Collector-emitter voltage, open base	VCEX VCEO	max. max.	30	_	400 V
Collector current (d.c.)	IC		max.	1,5	А
Total power dissipation up to $T_{mb} = 25$ °C	$P_{tot}$		max.	28	W
Collector-emitter saturation voltage IC = 1 A; IB = 0,25 A	V <sub>CEsat</sub>		<	1,0	V
D.C. current gain $I_C = 0.5 \text{ mA}$ ; $V_{CE} = 2 \text{ V}$	hFE		>	8 to 40	

#### **MECHANICAL DATA**

Dimensions in mm

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

Collector connected to case.

Collector connected to case.

For accessories and mounting instructions see Handbook high-voltage and switching power transistors.

## **RATINGS**

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

			PH13002	PH1	13003	
Collector-emitter voltage						
V <sub>BE</sub> = -1,5 V	$V_{CEX}$	max.	600		700	
Collector-emitter voltage, open base	VCEO	max.	300	1	400	V
Emitter-base voltage	$v_{EBO}$	max.		9		V
Collector current (d.c.)	l <sub>C</sub>	max.		1,5		Α
Collector current (peak value)	<sup>I</sup> CM	max.		3		Α
Base current (d.c.)	I <sub>B</sub>	max.	(	),75		Α
Base current (peak value)	<sup>I</sup> BM	max.		1,5		Α
Emitter current (d.c.)	ΙE	max.	2	2,25		Α
Emitter current (peak value)	IEM	max.		4,5		Α
Total power dissipation up to $T_{amb} = 25$ °C Derate above 25 °C	P <sub>tot</sub>	max. =	•	1,25 10		W mW/K
Total power dissipation up to $T_c = 25$ °C Derate above 25 °C	P <sub>tot</sub>	max. =		28 224		W mW/K
Storage temperature	T <sub>stg</sub>		-65 to +	150		oC
Junction temperature	Tj	max.		150		oC
THERMAL RESISTANCE						
From junction to case	R <sub>th j-c</sub>	=		4,5		K/W
From junction to ambient	R <sub>th j-a</sub>	=		100		K/W
CHARACTERISTICS						
T <sub>j</sub> = 25 °C unless otherwise specified						
Collector-emitter sustaining voltage $I_B = 0$ ; $I_C = 10 \text{ mA}$	VCEOsu	,s >	300		400	٧
Collector cut-off current						
V <sub>CE</sub> = V <sub>CEVmax</sub> ; V <sub>BE</sub> = -1,5 V V <sub>CE</sub> = V <sub>CEVmax</sub> ; V <sub>BE</sub> = -1,5 V; T <sub>c</sub> = 100 °C	ICEX	< <		1,0 5,0		mA mA
I <sub>C</sub> = 0; V <sub>EB</sub> = 9 V	I <sub>EBO</sub>	<		1,0		mA
D.C. current gain				0		
I <sub>C</sub> = 0,5 A; V <sub>CE</sub> = 2 V	hFE	<		8 40		
I <sub>C</sub> = 1 A; V <sub>CE</sub> = 2 V	hFE	> <		5 25		

ACCESSORIES

# TYPE NUMBER SURVEY ACCESSORIES

type number	description	envelope
<b>56201</b> d	mica washer (up to 500 V)	TO-3
56201j	insulating bushes (up to 500 V)	TO-3
56261a	insulating bushes (up to 500 V)	TO-3
56326	metal washer	TO-126
56339	mica washer (500 to 2000 V)	TO-3
56352	insulating mounting support	TO-3
56353	spring clip	TO-126/SOT-82
56354	mica insulator	TO-126/SOT-82
6359b	mica washer (up to 1000 V)	TO-220
56359c	insulating bush (up to 800 V)	TO-220
56359d	rectangular insulating bush (up to 1000 V)	TO-220
6360a	rectangular washer (brass)	TO-220
6363	spring clip (direct mounting)	TO-220
56364	spring clip (insulated mounting)	TO-220
56367	alumina insulator (up to 2000 V)	TO-220
56368a	mica insulator (up to 800 V)	SOT-93
56368b	insulating bush (up to 800 V)	SOT-93
56369	mica insulator (up to 2 kV)	TO-220
66378	mica insulator (up to 1500 V)	SOT-93
56379	spring clip	SOT-93
56387a	mica insulator (up to 300 V)	TO-126
56387b	insulating bush (up to 300 V)	TO-126

# **SELECTION GUIDE**

## **CLIP MOUNTING**

envelope	direct mounting		insulated mounting			
	clip		mica	alumina	clip	
TO-126 (SOT-32)	56353		56354		56353	
SOT-82	56353		56354		56353	
TO-220 (SOT-78)	56363		56369 or	56367	56364	
SOT-93	56379		56378		56379	

#### **SCREW MOUNTING**

	direct mounting		insulated mounting				
envelope	metal washer	mounting material	mica washer	insul. bush	metal washer	mounting material	
TO-126 (SOT-32) up to 300 V	56326	М3	56387a	56387b	56326	M2,5	
TO-220 (SOT-78) up to 800 V up to 1000 V	56360a	МЗ	56359b 56359b	56359c 56359d	56360a 56360a	M3 M3	
SOT-93		M4	56368a	56368b		M3	
TO-3 (SOT-3) up to 500 V	_	M4	56201d	56201j or 56261a		M3	
up to 2000 V			56339	56352		мз	

The accessories mentioned can be supplied on request.

See also chapter Mounting Instructions.

# **ACCESSORIES**

Mounting TO-126 and SOT-82 envelopes.

56353

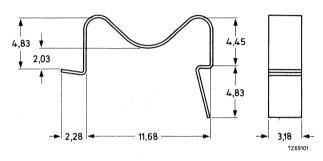
# CLIP

for TO-126 and SOT-82 envelopes

## MECHANICAL DATA

Material: high carbon spring steel

Dimensions in mm



Spring clip suitable for heatsink of 1,5 to 2 mm.

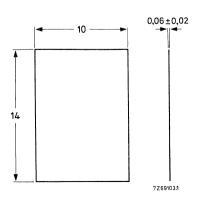
56354

# MICA INSULATOR

for TO-126 and SOT-82 envelopes

**MECHANICAL DATA** 

Dimensions in mm



Mounting of TO-126 envelopes

56326

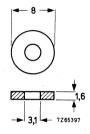
## **WASHER**

for direct mounting of TO-126 envelopes

**MECHANICAL DATA** 

Material: brass, nickel plated

Dimensions in mm

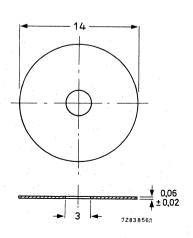


56387a

# MICA WASHER

for insulated screw mounting of TO-126 envelopes (up to 300 V)

**MECHANICAL DATA** 



Dimensions in mm

Mounting of TO-126 envelopes

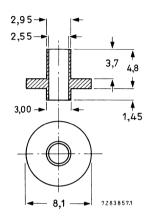
## 56387b

# INSULATING BUSH

for insulated screw mounting of TO-126 envelopes (up to 300 V)

#### MECHANICAL DATA

Material: polyester



Dimensions in mm

## **TEMPERATURE**

Maximum permissible temperature

T<sub>max</sub> 150 °C

Clip mounting TO-220 envelopes

56363

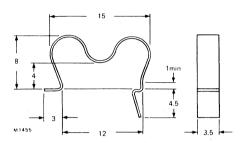
## SPRING CLIP

## for direct mounting of TO-220 envelopes

#### **MECHANICAL DATA**

Material: stainless steel; for mounting on heatsink of 1.0 to 2.0 mm.

Recommended force of clip on device is 20 N (2 kgf).



56364

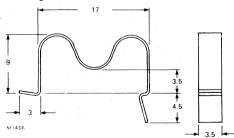
## SPRING CLIP

# for insulated mounting of TO-220 envelopes

#### **MECHANICAL DATA**

Material: stainless steel; for mounting on heatsink of 1.0 to 1.5 mm.

Recommended force of clip on device is 20 N (2 kgf).



Dimensions in mm

Dimensions in mm

To be used in conjunction with insulators 56367 or 56369

Clip mounting TO-220 envelopes

## 56367

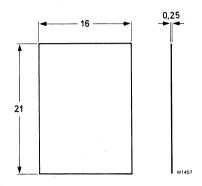
## ALUMINA INSULATOR

for insulated clip mounting of TO-220 envelopes (up to 2 kV)

#### **MECHANICAL DATA**

Material: 96-alumina.

Dimensions in mm



<sup>\*</sup>Because alumina is brittle, extreme care must be taken when mounting devices not to crack the alumina, particularly when used without heatsink compound.

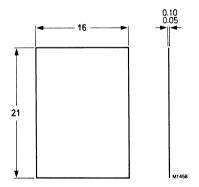
## 56369

## MICA INSULATOR

for insulated clip mounting of TO-220 envelopes (up to 2 kV)

## **MECHANICAL DATA**

Dimensions in mm



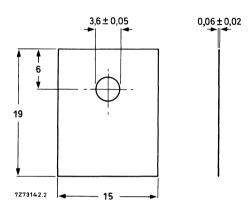
Mounting TO-220 envelopes

## 56359b

## **MICAWASHER**

for TO-220 envelopes (up to 1000 V)

Dimensions in mm



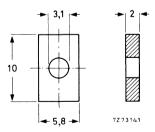
# 56360a

# RECTANGULAR WASHER

for direct and insulated mounting of TO-220 envelopes

## **MECHANICAL DATA**

Material: brass; nickel plated.



Dimensions in mm

# **ACCESSORIES**

Mounting TO-220 envelopes

56359c

## INSULATING BUSH

for TO-220 envelopes (up to 800 V)

**MECHANICAL DATA** 

Material: polyester

TEMPERATURE

Maximum permissible

temperature

T<sub>max</sub> = 150 °C 1 1 273143.1

Dimensions in mm



56359d

# RECTANGULAR INSULATING BUSH

for TO-220 envelopes (up to 1000 V)

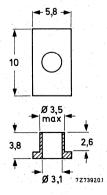
**MECHANICAL DATA** 

Dimensions in mm

**TEMPERATURE** 

Maximum permissible temperature

T<sub>max</sub> = 150 °C



410

Clip mounting of SOT-93 envelopes

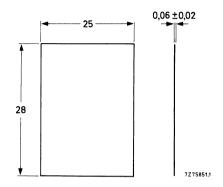
56378

# MICA INSULATOR

for SOT-93 clip mounting (up to 1500 V)

**MECHANICAL DATA** 

Dimensions in mm



56379

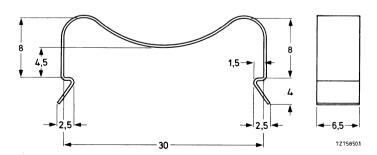
# SPRING CLIP

for direct and insulated mounting of SOT-93 envelopes

## **MECHANICAL DATA**

Dimensions in mm

Material: CrNi steel NLN-939; thickness 0,4 ± 0,04.



Screw mounting of SOT-93 envelopes

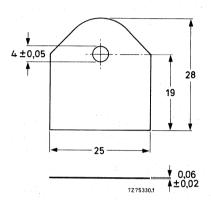
## 56368a

## MICA INSULATOR

for insulated screw mounting of SOT-93 envelopes (up to 800 V)

### **MECHANICAL DATA**

Dimensions in mm



# 56368b

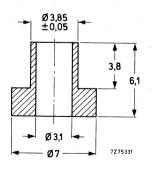
# INSULATING BUSH

for insulated screw mounting of SOT-93 envelopes (up to 800 V)

#### **MECHANICAL DATA**

Material: polyester

Dimensions in mm



#### **TEMPERATURE**

Maximum permissible temperature

 $T_{\text{max}} = 150 \, {}^{\circ}\text{C}$ 

Dimensions in mm

Mounting TO-3 envelopes

## 56201d

# MICA WASHER

Mica washer for up to 500 V insulation of TO-3 envelopes.

