

PHILIPS

Data handbook



Electronic
components
and materials

Semiconductors

Part 4b November 1983

High - voltage and switching
power transistors

SEMICONDUCTORS

PART 4b - NOVEMBER 1983

HIGH-VOLTAGE AND SWITCHING POWER TRANSISTORS

DATA HANDBOOK SYSTEM
SEMICONDUCTOR INDEX

TYPE NUMBER SURVEY
SELECTION GUIDE

GENERAL

TRANSISTOR DATA

MOUNTING INSTRUCTIONS

ACCESSORIES



DATA HANDBOOK SYSTEM

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

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

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

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

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

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COMPONENTS AND MATERIALS (GREEN SERIES)

The green series of data handbooks is comprised of the following parts:

- C1 Assemblies for industrial use**
PLC modules, PC20 modules, HNIL FZ/30 series, NORbits 60-, 61-, 90-series, input devices, hybrid ICs
- C2 Television tuners, video modulators, surface acoustic wave filters**
- C3 Loudspeakers**
- C4 Ferroxcube potcores, square cores and cross cores**
- C5 Ferroxcube for power, audio/video and accelerators**
- C6 Electric motors and accessories**
Permanent magnet synchronous motors, stepping motors, direct current motors
- C7 Variable capacitors**
- C8 Variable mains transformers**
- C9 Piezoelectric quartz devices**
Quartz crystal units, temperature compensated crystal oscillators, compact integrated oscillators, quartz crystal cuts for temperature measurements
- C10 Connectors**
- C11 Non-linear resistors**
Voltage dependent resistors (VDR), light dependent resistors (LDR), negative temperature coefficient thermistors (NTC), positive temperature coefficient thermistors (PTC)
- C12 Variable resistors and test switches**
- C13 Fixed resistors**
- C14 Electrolytic and solid capacitors**
- C15 Film capacitors, ceramic capacitors**
- C16 Piezoelectric ceramics, permanent magnet materials**

ELECTRON TUBES (BLUE SERIES)

The blue series of data handbooks is comprised of the following parts:

- T1 Tubes for r.f. heating**
- T2 Transmitting tubes for communications**
- T3 Klystrons, travelling-wave tubes, microwave diodes**
- ET3 Special Quality tubes, miscellaneous devices (will not be reprinted)**
- T4 Magnetrons**
- T5 Cathode-ray tubes**
Instrument tubes, monitor and display tubes, C.R. tubes for special applications
- T6 Geiger-Müller tubes**
- T7 Gas-filled tubes**
Segment indicator tubes, indicator tubes, dry reed contact units, thyratrons, industrial rectifying tubes, ignitrons, high-voltage rectifying tubes, associated accessories
- T8 Picture tubes and components**
Colour TV picture tubes, black and white TV picture tubes, colour monitor tubes for data graphic display, monochrome monitor tubes for data graphic display, components for colour television, components for black and white television and monochrome data graphic display
- T9 Photo and electron multipliers**
Photomultiplier tubes, phototubes, single channel electron multipliers, channel electron multiplier plates
- T10 Camera tubes and accessories, image intensifiers**
- T11 Microwave semiconductors and components**

SEMICONDUCTORS (RED SERIES)

The red series of data handbooks is comprised of the following parts:

- S1 Diodes**
Small-signal germanium diodes, small-signal silicon diodes, voltage regulator diodes(< 1,5 W), voltage reference diodes, tuner diodes, rectifier diodes
- S2 Power diodes, thyristors, triacs**
Rectifier diodes, voltage regulator diodes (> 1,5 W), rectifier stacks, thyristors, triacs
- S3 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**
- S7 Microminiature semiconductors for hybrid circuits**
- S8 Devices for optoelectronics**
Photosensitive diodes and transistors, light-emitting diodes, displays, photocouplers, infrared sensitive devices, photoconductive devices.
- S9 Taken into handbook T11 of the blue series**
- S10 Wideband transistors and wideband hybrid IC modules**

INTEGRATED CIRCUITS (PURPLE SERIES)

The purple series of data handbooks is comprised of the following parts:

- IC1 Bipolar ICs for radio and audio equipment
- IC2 Bipolar ICs for video equipment
- IC3 ICs for digital systems in radio, audio and video equipment
- IC4 Digital integrated circuits
CMOS HE4000B family
- IC5 Digital integrated circuits – ECL
ECL10 000 (GX family), ECL100 000 (HX family), dedicated designs
- IC6 Professional analogue integrated circuits
- IC7 Signetics bipolar memories
- IC8 Signetics analogue circuits
- IC9 Signetics TTL logic
- IC10 Signetics Integrated Fuse Logic (IFL)
- IC11 Microprocessors, microcomputers and peripheral circuitry

INDEX OF TYPE NUMBERS

Data Handbooks S1 to S10

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

type no.	book	section	type no.	book	section	type no.	book	section
AA119	S1	GD	BAS19	S7/S1	Mm/SD	BB109G	S1	T
AAZ15	S1	GD	BAS20	S7/S1	Mm/SD	BB112	S1	T
AAZ17	S1	GD	BAS21	S7/S1	Mm/SD	BB119	S1	T
AAZ18	S1	GD	BAT17	S7/S1	Mm/T	BB130	S1	T
BA220	S1	SD	BAT18	S7/S1	Mm/T	BB204B	S1	T
BA221	S1	SD	BAT81	S1	T	BB204G	S1	T
BA223	S1	T	BAT82	S1	T	BB212	S1	T
BA243	S1	T	BAT83	S1	T	BB405B	S1	T
BA244	S1	T	BAT85	S1	T	BB405G	S1	T
BA280	S1	T	BAV10	S1	SD	BB417	S1	T
BA314	S1	Vrg	BAV18	S1	SD	BB809	S1	T
BA315	S1	Vrg	BAV19	S1	SD	BB909A	S1	T
BA316	S1	SD	BAV20	S1	SD	BB909B	S1	T
BA317	S1	SD	BAV21	S1	SD	BBY31	S7/S1	Mm/T
BA318	S1	SD	BAV45	S1	Sp	BBY40	S7/S1	Mm/T
BA379	S1	T	BAV70	S7/S1	Mm/SD	BC107	S3	Sm
BA423	S1	T	BAV99	S7/S1	Mm/SD	BC108	S3	Sm
BA481	S1	T	BAW56	S7/S1	Mm/SD	BC109	S3	Sm
BA482	S1	T	BAW62	S1	SD	BC146	S3	Sm
BA483	S1	T	BAX12	S1	SD	BC177	S3	Sm
BA484	S1	T	BAX12A	S1	SD	BC178	S3	Sm
BAS11	S1	SD	BAX14	S1	SD	BC179	S3	Sm
BAS16	S7/S1	Mm/SD	BAX18	S1	SD	BC200	S3	Sm
BAS17	S7/S1	Mm/Vrg	BB105B	S1	T	BC264A	S5	FET
BAS18	S1	SD	BB105G	S1	T	BC264B	S5	FET

FET = Field-effect transistors
 GD = Germanium diodes
 Mm = Microminiature semiconductors
 for hybrid circuits
 SD = Small-signal diodes

Sm = Small-signal transistors
 Sp = Special diodes
 T = Tuner diodes
 Vrg = Voltage regulator diodes

type no.	book	section	type no.	book	section	type no.	book	section
BC264C	S5	FET	BC868	S7	Mm	BCY71	S3	Sm
BC264D	S5	FET	BC869	S7	Mm	BCY72	S3	Sm
BC327;A	S3	Sm	BCF29;R	S7	Mm	BCY78	S3	Sm
BC328	S3	Sm	BCF30;R	S7	Mm	BCY79	S3	Sm
BC337;A	S3	Sm	BCF32;R	S7	Mm	BCY87	S3	Sm
BC338	S3	Sm	BCF33;R	S7	Mm	BCY88	S3	Sm
BC368	S3	Sm	BCF70;R	S7	Mm	BCY89	S3	Sm
BC369	S3	Sm	BCF81;R	S7	Mm	BD131	S4a	P
BC375	S3	Sm	BCV71;R	S7	Mm	BD132	S4a	P
BC376	S3	Sm	BCV72;R	S7	Mm	BD135	S4a	P
BC546	S3	Sm	BCW29;R	S7	Mm	BD136	S4a	P
BC547	S3	Sm	BCW30;R	S7	Mm	BD137	S4a	P
BC548	S3	Sm	BCW31;R	S7	Mm	BD138	S4a	P
BC549	S3	Sm	BCW32;R	S7	Mm	BD139	S4a	P
BC550	S3	Sm	BCW33;R	S7	Mm	BD140	S4a	P
BC556	S3	Sm	BCW60*	S7	Mm	BD201	S4a	P
BC557	S3	Sm	BCW61*	S7	Mm	BD202	S4a	P
BC558	S3	Sm	BCW69;R	S7	Mm	BD203	S4a	P
BC559	S3	Sm	BCW70;R	S7	Mm	BD204	S4a	P
BC560	S3	Sm	BCW71;R	S7	Mm	BD226	S4a	P
BC635	S3	Sm	BCW72;R	S7	Mm	BD227	S4a	P
BC636	S3	Sm	BCW81;R	S7	Mm	BD228	S4a	P
BC637	S3	Sm	BCW89;R	S7	Mm	BD229	S4a	P
BC638	S3	Sm	BCX17;R	S7	Mm	BD230	S4a	P
BC639	S3	Sm	BCX18;R	S7	Mm	BD231	S4a	P
BC640	S3	Sm	BCX19;R	S7	Mm	BD233	S4a	P
BC807	S7	Mm	BCX20;R	S7	Mm	BD234	S4a	P
BC808	S7	Mm	BCX51	S7	Mm	BD235	S4a	P
BC817	S7	Mm	BCX52	S7	Mm	BD236	S4a	P
BC818	S7	Mm	BCX53	S7	Mm	BD237	S4a	P
BC846	S7	Mm	BCX54	S7	Mm	BD238	S4a	P
BC847	S7	Mm	BCX55	S7	Mm	BD239	S4a	P
BC848	S7	Mm	BCX56	S7	Mm	BD239A	S4a	P
BC849	S7	Mm	BCX70*	S7	Mm	BD239B	S4a	P
BC850	S7	Mm	BCX71*	S7	Mm	BD239C	S4a	P
BC856	S7	Mm	BCY56	S3	Sm	BD240	S4a	P
BC857	S7	Mm	BCY57	S3	Sm	BD240A	S4a	P
BC858	S7	Mm	BCY58	S3	Sm	BD240B	S4a	P
BC859	S7	Mm	BCY59	S3	Sm	BD240C	S4a	P
BC860	S7	Mm	BCY70	S3	Sm	BD241	S4a	P

* = series

FET = Field-effect transistors

Mm = Microminiature semiconductors
for hybrid circuits

P = Low-frequency power transistors

Sm = Small-signal transistors

type no.	book	section	type no.	book	section	type no.	book	section
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
BD242A	S4a	P	BD680	S4a	P	BD944	S4a	P
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
BD243A	S4a	P	BD684	S4a	P	BD948	S4a	P
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
BD244A	S4a	P	BD816	S4a	P	BD952	S4a	P
BD244B	S4a	P	BD817	S4a	P	BD953	S4a	P
BD244C	S4a	P	BD818	S4a	P	BD954	S4a	P
BD329	S4a	P	BD825	S4a	P	BD955	S4a	P
BD330	S4a	P	BD826	S4a	P	BD956	S4a	P
BD331	S4a	P	BD827	S4a	P	BDT20	S4a	P
BD332	S4a	P	BD828	S4a	P	BDT21	S4a	P
BD333	S4a	P	BD829	S4a	P	BDT29	S4a	P
BD334	S4a	P	BD830	S4a	P	BDT29A	S4a	P
BD335	S4a	P	BD839	S4a	P	BDT29B	S4a	P
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
BD433	S4a	P	BD843	S4a	P	BDT30B	S4a	P
BD434	S4a	P	BD844	S4a	P	BDT30C	S4a	P
BD435	S4a	P	BD845	S4a	P	BDT31	S4a	P
BD436	S4a	P	BD846	S4a	P	BDT31A	S4a	P
BD437	S4a	P	BD847	S4a	P	BDT31B	S4a	P
BD438	S4a	P	BD848	S4a	P	BDT31C	S4a	P
BD645	S4a	P	BD849	S4a	P	BDT32	S4a	P
BD646	S4a	P	BD850	S4a	P	BDT32A	S4a	P
BD647	S4a	P	BD933	S4a	P	BDT32B	S4a	P
BD648	S4a	P	BD934	S4a	P	BDT32C	S4a	P
BD649	S4a	P	BD935	S4a	P	BDT41	S4a	P
BD650	S4a	P	BD936	S4a	P	BDT41A	S4a	P
BD651	S4a	P	BD937	S4a	P	BDT41B	S4a	P
BD652	S4a	P	BD938	S4a	P	BDT41C	S4a	P
BD675	S4a	P	BD939	S4a	P	BDT42	S4a	P

P = Low-frequency power transistors

type no.	book	section	type no.	book	section	type no.	book	section
BDT42A	S4a	P	BDV65C	S4a	P	BDX64B	S4a	P
BDT42B	S4a	P	BDV66A	S4a	P	BDX64C	S4a	P
BDT42C	S4a	P	BDV66B	S4a	P	BDX65	S4a	P
BDT60	S4a	P	BDV66C	S4a	P	BDX65A	S4a	P
BDT60A	S4a	P	BDV66D	S4a	P	BDX65B	S4a	P
BDT60B	S4a	P	BDV67A	S4a	P	BDX65C	S4a	P
BDT60C	S4a	P	BDV67B	S4a	P	BDX66	S4a	P
BDT61	S4a	P	BDV67C	S4a	P	BDX66A	S4a	P
BDT61A	S4a	P	BDV67D	S4a	P	BDX66B	S4a	P
BDT61B	S4a	P	BDV91	S4a	P	BDX66C	S4a	P
BDT61C	S4a	P	BDV92	S4a	P	BDX67	S4a	P
BDT62	S4a	P	BDV93	S4a	P	BDX67A	S4a	P
BDT62A	S4a	P	BDV94	S4a	P	BDX67B	S4a	P
BDT62B	S4a	P	BDV95	S4a	P	BDX67C	S4a	P
BDT62C	S4a	P	BDV96	S4a	P	BDX68	S4a	P
BDT63	S4a	P	BDW55	S4a	P	BDX68A	S4a	P
BDT63A	S4a	P	BDW56	S4a	P	BDX68B	S4a	P
BDT63B	S4a	P	BDW57	S4a	P	BDX68C	S4a	P
BDT63C	S4a	P	BDW58	S4a	P	BDX69	S4a	P
BDT64	S4a	P	BDW59	S4a	P	BDX69A	S4a	P
BDT64A	S4a	P	BDW60	S4a	P	BDX69B	S4a	P
BDT64B	S4a	P	BDX35	S4a	P	BDX69C	S4a	P
BDT64C	S4a	P	BDX36	S4a	P	BDX77	S4a	P
BDT65	S4a	P	BDX37	S4a	P	BDX78	S4a	P
BDT65A	S4a	P	BDX42	S4a	P	BDX91	S4a	P
BDT65B	S4a	P	BDX43	S4a	P	BDX92	S4a	P
BDT65C	S4a	P	BDX44	S4a	P	BDX93	S4a	P
BDT91	S4a	P	BDX45	S4a	P	BDX94	S4a	P
BDT92	S4a	P	BDX46	S4a	P	BDX95	S4a	P
BDT93	S4a	P	BDX47	S4a	P	BDX96	S4a	P
BDT94	S4a	P	BDX62	S4a	P	BDY90	S4a	P
BDT95	S4a	P	BDX62A	S4a	P	BDY90A	S4a	P
BDT96	S4a	P	BDX62B	S4a	P	BDY91	S4a	P
BDV64	S4a	P	BDX62C	S4a	P	BDY92	S4a	P
BDV64A	S4a	P	BDX63	S4a	P	BF180	S3	Sm
BDV64B	S4a	P	BDX63A	S4a	P	BF181	S3	Sm
BDV64C	S4a	P	BDX63B	S4a	P	BF182	S3	Sm
BDV65	S4a	P	BDX63C	S4a	P	BF183	S3	Sm
BDV65A	S4a	P	BDX64	S4a	P	BF198	S3	Sm
BDV65B	S4a	P	BDX64A	S4a	P	BF199	S3	Sm

P = Low-frequency power transistors
 Sm = Small-signal transistors

type no.	book	section	type no.	book	section	type no.	book	section
BF200	S3	Sm	BF569	S7	Mm	BFG91A	S10	WBT
BF240	S3	Sm	BF579	S7	Mm	BFG96	S10	WBT
BF241	S3	Sm	BF620	S7	Mm	BFP90A	S10	WBT
BF245A	S5	FET	BF621	S7	Mm	BFP91A	S10	WBT
BF245B	S5	FET	BF622	S7	Mm	BFP96	S10	WBT
BF245C	S5	FET	BF623	S7	Mm	BFQ10	S5	FET
BF246A	S5	FET	BF660;R	S7	Mm	BFQ11	S5	FET
BF246B	S5	FET	BF689K	S10	WBT	BFQ12	S5	FET
BF246C	S5	FET	BF767	S7	Mm	BFQ13	S5	FET
BF256A	S5	FET	BF819	S4b	HVP	BFQ14	S5	FET
BF256B	S5	FET	BF820	S7	Mm	BFQ15	S5	FET
BF256C	S5	FET	BF821	S7	Mm	BFQ16	S5	FET
BF324	S3	Sm	BF822	S7	Mm	BFQ17	S7	Mm
BF370	S3	Sm	BF823	S7	Mm	BFQ18A	S7	Mm
BF410A	S5	FET	BF857	S4b	HVP	BFQ19	S7	Mm
BF410B	S5	FET	BF858	S4b	HVP	BFQ22	S10	WBT
BF410C	S5	FET	BF859	S4b	HVP	BFQ22S	S10	WBT
BF410D	S5	FET	BF869	S4b	HVP	BFQ23	S10	WBT
BF419	S4b	HVP	BF870	S4b	HVP	BFQ24	S10	WBT
BF422	S3	Sm	BF871	S4b	HVP	BFQ32	S10	WBT
BF423	S3	Sm	BF872	S4b	HVP	BFQ33	S10	WBT
BF450	S3	Sm	BF926	S3	Sm	BFQ34	S10	WBT
BF451	S3	Sm	BF936	S3	Sm	BFQ34T	S10	WBT
BF457	S4b	HVP	BF939	S3	Sm	BFQ42	S6	RFP
BF458	S4b	HVP	BF960	S5	FET	BFQ43	S6	RFP
BF459	S4b	HVP	BF964	S5	FET	BFQ51	S10	WBT
BF469	S4b	HVP	BF966	S5	FET	BFQ52	S10	WBT
BF470	S4b	HVP	BF967	S3	Sm	BFQ53	S10	WBT
BF471	S4b	HVP	BF970	S3	Sm	BFQ63	S10	WBT
BF472	S4b	HVP	BF979	S3	Sm	BFQ65	S10	WBT
BF480	S3	Sm	BF980	S5	FET	BFQ66	S10	WBT
BF494	S3	Sm	BF981	S5	FET	BFQ68	S10	WBT
BF495	S3	Sm	BF982	S5	FET	BFR29	S5	FET
BF496	S3	Sm	BF989	S7	Mm	BFR30	S7	Mm
BF510	S7	Mm	BF990	S7	Mm	BFR31	S7	Mm
BF511	S7	Mm	BF991	S7	Mm	BFR49	S10	WBT
BF512	S7	Mm	BF992	S7	Mm	BFR53;R	S7	Mm
BF513	S7	Mm	BF994	S7	Mm	BFR54	S3	Sm
BF536	S7	Mm	BF996	S7	Mm	BFR64	S10	WBT
BF550;R	S7	Mm	BFG90A	S10	WBT	BFR65	S10	WBT

FET = Field-effect transistors
 HVP = High-voltage power transistors
 Mm = Microminiature semiconductors
 for hybrid circuits

RFP = R.F. power transistors and modules
 Sm = Small-signal transistors
 WBT = Wideband hybrid IC transistors

type no.	book	section	type no.	book	section	type no.	book	section
BFR84	S5	FET	BFX29	S3	Sm	BGY55	S10	WBM
BFR90	S10	WBT	BFX30	S3	Sm	BGY56	S10	WBM
BFR90A	S10	WBT	BFX34	S3	Sm	BGY57	S10	WBM
BFR91	S10	WBT	BFX84	S3	Sm	BGY58	S10	WBM
BFR91A	S10	WBT	BFX85	S3	Sm	BGY58A	S10	WBT
BFR92;R	S7	Mm	BFX86	S3	Sm	BGY59	S10	WBM
BFR92A;R	S7	Mm	BFX87	S3	Sm	BGY60	S10	WBM
BFR93;R	S7	Mm	BFX88	S3	Sm	BGY61	S10	WBT
BFR93A;R	S7	Mm	BFX89	S10	WBT	BGY65	S10	WBT
BFR94	S10	WBT	BFY50	S3	Sm	BGY67	S10	WBT
BFR95	S10	WBT	BFY51	S3	Sm	BGY70	S10	WBT
BFR96	S10	WBT	BFY52	S3	Sm	BGY71	S10	WBT
BFR96S	S10	WBT	BFY55	S3	Sm	BGY74	S10	WBM
BFR101A;B	S7	Mm	BFY90	S10	WBT	BGY75	S10	WBM
BFS17;R	S7	Mm	BG2000	S1	RT	BLV10	S6	RFP
BFS18;R	S7	Mm	BG2097	S1	RT	BLV11	S6	RFP
BFS19;R	S7	Mm	BGX11*	S2	ThM	BLV20	S6	RFP
BFS20;R	S7	Mm	BGX12*	S2	ThM	BLV21	S6	RFP
BFS21	S5	FET	BGX13*	S2	ThM	BLV25	S6	RFP
BFS21A	S5	FET	BGX14*	S2	ThM	BLV30	S6	RFP
BFS22A	S6	RFP	BGX15*	S2	ThM	BLV31	S6	RFP
BFS23A	S6	RFP	BGX17*	S2	ThM	BLV32F	S6	RFP
BFT24	S10	WBT	BGY22	S6	RFP	BLV33	S6	RFP
BFT25;R	S7	Mm	BGY22A	S6	RFP	BLV33F	S6	RFP
BFT44	S3	Sm	BGY23	S6	RFP	BLV36	S6	RFP
BFT45	S3	Sm	BGY23A	S6	RFP	BLV57	S6	RFP
BFT46	S7	Mm	BGY32	S6	RFP	BLW29	S6	RFP
BFT92;R	S7	Mm	BGY33	S6	RFP	BLW31	S6	RFP
BFT93;R	S7	Mm	BGY35	S6	RFP	BLW32	S6	RFP
BFW10	S5	FET	BGY36	S6	RFP	BLW33	S6	RFP
BFW11	S5	FET	BGY40A	S6	RFP	BLW34	S6	RFP
BFW12	S5	FET	BGY40B	S6	RFP	BLW50F	S6	RFP
BFW13	S5	FET	BGY41A	S6	RFP	BLW60	S6	RFP
BFW16A	S10	WBT	BGY41B	S6	RFP	BLW60C	S6	RFP
BFW17A	S10	WBT	BGY43	S6	RFP	BLW64	S6	RFP
BFW30	S10	WBT	BGY50	S10	WBM	BLW75	S6	RFP
BFW61	S5	FET	BGY51	S10	WBM	BLW76	S6	RFP
BFW92	S10	WBT	BGY52	S10	WBM	BLW77	S6	RFP
BFW92A	S10	WBT	BGY53	S10	WBM	BLW78	S6	RFP
BFW93	S10	WBT	BGY54	S10	WBM	BLW79	S6	RFP

* = 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
BLW80	S6	RFP	BLY87A	S6	RFP	BSR18;R	S7	Mm
BLW81	S6	RFP	BLY87C	S6	RFP	BSR18A;R	S7	Mm
BLW82	S6	RFP	BLY88A	S6	RFP	BSR30	S7	Mm
BLW83	S6	RFP	BLY88C	S6	RFP	BSR31	S7	Mm
BLW84	S6	RFP	BLY89A	S6	RFP	BSR32	S7	Mm
BLW85	S6	RFP	BLY89C	S6	RFP	BSR33	S7	Mm
BLW86	S6	RFP	BLY90	S6	RFP	BSR40	S7	Mm
BLW87	S6	RFP	BLY91A	S6	RFP	BSR41	S7	Mm
BLW89	S6	RFP	BLY91C	S6	RFP	BSR42	S7	Mm
BLW90	S6	RFP	BLY92A	S6	RFP	BSR43	S7	Mm
BLW91	S6	RFP	BLY92C	S6	RFP	BSR50	S3	Sm
BLW95	S6	RFP	BLY93A	S6	RFP	BSR51	S3	Sm
BLW96	S6	RFP	BLY93C	S6	RFP	BSR52	S3	Sm
BLW98	S6	RFP	BLY94	S6	RFP	BSR56	S7	Mm
BLX13	S6	RFP	BLY97	S6	RFP	BSR57	S7	Mm
BLX13C	S6	RFP	BPF10	S8	PDT	BSR58	S7	Mm
BLX14	S6	RFP	BPF24	S8	PDT	BSR60	S3	Sm
BLX15	S6	RFP	BPW22A	S8	PDT	BSR61	S3	Sm
BLX39	S6	RFP	BPW50	S8	PDT	BSR62	S3	Sm
BLX65	S6	RFP	BPX25	S8	PDT	BSS38	S3	Sm
BLX66	S6	RFP	BPX29	S8	PDT	BSS50	S3	Sm
BLX67	S6	RFP	BPX40	S8	PDT	BSS51	S3	Sm
BLX68	S6	RFP	BPX41	S8	PDT	BSS52	S3	Sm
BLX69A	S6	RFP	BPX42	S8	PDT	BSS60	S3	Sm
BLX91A	S6	RFP	BPX71	S8	PDT	BSS61	S3	Sm
BLX92A	S6	RFP	BPX72	S8	PDT	BSS62	S3	Sm
BLX93A	S6	RFP	BPX95C	S8	PDT	BSS63;R	S7	Mm
BLX94A	S6	RFP	BR100/03	S2	Th	BSS64;R	S7	Mm
BLX94C	S6	RFP	BR101	S3	Sm	BSS68	S3	Sm
BLX95	S6	RFP	BRY39	S3	Sm	BST15	S7	Mm
BLX96	S6	RFP	BRY56	S3	Sm	BST16	S7	Mm
BLX97	S6	RFP	BRY61	S7	Mm	BST50	S7	Mm
BLX98	S6	RFP	BRY62	S7	Mm	BST51	S7	Mm
BLY33	S6	RFP	BSR12;R	S7	Mm	BST52	S7	Mm
BLY34	S6	RFP	BSR13;R	S7	Mm	BST60	S7	Mm
BLY35	S6	RFP	BSR14;R	S7	Mm	BST61	S7	Mm
BLY36	S6	RFP	BSR15;R	S7	Mm	BST62	S7	Mm
BLY83	S6	RFP	BSR16;R	S7	Mm	BSV15	S3	Sm
BLY84	S6	RFP	BSR17;R	S7	Mm	BSV16	S3	Sm
BLY85	S6	RFP	BSR17A;R	S7	Mm	BSV17	S3	Sm

Mm = Microminiature semiconductors
for hybrid circuits
PDT = Photodiodes or transistors

RFP = R.F. power transistors and modules
Sm = Small-signal transistors
Th = Thyristors

INDEX

type no.	book	section	type no.	book	section	type no.	book	section
BSV52;R	S7	Mm	BTW58*	S2	Th	BUX82	S4b	SP
BSV64	S3	Sm	BTW63*	S2	Th	BUX83	S4b	SP
BSV78	S5	FET	BTW92*	S2	Th	BUX84	S4b	SP
BSV79	S5	FET	BTX18*	S2	Th	BUX85	S4b	SP
BSV80	S5	FET	BTX94*	S2	Tri	BUX86	S4b	SP
BSV81	S5	FET	BTY79*	S2	Th	BUX87	S4b	SP
BSW66A	S3	Sm	BTY87*	S2	Th	BUX88	S4b	SP
BSW67A	S3	Sm	BTY91*	S2	Th	BUX90	S4b	SP
BSW68A	S3	Sm	BU208A	S4b	SP	BUX98	S4b	SP
BSX19	S3	Sm	BU208B	S4b	SP	BUX98A	S4b	SP
BSX20	S3	Sm	BU326	S4b	SP	BUY89	S4b	SP
BSX45	S3	Sm	BU326A	S4b	SP	BY184	S1	R
BSX46	S3	Sm	BU426	S4b	SP	BY188G	S1	R
BSX47	S3	Sm	BU426A	S4b	SP	BY223	S2	R
BSX59	S3	Sm	BU433	S4b	SP	BY224*	S2	R
BSX60	S3	Sm	BU505	S4b	SP	BY225*	S2	R
BSX61	S3	Sm	BU508A	S4b	SP	BY228	S1	R
BSY95A	S3	Sm	BU705	S4b	SP	BY229*	S2	R
BT136*	S2	Tri	BU806	S4b	SP	BY249	S2	R
BT137*	S2	Tri	BU807	S4b	SP	BY260*	S2	R
BT138*	S2	Tri	BU824	S4b	SP	BY261*	S2	R
BT139*	S2	Tri	BU826	S4b	SP	BY277*	S2	R
BT149*	S2	Th	BUS11;A	S4b	SP	BY438	S1	R
BT151*	S2	Th	BUS12;A	S4b	SP	BY448	S1	R
BT152*	S2	Th	BUS13;A	S4b	SP	BY458	S1	R
BT153	S2	Th	BUS14;A	S4b	SP	BY476	S1	R
BT154	S2	Th	BUT11;A	S4b	SP	BY477	S1	R
BT155*	S2	Th	BUV82	S4b	SP	BY478	S1	R
BTV24*	S2	Th	BUV83	S4b	SP	BY505	S1	R
BTV34*	S2	Tri	BUV89	S4b	SP	BY509	S1	R
BTV58*	S2	Th	BUW11;A	S4b	SP	BY527	S1	R
BTW23*	S2	Th	BUW12;A	S4b	SP	BY584	S1	R
BTW30S*	S2	Th	BUW13;A	S4b	SP	BY609	S1	R
BTW31W*	S2	Th	BUW84	S4b	SP	BY610	S1	R
BTW38*	S2	Th	BUW85	S4b	SP	BYV20	S2	R
BTW40*	S2	Th	BUX46;A	S4b	SP	BYV21*	S2	R
BTW42*	S2	Th	BUX47;A	S4b	SP	BYV22	S2	R
BTW43*	S2	Tri	BUX48;A	S4b	SP	BYV23	S2	R
BTW45*	S2	Th	BUX80	S4b	SP	BYV24	S2	R
BTW47*	S2	Th	BUX81	S4b	SP	BYV27	S1	R

* = series

FET = Field-effect transistors
Mm = Microminiature semiconductors
for hybrid circuits

R = Rectifier diodes

Sm = Small-signal transistors

SP = Low-frequency switching power transistors

Th = Thyristors

Tri = Triacs

type no.	book	section	type no.	book	section	type no.	book	section
BYV28	S1	R	BYX90	S1	R	CNX38	S8	PhC
BYV30*	S2	R	BYX91*	S1	R	CNX44	S8	PhC
BYV32*	S2	R	BYX94	S1	R	CNX48	S8	PhC
BYV92*	S2	R	BYX96*	S2	R	CNX62	S8	PhC
BYV95A	S1	R	BYX97*	S2	R	CNY50	S8	PhC
BYV95B	S1	R	BYX98*	S2	R	CNY52	S8	PhC
BYV95C	S1	R	BYX99*	S2	R	CNY53	S8	PhC
BYV96D	S1	R	BZT03	S1	Vrg	CNY57	S8	PhC
BYV96E	S1	R	BZV10	S1	Vrf	CNY57A	S8	PhC
BYW19*	S2	R	BZV11	S1	Vrf	CNY62	S8	PhC
BYW25	S2	R	BZV12	S1	Vrf	CNY63	S8	PhC
BYW29*	S2	R	BZV13	S1	Vrf	CQ209S	S8	D
BYW30*	S2	R	BZV14	S1	Vrf	CQ216X	S8	D
BYW31*	S2	R	BZV15*	S2	Vrf	CQ216Y	S8	D
BYW54	S1	R	BZV37	S1	Vrf	CQ327;R	S8	D
BYW55	S1	R	BZV46	S1	Vrg	CQ330;R	S8	D
BYW56	S1	R	BZV49*	S1/S7	Vrg	CQ331;R	S8	D
BYW92*	S2	R	BZV85	S1	Vrg	CQ332;R	S8	D
BYW93*	S2	R	BZW70*	S2	TS	CQ427;R	S8	D
BYW94*	S2	R	BZW86*	S2	TS	CQ430;R	S8	D
BYW95A	S1	R	BZW91*	S2	TS	CQ431;R	S8	D
BYW95B	S1	R	BZX55	S1	Vrg	CQ432;R	S8	D
BYW95C	S1	R	BZX70*	S2	Vrg	CQF24	S8	Ph
BYW96D	S1	R	BZX75	S1	Vrg	CQL10A	S8	Ph
BYW96E	S1	R	BZX79*	S1	Vrg	CQL13	S8	Ph
BYX10	S1	R	BZX84*	S7/S1	Mm/Vrg	CQL13A	S8	Ph
BYX22*	S2	R	BZX87*	S1	Vrg	CQL14A	S8	Ph
BYX25*	S2	R	BZX90	S1	Vrf	CQL14B	S8	Ph
BYX30*	S2	R	BZX91	S1	Vrf	CQN10	S8	LED
BYX32*	S2	R	BZX92	S1	Vrf	CQN11	S8	LED
BYX38*	S2	R	BZX93	S1	Vrf	CQT10	S8	LED
BYX39*	S2	R	BZX94	S1	Vrf	CQT11	S8	LED
BYX42*	S2	R	BZY91*	S2	Vrg	CQT12	S8	LED
BYX45*	S2	R	BZY93*	S2	Vrg	CQV60(L)	S8	LED
BYX46*	S2	R	BZY95*	S2	Vrg	CQV60A(L)	S8	LED
BYX49*	S2	R	BZY96*	S2	Vrg	CQV61A(L)	S8	LED
BYX50*	S2	R	CNX21	S8	PhC	CQV62(L)	S8	LED
BYX52*	S2	R	CNX35	S8	PhC	CQV70(L)	S8	LED
BYX56*	S2	R	CNX36	S8	PhC	CQV70A(L)	S8	LED
BYX71*	S2	R	CNX37	S8	PhC	CQV71A(L)	S8	LED

* = series

D = Displays

LED = Light emitting diodes

Mm = Microminiature semiconductors
for hybrid circuits

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
CQV72(L)	S8	LED	CQY97A	S8	LED	PH40*	S2	R
CQV80L	S8	LED	0A90	S1	GD	PH70*	S2	R
CQV80AL	S8	LED	0A91	S1	GD	RPY58A	S8	Ph
CQV81L	S8	LED	0A95	S1	GD	RPY76B	S8	Ph
CQV82L	S8	LED	OM320	S10	WBM	RPY86	S8	I
CQW10(L)	S8	LED	OM321	S10	WBM	RPY87	S8	I
CQW10A(L)	S8	LED	OM322	S10	WBM	RPY88	S8	I
CQW10B(L)	S8	LED	OM323	S10	WBM	RPY89	S8	I
CQW11A(L)	S8	LED	OM323A	S10	WBM	RPY90*	S8	I
CQW11B(L)	S8	LED	OM335	S10	WBM	RPY91*	S8	I
CQW12(L)	S8	LED	OM336	S10	WBM	RPY93	S8	I
CQW12B(L)	S8	LED	OM337	S10	WBM	RPY94	S8	I
CQW20A	S8	LED	OM337A	S10	WBM	RPY95	S8	I
CQW21	S8	LED	OM339	S10	WBM	RPY96	S8	I
CQW22	S8	LED	OM345	S10	WBM	RPY97	S8	I
CQW24(L)	S8	LED	OM350	S10	WBM	RTC901	S8	Ar
CQW54	S8	LED	OM360	S10	WBM	RTC902	S8	Ar
CQX10	S8	LED	OM361	S10	WBM	RTC903	S8	Ar
CQX11	S8	LED	OM370	S10	WBM	RTC904	S8	Ar
CQX12	S8	LED	OM931	S4a	P	1N821;A	S1	Vrf
CQX24(L)	S8	LED	OM961	S4a	P	1N823;A	S1	Vrf
CQX51	S8	LED	OSB9110	S2	St	1N825;A	S1	Vrf
CQX54(L)	S8	LED	OSB9210	S2	St	1N827;A	S1	Vrf
CQX64(L)	S8	LED	OSB9410	S2	St	1N829;A	S1	Vrf
CQX74(L)	S8	LED	OSM9110	S2	St	1N914	S1	SD
CQX74Y	S8	LED	OSM9210	S2	St	1N916	S1	SD
CQY11B	S8	LED	OSM9410	S2	St	1N3879	S2	R
CQY11C	S8	LED	OSM9510	S2	St	1N3880	S2	R
CQY24B(L)	S8	LED	OSM9511	S2	St	1N3881	S2	R
CQY49B	S8	LED	OSM9512	S2	St	1N3882	S2	R
CQY49C	S8	LED	OSS9110	S2	St	1N3889	S2	R
CQY50	S8	LED	OSS9210	S2	St	1N3890	S2	R
CQY52	S8	LED	OSS9410	S2	St	1N3891	S2	R
CQY54A	S8	LED	PH2222;R	S3	Sm	1N3892	S2	R
CQY58A	S8	LED	PH2222A;RS3	S3	Sm	1N3899	S2	R
CQY89A	S8	LED	PH2369	S3	Sm	1N3900	S2	R
CQY94	S8	LED	PH2907;R	S3	Sm	1N3901	S2	R
CQY94B(L)	S8	LED	PH2907A;RS3	S3	Sm	1N3902	S2	R
CQY95B	S8	LED	PH2955T	S4a	P	1N3903	S2	R
CQY96(L)	S8	LED	PH3055T	S4a	P	1N3909	S2	R

* = series

Ar = Arrays

GD = Germanium diodes

I = Infrared devices

LED = Light emitting diodes

P = Low-frequency power transistors

Ph = Photoconductive devices

R = Rectifier diodes

SD = Small-signal diodes

Sm = Small-signal transistors

St = Rectifier stacks

Vrf = Voltage reference diodes

WBM = Wideband hybrid IC modules

type no.	book	section	type no.	book	section	type no.	book	section
1N3910	S2	R	2N2369A	S3	Sm	2N4392	S5	FET
1N3911	S2	R	2N2483	S3	Sm	2N4393	S5	FET
1N3912	S2	R	2N2484	S3	Sm	2N4427	S6	RFP
1N3913	S2	R	2N2904	S3	Sm	2N4856	S5	FET
1N4001G	S1	R	2N2904A	S3	Sm	2N4857	S5	FET
1N4002G	S1	R	2N2905	S3	Sm	2N4858	S5	FET
1N4003G	S1	R	2N2905A	S3	Sm	2N4859	S5	FET
1N4004G	S1	R	2N2906	S3	Sm	2N4860	S5	FET
1N4005G	S1	R	2N2906A	S3	Sm	2N4861	S5	FET
1N4006G	S1	R	2N2907	S3	Sm	2N5415	S3	Sm
1N4007G	S1	R	2N2907A	S3	Sm	2N5416	S3	Sm
1N4148	S1	SD	2N3019	S3	Sm	61SV	S8	I
1N4150	S1	SD	2N3020	S3	Sm	375CQY/B	S8	Ph
1N4151	S1	SD	2N3053	S3	Sm	497CQF/A	S8	Ph
1N4154	S1	SD	2N3375	S6	RFP	498CQL	S8	Ph
1N4446	S1	SD	2N3553	S6	RFP	56201d	S4b	A
1N4448	S1	SD	2N3632	S6	RFP	56201j	S4b	A
1N4531	S1	SD	2N3822	S5	FET	56230	S2	HE
1N4532	S1	SD	2N3823	S5	FET	56231	S2	HE
1N5059	S1	R	2N3866	S6	RFP	56245	S3,6,10A	
1N5060	S1	R	2N3903	S3	Sm	56246	S3,5,10A	
1N5061	S1	R	2N3904	S3	Sm	56253	S2	DH
1N5062	S1	R	2N3905	S3	Sm	56256	S2	DH
2N918	S10	WBT	2N3906	S3	Sm	56261a	S4b	A
2N929	S3	Sm	2N3924	S6	RFP	56262A	S2	A
2N930	S3	Sm	2N3926	S6	RFP	56264A	S2	A
2N1613	S3	Sm	2N3927	S6	RFP	56268	S2	DH
2N1711	S3	Sm	2N3966	S5	FET	56290	S2	HE
2N1893	S3	Sm	2N4030	S3	Sm	56295	S2	A
2N2218	S3	Sm	2N4031	S3	Sm	56312	S2	DH
2N2218A	S3	Sm	2N4032	S3	Sm	56313	S2	DH
2N2219	S3	Sm	2N4033	S3	Sm	56316	S2	A
2N2219A	S3	Sm	2N4091	S5	FET	56317	S2	A
2N2221	S3	Sm	2N4092	S5	FET	56326	S4b	A
2N2221A	S3	Sm	2N4093	S5	FET	56339	S4b	A
2N2222	S3	Sm	2N4123	S3	Sm	56348	S2	DH
2N2222A	S3	Sm	2N4124	S3	Sm	56350	S2	DH
2N2297	S3	Sm	2N4125	S3	Sm	56352	S4b	A
2N2368	S3	Sm	2N4126	S3	Sm	56353	S4b	A
2N2369	S3	Sm	2N4391	S5	FET	56354	S4b	A

A = Accessories
 DH = Diecast heatsinks
 FET = Field-effect transistors
 HE = Heatsink extrusions
 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 hybrid IC transistors

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56359b	S4b	A	56364	S2,S4b	A	56369	S2,S4b	A
56359c	S4b	A	56366	S2	A	56378	S4b	A
56359d	S4b	A	56367	S2	A	56379	S4b	A
56360a	S4b	A	56368a	S4b	A	56387a,b	S4b	A
56363	S2,S4b	A	56368b	S4b	A			

A = Accessories



TYPE NUMBER SURVEY



TYPE NUMBER SURVEY POWER TRANSISTORS

type number		envelope	P _{tot} W	type number		envelope	P _{tot} W
NPN	PNP			NPN	PNP		
BD131	BD132	TO-126	15	BD651	BD652	TO-220	62,5
BD135	BD136	TO-126	8	BD675	BD676	TO-126	40
BD137	BD138	TO-126	8	BD677	BD678	TO-126	40
BD139	BD140	TO-126	8	BD679	BD680	TO-126	40
BD201	BD202	TO-220	60	BD681	BD682	TO-126	40
BD203	BD204	TO-220	60	BD683	BD684	TO-126	40
BD226	BD227	TO-126	12,5	BD813	BD814	TO-202	2
BD228	BD229	TO-126	12,5	BD815	BD816	TO-202	2
BD230	BD231	TO-126	12,5	BD817	BD818	TO-202	2
BD233	BD234	TO-126	25	BD825	BD826	TO-202	2
BD235	BD236	TO-126	25	BD827	BD828	TO-202	2
BD237	BD238	TO-126	25	BD829	BD830	TO-202	2
BD239	BD240	TO-220	30	BD839	BD840	TO-202	2
BD239A	BD240A	TO-220	30	BD841	BD842	TO-202	2
BD239B	BD240B	TO-220	30	BD843	BD844	TO-202	2
BD239C	BD240C	TO-220	30	BD845	BD846	TO-202	2
BD241	BD242	TO-220	40	BD847	BD848	TO-202	2
BD241A	BD242A	TO-220	40	BD849	BD850	TO-202	2
BD241B	BD242B	TO-220	40	BD933	BD934	TO-220	30
BD241C	BD242C	TO-220	40	BD935	BD936	TO-220	30
BD243	BD244	TO-220	65	BD937	BD938	TO-220	30
BD243A	BD244A	TO-220	65	BD939	BD940	TO-220	30
BD243B	BD244B	TO-220	65	BD941	BD942	TO-220	30
BD243C	BD244C	TO-220	65	BD943	BD944	TO-220	40
BD329	BD330	TO-126	15	BD945	BD946	TO-220	40
BD331	BD332	SOT-82	60	BD947	BD948	TO-220	40
BD333	BD334	SOT-82	60	BD949	BD950	TO-220	40
BD335	BD336	SOT-82	60	BD951	BD952	TO-220	40
BD337	BD338	SOT-82	60	BD953	BD954	TO-220	40
BD433	BD434	TO-126	36	BD955	BD956	TO-220	40
BD435	BD436	TO-126	36	BDT21	BDT20	TO-220	62,5
BD437	BD438	TO-126	36	BDT29	BDT30	TO-220	30
BD645	BD646	TO-220	62,5	BDT29A	BDT30A	TO-220	30
BD647	BD648	TO-220	62,5	BDT29B	BDT30B	TO-220	30
BD649	BD650	TO-220	62,5	BDT29C	BDT30C	TO-220	30

TYPE NUMBER SURVEY

type number		envelope	P _{tot} W	type number		envelope	P _{tot} W
NPN	PNP			NPN	PNP		
BDT31	BDT32	TO-220	40	BDX43	BDX46	TO-126	5
BDT31A	BDT32A	TO-220	40	BDX44	BDX47	TO-126	5
BDT31B	BDT32B	TO-220	40	BDX63	BDX62	TO-3	90
BDT31C	BDT32C	TO-220	40	BDX63A	BDX62A	TO-3	90
BDT41	BDT42	TO-220	65	BDX63B	BDX62B	TO-3	90
BDT41A	BDT42A	TO-220	65	BDX63C	BDX62C	TO-3	90
BDT41B	BDT42B	TO-220	65	BDX65	BDX64	TO-3	117
BDT41C	BDT42C	TO-220	65	BDX65A	BDX64A	TO-3	117
BDT61	BDT60	TO-220	50	BDX65B	BDX64B	TO-3	117
BDT61A	BDT60A	TO-220	50	BDX65C	BDX64C	TO-3	117
BDT61B	BDT60B	TO-220	50	BDX67	BDX66	TO-3	150
BDT61C	BDT60C	TO-220	50	BDX67A	BDX66A	TO-3	150
BDT63	BDT62	TO-220	90	BDX67B	BDX66B	TO-3	150
BDT63B	BDT62B	TO-220	90	BDX67C	BDX66C	TO-3	150
BDT63C	BDT62C	TO-220	90	BDX69	BDX68	TO-3	200
BDT65	BDT64	TO-220	125	BDX69A	BDX68A	TO-3	200
BDT65A	BDT64A	TO-220	125	BDX69B	BDX68B	TO-3	200
BDT65B	BDT64B	TO-220	125	BDX69C	BDX68C	TO-3	200
BDT65C	BDT64C	TO-220	125	BDX77	BDX78	TO-220	60
BDT91	BDT92	TO-220	90	BDX91	BDX92	TO-3	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	BDY90A		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	200	BF419		TO-126	6
BDV67B	BDV66B	SOT-93	200	BF457		TO-126	6
BDV67C	BDV66C	SOT-93	200	BF458		TO-126	6
BDV67D	BDV66D	SOT-93	200	BF459		TO-126	6
BDV91	BDV92	SOT-93	100	BF469	BF470	TO-126	1,8
BDV93	BDV94	SOT-93	100	BF471	BF472	TO-126	1,8
BDV95	BDV96	SOT-93	100	BF819		TO-202	6
BDW55	BDW56	TO-126	8	BF857		TO-202	6
BDW57	BDW58	TO-126	8	BF858		TO-202	6
BDW59	BDW60	TO-126	8	BF859		TO-202	6
BDX35		TO-126	15	BF869	BF870	TO-202	5
BDX36		TO-126	15	BF871	BF872	TO-202	5
BDX37		TO-126	15	BU208A		TO-3	80
BDX42	BDX45	TO-126	5	BU208B		TO-3	80

TYPE NUMBER SURVEY

type number		envelope	P _{tot} W	type number		envelope	P _{tot} W
NPN	PNP			NPN	PNP		
BU326;A		TO-3	60	BUV82;83		SOT-93	70
BU426;A		SOT-93	70	BUV89		SOT-93A	125
BU433		SOT-93	70	BUW11;A		SOT-93	100
BU505		TO-220	75	BUW12;A		SOT-93	125
BU508A		SOT-93A	125	BUW13;A		SOT-93	175
BU705		SOT-93A	75	BUW84;85		SOT-82	50
BU806		TO-220	60	BUX46;A		TO-3	85
BU807		TO-220	60	BUX47;A		TO-3	125
BU824		TO-202	2	BUX48;A		TO-3	175
BU826		SOT-93	125	BUX80;81		TO-3	100
BUS11;A		TO-3	100	BUX82;83		TO-3	60
BUS12;A		TO-3	125	BUX84;85		TO-220	40
BUS13;A		TO-3	175	BUX86;87		TO-126	20
BUS14;A		TO-3	250	BUX88		TO-3	160
BUT11;A		TO-220	100	BUX90		TO-3	125
				BUX98;A		TO-3	250
				BUY89		TO-3	80
				PH3055T	PH2955T	TO-220	75

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
56368b	insulating bush (up to 800 V)	SOT-93
56369	mica insulator (up to 2 kV)	TO-220
56378	mica insulator (up to 1500 V)	SOT-93
56379	spring clip	SOT-93
56387a	mica insulator (up to 300 V)	TO-126
56387b	insulating bush (up to 300 V)	TO-126

SELECTION GUIDE



SELECTION GUIDE



GENERAL PURPOSE DARLINGTON TRANSISTORS

IC	pol.	collector-emitter voltage (open base) V _{CEO} (V)										P _{tot} W	case		
		45	60	80	100	120	130	150	200						
1	N	BDX42*	BDX43*	BDX44*										5	TO-126
	P	BDX45*	BDX46*	BDX47*											
4	N	BD675	BD677	BD679	BD681	BD683								40	TO-126
	P	BD676	BD678	BD680	BD682	BD684									
	N		BDT61	BDT61A	BDT61B	BDT61C								50	TO-220
	P		BDT60	BDT60A	BDT60B	BDT60C									
6	N		BD331	BD333	BD335	BD337								60	SOT-82
	P		BD332	BD334	BD336	BD338									
8	N		BD645	BD647	BD649	BD651								62, 5	TO-220
	P		BD646	BD648	BD650	BD652									
	N													60	TO-220
	P													62, 5	TO-220
10	N		BDX63	BDX63A	BDX63B	BDX63C								90	TO-3
	P		BDX62	BDX62A	BDX62B	BDX62C									
	N		BDT63	BDT63A	BDT63B	BDT63C								90	TO-220
	P		BDT62	BDT62A	BDT62B	BDT62C									
12	N		BDT65	BDT65A	BDT65B	BDT65C								125	TO-220
	P		BDT64	BDT64A	BDT64B	BDT64C									
	N		BDV65	BDV65A	BDV65B	BDV65C								125	SOT-93
	P		BDV64	BDV64A	BDV64B	BDV64C									
16	N		BDX65	BDX65A	BDX65B	BDX65C								117	TO-3
	P		BDX64	BDX64A	BDX64B	BDX64C									
	N		BDV67	BDV67A	BDV67B	BDV67C								200	SOT-93
	P		BDV66	BDV66A	BDV66B	BDV66C									
25	N		BDX67	BDX67A	BDX67B	BDX67C								150	TO-3
	P		BDX66	BDX66A	BDX66B	BDX66C									
	N		BDX69	BDX69A	BDX69B	BDX69C								200	TO-3
	P		BDX68	BDX68A	BDX68B	BDX68C									

* V_{CER}

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

Ic	pol.	collector-emitter voltage (open base) V _{CEO} (V)								P _{tot} W	case	
		160	250	300	375	400	450	700	800			
0,05	N		BF469	BF471*							1,8	TO-126
	P		BF470	BF472*							5	TO-202
	N		BF869	BF871*							6	TO-126
0,1	P		BF870	BF872*							6	TO-202
	N		BF419	BF459							6	TO-202
	N	BF457	BF458	BF819							6	TO-202
0,5	N	BF857	BF858	BF859							20	TO-126
	N				BUX86	BUX87					50	SOT-82
	N				BUX84	BUX85					40	TO-220
3,5	N				BUX84	BUX85					85	TO-3
	N				BUX46	BUX46A					100	TO-220
	N				BUT11	BUT11A					100	SOT-93
6	N				BUX86	BUX87					100	TO-3
	N				BUS11	BUS11A					60	TO-3
	N				BUS11	BUS11A					70	SOT-93
8	N				BU326	BU326A					70	SOT-93
	N				BU426	BU426A					60	TO-3
	N				BU433						70	SOT-93
9	N				BUX82	BUX83					80	TO-3
	N				BUX82	BUX83					125	SOT-93
	N				BUX82	BUX83					125	SOT-93
10	N				BUX82	BUX83					125	TO-3
	N				BUX82	BUX83					125	TO-3
	N				BUX82	BUX83					125	TO-3
15	N				BUX82	BUX83					125	TO-3
	N				BUX82	BUX83					125	TO-3
	N				BUX82	BUX83					125	TO-3
30	N				BUX82	BUX83					125	TO-3
	N				BUX82	BUX83					125	TO-3
	N				BUX82	BUX83					125	TO-3

* V_{CER}



GENERAL PURPOSE POWER TRANSISTORS

IC	pol.	collector-emitter voltage (open base) V_{CEO} (V)							P_{tot} W	case
		20	22	32	40	45	60	80		
1	N					BD135	BD137	BD139	8	TO-126
	P					BD136	BD138	BD140		
	N					BD825	BD827	BD829		
	P					BD826	BD828	BD830		
	N					BDW55	BDW57	BDW59		
	P					BDW56	BDW58	BDW60		
1,5	N				BDT29		BDT29A	BDT29B	30	TO-220
	P				BDT30		BDT30A	BDT30B		
	N				BD226		BD228	BD230		
	P				BD227		BD229	BD231		
	N				BD839		BD841	BD843		
	P				BD840		BD842	BD844		
2	N					BD233	BD235	BD237	25	TO-126
	P					BD234	BD236	BD238		
	N					BD813	BD815	BD817		
	N					BD814	BD816	BD818		
	P					BD239	BD239A	BD239B		
	P					BD240	BD240A	BD240B		
3	N					BD131		BD239C	30	TO-220
	P					BD132		BD240C		
	N	BD329								
	P	BD330								
	N					BD933	BD935	BD937		
	P					BD934	BD936	BD938		
4	N							BD941	30	TO-220
	P							BD942		
	N				BDT31		BDT31A	BDT31B		
	P				BDT32		BDT32A	BDT32B		
	N				BD437					
	P				BD438					
4	N		BD433	BD435					36	TO-126
	P		BD434	BD436						

GENERAL PURPOSE POWER TRANSISTORS

IC	pol.	collector-emitter voltage (open base) V _{CEO} (V)								P _{tot} W	case			
		20	22	32	40	45	60	80	100			120	140	
5	N					BD241	BD241A	BD241B	BD241C				40	TO-220
	P					BD240	BD240A	BD240B	BD240C				15	TO-126
	N						BDX35							
	N		BD943	BD945		BD947	BDX36	BD951	BD953				40	TO-220
	P	BD944	BD946		BD948	BD950	BD952	BD955	BD954					
6	N					BD243	BD243A	BD243B	BD243C				65	TO-220
	P					BD244	BD244A	BD244B	BD244C					
	N				BDT41	BDT41A	BDT41B	BDT41C					65	TO-220
	P				BDT42	BDT42A	BDT42B	BDT42C						
	N					BD201	BD203	BDX77					60	TO-220
8	P					BD202	BD204	BDX78						
	N						BDX91	BDX93	BDX95				90	TO-3
	P						BDX92	BDX94	BDX96					
	N						PH3055T						75	TO-220
	P						PH2955T							
10	N						BDT91	BDT93	BDT95				90	TO-220
	P						BDT92	BDT94	BDT96					
	N						BDV91	BDV93	BDV95					
	N						BDV92	BDV94	BDV96				100	SOT-93
	P													

LOW-VOLTAGE SWITCHING TRANSISTORS

IC	pol.	collector-emitter voltage (open base) V _{CEO} (V)				P _{tot} W	case
		60	80	100	140		
A							
10	N	BDY92	BDY91	BDY90	40	TO-3	
12	N			BDY90A	40	TO-3	



ACCESSORIES

CLIP MOUNTING

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

SCREW MOUNTING

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

The accessories mentioned can be supplied on request.
See also chapter Mounting Instructions.



TO-126
(SOT-32)

type number		P _{tot} W	V _{CEO} V
NPN	PNP		
BUW84		50	400
BUW85			450
BD331	BD332	60	60
BD333	BD334		80
BD335	BD336		100
BD337	BD338		120



SOT-93
(SOT-93)

type number		P _{tot} W	V _{CEO} V
NPN	PNP		
BU426		70	375
BU426A			400
BU433			375
BUV82			400
BUV83			450
BDV91	BDV92	100	60
BDV93	BDV94		80
BDV95	BDV96		100
BUW11			400
BUW11A			450
BDV65	BDV64	125	60
BDV65A	BDV64A		80
BDV65B	BDV64B		100
BDV65C	BDV64C		120
BUW12			400
BUW12A		450	
BU508A		700	
BUV89		800	
BUW13		175	400
BUW13A			450
BDV67	BDV66	200	60
BDV67A	BDV66A		80
BDV67B	BDV66B		100
BDV67C	BDV66C		120

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

* V_{CER}

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TO-3
(SOT-3)

type number		P _{tot} W	V _{CEO} V	
NPN	PNP			
BDY90		40	100	
BDY90A			100	
BDY91			80	
BDY92			60	
BU326		60	375	
BU326A			400	
BUX82		60	400	
BUX83			450	
BUY89		80	800	
BUX46		85	400	
BUX46A			450	
BDX63	BDX62	90	60	
BDX91	BDX92		60	
BDX63A	BDX62A		80	
BDX93	BDX94		80	
BDX63B	BDX62B		100	
BDX95	BDX96		100	
BDX63C	BDX62C		120	
BUS11			100	400
BUS11A				450
BUX80		100	400	
BUX81			450	
BDX65	BDX64	117	60	
BDX65A	BDX64A		80	
BDX65B	BDX64B		100	
BDX65C	BDX64C		120	
BUS12		125	400	
BUS12A			450	
BUX47			400	
BUX47A			450	
BDX67	BDX66	150	60	
BDX67A	BDX66A		80	
BDX67B	BDX66B		100	
BDX67C	BDX66C		120	
BUX88		160	800	

type number		P _{tot} W	V _{CEO} V
NPN	PNP		
BUS13		175	400
BUS13A			450
BUX48			400
BUX48A			450
BDX69	BDX68	200	60
BDX69A	BDX68A		80
BDX69B	BDX68B		100
BDX69C	BDX68C		120
BUS14		250	400
BUS14A			450
BUX98			400
BUX98A			450



TO-202
(SOT-128)

type number		P _{tot} W	V _{CEO} V	
NPN	PNP			
BF869	BF870	5(1,6)	250	
BF871	BF872		300*	
BF819		6(1,2)	250	
BF857		6(2)	160	
BF858			250	
BF859			300	
BD825	BD826	8(2)	45	
BD827	BD828		60	
BD829	BD830		80	
BD839	BD840	10(2)	45	
BD841	BD842		60	
BD843	BD844		80	
BD845	BD846		100	
BD847	BD848		120	
BD849	BD850		140	
BD813	BD814		12,5 (2)	45
BD815	BD816	60		
BD817	BD818	80		

* V_{CER}
() free air dissipation



TO-220 (SOT-78)

type number		P _{tot} W	V _{CEO} V
NPN	PNP		
BD239	BD240	30	45
BD239A	BD240A		60
BD239B	BD240B		80
BD239C	BD240C		100
BD933	BD934	30	45
BD935	BD936		60
BD937	BD938		80
BD939	BD940		100
BD941	BD942		120
BDT29	BDT30		40
BDT29A	BDT30A		60
BDT29B	BDT30B		80
BDT29C	BDT30C		100
BD241	BD240		40
BD241A	BD241A	60	
BD241B	BD241B	80	
BD241C	BD241C	100	
BD943	BD944	40	22
BD945	BD946		32
BD947	BD948		45
BD949	BD950		60
BD951	BD952		80
BD953	BD954		100
BD955	BD956		120
BDT31	BDT32		45
BDT31A	BDT32A		60
BDT31B	BDT32B		80
BDT31C	BDT32C	100	
BUX84		40	400
BUX85			450
BDT61	BDT60	50	60
BDT61A	BDT60A		80
BDT61B	BDT60B		100
BDT61C	BDT60C		120
BD201	BD202	60	45
BD203	BD204		60
BDX77	BDX78		80
BU807		60	150
BU806			200

type number		P _{tot} W	V _{CEO} V
NPN	PNP		
BD645	BD646	62,5	60
BD647	BD648		80
BD649	BD650		100
BD651	BD652		120
BDT21	BDT20	62,5	130
BD243	BD244	65	45
BD243A	BD244A		60
BD243B	BD244B		80
BD243C	BD244C		100
BDT41	BDT42	65	40
BDT41A	BDT42A		60
BDT41B	BDT42B		80
BDT41C	BDT42C		100
PH3055T	PH2955T	75	60
BDT91	BDT92	90	60
BDT93	BDT94		80
BDT95	BDT96		100
BDT63	BDT62	90	60
BDT63A	BDT62A		80
BDT63B	BDT62B		100
BDT63C	BDT62C		120
BUT11		100	400
BUT11A			450
BDT65	BDT64	125	60
BDT65A	BDT64A		80
BDT65B	BDT64B		100
BDT65C	BDT64C		120

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

V_{CBmax} The maximum permissible instantaneous voltage between collector and base terminals. The collector voltage is negative with respect to base in PNP transistors and positive with respect to base in NPN types.

$V_{CBmax} (I_E = 0)$ The maximum permissible instantaneous voltage between collector and base terminals, when the emitter terminal is open circuited.

Emitter to base voltage ratings

V_{EBmax} The maximum permissible instantaneous reverse voltage between emitter and base terminal. The emitter voltage is negative with respect to base for PNP transistor and positive with respect to base for NPN types.

$V_{EBmax} (I_C = 0)$ The maximum permissible instantaneous reverse voltage between emitter and base terminals when the collector terminal is open circuited.

Collector to emitter voltage ratings

V_{CEmax} The maximum permissible instantaneous voltage between collector and emitter terminals. The collector voltage is negative with respect to emitter in PNP transistors and positive with respect to emitter in NPN types. This rating is very dependent on circuit conditions and collector current and it is necessary to refer to the curve of V_{CE} versus I_C for the appropriate circuit condition in order to obtain the correct rating.

$V_{CEmax} (Cut-off)$ The maximum permissible instantaneous voltage between collector and emitter terminals when the emitter current is reduced to zero by means of a reverse emitter base voltage, i.e. the base voltage is normally positive with respect to emitter for PNP transistor and negative with respect to emitter for NPN types.

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

$V_{CEmax} (I_C = x \text{ mA})$ The maximum permissible instantaneous voltage between collector and emitter terminals when the collector current is at a high value, often the max. rated value.

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

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

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:

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

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

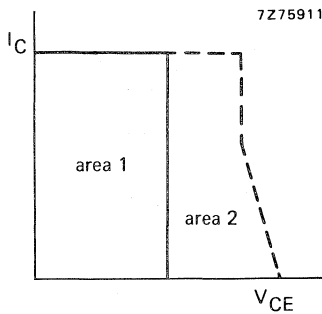


Fig. 1.

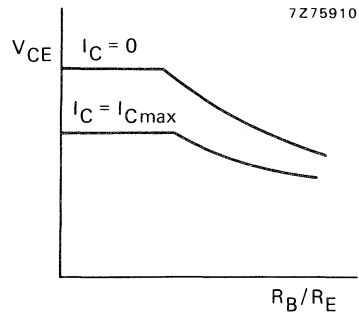


Fig. 2.

It should be noted that when R_E is shunted by a capacitor, the collector voltage V_{CE} during switching must be restricted to a value which does not rely on the effect of R_E .

In the case of an inductive load and when an energy rating is given, it may be permissible to operate outside the rated area provided the specified energy rating is not exceeded.

Transistor current ratings

Collector current ratings

I_{Cmax} The maximum permissible collector current. Without further qualification, the d.c. value is implied.

$I_{C(AV)max}$ The maximum permissible average value of the total collector current

I_{CM} The maximum permissible instantaneous value of the total collector current.

Emitter current ratings

I_{Emax} The maximum permissible emitter current. Without further qualification, the d.c. value is implied.

$I_{E(AV)max}$ The maximum permissible average value of the total emitter current.

$I_{ER(AV)max}$ The maximum permissible average value of the total emitter current when operating in the reverse emitter-base breakdown region.

I_{EM} The maximum permissible instantaneous value of the total emitter current.

I_{ERM} The maximum permissible instantaneous value of the total reverse emitter current allowable in the reverse breakdown region.

Base current ratings

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

Transistor power ratings

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

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

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

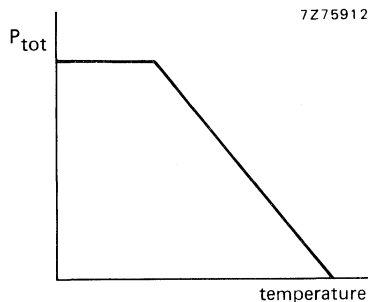


Fig. 3.

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

The efficiency of this clip or heatsink is measured in terms of its thermal resistance ($R_{th\ h}$) normally expressed in degrees 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.

Thus for any heatsink of known thermal resistance and any given ambient temperature, the maximum permissible power dissipation can be established. Alternatively, knowing the power dissipation which will occur and the ambient temperature, the necessary heatsink thermal resistance can be calculated. A general expression from which the total permissible steady state power dissipation can be calculated is:

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

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

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

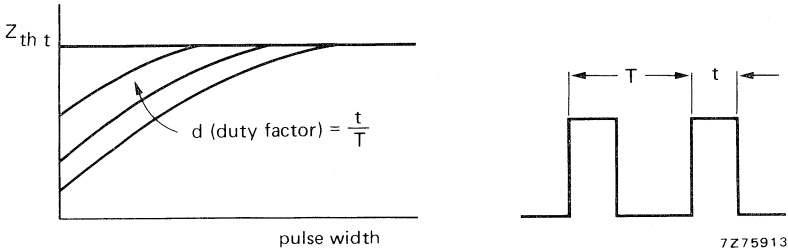


Fig. 4.

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

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

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

Temperature ratings

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

RATING SYSTEMS

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

DEFINITIONS OF TERMS USED

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

Note

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

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

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

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

Note

Limiting conditions may be either maxima or minima.

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

Note

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

ABSOLUTE MAXIMUM RATING SYSTEM

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

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

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

DESIGN MAXIMUM RATING SYSTEM

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

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

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

DESIGN CENTRE RATING SYSTEM

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

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

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



LETTER SYMBOLS FOR TRANSISTORS AND SIGNAL DIODES

based on IEC Publication 148

LETTER SYMBOLS FOR CURRENTS, VOLTAGES AND POWERS

Basic letters

The basic letters to be used are:

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

Lower-case basic letters shall be used for the representation of instantaneous values which vary with time.

In all other instances upper-case basic letters shall be used.

Subscripts

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

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

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

- a) continuous (d. c.) values (without signal)
Example I_B
- b) instantaneous total values
Example i_B
- c) average total values
Example $I_{B(AV)}$
- d) peak total values
Example I_{BM}
- e) root-mean-square total values
Example $I_{B(RMS)}$

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

- a) instantaneous values
Example i_b
- b) root-mean-square values
Example $I_{b(rms)}$
- c) peak values
Example I_{bm}
- d) average values
Example $I_{b(av)}$

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

Additional rules for subscripts

Subscripts for currents

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

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

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

Examples: $I_F, I_R, i_F, I_f(rms)$

Subscripts for voltages

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

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

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

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

Subscripts for supply voltages or supply currents

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

Examples: V_{CC} , I_{EE}

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

Example: V_{CCE}

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

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

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

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

Subscripts for multiple devices

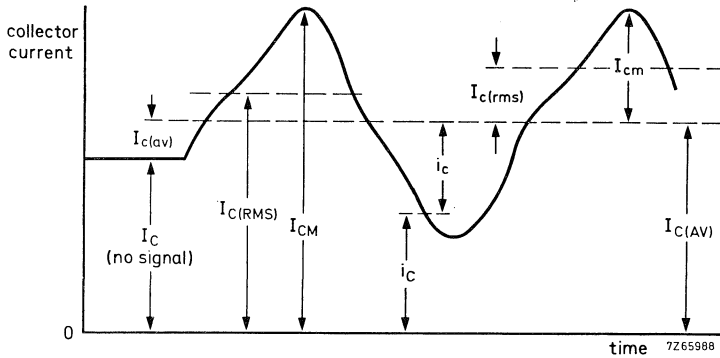
For multiple unit devices, the subscripts are modified by a number preceding the letter subscript; in the case of multiple subscripts, hyphens may be necessary to avoid misunderstanding.

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

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

Application of the rules

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



LETTER SYMBOLS FOR ELECTRICAL PARAMETERS

Definition

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

Basic letters

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

- B, b = susceptance; imaginary part of an admittance
- C = capacitance
- G, g = conductance; real part of an admittance
- H, h = hybrid parameter
- L = inductance
- R, r = resistance; real part of an impedance
- X, x = reactance; imaginary part of an impedance
- Y, y = admittance;
- Z, z = impedance;

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

- a) electrical parameters of external circuits and of circuits in which the device forms only a part;
- b) all inductances and capacitances.

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

Subscripts

General subscripts

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

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

Examples: Z_S , h_f , h_F

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

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

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

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

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

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

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

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

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

Subscripts for four-pole matrix parameters

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

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

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

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

Distinction between real and imaginary parts

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

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

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

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

TRANSISTOR SAFE OPERATING AREA

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

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

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

Collector current

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

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

Collector-emitter voltage

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

Power dissipation

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

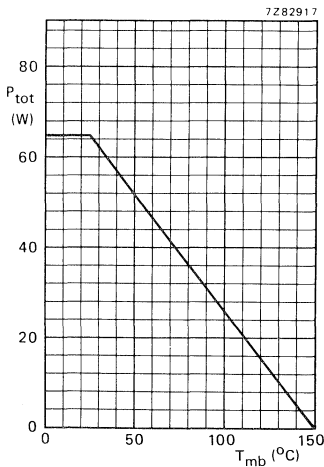
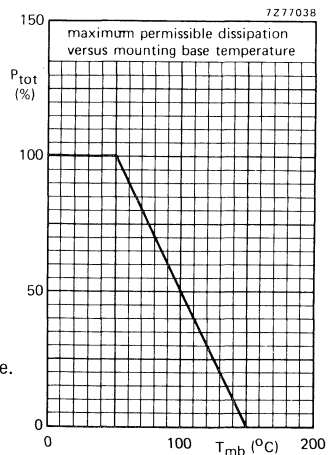


Fig. 1 Power derating curve.

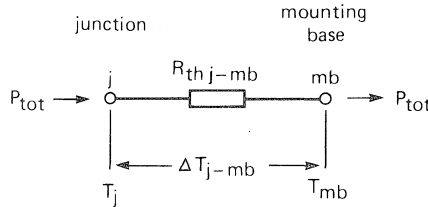


Total power dissipation is given by

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

The second term can usually be disregarded, so $P_{tot} \approx I_C V_{CE}$.

Heat dissipated in the collector-base junction flows through the thermal resistance between junction and mounting base, see Fig. 2.



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

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

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

There are two limitations to P_{tot}

– When $T_{mb} \leq T_{mb\ spec}$

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

– when $T_{mb} > T_{mb\ spec}$

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

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

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

For pulsed operation a higher dissipation is permitted, because

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

Analogy with

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

yields

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

where $P_{\text{tot M}}$ is the total pulsed power and $Z_{\text{th j-mb}}$ 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.

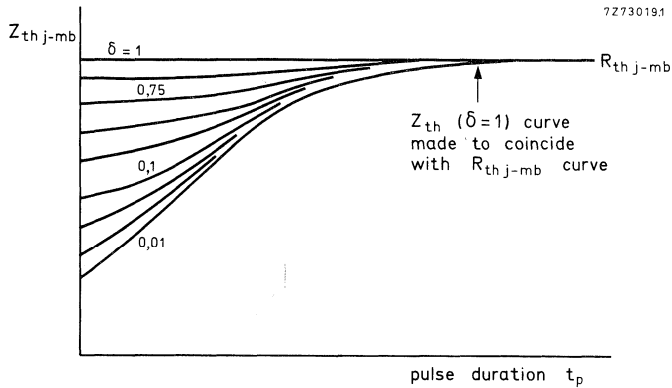


Fig. 3 A typical family of $Z_{\text{th j-mb}}$ curves for a power transistor.

Similar limitations apply as in the steady-state conditions:

(a) When $T_{\text{mb}} \leq T_{\text{mb spec}}$

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

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

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

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

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

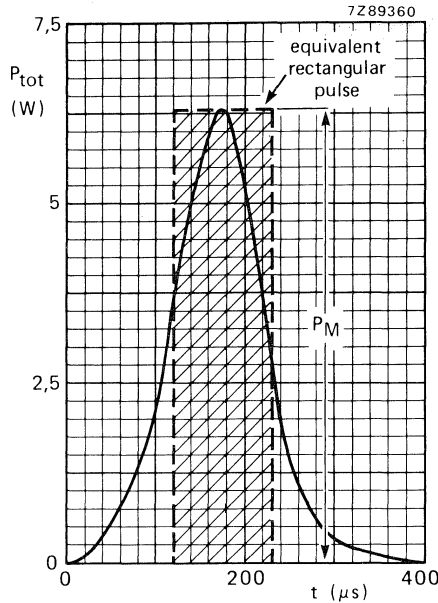


Fig. 4.

Second breakdown

In the forward-biased condition second breakdown is thermally triggered. Consider the chip as a large number of elemental transistors in parallel, some of which will have a lower forward voltage drop than others. Current will tend to concentrate in these, raising their temperature and further lowering their forward voltage drop. Current will concentrate still further, leading to local overheating and eventually to a short circuit between emitter and collector. This effect is independent of mounting base temperature, which is related to the average junction temperature. Under reverse-bias conditions, when V_{CE} is greater than $V_{CE0\ max}$, the chance of second breakdown is always present. This is a particular hazard in timebase and converter applications.

THE SOAR BOUNDARIES

The four limits just described form the boundaries of the Safe Operating Area. Figure 5 shows a SOAR plotted on a log-log grid. The right-hand boundary is formed by V_{CE0max} , which extends up to a collector current of about 300 mA. Above this point, as I_C is increased V_{CE} must be reduced to prevent second breakdown.

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

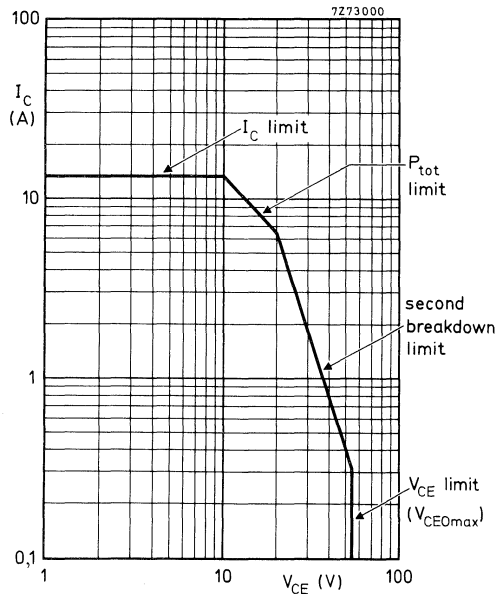


Fig. 5 A typical SOAR graph with boundaries named.

EXTENDING THE SOAR FOR SINGLE-SHOT AND REPETITIVE PULSED OPERATION

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

I_{CMmax}

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

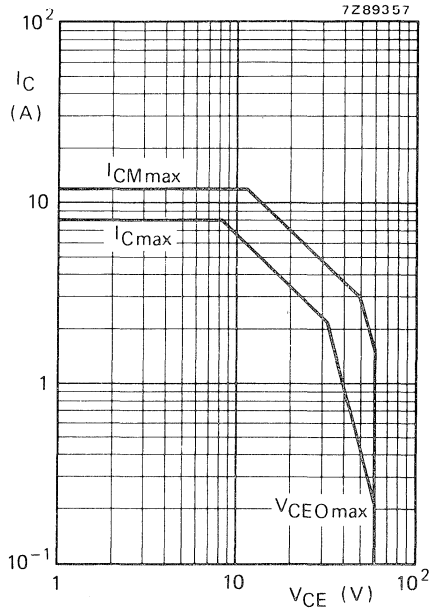


Fig. 6 Maximum collector current and collector-emitter voltage boundaries.

P_{tot max}

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

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

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

$$P_{totMmax} = \frac{T_{jmax} - T_{mb}}{Z_{thj-mb}} ;$$

T_{jmax} is stated in the data sheets; Z_{thj-mb} can be read from the curve, similar to Fig. 3, also given in the data sheets. Thus P_{totMmax} 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_{jmax} = 150 °C; T_{mb spec} = 25 °C; t_p = 0,2 ms and δ = 0,1.

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

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

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

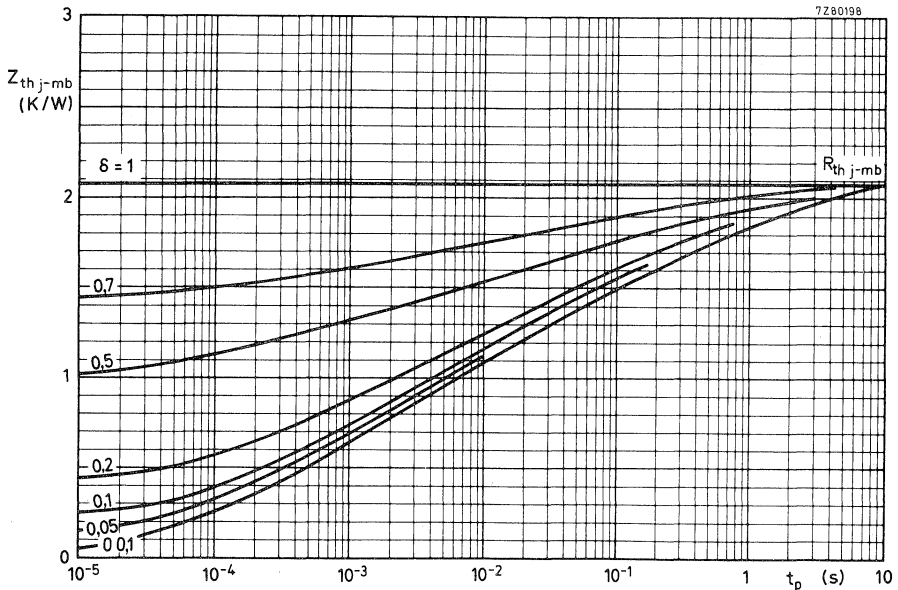


Fig. 7 Transient thermal impedance for example.

Second breakdown

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

- M_V — the voltage multiplying factor
- M_I — the current multiplying factors.*

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

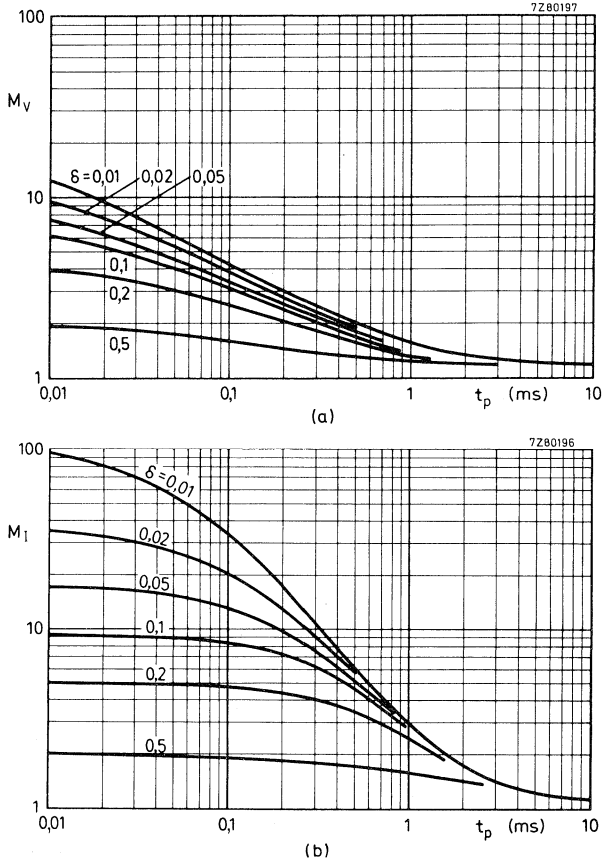


Fig. 8 Second breakdown multiplying factors as a function of pulse time, with duty factor as a parameter.

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

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

Referring to Fig. 9, where B is the point on the V_{CE0max} boundary at which voltage derating commences, B' can be calculated by:

$$I_C(B') = I_C(B) \times M_I.$$

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

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

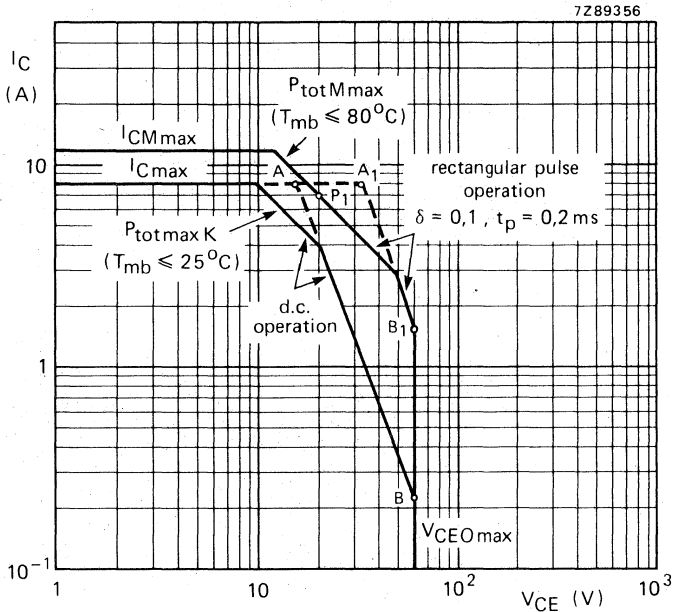


Fig. 9 Construction of the pulse operating area.

An example is worked in Fig. 9 for $t_p = 0,2\ ms$ and $\delta = 0,1$.

From Fig. 8, $M_V = 2,4$ and $M_I = 7,3$:

$$I_C(B') = 0,22 \times 7,3 = 1,6\ A$$

$$V_{CE}(A') = 13 \times 2,4 = 31\ V.$$

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

PULSE TRAINS AND COMPOSITE WAVEFORMS

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

Thermal considerations

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

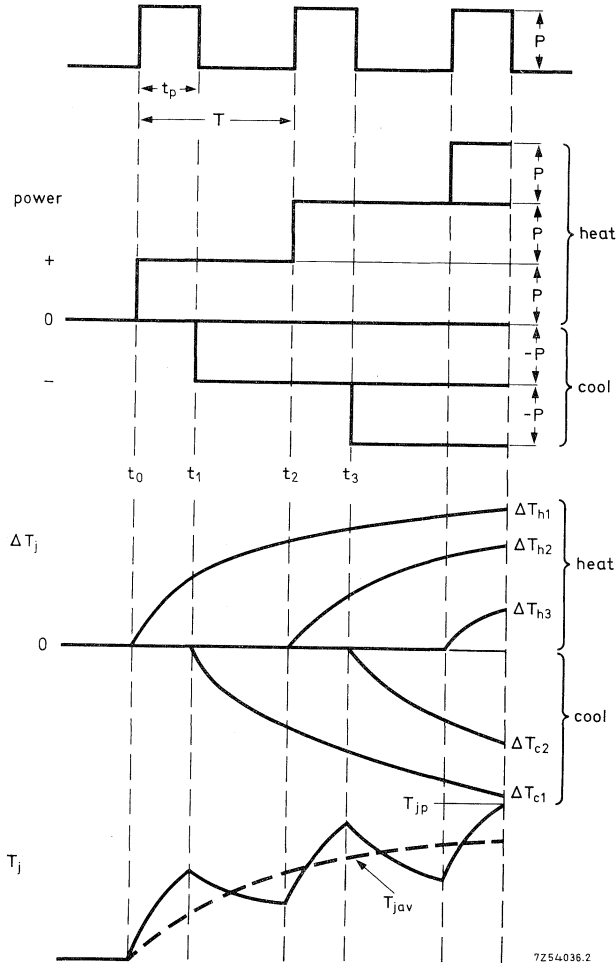


Fig. 10 The heating effect of three equidistant, equal-magnitude pulses. $T_{j\text{av}}$ is the average junction temperature. $P = 100\text{ W}$, $t_p = 100\ \mu\text{s}$; $T = 1\ \text{ms}$ and $\delta = 0,1$.

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

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

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

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

$$T_{h2} = PZ_{th}(1,1 \text{ ms})$$

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

and

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

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

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

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

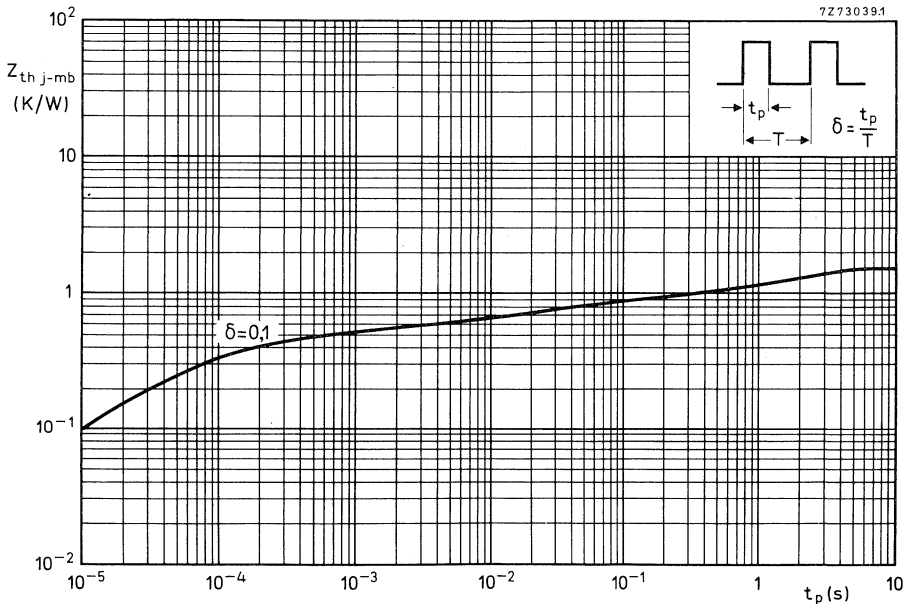


Fig. 11 Curve of $Z_{th \text{ j-mb}} = f(t_p)$.

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

$$\Delta T_j = \Delta T_{hav} + \Delta T_{h1} - \Delta T_{c1} + \Delta T_{h2}.$$

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

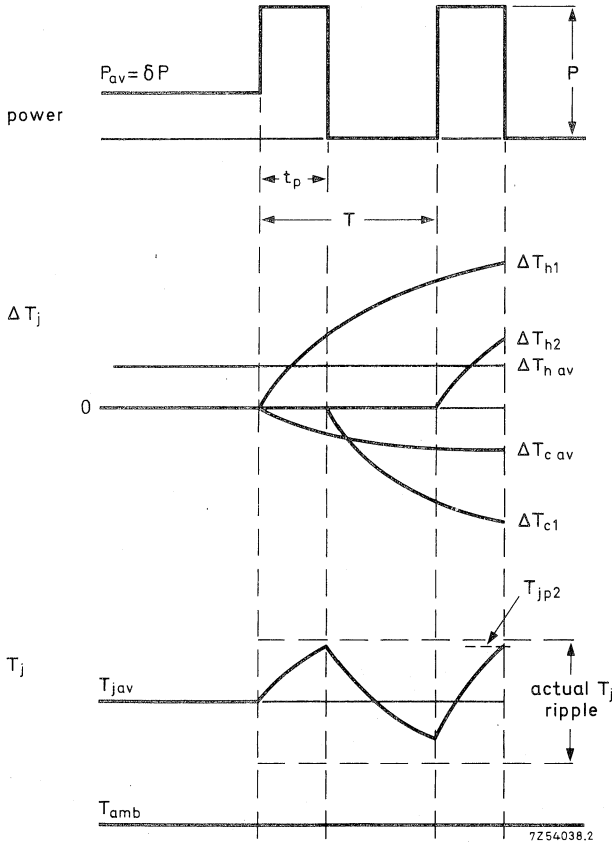


Fig. 12.

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

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

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

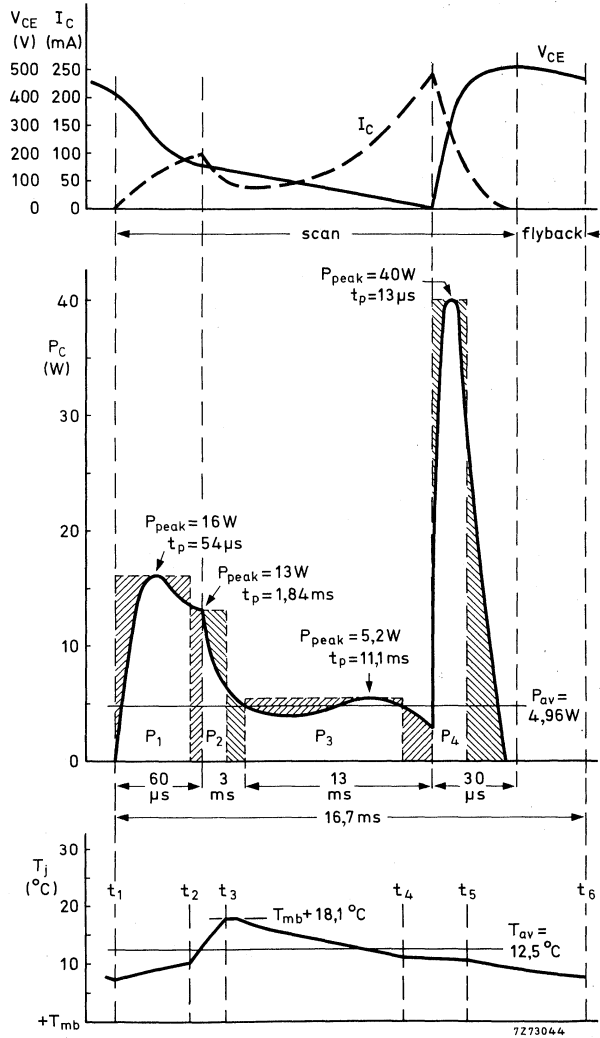


Fig. 13 Power waveforms showing their division into rectangular pulses and the junction temperature variations which they cause.

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

$$T_{j-mb}(t_1) = P_{av}R_{th j-mb} - P_{av}Z_{th j-mb}(16,1 \text{ ms}) + P_1Z_{th}(16,1 \text{ ms})$$

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

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

For t_3 yet another two terms:

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

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

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

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

EXAMPLE OF A SOAR CALCULATION

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

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

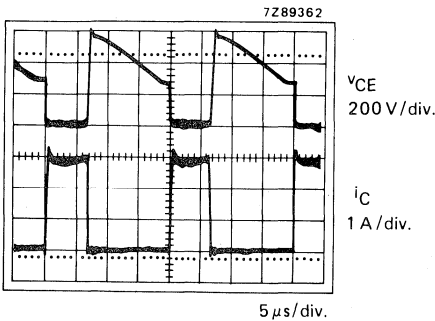


Fig. 14 Collector-current and collector-emitter voltage waveforms of a BU426A transistor in a 200 W SMPS.

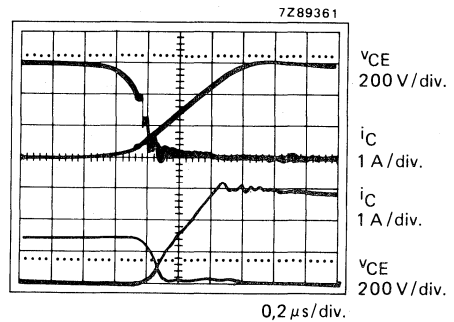


Fig. 15 Waveforms during turn-on and turn-off (lower part).

The duration of this equivalent pulse train is then given by

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

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

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

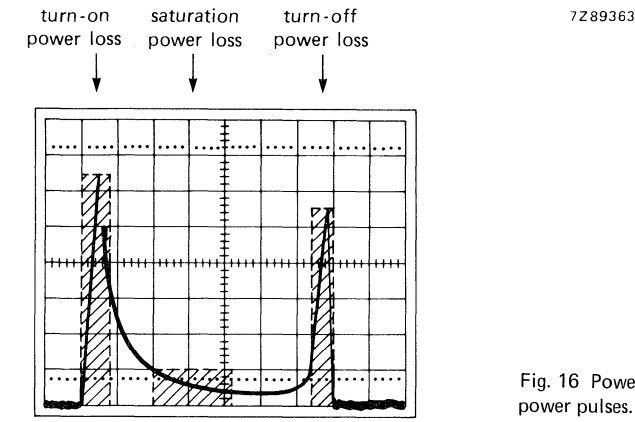


Fig. 16 Power loss and resultant rectangular power pulses.

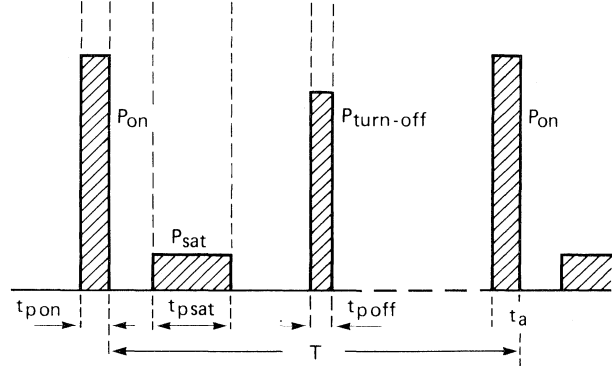


Fig. 17.

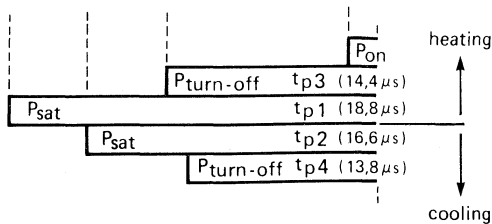


Fig. 18.

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

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

From

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

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

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

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

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

From

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

$$P_{tot\ av} = \delta_{on} \times P_{on} + \delta_{sat} \times P_{sat} + \delta_{turn-off} \times P_{off} = 0,04 \times 66 + 0,11 \times 10 + 0,03 \times 56 = 5,4 \text{ W.}$$

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

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

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

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

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

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

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

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

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

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

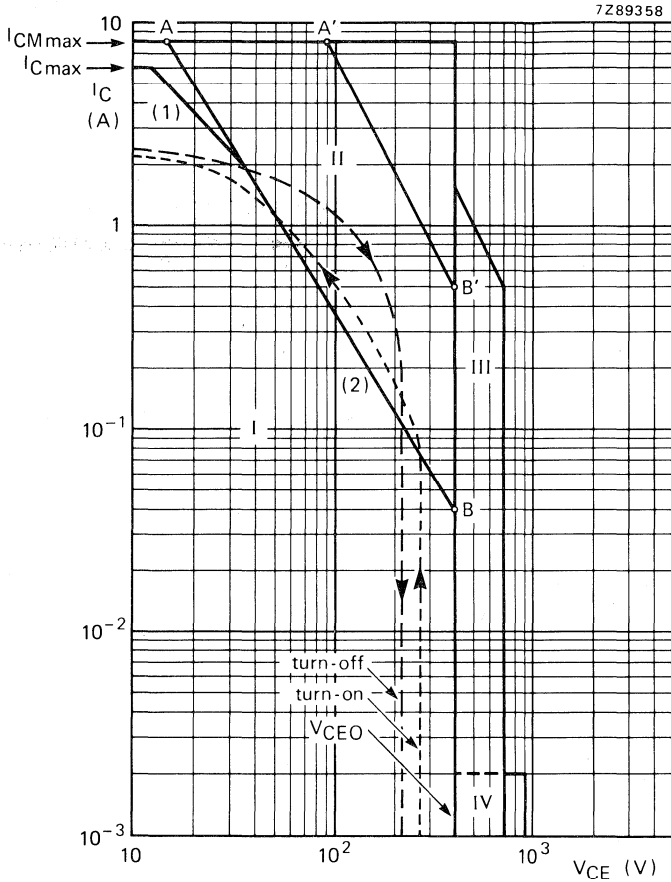


Fig. 19 Safe Operating ARea BU426A at $T_{\text{mb}} \leq 73 \text{ }^\circ\text{C}$.

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

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

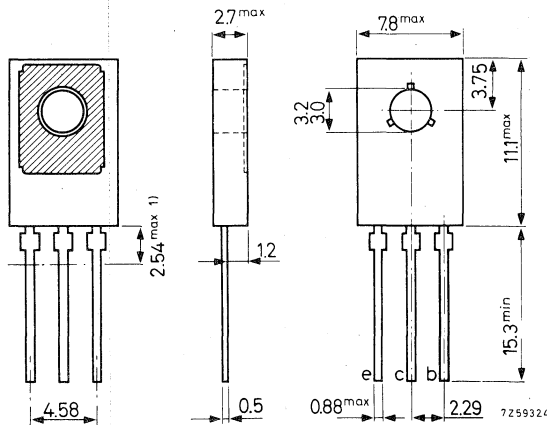
Collector-base voltage (open emitter)	V_{CBO}	max.	300	V
Collector-emitter voltage (open base)	V_{CEO}	max.	250	V
Collector current (peak value)	I_{CM}	max.	300	mA
Total power dissipation up to $T_{mb} = 90\text{ }^{\circ}\text{C}$	P_{tot}	max.	6	W
Junction temperature	T_j	max.	150	$^{\circ}\text{C}$
D.C. current gain	h_{FE}	typ.	45	
$I_C = 20\text{ mA}; V_{CE} = 10\text{ V}$				
Storage time	t_s	typ.	0.5	μs

MECHANICAL DATA

Dimensions in mm

Fig.1 TO-126 (SOT-32)

Collector connected to mounting base



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

RATINGS

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

Collector-base voltage (open emitter)	V_{CBO}	max.	300	V
Collector-emitter voltage ($R_{BE} \leq 1 \text{ k}\Omega$)	V_{CER}	max.	300	V
Collector-emitter voltage (open base)	V_{CEO}	max.	250	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V
Collector current (continuous)	I_C	max.	100	mA
Collector current (peak value) *	I_{CM}	max.	300	mA
Total power dissipation up to $T_{mb} = 90 \text{ }^\circ\text{C}$ up to $T_{amb} = 70 \text{ }^\circ\text{C}$	P_{tot}	max.	6	W
	P_{tot}	max.	0.8	W
Storage temperature	T_{stg}		-65 to +150	$^\circ\text{C}$
Operating junction temperature	T_j	max.	150	$^\circ\text{C}$

THERMAL RESISTANCE

From junction to mounting base	$R_{th \text{ j-mb}}$	=	10	K/W
From junction to ambient	$R_{th \text{ j-a}}$	=	100	K/W

* Precautions should be taken during switch-on of the BF419 where an overshoot of current is likely to occur. The amplitude of the overshoot depends on the relative magnitude of stray external capacities to the transistor collector capacity. It is desirable to keep the stray capacities to a minimum by short lead lengths etc. so as to minimise the area of the switching path.

CHARACTERISTICS

$T_j = 25\text{ }^\circ\text{C}$

Collector cut-off current

$I_E = 0; V_{CB} = 250\text{ V}$

$I_{CBO} < 50\text{ nA}$

Emitter cut-off current

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

$I_{EBO} < 50\text{ nA}$

D.C. current gain

$I_C = 20\text{ mA}; V_{CE} = 10\text{ V}$

$h_{FE}\text{ typ. } 45$

Collector-emitter saturation voltage

$I_C = 200\text{ mA}; I_B = 20\text{ mA}^*$

$V_{CEsat} < 11\text{ V}$

Collector output capacitance at $f = 1\text{ MHz}$

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

$C_{Tc} < 4.5\text{ pF}$

Storage time

(in the typical circuit below)

$t_s\text{ typ. } 0.5\text{ }\mu\text{s}$

* 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 $^\circ\text{C}$ is not exceeded. For the typical circuit shown below, a heatsink is not required for operation with $T_{amb} \leq 70\text{ }^\circ\text{C}$.

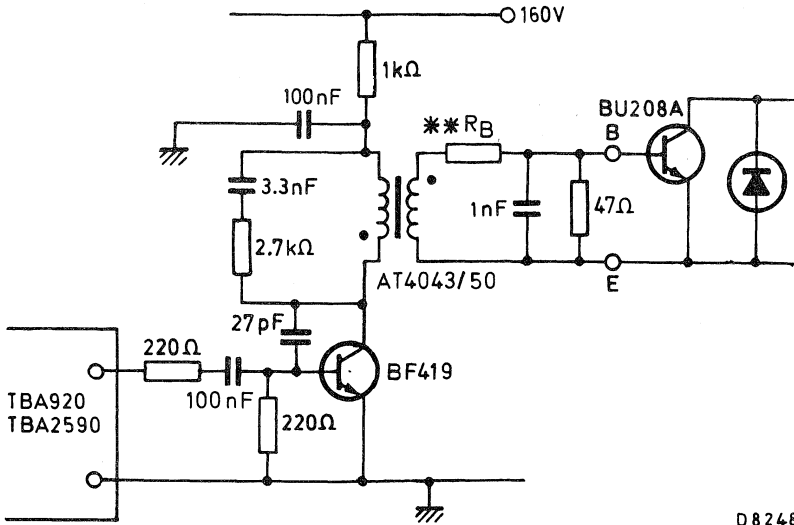


Fig.2 Typical circuit.

** R_B is chosen so that the end-of-scan base current for the BU208A is 1.4 A under nominal conditions. Typical value of R_B is 0.5 Ω plus 0.1 Ω lead resistance.

D8249

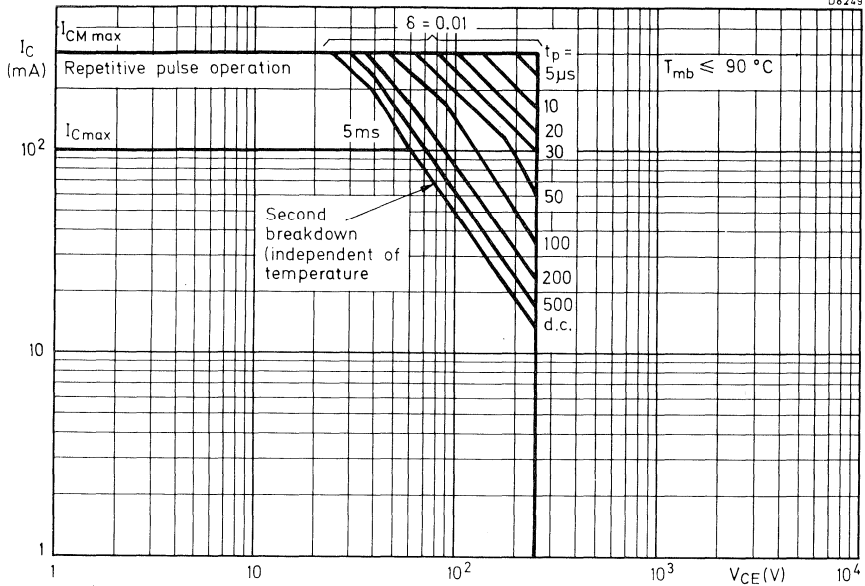


Fig.3 Safe Operating AReas with the transistor forward biased.

D8250a

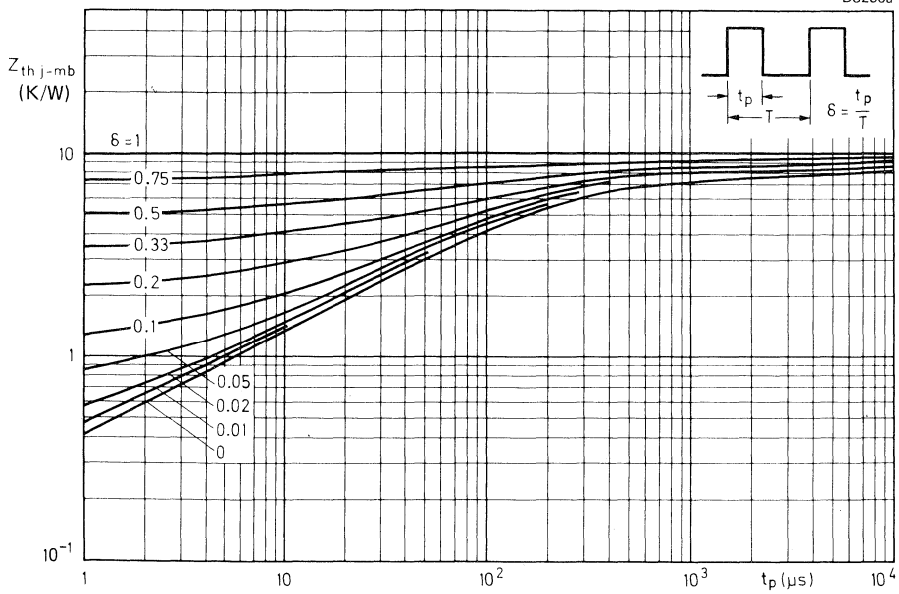


Fig. 4.

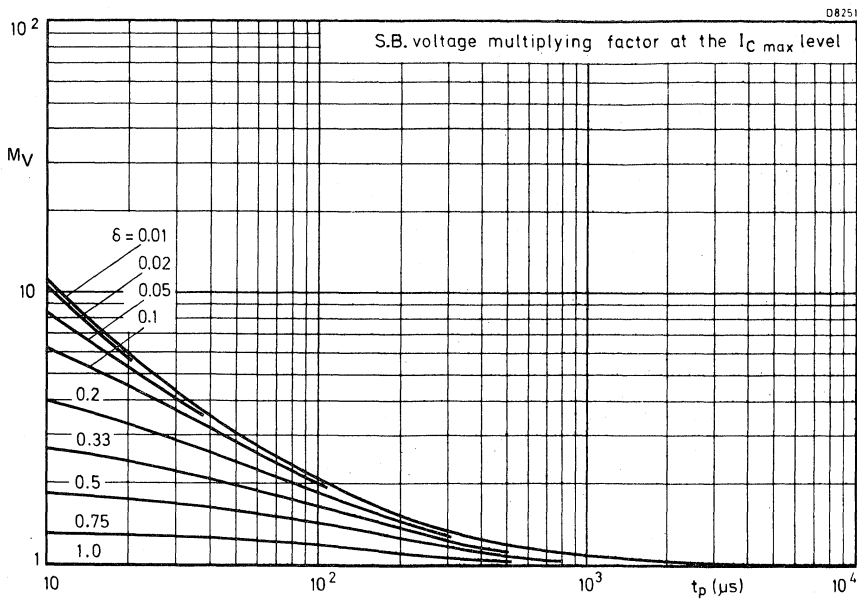


Fig. 5.

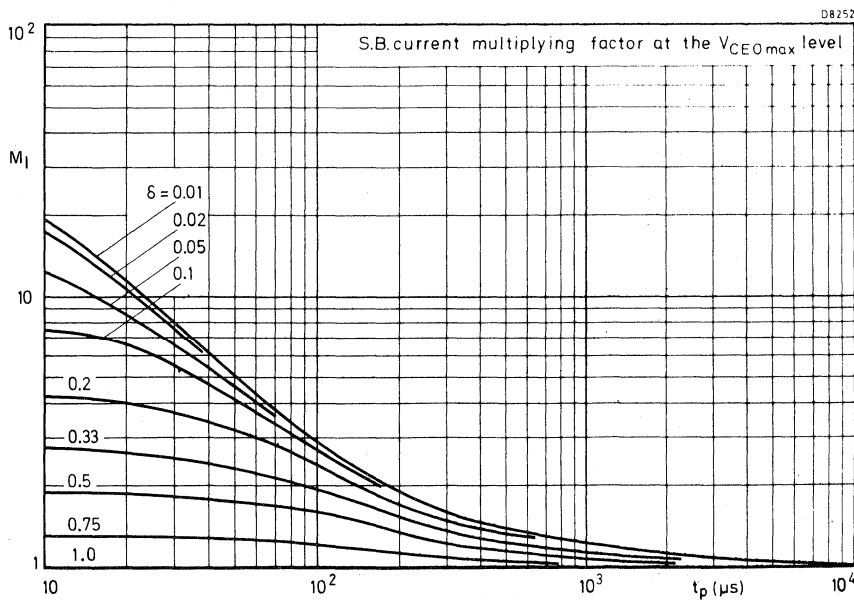


Fig. 6.

D8253

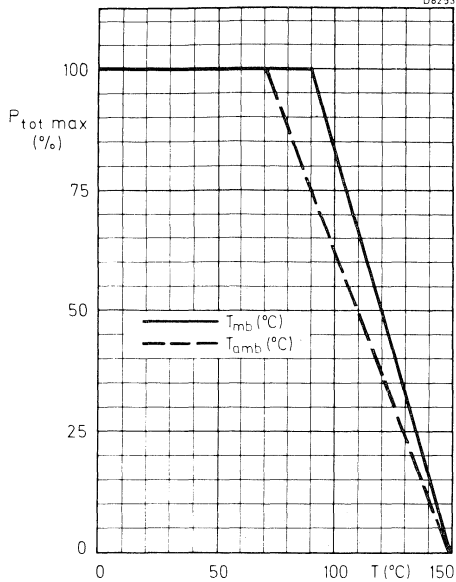


Fig. 7.

D8254

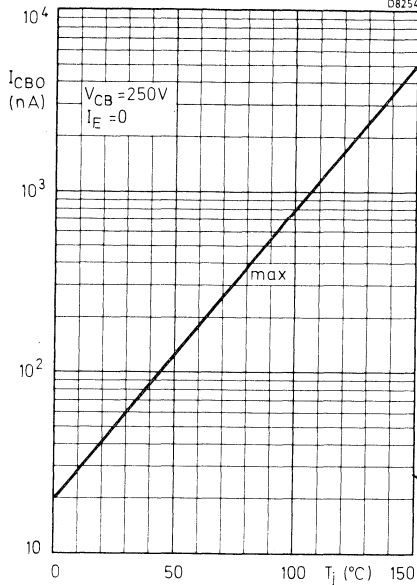


Fig. 8.

