

**PHILIPS**

Small-signal transistors

**S3 11-82**

**PHILIPS**

Data handbook



Electronic  
components  
and materials

Semiconductors

Part 3 November 1982

Small-signal transistors

# SEMICONDUCTORS

PART 3 - NOVEMBER 1982

## SMALL-SIGNAL TRANSISTORS

DATA HANDBOOK SYSTEM  
SEMICONDUCTOR INDEX  
MAINTENANCE TYPE LIST

SELECTION GUIDE  
TYPE NUMBER SURVEY

CECC  
APPROVED TYPES

GENERAL

TRANSISTOR DATA

SOLDERING RECOMMENDATIONS SOT-37  
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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May 1980



## 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 components and assemblies**

\* Will become available in the course of 1982.

## 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**
- S4 Low-frequency power transistors and hybrid IC modules**
- 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  
LOCOS 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

\* This handbook will be available by the end of 1982.

## 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, HN1L FZ/30 series, NORbits 60-, 61-, 90-series, input devices, hybrid ICs, peripheral devices
- C2 FM tuners, 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**

\* C7 is in preparation. Retain C15 05-80 for information on variable capacitors until C7 becomes available.



## 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

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type no.	book	section	type no.	book	section	type no.	book	section
BC264C	S5	FET	BCW61*	S7	Mm	BD202	S4	P
BC264D	S5	FET	BCW69;R	S7	Mm	BD203	S4	P
BC327;A	S3	Sm	BCW70;R	S7	Mm	BD204	S4	P
BC328	S3	Sm	BCW71;R	S7	Mm	BD226	S4	P
BC337;A	S3	Sm	BCW72;R	S7	Mm	BD227	S4	P
BC338	S3	Sm	BCW81;R	S7	Mm	BD228	S4	P
BC368	S3	Sm	BCW89;R	S7	Mm	BD229	S4	P
BC369	S3	Sm	BCX17;R	S7	Mm	BD230	S4	P
BC375	S3	Sm	BCX18;R	S7	Mm	BD231	S4	P
BC376	S3	Sm	BCX19;R	S7	Mm	BD233	S4	P
BC546	S3	Sm	BCX20;R	S7	Mm	BD234	S4	P
BC547	S3	Sm	BCX51	S7	Mm	BD235	S4	P
BC548	S3	Sm	BCX52	S7	Mm	BD236	S4	P
BC549	S3	Sm	BCX53	S7	Mm	BD237	S4	P
BC550	S3	Sm	BCX54	S7	Mm	BD238	S4	P
BC556	S3	Sm	BCX55	S7	Mm	BD291	S4	P
BC557	S3	Sm	BCX56	S7	Mm	BD292	S4	P
BC558	S3	Sm	BCX70*	S7	Mm	BD293	S4	P
BC559	S3	Sm	BCX71*	S7	Mm	BD294	S4	P
BC560	S3	Sm	BCY56	S3	Sm	BD295	S4	P
BC635	S3	Sm	BCY57	S3	Sm	BD296	S4	P
BC636	S3	Sm	BCY58	S3	Sm	BD329	S4	P
BC637	S3	Sm	BCY59	S3	Sm	BD330	S4	P
BC638	S3	Sm	BCY70	S3	Sm	BD331	S4	P
BC639	S3	Sm	BCY71	S3	Sm	BD332	S4	P
BC640	S3	Sm	BCY72	S3	Sm	BD333	S4	P
BCF29;R	S7	Mm	BCY78	S3	Sm	BD334	S4	P
BCF30;R	S7	Mm	BCY79	S3	Sm	BD335	S4	P
BCF32;R	S7	Mm	BCY87	S3	Sm	BD336	S4	P
BCF33;R	S7	Mm	BCY88	S3	Sm	BD337	S4	P
BCF70;R	S7	Mm	BCY89	S3	Sm	BD338	S4	P
BCF81;R	S7	Mm	BD131	S4	P	BD433	S4	P
BCV71;R	S7	Mm	BD132	S4	P	BD434	S4	P
BCV72;R	S7	Mm	BD135	S4	P	BD435	S4	P
BCW29;R	S7	Mm	BD136	S4	P	BD436	S4	P
BCW30;R	S7	Mm	BD137	S4	P	BD437	S4	P
BCW31;R	S7	Mm	BD138	S4	P	BD438	S4	P
BCW32;R	S7	Mm	BD139	S4	P	BD645	S4	P
BCW33;R	S7	Mm	BD140	S4	P	BD646	S4	P
BCW60*	S7	Mm	BD201	S4	P	BD647	S4	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
BD648	S4	P	BD940	S4	P	BDT42C	S4	P
BD649	S4	P	BD941	S4	P	BDT60	S4	P
BD650	S4	P	BD942	S4	P	BDT60A	S4	P
BD651	S4	P	BD943	S4	P	BDT60B	S4	P
BD652	S4	P	BD944	S4	P	BDT60C	S4	P
BD675	S4	P	BD945	S4	P	BDT61	S4	P
BD676	S4	P	BD946	S4	P	BDT61A	S4	P
BD677	S4	P	BD947	S4	P	BDT61B	S4	P
BD678	S4	P	BD948	S4	P	BDT61C	S4	P
BD679	S4	P	BD949	S4	P	BDT62	S4	P
BD680	S4	P	BD950	S4	P	BDT62A	S4	P
BD681	S4	P	BD951	S4	P	BDT62B	S4	P
BD682	S4	P	BD952	S4	P	BDT62C	S4	P
BD683	S4	P	BD953	S4	P	BDT63	S4	P
BD684	S4	P	BD954	S4	P	BDT63A	S4	P
BD813	S4	P	BD955	S4	P	BDT63B	S4	P
BD814	S4	P	BD956	S4	P	BDT63C	S4	P
BD815	S4	P	BDT29	S4	P	BDT64	S4	P
BD816	S4	P	BDT29A	S4	P	BDT64A	S4	P
BD817	S4	P	BDT29B	S4	P	BDT64B	S4	P
BD818	S4	P	BDT29C	S4	P	BDT64C	S4	P
BD825	S4	P	BDT30	S4	P	BDT65	S4	P
BD826	S4	P	BDT30A	S4	P	BDT65A	S4	P
BD827	S4	P	BDT30B	S4	P	BDT65B	S4	P
BD828	S4	P	BDT30C	S4	P	BDT65C	S4	P
BD829	S4	P	BDT31	S4	P	BDT91	S4	P
BD830	S4	P	BDT31A	S4	P	BDT92	S4	P
BD839	S4	P	BDT31B	S4	P	BDT93	S4	P
BD840	S4	P	BDT31C	S4	P	BDT94	S4	P
BD841	S4	P	BDT32	S4	P	BDT95	S4	P
BD842	S4	P	BDT32A	S4	P	BDT96	S4	P
BD843	S4	P	BDT32B	S4	P	BDV64	S4	P
BD844	S4	P	BDT32C	S4	P	BDV64A	S4	P
BD933	S4	P	BDT41	S4	P	BDV64B	S4	P
BD934	S4	P	BDT41A	S4	P	BDV64C	S4	P
BD935	S4	P	BDT41B	S4	P	BDV65	S4	P
BD936	S4	P	BDT41C	S4	P	BDV65A	S4	P
BD937	S4	P	BDT42	S4	P	BDV65B	S4	P
BD938	S4	P	BDT42A	S4	P	BDV65C	S4	P
BD939	S4	P	BDT42B	S4	P	BDV91	S4	P

P = Low-frequency power transistors



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type no.	book	section	type no.	book	section	type no.	book	section
BDV92	S4	P	BDX67	S4	P	BF419	S4	P
BDV93	S4	P	BDX67A	S4	P	BF422	S3	Sm
BDV94	S4	P	BDX67B	S4	P	BF423	S3	Sm
BDV95	S4	P	BDX67C	S4	P	BF450	S3	Sm
BDV96	S4	P	BDX77	S4	P	BF451	S3	Sm
BDW55	S4	P	BDX78	S4	P	BF457	S4	P
BDW56	S4	P	BDX91	S4	P	BF458	S4	P
BDW57	S4	P	BDX92	S4	P	BF459	S4	P
BDW58	S4	P	BDX93	S4	P	BF469	S4	P
BDW59	S4	P	BDX94	S4	P	BF470	S4	P
BDW60	S4	P	BDX95	S4	P	BF471	S4	P
BDX35	S4	P	BDX96	S4	P	BF472	S4	P
BDX36	S4	P	BDY90	S4	P	BF480	S3	Sm
BDX37	S4	P	BDY90A	S4	P	BF494	S3	Sm
BDX42	S4	P	BDY91	S4	P	BF495	S3	Sm
BDX43	S4	P	BDY92	S4	P	BF496	S3	Sm
BDX44	S4	P	BF180	S3	Sm	BF510	S7	Mm
BDX45	S4	P	BF181	S3	Sm	BF511	S7	Mm
BDX46	S4	P	BF182	S3	Sm	BF512	S7	Mm
BDX47	S4	P	BF183	S3	Sm	BF513	S7	Mm
BDX62	S4	P	BF198	S3	Sm	BF536	S7	Mm
BDX62A	S4	P	BF199	S3	Sm	BF550;R	S7	Mm
BDX62B	S4	P	BF200	S3	Sm	BF569	S7	Mm
BDX62C	S4	P	BF240	S3	Sm	BF579	S7	Mm
BDX63	S4	P	BF241	S3	Sm	BF622	S7	Mm
BDX63A	S4	P	BF245A	S5	FET	BF623	S7	Mm
BDX63B	S4	P	BF245B	S5	FET	BF660;R	S7	Mm
BDX63C	S4	P	BF245C	S5	FET	BF767	S7	Mm
BDX64	S4	P	BF246A	S5	FET	BF819	S4	P
BDX64A	S4	P	BF246B	S5	FET	BF857	S4	P
BDX64B	S4	P	BF246C	S5	FET	BF858	S4	P
BDX64C	S4	P	BF256A	S5	FET	BF859	S4	P
BDX65	S4	P	BF256B	S5	FET	BF869	S4	P
BDX65A	S4	P	BF256C	S5	FET	BF870	S4	P
BDX65B	S4	P	BF324	S3	Sm	BF871	S4	P
BDX65C	S4	P	BF370	S3	Sm	BF872	S4	P
BDX66	S4	P	BF410A	S5	FET	BF926	S3	Sm
BDX66A	S4	P	BF410B	S5	FET	BF936	S3	Sm
BDX66B	S4	P	BF410C	S5	FET	BF939	S3	Sm
BDX66C	S4	P	BF410D	S5	FET	BF960	S5	FET

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
BF967	S3	Sm	BFR91A	S10	WBT	BFX88	S3	Sm
BF970	S3	Sm	BFR92;R	S7	Mm	BFX89	S10	WBT
BF979	S3	Sm	BFR93;R	S7	Mm	BFY50	S3	Sm
BF981	S5	FET	BFR94	S10	WBT	BFY51	S3	Sm
BFQ10	S5	FET	BFR95	S10	WBT	BFY52	S3	Sm
BFQ11	S5	FET	BFR96	S10	WBT	BFY55	S3	Sm
BFQ12	S5	FET	BFR96S	S10	WBT	BFY90	S10	WBT
BFQ13	S5	FET	BFS17;R	S7	Mm	BG2000	S1	RT
BFQ14	S5	FET	BFS18;R	S7	Mm	BG2097	S1	RT
BFQ15	S5	FET	BFS19;R	S7	Mm	BGX11*	S2	ThM
BFQ16	S5	FET	BFS20;R	S7	Mm	BGX12*	S2	ThM
BFQ17	S7	Mm	BFS21	S5	FET	BGX13*	S2	ThM
BFQ18A	S7	Mm	BFS21A	S5	FET	BGX14*	S2	ThM
BFQ19	S7	Mm	BFS22A	S6	RFP	BGX15*	S2	ThM
BFQ22	S10	WBT	BFS23A	S6	RFP	BGX17*	S2	ThM
BFQ22S	S10	WBT	BFS28	S5	FET	BGY22	S6	RFP
BFQ23	S10	WBT	BFT24	S10	WBT	BGY22A	S6	RFP
BFQ24	S10	WBT	BFT25;R	S7	Mm	BGY23	S6	RFP
BFQ32	S10	WBT	BFT44	S3	Sm	BGY23A	S6	RFP
BFQ33	S10	WBT	BFT45	S3	Sm	BGY32	S6	RFP
BFQ34	S10	WBT	BFT46	S7	Mm	BGY33	S6	RFP
BFQ42	S6	RFP	BFT92;R	S7	Mm	BGY35	S6	RFP
BFQ43	S6	RFP	BFT93;R	S7	Mm	BGY36	S6	RFP
BFQ51	S10	WBT	BFW10	S5	FET	BGY40A	S6	RFP
BFQ52	S10	WBT	BFW11	S5	FET	BGY40B	S6	RFP
BFQ53	S10	WBT	BFW12	S5	FET	BGY41A	S6	RFP
BFQ63	S10	WBT	BFW13	S5	FET	BGY41B	S6	RFP
BFQ68	S10	WBT	BFW16A	S10	WBT	BGY43	S6	RFP
BFR29	S5	FET	BFW17A	S10	WBT	BGY50	S10	WBM
BFR30	S7	Mm	BFW30	S10	WBT	BGY51	S10	WBM
BFR31	S7	Mm	BFW61	S5	FET	BGY52	S10	WBM
BFR49	S10	WBT	BFW92	S10	WBT	BGY53	S10	WBM
BFR53;R	S7	Mm	BFW93	S10	WBT	BGY54	S10	WBM
BFR54	S3	Sm	BFX29	S3	Sm	BGY55	S10	WBM
BFR64	S10	WBT	BFX30	S3	Sm	BGY56	S10	WBM
BFR65	S10	WBT	BFX34	S3	Sm	BGY57	S10	WBM
BFR84	S5	FET	BFX84	S3	Sm	BGY58	S10	WBM
BFR90	S10	WBT	BFX85	S3	Sm	BGY59	S10	WBM
BFR90A	S10	WBT	BFX86	S3	Sm	BGY60	S10	WBM
BFR91	S10	WBT	BFX87	S3	Sm	BGY74	S10	WBM

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 modules

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BLV10	S6	RFP	BLX13	S6	RFP	BLY97	S6	RFP
BLV11	S6	RFP	BLX13C	S6	RFP	BPW22A	S8	PDT
BLV20	S6	RFP	BLX14	S6	RFP	BPW44	S8	PDT
BLV21	S6	RFP	BLX15	S6	RFP	BPW45	S8	PDT
BLV25	S6	RFP	BLX39	S6	RFP	BPW50	S8	PDT
BLV30	S6	RFP	BLX65	S6	RFP	BPX25	S8	PDT
BLV31	S6	RFP	BLX66	S6	RFP	BPX29	S8	PDT
BLV32F	S6	RFP	BLX67	S6	RFP	BPX40	S8	PDT
BLV33	S6	RFP	BLX68	S6	RFP	BPX41	S8	PDT
BLV33F	S6	RFP	BLX69A	S6	RFP	BPX42	S8	PDT
BLV36	S6	RFP	BLX91A	S6	RFP	BPX47B/18S8		PDT
BLV57	S6	RFP	BLX92A	S6	RFP	BPX47B/20S8		PDT
BLW29	S6	RFP	BLX93A	S6	RFP	BPX47C/36S8		PDT
BLW31	S6	RFP	BLX94A	S6	RFP	BPX70	S8	PDT
BLW32	S6	RFP	BLX94C	S6	RFP	BPX71	S8	PDT
BLW33	S6	RFP	BLX95	S6	RFP	BPX72	S8	PDT
BLW34	S6	RFP	BLX96	S6	RFP	BPX95C	S8	PDT
BLW50F	S6	RFP	BLX97	S6	RFP	BR100/03	S2	Th
BLW60	S6	RFP	BLX98	S6	RFP	BR101	S3	Sm
BLW60C	S6	RFP	BLY33	S6	RFP	BRY39	S3	Sm
BLW64	S6	RFP	BLY34	S6	RFP	BRY56	S3	Sm
BLW75	S6	RFP	BLY35	S6	RFP	BRY61	S7	Mm
BLW76	S6	RFP	BLY36	S6	RFP	BSR12;R	S7	Mm
BLW77	S6	RFP	BLY83	S6	RFP	BSR13;R	S7	Mm
BLW78	S6	RFP	BLY84	S6	RFP	BSR14;R	S7	Mm
BLW79	S6	RFP	BLY85	S6	RFP	BSR15;R	S7	Mm
BLW80	S6	RFP	BLY87A	S6	RFP	BSR16;R	S7	Mm
BLW81	S6	RFP	BLY87C	S6	RFP	BSR17;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

Mm = Microminiature semiconductors  
for hybrid circuits

PDT = Photodiodes or transistors

RFP = R.F. power transistors and modules

Sm = Small-signal transistors

Th = Thyristors

WBM = Wideband hybrid IC modules

type no.	book	section	type no.	book	section	type no.	book	section
BSR56	S7	Mm	BT139*	S2	Tri	BUW85	S4	P
BSR57	S7	Mm	BT149*	S2	Th	BUY46;A	S4	P
BSR58	S7	Mm	BT151*	S2	Th	BUY47;A	S4	P
BSR60	S3	Sm	BT152*	S2	Th	BUY48;A	S4	P
BSR61	S3	Sm	BT153	S2	Th	BUY80	S4	P
BSR62	S3	Sm	BT154	S2	Th	BUY81	S4	P
BSS38	S3	Sm	BT155*	S2	Th	BUY82	S4	P
BSS50	S3	Sm	BTV24*	S2	Th	BUY83	S4	P
BSS51	S3	Sm	BTV34*	S2	Tri	BUY84	S4	P
BSS52	S3	Sm	BTV58*	S2	Th	BUY85	S4	P
BSS60	S3	Sm	BTW23*	S2	Th	BUY86	S4	P
BSS61	S3	Sm	BTW30S*	S2	Th	BUY87	S4	P
BSS62	S3	Sm	BTW31W*	S2	Th	BUY98	S4	P
BSS63;R	S7	Mm	BTW38*	S2	Th	BUY89	S4	P
BSS64;R	S7	Mm	BTW40*	S2	Th	BY184	S1	R
BSS68	S3	Sm	BTW42*	S2	Th	BY188G	S1	R
BSV15	S3	Sm	BTW43*	S2	Tri	BY223	S2	R
BSV16	S3	Sm	BTW45*	S2	Th	BY224*	S2	R
BSV17	S3	Sm	BTW47*	S2	Th	BY225*	S2	R
BSV52;R	S7	Mm	BTW58*	S2	Th	BY228	S1	R
BSV64	S3	Sm	BTW63*	S2	Th	BY229*	S2	R
BSV78	S5	FET	BTW92*	S2	Th	BY249	S2	R
BSV79	S5	FET	BTX18*	S2	Th	BY260*	S2	R
BSV80	S5	FET	BTX94*	S2	Tri	BY261*	S2	R
BSV81	S5	FET	BTY79*	S2	Th	BY277*	S2	R
BSW66A	S3	Sm	BTY87*	S2	Th	BY438	S1	R
BSW67A	S3	Sm	BTY91*	S2	Th	BY448	S1	R
BSW68A	S3	Sm	BU208A	S4	P	BY458	S1	R
BSX19	S3	Sm	BU326	S4	P	BY476	S1	R
BSX20	S3	Sm	BU326A	S4	P	BY477	S1	R
BSX45	S3	Sm	BU426	S4	P	BY478	S1	R
BSX46	S3	Sm	BU426A	S4	P	BY505	S1	R
BSX47	S3	Sm	BU433	S4	P	BY509	S1	R
BSX59	S3	Sm	BUS11;A	S4	P	BY527	S1	R
BSX60	S3	Sm	BUS12;A	S4	P	BY584	S1	R
BSX61	S3	Sm	BUS13;A	S4	P	BY609	S1	R
BSY95A	S3	Sm	BUS14;A	S4	P	BY610	S1	R
BT136*	S2	Tri	BUV82	S4	P	BYV20	S2	R
BT137*	S2	Tri	BUV83	S4	P	BYV21*	S2	R
BT138*	S2	Tri	BUW84	S4	P	BYV22	S2	R

\* = series

FET = Field-effect transistors

Mm = Microminiature semiconductors  
for hybrid circuits

P = Low-frequency power transistors

R = Rectifier diodes

Sm = Small-signal transistors

Th = Thyristors

Tri = Triacs

# INDEX

type no.	book	section	type no.	book	section	type no.	book	section
BYV23	S2	R	BYX52*	S2	R	CNX21	S8	PhC
BYV24	S2	R	BYX56*	S2	R	CNX35	S8	PhC
BYV27	S1	R	BYX71*	S2	R	CNX36	S8	PhC
BYV28	S1	R	BYX90	S1	R	CNX38	S8	PhC
BYV30*	S2	R	BYX91*	S1	R	CNY48	S8	PhC
BYV32*	S2	R	BYX94	S1	R	CNY50	S8	PhC
BYV92*	S2	R	BYX96*	S2	R	CNY52	S8	PhC
BYV95A	S1	R	BYX97*	S2	R	CNY53	S8	PhC
BYV95B	S1	R	BYX98*	S2	R	CNY57	S8	PhC
BYV95C	S1	R	BYX99*	S2	R	CNY57A	S8	PhC
BYV96D	S1	R	BZT03	S1	Vrg	CNY62	S8	PhC
BYV96E	S1	R	BZV10	S1	Vrf	CNY63	S8	PhC
BYW19*	S2	R	BZV11	S1	Vrf	CQ209S	S8	D
BYW25	S2	R	BZV12	S1	Vrf	CQ216X	S8	D
BYW29*	S2	R	BZV13	S1	Vrf	CQ216Y	S8	D
BYW30*	S2	R	BZV14	S1	Vrf	CQ327;R	S8	D
BYW31*	S2	R	BZV15*	S2	Vrg	CQ330;R	S8	D
BYW54	S1	R	BZV37	S1	Vrf	CQ331;R	S8	D
BYW55	S1	R	BZV46	S1	Vrg	CQ332;R	S8	D
BYW56	S1	R	BZV49	S1	Vrg	CQ427;R	S8	D
BYW92*	S2	R	BZV85	S1	Vrg	CQ430;R	S8	D
BYW93*	S2	R	BZW70*	S2	TS	CQ431;R	S8	D
BYW94*	S2	R	BZW86*	S2	TS	CQ432;R	S8	D
BYW95A	S1	R	BZW91*	S2	TS	QLL10	S8	LED
BYW95B	S1	R	BZX55	S1	Vrg	CQW10	S8	LED
BYW95C	S1	R	BZX70*	S2	Vrg	CQW11	S8	LED
BYW96D	S1	R	BZX75	S1	Vrg	CQW12	S8	LED
BYW96E	S1	R	BZX78*	S7/S1	Mm/Vrg	CQX10	S8	LED
BYX10	S1	R	BZX79*	S1	Vrg	CQX11	S8	LED
BYX22*	S2	R	BZX84*	S7/S1	Mm/Vrg	CQX12	S8	LED
BYX25*	S2	R	BZX87*	S1	Vrg	CQX51	S8	LED
BYX30*	S2	R	BZX90	S1	Vrf	CQX54	S8	LED
BYX32*	S2	R	BZX91	S1	Vrf	CQX55	S8	LED
BYX38*	S2	R	BZX92	S1	Vrf	CQX56	S8	LED
BYX39*	S2	R	BZX93	S1	Vrf	CQX57	S8	LED
BYX42*	S2	R	BZX94	S1	Vrf	CQX58	S8	LED
BYX45*	S2	R	BZY91*	S2	Vrg	CQX60	S8	LED
BYX46*	S2	R	BZY93*	S2	Vrg	CQX61	S8	LED
BYX49*	S2	R	BZY95*	S2	Vrg	CQX62	S8	LED
BYX50*	S2	R	BZY96*	S2	Vrg	CQX63	S8	LED

\* = series

D = Displays

LED = Light emitting diodes

Mm = Microminiature semiconductors  
for hybrid circuits

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
CQX64	S8	LED	OM361	S10	WBM	RPY96	S8	I
CQX65	S8	LED	OM370	S10	WBM	SD205	S5	FET
CQX66	S8	LED	OM931	S4	P	SD210	S5	FET
CQX67	S8	LED	OM961	S4	P	SD211	S5	FET
CQX68	S8	LED	ORP60	S8	Ph	SD212	S5	FET
CQX74	S8	LED	ORP61	S8	Ph	SD213	S5	FET
CQX75	S8	LED	ORP62	S8	Ph	SD214	S5	FET
CQX76	S8	LED	ORP66	S8	Ph	SD215	S5	FET
CQX77	S8	LED	ORP68	S8	Ph	SD217	S5	FET
CQX78	S8	LED	ORP69	S8	Ph	SD220	S5	FET
CQY11B	S8	LED	OSB9110	S2	St	SD222	S5	FET
CQY11C	S8	LED	OSB9210	S2	St	SD226	S5	FET
CQY24B	S8	LED	OSB9410	S2	St	SD304	S5	FET
CQY49B	S8	LED	OSM9110	S2	St	SD306	S5	FET
CQY49C	S8	LED	OSM9210	S2	St	1N821;A	S1	Vrf
CQY50	S8	LED	OSM9410	S2	St	1N823;A	S1	Vrf
CQY52	S8	LED	OSM9510	S2	St	1N825;A	S1	Vrf
CQY54	S8	LED	OSM9511	S2	St	1N827;A	S1	Vrf
CQY58A	S8	LED	OSM9512	S2	St	1N829;A	S1	Vrf
CQY89A	S8	LED	OSS9110	S2	St	1N914	S1	SD
CQY94	S8	LED	OSS9210	S2	St	1N916	S1	SD
CQY95	S8	LED	OSS9410	S2	St	1N3879	S2	R
CQY96	S8	LED	PH2222;R	S3	Sm	1N3880	S2	R
CQY97	S8	LED	PH2222A;R	S3	Sm	1N3881	S2	R
OA90	S1	GD	PH2369	S3	Sm	1N3882	S2	R
OA91	S1	GD	PH2907;R	S3	Sm	1N3889	S2	R
OA95	S1	GD	PH2907A;R	S3	Sm	1N3890	S2	R
OM320	S10	WBM	PH40*	S2	R	1N3891	S2	R
OM321	S10	WBM	PH70*	S2	R	1N3892	S2	R
OM322	S10	WBM	RPY58A	S8	Ph	1N3899	S2	R
OM323	S10	WBM	RPY82	S8	Ph	1N3900	S2	R
OM323A	S10	WBM	RPY84	S8	Ph	1N3901	S2	R
OM335	S10	WBM	RPY85	S8	Ph	1N3902	S2	R
OM336	S10	WBM	RPY86	S8	I	1N3903	S2	R
OM337	S10	WBM	RPY87	S8	I	1N3909	S2	R
OM337A	S10	WBM	RPY88	S8	I	1N3910	S2	R
OM339	S10	WBM	RPY89	S8	I	1N3911	S2	R
OM345	S10	WBM	RPY90*	S8	I	1N3912	S2	R
OM350	S10	WBM	RPY91*	S8	I	1N3913	S2	R
OM360	S10	WBM	RPY93	S8	I	1N4001G	S1	R

FET = Field-effect transistors

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

# INDEX

type no.	book	section	type no.	book	section	type no.	book	section
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	368BPY	S8	PDT
1N4151	S1	SD	2N3053	S3	Sm	56201d	S4	A
1N4154	S1	SD	2N3375	S6	RFP	56201j	S4	A
1N4446	S1	SD	2N3553	S6	RFP	56230	S2	HE
1N4448	S1	SD	2N3632	S6	RFP	56231	S2	HE
1N4531	S1	SD	2N3822	S5	FET	56245	S3,6,10A	
1N4532	S1	SD	2N3823	S5	FET	56246	S3,5,10A	
1N5059	S1	R	2N3866	S6	RFP	56253	S2	DH
1N5060	S1	R	2N3903	S3	Sm	56256	S2	DH
1N5061	S1	R	2N3904	S3	Sm	56261a	S4	A
1N5062	S1	R	2N3905	S3	Sm	56262A	S2	A
2N918	S10	WBT	2N3906	S3	Sm	56264A	S2	A
2N929	S3	Sm	2N3924	S6	RFP	56268	S2	DH
2N930	S3	Sm	2N3926	S6	RFP	56290	S2	HE
2N1613	S3	Sm	2N3927	S6	RFP	56295	S2	A
2N1711	S3	Sm	2N3966	S5	FET	56312	S2	DH
2N1893	S3	Sm	2N4030	S3	Sm	56313	S2	DH
2N2218	S3	Sm	2N4031	S3	Sm	56316	S2	A
2N2218A	S3	Sm	2N4032	S3	Sm	56317	S2	A
2N2219	S3	Sm	2N4033	S3	Sm	56326	S4	A
2N2219A	S3	Sm	2N4091	S5	FET	56333	S4	A
2N2221	S3	Sm	2N4092	S5	FET	56339	S4	A
2N2221A	S3	Sm	2N4093	S5	FET	56348	S2	DH
2N2222	S3	Sm	2N4123	S3	Sm	56350	S2	DH
2N2222A	S3	Sm	2N4124	S3	Sm	56352	S4	A
2N2297	S3	Sm	2N4125	S3	Sm	56353	S4	A
2N2368	S3	Sm	2N4126	S3	Sm	56354	S4	A
2N2369	S3	Sm	2N4391	S5	FET	56359b	S4	A
2N2369A	S3	Sm	2N4392	S5	FET	56359c	S4	A
2N2483	S3	Sm	2N4393	S5	FET	56359d	S4	A
2N2484	S3	Sm	2N4427	S6	RFP	56360a	S4	A
2N2904	S3	Sm	2N4856	S5	FET	56363	S2,S4	A
2N2904A	S3	Sm	2N4857	S5	FET	56364	S2,S4	A

A = Accessories  
 DH = Diecast heatsinks  
 FET = Field-effect transistors  
 HE = Heatsink extrusions  
 I = Infrared devices  
 PDT = Photodiodes or transistors

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

type no.	book	section
56366	S2	A
56367	S2, S4	A
56368a	S4	A
56368b	S4	A
56369	S2, S4	A
56378	S4	A
56378	S4	A
56379	S4	A
56387a, b	S4	A

A = Accessories





## MAINTENANCE TYPE LIST

The types listed below are not included in this handbook.  
Detailed information will be supplied on request.

BCY30A to 34A  
BF115



SELECTION GUIDE





## Transistors for audio and general purpose applications

type number	polarity	envelope	RATINGS				CHARACTERISTICS				remarks
			V <sub>CEO</sub> V	I <sub>C</sub> mA	P <sub>tot</sub> mW at	T <sub>amb</sub> °C	h <sub>FE</sub> (h <sub>fe</sub> ) at	I <sub>C</sub> mA	f <sub>T</sub> MHz typ.	F dB typ.	
BC107			45				(125-500)			2	
BC108	n-p-n	TO-18	20	100	300	25	(125-900)	2	> 300	2	
BC109			20				(240-900)			1,2	low-noise type
BC146	n-p-n	SOT-42	20	50	50	45	80-550	0,2	150	2	hearing aids, watches
BC177			45				( 75-260)			—	
BC178	p-n-p	TO-18	25	100	300	25	(125-500)	2	150	—	
BC179			20				(125-500)			1,2	low-noise type
BC200	p-n-p	SOT-42	20	50	50	45	50-400	0,2	90	2	hearing aids, watches
BC327			45								
BC327A	p-n-p	TO-92 var.	60	500	800	25	100-600	100	100	—	driver and output stages
BC328			25								
BC337			45								
BC337A	n-p-n	TO-92 var.	60	500	800	25	100-600	100	200	—	driver and output stages
BC338			25								
BC368	n-p-n	TO-92 var.	20	1000	800	25	85-375	500	60	—	class-B audio output stage
BC369	p-n-p	TO-92 var.	20	1000	800	25	85-375	500	60	—	
BC375	n-p-n	TO-92 var.	20	1000	800	25	60-340	150	150	—	output stage
BC376	p-n-p	TO-92 var.	20	1000	800	25	60-340	150	150	—	
BC546			65				(125-500)				
BC547	n-p-n	TO-92 var.	45	100	500	25	(125-900)	2	300	2	driver stage audio amplifier
BC548			30				(125-900)				
BC549			30								
BC550	n-p-n	TO-92 var.	45	100	500	25	(240-900)	2	300	1,4	low-noise stage

## Transistors for audio and general purpose applications

type number	polarity	envelope	RATINGS				CHARACTERISTICS				remarks
			V <sub>CEO</sub> V	I <sub>C</sub> mA	P <sub>tot</sub> mW	at T <sub>amb</sub> °C	h <sub>FE</sub> (h <sub>fe</sub> )	at I <sub>C</sub> mA	f <sub>T</sub> MHz typ.	F dB typ.	
BC556	p-n-p	TO-92 var.	65	100	500	25	(75-500)	2	150	2	driver stage audio amp.
BC557			45								
BC558			30								
BC559	p-n-p	TO-92 var.	30	100	500	25	(125-500)	2	150	1,2	low-noise types
BC560			45								
BC635	n-p-n	TO-92 var.	45	1000	1000	25	40-250	150	130	-	driver stage
BC637			60								
BC639			80								
BC636	p-n-p	TO-92 var.	45	1000	1000	25	40-250	150	50	-	driver stage
BC638			60								
BC640			80								
BCY56	n-p-n	TO-18	45	100	300	25	100-450	2	85	1,5	low-noise types
BCY57			20								
BCY58	n-p-n	TO-18	32	200	330	45	(125-700)	2	280	2	switching
BCY59			45								
BCY70	p-n-p	TO-18	40	200	350	25	> 100	10	450	2,0	low-noise types
BCY71			45								
BCY72			25								
BCY78	p-n-p	TO-18	32	200	345	45	(125-700)	2	180	2	switching
BCY79			45								
BCY87*	p-n-p	TO-71	40	30	150	25	100-450	0,05	> 10	< 3	pre-stages of differential amplifiers
BCY88*										< 4	
BCY89*										< 4	

\* Dual transistors for differential amplifiers.

**Transistors for audio and general purpose applications**

type number	polarity	envelope	RATINGS				CHARACTERISTICS				remarks
			$V_{CE0}$ V	$I_C$ mA	$P_{tot}$ mW	at $T_{amb}$ $^{\circ}C$	$h_{FE}$ ( $h_{fe}$ )	at $I_C$ mA	$f_T$ MHz typ.	F dB typ.	
2N929 2N930	n-p-n	TO-18	45	30	300	25	100-350 150-600	10	80	2,5 2,0	low-level, low-noise amplifiers
2N2483 2N2484	n-p-n	TO-18	60	50*	360	25	< 500 < 800	10	80	4 3	low-level, low-noise amplifiers
2N4030 2N4031 2N4032 2N4033	p-n-p	TO-39	60 80 60 80	1000	800	25	40-120 40-120 100-300 100-300	100	> 100 > 100 > 150 > 150		large-signal, low-noise, low-power
2N4123 2N4124 2N4125 2N4126	n-p-n p-n-p	TO-92 TO-92	30 25 30 25	200	350	25	( 50-200) (120-480) ( 50-200) (120-480)	2 2	> 250 > 300 > 200 > 250	6 5 5 4	small-signal, low-power

**Transistors for h.f. applications**

type number	polarity	envelope	RATINGS				CHARACTERISTICS				remarks	
			$V_{CE0}$ V	$I_C$ mA	$P_{tot}$ mW	at $T_{amb}$ $^{\circ}C$	$h_{FE}$ at $I_C$ mA	$C_{re}$ pF typ.	$f_T$ MHz typ.	F dB typ.		f MHz
BF180	n-p-n	TO-72	20	20	150	25		0,28	675	5,7	800	gain-controlled u.h.f. preamplifier
BF181	n-p-n	TO-72	20	20	150	25		0,28	600	6,8	900	mixer osc. u.h.f. band
BF182	n-p-n	TO-72	20	15	150	25		0,33	650	7,4	800	mixer in TV tuners
BF183	n-p-n	TO-72	20	15	150	25		0,33	800			local osc. in TV tuners

 \*  $I_{CM}$ .



## Transistors for h.f. applications

type number	polarity	envelope	RATINGS				CHARACTERISTICS						remarks
			V <sub>CEO</sub> V	I <sub>C</sub> mA	P <sub>tot</sub> mW	at T <sub>amb</sub> °C	hFE at	I <sub>C</sub> mA	C <sub>re</sub> pF typ.	f <sub>T</sub> MHz typ.	F dB at	f MHz	
BF198	n-p-n	TO-92 var.	30	25	500	25	> 10	15	0,20	400	3	35	gain-controlled TV i.f. amp.
BF199	n-p-n	TO-92 var.	25	25	500	25	> 38	7	0,30	550			output video i.f. amp.
BF200	n-p-n	TO-72	20	20	150	25	> 15	3	0,28	650	2,7	200	gain-controlled v.h.f. amp.
BF240	n-p-n	TO-92 var.	40	25	250	25	67-220	1	0,34	380	3,5	0,2	a.m. mixers and i.f. amp.
BF241	n-p-n	TO-92 var.	40	25	250	25	36-125	1	0,34	350			in a.m./f.m. receivers
BF324	p-n-p	TO-92 var.	30	25	250	45	typ.50	4	0,10*	450	3	100	r.f. stages in f.m. front-ends
BF336			180										
BF337	n-p-n	TO-39	200	100	3000	140**	> 20	30	3,5	80			video output stages
BF338			225										
BF370	n-p-n	TO-92 var.	15	100	500	25	> 40	10	1,6	> 500			large signal, i.f. amp.
BF422	n-p-n	TO-92 var.	250	50	830	25	> 50	25	1,0	> 60			class-B video output
BF423	p-n-p	TO-92 var.	250	50	830	25	> 50	25	1,1	> 60			class-B video output
BF450	p-n-p	TO-92 var.	40	25	250	45	62-200	1	0,35	325	2	100	mixer stages in a.m. receivers
BF451	p-n-p	TO-92 var.	40	25	250	45	30-90	1	0,35	325	2	100	and i.f. stages for a.m./f.m.
BF480	n-p-n	SOT-37	15	20	200	60	typ. 28	10		2000	3,8	800	r.f. osc. stages in TV tuners
BF494	n-p-n	TO-92 var.	20	30	300	75	typ. 115	1	0,85	260	4	100	f.m. tuners, a.m. mixer-osc., i.f. amp. in a.m./f.m. receivers
BF495	n-p-n	TO-92 var.	20	30	300	75	typ. 67	1	0,85	200	4	100	f.m. tuners, i.f. amp. in a.m./f.m. receivers and a.m. input stages car radios
BF496	n-p-n	TO-92 var.	20	20	300	75	> 12	2	0,80	550	2	100	gain-controlled v.h.f. amp.

\* C<sub>rb</sub>.\*\* T<sub>mb</sub>.

**Transistors for h.f. applications**

type number	polarity	envelope	RATINGS				CHARACTERISTICS					remarks	
			$V_{CE0}$ V	$I_C$ mA	$P_{tot}$ mW	$T_{amb}$ $^{\circ}C$	$h_{FE}$ at typ.	$I_C$ mA	$C_{re}$ pF typ.	$f_T$ MHz typ.	$F$ dB at MHz		$f$ MHz
BF926	p-n-p	TO-92 var.	20	25	250	45	> 30	1	0,5	350	5	200	mixer/osc. in v.h.f./u.h.f.
BF936	p-n-p	TO-92 var.	20	25	250	45	> 25	1	0,9	350	5	200	mixer/osc. in v.h.f./u.h.f.
BF939	p-n-p	TO-92 var.	25	20	225	55	> 16	2	0,7	750	2,5	200	gain-controlled v.h.f. amp.
BF967	p-n-p	SOT-37	30	20	160	55	> 15	3	0,45	900	4	800	gain-controlled u.h.f. amp.
BF970	p-n-p	SOT-37	35	30	160	55	> 25	3	0,475	900	4,7	800	self-osc. u.h.f. mixer stage
BF979	p-n-p	SOT-37	20	30*	140	55	> 20	10	0,65	1350	4,5	800	r.f. stages in u.h.f. tuners
BFR54	n-p-n	TO-92 var.	15	500*	500	25	> 40	10		> 500			freq. multipliers
BFY50			35				112			140			general purpose industrial and switching applications
BFY51	n-p-n	TO-39	30	1000	5000	50**	123	150		160			
BFY52			20				142			185			
BFY55	n-p-n	TO-39	35	1000	800	25	> 40	150		> 60			
2N2297	n-p-n	TO-39	35	1000	800	25	40-120	150		> 60			

For data on tetrode-MOS-FET types for v.h.f./u.h.f. applications see Handbook part 5

**Transistors for switching applications**

type number	polarity	envelope	RATINGS				CHARACTERISTICS					remarks
			$V_{CE0}$ V	$I_C$ mA	$P_{tot}$ mW	$T_{amb}$ $^{\circ}C$	$h_{FE}$ at	$I_C$ mA	$f_T$ MHz typ.	$t_{off}$ ns max.	$I_C$ mA	
BCY58	n-p-n	TO-18	32	200	330	45	80-1000	10	280	800	10	
BCY59			45									

\*  $I_{CM}$       \*\*  $T_{mb}$



## Transistors for switching applications

type number	polarity	envelope	RATINGS				CHARACTERISTICS					remarks
			V <sub>CE0</sub> V	I <sub>C</sub> mA	P <sub>tot</sub> mW	T <sub>amb</sub> °C	h <sub>FE</sub> at	I <sub>C</sub> mA	f <sub>T</sub> MHz typ.	t <sub>off</sub> ns at max.	I <sub>C</sub> mA	
BCY70	p-n-p	TO-18	40	200	350	25	> 100	10	450	420	10	BCY71 is low-noise version
BCY71			45							420	10	
BCY72			25							420	10	
BCY78	p-n-p	TO-18	32	200	345	45	80-1000	10	180	800	10	amplifying and switching
BCY79			45							800	10	
BFT44	p-n-p	TO-39	300	500	5000	50**	50-150	10	70	125	500	
BFT45			250							125	500	
BFX34	n-p-n	TO-39	60	2000	5000	25**	40-150	2000	> 70	1200	5000	inverter and switching regulators
BFY50	n-p-n	TO-39	35	1000	5000	50**	typ. 112	150	140	360	150	general purpose
BFY51			30				typ. 123		160			
BFY52			20				typ. 142		185			
BSR50			45*									
BSR51	n-p-n	TO-92 var.	60*	1000	800	25	> 2000	500	1500	500	Darlington transistors	
BSR52			80*							500		
BSR60			45*									
BSR61	p-n-p	TO-92 var.	60*	1000	800	25	> 2000	500	1500	500	Darlington transistors	
BSR62			80*							500		
BSS38			n-p-n							TO-92 var.		100
BSS50	n-p-n	TO-39	45*	1000	5000	25**	> 2000	500	1000	500	Darlington transistors	
BSS51			60*							500		
BSS52			80*							500		
BSS60	p-n-p	TO-39	45*	1000	5000	25**	> 2000	500	1500	500	Darlington transistors	
BSS61			60*							500		
BSS62			80*							500		
BSS68	p-n-p	TO-92 var.	100	100	500	25	> 30	25	> 50			general purpose

\*V<sub>CE0</sub>. \*\*T<sub>case</sub>.

Transistors for switching applications

type number	polarity	envelope	RATINGS				CHARACTERISTICS					remarks
			V <sub>CEO</sub> (V <sub>CER</sub> ) V	I <sub>C</sub> mA	P <sub>tot</sub> at T <sub>amb</sub> mW °C	h <sub>FE</sub> at	I <sub>C</sub> mA	f <sub>T</sub> MHz typ.	t <sub>off</sub> at I <sub>C</sub> ns max.	I <sub>C</sub> mA		
BSV15			40									
BSV16	p-n-p	TO-39	60	1000	5000	25*	40-250	100	> 50	650	100	general purpose
BSV17			80									
BSV64	n-p-n	TO-39	60	2000	5000	50*	> 40	2000	100	1200	5000	high-current saturation characteristics
BSW66A			100									
BSW67A	n-p-n	TO-39	120	1000	5000	25*	> 30	500	130	900	500	general purpose
BSW68A			150									
BSX19			15	500**	360	25	20-60		> 400	15		
BSX20	n-p-n	TO-18					40-120	10	> 500	18	10	high-speed saturated switching and h.f. amplifier applications
BSX45			40				40-250					
BSX46	n-p-n	TO-39	60	1000	6250	25*	40-250	100	> 50	850	100	general purpose
BSX47			80				40-160					
BSX59			45						450	60		
BSX60	n-p-n	TO-39	30	1000	800	25	30-90	500	475	70	500	very high speed core-driving purposes
BSX61			45						475	100		
PH2222;R			30						> 250			
PH2222A;R	n-p-n	TO-92 var.	40	800	625	25	> 75	10	> 300	285	150	
PH2369	n-p-n	TO-92 var.	15	500**	500	25	40-120	10	> 500	18	10	
PH2907;R			40									
PH2907A;R	p-n-p	TO-92 var.	60	600	625	25	100-300	150	> 200	100	150	
2N1613	n-p-n	TO-39	(50)	500**	800	25	40-120	150	> 60			d.c. and high-speed amplifiers
2N1711	n-p-n	TO-39	(50)	1000**	800	25	100-300	150	> 70			
2N1893	n-p-n	TO-39	80	500	3000	25*	40-120	150	> 50			
2N2218			30									
2N2218A	n-p-n	TO-39	40	800	800	25	40-120	150	> 250	285	150	high-speed switching
2N2219			30									
2N2219A	n-p-n	TO-39	40	800	800	25	100-300	150	> 250 > 300	285	150	high-speed switching

\* T<sub>case</sub>

\*\* I<sub>CM</sub>

## Transistors for switching applications

type number	polarity	envelope	RATINGS				CHARACTERISTICS					remarks
			V <sub>CEO</sub> (V <sub>CER</sub> ) V	I <sub>C</sub> mA	P <sub>tot</sub> at mW	T <sub>amb</sub> (T <sub>case</sub> ) °C	h <sub>FE</sub> at	I <sub>C</sub> mA	f <sub>T</sub> MHz typ.	t <sub>off</sub> at ns max.	I <sub>C</sub> mA	
2N2221	n-p-n	TO-18	30	800	500	25	40-120	150	250	285	150	high-speed switching
2N2221A			40									
2N2222	n-p-n	TO-18	30	800	500	25	100-300	150	250	285	150	high-speed switching
2N2222A			40									
2N2368	n-p-n	TO-18	15	500*	360	25	20-60	10	> 400	15	10	very high speed saturated switching
2N2369			40-120				10	> 500	18	10		
2N2369A	n-p-n	TO-18	15	200	360	25	> 40	10	> 500	18	10	very high speed saturated switching
2N2904	p-n-p	TO-39	40	600	600	25	40-120	150	> 200	100	150	high-speed switching and driver applications
2N2904A			60									
2N2905	p-n-p	TO-39	40	600	600	25	100-300	150	> 200	100	150	high-speed switching and driver applications
2N2905A			60									
2N2906	p-n-p	TO-18	40	600	400	25	40-120	150	> 200	100	150	high-speed switching and driver applications
2N2906A			60									
2N2907	p-n-p	TO-18	40	600	400	25	100-300	150	> 200	100	150	high-speed switching and driver applications
2N2907A			60									
2N3019	n-p-n	TO-39	80	1000	800	25	100-300	150	> 100			amplifiers and medium-speed switching
2N3020			40-120				150	> 80				
2N3053	n-p-n	TO-39	40	700	5000	(25)	50-250	150	> 100	-	-	medium-speed switching
2N3903	n-p-n	TO-92	40	200	350	25	50-150	10	> 250	225	10	high-speed saturated switching
2N3904			100-300				10	> 300	250	10		
2N3905	p-n-p	TO-92	40	200	350	25	50-150	10	> 200	260	10	
2N3906			100-300				10	> 250	300	10		
2N4030	p-n-p	TO-39	60	1000	800	25	> 25	500	> 100	400	500	large signal, low-noise, low-power
2N4031			> 25				500	> 100				
2N4032			> 70				500	> 150				
2N4033			> 70				500	> 150				
2N5415	p-n-p	TO-39	200	1000	1000	50	30-150	50	> 15	850**	50	high-voltage general purpose amplifier applications
2N5416			300				30-120	50				

\* I<sub>CM</sub>.

\*\* Typical value.

## P-N-P-N DEVICES

### Programmable unijunction transistors

type number	envelope	RATINGS				CHARACTERISTICS				remarks
		$V_{GA}$ V	$I_A$ mA	$I_{ARM}$ A	$dI_A/dt$ A/ $\mu$ s	$I_p$ $\mu$ A max.	$I_V$ $\mu$ A min.	$t_r$ ns max.		
BRY39	TO-72	70	175	2,5	20	5	25	80	characteristics measured with $R_G = 10\text{ k}\Omega$	
BRY56	TO-92 var.	70	175	2,5	20	5	2	80	characteristics measured with $R_G = 10\text{ k}\Omega$	

### Silicon controlled switches

type number	envelope	RATINGS				CHARACTERISTICS				remarks	
		$V_{CBO}$ V	$I_E$ mA	$I_{ERM}$ A	$P_{tot}$ at $T_{amb}$ mW $^{\circ}$ C	$V_{AK}$ V max.	$I_H$ mA max.	$t_{on}$ $\mu$ s max.	$t_q$ $\mu$ s max.		
BR101	TO-72	50	175	2,5	275	25	1,4	1,0	—	—	characteristics measured with $R_{KG-K} = 10\text{ k}\Omega$
BRY39	TO-72	70	175	2,5	275	25	1,4	1,0	1,5	8	characteristics measured with $R_{KG-K} = 10\text{ k}\Omega$

### Thyristor tetrode

type number	envelope	RATINGS				CHARACTERISTICS at $T_j = 25\text{ }^{\circ}\text{C}$					remarks
		$I_T$ mA	$I_{TRM}$ A	$I_{TSM}$ A	$dI_T/dt$ A/ $\mu$ s	$V_{GKT}$ V min.	$I_{GKT}$ $\mu$ A min.	$V_{GAT}$ V min.	$I_{GAT}$ $\mu$ A min.	$t_q$ $\mu$ s max.	
BRY39	TO-72	250	2,5	3	20	0,5	1	-1	-100	3	$V_{RRMmax} = 70\text{ V}$



100-100-100  
100-100-100  
100-100-100  
100-100-100  
100-100-100  
100-100-100

TYPE NUMBER SURVEY



# TYPE NUMBER SURVEY

In this alphanumeric list we present all small-signal transistors mentioned in this handbook.

type number	polarity	envelope	V <sub>CEO</sub> V	I <sub>C</sub> mA	type number	polarity	envelope	V <sub>CEO</sub> V	I <sub>C</sub> mA
BC107	n-p-n	TO-18	45	100	BCY57	n-p-n	TO-18	20	100
BC108	n-p-n	TO-18	20	100	BCY58	n-p-n	TO-18	32	200
BC109	n-p-n	TO-18	20	100	BCY59	n-p-n	TO-18	45	200
BC146	n-p-n	SOT-42	20	50	BCY70	p-n-p	TO-18	40	200
BC177	p-n-p	TO-18	45	100	BCY71	p-n-p	TO-18	45	200
BC178	p-n-p	TO-18	25	100	BCY72	p-n-p	TO-18	25	200
BC179	p-n-p	TO-18	20	100	BCY78	p-n-p	TO-18	32	200
BC200	p-n-p	SOT-42	20	50	BCY79	p-n-p	TO-18	45	200
BC327	p-n-p	TO-92 var.	45	500	BCY87	n-p-n	TO-71	40	30
BC327A	p-n-p	TO-92 var.	60	500	BCY88	n-p-n	TO-71	40	30
BC328	p-n-p	TO-92 var.	25	500	BCY89	n-p-n	TO-71	40	30
BC337	n-p-n	TO-92 var.	45	500	BF180	n-p-n	TO-72	20	20
BC337A	n-p-n	TO-92 var.	60	500	BF181	n-p-n	TO-72	20	20
BC338	n-p-n	TO-92 var.	25	500	BF182	n-p-n	TO-72	20	15
BC368	n-p-n	TO-92 var.	20	1000	BF183	n-p-n	TO-72	20	15
BC369	p-n-p	TO-92 var.	20	1000	BF197	n-p-n	SOT-25	25	25
BC375	n-p-n	TO-92 var.	20	1000	BF198	n-p-n	TO-92 var.	30	25
BC376	p-n-p	TO-92 var.	20	1000	BF199	n-p-n	TO-92 var.	25	25
BC546	n-p-n	TO-92 var.	65	100	BF200	n-p-n	TO-72	20	20
BC547	n-p-n	TO-92 var.	45	100	BF240	n-p-n	TO-92 var.	40	25
BC548	n-p-n	TO-92 var.	30	100	BF241	n-p-n	TO-92 var.	40	25
BC549	n-p-n	TO-92 var.	30	100	BF324	p-n-p	TO-92 var.	30	25
BC550	n-p-n	TO-92 var.	45	100	BF370	n-p-n	TO-92 var.	15	100
BC556	p-n-p	TO-92 var.	65	100	BF422	n-p-n	TO-92 var.	250	50
BC557	p-n-p	TO-92 var.	45	100	BF423	p-n-p	TO-92 var.	250	50
BC558	p-n-p	TO-92 var.	30	100	BF450	p-n-p	TO-92 var.	40	25
BC559	p-n-p	TO-92 var.	30	100	BF451	p-n-p	TO-92 var.	40	25
BC560	p-n-p	TO-92 var.	45	100	BF480	n-p-n	SOT-37	15	20
BC635	n-p-n	TO-92 var.	45	1000	BF494	n-p-n	TO-92 var.	20	30
BC636	p-n-p	TO-92 var.	45	1000	BF495	n-p-n	TO-92 var.	20	30
BC637	n-p-n	TO-92 var.	60	1000	BF496	n-p-n	TO-92 var.	20	20
BC638	p-n-p	TO-92 var.	60	1000	BF926	p-n-p	TO-92 var.	20	25
BC639	n-p-n	TO-92 var.	80	1000	BF936	p-n-p	TO-92 var.	20	25
BC640	p-n-p	TO-92 var.	80	1000	BF939	p-n-p	TO-92 var.	25	20
BCY56	n-p-n	TO-18	45	100	BF967	p-n-p	SOT-37	30	20

# TYPE NUMBER SURVEY

type number	polarity	envelope	V <sub>CEO</sub> V	I <sub>C</sub> mA	type number	polarity	envelope	V <sub>CEO</sub> V	I <sub>C</sub> mA
BF970	p-n-p	SOT-37	35	30	BSX47	n-p-n	TO-39	80	1000
BF979	p-n-p	SOT-37	30	30*	BSX59	n-p-n	TO-39	45	1000
BFR54	n-p-n	TO-92 var.	15	500*	BSX60	n-p-n	TO-39	30	1000
BFT44	p-n-p	TO-39	300	500	BSX61	n-p-n	TO-39	45	1000
BFT45	p-n-p	TO-39	250	500	BSY95A	n-p-n	TO-18	15	100
BFX29	p-n-p	TO-39	60	600	PH2222;R	n-p-n	TO-92 var.	30	800
BFX30	p-n-p	TO-39	65	600	PH2222A	n-p-n	TO-92 var.	40	800
BFX34	n-p-n	TO-39	60	2000	PH2222AR	n-p-n	TO-92 var.	40	800
BFX84	n-p-n	TO-39	60	1000	PH2369	n-p-n	TO-92 var.	15	500*
BFX85	n-p-n	TO-39	60	1000	PH2907;R	p-n-p	TO-92 var.	40	600
BFX86	n-p-n	TO-39	35	1000	PH2907A	p-n-p	TO-92 var.	60	600
BFX87	p-n-p	TO-39	50	600	PH2907AR	p-n-p	TO-92 var.	60	600
BFX88	p-n-p	TO-39	40	600	2N929	n-p-n	TO-18	45	30
BFY50	n-p-n	TO-39	35	1000	2N930	n-p-n	TO-18	45	30
BFY51	n-p-n	TO-39	30	1000	2N1613	n-p-n	TO-39	50**	1000*
BFY52	n-p-n	TO-39	20	1000	2N1711	n-p-n	TO-39	50**	1000
BFY55	n-p-n	TO-39	35	1000	2N1893	n-p-n	TO-39	80	500
BR101	p-n-p-n	TO-72	50	175	2N2218	n-p-n	TO-39	30	800
BRY39	p-n-p-n	TO-72	70	175	2N2218A	n-p-n	TO-39	40	800
BRY56	p-n-p-n	TO-92 var.	70	175	2N2219	n-p-n	TO-39	30	800
BSR50	n-p-n	TO-92 var.	45**	1000	2N2219A	n-p-n	TO-39	40	800
BSR51	n-p-n	TO-92 var.	60**	1000	2N2221	n-p-n	TO-18	30	800
BSR52	n-p-n	TO-92 var.	80**	1000	2N2221A	n-p-n	TO-18	40	800
BSR60	p-n-p	TO-92 var.	45**	1000	2N2222	n-p-n	TO-18	30	800
BSR61	p-n-p	TO-92 var.	60**	1000	2N2222A	n-p-n	TO-18	40	800
BSR62	p-n-p	TO-92 var.	80**	1000	2N2297	n-p-n	TO-39	35	1000
BSS38	n-p-n	TO-92 var.	100	100	2N2368	n-p-n	TO-18	15	500*
BSS50	n-p-n	TO-39	45**	1000	2N2369	n-p-n	TO-18	15	500*
BSS51	n-p-n	TO-39	60**	1000	2N2369A	n-p-n	TO-18	15	200
BSS52	n-p-n	TO-39	80**	1000	2N2483	n-p-n	TO-18	60	50*
BSS60	p-n-p	TO-39	45**	1000	2N2484	n-p-n	TO-18	60	50*
BSS61	p-n-p	TO-39	60**	1000	2N2904	p-n-p	TO-39	40	600
BSS62	p-n-p	TO-39	80**	1000	2N2904A	p-n-p	TO-39	60	600
BSS68	p-n-p	TO-92 var.	100	100	2N2905	p-n-p	TO-39	40	600
BSV15	p-n-p	TO-39	40	1000	2N2905A	p-n-p	TO-39	60	600
BSV16	p-n-p	TO-39	60	1000	2N2906	p-n-p	TO-18	40	600
BSV17	p-n-p	TO-39	80	1000	2N2906A	p-n-p	TO-18	60	600
BSV64	n-p-n	TO-39	60	2000	2N2907	p-n-p	TO-18	40	600
BSW66A	n-p-n	TO-39	100	1000	2N2907A	p-n-p	TO-18	60	600
BSW67A	n-p-n	TO-39	120	1000	2N3019	n-p-n	TO-39	80	1000
BSW68A	n-p-n	TO-39	150	1000	2N3020	n-p-n	TO-39	80	1000
BSX19	n-p-n	TO-18	15	500*	2N3053	n-p-n	TO-39	40	700
BSX20	n-p-n	TO-18	15	500*	2N3903	n-p-n	TO-92	40	200
BSX45	n-p-n	TO-39	40	1000	2N3904	n-p-n	TO-92	40	200
BSX46	n-p-n	TO-39	60	1000	2N3905	p-n-p	TO-92	40	200

\* I<sub>CM</sub>.  
\*\* V<sub>CER</sub>.



# TYPE NUMBER SURVEY

type number	polarity	envelope	V <sub>CEO</sub> V	I <sub>C</sub> mA
2N3906	p-n-p	TO-92	40	200
2N4030	p-n-p	TO-39	60	1000
2N4031	p-n-p	TO-39	80	1000
2N4032	p-n-p	TO-39	60	1000
2N4033	p-n-p	TO-39	80	1000
2N4123	n-p-n	TO-92	30	200
2N4124	n-p-n	TO-92	25	200
2N4125	p-n-p	TO-92	30	200
2N4126	p-n-p	TO-92	25	200
2N5415	p-n-p	TO-39	200	1000
2N5416	p-n-p	TO-39	300	1000



CECC  
APPROVED TYPES



Products approved to CECC, available on request.

Type	CECC number	Type	CECC number
BC107	50 002-076	BSW66A	50 004-040
BC108	077	BSW67A	
BC109	078	BSW68A	
BCY56	50 002-164	BSX45	50 002-174
BCY57		BSX46	
BCY58	50 002-030	BSX47	
BCY59	031	2N1613	50 002-104
BCY70	50 002-079	2N1711	50 002-104
BCY71	080	2N1893	50 002-104
BCY72	081	2N2218	50 004-29
BF967	50 002-127	2N2218A	
BFX29	50 002-071	2N2219	50 004-029
BFX87		2N2219A	
BFX88		2N2221	
BFX30	50 004-083	2N2221A	50 004-030
BFX34	50 004-025	2N2222	50 004-030
BFX84	50 004-100	2N2222A	
BFX85		2N2904	50 002-102
BFX86		2N2904A	
BFY50	50 002-089	2N2905	50 002-102
BFY51		2N2905A	
BFY52		2N2906	
BSS50	50 004-073	2N2906A	50 002-103
BSS51		2N2907	50 002-103
BSS52		2N2907A	
BSS60	50 004-074	2N3019	50 002-175
BSS61		2N3020	
BSS62		2N4030	
BSV15	50 002-131	2N4031	50 002-131
BSV16		2N4032	
BSV17		2N4033	
BSV64	50 004-008	2N4033	50 002-131
			50 004-043



GENERAL

Type designation  
Rating systems  
Letter symbols  
SOAR curves  
s-parameters





PRO ELECTRON TYPE DESIGNATION CODE  
FOR SEMICONDUCTOR DEVICES

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

A basic type number consists of:

*TWO LETTERS FOLLOWED BY A SERIAL NUMBER*

**FIRST LETTER**

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

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

**SECOND LETTER**

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

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

# TYPE DESIGNATION

## SERIAL NUMBER

Three figures, running from 100 to 999, for devices primarily intended for consumer equipment. One letter (Z, Y, X, etc.) and two figures, running from 10 to 99, for devices primarily intended for industrial/professional equipment.

This letter has no fixed meaning except W, which is used for transient suppressor diodes.

## VERSION LETTER

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

## SUFFIX

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

### 1. VOLTAGE REFERENCE and VOLTAGE REGULATOR DIODES: *ONE LETTER and ONE NUMBER*

The LETTER indicates the nominal tolerance of the Zener (regulation, working or reference) voltage

A. 1% (according to IEC 63: series E96)

B. 2% (according to IEC 63: series E48)

C. 5% (according to IEC 63: series E24)

D. 10% (according to IEC 63: series E12)

E. 20% (according to IEC 63: series E6)

The number denotes the typical operating (Zener) voltage related to the nominal current rating for the whole range.

The letter 'V' is used instead of the decimal point.

### 2. TRANSIENT SUPPRESSOR DIODES: *ONE NUMBER*

The NUMBER indicates the maximum recommended continuous reversed (stand-off) voltage  $V_R$ . The letter 'V' is used as above.

### 3. CONVENTIONAL and CONTROLLED AVALANCHE RECTIFIER DIODES and THYRISTORS: *ONE NUMBER*

The NUMBER indicates the rated maximum repetitive peak reverse voltage ( $V_{RRM}$ ) or the rated repetitive peak off-state voltage ( $V_{DRM}$ ), whichever is the lower. Reversed polarity is indicated by letter R, immediately after the number.

### 4. RADIATION DETECTORS: *ONE NUMBER*, preceded by a hyphen (-)

The NUMBER indicates the depletion layer in  $\mu\text{m}$ . The resolution is indicated by a version LETTER.

### 5. ARRAY OF RADIATION DETECTORS and GENERATORS: *ONE NUMBER*, preceded by a stroke (/).

The NUMBER indicates how many basic devices are assembled into the array.

## 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

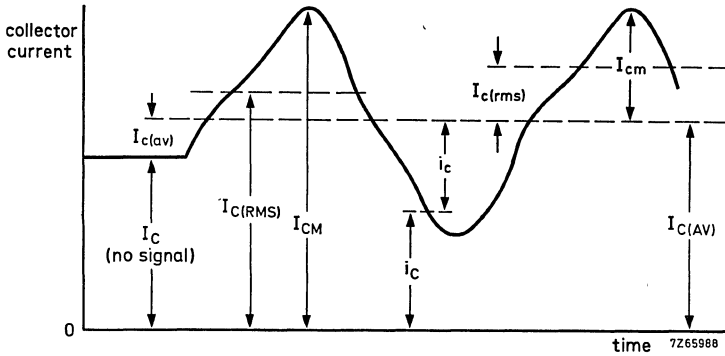
For multiple unit devices, the subscripts are modified by a number preceding the letter subscript; in the case of multiple subscripts, hyphens may be necessary to avoid misunderstanding.

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  $T_{j max}$ .

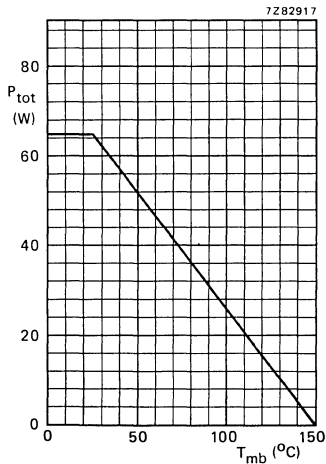
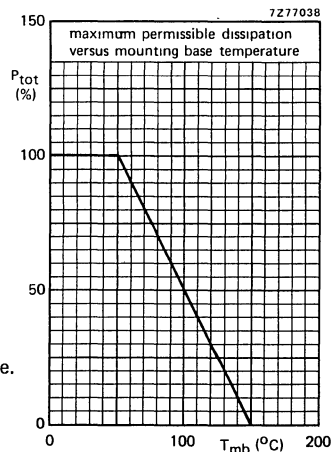


Fig. 1 Power derating curve.



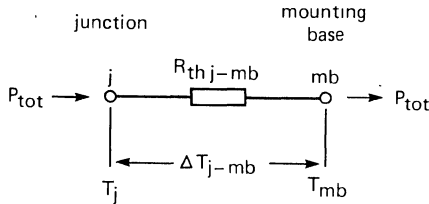


Total power dissipation is given by

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

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

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)

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

There are two limitations to  $P_{\text{tot}}$

– When  $T_{\text{mb}} \leq T_{\text{mb spec}}$

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

– when  $T_{\text{mb}} > T_{\text{mb spec}}$

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

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

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

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.

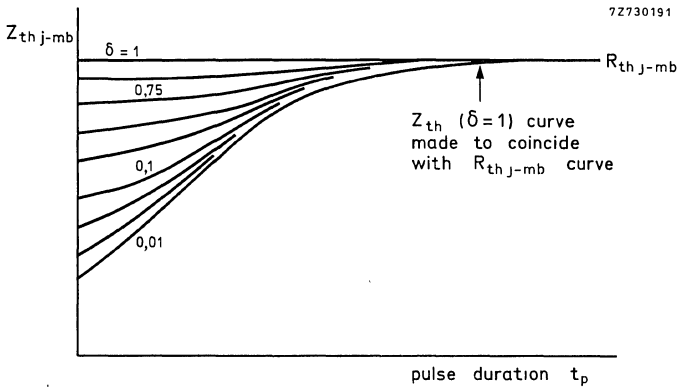


Fig. 3 A typical family of  $Z_{\text{th j-mb}}$  curves for a power transistor.

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

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

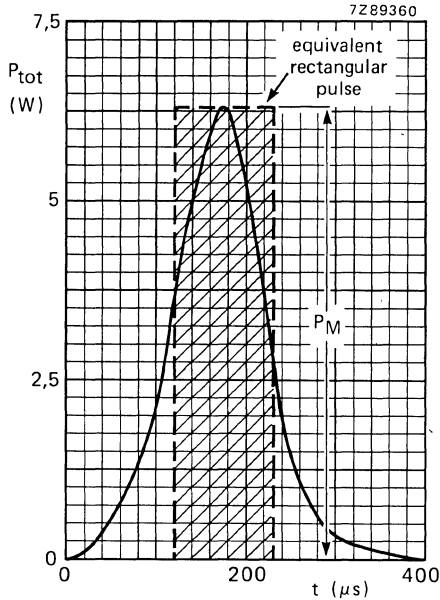


Fig. 4.

### 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  $T_{mb\text{spec}}$ ,  $P_{tot\text{max}}$  must be reduced (as shown by the broken line in Fig. 5), so that the boundary of maximum power dissipation intersects the second breakdown boundary at a lower point. With high values of  $T_{mb}$ , the second breakdown boundary may be excluded altogether.

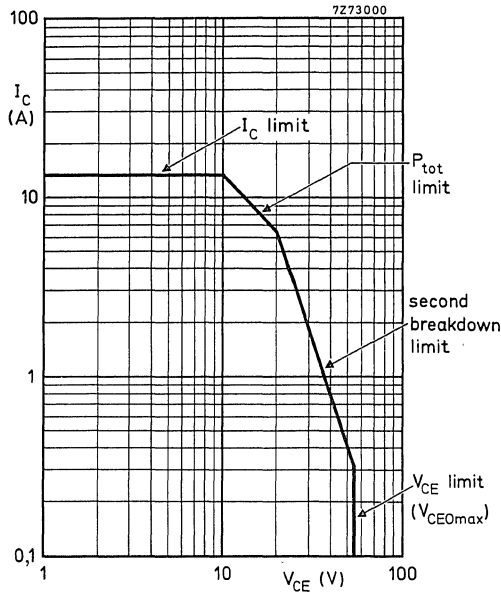


Fig. 5 A typical SOAR graph with boundaries named.

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

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

**$I_{CMmax}$**

The extent to which the  $I_C$  boundary can be extended for pulse operation depends on pulse duration and duty factor, the limit being  $I_{CMmax}$ , which applies at a duty factor of 0,01 and a pulse length of 20 ms or less. Together the  $I_{CMmax}$  and  $V_{CE0max}$  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  $V_{CE0max}$  of 60 V.

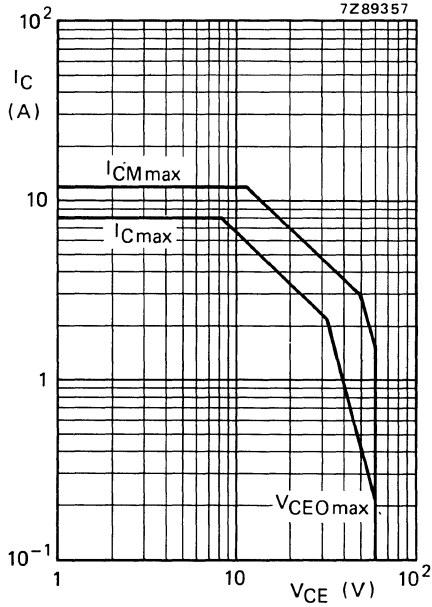


Fig. 6 Maximum collector current and collector-emitter voltage boundaries.

**P<sub>tot max</sub>**

The P<sub>tot max</sub> boundary given in the data sheet usually applies to:

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

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

From

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

T<sub>j max</sub> is stated in the data sheets; Z<sub>th j-mb</sub> can be read from the curve, similar to Fig. 3, also given in the data sheets. Thus P<sub>tot Mmax</sub> can be calculated and an appropriate boundary can be drawn in the SOAR curve parallel to the P<sub>tot max</sub> line. An example will illustrate this. Assume:

$$T_{jmax} = 150 \text{ }^\circ\text{C}; T_{mb spec} = 25 \text{ }^\circ\text{C}; t_p = 0,2 \text{ ms and } \delta = 0,1.$$

From Fig. 7, Z<sub>th j-mb</sub> = 0,42 K/W for the given values of t<sub>p</sub> and δ.

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

Thus from an arbitrary point (say 8,3 A, 20 V) we can draw a line parallel to the P<sub>tot max</sub> line (see Fig. 6).

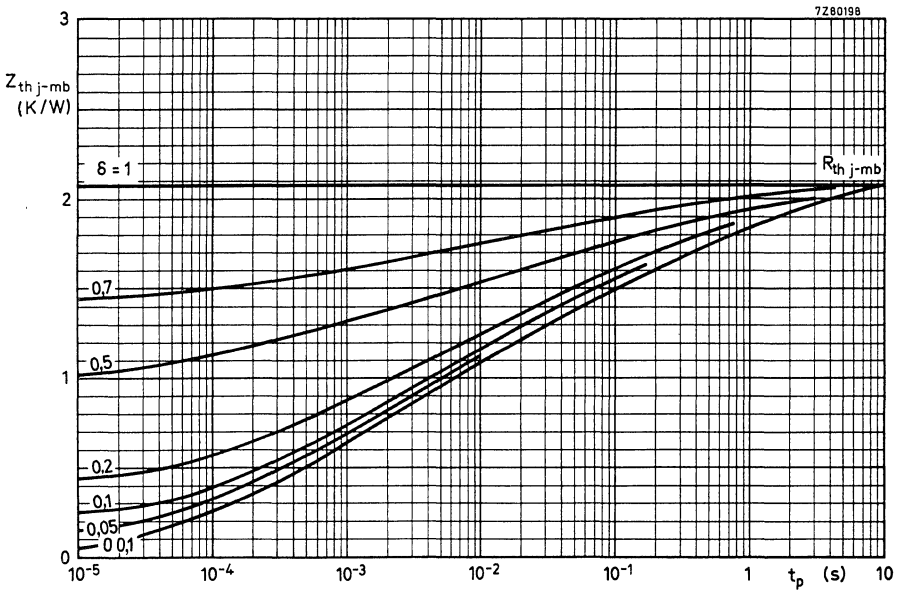


Fig. 7 Transient thermal impedance for example.

**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).

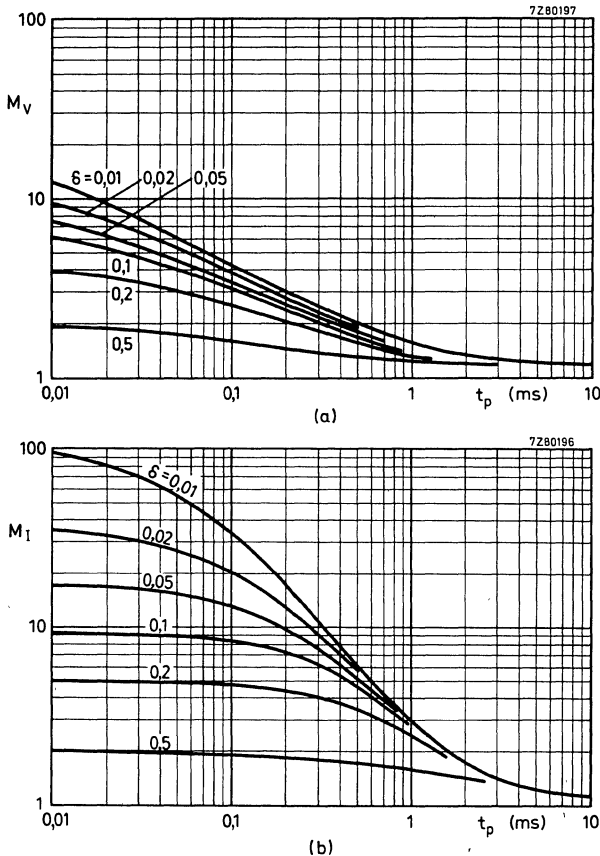


Fig. 8 Second breakdown multiplying factors as a function of pulse time, with duty factor as a parameter.

$M_V$  is used to calculate the point on the  $V_{CE0max}$  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

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

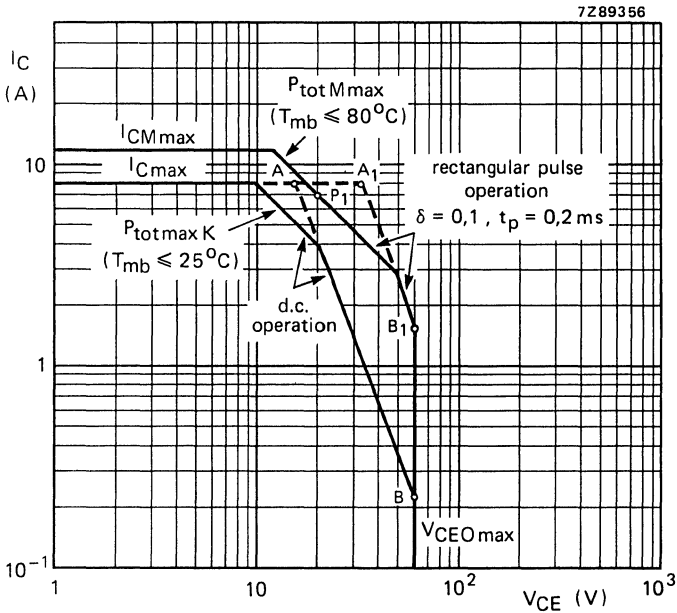


Fig. 9 Construction of the pulse operating area.

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  $M_I = 7,3$ :

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

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

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.

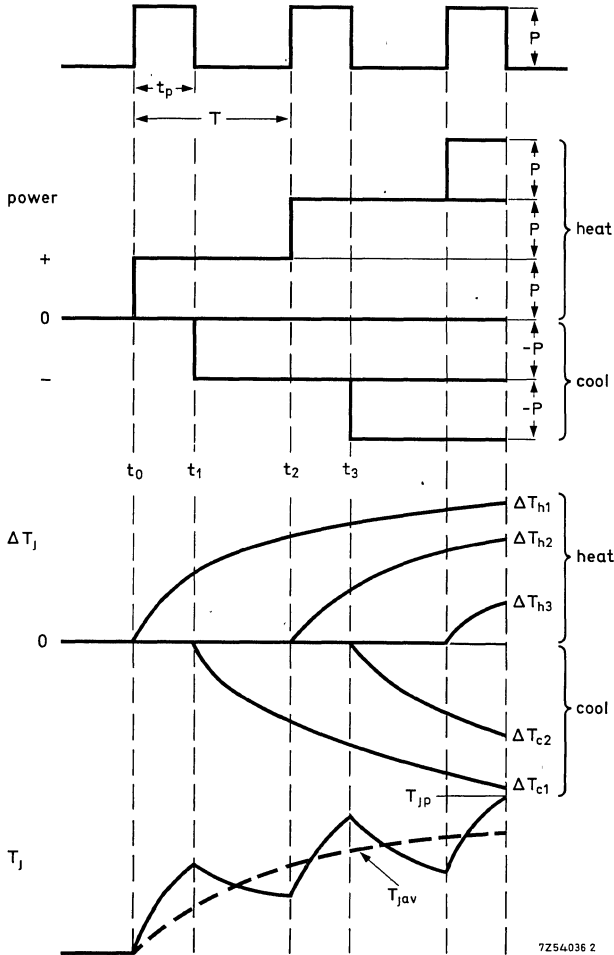


Fig. 10 The heating effect of three equidistant, equal-magnitude pulses.  $T_{J\text{av}}$  is the average junction temperature.  $P = 100\text{ W}$ ,  $t_p = 100\ \mu\text{s}$ ;  $T = 1\ \text{ms}$  and  $\delta = 0,1$ .

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

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

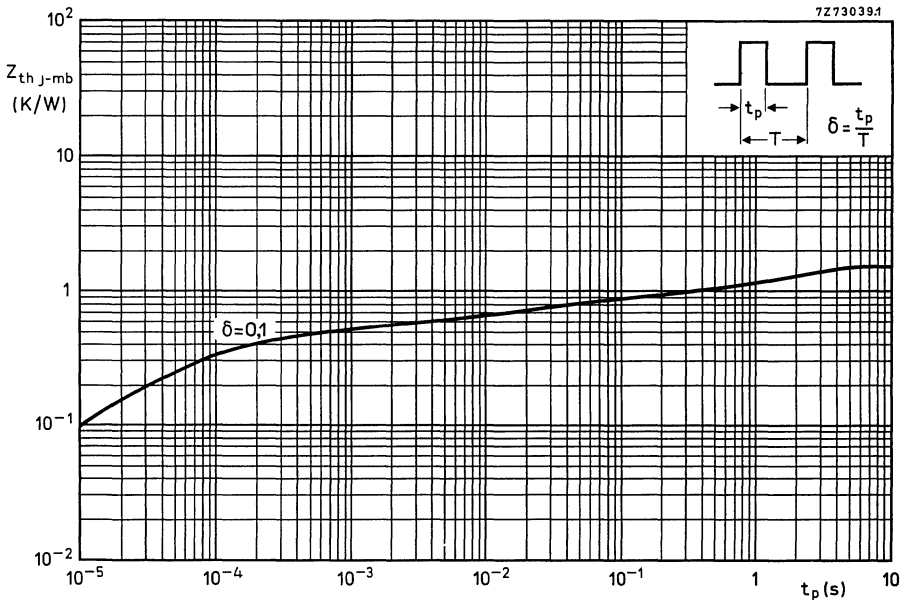


Fig. 11 Curve of  $Z_{th\ j-mb} = f(t_p)$ .

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

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

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

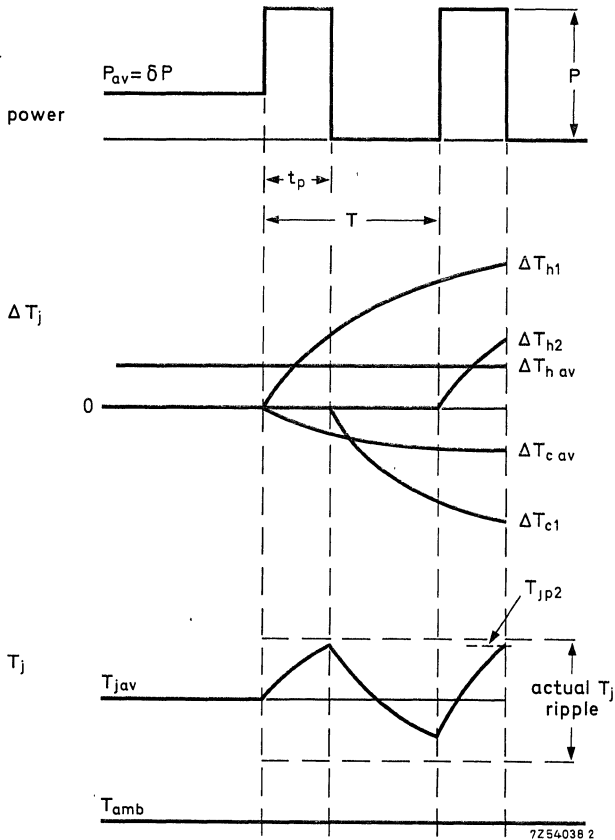


Fig. 12.

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

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

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.

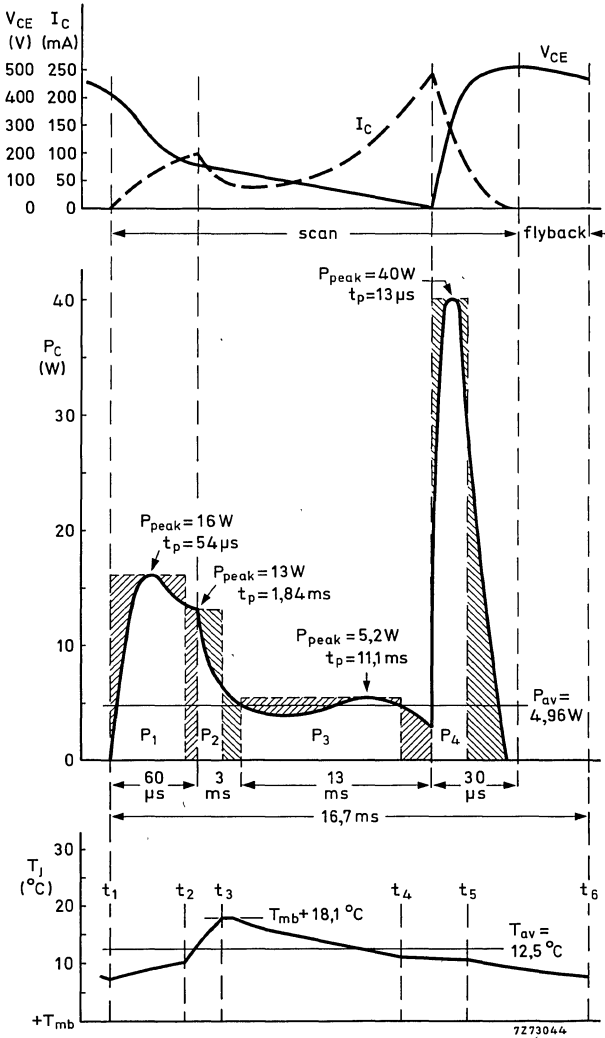


Fig. 13 Power waveforms showing their division into rectangular pulses and the junction temperature variations which they cause.

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

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

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

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

For  $t_3$  yet another two terms:

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

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

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

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

## 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.

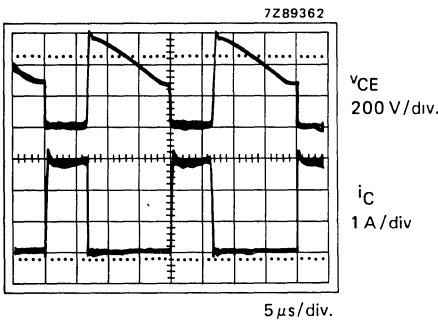


Fig. 14 Collector-current and collector-emitter voltage waveforms of a BU426A transistor in a 200 W SMPS.

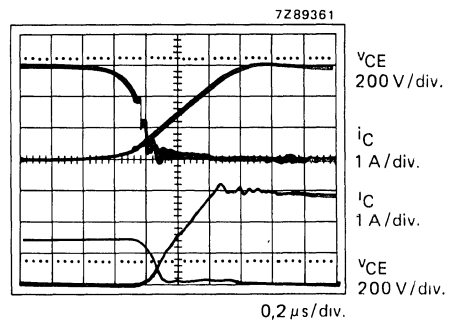


Fig. 15 Waveforms during turn-on and turn-off (lower part).

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:

$P_{turn-on} = 66\text{ W}$   
 $t_{pon} = 0,8\ \mu\text{s}$   
 $\delta_{on} = 0,04$

$P_{sat} = 10\text{ W}$   
 $t_{psat} = 2,2\ \mu\text{s}$   
 $\delta_{sat} = 0,11$

$P_{turn-off} = 56\text{ W}$   
 $t_{poff} = 0,6\ \mu\text{s}$   
 $\delta_{off} = 0,03$

7289363

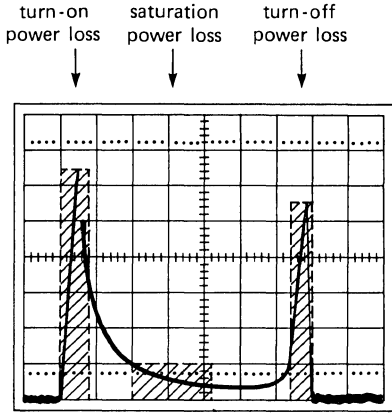


Fig. 16 Power loss and resultant rectangular power pulses.

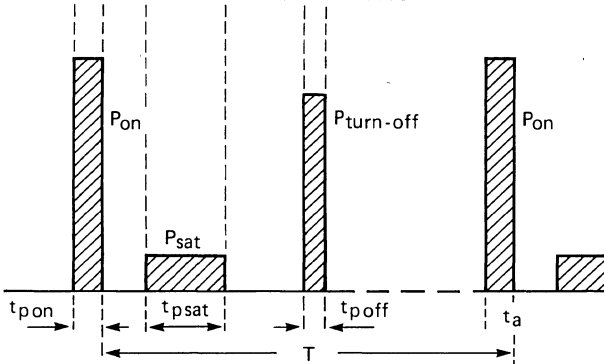


Fig. 17.

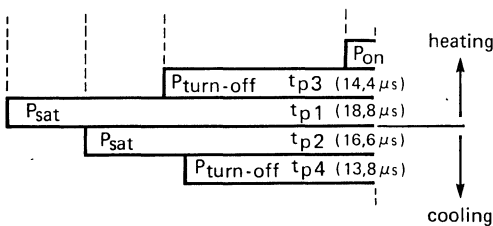


Fig. 18.

From Fig. 17 we can determine  $\delta_p$  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	$\mu s$
$\delta$	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  $\Delta T_{j-mb}$  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  $Z_{th j-mb} = 0,10 \text{ K/W}$ ;  $M_I \approx 12$ ;  $M_V \approx 7,5$ ;  $V_{CE(A')} = 7,5 \times 12 = 90 \text{ V}$ ;  $I_{C(B')} = 12 \times 40 = 480 \text{ mA}$ .

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

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

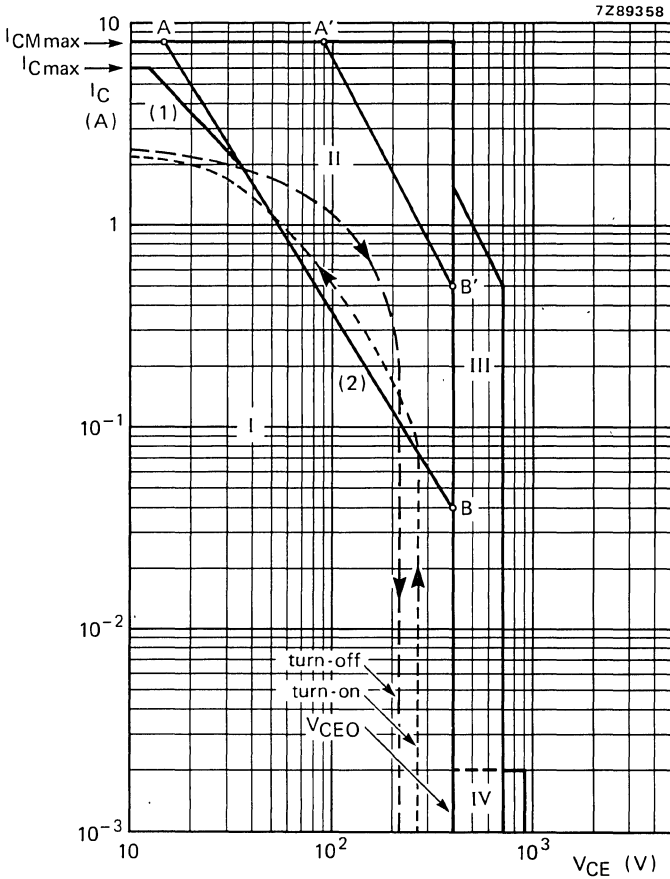


Fig. 19 Safe Operating Area BU426A at  $T_{mb} \leq 73\ ^\circ\text{C}$ .

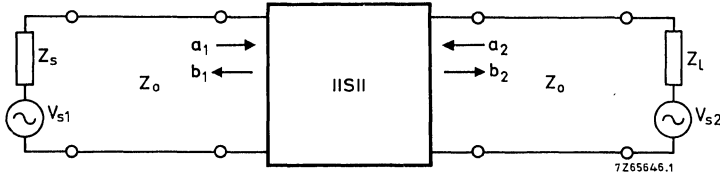
- I Region of permissible d.c. operation.
  - II Permissible extension for repetitive pulse operation.
  - III Area of permissible operation during turn-on in single-transistor converters, provided  $R_{BE} \leq 100\ \Omega$  and  $t_p \leq 0,6\ \mu\text{s}$ .
  - IV Repetitive pulse operation in this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





## SCATTERING PARAMETERS

In distinction to the conventional h, y and z-parameters, s-parameters relate to travelling wave conditions. The figure below shows a two-port network with the incident and reflected waves  $a_1$ ,  $b_1$ ,  $a_2$  and  $b_2$ .



$$a_1 = \frac{V_{i1}}{\sqrt{Z_0}}$$

$$a_2 = \frac{V_{i2}}{\sqrt{Z_0}}$$

$$b_1 = \frac{V_{r1}}{\sqrt{Z_0}}$$

$$b_2 = \frac{V_{r2}}{\sqrt{Z_0}}$$

1)

$Z_0$  = characteristic impedance of the transmission line in which the two-port is connected.

$V_i$  = incident voltage

$V_r$  = reflected (generated) voltage

The four-pole equations for s-parameters are:

$$b_1 = s_{11}a_1 + s_{12}a_2$$

$$b_2 = s_{21}a_1 + s_{22}a_2$$

Using the subscripts i for 11, r for 12, f for 21 and o for 22, it follows that:

$$s_i = s_{11} = \left. \frac{b_1}{a_1} \right|_{a_2 = 0}$$

$$s_r = s_{12} = \left. \frac{b_1}{a_2} \right|_{a_1 = 0}$$

$$s_f = s_{21} = \left. \frac{b_2}{a_1} \right|_{a_2 = 0}$$

$$s_o = s_{22} = \left. \frac{b_2}{a_2} \right|_{a_1 = 0}$$

1) The squares of these quantities have the dimension of power.

## S-PARAMETERS

The s-parameters can be named and expressed as follows:

$s_i = s_{11}$  = Input reflection coefficient.

The complex ratio of the reflected wave and the incident wave at the input, under the conditions  $Z_1 = Z_0$  and  $V_{s2} = 0$ .

$s_r = s_{12}$  = Reverse transmission coefficient.

The complex ratio of the generated wave at the input and the incident wave at the output, under the conditions  $Z_s = Z_0$  and  $V_{s1} = 0$ .

$s_f = s_{21}$  = Forward transmission coefficient.

The complex ratio of the generated wave at the output and the incident wave at the input, under the conditions  $Z_1 = Z_0$  and  $V_{s2} = 0$ .

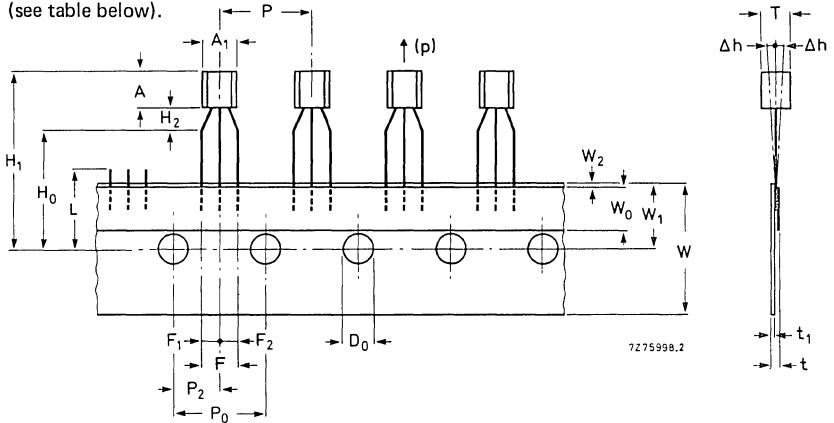
$s_o = s_{22}$  = Output reflection coefficient.

The complex ratio of the reflected wave and the incident wave at the output, under the conditions  $Z_s = Z_0$  and  $V_{s1} = 0$ .

TO-92 VARIANT TRANSISTORS ON TAPE

MECHANICAL DATA

Fig. 1 (see table below).



Dimensions in mm

Item	Symbol	Specifications				Remarks
		min.	nom.	max.	tol.	
Body width	A <sub>1</sub>	4,0		4,8		
Body height	A	4,8		5,2		
Body thickness	T	3,9		4,2		
Pitch of component	P		12,7		± 1	
Feed hole pitch	P <sub>0</sub>		12,7		± 0,3	Cumulative pitch error 1,0 mm/20 pitch
Feed hole centre to component centre	P <sub>2</sub>		6,35		± 0,4	To be measured at bottom of clinch
Distance between outer leads	F		5,08		+ 0,6 - 0,2	
Component alignment	Δh		0	1		At centre of body
Tape width	W		18		± 0,5	
Hold-down tape width	W <sub>0</sub>		6		± 0,2	
Hole position	W <sub>1</sub>		9		+ 0,7 - 0,5	
Hold-down tape position	W <sub>2</sub>		0,5		± 0,2	
Lead wire clinch height	H <sub>0</sub>		16		± 0,5	
Component height	H <sub>1</sub>			32,25		
Length of snapped leads	L			11,0		
Feed hole diameter	D <sub>0</sub>		4		± 0,2	
Total tape thickness	t			1,2		t <sub>1</sub> 0,3-0,6
Lead-to-lead distance	F <sub>1</sub> , F <sub>2</sub>		2,54		+ 0,4 - 0,1	
Clinch height	H <sub>2</sub>			3		
Pull-out force	(p)	6N				

# TAPE

## PACKING

The transistors are supplied on tape in boxes (ammopack) or on reels. The number per box or reel is 1600.

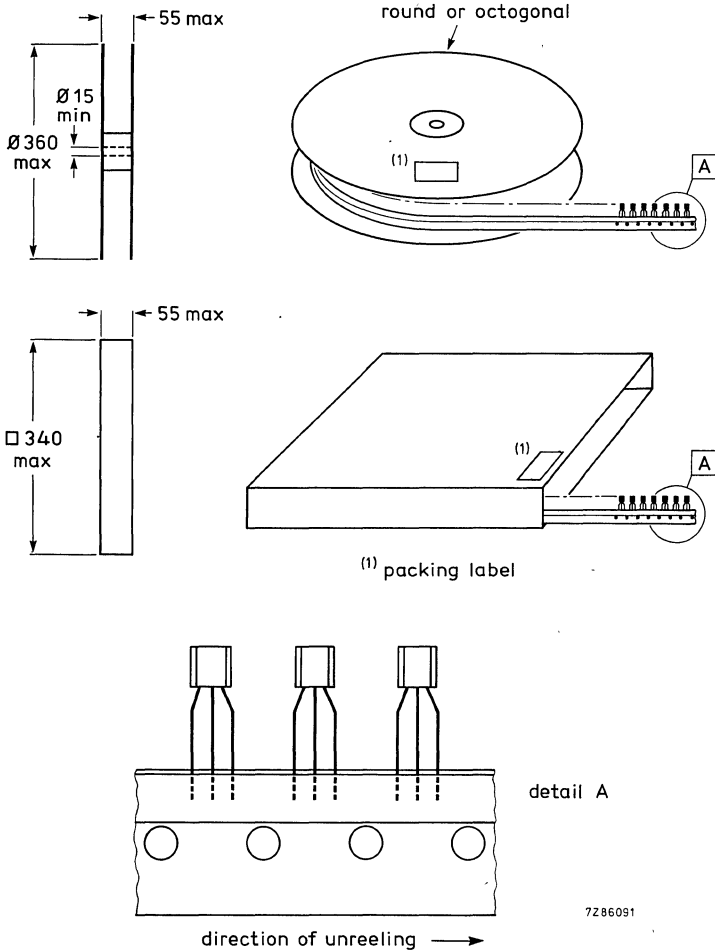


Fig. 2 Dimensions (in mm) of reel and box.

## DROPOUTS

A maximum of 0,5% of the specified number of transistors in each packing may be missing. Up to 3 consecutive components may be missing provided the gap is followed by 6 consecutive components.

## TAPE SPLICING

Slice the carrier tape on the back and/or front so that the feed hole pitch ( $P_0$ ) is maintained (see Fig. 3).

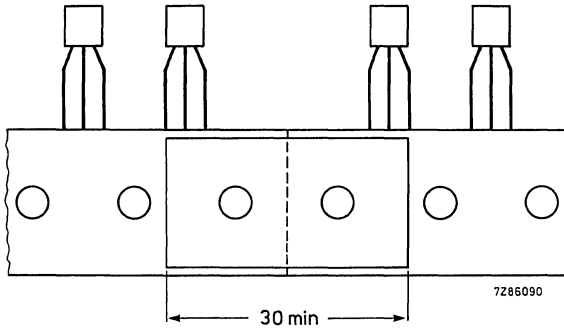


Fig. 3 Jointing tape with splicing patch.



TRANSISTOR DATA







## A.F. SILICON PLANAR EPITAXIAL TRANSISTORS



N-P-N transistors in TO-18 metal envelopes with the collector connected to the case.

The **BC107** is primarily intended for use in driver stages of audio amplifiers and in signal processing circuits of television receivers.

The **BC108** is suitable for multitude of low-voltage applications e.g. driver stages or audio preamplifiers and in signal processing circuits of television receivers.

The **BC109** is primarily intended for low-noise input stages in tape recorders, hi-fi amplifiers and other audio-frequency equipment.

## QUICK REFERENCE DATA

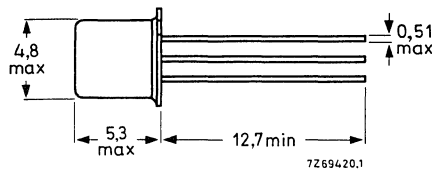
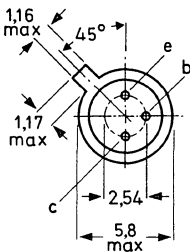
		BC107	BC108	BC109	
Collector-emitter voltage ( $V_{BE} = 0$ )	$V_{CES}$ max.	50	30	30	V
Collector-emitter voltage (open base)	$V_{CEO}$ max.	45	20	20	V
Collector current (peak value)	$I_{CM}$ max.	200	200	200	mA
Total power dissipation up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$ max.	300	300	300	mW
Junction temperature	$T_j$ max.	175	175	175	$^{\circ}\text{C}$
Small-signal current gain at $T_j = 25\text{ }^{\circ}\text{C}$ $I_C = 2\text{ mA}$ ; $V_{CE} = 5\text{ V}$ ; $f = 1\text{ kHz}$	$h_{fe}$	> 125 < 500	125 900	240 900	
Transition frequency at $f = 35\text{ MHz}$ $I_C = 10\text{ mA}$ ; $V_{CE} = 5\text{ V}$	$f_T$ typ.	300	300	300	MHz
Noise figure at $R_S = 2\text{ k}\Omega$ $I_C = 200\text{ }\mu\text{A}$ ; $V_{CE} = 5\text{ V}$ $f = 30\text{ Hz}$ to $15\text{ kHz}$	F	typ. < —	— —	1,4 4,0	dB
$f = 1\text{ kHz}$ ; $B = 200\text{ Hz}$	F	typ.	2	1,2	dB

## MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector connected  
to case



Accessories: 56246 (distance disc).

Products approved to CECC 50 002-076/078, available on request.

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

Voltages

		BC107	BC108	BC109
Collector-base voltage (open emitter)	$V_{CBO}$ max.	50	30	30 V
Collector-emitter voltage ( $V_{BE} = 0$ )	$V_{CES}$ max.	50	30	30 V
Collector-emitter voltage (open base)	$V_{CEO}$ max.	45	20	20 V
Emitter-base voltage (open collector)	$V_{EBO}$ max.	6	5	5 V

Currents

Collector current (d.c.)	$I_C$	max.	100	mA
Collector current (peak value)	$I_{CM}$	max.	200	mA
Emitter current (peak value)	$-I_{EM}$	max.	200	mA
Base current (peak value)	$I_{BM}$	max.	200	mA

Power dissipation

Total power dissipation up to $T_{amb} = 25^\circ C$	$P_{tot}$	max.	300	mW
--	-----------	------	-----	----

Temperatures

Storage temperature	$T_{stg}$	-65 to +175	$^\circ C$
Junction temperature	$T_j$	max.	175 $^\circ C$

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th\ j-a}$	=	0.5	$^\circ C/mW$
From junction to case	$R_{th\ j-c}$	=	0.2	$^\circ C/mW$

**CHARACTERISTICS**

$T_j = 25^\circ C$  unless otherwise specified

Collector cut-off current

$I_E = 0; V_{CB} = 20\ V; T_j = 150^\circ C$	$I_{CBO}$	<	15	$\mu A'$
--	-----------	---	----	----------

Base-emitter voltage<sup>1)</sup>

$I_C = 2\ mA; V_{CE} = 5\ V$	$V_{BE}$	typ.	620	mV
		550 to	700	mV
$I_C = 10\ mA; V_{CE} = 5\ V$	$V_{BE}$	<	770	mV

<sup>1)</sup>  $V_{BE}$  decreases by about 2 mV/ $^\circ C$  with increasing temperature.

**CHARACTERISTICS** (continued)

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

Saturation voltages <sup>1)</sup>

$I_C = 10\text{ mA}; I_B = 0.5\text{ mA}$

$V_{CEsat}$  typ. 90 mV  
< 250 mV

$V_{BEsat}$  typ. 700 mV

$I_C = 100\text{ mA}; I_B = 5\text{ mA}$

$V_{CEsat}$  typ. 200 mV  
< 600 mV

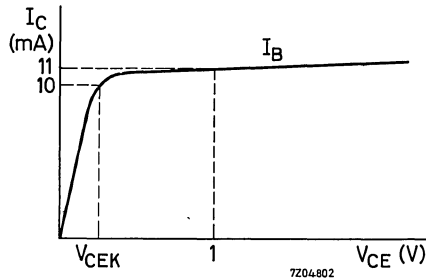
$V_{BEsat}$  typ. 900 mV

Knee voltage

$I_C = 10\text{ mA}; I_B = \text{value for which}$

$I_C = 11\text{ mA at } V_{CE} = 1\text{ V}$

$V_{CEK}$  typ. 300 mV  
< 600 mV



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

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

$C_C$  typ. 2.5 pF  
< 4.5 pF

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

$I_C = I_c = 0; V_{EB} = 0.5\text{ V}$

$C_e$  typ. 9 pF

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

$I_C = 10\text{ mA}; V_{CE} = 5\text{ V}$

$f_T$  typ. 300 MHz

Small signal current gain at  $f = 1\text{ kHz}$

$I_C = 2\text{ mA}; V_{CE} = 5\text{ V}$

		BC107	BC108	BC109
$h_{fe}$	>	125	125	240
	<	500	900	900
F	typ.			1.4 dB
	<			4 dB
F	typ.	2	2	1.2 dB
	<	10	10	4 dB

Noise figure at  $R_S = 2\text{ k}\Omega$

$I_C = 200\text{ }\mu\text{A}; V_{CE} = 5\text{ V}$

$f = 30\text{ Hz to } 15\text{ kHz}$

$f = 1\text{ kHz}; B = 200\text{ Hz}$

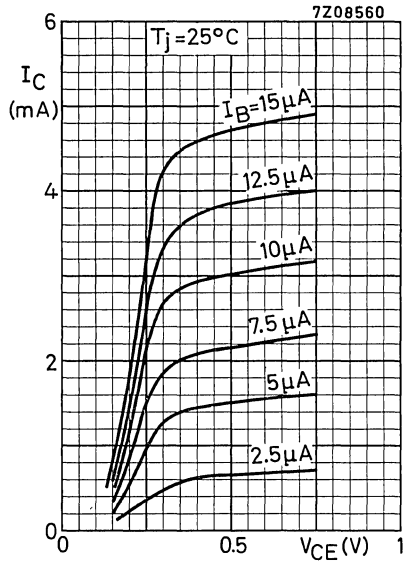
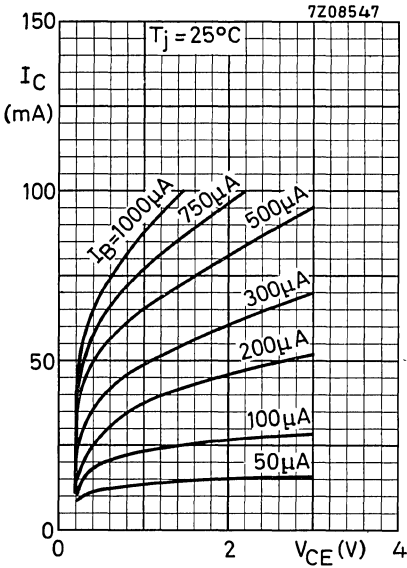
<sup>1)</sup>  $V_{BEsat}$  decreases by about 1.7 mV/ $^\circ\text{C}$  with increasing temperature.

**CHARACTERISTICS** (continued)

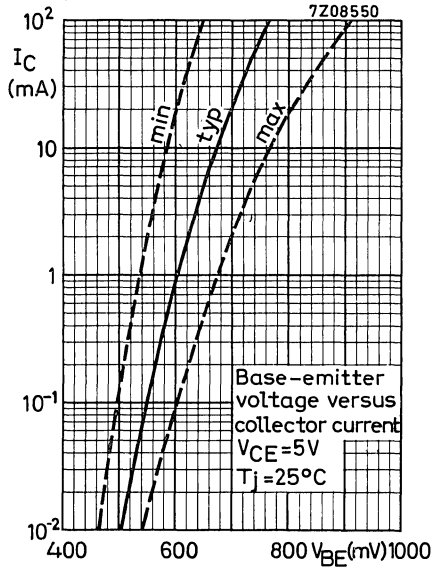
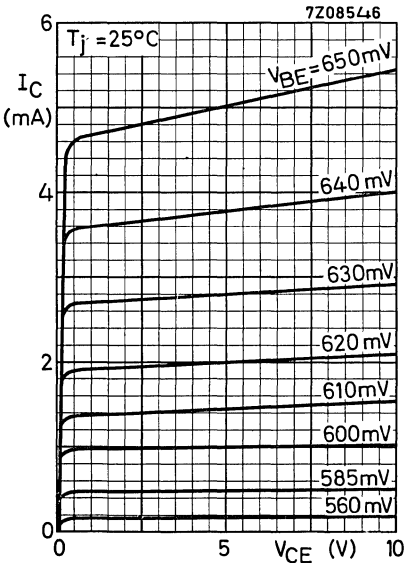
$T_j = 25\text{ }^\circ\text{C}$  unless otherwise specified

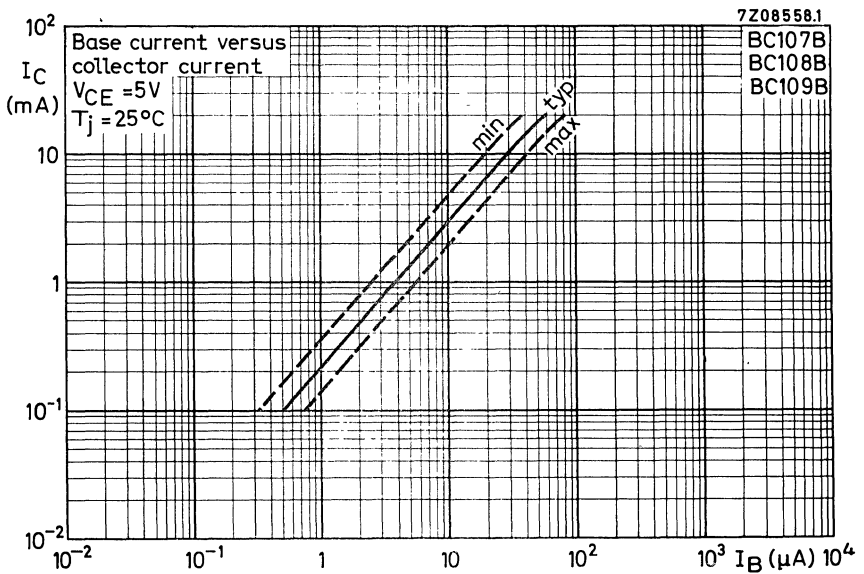
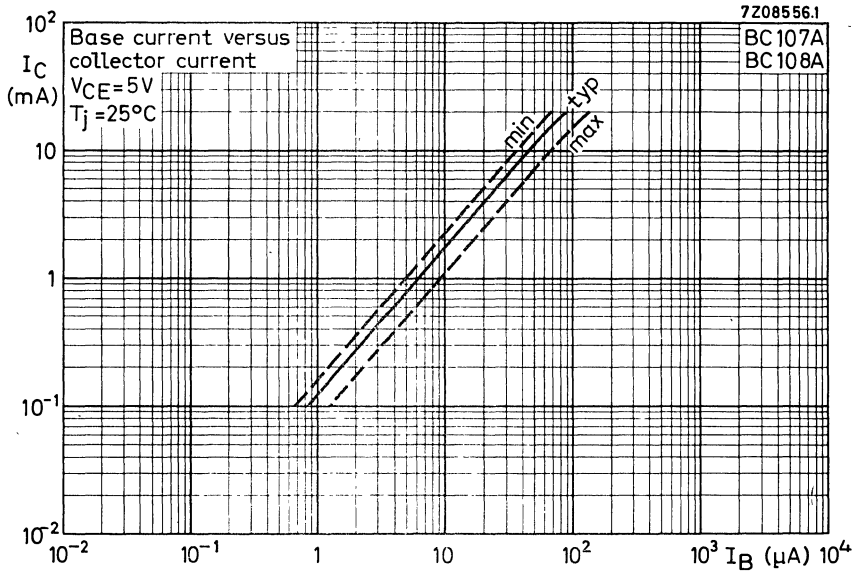
		BC107A BC108A	BC107B BC108B BC109B	BC108C BC109C		
<u>D.C. current gain</u>						
$I_C = 10\ \mu\text{A}; V_{CE} = 5\ \text{V}$	$h_{FE}$	>	40	100		
		typ.	90	270		
		>	110	200		
$I_C = 2\ \text{mA}; V_{CE} = 5\ \text{V}$	$h_{FE}$	typ.	180	290		
		<	220	450		
				800		
<u>h parameters at <math>f = 1\ \text{kHz}</math> (common emitter)</u>						
$I_C = 2\ \text{mA}; V_{CE} = 5\ \text{V}$	Input impedance	$h_{ie}$	>	1.6	3.2	6 $\text{k}\Omega$
			typ.	2.7	4.5	8.7 $\text{k}\Omega$
			<	4.5	8.5	15 $\text{k}\Omega$
Reverse voltage transfer ratio	$h_{re}$	typ.	1.5	2	3 $10^{-4}$	
		>	125	240	450	
		typ.	220	330	600	
Small signal current gain	$h_{fe}$	<	260	500	900	
		typ.	18	30	60 $\mu\Omega^{-1}$	
		<	30	60	110 $\mu\Omega^{-1}$	

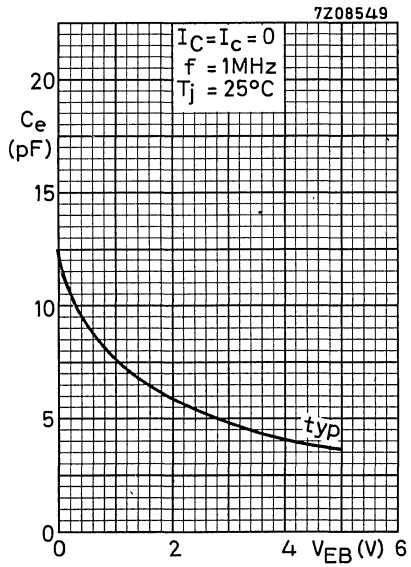
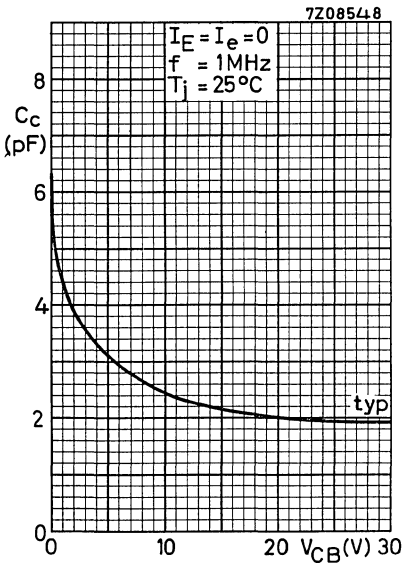
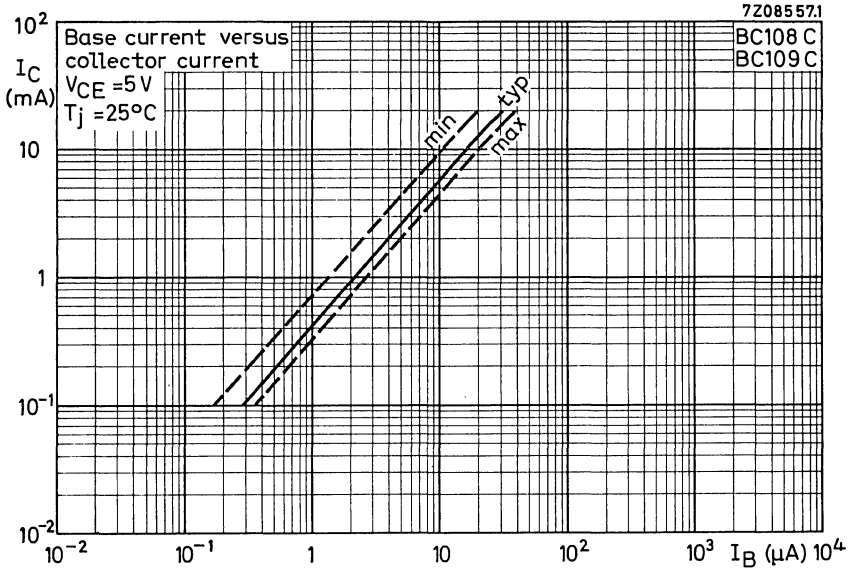
Typical behaviour of collector current versus collector-emitter voltage



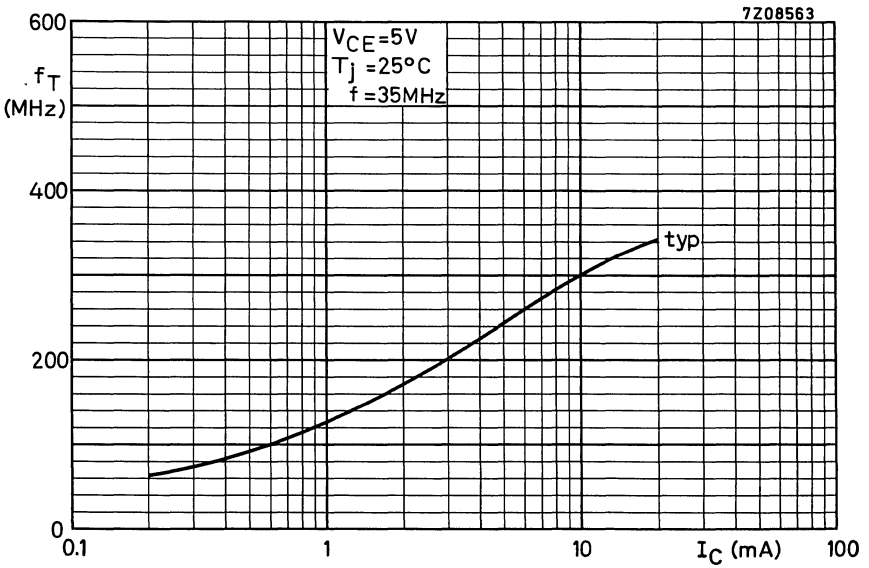
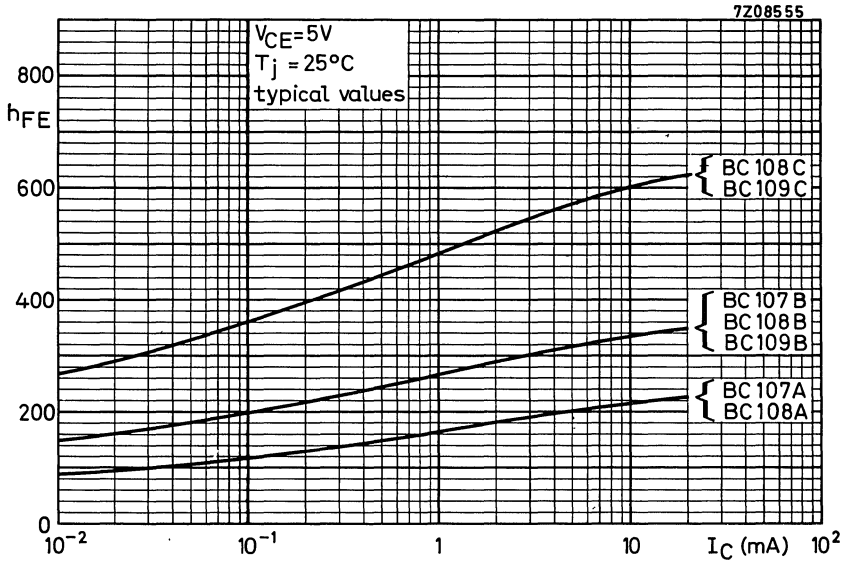
Typical behaviour of collector current versus collector-emitter voltage



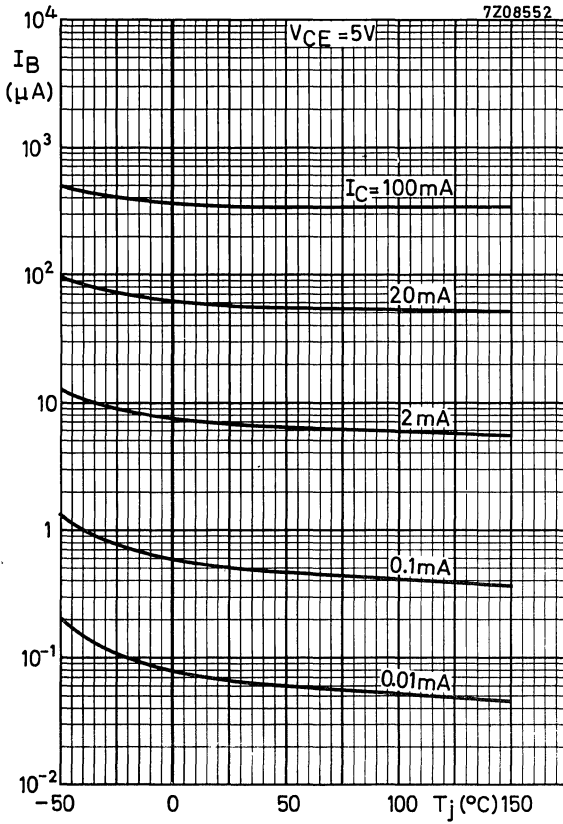


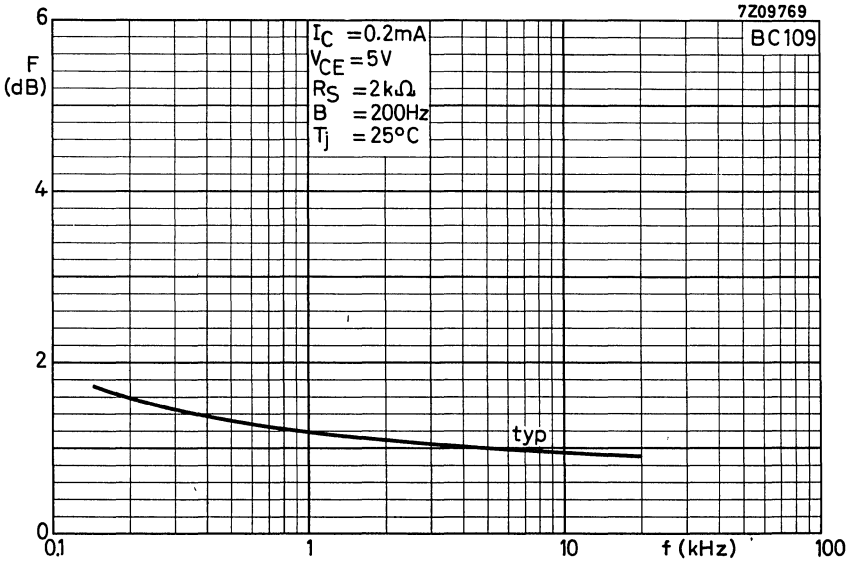
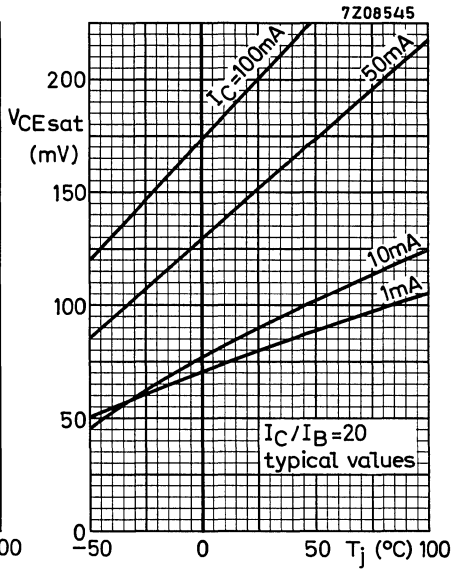
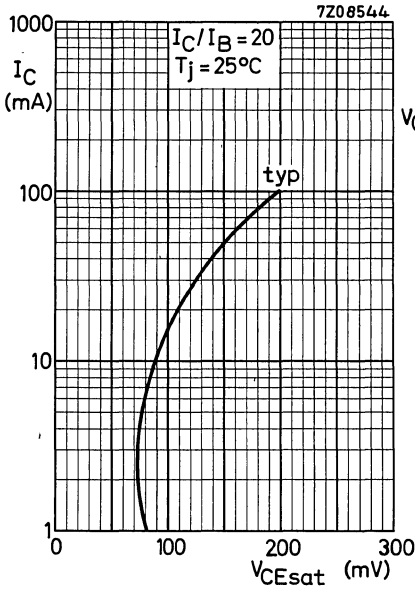




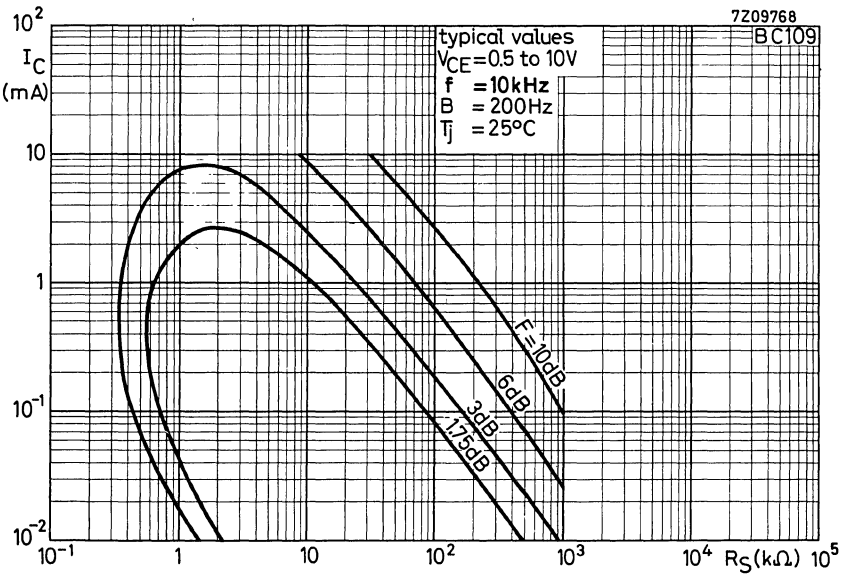
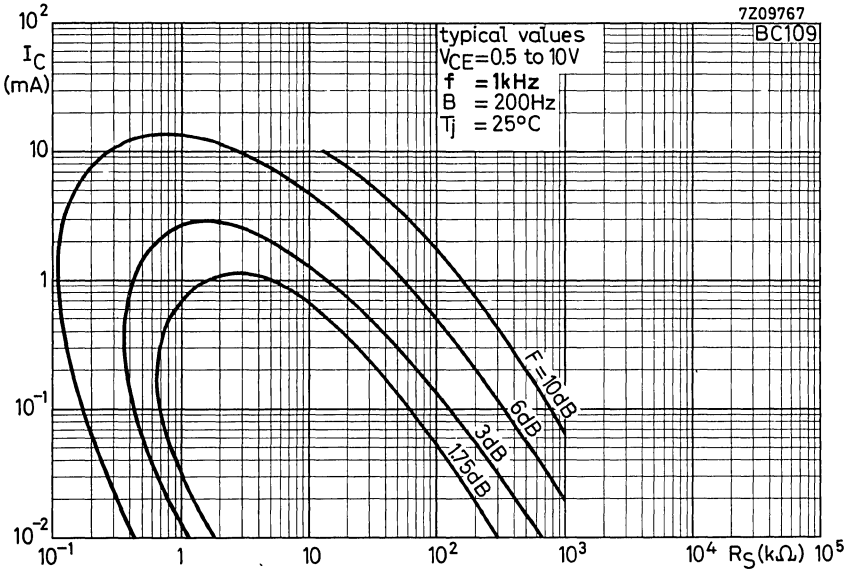


Typical behaviour of base current versus junction temperature

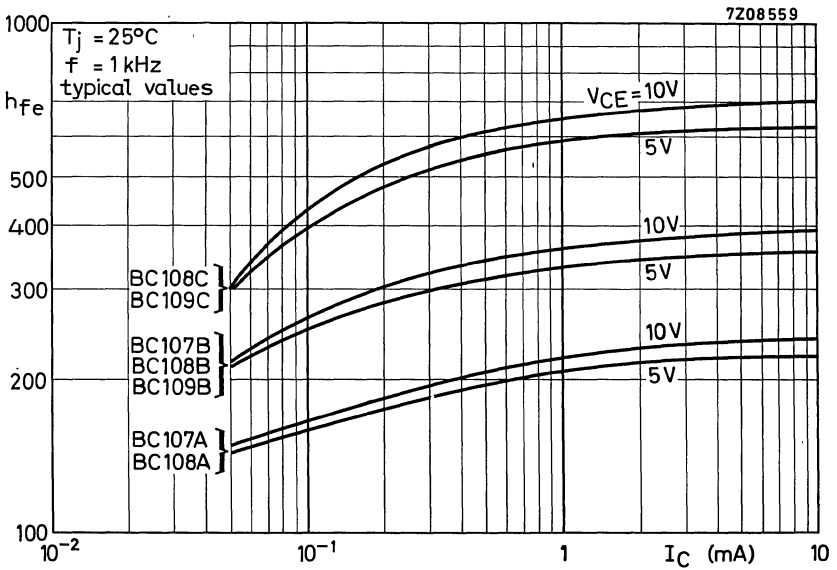
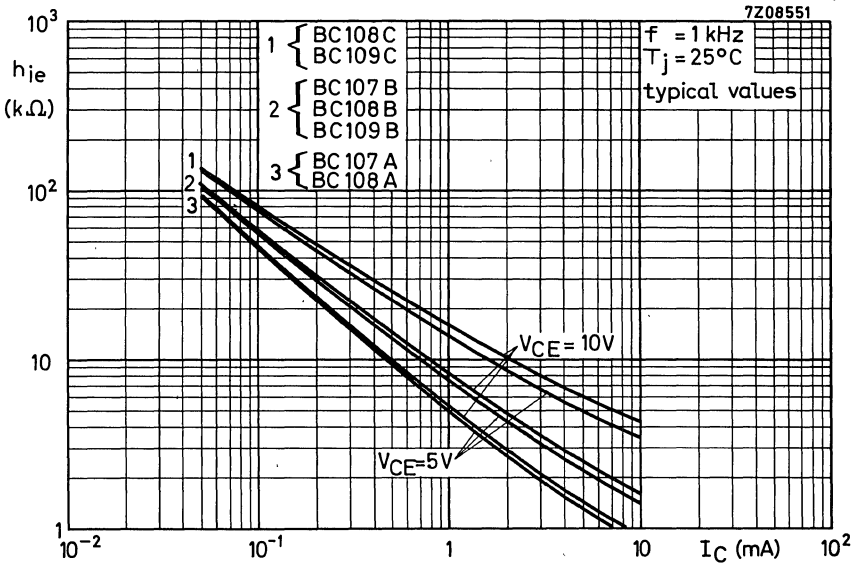


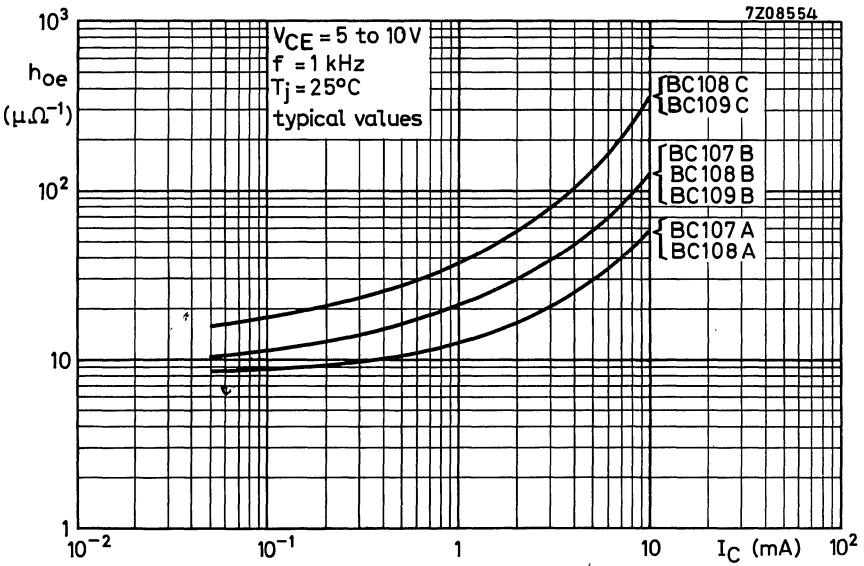
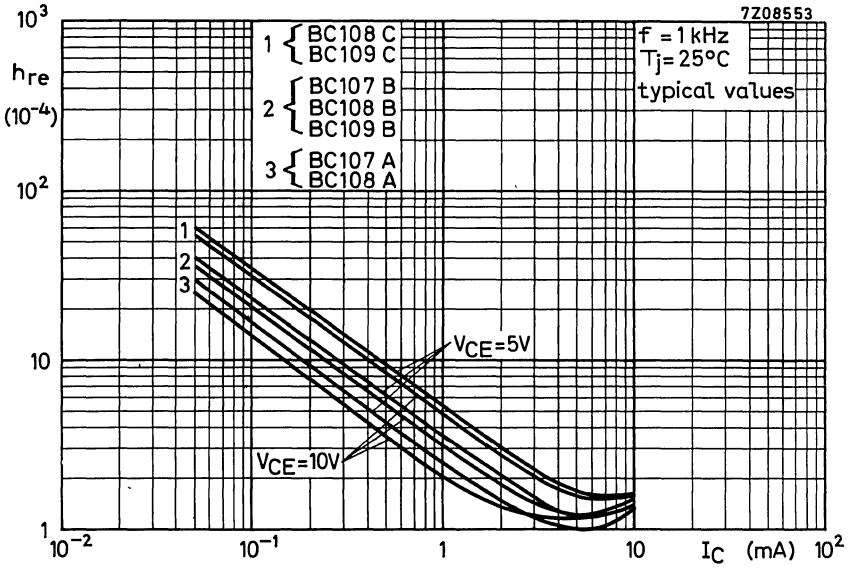


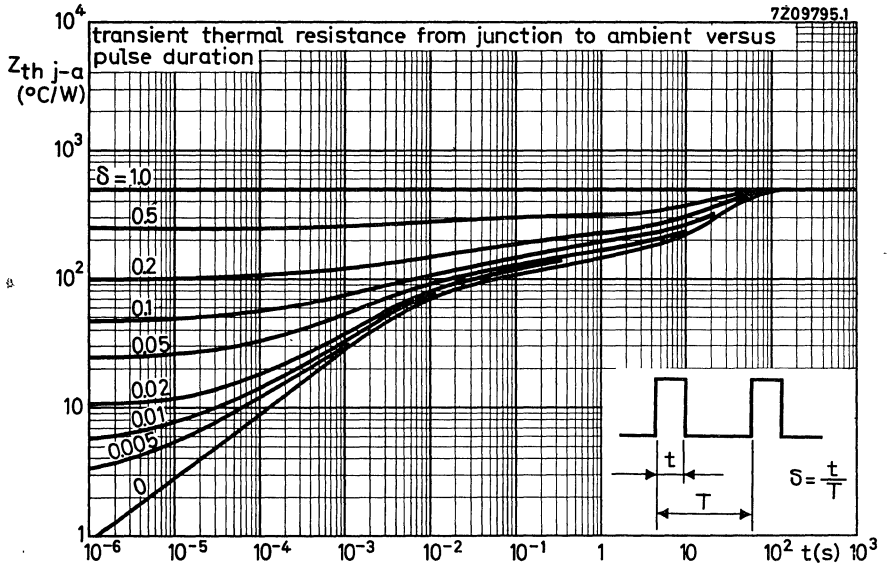
Curves of constant noise figure



# BC107 to 109







## SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a miniature plastic envelope designed for hearing aids, watches, etc.  
P-N-P complement is BC200.

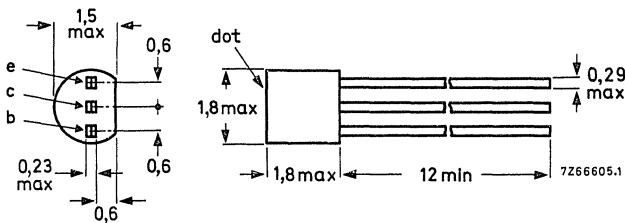
## QUICK REFERENCE DATA

			BC146/01	BC146/02	BC146/03	
Collector-base voltage (open emitter)	$V_{CBO}$	max.	20	20	20	V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	20	20	20	V
Collector current (d.c.)	$I_C$	max.	50	50	50	mA
Total power dissipation up to $T_{amb} = 45^\circ\text{C}$	$P_{tot}$	max.	50	50	50	mW
Junction temperature	$T_j$	max.	125	125	125	$^\circ\text{C}$
D.C. current gain $I_C = 0,2\text{ mA}; V_{CE} = 0,5\text{ V}$	$h_{FE}$	>	80	140	280	
		<	200	350	550	
Noise figure at $R_S = 2\text{ k}\Omega$ $I_C = 0,2\text{ mA}; V_{CE} = 5\text{ V}$ Bandwidth: $f = 30\text{ Hz to }15\text{ kHz}$	F	typ.	2	1,5	2	dB
		<	—	4,0	—	dB

## MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT-42.



Coloured dot on top of the black body indicates  $h_{FE}$  group:

BC146/01 red  
BC146/02 yellow  
BC146/03 green



**MOUNTING INSTRUCTIONS**

To avoid damaging the transistor, welded or soldered connections must be made with care; the following general recommendations should be observed:

1. The temperature of the soldering iron must be less than 250 °C and the soldering time less than 3 seconds at a lead length of not less than 1,5 mm.
2. To keep the heat capacity low, the smallest possible amount of solder should be used.
3. If the plastic capsule of the transistor makes contact with any other structure, care must be taken that its temperature never exceeds 125 °C.

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

Voltages

Collector-base voltage (open emitter)	$V_{CBO}$	max.	20	V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	20	V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	4	V

Currents

Collector current (d. c.)	$I_C$	max.	50	mA
Collector current (peak value)	$I_{CM}$	max.	50	mA

Power dissipation

Total power dissipation up to $T_{amb} = 45\text{ °C}$	$P_{tot}$	max.	50	mW
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Temperature

Storage temperature	$T_{stg}$	-65 to +125	°C
Junction temperature	$T_j$	max. 125	°C

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th\ j-a}$	=	1,6	°C/mW
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**CHARACTERISTICS**

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

Base-emitter voltage

$I_C = 0,2\text{ mA}; V_{CE} = 0,5\text{ V}$

$V_{BE}$  typ. 570 mV

$I_C = 2\text{ mA}; V_{CE} = 1\text{ V}$

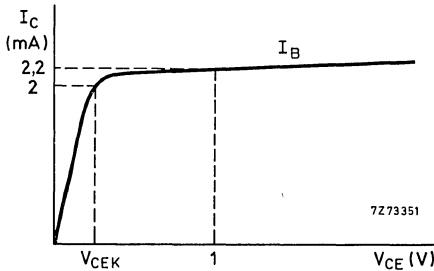
$V_{BE}$  typ. 630 mV

Knee voltage

$I_C = 2\text{ mA}; I_B = \text{value for which}$

$I_C = 2,2\text{ mA at } V_{CE} = 1\text{ V}$

$V_{CEK}$  typ. 180 mV



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

$I_E = I_e = 0; V_{CB} = 5\text{ V}$

$C_c$  typ. 4 pF

Transition frequency

$I_C = 2\text{ mA}; V_{CE} = 5\text{ V}$

$f_T$  typ. 150 MHz

D. C. current gain

$I_C = 0,2\text{ mA}; V_{CE} = 0,5\text{ V}$

BC146	/01	/02	/03
$h_{FE}$	typ. 115 80 to 200	220 140 to 350	380 280 to 550
$h_{FE}$	> 100	140	280
F	typ. 2 < -	1,5 4	2 dB - dB
$h_{ie}$	typ. 20	30	45 k $\Omega$
$h_{re}$	typ. 15	25	40 $10^{-4}$
$h_{fe}$	typ. 130	220	380
$h_{oe}$	typ. 15	20	35 $\mu\text{A/V}$

$I_C = 2\text{ mA}; V_{CE} = 1\text{ V}$

Noise figure

$I_C = 0,2\text{ mA}; V_{CE} = 5\text{ V}$

$R_s = 2\text{ k}\Omega$

Bandwidth:  $f = 30\text{ Hz to } 15\text{ kHz}$

h parameters at  $f = 1\text{ kHz}$

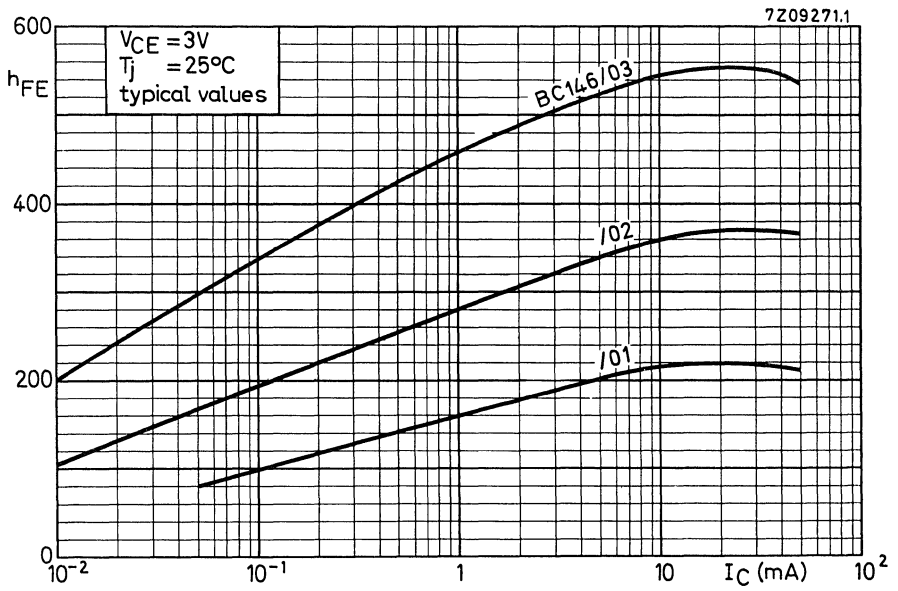
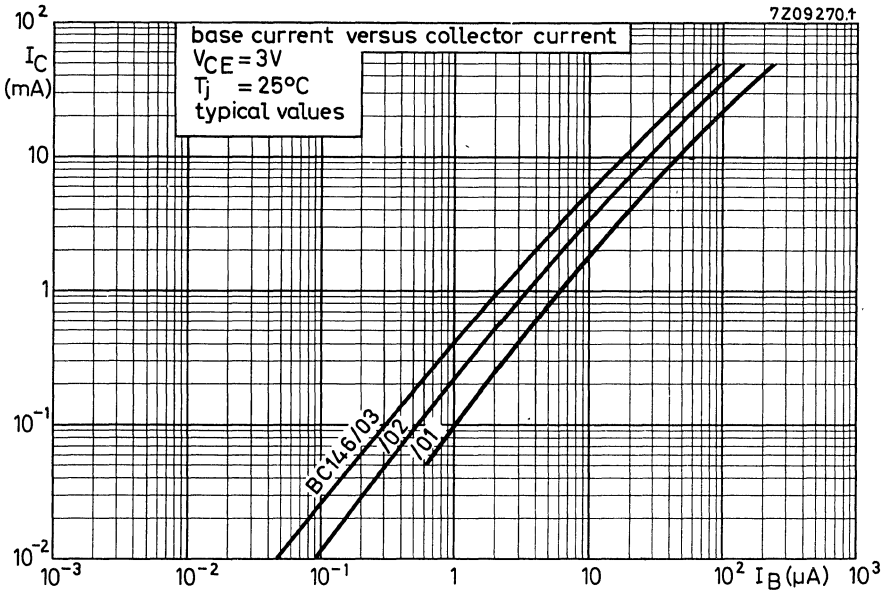
$I_C = 0,2\text{ mA}; V_{CE} = 0,5\text{ V}$

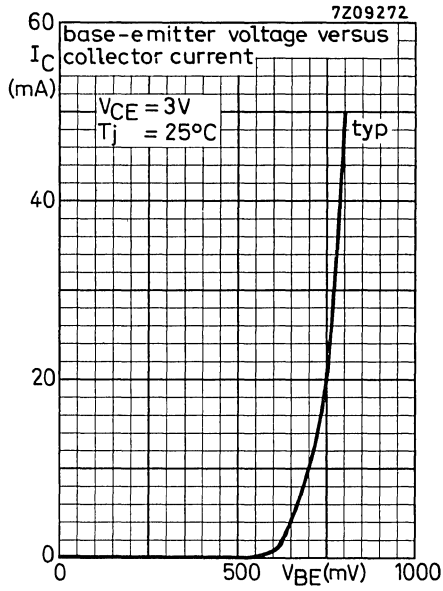
Input impedance

Reverse voltage transfer ratio

Small-signal current gain

Output admittance







## A.F. SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in TO-18 metal envelopes with the collector connected to the case.

The **BC177** is a high-voltage type and primarily intended for use in driver stages of audio amplifiers and in signal processing circuits of television receivers.

The **BC178** is suitable for a multitude of low-voltage applications e.g. driver stages or audio preamplifiers and in signal processing circuits of television receivers.

The **BC179** is primarily intended for low-noise input stages in tape recorders, hi-fi amplifiers and other audio-frequency equipment.

Moreover, they are intended as complementary types for the BC107, BC108 and BC109.

### QUICK REFERENCE DATA

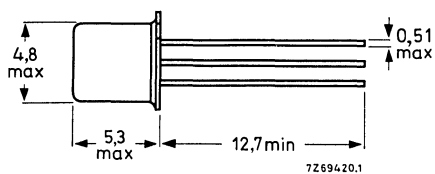
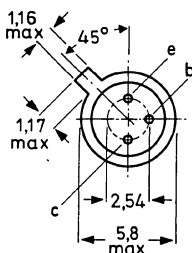
		BC177	BC178	BC179	
Collector-emitter voltage (+ $V_{BE} = 1$ V)	$-V_{CEX}$ max.	50	30	25	V
Collector-emitter voltage (open base)	$-V_{CEO}$ max.	45	25	20	V
Collector current (peak value)	$-I_{CM}$ max.	200	200	200	mA
Total power dissipation up to $T_{amb} = 25$ °C	$P_{tot}$ max.	300	300	300	mW
Junction temperature	$T_j$ max.	175	175	175	°C
Small-signal current gain at $T_j = 25$ °C $-I_C = 2$ mA; $-V_{CE} = 5$ V; $f = 1$ kHz	$h_{fe}$ > $h_{fe}$ <	75 260	75 500	125 500	
Transition frequency at $f = 35$ MHz $-I_C = 10$ mA; $-V_{CE} = 5$ V	$f_T$ typ.	150	150	150	MHz
Noise figure at $R_S = 2$ k $\Omega$ $-I_C = 200$ $\mu$ A; $-V_{CE} = 5$ V $f = 30$ Hz to 15 kHz	F typ. F <	— —	— —	1,2 4,0	dB
$f = 1$ kHz; B = 200 Hz	F <	10	10	4,0	dB

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector  
connected  
to case



Accessories: 56246 (distance disc).

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

<u>Voltages</u>		BC177	BC178	BC179
Collector-base voltage (open emitter)	$-V_{CBO}$	max. 50	30	25 V
Collector-emitter voltage ( $+V_{BE} = 1$ V)	$-V_{CEX}$	max. 50	30	25 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max. 45	25	20 V
Emitter-base voltage (open collector)	$-V_{EBO}$	max. 5	5	5 V

<u>Currents</u>				
Collector current (d.c.)	$-I_C$	max.	100	mA
Collector current (peak value)	$-I_{CM}$	max.	200	mA
Emitter current (peak value)	$I_{EM}$	max.	200	mA

<u>Power dissipation</u>				
Total power dissipation up to $T_{amb} = 25$ °C	$P_{tot}$	max.	300	mW

<u>Temperatures</u>				
Storage temperature	$T_{stg}$	-65 to	+175	°C
Junction temperature	$T_j$	max.	175	°C

### THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.5	°C/mW
From junction to case	$R_{th\ j-c}$	=	0.2	°C/mW

### CHARACTERISTICS

#### Collector cut-off current

$I_E = 0$ ; $-V_{CB} = 20$ V; $T_j = 25$ °C	$-I_{CBO}$	typ.	1	nA
		<	100	nA
$T_j = 150$ °C	$-I_{CBO}$	<	10	µA

#### Base-emitter voltage <sup>1)</sup>

$-I_C = 2$ mA; $-V_{CE} = 5$ V; $T_j = 25$ °C	$-V_{BE}$	typ.	650	mV
			600 to 750	mV

<sup>1)</sup>  $-V_{BE}$  decreases by about 2 mV/°C with increasing temperature.

**CHARACTERISTICS** (continued)

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

Saturation voltages

$-I_C = 10\text{ mA}; -I_B = 0.5\text{ mA}$

$-V_{CEsat}$  typ. 75 mV  
< 300 mV

$-V_{BEsat}$  typ. 700 mV

$-I_C = 100\text{ mA}; -I_B = 5\text{ mA}$

$-V_{CEsat}$  typ. 250 mV

$-V_{BEsat}$  typ. 850 mV

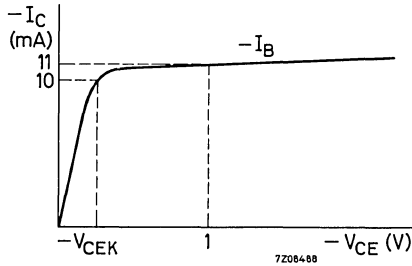
Knee voltage

$-I_C = 10\text{ mA}; -I_B = \text{value for which}$

$-I_C = 11\text{ mA}$  at  $-V_{CE} = 1\text{ V}$

$-V_{CEK}$  typ. 250 mV

< 600 mV



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

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

$C_c$  typ. 4.0 pF

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

$-I_C = 10\text{ mA}; -V_{CE} = 5\text{ V}$

$f_T$  typ. 150 MHz

Small signal current gain at  $f = 1\text{ kHz}$

$-I_C = 2\text{ mA}; -V_{CE} = 5\text{ V}$

		BC177	BC178	BC179
$h_{fe}$	>	75	75	125
	<	260	500	500
$F$	typ.			1.2 dB
	<			4 dB
$F$	typ.	2	2	1 dB
	<	10	10	4 dB

Noise figure at  $R_S = 2\text{ k}\Omega$

$-I_C = 200\text{ }\mu\text{A}; -V_{CE} = 5\text{ V}$

$f = 30\text{ Hz to }15\text{ kHz}$

$f = 1\text{ kHz}; B = 200\text{ Hz}$



## CHARACTERISTICS (continued)

### D.C. current gain

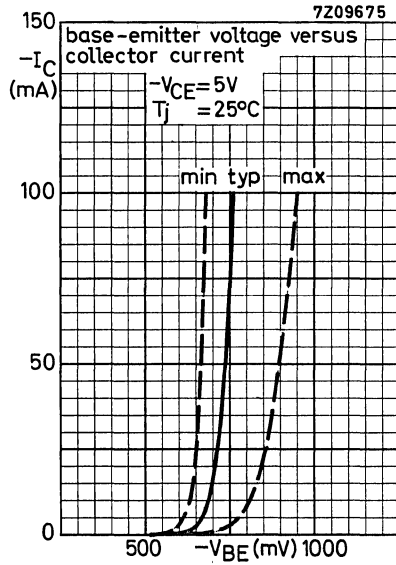
$-I_C = 2 \text{ mA}; -V_{CE} = 5 \text{ V}$

	BC177	BC178A BC179A	BC178B BC179B
hFE	typ. 140	180	290

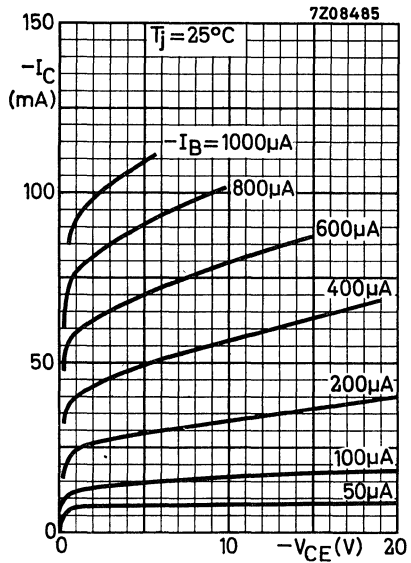
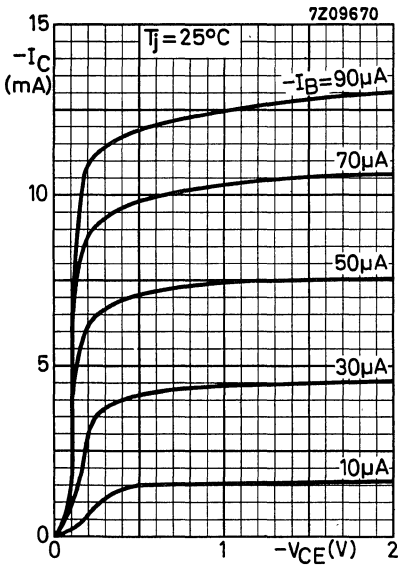
### Small signal current gain at $f = 1 \text{ kHz}$

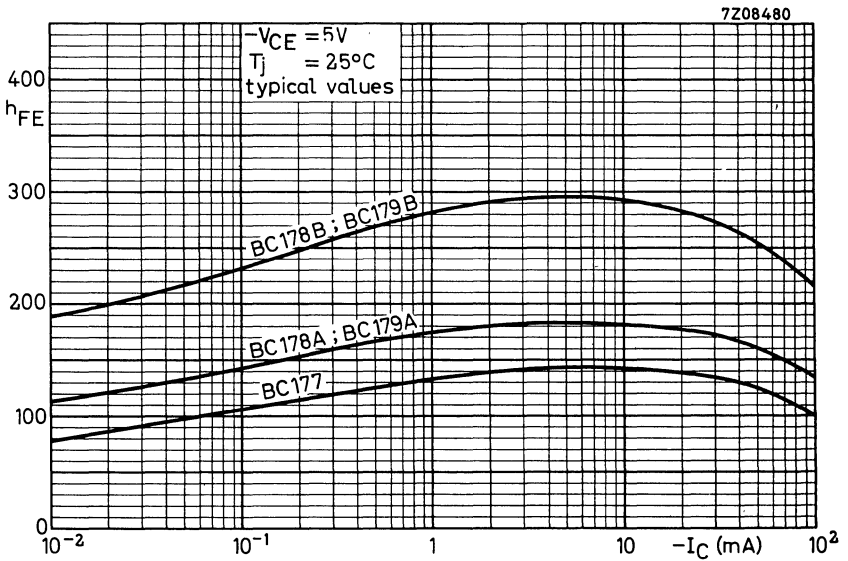
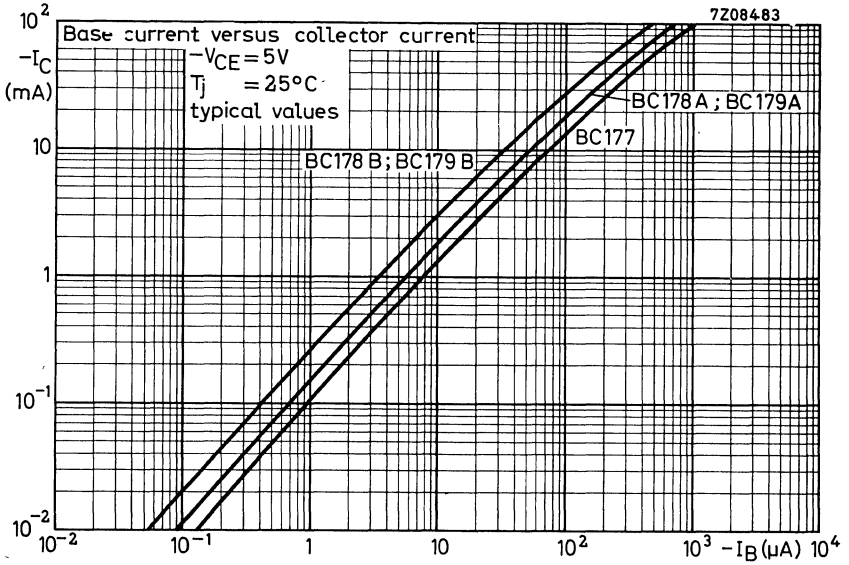
$-I_C = 2 \text{ mA}; -V_{CE} = 5 \text{ V}$

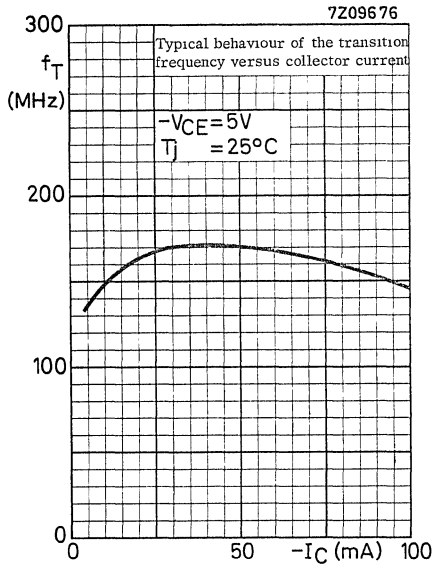
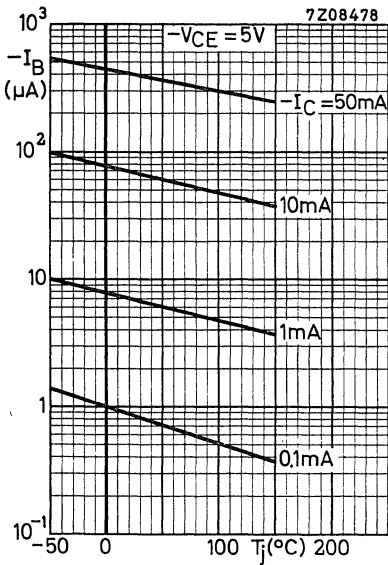
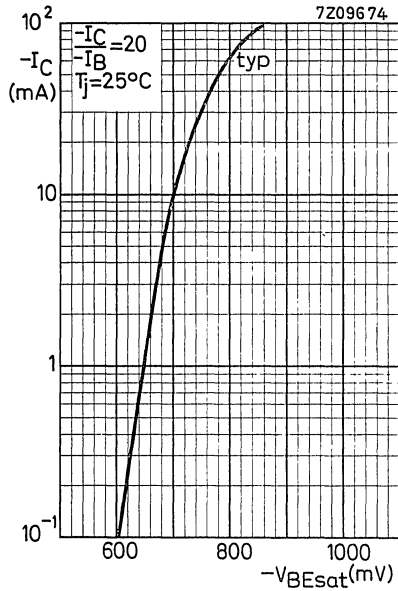
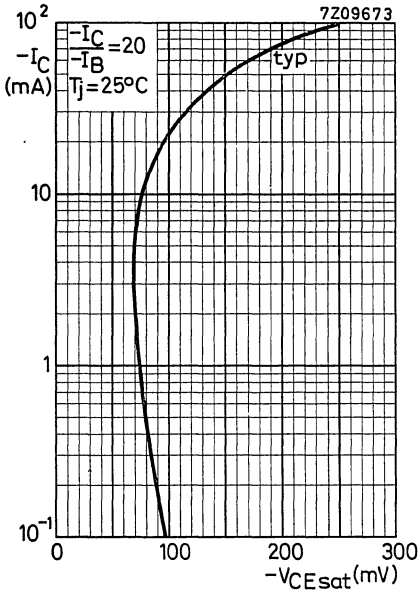
hfe	>	75	125	240
	<	260	260	500



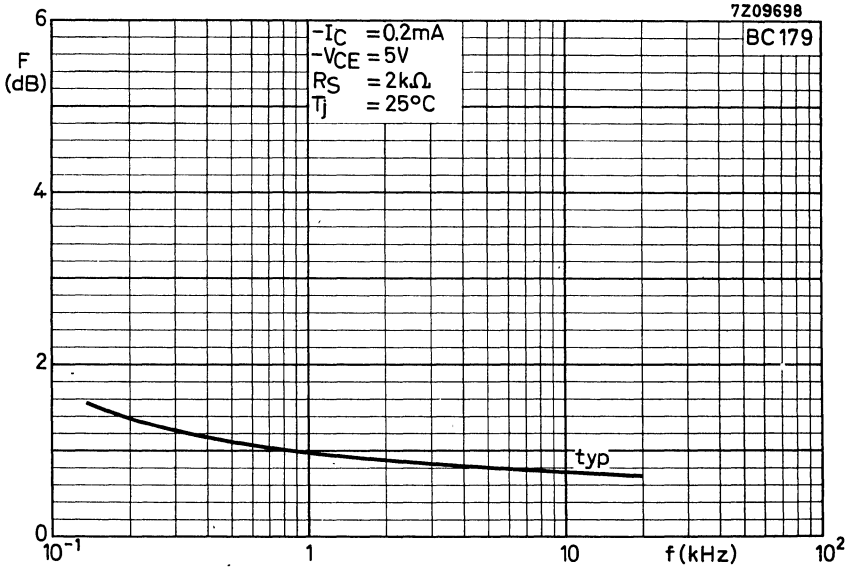
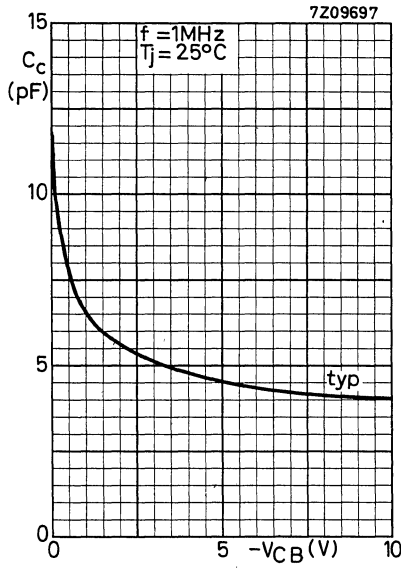
Typical behaviour of collector current versus collector-emitter voltage



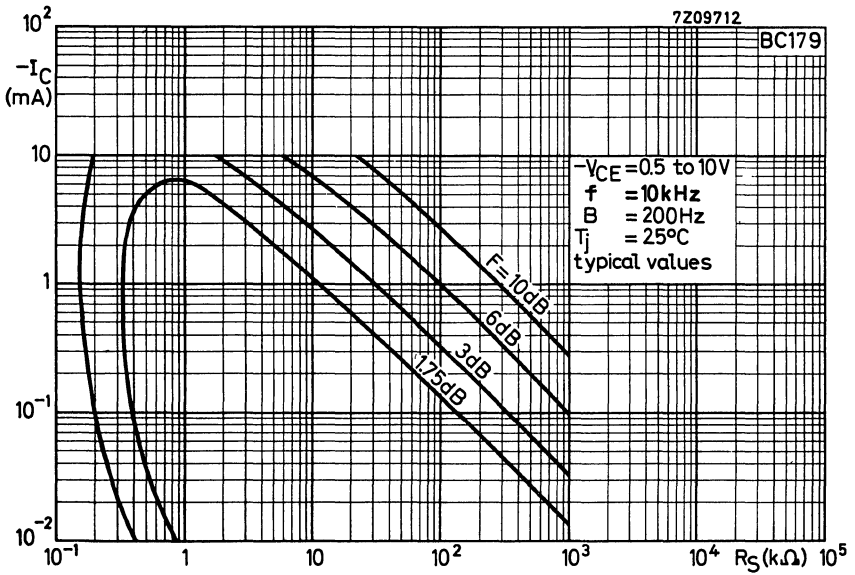
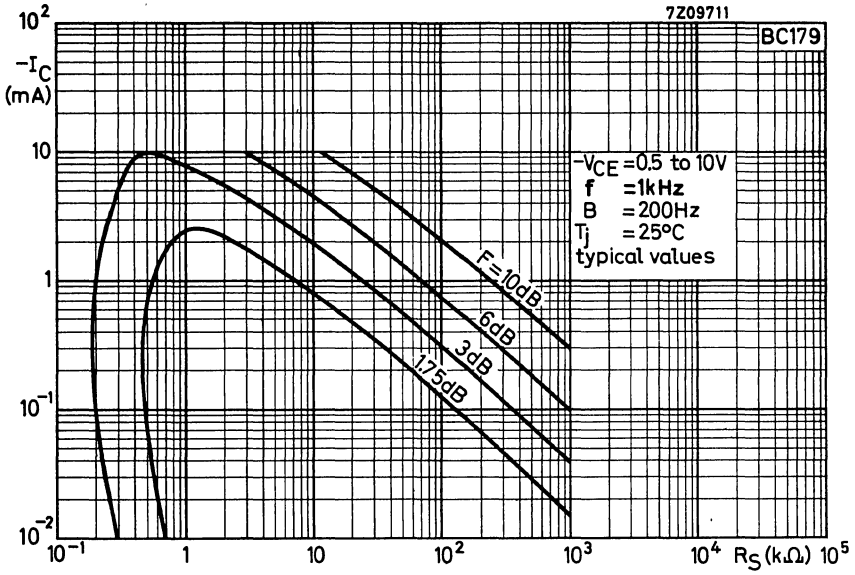


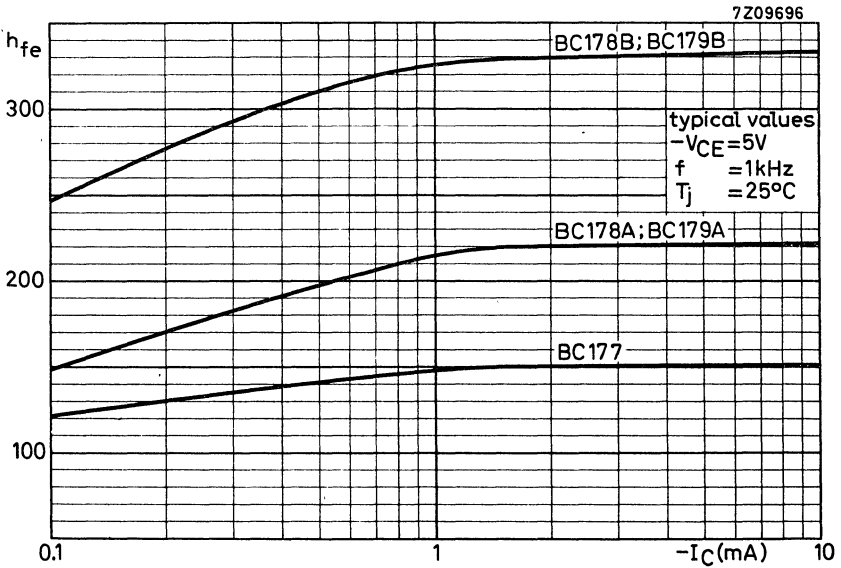
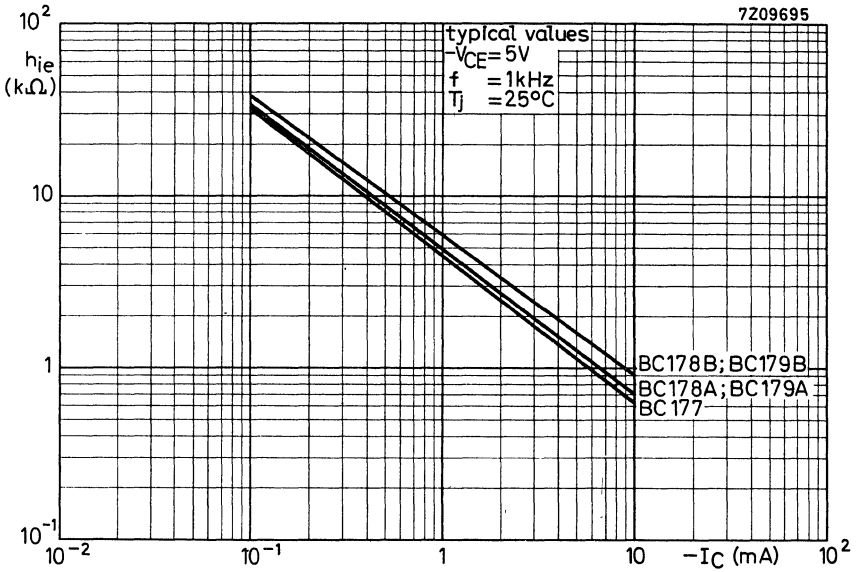


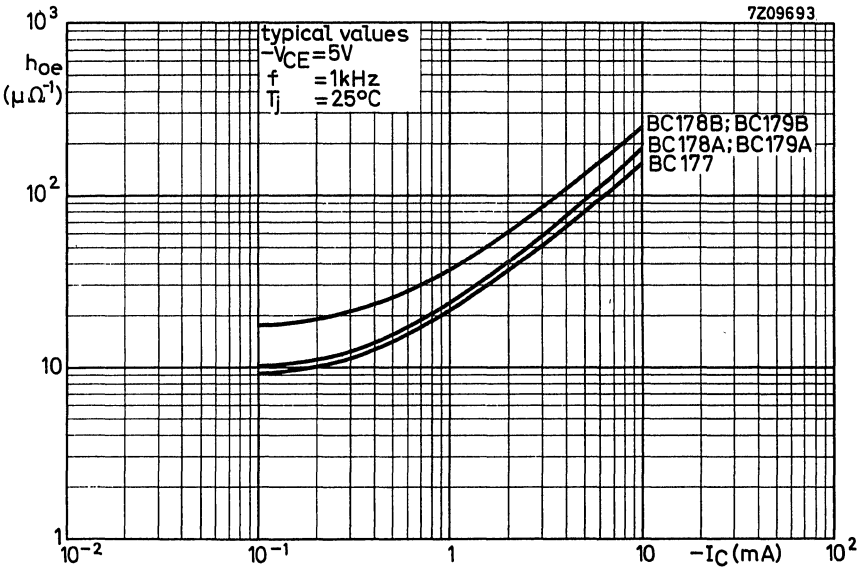
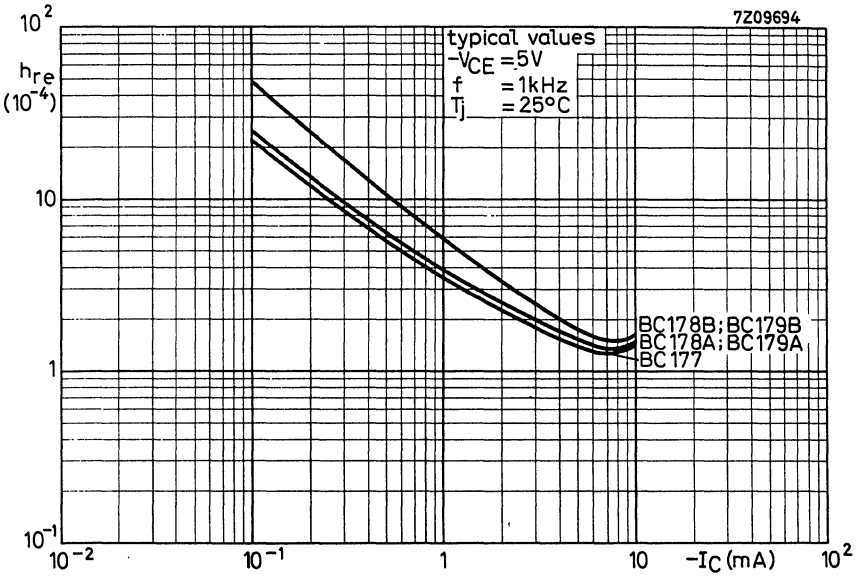
Typical behaviour of base current versus junction temperature



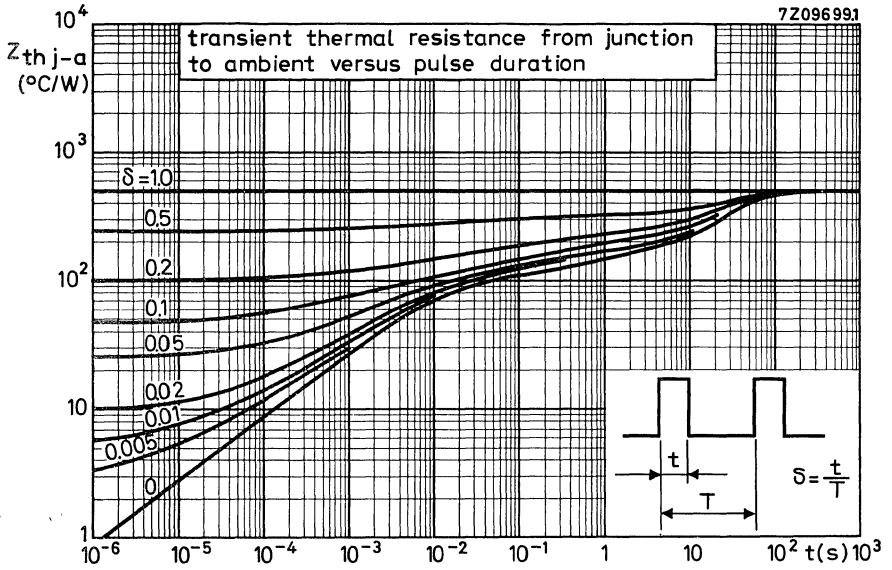
Curves of constant noise figure











## SILICON PLANAR EPITAXIAL TRANSISTOR

P-N-P transistor in a miniature plastic envelope designed for hearing aids, watches, etc.

N-P-N complement is BC146.

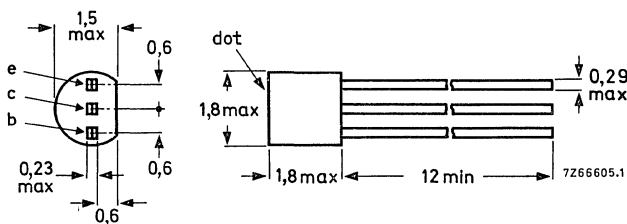
## QUICK REFERENCE DATA

		BC200/01	BC200/02	BC200/03	
Collector-base voltage (open emitter)	$-V_{CBO}$	max. 20	20	20	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max. 20	20	20	V
Collector current (d.c.)	$-I_C$	max. 50	50	50	mA
Total power dissipation up to $T_{amb} = 45^\circ\text{C}$	$P_{tot}$	max. 50	50	50	mW
Junction temperature	$T_j$	max. 125	125	125	$^\circ\text{C}$
D.C. current gain	$h_{FE}$	$>$ 50	85	165	
$-I_C = 0,2 \text{ mA}; -V_{CE} = 0,5 \text{ V}$		$<$ 105	200	400	
Noise figure at $R_S = 2 \text{ k}\Omega$	$F$	typ. 2	1,5	2	dB
$-I_C = 0,2 \text{ mA}; -V_{CE} = 5 \text{ V}$		$<$	4,0	—	dB
Bandwidth: $f = 30 \text{ Hz to } 15 \text{ kHz}$		—	—	—	

## MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT-42.



Coloured dot on top of the black body indicates  $h_{FE}$  group:

BC200/01 red  
 BC200/02 yellow  
 BC200/03 green

The flat side is blue to distinguish from BC146.

**MOUNTING INSTRUCTIONS**

To avoid damaging the transistor, welded or soldered connections must be made with care; the following general recommendations should be observed:

1. The temperature of the soldering iron must be less than 250 °C and the soldering time less than 3 seconds at a lead length of not less than 1,5 mm.
2. To keep the heat capacity low, the smallest possible amount of solder should be used.
3. If the plastic capsule of the transistor makes contact with any other structure, care must be taken that its temperature never exceeds 125 °C.