#### **MECHANICAL DATA**

10,9 10,9 43 30,1 10,85 max 4,25 30 0,06 72754444

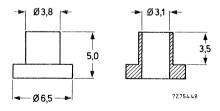
# 56201i

# 2 INSULATING BUSHES

Two insulating bushes for up to 500 V insulation of TO-3 envelopes.

#### **MECHANICAL DATA**

material: polyester



#### **TEMPERATURE**

Maximum permissible temperature

Dimensions in mm

 $T_{\text{max}} = 150 \, \text{oC}$ 

Mounting TO-3 envelopes

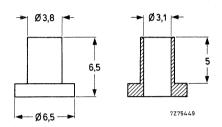
## 56261a

## 2 INSULATING BUSHES

Two insulating bushes for up to 500 V insulation of TO-3 envelopes.

#### MECHANICAL DATA

Material: polyester



Dimensions in mm

#### **TEMPERATURE**

Maximum permissible temperature

T<sub>max</sub> = 150 °C

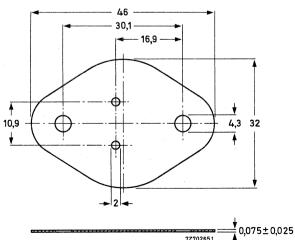
## 56339

## MICA WASHER

Mica washer for 500 to 2000 V insulation of TO-3 envelopes, for which it should be combined with mounting support 56352.

#### **MECHANICAL DATA**

Dimensions in mm



Mounting TO-3 envelopes

# 56352

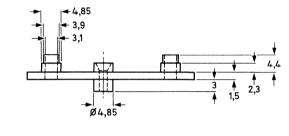
# MOUNTING SUPPORT

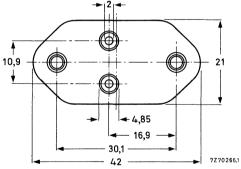
Mounting support for 500 to 2000 V insulation of TO-3 envelopes, for which it should be combined with mica washer 56339.

## MECHANICAL DATA

Dimensions in mm

Material: polyester





#### **TEMPERATURE**

Maximum permissible temperature

T<sub>max</sub> = 125 °C





## INTRODUCTION

#### 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:

- 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.
- Unblackened or thinner heatsinks
   Multiply by the factor given in Fig. 1 as a function of the heatsink size A.

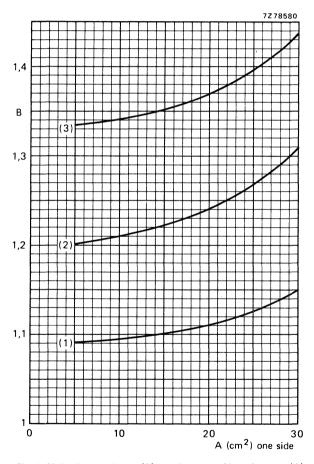


Fig. 1 Multiplication factor (B) as a function of heatsink area (A).

- (1) 1 mm blackened aluminium.
- (2) 1,5 mm unblackened aluminium.
- (3) 1 mm unblackened aluminium.

## MOUNTING INSTRUCTIONS FOR TO-3 ENVELOPES

#### GENERAL DATA AND INSTRUCTIONS

Instructions for direct mounting.

Mounting instructions for up to 500 V insulation.

Using insulating bushes 56201j or 56261a and mica washer 56201d.

Mounting instructions for 500 to 2000 V insulation.

Using mounting support 56352 and mica washer 56339.

#### Heatsink requirements

Flatness in the mounting area: 0,05 mm per 40 mm

Mounting holes must be deburred.

#### Mounting torques

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<sub>th mb-h</sub>) 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.

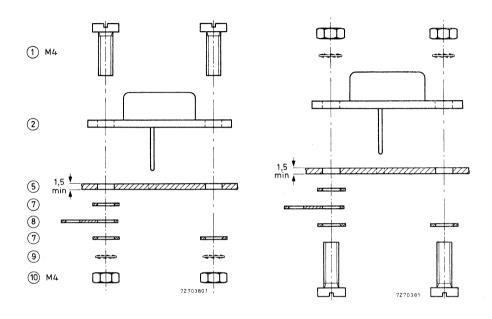
From mounting base to heatsink	Dir	ect mounting	Insulated 500 V mica		
without heatsink compound	R <sub>th mb-h</sub>	0,6	1,0	1,25	K/W
with heatsink compound	R <sub>th mb-h</sub>	0,1	0,3	0,5	K/W

# MOUNTING INSTRUCTIONS TO-3

#### INSTRUCTIONS FOR DIRECT MOUNTING

The transistors should be mounted with M4 screws, see Figs 1 and 2. Minimum heatsink thickness (for good heat transfer) 1,5 mm. Hole pattern: Fig. 3.

A heatsink with tapped holes or insert nuts can also be used, but a torque washer is necessary between metal washer and transistor. See Fig. 4.



Figs 1 and 2. Direct mounting with nuts.

# Legend (1) = screw (2) = TO-3 (4) = mica (5) = heatsink (6) = insulating bush (7) = metal washer (8) = soldering tag (9) = lock washer (10) = nut (11) = tapped hole (12) = insert nut Dimensions in mm

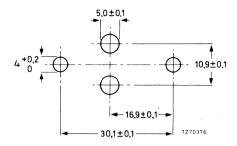


Fig. 3 Hole pattern for direct mounting with nuts.

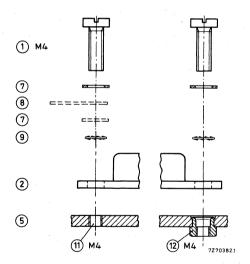


Fig. 4 Direct mounting with tapped holes or insert nuts.

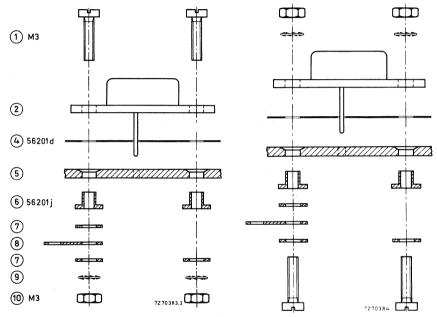
#### MOUNTING INSTRUCTIONS FOR UP TO 500 V INSULATION

#### Using insulating bushes 56201j and mica washer 56201d

For the component arrangement with minimum heatsink thickness see Figs 5 and 6. For hole pattern and shape of holes see Figs 7 and 8.

## Using insulating bush 56261a and mica washer 56201d

For an arrangement with M3 screws and nuts see Fig. 9, mounting holes are given in Figs 7 and 8. The accessories can also be used in combination with M3 screws and heatsinks provided with tapped holes or insert nuts. Lock washers are necessary between screw-head and metal washer, see Fig. 10. For an assembly drawing with tapped holes see Fig. 11, with insert nuts see Fig. 12.



Figs 5 and 6. Insulated mounting (500 V) with 56201j and 56201d. Heatsink thickness: 1,5 to 2,5 mm.

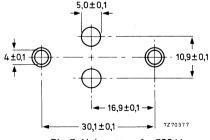


Fig. 7 Hole pattern for 500 V insulation, nut fastening.

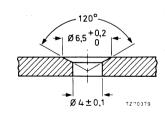


Fig. 8 Shape of hole for 500 V insulation, nut fastening.

For legend see page 420,

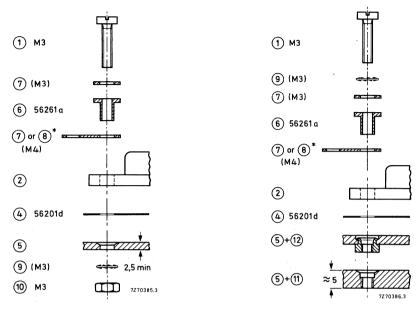


Fig. 9 Insulated mounting Fig. 10 Insulated mounting (500 V) (500 V) with nuts. with tapped holes or insert nuts.

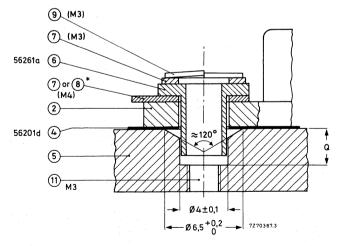


Fig. 11 Assembly (partial) for Fig. 10 - tapped holes. Q minimum 2,5 mm.

For legend see page 420.

\* Thickness approximately 0,6 mm, outer diameter 7,5 mm.

# MOUNTING INSTRUCTIONS TO-3

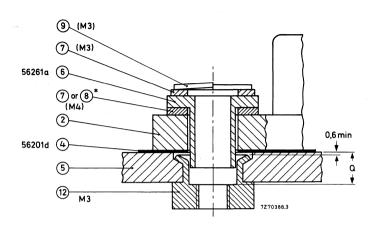


Fig. 12 Assembly (partial) for Fig. 10 - insert nuts Q minimum 2,5 mm.

For legend see page 420.

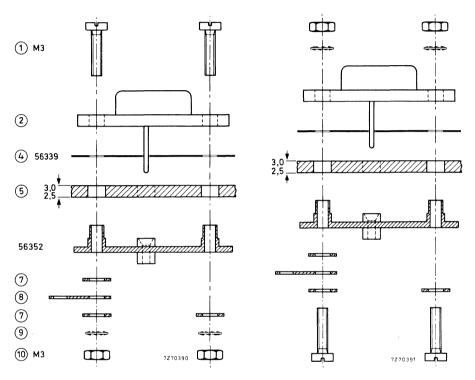
Dimensions in mm

<sup>\*</sup> Thickness approximately 0,6 mm, outer diameter 7,5 mm.

#### MOUNTING INSTRUCTIONS FOR 500 V TO 2000 V INSULATION

#### Using mounting support 56352 and mica washer 56339

The transistor should be mounted with M3 screws. For component arrangement see Figs 13 and 14. For hole pattern see Fig. 15. Thickness of heatsink 2,5 mm to 3 mm.



Figs 13 and 14. Insulated mounting (500 V-2000 V).

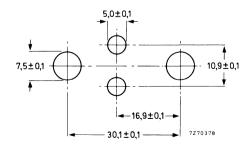


Fig. 15 Hole pattern for Figs 13 and 14.

For legend see page 420.



# MOUNTING INSTRUCTIONS FOR TO-126 AND SOT-82 ENVELOPES

#### GENERAL DATA AND INSTRUCTIONS

#### General rules

- 1. First fasten the devices to the heatsink before soldering the leads.
- 2. Avoid axial stress to the leads.
- 3. Keep mounting tool (e.g. screwdriver) clear of the plastic body.

#### Heatsink requirements

Minimum thickness: 2 mm.

Flatness in the mounting area: 0.02 mm maximum per 10 mm.

Mounting holes must be deburred and should also be perpendicular to the plane of the heatsink, within 10° 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<sub>th mb-h</sub>) given for mounting with heatsink compound refer to the use of a metallic oxide-loaded compound. Ordinary silicone grease is not recommended.

For insulated mounting, the compound should be applied to the bottom of both device and insulator.

#### Mounting methods for power transistors

1. Clip mounting (TO-126 and SOT-82)

Mounting by means of spring clip offers:

- a. A good thermal contact under the crystal area.
- b. Safe insulation for mains and high voltage operation
- 2. M2,5 and M3 screw mounting. (TO-126 only).

The spacing washer should be inserted between screw head and body.