D8255

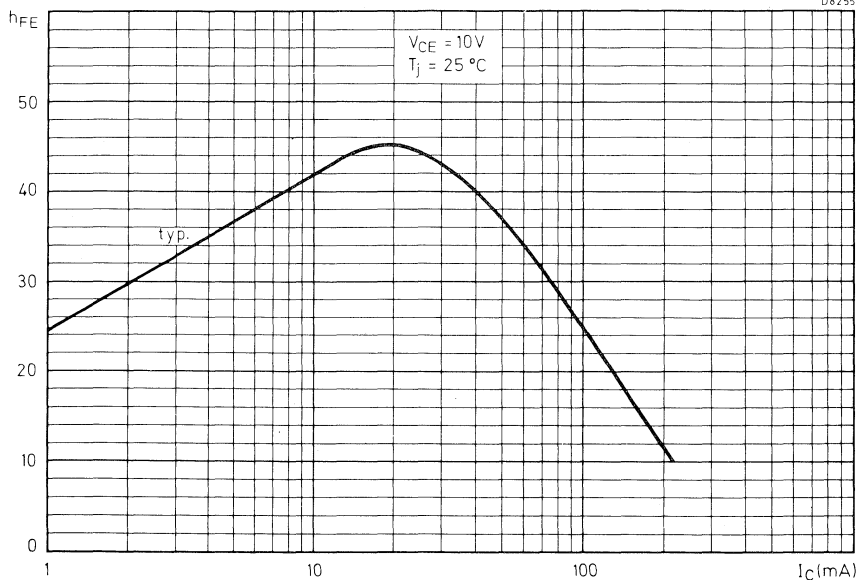


Fig. 9.



SILICON PLANAR TRANSISTORS

for video output stages

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

QUICK REFERENCE DATA

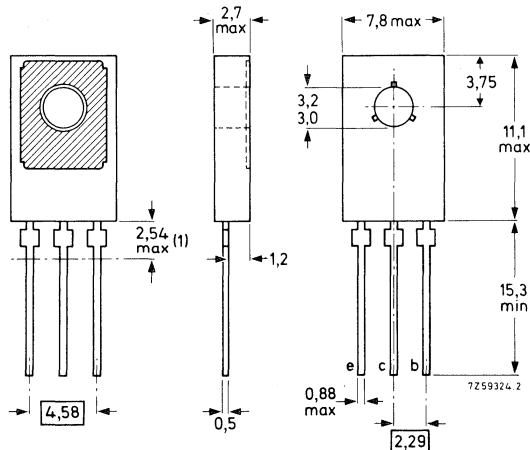
		BF457	BF458	BF459	
Collector-base voltage (open emitter)	V_{CB0} max.	160	250	300	V
Collector-emitter voltage (open base)	V_{CE0} max.	160	250	300	V
Collector current (peak value)	I_{CM} max.		300		mA
Total power dissipation up to $T_{mb} = 90\text{ }^{\circ}\text{C}$	P_{tot} max.		6		W
Junction temperature	T_j max.		150		$^{\circ}\text{C}$
D.C. current gain at $T_j = 25\text{ }^{\circ}\text{C}$ $I_C = 30\text{ mA}; V_{CE} = 10\text{ V}$	$h_{FE} >$		26		
Transition frequency $I_C = 15\text{ mA}; V_{CE} = 10\text{ V}$	f_T typ.		90		MHz
Feedback capacitance at $f = 1\text{ MHz}$ $I_E = 0; V_{CB} = 30\text{ V}$	$C_{re} <$		3,5		pF

MECHANICAL DATA

Dimensions in mm

Collector connected to metal part of mounting surface

TO-126 (SOT-32)



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

See also chapters Mounting instructions and Accessories.

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

<u>Voltage</u>		BF457	BF458	BF459	
Collector-base voltage (open emitter)	V_{CBO}	max. 160	250	300	V
Collector-emitter voltage (open base)	V_{CEO}	max. 160	250	300	V
Emitter-base voltage (open collector)	V_{EBO}	max. 5	5	5	V

<u>Current</u>					
Collector current (d. c.)		I_C	max.	100	mA
Collector current (peak value)		I_{CM}	max.	300	mA
Base current (d. c.)		I_B	max.	50	mA

<u>Power dissipation</u>					
Total power dissipation up to $T_{mb} = 90^\circ\text{C}$		P_{tot}	max.	6	W

<u>Temperature</u>					
Storage temperature		T_{stg}		-55 to +150	$^\circ\text{C}$
Junction temperature		T_j	max.	150	$^\circ\text{C}$

THERMAL RESISTANCE

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

CHARACTERISTICS

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

Collector cut-off current

$I_E = 0; V_{CB} = 100\text{ V}$ for BF457

$I_E = 0; V_{CB} = 200\text{ V}$ for BF458

$I_E = 0; V_{CB} = 250\text{ V}$ for BF459

$I_{CBO} < 50\text{ nA}$

Emitter cut-off current

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

$I_{EBO} < 50\text{ nA}$

D.C. current gain

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

$h_{FE} > 26$

Collector-emitter saturation voltage

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

$V_{CEsat} < 1\text{ V}$

High frequency knee voltage at $T_j = 150^\circ\text{C}$

$I_C = 50\text{ mA}$

V_{CEK} typ. 15 V

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

Transition frequency at $f = 100\text{ MHz}$

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

f_T typ. 90 MHz

Feedback capacitance at $f = 1\text{ MHz}$

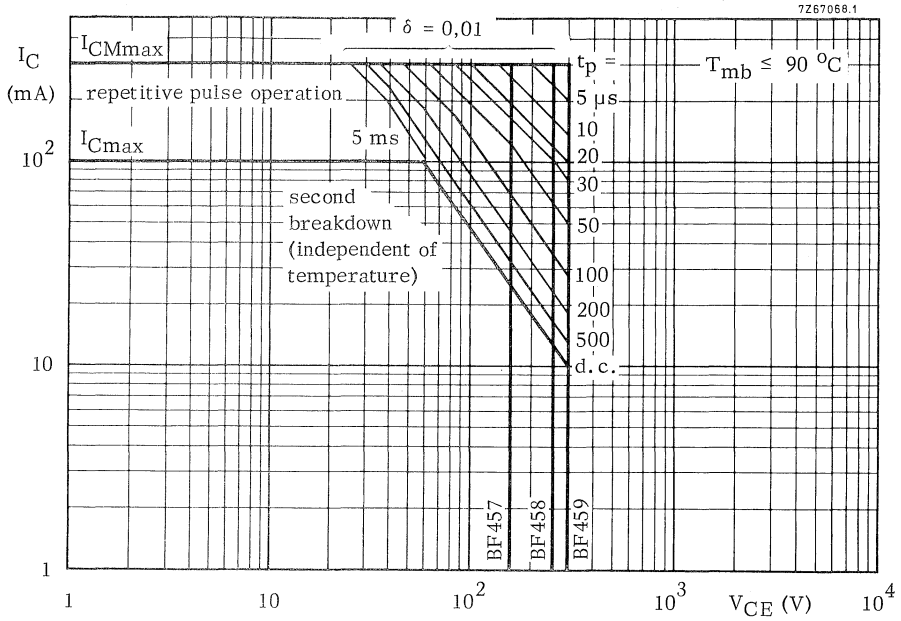
$I_E = 0; V_{CB} = 30\text{ V}$

$C_{re} < 3,5\text{ pF}$

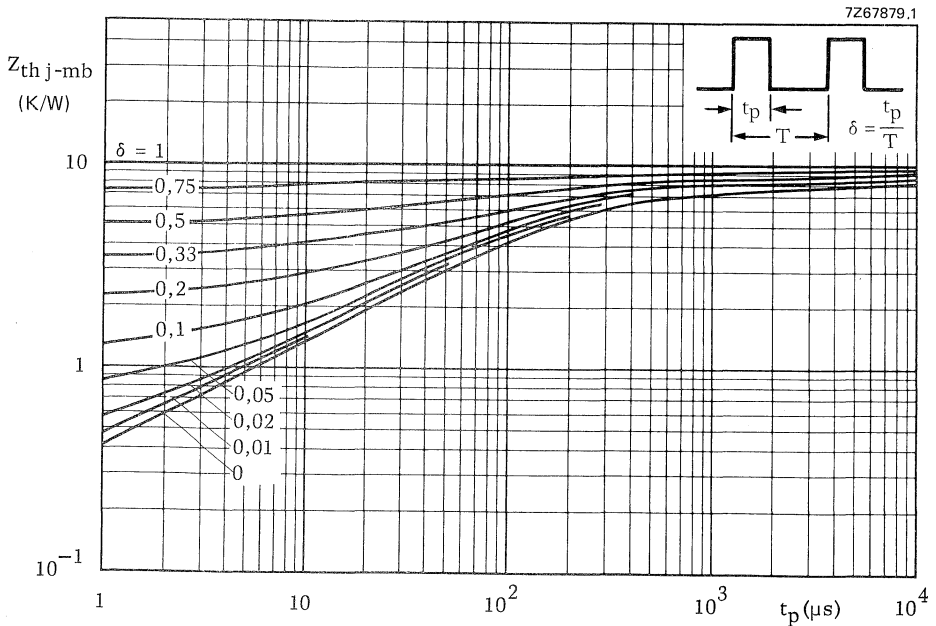
Output capacitance at $f = 1\text{ MHz}$

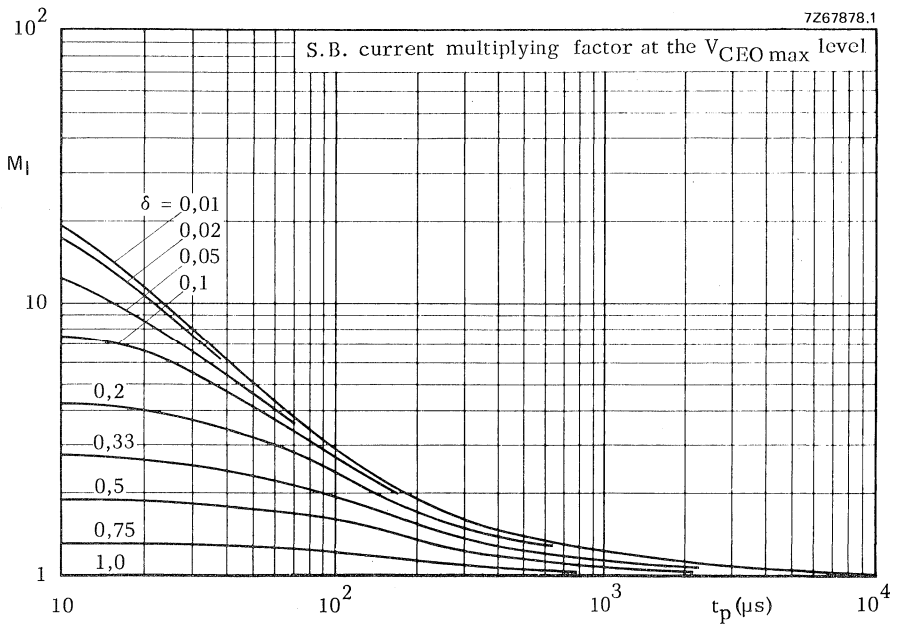
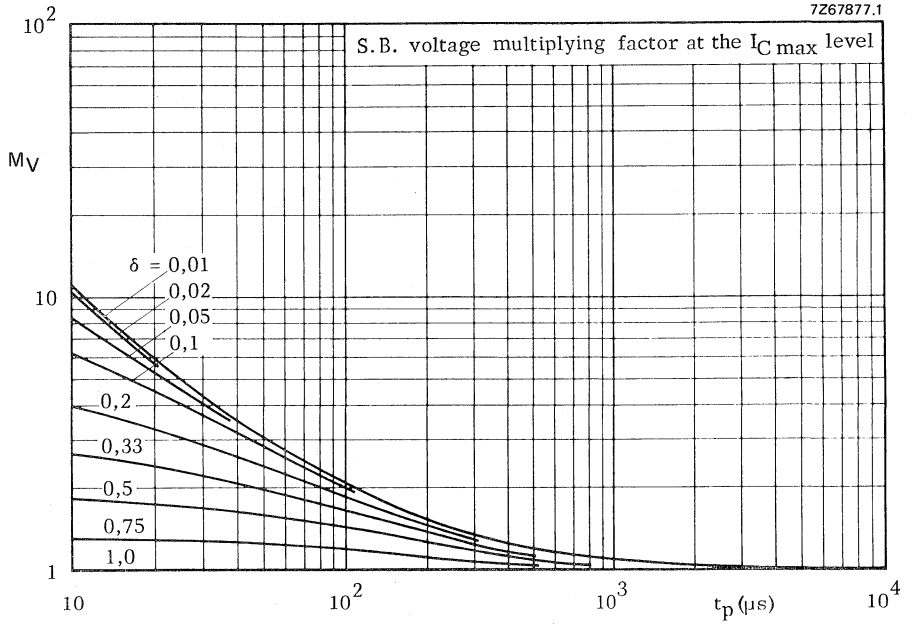
$I_E = 0; V_{CB} = 30\text{ V}$

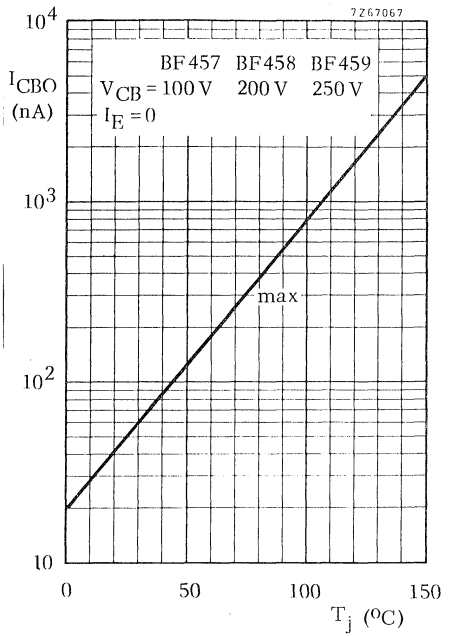
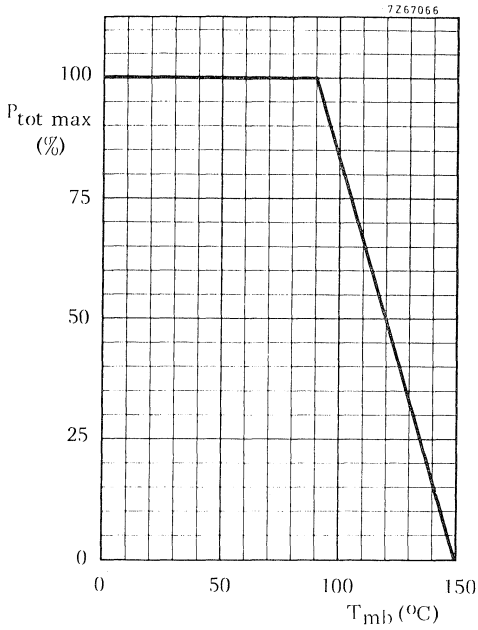
$C_{oe} < 4,5\text{ pF}$



Safe Operating Area with the transistor forward biased







SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in plastic envelope intended for class-B video output stages in television receivers and for high-voltage i.f. output stages.

P-N-P complements are BF470 and BF472 respectively.

QUICK REFERENCE DATA

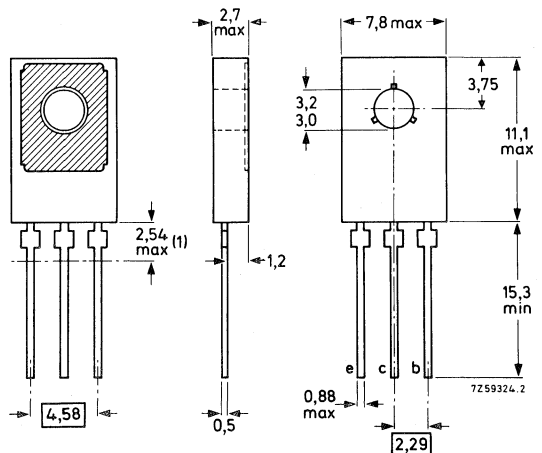
		BF469	BF471
Collector-base voltage (open emitter)	V_{CBO}	max. 250	300 V
Collector-emitter voltage open base	V_{CEO}	max. 250	— V
$R_{BE} = 2,7 \text{ k}\Omega$	V_{CER}	max. —	300 V
Collector current (peak value)	I_{CM}	max. 100	mA
Total power dissipation up to $T_{mb} \leq 114 \text{ }^\circ\text{C}$	P_{tot}	max. 1,8	W
Junction temperature	T_j	max. 150	$^\circ\text{C}$
D.C. current gain	h_{FE}	>	50
$I_C = 25 \text{ mA}; V_{CE} = 20 \text{ V}$			
Transition frequency	f_T	>	60 MHz
$I_C = 10 \text{ mA}; V_{CE} = 10 \text{ V}$			
Feedback capacitance at $f = 0,5 \text{ MHz}$	C_{re}	<	1,8 pF
$I_E = 0; V_{CB} = 30 \text{ V}$			

MECHANICAL DATA

Dimensions in mm

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	BF471
Collector-base voltage (open emitter)	V_{CBO}	max.	250	300 V
Collector-emitter voltage	V_{CER}	max.	—	300 V
$R_{BE} = 2,7 \text{ k}\Omega$ open base	V_{CEO}	max.	250	— V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V
Collector current (d.c.)	I_C	max.	50	mA
Collector current (peak value)	I_{CM}	max.	100	mA
Total power dissipation up to $T_{mb} = 114 \text{ }^\circ\text{C}$ *	P_{tot}	max.	1,8	W
Storage temperature	T_{stg}		-65 to + 150	$^\circ\text{C}$
Junction temperature	T_j	max.	150	$^\circ\text{C}$

THERMAL RESISTANCE

From junction to mounting base	$R_{th \text{ j-mb}}$	=	20	K/W
From junction to ambient in free air *	$R_{th \text{ j-a}}$	=	100	K/W

* Transistor mounted on a printed-circuit board, maximum lead length 4 mm, mounting pad for collector lead minimum 10 mm x 10 mm.

CHARACTERISTICS

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

Collector cut-off current

 $I_E = 0; V_{CB} = 200\text{ V}$ $R_{BE} = 2,7\text{ k}\Omega; V_{CE} = 200\text{ V}; T_j = 150\text{ }^\circ\text{C}$ $I_{CBO} < 10\text{ nA}$ $I_{CER} < 10\text{ }\mu\text{A}$

Emitter cut-off current

 $I_C = 0; V_{EB} = 5\text{ V}$ $I_{EBO} < 10\text{ }\mu\text{A}$

D.C. current gain

 $I_C = 25\text{ mA}; V_{CE} = 20\text{ V}$ $h_{FE} > 50$ High-frequency knee voltage at $T_j = 150\text{ }^\circ\text{C}^*$ $I_C = 25\text{ mA}$ $V_{CEK} \text{ typ. } 20\text{ V}$

Transition frequency

 $I_C = 10\text{ mA}; V_{CE} = 10\text{ V}$ $f_T > 60\text{ MHz}$ Feedback capacitance at $f = 0,5\text{ MHz}$ $I_E = 0; V_{CB} = 30\text{ V}$ $C_{re} < 1,8\text{ pF}$

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

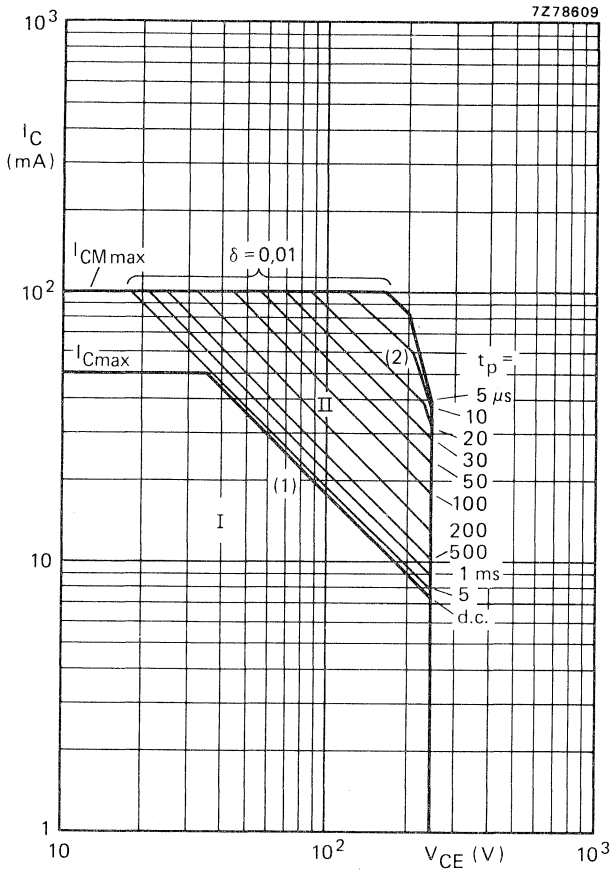
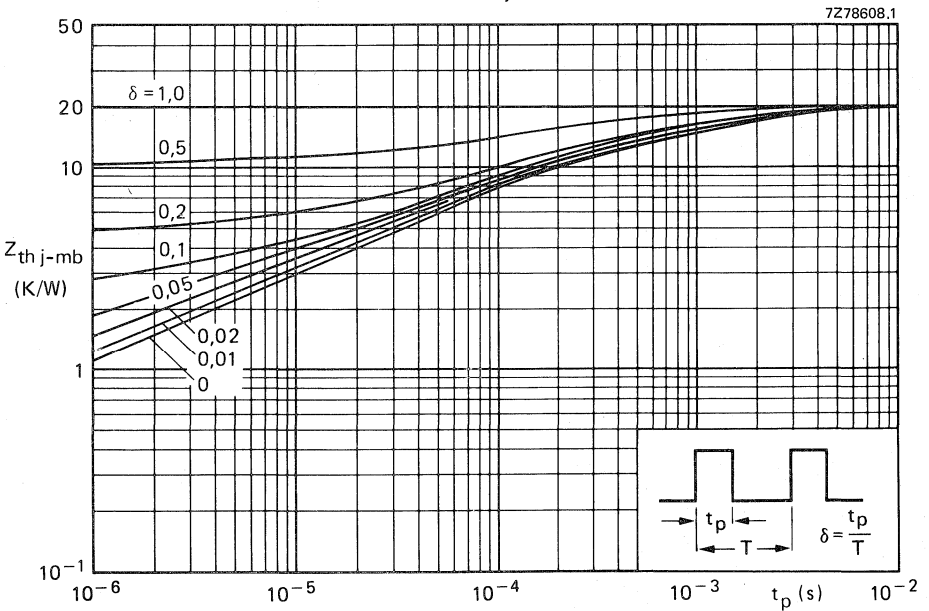
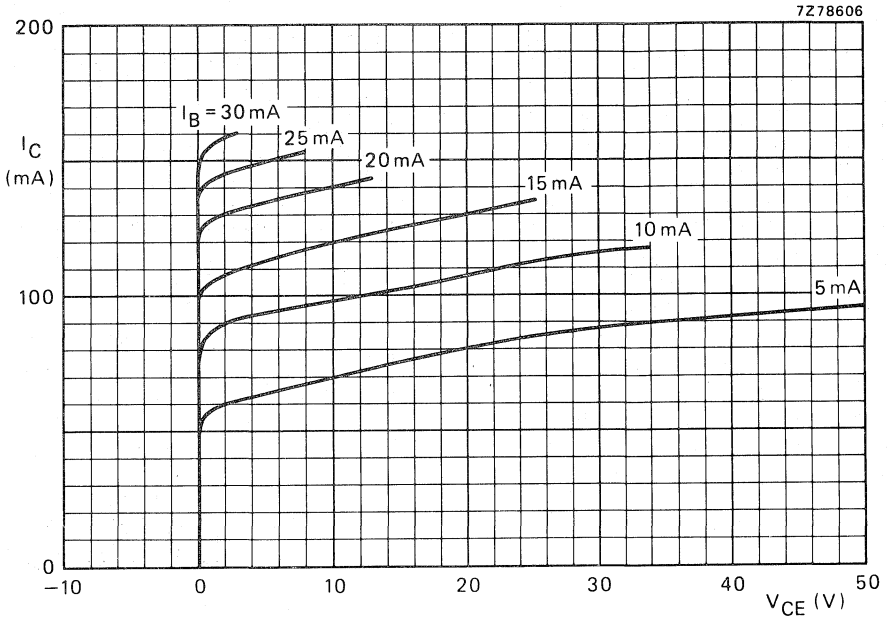


Fig. 2 Safe Operating Area at $T_{mb} = 114 \text{ }^\circ\text{C}$.

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



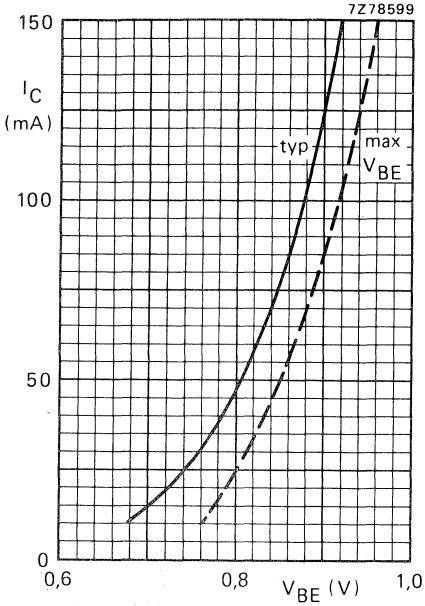


Fig. 5 $V_{CE} = 20$ V; $T_j = 25$ °C.

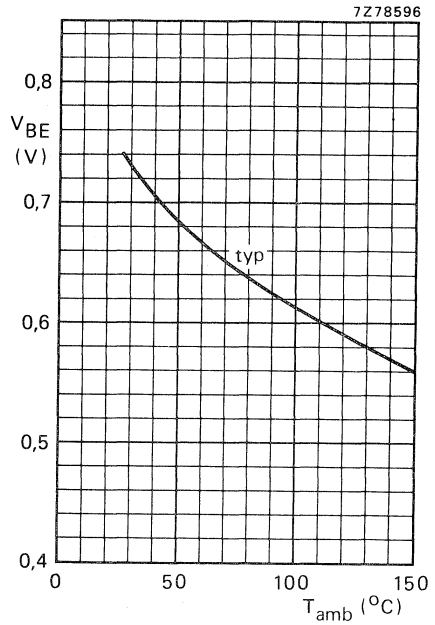


Fig. 6 $I_C = 25$ mA; $V_{CE} = 20$ V.

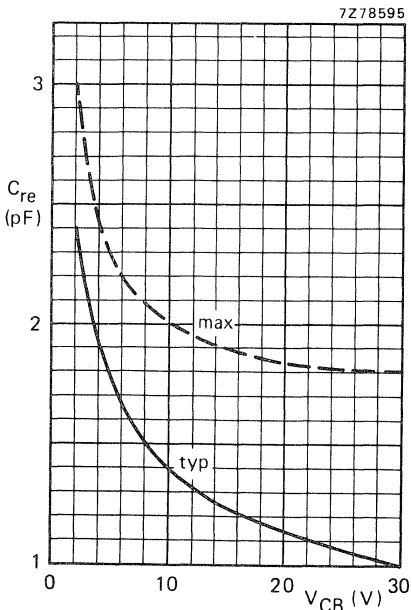


Fig. 7 $I_E = 0$; $f = 1$ MHz; $T_j = 25$ °C.

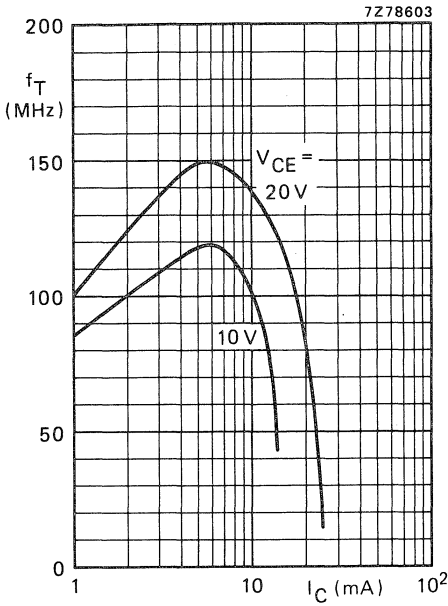


Fig. 8 $f_M = 35 \text{ MHz}$; $T_{amb} = 25 \text{ }^\circ\text{C}$.

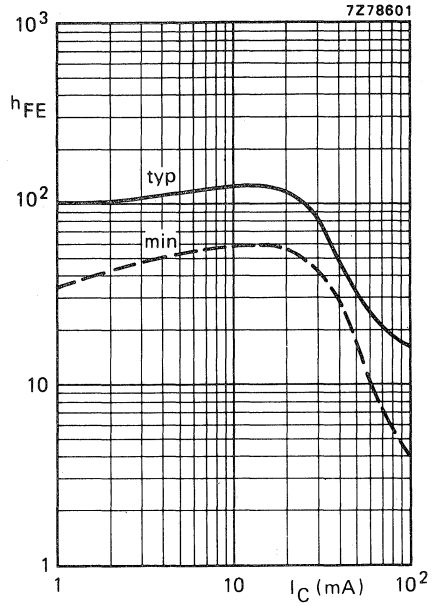


Fig. 9 $V_{CE} = 20 \text{ V}$; $T_{amb} = 25 \text{ }^\circ\text{C}$.

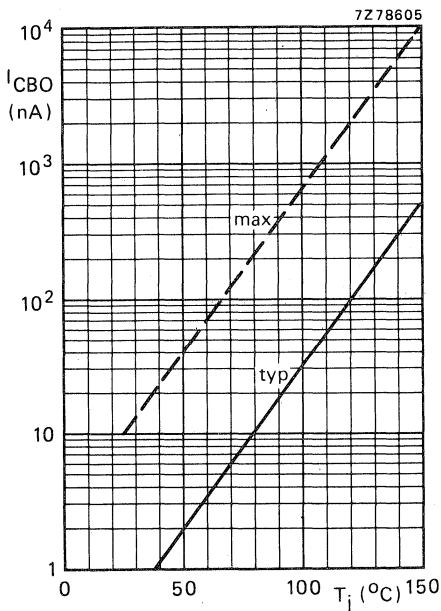


Fig. 10 $V_{CB} = 200 \text{ V}$.

SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in a plastic envelope intended for class-B video output stages in television receivers and for high-voltage i.f. output stages.

N-P-N complements are BF469 and BF471 respectively.

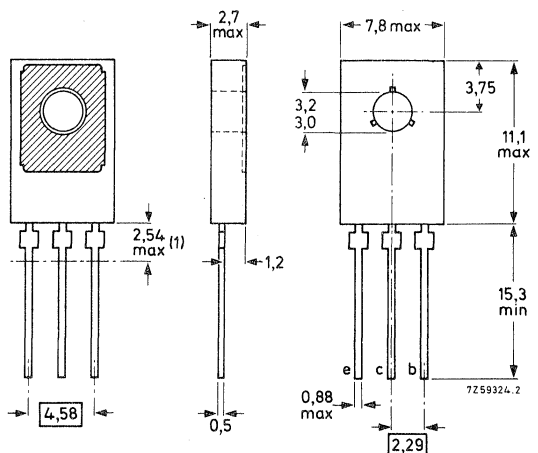
QUICK REFERENCE DATA

		BF470	BF472
Collector-base voltage (open emitter)	$-V_{CBO}$	max. 250	300 V
Collector-emitter voltage open base	$-V_{CEO}$	max. 250	— V
$R_{BE} = 2,7 \text{ k}\Omega$	$-V_{CER}$	max. —	300 V
Collector current (peak value)	$-I_{CM}$	max. 100	mA
Total power dissipation up to $T_{mb} = 114 \text{ }^\circ\text{C}$	P_{tot}	max. 1,8	W
Junction temperature	T_j	max. 150	$^\circ\text{C}$
D.C. current gain	h_{FE}	>	50
$-I_C = 25 \text{ mA}; -V_{CE} = 20 \text{ V}$	f_T	>	60 MHz
Transition frequency	C_{re}	<	1,8 pF
$-I_C = 10 \text{ mA}; -V_{CE} = 10 \text{ V}$			
Feedback capacitance at $f = 0,5 \text{ MHz}$			
$I_E = 0; -V_{CB} = 30 \text{ V}$			

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)	$-V_{CBO}$	max. 250	300 V
Collector-emitter voltage	$-V_{CER}$	max. —	300 V
$R_{BE} = 2,7 \text{ k}\Omega$	$-V_{CEO}$	max. 250	— V
open base			
Emitter-base voltage (open collector)	$-V_{EBO}$	max. 5	V
Collector current (d.c.)	$-I_C$	max. 50	mA
Collector current (peak value)	$-I_{CM}$	max. 100	mA
Total power dissipation up to $T_{mb} = 114 \text{ }^\circ\text{C}^*$	P_{tot}	max. 1,8	W
Storage temperature	T_{stg}	—65 to +150	$^\circ\text{C}$
Junction temperature	T_j	max. 150	$^\circ\text{C}$

THERMAL RESISTANCE

From junction to mounting base	$R_{th \text{ j-mb}}$	=	20	$^\circ\text{C/W}$
From junction to ambient in free air *	$R_{th \text{ j-a}}$	=	100	$^\circ\text{C/W}$

* Transistor mounted on a printed-circuit board, maximum lead length 4 mm; mounting pad for collector lead minimum 10 mm x 10 mm.

CHARACTERISTICS

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

Collector cut-off current

$I_E = 0; -V_{CB} = 200\text{ V}$

$R_{BE} = 2,7\text{ k}\Omega; -V_{CE} = 200\text{ V}; T_j = 150\text{ }^\circ\text{C}$

$-I_{CBO}$	<	10	nA
$-I_{CER}$	<	10	μA

Emitter cut-off current

$I_C = 0; -V_{EB} = 5\text{ V}$

$-I_{EBO}$	<	10	μA
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D.C. current gain

$-I_C = 25\text{ mA}; -V_{CE} = 20\text{ V}$

h_{FE}	>	50	
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High-frequency knee voltage at $T_j = 150\text{ }^\circ\text{C}^*$

$-I_C = 25\text{ mA}$

$-V_{CEK}$	typ.	20	V
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Transition frequency

$-I_C = 10\text{ mA}; -V_{CE} = 10\text{ V}$

f_T	>	60	MHz
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Feedback capacitance at $f = 0,5\text{ MHz}$

$I_E = 0; -V_{CB} = 30\text{ V}$

C_{re}	<	1,8	μF
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* The high-frequency knee voltage of a transistor is that value of the collector-emitter voltage at which the small-signal gain, measured in a practical circuit, has dropped to 80% of the gain at $-V_{CE} = 50\text{ V}$. A further reduction of the collector-emitter voltage results in a rapid increase of the distortion of the signal.

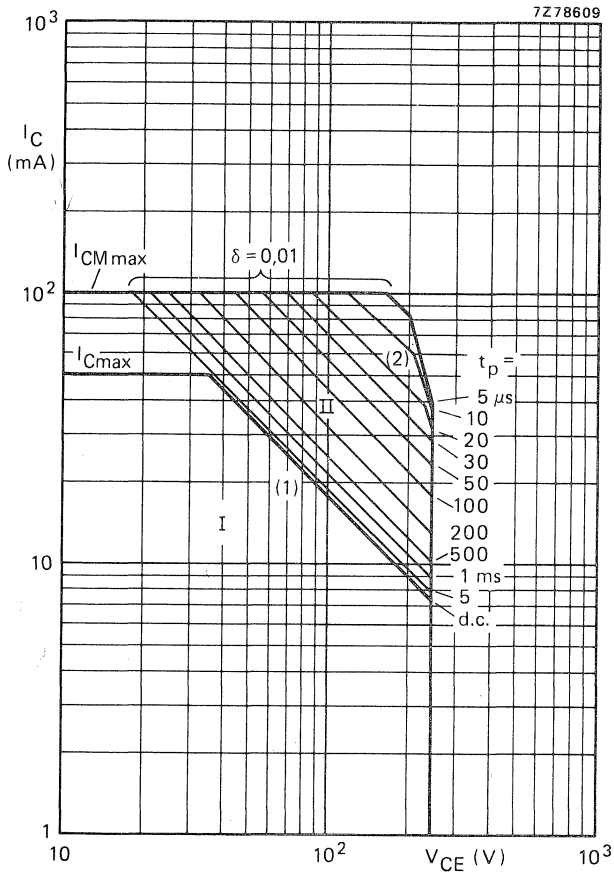


Fig. 2 Safe Operating Area at $T_{mb} = 114 \text{ }^\circ\text{C}$.

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

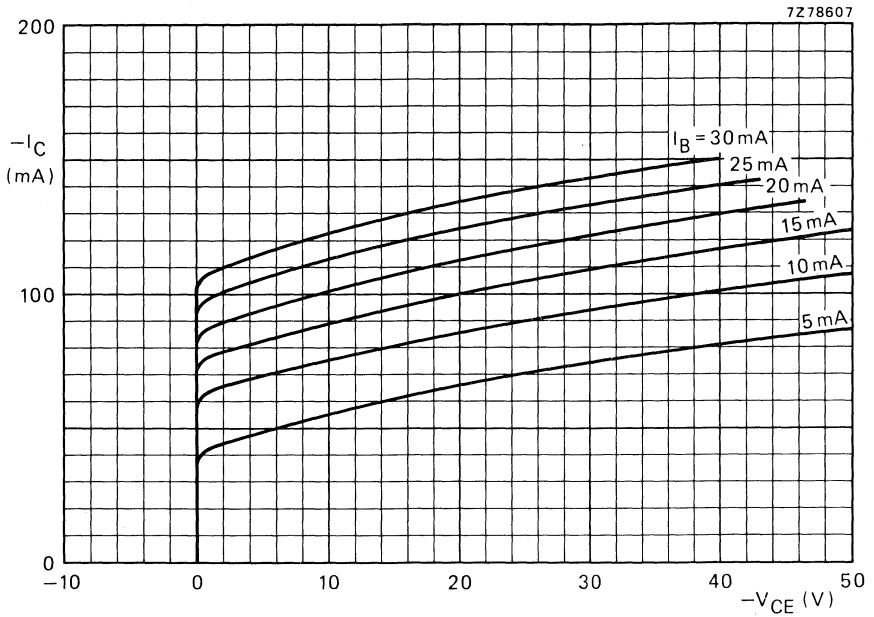


Fig. 3 $T_j = 25^\circ\text{C}$.

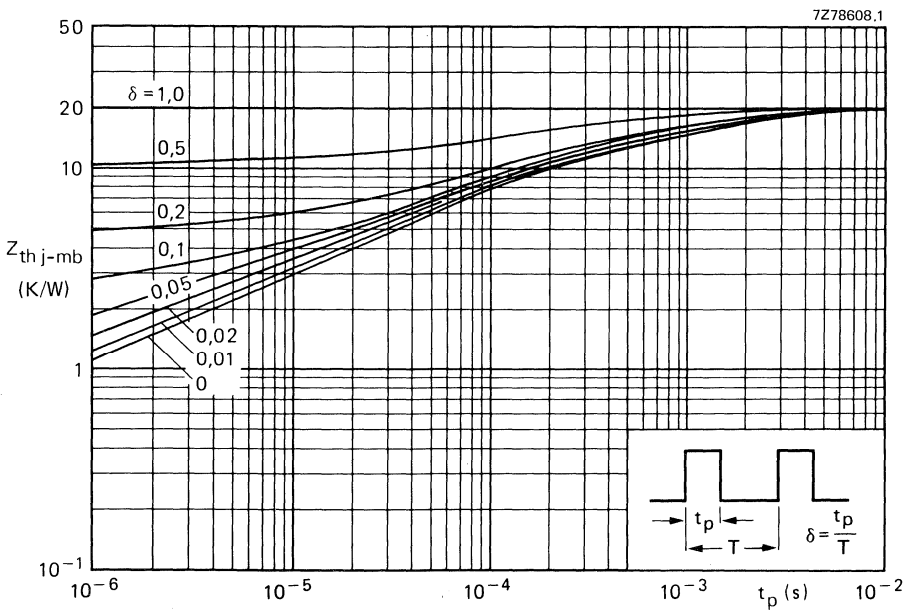


Fig. 4.

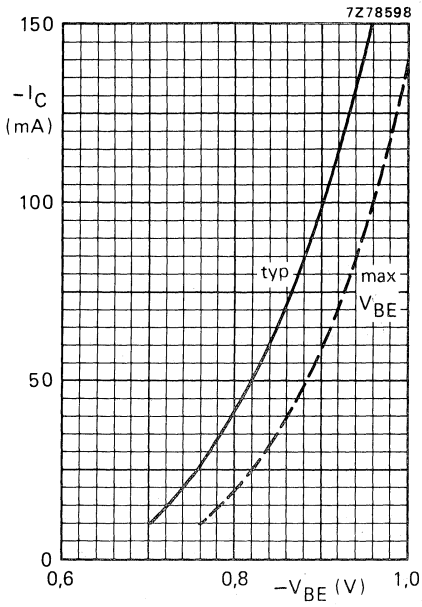


Fig. 5 $-V_{CE} = 20$ V; $T_j = 25$ °C.

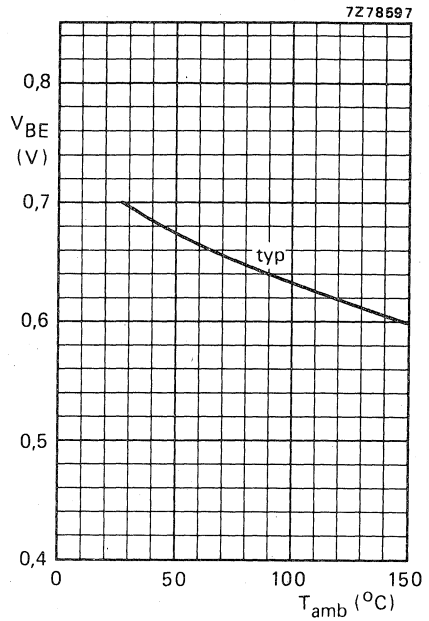


Fig. 6 $-V_{CE} = 20$ V; $-I_C = 25$ mA.

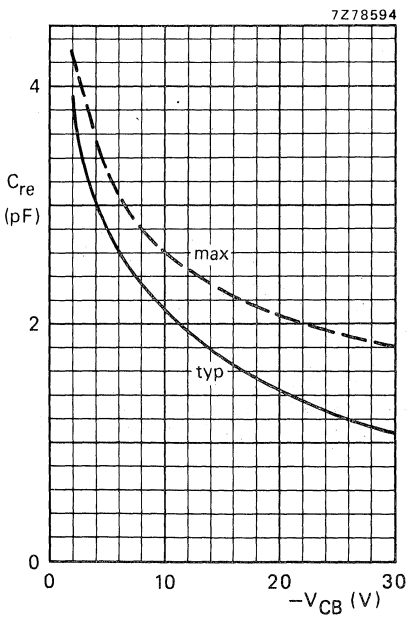


Fig. 7 $I_E = 0$; $f = 1$ MHz; $T_j = 25$ °C.

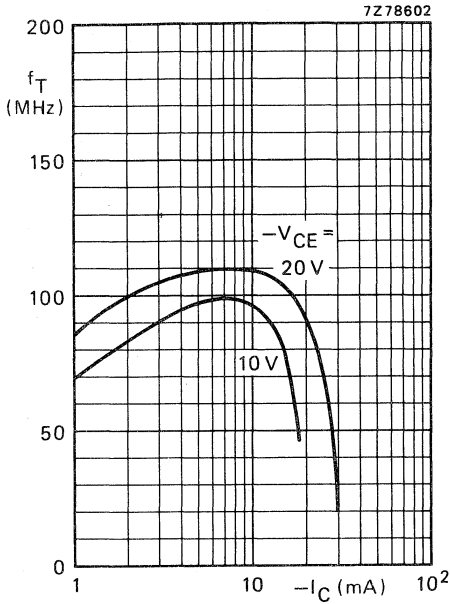


Fig. 8 $f_M = 35\text{ MHz}$; $T_{amb} = 25\text{ }^\circ\text{C}$.

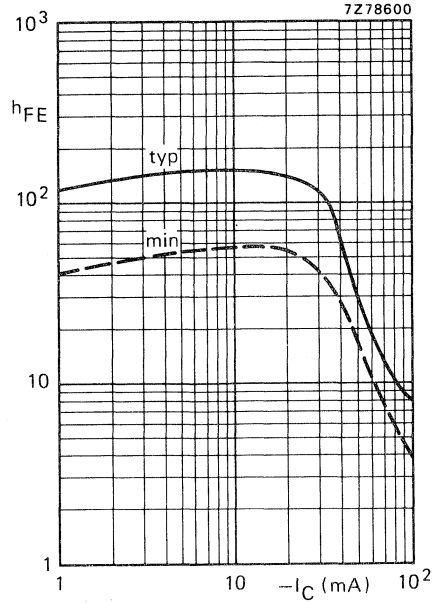


Fig. 9 $-V_{CE} = 20\text{ V}$; $T_{amb} = 25\text{ }^\circ\text{C}$.

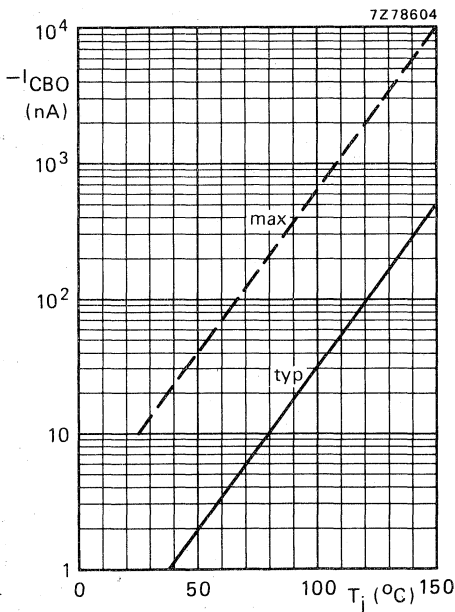


Fig. 10 $-V_{CB} = 200\text{ V}$.

SILICON PLANAR TRANSISTOR

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

QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CB0}	max.	300 V
Collector-emitter voltage (open base)	V_{CEO}	max.	250 V
Collector current (peak value)	I_{CM}	max.	300 mA
Total power dissipation up to $T_{mb} = 75\text{ }^\circ\text{C}$	P_{tot}	max.	6 W
Junction temperature	T_j	max.	150 $^\circ\text{C}$
D.C. current gain	h_{FE}	typ.	45
$I_C = 20\text{ mA}, V_{CE} = 10\text{ V}$			
Storage time	t_s	typ.	0,5 μs

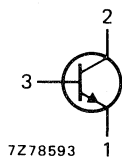
MECHANICAL DATA

Fig. 1 TO-202.

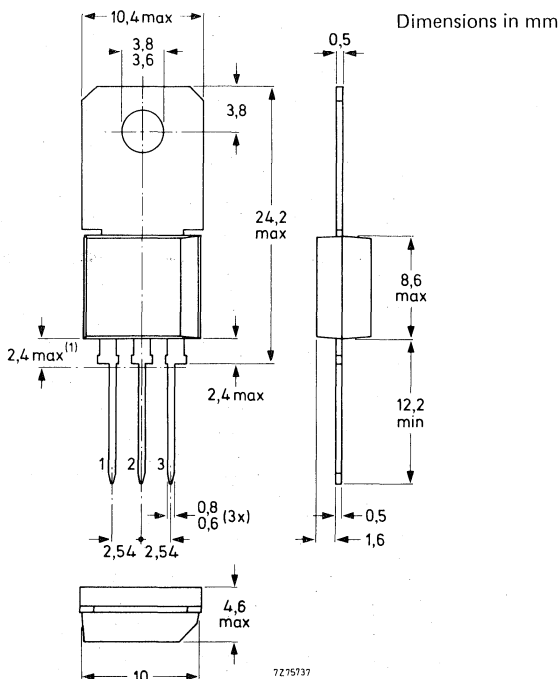
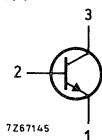
Collector connected to mounting base.

(1) Plastic flash allowed within this zone.

BF819



BF819A



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

RATINGS

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

Collector-base voltage (open emitter)	V_{CBO}	max.	300 V
Collector-emitter voltage (open base)	V_{CEO}	max.	250 V
Emitter-base voltage (open collector)	V_{EBO}	max.	5 V
Collector current (d.c.)	I_C	max.	100 mA
Collector current (peak value)*	I_{CM}	max.	300 mA
Base current (d.c.)	I_B	max.	50 mA
Total power dissipation up to $T_{amb} = 75\text{ }^{\circ}\text{C}$	P_{tot}	max.	1,2 W
Total power dissipation up to $T_{mb} = 75\text{ }^{\circ}\text{C}$	P_{tot}	max.	6 W
Storage temperature	T_{stg}		-65 to +150 $^{\circ}\text{C}$
Junction temperature	T_j	max.	150 $^{\circ}\text{C}$

THERMAL RESISTANCE

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

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

7Z85021.1

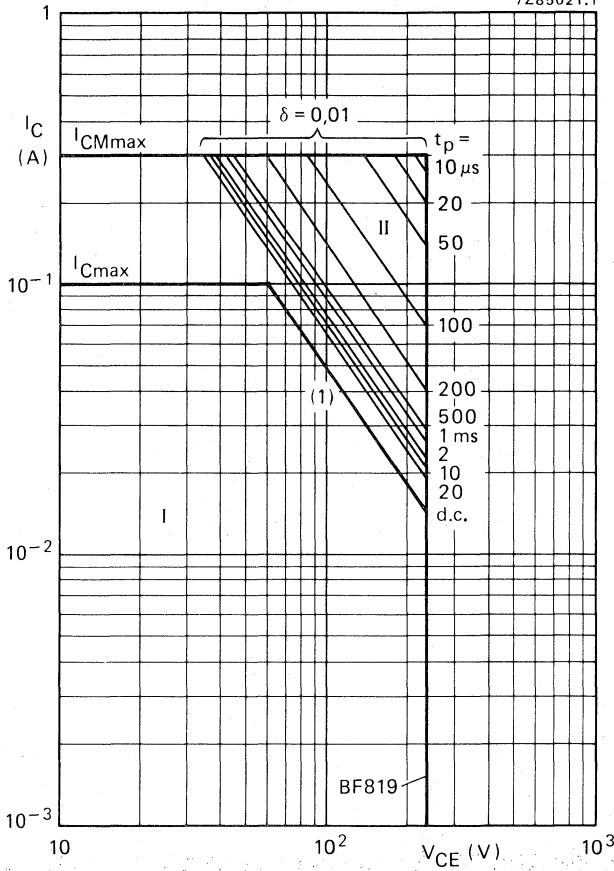


Fig. 3 Safe Operating Area; $T_{mb} = 25\text{ }^{\circ}\text{C}$.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

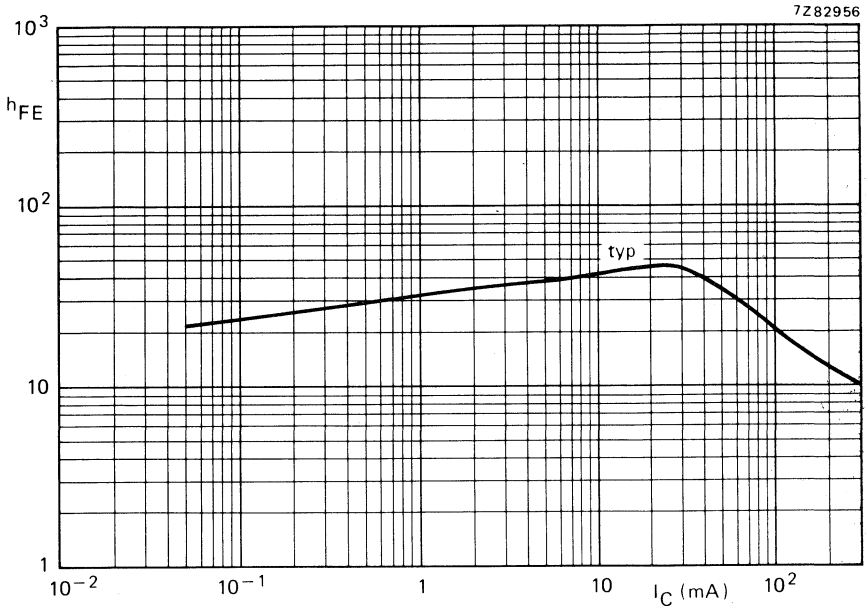


Fig. 4 D.C. current gain. $V_{CB} = 10$ V.

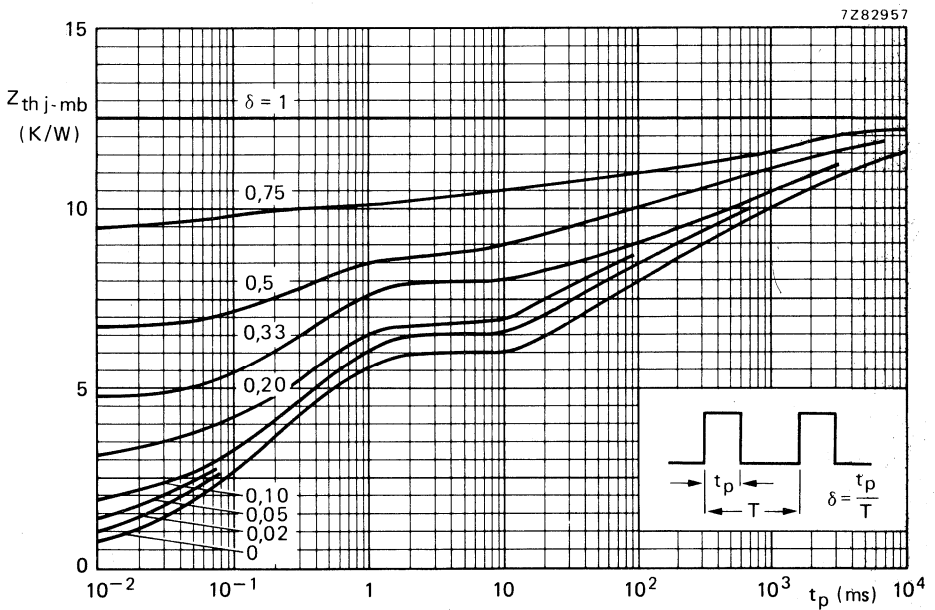


Fig. 5 Pulse power rating chart.

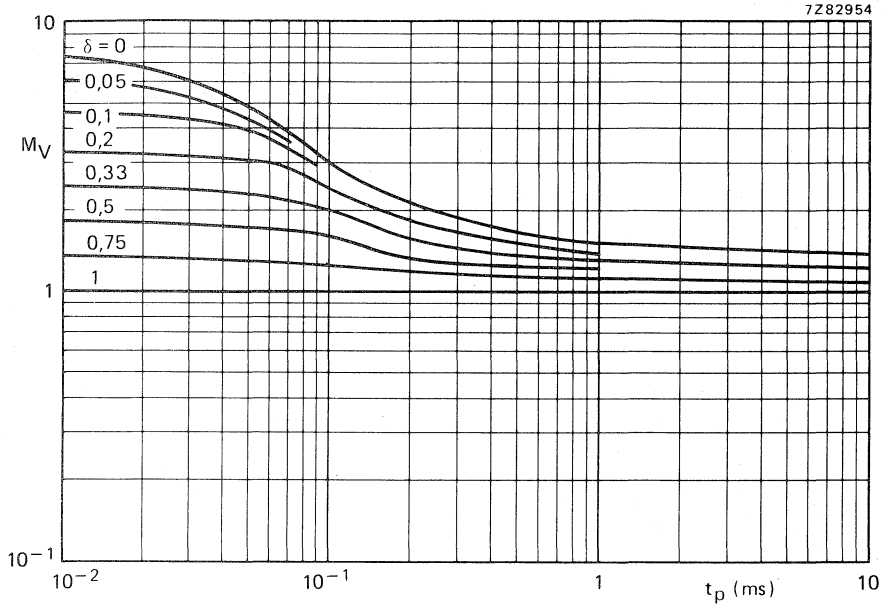


Fig. 6 S.B. voltage multiplying factor at the I_{Cmax} level.

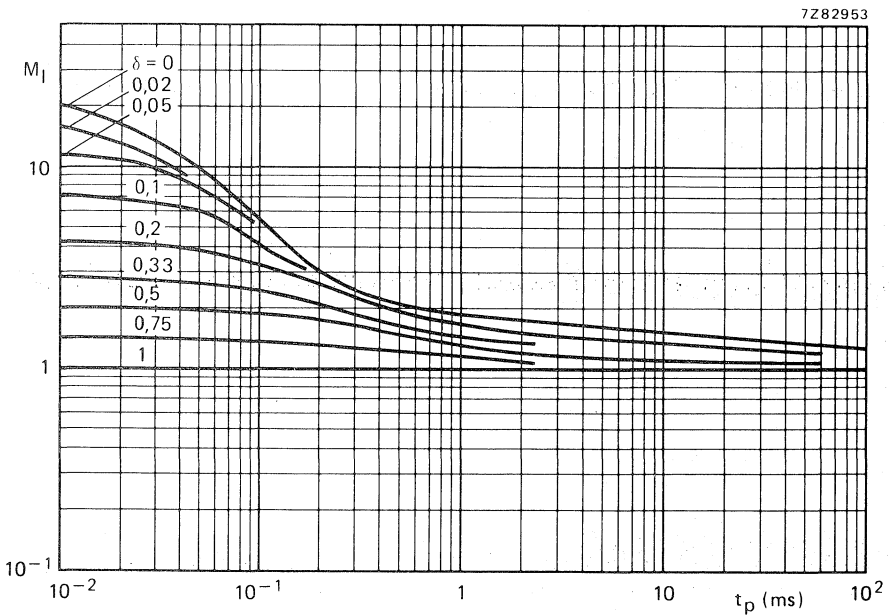


Fig. 7 S.B. current multiplying factor at the V_{CEOmax} level.

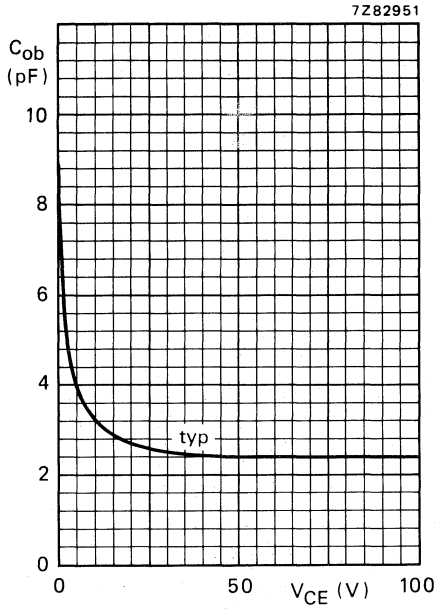
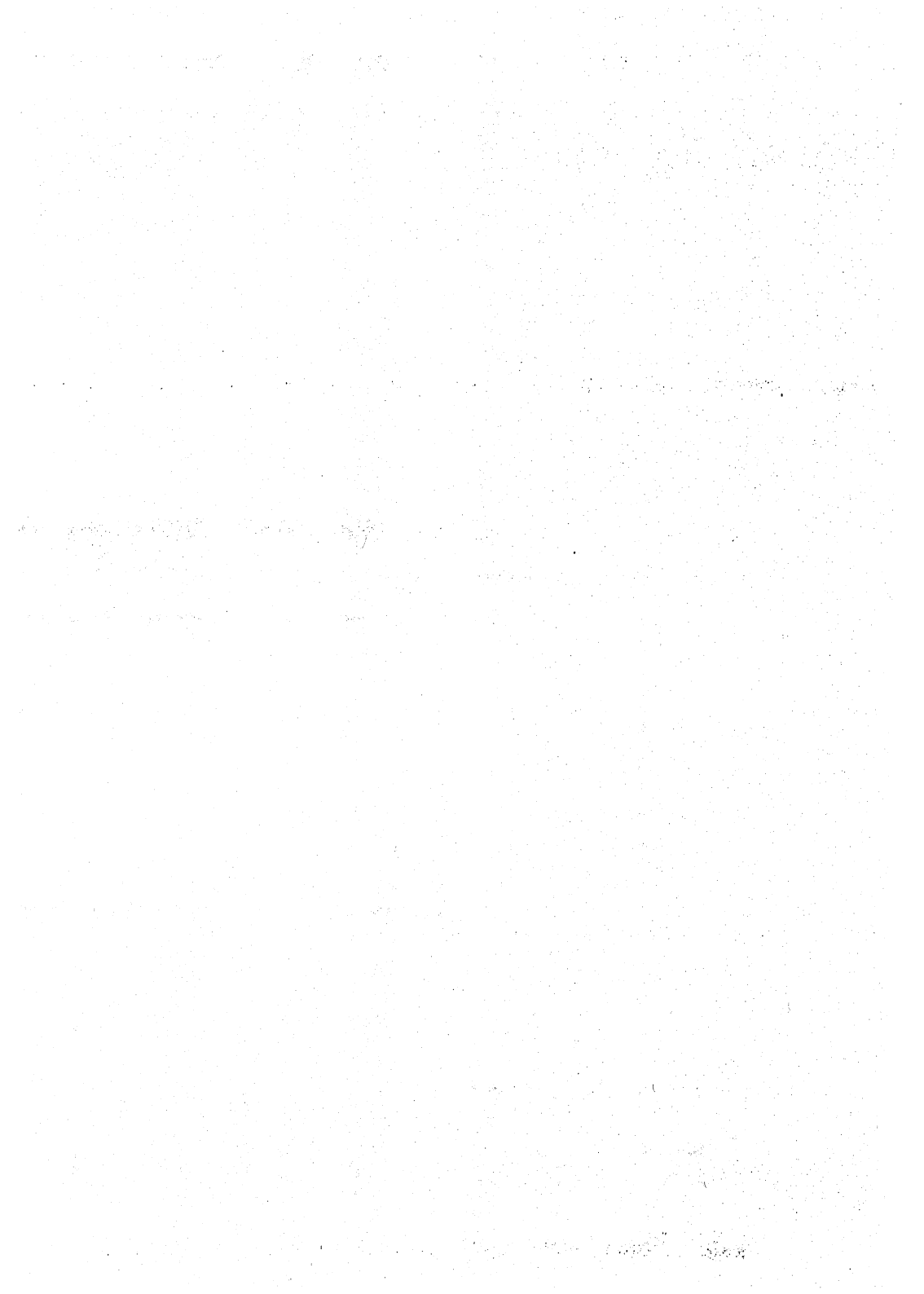


Fig. 8 Collector output capacitance
 $f = 1 \text{ MHz}; I_E = 0.$





SILICON PLANAR VIDEO OUTPUT TRANSISTORS

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

QUICK REFERENCE DATA

		BF857	BF858	BF859
Collector-base voltage (open emitter)	V_{CBO}	max. 160	250	300 V
Collector-emitter voltage (open base)	V_{CEO}	max. 160	250	300 V
Collector current (peak value)	I_{CM}	max.	300	mA
Total power dissipation up to $T_{mb} = 75\text{ }^{\circ}\text{C}$	P_{tot}	max.	6	W
Junction temperature	T_j	max.	150	$^{\circ}\text{C}$
D.C. current gain				
$I_C = 30\text{ mA}; V_{CE} = 10\text{ V}$	h_{FE}	>	26	
Transition frequency at $f = 35\text{ MHz}$				
$I_C = 15\text{ mA}; V_{CE} = 10\text{ V}$	f_T	typ.	90	MHz
Feedback capacitance at $f = 1\text{ MHz}$				
$I_E = 0; V_{CB} = 30\text{ V}$	C_{re}	<	3	pF

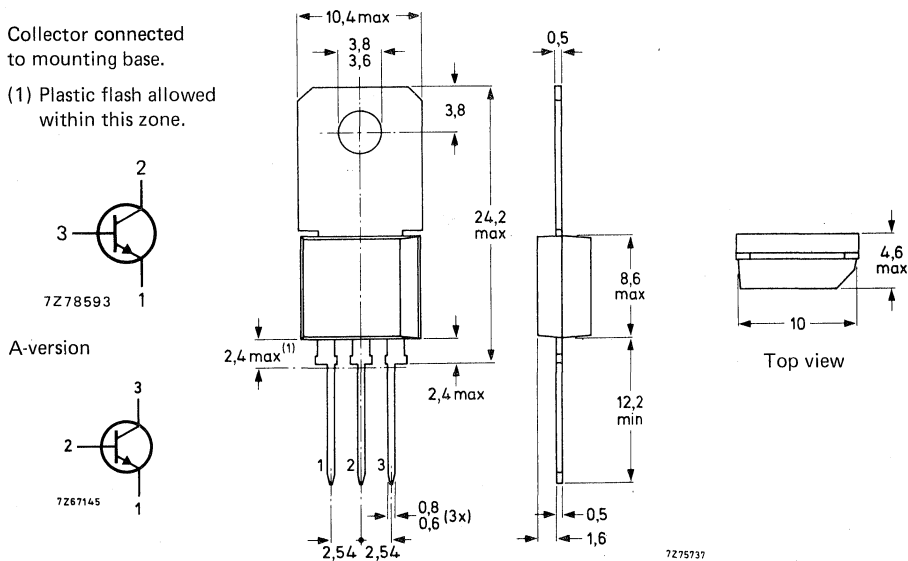
MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-202.

Collector connected to mounting base.

(1) Plastic flash allowed within this zone.



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

RATINGS

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

		BF857	BF858	BF859	
Collector-base voltage (open emitter)	V_{CBO}	max. 160	250	300	V
Collector-emitter voltage (open base)	V_{CEO}	max. 160	250	300	V
Emitter-base voltage (open collector)	V_{EBO}	max. 5	5	5	V
Collector current (d.c.)	I_C	max.	100		mA
Collector current (peak value)	I_{CM}	max.	300		mA
Base current (d.c.)	I_B	max.	50		mA
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	2		W
Total power dissipation up to $T_{mb} = 75\text{ }^\circ\text{C}$	P_{tot}	max.	6		W
Storage temperature	T_{stg}		-65 to + 150		$^\circ\text{C}$
Junction temperature	T_j	max.	150		$^\circ\text{C}$

THERMAL RESISTANCE

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

CHARACTERISTICS

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

Collector cut-off current

$I_E = 0; V_{CB} = 100\text{ V}$ for BF857	I_{CBO}	<	0,1		μA
$I_E = 0; V_{CB} = 200\text{ V}$ for BF858	I_{CBO}	<	0,1		μA
$I_E = 0; V_{CB} = 250\text{ V}$ for BF859	I_{CBO}	<	0,1		μA

Emitter cut-off current

$I_C = 0; V_{EB} = 5\text{ V}$	I_{EBO}	<	100		μA
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D.C. current gain

$I_C = 30\text{ mA}; V_{CE} = 10\text{ V}$	h_{FE}	>	26		
--	----------	---	----	--	--

Collector-emitter saturation voltage

$I_C = 30\text{ mA}; I_B = 6\text{ mA}$	V_{CEsat}	<	1		V
---	-------------	---	---	--	---

Transition frequency at $f = 35\text{ MHz}$

$I_C = 15\text{ mA}; V_{CE} = 10\text{ V}$	f_T	typ.	90		MHz
--	-------	------	----	--	-----

Feedback capacitance at $f = 1\text{ MHz}$

$I_E = 0; V_{CB} = 30\text{ V}$	C_{re}	<	3		pF
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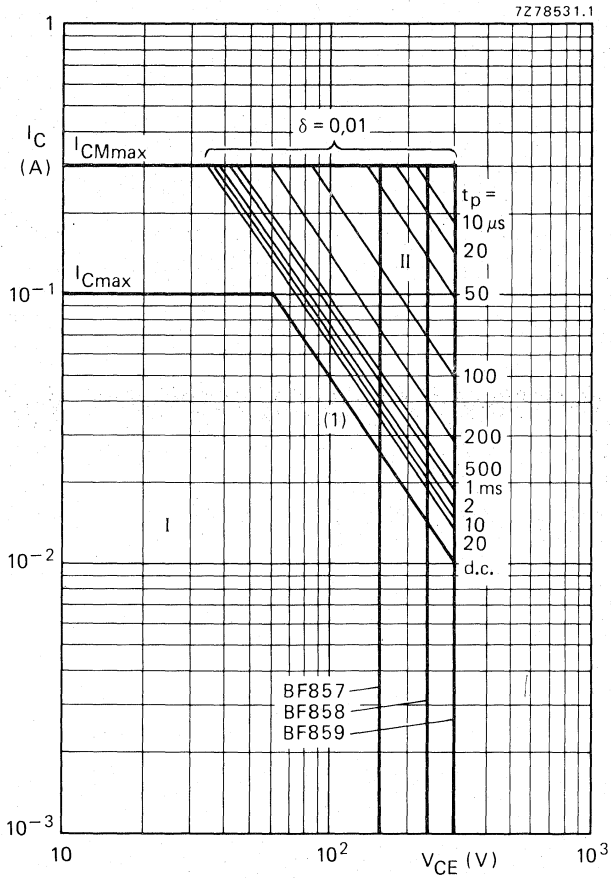


Fig. 2 Safe Operating Area; $T_{mb} = 75^\circ C$.

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

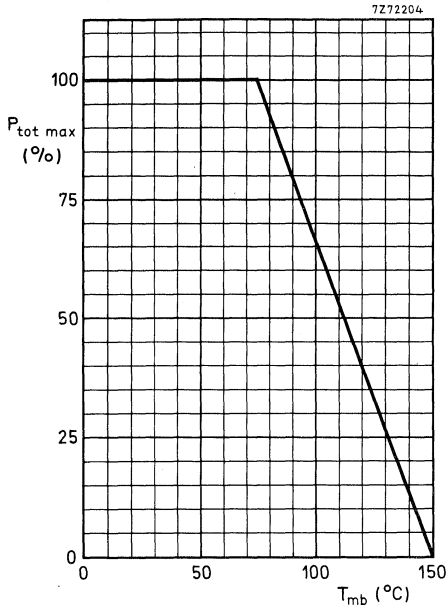


Fig. 3 Power derating curve.

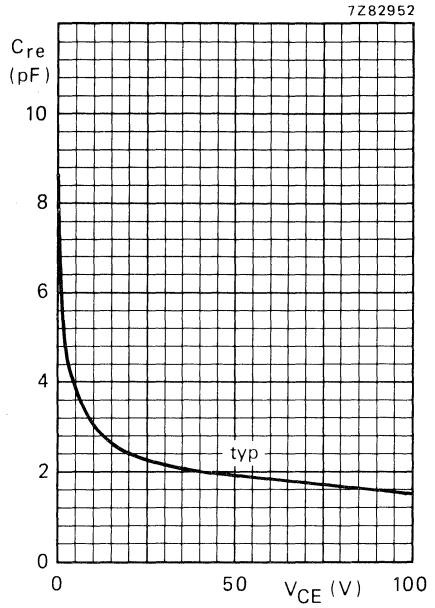


Fig. 4 Feedback capacitance $f = 1$ MHz.

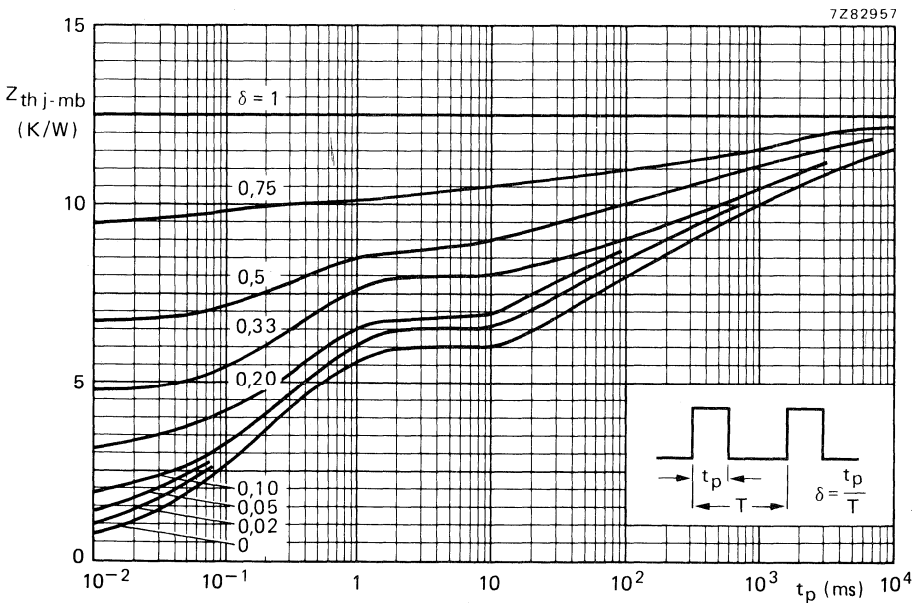


Fig. 5 Pulse power rating chart.

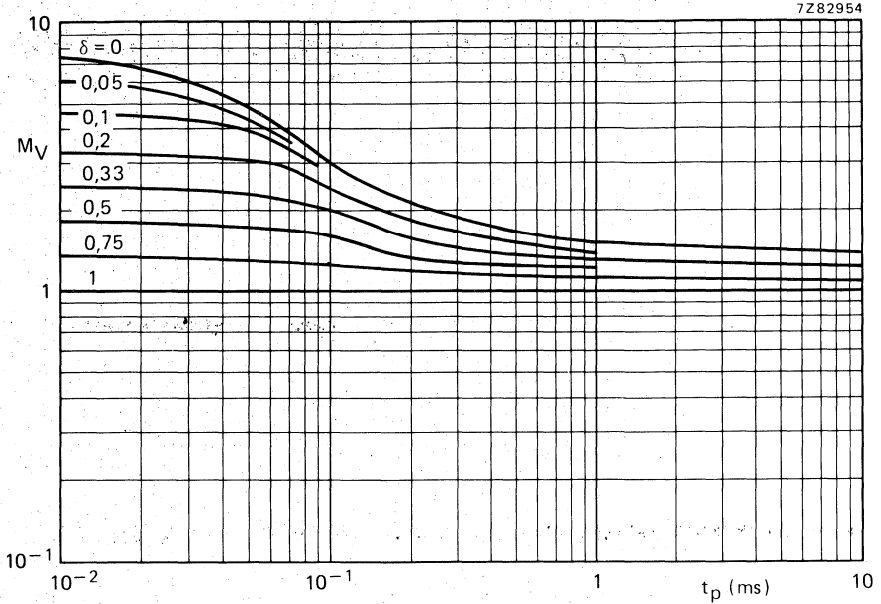


Fig. 6 S.B. voltage multiplying factor at the I_{Cmax} level.

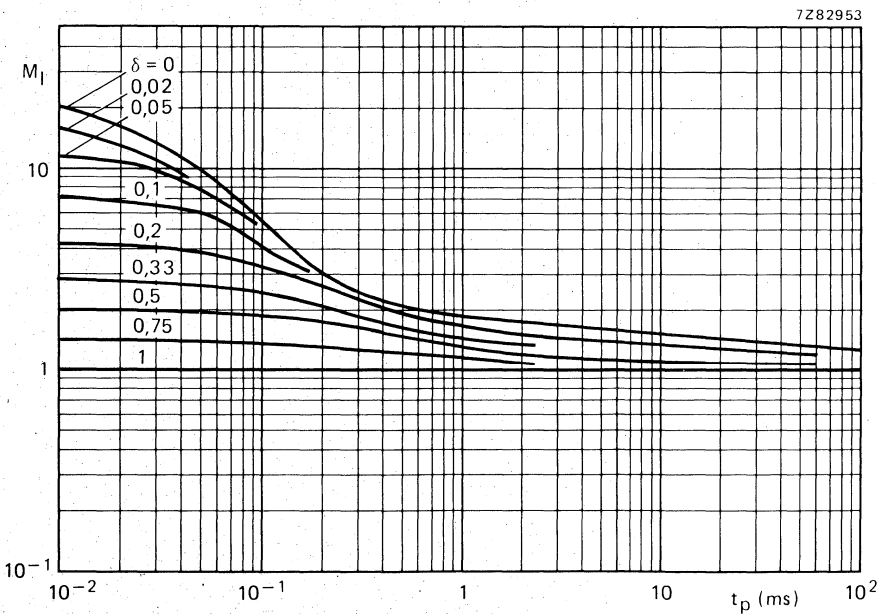


Fig. 7 S.B. current multiplying factor at the V_{CEmax} level.

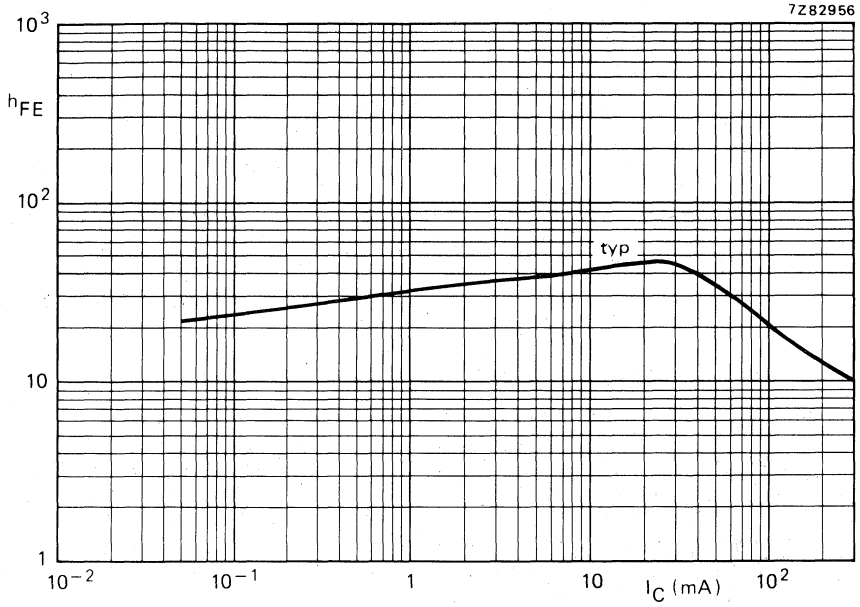


Fig. 8 D.C. current gain. $V_{CE} = 10$ V.

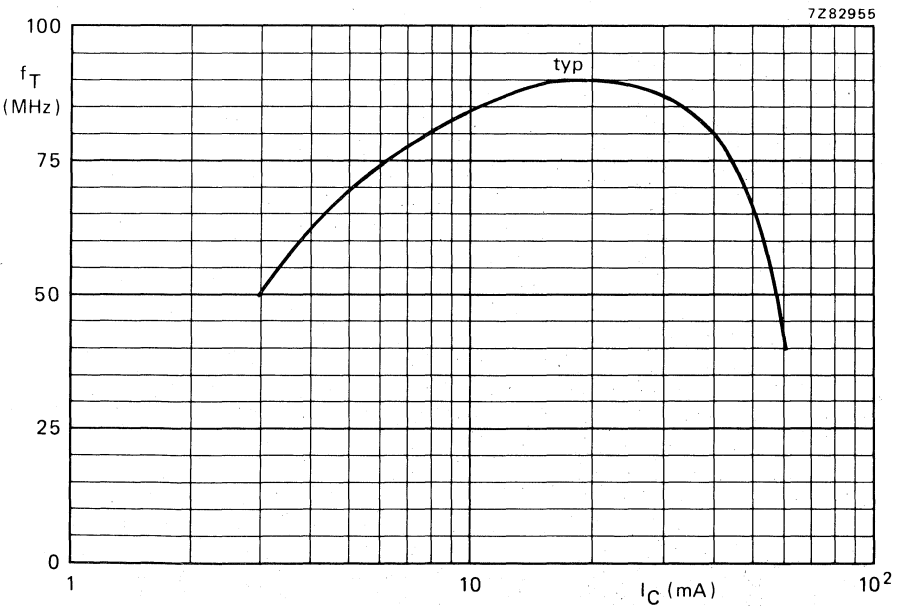


Fig. 9 Transition frequency. $V_{CE} = 10$ V; $f = 35$ MHz.

SILICON PLANAR VIDEO OUTPUT TRANSISTORS

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

QUICK REFERENCE DATA

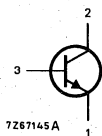
		BF869	BF871
Collector-base voltage (open emitter)	V_{CBO} max.	250	300 V
Collector-emitter voltage (open base)	V_{CEO} max.	250	— V
Collector-emitter voltage ($R_{BE} = 2,7 \text{ k}\Omega$)	V_{CER} max.	—	300 V
Collector current (peak value)	I_{CM} max.	100	mA
Total power dissipation up to $T_{mb} = 25 \text{ }^\circ\text{C}$	P_{tot} max.	5	W
Junction temperature	T_j max.	150	$^\circ\text{C}$
D.C. current gain	h_{FE}	>	50
$I_C = 25 \text{ mA}$; $V_{CE} = 20 \text{ V}$; $T_j = 25 \text{ }^\circ\text{C}$			
Transition frequency	f_T	>	60 MHz
$-I_E = 10 \text{ mA}$; $V_{CB} = 10 \text{ V}$			
Feedback capacitance at $f = 1 \text{ MHz}$	C_{re}	<	2 pF
$I_E = 0$; $V_{CB} = 30 \text{ V}$			

MECHANICAL DATA

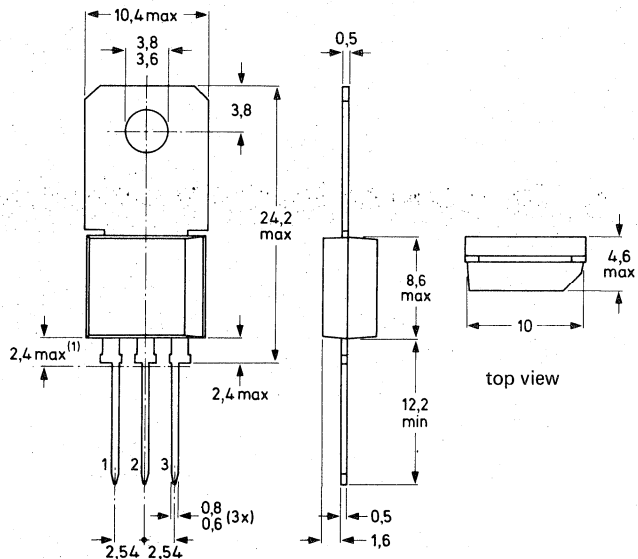
Dimensions in mm

Fig. 1 TO-202.

Collector connected to mounting base.



(1) Plastic flash allowed within this zone.



RATINGS

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

		BF869	BF871
Collector-base voltage (open emitter)	V_{CBO} max.	250	300 V
Collector-emitter voltage (open base)	V_{CEO} max.	250	— V
Collector-emitter voltage ($R_{BE} = 2,7 \text{ k}\Omega$)	V_{CER} max.	—	300 V
Emitter-base voltage (open collector)	V_{EBO} max.	5	V
Collector current (d.c.)	I_C max.	50	mA
Collector current (peak value)	I_{CM} max.	100	mA
Total power dissipation up to $T_{amb} = 25 \text{ }^\circ\text{C}$	P_{tot} max.	1,6	W
Total power dissipation up to $T_{mb} = 25 \text{ }^\circ\text{C}$	P_{tot} max.	5	W
Storage temperature	T_{stg}	-65 to +150	$^\circ\text{C}$
Junction temperature	T_j max.	150	$^\circ\text{C}$

THERMAL RESISTANCE

From junction to ambient	$R_{th j-a} =$	78	K/W
From junction to mounting base	$R_{th j-mb} =$	25	K/W

CHARACTERISTICS

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

		BF869	BF871
Collector cut-off current			
$I_E = 0; V_{CB} = 200 \text{ V}$	$I_{CBO} <$	10	10 nA
$R_{BE} = 2,7 \text{ k}\Omega; V_{CE} = 300 \text{ V}$	$I_{CER} <$	—	1 μA
$R_{BE} = 2,7 \text{ k}\Omega; V_{CE} = 200 \text{ V}; T_j = 150 \text{ }^\circ\text{C}$	$I_{CER} <$	10	μA
Emitter cut-off current			
$I_C = 0; V_{EB} = 5 \text{ V}$	$I_{EBO} <$	10	μA
D.C. current gain			
$I_C = 25 \text{ mA}; V_{CE} = 20 \text{ V}$	$h_{FE} >$	50	
Base-emitter voltage			
$I_C = 25 \text{ mA}; V_{CE} = 20 \text{ V}$	V_{BE} typ.	0,75	V
High frequency knee voltage			
$I_C = 25 \text{ mA}; T_j = 150 \text{ }^\circ\text{C}$	V_{CEK} typ.	20	V
Transition frequency			
$-I_E = 10 \text{ mA}; V_{CB} = 10 \text{ V}$	$f_T >$	60	MHz
Feedback capacitance at $f = 1 \text{ MHz}$			
$I_E = 0; V_{CB} = 30 \text{ V}$	$C_{re} <$	2	pF

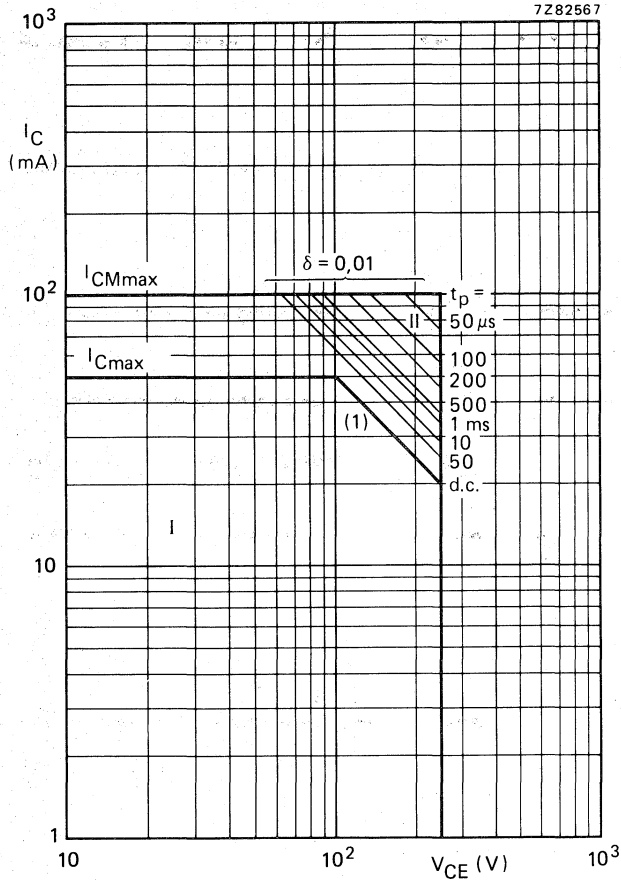


Fig. 2 Safe Operating Area at $T_{mb} = 25^\circ C$.

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

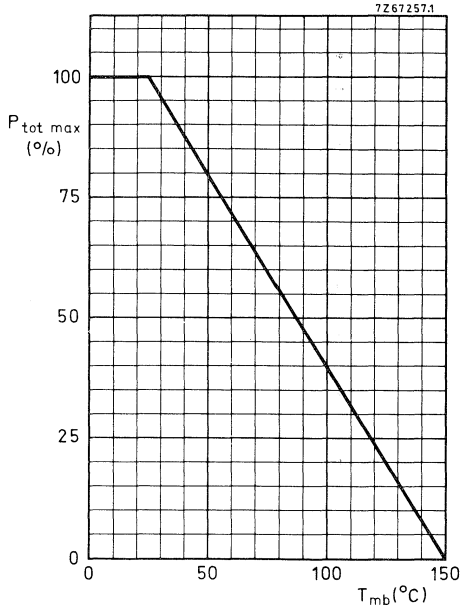


Fig. 3 Power derating curve.

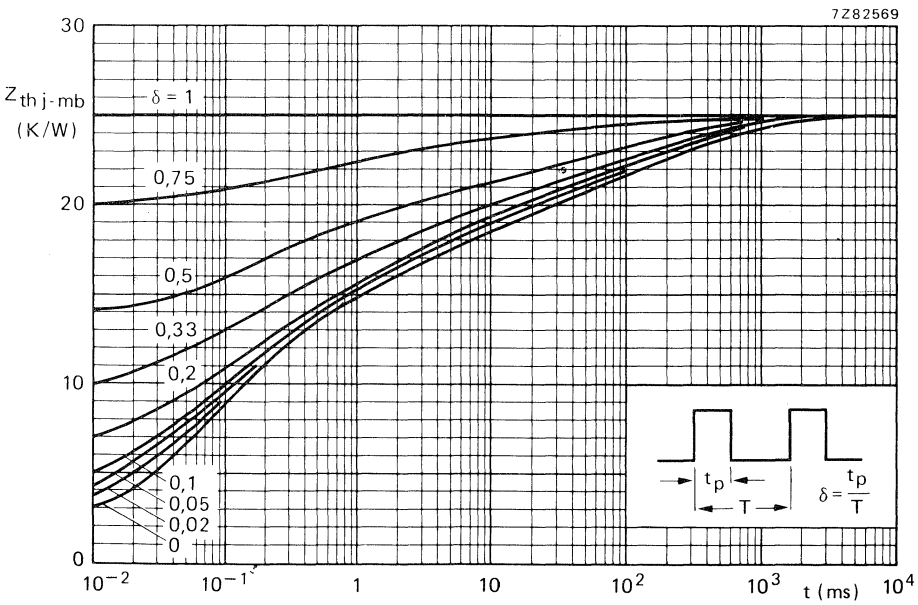


Fig. 4 Pulse power rating chart.

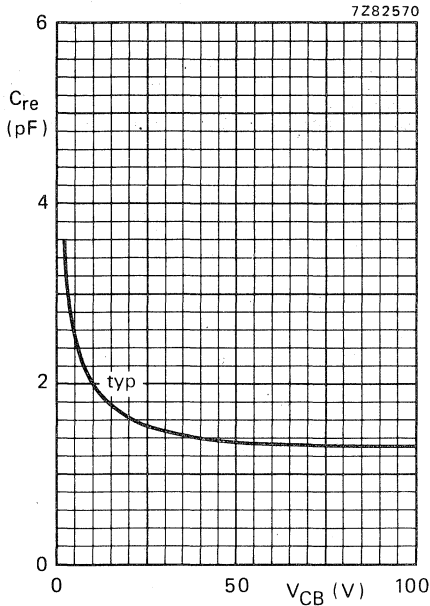


Fig. 5 $I_E = 0$; $f = 1$ MHz; $T_j = 25$ °C.

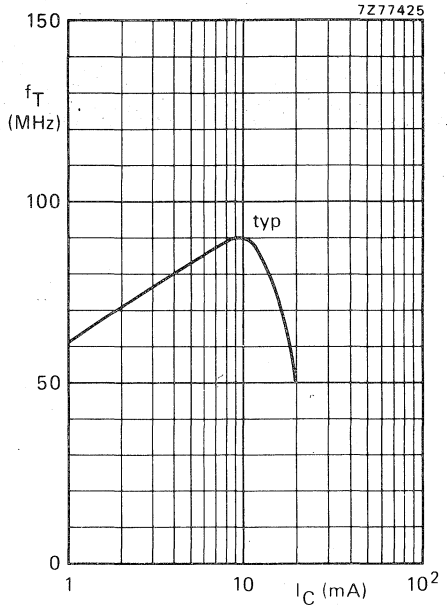


Fig. 6 $V_{CE} = 10$ V; $T_j = 25$ °C.

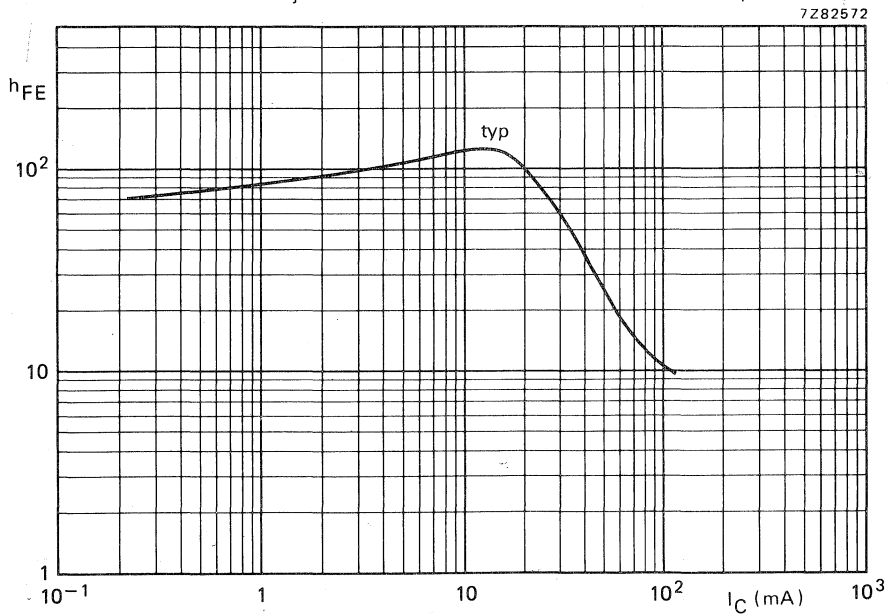


Fig. 7 D.C. current gain at $V_{CE} = 20$ V; $T_{amb} = 25$ °C.

SILICON PLANAR VIDEO OUTPUT TRANSISTORS

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

QUICK REFERENCE DATA

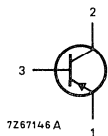
		BF870	BF872
Collector-base voltage (open emitter)	$-V_{CBO}$ max.	250	300 V
Collector-emitter voltage (open base)	$-V_{CEO}$ max.	250	— V
Collector-emitter voltage ($R_{BE} = 2,7 \text{ k}\Omega$)	$-V_{CER}$ max.	—	300 V
Collector current (peak value)	$-I_{CM}$ max.	100	mA
Total power dissipation up to $T_{mb} = 25 \text{ }^\circ\text{C}$	P_{tot} max.	5	W
Junction temperature	T_j max.	150	$^\circ\text{C}$
D.C. current gain			
$-I_C = 25 \text{ mA}; -V_{CE} = 20 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$	h_{FE} >	50	
Transition frequency			
$I_E = 10 \text{ mA}; -V_{CB} = 10 \text{ V}$	f_T >	60	MHz
Feedback capacitance at $f = 1 \text{ MHz}$			
$I_E = 0; -V_{CB} = 30 \text{ V}$	C_{re} <	2,2	pF

MECHANICAL DATA

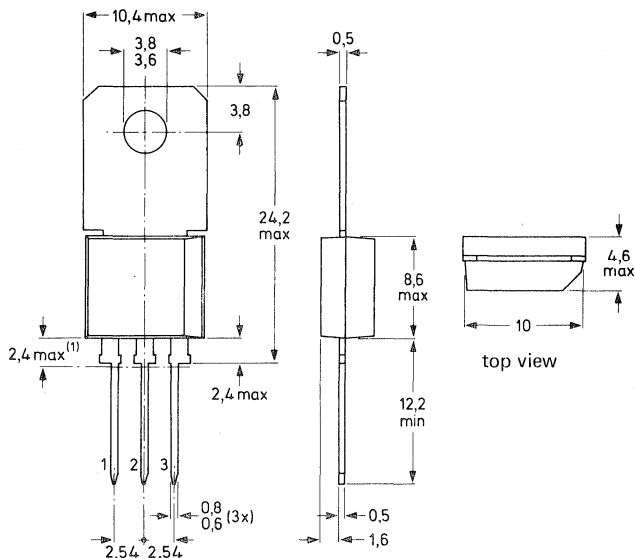
Dimensions in mm

Fig. 1 TO-202.

Collector connected to mounting base.



(1) Plastic flash allowed within this zone.



RATINGS

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

		BF870	BF872
Collector-base voltage (open emitter)	$-V_{CBO}$ max.	250	300 V
Collector-emitter voltage (open base)	$-V_{CEO}$ max.	250	— V
Collector-emitter voltage ($R_{BE} = 2,7 \text{ k}\Omega$)	$-V_{CER}$ max.	—	300 V
Emitter-base voltage (open collector)	$-V_{EBO}$ max.	5	V
Collector current (d.c.)	$-I_C$ max.	50	mA
Collector current (peak value)	$-I_{CM}$ max.	100	mA
Total power dissipation up to $T_{amb} = 25 \text{ }^\circ\text{C}$	P_{tot} max.	1,6	W
Total power dissipation up to $T_{mb} = 25 \text{ }^\circ\text{C}$	P_{tot} max.	5	W
Storage temperature	T_{stg}	-65 to +150	$^\circ\text{C}$
Junction temperature	T_j max.	150	$^\circ\text{C}$

THERMAL RESISTANCE

From junction to ambient	$R_{th j-a}$ =	78	K/W
From junction to mounting base	$R_{th j-mb}$ =	25	K/W

CHARACTERISTICS

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

		BF870	BF872
Collector cut-off current			
$I_E = 0; -V_{CB} = 200 \text{ V}$	$-I_{CBO} <$	10	10 nA
$R_{BE} = 2,7 \text{ k}\Omega; -V_{CE} = 300 \text{ V}$	$-I_{CER} <$	—	1 μA
$R_{BE} = 2,7 \text{ k}\Omega; -V_{CE} = 200 \text{ V}; T_j = 150 \text{ }^\circ\text{C}$	$-I_{CER} <$	10	μA
Emitter cut-off current			
$I_C = 0; -V_{EB} = 5 \text{ V}$	$-I_{EBO} <$	10	μA
D.C. current gain			
$-I_C = 25 \text{ mA}; -V_{CE} = 20 \text{ V}$	$h_{FE} >$	50	
Base emitter voltage			
$-I_C = 25 \text{ mA}; -V_{CE} = 20 \text{ V}$	$-V_{BE}$ typ.	0,75	V
High-frequency knee voltage			
$-I_C = 25 \text{ mA}; T_j = 150 \text{ }^\circ\text{C}$	$-V_{CEK}$ typ.	20	V
Transition frequency			
$I_E = 10 \text{ mA}; -V_{CB} = 10 \text{ V}$	$f_T >$	60	MHz
Feedback capacitance at $f = 1 \text{ MHz}$			
$I_E = 0; -V_{CB} = 30 \text{ V}$	$C_{re} <$	2,2	pF

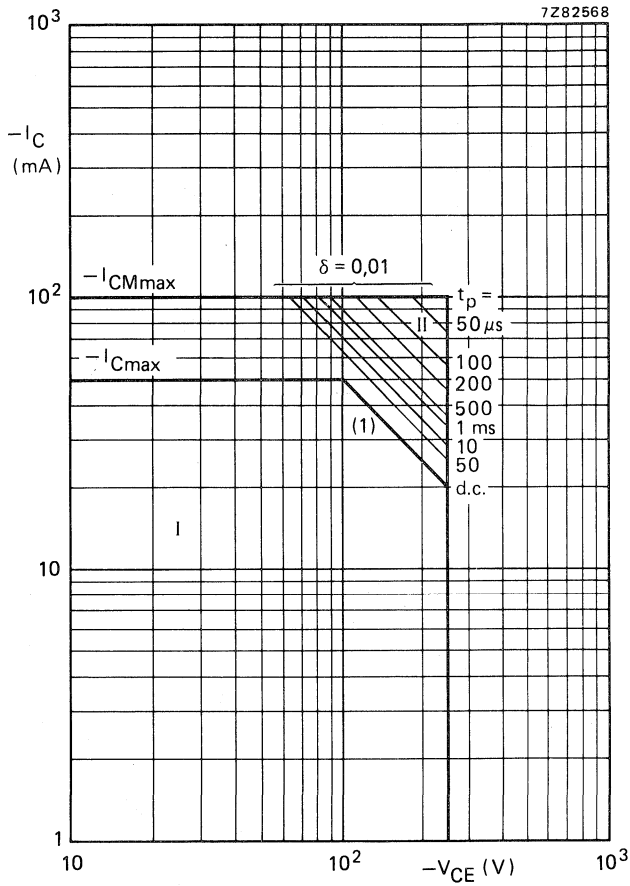


Fig. 2 Safe Operating Area; $T_{mb} = 25^\circ\text{C}$.

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

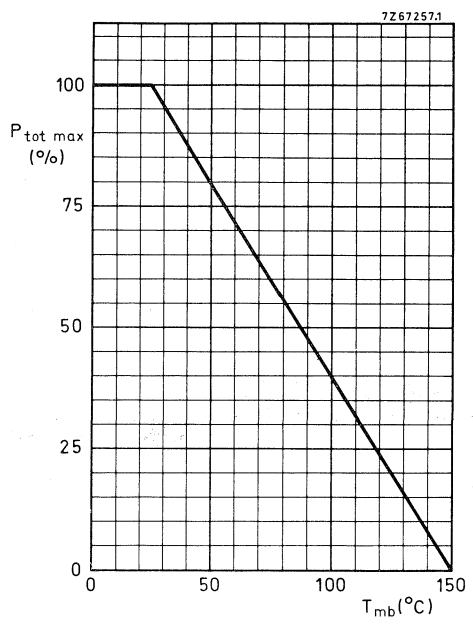


Fig. 3 Power derating curve.

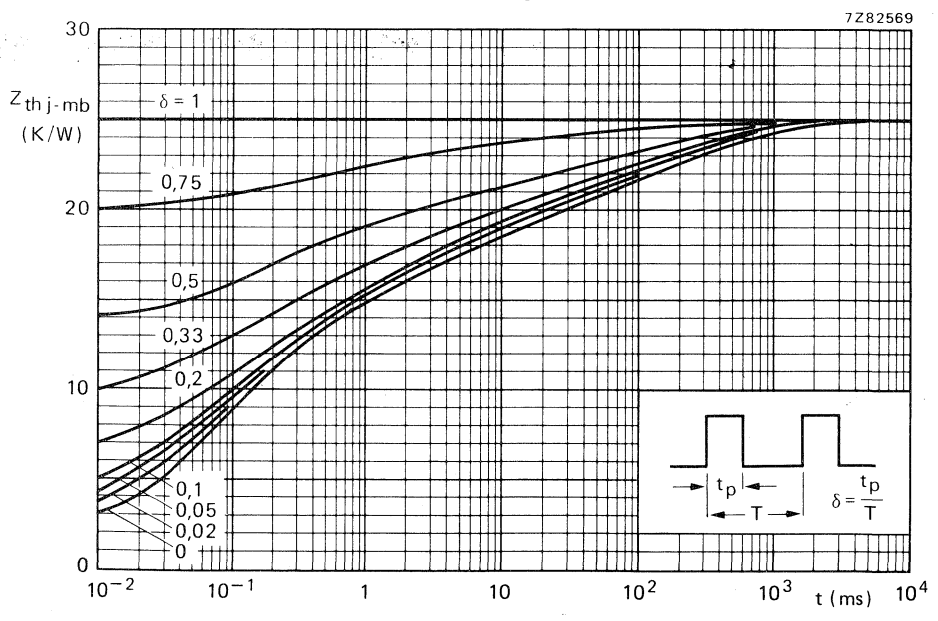


Fig. 4 Pulse power rating chart.

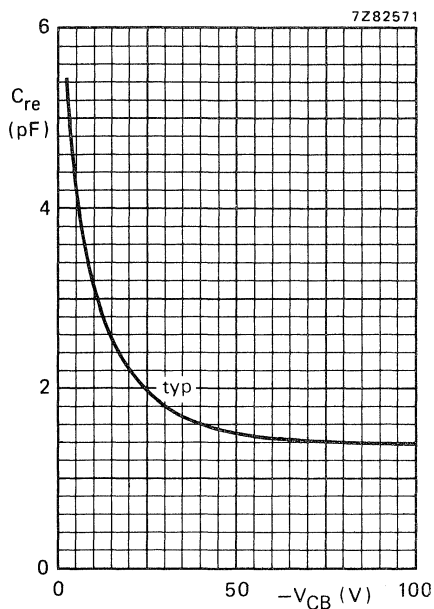


Fig. 5 $I_E = 0$; $f = 1$ MHz; $T_{amb} = 25$ °C.

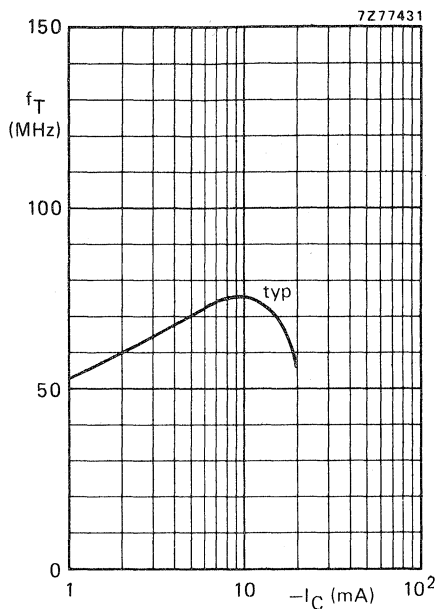


Fig. 6 $-V_{CE} = 10$ V; $T_j = 25$ °C.

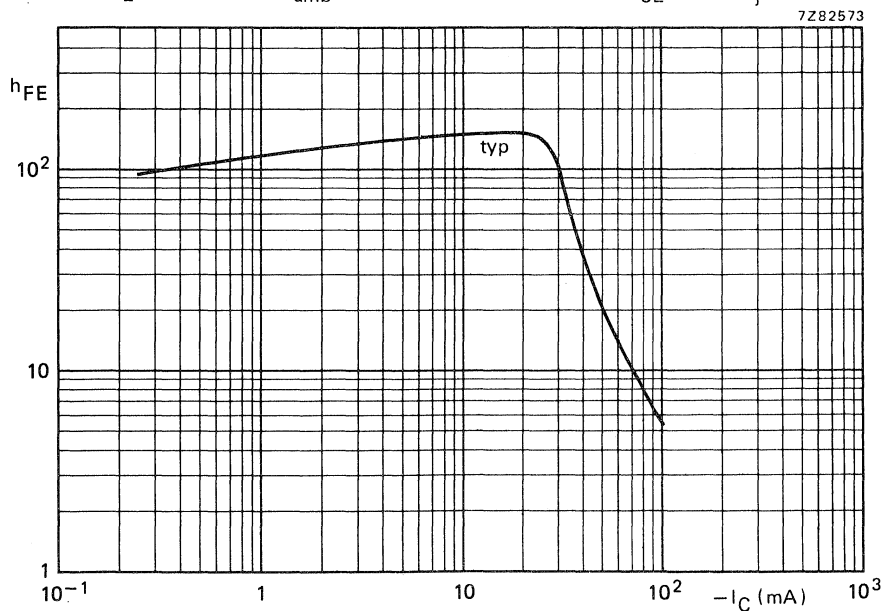


Fig. 7 D.C. current gain at $-V_{CE} = 20$ V; $T_{amb} = 25$ °C.

Successor type is BU508A

SILICON DIFFUSED POWER TRANSISTOR

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

QUICK REFERENCE DATA

Collector-emitter voltage ($V_{BE} = 0$, peak value)

V_{CESM} max. 1500 V

Collector current (d.c.)

I_C max. 5 A

Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$

P_{tot} max. 80 W

Collector-emitter saturation voltage

$I_C = 4,5\text{ A}; I_B = 2\text{ A}$

V_{CEsat} < 1 V

Fall time

$I_{CM} = 4,5\text{ A}; I_{B(end)} = 1,4\text{ A}$

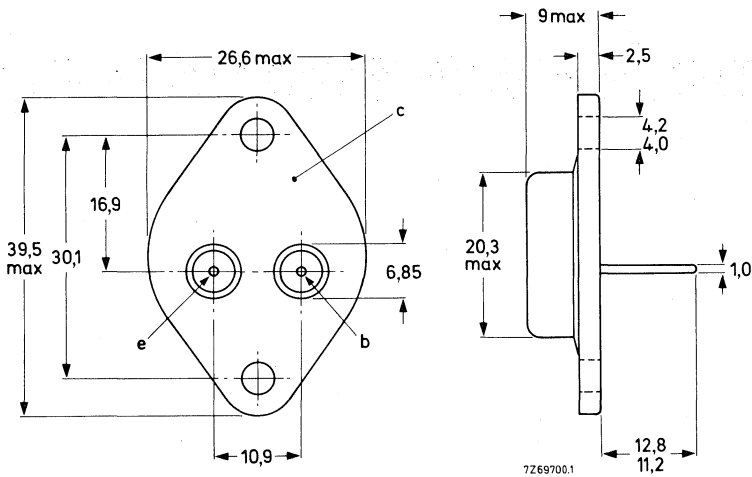
t_f typ. 0,7 μs

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.



See also chapters Mounting Instructions and Accessories.

RATINGS

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

Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM}	max.	1500 V
Collector-emitter voltage (open base)	V_{CEO}	max.	700 V
Collector current (d.c.)	I_C	max.	5 A
Collector current (peak value)	I_{CM}	max.	7,5 A
Collector current (non-repetitive peak)	I_{CSM}	max.	15 A
Base current (peak value)	I_{BM}	max.	4 A
Reverse base current (d.c. or average over any 20 ms period)	$-I_{B(AV)}$	max.	100 mA
Reverse base current (peak value) *	$-I_{BM}$	max.	4 A
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	80 W
Storage temperature	T_{stg}		-65 to + 115 $^\circ\text{C}$
Junction temperature	T_j	max.	115 $^\circ\text{C}$

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	max.	1,12 K/W
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CHARACTERISTICS

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

Collector cut-off current $V_{BE} = 0; V_{CE} = V_{CESMmax}$	I_{CES}	<	1,0 mA
D.C. current gain $I_C = 4,5\text{ A}; V_{CE} = 5\text{ V}$	h_{FE}	>	2,5
Emitter-base voltage $I_C = 0; I_E = 10\text{ mA}$	$+V_{EBO}$	>	5 V
$I_C = 0; I_E = 100\text{ mA}$	$+V_{EBO}$	typ.	7 V
Saturation voltage $I_C = 4,5\text{ A}; I_B = 2\text{ A}$	V_{CEsat}	<	1 V
$I_C = 4,5\text{ A}; I_B = 2\text{ A}$	V_{BEsat}	<	1,5 V
Collector-emitter sustaining voltage $I_B = 0; I_C = 100\text{ mA}; L = 25\text{ mH}$	$V_{CEO sust}$	>	700 V
Transition frequency at $f = 5\text{ MHz}$ $I_C = 0,1\text{ A}; V_{CE} = 5\text{ V}$	f_T	typ.	7 MHz
Collector capacitance at $f = 1\text{ MHz}$ $I_E = I_e = 0; V_{CB} = 10\text{ V}$	C_C	typ.	125 pF
Switching times (in line deflection circuit) $L_B = 6\text{ } \mu\text{H}; -V_{IM} = 4\text{ V};$ $I_{CM} = 4,5\text{ A}; I_{B(end)} = 1,4\text{ A}$ ($-dI_B/dt = 0,6\text{ A}/\mu\text{s}$)	t_f	typ.	0,7 μs
	t_s	typ.	6,5 μs

* Turn-off current.

Successor type is BU508

SILICON DIFFUSED POWER TRANSISTOR

High-voltage, high-speed switching n-p-n transistor in a metal envelope especially intended for use in supply and horizontal deflection systems of colour television receivers.

QUICK REFERENCE DATA

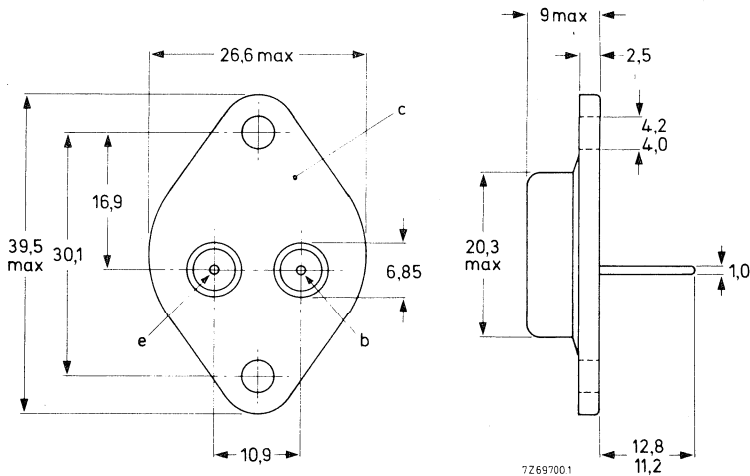
Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM}	max.	1500 V
Collector current (d.c.)	I_C	max.	5 A
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	80 W
Collector-emitter saturation voltage $I_C = 4,0\text{ A}; I_B = 2\text{ A}$	V_{CEsat}	<	1 V
Fall time $I_{CM} = 4,0\text{ A}; I_{B(end)} = 1,4\text{ A}$	t_f	typ.	0,7 μs

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.