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

Voltages

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

Currents

Collector current (d.c.)	$-I_C$	max.	50 mA
Collector current (peak value)	$-I_{CM}$	max.	50 mA

Power dissipation

Total power dissipation up to $T_{amb} = 45\text{ °C}$	$P_{tot}$	max.	50 mW
--	-----------	------	-------

Temperatures

Storage temperature	$T_{stg}$	-65 to +125 °C
Junction temperature	$T_j$	max. 125 °C

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th\ j-a}$	=	1,6 °C/mW
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## CHARACTERISTICS

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

### Collector cut-off current

$I_E = 0; -V_{CB} = 20\text{ V}$   $-I_{CBO} < 100\text{ nA}$

$I_E = 0; -V_{CB} = 20\text{ V}; T_j = 125\text{ }^\circ\text{C}$   $-I_{CBO} < 1\text{ }\mu\text{A}$

### Base-emitter voltage

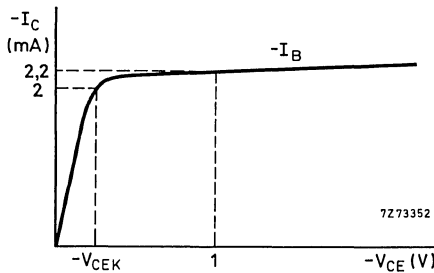
$-I_C = 0,2\text{ mA}; -V_{CE} = 0,5\text{ V}$   $-V_{BE}$  typ. 580 mV

$-I_C = 2\text{ mA}; -V_{CE} = 1\text{ V}$   $-V_{BE}$  typ. 650 mV

### Knee voltage

$-I_C = 2\text{ mA}; -I_B =$  value for which

$-I_C = 2,2\text{ mA}$  at  $-V_{CE} = 1\text{ V}$   $-V_{CEK}$  typ. 200 mV



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

$I_E = I_e = 0; -V_{CB} = 5\text{ V}$   $C_c$  typ. 5 pF

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

$-I_C = 2\text{ mA}; -V_{CE} = 5\text{ V}$   $f_T$  typ. 90 MHz

### D.C. current gain

$-I_C = 0,2\text{ mA}; -V_{CE} = 0,5\text{ V}$

BC200	/01	/02	/03
$h_{FE}$	typ. 75 50 to 105	140 85 to 200	250 165 to 400
$h_{FE}$	> 60	100	175

$-I_C = 2\text{ mA}; -V_{CE} = 1\text{ V}$

### h parameters at $f = 1\text{ kHz}$

$-I_C = 0,2\text{ mA}; -V_{CE} = 0,5\text{ V}$

Input impedance

$h_{ie}$  typ. 12 15 20 k $\Omega$

Reverse voltage transfer ratio

$h_{re}$  typ. 13 25 40 10<sup>-4</sup>

Small-signal current gain

$h_{fe}$  typ. 75 140 250

Output admittance

$h_{oe}$  typ. 13 18 33  $\mu\Omega^{-1}$

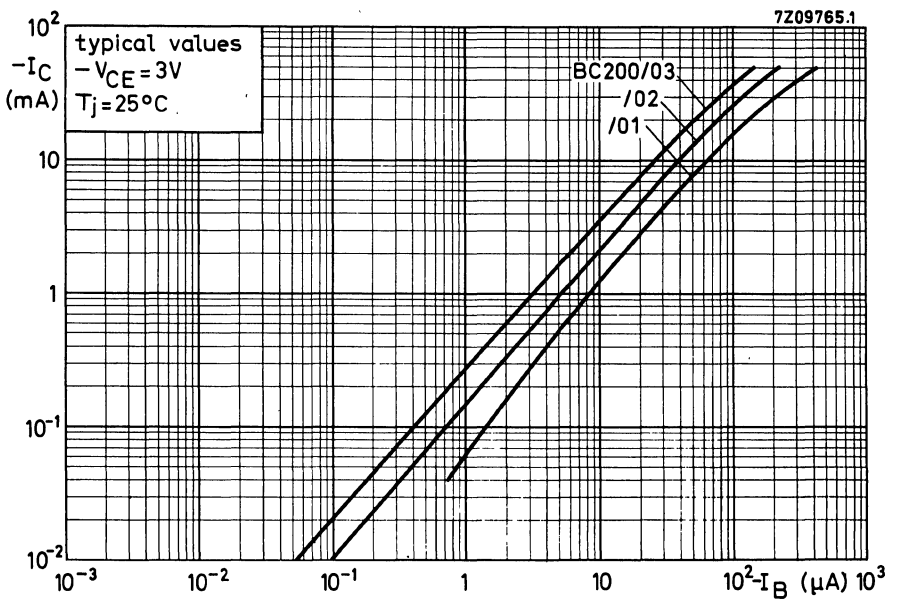
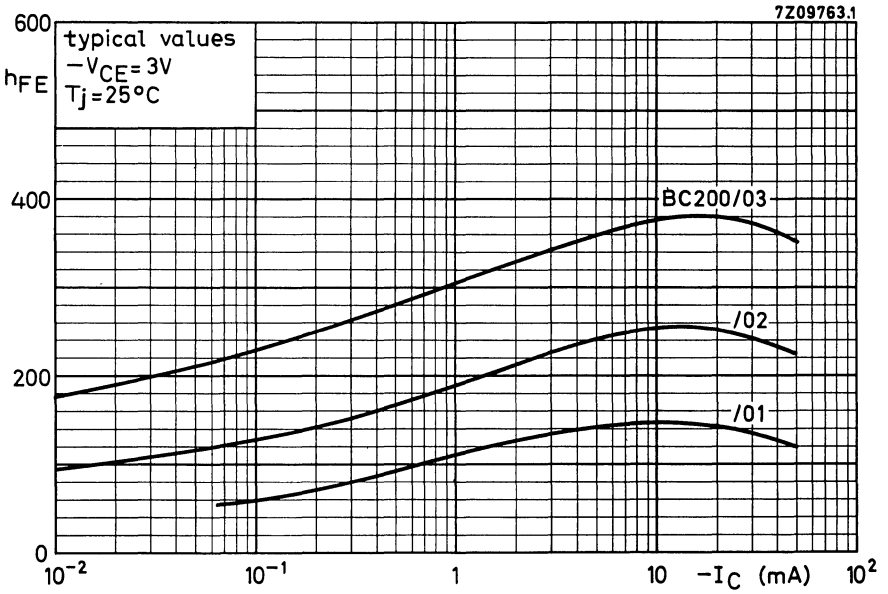
### Noise figure

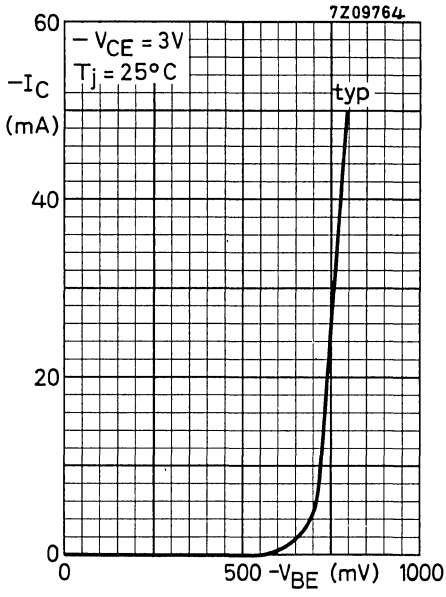
$-I_C = 0,2\text{ mA}; -V_{CE} = 5\text{ V};$

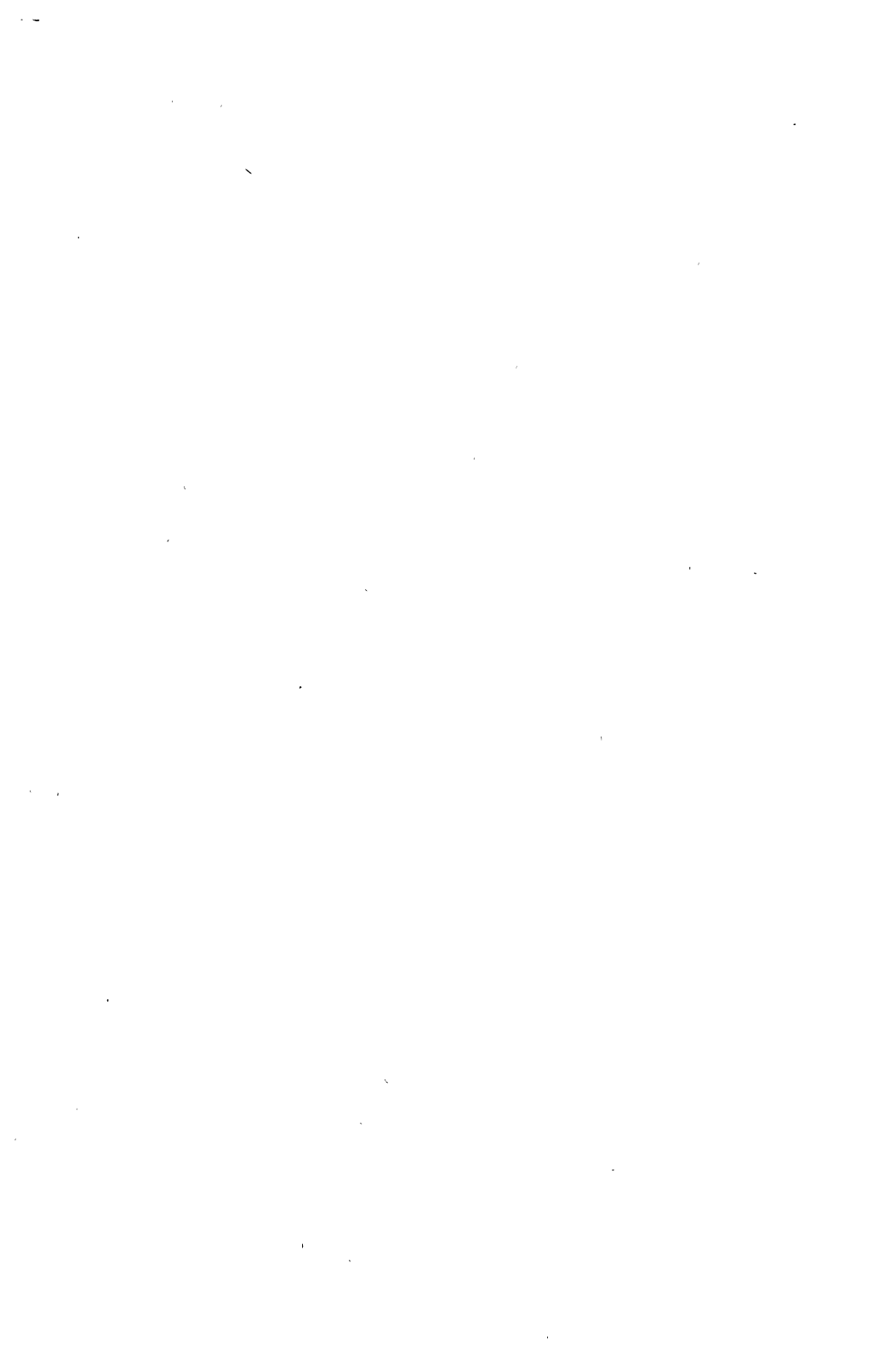
$R_s = 2\text{ k}\Omega$

Bandwidth:  $f = 30\text{ Hz}$  to  $15\text{ kHz}$

F	typ. 2	1,5	2 dB
	< -	4	- dB







## SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in plastic TO-92 variant envelopes, primarily intended for use in driver and output stages of audio amplifiers.

The BC327, BC327A, BC328 are complementary to the BC337, BC337A and BC338 respectively.

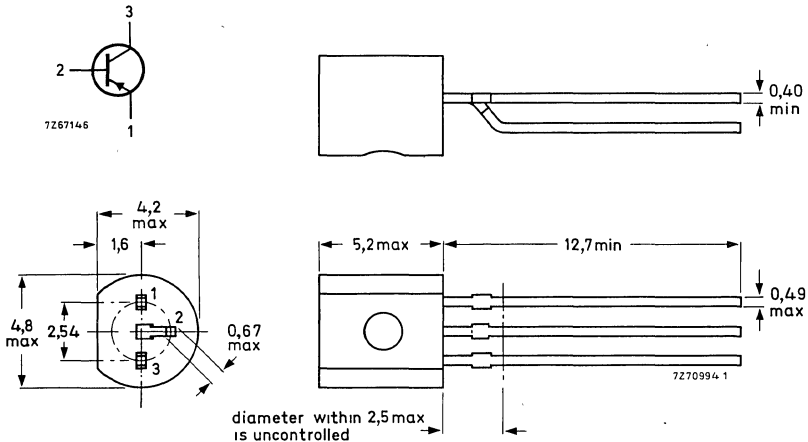
### QUICK REFERENCE DATA

		BC327	BC327A	BC328	
Collector-emitter voltage ( $V_{BE} = 0$ )	$-V_{CES}$ max.	50	60	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$ max.	45	60	25	V
Collector current (peak value)	$-I_{CM}$ max.	1000			mA
Total power dissipation up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$ max.	800			mW
Junction temperature	$T_j$ max.	150			$^{\circ}\text{C}$
Transition frequency at $f = 35\text{ MHz}$ $-I_C = 10\text{ mA}; -V_{CE} = 5\text{ V}$	$f_T$ typ.	100			MHz

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.





→ RATINGS

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

		BC327	BC327A	BC328	
Collector-emitter voltage ( $V_{BE} = 0$ )	$-V_{CES}$ max.	50	60	30	V
Collector-emitter voltage (open base) $-I_C = 10$ mA	$-V_{CEO}$ max.	45	60	25	V
Emitter-base voltage (open collector)	$-V_{EBO}$ max.	5	5	5	V
Collector current (d.c.)	$-I_C$ max.	500			mA
Collector current (peak value)	$-I_{CM}$ max.	1000			mA
Emitter current (peak value)	$I_{EM}$ max.	1000			mA
Base current (d.c.)	$-I_B$ max.	100			mA
Base current (peak value)	$-I_{BM}$ max.	200			mA
Total power dissipation at $T_{amb} = 25$ °C	$P_{tot}$ max.	625			mW
up to $T_{amb} = 25$ °C	$P_{tot}$ max.	800			mW*
Storage temperature	$T_{stg}$	-65 to +150			°C
Junction temperature	$T_j$ max.	150			°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$ =	0,2	K/mW
From junction to ambient	$R_{th\ j-a}$ =	0,156	K/mW*

\* Transistor mounted on printed circuit board, max. lead length 4 mm, mounting pad for collector lead min. 10 mm x 10 mm.

## CHARACTERISTICS

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

Collector cut-off current

$I_E = 0; -V_{CB} = 20\text{ V}; T_j = 25\text{ }^\circ\text{C}$

$-I_{CBO} < 100\text{ nA}$

$I_E = 0; -V_{CB} = 20\text{ V}; T_j = 150\text{ }^\circ\text{C}$

$-I_{CBO} < 5\text{ }\mu\text{A}$

Emitter cut-off current

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

$-I_{EBO} < 10\text{ }\mu\text{A}$

Base emitter voltage\*

$-I_C = 500\text{ mA}; -V_{CE} = 1\text{ V}$

$-V_{BE} < 1,2\text{ V}$

Saturation voltage

$-I_C = 500\text{ mA}; -I_B = 50\text{ mA}$

$-V_{CEsat} < 700\text{ mV}$

D.C. current gain

$-I_C = 500\text{ mA}; -V_{CE} = 1\text{ V}$

$h_{FE} > 40$

$-I_C = 100\text{ mA}; -V_{CE} = 1\text{ V}; \text{BC327; BC328}$

$h_{FE} 100\text{ to }600$

BC327A

$h_{FE} 100\text{ to }400$

BC327-16 }

$h_{FE} 100\text{ to }250$

BC328-16 }

BC327-25 }

$h_{FE} 160\text{ to }400$

BC328-25 }

BC327-40 }

$h_{FE} 250\text{ to }600$

BC328-40 }

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

$-I_C = 10\text{ mA}; -V_{CE} = 5\text{ V}$

$f_T \text{ typ. } 100\text{ MHz}$

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

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

$C_c \text{ typ. } 8\text{ pF}$

D.C. current gain ratio of matched pairs

BC327/BC337; BC328/BC338

$|I_C| = 100\text{ mA}; |V_{CE}| = 1\text{ V}$

$h_{FE1}/h_{FE2} \text{ typ. } 1,25$   
 $< 1,40$

\*  $-V_{BE}$  decreases by about  $2\text{ mV}/^\circ\text{C}$  with increasing temperature.

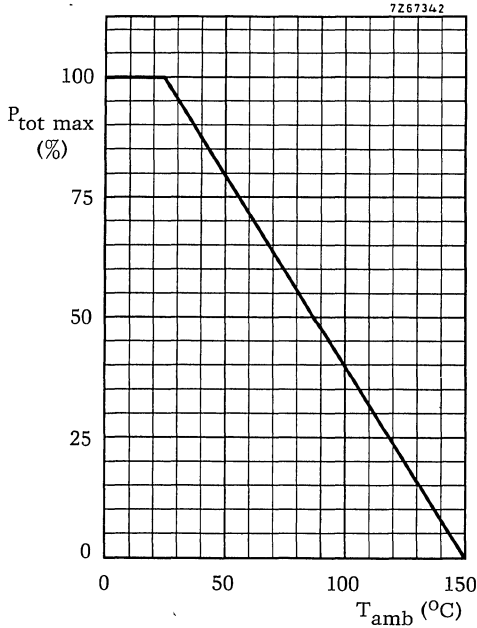


Fig. 2.

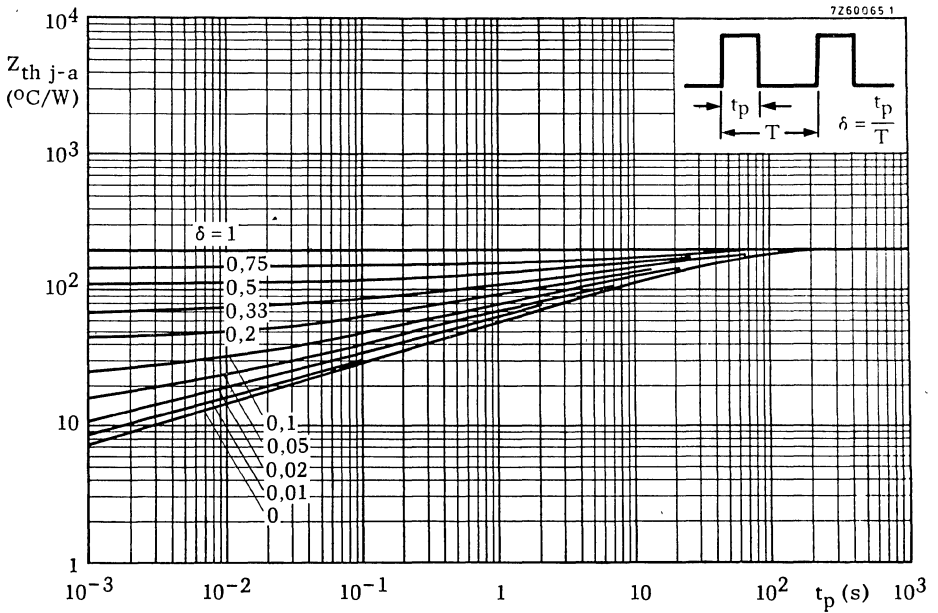


Fig. 3.

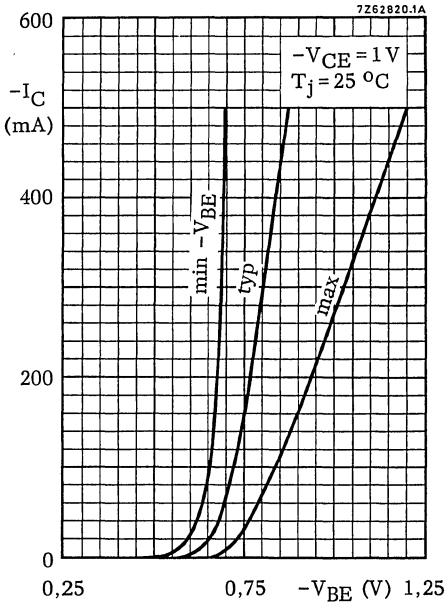


Fig. 4.

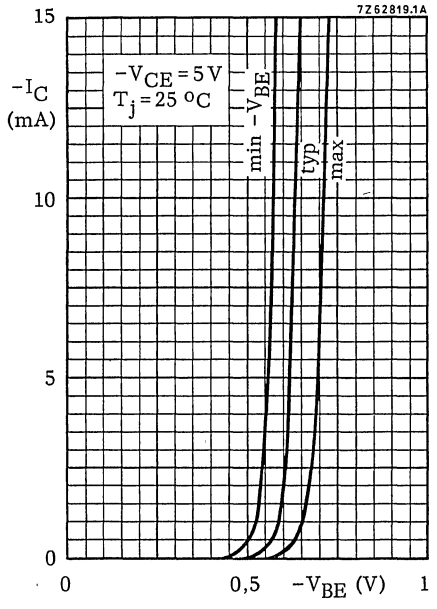


Fig. 5.

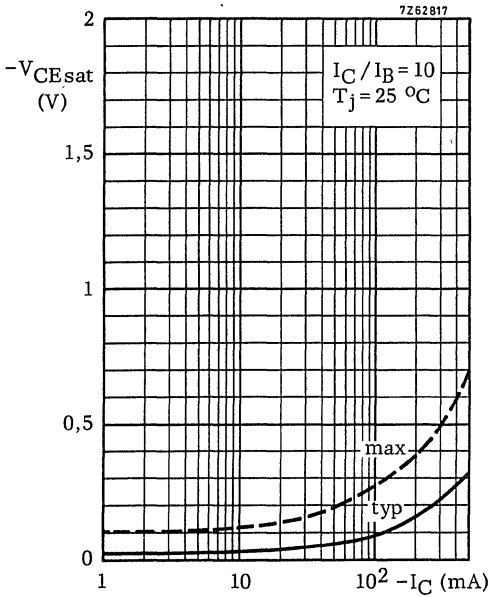


Fig. 6.

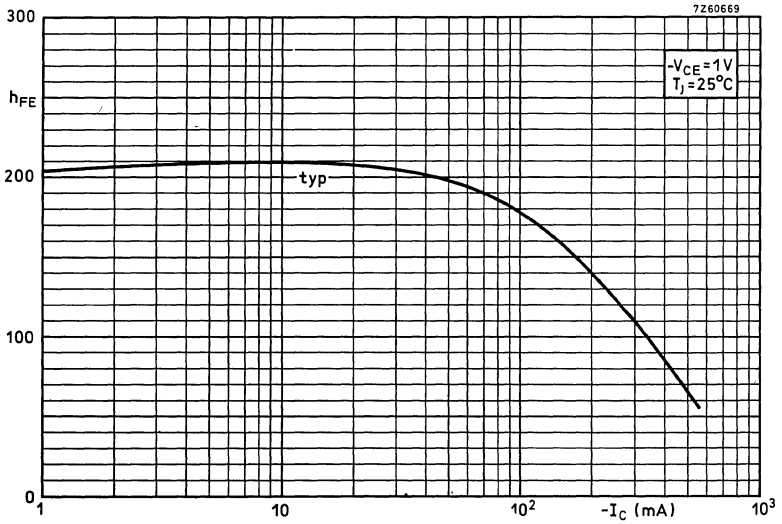


Fig. 7.

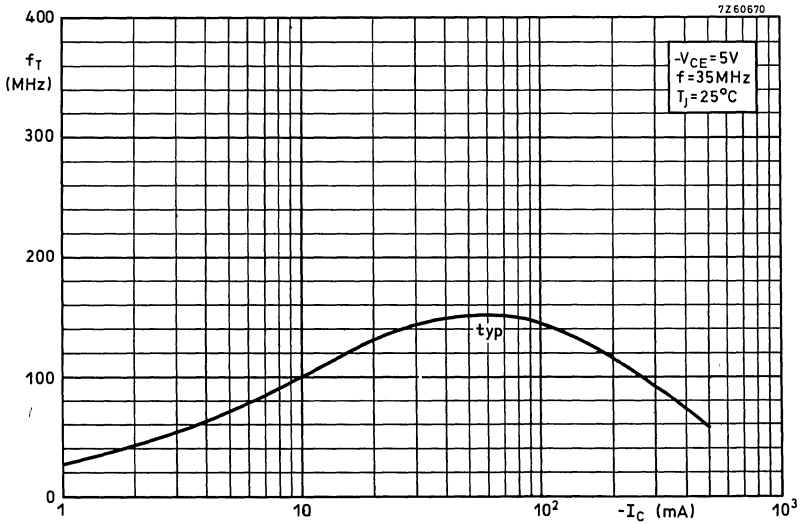


Fig. 8.

## APPLICATION INFORMATION

2,8 W transformerless audio-frequency amplifier with matched pair BC328/BC338 in complementary class-B output stage up to  $T_{amb} = 45^{\circ}\text{C}$ .

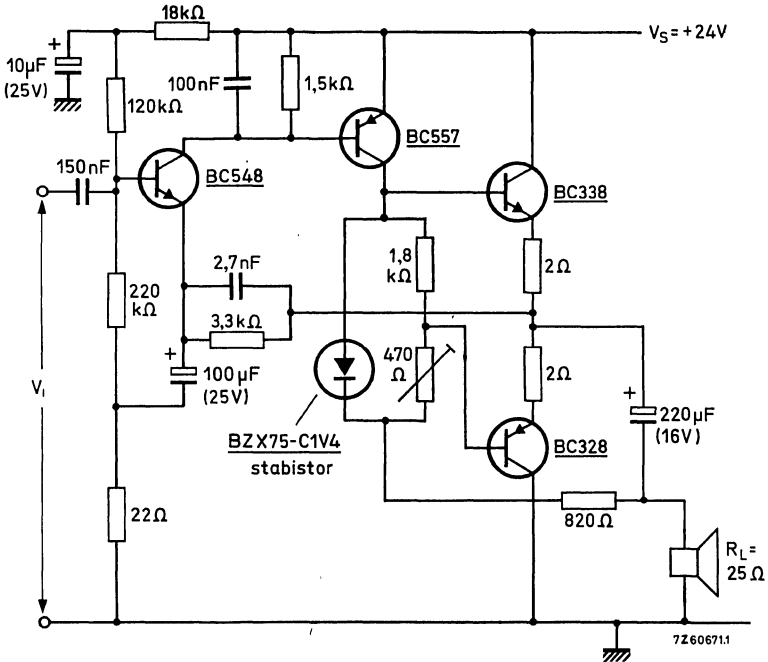


Fig. 9.

Performance at  $V_S = 24\text{ V}$ ;  $R_L = 25\ \Omega$

Collector quiescent current of BC338

$I_{CQ}$  typ. 1 mA

Input voltage for  $P_L = 50\text{ mW}$

$V_i$  typ. 8 mV

Input voltage for  $P_L = 2,8\text{ W}$

$V_i$  typ. 67 mV

Output power at  $f = 1\text{ kHz}$ ;  $d_{tot} = 10\%$

$P_L$  typ. 2,8 W

Frequency response (3 dB)

70 to 16 000 Hz

This amplifier needs no external cooling fin, provided each output transistor is mounted with its leads not longer than 3 mm. The collector lead must, in addition, be soldered to a copper area of at least 10 mm x 10 mm. (See page 2.)

APPLICATION INFORMATION (continued)

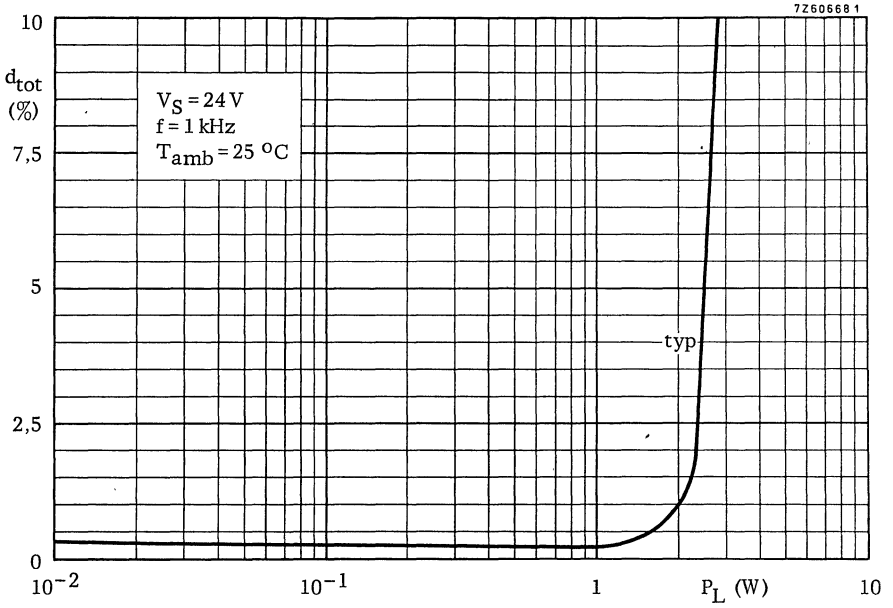


Fig. 10.

## SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in plastic TO-92 variant envelopes, primarily intended for use in driver and output stages of audio amplifiers.

The BC337, BC337A, BC338 are complementary to the BC327, BC327A and BC328 respectively.

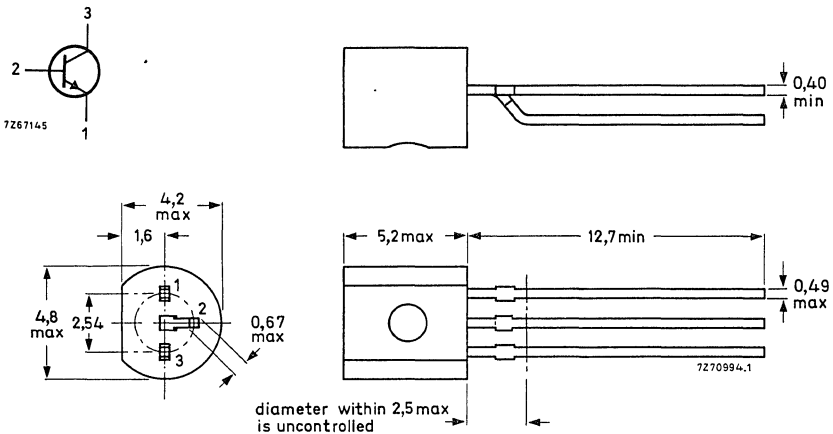
### QUICK REFERENCE DATA

		BC337	BC337A	BC338	
Collector-emitter voltage ( $V_{BE} = 0$ )	$V_{CES}$ max.	50	60	30	V
Collector-emitter voltage (open base)	$V_{CEO}$ max.	45	60	25	V
Collector current (peak value)	$I_{CM}$ max.	1000			mA
Total power dissipation up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$ max.	800			mW
Junction temperature	$T_j$ max.	150			$^{\circ}\text{C}$
Transition frequency at $f = 35\text{ MHz}$ $I_C = 10\text{ mA}; V_{CE} = 5\text{ V}$	$f_T$ typ.	100			MHz

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.





→ RATINGS

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

		BC337	BC337A	BC338	
Collector-emitter voltage ( $V_{BE} = 0$ )	$V_{CES}$ max.	50	60	30	V
Collector-emitter voltage (open base) $I_C = 10 \text{ mA}$	$V_{CEO}$ max.	45	60	25	V
Emitter-base voltage (open collector)	$V_{EBO}$ max.	5	5	5	V
Collector current (d.c.)	$I_C$ max.	500			mA
Collector current (peak value)	$I_{CM}$ max.	1000			mA
Emitter current (peak value)	$-I_{EM}$ max.	1000			mA
Base current (d.c.)	$I_B$ max.	100			mA
Base current (peak value)	$I_{BM}$ max.	200			mA
Total power dissipation at $T_{amb} = 25 \text{ }^\circ\text{C}$ up to $T_{amb} = 25 \text{ }^\circ\text{C}$	$P_{tot}$ max.	625			mW
	$P_{tot}$ max.	800			mW*
Storage temperature	$T_{stg}$	-65 to +150			$^\circ\text{C}$
Junction temperature	$T_j$ max.	150			$^\circ\text{C}$
<b>THERMAL RESISTANCE</b>					
From junction to ambient in free air	$R_{th j-a}$ =	0,2			K/mW
From junction to ambient	$\bar{R}_{th j-a}$ =	0,156			K/mW*

\* Transistor mounted on printed circuit board, max. lead length 4 mm, mounting pad for collector lead min. 10 mm x 10 mm.

## CHARACTERISTICS

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

Collector cut-off current

 $I_E = 0; V_{CB} = 20\text{ V}; T_j = 25\text{ }^\circ\text{C}$  $I_{CBO} < 100\text{ nA}$  $I_E = 0; V_{CB} = 20\text{ V}; T_j = 150\text{ }^\circ\text{C}$  $I_{CBO} < 5\text{ }\mu\text{A}$ 

Emitter cut-off current

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

Base emitter voltage\*

 $I_C = 500\text{ mA}; V_{CE} = 1\text{ V}$  $V_{BE} < 1,2\text{ V}$ 

Saturation voltage

 $I_C = 500\text{ mA}; I_B = 50\text{ mA}$  $V_{CEsat} < 700\text{ mV}$ 

D.C. current gain

 $I_C = 500\text{ mA}; V_{CE} = 1\text{ V}$  $h_{FE} > 40$  $I_C = 100\text{ mA}; V_{CE} = 1\text{ V}; \text{BC337; BC338}$  $h_{FE} 100\text{ to }600$ 

BC337A

 $h_{FE} 100\text{ to }400$ 

BC337-16 }

 $h_{FE} 100\text{ to }250$ 

BC338-16 }

BC337-25 }

 $h_{FE} 160\text{ to }400$ 

BC338-25 }

BC337-40 }

 $h_{FE} 250\text{ to }600$ 

BC338-40 }

Transition frequency at  $f = 35\text{ MHz}$  $I_C = 10\text{ mA}; V_{CE} = 5\text{ V}$  $f_T$  typ. 200 MHzCollector capacitance at  $f = 1\text{ MHz}$  $I_E = I_C = 0; V_{CB} = 10\text{ V}$  $C_C$  typ. 5 pF

D.C. current gain ratio of matched pairs

BC327/BC337; BC328/BC338

 $|I_C| = 100\text{ mA}; |V_{CE}| = 1\text{ V}$  $h_{FE1}/h_{FE2}$  typ. 1,25  
< 1,40\*  $V_{BE}$  decreases by about  $2\text{ mV}/^\circ\text{C}$  with increasing temperature.

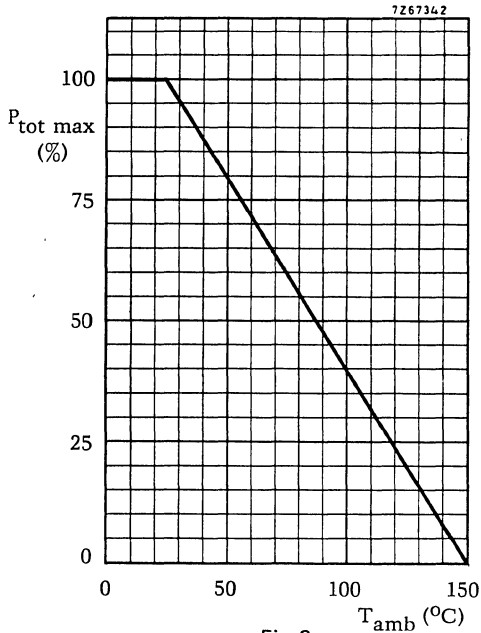


Fig. 2.

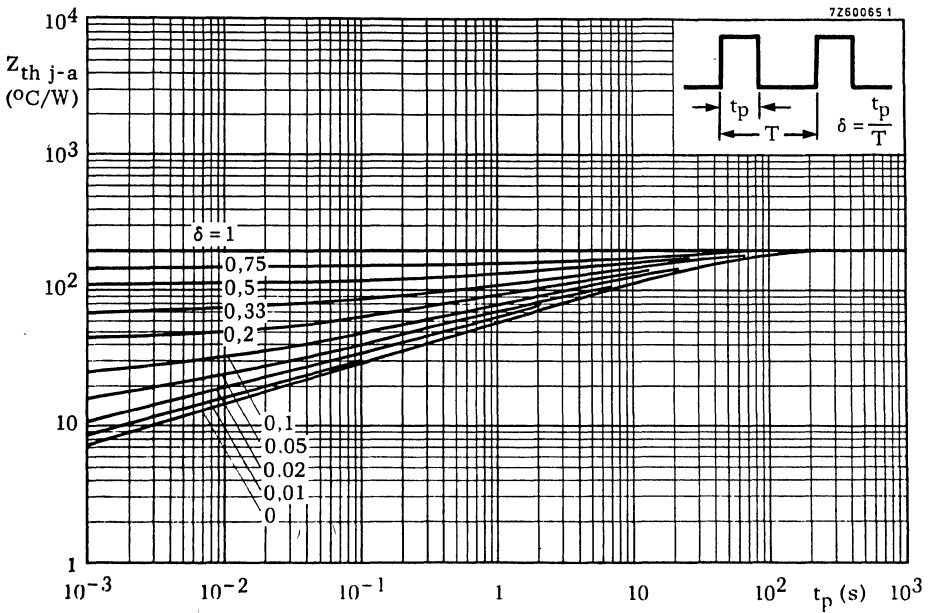


Fig. 3.

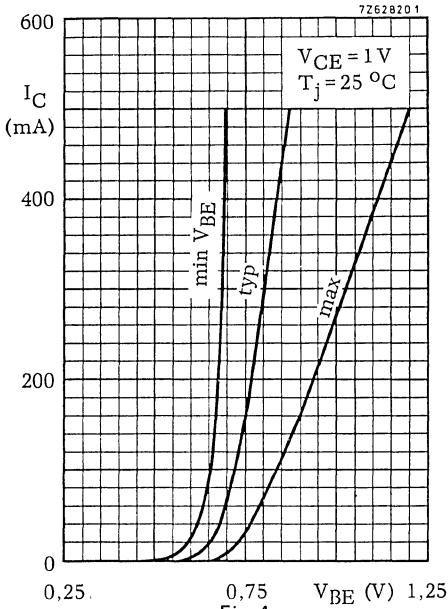


Fig. 4.

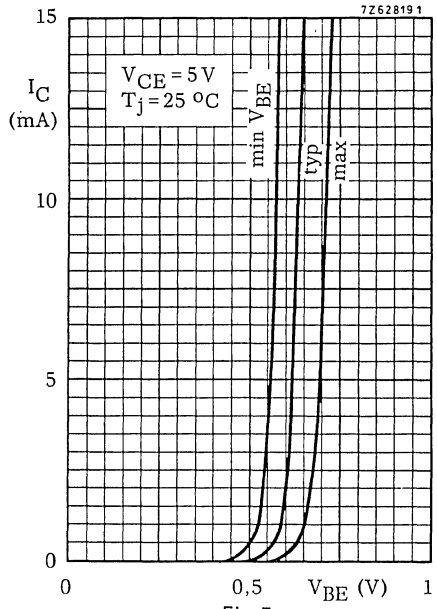


Fig. 5.

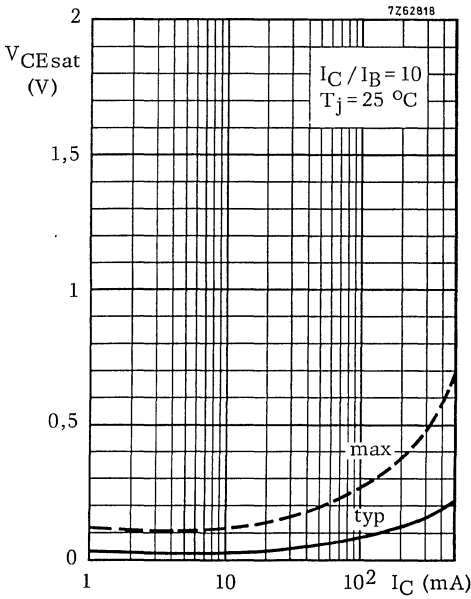


Fig. 6.

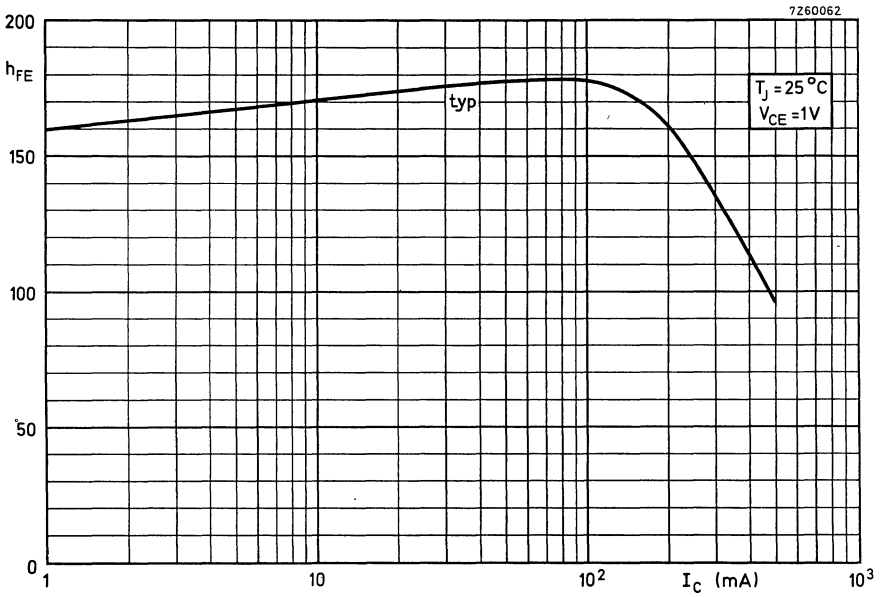


Fig. 7.

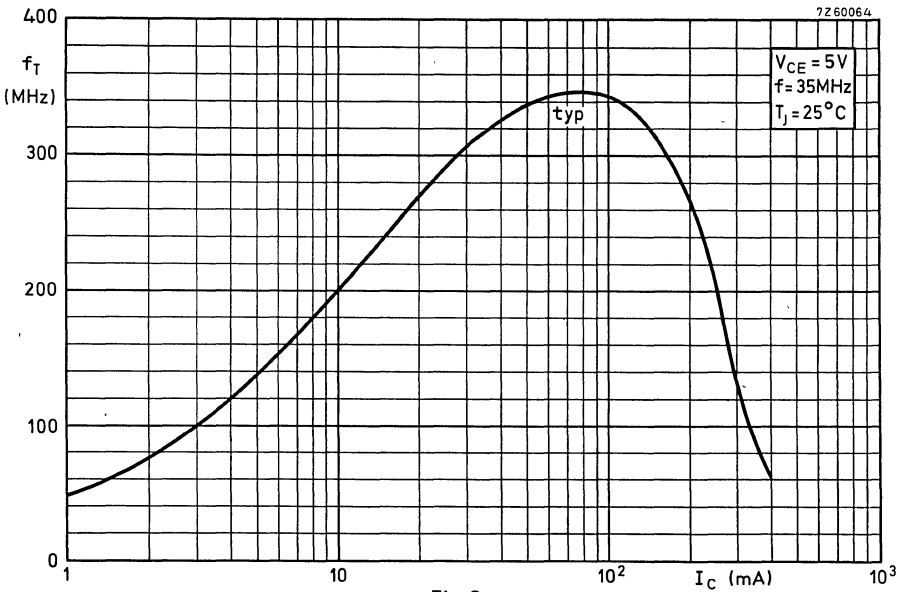


Fig. 8.

APPLICATION INFORMATION, see BC327; BC328.

## SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a plastic TO-92 variant, intended for low-voltage, high-current l.f. applications. BC368/BC369 is the matched complementary pair suitable for class-B audio output stages up to 3 W.

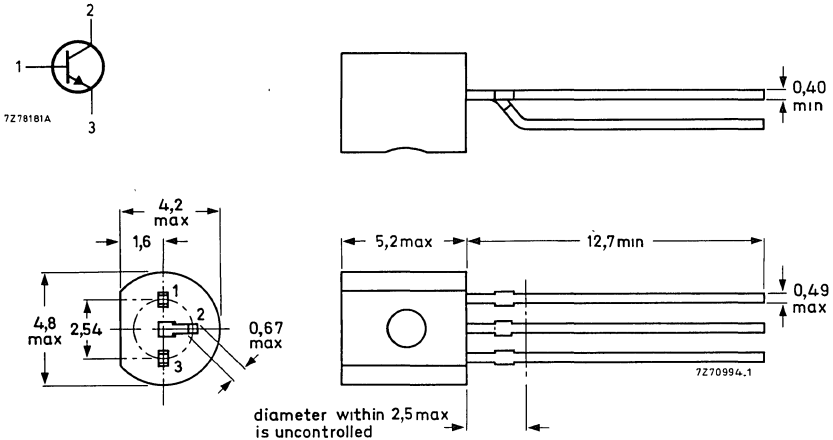
## QUICK REFERENCE DATA

Collector-emitter voltage ( $V_{BE} = 0$ )	$V_{CES}$	max.	25 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	20 V
Collector current (peak value)	$I_{CM}$	max.	2 A
Total power dissipation up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	1 W
Junction temperature	$T_j$	max.	150 $^{\circ}\text{C}$
D.C. current gain	$h_{FE}$		85 to 375
$I_C = 500\text{ mA}; V_{CE} = 1\text{ V}$			
Transition frequency at $f = 35\text{ MHz}$	$f_T$	typ.	60 MHz
$I_C = 10\text{ mA}; V_{CE} = 1\text{ V}$			

## MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



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

Voltages

Collector-emitter voltage ( $V_{BE} = 0$ )	$V_{CES}$	max.	25 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	20 V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	5 V

Currents

Collector current (d. c.)	$I_C$	max.	1 A
Collector current (peak value)	$I_{CM}$	max.	2 A
Base current (d. c.)	$I_B$	max.	100 mA
Base current (peak value)	$I_{BM}$	max.	200 mA

Power dissipation

Total power dissipation at $T_{amb} = 25\text{ }^\circ\text{C}$ (in free air)	$P_{tot}$	max.	0,8 W
up to $T_{amb} = 25\text{ }^\circ\text{C}$ <sup>1)</sup>	$P_{tot}$	max.	1 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 ambient in free air	$R_{th\ j-a}$	=	156 $^\circ\text{C}/\text{W}$
From junction to ambient <sup>1)</sup>	$R_{th\ j-a}$	=	125 $^\circ\text{C}/\text{W}$
From junction to case	$R_{th\ j-c}$	=	60 $^\circ\text{C}/\text{W}$

<sup>1)</sup> Transistor mounted on printed-circuit board, max. lead length 4 mm, mounting pad for collector lead min. 10 mm x 10 mm.

**CHARACTERISTICS**

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

Collector cut-off current

$I_E = 0; V_{CB} = 25\text{ V}$

$I_{CBO} < 10\text{ }\mu\text{A}$

$I_E = 0; V_{CB} = 25\text{ V}; T_j = 150\text{ }^\circ\text{C}$

$I_{CBO} < 1\text{ mA}$

Emitter cut-off current

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

$I_{EBO} < 10\text{ }\mu\text{A}$

Base-emitter voltage

$I_C = 5\text{ mA}; V_{CE} = 10\text{ V}$

$V_{BE} \text{ typ. } 0,62\text{ V}$

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

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

Collector-emitter saturation voltage

$I_C = 1\text{ A}; I_B = 100\text{ mA}$

$V_{CEsat} < 0,5\text{ V}$

D.C. current gain

$I_C = 5\text{ mA}; V_{CE} = 10\text{ V}$

$h_{FE} > 50$

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

$h_{FE} \text{ 85 to 375}$

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

$h_{FE} > 60$

Collector capacitance at  $f = 450\text{ kHz}$

$I_E = I_e = 0; V_{CB} = 5\text{ V}$

$C_c \text{ typ. } 27\text{ pF}$

Cut-off frequency

$I_C = 10\text{ mA}; V_{CE} = 5\text{ V}$

$f_{hfe} \text{ typ. } 400\text{ kHz}$

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

$I_C = 10\text{ mA}; V_{CE} = 5\text{ V}$

$f_T \text{ typ. } 60\text{ MHz}$

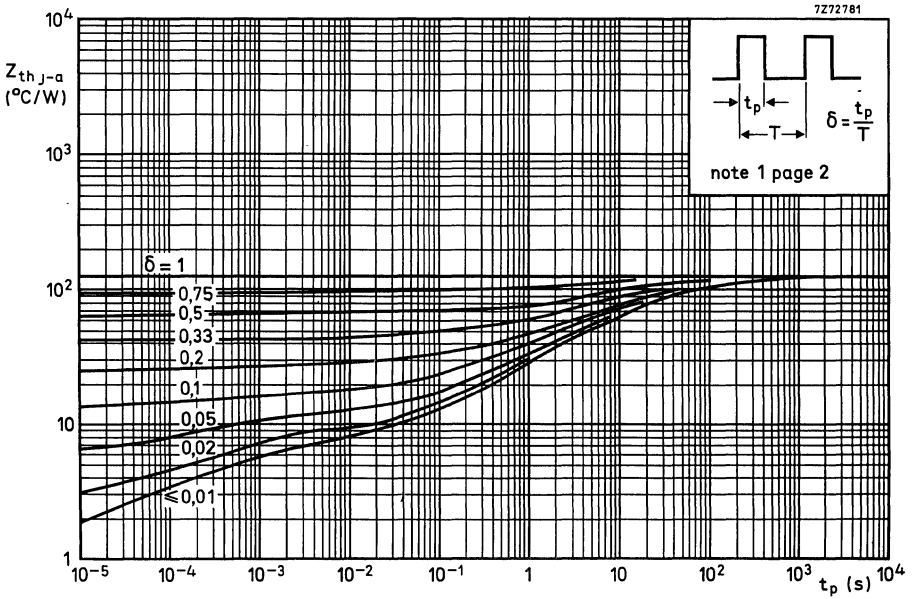
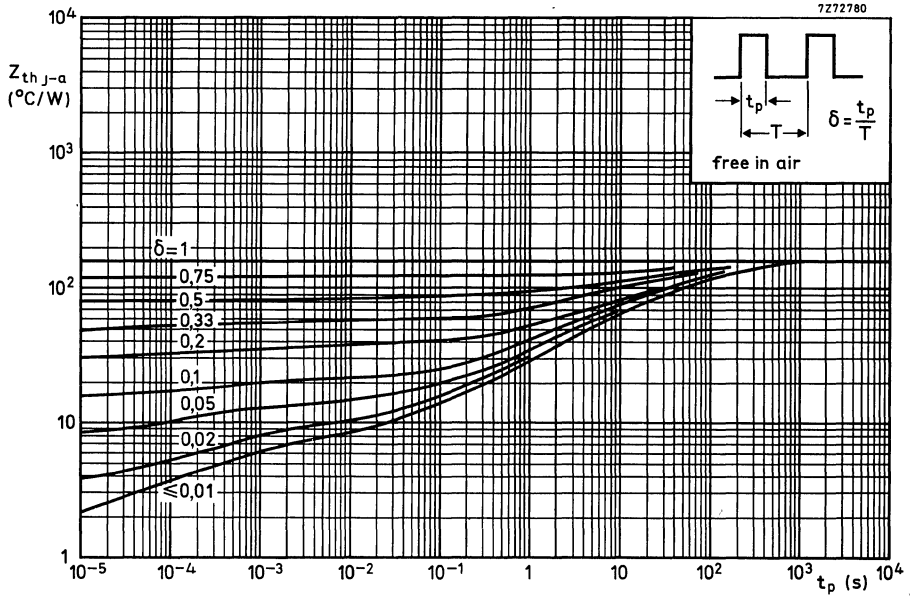
D.C. current gain ratio of matched pair BC368/BC369

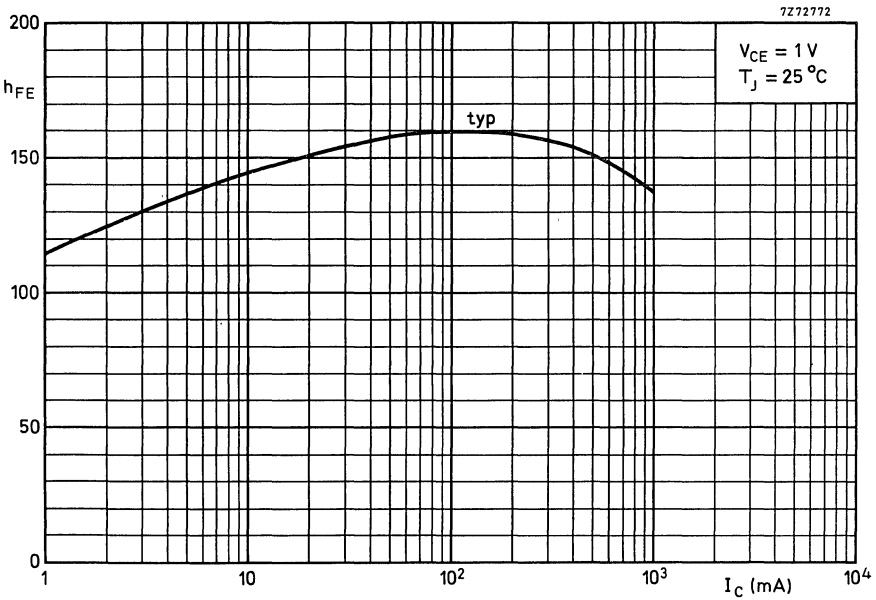
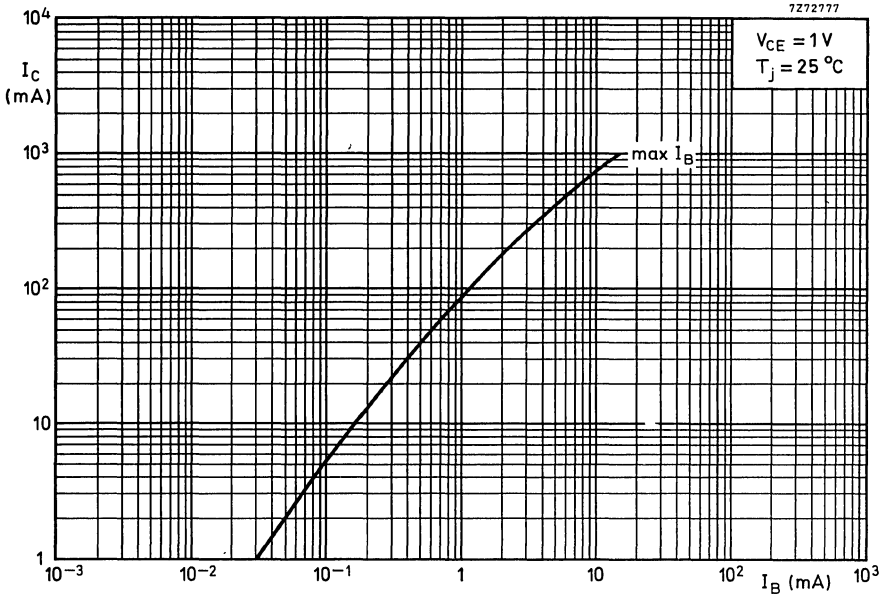
$|I_C| = 500\text{ mA}; |V_{CE}| = 1\text{ V}$

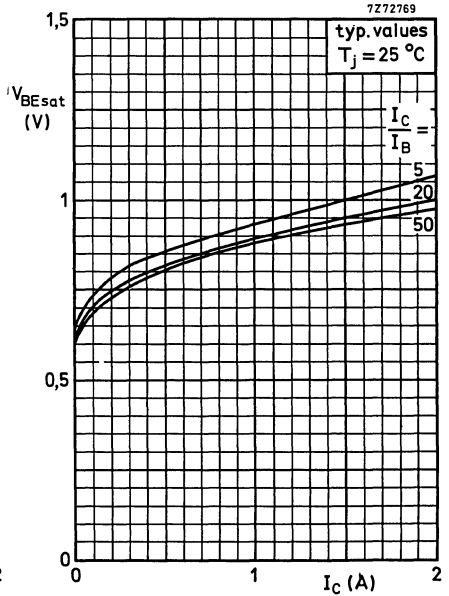
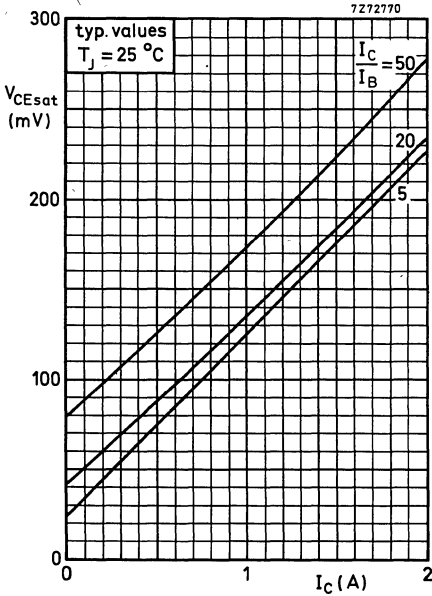
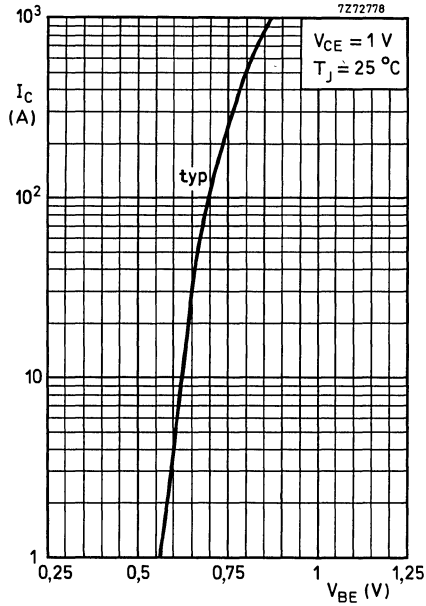
$h_{FE1}/h_{FE2} < 1,4$

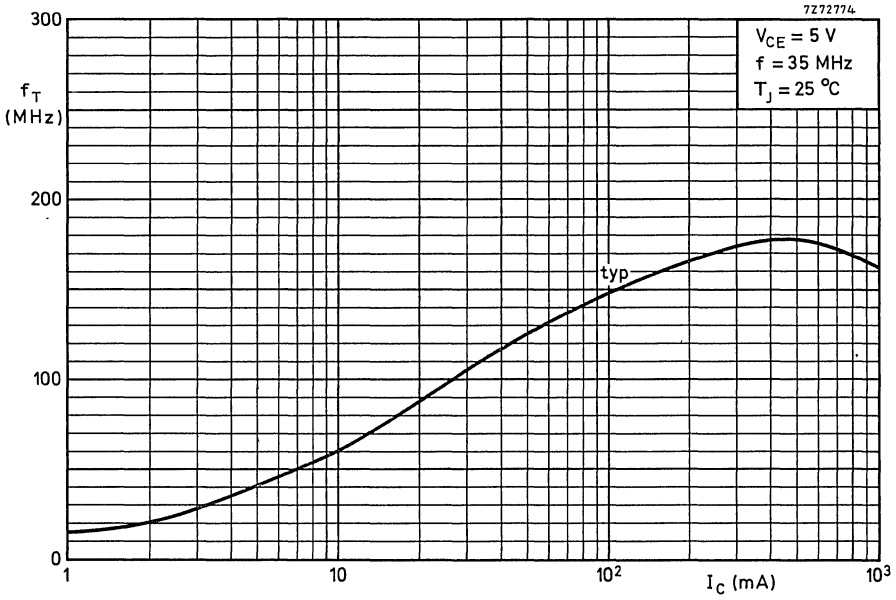














## SILICON PLANAR EPITAXIAL TRANSISTOR

P-N-P transistor in a plastic TO-92 variant, intended for low-voltage, high-current l.f. applications. BC368/BC369 is the matched complementary pair suitable for class-B output stages up to 3 W.

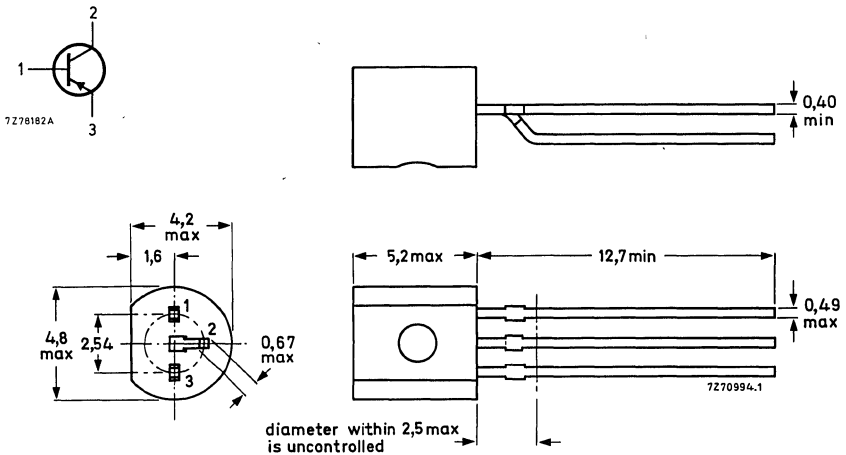
## QUICK REFERENCE DATA

Collector-emitter voltage ( $V_{BE} = 0$ )	$-V_{CES}$ max.	25 V
Collector-emitter voltage (open base)	$-V_{CEO}$ max.	20 V
Collector current (peak value)	$-I_{CM}$ max.	2 A
Total power dissipation up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$ max.	1 W
Junction temperature	$T_j$ max.	150 $^{\circ}\text{C}$
D.C. current gain $-I_C = 500\text{ mA}; -V_{CE} = 1\text{ V}$	$h_{FE}$	85 to 375
Transition frequency at $f = 35\text{ MHz}$ $-I_C = 10\text{ mA}; -V_{CE} = 1\text{ V}$	$f_T$ typ.	60 MHz

## MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



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

Voltages

Collector-emitter voltage ( $V_{BE} = 0$ )	$-V_{CES}$	max.	25	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	V

Currents

Collector current (d. c.)	$-I_C$	max.	1	A
Collector current (peak value)	$-I_{CM}$	max.	2	A
Base current (d. c.)	$-I_B$	max.	100	mA
Base current (peak value)	$-I_{BM}$	max.	200	mA

Power dissipation

Total power dissipation at $T_{amb} = 25\text{ }^{\circ}\text{C}$ (in free air)	$P_{tot}$	max.	0,8	W
up to $T_{amb} = 25\text{ }^{\circ}\text{C}$ <sup>1)</sup>	$P_{tot}$	max.	1	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 ambient in free air	$R_{th\ j-a}$	=	156	$^{\circ}\text{C}/\text{W}$
From junction to ambient <sup>1)</sup>	$R_{th\ j-a}$	=	125	$^{\circ}\text{C}/\text{W}$
From junction to case	$R_{th\ j-c}$	=	60	$^{\circ}\text{C}/\text{W}$

<sup>1)</sup> Transistor mounted on printed-circuit board, max. lead length 4 mm, mounting pad for collector lead min. 10 mm x 10 mm.

**CHARACTERISTICS**

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

Collector cut-off current

$I_E = 0; -V_{CB} = 25\text{ V}$	$-I_{CBO}$	<	10 $\mu\text{A}$
$I_E = 0; -V_{CB} = 25\text{ V}; T_j = 150\text{ }^\circ\text{C}$	$-I_{CBO}$	<	1 mA

Emitter cut-off current

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

$-I_C = 5\text{ mA}; -V_{CE} = 10\text{ V}$	$-V_{BE}$	typ.	0,62 V
$-I_C = 1\text{ A}; -V_{CE} = 1\text{ V}$	$-V_{BE}$	<	1 V

Collector-emitter saturation voltage

$-I_C = 1\text{ A}; -I_B = 100\text{ mA}$	$-V_{CEsat}$	<	0,5 V
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D. C. current gain

$-I_C = 5\text{ mA}; -V_{CE} = 10\text{ V}$	$h_{FE}$	>	50
$-I_C = 500\text{ mA}; -V_{CE} = 1\text{ V}$	$h_{FE}$		85 to 375
$-I_C = 1\text{ A}; -V_{CE} = 1\text{ V}$	$h_{FE}$	>	60

Collector capacitance at  $f = 450\text{ kHz}$

$I_E = I_e = 0; -V_{CB} = 5\text{ V}$	$C_c$	typ.	45 pF
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Cut-off frequency

$-I_C = 10\text{ mA}; -V_{CE} = 5\text{ V}$	$f_{hfe}$	typ.	350 kHz
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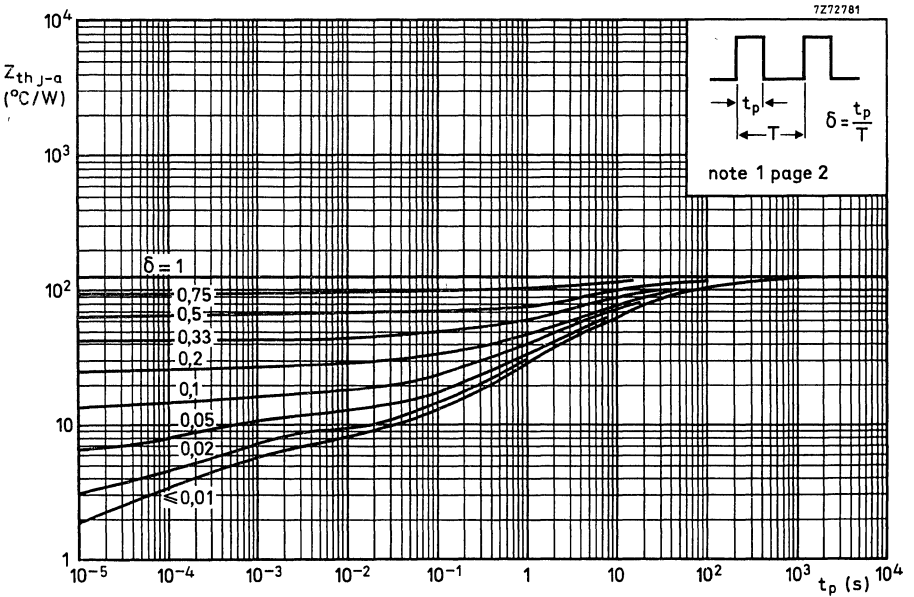
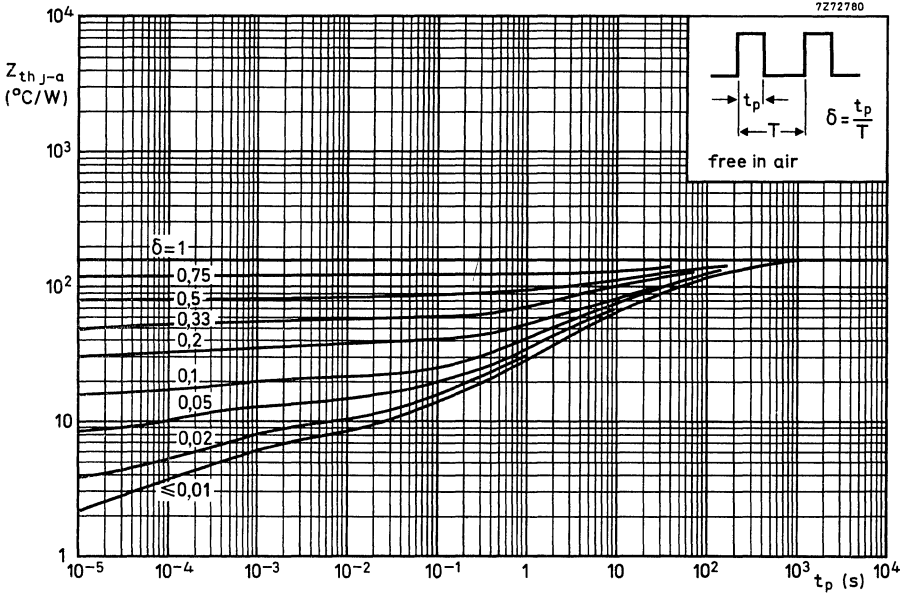
Transition frequency at  $f = 35\text{ MHz}$

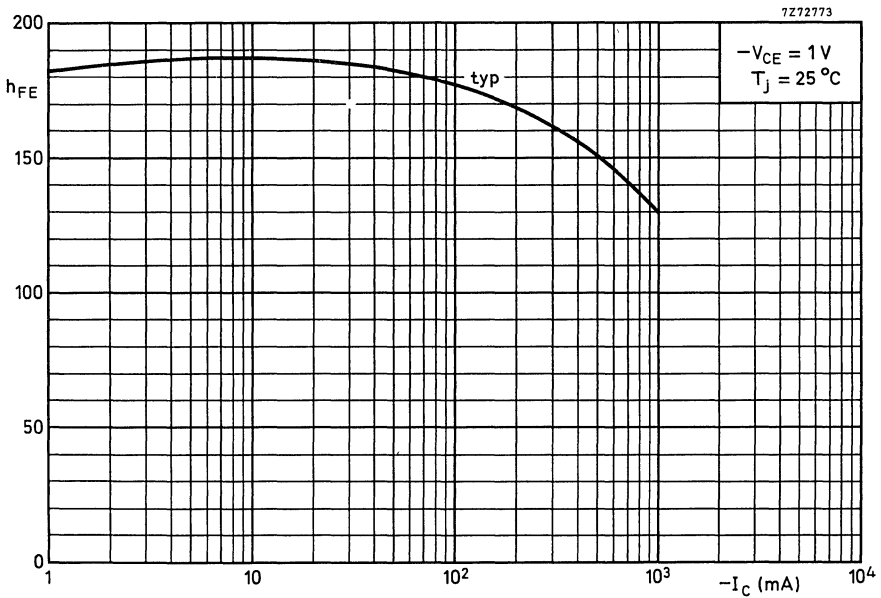
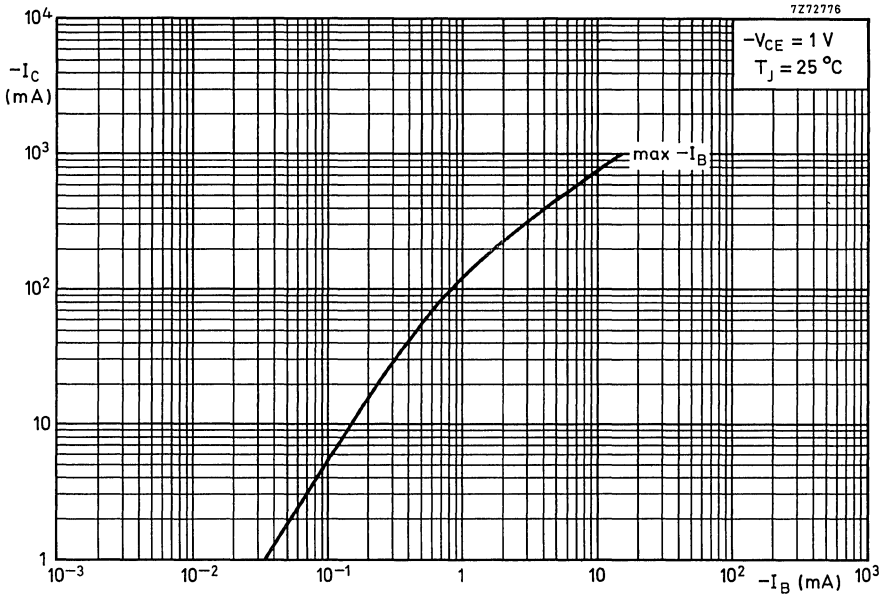
$-I_C = 10\text{ mA}; -V_{CE} = 5\text{ V}$	$f_T$	typ.	60 MHz
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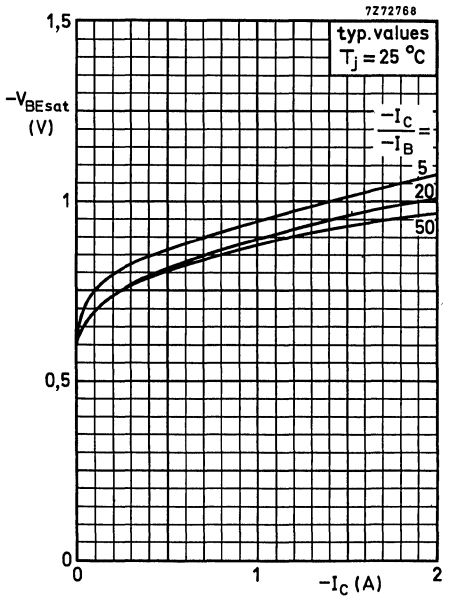
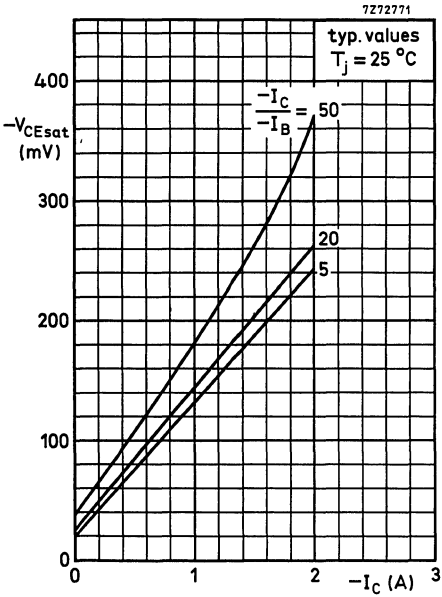
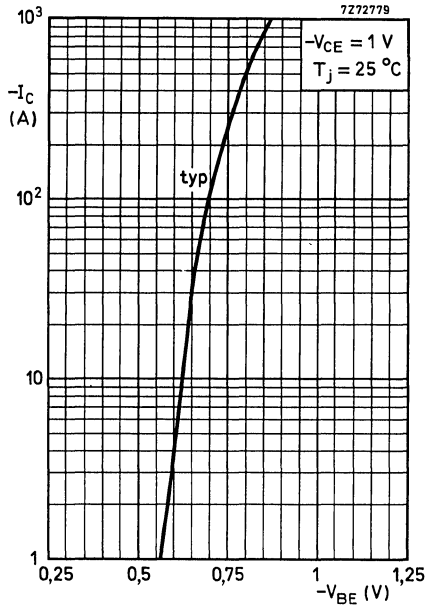
D. C. current gain ratio of matched pair BC368/BC369

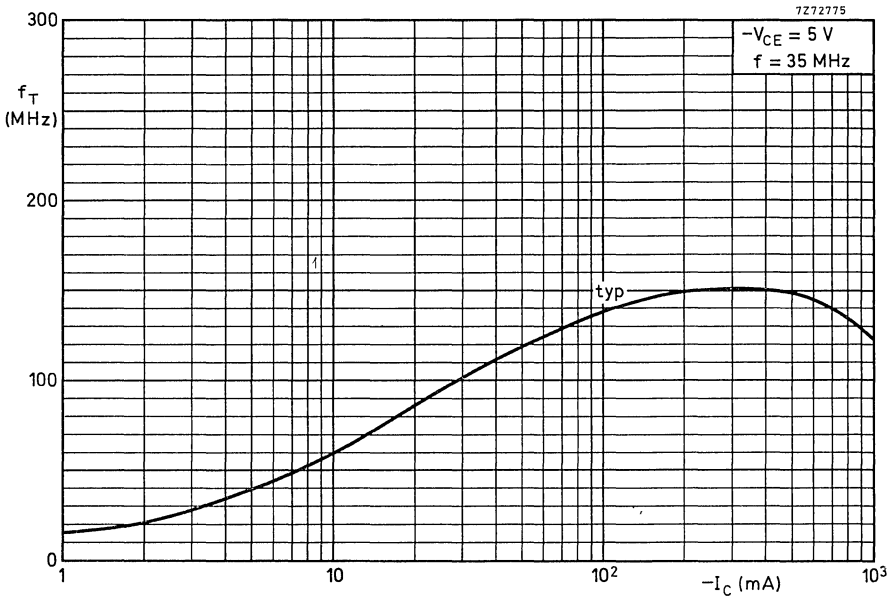
$ I_C  = 500\text{ mA};  V_{CE}  = 1\text{ V}$	$h_{FE1}/h_{FE2}$	<	1,4
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## SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a plastic TO-92 variant, intended for low-voltage, high-current l.f. applications. BC375/BC376 is the matched complementary pair suitable for output stages up to 2 W.

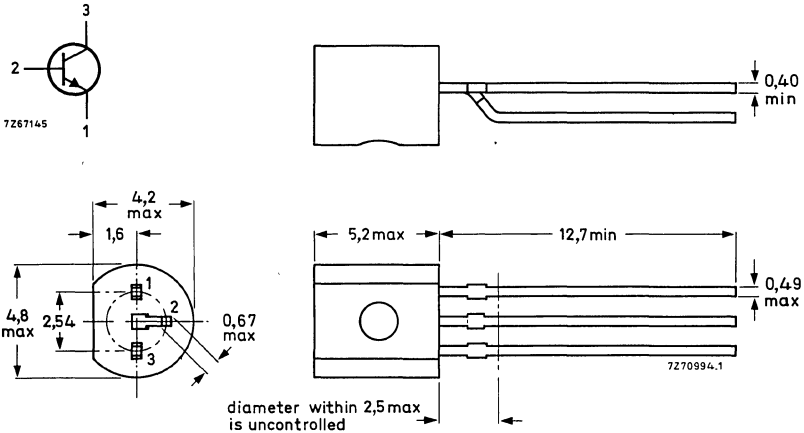
## QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$V_{CBO}$	max.	25 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	20 V
Collector current (peak value)	$I_{CM}$	max.	1,5 A
Total power dissipation up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	800 mW
Junction temperature	$T_j$	max.	150 $^{\circ}\text{C}$
D.C. current gain	$h_{FE}$		60 to 340
$I_C = 150\text{ mA}$ ; $V_{CE} = 1\text{ V}$			
Transition frequency at $f = 35\text{ MHz}$	$f_T$	typ.	150 MHz
$I_C = 150\text{ mA}$ ; $V_{CE} = 1\text{ V}$			

## MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



**RATINGS**

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

Collector-base voltage (open emitter)	$V_{CBO}$	max.	25 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	20 V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	5 V
Collector current (d.c.)	$I_C$	max.	1 A
Collector current (peak value)	$I_{CM}$	max.	1,5 A
Base current (d.c.)	$I_B$	max.	100 mA
Base current (peak value)	$I_{BM}$	max.	200 mA
Total power dissipation			
at $T_{amb} = 25\text{ }^\circ\text{C}$ (in free air)	$P_{tot}$	max.	625 mW
up to $T_{amb} = 25\text{ }^\circ\text{C}^*$	$P_{tot}$	max.	800 mW
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	$R_{th\ j-a}$	=	200 K/W
From junction to ambient *	$R_{th\ j-a}$	=	156 K/W
From junction to case	$R_{th\ j-c}$	=	95 K/W

**CHARACTERISTICS**

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

Collector cut-off current			
$I_E = 0; V_{CB} = 20\text{ V}$	$I_{CBO}$	<	100 nA
$I_E = 0; V_{CB} = 20\text{ V}; T_j = 150\text{ }^\circ\text{C}$	$I_{CBO}$	<	5 $\mu\text{A}$
Emitter cut-off current			
$I_C = 0; V_{EB} = 5\text{ V}$	$I_{EBO}$	<	10 $\mu\text{A}$
Base-emitter voltage**			
$I_C = 5\text{ mA}; V_{CE} = 10\text{ V}$	$V_{BE}$	typ.	650 mV
$I_C = 700\text{ mA}; V_{CE} = 1\text{ V}$	$V_{BE}$	<	1000 mV
Collector-emitter saturation voltage			
$I_C = 700\text{ mA}; I_B = 70\text{ mA}$	$V_{CEsat}$	typ.	250 mV
		<	500 mV
D.C. current gain			
$I_C = 5\text{ mA}; V_{CE} = 10\text{ V}$	$h_{FE}$	>	55
$I_C = 150\text{ mA}; V_{CE} = 1\text{ V}$	$h_{FE}$		60 to 340
$I_C = 700\text{ mA}; V_{CE} = 1\text{ V}$	$h_{FE}$	>	35
Transition frequency at $f = 35\text{ MHz}$			
$I_C = 150\text{ mA}; V_{CE} = 1\text{ V}$	$f_T$	typ.	150 MHz
D.C. current gain ratio of matched pair BC375/BC376			
$ I_C  = 150\text{ mA};  V_{CE}  = 1\text{ V}$	$h_{FE1}/h_{FE2}$	<	2

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

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

## SILICON PLANAR EPITAXIAL TRANSISTOR

P-N-P transistor in a plastic TO-92 variant, intended for low-voltage, high-current l.f. applications. BC375/BC376 is the matched complementary pair suitable for output stages up to 2 W.

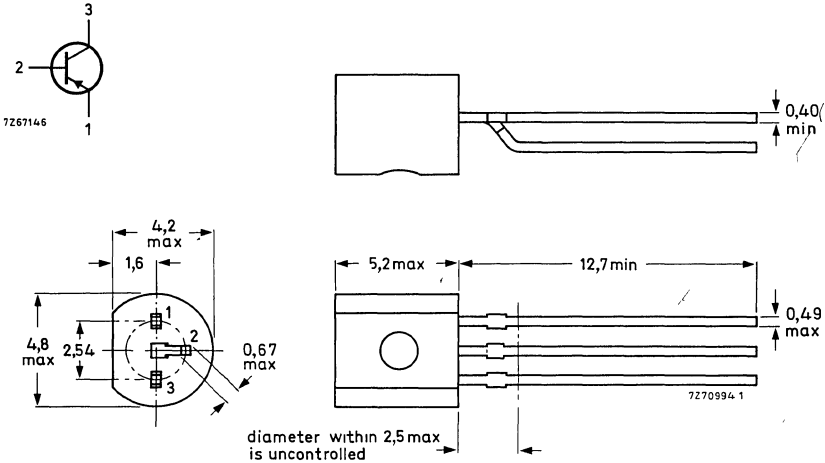
### QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	25 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20 V
Collector current (peak value)	$-I_{CM}$	max.	1,5 A
Total power dissipation up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	800 mW
Junction temperature	$T_j$	max.	150 $^{\circ}\text{C}$
D.C. current gain	$h_{FE}$		60 to 340
Transition frequency at $f = 35\text{ MHz}$	$f_T$	typ.	150 MHz

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.





**RATINGS**

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

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	25 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20 V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5 V
Collector current (d.c.)	$-I_C$	max.	1 A
Collector current (peak value)	$-I_{CM}$	max.	1,5 A
Base current (d.c.)	$-I_B$	max.	100 mA
Base current (peak value)	$-I_{BM}$	max.	200 mA
Total power dissipation at $T_{amb} = 25\text{ }^\circ\text{C}$ (in free air)	$P_{tot}$	max.	625 mW
up to $T_{amb} = 25\text{ }^\circ\text{C}^*$	$P_{tot}$	max.	800 mW
Storage temperature	$T_{stg}$		$-65$ to $+150\text{ }^\circ\text{C}$
Junction temperature	$T_j$	max.	150 $^\circ\text{C}$

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th\ j-a}$	=	200 K/W
From junction to ambient *	$R_{th\ j-a}$	=	156 K/W
From junction to case	$R_{th\ j-c}$		95 K/W

**CHARACTERISTICS**

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

Collector cut-off current

$I_E = 0; -V_{CB} = 20\text{ V}$	$-I_{CBO}$	<	100 nA
$I_E = 0; -V_{CB} = 20\text{ V}; T_j = 150\text{ }^\circ\text{C}$	$-I_{CBO}$	<	5 $\mu\text{A}$

Emitter cut-off current

$I_C = 0; -V_{EB} = 5\text{ V}$	$-I_{EBO}$	<	10 $\mu\text{A}$
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Base-emitter voltage\*\*

$-I_C = 5\text{ mA}; -V_{CE} = 10\text{ V}$	$-V_{BE}$	typ.	650 mV
$-I_C = 700\text{ mA}; -V_{CE} = 1\text{ V}$	$-V_{BE}$	<	1000 mV

Collector-emitter saturation voltage

$-I_C = 700\text{ mA}; -I_B = 70\text{ mA}$	$-V_{CEsat}$	typ.	280 mV
		<	500 mV

D.C. current gain

$-I_C = 5\text{ mA}; -V_{CE} = 10\text{ V}$	$h_{FE}$	>	55
$-I_C = 150\text{ mA}; -V_{CE} = 1\text{ V}$	$h_{FE}$		60 to 340
$-I_C = 700\text{ mA}; -V_{CE} = 1\text{ V}$	$h_{FE}$	>	35

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

$-I_C = 150\text{ mA}; -V_{CE} = 1\text{ V}$	$f_T$	typ.	150 MHz
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D.C. current gain ratio of matched pair BC375/BC376

$ I_C  = 150\text{ mA};  V_{CE}  = 1\text{ V}$	$h_{FE1}/h_{FE2}$	<	2
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\* Transistor mounted on printed-circuit board, maximum lead length 4 mm, mounting pad for collector lead minimum 10 mm x 10 mm.

\*\*  $-V_{BE}$  decreases by about 2 mV/K with increasing temperature.

## SILICON PLANAR EPITAXIAL TRANSISTORS

General purpose n-p-n transistors in a plastic TO-92 variant, especially suitable for use in driver stages of audio amplifiers.

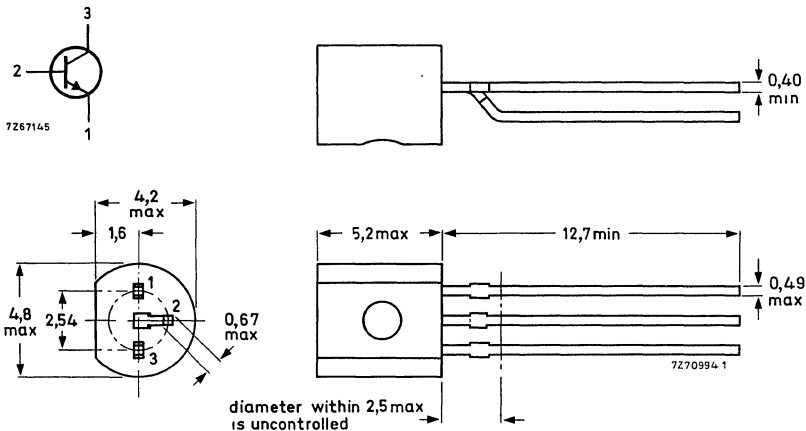
## QUICK REFERENCE DATA

	BC546	BC547	BC548
Collector-emitter voltage ( $V_{BE} = 0$ )	$V_{CES}$ max. 80	50	30 V
Collector-emitter voltage (open base)	$V_{CEO}$ max. 65	45	30 V
Collector current (peak value)	$I_{CM}$ max. 200	200	200 mA
Total power dissipation up to $T_{amb} = 25^\circ\text{C}$	$P_{tot}$ max. 500	500	500 mW
Junction temperature	$T_j$ max. 150	150	150 $^\circ\text{C}$
Small-signal current gain $I_C = 2\text{ mA}; V_{CE} = 5\text{ V}; f = 1\text{ kHz}$	$h_{fe} >$	125	125
	$h_{fe} <$	500	900
Transition frequency $I_C = 10\text{ mA}; V_{CE} = 5\text{ V}$	$f_T$ typ. 300	300	300 MHz
Noise figure at $R_S = 2\text{ k}\Omega$ $I_C = 200\ \mu\text{A}; V_{CE} = 5\text{ V}$ $f = 1\text{ kHz}; B = 200\text{ Hz}$	F typ. 2	2	2 dB

## MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



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

		BC546	BC547	BC548	
<u>Voltage</u>					
Collector-base voltage (open emitter)	$V_{CBO}$ max.	80	50	30	V
Collector-emitter voltage ( $V_{BE} = 0$ )	$V_{CES}$ max.	80	50	30	V
Collector-emitter voltage (open base)	$V_{CEO}$ max.	65	45	30	V
Emitter-base voltage (open collector)	$V_{EBO}$ max.	6	6	5	V
<u>Current</u>					
Collector current (d. c.)	$I_C$	max.	100		mA
Collector current (peak value)	$I_{CM}$	max.	200		mA
Emitter current (peak value)	$-I_{EM}$	max.	200		mA
Base current (peak value)	$I_{BM}$	max.	200		mA
<u>Power dissipation</u>					
Total power dissipation up to $T_{amb} = 25^\circ C$	$P_{tot}$	max.	500		mW
<u>Temperature</u>					
Storage temperature	$T_{stg}$		-65 to +150		$^\circ C$
Junction temperature	$T_j$	max.	150		$^\circ C$
<b>THERMAL RESISTANCE</b>					
From junction to ambient in free air	$R_{th j-a}$	=	0,25		$^\circ C/mW$
From junction to case	$R_{th j-c}$	=	0,15		$^\circ C/mW$

**CHARACTERISTICS**

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

Collector cut-off current

$I_E = 0; V_{CB} = 30\text{ V}$   
 $I_E = 0; V_{CB} = 30\text{ V}; T_j = 150\text{ }^\circ\text{C}$

$I_{CBO} < 15\text{ nA}$   
 $I_{CBO} < 5\text{ }\mu\text{A}$

Base-emitter voltage <sup>1)</sup>

$I_C = 2\text{ mA}; V_{CE} = 5\text{ V}$

$V_{BE}$  typ. 660 mV  
 580 to 700 mV

$I_C = 10\text{ mA}; V_{CE} = 5\text{ V}$

$V_{BE} < 770\text{ mV}$

Saturation voltage <sup>2)</sup>

$I_C = 10\text{ mA}; I_B = 0.5\text{ mA}$

$V_{CEsat}$  typ. 90 mV  
 $< 250\text{ mV}$

$V_{BEsat}$  typ. 700 mV

$I_C = 100\text{ mA}; I_B = 5\text{ mA}$

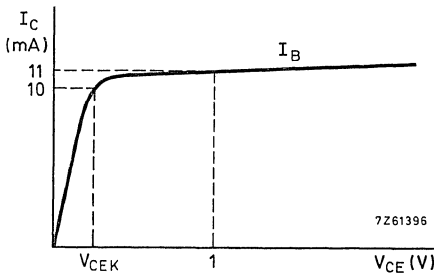
$V_{CEsat}$  typ. 200 mV  
 $< 600\text{ mV}$

$V_{BEsat}$  typ. 900 mV

Knee voltage

$I_C = 10\text{ mA}; I_B = \text{value for which}$   
 $I_C = 11\text{ mA at } V_{CE} = 1\text{ V}$

$V_{CEK}$  typ. 300 mV  
 $< 600\text{ mV}$



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

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

$C_c$  typ. 2,5 pF  
 $< 4,5\text{ pF}$

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

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

$C_e$  typ. 9 pF

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

$I_C = 10\text{ mA}; V_{CE} = 5\text{ V}$

$f_T$  typ. 300 MHz

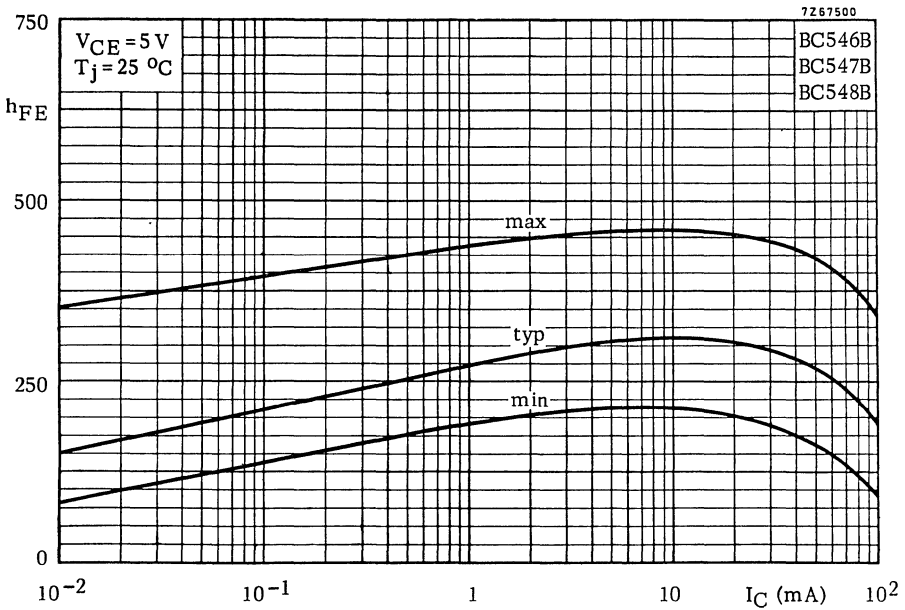
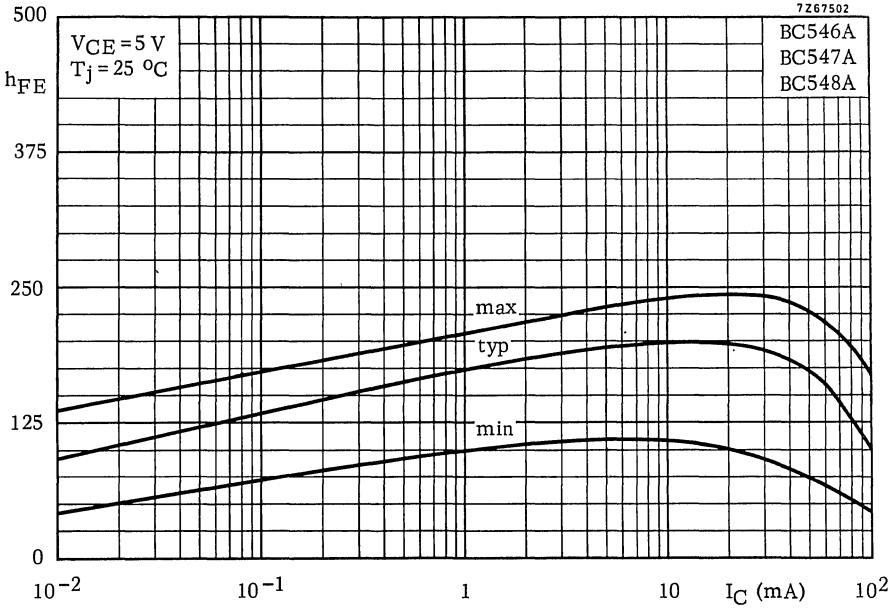
1)  $V_{BE}$  decreases by about  $2\text{ mV}/^\circ\text{C}$  with increasing temperature.

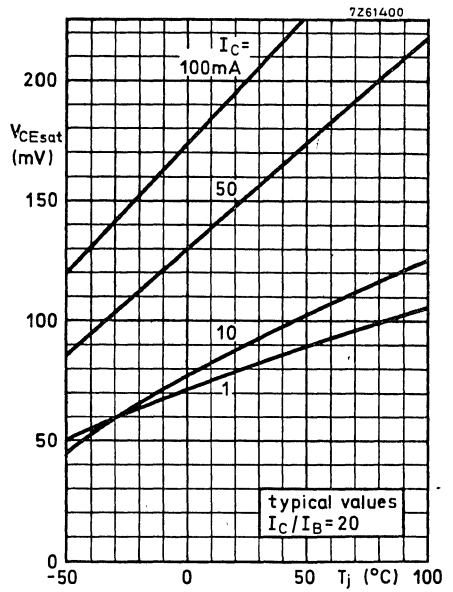
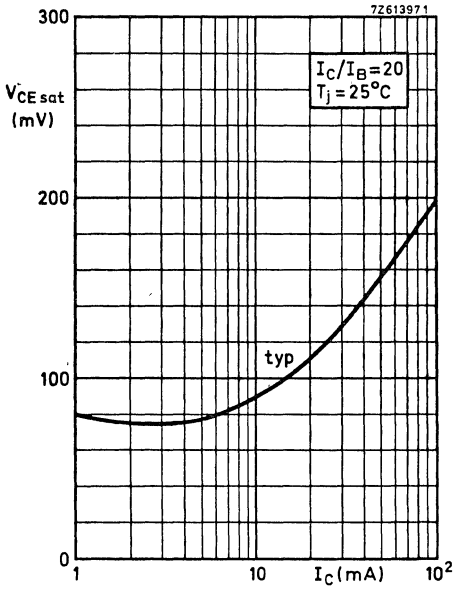
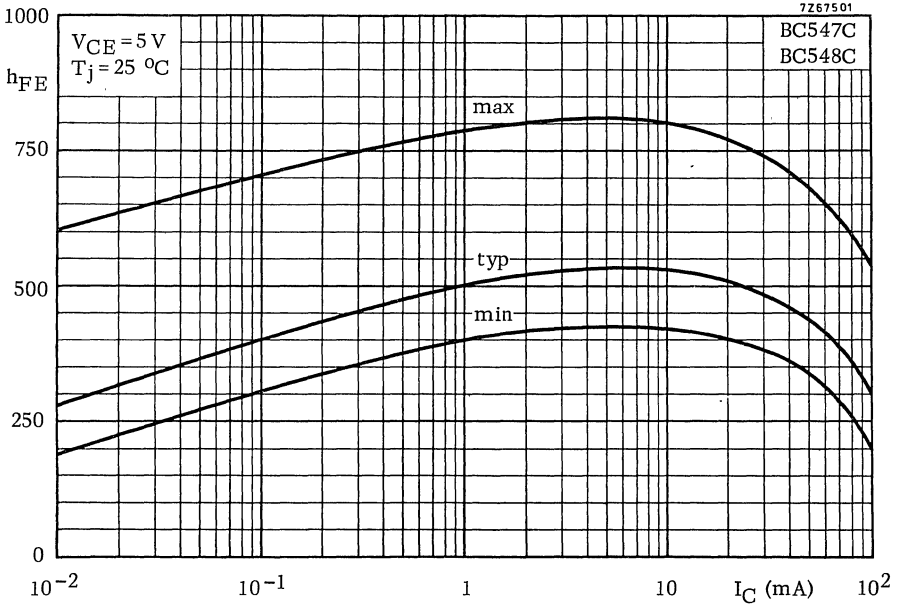
2)  $V_{BEsat}$  decreases by about  $1,7\text{ mV}/^\circ\text{C}$  with increasing temperature.

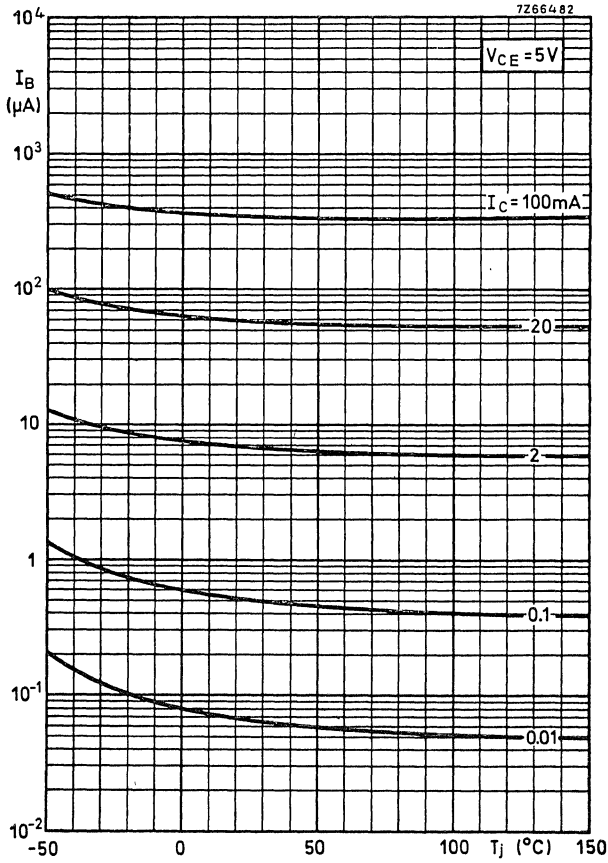
CHARACTERISTICS (continued)

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

		BC546	BC547	BC548
<u>Small signal current gain</u> at $f = 1\text{ kHz}$				
$I_C = 2\text{ mA}; V_{CE} = 5\text{ V}$	$h_{fe}$	125	125	125
	>	500	900	900
	<			
<u>Noise figure</u> at $R_S = 2\text{ k}\Omega$				
$I_C = 200\text{ }\mu\text{A}; V_{CE} = 5\text{ V}$	F	2	2	2 dB
$f = 1\text{ kHz}; B = 200\text{ Hz}$	>	10	10	10 dB
	<			
		BC546A	BC546B	
		BC547A	BC547B	BC547C
		BC548A	BC548B	BC548C
<u>D. C. current gain</u>				
$I_C = 10\text{ }\mu\text{A}; V_{CE} = 5\text{ V}$	$h_{FE}$	90	150	270
	>	110	200	420
	<			
$I_C = 2\text{ mA}; V_{CE} = 5\text{ V}$	$h_{FE}$	180	290	520
	>	220	450	800
	<			
<u>h parameters</u> at $f = 1\text{ kHz}$ (common emitter)				
$I_C = 2\text{ mA}; V_{CE} = 5\text{ V}$				
Input impedance	$h_{ie}$	1,6	3,2	6 $\text{k}\Omega$
	>	2,7	4,5	8,7 $\text{k}\Omega$
	<	4,5	8,5	15 $\text{k}\Omega$
Reverse voltage transfer ratio	$h_{re}$	1,5	2	3 $10^{-4}$
	>	125	240	450
	<			
Small signal current gain	$h_{fe}$	220	330	600
	>	260	500	900
	<			
Output admittance	$h_{oe}$	18	30	60 $\mu\text{A}/\text{V}$
	>	30	60	110 $\mu\text{A}/\text{V}$
	<			

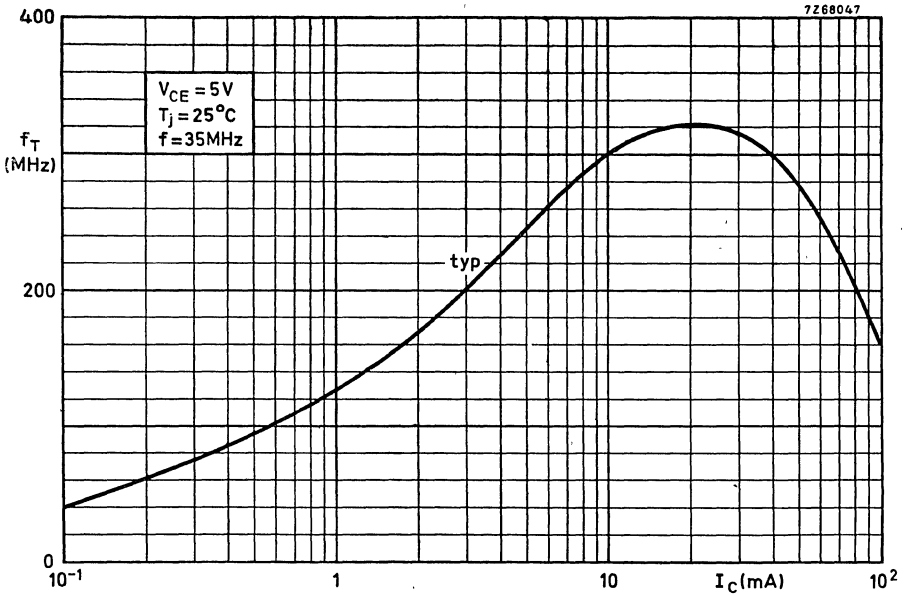
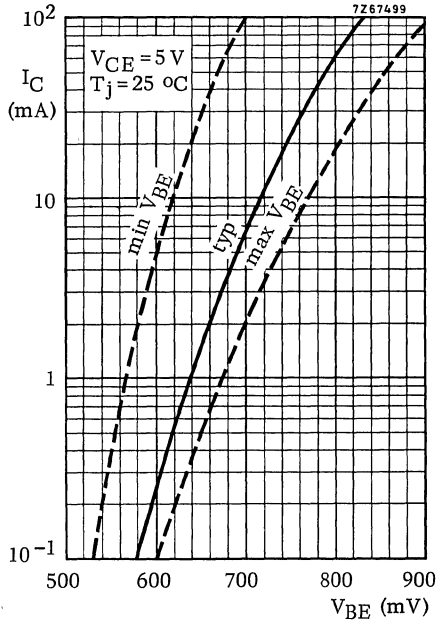


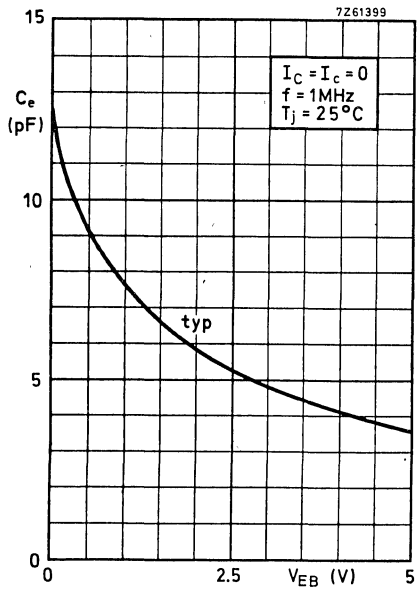
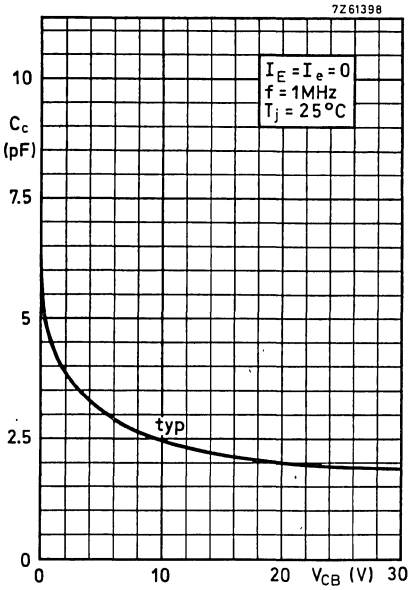




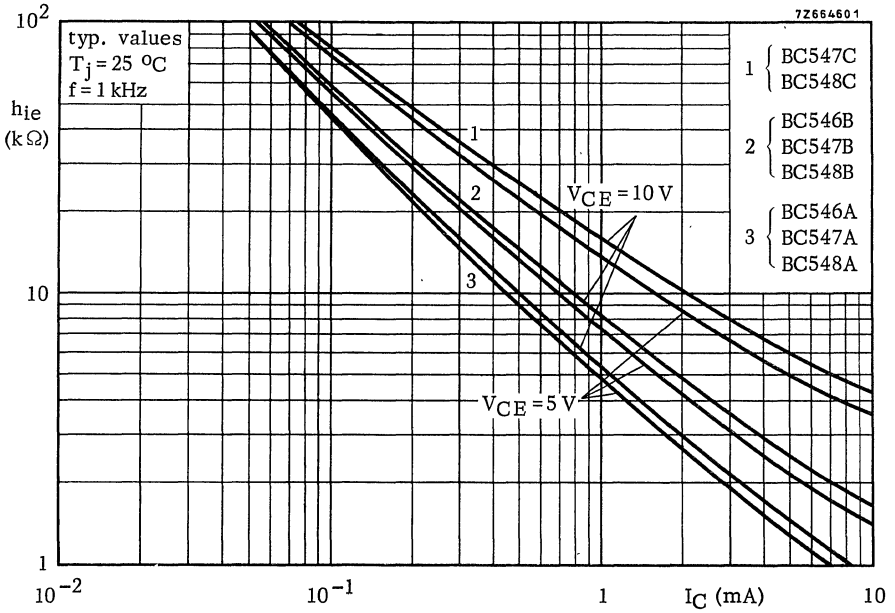
Typical behaviour of base current versus junction temperature



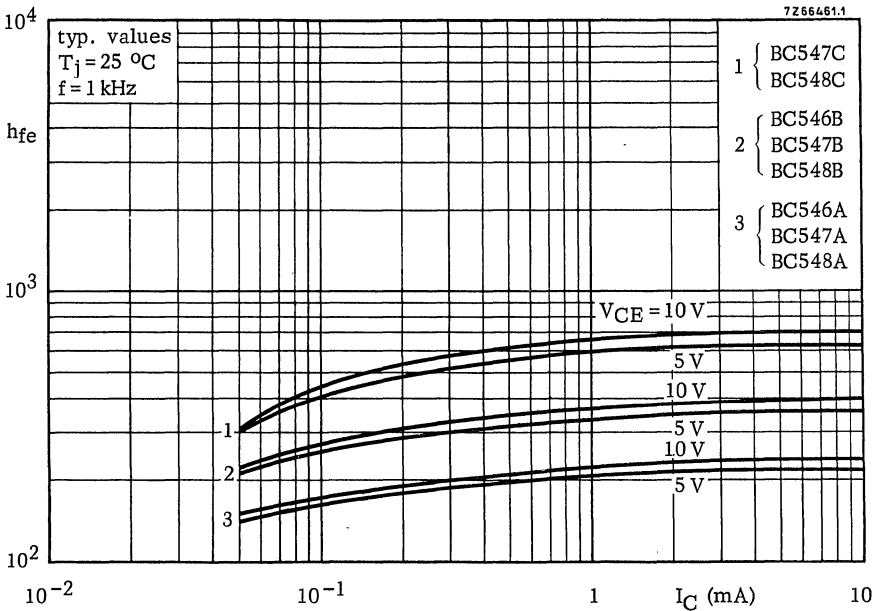


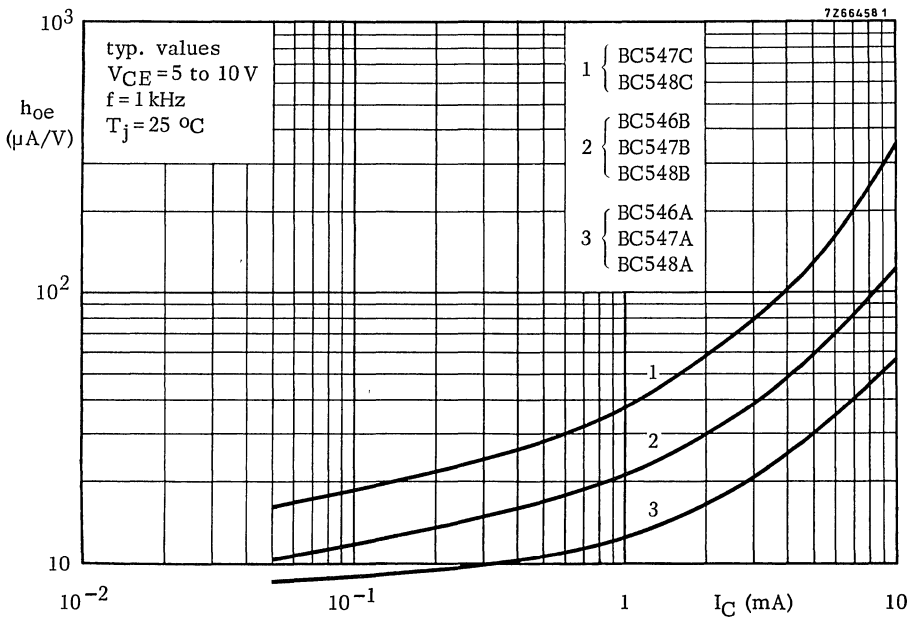
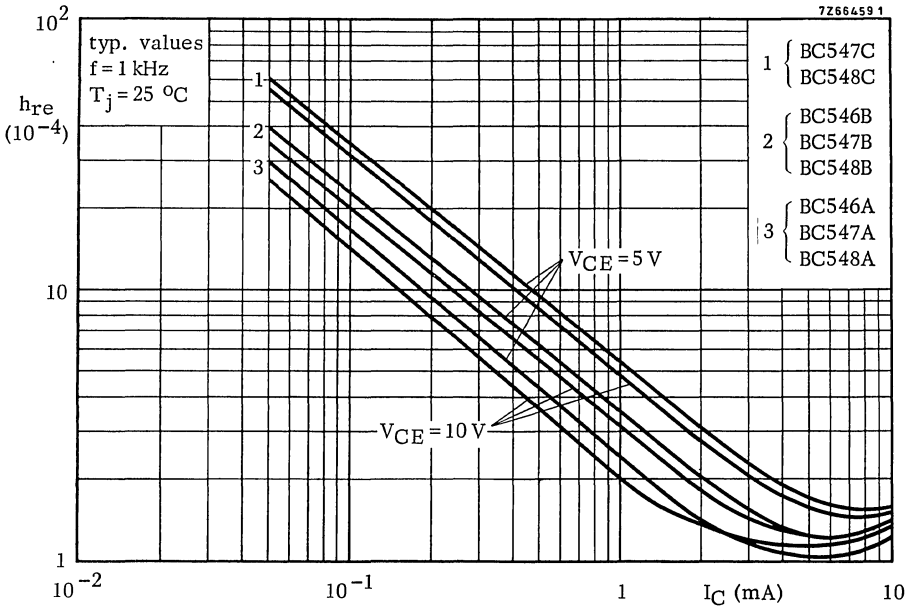


7Z66460.1



7Z66461.1







## SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in plastic TO-92 variants, primarily intended for low-noise input stages in tape recorders, hi-fi amplifiers and other audio-frequency equipment.

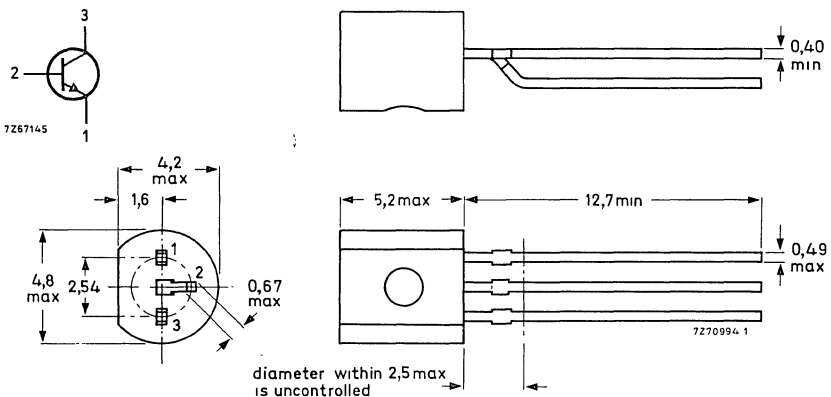
### QUICK REFERENCE DATA

		BC549	BC550
Collector-emitter voltage ( $V_{BE} = 0$ )	$V_{CES}$ max	30	50 V
Collector-emitter voltage (open base)	$V_{CEO}$ max	30	45 V
Collector current (peak value)	$I_{CM}$ max	200	200 mA
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$ max	500	500 mW
Junction temperature	$T_j$ max	150	150 $^\circ\text{C}$
Small-signal current gain $I_C = 2\text{ mA}; V_{CE} = 5\text{ V}; f = 1\text{ kHz}$	$h_{fe}$ >	240	240
	$h_{fe}$ <	900	900
Transition frequency $I_C = 10\text{ mA}; V_{CE} = 5\text{ V}$	$f_T$ typ	300	300 MHz
Noise figure at $R_S = 2\text{ k}\Omega$ $I_C = 200\text{ }\mu\text{A}; V_{CE} = 5\text{ V}$ $f = 30\text{ Hz to } 15\text{ kHz}$	F typ	1,4	1,4 dB
	F <	4	3 dB
$f = 1\text{ kHz}; B = 200\text{ Hz}$ $f = 10\text{ Hz to } 50\text{ Hz}$ (equivalent noise voltage)	F typ	1,2	1 dB
	$V_n$ <	—	0,135 $\mu\text{V}$

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



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

			BC549	BC550	
<u>Voltage</u>					
Collector-base voltage (open emitter)	$V_{CBO}$	max.	30	50	V
Collector-emitter voltage ( $V_{BE} = 0$ )	$V_{CES}$	max.	30	50	V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	30	45	V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	5	5	V
<u>Current</u>					
Collector current (d. c.)	$I_C$	max.		100	mA
Collector current (peak value)	$I_{CM}$	max.		200	mA
Emitter current (peak value)	$-I_{EM}$	max.		200	mA
Base current (peak value)	$I_{BM}$	max.		200	mA
<u>Power dissipation</u>					
Total power dissipation up to $T_{amb} = 25^{\circ}C$	$P_{tot}$	max.		500	mW
<u>Temperature</u>					
Storage temperature	$T_{stg}$			-65 to +150	$^{\circ}C$
Junction temperature	$T_j$	max.		150	$^{\circ}C$
<b>THERMAL RESISTANCE</b>					
From junction to ambient in free air	$R_{th\ j-a}$	=		0,25	$^{\circ}C/mW$
From junction to case	$R_{th\ j-c}$	=		0,15	$^{\circ}C/mW$

**CHARACTERISTICS**

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

Collector cut-off current

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

$I_{CBO} < 15\text{ nA}$

$I_E = 0; V_{CB} = 30\text{ V}; T_j = 150\text{ }^\circ\text{C}$

$I_{CBO} < 5\text{ }\mu\text{A}$

Base emitter voltage

$I_C = 2\text{ mA}; V_{CE} = 5\text{ V}$

$V_{BE}$  typ. 660 mV  
580 to 700 mV

$I_C = 10\text{ mA}; V_{CE} = 5\text{ V}$

$V_{BE} < 770\text{ mV}$

Saturation voltages 2)

$I_C = 10\text{ mA}; I_B = 0,5\text{ mA}$

$V_{CEsat}$  typ. 90 mV  
< 250 mV

$V_{BEsat}$  typ. 700 mV

$I_C = 100\text{ mA}; I_B = 5\text{ mA}$

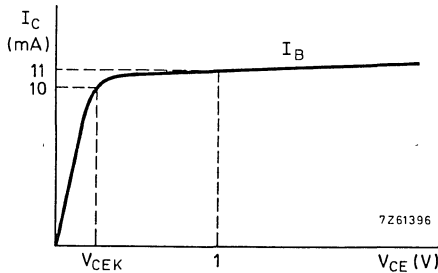
$V_{CEsat}$  typ. 200 mV  
< 600 mV

$V_{BEsat}$  typ. 900 mV

Knee voltage

$I_C = 10\text{ mA}; I_B = \text{value for which}$   
 $I_C = 11\text{ mA at } V_{CE} = 1\text{ V}$

$V_{CEK}$  typ. 300 mV  
< 600 mV



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

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

$C_c$  typ. 2,5 pF  
< 4,5 pF

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

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

$C_e$  typ. 9 pF

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

$I_C = 10\text{ mA}; V_{CE} = 5\text{ V}$

$f_T$  typ. 300 MHz

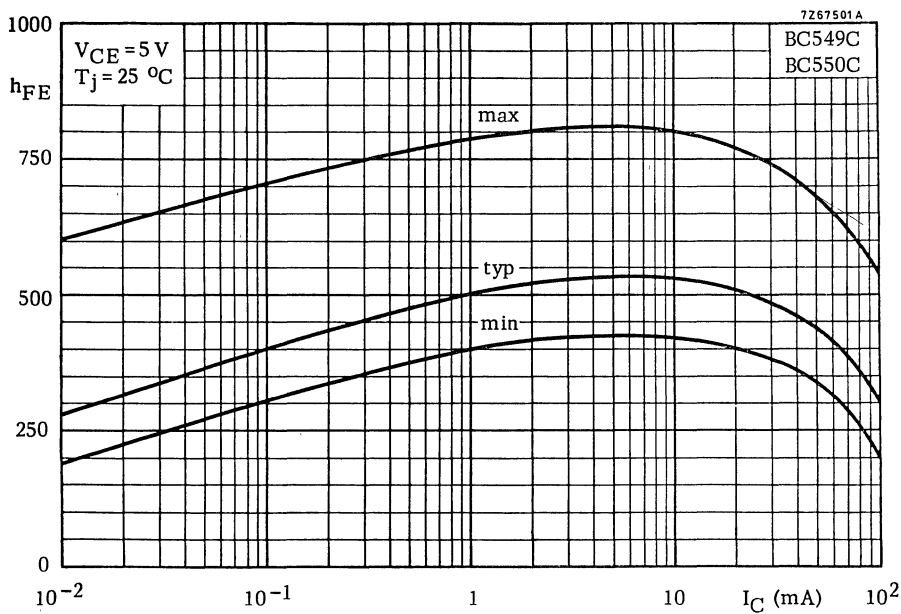
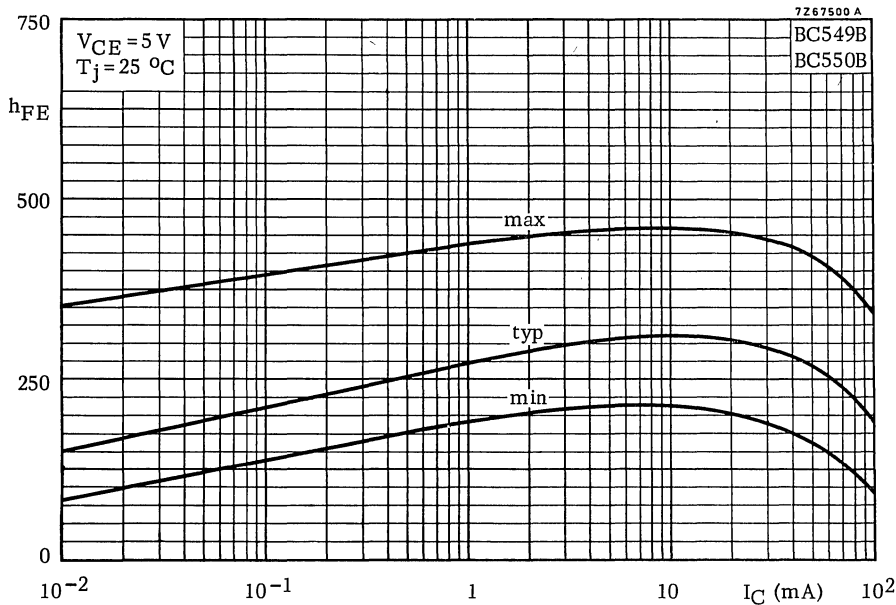
- 1)  $V_{BE}$  decreases by about  $2\text{ mV}/^\circ\text{C}$  with increasing temperature.
- 2)  $V_{BEsat}$  decreases by about  $1,7\text{ mV}/^\circ\text{C}$  with increasing temperature.



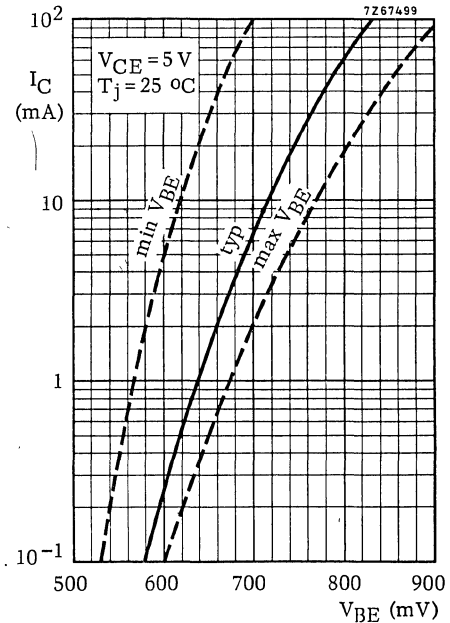
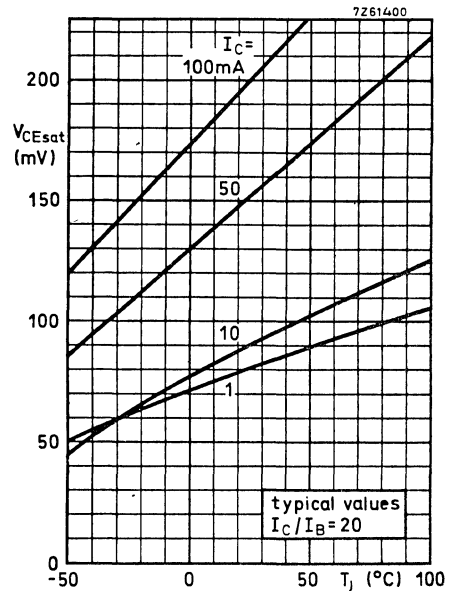
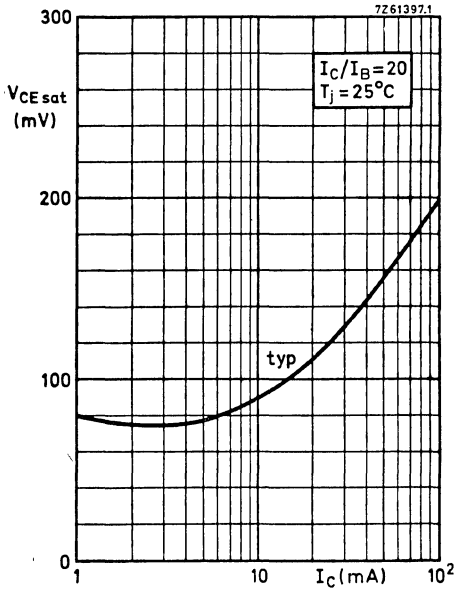
**CHARACTERISTICS** (continued)

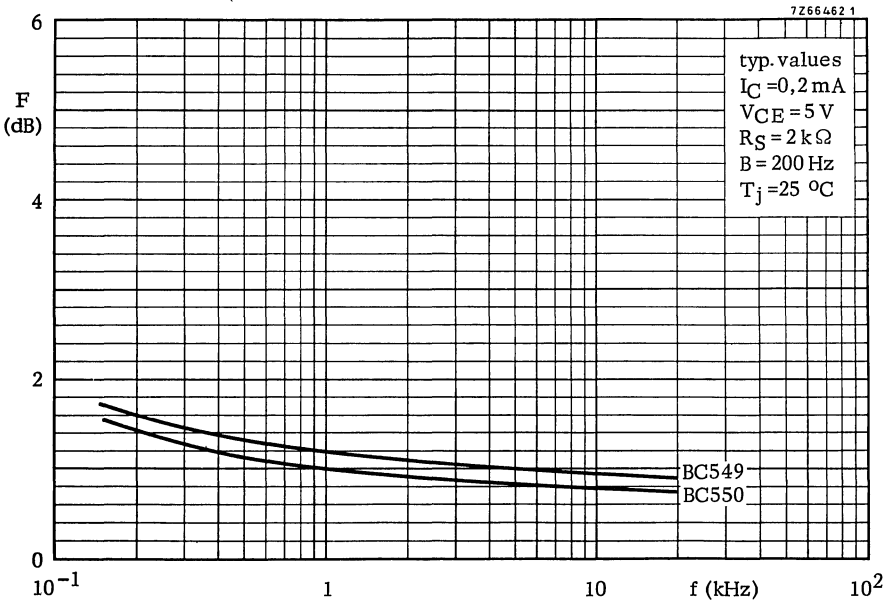
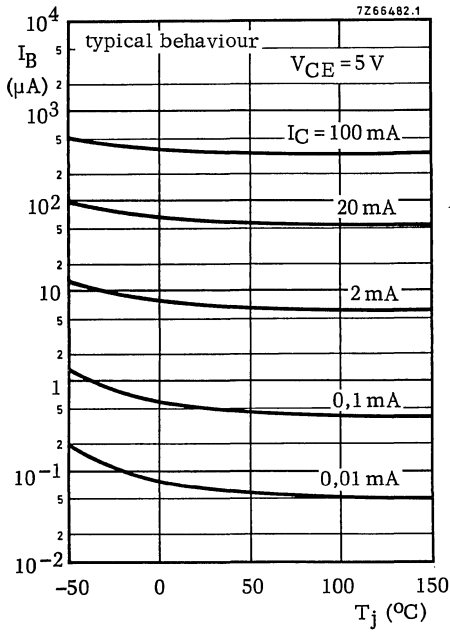
$T_j = 25\text{ }^\circ\text{C}$  unless otherwise specified

			BC549	BC550	
<u>Small signal current gain</u> at $f = 1\text{ kHz}$					
$I_C = 2\text{ mA}; V_{CE} = 5\text{ V}$	$h_{fe}$	>	240	240	
		<	900	900	
<u>Noise figure</u> at $R_S = 2\text{ k}\Omega$					
$I_C = 200\text{ }\mu\text{A}; V_{CE} = 5\text{ V}$ $f = 30\text{ Hz to }15\text{ kHz}$	F	typ.	1, 4	1, 4	dB
		<	4	3	dB
$f = 1\text{ kHz}; B = 200\text{ Hz}$	F	typ.	1, 2	1	dB
		<	4	4	dB
<u>Equivalent noise voltage</u> at $R_S = 2\text{ k}\Omega$					
$I_C = 200\text{ }\mu\text{A}; V_{CE} = 5\text{ V}$ $f = 10\text{ Hz to }50\text{ Hz}; T_{amb} = 25\text{ }^\circ\text{C}$	$V_n$	max.			
					0, 135
			BC549B	BC549C	
			BC550B	BC550C	
<u>D. C. current gain</u>					
$I_C = 10\text{ }\mu\text{A}; V_{CE} = 5\text{ V}$	$h_{FE}$	typ.	150	270	
		>	200	420	
$I_C = 2\text{ mA}; V_{CE} = 5\text{ V}$	$h_{FE}$	typ.	290	520	
		<	450	800	
<u>h parameters</u> at $f = 1\text{ kHz}$ (common emitter)					
$I_C = 2\text{ mA}; V_{CE} = 5\text{ V}$	Input impedance	>	3, 2	6	$\text{k}\Omega$
		typ.	4, 5	8, 7	$\text{k}\Omega$
Reverse voltage transfer ratio	$h_{re}$	<	8, 5	15	$\text{k}\Omega$
		typ.	2	3	$10^{-4}$
Small signal current gain	$h_{fe}$	>	240	450	
		typ.	330	600	
Output admittance	$h_{oe}$	<	500	900	
		typ.	30	60	$\mu\text{A}/\text{V}$
		<	60	110	$\mu\text{A}/\text{V}$

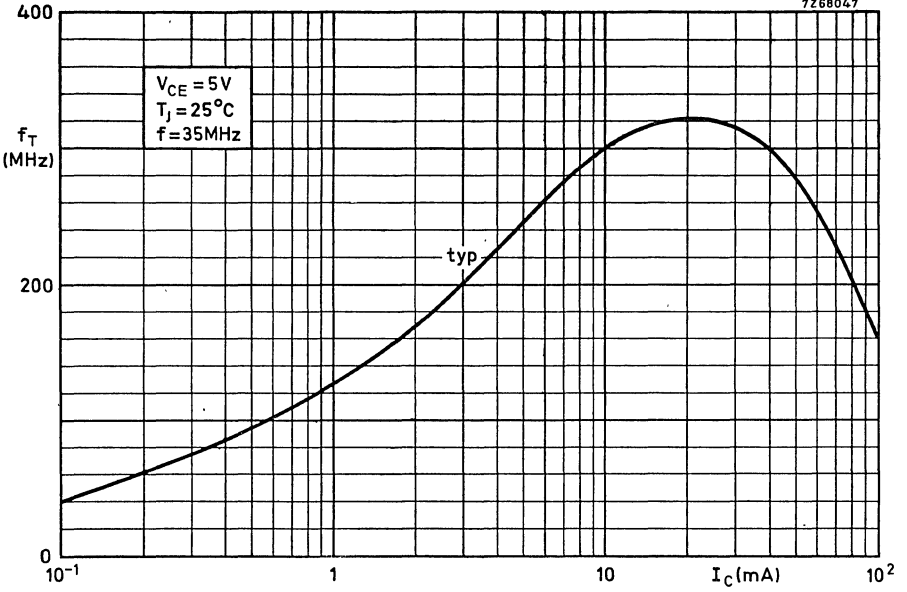


**BC549  
BC550**

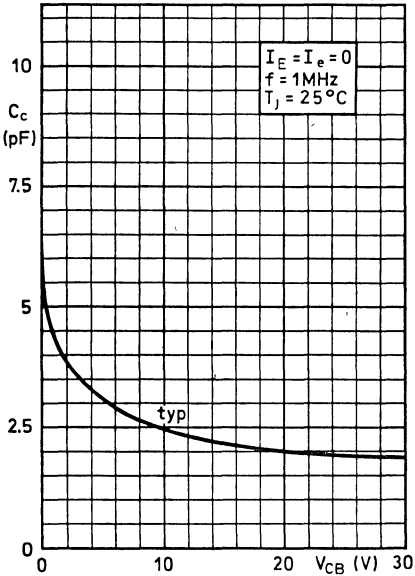




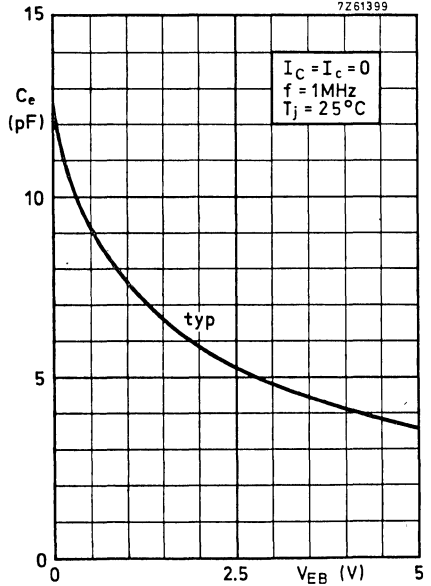
7268047

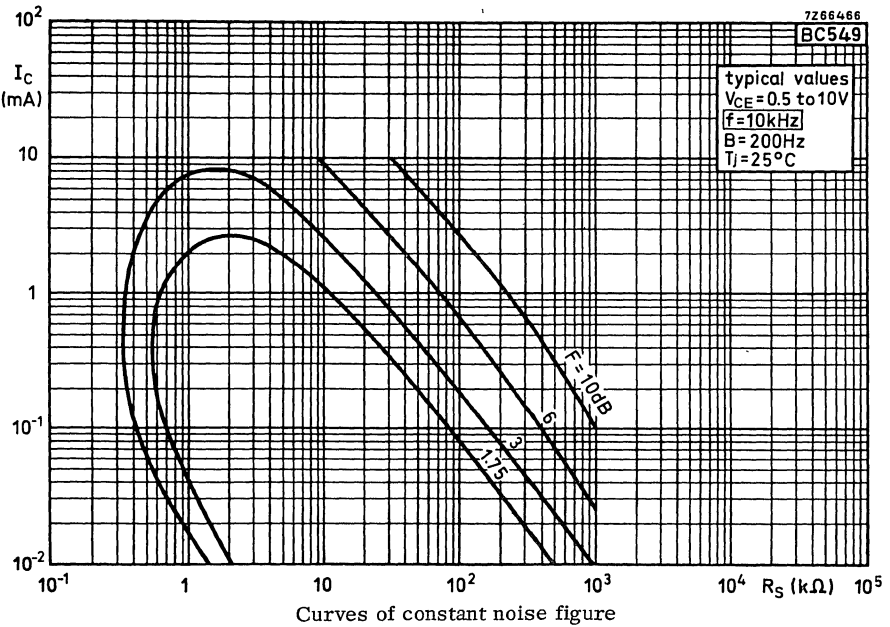
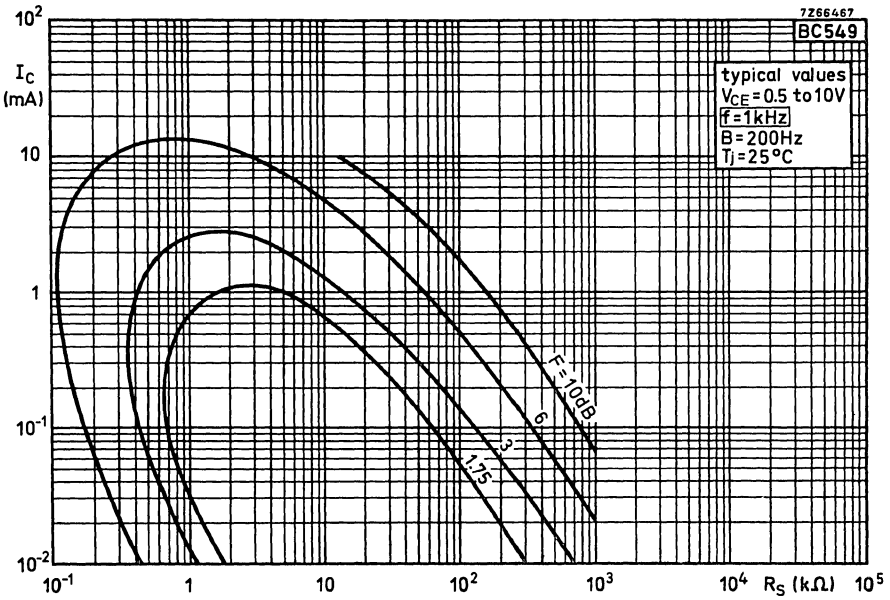


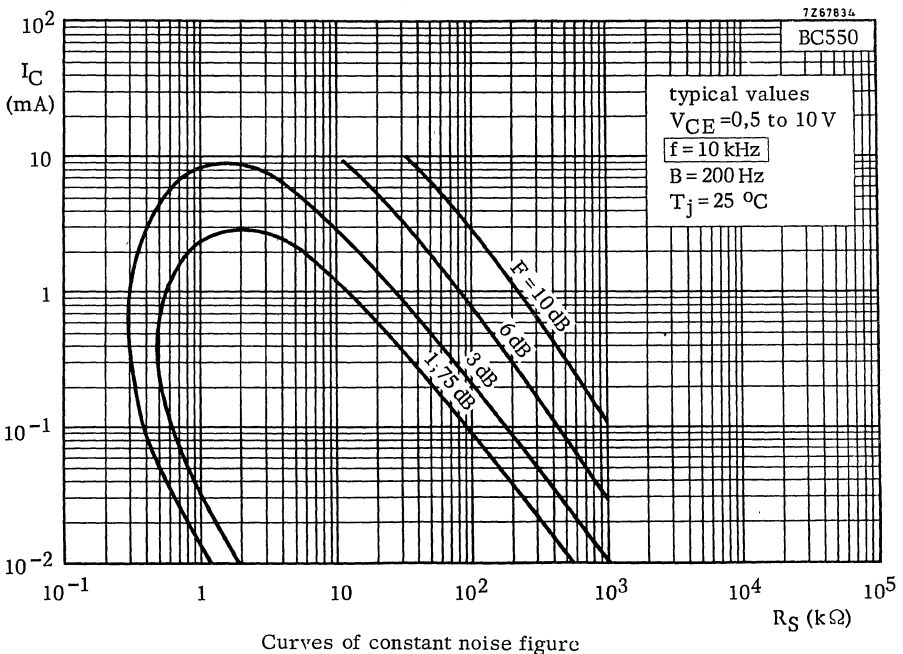
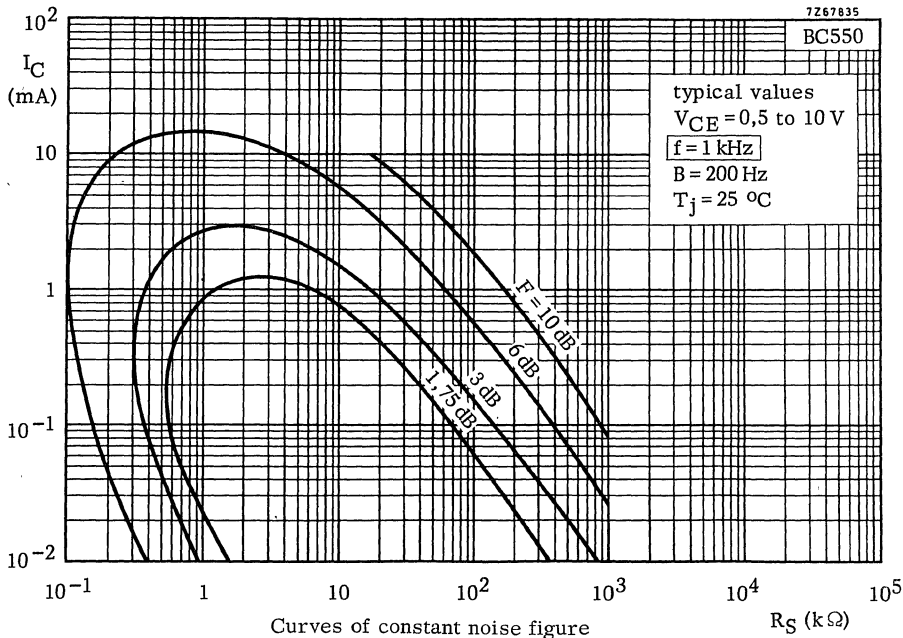
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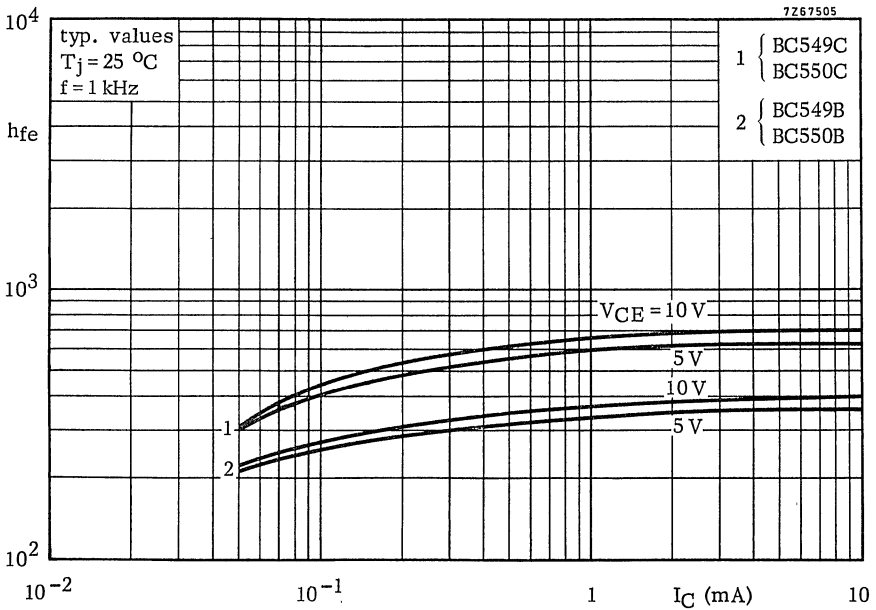
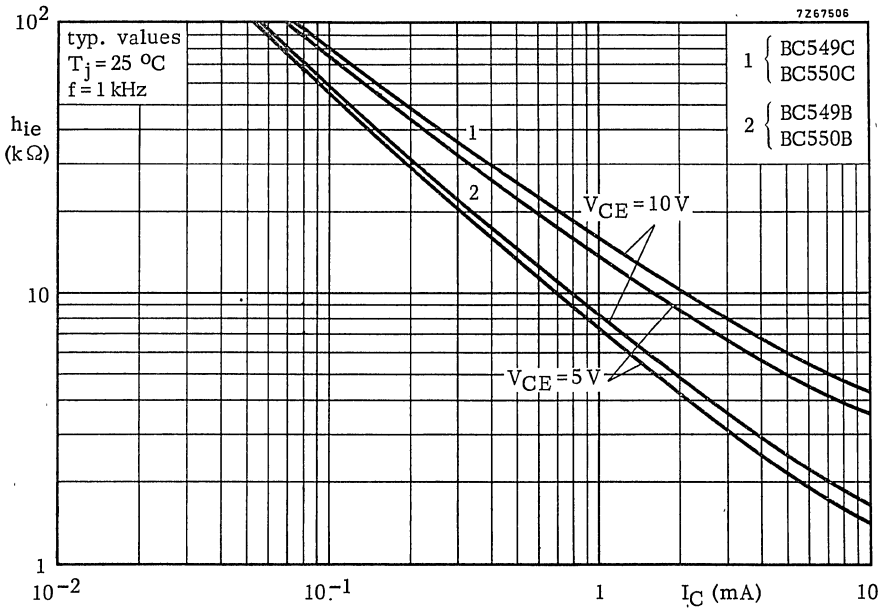


7261399



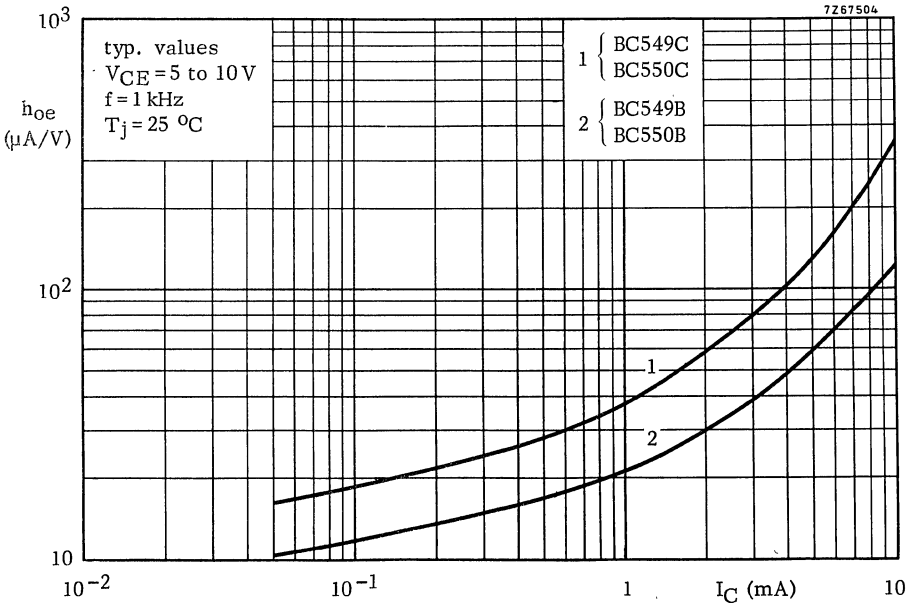
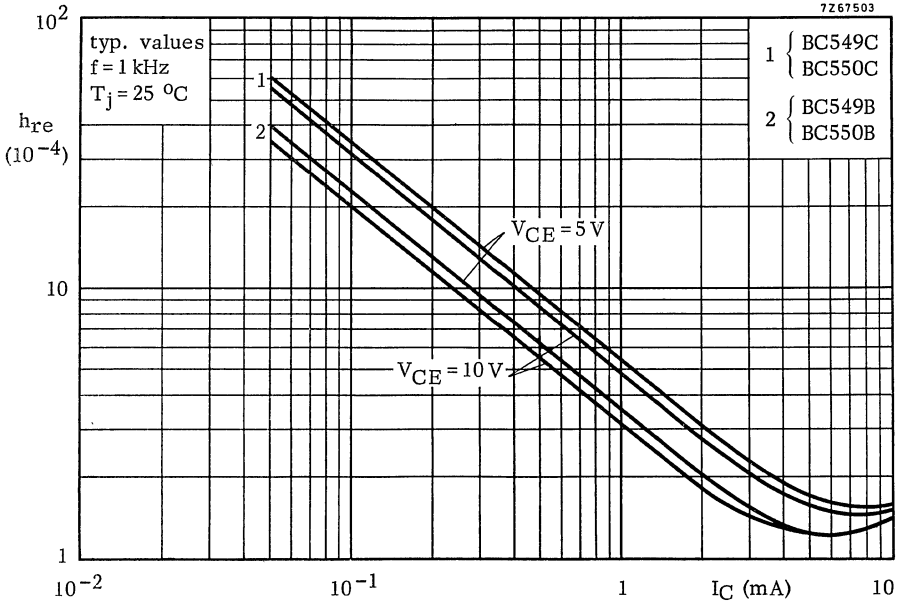








**BC549  
BC550**



## SILICON PLANAR EPITAXIAL TRANSISTORS

General purpose p-n-p transistors in plastic TO-92 envelopes, especially suitable for use in driver stages of audio amplifiers.

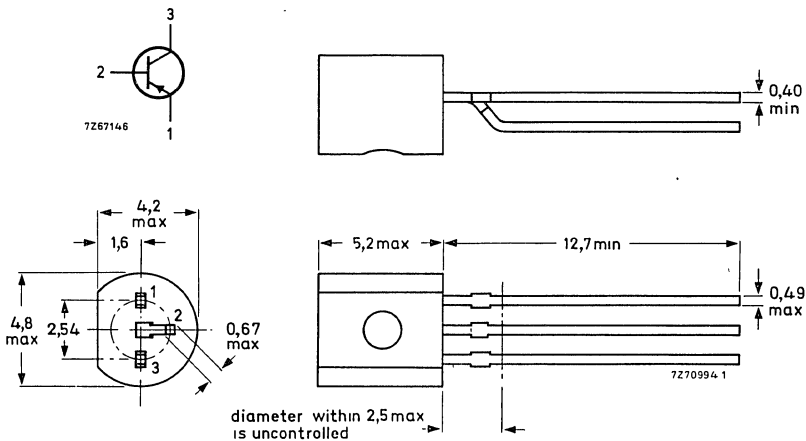
### QUICK REFERENCE DATA

		BC556	BC557	BC558	
Collector-emitter voltage (+ $V_{BE} = 1\text{ V}$ )	$-V_{CEX}$ max.	80	50	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$ max.	65	45	30	V
Collector current (peak value)	$-I_{CM}$ max.		200		mA
Total power dissipation up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$ max.		500		mW
Junction temperature	$T_j$ max.		150		$^{\circ}\text{C}$
Small-signal current gain $-I_C = 2\text{ mA}; -V_{CE} = 5\text{ V}; f = 1\text{ kHz}$	$h_{fe}$		75 to 900		←
Transition frequency at $f = 35\text{ MHz}$ $-I_C = 10\text{ mA}; -V_{CE} = 5\text{ V}$	$f_T$ typ.		200		MHz ←
Noise figure at $R_S = 2\text{ k}\Omega$ $-I_C = 200\text{ }\mu\text{A}; -V_{CE} = 5\text{ V}$ $f = 1\text{ kHz}; B = 200\text{ Hz}$	F	<	10		dB

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



## RATINGS

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

			BC556	BC557	BC558	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	80	50	30	V
Collector-emitter voltage (+ $V_{BE} = 1$ V)	$-V_{CEX}$	max.	80	50	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	65	45	30	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.		200		mA
Emitter current (peak value)	$I_{EM}$	max.		200		mA
Base current (peak value)	$-I_{BM}$	max.		200		mA
Total power dissipation up to $T_{amb} = 25$ °C	$P_{tot}$	max.		500		mW
Storage temperature	$T_{stg}$		-65 to + 150			°C
Junction temperature	$T_j$	max.		150		°C

## THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=		250		K/W
From junction to case	$R_{th\ j-c}$	=		150		K/W

## CHARACTERISTICS

 $T_j = 25$  °C unless otherwise specified.

Collector cut-off current

$I_E = 0; -V_{CB} = 30$ V; $T_j = 25$ °C	$-I_{CBO}$	typ.		1		nA
		<		15		nA
$T_j = 150$ °C	$-I_{CBO}$	<		4		$\mu$ A

Base-emitter voltage\*

$-I_C = 2$ mA; $-V_{CE} = 5$ V	$-V_{BE}$	typ.		650		mV
$-I_C = 10$ mA; $-V_{CE} = 5$ V	$-V_{BE}$	<		600 to 750		mV
				820		mV

→ Saturation voltages\*\*

$-I_C = 10$ mA; $-I_B = 0,5$ mA	$-V_{CEsat}$	typ.		60		mV
		<		300		mV
	$-V_{BEsat}$	typ.		750		mV
				180		mV
$-I_C = 100$ mA; $-I_B = 5$ mA	$-V_{CEsat}$	typ.		650		mV
		<		930		mV
	$-V_{BEsat}$	typ.				mV

→ \*  $-V_{BE}$  decreases by about 2 mV/K with increasing temperature.→ \*\*  $-V_{BEsat}$  decreases by about 1,7 mV/K with increasing temperature.

Knee voltage

$-I_C = 10 \text{ mA}$ ;  $-I_B =$  value for which  
 $-I_C = 11 \text{ mA}$  at  $-V_{CE} = 1 \text{ V}$

$-V_{CEK}$	typ.	250	mV
<		600	mV

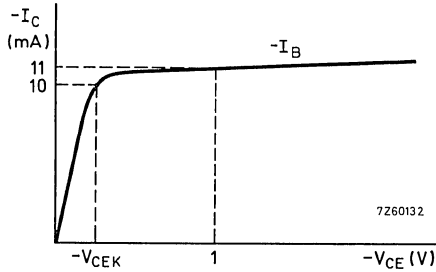


Fig. 2.

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

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

$C_C$	typ.	4	pF	←
-------	------	---	----	---

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

$-I_C = 10 \text{ mA}$ ;  $-V_{CE} = 5 \text{ V}$

$f_T$	typ.	200	MHz	←
-------	------	-----	-----	---

Small-signal current gain at  $f = 1 \text{ kHz}$

$-I_C = 2 \text{ mA}$ ;  $-V_{CE} = 5 \text{ V}$

$h_{fe}$		75 to 900		←
----------	--	-----------	--	---

Noise figure at  $R_S = 2 \text{ k}\Omega$

$-I_C = 200 \mu\text{A}$ ;  $-V_{CE} = 5 \text{ V}$   
 $f = 1 \text{ kHz}$ ;  $B = 200 \text{ Hz}$

$F$	typ.	2	dB	
<		10	dB	

BC556	BC556A	BC556B	
BC557	BC557A	BC557B	BC557C
BC558	BC558A	BC558B	BC558C

D.C. current gain

$-I_C = 2 \text{ mA}$ ;  $-V_{CE} = 5 \text{ V}$

$h_{FE}$	>	75	125	220	420	
	<	475	250	475	800	

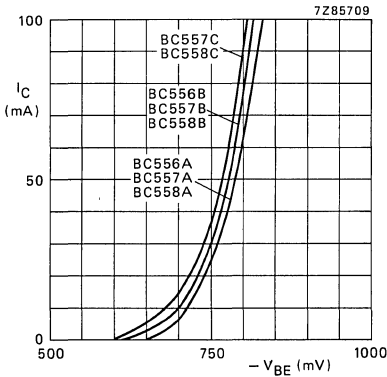


Fig. 3  $-V_{CE} = 5 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$ .

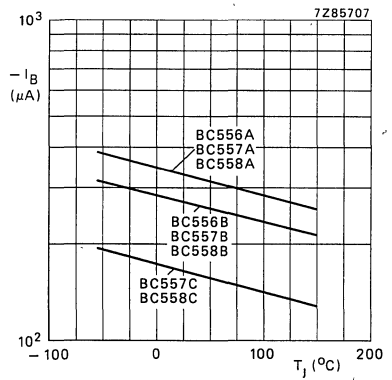


Fig. 4  $-V_{CE} = 5 \text{ V}; I_C = 50 \text{ mA}$ .

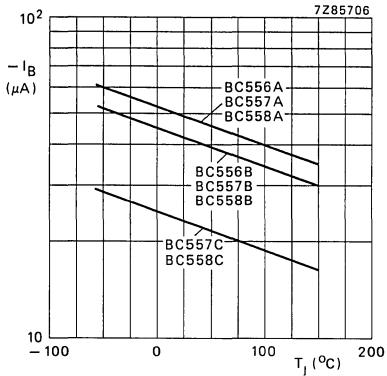


Fig. 5  $-V_{CE} = 5 \text{ V}; I_C = 10 \text{ mA}$ .

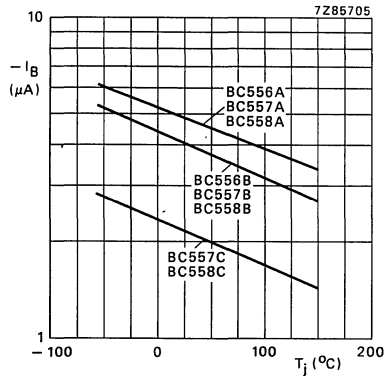


Fig. 6  $-V_{CE} = 5 \text{ V}; I_C = 1 \text{ mA}$ .

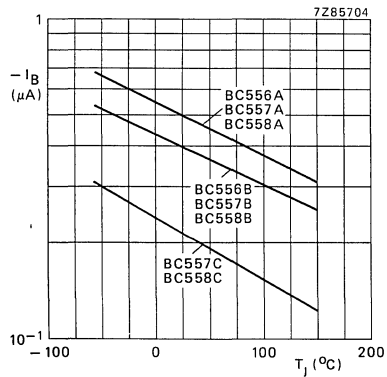


Fig. 7  $-V_{CE} = 5 \text{ V}; I_C = 0,1 \text{ mA}$ .

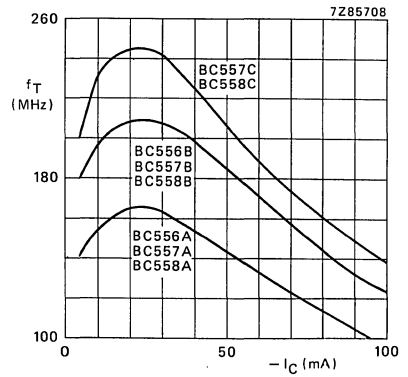


Fig. 8  $-V_{CE} = 5 \text{ V}; T_j = 25 \text{ }^\circ\text{C}; f = 35 \text{ MHz}$ .

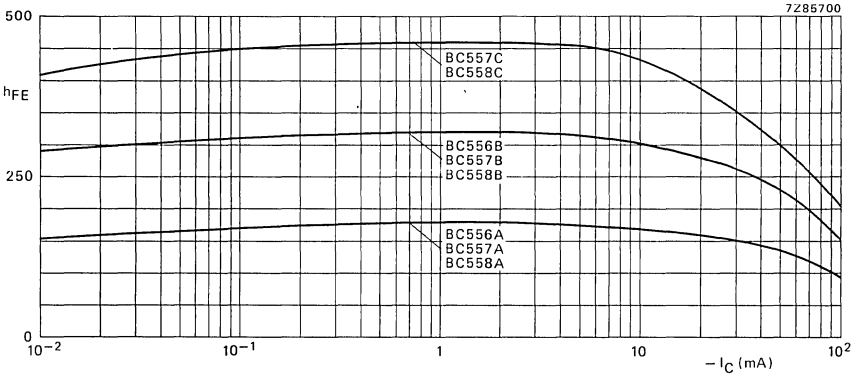


Fig. 9  $-V_{CE} = 5 \text{ V}; T_j = 25 \text{ }^\circ\text{C}.$

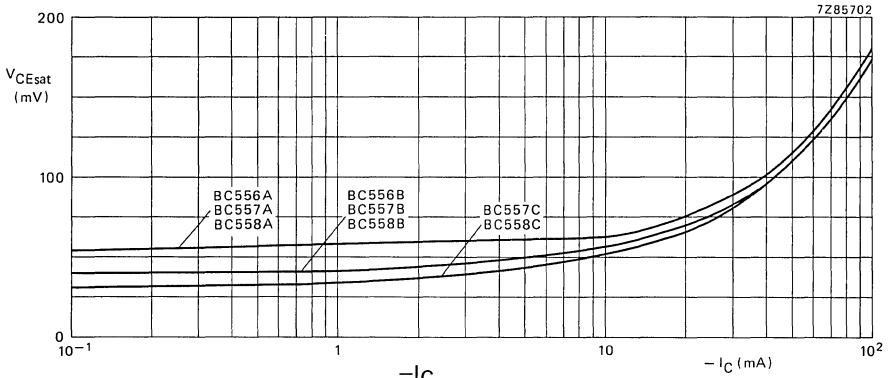


Fig. 10  $\frac{-I_C}{-I_B} = 20; T_j = 25 \text{ }^\circ\text{C}.$

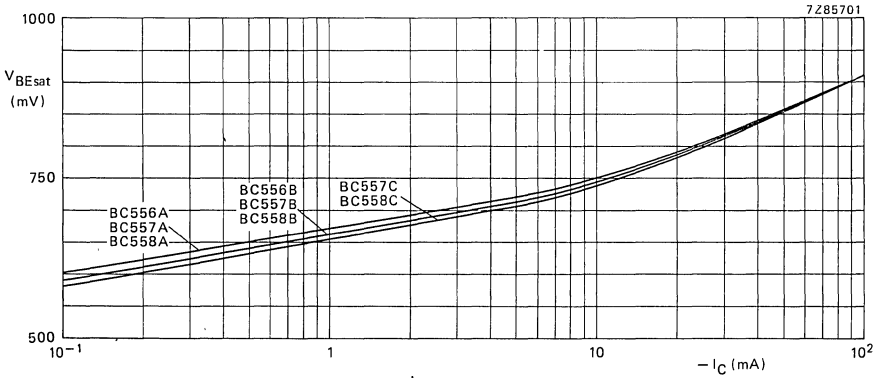


Fig. 11  $\frac{-I_C}{-I_B} = 20; T_j = 25 \text{ }^\circ\text{C}.$

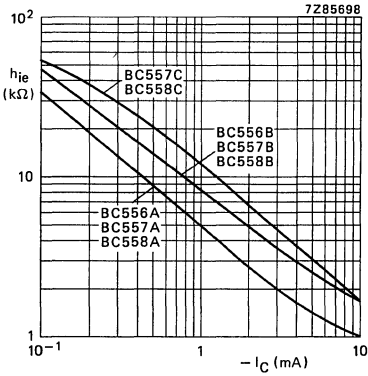


Fig. 12.

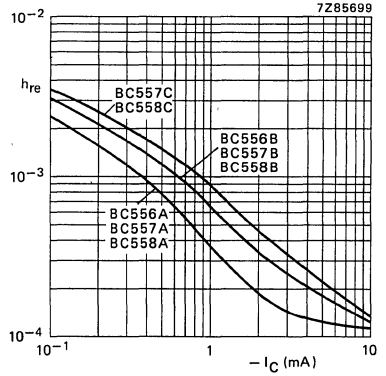


Fig. 13.

For Figs 12, 13, 14 and 15 the following conditions apply:  $-V_{CE} = 5 \text{ V}$ ;  $f = 1 \text{ kHz}$ ;  $T_j = 25 \text{ }^\circ\text{C}$ .

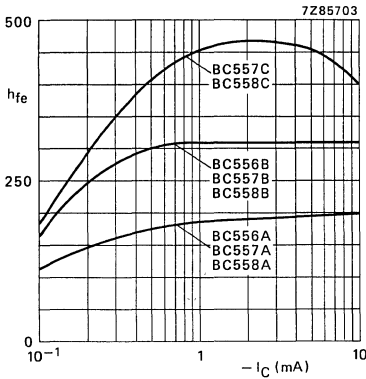


Fig. 14.

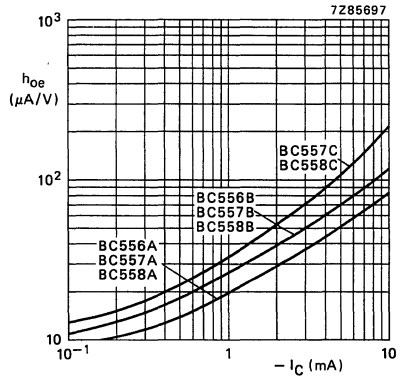


Fig. 15.

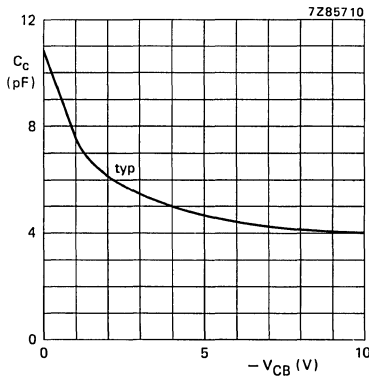


Fig. 16  $f = 1 \text{ MHz}$ ;  $T_j = 25 \text{ }^\circ\text{C}$ .

## SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in a plastic TO-92 variant, primarily intended for low-noise input stages in tape recorders, hi-fi amplifiers and other audio-frequency equipment.

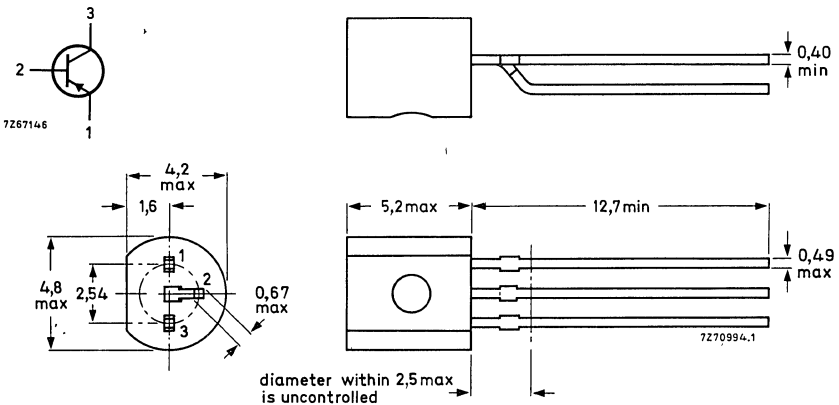
### QUICK REFERENCE DATA

		BC559	BC560
Collector-emitter voltage (+ $V_{BE} = 1\text{ V}$ )	$-V_{CEX}$ max.	30	50 V
Collector-emitter voltage (open base)	$-V_{CEO}$ max.	30	45 V
Collector current (peak value)	$-I_{CM}$ max.	200	200 mA
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$ max.	500	500 mW
Junction temperature	$T_j$ max.	150	150 $^\circ\text{C}$
Small-signal current gain $-I_C = 2\text{ mA}; -V_{CE} = 5\text{ V}; f = 1\text{ kHz}$	$h_{fe}$	$> 125$ $< 900$	125 900
Transition frequency $-I_C = 10\text{ mA}; -V_{CE} = 5\text{ V}$	$f_T$ typ.	200	200 MHz
Noise figure at $R_s = 2\text{ k}\Omega$ $-I_C = 200\text{ }\mu\text{A}; -V_{CE} = 5\text{ V}$ $f = 30\text{ Hz to } 15\text{ kHz}$	F	typ. 1,2 $< 4$	1 dB 3 dB
$f = 1\text{ kHz}; B = 200\text{ Hz}$	F	$< 4$	4 dB

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.





# BC559 BC560

## RATINGS

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

		BC559	BC560
Collector-base voltage (open emitter)	$-V_{CBO}$ max.	30	50 V
Collector-emitter voltage ( $+V_{BE} = 1$ V)	$-V_{CEX}$ max.	30	50 V
Collector-emitter voltage (open base)	$-V_{CEO}$ max.	30	45 V
Emitter-base voltage (open collector)	$-V_{CBO}$ max.	5	5 V
Collector current (d.c.)	$-I_C$ max.	100 mA	
Collector current (peak value)	$-I_{CM}$ max.	200 mA	
Emitter current (peak value)	$I_{EM}$ max.	200 mA	
Base current (peak value)	$-I_{BM}$ max.	200 mA	
Total power dissipation up to $T_{amb} = 25$ °C	$P_{tot}$ max.	500 mW	
Storage temperature	$T_{stg}$	-65 to +150 °C	
Junction temperature	$T_j$ max.	150 °C	

## → THERMAL RESISTANCE

From junction to ambient in free air

$$R_{th\ j-a} = 250 \text{ K/W}$$

From junction to case

$$R_{th\ j-c} = 150 \text{ K/W}$$

## CHARACTERISTICS

$T_j = 25$  °C unless otherwise specified

### Collector cut-off current

$$I_E = 0; -V_{CB} = 30 \text{ V}; T_j = 25 \text{ °C}$$

$$T_j = 150 \text{ °C}$$

$$-I_{CBO} \text{ typ. } 1 \text{ nA}$$

$$-I_{CBO} < 15 \text{ nA}$$

$$-I_{CBO} < 4 \text{ } \mu\text{A}$$

### Base-emitter voltage\*

$$-I_C = 2 \text{ mA}; -V_{CE} = 5 \text{ V}$$

$$-I_C = 10 \text{ mA}; -V_{CE} = 5 \text{ V}$$

$$-V_{BE} \text{ typ. } 650 \text{ mV}$$

$$-V_{BE} < 600 \text{ to } 750 \text{ mV}$$

$$-V_{BE} < 820 \text{ mV}$$

### → Saturation voltages\*\*

$$-I_C = 10 \text{ mA}; -I_B = 0,5 \text{ mA}$$

$$-I_C = 100 \text{ mA}; -I_B = 5 \text{ mA}$$

$$-V_{CEsat} \text{ typ. } 60 \text{ mV}$$

$$-V_{CEsat} < 300 \text{ mV}$$

$$-V_{BEsat} \text{ typ. } 750 \text{ mV}$$

$$-V_{CEsat} \text{ typ. } 180 \text{ mV}$$

$$-V_{CEsat} < 650 \text{ mV}$$

$$-V_{BEsat} \text{ typ. } 930 \text{ mV}$$

→ \*  $-V_{BE}$  decreases by about 2 mV/K with increasing temperature.

→ \*\*  $-V_{BEsat}$  decreases by about 1,7 mV/K with increasing temperature.

Knee voltage

$-I_C = 10 \text{ mA}$ ;  $-I_B =$  value for which  
 $-I_C = 11 \text{ mA}$  at  $-V_{CE} = 1 \text{ V}$

$-V_{CEK}$  typ.  
 $<$

250 mV  
 600 mV

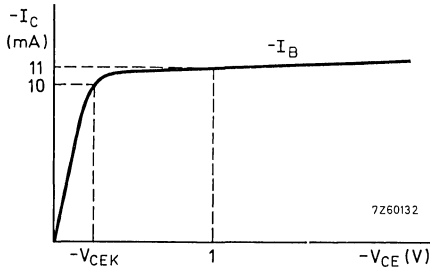


Fig. 2.

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

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

$C_C$  typ.

4 pF ←

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

$-I_C = 10 \text{ mA}$ ;  $-V_{CE} = 5 \text{ B}$

$f_T$  typ.

200 MHz ←

Small-signal current gain at  $f = 1 \text{ kHz}$

$-I_C = 2 \text{ mA}$ ;  $-V_{CE} = 5 \text{ V}$

$h_{fe}$

125 to 900 ←

Noise figure at  $R_S = 2 \text{ k}\Omega$

$-I_C = 200 \mu\text{A}$ ;  $-V_{CE} = 5 \text{ V}$

$f = 30 \text{ Hz}$  to  $15 \text{ kHz}$

$f = 1 \text{ kHz}$ ;  $B = 200 \text{ Hz}$

Equivalent noise voltage at  $R_S = 2 \text{ k}\Omega$

$-I_C = 200 \mu\text{A}$ ;  $-V_{CE} = 5 \text{ V}$   
 $f = 10 \text{ Hz}$  to  $50 \text{ Hz}$ ;  $T_{amb} = 25 \text{ }^\circ\text{C}$

$V_n$   $<$

		BC559		BC560	
F	typ.	1,2		1	dB
	$>$	4		3	dB
F	typ.	1		1	dB
	$<$	4		4	dB
$V_n$	$<$	-		0,11	$\mu\text{V}$

D.C. current gain

$-I_C = 2 \text{ mA}$ ;  $-V_{CE} = 5 \text{ V}$

$h_{FE}$   $>$   
 $<$

	BC559	BC559A	BC559B	BC559C
	BC560	BC560A	BC560B	BC560C
$h_{FE}$ $>$	125	125	220	420
$h_{FE}$ $<$	475	250	470	800

# BC559 BC560

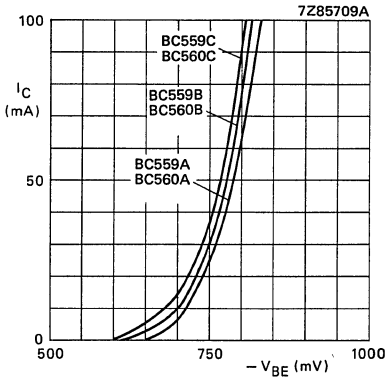


Fig. 3  $-V_{CE} = 5 \text{ V}; T_j = 25^\circ \text{C}$ .

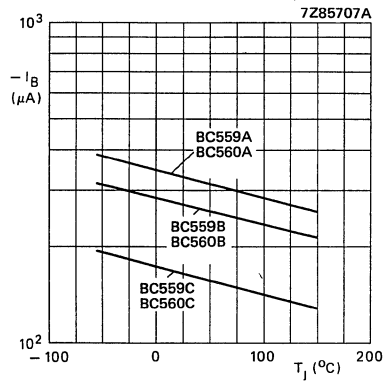


Fig. 4  $-V_{CE} = 5 \text{ V}; I_C = 50 \text{ mA}$ .

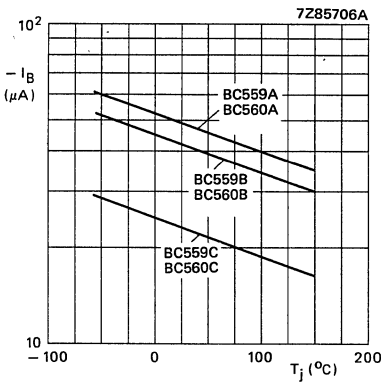


Fig. 5  $-V_{CE} = 5 \text{ V}; I_C = 10 \text{ mA}$ .

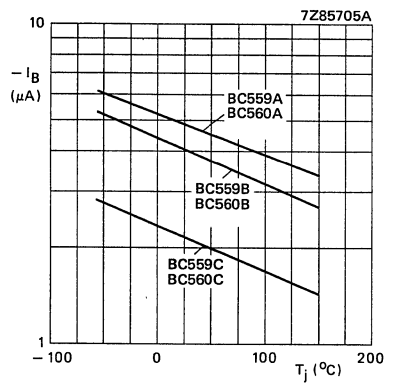


Fig. 6  $-V_{CE} = 5 \text{ V}; I_C = 1 \text{ mA}$ .

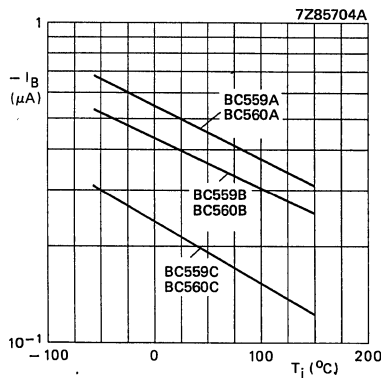


Fig. 7  $-V_{CE} = 5 \text{ V}; I_C = 0,1 \text{ mA}$ .

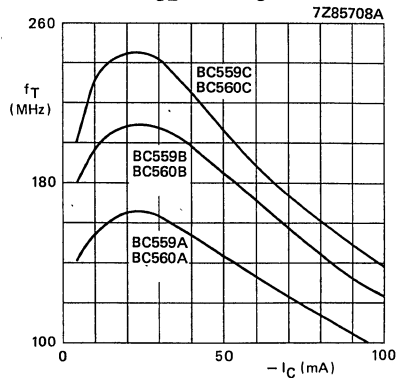


Fig. 8  $-V_{CE} = 5 \text{ V}; T_j = 25^\circ \text{C}; f = 35 \text{ MHz}$ .

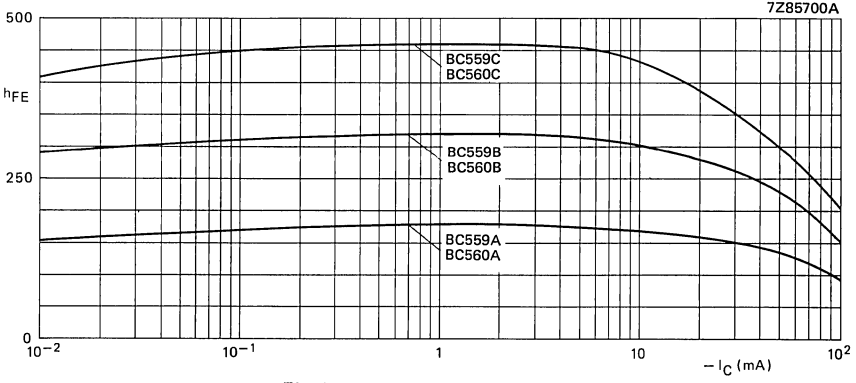


Fig. 9  $-V_{CE} = 5 \text{ V}; T_j = 25 \text{ }^\circ\text{C}.$

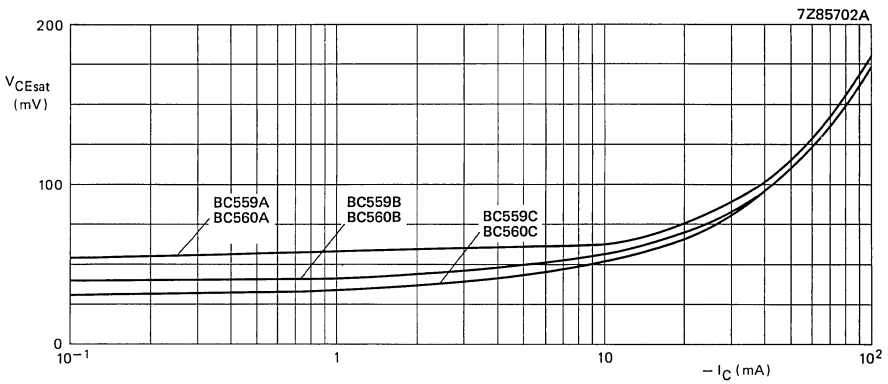


Fig. 10  $\frac{-I_C}{-I_B} = 20; T_j = 25 \text{ }^\circ\text{C}.$

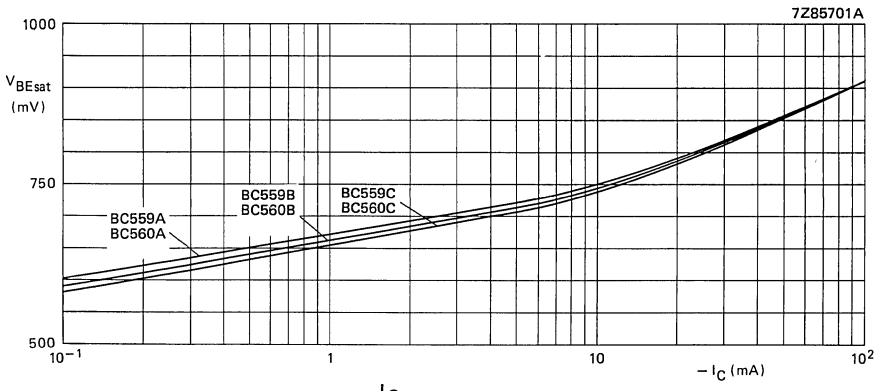


Fig. 11  $\frac{-I_C}{-I_B} = 20; T_j = 25 \text{ }^\circ\text{C}.$

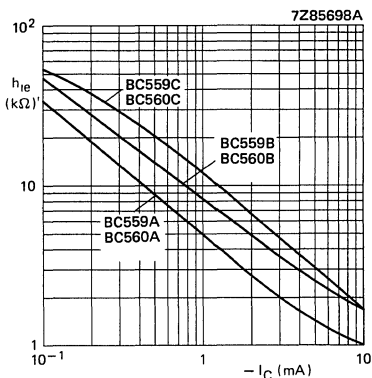


Fig. 12.

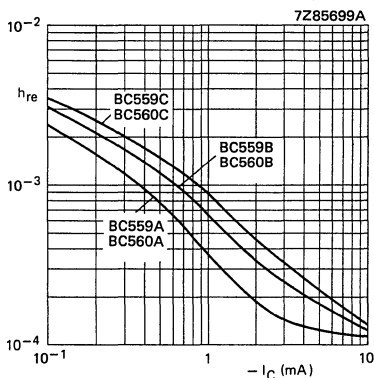


Fig. 13

For Figs 12, 13, 14 and 15 the following conditions apply:  $-V_{CE} = 5\text{ V}$ ;  $f = 1\text{ kHz}$ ;  $T_j = 25\text{ }^\circ\text{C}$ .

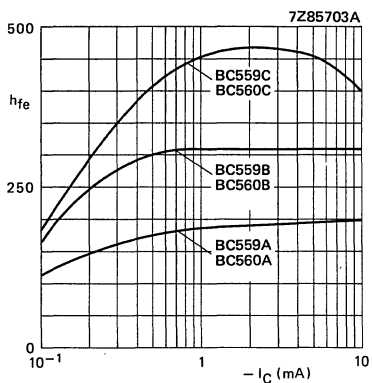


Fig. 14.

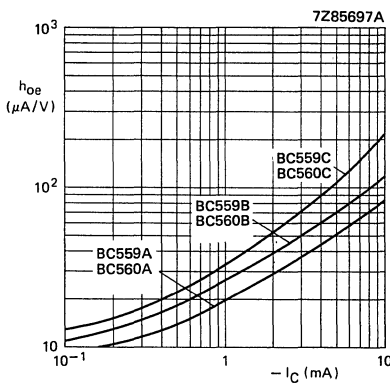


Fig. 15.

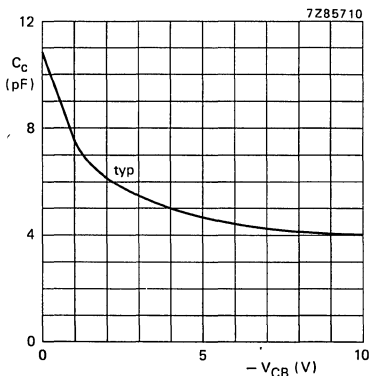


Fig. 16  $f = 1\text{ MHz}$ ;  $T_j = 25\text{ }^\circ\text{C}$ .

curves of constant noise figure

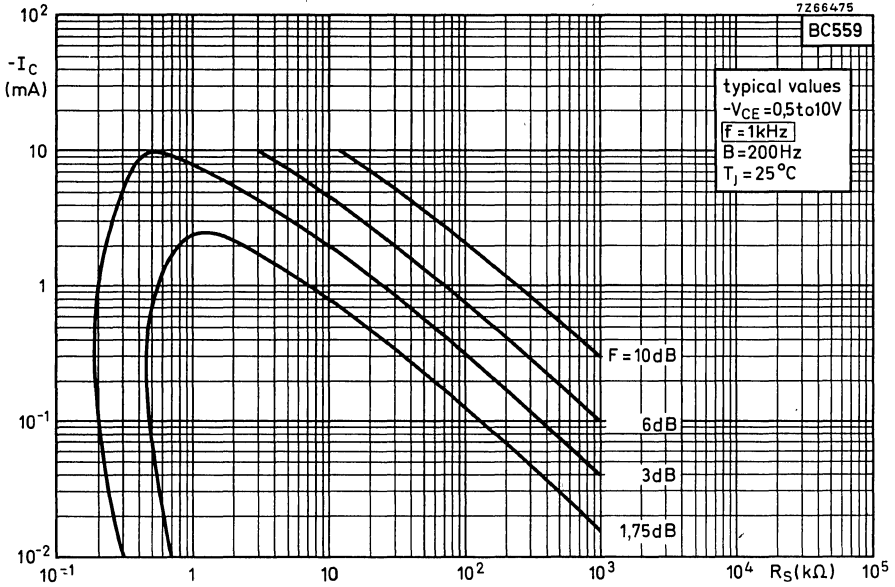


Fig. 17.