Mounting torque for screw mounting:

Minimum torque (for good heat transfer)

0,4 Nm (4 kgcm)

Maximum torque (to avoid damaging the device)

0.6 Nm (6 kgcm)

N.B. when the driven nut or screw is in direct contact with a toothed lock washer the torques are as follows:

Minimum torque (for good heat transfer)

0,55 Nm (5,5 kgcm)

Maximum torque (to avoid damaging the device)

0,80 Nm (8,0 kgcm)

3. Body mounting (SOT-82).

A SOT-82 envelope can be adhesive mounted or soldered into a hybrid circuit.

For soldering a copper plate or an anodized aluminium plate with copper layer is recommended.

When adhesive mounting is applied also a ceramic substrate may be used.

# MOUNTING INSTRUCTIONS TO-126/SOT-82

#### Thermal data

From mounting base to heatsink	R <sub>th mb-h</sub> (K/W)					
			nounting insulated		mounting insulated	
TO-126, with heatsink compound TO-126, without heatsink compound		1,0 3,0	3,0 6,0	0,5 1,0	3,0 6,0	
SOT-82, with heatsink compound SOT-82, without heatsink compound		0,4 2.0	2,0 5.0	-  -		

#### Lead bending

Maximum permissible tensile force on the body, for 5 seconds is 20 N (2 kgf).

The leads can be bent through 90° maximum, twisted or straightened. To keep forces within the above-mentioned limits, the leads are generally clamped near the body, using pliers. The leads should neither be bent nor twisted less than 2.4 mm from the body.

#### Lead soldering

For devices with a maximum junction temperature ≤ 150 °C.

- a. Dip or wave soldering
  - Temperature  $\le$  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  $^{\rm o}$ C or < 250  $^{\rm o}$ C for a total contact time of < 10 s,

The body of the device must be kept clear of anything with a temperature > 200 °C.

Avoid any force on body and leads during or after soldering; do not correct the position of the device or of its leads after soldering.

#### Mounting base soldering

Recommended metal-alloy of solder paste (85% metal weight)

62 Sm/36 Pb/2 Ag or 60 Sn/40 Pb.

Maximum soldering temperature ≤ 200 °C (tab-temperature).

Soldering cycle duration including pre-heating ≤ 30 sec.

For good soldering and avoiding damage to the encapsulation pre-heating is recommended to a temperature  $\leq$  165 °C at a duration  $\leq$  10 s.

#### INSTRUCTIONS FOR CLIP MOUNTING

#### Direct mounting with clip 56353

- 1. Place the device on the heatsink, applying heatsink compound to the mounting base.
- 2. Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10° to 30° to the vertical (see Figs 1 and 2).
- 3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body (see Fig. 3).

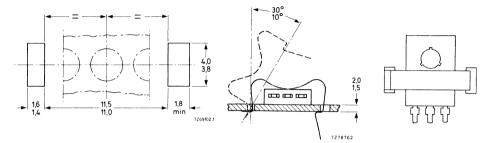


Fig. 1 Heatsink requirements.

Fig. 2 Mounting spring clip.

Fig. 3 Position of transistor (top view).

#### Insulated mounting with clip 56353 and mica 56354 (up to 1000 V insulation)

- 1. Place the device with the insulator on the heatsink, applying heatsink compound to the bottom of both device and insulator.
- 2. Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10° to 30° to the vertical (see Figs 4 and 5).
- 3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body (Fig. 6). Ensure that the device is centred on the mica insulator to prevent creepage.

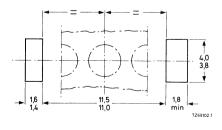


Fig. 4 Heatsink requirements.

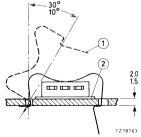
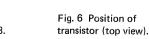


Fig. 5 Mounting. (1) spring clip 56353. (2) insulator 56354.



# INSTRUCTIONS FOR SCREW MOUNTING

Direct mounting with screw and spacing washer

Dimensions in mm

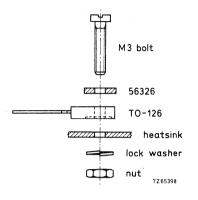


Fig. 7 Assembly through heatsink with nut.

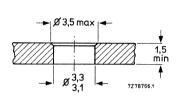


Fig. 8 Heatsink requirements.

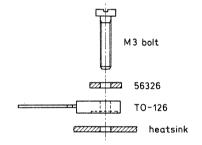


Fig. 9 Assembly into tapped heatsink.

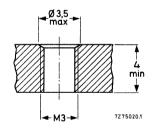
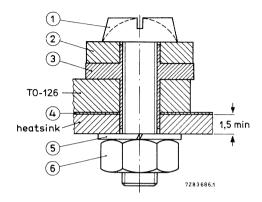


Fig. 10 Heatsink requirements.

#### INSTRUCTIONS FOR SCREW MOUNTING

Insulated mounting with 56326, 56387a and 56387b (up to 300 V)



Ø 3,5 max 1,5 min 7278766.1

Fig. 15 Assembly through heatsink with nut.

Fig. 16 Heatsink requirements.

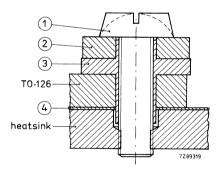


Fig. 17 Assembly with tapped heatsink.

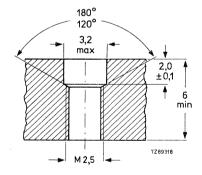


Fig. 18 Heatsink requirements.

#### Legend

- 1 M2,5 screw
- 2 metal washer 56326
- 3 insulating bush 56387b

- 4 mica washer 56387 a
- 5 lock washer
- 6 M2,5 nut

# MOUNTING INSTRUCTIONS FOR TO-220 AND SOT-186 ENVELOPES

#### GENERAL DATA AND INSTRUCTIONS

#### General rules

- 1. First fasten the device to the heatsink before soldering the leads.
- 2. Avoid axial stress to the leads.
- 3. Keep mounting tool (e.g. screwdriver) clear of the plastic body.
- 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<sub>th mb-h</sub>) given for mounting with heatsink compound refer to the use of a metallic oxide-loaded compound. Ordinary silicone grease is not recommended.

For insulated mounting, the compound should be applied to the bottom of both device and insulator.

#### Mounting methods for power transistors

1. Clip mounting

Mounting with a spring clip gives:

- a. A good thermal contact under the crystal area, and slightly lower R<sub>th mb-h</sub> 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.

# MOUNTING INSTRUCTIONS TO-220/SOT-186

#### 3. Rivet mounting non-insulated

The device should not be pop-rivetted to the heatsink. However, it is permissible to press-rivet providing that evelet 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			lip unting	screw	
From mounting base to heatsink			arrenig	mounting	
with heatsink compound, direct mounting	R <sub>th mb-h</sub>	=	0,3	0,5	K/W
without heatsink compound, direct mounting	Rth mb-h	=	1,4	1,4	K/W
with heatsink compound and 0,1 mm					
maximum mica washer	R <sub>th</sub> mb-h	=	2,2	_	K/W
with heatsink compound and 0,25 mm					
maximum alumina insulator	R <sub>th mb-h</sub>	=	8,0	_	K/W
with heatsink compound and 0,05 mm mica washer					
insulated up to 500 V	R <sub>th mb-h</sub>	=		1,4	K/W
insulated up to 800 V/1000 V	R <sub>th mb-h</sub>	=		1,6	K/W
without heatsink compound and 0,05 mm mica washer				1	
insulated up to 500 V	R <sub>th mb-h</sub>	=		3,0	K/W
insulated up to 800 V/1000 V	R <sub>th mb-h</sub>	=		4,5	K/W

#### Lead bending

Maximum permissible tensile force on the body, for 5 seconds is 20 N (2 kgf).

The leads can be bent through 90° maximum, twisted or straightened. To keep forces within the 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 $_{j~max} \le$  175 °C, soldering temperature T $_{sld~max}$  = 275 °C. Devices with T $_{j~max} \le$  110 °C, soldering temperature T $_{sld~max}$  = 240 °C.

Avoid any force on body and leads during or after soldering: do not correct the position of the device or of its leads after soldering.

It is not permitted to solder the metal tab of the device to a heatsink, otherwise its junction temperature rating will be exceeded.

#### Mounting base soldering

Recommended metal-alloy of solder paste (85% metal weight)

62 Sm/36 Pb/2 Ag or 60 Sn/40 Pb.

Maximum soldering temperature ≤ 200 °C (tab-temperature).

Soldering cycle duration including pre-heating ≤ 30 sec.

For good soldering and avoiding damage to the encapsulation pre-heating is recommended to a temperature  $\leq 165$  °C at a duration  $\leq 10$  s.

#### INSTRUCTIONS FOR CLIP MOUNTING

#### Direct mounting with clip 56363

- 1. Apply heatsink compound to the mounting base, then place the transistor on the heatsink.
- 2. Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10° to 30° to the vertical (see Figs. 1 and 2).
- 3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body, not on the tab (see Fig. 2a).

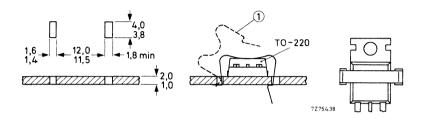


Fig. 1 Heatsink requirements.

Fig. 2 Mounting. (1) spring clip 56363.

Fig. 2a Position of transistor (top view).

#### Insulated mounting with clip 56364

With the insulators 56367 or 56369 insulation up to 2 kV is obtained.

- 1. Apply heatsink compound to the bottom of both transistor and insulator, then place the transistor with the insulator on the heatsink
- 2. Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10° to 30° to the vertical (see Figs 3 and 4).
- 3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body, not on the tab. Ensure that the device is centred on the mica insulator to prevent creepage.

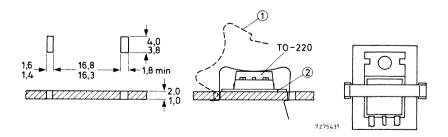


Fig. 3 Heatsink requirements.

Fig. 4 Mounting.
(1) spring clip 56364.

(2) insulator 56369 or 56367.

Fig. 4a Position of transistor (top view).

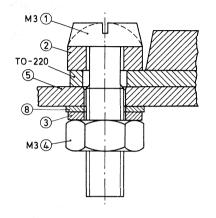
#### INSTRUCTIONS FOR SCREW MOUNTING

Direct mounting with screw and spacing washer

through heatsink with nut



Dimensions in mm



Ø 3,5 \_ min 7Z69693.2

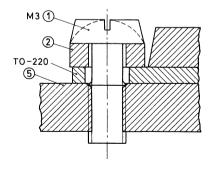
Fig. 5 Assembly.

(1) M3 screw.

- (2) rectangular washer (56360a).
- (3) lock washer.
- (4) M3 nut.
- (5) heatsink.
- (8) plain washer.

Fig. 6 Heatsink requirements.

### into tapped heatsink



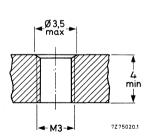


Fig. 7 Assembly.

(1) M3 screw.

- (2) rectangular washer 56360a.
- (5) heatsink.

Fig. 8 Heatsink requirements.

# Insulated mounting with screw and spacing washer (not recommended where mounting tab is on mains voltage)

Dimensions in mm

#### • through heatsink with nut

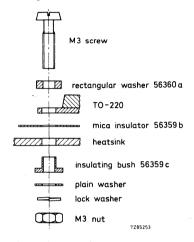


Fig. 9 Insulated screw mounting with rectangular washer. Known as a "bottom mounting".

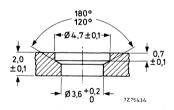


Fig. 10 Heatsink requirements for 500 V insulation.

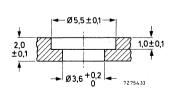


Fig. 11 Heatsink requirements for 800 V insulation.

#### • into tapped heatsink

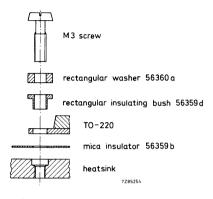


Fig. 12 Insulated screw mounting with rectangular washer into tapped heatsink. Known as a "top mounting".