See also chapters Mounting instructions and Accessories.

RATINGS

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

Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM}	max.	1500 V
Collector-emitter voltage ($R_{BE} \leq 100 \Omega$, peak value)	V_{CERM}	max.	1500 V
Collector-emitter voltage (open base)	V_{CEO}	max.	700 V
Collector current (d.c.)	I_C	max.	5 A
Collector current (peak value)	I_{CM}	max.	7,5 A
Collector current (non-repetitive peak)	I_{CSM}	max.	15 A
Base current (peak value)	I_{BM}	max.	4 A
Reverse base current (d.c. or average over any 20 ms period)	$-I_{B(AV)}$	max.	100 mA
Reverse base current (peak value) *	$-I_{BM}$	max.	4 A
Total power dissipation up to $T_{mb} = 25 \text{ }^\circ\text{C}$	P_{tot}	max.	80 W
Storage temperature	T_{stg}		-65 to + 115 $^\circ\text{C}$
Junction temperature	T_j	max.	115 $^\circ\text{C}$

THERMAL RESISTANCE

From junction to mounting base	$R_{th j-mb}$	max.	1,12 K/W
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CHARACTERISTICS

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

Collector cut-off current $V_{BE} = 0; V_{CE} = V_{CESMmax}$	I_{CES}	<	1,0 mA
D.C. current gain $I_C = 4,0 \text{ A}; V_{CE} = 5 \text{ V}$	h_{FE}	>	2,5
Emitter-base voltage $I_C = 0; I_E = 10 \text{ mA}$	$+V_{EBO}$	>	5 V
$I_C = 0; I_E = 100 \text{ mA}$	$+V_{EBO}$	typ.	7 V
Saturation voltage $I_C = 4,0 \text{ A}; I_B = 2 \text{ A}$	V_{CEsat}	<	1 V
$I_C = 4,0 \text{ A}; I_B = 2 \text{ A}$	V_{BEsat}	<	1,5 V

* Turn-off current.

SILICON DIFFUSED POWER TRANSISTORS

High-voltage, high-speed switching n-p-n power transistors in TO-3 envelopes, intended for use in the switched-mode power supply of 90° and 110° colour television receivers.

QUICK REFERENCE DATA

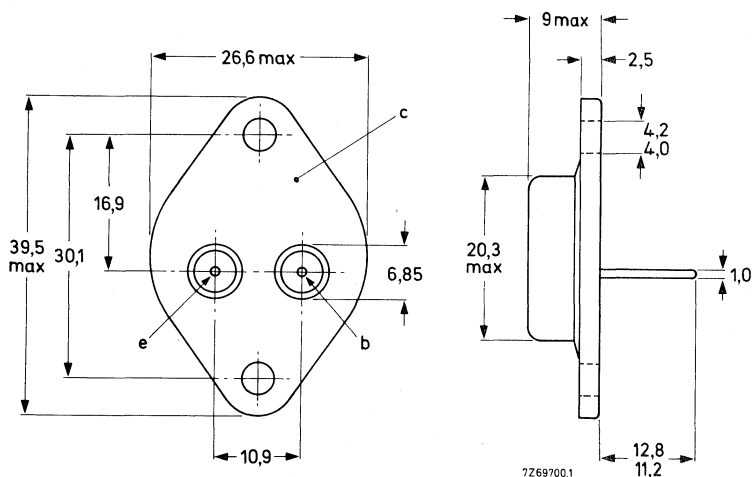
		BU326	BU326A	
Collector-emitter voltage ($V_{BE} = 0$; peak value)	V_{CESM} max.	800	900	V
Collector-emitter voltage (open base)	V_{CEO} max.	375	400	V
Collector current (d.c.)	I_C max.	6	8	A
Collector current (peak value; $t_p < 2$ ms)	I_{CM} max.	8	8	A
Total power dissipation up to $T_{mb} = 50$ °C	P_{tot} max.	60	60	W
Collector-emitter saturation voltage $I_C = 2,5$ A; $I_B = 0,5$ A	V_{CEsat} <	1,5	1,5	V
Fall time $I_{Con} = 2,5$ A; $I_{Bon} = 0,5$ A; $-I_{Boff} = 1$ A	t_f typ.	0,3	0,3	μs

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.



See also chapters Mounting instructions and Accessories.

RATINGS

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

			BU326	BU326A	
Collector-emitter voltage ($V_{BE} = 0$; peak value)	V_{CESM}	max.	800	900	V
Collector-emitter voltage (open base)	V_{CEO}	max.	375	400	V
Collector current (d.c.)	I_C	max.		6	A
Collector current (peak value; $t_p < 2$ ms)	I_{CM}	max.		8	A
Base current (d.c.)	I_B	max.		2	A
Base current (peak value)	I_{BM}	max.		3	A
Reverse base current (d.c. or average over any 20 ms period)	$-I_{B(AV)}$	max.		0,1	A
Reverse base current (peak value; turn-off current)	$-I_{BM}$	max.		3	A
Total power dissipation up to $T_{mb} = 50$ °C	P_{tot}	max.		60	W
Storage temperature	T_{stg}			-65 to + 150	°C
Junction temperature	T_j	max.		150	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=		1,65	K/W
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CHARACTERISTICS

$T_j = 25$ °C unless otherwise specified

Collector cut-off current *

$V_{BE} = 0$; $V_{CEM} = V_{CESMmax}$	I_{CES}	<		1	mA
--	-----------	---	--	---	----

$V_{BE} = 0$; $V_{CEM} = V_{CESMmax}$; $T_j = 125$ °C	I_{CES}	<		2	mA
---	-----------	---	--	---	----

Emitter cut-off current

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

Saturation voltages

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

	V_{BEsat}	<		1,4	V
--	-------------	---	--	-----	---

$I_C = 4$ A; $I_B = 1,25$ A	V_{CEsat}	<		3	V
-----------------------------	-------------	---	--	---	---

	V_{BEsat}	<		1,6	V
--	-------------	---	--	-----	---

Collector-emitter sustaining voltage (see Figs 2 and 3)

$I_{Boff} = 0$; $I_C = 0,1$ A; $L = 25$ mH BU326	$V_{CEO_{sust}}$	>		375	V
---	------------------	---	--	-----	---

BU326A	$V_{CEO_{sust}}$	>		400	V
--------	------------------	---	--	-----	---

D.C. current gain

$I_C = 0,6$ A; $V_{CE} = 5$ V	h_{FE}	typ.		30	
-------------------------------	----------	------	--	----	--

Transition frequency at $f = 1$ MHz

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

* Measured with a half sine-wave voltage (curve tracer).

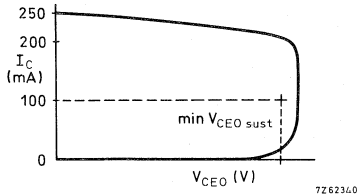


Fig. 2 Oscilloscope display for $V_{CE0sust}$.

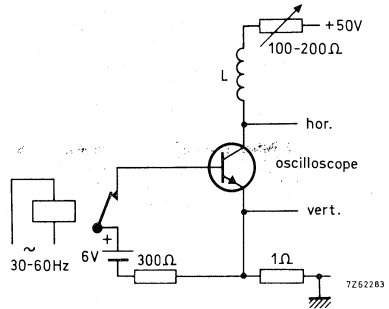


Fig. 3 Test circuit for $V_{CE0sust}$.

Switching times (see Figs 4 and 5)

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

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

Turn-on time

Turn-off time ($t_{off} = t_s + t_f$)

Storage time

Fall time

Fall time at $T_{mb} = 95 \text{ }^\circ\text{C}$

- $t_{on} < \begin{matrix} \text{typ. } 0,3 \mu\text{s} \\ 0,5 \mu\text{s} \end{matrix}$
- $t_s < \begin{matrix} \text{typ. } 2 \mu\text{s} \\ 3,5 \mu\text{s} \end{matrix}$
- $t_f < \begin{matrix} \text{typ. } 0,3 \mu\text{s} \\ 1 \mu\text{s} \end{matrix}$

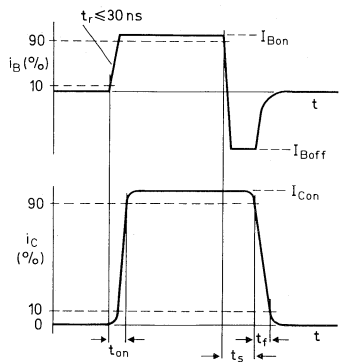
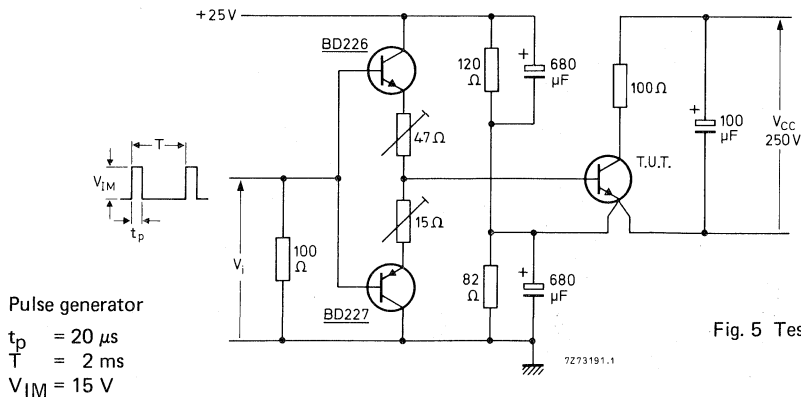


Fig. 4 Waveforms.



Pulse generator

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

Fig. 5 Test circuit.

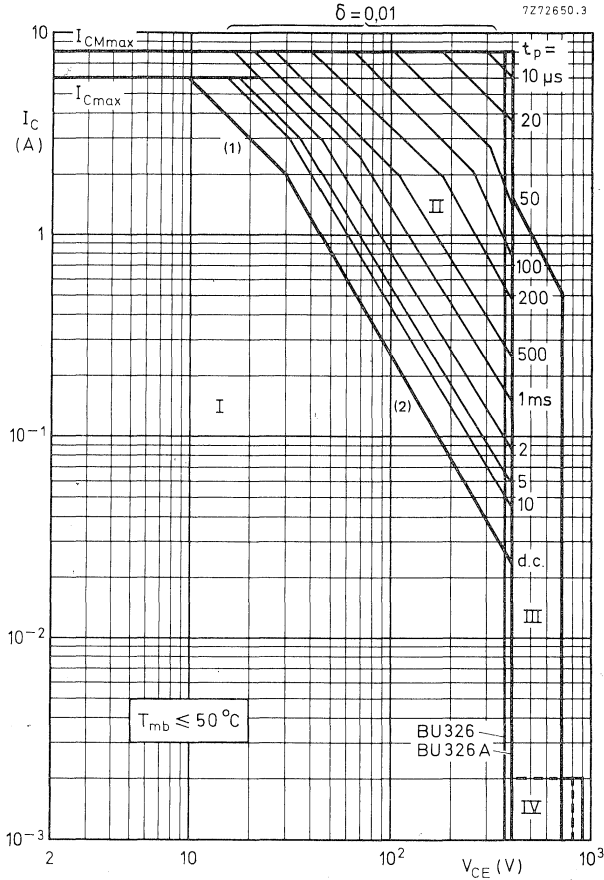


Fig. 6 Safe Operating Area.

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

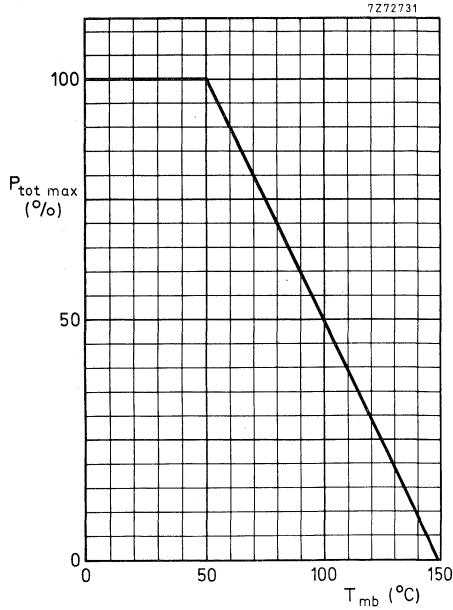


Fig. 7 Power derating curve.

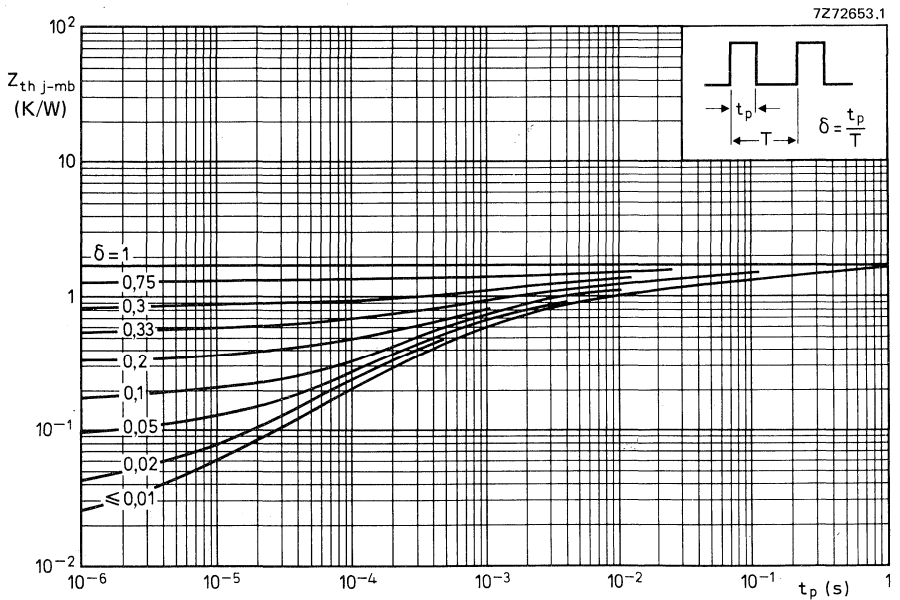


Fig. 8 Pulse power rating chart.

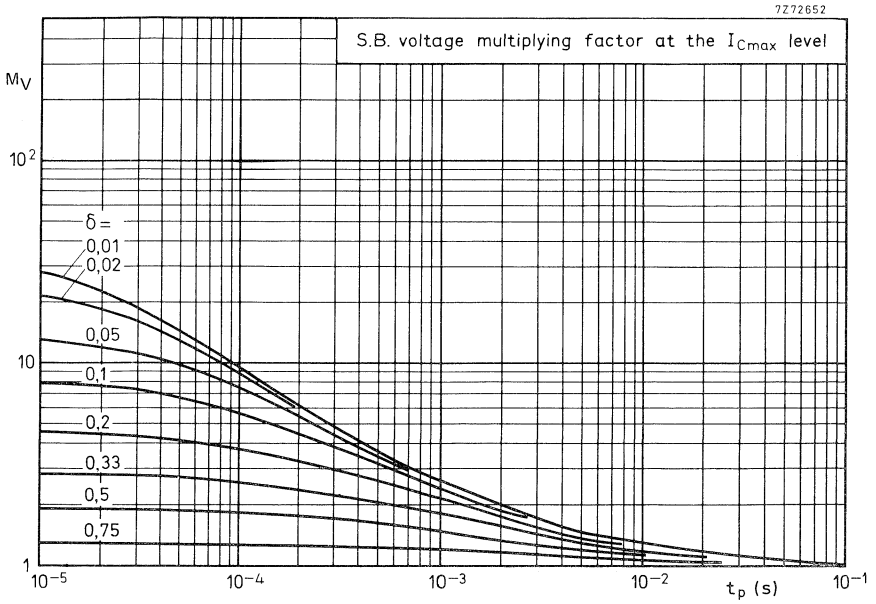


Fig. 9 S.B. voltage multiplying factor at the I_{Cmax} level.

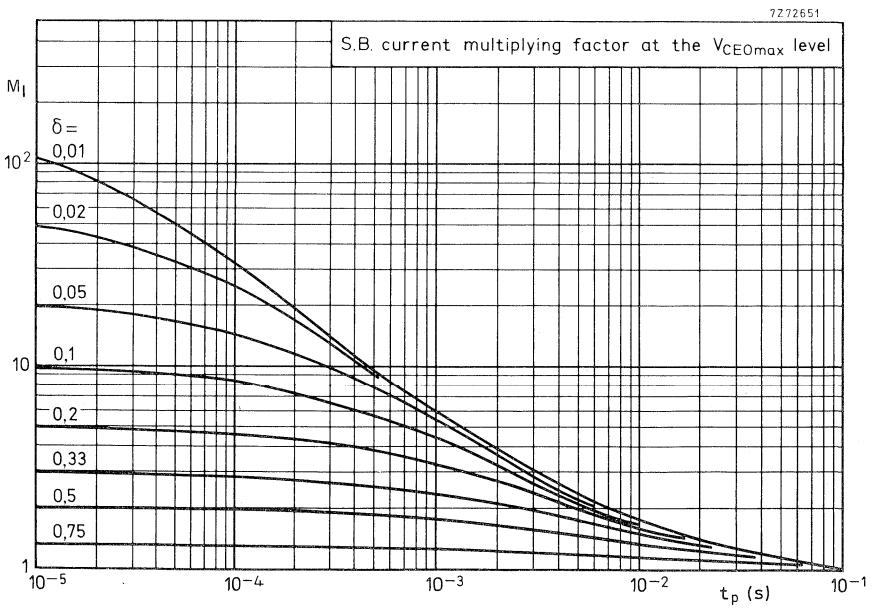


Fig. 10 S.B. current multiplying factor at the V_{CE0max} level.

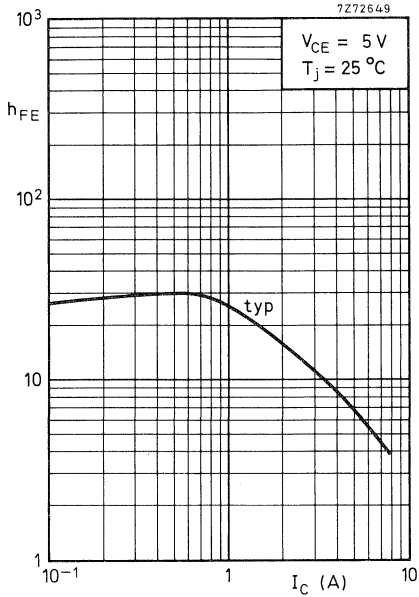


Fig. 11 D.C. current gain.

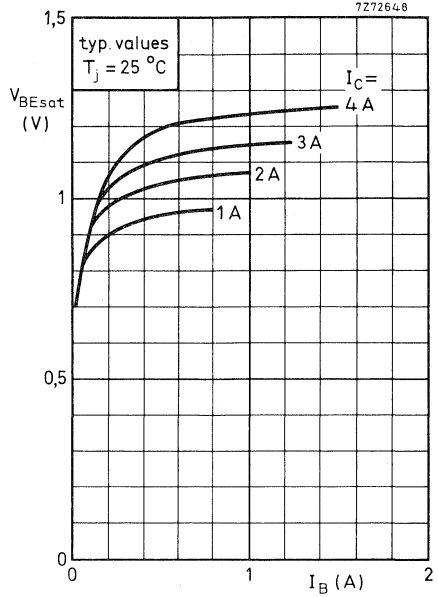


Fig. 12 Base-emitter saturation voltage.

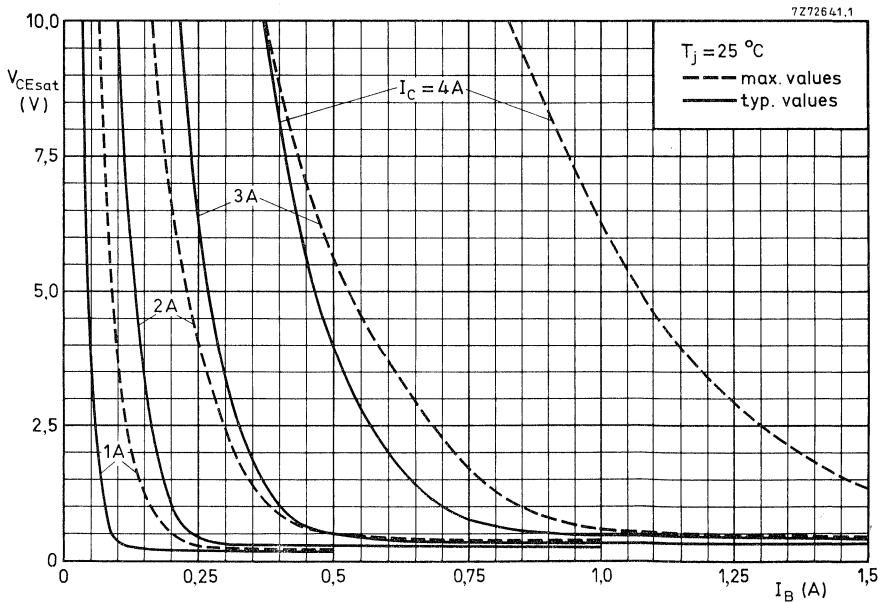


Fig. 13 Collector-emitter saturation voltage.

APPLICATION INFORMATION BU326A (detailed information on request)

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

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

As the BU326A will mainly be used in flyback converters the information on optimum base drive and device dissipation given in the graphs on page 10 is concentrated on this application. In these figures I_{CM} represents the highest repetitive peak collector current that can occur in the given circuit, e.g. during overload.

The total power dissipation for a limit-case transistor is given in Fig. 18 which applies for a mounting base temperature of 100 °C. The required thermal resistance for the heatsink can be calculated from

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

* Including additional thermal resistances resulting from mounting hardware.

To ensure thermal stability the thermal resistance of the heatsink used must not exceed the values plotted in Fig. 19.

A practical SMPS output circuit for an output power in the order of 180 W is given in Fig. 15.

At a collector current of 2,5 A and a base current of 0,25 A in this circuit the following turn-off times can be expected.

Storage time
Fall time

	$T_{mb} = 25\ ^\circ C$	$= 100\ ^\circ C$
t_s	typ. 1,4	< 20 μs
t_f	typ. 0,15	< 0,5 μs

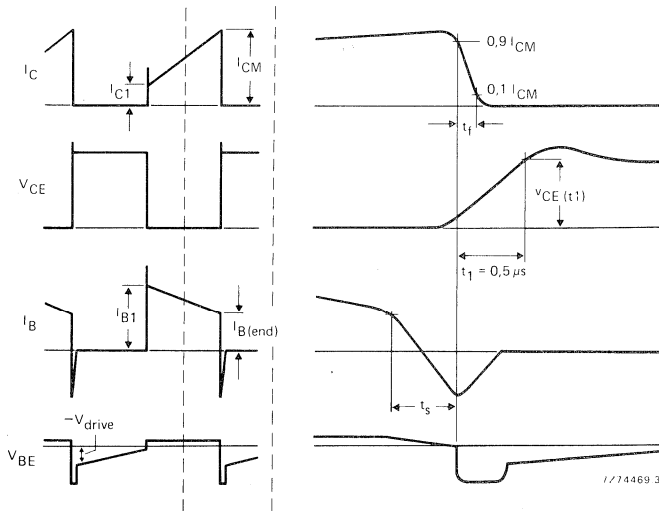


Fig. 14 Relevant waveforms of switching transistor.

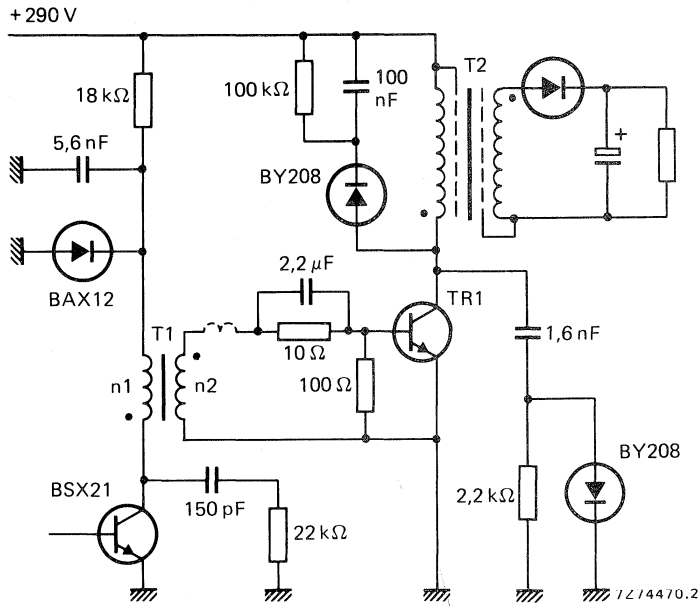


Fig. 15 Practical SMPS output circuit.

TR1 = BU326A

T1 (driver transformer): Core U20; $n_1 = 400$ turns; $n_2 = 25$ turns
total inductance in base circuit $\approx 4,5 \mu\text{H}$

T2 (output transformer): $L_p = 6 \text{ mH}$

$v_{CE}(t_1) < 500 \text{ V}$ (see Fig. 14)

Next page:

Fig. 16 Recommended nominal "end" value of the base current versus maximum peak collector current.

Fig. 17 Minimum required base inductance and recommended negative drive voltage versus maximum peak collector current.

Fig. 18 Maximum total power dissipation of a limit-case transistor if the base current is chosen in accordance with Fig. 16.

Fig. 19 Maximum permissible thermal resistance of the heatsink versus maximum peak collector current to ensure thermal stability.

Note: For all curves the duty factor $\delta = 0,5$, as shown in Fig. 14.

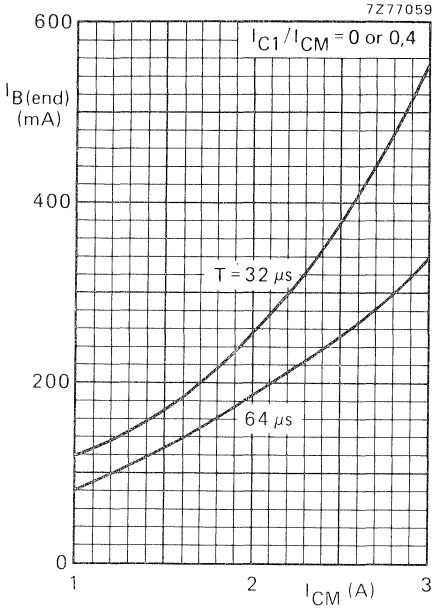


Fig. 16.

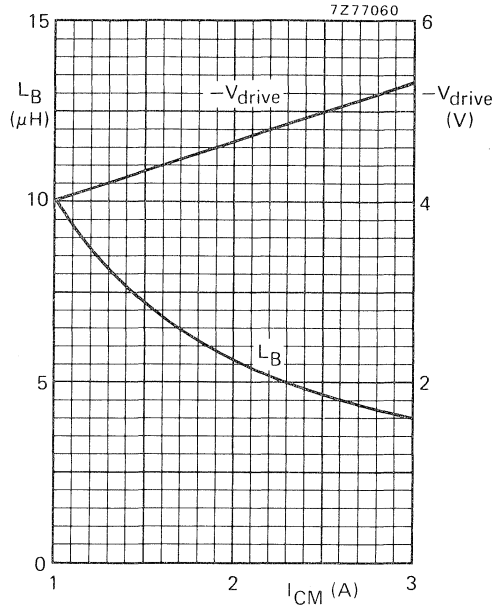


Fig. 17.

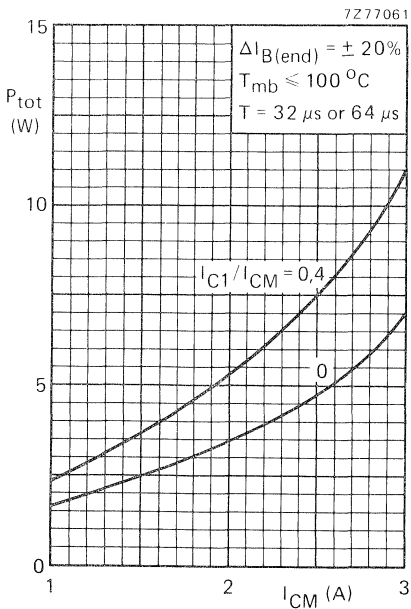


Fig. 18.

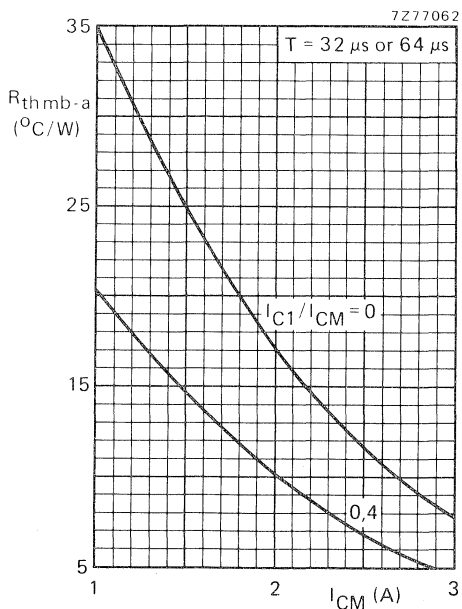


Fig. 19.

SILICON DIFFUSED POWER TRANSISTORS

High voltage, high speed switching n-p-n power transistor in plastic SOT-93 envelope, intended for use in the switched-mode power supply of 90° and 110° colour television receivers.

QUICK REFERENCE DATA

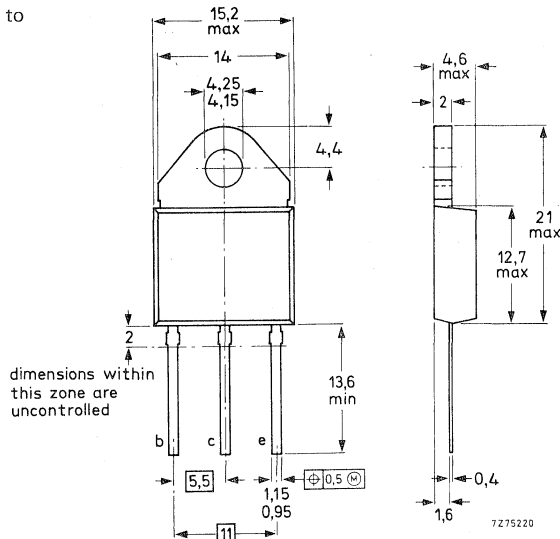
		BU426	426A	433
Collector-emitter voltage ($V_{BE} = 0$; peak value)	V_{CESM} max.	800	900	800 V
Collector-emitter voltage (open base)	V_{CEO} max.	375	400	375 V
Collector current (d.c.)	I_C max.		6	A
Collector current (peak value) $t_p = 2$ ms	I_{CM} max.		10	A
Total power dissipation up to $T_{mb} = 73$ °C	P_{tot} max.		70	W
Collector-emitter saturation voltage $I_C = 2,5$ A; $I_B = 0,5$ A	V_{CEsat} <		1,5	V
Fall time $I_{Con} = 2,5$ A; $I_{Bon} = 0,5$ A; $-I_{Boff} = 1$ A	t_f typ.	0,3	0,3	0,45 μ s

MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT-93.

Collector connected to mounting base



See also chapters Mounting instructions and Accessories.

RATINGS

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

			BU426	426A	433
Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM}	max.	800	900	800 V
Collector-emitter voltage (open base)	V_{CEO}	max.	375	400	375 V
Collector current (d.c.)	I_C	max.		6	A
Collector current (peak value) $t_p < 2$ ms	I_{CM}	max.		10	A
Base current (d.c.)	I_B	max.		2	A
Base current (peak value)	I_{BM}	max.		3	A
Reverse base current (d.c. or average over any 20 ms period)	$-I_{B(AV)}$	max.		100	mA
Reverse base current (peak value)*	$-I_{BM}$	max.		3	A
Total power dissipation up to $T_{mb} = 73$ °C	P_{tot}	max.		70	W
Storage temperature	T_{stg}		-65 to + 150		°C
Junction temperature	T_j	max.		150	°C

THERMAL RESISTANCE

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

CHARACTERISTICS

$T_j = 25$ °C unless otherwise specified

Collector cut-off current **

$V_{CEM} = 900$ V; $V_{BE} = 0$

I_{CES}	<	1	mA
-----------	---	---	----

$V_{CEM} = 900$ V; $V_{BE} = 0$; $T_j = 125$ °C

I_{CES}	<	2	mA
-----------	---	---	----

D.C. current gain

$I_C = 0,6$ A; $V_{CE} = 5$ V; BU426; BU426A

h_{FE}	typ.	30	
	<	60	

$I_C = 0,6$ A; $V_{CE} = 5$ V; BU433

h_{FE}	typ.	40	
----------	------	----	--

Transition frequency at $f = 1$ MHz

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

f_T	typ.	6	MHz
-------	------	---	-----

* Turn-off current.

** Measured with a half sine-wave voltage (curve tracer).

CHARACTERISTICS (continued)

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

Emitter cut-off current

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

$I_{EBO} < 10\text{ mA}$

Saturation voltages

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

$V_{CEsat} < 1,5\text{ V}$

$V_{BEsat} < 1,4\text{ V}$

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

$V_{CEsat} < 3\text{ V}$

$V_{BEsat} < 1,6\text{ V}$

Collector-emitter sustaining voltage

$I_C = 100\text{ mA}; I_{Boff} = 0; L = 25\text{ mH}; \text{BU426}; \text{BU433}$

$V_{CEOsust} > 375\text{ V}$

$I_C = 100\text{ mA}; I_{Boff} = 0; L = 25\text{ mH}; \text{BU426A}$

$V_{CEOsust} > 400\text{ V}$

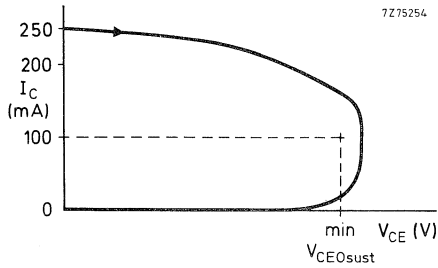


Fig. 2 Oscilloscope display for $V_{CEOsust}$.

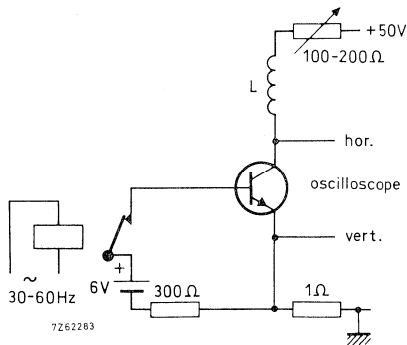


Fig. 3 Test circuit for $V_{CEOsust}$.

CHARACTERISTICS (continued)

Switching times (between 10% and 90% levels)

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

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

Turn-on time

t_{on} typ. $0,5 \mu\text{s}$
< $0,6 \mu\text{s}$

Storage time

t_s typ. $2 \mu\text{s}$
< $3,5 \mu\text{s}$

Fall time $\left\{ \begin{array}{l} \text{BU426; 426A} \\ \text{BU433} \end{array} \right.$

t_f typ. $0,3 \mu\text{s}$
 t_f typ. $0,45 \mu\text{s}$
< $0,7 \mu\text{s}$

Turn-off time ($t_{off} = t_s + t_f$)

Fall time, $T_{mb} = 95 \text{ }^\circ\text{C}$ $\left\{ \begin{array}{l} \text{BU433} \\ \text{BU426; 426A} \end{array} \right.$

t_f typ. $0,7 \mu\text{s}$
< $1,0 \mu\text{s}$
 t_f < $0,75 \mu\text{s}$

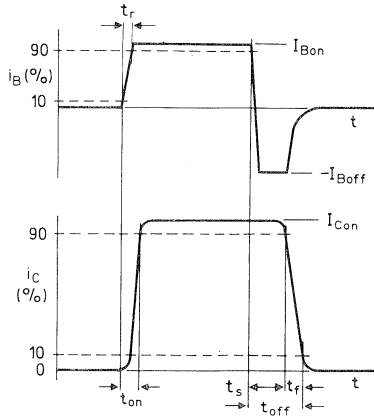


Fig. 4 Waveforms.

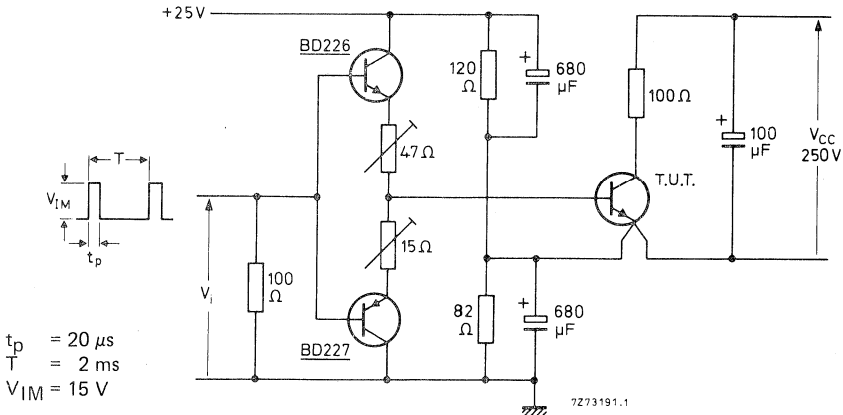


Fig. 5 Test circuit.

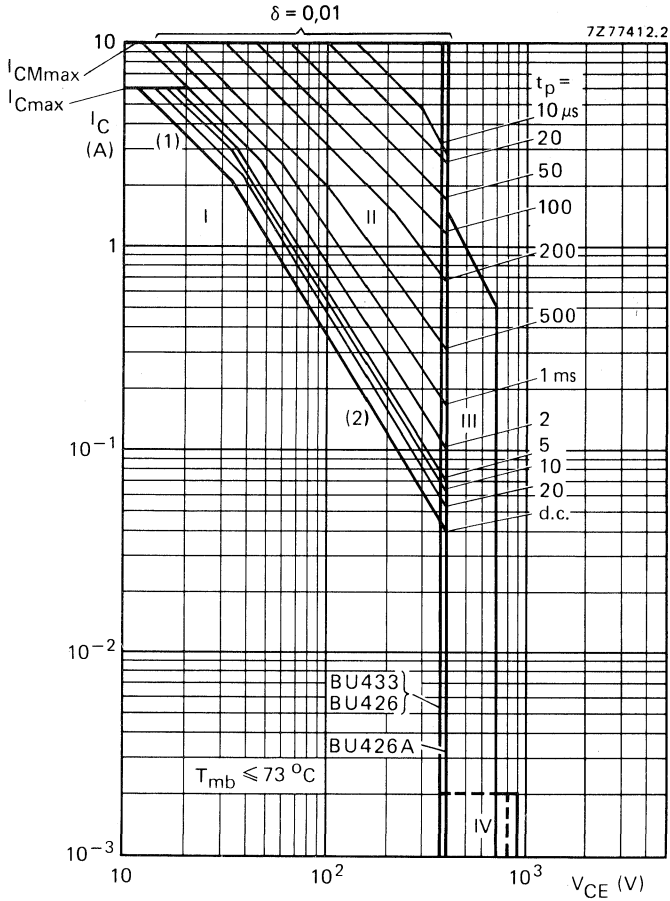


Fig. 6 Safe Operating Area.

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

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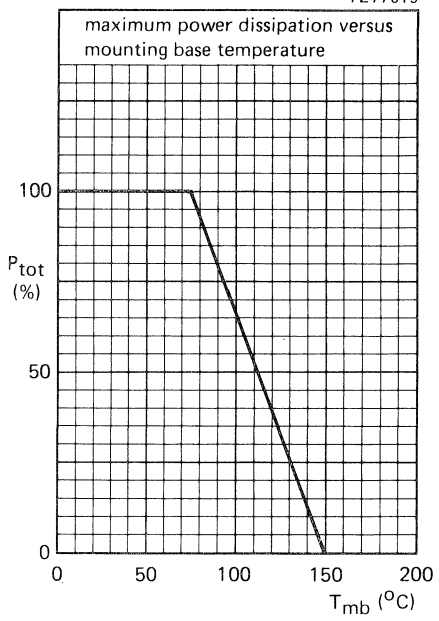


Fig. 7 Power derating curve.

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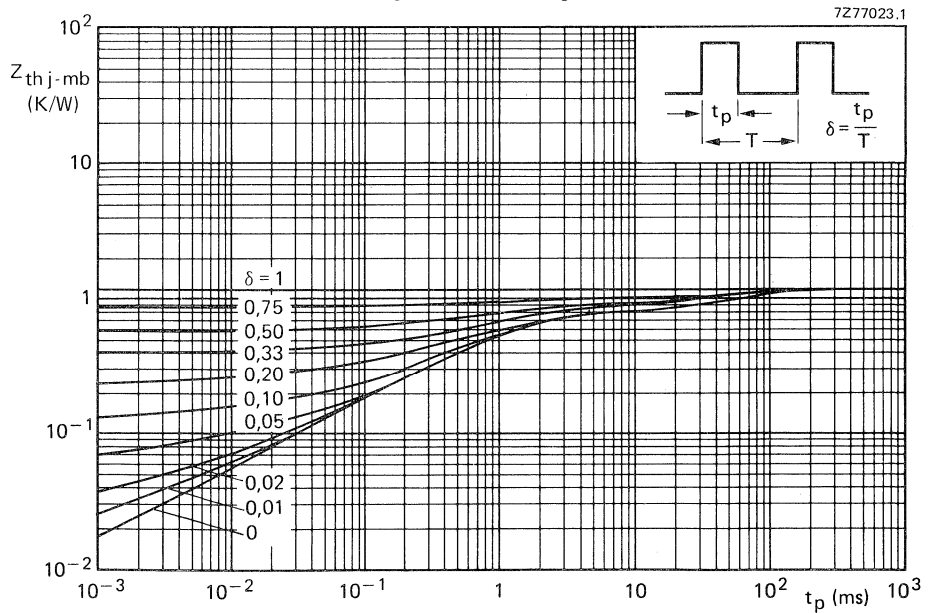


Fig. 8 Pulse power rating chart.

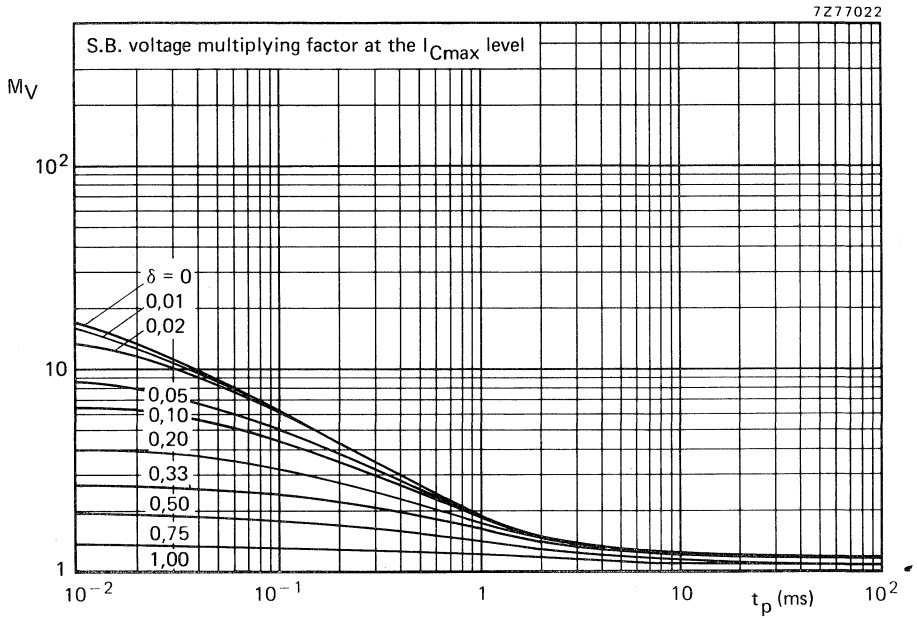


Fig. 9 S.B. voltage multiplying factor at the I_{Cmax} level.

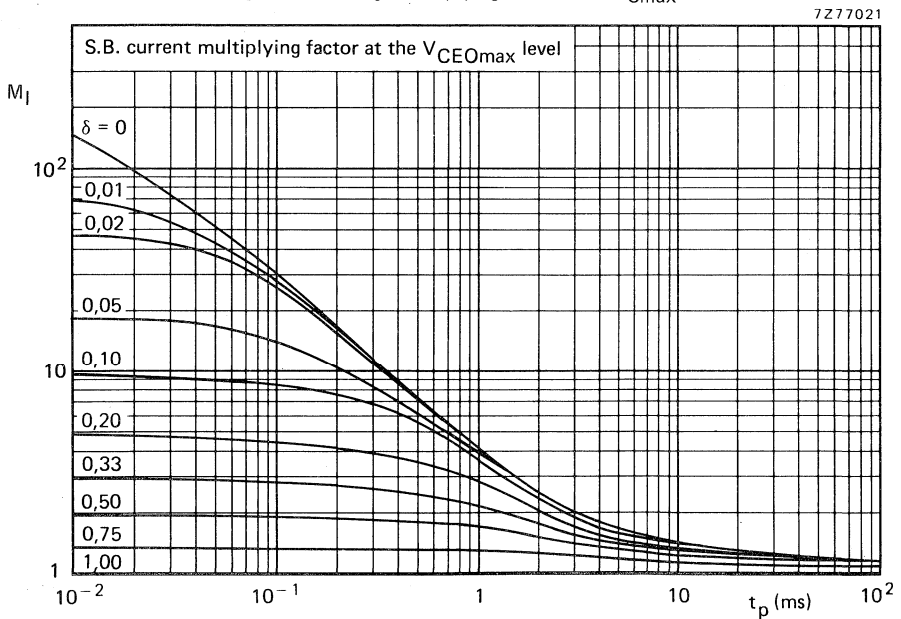


Fig. 10 S.B. current multiplying factor at the V_{CE0max} level.

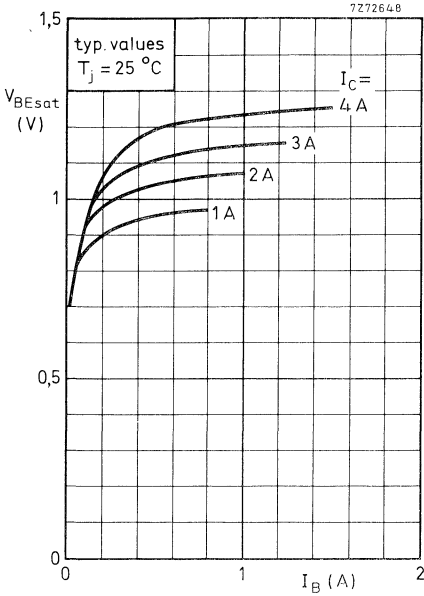


Fig. 11 Typical values. Base-emitter saturation voltage for BU426 and BU426A.

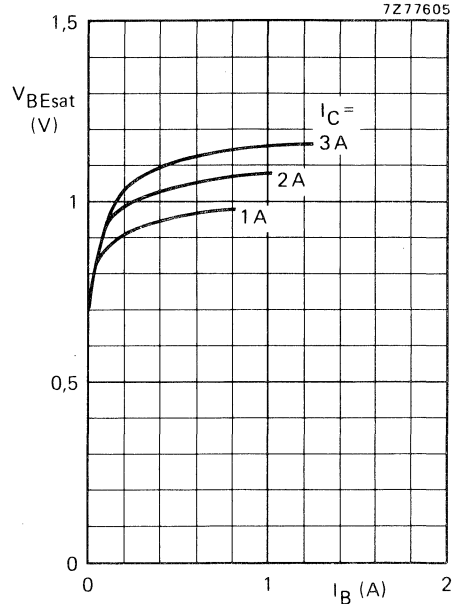


Fig. 11A. Typical values. Base-emitter saturation voltage for BU433; $T_J = 25^\circ\text{C}$.

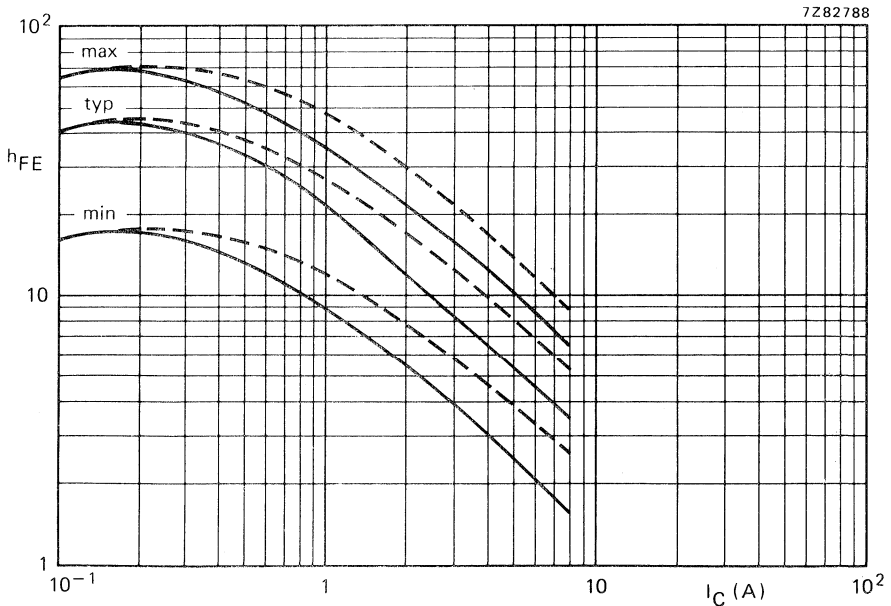


Fig. 12 D.C. current gain BU426 and BU426A. $T_J = 25^\circ\text{C}$. ---- at $V_{CE} = 5\text{ V}$; — at $V_{CE} = 1\text{ V}$.

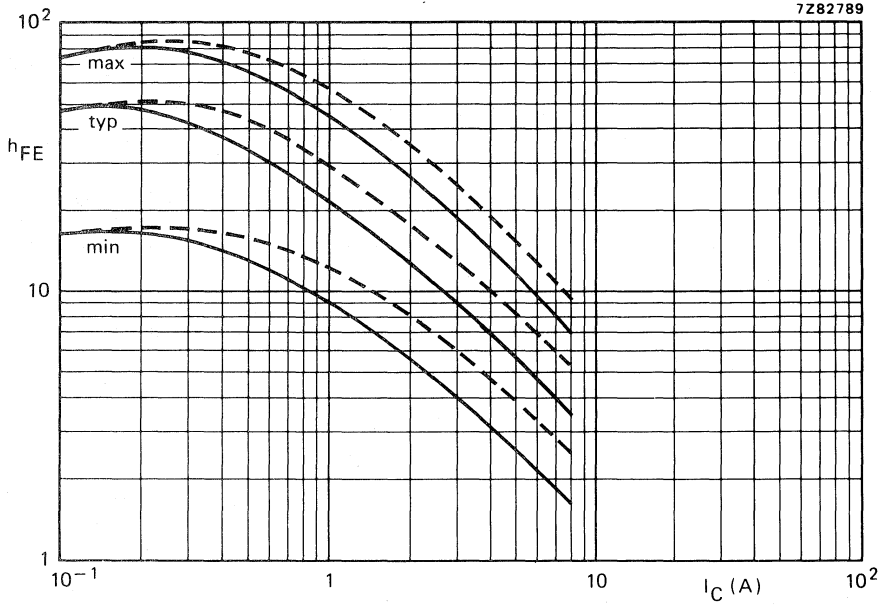


Fig. 13 D.C. current gain BU433; $T_j = 25\text{ }^\circ\text{C}$; ----- at $V_{CE} = 5\text{ V}$; ——— at $V_{CE} = 1\text{ V}$.

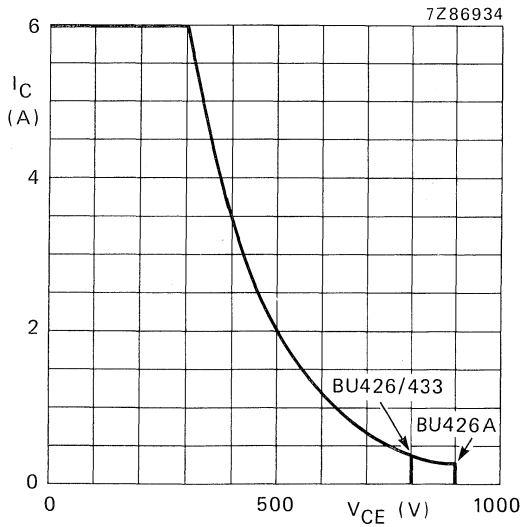


Fig. 14 Reverse bias SOAR.
 $-V_{drive} = 2\text{ to }6\text{ V}$; $L_B = 0\text{ to }4,7\text{ }\mu\text{H}$; $T_{mb} = 100\text{ }^\circ\text{C}$.

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/ μ s. Application of this transistor in low-power flyback converters is also possible, provided that the rate-of-rise is limited to 500 V/ μ s. For the BU426(A) a rate-of-rise of 1000 V/ μ 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 _{mb}	
		25 °C	100 °C
BU426 (426A)	Storage time t _s	typ. 1,4	< 2,0 μ s
	Fall time t _f	0,15	< 0,5 μ s
BU433	Storage time t _s	typ. 1,4	< 2,0 μ s
	Fall time t _f	0,18	< 0,6 μ s

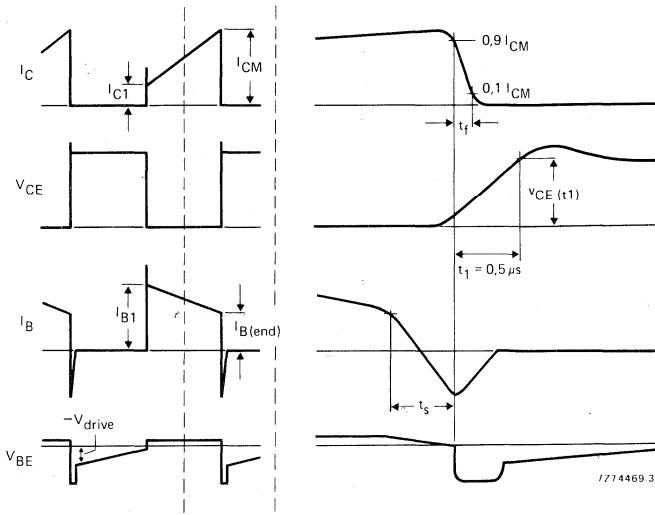


Fig. 15 Relevant waveforms of switching transistor.

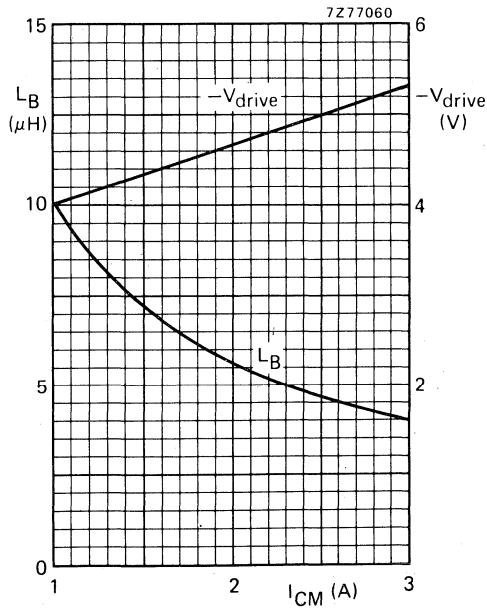


Fig. 16 Minimum required base inductance and recommended negative drive voltage versus maximum peak collector current.

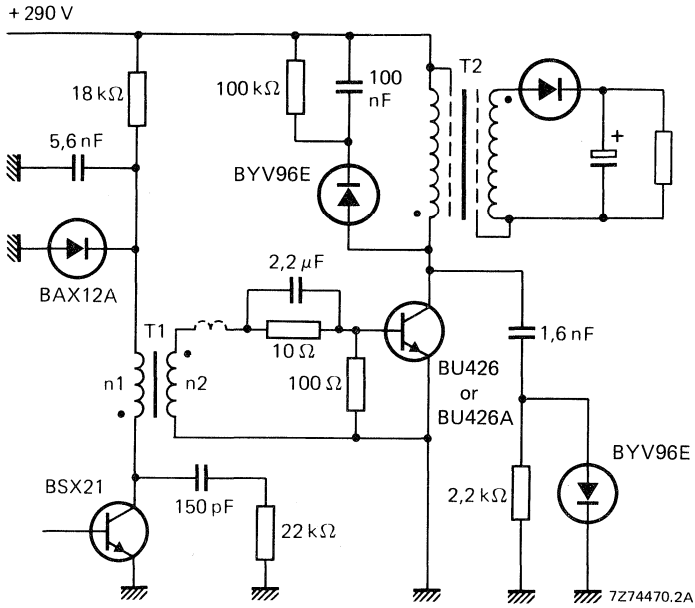


Fig. 17 Practical output circuit of a flyback SMPS of BU426 or BU426A.

T1 (driver transformer)

core U20; $n_1 = 400$ turns

$n_2 = 25$ turns

$L_{Btot} \approx 4,5 \mu\text{H}$

T2 (output transformer)

$L_p = 6 \text{ mH}$

$V_{CE}(t_1) < 500 \text{ V}$ (see Fig. 15)

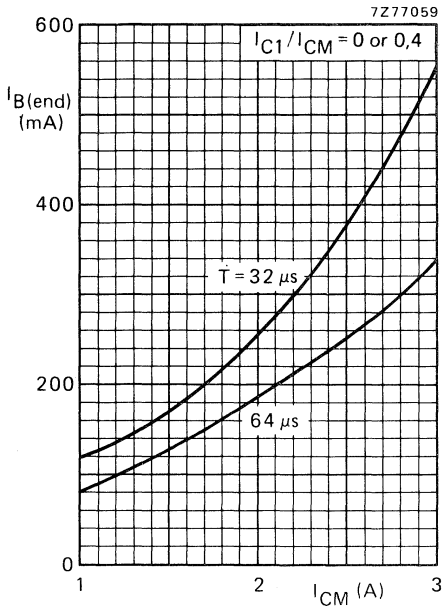


Fig. 18 Recommended nominal "end" value of the base current versus maximum peak collector current.

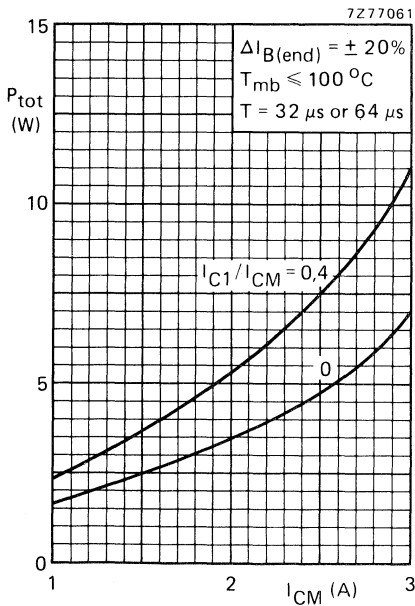


Fig. 19 Maximum total power dissipation of a limit-case transistor of the base current is chosen in accordance with Fig. 18.

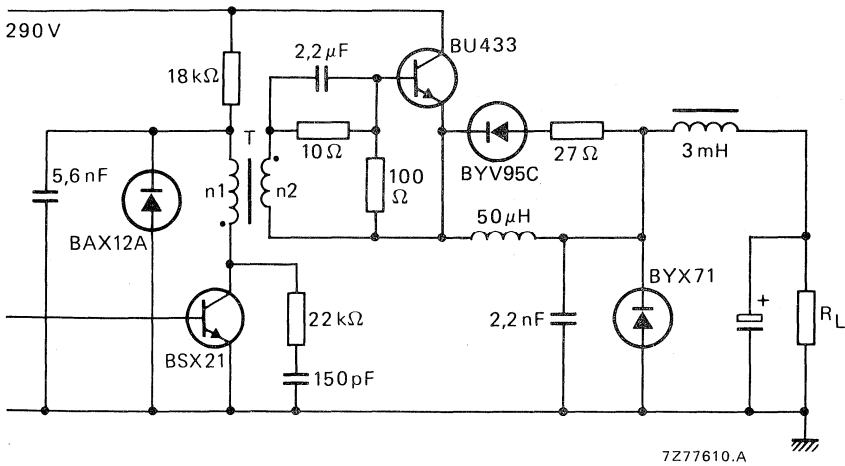


Fig. 20 Practical output circuit of a forward SMPS with BU433.

T (driver transformer): Core U20

$n_1 = 400$ turns; $n_2 = 25$ turns

$L_{Btot} \approx 4,5 \mu\text{H}$

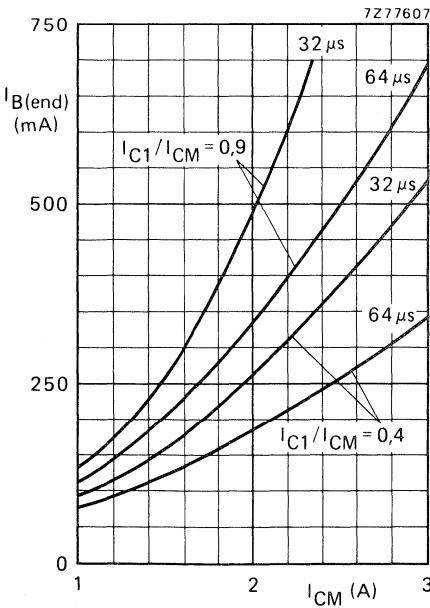


Fig. 21 Recommended nominal "end" value of the base current versus maximum peak collector current.

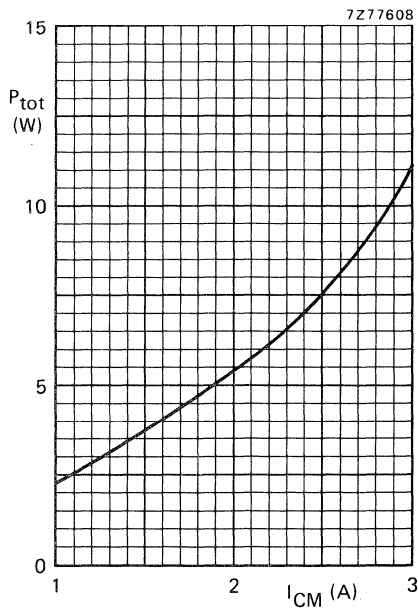


Fig. 22 Maximum total power dissipation of a limit-case transistor if the base current is chosen in accordance with Fig. 21.

DEVELOPMENT SAMPLE DATA

This information is derived from development samples made available for evaluation. It does not necessarily imply that the device will go into regular production.

BU505

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.

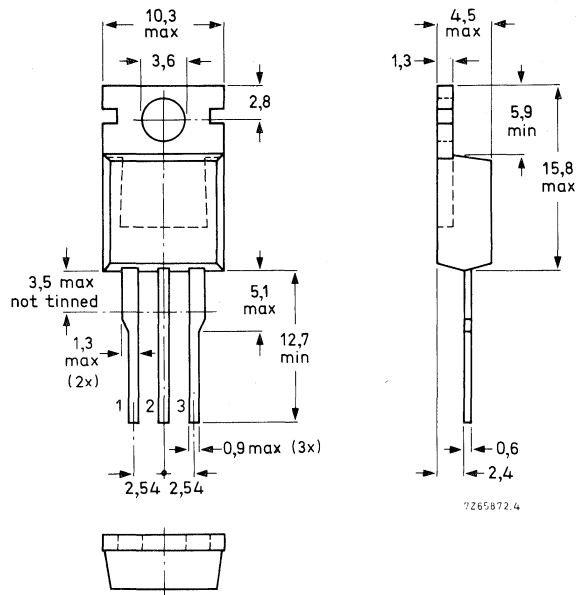
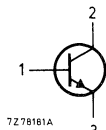
QUICK REFERENCE DATA

Collector-emitter voltage ($V_{BE} = 0$; peak value)	V_{CESM}	max.	1500 V
Collector-emitter voltage (open base)	V_{CEO}	max.	700 V
Collector current (d.c.)	I_C	max.	2,5 A
Collector current (peak value, $t_p = 2$ ms)	I_{CM}	max.	4 A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot}	max.	75 W
Collector-emitter saturation voltage $I_C = 2$ A; $I_B = 0,9$ A	V_{CEsat}	<	5 V
Fall time $I_{Con} = 2$ A; $I_{Bon} = 0,9$ A	t_f	typ.	0,7 μ s

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; $V_{BE} = 0$)	V_{CESM}	max.	1500 V
Collector-emitter voltage (open base)	V_{CEO}	max.	700 V
Collector current (d.c.)	I_C	max.	2,5 A
Collector current (peak value); $t_p < 2$ ms	I_{CM}	max.	4 A
Base current (d.c.)	I_B	max.	2 A
Base current (peak value); $t_p < 2$ ms	I_{BM}	max.	4 A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot}	max.	75 W
Storage temperature	T_{stg}		-65 to +150 °C
Junction temperature	T_j	max.	150 °C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}^*$		1,67 K/W
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CHARACTERISTICS

$T_j = 25$ °C unless otherwise specified

Collector cut off current*

$V_{CE} = V_{CESMmax}; V_{BE} = 0$	I_{CES}	<	0,15 mA
------------------------------------	-----------	---	---------

$V_{CE} = V_{CESMmax}; V_{BE} = 0; T_j = 125$ °C	I_{CES}	<	1 mA
--	-----------	---	------

Emitter cut-off current

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

Saturation voltages

$I_C = 2$ A; $I_B = 0,9$ A	V_{CEsat}	<	5 V
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V_{BEsat}	<	1,3 V
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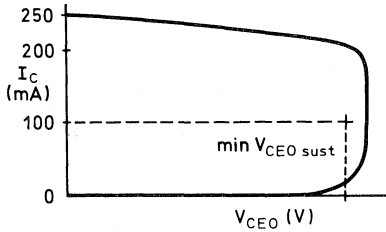
Collector-emitter sustaining voltage

$I_C = 100$ mA; $I_B = 0; L = 50$ mH	V_{CEOust}	>	700 V
--------------------------------------	--------------	---	-------

D.C. current gain

$I_C = 2$ A; $V_{CE} = 5$ V	h_{FE}	>	2,22
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* Measured with a half sine-wave voltage (curve tracer).



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Fig. 2 Oscilloscope display for sustaining voltage.

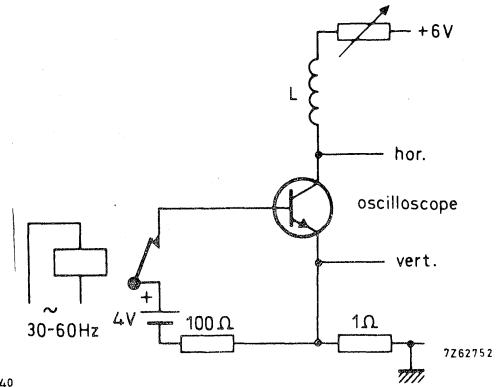


Fig. 3 Test circuit for $V_{CE0sust}$.

DEVELOPMENT SAMPLE DATA

Second-breakdown current

$$V_{CE} = 120 \text{ V}; T = 200 \mu\text{s}$$

Transition frequency at $f = 5 \text{ MHz}$

$$I_C = 0,1 \text{ A}; V_{CE} = 5 \text{ V}$$

Collector capacitance at $f = 1 \text{ MHz}$

$$I_E = I_e = 0; V_{CB} = 10 \text{ V}$$

Switching times

in horizontal deflection circuit

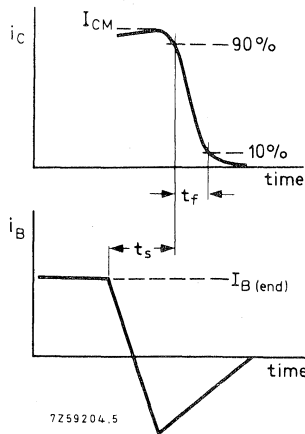
$$-V_{IM} = 4 \text{ V}; L_B = 25 \mu\text{H};$$

$$I_{CM} = 2 \text{ A}; I_{B(\text{end})} = 0,9 \text{ A}$$

fall time

storage time

I_{SB}	>	2 A
f_T	typ.	7 MHz
C_C	typ.	65 pF
t_f	typ.	0,7 μs
t_s	typ.	10 μs



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Fig. 4 Switching times waveforms.

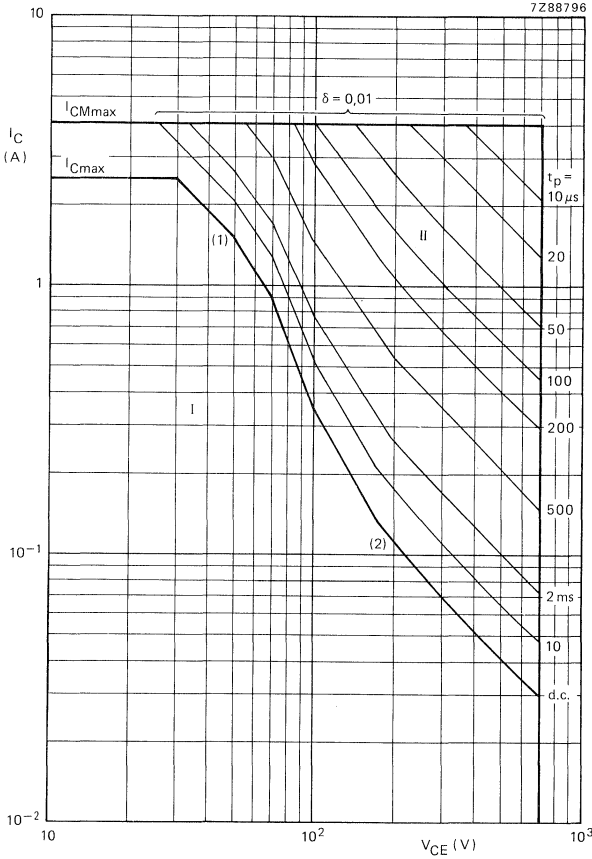


Fig. 5 Safe Operating Area at $T_{mb} \leq 25 \text{ }^\circ\text{C}$.

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

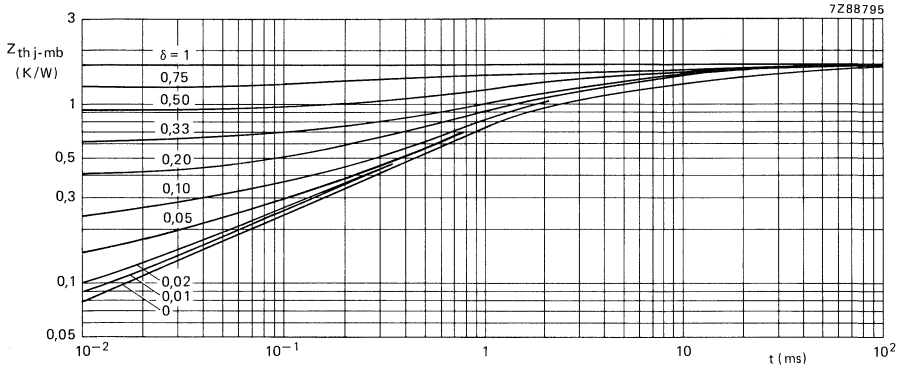


Fig. 6 Pulse power rating chart.

DEVELOPMENT SAMPLE DATA

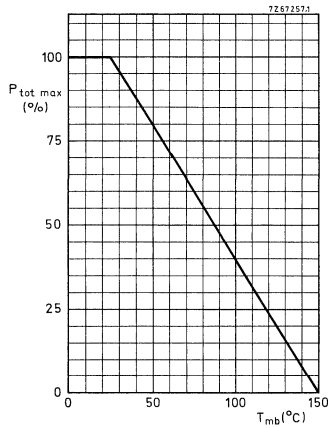


Fig. 7 Power derating curve.

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

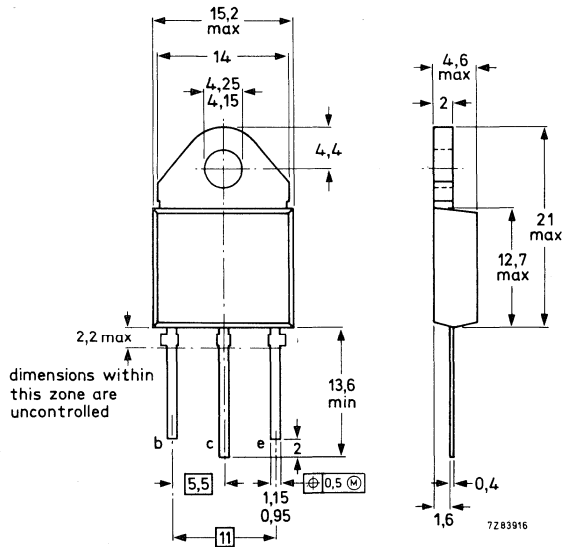
Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM}	max.	1500 V
Collector-emitter voltage (open base)	V_{CEO}	max.	700 V
Collector current (d.c.)	I_C	max.	8 A
Collector current (peak value)	I_{CM}	max.	15 A
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	125 W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

MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT-93A.

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 ($V_{BE} = 0$, peak value)	V_{CESM}	max.	1500 V
Collector-emitter voltage (open base)	V_{CEO}	max.	700 V
Collector current (d.c.)	I_C	max.	8 A
Collector current (peak value)	I_{CM}	max.	15 A
Base current (d.c.)	I_B	max.	4 A
Base current (peak value)	I_{BM}	max.	6 A
Reverse base current (d.c. or average over any 20 ms period)	$-I_{B(AV)}$	max.	100 mA
Reverse base current * (peak value)	$-I_{BM}$	max.	5 A
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	125 W
Storage temperature	T_{stg}		-65 to +150 $^\circ\text{C}$
Junction temperature	T_j	max.	150 $^\circ\text{C}$

THERMAL RESISTANCE

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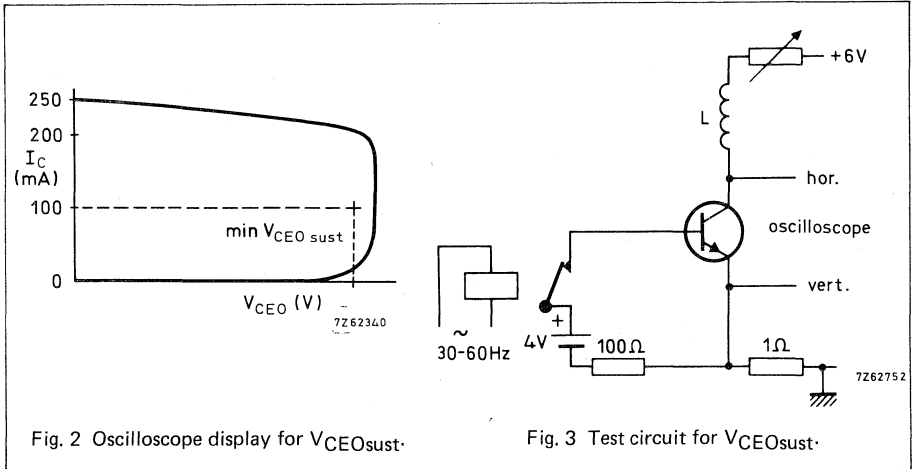
CHARACTERISTICS

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

Collector cut-off current * $V_{BE} = 0; V_{CE} = V_{CESMmax}$	I_{CES}	<	1,0 mA
$V_{BE} = 0; V_{CE} = V_{CESMmax}; T_j = 125\text{ }^\circ\text{C}$	I_{CES}	<	2,0 mA
Emitter cut-off current $V_{EB} = 6\text{ V}; I_C = 0$	I_{EBO}	<	10 mA
Saturation collector current $V_{CEsat} < 1\text{ V}$	I_{Csat}	typ.	4,5 A
Collector-emitter sustaining voltage $I_B = 0; I_C = 100\text{ mA}; L = 25\text{ mH}$	$V_{CEO_{sust}}$	>	700 V
Saturation voltage $I_C = 4,5\text{ A}; I_B = 2\text{ A}$	V_{CEsat}	<	1 V
$I_C = 4,5\text{ A}; I_B = 2\text{ A}$	V_{BEsat}	<	1,3 V
Transition frequency at $f = 5\text{ MHz}$ $I_C = 0,1\text{ A}; V_{CE} = 5\text{ V}$	f_T	typ.	7 MHz
Collector capacitance at $f = 1\text{ MHz}$ $I_E = I_e = 0; V_{CB} = 10\text{ V}$	C_c	typ.	125 pF
Second-breakdown current $V_{CE} = 120\text{ V}; t = 200\text{ }\mu\text{s}$	$I_{(SB)}$	>	11 A

* Turn-off current.

** Measured with a half-sinewave voltage (curve tracer).



Switching times (in line deflection circuit)

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

t_f	typ.	0,7 μs
t_s	typ.	6,5 μs

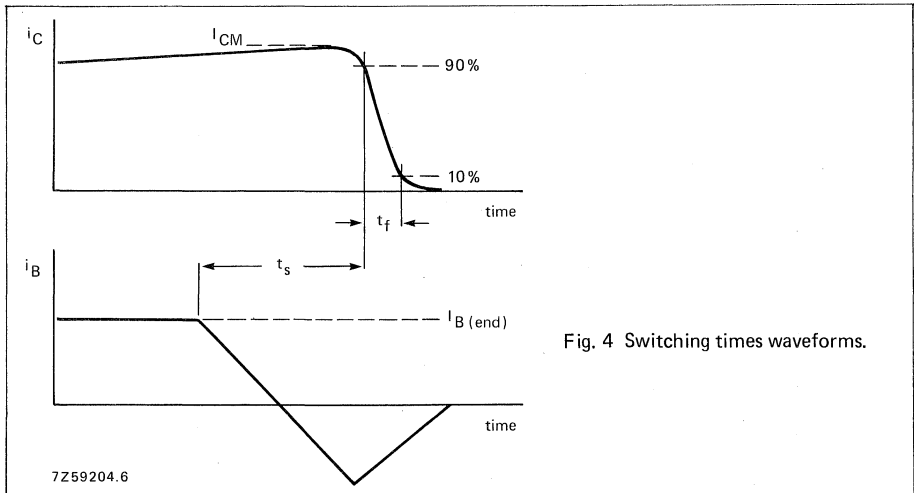


Fig. 4 Switching times waveforms.

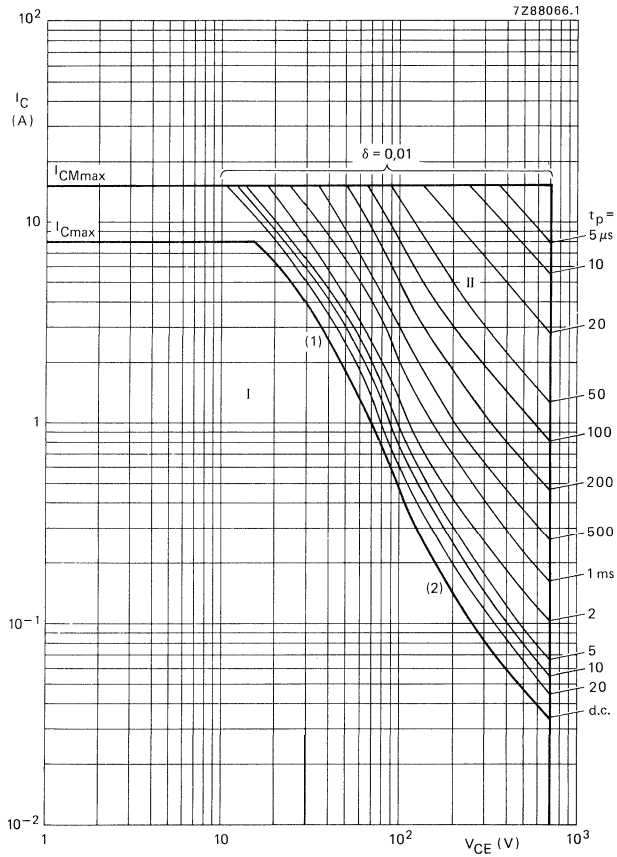


Fig. 5 Safe Operating Area; $T_{mb} \leq 25^\circ\text{C}$.

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

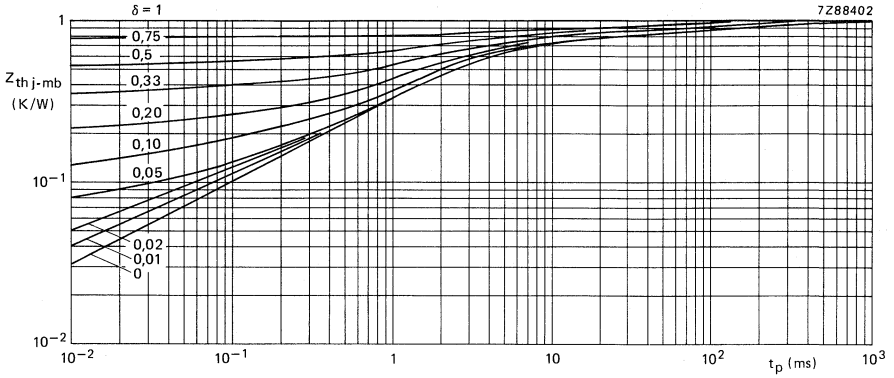


Fig. 6 Pulse power rating chart.

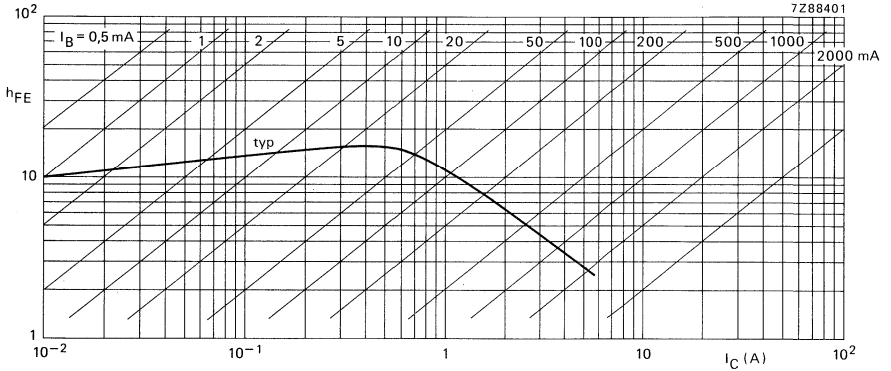


Fig. 7 Typical values d.c. current gain at $V_{CE} = 5\text{ V}$; $T_{mb} = 25\text{ }^\circ\text{C}$.

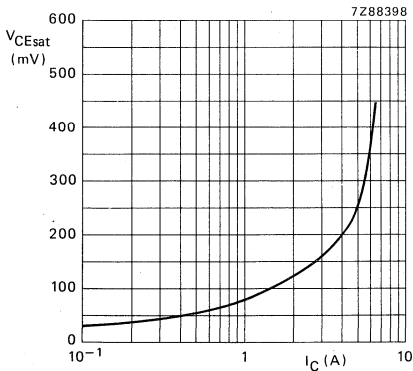


Fig. 8 Typical values $I_C/I_B = 2$; $T_j = 25\text{ }^\circ\text{C}$.

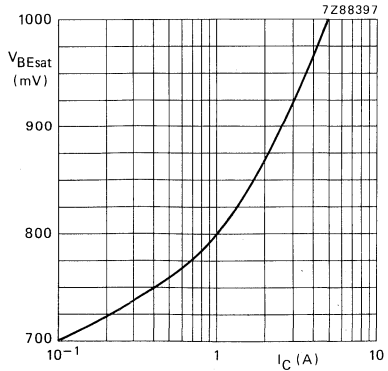


Fig. 9 Typical values $I_C/I_B = 2$; $T_j = 25\text{ }^\circ\text{C}$.

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 ± 10%.

To obtain a short fall time and minimum turn-off dissipation with a high-voltage transistor, the storage time must be sufficiently long and, during turn-off, the negative base-emitter voltage must be sufficiently high. Both requirements can easily be realized by including a small coil in series with the base of the output transistor. However, to reduce base current variations, a series base resistor is also added to most designs. This has the disadvantage of reducing the energy in the base inductance during turn-off, which in turn reduces the negative base-emitter voltage and with large resistor values may lead to an insufficient negative voltage for correct device turn-off. This can be improved by shunting the base resistor by a diode and/or a capacitor. Instead of giving various detailed base circuits based on these considerations, it is a more direct approach to specify the recommended $-di_B/dt$, see Fig. 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 $-di_B/dt$ tolerances of ± 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

$T_{amb\ max}$ 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.

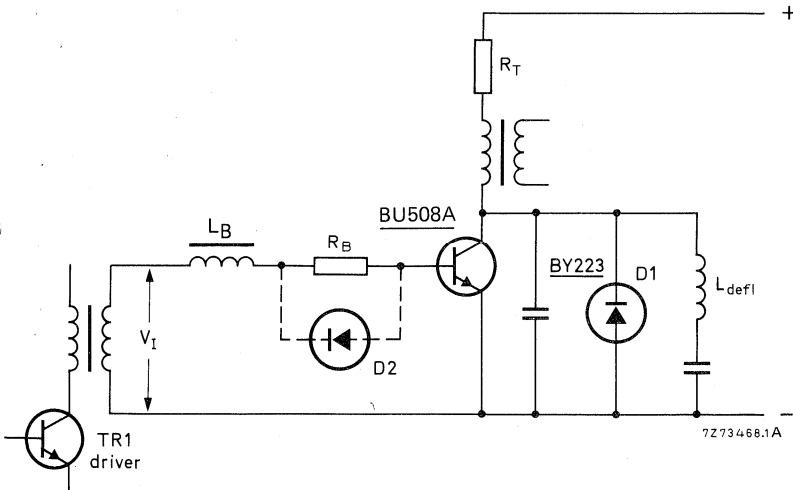
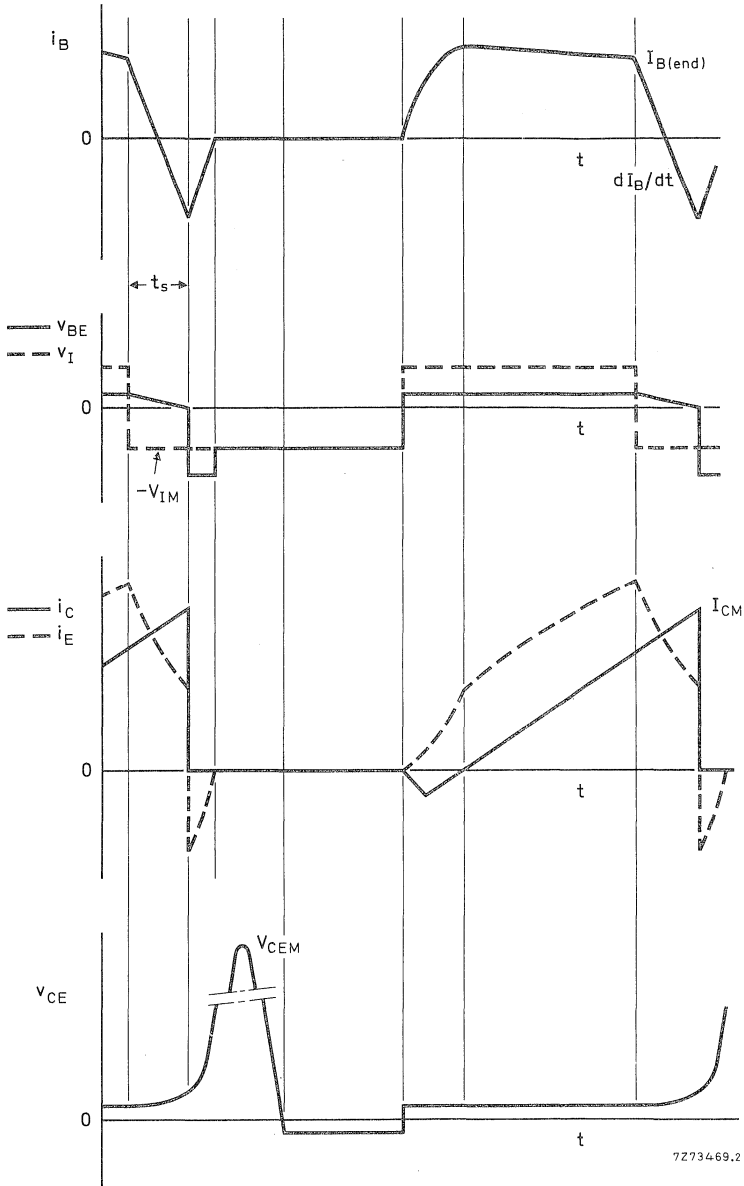


Fig. 10 Simplified horizontal deflection circuit.



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Fig. 11 Fundamental waveforms.

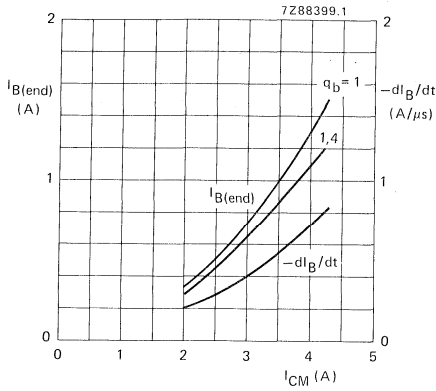


Fig. 12 Nominal end value of the base current and its rate of fall during turn-off as a function of nominal peak collector current.

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.

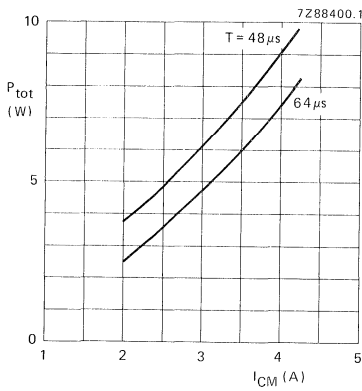


Fig. 13 Worst-case dissipation of BU508A under limited operational conditions according to Fig. 12. $T_{mb} = 85$ °C.

DEVELOPMENT SAMPLE DATA

This information is derived from development samples made available for evaluation. It does not necessarily imply that the device will go into regular production.

BU705

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

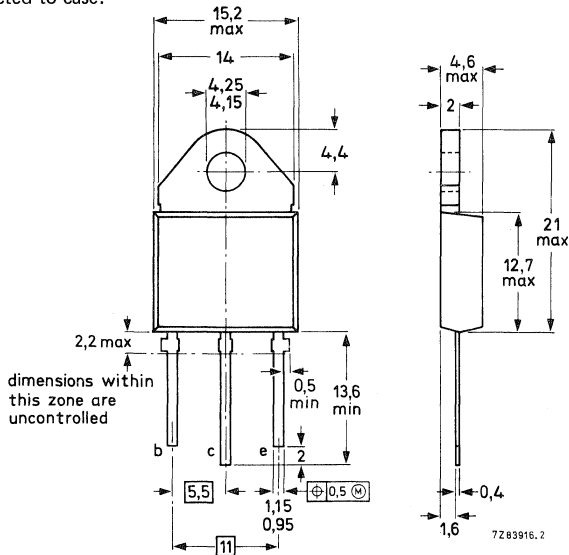
Collector-emitter voltage ($V_{BE} = 0$; peak value)	V_{CESM}	max.	1500 V
Collector-emitter voltage (open base)	V_{CEO}	max.	700 V
Collector current (d.c.)	I_C	max.	2,5 A
Collector current (peak value, $t_p < 2$ ms)	I_{CM}	max.	4 A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot}	max.	75 W
Collector-emitter saturation voltage $I_C = 2$ A; $I_B = 0,9$ A	V_{CEsat}	<	5 V
Fall time $I_{Con} = 2$ A; $I_{B(end)} = 0,9$ A	t_f	typ.	0,9 μ s

MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT-93A.

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; $V_{BE} = 0$)	V_{CESM}	max.	1500 V
Collector-emitter voltage (open base)	V_{CEO}	max.	700 V
Collector current (d.c.)	I_C	max.	2,5 A
Collector current (peak value; $t_p < 2$ ms)	I_{CM}	max.	4 A
Base current	I_B	max.	2 A
Base current (peak value; $t_p < 2$ ms)	I_{BM}	max.	4 A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot}	max.	75 W
Storage temperature	T_{stg}		-65 to + 150 °C
Junction temperature	T_j	max.	150 °C

THERMAL RESISTANCE

From junction to mounting base	R_{thj-mb}	=	1,67 K/W
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CHARACTERISTICS

$T_j = 25$ °C unless otherwise specified

Collector cut-off current*

$V_{CE} = V_{CESMmax}; V_{BE} = 0$	I_{CES}	<	0,15 mA
$V_{CE} = V_{CESMmax}; V_{BE} = 0; T_j = 125$ °C	I'_{CES}	<	1 mA

Emitter cut-off current

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

Emitter-base voltage

$I_C = 0; I_E = 10$ mA	V_{EBO}	>	6 V
------------------------	-----------	---	-----

Saturation voltage

$I_C = 2$ A; $I_B = 0,9$ A	V_{CEsat}	<	5 V
	V_{BEsat}	<	1,3 V

Collector-emitter sustaining voltage

$I_C = 100$ mA; $I_B = 0; L = 25$ mH	$V_{CEO_{sust}}$	>	700 V
--------------------------------------	------------------	---	-------

Collector saturation current

$V_{CE} = 5$ V	$I_{C_{sat}}$	=	2 A
----------------	---------------	---	-----

D.C. current gain

$I_C = 2$ A; $V_{CE} = 5$ V	h_{FE}	>	2,2
-----------------------------	----------	---	-----

Second breakdown current

$V_{CE} = 120$ V; $t = 200$ μ s	$I_{(SB)}$	>	2,0 A
-------------------------------------	------------	---	-------

Transition frequency at $f = 5$ MHz

$I_C = 0,1$ A; $V_{CE} = 5$ V	f_T	typ.	7 MHz
-------------------------------	-------	------	-------

Collector capacitance at $f = 1$ MHz

$I_E = I_e = 0; V_{CB} = 10$ V	C_c	typ.	65 pF
--------------------------------	-------	------	-------

* Measured with a half-sinewave voltage (curve tracer).

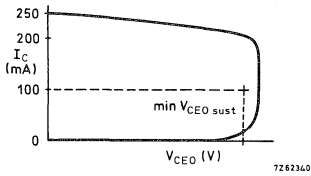


Fig. 2 Oscilloscope display for sustaining voltage.

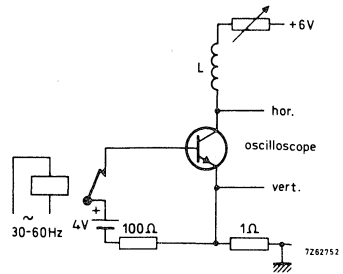


Fig. 3 Test circuit for sustaining voltage.

Switching times (in horizontal deflection circuit)

$-V_{IM} = 4 \text{ V}$; $L_B = 15 \mu\text{H}$; $I_{CM} = 2 \text{ A}$

$I_{B(\text{end})} = 0,9 \text{ A}$; $-dI_B/dt = 0,24 \text{ A}/\mu\text{s}$

fall time

storage time

t_f	typ.	0,9 μs
t_s	typ.	7,5 μs

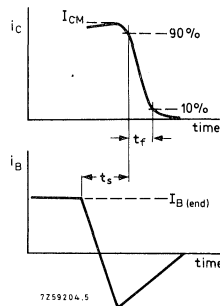


Fig. 4 Switching times waveform.

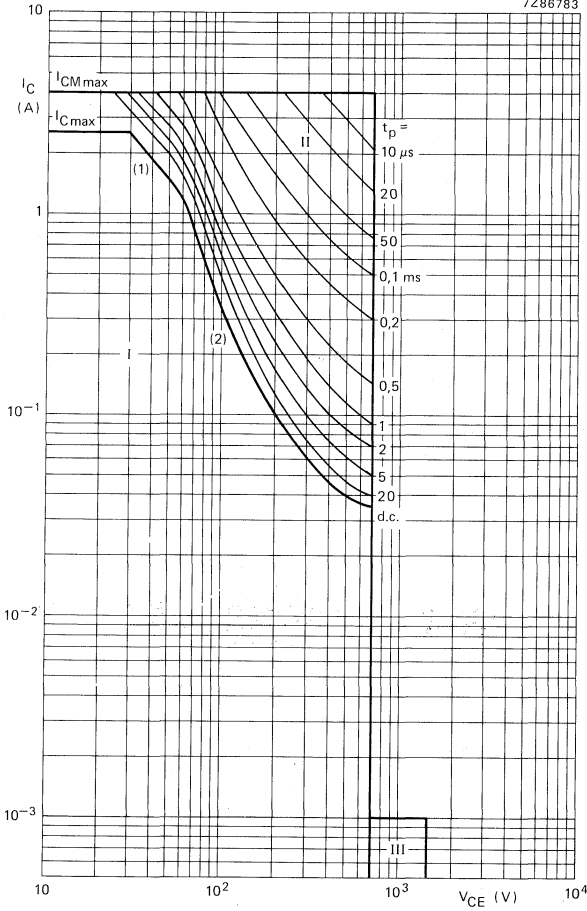


Fig. 5 Safe Operating Area; $T_{mb} = 25\text{ °C}$.

- (1) $P_{tot\text{ max}}$ and $P_{peak\text{ max}}$ lines.
- (2) Second breakdown limits (independent of temperature).
- I Region of permissible d.c. operation.
- II Permissible extension for repetitive pulse operation.
- III Repetitive pulse operation in this region is allowable, provided $R_{BE} < 100\ \Omega$, $t_p = 20\ \mu\text{s}$, $d = 0,25$.

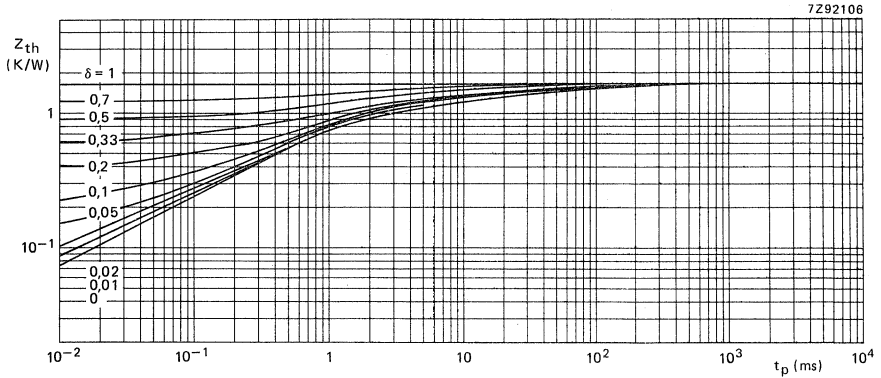


Fig. 6 Pulse power rating chart.

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

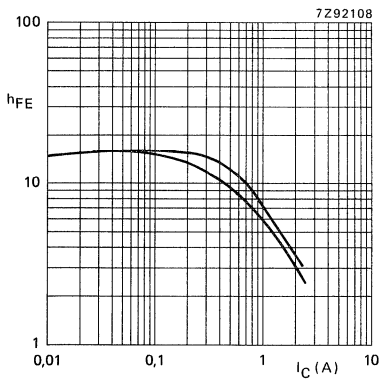


Fig. 7 Typical d.c. current gain.

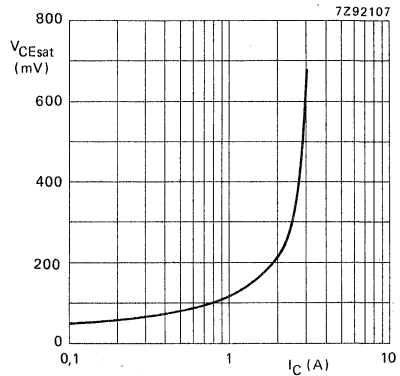


Fig. 8 Typical values V_{CEsat}
 $I_C/I_B = 2; T_j = 25\ ^\circ C$.

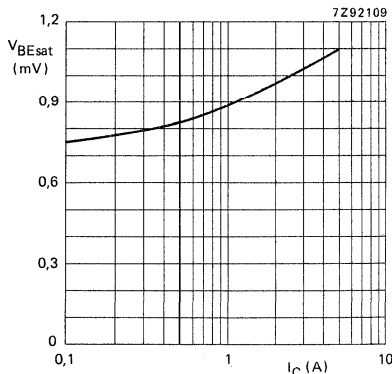


Fig. 9 Typical values $V_{BEsat}; I_C/I_B = 2; T_j = 25\ ^\circ C$.

DEVELOPMENT SAMPLE DATA

This information is derived from development samples made available for evaluation. It does not necessarily imply that the device will go into regular production.

BU806
BU807

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.

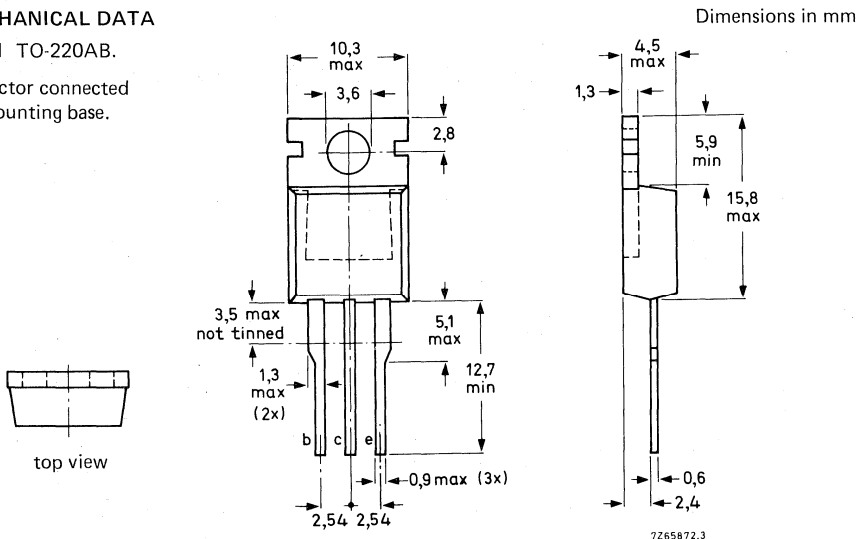
QUICK REFERENCE DATA

		BU806	BU807
Collector-base voltage (open emitter)	V_{CBO}	max. 400	330 V
Collector-emitter voltage ($V_{EB} = 6$ V)	V_{CEX}	max. 400	330 V
Collector-emitter voltage (open base)	V_{CEO}	max. 200	150 V
Collector current (d.c.)	I_C	max. 8	A
Collector current (peak value) $t_p = 0,3$ ms; $\delta = 10\%$	I_{CM}	max. 15	A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot}	max. 60	W
Junction temperature	T_j	max. 150	°C
Fall time $I_{Con} = 5$ A; $I_{Bon} = 50$ mA; $-I_{Boff} = 500$ mA	t_f	typ. 0,2	μ s

MECHANICAL DATA

Fig. 1 TO-220AB.

Collector connected to mounting base.



See also chapters Mounting instructions and Accessories.

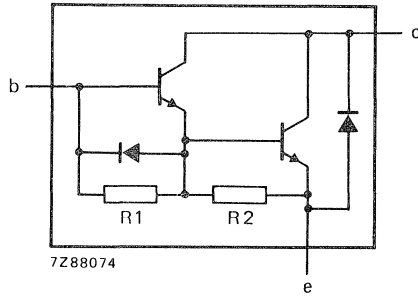


Fig. 2 Circuit diagram.

RATINGS

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

		BU806	BU807
Collector-base voltage (open emitter)	V_{CBO}	max. 400	330 V
Collector-emitter voltage ($V_{EB} = 6$ V)	V_{CEX}	max. 400	330 V
Collector-emitter voltage (open base)	V_{CEO}	max. 200	150 V
Emitter-base voltage (open collector)	V_{EBO}	max. 6	V
Collector current (d.c.)	I_C	max. 8	A
Collector current (peak value) $t_p = 0,3$ ms; $\delta = 0,1$	I_{CM}	max. 15	A
Base current (d.c.)	I_B	max. 100	mA
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot}	max. 60	W
Storage temperature	T_{stg}	-65 to +150 °C	
Junction temperature*	T_j	max. 150	°C

THERMAL RESISTANCE*

From junction to mounting base	$R_{th\ j-mb}$	=	2,08	K/W
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CHARACTERISTICS

$T_j = 25$ °C unless otherwise specified

Collector cut-off current**

$V_{CE} = V_{CESmax}; V_{BE} = 0$ $I_{CES} < 100 \mu A$

$V_{CE} = V_{CEXmax}; V_{EB} = 6$ V $I_{CEX} < 100 \mu A$

Emitter cut-off current

$I_C = 0; V_{EB} = 6$ V $I_{EBO} < 3$ mA

Collector-emitter sustaining voltage

$I_C = 100$ mA; $I_{Boff} = 0$; $L = 25$ mH $V_{CEO\ sust} > \begin{matrix} BU806 & BU807 \\ 200 & 150 \text{ V} \end{matrix}$

* 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.

** Measured with a half sine wave voltage (curve tracer).

Saturation voltages

$$I_C = 5 \text{ A}; I_B = 50 \text{ mA}$$

Diode, forward voltage

$$I_F = 4 \text{ A}$$

$$V_{CEsat} < 1,5 \text{ V}$$

$$V_{BEsat} < 2,8 \text{ V}$$

$$V_F < 2 \text{ V}$$

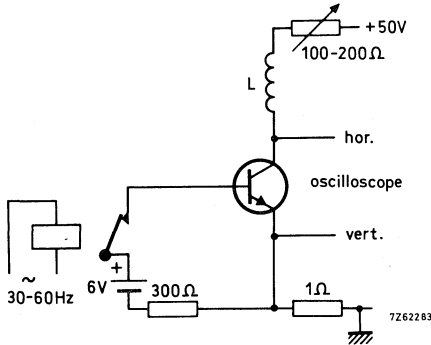


Fig. 3 Test circuit for $V_{CEOsust}$.

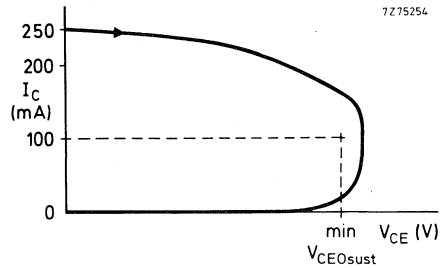


Fig. 4 Oscilloscope display for $V_{CEOsust}$.

DEVELOPMENT SAMPLE DATA

Switching times (between 10% and 90% levels)

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

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

Turn-on time

Turn-off time: Storage time

Fall time

$$t_{on} \text{ typ. } 0,35 \mu\text{s}$$

$$t_s \text{ typ. } 0,55 \mu\text{s}$$

$$t_f \text{ typ. } 0,2 \mu\text{s}$$

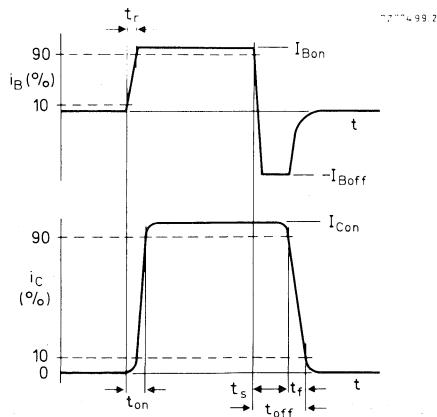


Fig. 5 Waveforms.

7Z88115

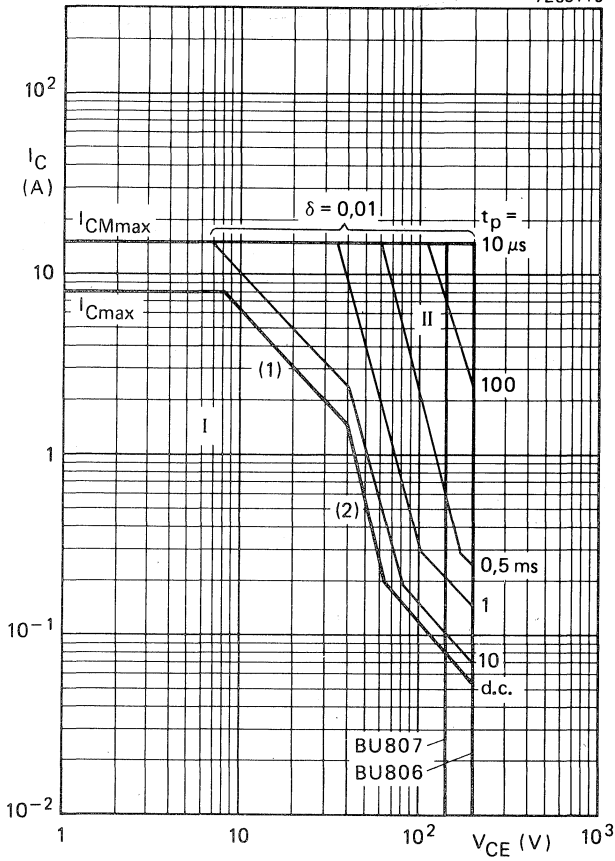


Fig. 6 D.C. Safe Operating Area.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

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

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

DEVELOPMENT SAMPLE DATA

This information is derived from development samples made available for evaluation. It does not necessarily imply that the device will go into regular production.

BU824

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

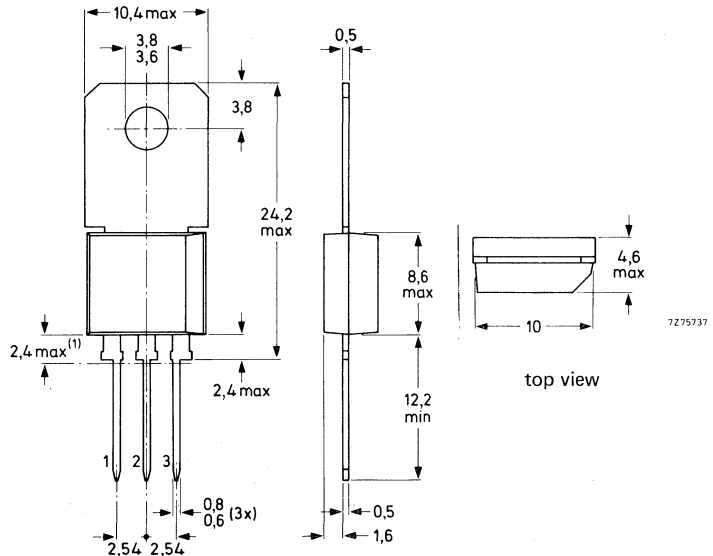
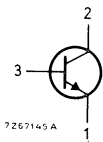
Collector-emitter voltage $V_{BE} = 0$; peak value	V_{CESM}	max.	650 V
Collector-emitter voltage (open base)	V_{CEO}	max.	375 V
Collector current (d.c.)	I_C	max.	0,5 A
Collector current (peak value)	I_{CM}	max.	1 A
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$ up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	2 W
Collector-emitter saturation voltage $I_C = 200\text{ mA}$; $I_B = 600\text{ }\mu\text{A}$	V_{CEsat}	<	5 V
Collector saturation current	I_{Csat}		0,2 A

MECHANICAL DATA

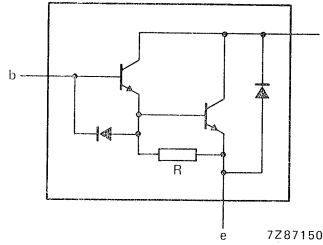
Dimensions in mm

Fig. 1 TO-202.