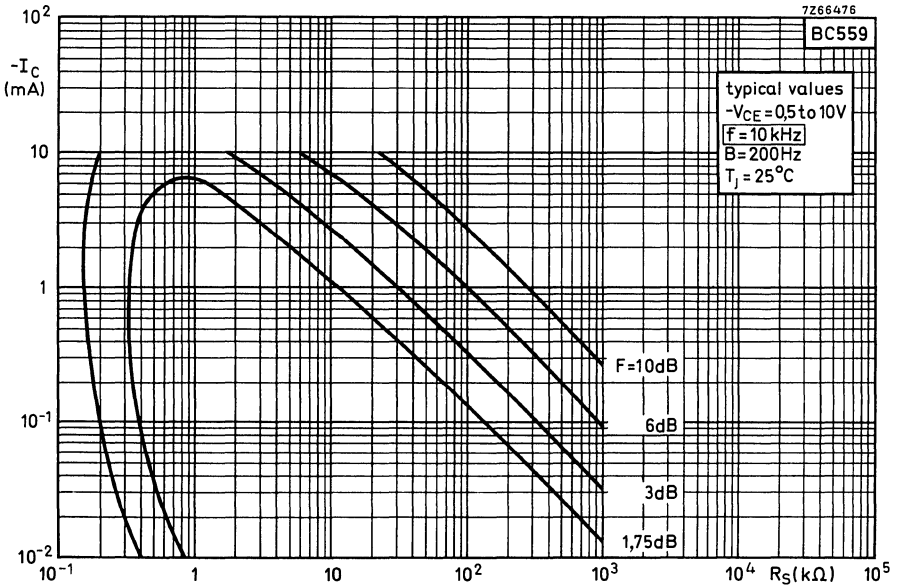


Fig. 18.

7268474.1

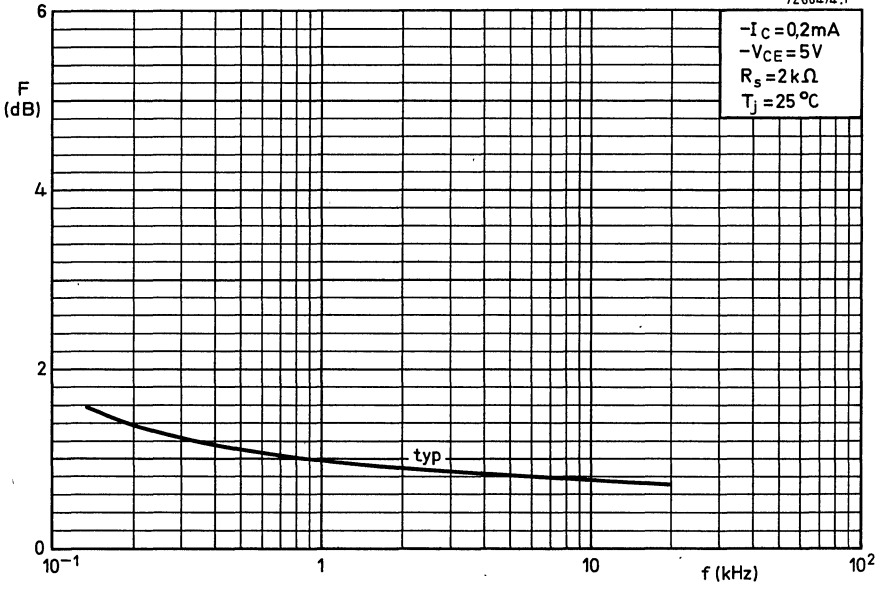


Fig. 19.

## SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in a plastic TO-92 variant, primarily intended for use in driver stages of audio amplifiers. P-N-P complements are BC636, BC638 and BC640.

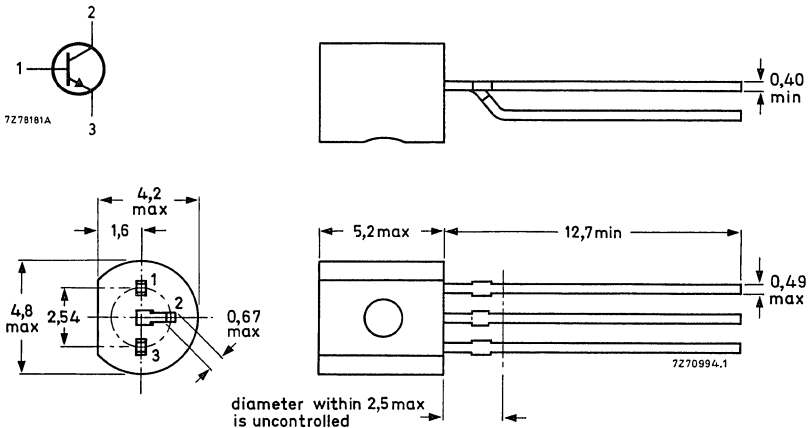
### QUICK REFERENCE DATA

		BC635	BC637	BC639
Collector-base voltage (open emitter)	$V_{CBO}$ max.	45	60	100 V
Collector-emitter voltage (open base)	$V_{CEO}$ max.	45	60	80 V
Collector-emitter voltage ( $R_{BE} = 1 \text{ k}\Omega$ )	$V_{CER}$ max.	45	60	100 V
Collector-current (peak value)	$I_{CM}$ max.	1,5	1,5	1,5 A
Total power dissipation up to $T_{amb} = 25 \text{ }^\circ\text{C}$	$P_{tot}$ max.	1	1	1 W
Junction temperature	$T_j$ max.	150	150	150 $^\circ\text{C}$
D.C. current gain $I_C = 150 \text{ mA}; V_{CE} = 2 \text{ V}$	$h_{FE}$	$> 40$ $< 250$	40 160	40 160
Transition frequency $I_C = 10 \text{ mA}; V_{CE} = 5 \text{ V}$	$f_T$ typ.	130	130	130 MHz

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.





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

<u>Voltages</u>			BC635	BC637	BC639
Collector-base voltage (open emitter)	$V_{CBO}$	max.	45	60	100 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	45	60	80 V
Collector-emitter voltage ( $R_{BE} = 1 \text{ k}\Omega$ )	$V_{CER}$	max.	45	60	100 V
Collector-emitter voltage ( $R_{BE} = 0$ )	$V_{CES}$	max.	45	60	100 V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	5	5	5 V
<u>Currents</u>					
Collector current (d. c.)	$I_C$	max.		1	A
Collector current (peak value)	$I_{CM}$	max.		1,5	A
Emitter current (peak value)	$-I_{EM}$	max.		1,5	A
Base current (d. c.)	$I_B$	max.		100	mA
Base current (peak value)	$I_{BM}$	max.		200	mA
<u>Power dissipation</u>					
Total power dissipation at $T_{amb} = 25 \text{ }^\circ\text{C}$ up to $T_{amb} = 25 \text{ }^\circ\text{C}$	$P_{tot}$	max.		0,8	W
	$P_{tot}$	max.		1	W <sup>1)</sup>
<u>Temperatures</u>					
Storage temperature	$T_{stg}$			-65 to +150	$^\circ\text{C}$
Junction temperature	$T_j$	max.		150	$^\circ\text{C}$
<b>THERMAL RESISTANCE</b>					
From junction to ambient in free air	$R_{th \text{ j-a}}$	=		156	$^\circ\text{C/W}$
From junction to ambient	$R_{th \text{ j-a}}$	=		125	$^\circ\text{C/W}$ <sup>1)</sup>
From junction to case	$R_{th \text{ j-c}}$	=		60	$^\circ\text{C/W}$

<sup>1)</sup> Transistor mounted on printed circuit board, max. lead length 4 mm, mounting pad for collector lead min. 10 mm x 10 mm.

**CHARACTERISTICS**

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

Collector cut-off current

$I_E = 0; V_{CB} = 30\text{ V}$   $I_{CBO} < 100\text{ nA}$

$I_E = 0; V_{CB} = 30\text{ V}; T_j = 150\text{ }^\circ\text{C}$   $I_{CBO} < 10\text{ }\mu\text{A}$

Emitter cut-off current

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

Base-emitter voltage

$I_C = 500\text{ mA}; V_{CE} = 2\text{ V}$   $V_{BE} < 1\text{ V}$

Saturation voltage

$I_C = 500\text{ mA}; I_B = 50\text{ mA}$   $V_{CEsat} < 0,5\text{ V}$

D.C. current gain

	BC635	BC637	BC639
$I_C = 5\text{ mA}; V_{CE} = 2\text{ V}$ $h_{FE} >$	25	25	25
$I_C = 150\text{ mA}; V_{CE} = 2\text{ V}$ $h_{FE} >$	40	40	40
$I_C = 150\text{ mA}; V_{CE} = 2\text{ V}$ $h_{FE} <$	250	160	160
$I_C = 500\text{ mA}; V_{CE} = 2\text{ V}$ $h_{FE} >$	25	25	25

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

$I_C = 10\text{ mA}; V_{CE} = 5\text{ V}$   $f_T$  typ. 130 MHz

D.C. current gain ratio of matched pairs

$|I_C| = 150\text{ mA}; |V_{CE}| = 2\text{ V}$

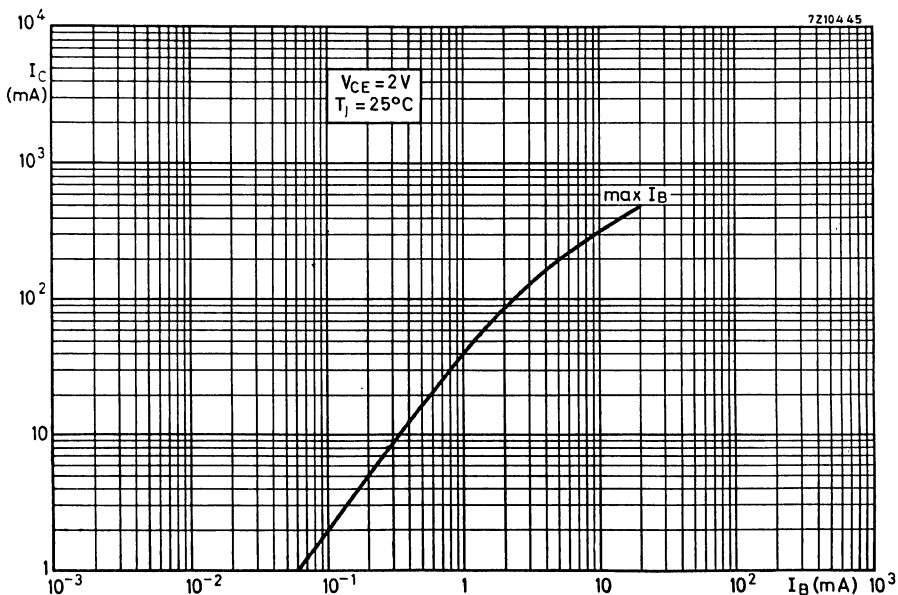
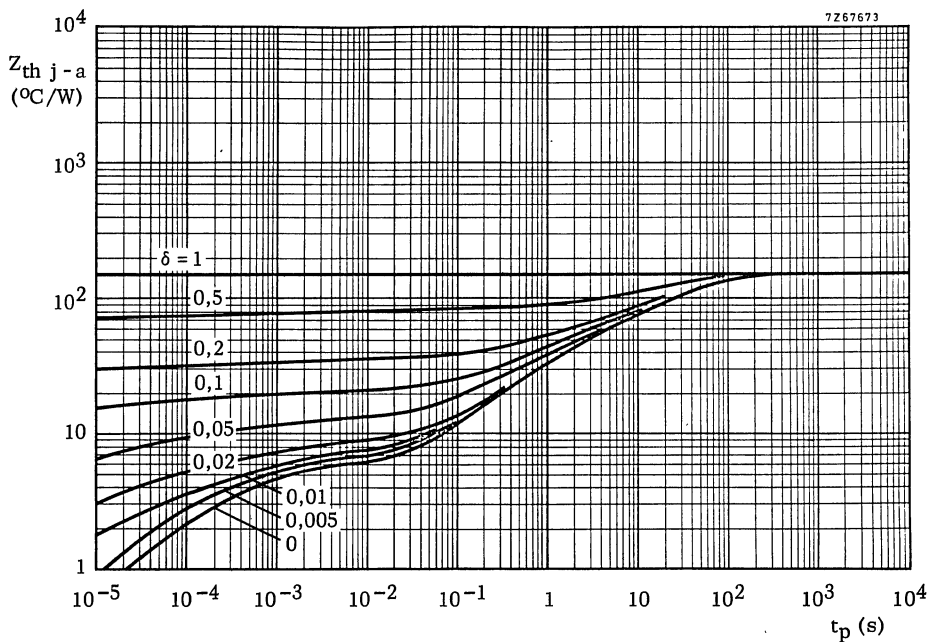
BC635/BC636,

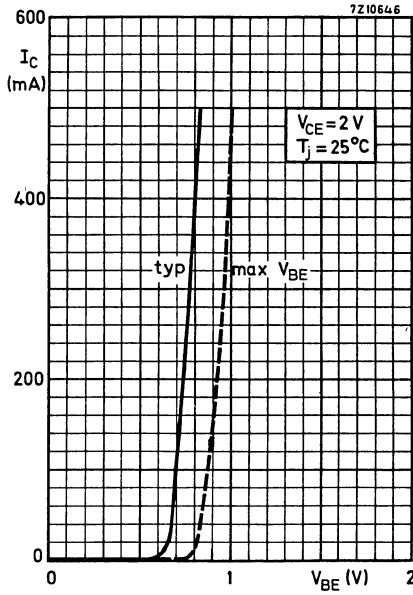
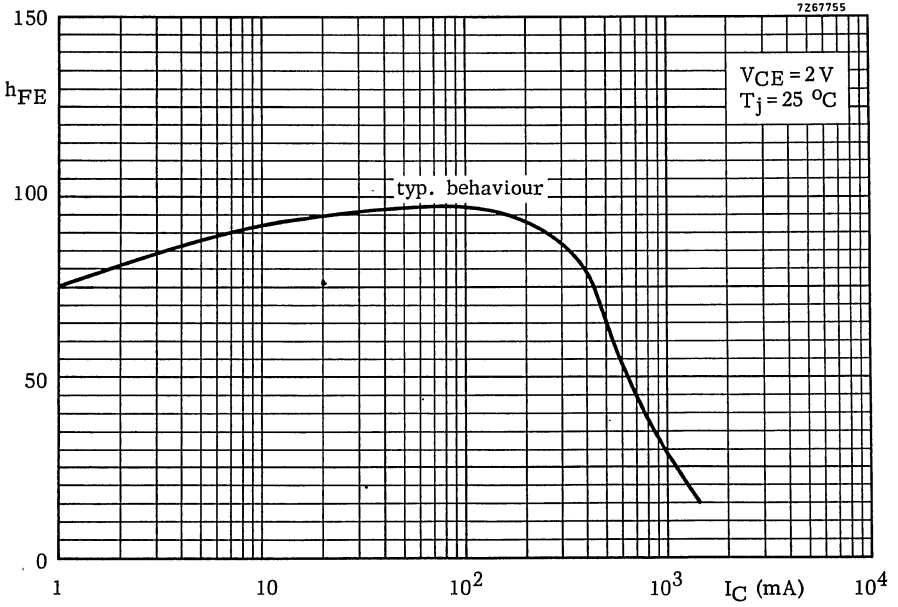
BC637/BC638 and

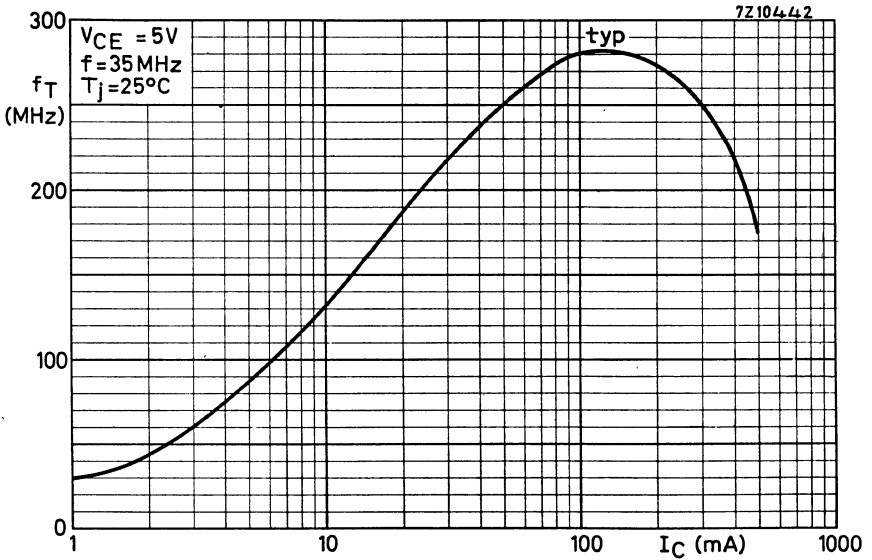
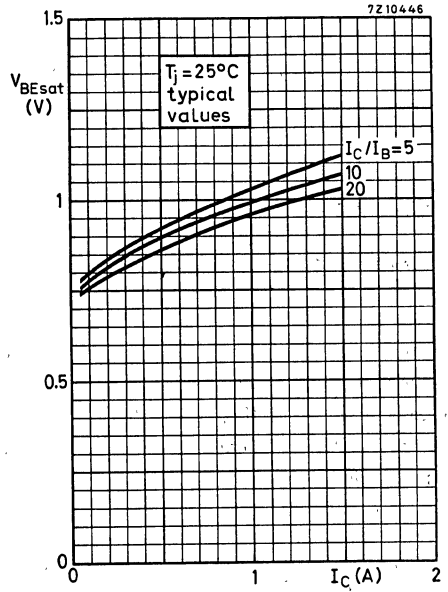
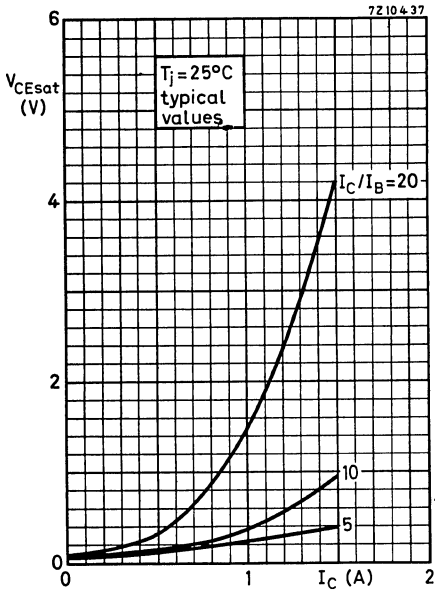
BC639/BC640

$h_{FE1}/h_{FE2}$  typ. 1,3  
< 1,6

**BC635; BC637;  
BC639**







## SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in a plastic TO-92 variant, primarily intended for use in driver stages of audio amplifiers. N-P-N complements are BC635, BC637 and BC639.

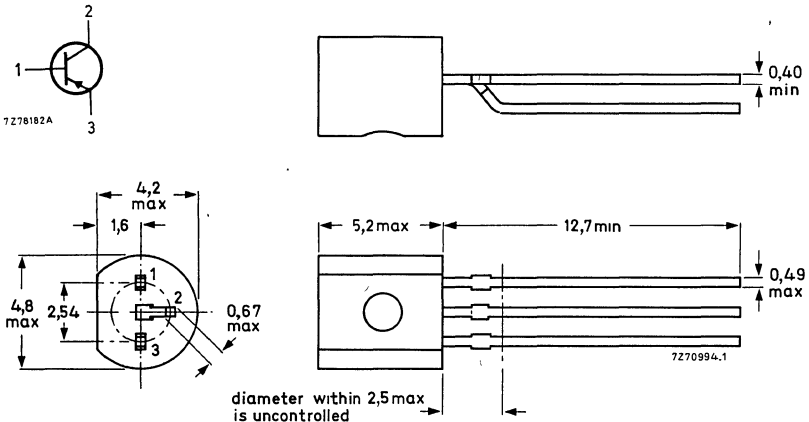
### QUICK REFERENCE DATA

		BC636	BC638	BC640
Collector-base voltage (open emitter)	$-V_{CB0}$ max.	45	60	100 V
Collector-emitter voltage (open base)	$-V_{CEO}$ max.	45	60	80 V
Collector-emitter voltage ( $R_{BE} = 1 \text{ k}\Omega$ )	$-V_{CER}$ max.	45	60	100 V
Collector-current (peak value)	$-I_{CM}$ max.	1,5	1,5	1,5 A
Total power dissipation up to $T_{amb} = 25 \text{ }^\circ\text{C}$	$P_{tot}$ max.	1	1	1 W
Junction temperature	$T_j$ max.	150	150	150 $^\circ\text{C}$
D.C. current gain	$h_{FE}$	> 40 < 250	40 160	40 160
Transition frequency	$f_T$ typ.	50	50	50 MHz

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



# BC636; BC638; BC640

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

## Voltages

			BC636	BC638	BC640
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	100 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80 V
Collector-emitter voltage ( $R_{BE} = 1 \text{ k}\Omega$ )	$-V_{CER}$	max.	45	60	100 V
Collector-emitter voltage ( $-V_{BE} = 0$ )	$-V_{CES}$	max.	45	60	100 V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5 V

## Currents

Collector current (d. c.)	$-I_C$	max.			1 A
Collector current (peak value)	$-I_{CM}$	max.			1,5 A
Emitter current (peak value)	$I_{EM}$	max.			1,5 A
Base current (d. c.)	$-I_B$	max.			100 mA
Base current (peak value)	$-I_{BM}$	max.			200 mA

## Power dissipation

Total power dissipation at $T_{amb} = 25 \text{ }^\circ\text{C}$ up to $T_{amb} = 25 \text{ }^\circ\text{C}$	$P_{tot}$	max.			0,8 W
	$P_{tot}$	max.			1 W <sup>1)</sup>

## 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 ambient in free air	$R_{th \text{ j-a}}$	=			156 $^\circ\text{C/W}$
From junction to ambient	$R_{th \text{ j-a}}$	=			125 $^\circ\text{C/W}$ <sup>1)</sup>
From junction to case	$R_{th \text{ j-c}}$	=			60 $^\circ\text{C/W}$

<sup>1)</sup> Transistor mounted on printed circuit board, max. lead length 4 mm, mounting pad for collector lead min. 10 mm x 10 mm.

**CHARACTERISTICS**

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

Collector cut-off current

$I_E = 0; -V_{CB} = 30\text{ V}$	$-I_{CBO} <$	100	nA
$I_E = 0; -V_{CB} = 30\text{ V}; T_j = 150\text{ }^\circ\text{C}$	$-I_{CBO} <$	10	$\mu\text{A}$

Emitter cut-off current

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

$-I_C = 500\text{ mA}; -V_{CE} = 2\text{ V}$	$-V_{BE} <$	1	V
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Saturation voltage

$-I_C = 500\text{ mA}; -I_B = 50\text{ mA}$	$-V_{CEsat} <$	0,5	V
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D.C. current gain

		BC636	BC638	BC640
$-I_C = 5\text{ mA}; -V_{CE} = 2\text{ V}$	$h_{FE} >$	25	25	25
$-I_C = 150\text{ mA}; -V_{CE} = 2\text{ V}$	$h_{FE} >$	40	40	40
	$h_{FE} <$	250	160	160
$-I_C = 500\text{ mA}; -V_{CE} = 2\text{ V}$	$h_{FE} >$	25	25	25

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

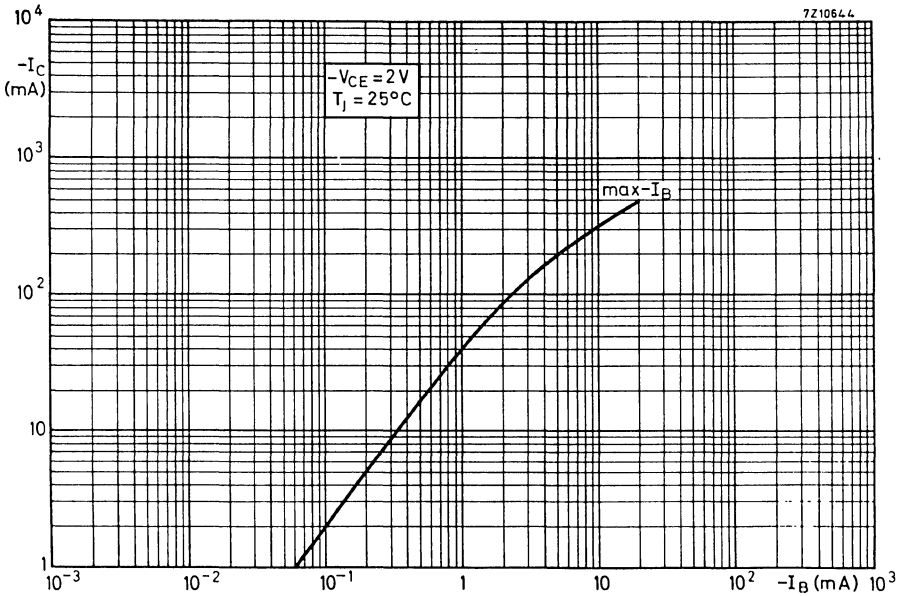
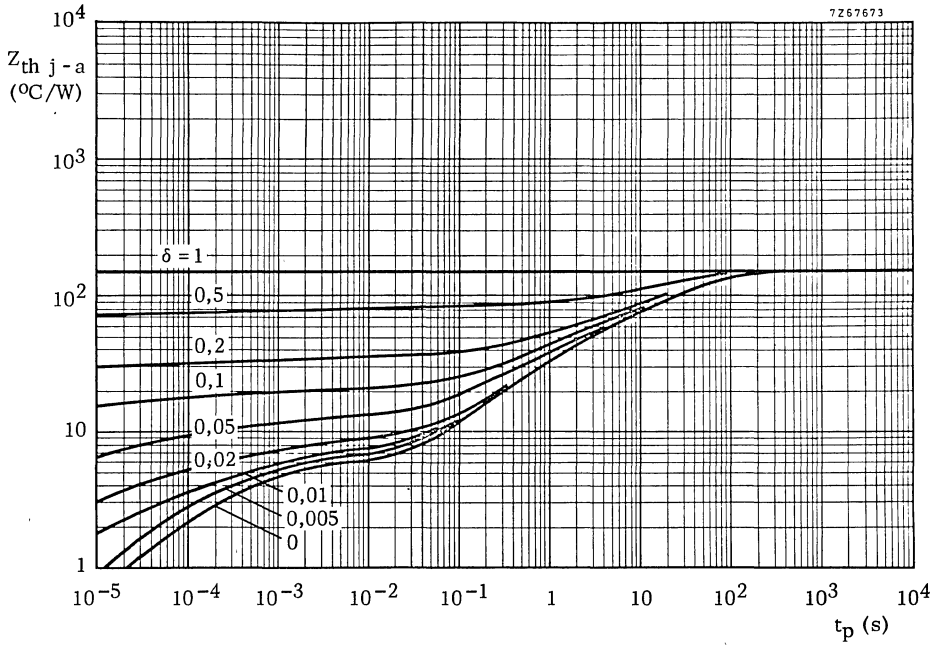
$-I_C = 10\text{ mA}; -V_{CE} = 5\text{ V}$	$f_T$ typ.	50	MHz
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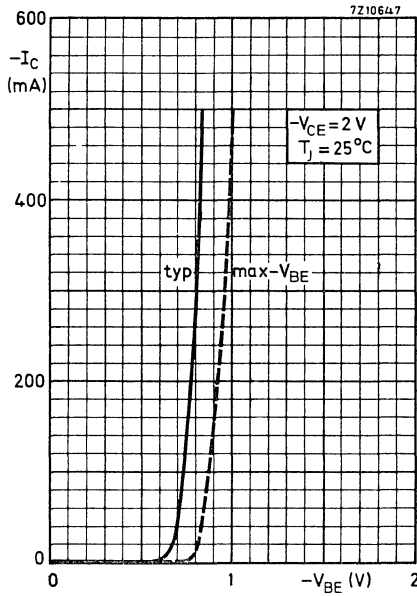
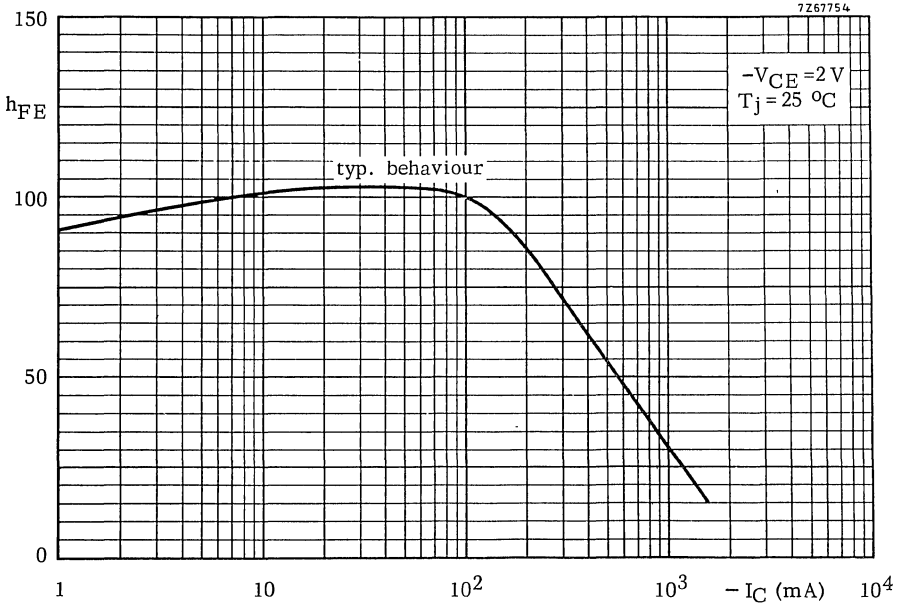
D.C. current gain ratio of matched pairs

$ I_C  = 150\text{ mA};  V_{CE}  = 2\text{ V}$			
BC635/BC636,			
BC637/BC638 and			
BC639/BC640	$h_{FE1}/h_{FE2}$	typ.	1,3
		<	1,6

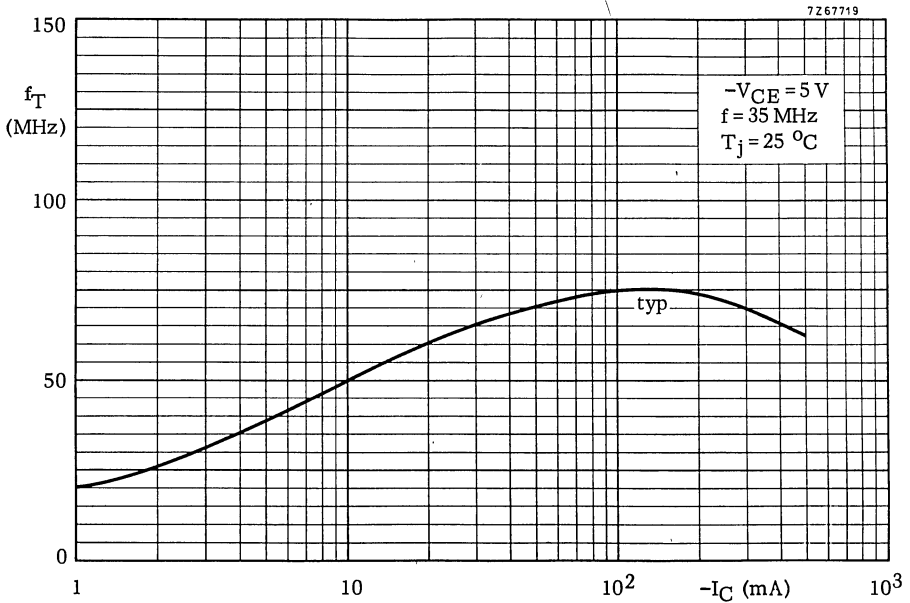
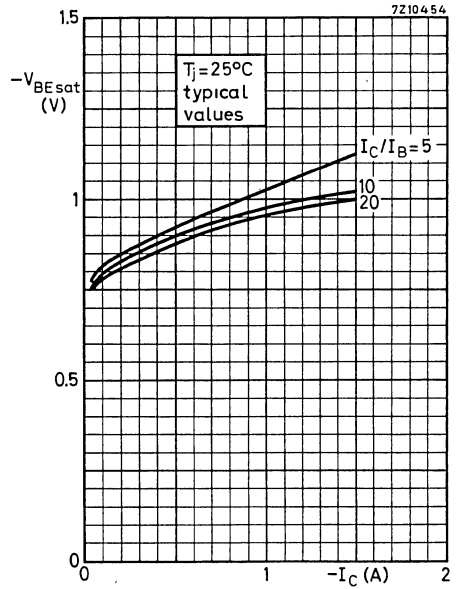
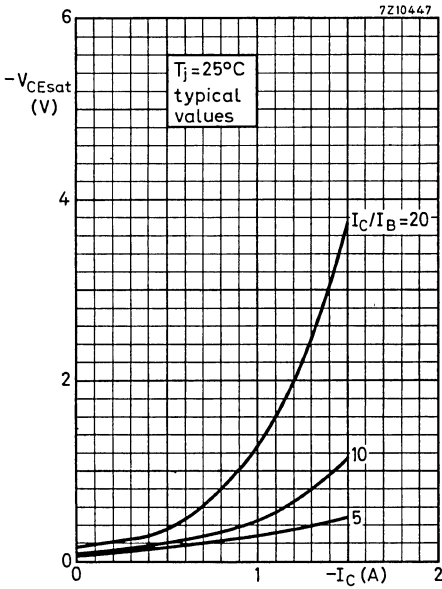


**BC636; BC638;  
BC640**





**BC636; BC638;  
BC640**



## SILICON TRANSISTORS

P-N-P transistors in TO-5 metal envelopes featuring high emitter-base voltage ratings, intended for use in relay switching, resistor logic circuits and general industrial applications.

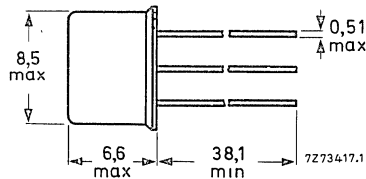
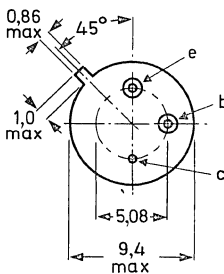
### QUICK REFERENCE DATA

		BCY 30A	BCY 31A	BCY 32A	BCY 33A	BCY 34A
Collector-base voltage (open emitter)	$-V_{CBO}$ max.	64	64	64	32	32 V
Collector-emitter voltage (open base)	$-V_{CEO}$ max.	64	64	64	32	32 V
Emitter-base voltage (open collector)	$-V_{EBO}$ max.	45	45	32	32	32 V
Collector current (d.c.)	$-I_C$ max.	100	100	100	100	100 mA
Total power dissipation up to $T_{amb} = 25^\circ\text{C}$	$P_{tot}$ max.	600	600	600	600	600 mW
Small-signal current gain $-I_C = 1\text{ mA}; -V_{CE} = 6\text{ V}; f = 1\text{ kHz}$	$h_{fe}$ typ.	25	35	55	25	35
Transition frequency $-I_C = 1\text{ mA}; -V_{CE} = 6\text{ V}$	$f_T$ typ.	2,0	2,0	2,0	2,0	2,0 MHz

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-5; collector connected to case.



Accessories: 56245 (distance disc).

**RATINGS**

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

			BCY30A BCY31A	BCY32A	BCY33A BCY34A	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	64	64	32	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	64	64	32	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	45	32	32	V
Collector current (d.c.)	$-I_C$	max.		100		mA
Collector current (peak value)	$-I_{CM}$	max.		100		mA
Base current (d.c.)	$-I_B$	max.		50		mA
Base current (peak value)	$-I_{BM}$	max.		50		mA
Emitter current (d.c.)	$I_E$	max.		100		mA
Emitter current (peak value)	$I_{EM}$	max.		100		mA
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.		600		mW
up to $T_{case} = 45\text{ }^\circ\text{C}$	$P_{tot}$	max.		3		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	$R_{th\ j-a}$	=		200		K/W
From junction to case	$R_{th\ j-c}$	=		35		K/W

## SILICON PLANAR EPITAXIAL TRANSISTORS



N-P-N transistors in TO-18 metal envelopes with the collector connected to the case.

They are intended for general purpose very high-gain low level and low-noise applications. Moreover, they are also suitable for low-speed switching applications.

### QUICK REFERENCE DATA

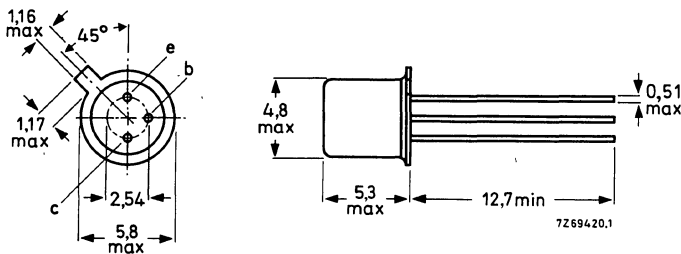
			BCY56	BCY57	
Collector-base voltage (open emitter)	$V_{CBO}$	max.	45	25	V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	45	20	V
Collector current (d.c.)	$I_C$	max.	100	100	mA
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	300	300	mW
Junction temperature	$T_j$	max.	175	175	$^\circ\text{C}$
D.C. current gain at $T_j = 25\text{ }^\circ\text{C}$					
$I_C = 10\text{ }\mu\text{A}; V_{CE} = 5\text{ V}$	$h_{FE}$	>	40	100	
$I_C = 2\text{ mA}; V_{CE} = 5\text{ V}$	$h_{FE}$	>	100	200	
	$h_{FE}$	<	450	800	
Transition frequency					
$I_C = 0,5\text{ mA}; V_{CE} = 5\text{ V}$	$f_T$	typ.	85	100	MHz
Noise figure at $R_S = 2\text{ k}\Omega$					
$I_C = 200\text{ }\mu\text{A}; V_{CE} = 5\text{ V}$	F	typ.	1,5	1,5	dB
$f = 30\text{ Hz to } 15,7\text{ kHz}$	F	<	5,0	5,0	dB

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector connected to case



Accessories 56246 (distance disc).

Products approved to CECC 50 002-164, available on request.

**RATINGS** (Limiting values) <sup>1)</sup>

Voltages

		BCY56	BCY57	
Collector-base voltage (open emitter)	$V_{CBO}$	max. 45	25	V
Collector-emitter voltage (open base)	$V_{CEO}$	max. 45	20	V
Emitter-base voltage (open collector)	$V_{EBO}$	max. 5	5	V

Currents

Collector current (d. c.)	$I_C$	max. 100	mA
Collector current (peak value)	$I_{CM}$	max. 100	mA

Power dissipation

Total power dissipation up to $T_{amb} = 25^\circ C$	$P_{tot}$	max. 300	mW
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Temperatures

Storage temperature	$T_{stg}$	-65 to +175	$^\circ C$
Junction temperature	$T_j$	max. 175	$^\circ C$

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th\ j-a}$	= 0.5	$^\circ C/mW$
From junction to case	$R_{th\ j-c}$	= 0.2	$^\circ C/mW$

**CHARACTERISTICS**

$T_j = 25^\circ C$  unless otherwise specified

Collector cut-off current

$I_E = 0; V_{CB} = 20\ V$	$I_{CBO}$	< 100	nA
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Emitter cut-off current

$I_C = 0; V_{EB} = 5\ V$	$I_{EBO}$	< 100	nA
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Base-emitter voltage <sup>2)</sup>

$I_C = 2\ mA; V_{CE} = 5\ V$	$V_{BE}$	typ. 650	mV
		600 to 700	mV

Collector-emitter saturation voltage

$I_C = 10\ mA; I_B = 1\ mA$	$V_{CEsat}$	typ. 80	mV
$I_C = 100\ mA; I_B = 10\ mA$	$V_{CEsat}$	typ. 200	mV

1) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

2)  $V_{BE}$  decreases with about 2 mV/ $^\circ C$  at increasing temperature.

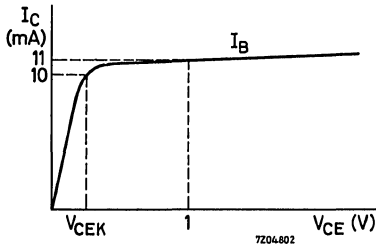
**CHARACTERISTICS** (continued)

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

Knee voltage

$I_C = 10\text{ mA}$ ;  $I_B =$  value for which  
 $I_C = 11\text{ mA}$  at  $V_{CE} = 1\text{ V}$

$V_{CEK}$       typ.    300 mV  
                 <      600 mV



7204802

D.C. current gain

$I_C = 10\text{ }\mu\text{A}$ ;  $V_{CE} = 5\text{ V}$

$h_{FE}$       >      BCY56 40    BCY57 100

$I_C = 2\text{ mA}$ ;  $V_{CE} = 5\text{ V}$

$h_{FE}$       typ. 200    400  
                 100 to 450    200 to 800

$I_C = 10\text{ mA}$ ;  $V_{CE} = 5\text{ V}$

$h_{FE}$       >      100    200

Transition frequency

$I_C = 0.5\text{ mA}$ ;  $V_{CE} = 5\text{ V}$

$f_T$       typ. 85    100 MHz

$I_C = 10\text{ mA}$ ;  $V_{CE} = 5\text{ V}$

$f_T$       typ. 250    350 MHz

h parameters at  $f = 1\text{ kHz}$

$I_C = 2\text{ mA}$ ;  $V_{CE} = 5\text{ V}$

Input impedance

$h_{ie}$       typ. 3.5    7.5  $\text{k}\Omega$

Reverse voltage transfer

$h_{re}$       typ. 1.75     $3.5 \times 10^{-4}$

Small signal current gain

$h_{fe}$       typ. 250    500  
                 125 to 500    240 to 900

Output admittance

$h_{oe}$       typ. 17.5     $35\text{ }\mu\Omega^{-1}$

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

$I_E = I_e = 0$ ;  $V_{CB} = 5\text{ V}$

$C_c$       typ. 4.5    4.5 pF

Noise figure

$I_C = 200\text{ }\mu\text{A}$ ;  $V_{CE} = 5\text{ V}$ ;  $R_S = 2\text{ k}\Omega$

$f = 30\text{ Hz}$  to  $15.7\text{ kHz}$

$F$       typ. 1.5    1.5 dB  
                 < 5    5 dB





SILICON PLANAR EPITAXIAL TRANSISTORS



N-P-N transistors in TO-18 metal envelopes with the collector connected to the case, for use in amplifier and switching applications.

QUICK REFERENCE DATA

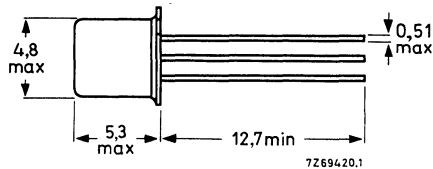
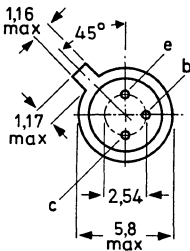
		BCY58	BCY59	
Collector-emitter voltage (open base)	$V_{CE0}$ max.	32	45	V
Collector current (d.c.)	$I_C$ max.	200	200	mA
Total power dissipation up to $T_{amb} = 45^\circ\text{C}$ up to $T_{case} = 45^\circ\text{C}$	$P_{tot}$ max.	330	330	mW
	$P_{tot}$ max.	1000	1000	mW
Junction temperature	$T_j$ max.	200	200	$^\circ\text{C}$
		BCY58-VII BCY59-VII	VIII VIII	IX IX
Small-signal current gain at $T_j = 25^\circ\text{C}$ $I_C = 2\text{ mA}$ ; $V_{CE} = 5\text{ V}$ ; $f = 1\text{ kHz}$	$h_{fe} >$	125	175	250
	$h_{fe} <$	250	350	500
Transition frequency at $f = 100\text{ MHz}$ $I_C = 10\text{ mA}$ ; $V_{CE} = 5\text{ V}$	$f_T$ typ.	280		MHz
	F typ.	2		dB
Noise figure at $R_S = 2\text{ k}\Omega$ $I_C = 200\ \mu\text{A}$ ; $V_{CE} = 5\text{ V}$ $f = 1\text{ kHz}$ ; $B = 200\text{ Hz}$				

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector connected to case



Accessories 56246 (distance disc).

Products approved to CECC 50 002-030/031, available on request.

**BCY58**  
**BCY59**

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

Voltages

			BCY58	BCY59
Collector-emitter voltage ( $V_{BE} = 0$ )	$V_{CES}$	max.	32	45 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	32	45 V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	7	7 V

Currents

Collector current	$I_C$	max.	200	mA
Base current	$I_B$	max.	50	mA

Power dissipation

Total power dissipation up to $T_{case} = 45^\circ C$	$P_{tot}$	max.	1000	mW
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Temperatures

Storage temperature	$T_{stg}$	- 65	to +200	$^\circ C$
Junction temperature	$T_j$	max.	200	$^\circ C$

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th j-a}$	=	0.45	$^\circ C/mW$
From junction to case	$R_{th j-c}$	=	0.15	$^\circ C/mW$

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

**CHARACTERISTICS**

Collector cut-off currents

BCY58 | BCY59

$V_{CE} = 32 \text{ V}; V_{BE} = 0$

ICES

typ. 0.2  
< 10

nA  
nA

$V_{CE} = 45 \text{ V}; V_{BE} = 0$

ICES

typ.  
<

0.2 nA  
10 nA

$V_{CE} = 32 \text{ V}; V_{BE} = 0; T_j = 150^\circ\text{C}$

ICES

typ. 0.2  
< 10

$\mu\text{A}$   
 $\mu\text{A}$

$V_{CE} = 45 \text{ V}; V_{BE} = 0; T_j = 150^\circ\text{C}$

ICES

typ.  
<

0.2  $\mu\text{A}$   
10  $\mu\text{A}$

Emitter cut-off current

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

IEBO

< 10

10 nA

Collector-emitter breakdown voltage

$I_B = 0; I_C = 2 \text{ mA}$

$V_{(BR)CEO} >$

32

45 V

Emitter-base breakdown voltage

$I_C = 0; I_E = 1 \mu\text{A}$

$V_{(BR)EBO} >$

7

7 V

Base emitter voltage

$I_C = 10 \mu\text{A}; V_{CE} = 5 \text{ V}$

$V_{BE}$

typ.

0.5 V

$I_C = 20 \mu\text{A}; V_{CE} = V_{CEO \text{ max}}; T_j = 100^\circ\text{C}$

$V_{BE}$

>

0.2 V

$I_C = 2 \text{ mA}; V_{CE} = 5 \text{ V}$

$V_{BE}$

typ.  
0.55 to 0.70

0.62 V  
V

$I_C = 10 \text{ mA}; V_{CE} = 1 \text{ V}$

$V_{BE}$

typ.

0.70 V

$I_C = 100 \text{ mA}; V_{CE} = 1 \text{ V}$

$V_{BE}$

typ.

0.76 V

Saturation voltages

$I_C = 10 \text{ mA}; I_B = 0.25 \text{ mA}$

$V_{CEsat}$

typ.

100 mV  
50 to 350 mV

$V_{BEsat}$

typ.

700 mV  
600 to 850 mV

$I_C = 100 \text{ mA}; I_B = 2.5 \text{ mA}$

$V_{CEsat}$

typ.

250 mV  
150 to 700 mV

$V_{BEsat}$

typ.

875 mV  
750 to 1200 mV

**BCY58**  
**BCY59**

**CHARACTERISTICS (continued)**

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

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

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

$C_c$	typ.	3.0	pF
	<	5.0	pF

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

$I_C = I_c = 0; V_{EB} = 0.5\text{ V}$

$C_e$	typ.	10	pF
	<	15	pF

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

$I_C = 10\text{ mA}; V_{CE} = 5\text{ V}$

$f_T$	>	150	MHz
	typ.	280	MHz

Noise figure at  $R_S = 2\text{ k}\Omega$

$I_C = 200\text{ }\mu\text{A}; V_{CE} = 5\text{ V}$

$f = 1\text{ kHz}; B = 200\text{ Hz}$

F	typ.	2	dB
	<	6	dB

BCY58VII	BCY58VIII	BCY58IX	BCY58X
BCY59VII	BCY59VIII	BCY59IX	BCY59X

D. C. current gain

$I_C = 10\text{ }\mu\text{A}; V_{CE} = 5\text{ V}$

$h_{FE}$	>	20	40	100
	typ.	20	95	300

$I_C = 2\text{ mA}; V_{CE} = 5\text{ V}$

$h_{FE}$	>	120	180	250	380
	typ.	170	250	350	500
	<	220	310	460	630

$I_C = 10\text{ mA}; V_{CE} = 1\text{ V}$

$h_{FE}$	>	80	120	160	240
	typ.	250	300	390	550
	<	-	400	630	1000

$I_C = 100\text{ mA}; V_{CE} = 1\text{ V}$

$h_{FE}$	>	40	45	60	60
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h parameters at  $f = 1\text{ kHz}$

$I_C = 2\text{ mA}; V_{CE} = 5\text{ V}$

Input impedance	$h_{ie}$	>	1.6	2.5	3.2	4.5	$\text{k}\Omega$
		typ.	2.7	3.6	4.5	7.5	$\text{k}\Omega$
		<	4.5	6.0	8.5	12	$\text{k}\Omega$

Reverse voltage transfer ratio  $h_{re}$  typ. 1.5 2 3 3  $10^{-4}$

Small signal current gain	$h_{fe}$	>	125	175	250	350
		typ.	200	260	330	520
		<	250	350	500	700

Output admittance	$h_{oe}$	typ.	18	24	30	50	$\mu\text{A/V}$
		<	30	50	60	100	$\mu\text{A/V}$

**CHARACTERISTICS** (continued)

Switching times

$I_C = 10 \text{ mA}; I_B = 1 \text{ mA}; -I_{BM} = 1 \text{ mA}$

$R_1 = 5 \text{ k}\Omega; R_2 = 5 \text{ k}\Omega; R_L = 990 \Omega$

$V_{BB} = 3.6 \text{ V}$

delay time	$t_d$	typ.	35	ns
rise time	$t_r$	typ.	50	ns
turn on time	$t_{on}$	typ.	85	ns
		<	150	ns
storage time	$t_s$	typ.	400	ns
fall time	$t_f$	typ.	80	ns
turn off time	$t_{off}$	typ.	480	ns
		<	800	ns

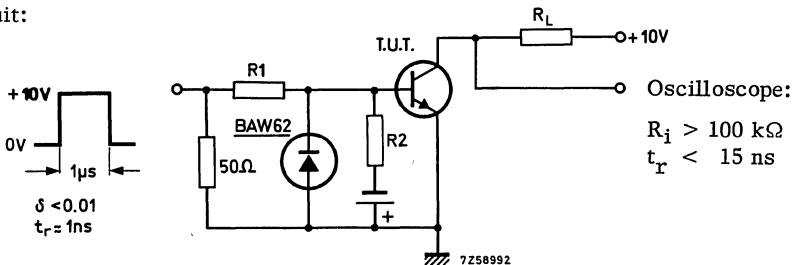
$I_C = 100 \text{ mA}; I_B = 10 \text{ mA}; -I_{BM} = 10 \text{ mA}$

$R_1 = 500 \Omega; R_2 = 700 \Omega; R_L = 98 \Omega$

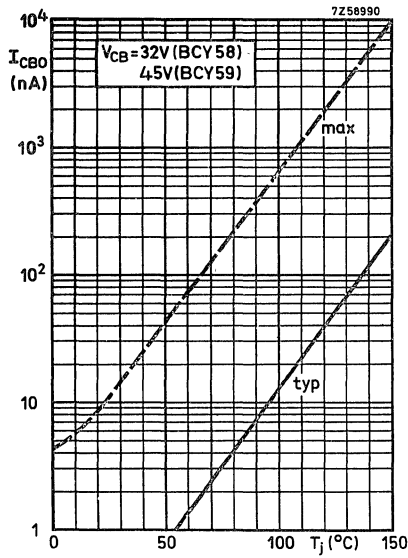
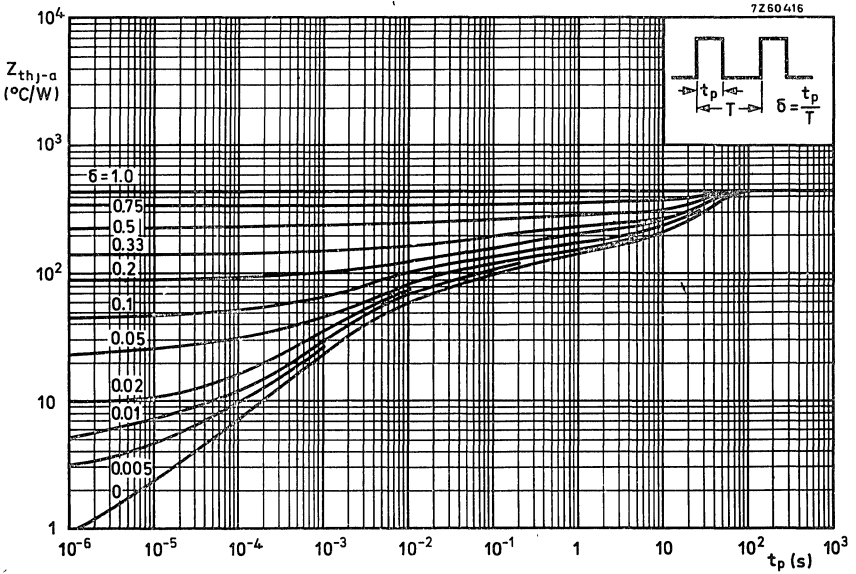
$V_{BB} = 5 \text{ V}$

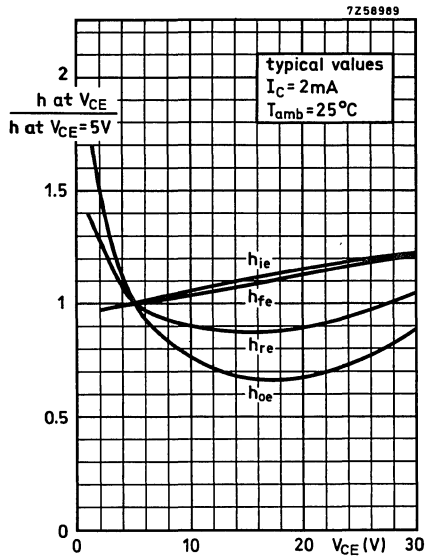
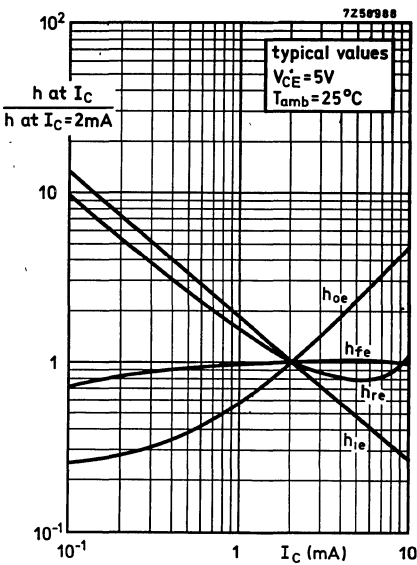
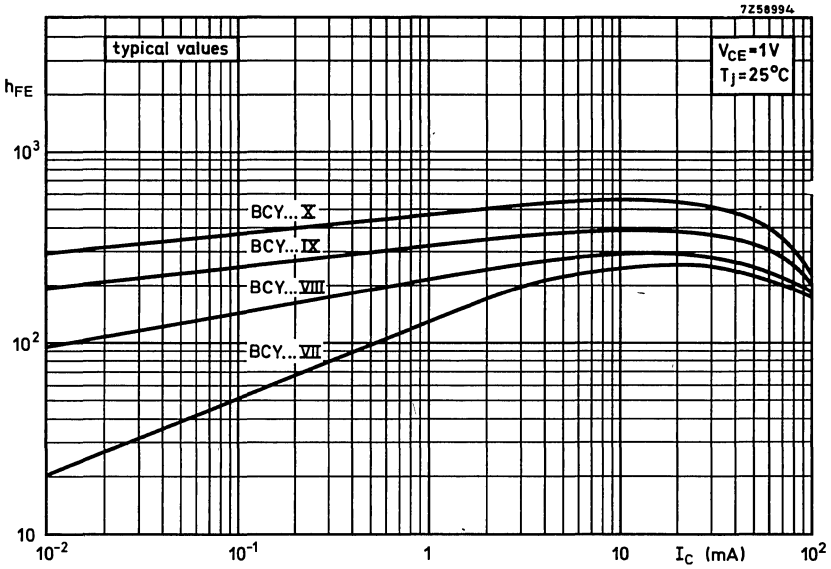
delay time	$t_d$	typ.	5	ns
rise time	$t_r$	typ.	50	ns
turn on time	$t_{on}$	typ.	55	ns
		<	150	ns
storage time	$t_s$	typ.	250	ns
fall time	$t_f$	typ.	200	ns
turn off time	$t_{off}$	typ.	450	ns
		<	800	ns

Test circuit:



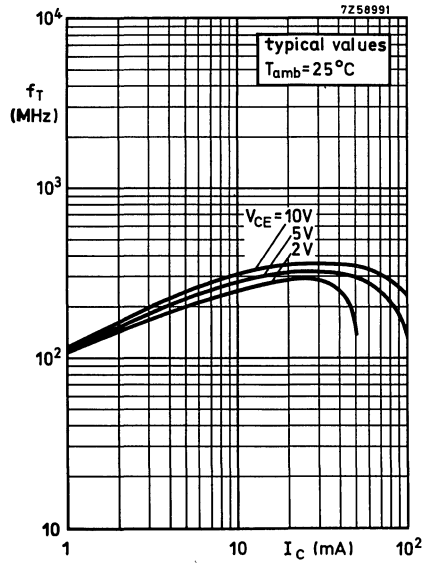
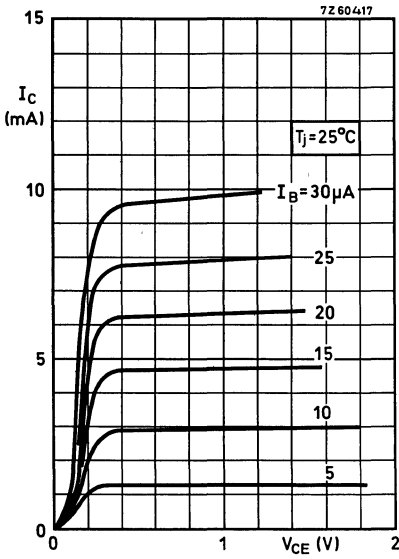
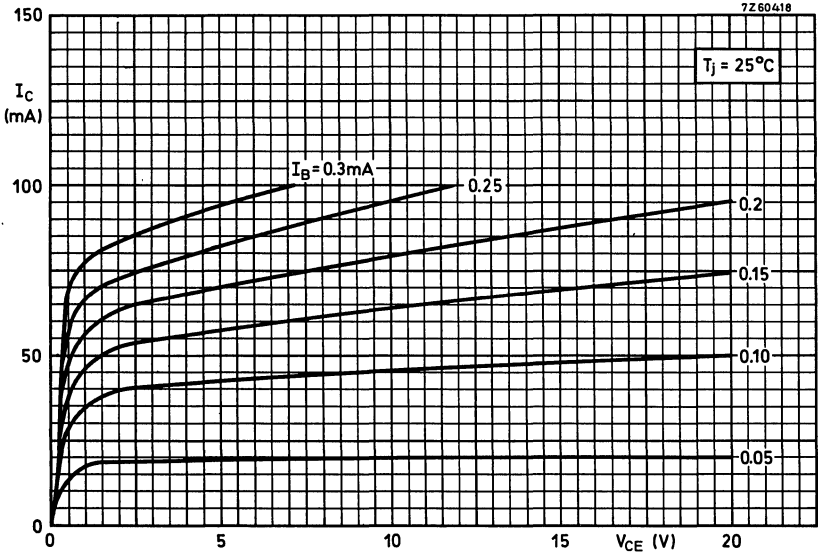
**BCY58**  
**BCY59**

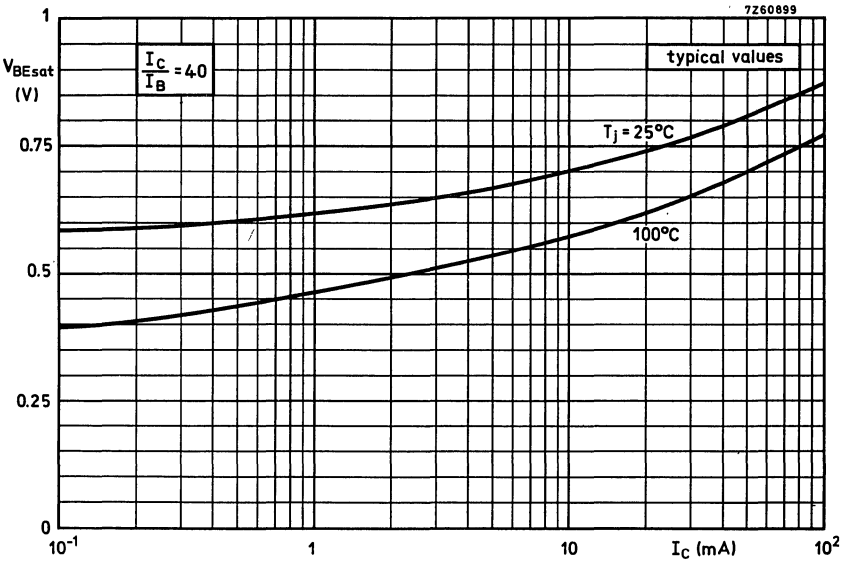
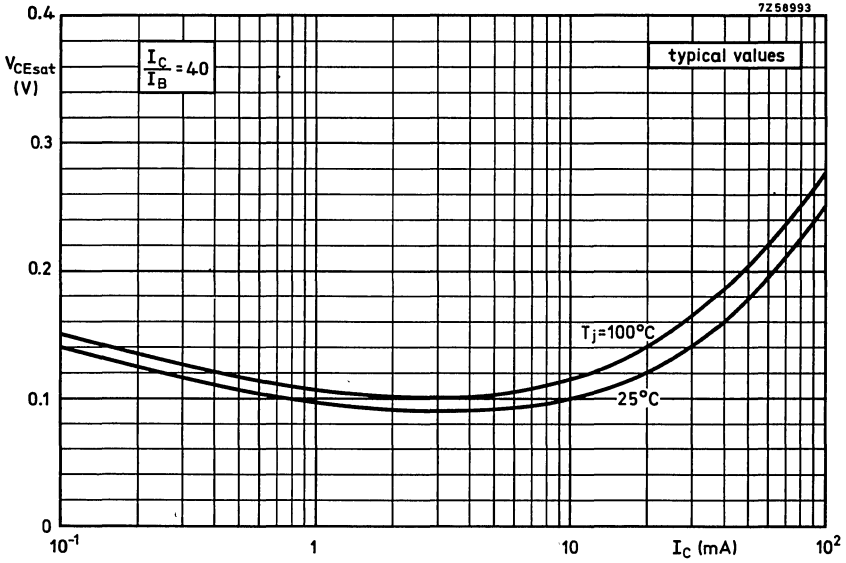






**BCY58  
BCY59**







## SILICON PLANAR EPITAXIAL TRANSISTORS



P-N-P transistors in TO-18 metal envelopes intended for general purpose industrial applications. The BCY71 is a low noise version.

## QUICK REFERENCE DATA

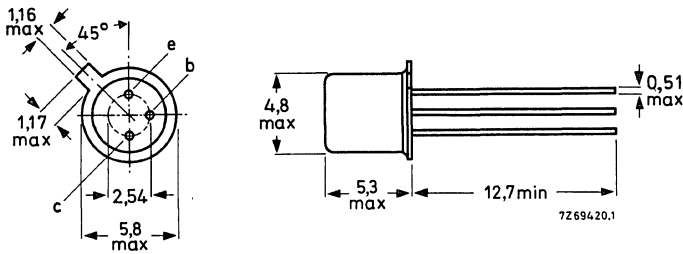
		BCY70	BCY71	BCY72	
Collector-base voltage (open emitter)	$-V_{CBO}$	max. 50	45	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max. 40	45	25	V
Collector current (peak value)	$-I_{CM}$	max.	200		mA
Total power dissipation up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	350		mW
Junction temperature	$T_j$	max.	200		$^{\circ}\text{C}$
D.C. current gain					
$-I_C = 10\text{ mA}; -V_{CE} = 1\text{ V}$	$h_{FE}$	>	100		
Transition frequency at $f = 100\text{ MHz}$					
$-I_C = 10\text{ mA}; -V_{CE} = 20\text{ V}$	$f_T$	>	250		MHz

## MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector connected to case.



Accessories: 56246 (distance disc).

**RATINGS**

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

			BCY70	BCY71	BCY72	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	50	45	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	45	25	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5,0	5,0	5,0	V
Collector current (d.c.)	$-I_C$	max.		200		mA
Collector current (peak value)	$-I_{CM}$	max.		200		mA
Emitter current (peak value)	$I_{EM}$	max.		200		mA
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.		350		mW
Storage temperature	$T_{stg}$			-65 to +200		$^\circ\text{C}$
Junction temperature	$T_j$	max.		200		$^\circ\text{C}$

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th\ j-a}$	=	500	K/W
From junction to case	$R_{th\ j-c}$	=	150	K/W

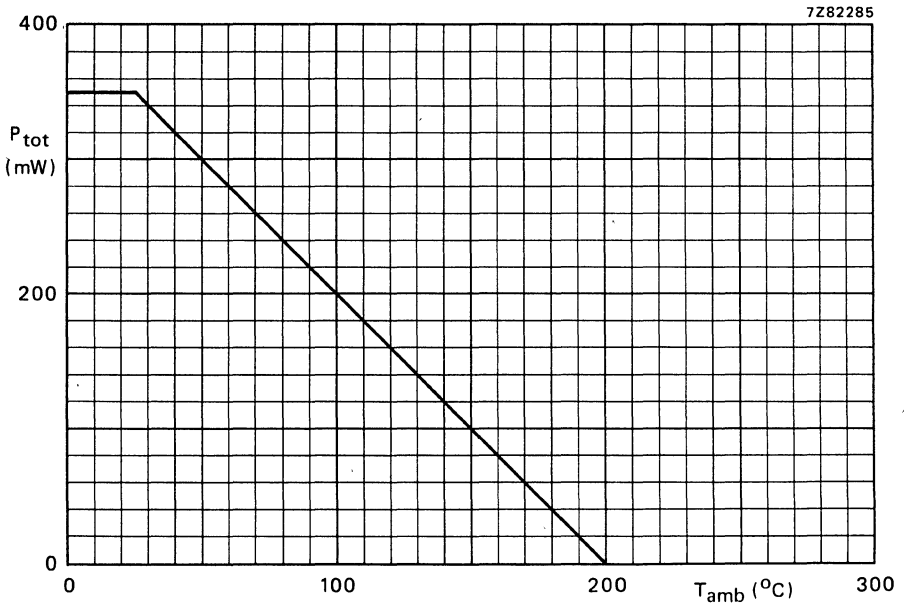


Fig. 2 Maximum permissible power dissipation as a function of ambient temperature.

**CHARACTERISTICS**

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

		BCY70	BCY71	BCY72
Collector cut-off current $I_E = 0; -V_{CB} = -V_{CB0max}$	$-I_{CBO}$	typ. 10 < 500	10 500	10 500 nA
	$I_E = 0; -V_{CB} = 40\text{ V}$	$-I_{CBO}$	typ. 0,5 < 10	0,5 50 nA
$I_E = 0; -V_{CB} = 40\text{ V}; T_j = 100\text{ }^\circ\text{C}$	$-I_{CBO}$	typ. 0,1 < 0,5	0,1 2,0	— — $\mu\text{A}$
	$I_E = 0; -V_{CB} = 25\text{ V}$	$-I_{CBO}$	typ. — < —	— — 0,5 50 nA
$I_E = 0; -V_{CB} = 25\text{ V}; T_j = 100\text{ }^\circ\text{C}$	$-I_{CBO}$	typ. — < —	— —	0,1 2,0 $\mu\text{A}$
	$-V_{CE} = 50\text{ V}; -V_{EB} = 3,0\text{ V}$	$-I_{CEX}$	typ. 1,0 < 20	— — nA
Emitter cut-off current $I_C = 0; -V_{EB} = 4,0\text{ V}$	$-I_{EBO}$	typ. — < —	0,3 10	nA nA
	$I_C = 0; -V_{EB} = 4,0\text{ V}; T_j = 100\text{ }^\circ\text{C}$	$-I_{EBO}$	typ. — < —	20 2,0 $\mu\text{A}$
$I_C = 0; -V_{EB} = 5,0\text{ V}$	$-I_{EBO}$	typ. — < —	5,0 500	nA nA
Saturation voltages $-I_C = 10\text{ mA}; -I_B = 1,0\text{ mA}$	$-V_{CEsat}$	typ. — < —	95 250	mV mV
	$-V_{BEsat}$	typ. — < —	750 600 to 900	mV mV
$-I_C = 50\text{ mA}; -I_B = 5,0\text{ mA}$	$-V_{CEsat}$	typ. — < —	190 500	mV mV
	$-V_{BEsat}$	typ. — < —	860 1200	mV mV
Knee voltage (see Fig. 3) $-I_C = 10\text{ mA}; -I_B = \text{value for which}$ $-I_C = 11\text{ mA at } -V_{CE} = 1\text{ V}$	$-V_{CEK}$	typ. — < —	270 600	mV mV

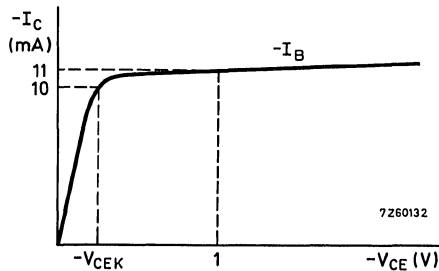


Fig. 3.

# BCY70 to 72

## D.C. current gain

$-I_C = 10 \mu\text{A}; -V_{CE} = 1,0 \text{ V}$	$h_{FE}$	>	60	
		typ.	245	
$-I_C = 0,1 \text{ mA}; -V_{CE} = 1,0 \text{ V}$	$h_{FE}$	>	80	
		typ.	270	
$-I_C = 1,0 \text{ mA}; -V_{CE} = 1,0 \text{ V}$	$h_{FE}$	>	100	
		typ.	300	
$-I_C = 10 \text{ mA}; -V_{CE} = 1,0 \text{ V}$	$h_{FE}$	>	100	
		typ.	290	
$-I_C = 10 \text{ mA}; -V_{CE} = 1,0 \text{ V}$	<b>BCY71</b> $h_{FE}$	<	400	
$-I_C = 50 \text{ mA}; -V_{CE} = 1,0 \text{ V}$	$h_{FE}$	>	45	
		typ.	175	

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

$I_E = I_e = 0; -V_{CB} = 10 \text{ V}$	$C_c$	typ.	4,5	pF
		<	6,0	pF

## Emitter capacitance at $f = 1 \text{ MHz}$

$I_C = I_c = 0; -V_{EB} = 1,0 \text{ V}$	$C_e$	typ.	6,0	pF
		<	8,0	pF

## Transition frequency at $T_{amb} = 25 \text{ }^\circ\text{C}$

			BCY70	BCY71	BCY72	
$-I_C = 10 \text{ mA}; -V_{CE} = 20 \text{ V}; f = 100 \text{ MHz}$	$f_T$	>	250	250	250	MHz
		typ.	450	450	450	MHz
$-I_C = 100 \mu\text{A}; -V_{CE} = 20 \text{ V}; f = 10,7 \text{ MHz}$	$f_T$	>	—	15	—	MHz
		typ.	—	30	—	MHz

## Noise figure

$-I_C = 100 \mu\text{A}; -V_{CE} = 5,0 \text{ V}$	$F$	typ.	2,0	0,8	2,0	dB
$f = 10 \text{ Hz to } 10 \text{ kHz}; R_S = 2,0 \text{ k}\Omega$		<	6,0	2,0	6,0	dB

## h-parameters (common emitter)

$-I_C = 1,0 \text{ mA}; -V_{CE} = 10 \text{ V}; f = 1 \text{ kHz};$						
$T_{amb} = 25 \text{ }^\circ\text{C}$						
Input impedance	$h_{ie}$	>	—	2,0	—	$\text{k}\Omega$
		typ.	—	4,0	—	$\text{k}\Omega$
		<	—	12,0	—	$\text{k}\Omega$
Reverse voltage transfer ratio	$h_{re}$	typ.	—	2,1	—	$10^{-4}$
		<	—	20,0	—	$10^{-4}$
		>	—	150	—	
Small-signal current gain	$h_{fe}$	typ.	—	325	—	
		<	—	400	—	
		>	—	10	—	$\mu\text{A/V}$
Output admittance	$h_{oe}$	typ.	—	20	—	$\mu\text{A/V}$
		<	—	60	—	$\mu\text{A/V}$

Switching times of the BCY70 and BCY72.

$-I_C = 10 \text{ mA}$ ;  $-I_{Bon} = +I_{Boff} = 1 \text{ mA}$   
 delay time

rise time

turn-on time

storage time

fall time

turn-off time

$t_d$	typ.	23 ns
	<	35 ns
$t_r$	typ.	25 ns
	<	35 ns
$t_{on}$	typ.	48 ns
	<	65 ns
$t_s$	typ.	270 ns
	<	350 ns
$t_f$	typ.	50 ns
	<	80 ns
$t_{off}$	typ.	320 ns
	<	420 ns

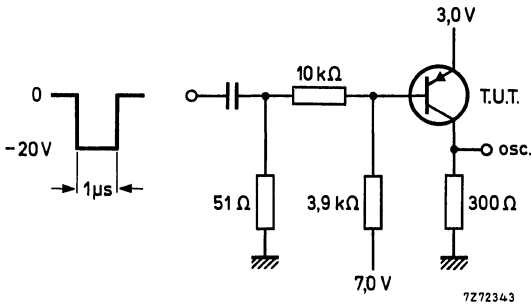


Fig. 4 Test circuit.

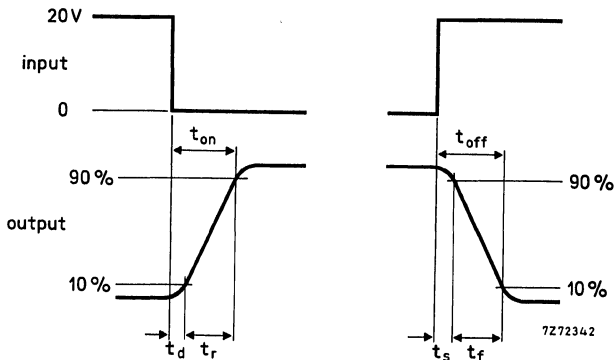


Fig. 5 Switching waveforms.



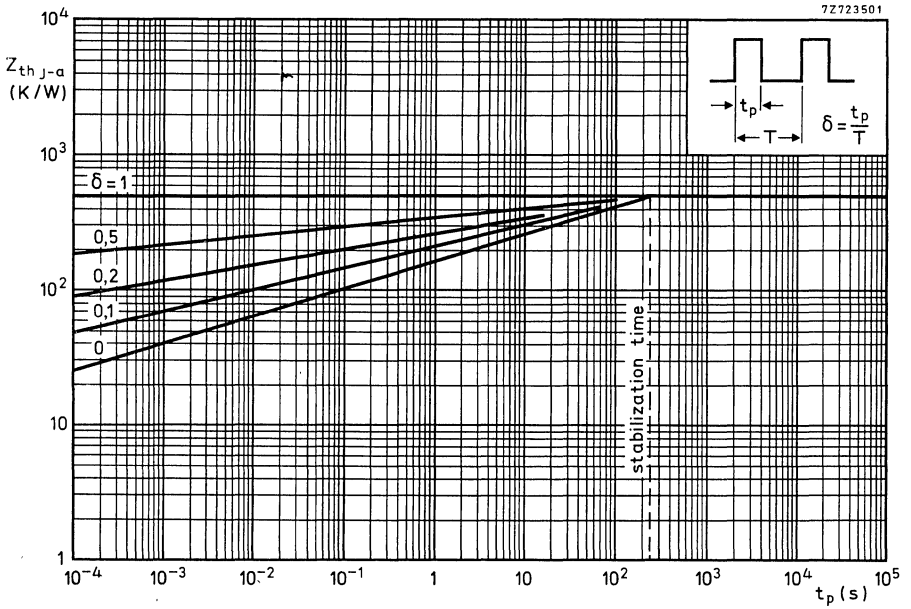


Fig. 6.

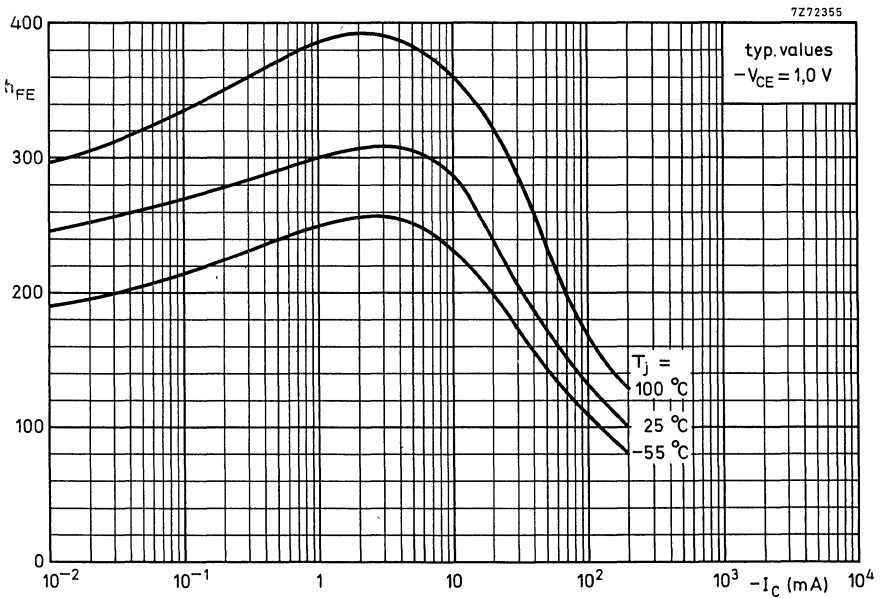


Fig. 7.

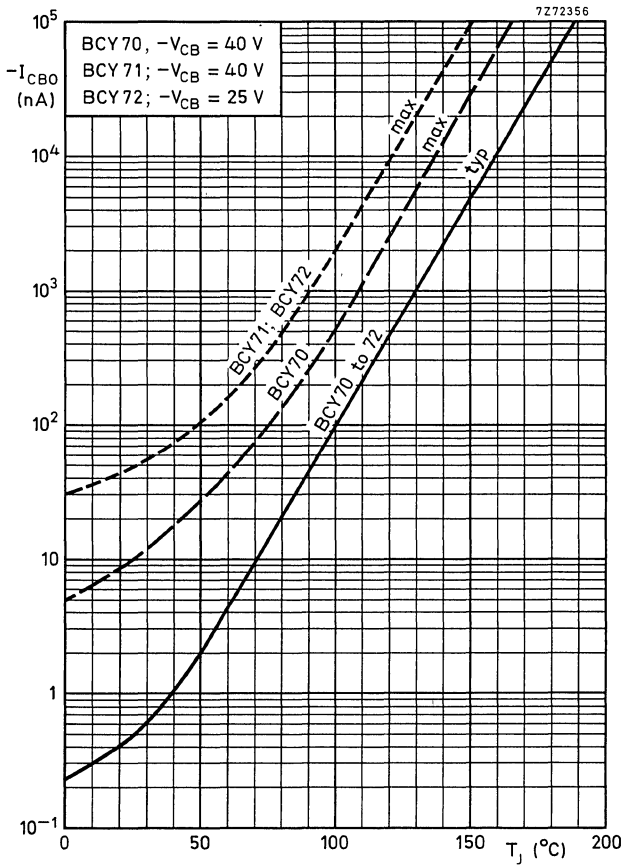


Fig. 8.

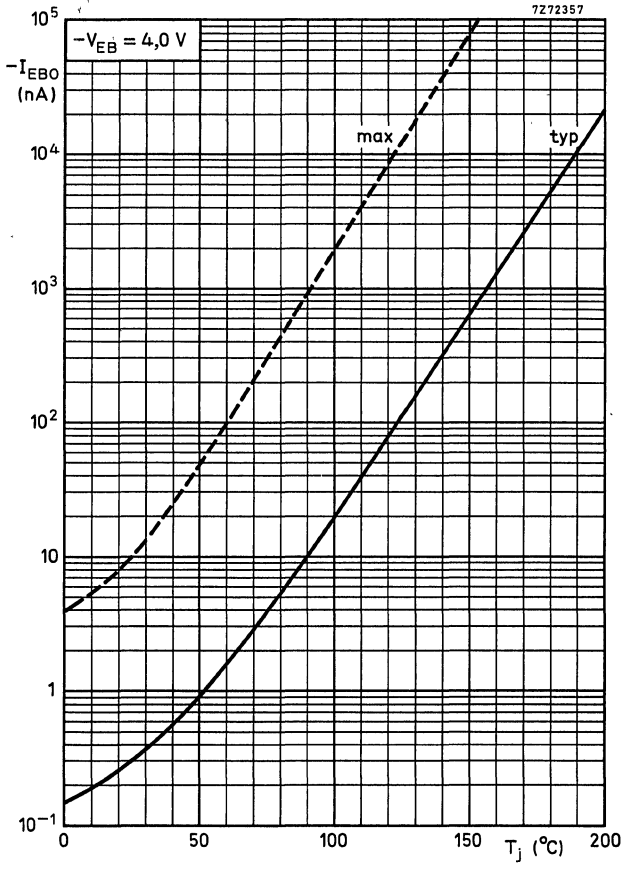


Fig. 9.

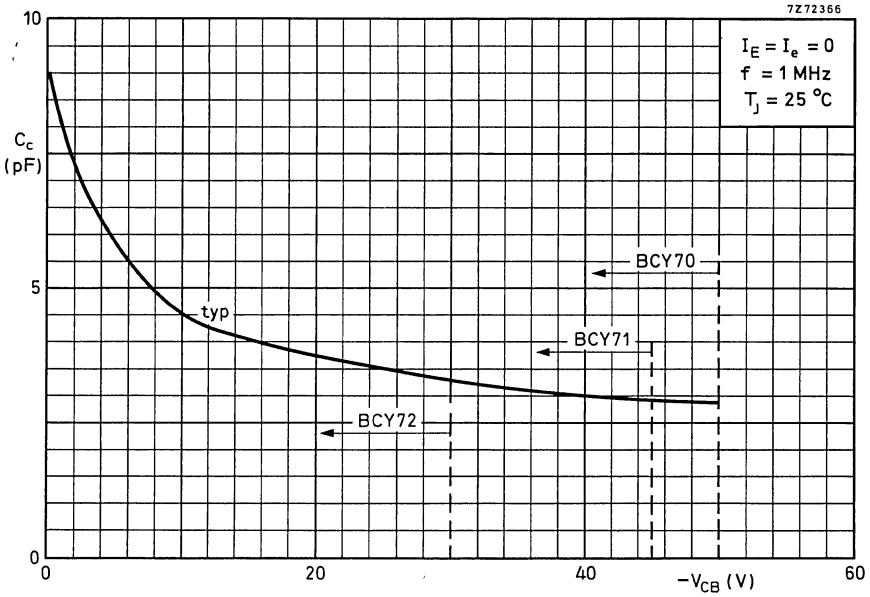


Fig. 10.

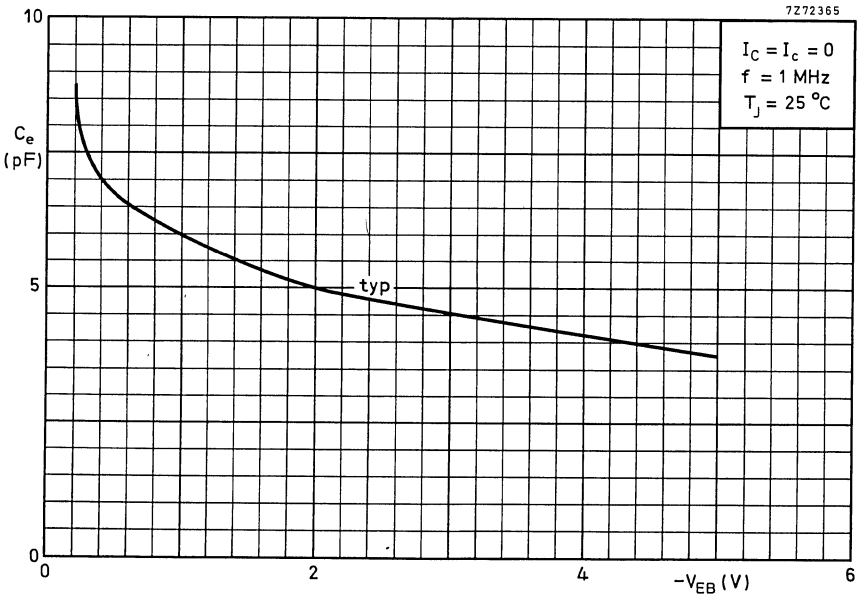


Fig. 11.

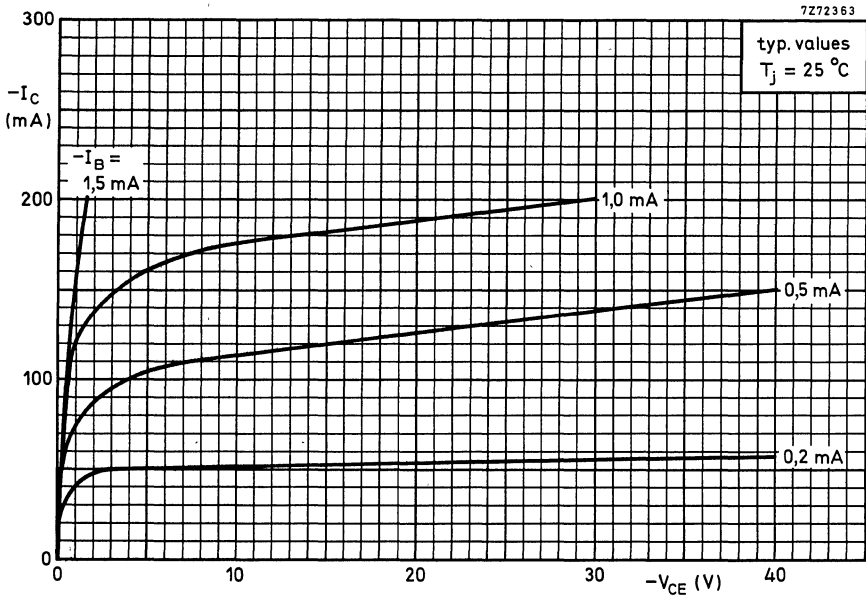


Fig. 12.

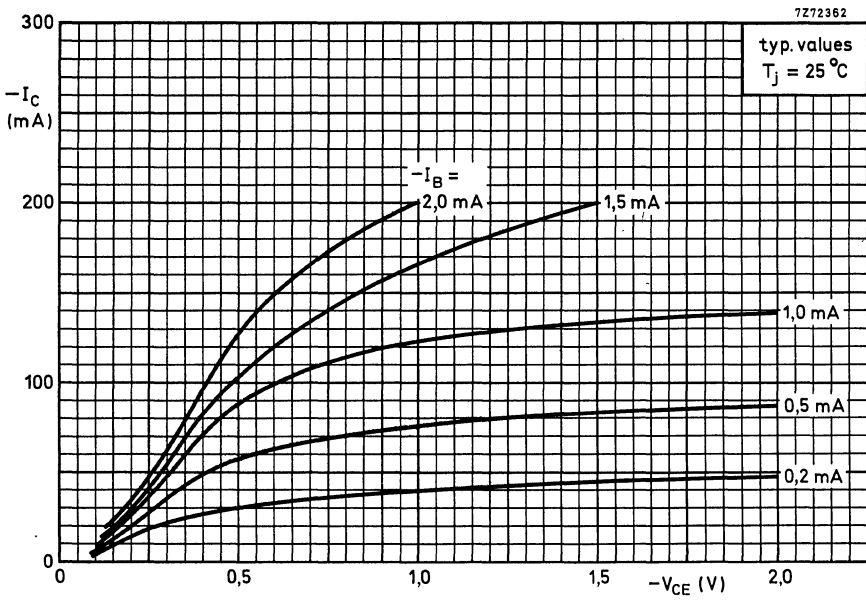


Fig. 13.

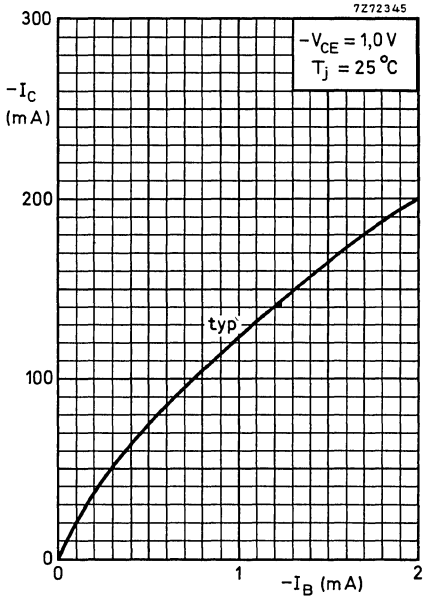


Fig. 14.

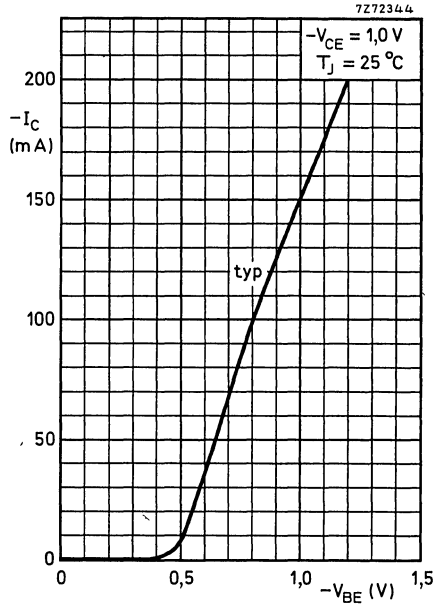


Fig. 15.

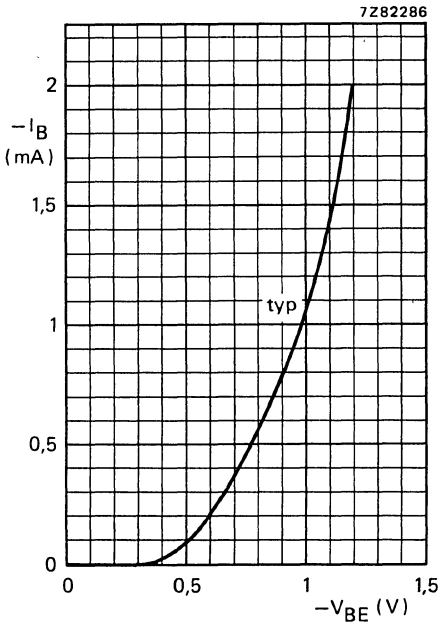


Fig. 16  $-V_{CE} = 1,0 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$

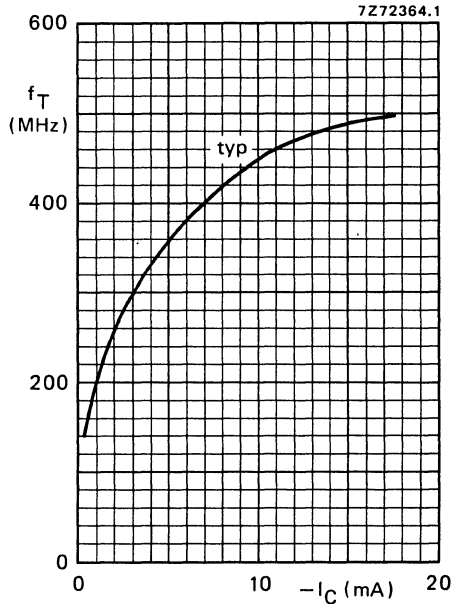


Fig. 17  $-V_{CE} = 20 \text{ V}; f = 100 \text{ MHz}; T_{amb} = 25 \text{ }^\circ\text{C}$ .

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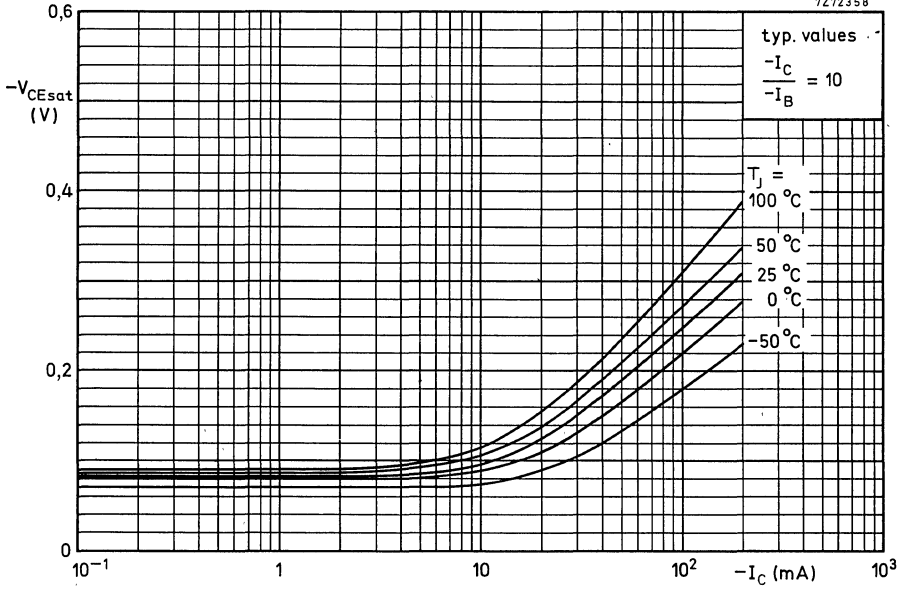


Fig. 18.

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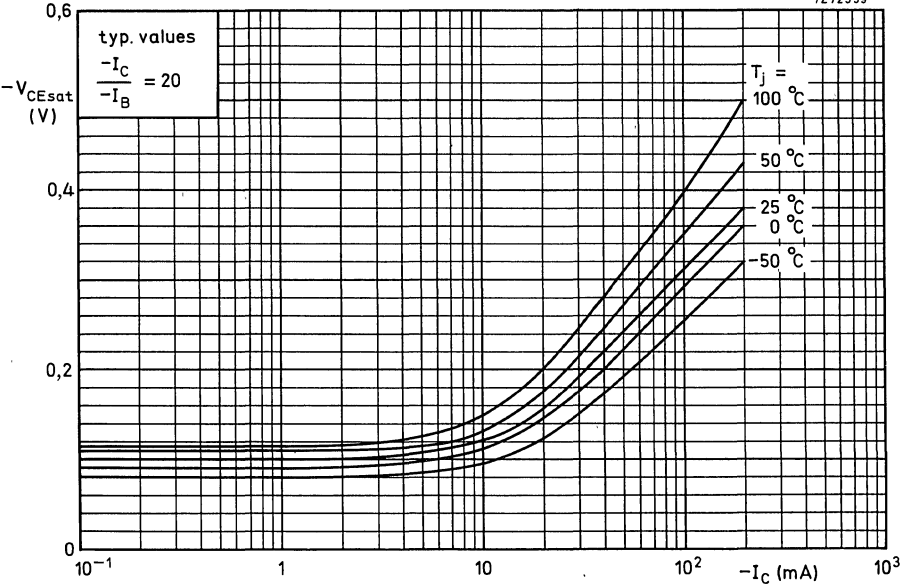


Fig. 19.

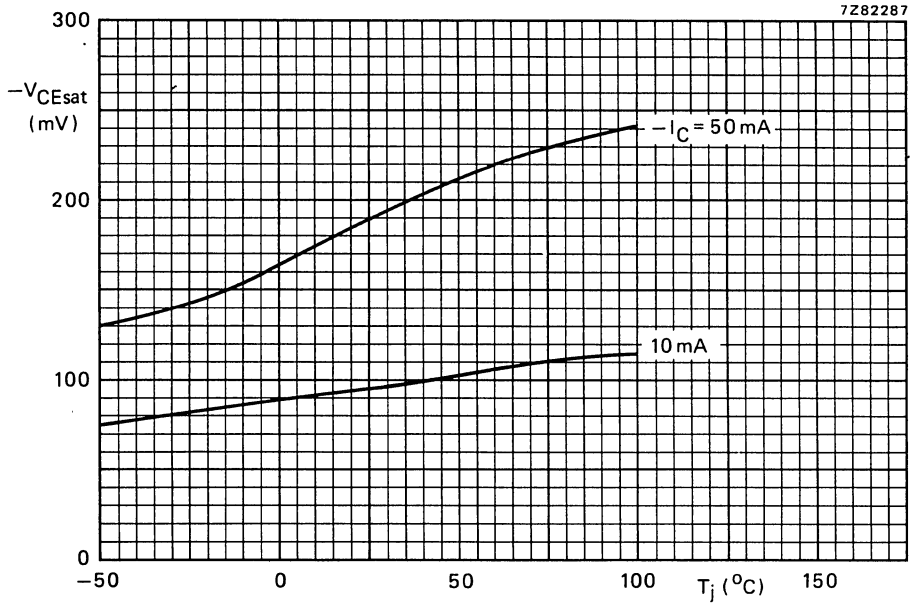


Fig. 20  $-I_C/-I_B = 10$ ; typical values.

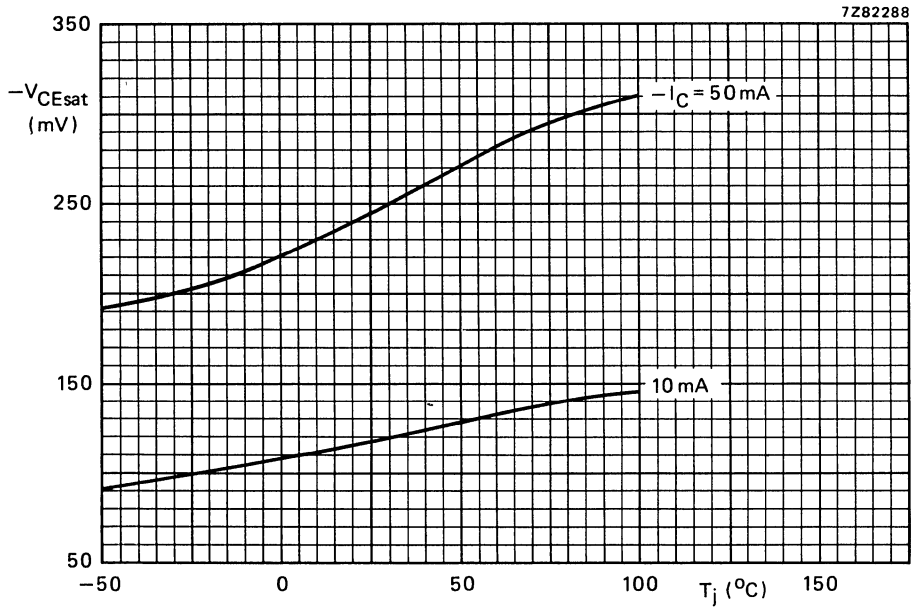


Fig. 21  $-I_C/-I_B = 20$ ; typical values.



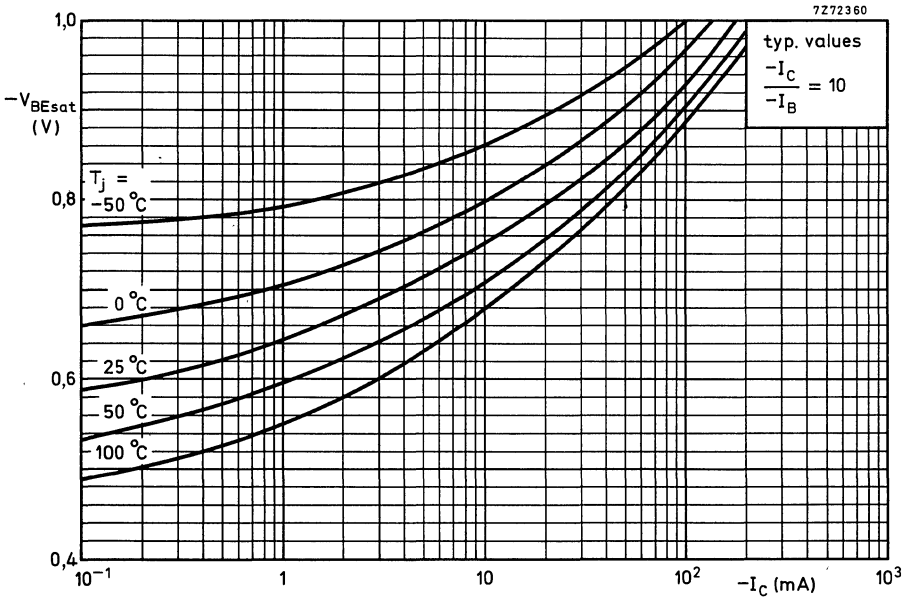


Fig. 22.

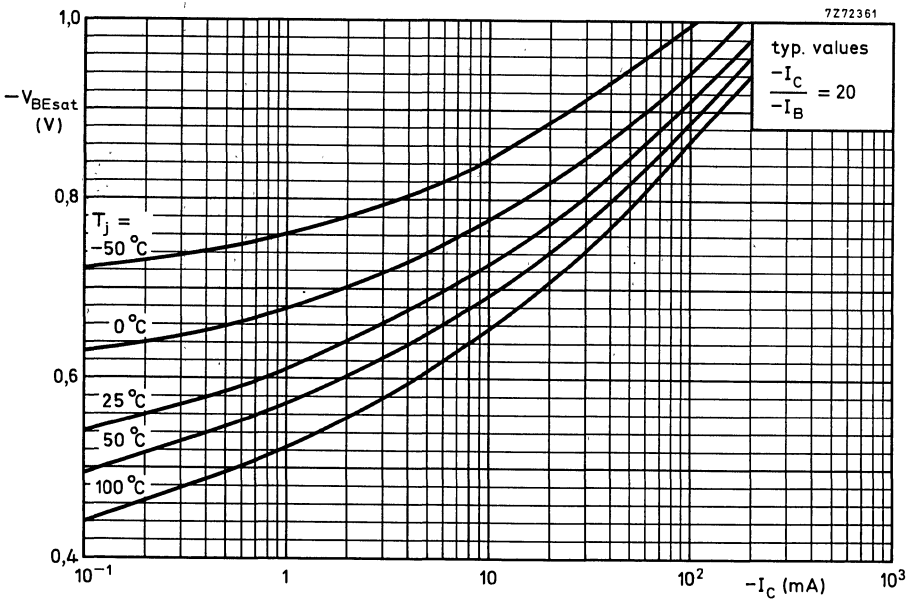


Fig. 23.

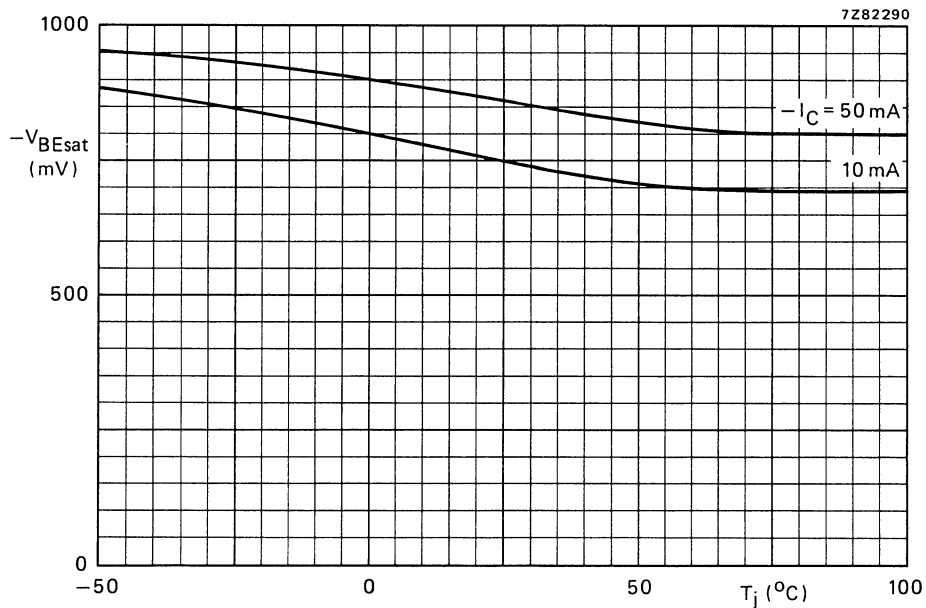


Fig. 24  $-I_C/-I_B = 10$ ; typical values.

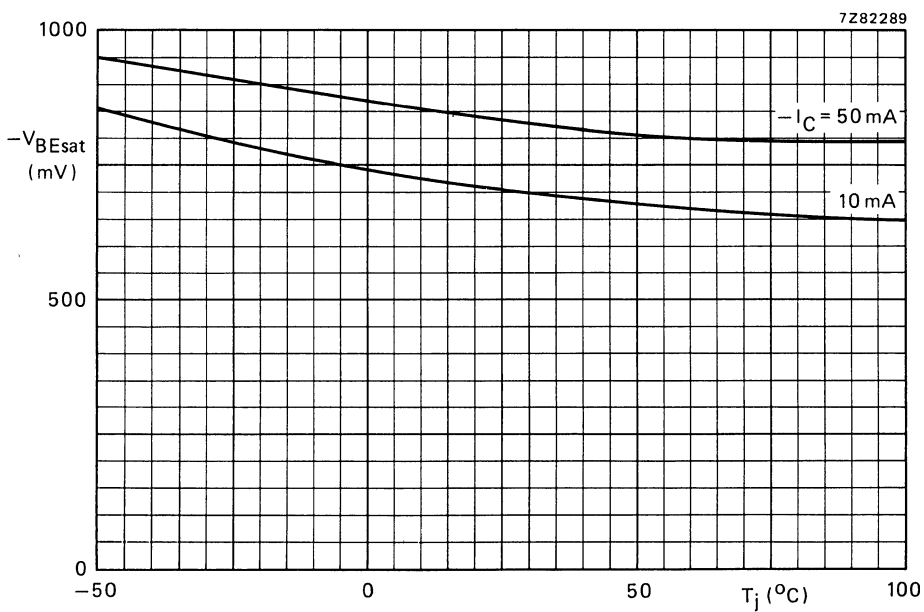


Fig. 25  $-I_C/-I_B = 20$ ; typical values.

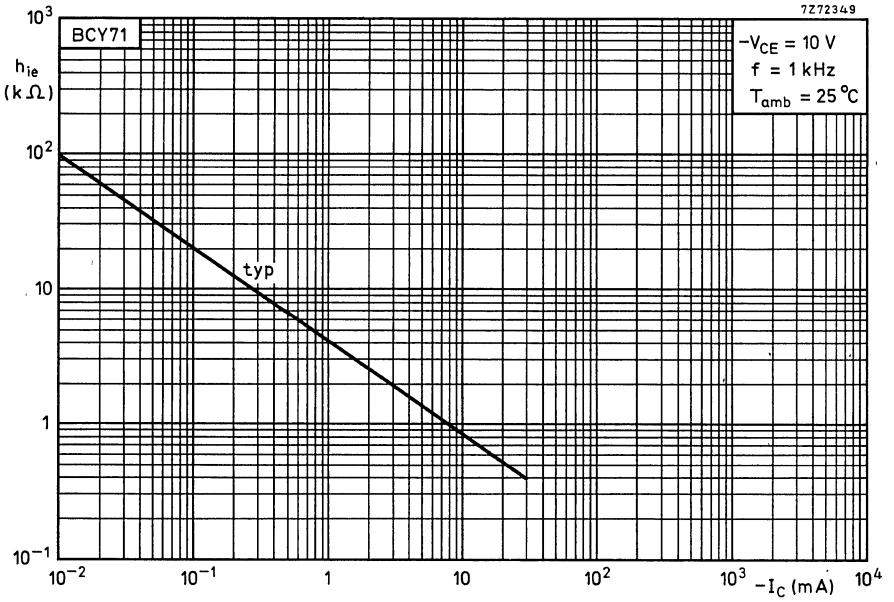


Fig. 26.

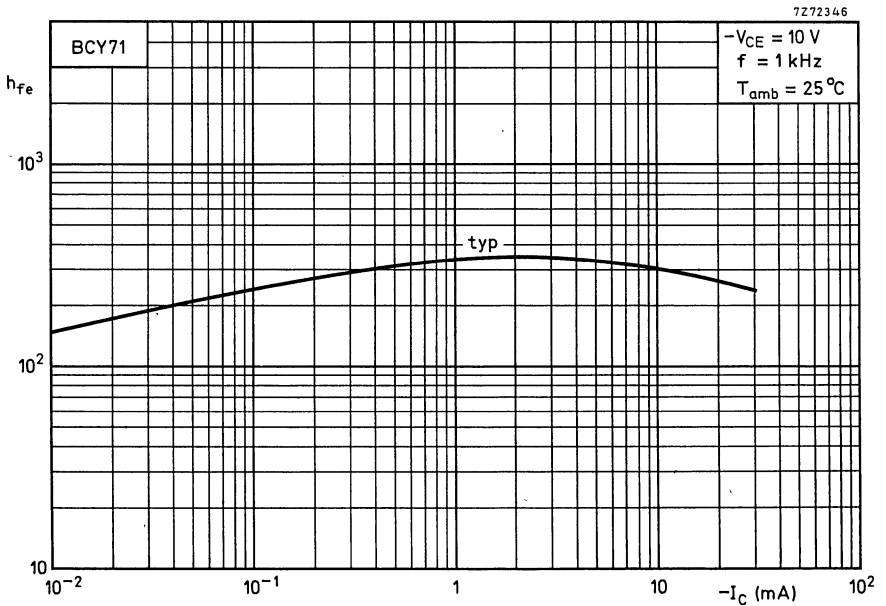


Fig. 27.

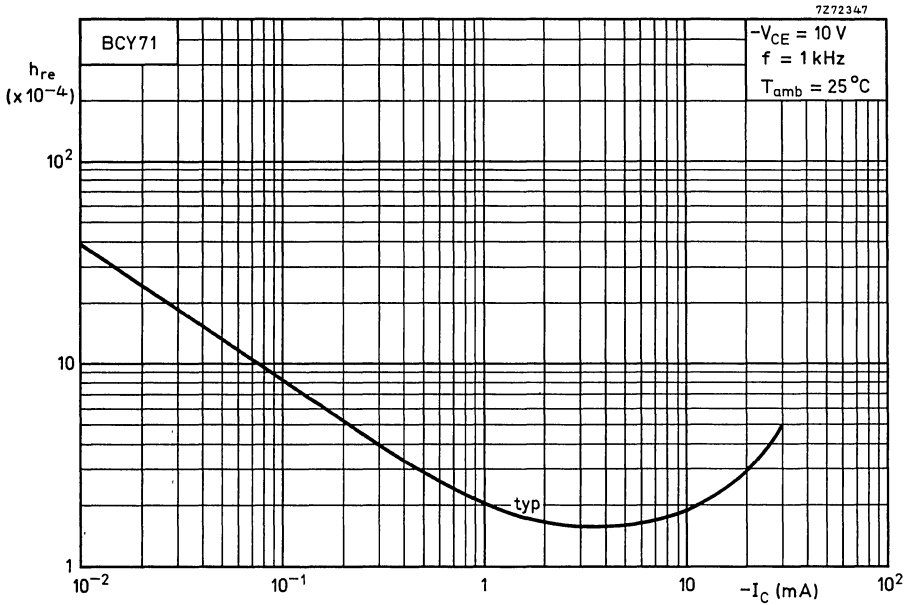


Fig. 28.

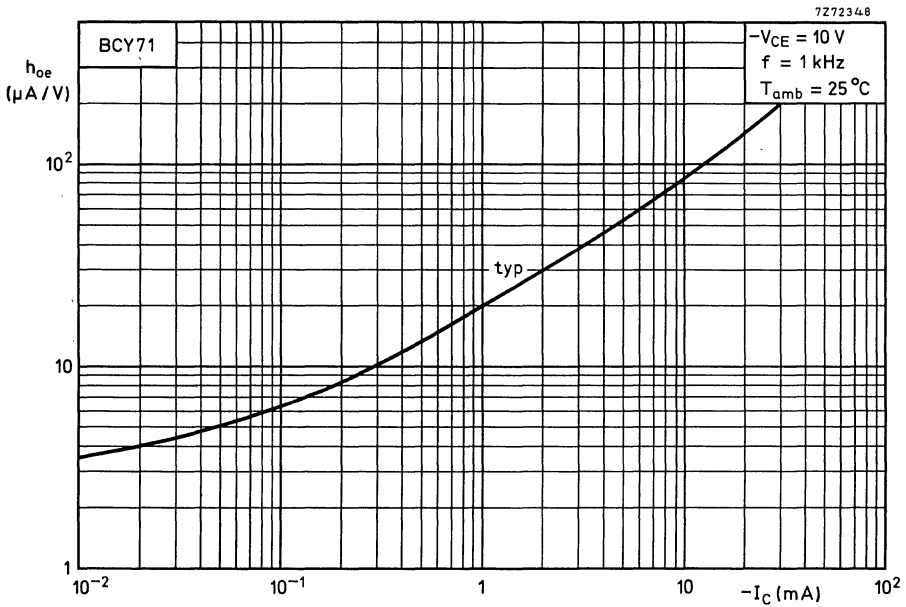


Fig. 29.

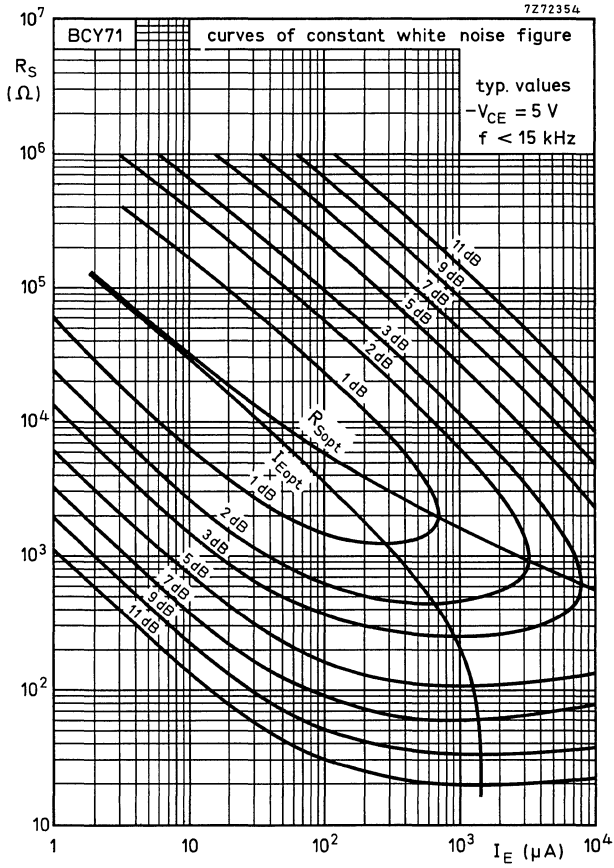


Fig. 30.

See also the graph and text on next page.

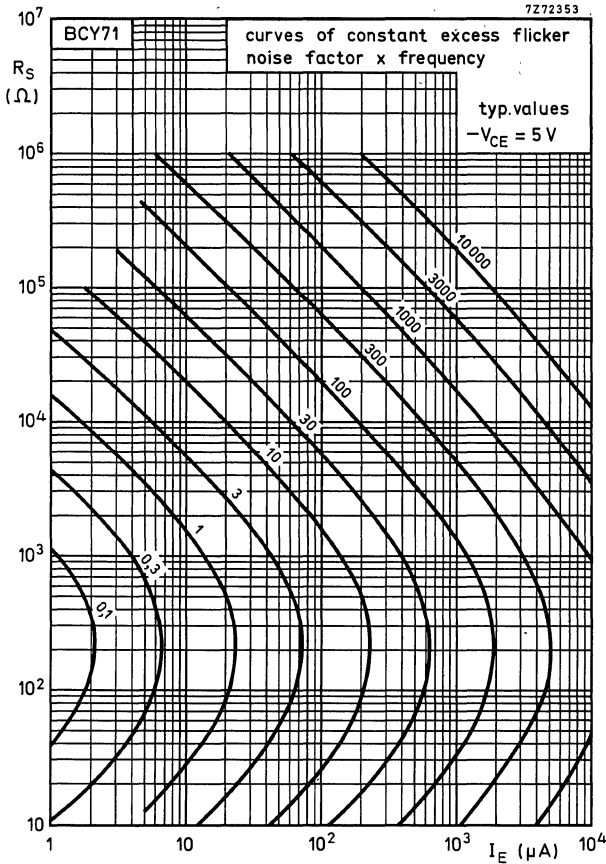


Fig. 31.

#### Determination of total noise figure

Total noise at  $f < 15\text{ kHz}$  includes flicker noise and white noise.

The relationship is as follows: noise factor = 1 + flicker noise factor + white noise factor.

The flicker noise factor can be derived from the curves of the graph above, the white noise factor from the curves of the graph on page 18.

#### Example:

Assume a BCY71 operating at  $f = 200\text{ Hz}$ ;  $I_E = 200\ \mu\text{A}$  with a source resistance  $R_S = 10\text{ k}\Omega$ . From the graph on this page it follows that at  $I_E = 200\ \mu\text{A}$  with  $R_S = 10\text{ k}\Omega$  the product of frequency and flicker noise factor is 110. Since the frequency is 200 Hz, the flicker noise factor is  $110/200 = 0,55$ . From page 18 it follows that at  $I_E = 200\ \mu\text{A}$  with  $R_S = 10\text{ k}\Omega$  the white noise figure is 0,9 dB, representing a factor of 1,23. Thus the total noise factor =  $0,55 + 1,23 = 1,78$  or 2,5 dB.

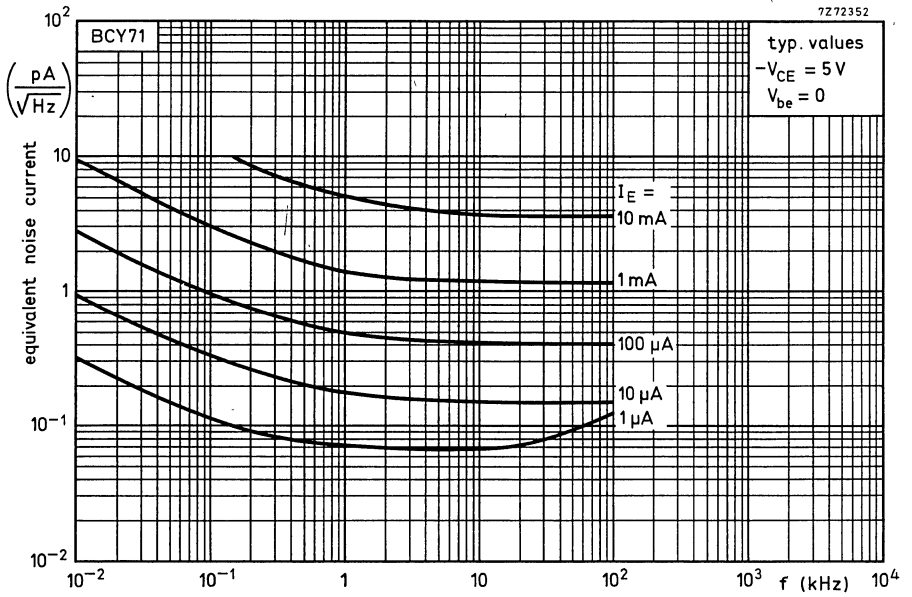


Fig. 32.

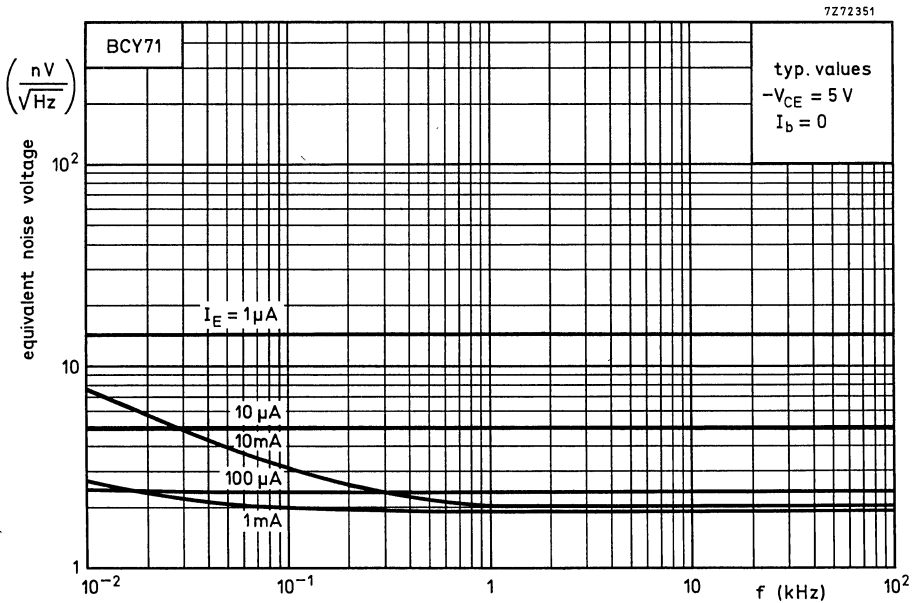


Fig. 33.

## SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in TO-18 metal envelopes, intended for use in amplifier and switching applications.

### QUICK REFERENCE DATA

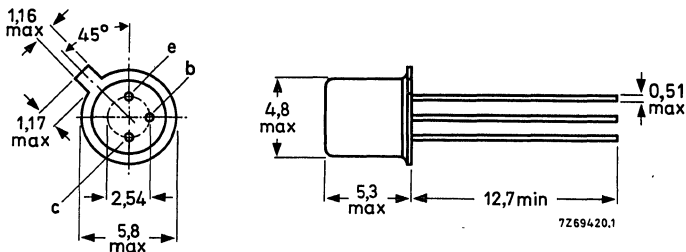
		BCY78	BCY79		
Collector-emitter voltage (open base)	$-V_{CEO}$ max.	32	45	V	
Collector current (d.c.)	$-I_C$ max.	200		mA	
Total power dissipation up to $T_{amb} = 45^\circ\text{C}$ up to $T_{case} = 45^\circ\text{C}$	$P_{tot}$ max.	345		mW	
	$P_{tot}$ max.	1000		mW	
Junction temperature	$T_j$ max.	200		$^\circ\text{C}$	
		BCY78-VII BCY79-VII	VIII VIII	IX IX	X
Small-signal current gain $-I_C = 2\text{ mA}; -V_{CE} = 5\text{ V}$	$h_{fe} >$	125	175	250	350
	$h_{fe} <$	250	350	500	700
Transition frequency at $f = 35\text{ MHz}$ $-I_C = 10\text{ mA}; -V_{CE} = 5\text{ V}$	$f_T$ typ.	180		MHz	
Noise figure at $R_S = 2\text{ k}\Omega$ $-I_C = 200\text{ }\mu\text{A}; -V_{CE} = 5\text{ V}$ $f = 1\text{ kHz}; B = 200\text{ Hz}$	F typ.	2		dB	

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector connected to case



Accessories: 56246 (distance disc).



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

Voltages

			BCY78	BCY79	
Collector-emitter voltage ( $V_{BE} = 0$ )	$-V_{CES}$	max.	32	45	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	32	45	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	V

Currents

Collector current (d. c.)	$-I_C$	max.	200	mA
Base current (d. c.)	$-I_B$	max.	20	mA

Power dissipation

Total power dissipation up to $T_{amb} = 45\text{ }^{\circ}\text{C}$ up to $T_{case} = 45\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	345	mW
	$P_{tot}$	max.	1000	mW

Temperatures

Storage temperature	$T_{stg}$		-65 to 200	$^{\circ}\text{C}$
Junction temperature	$T_j$	max.	200	$^{\circ}\text{C}$

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th\ j-a}$	=	0,45	$^{\circ}\text{C}/\text{mW}$
From junction to case	$R_{th\ j-c}$	=	0,15	$^{\circ}\text{C}/\text{mW}$

**CHARACTERISTICS**

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

Collector cut-off currents

		BCY78	BCY79	
$V_{BE} = 0; -V_{CE} = 25\text{ V}$	$-I_{CES}$	typ. 2 < 20	-	nA nA
$V_{BE} = 0; -V_{CE} = 35\text{ V}$	$-I_{CES}$	typ. - < -	2 20	nA nA
$V_{BE} = 0; -V_{CE} = 25\text{ V}; T_{amb} = 150\text{ }^{\circ}\text{C}$	$-I_{CES}$	< 10	-	$\mu\text{A}$
$V_{BE} = 0; -V_{CE} = 35\text{ V}; T_{amb} = 150\text{ }^{\circ}\text{C}$	$-I_{CES}$	< -	10	$\mu\text{A}$
$V_{BE} = 0; -V_{CE} = -V_{CEOmax}$	$-I_{CES}$	< 100	100	nA
$-V_{EB} = 0,2\text{ V}; -V_{CE} = -V_{CEOmax}; T_{amb} = 100\text{ }^{\circ}\text{C}$	$-I_{CEX}$	< 20	20	$\mu\text{A}$

Emitter cut-off current

$I_C = 0; -V_{EB} = 4\text{ V}$	$-I_{EBO}$	< 20	20	nA
---------------------------------	------------	------	----	----

Collector-emitter breakdown voltage

$V_{BE} = 0; -I_C = 10\text{ }\mu\text{A}$	$-V_{(BR)CES}$	> 32	45	V
$I_B = 0; -I_C = 2\text{ mA}$	$-V_{(BR)CEO}$	> 32	45	V

Emitter-base breakdown voltage

$I_C = 0; -I_E = 1\text{ }\mu\text{A}$	$-V_{(BR)EBO}$	> 5		V
--	----------------	-----	--	---

Base-emitter voltage

$-I_C = 10\text{ }\mu\text{A}; -V_{CE} = 5\text{ V}$	$-V_{BE}$	typ. 550		mV
$-I_C = 2\text{ mA}; -V_{CE} = 5\text{ V}$	$-V_{BE}$	typ. 650 600 to 750		mV mV
$-I_C = 10\text{ mA}; -V_{CE} = 1\text{ V}$	$-V_{BE}$	typ. 680		mV
$-I_C = 100\text{ mA}; -V_{CE} = 1\text{ V}$	$-V_{BE}$	typ. 750		mV

Saturation voltages

$-I_C = 10\text{ mA}; -I_B = 250\text{ }\mu\text{A}$	$-V_{CEsat}$	typ. 120 < 250		mV mV
	$-V_{BEsat}$	typ. 700 600 to 850		mV mV
$-I_C = 100\text{ mA}; -I_B = 2,5\text{ mA}$	$-V_{CEsat}$	typ. 400 < 800		mV mV
	$-V_{BEsat}$	typ. 850 700 to 1200		mV mV

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

$-I_C = 10\text{ mA}; -V_{CE} = 5\text{ V}$	$f_T$	typ. 180		MHz
---	-------	----------	--	-----

**BCY78**  
**BCY79**

**CHARACTERISTICS (continued)**

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

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

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

$C_c$	typ.	4,5	pF
	<	7,0	

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

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

$C_e$	typ.	11	pF
	<	15	

Noise figure at  $R_S = 2\text{ k}\Omega$

$-I_C = 200\text{ }\mu\text{A}; -V_{CE} = 5\text{ V}$   
 $f = 1\text{ kHz}; B = 200\text{ Hz}$

F	typ.	2	dB
	<	6	

D. C. current gain

$-I_C = 10\text{ }\mu\text{A}; -V_{CE} = 5\text{ V}$

	BCY78-VII	VIII	IX	X	
	BCY79-VII	VIII	IX		
$h_{FE}$	>	-	30	40	100
	typ.	140	200	270	340

$-I_C = 2\text{ mA}; -V_{CE} = 5\text{ V}$

$h_{FE}$	>	120	180	250	380
	typ.	170	250	350	500
<	220	310	460	630	

$-I_C = 10\text{ mA}; -V_{CE} = 1\text{ V}$

$h_{FE}$	>	80	120	160	240
	typ.	180	260	360	500
<	-	400	630	1000	

$-I_C = 100\text{ mA}; -V_{CE} = 1\text{ V}$

$h_{FE}$	>	40	45	60	60
----------	---	----	----	----	----

h-parameters at  $f = 1\text{ kHz}$

$-I_C = 2\text{ mA}; -V_{CE} = 5\text{ V}$

$h_{ie}$	typ.	2,7	3,6	4,5	7,5	k $\Omega$
$h_{re}$	typ.	1,5	2	2	3	$10^{-4}$
$h_{fe}$	>	125	175	250	350	
	typ.	200	260	330	520	
<	250	350	500	700		
$h_{oe}$	typ.	18	24	30	50	$\mu\text{A}/\text{V}$
	<	30	50	60	100	$\mu\text{A}/\text{V}$

Input impedance

Reverse voltage transfer ratio

Small-signal current gain

Output admittance

**CHARACTERISTICS** (continued)

Switching times

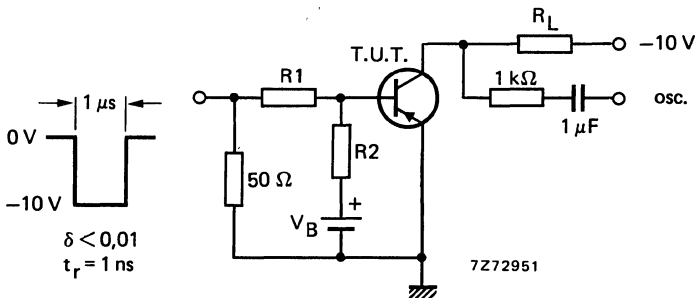
$-I_{C\text{on}} = 10 \text{ mA}; -I_{B\text{on}} = I_{B\text{off}} = 1 \text{ mA}$   
 $R_1 = R_2 = 5 \text{ k}\Omega; R_L = 990 \Omega$   
 $V_B = 3,6 \text{ V}$

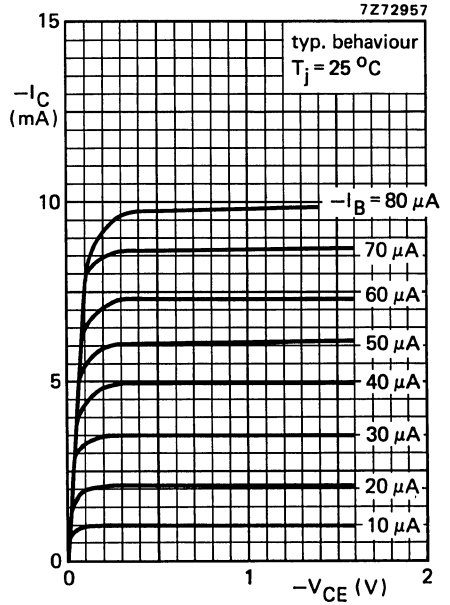
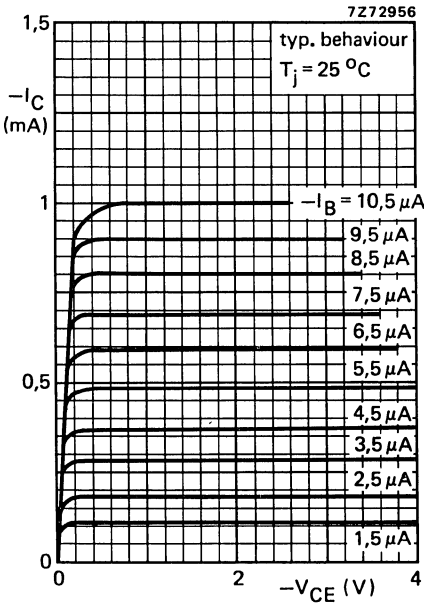
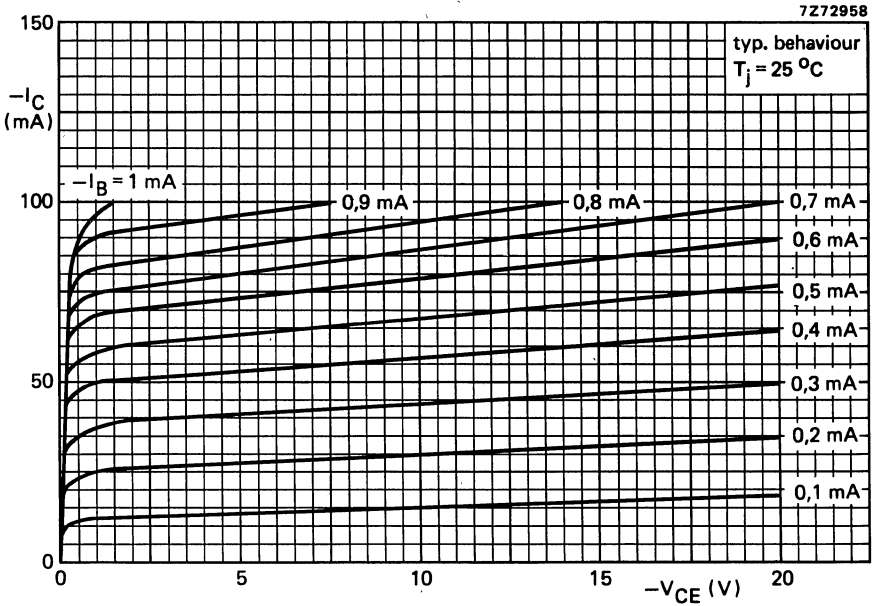
delay time	$t_d$	typ.	35 ns
rise time	$t_r$	typ.	50 ns
turn-on time ( $t_d + t_r$ )	$t_{\text{on}}$	typ.	85 ns
		<	150 ns
storage time	$t_s$	typ.	400 ns
fall time	$t_f$	typ.	80 ns
turn-off time ( $t_s + t_f$ )	$t_{\text{off}}$	typ.	480 ns
		<	800 ns

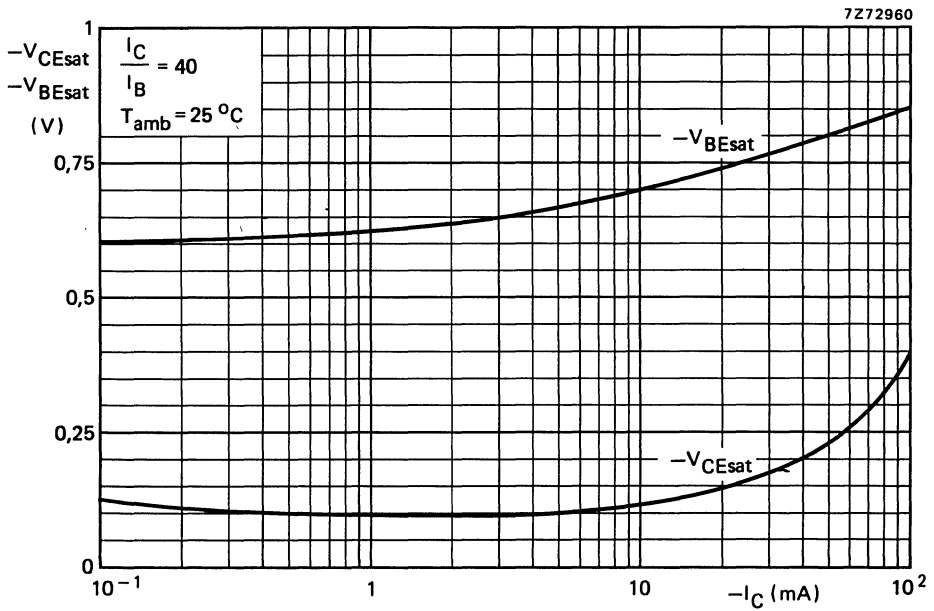
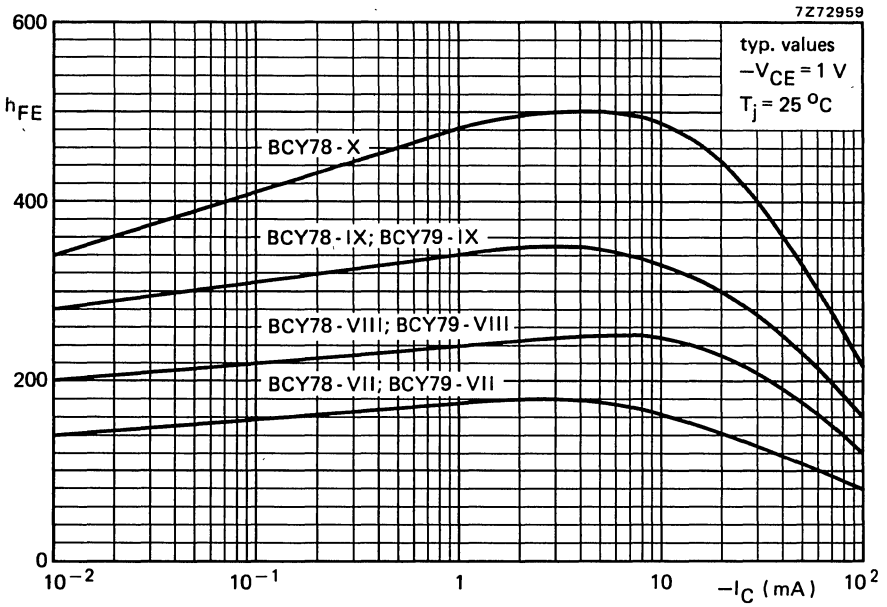
$-I_{C\text{on}} = 100 \text{ mA}; -I_{B\text{on}} = I_{B\text{off}} = 10 \text{ mA}$   
 $R_1 = 500 \Omega; R_2 = 700 \Omega; R_L = 98 \Omega$   
 $V_B = 5 \text{ V}$

delay time	$t_d$	typ.	5 ns
rise time	$t_r$	typ.	50 ns
turn-on time ( $t_d + t_r$ )	$t_{\text{on}}$	typ.	55 ns
		<	150 ns
storage time	$t_s$	typ.	250 ns
fall time	$t_f$	typ.	200 ns
turn-off time ( $t_s + t_f$ )	$t_{\text{off}}$	typ.	450 ns
		<	800 ns

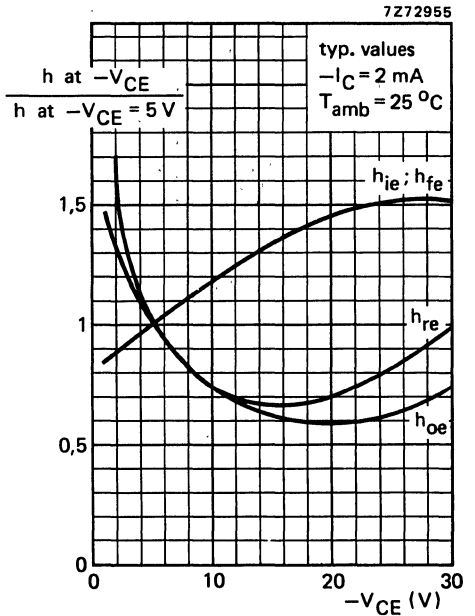
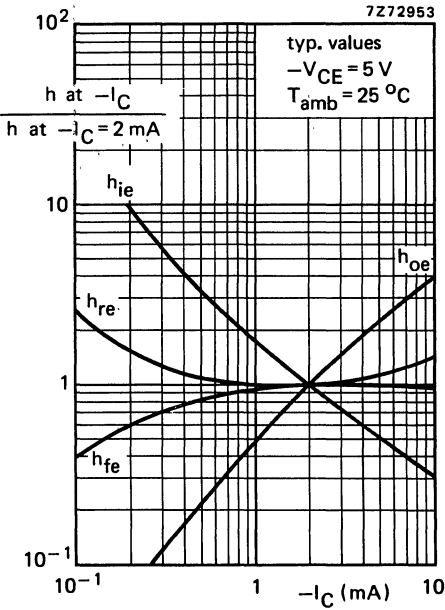
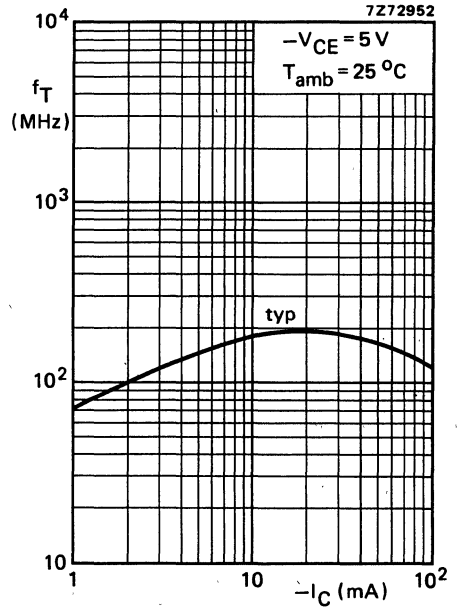
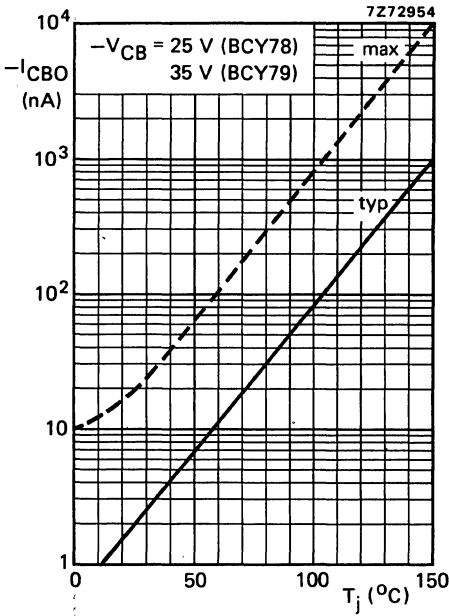
Test circuit:







**BCY78  
BCY79**



## N-P-N SILICON PLANAR DUAL TRANSISTORS FOR DIFFERENTIAL AMPLIFIERS

Matched dual n-p-n transistors in a TO-71 metal envelope with all leads insulated from the case. They are primarily intended for differential amplifier applications in general industrial service; e.g. instrumentation and control.

Products are divided into three types according to their matching accuracy.

The BCY87 and BCY88 are intended for applications in pre-stages of differential amplifiers where low offset, drift and noise are of prime importance. The BCY89 is for second stages, long-tailed pairs and more general purposes.

### QUICK REFERENCE DATA

#### Ratings

Collector-base voltage (open emitter)	$V_{CBO}$	max	45 V
Collector-emitter voltage (open base)	$V_{CEO}$	max	40 V
Total power dissipation up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$	max	150 mW
Junction temperature	$T_j$	max	175 $^{\circ}\text{C}$

**Characteristics** of the complete device with collector-base voltage of 10 V and sum of emitter currents from 10 to 100  $\mu\text{A}$ .

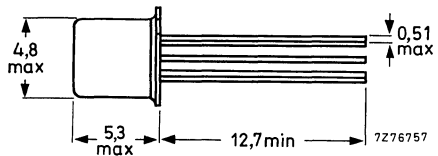
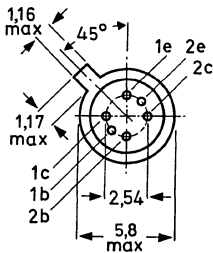
		BCY87	BCY88	BCY89
Ratio of collector currents at $V_{1B-1E} = V_{2B-2E}$	$I_{1C}/I_{2C}$	0,9-1,11	0,8-1,25	0,67-1,5
Base current difference at $V_{1B-1E} = V_{2B-2E}$	$ I_{1B}-I_{2B} $	< 25	80	300 nA
Equivalent differential voltage change with temperature *	$\left  \frac{\Delta V}{\Delta T} \right $	< 3	6	10 $\mu\text{V}/^{\circ}\text{C}$
Equivalent differential current change with temperature *	$\left  \frac{\Delta I}{\Delta T} \right $	< 0,5	2	10 nA/ $^{\circ}\text{C}$

### MECHANICAL DATA

Dimensions in mm

#### TO-71

All leads insulated from the case



\*  $T_{amb} = -20\text{ }^{\circ}\text{C}$  to  $+90\text{ }^{\circ}\text{C}$ .



**RATINGS** see page 7

**CHARACTERISTICS** of the individual transistors

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

	BCY87	BCY88	BCY89
<u>Collector cut-off currents</u>			
$I_E = 0; V_{CB} = 20\text{ V}; T_{amb} = 90\text{ }^{\circ}\text{C}$	$I_{CBO} < 5$	20	- nA
$I_E = 0; V_{CB} = 20\text{ V}$	$I_{CBO} < -$	-	10 nA
<u>D.C. current gain</u>			
$I_C = 5\text{ }\mu\text{A}; V_{CB} = 10\text{ V}$	$h_{FE} > 80$	-	-
$I_C = 50\text{ }\mu\text{A}; V_{CB} = 10\text{ V}$	$h_{FE} > 100$	100	100
	$h_{FE} < 450$	450	450
$I_C = 500\text{ }\mu\text{A}; V_{CB} = 10\text{ V}$	$h_{FE} > -$	120	-
	$h_{FE} < -$	600	-
$I_C = 10\text{ mA}; V_{CB} = 10\text{ V}$	$h_{FE} > -$	-	100
	$h_{FE} < -$	-	600
<u>Transition frequency</u>			
$-I_E = 50\text{ }\mu\text{A}; V_{CB} = 10\text{ V}$	$f_T > 10$	10	10 MHz
$-I_E = 500\text{ }\mu\text{A}; V_{CB} = 10\text{ V}$	$f_T > 50$	50	50 MHz
<u>Collector capacitance at <math>f = 1\text{ MHz}</math></u>			
$I_E = I_e = 0; V_{CB} = 10\text{ V}$	$C_C < 3.5$	3.5	3.5 pF
<u>Noise figures</u>			
$I_C = 50\text{ }\mu\text{A}; V_{CE} = 5\text{ V}; R_S = 10\text{ k}\Omega$ Bandwidth 10 Hz to 15 kHz	$F < 3$	4	4 dB
1 kHz spot noise figure $I_C = 50\text{ }\mu\text{A}; V_{CE} = 5\text{ V}; R_S = \text{opt.}$ Bandwidth = 200 Hz	$F < 4$	5	5 dB

**CHARACTERISTICS** of the complete device.

These characteristics are valid under the following conditions:

- a. Collector-base voltage of both transistors not exceeding 10 V ( $V_{1C-1B} = V_{2C-2B} \leq 10$  V)
- b. Sum of the emitter currents from 10 to 100  $\mu$ A  
 $-(I_{1E} + I_{2E}) = 10$  to 100  $\mu$ A

MATCHING CHARACTERISTICS

Ratio of collector currents

$$V_{1B-1E} = V_{2B-2E} \quad I_{1C}/I_{2C}$$

BCY87	BCY88	BCY89
0.9-1.11	0.8-1.25	0.67-1.5

Difference between base-emitter voltages

$$I_{1C} = I_{2C} \quad |V_{1B-1E} - V_{2B-2E}| < 3 \quad 6 \quad 10 \text{ mV}$$

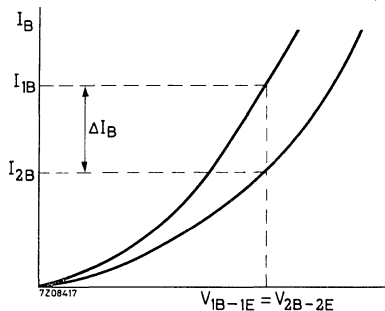
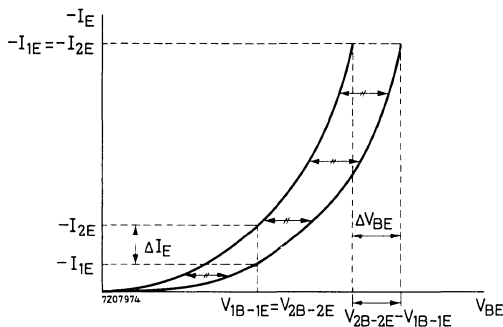
Difference between base currents

$$V_{1B-1E} = V_{2B-2E} \quad |I_{1B} - I_{2B}| < 25 \quad 80 \quad 300 \text{ nA}$$

D.C. current gain ratio

$$I_{1C} = I_{2C} \quad h_{1FE} / h_{2FE} \quad 0.9-1.11 \quad 0.8-1.25 \quad -$$

Illustration of matching characteristics:



$$\frac{I_{2E}}{I_{1E}} = \exp. \frac{q}{KT} \cdot \Delta V_{BE}$$

$$\frac{I_{2E}}{I_{1E}} \text{ measured at } \Delta V_{BE} = 0$$

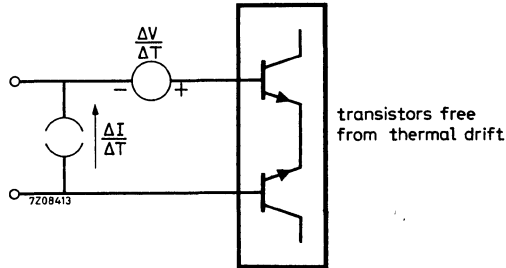
$$\Delta V_{BE}; \text{ measured at } \frac{I_{2E}}{I_{1E}} = 1$$

**CHARACTERISTICS** of the complete device (continued)

Equivalent circuit for drift

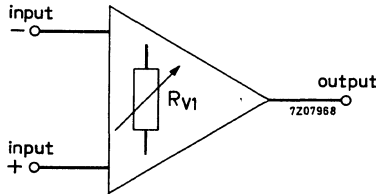
In the equivalent circuit the transistors are considered to be drift free. All temperature coefficients are concentrated in the voltage source  $\frac{\Delta V}{\Delta T}$  and in the current source  $\frac{\Delta I}{\Delta T}$ .

It should be noted that the differential current change given is only valid when the source resistances are almost equal; the differential voltage change only when the base-emitter voltages are almost equal.



Block symbol of test amplifier

The test amplifier, used in the tests on page 5, is described on pages 6 and 7. It is represented by the following amplifier symbol:



## CHARACTERISTICS of the complete device (continued)

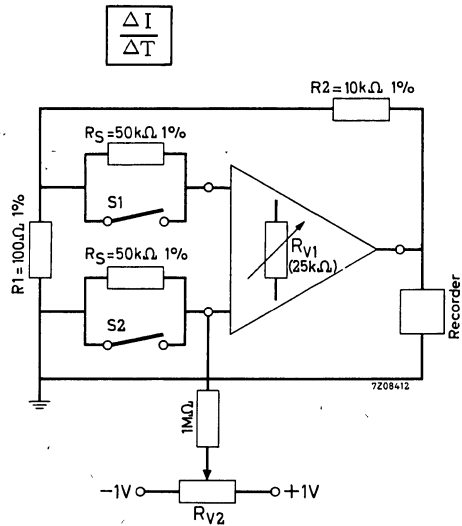
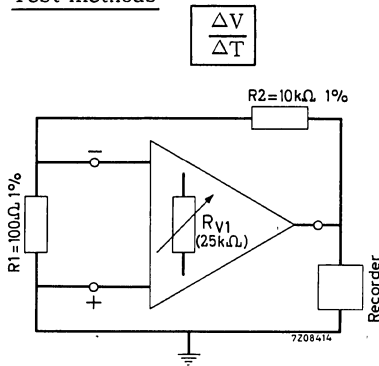
### Equivalent differential voltage change with temperature

$T_{amb} = -20 \text{ to } +90 \text{ }^\circ\text{C}$	$\left  \frac{\Delta V}{\Delta T} \right $	typ.	BCY87	BCY88	BCY89
			<	1	2
			3	6	10 $\mu\text{V}/^\circ\text{C}$

### Equivalent differential current change with temperature

$T_{amb} = -20 \text{ to } +90 \text{ }^\circ\text{C}$	$\left  \frac{\Delta I}{\Delta T} \right $	<	BCY87	BCY88	BCY89
				0.5	2

### Test methods



### NOTE

To prevent contact potentials, connections should be soldered.

Amplification factor determined by feedback circuit:  $\frac{R2}{R1} = 100$

Output voltage against time is recorded.

The temperature of the amplifier is adjusted to  $T_1$  between  $-20$  and  $+90 \text{ }^\circ\text{C}$ . When it has stabilized, the output voltage is brought to zero ( $|V_{T1}| < 1 \text{ mV}$ ). The amplifier temperature is then adjusted to  $T_2$  between  $-20$  and  $+90 \text{ }^\circ\text{C}$ . When it has stabilized the output voltage can be read off.

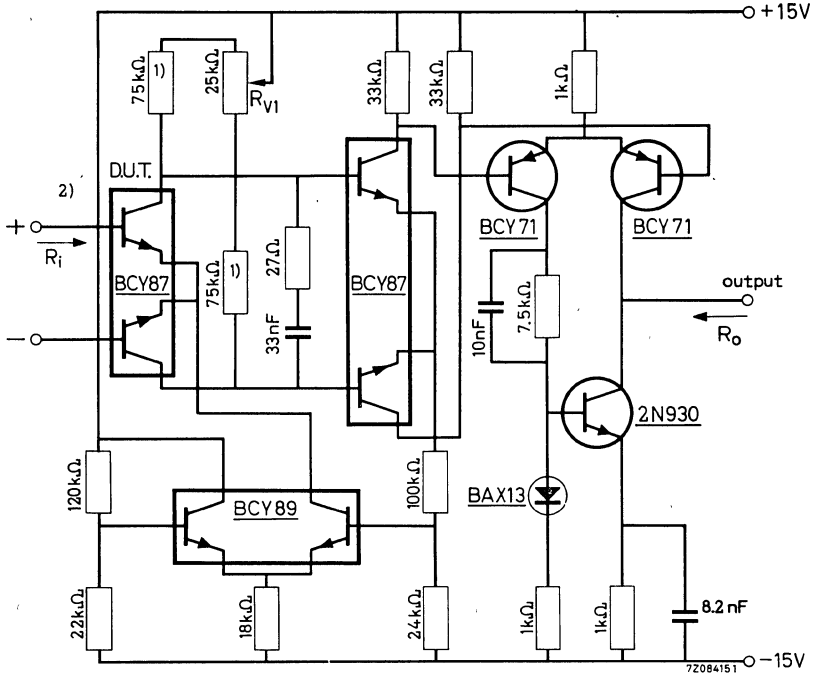
$$\text{Then: } \frac{\Delta V}{\Delta T} = \frac{V_{T2} - V_{T1}}{T_2 - T_1} \cdot \frac{R1}{R2} \quad \text{or} \quad \frac{\Delta I}{\Delta T} = \frac{V_{T2} - V_{T1}}{T_2 - T_1} \cdot \frac{R1}{R2} \cdot \frac{1}{2R_S}$$

1) For  $\frac{\Delta V}{\Delta T}$ : adjusted by  $R_{V1}$

For  $\frac{\Delta I}{\Delta T}$ : first by  $R_{V1}$  with  $S1$  and  $S2$  closed, then by  $R_{V2}$  with the switches open.

Differential test-amplifier

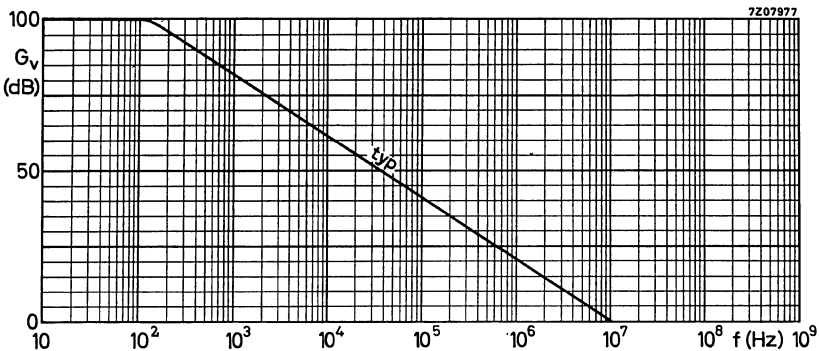
The test amplifier (including feedback resistors, source-resistors and biasing-resistors) should be mounted in a small box to ensure a uniform temperature throughout.



- 1) Relative temperature coefficient  $< 10^{-5}/^{\circ}\text{C}$
- 2) The device at the input is the device under test

Performance of the test amplifier

Open loop voltage gain ( $Z_L = 10\text{ k}\Omega$ )	$G_V$	typ.	$10^5$
Frequency at which $G_V = 1$	$f_1$	typ.	10 MHz
Max. common mode input voltage range			$\pm 10\text{ V}$
Max. output current			$\pm 2.5\text{ mA}$
Max. output voltage			$\pm 10\text{ V}$
Input resistance	$R_i$		100 $\text{k}\Omega$
Output resistance	$R_o$	typ.	20 $\text{k}\Omega$
Common mode rejection ratio			$10^5$



**RATINGS (Limiting values) 1)**

Voltages (each transistor)

Collector-base voltage (open emitter)	$V_{CBO}$	max.	45 V
Collector-emitter voltage (open base) $I_C = 10\text{ mA}$	$V_{CEO}$	max.	40 V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	5 V

Currents (each transistor)

Collector current (d.c.)	$I_C$	max.	30 mA
--------------------------	-------	------	-------

<u>Total power dissipation up to <math>T_{amb} = 25\text{ }^\circ\text{C}</math></u>	$P_{tot}$	max.	150 mW
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Temperatures

Storage temperature	$T_{stg}$	max.	175 $^\circ\text{C}$
Junction temperature	$T_j$	max.	175 $^\circ\text{C}$

**THERMAL RESISTANCE**

From junction to ambient	$R_{th\ j-a}$	=	1 $^\circ\text{C}/\text{mW}$
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1) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.



## SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a TO-72 metal envelope with insulated electrodes and a shield lead connected to the case. It is intended for general broadcast and television.

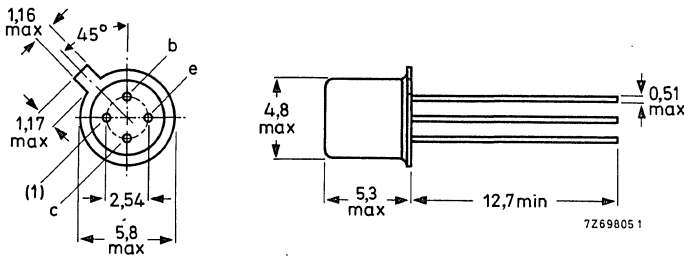
### QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$V_{CBO}$	max.	50 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	30 V
Collector current (d.c.)	$I_C$	max.	30 mA
Total power dissipation up to $T_{amb} = 45\text{ }^\circ\text{C}$	$P_{tot}$	max.	145 mW
Junction temperature	$T_j$	max.	175 $^\circ\text{C}$
Transition frequency $I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$	$f_T$	typ.	230 MHz
Noise figure $I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$ $f = 1\text{ MHz}; G_S = 3,3\text{ mA/V}$ $f = 100\text{ MHz}; G_S = 10\text{ mA/V}$	F	typ.	1,2 dB
	F	typ.	4 dB

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-72.



(1) = shield lead (connected to case).

Accessories: 56246 (distance disc).

FOR NEW DESIGN THE SUCCESSOR TYPES BF494 OR BF495 ARE RECOMMENDED



**RATINGS**

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

Collector-base voltage (open emitter)	$V_{CBO}$	max.	50 V
Collector-emitter voltage (open base) (see also page 5)	$V_{CEO}$	max.	30 V
Collector-emitter voltage (see page 5)	$V_{CER}$	max.	50 V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	5 V
Collector current (d.c.)	$I_C$	max.	30 mA
Collector current (peak value)	$I_{CM}$	max.	30 mA
Total power dissipation up to $T_{amb} = 45\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	145 mW
Storage temperature	$T_{stg}$		-65 to +175 $^{\circ}\text{C}$
Junction temperature	$T_j$	max.	175 $^{\circ}\text{C}$

**THERMAL RESISTANCE**

From junction to ambient in free air

$$R_{th\ j-a} = 0,9\ \text{K/mW}$$

## SILICON PLANAR TRANSISTOR

N-P-N transistor in a TO-72 metal envelope with insulated electrodes and a shield lead connected to the case. The BF180 is primarily intended for application in a forward gain controlled preamplifier in u.h.f. and integrated television tuners.

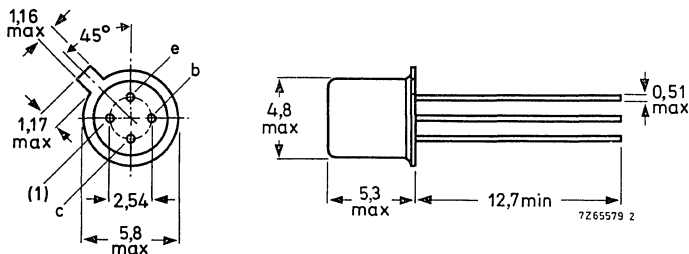
### QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$V_{CBO}$	max.	30 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	20 V
Collector current (d.c.)	$I_C$	max.	20 mA
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	150 mW
Junction temperature	$T_j$	max.	175 $^\circ\text{C}$
Transition frequency	$f_T$	typ.	675 MHz
$I_C = 2\text{ mA}; V_{CE} = 10\text{ V}$			
Feedback capacitance at $f = 10,7\text{ MHz}$	$C_{re}$	typ.	280 fF
$I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$			
Maximum unilateralized power gain	$G_{UM}$	typ.	24 dB
$-I_E = 2\text{ mA}; V_{CB} = 10\text{ V}; f = 200\text{ MHz}$	$G_{UM}$	typ.	12 dB
$-I_E = 2\text{ mA}; V_{CB} = 10\text{ V}; f = 900\text{ MHz}$			
Noise figure at optimum source admittance	F	typ.	2,5 dB
$-I_E = 2\text{ mA}; V_{CB} = 10\text{ V}; f = 200\text{ MHz}$	F	typ.	5,7 dB
$-I_E = 2\text{ mA}; V_{CB} = 10\text{ V}; f = 800\text{ MHz}$			

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-72.



(1) = shield lead (connected to case).

Accessories: 56246 (distance disc).

**RATINGS** (Limiting values) <sup>1)</sup>

Voltages

Collector-base voltage (open emitter)	$V_{CBO}$	max.	30 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	20 V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	3 V

Currents

Collector current (d.c.)	$I_C$	max.	20 mA
Collector current (peak value)	$I_{CM}$	max.	20 mA

Power dissipation

Total power dissipation up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	150 mW
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Temperatures

Storage temperature	$T_{stg}$	-65 to +175	$^{\circ}\text{C}$
Junction temperature	$T_j$	max.	175 $^{\circ}\text{C}$

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th\ j-a}$	=	1 $^{\circ}\text{C}/\text{mW}$
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<sup>1)</sup> Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

**CHARACTERISTICS**

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

Base current

$-I_E = 2\text{ mA}; V_{CB} = 10\text{ V}$

$I_B$       typ.    45  $\mu\text{A}$   
             <      150  $\mu\text{A}$

$-I_E = 12\text{ mA}; V_{CB} = 7\text{ V}$

$I_B$       <      2.2 mA

Emitter-base voltage

$-I_E = 2\text{ mA}; V_{CB} = 10\text{ V}$

$-V_{EB}$     typ. 0.75 V

Feedback capacitance at  $f = 10.7\text{ MHz}$

$I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$

$C_{re}$       typ. 280 fF<sup>1)</sup>

Transition frequency

$I_C = 2\text{ mA}; V_{CE} = 10\text{ V}$

$f_T$       typ. 675 MHz

Noise figure 2)

$-I_E = 2\text{ mA}; V_{CB} = 10\text{ V};$

$G_S = 40\text{ m}\Omega^{-1}; B_S = 0; f = 200\text{ MHz}$

F      typ. 4.5 dB

$-I_E = 2\text{ mA}; V_{CB} = 10\text{ V};$

$G_S = 10\text{ m}\Omega^{-1}; B_S = 0; f = 800\text{ MHz}$

F      typ. 7.0 dB  
             <      9.5 dB

Maximum unilateralised power gain 2)

$$G_{UM} = \frac{|y_{fb}|^2}{4 g_{ib} g_{ob}}$$

$-I_E = 2\text{ mA}; V_{CB} = 10\text{ V}; f = 50\text{ MHz}$

$G_{UM}$       >      32 dB

$-I_E = 2\text{ mA}; V_{CB} = 10\text{ V}; f = 200\text{ MHz}$

$G_{UM}$       typ. 24 dB

$-I_E = 2\text{ mA}; V_{CB} = 10\text{ V}; f = 500\text{ MHz}$

$G_{UM}$       typ. 14 dB

$-I_E = 2\text{ mA}; V_{CB} = 10\text{ V}; f = 900\text{ MHz}$

$G_{UM}$       typ. 12 dB

Transducer gain 2)

$-I_E = 2\text{ mA}; V_{CB} = 10\text{ V}; f = 200\text{ MHz};$

$G_S = 40\text{ m}\Omega^{-1}; B_S = 0$

$G_L = 1\text{ m}\Omega^{-1}; B_L : \text{tuned}$

$G_{tr}$       typ. 16.5 dB

$-I_E = 2\text{ mA}; V_{CB} = 10\text{ V}; f = 900\text{ MHz};$

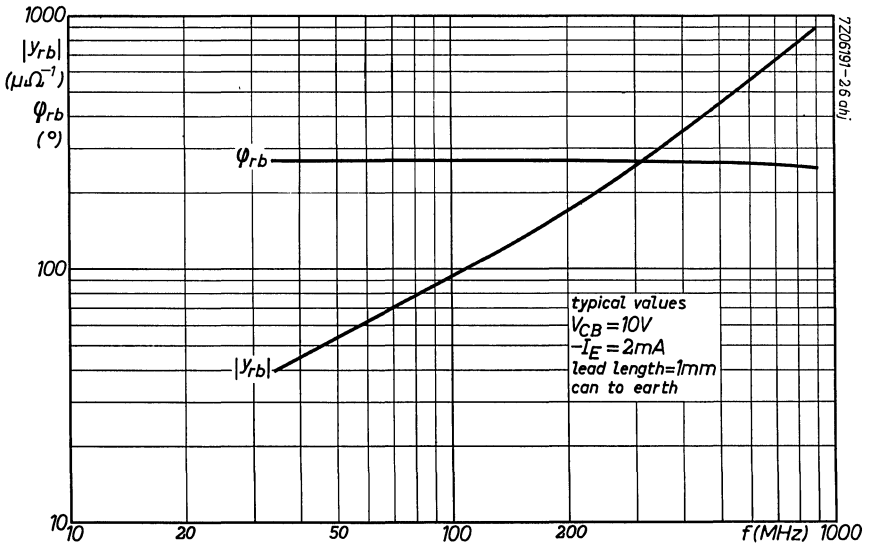
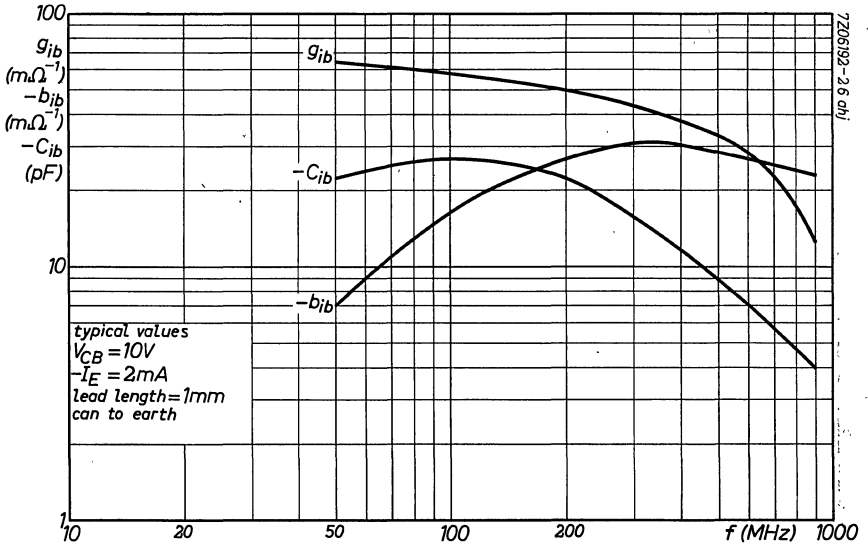
$G_S = 20\text{ m}\Omega^{-1}; B_S = 0$

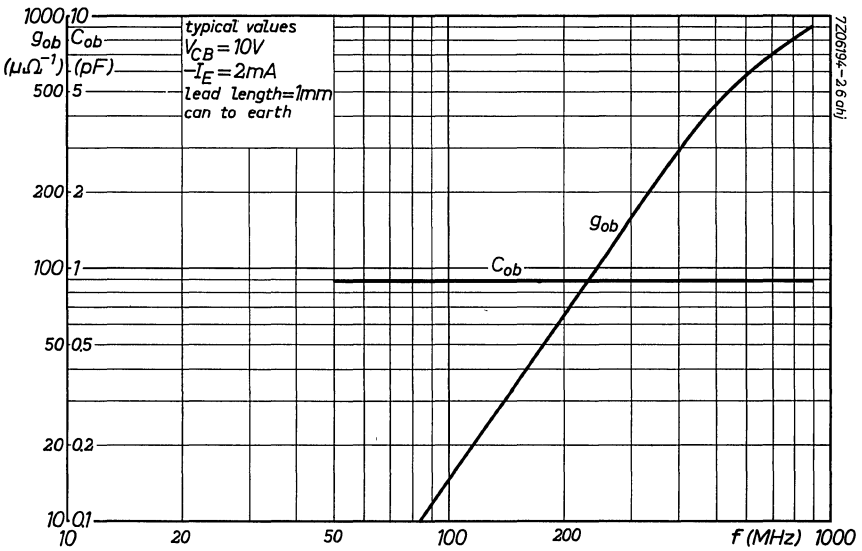
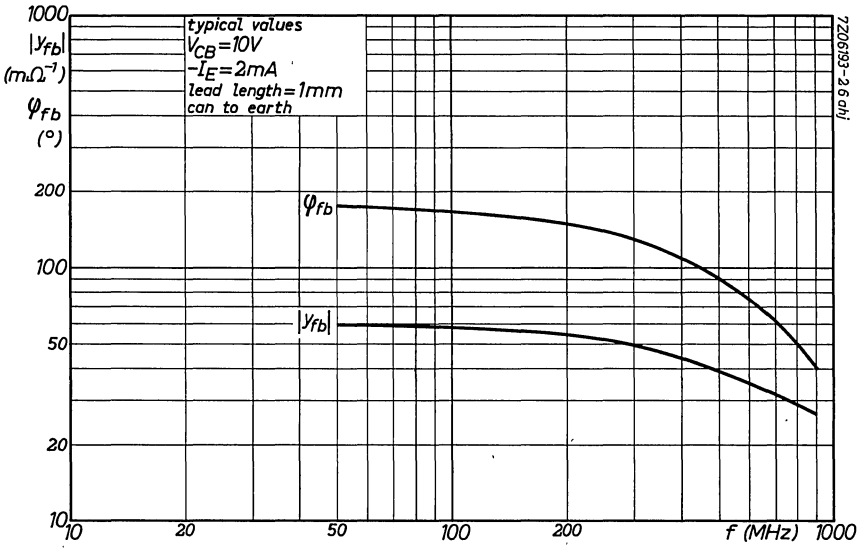
$G_L = 2\text{ m}\Omega^{-1}; B_L : \text{tuned}$

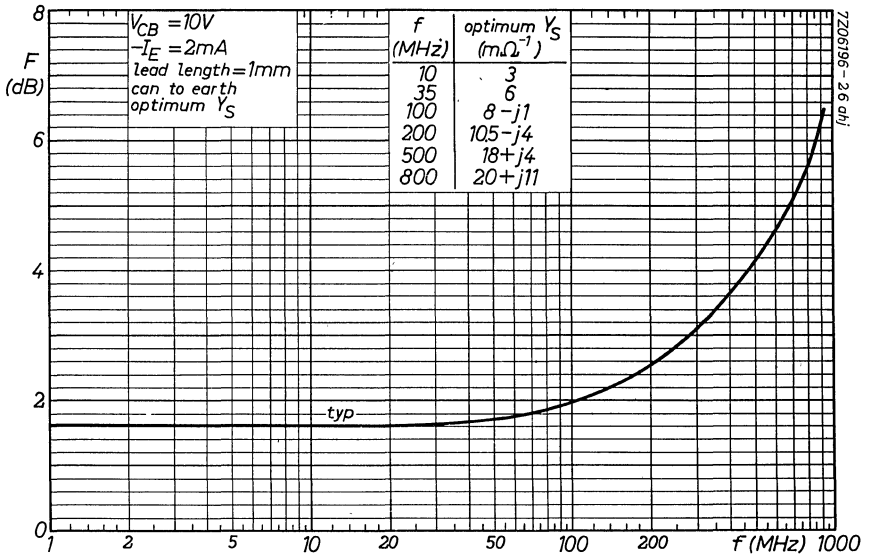
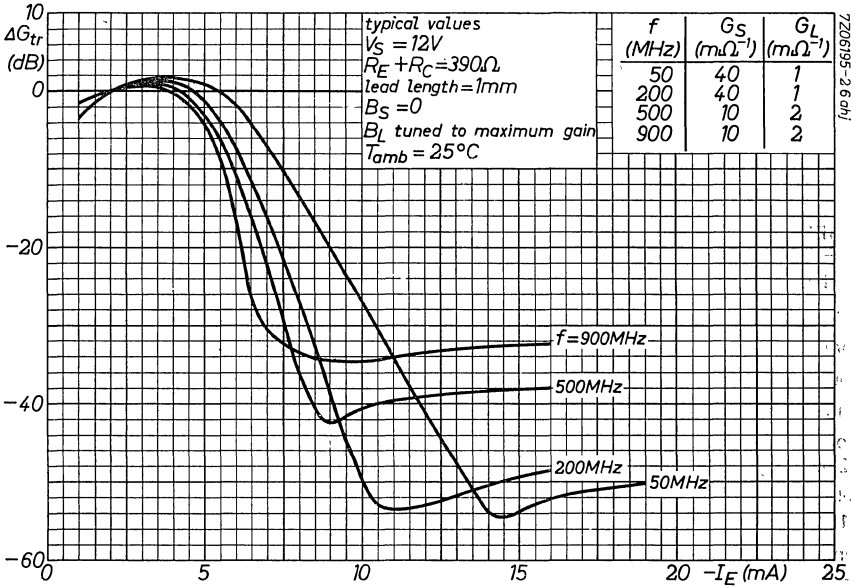
$G_{tr}$       >      7.5 dB  
             typ. 9 dB

1) 1 fF = 1 femtofarad =  $10^{-15}\text{ F}$

2) Common base configuration, metal envelope contacted to earth directly, external lead length: 1 mm.







## SILICON PLANAR TRANSISTOR

N-P-N transistor in a TO-72 metal envelope with insulated electrodes and a shield lead connected to the case. The BF181 is primarily intended for application as mixer-oscillator in the u.h.f. band.

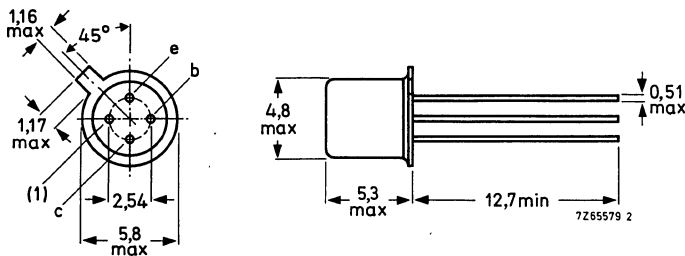
## QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$V_{CBO}$	max.	30 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	20 V
Collector current (d.c.)	$I_C$	max.	20 mA
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	150 mW
Junction temperature	$T_j$	max.	175 $^\circ\text{C}$
Transition frequency $I_C = 2\text{ mA}$ ; $V_{CE} = 10\text{ V}$	$f_T$	typ.	600 MHz
Feedback capacitance at $f = 10,7\text{ MHz}$ $I_C = 1\text{ mA}$ ; $V_{CE} = 10\text{ V}$	$C_{re}$	typ.	280 fF
Maximum unilateralized power gain $-I_E = 2\text{ mA}$ ; $V_{CB} = 10\text{ V}$ ; $f = 900\text{ MHz}$	$G_{UM}$	typ.	11 dB
Noise figure at optimum source admittance $-I_E = 2\text{ mA}$ ; $V_{CB} = 10\text{ V}$ ; $f = 900\text{ MHz}$	F	typ.	6,8 dB

## MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-72.



(1) = shield lead (connected to case).

Accessories: 56246 (distance disc).