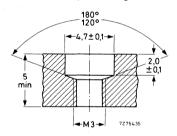


Fig. 13 Heatsink requirements for 500 V insulation.

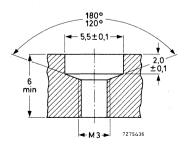


Fig. 14 Heatsink requirements for 1000 V insulation.

# MOUNTING INSTRUCTIONS FOR SOT-93 ENVELOPES

#### GENERAL DATA AND INSTRUCTIONS

#### General rule

Avoid any sudden forces on leads and body; these forces, such as from falling on a hard surface, are easily underestimated. In the direct screw mounting an M4 screw must be used; an M3 screw in the insulating mounting.

#### Heatsink requirements

Flatness in the mounting area: 0,02 mm maximum per 10 mm.

The mounting hole must be deburred.

#### Heatsink compound

The thermal resistance from mounting base to heatsink ( $R_{th\,mb-h}$ ) can be reduced by applying a metallic-oxide heatsink compound between the contact surfaces. For insulated mounting the compound should be applied to the bottom of both device and insulator.

#### Maximum play

The bush or the washer may only just touch the plastic part of the body, but should not exert any force on that part. Keep mounting tool (e.g. screwdriver) clear of the plastic body.

#### Mounting torques

For	M3	corow	lingulated	mounting!	١.

Minimum torque (for good heat transfer)	0,4 Nm ( 4 kgcm)
Maximum torque (to avoid damaging the device)	0.6 Nm (.6 kgcm)

For M4 screw (direct mounting only):

Minimum torque (for good heat transfer)	0,4 Nm ( 4 kgcm)
Maximum torque (to avoid damaging the device)	1,0 Nm (10 kgcm)

Note: The M4 screw head should not touch the plastic part of the envelope.

#### Lead bending

Maximum permissible tensile force on the body for 5 s 20 N (2 kgf)

No torsion is permitted at the emergence of the leads.

Bending or twisting is not permitted within a lead length of 0,3 mm.

The leads can be bent through 90° maximum, twisted or straightened; to keep forces within the above-mentioned limits, the leads are generally clamped near the body.

N.B.: Data on accessories are given in chapter Accessories.

#### Soldering

Recommendations for devices with a maximum junction temperature rating ≤ 175 °C:

a. Dip or wave soldering

Maximum permissible solder temperature is 260  $^{\circ}$ 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  $^{\circ}$ 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 ounting	screw mounting
Thermal resistance from mounting base to heatsink				
direct mounting with heatsink compound without heatsink compound	R <sub>th mb-h</sub> R <sub>th mb-h</sub>	=	0,3 1,5	0,3 K/W 0,8 K/W
with 0,05 mm mica washer with heatsink compound without heatsink compound	R <sub>th mb-h</sub> R <sub>th mb-h</sub>	= -	0,8 3,0	0,8 K/W 2,2 K/W

#### INSTRUCTIONS FOR CLIP MOUNTING

#### Direct mounting with clip 56379

- 1. Place the device on the heatsink, applying heatsink compound to the mounting base.
- Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10° to 20° to the vertical (see Fig. 1b).
- 3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body, not on the tab (see Fig. 1(c)).

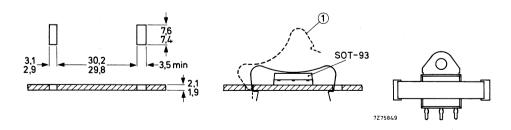


Fig. 1a Heatsink requirements.

Fig. 1b Mounting. (1) = spring clip 56379.

Fig. 1c Position of the device.

#### Insulated mounting with clip 56379

With the mica 56378 insulation up to 1500 V is obtained.

- 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.

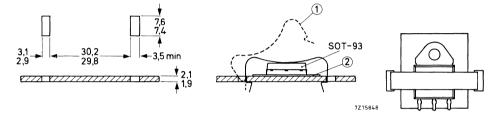


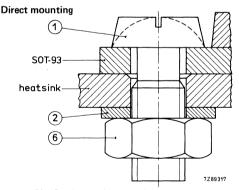
Fig. 2a Heatsink requirements.

Fig. 2b Mounting. (1) = spring clip 56379

Fig. 2c Position of the device.

(2) = insulator 56378

#### INSTRUCTIONS FOR SCREW MOUNTING





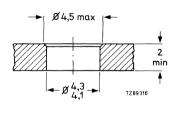


Fig. 3b Heatsink requirements.

When screw mounting the SOT-93 envelope, it is particularly important to apply a thin, even layer of heatsink compound to the mounting base, and to apply torque to the screw slowly so that the compound has time to flow and the mounting base is not deformed. Most SOT-93 envelopes contain a crystal larger than that in the other plastic envelopes, and it is more likely to crack if the mounting base is deformed.

Legend: (1) M4 screw; (2) plain washer; (6) M4 nut.

Where vibrations are to be expected the use of a lock washer or of a curved spring washer is recommended, with a plain washer between aluminium heatsink and spring washer.

#### Insulated screw mounting with nut; up to 800 V.

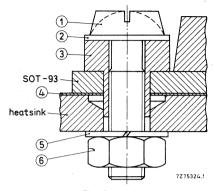


Fig. 4 Assembly. See also Fig. 9.

- (1) M3 screw
- (2) plain washer
- (3) insulating bush (56368b)
- (4) mica insulator (56368a)
- (5) lock washer
- (6) M3 nut

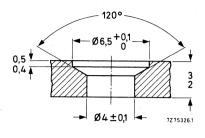


Fig. 5 Heatsink requirements up to 800 V insulation.

### Insulated screw mounting with tapped hole; up to 800 V.

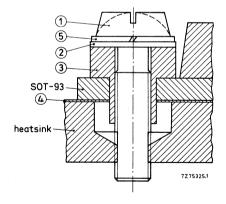


Fig. 6 Assembly. See also Fig. 9.

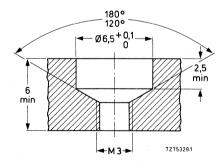


Fig. 7 Heatsink requirements up to  $800\ V$  insulation.

- (1) M3 screw
- (2) plain washer
- (3) insulating bush (56368b)

(56368a)

- (4) mica insulator
- (5) lock washer

## Insulated screw mounting with insert nut; up to 500 V

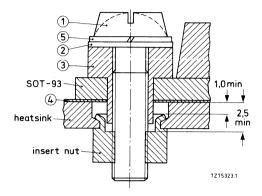


Fig. 8 Assembly and heatsink requirements for 500 V insulation. See also Fig. 3.

- (1) M3 screw
- (2) plain washer
- (3) insulating bush
- (4) mica insulator
- (56368b)
- (5) lock washer

(56368a)

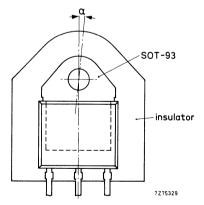


Fig. 9 Mica insulator.

The axial deviation ( $\alpha$ ) between SOT-93 and mica should not exceed 5°.







# INDEX OF TYPE NUMBERS

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

type no.	book	section	type no.	book	section	type no.	book	section
BA220	S1	SD	BAS29	S7/S1	Mm/SD	BAV101	S7/S1	Mm/SD
BA221	S1	SD	BAS31	S7/S1	Mm/SD	BAV 102	S7/S1	Mm/SD
BA223	S1	T	BAS32	S7/S1	Mm/SD	BAV103	S7/S1	Mm/SD
BA281	S1	SD	BAS35	S7/S1	Mm/SD	BAW56	S7/S1	Mm/SD
BA314	S1	Vrg	BAS45	S1	SD	BAW62	S1	SD
BA315	S1	Vrg	BAS56	S1	SD	BAX12	<b>S</b> 1	SD
BA316	S1	SD	BAT17	S7/S1	Mm/T	BAX14	S1	SD
BA317	S1	SD	BAT18	S7/S1	Mm/T	BAX18	S1	SD
BA318	S1	SD	BAT54	S1	SD	BAY80	S1	SD
BA423	S1	T	BAT74	S1	SD	BB112	S1	T
BA480	S1	T	BAT81	S1	Т	BB119	S1	т
BA481	S1	T	BAT82	S1	T	BB130	S1	T
BA482	S1	T	BAT83	S1	T	BB204B	S1	T
BA483	S1	T	BAT85	S1	T	BB204G	S1	T
BA484	S1	T	BAT86	S1	T	BB212	S1	T
BA682	S1	T	BAV10	S1	SD	BB405B	S1	T
BA683	S1	T	BAV18	S1	SD	BB417	S1	т
BAS11	S1	SD	BAV19	S1	SD	BB809	S1	T
BAS15	S1	SD	BAV20	S1	SD	BB9O9A	S1	T
BAS16	S7/S1	Mm/SD	BAV21	S1	SD	BB909B	S1	T
BAS17	S7/S1	Mm/Vrg	BAV23	S7/S1	Mm/SD	BBY31	S7/S1	Mm/T
BAS19	S7/S1	Mm/SD	BAV45	S1	Sp	BBY40	S7/S1	Mm/T
BAS20	S7/S1	Mm/SD	BAV70	S7/S1	Mm/SD	BC107	S3	Sm
BAS21	S7/S1	Mm/SD	BAV99	S7/S1	Mm/SD	BC108	S3	Sm
BAS28	S7/S1	Mm/SD	BAV100	S7/S1	Mm/SD	BC109	S3	Sm

Mm = Microminiature semiconductors for hybrid circuits

SD = Small-signal diodes

Sp = Special diodes

T = Tuner diodes

Vrg = Voltage regulator diodes Sm = Small-signal transistors

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BC146	<b>S</b> 3	Sm	BC847	S7	Mm	BCX53	S7	Mm
BC160	S3	Sm	BC848	S7	Mm	BCX54	S7	Mm
BC161	S3	Sm	BC849	S7	Mm	BCX55	S7	Mm
BCIGI	33	Siii	BC043	.57	PIR	BCAJJ	. 31	Pin
BC177	S3	Sm	BC850	S7	Mm	BCX56	S7	Mm
BC178	S3	Sm	BC856	S7	Mm	BCX68	S7	Mm
BC179	S3	Sm	BC857	S7	Mm	BCX69	<b>S</b> 7	mm
BC200	<b>S</b> 3	Sm	BC858	S7	Mm	BCX70*	S7	Mm
BC264A	S5	FET	BC859	S7	Mm	BCX71*	<b>S</b> 7	Mm
BC264B	S5	FET	BC860	S7	Mm	BCY56	<b>S</b> 3	Sm
BC264C	S5	FET	BC868	<b>S</b> 7	Mm	BCY57	<b>S</b> 3	Sm
BC264D	S5	FET	BC869	S7	Mm	BCY58	<b>S</b> 3	Sm
BC327;A	S3	Sm	BCF29:R	S7	Mm	BCY59	S3	Sm
BC328	S3	Sm	BCF30;R	S7	Mm	BCY70	S3	Sm
BC320	33	SIII	BCF30;R	31	1-1111	BC170	. 33	JII
BC337;A	53	Sm	BCF32;R	<b>S</b> 7	Mm	BCY71	<b>S</b> 3	Sm
BC338	S3	Sm	BCF33;R	S7	Mm	BCY72	S3	Sm
BC368	S3	Sm	BCF70;R	S7	Mm	BCY78	<b>S</b> 3	Sm
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BC548	S3	Sm	BCW29:R	S7	Mm	BD132	S4a	P
BC549	<b>S</b> 3	Sm	BCW30; R	s7	Mm	BD135	S4a	P
DC343	33	Sm.	DCW30,R	5,	Paul	BB 133	544	•
BC550	s3	Sm	BCW31;R	S7	Mm	BD136	S4a	P
BC556	s3	Sm	BCW32;R	S7	Mm	BD137	S4a	P
BC557	S3	Sm	BCW33;R	s7	Mm	BD138	S4a	P
BC558	S3	Sm	BCW60*	S7	Mm	BD139	S4a	P
BC559	<b>S</b> 3	Sm	BCW61*	S7	Mm	BD140	S4a	P
BC560	s3	Sm	BCW69:R	S7	Mm	BD201	S4a	P
BC635	<b>S</b> 3	Sm	BCW70:R	S7	Mm	BD202	S4a	P
BC636	S3	Sm	BCW71;R	S7	Mm	BD203	S4a	P
BC637	S3	Sm	BCW72;R	S7	Mm	BD204	S4a	P
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BC640	S3	Sm	BCX17;R	S7	Mm	BD228	S4a	P
BC807	s7	Mm	BCX18;R	S7	Mm	BD229	S4a	P
BC808	<b>S</b> 7	Mm	BCX19;R	<b>S</b> 7	Mm	BD230	S4a	P
BC817	S7	Mm	BCX20;R	S7	Mm	BD231	S4a	P