Collector connected to mounting base.



See also chapters Mounting instructions and Accessories.



R typ. 600 Ω

Fig. 2 Circuit diagram.

RATINGS

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

Collector-emitter voltage $V_{BE} = 0$; peak value	V_{CESM}	max.	650 V
Collector-emitter voltage (open base)	V_{CEO}	max.	375 V
Collector current (d.c.)	I_C	max.	0,5 A
Collector current (peak value)	I_{CM}	max.	1 A
Base current (d.c.)	I_B	max.	0,2 A
Base current	I_{BM}	max.	1 A
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	2 W
up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot}	max.	12,5 W
Storage temperature	T_{stg}		-65 to + 150 °C
Junction temperature	T_j	max.	150 °C

THERMAL RESISTANCE

From junction to mounting base	R_{thj-mb}	=	10 K/W
From junction to ambient	$R_{thj-amb}$	=	62,5 K/W

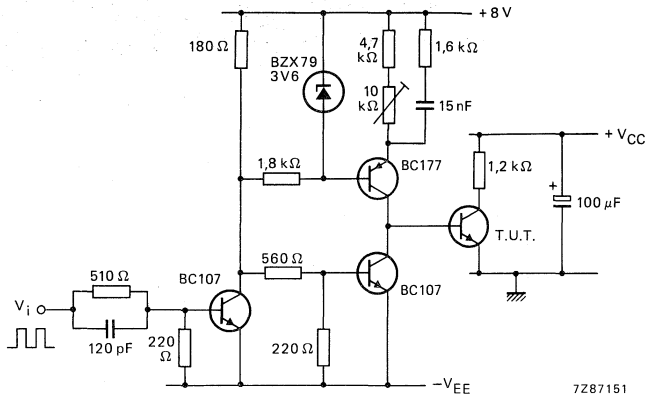
CHARACTERISTICS

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

Collector cut-off current* $V_{CE} = V_{CESMmax}$; $V_{BE} = 0$	I_{CES}	<	0,1 mA
$V_{CE} = V_{CESMmax}$; $V_{BE} = 0$; $T_j = 125\text{ }^\circ\text{C}$	I_{CES}	<	0,2 mA
Emitter cut-off current $I_C = 0$; $V_{EB} = 5\text{ V}$	I_{EBO}		3,3 to 20 mA
Collector-emitter sustaining voltage $I_B = 0$; $I_C = 250\text{ mA}$; $L = 25\text{ mH}^{**}$	$V_{CEO_{sust}}$	>	375 V
Saturation voltages $I_C = 200\text{ mA}$; $I_B = 600\text{ }\mu\text{A}$	V_{CEsat}	<	5 V
	V_{BEsat}	<	2 V

* Measured with a half-sinewave voltage (curve tracer).

** Clamped at rated $V_{CEO_{sust}}$.



7Z87151

Fig. 3 Switching times test circuit.

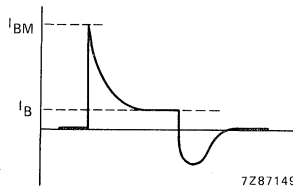
Switching times

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

rise time
 storage time
 fall time

t_r	<	1 μs
t_s	<	1,5 μs
t_f	<	1 μs

DEVELOPMENT SAMPLE DATA



7Z87149

Fig. 4 Base current waveform.

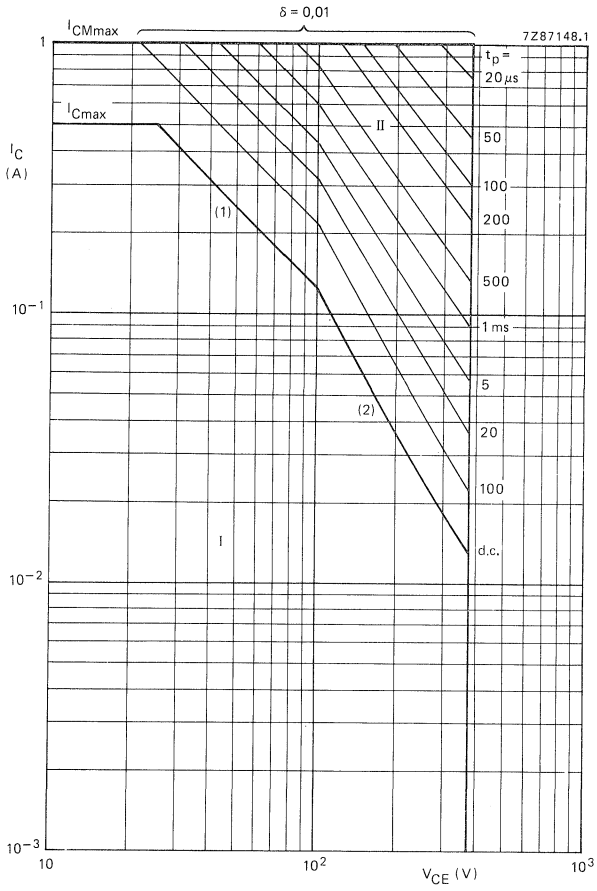


Fig. 5 Safe Operating Area, $T_{mb} \leq 25^\circ\text{C}$.

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

DEVELOPMENT SAMPLE DATA

This information is derived from development samples made available for evaluation. It does not necessarily imply that the device will go into regular production.

728BDY
(BU826)

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

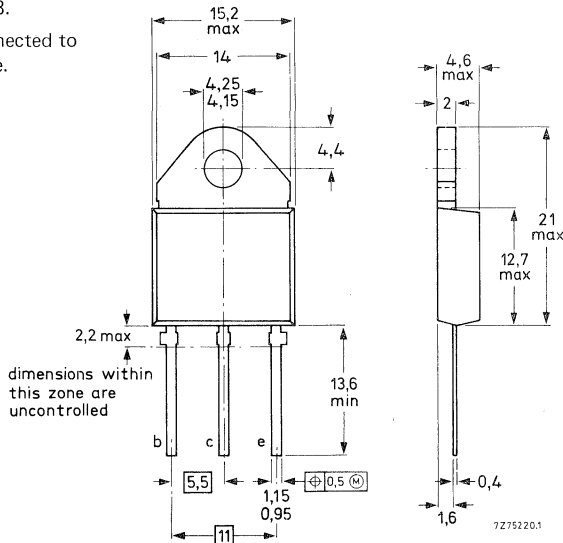
Collector-emitter voltage ($V_{BE} = 0$; peak value)	V_{CESM} max.	800 V
Collector-emitter voltage (open base)	V_{CEO} max.	375 V
Collector current (d.c.)	I_C max.	6 A
Collector current (peak value) $t_p < 2$ ms	I_{CM} max.	8 A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot} max.	125 W
Collector-emitter saturation voltage $I_C = 2,5$ A; $I_B = 55$ mA	V_{CEsat}	$< 2,0$ V
$I_C = 4$ A; $I_B = 200$ mA	V_{CEsat}	$< 2,5$ V
Collector saturation current	I_{Csat}	$= 2,5$ A
Fall time $I_{Con} = 2,5$ A; $I_{Bon} = 55$ mA; $-I_{Boff} = 1$ A	t_f typ.	$0,2$ μ s

MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT-93.

Collector connected to mounting base.



See also chapters Mounting instructions and Accessories.

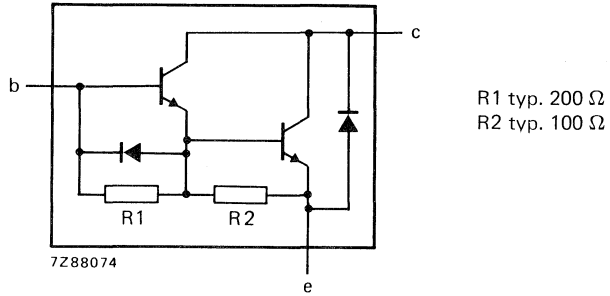


Fig. 2 Circuit diagram.

RATINGS

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

Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM}	max.	800 V
Collector-emitter voltage (open base)	V_{CEO}	max.	375 V
Collector current (d.c.)	I_C	max.	6 A
Collector current (peak value) $t_p < 2$ ms	i_{CM}	max.	8 A
Base current (d.c.)	I_B	max.	2 A
Base current (peak value)	I_{BM}	max.	3 A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot}	max.	125 W
Storage temperature	T_{stg}		-65 to + 150 °C
Junction temperature*	T_j	max.	150 °C

THERMAL RESISTANCE*

From junction to mounting base	$R_{th\ j-mb}$	=	1,0 K/W
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* Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

CHARACTERISTICS

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

Collector cut-off current*

$V_{CE} = V_{CESMmax}; V_{BE} = 0$

$V_{CE} = V_{CESMmax}; V_{BE} = 0; T_j = 125\text{ }^\circ\text{C}$

Emitter cut-off current

$I_C = 0; V_{EB} = 8\text{ V}$

Collector-emitter sustaining voltage

$I_C = 100\text{ mA}; I_{Boff} = 0; L = 25\text{ mH}$

Saturation voltages

$I_C = 2,5\text{ A}; I_B = 55\text{ mA}$

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

Collector saturation current

$V_{CEsat} < 2\text{ V}$

I_{CES}	<	1 mA
I_{CES}	<	2 mA
I_{EBO}	<	150 mA
I_{EBO}	>	50 mA
$V_{CEOsust}$	>	375 V
V_{CEsat}	<	2,0 V
V_{BEsat}	<	2,2 V
V_{CEsat}	<	2,5 V
I_{Csat}	=	2,5 A

DEVELOPMENT SAMPLE DATA

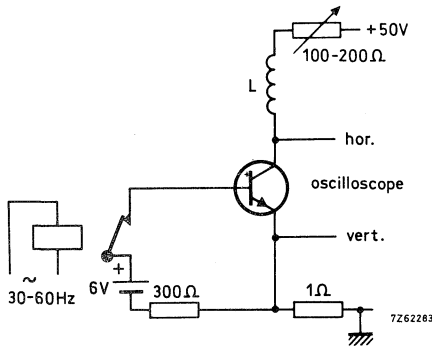


Fig. 3 Test circuit for $V_{CEOsust}$.

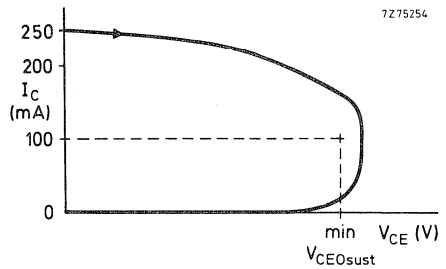


Fig. 4 Oscilloscope display for $V_{CEOsust}$.

* Measured with a half sine wave voltage (curve tracer).

CHARACTERISTICS (continued)

Switching times (between 10% and 90% levels)

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

$I_{Bon} = 55 \text{ mA}; -I_{Boff} = 1 \text{ A}$

Turn-on time

$t_{on} < 1,3 \mu\text{s}$

Turn-off time: Storage time

$t_s < 2,0 \mu\text{s}$

Fall time

$t_f \text{ typ. } 0,2 \mu\text{s}$

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

$t_f < 0,6 \mu\text{s}$

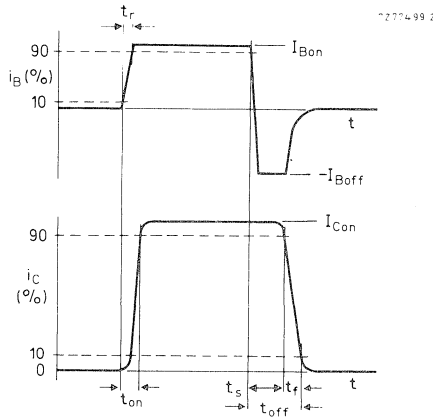


Fig. 5 Waveforms.

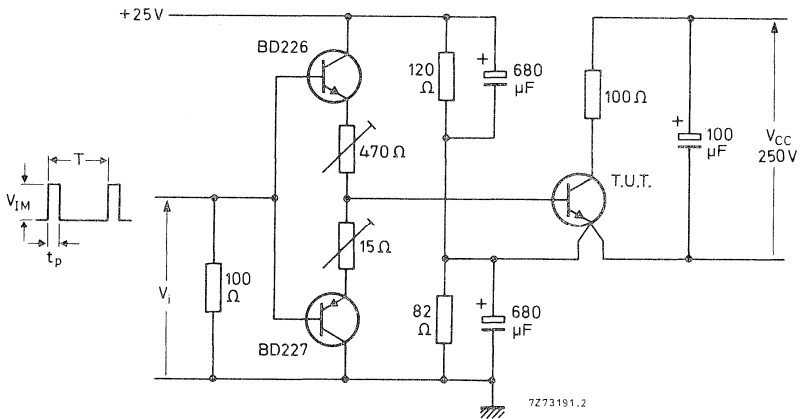


Fig. 6 Test circuit. $T = 2 \text{ ms}; t_p = 20 \mu\text{s}; V_{IM} = 15 \text{ V}$.

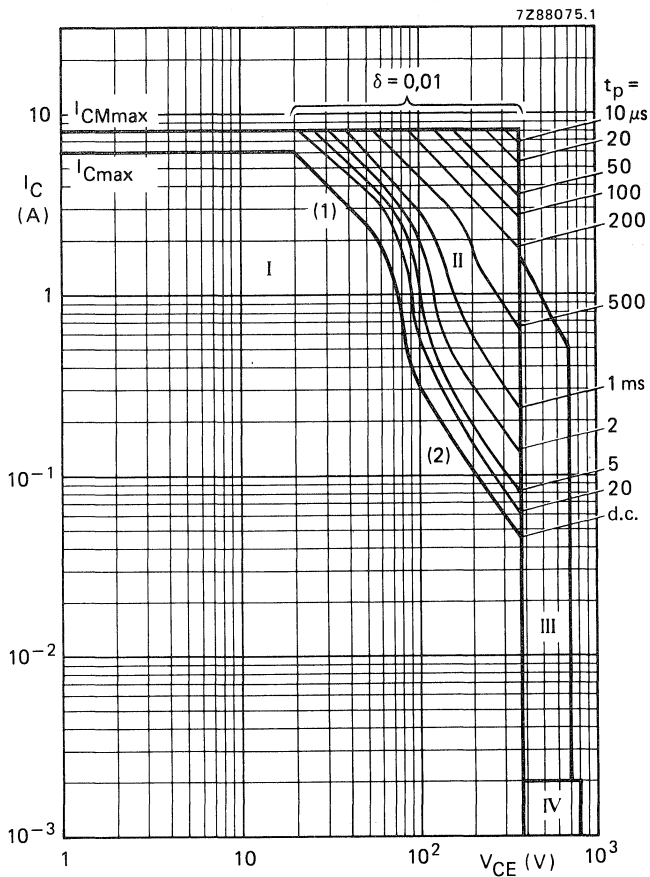


Fig. 7 Safe Operating Area at $T_{amb} = 25\text{ }^{\circ}\text{C}$.

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 $t_p < 1,3\text{ }\mu\text{s}$.

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

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

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

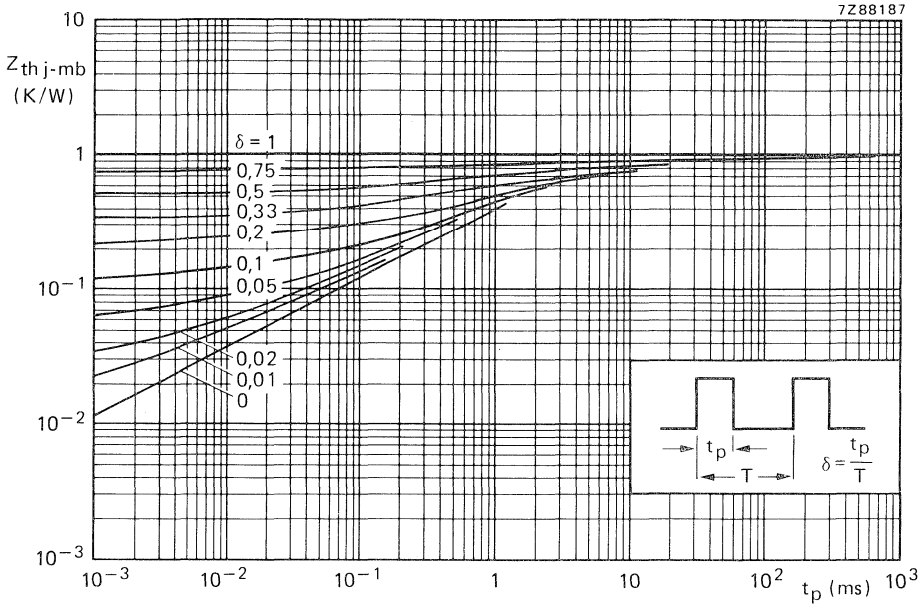


Fig. 8 Pulse power rating chart.

SILICON DIFFUSED POWER TRANSISTORS



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

QUICK REFERENCE DATA

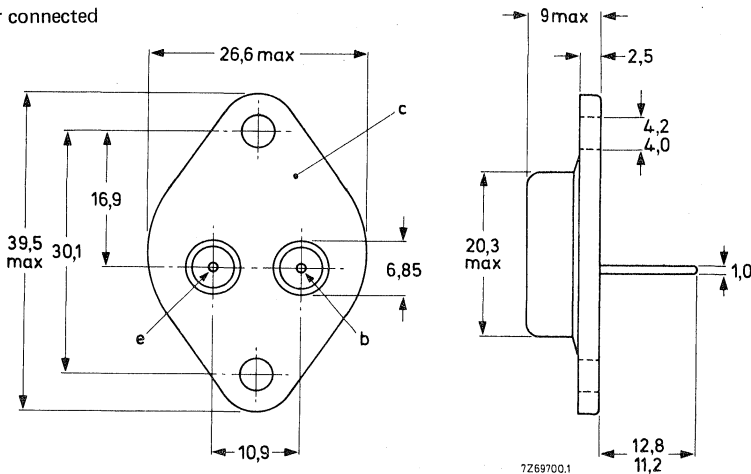
		BUS11	BUS11A
Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM} max.	850	1000 V
Collector-emitter voltage (open base)	V_{CEO} max.	400	450 V
Collector current (d.c.)	I_C max.	5	A
Collector current (peak value) $t_p \leq 2$ ms	I_{CM} max.	10	A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot} max.	100	W
Collector-emitter saturation voltage			
$I_C = 3$ A; $I_B = 0,6$ A	V_{CEsat} <	1,5	— V
$I_C = 2,5$ A; $I_B = 0,5$ A	V_{CEsat} <	—	1,5 V
Fall time (resistive load)			
$I_{Con} = 3$ A; $I_{Bon} = -I_{Boff} = 0,6$ A	t_f <	0,8	— μ s
$I_{Con} = 2,5$ A; $I_{Bon} = -I_{Boff} = 0,5$ A	t_f <	—	0,8 μ s

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.

RATINGS

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

		BUS11	BUS11A
Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM} max.	850	1000 V
Collector-emitter voltage (open base)	V_{CEO} max.	400	450 V
Collector current (d.c.)	I_C max.	5	A
Collector current (peak value) $t_p < 2$ ms	I_{CM} max.	10	A
Base current (d.c.)	I_B max.	2	A
Base current (peak value); $t_p < 2$ ms	I_{BM} max.	3	A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot} max.	100	W
Storage temperature	T_{stg}	-65 to +200	°C
Junction temperature	T_j max.	200	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb} =$	1,75	K/W
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CHARACTERISTICS

$T_j = 25$ °C unless otherwise specified

Collector cut-off current *

$V_{CE} = V_{CESMmax}; V_{BE} = 0$

$I_{CES} < 1$ mA

$V_{CE} = V_{CESMmax}; V_{BE} = 0; T_j = 125$ °C

$I_{CES} < 2$ mA

Emitter cut-off current

$I_C = 0; V_{EB} = 9$ V

$I_{EBO} < 10$ mA

Saturation voltages

$I_C = 3$ A; $I_B = 0,6$ A

	BUS11	BUS11A
$V_{CEsat} <$	1,5	- V
$V_{CEsat} <$	-	1,5 V
$V_{BEsat} <$	1,4	- V
$V_{BEsat} <$	-	1,4 V

$I_C = 2,5$ A; $I_B = 0,5$ A

$I_C = 3$ A; $I_B = 0,6$ A

$I_C = 2,5$ A; $I_B = 0,5$ A

Collector-emitter sustaining voltage

$I_C = 100$ mA; $I_{Boff} = 0$; $L = 25$ mH

$V_{CEO_{sust}} > 400$ 450 V

D.C. current gain

$I_C = 0,5$ A; $V_{CE} = 5$ V

h_{FE} typ. 30

* Measured with a half sine-wave voltage (curve tracer).

CHARACTERISTICS (continued)

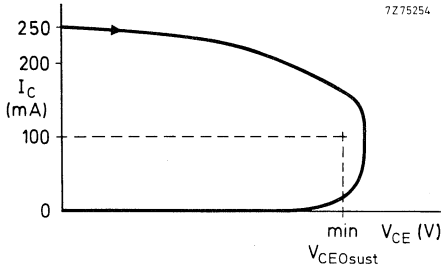


Fig. 2 Oscilloscope display for sustaining voltage.

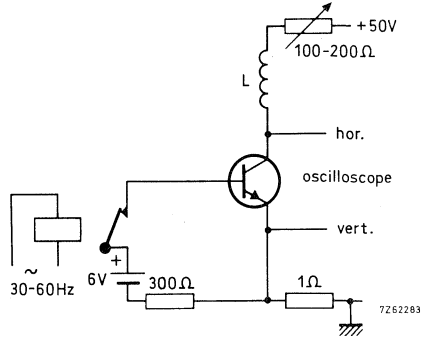


Fig. 3 Test circuit for $V_{CE(sust)}$.

Switching times resistive load (Figs 4 and 5)

$I_{Con} = 3 \text{ A}; I_{Bon} = I_{Boff} = 0,6 \text{ A}$

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

$I_{Con} = 3 \text{ A}; I_B = 0,6 \text{ A}; T_j = 100 \text{ }^\circ\text{C}$

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

$I_{Con} = 2,5 \text{ A}; I_B = 0,5 \text{ A}; T_j = 100 \text{ }^\circ\text{C}$

Turn-off: Storage time

Fall time

	BUS11	BUS11A	
t_{on}	< 1	—	μs
t_s	< 4	—	μs
t_f	< 0,8	—	μs
t_{on}	< —	1	μs
t_s	< —	4	μs
t_f	< —	0,8	μs
t_s	typ. 1,1	—	μs
	< 1,4	—	μs
t_f	typ. 80	—	ns
	< 150	—	ns
t_s	typ. 1,2	—	μs
	< 1,5	—	μs
t_f	typ. 140	—	ns
	< 300	—	ns
t_s	typ. —	1,1	μs
	< —	1,4	μs
t_f	typ. —	80	ns
	< —	150	ns
t_s	typ. —	1,2	μs
	< —	1,5	μs
t_f	typ. —	140	ns
	< —	300	ns

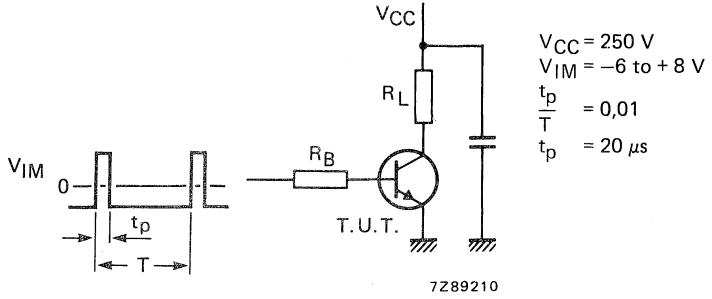


Fig. 4 Test circuit resistive load.

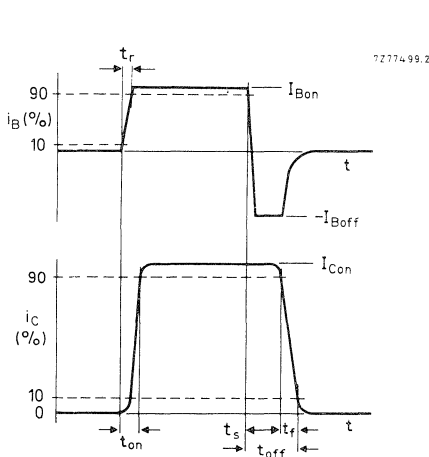


Fig. 5 Switching times waveforms with resistive load.

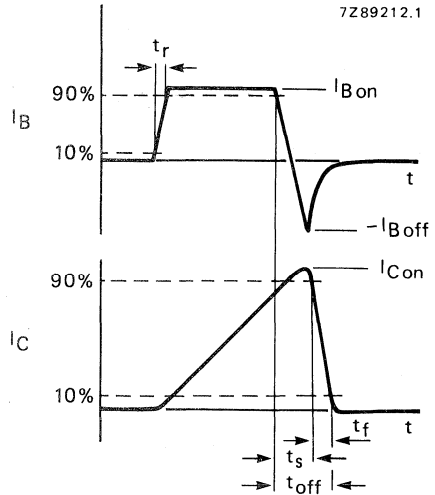


Fig. 6 Switching times waveforms with inductive load.

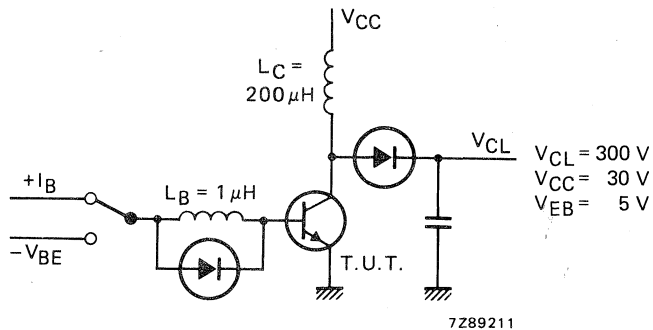


Fig. 7 Test circuit inductive load.

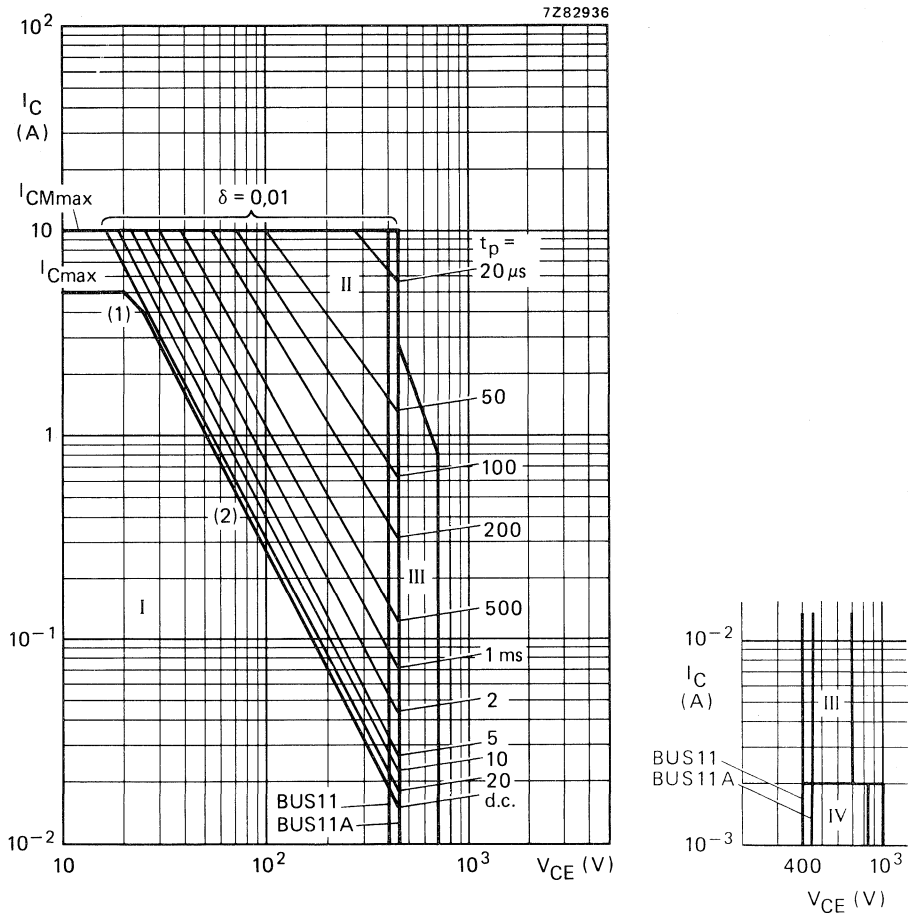


Fig. 8 Safe Operating Area at $T_{mb} \leq 25^\circ C$.

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

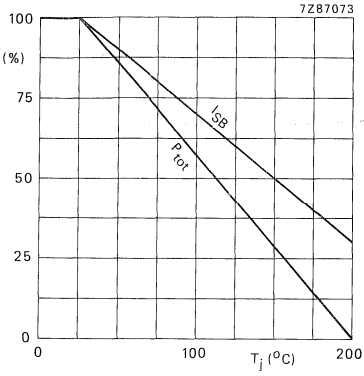


Fig. 9 Total power dissipation and second-breakdown current derating curve.

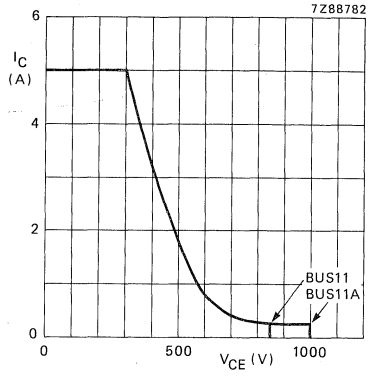


Fig. 10 Reverse bias SOAR.

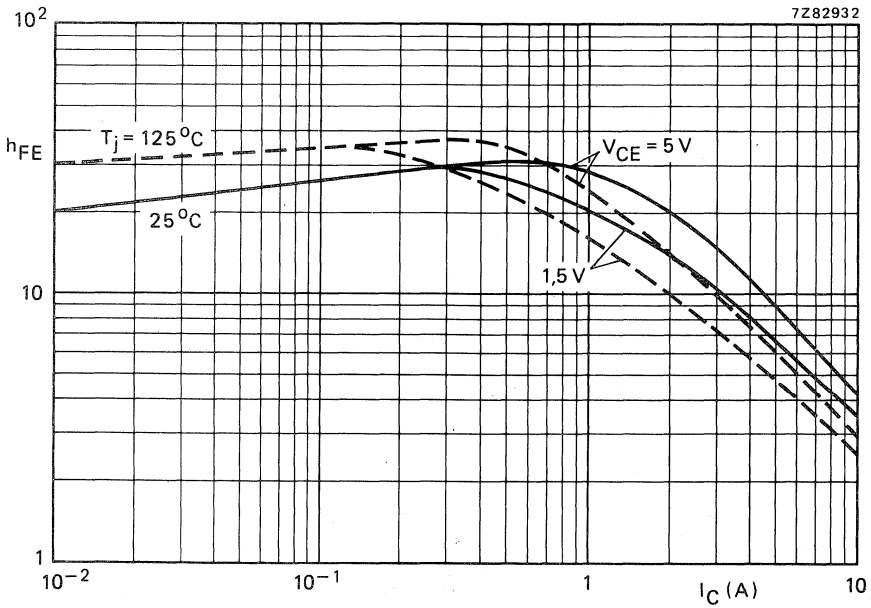


Fig. 11 D.C. current gain.

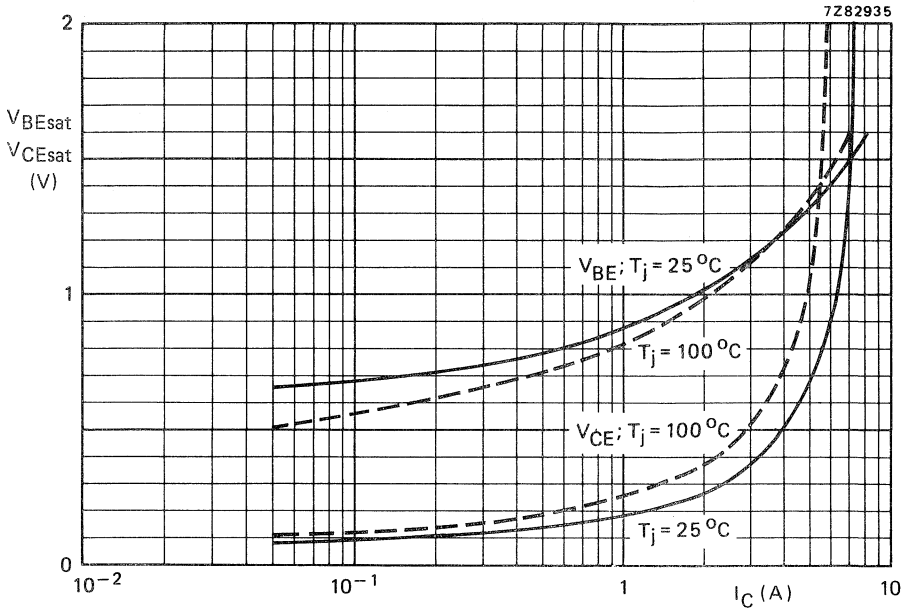


Fig. 12 Typical values base-emitter and collector-emitter voltage, $I_C/I_B = 5$.

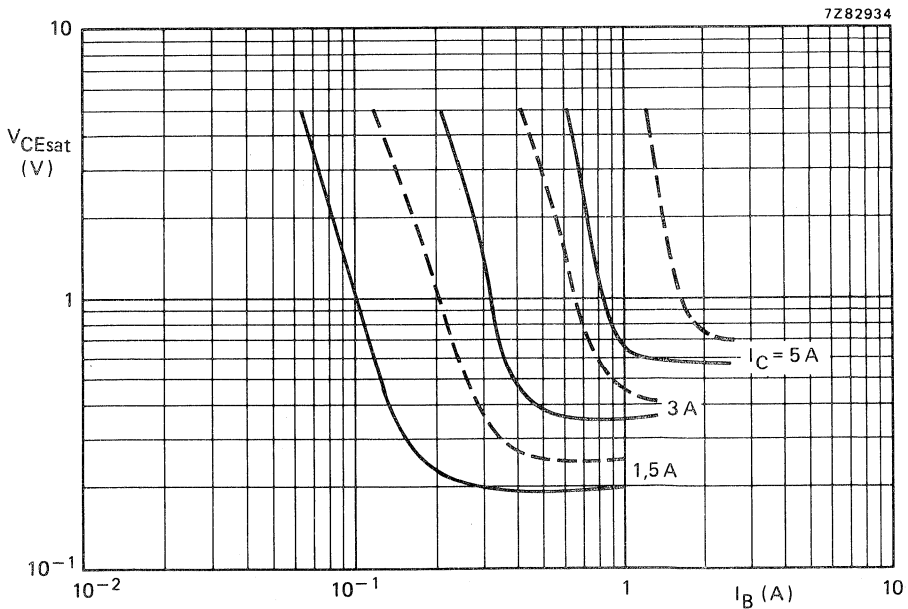


Fig. 13 Typ. (—) and max. (---) values collector-emitter saturation voltage at $T_j = 25^\circ C$.

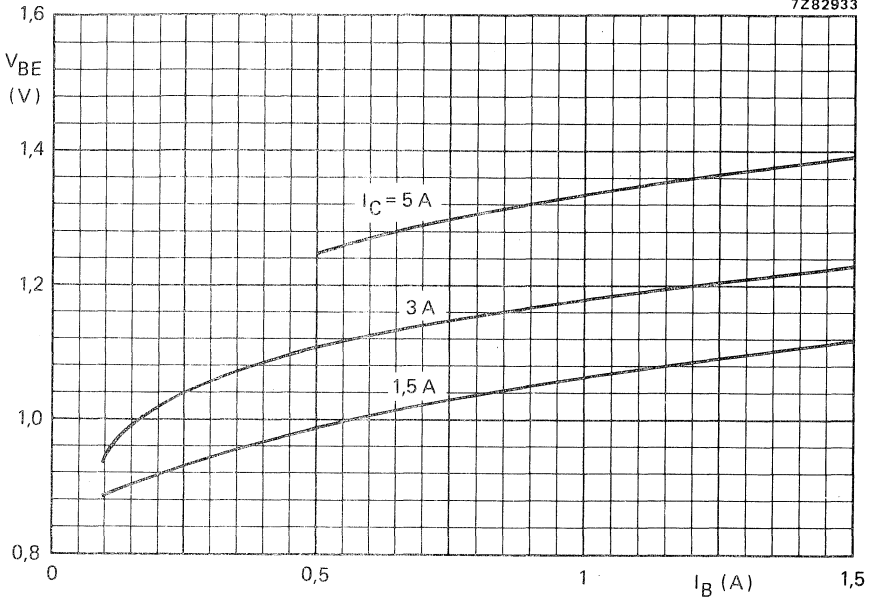


Fig. 14 Typical values at $T_j = 25$ °C.

1983
1982
1981
1980
1979
1978

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.

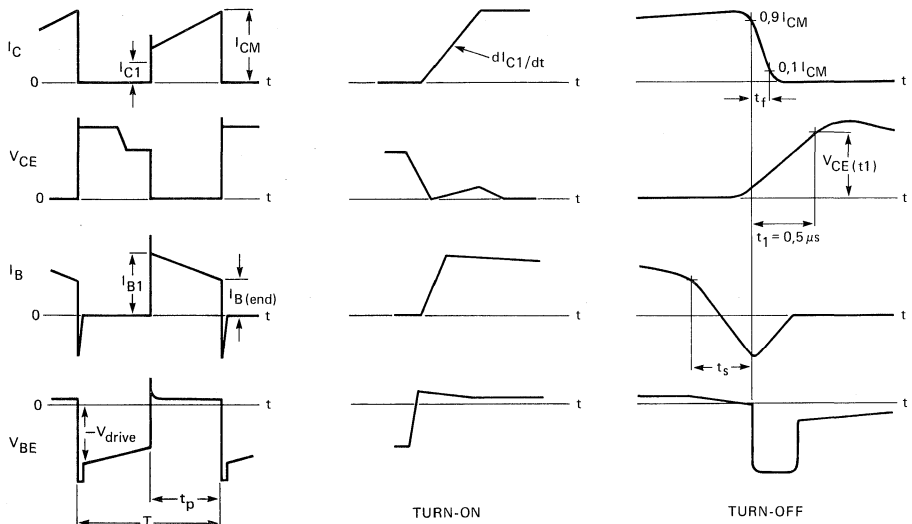
Information on nominal base drive, optimum base inductance and maximum transistor dissipation applied in a forward converter is given in Figs 15, 16 and 17. In these figures I_{CM} represents the maximum repetitive peak collector current, which occurs during overload. The information is derived from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

- collector current shape $I_{C1}/I_{CM} = 0,9$
- duty factor $t_p/T = 0,45$
- rate of rise of I_C during turn-on = 4 A/ μ s
- rate of rise of V_{CE} during turn-off = 1 kV/ μ 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

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

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



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

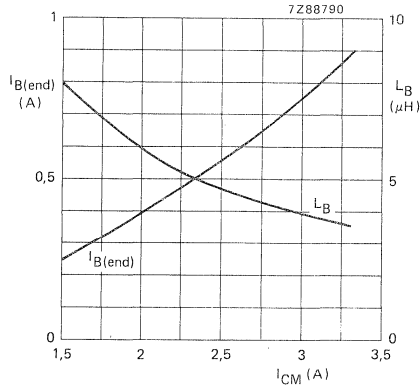


Fig. 16 Recommended nominal "end" value of the base current ($I_{B(e)}$) and optimum base inductance (L_B) at $-V_{drive} = 5$ V versus maximum peak collector current. $dI_{B(end)} = \pm 20\%$.

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

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

L_{Bnom} is the value given in this graph.

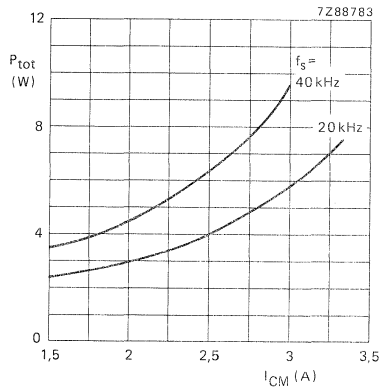


Fig. 17 Maximum transistor dissipation under worse-case operating condition versus maximum peak collector current. $T_{mb} = 100$ °C; $dI_{B(end)} = \pm 20\%$.

SILICON DIFFUSED POWER TRANSISTORS



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

QUICK REFERENCE DATA

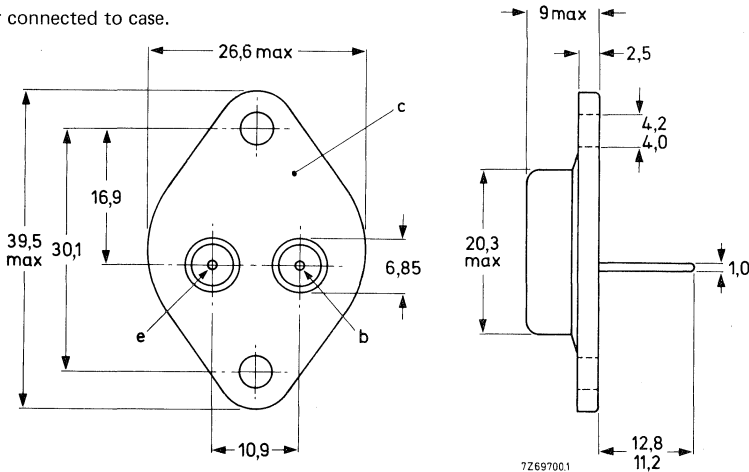
	BUS12		BUS12A
Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM} max.	850	1000 V
Collector-emitter voltage (open base)	V_{CEO} max.	400	450 V
Collector current (d.c.)	I_C max.		8 A
Collector current (peak value) $t_p \leq 2$ ms	I_{CM} max.		20 A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot} max.		125 W
Collector-emitter saturation voltage			
$I_C = 6$ A; $I_B = 1,2$ A	V_{CEsat} <	1,5	— V
$I_C = 5$ A; $I_B = 1$ A	V_{CEsat} <	—	1,5 V
Fall time (resistive load)			
$I_{Con} = 6$ A; $I_{Bon} = -I_{Boff} = 1,2$ A	t_f <	0,8	— μs
$I_{Con} = 5$ A; $I_{Bon} = -I_{Boff} = 1$ A	t_f <	—	0,8 μs

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.



See also chapters Mounting instructions and Accessories.

Products approved to CECC50 004-106 available on request.

RATINGS

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

		BUS12	BUS12A
Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM}	max. 850	1000 V
Collector-emitter voltage (open base)	V_{CEO}	max. 400	450 V
Collector current (d.c.)	I_C	max.	8 A
Collector current (peak value); $t_p < 2$ ms	I_{CM}	max.	20 A
Base current (d.c.)	I_B	max.	4 A
Base current (peak value); $t_p \leq 2$ ms	I_{BM}	max.	6 A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot}	max.	125 W
Storage temperature	T_{stg}	-65 to +200	°C
Junction temperature	T_j	max.	200 °C

THERMAL RESISTANCE

From junction to mounting base	$R_{th j-mb}$	=	1,4	K/W
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CHARACTERISTICS

$T_j = 25$ °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

I_{CES}	<	1	mA
I_{CES}	<	3	mA

Emitter cut-off current

$I_C = 0; V_{EB} = 9$ V

I_{EBO}	<	10	mA
-----------	---	----	----

		BUS12	BUS12A
Saturation voltages			
$I_C = 6$ A; $I_B = 1,2$ A	V_{CEsat}	< 1,5	- V
$I_C = 5$ A; $I_B = 1$ A	V_{CEsat}	< -	1,5 V
$I_C = 6$ A; $I_B = 1,2$ A	V_{BEsat}	< 1,5	- V
$I_C = 5$ A; $I_B = 1$ A	V_{BEsat}	< -	1,5 V
Collector-emitter sustaining voltage			
$I_C = 100$ mA; $I_{Boff} = 0$; $L = 25$ mH	$V_{CEO sust}$	> 400	450 V

* Measured with a half sine-wave voltage (curve tracer).

CHARACTERISTICS (continued)

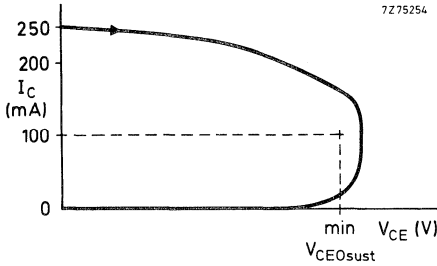


Fig. 2 Oscilloscope display for sustaining voltage.

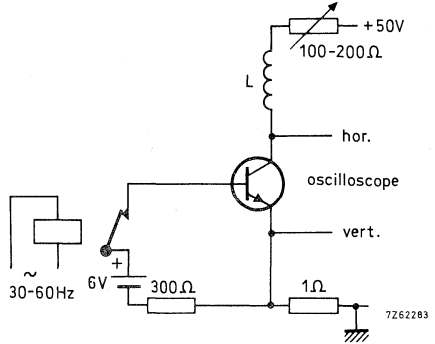


Fig. 3 Test circuit for $V_{CE0sust}$.

Switching times resistive load (Figs 4 and 5)

$I_{Con} = 6 \text{ A}; I_{Bon} = -I_{Boff} = 1,2 \text{ A}$

Turn-on time

		BUS12	BUS12A
t_{on}	<	1	— μs
t_s	<	4	— μs
t_f	<	0,8	— μs

Turn-off: Storage time
Fall time

$I_{Con} = 5 \text{ A}; I_{Bon} = -I_{Boff} = 1 \text{ A}$

Turn-on time

t_{on}	<	—	1 μs
t_s	<	—	4 μs
t_f	<	—	0,8 μs

Turn-off: Storage time
Fall time

Switching times inductive load (Figs 6 and 7)

$I_{Con} = 6 \text{ A}; I_B = 1,2 \text{ A}$

Turn-off: Storage time

t_s	typ.	1,6	— μs
	<	2,1	— μs

Fall time

t_f	typ.	80	— ns
	<	150	— ns

$I_{Con} = 6 \text{ A}; I_B = 1,2 \text{ A}; T_j = 100 \text{ }^\circ\text{C}$

Turn-off: Storage time

t_s	typ.	1,8	— μs
	<	2,3	— μs

Fall time

t_f	typ.	140	— ns
	<	300	— ns

Switching times inductive load (Figs 6 and 7)

$I_{Con} = 5 \text{ A}; I_B = 1 \text{ A}$

Turn-off: Storage time

t_s	typ.	—	1,6 μs
	<	—	2,1 μs

Fall time

t_f	typ.	—	80 ns
	<	—	150 ns

$I_{Con} = 5 \text{ A}; I_B = 1 \text{ A}; T_j = 100 \text{ }^\circ\text{C}$

Turn-off: Storage time

t_s	typ.	—	1,8 μs
	<	—	2,3 μs

Fall time

t_f	typ.	—	140 ns
	<	—	300 ns

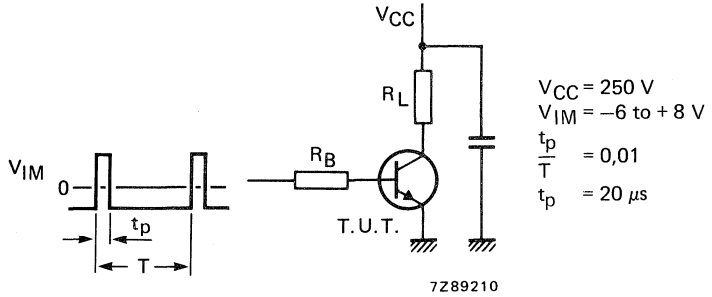


Fig. 4 Test circuit resistive load.

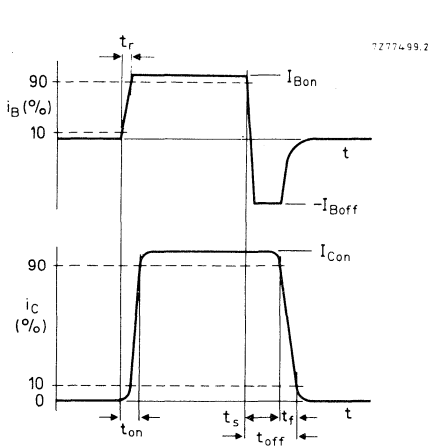


Fig. 5 Switching times waveforms with resistive load.

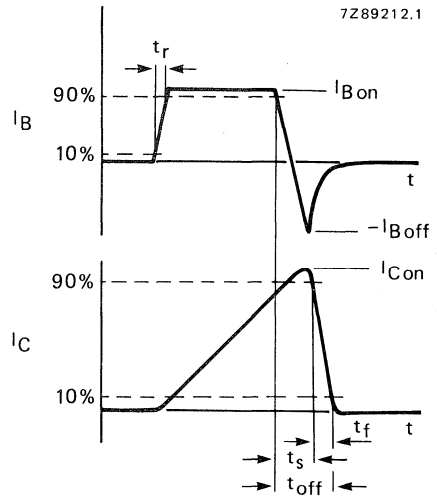


Fig. 6 Switching times waveforms with inductive load.

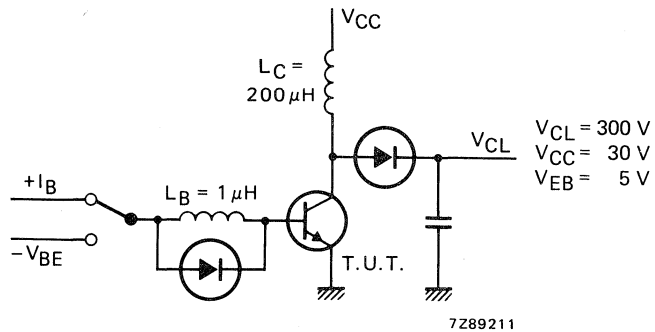


Fig. 7 Test circuit inductive load.

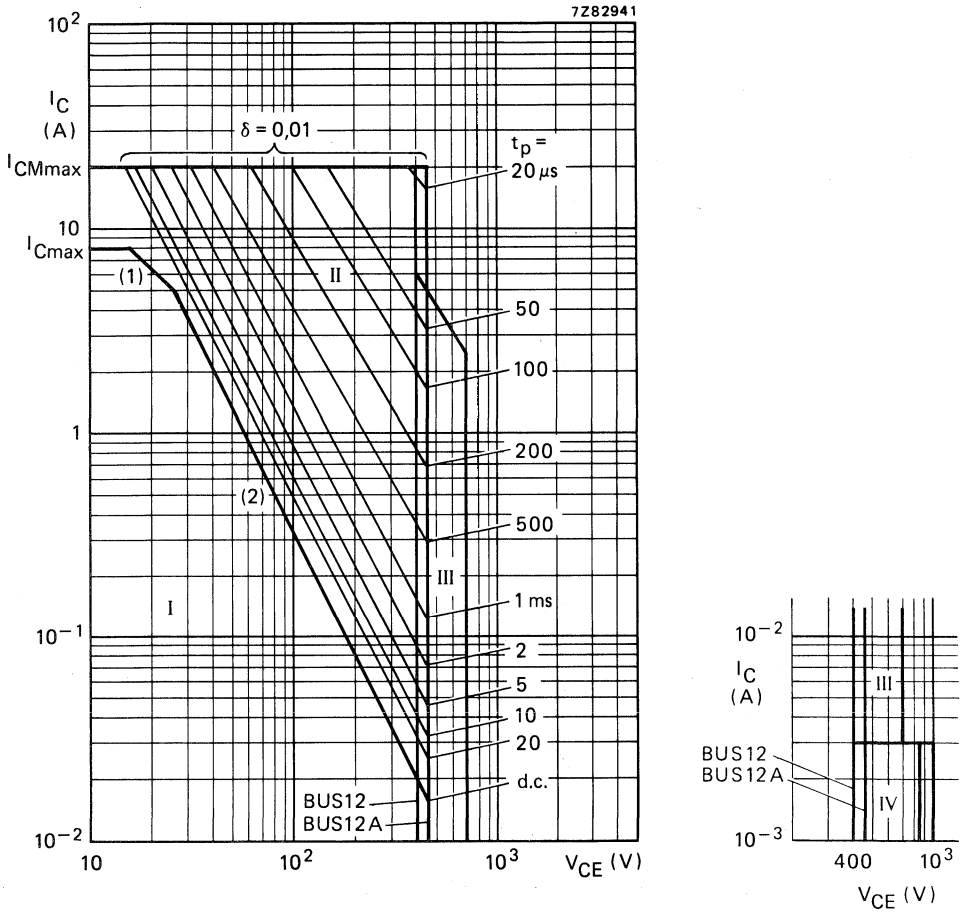


Fig. 8 Safe Operating Area at $T_{mb} \leq 25^\circ C$.

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

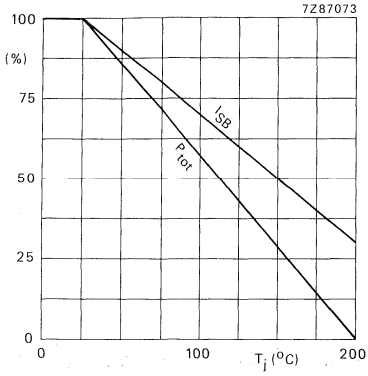


Fig. 9 Total power dissipation and second-breakdown current derating curve.

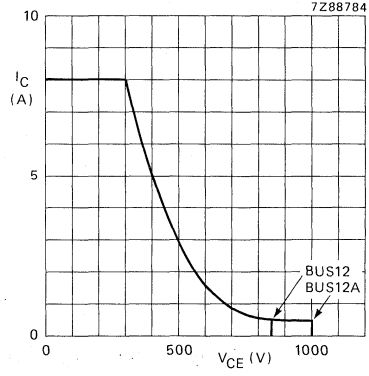


Fig. 10 Reverse bias SOAR.

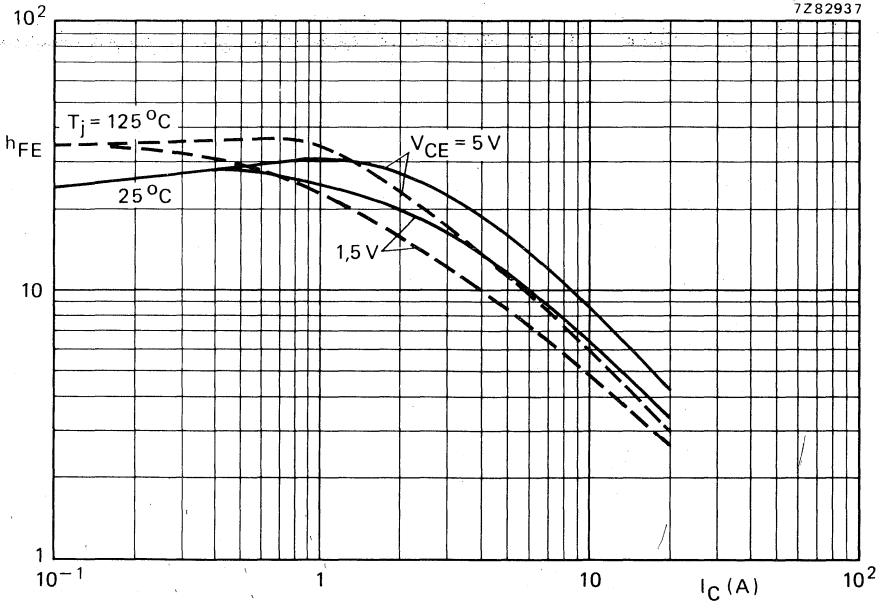


Fig. 11 Typical values d.c. current gain.

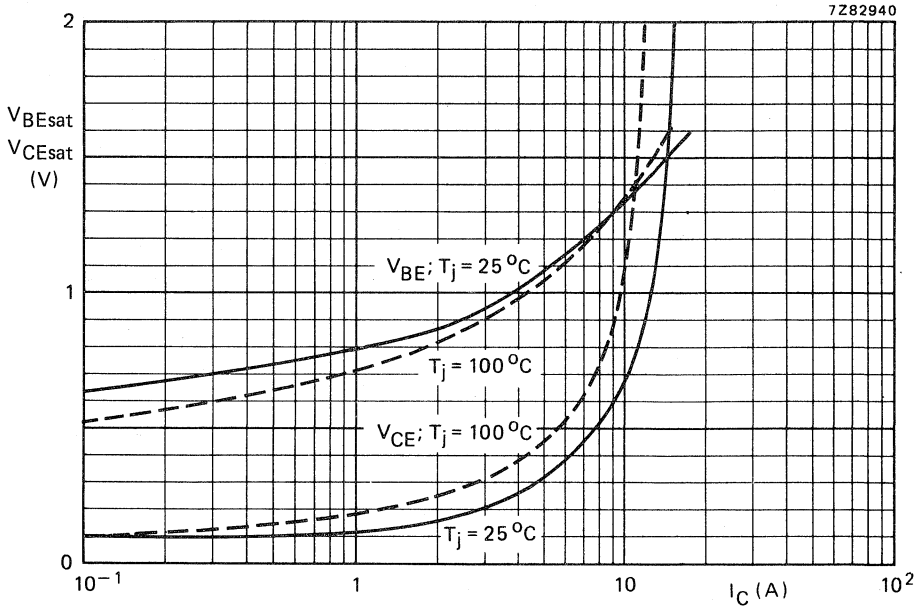


Fig. 12 Typical values base and collector voltage at $I_C/I_B = 5$.

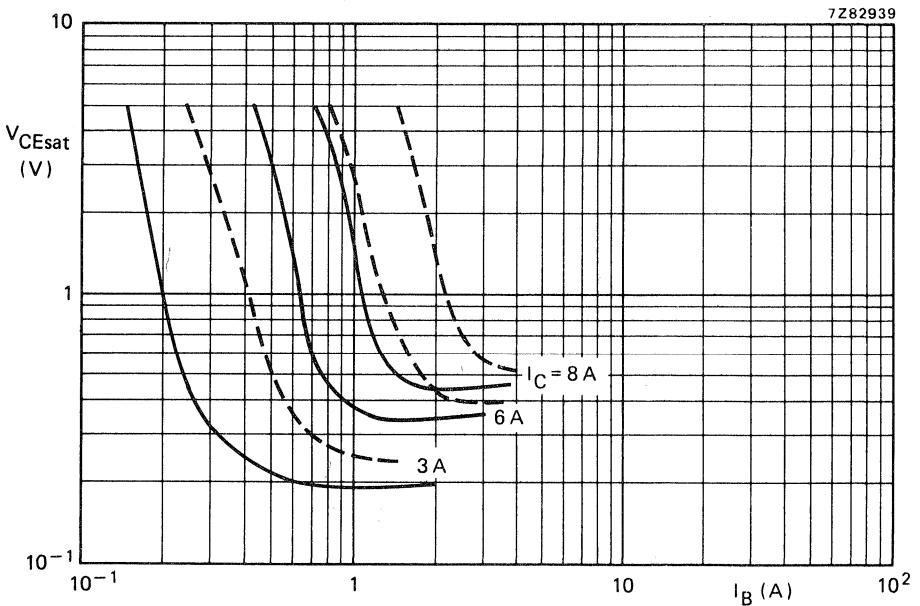


Fig. 13 Typ. (—) and max. (---) values collector-emitter saturation voltage at $T_j = 25^\circ\text{C}$.

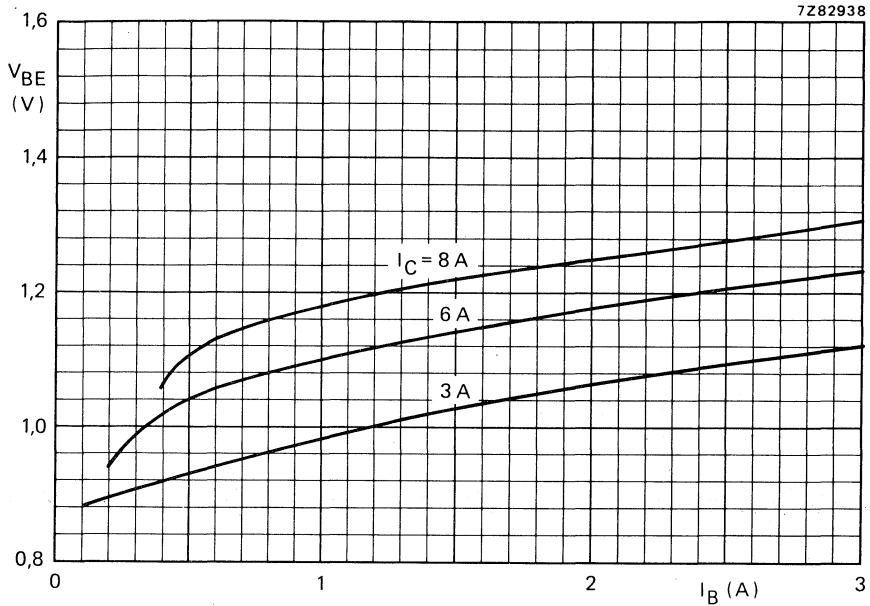


Fig. 14 Typical values base-emitter voltage at $T_j = 25$ °C.

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_{CM} 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 $I_{C1}/I_{CM} = 0,9$
- duty factor $t_p/T = 0,45$
- rate of rise of I_C during turn-on = 8 A/ μ s
- rate of rise of V_{CE} during turn-off = 1 kV/ μ 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

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

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

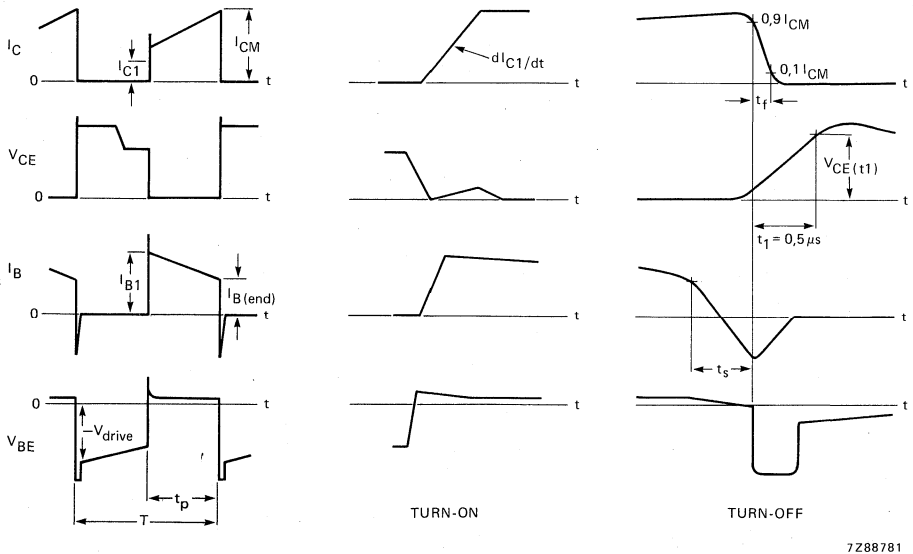


Fig. 15 Relevant waveforms of the switching transistor in a forward SMPS.

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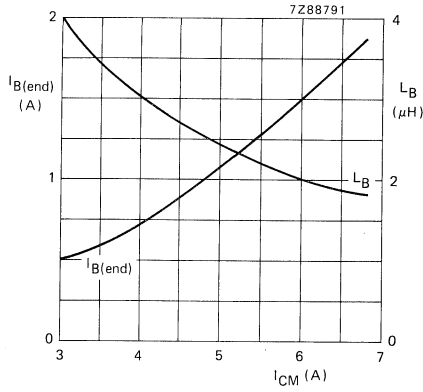


Fig. 16 Recommended nominal "end" value of the base current ($I_{B(e)}$) and optimum base inductance (L_B) at $-V_{drive} = 5$ V versus maximum peak collector current. $dI_{B(end)} = \pm 20\%$.

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

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

L_{Bnom} is the value given in this graph.

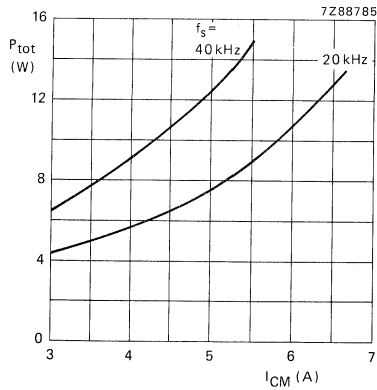


Fig. 17 Maximum transistor dissipation under worst-case operating condition versus maximum peak collector current. $T_{mb} = 100$ °C; $dI_{B(end)} = \pm 20\%$.

SILICON DIFFUSED POWER TRANSISTORS



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

QUICK REFERENCE DATA

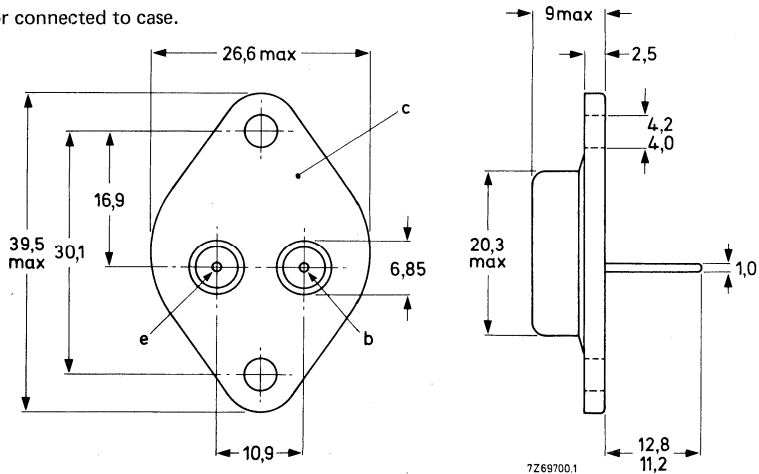
		BUS13	BUS13A
Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM}	max. 850	1000 V
Collector-emitter voltage (open base)	V_{CEO}	max. 400	450 V
Collector current (d.c.)	I_C	max.	15 A
Collector current (peak value) $t_p < 2$ ms	I_{CM}	max.	30 A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot}	max.	175 W
Collector-emitter saturation voltage			
$I_C = 10$ A; $I_B = 2$ A	V_{CEsat}	< 1,5	— V
$I_C = 8$ A; $I_B = 1,6$ A	V_{CEsat}	< —	1,5 V
Fall time (resistive load)			
$I_{Con} = 10$ A; $I_{Bon} = -I_{Boff} = 2$ A	t_f	< 0,8	— μs
$I_{Con} = 8$ A; $I_{Bon} = -I_{Boff} = 1,6$ A	t_f	< —	0,8 μs

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.



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

RATINGS

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

		BUS13	BUS13A
Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM}	max. 850	1000 V
Collector-emitter voltage (open base)	V_{CEO}	max. 400	450 V
Collector current (d.c.)	I_C	max.	15 A
Collector current (peak value); $t_p < 2$ ms	I_{CM}	max.	30 A
Base current (d.c.)	I_B	max.	6 A
Base current (peak value); $t_p < 2$ ms	I_{BM}	max.	9 A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot}	max.	175 W
Storage temperature	T_{stg}	-65 to +200	°C
Junction temperature	T_j	max.	200 °C

THERMAL RESISTANCE

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

$T_j = 25$ °C unless otherwise specified

Collector cut-off current *

$V_{CE} = V_{CESMmax}; V_{BE} = 0$	I_{CES}	<	1	mA
$V_{CE} = V_{CESMmax}; V_{BE} = 0; T_j = 125$ °C	I_{CES}	<	4	mA

Emitter cut-off current

$I_C = 0; V_{EB} = 9$ V	I_{EBO}	<	10	mA
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		BUS13	BUS13A
Saturation voltages			
$I_C = 10$ A; $I_B = 2$ A	V_{CEsat}	< 1,5	- V
$I_C = 8$ A; $I_B = 1,6$ A	V_{CEsat}	< -	1,5 V
$I_C = 10$ A; $I_B = 2$ A	V_{BEsat}	< 1,6	- V
$I_C = 8$ A; $I_B = 1,6$ A	V_{BEsat}	< -	1,6 V
Collector-emitter sustaining voltage			
$I_C = 100$ mA; $I_{Boff} = 0$; $L = 25$ mH	$V_{CEO_{sust}}$	> 400	450 V

* Measured with a half sine-wave voltage (curve tracer).

CHARACTERISTICS (continued)

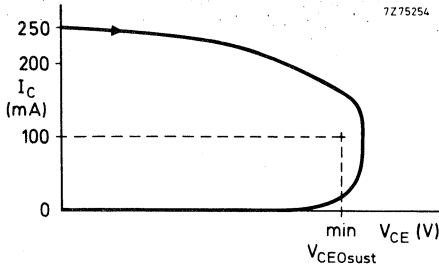


Fig. 2 Oscilloscope display for sustaining voltage.

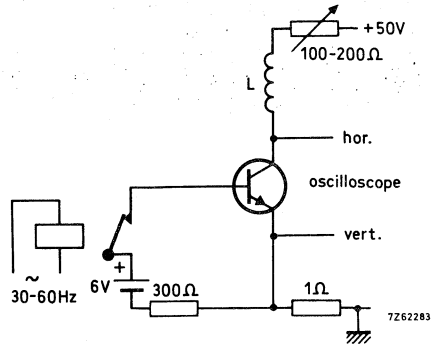


Fig. 3 Test circuit for $V_{CEO\text{sust}}$.

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

$I_{Con} = 10 \text{ A}; I_B = 2 \text{ A}; T_j = 100 \text{ }^\circ\text{C}$

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

$I_{Con} = 8 \text{ A}; I_B = 1,6 \text{ A}; T_j = 100 \text{ }^\circ\text{C}$

Turn-off: Storage time

Fall time

	BUS13	BUS13A	
t_{on}	< 1	—	μs
t_s	< 4	—	μs
t_f	< 0,8	—	μs
t_{on}	< —	1	μs
t_s	< —	4	μs
t_f	< —	0,8	μs
t_s	typ. 2,3	—	μs
	< 3,0	—	μs
t_f	typ. 80	—	ns
	< 150	—	ns
t_s	typ. 2,5	—	μs
	< 3,2	—	μs
t_f	typ. 140	—	ns
	< 300	—	ns
t_s	typ. —	2,3	μs
	< —	3,0	μs
t_f	typ. —	80	ns
	< —	150	ns
t_s	typ. —	2,5	μs
	< —	3,2	μs
t_f	typ. —	140	ns
	< —	300	ns

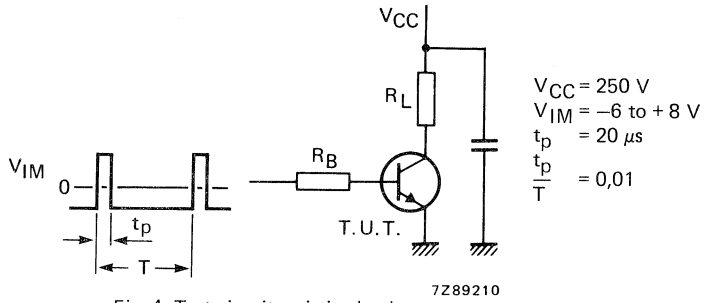


Fig. 4 Test circuit resistive load.

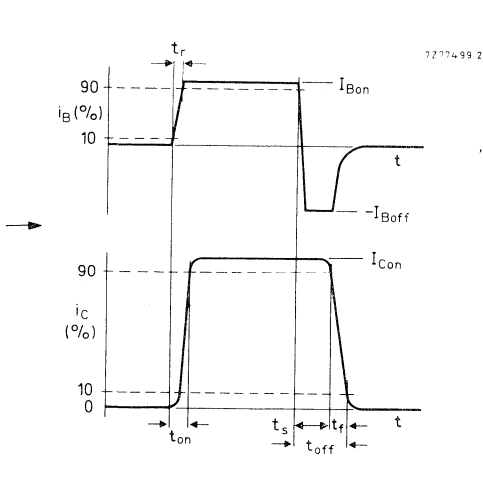


Fig. 5 Switching times waveforms with resistive load.

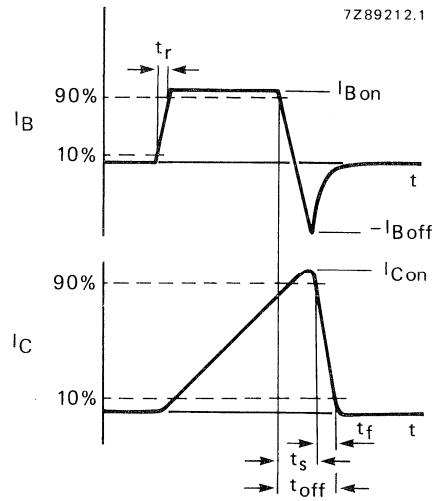


Fig. 6 Switching times waveforms with inductive load.

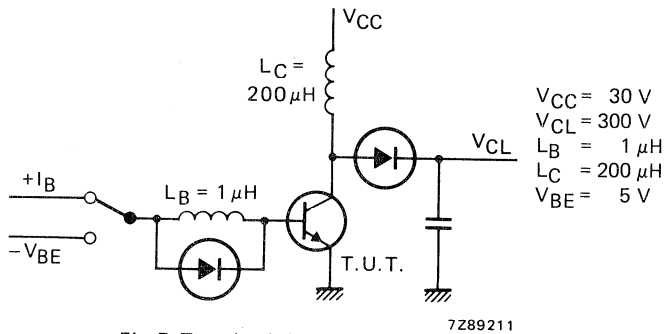


Fig. 7 Test circuit inductive load.

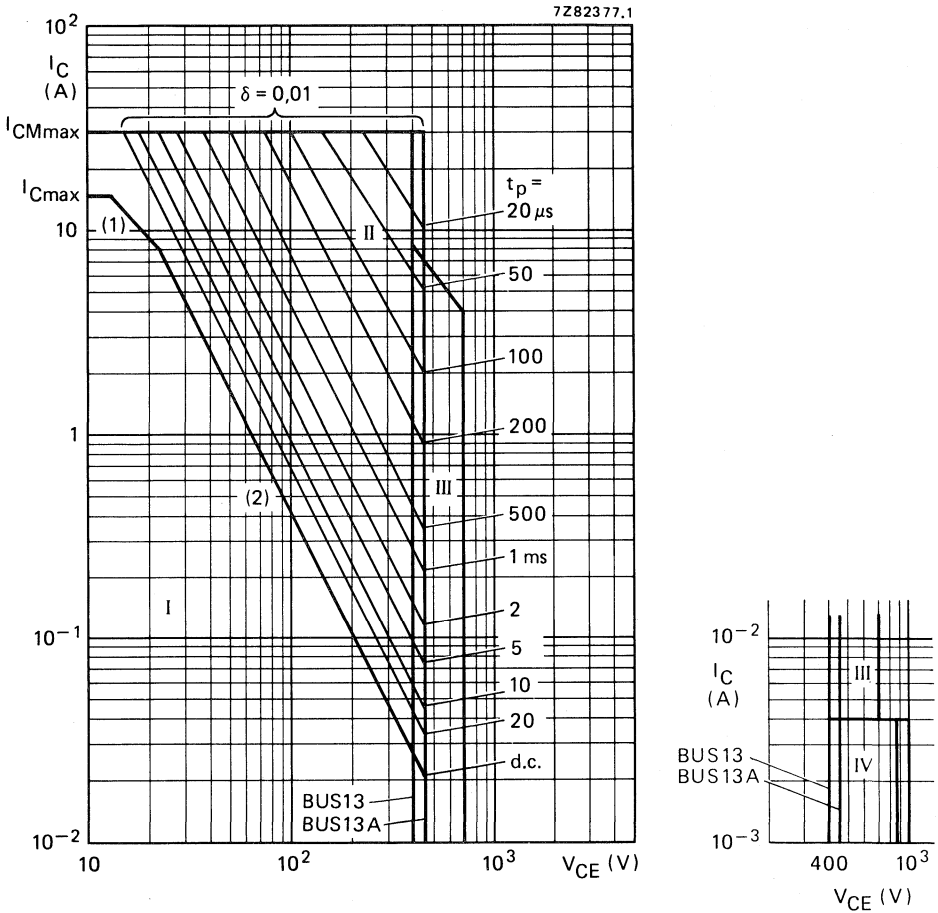


Fig. 8 Safe Operating Area at $T_{mb} \leq 25^\circ C$.

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

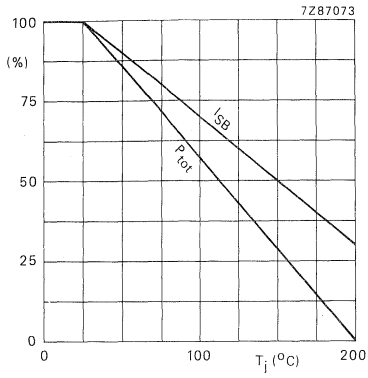


Fig. 9 Total power dissipation and second-breakdown current derating curve.

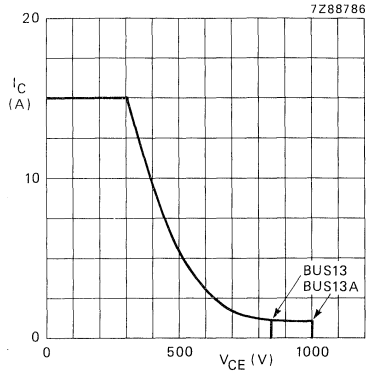


Fig. 10 Reverse bias SOAR.

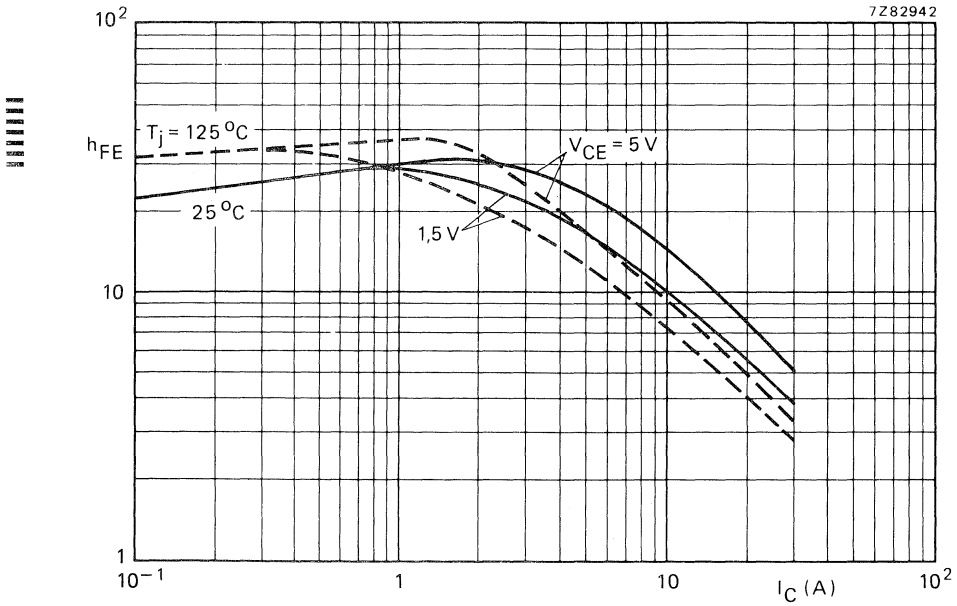


Fig. 11 Typical values d.c. current gain.

7Z82945

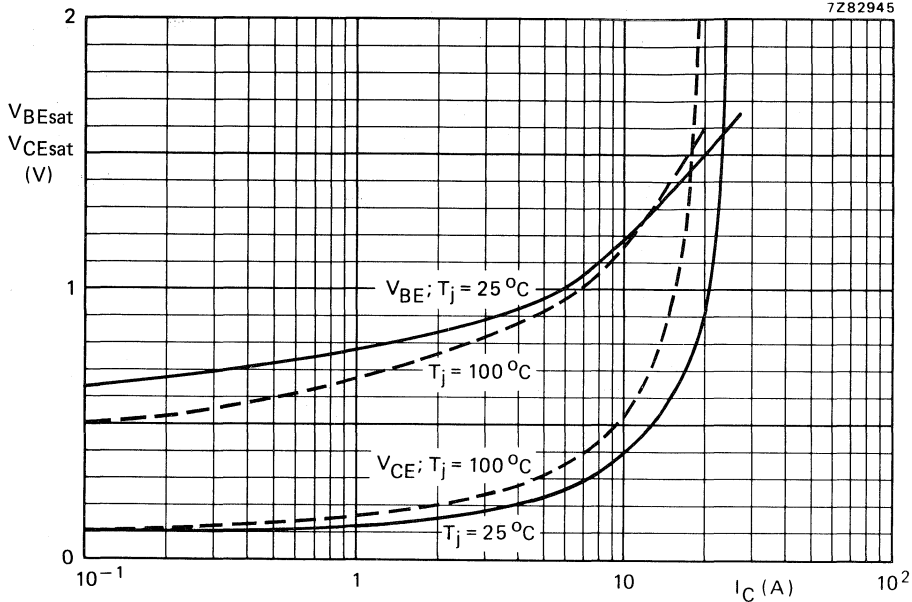


Fig. 12 Typical values base and collector voltage at $I_C/I_B = 5$.

7Z82944

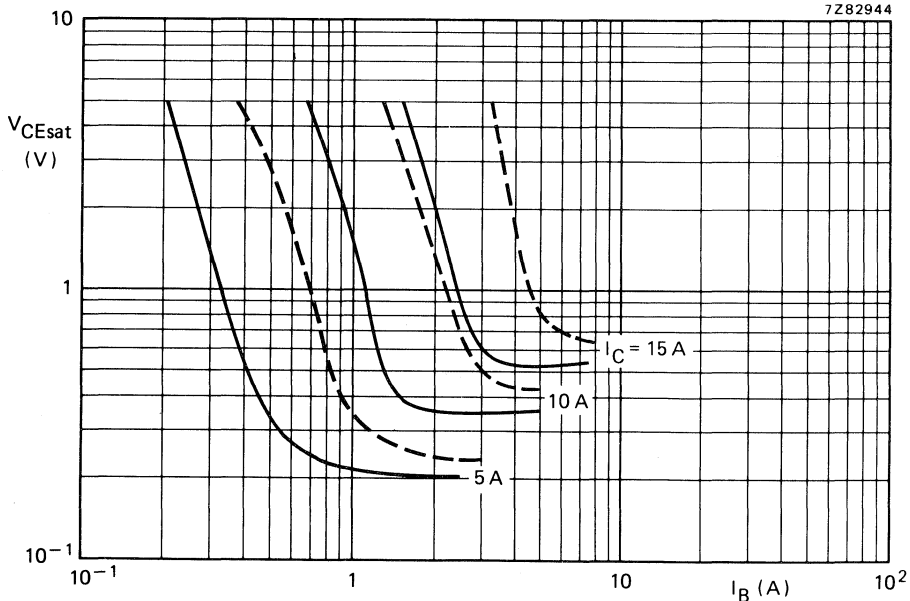


Fig. 13 Typical (—) and maximum (---) values saturation voltage. $T_j = 25^\circ\text{C}$.

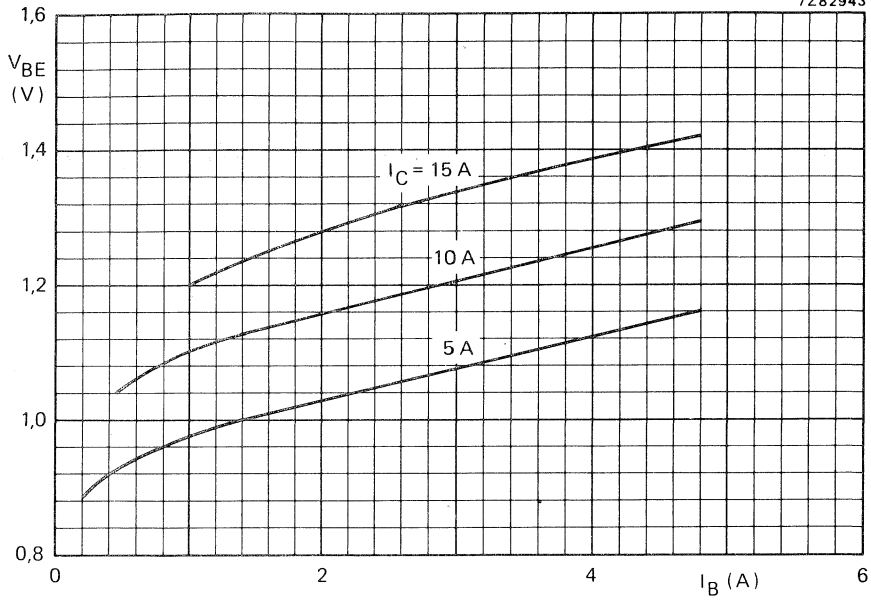


Fig. 14 Typical values base-emitter voltage at $T_j = 25$ °C.



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.

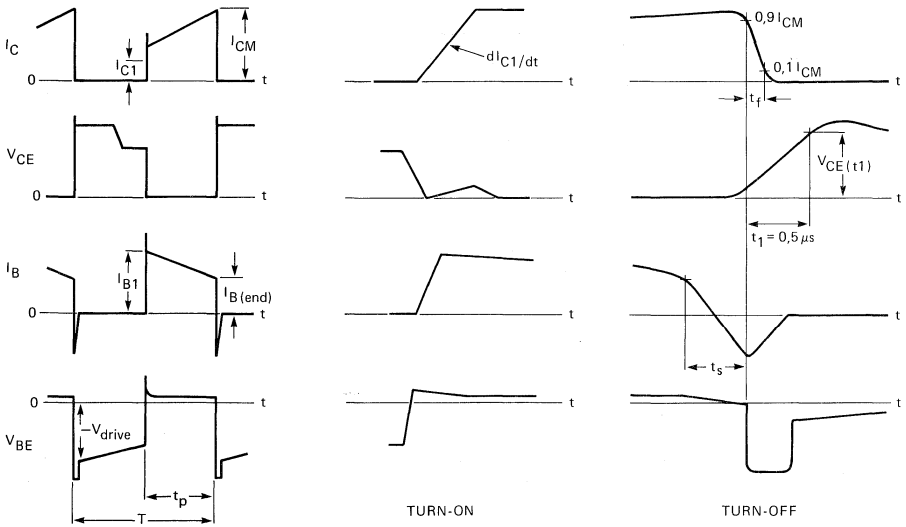
Information on nominal base drive, optimum base inductance and maximum transistor dissipation applied in a forward converter is given in Figs 15, 16 and 17. In these figures I_{CM} represents the maximum repetitive peak collector current, which occurs during overload. The information is derived from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

- collector current shape $I_{C1}/I_{CM} = 0,9$
- duty factor $t_p/T = 0,45$
- rate of rise of I_C during turn-on = 10 A/ μ s
- rate of rise of V_{CE} during turn-off = 1 kV/ μ 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

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

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



7 288 781-

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

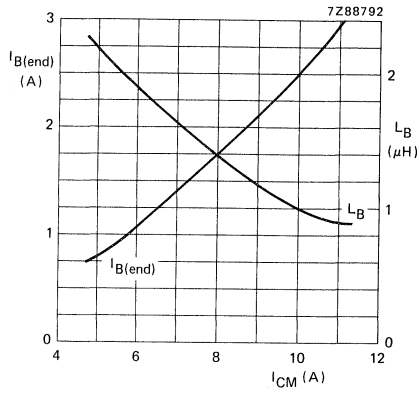


Fig. 16 Recommended nominal "end" value of the base current ($I_{B(e)}$) and optimum base inductance (L_B) at $-V_{drive} = 5$ V versus maximum peak collector current. $dI_{B(end)} = \pm 20\%$.

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

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

L_{Bnom} is the value given in this graph.

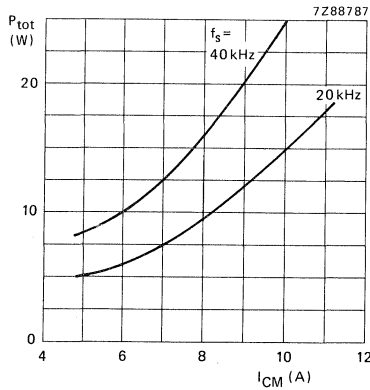


Fig. 17 Maximum transistor dissipation under worst-case operating condition versus maximum peak collector current. $T_{mb} = 100$ °C; $dI_{B(end)} = \pm 20\%$.

SILICON DIFFUSED POWER TRANSISTORS

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

QUICK REFERENCE DATA

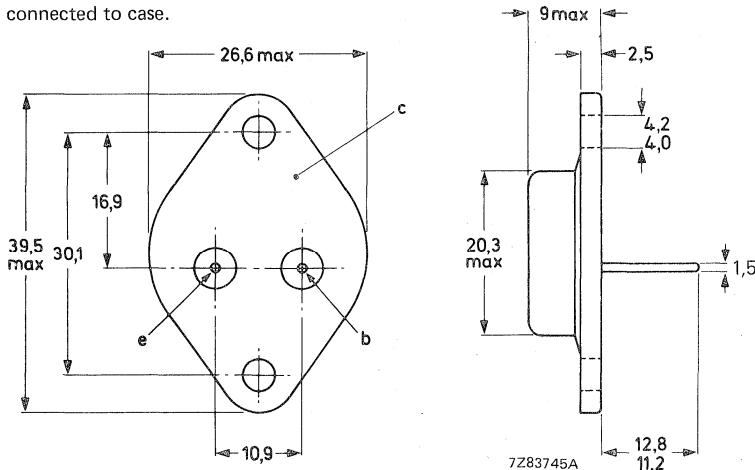
		BUS14		BUS14A	
Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM}	max.	850	1000 V	
Collector-emitter voltage (open base)	V_{CEO}	max.	400	450 V	
Collector current (d.c.)	I_C	max.		30	A
Collector current (peak value) $t_p \leq 2$ ms	I_{CM}	max.		50	A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot}	max.		250	W
Collector-emitter saturation voltage					
$I_C = 20$ A; $I_B = 4$ A	V_{CEsat}	<	1,5	— V	
$I_C = 16$ A; $I_B = 3,2$ A	V_{CEsat}	<	—	1,5 V	
Fall time (resistive load)					
$I_{Con} = 20$ A; $I_{Bon} = -I_{Boff} = 4$ A	t_f	<	0,8	— μ s	
$I_{Con} = 16$ A; $I_{Bon} = -I_{Boff} = 3,2$ A	t_f	<	—	0,8 μ s	

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)

		BUS14	BUS14A
Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM}	max. 850	1000 V
Collector-emitter voltage (open base)	V_{CEO}	max. 400	450 V
Collector current (d.c.)	I_C	max. 30	A
Collector current (peak value); $t_p < 2$ ms	I_{CM}	max. 50	A
Base current (d.c.)	I_B	max. 6	A
Base current (peak value); $t_p < 2$ ms	I_{BM}	max. 10	A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot}	max. 250	W
Storage temperature	T_{stg}	-65 to +200	°C
Junction temperature	T_j	max. 200	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=	0,7	K/W
--------------------------------	----------------	---	-----	-----

CHARACTERISTICS

$T_j = 25$ °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

I_{CES}	<	1	mA
I_{CES}	<	5	mA

Emitter cut-off current

$I_C = 0; V_{EB} = 9$ V

I_{EBO}	<	10	mA
-----------	---	----	----

Saturation voltages

$I_C = 20$ A; $I_B = 4$ A

$I_C = 16$ A; $I_B = 3,2$ A

$I_C = 20$ A; $I_B = 4$ A

$I_C = 16$ A; $I_B = 3,2$ A

		BUS14	BUS14A
V_{CEsat}	<	1,5	- V
V_{CEsat}	<	-	1,5 V
V_{BEsat}	<	1,7	- V
V_{BEsat}	<	-	1,7 V

Collector-emitter sustaining voltage

$I_C = 100$ mA; $I_{Boff} = 0$; $L = 25$ mH

$V_{CEO sust}$	>	400	450 V
----------------	---	-----	-------

* Measured with a half sine-wave voltage (curve tracer).

CHARACTERISTICS (continued)

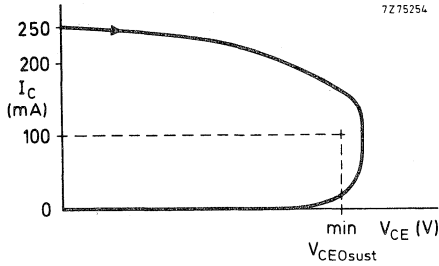


Fig. 2 Oscilloscope display for sustaining voltage.

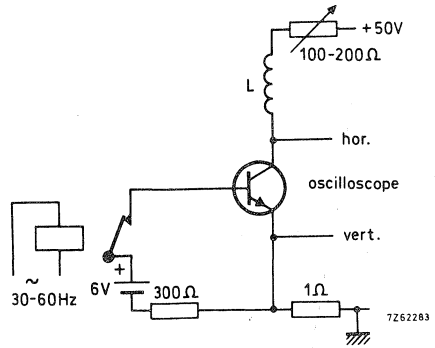


Fig. 3 Test circuit for $V_{CE(sust)}$.

Switching times resistive load (Figs 4 and 5)

$I_{Con} = 20\text{ A}; I_{Bon} = -I_{Boff} = 4\text{ A}$

Turn-on time

Turn-off: Storage time

Fall time

$I_{Con} = 16\text{ A}; I_{Bon} = -I_{Boff} = 3,2\text{ A}$

Turn-on time

Turn-off: Storage time

Fall time

Switching times inductive load (Figs 6 and 7)

$I_{Con} = 20\text{ A}; I_B = 4\text{ A}$

Turn-off: Storage time

Fall time

$I_{Con} = 20\text{ A}; I_B = 4\text{ A}; T_j = 100\text{ }^\circ\text{C}$

Turn-off: Storage time

Fall time

Switching times inductive load (Figs 6 and 7)

$I_{Con} = 16\text{ A}; I_B = 3,2\text{ A}$

Turn-off: Storage time

Fall time

$I_{Con} = 16\text{ A}; I_B = 3,2\text{ A}; T_j = 100\text{ }^\circ\text{C}$

Turn-off: Storage time

Fall time

		BUS14	BUS14A	
t_{on}	<	1	—	μs
t_s	<	4	—	μs
t_f	<	0,8	—	μs
t_{on}	<	—	1	μs
t_s	<	—	4	μs
t_f	<	—	0,8	μs
t_s	typ.	2,8	—	μs
	<	3,6	—	μs
t_f	typ.	80	—	ns
	<	150	—	ns
t_s	typ.	3,1	—	μs
	<	4,0	—	μs
t_f	typ.	140	—	ns
	<	300	—	ns
t_s	typ.	—	28	μs
	<	—	3,6	μs
t_f	typ.	—	80	ns
	<	—	150	ns
t_s	typ.	—	3,1	μs
	<	—	4,0	μs
t_f	typ.	—	140	ns
	<	—	300	ns

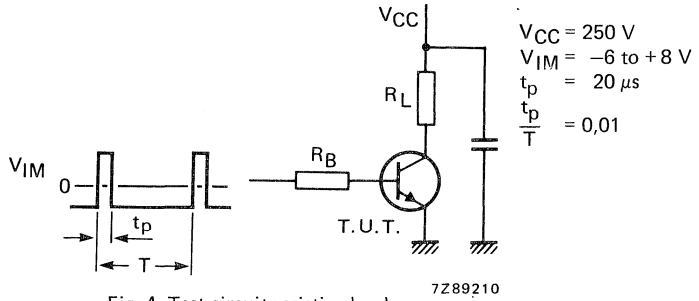


Fig. 4 Test circuit resistive load.

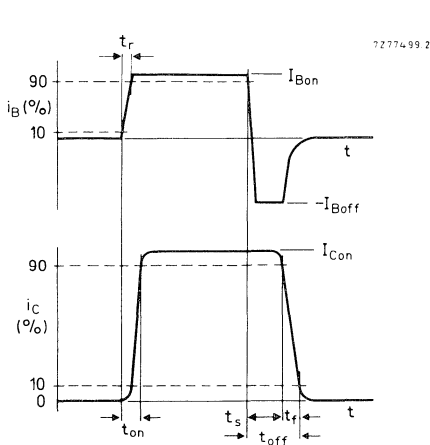


Fig. 5 Switching times waveforms with resistive load.

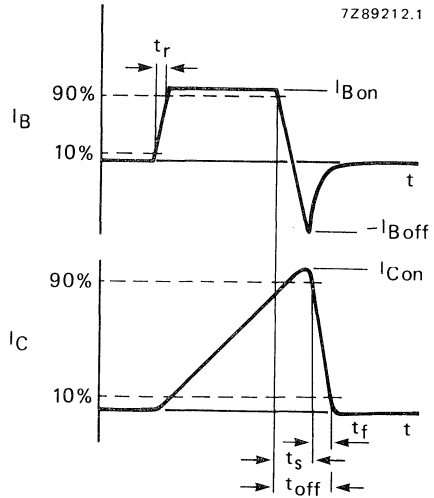


Fig. 6 Switching times waveforms with inductive load.

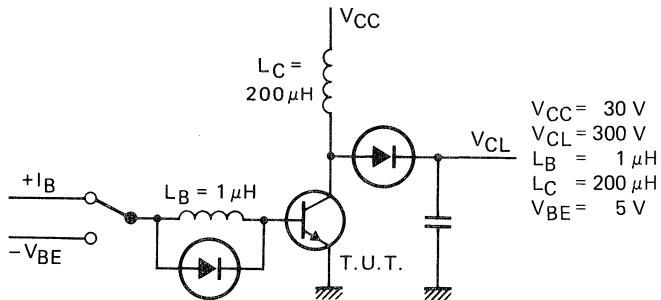


Fig. 7 Test circuit inductive load.

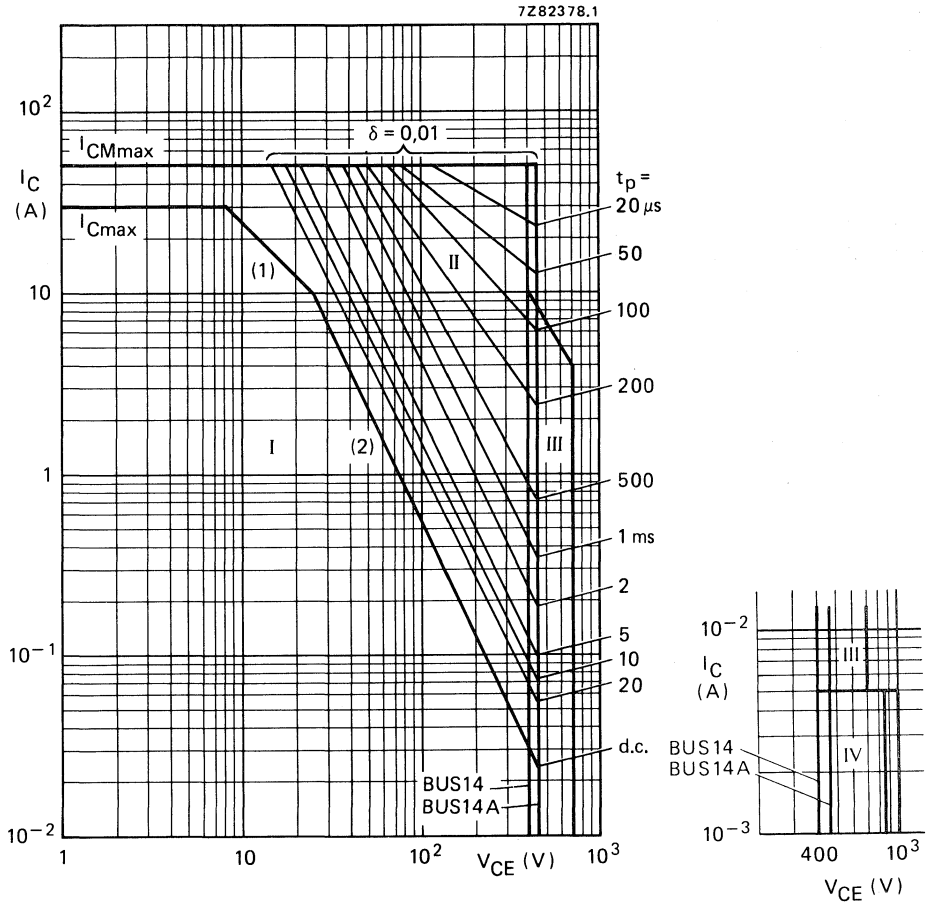


Fig. 8 Safe Operating Area at $T_{mb} \leq 25^\circ\text{C}$.

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

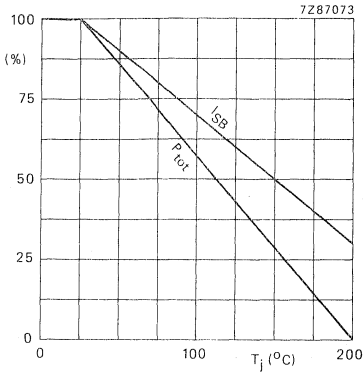


Fig. 9 Total power dissipation and second-breakdown current derating curve.

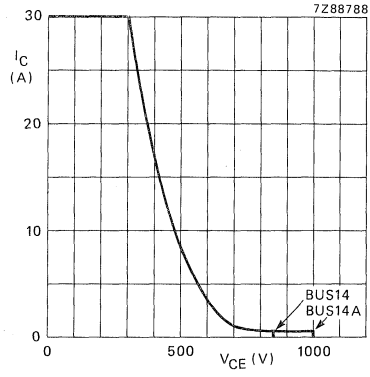


Fig. 10 Reverse bias SOAR.

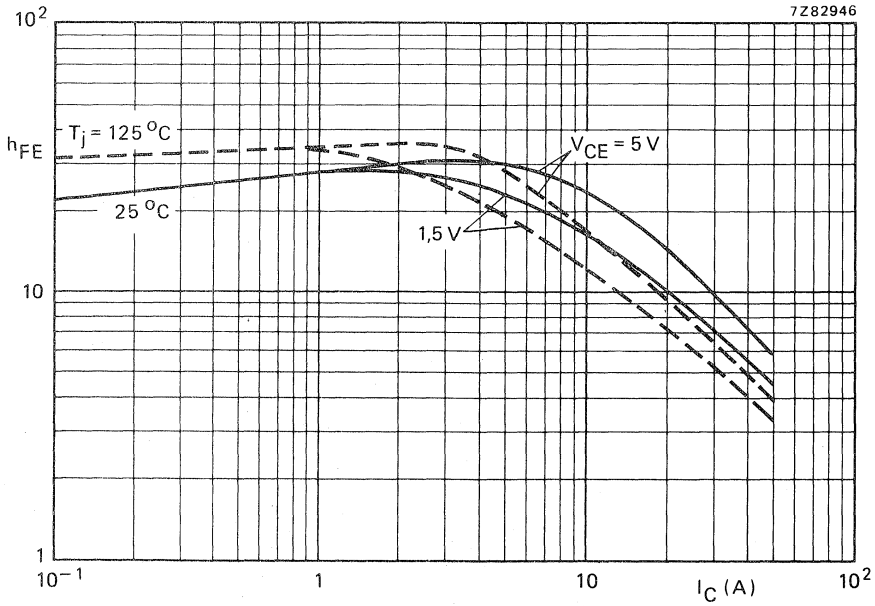


Fig. 11 Typical values d.c. current gain.

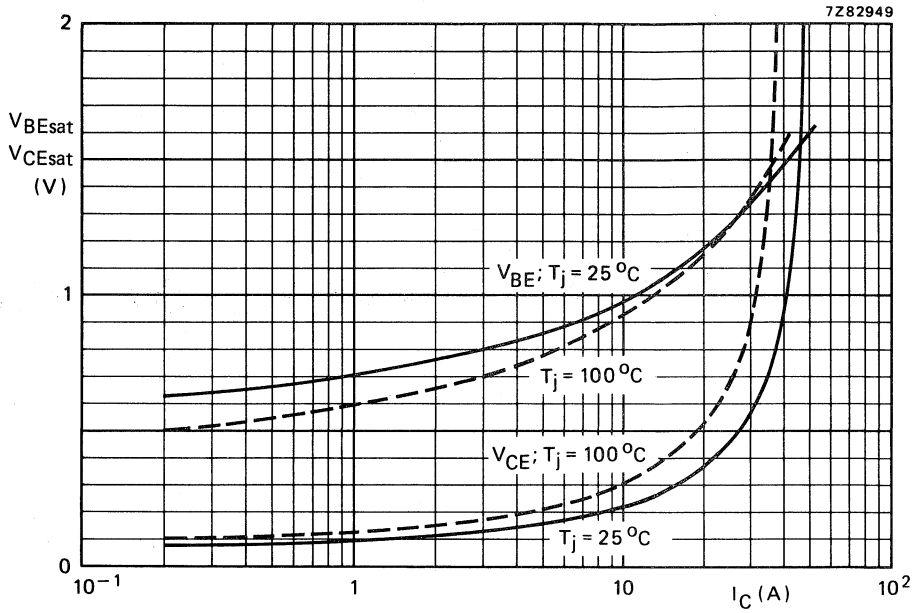


Fig. 12 Typical values base and collector voltage. $I_C/I_B = 5$.

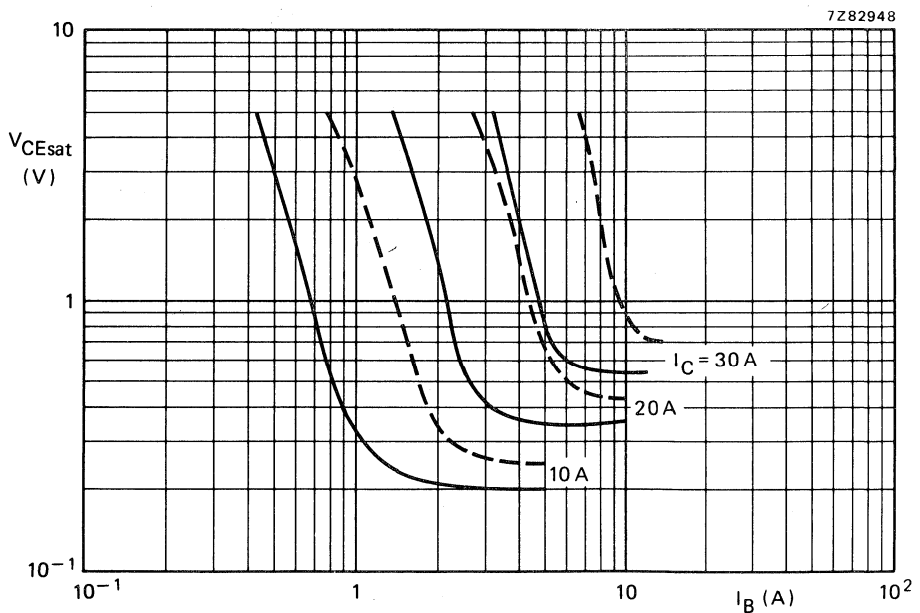


Fig. 13 Typical (—) and maximum (---) values saturation voltage. $T_j = 25^\circ C$.

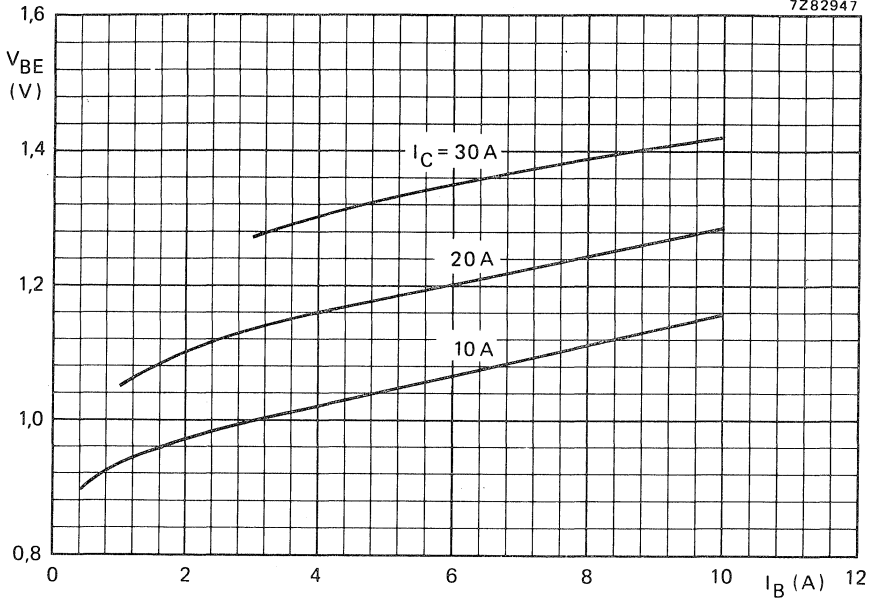


Fig. 14 Typical values at $T_j = 25\text{ }^\circ\text{C}$.



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.

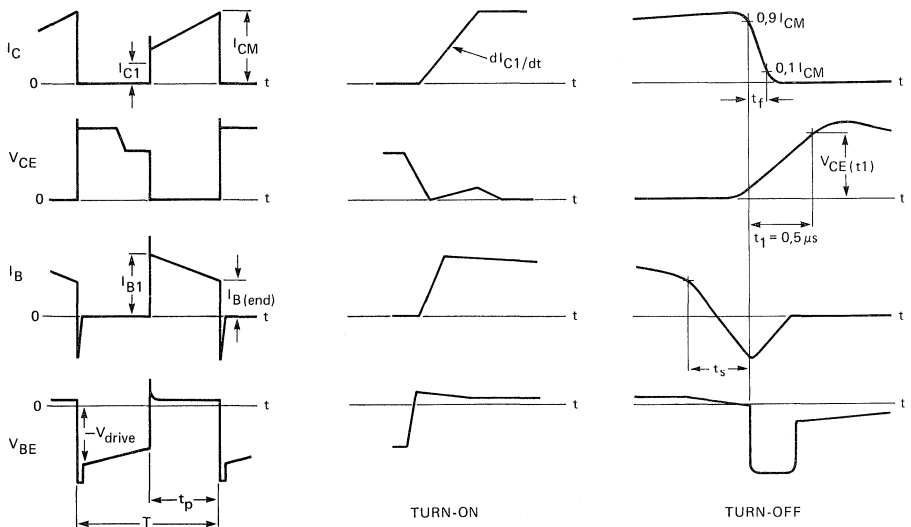
Information on nominal base drive, optimum base inductance and maximum transistor dissipation applied in a forward converter is given in Figs 15, 16 and 17. In these figures I_{CM} represents the maximum repetitive peak collector current, which occurs during overload. The information is derived from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

- collector current shape $I_{C1}/I_{CM} = 0,9$
- duty factor $t_p/T = 0,45$
- rate of rise of I_C during turn-on = 20 A/ μ s
- rate of rise of V_{CE} during turn-off = 1 kV/ μ 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

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

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



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

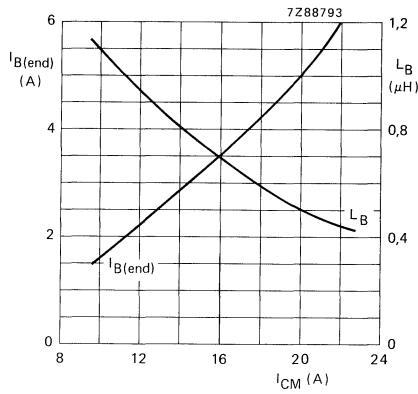


Fig. 16 Recommended nominal "end" value of the base current ($I_{B(e)}$) and optimum base inductance (L_B) at $-V_{drive} = 5 V$ versus maximum peak collector current. $dI_{B(end)} = \pm 20\%$.