**RATINGS** (Limiting values) <sup>1)</sup>Voltages

Collector-base voltage (open emitter)	$V_{CBO}$	max.	30 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	20 V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	3 V

Currents

Collector current (d.c.)	$I_C$	max.	20 mA
Collector current (peak value)	$I_{CM}$	max.	20 mA

Power dissipation

Total power dissipation up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	150 mW
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Temperatures

Storage temperature	$T_{stg}$	-65 to +175	$^{\circ}\text{C}$
Junction temperature	$T_j$	max.	175 $^{\circ}\text{C}$

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th\ j-a}$	=	1 $^{\circ}\text{C}/\text{mW}$
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<sup>1)</sup> Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

**CHARACTERISTICS**

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

Base current

$-I_E = 2\text{ mA}; V_{CB} = 10\text{ V}$

$I_B$  typ. 70  $\mu\text{A}$   
< 150  $\mu\text{A}$

Emitter-base voltage

$-I_E = 2\text{ mA}; V_{CB} = 10\text{ V}$

$-V_{EB}$  typ. 0.75 V

Feedback capacitance at  $f = 10.7\text{ MHz}$

$I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$

$C_{re}$  typ. 280 fF<sup>1)</sup>

Transition frequency

$I_C = 2\text{ mA}; V_{CE} = 10\text{ V}$

$f_T$  typ. 600 MHz

y parameters at  $f = 35\text{ MHz}$  <sup>2)</sup>

$-I_E = 2\text{ mA}; V_{CB} = 10\text{ V}$

Output conductance

$g_{ob}$  typ. 10  $\mu\Omega^{-1}$

Output capacitance

$C_{ob}$  typ. 0.9 pF

Maximum unilateralised power gain <sup>2)</sup>

$$G_{UM} = \frac{|\hat{y}_{fb}|^2}{4 g_{ib} g_{ob}}$$

$-I_E = 2\text{ mA}; V_{CB} = 10\text{ V}; f = 500\text{ MHz}$

$G_{UM}$  typ. 13.5 dB

$-I_E = 2\text{ mA}; V_{CB} = 10\text{ V}; f = 900\text{ MHz}$

$G_{UM}$  typ. 11 dB

Transducer gain <sup>2)</sup>

$-I_E = 2\text{ mA}; V_{CB} = 10\text{ V}; f = 900\text{ MHz};$

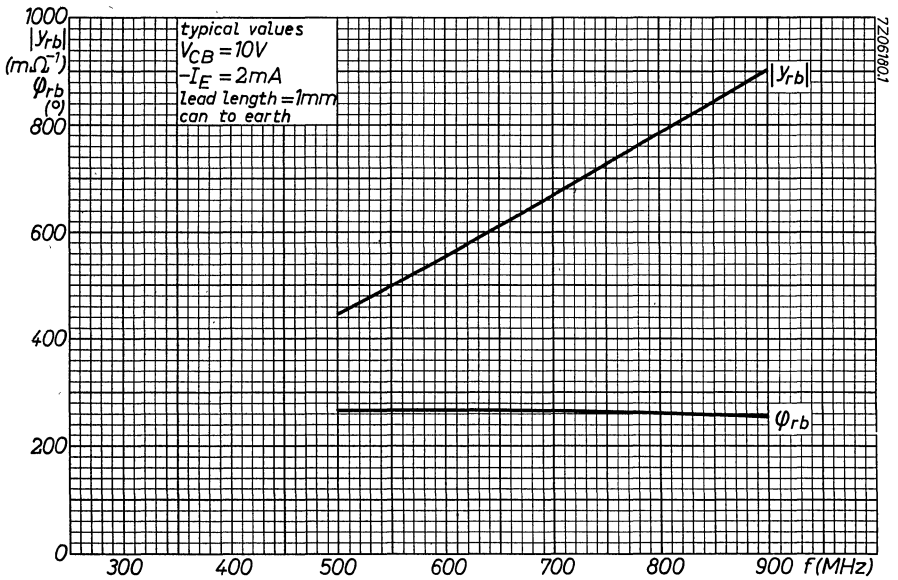
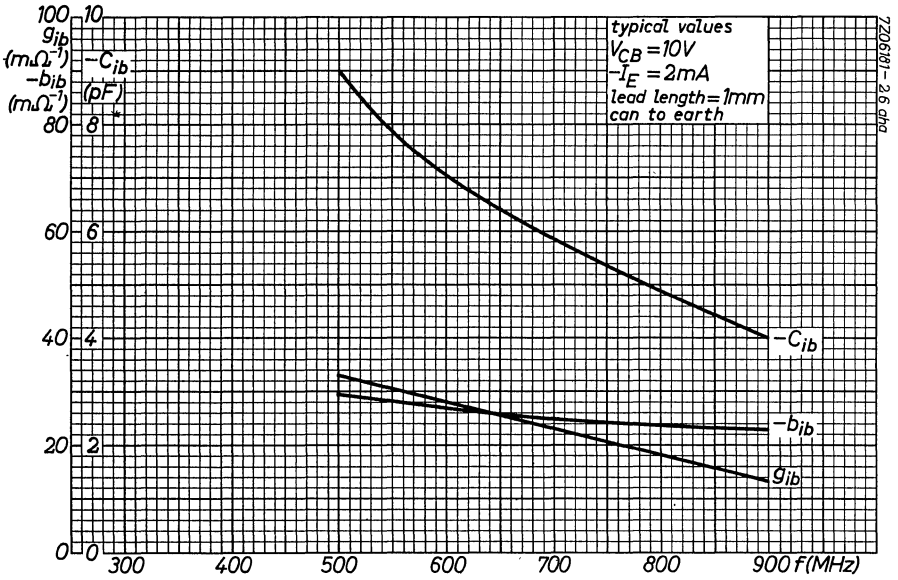
$G_S = 20\text{ m}\Omega^{-1}; B_S = 0$

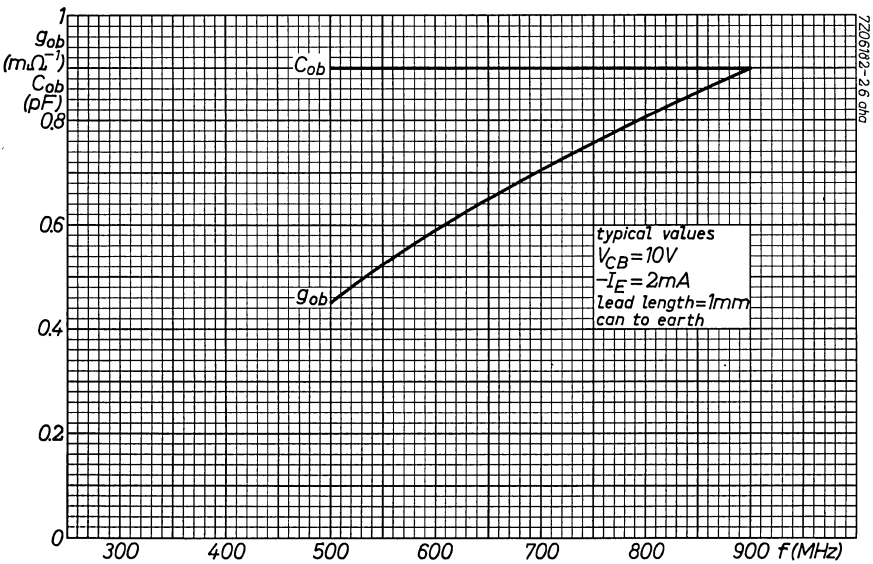
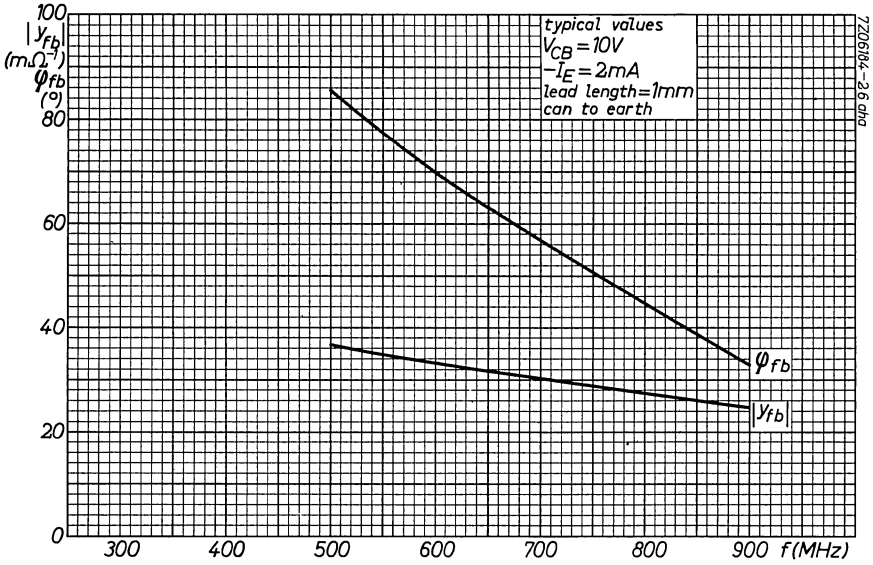
$G_L = 2\text{ m}\Omega^{-1}; B_L : \text{tuned}$

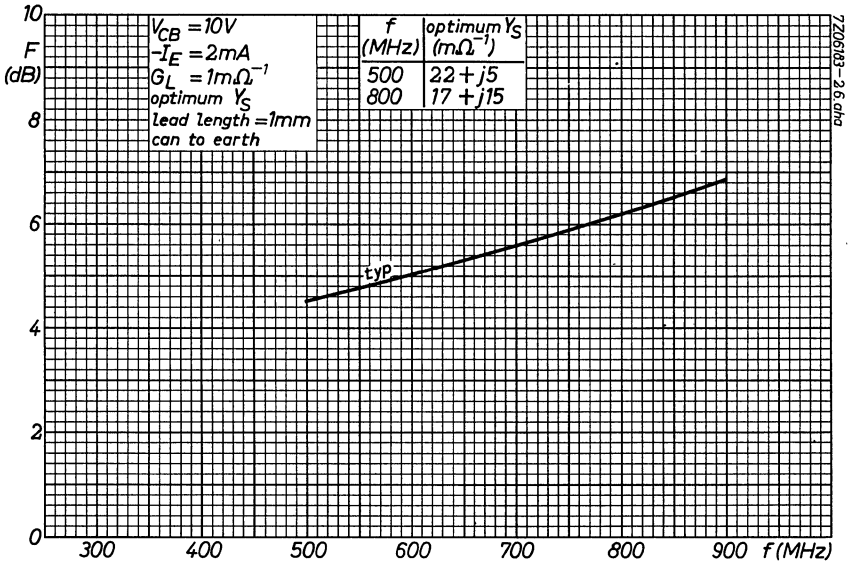
$G_{tr}$  typ. 8 dB

1) 1 fF = 1 femtofarad =  $10^{-15}\text{ F}$ .

2) Common base configuration, metal envelope contacted to earth directly, external lead length: 1 mm.







## U.H.F. SILICON PLANAR TRANSISTOR

N-P-N transistor in a TO-72 metal envelope with insulated electrodes and a shield lead connected to the case. The BF182 is primarily intended for application as mixer in integrated television tuners.

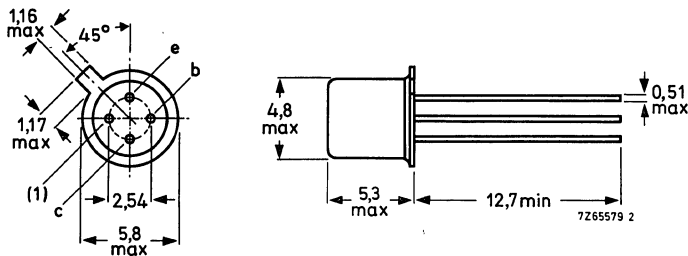
### QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$V_{CB0}$	max.	25 V
Collector-emitter voltage (open base)	$V_{CE0}$	max.	20 V
Collector current (d.c.)	$I_C$	max.	15 mA
Total power dissipation up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	150 mW
Junction temperature	$T_j$	max.	175 $^{\circ}\text{C}$
Transition frequency $I_C = 2\text{ mA}; V_{CE} = 10\text{ V}$	$f_T$	typ.	650 MHz
Maximum unilateralized power gain $-I_E = 2\text{ mA}; V_{CB} = 10\text{ V}; f = 900\text{ MHz}$	GUM	typ.	11 dB
Noise figure at optimum source admittance $-I_E = 2\text{ mA}; V_{CB} = 10\text{ V}; f = 800\text{ MHz}$	F	typ.	7,4 dB

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-72.



(1) = shield lead (connected to case).

Accessories: 56246 (distance disc).

## RATINGS (Limiting values) <sup>1)</sup>

### Voltages

Collector-base voltage (open emitter)	$V_{CBO}$	max.	25 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	20 V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	3 V

### Currents

Collector current (d.c.)	$I_C$	max.	15 mA
Collector current (peak value)	$I_{CM}$	max.	15 mA

### Power dissipation

Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	150 mW
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### Temperatures

Storage temperature	$T_{stg}$	-65 to +175	$^\circ\text{C}$
Junction temperature	$T_j$	max.	175 $^\circ\text{C}$

## THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	1 $^\circ\text{C}/\text{mW}$
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## CHARACTERISTICS

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

### Base current

$-I_E = 2\text{ mA}; V_{CB} = 10\text{ V}$	$I_B$	typ.	100 $\mu\text{A}$
		<	200 $\mu\text{A}$

### Emitter-base voltage <sup>2)</sup>

$-I_E = 2\text{ mA}; V_{CB} = 10\text{ V}$	$-V_{EB}$	typ.	770 mV
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### Transition frequency

$I_C = 2\text{ mA}; V_{CE} = 10\text{ V}$	$f_T$	typ.	650 MHz
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### Feedback capacitance at $f = 10.7\text{ MHz}$

$I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$	$C_{re}$	typ.	330 fF
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1) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

2)  $-V_{EB}$  decreases by about  $1.6\text{ mV}/^\circ\text{C}$  with increasing temperature.

**CHARACTERISTICS (continued)**

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

Output conductance at  $f = 35\text{ MHz}$

$-I_E = 2\text{ mA}; V_{CB} = 10\text{ V}$   $g_{ob}$  typ. 8  $\mu\Omega^{-1}$

Transducer gain at  $f = 900\text{ MHz}$  (common base) <sup>1)</sup>

$-I_E = 2\text{ mA}; V_{CB} = 10\text{ V}$   
 $G_S = 20\text{ m}\Omega^{-1}; G_L = 2\text{ m}\Omega^{-1}$   $G_{tr}$  > 8 dB  
typ. 10 dB

Max. unilateralised power gain

$$G_{UM} = \frac{|y_{fb}|^2}{4 g_{ib}g_{ob}}$$

$-I_E = 2\text{ mA}; V_{CB} = 10\text{ V}; f = 500\text{ MHz}$   $G_{UM}$  typ. 15 dB

$-I_E = 2\text{ mA}; V_{CB} = 10\text{ V}; f = 900\text{ MHz}$   $G_{UM}$  typ. 11 dB

Noise figure at optimum source admittance

$-I_E = 2\text{ mA}; V_{CB} = 10\text{ V}; f = 200\text{ MHz}$  F typ. 3.3 dB

$-I_E = 2\text{ mA}; V_{CB} = 10\text{ V}; f = 800\text{ MHz}$  F typ. 7.4 dB

<sup>1)</sup> Envelope connected to earth directly, lead length = 3 mm.







## U.H.F. SILICON PLANAR TRANSISTOR

N-P-N transistor in a TO-72 metal envelope with insulated electrodes and a shield lead connected to the case. The BF183 is primarily intended for application in integrated television tuners as local oscillator with excellent frequency stability.

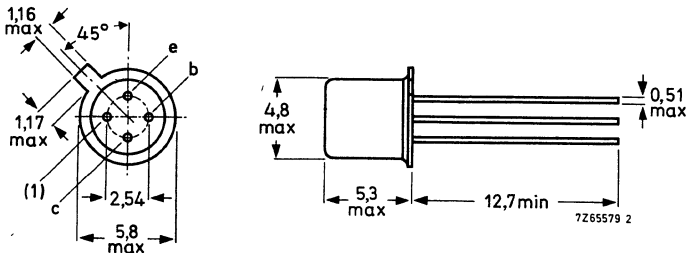
### QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$V_{CBO}$	max.	25 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	20 V
Collector current (d.c.)	$I_C$	max.	15 mA
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	150 mW
Junction temperature	$T_j$	max.	175 $^\circ\text{C}$
Transition frequency $I_C = 3\text{ mA}; V_{CE} = 10\text{ V}$	$f_T$	typ.	800 MHz
Maximum unilateralized power gain $-I_E = 3\text{ mA}; V_{CB} = 10\text{ V}; f = 900\text{ MHz}$	$G_{UM}$	typ.	13 dB

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-72.



(1) = shield lead (connected to case).

Accessories: 56246 (distance disc).

**RATINGS**

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

Collector-base voltage (open emitter)	$V_{CBO}$	max.	25 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	20 V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	3 V
Collector current			
d.c.	$I_C$	max.	15 mA
peak value	$I_{CM}$	max.	15 mA
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	150 mW
Storage temperature	$T_{stg}$		-65 to + 175 $^\circ\text{C}$
Junction temperature	$T_j$	max.	175 $^\circ\text{C}$

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th\ j-a}$	=	1 K/mW
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**CHARACTERISTICS**

$T_{amb} = 25\text{ }^\circ\text{C}$

Base current

$-I_E = 3\text{ mA}; V_{CB} = 10\text{ V}$

$I_B$	typ.	125 $\mu\text{A}$
	<	300 $\mu\text{A}$

Emitter-base voltage \*

$-I_E = 3\text{ mA}; V_{CB} = 10\text{ V}$

$-V_{EB}$	typ.	770 mV
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Transition frequency

$I_C = 3\text{ mA}; V_{CE} = 10\text{ V}$

$f_T$	typ.	800 MHz
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Feedback capacitance at  $f = 10,7\text{ MHz}$

$I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$

$C_{re}$	typ.	330 fF
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Transducer gain (common base) \*\*

$-I_E = 3\text{ mA}; V_{CB} = 10\text{ V}$

$G_S = 20\text{ mA/V}; G_L = 2\text{ mA/V}; f = 900\text{ MHz}$

$G_{tr}$	>	8,5 dB
	typ.	12,0 dB

Maximum unilateral power gain

$$G_{UM} \text{ (in dB)} = 10 \log \frac{|y_{fb}|^2}{4 g_{ib} g_{ob}}$$

$-I_E = 3\text{ mA}; V_{CB} = 10\text{ V}; f = 500\text{ MHz}$

$G_{UM}$	typ.	16 dB
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$-I_E = 3\text{ mA}; V_{CB} = 10\text{ V}; f = 900\text{ MHz}$

$G_{UM}$	typ.	13 dB
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\*  $-V_{EB}$  decreases by about 1,6 mV/K with increasing temperature.

\*\* Envelope connected to earth directly, lead length = 3 mm.

## SILICON PLANAR TRANSISTOR

N-P-N transistor in a plastic TO-92 variant. The BF198 has a very low feedback capacitance and is intended for use in the forward gain control stage of the television i.f. amplifier.

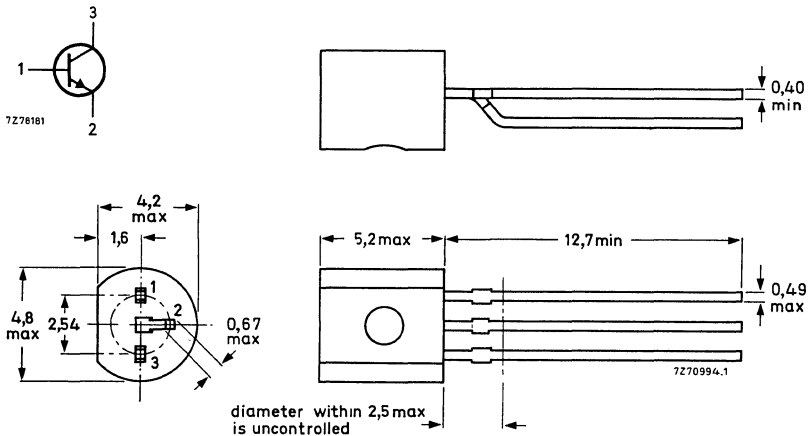
### QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$V_{CBO}$	max.	40 V
Collector-emitter voltage (open base)	$V_{CBO}$	max.	30 V
Collector current (d.c.)	$I_C$	max.	25 mA
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	500 mW
Junction temperature	$T_j$	max.	150 $^\circ\text{C}$
Transition frequency at $f = 100\text{ MHz}$ $I_C = 4\text{ mA}; V_{CE} = 10\text{ V}$	$f_T$	typ.	400 MHz
Feedback capacitance at $f = 10,7\text{ MHz}$ $I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$	$-C_{re}$	typ.	200 fF
Max. unilateralized power gain $I_C = 4\text{ mA}; V_{CE} = 10\text{ V}; f = 35\text{ MHz}$ $f = 45\text{ MHz}$	$G_{UM}$	typ.	42 dB
	$G_{UM}$	typ.	39 dB
Gain control range	$\Delta G_{tr}$	typ.	60 dB

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



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

Voltages

Collector-base voltage (open emitter)	$V_{CBO}$	max.	40	V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	30	V <sup>1)</sup>
Emitter-base voltage (open collector)	$V_{EBO}$	max.	4	V

Currents

Collector current (d. c.)	$I_C$	max.	25	mA
Collector current (peak value)	$I_{CM}$	max.	25	mA

Power dissipation

Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	500	mW
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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 ambient in free air	$R_{th\ j-a}$	=	0.25	$^\circ\text{C}/\text{mW}$
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<sup>1)</sup> See also page 6.

**CHARACTERISTICS**

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

Base current at about 50 dB gain control

$I_C = 6\text{ mA}; V_{CE} = 2\text{ V}$

$I_B < 270\text{ }\mu\text{A}$

$I_C = 15\text{ mA}; V_{CE} = 5\text{ V}$

$I_B < 1.5\text{ mA}$

Base current

$I_C = 4\text{ mA}; V_{CE} = 10\text{ V}$

$I_B$  typ. 60  $\mu\text{A}$   
< 150  $\mu\text{A}$

Base-emitter voltage <sup>1)</sup>

$I_C = 4\text{ mA}; V_{CE} = 10\text{ V}$

$V_{BE}$  typ. 760 mV  
< 850 mV

Feedback capacitance at  $f = 10.7\text{ MHz}$

$I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$

$C_{re}$  typ. 200 fF

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

$I_C = 4\text{ mA}; V_{CE} = 10\text{ V}$

$f_T$  typ. 400 MHz

Noise figure

$I_C = 4\text{ mA}; V_{CE} = 10\text{ V}$   
 $G_S = 10\text{ mA/V}; f = 35\text{ MHz}; B_S = 0$

F typ. 3 dB

y parameters (common emitter)

$I_C = 4\text{ mA}; V_{CE} = 10\text{ V}$

			$f = 35$	45	MHz
Input conductance	$g_{ie}$	typ.	3.2	4.8	$\text{mA/V}$
Input capacitance	$C_{ie}$	typ.	37	35	pF
Feedback admittance	$ y_{re} $	typ.	47	60	$\mu\text{A/V}$
Phase angle of feedback admittance	$\phi_{re}$	typ.	268°	268°	
Transfer admittance	$ y_{fe} $	typ.	105	100	$\text{mA/V}$
Phase angle of transfer admittance	$\phi_{fe}$	typ.	340°	340°	
Output conductance	$g_{oe}$	typ.	50	60	$\mu\text{A/V}$
Output capacitance	$C_{oe}$	typ.	1.3	1.3	pF

Maximum unilateralized power gain

$$G_{UM} (\text{in dB}) = 10 \log \frac{|y_{fe}|^2}{4g_{ie}g_{oe}}$$

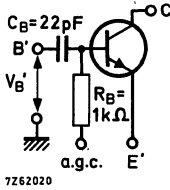
$I_C = 4\text{ mA}; V_{CE} = 10\text{ V}$

$G_{UM}$  typ. 42 39 dB

1)  $V_{BE}$  decreases by about 1.7 mV/°C with increasing temperature.

Equivalent gain control transistor

To ensure an almost constant input admittance and an output conductance that varies little with gain control, we recommend that where a BF198 is used in a gain controlled i.f. stage, a series base capacitor of 22 pF and a bias resistor of 1 kΩ be used.

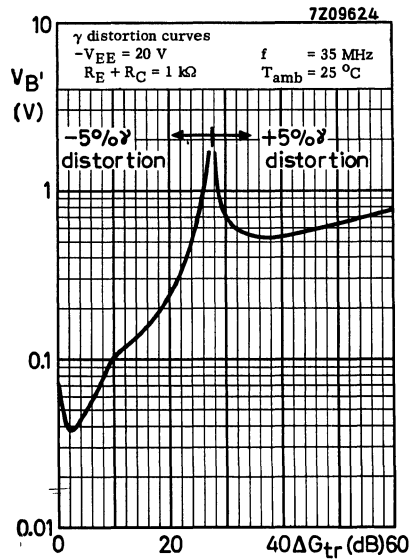
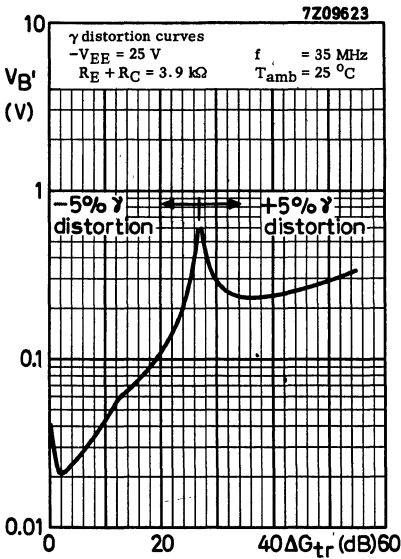


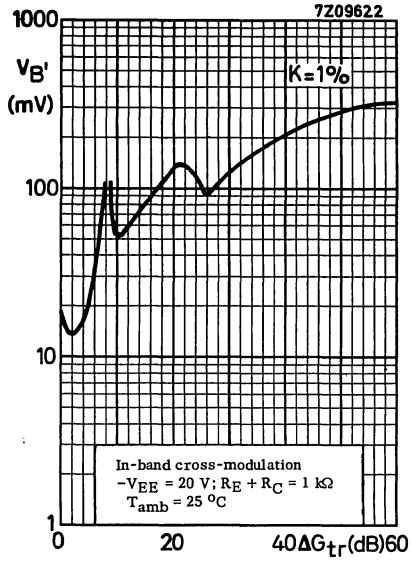
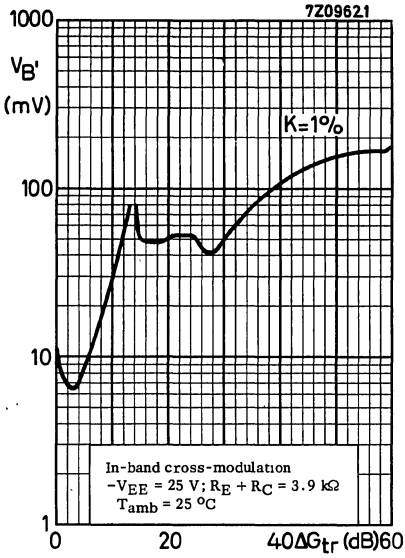
The transistor with these additional components is effectively an "equivalent transistor" for gain control purposes, the signal handling capability of which may be expressed in terms of voltage. (Without these components the varying input admittance means that the signal handling capability can only be expressed in terms of power).

The signal handling capability of the equivalent transistor as a function of  $\Delta G_{tr}$  (the reduction in transducer gain with gain control) will be found on pages 4 and 5.

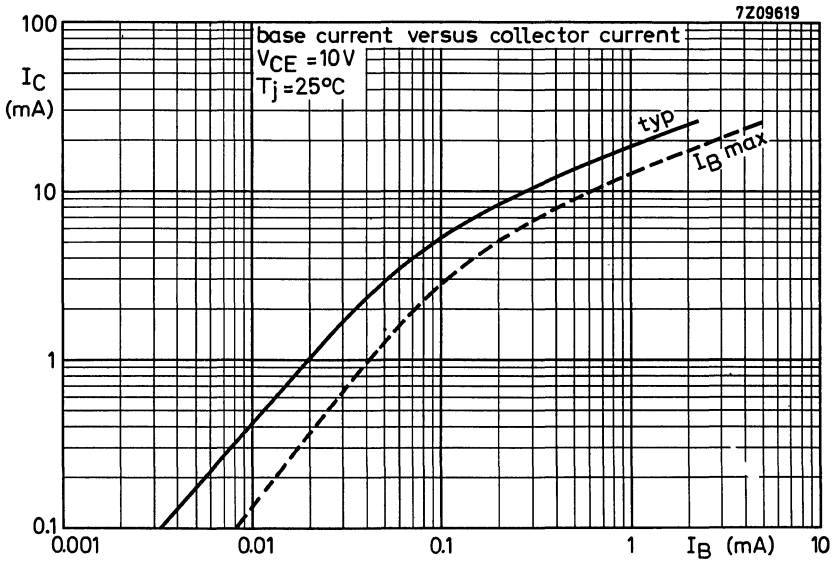
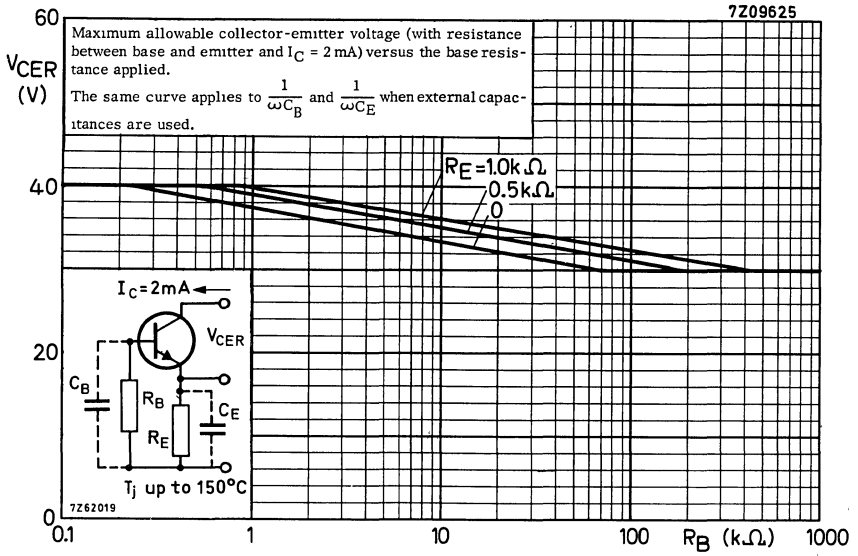
- a. Voltage versus  $\Delta G_{tr}$  curves for a  $\gamma$  distortion of 5% are below.
- b. Voltage versus  $\Delta G_{tr}$  curves for an in-band cross modulation factor of 1% are on page 5.

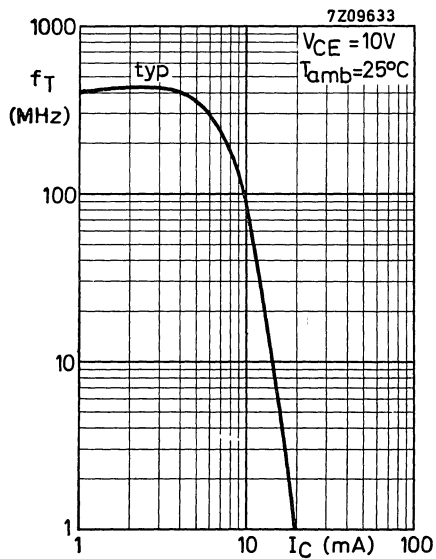
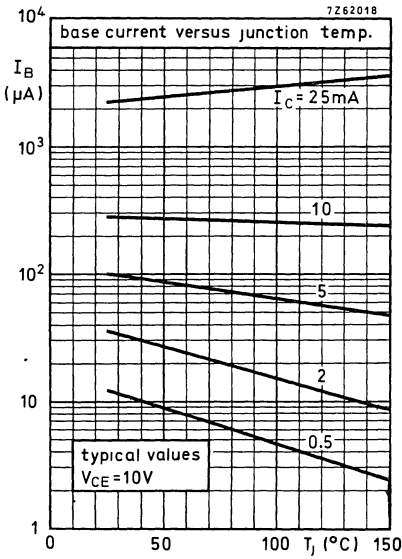
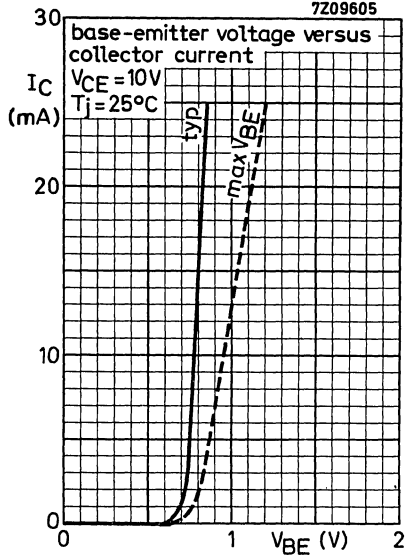
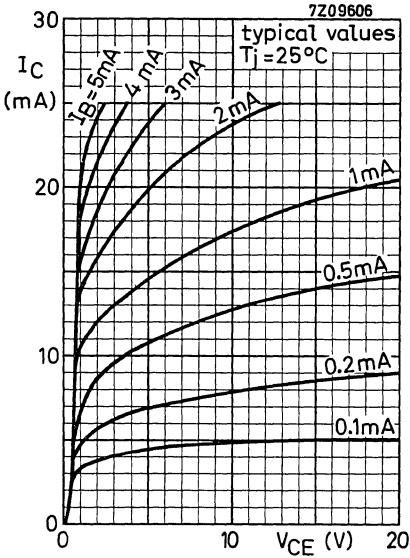
Graphs of the y-parameters are on pages 8 to 11.



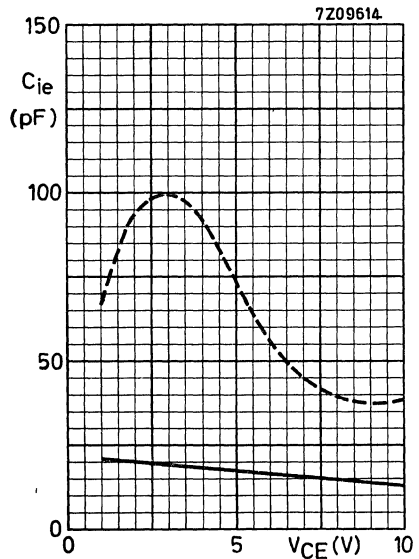
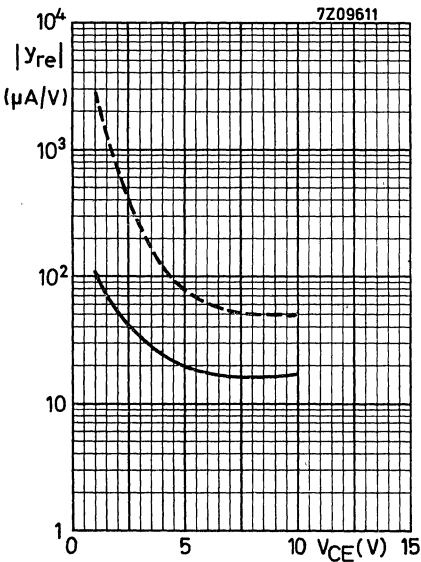
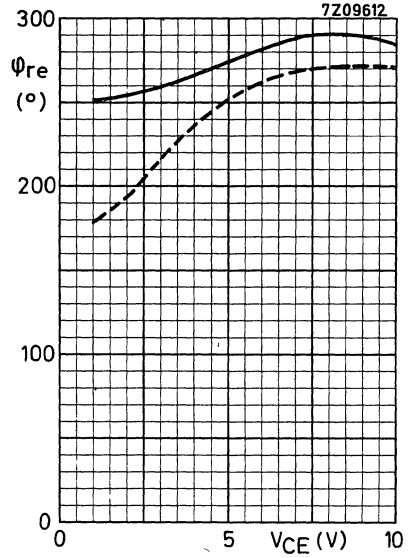
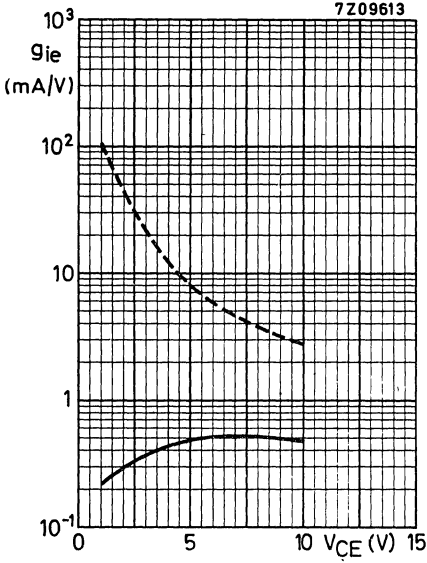






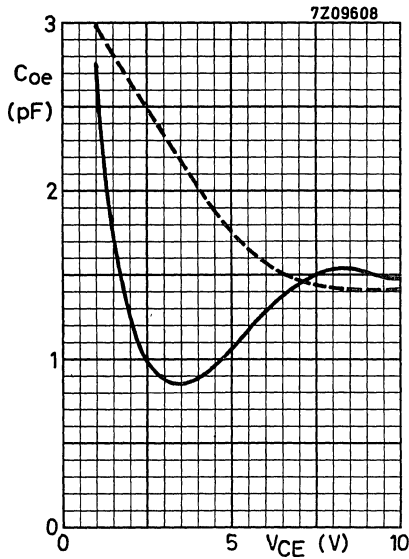
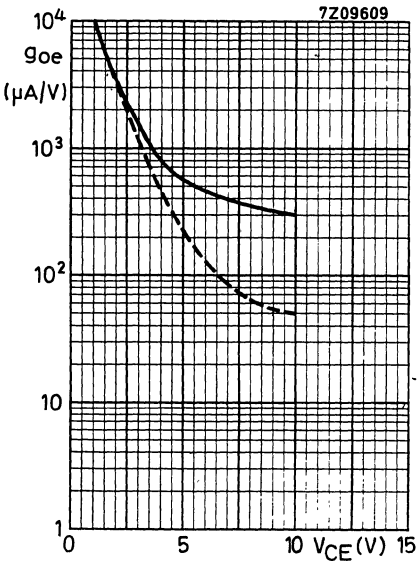
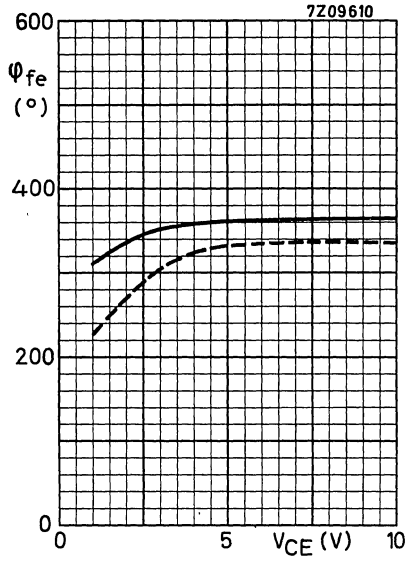
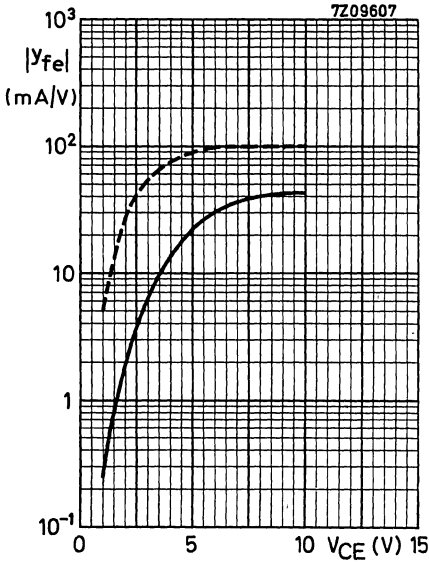


Voltage control;  $-V_{EE} = 25$  V;  $R_E + R_C = 3.9$  k $\Omega$ ;  $f = 35$  MHz



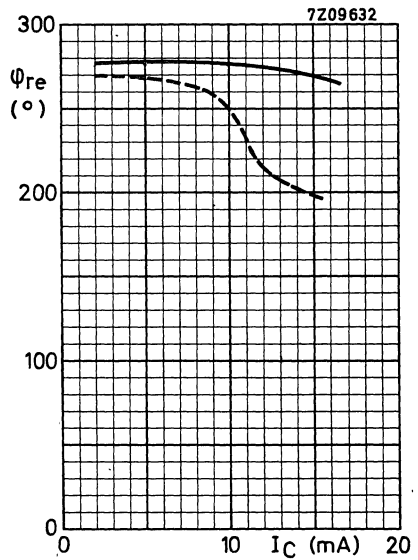
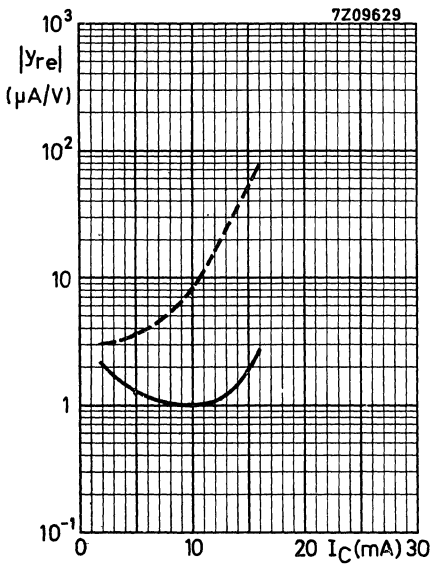
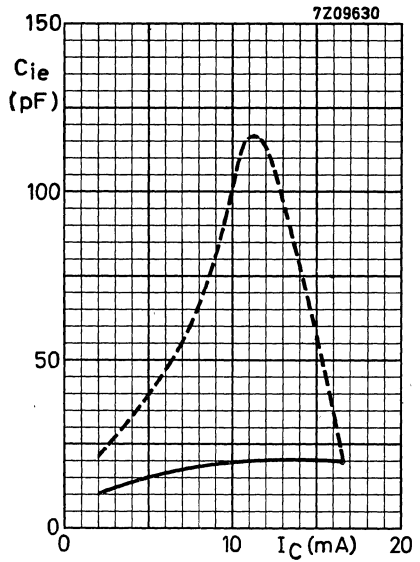
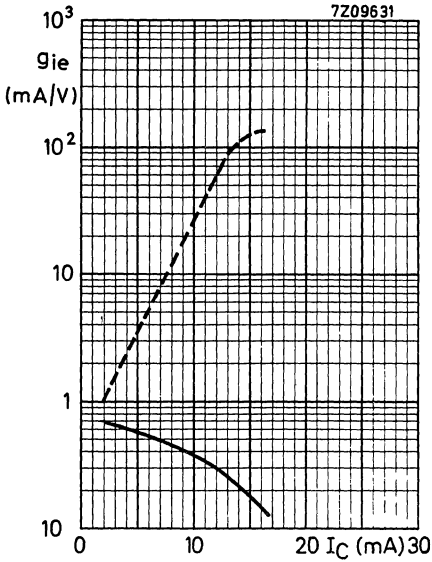
y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on page 4 (dashed curves apply to the transistor only).

Voltage control;  $-V_{EE} = 25 \text{ V}$ ;  $R_E + R_C = 3.9 \text{ k}\Omega$ ;  $f = 35 \text{ MHz}$



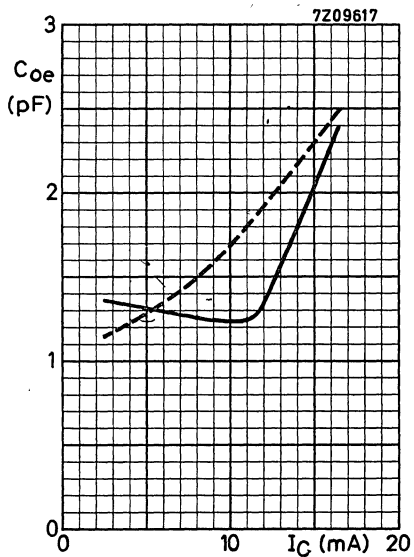
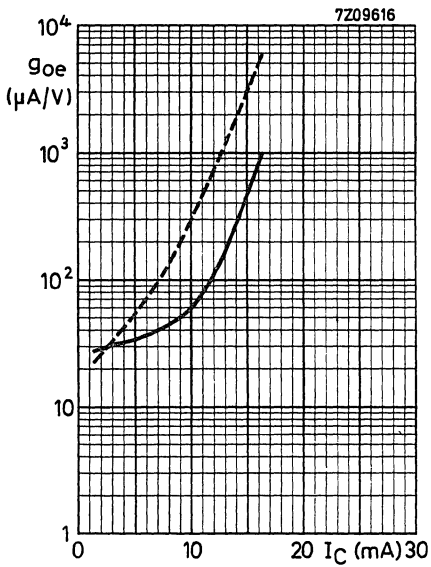
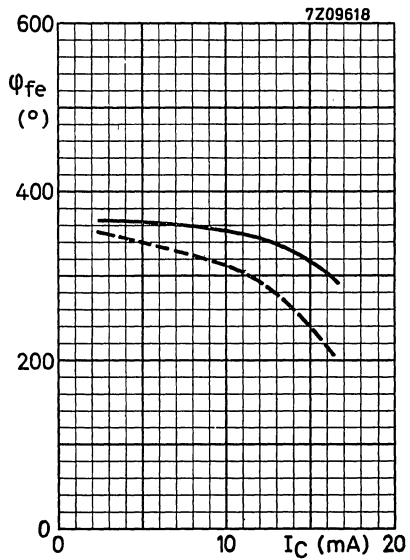
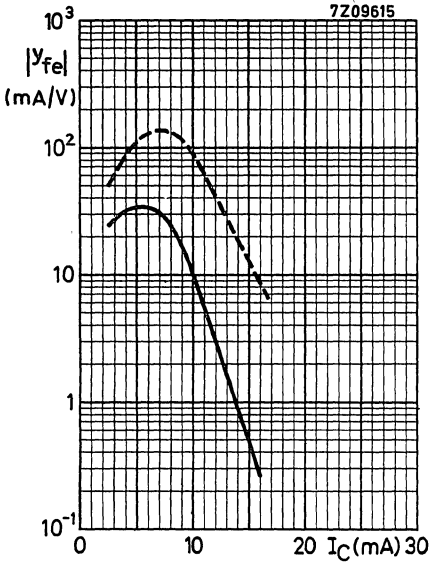
y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on page 4 (dashed curves apply to the transistor only).

Current control;  $-V_{EE} = 20 \text{ V}$ ;  $R_E + R_C = 1 \text{ k}\Omega$ ;  $f = 35 \text{ MHz}$



y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on page 4 (dashed curves apply to the transistor only).

Current control;  $-V_{EE} = 20\text{ V}$ ;  $R_E + R_C = 1\text{ k}\Omega$ ;  $f = 35\text{ MHz}$



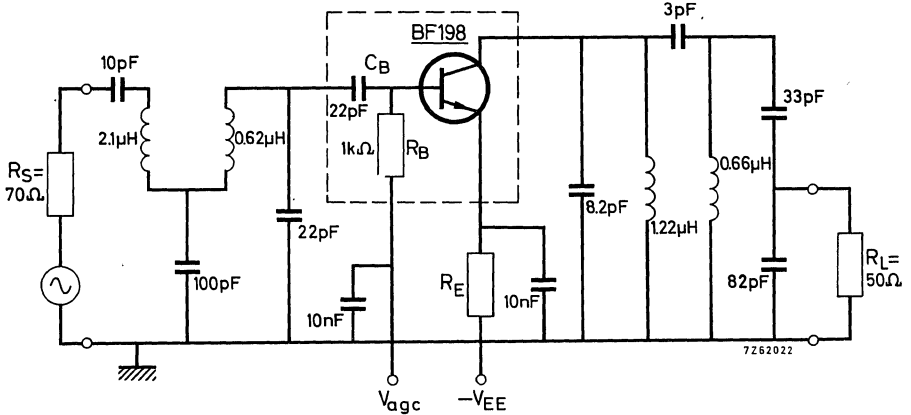
y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on page 4 (dashed curves apply to the transistor only).

**APPLICATION INFORMATION**

First stage of an i. f. amplifier

Basic circuit with voltage gain control:  $R_E + R_C = 3.9 \text{ k}\Omega$ ;  $-V_{EE} = 25 \text{ V}$

current gain control:  $R_E + R_C = 1 \text{ k}\Omega$ ;  $-V_{EE} = 20 \text{ V}$



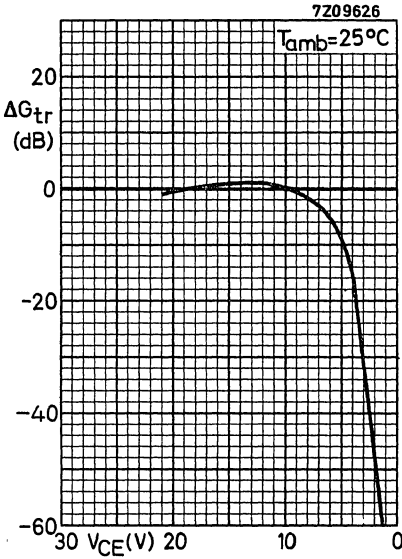
Transducer gain

$$G_{tr} \text{ (in dB)} = 10 \log \frac{\text{output power in load } R_L}{\text{available power from source } R_S}$$

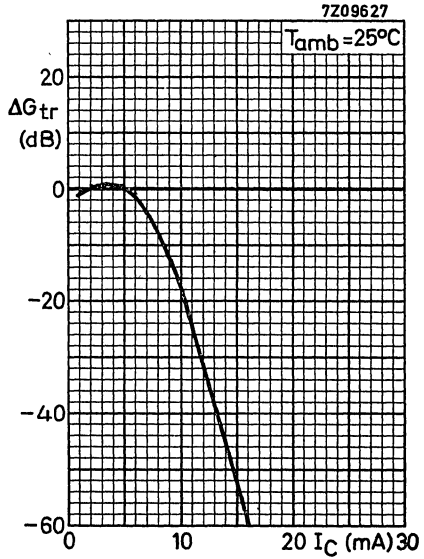
$f = 36.4 \text{ MHz}$ ;  $I_C = 4 \text{ mA}$ ;  $R_E + R_C = 3.9 \text{ k}\Omega$ ;  $-V_{EE} = 25 \text{ V}$        $G_{tr}$  typ. 25.5 dB

Gain control range (see also upper graphs next page)       $\Delta G_{tr}$  typ. 60 dB

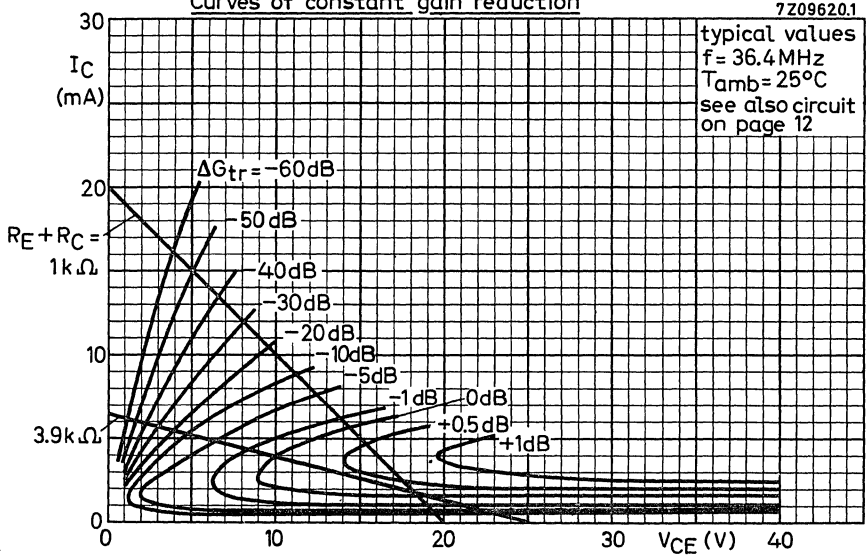
Voltage gain control



Current gain control



Curves of constant gain reduction







## SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a plastic TO-92 variant envelope.

The BF199 has a very low feedback capacitance and is intended for use in the output stage of a vision i.f. amplifier.

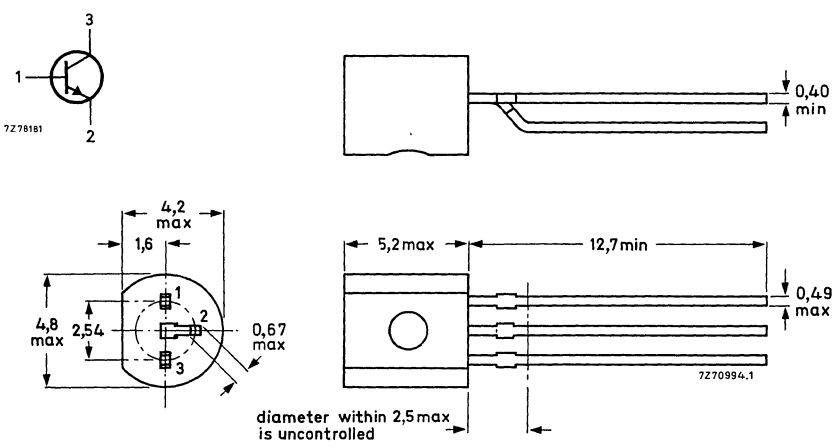
### QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$V_{CBO}$	max.	40 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	25 V
Collector current (d.c.)	$I_C$	max.	25 mA
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	500 mW
Junction temperature	$T_j$	max.	150 $^\circ\text{C}$
Transition frequency at $f = 100\text{ MHz}$ $I_C = 5\text{ mA}; V_{CE} = 10\text{ V}$	$f_T$	typ.	550 MHz
Feedback capacitance at $f = 10,7\text{ MHz}$ $I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$	$C_{re}$	typ.	340 fF
Maximum unilateral power gain $I_C = 7\text{ mA}; V_{CE} = 10\text{ V}; f = 35\text{ MHz}$	GUM	typ.	44,4 dB
Video detector output voltage	$V_O$	typ.	7,7 V

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



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

Voltages

Collector-base voltage (open emitter)	V <sub>CBO</sub>	max.	40	V
Collector-emitter voltage (open base)	V <sub>CEO</sub>	max.	25	V 1)
Emitter-base voltage (open collector)	V <sub>EBO</sub>	max.	4	V

Currents

Collector current (d. c.)	I <sub>C</sub>	max.	25	mA
Collector current (peak value)	I <sub>CM</sub>	max.	25	mA

Power dissipation

Total power dissipation up to T <sub>amb</sub> = 25 °C	P <sub>tot</sub>	max.	500	mW
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Temperatures

Storage temperature	T <sub>stg</sub>	-65 to +150	°C
Junction temperature	T <sub>j</sub>	max. 150	°C

**THERMAL RESISTANCE**

From junction to ambient in free air	R <sub>th j-a</sub>	=	0.25	°C/mW.
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1) See also page 4

## CHARACTERISTICS

 $T_{amb} = 25\text{ }^{\circ}\text{C}$ 

Base current

 $I_C = 7\text{ mA}; V_{CE} = 10\text{ V}$ 

$I_B$	typ.	60 $\mu\text{A}$
	<	185 $\mu\text{A}$

Base-emitter voltage \*

 $I_C = 7\text{ mA}; V_{CE} = 10\text{ V}$ 

$V_{BE}$	typ.	775 mV
	<	925 mV

Transition frequency at  $f = 100\text{ MHz}$  $I_C = 5\text{ mA}; V_{CE} = 10\text{ V}$ 

$f_T$	typ.	550 MHz
-------	------	---------

Feedback capacitance at  $f = 10,7\text{ MHz}$  $I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$ 

$C_{re}$	typ.	340 fF
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y-parameters (common emitter)

 $I_C = 7\text{ mA}; V_{CE} = 10\text{ V}; f = 35\text{ MHz}$ 

input conductance

$g_{ie}$	typ.	5,5 mA/V
----------	------	----------

input capacitance

$C_{ie}$	typ.	55 pF
----------	------	-------

feedback admittance

$ Y_{re} $	typ.	75 $\mu\text{A/V}$
------------	------	--------------------

phase angle of feedback admittance

$\varphi_{re}$	typ.	268 $^{\circ}$
----------------	------	----------------

transfer admittance

$ Y_{fe} $	typ.	220 mA/V
------------	------	----------

phase angle of transfer admittance

$\varphi_{fe}$	typ.	338 $^{\circ}$
----------------	------	----------------

output conductance

$g_{oe}$	typ.	80 $\mu\text{A/V}$
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output capacitance

$C_{oe}$	typ.	2,0 pF
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Maximum unilateral power gain

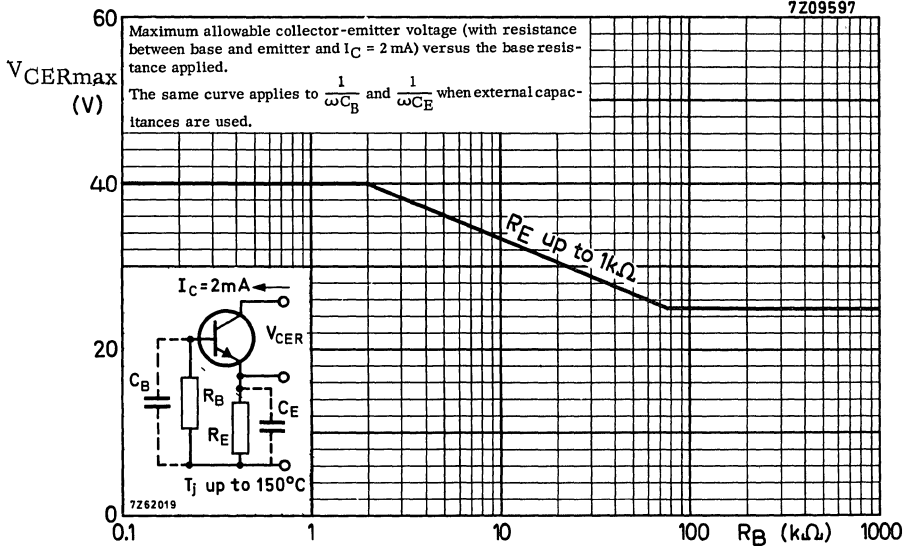
$$G_{UM} \text{ (in dB)} = 10 \log \frac{|Y_{fe}|^2}{4 g_{ie} g_{oe}}$$

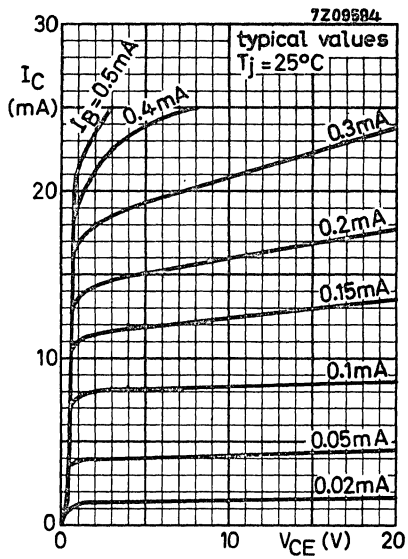
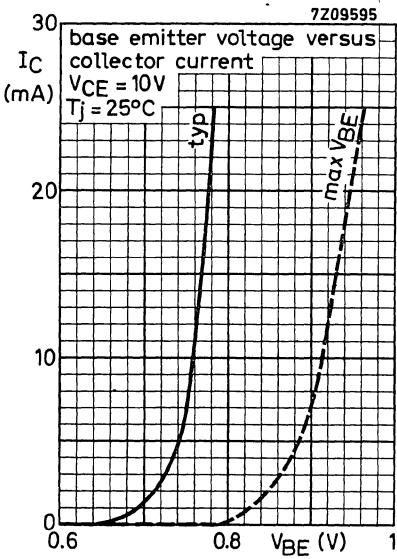
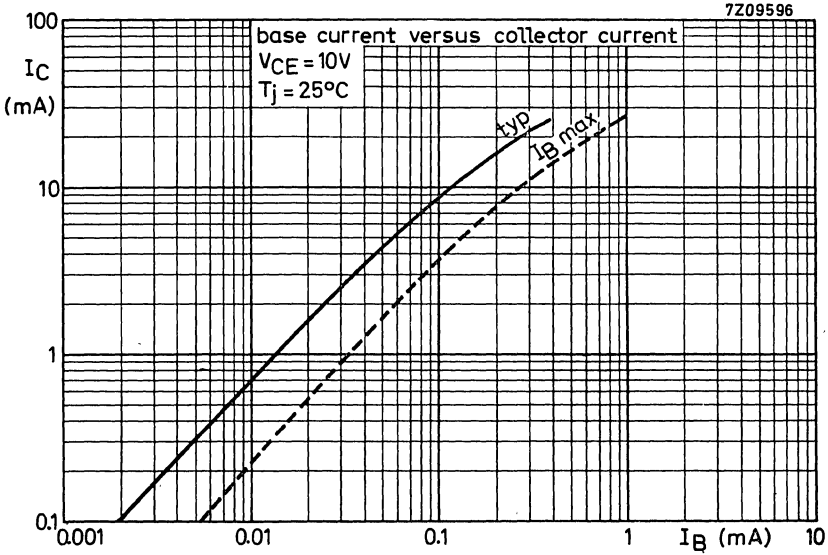
 $I_C = 7\text{ mA}; V_{CE} = 10\text{ V}$ 

$G_{UM}$	typ.	44,4 dB
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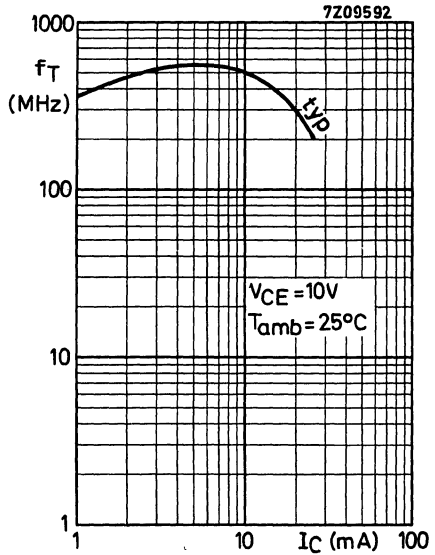
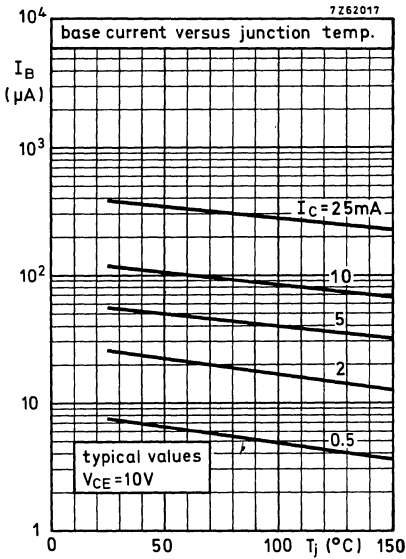
\*  $V_{BE}$  decreases by about 1,7 mV/K with increasing temperature.

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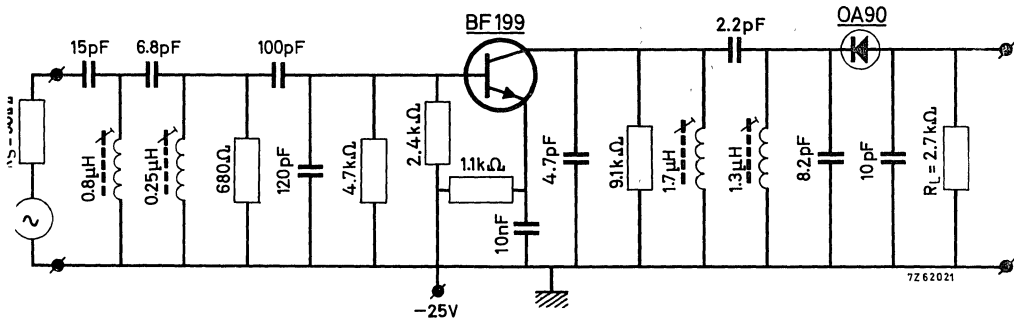


# BF199



## APPLICATION INFORMATION

Output stage of television video i. f. amplifier with the BF199 transistor, followed by a video detector circuit.



APPLICATION INFORMATION (continued)

Video detector output voltage at  $f = 38.9 \text{ MHz}$  <sup>1)</sup>

$I_C = 7.2 \text{ mA}; V_{CE} = 16.6 \text{ V}$

$V_O > \begin{matrix} 6 \\ \text{typ. } 7.7 \end{matrix} \text{ V}$

Transducer gain at  $f = 36.4 \text{ MHz}$

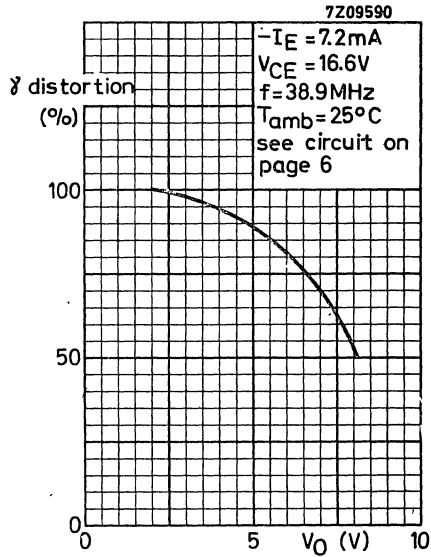
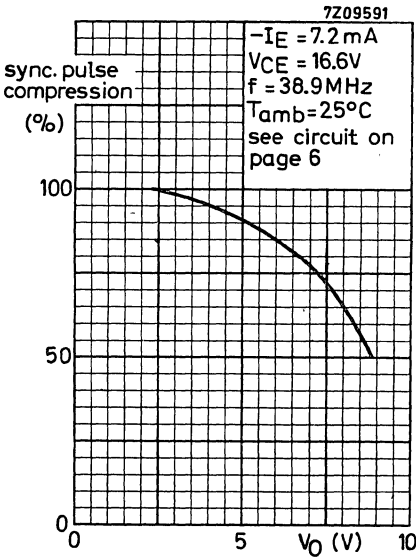
$G_{tr} \text{ (in dB)} = 10 \log \frac{\text{output power in load } R_L}{\text{available power from source with } R_S}$

$I_C = 7.2 \text{ mA}; V_{CE} = 16.6 \text{ V}$

$G_{tr} \text{ typ. } 25.5 \text{ dB}$

Tuning frequency for all tuned circuits is 37 MHz

<sup>1)</sup> The output voltage  $V_O$  is defined as the voltage across the  $2.7 \text{ k}\Omega$  detector load  $R_L$  for 30% synchronisation pulse compression.







## SILICON PLANAR TRANSISTOR

N-P-N transistor in a TO-72 metal envelope with insulated electrodes and a shield lead connected to the case. The BF200 is primarily intended for application in a forward gain controlled preamplifier in v.h.f. television tuners and f.m. tuners.

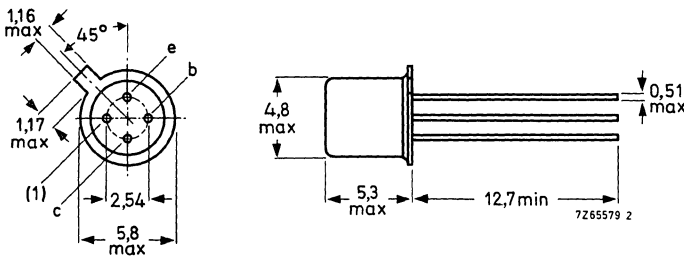
### QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$V_{CB0}$	max.	30 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	20 V
Collector current (d.c.)	$I_C$	max.	20 mA
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	150 mW
Junction temperature	$T_j$	max.	175 $^\circ\text{C}$
Transition frequency $-I_E = 3\text{ mA}; V_{CB} = 10\text{ V}$	$f_T$	typ.	650 MHz
Maximum unilateral power gain $-I_E = 3\text{ mA}; V_{CB} = 10\text{ V}; f = 50\text{ MHz}$	GUM	typ.	30 dB
$-I_E = 3\text{ mA}; V_{CB} = 10\text{ V}; f = 200\text{ MHz}$	GUM	typ.	22 dB
Noise figure at optimum source admittance $-I_E = 2\text{ mA}; V_{CB} = 10\text{ V}; f = 100\text{ MHz}$	F	typ.	2 dB
$-I_E = 3\text{ mA}; V_{CB} = 10\text{ V}; f = 200\text{ MHz}$	F	typ.	2,7 dB

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-72.



(1) = shield lead (connected to case).

Accessories: 56246 (distance disc).

**RATINGS** (Limiting values) <sup>1)</sup>Voltages

Collector-base voltage (open emitter)	$V_{CBO}$	max.	30	V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	20	V
Collector-emitter voltage ( $R_{BE} \leq 1 \text{ k}\Omega$ )	$V_{CER}$	max.	30	V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	3	V

Currents

Collector current (d.c.)	$I_C$	max.	20	mA
Collector current (peak value)	$I_{CM}$	max.	20	mA

Power dissipation

Total power dissipation up to $T_{amb} = 25 \text{ }^\circ\text{C}$	$P_{tot}$	max.	150	mW
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Temperatures

Storage temperature	$T_{stg}$	-65 to +175	$^\circ\text{C}$
Junction temperature	$T_j$	max.	175 $^\circ\text{C}$

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th \text{ j-a}}$	=	1	$^\circ\text{C/mW}$
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<sup>1)</sup> Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

**CHARACTERISTICS**

$T_{amb} = 25^{\circ}C$  unless otherwise specified

Base current

$-I_E = 3 \text{ mA}; V_{CB} = 10 \text{ V}$	$I_B$	typ. 100 $\mu A$ < 200 $\mu A$
$-I_E = 12 \text{ mA}; V_{CB} = 7 \text{ V}$	$I_B$	< 2.2 mA

Emitter-base voltage

$-I_E = 3 \text{ mA}; V_{CB} = 10 \text{ V}$	$-V_{EB}$	typ. 0.75 V
$-I_E = 12 \text{ mA}; V_{CB} = 7 \text{ V}$	$-V_{EB}$	< 1.0 V

Transition frequency

$-I_E = 3 \text{ mA}; V_{CB} = 10 \text{ V}$	$f_T$	typ. 650 MHz
--	-------	--------------

Feedback capacitance at  $f = 10.7 \text{ MHz}$

$I_C = 1 \text{ mA}; V_{CE} = 10 \text{ V}$	$C_{re}$	typ. 280 fF <sup>1)</sup>
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Noise figure at optimum source admittance

$-I_E = 3 \text{ mA}; V_{CB} = 10 \text{ V}; f = 50 \text{ MHz}$	F	typ. 1.9 dB
$f = 200 \text{ MHz}$	F	typ. 2.7 dB
$-I_E = 2 \text{ mA}; V_{CB} = 10 \text{ V}; f = 100 \text{ MHz}$	F	typ. 2.0 dB

Maximum unilateralised power gain <sup>2)</sup>

$$GUM = \frac{|y_{fb}|^2}{4 g_{ib}g_{ob}}$$

$-I_E = 3 \text{ mA}; V_{CB} = 10 \text{ V}; f = 50 \text{ MHz}$	GUM	typ. 30 dB
$f = 200 \text{ MHz}$	GUM	typ. 22 dB
$-I_E = 2 \text{ mA}; V_{CB} = 10 \text{ V}; f = 100 \text{ MHz}$	GUM	typ. 28 dB

1) 1 fF = 1 femtofarad =  $10^{-15} \text{ F}$ .

2) Commonbase configuration, metal envelope connected to earth directly, external lead length = 3 mm.

**CHARACTERISTICS** (continued)

$T_{amb} = 25^{\circ}C$  unless otherwise specified

y parameters at  $f = 100$  MHz (common emitter)

$I_C = 2$  mA;  $V_{CE} = 10$  V

Input conductance	$g_{ie}$	typ.	5 $m\Omega^{-1}$
Input capacitance	$C_{ie}$	typ.	16 pF
Feedback admittance	$ y_{re} $	typ.	0.16 $m\Omega^{-1}$
Phase angle of feedback admittance	$\phi_{re}$	typ.	$270^{\circ}$
Transfer admittance	$ y_{fe} $	typ.	56 $m\Omega^{-1}$
Phase angle of transfer admittance	$\phi_{fe}$	typ.	$340^{\circ}$
Output conductance	$g_{oe}$	typ.	15 $\mu\Omega^{-1}$
Output capacitance	$C_{oe}$	typ.	0.9 pF

y parameters at  $f = 50$  MHz (common base)

$-I_E = 3$  mA;  $V_{CB} = 10$  V

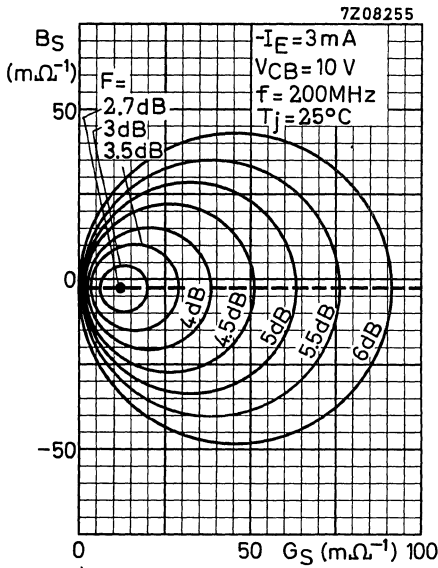
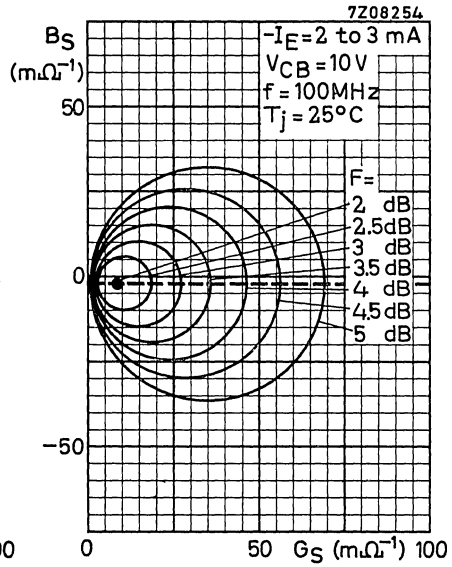
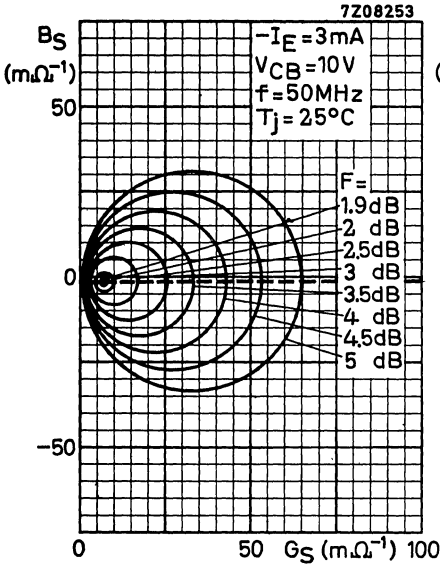
Input conductance	$g_{ib}$	typ.	85 $m\Omega^{-1}$
Input susceptance	$-b_{ib}$	typ.	15 $m\Omega^{-1}$
Feedback admittance	$ y_{rb} $	typ.	55 $\mu\Omega^{-1}$
Phase angle of feedback admittance	$\phi_{rb}$	typ.	$270^{\circ}$
Transfer admittance	$ y_{fb} $	typ.	85 $m\Omega^{-1}$
Phase angle of transfer admittance	$\phi_{fb}$	typ.	$165^{\circ}$
Output conductance	$g_{ob}$	typ.	15 $\mu\Omega^{-1}$
Output susceptance	$b_{ob}$	typ.	280 $\mu\Omega^{-1}$

y parameters at  $f = 200$  MHz (common base)

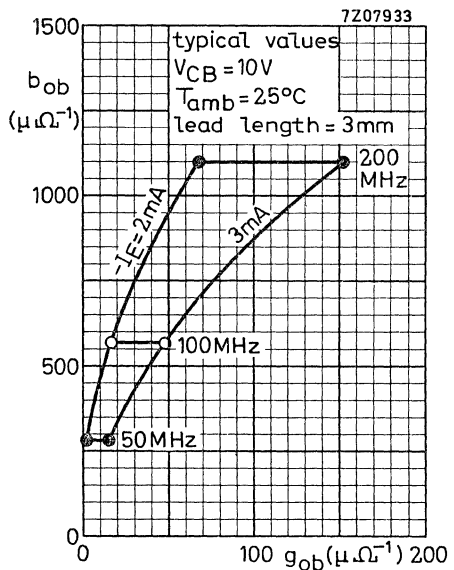
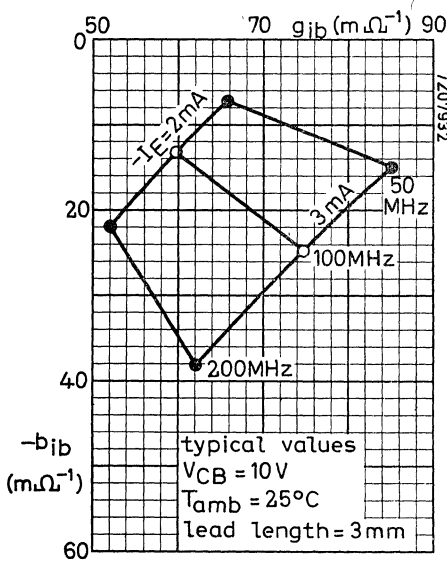
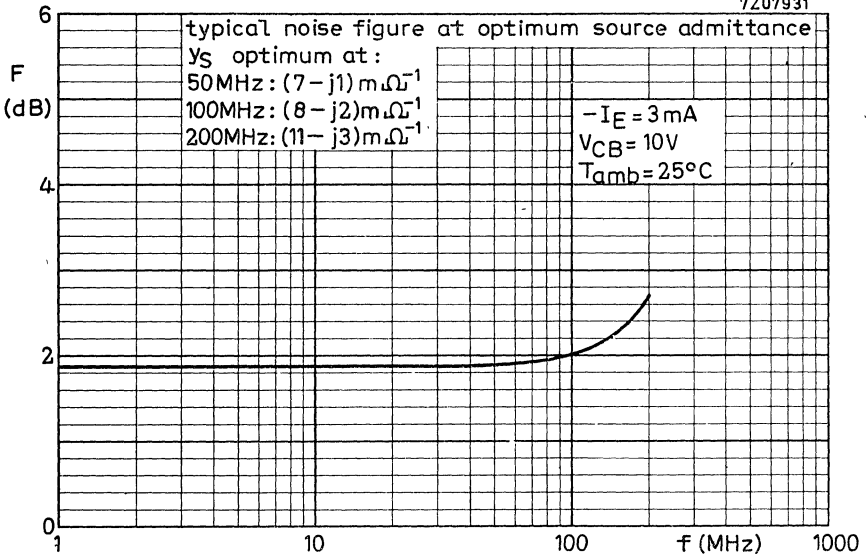
$-I_E = 3$  mA;  $V_{CB} = 10$  V

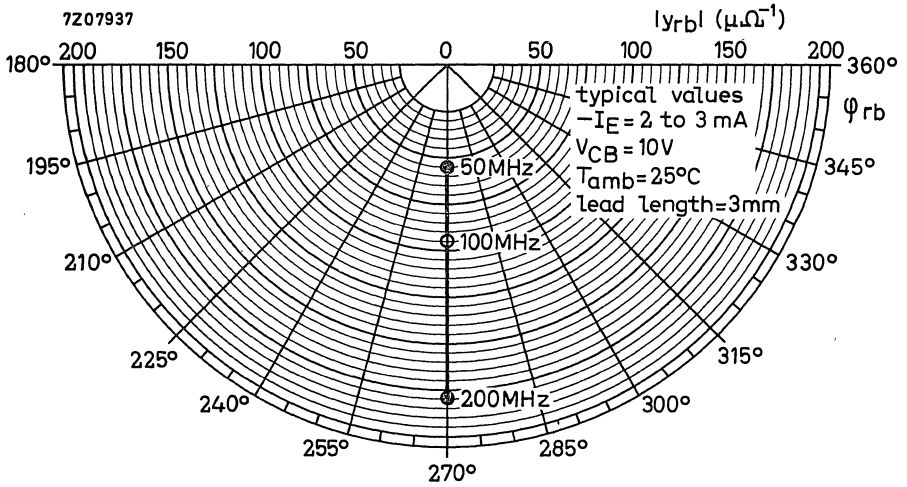
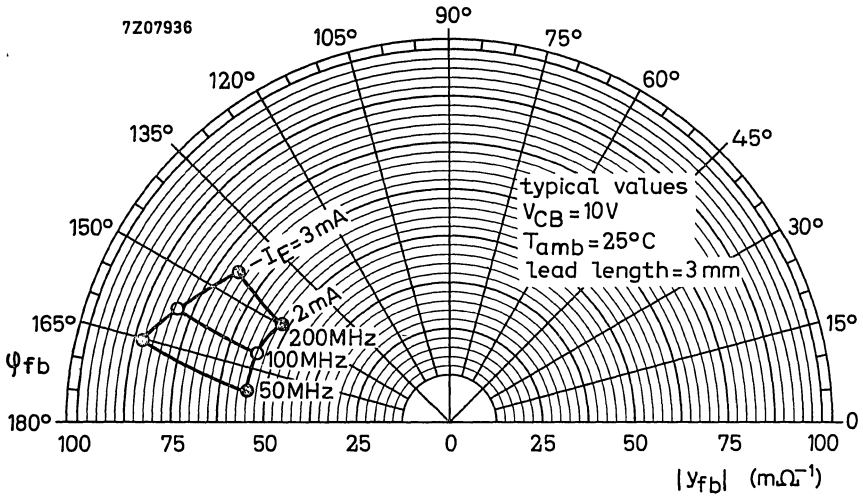
Input conductance	$g_{ib}$	typ.	62 $m\Omega^{-1}$
Input susceptance	$-b_{ib}$	typ.	38 $m\Omega^{-1}$
Feedback admittance	$ y_{rb} $	typ.	180 $\mu\Omega^{-1}$
Phase angle of feedback admittance	$\phi_{rb}$	typ.	$270^{\circ}$
Transfer admittance	$ y_{fb} $	typ.	70 $m\Omega^{-1}$
Phase angle of transfer admittance	$\phi_{fb}$	typ.	$145^{\circ}$
Output conductance	$g_{ob}$	typ.	150 $\mu\Omega^{-1}$
Output susceptance	$b_{ob}$	typ.	1.1 $m\Omega^{-1}$

circles of constant noise figure

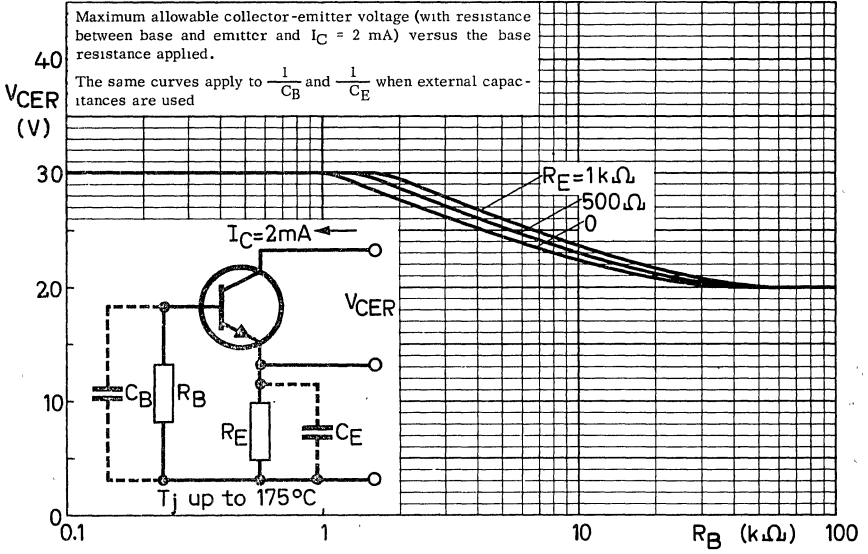


7Z07931









## H.F. SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in a plastic envelope, recommended for a.m. mixers and i.f. amplifiers in a.m./f.m. receivers.

### QUICK REFERENCE DATA

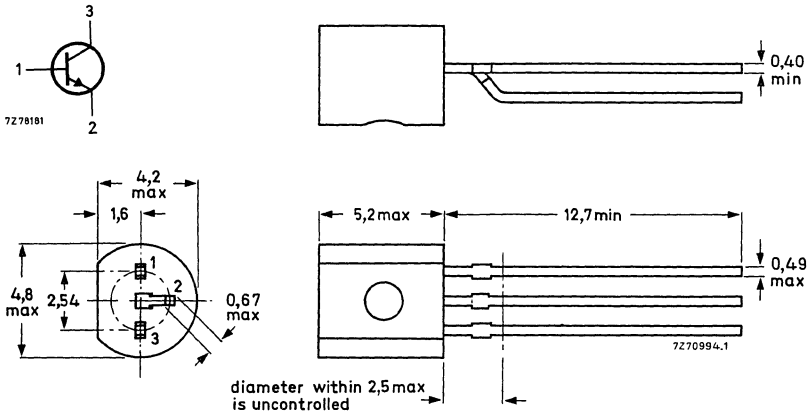
Collector-base voltage (open emitter)	$V_{CBO}$	max.	40 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	40 V
Collector current (d.c.)	$I_C$	max.	25 mA
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	250 mW
Junction temperature	$T_j$	max.	125 $^\circ\text{C}$

		BF240	BF241
Base current $I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$	$I_B$	4,5-15	8-28 $\mu\text{A}$
Transition frequency $I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$	$f_T$	typ. 380	350 MHz
Feedback capacitance at $f = 1\text{ MHz}$ $I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$	$-C_{re}$	<	0,34 pF
Noise figure $I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$ $R_S = 200\text{ }\Omega; f = 0,2\text{ MHz}$	F	<	3,5 dB

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



**BF240**  
**BF241**

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

Voltages

Collector-base voltage (open emitter)	$V_{CBO}$	max.	40	V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	40	V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	4	V

Current

Collector current (d.c.)	$I_C$	max.	25	mA
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Power dissipation

Total power dissipation up to $T_{amb} = 25^\circ C$	$P_{tot}$	max.	250	mW
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Temperatures

Storage temperature	$T_{stg}$		-55 to +125	$^\circ C$
Junction temperature	$T_j$	max.	125	$^\circ C$

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th\ j-a}$	=	0,4	$^\circ C/mW$
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**CHARACTERISTICS**

$T_j = 25^\circ C$  unless otherwise specified

Collector cut-off current

$I_E = 0; V_{CB} = 20\ V$	$I_{CBO}$	<	100	nA
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Base-emitter voltage

$I_C = 1\ mA; V_{CE} = 10\ V$	$V_{BE}$	typ.	700	mV
			650 to 740	mV

Base current

$I_C = 1\ mA; V_{CE} = 10\ V$	$I_B$		BF240 4,5-15	BF241 8-28	$\mu A$
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Transition frequency at  $f = 100\ MHz$

$I_C = 1\ mA; V_{CE} = 10\ V$	$f_T$	typ.	380	350	MHz
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Feedback capacitance at  $f = 1\ MHz$

$I_C = 1\ mA; V_{CE} = 10\ V$	$C_{re}$	typ.	0,27	0,27	pF
		<	0,34	0,34	pF

Noise figure

$I_C = 1\ mA; V_{CE} = 10\ V$					
$R_S = 200\ \Omega; f = 0,2\ MHz$	$F$	typ.	1,5	2,0	dB
		<	3,5	3,5	dB

**CHARACTERISTICS** (continued)

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

y parameters (common emitter) Lead length = 3 mm

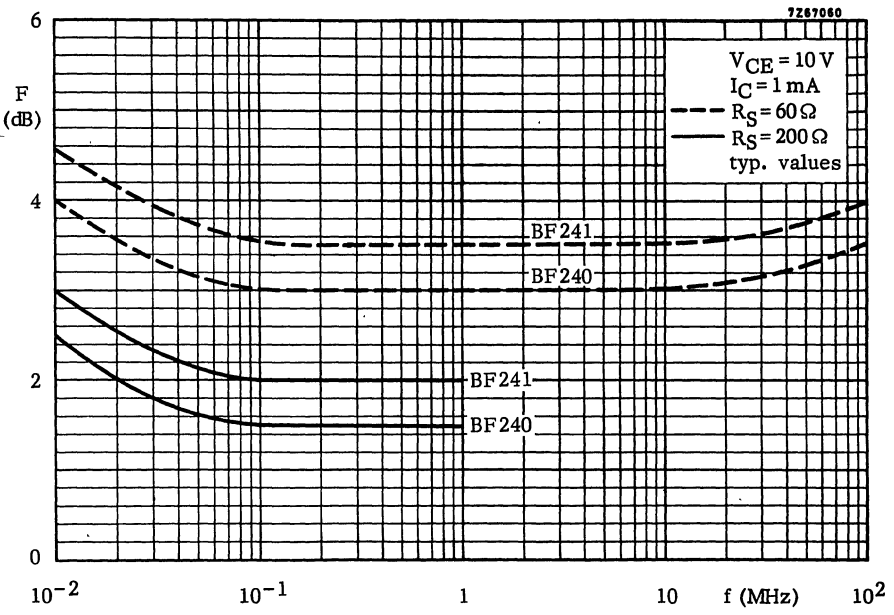
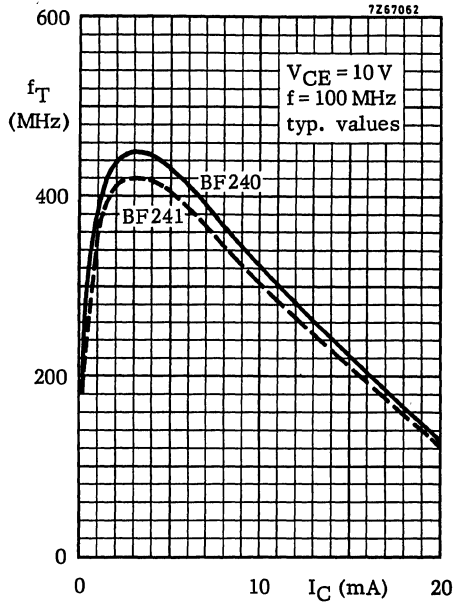
$I_C = 1\text{ mA}$ ;  $V_{CE} = 10\text{ V}$

		BF240		BF241		MHz
		f =		0,45	10,7	
Input conductance	$g_{ie}$ typ.	0,2	0,3	0,4	0,5	mA/V
Input capacitance	$C_{ie}$ typ.	17	14	23	19	pF
Transfer admittance	$ y_{fe} $ typ.	37	37	37	37	mA/V
Phase angle of transfer admittance	$\varphi_{fe}$ typ.	$0^\circ$	$0^\circ$	$0^\circ$	$0^\circ$	
Output conductance	$g_{oe}$ <	8,3	10,5	8,3	10,5	$\mu\text{A/V}$
Output capacitance	$C_{oe}$ typ.	1	1	1	1	pF
Feedback admittance	$ y_{re} $ typ.	0,75	18	0,75	18	$\mu\text{A/V}$
Phase angle of feedback admittance	$\varphi_{re}$ typ.	$270^\circ$	$270^\circ$	$270^\circ$	$270^\circ$	

$I_C = 4\text{ mA}$ ;  $V_{CE} = 10\text{ V}$ ;  $f = 35\text{ MHz}$  (BF240, BF241)

Input conductance	$g_{ie}$ typ.	4	mA/V
Input capacitance	$C_{ie}$ typ.	25	pF
Transfer admittance	$ y_{fe} $ typ.	125	mA/V
Output conductance	$g_{oe}$ typ.	62	$\mu\text{A/V}$
Output capacitance	$C_{oe}$ typ.	1	pF

**BF240**  
**BF241**



## H.F. SILICON PLANAR EPITAXIAL TRANSISTOR

P-N-P transistor in a plastic envelope especially intended for r.f. stages in f.m. front-ends in common base configuration.

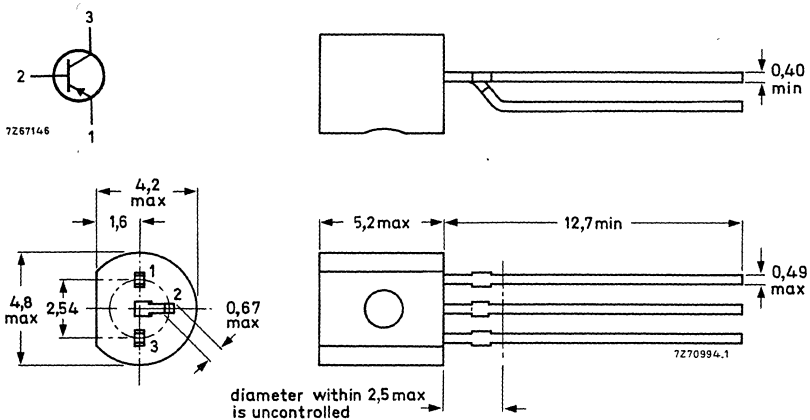
### QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$-V_{CBO}$ max.	30 V
Collector-emitter voltage (open base)	$-V_{CEO}$ max.	30 V
Collector current (d.c.)	$-I_C$ max.	25 mA
Total power dissipation up to $T_{amb} = 45^\circ\text{C}$	$P_{tot}$ max.	250 mW
Junction temperature	$T_j$ max.	150 $^\circ\text{C}$
Base current	$-I_B$ typ.	80 $\mu\text{A}$
$-I_C = 4 \text{ mA}; -V_{CE} = 10 \text{ V}$	$-I_B >$	160 $\mu\text{A}$
Transition frequency	$f_T$ typ.	450 MHz
$-I_C = 4 \text{ mA}; -V_{CE} = 10 \text{ V}$		
Noise figure at $f = 100 \text{ MHz}$	F typ.	3 dB
$-I_C = 2 \text{ mA}; -V_{CE} = 10 \text{ V}; G_s = 16,7 \text{ mA/V}$		
Feedback capacitance at $f = 1 \text{ MHz}$	$C_{rb}$ typ.	0,1 pF
$V_{EB} = 0; -V_{CB} = 10 \text{ V}$		

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



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

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	30	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	4	V

Current

Collector current (d. c.)	$-I_C$	max.	25	mA
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Power dissipation

Total power dissipation up to $T_{amb} = 45\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	250	mW
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Temperatures

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 in free air	$R_{th\ j-a}$	=	0,42	$^{\circ}\text{C}/\text{mW}$
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**CHARACTERISTICS**

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

Collector cut-off current

$I_E = 0; -V_{CB} = 30\text{ V}$   $-I_{CBO} < 50\text{ nA}$

Emitter cut-off current

$I_C = 0; -V_{EB} = 4\text{ V}$   $-I_{EBO} < 10\text{ }\mu\text{A}$

Base current

$-I_C = 4\text{ mA}; -V_{CE} = 10\text{ V}$   $-I_B$  typ. 80  $\mu\text{A}$   
 $< 160\text{ }\mu\text{A}$

$-I_C = 1\text{ mA}; -V_{CE} = 10\text{ V}$   $-I_B$  typ. 22  $\mu\text{A}$

Base-emitter voltage

$-I_C = 4\text{ mA}; -V_{CE} = 10\text{ V}$   $-V_{BE}$  typ. 0,76 V

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

$-I_C = 1\text{ mA}; -V_{CE} = 10\text{ V}$   $f_T$  typ. 350 MHz

$-I_C = 4\text{ mA}; -V_{CE} = 10\text{ V}$   $f_T$  typ. 450 MHz

$-I_C = 8\text{ mA}; -V_{CE} = 10\text{ V}$   $f_T$  typ. 440 MHz

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

$V_{EB} = 0; -V_{CB} = 10\text{ V}$   $C_{rb}$  typ. 0,1 pF

Noise factor at  $f = 100\text{ MHz}$

$-I_C = 2\text{ mA}; -V_{CE} = 10\text{ V};$   
 $G_s = 16,7\text{ mA/V}$   $F$  typ. 3 dB

$-I_C = 5\text{ mA}; -V_{CE} = 10\text{ V};$   
 $G_s = 6,7\text{ mA/V}; -jB_s = 5\text{ mA/V}$   $F$  typ. 3,5 dB

y-parameters (common base) at  $f = 100\text{ MHz}$

$-I_C = 4\text{ mA}; -V_{CB} = 10\text{ V}$

Input conductance  $g_{ib}$  typ. 125 mA/V

Input capacitance  $-C_{ib}$  typ. 64 pF

Transfer admittance  $|y_{fb}|$  typ. 100 mA/V

Phase angle of transfer admittance  $\varphi_{fb}$  typ. 147°

Output conductance  $g_{ob}$  typ. 40  $\mu\text{A/V}$

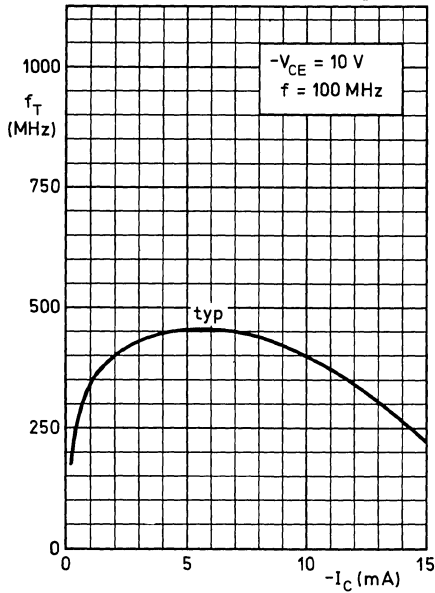
Output capacitance  $C_{ob}$  typ. 1,25 pF

Feedback admittance  $|y_{rb}|$  typ. 220  $\mu\text{A/V}$

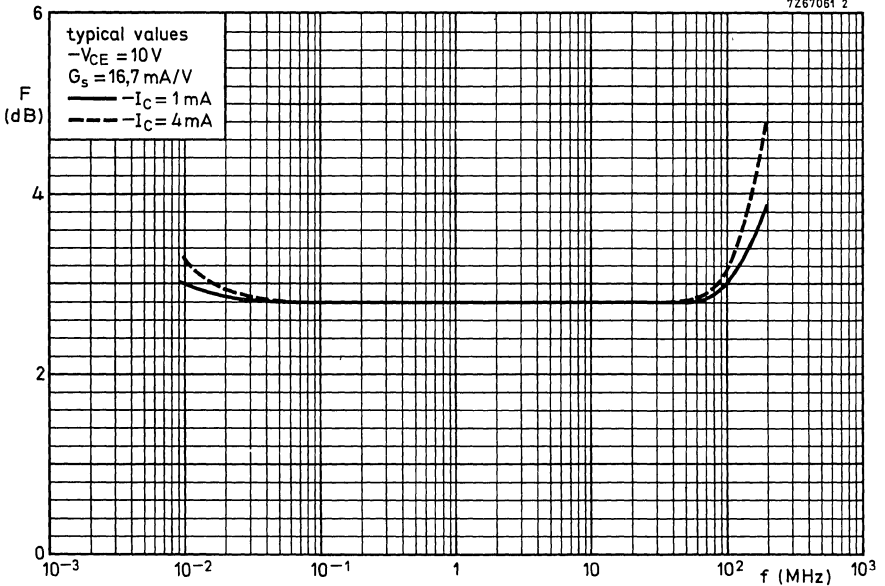
Phase angle of feedback admittance  $-\varphi_{rb}$  typ. 85°



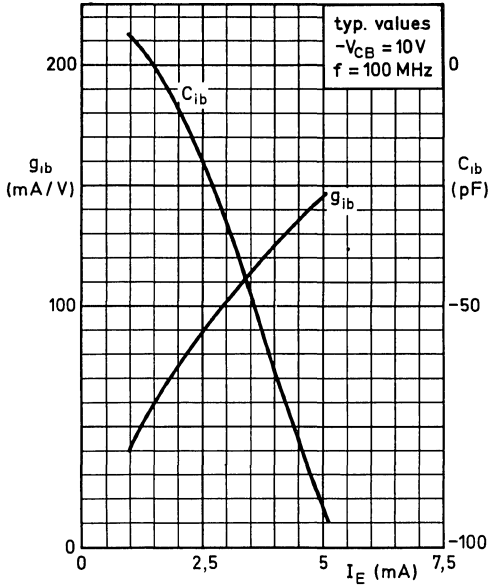
7267064 1



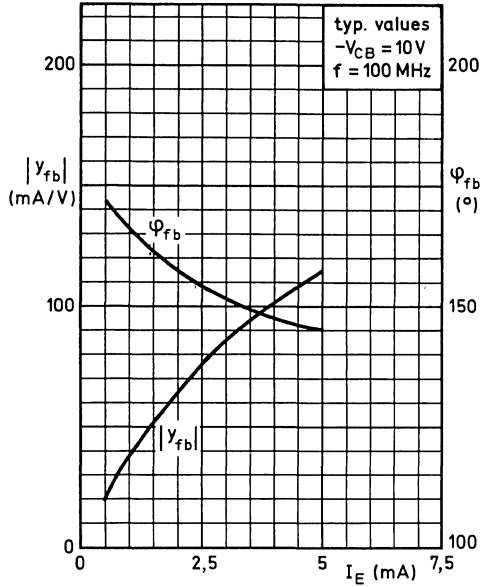
7267061 2



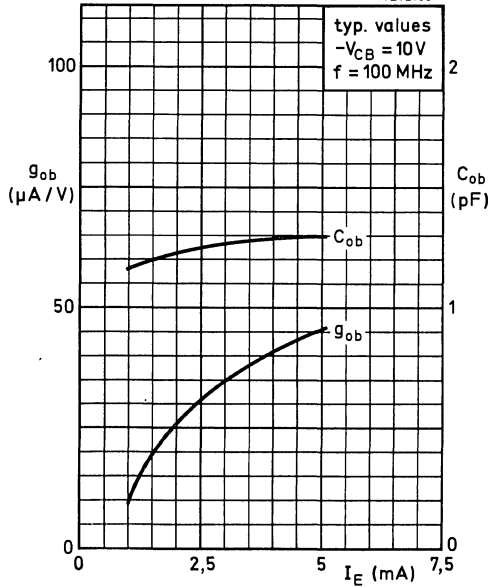
7272155



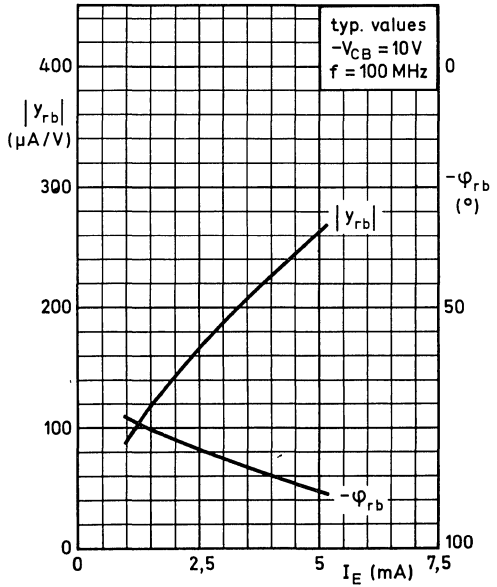
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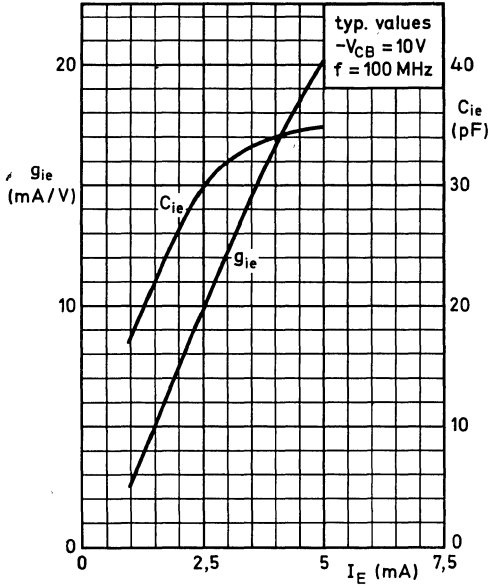
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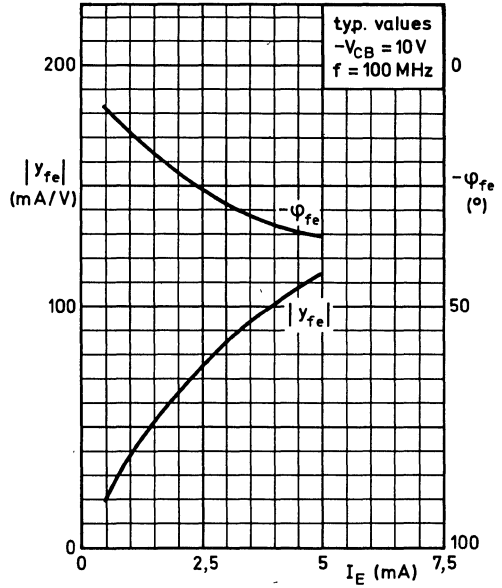
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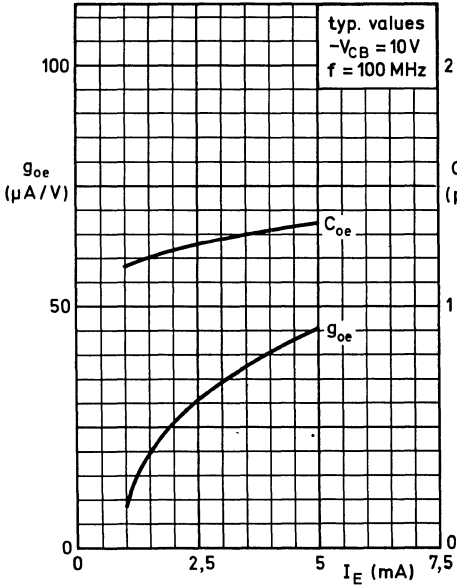
7Z72154



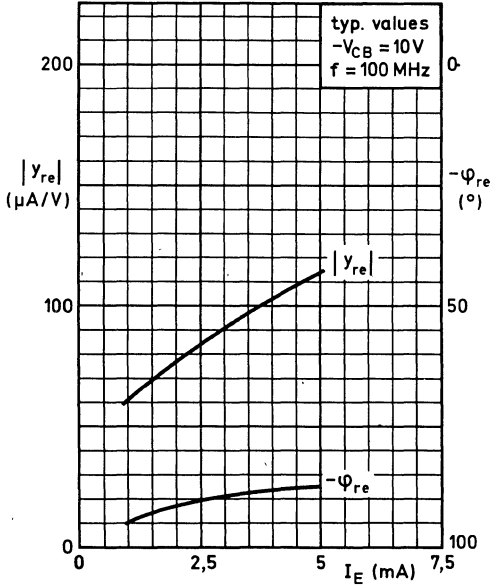
7Z72158



7Z72157



7Z72161



## SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a plastic TO-92 variant envelope, intended for use in large-signal handling i.f. pre-amplifiers of TV receivers in combination with surface acoustic wave filters.

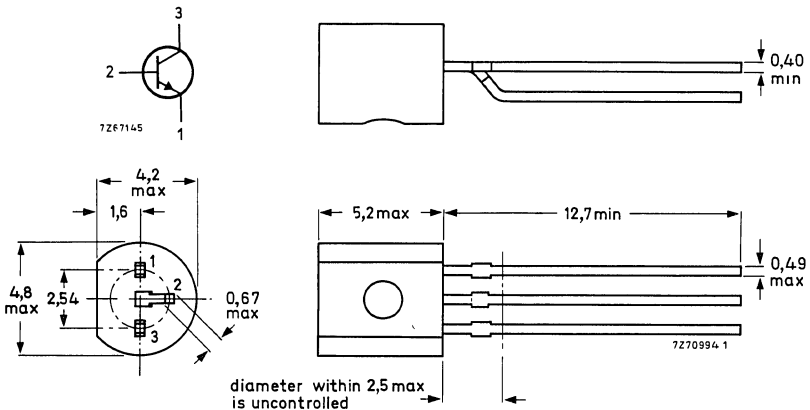
### QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$V_{CBO}$	max.	40 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	15 V
Collector current (d.c.)	$I_C$	max.	100 mA
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	500 mW
Junction temperature	$T_j$	max.	150 $^\circ\text{C}$
D.C. current gain	$h_{FE}$	>	40
$I_C = 10\text{ mA}; V_{CE} = 1\text{ V}$			
Transition frequency at $f = 100\text{ MHz}$	$f_T$	>	490 MHz
$I_C = 40\text{ mA}; V_{CE} = 10\text{ V}$			
Voltage gain at $f = 36\text{ MHz}$ (see Fig. 4)	$G_v$	typ.	24 dB
$I_C = 20\text{ mA}; V_{CE} \approx 10,4\text{ V}$			
Interference voltage for $K = 1\%$ (see Fig. 4)	$V_{(int)rms}$	typ.	120 mV

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



**RATINGS**

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

Collector-base voltage (open emitter)	$V_{CBO}$	max.	40 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	15 V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	4,5 V
Collector current (d.c.)	$I_C$	max.	100 mA
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	500 mW
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 in free air	$R_{th\ j-a}$	=	250 K/W
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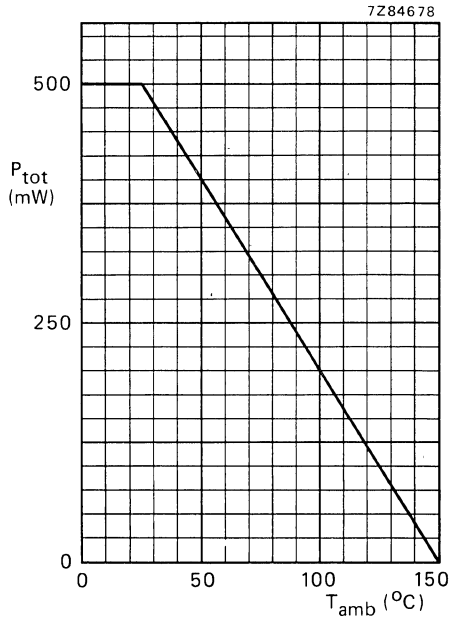


Fig. 2 Power dissipation derating curve as a function of ambient temperature.

## CHARACTERISTICS

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

Collector cut-off current

$I_E = 0; V_{CB} = 20\text{ V}$

$I_{CBO} < 400\text{ nA}$

$I_E = 0; V_{CB} = 20\text{ V}; T_j = 125\text{ }^\circ\text{C}$

$I_{CBO} < 30\text{ }\mu\text{A}$

Emitter cut-off current

$I_C = 0; V_{EB} = 2\text{ V}$

$I_{EBO} < 100\text{ nA}$

D.C. current gain

$I_C = 10\text{ mA}; V_{CE} = 1\text{ V}$

$h_{FE} > 40$

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

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

$f_T > 500\text{ MHz}$

$I_C = 40\text{ mA}; V_{CE} = 10\text{ V}$

$f_T > 490\text{ MHz}$

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

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

$C_c$  typ.  $2,2\text{ pF}$   
 $< 3,5\text{ pF}$

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

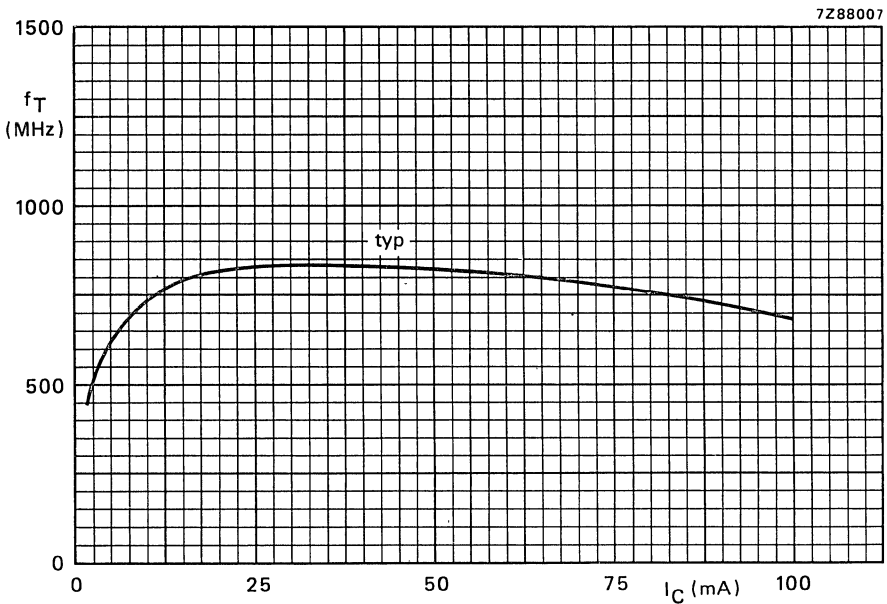
$I_C = I_c = 0; V_{EB} = 1\text{ V}$

$C_e < 4,5\text{ pF}$

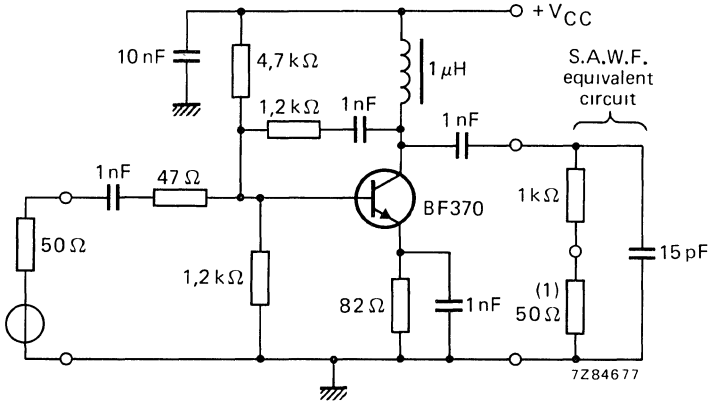
Feedback capacitance at  $f = 1\text{ MHz}$ 

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

$C_{re}$  typ.  $1,6\text{ pF}$   
 $< 2,2\text{ pF}$

Fig. 3  $V_{CE} = 10\text{ V}; T_j = 25\text{ }^\circ\text{C}$ .

APPLICATION INFORMATION



(1) Test instrument load.

Fig. 4 Large-signal handling i.f. preamplifier for surface acoustic wave filter.

Performance

Supply voltage	$V_{CC}$	=	12 V
Collector current	$I_C$	=	20 mA
Measuring frequency	$f_i$	=	36 MHz
Input impedance	$Z_i$	typ.	50 Ω//1 pF
Output impedance	$Z_o$	<	100 Ω
Voltage gain	$G_V$	typ.	24 dB
$G_V$ (in dB) = $20 \log \frac{V_o}{V_i}$			
Interference voltage for $K = 1\%*$	$V_{(int)rms}$	typ.	120 mV

\* Input terminal voltage at 50 Ω internal resistance of signal generator, interference frequency 40 MHz, 80% modulated with 1 kHz.

## SILICON EPITAXIAL TRANSISTOR

N-P-N transistor in plastic TO-92 variant intended for class-B video output stages in colour television receivers. P-N-P complement is BF423.

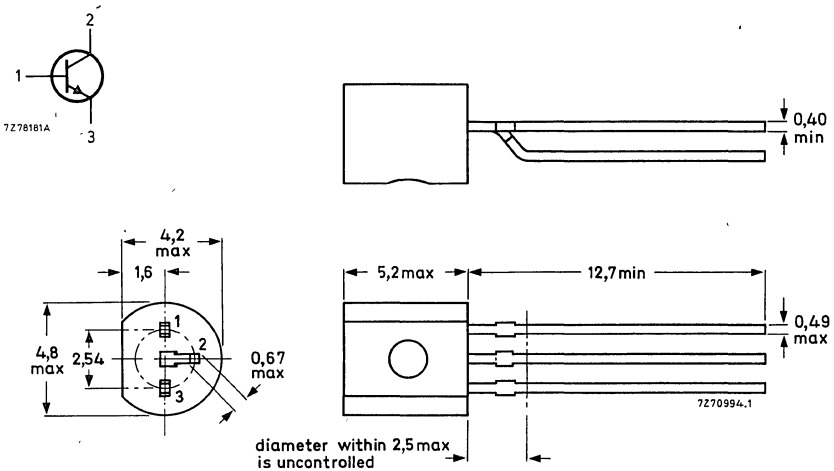
### QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$V_{CBO}$	max.	250 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	250 V
Collector current (peak value)	$I_{CM}$	max.	100 mA
Total power dissipation up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	830 mW
Junction temperature	$T_j$	max.	150 $^{\circ}\text{C}$
D.C. current gain at $T_j = 25\text{ }^{\circ}\text{C}$ $I_C = 25\text{ mA}; V_{CE} = 20\text{ V}$	$h_{FE}$	>	50
Transition frequency $-I_E = 10\text{ mA}; V_{CB} = 10\text{ V}$	$f_T$	>	60 MHz
Feedback capacitance at $f = 1\text{ MHz}$ $I_E = 0; V_{CB} = 30\text{ V}$	$C_{re}$	<	1,6 pF

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.





## RATINGS

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

Collector-base voltage (open emitter)	$V_{CBO}$	max.	250 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.	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.	830 mW
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 ambient *	$R_{th\ j-a}$	=	150 K/W
----------------------------	---------------	---	---------

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

## CHARACTERISTICS

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

Collector cut-off currents

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

$$I_{CBO} < 10\text{ nA}$$

$$R_{BE} = 10\text{ k}\Omega; V_{CE} = 200\text{ V}; T_j = 150\text{ }^\circ\text{C}$$

$$I_{CER} < 10\text{ }\mu\text{A}$$

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\*

$$I_C = 25\text{ mA}; T_j = 150\text{ }^\circ\text{C}$$

$$V_{CEK} \text{ typ. } 20\text{ V}$$

Transition frequency

$$-I_E = 10\text{ mA}; V_{CB} = 10\text{ V}$$

$$f_T > 60\text{ MHz}$$

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

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

$$C_{re} < 1,6\text{ pF}$$

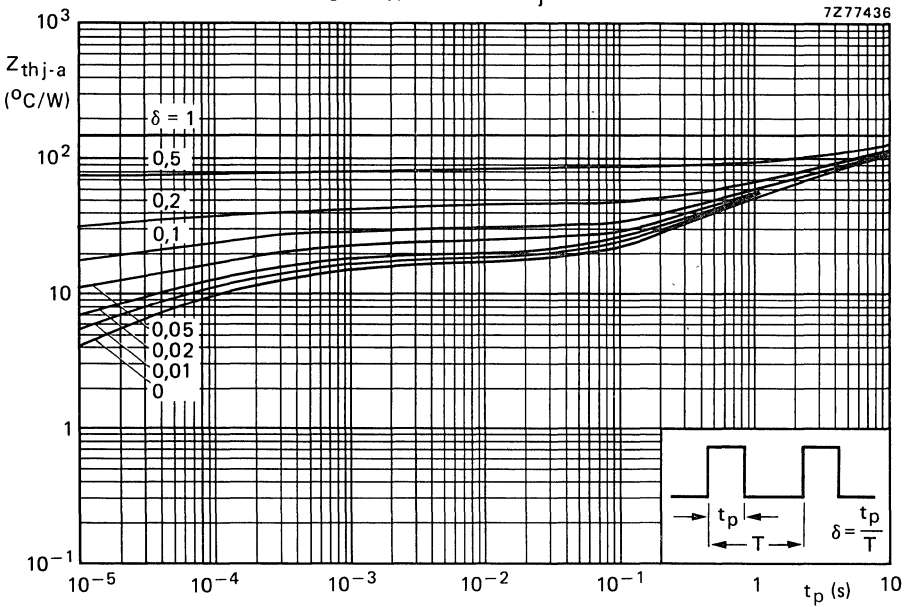
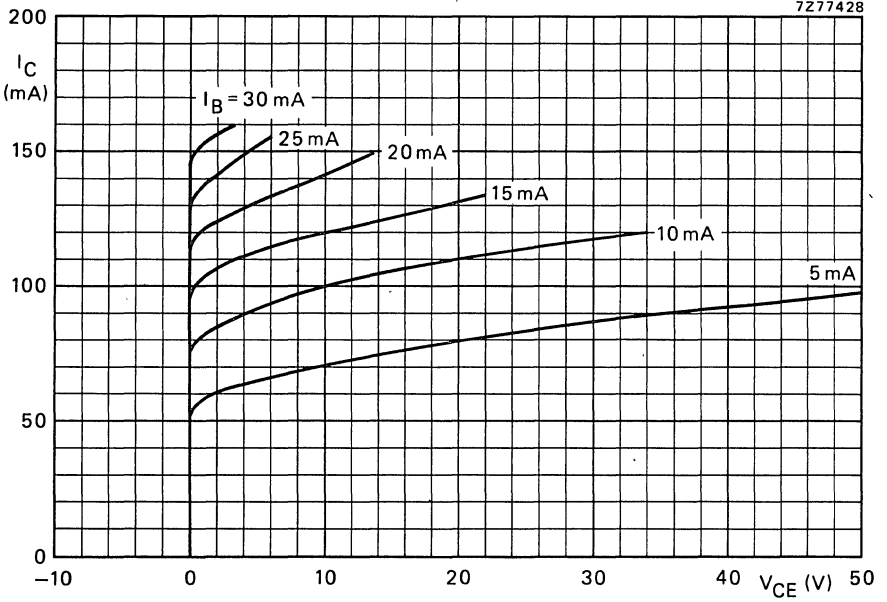
Feedback time constant at  $f = 10,7\text{ MHz}$

$$-I_E = 30\text{ mA}; V_{CB} = 20\text{ V}$$

$$r_{bb'}C_{b'c} < 70\text{ ps}^{**}$$

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

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



7Z77423

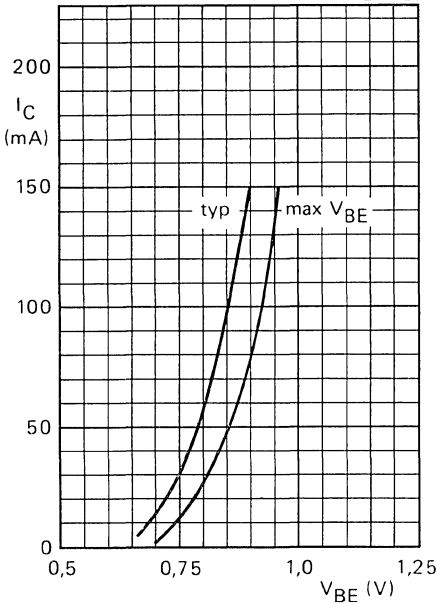


Fig. 4  $V_{CB} = 20$  V;  $T_j = 25$  °C.

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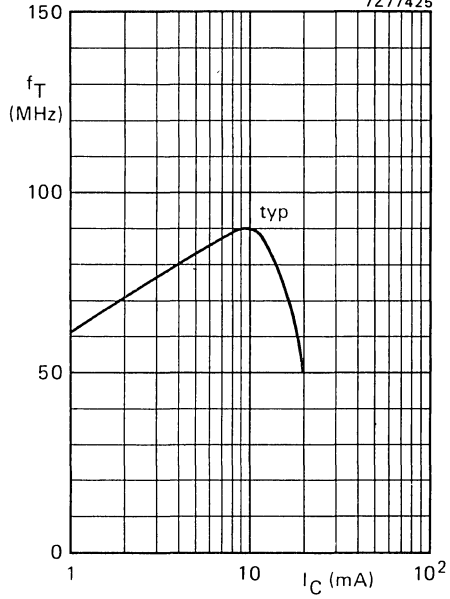


Fig. 5  $V_{CE} = 10$  V;  $T_j = 25$  °C.

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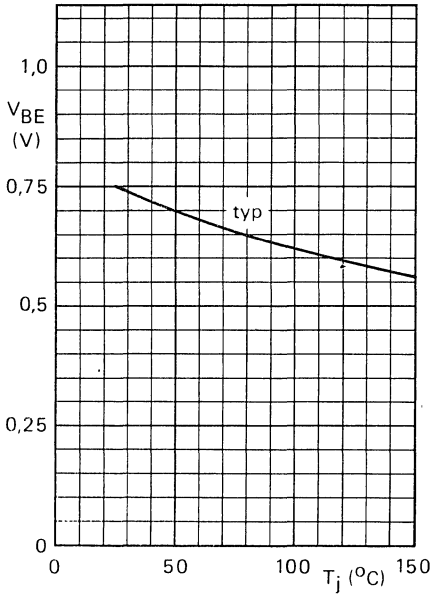


Fig. 6  $I_C = 25$  mA;  $V_{CE} = 20$  V.

7Z77426

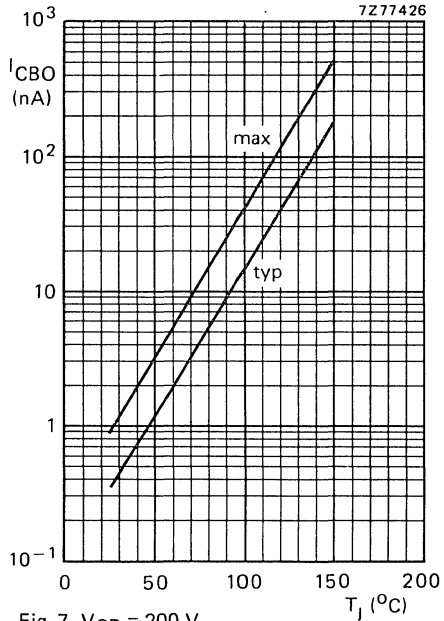


Fig. 7  $V_{CB} = 200$  V.

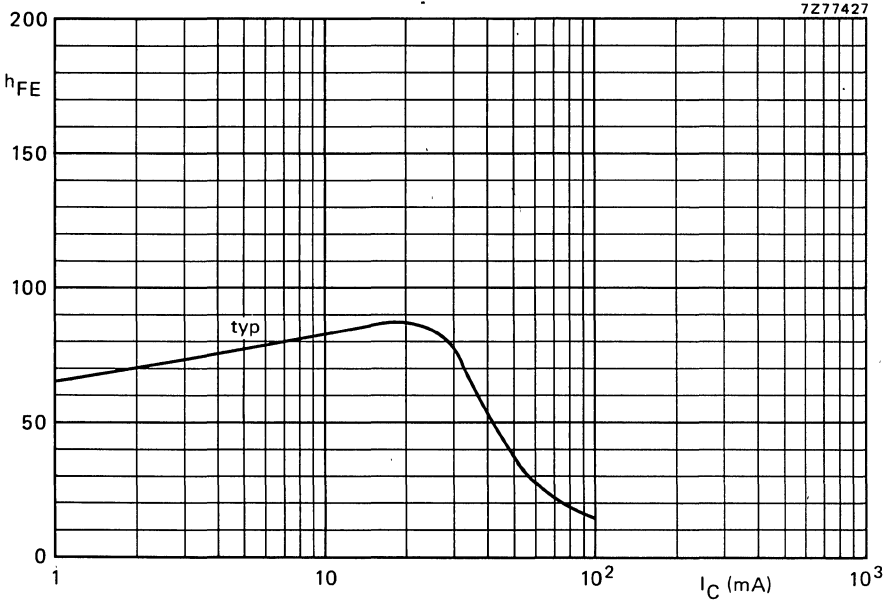


Fig. 8  $V_{CE} = 20\text{ V}$ ;  $T_j = 25\text{ }^\circ\text{C}$ .

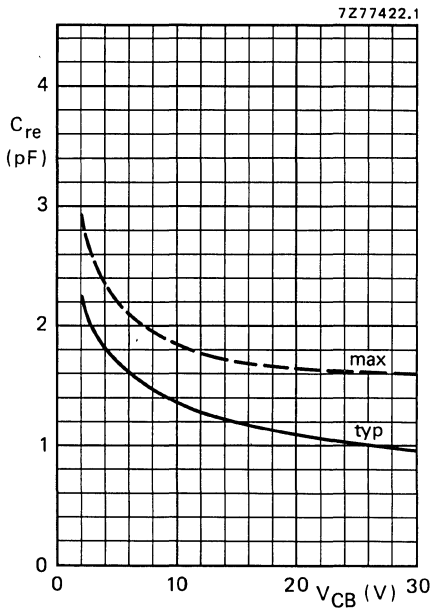


Fig. 9  $I_E = 0$ ;  $f = 1\text{ MHz}$ ;  $T_j = 25\text{ }^\circ\text{C}$ .

## SILICON EPITAXIAL TRANSISTOR

P-N-P transistor in plastic TO-92 variant intended for class-B video output stages in colour television receivers. N-P-N complement is BF422.

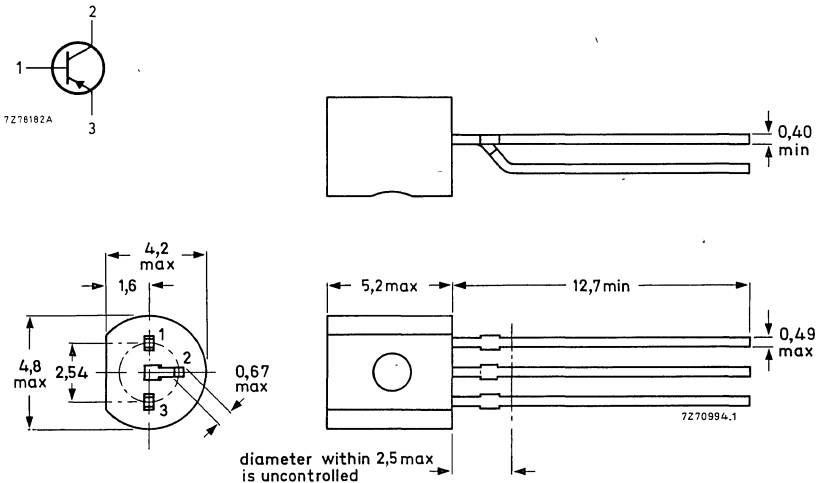
### QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	250 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	250 V
Collector current (peak value)	$-I_{CM}$	max.	100 mA
Total power dissipation up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	830 mW
Junction temperature	$T_j$	max.	150 $^{\circ}\text{C}$
D.C. current gain at $T_j = 25\text{ }^{\circ}\text{C}$ $-I_C = 25\text{ mA}; -V_{CE} = 20\text{ V}$	$h_{FE}$	>	50
Transition frequency $I_E = 10\text{ mA}; -V_{CB} = 10\text{ V}$	$f_T$	>	60 MHz
Feedback capacitance at $f = 1\text{ MHz}$ $I_E = 0; -V_{CB} = 30\text{ V}$	$C_{re}$	<	1,6 pF

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



**RATINGS**

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

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	250 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.	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.	830 mW
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 ambient *	$R_{th\ j-a}$	=	150 K/W
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\* Transistor mounted on a printed-circuit board, mounting pad for collector lead minimum 10 mm x 10 mm; maximum lead length 4 mm.

## CHARACTERISTICS

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

Collector cut-off currents

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

$$R_{BE} = 10\text{ k}\Omega; -V_{CE} = 200\text{ V}; T_j = 150\text{ }^\circ\text{C}$$

$$-I_{CBO} < 10\text{ nA}$$

$$-I_{CER} < 10\text{ }\mu\text{A}$$

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\*

$$-I_C = 25\text{ mA}; T_j = 150\text{ }^\circ\text{C}$$

$$-V_{CEK} \text{ typ. } 20\text{ V}$$

Transition frequency

$$I_E = 10\text{ mA}; -V_{CB} = 10\text{ V}$$

$$f_T > 60\text{ MHz}$$

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

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

$$C_{re} < 1,6\text{ pF}$$

Feedback time constant at  $f = 10,7\text{ MHz}$

$$I_E = 30\text{ mA}; -V_{CB} = 20\text{ V}$$

$$r_{bb'}C_{b'c} < 70\text{ ps}^{**}$$

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

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



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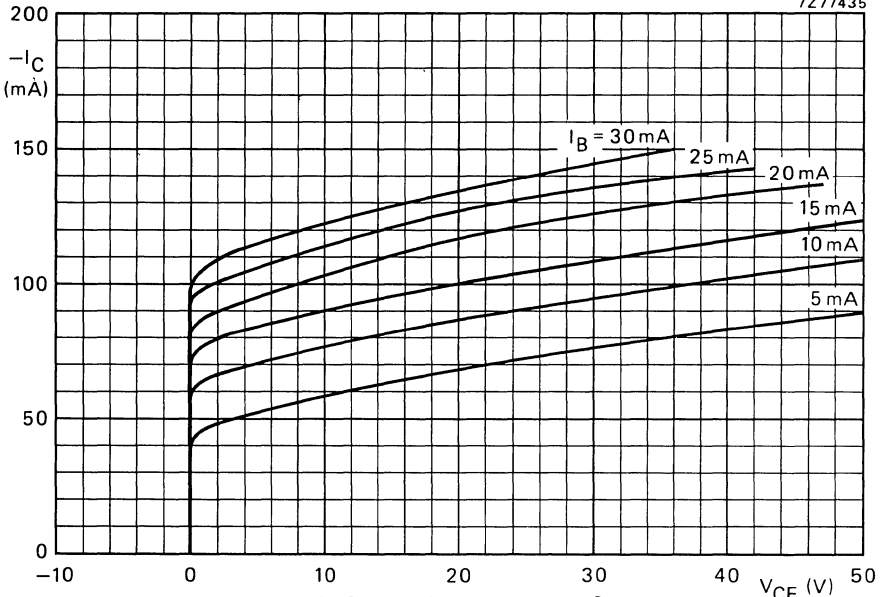


Fig. 2 Typical values at  $T_j = 25^\circ\text{C}$ .

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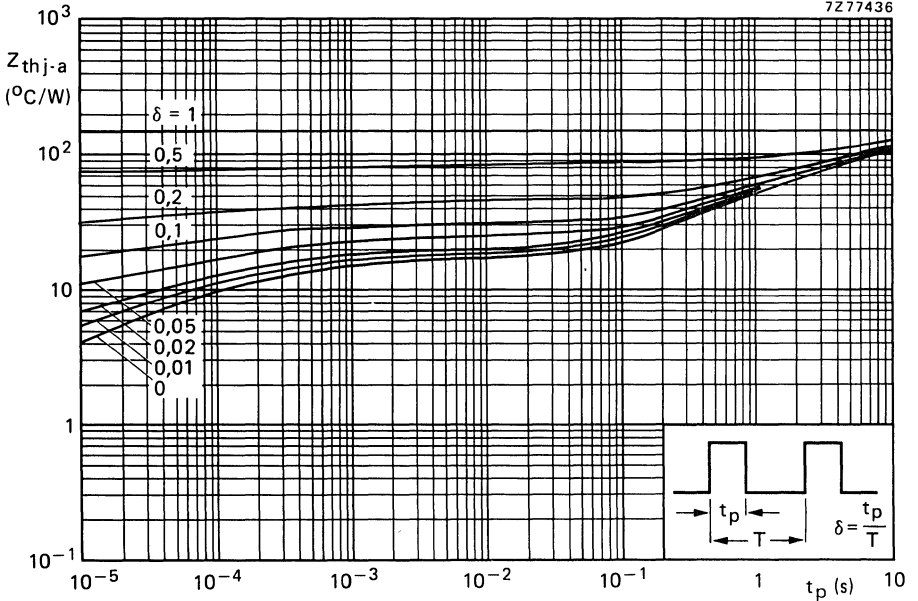


Fig. 3 Thermal impedance from junction to ambient versus pulse duration. Maximum lead length 3 mm; mounting-pad for collector lead minimum 10 mm x 10 mm.

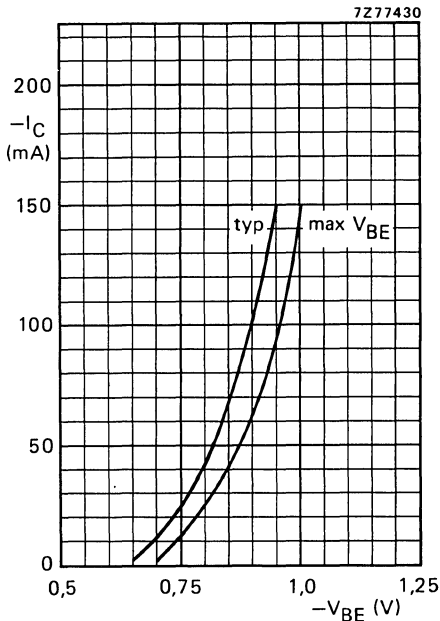


Fig. 4  $-V_{CE} = 20$  V;  $T_j = 25$  °C.

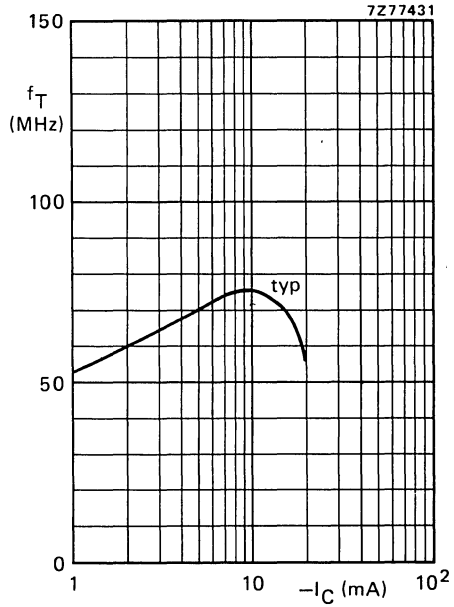


Fig. 5  $-V_{CE} = 10$  V;  $T_j = 25$  °C.

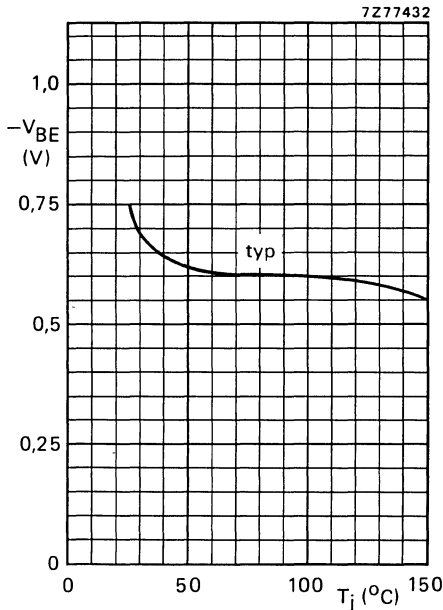


Fig. 6  $-I_C = 25$  mA;  $-V_{CE} = 20$  V.

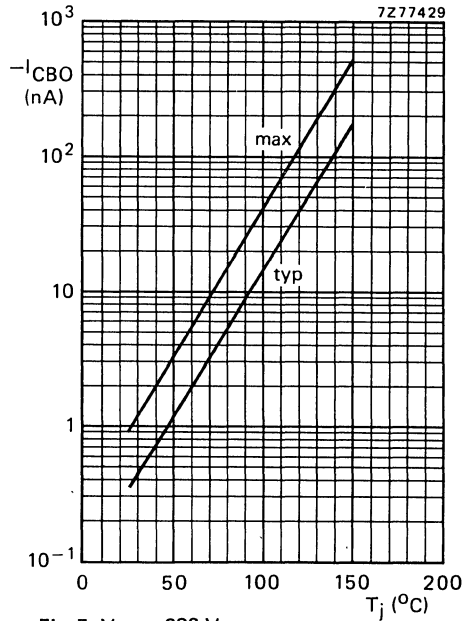


Fig. 7  $V_{CB} = 200$  V.

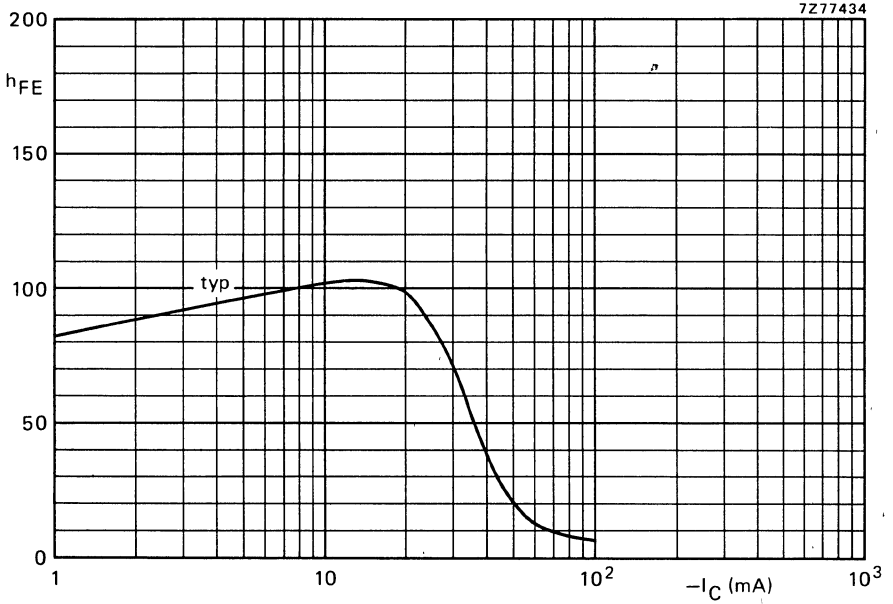


Fig. 8  $-V_{CE} = 20$  V;  $T_j = 25$  °C.

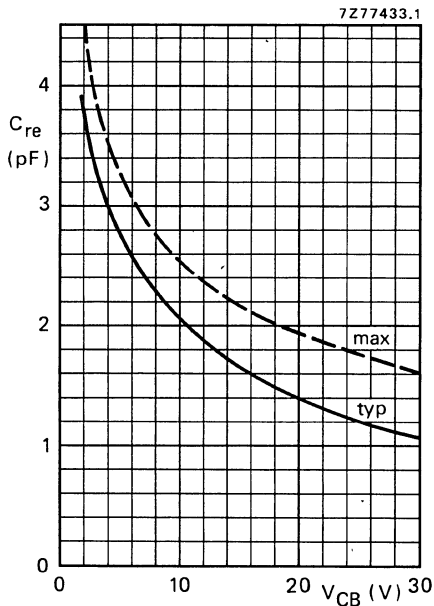


Fig. 9  $I_E = 0$ ;  $f = 1$  MHz;  $T_j = 25$  °C.

## H.F. SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in a plastic envelope intended for h.f. and i.f. applications in radio receivers, especially for mixer stages in a.m. receivers and i.f. stages in a.m./f.m. receivers with negative earth.

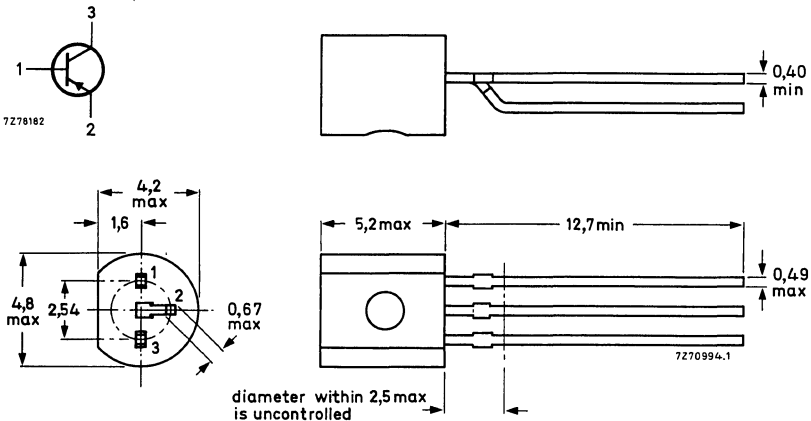
### QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$-V_{CBO}$ max.	40 V
Collector-emitter voltage (open base)	$-V_{CEO}$ max.	40 V
Collector current (d.c.)	$-I_C$ max.	25 mA
Total power dissipation up to $T_{amb} = 45^\circ\text{C}$	$P_{tot}$ max.	250 mW
Junction temperature	$T_j$ max.	150 $^\circ\text{C}$
Base current		
$-I_C = 1\text{ mA}; -V_{CE} = 10\text{ V}$	BF450: $-I_B$	5 to 16 $\mu\text{A}$
	BF451: $-I_B$	11 to 33 $\mu\text{A}$
Transition frequency		
$-I_C = 1\text{ mA}; -V_{CE} = 10\text{ V}$	$f_T$ typ.	325 MHz
Noise figure at $f = 100\text{ kHz}$		
$-I_C = 1\text{ mA}; -V_{CE} = 10\text{ V}; R_S = 300\ \Omega$	F typ.	2 dB

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



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

Voltages

Collector-base voltage (open emitter)	$-V_{CB0}$	max.	40	V
Collector-emitter voltage (open base)	$-V_{CE0}$	max.	40	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	4	V

Current

Collector current (d.c.)	$-I_C$	max.	25	mA
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Power dissipation

Total power dissipation up to $T_{amb} = 45^\circ\text{C}$	$P_{tot}$	max.	250	mW
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Temperatures

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 in free air	$R_{th\ j-a}$	=	0,42	$^\circ\text{C}/\text{mW}$
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**CHARACTERISTICS**

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

Collector cut-off current

$I_E = 0; -V_{CB} = 30\text{ V}$	$-I_{CBO}$	<	50	nA
$I_E = 0; -V_{CB} = 40\text{ V}$	$-I_{CBO}$	<	10	$\mu\text{A}$

Emitter cut-off current

$I_C = 0; -V_{EB} = 4\text{ V}$	$-I_{EBO}$	<	10	$\mu\text{A}$
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Base current

$-I_C = 1\text{ mA}; -V_{CE} = 10\text{ V}$	<u>BF450:</u>	$-I_B$	<	5 to 16	$\mu\text{A}$
	<u>BF451:</u>	$-I_B$	<	11 to 33	$\mu\text{A}$

Base-emitter voltage

$-I_C = 1\text{ mA}; -V_{CE} = 10\text{ V}$	$-V_{BE}$	typ.	700	mV
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**CHARACTERISTICS** (continued)

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

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

$-I_C = 1\text{ mA}; -V_{CE} = 10\text{ V}$   $f_T$  typ. 325 MHz

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

$-I_C = 1\text{ mA}; -V_{CE} = 10\text{ V}$   $C_{re}$  typ. 0,35 pF

Noise figure at  $f = 100\text{ kHz}$

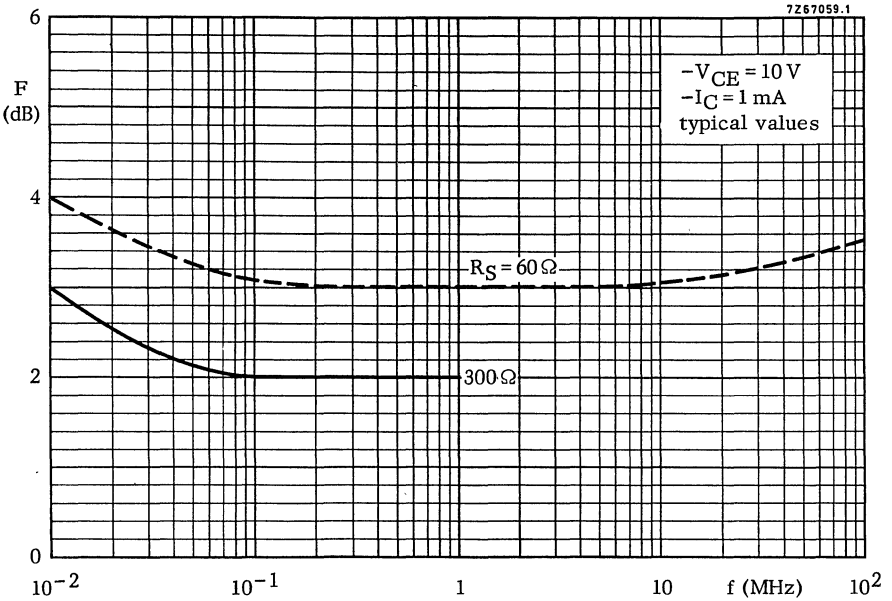
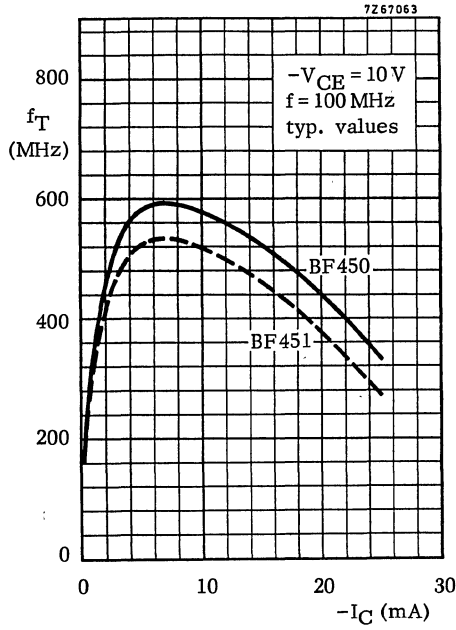
$-I_C = 1\text{ mA}; -V_{CE} = 10\text{ V}; R_S = 300\text{ }\Omega$   $F$  typ. 2 dB

y-parameters (common emitter)

$-I_C = 1\text{ mA}; -V_{CE} = 10\text{ V}$

		BF450		BF451		
f	=	0,45	10,7	0,45	10,7	MHz
Input conductance	$g_{ie}$ typ.	0,3	0,4	0,7	0,8	mA/V
Input capacitance	$C_{ie}$ typ.	20	13	30	20	pF
Transfer admittance	$ y_{fe} $ typ.	37	37	37	37	mA/V
Phase angle of transfer admittance	$\varphi_{fe}$ typ.	$0^\circ$	$0^\circ$	$0^\circ$	$0^\circ$	
Output conductance	$g_{oe}$ typ.	8	10	8	10	$\mu\text{A/V}$
Output capacitance	$C_{oe}$ typ.	1	1	1	1	pF
Feedback admittance	$ y_{re} $ typ.	1	24	1	24	$\mu\text{A/V}$
Phase angle of feedback admittance	$\varphi_{re}$ typ.	$270^\circ$	$270^\circ$	$270^\circ$	$270^\circ$	

**BF450**  
**BF451**







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

**Voltages**

Collector-base voltage (open emitter)	$V_{CBO}$ max	20 V
Collector-emitter voltage (open base)	$V_{CEO}$ max	15 V
Emitter-base voltage (open collector)	$V_{EBO}$ max	2 V

**Current**

Collector current (d.c.)	$I_C$ max	20 mA
Collector current (peak value)	$I_{CM}$ max	30 mA

**Power dissipation**

Total power dissipation up to $T_{amb} = 60\text{ }^\circ\text{C}$	$P_{tot}$ max	200 mW
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**Temperatures**

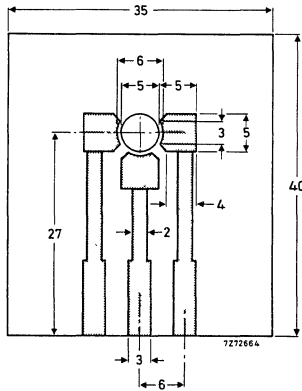
Storage temperature	$T_S$	-65 to +150 $^\circ\text{C}$
Junction temperature	$T_j$ max	150 $^\circ\text{C}$

**THERMAL RESISTANCE**

From junction to ambient  
 mounted on the printed-circuit board  
 shown below, which is in free air

$R_{th\ j-a} = 0,45\text{ }^\circ\text{C/mW}$

Dimensions in mm



Single-sided 35  $\mu\text{m}$  Cu-clad epoxy fibre-glass printed-circuit board, thickness 1,5 mm.  
 Tracks are fully tin-lead plated. Board in horizontal position for  $R_{th}$  measurement.

## CHARACTERISTICS

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

## Base current

$-I_E = 10\text{ mA}; V_{CB} = 10\text{ V}$

$I_B$  typ  $350\text{ }\mu\text{A}$   
<  $750\text{ }\mu\text{A}$

## Emitter-base voltage

$-I_E = 10\text{ mA}; V_{CB} = 10\text{ V}$

$-V_{EB}$  typ  $0,8\text{ V}$

Transition frequency at  $f = 500\text{ MHz}$ 

$-I_E = 10\text{ mA}; V_{CB} = 10\text{ V}$

$f_T$  typ  $2\text{ GHz}$

## Noise figure at optimum source admittance (common base)

$-I_E = 10\text{ mA}; V_{CB} = 10\text{ V}; f = 800\text{ MHz}$

F typ  $3,8\text{ dB}$

$-I_E = 10\text{ mA}; V_{CB} = 10\text{ V}; f = 200\text{ MHz}$

F typ  $2,9\text{ dB}$

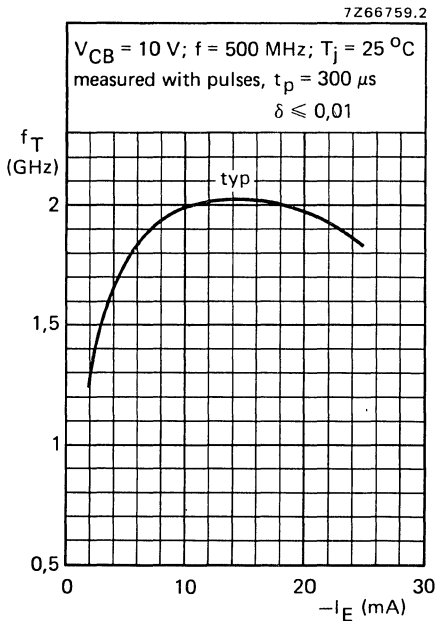
## Transducer gain (common base)

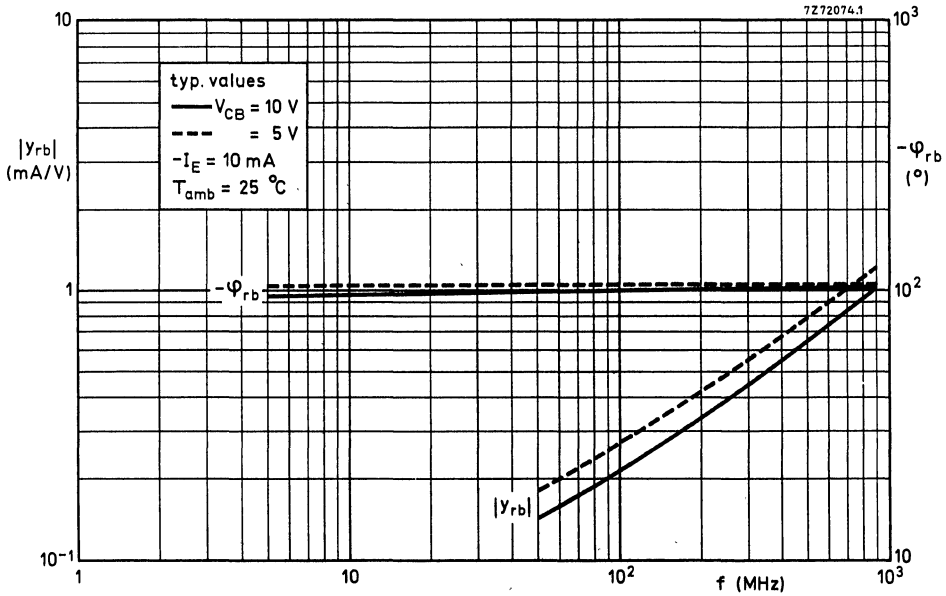
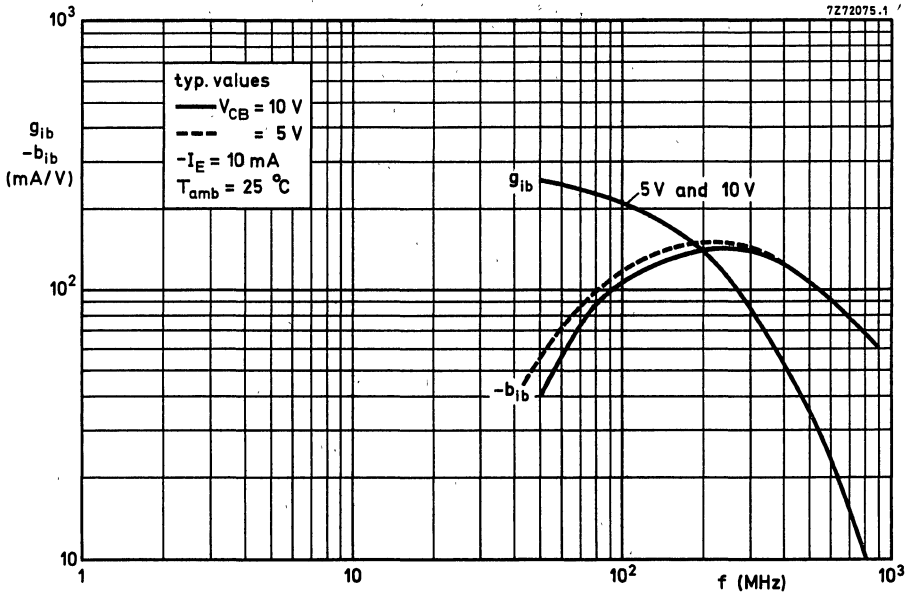
$-I_E = 10\text{ mA}; V_{CB} = 10\text{ V}; f = 900\text{ MHz}$

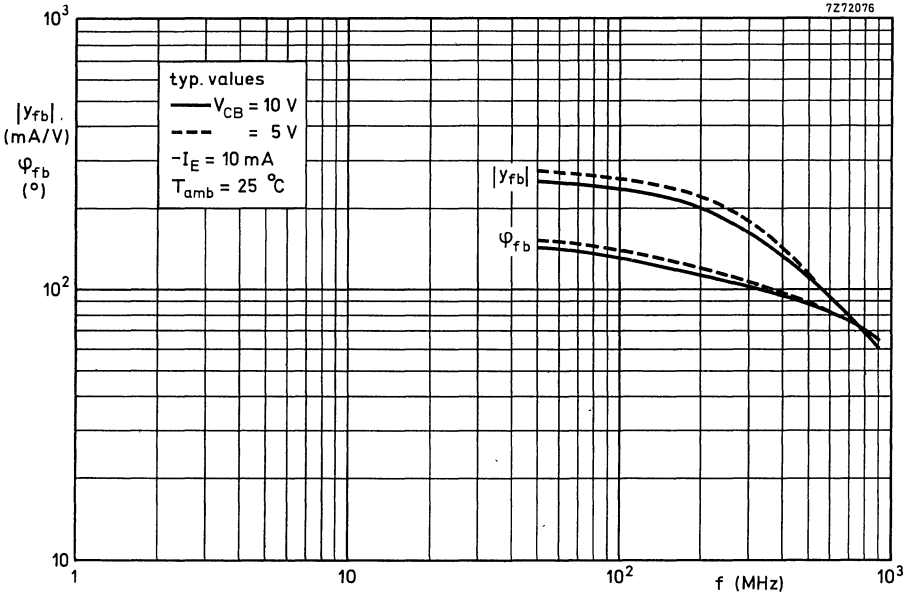
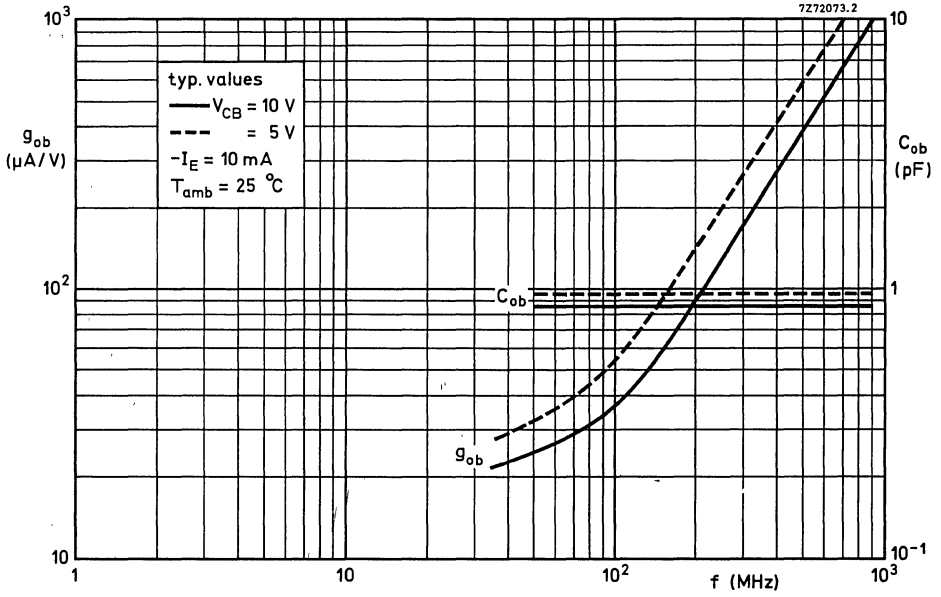
$G_s = 20\text{ mA/V}; B_s = 0$

$G_{\rho} = 2\text{ mA/V}; B_{\rho} = \text{tuned}$

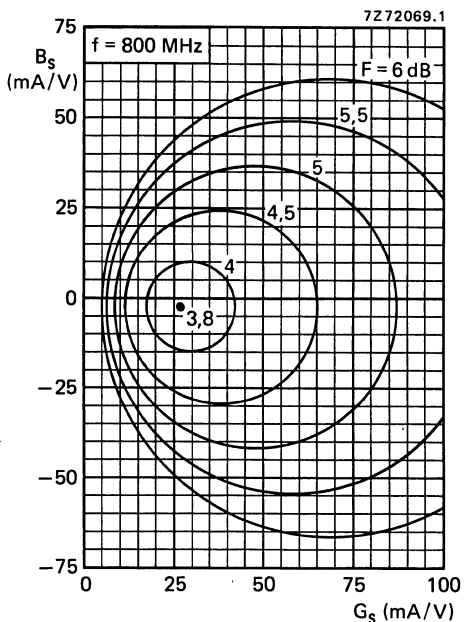
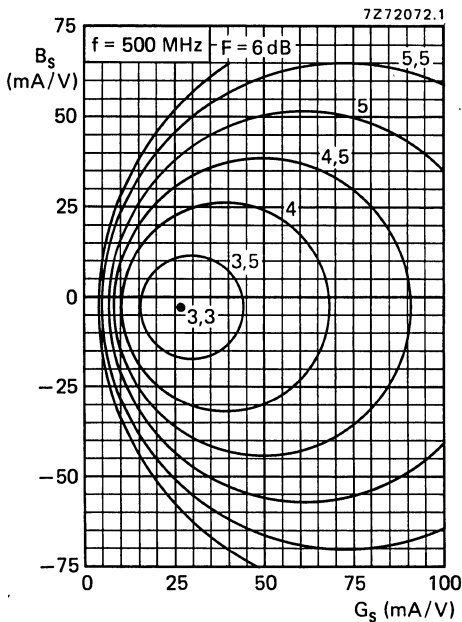
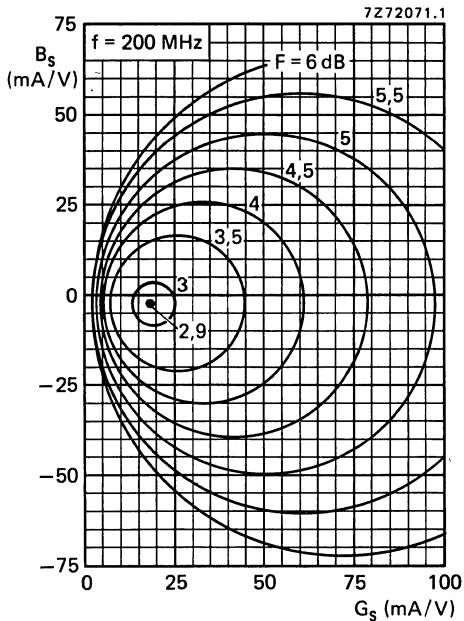
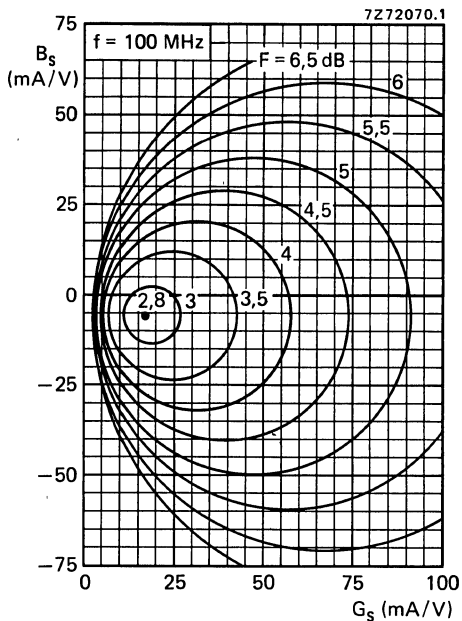
$G_{tr}$  typ  $15\text{ dB}$





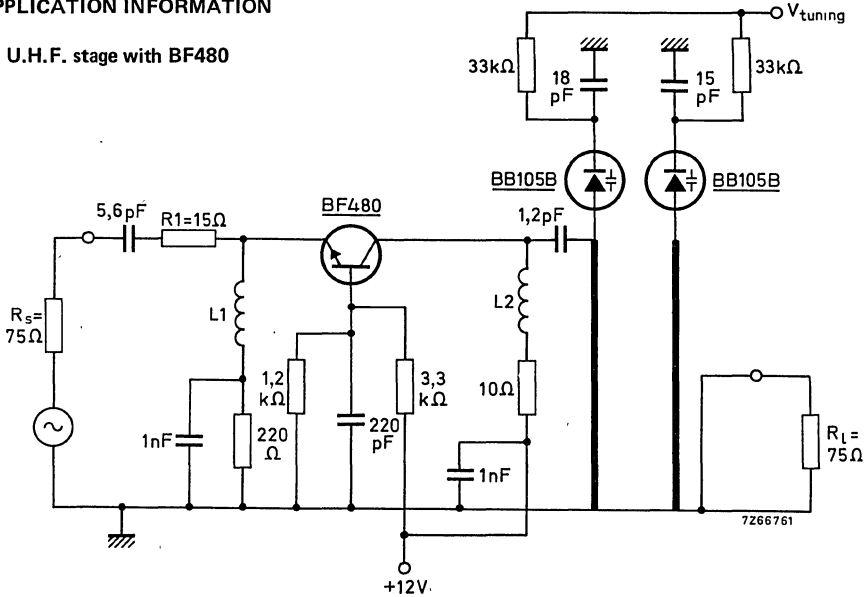


Conditions for all four graphs:  $-I_E = 10 \text{ mA}$ ;  $V_{CB} = 10 \text{ V}$ ;  $T_{amb} = 25 \text{ }^\circ\text{C}$



## APPLICATION INFORMATION

## 1. U.H.F. stage with BF480



$L_1 = 6 \text{ turns, } \varnothing 3 \text{ mm}$   
 $L_2 = 4,5 \text{ turns, } \varnothing 3 \text{ mm}$

PERFORMANCE at  $T_{\text{amb}} = 25^\circ\text{C}$ 

Measuring frequency

3 dB bandwidth

Emitter current

Collector-emitter voltage

Transducer gain

Noise figure including influence of

a. mixer stage with a noise figure of 10 dB

b.  $R_1 = 15 \Omega$ Voltage standing wave ratio (incl.  $R_1 = 15 \Omega$ )

Cross-modulation\*

Interference voltage for  $K = 1\%$  $f_i = 800 \text{ MHz}$  $B_{3\text{dB}} \text{ typ } 25 \text{ MHz}$  $-I_E \text{ typ } 10,3 \text{ mA}$  $V_{CE} \text{ typ } 9,7 \text{ V}$  $G_{tr} \text{ typ } 10 \text{ dB}$  $F \text{ typ } 6,5 \text{ dB}$  $VSWR < 4$  $V_{(\text{int})\text{rms}} \text{ typ } 300 \text{ mV}$ 

\* Cross-modulation is defined here as the e.m.f. in  $75 \Omega$  of an unwanted signal with 80% modulation depth, giving 0,8% modulation depth on the wanted signal.



## SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a plastic TO-92 variant intended for h.f. applications in radio and television receivers; it is especially recommended for f.m. tuners, low noise a.m. mixer-oscillators with high source impedance and i.f. amplifiers in a.m./f.m. receivers where a high current gain is of importance.

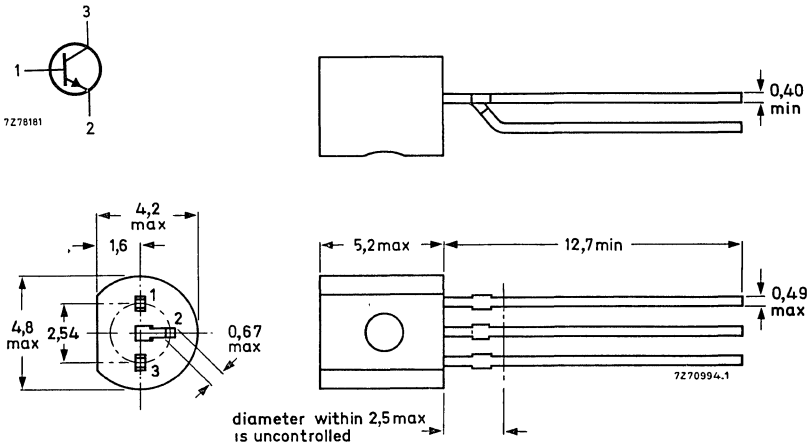
### QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$V_{CBO}$	max.	30 V
Collector-emitter voltage (open base)	$V_{CBO}$	max.	20 V
Collector current (d.c.)	$I_C$	max.	30 mA
Total power dissipation up to $T_{amb} = 75\text{ }^\circ\text{C}$	$P_{tot}$	max.	300 mW
Junction temperature	$T_j$	max.	150 $^\circ\text{C}$
D.C. current gain at $T_j = 25\text{ }^\circ\text{C}$ $I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$	$h_{FE}$	typ.	115
Transition frequency $I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$	$f_T$	typ.	260 MHz
Noise figure at $f = 100\text{ MHz}$ $I_C = 1\text{ mA}; V_{CE} = 10\text{ V}; G_S = 10\text{ mA/V}$	F	typ.	4 dB
Conversion noise figure at $f = 1\text{ MHz}$ $I_C = 1\text{ mA}; V_{CE} = 10\text{ V}; G_S = 1,2\text{ mA/V}$	$F_c$	typ.	2 dB

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.





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

Voltages

Collector-base voltage (open emitter)	$V_{CBO}$	max.	30 V
Collector-emitter voltage (open base) (See also page 4)	$V_{CEO}$	max.	20 V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	5 V

Currents

Collector current (d.c.)	$I_C$	max.	30 mA
Collector current (peak value)	$I_{CM}$	max.	30 mA

Power dissipation

Total power dissipation up to $T_{amb} = 75\text{ }^\circ\text{C}$	$P_{tot}$	max.	300 mW
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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 ambient in free air	$R_{th\ j-a}$	=	0,25 $^\circ\text{C}/\text{mW}$
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**CHARACTERISTICS**

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

Base-emitter voltage <sup>2)</sup>

$I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$	$V_{BE}$	0,65 to 0,74	V
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Base current

$I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$	$I_B$	4,5 to 15 $\mu\text{A}$ typ. 8,7 $\mu\text{A}$
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Feedback capacitance at  $f = 0,45\text{ MHz}$

$I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$	$C_{re}$	typ.	0,85 pF
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1)  $V_{BE}$  decreases by about 1,7 mV/ $^\circ\text{C}$  with increasing temperature.

**CHARACTERISTICS** (continued)

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

Transition frequency

$I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$   $f_T$  typ. 260 MHz

Noise figure

$I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$

$G_S = 2\text{ mA/V}; f = 0,2\text{ MHz}$  F typ. 1,5 dB

$G_S = 1,5\text{ mA/V}; f = 1,0\text{ MHz}$  F typ. 1,2 dB

$G_S = 10\text{ mA/V}; f = 100\text{ MHz}$  F typ. 4 dB

Conversion noise figure

$I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$

$G_S = 0,6\text{ mA/V}; f = 0,2\text{ MHz}$   $F_C$  typ. 3 dB

$G_S = 1,2\text{ mA/V}; f = 1,0\text{ MHz}$   $F_C$  typ. 2 dB

y parameters at  $f = 100\text{ MHz}$  (common base)

$I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$  (lead length = 3 mm)

Input conductance  $g_{ib}$  typ. 32 mA/V

Input susceptance  $-b_{ib}$  typ. 3 mA/V

Feedback admittance  $|y_{rb}|$  typ. 500  $\mu\text{A/V}$

Phase angle of feedback admittance  $\varphi_{rb}$  typ.  $272^\circ$

Transfer admittance  $|y_{fb}|$  typ. 33 mA/V

Phase angle of transfer admittance  $\varphi_{fb}$  typ.  $150^\circ$

Output conductance  $g_{ob}$  typ. 22  $\mu\text{A/V}$

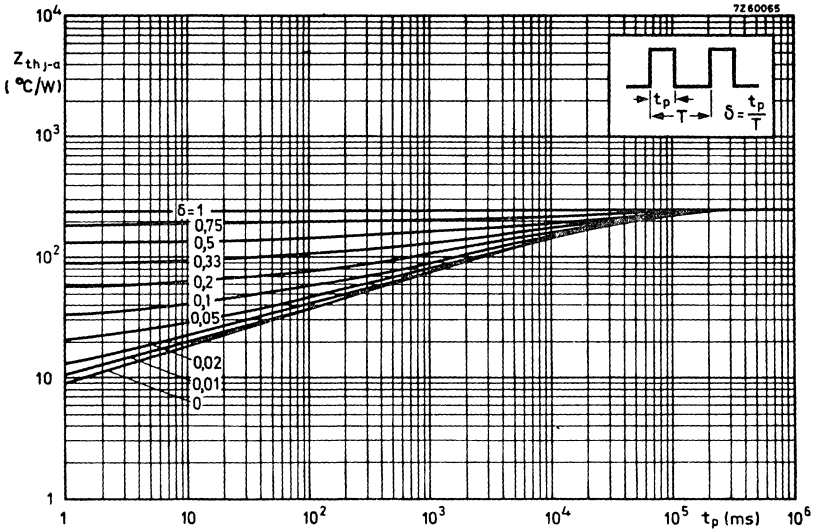
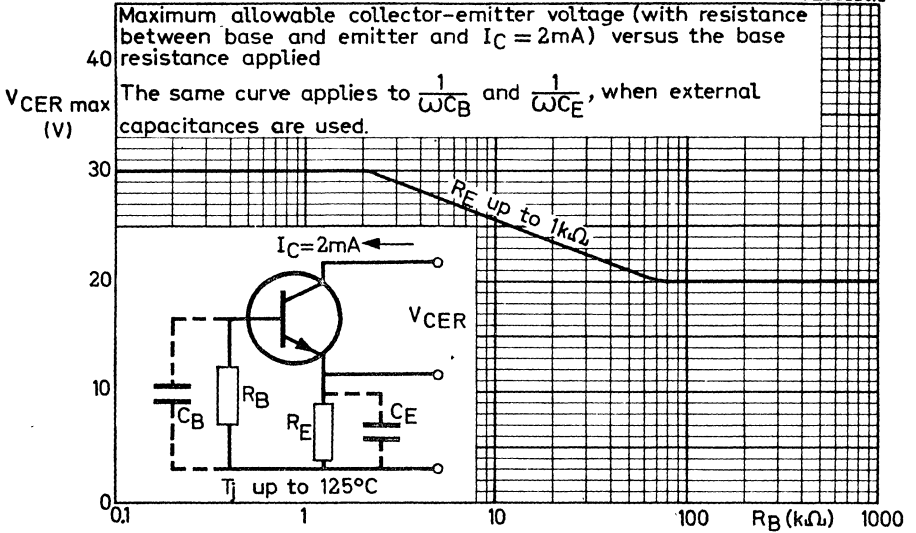
Output susceptance  $b_{ob}$  typ. 1,1 mA/V

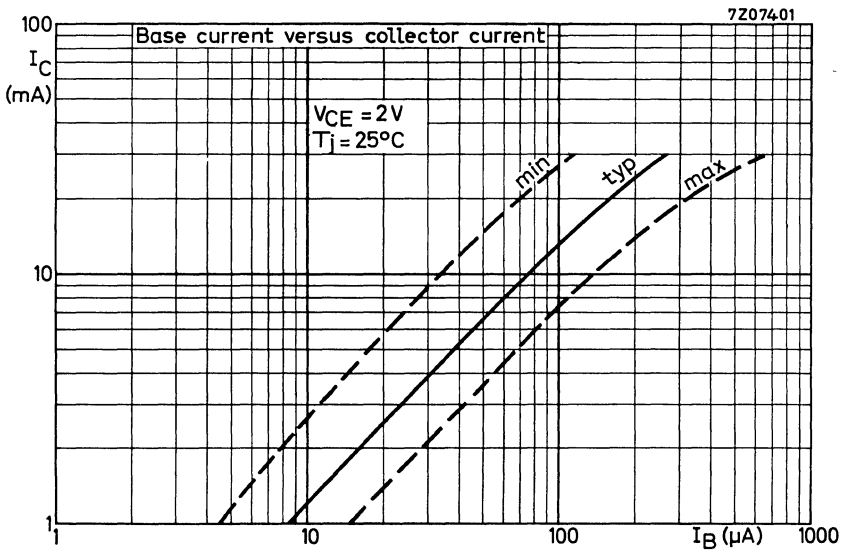
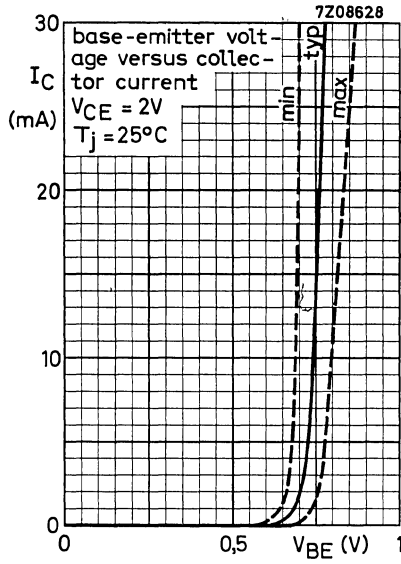
y parameters (common emitter)

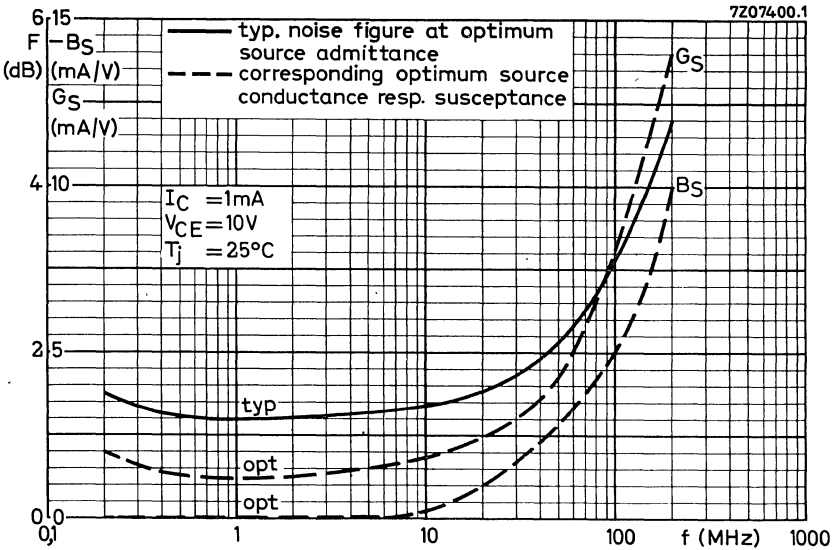
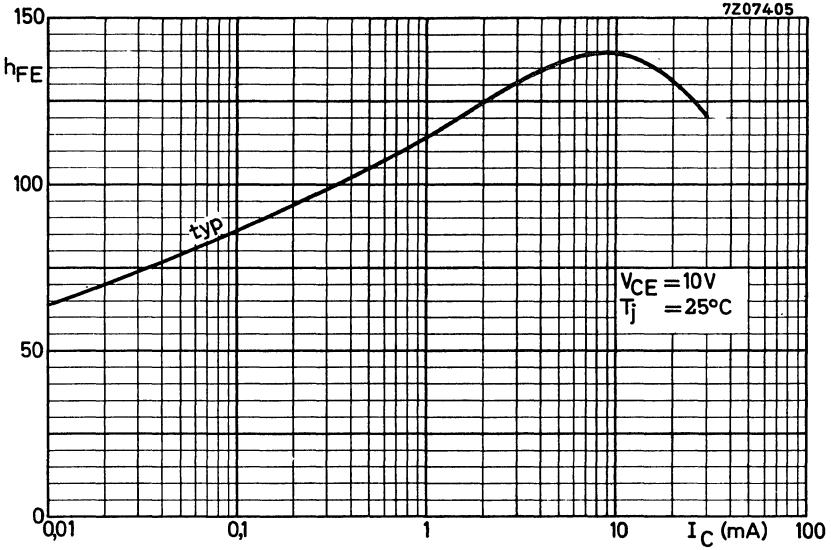
$I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$  (lead length = 3 mm)

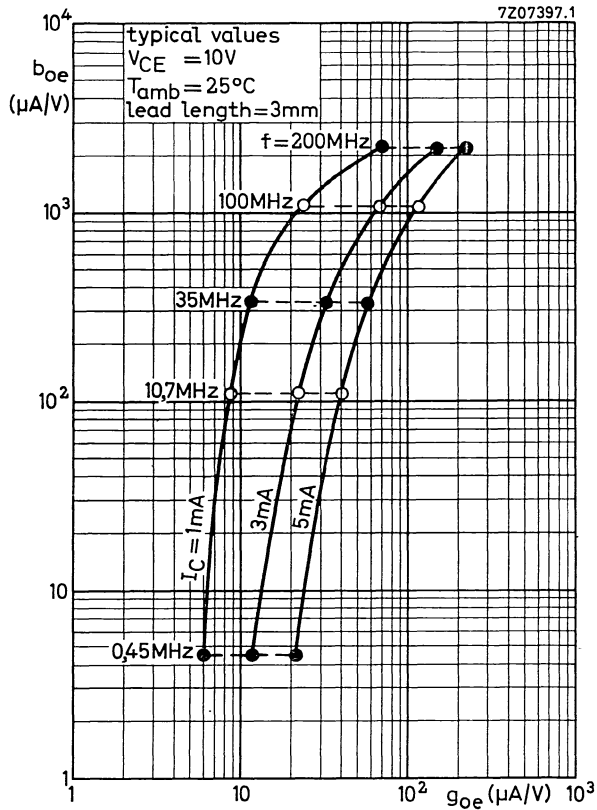
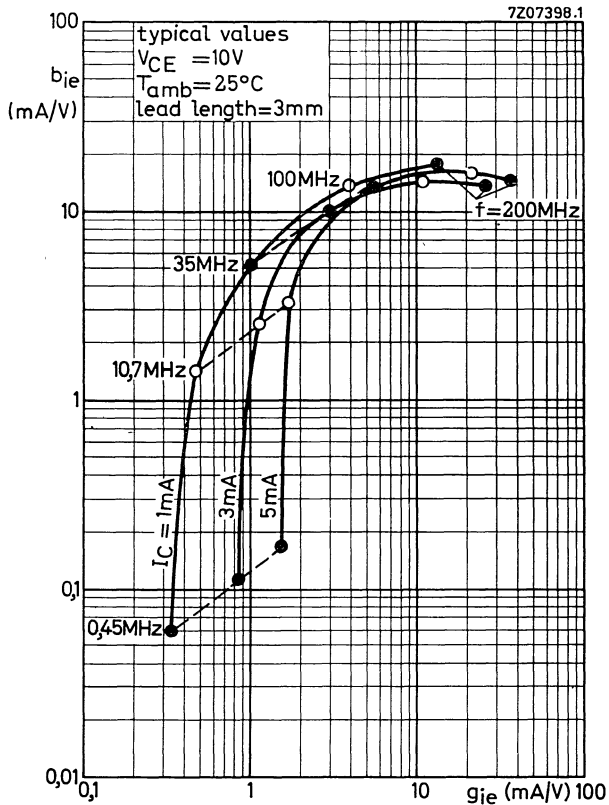
	$f = 10,7\text{ MHz}$	$f = 0,45\text{ MHz}$
Input conductance	$g_{ie} < 0,64$	0,54 mA/V
Output conductance	$g_{oe} < 13,5$	11,5 $\mu\text{A/V}$

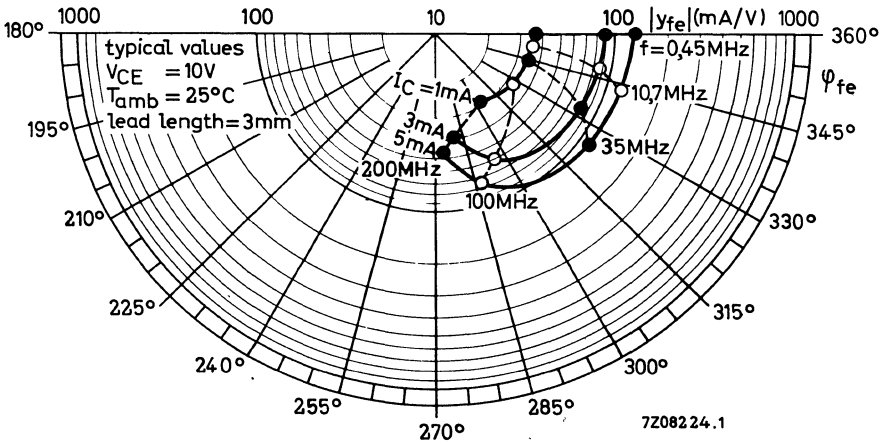
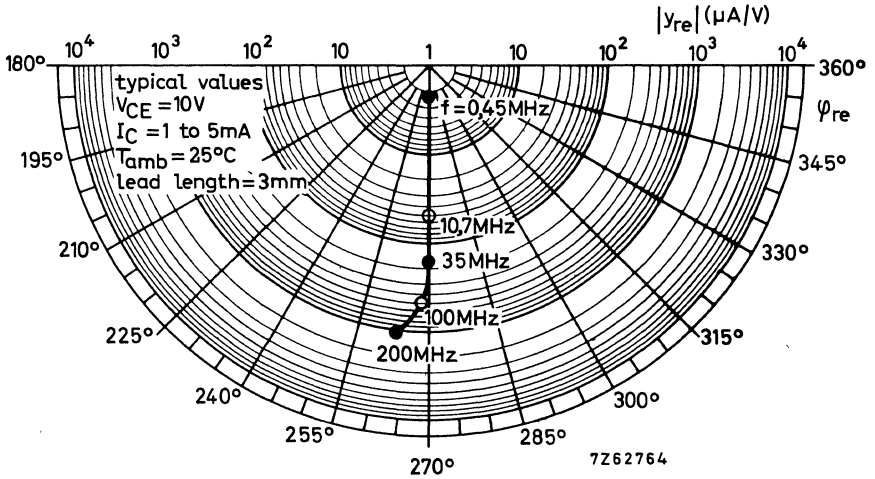
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## SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a plastic TO-92 variant intended for h.f. applications in radio and television receivers; it is especially recommended for f.m. tuners, i.f. amplifiers in a.m./f.m. receivers where a low transistor output conductance is of importance, a.m. input stages of car radios where a low noise figure at low source impedance is required.