<sup>=</sup> series

P = Low-frequency power transistors Sm = Small-signal transistors

FET = Field-effect transistors

Mm = Microminiature semicondcutors for hybrid circuits

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BD234	S4a	P	BD434	S4a	P	BD844	S4a	P
BD235	S4a	P	BD435	S4a	P	BD845	S4a	P
BD236	S4a	P	BD436	S4a	P	BD846	S4a	P
BD237	S4a	P	BD437	S4a	P	BD847	S4a	P
BD238	S4a	P	BD438	S4a	P	BD848	S4a	P
BD239	S4a	P	BD645	S4a	P	BD849	S4a	P
BD239A	S4a	P	BD646	S4a	P	BD850	S4a	P
BD239B	S4a	P	BD647	S4a	P	BD933	S4a	P
BD239C	S4a	P	BD648	S4a	P	BD934	S <b>4</b> a	P
BD240	S4a	p	BD649	S4a	P	BD935	S <b>4</b> a	P
BD240A	S4a	P	BD650	S4a	P	BD936	S4a	P
BD240B	S4a	P	BD651	S4a	P	BD937	S4a	P
BD24OC	S4a	P	BD652	S4a	P	BD938	S4a	P
BD241	S4a	. <b>P</b>	BD675	S4a	P	BD939	S4a	P
BD241A	S4a	P	BD676	S4a	P	BD940	S4a	P
BD241B	S4a	P	BD677	S4a	P	BD941	S4a	P
BD241C	S4a	P	BD678	S4a	P	BD942	S4a	P
BD242	S4a	P	BD679	S4a	P	BD943	S4a	P
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BD242B	S4a	P	BD681	S4a	P	BD945	S4a	P
BD242C	S4a	P	BD682	S4a	P	BD946	S4a	P
BD243	S4a	P	BD683	S4a	P	BD947	S4a	P
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BD243B	S4a	P	BD813	S4a	P	BD949	S4a	P
BD243C	S4a	P	BD814	S4a	P	BD950	S4a	P
BD244	S4a	P	BD815	S4a	P	BD951	S4a	P
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BD331	S4a	P	BD827	S4a	P	BDT20	S4a	P
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BD333	S <b>4</b> a	P	BD829	S4a	P	BDT29	S4a	P
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BD336	S4a	P	BD840	S4a	P	BDT29C	S4a	P
BD337	S4a	P	BD841	S4a	P	BDT30	S4a	P
BD338	S4a	P	BD842	S4a	P	BDT30A	S4a	P

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BDT30C	S4a	P	BDT63C	S4a	P	BDV92	S4a	P
BDT31	S4a	P	BDT64	S4a	P	BDV93	S4a	P
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BDT32	S4a	P	BDT65	S4a	P	BDW55	S4a	P
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BDT55	S4a	P	BDT95	S4a	P	BDX62A	S4a	P
BDT56	S4a	P	BDT96	S4a	P	BDX62B	S4a	P
BDT57	S4a	P	BDV64	S4a	P	BDX62C	S4a	P
BDT58	S4a	P	BDV64A	S4a	P	BDX63	S4a	P
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BDT60A	S4a	P	BDV64C	S4a	Þ	BDX63B	S4a	P
BDT60B	S4a	P	BDV65	S4a	P	BDX63C	S4a	P
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BDT61	S4a	P	BDV65B	S4a	P	BDX64A	S4a	P
BDT61A	S4a	Þ	BDV65C	S4a	P	BDX64B	S4a	P
BDT61B	S4a	P	BDV66A	S4a	P	BDX64C	S4a	P
BDT61C	S4a	P	BDV66B	S4a	P	BDX65	S4a	P
BDT62	S4a	P	BDV66C	S4a	P	BDX65A	S4a	P
BDT62A	S4a	P	BDV66D	S4a	P	BDX65B	S4a	P
BDT62B	S4a	P	BDV67A	S4a	P	BDX65C	S4a	P
BDT62C	S4a	P	BDV67B	S4a	P	BDX66	S4a	P
BDT63	S4a	P	BDV67C	S4a	P	BDX66A	S4a	P
BDT63A	S4a	P	BDV67D	S4a	P	BDX66B	S4a	P

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BDX66C	S4a	P	BF410A	<b>S</b> 5	FET	BF623	s7	Mm
BDX67	S4a	P	BF410B	S5	FET	BF660;R	s7	Mm
BDX67A	S4a	P	BF410C	S5	FET	BF689K	S10	WBT
BDX67B	S4a	P	BF410D	S5	FET	BF763	S10	WBT
BDX67C	S4a	P	BF419	S4b	HVP	BF767	s7	Mm
BDX68	S4a	Р	BF420	S3	Sm	BF819	S4b	HVP
BDX68A	S4a	P	BF421	S3	Sm	BF820	s7	Mm
BDX68B	S4a	P	BF422	S3	Sm	BF821	<b>S</b> 7	Mm
BDX68C	S4a	P	BF423	<b>S</b> 3	Sm	BF822	S7	Mm
BDX69	S4a	P	BF450	<b>S</b> 3	Sm	BF823	<b>S</b> 7	Mm
BDX69A	S4a	P	BF451	<b>S</b> 3	Sm	BF824	s7	Mm
BDX69B	S4a	P	BF457	S4b	HVP	BF857	S4b	HVP
BDX69C	S4a	P	BF458	S4b	HVP	BF858	S4b	HVP
BDX77	S4a	P	BF459	S4b	HVP	BF859	S4b	HVP
BDX78	S4a	P	BF469	S4b	HVP	BF869	S4b	HVP
BDX91	S4a	P	BF470	S4b	HVP	BF870	S4b	HVP
BDX92	S4a	P	BF471	S4b	HVP	BF871	S4b	HVP
BDX93	S4a	P	BF472	S4b	HVP	BF872	S4b	HVP
BDX94	S4a	P	BF483	S3	Sm	BF926	S3	Sm
BDX95	S4a	P	BF485	S3	Sm	BF936	S3	Sm
BDX96	S4a	P	BF487	<b>S</b> 3	Sm	BF939	s3	Sm
BDY90	S4a	P	BF494	S3	Sm	BF960	S5	FET
BDY90A	S4a	P	BF495	S3	Sm	BF964	S5	FET
BDY91	S4a	P	BF496	S3	Sm	BF966	S5	FET
BDY92	S4a	P	BF510	S7/S5	Mm/FET	BF967	S3	Sm
BF198	<b>s</b> 3	Sm	BF511	S7/S5	Mm/FET	BF970	s3	Sm
BF199	S3	Sm	BF512	S7/S5	Mm/FET	BF979	s3	Sm
BF240	<b>S</b> 3	Sm	BF513	S7/S5	Mm/FET	BF980	S5	FET
BF241	S3	Sm	BF536	s7	Mm	BF981	S5	FET
BF245A	S5	FET	BF550;R	S7	Mm	BF982	<b>S</b> 5	FET
BF245B	<b>S</b> 5	FET	BF569	s7	Mm	BF989	S7/S5	Mm/F
BF245C	S5	FET	BF579	s7	Mm	BF990	S7/S5	Mm/F
BF247A	<b>S</b> 5	FET	BF583	S4b	HVP	BF991	S7/S5	Mm/F
BF247B	S5	FET	BF585	S4b	HVP	BF992	S7/S5	Mm/F
BF247C	S5	FET	BF587	S4b	HVP	BF994	S7/S5	Mm/F
BF256A	<b>S</b> 5	FET	BF591	S4b	HVP	BF996	\$7/\$5	Mm/F
BF256B	S5	FET	BF593	S4b	HVP	BFG23	S10	WBT
BF256C	S5	FET	BF620	s7	Mm	BFG32	S10	WBT
BF324	<b>S</b> 3	Sm	BF621	s7	Mm	BFG34	S10	WBT
BF370	S3	Sm	BF622	S7	Mm	BFG51	S10	WBT

FET = Field-effect transistors
HVP = High-voltage power transistors
Mm = Microministure semiconductors

Mm = Microminiature semiconductors for hybrid circuits

= Low-frequency power transistors

Sm = Small-signal transistors

WBT = Wideband hybrid IC transistors

type no.	book	section	type no.	book	section	type no.	book	section
BFG65	S10	WBT	BFR31	S5/S7	FET/Mm	BFW17A	S10	WBT
BFG9OA	S10	WBT	BFR49	S10	WBT	BFW30	S10	WBT
BFG91A	S10	WBT	BFR53;R	S7	Mm	BFW61	S5	FET
BFG96	S10	WBT	BFR54	S3	Sm	BFW92	S10	WBT
BFP90A	S10	WBT	BFR64	s.10	WBT	BFW92A	S10	WBT
BFP91A	S10	WBT	BFR65	S10	WBT	BFW93	S10	WBT
BFP96	S10	WBT	BFR84	S5	FET	BFX29	S3	Sm
BFQ10	S5	FET	BFR90	S10	WBT	BFX30	<b>S</b> 3	Sm
BFO11	S5	FET	BFR90A	S10	WBT	BFX34	53	Sm
BFQ12	S5	FET	BFR91	S10	WBT	BFX84	s3	Sm
BFQ13	<b>S</b> 5	FET	BFR91A	S10	WBT	BFX85	<b>S</b> 3	Sm
BFQ14	S5	FET	BFR92;R	s7	Mm	BFX86	S3	Sm
BFQ15	S5	FET	BFR92A;R	S7	Mm	BFX87	S3	Sm
BFQ16	S5	FET	BFR93:R	<b>S</b> 7	Mm	BFX88	S3	Sm
BFQ17	s7	Mm	BFR93A;R		Mm	BFX89	S10	WBT
BFQ18A	s7	Mm	BFR94	S10	WBT	BFY50	<b>s</b> 3	Sm
BFQ19	S7	Mm	BFR95	S10	WBT	BFY51	S3	Sm
BFO22S	S10	WBT	BFR96	S10	WBT	BFY52	S3	Sm
BFO23	S10	WBT	BFR96S	S10	WBT	BFY55	S3	Sm
BFQ23C	S10	WBT	BFR101A;			BFY90	S10	WBT
BFO24	S10	WBT	BFS17;R	s7	Mm	BG2000	S1	RT
BFQ32	S10	WBT	BFS18:R	<b>S</b> 7	Mm	BG2097	S1	RT
BF032C	S10	WBT	BFS19;R	S7	Mm	BGD102	S10	WBM
BFQ32S	S10	WBT	BFS20;R	<b>S</b> 7	Mm	BGD102E	S10	WBM
BFQ33	S10	WBT	BFS21	S5	FET	BGD104	S10	WBM
BFQ34	S10	WBT	BFS21A	S5	FET	BGD104E	S10	WBM
BFQ34T	S10	WBT	BFS22A	S6	RFP	BGX11*	S2b	ThM
BFO42	S6	RFP	BFS23A	S6	RFP	BGX12*	S2b	ThM
BFQ43	S6	RFP	BFT24	S10	WBT	BGX13*	S2b	ThM
BFQ51	S10	WBT	BFT25;R	s7	Mm	BGX14*	S2b	ThM
BFQ51C	S10	WBT	BFT44	<b>S</b> 3	Sm	BGX15*	S2b	ThM
BFQ52	S10	WBT	BFT45	S3	Sm	BGX17*	S2b	ThM
BFQ53	S10	WBT	BFT46	S7/S5	Mm/FET	BGX25	S2a	ThM
BFQ63	S10	WBT	BFT92:R	s7	Mm	BGY22	S6	RFP
BFQ65	S10	WBT	BFT93;R	<b>S</b> 7	Mm	BGY22A	S6	RFP
BFQ66	S10	WBT	BFW10	S5	FET	BGY23	S6	RFP
BFQ68	S10	WBT	BFW11	S5	FET	BGY23A	S6	RFP
BFQ136	S10	WBT	BFW12	<b>S</b> 5	FET	BGY32	S6	RFP
BFR29	S5	FET	BFW13	S5	FET	BGY33	S6	RFP
BFR30	S5/S7	FET/Mm	BFW16A	S10	WBT	BGY35	S6	RFP