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

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

L_{Bnom} is the value given in this graph.

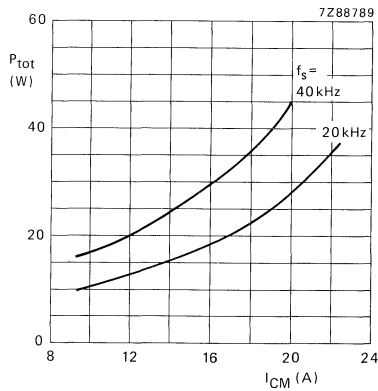


Fig. 17 Maximum transistor dissipation under worse-case operating condition versus maximum peak collector current. $T_{mb} = 100\text{ }^\circ C$; $dI_{B(end)} = \pm 20\%$.

DEVELOPMENT SAMPLE DATA

This information is derived from development samples made available for evaluation. It does not necessarily imply that the device will go into regular production.

**BUT11
BUT11A**

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.

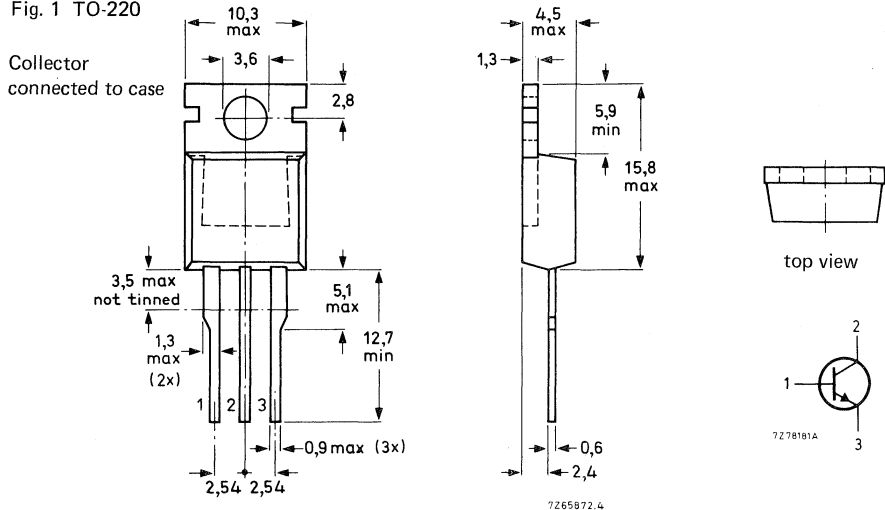
QUICK REFERENCE DATA

		BUT11	BUT11A
Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM} max.	850	1000 V
Collector-emitter voltage (open base)	V_{CEO} max.	400	450 V
Collector current (d.c.)	I_C max.	5	A
Collector current (peak value) $t_p \leq 2$ ms	I_{CM} max.	10	A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot} max.	100	W
Collector-emitter saturation voltage	$V_{CEsat} <$	1,5	— V
$I_C = 3$ A; $I_B = 0,6$ A	$V_{CEsat} <$	—	1,5 V
$I_C = 2,5$ A; $I_B = 0,5$ A			
Fall time	$t_f <$	0,8	— μs
$I_{Con} = 3$ A; $I_{Bon} = -I_{Boff} = 0,6$ A	$t_f <$	—	0,8 μs
$I_{Con} = 2,5$ A; $I_{Bon} = -I_{Boff} = 0,5$ A			

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-220



See also chapters Mounting instructions and Accessories.

RATINGS

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

		BUT11	BUT11A
Collector-emitter voltage (peak value, $V_{BE} = 0$)	V_{CESM} max.	850	1000 V
Collector-emitter voltage (open base)	V_{CEO} max.	400	450 V
Collector current (d.c.)	I_C max.	5	A
Collector current (peak value) $t_p < 2$ ms	I_{CM} max.	10	A
Base current (d.c.)	I_B max.	2	A
Base current (peak value); $t_p < 2$ ms	I_{BM} max.	4	A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot} max.	100	W
Storage temperature	T_{stg}	-65 to +150	°C
Junction temperature	T_j max.	150	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb} =$	1,25	K/W
--------------------------------	------------------	------	-----

CHARACTERISTICS

$T_j = 25$ °C unless otherwise specified

Collector cut-off current *

$V_{CE} = V_{CESMmax}; V_{BE} = 0$

I_{CES}	<	1	mA
-----------	---	---	----

$V_{CE} = V_{CESMmax}; V_{BE} = 0; T_j = 125$ °C

I_{CES}	<	2	mA
-----------	---	---	----

Emitter cut-off current

$I_C = 0; V_{EB} = 9$ V

I_{EBO}	<	10	mA
-----------	---	----	----

Saturation voltages

$I_C = 3$ A; $I_B = 0,6$ A

V_{CEsat}	<	1,5	V
-------------	---	-----	---

V_{BEsat}	<	1,3	V
-------------	---	-----	---

$I_C = 2,5$ A; $I_B = 0,5$ A

V_{CEsat}	<	—	1,5 V
-------------	---	---	-------

V_{BEsat}	<	—	1,3 V
-------------	---	---	-------

Collector-emitter sustaining voltage

$I_C = 100$ mA; $I_{Boff} = 0$; $L = 25$ mA

$V_{CEO_{sust}}$	>	400	450 V
------------------	---	-----	-------

* Measured with a half sine-wave voltage (curve tracer).

CHARACTERISTICS (continued)

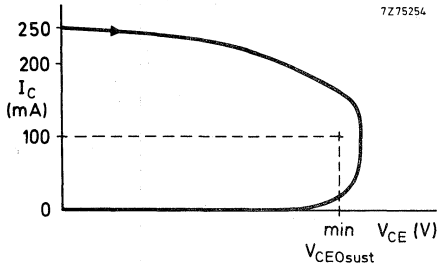


Fig. 2 Oscilloscope display for sustaining voltage.

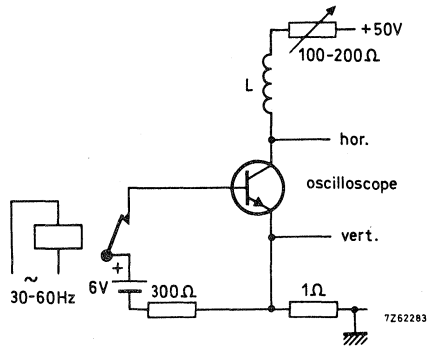


Fig. 3 Test circuit for $V_{CEO\text{sust}}$.

DEVELOPMENT SAMPLE DATA

Switching times resistive load (Figs 4 and 5)

$I_{Con} = 3 \text{ A}; I_{Bon} = -I_{Boff} = 0,6 \text{ A}$

Turn-on time

		BUT11	BUT11A
t_{on}	<	1	— μs

Turn-off: Storage time

t_s	<	4	— μs
-------	---	---	-----------------

Fall time

t_f	<	0,8	— μs
-------	---	-----	-----------------

$I_{Con} = 2,5 \text{ A}; I_{Bon} = -I_{Boff} = 0,5 \text{ A}$

Turn-on time

t_{on}	<	—	1 μs
----------	---	---	-----------------

Turn-off: Storage time

t_s	<	—	4 μs
-------	---	---	-----------------

Fall time

t_f	<	—	0,8 μs
-------	---	---	-------------------

Switching times inductive load (Figs 6 and 7)

$I_{Con} = 3 \text{ A}; I_B = 0,6 \text{ A}$

Turn-off: Storage time

t_s	typ.	1,1	— μs
-------	------	-----	-----------------

Fall time

t_f	<	1,4	— μs
-------	---	-----	-----------------

t_f	typ.	80	— ns
-------	------	----	------

t_f	<	150	— ns
-------	---	-----	------

$I_{Con} = 3 \text{ A}; I_B = 0,6 \text{ A}; T_j = 100 \text{ }^\circ\text{C}$

Turn-off: Storage time

t_s	typ.	1,2	— μs
-------	------	-----	-----------------

Fall time

t_f	<	1,5	— μs
-------	---	-----	-----------------

t_f	typ.	140	— ns
-------	------	-----	------

t_f	<	300	— 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_s	typ.	—	1,1 μs
-------	------	---	-------------------

Fall time

t_f	<	—	1,4 μs
-------	---	---	-------------------

t_f	typ.	—	80 ns
-------	------	---	-------

t_f	<	—	150 ns
-------	---	---	--------

$I_{Con} = 2,5 \text{ A}; I_B = 0,5 \text{ A}; T_j = 100 \text{ }^\circ\text{C}$

Turn-off: Storage time

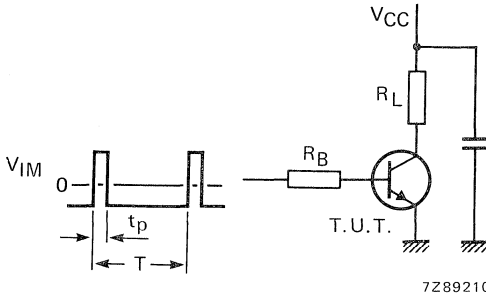
t_s	typ.	—	1,2 μs
-------	------	---	-------------------

Fall time

t_f	<	—	1,5 μs
-------	---	---	-------------------

t_f	typ.	—	140 ns
-------	------	---	--------

t_f	<	—	300 ns
-------	---	---	--------



$V_{CC} = 250 \text{ V}$
 $V_{IM} = -6 \text{ to } +8 \text{ V}$
 $\frac{t_p}{T} = 0,01$
 $t_p = 20 \mu\text{s}$

The values of R_B and R_L are selected in accordance with I_{Con} and I_B requirements.

Fig. 4 Test circuit resistive load.

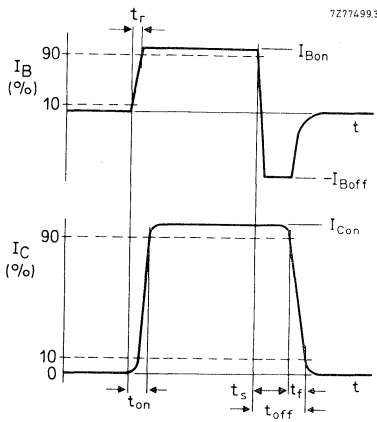


Fig. 5 Switching times waveforms with resistive load.

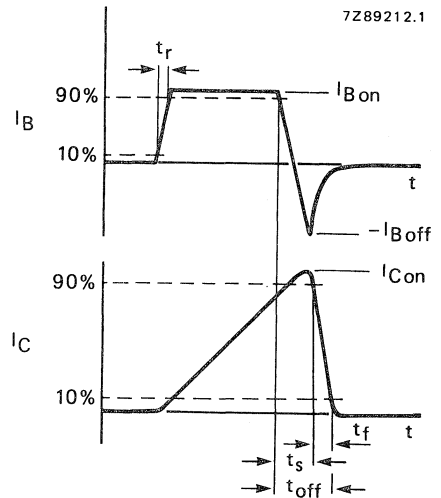
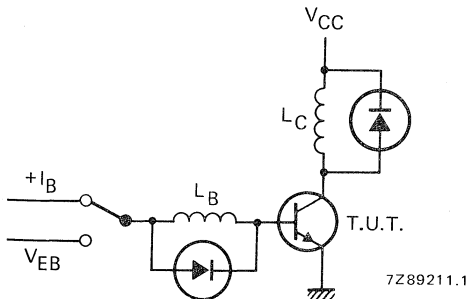


Fig. 6 Switching times waveforms with inductive load.



$V_{CL} = 300 \text{ V}$
 $V_{CC} = 30 \text{ V}$
 $V_{EB} = 5 \text{ V}$

Fig. 7 Test circuit inductive load.

DEVELOPMENT SAMPLE DATA

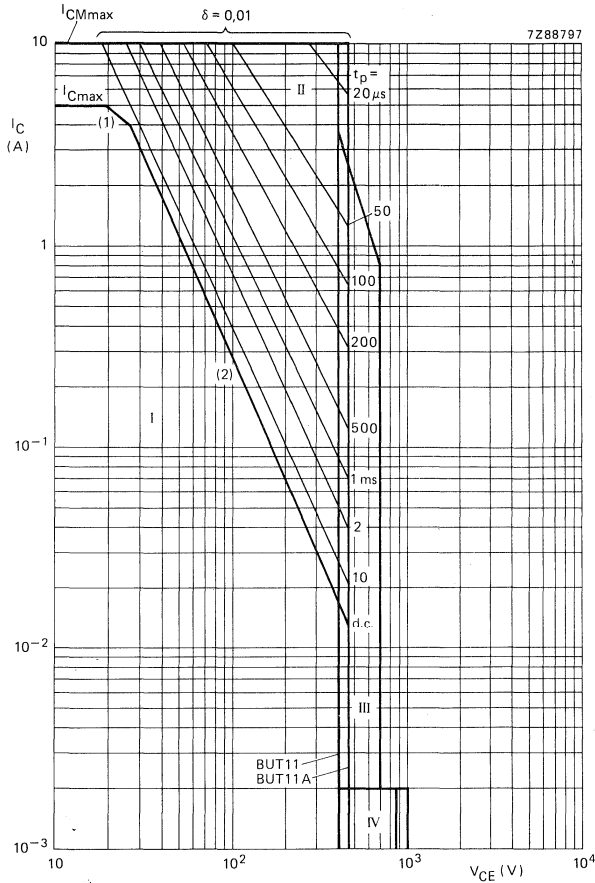


Fig. 8 Safe Operating Area at $T_{mb} \leq 25^\circ C$.

- (1) P_{tot} max and P_{tot} peak max. lines.
- (2) Second-breakdown limits (independent of temperature).
- I Region of permissible d.c. operation
- II Permissible extension for repetitive pulse operation
- III Area of permissible operation during turn-on in single transistor converters, provided $R_{BE} \leq 100 \Omega$ and $t_p \leq 0,6 \mu s$.
- IV Repetitive pulse operation in this region is permissible provided $V_{BE} \leq 0$ and $t_p \leq 5 ms$.

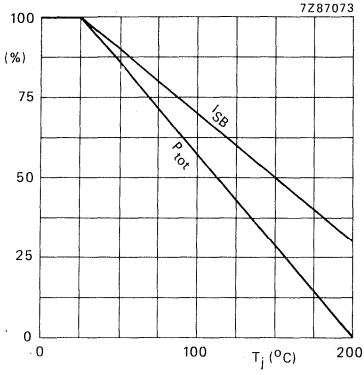


Fig. 9 Total power dissipation and second-breakdown current derating curve.

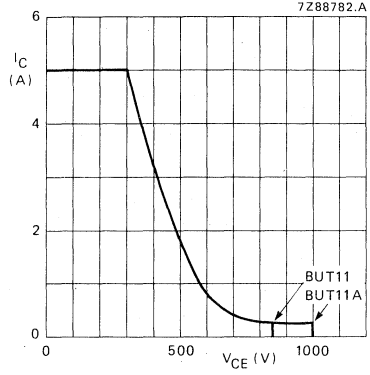


Fig. 10 Reverse bias SOAR.

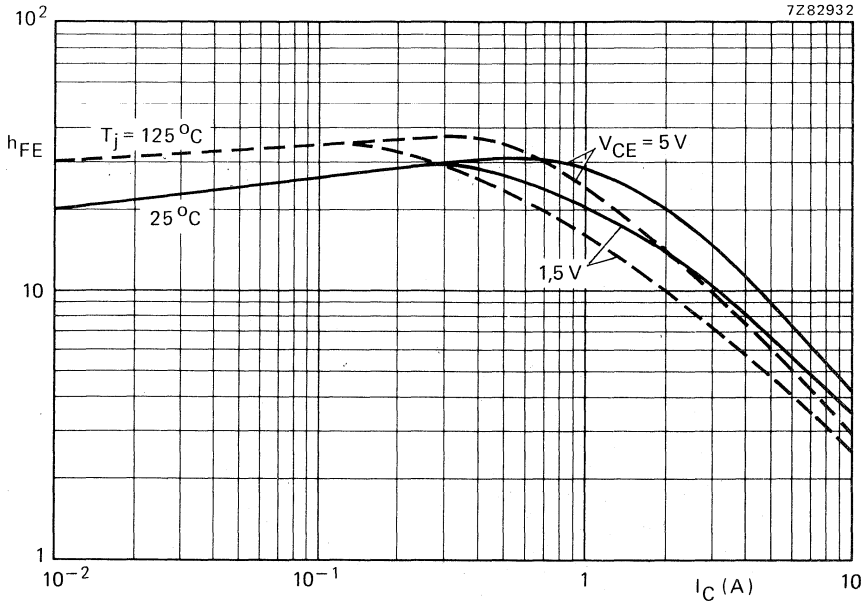


Fig. 11 D.C. current gain.

DEVELOPMENT SAMPLE DATA

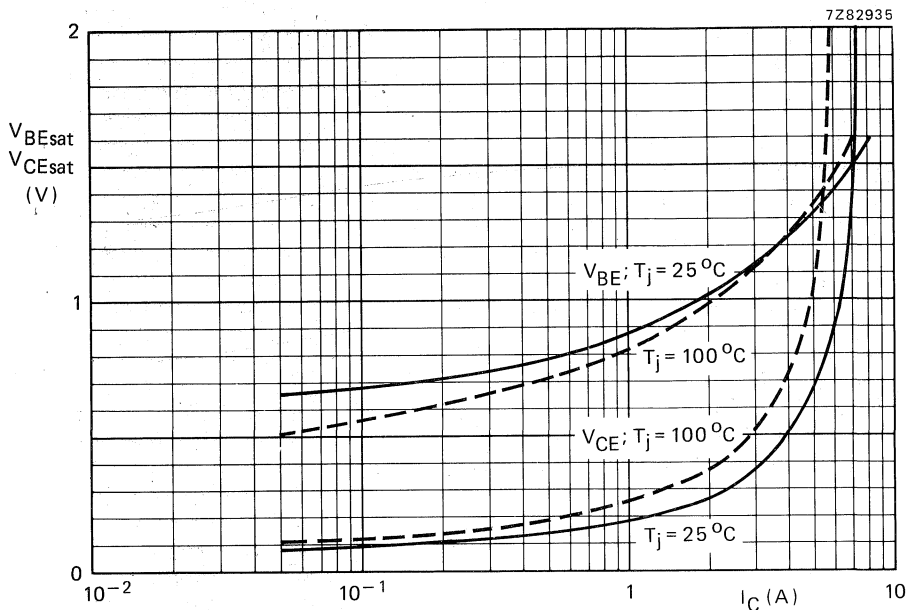


Fig. 12 Typical values base-emitter and collector-emitter voltage, $I_C/I_B = 5$.

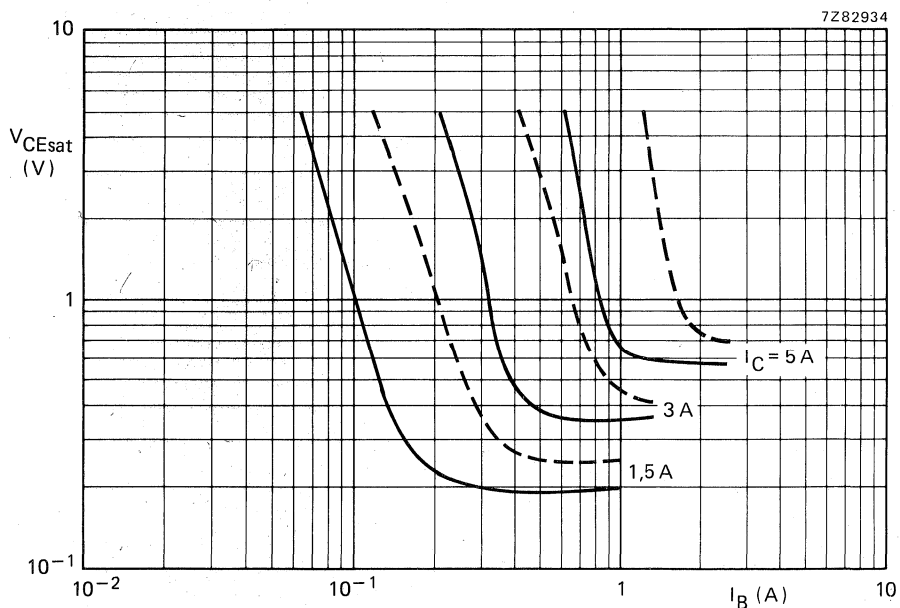


Fig. 13 Typ. (—) and max. (---) values collector-emitter saturation voltage at $T_j = 25^\circ C$.

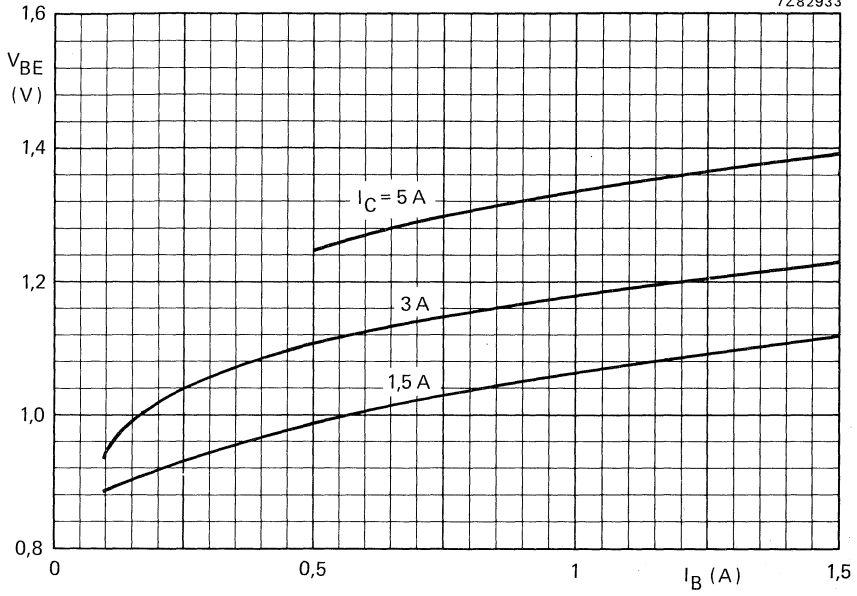


Fig. 14 Typical values at $T_j = 25$ °C.



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_{CM} 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):

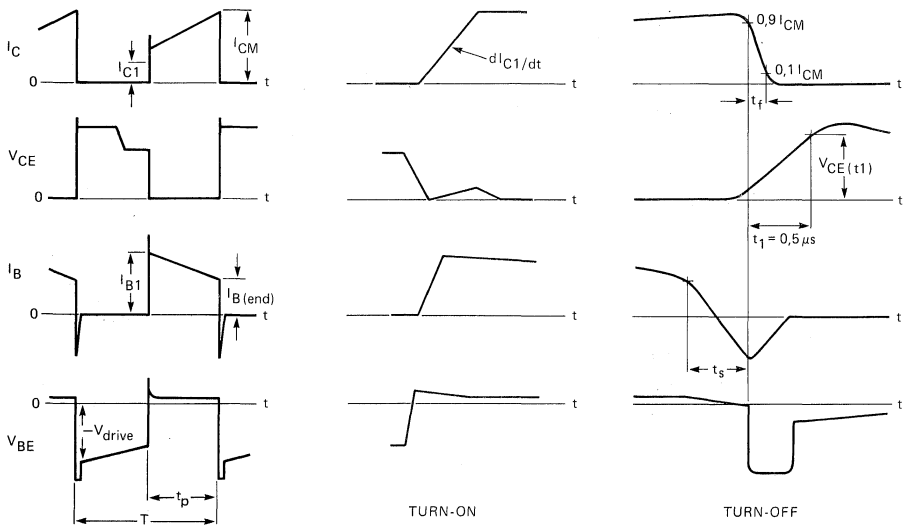
- collector current shape $I_{C1}/I_{CM} = 0,9$
- duty factor $(t_p/T) = 0,45$
- rate of rise of I_C during turn-on = $4 \text{ A}/\mu\text{s}$
- rate of rise of V_{CE} during turn-off = $1 \text{ kV}/\mu\text{s}$
- reverse drive voltage during turn-off = 5 V
- base current shape $I_{B1}/I_{Be} = 1,5$

The required thermal resistance of the heatsink can be calculated from

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

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

DEVELOPMENT SAMPLE DATA



7288781

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

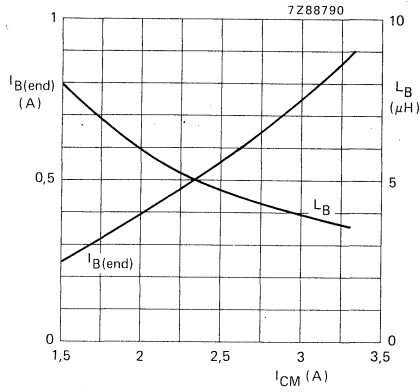


Fig. 16 Recommended nominal "end" value of the base current ($I_{B(e)}$) and optimum base inductance (L_B) at $-V_{drive} = 5 V$ versus maximum peak collector current. $dI_{B(end)} = \pm 20\%$.

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

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

L_{Bnom} is the value given in this graph.

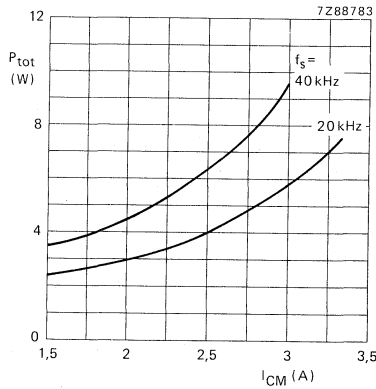


Fig. 17 Maximum transistor dissipation under worst-case operating condition versus maximum peak collector current. $T_{mb} = 100\text{ }^\circ C$; $dI_{B(end)} = \pm 20\%$.

SILICON DIFFUSED POWER TRANSISTORS

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

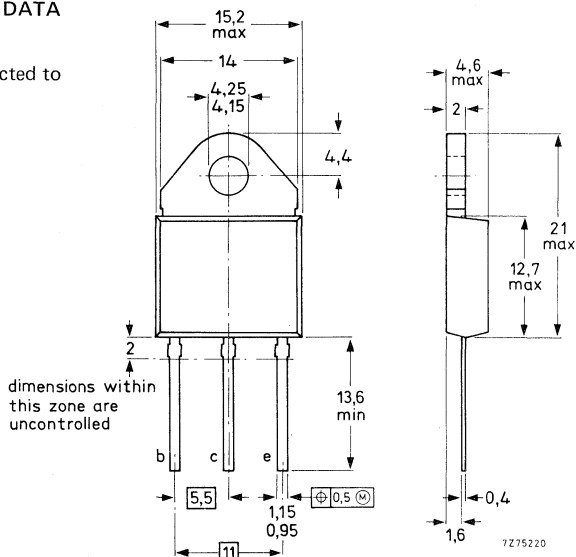
QUICK REFERENCE DATA

		BUV82	BUV83	
Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM} max.	850	1000	V
Collector-emitter voltage ($R_{BE} = 100 \Omega$)	V_{CER} max.	500	500	V
Collector-emitter voltage (open base)	V_{CEO} max.	400	450	V
Collector current (d.c.)	I_C max.	6	6	A
Collector current (peak value) $t_p = 2$ ms	I_{CM} max.	10	10	A
Total power dissipation up to $T_{mb} = 73$ °C	P_{tot} max.	70	70	W
Collector-emitter saturation voltage $I_C = 2,5$ A; $I_B = 0,5$ A	V_{CEsat} <	1,5	1,5	V
Fall time $I_{Con} = 2,5$ A; $I_{Bon} = 0,5$ A; $-I_{Boff} = 1$ A	t_f typ.	0,3	0,3	μ s

MECHANICAL DATA

Fig. 1 SOT-93.

Collector connected to mounting base



See also chapters Mounting instructions and Accessories.

RATINGS

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

			BUV82	BUV83	
Collector-emitter voltage ($V_{BE} = 0$; peak value)	V_{CESM}	max.	850	1000	V
Collector-emitter voltage ($R_{BE} = 100 \Omega$)	V_{CER}	max.	500	500	V
Collector-emitter voltage (open base)	V_{CEO}	max.	400	450	V
Collector current (d.c.)	I_C	max.		6	A
Collector current (peak value) $t_p = 2 \text{ ms}$	I_{CM}	max.		10	A
Base current (d.c.)	I_B	max.		2	A
Base current (peak value)	I_{BM}	max.		3	A
Reverse base current (d.c. or average over any 20 ms period)	$-I_{B(AV)}$	max.		100	mA
Reverse base current (peak value)*	$-I_{BM}$	max.		3	A
Total power dissipation up to $T_{mb} = 73 \text{ }^\circ\text{C}$	P_{tot}	max.		70	W
Storage temperature	T_{stg}			-65 to + 150	$^\circ\text{C}$
Junction temperature	T_j	max.		150	$^\circ\text{C}$

THERMAL RESISTANCE

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

CHARACTERISTICS

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

Collector cut-off current**

$V_{CEM} = V_{CESMmax}; V_{BE} = 0$	I_{CES}	<		1	mA
-------------------------------------	-----------	---	--	---	----

$V_{CEM} = V_{CESMmax}; V_{BE} = 0; T_j = 125 \text{ }^\circ\text{C}$	I_{CES}	<		2	mA
---	-----------	---	--	---	----

D.C. current gain

$I_C = 0,6 \text{ A}; V_{CE} = 5 \text{ V}$	h_{FE}	typ.		35	
---	----------	------	--	----	--

* Turn-off current.

** Measured with a half sine wave voltage (curve tracer).

CHARACTERISTICS (continued)

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

Emitter cut-off current

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

$I_{EBO} < 10\text{ mA}$

Saturation voltages

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

$V_{CEsat} < 1,5\text{ V}$

$V_{BEsat} < 1,4\text{ V}$

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

$V_{CEsat} < 3\text{ V}$

$V_{BEsat} < 1,6\text{ V}$

Collector-emitter sustaining voltages

$I_C = 100\text{ mA}; I_{Boff} = 0; L = 25\text{ mH}$

	BUV82	BUV83	
$V_{CEO\text{sust}} >$	400	450	V
$V_{CER\text{sust}} >$	500	500	V

$I_C = 100\text{ mA}; R_{BE} = 100\ \Omega; L = 15\text{ mH}$

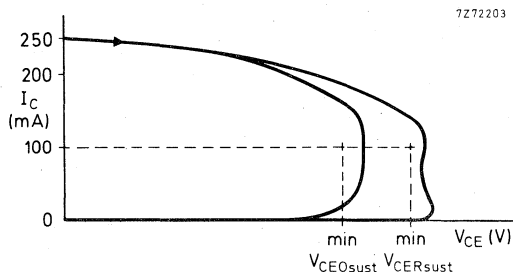


Fig. 2 Oscilloscope display for sustaining voltages.

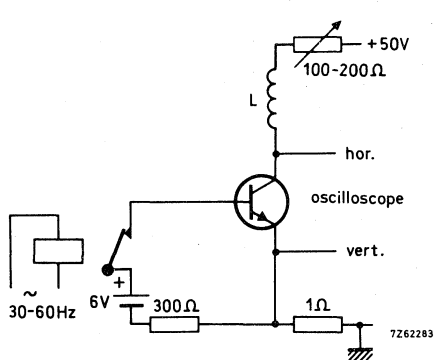


Fig. 3 Test circuit for $V_{CEO\text{sust}}$.

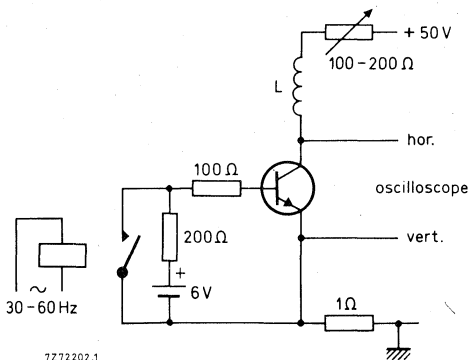


Fig. 4 Test circuit for $V_{CER\text{sust}}$.

CHARACTERISTICS (continued)

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

Transition frequency at $f = 1\text{ MHz}$

$I_C = 0,2\text{ A}; V_{CE} = 10\text{ V}$

f_T typ. 6 MHz

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

t_{on} typ. 0,3 μs
< 0,6 μs

Turn-off: Storage time

t_s typ. 2 μs
< 3,5 μs

Fall time

t_f typ. 0,3 μs

Fall time, $T_{mb} = 95\text{ }^\circ\text{C}$

t_f < 0,75 μs

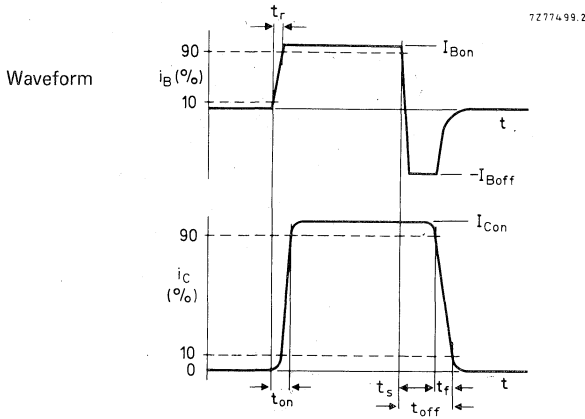


Fig. 5 Switching times waveform.

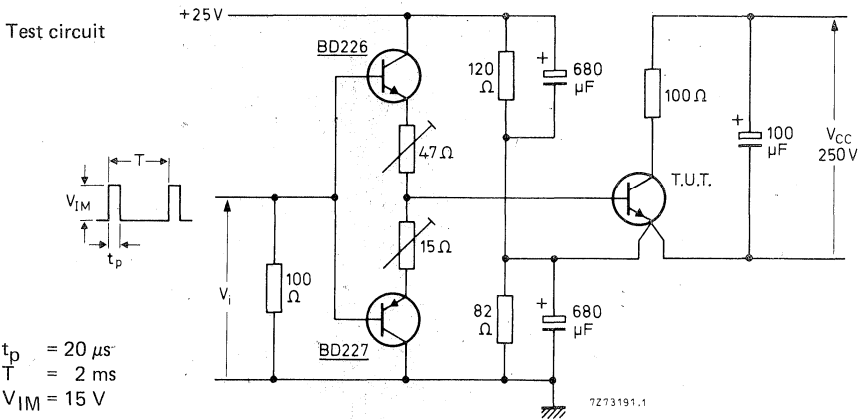


Fig. 6 Switching times test circuit.

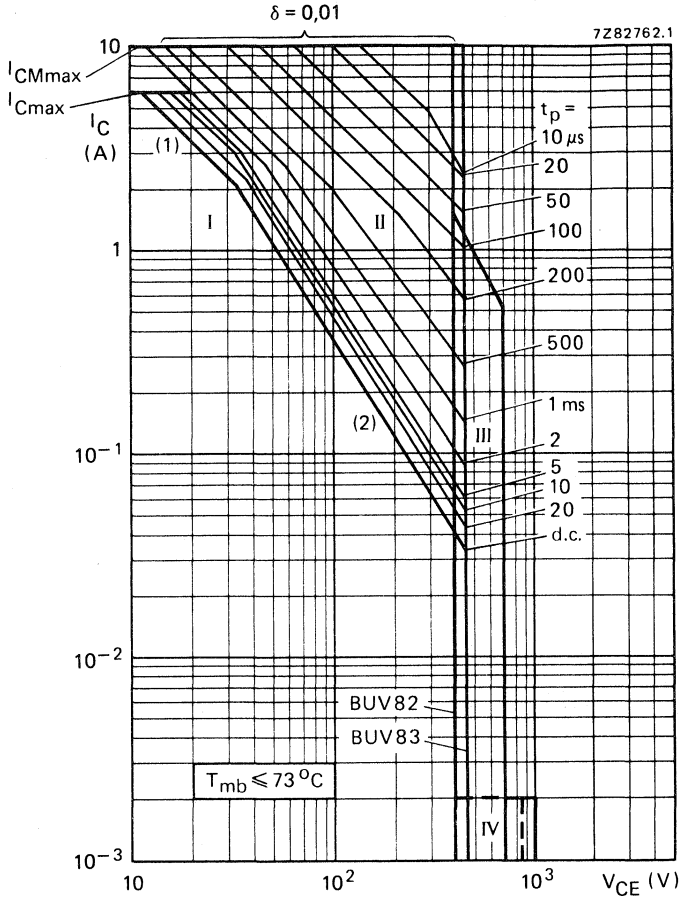


Fig. 7 Safe Operating Area.

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 $R_{BE} \leq 100 \Omega$ and $t_p \leq 0,6 \mu s$.

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

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

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

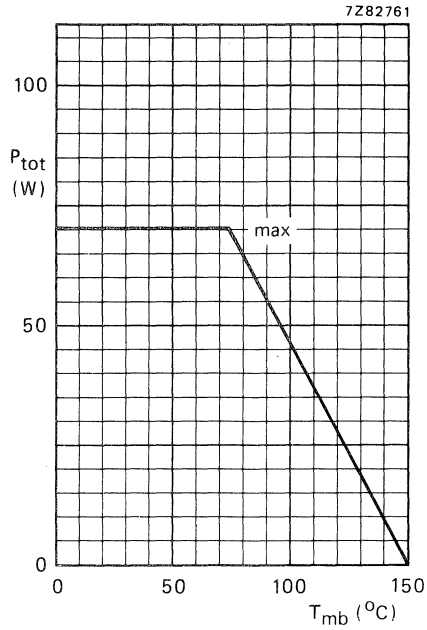


Fig. 8 Power derating curve.

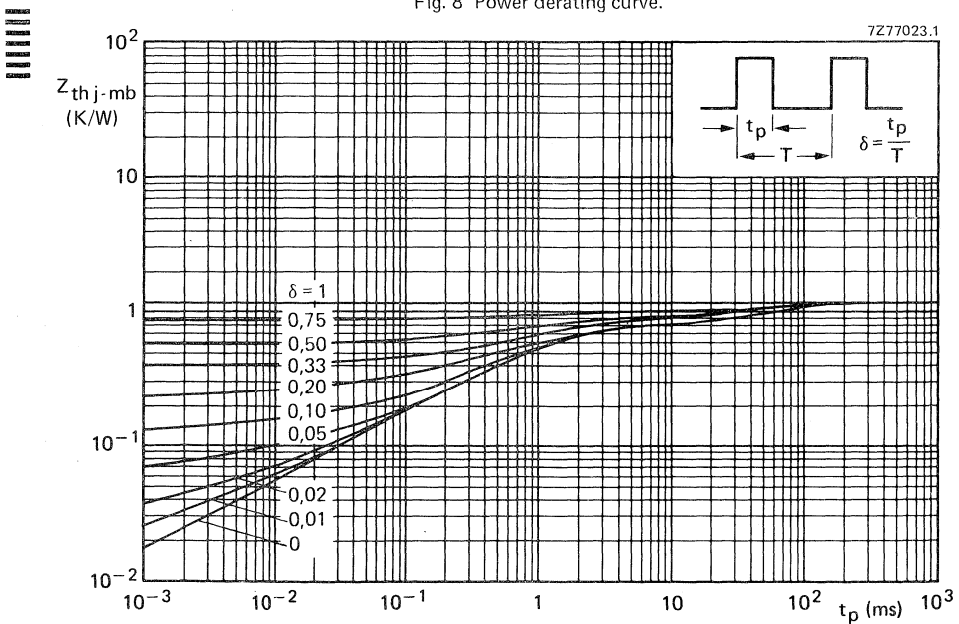


Fig. 9 Pulse power rating chart.

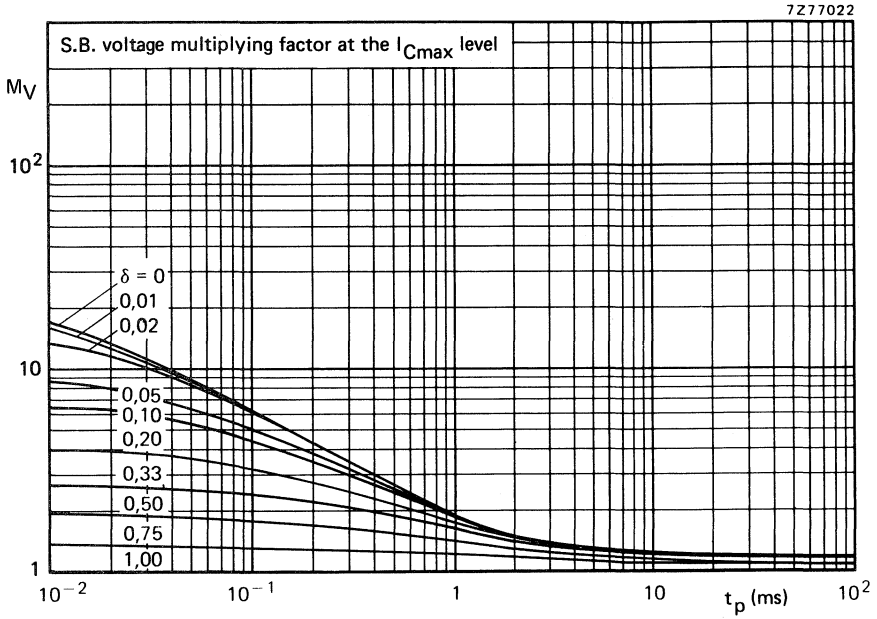


Fig. 10 S.B. voltage multiplying factor at the I_{Cmax} level.

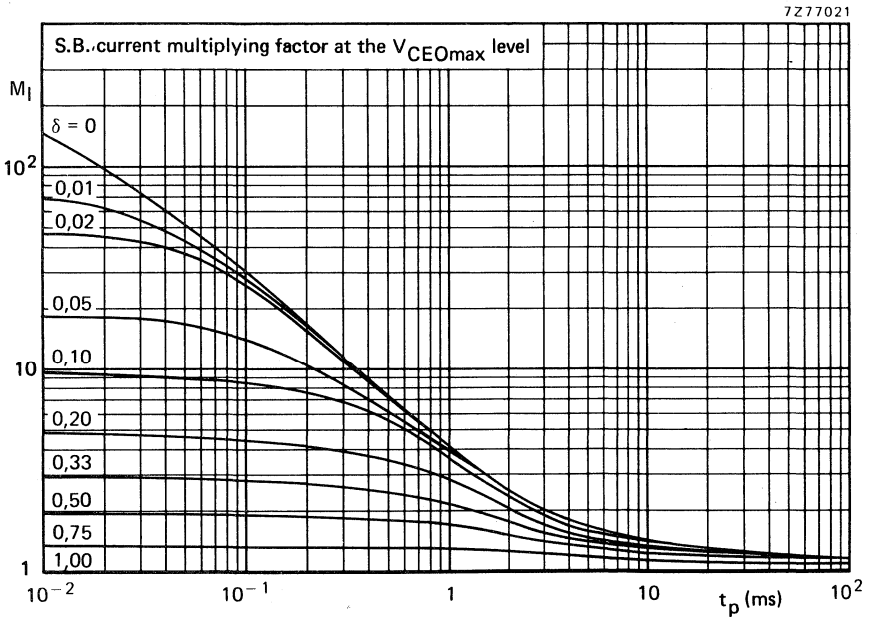


Fig. 11 S.B. current multiplying factor at the V_{CE0max} level.

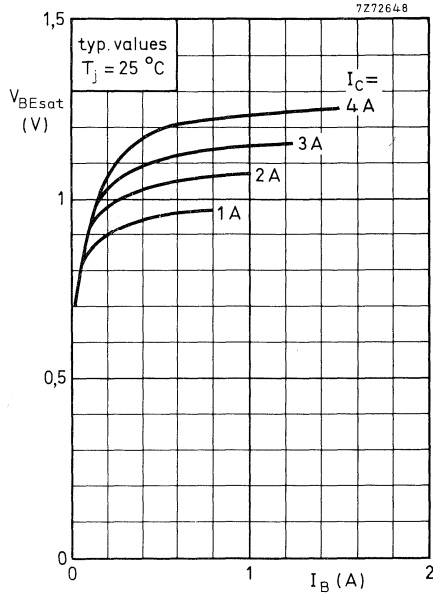


Fig. 12 Base-emitter saturation voltage.

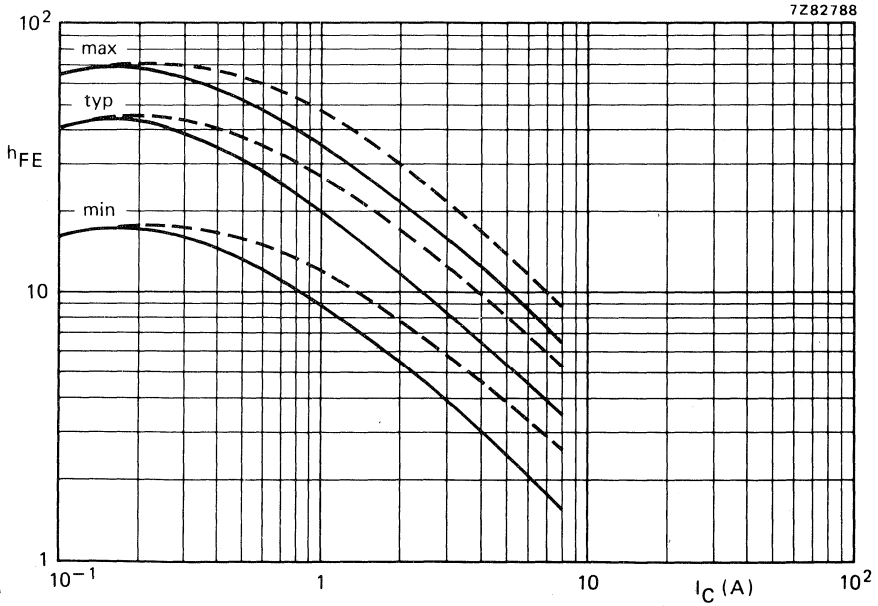


Fig. 13 D.C. current gain. $T_j = 25^\circ\text{C}$; --- at $V_{CE} = 5\text{ V}$; — at $V_{CE} = 1\text{ V}$.

DEVELOPMENT SAMPLE DATA

This information is derived from development samples made available for evaluation. It does not necessarily imply that the device will go into regular production.

BUV89

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

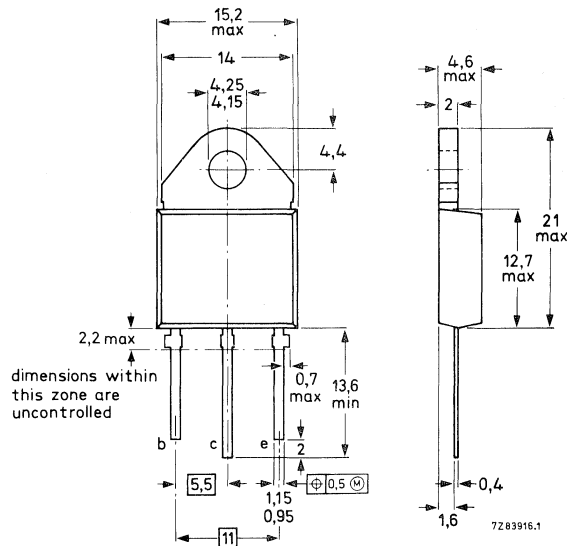
Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM} max.	1200 V
Collector-emitter voltage (open base)	V_{CEO} max.	800 V
Collector current (d.c.)	I_C max.	8 A
Collector current (peak value)	I_{CM} max.	15 A
Total power dissipation up to $T_{mb} = 25^\circ\text{C}$	P_{tot} max.	125 W
Collector-emitter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

MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT93A

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; $V_{BE} = 0$)	V_{CESM}	max.	1200 V
Collector-emitter voltage (open base)	V_{CEO}	max.	800 V
Collector current (d.c.)	I_C	max.	8 A
Collector current (peak value)	I_{CM}	max.	15 A
Base current (d.c.)	I_B	max.	4 A
Base current (peak value)	I_{BM}	max.	6 A
Total power dissipation up to $T_{mb} = 25\text{ °C}$	P_{tot}	max.	125 W
Storage temperature	T_{stg}		-65 to + 150 °C
Junction temperature	T_j	max.	150 °C

THERMAL RESISTANCE

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

CHARACTERISTICS

$T_j = 25\text{ °C}$ unless otherwise specified

Collector cut-off current*

$V_{BE} = 0; V_{CE} = V_{CESMmax}$	I_{CES}	<	1,0 mA
------------------------------------	-----------	---	--------

$V_{BE} = 0; V_{CE} = V_{CESMmax}; T_j = 125\text{ °C}$	I_{CES}	<	2,0 mA
---	-----------	---	--------

Emitter cut-off current

$V_{EB} = 5\text{ V}; I_C = 0$	I_{EBO}	<	10 mA
--------------------------------	-----------	---	-------

Collector-emitter sustaining voltage

$I_B = 0; I_C = 100\text{ mA}; L = 25\text{ mH}$	$V_{CEO_{sust}}$	>	800 V
--	------------------	---	-------

Saturation voltage

$I_C = 4,5\text{ A}; I_B = 2\text{ A}$	V_{CEsat}	<	1 V
--	-------------	---	-----

$I_C = 6\text{ A}; I_B = 3\text{ A}$	V_{BEsat}	<	1,3 V
--------------------------------------	-------------	---	-------

	V_{CEsat}	typ.	1 V
--	-------------	------	-----

Transition frequency at $f = 5\text{ MHz}$

$I_C = 0,1\text{ A}; V_{CE} = 5\text{ V}$	f_T	typ.	7 MHz
---	-------	------	-------

Collector capacitance at $f = 1\text{ MHz}$

$I_E = I_e = 0; V_{CB} = 10\text{ V}$	C_c	typ.	125 pF
---------------------------------------	-------	------	--------

Switching times in resistive switching circuit (Fig. 5)

$I_{Con} = 4,5\text{ A}; I_{Bon} = -I_{Boff} = 2\text{ A}$	t_{on}	typ.	0,2 μ s
--	----------	------	-------------

Turn-on time	t_s	typ.	3,5 μ s
--------------	-------	------	-------------

Storage time	t_f	typ.	0,5 μ s
--------------	-------	------	-------------

Fall time			
-----------	--	--	--

Second-breakdown current

$V_{CE} = 100\text{ V}; t_p = 1\text{ s}$	$I_{(SB)}$	>	0,3 A
---	------------	---	-------

* Measured with a half-sinewave voltage (curve tracer).

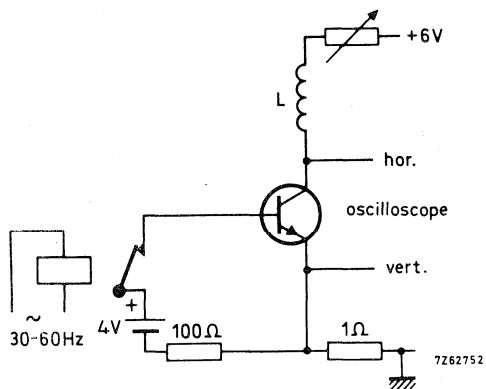


Fig. 2 Test circuit for $V_{CE0sust}$

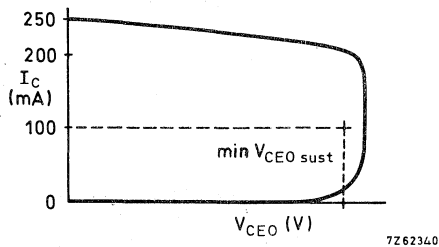


Fig. 3 Oscilloscope display for $V_{CE0sust}$.

DEVELOPMENT SAMPLE DATA

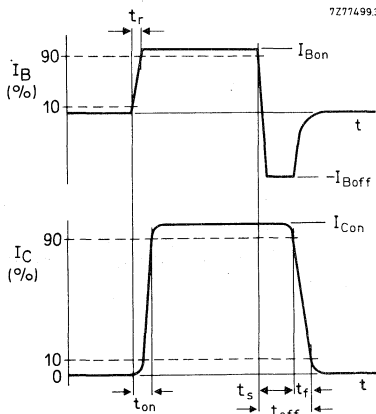


Fig. 4 Waveforms.

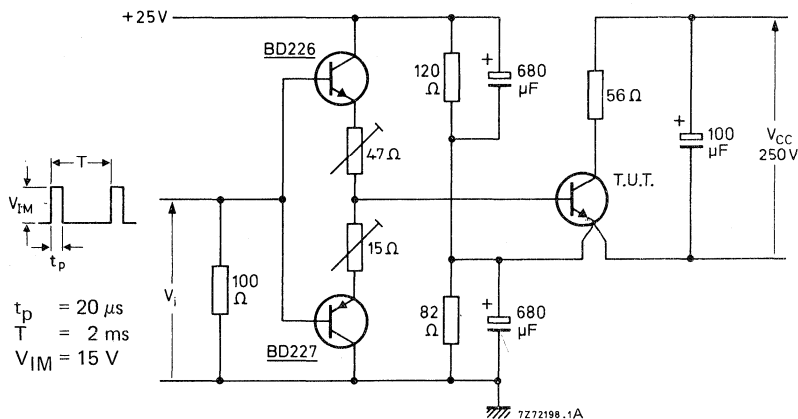


Fig. 5 Switching times test circuit.

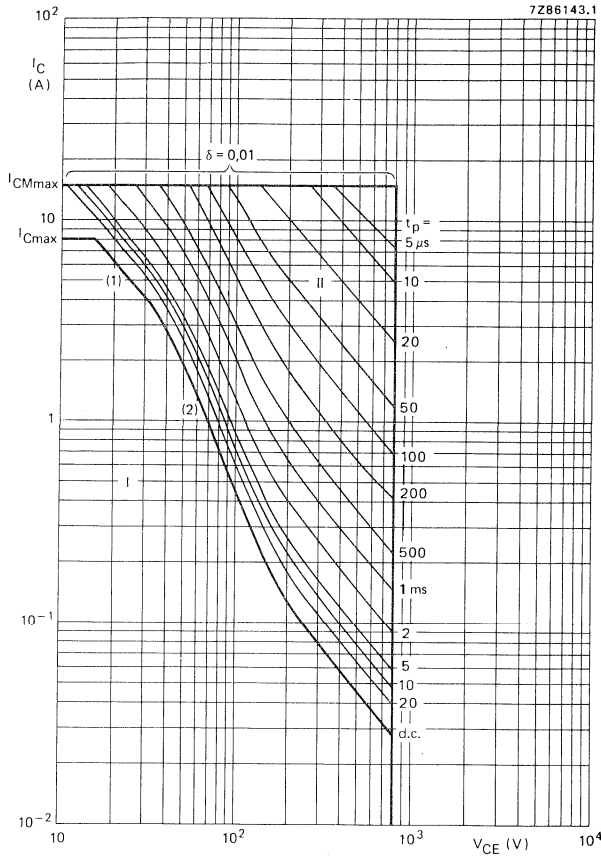


Fig. 6 Safe Operating Area; $T_{mb} \leq 25 \text{ }^\circ\text{C}$.

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

DEVELOPMENT SAMPLE DATA

This information is derived from development samples made available for evaluation. It does not necessarily imply that the device will go into regular production.

BUW11
BUW11A

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.

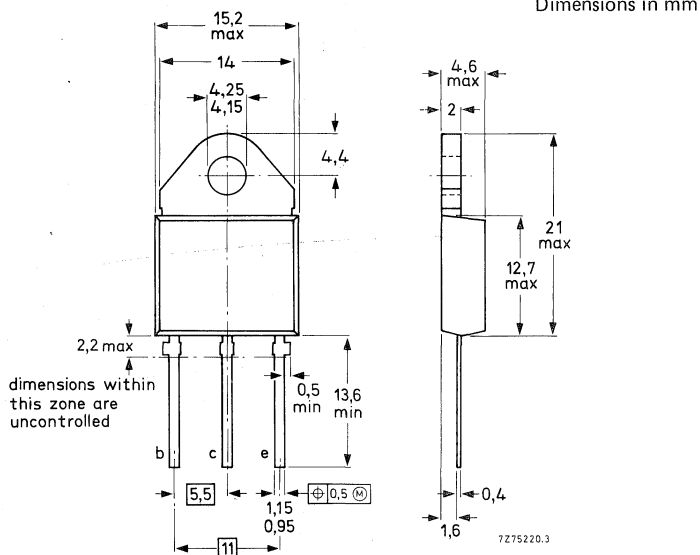
QUICK REFERENCE DATA

		BUW11	BUW11A	
Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM} max.	850	1000	V
Collector-emitter voltage (open base)	V_{CEO} max.	400	450	V
Collector current (d.c.)	I_C max.	5	A	
Collector current (peak value) $t_p \leq 2$ ms	I_{CM} max.	10	A	
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot} max.	100	W	
Collector-emitter saturation voltage				
$I_C = 3$ A; $I_B = 0,6$ A	V_{CEsat} <	1,5	—	V
$I_C = 2,5$ A; $I_B = 0,5$ A	V_{CEsat} <	—	1,5	V
Fall time (resistive load)				
$I_{Con} = 3$ A; $I_{Bon} = -I_{Boff} = 0,6$ A	t_f <	0,8	—	μs
$I_{Con} = 2,5$ A; $I_{Bon} = -I_{Boff} = 0,5$ A	t_f <	—	0,8	μs

MECHANICAL DATA

Fig. 1 SOT-93.

Collector connected to mounting base.



See also chapters Mounting instructions and Accessories.

RATINGS

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

		BUW11	BUW11A
Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM}	max. 850	1000 V
Collector-emitter voltage (open base)	V_{CEO}	max. 400	450 V
Collector current (d.c.)	I_C	max. 5	A
Collector current (peak value) $t_p < 2$ ms	I_{CM}	max. 10	A
Base current (d.c.)	I_B	max. 2	A
Base current (peak value); $t_p < 2$ ms	I_{BM}	max. 4	A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot}	max. 100	W
Storage temperature	T_{stg}	-65 to +150	°C
Junction temperature	T_j	max. 150	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=	1,25	K/W
--------------------------------	----------------	---	------	-----

CHARACTERISTICS

$T_j = 25$ °C unless otherwise specified

Collector cut-off current*

$V_{CE} = V_{CESMmax}; V_{BE} = 0$

I_{CES}	<	1	mA
-----------	---	---	----

$V_{CE} = V_{CESMmax}; V_{BE} = 0; T_j = 125$ °C

I_{CES}	<	2	mA
-----------	---	---	----

Emitter cut-off current

$I_C = 0; V_{EB} = 9$ V

I_{EBO}	<	10	mA
-----------	---	----	----

Saturation voltages

$I_C = 3$ A; $I_B = 0,6$ A

		BUW11	BUW11A
V_{CEsat}	<	1,5	- V
V_{BEsat}	<	1,4	- V
V_{CEsat}	<	-	1,5 V
V_{BEsat}	<	-	1,4 V

$I_C = 2,5$ A; $I_B = 0,5$ A

Collector-emitter sustaining voltage

$I_C = 100$ mA; $I_{Boff} = 0$; $L = 25$ mH

$V_{CEO sust}$	>	400	450 V
----------------	---	-----	-------

Collector saturation current

$V_{CE} = 1,5$ V

I_{Csat}	<	3	2,5 A
------------	---	---	-------

* Measured with a half sine-wave voltage (curve tracer).

CHARACTERISTICS (continued)

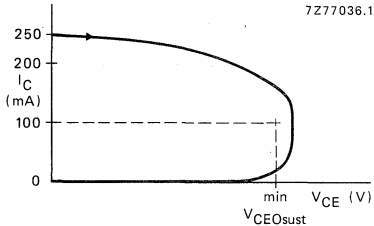


Fig. 2 Oscilloscope display for sustaining voltage.

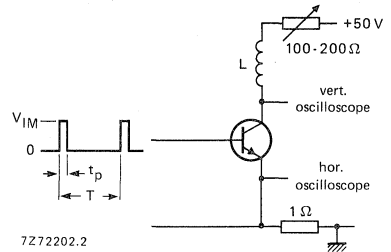


Fig. 3 Test circuit for $V_{CE0sust}$.

DEVELOPMENT SAMPLE DATA

Switching times resistive load (Figs 4 and 5)

$I_{Con} = 3 \text{ A}; I_{Bon} = I_{Boff} = 0,6 \text{ A}$

Turn-on time

	BUW11	BUW11A
$t_{on} <$	1	— μs
$t_s <$	4	— μs
$t_f <$	0,8	— μs

Turn-off: Storage time

Fall time

$I_{Con} = 2,5 \text{ A}; I_{Bon} = -I_{Boff} = 0,5 \text{ A}$

Turn-on time

$t_{on} <$	—	1 μs
$t_s <$	—	4 μs
$t_f <$	—	0,8 μs

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

t_s typ.	1,1	— μs
$t_s <$	1,4	— μs
t_f typ.	80	— ns
$t_f <$	150	— ns

Fall time

$I_{Con} = 3 \text{ A}; I_B = 0,6 \text{ A}; T_j = 100 \text{ }^\circ\text{C}$

Turn-off: Storage time

t_s typ.	1,2	— μs
$t_s <$	1,5	— μs
t_f typ.	140	— ns
$t_f <$	300	— ns

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

t_s typ.	—	1,1 μs
$t_s <$	—	1,4 μs
t_f typ.	—	80 ns
$t_f <$	—	150 ns

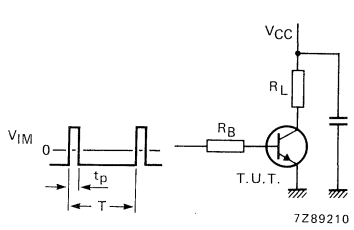
Fall time

$I_{Con} = 2,5 \text{ A}; I_B = 0,5 \text{ A}; T_j = 100 \text{ }^\circ\text{C}$

Turn-off: Storage time

t_s typ.	—	1,2 μs
$t_s <$	—	1,5 μs
typ.	—	140 ns
$<$	—	300 ns

Fall time



$V_{CC} = 250 \text{ V}$
 $V_{IM} = -6 \text{ to } +8 \text{ V}$
 $\frac{t_p}{T} = 0,01$
 $t_p = 20 \mu\text{s}$
 The values of R_B and R_L are selected in accordance with I_{Con} and I_B requirements.

Fig. 4 Test circuit resistive load.

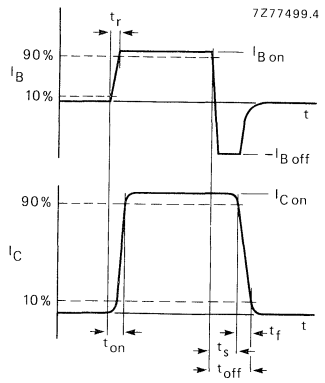


Fig. 5 Switching times waveforms with resistive load.

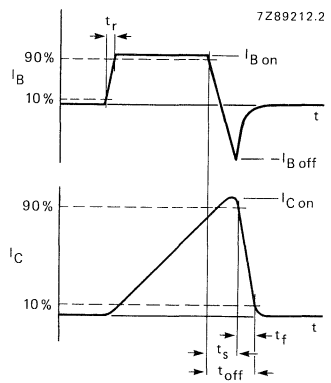
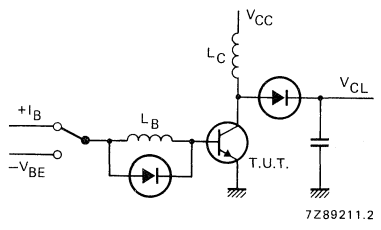


Fig. 6 Switching times waveforms with inductive load.



$V_{CL} = 300 \text{ V}$
 $V_{CC} = 30 \text{ V}$
 $-V_{BE} = 5 \text{ V}$
 $L_B = 1 \mu\text{H}$
 $L_C = 200 \mu\text{H}$

Fig. 7 Test circuit inductive load.

DEVELOPMENT SAMPLE DATA

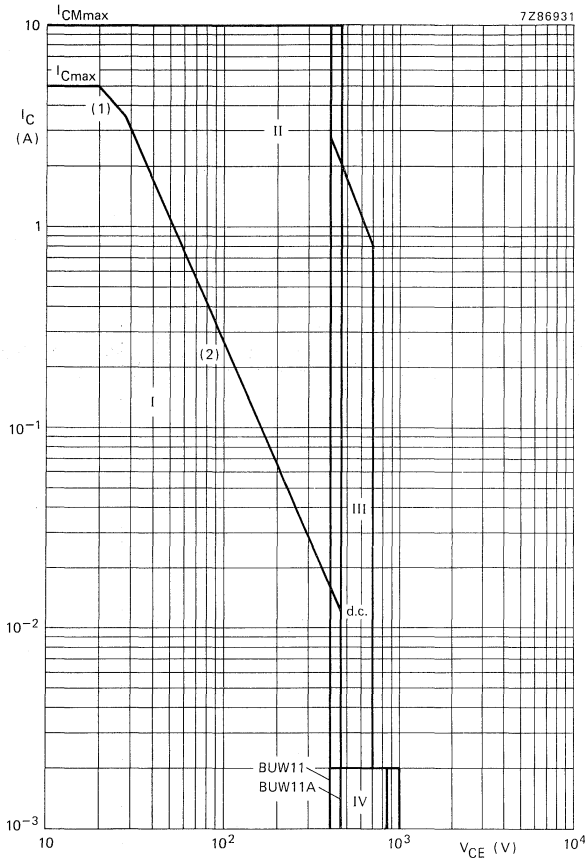


Fig. 8 Safe Operating Area at $T_{mb} \leq 25^\circ C$.

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

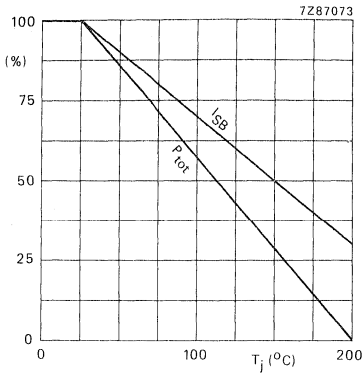


Fig. 9 Total power dissipation and second-breakdown current derating curve.

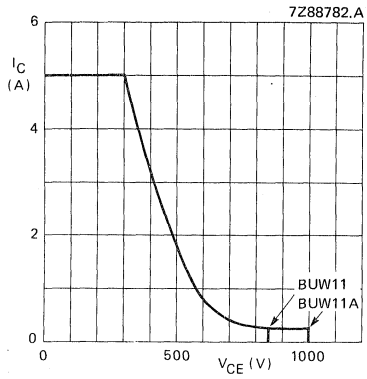


Fig. 10 Reverse bias SOAR.

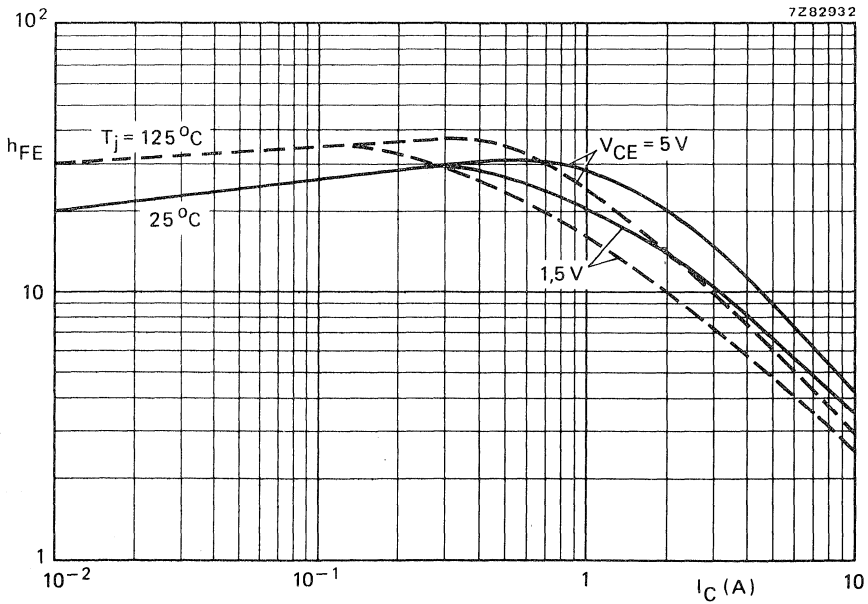


Fig. 11 Typical values d.c. current gain.

DEVELOPMENT SAMPLE DATA

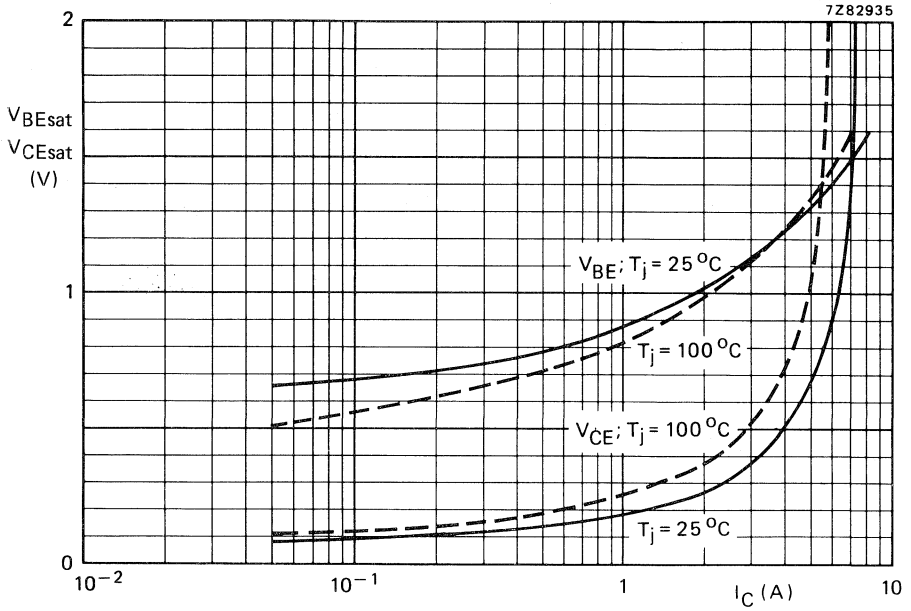


Fig. 12 Typical values base-emitter and collector-emitter voltage, $I_C/I_B = 5$.

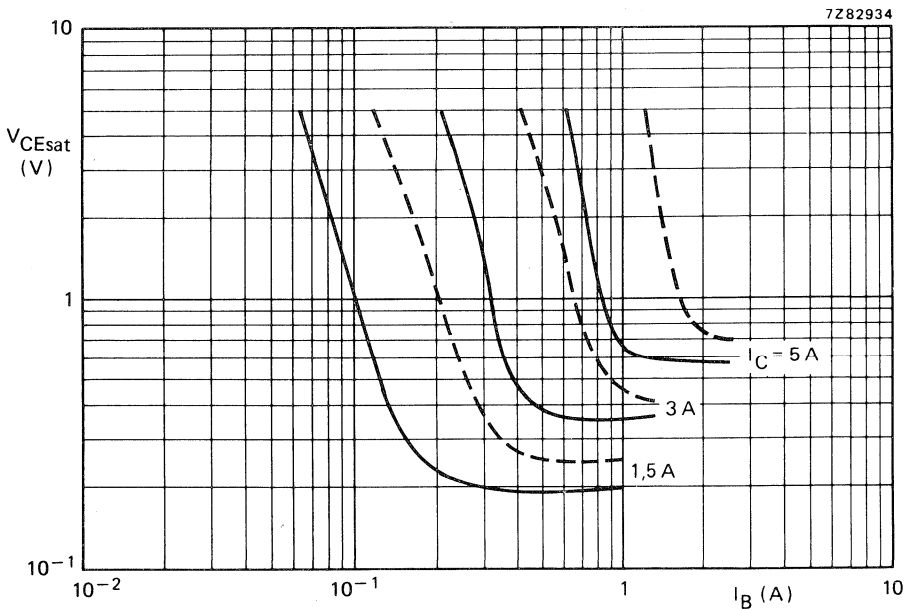


Fig. 13 Typ. (—) and max. (---) values collector-emitter saturation voltage at $T_j = 25^\circ\text{C}$.

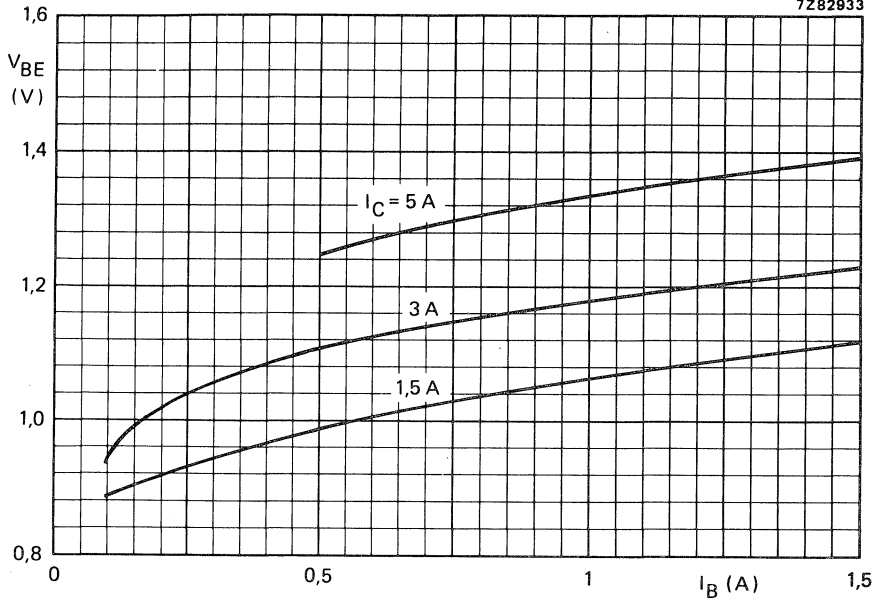


Fig. 14 Typical values at $T_j = 25^\circ\text{C}$.

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_{CM} 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):

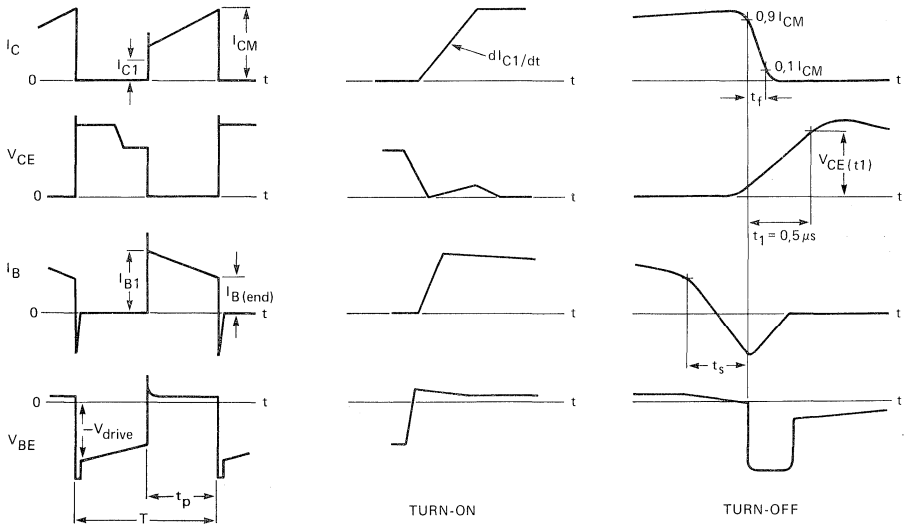
- collector current shape $I_{C1}/I_{CM} = 0,9$
- duty factor $t_p/T = 0,45$
- rate of rise of I_C during turn-on = 4 A/ μ s
- rate of rise of V_{CE} during turn-off = 1 kV/ μ s
- reverse drive voltage during turn-off = 5 V
- base current shape $I_{B1}/I_{Be} = 1,5$

The required thermal resistance of the heatsink can be calculated from

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

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

DEVELOPMENT SAMPLE DATA



7Z88781

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

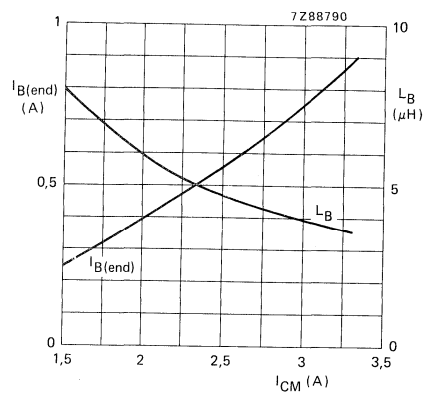


Fig. 16 Recommended nominal "end" value of the base current ($I_{B(e)}$) and optimum base inductance (L_B) at $-V_{drive} = 5$ V versus maximum peak collector current. $dI_{B(end)} = \pm 20\%$.

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

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

L_{Bnom} is the value given in this graph.

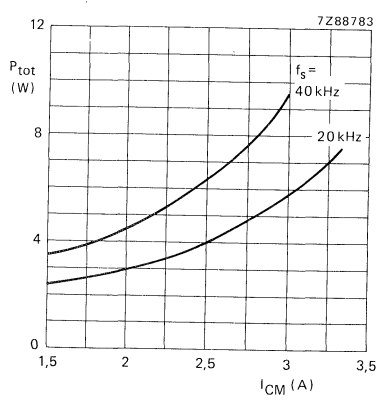


Fig. 17 Maximum transistor dissipation under worse-case operating condition versus maximum peak collector current. $T_{mb} = 100$ °C; $dI_{B(end)} = \pm 20\%$.

DEVELOPMENT SAMPLE DATA

This information is derived from development samples made available for evaluation. It does not necessarily imply that the device will go into regular production.

BUW12
BUW12A

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.

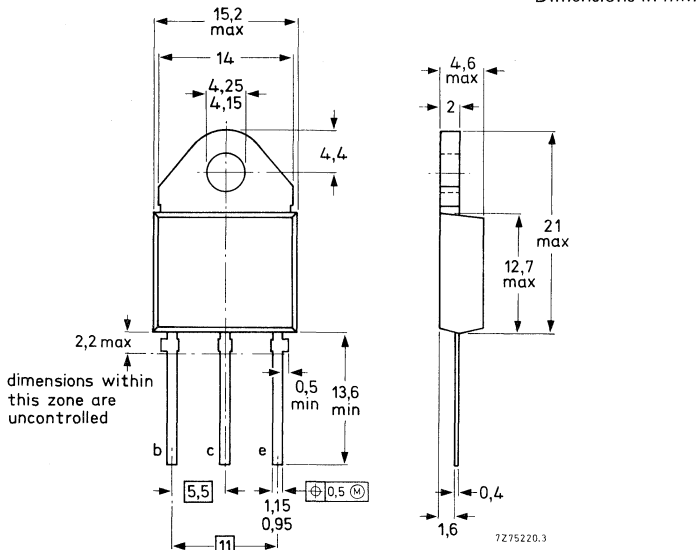
QUICK REFERENCE DATA

		BUW12	BUW12A	
Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM}	max. 850	1000	V
Collector-emitter voltage (open base)	V_{CEO}	max. 400	450	V
Collector current (d.c.)	I_C	max. 8	A	
Collector current (peak value) $t_p \leq 2$ ms	I_{CM}	max. 20	A	
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot}	max. 125	W	
Collector-emitter saturation voltage				
$I_C = 6$ A; $I_B = 1,2$ A	V_{CEsat}	< 1,5	—	V
$I_C = 5$ A; $I_B = 1$ A	V_{CEsat}	< —	1,5	V
Fall time (resistive load)				
$I_{Con} = 6$ A; $I_{Bon} = -I_{Boff} = 1,2$ A	t_f	< 0,8	—	μs
$I_{Con} = 5$ A; $I_{Bon} = -I_{Boff} = 1$ A	t_f	< —	0,8	μs

MECHANICAL DATA

Fig. 1 SOT-93.

Collector connected to mounting base.



See also chapters Mounting instructions and Accessories.

RATINGS

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

			BUW12	BUW12A
Collector-emitter voltage (peak value; $V_{BE} = 0$)	V_{CESM}	max.	850	1000 V
Collector-emitter voltage (open base)	V_{CEO}	max.	400	450 V
Collector current (d.c.)	I_C	max.		8 A
Collector current (peak value); $t_p < 2$ ms	I_{CM}	max.	20	A
Base current (d.c.)	I_B	max.	4	A
Base current (peak value); $t_p \leq 2$ ms	I_{BM}	max.	6	A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot}	max.	125	W
Storage temperature	T_{stg}		-65 to + 150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

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

$T_j = 25$ °C unless otherwise specified

Collector cut-off current*

$V_{CE} = V_{CESMmax}; V_{BE} = 0$

I_{CES}	<	1	mA
-----------	---	---	----

$V_{CE} = V_{CESMmax}; V_{BE} = 0; T_j = 125$ °C

I_{CES}	<	3	mA
-----------	---	---	----

Emitter cut-off current

$I_C = 0; V_{EB} = 9$ V

I_{EBO}	<	10	mA
-----------	---	----	----

Saturation voltages

$I_C = 6$ A; $I_B = 1,2$ A

		BUW12	BUW12A
V_{CEsat}	<	1,5	- V
V_{BEsat}	<	1,5	- V
V_{CEsat}	<	-	1,5 V
V_{BEsat}	<	-	1,5 V

$I_C = 5$ A; $I_B = 1,0$ A

Collector-emitter sustaining voltage

$I_C = 100$ mA; $I_{Boff} = 0$; $L = 25$ mH

$V_{CEOsust}$	>	400	450 V
---------------	---	-----	-------

* Measured with a half sine-wave voltage (curve tracer).

CHARACTERISTICS (continued)

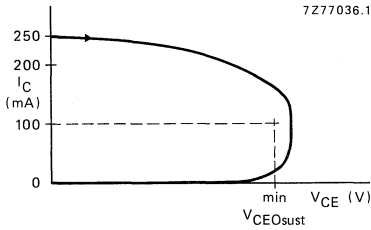


Fig. 2 Oscilloscope display for sustaining voltage.

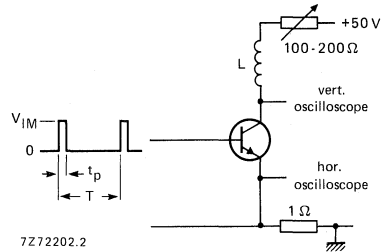


Fig. 3 Test circuit for $V_{CEOsust}$.

DEVELOPMENT SAMPLE DATA

Switching times resistive load (Figs 4 and 5)

$I_{Con} = 6 \text{ A}; I_{Bon} = -I_{Boff} = 1,2 \text{ A}$

Turn-on time

Turn-off: Storage time

Fall time

$I_{Con} = 5 \text{ A}; I_{Bon} = -I_{Boff} = 1 \text{ A}$

Turn-on time

Turn-off: Storage time

Fall time

Switching times inductive load (Figs 6 and 7)

$I_{Con} = 6 \text{ A}; I_B = 1,2 \text{ A}$

Turn-off: Storage time

Fall time

$I_{Con} = 6 \text{ A}; I_B = 1,2 \text{ A}; T_j = 100 \text{ }^\circ\text{C}$

Turn-off: Storage time

Fall time

Switching times inductive load (Figs 6 and 7)

$I_{Con} = 5 \text{ A}; I_B = 1 \text{ A}$

Turn-off: Storage time

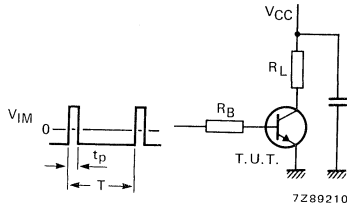
Fall time

$I_{Con} = 5 \text{ A}; I_B = 1 \text{ A}; T_j = 100 \text{ }^\circ\text{C}$

Turn-off: Storage time

Fall time

	BUW12	BUW12A	
t_{on}	< 1	—	μs
t_s	< 4	—	μs
t_f	< 0,8	—	μs
t_{on}	< —	1	μs
t_s	< —	4	μs
t_f	< —	0,8	μs
t_s	typ. 1,6	—	μs
	< 2,1	—	μs
t_f	typ. 80	—	ns
	< 150	—	ns
t_s	typ. 1,8	—	μs
	< 2,3	—	μs
t_f	typ. 140	—	ns
	< 300	—	ns
t_s	typ. —	1,6	μs
	< —	2,1	μs
t_f	typ. —	80	ns
	< —	150	ns
t_s	typ. —	1,8	μs
	< —	2,3	μs
t_f	typ. —	140	ns
	< —	300	ns



$V_{CC} = 250 \text{ V}$
 $V_{IM} = -6 \text{ to } +8 \text{ V}$
 $\frac{t_p}{T} = 0,01$
 $t_p = 20 \mu\text{s}$
 The values of R_B and R_L are selected in accordance with I_{Con} and I_B requirements.

Fig. 4 Test circuit resistive load.

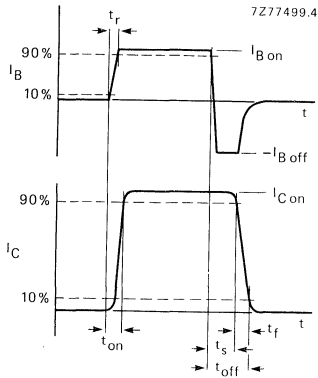


Fig. 5 Switching times waveforms with resistive load.

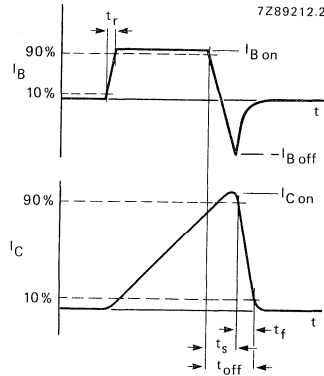
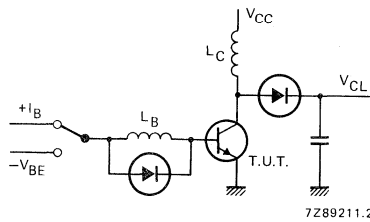


Fig. 6 Switching times waveforms with inductive load.



$V_{CL} = 300 \text{ V}$
 $V_{CC} = 30 \text{ V}$
 $-V_{BE} = 5 \text{ V}$
 $L_B = 1 \mu\text{H}$
 $L_C = 200 \mu\text{H}$

Fig. 7 Test circuit inductive load.

DEVELOPMENT SAMPLE DATA

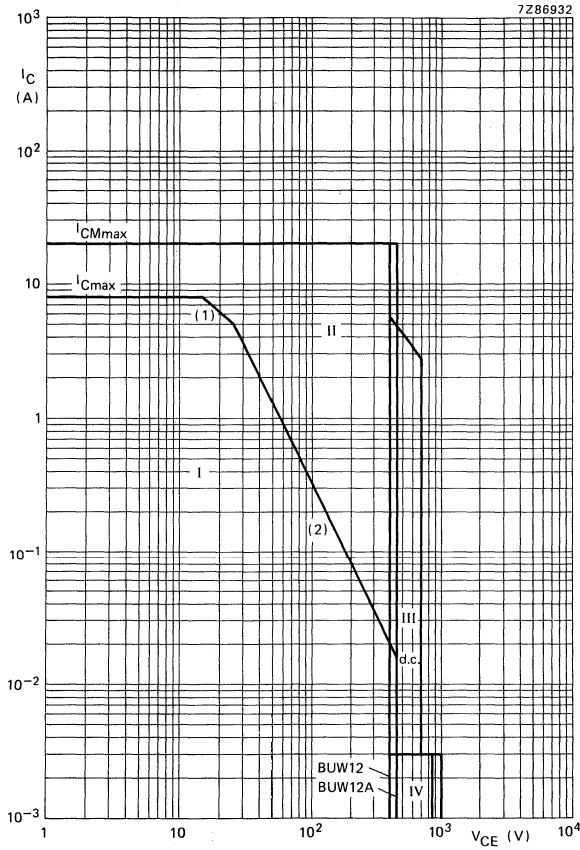


Fig. 8 Safe Operating Area at $T_{mb} \leq 25^\circ\text{C}$.

- (1) P_{tot} max line.
- (2) Second-breakdown limits (independent of temperature).
- I Region of permissible d.c. operation.
- II Permissible extension for repetitive pulse operation.
- III Area of permissible operation during turn-on in single transistor converters, provided $R_{BE} \leq 100 \Omega$ and $t_p \leq 0,6 \mu\text{s}$.
- IV Repetitive pulse operation in this region is permissible provided $V_{BE} \leq 0$ and $t_p \leq 2 \text{ms}$.

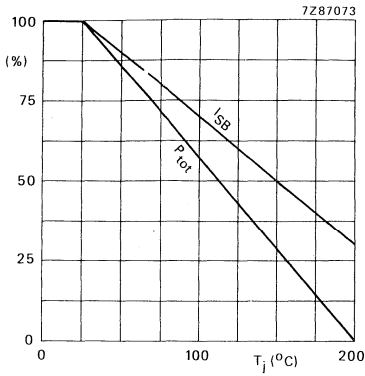


Fig. 9 Total power dissipation and second-breakdown current derating curve.

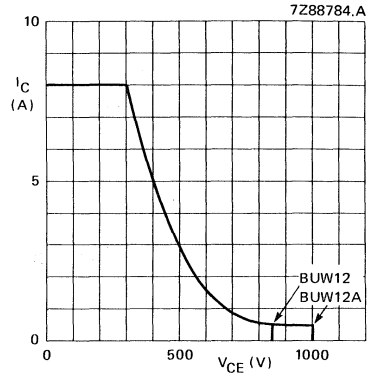


Fig. 10 Reverse bias SOAR.

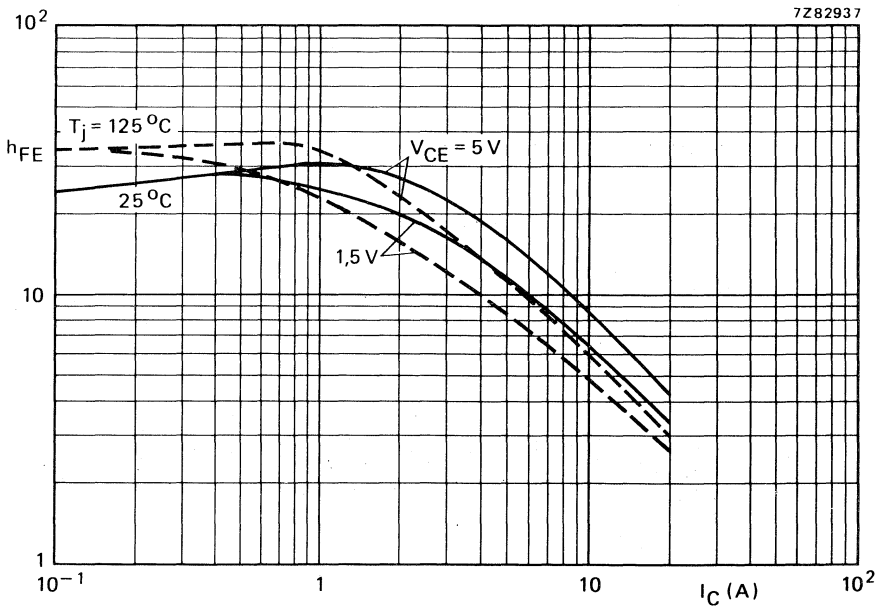


Fig. 11 Typical values d.c. current gain.

DEVELOPMENT SAMPLE DATA

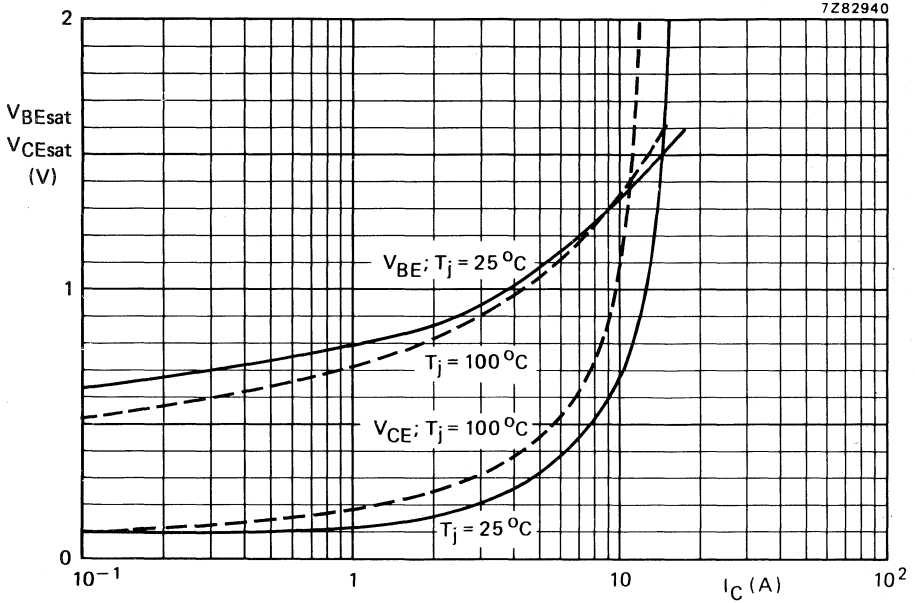


Fig. 12 Typical values base and collector voltage at $I_C/I_B = 5$.

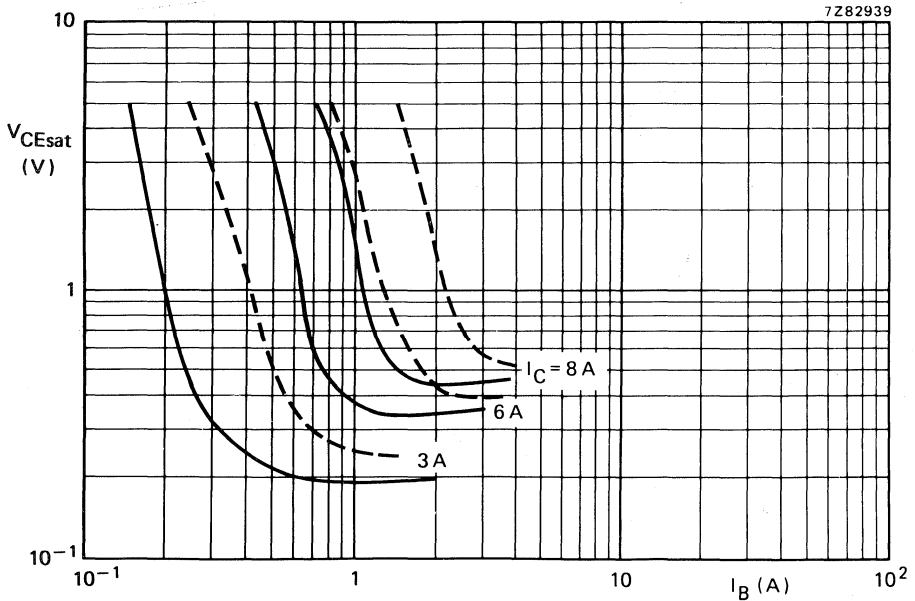


Fig. 13 Typ. (—) and max. (---) values collector-emitter saturation voltage at $T_j = 25^\circ C$.

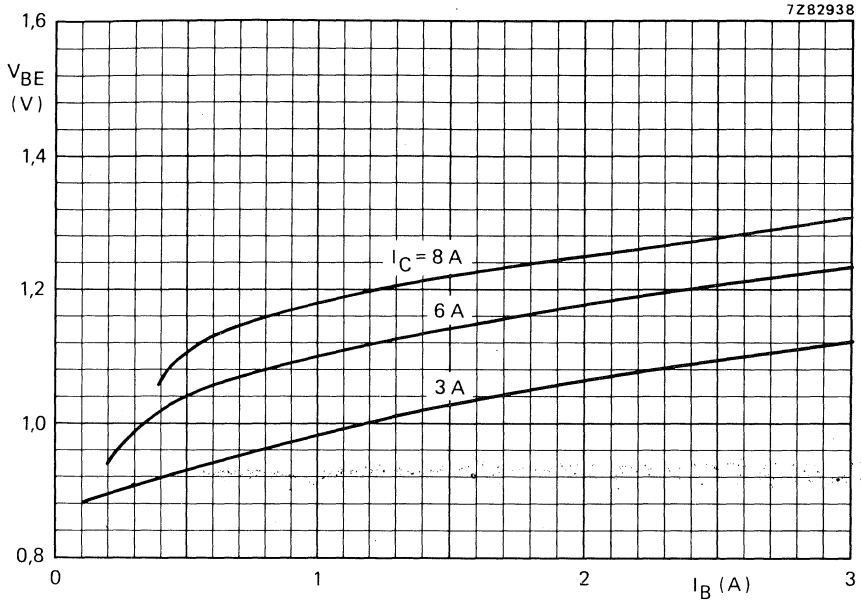


Fig. 14 Typical values base-emitter voltage at $T_j = 25$ °C.

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_{CM} 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):

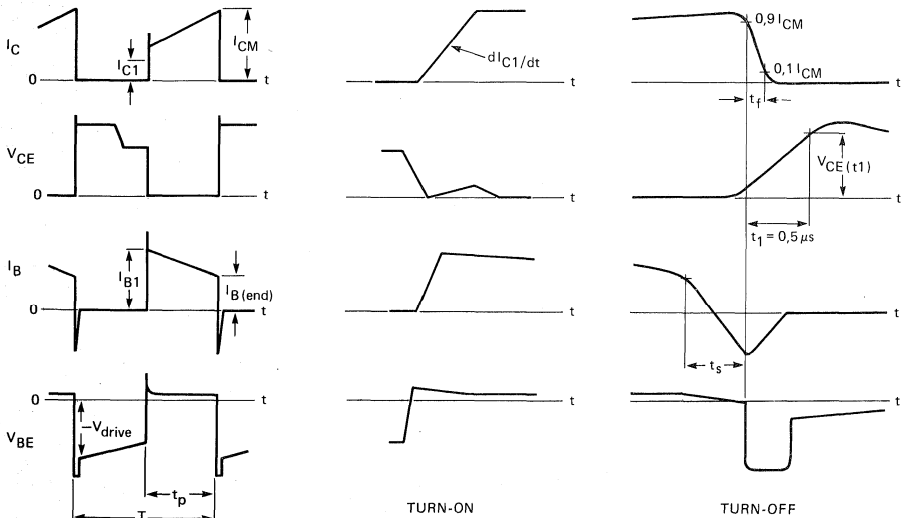
- collector current shape $I_{C1}/I_{CM} = 0,9$
- duty factor $t_p/T = 0,45$
- rate of rise of I_C during turn-on = 8 A/ μ s
- rate of rise of V_{CE} during turn-off = 1 kV/ μ s
- reverse drive voltage during turn-off = 5 V
- base current shape $I_{B1}/I_{BE} = 1,5$

The required thermal resistance of the heatsink can be calculated from

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

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

DEVELOPMENT SAMPLE DATA



7288781

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

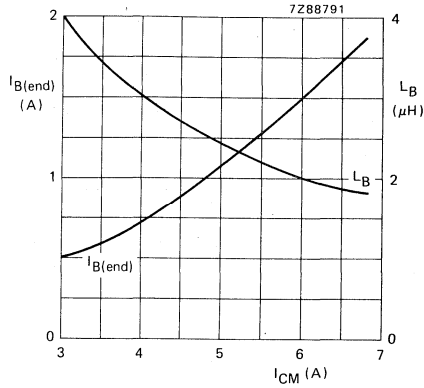


Fig. 16 Recommended nominal "end" value of the base current ($I_{B(e)}$) and optimum base inductance (L_B) at $-V_{drive} = 5 V$ versus maximum peak collector current. $dI_{B(end)} = \pm 20\%$.

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

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

L_{Bnom} is the value given in this graph.

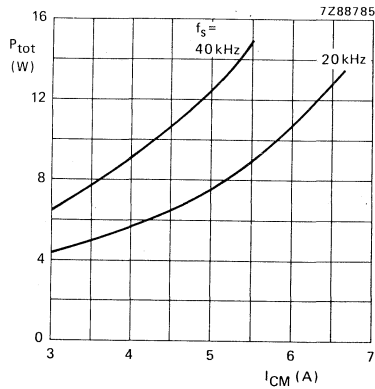


Fig. 17 Maximum transistor dissipation under worst-case operating condition versus maximum peak collector current. $T_{mb} = 100^\circ C$; $dI_{B(end)} = \pm 20\%$.

DEVELOPMENT SAMPLE DATA

This information is derived from development samples made available for evaluation. It does not necessarily imply that the device will go into regular production.

BUW13
BUW13A

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.

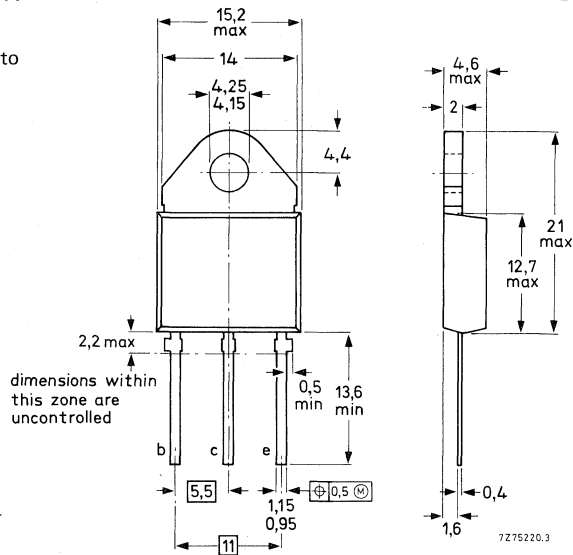
QUICK REFERENCE DATA

		BUW13	BUW13A
Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM} max.	850	1000 V
Collector-emitter voltage (open base)	V_{CEO} max.	400	450 V
Collector current (d.c.)	I_C max.	15	A
Collector current (peak value) $t_p < 2$ ms	I_{CM} max.	30	A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot} max.	175	W
Collector-emitter saturation voltage	$V_{CEsat} <$	1,5	— V
	$V_{CEsat} <$	—	1,5 V
Fall time	$t_f <$	0,8	— μs
	$t_f <$	—	0,8 μs
$I_C = 10$ A; $I_B = 2$ A			
$I_C = 8$ A; $I_B = 1,6$ A			
$I_{Con} = 10$ A; $I_{Bon} = -I_{Boff} = 2$ A			
$I_{Con} = 8$ A; $I_{Bon} = -I_{Boff} = 1,6$ A			

MECHANICAL DATA

Fig. 1 SOT-93.

Collector connected to mounting base



See also chapters Mounting instructions and Accessories.

RATINGS

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

		BUW13	BUW13A	
Collector-emitter voltage (peak value, $V_{BE} = 0$)	V_{CESM}	max. 850	1000	V
Collector-emitter voltage (open base)	V_{CEO}	max. 400	450	V
Collector current (d.c.)	I_C	max. 15		A
Collector current (peak value); $t_p < 2$ ms	I_{CM}	max. 30		A
Base current (d.c.)	I_B	max. 6		A
Base current (peak value); $t_p < 2$ ms	I_{BM}	max. 9		A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot}	max. 175		W
Storage temperature	T_{stg}	-65 to +150		°C
Junction temperature	T_j	max. 150		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=	0,7	K/W
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CHARACTERISTICS

$T_j = 25$ °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

I_{CES}	<	1	mA
I_{CES}	<	4	mA

Emitter cut-off current

I_{EBO}	<	10	mA
-----------	---	----	----

Saturation voltages

$I_C = 10$ A; $I_B = 2$ A

$I_C = 8$ A; $I_B = 1,6$ A

	BUW13	BUW13A	
V_{CEsat}	< 1,5	-	V
V_{BEsat}	< 1,6	-	V
V_{CEsat}	< -	1,5	V
V_{BEsat}	< -	1,6	V

Collector-emitter sustaining voltage

$I_C = 100$ mA; $I_{Boff} = 0$; $L = 25$ mH

$V_{CEO_{sust}}$	> 400	450	V
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* Measured with a half sine-wave voltage (curve tracer).

CHARACTERISTICS (continued)

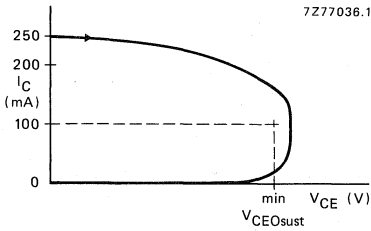


Fig. 2 Oscilloscope display for sustaining voltage.

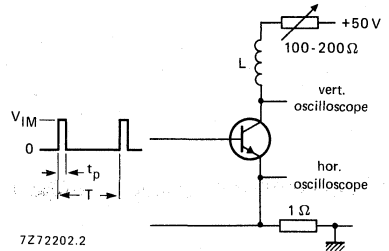


Fig. 3 Test circuit for $V_{CE0sust}$

DEVELOPMENT SAMPLE DATA

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

$I_{Con} = 10 \text{ A}; I_B = 2 \text{ A}; T_j = 100 \text{ }^\circ\text{C}$

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

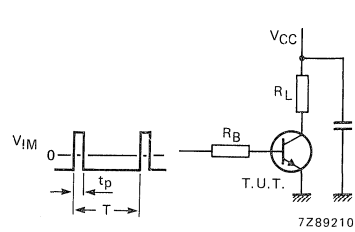
Fall time

$I_{Con} = 8 \text{ A}; I_B = 1,6 \text{ A}; T_j = 100 \text{ }^\circ\text{C}$

Turn-off: Storage time

Fall time

	BUW13	BUW13A	
t_{on}	< 1	—	μs
t_s	< 4	—	μs
t_f	< 0,8	—	μs
t_{on}	< —	1	μs
t_s	< —	4	μs
t_f	< —	0,8	μs
t_s	typ. < 2,3	—	μs
	< 3,0	—	μs
t_f	typ. < 80	—	ns
	< 150	—	ns
t_s	typ. < 2,5	—	μs
	< 3,2	—	μs
t_f	typ. < 140	—	ns
	< 300	—	ns
t_s	typ. < —	2,3	μs
	< —	3,0	μs
t_f	typ. < —	80	ns
	< —	150	ns
t_s	typ. < —	2,5	μs
	< —	3,2	μs
t_f	typ. < —	140	ns
	< —	300	ns



$V_{CC} = 250 \text{ V}$
 $V_{IM} = -6 \text{ to } +8 \text{ V}$
 $t_p = 20 \mu\text{s}$
 $\frac{t_p}{T} = 0,01$
 The values of R_B and R_L are selected in accordance with I_{Con} and I_B requirements.

Fig. 4 Test circuit resistive load.

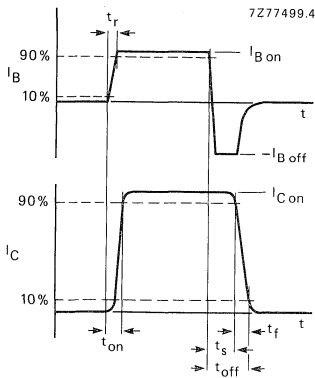


Fig. 5 Switching times waveforms with resistive load.

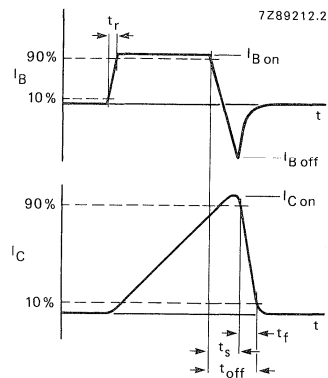
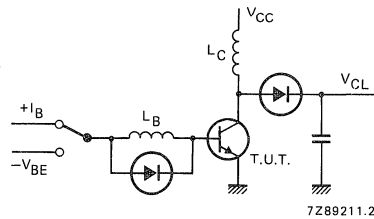


Fig. 6 Switching times waveforms with inductive load.



$V_{CL} = 300 \text{ V}$
 $V_{CC} = 30 \text{ V}$
 $-V_{BE} = 5 \text{ V}$
 $L_B = 1 \mu\text{H}$
 $L_C = 200 \mu\text{H}$

Fig. 7 Test circuit inductive load.

DEVELOPMENT SAMPLE DATA

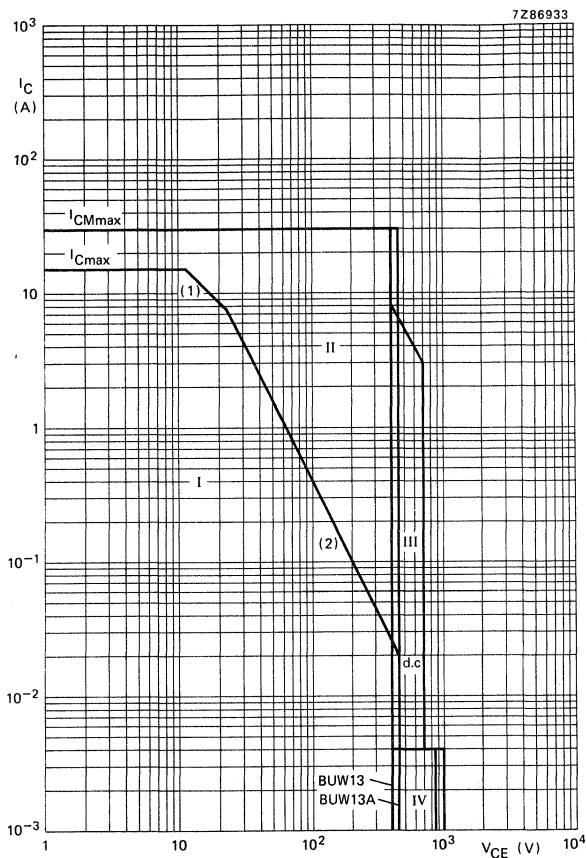


Fig. 8 Safe Operating Area at $T_{mb} \leq 25^\circ\text{C}$.

- (1) P_{tot} max line.
- (2) Second-breakdown limits (independent of temperature).

- I Region of permissible d.c. operation.
- II Permissible extension for repetitive pulse operation.
- III Area of permissible operation during turn-on in single transistor converters, provided $R_{BE} \leq 100 \Omega$ and $t_p \leq 0,6 \mu\text{s}$.
- IV Repetitive pulse operation in this region is permissible provided $V_{BE} \leq 0$ and $t_p \leq 5 \text{ms}$.

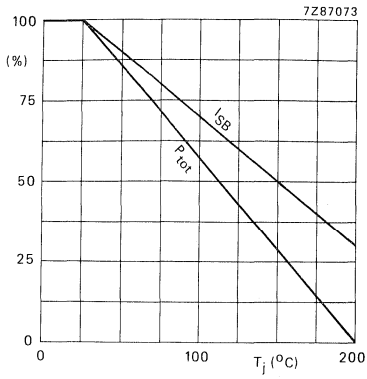


Fig. 9 Total power dissipation and second-breakdown current derating curve.

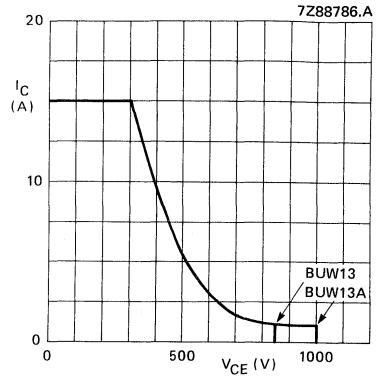


Fig. 10 Reverse bias SOAR.