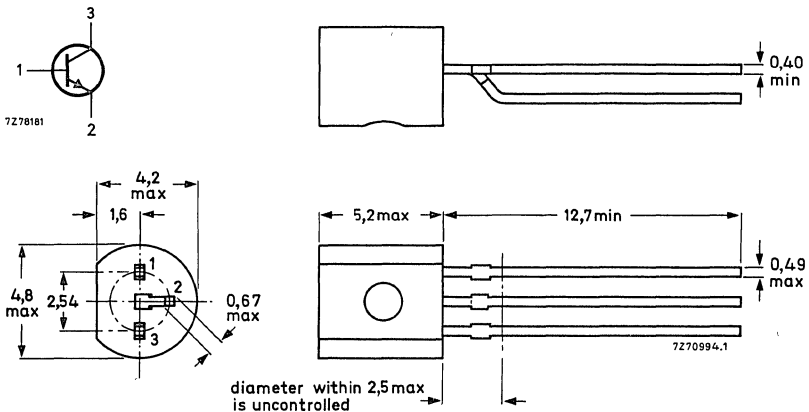
### QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$V_{CBO}$	max.	30 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	30 V
Collector current (d.c.)	$I_C$	max.	30 mA
Total power dissipation up to $T_{amb} = 75\text{ }^\circ\text{C}$	$P_{tot}$	max.	300 mW
Junction temperature	$T_j$	max.	150 $^\circ\text{C}$
D.C. current gain at $T_j = 25\text{ }^\circ\text{C}$ $I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$	$h_{FE}$	typ.	67
Transition frequency $I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$	$f_T$	typ.	200 MHz
Noise figure $I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$ $G_S = 20\text{ mA/V}; f = 1\text{ MHz}$ $G_S = 10\text{ mA/V}; f = 100\text{ MHz}$	F	typ.	3,5 dB
	F	typ.	4 dB

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.





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

Voltages

Collector-base voltage (open emitter)	$V_{CBO}$	max.	30	V
Collector-emitter voltage (open base) (See also page 4)	$V_{CEO}$	max.	20	V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	5	V

Currents

Collector current (d.c.)	$I_C$	max.	30	mA
Collector current (peak value)	$I_{CM}$	max.	30	mA

Power dissipation

Total power dissipation up to $T_{amb} = 75\text{ }^\circ\text{C}$	$P_{tot}$	max.	300	mW
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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 ambient in free air	$R_{th\ j-a}$	=	0,25	$^\circ\text{C}/\text{mW}$
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**CHARACTERISTICS**

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

Base-emitter voltage <sup>2)</sup>

$I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$	$V_{BE}$	0,65 to 0,74	V
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Base current

$I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$	$I_B$	typ.	8 to 28 15	$\mu\text{A}$ $\mu\text{A}$
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Feedback capacitance at  $f = 0,45\text{ MHz}$

$I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$	$C_{re}$	typ.	0,85	pF
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<sup>1)</sup>  $V_{BE}$  decreases by about 1,7 mV/ $^\circ\text{C}$  with increasing temperature.

**CHARACTERISTICS** (continued)

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

Transition frequency

$I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$   $f_T$  typ. 200 MHz

Noise figure

$I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$   
 $G_S = 20\text{ mA/V}; f = 1\text{ MHz}$  F typ. 3,5 dB  
 $G_S = 10\text{ mA/V}; f = 100\text{ MHz}$  F typ. 4 dB

Conversion noise figure

$I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$   
 $G_S = 1, 2\text{ mA/V}; f = 0, 2\text{ MHz}$   $F_C$  typ. 4 dB  
 $G_S = 1, 5\text{ mA/V}; f = 1\text{ MHz}$   $F_C$  typ. 2,5 dB

y parameters at  $f = 100\text{ MHz}$  (common base)

$I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$  (lead length = 3 mm)

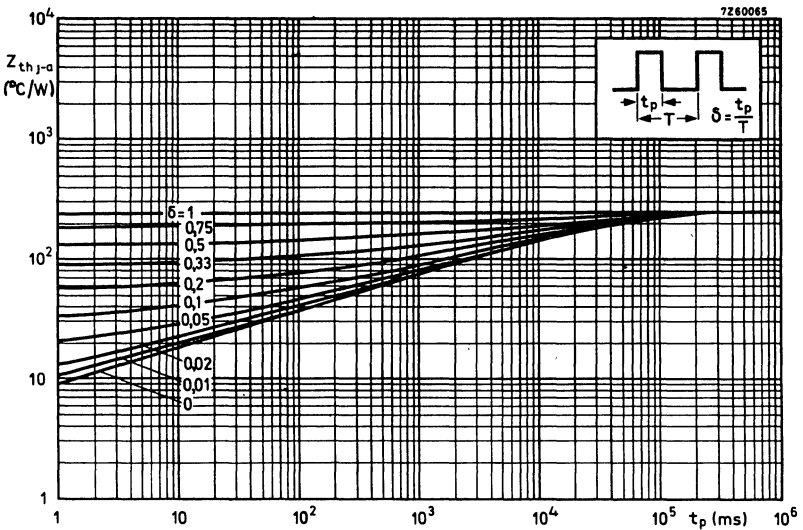
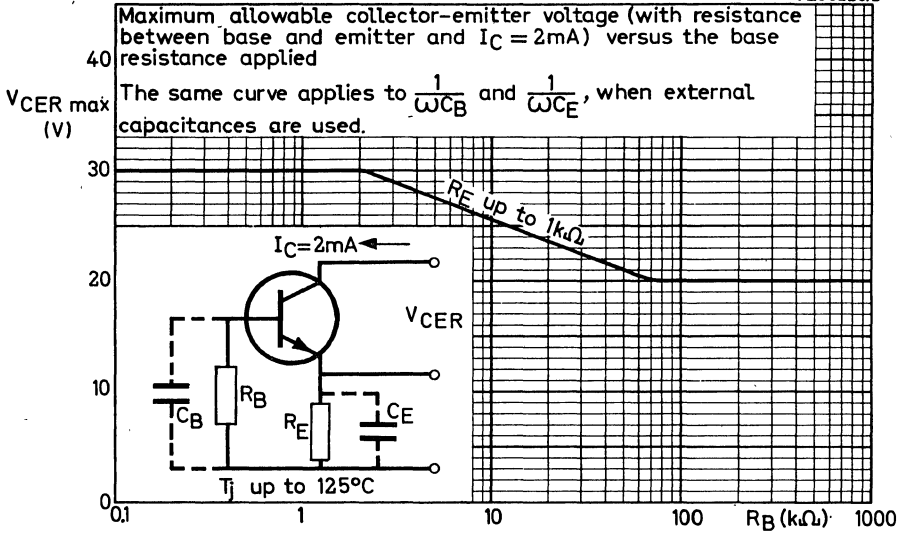
Input conductance	$g_{ib}$	typ.	34	mA/V
Input susceptance	$-b_{ib}$	typ.	1	mA/V
Feedback admittance	$ y_{rb} $	typ.	490	$\mu\text{A/V}$
Phase angle of feedback admittance	$\varphi_{rb}$	typ.	272°	
Transfer admittance	$ y_{fb} $	typ.	34	mA/V
Phase angle of transfer admittance	$\varphi_{fb}$	typ.	144°	
Output conductance	$g_{ob}$	typ.	12	$\mu\text{A/V}$
Output susceptance	$b_{ob}$	typ.	1,1	mA/V

y parameters (common emitter)

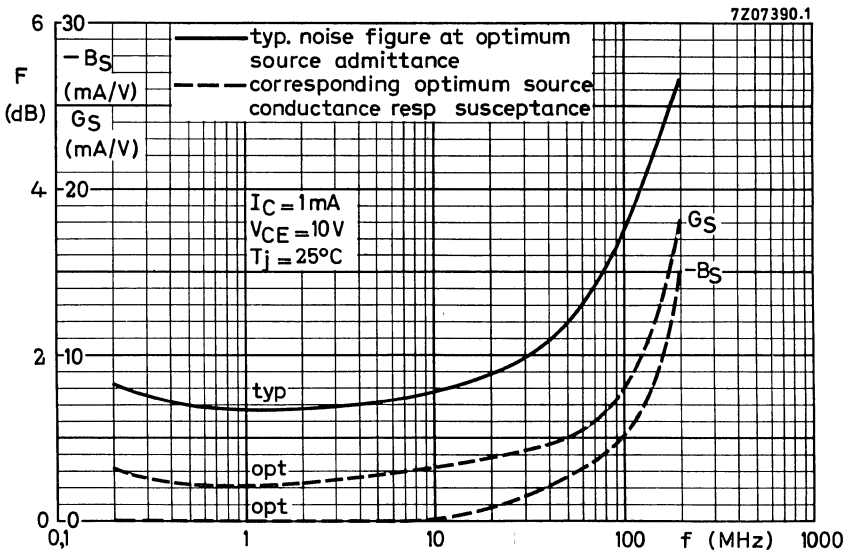
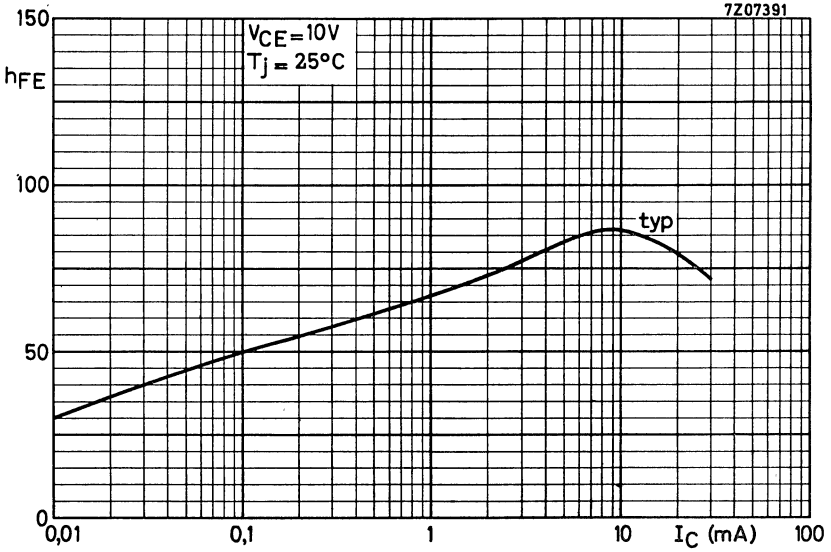
$I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$  (lead length = 3 mm)

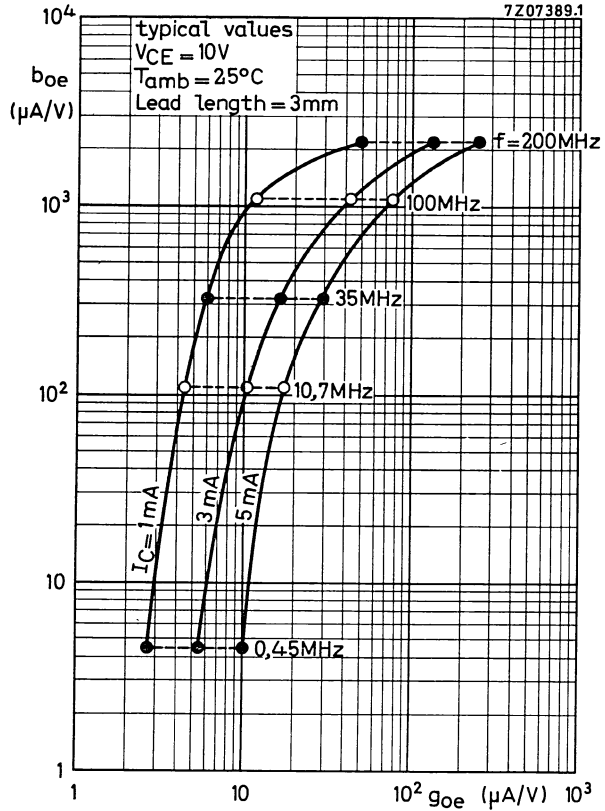
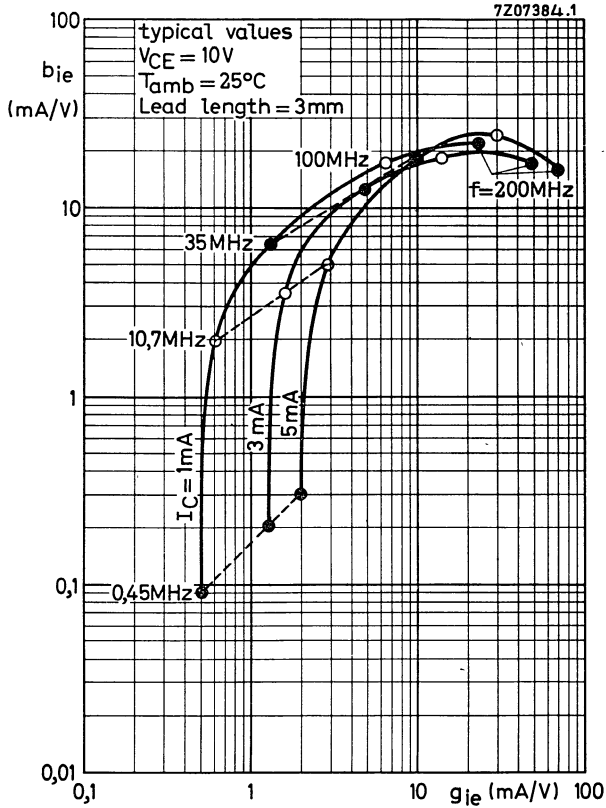
	$f = 10, 7\text{ MHz}$	$f = 0, 45\text{ MHz}$
Input conductance	$g_{ie} < 0, 96$	0, 86 mA/V
Output conductance	$g_{oe} < 9, 5$	7, 0 $\mu\text{A/V}$

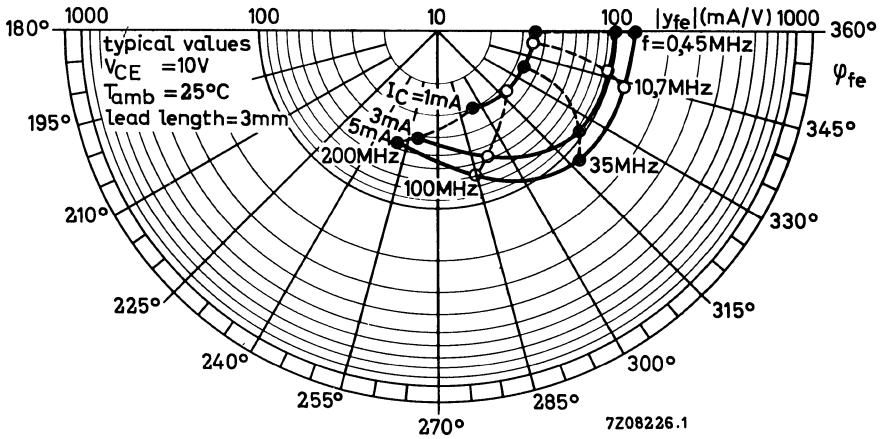
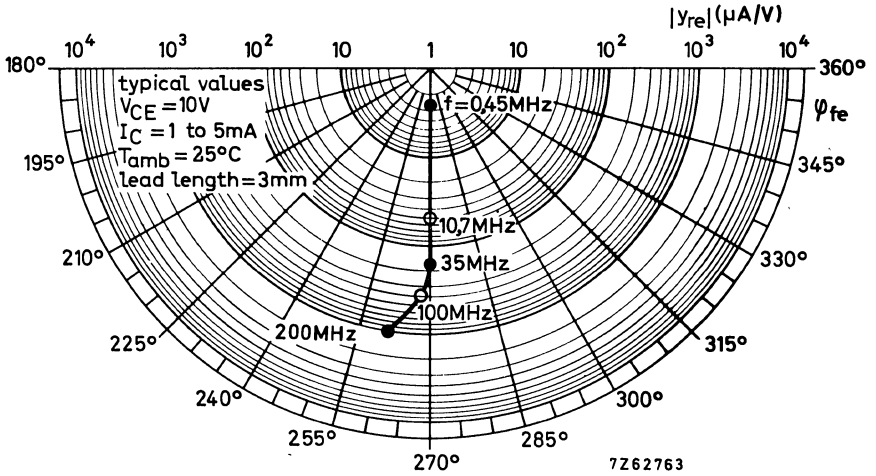
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## SILICON PLANAR TRANSISTOR

N-P-N transistor in a plastic TO-92 variant intended for v.h.f. applications, e.g. as gain controlled pre-amplifier in v.h.f. television and f.m. tuners.

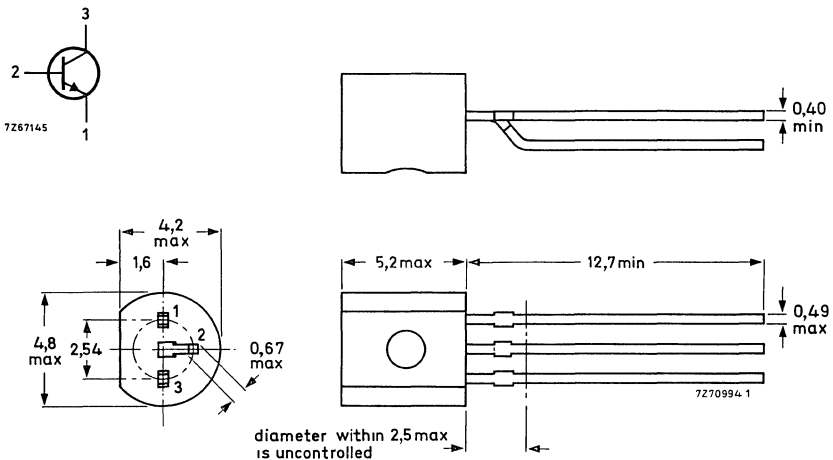
### QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$V_{CBO}$	max.	30 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	20 V
Collector current (d.c.)	$I_C$	max.	20 mA
Total power dissipation up to $T_{amb} = 75\text{ }^\circ\text{C}$	$P_{tot}$	max.	300 mW
Junction temperature	$T_j$	max.	150 $^\circ\text{C}$
Transition frequency	$f_T$	typ.	550 MHz
$-I_E = 2\text{ mA}; V_{CB} = 10\text{ V}$			
Maximum unilateral power gain	$G_{UM}$	typ.	34 dB
$-I_E = 3\text{ mA}; V_{CB} = 10\text{ V}; f = 50\text{ MHz}$			
$-I_E = 3\text{ mA}; V_{CB} = 10\text{ V}; f = 200\text{ MHz}$	$G_{UM}$	typ.	27 dB
Noise figure at optimum source admittance	F	typ.	2 dB
$-I_E = 2\text{ mA}; V_{CB} = 10\text{ V}; f = 100\text{ MHz}$			
$-I_E = 3\text{ mA}; V_{CB} = 10\text{ V}; f = 200\text{ MHz}$	F	typ.	2,7 dB

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant





**RATINGS**

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

Collector-base voltage (open emitter)	V <sub>CB0</sub>	max.	30 V
Collector-emitter voltage (open base)	V <sub>CEO</sub>	max.	20 V
Collector-emitter voltage (R <sub>BE</sub> ≤ 1 kΩ)	V <sub>CER</sub>	max.	30 V
Emitter-base voltage (open collector)	V <sub>EBO</sub>	max.	3 V
Collector current (d.c.)	I <sub>C</sub>	max.	20 mA
Collector current (peak value)	I <sub>CM</sub>	max.	20 mA
Total power dissipation up to T <sub>amb</sub> = 75 °C	P <sub>tot</sub>	max.	300 mW
Storage temperature	T <sub>stg</sub>		-55 to + 150 °C
Junction temperature	T <sub>j</sub>	max.	150 °C

**THERMAL RESISTANCE**

From junction to ambient in free air	R <sub>th j-a</sub>	=	250 K/W
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**CHARACTERISTICS**

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

Base current

-I <sub>E</sub> = 2 mA; V <sub>CB</sub> = 10 V	I <sub>B</sub>	typ.	50 μA
		<	150 μA
-I <sub>E</sub> = 12 mA; V <sub>CB</sub> = 7 V	I <sub>B</sub>	<	2,2 mA

Emitter-base voltage

-I <sub>E</sub> = 2 mA; V <sub>CB</sub> = 10 V	-V <sub>EB</sub>	typ.	0,84 V
-I <sub>E</sub> = 12 mA; V <sub>CB</sub> = 7 V	-V <sub>EB</sub>	<	1,0 V

Transition frequency

-I <sub>E</sub> = 2 mA; V <sub>CB</sub> = 10 V	f <sub>T</sub>	typ.	550 MHz
-I <sub>E</sub> = 4 mA; V <sub>CB</sub> = 5 V	f <sub>T</sub>	<	530 MHz

Feedback capacitance at f = 10,7 MHz

I <sub>C</sub> = 1 mA; V <sub>CE</sub> = 10 V	C <sub>re</sub>	typ.	0,8 pF
		<	1,0 pF

Noise figure at optimum source admittance

-I <sub>E</sub> = 3 mA; V <sub>CB</sub> = 10 V; f = 50 MHz	F	typ.	1,9 dB
-I <sub>E</sub> = 3 mA; V <sub>CB</sub> = 10 V; f = 200 MHz	F	typ.	2,5 dB
-I <sub>E</sub> = 2 mA; V <sub>CB</sub> = 10 V; f = 100 MHz	F	typ.	2,0 dB

Maximum unilateral power gain (common base)

$G_{UM} \text{ (in dB)} = 10 \log \frac{ Y_{fb} ^2}{4g_{ib}g_{ob}}$			
-I <sub>E</sub> = 3 mA; V <sub>CB</sub> = 10 V; f = 50 MHz	G <sub>UM</sub>	typ.	34 dB
-I <sub>E</sub> = 3 mA; V <sub>CB</sub> = 10 V; f = 200 MHz	G <sub>UM</sub>	typ.	27 dB
-I <sub>E</sub> = 2 mA; V <sub>CB</sub> = 10 V; f = 100 MHz	G <sub>UM</sub>	typ.	30 dB

y-parameters at  $f = 100$  MHz (common base) $I_C = 2$  mA;  $V_{CE} = 10$  V

Input conductance	$g_{ib}$	typ.	66 mA/V
Input susceptance	$-b_{ib}$	typ.	15 mA/V
Feedback admittance	$ Y_{rb} $	typ.	190 mA/V
Phase angle of feedback admittance	$\varphi_{rb}$	typ.	280°
Transfer admittance	$ Y_{fb} $	typ.	66 mA/V
Phase angle of transfer admittance	$\varphi_{fb}$	typ.	155°
Output conductance	$g_{ob}$	typ.	15 $\mu$ A/V
Output susceptance	$b_{ob}$	typ.	660 $\mu$ A/V

y-parameters at  $f = 50$  MHz (common base) $-I_E = 3$  mA;  $V_{CB} = 10$  V

Input conductance	$g_{ib}$	typ.	9,5 mA/V
Input susceptance	$-b_{ib}$	typ.	12 mA/V
Feedback admittance	$ Y_{rb} $	typ.	100 $\mu$ A/V
Phase angle of feedback admittance	$\varphi_{rb}$	typ.	270°
Transfer admittance	$ Y_{fb} $	typ.	95 mA/V
Phase angle of transfer admittance	$\varphi_{fb}$	typ.	160°
Output conductance	$g_{ob}$	typ.	10 $\mu$ A/V
Output susceptance	$b_{ob}$	typ.	350 $\mu$ A/V

y-parameters at  $f = 200$  MHz (common base) $-I_E = 3$  mA;  $V_{CB} = 10$  V

Input conductance	$g_{ib}$	typ.	70 mA/V
Input susceptance	$-b_{ib}$	typ.	46 mA/V
Feedback admittance	$ Y_{rb} $	typ.	340 $\mu$ A/V
Phase angle of feedback admittance	$\varphi_{rb}$	typ.	275°
Transfer admittance	$ Y_{fb} $	typ.	85 mA/V
Phase angle of transfer admittance	$\varphi_{fb}$	typ.	130°
Output conductance	$g_{ob}$	typ.	75 $\mu$ A/V
Output susceptance	$b_{ob}$	typ.	1,3 mA/V



## SILICON PLANAR EPITAXIAL TRANSISTOR

P-N-P transistor in a TO-92 envelope intended for use as preamplifier, mixer and oscillator in v.h.f. and u.h.f. tuners.

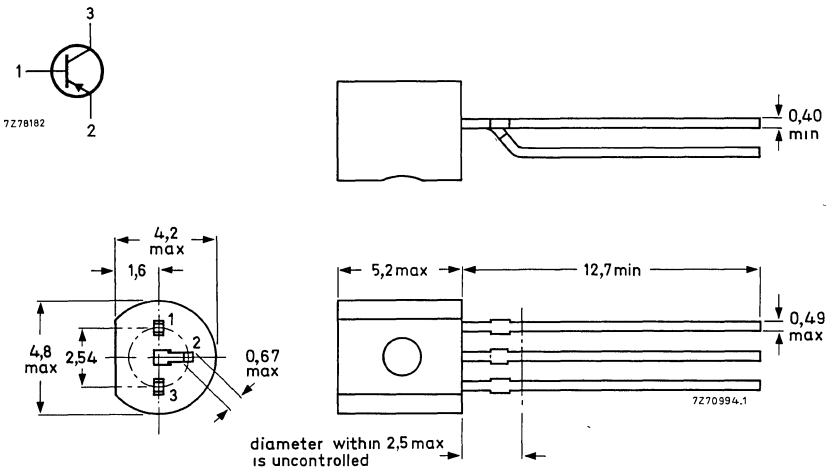
### QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$-V_{CB0}$	max.	30 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20 V
Collector current (d.c.)	$-I_C$	max.	25 mA
Total power dissipation up to $T_{amb} = 45\text{ }^\circ\text{C}$	$P_{tot}$	max.	250 mW
Junction temperature	$T_j$	max.	150 $^\circ\text{C}$
Transition frequency at $f = 100\text{ MHz}$ $I_E = 1\text{ mA}; -V_{CB} = 10\text{ V}$	$f_T$	typ.	350 MHz
Noise figure at $f = 200\text{ MHz}$ $I_E = 1\text{ mA}; -V_{CB} = 10\text{ V}$	F	<	6 dB
Transducer gain (common base) $I_E = 3\text{ mA}; -V_{CB} = 10\text{ V}$	$G_{tr}$	>	14 dB

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



**RATINGS**

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

Collector-base voltage (open emitter)	$-V_{CB0}$	max.	30 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20 V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	4 V
Collector current (d.c.)	$-I_C$	max.	25 mA
Total power dissipation up to $T_{amb} = 45\text{ }^\circ\text{C}$	$P_{tot}$	max.	250 mW
Storage temperature	$T_{stg}$		$-55$ to $+150\text{ }^\circ\text{C}$
Junction temperature	$T_j$	max.	150 $^\circ\text{C}$

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th\ j-a}$	=	420 K/W
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**CHARACTERISTICS**

$T_{amb} = 25\text{ }^\circ\text{C}$

Collector cut-off current

$I_E = 0; -V_{CB} = 20\text{ V}$	$-I_{CBO}$	<	50 nA
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Base current

$I_E = 1\text{ mA}; -V_{CB} = 10\text{ V}$	$-I_B$	<	33 $\mu\text{A}$
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Collector-base breakdown voltage

open emitter; $-I_C = 10\text{ }\mu\text{A}$	$-V_{(BR)CBO}$	>	30 V
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Collector-emitter breakdown voltage

open base; $-I_C = 2\text{ mA}$	$-V_{(BR)CEO}$	>	20 V
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Emitter-base breakdown voltage

open collector; $-I_E = 10\text{ }\mu\text{A}$	$-V_{(BR)EBO}$	>	4 V
--	----------------	---	-----

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

$I_E = 1\text{ mA}; -V_{CB} = 10\text{ V}$	$f_T$	typ.	350 MHz
$I_E = 5\text{ mA}; -V_{CB} = 10\text{ V}$	$f_T$	typ.	500 MHz
			400 to 700 MHz

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

$I_E = 1\text{ mA}; -V_{CB} = 10\text{ V}$	$C_{re}$	typ.	0,5 pF
--	----------	------	--------

Noise figure at  $f = 200\text{ MHz}$

$I_E = 1\text{ mA}; -V_{CB} = 10\text{ V}$	F	typ.	5 dB
		<	6 dB

Transducer gain (common base) at  $f = 200\text{ MHz}$

$I_E = 3\text{ mA}; -V_{CB} = 10\text{ V}; R_S = 60\text{ }\Omega; R_L = 920\text{ }\Omega$	$G_{tr}$	>	14 dB
		typ.	17,5 dB

## SILICON PLANAR TRANSISTOR

P-N-P transistor in a TO-92 envelope intended for use in h.f. amplifiers and also in mixer and oscillator stages in v.h.f. and u.h.f. television receivers.

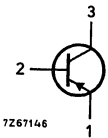
### QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$-V_{CB0}$	max.	30 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20 V
Collector current (d.c.)	$-I_C$	max.	25 mA
Total power dissipation up to $T_{amb} = 45\text{ }^\circ\text{C}$	$P_{tot}$	max.	250 mW
Junction temperature	$T_j$	max.	150 $^\circ\text{C}$
D.C. current gain	$h_{FE}$	>	25
Transition frequency at $f = 100\text{ MHz}$	$f_T$	typ.	350 MHz
Noise figure at $f = 200\text{ MHz}$	F	<	6 dB
Transducer gain (common base)	$G_{tr}$	>	14 dB

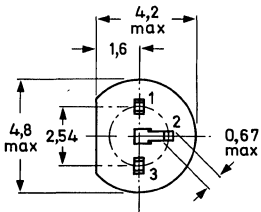
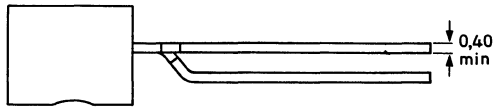
### MECHANICAL DATA

Dimensions in mm

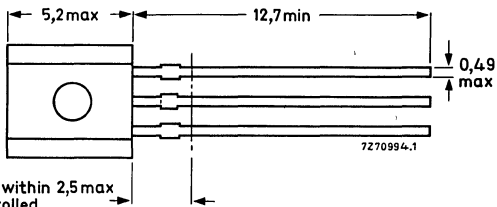
Fig. 1 TO-92 variant.



7267146



diameter within 2,5max  
is uncontrolled



7270994.1

**RATINGS**

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

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20 V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	4 V
Collector current (d.c.)	$-I_C$	max.	25 mA
Total power dissipation up to $T_{amb} = 45\text{ }^\circ\text{C}$	$P_{tot}$	max.	250 mW
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 in free air	$R_{th\ j-a}$	=	420 K/W
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**CHARACTERISTICS**

$T_{amb} = 25\text{ }^\circ\text{C}$

Collector cut-off current

$I_E = 0; -V_{CB} = 20\text{ V}$	$-I_{CBO}$	<	50 nA
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Base current

$I_E = 1\text{ mA}; -V_{CB} = 10\text{ V}$	$-I_B$	<	38 $\mu\text{A}$
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Collector-base breakdown voltage

open emitter; $-I_C = 10\text{ }\mu\text{A}$	$-V_{(BR)CBO}$	>	30 V
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Collector-emitter breakdown voltage

open base; $-I_C = 2\text{ mA}$	$-V_{(BR)CEO}$	>	20 V
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Emitter-base breakdown voltage

open collector; $-I_E = 10\text{ }\mu\text{A}$	$-V_{(BR)EBO}$	>	4 V
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D.C. current gain

$I_E = 1\text{ mA}; -V_{CB} = 10\text{ V}$	$h_{FE}$	>	25
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Transition frequency at  $f = 100\text{ MHz}$

$I_E = 1\text{ mA}; -V_{CB} = 10\text{ V}$	$f_T$	typ.	350 MHz
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Feedback capacitance at  $f = 1\text{ MHz}$

$I_E = 1\text{ mA}; -V_{CB} = 10\text{ V}$	$C_{re}$	typ.	0,9 pF
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Noise figure at  $f = 200\text{ MHz}$

$I_E = 1\text{ mA}; -V_{CB} = 10\text{ V}; R_S = 50\text{ }\Omega$	F	typ.	5 dB
		<	6 dB

Transducer gain (common base) at  $f = 200\text{ MHz}$

$I_E = 3\text{ mA}; -V_{CB} = 10\text{ V}; R_S = 60\text{ }\Omega; R_L = 920\text{ }\Omega$	$G_{tr}$	>	14 dB
		typ.	17,5 dB

## SILICON PLANAR TRANSISTOR

P-N-P transistor in a TO-92 envelope intended for application as a gain controlled preamplifier in v.h.f. tuners.

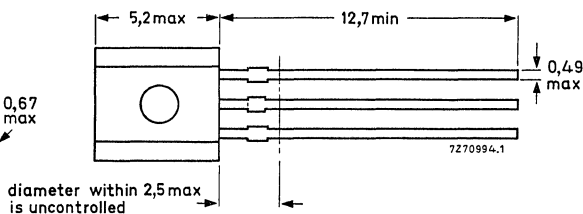
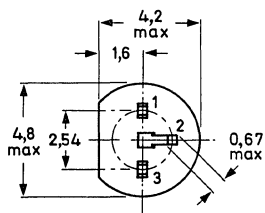
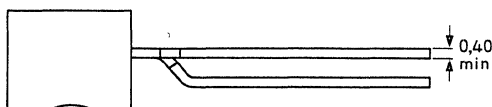
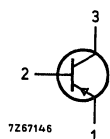
## QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	25 V
Collector current (d.c.)	$-I_C$	max.	20 mA
Total power dissipation up to $T_{amb} = 55\text{ }^\circ\text{C}$	$P_{tot}$	max.	225 mW
Junction temperature	$T_j$	max.	150 $^\circ\text{C}$
Transition frequency at $f = 100\text{ MHz}$ $I_E = 2\text{ mA}; -V_{CB} = 10\text{ V}$	$f_T$	typ.	750 MHz
Noise figure at $f = 200\text{ MHz}$ $I_E = 2\text{ mA}; -V_{CB} = 10\text{ V}$ $R_S = 60\ \Omega; R_L = 1\text{ k}\Omega$	F	typ.	2,5 dB
Transducer gain (common base) $I_E = 2\text{ mA}; -V_{CB} = 10\text{ V}; f = 200\text{ MHz}$ $R_S = 60\ \Omega; R_L = 1\text{ k}\Omega$	$G_{tr}$	typ.	16 dB

## MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.





**RATINGS**

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

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	25 V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	3 V
Collector current (d.c.)	$-I_C$	max.	20 mA
Total power dissipation up to $T_{amb} = 55\text{ }^\circ\text{C}$	$P_{tot}$	max.	225 mW
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 in free air	$R_{th\ j-a}$	=	420 K/W
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**CHARACTERISTICS**

$T_{amb} = 25\text{ }^\circ\text{C}$

Collector cut-off current

$I_E = 0; -V_{CB} = 15\text{ V}$	$-I_{CBO}$	<	100 nA
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Emitter cut-off current

$I_C = 0; -V_{EB} = 1\text{ V}$	$-I_{EBO}$	<	100 nA
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Base current

$I_E = 2\text{ mA}; -V_{CB} = 10\text{ V}$	$-I_B$	typ.	55 $\mu\text{A}$
		<	125 $\mu\text{A}$

$-I_C = 9\text{ mA}; -V_{CE} = 4\text{ V}$	$-I_B$	<	3,6 mA
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Collector-base breakdown voltage

open emitter; $-I_C = 10\text{ }\mu\text{A}$	$-V_{(BR)CBO}$	>	30 V
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Collector-emitter breakdown voltage

open base; $-I_C = 1\text{ mA}$	$-V_{(BR)CEO}$	>	25 V
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Emitter-base breakdown voltage

open collector; $-I_E = 10\text{ }\mu\text{A}$	$-V_{(BR)EBO}$	>	3 V
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Transition frequency at  $f = 100\text{ MHz}$

$I_E = 2,0\text{ mA}; -V_{CB} = 10\text{ V}$	$f_T$	typ.	750 MHz
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$I_E = 6,5\text{ mA}; -V_{CB} = 5,5\text{ V}$	$f_T$	<	200 MHz
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Feedback capacitance at  $f = 500\text{ kHz}$

$I_E = 0; -V_{CB} = 10\text{ V}$	$C_{re}$	typ.	0,7 pF
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$I_E = 0; -V_{CB} = 10\text{ V}$	$C_{rb}$	typ.	135 fF
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		<	160 fF
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Noise figure at  $f = 200\text{ MHz}$

$I_E = 2\text{ mA}; -V_{CB} = 10\text{ V}; R_S = 60\text{ }\Omega; R_L = 1\text{ k}\Omega$	F	typ.	2,5 dB
--	---	------	--------

		<	4 dB
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Transducer gain (common base) at  $f = 200\text{ MHz}$

$I_E = 2\text{ mA}; -V_{CB} = 10\text{ V}; R_S = 60\text{ }\Omega; R_L = 1\text{ k}\Omega$	$G_{tr}$	typ.	16 dB
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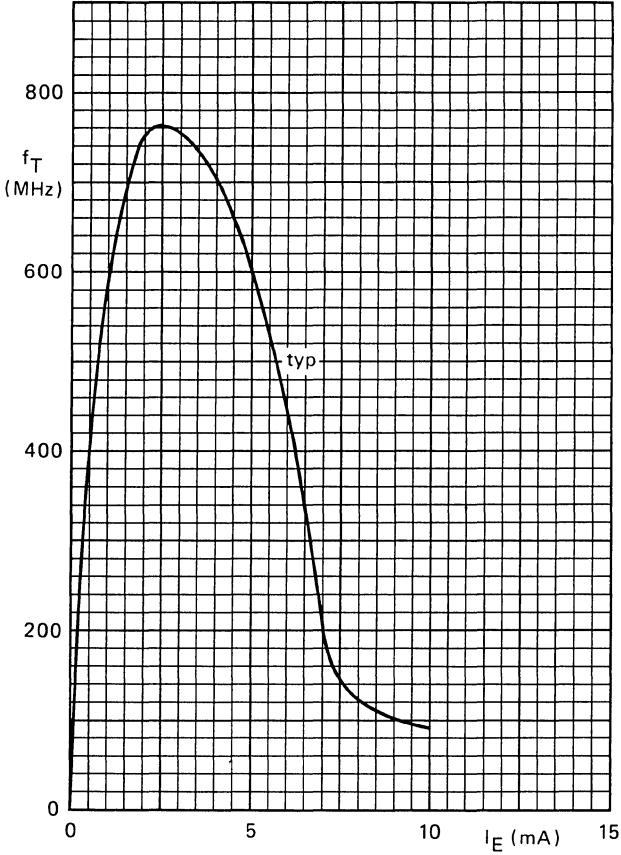


Fig. 2  $-V_{CB} = 10$  V;  $f = 100$  MHz;  $T_{amb} = 25$  °C.

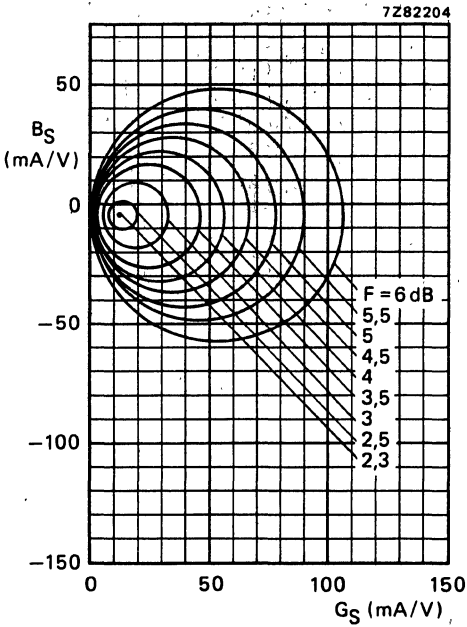


Fig. 3 Circles of constant noise figure.  
 $-V_{CB} = 10 \text{ V}$ ;  $I_E = 2 \text{ mA}$ ;  $f = 200 \text{ MHz}$ ;  
 $T_{amb} = 25 \text{ }^\circ\text{C}$ ; typical values.

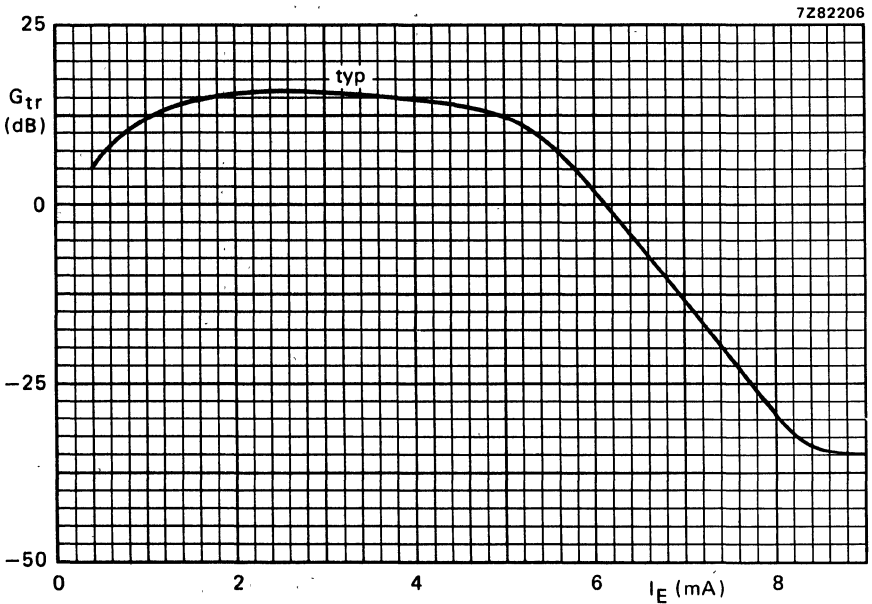


Fig. 4  $-V_{CC} = 12 \text{ V}$ ;  $R_C = 1 \text{ k}\Omega$ ;  $R_L = 920 \Omega$ ;  $R_S = 60 \Omega$ ;  $f = 200 \text{ MHz}$ ;  $T_{amb} = 25 \text{ }^\circ\text{C}$ .

## SILICON PLANAR TRANSISTOR



P-N-P transistor in a plastic T-package, primarily intended for application as gain controlled preamplifier in u.h.f. television tuners.

## QUICK REFERENCE DATA

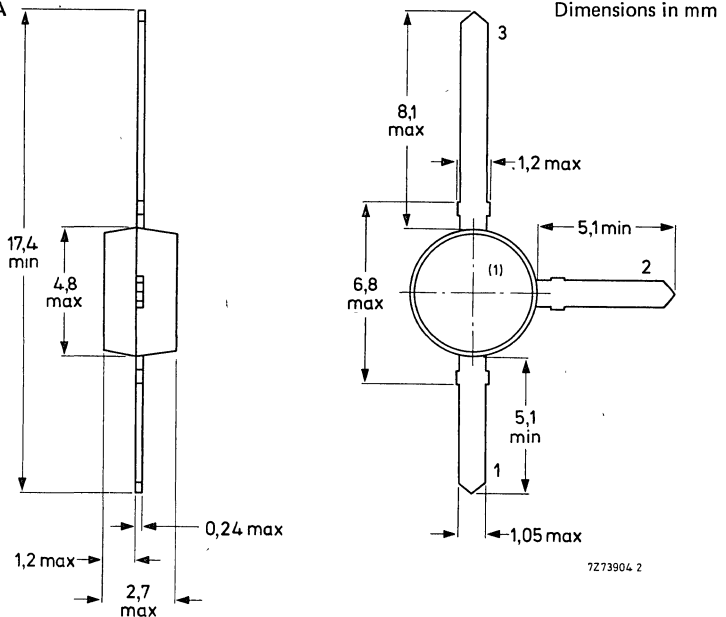
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	30 V
Collector current (d.c.)	$-I_C$	max.	20 mA
Total power dissipation up to $T_{amb} = 55\text{ }^\circ\text{C}$	$P_{tot}$	max.	160 mW
Junction temperature	$T_j$	max.	150 $^\circ\text{C}$
Transition frequency at $f = 100\text{ MHz}$ $I_E = 3\text{ mA}; -V_{CB} = 10\text{ V}$	$f_T$	typ.	900 MHz
Noise figure (common base) $I_E = 3\text{ mA}; -V_{CB} = 10\text{ V}; f = 800\text{ MHz}$ $R_S = 60\ \Omega; R_L = 500\ \Omega$	F	typ.	4 dB
Transducer gain (common base) $I_E = 3\text{ mA}; -V_{CB} = 10\text{ V}; f = 800\text{ MHz}$ $R_S = 60\ \Omega; R_L = 500\ \Omega$	$G_{tr}$	typ.	13 dB

## MECHANICAL DATA

Fig. 1 SOT-37.

## Connections

1. Emitter
2. Base
3. Collector



7273904 2

(1) = type number marking.

Products approved to CECC 50 002-127, available on request.

**RATINGS**

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

Collector-base voltage (open emitter)	$-V_{CB0}$	max.	30 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	30 V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	3 V
Collector current (d.c.)	$-I_C$	max.	20 mA
Base current (d.c.)	$-I_B$	max.	5 mA
Total power dissipation up to $T_{amb} = 55^\circ C$	$P_{tot}$	max.	160 mW
Storage temperature	$T_{stg}$		-55 to +150 °C
Junction temperature	$T_j$	max.	150 °C

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{thj-a}$	=	600 K/W
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**CHARACTERISTICS**

$T_{amb} = 25^\circ C$

Collector cut-off current

$I_E = 0; -V_{CB} = 15 V$	$-I_{CBO}$	<	100 nA
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Emitter cut-off current

$I_C = 0; -V_{EB} = 1 V$	$-I_{EBO}$	<	100 nA
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Collector-base breakdown voltage

open emitter; $-I_C = 10 \mu A$	$-V_{(BR)CBO}$	>	30 V
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Collector-emitter breakdown voltage

open base; $-I_C = 1 mA$	$-V_{(BR)CEO}$	>	30 V
--------------------------	----------------	---	------

Emitter-base breakdown voltage

open collector; $-I_E = 10 \mu A$	$-V_{(BR)EBO}$	>	3 V
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D.C. current gain

$I_E = 3 mA; -V_{CE} = 10 V$	$h_{FE}$	>	15
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		typ.	60
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$I_E = 7 mA; -V_{CE} = 4 V$	$h_{FE}$	>	10
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Transition frequency at  $f = 100 MHz$

$I_E = 3 mA; -V_{CB} = 10 V$	$f_T$	typ.	900 MHz
------------------------------	-------	------	---------

		700 to	1100 MHz
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$I_E = 7 mA; -V_{CB} = 5 V$	$f_T$	<	200 MHz
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Feedback capacitance at  $f = 500 kHz$

$I_E = 1 mA; -V_{CB} = 10 V$	$C_{re}$	typ.	0,45 pF
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	$C_{rb}$	typ.	115 fF
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$I_E = 0; -V_{CB} = 10 V$		<	140 fF
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Noise figure (common base)

$I_E = 3 mA; -V_{CB} = 10 V; f = 800 MHz$	$F$	typ.	4 dB
---	-----	------	------

$R_S = 60 \Omega; R_L = 500 \Omega$		<	5 dB
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Transducer gain (common base)

$I_E = 3 mA; -V_{CB} = 10 V; f = 800 MHz$	$G_{tr}$	>	11 dB
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$R_S = 60 \Omega; R_L = 500 \Omega$		typ.	13 dB
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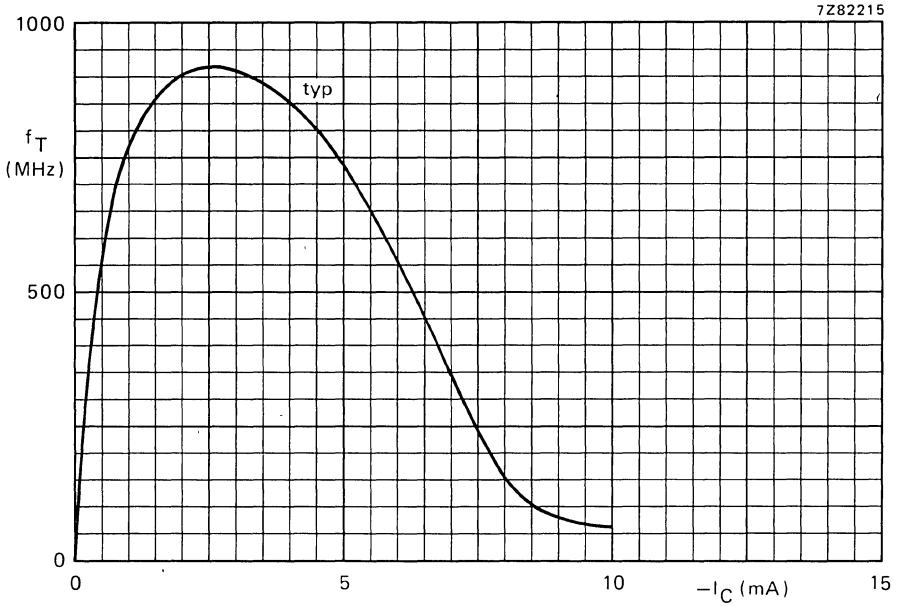


Fig. 2  $-V_{CB} = 10$  V;  $f = 100$  MHz;  $T_{amb} = 25$  °C.

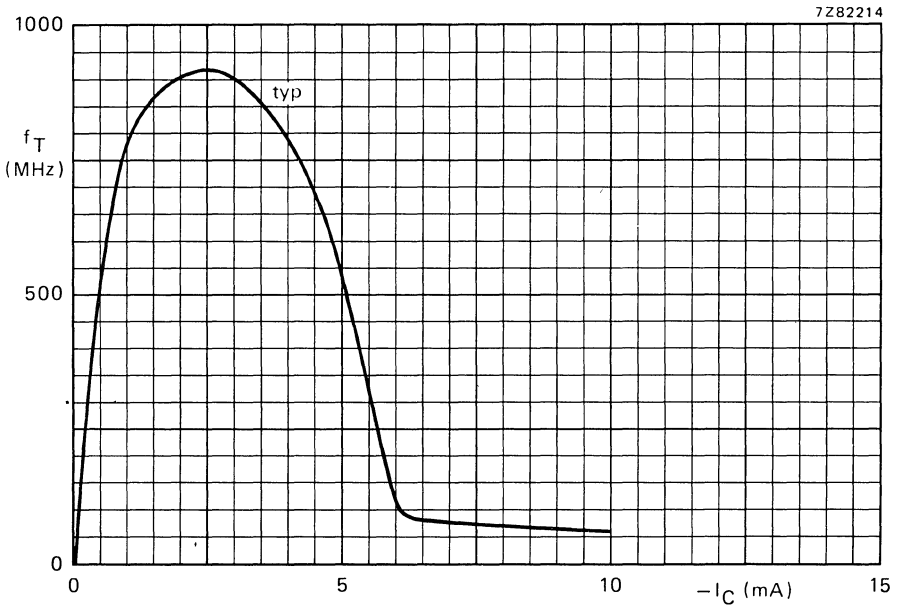


Fig. 3  $-V_{CC} = 12$  V;  $R_C = 1$  k $\Omega$ ;  $f = 100$  MHz;  $T_{amb} = 25$  °C.

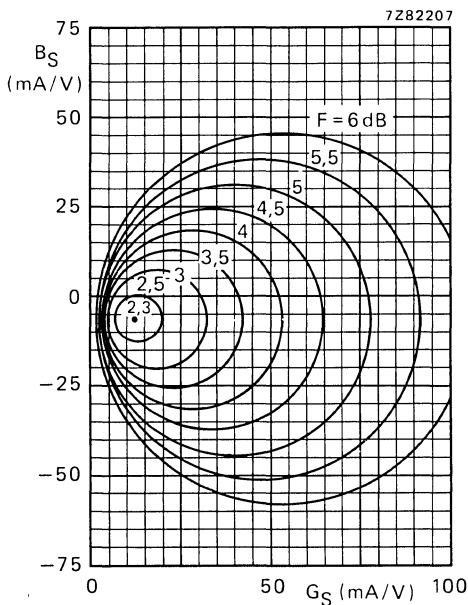


Fig. 4 Circles of constant noise figure.

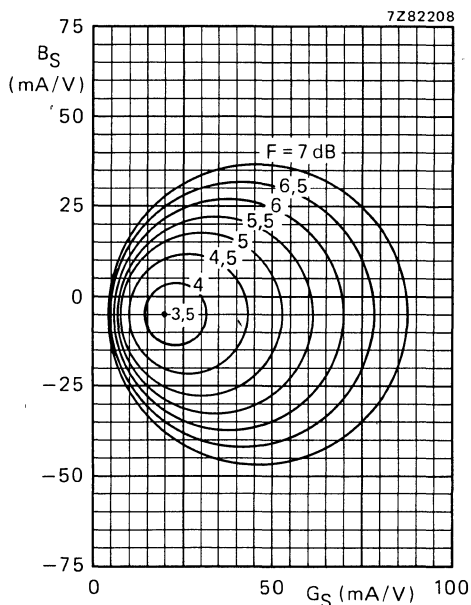
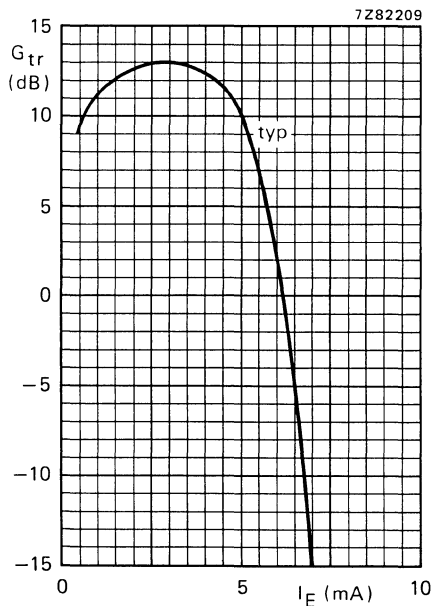


Fig. 5 Circles of constant noise figure.



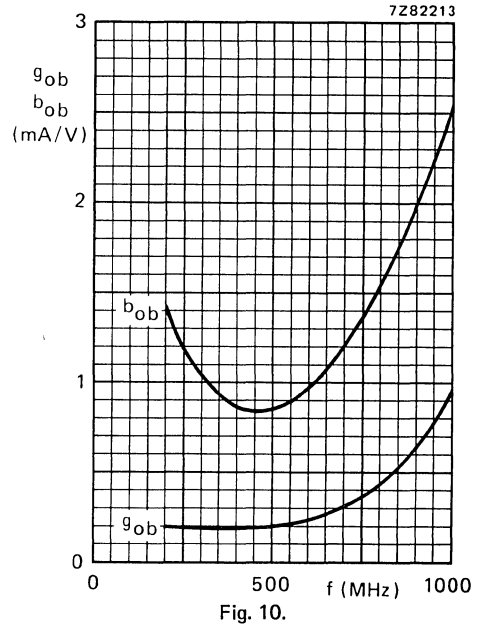
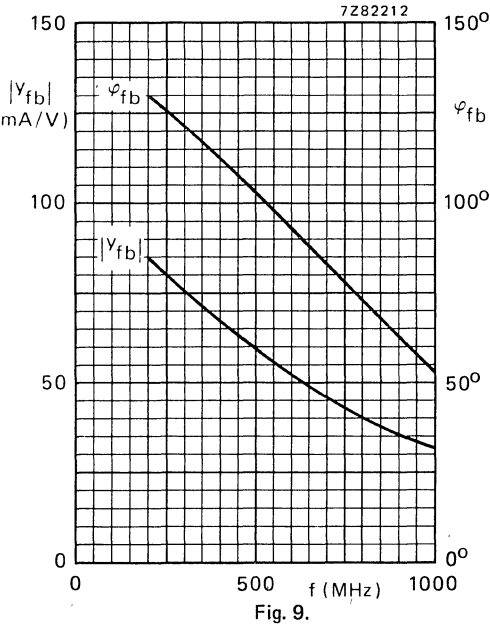
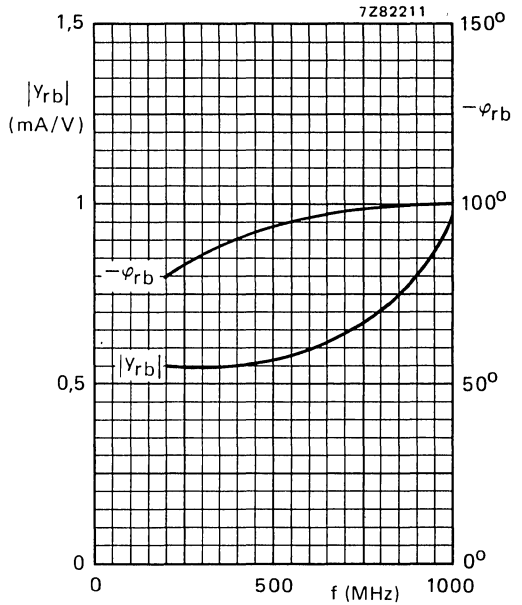
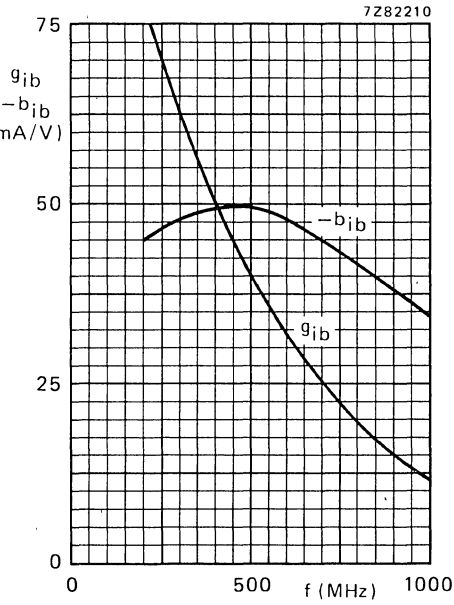
Measuring conditions:

Fig. 4  $-V_{CB} = 10 \text{ V}$ ;  $I_E = 3 \text{ mA}$ ;  $f = 200 \text{ MHz}$ ;  
 $T_{amb} = 25 \text{ }^\circ\text{C}$ ; typical values.

Fig. 5  $-V_{CB} = 10 \text{ V}$ ;  $I_E = 3 \text{ mA}$ ;  $f = 800 \text{ MHz}$ ;  
 $T_{amb} = 25 \text{ }^\circ\text{C}$ ; typical values.

Fig. 6  $-V_{CC} = 12 \text{ V}$ ;  $R_C = 1 \text{ k}\Omega$ ;  $R_L = 500 \Omega$ ;  
 $f = 800 \text{ MHz}$ ;  $T_{amb} = 25 \text{ }^\circ\text{C}$ .

Conditions for Figs 7 to 10:  $I_E = 3 \text{ mA}$ ;  $-V_{CB} = 10 \text{ V}$ ;  $T_{amb} = 25^\circ\text{C}$ ; typical values.







## SILICON PLANAR EPITAXIAL TRANSISTOR

P-N-P transistor in a plastic T-package intended for application as self-oscillating mixer stage in u.h.f. tuners.

## QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	40 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	35 V
Collector current (d.c.)	$-I_C$	max.	30 mA
Total power dissipation up to $T_{amb} = 55\text{ }^\circ\text{C}$	$P_{tot}$	max.	160 mW
Junction temperature	$T_j$	max.	150 $^\circ\text{C}$
Transition frequency at $f = 100\text{ MHz}$ $I_E = 3\text{ mA}; -V_{CB} = 10\text{ V}$	$f_T$	typ.	900 MHz

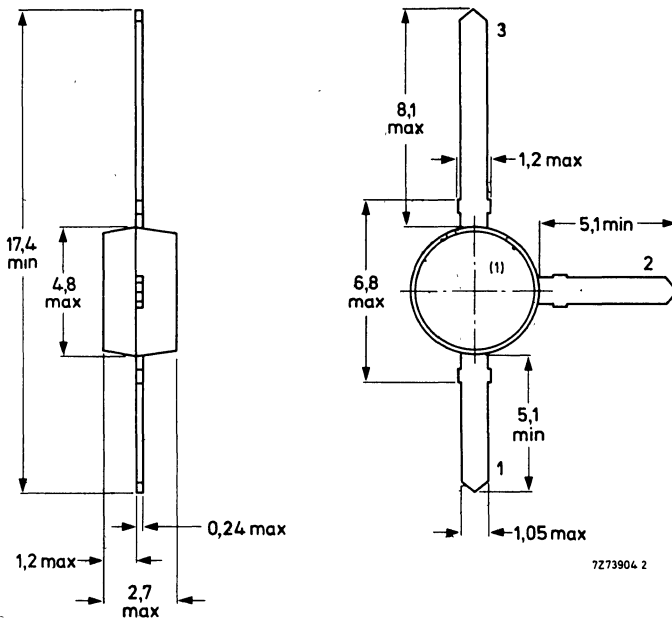
## MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT-37.

Connections

1. Emitter
2. Base
3. Collector



7273904 2

(1) = type number marking.

**RATINGS**

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

Collector-base voltage (open emitter)	$-V_{CB0}$	max.	40 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	35 V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	3 V
Collector current (d.c.)	$-I_C$	max.	30 mA
Emitter current (d.c.)	$I_E$	max.	35 mA
Total power dissipation up to $T_{amb} = 55^\circ\text{C}$	$P_{tot}$	max.	160 mW
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 in free air	$R_{th\ j-a}$	=	600 K/W
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**CHARACTERISTICS**

$T_{amb} = 25^\circ\text{C}$

Collector cut-off current $I_E = 0; -V_{CB} = 20\text{ V}$	$-I_{CBO}$	<	100 nA
Emitter cut-off current $I_C = 0; -V_{EB} = 1\text{ V}$	$-I_{EBO}$	<	100 nA
D.C. current gain $-I_C = 3\text{ mA}; -V_{CB} = 10\text{ V}$	$h_{FE}$	> typ.	25 50
Transition frequency at $f = 100\text{ MHz}$ $I_E = 3\text{ mA}; -V_{CB} = 10\text{ V}$	$f_T$	typ.	900 MHz 750 to 1060 MHz
$I_E = 7\text{ mA}; -V_{CB} = 5\text{ V}$	$f_T$	> typ.	400 MHz 700 MHz
Feedback capacitance at $f = 1\text{ MHz}$ $I_E = 0; -V_{CB} = 10\text{ V}$	$C_{rb}$	typ. <	110 fF 140 fF
$I_E = 1\text{ mA}; -V_{CB} = 5\text{ V}$	$C_{re}$	typ.	475 fF
Noise figure at $R_S = 60\ \Omega$ $I_E = 3\text{ mA}; -V_{CB} = 10\text{ V}; f = 200\text{ MHz}$	F	typ.	2,6 dB
$I_E = 3\text{ mA}; -V_{CB} = 10\text{ V}; f = 800\text{ MHz}$	F	typ. <	4,7 dB 6,0 dB
Transducer gain (common base) at $f = 800\text{ MHz}$ $I_E = 3\text{ mA}; -V_{CB} = 10\text{ V}; R_S = 60\ \Omega; R_L = 500\ \Omega$	$G_{tr}$	> typ.	13,0 dB 14,5 dB

## SILICON PLANAR TRANSISTOR

P-N-P transistor in a subminiature plastic T-package, primarily intended for application in r.f. stages in u.h.f. tuners using p-i-n diode attenuators.

### QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	20 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20 V
Collector current (peak value)	$-I_{CM}$	max.	30 mA
Total power dissipation up to $T_{amb} = 55\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	140 mW
Junction temperature	$T_j$	max.	125 $^{\circ}\text{C}$
Transition frequency at $f = 100\text{ MHz}$ $I_E = 10\text{ mA}; -V_{CB} = 10\text{ V}$	$f_T$	typ.	1350 MHz
Noise figure (common base) $I_E = 10\text{ mA}; -V_{CB} = 10\text{ V}; f = 800\text{ MHz}$ $R_S = 80\text{ }\Omega; R_L = 500\text{ }\Omega$	F	typ.	4,5 dB
Transducer gain (common base) $I_E = 10\text{ mA}; -V_{CB} = 10\text{ V}; f = 800\text{ MHz}$ $R_S = 60\text{ }\Omega; R_L = 500\text{ }\Omega$	$G_{tr}$	typ.	16 dB

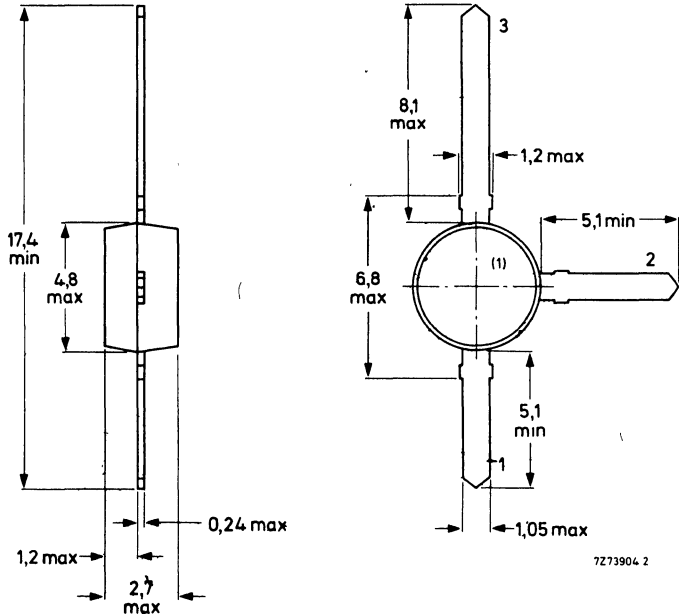
### MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT-37.

#### Connections

1. Emitter
2. Base
3. Collector



7273904 2

(1) = type number marking.

**RATINGS**

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

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	20 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20 V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	3 V
Collector current (peak value)	$-I_{CM}$	max.	30 mA
Base current (d.c.)	$-I_B$	max.	10 mA
Total power dissipation up to $T_{amb} = 55\text{ }^\circ\text{C}$	$P_{tot}$	max.	140 mW
Storage temperature	$T_{stg}$		$-55$ to $+125\text{ }^\circ\text{C}$
Junction temperature	$T_j$	max.	125 $^\circ\text{C}$

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th\ j-a}$	=	500 K/W
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**CHARACTERISTICS**

$T_{amb} = 25\text{ }^\circ\text{C}$

Collector cut-off current $I_E = 0; -V_{CB} = 15\text{ V}$	$-I_{CBO}$	<	100 nA
Emitter cut-off current $I_C = 0; -V_{EB} = 1\text{ V}$	$-I_{EBO}$	<	100 nA
Collector-base breakdown voltage open emitter; $-I_C = 10\text{ }\mu\text{A}$	$-V_{(BR)CBO}$	>	20 V
Collector-emitter breakdown voltage open base; $-I_C = 1\text{ mA}$	$-V_{(BR)CEO}$	>	20 V
Emitter-base breakdown voltage open collector; $-I_E = 10\text{ }\mu\text{A}$	$-V_{(BR)EBO}$	>	3 V
D.C. current gain $I_E = 2\text{ mA}; -V_{CB} = 10\text{ V}$	$h_{FE}$	>	15
$I_E = 10\text{ mA}; -V_{CB} = 10\text{ V}$	$h_{FE}$	>	20
Transition frequency at $f = 100\text{ MHz}$ $I_E = 10\text{ mA}; -V_{CB} = 10\text{ V}$	$f_T$	typ.	1350 MHz
$I_E = 15\text{ mA}; -V_{CB} = 5\text{ V}$	$f_T$	typ.	1000 MHz
Feedback capacitance at $f = 500\text{ kHz}$ $I_E = 0; -V_{CB} = 10\text{ V}$	$C_{re}$	typ.	0,65 pF
$I_E = 0; -V_{CB} = 10\text{ V}$	$C_{rb}$	typ.	120 fF
Noise figure (common base) $I_E = 10\text{ mA}; -V_{CB} = 10\text{ V}; f = 800\text{ MHz}$ $R_S = 60\text{ }\Omega; R_L = 500\text{ }\Omega$	$F$	typ.	4,5 dB
		<	6,0 dB
Transducer gain (common base) $I_E = 10\text{ mA}; -V_{CB} = 10\text{ V}; f = 800\text{ MHz}$ $R_S = 60\text{ }\Omega; R_L = 500\text{ }\Omega$	$G_{tr}$	typ.	16 dB

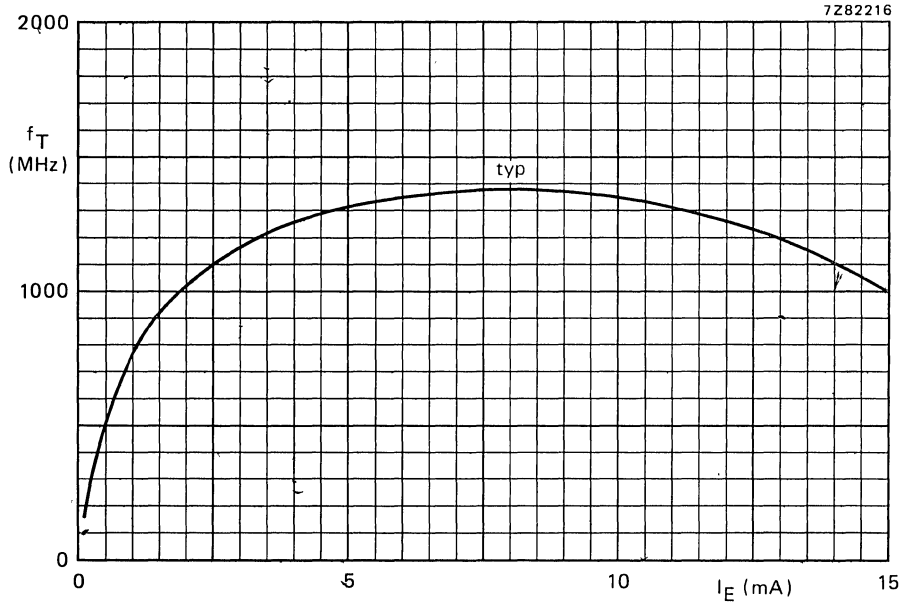


Fig. 2  $-V_{CB} = 10 \text{ V}$ ;  $T_j = 25 \text{ }^\circ\text{C}$ .

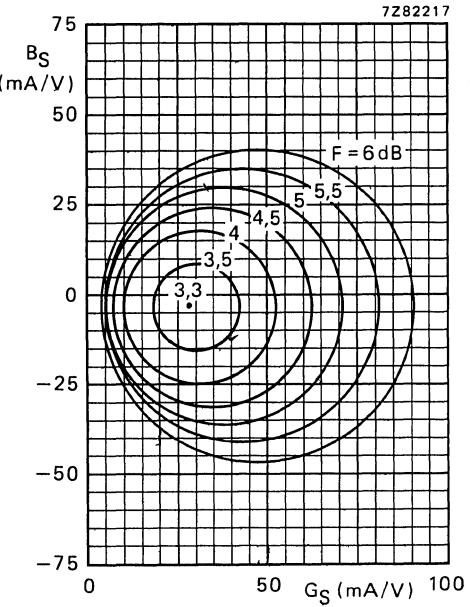


Fig. 3  $I_E = 10 \text{ mA}$ ;  $-V_{CB} = 10 \text{ V}$ ;  $f = 200 \text{ MHz}$ ;  $T_{amb} = 25 \text{ }^\circ\text{C}$ ; typical values.

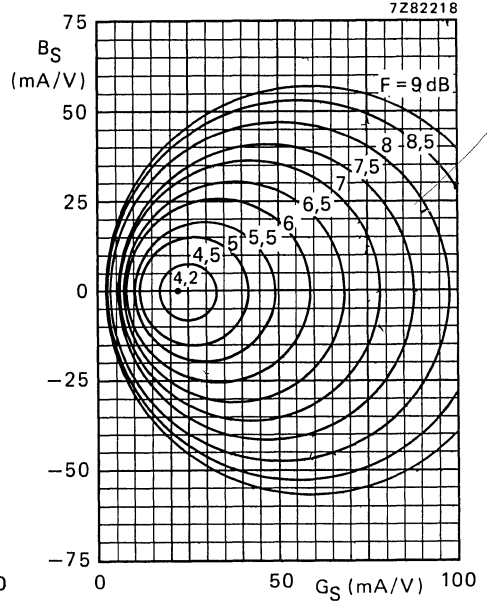


Fig. 4  $I_E = 10 \text{ mA}$ ;  $-V_{CB} = 10 \text{ V}$ ;  $f = 800 \text{ MHz}$ ;  $T_{amb} = 25 \text{ }^\circ\text{C}$ ; typical values.

Conditions for Figs 5 to 8:  $I_E = 10 \text{ mA}$ ;  $-V_{CB} = 10 \text{ V}$ ;  $T_{amb} = 25 \text{ }^\circ\text{C}$ ; typical values.  
 —  $-V_{CB} = 10 \text{ V}$ ; - - -  $-V_{CB} = 5 \text{ V}$

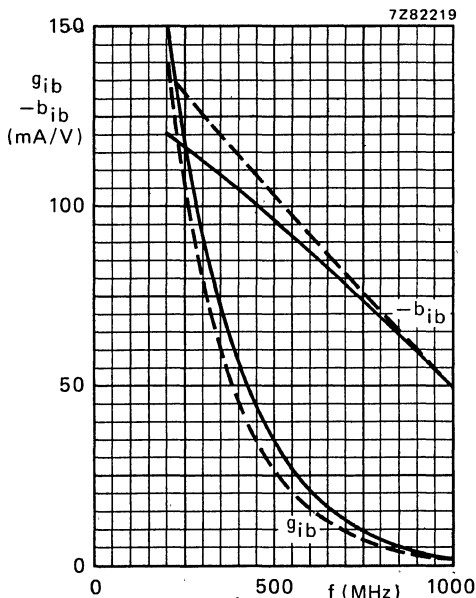


Fig. 5.

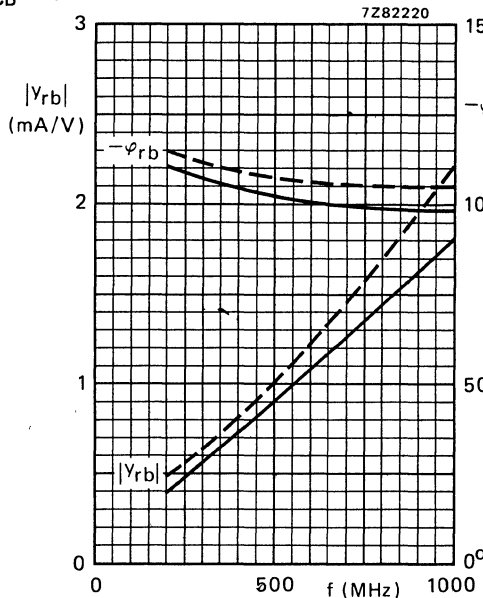


Fig. 6.

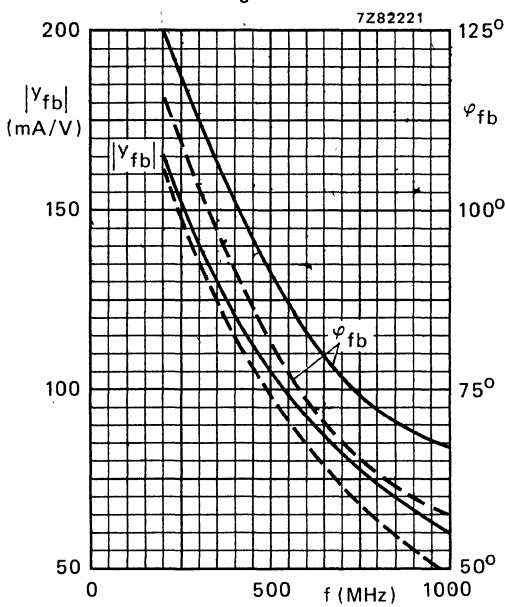


Fig. 7.

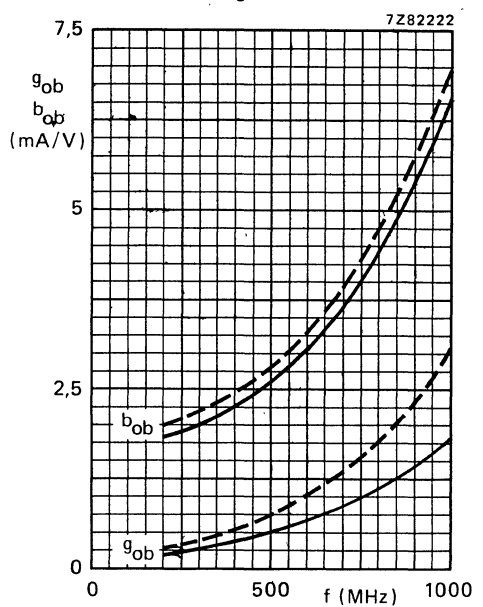


Fig. 8.

## SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a plastic TO-92 variant envelope primarily intended for use in active probes, frequency multipliers and linear amplifiers.

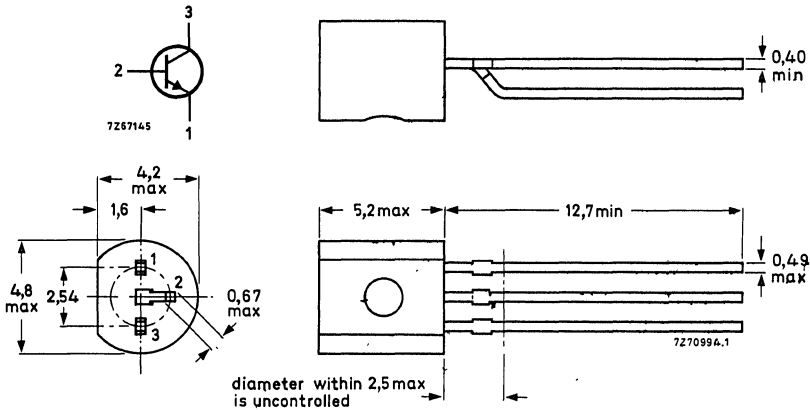
### QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$V_{CBO}$	max.	40 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	15 V
Collector current (peak value)	$I_{CM}$	max.	500 mA
Total power dissipation up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	500 mW
D.C. current $I_C = 10\text{ mA}$ ; $V_{CE} = 1\text{ V}$	$h_{FE}$	>	40
Transition frequency at $f = 100\text{ MHz}$ $I_C = 10\text{ mA}$ ; $V_{CE} = 10\text{ V}$	$f_T$	>	500 MHz

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.





## RATINGS

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

Collector-base voltage (open emitter)	$V_{CBO}$	max.	40 V
Collector-emitter voltage ( $V_{BE} = 0$ )	$V_{CES}$	max.	40 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	15 V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	4,5 V
Collector current (peak value; $t_p = 10 \mu s$ )	$I_{CM}$	max.	500 mA
Total power dissipation up to $T_{amb} = 25 \text{ }^\circ\text{C}$	$P_{tot}$	max.	500 mW
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	$R_{th j-a}$	=	250 K/W
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## CHARACTERISTICS

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

Collector cut-off current

$$I_E = 0; V_{CB} = 20 \text{ V}$$

$$I_E = 0; V_{CB} = 20 \text{ V}; T_j = 125 \text{ }^\circ\text{C}$$

$$I_{CBO} < 400 \text{ nA}$$

$$I_{CBO} < 30 \text{ } \mu\text{A}$$

Emitter cut-off current

$$I_C = 0; V_{EB} = 2 \text{ V}$$

$$I_{EBO} < 100 \text{ nA}$$

Saturation voltage

$$I_C = 10 \text{ mA}; I_B = 1 \text{ mA}$$

$$V_{CEsat} < 0,25 \text{ V}$$

$$V_{BEsat} \text{ 0,70 to 0,85 V}$$

Knee voltage

$$I_C = 45 \text{ mA}; I_B = \text{value for which}$$

$$I_C = 50 \text{ mA at } V_{CE} = 2 \text{ V}$$

$$V_{CEK} < 0,8 \text{ V}$$

D.C. current gain

$$I_C = 10 \text{ mA}; V_{CE} = 1 \text{ V}$$

$$h_{FE} > 40$$

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

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

$$f_T > 500 \text{ MHz}$$

$$I_C = 40 \text{ mA}; V_{CE} = 10 \text{ V}$$

$$f_T > 490 \text{ MHz}$$

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

$$I_E = I_e = 0; V_{CB} = 5 \text{ V}$$

$$C_c < 4 \text{ pF}$$

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

$$I_C = I_c = 0; V_{EB} = 1 \text{ V}$$

$$C_e < 4,5 \text{ pF}$$

Maximum unilateral power gain ( $y_{re}$  assumed to be zero)

$$G_{UM} \text{ (in dB)} = 10 \log \frac{|y_{fe}|^2}{4g_{ie}g_{oe}}$$

$$I_C = 10 \text{ mA}; V_{CE} = 10 \text{ V}; f = 200 \text{ MHz}$$

$$G_{UM} \text{ typ. } 19 \text{ dB}$$

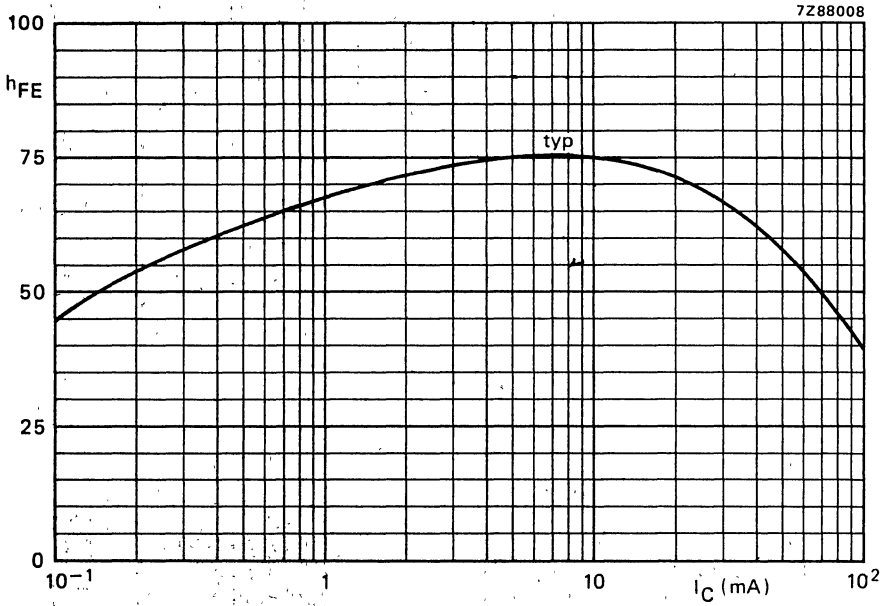


Fig. 2  $V_{CE} = 1$  V;  $T_j = 25$  °C.

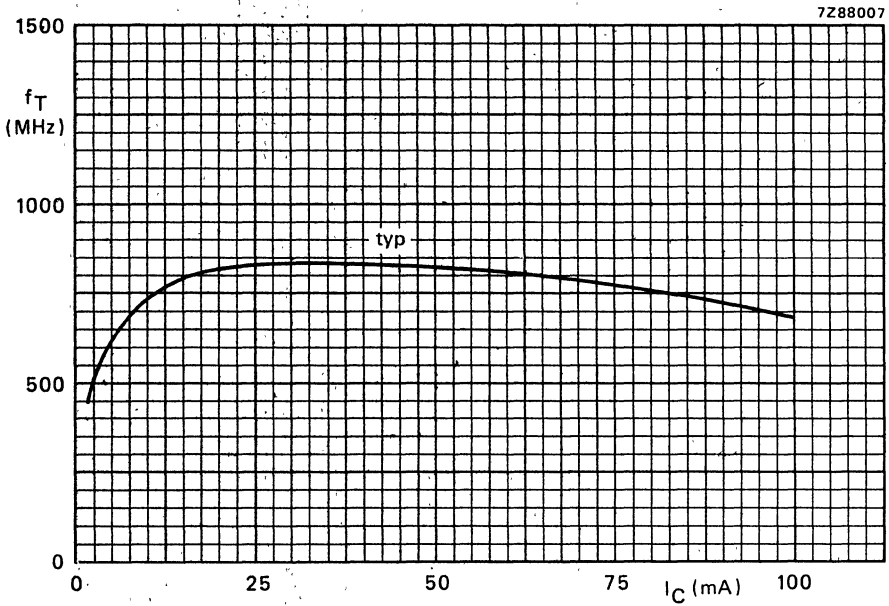


Fig. 3  $V_{CE} = 10$  V;  $T_j = 25$  °C.

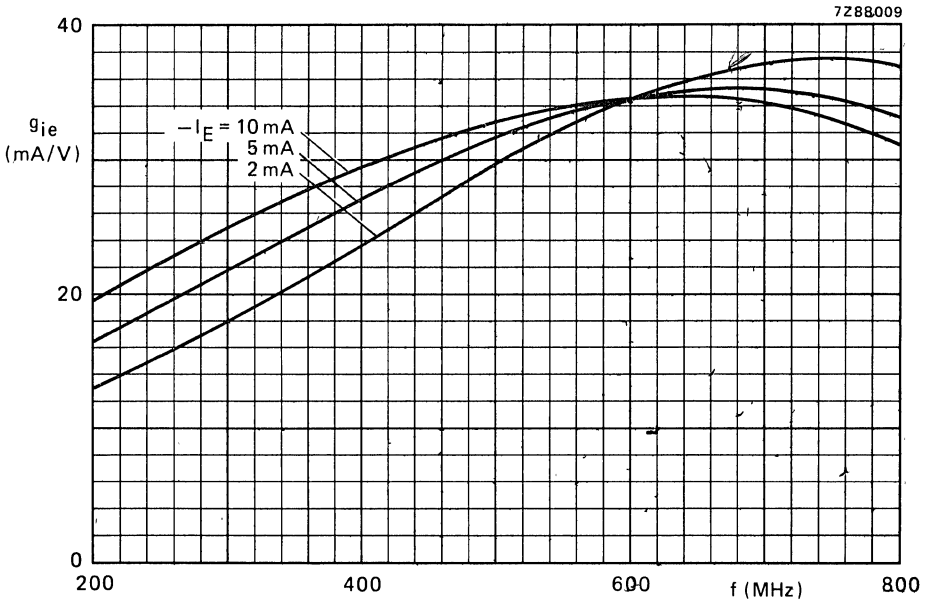


Fig. 4  $V_{CB} = 10 \text{ V}$ ;  $T_{amb} = 25 \text{ }^\circ\text{C}$ ; typical values.

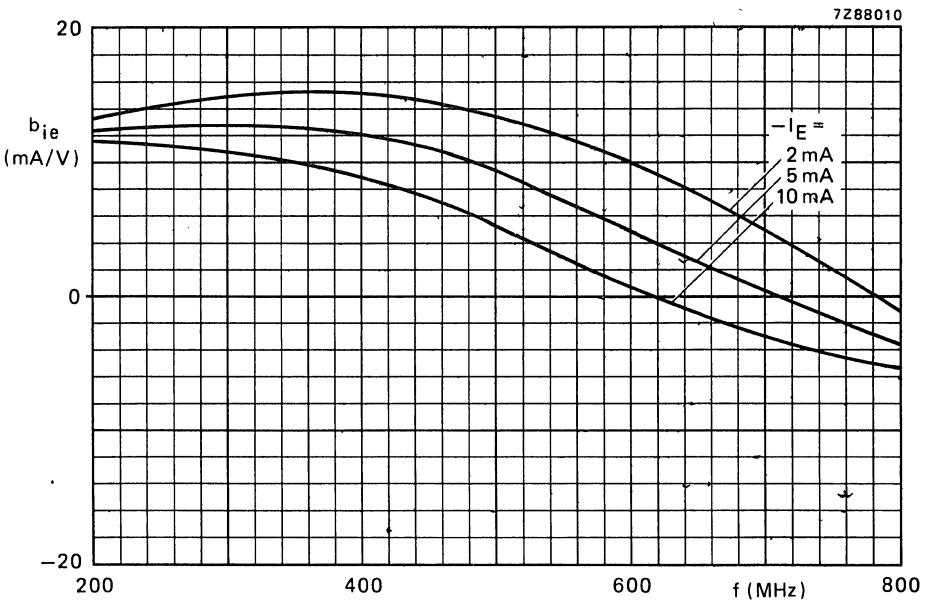


Fig. 5  $V_{CB} = 10 \text{ V}$ ;  $T_{amb} = 25 \text{ }^\circ\text{C}$ ; typical values.

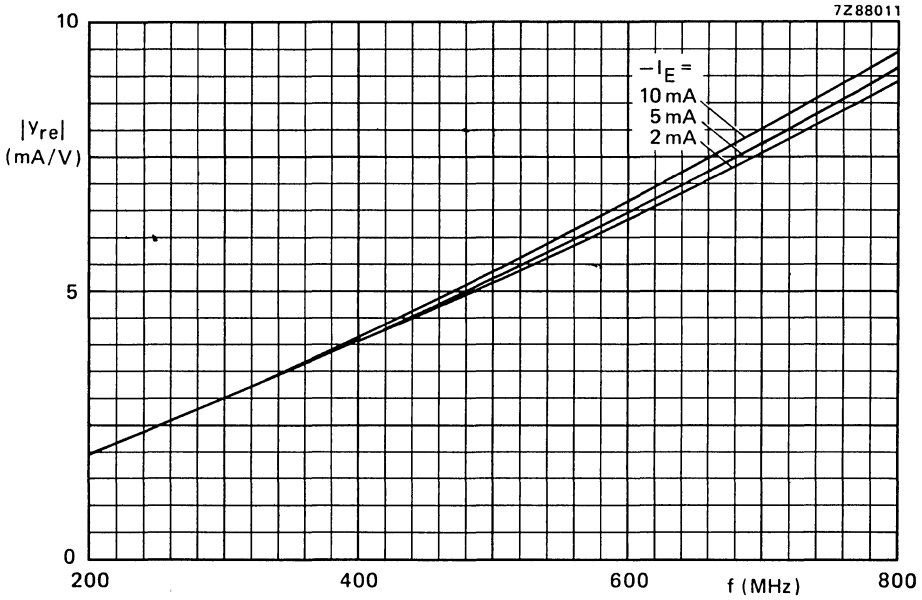


Fig. 6  $V_{CB} = 10$  V;  $T_{amb} = 25$  °C; typical values.

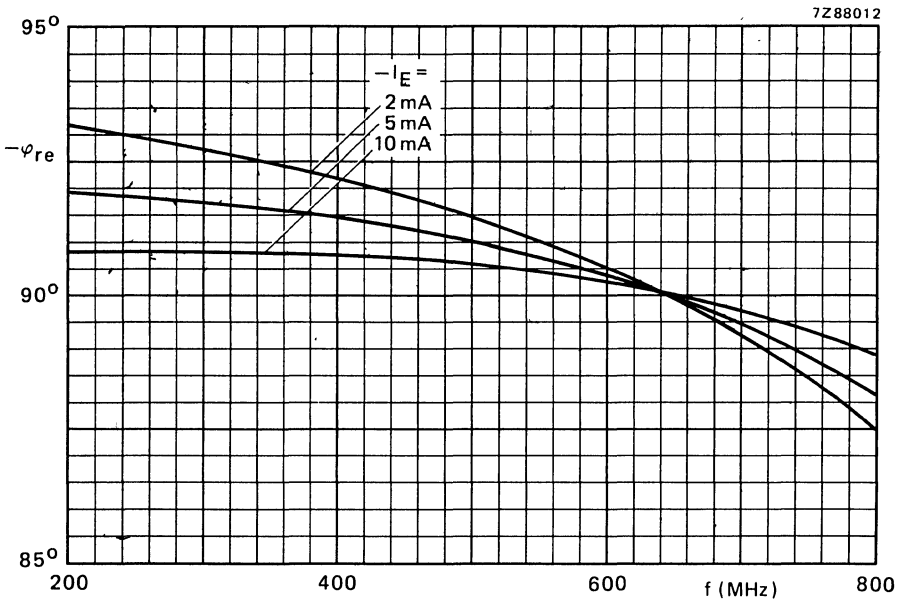


Fig. 7  $V_{CB} = 10$  V;  $T_{amb} = 25$  °C; typical values.

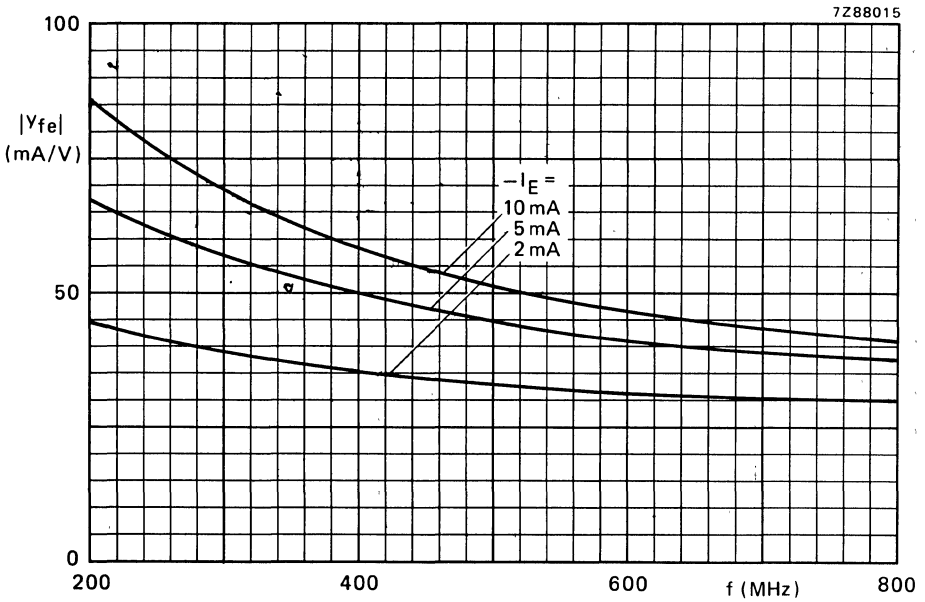


Fig. 8  $V_{CB} = 10$  V;  $T_{amb} = 25$  °C; typical values.

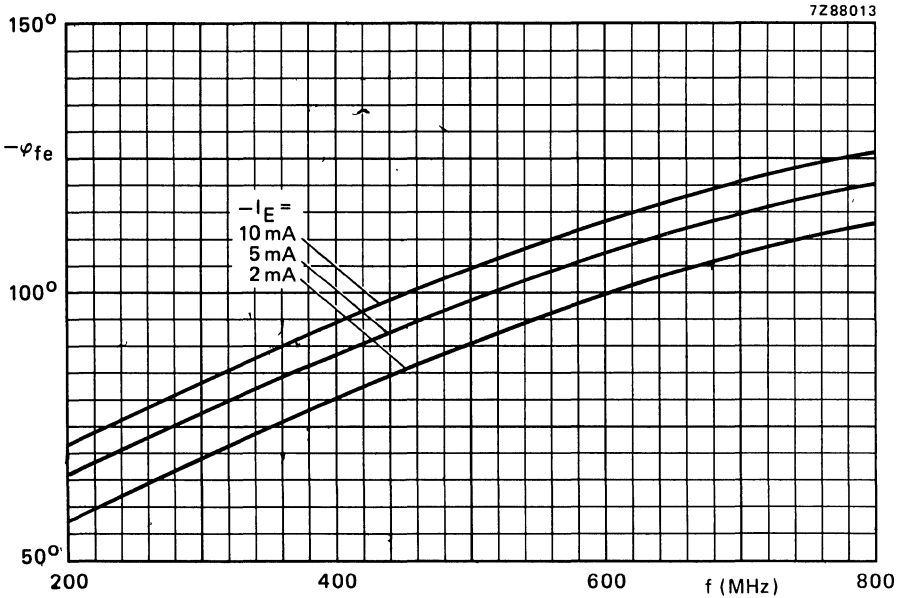


Fig. 9  $V_{CB} = 10$  V;  $T_{amb} = 25$  °C; typical values.

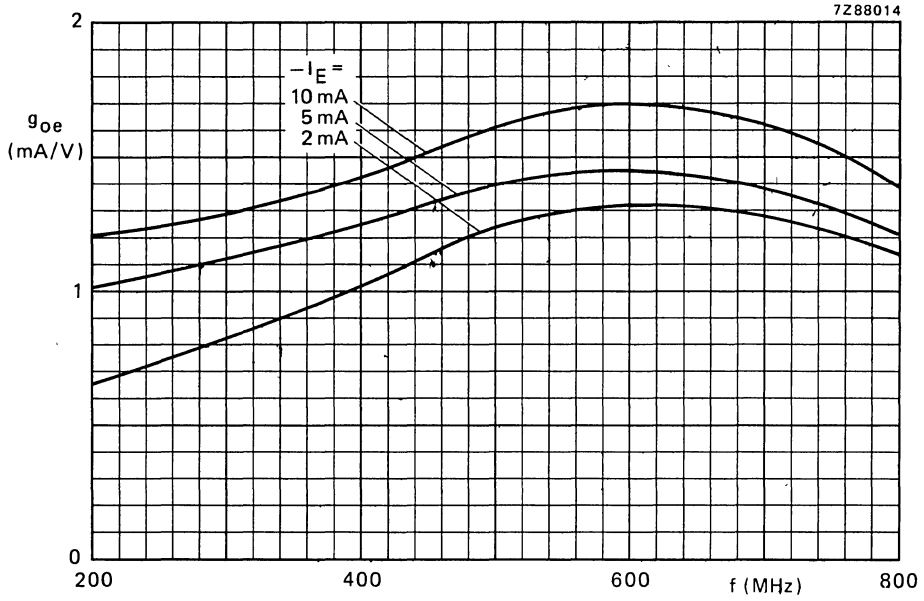


Fig. 10  $V_{CB} = 10$  V;  $T_{amb} = 25$  °C; typical values.

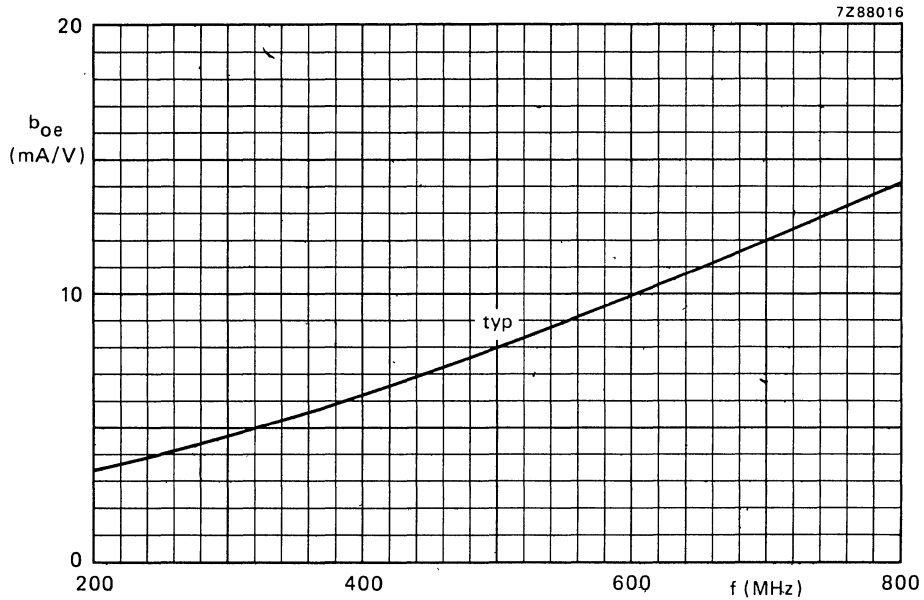


Fig. 11  $V_{CB} = 10$  V;  $-I_E = 2$  to 10 mA;  $T_{amb} = 25$  °C



## SILICON P-N-P HIGH-VOLTAGE TRANSISTORS

Planar epitaxial transistors in TO-39 metal envelopes, intended as general purpose amplifiers and switching devices in industrial and telephone applications.

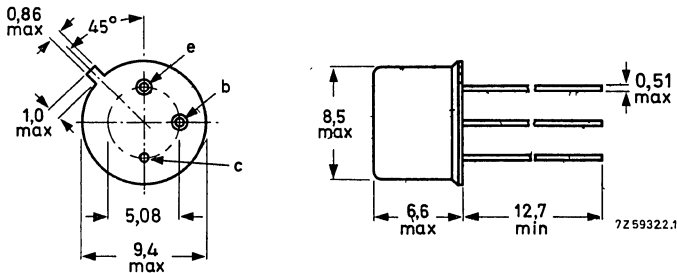
QUICK REFERENCE DATA					
			BFT44	BFT45	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	300	250	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	300	250	V
Collector current (d. c.)	$-I_C$	max.	0,5		A
Total power dissipation up to $T_{case} = 50\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	5,0		W
Junction temperature	$T_j$	max.	200		$^{\circ}\text{C}$
D.C. current gain $-I_C = 10\text{ mA}; -V_{CE} = 10\text{ V}$	$h_{FE}$		50 to 150		
Transition frequency at $f = 35\text{ MHz}$ $-I_C = 15\text{ mA}; -V_{CE} = 10\text{ V}$	$f_T$	typ.	70		MHz

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



max. lead diameter is guaranteed only for 12,7 mm

Accessories: 56245 (distance disc).



# BFT44 BFT45

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

Voltages

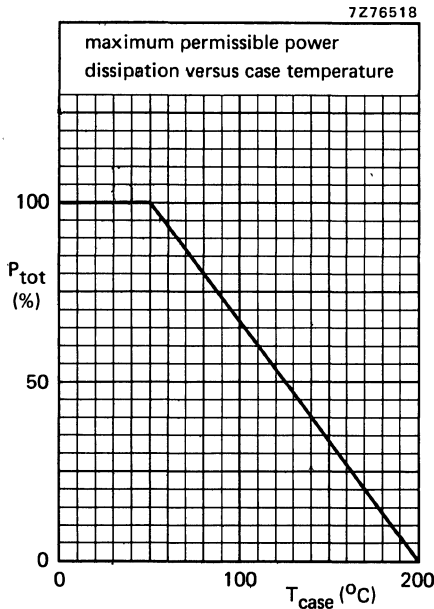
			BFT44	BFT45	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	300	250	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	300	250	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	V

Current

Collector current (d. c.)	$-I_C$	max.	0,5	A
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Power dissipation

Total power dissipation up to $T_{case} = 50\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	5,0	W
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Temperatures

Storage temperature	$T_{stg}$	-65 to +200	$^{\circ}\text{C}$
Junction temperature	$T_j$	max. 200	$^{\circ}\text{C}$

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th\ j-a}$	=	200	$^{\circ}\text{C}/\text{W}$
From junction to case	$R_{th\ j-c}$	=	30	$^{\circ}\text{C}/\text{W}$

**CHARACTERISTICS**

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

Collector cut-off current

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

$-I_{CBO} < 5\text{ }\mu\text{A}$

$I_B = 0; -V_{CE} = 200\text{ V}; T_j = 125\text{ }^\circ\text{C}$

$-I_{CEO} < 300\text{ }\mu\text{A}$

Emitter cut-off current

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

$-I_{EBO} < 5\text{ }\mu\text{A}$

Collector-emitter sustaining voltage

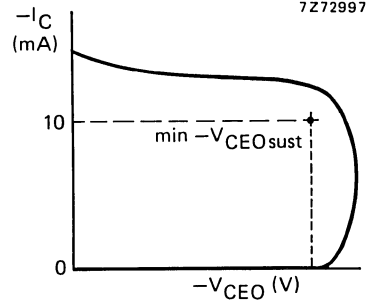
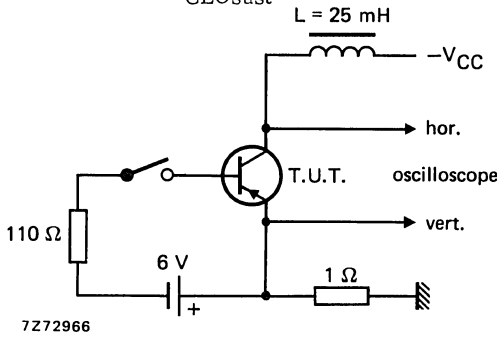
$-I_C = 10\text{ mA}; I_B = 0; L = 25\text{ mH}$

	BFT44	BFT45
$-V_{CEO\text{sust}}$	$> 300$	$250$

V 1)

Test circuit for  $V_{CEO\text{sust}}$

Oscilloscope display for  $V_{CEO\text{sust}}$



Saturation voltages

$-I_C = 10\text{ mA}; -I_B = 1\text{ mA}$

$-V_{CE\text{sat}} < 0,5\text{ V}$

$-V_{BE\text{sat}} < 0,8\text{ V}$

$-I_C = 100\text{ mA}; -I_B = 10\text{ mA}$

$-V_{CE\text{sat}} < 1,4\text{ V}$

$-V_{BE\text{sat}} < 0,9\text{ V}$

$-I_C = 500\text{ mA}; -I_B = 100\text{ mA}$

BFT44  
BFT45

$-V_{CE\text{sat}} < 5,0\text{ V } 2)$

$-V_{CE\text{sat}} < 3,0\text{ V } 2)$

$-V_{BE\text{sat}} < 1,2\text{ V } 2)$

D.C. current gain

$-I_C = 1\text{ mA}; -V_{CE} = 10\text{ V}$

$h_{FE} > 30$

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

$h_{FE} \text{ 50 to 150}$

$-I_C = 100\text{ mA}; -V_{CE} = 10\text{ V}$

$h_{FE} > 50 \quad 2)$

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

$I_E = I_e = 0; -V_{CB} = 20\text{ V}$

$C_c < 15\text{ pF}$

1)  $-V_{CC} = 0$  to  $50\text{ V}$ ;  $f = 400\text{ Hz}$ ;  $\delta = 0,5$  (see also test circuit).

2) Measured under pulse conditions:  $t_p = 300\text{ }\mu\text{s}$ ;  $\delta \leq 0,02$ .

**CHARACTERISTICS** (continued)

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

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

$-I_{C} = 15\text{ mA}; -V_{CE} = 10\text{ V}$	$f_T$	typ.	70	MHz
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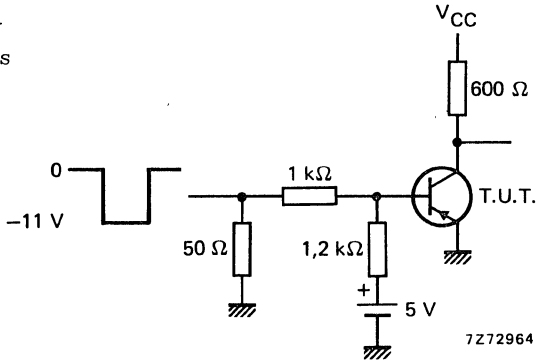
Switching times

$-I_{Con} = 50\text{ mA}; -I_{Bon} = I_{Boff} = 5\text{ mA}$ (test circuit 1)	$t_{on}$	typ.	125	ns
	$t_{off}$	typ.	850	ns

$-I_{Con} = 500\text{ mA}; -I_{Bon} = I_{Boff} = 100\text{ mA}$ (test circuit 2)	$t_{on}$	typ.	125	ns
	$t_{off}$	typ.	125	ns

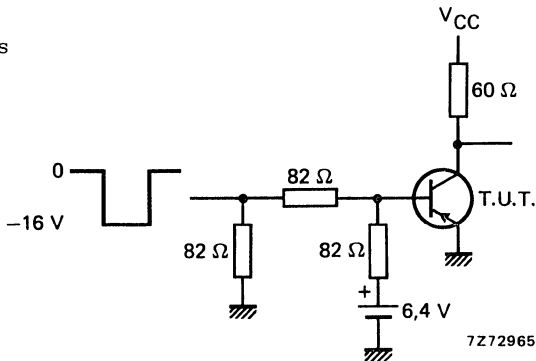
Test circuit 1

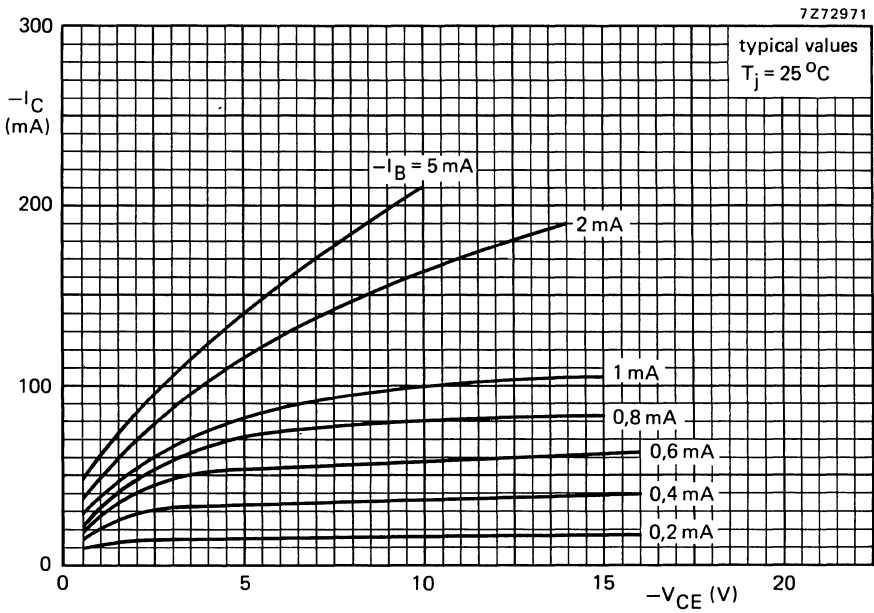
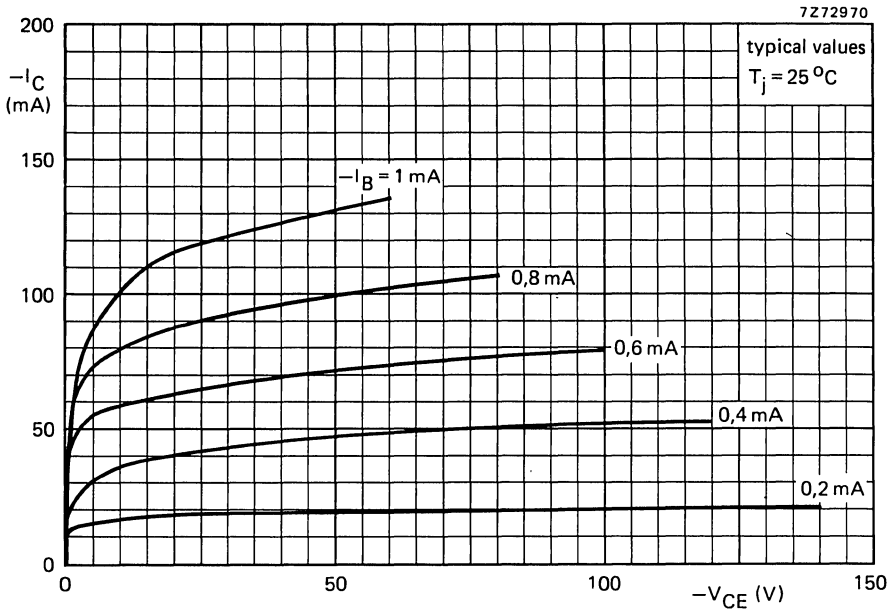
$V_{CC} = -31\text{ V}$   
 $t_p = 10\text{ }\mu\text{s}$

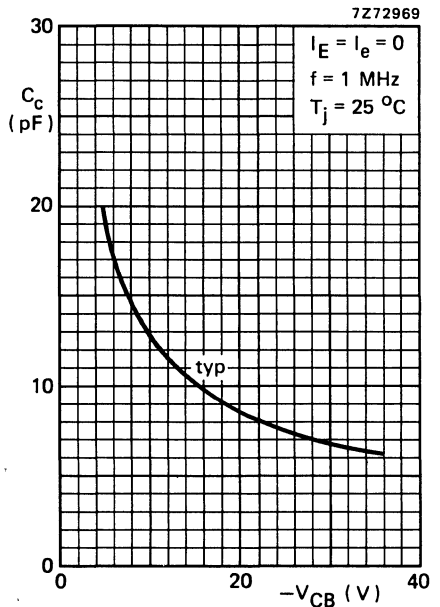
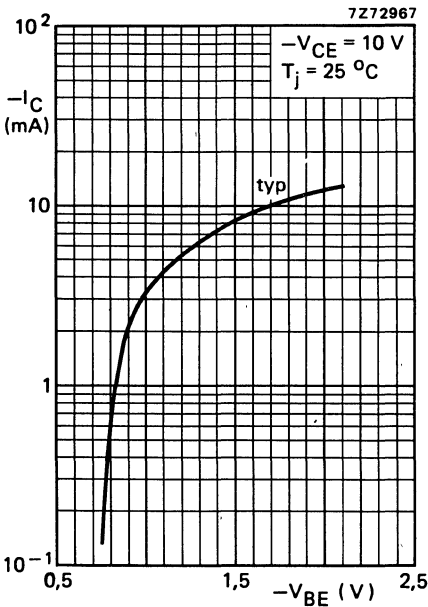
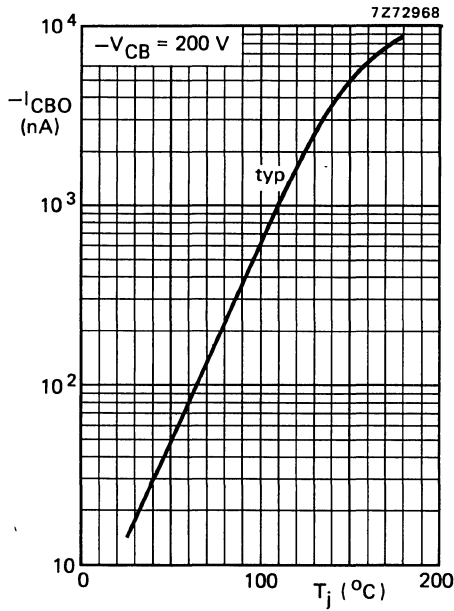


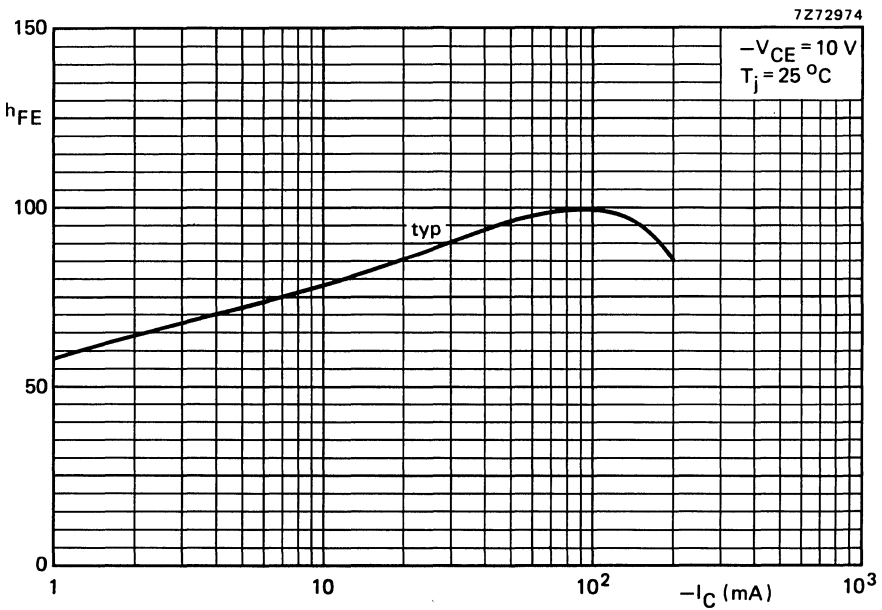
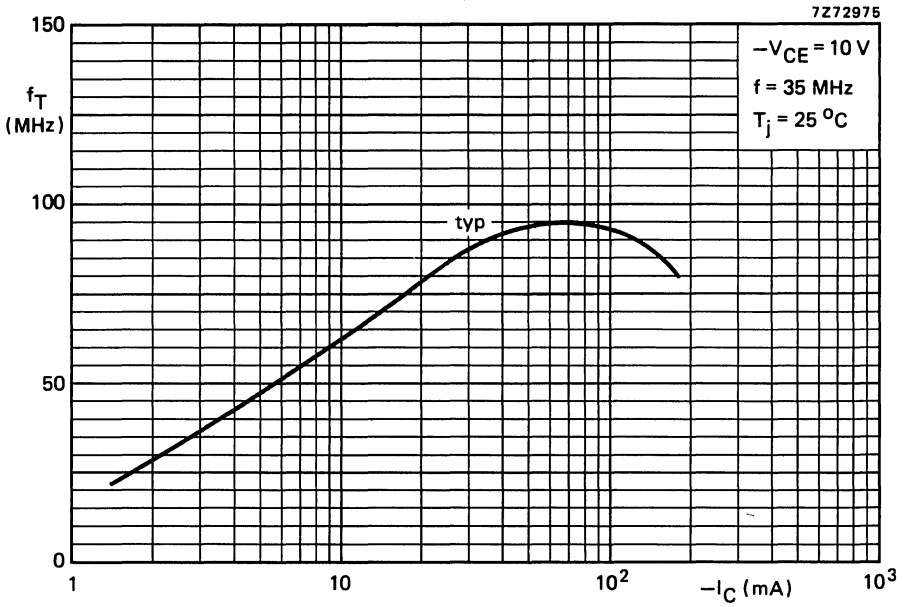
Test circuit 2

$V_{CC} = -31\text{ V}$   
 $t_p = 10\text{ }\mu\text{s}$

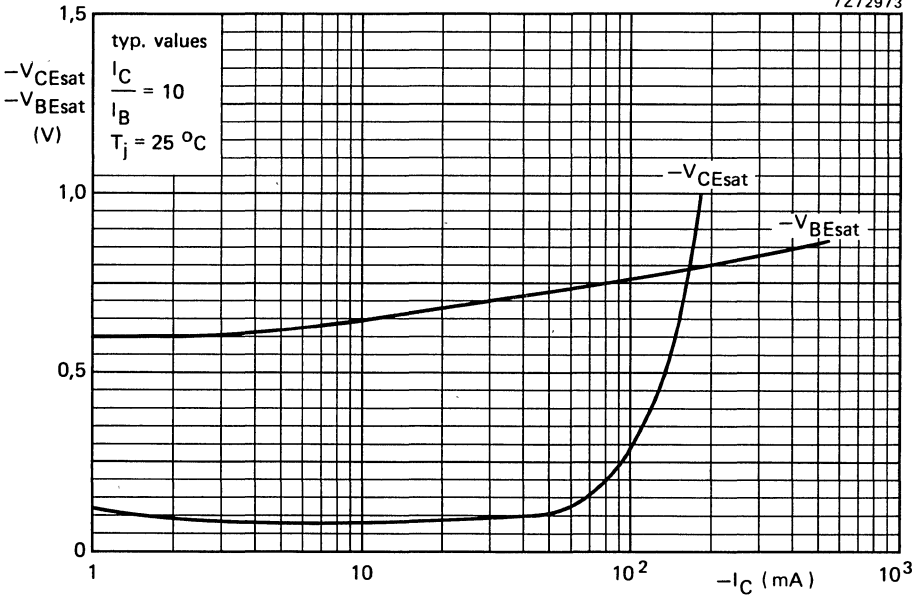




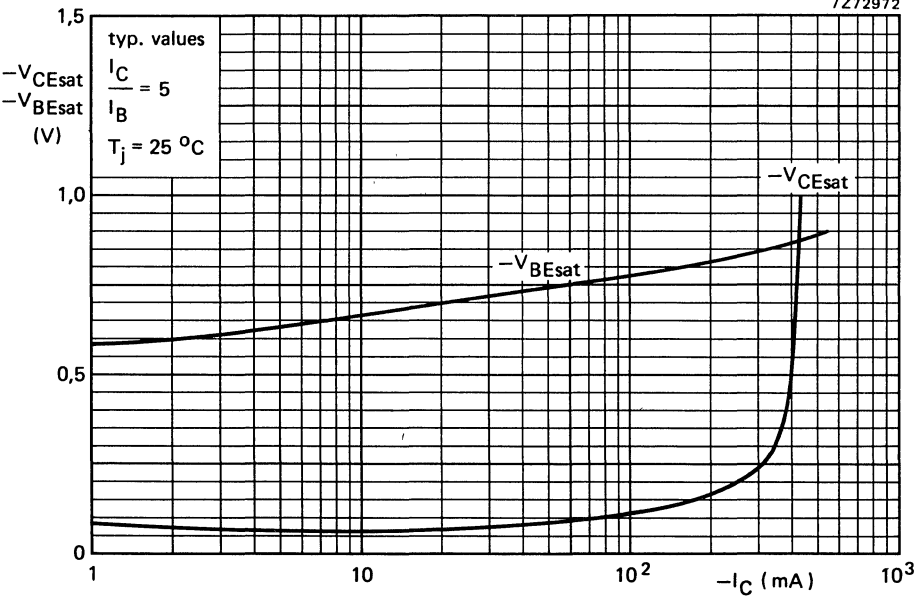




7272973



7272972



# SILICON PLANAR EPITAXIAL TRANSISTORS



P-N-P transistors in TO-39 metal envelopes for general industrial applications.

## QUICK REFERENCE DATA

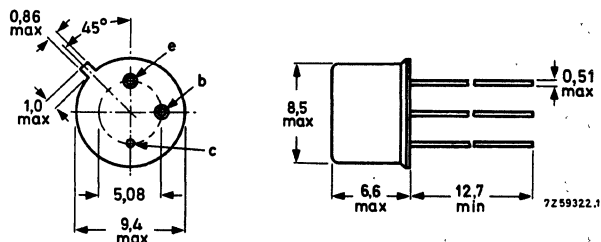
		BFX29	BFX87	BFX88	
Collector-base voltage (open emitter)	$-V_{CBO}$ max.	60	50	40	V
Collector-emitter voltage (open base)	$-V_{CEO}$ max.	60	50	40	V
Collector current (peak value)	$-I_{CM}$ max.	600	600	600	mA
Total power dissipation up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$ max.	600	600	600	mW
D.C. current gain	$h_{FE}$	> 50	40	40	
$-I_C = 10\text{ mA}; -V_{CE} = 10\text{ V}$	typ.	125	125	125	
Transition frequency at $f = 100\text{ MHz}$	$f_T$	> 100	100	100	MHz
$-I_C = 50\text{ mA}; -V_{CE} = 10\text{ V}$					

## MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).



RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical	BFX29	BFX87	BFX88	
$-V_{CBO}$ max.	60	50	40	V
$-V_{CEO}$ max.	60	50	40	V
$-V_{EBO}$ max.	5.0	4.0	4.0	V
$-I_C$ max.			600	mA
$-I_{CM}$ max.			600	mA
$I_{EM}$ max.			600	mA
$P_{tot}$ max. ( $T_{amb} \leq 25^\circ C$ )			600	mW
<b>Temperature</b>				
$T_{stg}$ range			-65 to +200	$^\circ C$
$T_j$ max.			+200	$^\circ C$

THERMAL CHARACTERISTIC

$$R_{th(j-amb)} = 292 \text{ degC/W}$$

ELECTRICAL CHARACTERISTICS ( $T_j = 25^\circ C$  unless otherwise stated)

		Min.	Typ.	Max.		
$-I_{CBO}$	Collector cut-off current					
	$-V_{CB} = 60V, I_E = 0$	BFX29	-	1.0	500	nA
	$-V_{CB} = 50V, I_E = 0$	BFX87	-	1.0	500	nA
	$-V_{CB} = 40V, I_E = 0$	BFX88	-	1.0	500	nA
	$-V_{CB} = 50V, I_E = 0$	BFX29	-	0.5	50	nA
	$-V_{CB} = 40V, I_E = 0$	BFX87	-	0.5	50	nA
	$-V_{CB} = 30V, I_E = 0$	BFX88	-	0.5	50	nA
	$-V_{CB} = 50V, I_E = 0,$ $T_j = 100^\circ C$	BFX29	-	0.03	2.0	$\mu A$
	$-V_{CB} = 40V, I_E = 0,$ $T_j = 100^\circ C$	BFX87	-	0.03	2.0	$\mu A$
	$-V_{CB} = 30V, I_E = 0,$ $T_j = 100^\circ C$	BFX88	-	0.03	2.0	$\mu A$
	$-I_{EBO}$	Emitter cut-off current				
		$-V_{EB} = 5.0V, I_C = 0$	BFX29	-	30	500
$-V_{EB} = 4.0V, I_C = 0$		BFX87, 88	-	2.0	500	nA
$-V_{EB} = 3.0V, I_C = 0$		BFX29, 87, BFX88	-	1.0	100	nA

## ELECTRICAL CHARACTERISTICS (cont'd)

			Min.	Typ.	Max.	
$h_{FE}$	Static forward current transfer ratio					
	$-I_C = 0.1\text{mA}$ , $-V_{CE} = 10\text{V}$	BFX29	20	90	-	
	$-I_C = 1.0\text{mA}$ , $-V_{CE} = 10\text{V}$	BFX29, 87, BFX88	40	105	-	
	$-I_C = 10\text{mA}$ , $-V_{CE} = 10\text{V}$	BFX29	50	125	-	
		BFX87, 88	40	125	-	
	$-I_C = 150\text{mA}$ , $-V_{CE} = 10\text{V}$	BFX29	50	125	-	
	BFX87, 88	40	90	-		
	$-I_C = 500\text{mA}$ , $-V_{CE} = 10\text{V}$	BFX87, 88	25	40	-	
$-V_{CE(\text{sat})}$	Collector-emitter saturation voltage					
	$-I_C = 150\text{mA}$ , $-I_B = 15\text{mA}$		-	0.15	0.40	V
$-V_{BE(\text{sat})}$	Base-emitter saturation voltage					
	$-I_C = 30\text{mA}$ , $-I_B = 1.0\text{mA}$		-	0.77	0.90	V
	$-I_C = 150\text{mA}$ , $-I_B = 15\text{mA}$		-	1.05	1.30	V
$C_{tc}$	Collector capacitance					
	$-V_{CB} = 10\text{V}$ , $I_E = I_e = 0$ , $f = 1.0\text{MHz}$		-	6.0	12	pF
$C_{te}$	Emitter capacitance					
	$-V_{EB} = 2.0\text{V}$ , $I_C = I_c = 0$ , $f = 1.0\text{MHz}$		-	18	30	pF
$f_T$	Transition frequency					
	$-I_C = 50\text{mA}$ , $-V_{CE} = 10\text{V}$ , $f = 100\text{MHz}$ , $T_{\text{amb}} = 25^\circ\text{C}$		100	360	-	MHz

ELECTRICAL CHARACTERISTICS (cont'd)

Saturated switching times (see test circuits)

		Min.	Typ.	Max.	
$t_{on}$	Turn-on time	-	25	60	ns
$t_{off}$	Turn-off time	-	55	150	ns

h-parameters

Measured at  $-I_C = 10\text{mA}$ ,  $-V_{CE} = 10\text{V}$ ,  $f = 1.0\text{kHz}$ ,  $T_{amb} = 25^\circ\text{C}$

		Min.	Typ.	Max.	
$h_{ie}$	Input impedance	-	600	-	$\Omega$
$h_{re}$	Voltage feedback ratio	-	1.50	-	$\times 10^{-4}$
$h_{fe}$	Forward current transfer ratio	-	155	-	
$h_{oe}$	Output admittance	-	104	-	$\mu\text{mho}$

SOLDERING AND WIRING RECOMMENDATIONS

1. When using a soldering iron, transistors may be soldered directly into the circuit, but heat conducted to the junction should if possible be kept to a minimum by the use of a thermal shunt.
2. Transistors may be dip-soldered at a solder temperature of  $245^\circ\text{C}$  for a maximum soldering time of 5 seconds. The case temperature during soldering must not at any time exceed the maximum storage temperature. These recommendations apply to a transistor mounted flush on a board having punched-through holes, or spaced at least 1.5mm above a board having plated-through holes.
3. Care should be taken not to bend the leads nearer than 1.5mm from the seal.
4. If devices are stored at temperatures above  $100^\circ\text{C}$  before incorporation into equipment, some deterioration of the external surface is likely to occur which may make soldering into the circuit difficult. Under these circumstances the leads should be retinned using a suitable activated flux.

TEST CIRCUITS

Saturated turn-on switching time

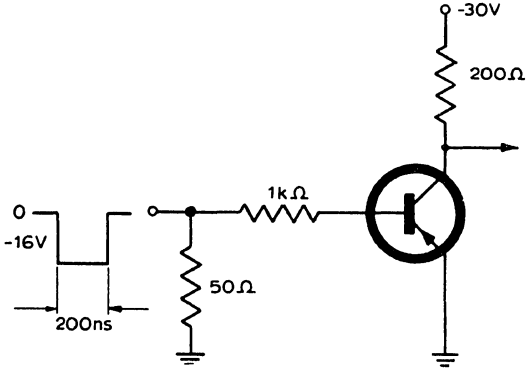


Fig.1

Saturated turn-off switching time

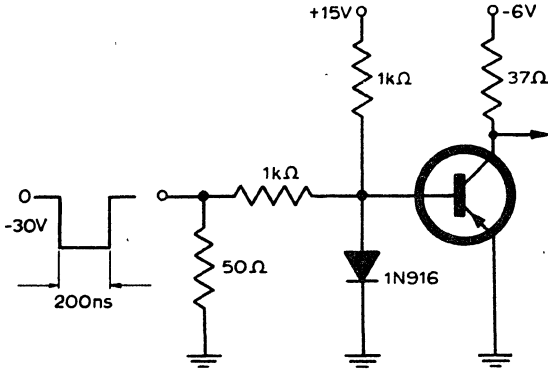
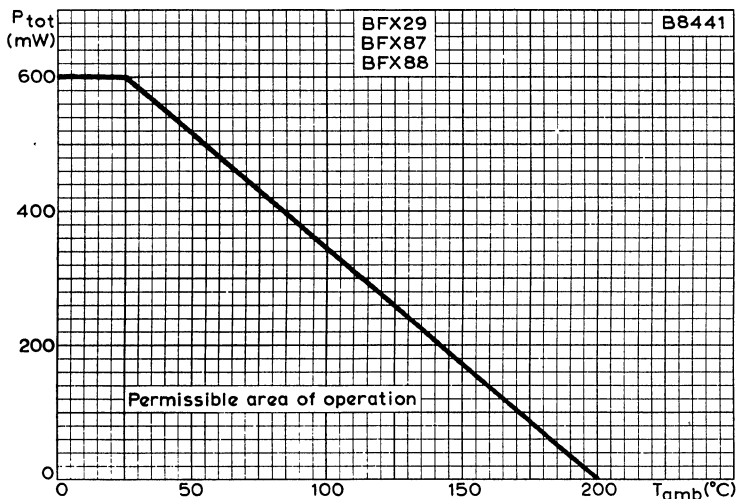
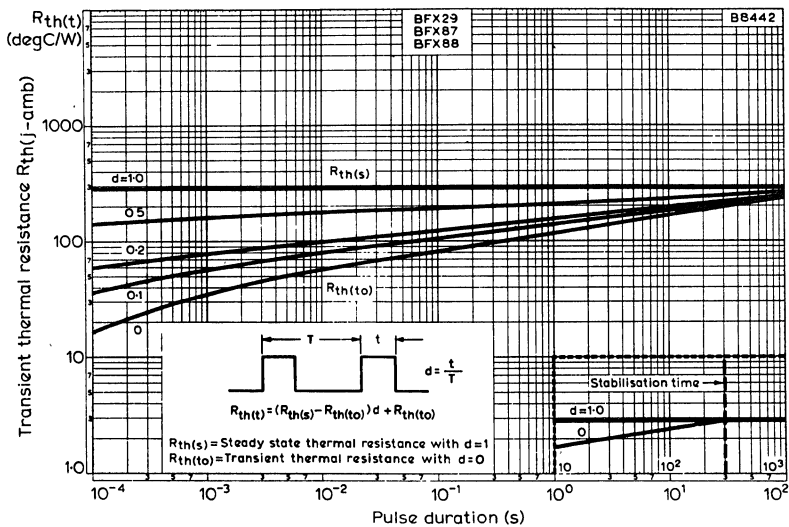


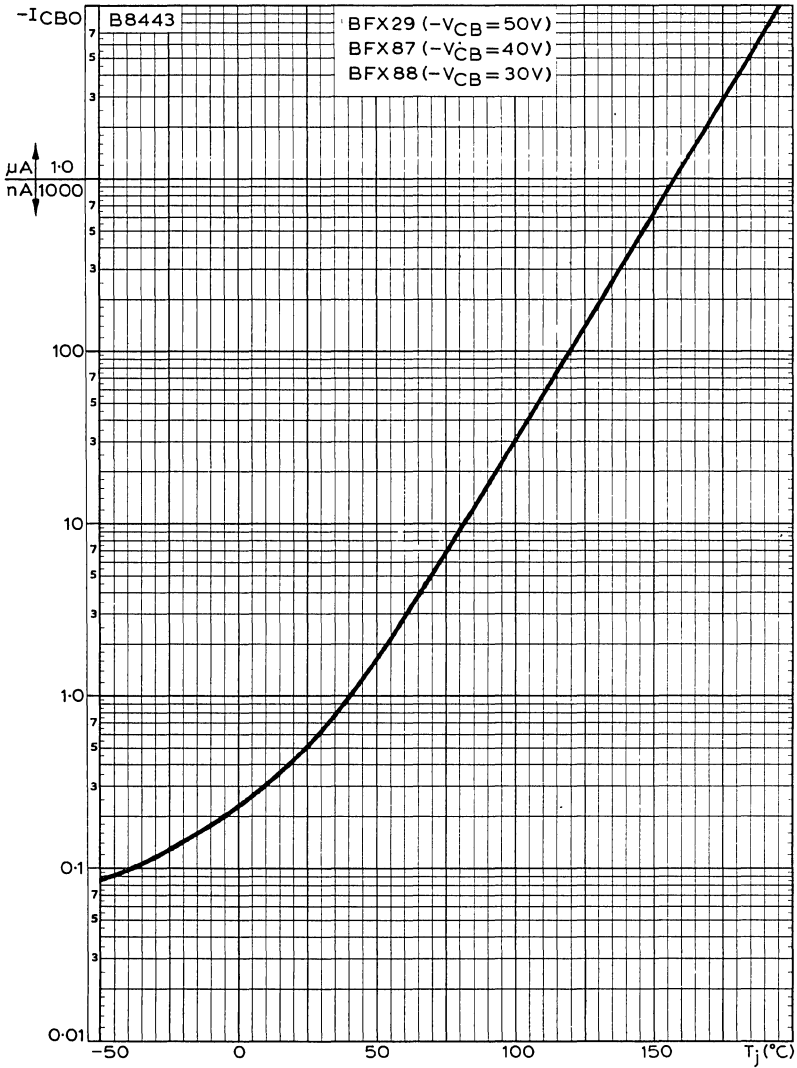
Fig.2



MAXIMUM TOTAL DISSIPATION PLOTTED AGAINST AMBIENT TEMPERATURE

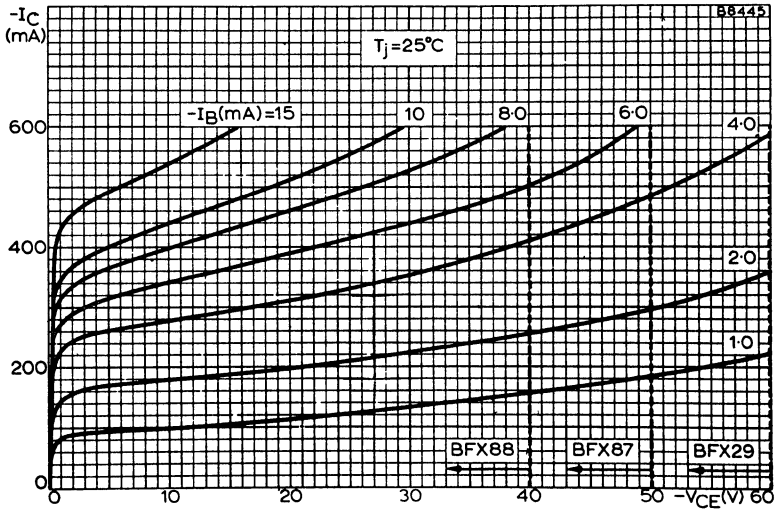
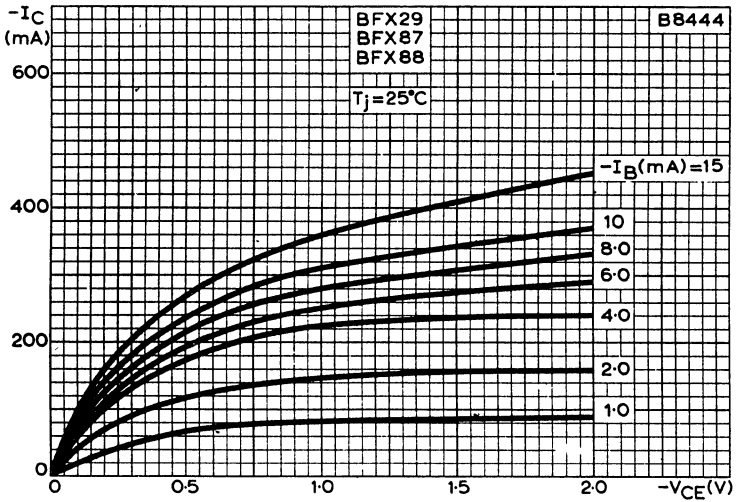


TRANSIENT THERMAL RESISTANCE FOR VARIOUS DUTY FACTORS PLOTTED AGAINST PULSE DURATION

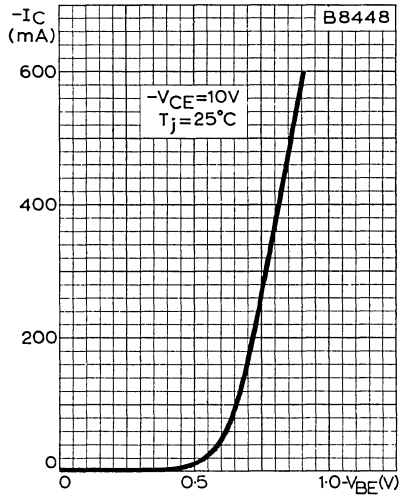
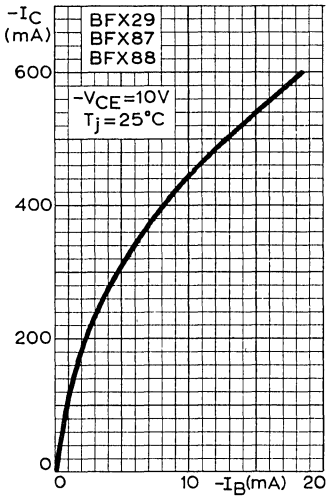


TYPICAL VARIATION OF COLLECTOR CUT-OFF CURRENT  
WITH JUNCTION TEMPERATURE

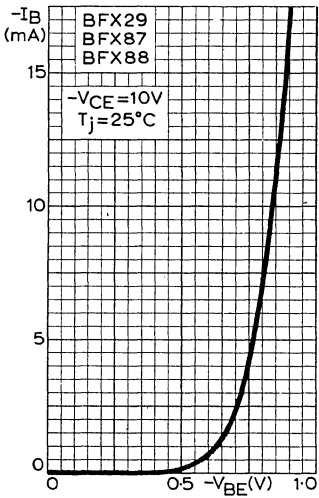
BFX29  
 BFX87  
 BFX88



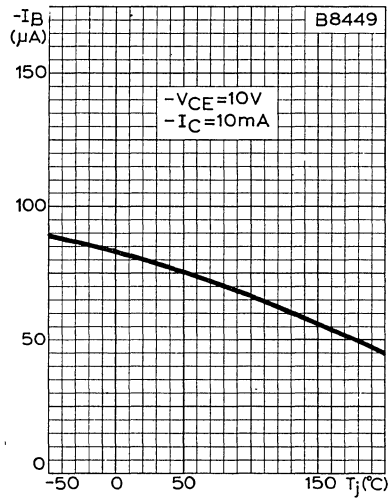
TYPICAL OUTPUT CHARACTERISTICS AT LOW AND HIGH  
 COLLECTOR-EMITTER VOLTAGES



TYPICAL TRANSFER AND MUTUAL CHARACTERISTICS



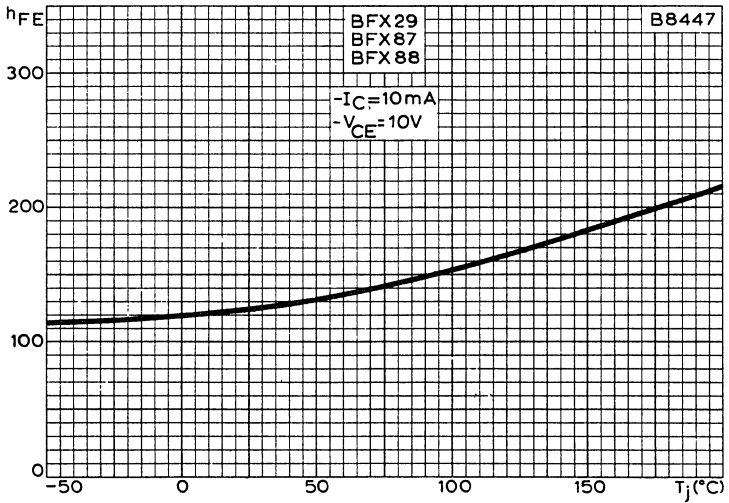
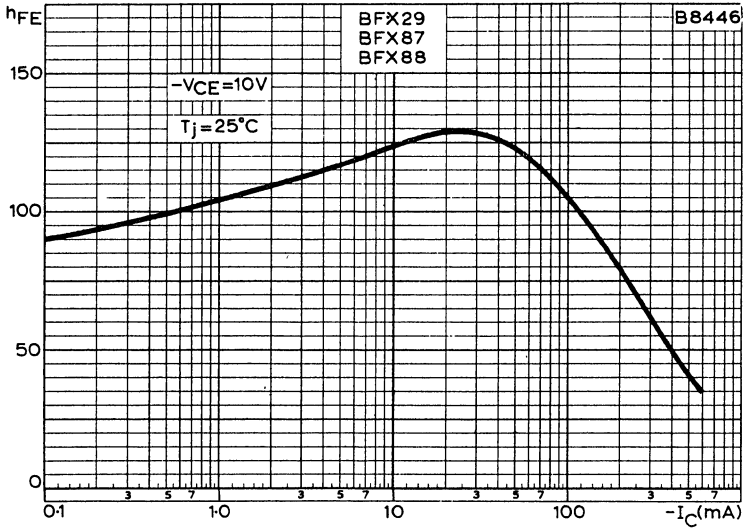
Typical input characteristic



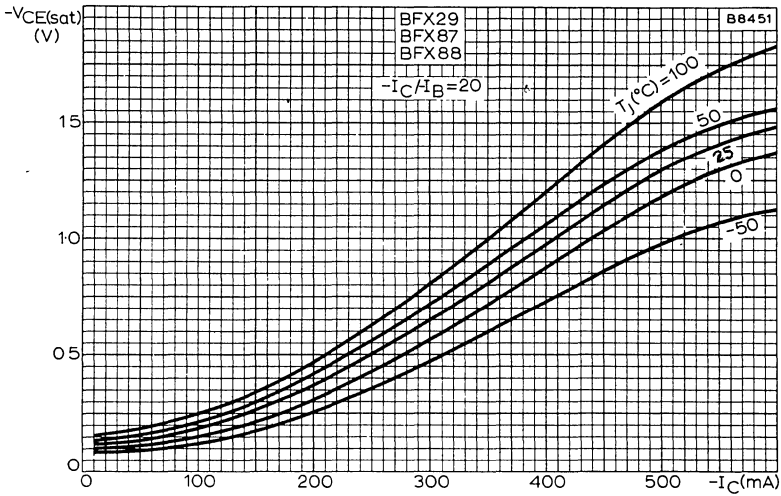
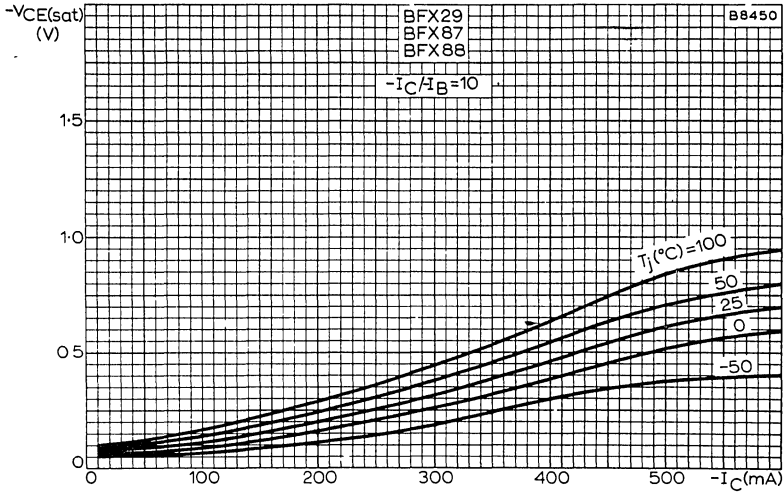
Typical base current versus junction temperature



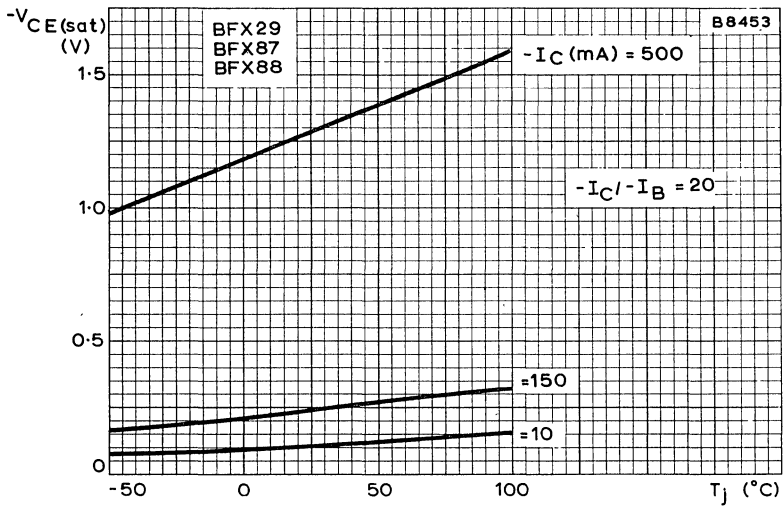
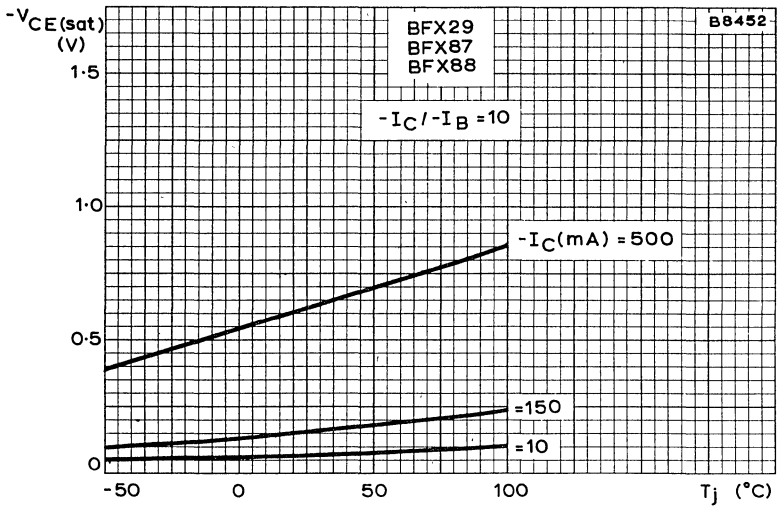
BFX29  
 BFX87  
 BFX88



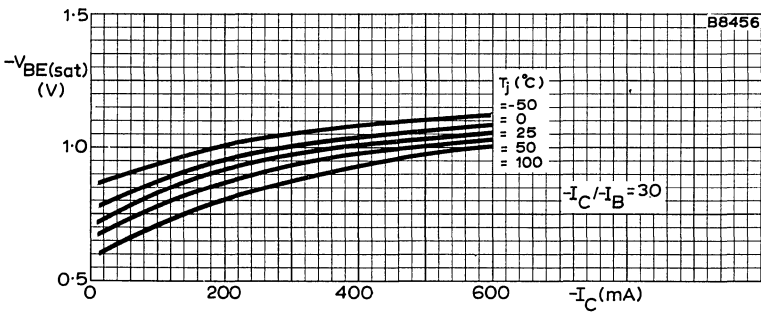
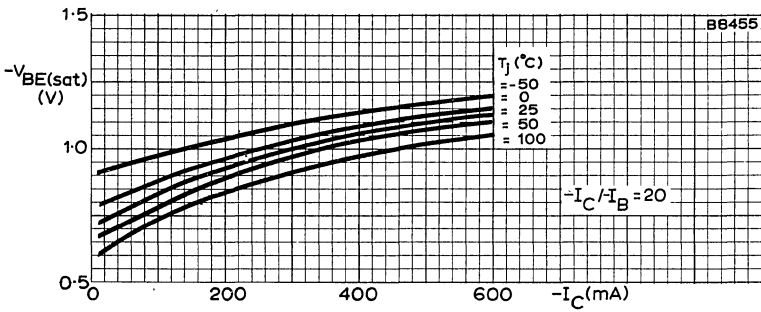
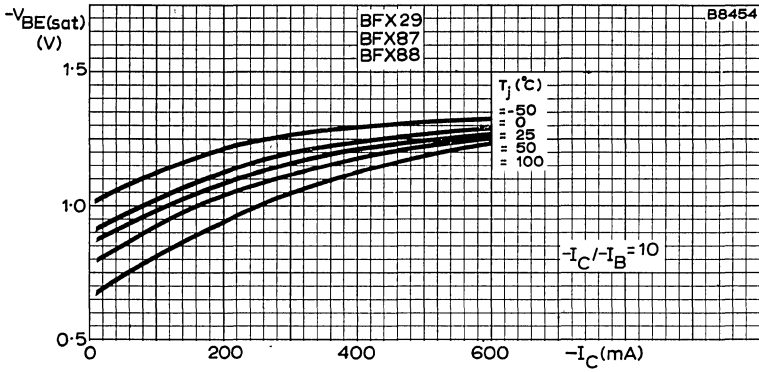
TYPICAL VARIATION OF STATIC FORWARD CURRENT TRANSFER RATIO WITH COLLECTOR CURRENT AND JUNCTION TEMPERATURE



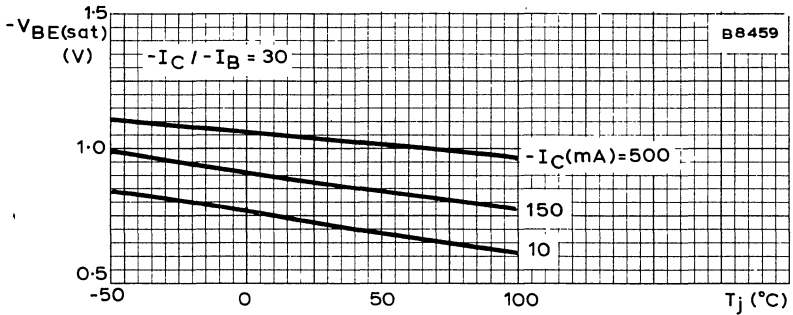
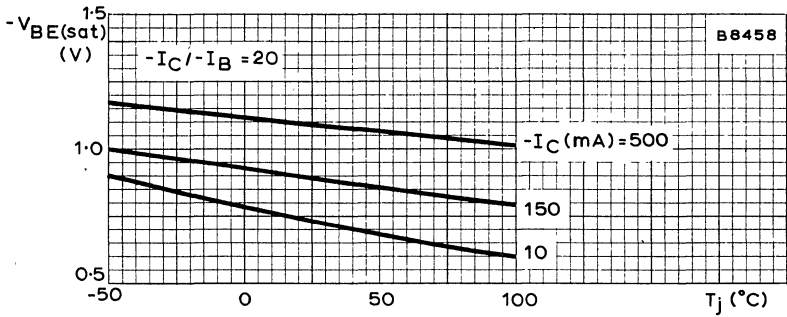
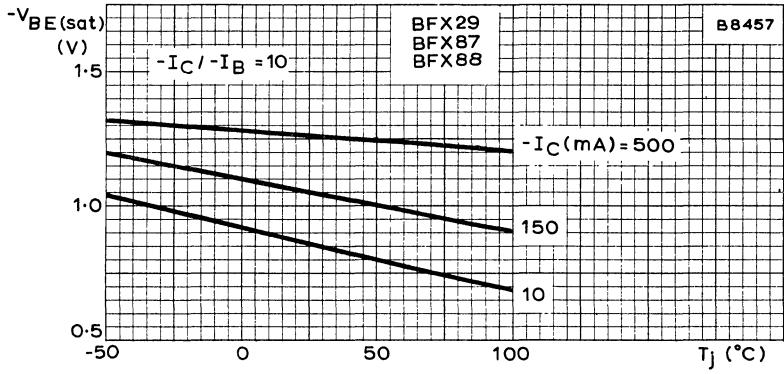
TYPICAL VARIATION OF COLLECTOR-EMITTER SATURATION VOLTAGE WITH COLLECTOR CURRENT



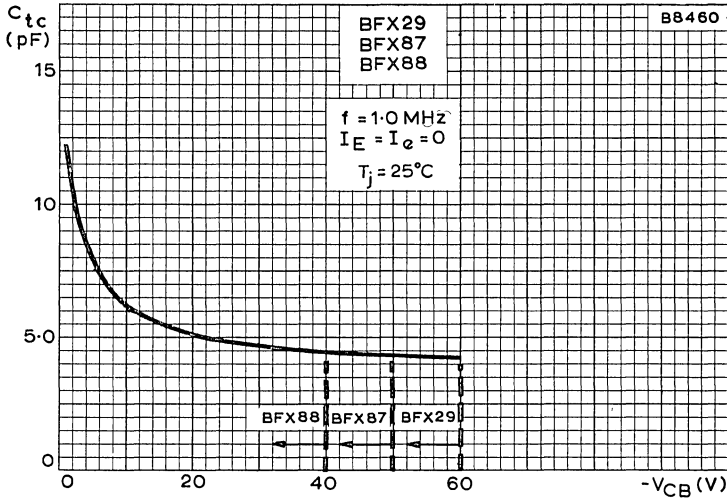
TYPICAL VARIATION OF COLLECTOR-EMITTER SATURATION VOLTAGE WITH JUNCTION TEMPERATURE



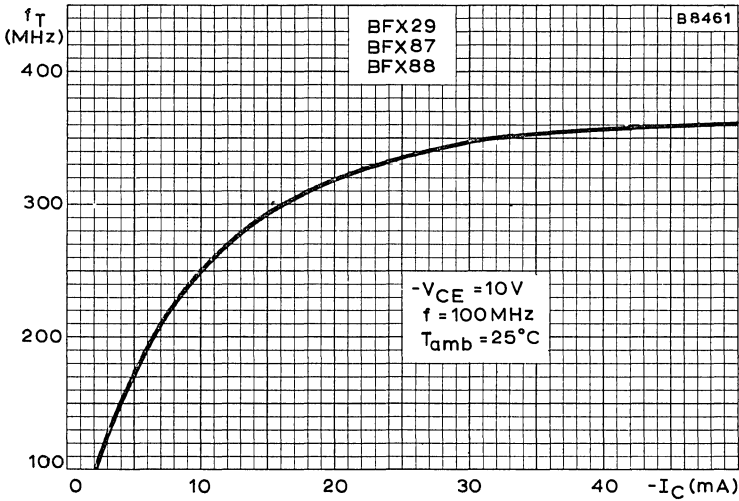
TYPICAL VARIATION OF BASE-EMITTER SATURATION VOLTAGE WITH COLLECTOR CURRENT



TYPICAL VARIATION OF BASE-EMITTER SATURATION  
 VOLTAGE WITH JUNCTION TEMPERATURE

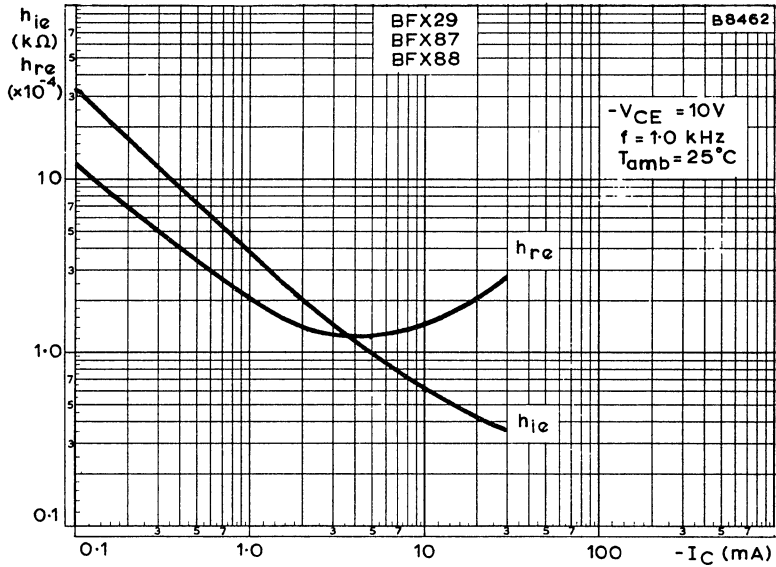


TYPICAL VARIATION OF COLLECTOR CAPACITANCE WITH COLLECTOR-BASE VOLTAGE

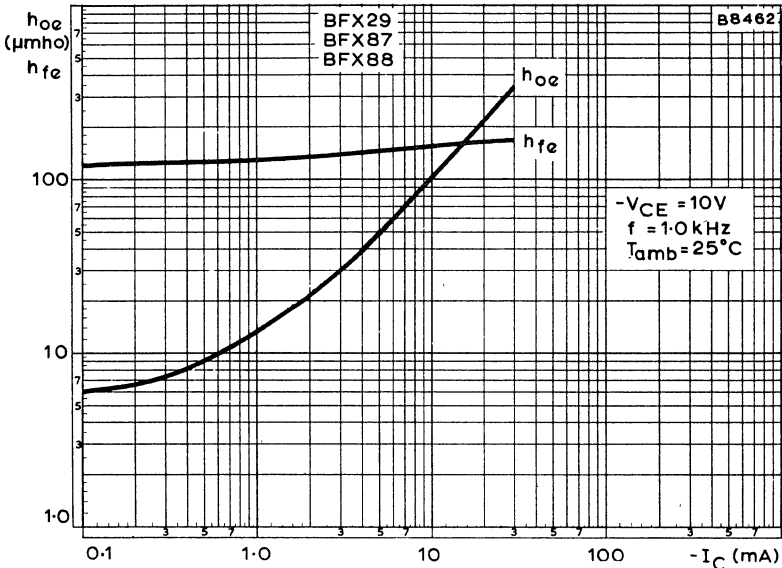


TYPICAL VARIATION OF TRANSITION FREQUENCY WITH COLLECTOR CURRENT

BFX29  
 BFX87  
 BFX88



TYPICAL INPUT IMPEDANCE AND TYPICAL VOLTAGE FEEDBACK RATIO PLOTTED AGAINST COLLECTOR CURRENT



TYPICAL FORWARD CURRENT TRANSFER RATIO AND TYPICAL OUTPUT ADMITTANCE PLOTTED AGAINST COLLECTOR CURRENT

## SILICON PLANAR EPITAXIAL TRANSISTOR



P-N-P transistor in a TO-39 metal envelope intended for switching applications.

## QUICK REFERENCE DATA

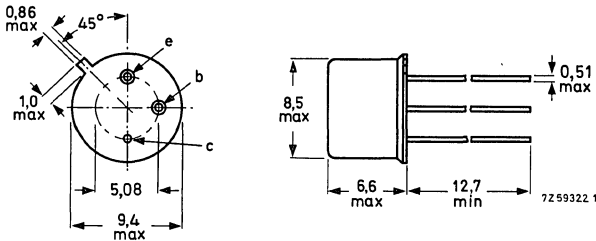
Collector-base voltage (open emitter)	$-V_{CBO}$ max.	65 V
Collector-emitter voltage (open base)	$-V_{CEO}$ max.	65 V
Collector current (peak value)	$-I_{CM}$ max.	600 mA
Total power dissipation up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$ max.	600 mW
D.C. current gain	$h_{FE}$ typ.	90
$-I_C = 10\text{ mA}; -V_{CE} = 0,4\text{ V}$		50 to 200
Storage time	$t_s$	< 250 ns
$-I_{Con} = 100\text{ mA}; -I_{Bon} = I_{Boff} = 10\text{ mA}$		

## MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).



## RATINGS

Limiting values of operation according to the absolute maximum system.

### Electrical

$-V_{CBO}$ max.	65	V
$-V_{CEO}$ max.	65	V
$-V_{EBO}$ max.	5.0	V
$-I_C$ max.	600	mA
$-I_{CM}$ max.	600	mA
$-I_{EM}$ max.	600	mA
$P_{tot}$ max. ( $T_{amb} \leq 25^\circ\text{C}$ )	600	mW

### Temperature

$T_{stg}$ min.	-65	$^\circ\text{C}$
$T_{stg}$ max.	200	$^\circ\text{C}$
$T_j$ max.	200	$^\circ\text{C}$

## THERMAL CHARACTERISTIC

$R_{th(j-amb)}$	292	degC/W
-----------------	-----	--------

## ELECTRICAL CHARACTERISTICS ( $T_j = 25^\circ\text{C}$ unless otherwise stated)

		Min.	Typ.	Max.	
$-I_{CBO}$	Collector cut-off current				
	$-V_{CB} = 65\text{V}, I_E = 0$	-	1.0	500	nA
	$-V_{CB} = 50\text{V}, I_E = 0$	-	0.5	50	nA
	$-V_{CB} = 50\text{V}, I_E = 0,$ $T_j = 100^\circ\text{C}$	-	0.03	2.0	$\mu\text{A}$
$-I_{EBO}$	Emitter cut-off current				
	$-V_{EB} = 5.0\text{V}, I_C = 0$	-	30	500	nA
	$-V_{EB} = 3.0\text{V}, I_C = 0$	-	1.0	100	nA
$-V_{BE(sat)}$	Base-emitter saturation voltage				
	$-I_C = 30\text{mA}, -I_B = 1.0\text{mA}$	-	0.77	0.90	V
	$-I_C = 150\text{mA}, -I_B = 15\text{mA}$	-	1.05	1.30	V
$h_{FE}$	Static forward current transfer ratio				
	$-I_C = 1.0\text{mA}, -V_{CE} = 0.4\text{V}$	40	80	-	
	$-I_C = 10\text{mA}, -V_{CE} = 0.4\text{V}$	50	90	200	
	$-I_C = 50\text{mA}, -V_{CE} = 0.4\text{V}$	20	92	-	
	$-I_C = 150\text{mA}, -V_{CE} = 0.4\text{V}$	10	50	-	

## ELECTRICAL CHARACTERISTICS (cont'd)

		Min.	Typ.	Max.	
$C_{tc}$	Collector capacitance $-V_{CB} = 10V, I_E = I_e = 0,$ $f = 1.0MHz$	-	6.0	12	pF
$C_{te}$	Emitter capacitance $-V_{EB} = 2.0V, I_C = I_c = 0,$ $f = 1.0MHz$	-	18	30	pF
Saturated switching times (see page 4)					
$-I_C = 100mA, -I_{Bon} = I_{Boff} = 10mA, V_{EE} = 10V, V_{BEoff} = 2.0V$					
$t_d$	Delay time	-	9	15	ns
$t_r$	Rise time	-	18	40	ns
$t_{on}$	Turn-on time ( $t_d + t_r$ )	-	27	50	ns
$t_s$	Storage time	-	95	250	ns
$t_f$	Fall time	-	30	50	ns
$t_{off}$	Turn-off time ( $t_s + t_f$ )	-	125	290	ns

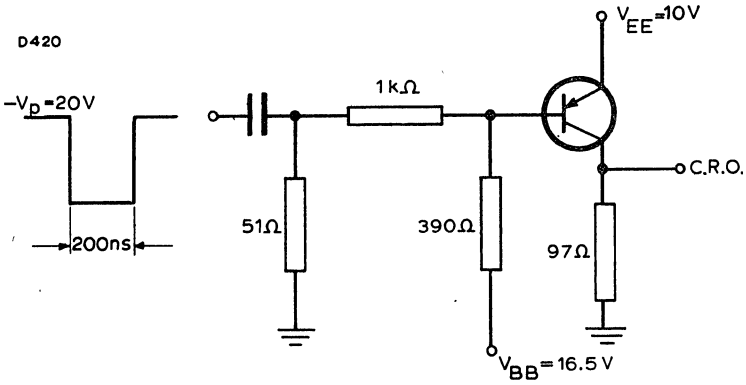
## SOLDERING AND WIRING RECOMMENDATIONS

1. When using a soldering iron, transistors may be soldered directly into the circuit, but heat conducted to the junction should if possible be kept to a minimum by the use of a thermal shunt.
2. Transistors may be dip-soldered at a solder temperature of  $245^{\circ}C$  for a maximum soldering time of 5 seconds. The case temperature during soldering must not at any time exceed the maximum storage temperature. These recommendations apply to a transistor mounted flush on a board having punched-through holes, or spaced at least 1.5mm above a board having plated-through holes.
3. Care should be taken not to bend the leads nearer than 1.5mm from the seal.
4. If devices are stored at temperatures above  $100^{\circ}C$  before incorporation into equipment, some deterioration of the external surface is likely to occur which may make soldering into the circuit difficult. Under these circumstances the leads should be retinned using a suitable activated flux.