<sup>\* =</sup> series

FET = Field-effect transistors

Mm = Microminiature semiconductors for hybrid circuits

RFP = R.F. power transistors and modules

RT = Tripler

Sm = Small-signal transistors

ThM = Thyristor modules

WBM = Wideband hybrid IC modules

WBT = Wideband hybrid IC transistors

type no.	book	section	type no.	book	section	type no.	book	section
BGY36	S6	RFP	BLU45/12	s6	RFP	BLW33	S6	RFP
BGY40A	S6	RFP	BLU50	S6	RFP	BLW34	S6	RFP
BGY40B	S6	RFP	BLU51	S6	RFP	BLW50F	S6	RFP
BGY41A	S6	RFP	BLU52	S6	RFP	BLW60	S6	RFP
BGY41B	<b>S6</b>	RFP	BLU53	<b>S</b> 6	RFP	BLW60C	S6	RFP
BGY43	s6	RFP	BLU60/12	S6	RFP	BLW76	<b>S</b> 6	RFP
BGY45A	S6	RFP	BLU97	S6	RFP	BLW77	S6	RFP
BGY45B	S6	RFP	BLU98	S6	RFP	BLW78	S6	RFP
BGY46A	S6	RFP	BLU99	S6	RFP	BLW79	S6	RFP
BGY46B	S6	RFP	BLV10	S6	RFP	BLW80	S6	RFP
BGY47*	s6	RFP	BLV11	s6	RFP	BLW81	S6	RFP
BGY50	S10	WBM	BLV20	S6	RFP	BLW82	S6	RFP
BGY51	S10	WBM	BLV21	S6	RFP	BLW83	S6	RFP
BGY52	S10	WBM	BLV25	S6	RFP	BLW84	S6	RFP
BGY53	S10	WBM	BLV30	s6	RFP	BLW85	S6	RFP
BGY54	S10	WBM	BLV30/12	S6	RFP	BLW86	56	RFP
BGY55	S10	WBM	BLV31	S6	RFP	BLW87	S6	RFP
BGY56	S10	WBM	BLV32F	S6	RFP	BLW89	S6	RFP
BGY57	S10	WBM	BLV33	S6	RFP	BLW90	S6	RFP
BGY58	S10	WBM	BLV33F	S6	RFP	BLW91	S6	RFP
BGY58A	S10	WBM	BLV36	<b>S</b> 6	RFP	BLW95	S6	RFP
BGY59	S10	WBM	BLV37	S6	RFP	BLW96	S6	RFP
BGY60	S10	WBM	BLV45/12		RFP	BLW97	S6	RFP
BGY61	S10	WBM	BLV57	S6	RFP	BLW98	S6	RFP
BGY65	510	WBM	BLV59	S6	RFP	BLW99	S6	RFP
BGY67	S10	WBM	BLV75/12	s6	RFP	BLX13	S6	RFP
BGY67A	S10	WBM	BLV80/28		RFP	BLX13C	S6	RFP
BGY70	S10	WBM	BLV90	S6	RFP	BLX14	S6	RFP
BGY71	S10	WBM	BLV91	S6	RFP	BLX15	S6	RFP
BGY74	S10	WBM	BLV92	S6	RFP	BLX39	S6	RFP
BGY75	S10	WBM	BLV93	s6	RFP	BLX65	s6	RFP
BGY84	S10	WBM	BLV94	S6	RFP	BLX65E	S6	RFP
BGY84A	S10	WBM	BLV95	56	RFP	BLX67	S6	RFP
BGY85	S10	WBM	BLV96	S6	RFP	BLX68	S6	RFP
BGY85A	S10	WBM	BLV97	S6	RFP	BLX69A	<b>S6</b>	RFP
BGY93A	s6	RFP	BLV98	S6	RFP	BLX91A	s6	RFP
BGY93B	S6	RFP	BLV99	S6	RFP	BLX91CB	S6	RFP
BGY93C	56	RFP	BLW29	S6	RFP	BLX92A	S6	RFP
BLU20/12		RFP	BLW31	S6	RFP	BLX93A	S6	RFP
BLU30/12		RFP	BLW32	S6	RFP	BLX94A	S6	RFP
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RFP = R.F. power transistors and modules WBM = Wideband hybrid IC modules

<sup>\* =</sup> series

type no.	book	section	type no.	book	section	type no.	book	section
BLX94C	s6	RFP	BS170	S5	FET	BSS61	<b>s</b> 3	Sm
BLX95	S6	RFP	BSD10	S5	FET	BSS62	<b>S</b> 3	Sm
BLX96	S6	RFP	BSD12	S5	FET	BSS63:R	S7	Mm
BLX97	S6	RFP	BSD20	S5/7	FET	BSS64:R	S7	Mm
BLX98	S6	RFP	BSD22	S5/7	FET	BSS68	S3	Sm
DERIG	50	KI I	D3D22	33/1	FEI	55500	33	3m
BLY85	S6	RFP	BSD212	S5	FET	BSS83	S5/7	FET/Mm
BLY87A	S6	RFP	BSD213	S5	FET	BST15	S7	Mm
BLY87C	S6	RFP	BSD214	S5	FET	BST16	<b>S</b> 7	Mm
BLY88A	S6	RFP	BSD215	S5	FET	BST39	<b>S</b> 7	Mm
BLY88C	S6	RFP	BSR12;R	s7	Mm	BST40	<b>S</b> 7	Mm
BLY89A	s6	RFP	BSR13;R	s7	Mm	BST50	S7	Mm
BLY89C	S6	RFP	BSR14;R	S7	Mm	BST51	57 57	Mm
BLY90	S6	RFP	BSR15;R	S7	Mm	BST52	S7	Mm
BLY91A	S6	RFP		S7	Mm	BST60	57 57	
BLY91C	S6	RFP	BSR16;R			1		Mm
БЦТЭТС	30	KFF	BSR17;R	S7	Mm	BST61	S7	Mm
BLY92A	S6	RFP	BSR17A;R	s7	Mm	BST62	<b>S</b> 7	Mm
BLY92C	S6	RFP	BSR18;R	S7	Mm	BST70A	S5	FET
BLY93A	S6	RFP	BSR18A;R	S7	Mm	BST72A	S5	FET
BLY93C	S6	RFP	BSR30	S7	Mm	BST74A	S5	FET
BLY94	S6	RFP	BSR31	<b>S</b> 7	Mm	BST76A	S5	FET
BLY97	S6	RFP	BSR32	<b>S</b> 7	Mm	BST78	S5	FET
BPF 10	S8	PDT	BSR33	S7	Mm	BST80	S5	FET
BPF24	S8	PDT	BSR40	s7	Mm	BST82	S5	FET
BPW22A	S8	PDT	BSR41	S7	Mm	BST84	S5	FET
BPW50	58	PDT	BSR42	S7	Mm	BST86	S5	FET
			DSK42	5,	1-110	D3100	33	11.1
BPX25	S8	PDT	BSR43	S7	Mm	BST90	S5	FET
BPX29	S8	PDT	BSR50	S3	Sm	BST97	S5	FET
BPX40	S8	PDT	BSR51	S3	Sm	BST 100	S5	FET
BPX41	58	PDT	BSR52	<b>S</b> 3	Sm	BST110	S5	FET
BPX42	S8	PDT	BSR56	S7/S5	Mm/FET	BST120	<b>S</b> 5	FET
BPX71	S8	PDT	BSR57	S7/S5	Mm/FET	BST122	S5	FET
BPX72	S8	PDT	BSR58	S7/S5	Mm/FET	BSV15	53	Sm
BPX95C	S8	PDT	BSR60	S3	Sm	BSV16	S3	Sm
BR 100/03	S2b	Th	BSR61	S3	Sm	BSV17	S3	Sm
BR101	<b>S</b> 3	Sm	BSR62	<b>S</b> 3	Sm	BSV52;R	S7	Mm
BRY39	<b>S</b> 3	Sm	. Dadao	an a	G	DCUCA	<b>s</b> 3	C
BRY56	53 53	Sm Sm	BSS38	S3	Sm C	BSV64		Sm
BRY61	53 57	Mm	BSS50	S3	Sm	BSV78 BSV79	S5 S5	FET
BRY62	57 57	Mm	BSS51	<b>53</b>	Sm C	1	55 55	FET
BS107	S5	FET	BSS52	S3	Sm S-	BSV80 BSV81	S5	FET
55107		FLI	BSS60	<b>S</b> 3	Sm	65761	33	FET