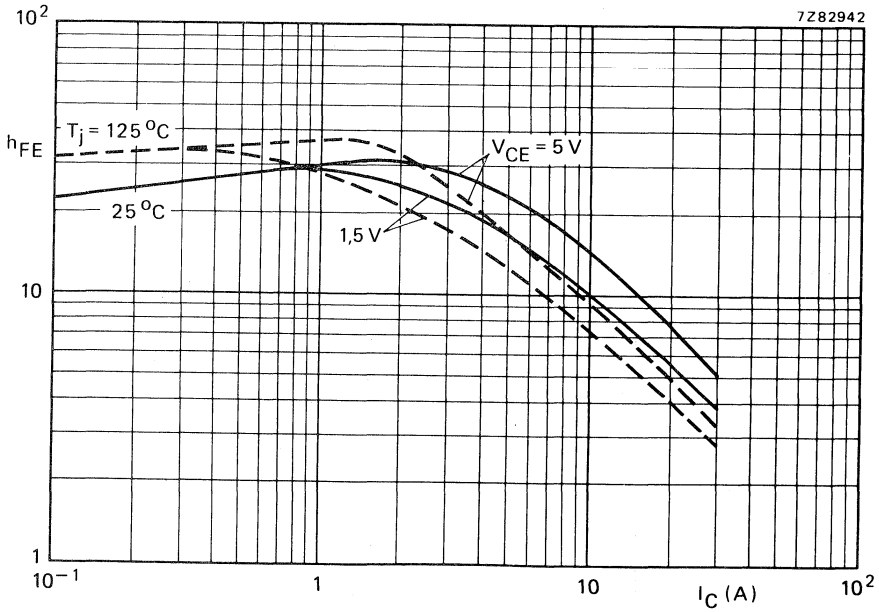


Fig. 11 Typical values d.c. current gain.

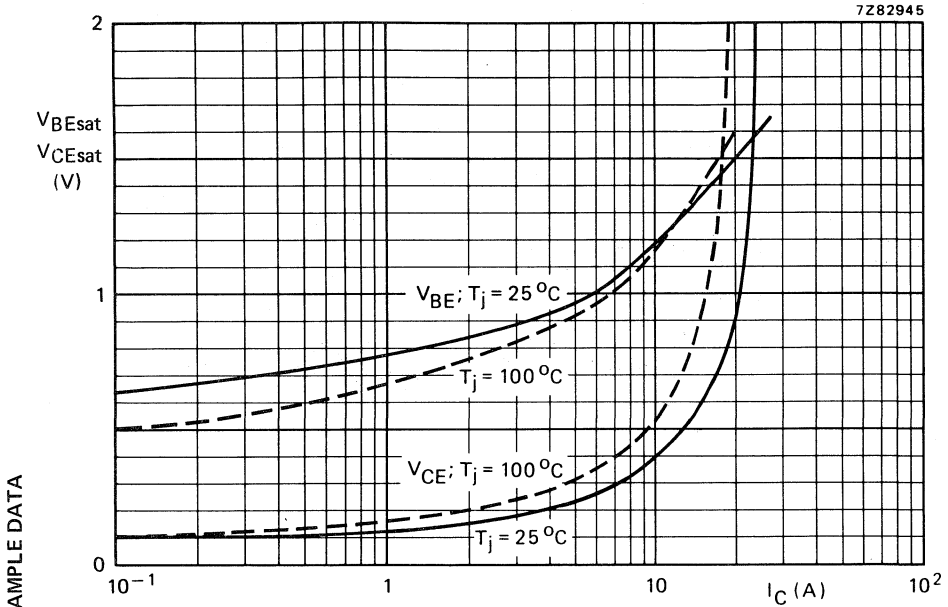


Fig. 12 Typical values base and collector voltage at $I_C/I_B = 5$.

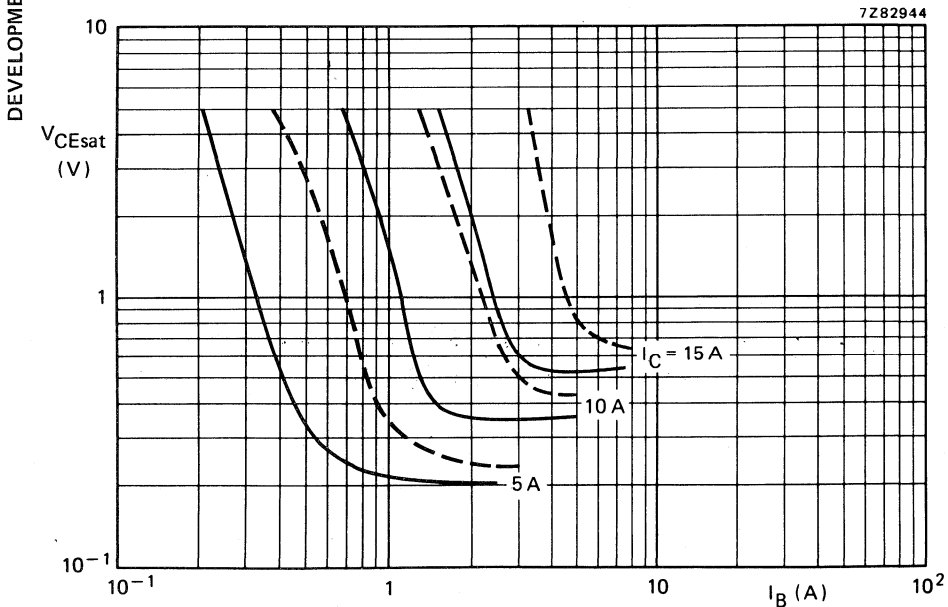


Fig. 13 Typical (—) and maximum (---) values saturation voltage. $T_j = 25^\circ\text{C}$.

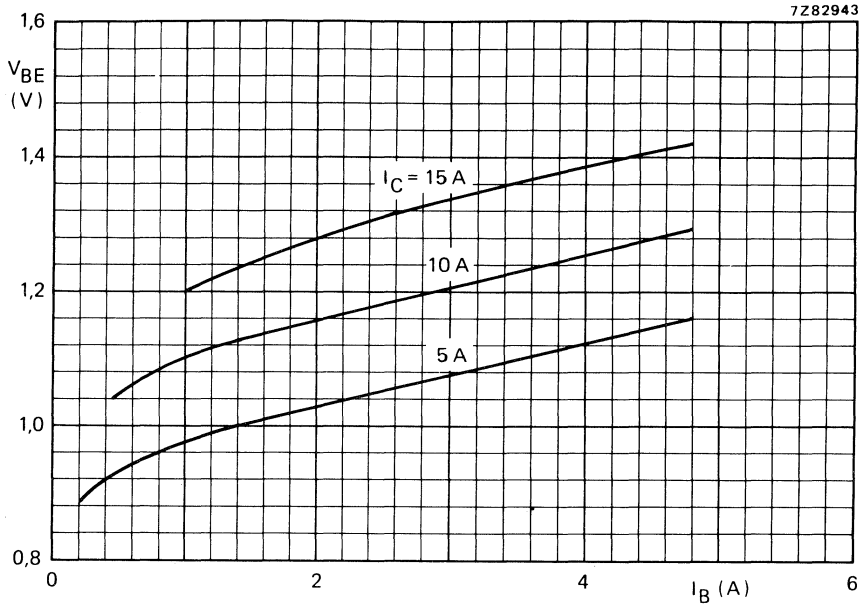


Fig. 14 Typical values base-emitter voltage at $T_j = 25$ °C.



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_{CM} 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):

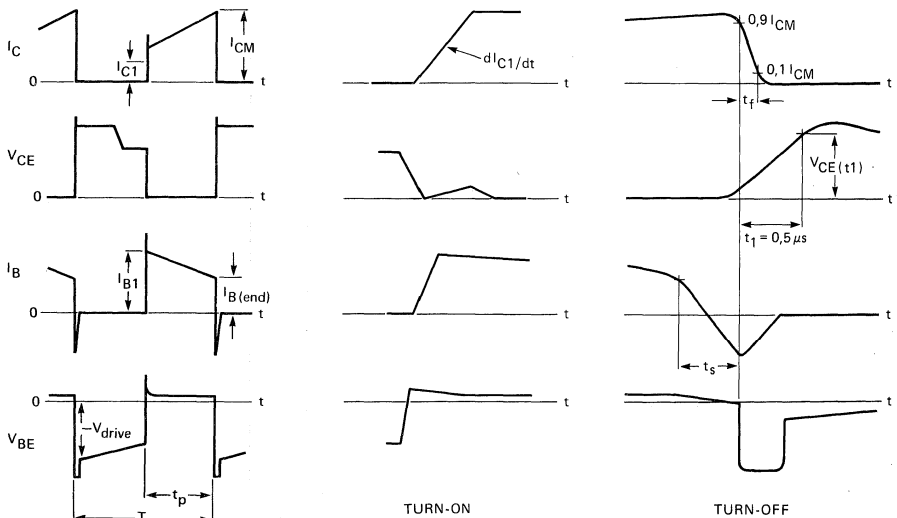
- collector current shape $I_{C1}/I_{CM} = 0,9$
- duty factor $t_p/T = 0,45$
- rate of rise of I_C during turn-on = 10 A/ μ s
- rate of rise of V_{CE} during turn-off = 1 kV/ μ s
- reverse drive voltage during turn-off = 5 V
- base current shape $I_{B1}/I_{Be} = 1,5$

The required thermal resistance of the heatsink can be calculated from

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

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

DEVELOPMENT SAMPLE DATA



7Z88781

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

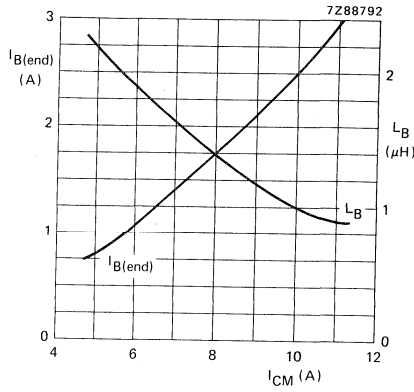


Fig. 16 Recommended nominal "end" value of the base current ($I_{B(e)}$) and optimum base inductance (L_B) at $-V_{drive} = 5$ V versus maximum peak collector current. $dI_{B(end)} = \pm 20\%$.

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

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

L_{Bnom} is the value given in this graph.

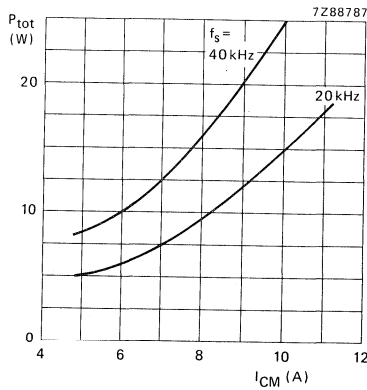


Fig. 17 Maximum transistor dissipation under worst-case operating condition versus maximum peak collector current. $T_{mb} = 100$ $^{\circ}C$; $dI_{B(end)} = \pm 20\%$.

RATINGS

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

		BUW84	BUW85
Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM}	max. 800	1000 V
Collector-emitter voltage (open base)	V_{CEO}	max. 400	450 V
→ Emitter-base voltage (open collector)	V_{EBO}	max. 5	5 V
Collector current (d.c.)	I_C	max. 2	A
Collector current (peak value) $t_p = 2$ ms	I_{CM}	max. 3	A
Base current (d.c.)	I_B	max. 0,75	A
Base current (peak value)	I_{BM}	max. 1	A
Reverse base current (peak value) *	$-I_{BM}$	max. 1	A
Total power dissipation up to $T_{mb} = 45$ °C	P_{tot}	max. 50	W
Storage temperature	T_{stg}	-65 to +150	°C
Junction temperature	T_j	max. 150	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=	2,1	K/W
From junction to ambient in free air	$R_{th\ j-a}$	=	100	K/W

CHARACTERISTICS

$T_j = 25$ °C unless otherwise specified

Collector cut-off current **

$V_{CEM} = V_{CESMmax}; V_{BE} = 0$	I_{CES}	<	200	μA
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$V_{CEM} = V_{CESMmax}; V_{BE} = 0; T_j = 125$ °C	I_{CES}	<	1,5	mA
---	-----------	---	-----	----

D.C. current gain

$I_C = 0,1$ A; $V_{CE} = 5$ V	h_{FE}	typ.	50	
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* Turn-off current.

** Measured with a half sine-wave voltage (curve tracer).

CHARACTERISTICS (continued)

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

Emitter cut-off current

$I_C = 0; V_{EB} = 5\text{ V}$

$I_{EBO} < 1\text{ mA}$

Saturation voltages

$I_C = 0,3\text{ A}; I_B = 30\text{ mA}$

$V_{CEsat} < 0,8\text{ V}$

$I_C = 1\text{ A}; I_B = 0,2\text{ A}$

$V_{CEsat} < 1\text{ V}$

$I_C = 1\text{ A}; I_B = 0,2\text{ A}$

$V_{BEsat} < 1,1\text{ V}$

Collector-emitter sustaining voltage

$I_C = 100\text{ mA}; I_{Boff} = 0; L = 25\text{ mH}$

	BUW84	BUW85	
$V_{CEOsust} >$	400	450	V

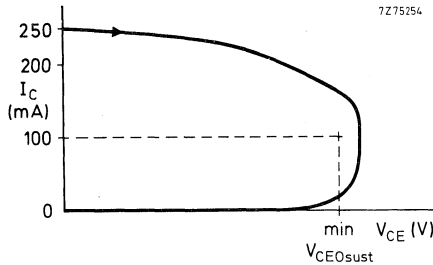


Fig. 2 Oscilloscope display for sustaining voltage.

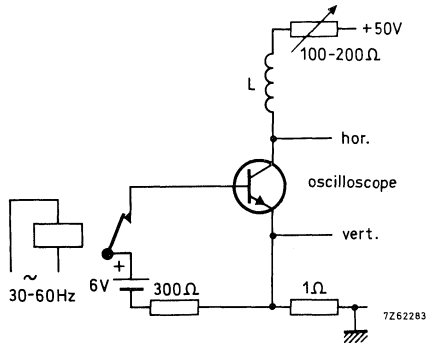


Fig. 3 Test circuit for $V_{CEOsust}$.

CHARACTERISTICS (continued)

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

Transition frequency at $f = 1\text{ MHz}$

$I_C = 0,2\text{ A}; V_{CE} = 10\text{ V}$

f_T typ. 20 MHz

Switching times

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

$I_{Bon} = 0,2\text{ A}; -I_{Boff} = 0,4\text{ A}$

Turn-on time

t_{on} typ. 0,2 μs
< 0,5 μs

Turn-off: Storage time

t_s typ. 2 μs
< 3,5 μs

Fall time

t_f typ. 0,4 μs

Fall time, $T_{mb} = 95\text{ }^\circ\text{C}$

t_f < 1,4 μs

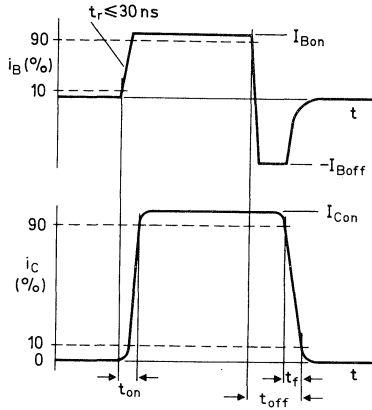


Fig. 4 Waveforms.

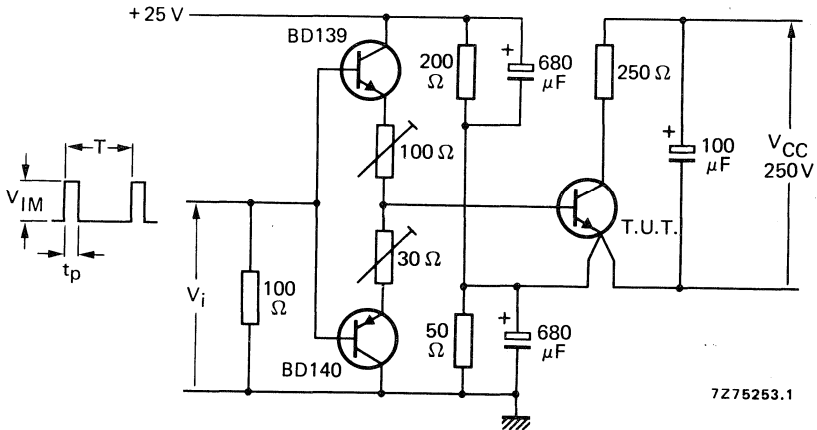


Fig. 5 Test circuit.

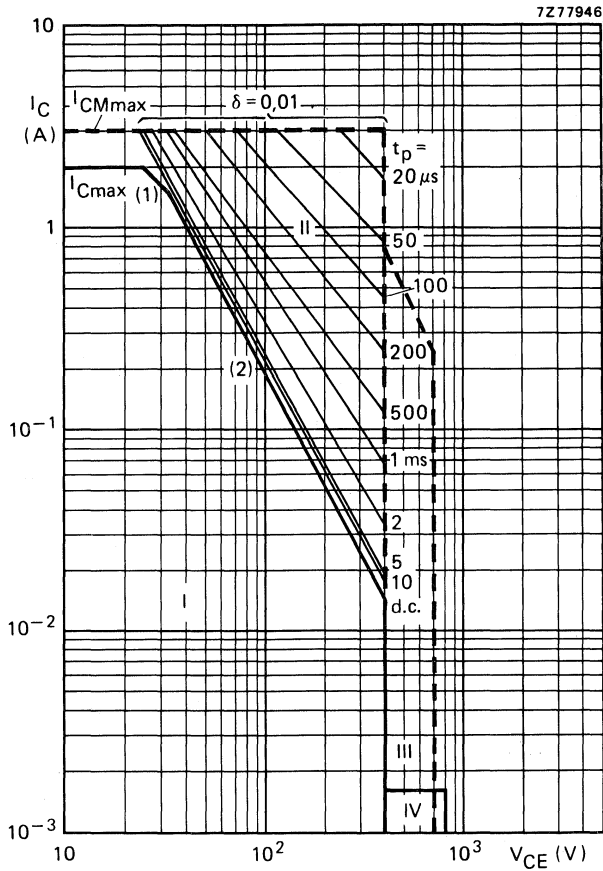


Fig. 6 Safe Operating ARea at $T_{mb} \leq 25^\circ\text{C}$ of BUW84.

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

(1) P_{tot} max line.

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

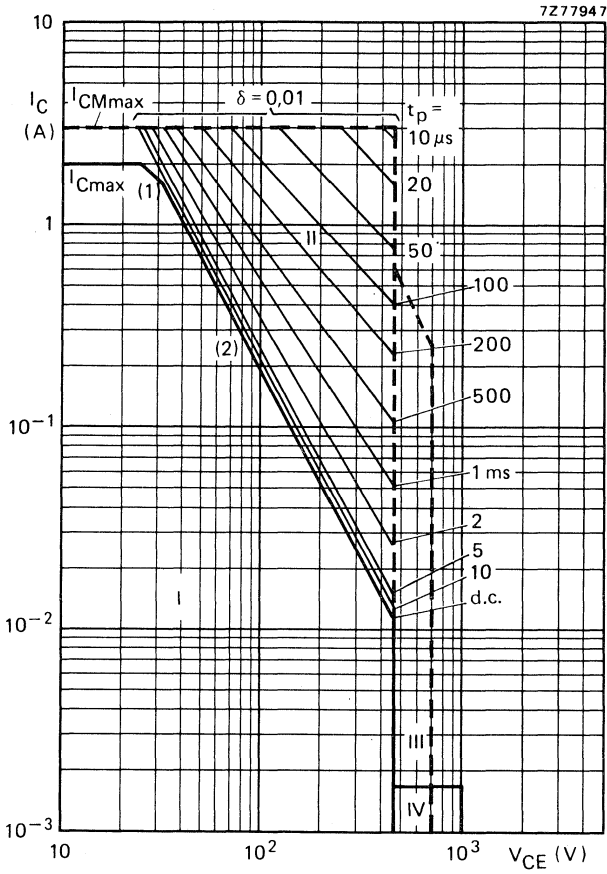


Fig. 7 Safe Operating Area at $T_{mb} \leq 25^\circ C$ of BUW85.

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

(1) P_{tot} max line.

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

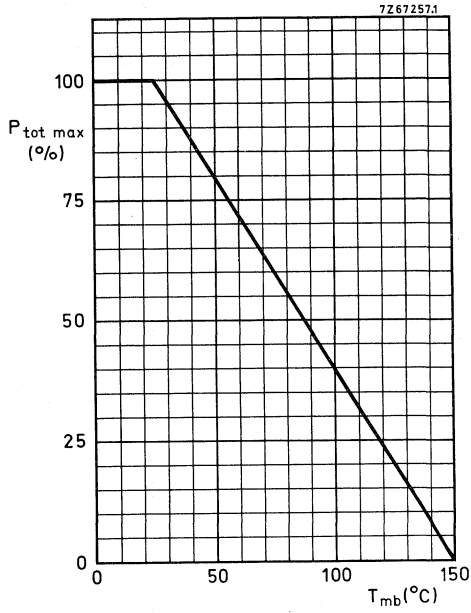


Fig. 8.

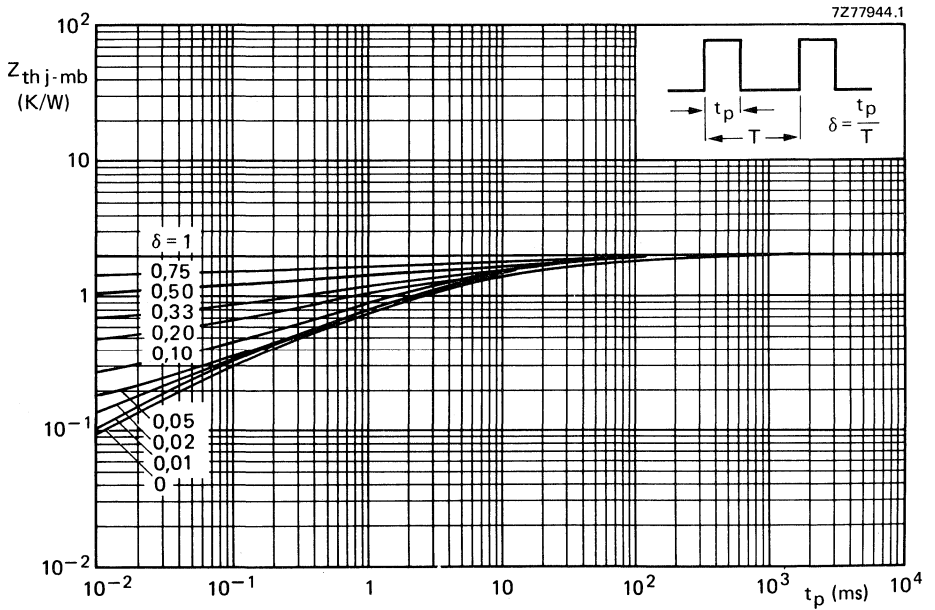


Fig. 9.

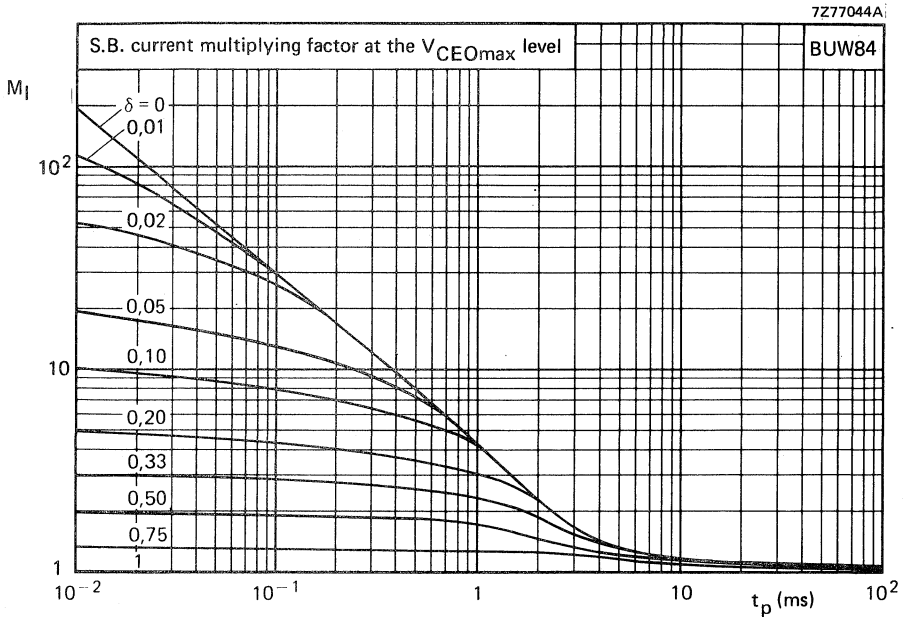


Fig. 10.

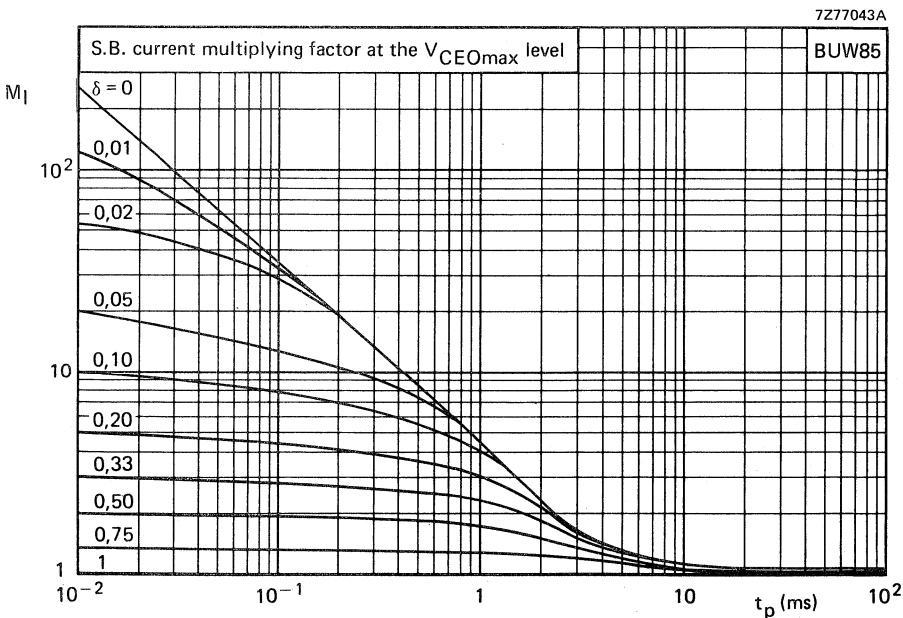


Fig. 11.

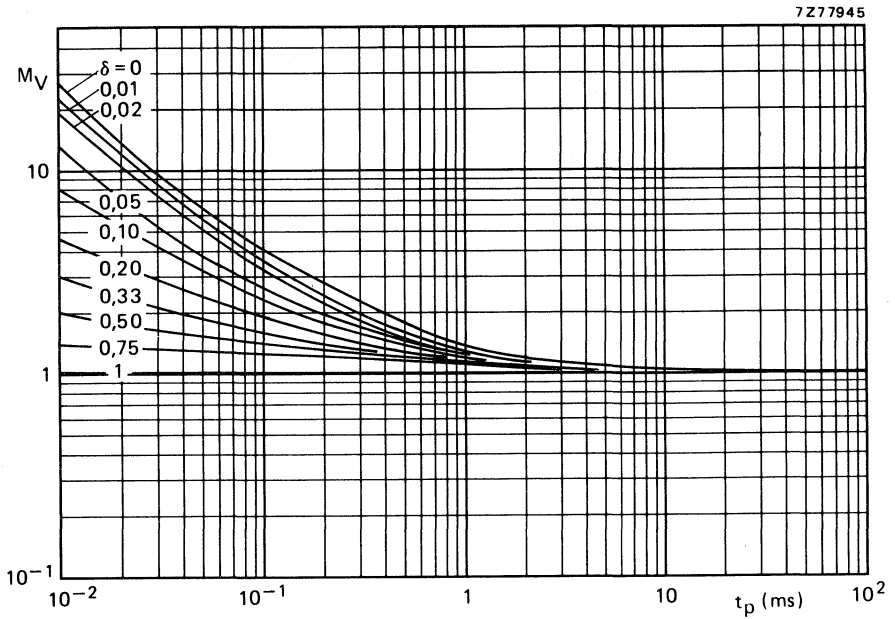


Fig. 12 S.B. voltage multiplying factor at the I_{Cmax} level.

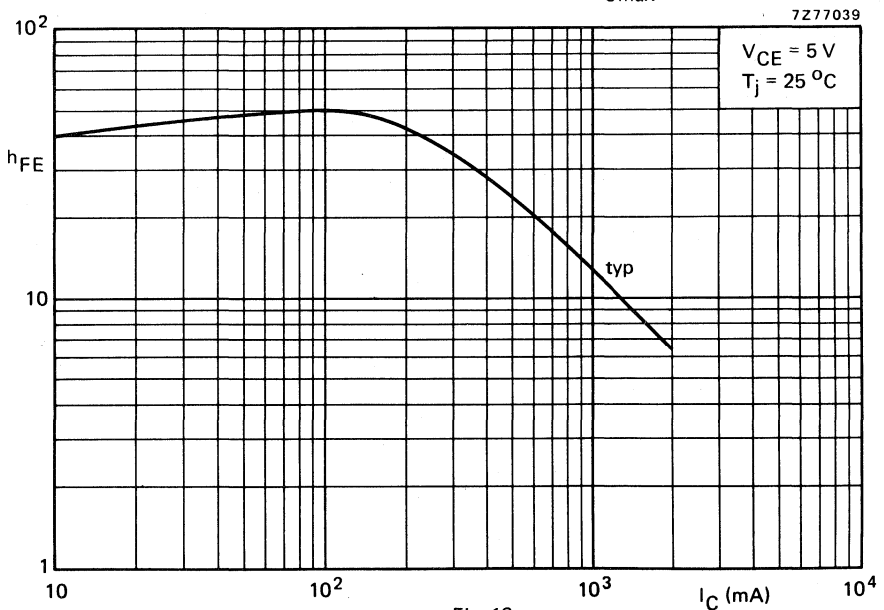


Fig. 13.

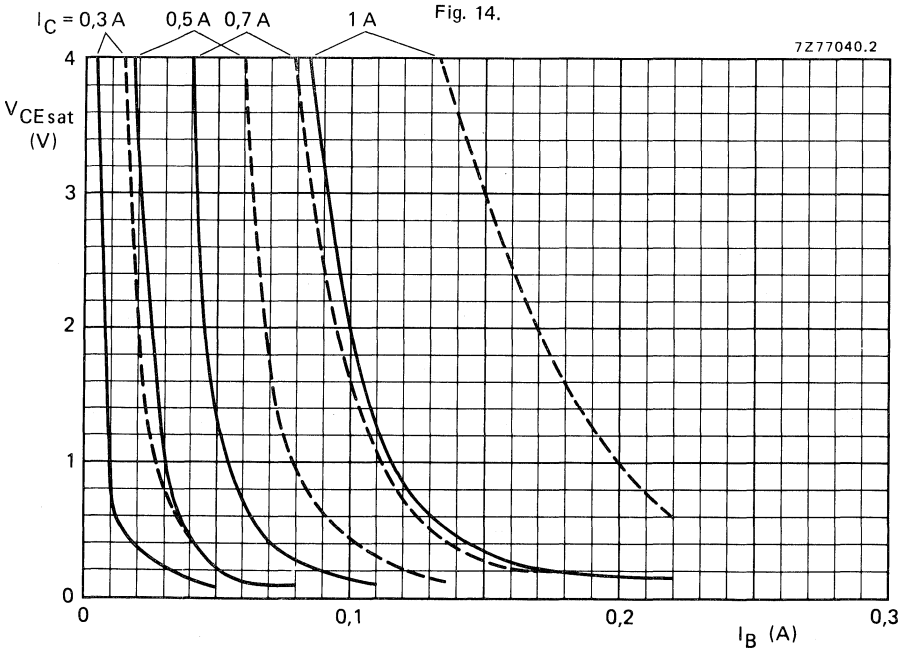
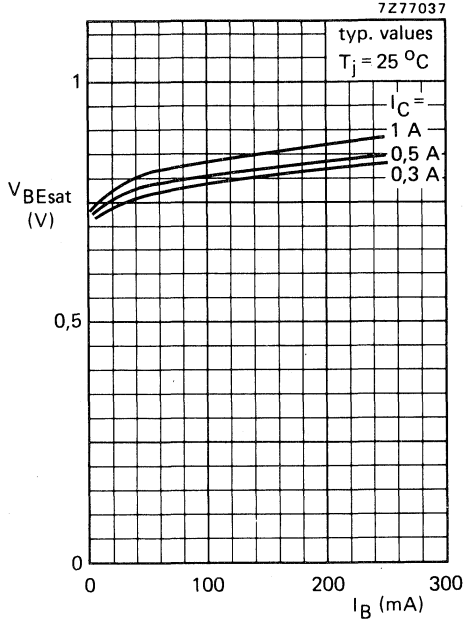


Fig. 15 Typical (—) and maximum (---) values saturation voltage at $T_j = 25^\circ\text{C}$.

SILICON DIFFUSED POWER TRANSISTORS

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

QUICK REFERENCE DATA

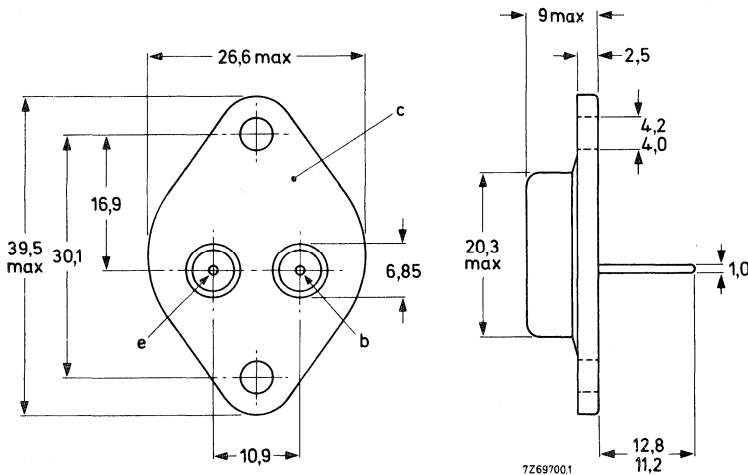
		BUX46	BUX46A	
Collector-emitter voltage ($V_{EB} = 2,5 \text{ V}$)	V_{CEX} max.	850	1000	V
Collector-emitter voltage ($R_{BE} \leq 10 \Omega$)	V_{CER} max.	850	1000	V
Collector-emitter voltage (open base)	V_{CEO} max.	400	450	V
Collector current (d.c.)	I_C max.	3,5		A
Collector current (peak value) $t_p \leq 2 \text{ ms}$	I_{CM} max.	5		A
Total power dissipation up to $T_{mb} = 25 \text{ }^\circ\text{C}$	P_{tot} max.	85		W
Collector-emitter saturation voltage $I_C = 2,5 \text{ A}; I_B = 0,5 \text{ A}$	V_{CEsat} <	1,5		V
Fall time (resistive load) $I_{Con} = 2,5 \text{ A}; I_{Bon} = -I_{Boff} = 0,5 \text{ A}$	t_f <	0,8		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).

			BUX46	BUX46A
Collector-emitter voltage ($V_{EB} = 2,5 \text{ V}$)	V_{CEX}	max.	850	1000 V
Collector-emitter voltage ($R_{BE} \leq 10 \Omega$)	V_{CER}	max.	850	1000 V
Collector-emitter voltage (open base)	V_{CEO}	max.	400	450 V
Collector current (d.c.)	I_C	max.	3,5	A
Collector current (peak value) $t_p < 2 \text{ ms}$	I_{CM}	max.	5	A
Base current (d.c.)	I_B	max.	1,5	A
Base current (peak value); $t_p < 2 \text{ ms}$	I_{BM}	max.	3	A
Total power dissipation up to $T_{mb} = 25 \text{ }^\circ\text{C}$	P_{tot}	max.	85	W
Storage temperature	T_{stg}		-65 to +175	$^\circ\text{C}$
Junction temperature	T_j	max.	175	$^\circ\text{C}$

THERMAL RESISTANCE

From junction to mounting base	$R_{th \text{ j-mb}}$	=	1,75	K/W
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CHARACTERISTICS

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

Collector cut-off current *

$V_{CE} = V_{CERmax}; R_{BE} \leq 10 \Omega$

$V_{CE} = V_{CERmax}; R_{BE} \leq 10 \Omega; T_j = 125 \text{ }^\circ\text{C}$

I_{CER}	<	0,3	mA
I_{CER}	<	2	mA

Emitter cut-off current

$I_C = 0; V_{EB} = 5 \text{ V}$

I_{EBO}	<	1	mA
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Saturation voltages

$I_C = 3,5 \text{ A}; I_B = 0,7 \text{ A}$

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

V_{CEsat}	<	5	V
V_{CEsat}	<	1,5	V
V_{BEsat}	<	1,3	V

Collector-emitter sustaining voltage

$I_C = 200 \text{ mA}; I_B = 0; L = 25 \text{ mH}$

$V_{CEO_{sust}}$	>	400	450 V
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Collector-emitter cut-off current

$V_{CE} = V_{CEXmax}; V_{BE} = -2,5 \text{ V}$

$V_{CE} = V_{CEXmax}; V_{BE} = -2,5 \text{ V}; T_j = 125 \text{ }^\circ\text{C}$

I_{CEX}	<	0,1	mA
I_{CEX}	<	1	mA

Emitter-base breakdown voltage

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

$V_{(BR)EBO}$	<	30	V
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Second breakdown collector current

$V_{CE} = 70 \text{ V}; t = 1 \text{ sec.}$

$I_{(SB)C}$	>	0,5	A
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* Measured with a half sine-wave voltage (curve tracer).

CHARACTERISTICS (continued)

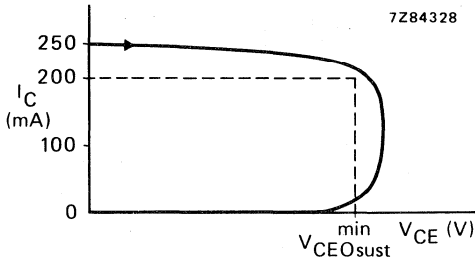


Fig. 2 Oscilloscope display for sustaining voltage.

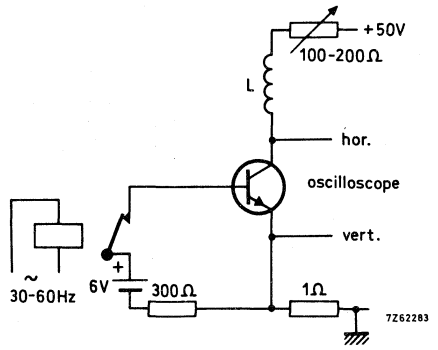


Fig. 3 Test circuit for $V_{CEOsust}$.

Switching times resistive load (Figs 4 and 5)

$I_{Con} = 2,5 \text{ A}$; $I_{Bon} = -I_{Boff} = 0,5 \text{ A}$

Turn-on time

t_{on}	typ.	0,5 μs
	<	1 μs

Turn-off: Storage time

t_s	typ.	1,5 μs
	<	3 μs

Fall time

t_f	typ.	0,5 μs
	<	0,8 μs

Switching times inductive load (Figs 6 and 7)

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

Fall time

t_f	typ.	0,2 μs
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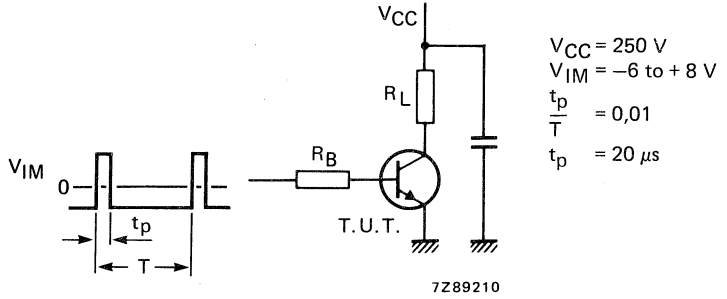


Fig. 4 Test circuit resistive load.

The values of R_B and R_L are selected in accordance with $I_{C\text{on}}$ and I_B requirements.

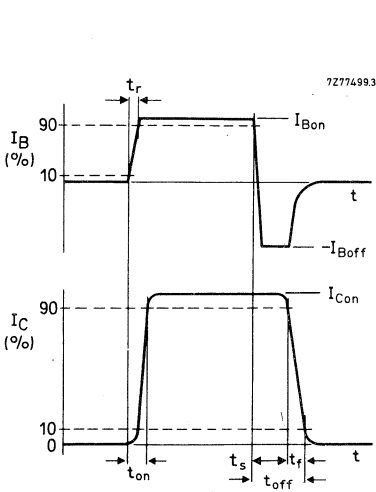


Fig. 5 Switching times waveforms with resistive load.

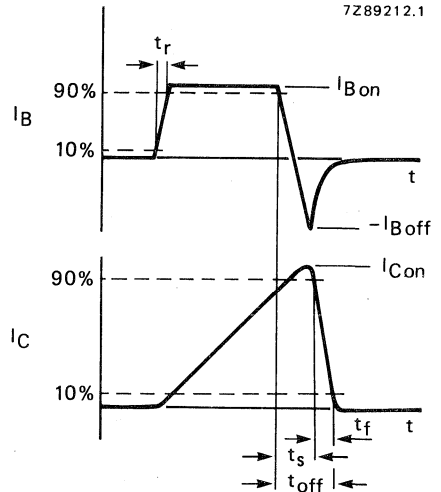


Fig. 6 Switching times waveforms with inductive load.

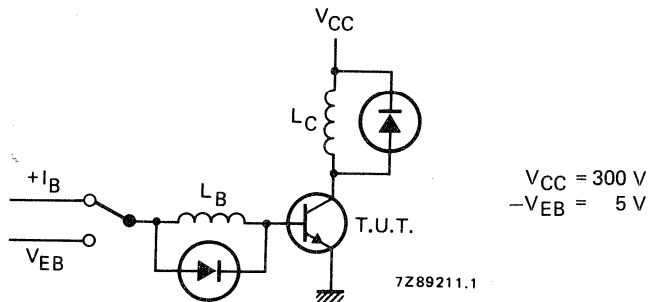


Fig. 7 Test circuit inductive load. $L_C = 1 \text{ mH}$; $L_B = 3 \mu\text{H}$.

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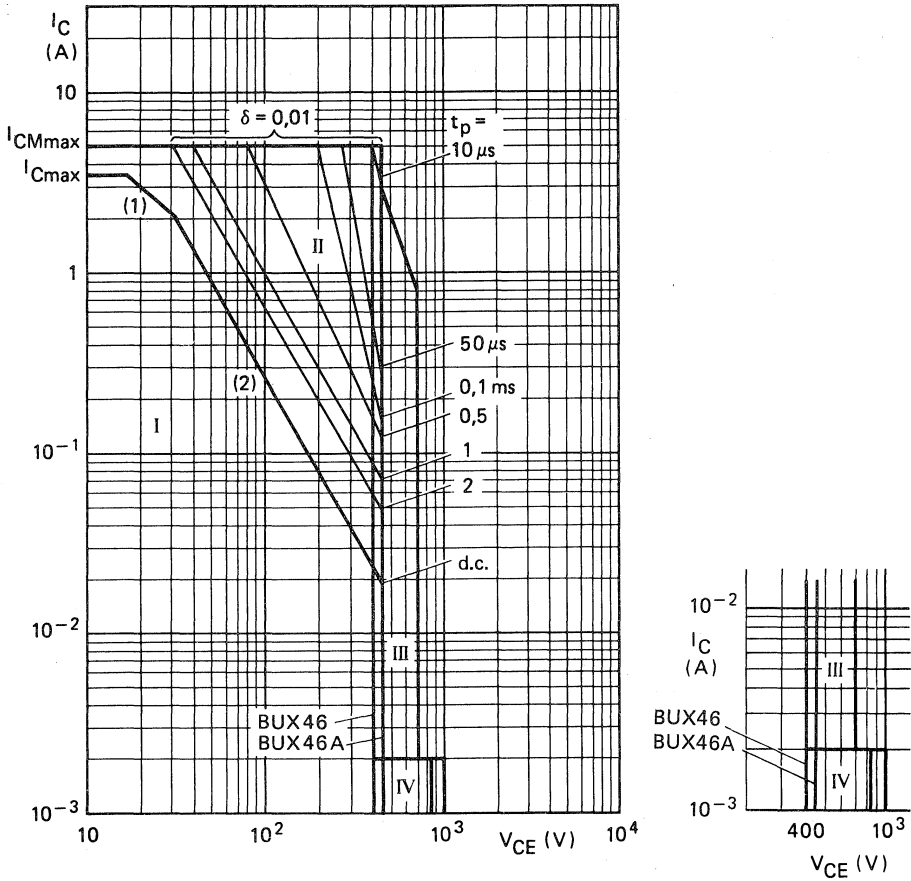


Fig. 8 Safe Operating Area at $T_{mb} \leq 60^\circ C$.

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

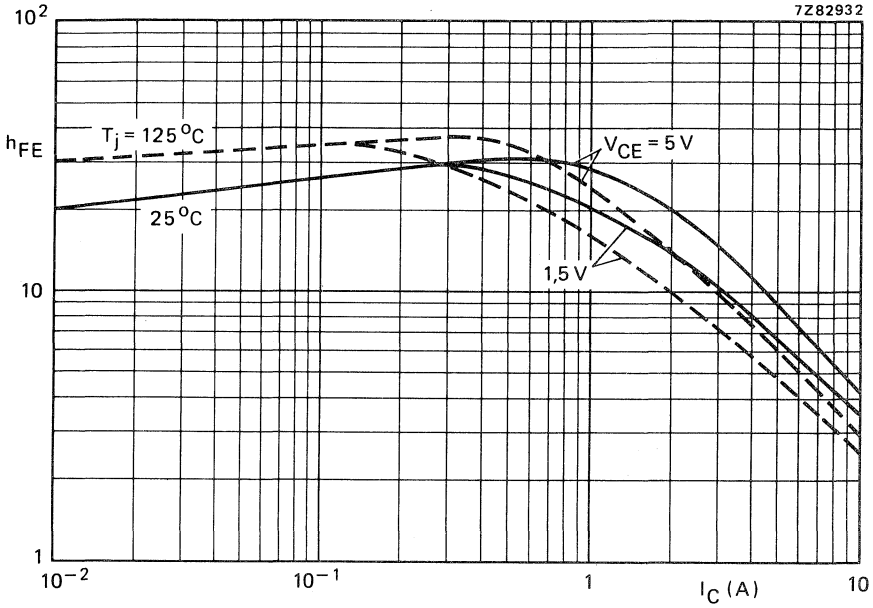


Fig. 9 D.C. current gain.

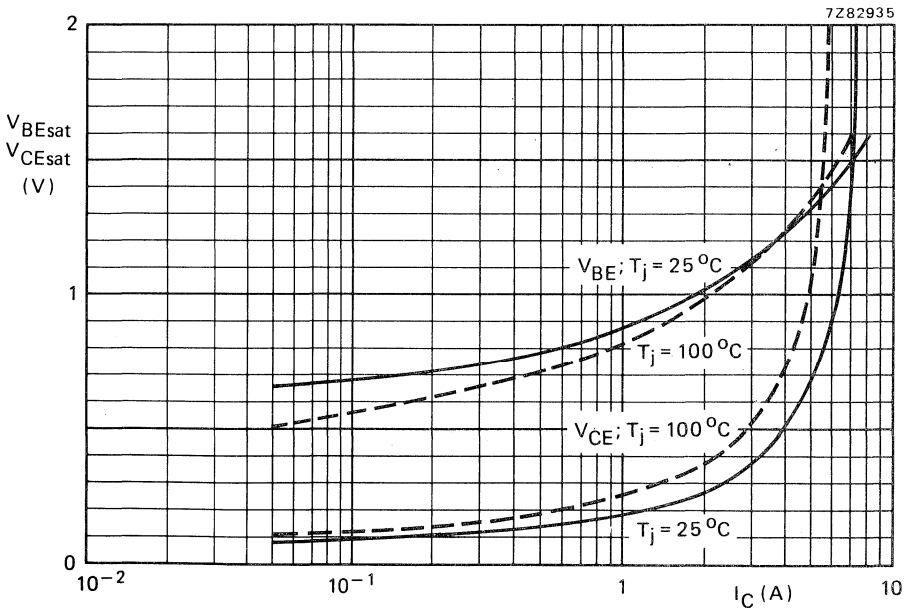


Fig. 10 Typical values base-emitter and collector-emitter voltage, $I_C/I_B = 5$.

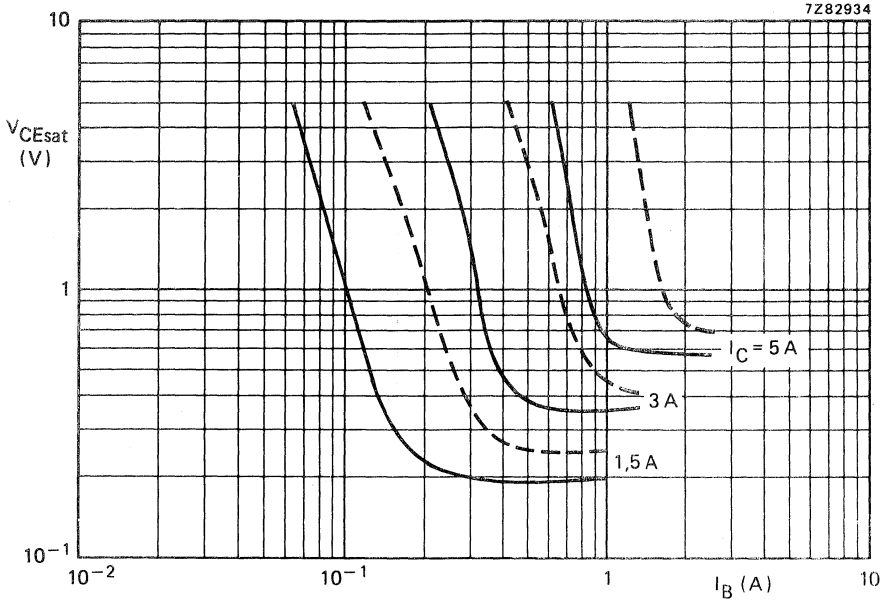


Fig. 11 Typ. (—) and max. (---) values collector-emitter saturation voltage at $T_j = 25^\circ C$.

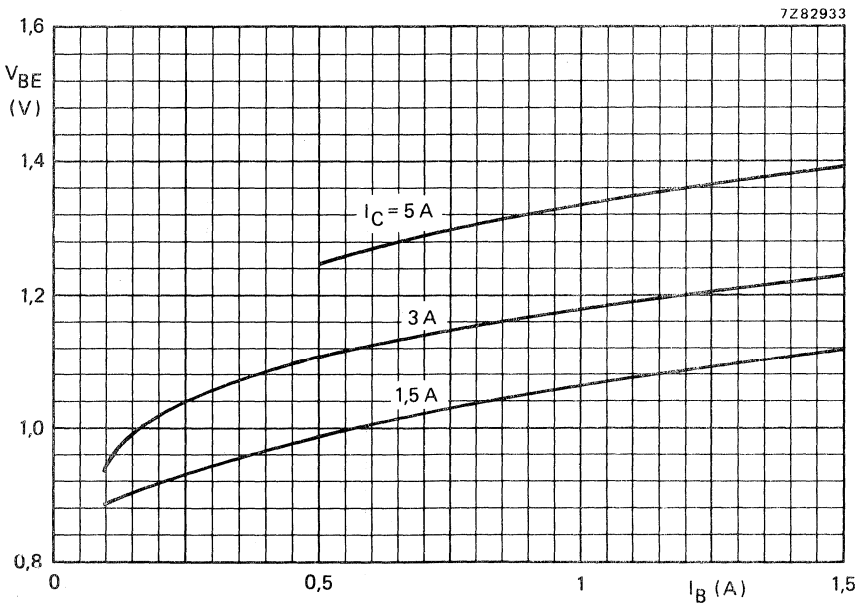


Fig. 12 Typical values at $T_j = 25^\circ C$.

SILICON DIFFUSED POWER TRANSISTORS

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

QUICK REFERENCE DATA

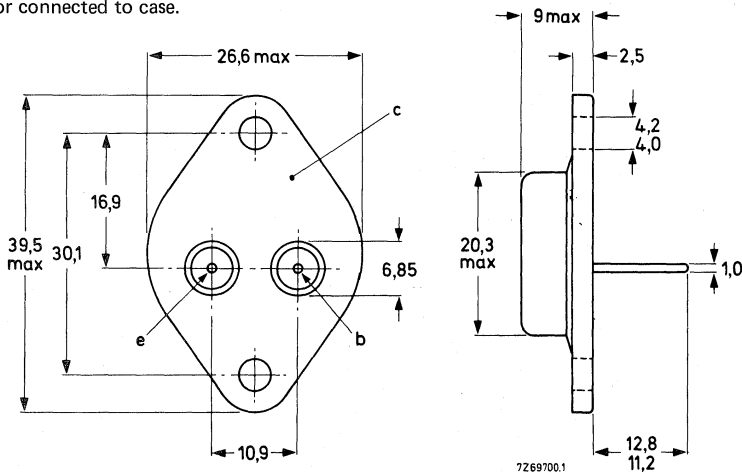
		BUX47	BUX47A	
Collector-emitter voltage ($V_{EB} = 2,5 \text{ V}$)	V_{CEX} max.	850	1000	V
Collector-emitter voltage ($R_{BE} \leq 10 \Omega$)	V_{CER} max.	850	1000	V
Collector-emitter voltage (open base)	V_{CEO} max.	400	450	V
Collector current (d.c.)	I_C max.		9	A
Collector current (peak value) $t_p \leq 5 \text{ ms}$	I_{CM} max.		15	A
Total power dissipation up to $T_{mb} = 25 \text{ }^\circ\text{C}$	P_{tot} max.		125	W
Collector-emitter saturation voltage				
$I_C = 6 \text{ A}; I_B = 1,2 \text{ A}$	$V_{CEsat} <$	1,5	—	V
$I_C = 5 \text{ A}; I_B = 1 \text{ A}$	$V_{CEsat} <$	—	1,5	V
Fall time (resistive load)				
$I_{Con} = 6 \text{ A}; I_{Bon} = -I_{Boff} = 1,2 \text{ A}$	$t_f <$	0,8	—	μs
$I_{Con} = 5 \text{ A}; I_{Bon} = -I_{Boff} = 1 \text{ A}$	$t_f <$	—	0,8	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)

			BUX47	BUX47A	
Collector-emitter voltage ($V_{EB} = 2,5 \text{ V}$)	V_{CEX}	max.	850	1000	V
Collector-emitter voltage ($R_{BE} \leq 10 \Omega$)	V_{CER}	max.	850	1000	V
Collector-emitter voltage (open base)	V_{CEO}	max.	400	450	V
Collector current (d.c.)	I_C	max.	9		A
Collector current (peak value); $t_p \leq 5 \text{ ms}$	I_{CM}	max.	15		A
Base current (d.c.)	I_B	max.	3		A
Base current (peak value); $t_p \leq 5 \text{ ms}$	I_{BM}	max.	6		A
Total power dissipation up to $T_{mb} = 25 \text{ }^\circ\text{C}$	P_{tot}	max.	125		W
Storage temperature	T_{stg}		-65 to +200		$^\circ\text{C}$
Junction temperature	T_j	max.	200		$^\circ\text{C}$

THERMAL RESISTANCE

From junction to mounting base	$R_{th \text{ j-mb}}$	=	1,4		K/W
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CHARACTERISTICS

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

Collector cut-off current*

$V_{CE} = V_{CERmax}; R_{BE} \leq 10 \Omega$	I_{CER}	<	0,4		mA
$V_{CE} = V_{CERmax}; R_{BE} \leq 10 \Omega; T_j = 125 \text{ }^\circ\text{C}$	I_{CER}	<	3		mA

Emitter cut-off current

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

$I_C = 6 \text{ A}; I_B = 1,2 \text{ A}$	V_{CEsat}	<	1,5		V
$I_C = 9 \text{ A}; I_B = 1,8 \text{ A}$	V_{CEsat}	<	5		V
$I_C = 5 \text{ A}; I_B = 1 \text{ A}$	V_{CEsat}	<	-	1,5	V
$I_C = 8 \text{ A}; I_B = 1,6 \text{ A}$	V_{CEsat}	<	-	5	V
$I_C = 6 \text{ A}; I_B = 1,2 \text{ A}$	V_{BEsat}	<	1,6		V
$I_C = 5 \text{ A}; I_B = 1 \text{ A}$	V_{BEsat}	<	-	1,6	V

Collector-emitter sustaining voltage

$I_C = 200 \text{ mA}; I_B = 0; L = 25 \text{ mH}$	$V_{CEO_{sust}}$	>	400	450	V
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Emitter-base breakdown voltage

$I_C = 0; I_B = 0,5 \text{ A}$	$V_{(BR)EBO}$		7 to 30		V
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Collector cut-off current

$V_{CE} = V_{CEXmax}; V_{BE} = -2,5 \text{ V}$	I_{CEX}	<	0,15		mA
$V_{CE} = V_{CEXmax}; V_{BE} = -2,5 \text{ V}; T_j = 125 \text{ }^\circ\text{C}$	I_{CEX}	<	1,5		mA

* Measured with a half sine-wave voltage (curve tracer).

CHARACTERISTICS (continued)

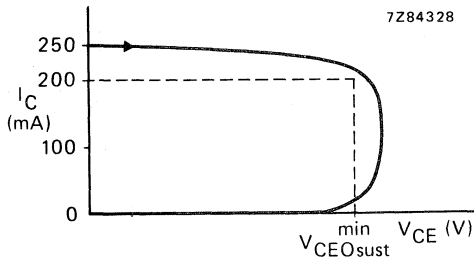


Fig. 2 Oscilloscope display for sustaining voltage.

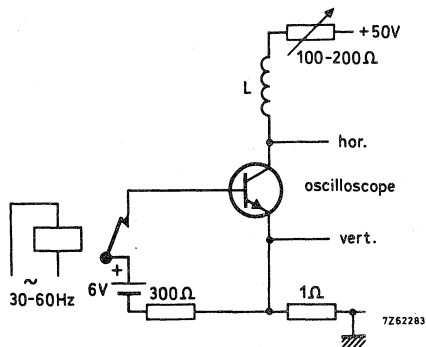


Fig. 3 Test circuit for $V_{CE(sust)}$.

Switching times resistive load (Figs 4 and 5)

BUX47: $I_{Con} = 6\text{ A}$; $I_{Bon} = -I_{Boff} = 1,2\text{ A}$

BUX47A: $I_{Con} = 5\text{ A}$; $I_{Bon} = -I_{Boff} = 1\text{ A}$

Turn-on time

t_{on}	typ.	0,6 μs
	<	1,0 μs

Turn-off: Storage time

t_s	typ.	2,8 μs
	<	3,0 μs

Fall time

t_f	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_s	typ.	2,5 μs
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Storage time; $T_j = 100\text{ }^\circ\text{C}$

t_s	<	4 μs
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Fall time

t_f	typ.	80 ns
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Fall time; $T_j = 100\text{ }^\circ\text{C}$

t_f	<	400 ns
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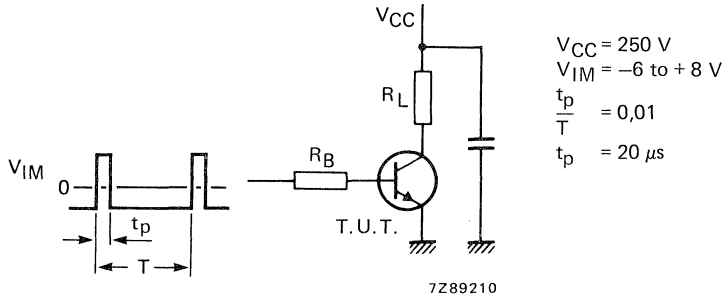


Fig. 4 Test circuit resistive load. The values of R_B and R_L are selected in accordance with $I_{C\text{on}}$ and I_B requirements.

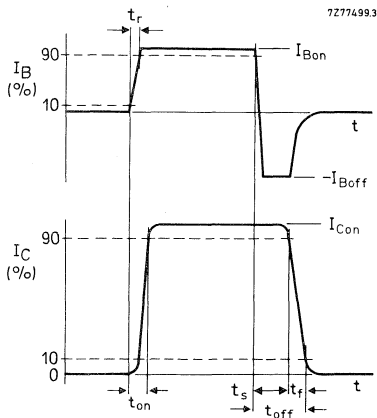


Fig. 5 Switching times waveforms with resistive load.

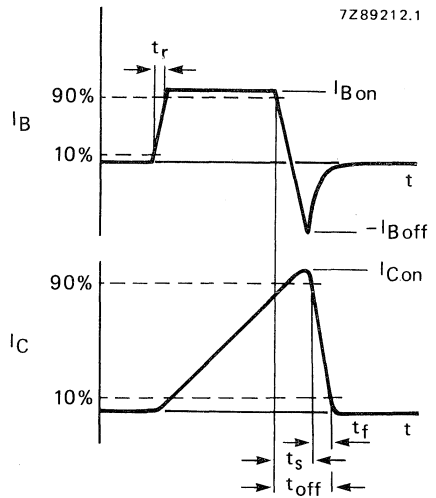


Fig. 6 Switching times waveforms with inductive load.

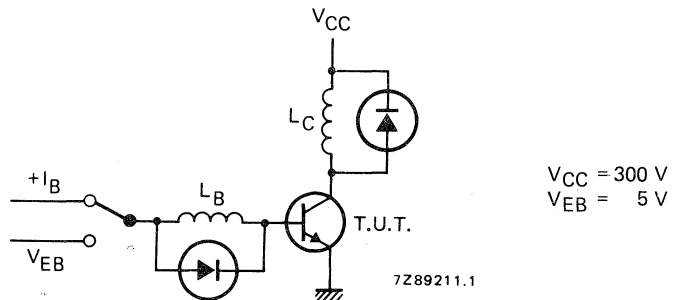


Fig. 7 Test circuit inductive load. $L_C = 1,5 \text{ mH}$; $L_B = 3 \mu\text{H}$.

7Z88306

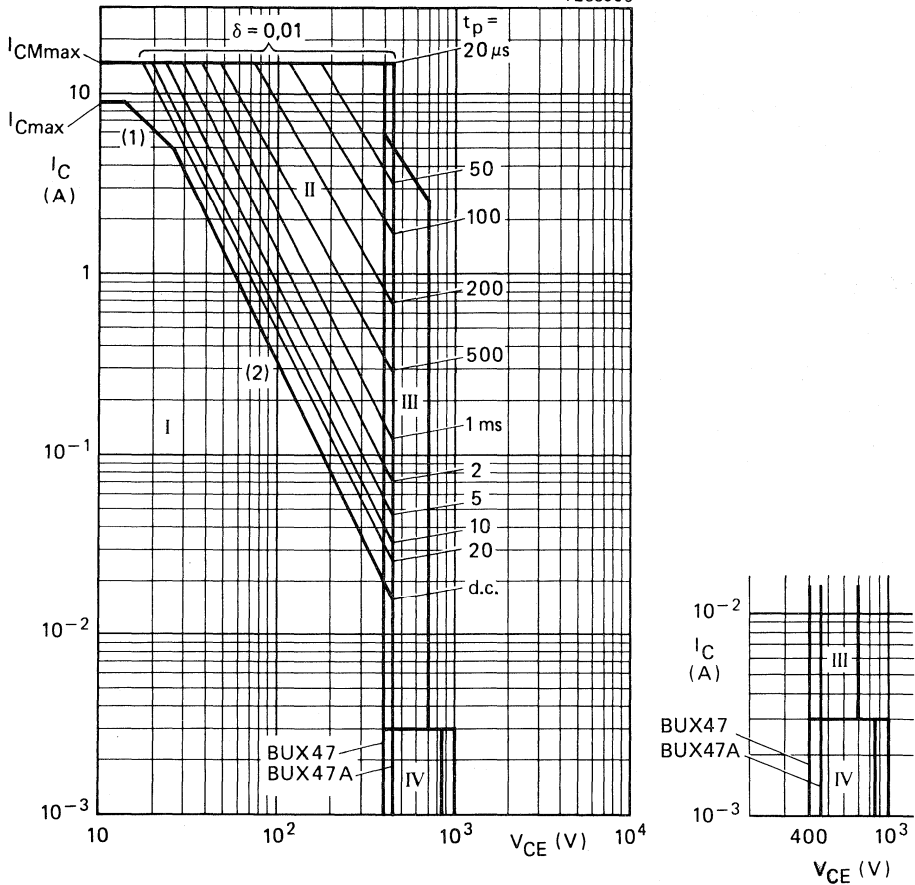


Fig. 8 Safe Operating Area at $T_{mb} \leq 25^\circ\text{C}$.

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

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

7Z82937

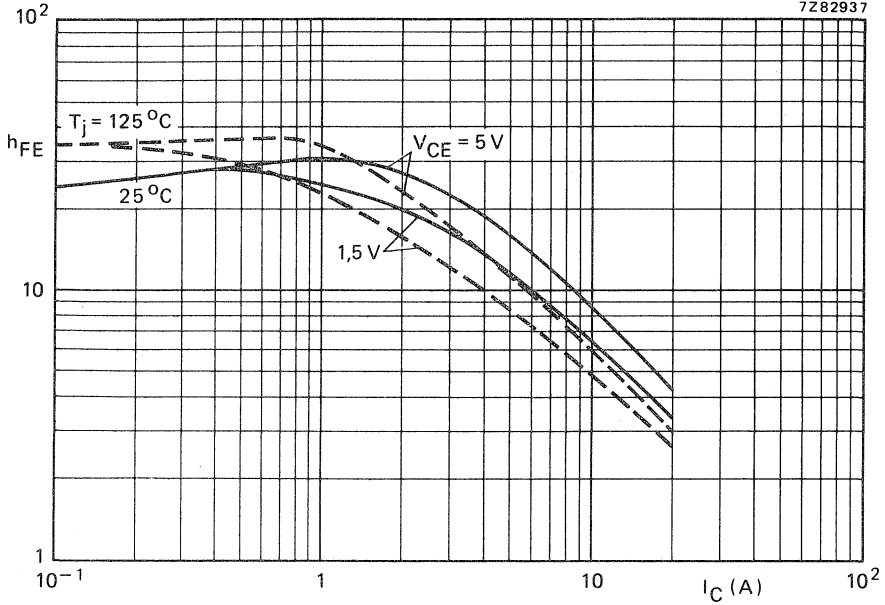


Fig. 9 Typical values d.c. current gain.

7Z82940

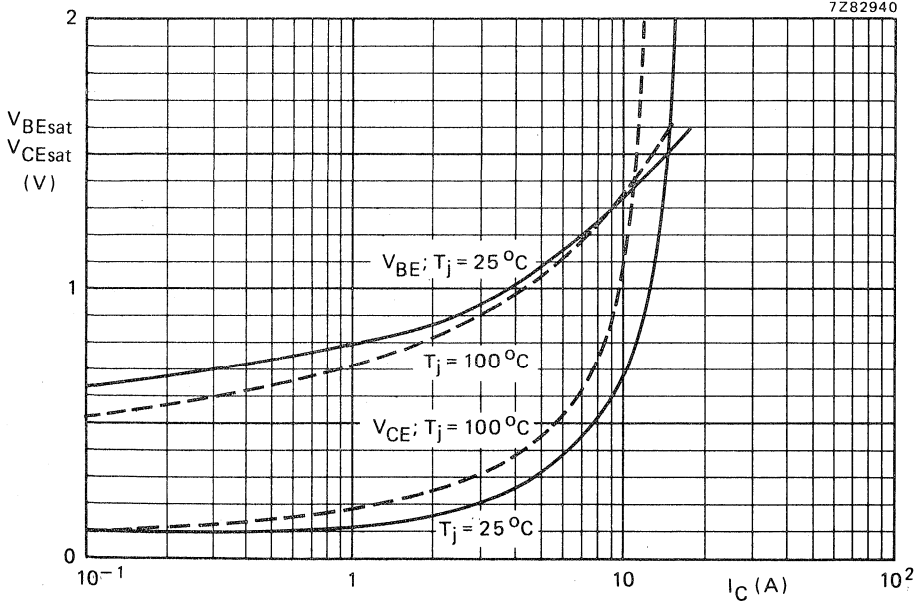


Fig. 10 Typical values base and collector voltage at $I_C/I_B = 5$.

7Z82939

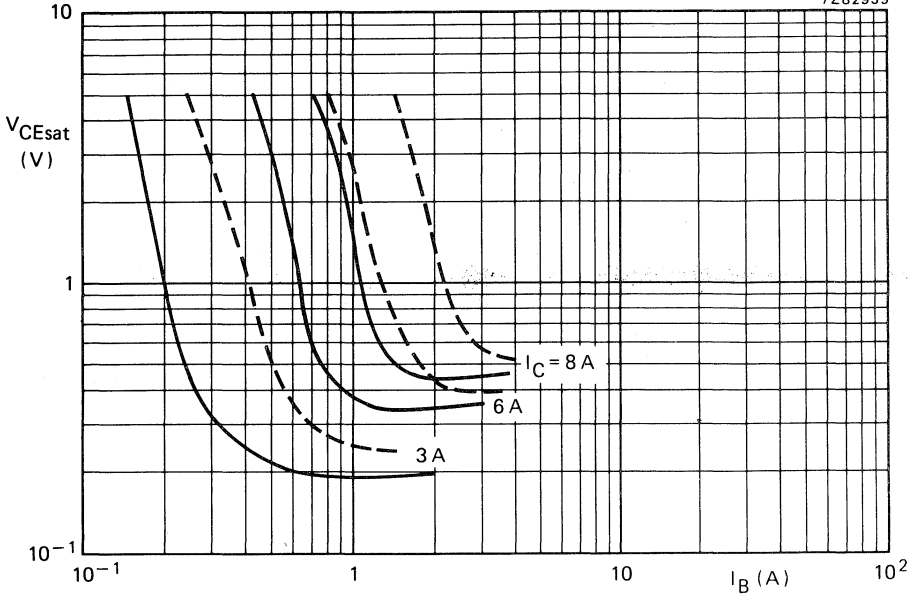


Fig. 11 Typ. (—) and max. (---) values collector-emitter saturation voltage at $T_j = 25^\circ C$.

7Z82938

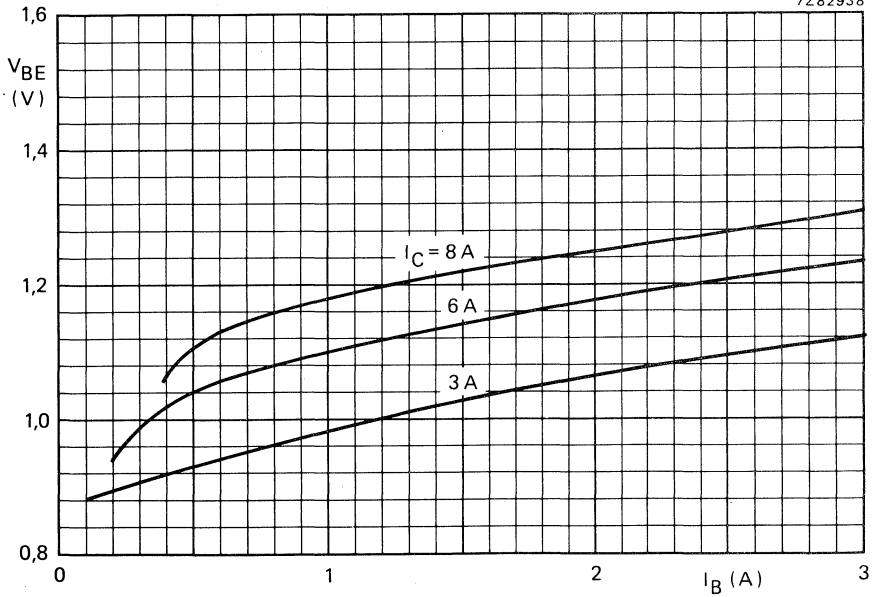


Fig. 12 Typical values base-emitter voltage at $T_j = 25^\circ C$.

SILICON DIFFUSED POWER TRANSISTORS

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

QUICK REFERENCE DATA

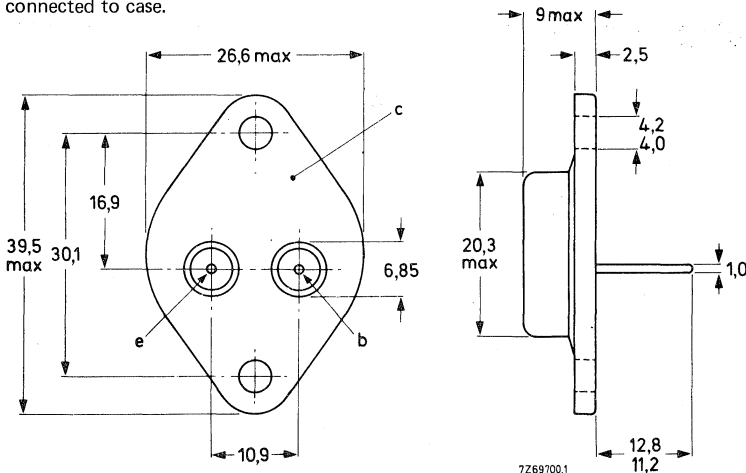
		BUX48	BUX48A	
Collector-emitter voltage (peak value; $V_{BE} = 0$)	V_{CESM} max.	850	1000	V
Collector-emitter voltage (open base)	V_{CEO} max.	400	450	V
Collector current (d.c.)	I_C max.		15	A
Collector current (peak value; $t_p < 2$ ms)	I_{CM} max.		30	A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot} max.		175	W
Collector-emitter saturation voltage				
$I_C = 10$ A; $I_B = 2$ A	$V_{CESat} <$	1,5	—	V
$I_C = 8$ A; $I_B = 1,6$ A	$V_{CESat} <$	—	1,5	V
Fall time (resistive load)				
$I_{Con} = 10$ A; $I_{Bon} = -I_{Boff} = 2$ A	$t_f <$	800	—	ns
$I_{Con} = 8$ A; $I_{Bon} = -I_{Boff} = 1,6$ A	$t_f <$	—	800	ns

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)

			BUX48	BUX48A
Collector-emitter voltage (peak value; $V_{BE} = 0$)	V_{CESM}	max.	850	1000 V
Collector-emitter voltage (peak value; $V_{BE} = -2,5$ V)	V_{CEX}	max.	850	1000 V
Collector-emitter voltage (open base)	V_{CEO}	max.	400	450 V
Collector current (d.c.)	I_C	max.	15	A
Collector current (peak value)	I_{CM}	max.	30	A
Base current (d.c.)	I_B	max.	4	A
Base current (peak value)	I_{BM}	max.	20	A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot}	max.	175	W
Storage temperature	T_{stg}		-65 to +200	°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

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

$T_j = 25$ °C unless otherwise specified

Collector-emitter current

$V_{CE} = V_{CEX}; R_{BE} \leq 10 \Omega;$

$I_{CER} < 0,5$ mA

$V_{CE} = V_{CEX}; R_{BE} \leq 10 \Omega; T_j = 125$ °C

$I_{CER} < 4$ mA

Collector-emitter current

$V_{CE} = V_{CEX}; V_{BE} = -2,5$ V

$I_{CEX} < 0,2$ mA

$V_{CE} = V_{CEX}; V_{BE} = -2,5$ V; $T_j = 125$ °C

$I_{CEX} < 2$ mA

Emitter cut-off current

$I_C = 0; V_{EB} = 5$ V

$I_{EBO} < 1$ mA

Saturation voltages

$I_C = 10$ A; $I_B = 2$ A

$V_{CEsat} < 1,5$ V

$V_{BEsat} < 1,6$ V

$I_C = 8$ A; $I_B = 1,6$ A

$V_{CEsat} < 1,5$ V

$V_{BEsat} < 1,6$ V

$I_C = 15$ A; $I_B = 3$ A

$V_{CEsat} < 5$ V

$I_C = 12$ A; $I_B = 2,4$ A

$V_{CEsat} < 5$ V

Collector-emitter sustaining voltage

$I_C = 200$ mA; $I_{Boff} = 0$; $L = 25$ mH

$V_{CEO sust} > 400$ V

Emitter-base breakdown voltage

$I_C = 0; I_B = 50$ mA;

$V_{(BR)EBO} 7$ to 30 V

* Measured with a half sine-wave voltage (curve tracer).

CHARACTERISTICS (continued)

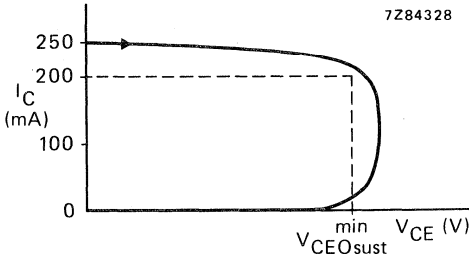


Fig. 2 Oscilloscope display for sustaining voltage.

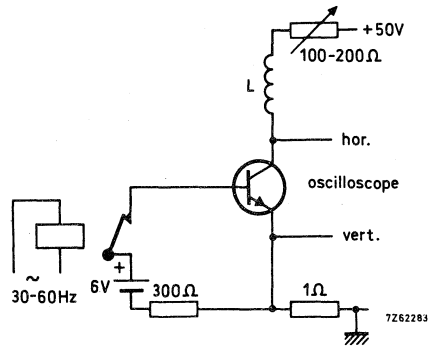


Fig. 3 Test circuit for $V_{CE(sust)}$.

Switching times resistive load (Fig. 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 (Fig. 6 and 7)

$I_{Con} = 10\text{ A}; I_{Bon} = 2\text{ A}; T_{mb} = 25\text{ }^\circ\text{C}$

Turn-off: Storage time
Fall time

$I_{Con} = 10\text{ A}; I_{Bon} = 2\text{ A}; T_{mb} = 100\text{ }^\circ\text{C}$

Turn-off: Storage time
Fall time

$I_{Con} = 8\text{ A}; I_{Bon} = 1,6\text{ A}; T_{mb} = 25\text{ }^\circ\text{C}$

Turn-off: Storage time
Fall time

$I_{Con} = 8\text{ A}; I_{Bon} = 1,6\text{ A}; T_{mb} = 100\text{ }^\circ\text{C}$

Turn-off: Storage time
Fall time

		BUX48	BUX48A	
t_{on}	<	1	—	μs
t_s	<	3	—	μs
t_f	<	0,8	—	μs
t_{on}	<	—	1	μs
t_s	<	—	3	μs
t_f	<	—	0,8	μs
t_s	typ.	3	—	μs
t_f	typ.	80	—	ns
				—
t_s	<	5	—	μs
t_f	<	0,4	—	μs
t_s	typ.	—	3	μs
t_f	typ.	—	80	ns
t_s	<	—	5	μs
t_f	<	—	0,4	μs

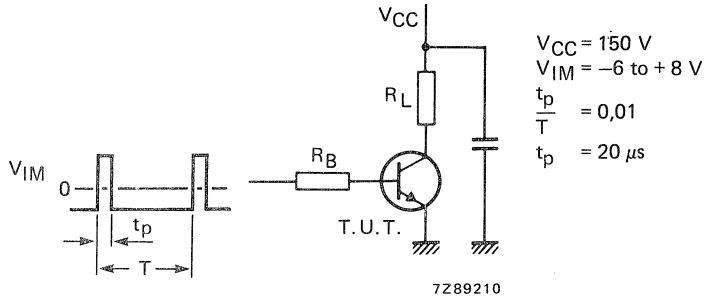


Fig. 4 Test circuit resistive load.

The values of R_B and R_L are selected in accordance with I_{CCon} and I_B requirements.

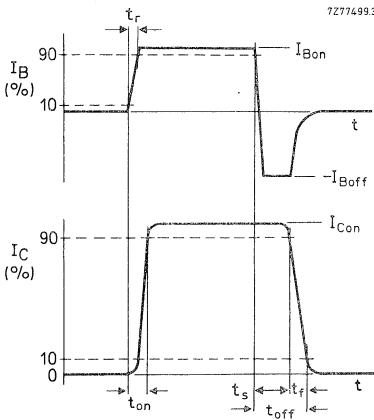


Fig. 5 Switching times waveforms with resistive load.

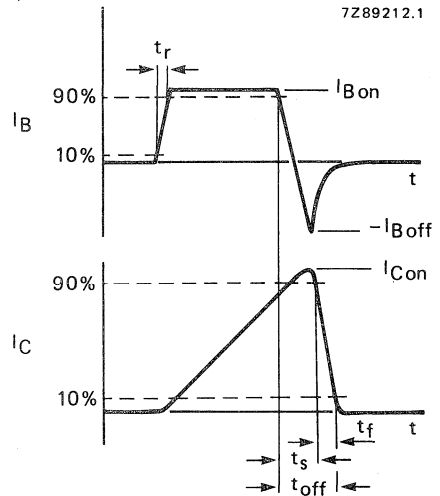


Fig. 6 Switching times waveforms with inductive load.

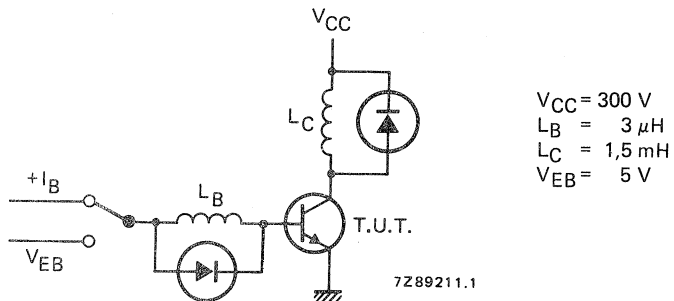


Fig. 7 Test circuit inductive load.

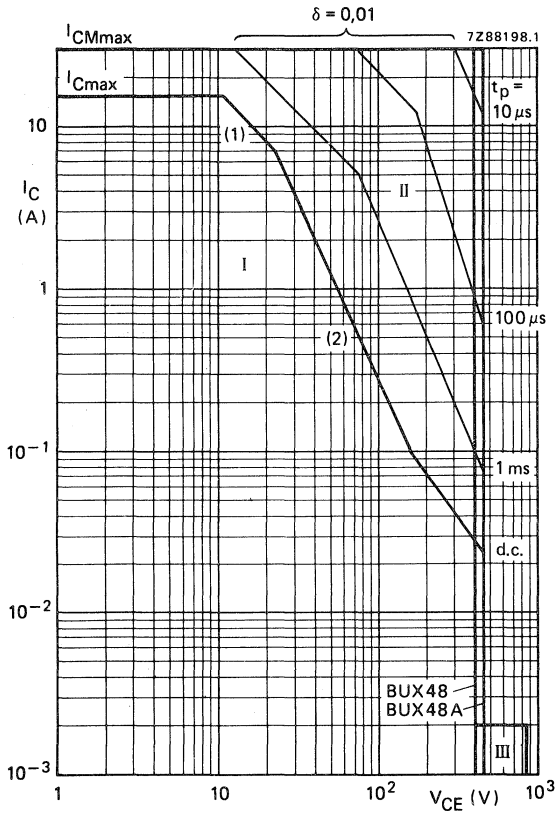


Fig. 8 Safe Operating Area at $T_{mb} \leq 25^\circ\text{C}$.

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

- I Region of permissible d.c. operation.
- II Permissible extension for repetitive pulse operation.
- III Repetitive pulse operation in this region is permissible, provided $V_{BE} \leq 0$ and $t_p \leq 5\ \text{ms}$.

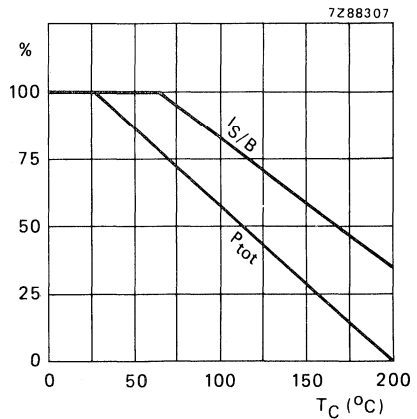


Fig. 8a Derating curve.

Fig. 9 Forward bias safe operation area, $T_j \leq 125^\circ\text{C}$.

- I Safe operation area during turn-off and during turn-on.
For BUX48A the right-hand limit is 450 V.
- II Safe operation area during turn-on only provided $t_r < 0,2 \mu\text{s}$.
- III Safe operation area during turn-on only provided $t_r < 0,5 \mu\text{s}$ and $R_{BE} < 100 \Omega$.

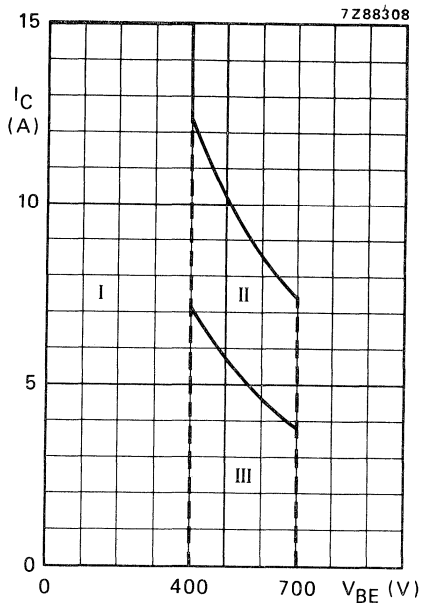
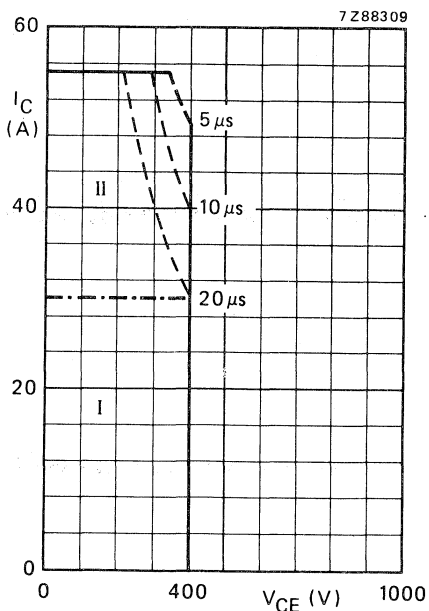


Fig. 10 Forward bias accidental overload area, $T_j \leq 125^\circ\text{C}$.

- I Safe operation provided normal forward bias conditions are respected ($I_{S/B}$, $T_j \text{ max}$).
- II Safe operation area for non-repetitive pulses. During component life the number of pulses in area II should not exceed 3000 times.



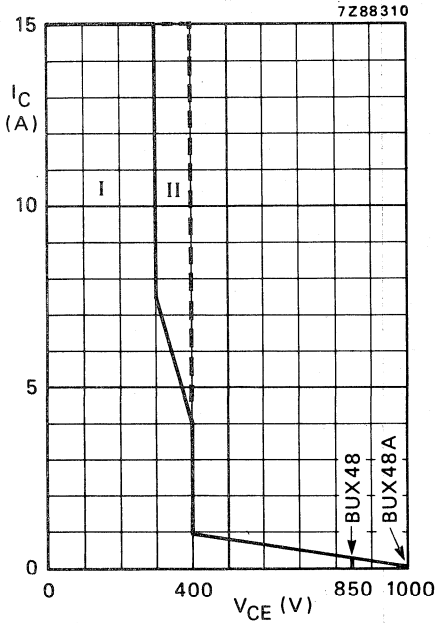


Fig. 11 Reverse bias safe operation area, $I_{Cend}/I_{Bend} \geq 5$; $-V_{BE} = 3$ V.

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

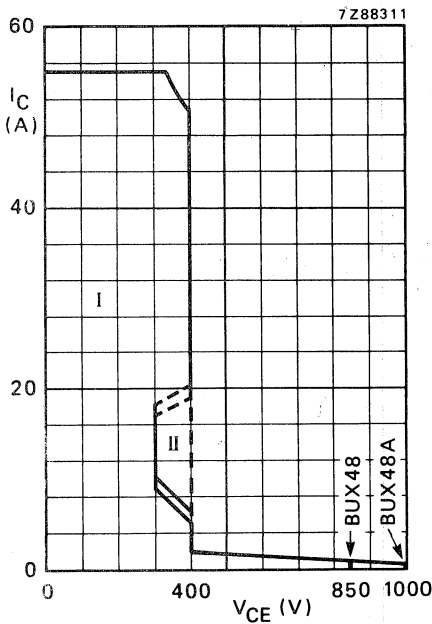


Fig. 12 Reverse bias accidental overload area, $-V_{BE} = 3$ V; $T_j \leq 125$ °C.

- I Operation at high currents ($I_C > I_{CM}$) 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.

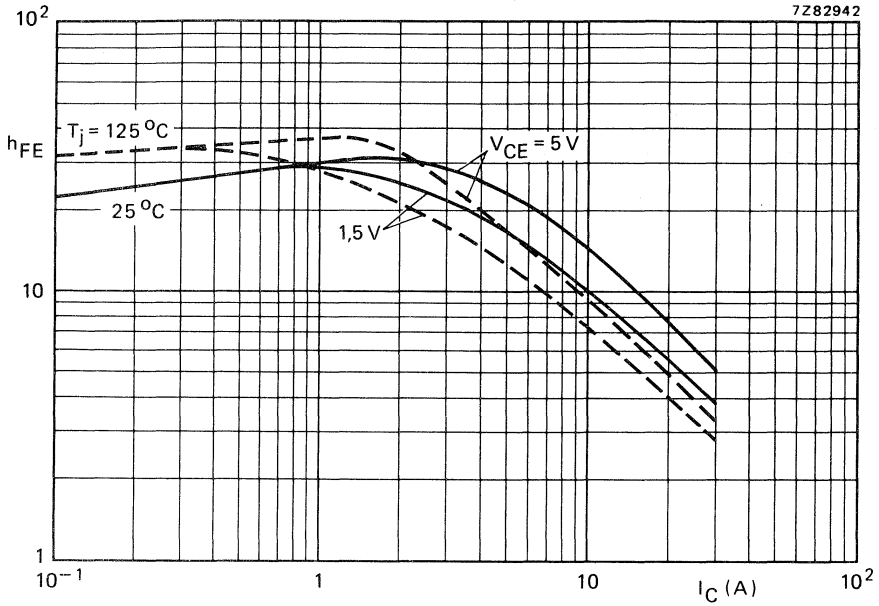


Fig. 13 Typical values d.c. current gain.

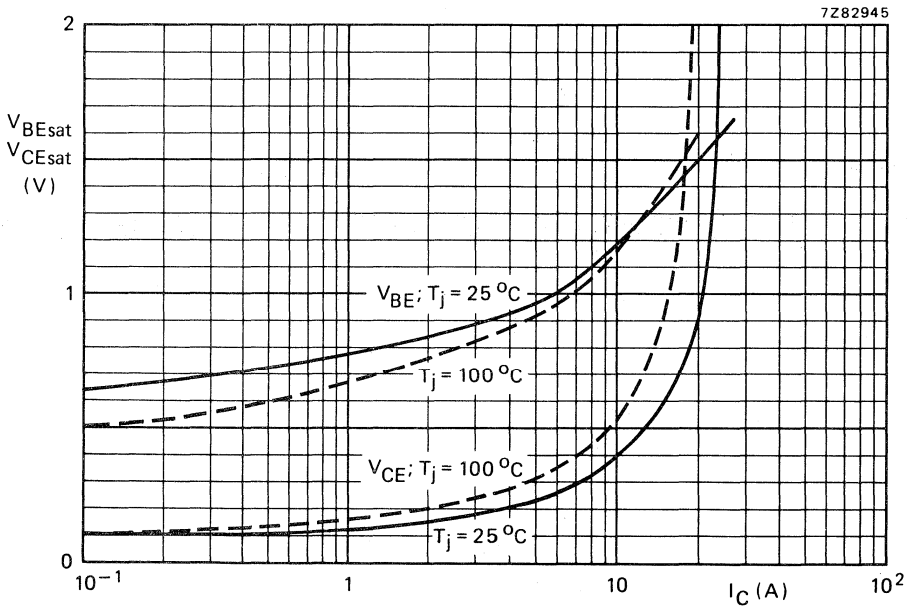


Fig. 14 Typical values base and collector voltage at $I_C/I_B = 5$.

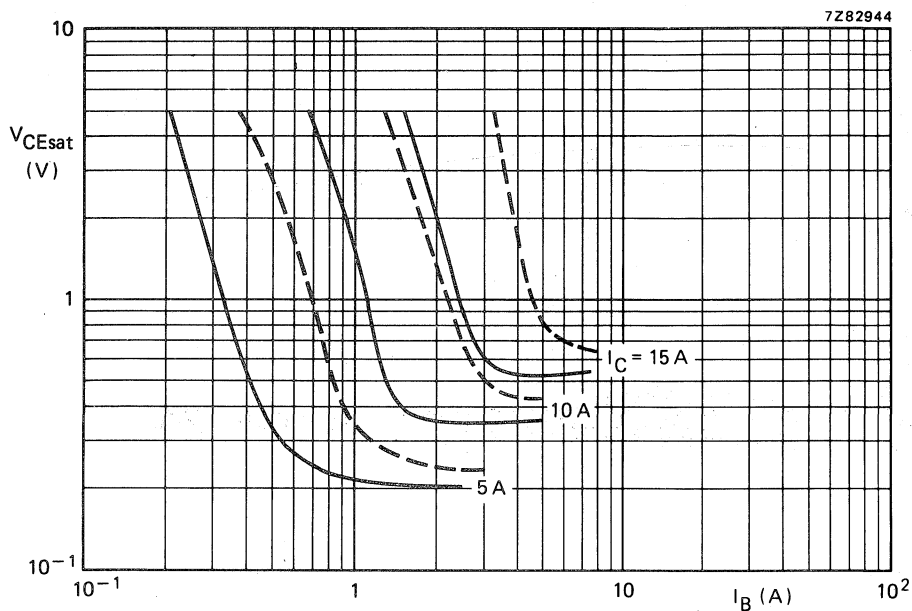


Fig. 15 Typical (—) and maximum (---) values saturation voltage. $T_j = 25^\circ C$.

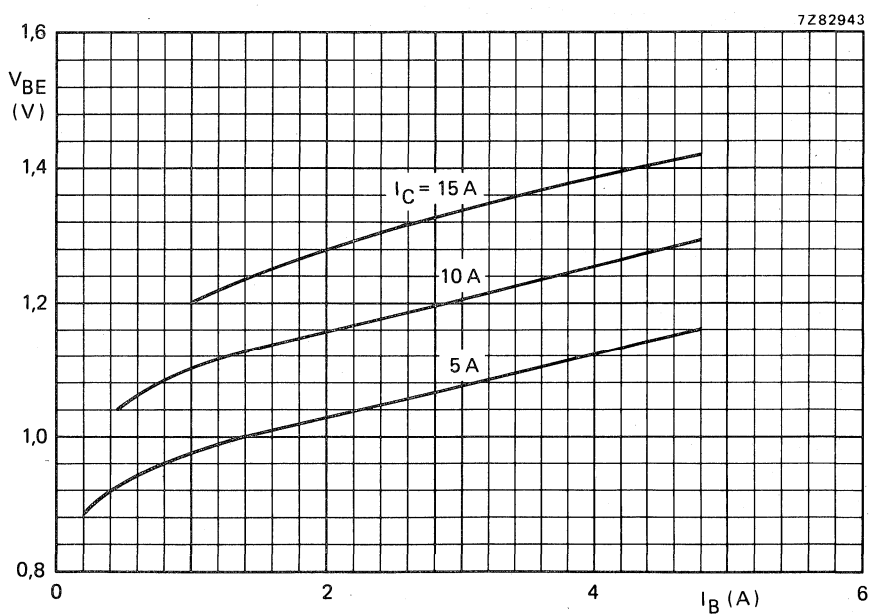


Fig. 16 Typical values base-emitter voltage at $T_j = 25^\circ C$.

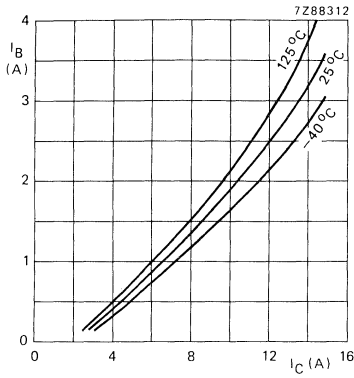


Fig. 17 Minimum base current to saturate the transistor as a function of the collector current.

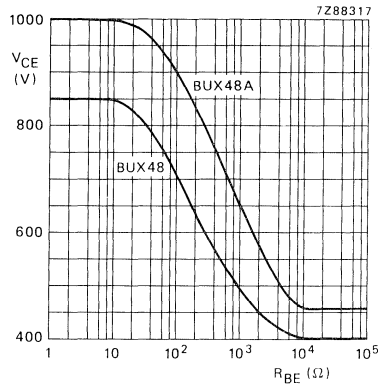


Fig. 18 Typical values collector-emitter voltage as a function of the base-emitter resistance.

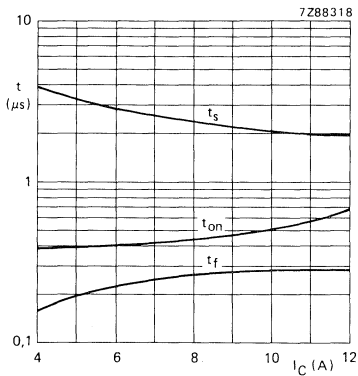


Fig. 19 Typical values switching times resistive circuits as a function of collector current.

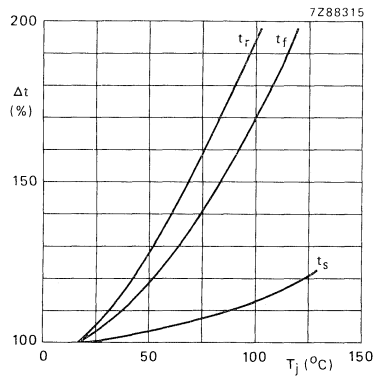


Fig. 20 Increase of switching times as a function of temperature. To read in connection with Fig. 19.

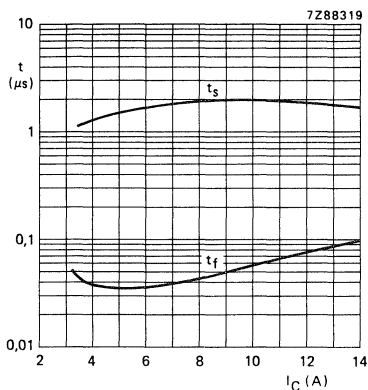


Fig. 21 Typical values switching times inductive circuits as a function of collector current.

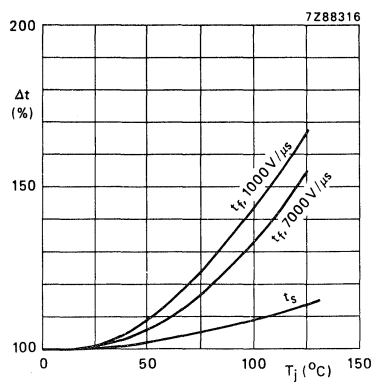


Fig. 22 Increase of storage and fall times to read in connection with Fig. 21 as a function of junction temperature.

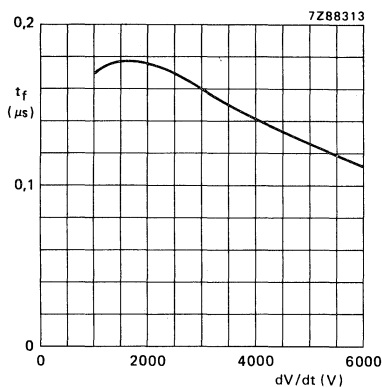


Fig. 23 Typical values fall time as a function of dV_{CE}/dt at $T_{mb} = 25^{\circ}\text{C}$ and $I_C = 10\text{ A}$.

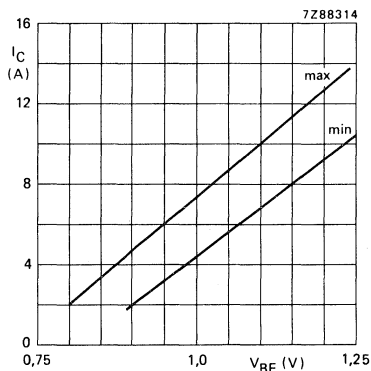


Fig. 24 Base-emitter voltage as a function of collector current at $V_{CE} = 1,5\text{ V}$; $T_{mb} = 25^{\circ}\text{C}$ and 90% confidence.

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.

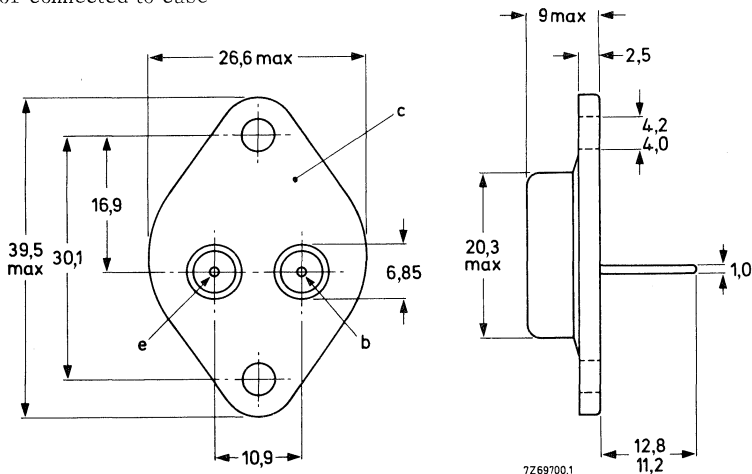
QUICK REFERENCE DATA				
		BUX80	BUX81	
Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM} max.	800	1000	V
Collector-emitter voltage ($R_{BE} = 50 \Omega$)	V_{CER} max.	500	500	V
Collector-emitter voltage (open base)	V_{CEO} max.	400	450	V
Collector current (d. c.)	I_C max.	10		A
Collector current (peak value) $t_p = 2$ ms	I_{CM} max.	15		A
Total power dissipation up to $T_{mb} = 40^\circ C$	P_{tot} max.	100		W
Collector-emitter saturation voltage $I_C = 5$ A; $I_B = 1$ A	$V_{CEsat} <$	1,5		V
Fall time $I_{Con} = 5$ A; $I_{Bon} = 1$ A; $-I_{Boff} = 2$ A	t_f typ.	0,3		μs

MECHANICAL DATA

Dimensions in mm

TO-3

Collector connected to case



See also chapters Mounting instructions and Accessories.

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

Voltages

			BUX80	BUX81
Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM}	max.	800	1000 V
Collector-emitter voltage ($R_{BE} = 50 \Omega$)	V_{CER}	max.	500	500 V
Collector-emitter voltage (open base)	V_{CEO}	max.	400	450 V

Currents

Collector current (d.c.)	I_C	max.	10	A
Collector current (peak value) $t_p = 2 \text{ ms}$	I_{CM}	max.	15	A
Base current (d.c.)	I_B	max.	4	A
Base current (peak value)	I_{BM}	max.	6	A
Reverse base current (d.c. or average over any 20 ms period)	$-I_{B(AV)}$	max.	100	mA
Reverse base current (peak value) ¹⁾	$-I_{BM}$	max.	6	A

Power dissipation

Total power dissipation up to $T_{mb} = 40 \text{ }^\circ\text{C}$	P_{tot}	max.	100	W
--	-----------	------	-----	---

Temperatures

Storage temperature	T_{stg}	-65 to +150	$^\circ\text{C}$
Junction temperature	T_j	max. 150	$^\circ\text{C}$

THERMAL RESISTANCE

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

CHARACTERISTICS

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

Collector cut-off current ²⁾

$V_{CEM} = V_{CESMmax}; V_{BE} = 0$	I_{CES}	<	1	mA
-------------------------------------	-----------	---	---	----

$V_{CEM} = V_{CESMmax}; V_{BE} = 0; T_j = 125 \text{ }^\circ\text{C}$	I_{CES}	<	3	mA
---	-----------	---	---	----

D. C. current gain

$I_C = 1, 2 \text{ A}; V_{CE} = 5 \text{ V}$	h_{FE}	typ.	30
--	----------	------	----

¹⁾ Turn-off current.

²⁾ Measured with a half sine wave voltage (curve tracer).

CHARACTERISTICS (continued)

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

Emitter cut-off current

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

$I_{EBO} < 10\text{ mA}$

Saturation voltages

$I_C = 5\text{ A}; I_B = 1\text{ A}$

$V_{CEsat} < 1,5\text{ V}$

$V_{BEsat} < 1,4\text{ V}$

$I_C = 8\text{ A}; I_B = 2,5\text{ A}$

$V_{CEsat} < 3\text{ V}$

$V_{BEsat} < 1,8\text{ V}$

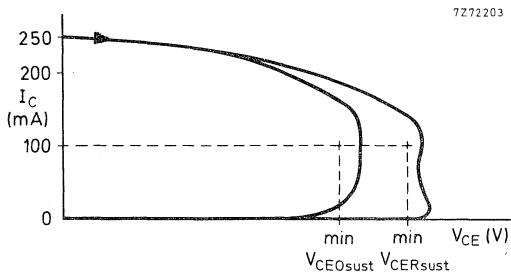
Collector-emitter sustaining voltages

$I_C = 100\text{ mA}; I_{Boff} = 0; L = 25\text{ mH}$

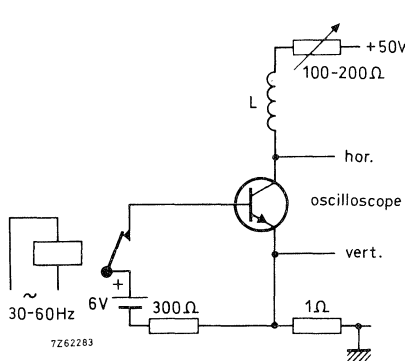
	BUX 80	BUX 81
$V_{CEOsust} >$	400	450
$V_{CERsust} >$	500	500

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

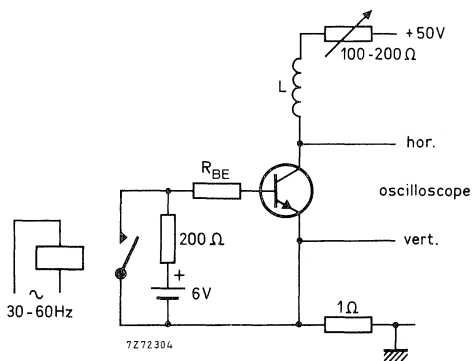
$V_{CERsust} >$	500	500
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Oscilloscope display for sustaining voltages



Test circuit for $V_{CEOsust}$



Test circuit for $V_{CERsust}$

CHARACTERISTICS (continued)

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

Transition frequency at $f = 1\text{ MHz}$

$I_C = 0,2\text{ A}; V_{CE} = 10\text{ V}$

f_T typ. 6 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_{on} typ. 0,35 μs
< 0,5 μs

Turn-off: Storage time

t_s typ. 2,5 μs
< 3,5 μs

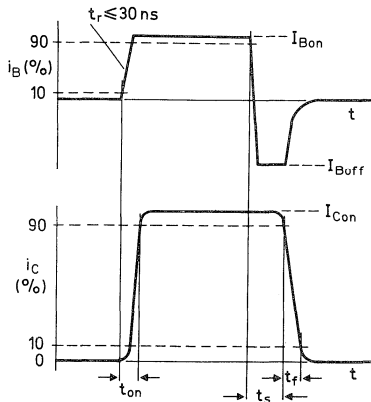
Fall time

t_f typ. 0,3 μs

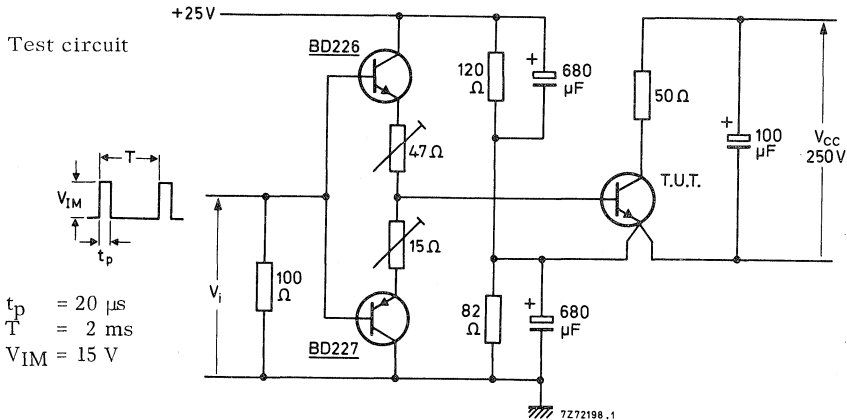
Fall time, $T_{mb} = 95\text{ }^\circ\text{C}$

t_f < 0,8 μs

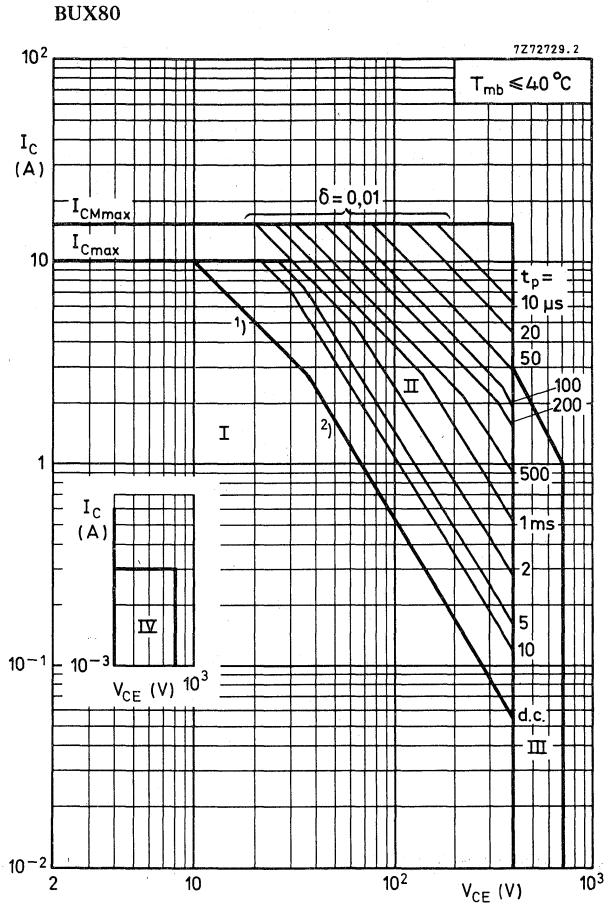
Waveform



Test circuit



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



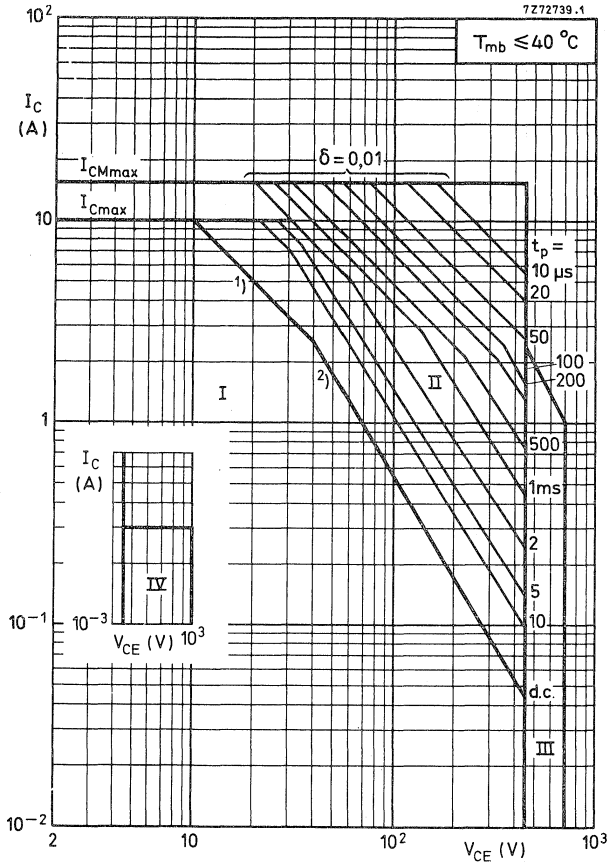
Safe Operating ARea

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

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

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

BUX81

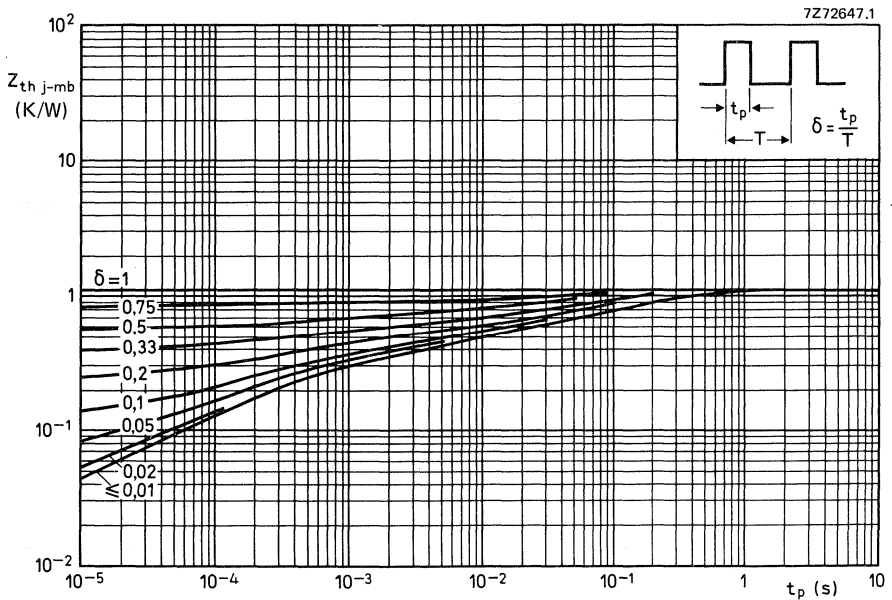
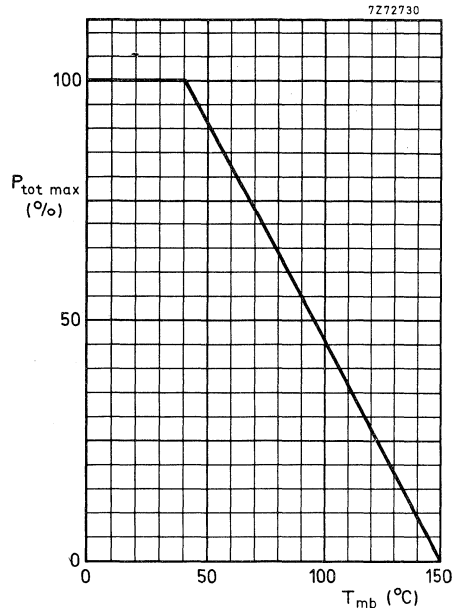


Safe Operating Area

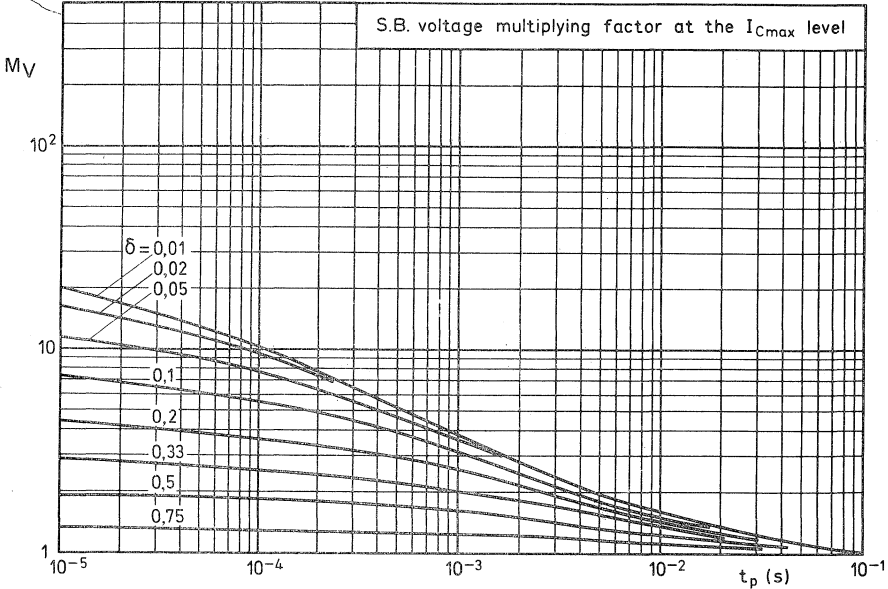
- I Region of permissible d. c. operation
- II Permissible extension for repetitive pulse operation
- III Area of permissible operation during turn-on in single-transistor converters, provided $R_{BE} \leq 100 \Omega$ and $t_p \leq 0,6 \mu\text{s}$
- IV Repetitive pulse operation in this region is permissible,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

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

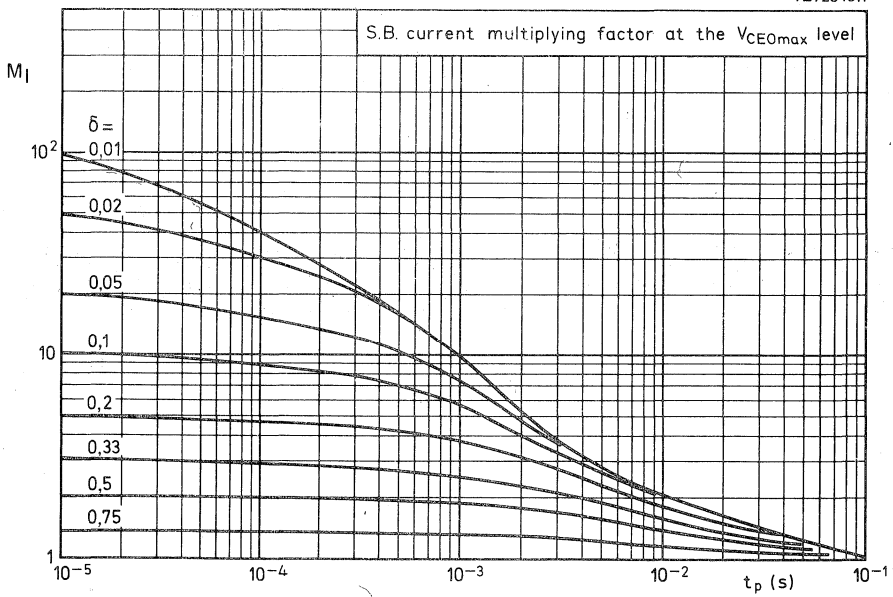
2) Second-breakdown limits (independent of temperature).