ELECTRICAL CHARACTERISTICS (cont'd)

Saturated switching times

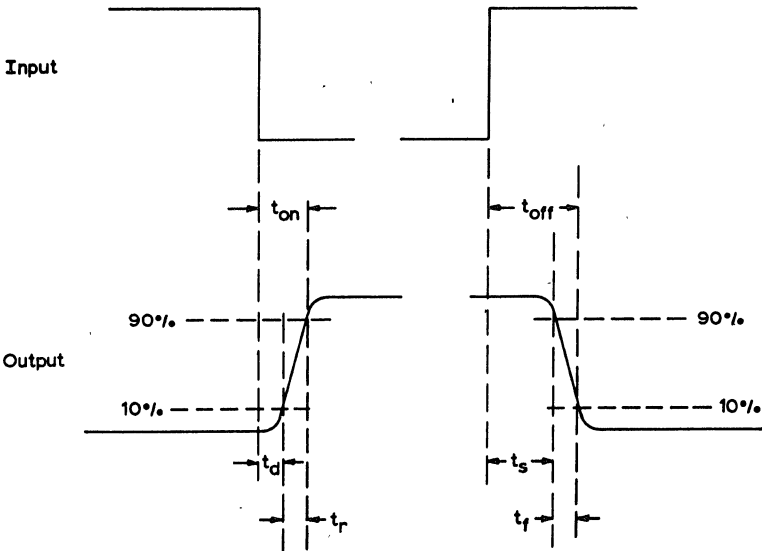
Test circuit

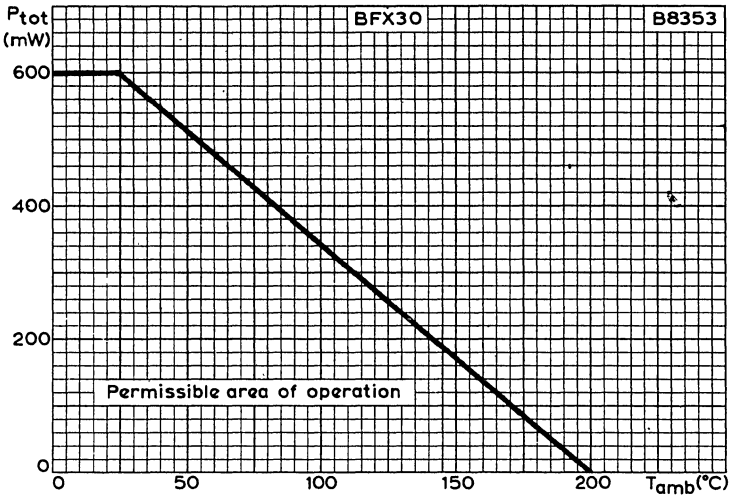


$-I_C = 100mA, -I_{B(on)} = I_{B(off)} = 10mA$

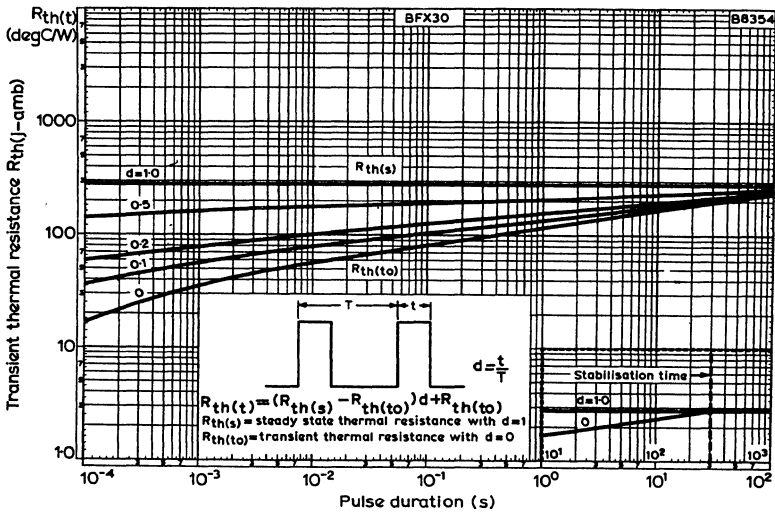
$V_{BE(off)} = 2.0V$

Waveforms

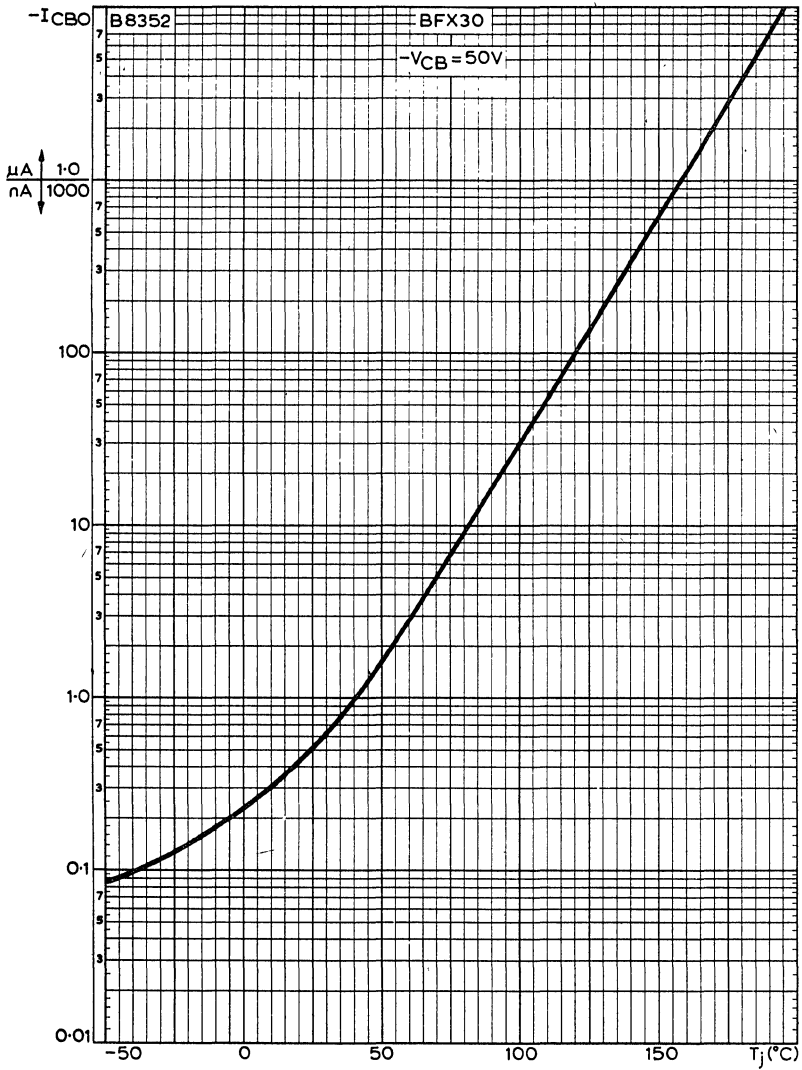




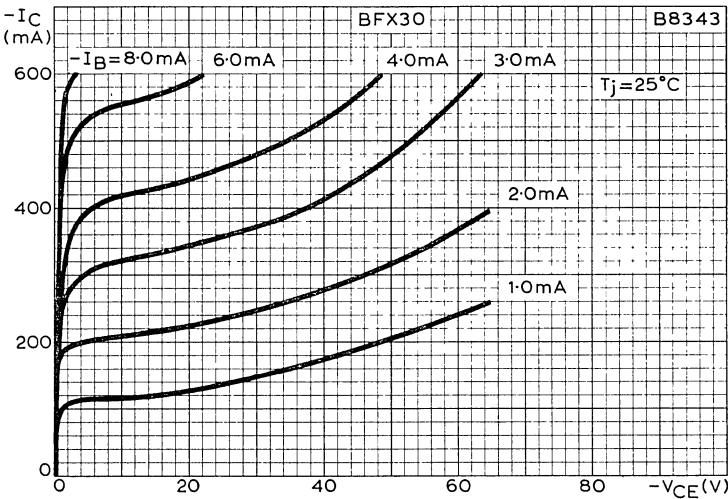
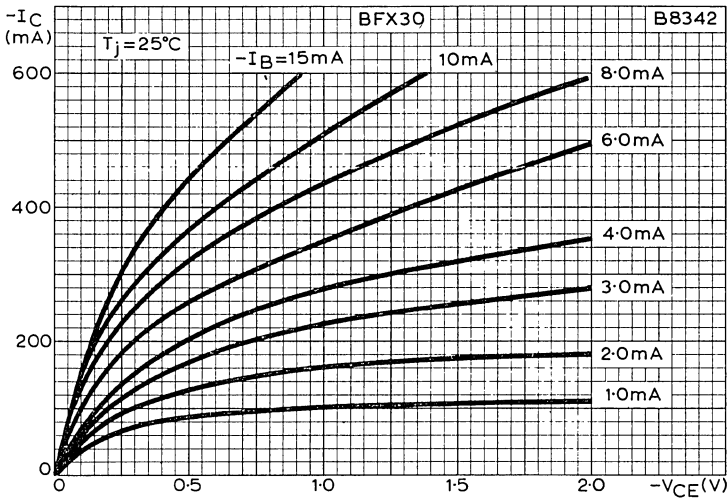
TOTAL DISSIPATION PLOTTED AGAINST AMBIENT TEMPERATURE



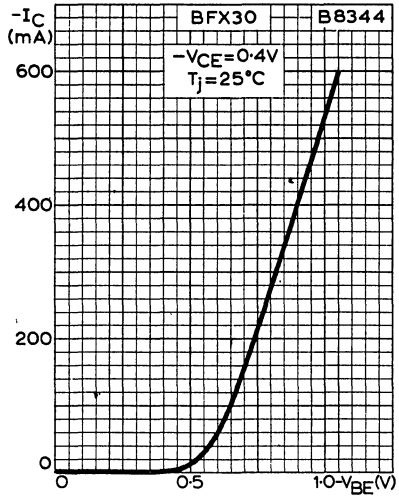
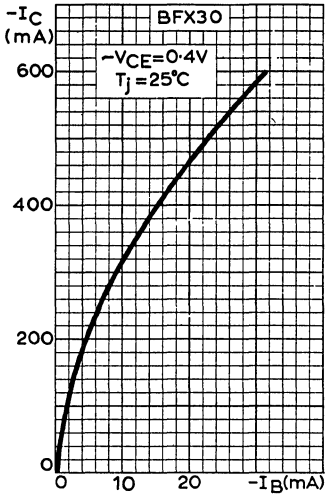
TRANSIENT THERMAL RESISTANCE FOR VARIOUS DUTY FACTORS PLOTTED AGAINST PULSE DURATION



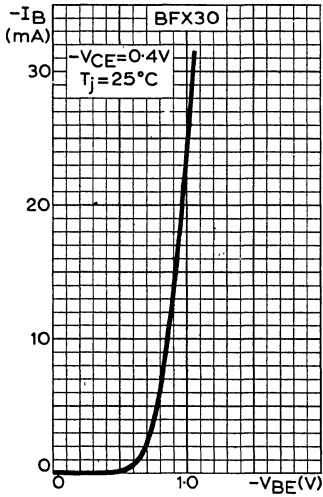
TYPICAL VARIATION OF COLLECTOR CUT-OFF CURRENT WITH JUNCTION TEMPERATURE



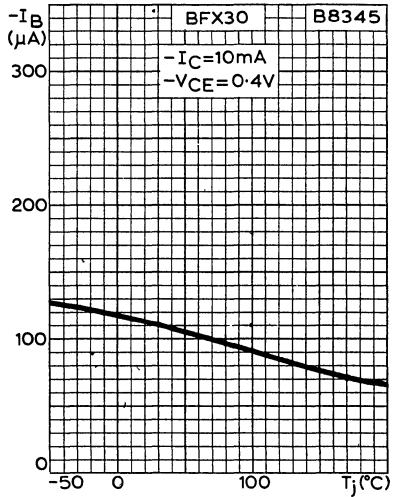
TYPICAL OUTPUT CHARACTERISTICS AT LOW AND HIGH COLLECTOR-EMITTER VOLTAGES



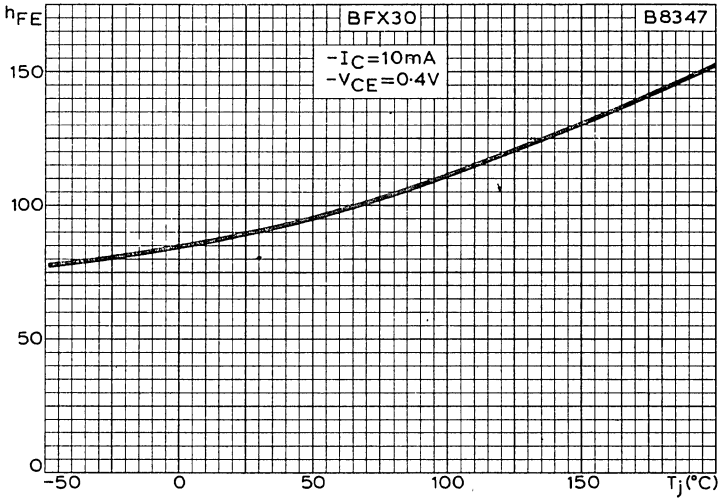
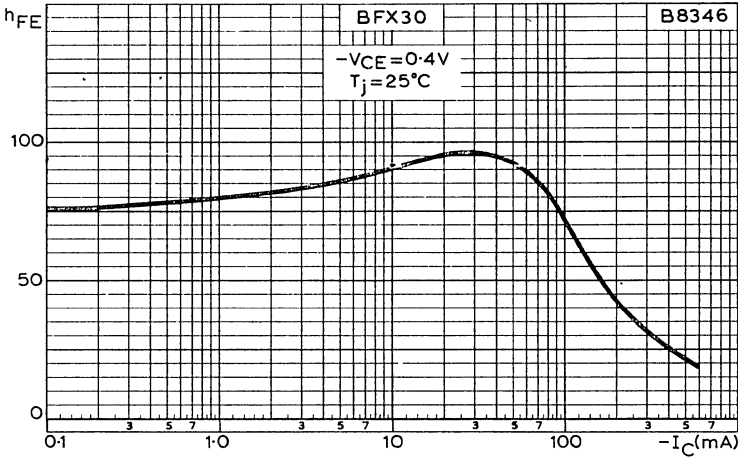
TYPICAL TRANSFER AND MUTUAL CHARACTERISTICS



Typical input characteristics

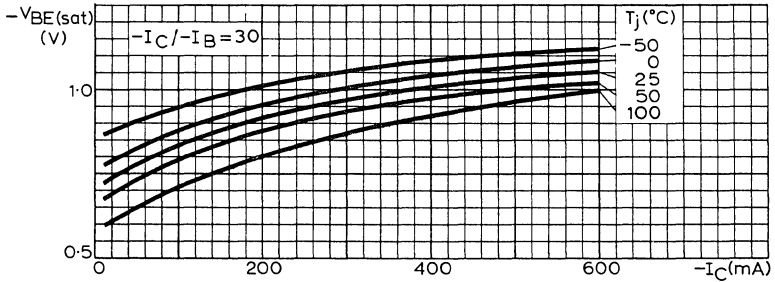
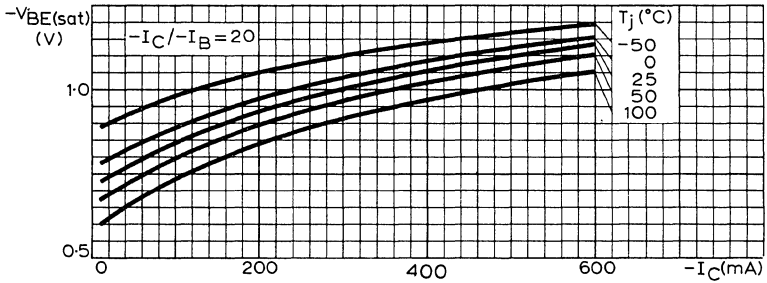
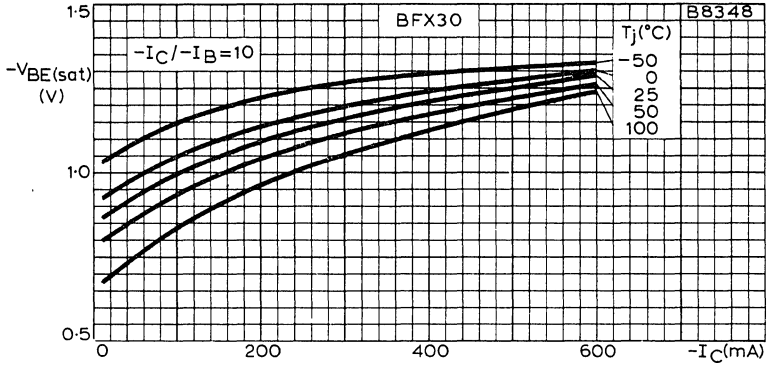


Typical base current versus junction temperature

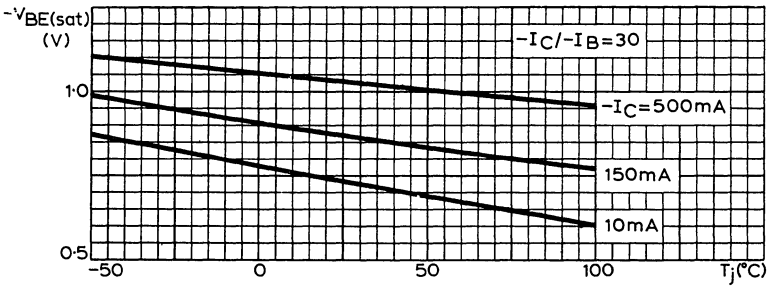
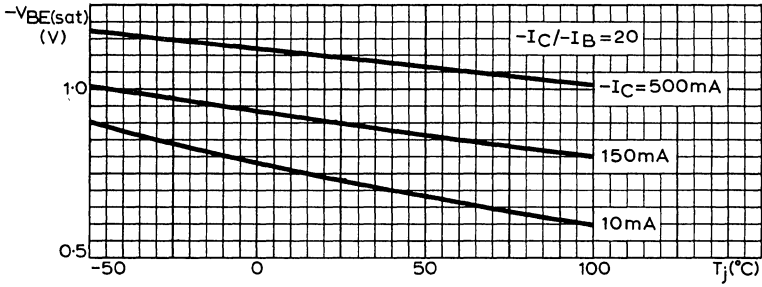
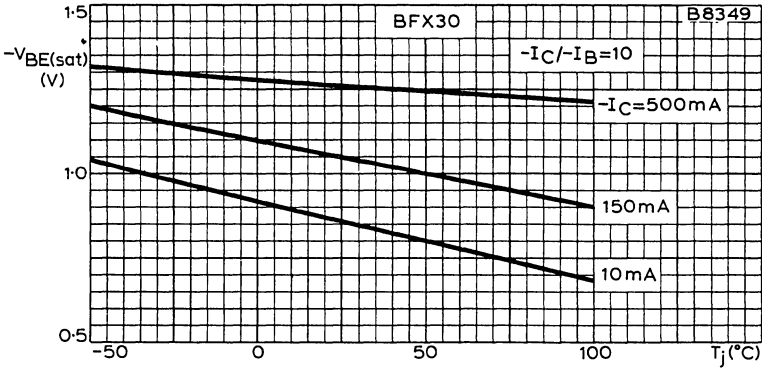


TYPICAL VARIATION OF STATIC FORWARD CURRENT TRANSFER RATIO WITH COLLECTOR CURRENT AND JUNCTION TEMPERATURE

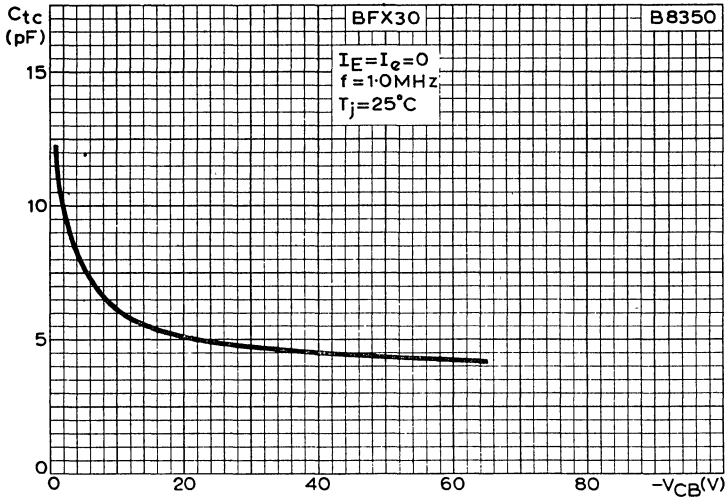




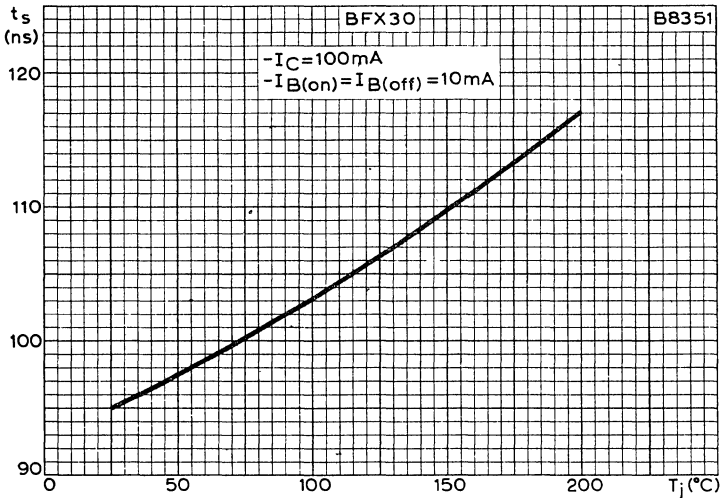
TYPICAL VARIATION OF BASE-EMITTER SATURATION VOLTAGE  
WITH COLLECTOR CURRENT AND  $I_C / I_B$  RATIO



TYPICAL VARIATION OF BASE-EMITTER SATURATION VOLTAGE  
WITH JUNCTION TEMPERATURE AND  $I_C / I_B$  RATIO



TYPICAL VARIATION OF COLLECTOR CAPACITANCE WITH COLLECTOR-BASE VOLTAGE



TYPICAL VARIATION OF STORAGE TIME WITH JUNCTION TEMPERATURE

## SILICON PLANAR EPITAXIAL TRANSISTOR



N-P-N transistor in a TO-39 metal envelope primarily intended for use as high-current switching device, e.g. inverters and switching regulators.

## QUICK REFERENCE DATA

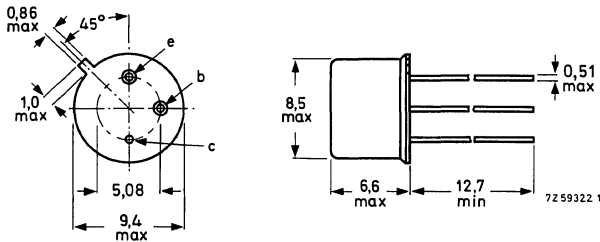
Collector-base voltage (open emitter)	$V_{CBO}$	max.	120 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	60 V
Collector current (peak value)	$I_{CM}$	max.	5,0 A
Total power dissipation up to $T_{case} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	5,0 W
Junction temperature	$T_j$	max.	200 $^{\circ}\text{C}$
D.C. current gain $I_C = 2\text{ A}; V_{CE} = 2\text{ V}$	$h_{FE}$	40 to	150
Transition frequency at $f = 35\text{ MHz}$ $I_C = 0,5\text{ A}; V_{CE} = 5\text{ V}$	$f_T$	>	70 MHz
Turn-off time when switched from $I_C = 5\text{ A}; I_B = 0,5\text{ A}$ to cut-off with $-I_{BM} = 0,5\text{ A}$	$t_{off}$	<	1,2 $\mu\text{s}$

## MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56254 (distance disc).

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

Voltages

Collector-base voltage (open emitter)	$V_{CBO}$	max.	120	V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	60	V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	6	V

Currents

Collector current (d. c.)	$I_C$	max.	2.0	A
Collector current (peak value)	$I_{CM}$	max.	5.0	A
Base current (d. c.)	$I_B$	max.	1.0	A

Power dissipation

Total power dissipation up to $T_{case} = 25^{\circ}C$	$P_{tot}$	max.	5.0	W
up to $T_{amb} = 25^{\circ}C$	$P_{tot}$	max.	0.87	W

Temperatures

Storage temperature	$T_{stg}$	-55 to +200	$^{\circ}C$
Junction temperature	$T_j$	max. 200	$^{\circ}C$

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th\ j-a}$	=	200	$^{\circ}C/W$
From junction to case	$R_{th\ j-c}$	=	35	$^{\circ}C/W$

**CHARACTERISTICS**

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

Collector cut-off current

$V_{EB} = 0; V_{CE} = 60\text{ V}$

$I_{CES} < 10\ \mu\text{A}$

Emitter cut-off current

$I_C = 0; V_{EB} = 4\text{ V}$

$I_{EBO}$  typ. 0.01  $\mu\text{A}$   
< 10  $\mu\text{A}$

Saturation voltages

$I_C = 5\text{ A}; I_B = 0.5\text{ A}$

$V_{CEsat}$  typ. 0.77 V  
< 1.0 V

$V_{BEsat}$  typ. 1.43 V  
< 1.8 V

D. C. current gain

$I_C = 1.0\text{ A}; V_{CE} = 2.0\text{ V}$

$h_{FE}$  typ. 130

$I_C = 1.5\text{ A}; V_{CE} = 0.6\text{ V}$

$h_{FE}$  typ. 60

$I_C = 2.0\text{ A}; V_{CE} = 2.0\text{ V}$

$h_{FE}$  typ. 110  
40 to 150

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

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

$C_c$  typ. 36 pF  
< 100 pF

Emitter-capacitance at  $f = 1\text{ MHz}$

$I_C = I_c = 0; V_{EB} = 0.5\text{ V}$

$C_e$  typ. 345 pF

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

$I_C = 0.5\text{ A}; V_{CE} = 5\text{ V}$

$f_T > 70\text{ MHz}$   
typ. 100 MHz

Turn on time when switched from

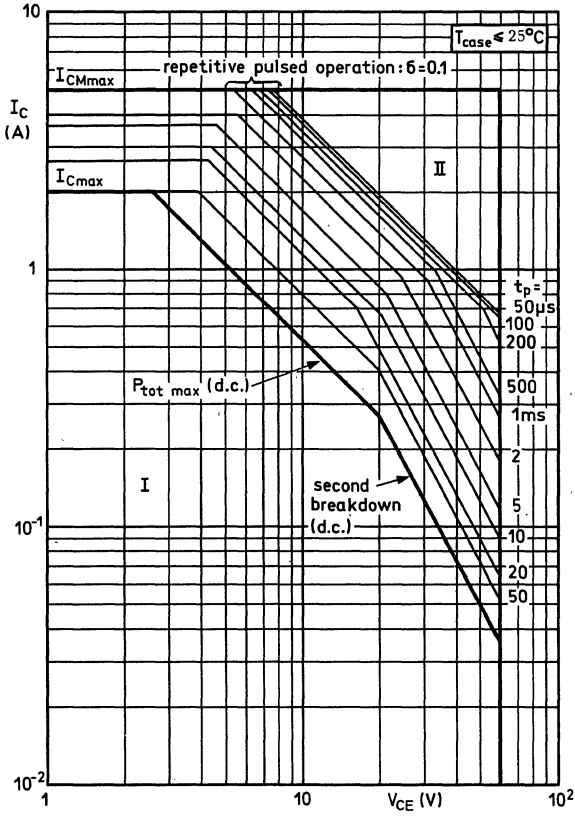
$-V_{BE} = 2.0\text{ V}$  to  $I_C = 5\text{ A}; I_B = 0.5\text{ A}$   
with  $I_{BM} = 0.5\text{ A}$

$t_{on}$  typ. 0.2  $\mu\text{s}$   
< 0.6  $\mu\text{s}$

Turn off time when switched from

$I_C = 5\text{ A}; I_B = 0.5\text{ A}$  to  $-V_{BE} = 2.0\text{ V}$   
with  $-I_{BM} = 0.5\text{ A}$

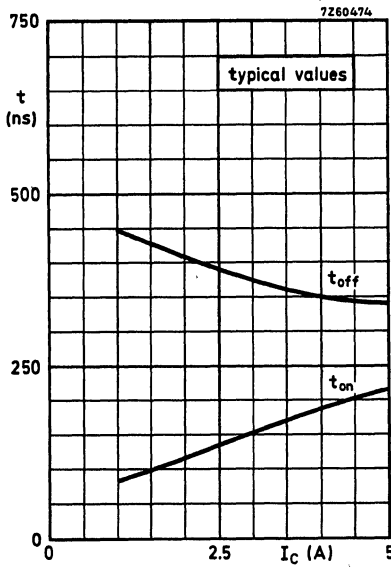
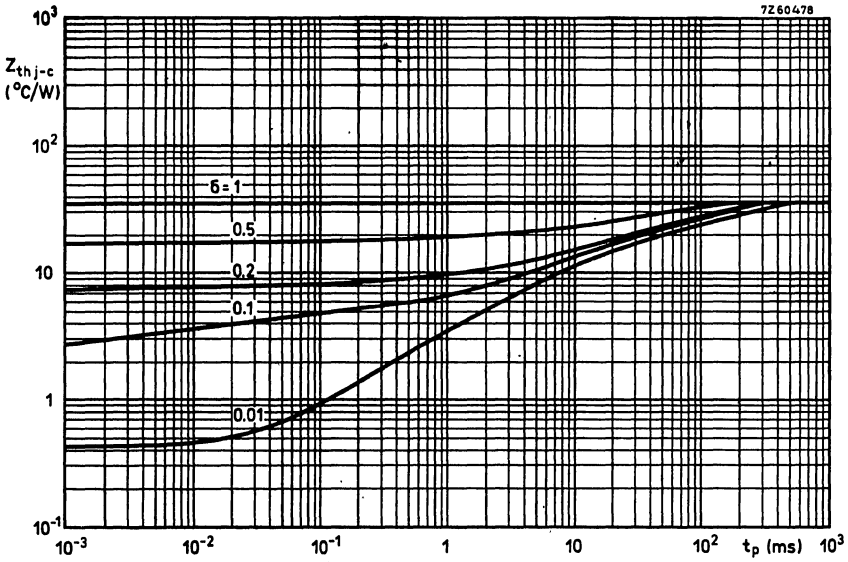
$t_{off}$  typ. 0.34  $\mu\text{s}$   
< 1.2  $\mu\text{s}$



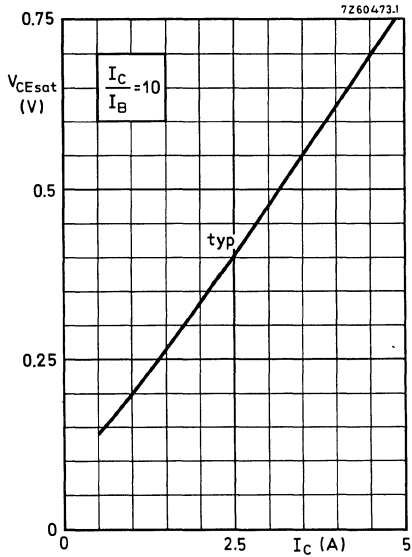
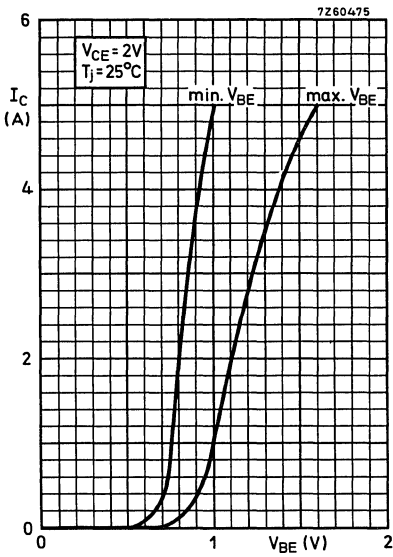
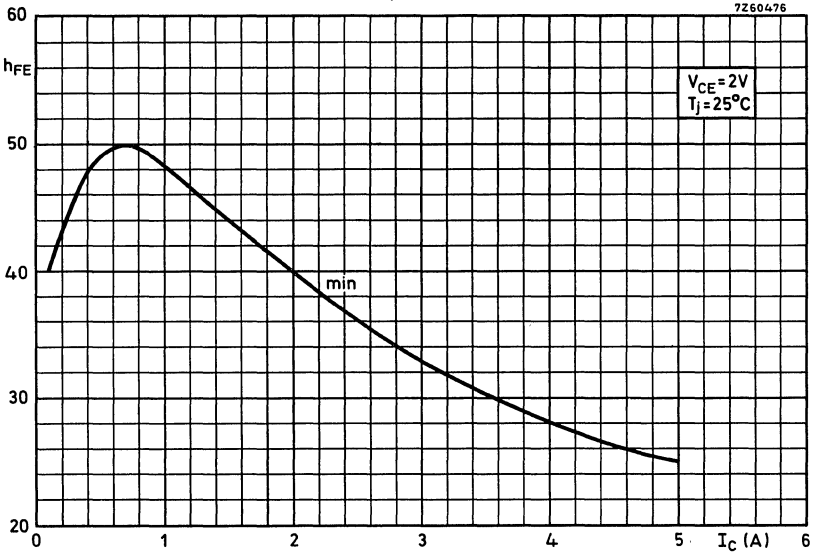
Safe Operation Area with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulsed operation







## SILICON PLANAR EPITAXIAL TRANSISTORS



N-P-N transistors in TO-39 metal envelopes for general purpose industrial applications.

### QUICK REFERENCE DATA

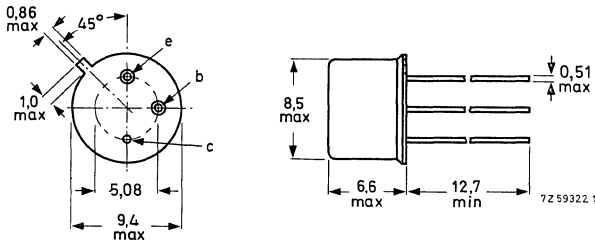
		BFX84	BFX85	BFX86	
Collector-base voltage (open emitter)	$V_{CBO}$	max. 100	100	40	V
Collector-emitter voltage (open base)	$V_{CEO}$	max. 60	60	35	V
Collector current (peak value)	$I_{CM}$	max. 1,0	1,0	1,0	A
Total power dissipation up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$	max. 800	800	800	mW
Total power dissipation up to $T_{case} = 100\text{ }^{\circ}\text{C}$	$P_{tot}$	max. 2,86	2,86	2,86	W
D.C. current gain	$h_{FE}$	> 30	70	70	
$I_C = 150\text{ mA}; V_{CE} = 10\text{ V}$		typ. 112	142	142	
Transition frequency at $f = 35\text{ MHz}$	$f_T$	> 50	50	50	MHz
$I_C = 50\text{ mA}; V_{CE} = 10\text{ V}; T_{amb} = 25\text{ }^{\circ}\text{C}$					

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).

**RATINGS**

Limiting values of operation according to the absolute maximum system.

**Electrical**

	BFX84	BFX85	BFX86	
$V_{CBO}$ max.	100	100	40	V
$V_{CE}$ max. (cut-off, $I_C \leq 1\text{mA}$ )	100	100	40	V
$V_{CEO}$ max.	60	60	35	V
$V_{EBO}$ max.		6.0		V
$I_C$ max.		1.0		A
$I_{CM}$ max.		1.0		A
$-I_E$ max.		1.0		A
$-I_{EM}$ max.		1.0		A
$I_B$ max.		100		mA
$\pm I_{BM}$ max.		100		mA
$P_{tot}$ max. $T_{amb} \leq 25^\circ\text{C}$		800		mW
$T_{case} \leq 25^\circ\text{C}$		5.0		W
$T_{case} > 25, < 100^\circ\text{C}$		2.86		W

**Temperature**

$T_{stg}$	-65 to +200	$^\circ\text{C}$
$T_j$ max.	200	$^\circ\text{C}$

**THERMAL CHARACTERISTICS**

$R_{th(j-amb)}$ in free air	220	degC/W
$R_{th(j-case)}$	35	degC/W

## BFX84

ELECTRICAL CHARACTERISTICS ( $T_j = 25^\circ\text{C}$  unless otherwise stated)

		Min.	Typ.	Max.	
$I_{CBO}$	Collector cut-off current				
	$V_{CB} = 100\text{V}, I_E = 0$	-	10	500	nA
	$V_{CB} = 100\text{V}, I_E = 0, T_j = 100^\circ\text{C}$	-	0.5	30	$\mu\text{A}$
	$V_{CB} = 80\text{V}, I_E = 0$	-	2.0	50	nA
$I_{EBO}$	Emitter cut-off current				
	$V_{EB} = 6.0\text{V}, I_C = 0$	-	10	500	nA
	$V_{EB} = 5.0\text{V}, I_C = 0$	-	2.0	50	nA
$h_{FE}$	Static forward current transfer ratio				
	$I_C = 10\text{mA}, V_{CE} = 10\text{V}$	20	80	-	
	$I_C = 150\text{mA}, V_{CE} = 10\text{V}$	30	112	-	
	$I_C = 500\text{mA}, V_{CE} = 10\text{V}$	20	70	-	
	$I_C = 1.0\text{A}, V_{CE} = 10\text{V}$	15	35	-	
$V_{CE(sat)}$	Collector-emitter saturation voltage				
	$I_C = 10\text{mA}, I_B = 1.0\text{mA}$	-	0.15	0.20	V
	$I_C = 150\text{mA}, I_B = 15\text{mA}$	-	0.15	0.35	V
	$I_C = 500\text{mA}, I_B = 50\text{mA}$	-	0.35	1.00	V
$V_{BE(sat)}$	Base-emitter saturation voltage				
	$I_C = 10\text{mA}, I_B = 1.0\text{mA}$	-	0.69	1.2	V
	$I_C = 150\text{mA}, I_B = 15\text{mA}$	-	0.92	1.3	V
	$I_C = 500\text{mA}, I_B = 50\text{mA}$	-	1.15	1.5	V
	$I_C = 1.0\text{A}, I_B = 100\text{mA}$	-	1.40	2.0	V
$C_{Te}$	Collector capacitance				
	$V_{CB} = 10\text{V}, I_E = I_e = 0,$ $f = 1.0\text{MHz}$	-	7.0	12	pF

BFX84

ELECTRICAL CHARACTERISTICS (contd.)

		Min.	Typ.	Max.	
$f_T$	Transition frequency $I_C = 50\text{mA}$ , $V_{CE} = 10\text{V}$ , $f = 35\text{MHz}$ , $T_{\text{amb}} = 25^\circ\text{C}$	50	140	-	MHz
Saturated switching times					
$I_C = 150\text{mA}$ , $I_{B(\text{on})} = -I_{B(\text{off})} = 15\text{mA}$ , $-V_{EE} = 10\text{V}$ , $-V_{BE(\text{off})} = 2.0\text{V}$					
$t_d$	Delay time	-	15	-	ns
$t_r$	Rise time	-	40	-	ns
$t_{\text{on}}$	Turn-on time	-	55	-	ns
$t_s$	Storage time	-	300	-	ns
$t_f$	Fall time	-	60	-	ns
$t_{\text{off}}$	Turn-off time	-	360	-	ns
h-parameters					
$h_{fe}$	$I_C = 1.0\text{mA}$ , $V_{CE} = 5.0\text{V}$ , $f = 1.0\text{kHz}$ , $T_{\text{amb}} = 25^\circ\text{C}$	10	65	-	
$h_{ie}$	$I_C = 10\text{mA}$ , $V_{CE} = 5.0\text{V}$ , $f = 1.0\text{kHz}$ , $T_{\text{amb}} = 25^\circ\text{C}$	-	750	-	$\Omega$
$h_{re}$		-	0.85	5.0	$\times 10^{-4}$
$h_{fe}$		15	80	-	
$h_{oe}$		-	35	80	$\mu\text{mho}$

## BFX85

ELECTRICAL CHARACTERISTICS ( $T_j = 25^\circ\text{C}$  unless otherwise stated)

		Min.	Typ.	Max.	
$I_{CBO}$	Collector cut-off current				
	$V_{CB} = 100\text{V}, I_E = 0$	-	10	500	nA
	$V_{CB} = 100\text{V}, I_E = 0, T_j = 100^\circ\text{C}$	-	0.5	30	$\mu\text{A}$
	$V_{CB} = 80\text{V}, I_E = 0$	-	2.0	50	nA
	$V_{CB} = 80\text{V}, I_E = 0, T_j = 100^\circ\text{C}$	-	0.1	2.5	$\mu\text{A}$
$I_{EBO}$	Emitter cut-off current				
	$V_{EB} = 6.0\text{V}, I_C = 0$	-	10	500	nA
	$V_{EB} = 5.0\text{V}, I_C = 0$	-	2.0	50	nA
	$V_{EB} = 5.0\text{V}, I_C = 0, T_j = 100^\circ\text{C}$	-	0.1	2.5	$\mu\text{A}$
$h_{FE}$	Static forward current transfer ratio				
	$I_C = 10\text{mA}, V_{CE} = 10\text{V}$	50	90	-	
	$I_C = 150\text{mA}, V_{CE} = 10\text{V}$	70	142	-	
	$I_C = 500\text{mA}, V_{CE} = 10\text{V}$	30	90	-	
	$I_C = 1.0\text{A}, V_{CE} = 10\text{V}$	15	50	-	
$V_{CE(sat)}$	Collector-emitter saturation voltage				
	$I_C = 10\text{mA}, I_B = 1.0\text{mA}$	-	0.15	0.20	V
	$I_C = 150\text{mA}, I_B = 15\text{mA}$	-	0.15	0.35	V
	$I_C = 500\text{mA}, I_B = 50\text{mA}$	-	0.35	1.00	V
	$I_C = 1.0\text{A}, I_B = 100\text{mA}$	-	0.66	1.60	V
$V_{BE(sat)}$	Base-emitter saturation voltage				
	$I_C = 10\text{mA}, I_B = 1.0\text{mA}$	-	0.69	1.2	V
	$I_C = 150\text{mA}, I_B = 15\text{mA}$	-	0.92	1.3	V
	$I_C = 500\text{mA}, I_B = 50\text{mA}$	-	1.15	1.5	V
	$I_C = 1.0\text{A}, I_B = 100\text{mA}$	-	1.40	2.0	V
$C_{Tc}$	Collector capacitance				
	$V_{CB} = 10\text{V}, I_E = I_e = 0,$ $f = 1.0\text{MHz}$	-	7.0	12	pF

BFX85/BFX86

ELECTRICAL CHARACTERISTICS (contd.)

		Min.	Typ.	Max.	
$f_T$	Transition frequency $I_C = 50\text{mA}$ , $V_{CE} = 10\text{V}$ , $f = 35\text{MHz}$ , $T_{\text{amb}} = 25^\circ\text{C}$	50	185	-	MHz

Saturated switching times

$$I_C = 150\text{mA}, I_{B(\text{on})} = -I_{B(\text{off})} = 15\text{mA},$$

$$-V_{EE} = 10\text{V}, -V_{BE(\text{off})} = 2.0\text{V}$$

$t_d$	Delay time	-	15	-	ns
$t_r$	Rise time	-	40	-	ns
$t_{\text{on}}$	Turn-on time	-	55	-	ns
$t_s$	Storage time	-	300	-	ns
$t_f$	Fall time	-	60	-	ns
$t_{\text{off}}$	Turn-off time	-	360	-	ns

h-parameters

$h_{fe}$	$I_C = 1.0\text{mA}$ , $V_{CE} = 5.0\text{V}$ , $f = 1.0\text{kHz}$ , $T_{\text{amb}} = 25^\circ\text{C}$	20	65	-	
$h_{ie}$	$I_C = 10\text{mA}$ , $V_{CE} = 5.0\text{V}$ , $f = 1.0\text{kHz}$ , $T_{\text{amb}} = 25^\circ\text{C}$	-	750	-	$\Omega$
$h_{re}$		-	0.85	$5.0 \times 10^{-4}$	
$h_{fe}$		25	80	-	
$h_{oe}$		-	35	80	$\mu\text{mho}$

## BFX86

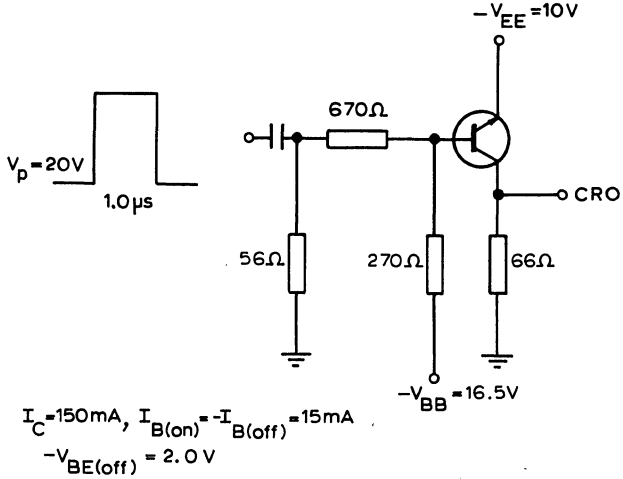
ELECTRICAL CHARACTERISTICS ( $T_j = 25^\circ\text{C}$  unless otherwise stated)

		Min.	Typ.	Max.	
$I_{\text{CBO}}$	Collector cut-off current				
	$V_{\text{CB}} = 40\text{V}, I_{\text{E}} = 0$	-	10	500	nA
	$V_{\text{CB}} = 40\text{V}, I_{\text{E}} = 0, T_j = 100^\circ\text{C}$	-	0.5	30	$\mu\text{A}$
	$V_{\text{CB}} = 30\text{V}, I_{\text{E}} = 0$	-	2.0	50	nA
	$V_{\text{CB}} = 30\text{V}, I_{\text{E}} = 0, T_j = 100^\circ\text{C}$	-	0.1	2.5	$\mu\text{A}$
$I_{\text{EBO}}$	Emitter cut-off current				
	$V_{\text{EB}} = 6.0\text{V}, I_{\text{C}} = 0$	-	10	500	nA
	$V_{\text{EB}} = 5.0\text{V}, I_{\text{C}} = 0$	-	2.0	50	nA
	$V_{\text{EB}} = 5.0\text{V}, I_{\text{C}} = 0, T_j = 100^\circ\text{C}$	-	0.1	2.5	$\mu\text{A}$
$h_{\text{FE}}$	Static forward current transfer ratio				
	$I_{\text{C}} = 10\text{mA}, V_{\text{CE}} = 10\text{V}$	50	90	-	
	$I_{\text{C}} = 150\text{mA}, V_{\text{CE}} = 10\text{V}$	70	142	-	
	$I_{\text{C}} = 500\text{mA}, V_{\text{CE}} = 10\text{V}$	30	90	-	
	$I_{\text{C}} = 1.0\text{A}, V_{\text{CE}} = 10\text{V}$	15	50	-	
$V_{\text{CE(sat)}}$	Collector-emitter saturation voltage				
	$I_{\text{C}} = 10\text{mA}, I_{\text{B}} = 1.0\text{mA}$	-	0.15	0.20	V
	$I_{\text{C}} = 150\text{mA}, I_{\text{B}} = 15\text{mA}$	-	0.15	0.35	V
	$I_{\text{C}} = 500\text{mA}, I_{\text{B}} = 50\text{mA}$	-	0.35	1.00	V
	$I_{\text{C}} = 1.0\text{A}, I_{\text{B}} = 100\text{mA}$	-	0.66	1.60	V
$V_{\text{BE(sat)}}$	Base-emitter saturation voltage				
	$I_{\text{C}} = 10\text{mA}, I_{\text{B}} = 1.0\text{mA}$	-	0.69	1.2	V
	$I_{\text{C}} = 150\text{mA}, I_{\text{B}} = 15\text{mA}$	-	0.92	1.3	V
	$I_{\text{C}} = 500\text{mA}, I_{\text{B}} = 50\text{mA}$	-	1.15	1.5	V
	$I_{\text{C}} = 1.0\text{A}, I_{\text{B}} = 100\text{mA}$	-	1.40	2.0	V
$C_{\text{Tc}}$	Collector capacitance				
	$V_{\text{CB}} = 10\text{V}, I_{\text{E}} = I_{\text{C}} = 0,$ $f = 1.0\text{MHz}$	-	7.0	12	pF

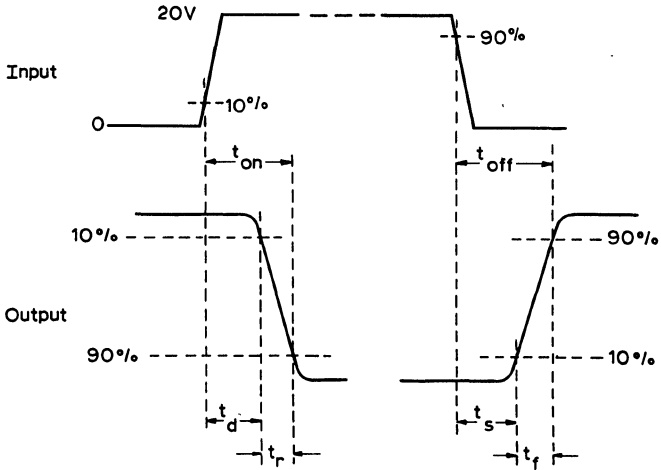


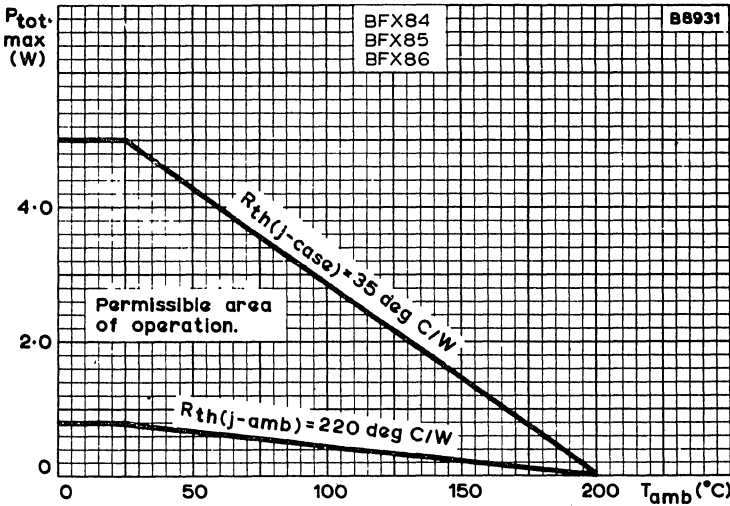
MEASUREMENT OF SATURATED SWITCHING TIMES

Test circuit

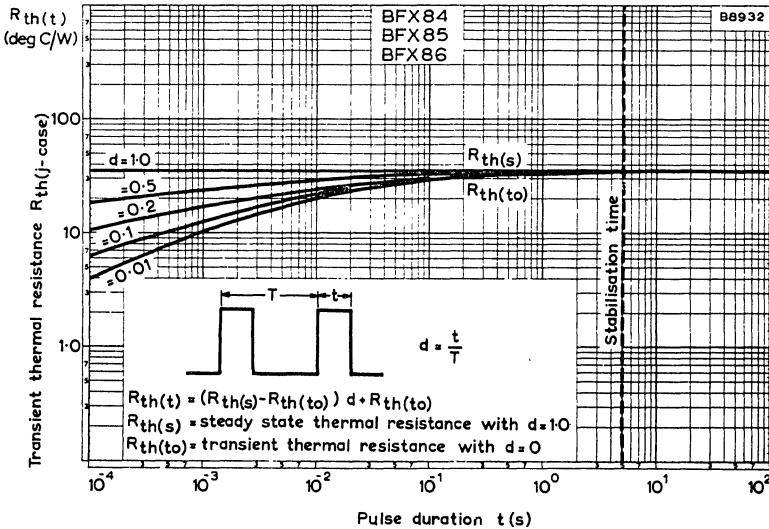


Switching waveforms

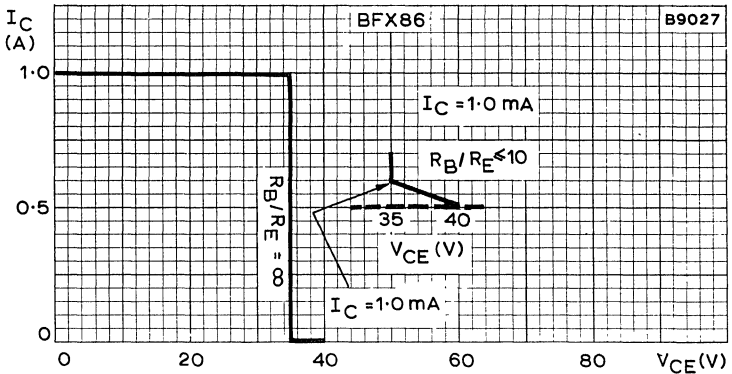
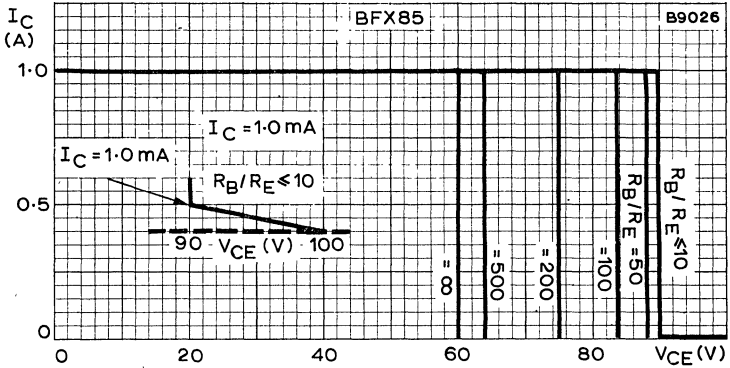
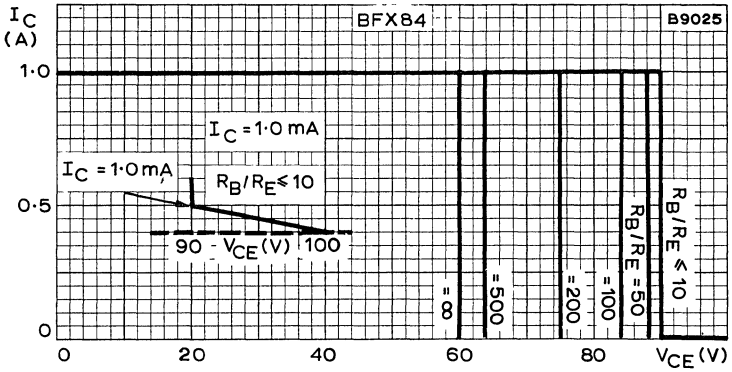




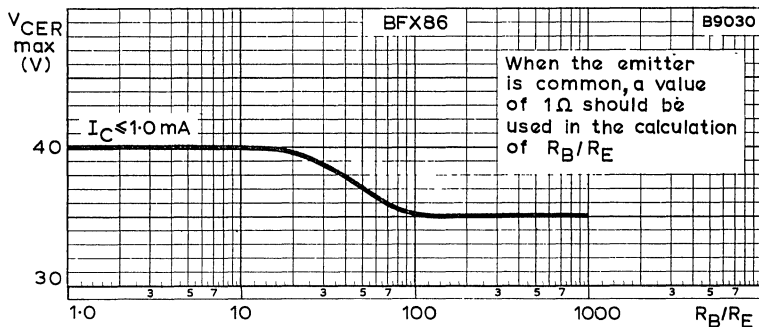
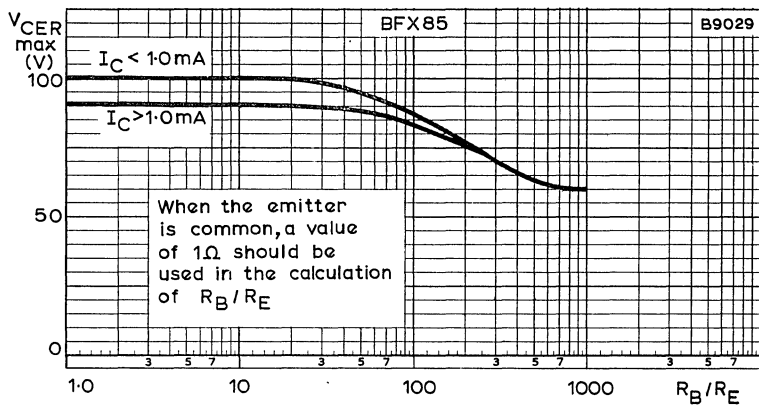
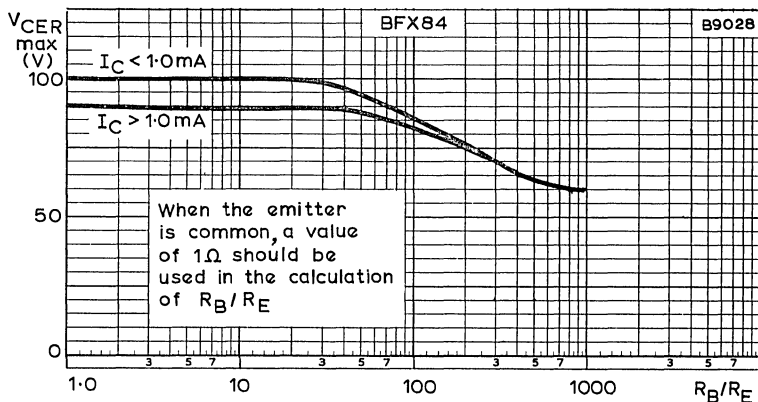
MAXIMUM TOTAL DISSIPATION PLOTTED AGAINST AMBIENT TEMPERATURE



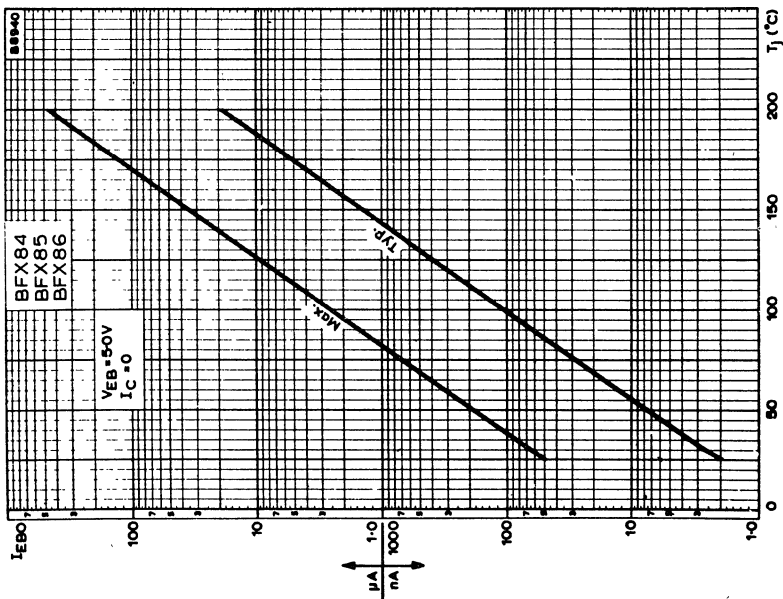
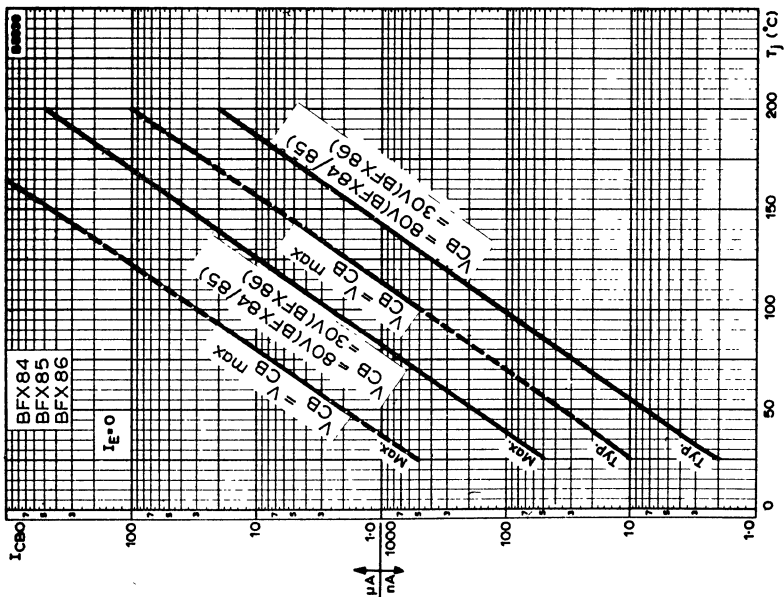
TRANSIENT THERMAL RESISTANCE FOR VARIOUS DUTY FACTORS PLOTTED AGAINST PULSE DURATION



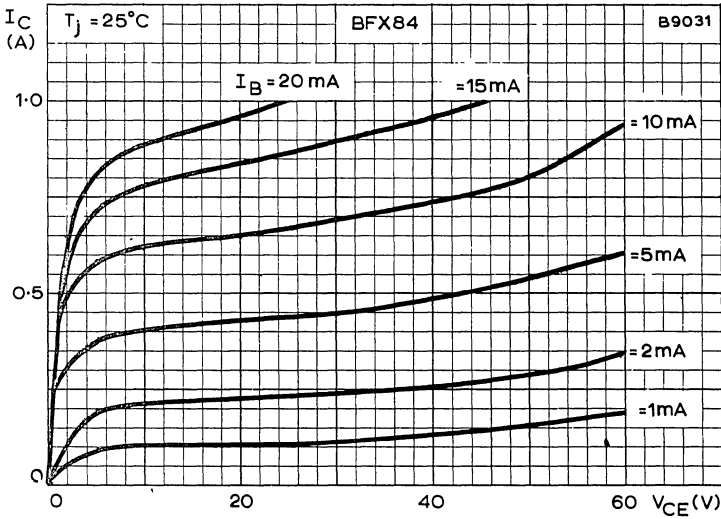
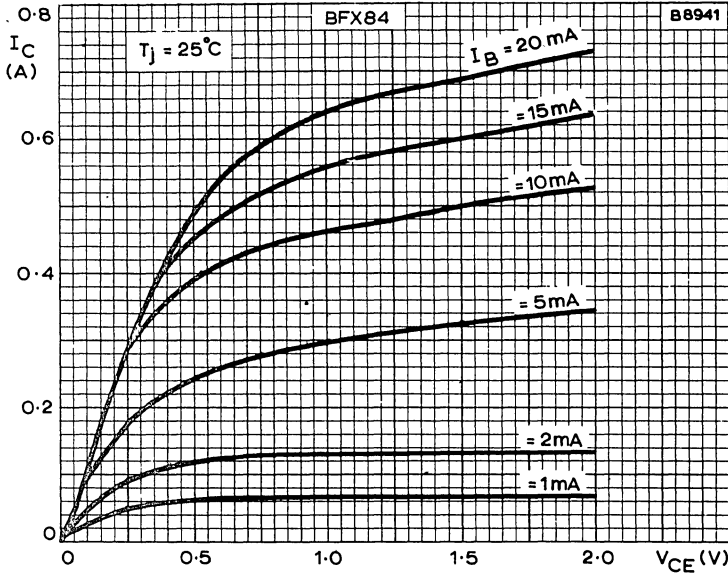
COLLECTOR CURRENT PLOTTED AGAINST MAXIMUM  
 COLLECTOR-EMITTER VOLTAGE WITH  $R_B/R_E$  AS PARAMETER



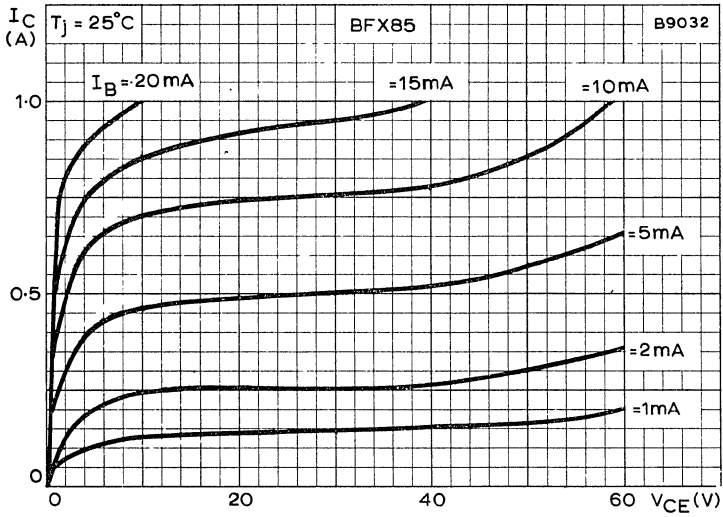
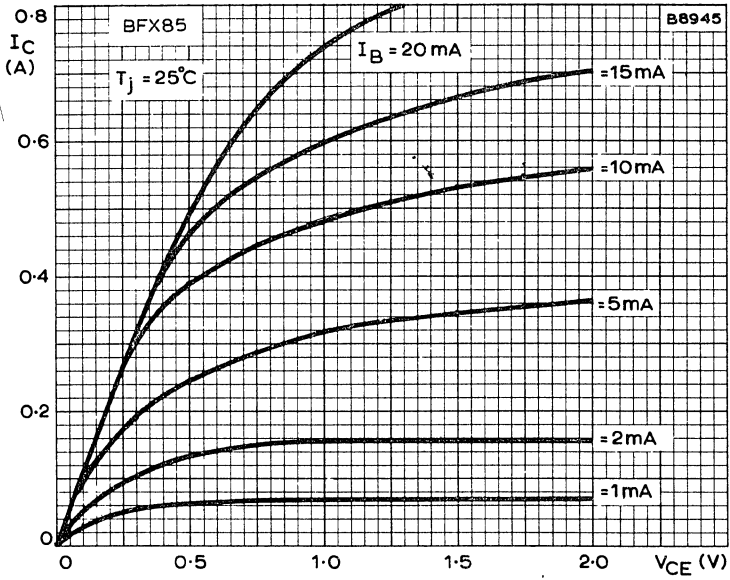
MAXIMUM COLLECTOR-EMITTER VOLTAGE PLOTTED AGAINST  
 $R_B/R_E$  RATIO



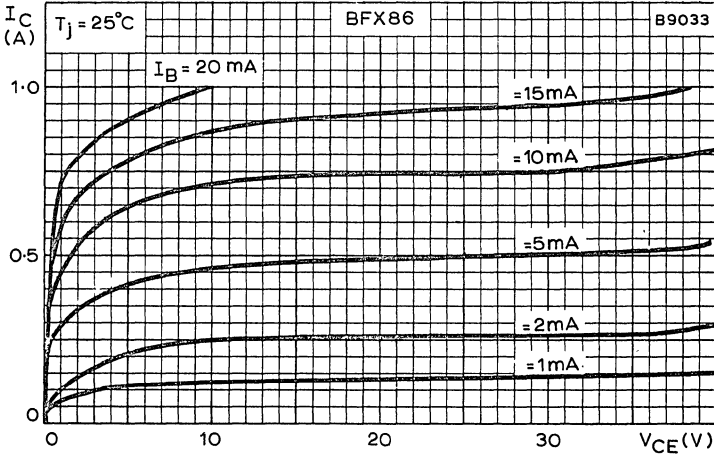
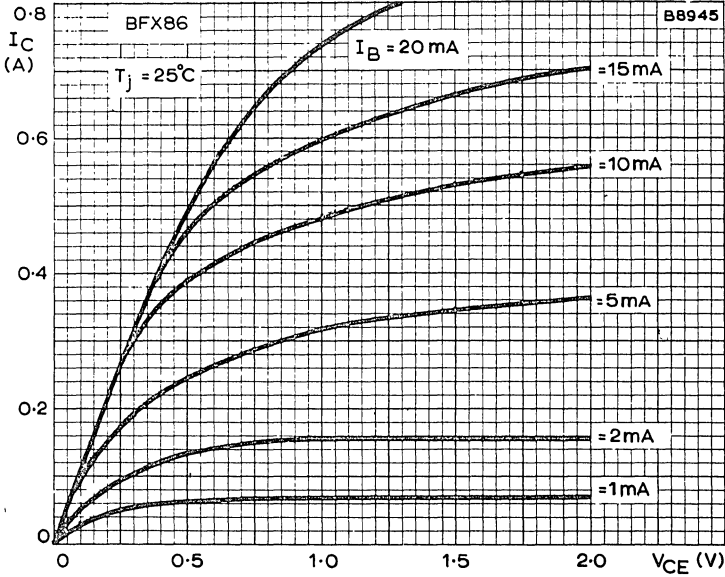
COLLECTOR AND EMITTER CUT-OFF CURRENTS PLOTTED AGAINST JUNCTION TEMPERATURE



TYPICAL OUTPUT CHARACTERISTICS

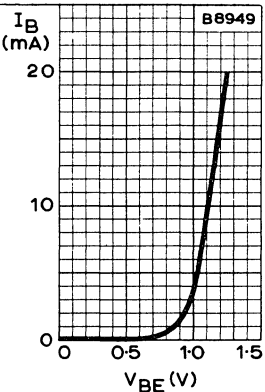
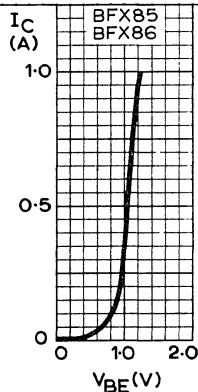
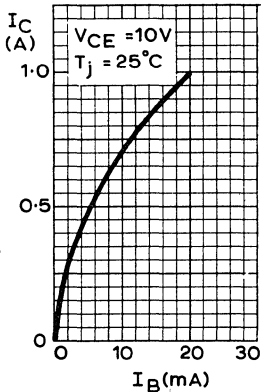
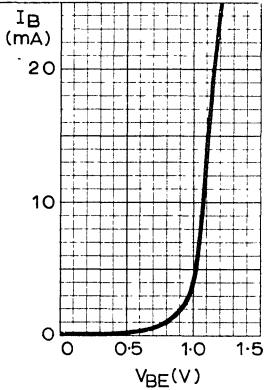
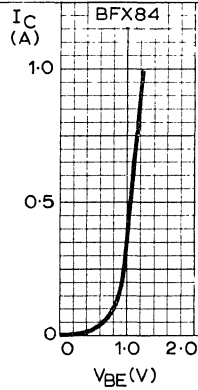
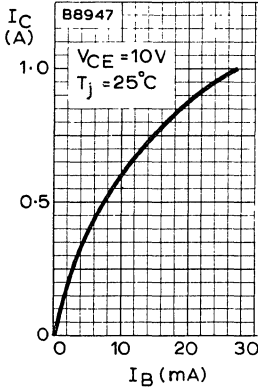


TYPICAL OUTPUT CHARACTERISTICS

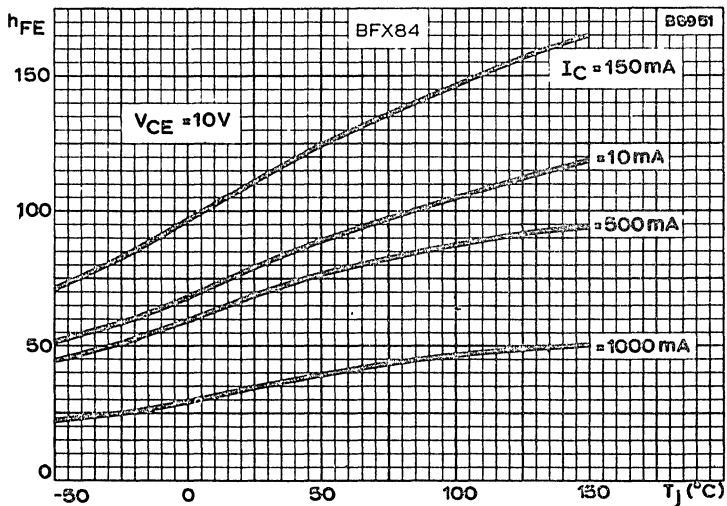
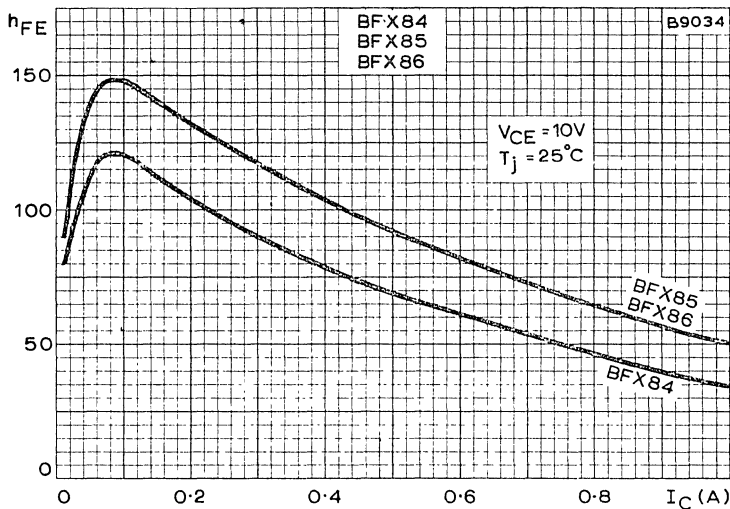


TYPICAL OUTPUT CHARACTERISTICS



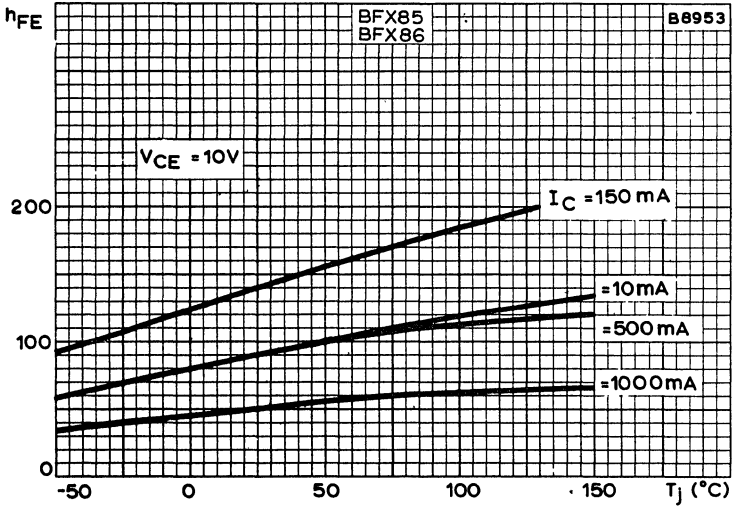


TYPICAL TRANSFER, MUTUAL AND INPUT CHARACTERISTICS

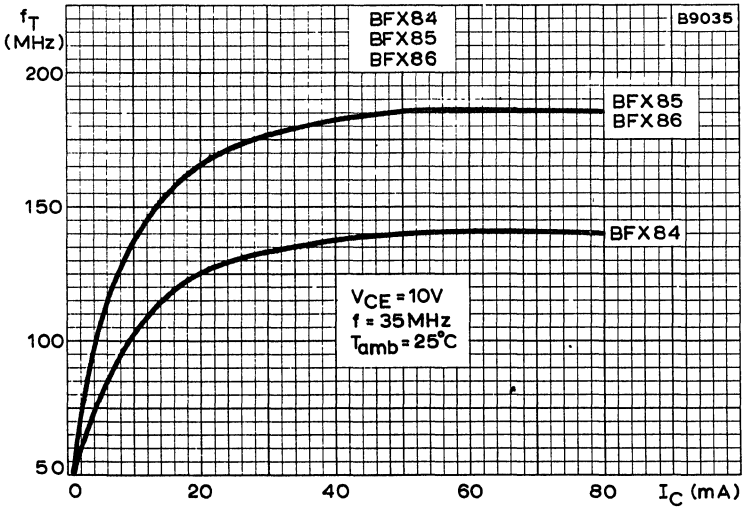


TYPICAL STATIC FORWARD CURRENT TRANSFER RATIO PLOTTED AGAINST COLLECTOR CURRENT AND JUNCTION TEMPERATURE

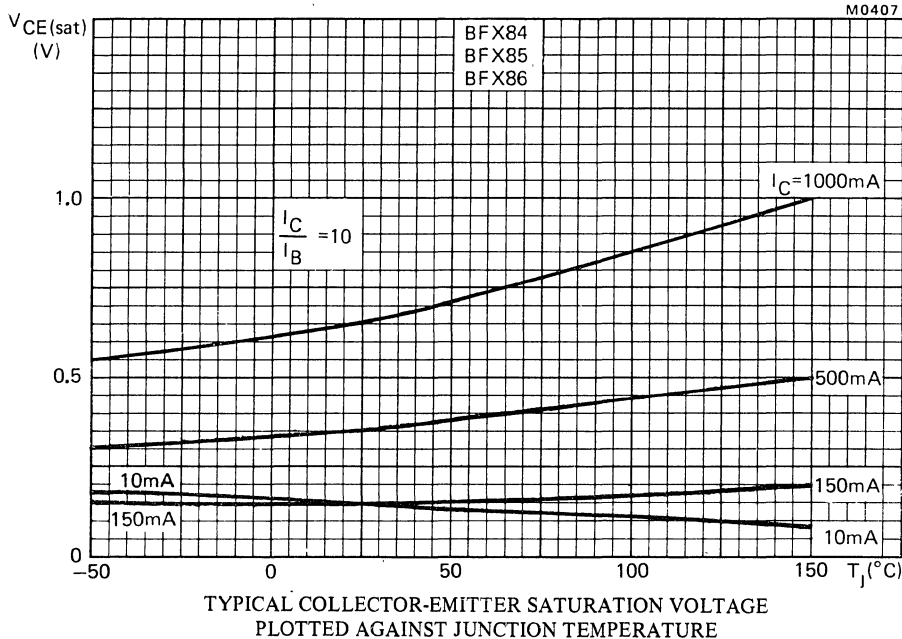
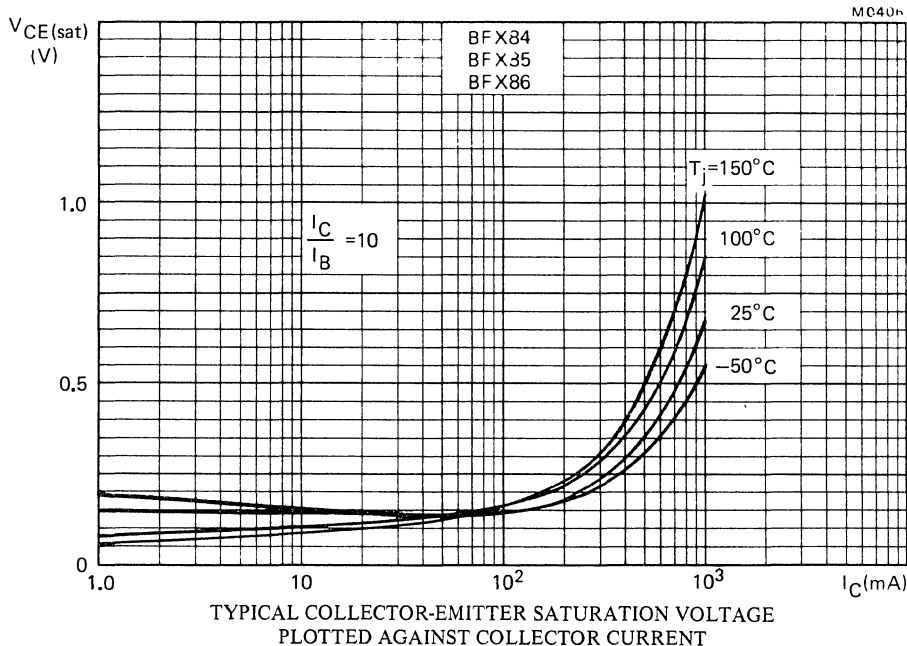
BFX84  
 BFX85  
 BFX86



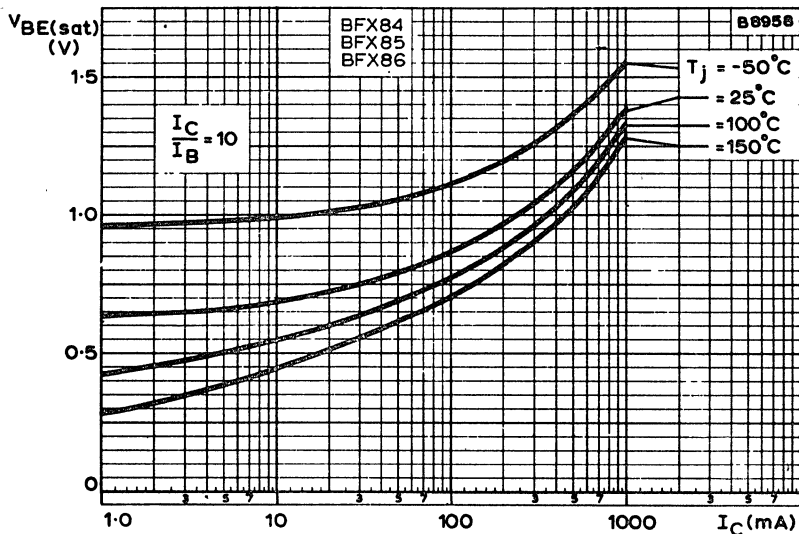
TYPICAL STATIC FORWARD CURRENT TRANSFER RATIO PLOTTED AGAINST JUNCTION TEMPERATURE



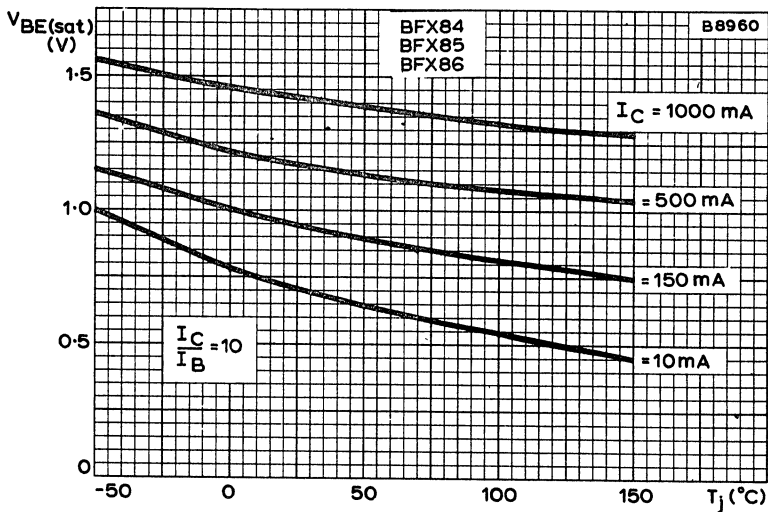
TYPICAL TRANSITION FREQUENCY PLOTTED AGAINST COLLECTOR CURRENT



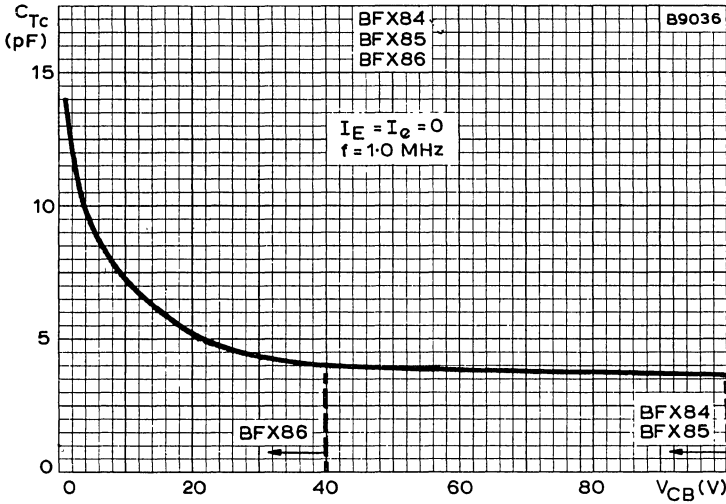
BFX84  
 BFX85  
 BFX86



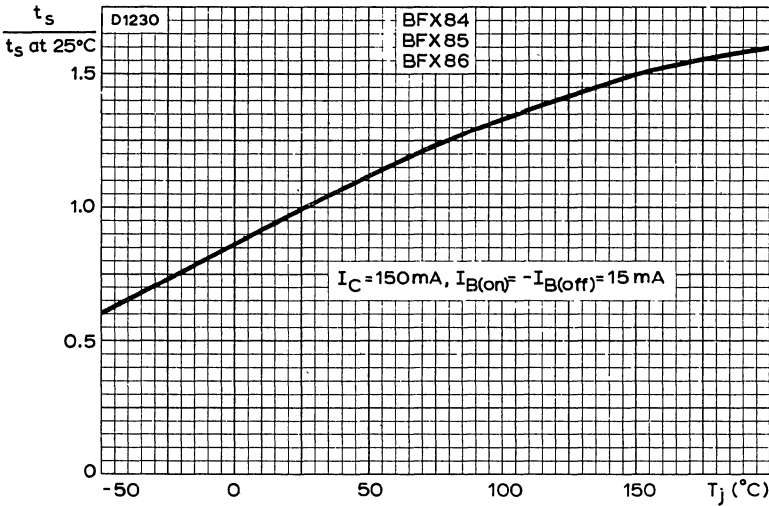
TYPICAL BASE-EMITTER SATURATION VOLTAGE  
 PLOTTED AGAINST COLLECTOR CURRENT



TYPICAL BASE-EMITTER SATURATION VOLTAGE  
 PLOTTED AGAINST JUNCTION TEMPERATURE

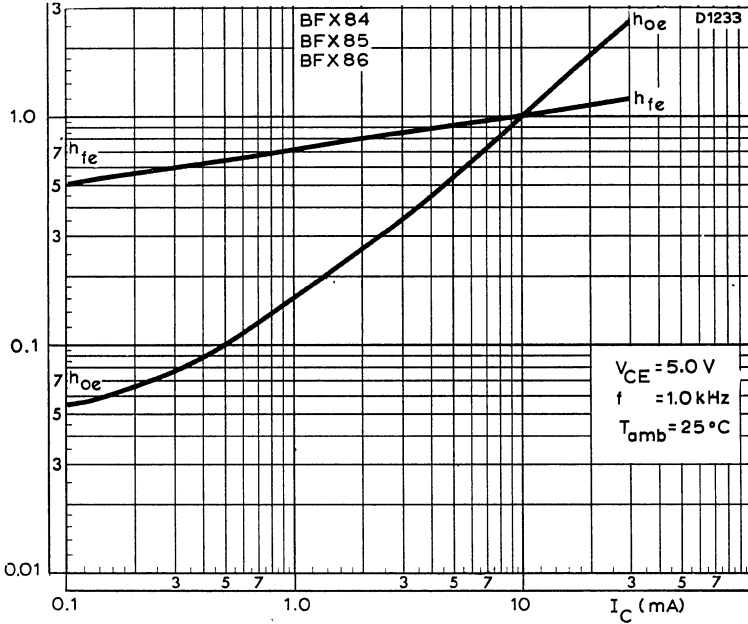
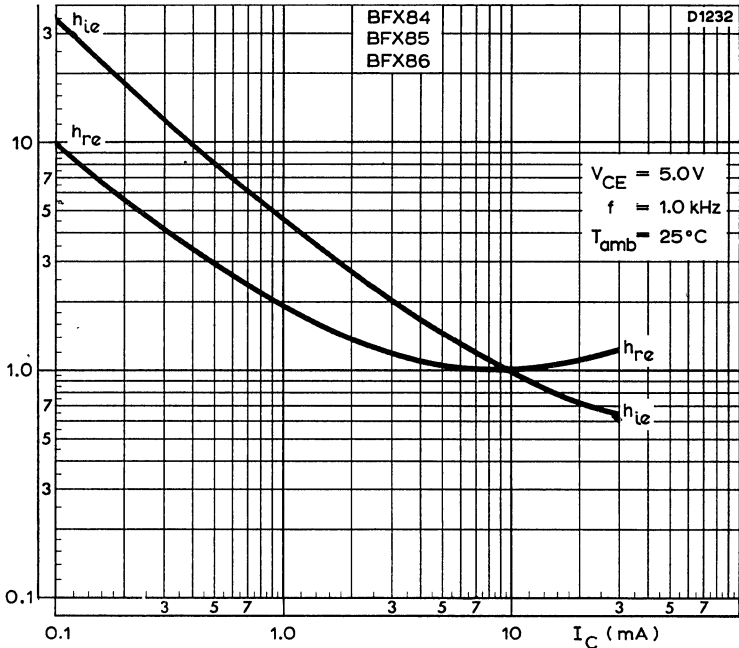


TYPICAL COLLECTOR CAPACITANCE PLOTTED AGAINST COLLECTOR-BASE VOLTAGE



TYPICAL STORAGE TIME NORMALISED AT 25°C

BFX84  
 BFX85  
 BFX86



TYPICAL h-PARAMETERS NORMALISED AT  $I_C = 10\text{mA}$

## P-N-P SILICON PLANAR EPITAXIAL TRANSISTORS

For data of these transistors please refer to type BFX29.







SILICON PLANAR EPITAXIAL TRANSISTORS



N-P-N transistors in TO-39 metal envelopes intended for general purpose industrial applications.

QUICK REFERENCE DATA

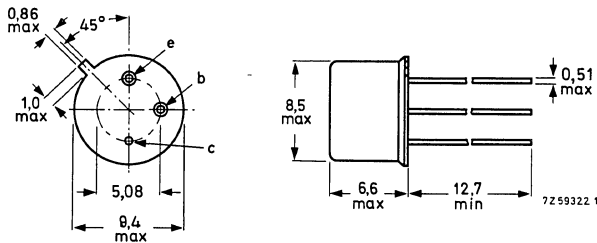
			BFY50	BFY51	BFY52	
Collector-base voltage (open emitter)	$V_{CBO}$	max.	80	60	40	V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	35	30	20	V
Collector current (peak value)	$I_{CM}$	max.	1,0	1,0	1,0	A
Total power dissipation up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	800	800	800	mW
Total power dissipation up to $T_{case} = 100\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	2,86	2,86	2,86	W
D.C. current gain						
$I_C = 150\text{ mA}; V_{CE} = 10\text{ V}$	$h_{FE}$	>	30	40	60	
		typ.	112	123	142	
Transition frequency at $f = 35\text{ MHz}$						
$I_C = 50\text{ mA}; V_{CE} = 10\text{ V}; T_{amb} = 25\text{ }^{\circ}\text{C}$	$f_T$	>	60	50	50	MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

	BFY50	BFY51	BFY52	
$V_{CBO}$ max.	80	60	40	V
$V_{CE}$ max. (cut-off, $I_C \leq 1\text{mA}$ )	80	60	40	V
$V_{CEO}$ max.	35	30	20	V
$V_{EBO}$ max.		6.0		V
$I_C$ max.		1.0		A
$I_{CM}$ max.		1.0		A
$-I_E$ max.		1.0		A
$-I_{EM}$ max.		1.0		A
$I_B$ max.		100		mA
$\pm I_{BM}$ max.		100		mA
$P_{tot}$ max. $T_{amb} \leq 25^\circ\text{C}$		800		mW
$T_{case} \leq 25^\circ\text{C}$		5.0		W
$T_{case} > 25, < 100^\circ\text{C}$		2.86		W

Temperature

$T_{stg}$	-65 to +200	$^\circ\text{C}$
$T_j$ max.	200	$^\circ\text{C}$

THERMAL CHARACTERISTICS

$R_{th(j-amb)}$ in free air	220	degC/W
$R_{th(j-case)}$	35	degC/W

## BFY50

ELECTRICAL CHARACTERISTICS ( $T_j = 25^\circ\text{C}$  unless otherwise stated)

		Min.	Typ.	Max.	
$I_{CBO}$	Collector cut-off current $V_{CB} = 80\text{V}, I_E = 0$	-	10	500	nA
	$V_{CB} = 80\text{V}, I_E = 0, T_j = 100^\circ\text{C}$	-	0.5	30	$\mu\text{A}$
	$V_{CB} = 60\text{V}, I_E = 0$	-	2.0	50	nA
	$V_{CB} = 60\text{V}, I_E = 0, T_j = 100^\circ\text{C}$	-	0.1	2.5	$\mu\text{A}$
$I_{EBO}$	Emitter cut-off current $V_{EB} = 6.0\text{V}, I_C = 0$	-	10	500	nA
	$V_{EB} = 5.0\text{V}, I_C = 0$	-	2.0	50	nA
	$V_{EB} = 5.0\text{V}, I_C = 0, T_j = 100^\circ\text{C}$	-	0.1	2.5	$\mu\text{A}$
$h_{FE}$	Static forward current transfer ratio $I_C = 10\text{mA}, V_{CE} = 10\text{V}$	20	80	-	
	$I_C = 150\text{mA}, V_{CE} = 10\text{V}$	30	112	-	
	$I_C = 500\text{mA}, V_{CE} = 10\text{V}$	20	70	-	
	$I_C = 1.0\text{A}, V_{CE} = 10\text{V}$	15	35	-	
$V_{CE(sat)}$	Collector-emitter saturation voltage $I_C = 10\text{mA}, I_B = 1.0\text{mA}$	-	0.15	0.20	V ←
	$I_C = 150\text{mA}, I_B = 15\text{mA}$	-	0.15	0.20	V
	$I_C = 500\text{mA}, I_B = 50\text{mA}$	-	0.35	0.70	V
	$I_C = 1.0\text{A}, I_B = 100\text{mA}$	-	0.66	1.00	V
$V_{BE(sat)}$	Base-emitter saturation voltage $I_C = 10\text{mA}, I_B = 1.0\text{mA}$	-	0.69	1.2	V
	$I_C = 150\text{mA}, I_B = 15\text{mA}$	-	0.92	1.3	V
	$I_C = 500\text{mA}, I_B = 50\text{mA}$	-	1.15	1.5	V
	$I_C = 1.0\text{A}, I_B = 100\text{mA}$	-	1.40	2.0	V
$C_{Tc}$	Collector capacitance $V_{CB} = 10\text{V}, I_E = I_e = 0,$ $f = 1.0\text{MHz}$	-	7.0	12	pF

BFY50

ELECTRICAL CHARACTERISTICS (contd.)

		Min.	Typ.	Max.	
$f_T$	Transition frequency $I_C = 50\text{mA}$ , $V_{CE} = 10\text{V}$ , $f = 35\text{MHz}$ , $T_{amb} = 25^\circ\text{C}$	60	140	-	MHz

Saturated switching times

$I_C = 150\text{mA}$ ,  $I_{B(on)} = -I_{B(off)} = 15\text{mA}$ ,  
 $-V_{EE} = 10\text{V}$ ,  $-V_{BE(off)} = 2.0\text{V}$

$t_d$	Delay time	-	15	-	ns
$t_r$	Rise time	-	40	-	ns
$t_{on}$	Turn-on time	-	55	-	ns
$t_s$	Storage time	-	300	-	ns
$t_f$	Fall time	-	60	-	ns
$t_{off}$	Turn-off time	-	360	-	ns

h-parameters

$h_{fe}$	$I_C = 1.0\text{mA}$ , $V_{CE} = 5.0\text{V}$ , $f = 1.0\text{kHz}$ , $T_{amb} = 25^\circ\text{C}$	10	65	-	
$h_{ie}$	$I_C = 10\text{mA}$ , $V_{CE} = 5.0\text{V}$ , $f = 1.0\text{kHz}$ , $T_{amb} = 25^\circ\text{C}$	-	750	-	$\Omega$
$h_{re}$		-	0.85	5.0	$\times 10^{-4}$
$h_{fe}$		15	80	-	
$h_{oe}$		-	35	80	$\mu\text{mho}$

## BFY51

ELECTRICAL CHARACTERISTICS ( $T_j = 25^\circ\text{C}$  unless otherwise stated)

		Min.	Typ.	Max.	
$I_{\text{CBO}}$	Collector cut-off current				
	$V_{\text{CB}} = 60\text{V}, I_{\text{E}} = 0$	-	10	500	nA
	$V_{\text{CB}} = 60\text{V}, I_{\text{E}} = 0, T_j = 100^\circ\text{C}$	-	0.5	30	$\mu\text{A}$
	$V_{\text{CB}} = 40\text{V}, I_{\text{E}} = 0$	-	2.0	50	nA
$I_{\text{EBO}}$	Emitter cut-off current				
	$V_{\text{EB}} = 6.0\text{V}, I_{\text{C}} = 0$	-	10	500	nA
	$V_{\text{EB}} = 5.0\text{V}, I_{\text{C}} = 0$	-	2.0	50	nA
$h_{\text{FE}}$	Static forward current transfer ratio				
	$I_{\text{C}} = 10\text{mA}, V_{\text{CE}} = 10\text{V}$	30	85	-	
	$I_{\text{C}} = 150\text{mA}, V_{\text{CE}} = 10\text{V}$	40	123	-	
	$I_{\text{C}} = 500\text{mA}, V_{\text{CE}} = 10\text{V}$	25	79	-	
$V_{\text{CE(sat)}}$	Collector-emitter saturation voltage				
	$I_{\text{C}} = 10\text{mA}, I_{\text{B}} = 1.0\text{mA}$	-	0.15	0.20	V
	$I_{\text{C}} = 150\text{mA}, I_{\text{B}} = 15\text{mA}$	-	0.15	0.35	V
	$I_{\text{C}} = 500\text{mA}, I_{\text{B}} = 50\text{mA}$	-	0.35	1.00	V
$V_{\text{BE(sat)}}$	Base-emitter saturation voltage				
	$I_{\text{C}} = 10\text{mA}, I_{\text{B}} = 1.0\text{mA}$	-	0.69	1.2	V
	$I_{\text{C}} = 150\text{mA}, I_{\text{B}} = 15\text{mA}$	-	0.92	1.3	V
	$I_{\text{C}} = 500\text{mA}, I_{\text{B}} = 50\text{mA}$	-	1.15	1.5	V
$C_{\text{Tc}}$	Collector capacitance				
	$V_{\text{CB}} = 10\text{V}, I_{\text{E}} = I_{\text{e}} = 0,$ $f = 1.0\text{MHz}$	-	7.0	12	pF

ELECTRICAL CHARACTERISTICS (contd.)

		Min.	Typ.	Max.	
$f_T$	Transition frequency $I_C = 50\text{mA}$ , $V_{CE} = 10\text{V}$ , $f = 35\text{MHz}$ , $T_{amb} = 25^\circ\text{C}$	50	-	-	MHz
Saturated switching times					
	$I_C = 150\text{mA}$ , $I_{B(on)} = -I_{B(off)} = 15\text{mA}$ , $-V_{EE} = 10\text{V}$ , $-V_{BE(off)} = 2.0\text{V}$				
$t_d$	Delay time	-	15	-	ns
$t_r$	Rise time	-	40	-	ns
$t_{on}$	Turn-on time	-	55	-	ns
$t_s$	Storage time	-	300	-	ns
$t_f$	Fall time	-	60	-	ns
$t_{off}$	Turn-off time	-	360	-	ns
h-parameters					
$h_{fe}$	$I_C = 1.0\text{mA}$ , $V_{CE} = 5.0\text{V}$ , $f = 1.0\text{kHz}$ , $T_{amb} = 25^\circ\text{C}$	20	65	-	
$h_{ie}$	$I_C = 10\text{mA}$ , $V_{CE} = 5.0\text{V}$ , $f = 1.0\text{kHz}$ , $T_{amb} = 25^\circ\text{C}$	-	750	-	$\Omega$
$h_{re}$		-	0.85	5.0	$\times 10^{-4}$
$h_{fe}$		25	80	-	
$h_{oe}$		-	35	80	$\mu\text{mho}$

## BFY52

ELECTRICAL CHARACTERISTICS ( $T_j = 25^\circ\text{C}$  unless otherwise stated)

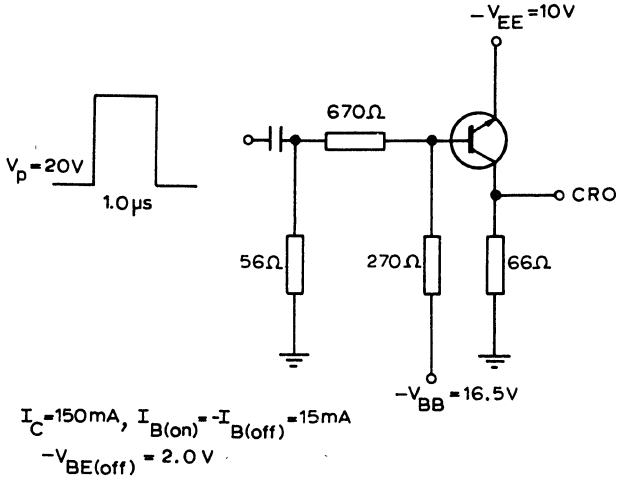
		Min.	Typ.	Max.	
$I_{CBO}$	Collector cut-off current				
	$V_{CB} = 40\text{V}, I_E = 0$	-	10	500	nA
	$V_{CB} = 40\text{V}, I_E = 0, T_j = 100^\circ\text{C}$	-	0.5	30	$\mu\text{A}$
	$V_{CB} = 30\text{V}, I_E = 0$	-	2.0	50	nA
$I_{EBO}$	Emitter cut-off current				
	$V_{EB} = 6.0\text{V}, I_C = 0$	-	10	500	nA
	$V_{EB} = 5.0\text{V}, I_C = 0$	-	2.0	50	nA
$h_{FE}$	Static forward current transfer ratio				
	$I_C = 10\text{mA}, V_{CE} = 10\text{V}$	30	90	-	
	$I_C = 150\text{mA}, V_{CE} = 10\text{V}$	60	142	-	
	$I_C = 500\text{mA}, V_{CE} = 10\text{V}$	30	90	-	
	$I_C = 1.0\text{A}, V_{CE} = 10\text{V}$	15	50	-	
$V_{CE(sat)}$	Collector-emitter saturation voltage				
	$I_C = 10\text{mA}, I_B = 1.0\text{mA}$	-	0.15	0.20	V
	$I_C = 150\text{mA}, I_B = 15\text{mA}$	-	0.15	0.35	V
	$I_C = 500\text{mA}, I_B = 50\text{mA}$	-	0.35	1.00	V
$V_{BE(sat)}$	Base-emitter saturation voltage				
	$I_C = 10\text{mA}, I_B = 1.0\text{mA}$	-	0.69	1.2	V
	$I_C = 150\text{mA}, I_B = 15\text{mA}$	-	0.92	1.3	V
	$I_C = 500\text{mA}, I_B = 50\text{mA}$	-	1.15	1.5	V
$C_{Tc}$	Collector capacitance				
	$V_{CB} = 10\text{V}, I_E = I_e = 0,$ $f = 1.0\text{MHz}$	-	7.0	12	pF



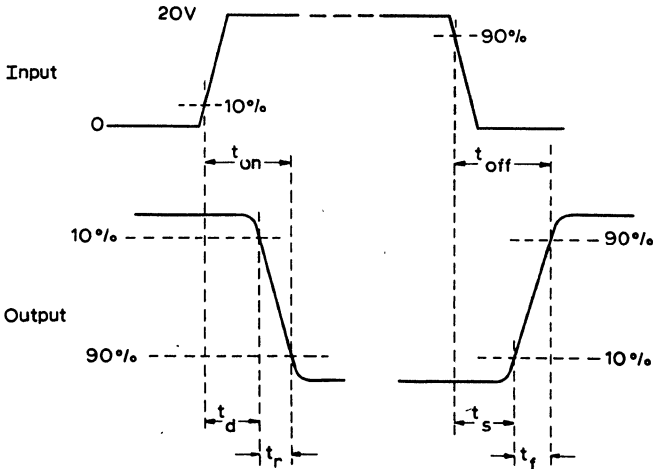
BFY50  
 BFY51  
 BFY52

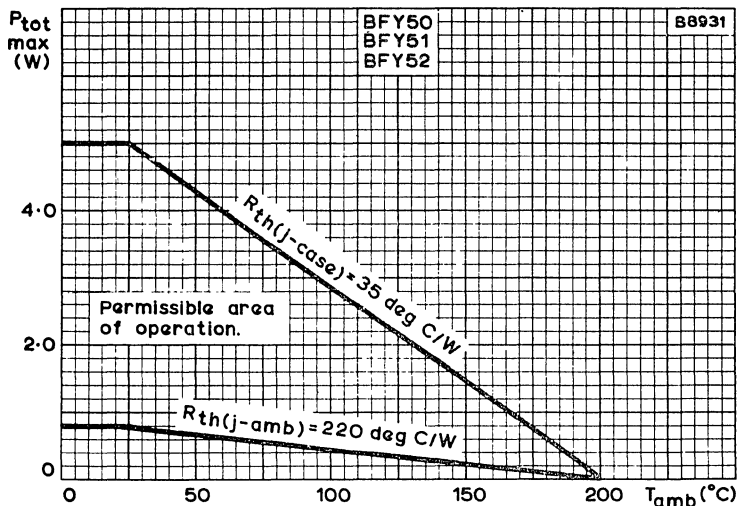
MEASUREMENT OF SATURATED SWITCHING TIMES

Test circuit

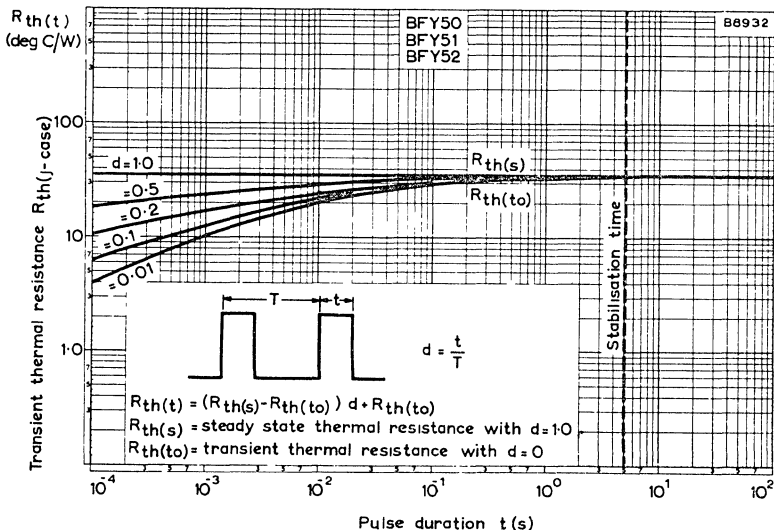


Switching waveforms



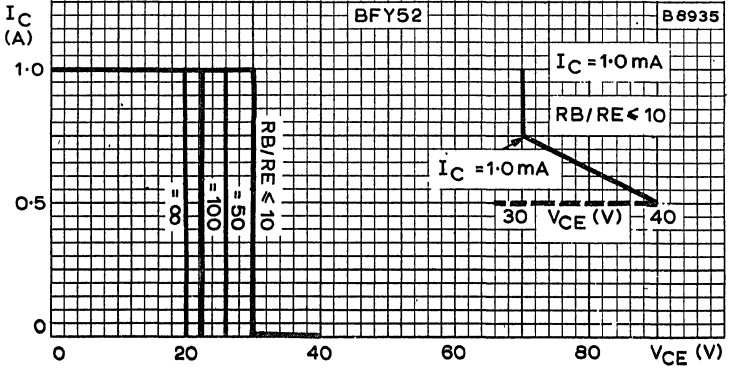
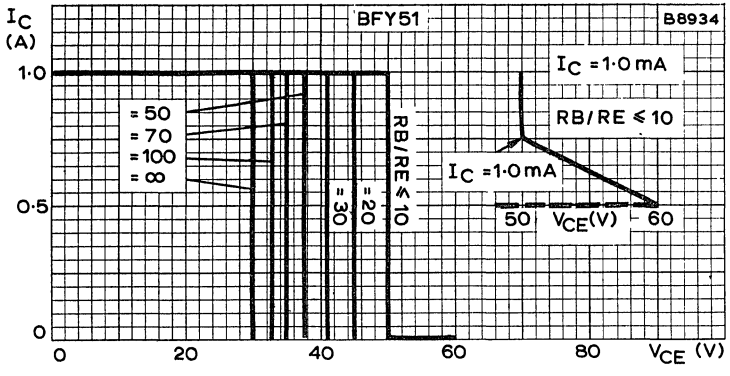
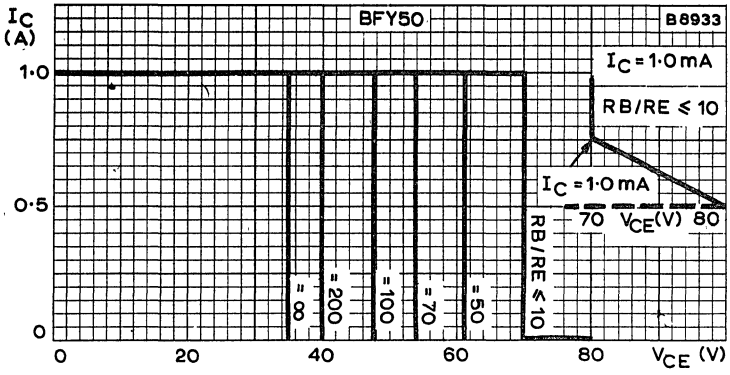


MAXIMUM TOTAL DISSIPATION PLOTTED AGAINST AMBIENT TEMPERATURE

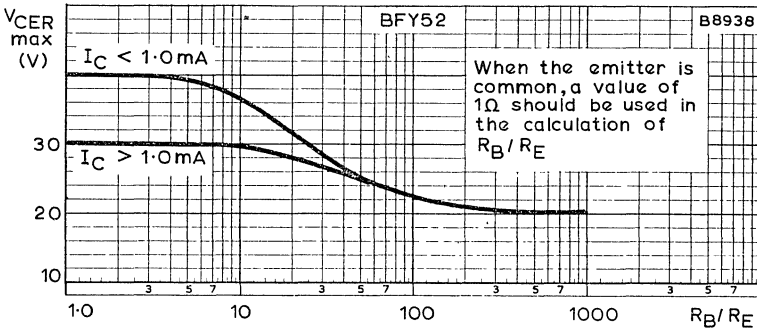
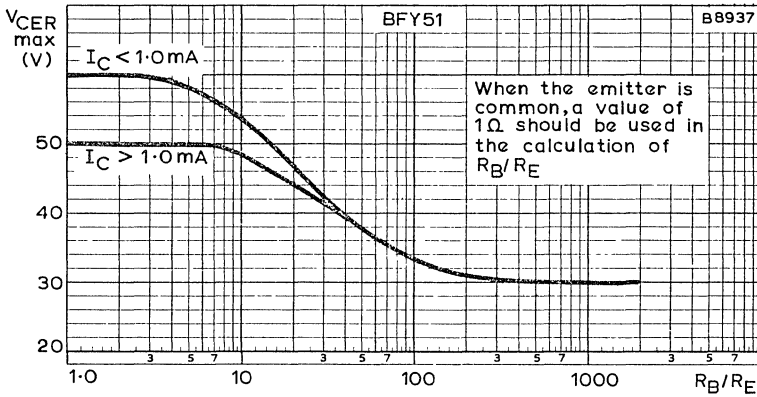
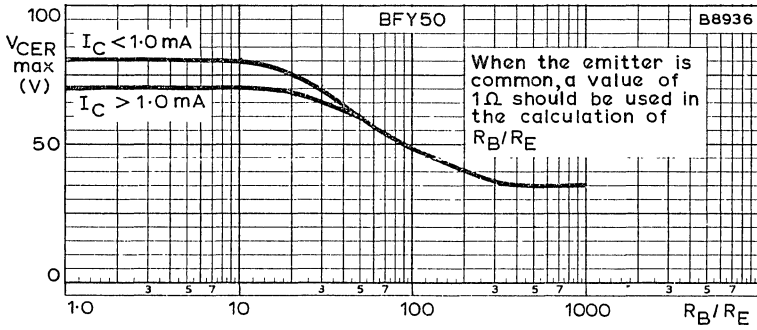


TRANSIENT THERMAL RESISTANCE FOR VARIOUS DUTY FACTORS PLOTTED AGAINST PULSE DURATION

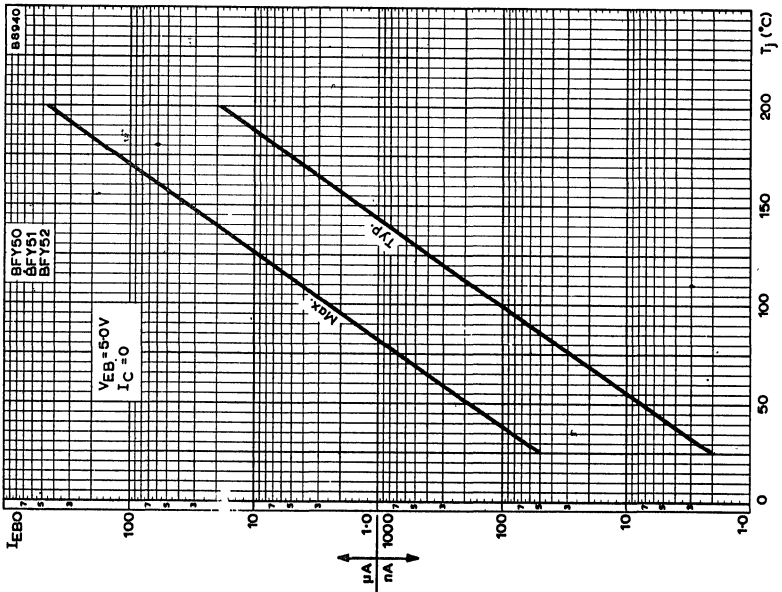
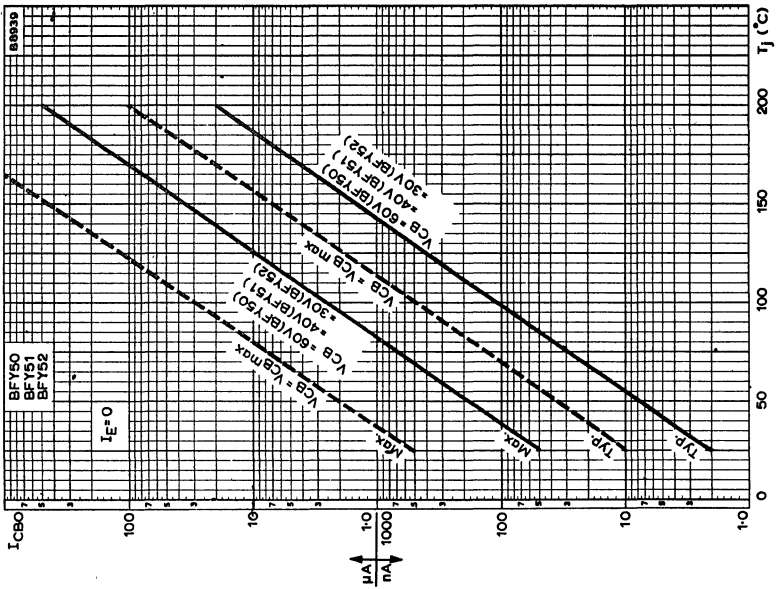
BFY50  
 BFY51  
 BFY52



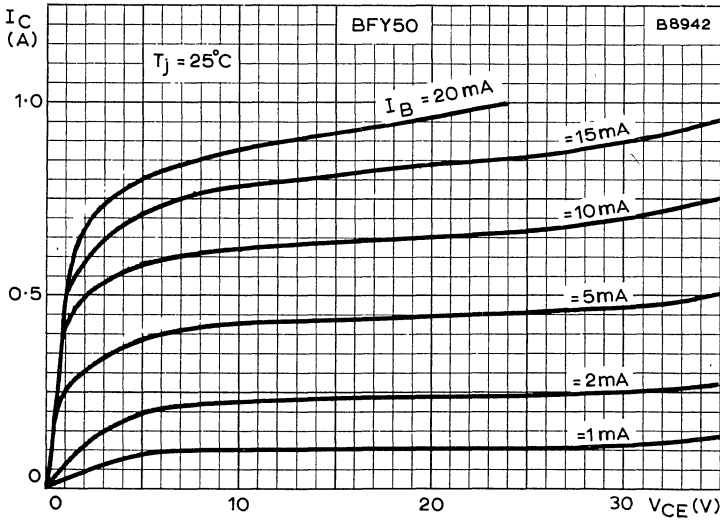
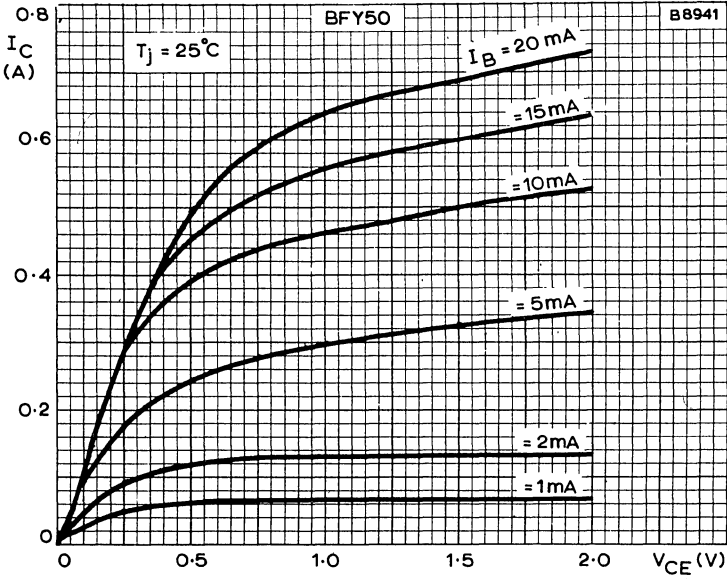
COLLECTOR CURRENT PLOTTED AGAINST MAXIMUM  
 COLLECTOR-EMITTER VOLTAGE WITH  $R_B/R_E$  AS PARAMETER



MAXIMUM COLLECTOR-EMITTER VOLTAGE PLOTTED AGAINST  $R_B/R_E$  RATIO

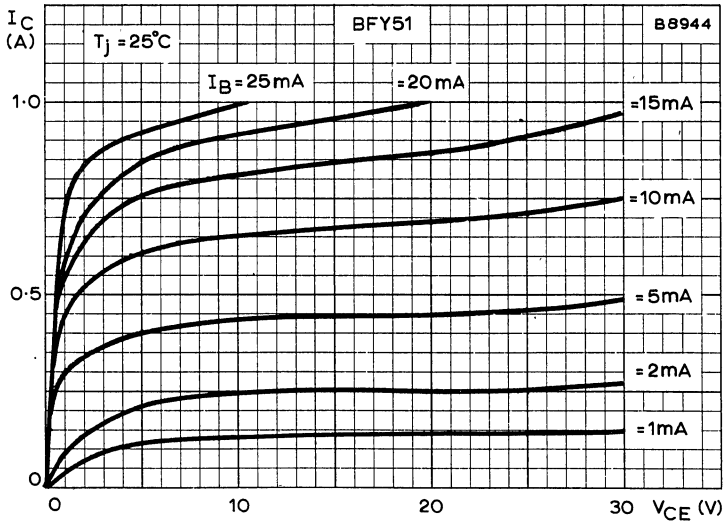
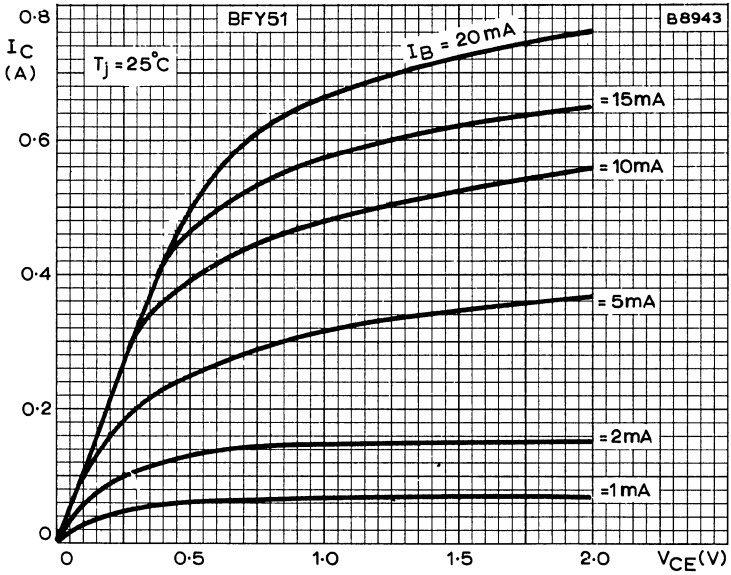


COLLECTOR AND EMITTER CUT-OFF CURRENTS PLOTTED AGAINST JUNCTION TEMPERATURE

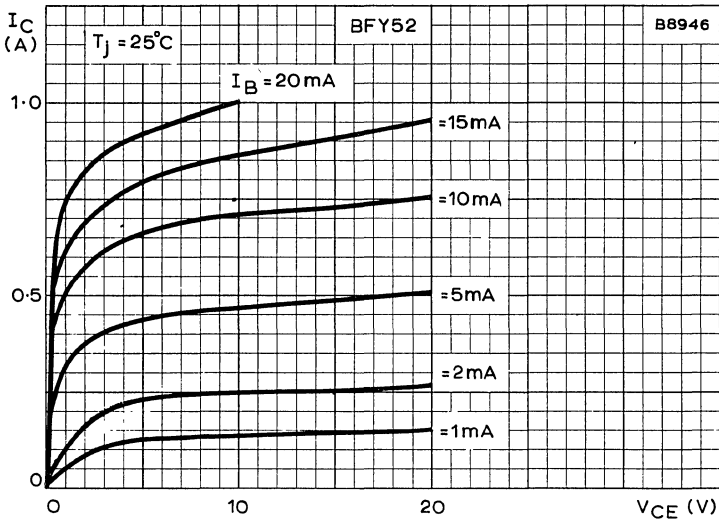
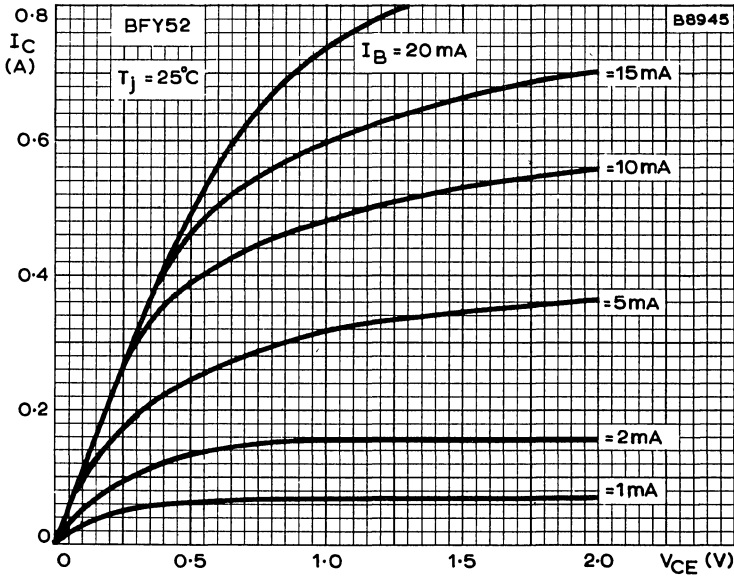


TYPICAL OUTPUT CHARACTERISTICS

BFY50  
BFY51  
BFY52



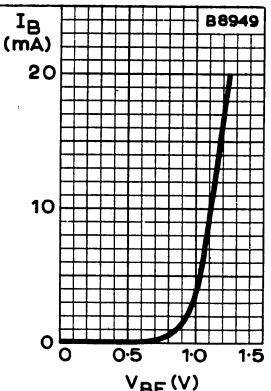
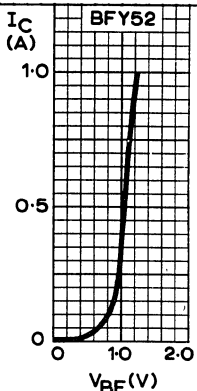
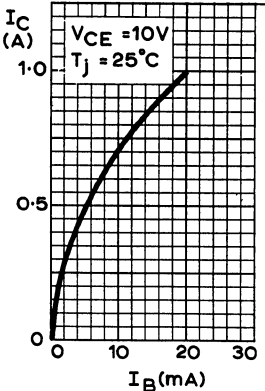
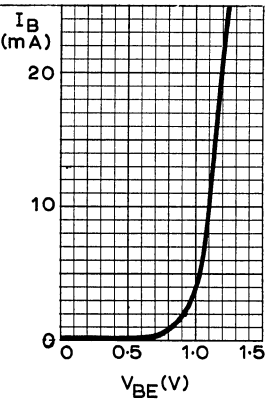
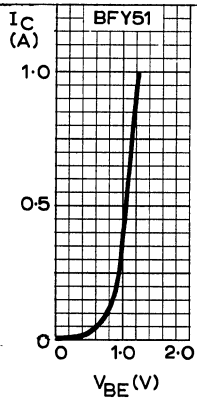
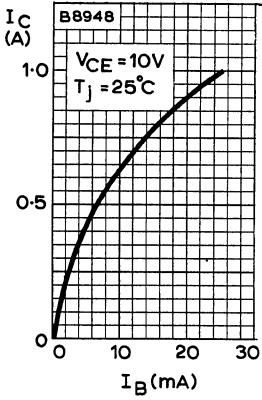
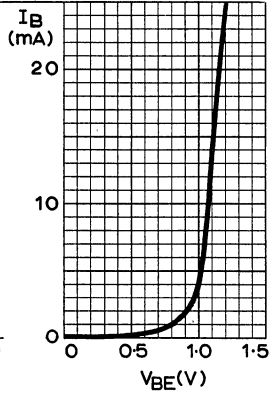
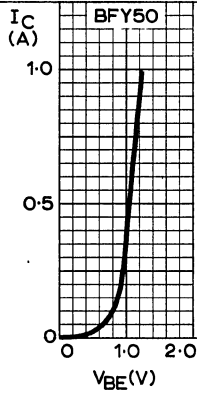
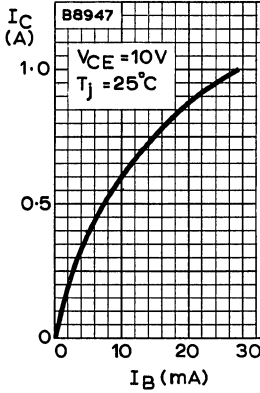
TYPICAL OUTPUT CHARACTERISTICS



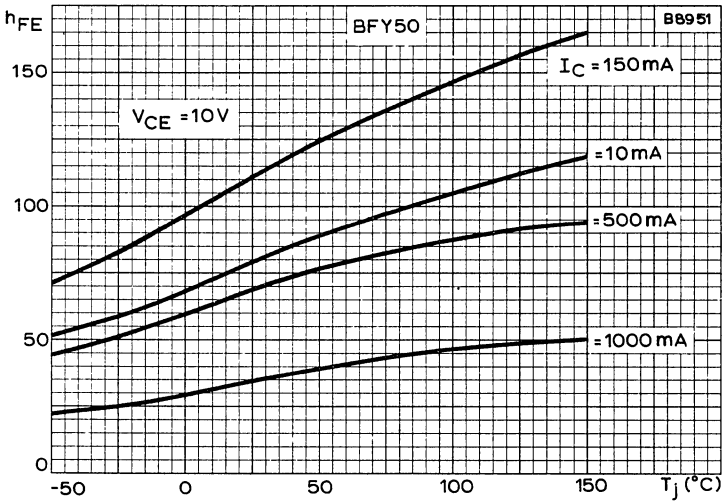
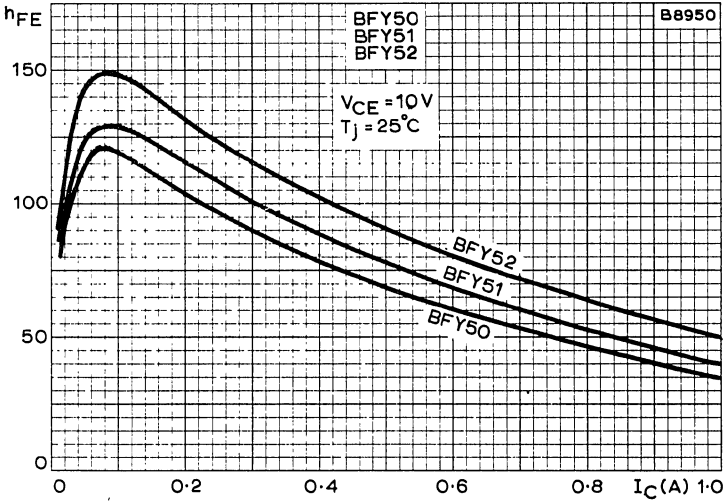
TYPICAL OUTPUT CHARACTERISTICS



BFY50  
BFY51  
BFY52

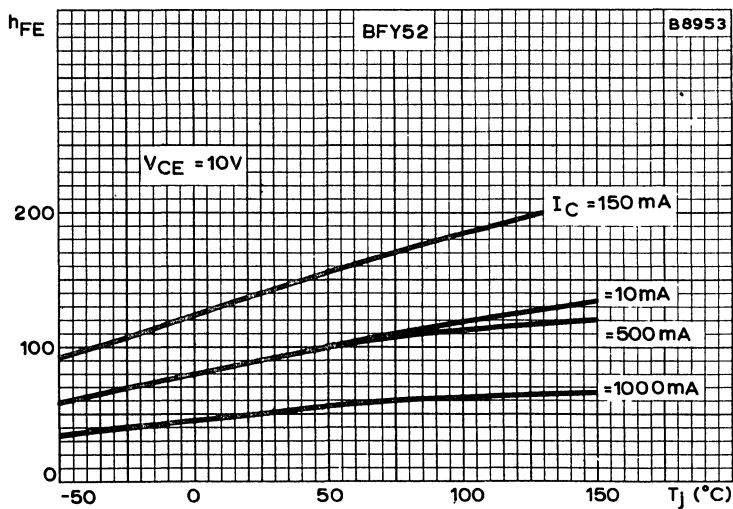
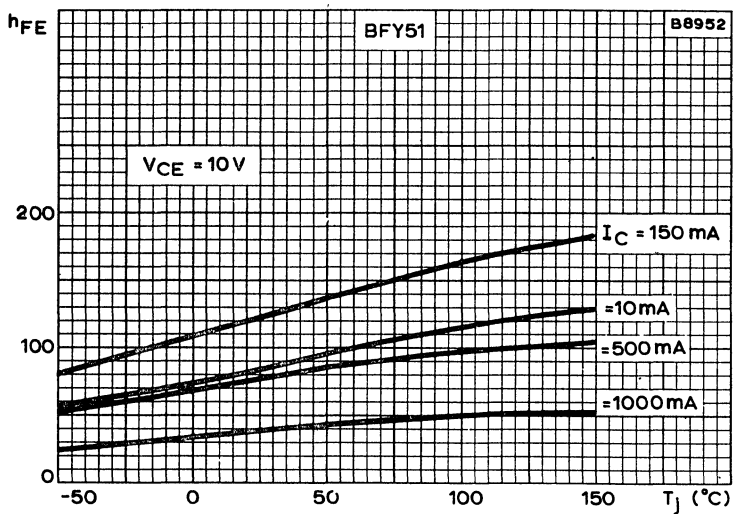


TYPICAL TRANSFER, MUTUAL AND INPUT CHARACTERISTICS

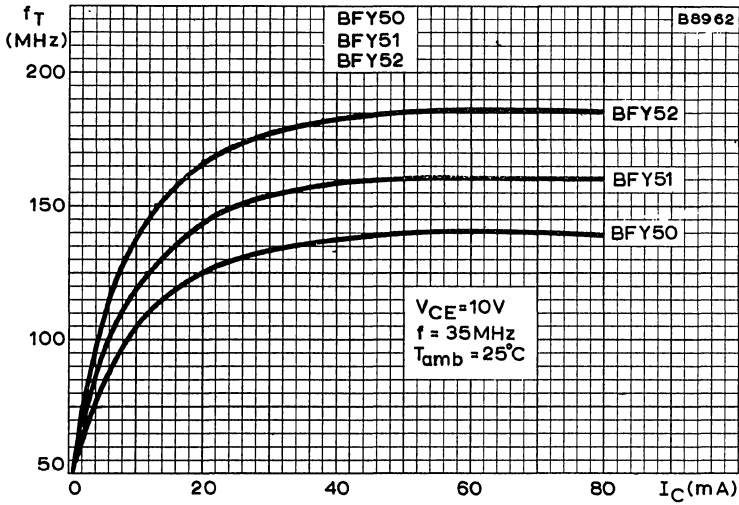


TYPICAL STATIC FORWARD CURRENT TRANSFER RATIO PLOTTED AGAINST COLLECTOR CURRENT AND JUNCTION TEMPERATURE

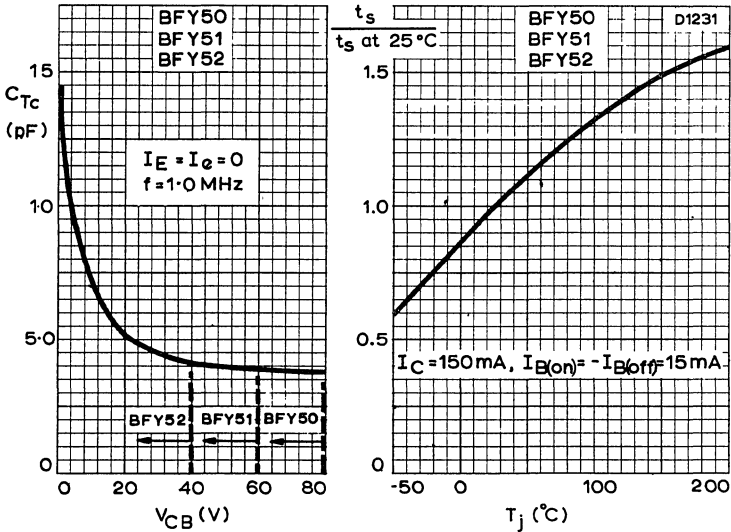
BFY50  
BFY51  
BFY52



TYPICAL STATIC FORWARD CURRENT TRANSFER RATIO PLOTTED AGAINST JUNCTION TEMPERATURE



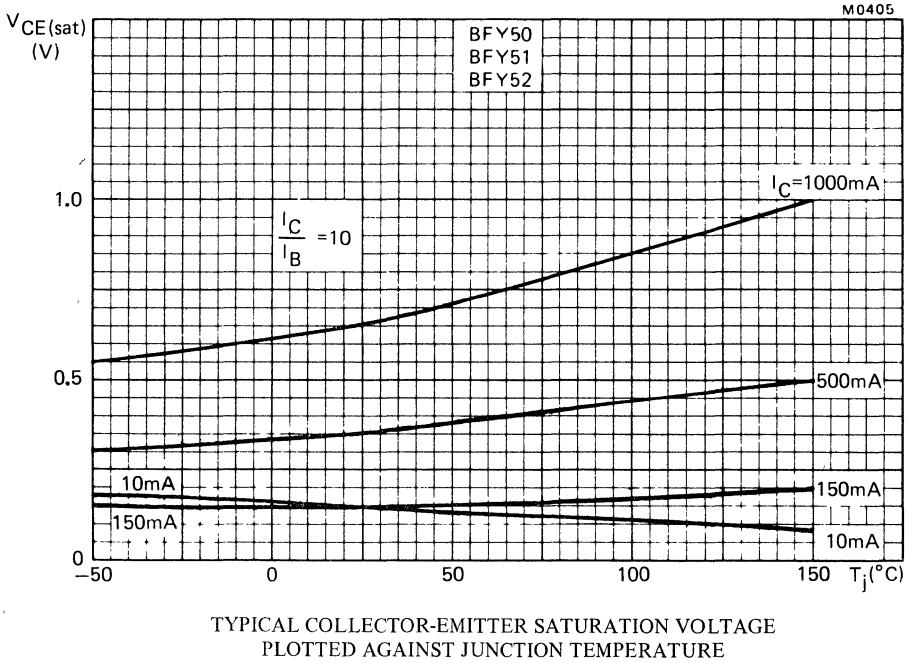
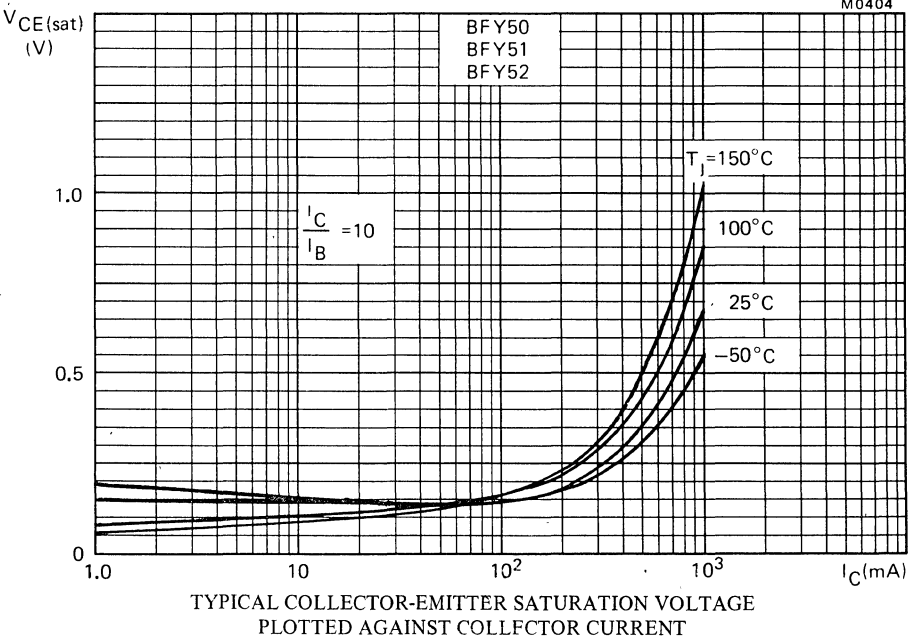
TYPICAL TRANSITION FREQUENCY PLOTTED AGAINST COLLECTOR CURRENT

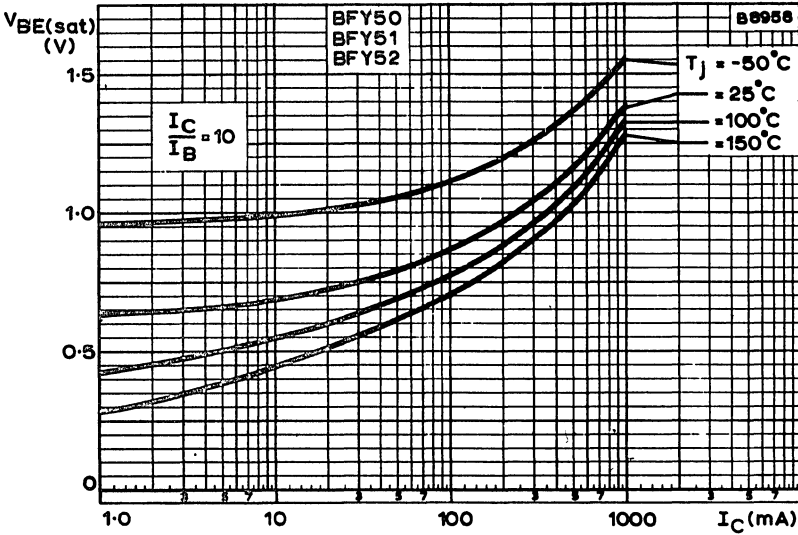


Typical collector capacitance versus collector-base voltage

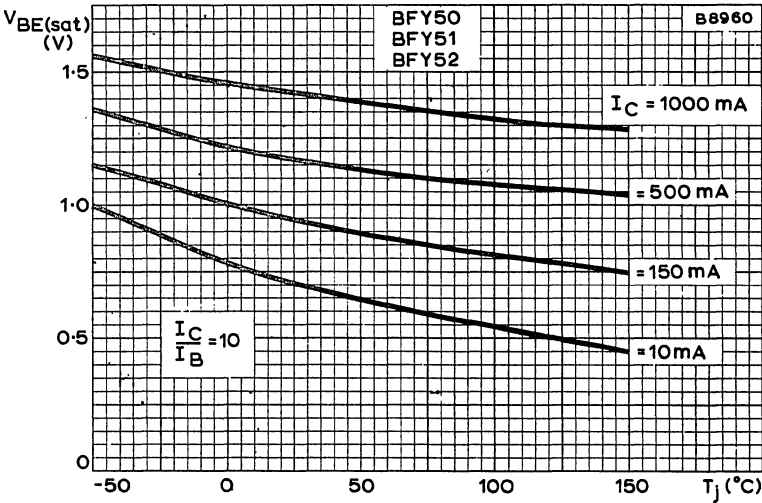
Typical storage time normalised at  $25^{\circ}C$

BFY50  
 BFY51  
 BFY52



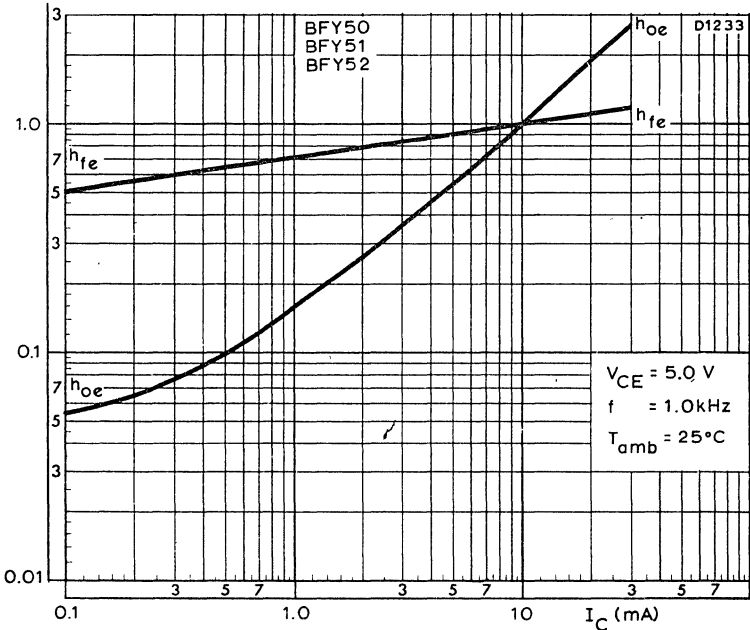
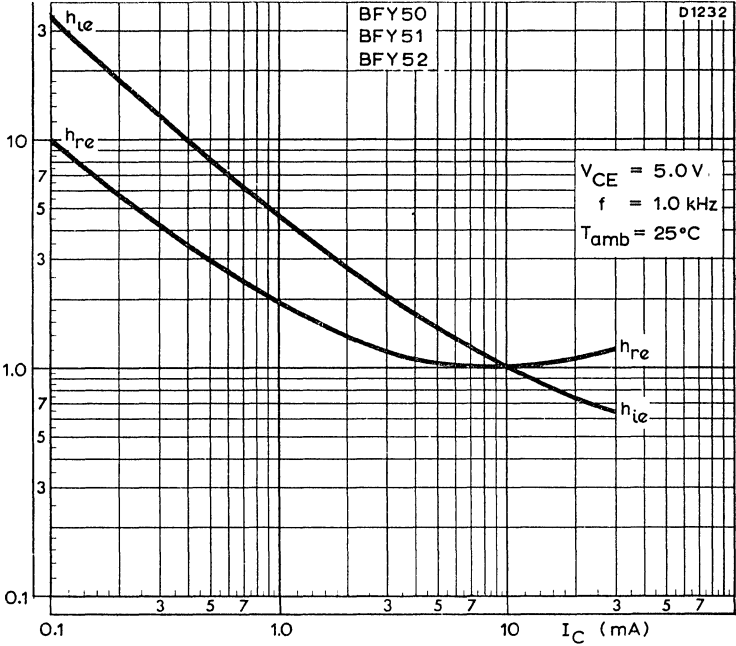


TYPICAL BASE-EMITTER SATURATION VOLTAGE  
PLOTTED AGAINST COLLECTOR CURRENT



TYPICAL BASE-EMITTER SATURATION VOLTAGE  
PLOTTED AGAINST JUNCTION TEMPERATURE

BFY50  
 BFY51  
 BFY52



TYPICAL  $h$ -PARAMETERS NORMALIZED AT  $I_C = 10$  mA

## SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in TO-39 metal case with the collector connected to the case. It is primarily intended for use in high frequency and very high frequency oscillators and amplifiers as well as for output stages of servo amplifiers.

### QUICK REFERENCE DATA

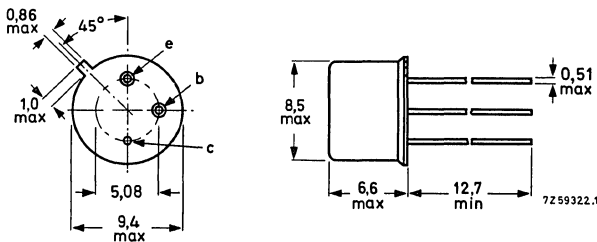
Collector-base voltage (open emitter)	$V_{CBO}$	max.	80 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	35 V
Collector current (d.c.)	$I_C$	max.	1 A
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	800 mW
Junction temperature	$T_j$	max.	200 $^\circ\text{C}$
D.C. current gain at $T_j = 25\text{ }^\circ\text{C}$ $I_C = 150\text{ mA}$ ; $V_{CE} = 10\text{ V}$	$h_{FE}$	>	40
Transition frequency $I_C = 50\text{ mA}$ ; $V_{CE} = 10\text{ V}$	$f_T$	>	60 MHz
Collector-emitter saturation voltage $I_C = 1\text{ A}$ ; $I_B = 100\text{ mA}$	$V_{CEsat}$	<	1 V

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).



**RATINGS** (Limiting values) <sup>1)</sup>

Voltages

Collector-base voltage (open emitter)	$V_{CBO}$	max.	80 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	35 V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	7 V

Currents

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

Power dissipation (See also page 4)

Total power dissipation up to $T_{amb} = 40\text{ }^\circ\text{C}$	$P_{tot}$	max.	4 W
Total power dissipation without cooling fin up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	0.8 W

Temperatures

Storage temperature	$T_{stg}$	-65 to +200	$^\circ\text{C}$
Junction temperature	$T_j$	max.	200 $^\circ\text{C}$

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th\ j-a}$	=	0.22 $^\circ\text{C}/\text{mW}$
From junction to case	$R_{th\ j-c}$	=	0.035 $^\circ\text{C}/\text{mW}$

<sup>1)</sup> Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

**CHARACTERISTICS**

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

Collector cut-off current

$I_E = 0; V_{CB} = 60\text{ V}$   $I_{CBO} < 10\text{ nA}$

$I_E = 0; V_{CB} = 60\text{ V}; T_j = 150\text{ }^\circ\text{C}$   $I_{CBO} < 10\text{ }\mu\text{A}$

Emitter cut-off current

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

Saturation voltages

$I_C = 150\text{ mA}; I_B = 15\text{ mA}$   $V_{CEsat} < 0.2\text{ V}$

$I_C = 1\text{ A}; I_B = 100\text{ mA}$  <sup>1)2)</sup>  $V_{CEsat} < 1.0\text{ V}$   
 $V_{BEsat} < 1.6\text{ V}$

Sustaining voltage

$I_C = 30\text{ mA}; I_B = 0$  <sup>2)</sup>  $V_{CEOsust} > 35\text{ V}$

D.C. current gain <sup>2)</sup>

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

$I_C = 150\text{ mA}; V_{CE} = 10\text{ V}$   $h_{FE} 40\text{ to }120$

$I_C = 1\text{ A}; V_{CE} = 10\text{ V}$   $h_{FE} > 15$

Feedback time constant

$I_C = 10\text{ mA}; V_{CB} = 10\text{ V}; f = 4\text{ MHz}$   $r_b' C_c < 800\text{ ps}$

Collector capacitance at  $f = 500\text{ kHz}$

$I_E = I_e = 0; V_{CB} = 10\text{ V}$   $C_c < 12\text{ pF}$

Emitter capacitance at  $f = 500\text{ kHz}$

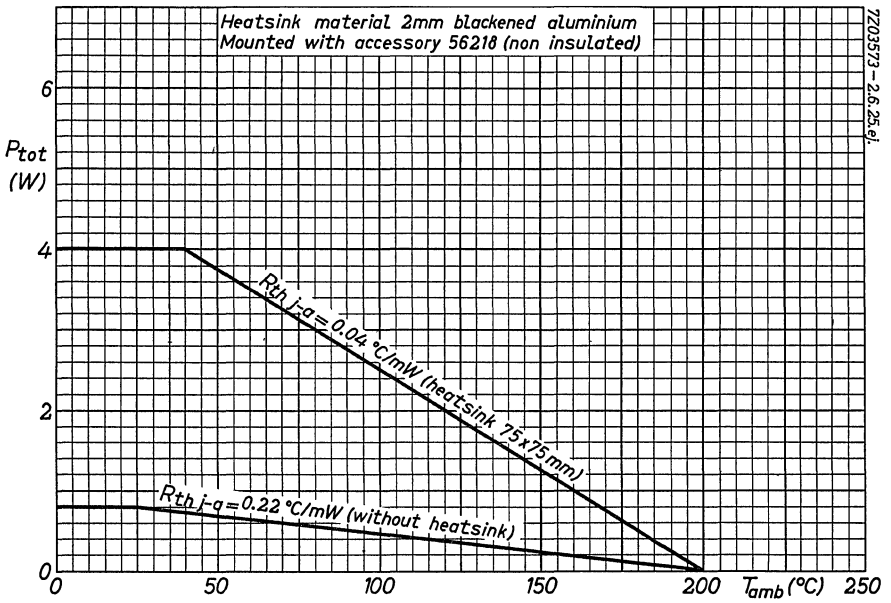
$I_C = I_c = 0; V_{EB} = 0.5\text{ V}$   $C_e < 80\text{ pF}$

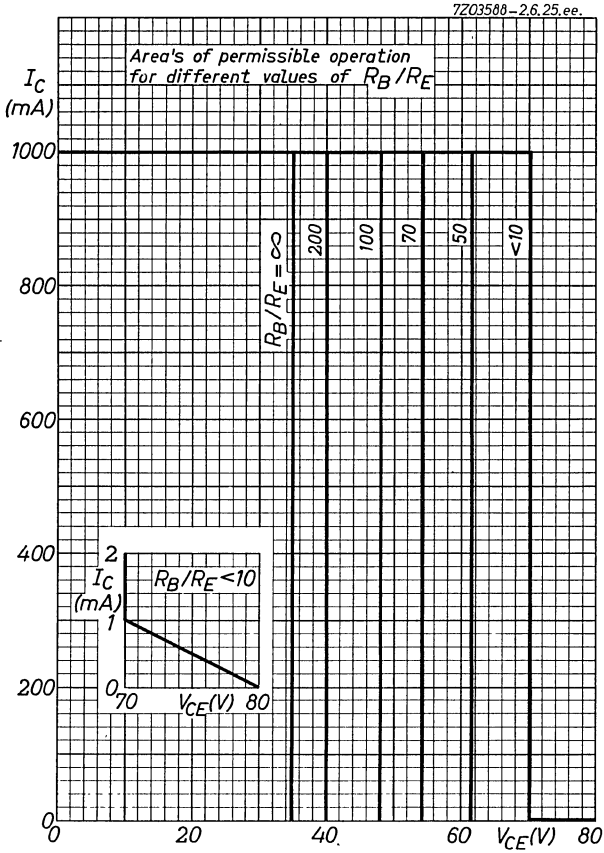
Transition frequency

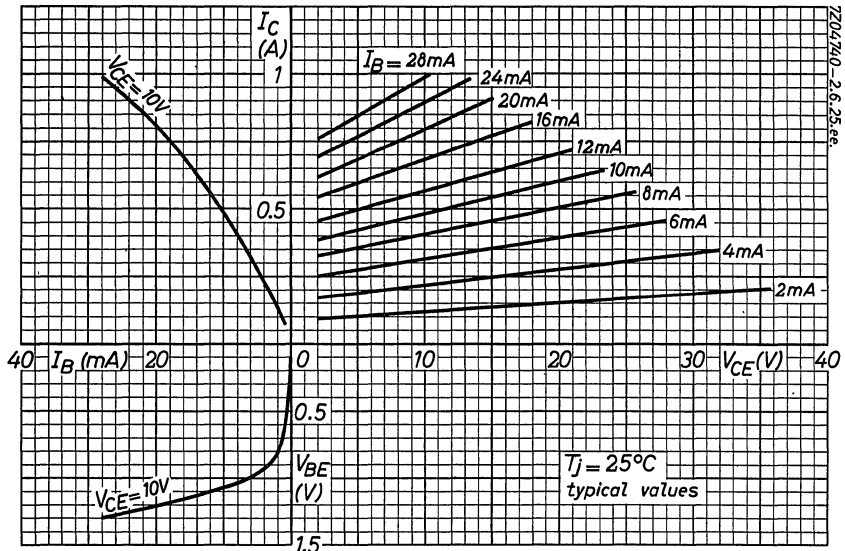
$I_C = 50\text{ mA}; V_{CE} = 10\text{ V}$   $f_T > 60\text{ MHz}$

<sup>1)</sup> Measured with a lead length of 1 cm.

<sup>2)</sup> Measured under pulsed conditions to avoid excessive dissipation.  
 Pulse duration = 300  $\mu\text{s}$ ; duty cycle  $\delta < 0.01$

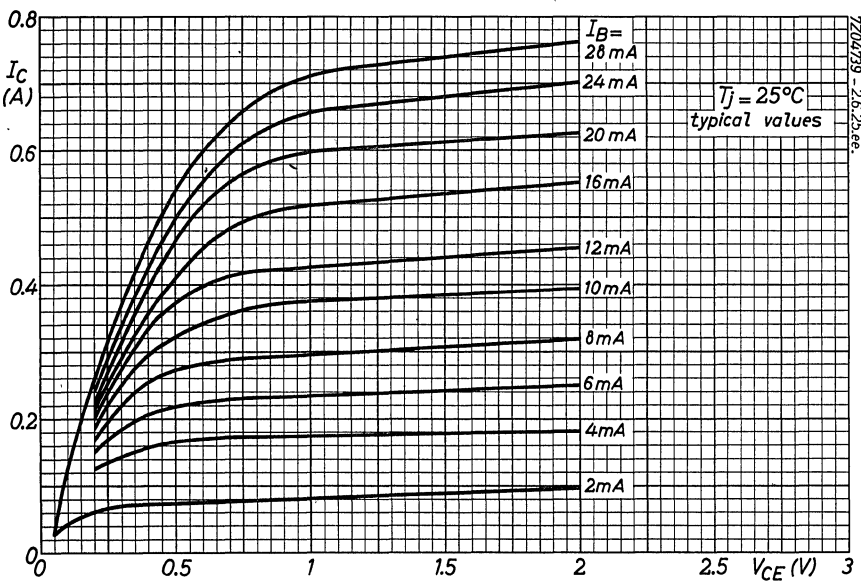


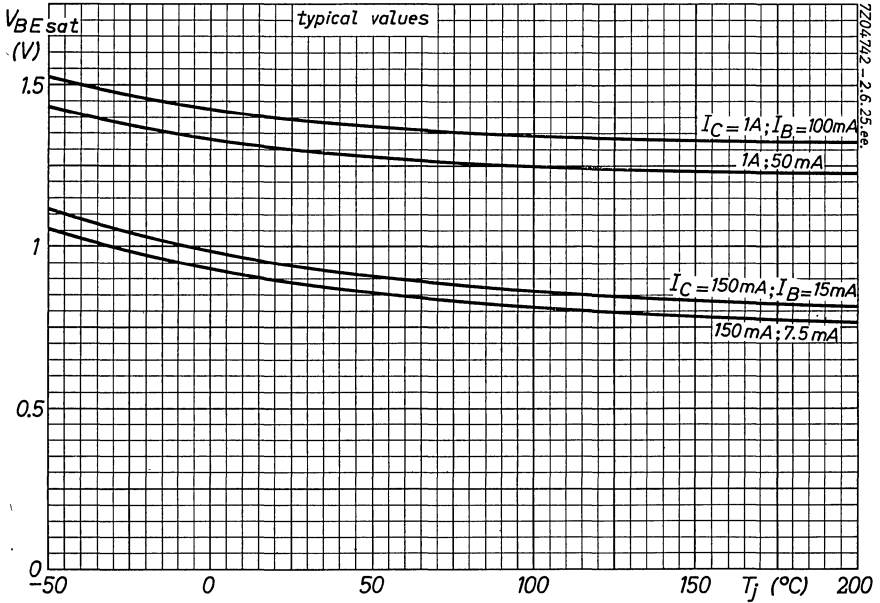
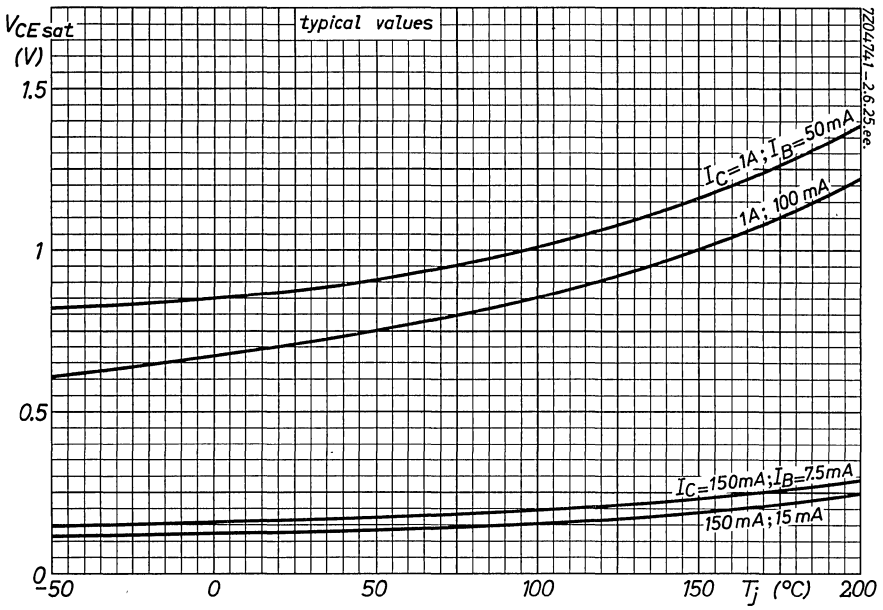


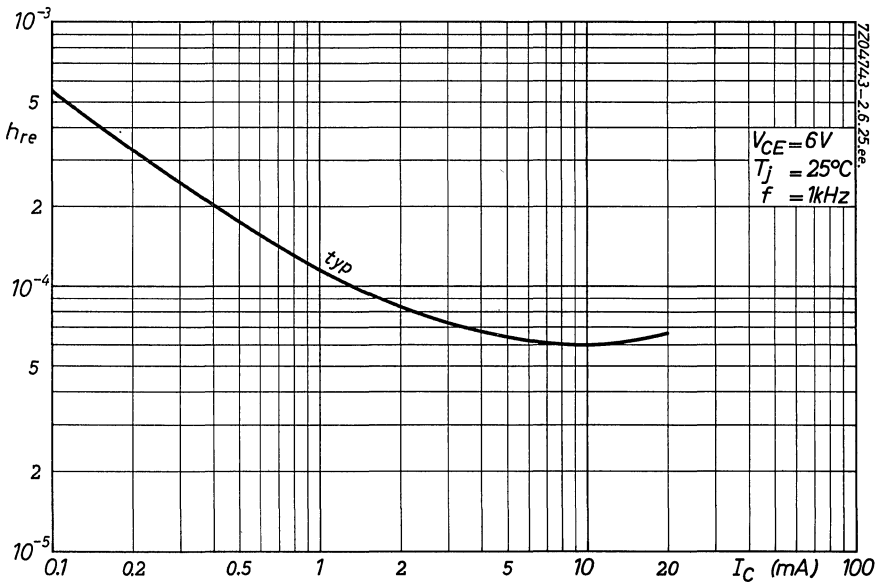
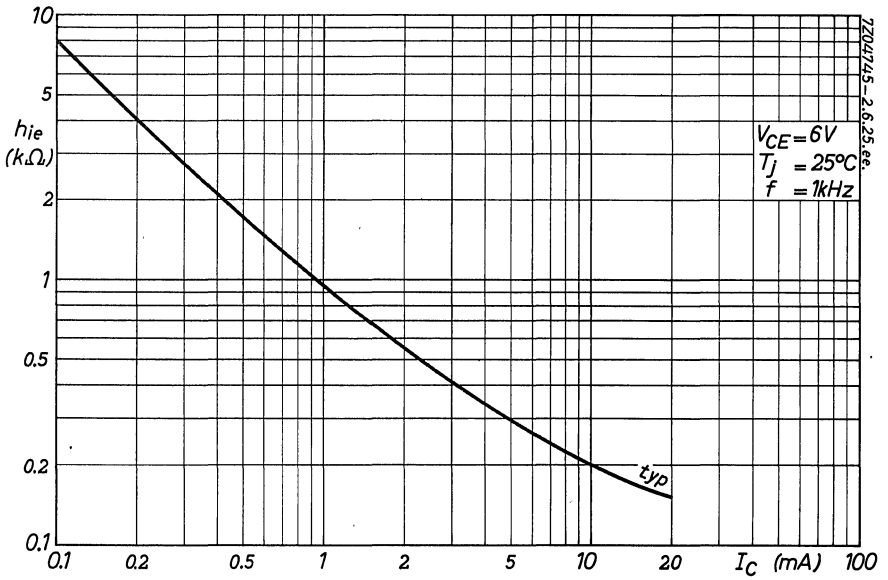


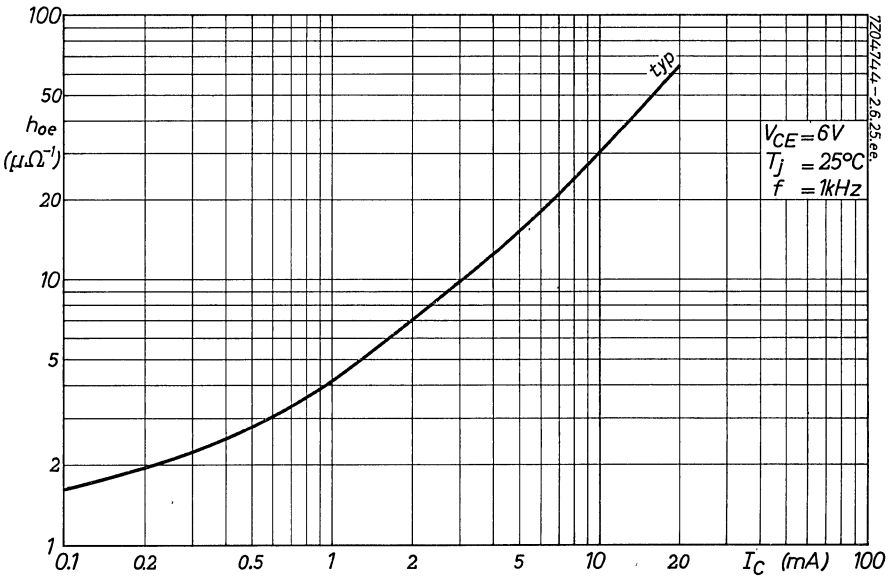
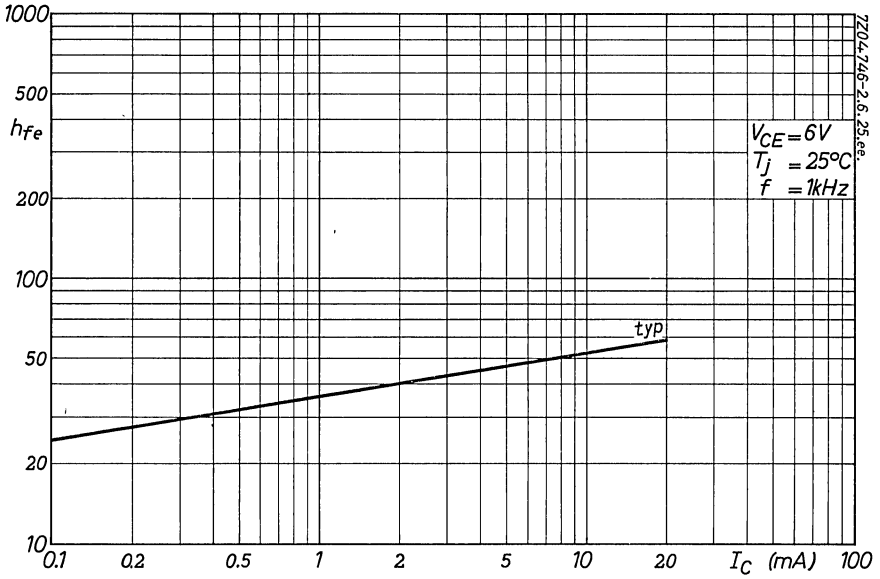
7204740-2.6.25.ee

7204739-2.6.25.ee

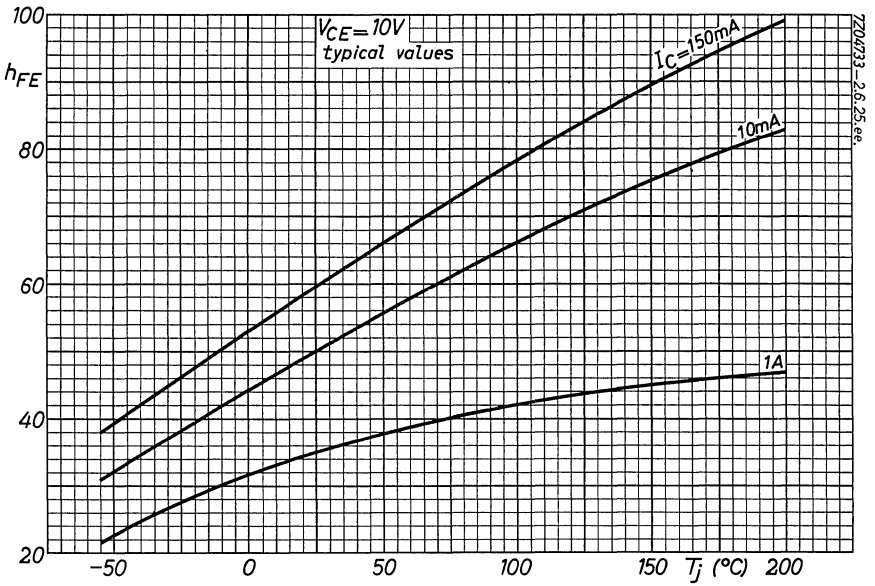
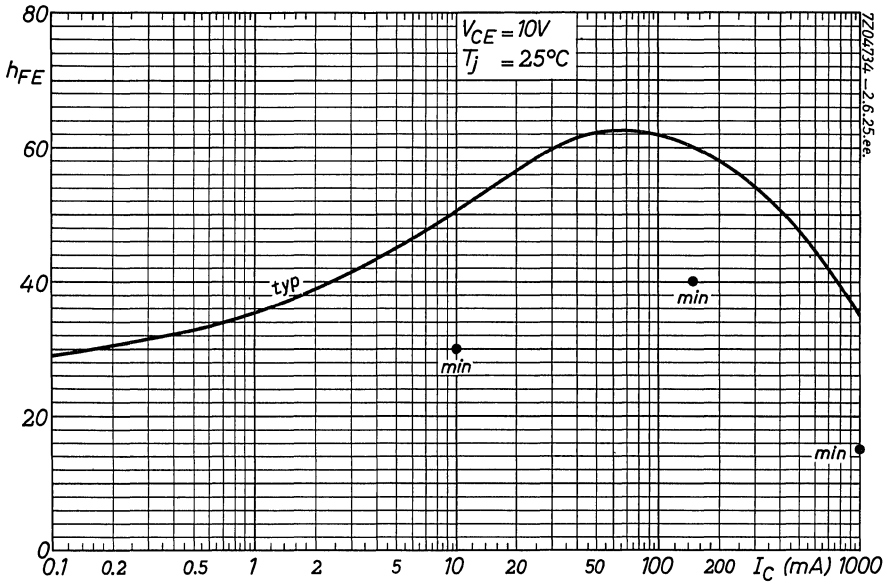


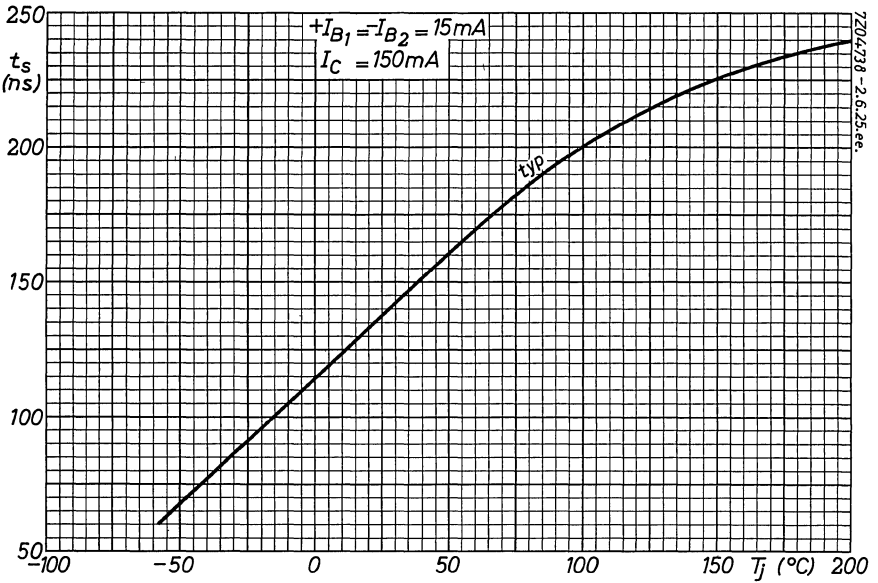
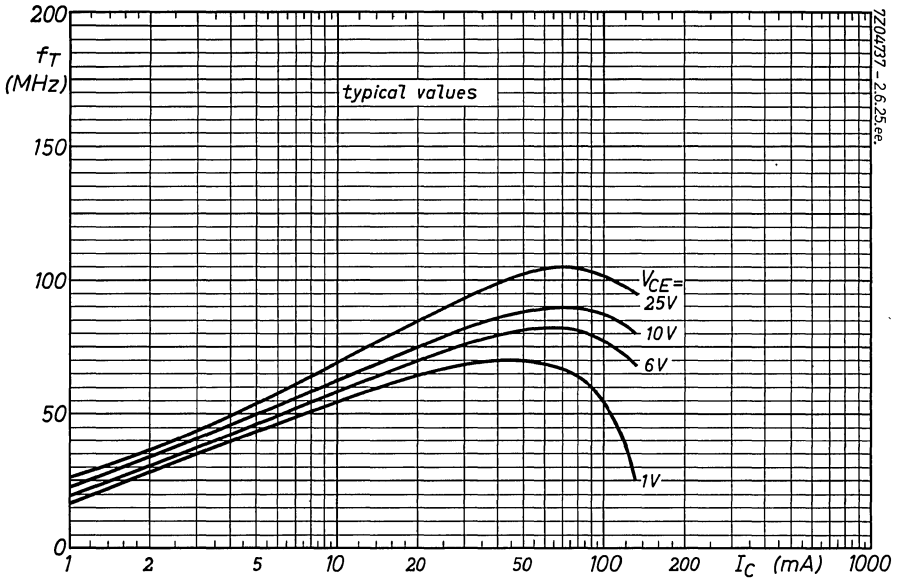


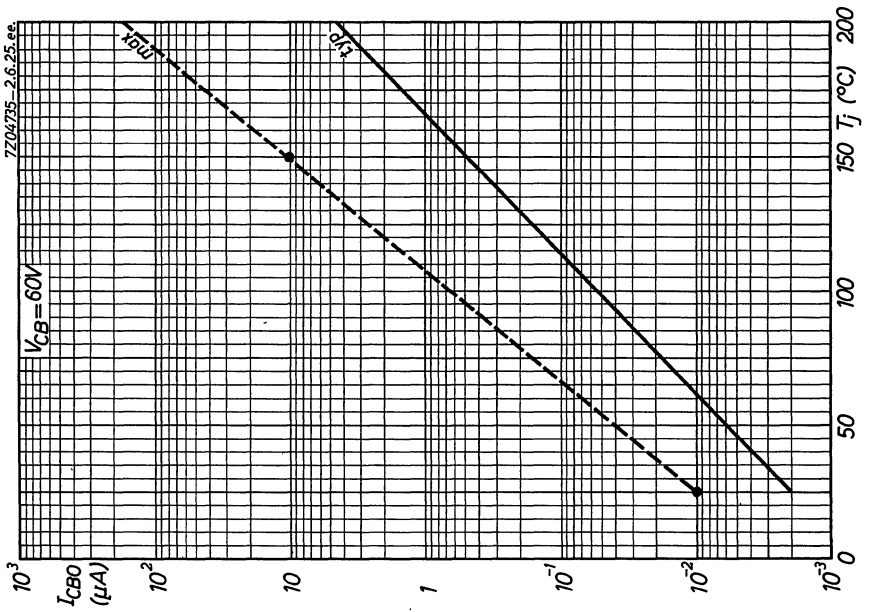
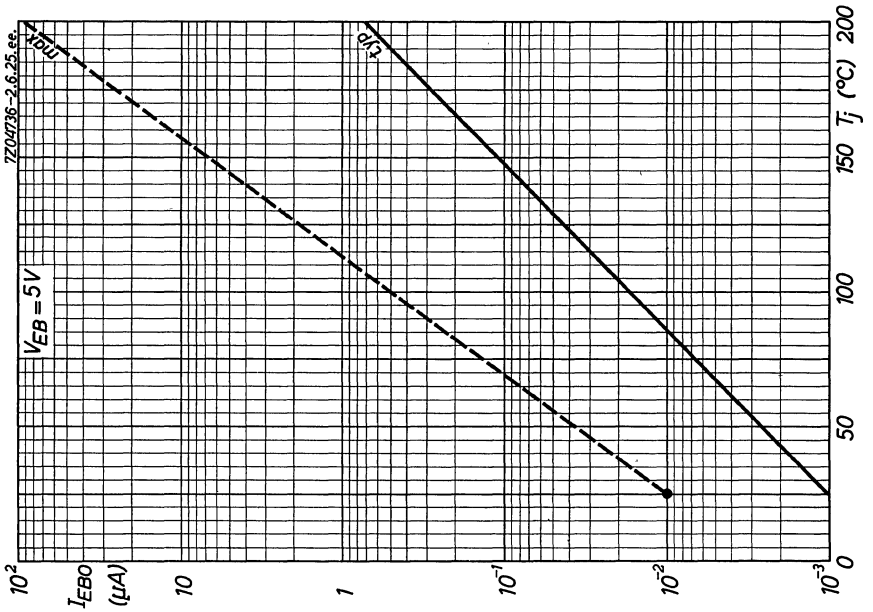












## SILICON CONTROLLED SWITCH

The BR101 is a planar p-n-p switch in a TO-72 metal envelope, intended for time base circuits and other television applications. It is also suitable as trigger device for thyristors. It is an integrated p-n-p/n-p-n transistor pair of which all electrodes are accessible. The collector of the n-p-n transistor is connected to the case.

### QUICK REFERENCE DATA

#### p-n-p transistor

Emitter-base voltage (open collector)  $-V_{EBO}$  max. 50 V

#### n-p-n transistor

Collector-base voltage (open emitter)  $V_{CBO}$  max. 50 V

Repetitive peak emitter current (peak value)  $-I_{ERM}$  max. 2,5 A

Total power dissipation up to  $T_{amb} = 25\text{ }^{\circ}\text{C}$   $P_{tot}$  max. 275 mW

Junction temperature  $T_j$  max. 150  $^{\circ}\text{C}$

#### Forward on-state voltage

$I_A = 50\text{ mA}$ ;  $I_{AG} = 0$ ;  $R_{KG-K} = 10\text{ k}\Omega$   $V_{AK} < 1,4\text{ V}$

#### Holding current

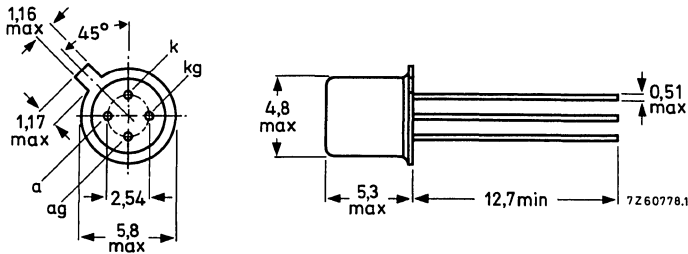
$I_{AG} = 10\text{ mA}$ ;  $-V_{BB} = 2\text{ V}$ ;  $R_{KG-K} = 10\text{ k}\Omega$   $I_H < 1,0\text{ mA}$

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-72.

Collector of the n-p-n transistor (ag = anode gate) connected to the case



Accessories: 56246 (distance disc).

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

Voltages

		p-n-p	n-p-n	
Collector-base voltage (open emitter)	$V_{CBO}$	max. -50	50	V
Collector-emitter voltage ( $R_{BE} = 10\text{ k}\Omega$ )	$V_{CER}$	max. -	50	V
Collector-emitter voltage (open base)	$V_{CEO}$	max. -50	-	V
Emitter-base voltage (open collector)	$V_{EBO}$	max. -50	5 1)	V

Currents

Emitter current (d. c.)	$I_E$	max. 175	-175	mA
Repetitive peak emitter current $t_p = 10\ \mu\text{s}; \delta = 0,01$	$I_{ERM}$	max. 2,5	-2,5	A
Collector current (d. c.)	$I_C$	max. -	175 2)	mA
Collector current (peak value)	$I_{CM}$	max. -	175	mA

Power dissipation

Total power dissipation up to $T_{amb} = 25\ ^\circ\text{C}$	$P_{tot}$	max. 275		mW
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Temperatures

Storage temperature	$T_{stg}$	-65 to +200		$^\circ\text{C}$
Operating junction temperature	$T_j$	max. 150		$^\circ\text{C}$

**THERMAL RESISTANCE**

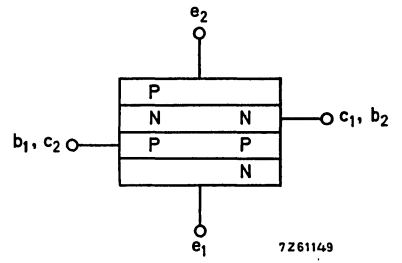
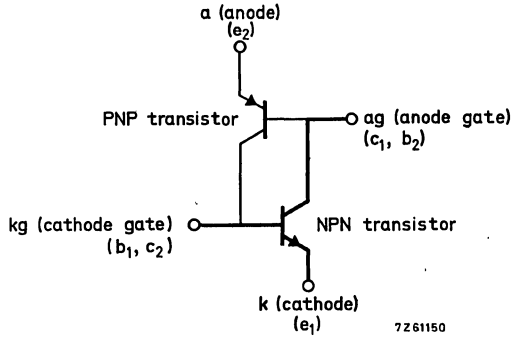
From junction to ambient	$R_{th\ j-a}$	=	0,45	$^\circ\text{C}/\text{mW}$
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- 1) Exceeding of this voltage is allowed during the discharge of a capacitor of max. 390 pF, provided the charge does not exceed 50 nC.
- 2) Provided the  $I_E$  rating will not be exceeded.

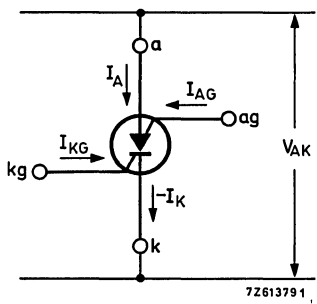
MEANING OF SYMBOLS , used in the schematic presentation of the S. C. S.

2 transistors equivalent circuit  
n-p-n transistor + p-n-p transistor

p-n-p-n S. C. S. equivalent circuit



S. C. S. symbol



**CHARACTERISTICS**

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

Individual N-P-N transistor

Collector cut-off current

$V_{CE} = 50\text{ V}; R_{BE} = 10\text{ k}\Omega$   $I_{CER} < 0,5\text{ }\mu\text{A}$

$V_{CE} = 50\text{ V}; R_{BE} = 10\text{ k}\Omega; T_j = 150\text{ }^\circ\text{C}$   $I_{CER} < 50\text{ }\mu\text{A}$

Emitter cut-off current

$I_C = 0; V_{EB} = 5\text{ V}; T_j = 150\text{ }^\circ\text{C}$   $I_{EBO} < 50\text{ }\mu\text{A}$

## CHARACTERISTICS (continued)

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

### Individual N-P-N transistor

#### Saturation voltages

$$I_C = 10\text{ mA}; I_B = 1\text{ mA}$$

$V_{CEsat}$	<	500	mV
$V_{BEsat}$	<	900	mV

#### D. C. current gain

$$I_C = 10\text{ mA}; V_{CE} = 2\text{ V}$$

$h_{FE}$	>	50	
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#### Transition frequency

$$I_C = 10\text{ mA}; V_{CE} = 2\text{ V}$$

$f_T$	typ.	300	MHz
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#### Collector capacitance

$$I_E = I_e = 0; V_{CB} = 20\text{ V}$$

$C_c$	<	5	pF
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#### Emitter capacitance

$$I_C = I_c = 0; V_{EB} = 1\text{ V}$$

$C_e$	<	25	pF
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### Individual P-N-P transistor

#### Collector cut-off current

$$I_B = 0; -V_{CE} = 50\text{ V}; T_j = 150\text{ }^\circ\text{C}$$

$-I_{CEO}$	<	50	$\mu\text{A}$
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#### Emitter cut-off current

$$I_C = 0; -V_{EB} = 50\text{ V}; T_j = 150\text{ }^\circ\text{C}$$

$-I_{EBO}$	<	50	$\mu\text{A}$
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#### D. C. current gain

$$I_E = 1\text{ mA}; V_{CB} = 0$$

$h_{FE}$		0,25 to 2,5	
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### Combined device

#### Forward on-state voltage at $R_{KG-K} = 10\text{ k}\Omega$

$$I_A = 50\text{ mA}; I_{AG} = 0$$

$V_{AK}$	<	1,4	V
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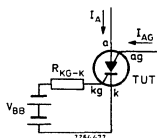
$$I_A = 1\text{ mA}; I_{AG} = 10\text{ mA}$$

$V_{AK}$	<	1,2	V
----------	---	-----	---

#### Holding current at $R_{KG-K} = 10\text{ k}\Omega$

$$I_{AG} = 10\text{ mA}; -V_{BB} = 2\text{ V}$$

$I_H$	<	1,0	mA
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## PROGRAMMABLE UNIJUNCTION TRANSISTOR

The BRY39 is a planar p-n-p-n trigger device in a TO-72 metal envelope, intended for use in switching applications such as motor control, oscillators, relay replacement, timers, pulse shaper etc.

### QUICK REFERENCE DATA

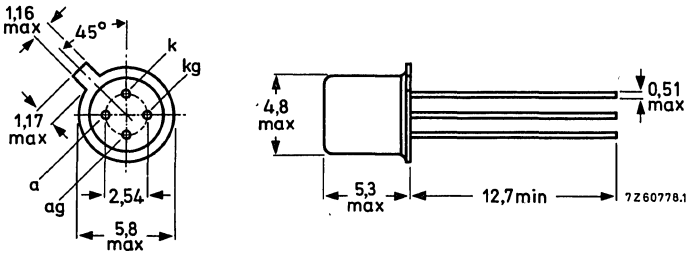
Gate-anode voltage	$V_{GA}$	max.	70 V
Anode current (d.c.) up to $T_{case} = 85\text{ }^{\circ}\text{C}$	$I_A$	max.	250 mA
Operating junction temperature	$T_j$	max.	150 $^{\circ}\text{C}$
Peak point current	$I_P$	<	5 $\mu\text{A}$
Valley point current	$I_V$	>	25 $\mu\text{A}$
$V_S = 10\text{ V}; R_G = 10\text{ k}\Omega$			
$V_S = 10\text{ V}; R_G = 10\text{ k}\Omega$			

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-72.

Anode gate (ag) connected to case



Accessories: 56246 (distance disc).



**RATINGS**

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

Gate-anode voltage	$V_{GA}$	max.	70 V
Anode current (d.c.) up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$I_A$	max.	175 mA
Anode current (d.c.) up to $T_{case} = 85\text{ }^{\circ}\text{C}$	$I_A$	max.	250 mA
Repetitive peak anode current $t = 10\text{ }\mu\text{s}; \delta = 0,01$	$I_{ARM}$	max.	2,5 A
Non-repetitive peak anode current $t = 10\text{ }\mu\text{s}; T_j = 150\text{ }^{\circ}\text{C}$	$I_{ASM}$	max.	3 A
Rate of rise of anode current up to $I_A = 2,5\text{ A}$	$\frac{dI_A}{dt}$	max.	20 A/ $\mu\text{s}$
Storage temperature	$T_{stg}$		-65 to + 200 $^{\circ}\text{C}$
Operating junction temperature	$T_j$	max.	150 $^{\circ}\text{C}$

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th\ j-a}$	=	450 K/W
From junction to case	$R_{th\ j-c}$	=	150 K/W

**EXPLANATION OF SYMBOLS**

For application of the BRY39 as a programmable unijunction transistor only the anode gate is used. To simplify the symbols the term gate instead of anode gate will be used.

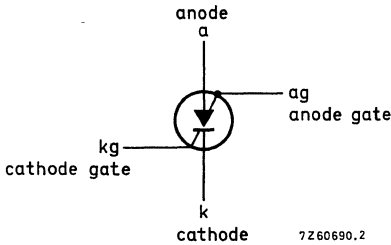


Fig. 2.

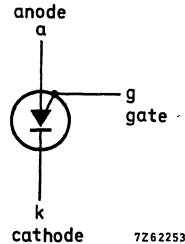


Fig. 3.

**CHARACTERISTICS**

$T_{amb} = 25\text{ }^{\circ}\text{C}$

Peak point current

$V_S = 10\text{ V}; R_G = 10\text{ k}\Omega$

$I_p < 5\text{ }\mu\text{A}$

$V_S = 10\text{ V}; R_G = 1\text{ M}\Omega$

$I_p < 1\text{ }\mu\text{A}$

Valley point current

$V_S = 10\text{ V}; R_G = 10\text{ k}\Omega$

$I_V > 25\text{ }\mu\text{A}$

$V_S = 10\text{ V}; R_G = 1\text{ M}\Omega$

$I_V < 50\text{ }\mu\text{A}$

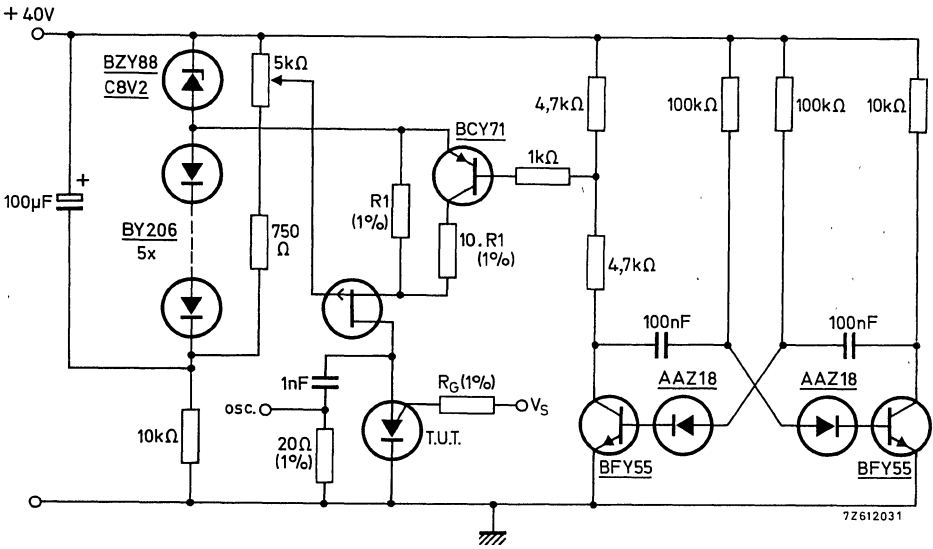


Fig. 4 Practical test circuit:

1. Remove BCY71 during measurement of  $I_p$ .
2. Value of  $R_1$  depends on the voltage range of voltmeter.

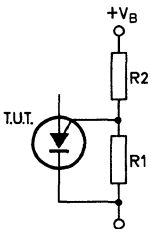


Fig. 5 BRY39 with "program" resistors  $R_1$  and  $R_2$ .