FET = Field-effect transistors

Mm = Microminiature semiconductors

for hybrid circuits

Sm = Small-signal transistors

PDT = Photodiodes or transistors

Th = Thyristors

Tri = Triacs

RFP = R.F. power transistors and modules

type no.	book	section	type no.	book	section	type no.	book	section
BSW66A	<b>s</b> 3	Sm	BTY91*	S2b	Th	BUX48;A	S4b	SP
BSW67A	<b>S</b> 3	Sm	BU426	S4b	SP	BUX80	S4b	SP
BSW68A	S3	Sm	BU426A	S4b	SP	BUX81	S4b	SP
BSX19	<b>S</b> 3	Sm	BU433	S4b	SP	BUX82	S4b	SP
BSX20	<b>S</b> 3	Sm	BU505	S4b	SP	BUX83	S4b	SP
BSX45	S3	Sm	BU506	S4b	SP	BUX84	S4b	SP
BSX46	<b>S</b> 3	Sm	BU506D	S4b	SP	BUX84F	S4b	SP
BSX47	S3	Sm	BU508A	S4b	SP	BUX85	S4b	SP
BSX59	<b>S</b> 3	Sm	BU508D	S4b	SP	BUX85F	S4b	SP
BSX60	S3	Sm	BU705	S4b	SP	BUX86	S4b	SP
BSX61	S3	Sm	BU706	S4b	SP	BUX87	S4b	SP
BSY95A	s3	Sm	BU706D	S4b	SP	BUX88	S4b	SP
BT136*	S2b	Tri	BU806	S4b	SP	BUX90	S4b	SP
BT137*	S2b	Tri	BU807	S4b	SP	BUX98	S4b	SP
BT138*	S2b	Tri	BU804	S4b	SP	BUX98A	S4b	SP
			1					
BT139*	S2b	Tri	BU824	S4b	SP	BUX99	S4b	SP
BT149*	S2b	Th	BU826	S4b	SP	BUY89	S4b	SP
BT151*	S2b	Th	BUP22*	S4b	SP	BUZ 10	S9	PM
BT152*	S2b	Th	BUP23*	S4b	SP	BUZ 1OA	S9	PM
BT153	S2b	Th	BUS11; A	S4b	SP	BUZ11	S9	PM
BT155*	S2b	Th	BUS12;A	S4b	SP	BUZ11A	S9	P <b>M</b>
BT157*	S2b	Th	BUS13;A	S4b	SP	BUZ14	S9	P <b>M</b>
BTV24*	S2b	Th	BUS14;A	S4b	SP	BUZ15	S9	PM
BTV34*	S2b	Tri	BUS21*	S4b	SP	BUZ2O	S9	P <b>M</b>
BTV58*	S2b	Th	BUS22*	S4b	SP	BUZ21	S9	P <b>M</b>
BTV59*	S2b	Th	BUS23*	S4b	SP	BUZ23	<b>S</b> 9	P <b>M</b>
BTV60*	52b 52b	Th	BUT11; A	S4b	SP	BUZ24	S9	PM
BTW23*	S2b	Th	BUT11F	S4b	SP	BUZ25	S 9	PM
BTW23* BTW38*	S2b S2b	Th	BUT11AF	S4b	SP	BUZ30	S9	PM
BTW40*	S2b S2b	Th	BUV82	S4b	SP	BUZ31	S9	PM
DI#40	325	111	50102	515	51	]		
BTW42*	S2b	Th	BUV83	S4b	SP	BUZ32	<b>S</b> 9	PM
BTW43*	S2b	Tri	BUV89	S4b	SP	BUZ33	S 9	PM
BTW45*	S2b	Th	BUV90; A	S4b	SP	BUZ34	S 9	PM
BTW58*	S2b	Th	BUW11; A	S4b	SP	BUZ35	S 9	PM
BTW59*	S2b	Th	BUW12; A	S4b	SP	BUZ36	S9	PM
213								
BTW63*	S2b	Th	BUW13;A	S4b	SP	BUZ4O	S9	P <b>M</b>
BTW92*	S2b	Th	BUW84	S4b	SP	BUZ41A	S9	PM
BTX18*	S2b	Th	BUW85	S4b	SP	BUZ42	<b>S</b> 9	PM
BTX94*	S2b	Tri	BUX46;A	S4b	SP	BUZ43	S9	PM
BTY79*	S2b	Th	BUX47;A	S4b	SP	BUZ44A	S9	P <b>M</b>
			L					

<sup>\* =</sup> series

Sm = Small-signal transistors

Th = Thyristors

Tri = Triacs

PM = Power MOS transistors

R = Rectifier diodes

SP = Low-frequency switching power transistors

type no.	book	section	type no.	book	section	type no.	book	sectio
BUZ45	S9	PM	BY505	S1	R	BYV36*	S1	R
BUZ 45A	S9	PM	BY509	S1	R	BYV39*	S2a	R
BUZ 45B	S9	PM	BY527	S1	R	BYV42*	S2a	R
BUZ45C	S9	PM	BY584	S1	R	BYV43*	S2a	R
BUZ45C	S9	PM	BY588	S1	R	BYV72*	S2a	R
D0240	33	rri	B1300	31	T.	BIVIZ	SZa	K.
BUZ50A	S9	PM	BY609	S1	R	BYV73*	S2a	R
BUZ50B	S9	P <b>M</b>	BY610	S1	R	BYV79*	S2a	R
BUZ53A	S9	PM .	BY614	S1	R	BYV92*	S2a	R
BUZ54	S9	PM	BY619	S1	R	BYV95A	S1	R
BUZ54A	<b>S</b> 9	P <b>M</b>	BY620	S1	R	BYV95B	S1	R
BUZ 60	<b>S</b> 9	PM	BY707	S1	R	BYV95C	S1	R
BUZ 60B	S9	PM	BY708	S1	R	BYV96D	S1	R
BUZ63	S9	PM	BY709	S1	R	BYV96E	S1	R
BUZ63B	S9	PM .	BY710	S1	R	BYW25*	S2a	R
BUZ64	S9	PM	BY711	S1	R	BYW29*	S2a	R
50204	33	rn	BI/II	51	K	B1#25"	52a	К
BUZ71	S9	PM	BY712	S1	R	BYW30*	S2a	R
BUZ71A	S9 .	PM	BY713	S1	R	BYW31*	S2a	R
BUZ72	59	PM	BY714	S1	R	BYW54	S1	R
BUZ72A	59	PM	BYD13	S1	R	BYW55	S1	R
BUZ73A	S9	PM	BYD33	S1	R	BYW56	S1	R
BUZ74	<b>S</b> 9	P <b>M</b>	BYD73*	S1	R	BYW92*	S2a	R
BUZ74A	S9	PM	BYM56*	S1	R	BYW93*	S2a	R
BUZ76	S9	PM	BYQ28*	S2a	R	BYW94*	S2a	R
BUZ76A	59	PM	BYR29*	S2a S2a	R	BYW95A	S1	R
BUZ80	S9	PM	BYT79*	S2a S2a	R	BYW95B	S1	R
Бойоо	5,	111	B11/3	32a	K .	DI#33B	51	K
BUZ8OA	<b>S</b> 9	PM	BYV10	S1	R	BYW95C	S1	R
BUZ83	S9	PM	BYV19*	S2a	R	BYW96D	S1	R
BUZ83A	S9	PM .	BYV20*	S2a	R	BYW96E	S1	R
BUZ84	S9	PM	BYV21*	S2a	R	BYX25*	S2a	R
BUZ84A	S9	P <b>M</b>	BYV22*	S2a	R	BYX30*	S2a	R
BY228	S1	R	BYV23*	S2a	R	BYX32*	S2a	R
BY229*	S2a	R	BYV24*	S2a	R	BYX38*	S2a	R
BY249*	S2a	R	BYV26*	S1	R	BYX39*	S2a	R
BY260*	S2a	R	BYV27*	S1/S2a	R	BYX42*	S2a	R
BY261*	S2a	R	BYV28*	S1/S2a	R	BYX46*	S2a	R
BY329*	C22	D	DUITOA	g2.	<b>n</b>	DVVCO+	<b>G</b> 2 -	
BY359*	S2a S2a	R	BYV29*	S2a	R	BYX50*	S2a	R
		R	BYV30*	S2a	R	BYX52*	S2a	R
BY438	S1	R	BYV32*	S2a	R	BYX56*	S2a	R
BY448 BY458	S1	R	BYV33*	S2a	R	BYX90G	S1	R
D1430	S1	R	BYV34*	S2a	R	BYX94	S1	R

<sup>\* =</sup> series

R = Rectifier diodes

PM = Power MOS transistors

type no.	book	section	type no.	book	section	type no. book	section
BYX96*	S2a	R	CFX33	S11	M	CQV61A(L) S8	LED
BYX97*	S2a	R	CNX21	S8	PhC	CQV62(L) S8	LED
BYX98*	S2a	R	CNX35	S8	PhC	CQV70(L) S8	LED
BYX99*	S2a	R	CNX36	S8	PhC	CQV7OA(L) S8	LED
BZD23	S1	Vrg	CNX37	S8	PhC	CQV71A(L) S8	LED
BZTC3	S1	Vrg	CNX38	S8	PhC	CQV72(L) S8	LED
BZV10	S1	Vrf	CNX44	S8	PhC	CQV8OL S8	LED
BZV11	S1	Vrf	CNX48	S8	PhC	CQV8OAL S8	LED
BZV12	S1	Vrf	CNX62	S8	PhC	CQV81L S8	LED
BZV13	S1	Vrf	CNY50	S8	PhC	CQV82L S8	LED
BZV14	S1	Vrf	CNY52	S8	PhC	CQW10(L) S8	LED
BZV37	S1	Vrf	CNY53	S8	PhC	CQW10A(L) S8	LED
BZV46	S1	Vrg	CNY57	S8	PhC	CQW1OB(L) S8	LED
BZV49*	S1/S7	Vrg/Mm	CNY57A	S8	PhC	CQW11A(L) S8	LED
BZV55*	<b>S</b> 7	Mm	CNY62	S8	PhC	CQW11B(L) S8	LED
BZV85*	<b>S</b> 1	Vrg	CNY63	S8	PhC	CQW12(L) S8	LED
BZWO3 <sup>^</sup>	S1	Vrg	CQ209S	S8	D	CQW12B(L) S8	LED
BZW14	S1	Vrg	CQ216X	S8	D	CQW2OA S8	LED
BZW70*	S2a	TS	CQ216Y	S8	D	CQW21 S8	LED
BZW86*	S2a	TS	CQ327;R	S8	D	CQW22 S8	LED
BZW91*	S2a	TS	CQ330;R	S8	D	CQW24(L) S8	LED
BZX55 <sup>*</sup>	S1	Vrg	CQ331;R	S8	D	CQW54 S8	LED
BZX70*	S2a	Vrg	CQ332;R	S8	D	CQX10 S8	LED
BZX75 <sup>*</sup>	S1	Vrg	CQ427;R	S8	D	CQX11 S8	LED
BZX79*	S1	Vrg	CQ430;R	S8	D	CQX12 S8	LED
BZX84*	S7/S1	Mm/Vrg	CQ431;R	S8	D	CQX24(L) S8	LED
BZX90	S1	Vrf	CQ432;R	S8	D	CQX51 S8	LED
BZX91	S1	Vrf	CQF24	S8	Ph	CQX54(L) S8	LED
BZX92	S1	Vrf	CQL10A	S8	Ph	CQX64(L) S8	LED
BZX93	S1	Vrf	CQL13	S8	Ph	CQX74(L) S8	LED
BZX94	S1	Vrf	CQL13A	S8	Ph	CQX74Y S8	LED
BZY91*	S2a	Vrg	CQL14A	S8	Ph	CQY11B S8	LED
BZY93*	S2a	Vrg	CQL14B	S8	Ph	CQY11C S8	LED
BZY95*	S2a	Vrg	CQN10	S8	LED	CQY24B(L) S8	LED
BZY96*	S2a	Vrg	CQN11	S8	LED	CQY49B S8	LED
CFX13	S11	M	CQT10	S8	LED	CQY49C S8	LED
CFX21	S11	M	CQT11	S8	LED	CQY50 S8	LED
CFX30	S11	M	CQT12	S8	LED	CQY52 S8	LED
CFX31	S11	M	COA60(F)		LED	CQY54A S8	LED
CFX32	S11	M	COA60V(I	)\$8	LED	CQY58A S8	LED