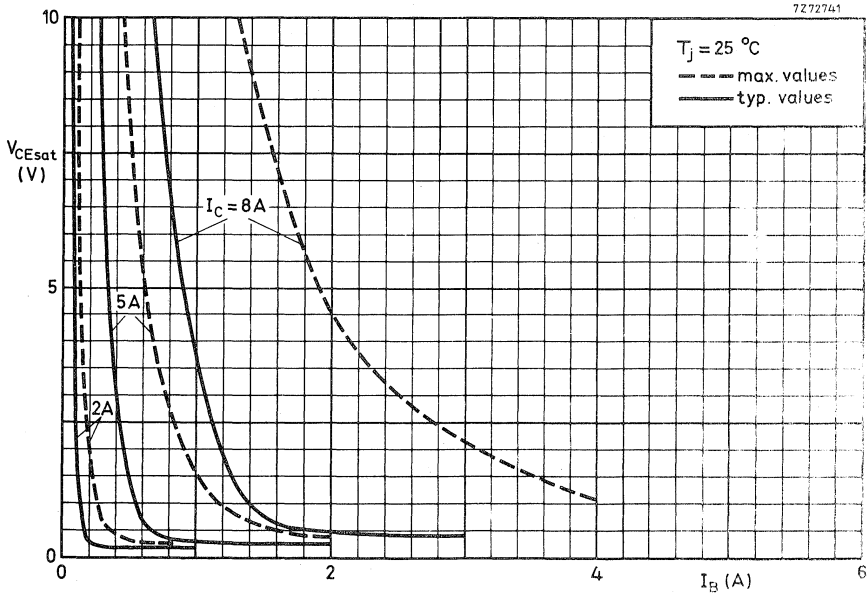
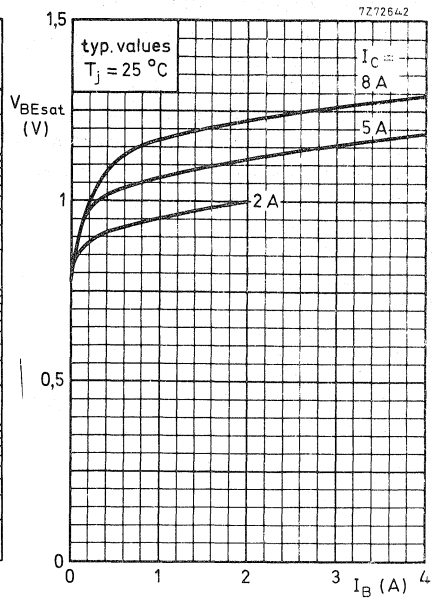
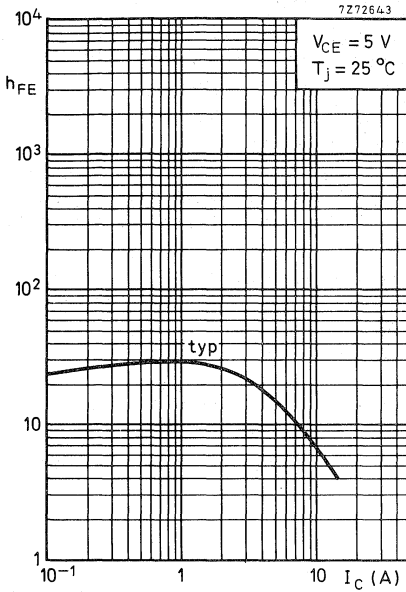


7Z72646.1



7Z72645.1





APPLICATION INFORMATION ON BUX80 (detailed information on request)

Important factors in the design of SMPS circuits are the power losses and heatsink requirements of the supply output transistor and the base drive conditions during turn-off. In SMPS circuits with mains isolation the duty factor of the collector current generally varies between 0,25 and 0,5.

The operating frequency lies between 15 kHz and 50 kHz and the shape of the collector current varies from rectangular in a forward converter to a sawtooth in a flyback circuit.

As the BUX80 will mainly be used in forward or push-pull converters the information on optimum base drive and device dissipation given in the graphs on page 12 is concentrated on this application. In these figures I_{CM} represents the highest repetitive peak collector current that can occur in the given circuit, e.g. during overload.

The total power dissipation for a limit-case transistor is given in Fig. 5 which applies for a mounting base temperature of 100 °C. The required thermal resistance for the heatsink can be calculated from

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

To ensure thermal stability the minimum value of T_{amb} in the above equation is 40 °C.

A practical SMPS output circuit for an output power in the order of 400 W is given in Fig. 2.

At a collector current of 5 A and a base current of 1 A in this circuit the following turn-off times can be expected.

	$T_{mb} = 25\ ^\circ C$		$100\ ^\circ C$
Storage time	t_s typ	2	2,7 μs
Fall time	t_f typ	0,18	0,5 μs

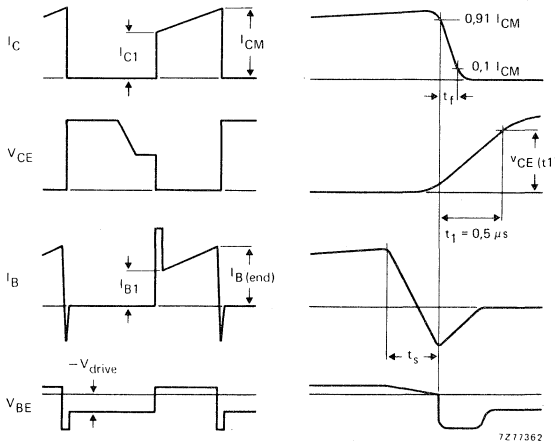


Fig. 1 Relevant waveforms of switching transistor.

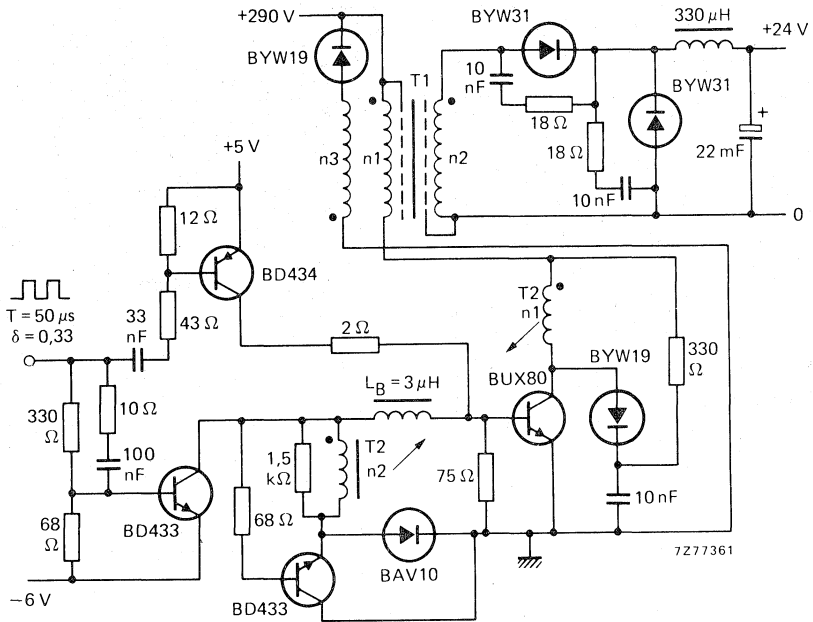


Fig. 2 Practical SMPS output circuit.

T1 (output transformer): Core U64; $n_1 = n_3 = 56$ turns; $n_2 = 17$ turns

T2 (base current transformer): Core U20; $n_1 = 5$ turns; $n_2 = 25$ turns

$V_{CE}(t_1) < 300$ V (see Fig. 1)

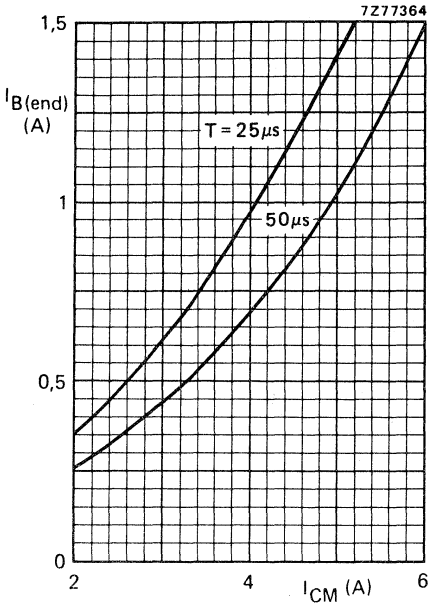


Fig. 3.

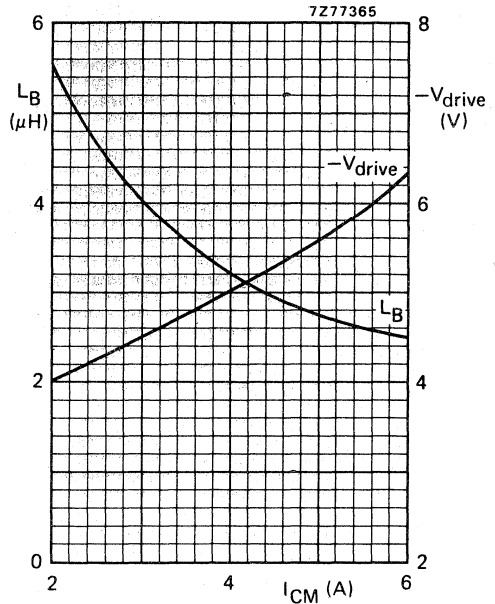


Fig. 4.

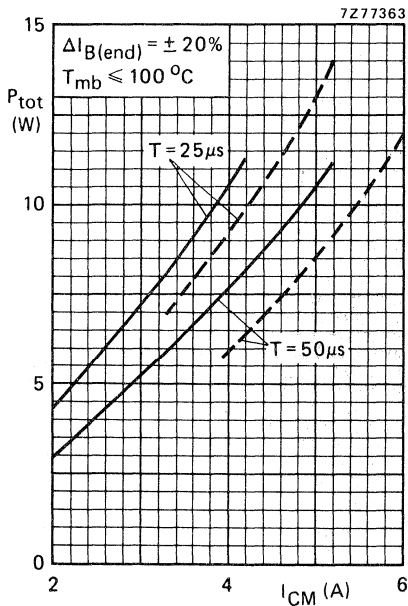


Fig. 5.

Fig. 3 Recommended nominal "end" value of the base current versus maximum peak collector current.

Fig. 4 Minimum required base inductance and recommended negative drive voltage versus maximum peak collector current.

Fig. 5 Maximum total power dissipation of a limit-case transistor if the base current is chosen in accordance with Fig. 3. Solid lines for transformer drive and dotted lines for collector-coupled current drive.

SILICON DIFFUSED POWER TRANSISTORS

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

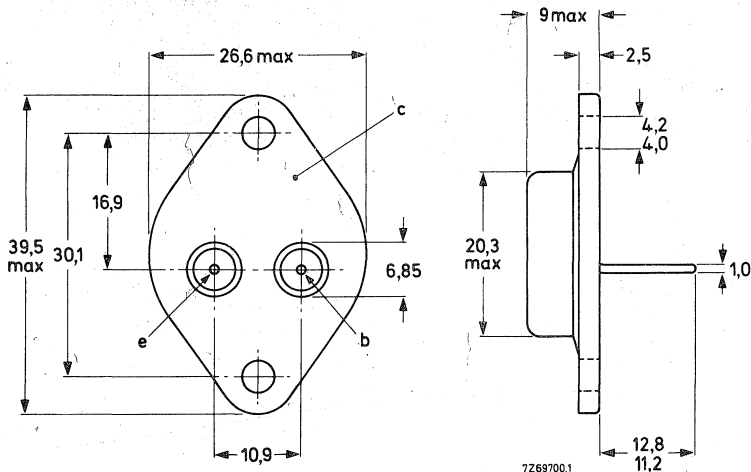
QUICK REFERENCE DATA			
		BUX82	BUX83
Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM}	max. 800	1000 V
Collector-emitter voltage ($R_{BE} = 100 \Omega$)	V_{CER}	max. 500	500 V
Collector-emitter voltage (open base)	V_{CEO}	max. 400	450 V
Collector current (d. c.)	I_C	max.	6 A
Collector current (peak value) $t_p = 2$ ms	I_{CM}	max.	8 A
Total power dissipation up to $T_{mb} = 50^\circ\text{C}$	P_{tot}	max.	60 W
Collector-emitter saturation voltage $I_C = 2,5$ A; $I_B = 0,5$ A	V_{CEsat}	<	1,5 V
Fall time $I_{Con} = 2,5$ A; $I_{Bon} = 0,5$ A; $-I_{Boff} = 1$ A	t_f	typ.	0,3 μs

MECHANICAL DATA

Dimensions in mm

TO-3

Collector connected to case



See also chapters Mounting instructions and Accessories.

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

Voltages

		BUX82	BUX83
Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM}	max. 800	1000 V
Collector-emitter voltage ($R_{BE} = 100 \Omega$)	V_{CER}	max. 500	500 V
Collector-emitter voltage (open base)	V_{CEO}	max. 400	450 V

Currents

Collector current (d. c.)	I_C	max.	6	A
Collector current (peak value) $t_p = 2$ ms	I_{CM}	max.	8	AC
Base current (d. c.)	I_B	max.	2	A
Base current (peak value)	I_{BM}	max.	3	A
Reverse base current (d. c. or average over any 20 ms period)	$-I_{B(AV)}$	max.	100	mA
Reverse base current (peak value) ¹⁾	$-I_{BM}$	max.	3	A

Power dissipation

Total power dissipation up to $T_{mb} = 50^\circ\text{C}$	P_{tot}	max.	60	W
---	-----------	------	----	---

Temperatures

Storage temperature	T_{stg}	-65 to +150	$^\circ\text{C}$
Junction temperature	T_j	max. 150	$^\circ\text{C}$

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=	1,65	K/W
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CHARACTERISTICS

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

Collector cut-off current ²⁾

$V_{CEM} = V_{CESMmax}; V_{BE} = 0$	I_{CES}	<	1	mA
$V_{CEM} = V_{CESMmax}; V_{BE} = 0; T_j = 125^\circ\text{C}$	I_{CES}	<	2	mA

D. C. current gain

$I_C = 0,6$ A; $V_{CE} = 5$ V	h_{FE}	typ.	30
-------------------------------	----------	------	----

1) Turn-off current.

2) Measured with a half sine wave voltage (curve tracer).

CHARACTERISTICS (continued)

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

Emitter cut-off current

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

$I_{EBO} < 10\text{ mA}$

Saturation voltages

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

$V_{CEsat} < 1,5\text{ V}$

$V_{BEsat} < 1,4\text{ V}$

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

$V_{CEsat} < 3\text{ V}$

$V_{BEsat} < 1,6\text{ V}$

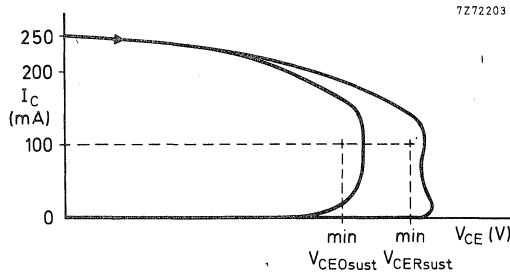
Collector-emitter sustaining voltages

$I_C = 100\text{ mA}; I_{Boff} = 0; L = 25\text{ mH}$

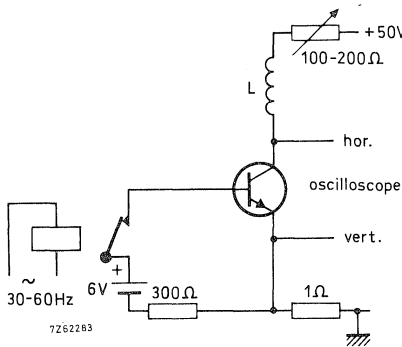
	BUX82	BUX83	
$V_{CE0sust}$	> 400	450	V
$V_{CERsust}$	> 500	500	V

$I_C = 100\text{ mA}; R_{BE} = 100\ \Omega; L = 15\text{ mH}$

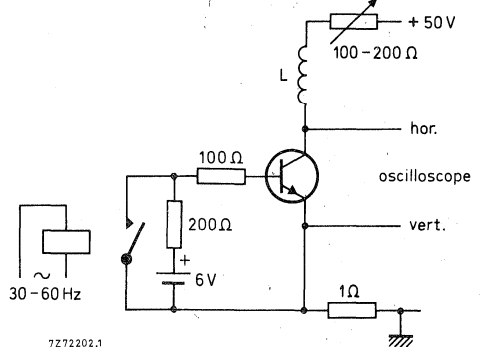
$V_{CERsust} > 500\text{ V}$



Oscilloscope display for sustaining voltages



Test circuit for $V_{CE0sust}$



Test circuit for $V_{CERsust}$

CHARACTERISTICS (continued)

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

Transition frequency at $f = 1\text{ MHz}$

$I_C = 0,2\text{ A}; V_{CE} = 10\text{ V}$

f_T typ. 6 MHz

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

t_{on} typ. 0,3 μs
< 0,5 μs

Turn-off: Storage time

t_s typ. 2 μs
< 3,5 μs

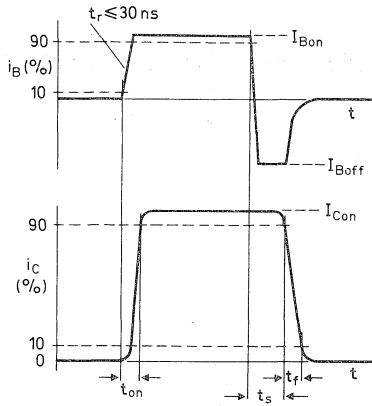
Fall time

t_f typ. 0,3 μs

Fall time, $T_{mb} = 95\text{ }^\circ\text{C}$

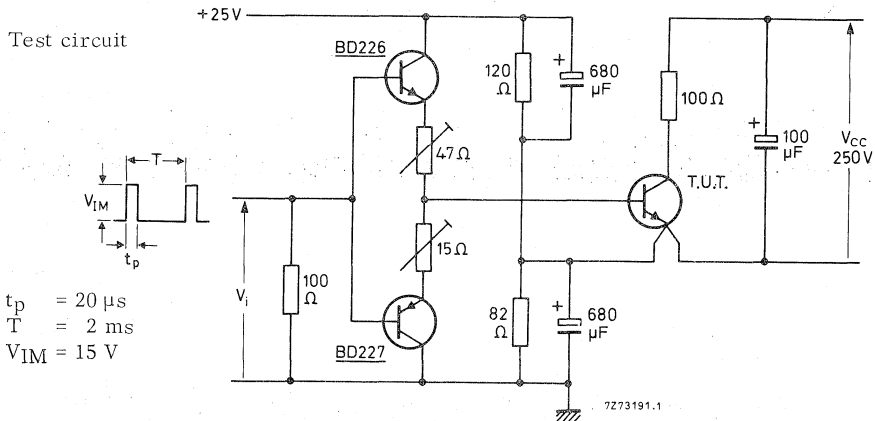
t_f < 1 μs

Waveform



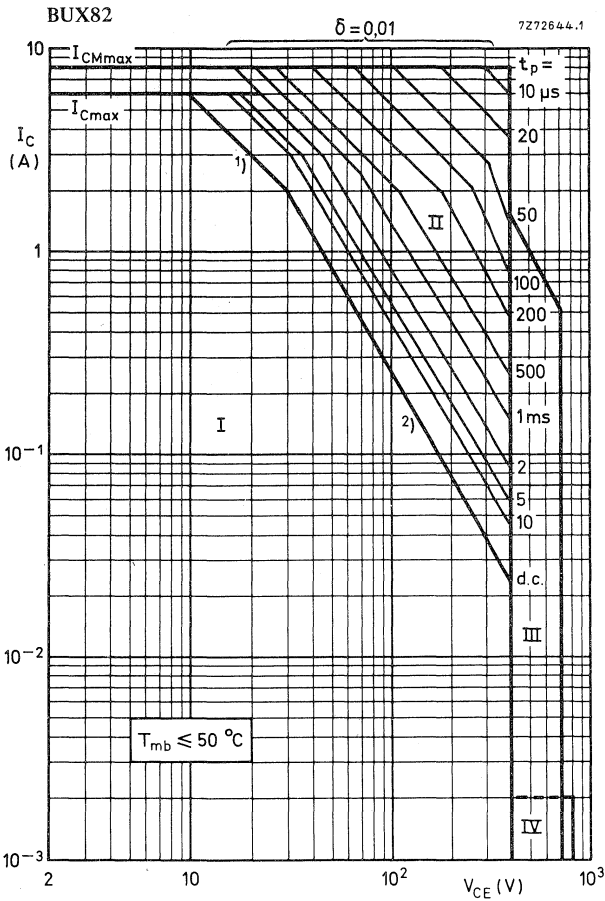
7272640

Test circuit



7273191.1

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

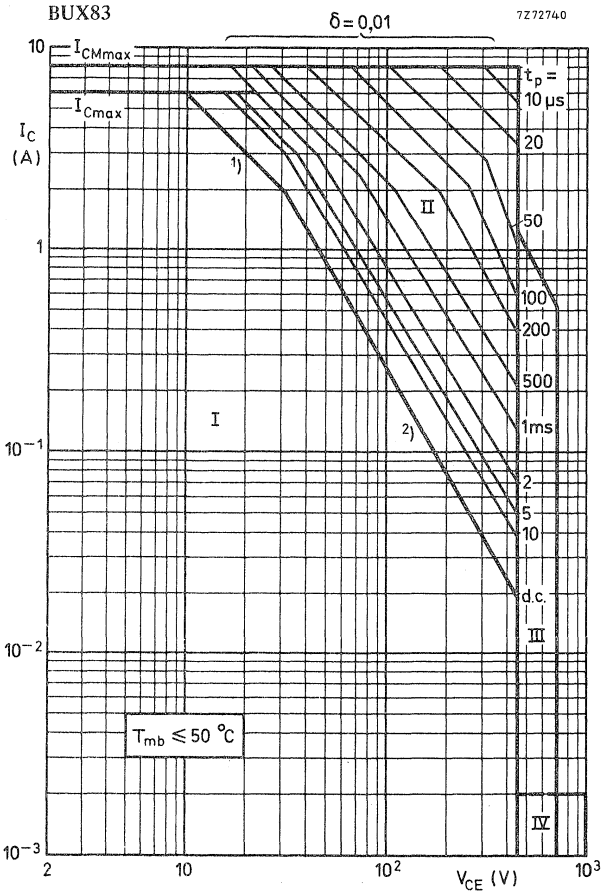


Safe Operating Area

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

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

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

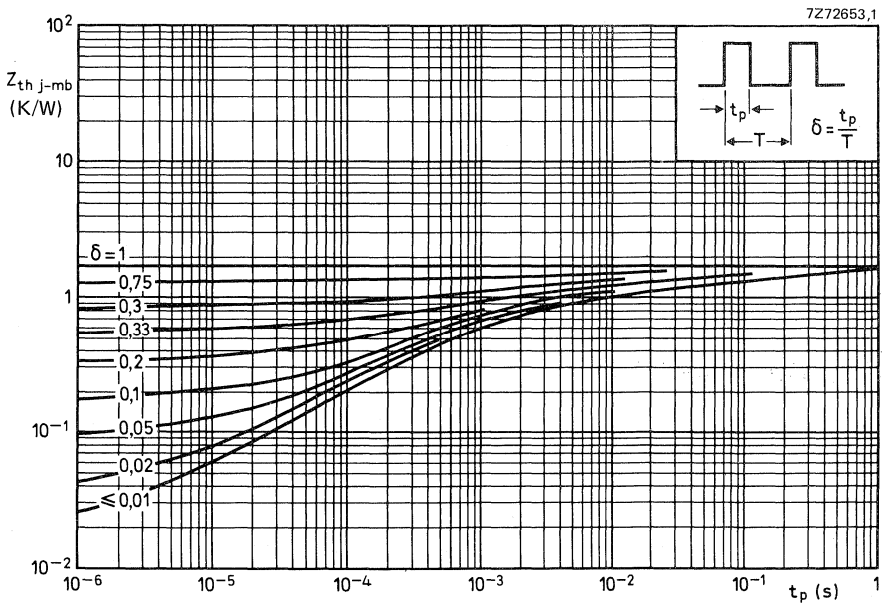
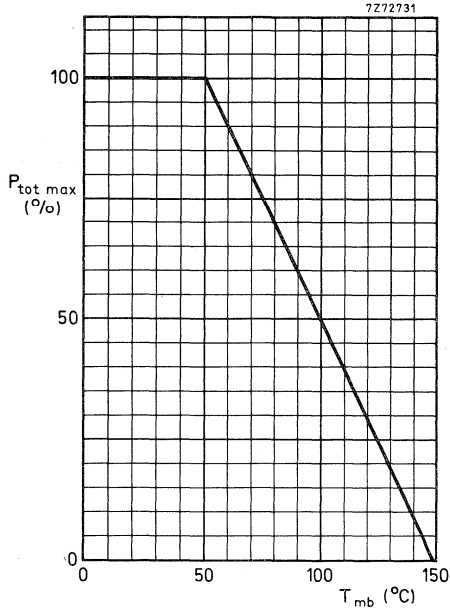


Safe Operating Area

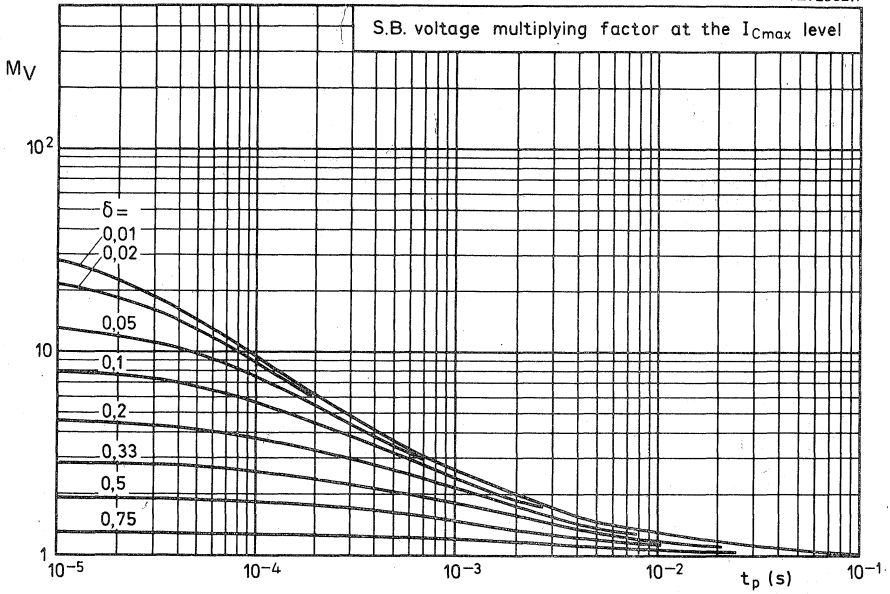
- I Region of permissible d. c. operation
- II Permissible extension for repetitive pulse operation
- III Area of permissible operation during turn-on in single-transistor converters, provided $R_{BE} \leq 100 \Omega$ and $t_p \leq 0,6 \mu s$
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1) $P_{tot max}$ and $P_{peak max}$ lines.

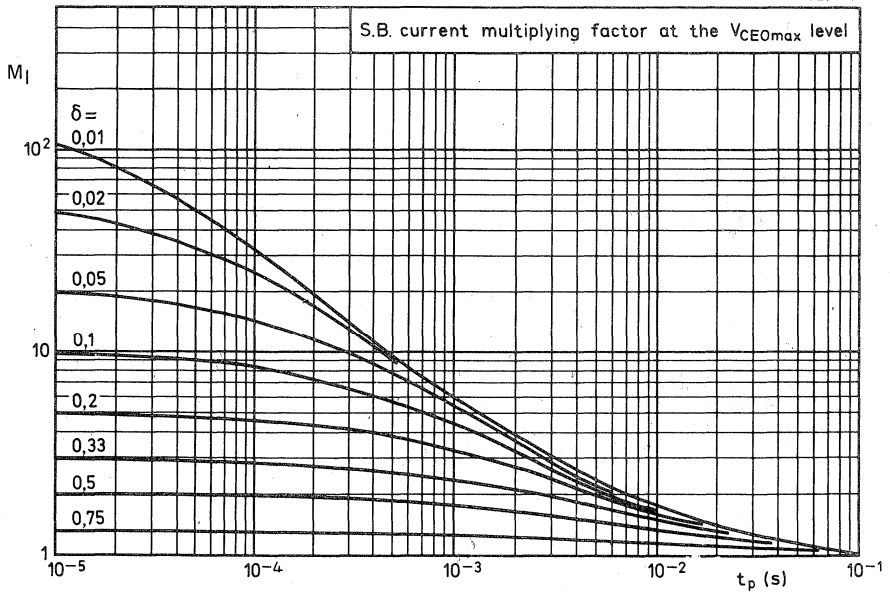
2) Second-breakdown limits (independent of temperature).

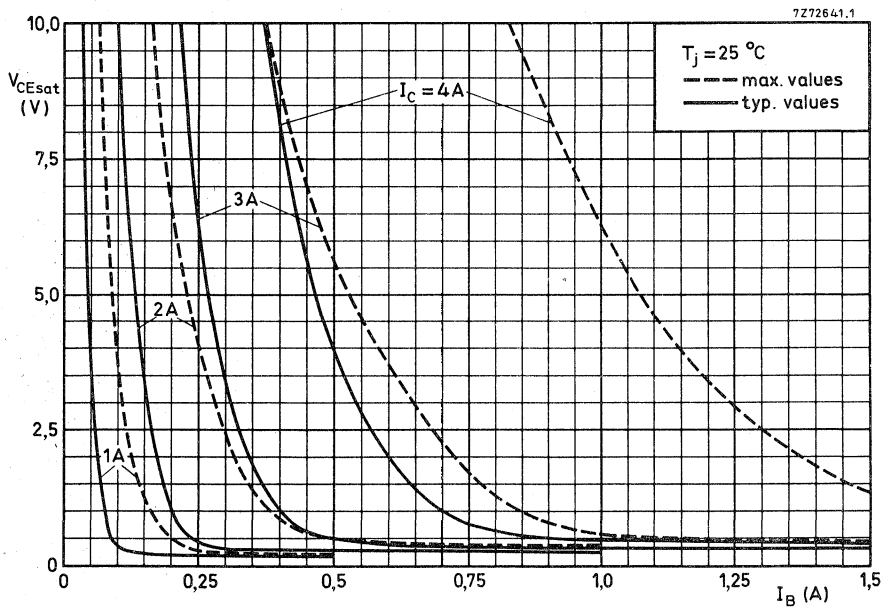
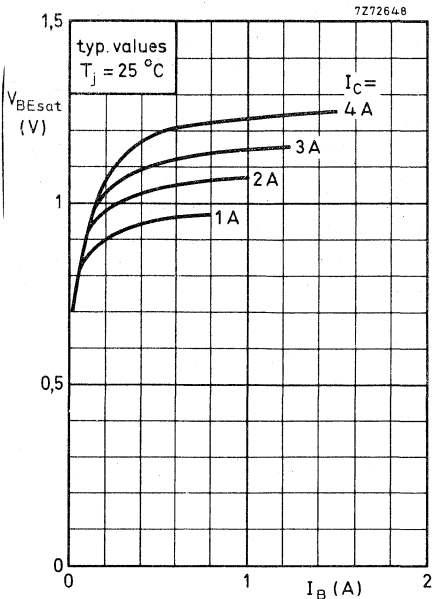
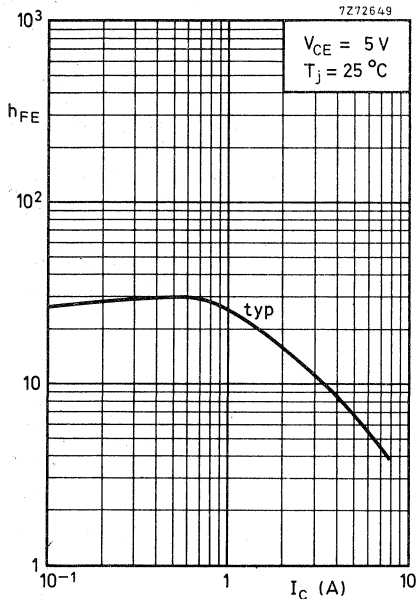


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7Z72651.1





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_{amb} in the above equation is 40 °C.

A practical forward converter output circuit for an output power in the order of 200 W is given in Fig. 2.

At a collector current of 2,5 A and a base current of 0,5 A in this circuit the following turn-off times can be expected.

Storage time
Fall time

		$T_{mb} = 25\ ^\circ\text{C}$	$100\ ^\circ\text{C}$
t_s	typ	1,9	2,7 μs
t_f	typ	0,17	0,7 μs

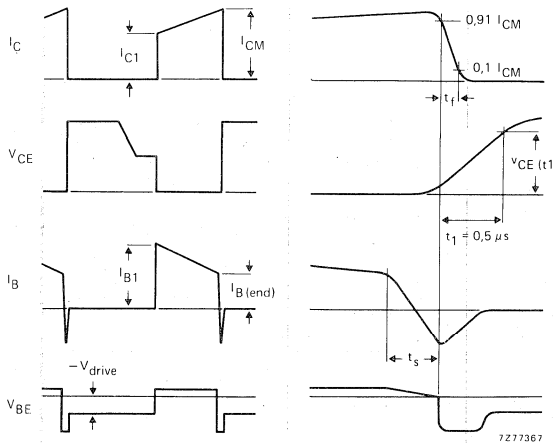


Fig. 1 Relevant waveforms of switching transistor.

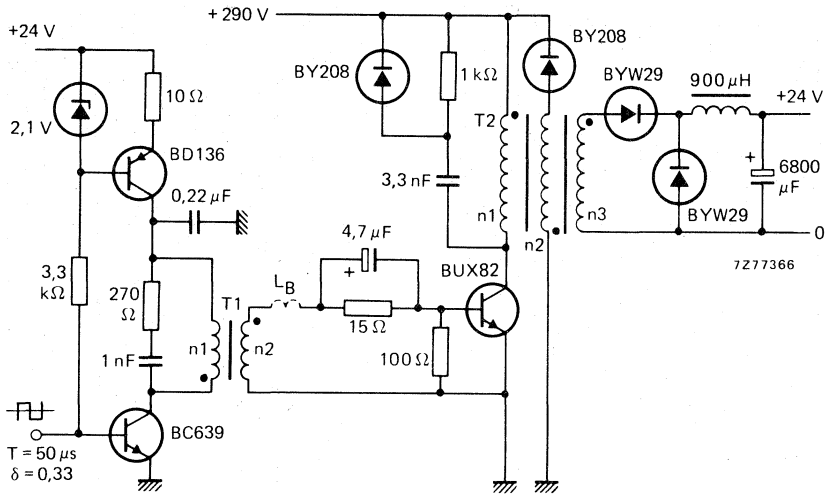


Fig. 2 Practical forward converter SMPS output circuit.

T1 (driver transformer): Core U20; $n_1 = 75$ turns; $n_2 = 20$ turns

T2 (output transformer): Core E55; $n_1 = n_2 = 72$ turns; $n_3 = 19$ turns

$v_{CE}(t_1) < 300$ V (see Fig. 1)

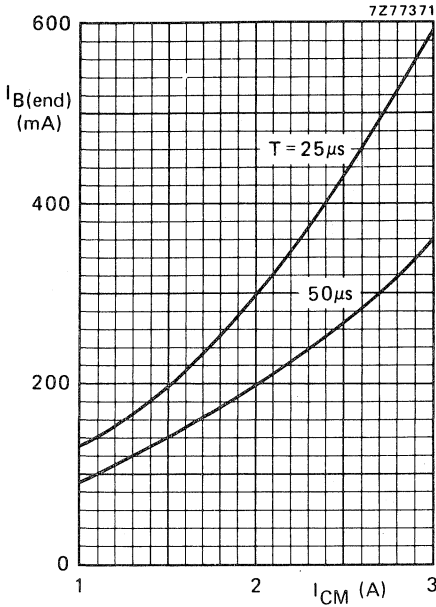


Fig. 3.

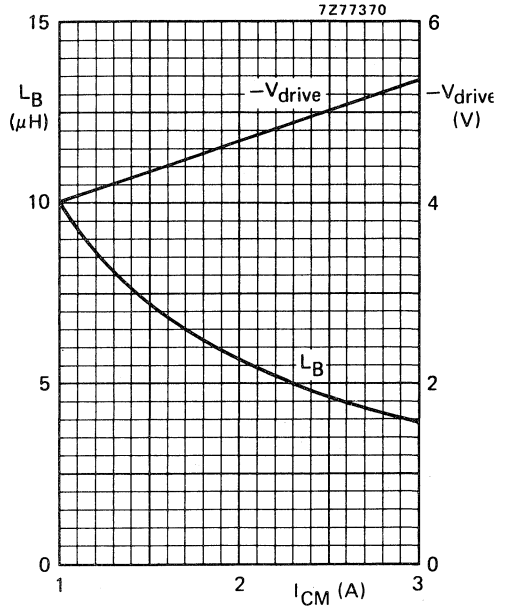


Fig. 4.

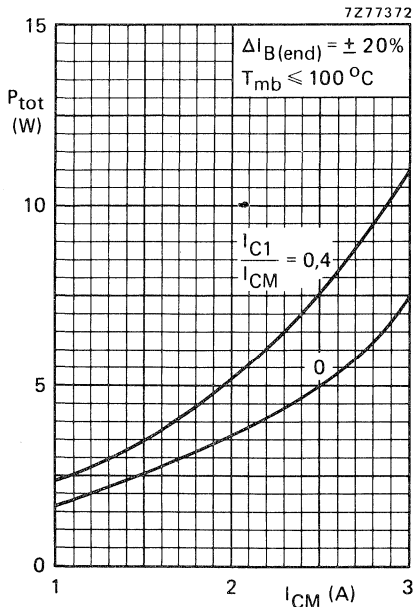


Fig. 5.

Fig. 3 Recommended nominal "end" value of the base current versus maximum peak collector current in a flyback converter.

Fig. 4 Minimum required base inductance and recommended negative drive voltage versus maximum peak collector current.

Fig. 5 Maximum total power dissipation of a limit-case transistor if the base current is chosen in accordance with Fig. 3.

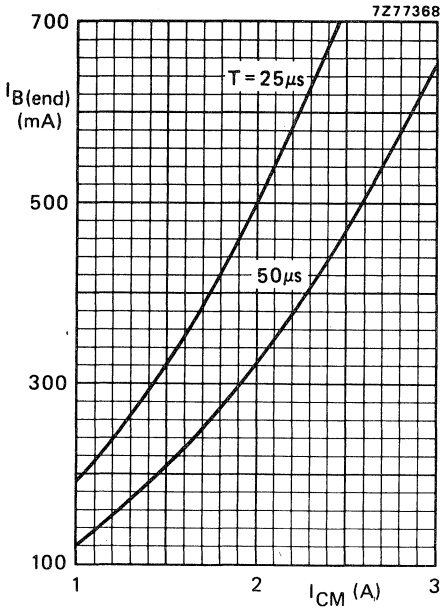


Fig. 6.

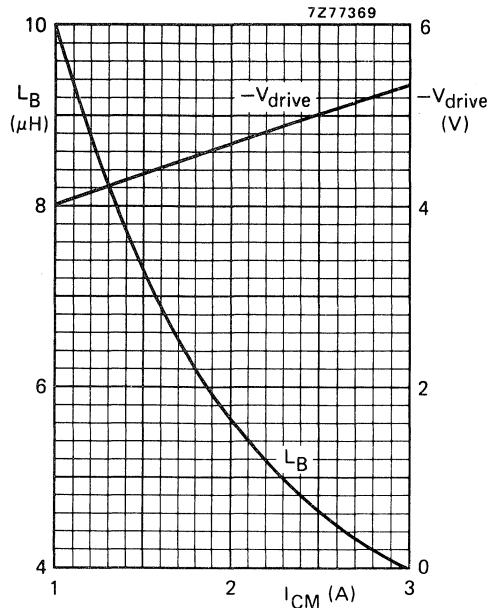


Fig. 7.

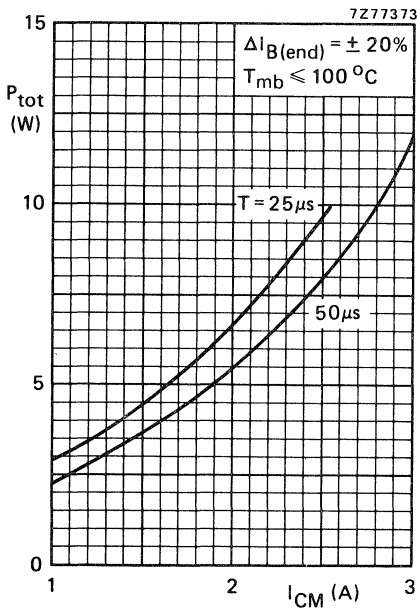


Fig. 8.

Fig. 6 Recommended nominal "end" value of the base current versus maximum peak collector current in a forward converter.

Fig. 7 Minimum required base inductance and recommended negative drive voltage versus maximum peak collector current.

Fig. 8 Maximum total power dissipation of a limit-case transistor if the base current is chosen in accordance with Fig. 6.

SILICON DIFFUSED POWER TRANSISTORS

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

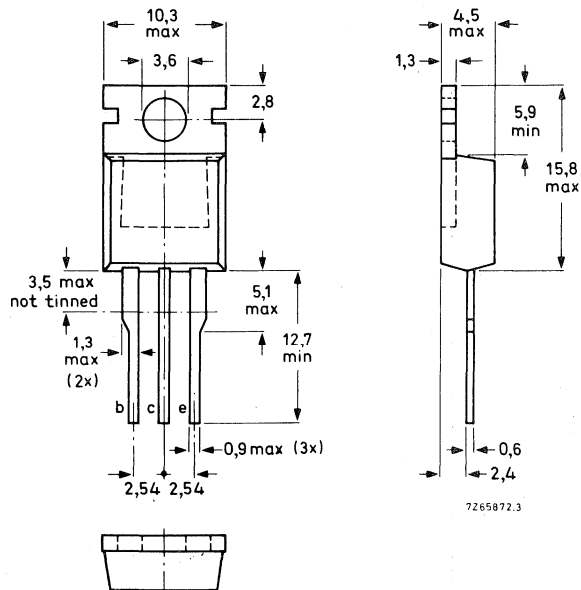
QUICK REFERENCE DATA

		BUX84	BUX85	
Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM} max	800	1000	V
Collector-emitter voltage (open base)	V_{CEO} max	400	450	V
Collector current (d.c.)	I_C max	2	A	
Collector current (peak value) $t_p = 2$ ms	I_{CM} max	3	A	
Total power dissipation up to $T_{mb} = 50$ °C	P_{tot} max	40	W	
Collector-emitter saturation voltage $I_C = 1$ A; $I_B = 0,2$ A	V_{CEsat} <	1	V	
Fall time $I_{Con} = 1$ A; $I_{Bon} = 0,2$ A; $-I_{Boff} = 0,4$ A	t_f typ	0,4	μ s	

MECHANICAL DATA

TO-220
Collector connected
to mounting base

Dimensions in mm



See also chapters Mounting Instructions and Accessories.

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

Voltages

	BUX84		BUX85	
Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM}	max 800	1000	V
Collector-emitter voltage (open base)	V_{CEO}	max 400	450	V

Currents

Collector current (d.c.)	I_C	max	2	A
Collector current (peak value) $t_p = 2$ ms	I_{CM}	max	3	A
Base current (d.c.)	I_B	max	0,75	A
Base current (peak value)	I_{BM}	max	1	A
Reverse base current (peak value) *	$-I_{BM}$	max	1	A

Power dissipation

Total power dissipation up to $T_{mb} = 50$ °C	P_{tot}	max	40	W
--	-----------	-----	----	---

Temperatures

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

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=	2,5	K/W
From junction to ambient in free air	$R_{th\ j-a}$	=	70	K/W

CHARACTERISTICS

$T_j = 25$ °C unless otherwise specified

Collector cut-off current **

$V_{CEM} = V_{CESMmax}; V_{BE} = 0$	I_{CES}	<	200	μA
$V_{CEM} = V_{CESMmax}; V_{BE} = 0; T_j = 125$ °C	I_{CES}	<	1,5	mA

D.C. current gain

$I_C = 0,1$ A; $V_{CE} = 5$ V	h_{FE}	typ	50
-------------------------------	----------	-----	----

* Turn-off current.

** Measured with a half sine-wave voltage (curve tracer).

CHARACTERISTICS (continued)

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

Emitter cut-off current

$I_C = 0; V_{EB} = 5\text{ V}$

$I_{EBO} < 1\text{ mA}$

Saturation voltages

$I_C = 0,3\text{ A}; I_B = 30\text{ mA}$

$V_{CEsat} < 0,8\text{ V}$

$I_C = 1\text{ A}; I_B = 0,2\text{ A}$

$V_{CEsat} < 1,0\text{ V}$

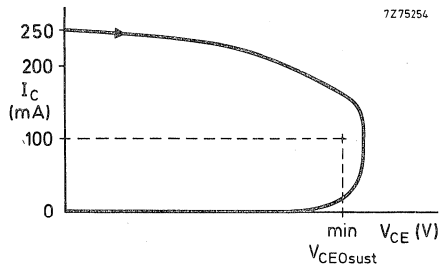
$I_C = 1\text{ A}; I_B = 0,2\text{ A}$

$V_{BEsat} < 1,1\text{ V}$

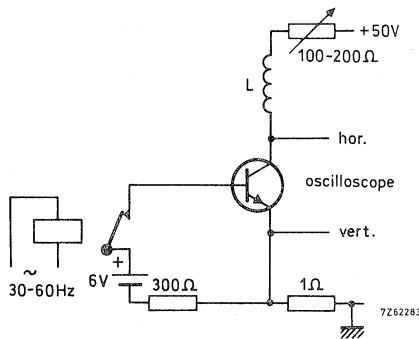
Collector-emitter sustaining voltage

$I_C = 100\text{ mA}; I_{Boff} = 0; L = 25\text{ mH}$

	BUX84	BUX85	
$V_{CEOsust} >$	400	450	V



Oscilloscope display for sustaining voltage.



Test circuit for $V_{CEOsust}$

CHARACTERISTICS (continued)

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

Transition frequency at $f = 1\text{ MHz}$

$I_C = 0,2\text{ A}$; $V_{CE} = 10\text{ V}$

f_T typ 20 MHz

Switching times

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

$I_{Bon} = 0,2\text{ A}$; $-I_{Boff} = 0,4\text{ A}$

Turn-on time

t_{on} typ 0,2 μs
< 0,5 μs

Turn-off: Storage time

t_s typ 2 μs
< 3,5 μs

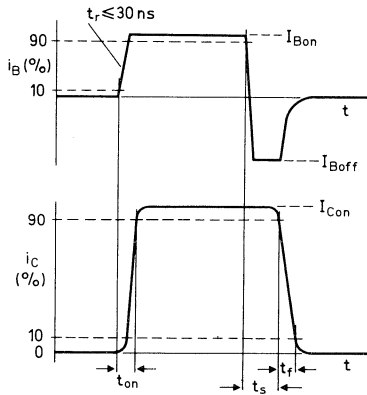
Fall time

t_f typ 0,4 μs

Fall time, $T_{mb} = 95\text{ }^\circ\text{C}$

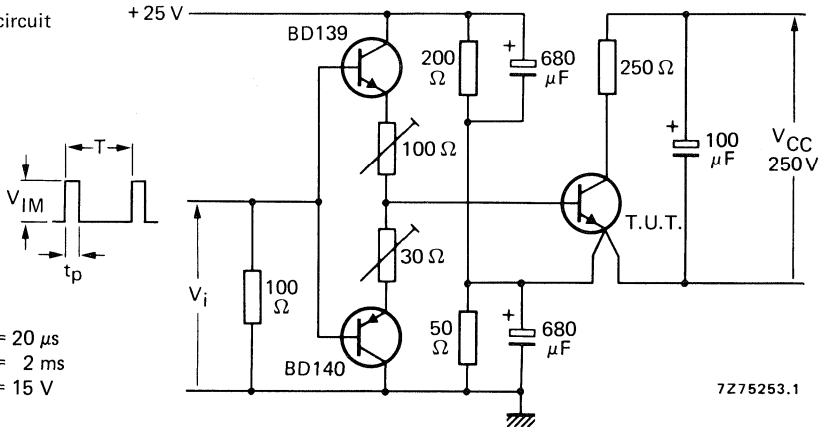
t_f < 1,4 μs

Waveform



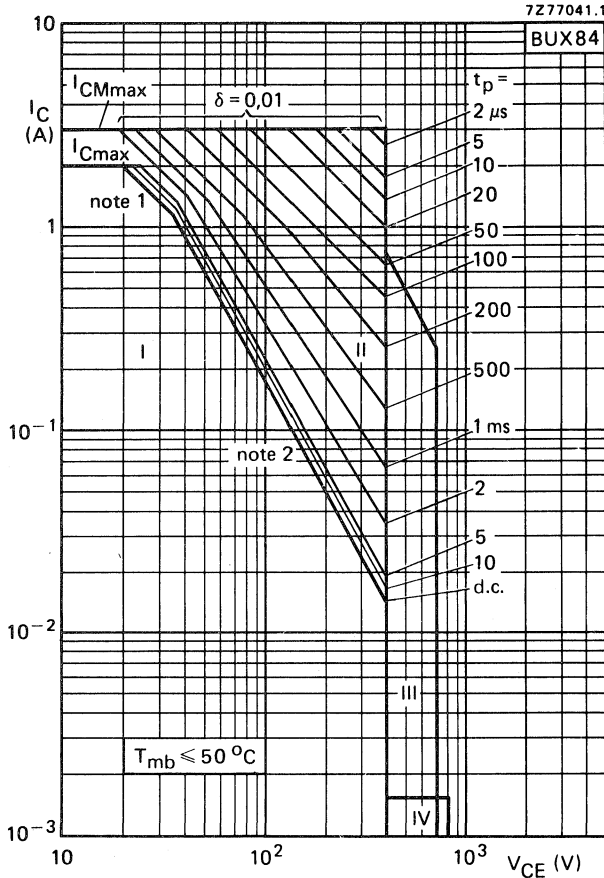
7Z72640

Test circuit



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

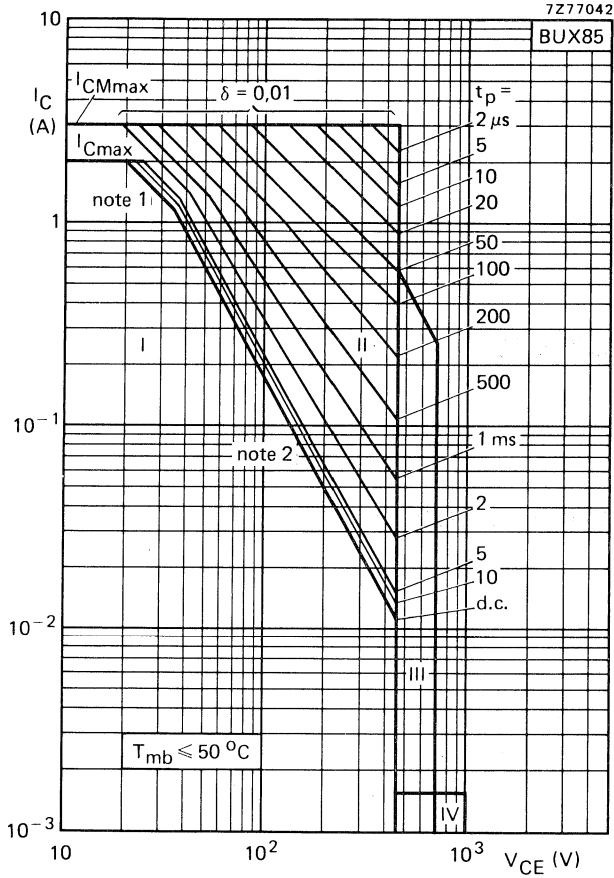


Safe Operating Area

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

Notes

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

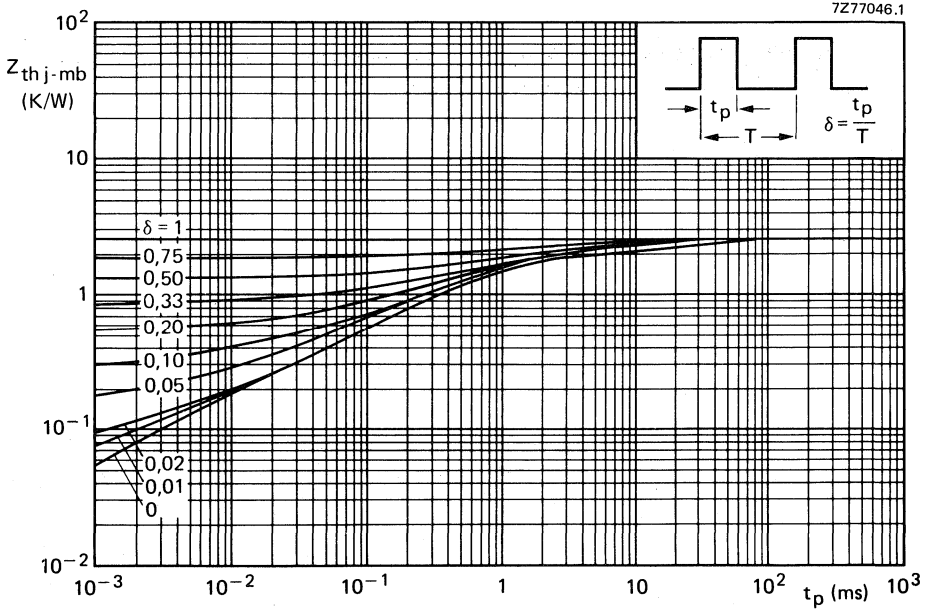
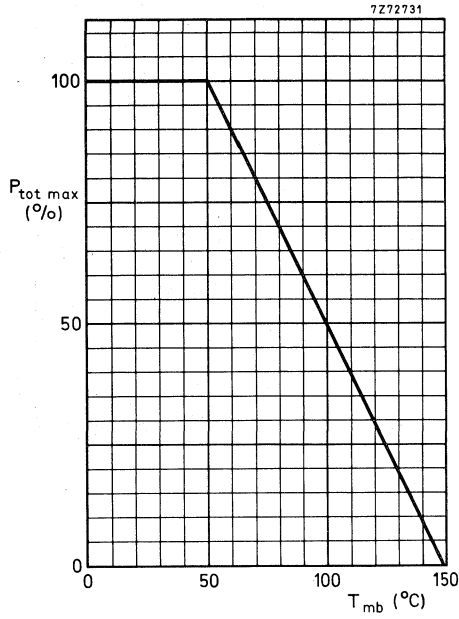


Safe Operating Area

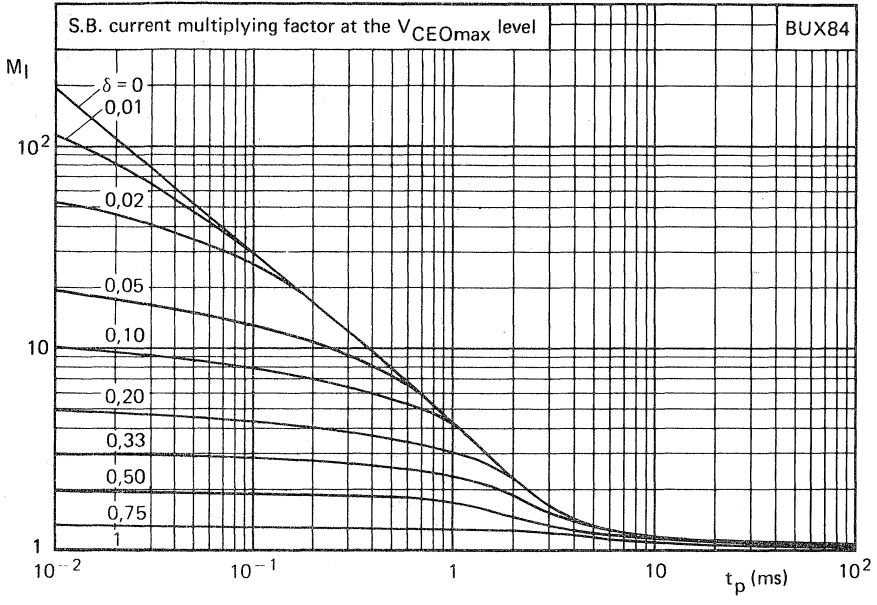
- I Region of permissible d.c. operation
- II Permissible extension for repetitive pulse operation
- III Area of permissible operation during turn-on in single transistor converters, provided $R_{BE} \leq 100 \Omega$ and $t_p \leq 0,6 \mu s$
- IV Repetitive pulse operation in this region is permissible,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

Notes

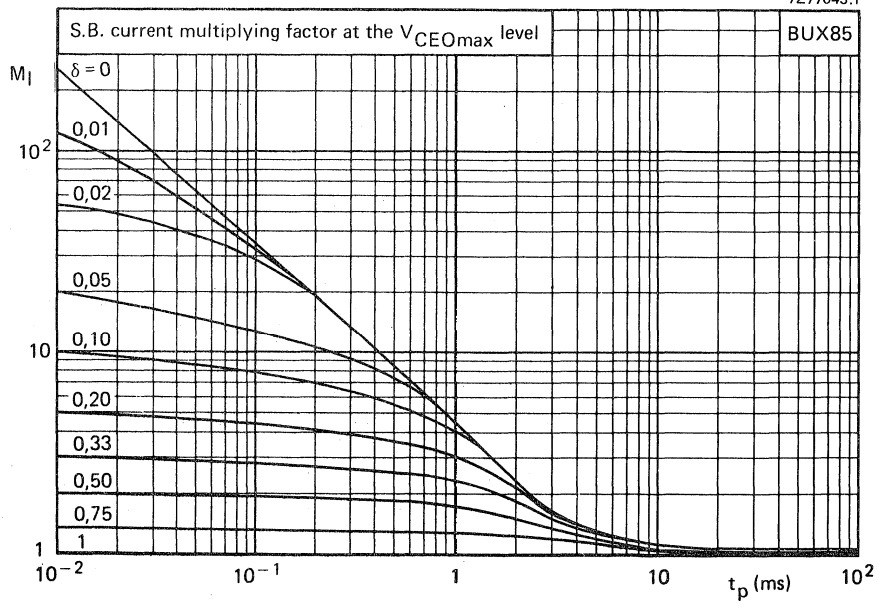
1. $P_{tot \text{ max}}$ and $P_{peak \text{ max}}$ lines.
2. Second-breakdown limits (independent of temperature).

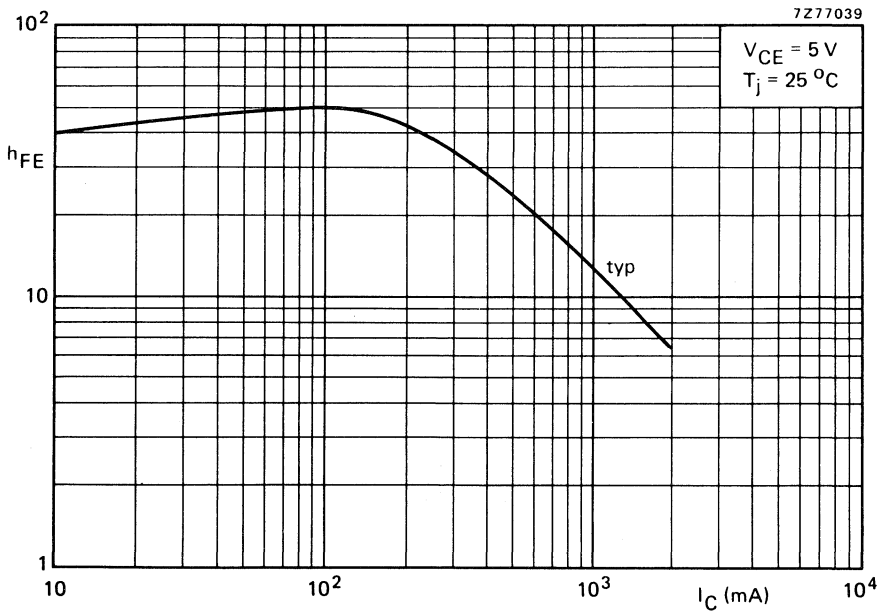
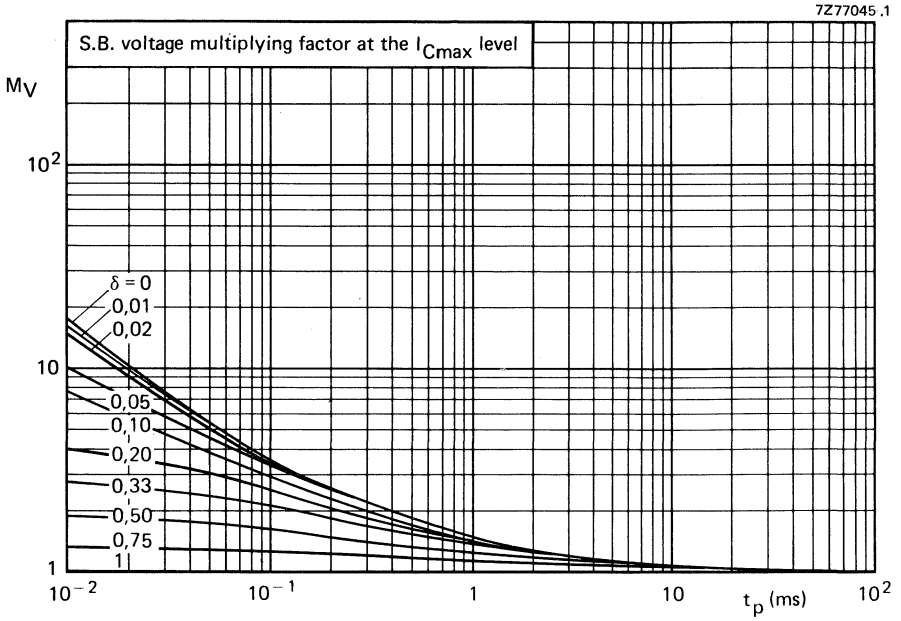


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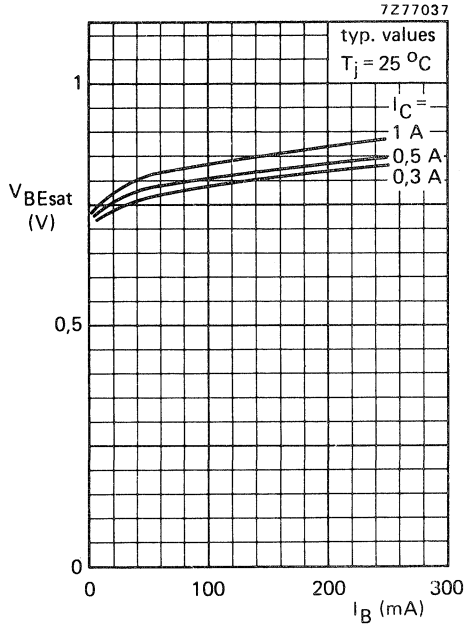


Fig. 14 Typical values saturation voltage, $T_j = 25^\circ\text{C}$.

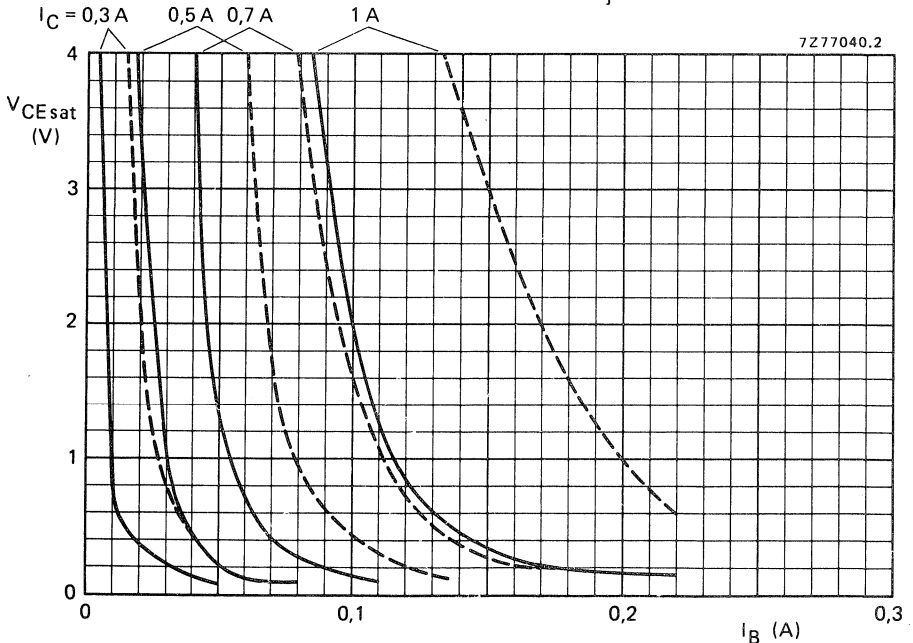


Fig. 15 Typical (—) and maximum (---) values saturation voltage at $T_j = 25^\circ\text{C}$.

APPLICATION INFORMATION ON BUX84 (detailed information on request)

Important factors in the design of SMPS circuits are the power losses and heatsink requirements of the supply output transistor and the base drive conditions during turn-off. In most SMPS circuits with mains isolation the duty factor of the collector current generally varies between 0,25 and 0,5.

The operating frequency lies between 15 kHz and 50 kHz and the shape of the collector current varies from rectangular in a forward converter to a sawtooth in a flyback circuit.

Information on optimum base drive and device dissipation of the BUX84 in a flyback converter is given in Figs 3 to 5. Figs 6 to 8 apply to a forward converter. In these figures I_{CM} represents the highest repetitive peak collector current that can occur in the given circuit, e.g. during overload.

The total power dissipation for a limit-case transistor is given in Figs 5 and 8 which apply for a mounting base temperature of 100 °C. The required thermal resistance for the heatsink can be calculated from

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

To ensure thermal stability the minimum value of T_{amb} in the above equation is 40 °C.

A practical SMPS output circuit for an output power in the order of 50 W is given in Fig. 2.

At a collector current of 0,7 A and a base current of 70 mA in this circuit the following turn-off times can be expected.

	$T_{mb} = 25\ ^\circ C$		$100\ ^\circ C$	
Storage time	t_s	typ 2,2	2,8	μs
Fall time	t_f	typ 0,25	0,85	μs

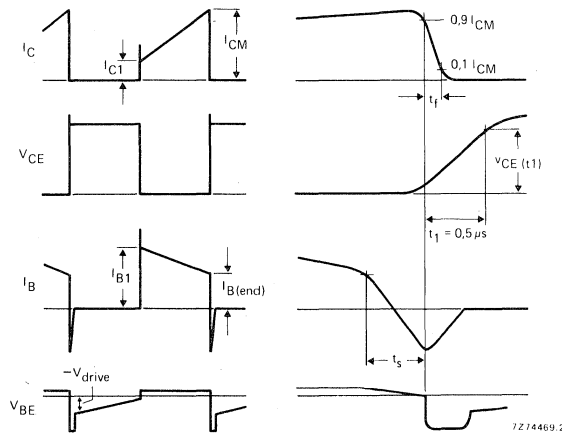


Fig. 1 Relevant waveforms of switching transistor.

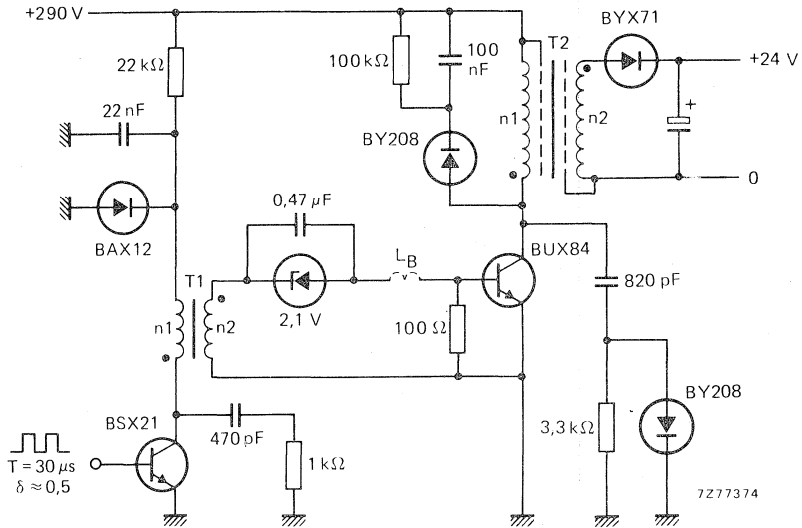


Fig. 2 Practical SMPS output circuit.

T1 (driver transformer): Core U15; $n_1 = 360$ turns; $n_2 = 60$ turns
total inductance in base circuit $\approx 15 \mu\text{H}$

T2 (output transformer): Core E55; primary inductance $L_p = 16 \text{ mH}$
 $n_1 = 116$ turns; $n_2 = 12$ turns

$v_{CE}(t_1) < 300 \text{ V}$ (see Fig. 1)

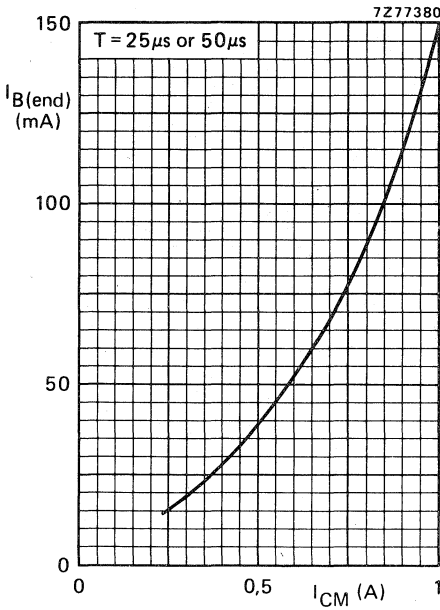


Fig. 3.

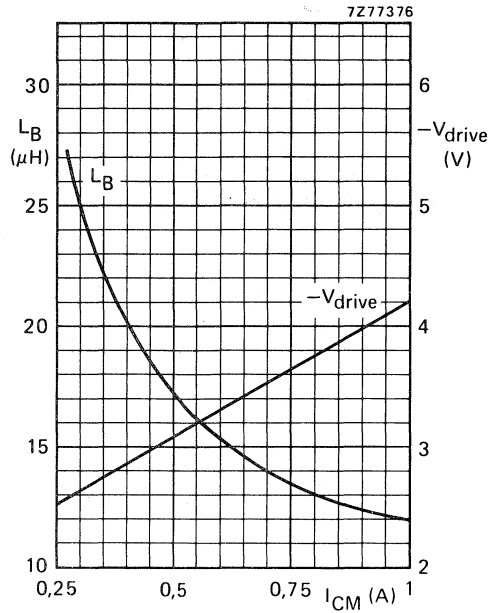


Fig. 4.

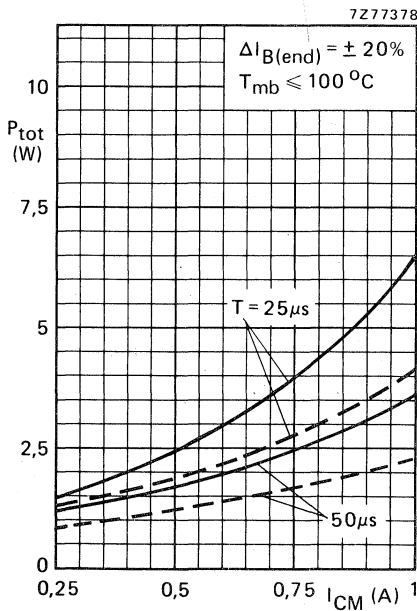


Fig. 5.

Fig. 3 Recommended nominal "end" value of the base current versus maximum peak collector current in a flyback converter.

Fig. 4 Minimum required base inductance and recommended negative drive voltage versus maximum peak collector current.

Fig. 5 Maximum total power dissipation of a limit-case transistor if the base current is chosen in accordance with Fig. 3. Solid lines for $I_{C1}/I_{CM} = 0,4$ and dotted lines for $I_{C1}/I_{CM} = 0$.

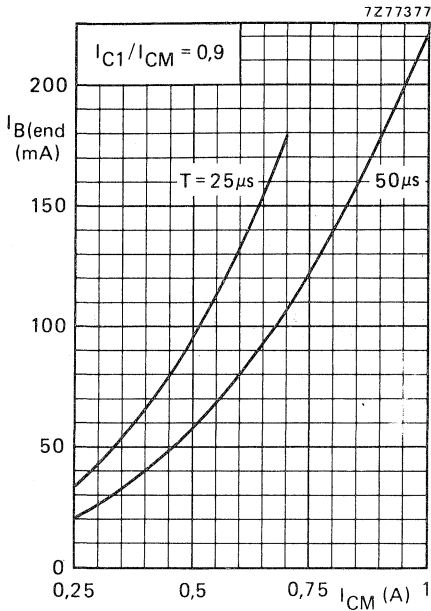


Fig. 6.

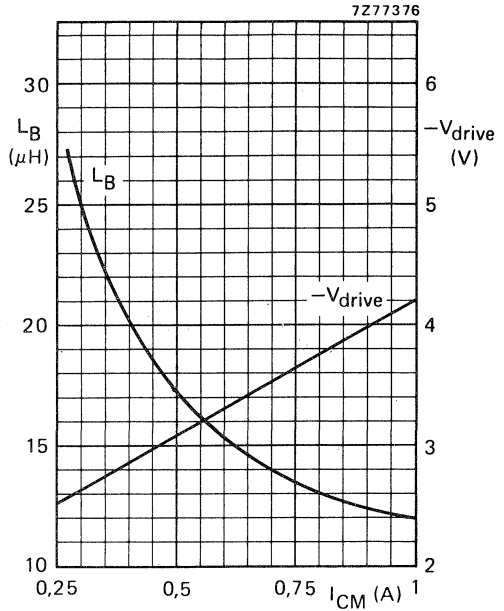


Fig. 7.

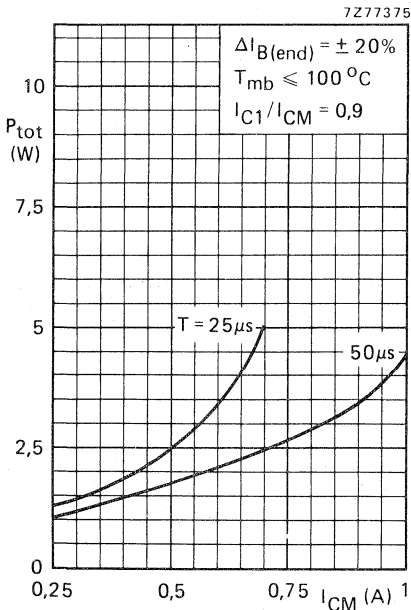


Fig. 8.

Fig. 6 Recommended nominal "end" value of the base current versus maximum peak collector current in a forward converter.

Fig. 7 Minimum required base inductance and recommended negative drive voltage versus maximum peak collector current.

Fig. 8 Maximum total power dissipation of a limit-case transistor if the base current is chosen in accordance with Fig. 6.

SILICON DIFFUSED POWER TRANSISTORS

High-voltage, high-speed, glass-passivated n-p-n power transistors in SOT-32 envelopes, for use in converters, inverters, switching regulators, motor control systems and switching applications.

QUICK REFERENCE DATA

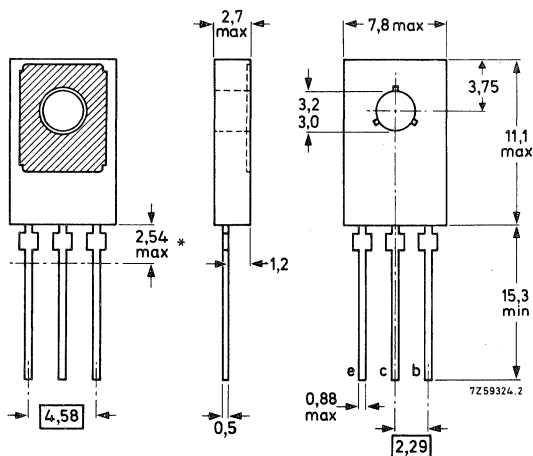
		BUX86	BUX87	
Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM} max	800	1000	V
Collector-emitter voltage (open base)	V_{CEO} max	400	450	V
Collector current (d.c.)	I_C max	0,5		A
Collector current (peak value): $t_p = 2$ ms	I_{CM} max	1		A
Total power dissipation up to $T_{mb} = 60$ °C	P_{tot} max	20		W
Collector-emitter saturation voltage: $I_C = 0,2$ A; $I_B = 20$ mA	V_{CEsat} <	1		V ←
Fall time: $I_{Con} = 0,2$ A; $I_{Bon} = 20$ mA; $-I_{Boff} = 40$ mA	t_f typ	0,4		µs

MECHANICAL DATA

Dimensions in mm

TO-126 (SOT-32)

Collector connected to metal part of mounting surface



* 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)

Voltages

		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
→ Emitter-base voltage (open collector)	V_{EBO}	max. 5	5	V

Currents

Collector current (d.c.)	I_C	max.	0,5	A
Collector current (peak value) $t_p = 2$ ms	I_{CM}	max.	1	A
Base current (d.c.)	I_B	max.	0,2	A
Base current (peak value)	I_{BM}	max.	0,3	A
Reverse base current (peak value) (note 1)	$-I_{BM}$	max.	0,3	A

Power dissipation

Total power dissipation up to $T_{mb} = 60$ °C	P_{tot}	max.	20	W
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Temperatures

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

THERMAL RESISTANCE

From junction to mounting base	R_{thj-mb}	=	4,5	K/W
From junction to ambient in free air	R_{thj-a}	=	100	K/W

CHARACTERISTICS

$T_j = 25$ °C unless otherwise specified

Collector-cut-off current (note 2)

$V_{CEM} = V_{CESMmax}; V_{BE} = 0$	I_{CES}	<	100	μ A
$V_{CEM} = V_{CESMmax}; V_{BE} = 0; T_j = 125$ °C	I_{CES}	<	1	mA

D.C. current gain

$I_C = 50$ mA; $V_{CE} = 5$ V	h_{FE}	typ.	50	
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Notes

1. Turn-off current.
2. Measured with a half sine-wave voltage (curve tracer).

CHARACTERISTICS (continued)

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

Emitter cut-off current

$I_C = 0; V_{EB} = 5\text{ V}$

$I_{EBO} < 1\text{ mA}$

Saturation voltage

$I_C = 0,1\text{ A}; I_B = 10\text{ mA}$

$V_{CEsat} < 0,8\text{ V}$ ←

$I_C = 0,2\text{ A}; I_B = 20\text{ mA}$

$V_{CEsat} < 1,0\text{ V}$ ←

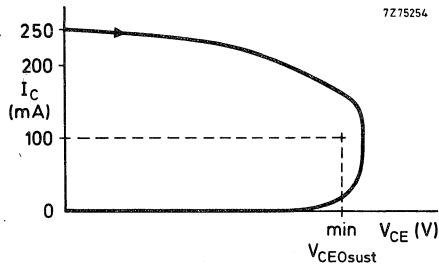
$I_C = 0,2\text{ A}; I_B = 20\text{ mA}$

$V_{BEsat} < 1,0\text{ V}$

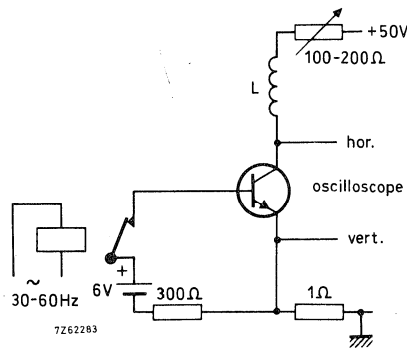
Collector-emitter sustaining voltages

$I_C = 100\text{ mA}; I_{Boff} = 0; L = 25\text{ mH}$

	BUX86	BUX87	
$V_{CEO\text{sust}} >$	400	450	V



Oscilloscope display for sustaining voltage



Test circuit for $V_{CEO\text{sust}}$

CHARACTERISTICS (continued)

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

Transition frequency at $f = 1\text{ MHz}$

$I_C = 50\text{ mA}; V_{CE} = 10\text{ V}$

f_T typ 20 MHz

Switching times

$I_{Con} = 0,2\text{ A}; V_{CC} = 250\text{ V}$

$I_{Bon} = 20\text{ mA}; -I_{Boff} = 40\text{ mA}$

Turn-on time

t_{on} typ 0,25 μs
< 0,5 μs

Turn-off: Storage time

t_s typ 2 μs
< 3,5 μs

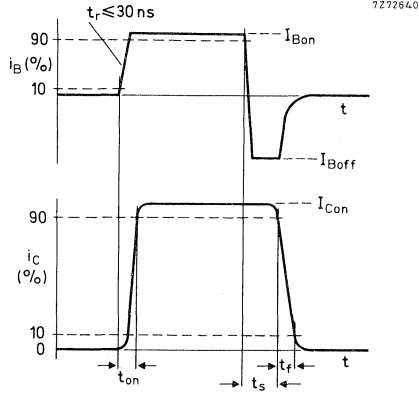
Fall time

t_f typ 0,4 μs

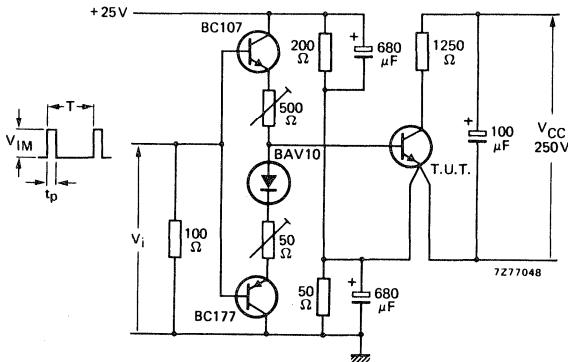
Fall time, $T_{mb} = 95\text{ }^\circ\text{C}$

t_f < 1,3 μs

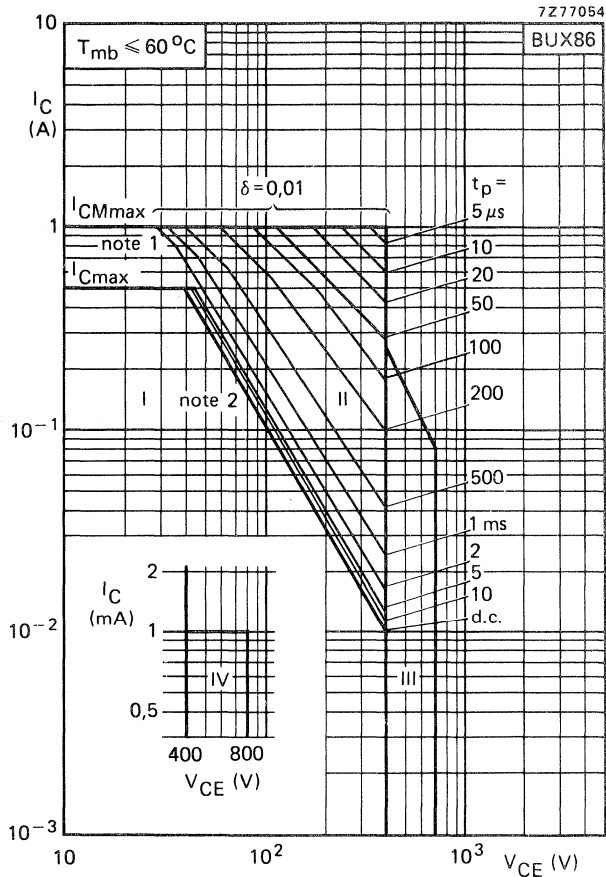
Waveform



Test circuit



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

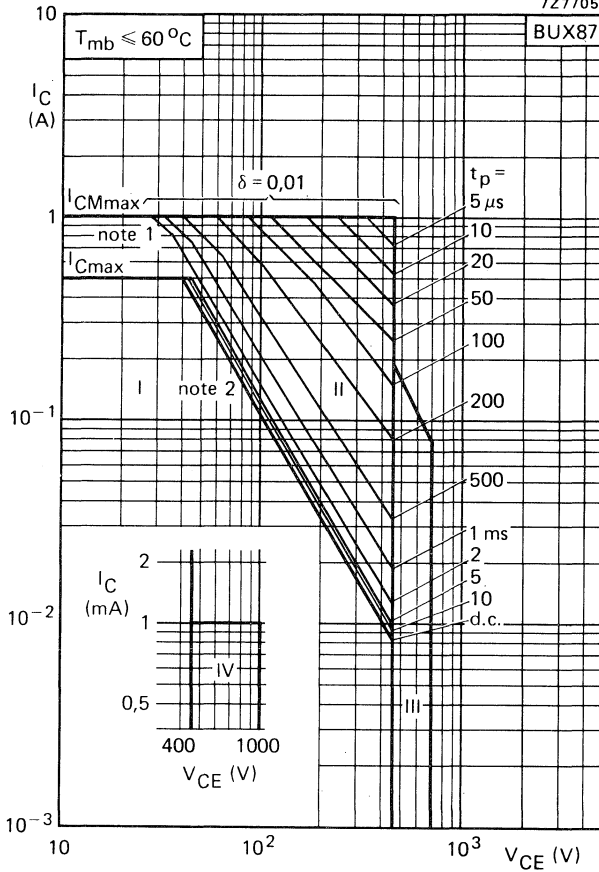


Safe Operating ARea

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

Notes

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

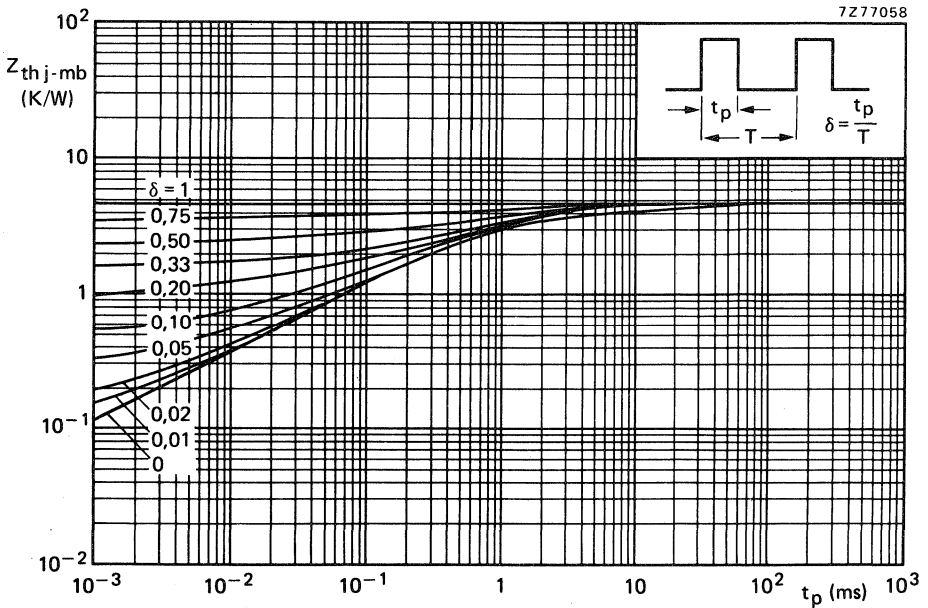
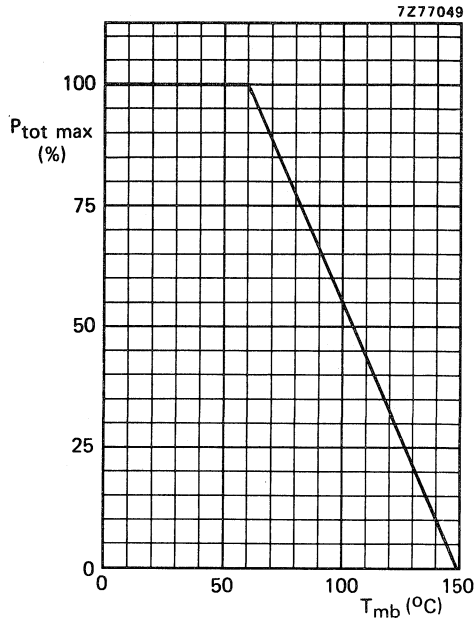


Safe Operating ARea

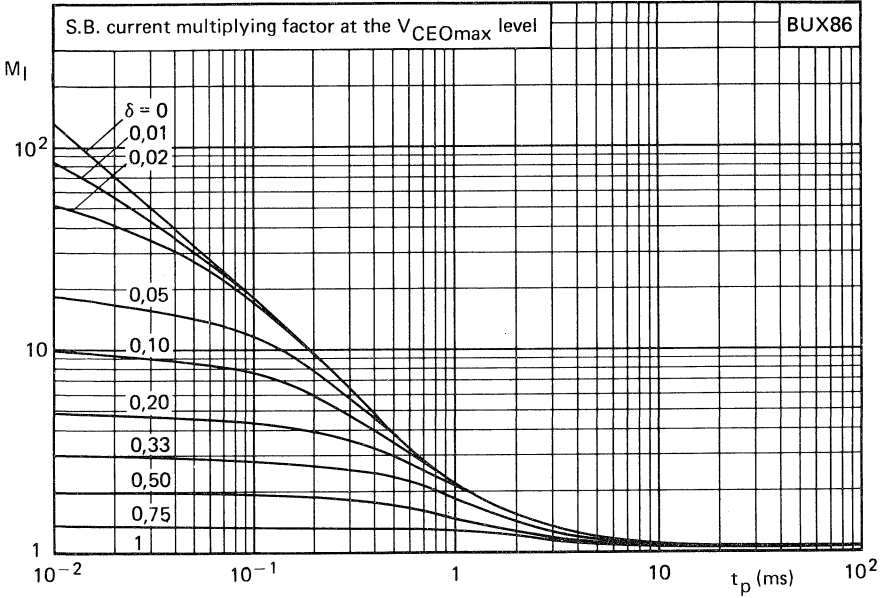
- I Region of permissible d.c. operation
- II Permissible extension for repetitive pulse operation
- III Area of permissible operation during turn-on in single-transistor converters, provided $R_{BE} \leq 100 \Omega$ and $t_p \leq 0,6 \mu s$
- IV Repetitive pulse operation in this region is permissible,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

Notes

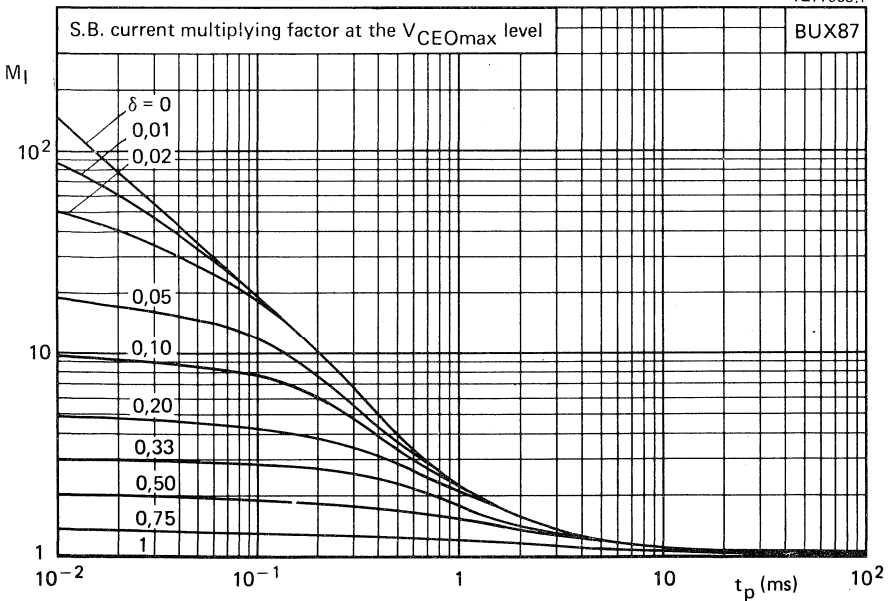
- 1. P_{peak} max lines.
- 2. Second-breakdown limits (independent of temperature).

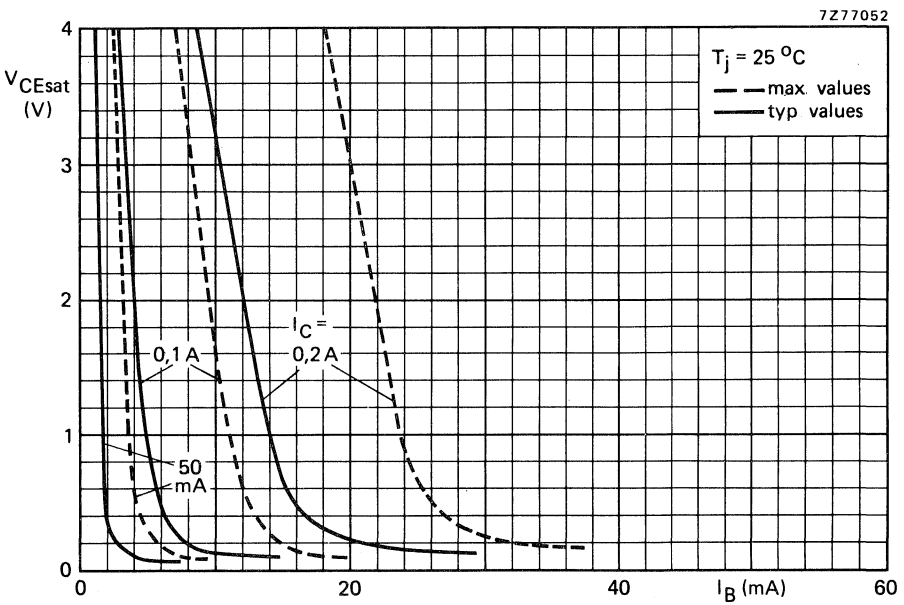
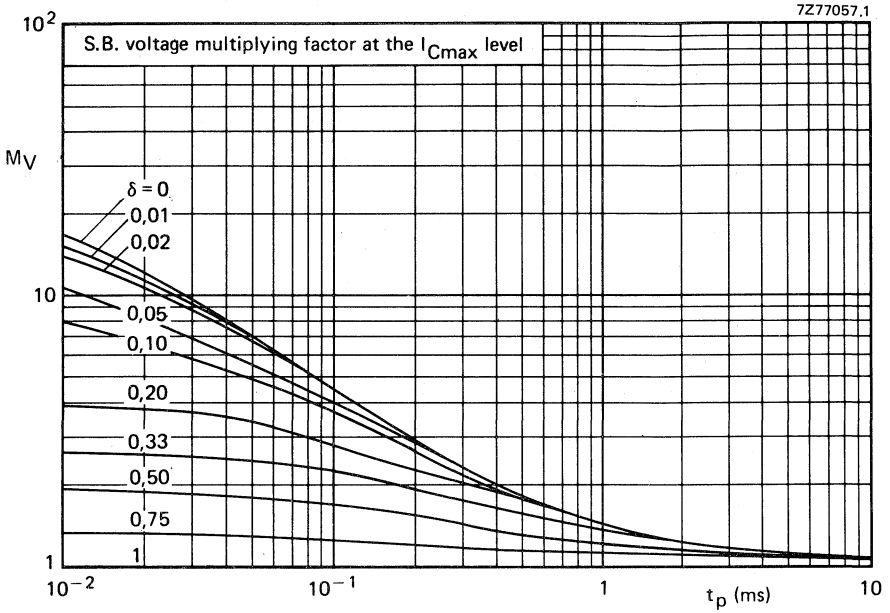


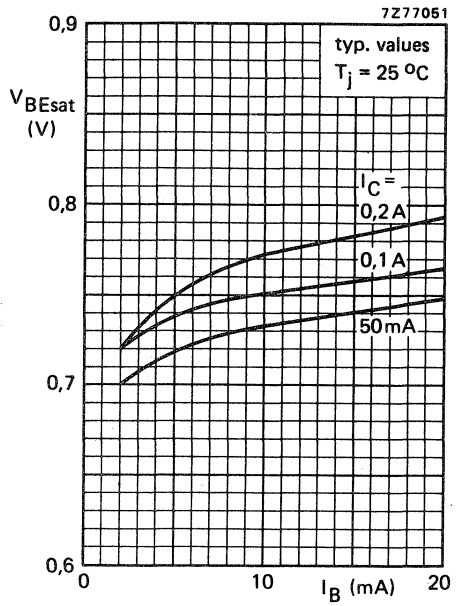
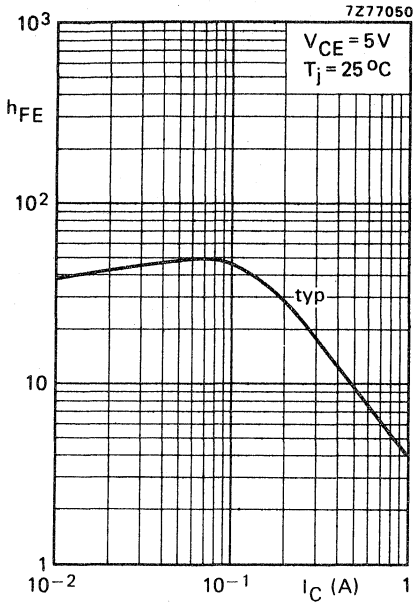
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7277055.1







APPLICATION INFORMATION ON BUX86 (detailed information on request)

Important factors in the design of SMPS circuits are the power losses and heatsink requirements of the supply output transistor and the base drive conditions during turn-off. In SMPS circuits with mains isolation the duty factor of the collector current generally varies between 0,25 to 0,5.

The operating frequency lies between 15 kHz and 50 kHz and the shape of the collector current varies from rectangular in a forward converter to a sawtooth in a flyback circuit.

As the BUX86 will mainly be used in low-power flyback converters the information on optimum base drive and device dissipation given in the graphs on page 13 is concentrated on this application. In these figures I_{CM} represents the highest repetitive peak collector current that can occur in the given circuit, e.g. during overload.

The total power dissipation for a limit-case transistor is given in Fig. 5 which applies for a mounting base temperature of 100 °C. The required thermal resistance for the heatsink can be calculated from

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

To ensure thermal stability the minimum value of T_{amb} in the above equation is 40 °C.

A practical SMPS output circuit for an output of power in the order of 15 W is given in Fig. 2.

At a collector current of 200 mA and a base current of 20 mA in this circuit the following turn-off times can be expected.

	$T_{mb} = 25\ ^\circ\text{C}$		$100\ ^\circ\text{C}$	
Storage time	t_s	typ 1,3	1,8	μs
Fall time	t_f	typ 0,2	0,8	μs

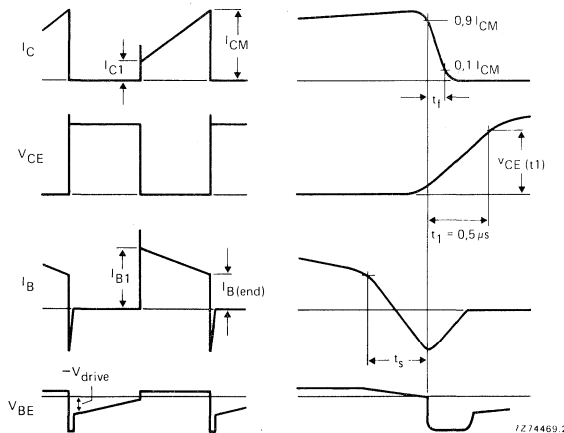


Fig. 1 Relevant waveforms of switching transistor.

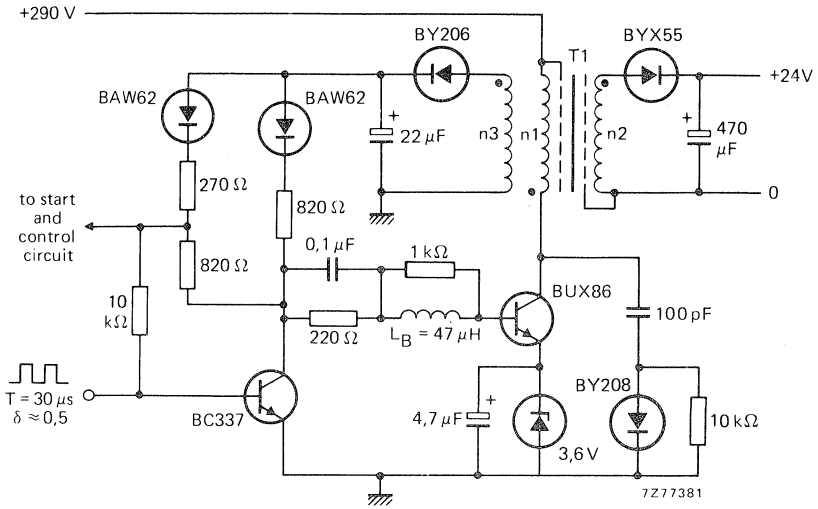


Fig. 2 Practical SMPS output circuit.

T1 (output transformer): Core U20; primary inductance $L_p = 23 \text{ mH}$
 $n_1 = 252$ turns; $n_2 = 27$ turns; $n_3 = 22$ turns

$v_{CE}(t_1) < 300 \text{ V}$ (see Fig. 1)

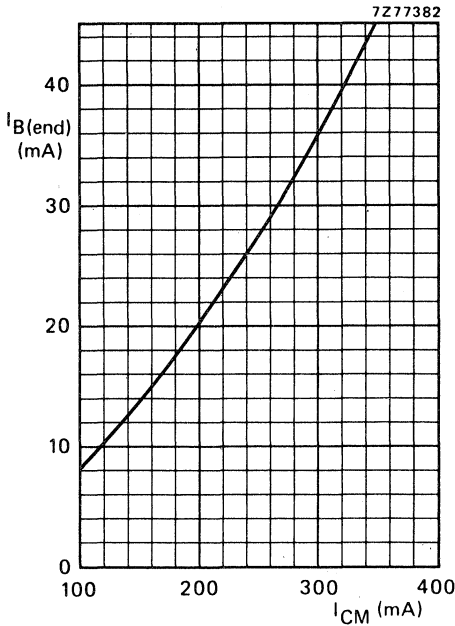


Fig. 3.

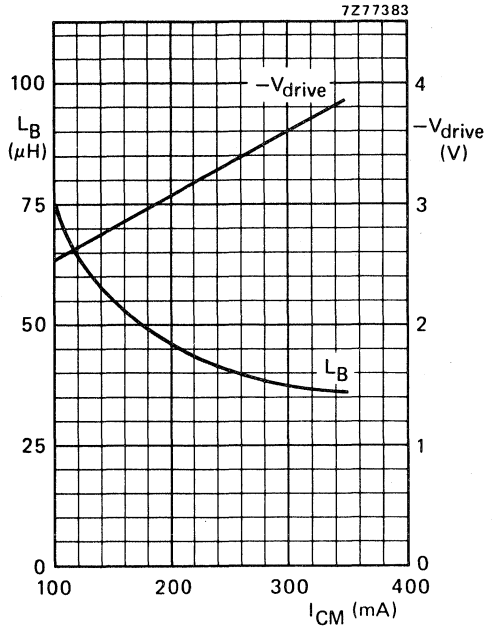


Fig. 4.

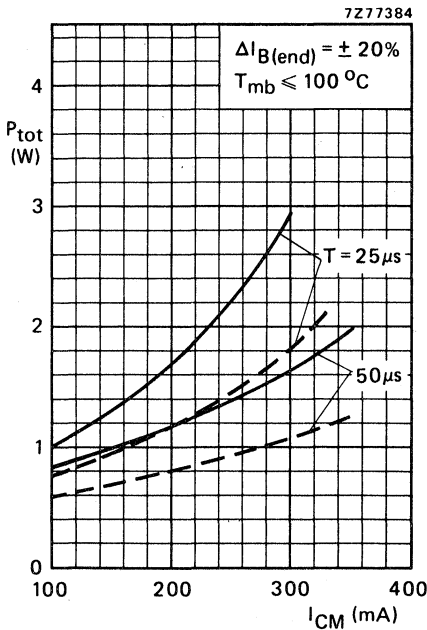


Fig. 5.

Fig. 3 Recommended nominal "end" value of the base current versus maximum peak collector current.

Fig. 4 Minimum required base inductance and recommended negative drive voltage versus maximum peak collector current.

Fig. 5 Maximum total power dissipation of a limit-case transistor if the base current is chosen in accordance with Fig. 3. Solid lines for $I_{C1}/I_{CM} = 0,4$ and dotted lines for $I_{C1}/I_{CM} = 0$.