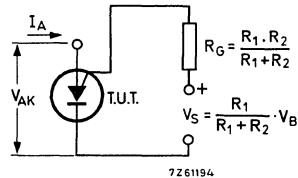


Fig. 6 Equivalent test circuit for characteristics testing.

Gate-anode leakage current (see Fig. 7)

$I_K = 0; V_{GA} = 70 \text{ V}$

$I_{GAO} < 10 \text{ nA}$

Gate-cathode leakage current (see Fig. 8)

$V_{AK} = 0; V_{GK} = 70 \text{ V}$

$I_{GKS} < 100 \text{ nA}$

Offset voltage (see Figs 9 and 16)

$V_{\text{offset}} = V_P - V_S (I_A = 0)$

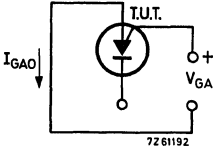


Fig. 7.

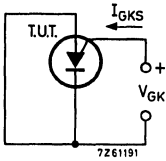


Fig. 8.

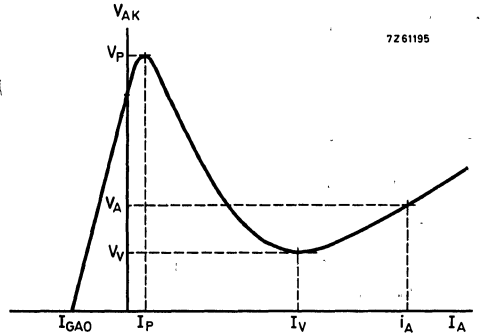


Fig. 9.

Anode voltage

$I_A = 100 \text{ mA}$

$V_A < 1,4 \text{ V}$

Peak output voltage (see Figs 10 and 11)

$V_{AA} = 20 \text{ V}; C = 0,2 \mu\text{F}$

$V_{OM} > 6 \text{ V}$

Rise time (see Figs 10 and 11)

$V_{AA} = 20 \text{ V}; C = 10 \text{ nF}$

$t_r < 80 \text{ ns}$

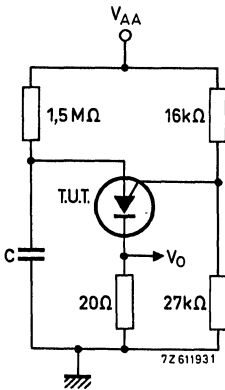


Fig. 10.

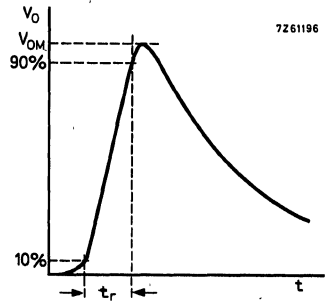


Fig. 11.

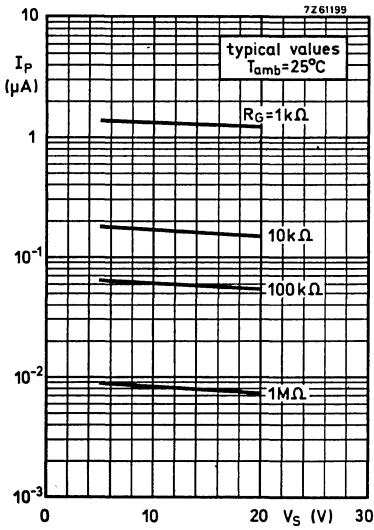


Fig. 12.

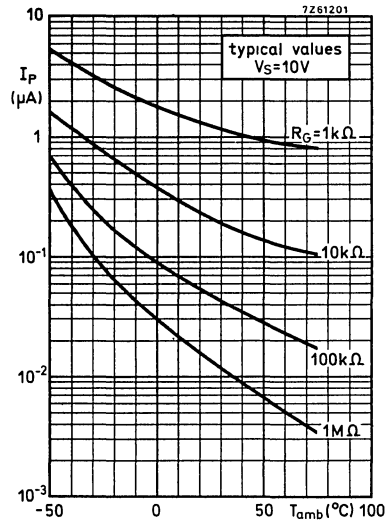


Fig. 13.

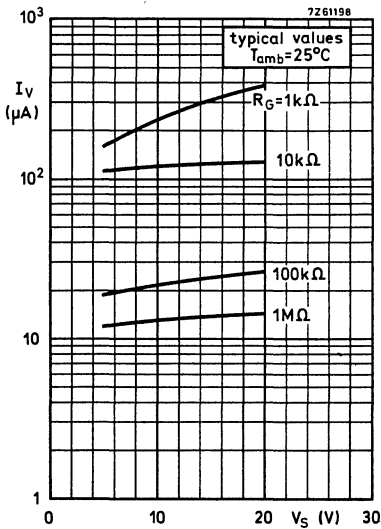


Fig. 14.

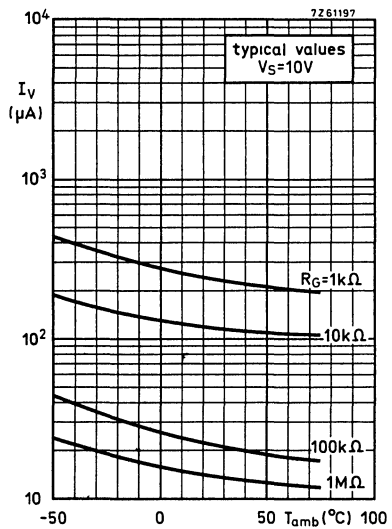


Fig. 15.

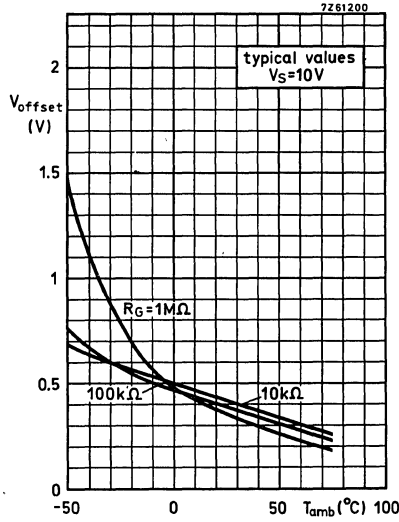


Fig. 16.

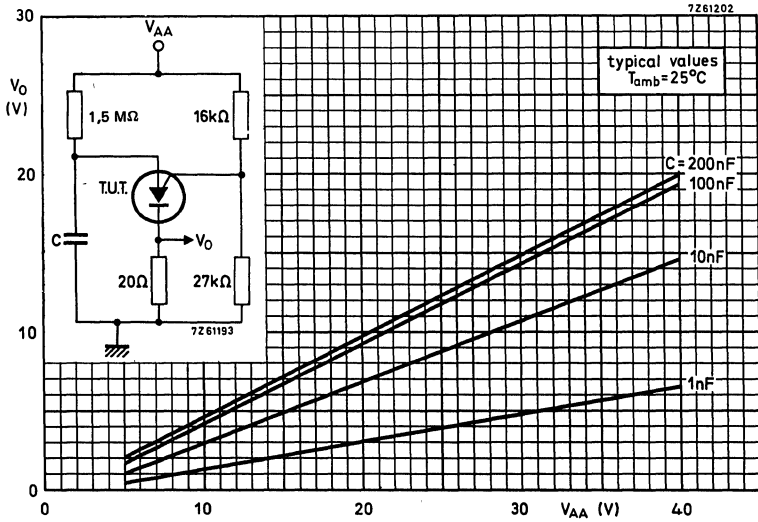


Fig. 17.

## SILICON CONTROLLED SWITCH

The BRY39 is a planar p-n-p-n switch in a TO-72 metal envelope, intended for switching applications. It is an integrated p-n-p/n-p-n transistor pair, with all electrodes accessible.

### QUICK REFERENCE DATA

#### p-n-p transistor

Emitter-base voltage (open collector)  $-V_{EBO}$  max. 70 V

#### n-p-n transistor

Collector-base voltage (open emitter)  $V_{CBO}$  max. 70 V

Repetitive peak emitter current  $-I_{ERM}$  max. 2,5 A

Total power dissipation up to  $T_{amb} = 25\text{ }^{\circ}\text{C}$   $P_{tot}$  max. 275 mW

Operating junction temperature  $T_j$  max. 150  $^{\circ}\text{C}$

#### Forward on-state voltage

$I_A = 50\text{ mA}$ ;  $I_{AG} = 0$ ;  $R_{KG-K} = 10\text{ k}\Omega$   $V_{AK} < 1,4\text{ V}$

#### Holding current

$I_{AG} = 10\text{ mA}$ ;  $-V_{BB} = 2\text{ V}$ ;  $R_{KG-K} = 10\text{ k}\Omega$   $I_H < 1,0\text{ mA}$

Turn-on time  $t_{on} < 0,25\text{ }\mu\text{s}$

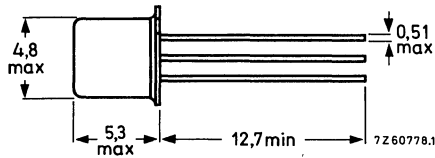
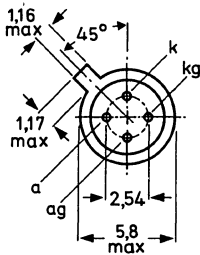
Turn-off time  $t_q < 5,0\text{ }\mu\text{s}$

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-72.

Collector of the n-p-n transistor (ag = anode gate) connected to the case



Accessories: 56246 (distance disc).

**RATINGS**

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

		p-n-p	n-p-n	
Collector-base voltage (open emitter)	$V_{CBO}$	max. -70	70	V
Collector-emitter voltage ( $R_{BE} = 10\text{ k}\Omega$ )	$V_{CER}$	max. -	70	V
Collector-emitter voltage (open base)	$V_{CEO}$	max. -70	-	V
Emitter-base voltage (open collector)	$V_{EBO}$	max. -70	5	V
Collector current (d.c.) *	$I_C$	max. -	175	mA
Collector current (peak value) **	$I_{CM}$	max. -	175	mA
Emitter current (d.c.)	$I_E$	max. 175	-175	mA
Repetitive peak emitter current	$I_{ERM}$	max. 2,5	-2,5	A
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max. 275		mW
Storage temperature	$T_{stg}$	-65 to +200		$^\circ\text{C}$
Operating junction temperature	$T_j$	max. 150		$^\circ\text{C}$

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th\ j-a}$	=	450	K/W
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\* Provided the  $I_E$  rating is not exceeded.

\*\* During switching on, the device can withstand the discharge of a capacitor of maximum value of 500 pF. This capacitor is charged when the transistor is in cut-off condition, with a collector supply voltage of 160 V and a series resistance of 100 k $\Omega$ .

SYMBOLS AND EQUIVALENT CIRCUIT

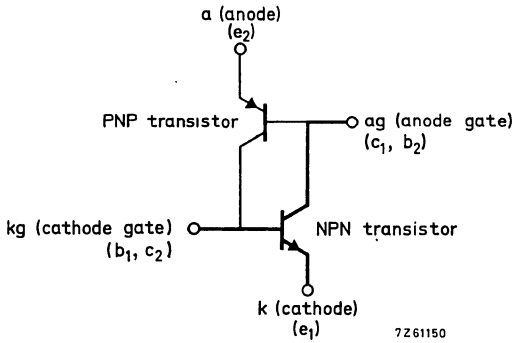


Fig. 2 Two transistor equivalent circuit.

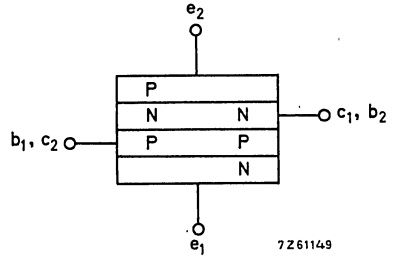


Fig. 3 P-N-P-N silicon controlled switch structure.

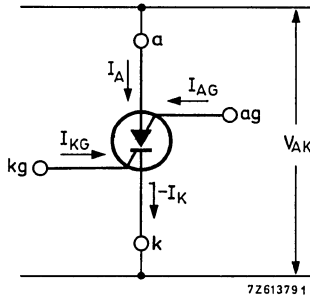


Fig. 4 Silicon controlled switch symbol.

CHARACTERISTICS

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

Individual n-p-n transistor

Collector cut-off current

$V_{CE} = 70\text{ V}; R_{BE} = 10\text{ k}\Omega$

$V_{CE} = 70\text{ V}; R_{BE} = 10\text{ k}\Omega; T_j = 150\text{ }^\circ\text{C}$

Emitter cut-off current

$I_C = 0; V_{EB} = 5\text{ V}; T_j = 150\text{ }^\circ\text{C}$

Saturation voltages

$I_C = 10\text{ mA}; I_B = 1\text{ mA}$

D.C. current gain

$I_C = 10\text{ mA}; V_{CE} = 2\text{ V}$

Transition frequency

$I_C = 10\text{ mA}; V_{CE} = 2\text{ V}$

$I_{CER} < 100\text{ nA}$

$I_{CER} < 10\text{ }\mu\text{A}$

$I_{EBO} < 10\text{ }\mu\text{A}$

$V_{CEsat} < 500\text{ mV}$

$V_{BEsat} < 900\text{ mV}$

$h_{FE} > 50$

$f_T$  typ.  $300\text{ MHz}$



**Collector capacitance**

$I_E = I_e = 0; V_{CB} = 20 \text{ V}$

$C_c < 5 \text{ pF}$

**Emitter capacitance**

$I_C = I_c = 0; V_{EB} = 1 \text{ V}$

$C_e < 25 \text{ pF}$

**Individual p-n-p transistor**

**Collector cut-off current**

$I_B = 0; -V_{CE} = 70 \text{ V}; T_j = 150 \text{ }^\circ\text{C}$

$-I_{CEO} < 10 \text{ } \mu\text{A}$

**Emitter cut-off current**

$I_C = 0; -V_{EB} = 70 \text{ V}; T_j = 150 \text{ }^\circ\text{C}$

$-I_{EBO} < 10 \text{ } \mu\text{A}$

**D.C. current gain**

$I_E = 1 \text{ mA}; V_{CB} = 0$

$h_{FE} \text{ 0,25 to 2,5}$

**Combined device**

**Forward on-state voltage at  $R_{KG-K} = 10 \text{ k}\Omega$**

$I_A = 50 \text{ mA}; I_{AG} = 0$

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

$I_A = 50 \text{ mA}; I_{AG} = 0; T_j = -55 \text{ }^\circ\text{C}$

$V_{AK} < 1,9 \text{ V}$

$I_A = 1 \text{ mA}; I_{AG} = 10 \text{ mA}$

$V_{AK} < 1,2 \text{ V}$

**Holding current at  $R_{KG-K} = 10 \text{ k}\Omega$  (see Fig. 5)**

$I_{AG} = 10 \text{ mA}; -V_{BB} = 2 \text{ V}$

$I_H < 1,0 \text{ mA}$

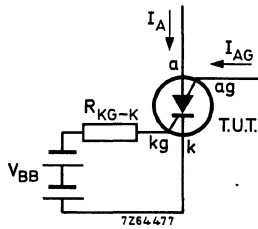


Fig. 5.

Switching times (see Figs 6 to 11)

Turn-on time when switched from  
 $-V_{KG-K} = 0,5 \text{ V}$  to  $+V_{KG-K} = 4,5 \text{ V}$   
 $R_{KG-K} = 1 \text{ k}\Omega$   
 $R_{KG-K} = 10 \text{ k}\Omega$

$t_{on} < 0,25 \mu\text{s}$   
 $t_{on} < 1,50 \mu\text{s}$

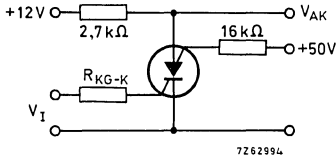


Fig. 6.

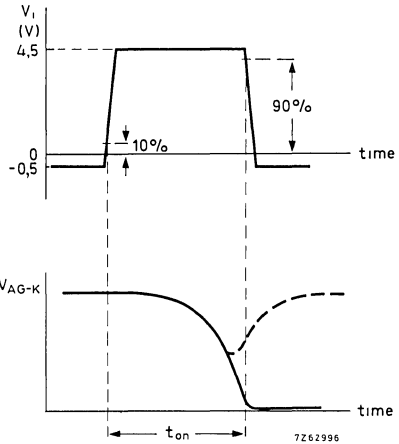


Fig. 7 Pulse duration increased until dashed curve disappears.

Turn-off time (see also Figs 8 and 9)

$R_{KG-K} = 1 \text{ k}\Omega$   
 $R_{KG-K} = 10 \text{ k}\Omega$   
 $R_{KG-K} = 10 \text{ k}\Omega; T_j = 125 \text{ }^\circ\text{C}$

$t_q < 5 \mu\text{s}$   
 $t_q < 8 \mu\text{s}$   
 $t_q < 15 \mu\text{s}$

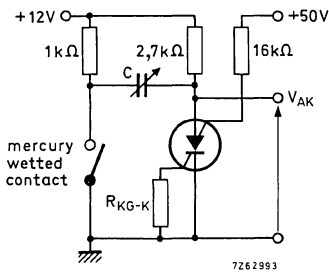


Fig. 8.

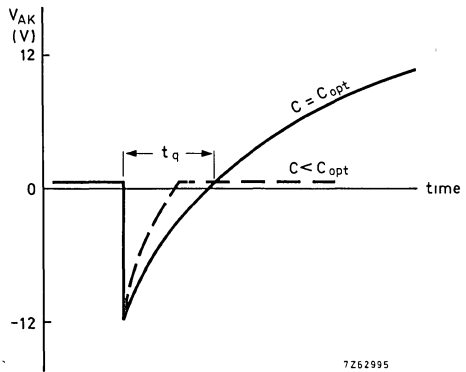


Fig. 9 Capacitance increased until at  $C = C_{opt}$  dashed curve disappears.

7Z62986

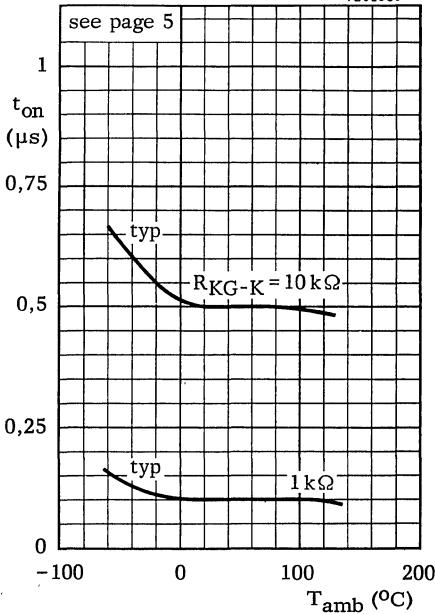


Fig. 10.

7Z62981

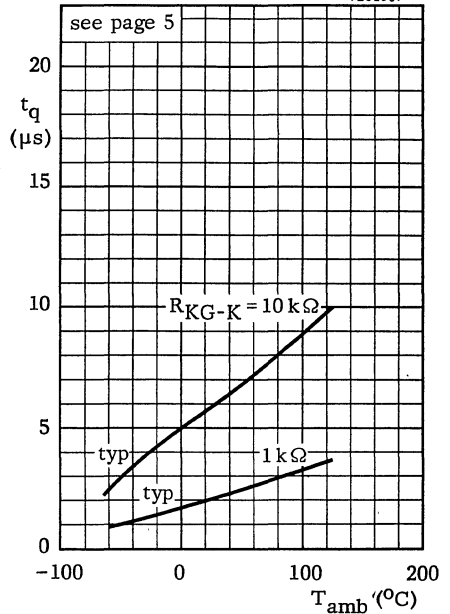


Fig. 11.

7Z62988

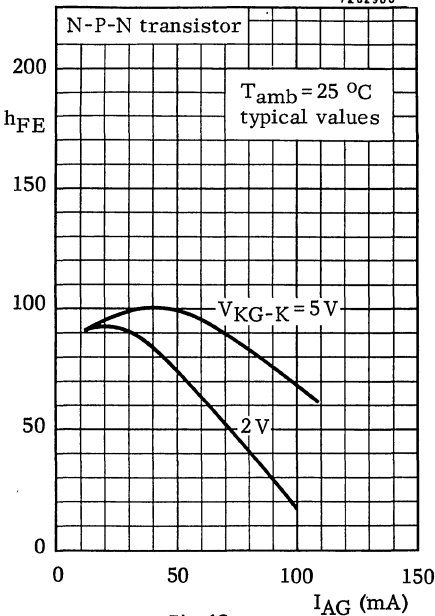


Fig. 12.

7Z62985

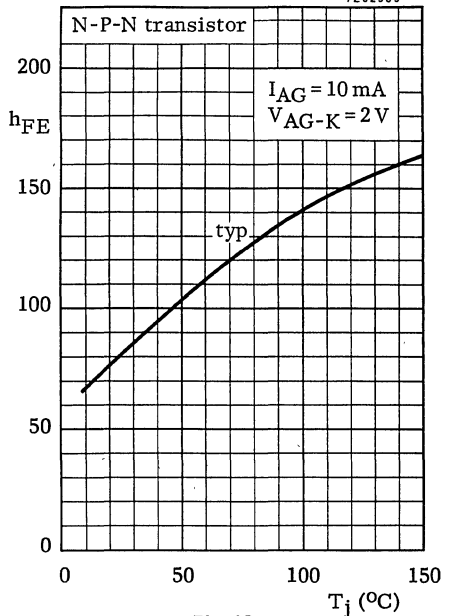


Fig. 13.

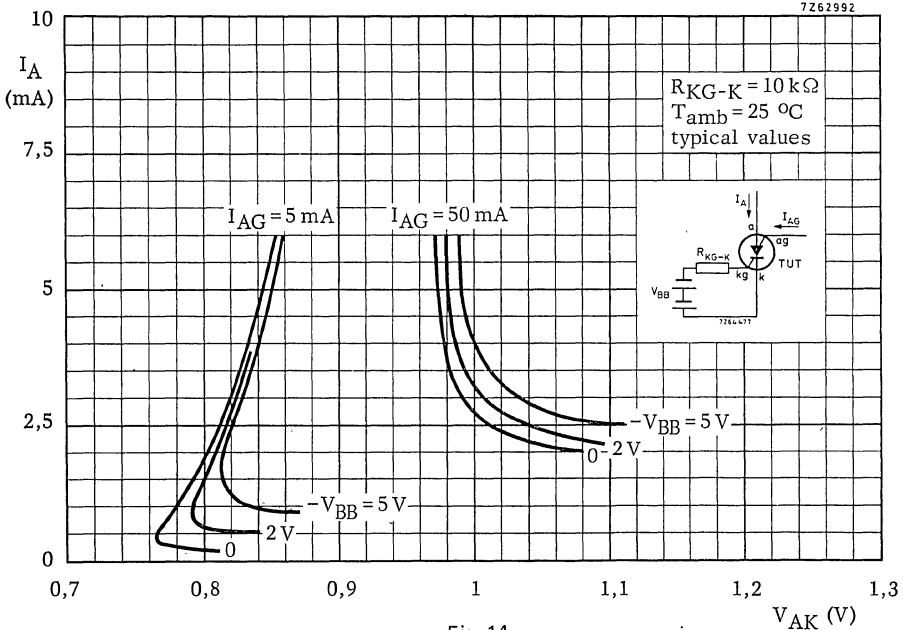


Fig. 14.

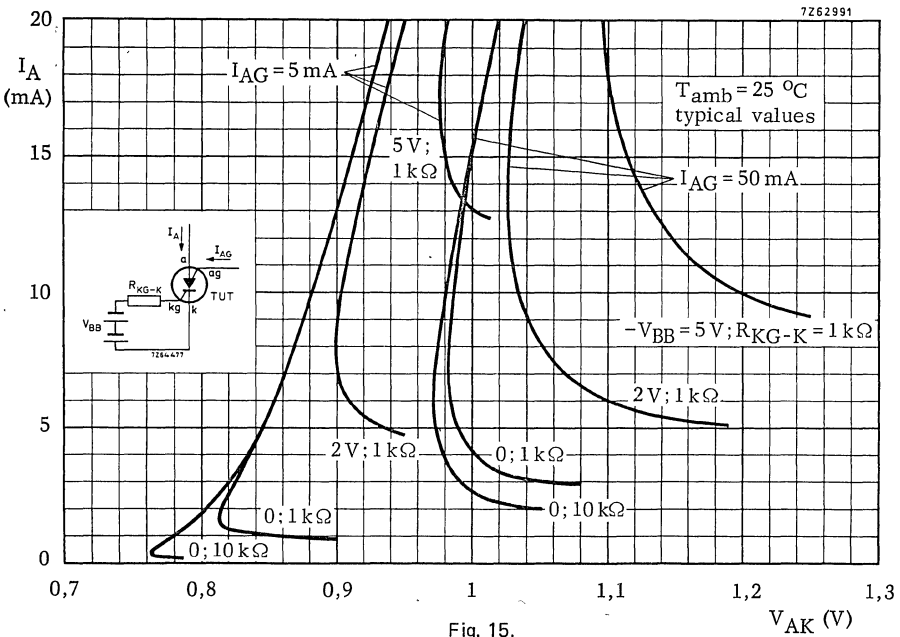


Fig. 15.

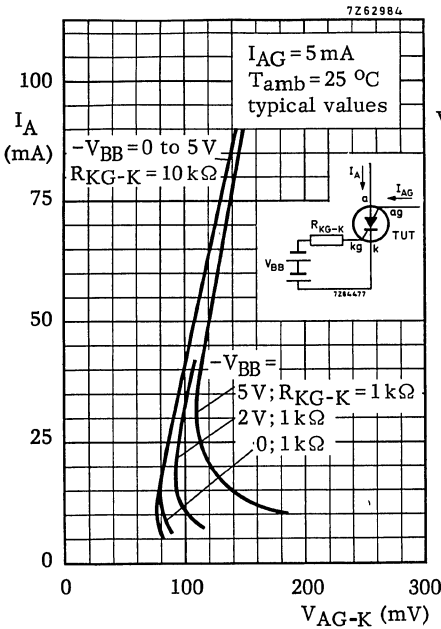


Fig. 16.

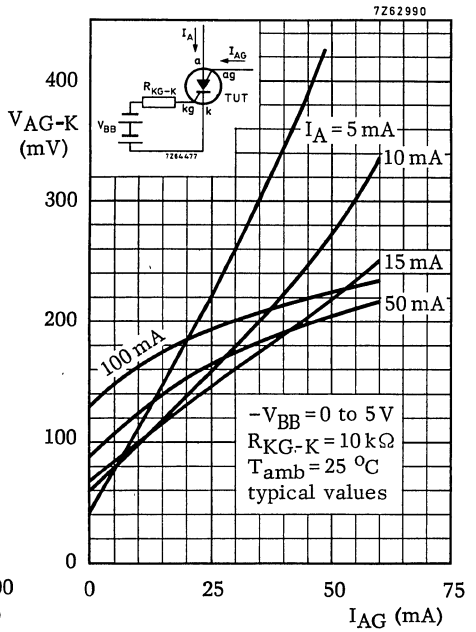


Fig. 17.

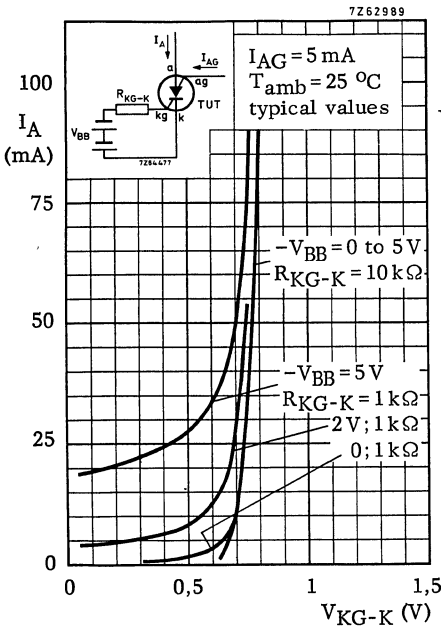


Fig. 18.

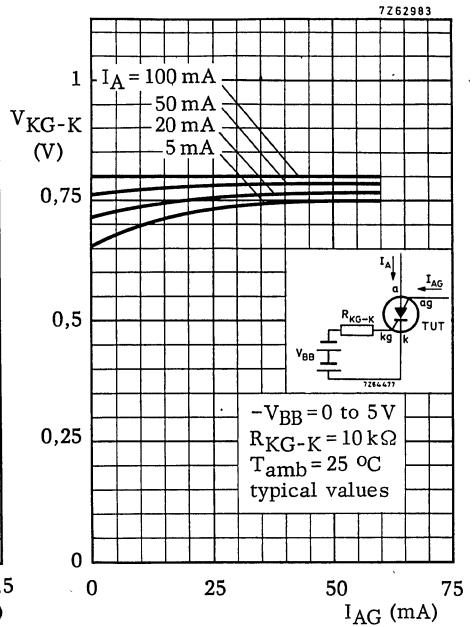
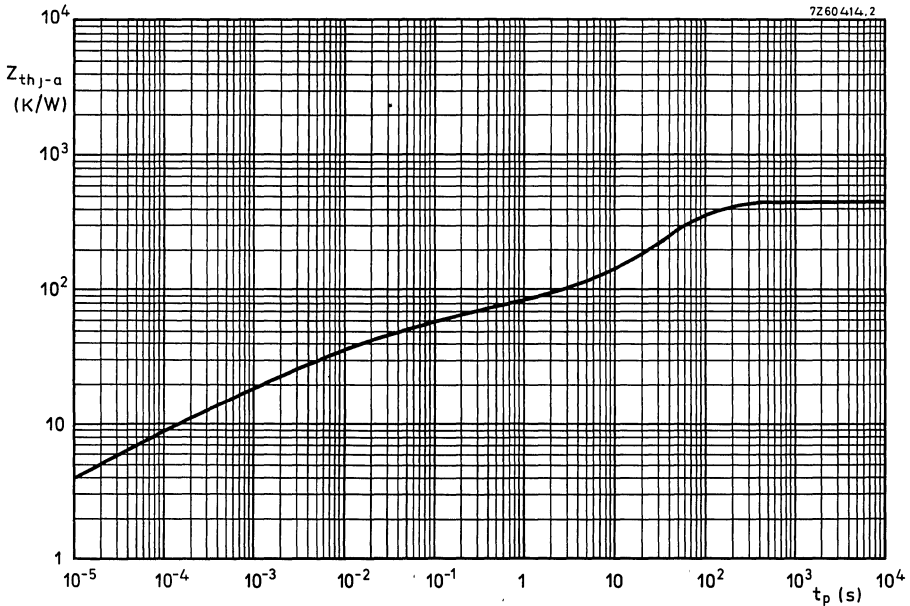
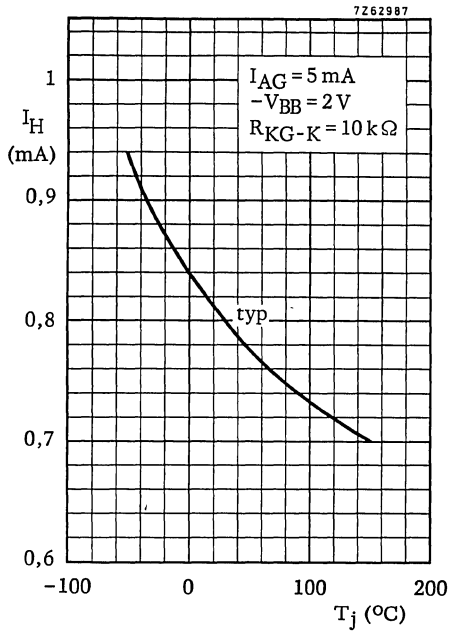
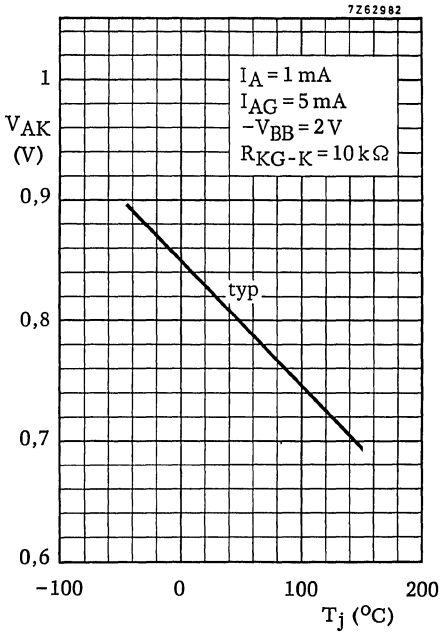


Fig. 19.



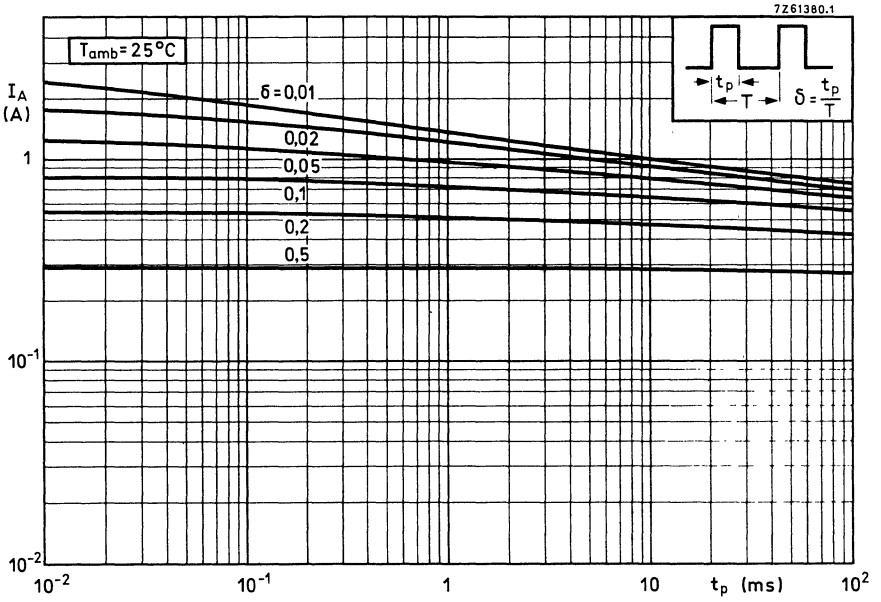


Fig. 23.

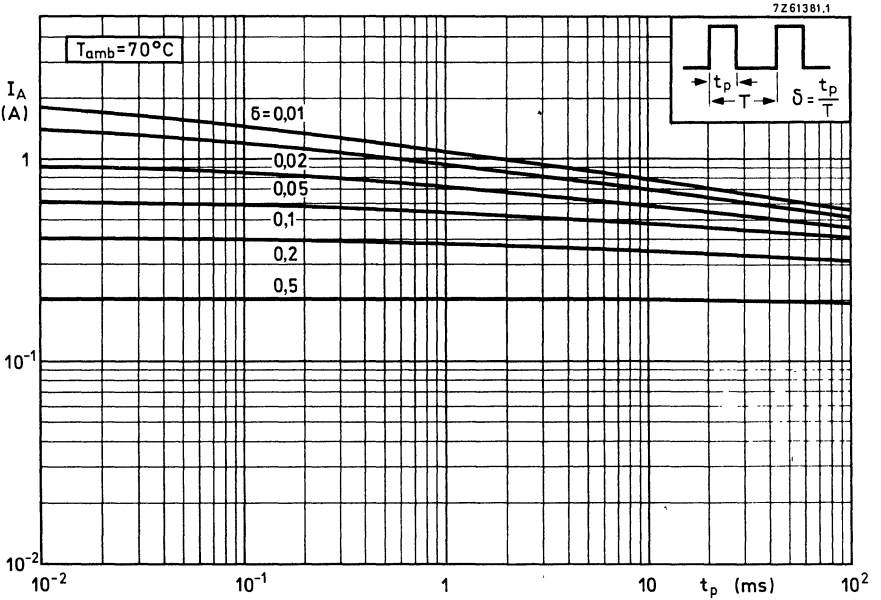


Fig. 24.

## THYRISTOR TETRODE

The BRY39 is a planar p-n-p-n trigger device in a TO-72 metal envelope, intended for use in low-power switching applications such as relay and lamp drivers, sensing network for temperature and as a trigger device for thyristors and triacs.

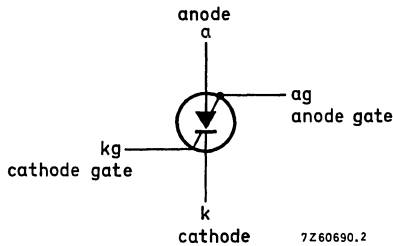
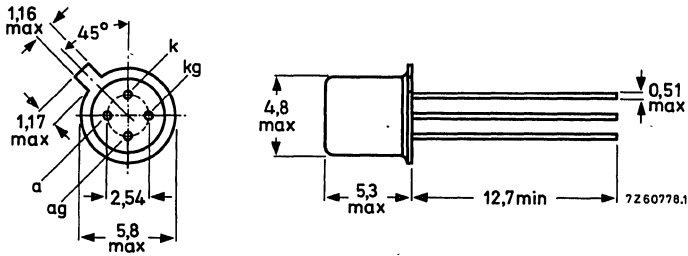
### QUICK REFERENCE DATA

Repetitive peak voltages	$V_{DRM} = V_{RRM}$	max.	70 V
Average on-state current	$I_{T(AV)}$	max.	250 mA
Non-repetitive peak on-state current	$I_{TSM}$	max.	3 A

### MECHANICAL DATA

Dimensions in mm

Fig.1 TO-72; Anode gate connected to case.



Accessories supplied on request: 56246 (distance disc).



**RATINGS**

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

**Anode to cathode**

Non-repetitive peak voltages	$V_{DSM} = V_{RSM}$	max.	70 V*
Repetitive peak voltages	$V_{DRM} = V_{RRM}$	max.	70 V*
Continuous voltages	$V_D = V_R$	max.	70 V*
Average on-state current up to $T_{case} = 85\text{ }^{\circ}\text{C}$ in free air up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$I_{T(AV)}$	max.	250 mA
	$I_{T(AV)}$	max.	175 mA
Repetitive peak on-state current $t = 10\text{ }\mu\text{s}; \delta = 0.01$	$I_{TRM}$	max.	2,5 A
Non-repetitive peak on-state current $t = 10\text{ }\mu\text{s}; T_j = 150\text{ }^{\circ}\text{C}$ prior to surge	$I_{TSM}$	max.	3 A
Rate of rise of on-state current after triggering to $I_T = 2.5\text{ A}$	$\frac{dI_T}{dt}$	max.	20 A/ $\mu\text{s}$

**Cathode gate to cathode**

Peak reverse voltage	$V_{RGKM}$	max.	5 V
Peak forward current	$I_{FGKM}$	max.	100 mA

**Anode gate to anode**

Peak reverse voltage	$V_{RGAM}$	max.	70 V
Peak forward current	$I_{FGAM}$	max.	100 mA

**Temperatures**

Storage temperature	$T_{stg}$	-65 to +200	$^{\circ}\text{C}$
Operating junction temperature	$T_j$	max.	150 $^{\circ}\text{C}$

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th\ j-a}$	=	450 K/W
From junction to case	$R_{th\ j-c}$	=	150 K/W

\*These ratings apply for zero or negative bias on the cathode gate with respect to the cathode, and when a resistor  $R \leq 10\text{ k}\Omega$  is connected between cathode gate and cathode.

**CHARACTERISTICS****Anode to cathode**

On-state voltage

$I_T = 100 \text{ mA}; T_j = 25 \text{ }^\circ\text{C}$

$V_T < 1.4 \text{ V}^*$

Rate of rise of off-state voltage

that will not trigger any device

$\frac{dV_D^{**}}{dt}$

Reverse current

$V_R = 70 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$

$I_R \text{ typ. } 1 \text{ nA}$

$T_j = 150 \text{ }^\circ\text{C}$

$I_R < 100 \text{ nA}$

Off-state current

$V_D = 70 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$

$I_D \text{ typ. } 1 \text{ nA}$

$T_j = 150 \text{ }^\circ\text{C}$

$I_D < 100 \text{ nA}$

Holding current

$R_{GK} = 10 \text{ k}\Omega; R_{GA} = 220 \text{ k}\Omega; T_j = 25 \text{ }^\circ\text{C}$

$I_H < 250 \text{ }\mu\text{A}$

**Cathode gate to cathode**

Voltage that will trigger all devices

$V_D = 6 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$

$V_{GKT} > 0.5 \text{ V}$

Current that will trigger all devices

$V_D = 6 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$

$I_{GKT} > 1 \text{ }\mu\text{A}$

**Anode gate to anode**

Voltage that will trigger all devices

$V_D = 6 \text{ V}; T_j = 25 \text{ }^\circ\text{C}$

$-V_{GAT} > 1 \text{ V}$

Current that will trigger all devices

$V_D = 6 \text{ V}; R_{GK} = 10 \text{ k}\Omega; T_j = 25 \text{ }^\circ\text{C}$

$-I_{GAT} > 100 \text{ }\mu\text{A}$

\*Measured under pulse conditions to avoid excessive dissipation.

\*\*The  $dV_D/dt$  is unlimited when the anode gate lead is returned to the supply voltage through a current limiting resistor.

**Switching characteristics**

Gate-controlled turn-on time ( $t_{gt} = t_d + t_r$ )

when switched from  $V_D = 15$  V  
 to  $I_T = 150$  mA;  $I_{GK} = 5$   $\mu$ A;  
 $dI_{GK}/dt = 5$   $\mu$ A/ $\mu$ s;  $T_j = 25$   $^{\circ}$ C

$$t_{gt} < 300 \text{ ns}$$

Circuit-commutated turn-off time  
 when switched from  $I_T = 150$  mA  
 to  $V_R = 15$  V;  $-dI_T/dt = 3$  A/ $\mu$ s;  
 $dV_D/dt = 70$  V/ $\mu$ s;  $V_D = 15$  V

$$t_q < 3 \text{ } \mu\text{s}$$

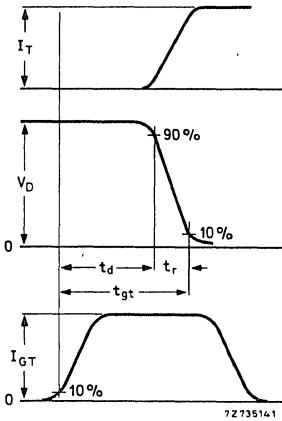


Fig.2 Gate-controlled turn-on time definition.

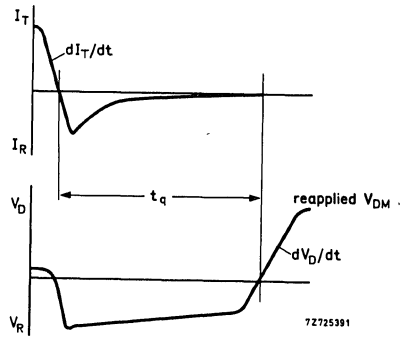


Fig.3 Circuit-commutated turn-off time definition.

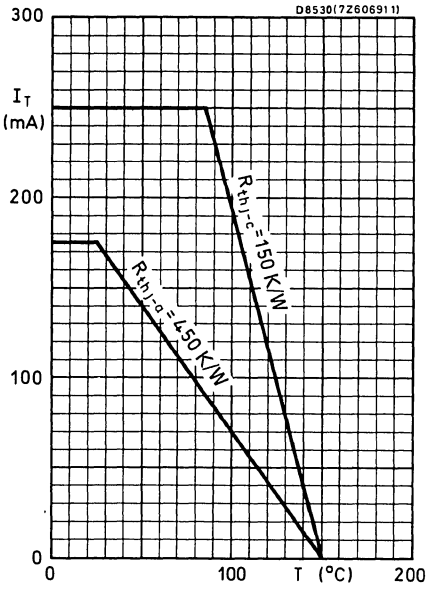


Fig.4

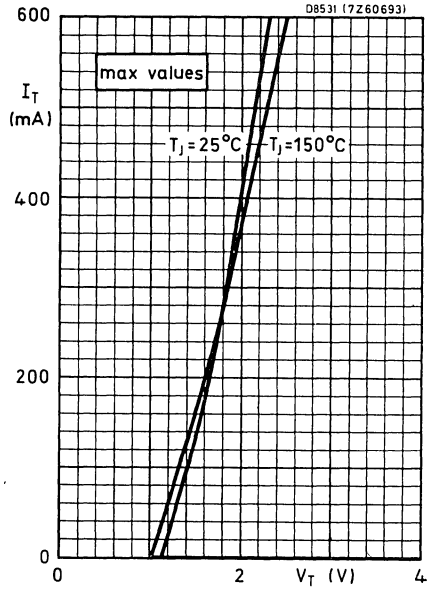


Fig.5

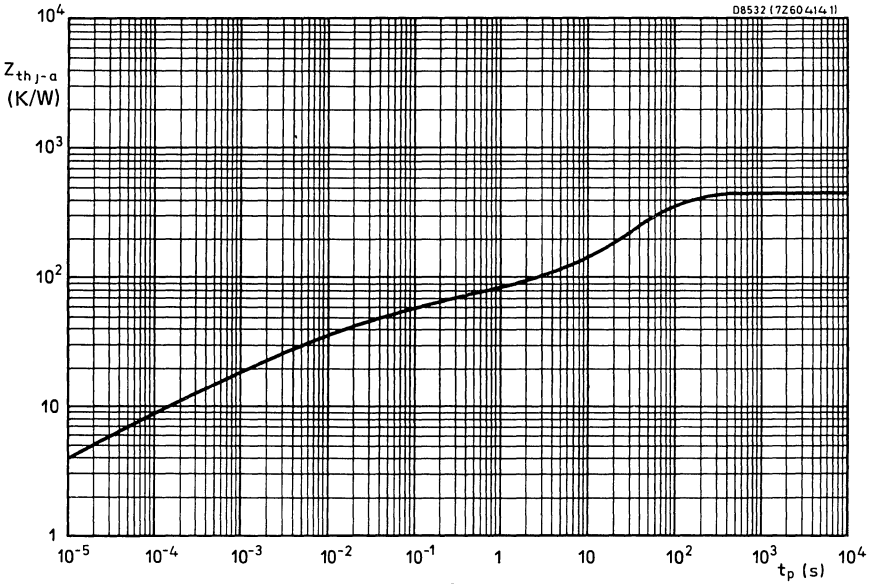


Fig.6

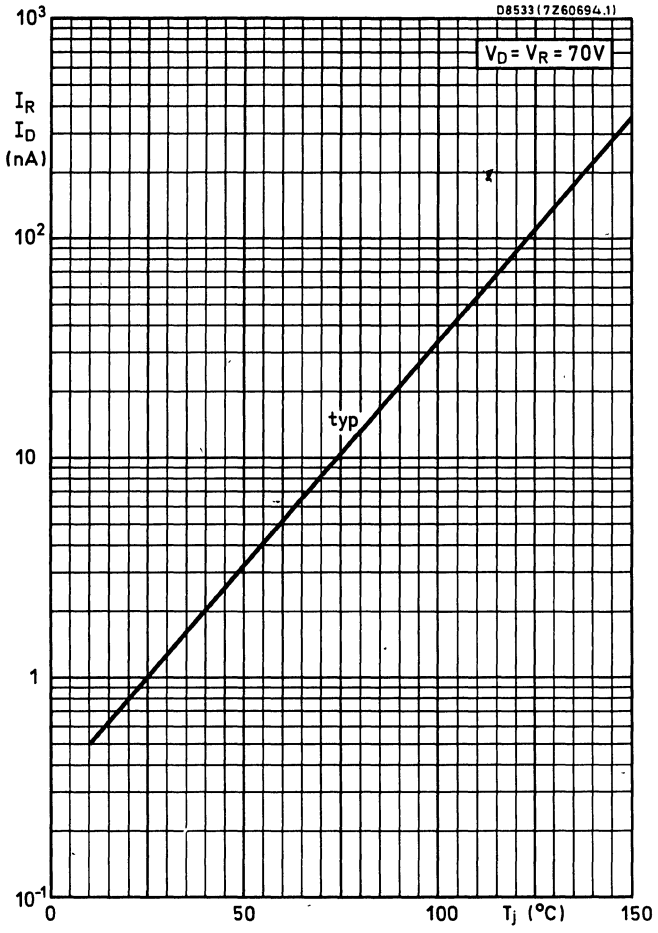


Fig.7

## APPLICATION INFORMATION

## Sensing network

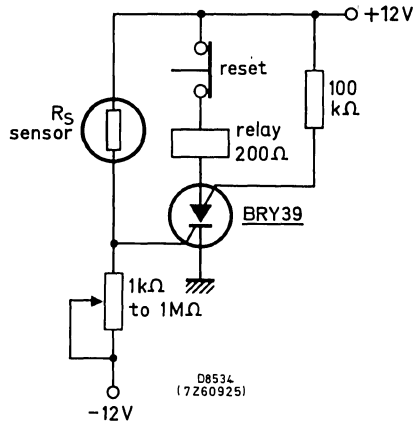


Fig.8

$R_S$  must be chosen in accordance with the light, temperature, or radiation intensity to be sensed; its resistance should be of the same order as that of the potentiometer.

In the arrangement shown, a decline in resistance of  $R_S$  triggers the thyristor, closing the relay that activates the warning system. If the positions of  $R_S$  and the potentiometer are interchanged, an increase in the resistance of  $R_S$  triggers the thyristor.



## PROGRAMMABLE UNIJUNCTION TRANSISTOR

Silicon planar p-n-p-n trigger device in a plastic TO-92 variant, intended for use in switching applications such as motor control, oscillators, relay replacement, timers, pulse shaper etc.

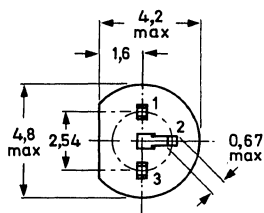
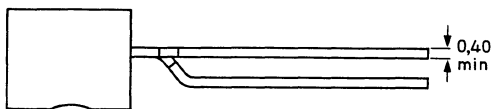
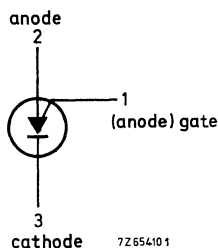
### QUICK REFERENCE DATA

Gate-anode voltage	$V_{GA}$	max.	70 V
Anode current (average)	$I_{A(AV)}$	max.	175 mA
Total power dissipation up to $T_{amb} = 75\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	300 mW
Junction temperature	$T_j$	max.	150 $^{\circ}\text{C}$
Peak point current $V_S = 10\text{ V}; R_G = 10\text{ k}\Omega$	$I_p$	<	5 $\mu\text{A}$
Valley point current $V_S = 10\text{ V}; R_G = 10\text{ k}\Omega$	$I_v$	>	50 $\mu\text{A}$

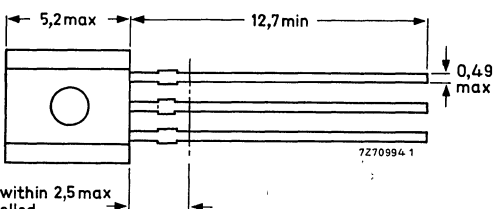
### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



diameter within 2,5 max is uncontrolled





**RATINGS**

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

Gate-anode voltage	$V_{GK}$	max.	70 V
Anode current (average)	$I_A(AV)$	max.	175 mA
Repetitive peak anode current $t_p = 10 \mu s; \delta = 0,01$	$I_{ARM}$	max.	2,5 A
Non-repetitive peak anode current $t_p = 10 \mu s$	$I_{ASM}$	max.	3,0 A
Rate of rise of anode current up to $I_A = 2,5 A$	$\frac{dI_A}{dt}$	max.	20 A/ $\mu s$
Total power dissipation up to $T_{amb} = 75 \text{ }^\circ C$	$P_{tot}$	max.	300 mW
Storage temperature	$T_{stg}$		-65 to + 150 $^\circ C$
Junction temperature	$T_j$	max.	150 $^\circ C$

**THERMAL RESISTANCE**

From junction to ambient in free air  $R_{th j-a} = 250 \text{ K/W}$

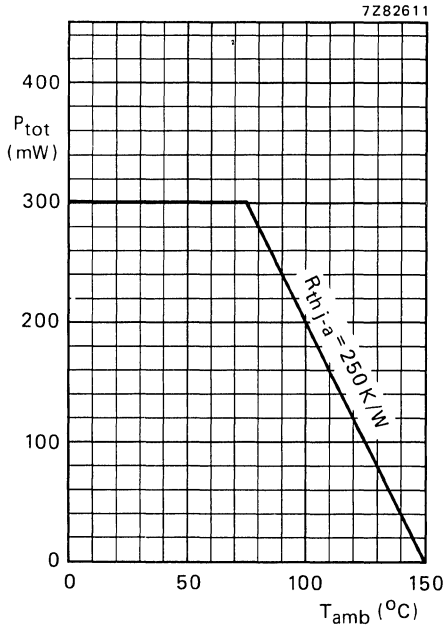


Fig. 2 Maximum permissible power dissipation as a function of ambient temperature.

**CHARACTERISTICS**

$T_{amb} = 25\text{ }^{\circ}\text{C}$

Peak point current (see Fig. 10)

$V_S = 10\text{ V}; R_G = 10\text{ k}\Omega$

$I_P < 5\text{ }\mu\text{A}$

$V_S = 10\text{ V}; R_G = 100\text{ k}\Omega$

$I_P < 2\text{ }\mu\text{A}$

Valley point current (see Fig. 10)

$V_S = 10\text{ V}; R_G = 10\text{ k}\Omega$

$I_V > 50\text{ }\mu\text{A}$

$V_S = 10\text{ V}; R_G = 100\text{ k}\Omega$

$I_V > 5\text{ }\mu\text{A}$

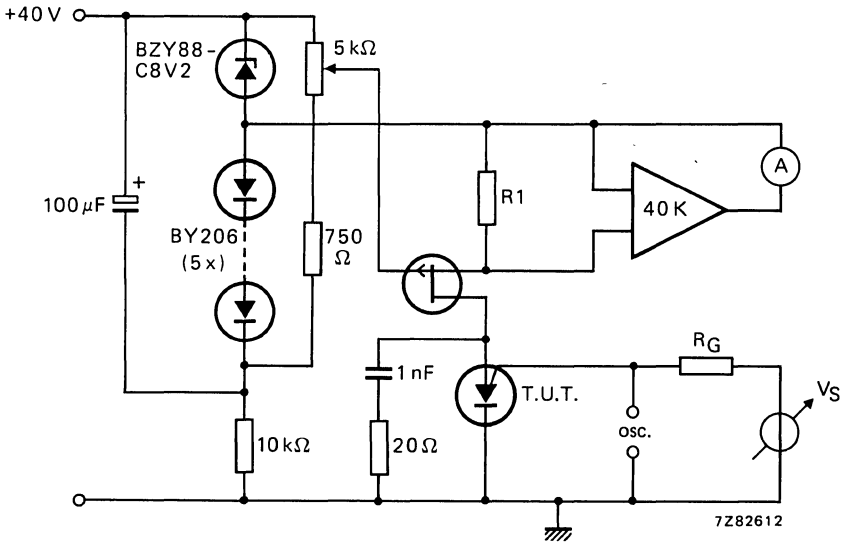


Fig. 3 Measuring circuit for  $I_P$  and  $I_V$  by means of value of  $R_1$ .  $R_1 = \frac{1}{I_A}$  (that is maximum voltage drop over  $R_1$  is 1 V). Internal resistance of oscilloscope is 10 M $\Omega$ .

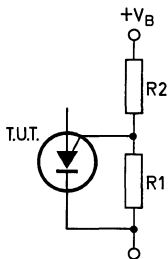


Fig. 4 BRY56 with "program" resistors  $R_1$  and  $R_2$ .

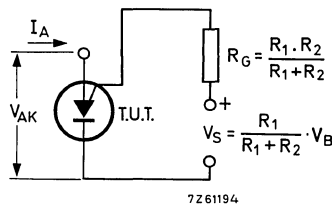


Fig. 5 Equivalent test circuit for characteristics testing.

Gate-anode leakage current (see Fig. 6)

$$I_K = 0; V_{GA} = 70 \text{ V}$$

$$I_{GAO} < 10 \text{ nA}$$

Gate-cathode leakage current (see Fig. 7)

$$V_{AK} = 0; V_{GK} = 70 \text{ V}$$

$$I_{GKS} < 100 \text{ nA}$$

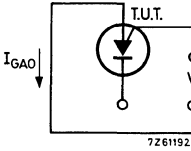


Fig. 6.

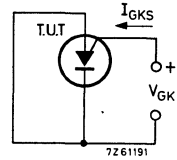


Fig. 7.

Anode-cathode voltage

$$I_A = 100 \text{ mA}$$

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

Peak output voltage (see Figs 8 and 9)

$$V_{AA} = 20 \text{ V}; C = 10 \text{ nF}$$

$$V_{OM} > 6 \text{ V}$$

Offset voltage (see Fig. 10)  $V_{offset} = V_P - V_S (I_A = 0)$

Rise time (see Fig. 9)

$$V_{AA} = 20 \text{ V}; C = 10 \text{ nF}$$

$$t_r < 80 \text{ ns}$$

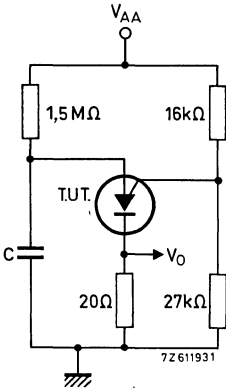


Fig. 8.

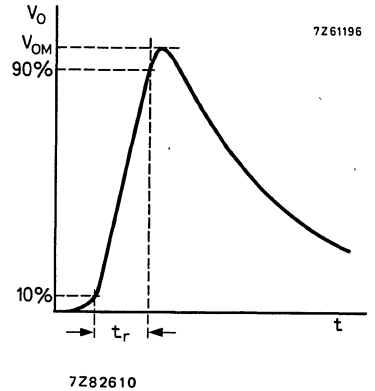


Fig. 9.

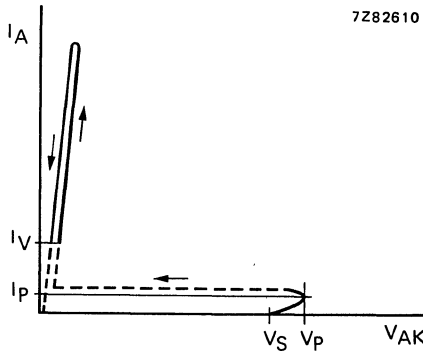


Fig. 10.

## N-P-N DARLINGTON TRANSISTORS

Silicon planar transistors in plastic TO-92 envelopes, intended for industrial switching applications e.g. print hammer, solenoid, relay and lamp driving.

P-N-P complements are the BSR60, BSR61 and BSR62.

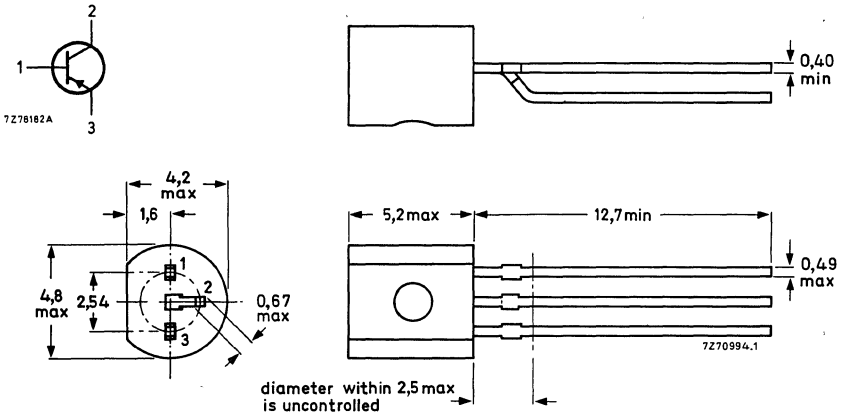
## QUICK REFERENCE DATA

			BSR50	BSR51	BSR52	
Collector-base voltage (open emitter)	$V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (see Fig. 5)	$V_{CER}$	max.	45	60	80	V
Collector current (average)	$I_{C(AV)}$	max.	1,0			A
Total power dissipation up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	0,8			W
Junction temperature	$T_j$	max.	150			$^{\circ}\text{C}$
Collector-emitter saturation voltage $I_C = 0,5\text{ A}; I_B = 0,5\text{ mA}$	$V_{CEsat}$	<	1,3			V
D.C. current gain $I_C = 150\text{ mA}; V_{CE} = 10\text{ V}$	$h_{FE}$	>	1000			
$I_C = 500\text{ mA}; V_{CE} = 10\text{ V}$	$h_{FE}$	>	2000			
Turn-off time when switched from $I_{Con} = 500\text{ mA}; I_{Bon} = 0,5\text{ mA}$ to cut-off with $-I_{Boff} = 0,5\text{ mA}$	$t_{off}$	<	1,5			$\mu\text{s}$

## MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant, for circuit diagram see Fig. 2.



**RATINGS**

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

			BSR50	BSR51	BSR52	
Collector-base voltage (open emitter)	$V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (see Fig. 5)	$V_{CER}$	max.	45	60	80	V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	5	5	5	V
Collector current (average)	$I_C(AV)$	max.		1,0		A
Collector current (peak value)	$I_{CM}$	max.		2,0		A
Base current (d.c.)	$I_B$	max.		0,1		A
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.		0,8		W
up to $T_{amb} = 25\text{ }^\circ\text{C}^*$	$P_{tot}$	max.		1,0		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	$R_{th\ j-a}$	=	156		K/W
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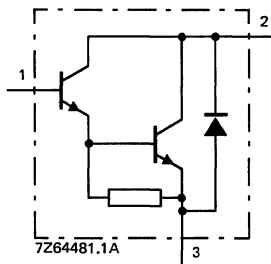


Fig. 2 Circuit diagram.

\* Transistor mounted on printed-circuit board, maximum lead length 3 mm, mounting pad for collector lead minimum 10 mm x 10 mm.

\*\* 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

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

Collector cut-off voltage

 $I_E = 0; V_{CB} = 45\text{ V}$ BSR50  $I_{CBO} < 50\text{ nA}$  $I_E = 0; V_{CB} = 60\text{ V}$ BSR51  $I_{CBO} < 50\text{ nA}$  $I_E = 0; V_{CB} = 80\text{ V}$ BSR52  $I_{CBO} < 50\text{ nA}$ 

Emitter cut-off current

 $I_C = 0; V_{EB} = 4\text{ V}$  $I_{EBO} < 50\text{ nA}$ 

Saturation voltages

 $I_C = 0,5\text{ A}; I_B = 0,5\text{ mA}$  $V_{CEsat} < 1,3\text{ V}$  $V_{BEsat} < 1,9\text{ V}$  $I_C = 1,0\text{ A}; I_B = 1,0\text{ mA}$ BSR51  $V_{CEsat} < 1,6\text{ V}$  $V_{BEsat} < 2,2\text{ V}$  $I_C = 1,0\text{ A}; I_B = 4,0\text{ mA}$ BSR50; BSR52  $V_{CEsat} < 1,6\text{ V}$  $V_{BEsat} < 2,2\text{ V}$ 

D.C. current gain

 $I_C = 150\text{ mA}; V_{CE} = 10\text{ V}$  $h_{FE} > 1000$  $I_C = 500\text{ mA}; V_{CE} = 10\text{ V}$  $h_{FE} > 2000$ Small-signal current gain at  $f = 35\text{ MHz}$  $I_C = 500\text{ mA}; V_{CE} = 5\text{ V}$  $h_{fe}$  typ. 10

Switching times see page 4.



Switching times (see Figs 3 and 4)

$I_{Con} = 500 \text{ mA}$ ;  $I_{Bon} = -I_{Boff} = 0,5 \text{ mA}$

Turn-on time

Turn-off time

$t_{on}$	typ.	0,4 $\mu\text{s}$
$t_{off}$	<	1,5 $\mu\text{s}$

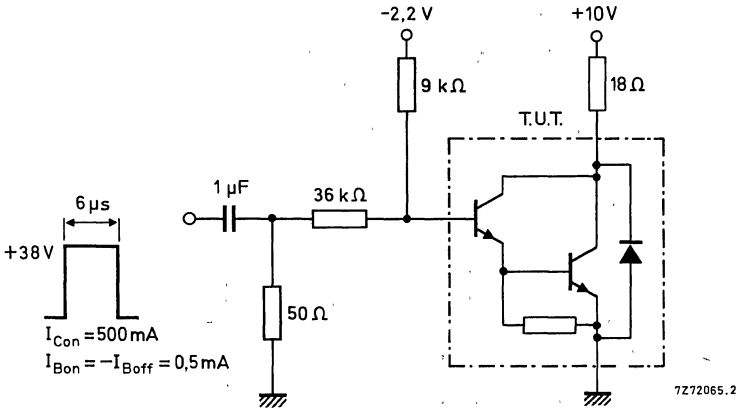


Fig. 3 Test circuit for 500 mA switching.

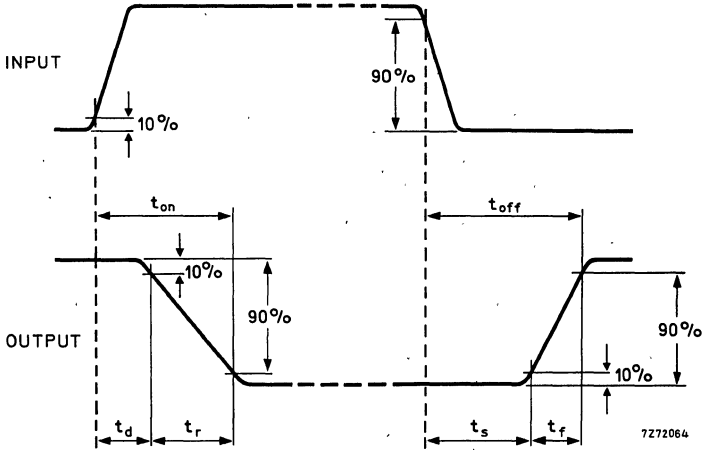


Fig. 4 Switching waveforms.

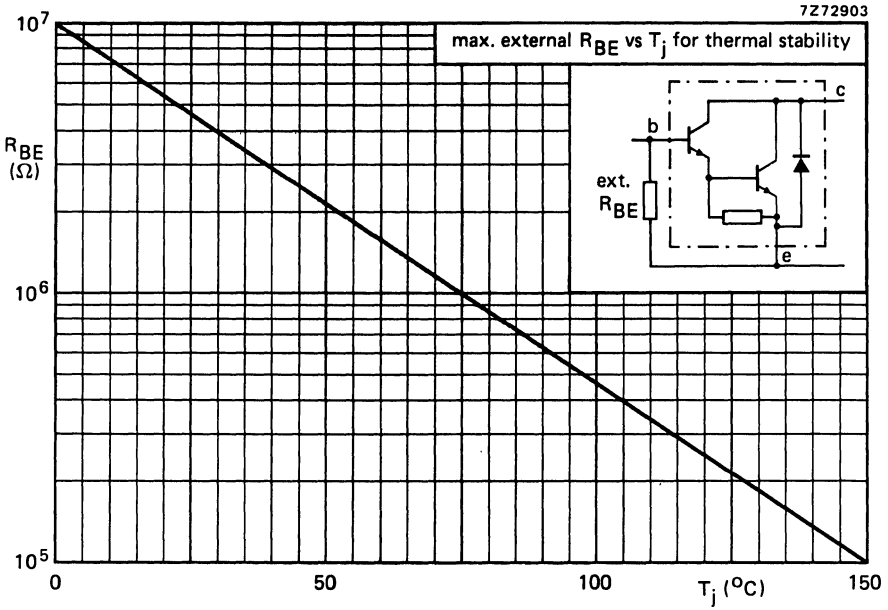


Fig. 5.

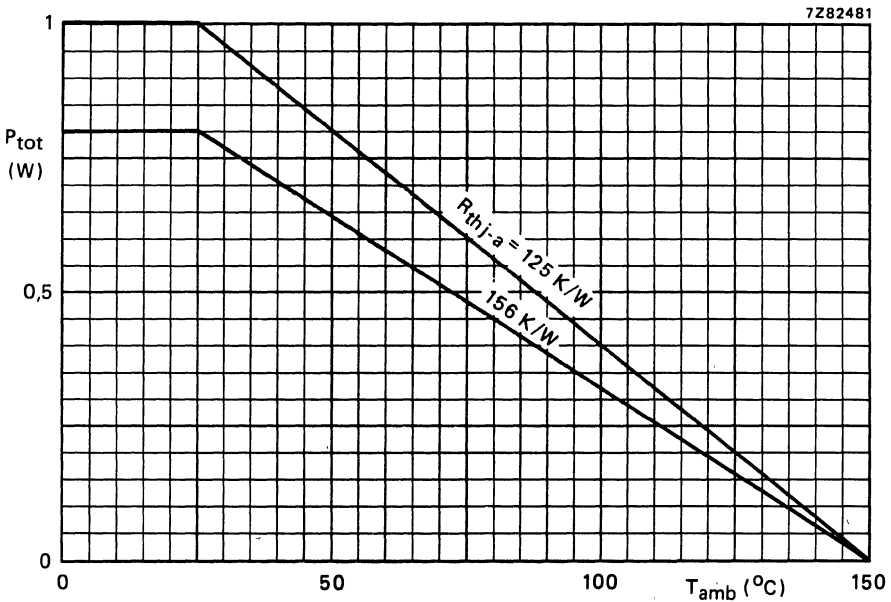


Fig. 6 Maximum permissible power dissipation as a function of ambient temperature.



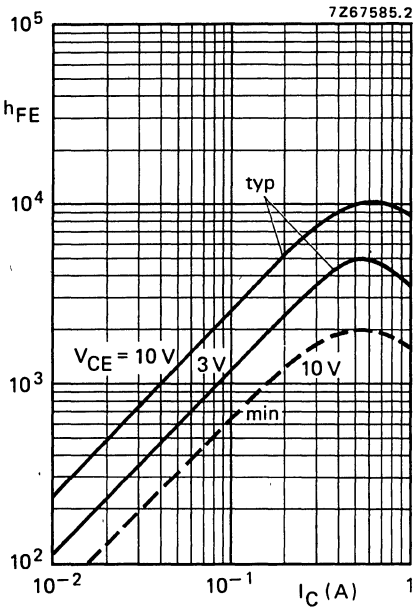


Fig. 7  $T_j = 25^\circ\text{C}$ .

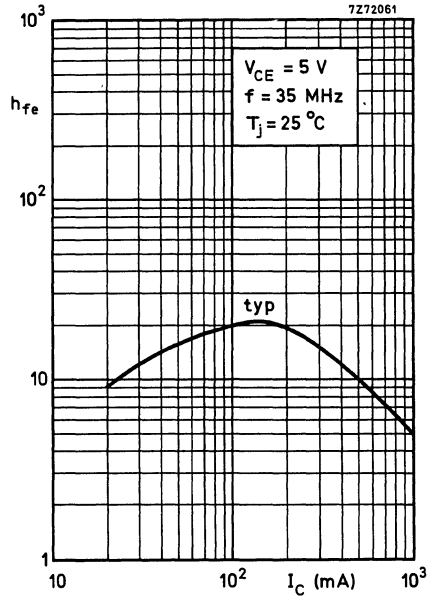


Fig. 8.

## P-N-P DARLINGTON TRANSISTORS

Silicon planar transistors in plastic TO-92 envelopes, intended for industrial applications e.g. print hammer, solenoid, relay and lamp driving.

N-P-N complements are the BSR50, BSR51 and BSR52.

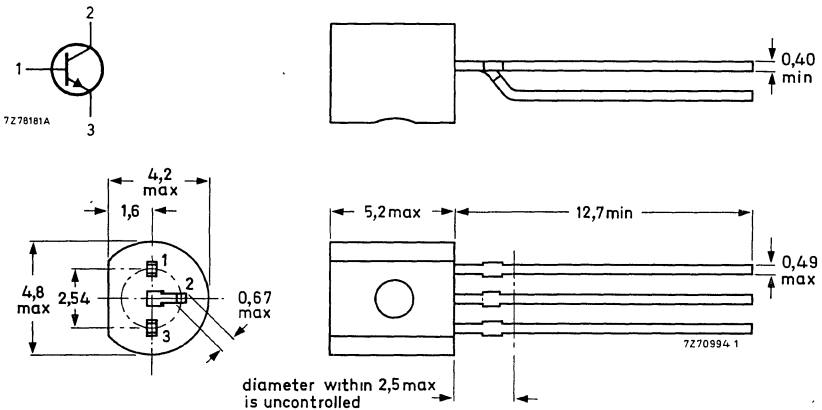
## QUICK REFERENCE DATA

			BSR60	BSR61	BSR62	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (see Fig. 6)	$-V_{CER}$	max.	45	60	80	V
Collector current (average)	$-I_{C(AV)}$	max.	1,0	1,0	1,0	A
Total power dissipation up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	0,8	0,8	0,8	W
Junction temperature	$T_j$	max.	150	150	150	$^{\circ}\text{C}$
Collector-emitter saturation voltage $-I_C = 0,5\text{ A}; -I_B = 0,5\text{ mA}$	$-V_{CEsat}$	<	1,3	1,3	1,4	V
D.C. current gain						
$-I_C = 150\text{ mA}; -V_{CE} = 10\text{ V}$	$h_{FE}$	>		1000		
$-I_C = 500\text{ mA}; -V_{CE} = 10\text{ V}$	$h_{FE}$	>		2000		
Turn-off time when switched from $-I_{Con} = 500\text{ mA}; -I_{BOn} = 0,5\text{ mA}$ to cut-off with $+I_{Boff} = 0,5\text{ mA}$	$t_{off}$	<		1,5		$\mu\text{s}$

## MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant, for circuit diagram see Fig. 2.



**RATINGS**

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

			BSR60	BSR61	BSR62	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (see Fig. 6)	$-V_{CER}$	max.	45	60	80	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V
Collector current (average)	$-I_{C(AV)}$	max.	1,0			A
Collector current (peak value)	$-I_{CM}$	max.	2,0			A
Base current (d.c.)	$-I_B$	max.	0,1			A
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	0,8			W
up to $T_{amb} = 25\text{ }^\circ\text{C}^*$	$P_{tot}$	max.	1,0			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	$R_{th\ j-a}$	=	156		K/W
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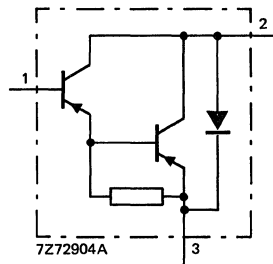


Fig. 2 Circuit diagram.

\* Transistor mounted on printed-circuit board, maximum lead length 3 mm, mounting pad for collector lead minimum 10 mm x 10 mm.

\*\* 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

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

Collector cut-off current

 $I_E = 0; -V_{CB} = 45\text{ V}$ BSR60  $-I_{CBO} < 50\text{ nA}$  $I_E = 0; -V_{CB} = 60\text{ V}$ BSR61  $-I_{CBO} < 50\text{ nA}$  $I_E = 0; -V_{CB} = 80\text{ V}$ BSR62  $-I_{CBO} < 50\text{ nA}$ 

Emitter cut-off current

 $I_C = 0; -V_{EB} = 4\text{ V}$  $-I_{EBO} < 50\text{ nA}$ 

Saturation voltages

 $-I_C = 0,5\text{ A}; -I_B = 0,5\text{ mA}$ BSR60; BSR61  $-V_{CEsat} < 1,3\text{ V}$  $-V_{BEsat} < 1,9\text{ V}$  $-I_C = 0,5\text{ A}; -I_B = 0,5\text{ mA}$ BSR62  $-V_{CEsat} < 1,4\text{ V}$  $-V_{BEsat} < 2,0\text{ V}$  $-I_C = 1,0\text{ A}; -I_B = 1,0\text{ mA}$ BSR61  $-V_{CEsat} < 1,6\text{ V}$  $-V_{BEsat} < 2,2\text{ V}$  $-I_C = 1,0\text{ A}; -I_B = 4,0\text{ mA}$ BSR60  $-V_{CEsat} < 1,6\text{ V}$  $-V_{BEsat} < 2,2\text{ V}$  $-I_C = 1,0\text{ A}; -I_B = 4,0\text{ mA}$ BSR62  $-V_{CEsat} < 1,8\text{ V}$  $-V_{BEsat} < 2,4\text{ V}$ 

D.C. current gain

 $-I_C = 150\text{ mA}; -V_{CE} = 10\text{ V}$  $h_{FE} > 1000$  $-I_C = 500\text{ mA}; -V_{CE} = 10\text{ V}$  $h_{FE} > 2000$ Small-signal current gain at  $f = 35\text{ MHz}$  $-I_C = 500\text{ mA}; -V_{CE} = 5\text{ V}$  $h_{fe}$  typ. 10

Switching times see page 4.

Switching times (see Figs 3 and 4)

$-I_{Con} = 500 \text{ mA}$ ;  $-I_{Bon} = +I_{Boff} = 0,5 \text{ mA}$

Turn-on time

$t_{on} < 1,0 \mu\text{s}$

Turn-off time

$t_{off} < 1,5 \mu\text{s}$

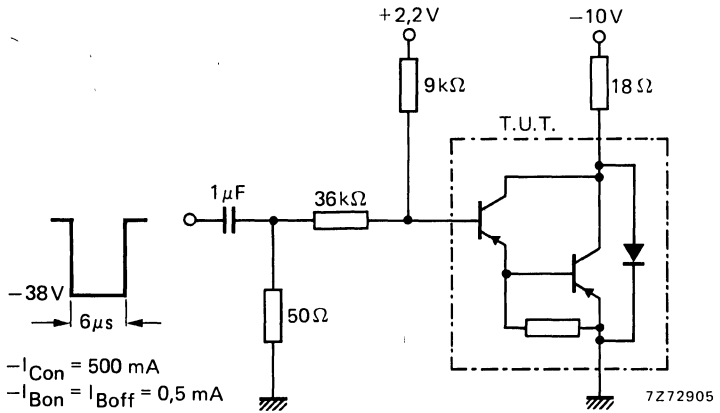


Fig. 3 Test circuit for 500 mA switching.

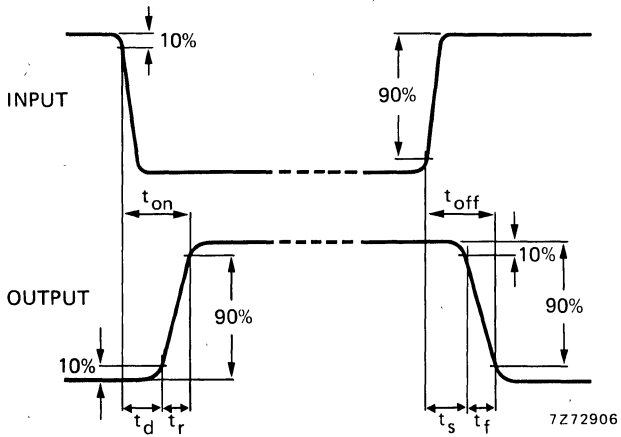


Fig. 4 Switching waveforms.

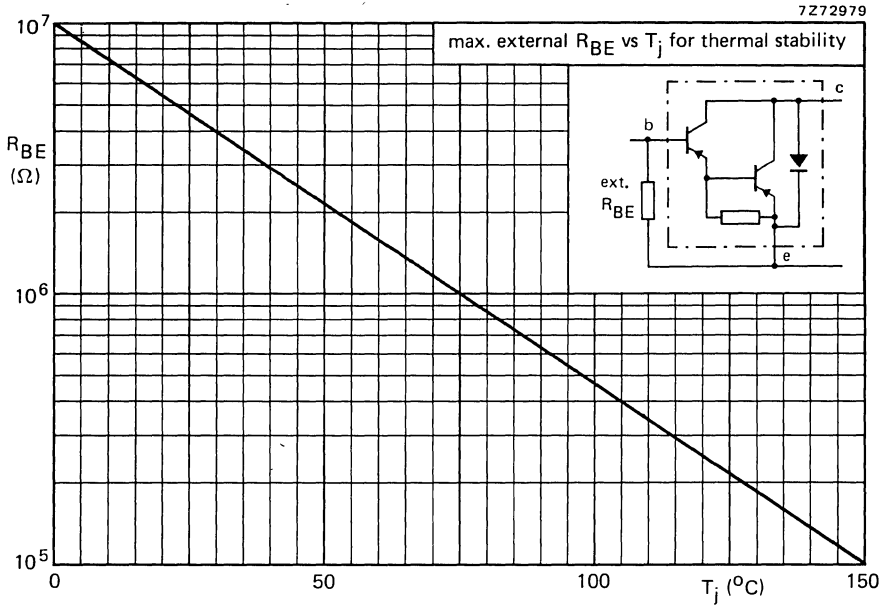


Fig. 5.

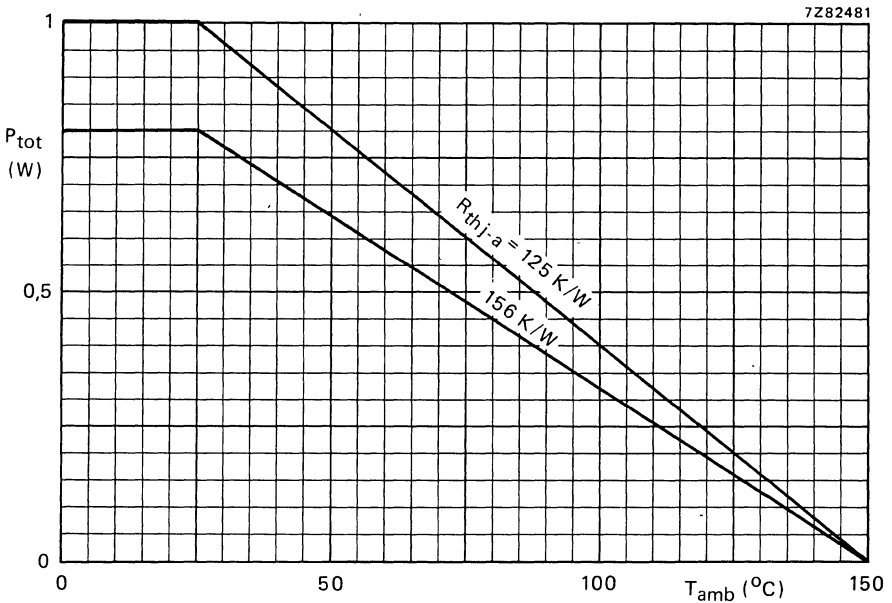


Fig. 6 Maximum permissible power dissipation as a function of ambient temperature.

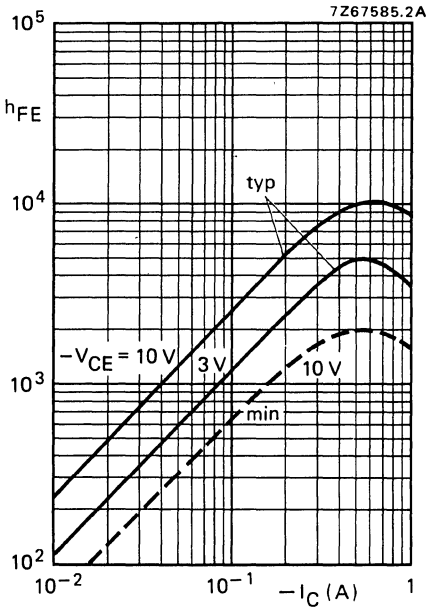


Fig. 7  $T_j = 25$  °C.

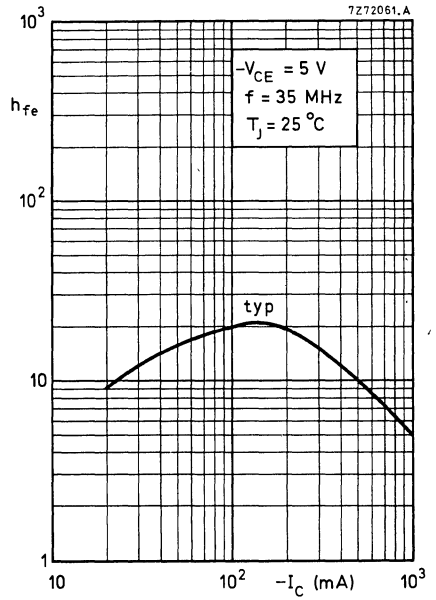


Fig. 8.

## SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a plastic TO-92 variant. It is primarily intended for general purpose switching and as driver for numerical indicator tubes.

### QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$V_{CBO}$	max.	120 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	100 V
Collector current (peak value)	$I_{CM}$	max.	250 mA
Total power dissipation up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	500 mW
Junction temperature	$T_j$	max.	150 $^{\circ}\text{C}$
D.C. current gain	$h_{FE}$	>	20
$I_C = 4\text{ mA}; V_{CE} = 1\text{ V}$		typ.	80
Transition frequency at $f = 35\text{ MHz}$	$f_T$	>	60 MHz
$I_C = 4\text{ mA}; V_{CE} = 10\text{ V}$			
Turn-off time	$t_{off}$	<	1 $\mu\text{s}$
$I_{Con} = 15\text{ mA}; I_{Bon} = 1\text{ mA}; -I_{Boff} = 1\text{ mA}$			

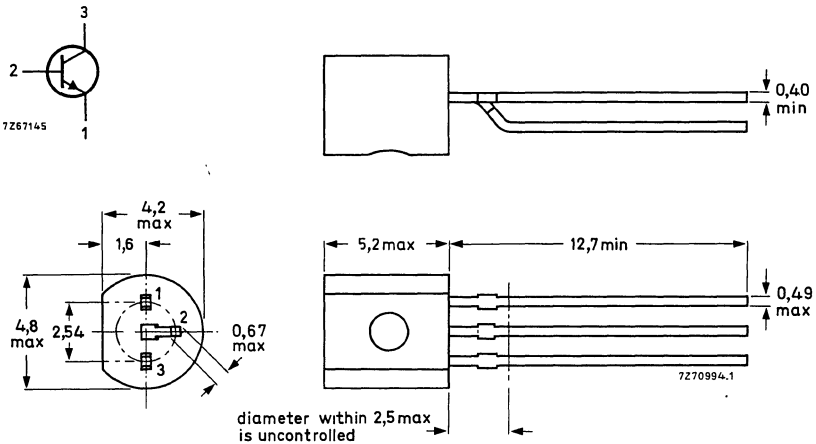
### Note

The BSS38 may be operated in the breakdown region up to  $V_{CE} = 160\text{ V}$ , provided  $P_{tot}$  at  $T_{amb} = 85\text{ }^{\circ}\text{C}$  does not exceed 100 mW.

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.





**RATINGS**

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

Collector-base voltage (open emitter)	$V_{CBO}$	max.	120 V*
Collector-emitter voltage (open base)	$V_{CEO}$	max.	100 V*
Emitter-base voltage (open collector)	$V_{EBO}$	max.	5 V
Collector current (d.c. or averaged over any 20 ms period)	$I_{C(AV)}$	max.	100 mA
Collector current (peak value)	$I_{CM}$	max.	250 mA
Total power dissipation up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	500 mW
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	$R_{th\ j-a}$	=	0,25 $^{\circ}\text{C}/\text{mW}$
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**CHARACTERISTICS**

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

Collector cut-off current

$I_E = 0; V_{CB} = 90\text{ V}$	$I_{CBO}$	<	200 nA
$I_E = 0; V_{CB} = 90\text{ V}; T_j = 150\text{ }^{\circ}\text{C}$	$I_{CBO}$	<	50 $\mu\text{A}$
$V_{BE} = 0; V_{CE} = 80\text{ V}; T_j = 85\text{ }^{\circ}\text{C}$	$I_{CES}$	<	20 $\mu\text{A}$

Emitter cut-off current

$I_C = 0; V_{EB} = 4\text{ V}$	$I_{EBO}$	<	200 nA
$I_C = 0; V_{EB} = 4\text{ V}; T_j = 150\text{ }^{\circ}\text{C}$	$I_{EBO}$	<	50 $\mu\text{A}$

Saturation voltages

$I_C = 4\text{ mA}; I_B = 0,4\text{ mA}$	$V_{CEsat}$	<	0,7 V
	$V_{BEsat}$	<	1,2 V
$I_C = 50\text{ mA}; I_B = 15\text{ mA}$	$V_{CEsat}$	<	3,0 V

D.C. current gain

$I_C = 4\text{ mA}; V_{CE} = 1\text{ V}$	$h_{FE}$	>	20
		typ.	80
$I_C = 10\text{ mA}; V_{CE} = 1\text{ V}$	$h_{FE}$	typ.	80

\* The BSS38 may be operated in the breakdown region up to  $V_{CE} = 160\text{ V}$ , provided  $P_{tot}$  at  $T_{amb} = 85\text{ }^{\circ}\text{C}$  does not exceed 100 mW.

**CHARACTERISTICS** (continued)Transition frequency at  $f = 35$  MHz

$I_C = 4 \text{ mA}; V_{CE} = 10 \text{ V}$

$f_T > 60 \text{ MHz}$

Collector capacitance at  $f = 1$  MHz

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

$C_c < 4,5 \text{ pF}$

Emitter capacitance at  $f = 1$  MHz

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

$C_e < 17 \text{ pF}$

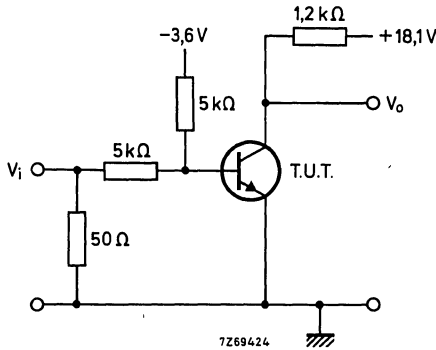
Switching time

Turn-off time when switched from

$I_{Con} = 15 \text{ mA}; I_{Bon} = 1 \text{ mA}$  to cut-off with  $-I_{Boff} = 1 \text{ mA}$

$t_{off} < 1 \mu\text{s}$

Test circuit for measuring turn-off time:



Pulse generator:

Input voltage  $V_i = +10 \text{ V}$

Pulse duration  $t_p = 1 \mu\text{s}$

Duty factor  $\delta = 0,01$

Source impedance  $Z_S = 50 \Omega$



## N-P-N DARLINGTON TRANSISTORS



Silicon planar transistors in TO-39 metal envelopes, intended for industrial switching applications e.g. print hammer, solenoid, relay and lamp driving.

P-N-P complements are the BSS60, BSS61 and BSS62.

### QUICK REFERENCE DATA

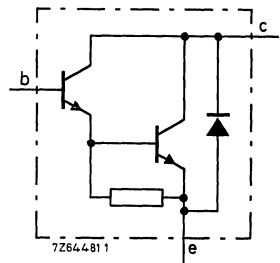
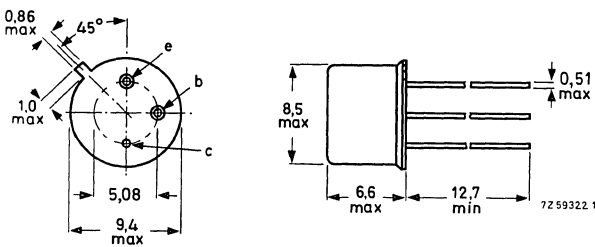
		BSS50	BSS51	BSS52	
Collector-base voltage (open emitter)	$V_{CBO}$	max. 60	80	100	V
Collector-emitter voltage (see Fig. 4)	$V_{CER}$	max. 45	60	80	V
Collector current (d.c.)	$I_C$	max.	1,0		A
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$ up to $T_{case} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	0,8		W
	$P_{tot}$	max.	5,0		W
Collector-emitter saturation voltage $I_C = 1,0\text{ A}; I_B = 1,0\text{ mA}$	$V_{CEsat}$	BSS51	< 1,6		V
		BSS50; BSS52	< 1,6		V
D.C. current gain $I_C = 500\text{ mA}; V_{CE} = 10\text{ V}$	$h_{FE}$		> 2000		
Turn-off time when switched from $I_{Con} = 500\text{ mA}; I_{Bon} = 0,5\text{ mA}$ cut-off with $-I_{Boff} = 0,5\text{ mA}$	$t_{off}$	typ.	1,5		$\mu\text{s}$

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).

Products approved to CECC 50 004-073, available on request.

**RATINGS**

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

		BSS50	BSS51	BSS52	
Collector-base voltage (open emitter)	$V_{CB0}$	max. 60	80	100	V
Collector-emitter voltage (see Fig. 4)	$V_{CER}$	max. 45	60	80	V
Emitter-base voltage (open collector)	$V_{EBO}$	max. 5,0	5,0	5,0	V
Collector current (d.c.)	$I_C$		1,0		A
Collector current (peak value)	$I_{CM}$		2,0		A
Base current (d.c.)	$I_B$		0,1		A
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$		0,8		W
up to $T_{case} = 25\text{ }^\circ\text{C}$	$P_{tot}$		5,0		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 ambient in free air	$R_{th\ j-a}$	=	220	K/W
From junction to case	$R_{th\ j-c}$	=	35	K/W

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

## CHARACTERISTICS

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

Collector cut-off current

$I_E = 0; V_{CB} = 45\text{ V}$

**BSS50**  $I_{CBO} < 50\text{ nA}$

$I_E = 0; V_{CB} = 60\text{ V}$

**BSS51**  $I_{CBO} < 50\text{ nA}$

$I_E = 0; V_{CB} = 80\text{ V}$

**BSS52**  $I_{CBO} < 50\text{ nA}$

Emitter cut-off current

$I_C = 0; V_{EB} = 4,0\text{ V}$

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

Base-emitter voltage

$I_C = 150\text{ mA}; V_{CE} = 10\text{ V}$

$V_{BE} = 1,3\text{ to }1,65\text{ V}$

$I_C = 500\text{ mA}; V_{CE} = 10\text{ V}$

$V_{BE} = 1,4\text{ to }1,75\text{ V}$

Saturation voltages

$I_C = 500\text{ mA}; I_B = 0,5\text{ mA}$

$V_{CEsat} < 1,3\text{ V}$

$V_{BEsat} < 1,9\text{ V}$

$I_C = 500\text{ mA}; I_B = 0,5\text{ mA}; T_j = 200\text{ }^\circ\text{C}$

$V_{CEsat} < 1,3\text{ V}$

$I_C = 1,0\text{ A}; I_B = 1,0\text{ mA}$

**BSS51**  $V_{CEsat} < 1,6\text{ V}$

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

$I_C = 1,0\text{ A}; I_B = 1,0\text{ mA}; T_j = 200\text{ }^\circ\text{C}$

**BSS51**  $V_{CEsat} < 2,3\text{ V}$

$I_C = 1,0\text{ A}; I_B = 4,0\text{ mA}$

**BSS50; BSS52**  $V_{CEsat} < 1,6\text{ V}$

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

$I_C = 1,0\text{ A}; I_B = 4,0\text{ mA}; T_j = 200\text{ }^\circ\text{C}$

**BSS50; BSS52**  $V_{CEsat} < 1,6\text{ V}$

D.C. current gain

$I_C = 150\text{ mA}; V_{CE} = 10\text{ V}$

$h_{FE} > 1000$

$I_C = 500\text{ mA}; V_{CE} = 10\text{ V}$

$h_{FE} > 2000$

Small-signal current gain at  $f = 35\text{ MHz}$

$I_C = 500\text{ mA}; V_{CE} = 5\text{ V}$

$h_{fe}$  typ. 10

Switching times (see Figs 2 and 3)

$I_{Con} = 500 \text{ mA}$ ;  $I_{Bon} = -I_{Boff} = 0,5 \text{ mA}$

Turn-on time

$t_{on}$  typ.  $0,4 \mu\text{s}$

Turn-off time

$t_{off}$  typ.  $1,5 \mu\text{s}$

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

Turn-on time

$t_{on}$  typ.  $0,4 \mu\text{s}$

Turn-off time

$t_{off}$  typ.  $1,5 \mu\text{s}$

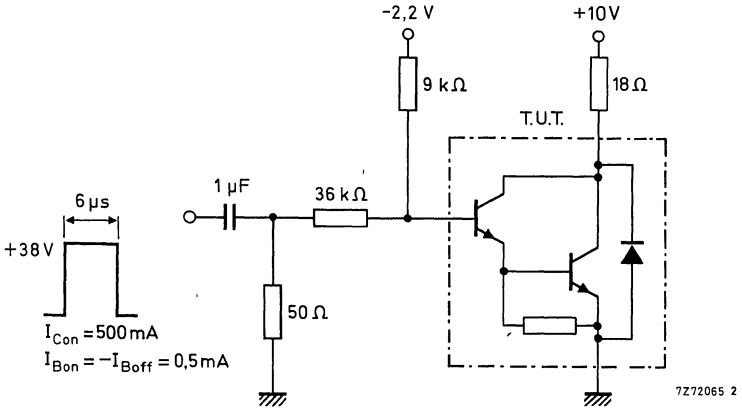


Fig. 2 Test circuit for 500 mA switching.

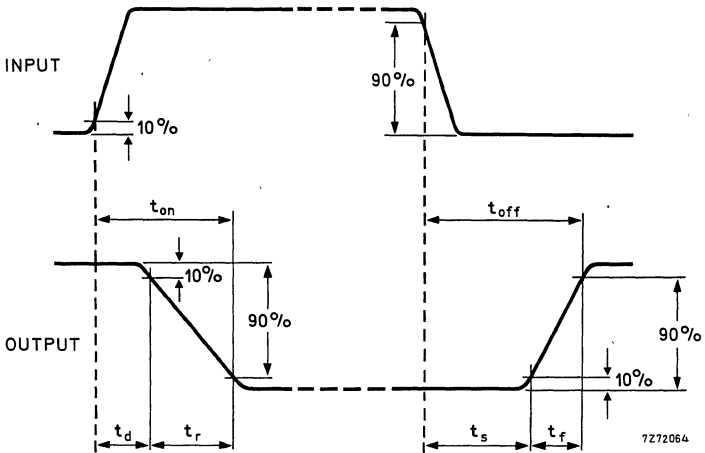


Fig. 3 Switching waveforms.

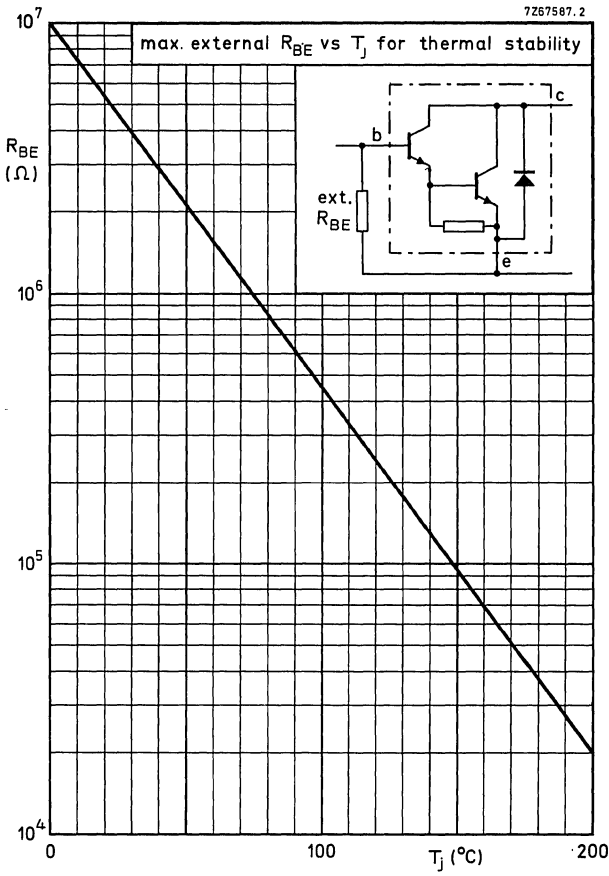


Fig. 4.



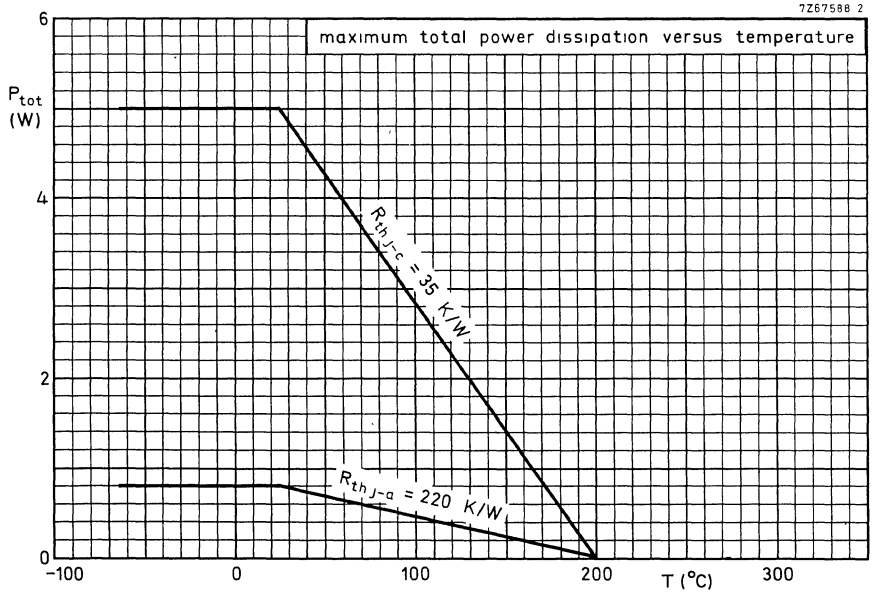


Fig. 5.

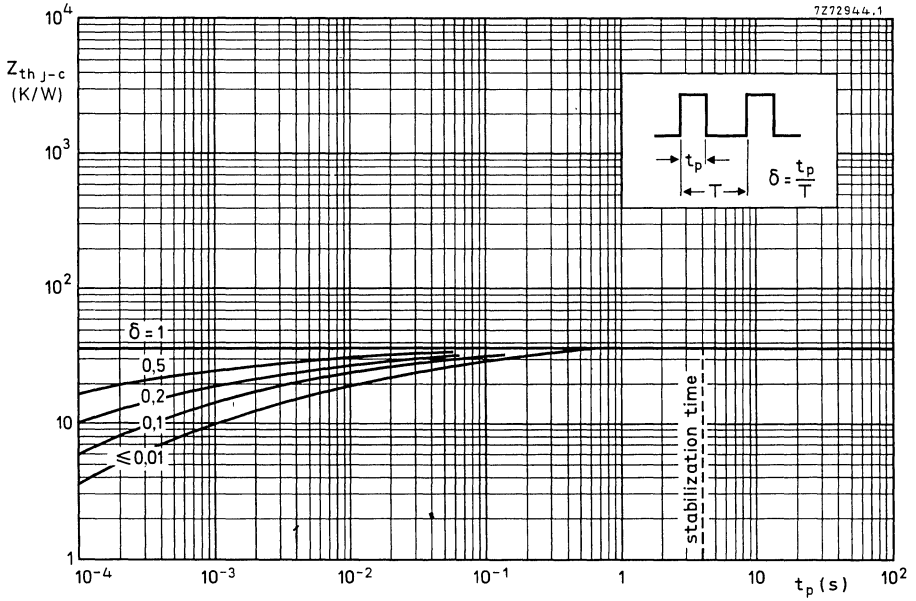


Fig. 6.

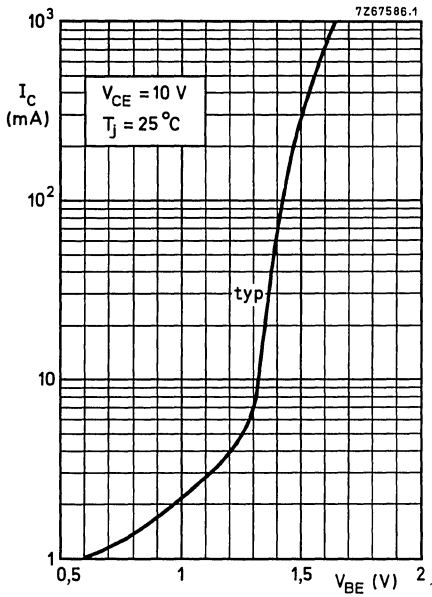


Fig. 7.

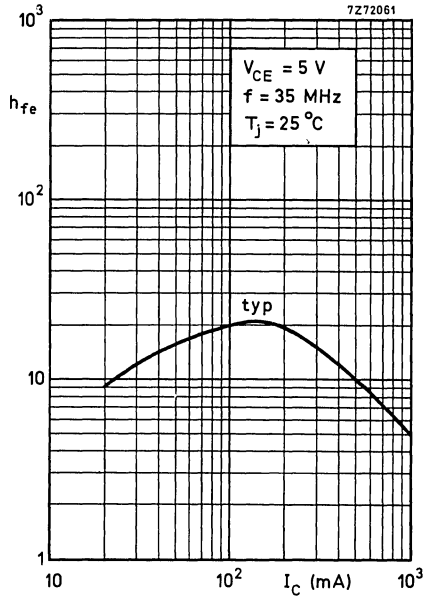


Fig. 8.

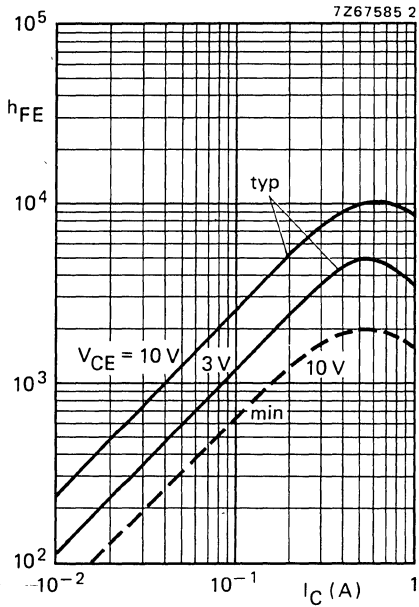


Fig. 9  $T_J = 25\text{ }^\circ\text{C}$ .

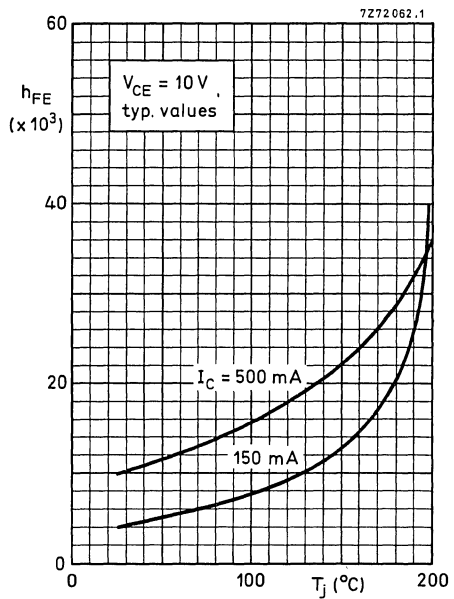


Fig. 10.

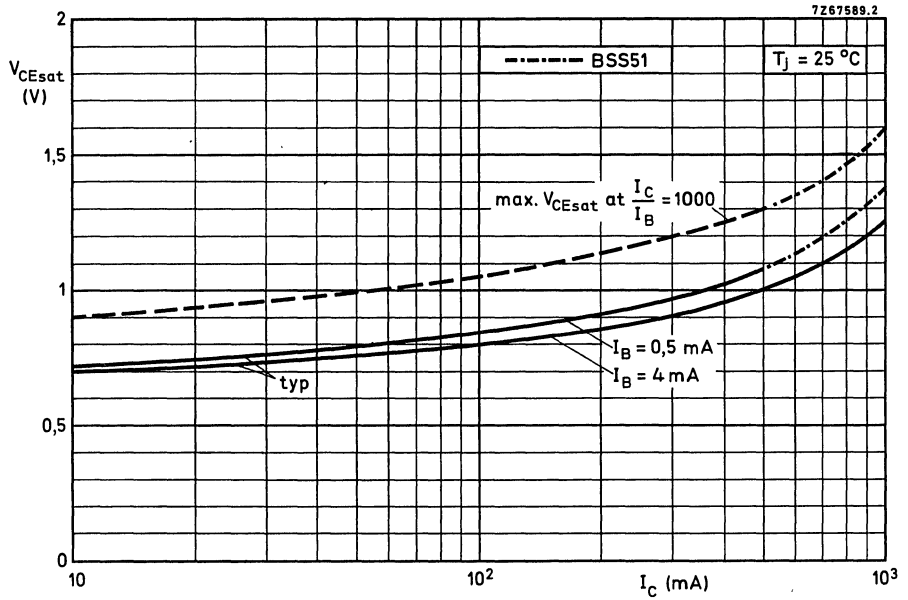


Fig. 11.

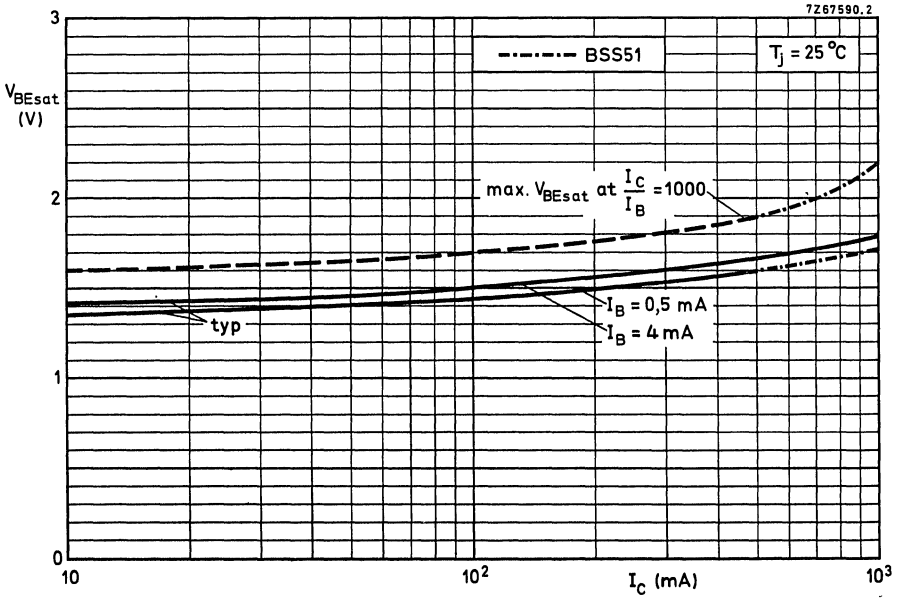


Fig. 12.

## P-N-P DARLINGTON TRANSISTORS



Silicon planar transistors in TO-39 metal envelopes, intended for industrial switching applications e.g. print hammer, solenoid, relay and lamp driving.

N-P-N complements are the BSS50, BSS51 and BSS52.

### QUICK REFERENCE DATA

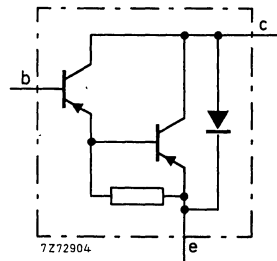
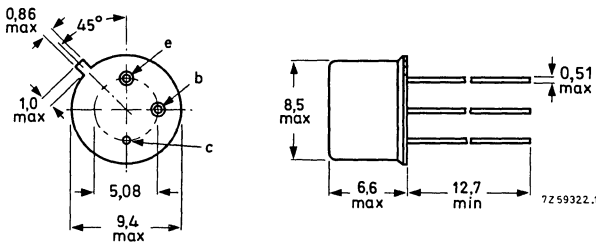
			BSS60	BSS61	BSS62	
Collector-base voltage (open emitter)	$-V_{CB0}$	max.	60	80	100	V
Collector-emitter voltage (see Fig. 4)	$-V_{CER}$	max.	45	60	80	V
Collector current (d.c.)	$-I_C$	max.	1,0			A
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$ up to $T_{case} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	0,8			W
	$P_{tot}$	max.	5,0			W
Collector-emitter saturation voltage						
$-I_C = 1,0\text{ A}; -I_B = 1,0\text{ mA}$	BSS61	$-V_{CEsat}$	<	1,6		V
$-I_C = 1,0\text{ A}; -I_B = 4,0\text{ mA}$	BSS60; BSS62	$-V_{CEsat}$	<	1,6		V
D.C. current gain						
$-I_C = 500\text{ mA}; -V_{CE} = 10\text{ V}$		$h_{FE}$	>	2000		
Turn-off time when switched from $-I_{Con} = 500\text{ mA}; -I_{Bon} = 0,5\text{ mA}$ to cut-off with $-I_{Boff} = 0,5\text{ mA}$		$t_{off}$	typ.	1,5		$\mu\text{s}$

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm

Accessories: 56245 (distance disc).

Products approved to CECC 50 004-074, available on request.

## RATINGS

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

			BSS60	BSS61	BSS62	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (see Fig. 4)	$-V_{CER}$	max.	45	60	80	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5,0	5,0	5,0	V
Collector current (d.c.)	$-I_C$	max.		1,0		A
Collector current (peak value)	$-I_{CM}$	max.		2,0		A
Base current (d.c.)	$-I_B$	max.		0,1		A
Total power dissipation up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$	max.		0,8		W
up to $T_{case} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$	max.		5,0		W
Storage temperature	$T_{stg}$		-65 to + 200			$^{\circ}\text{C}$
Junction temperature *	$T_j$	max.	200			$^{\circ}\text{C}$
<b>THERMAL RESISTANCE *</b>						
From junction to ambient in free air	$R_{th\ j-a}$	=		220		K/W
From junction to case	$R_{th\ j-c}$	=		35		K/W

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

## CHARACTERISTICS

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

Collector cut-off current

$I_E = 0; -V_{CB} = 45\text{ V}$  BSS60  $-I_{CBO} < 50\text{ nA}$

$I_E = 0; -V_{CB} = 60\text{ V}$  BSS61  $-I_{CBO} < 50\text{ nA}$

$I_E = 0; -V_{CB} = 80\text{ V}$  BSS62  $-I_{CBO} < 50\text{ nA}$

Emitter cut-off current

$I_C = 0; -V_{EB} = 4,0\text{ V}$   $-I_{EBO} < 100\text{ nA}$

Saturation voltages

$-I_C = 500\text{ mA}; -I_B = 0,5\text{ mA}$   $-V_{CEsat} < 1,3\text{ V}$

$-I_C = 500\text{ mA}; -I_B = 0,5\text{ mA}; T_j = 200\text{ }^\circ\text{C}$   $-V_{BEsat} < 1,9\text{ V}$

$-I_C = 500\text{ mA}; -I_B = 0,5\text{ mA}; T_j = 200\text{ }^\circ\text{C}$   $-V_{CEsat} < 1,3\text{ V}$

$-I_C = 1,0\text{ A}; -I_B = 1,0\text{ mA}$  BSS61  $-V_{CEsat} < 1,6\text{ V}$

$-I_C = 1,0\text{ A}; -I_B = 1,0\text{ mA}; T_j = 200\text{ }^\circ\text{C}$  BSS61  $-V_{BEsat} < 2,2\text{ V}$

$-I_C = 1,0\text{ A}; -I_B = 1,0\text{ mA}; T_j = 200\text{ }^\circ\text{C}$  BSS61  $-V_{CEsat} < 1,6\text{ V}$

$-I_C = 1,0\text{ A}; -I_B = 4,0\text{ mA}$  BSS60; BSS62  $-V_{CEsat} < 1,6\text{ V}$

$-I_C = 1,0\text{ A}; -I_B = 4,0\text{ mA}; T_j = 200\text{ }^\circ\text{C}$  BSS60; BSS62  $-V_{BEsat} < 2,2\text{ V}$

$-I_C = 1,0\text{ A}; -I_B = 4,0\text{ mA}; T_j = 200\text{ }^\circ\text{C}$  BSS60; BSS62  $-V_{CEsat} < 1,6\text{ V}$

D.C. current gain

$-I_C = 150\text{ mA}; -V_{CE} = 10\text{ V}$   $h_{FE} > 1000$

$-I_C = 500\text{ mA}; -V_{CE} = 10\text{ V}$   $h_{FE} > 2000$

Small-signal current gain at  $f = 35\text{ MHz}$

$-I_C = 500\text{ mA}; -V_{CE} = 5\text{ V}$   $h_{fe}$  typ. 10

Switching times (see Figs 2 and 3)

$-I_{Con} = 500 \text{ mA}; -I_{Bon} = I_{Boff} = 0,5 \text{ mA}$

Turn-on time

$t_{on}$  typ.  $0,4 \mu\text{s}$

Turn-off time

$t_{off}$  typ.  $1,5 \mu\text{s}$

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

Turn-on time

$t_{on}$  typ.  $0,4 \mu\text{s}$

Turn-off time

$t_{off}$  typ.  $1,5 \mu\text{s}$

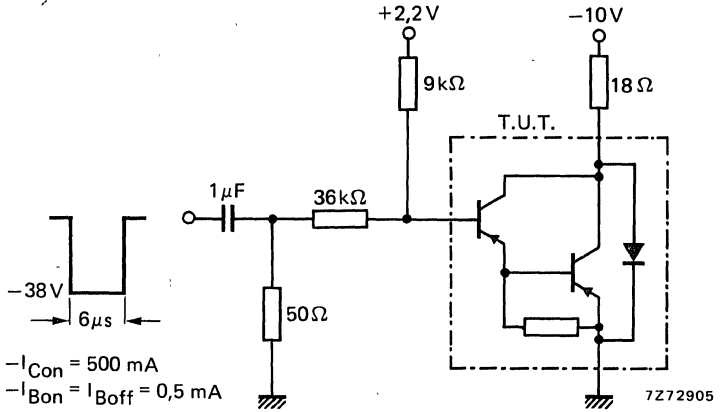


Fig. 2 Test circuit for 500 mA switching.

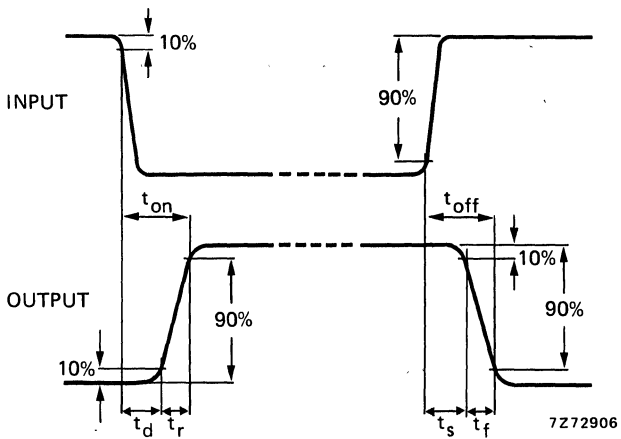


Fig. 3 Switching waveforms.

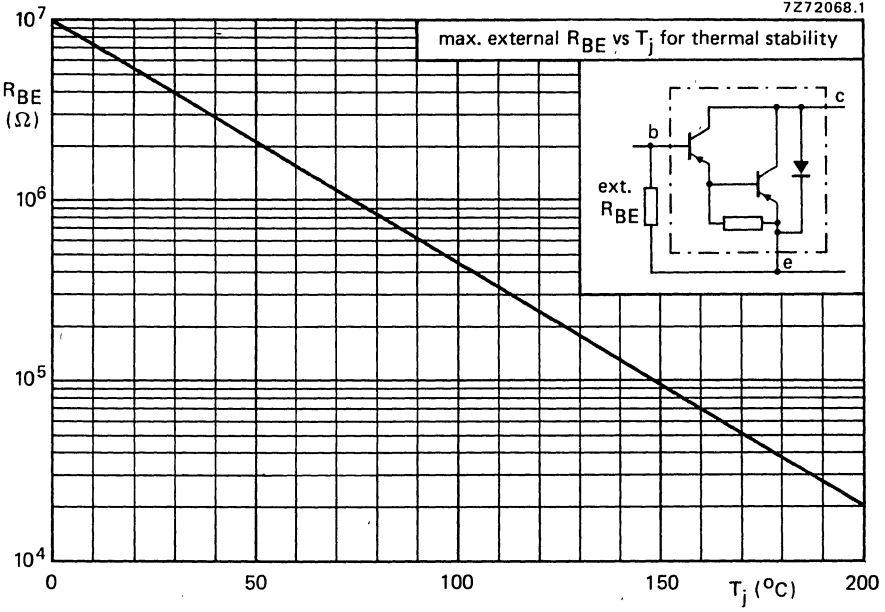


Fig. 4.

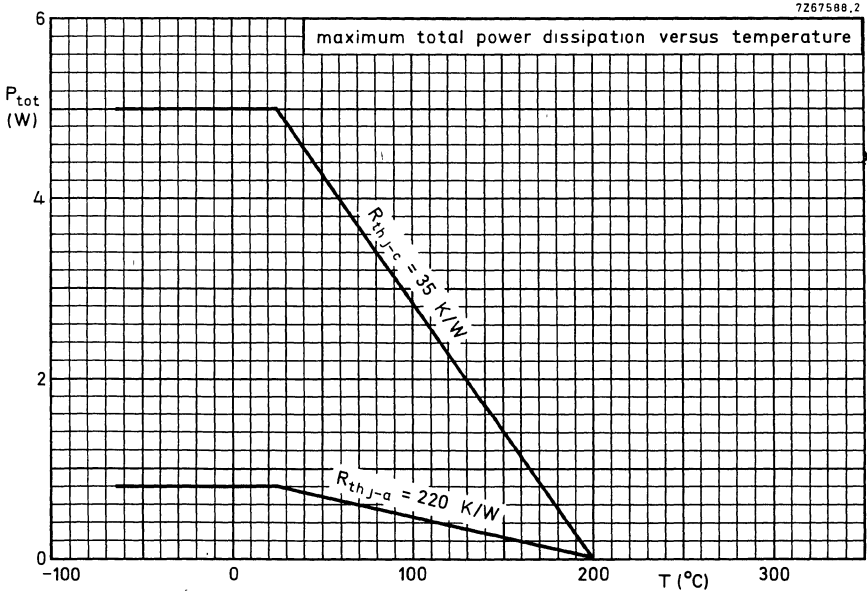


Fig. 5.



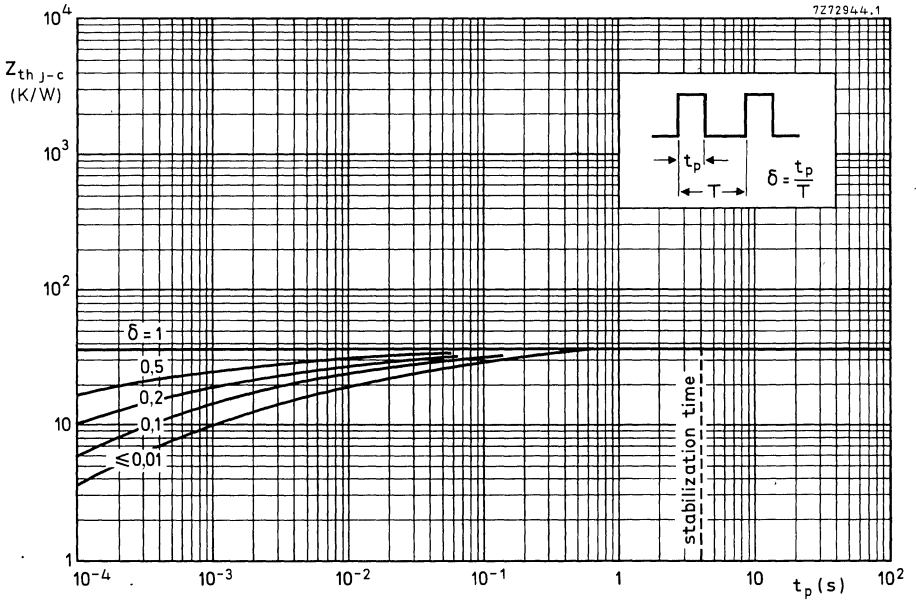


Fig. 6 Thermal impedance as a function of pulse duration.

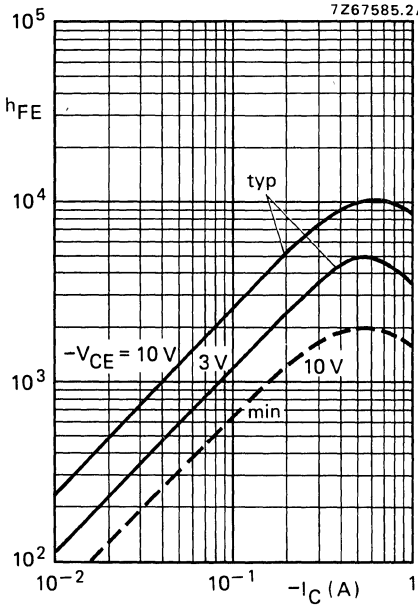


Fig. 7  $T_j = 25^\circ C$ .

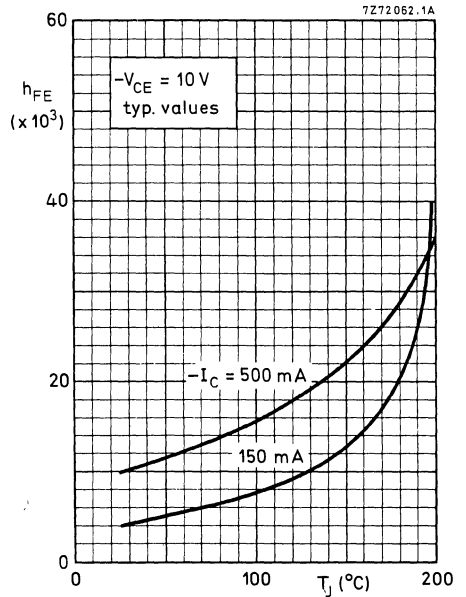


Fig. 8.

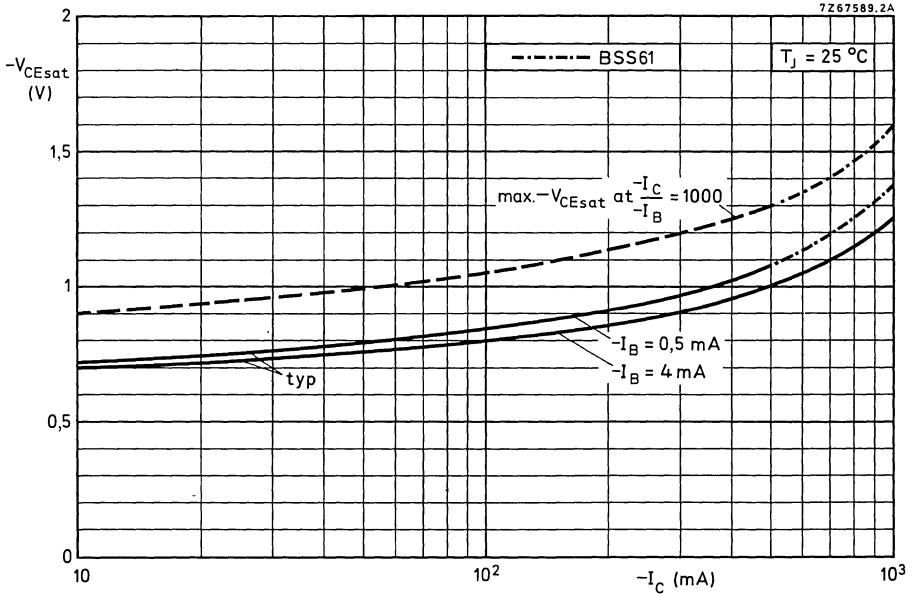


Fig. 9.

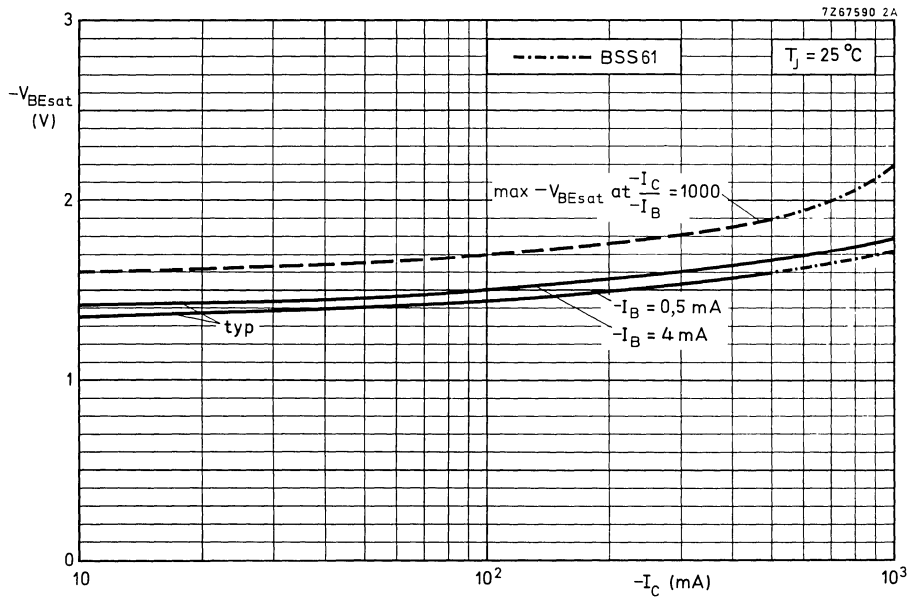


Fig. 10.

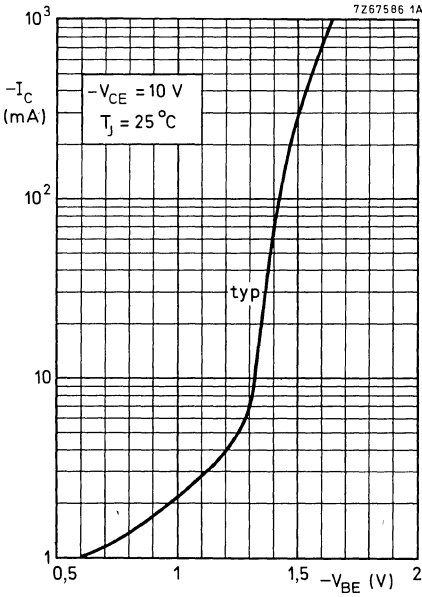


Fig. 11.

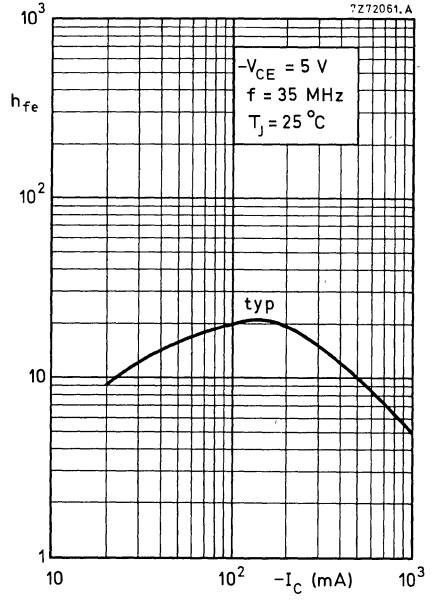


Fig. 12.

## HIGH-VOLTAGE P-N-P TRANSISTOR

Silicon planar epitaxial transistor in a plastic TO-92 variant. It is intended for anode switching in dynamically driven numerical indicator tubes and as general purpose switching device.

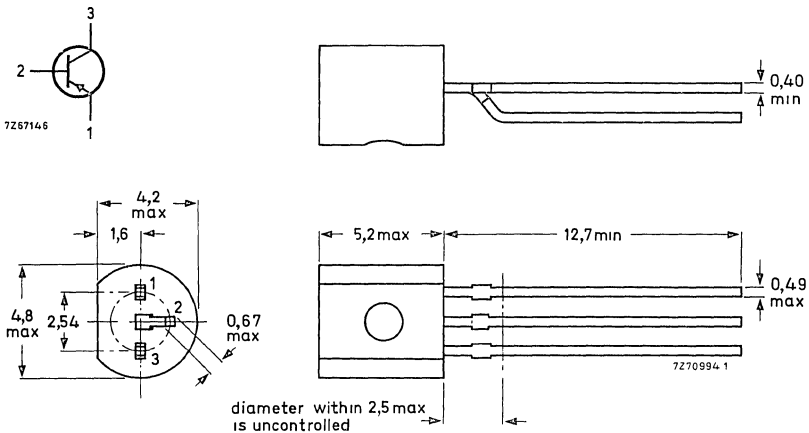
## QUICK REFERENCE DATA

Collector-emitter voltage ( $R_{BE} = 10 \text{ k}\Omega$ )	$-V_{CER}$ max.	110 V
Collector-emitter voltage (open base)	$-V_{CEO}$ max.	100 V
Collector current (d.c.)	$-I_C$ max.	100 mA
Total power dissipation up to $T_{amb} = 25 \text{ }^\circ\text{C}$	$P_{tot}$ max.	500 mW
Junction temperature	$T_j$ max.	150 $^\circ\text{C}$
D.C. current gain at $T_j = 25 \text{ }^\circ\text{C}$ $-I_C = 25 \text{ mA}; -V_{CE} = 5 \text{ V}$	$h_{FE}$	> 30
Transition frequency at $f = 35 \text{ MHz}$ $-I_C = 25 \text{ mA}; -V_{CE} = 5 \text{ V}$	$f_T$	> 50 MHz

## MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



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

Voltages

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	110 V
Collector-emitter voltage ( $R_{BE} = 10 \text{ k}\Omega$ )	$-V_{CER}$	max.	110 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	100 V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	6 V

Current

Collector current (d. c.)	$-I_C$	max.	100 mA
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Power dissipation

Total power dissipation up to $T_{amb} = 25 \text{ }^\circ\text{C}$	$P_{tot}$	max.	500 mW
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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 ambient in free air	$R_{th \text{ j-a}}$	=	0,25 $^\circ\text{C}/\text{mW}$
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**CHARACTERISTICS**

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

Collector cut-off current

$I_E = 0; -V_{CB} = 100 \text{ V}; T_j = 70 \text{ }^\circ\text{C}$	$-I_{CBO}$	<	10 $\mu\text{A}$
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Saturation voltages

$-I_C = 25 \text{ mA}; -I_B = 2,5 \text{ mA}$	$-V_{CEsat}$	<	250 mV
	$-V_{BEsat}$	<	900 mV

D. C. current gain

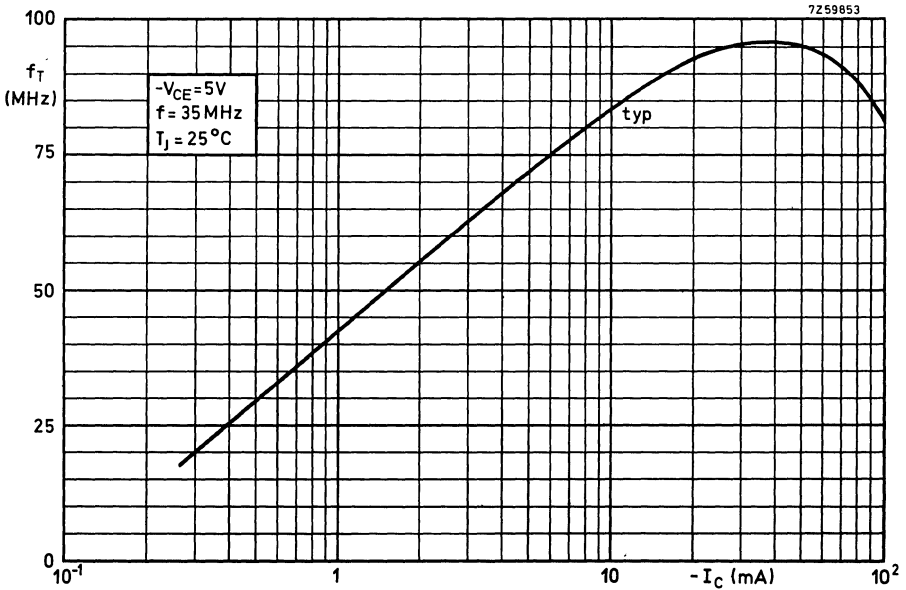
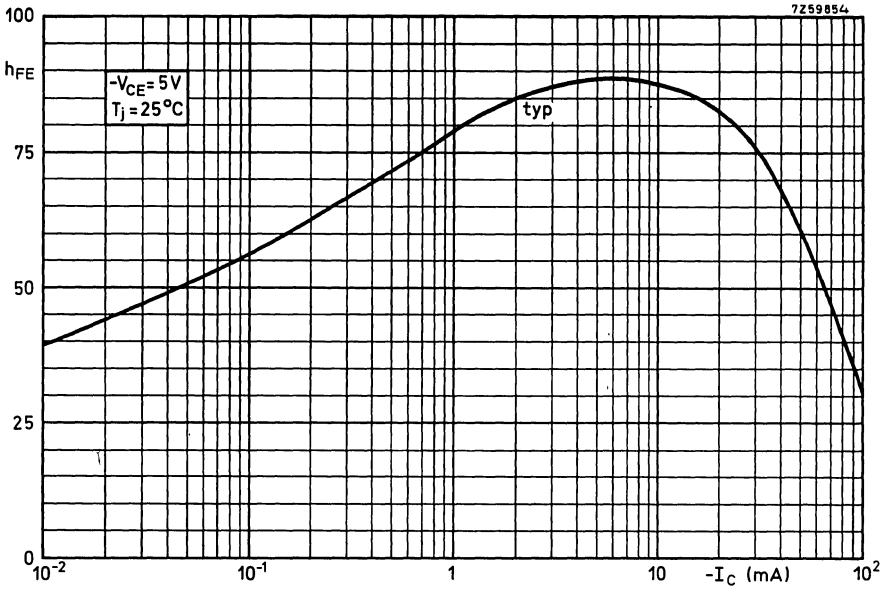
$-I_C = 10 \text{ mA}; -V_{CE} = 5 \text{ V}$	$h_{FE}$	>	30
$-I_C = 25 \text{ mA}; -V_{CE} = 5 \text{ V}$	$h_{FE}$	>	30

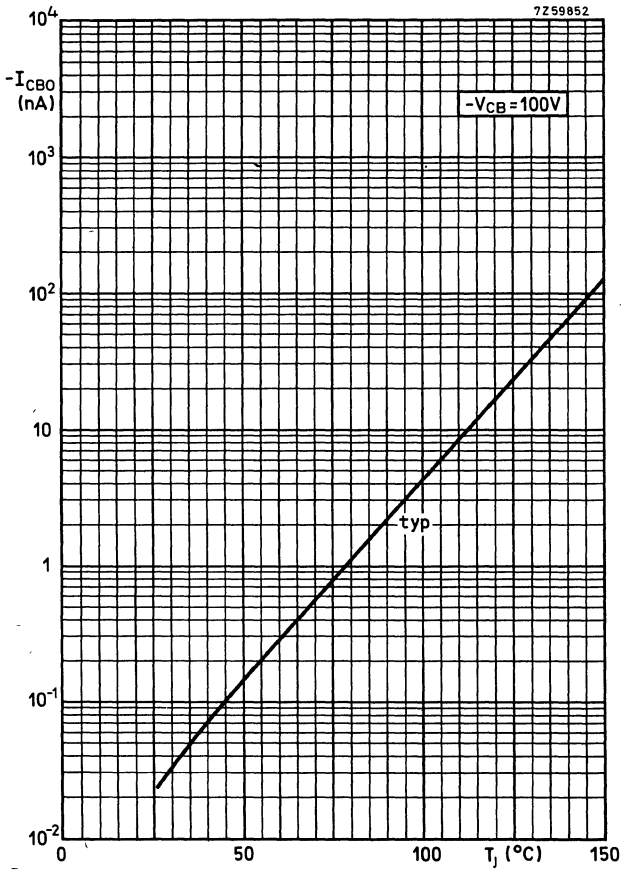
Collector capacitance at  $f = 1 \text{ MHz}$

$I_E = I_e = 0; -V_{CB} = 10 \text{ V}$	$C_c$	<	5 pF
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Transition frequency at  $f = 35 \text{ MHz}$

$-I_C = 25 \text{ mA}; -V_{CE} = 5 \text{ V}$	$f_T$	>	50 MHz
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## SILICON PLANAR EPITAXIAL TRANSISTORS



P-N-P transistors in TO-39 metal envelopes with the collector connected to the case. These transistors are intended for general industrial applications.

## QUICK REFERENCE DATA

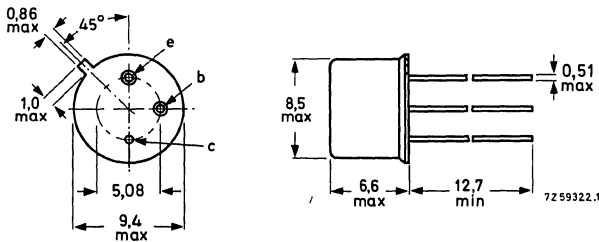
		BSV15	BSV16	BSV17	
Collector-emitter voltage (open base)	$-V_{CEO}$ max.	40	60	80	V
Collector current (d.c.)	$-I_C$ max.	1,0			A
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$ up to $T_{case} = 25\text{ }^\circ\text{C}$	$P_{tot}$ max.	0,8			W
	$P_{tot}$ max.	5,0			W
Junction temperature	$T_j$ max.	200			$^\circ\text{C}$
Transition frequency at $f = 20\text{ MHz}$ $-I_C = 50\text{ mA}; -V_{CE} = 10\text{ V}$	$f_T$	> 50			MHz
		BSV15-6 BSV16-6 BSV17-6	BSV15-10 BSV16-10 BSV17-10	BSV15-16 BSV16-16	
D.C. current gain $-I_C = 100\text{ mA}; -V_{CE} = 1\text{ V}$	$h_{FE}$	40-100	63-160	100-250	

## MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).



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

Voltages

			BSV15	BSV16	BSV17
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	80 V
Collector-emitter voltage ( $V_{BE} = 0$ )	$-V_{CES}$	max.	40	60	90 V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5 V

Currents

Collector current (d.c.)	$-I_C$	max.	1.0	A
Base current (d.c.)	$-I_B$	max.	200	mA

Power dissipation

Total power dissipation up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	0.8	W
up to $T_{case} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	5.0	W
up to $T_{mb} = 50\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	5.0	W

Temperatures

Storage temperature	$T_{stg}$	-65 to +200	$^{\circ}\text{C}$
Junction temperature	$T_j$	max. 200	$^{\circ}\text{C}$

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th\ j-a}$	=	220	$^{\circ}\text{C}/\text{W}$
From junction to case	$R_{th\ j-c}$	=	35	$^{\circ}\text{C}/\text{W}$
From junction to mounting base	$R_{th\ j-mb}$	=	30	$^{\circ}\text{C}/\text{W}$

**CHARACTERISTICS**

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

Collector cut-off currents

BSV15 | BSV16 | BSV17

$V_{BE} = 0; -V_{CE} = 40\text{ V}$	$-I_{CES}$	< 100	-	-	nA
$V_{BE} = 0; -V_{CE} = 40\text{ V}; T_{amb} = 150\text{ }^{\circ}\text{C}$	$-I_{CES}$	< 50	-	-	$\mu\text{A}$
$V_{BE} = 0; -V_{CE} = 60\text{ V}$	$-I_{CES}$	< -	100	-	nA
$V_{BE} = 0; -V_{CE} = 60\text{ V}; T_{amb} = 150\text{ }^{\circ}\text{C}$	$-I_{CES}$	< -	50	-	$\mu\text{A}$
$V_{BE} = 0; -V_{CE} = 80\text{ V}$	$-I_{CES}$	< -	-	100	nA
$V_{BE} = 0; -V_{CE} = 80\text{ V}; T_{amb} = 150\text{ }^{\circ}\text{C}$	$-I_{CES}$	< -	-	50	$\mu\text{A}$
$-V_{BE} = 0,2\text{ V}; -V_{CE} = 40\text{ V}; T_{amb} = 100\text{ }^{\circ}\text{C}$	$-I_{CEX}$	< 50	-	-	$\mu\text{A}$
$-V_{BE} = 0,2\text{ V}; -V_{CE} = 60\text{ V}; T_{amb} = 100\text{ }^{\circ}\text{C}$	$-I_{CEX}$	< -	50	-	$\mu\text{A}$
$-V_{BE} = 0,2\text{ V}; -V_{CE} = 80\text{ V}; T_{amb} = 100\text{ }^{\circ}\text{C}$	$-I_{CEX}$	< -	-	50	$\mu\text{A}$

Emitter cut-off current

$I_C = 0; -V_{EB} = 4\text{ V}$	$-I_{EBO}$	< 50	50	50	nA
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Breakdown voltages

$I_B = 0; -I_C = 50\text{ mA}; t_p = 200\text{ }\mu\text{s}; \delta = 0,01$	$-V_{(BR)CEO}$	> 40	60	80	V
$V_{BE} = 0; -I_C = 10\text{ }\mu\text{A}$	$-V_{(BR)CES}$	> 40	60	90	V
$I_C = 0; -I_E = 10\text{ }\mu\text{A}$	$-V_{(BR)EBO}$	> 5	5	5	V

Base-emitter voltage

$-I_C = 100\text{ mA}; -V_{CE} = 1\text{ V}$	$-V_{BE}$	<	1,0	V
$-I_C = 500\text{ mA}; -V_{CE} = 1\text{ V}$	$-V_{BE}$	typ.	0,85	V
			0,7 to 1,4	V

Saturation voltage

$-I_C = 500\text{ mA}; -I_B = 25\text{ mA}$	$-V_{CEsat}$	<	1,0	V
---	--------------	---	-----	---

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

$I_E = I_e = 0; -V_{CB} = 10\text{ V}$	<u>BSV15; BSV16</u>	$C_c$	typ.	20	pF
			<	30	pF
$I_E = I_e = 0; -V_{CB} = 10\text{ V}$	<u>BSV17</u>	$C_c$	typ.	15	pF
			<	25	pF

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

$I_C = I_c = 0; -V_{EB} = 0,5\text{ V}$	$C_e$	typ.	180	pF
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Transition frequency at  $f = 20\text{ MHz}$

$-I_C = 50\text{ mA}; -V_{CE} = 10\text{ V}$	$f_T$	>	50	MHz
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## CHARACTERISTICS (continued)

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

### D.C. current gain

$-I_C = 0.1\text{ mA}; -V_{CE} = 1\text{ V}$

	BSV15-6, BSV16-6 BSV17-6	BSV15-10 BSV16-10 BSV17-10	BSV15-16 BSV16-16
$h_{FE}$	$> 15$ typ. 44	20 75	30 120
$h_{FE}$	typ. 63 40 to 100	100 63 to 160	160 100 to 250
$h_{FE}$	$> 20$ typ. 40	25 55	35 85

$-I_C = 100\text{ mA}; -V_{CE} = 1\text{ V}$

$-I_C = 500\text{ mA}; -V_{CE} = 1\text{ V}$

### h parameter at $f = 1\text{ kHz}$

$-I_C = 1\text{ mA}; -V_{CE} = 5\text{ V}$

Small signal current gain

$h_{fe} > 20$

### Switching times

Turn-on time

$-I_C = 100\text{ mA}; -I_B = +I_{BM} = 5\text{ mA}$

$t_{on} < 500\text{ ns}$

Turn-off time

$-I_C = 100\text{ mA}; -I_B = +I_{BM} = 5\text{ mA}$

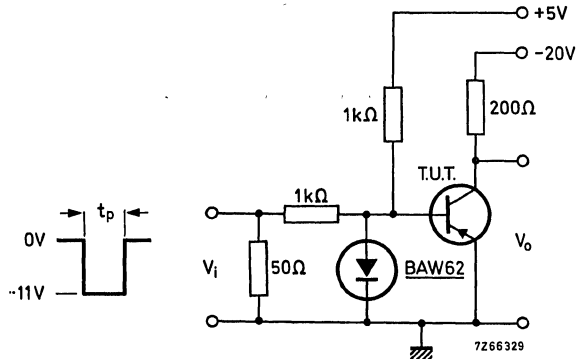
$t_s < 500\text{ ns}$

Storage time

Fall time

$t_f < 150\text{ ns}$

Test circuit:

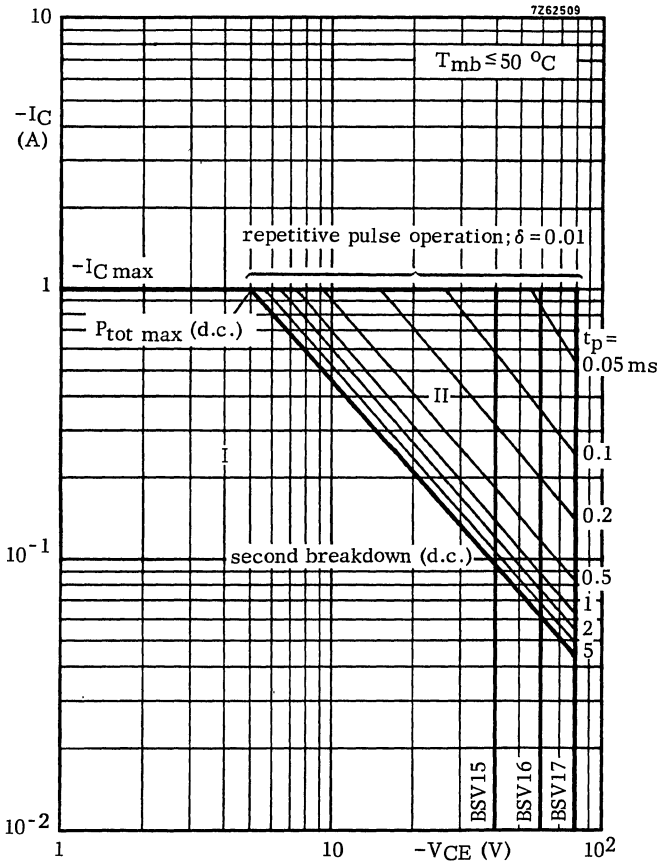


Pulse generator:

Pulse duration  $t_p \geq 10\text{ }\mu\text{s}$   
 Rise time  $t_r \leq 15\text{ ns}$   
 Fall time  $t_f \leq 15\text{ ns}$   
 Source impedance  $R_S = 50\text{ }\Omega$

Oscilloscope:

Rise time  $\leq 15\text{ ns}$   
 Input impedance  $\geq 100\text{ k}\Omega$



Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

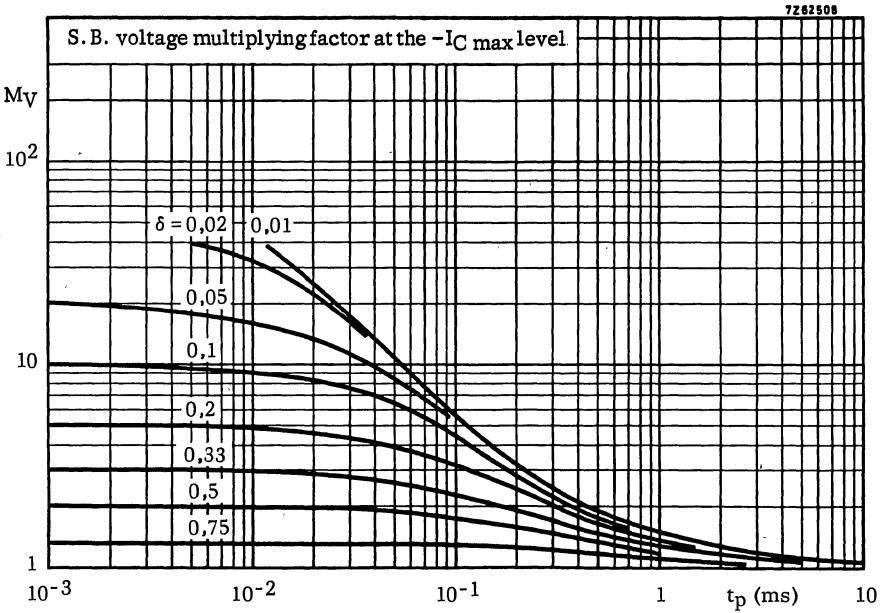


Fig. 4.

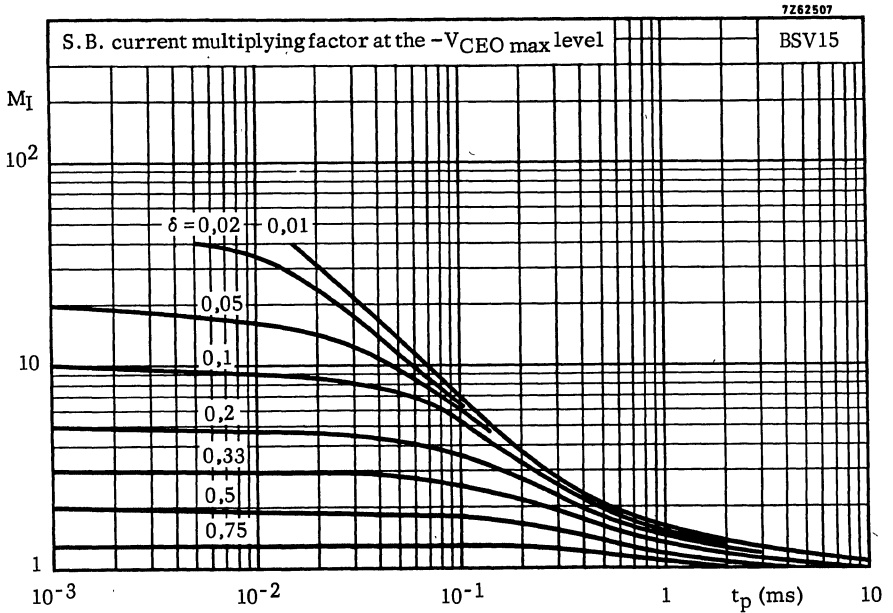


Fig. 5.

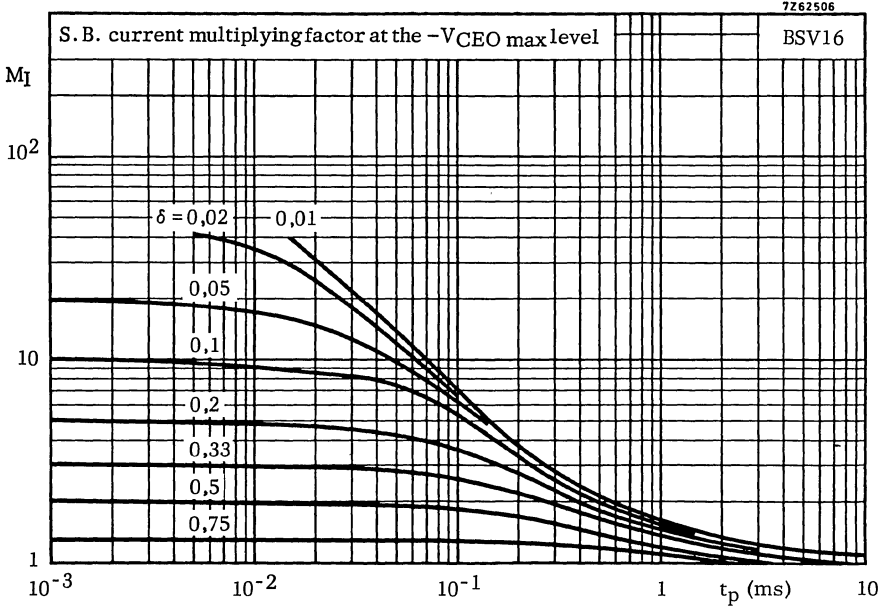


Fig. 6.

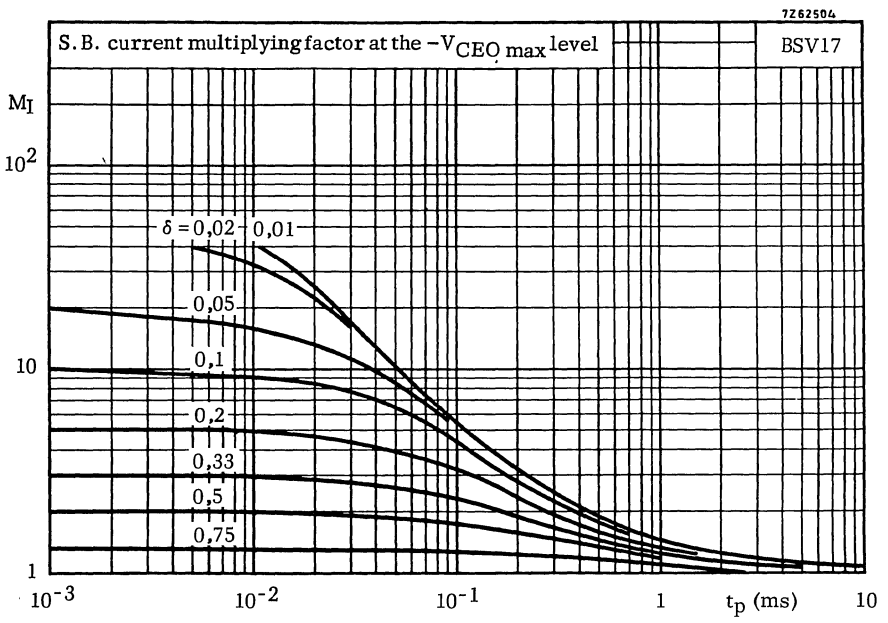
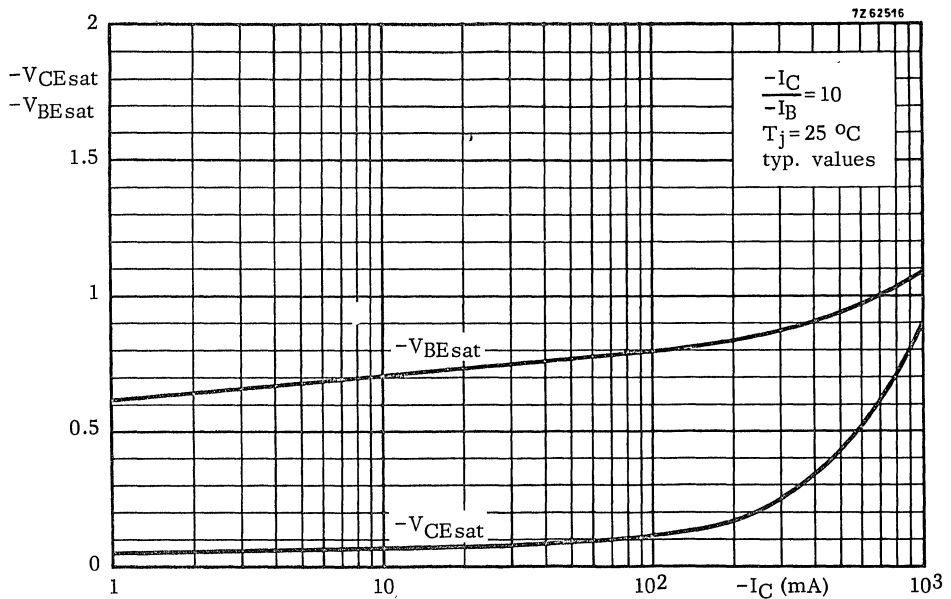
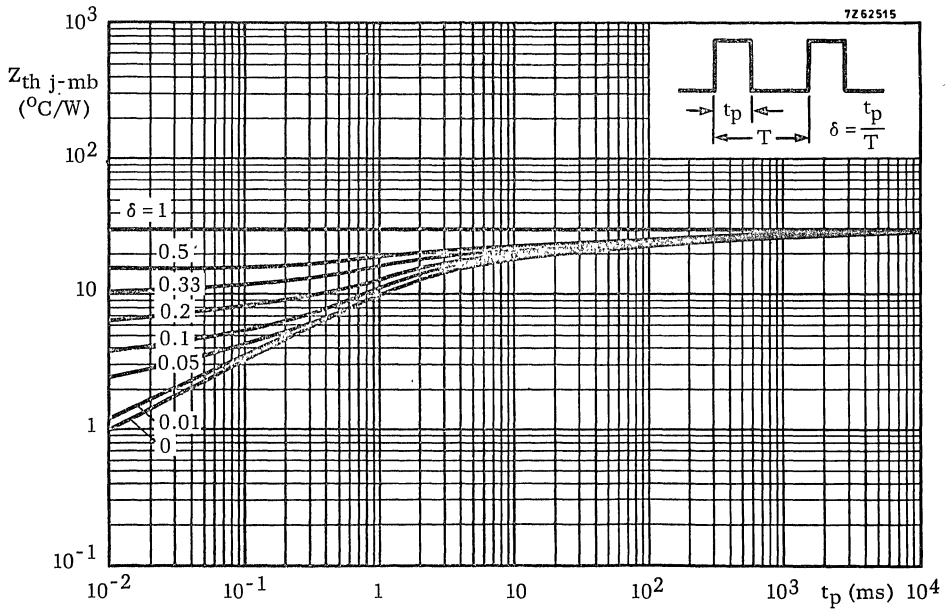
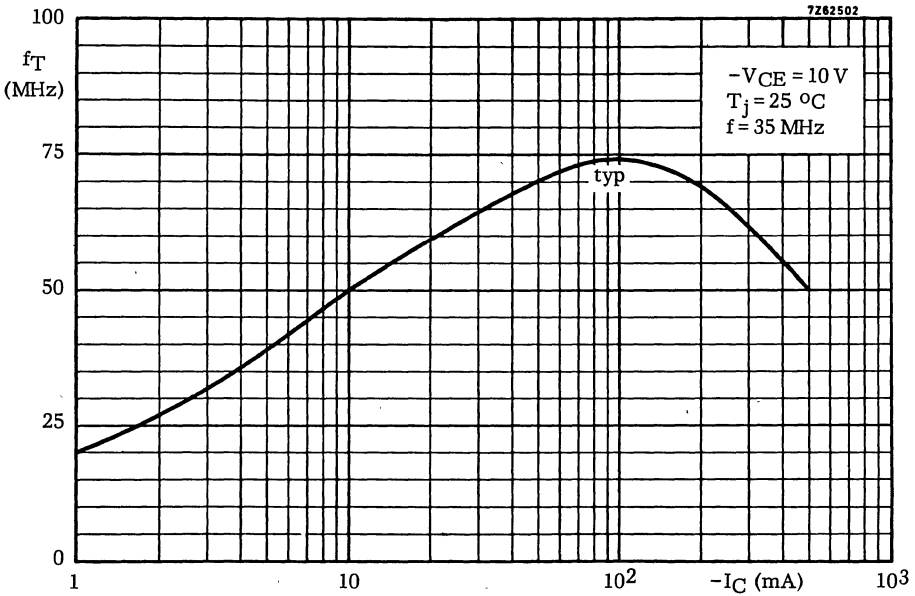
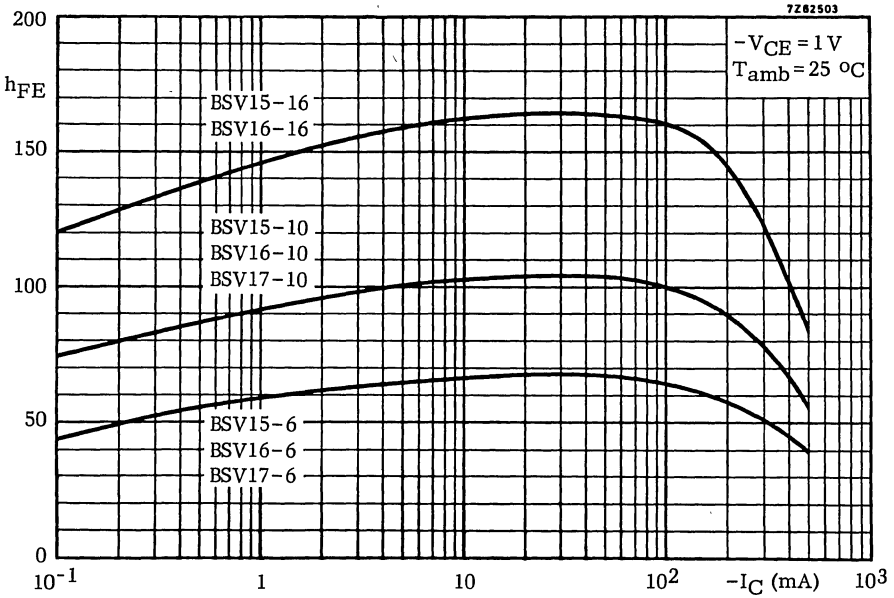
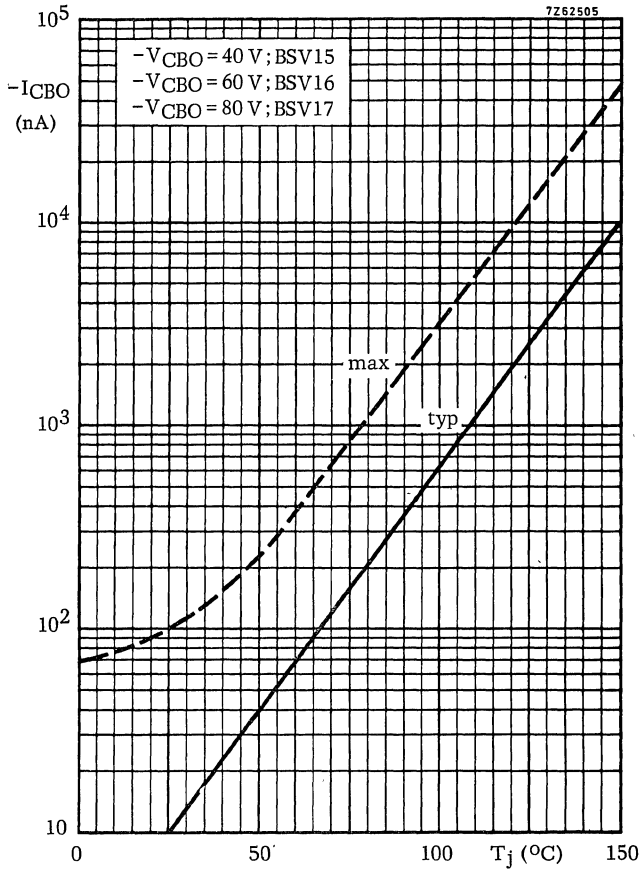


Fig. 7.









## SILICON PLANAR EPITAXIAL TRANSISTOR



N-P-N transistor in a TO-39 metal envelope primarily intended for use as a print hammer drive. It has good high current saturation characteristics.

## QUICK REFERENCE DATA

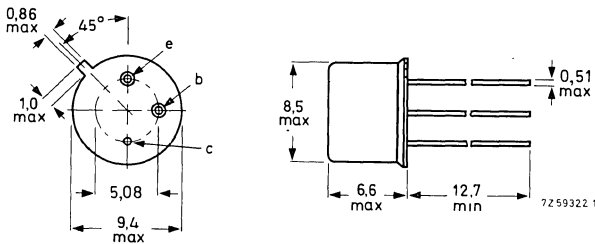
Collector-base voltage (open emitter)	$V_{CBO}$	max.	100 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	60 V
Collector current (peak value)	$I_{CM}$	max.	5,0 A
Total power dissipation up to $T_{case} = 50\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	5,0 W
Junction temperature	$T_j$	max.	175 $^{\circ}\text{C}$
D.C. current gain	$h_{FE}$	>	40
$I_C = 2\text{ A}; V_{CE} = 2\text{ V}$			
Transition frequency at $f = 35\text{ MHz}$	$f_T$	typ.	100 MHz
$I_C = 0,5\text{ A}; V_{CE} = 5\text{ V}$			
Turn-off time when switched from	$t_{off}$	<	1,2 $\mu\text{s}$
$I_{Con} = 5\text{ A}; I_{BOn} = 0,5\text{ A}$ to cut-off			
with $-I_{BOff} = 0,5\text{ A}$			

## MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).

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

Collector-base voltage (open emitter)	$V_{CBO}$	max.	100	V
Collector-emitter voltage ( $R_{BE} \leq 50 \Omega$ )	$V_{CER}$	max.	80	V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	60	V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	5	V

Currents

Collector current (d. c.)	$I_C$	max.	2,0	A
Collector current (peak value)	$I_{CM}$	max.	5,0	A
Base current (d. c.)	$I_B$	max.	1,0	A

Power dissipation

Total power dissipation up to $T_{case} = 50 \text{ }^\circ\text{C}$	$P_{tot}$	max.	5,0	W
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Temperatures

Storage temperature	$T_{stg}$	-55 to +175	$^\circ\text{C}$
Junction temperature	$T_j$	max. 175	$^\circ\text{C}$

**THERMAL RESISTANCE**

From junction to case	$R_{th j-c}$	=	25	$^\circ\text{C/W}$
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## CHARACTERISTICS

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

Collector cut-off current

 $I_E = 0; V_{CB} = 60\text{ V}$  $I_{CBO} < 10\text{ }\mu\text{A}$ 

Emitter cut-off current

 $I_C = 0; V_{EB} = 4\text{ V}$  $I_{EBO} < 10\text{ }\mu\text{A}$ 

Saturation voltages

 $I_C = 5\text{ A}; I_B = 0,5\text{ A}$  $V_{CEsat} < 1,0\text{ V}$  $V_{BEsat} < 1,8\text{ V}$ 

D.C. current gain

 $I_C = 2\text{ A}; V_{CE} = 2\text{ V}$  $h_{FE} > 40$ Collector capacitance at  $f = 1\text{ MHz}$  $I_E = I_e = 0; V_{CB} = 10\text{ V}$  $C_C < 80\text{ pF}$ Transition frequency at  $f = 35\text{ MHz}$  $I_C = 0,5\text{ A}; V_{CE} = 5\text{ V}$  $f_T \text{ typ. } 100\text{ MHz}$ 

Switching times

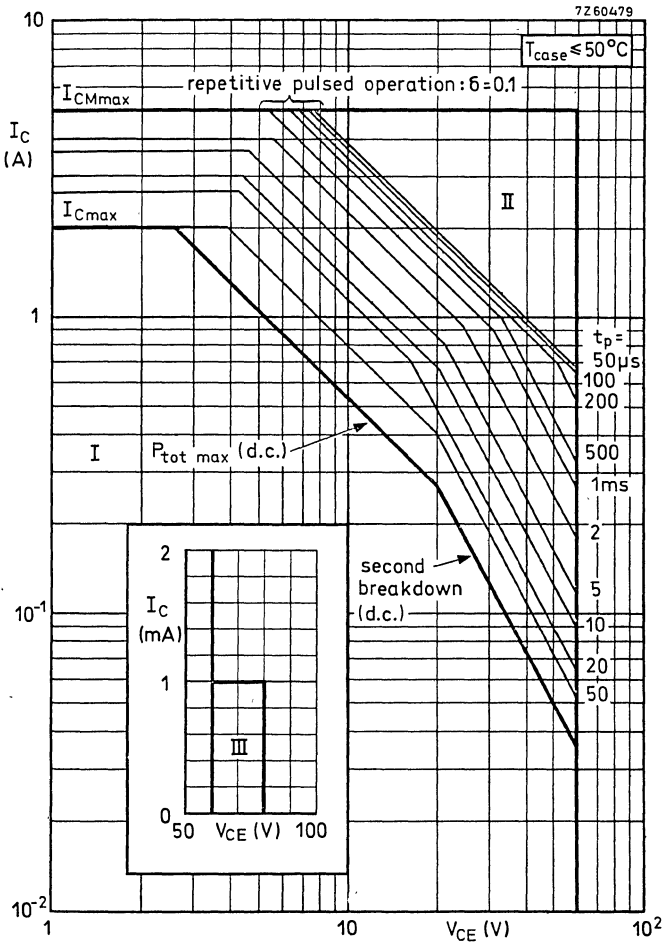
 $I_{Con} = 5\text{ A}; I_{Bon} = -I_{Boff} = 0,5\text{ A}$  $-V_{BEoff} = 2\text{ V}$ 

turn-on time

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

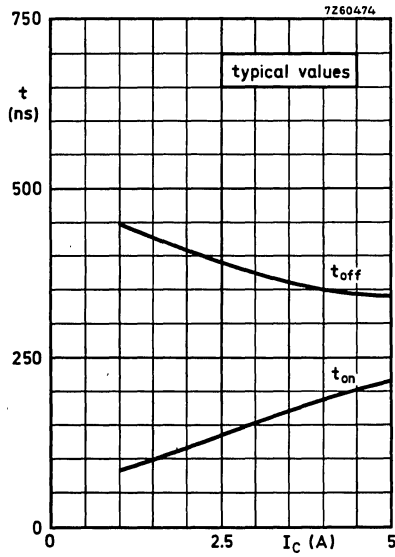
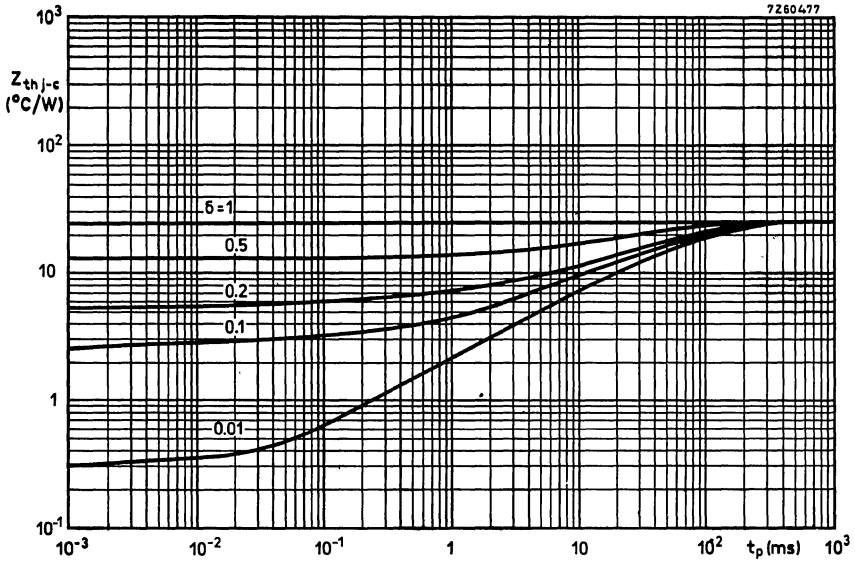
turn-off time

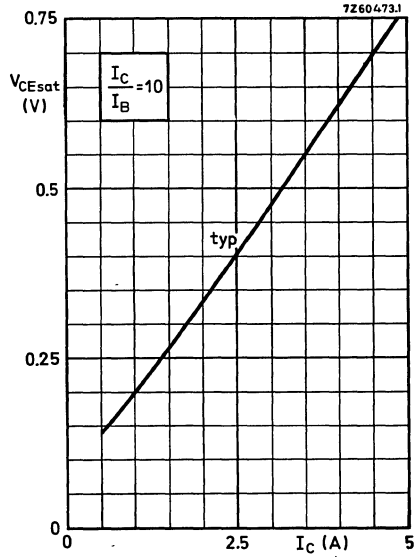
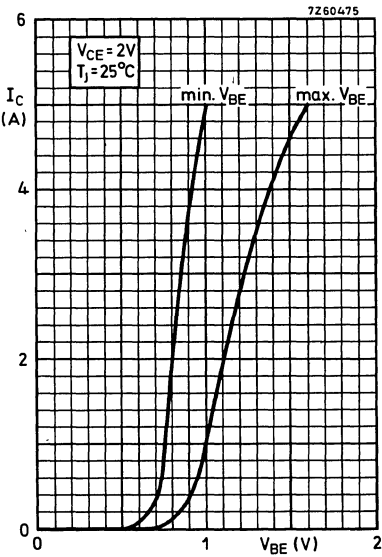
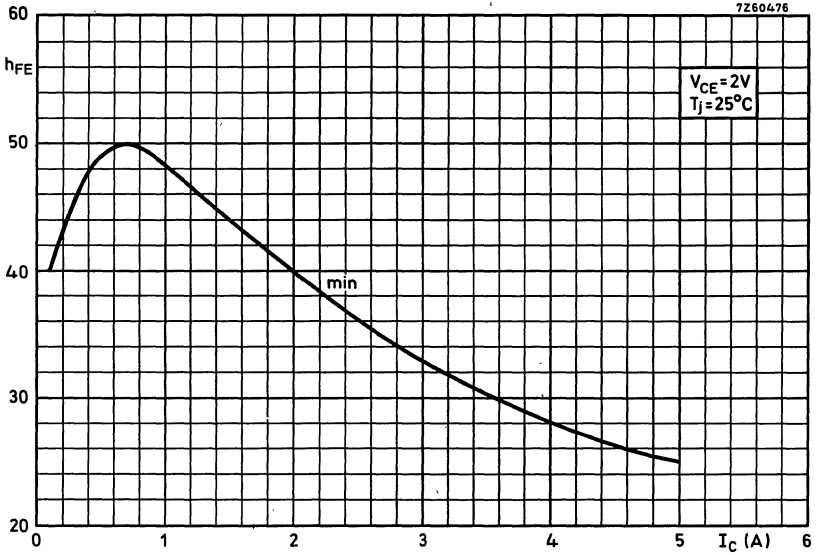
 $t_{off} < 1,2\text{ }\mu\text{s}$



Safe Operating Area

- I Region of permissible d.c. operation
- II Permissible extension for repetitive pulsed operation
- III D.C. operation in this region is allowable, provided  $R_{BE} \leq 50 \Omega$





## SILICON PLANAR EPITAXIAL TRANSISTORS



N-P-N transistors primarily intended for general purpose industrial and switching applications.

## QUICK REFERENCE DATA

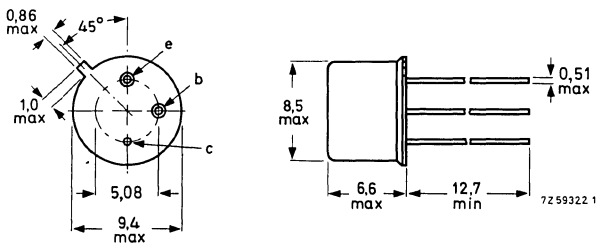
		BSW66A	BSW67A	BSW68A	
Collector-base voltage (open emitter)	$V_{CBO}$	max. 100	120	150	V
Collector-emitter voltage (open base)	$V_{CEO}$	max. 100	120	150	V
Collector current (peak value)	$I_{CM}$	max.	2		A
Total power dissipation up to $T_{case} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	5,0		W
Collector-emitter saturation voltage $I_C = 500\text{ mA}; I_B = 50\text{ mA}$	$V_{CEsat}$	<	400		mV
D.C. current gain $I_C = 10\text{ mA}; V_{CE} = 5\text{ V}$	$h_{FE}$	>	30		
$I_C = 500\text{ mA}; V_{CE} = 5\text{ V}$	$h_{FE}$	>	30		
Transition frequency at $f = 35\text{ MHz}$ $I_C = 100\text{ mA}; V_{CE} = 20\text{ V}$	$f_T$	typ.	130		MHz

## MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case.



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).