\* = series

D = Displays

LED = Light-emitting diodes

M = Microwave transistors

Mm = Microminiature semiconductors

Ph = Photoconductive devices

PhC = Photocouplers

R = Rectifier diodes

TS = Transient suppressor diodes

Vrf = Voltage reference diodes

Vrg = Voltage regulator diodes

type no.	book	section	type no.	book	section	type no.	book	section
CQY89A	S8	LED	LV3742E16R S	511	M	OSB9210	S2a	St
CQY94	S8	LED	LV3742E24R S	511	M	OSB9215	S2a	St
COY94B(L)	S8	LED	LWE2015R 9	311	М	OSB9410	S2a	St
COY95B	S8	LED	LWE2025R S	311	M	OSB9415	S2a	St
CQY96(L)	S8	LED	LZ1418E100RS		M	OSM9110	S2a	St
CQY97A	S8	LED	MKB12040WS S	511	М	OSM9115	S2a	St
LAE2001R	S11	M	MKB12100WS S	511	M	OSM9210	S2a	St
LAE4001Q	S11	M	MKB12140W S	311	M	OSM9215	S2a	St
LAE4001R	S11	M	M06075B200ZS	311	M	OSM9410	S2a	St
LAE4002S	S11	M	MO6075B400ZS	511	M	OSM9415	S2a	St
LAE6000Q	S11	M	MRB12175YR S		M	OSM9510	S2a	St
LBE1004R	S11	M	MRB12350YR S	511	M	OSM9511	S2a	St
LBE1010R	S11	M	MS1011B700YS	311	M	OSM9512	S2a	St
LBE2003S	S11	M	MS6075B800ZS	311	M	0559110	S2a	St
LBE2005Q	S11	M	MSB12900Y S	51.1	M	0559115	S2a	St
LBE2008T	S11	М	MZ0912B75Y S	511	M	0559210	S2a	St
LBE2009S	S11	M	MZO912B150YS	311	M	0559215	S2a	St
LCE1010R	S11	М	OM286 S	13	SEN	0559410	S2a	St
LCE2003S	S11	М	OM287 S	13	SEN	0559415	S2a	St
LCE2005Q	S11	М	OM320 S	10	WBM	PBMF4391	S5	FET
LCE2008T	S11	M	OM321 S	10	WBM	PBMF4392	S5	FET
LCE2009S	S11	М	OM322 S	10	WBM	PBMF4393	S5	FET
LJE42002T	S11	M	OM323 S	10	WBM	PDE 100 1U	S11	M
LKE1004R	S11	М	OM323A S	10	WBM	PDE1003U	S11	M
LKE2002T	S11	M	OM335 S	10	WBM	PDE 1005U	S11	M
LKE2004T	S11	M	OM336 S	10	WBM	PDE1010U	S11	M
LKE2O15T	S11	M	OM337 S	10	WBM	PEE 100 1U	S11	M
LKE21004R	S11	M	OM337A S	10	WBM	PEE1003U	S11	M
LKE21015T	S11	М	OM339 S	10	WBM	PEE 1005U	S11	M
LKE21050T	S11	M	OM345 S	10	WBM	PEE1010U	S11	M
LKE27010R	S11	M		10	WBM	PH2222;R	<b>S</b> 3	Sm
LKE27025R	S11	М		10	WBM	PH2222A;R	<b>S</b> 3	Sm
LKE32002T	S11	M	OM361 S	10	WBM	PH2369	<b>S</b> 3	Sm
LKE32004T	S11	М	OM370 S	10	WBM	PH2907;R	<b>S</b> 3	Sm
LTE42005S	S11	M	OM386 S	13	SEN	PH2907A;R	<b>S</b> 3	Sm
LTE42008R	S11	М	OM387 S	13	SEN	PH2955T	S4a	p
LTE42012R	S11	M	OM931 S	4a	P	PH3055T	S4a	P
LV1721E50R		М	OM961 S	4a	P	PH5415	<b>S</b> 3	Sm
LV2024E45R	S11	M	OSB9110 S	2a	St	PH5416	S3	Sm
LV2327E40R	S11	M	OSB9115 S	2a	St	PH13002	S4b	SP

FET = Field-effect transistors

LED = Light-emitting diodes

M = Microwave transistors

P = Low-frequency power transistors

SEN = Sensors

Sm = Small-signal transistors

St = Rectifier stacks

WBM= Wideband hybrid IC modules

type no.	book	section	type no.	book	section	type no.	book	sectio
PH13003	S4b	SP	RPY89	S8	I	TIP115 ·	S4a	P
PHSD51	S2a	R	RPY90*	S8	I	TIP116	S4a	Р
PKB3001U	S11	M	RPY91*	S8	Ī	TIP117	S4a	P
PKB3003U	S11	M	RPY93	S8	Ī	TIP120	S4a	P
PKB3005U	S11	M	RPY94	58	Ī	TIP121	S4a	P
PKB12005U	S11	м	RPY95	S8	I	TIP122	S4a	P
PKB20010U	S11	M	RPY96	S8	Ī	TIP125	S4a	P
	S11	M	RPY97	S8	Ī	TIP126	S4a	P
PKB23001U					M	TIP127	S4a	P
PKB23003U	511	M	RV3135B5X	S11		1		P
PKB23005U	S11	М	RX1214B300Y	511	М	TIP130	5 <b>4</b> a	P
PKB25006T	S11	М	RXB12350Y	S11	M	TIP131	S <b>4</b> a	P
PKB32001U	S11	M	RZ1214B35Y	S11	М	TIP132	S4a	P
PKB32003U	S11	М	RZ1214B60W	S11	M	TIP135	S4a	P
PKB32005U	S11	М	RZ1214B65Y	S11	M	TIP136	S4a	P
PPC5001T	S11	М	RZ1214B125W	S11	M	TIP137	S4a	P
POC5001T	S11	м	RZ1214B125Y	S11	М	TIP140	S4a	P
PTB23001X	S11	M	RZ1214B150Y		M	TIP141	S4a	P
PTB23003X	S11	M	RZ2833B45W	S11	M	TIP145	S4a	P
	S11	M	RZ3135B15U	S11	M	TIP146	S4a	P
PTB23005X PTB32001X	S11	M	RZ3135B15W	S11	M	TIP147	54a	P
						m=n0055	24	
PTB32003X	S11	M	RZ3135B25U	S11	M	TIP2955	S4a	P P
PTB32005X	S11	M	RZ3135B30W	S11	M	TIP3055	S4a	-
PTB42001X	S11	M	RZB12100Y	S11	M	1N821;A	S1	Vr:
PTB42002X	S11	М	RZB12350Y	S11	M	1N823;A	S 1	۷r
PTB42003X	S11	M	RZZ1214B300	YS11	М	1N825;A	<b>S1</b>	۷r
PV3742B4X	S11	м	TIP29*	S4a	p	1N827;A	S1	۷r
PVB42004X	S11	м	TIP30*	S4a	P	1N829;A	S1	۷r
PZ 14 18B 15U	S11	М	TIP31*	S4a	P	1N914	S 1	SD
PZ1418B30U	S11	M	TIP32*	S4a	P	1N916	S1	SD
PZ1721B12U	S11	М	TIP33*	S4a	P	1N3879	S2a	R
PZ1721B25U	S11	М	TIP34*	S4a	P	1N3880	S2a	R
PZ2024B10U	S11	M	TIP41*	S4a	P	1N3881	S2a	R
PZ2024B100 PZ2024B20U	S11	M M	TIP42*	54a	P P	1N3882	52a	R
PZB16035U		M M	TIP47	54a 54a	p	1N3883	S2a S2a	R
	S11		TIP48	54a 54a	P	1N3889	S2a S2a	R
PZB27020U	S11	М	11140	Jad	r	1143003	32a	I
RPY58A	S8	Ph	TIP49	S4a	P	1N3890	S2a	R
RPY76B	S8	Ph	TIP50	S4a	P	1N3891	S2a	R
RPY86	S8	I	TIP110	S4a	P	1N3892	S2a	R
RPY87	S8	I	TIP111	S4a	P	1N3893	S2a	R
RPY88	S8	I	TIP112	S4a	P	1N3909	S2a	R

\* = series

I = Infrared devices

M = Microwave transistors

P = Low-frequency power transistors

Ph = Photoconductive devices

R = Rectifier diodes

RFP = R.F. power transistors and modules

SD = Small-signal diodes

Sm = Small-signal transistors

SP = Low-frequency switching power transistors

Vrf = Voltage reference diodes

type no.	book	section	type no.	book	section	type no.	book s	ection
1N3910	S2a	R	2N2369	·S3	Sm	2N4391	S5	FET
1N3910	S2a	R	2N2369A	S3	Sm	2N4392	S5	FET
1N3912	S2a	R	2N2483	S3	Sm	2N4393	S5	FET
1N3912	S2a	R	2N2484	S3	Sm	2N4427	S6	RFP
1N4001G	S1	R	2N2904	S3	Sm	2N4856	S5	FET
1140010	31	K	2112304	55	Ja	2114030	55	1151
1N4002G	S1	R	2N2904A	S3	Sm	2N4857	<b>S</b> 5	FET
1N4003G	S1	R	2N2905	s3	Sm	2N4858	S5	FET
1N4004G	S1	R	2N2905A	<b>S</b> 3	Sm	2N4859	S5	FET
1N4005G	S1	R	2N2906	<b>S</b> 3	Sm	2N4860	<b>S</b> 5	FET
1N4006G	S1	R	2 <b>N2906A</b>	s3	Sm	2N4861	\$5	FET
1N4007G	S1	R	2N2907	s3	Sm	2N5400	s3	Sm
1N4148	S1	SD	2N2907A	<b>S</b> 3	Sm	2N5401	S3	Sm
1N4150	S1	SD	2N3O19	53	Sm	2N5415	S3	Sm
1N4151	S1	SD	2N3O2O	53	Sm	2N5416	<b>S</b> 3	Sm
1N4153	S1	SD	2N3O53	S3	Sm	2 <b>N</b> 5550	<b>S</b> 3	Sm
4374446		an.	2N3375	S6	RFP	2N5551	s3	Sm
1N4446	S1	SD	2N3553	S6	RFP	2N6659	S5	FET
1N4448	S1	SD					S5	
1N4531	S1	SD	2N3632	S6	RFP	2N6660 2N6661	55 S5	FET
1N4532	S1	SD	2N3822	S5	FET			FET
1N5059	S1	R	2N3823	S5	FET	61SV	S8	Ι
1N5060	S1	R	2N3866	S6	RFP	375CQY/B	<b>S8</b>	Ph
1N5061	S1	R	2N39O3	<b>S</b> 3	Sm	497CQF/A	S8	Ph
1N5062	S1	R	2N39O4	<b>S</b> 3	Sm	498CQL	S8	Ph
1N5832	S2a	R	2N3905	S3	Sm	56201d	S4b	A
1N5833	S2a	R	2N3906	<b>S</b> 3	Sm	56201j	S4b	A
1N5834	S2a	R	2N3924	s6	RFP	56245	S3,10	. λ
1N6097	S2a S2a	R	2N3926	S6	RFP	56246	53,10	
1N6097	S2a S2a	R	2N3927	S6	RFP	56261a	S4b	A
2N918	S10	WBT	2N3966	S5	FET	56264a,b	S2a/k	
2N929	S3	Sm	2N4030	* <b>5</b> 3	Sm	56295	S2a/h	
0**0.00		_	2014024	<b>a</b> 2	a	56226	CAL	
2N930	S3	Sm	2N4O31	S3	Sm C==	56326	S4b	A
2N1613	S3	Sm	2N4032	S3	Sm	56339 56352	S4b	A
2N1711	S3	Sm C	2N4O33	S3	Sm		S4b	A
2N1893	S3	Sm C-	2N4091 2N4092	S5	FET	56353 56354	S4b	A A
2N2219	<b>S</b> 3	Sm	2114032	S5	FET	30334	S4b	A
2N2219A	<b>S</b> 3	Sm	2N4093	<b>S</b> 5	FET	56359b	S2,4b	
2N2222	<b>S</b> 3	Sm	2N4123	<b>S</b> 3	Sm	56359c	S2,4b	
2N2222A	<b>S</b> 3	Sm	2N4124	<b>S</b> 3	Sm	56359d	S2,4b	
2N2297	<b>S</b> 3	Sm	2N4125	S3	Sm	56360a	S2,4b	
2N2368	<b>S</b> 3	Sm	2N4126	S3	Sm	56363	S2,4b	A

A = Accessories

FET = Field-effect transistors

I = Infrared devices

Ph = Photoconductive devices

R = Rectifier diodes

RFP = R.F. power transistors and modules

SD = Small-signal diodes

Sm = Small-signal transistors

WBT= Wideband transistors

type no.	book	section
56364	S2,4b	
56367	52,4b S2a/b	
56368a	S2,4b	A
56368b	S2,4b	A
56369	S2,4b	A
56378	S2,4b	A
56379	S2,4b	A
56387a,b	S4b	A

NOTES

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