SILICON DIFFUSED POWER TRANSISTOR

High-voltage, high-speed, 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

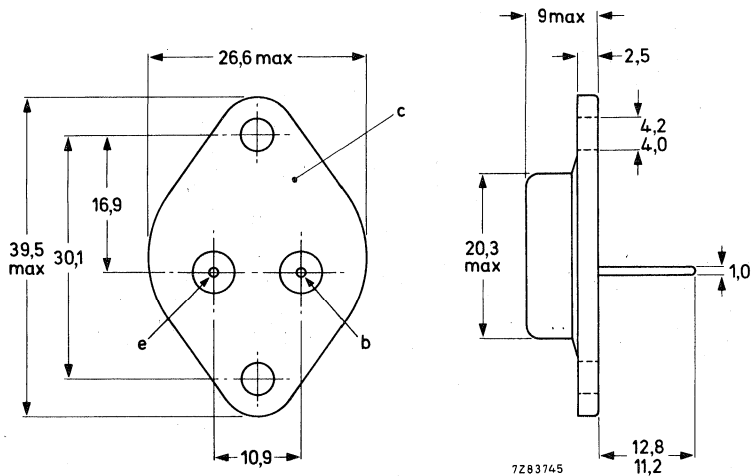
Collector-emitter voltage (peak value; $V_{BE} = 0$)	V_{CESM}	max.	1200	V
Collector-emitter voltage (open base)	V_{CEO}	max.	800	V
Collector current (d.c.)	I_C	max.	12	A
Collector current (peak value) $t_p < 2$ ms	I_{CM}	max.	20	A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot}	max.	160	W
Collector-emitter saturation voltage $I_C = 9$ A; $I_B = 4$ A	V_{CEsat}	<	1	V
Collector saturation current	I_{Csat}	=	9	A
Fall time $I_{Con} = 9$ A; $I_{Bon} = -I_{Boff} = 4$ A	t_f	typ.	0,5	μ s

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; $V_{BE} = 0$)	V_{CESM}	max.	1200 V
Collector-emitter voltage (open base)	V_{CEO}	max.	800 V
Collector current (d.c.)	I_C	max.	12 A
Collector current (peak value); $t_p < 2$ ms	I_{CM}	max.	20 A
Base current (d.c.)	I_B	max.	8 A
Base current (peak value); $t_p < 2$ ms	I_{BM}	max.	12 A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot}	max.	160 W
Storage temperature	T_{stg}		-65 to + 150 °C
Junction temperature	T_j	max.	150 °C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=	0,78 K/W
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CHARACTERISTICS

$T_j = 25$ °C unless otherwise specified

Collector cut-off current*

$V_{CE} = V_{CESMmax}; V_{BE} = 0$	I_{CES}	<	1 mA
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$V_{CE} = V_{CESMmax}; V_{BE} = 0; T_j = 125$ °C	I_{CES}	<	4 mA
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Emitter cut-off current

$I_C = 0; V_{EB} = 5$ V	I_{EBO}	<	10 mA
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Saturation voltages

$I_C = 9$ A; $I_B = 4$ A	V_{CEsat}	<	1 V
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	V_{BEsat}	<	1,5 V
--	-------------	---	-------

	V_{CEsat}	<	3 V
--	-------------	---	-----

$I_C = 12$ V; $I_B = 6$ A

Collector-emitter sustaining voltage

$I_C = 200$ mA; $I_B = 0; L = 25$ mH	$V_{CEO_{sust}}$	>	800 V
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Second breakdown collector current

$V_{CE} = 100$ V; $t_p = 1$ s	$I_{(SB)C}$	>	0,4 A
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Transition frequency at $f = 5$ MHz

$I_C = 0,1$ A; $V_{CE} = 5$ V	f_T	typ.	7 MHz
-------------------------------	-------	------	-------

Collector capacitance at $f = 1$ MHz

$I_E = I_e = 0; V_{CB} = 10$ V	C_C	typ.	200 pF
--------------------------------	-------	------	--------

* Measured with a half sine-wave voltage (curve tracer).

Switching times resistive load (Figs 2 and 3)

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

Turn-on time

t_{on} typ. 1,5 μs

Turn-off: Storage time

t_s typ. 4,5 μs

Fall time

t_f typ. 0,5 μs

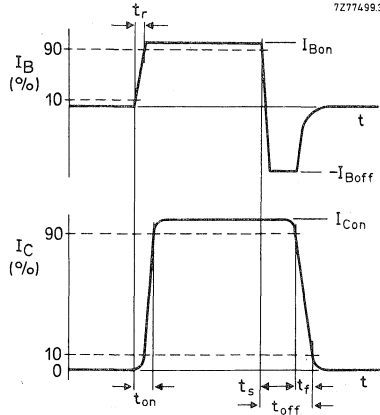


Fig. 2 Switching times waveforms with resistive load.

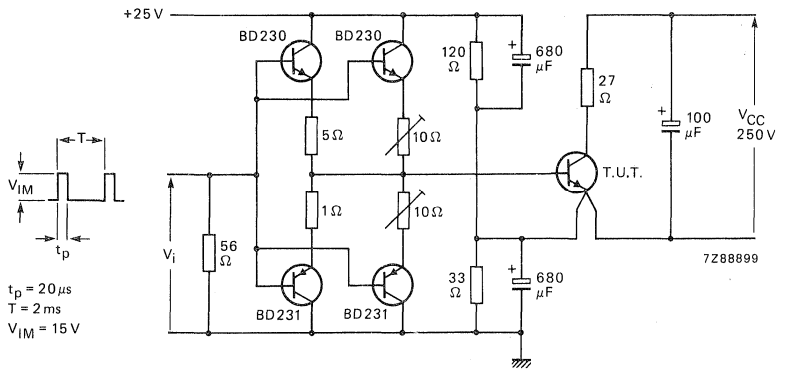


Fig. 3 Test circuit resistive load.

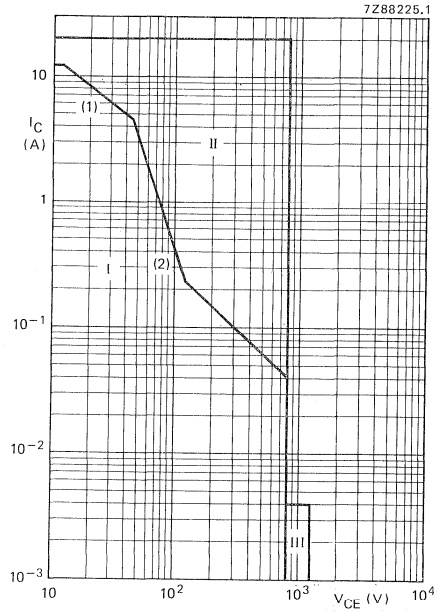


Fig. 4 Safe Operating ARea at $T_{mb} \leq 25 \text{ }^\circ\text{C}$.

- (1) P_{tot} max 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 $V_{BE} \leq 0$ and $t_p \leq 5 \text{ ms}$.

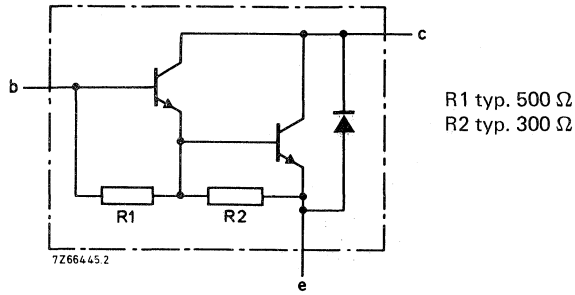


Fig. 2 Circuit diagram.

RATINGS

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

Collector-emitter voltage ($V_{EB} = 0$); peak value	V_{CESM}	max.	650 V
Collector-emitter voltage (open base)	V_{CEO}	max.	400 V
Emitter-base voltage (open collector)	V_{EBO}	max.	6 V
Collector current (d.c.)	I_C	max.	12 A
Collector current (peak value); $t_p < 5$ ms	I_{CM}	max.	30 A
Base current (d.c.)	I_B	max.	4 A
Base current (peak value); $t_p \leq 5$ ms	I_{BM}	max.	6 A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot}	max.	125 W
Storage temperature	T_{stg}		-65 to +200 °C
Junction temperature*	T_j	max.	200 °C

THERMAL RESISTANCE*

From junction to mounting base	$R_{th\ j-mb}$	=	1,4 K/W
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* Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

CHARACTERISTICS

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

Collector cut-off current*

$V_{BE} = 0; V_{CE} = V_{CESMmax}$

$I_{CES} < 1\text{ mA}$

$V_{BE} = 0; V_{CE} = V_{CESMmax}; T_j = 125\text{ }^\circ\text{C}$

$I_{CES} < 3\text{ mA}$

Emitter cut-off current

$I_C = 0; V_{EB} = 6\text{ V}$

$I_{EBO} < 20\text{ mA}$

Collector-emitter sustaining voltage

$I_C = 5\text{ A}; I_{Boff} = 0; L = 8\text{ mH}$

$V_{CEOsust} > 400\text{ V}$

Saturation voltages

$I_C = 5\text{ A}; I_B = 50\text{ mA}$

$V_{CEsat} < 1,5\text{ V}$

$V_{BEsat} < 2,0\text{ V}$

$I_C = 5\text{ A}; I_B = 60\text{ mA}; T_j = -40\text{ }^\circ\text{C}$

$V_{CEsat} < 1,5\text{ V}$

$V_{BEsat} < 2,0\text{ V}$

$I_C = 6\text{ A}; I_B = 100\text{ mA}; T_j = 150\text{ }^\circ\text{C}$

$V_{CEsat} < 1,5\text{ V}$

$V_{BEsat} < 2,0\text{ V}$

$I_C = 10\text{ A}; I_B = 300\text{ mA}$

$V_{CEsat} < 2,0\text{ V}$

$V_{BEsat} < 2,5\text{ V}$

Turn-off breakdown energy with inductive load (Fig. 3)

$-I_{Boff} = 0; I_{CC} = 10\text{ A}; L = 8\text{ mH}; I_{Bon} = 300\text{ mA};$

$V_{CL} = 400\text{ V}$

$E_{(BR)} > 400\text{ mJ}$

Collector-emitter diode, forward voltage

$I_F = 8\text{ A}; I_B = 0$

$V_F < 3,0\text{ V}$

DEVELOPMENT SAMPLE DATA

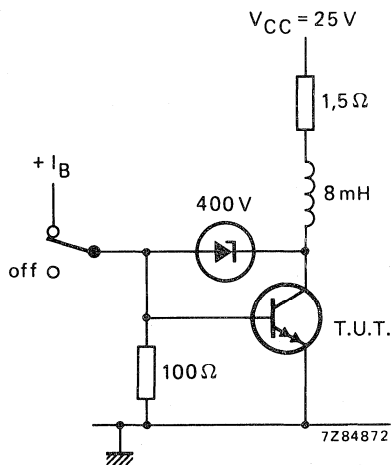


Fig. 3 Energy test circuit.

* Measured with a half sine-wave voltage (curve tracer).

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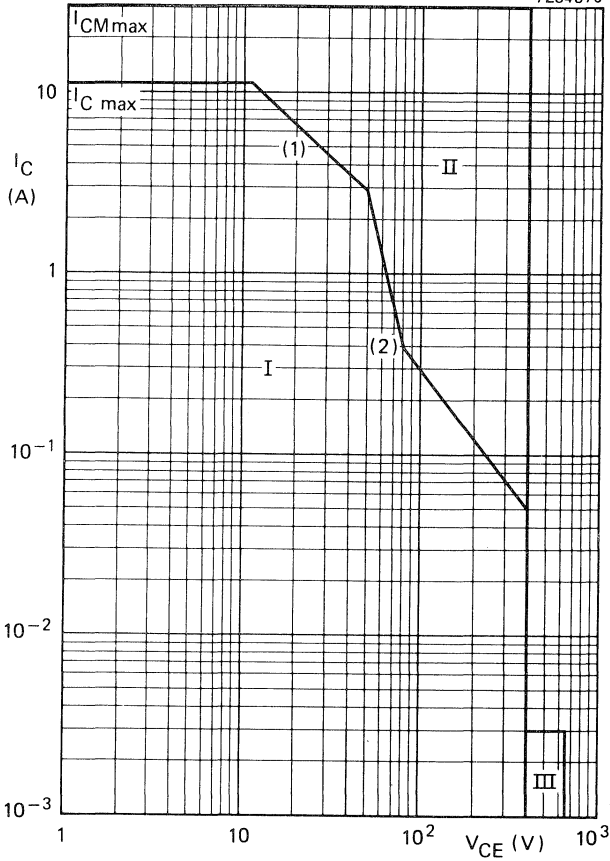


Fig. 4 Safe Operating Area at $T_{mb} \leq 25^\circ\text{C}$.

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

- I Region of permissible d.c. operation
- II Permissible extension for repetitive pulse operation
- III Repetitive pulse operation in this region is permissible, provided $V_{BE} \leq 0$ and $t_p \leq 5\text{ ms}$.

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

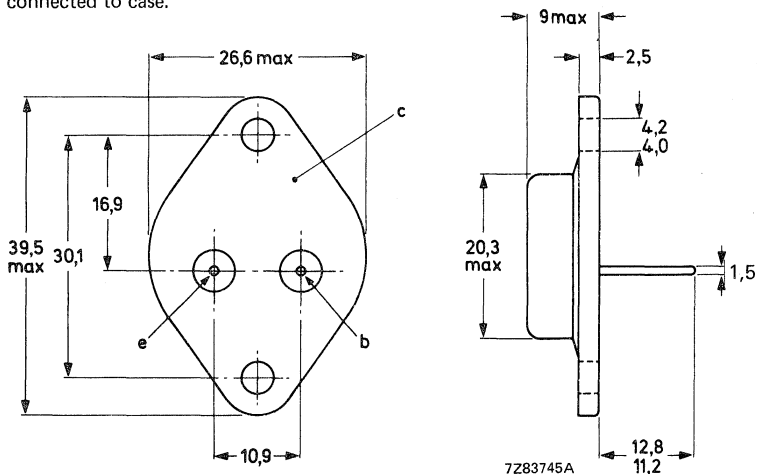
	BUX98	BUX98A
Collector-emitter voltage ($V_{EB} = 3\text{ V}$)	V_{CEX} max. 850	1000 V
Collector-emitter voltage ($R_{BE} < 5\ \Omega$)	V_{CER} max. 850	1000 V
Collector-emitter voltage (open base)	V_{CEO} max. 400	450 V
Collector current (d.c.)	I_C max.	30 A
Collector current (peak value) $t_p \leq 5\text{ ms}$	I_{CM} max.	60 A
Total power dissipation up to $T_{mb} = 25\text{ }^\circ\text{C}$	P_{tot} max.	250 W
Collector-emitter saturation voltage	V_{CEsat} <	1,5 V
$I_C = 20\text{ A}; I_B = 4\text{ A}$	V_{CEsat} <	— V
$I_C = 16\text{ A}; I_B = 3,2\text{ A}$		1,5 V
Fall time (resistive load)	t_f <	0,8 μs
$I_{Con} = 20\text{ A}; I_{Bon} = -I_{Boff} = 4\text{ A}$	t_f <	— μs
$I_{Con} = 16\text{ A}; I_{Bon} = -I_{Boff} = 3,2\text{ A}$		0,8 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)

			BUX98	BUX98A	
Collector-emitter voltage ($V_{EB} = 3\text{ V}$)	V_{CEX}	max.	850	1000	V
Collector-emitter voltage ($R_{BE} \leq 5\ \Omega$)	V_{CER}	max.	850	1000	V
Collector-emitter voltage (open base)	V_{CEO}	max.	400	450	V
Collector current (d.c.)	I_C	max.	30		A
Collector current (peak value); $t_p < 5\text{ ms}$	I_{CM}	max.	60		A
Base current (d.c.)	I_B	max.	8		A
Base current (peak value); $t_p < 5\text{ ms}$	I_{BM}	max.	30		A
Total power dissipation up to $T_{mb} = 25\ ^\circ\text{C}$	P_{tot}	max.	250		W
Storage temperature	T_{stg}		-65 to +200		$^\circ\text{C}$
Junction temperature	T_j	max.	200		$^\circ\text{C}$

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=	0,7		K/W
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CHARACTERISTICS

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

Collector cut-off current*

$V_{CE} = V_{CERmax}; R_{BE} \leq 5\ \Omega$

$V_{CE} = V_{CERmax}; R_{BE} \leq 5\ \Omega; T_j = 125\ ^\circ\text{C}$

I_{CER}	<	1	mA
I_{CER}	<	8	mA

Collector cut-off current

$V_{CE} = V_{CEXmax}; V_{EB} = 2,5\text{ V}$

$V_{CE} = V_{CEXmax}; V_{EB} = 2,5\text{ V}; T_j = 125\ ^\circ\text{C}$

I_{CEX}	<	0,4	mA
I_{CEX}	<	4	mA

Emitter cut-off current

$I_C = 0; V_{EB} = 5\text{ V}$

I_{EBO}	<	2	mA
-----------	---	---	----

Saturation voltages

$I_C = 20\text{ A}; I_B = 4\text{ A}$

V_{CEsat}	<	1,5	- V
V_{BEsat}	<	1,6	- V

$I_C = 30\text{ A}; I_B = 8\text{ A}$

V_{CEsat}	<	3,5	- V
-------------	---	-----	-----

$I_C = 16\text{ A}; I_B = 3,2\text{ A}$

V_{CEsat}	<	-	1,5 V
V_{BEsat}	<	-	1,6 V

$I_C = 24\text{ A}; I_B = 5\text{ A}$

V_{CEsat}	<	-	5 V
-------------	---	---	-----

Collector-emitter sustaining voltage

$I_C = 200\text{ mA}; I_{Boff} = 0; L = 25\text{ mH}$

$V_{CEO_{sust}}$	>	400	450 V
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Transition frequency at $f = 1\text{ MHz}$

$I_C = 1\text{ A}; V_{CE} = 10\text{ V}$

f_T	typ.	5	MHz
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Emitter-base breakdown voltage

$I_C = 0; I_B = 0,1\text{ A}$

$V_{(BR)EBO}$		7 to 30	V
---------------	--	---------	---

Collector capacitance at $f = 1\text{ MHz}$

$V_{CE} = 10\text{ V}$

C_C	typ.	500	pF
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* Measured with a half sine-wave voltage (curve tracer).

CHARACTERISTICS (continued)

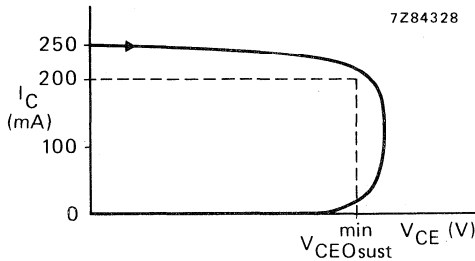


Fig. 2 Oscilloscope display for sustaining voltage.

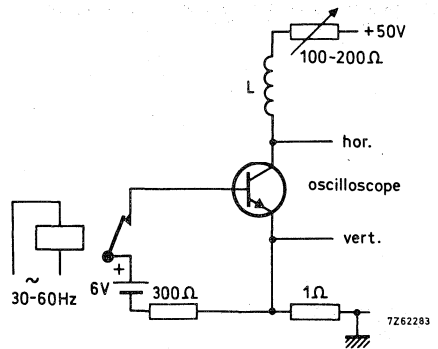


Fig. 3 Test circuit for $V_{CE(sust)}$.

Switching times resistive load

$I_{Con} = 20 \text{ A}; I_{Bon} = -I_{Boff} = 4 \text{ A}$

Turn-on time

	BUX98	BUX98A
t_{on}	typ. 0,55 < 1	— μs — μs

Turn-off: Storage time

t_s	typ. 1,5 < 3	— μs — μs
-------	-----------------	------------------------

Fall time

t_f	typ. 0,3 < 0,8	— μs — μs
-------	-------------------	------------------------

$I_{Con} = 16 \text{ A}; I_{Bon} = -I_{Boff} = 3,2 \text{ A}$

Turn-on time

t_{on}	typ. — < —	0,55 μs 1 μs
----------	---------------	---------------------------

Turn-off: Storage time

t_s	typ. — < —	1,5 μs 3 μs
-------	---------------	--------------------------

Fall time

t_f	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_s	typ. 3,5	— μs
-------	----------	-----------

Fall time

t_f	typ. 80	— ns
-------	---------	------

$I_{Con} = 20 \text{ A}; I_B = 4 \text{ A}; T_j = 100 \text{ }^\circ\text{C}$

Storage time

t_s	< 5	— μs
-------	-----	-----------

Fall time

t_f	< 400	— ns
-------	-------	------

$I_{Con} = 16 \text{ A}; I_B = 3,2 \text{ A}$

Turn-off: Storage time

t_s	typ. —	3,5 μs
-------	--------	-------------

Fall time

t_f	typ. —	80 ns
-------	--------	-------

$I_{Con} = 16 \text{ A}; I_B = 3,2 \text{ A}; T_j = 100 \text{ }^\circ\text{C}$

Turn-off: Storage time

t_s	< —	5 μs
-------	-----	-----------

Fall time

t_f	< —	400 ns
-------	-----	--------

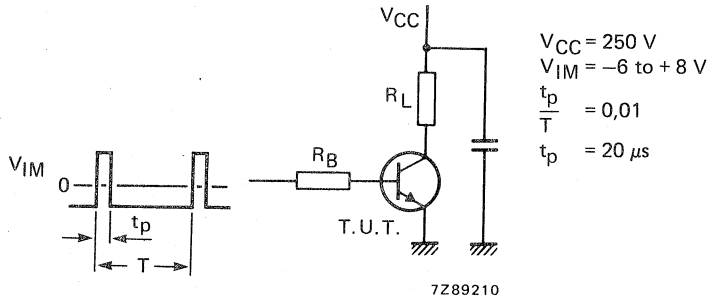


Fig. 4 Test circuit resistive load.

The values of R_B and R_L are selected in accordance with I_{Con} and I_B requirements.

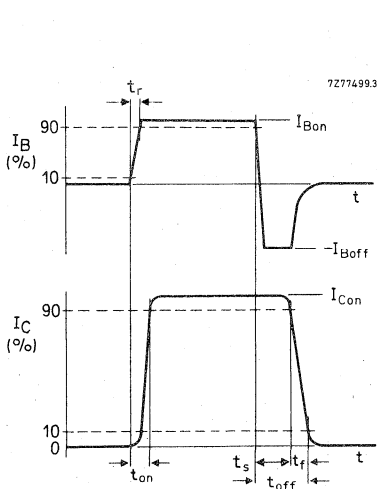


Fig. 5 Switching times waveforms with resistive load.

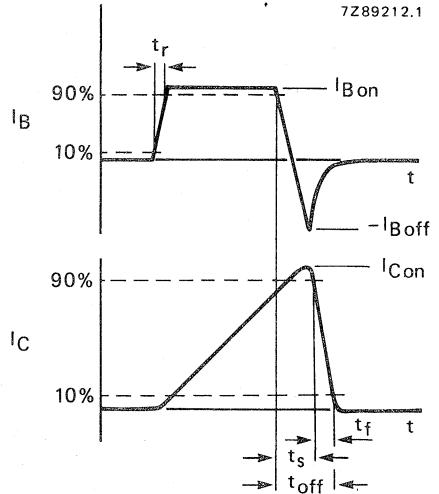


Fig. 6 Switching times waveforms with inductive load.

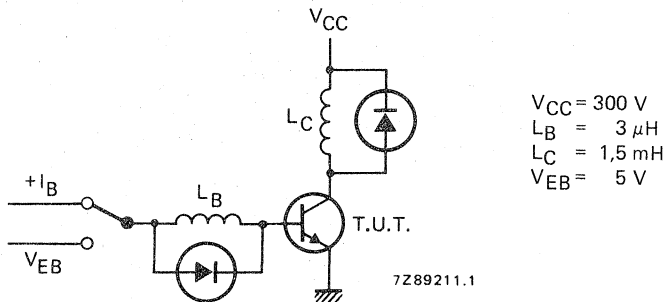


Fig. 7 Test circuit inductive load.

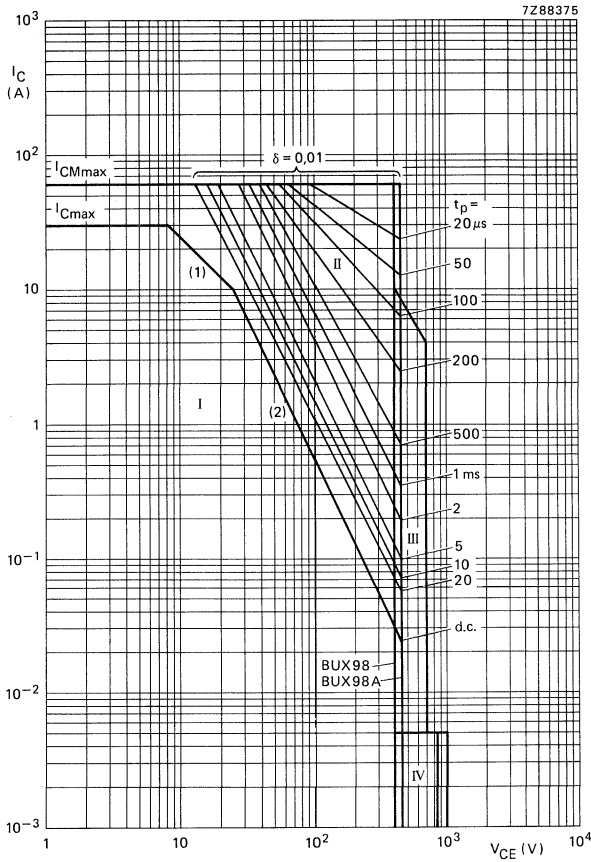


Fig. 8 Safe Operating Area at $T_{mb} \leq 25 \text{ }^\circ\text{C}$.

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

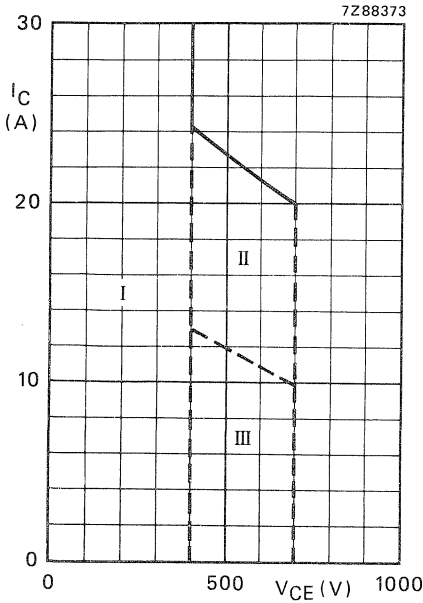


Fig. 9 Forward bias safe operation area, $T_j \leq 125^\circ\text{C}$.

- 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 $t_r < 0,2 \mu\text{s}$.
- III Safe operation area during turn-on only; provided $t_r < 0,5 \mu\text{s}$ and $R_{BE} < 50 \Omega$.

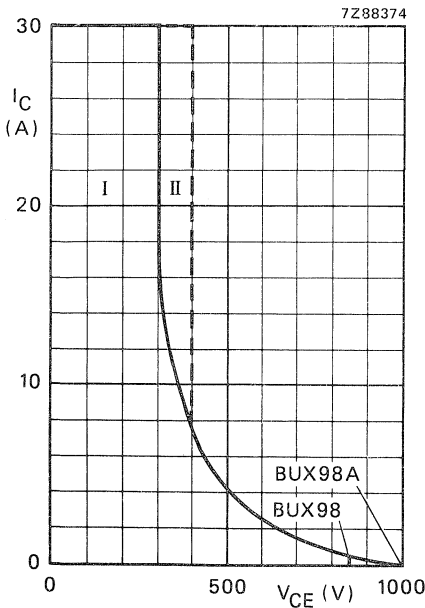


Fig. 10 Reverse bias safe operation area,

$I_{Cend}/I_{Bend} \geq 5$; $-V_{BE} = 3 \text{ V}$.

- I Normal reverse bias safe operation area $V_{BE} < 0 \text{ V}$.
 - II Extension of the reverse bias safe operation area provided a desaturation network (Baker clamp) is used.
- For BUX98A V_{CE} limit = 450 V.

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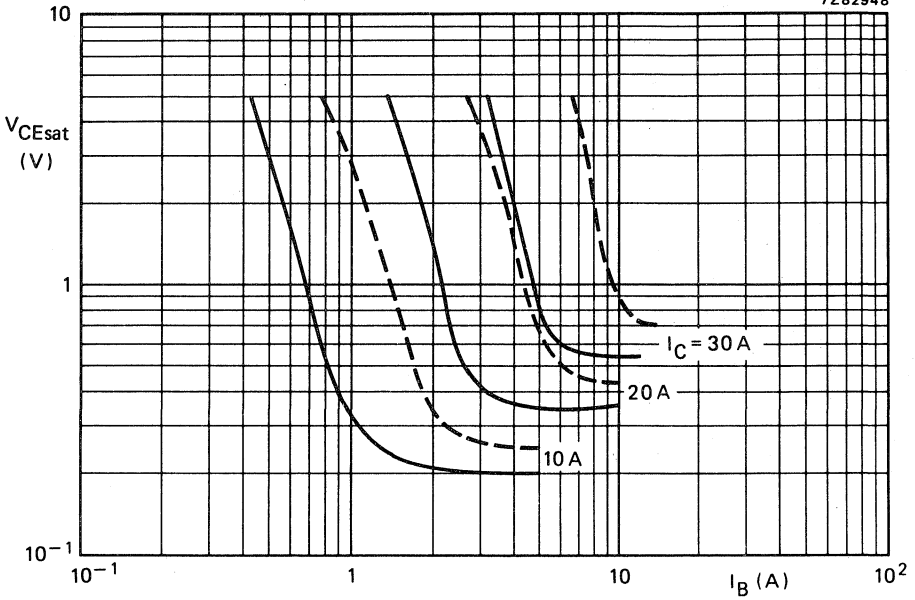


Fig. 11 Typical (—) and maximum (---) values saturation voltage. $T_j = 25^\circ C$.

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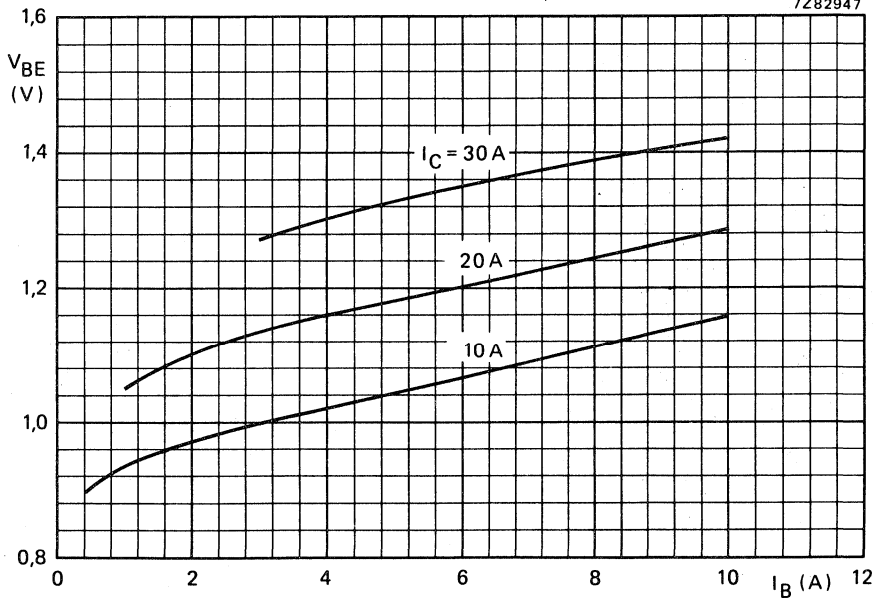


Fig. 12 Typical values at $T_j = 25^\circ C$.

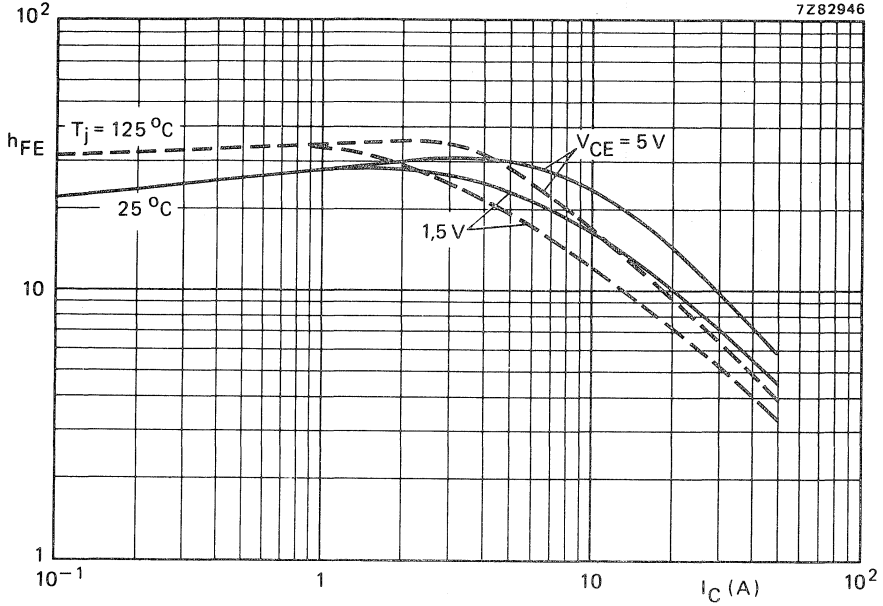


Fig. 13 Typical values d.c. current gain.

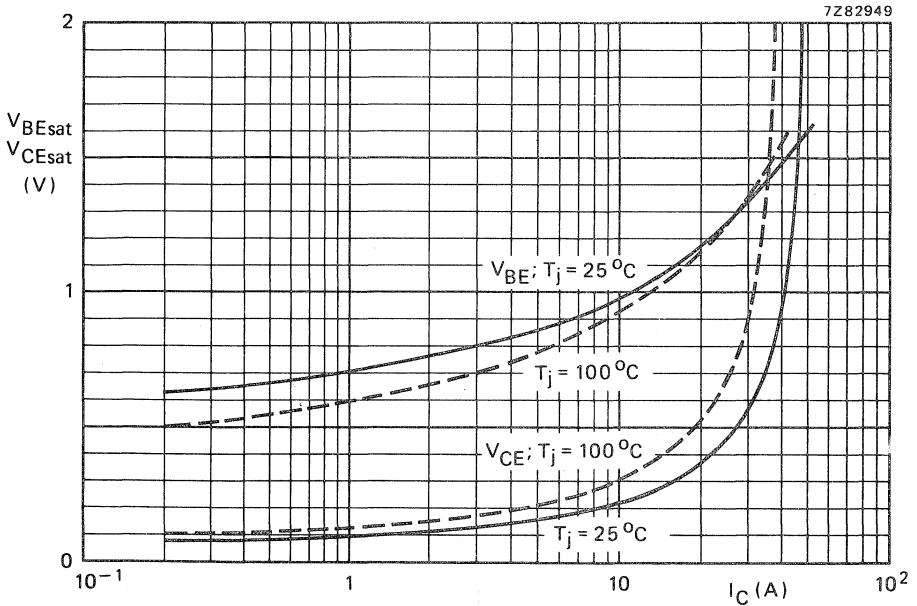


Fig. 14 Typical values base and collector voltage. $I_C/I_B = 5$.

SILICON DIFFUSED POWER TRANSISTOR

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

QUICK REFERENCE DATA

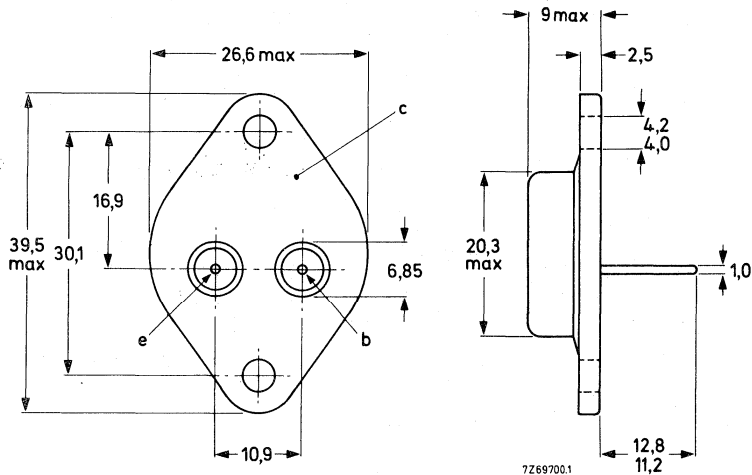
Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM}	max.	1500 V
Collector-emitter voltage (open base)	V_{CEO}	max.	800 V
Collector current (d.c.)	I_C	max.	6 A
Total power dissipation up to $T_{mb} = 60\text{ }^\circ\text{C}$	P_{tot}	max.	80 W
Collector-emitter saturation voltage $I_C = 4,5\text{ A}; I_B = 2\text{ A}$	V_{CEsat}	<	1 V
D.C. current gain $I_C = 4,5\text{ A}; V_{CE} = 5\text{ V}$	h_{FE}	>	2,5

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-3.

Collector connected to case.



See also chapters Mounting instructions and Accessories.

RATINGS

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

Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM}	max.	1500 V
Collector-emitter voltage (open base)	V_{CEO}	max.	800 V
Collector current (d.c.)	I_C	max.	6 A
Collector current (peak value)	I_{CM}	max.	10 A
Collector current (non-repetitive peak)	I_{CSM}	max.	15 A
Base current (d.c.)	I_B	max.	4 A
Base current (peak value)	I_{BM}	max.	6 A
Reverse base current (d.c. or average over any 20 ms period)	$-I_{B(AV)}$	max.	100 mA
Reverse base current (peak value) *	$-I_{BM}$	max.	4 A
Total power dissipation up to $T_{mb} = 60\text{ }^\circ\text{C}$	P_{tot}	max.	80 W
Storage temperature	T_{stg}		-65 to $+150\text{ }^\circ\text{C}$
Junction temperature	T_j	max.	$150\text{ }^\circ\text{C}$

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	max.	1,12 K/W
--------------------------------	----------------	------	----------

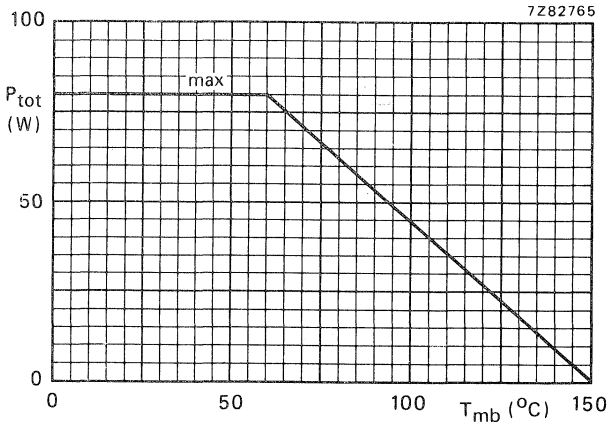


Fig. 2 Power derating curve.

* Turn-off current.

CHARACTERISTICS

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

Collector cut-off current

$V_{BE} = 0; V_{CE} = V_{CESMmax}; T_j = 125\text{ }^\circ\text{C}$

$I_{CES} < 1,0\text{ mA}$

D.C. current gain

$I_C = 4,5\text{ A}; V_{CE} = 5\text{ V}$

$h_{FE} > 2,5$

Emitter cut-off current

$I_C = 0; V_{EB} = 5\text{ V}$

$I_{EBO} < 10\text{ mA}$

Saturation voltage

$I_C = 4,5\text{ A}; I_B = 2\text{ A}$

$V_{CEsat} < 1\text{ V}$

$I_C = 4,5\text{ A}; I_B = 2\text{ A}$

$V_{BEsat} < 1,5\text{ V}$

Collector-emitter sustaining voltage

$I_B = 0; I_C = 100\text{ mA}; L = 25\text{ mH}$

$V_{CEOsust} > 800\text{ V}$

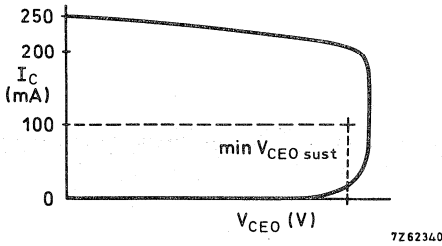


Fig. 3 Oscilloscope display for $V_{CEOsust}$.

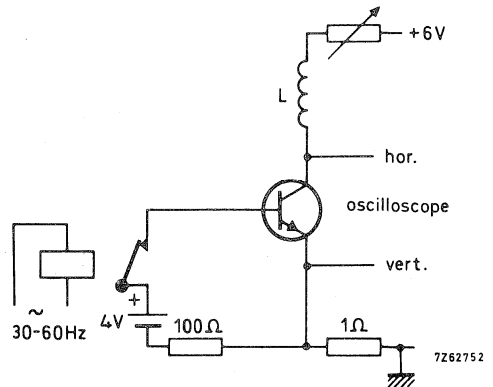


Fig. 4 Test circuit for $V_{CEOsust}$.

Second-breakdown collector current

$V_{CE} = 100\text{ V}; t_p = 1\text{ s}$

$I_{(SB)} > 0,3\text{ A}$

Transition frequency at $f = 5\text{ MHz}$

$I_C = 0,1\text{ A}; V_{CE} = 5\text{ V}$

f_T typ. 7 MHz

Collector capacitance at $f = 1\text{ MHz}$

$I_E = I_e = 0; V_{CB} = 10\text{ V}$

C_c typ. 125 pF

CHARACTERISTICS (continued)

Switching times (between 10% and 90% levels)

in resistive switching circuit

$I_{Con} = 4,5 \text{ A}$; $V_{CC} = 250 \text{ V}$; $R_L = 56 \Omega$

$I_{Bon} = -I_{Boff} = 2 \text{ A}$

→ Turn-on time

→ Storage time ($t_s = t_{off} - t_f$)

Fall time

t_{on} typ. 1,5 μs

t_s typ. 4,5 μs

t_f typ. 0,5 μs

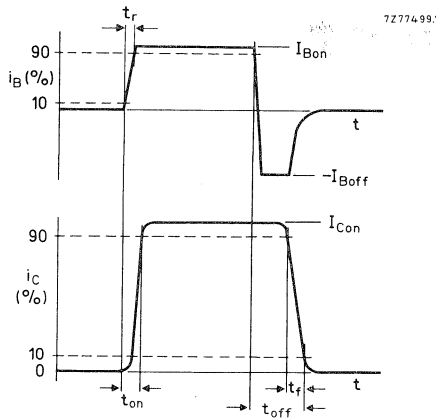


Fig. 5 Waveforms.

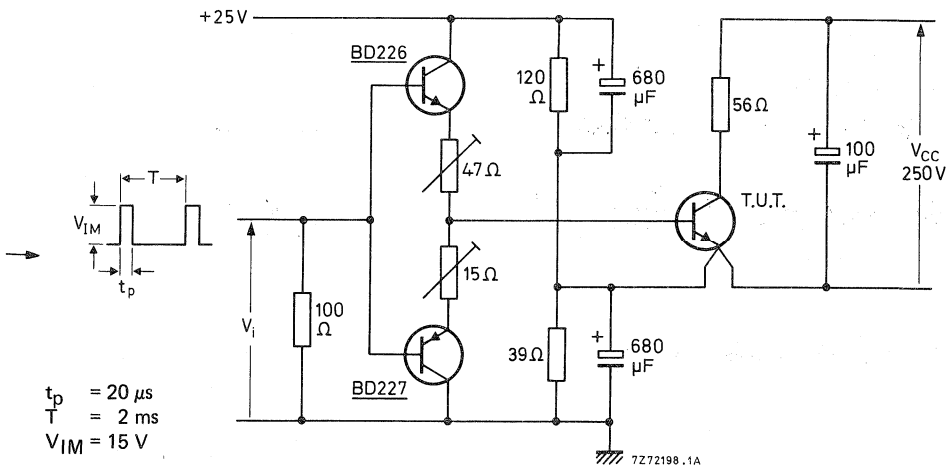


Fig. 6 Test circuit.

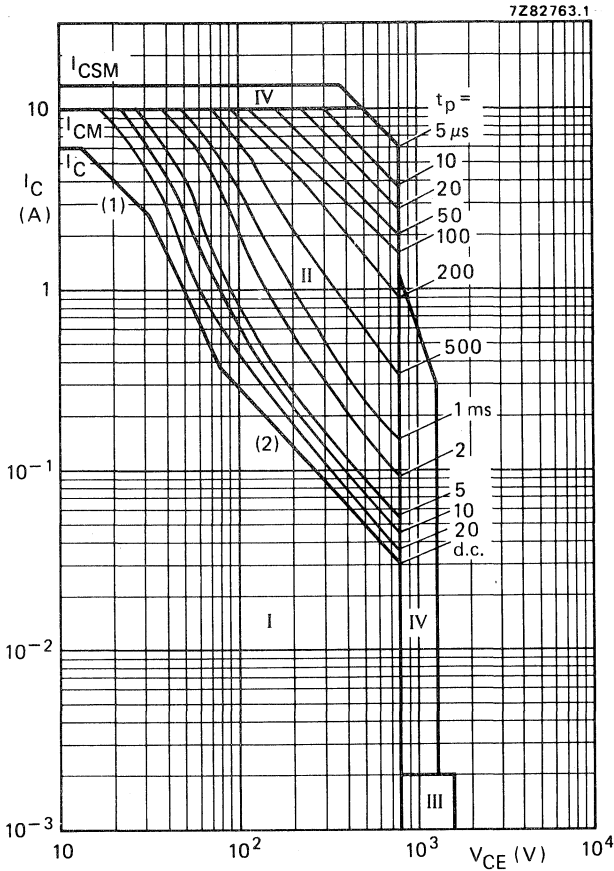


Fig. 7 Safe Operating Area with the transistor forward biased.

$T_{mb} \leq 60\text{ }^\circ\text{C}$; $\delta = 0,01$.

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

- I Region of permissible d.c. operation.
- II Permissible extension for repetitive pulse operation.
- III Repetitive pulse operation in this region is permissible, provided $V_{BE} \leq 0\text{ V}$; $t_p \leq 20\ \mu\text{s}$; $\delta \leq 0,25$.
- IV Transient I_C/V_{CE} limit
for V_{CE} less than 700 V then t_p less than or equal to 25 μs
for V_{CE} greater than 700 V then t_p less than 5 μs .

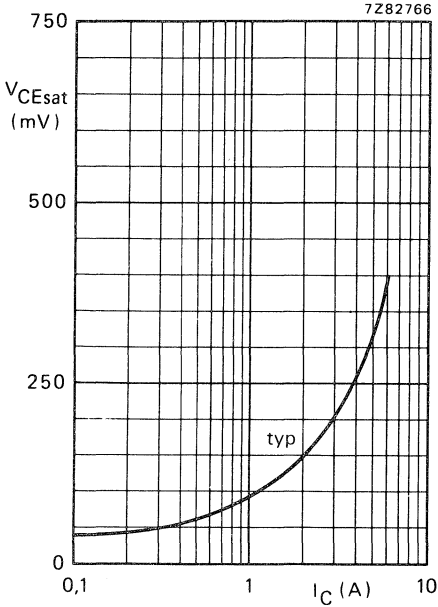


Fig. 8 Collector-emitter saturation voltage at $I_C/I_B = 2$; $T_j = 25^\circ\text{C}$.

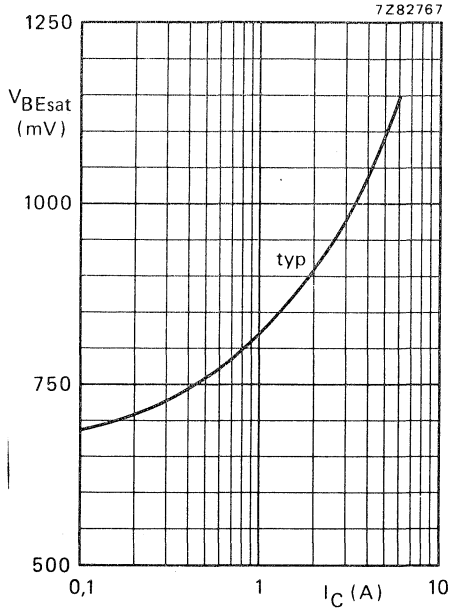


Fig. 9 Base-emitter saturation voltage at $I_C/I_B = 2$; $T_j = 25^\circ\text{C}$.

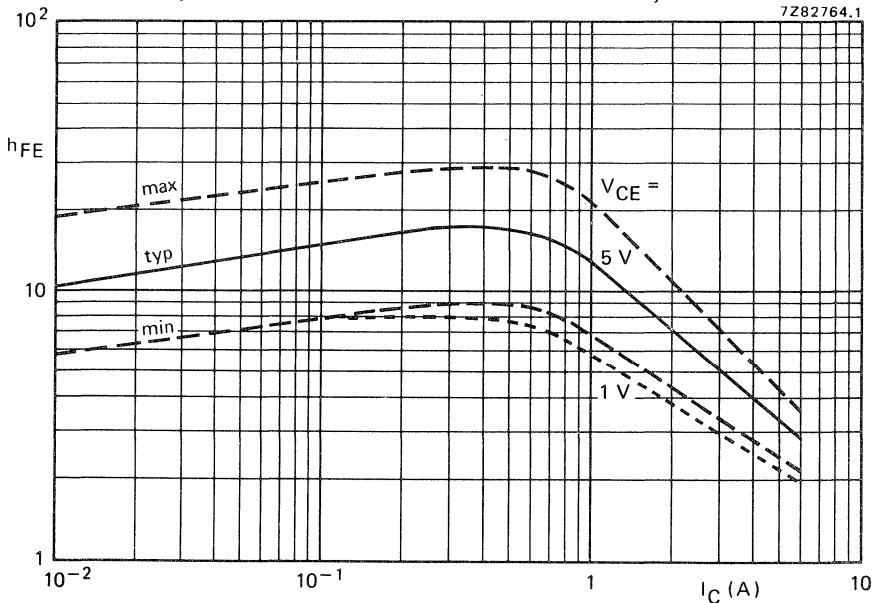


Fig. 10 D.C. current gain at $V_{CE} = 5\text{ V}$; $T_j = 25^\circ\text{C}$; at $V_{CE} = 1\text{ V}$.

MOUNTING INSTRUCTIONS



General note on flat heatsinks

All information on thermal resistances of the accessories combined with flat heatsinks is valid for *square* heatsinks of 1,5 mm blackened aluminium.

For a few variations the thermal resistance may be derived as follows:

- 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.

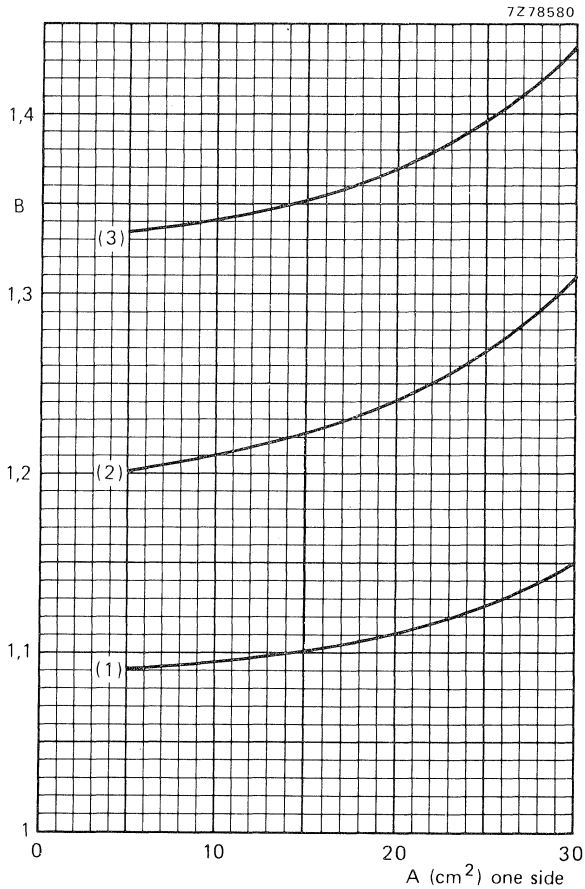


Fig. 1 Multiplication factor (B) as a function of heatsink area (A).
 (1) 1 mm blackened aluminium.
 (2) 1,5 mm unblackened aluminium.
 (3) 1 mm unblackened aluminium.

MOUNTING INSTRUCTIONS FOR TO-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 ($R_{th\ mb-h}$) given for mounting with heatsink compound refer to the use of a metallic oxide-loaded compound. Ordinary silicone grease is not recommended.

For insulated mounting, the compound should be applied to the bottom of both device and insulator.

Mounting methods for power transistors

1. Clip mounting (TO-126 and SOT-82)

Mounting by means of spring clip offers:

- a. A good thermal contact under the crystal area.
- b. Safe insulation for mains and high voltage operation

2. M2,5 and M3 screw mounting. (TO-126 only).

The spacing washer should be inserted between screw head and body.

Mounting torque for screw mounting:

Minimum torque (for good heat transfer) 0,4 Nm (4 kgcm)

Maximum torque (to avoid damaging the device) 0,6 Nm (6 kgcm)

N.B. when the driven nut or screw is in direct contact with a toothed lock washer the torques are as follows:

Minimum torque (for good heat transfer) 0,55 Nm (5,5 kgcm)

Maximum torque (to avoid damaging the device) 0,80 Nm (8,0 kgcm)

3. Body mounting (SOT-82).

A SOT-82 envelope can be adhesive mounted or soldered into a hybrid circuit.

For soldering a copper plate or an anodized aluminium plate with copper layer is recommended.

When adhesive mounting is applied also a ceramic substrate may be used.

MOUNTING INSTRUCTIONS TO-126/SOT-82

Thermal data

From mounting base to heatsink

	$R_{th\ mb-h}$ (K/W)			
	clip mounting direct	clip mounting insulated	screw mounting direct	screw mounting insulated
TO-126, with heatsink compound	1,0	3,0	0,5	3,0
TO-126, without heatsink compound	3,0	6,0	1,0	6,0
SOT-82, with heatsink compound	0,4	2,0	—	—
SOT-82, without heatsink compound	2,0	5,0	—	—

Lead bending

Maximum permissible tensile force on the body, for 5 seconds is 20 N (2 kgf).

The leads can be bent through 90° maximum, twisted or straightened. To keep forces within the above-mentioned limits, the leads are generally clamped near the body, using pliers. The leads should neither be bent nor twisted less than 2,4 mm from the body.

Lead soldering

For devices with a maximum junction temperature ≤ 150 °C.

a. Dip or wave soldering

Temperature ≤ 260 °C at a distance from the body > 5 mm and for a total contact time with soldering bath or waves < 7 s.

b. Hand soldering

Temperature at a distance from the body > 3 mm for a total contact time < 5 s is < 275 °C or < 250 °C for a total contact time of < 10 s.

The body of the device must be kept clear of anything with a temperature > 200 °C.

Avoid any force on body and leads during or after soldering; do not correct the position of the device or of its leads after soldering.

Mounting base soldering

Recommended metal-alloy of solder paste (85% metal weight)

62 Sn/36 Pb/2 Ag or 60 Sn/40 Pb.

Maximum soldering temperature ≤ 200 °C (tab-temperature).

Soldering cycle duration including pre-heating ≤ 30 sec.

For good soldering and avoiding damage to the encapsulation pre-heating is recommended to a temperature ≤ 165 °C at a duration ≤ 10 s.

INSTRUCTIONS FOR CLIP MOUNTING

Direct mounting with clip 56353

1. Place the device on the heatsink, applying heatsink compound to the mounting base.
2. Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10° to 30° to the vertical (see Figs 1 and 2).
3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body (see Fig. 3).

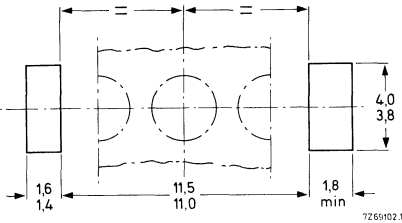


Fig. 1 Heatsink requirements.

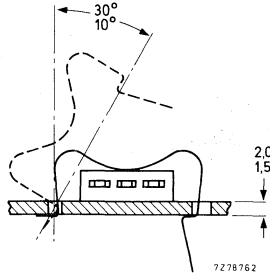


Fig. 2 Mounting spring clip.

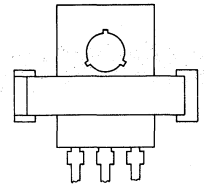


Fig. 3 Position of transistor (top view).

Insulated mounting with clip 56353 and mica 56354 (up to 1000 V insulation)

1. Place the device with the insulator on the heatsink, applying heatsink compound to the bottom of both device and insulator.
2. Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10° to 30° to the vertical (see Figs 4 and 5).
3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body (Fig. 6). Ensure that the device is centred on the mica insulator to prevent creepage.

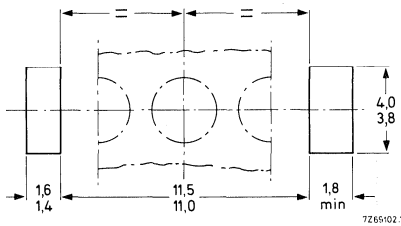


Fig. 4 Heatsink requirements.

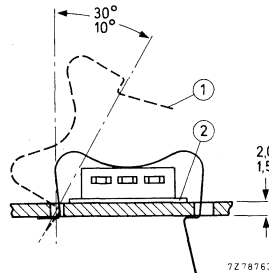


Fig. 5 Mounting.
(1) spring clip 56353.
(2) insulator 56354.

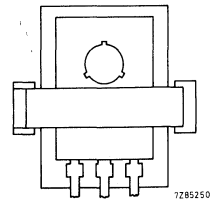


Fig. 6 Position of transistor (top view).

INSTRUCTIONS FOR SCREW MOUNTING

Dimensions in mm

Direct mounting with screw and spacing washer

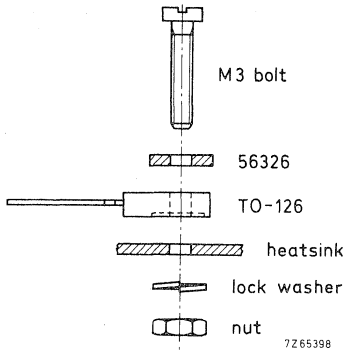


Fig. 7 Assembly through heatsink with nut.

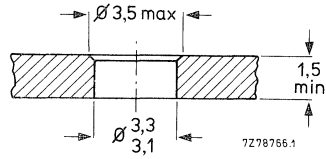


Fig. 8 Heatsink requirements.

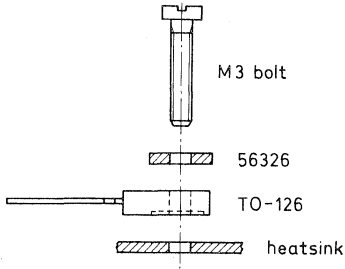


Fig. 9 Assembly into tapped heatsink.

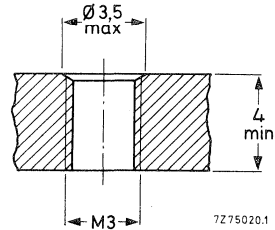


Fig. 10 Heatsink requirements.

INSTRUCTIONS FOR SCREW MOUNTING

Insulated mounting with 56326, 56387a and 56387b (up to 300 V)

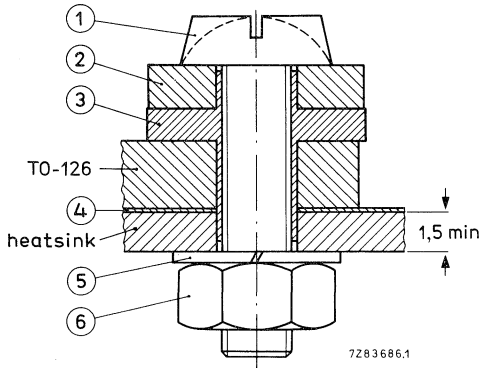


Fig. 15 Assembly through heatsink with nut.

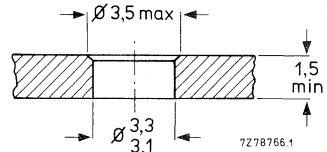


Fig. 16 Heatsink requirements.

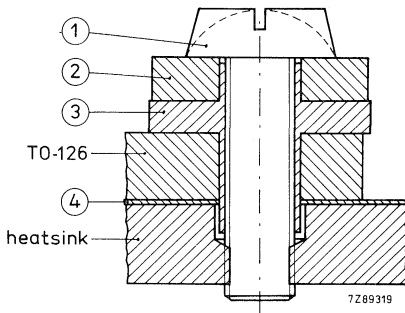


Fig. 17 Assembly with tapped heatsink.

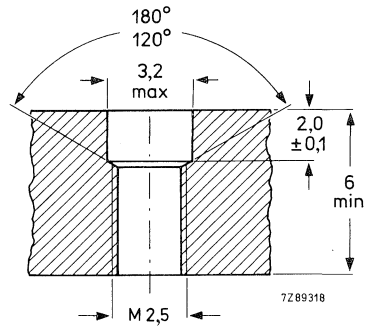


Fig. 18 Heatsink requirements.

Legend

- | | |
|--------------------------|-----------------------|
| 1 M2,5 screw | 4 mica washer 56387 a |
| 2 metal washer 56326 | 5 lock washer |
| 3 insulating bush 56387b | 6 M2,5 nut |

MOUNTING INSTRUCTIONS FOR TO-220 ENVELOPES

GENERAL DATA AND INSTRUCTIONS

General rules

1. First fasten the device to the heatsink before soldering the leads.
2. Avoid axial stress to the leads.
3. Keep mounting tool (e.g. screwdriver) clear of the plastic body.
4. The rectangular washer may only touch the plastic part of the body; it should not exert any force on that part (screw mounting).

Heatsink requirements

Flatness in the mounting area: 0,02 mm maximum per 10 mm.
Mounting holes must be deburred, see further mounting instructions.

Heatsink compound

Values of the thermal resistance from mounting base to heatsink ($R_{th\ mb-h}$) given for mounting with heatsink compound refer to the use of a metallic oxide-loaded compound. Ordinary silicone grease is not recommended.

For insulated mounting, the compound should be applied to the bottom of both device and insulator.

Mounting methods for power transistors

1. Clip mounting

Mounting with a spring clip gives:

- a. A good thermal contact under the crystal area, and slightly lower $R_{th\ mb-h}$ values than screw mounting.
- b. Safe insulation for mains operation.

2. M3 screw mounting

It is recommended that the rectangular spacing washer is inserted between screw head and mounting tab.

Mounting torque for screw mounting:

(For thread-forming screws these are final values. Do not use self-tapping screws.)

Minimum torque (for good heat transfer)	0,55 Nm (5,5 kgcm)
Maximum torque (to avoid damaging the device)	0,80 Nm (8,0 kgcm)

N.B.: When a nut or screw is not driven direct against a curved spring washer or lock washer (not for thread-forming screw), the torques are as follows:

Minimum torque (for good heat transfer)	0,4 Nm (4 kgcm)
Maximum torque (to avoid damaging the device)	0,6 Nm (6 kgcm)

N.B.: Data on accessories are given in separate data sheets.

3. Rivet mounting non-insulated

The device should not be pop-riveted to the heatsink. However, it is permissible to press-rivet providing that eyelet rivets of soft material are used, and the press forces are slowly and carefully controlled so as to avoid shock and deformation of either heatsink or mounting tab.

Thermal data

		clip mounting	screw mounting	
From mounting base to heatsink				
with heatsink compound, direct mounting	$R_{th\ mb-h}$	= 0,3	0,5	K/W
without heatsink compound, direct mounting	$R_{th\ mb-h}$	= 1,4	1,4	K/W
with heatsink compound and 0,1 mm maximum mica washer	$R_{th\ mb-h}$	= 2,2	—	K/W
with heatsink compound and 0,25 mm maximum alumina insulator	$R_{th\ mb-h}$	= 0,8	—	K/W
with heatsink compound and 0,05 mm mica washer insulated up to 500 V	$R_{th\ mb-h}$	= —	1,4	K/W
insulated up to 800 V/1000 V	$R_{th\ mb-h}$	= —	1,6	K/W
without heatsink compound and 0,05 mm mica washer insulated up to 500 V	$R_{th\ mb-h}$	= —	3,0	K/W
insulated up to 800 V/1000 V	$R_{th\ mb-h}$	= —	4,5	K/W

Lead bending

Maximum permissible tensile force on the body, for 5 seconds is 20 N (2 kgf).

The leads can be bent through 90° maximum, twisted or straightened. To keep forces within the above-mentioned limits, the leads are generally clamped near the body, using pliers. The leads should neither be bent nor twisted less than 2,4 mm from the body.

Soldering

Lead soldering temperature at > 3 mm from the body; $t_{sld} < 5$ s:

Devices with $T_{j\ max} \leq 175$ °C, soldering temperature $T_{sld\ max} = 275$ °C.

Devices with $T_{j\ max} \leq 110$ °C, soldering temperature $T_{sld\ max} = 240$ °C.

Avoid any force on body and leads during or after soldering: do not correct the position of the device or of its leads after soldering.

It is not permitted to solder the metal tab of the device to a heatsink, otherwise its junction temperature rating will be exceeded.

Mounting base soldering

Recommended metal-alloy of solder paste (85% metal weight)

62 Sn/36 Pb/2 Ag or 60 Sn/40 Pb.

Maximum soldering temperature ≤ 200 °C (tab-temperature).

Soldering cycle duration including pre-heating ≤ 30 sec.

For good soldering and avoiding damage to the encapsulation pre-heating is recommended to a temperature ≤ 165 °C at a duration ≤ 10 s.

INSTRUCTIONS FOR CLIP MOUNTING

Direct mounting with clip 56363

1. Apply heatsink compound to the mounting base, then place the transistor on the heatsink.
2. Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10° to 30° to the vertical (see Figs 1 and 2).
3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body, not on the tab (see Fig. 2a).

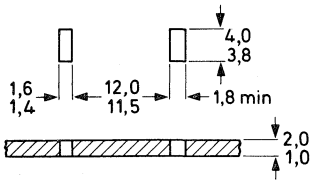


Fig. 1 Heatsink requirements.

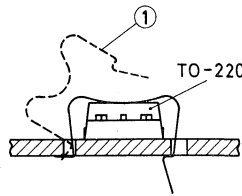


Fig. 2 Mounting.
(1) spring clip 56363.

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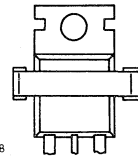


Fig. 2a Position of transistor (top view).

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.

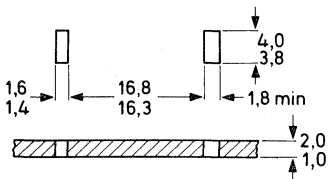


Fig. 3 Heatsink requirements.

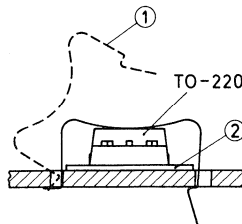


Fig. 4 Mounting.
(1) spring clip 56364.
(2) insulator 56369 or 56367.

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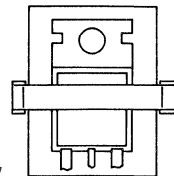


Fig. 4a Position of transistor (top view).

INSTRUCTIONS FOR SCREW MOUNTING
Direct mounting with screw and spacing washer

Dimensions in mm

- *through heatsink with nut*

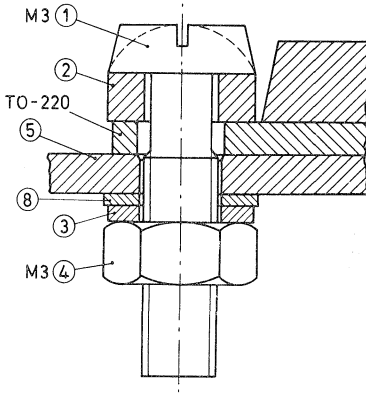
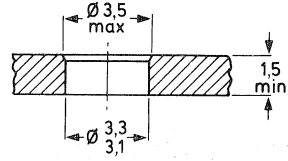


Fig. 5 Assembly.

- (1) M3 screw.
- (2) rectangular washer (56360a).
- (3) lock washer.
- (4) M3 nut.
- (5) heatsink.
- (8) plain washer.



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Fig. 6 Heatsink requirements.

- *into tapped heatsink*

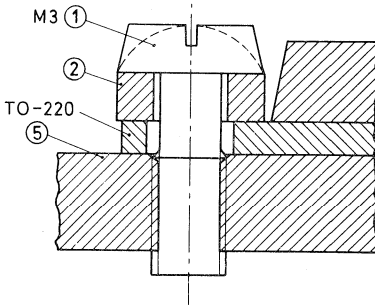
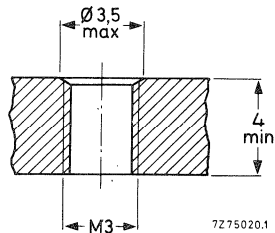


Fig. 7 Assembly.

- (1) M3 screw.
- (2) rectangular washer 56360a.
- (5) heatsink.



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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*

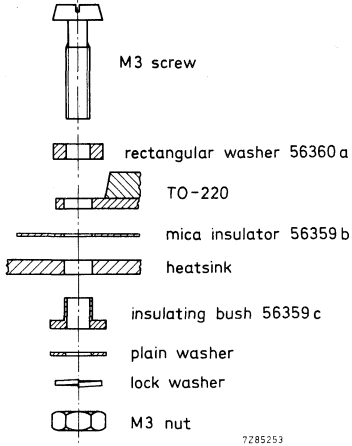


Fig. 9 Insulated screw mounting with rectangular washer. Known as a "bottom mounting".

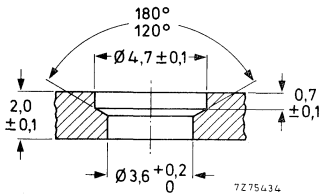


Fig. 10 Heatsink requirements for 500 V insulation.

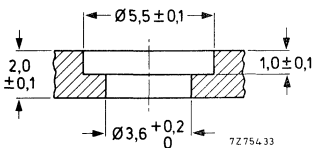


Fig. 11 Heatsink requirements for 800 V insulation.

• *into tapped heatsink*

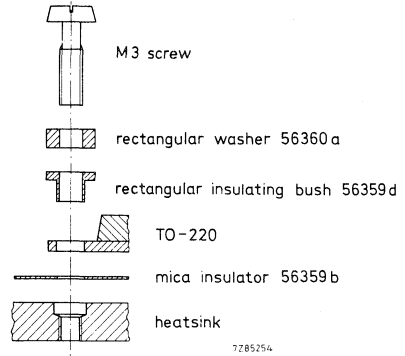


Fig. 12 Insulated screw mounting with rectangular washer into tapped heatsink. Known as a "top mounting".

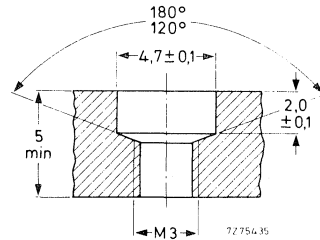


Fig. 13 Heatsink requirements for 500 V insulation.

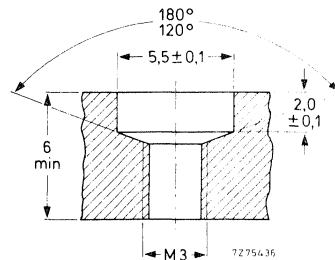


Fig. 14 Heatsink requirements for 1000 V insulation.



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 screw (insulated mounting):

Minimum torque (for good heat transfer)	0,4 Nm (4 kgcm)
Maximum torque (to avoid damaging the device)	0,6 Nm (6 kgcm)

For M4 screw (direct mounting only):

Minimum torque (for good heat transfer)	0,4 Nm (4 kgcm)
Maximum torque (to avoid damaging the device)	1,0 Nm (10 kgcm)

Note: The M4 screw head should not touch the plastic part of the envelope.

Lead bending

Maximum permissible tensile force on the body for 5 s 20 N (2 kgf)

No torsion is permitted at the emergence of the leads.

Bending or twisting is not permitted within a lead length of 0,3 mm.

The leads can be bent through 90° maximum, twisted or straightened; to keep forces within the above-mentioned limits, the leads are generally clamped near the body.

Soldering

Recommendations for devices with a maximum junction temperature rating $\leq 175\text{ }^{\circ}\text{C}$:

a. Dip or wave soldering

Maximum permissible solder temperature is $260\text{ }^{\circ}\text{C}$ at a distance from the body of $> 5\text{ mm}$ and for a total contact time with soldering bath or waves of $< 7\text{ s}$.

b. Hand soldering

Maximum permissible temperature is $275\text{ }^{\circ}\text{C}$ at a distance from the body of $> 3\text{ mm}$ and for a total contact time with the soldering iron of $< 5\text{ s}$.

The body of the device must not touch anything with a temperature $> 200\text{ }^{\circ}\text{C}$.

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

Thermal resistance from mounting base to heatsink

direct mounting

with heatsink compound

without heatsink compound

with 0,05 mm mica washer

with heatsink compound

without heatsink compound

	clip mounting	screw mounting
$R_{th\ mb-h}$ =	0,3	0,3 K/W
$R_{th\ mb-h}$ =	1,5	0,8 K/W
$R_{th\ mb-h}$ =	0,8	0,8 K/W
$R_{th\ mb-h}$ =	3,0	2,2 K/W

INSTRUCTIONS FOR CLIP MOUNTING

Direct mounting with clip 56379

- 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).
- 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)).

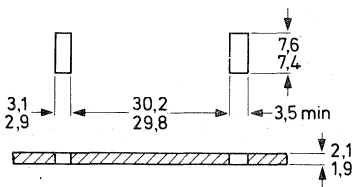


Fig. 1a Heatsink requirements.

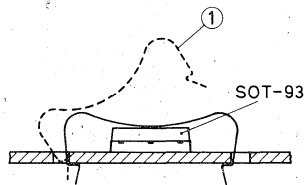
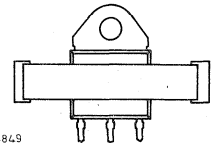


Fig. 1b Mounting.
(1) = spring clip 56379.



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Fig. 1c Position of the device.

Insulated mounting with clip 56379

With the mica 56378 insulation up to 1500 V is obtained.

1. Place the device with the insulator on the heatsink, applying heatsink compound to the bottom of both device and insulator.
2. Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10° to 20° to the vertical (see Figs 2a and 2b).
3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body, not on the tab (see Fig. 2c). There should be minimum 3 mm distance between the device and the edge of the insulator for adequate creepage.

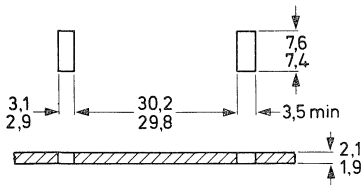


Fig. 2a Heatsink requirements.

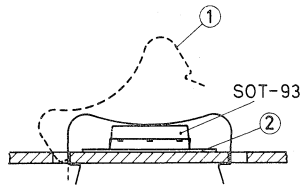


Fig. 2b Mounting.
(1) = spring clip 56379
(2) = insulator 56378

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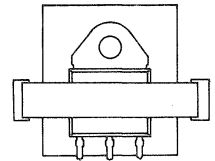


Fig. 2c Position of the device.

INSTRUCTIONS FOR SCREW MOUNTING

Direct mounting

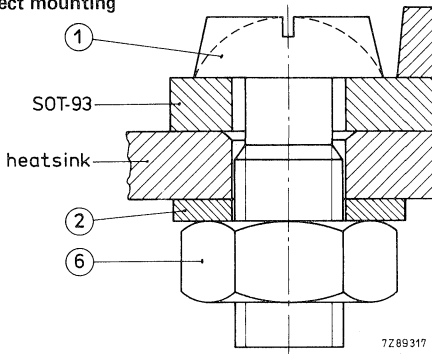


Fig. 3a Assembly through heatsink with nut.

7289317

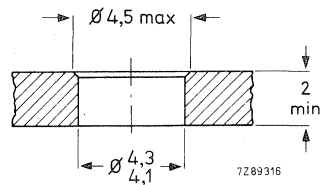


Fig. 3b Heatsink requirements.

7289316

When screw mounting the SOT-93 envelope, it is particularly important to apply a thin, even layer of heatsink compound to the mounting base, and to apply torque to the screw slowly so that the compound has time to flow and the mounting base is not deformed. Most SOT-93 envelopes contain a crystal larger than that in the other plastic envelopes, and it is more likely to crack if the mounting base is deformed.

Legend: (1) M4 screw; (2) plain washer; (6) M4 nut.

Where vibrations are to be expected the use of a lock washer or of a curved spring washer is recommended, with a plain washer between aluminium heatsink and spring washer.

Insulated screw mounting with nut; up to 800 V.

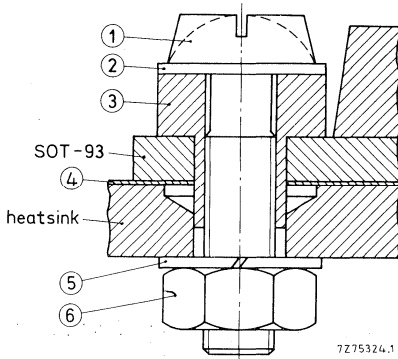


Fig. 4 Assembly.
See also Fig. 9.

- (1) M3 screw
- (2) plain washer
- (3) insulating bush (56368b)
- (4) mica insulator (56368a)
- (5) lock washer
- (6) M3 nut

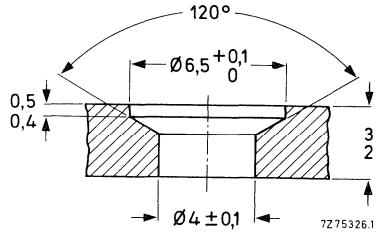


Fig. 5 Heatsink requirements
up to 800 V insulation.

Insulated screw mounting with tapped hole; up to 800 V.

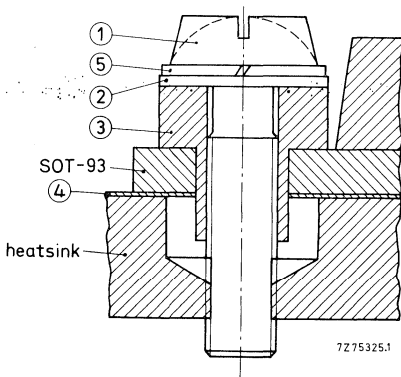


Fig. 6 Assembly.
See also Fig. 9.

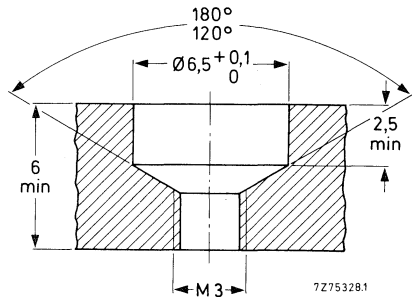


Fig. 7 Heatsink requirements
up to 800 V insulation.

- (1) M3 screw
- (2) plain washer
- (3) insulating bush (56368b)
- (4) mica insulator (56368a)
- (5) lock washer

Insulated screw mounting with insert nut; up to 500 V

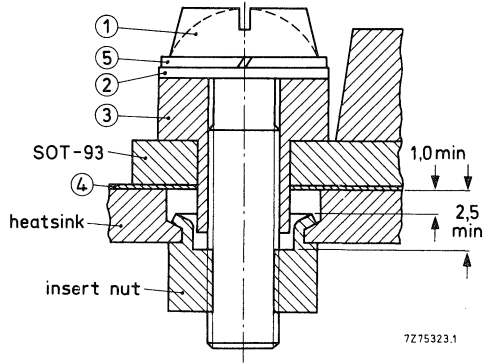


Fig. 8 Assembly and heatsink requirements for 500 V insulation. See also Fig. 3.

- (1) M3 screw
- (2) plain washer
- (3) insulating bush (56368b)
- (4) mica insulator (56368a)
- (5) lock washer

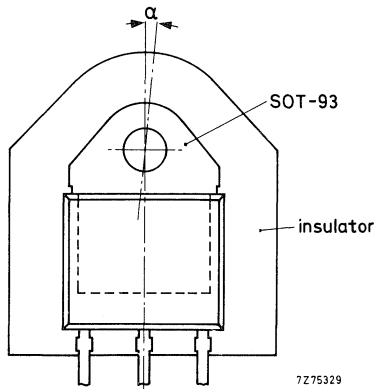


Fig. 9 Mica insulator.

The axial deviation (α) between SOT-93 and mica should not exceed 5° .

MOUNTING INSTRUCTIONS FOR TO-3 ENVELOPES

GENERAL DATA AND INSTRUCTIONS

Instructions for direct mounting.

Mounting instructions for up to 500 V insulation.

Using insulating bushes 56201j or 56261a and mica washer 56201d.

Mounting instructions for 500 to 2000 V insulation.

Using mounting support 56352 and mica washer 56339.

Heatsink requirements

Flatness in the mounting area: 0,05 mm per 40 mm

Mounting holes must be deburred.

Mounting torques

Minimum torque (for good heat transfer)

0,4 Nm (4 kgcm)

Maximum torque (to avoid damaging the transistor)

0,6 Nm (6 kgcm)

N.B.: When the driven nut or screw is in direct contact with a toothed lock washer (e.g. Fig. 10), the torques are as follows:

Minimum torque

0,55 Nm (5,5 kgcm)

Maximum torque

0,8 Nm (8 kgcm)

Thermal data

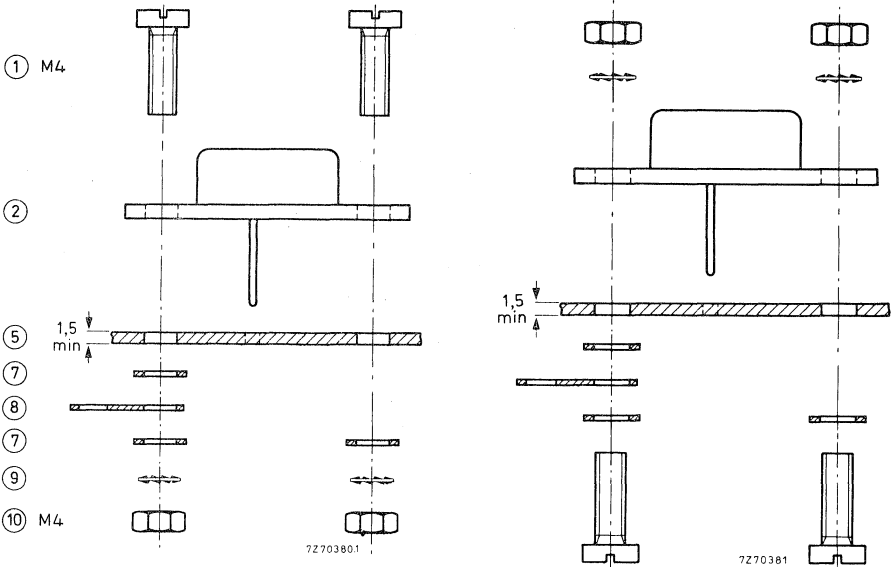
The thermal resistance from mounting base to heatsink ($R_{th\ mb-h}$) can be reduced by applying a heat conducting compound between transistor and heatsink. For insulated mounting the compound should be applied to the bottom of both device and insulator.

	Direct mounting	Insulated mounting		K/W
		500 V mica	2000 V mica	
From mounting base to heatsink without heatsink compound	$R_{th\ mb-h}$ 0,6	1,0	1,25	K/W
with heatsink compound	$R_{th\ mb-h}$ 0,1	0,3	0,5	K/W

INSTRUCTIONS FOR DIRECT MOUNTING

The transistors should be mounted with M4 screws, see Figs 1 and 2. Minimum heatsink thickness (for good heat transfer) 1,5 mm. Hole pattern: Fig. 3.

A heatsink with tapped holes or insert nuts can also be used, but a torque washer is necessary between metal washer and transistor. See Fig. 4.



Figs 1 and 2. Direct mounting with nuts.

Legend

- (1) = screw
 - (2) = TO-3
 - (4) = mica
 - (5) = heatsink
 - (6) = insulating bush
 - (7) = metal washer
 - (8) = soldering tag
 - (9) = lock washer
 - (10) = nut
 - (11) = tapped hole
 - (12) = insert nut
- Dimensions in mm

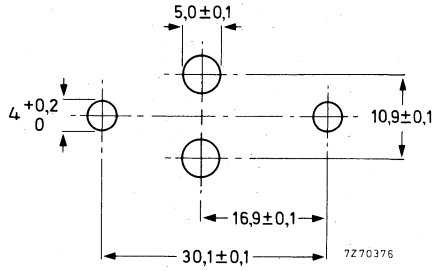


Fig. 3 Hole pattern for direct mounting with nuts.

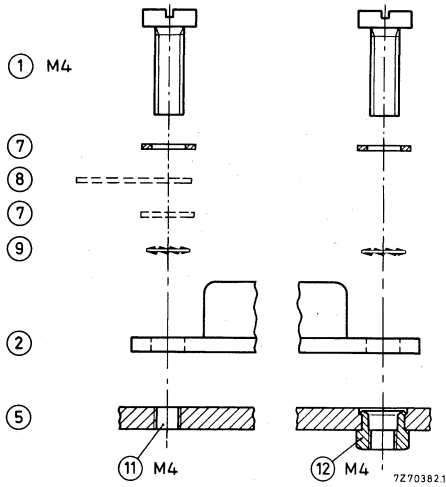


Fig. 4 Direct mounting with tapped holes or insert nuts.

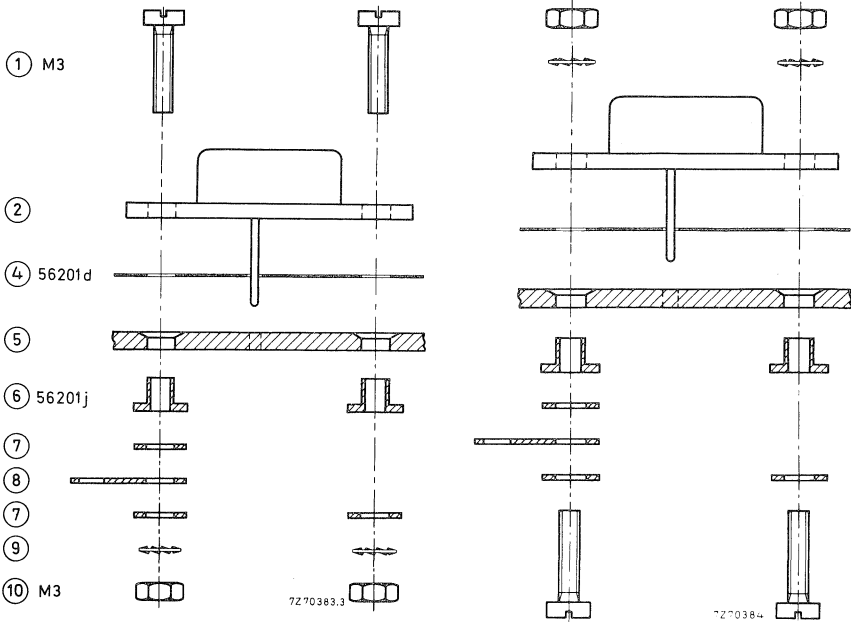
MOUNTING INSTRUCTIONS FOR UP TO 500 V INSULATION

Using insulating bushes 56201j and mica washer 56201d

For the component arrangement with minimum heatsink thickness see Figs 5 and 6. For hole pattern and shape of holes see Figs 7 and 8.

Using insulating bush 56261a and mica washer 56201d

For an arrangement with M3 screws and nuts see Fig. 9, mounting holes are given in Figs 7 and 8. The accessories can also be used in combination with M3 screws and heatsinks provided with tapped holes or insert nuts. Lock washers are necessary between screw-head and metal washer, see Fig. 10. For an assembly drawing with tapped holes see Fig. 11, with insert nuts see Fig. 12.



Figs 5 and 6. Insulated mounting (500 V) with 56201j and 56201d. Heatsink thickness: 1,5 to 2,5 mm.

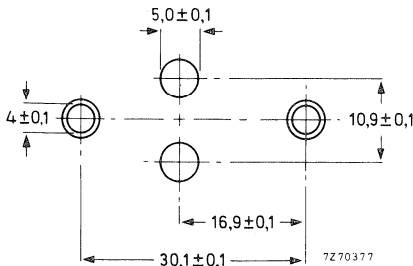


Fig. 7 Hole pattern for 500 V insulation, nut fastening.

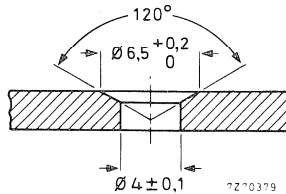


Fig. 8 Shape of hole for 500 V insulation, nut fastening.

For legend see page 378.

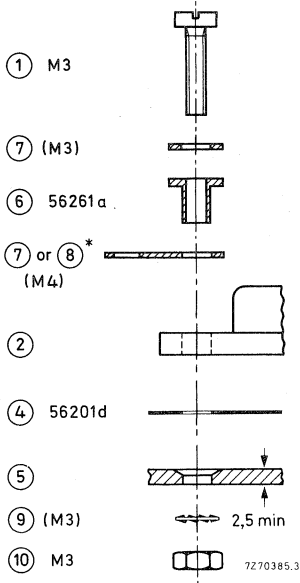


Fig. 9 Insulated mounting (500 V) with nuts.

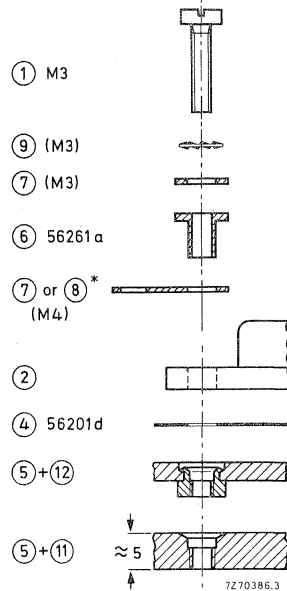


Fig. 10 Insulated mounting (500 V) with tapped holes or insert nuts.

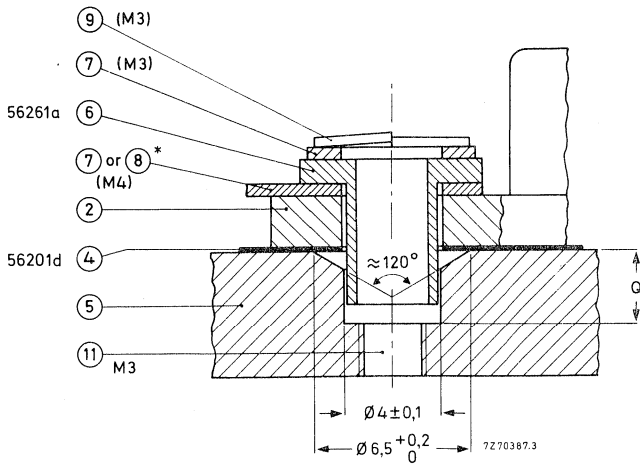


Fig. 11 Assembly (partial) for Fig. 10 - tapped holes.
Q minimum 2,5 mm.

For legend see page 378.

* Thickness approximately 0,6 mm, outer diameter 7,5 mm.

MOUNTING
INSTRUCTIONS
TO-3

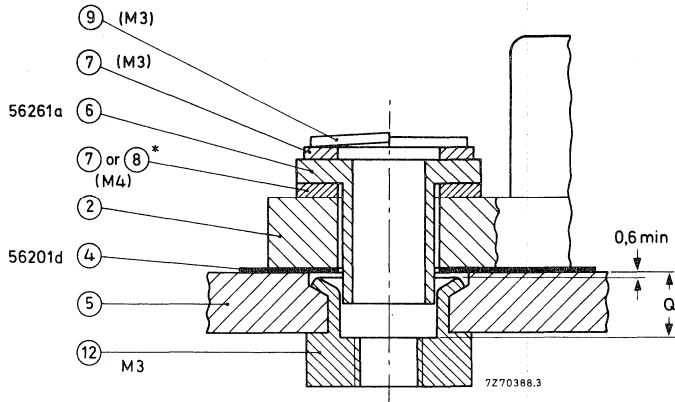


Fig. 12 Assembly (partial) for Fig. 10 - insert nuts Q minimum 2,5 mm.

For legend see page 378.

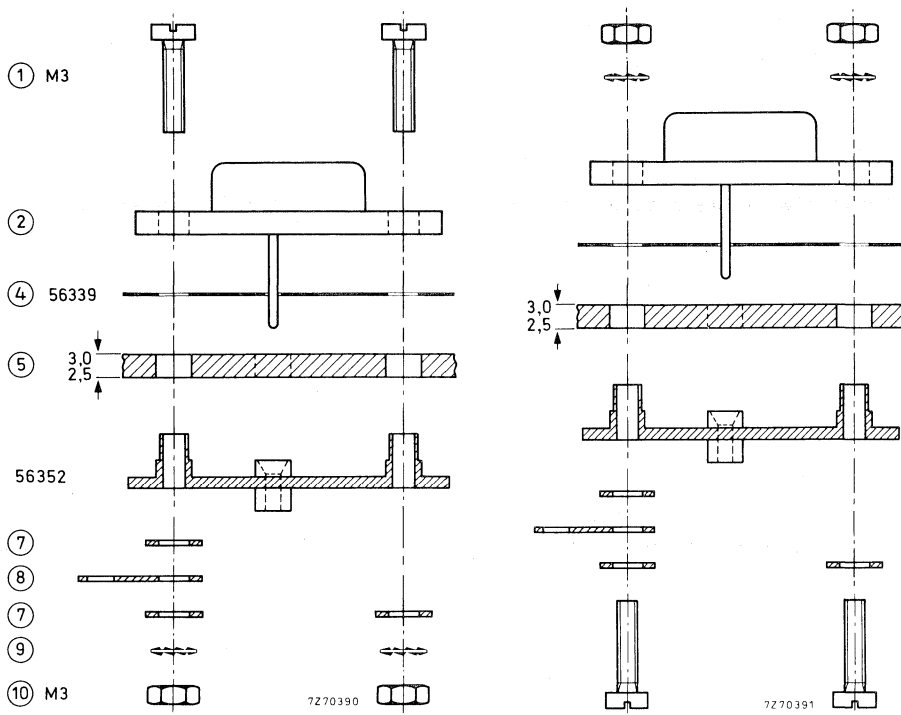
Dimensions in mm

* Thickness approximately 0,6 mm, outer diameter 7,5 mm.

MOUNTING INSTRUCTIONS FOR 500 V TO 2000 V INSULATION

Using mounting support 56352 and mica washer 56339

The transistor should be mounted with M3 screws. For component arrangement see Figs 13 and 14. For hole pattern see Fig. 15. Thickness of heatsink 2,5 mm to 3 mm.



Figs 13 and 14. Insulated mounting (500 V–2000 V).

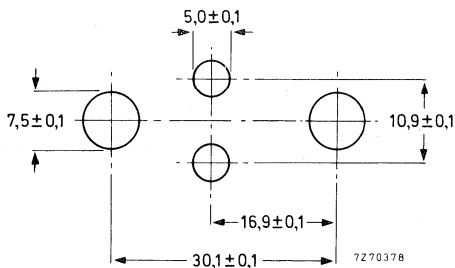


Fig. 15 Hole pattern for Figs 13 and 14.

For legend see page 378.

ACCESSORIES



TYPE NUMBER SURVEY ACCESSORIES

type number	description	envelope
56201d	mica washer (up to 500 V)	TO-3
56201j	insulating bushes (up to 500 V)	TO-3
56261a	insulating bushes (up to 500 V)	TO-3
56326	metal washer	TO-126
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
56368b	insulating bush (up to 800 V)	SOT-93
56369	mica insulator (up to 2 kV)	TO-220
56378	mica insulator (up to 1500 V)	SOT-93
56379	spring clip	SOT-93
56387a	mica insulator (up to 300 V)	TO-126
56387b	insulating bush (up to 300 V)	TO-126



SELECTION GUIDE

CLIP MOUNTING

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

SCREW MOUNTING

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

The accessories mentioned can be supplied on request.

See also chapter Mounting Instructions.

Mounting TO-126 and SOT-82 envelopes.

56353

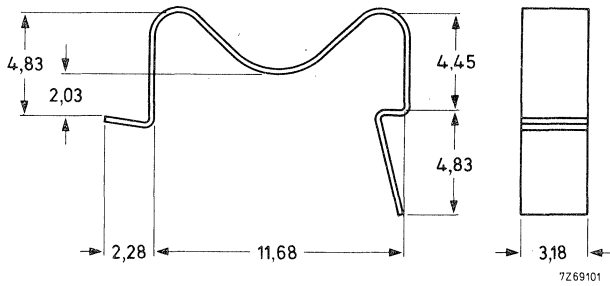
CLIP

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.

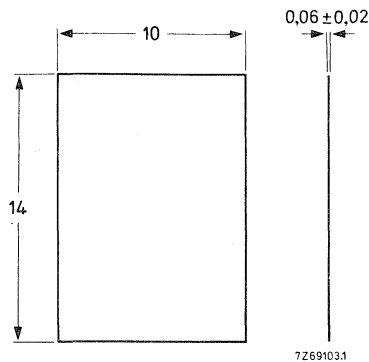
56354

MICA INSULATOR

for TO-126 and SOT-82 envelopes

MECHANICAL DATA

Dimensions in mm



Mounting of TO-126 envelopes

56326

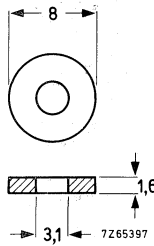
WASHER

for direct mounting of TO-126 envelopes

MECHANICAL DATA

Material: brass, nickel plated

Dimensions in mm



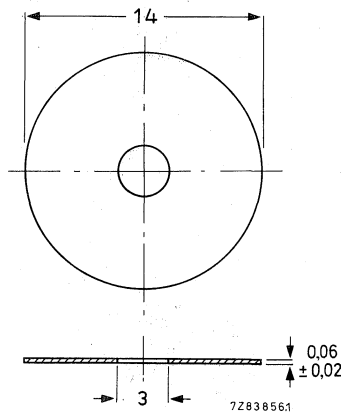
56387a

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

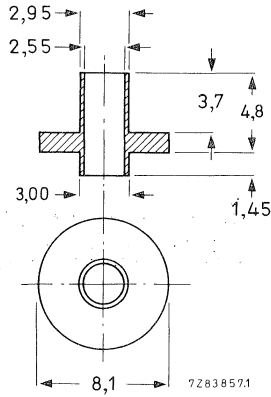
INSULATING BUSH

for insulated screw mounting of TO-126 envelopes (up to 300 V)

MECHANICAL DATA

Material: polyester

Dimensions in mm



TEMPERATURE

Maximum permissible temperature

T_{\max} 150 °C

Clip mounting TO-220 envelopes

56363

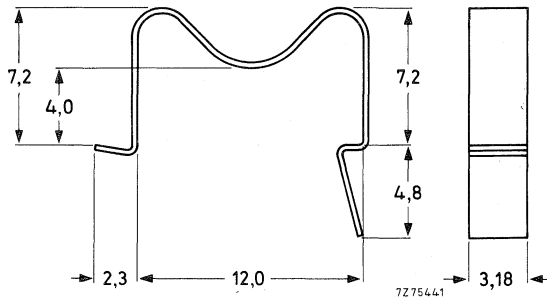
SPRING CLIP

for direct mounting of TO-220 envelopes

MECHANICAL DATA

Material: steel, zinc-chromate passivated.

Dimensions in mm



56364

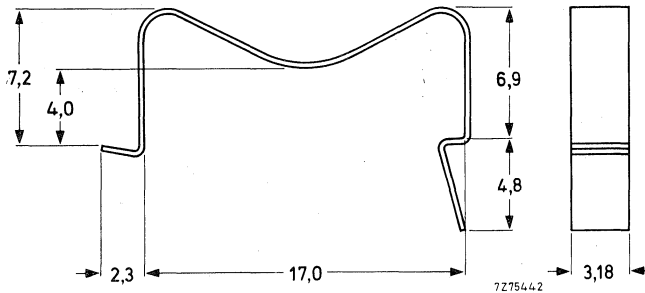
SPRING CLIP

for insulated mounting of TO-220 envelopes

MECHANICAL DATA

Material: steel, zinc-chromate passivated.

Dimensions in mm



to be used in conjunction with 56367 or 56369.

Clip mounting TO-220 envelopes

56367

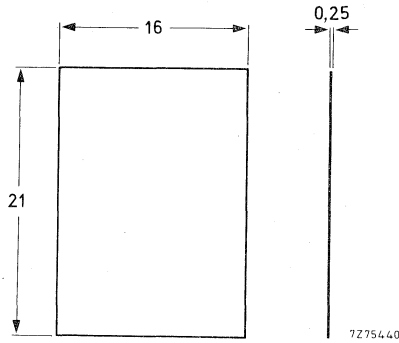
ALUMINA INSULATOR

for insulated clip mounting of TO-220 envelopes (up to 2 kV)

MECHANICAL DATA

Material: 96-alumina.

Dimensions in mm



* Because alumina is brittle, extreme care must be taken when mounting devices not to crack the alumina, particularly when used without heatsink compound.

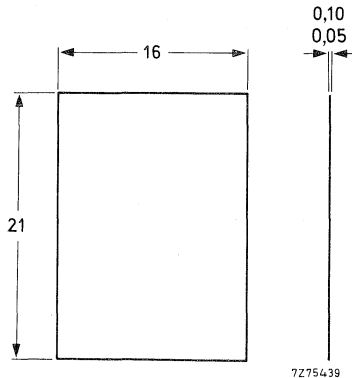
56369

MICA INSULATOR

for insulated clip mounting of TO-220 envelopes (up to 2 kV)

MECHANICAL DATA

Dimensions in mm



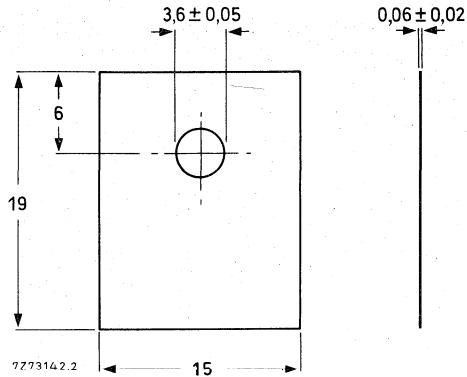
Mounting TO-220 envelopes

56359b

MICA WASHER
for TO-220 envelopes (up to 1000 V)

MECHANICAL DATA

Dimensions in mm



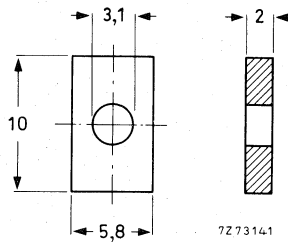
56360a

RECTANGULAR WASHER
for direct and insulated mounting of TO-220 envelopes

MECHANICAL DATA

Material: brass; nickel plated

Dimensions in mm



Mounting TO-220 envelopes

56359c

INSULATING BUSH

for TO-220 envelopes (up to 800 V)

MECHANICAL DATA

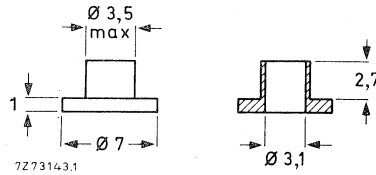
Material: polyester

TEMPERATURE

Maximum permissible temperature

$T_{max} = 150\text{ }^{\circ}\text{C}$

Dimensions in mm



56359d

RECTANGULAR INSULATING BUSH

for TO-220 envelopes (up to 1000 V)

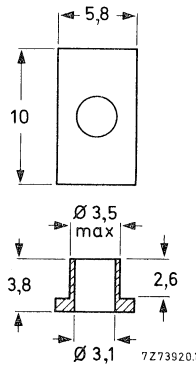
MECHANICAL DATA

TEMPERATURE

Maximum permissible temperature

$T_{max} = 150\text{ }^{\circ}\text{C}$

Dimensions in mm



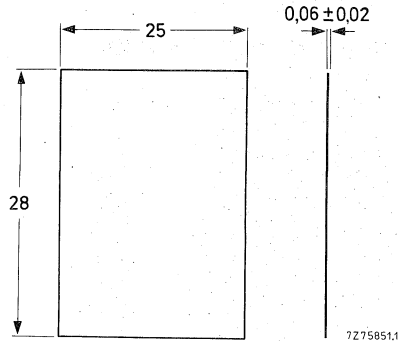
Clip mounting of SOT-93 envelopes

56378

MICA INSULATOR
for SOT-93 clip mounting (up to 1500 V)

MECHANICAL DATA

Dimensions in mm



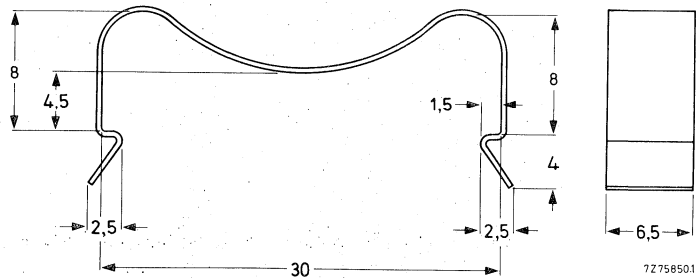
56379

SPRING CLIP
for direct and insulated mounting of SOT-93 envelopes

MECHANICAL DATA

Dimensions in mm

Material:
CrNi steel NLN-939;
thickness $0,4 \pm 0,04$.



Screw mounting of SOT-93 envelopes

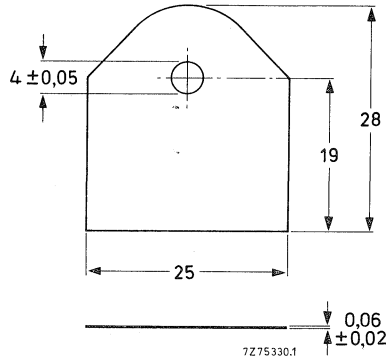
56368a

MICA INSULATOR

for insulated screw mounting of SOT-93 envelopes (up to 800 V)

MECHANICAL DATA

Dimensions in mm



56368b

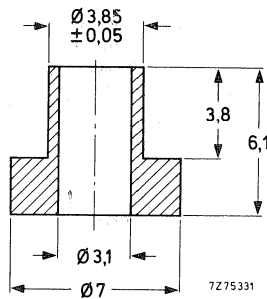
INSULATING BUSH

for insulated screw mounting of SOT-93 envelopes (up to 800 V)

MECHANICAL DATA

Dimensions in mm

Material: polyester



TEMPERATURE

Maximum permissible temperature

$T_{max} = 150\text{ }^{\circ}\text{C}$

Mounting TO-3 envelopes

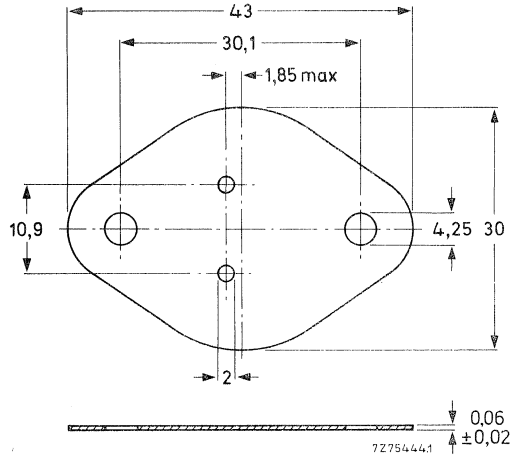
56201d

MICA WASHER

Mica washer for up to 500 V insulation of TO-3 envelopes.

MECHANICAL DATA

Dimensions in mm



56201j

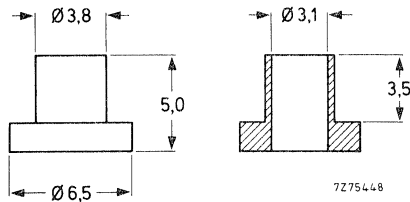
2 INSULATING BUSHES

Two insulating bushes for up to 500 V insulation of TO-3 envelopes.

MECHANICAL DATA

Dimensions in mm

Material: polyester



TEMPERATURE

Maximum permissible temperature

 T_{\max} 150 °C

Mounting TO-3 envelopes

56261a

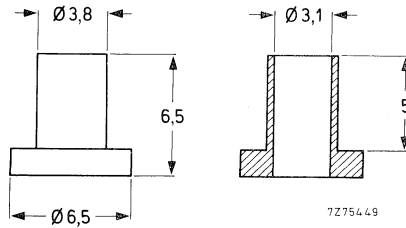
2 INSULATING BUSHES

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_{max} 150 °C

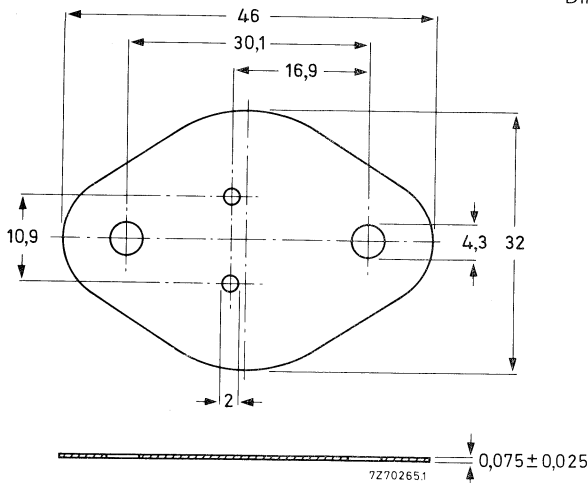
56339

MICA WASHER

Mica washer for 500 to 2000 V insulation of TO-3 envelopes, for which it should be combined with mounting support 56352.

MECHANICAL DATA

Dimensions in mm



Mounting TO-3 envelopes

56352

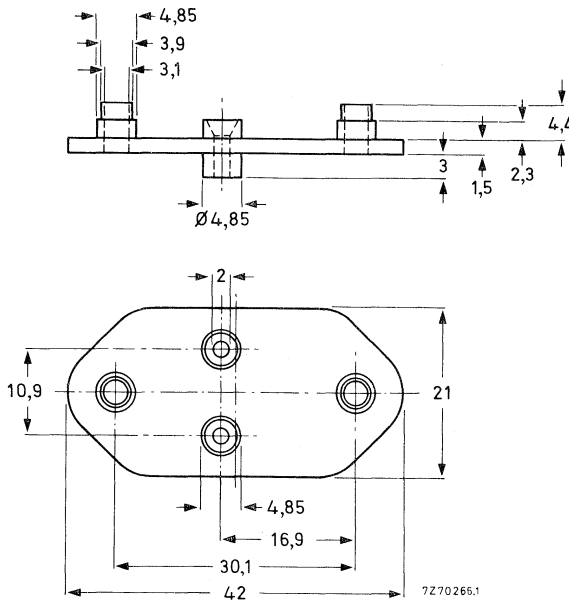
MOUNTING SUPPORT

Mounting support for 500 to 2000 V insulation of TO-3 envelopes, for which it should be combined with mica washer 56339.

MECHANICAL DATA

Material: polyester

Dimensions in mm



TEMPERATURE

Maximum permissible temperature

T_{max} 125 °C

HIGH-VOLTAGE AND SWITCHING POWER TRANSISTORS

TYPE NUMBER SURVEY
SELECTION GUIDE

GENERAL

TRANSISTOR DATA

MOUNTING INSTRUCTIONS

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