## RATINGS

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

			BSW66A	BSW67A	BSW68A	
Collector-base voltage (open emitter)	$V_{CBO}$	max.	100	120	150	V
Collector-emitter voltage (open base) *	$V_{CEO}$	max.	100	120	150	V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	6	6	6	V
Collector current (d.c. or average)	$I_C$	max.	1			A
Collector current (peak value; $t_p \leq 20$ ms)	$I_{CM}$	max.	2			A
Total power dissipation up to						
$T_{amb} = 25$ °C	$P_{tot}$	max.	0,8			W
$T_{case} = 25$ °C	$P_{tot}$	max.	5,0			W
Storage temperature	$T_{stg}$		-65 to +200			°C
Junction temperature	$T_j$	max.	200			°C

## THERMAL RESISTANCE

From junction to ambient in free air	$R_{th j-a}$	=	220	°C/W
From junction to case	$R_{th j-c}$	=	35	°C/W

## CHARACTERISTICS

 $T_j = 25$  °C unless otherwise specified

Collector cut-off current

$I_E = 0; V_{CB} = V_{CBOmax}$	$I_{CBO}$	<	100	$\mu$ A
$I_E = 0; V_{CB} = \frac{1}{2}V_{CBOmax}$	$I_{CBO}$	<	100	nA
$I_E = 0; V_{CB} = \frac{1}{2}V_{CBOmax}; T_j = 150$ °C	$I_{CBO}$	<	50	$\mu$ A

Emitter cut-off current

$I_C = 0; V_{EB} = 6$ V	$I_{EBO}$	<	100	$\mu$ A
$I_C = 0; V_{EB} = 3$ V	$I_{EBO}$	<	100	nA

Collector-emitter breakdown voltage

			BSW66A	BSW67A	BSW68A	
$I_B = 0; I_C = 10$ mA	$V_{(BR)CEO}$	>	100	120	150	V

Saturation voltages

$I_C = 100$ mA; $I_B = 10$ mA	$V_{CEsat}$	<	150	mV
	$V_{BEsat}$	<	900	mV
$I_C = 500$ mA; $I_B = 50$ mA	$V_{CEsat}$	<	400	mV
	$V_{BEsat}$	<	1,1	V
$I_C = 1,0$ A; $I_B = 150$ mA	$V_{CEsat}$	<	1,0	V
	$V_{BEsat}$	<	1,4	V

\* See Application Information on page 8.

D.C. current gain

$I_C = 10 \text{ mA}; V_{CE} = 5 \text{ V}$

$h_{FE}$	>	30
	typ.	75

$I_C = 100 \text{ mA}; V_{CE} = 5 \text{ V}$

$h_{FE}$	>	40
	typ.	90

$I_C = 500 \text{ mA}; V_{CE} = 5 \text{ V}$

$h_{FE}$	>	30
	typ.	80

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

$h_{FE}$	>	15
	typ.	20

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

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

$C_c$	<	20 pF
-------	---	-------

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

$I_C = I_c = 0; V_{EB} = 0$

$C_e$	<	300 pF
-------	---	--------

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

$I_C = 100 \text{ mA}; V_{CE} = 20 \text{ V}$

$f_T$	typ.	130 MHz
-------	------	---------

Turn-on time (see Fig. 2)

$I_{Con} = 500 \text{ mA}; I_{Bon} = 50 \text{ mA}; -V_{BEoff} = 4 \text{ V}$

$t_{on}$	typ.	0,5 $\mu\text{s}$
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Turn-off time (see Fig. 2)

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

$t_{off}$	typ.	0,9 $\mu\text{s}$
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Pulse generator:

$t_p \geq 5 \mu\text{s}$   
 $t_r \leq 10 \text{ ns}$   
 $t_f \leq 10 \text{ ns}$

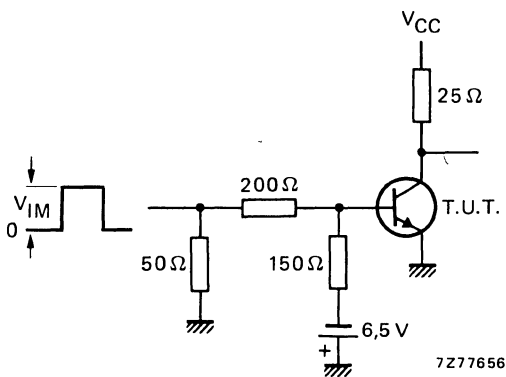


Fig. 2 Test circuit for saturated switching characteristics.  $V_{CC} = 13 \text{ V}; V_{IM} = 21 \text{ V}$ .

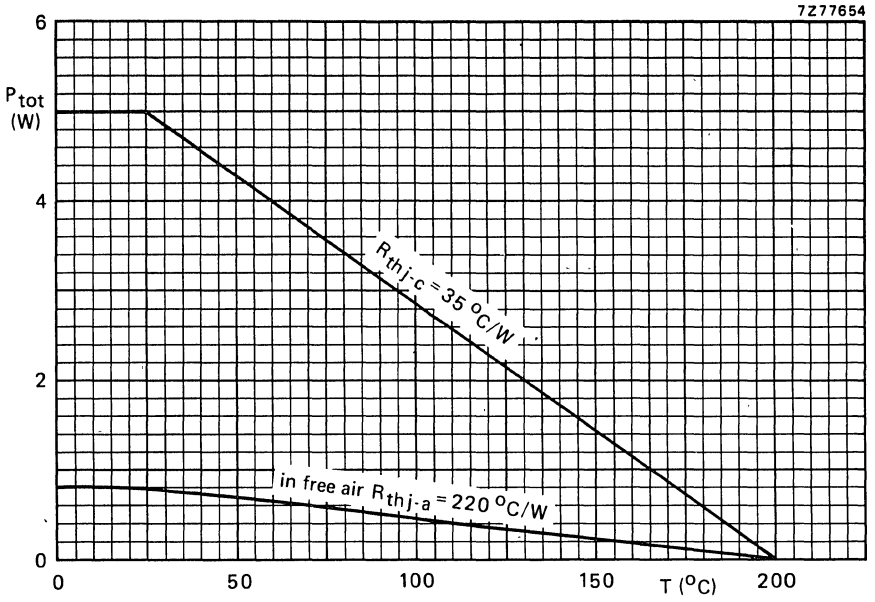


Fig. 3 Maximum permissible power dissipation versus temperature.

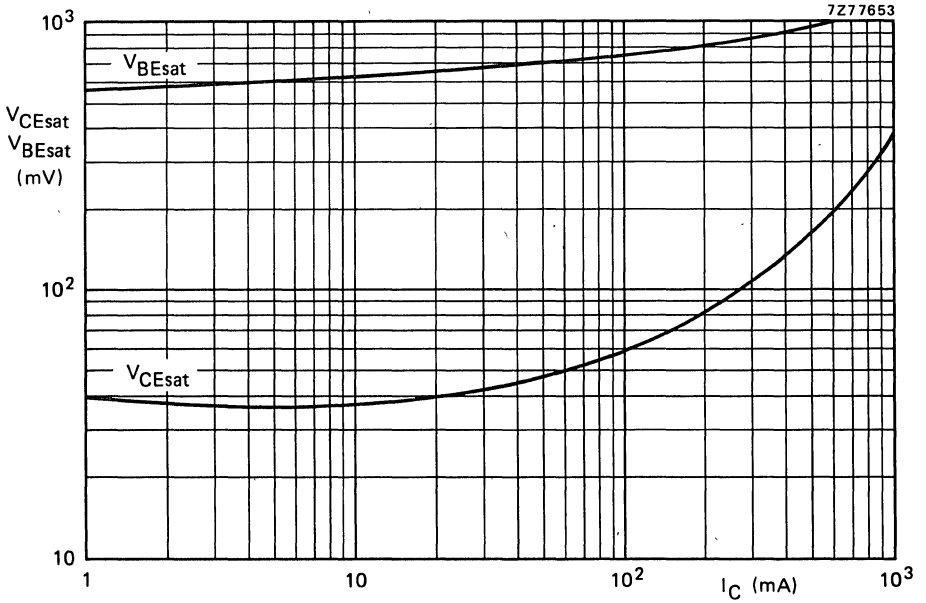


Fig. 4  $I_C/I_B = 10$ ;  $T_j = 25\text{ }^{\circ}\text{C}$ ; typical values.

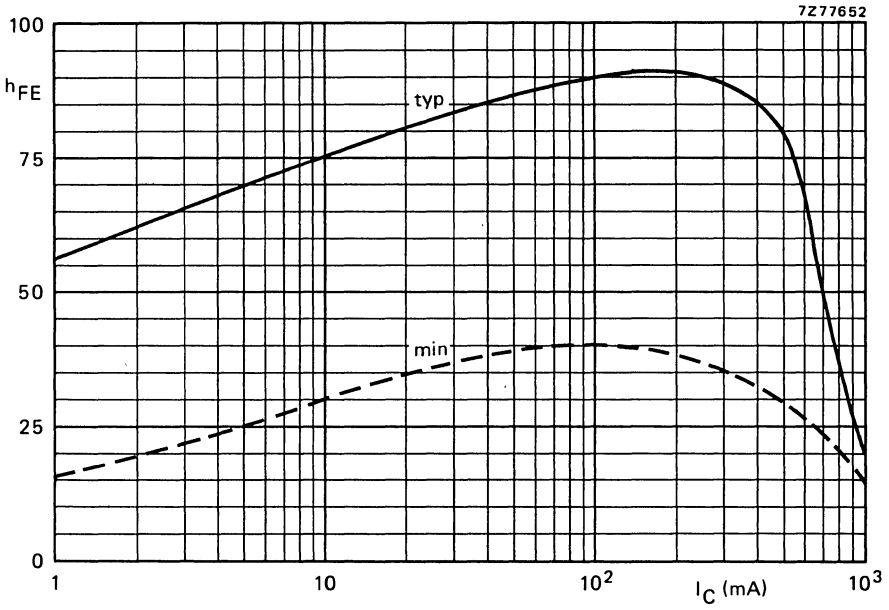


Fig. 5  $V_{CE} = 5 \text{ V}$ ;  $T_j = 25 \text{ }^\circ\text{C}$ .

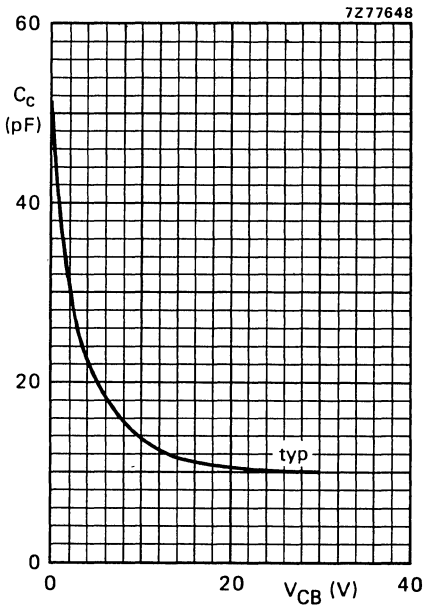


Fig. 6  $I_E = I_c = 0$ ;  $T_j = 25 \text{ }^\circ\text{C}$ .

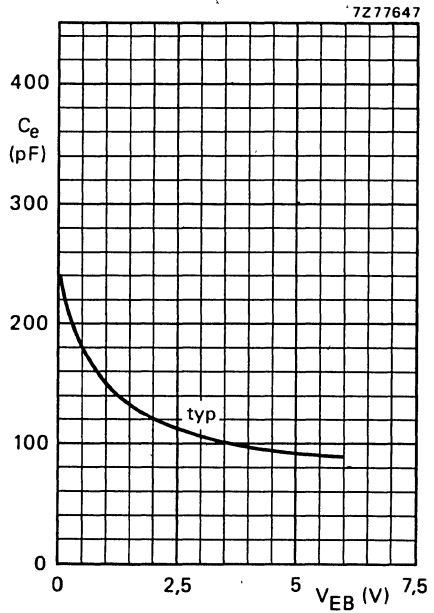


Fig. 7  $I_C = I_c = 0$ ;  $T_j = 25 \text{ }^\circ\text{C}$ .

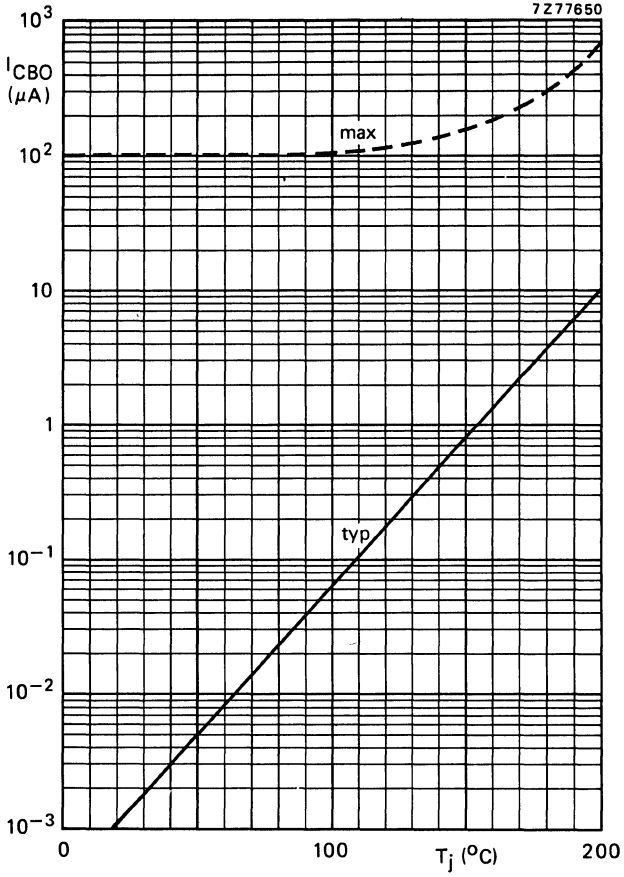


Fig. 8  $V_{CB} = V_{CBOmax}$ .

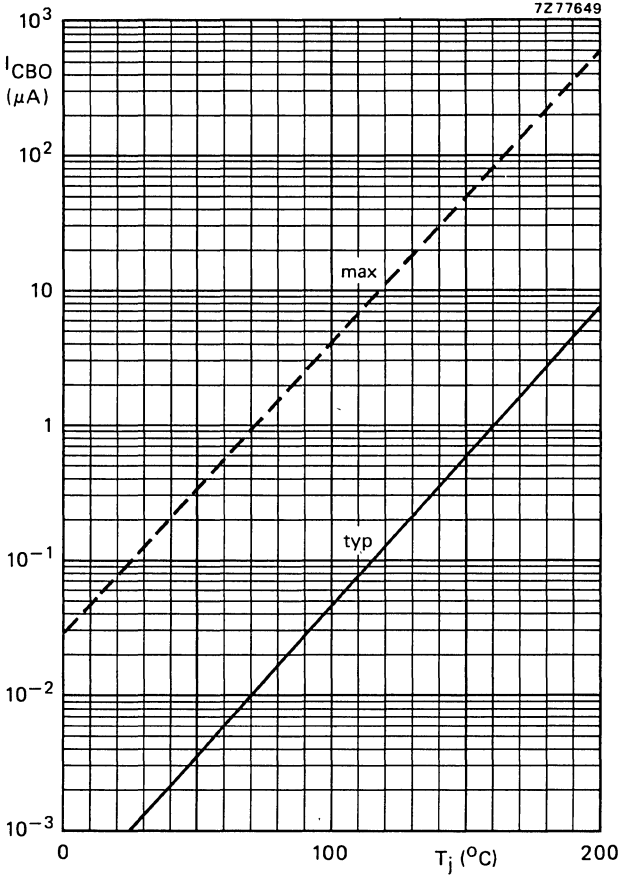


Fig. 9  $V_{CB} = \frac{1}{2}V_{CBOmax}$

APPLICATION INFORMATION

Clamped inductive load turn-off capability

With a base-emitter resistance of  $\geq 330 \Omega$ , i.e. an available reverse base current of  $\leq 2 \text{ mA}$ , and the maximum permitted clamping voltage i.e. the rated  $V_{CE0max}$ , the transistor will be free from second-breakdown effects when turning off from collector current values up to the rated  $I_{CMmax}$  of 2 A.

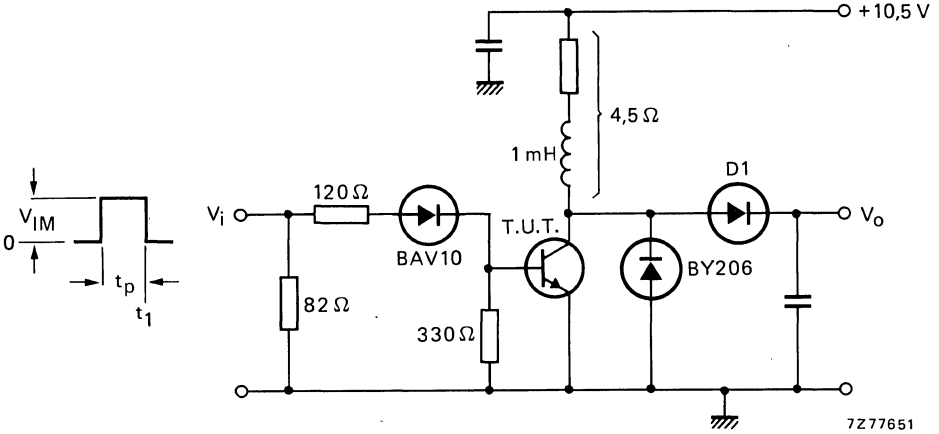


Fig. 10 Test circuit:  $V_{IM} = 50 \text{ V}$ ;  $t_p = 3 \text{ ms}$ ;  $\delta \leq 0,03$ .  
 D1 = BY206 or combinations of suitable faster diodes.  
 $V_o$  Adjusted to make  $V_{(CL)}$  equal to rated  $V_{CE0max}$  (see Fig. 11).

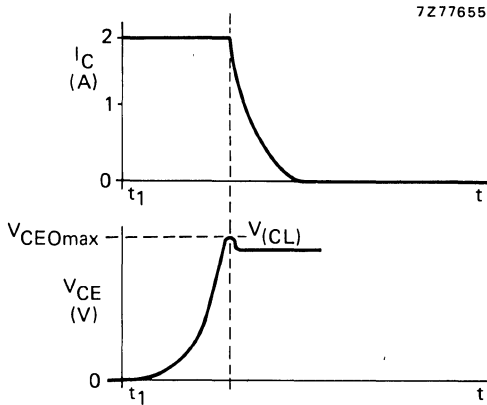


Fig. 11 Waveforms.

## SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in TO-18 metal envelopes, primarily intended for high-speed saturated switching and h.f. amplifier applications.

### QUICK REFERENCE DATA

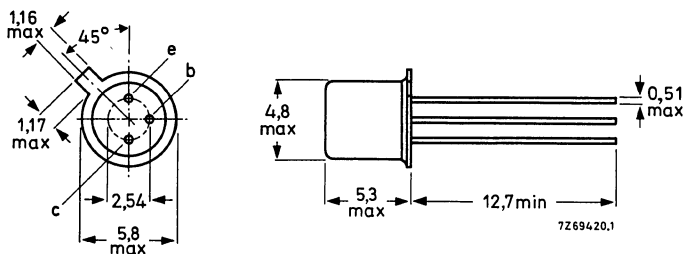
		BSX19	BSX20	
Collector-base voltage (open emitter)	$V_{CBO}$	max. 40	40	V
Collector-emitter voltage (open base)	$V_{CEO}$	max. 15	15	V
Collector-emitter voltage ( $V_{BE} = 0$ )	$V_{CES}$	max. 40	40	V
Collector current (peak value)	$I_{CM}$	max. 500	500	mA
Total power dissipation up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$	max. 360	360	mW
D.C. current gain at $T_j = 25\text{ }^{\circ}\text{C}$				
$I_C = 10\text{ mA}; V_{CE} = 1\text{ V}$	$h_{FE}$	20 to 60	40 to 120	
$I_C = 100\text{ mA}; V_{CE} = 2\text{ V}$	$h_{FE}$	> 10	20	
Transition frequency				
$I_C = 10\text{ mA}; V_{CE} = 10\text{ V}$	$f_T$	> 400	500	MHz
Storage time				
$I_C = I_B = -I_{BM} = 10\text{ mA}$	$t_s$	< 10	13	ns

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector connected to case



Accessories: 56246 (distance disc).



**RATINGS** (Limiting values) <sup>1)</sup>Voltages

Collector-base voltage (open emitter)	$V_{CBO}$	max.	40 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	15 V
Collector-emitter voltage with $V_{BE} = 0$	$V_{CES}$	max.	40 V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	4.5 V

Current

Collector current (peak value; $t = 10 \mu s$ )	$I_{CM}$	max.	500 mA
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Power dissipation

Total power dissipation up to $T_{amb} = 25 \text{ }^\circ\text{C}$	$P_{tot}$	max.	360 mW
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Temperatures

Storage temperature	$T_{stg}$	-65 to +200	$^\circ\text{C}$
Junction temperature	$T_j$	max.	200 $^\circ\text{C}$

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th j-a}$	=	0.48 $^\circ\text{C}/\text{mW}$
From junction to case	$R_{th j-c}$	=	0.15 $^\circ\text{C}/\text{mW}$

<sup>1)</sup> Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

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

Collector cut-off current

$I_E = 0; V_{CB} = 20\text{ V}$	$I_{CBO}$	<	400 nA
$I_E = 0; V_{CB} = 20\text{ V}; T_j = 150^\circ\text{C}$	$I_{CBO}$	<	30 $\mu\text{A}$
$V_{BE} = 0; V_{CE} = 15\text{ V}; T_j = 55^\circ\text{C}$	$I_{CES}$	<	0.40 $\mu\text{A}$
$V_{BE} = 0; V_{CE} = 40\text{ V}$	$I_{CES}$	<	1.0 $\mu\text{A}$

Emitter cut-off current

$I_C = 0; V_{EB} = 4.5\text{ V}$	$I_{EBO}$	<	10 $\mu\text{A}$
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Currents at reverse biased emitter junction

$V_{CE} = 15\text{ V}; -V_{BE} = 3\text{ V}; T_j = 55^\circ\text{C}$	$I_{CEX}$	<	0.60 $\mu\text{A}$
	$-I_{BEX}$	<	0.60 $\mu\text{A}$

Sustaining voltages

$I_C = 10\text{ mA}; I_B = 0$	$V_{CEO\text{sust}}$	>	15 V
$I_C = 10\text{ mA}; R_{BE} = 10\ \Omega$	$V_{CER\text{sust}}$	>	20 V

Base-emitter voltage (see also page 8)

$I_C = 30\ \mu\text{A}; V_{CE} = 20\text{ V}; T_j = 100^\circ\text{C}$	$V_{BE}$	>	0.35 V
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Saturation voltages

$I_C = 10\text{ mA};$ BSX19: $I_B = 0.6\text{ mA}$ BSX20: $I_B = 0.3\text{ mA}$	$V_{CE\text{sat}}$	<	0.3 V
$I_C = 10\text{ mA}; I_B = 1\text{ mA}$	$V_{CE\text{sat}}$	<	0.25 V
	$V_{BE\text{sat}}$	>	0.70 to 0.85 V
$I_C = 100\text{ mA}; I_B = 10\text{ mA}$	$V_{CE\text{sat}}$	<	0.60 V
	$V_{BE\text{sat}}$	<	1.50 V

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

$I_E = I_e = 0; V_{CB} = 5\text{ V}$	$C_c$	<	4 pF
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Emitter capacitance at  $f = 1\text{ MHz}$ 

$I_C = I_c = 0; V_{EB} = 1\text{ V}$	$C_e$	<	4.5 pF
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**CHARACTERISTICS (continued)**

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

D.C. current gain

$I_C = 10\text{ mA}; V_{CE} = 1\text{ V}$

$h_{FE}$

BSX19	BSX20
20 to 60	40 to 120
$> 10$	20
$> 10$	20

$I_C = 10\text{ mA}; V_{CE} = 1\text{ V}; T_j = -55\text{ }^\circ\text{C}$

$h_{FE}$

$I_C = 100\text{ mA}; V_{CE} = 2\text{ V}$

$h_{FE}$

Transition frequency

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

$f_T$

$> 400$	500 MHz
typ. 500	600 MHz

Switching times

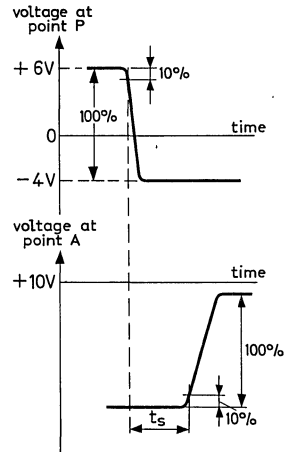
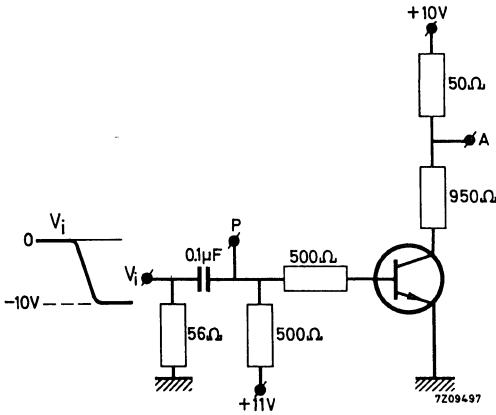
Storage time (see also pages 20 and 21)

$I_C = I_B = -I_{BM} = 10\text{ mA}$

$t_s$

typ. 5	6 ns
$< 10$	13 ns

Test circuit:



Pulse generator:

Rise time	$t_r < 1\text{ ns}$
Pulse duration	$t > 300\text{ ns}$
Duty cycle	$\delta < 0.02$
Source impedance	$R_S = 50\text{ }\Omega$

Oscilloscope:

Input impedance	$R_i = 50\text{ }\Omega$
Rise time	$t_r < 1\text{ ns}$

**CHARACTERISTICS (continued)**

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

Switching times

Turn on time (see also pages 14 and 15)

from  $-V_{BE} = 1.5\text{ V}$  to  $I_C = 10\text{ mA}$ ;  $I_B = 3\text{ mA}$

from  $-V_{BE} = 2.25\text{ V}$  to  $I_C = 100\text{ mA}$ ;  $I_B = 40\text{ mA}$

$t_{on} < 12\text{ ns}$

$t_{on} < 7\text{ ns}$

Turn off time (see also pages 16 to 19)

from  $I_C = 10\text{ mA}$ ;  $I_B = 3\text{ mA}$

to cut-off with  $-I_{BM} = 1.5\text{ mA}$

from  $I_C = 100\text{ mA}$ ;  $I_B = 40\text{ mA}$  to cut-off

with  $-I_{BM} = 20\text{ mA}$

BSX19

$t_{off} < 15\text{ ns}$

BSX20

$t_{off} < 18\text{ ns}$

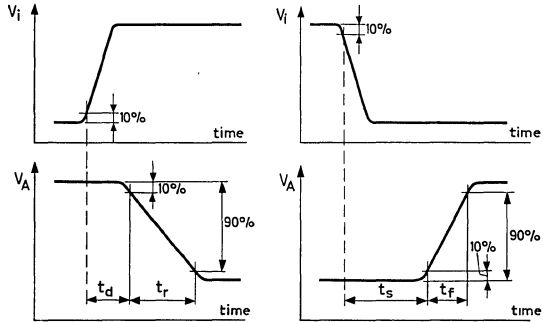
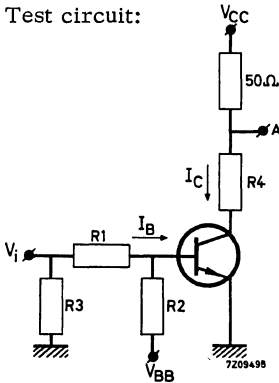
BSX19

$t_{off} < 18\text{ ns}$

BSX20

$t_{off} < 21\text{ ns}$

Test circuit:



Pulse generator:

Rise time  $t_r < 1\text{ ns}$

Pulse duration  $t > 300\text{ ns}$

Duty cycle  $\delta < 0.02$

Source impedance  $R_s = 50\text{ }\Omega$

Oscilloscope:

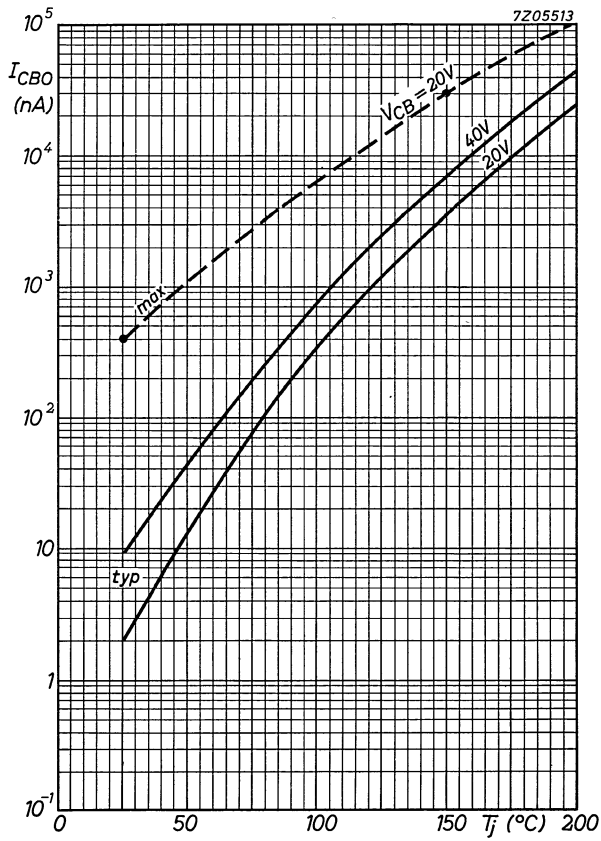
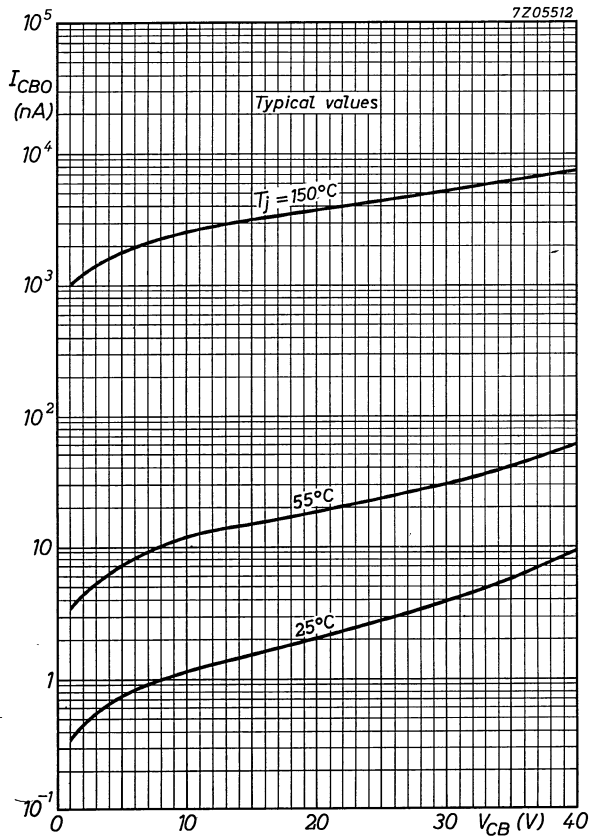
Input impedance  $R_i = 50\text{ }\Omega$

Rise time  $t_r < 1\text{ ns}$

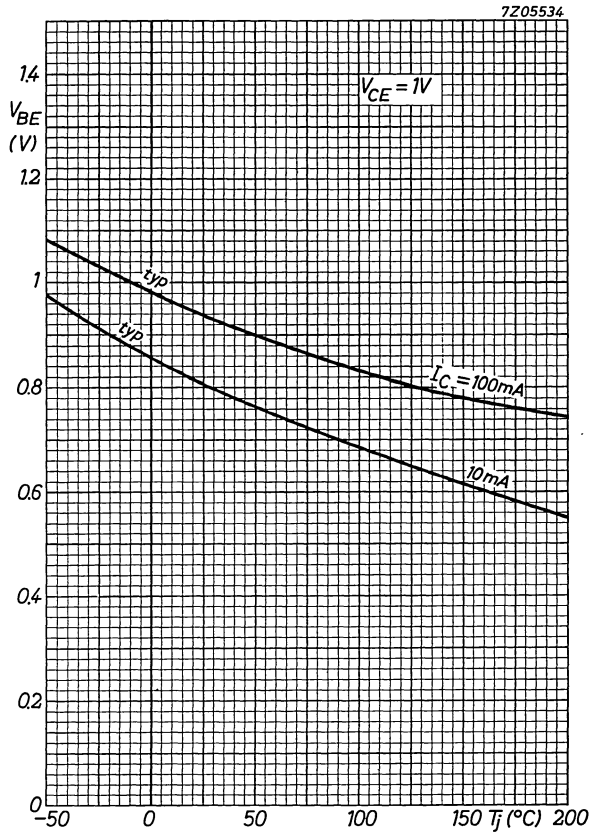
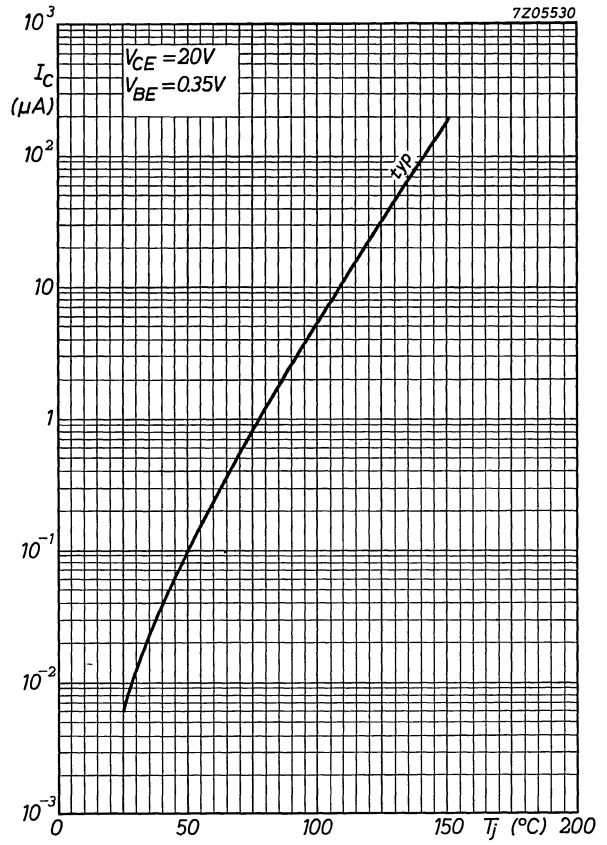
$I_C$ (mA)	$I_B$ (mA)	$-I_{BM}$ (mA)	$V_{CC}$ (V)	R1;R2 (k $\Omega$ )	R3 ( $\Omega$ )	R4 ( $\Omega$ )	turn on time			turn off time	
							$-V_{BB}$ (V)	$-V_{BE}$ (V)	$V_i$ (V)	$V_{BB}$ (V)	$-V_i$ (V)
10	3	1.5	3	3.3	50	220	3.0	1.5	15	12.0	15
100	40	20	6	0.33	56	0	4.5	2.25	20	15.3	20

Note

$-I_{BM}$  is the reverse current that can flow during switching off. The indicated  $-I_{BM}$  is determined and limited by the applied cut-off voltage and series resistance.

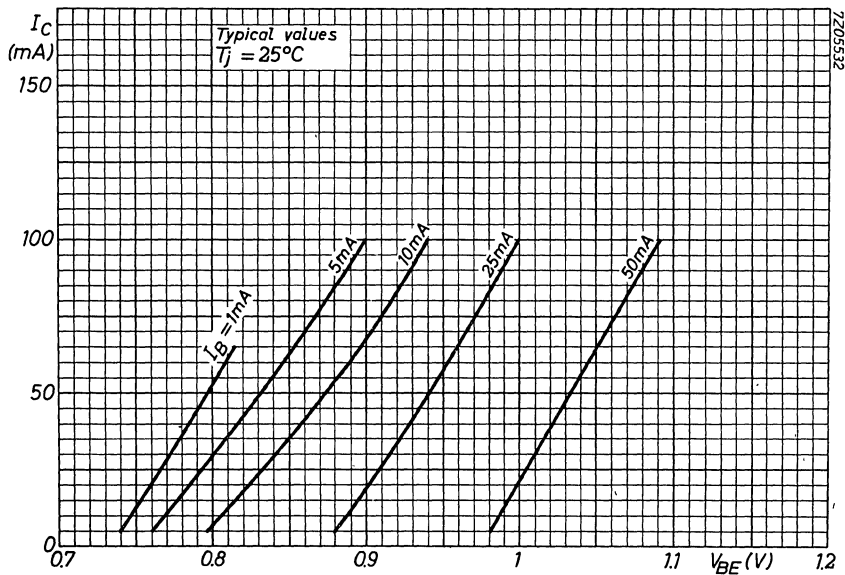
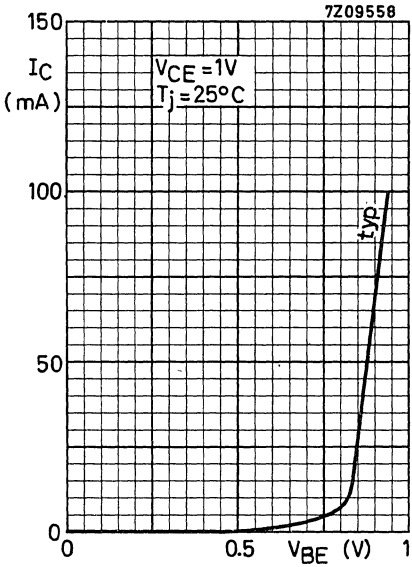
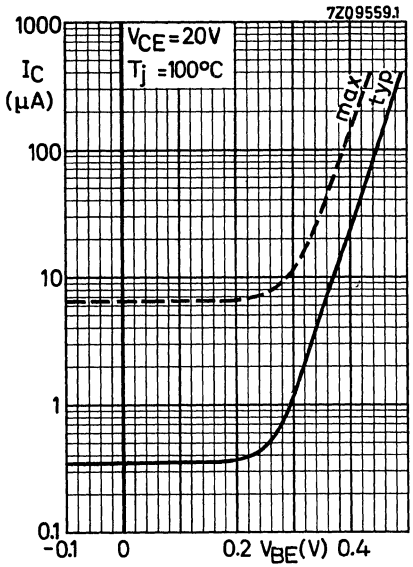


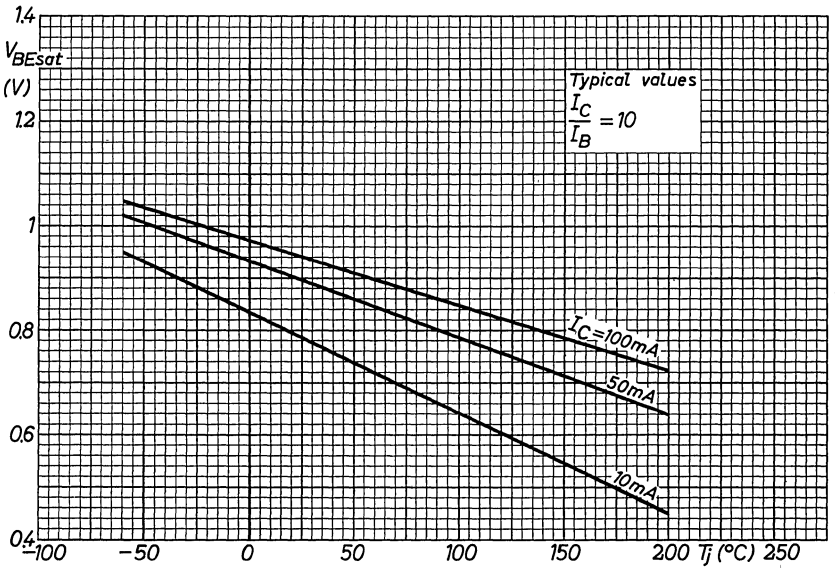
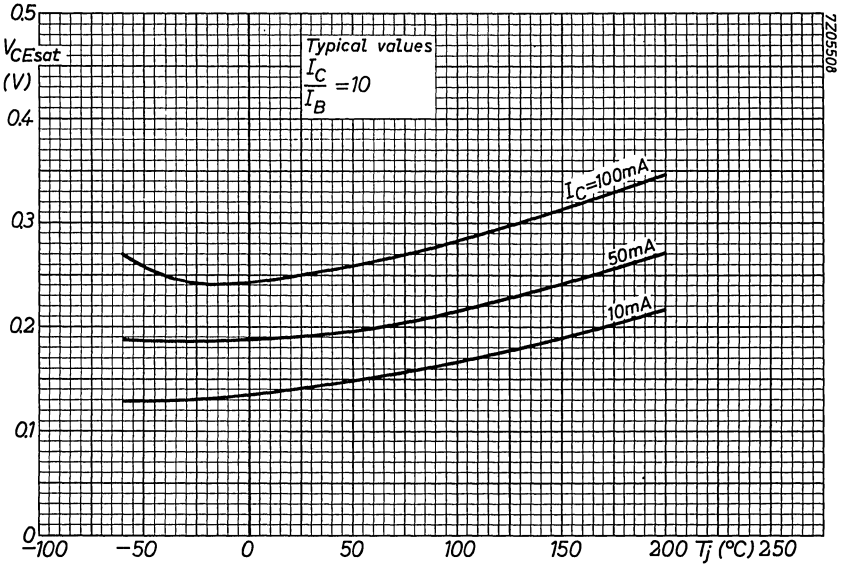
BSX 19  
BSX 20



**BSX 19**  
**BSX 20**

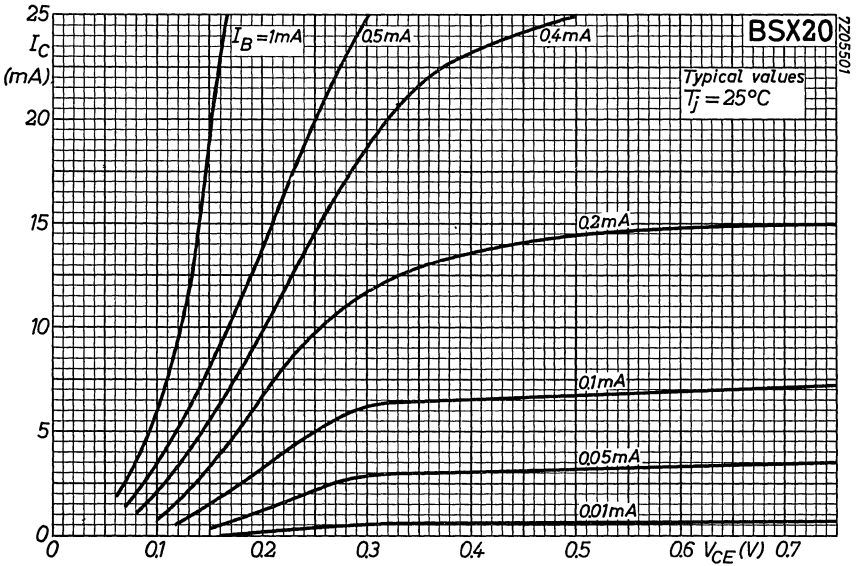
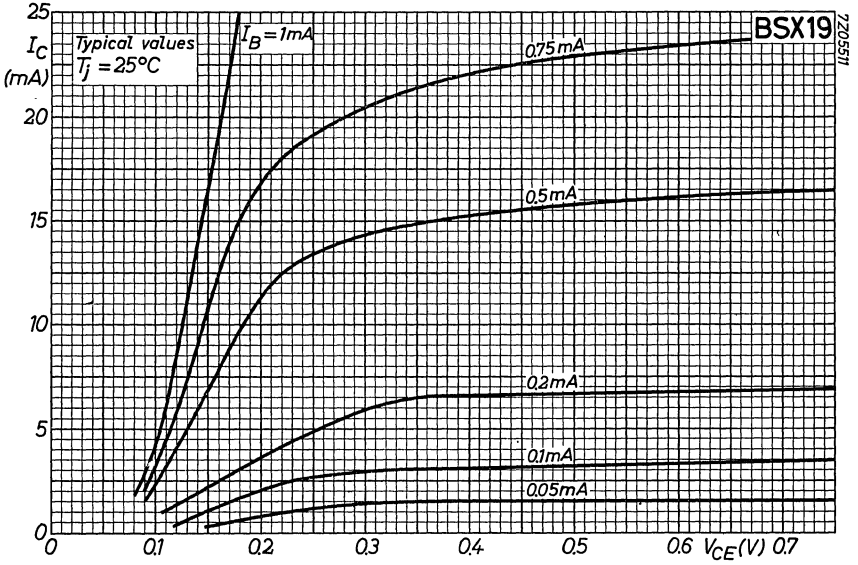
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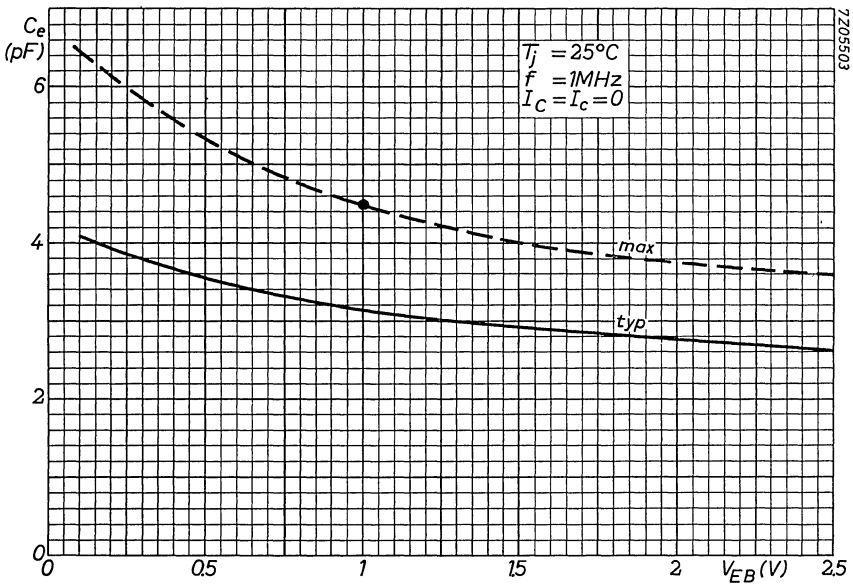
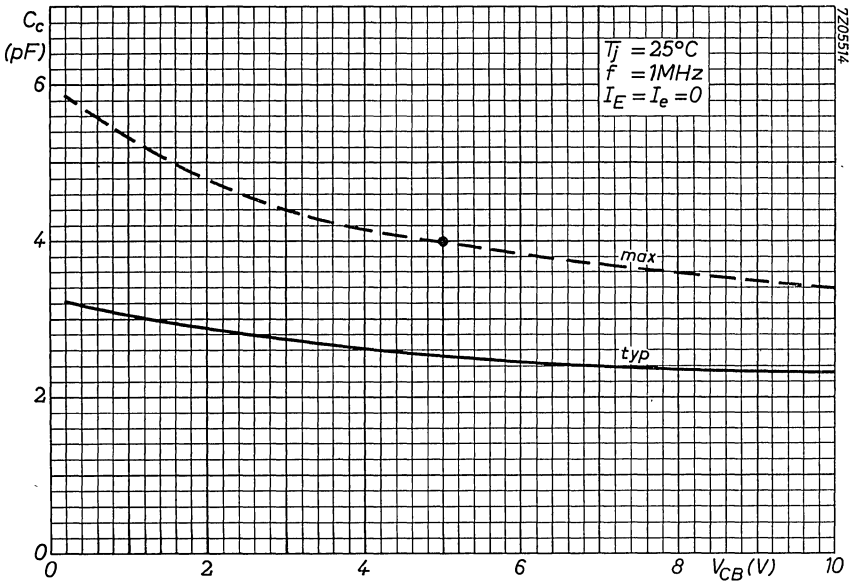




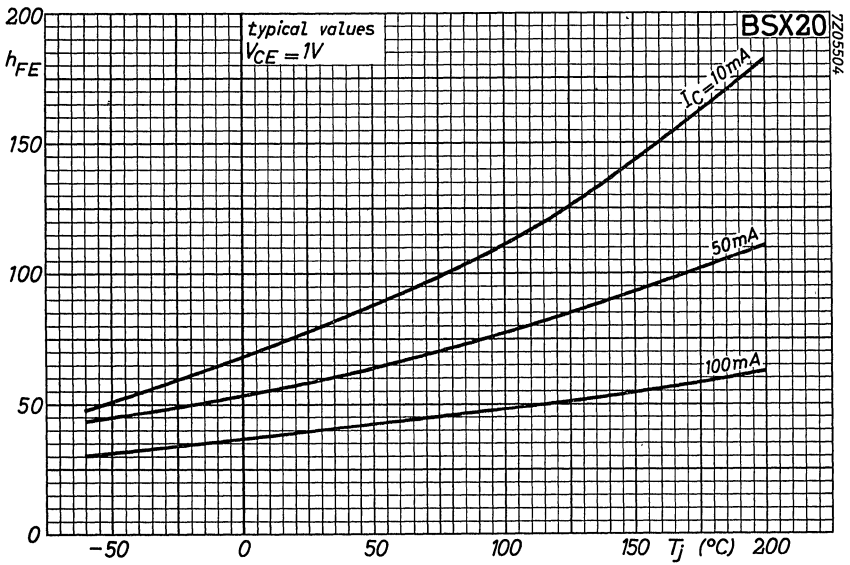
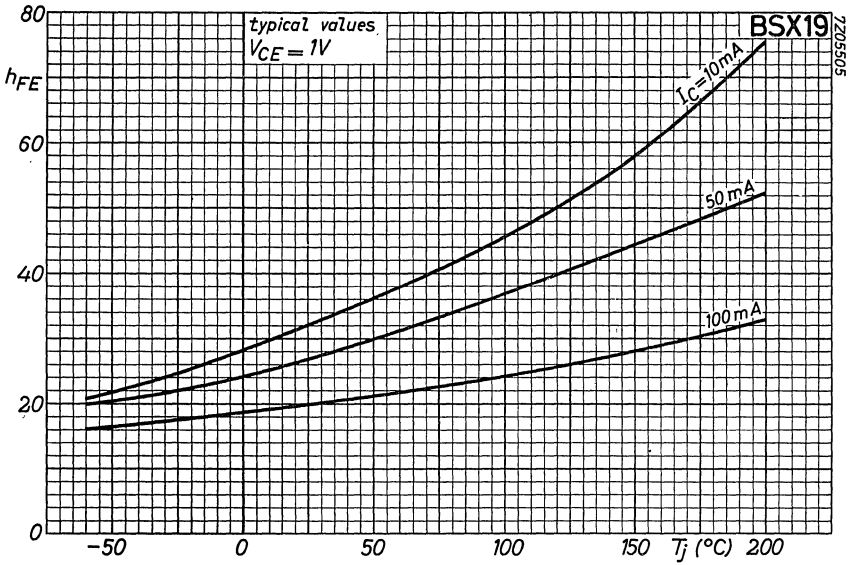


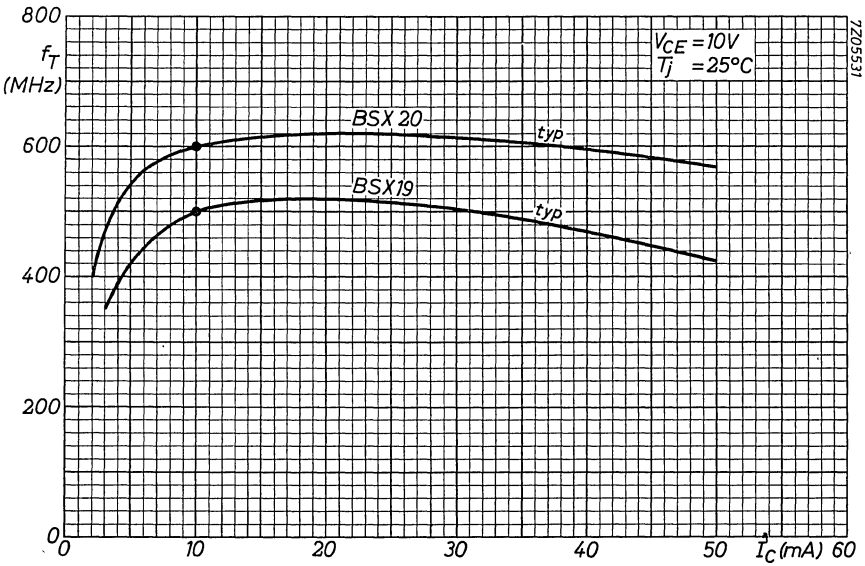
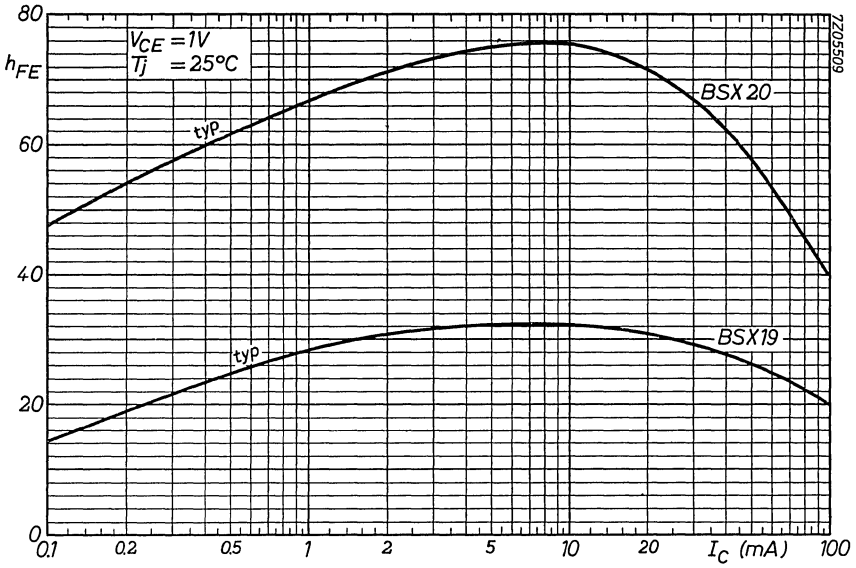
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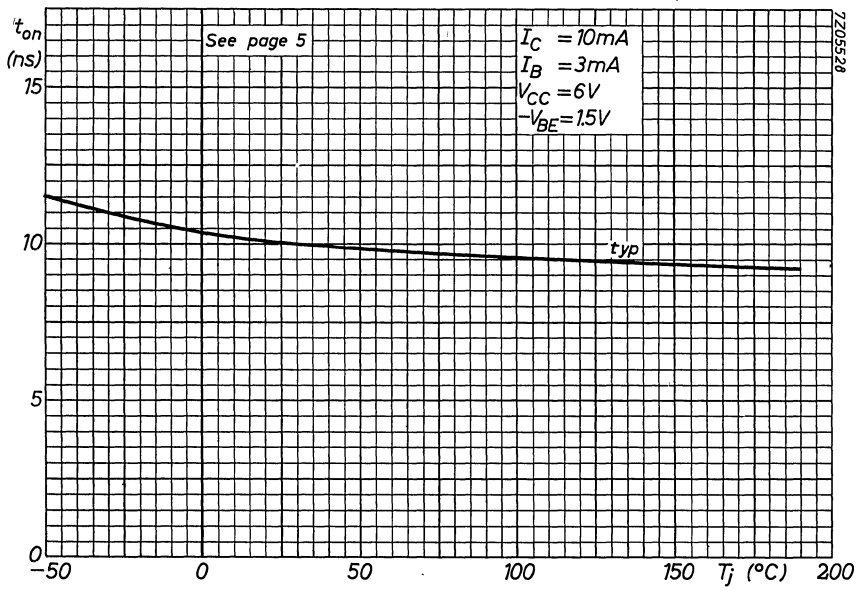
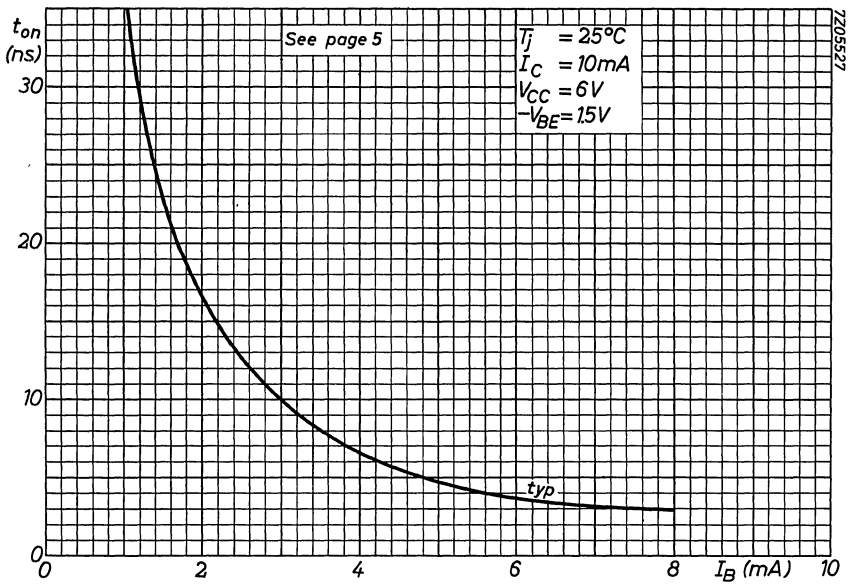


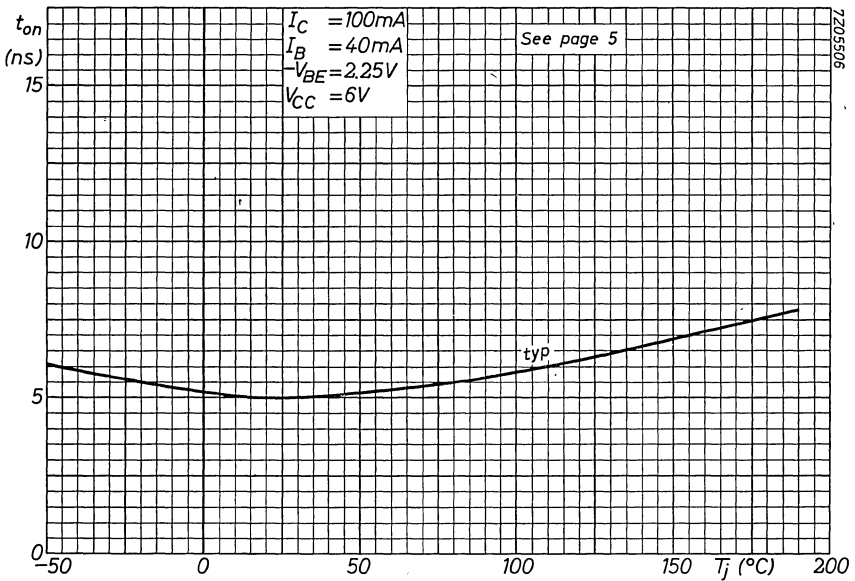
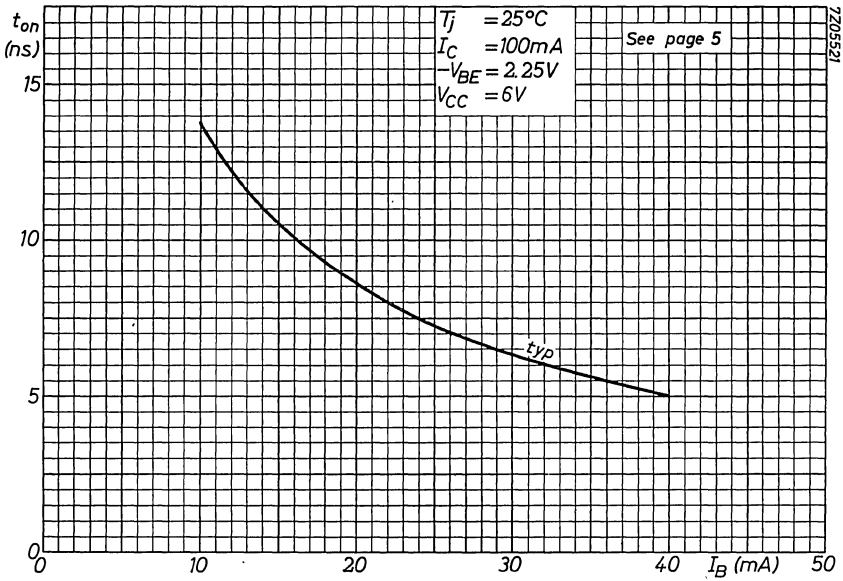


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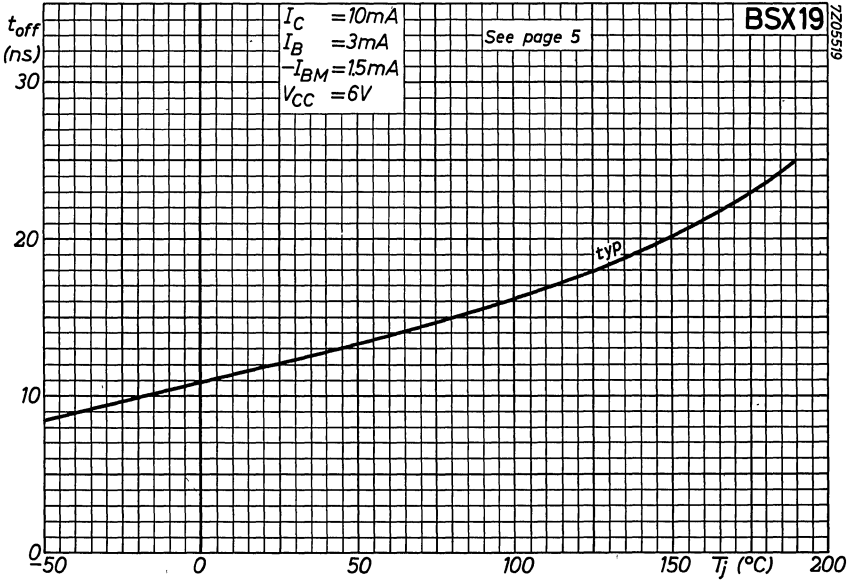
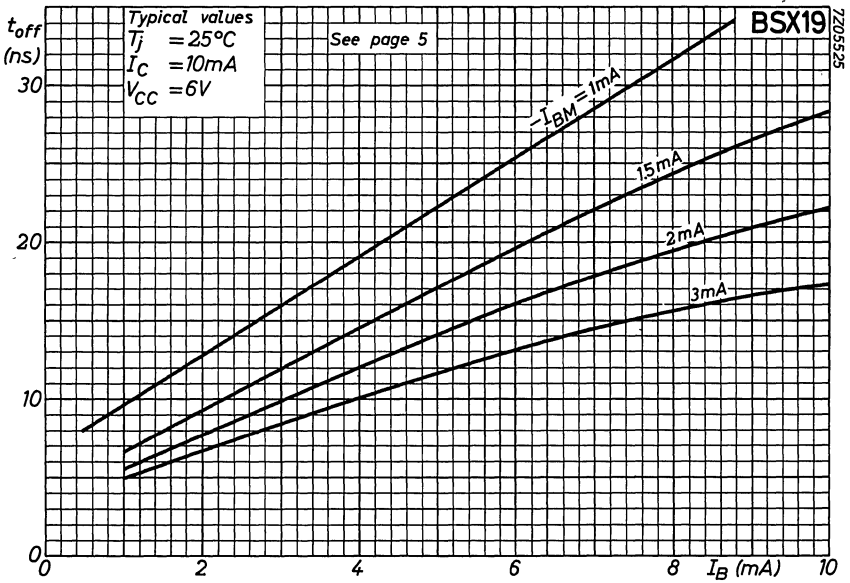


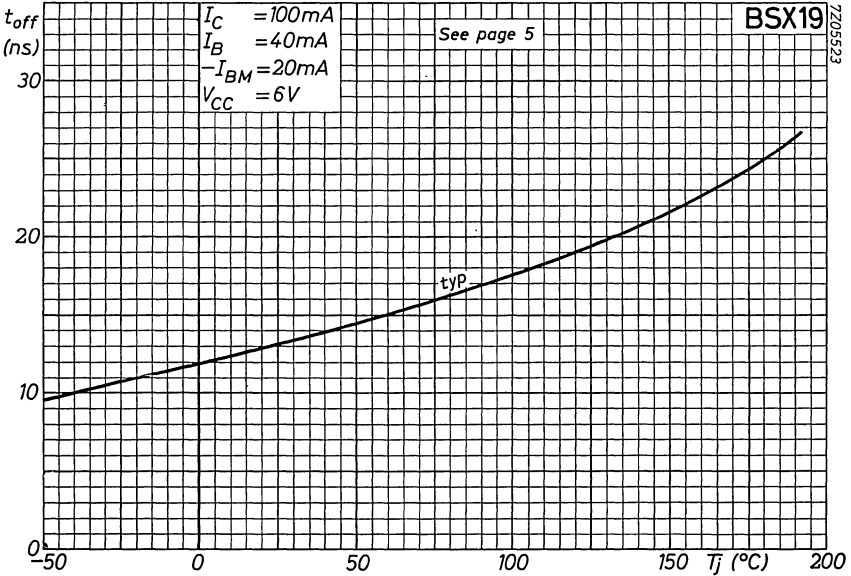
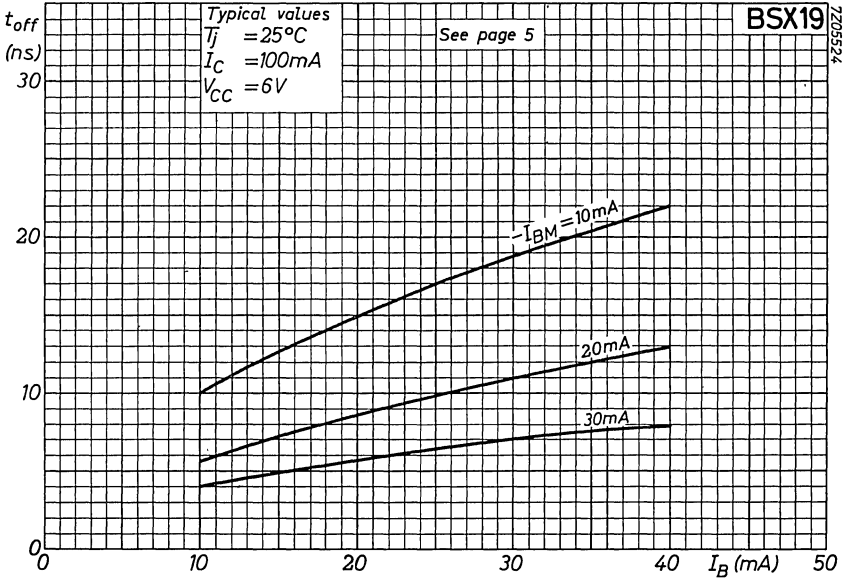






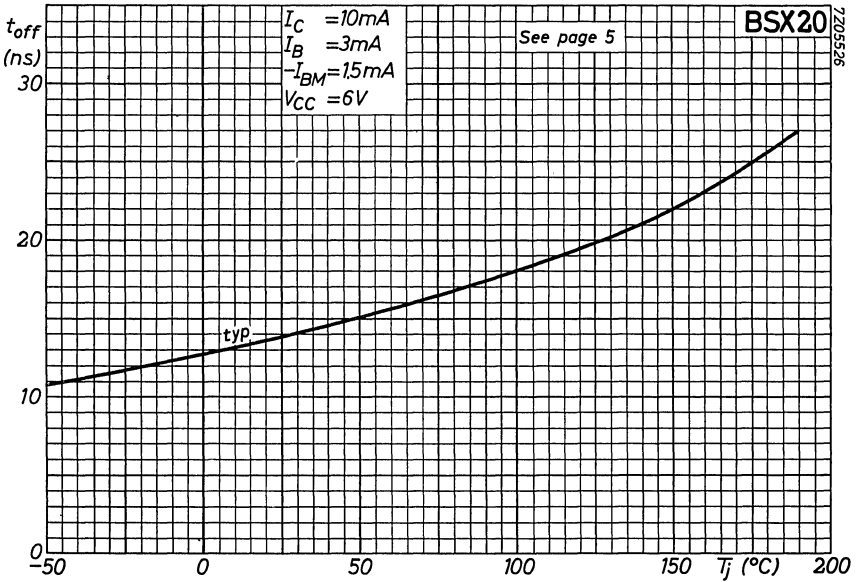
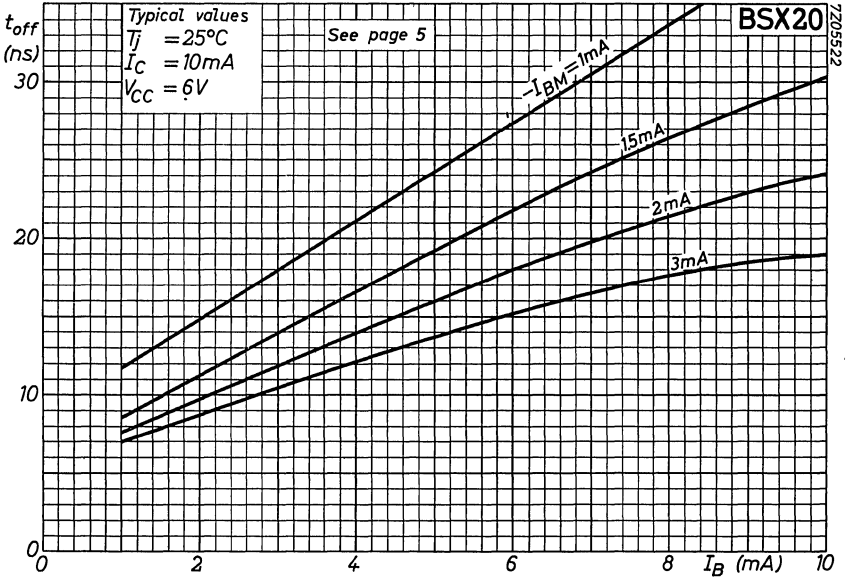
**BSX19  
BSX20**

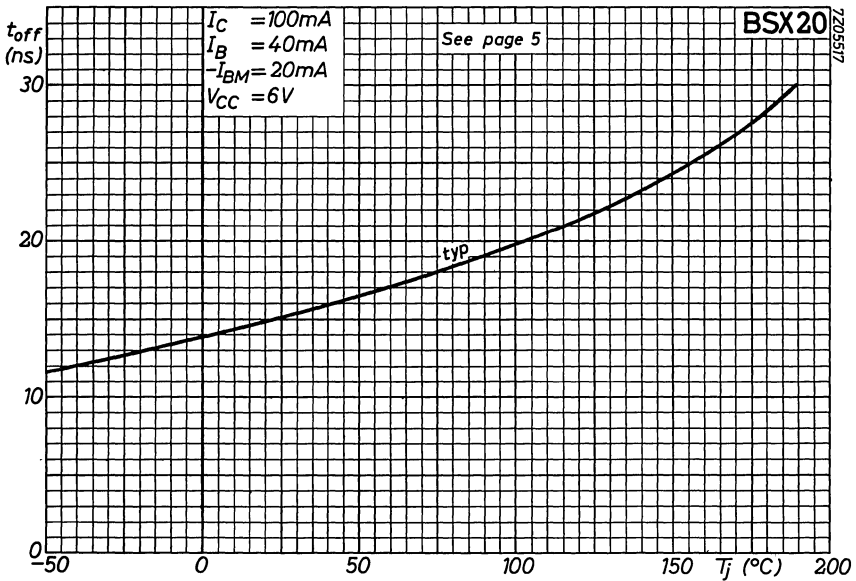
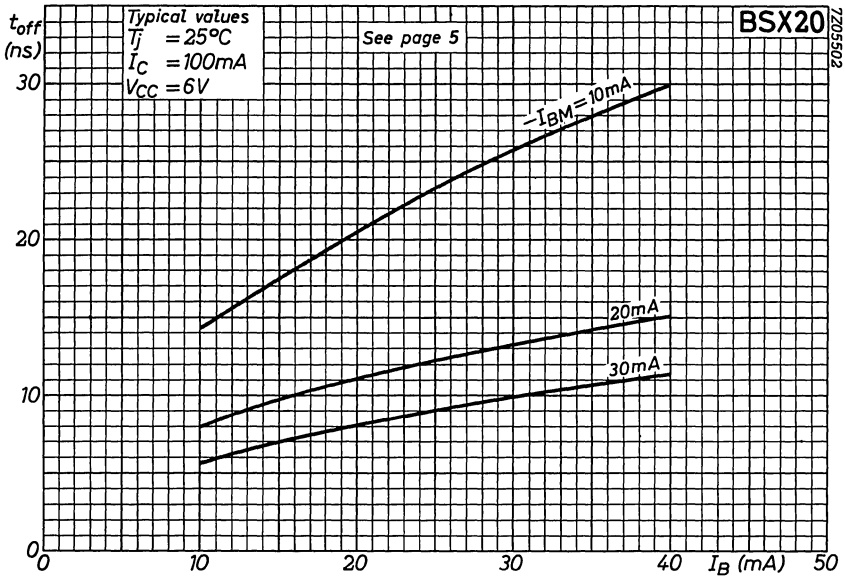




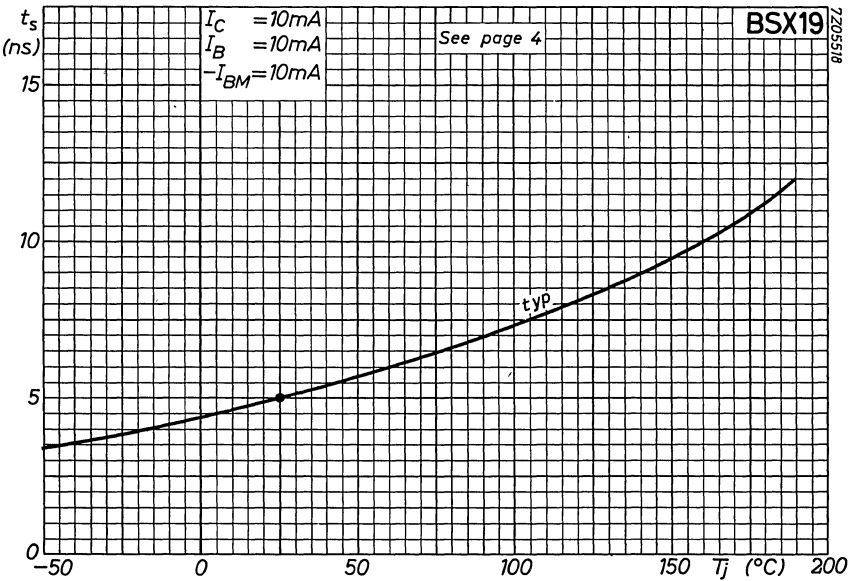
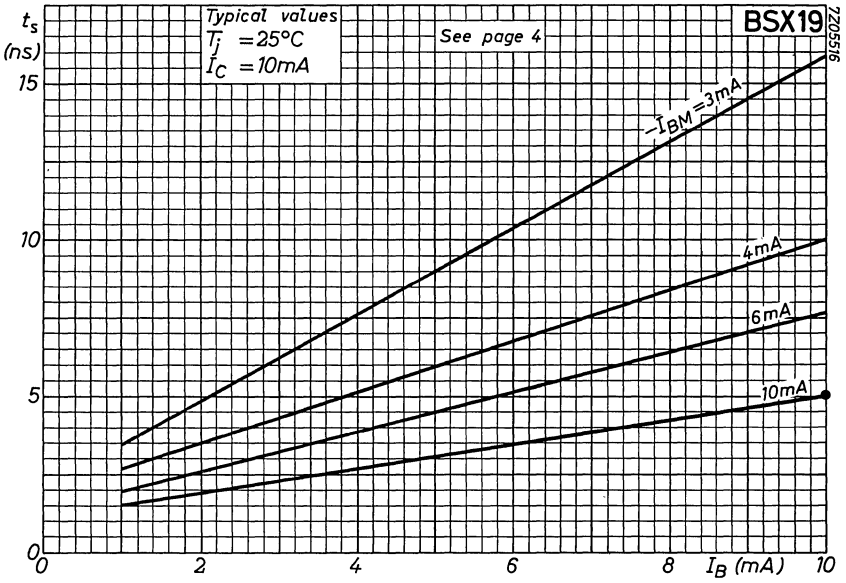


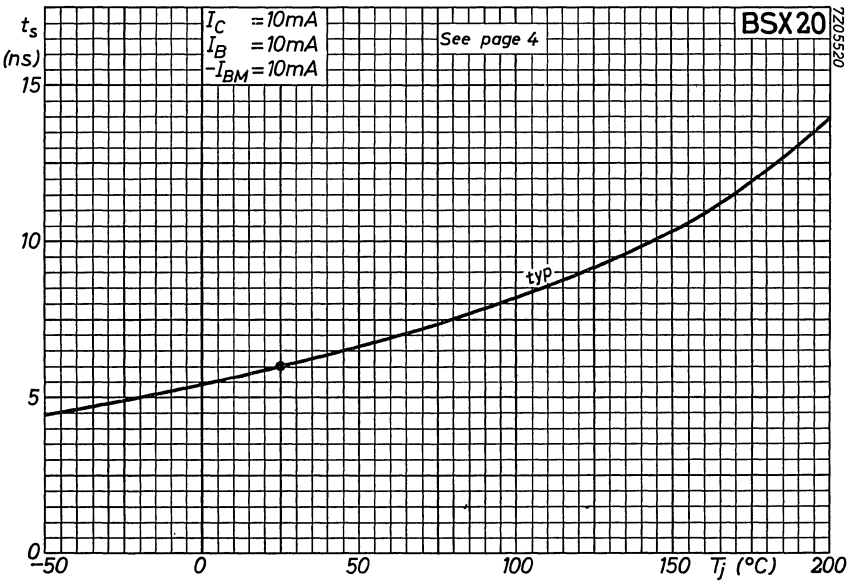
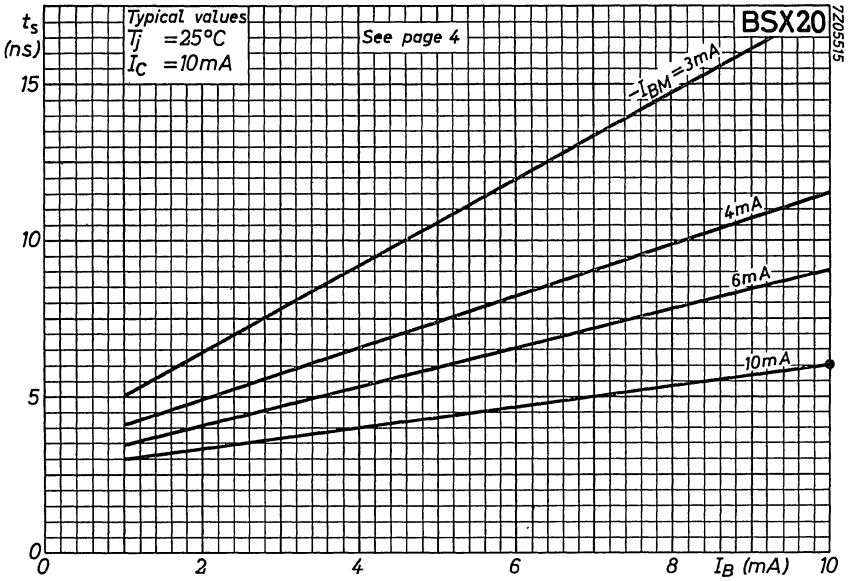
**BSX 19**  
**BSX 20**





**BSX 19**  
**BSX 20**







## SILICON PLANAR EPITAXIAL TRANSISTORS



N-P-N transistors in TO-39 metal envelopes with the collector connected to the case. These transistors are intended for general industrial applications.

## QUICK REFERENCE DATA

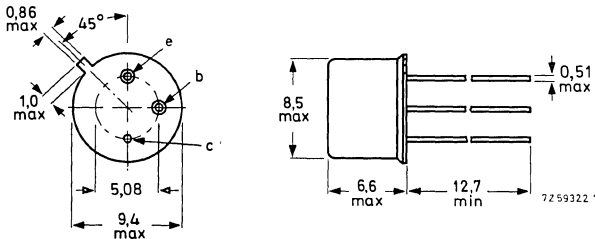
		BSX45	BSX46	BSX47	
Collector-emitter voltage (open base)	$V_{CE0}$ max.	40	60	80	V
Collector current (d.c.)	$I_C$ max.	1			A
Total power dissipation up to $T_{case} = 25\text{ }^\circ\text{C}$	$P_{tot}$ max.	6,25			W
Junction temperature	$T_j$ max.	200			$^\circ\text{C}$
Transition frequency at $f = 20\text{ MHz}$ $I_C = 50\text{ mA}$ ; $V_{CE} = 10\text{ V}$	$f_T$ >	50			MHz
		BSX45-6	BSX45-10	BSX45-16	
		BSX46-6	BSX46-10	BSX46-16	
		BSX47-6	BSX47-10		
D.C. current gain $I_C = 100\text{ mA}$ ; $V_{CE} = 1\text{ V}$	$h_{FE}$ >	40	63	100	
	$h_{FE}$ <	100	160	250	

## MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case.



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).

**RATINGS**

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

		BSX45	BSX46	BSX47	
Collector-emitter voltage (open base)	$V_{CEO}$	max. 40	60	80	V
Collector-emitter voltage ( $V_{BE} = 0$ )	$V_{CES}$	max. 80	100	120	V
Emitter-base voltage (open collector)	$V_{EBO}$	max. 7	7	7	V
Collector current (d.c.)	$I_C$	max.	1		A
Base current (d.c.)	$I_B$	max.	200		mA
Total power dissipation up to $T_{case} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	6,25		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 ambient in free air	$R_{th\ j-a}$	=	200	K/W
From junction to case	$R_{th\ j-c}$	=	28	K/W

## CHARACTERISTICS

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

		BSX45	BSX46	BSX47
Collector cut-off currents				
$V_{BE} = 0; V_{CE} = 60\text{ V}$	$I_{CES}$	typ. 1 < 30	1 30	– nA – nA
$V_{BE} = 0; V_{CE} = 60\text{ V}; T_{amb} = 150\text{ }^{\circ}\text{C}$	$I_{CES}$	typ. 1 < 10	1 10	– $\mu\text{A}$ – $\mu\text{A}$
$V_{BE} = 0; V_{CE} = 80\text{ V}$	$I_{CES}$	< –	–	30 nA
$V_{BE} = 0; V_{CE} = 80\text{ V}; T_{amb} = 150\text{ }^{\circ}\text{C}$	$I_{CES}$	< –	–	10 $\mu\text{A}$
$V_{BE} = 0,2\text{ V}; V_{CE} = 60\text{ V}; T_{amb} = 100\text{ }^{\circ}\text{C}$	$I_{CEX}$	< 50	50	– $\mu\text{A}$
$V_{BE} = 0,2\text{ V}; V_{CE} = 80\text{ V}; T_{amb} = 100\text{ }^{\circ}\text{C}$	$I_{CEX}$	< –	–	50 $\mu\text{A}$
Emitter cut-off current				
$I_C = 0; V_{EB} = 5\text{ V}$	$I_{EBO}$	< 10	10	10 nA
Collector-emitter breakdown voltage open base; $I_C = 50\text{ mA}$	$V_{(BR)CEO}$	> 40	60	80 V
$V_{BE} = 0; I_C = 100\text{ }\mu\text{A}$	$V_{(BR)CES}$	> 80	100	120 V
Emitter-base breakdown voltage open collector; $I_E = 100\text{ }\mu\text{A}$	$V_{(BR)EBO}$	> 7	7	7 V
Base-emitter voltage				
$I_C = 100\text{ mA}; V_{CE} = 1\text{ V}$	$V_{BE}$	< 1	1	1 V
$I_C = 500\text{ mA}; V_{CE} = 1\text{ V}$	$V_{BE}$	> 0,75 < 1,50	0,75 1,50	0,75 V 1,50 V
$I_C = 1\text{ A}; V_{CE} = 1\text{ V}$	$V_{BE}$	typ. 1,30 < 2,00	1,30 2,00	1,30 V 2,00 V
Saturation voltage				
$I_C = 1000\text{ mA}; I_B = 100\text{ mA}$	$V_{CEsat}$	typ. 0,7 < 1,0	0,7 1,0	– V – V
$I_C = 500\text{ mA}; I_B = 25\text{ mA}$	$V_{CEsat}$	typ. – < –	– –	0,5 V 0,9 V
Transition frequency at $f = 20\text{ MHz}$				
$I_C = 50\text{ mA}; V_{CE} = 10\text{ V}$	$f_T$	> 50	50	50 MHz
Collector capacitance at $f = 1\text{ MHz}$				
$I_E = I_e = 0; V_{CB} = 10\text{ V}$	$C_c$	< 25	20	15 pF
Emitter capacitance at $f = 1\text{ MHz}$				
$I_C = I_c = 0; V_{EB} = 0,5\text{ V}$	$C_e$	< 80	80	80 pF
Noise figure at $f = 1\text{ kHz}$				
$I_C = 100\text{ }\mu\text{A}; V_{CE} = 10\text{ V}$ $R_S = 1\text{ k}\Omega; B = 200\text{ Hz}$	F	typ. 3,5	3,5	3,5 dB



D.C. current gain

$I_C = 100 \mu A; V_{CE} = 1 V$

$I_C = 100 mA; V_{CE} = 1 V$

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

$I_C = 1 A; V_{CE} = 1 V$

Switching times (see Fig. 2)

$I_{Con} = 100 mA; I_{Bon} = -I_{Boff} = 5 mA$

Turn-on time

Turn-off time

	BSX45-6 BSX46-6 BSX47-6	BSX45-10 BSX46-10 BSX47-10	BSX45-16 BSX46-16
$h_{FE} >$	10	15	25
typ.	28	40	90
$h_{FE} >$	40	63	100
typ.	63	100	160
$h_{FE} <$	100	160	250
$h_{FE} >$	15	25	35
typ.	25	40	60
$h_{FE} >$	15	20	30
typ.			
$t_{on} <$		200	ns
$t_{off} <$		850	ns

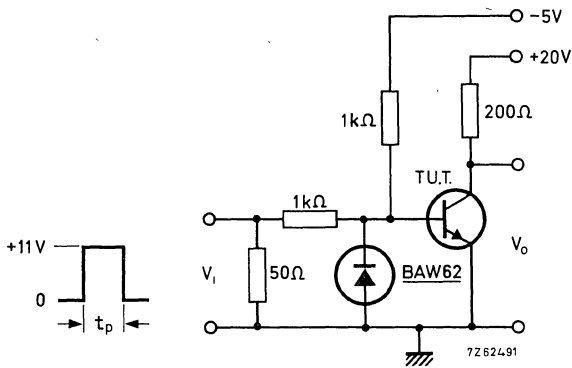


Fig. 2 Switching times test circuit.

Pulse generator:

Pulse duration

Rise time

Fall time

Source impedance

$t_p = 10 \mu s$

$t_r \leq 15 ns$

$t_f \leq 15 ns$

$Z_S = 50 \Omega$

Oscilloscope:

Rise time

Input impedance

$t_r \leq 15 ns$

$Z_i \geq 100 k\Omega$

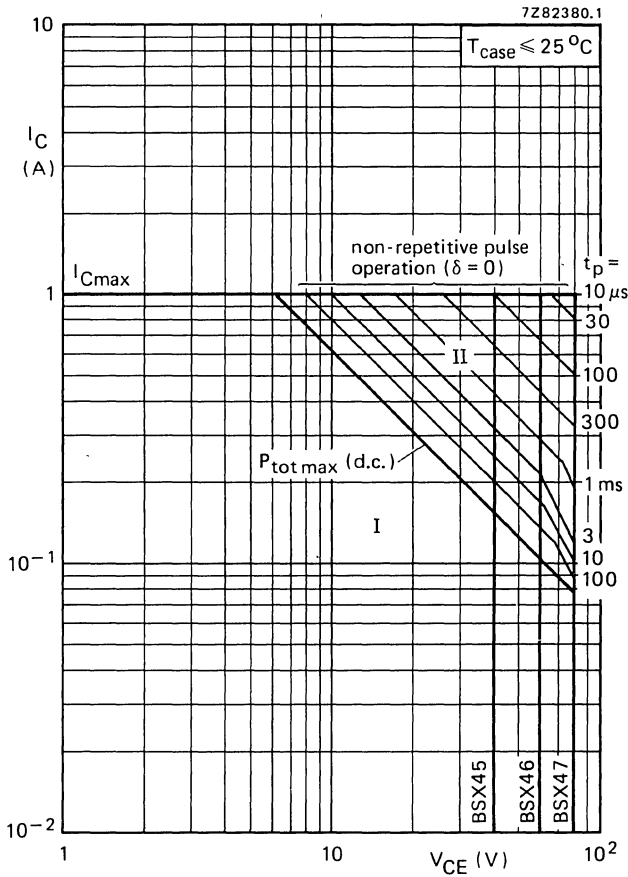


Fig. 3 Safe Operating Area;  $T_{case} \leq 25^\circ C^*$ .

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

\* At case temperatures  $> 25^\circ C$  derate constant power portion of boundaries such that:

$$P(t_p, \theta) = \frac{200 - T_{case}}{Z_{th}(t_p, \theta)}$$

(For very short forward mode pulse durations, i.e.  $t_p < 3 \mu s$ , assume  $3 \mu s$  values for  $Z_{th}$ .)

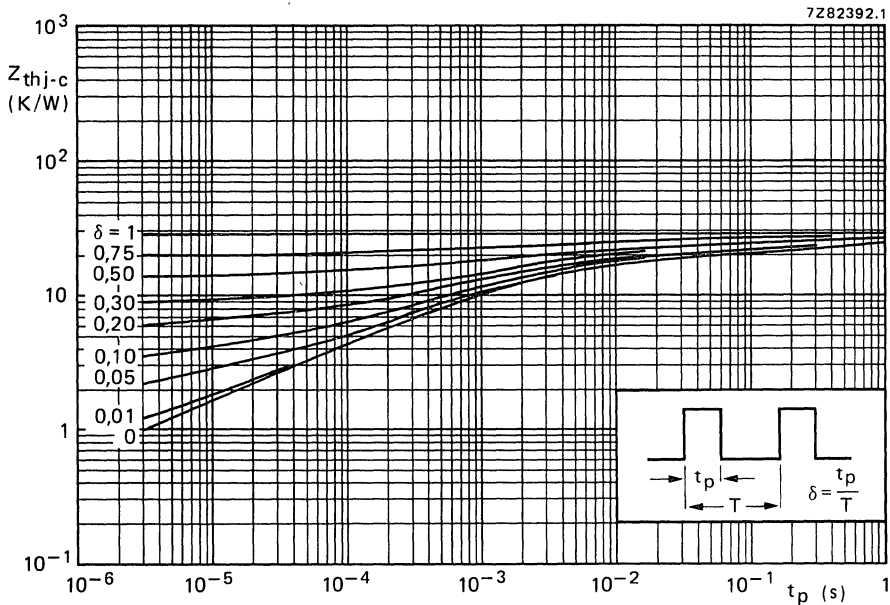


Fig. 4 Thermal impedance versus pulse duration. Stabilization time is 10 s.

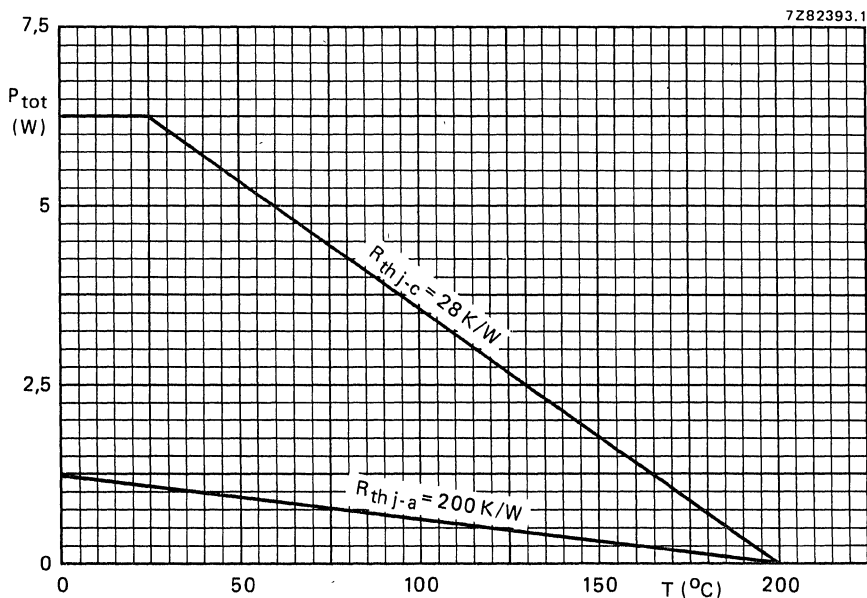


Fig. 5 Maximum permissible power dissipation as a function of temperature.

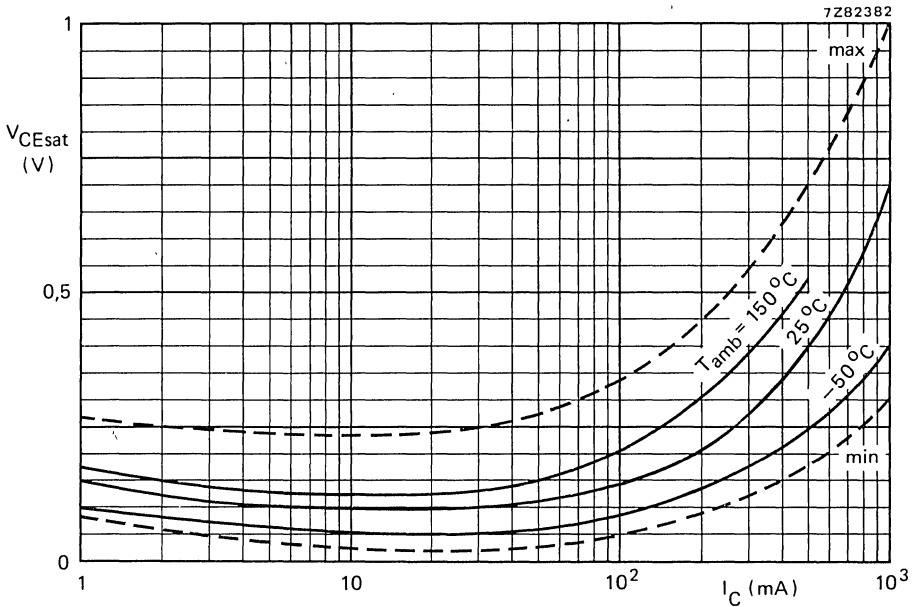


Fig. 6  $I_C/I_B = 10$ ; — typical values; - - - limit values at  $T_{amb} = 25^\circ\text{C}$ .

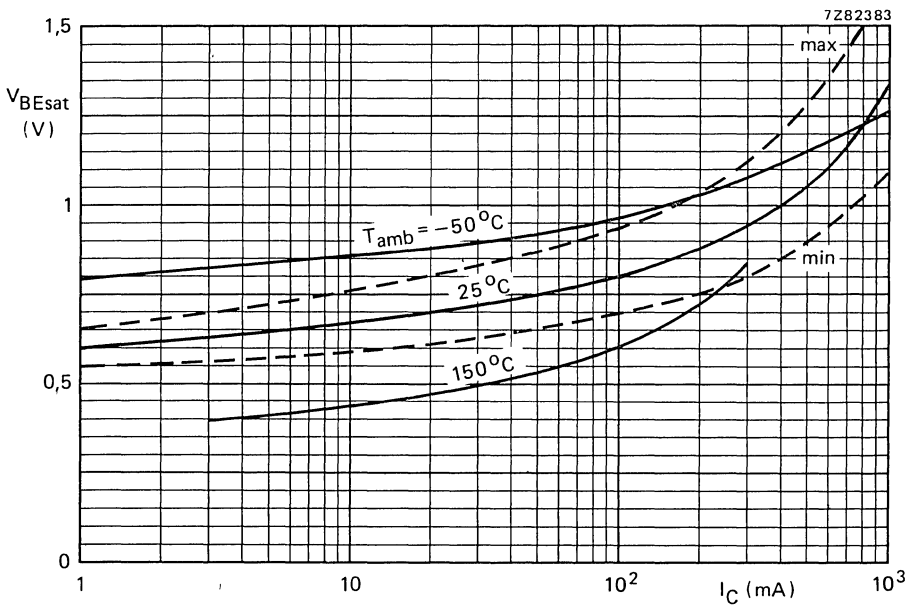


Fig. 7  $I_C/I_B = 10$ ; — typical values; - - - limit values at  $T_{amb} = 25^\circ\text{C}$ .

7Z82388.1

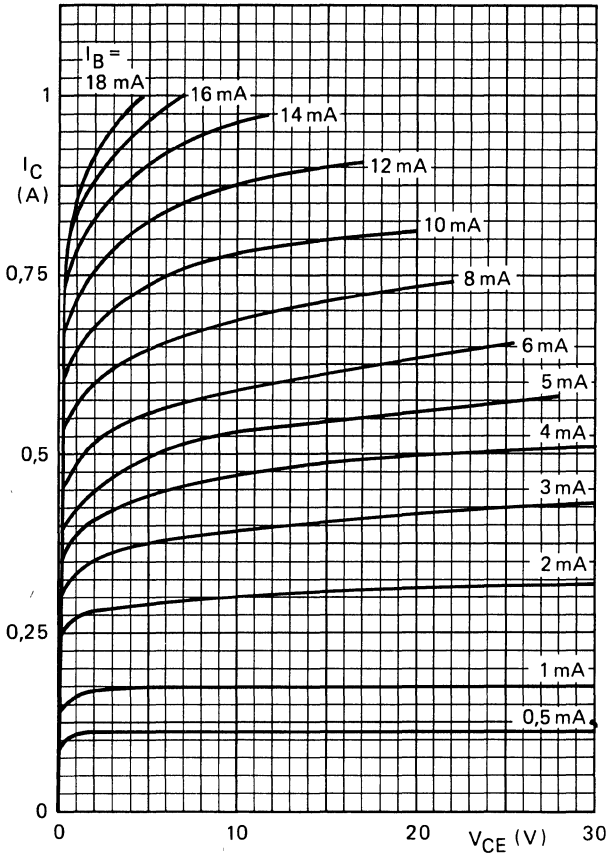


Fig. 8 Typical values;  $T_j = 25^\circ\text{C}$ .

7282389.1

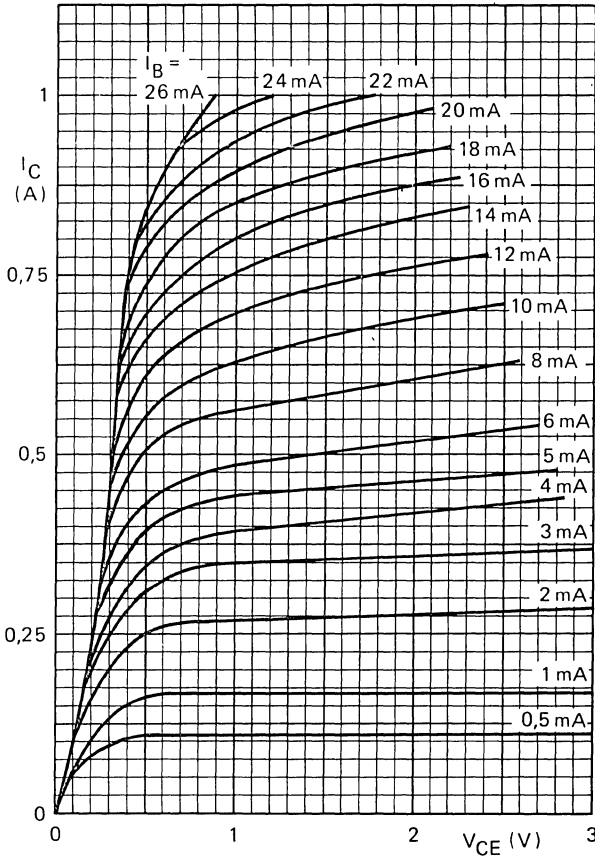


Fig. 9 Typical values;  $T_j = 25^\circ\text{C}$ .

7Z82396

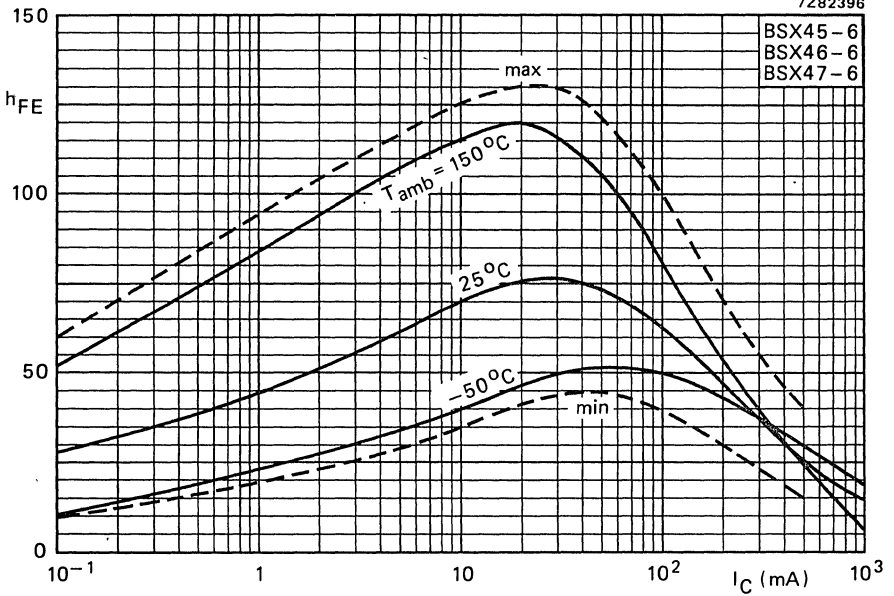


Fig. 10 V<sub>CE</sub> = 1 V; — typical values; - - - limit values at T<sub>amb</sub> = 25 °C.

7Z82397

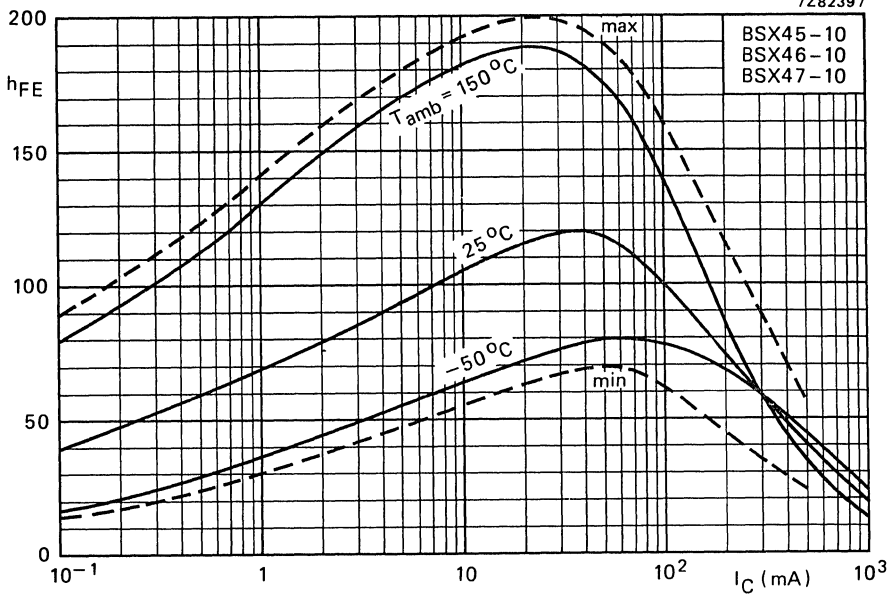


Fig. 11 V<sub>CE</sub> = 1 V; — typical values; - - - limit values at T<sub>amb</sub> = 25 °C.

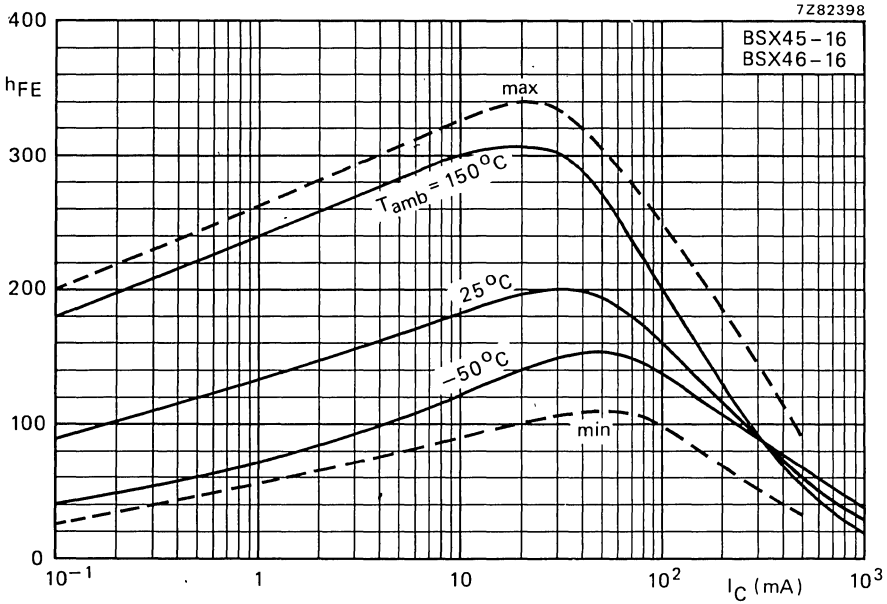


Fig. 12  $V_{CE} = 1\text{ V}$ ; — typical values; - - - limit values at  $T_{amb} = 25\text{ }^\circ\text{C}$ .

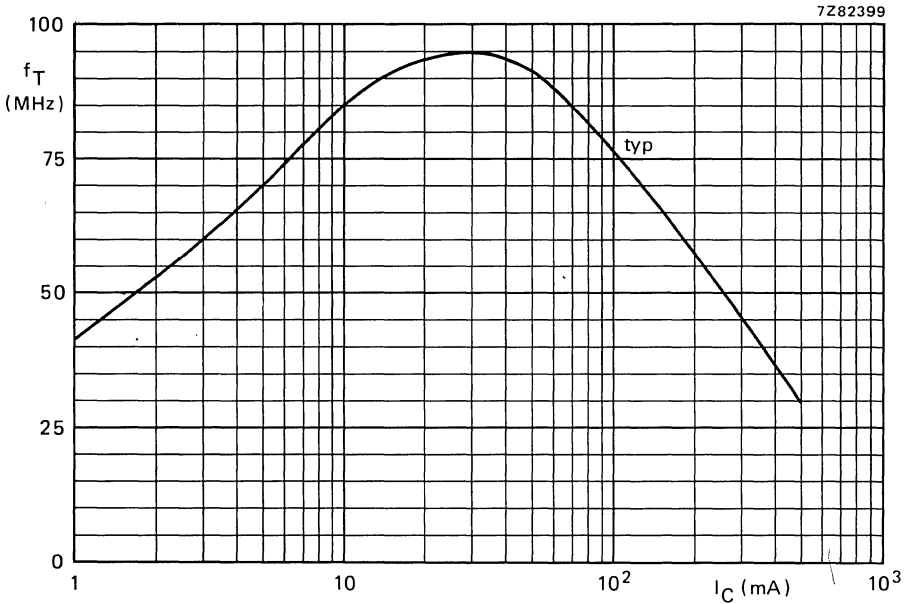


Fig. 13  $V_{CE} = 10\text{ V}$ ;  $f = 20\text{ MHz}$ ;  $T_j = 25\text{ }^\circ\text{C}$ .



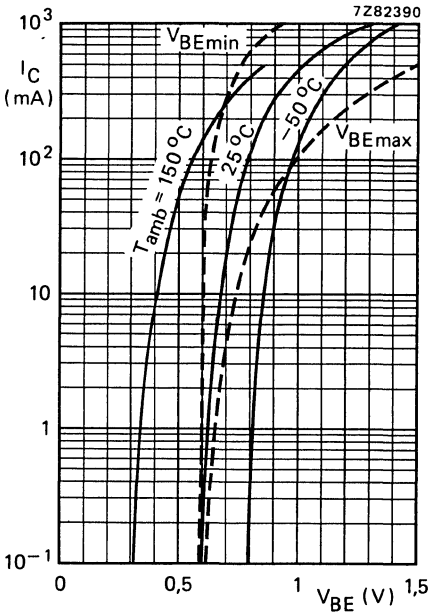


Fig. 14  $V_{CE} = 1\text{ V}$ ; — typical values; --- limit values at  $T_{amb} = 25^\circ\text{C}$ .

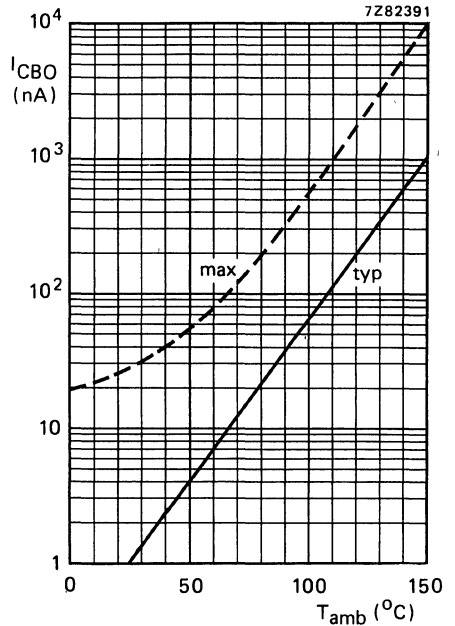


Fig. 15  $V_{CBO} = 60\text{ V}$  for **BSX45** and **BSX46**;  $V_{CBO} = 80\text{ V}$  for **BSX47**.

## SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in a TO-39 metal envelope with the collector connected to the case. The BSX59, BSX60 and BSX61 are primarily intended for very high speed core-driving purposes.

## QUICK REFERENCE DATA

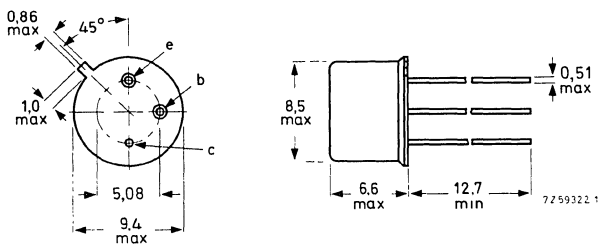
		BSX59	BSX60	BSX61	
Collector-base voltage (open emitter)	$V_{CBO}$	max. 70	70	70	V
Collector-emitter voltage (open base)	$V_{CEO}$	max. 45	30	45	V
Collector current (peak value)	$I_{CM}$	max. 1	1	1	A
Total power dissipation up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$	max. 0,8	0,8	0,8	W
Junction temperature	$T_j$	max. 200	200	200	$^{\circ}\text{C}$
D.C. current gain $I_C = 500\text{ mA}; V_{CE} = 1\text{ V}$	$h_{FE}$	> 30	30	30	
Saturation voltage $I_C = 500\text{ mA}; I_B = 50\text{ mA}$	$V_{CEsat}$	< 0,5	0,5	0,7	V
Transition frequency $I_C = 50\text{ mA}; V_{CE} = 10\text{ V}$	$f_T$	typ. 450	475	475	MHz
Turn-off time $I_{Con} = 500\text{ mA}; I_{Bon} = -I_{Boff} = 50\text{ mA}$	$t_{off}$	< 60	70	100	ns

## MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case.



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).

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

### Voltages

		BSX59	BSX60	BSX61	
Collector-base voltage (open emitter)	$V_{CBO}$	max. 70	70	70	V
Collector-emitter voltage (open base) $I_C = 10 \text{ mA}$	$V_{CEO}$	max. 45	30	45	V
Emitter-base voltage (open collector)	$V_{EBO}$	max. 5	5	5	V

### Currents

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

### Power dissipation

Total power dissipation up to $T_{amb} = 25 \text{ }^\circ\text{C}$	$P_{tot}$	max.	0.8	W
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### Temperatures

Storage temperature	$T_{stg}$	-65 to +200	$^\circ\text{C}$
Junction temperature	$T_j$	max. 200	$^\circ\text{C}$

### THERMAL RESISTANCE

From junction to ambient in free air	$R_{th j-a}$	=	220	$^\circ\text{C/W}$
From junction to case	$R_{th j-c}$	=	43	$^\circ\text{C/W}$
From junction to mounting base	$R_{th j-mb}$	=	35	$^\circ\text{C/W}$



**CHARACTERISTICS (continued)**

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

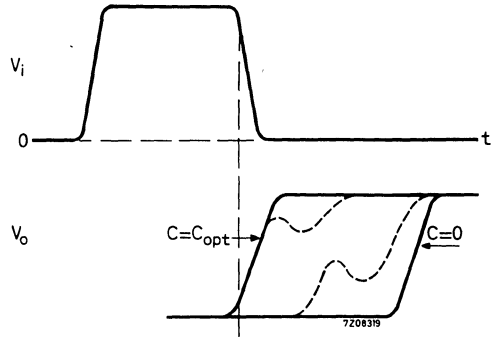
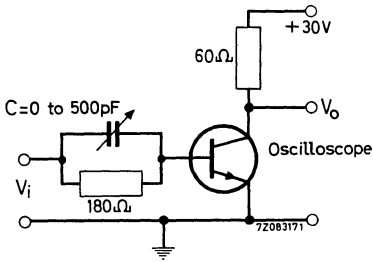
Recovered charge

$I_C = 500\text{ mA}; I_B = 50\text{ mA}$

BSX60

$Q_S < 5\text{ nC}$

Test circuit:



Adjust C from zero to  $C_{opt}$

$$Q_S = C_{opt} \cdot V_i$$

Pulse generator:

Pulse duration  $t_p = 10\text{ }\mu\text{s}$

Duty cycle  $\delta = 0.02$

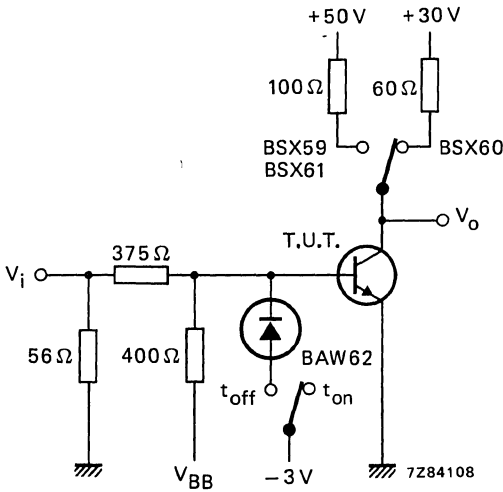
Switching times (see also Figs 4, 11 and 12)

Turn-on time when switched from  $-V_{BE} = 2\text{ V}$  to  $I_{Con} = 500\text{ mA}$ ;  $I_{Bon} = 50\text{ mA}$

		BSX59	BSX60	BSX61
$t_{on}$	typ.	17	17	18 ns
	<	35	40	50 ns

Turn-off time when switched from  $I_{Con} = 500\text{ mA}$ ;  $I_{Bon} = 50\text{ mA}$  to cut-off with  $-I_{Boff} = 50\text{ mA}^*$

$t_{off}$	typ.	45	58	70 ns
	<	60	70	100 ns



	$t_{on}$	$t_{off}$
$-V_{BB}$	4	16,7 V
$V_i$	24,75	37,5 V

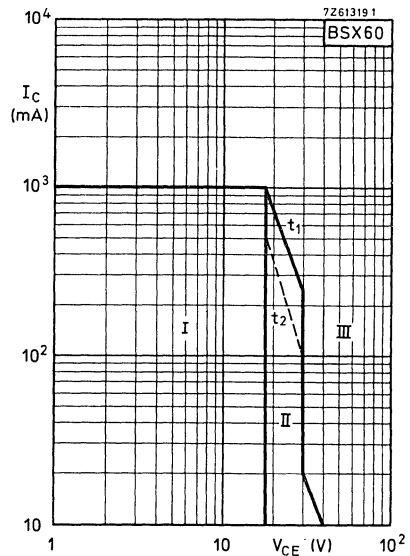
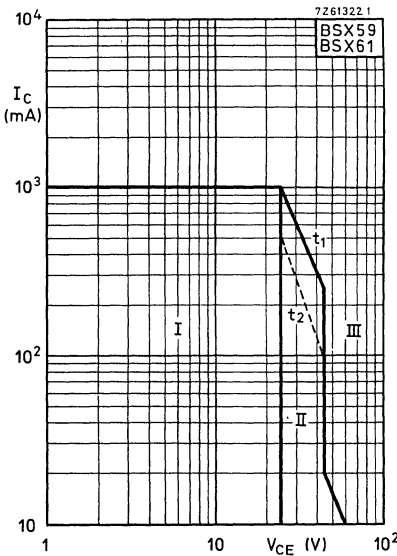
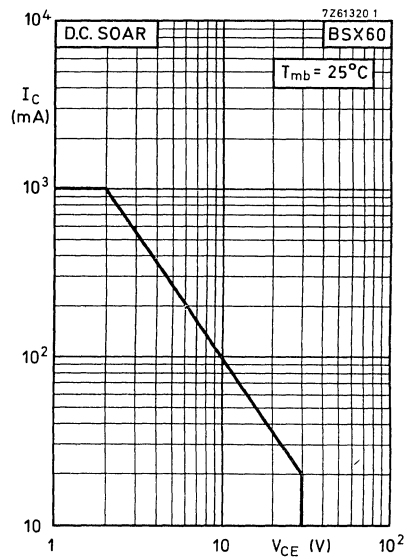
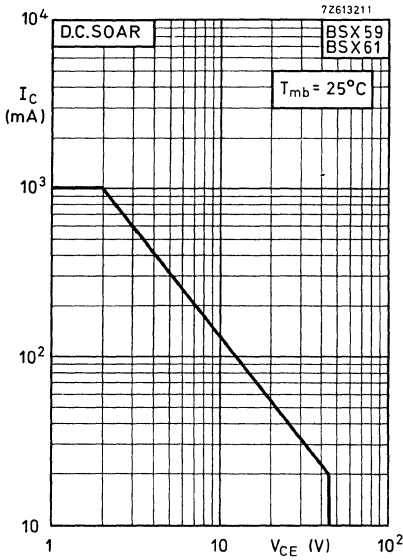
Fig. 4 Switching circuit.

Pulse generator:

Pulse duration	$t_p \geq 500\text{ ns}$
Rise time	$t_r \leq 5\text{ ns}$
Fall time	$t_f \leq 5\text{ ns}$
Output resistance	$R_o = 50\ \Omega$ (during pulse, otherwise infinite)

\*  $-I_{Boff}$  is the reverse current that can flow during switching off. The indicated  $-I_{Boff}$  is determined and limited by the applied cut-off voltage and the series resistance.

# BSX59 to 61



- I Region of permissible operation during switching off with  $-V_{BB} = 4 \text{ V}$ ;  $R_{BE} = 39 \Omega$
- II Permissible extension for repetitive pulsed operation.
  - $t_1$  limits operations with  $t_p \leq 0.1 \mu\text{s}$ ;  $\delta = 0.25$
  - $t_2$  limits operations with  $t_p \leq 1 \mu\text{s}$ ;  $\delta = 0.25$
- III Operation in this area is not allowed.

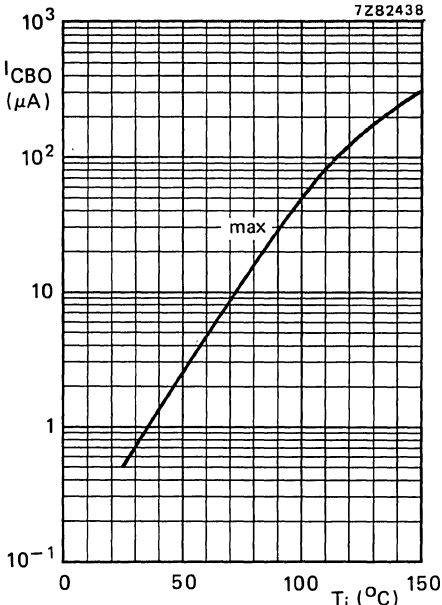


Fig. 9  $V_{CB} = 40 V$ .

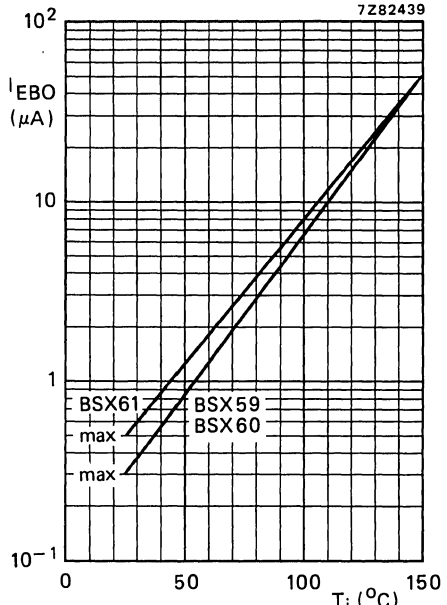


Fig. 10  $V_{EB} = 4 V$ .

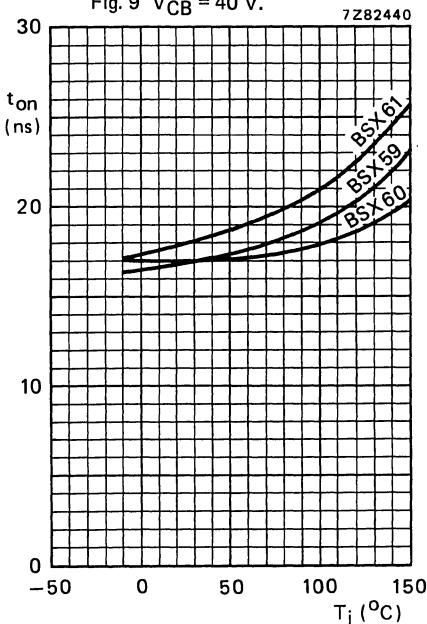


Fig. 11  $-V_{BEoff} = 2 V$ ;  $I_{Con} = 500 mA$ ;  $I_{Bon} = 50 mA$ ; typ. values. (See also Fig. 4.)

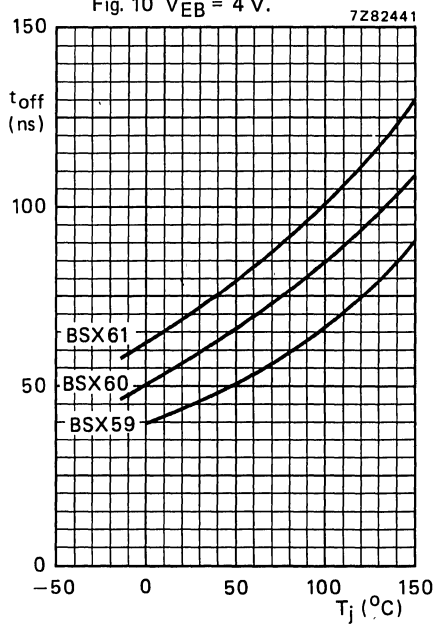


Fig. 12  $I_{Con} = 500 mA$ ;  $I_{Bon} = -I_{Boff} = 50 mA$ ; typical values. (See also Fig. 4.)



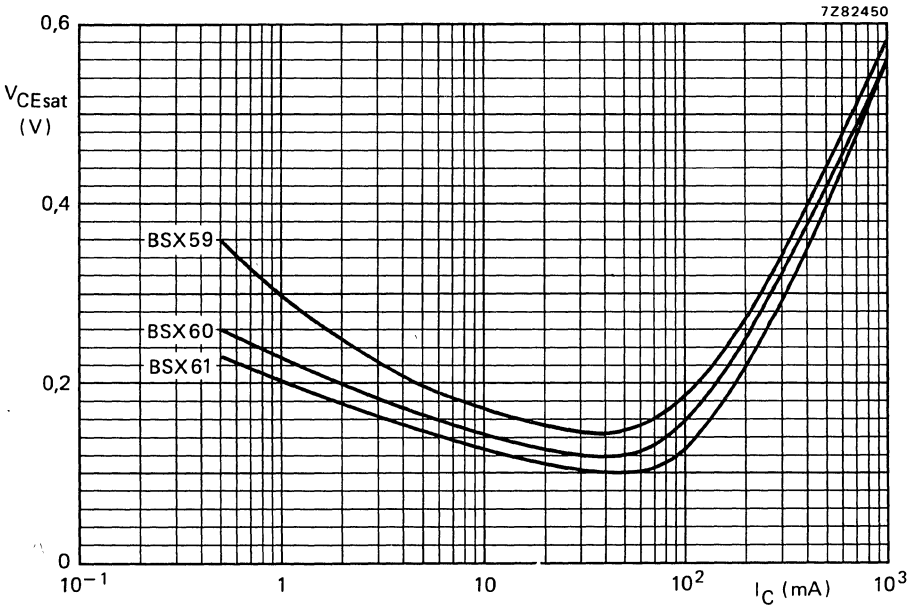


Fig. 13  $I_C/I_B = 10$ ;  $T_j = 25^\circ\text{C}$ ; typical values.

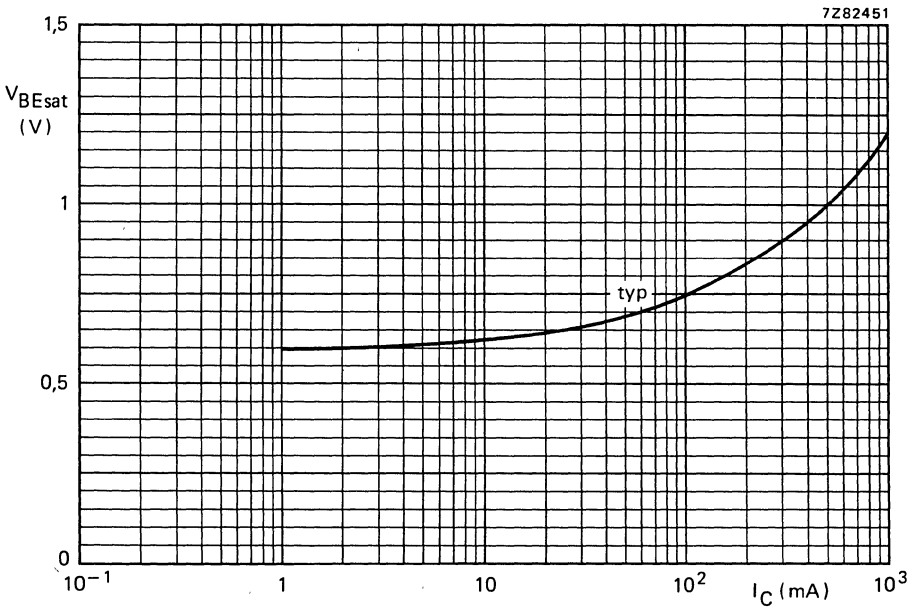


Fig. 14  $I_C/I_B = 10$ ;  $T_j = 25^\circ\text{C}$ .

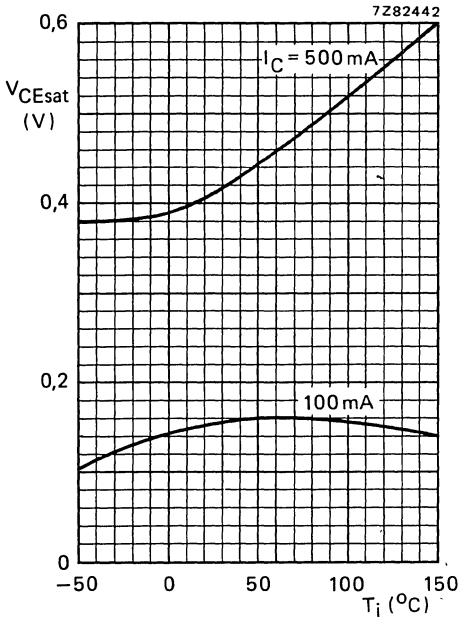


Fig. 15  $I_C/I_B = 10$ ; typical values.

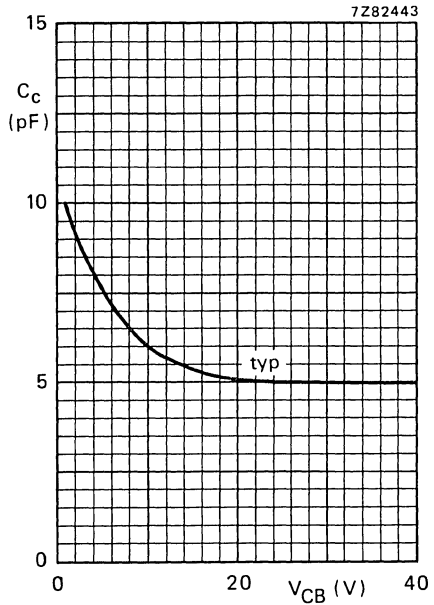


Fig. 16  $I_E = I_e = 0$ ;  $f = 1\text{ MHz}$ ;  $T_j = 25^\circ\text{C}$ .

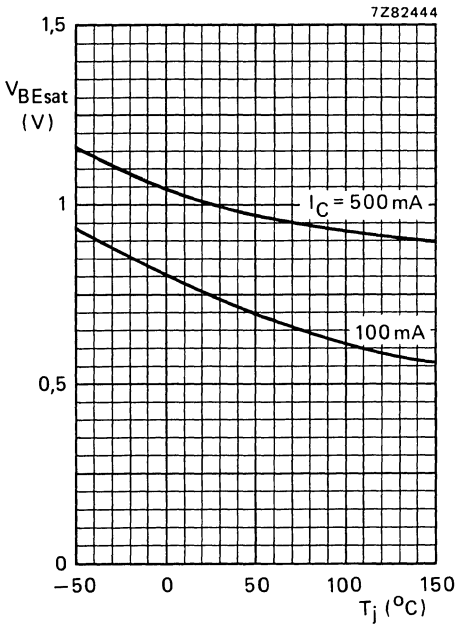


Fig. 17  $I_C/I_B = 10$ ; typical values.

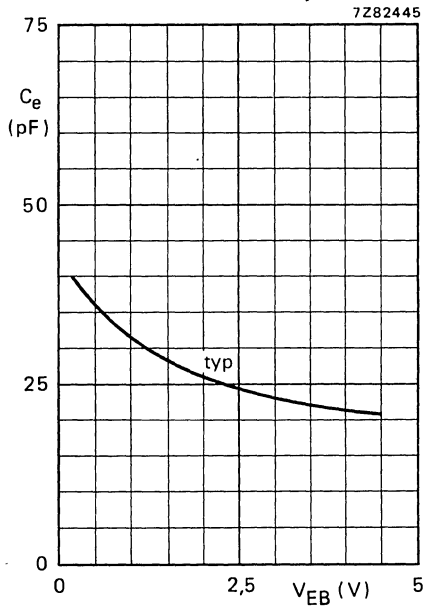


Fig. 18  $I_C = I_c = 0$ ;  $f = 1\text{ MHz}$ ;  $T_j = 25^\circ\text{C}$ .

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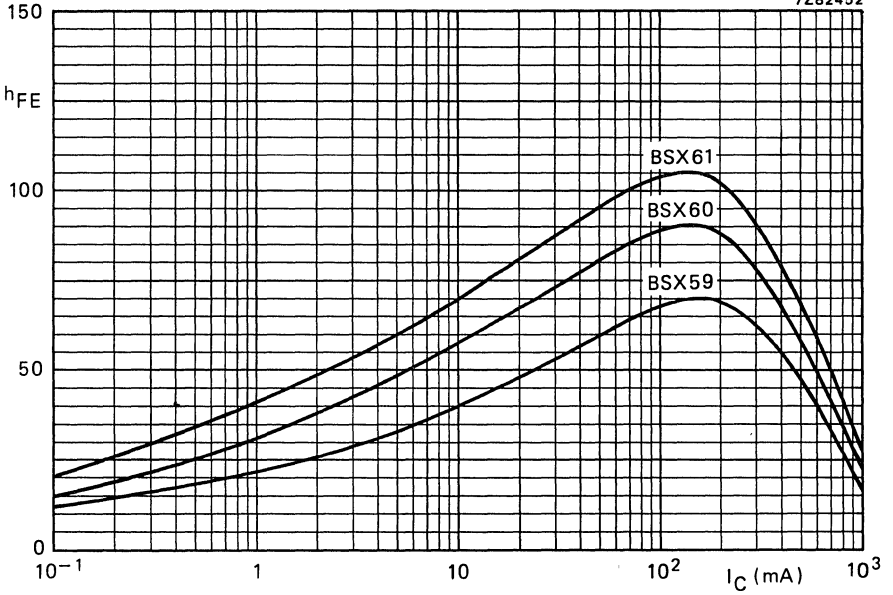


Fig. 19  $V_{CE} = 1$  V;  $T_j = 25$  °C; typical values.

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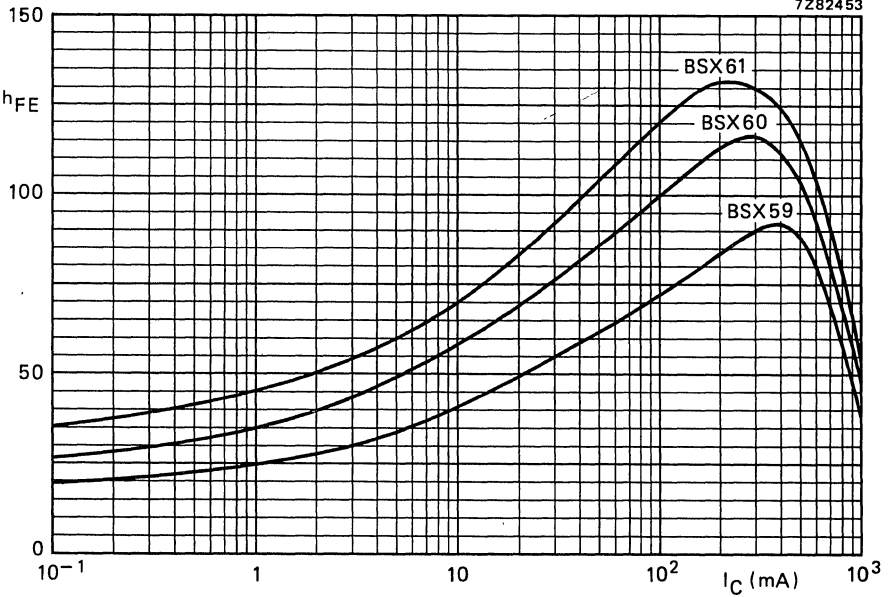


Fig. 20  $V_{CE} = 5$  V;  $T_j = 25$  °C; typical values.

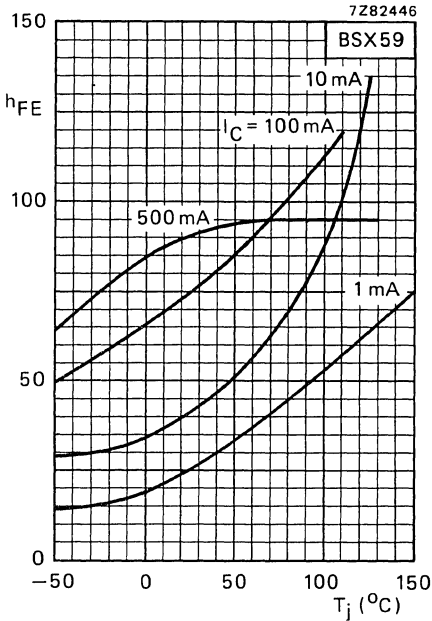


Fig. 21  $V_{CE} = 5 \text{ V}$ ; typical values.

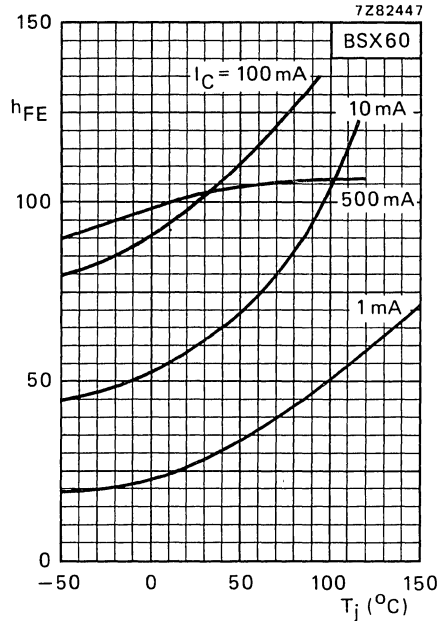


Fig. 22  $V_{CE} = 5 \text{ V}$ ; typical values.

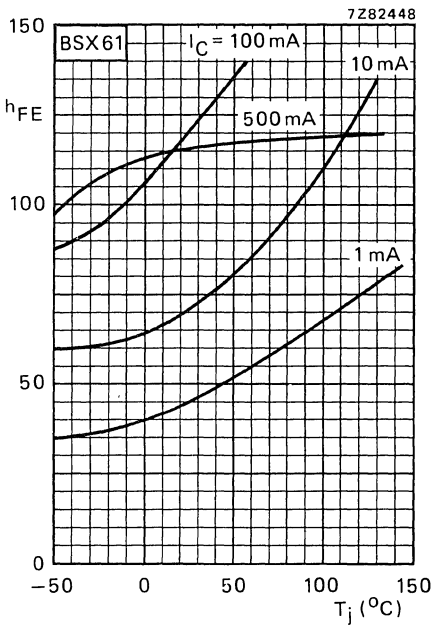


Fig. 23  $V_{CE} = 5 \text{ V}$ ; typical values.

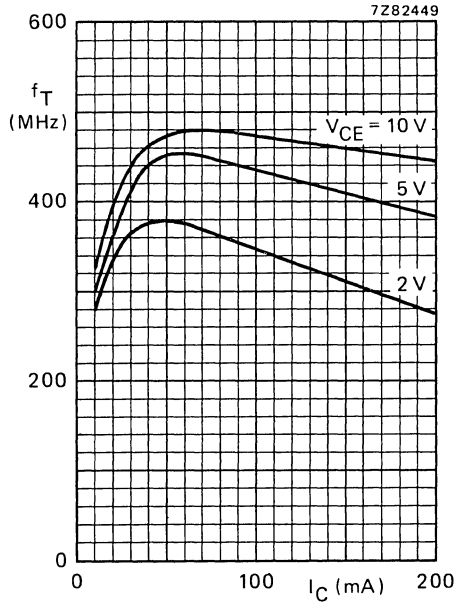


Fig. 24  $f = 100 \text{ MHz}$ ;  $T_j = 25 \text{ }^{\circ}\text{C}$ ; typ. values.



## SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a TO-18 metal envelope intended for general purpose low level switching applications.

### QUICK REFERENCE DATA

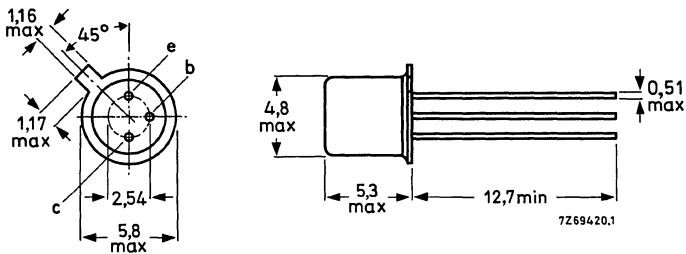
Collector-base voltage (open emitter)	$V_{CBO}$	max.	20 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	15 V
Collector current (peak value)	$I_{CM}$	max.	200 mA
Total power dissipation up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	300 mW
D.C. current gain	$h_{FE}$		50 to 200
$I_C = 10\text{ mA}; V_{CE} = 0,35\text{ V}$			
Transition frequency at $f = 100\text{ MHz}$	$f_T$	>	200 MHz
$I_C = 10\text{ mA}; V_{CE} = 9,0\text{ V}$			
Storage time	$t_s$	<	50 ns

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector connected to case



Accessories: 56246 (distance disc).

## RATINGS

Limiting values of operation according to the absolute maximum system.

### Electrical

$V_{CBO}$ max.	20	V
$V_{CEO}$ max.	15	V
$V_{EBO}$ max.	5.0	V
* $I_{C(AV)}$ max.	100	mA
$I_{CM}$ max.	200	mA
$P_{tot}$ max. ( $T_{amb} \leq 25^{\circ}C$ )	300	mW

\*Averaged over any 20ms period.

### Temperature

$T_{stg}$ min.	-65	$^{\circ}C$
$T_{stg}$ max.	175	$^{\circ}C$
$T_j$ max. (operating)	175	$^{\circ}C$

### THERMAL CHARACTERISTIC

$R_{th(j-amb)}$	0.5	degC/mW
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### ELECTRICAL CHARACTERISTICS ( $T_{amb} = 25^{\circ}C$ unless otherwise stated)

		Min.	Max.	
$I_{CBO}$	Collector cut-off current $V_{CB} = 16V, I_E = 0$	-	50	nA
$V_{BR(CBO)}$	Collector-base breakdown voltage $I_C = 1.0\mu A$	20	-	V
$I_{EBO}$	Emitter cut-off current $V_{EB} = 1.5V, I_C = 0$	-	25	nA
$V_{(BR)EBO}$	Emitter-base breakdown voltage $I_E = 10\mu A$	5.0	-	V
$I_{CEO}$	Collector-emitter cut-off current $V_{CE} = 12V, I_B = 0$	-	250	nA
$V_{(BR)CEO}$	Collector-emitter breakdown voltage $I_C = 10mA^{**}$	15	-	V
$f_T$	Transition frequency $I_C = 10mA, V_{CE} = 9.0V,$ $f = 100MHz$	200	-	MHz

\*\*Pulsed: Pulse width = 300 $\mu s$ , duty cycle < 2%.

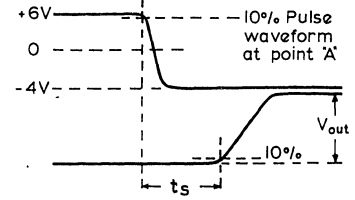
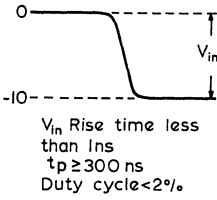
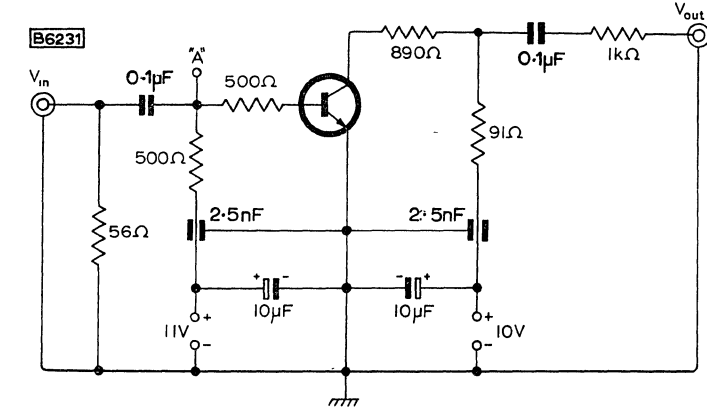
		Min.	Max.	
$h_{FE}$	Common emitter forward current transfer ratio			
	$I_C = 1.0\text{mA}$ , $V_{CE} = 0.35\text{V}$	30	-	
	$I_C = 10\text{mA}$ , $V_{CE} = 0.35\text{V}$	50	200	
$V_{CE(sat)}$	Collector-emitter saturation voltage			
	$I_C = 10\text{mA}$ , $I_B = 0.2\text{mA}$	-	0.35	V
$V_{BE(sat)}$	Base-emitter saturation voltage			
	$I_C = 10\text{mA}$ , $I_B = 0.2\text{mA}$	0.67	0.87	V
$C_{ob}$	Collector-base capacitance			
	$V_{CB} = 9.0\text{V}$ , $I_E = 0$			
	$f = 1.0\text{MHz}$	-	6.0	pF
$t_s$	Storage time			
	$I_C = 10\text{mA}$	-	50	ns
See test circuit on page 4				

## SOLDERING AND WIRING RECOMMENDATIONS

1. When using a soldering iron, transistors may be soldered directly into the circuit, but heat conducted to the junction should if possible be kept to a minimum by the use of a thermal shunt.
2. Transistors may be dip-soldered at a solder temperature of  $245^{\circ}\text{C}$  for a maximum soldering time of 5 seconds. The case temperature during soldering must not at any time exceed the maximum storage temperature. These recommendations apply to a transistor mounted flush on a board having punched-through holes, or spaced at least 1.5mm above a board having plated-through holes.
3. Care should be taken not to bend the leads nearer than 1.5mm from the seal.
4. If devices are stored at temperatures above  $100^{\circ}\text{C}$  before incorporation into equipment, some deterioration of the external surface is likely to occur which may make soldering into the circuit difficult. Under these circumstances the leads should be retinned using a suitable activated flux.



STORAGE TIME TEST CIRCUIT



Input and output waveforms

## SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in plastic TO-92 variant envelopes, primarily intended for switching and linear applications.

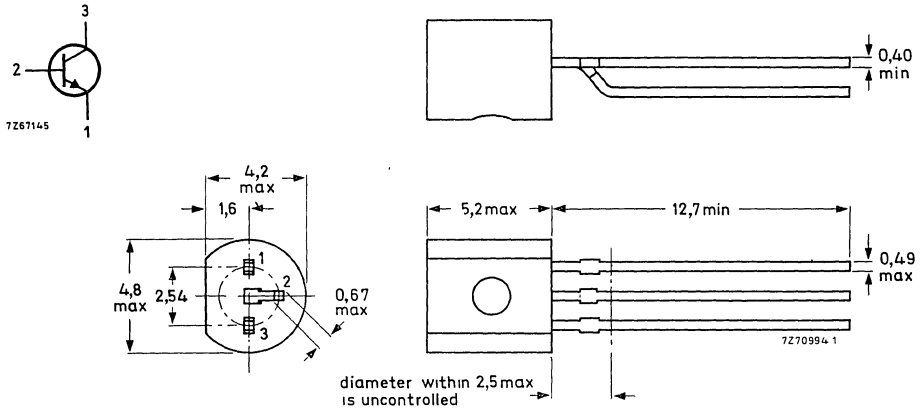
### QUICK REFERENCE DATA

		PH2222; R	PH2222A; R	
Collector-base voltage (open emitter)	$V_{CB0}$	max. 60	75	V
Collector-emitter voltage (open base)	$V_{CE0}$	max. 30	40	V
Collector current (d.c.)	$I_C$	max. 800	800	mA
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max. 625	625	mW
Junction temperature	$T_j$	max. 150	150	$^\circ\text{C}$
D.C. current gain at $T_j = 25\text{ }^\circ\text{C}$ $I_C = 10\text{ mA}; V_{CE} = 10\text{ V}$	$h_{FE}$	> 75	75	
Transition frequency at $f = 100\text{ MHz}$ $I_C = 20\text{ mA}; V_{CE} = 20\text{ V}$	$f_T$	> 250	300	MHz
Storage time $I_{Con} = 150\text{ mA}; I_{Bon} = -I_{Boff} = 15\text{ mA}$	$t_s$	< -	225	ns

### MECHANICAL DATA of PH2222 and PH2222A

Dimensions in mm

Fig. 1 TO-92 variant.



The PH2222R and PH2222AR are available on request; they have cbe pinning instead of ebc.

**RATINGS**

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

		PH2222; R	PH2222A; R	
Collector-base voltage (open emitter)	$V_{CBO}$	max. 60	75	V
Collector-emitter voltage (open base)	$V_{CEO}$	max. 30	40	V
Emitter-base voltage (open collector)	$V_{EBO}$	max. 5	6	V
Collector current (d.c.)	$I_C$	max. 800		mA
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max. 625		mW
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	$R_{th\ j-a}$	=	200	K/W
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**CHARACTERISTICS**

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

		PH2222; R	PH2222A; R	
Collector cut-off current $I_E = 0; V_{CB} = 50\text{ V}$	$I_{CBO}$	< 10	—	nA
$I_E = 0; V_{CB} = 50\text{ V}; T_{amb} = 150\text{ }^\circ\text{C}$	$I_{CBO}$	< 10	—	$\mu\text{A}$
$I_E = 0; V_{CB} = 60\text{ V}$	$I_{CBO}$	< —	10	nA
$I_E = 0; V_{CB} = 60\text{ V}; T_{amb} = 150\text{ }^\circ\text{C}$	$I_{CBO}$	< —	10	$\mu\text{A}$
Emitter cut-off current $I_C = 0; V_{EB} = 3\text{ V}$	$I_{EBO}$	< 10	10	nA
Currents at reverse biased emitter junction $V_{CE} = 60\text{ V}; -V_{BE} = 3\text{ V}$	$I_{CEX}$	< —	10	nA
	$-I_{BEX}$	< —	20	nA
Breakdown voltages $I_E = 0; I_C = 10\text{ }\mu\text{A}$	$V_{(BR)CBO}$	> 60	75	V
$I_B = 0; I_C = 10\text{ mA}$	$V_{(BR)CEO}$	> 30	40	V
$I_C = 0; I_E = 10\text{ }\mu\text{A}$	$V_{(BR)EBO}$	> 5	6	V
Saturation voltages * $I_C = 150\text{ mA}; I_B = 15\text{ mA}$	$V_{CEsat}$	< 0,4	0,3	V
	$V_{BEsat}$	> —	0,6	V
	$V_{BEsat}$	< 1,3	1,2	V
$I_C = 500\text{ mA}; I_B = 50\text{ mA}$	$V_{CEsat}$	< 1,6	1,0	V
	$V_{BEsat}$	< 2,6	2,0	V

\* Measured under pulse conditions:  $t_p \leq 300\text{ }\mu\text{s}; \delta \leq 0,02$ .

		PH2222; R	PH2222A; R	
<b>D.C. current gain</b>				
$I_C = 0,1 \text{ mA}; V_{CE} = 10 \text{ V}$	$h_{FE}$	> 35	35	
$I_C = 1 \text{ mA}; V_{CE} = 10 \text{ V}$	$h_{FE}$	> 50	50	
$I_C = 10 \text{ mA}; V_{CE} = 10 \text{ V}$	$h_{FE}$	> 75	75	
$I_C = 10 \text{ mA}; V_{CE} = 10 \text{ V}; T_{amb} = -55 \text{ }^\circ\text{C}$	$h_{FE}$	> —	35	
$I_C = 150 \text{ mA}; V_{CE} = 1 \text{ V}^*$	$h_{FE}$	> 50	50	
$I_C = 150 \text{ mA}; V_{CE} = 10 \text{ V}^*$	$h_{FE}$	> 100	100	
$I_C = 500 \text{ mA}; V_{CE} = 10 \text{ V}^*$	$h_{FE}$	< 300	300	
$I_C = 500 \text{ mA}; V_{CE} = 10 \text{ V}^*$	$h_{FE}$	> 30	40	
<b>Transition frequency at <math>f = 100 \text{ MHz}</math></b>				
$I_C = 20 \text{ mA}; V_{CE} = 20 \text{ V}$	$f_T$	> 250	300	MHz
<b>Collector capacitance at <math>f = 100 \text{ kHz}</math></b>				
$I_E = I_e = 0; V_{CB} = 10 \text{ V}$	$C_c$	< 8	8	pF
<b>Emitter capacitance at <math>f = 100 \text{ kHz}</math></b>				
$I_C = I_c = 0; V_{EB} = 0,5 \text{ V}$	$C_e$	< —	25	pF
<b>Feedback time constant at <math>f = 31,8 \text{ MHz}</math></b>				
$I_C = 20 \text{ mA}; V_{CE} = 20 \text{ V}$	$r_{bb}' C_{b'c}$	< —	150	ps
<b>h-parameters (common emitter)</b>				
$I_C = 1 \text{ mA}; V_{CE} = 10 \text{ V}; f = 1 \text{ kHz}$				
Input impedance	$h_{ie}$	> —	2	k $\Omega$
Reverse voltage transfer ratio	$h_{re}$	< —	8	k $\Omega$
Small-signal current gain	$h_{fe}$	> —	8	$10^{-4}$
Output admittance	$h_{oe}$	< —	50	
$I_C = 10 \text{ mA}; V_{CE} = 10 \text{ V}; f = 1 \text{ kHz}$			300	
Input impedance	$h_{ie}$	> —	5	$\mu\text{A/V}$
Reverse voltage transfer ratio	$h_{re}$	< —	35	$\mu\text{A/V}$
Small-signal current gain	$h_{fe}$	> —	0,25	k $\Omega$
Output admittance	$h_{oe}$	< —	1,25	k $\Omega$
$I_C = 20 \text{ mA}; V_{CE} = 20 \text{ V}; f = 100 \text{ MHz}$			4	$10^{-4}$
Small-signal current gain	$h_{fe}$	> —	75	
Output admittance	$h_{oe}$	< —	375	
$I_C = 20 \text{ mA}; V_{CE} = 20 \text{ V}; f = 300 \text{ MHz}$			25	$\mu\text{A/V}$
Real part of input impedance	$\text{Re}(h_{ie})$	< 60	200	$\mu\text{A/V}$
<b>Noise figure at <math>f = 1 \text{ kHz}</math></b>				
$I_C = 0,1 \text{ mA}; V_{CE} = 10 \text{ V}$				
$R_G = 1 \text{ k}\Omega; B = 1 \text{ Hz}$	F	< —	4	dB

\* Measured under pulse conditions:  $t_p \leq 300 \mu\text{s}; \delta \leq 0,02$ .

Switching times (between 10% and 90% levels) for PH2222A; R

Turn-on time when switched to  $I_{Con} = 150 \text{ mA}$  (see Fig. 2)

delay time  
rise time

$t_d < 10 \text{ ns}$   
 $t_r < 25 \text{ ns}$

Turn-off time when switched from  $I_{Con} = 150 \text{ mA}$  (see Fig. 3)

storage time  
fall time

$t_s < 225 \text{ ns}$   
 $t_f < 60 \text{ ns}$

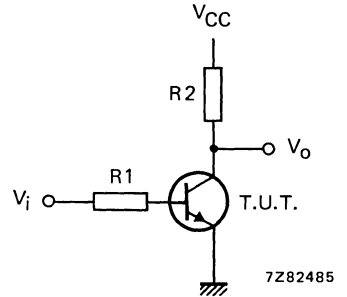
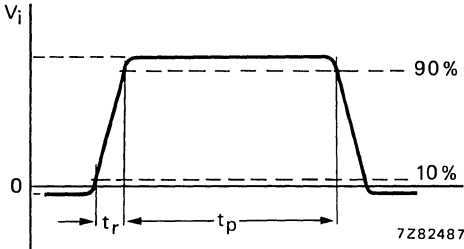


Fig. 2 Input waveform and test circuit for determining delay time and rise time.

$V_i = -0,5 \text{ V to } +9,9 \text{ V}$ ;  $V_{CC} = +30 \text{ V}$ ;  $R_1 = 619 \Omega$ ;  $R_2 = 200 \Omega$ .

Pulse generator:

pulse duration  $t_p \leq 200 \text{ ns}$   
rise time  $t_r \leq 2 \text{ ns}$   
duty factor  $\delta = 0,02$

Oscilloscope:

input impedance  $Z_i > 100 \text{ k}\Omega$   
input capacitance  $C_i < 12 \text{ pF}$   
rise time  $t_r < 5 \text{ ns}$

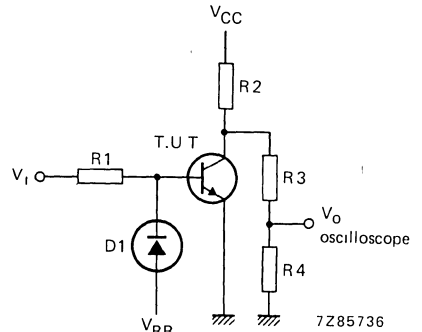
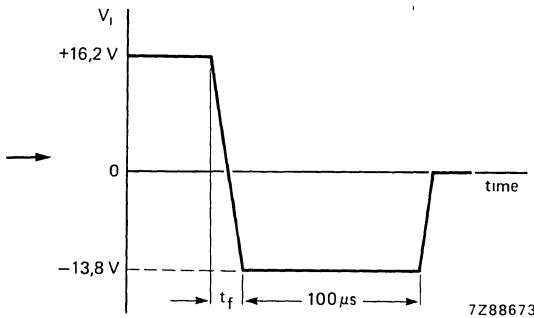


Fig. 3 Input waveform and test circuit for determining storage time and fall time.

$V_{CC} = +30 \text{ V}$ ;  $V_{BB} = -3 \text{ V}$ ;  $R_1 = 1 \text{ k}\Omega$ ;  $R_2 = 200 \Omega$ ;  $R_3 = 20 \text{ k}\Omega$ ;  $R_4 = 50 \Omega$ ;  $D_1 = 1N916$ .

Pulse generator:

fall time  $t_f < 5 \text{ ns}$

Oscilloscope:

input impedance  $Z_i > 100 \text{ k}\Omega$   
input capacitance  $C_i < 12 \text{ pF}$   
rise time  $t_r < 5 \text{ ns}$

## SILICON PLANAR EPITAXIAL SWITCHING TRANSISTOR

N-P-N transistor in a plastic TO-92 variant envelope intended for high-speed switching applications.

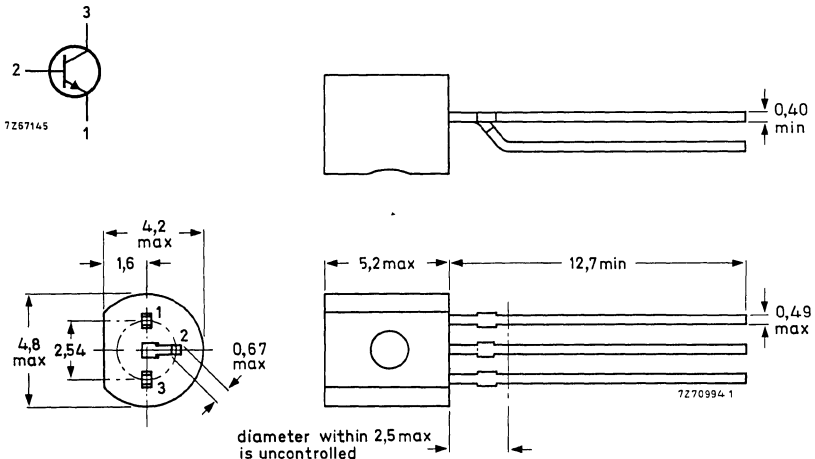
### QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$V_{CB0}$	max.	40 V
Collector-emitter voltage ( $V_{BE} = 0$ )	$V_{CES}$	max.	40 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	15 V
Collector current (peak value)	$I_{CM}$	max.	500 mA
Total power dissipation up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	500 mW
D.C. current gain			
$I_C = 10\text{ mA}; V_{CE} = 1\text{ V}$	$h_{FE}$	>	40
$I_C = 100\text{ mA}; V_{CE} = 2\text{ V}$	$h_{FE}$	>	20
Transition frequency at $f = 100\text{ MHz}$			
$I_C = 10\text{ mA}; V_{CE} = 10\text{ V}$	$f_T$	>	500 MHz
Storage time			
$I_{Con} = I_{Bon} = -I_{Boff} = 10\text{ mA}$	$t_s$	<	13 ns

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



**RATINGS**

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

Collector-base voltage (open emitter)	$V_{CB0}$	max.	40 V
Collector-emitter voltage ( $V_{BE} = 0$ )	$V_{CES}$	max.	40 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	15 V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	4,5 V
Collector current (peak value; $t_p = 10 \mu s$ )	$I_{CM}$	max.	500 mA
Total power dissipation up to $T_{amb} = 25 \text{ }^\circ\text{C}$	$P_{tot}$	max.	500 mW
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 in free air	$R_{th\ j-a}$	=	250 K/W
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**CHARACTERISTICS**

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

Collector cut-off current

$I_E = 0; V_{CB} = 20 \text{ V}$	$I_{CBO}$	<	400 nA
$I_E = 0; V_{CB} = 20 \text{ V}; T_j = 125 \text{ }^\circ\text{C}$	$I_{CBO}$	<	30 $\mu\text{A}$

Emitter cut-off current

$I_C = 0; V_{EB} = 2 \text{ V}$	$I_{EBO}$	<	100 nA
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Saturation voltages

$I_C = 10 \text{ mA}; I_B = 0,3 \text{ mA}$	$V_{CEsat}$	<	0,30 V
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$I_C = 10 \text{ mA}; I_B = 1 \text{ mA}$	$V_{CEsat}$	<	0,25 V
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	$V_{BEsat}$	0,70 to 0,85 V	
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$I_C = 100 \text{ mA}; I_B = 10 \text{ mA}$	$V_{CEsat}$	<	0,60 V
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	$V_{BEsat}$	<	1,50 V
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D.C. current gain

$I_C = 10 \text{ mA}; V_{CE} = 1 \text{ V}$	$h_{FE}$	40 to 120	
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$I_C = 10 \text{ mA}; V_{CE} = 1 \text{ V}; T_{amb} = -55 \text{ }^\circ\text{C}$	$h_{FE}$	>	20
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$I_C = 100 \text{ mA}; V_{CE} = 2 \text{ V}$	$h_{FE}$	>	20
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Transition frequency at  $f = 100 \text{ MHz}$

$I_C = 10 \text{ mA}; V_{CE} = 10 \text{ V}$	$f_T$	>	500 MHz
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Collector capacitance at  $f = 1 \text{ MHz}$

$I_E = I_e = 0; V_{CB} = 5 \text{ V}$	$C_c$	<	4 pF
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Emitter capacitance at  $f = 1 \text{ MHz}$

$I_C = I_c = 0; V_{EB} = 1 \text{ V}$	$C_e$	<	4,5 pF
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**Switching times**

Storage time (see Fig. 2)

$I_{Con} = I_{Bon} = -I_{Boff} = 10 \text{ mA}$	$t_s$	typ.	6 ns
		<	13 ns

Pulse generator:

- $t_r < 1 \text{ ns}$
- $t_p > 300 \text{ ns}$
- $\delta < 0,02$
- $R_s = 50 \Omega$

Oscilloscope:

- $R_i = 50 \Omega$
- $t_r < 1 \text{ ns}$

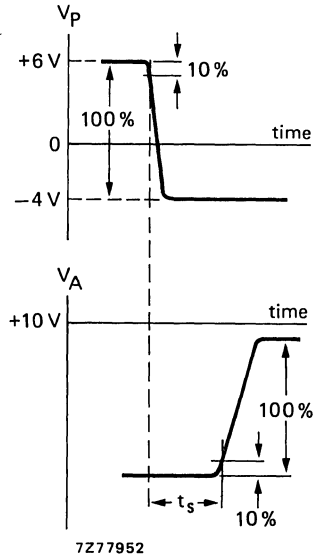
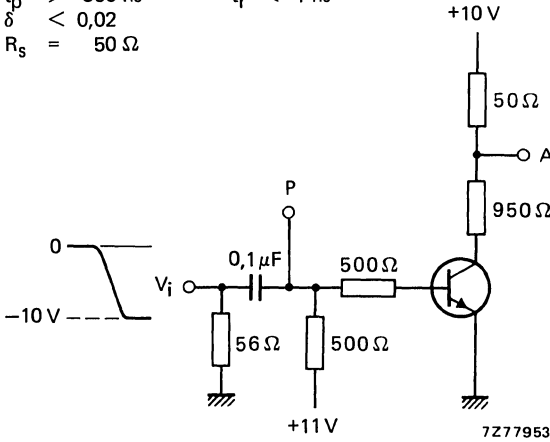


Fig. 2 Test circuit and waveforms.

Turn-on time (see Fig. 3)

- from  $-V_{BEoff} = 1,5 \text{ V}$  to  $I_{Con} = 10 \text{ mA}$ ;  $I_{Bon} = 3 \text{ mA}$
- from  $-V_{BEoff} = 2,25 \text{ V}$  to  $I_{Con} = 100 \text{ mA}$ ;  $I_{Bon} = 40 \text{ mA}$

- $t_{on} < 12 \text{ ns}$
- $t_{on} < 7 \text{ ns}$

Turn-off time (see Fig. 3)

- $I_{Con} = 10 \text{ mA}$ ;  $I_{Bon} = 3 \text{ mA}$ ;  $-I_{Boff} = 1,5 \text{ mA}$
- $I_{Con} = 100 \text{ mA}$ ;  $I_{Bon} = 40 \text{ mA}$ ;  $-I_{Boff} = 20 \text{ mA}$

- $t_{off} < 18 \text{ ns}$
- $t_{off} < 21 \text{ ns}$



Pulse generator:

- $t_r < 1 \text{ ns}$
- $t_p > 300 \text{ ns}$
- $\delta < 0,02$
- $R_s = 50 \Omega$

Oscilloscope:

- $R_i = 50 \Omega$
- $t_r < 1 \text{ ns}$

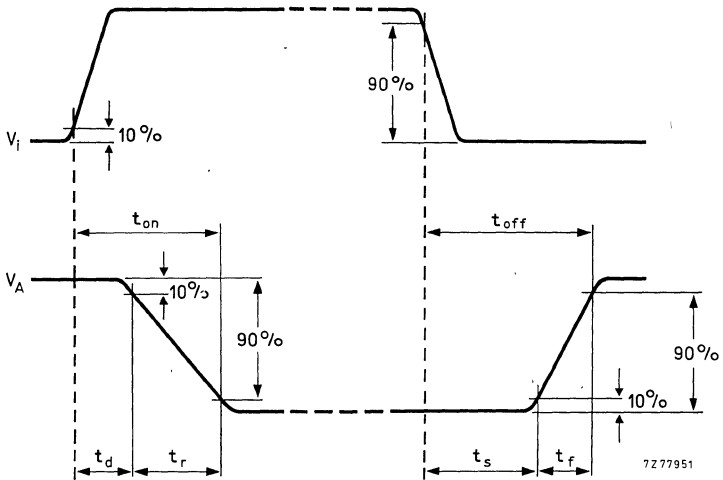
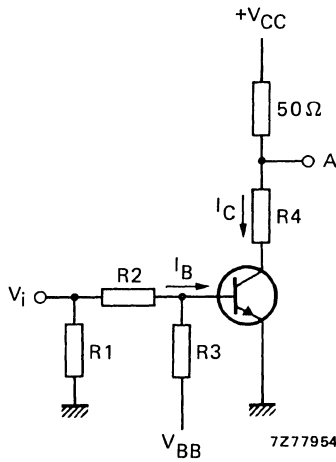


Fig. 3 Test circuit and waveforms.

$I_{Con}$ mA	$I_{Bon}$ mA	$I_{Boff}$ mA	$V_{CC}$ V	$R_1$ $\Omega$	$R_2; R_3$ k $\Omega$	$R_4$ $\Omega$	turn-on time			turn-off time	
							$V_{BB}$ V	$V_{BE}$ V	$V_i$ V	$V_{BB}$ V	$V_i$ V
10	3	-1,5	3	50	3,30	220	-3,0	-1,50	15	12,0	-15
100	40	-20	6	56	0,33	0	-4,5	-2,25	20	15,3	-20

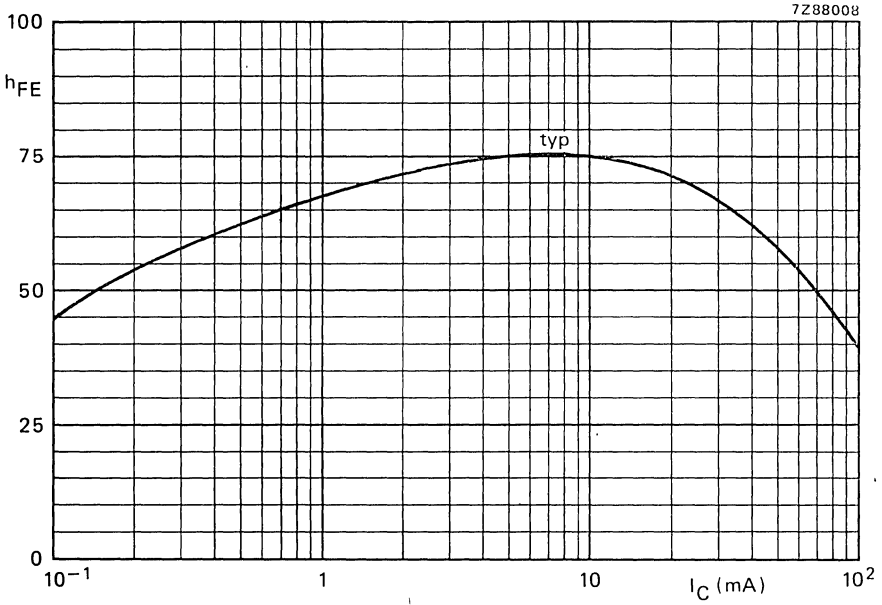


Fig. 4  $V_{CE} = 1$  V;  $T_j = 25$  °C.

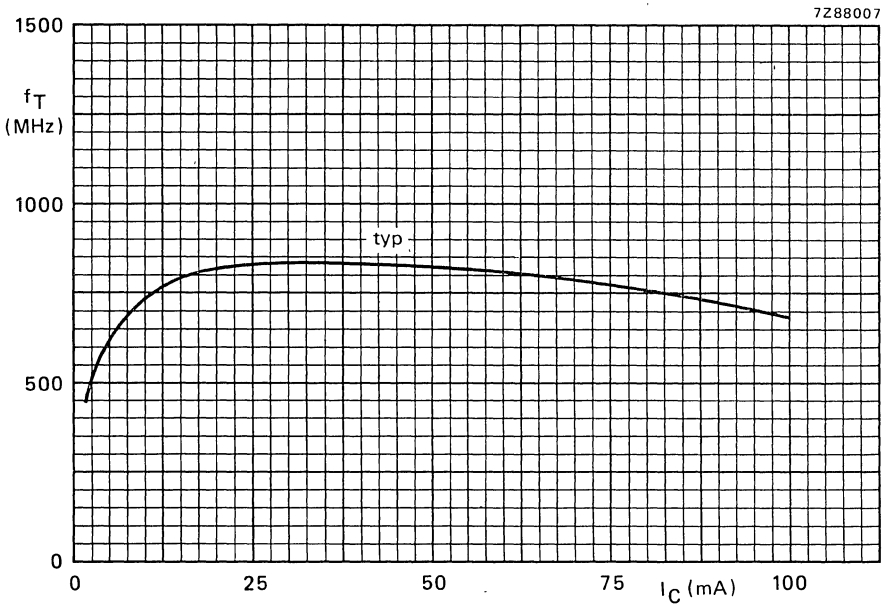


Fig. 5  $V_{CE} = 10$  V;  $T_j = 25$  °C.

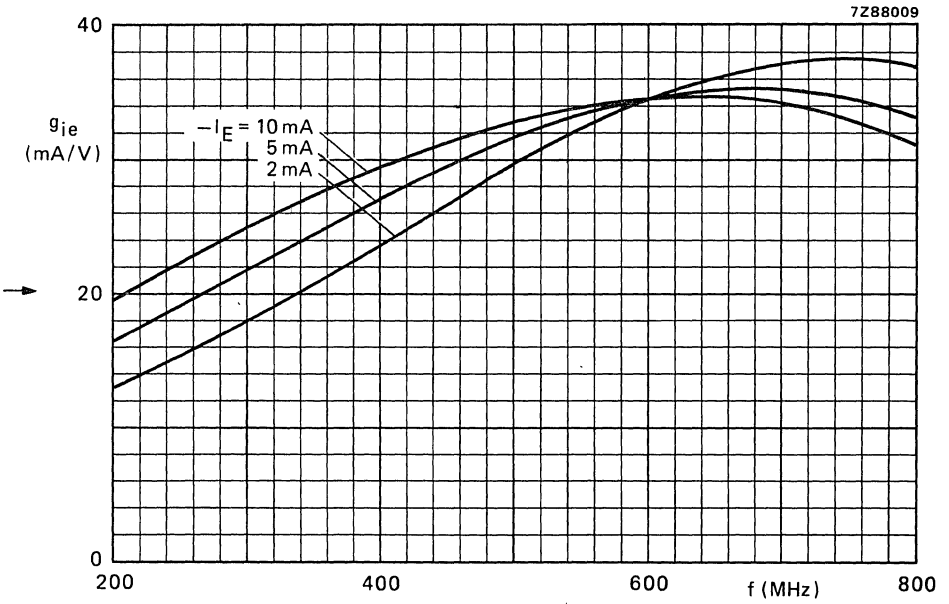


Fig. 6  $V_{CB} = 10$  V;  $T_{amb} = 25$  °C; typical values.

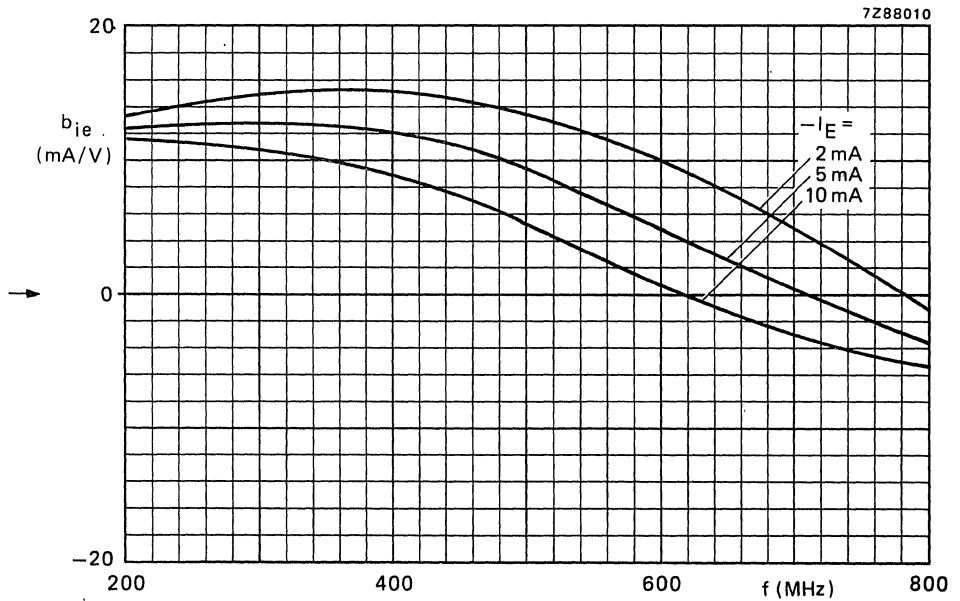


Fig. 7  $V_{CB} = 10$  V;  $T_{amb} = 25$  °C; typical values.

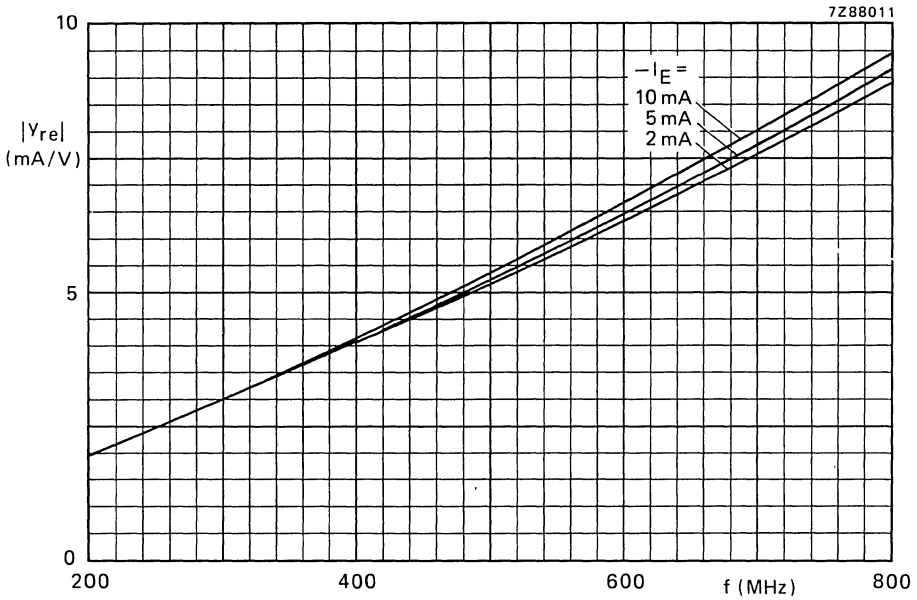


Fig. 8  $V_{CB} = 10$  V;  $T_{amb} = 25$  °C; typical values.

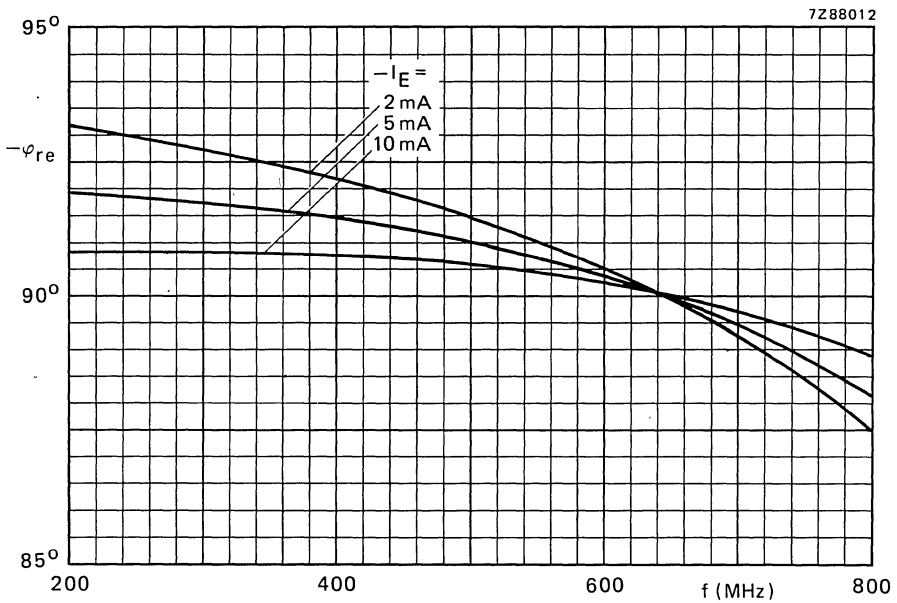


Fig. 9  $V_{CB} = 10$  V;  $T_{amb} = 25$  °C; typical values.

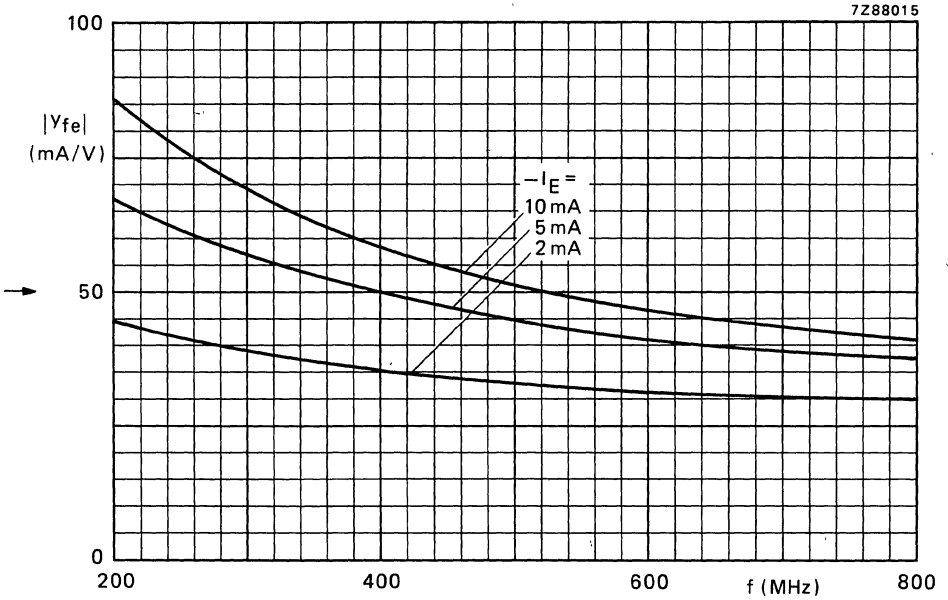


Fig. 10  $V_{CB} = 10$  V;  $T_{amb} = 25$  °C; typical values.

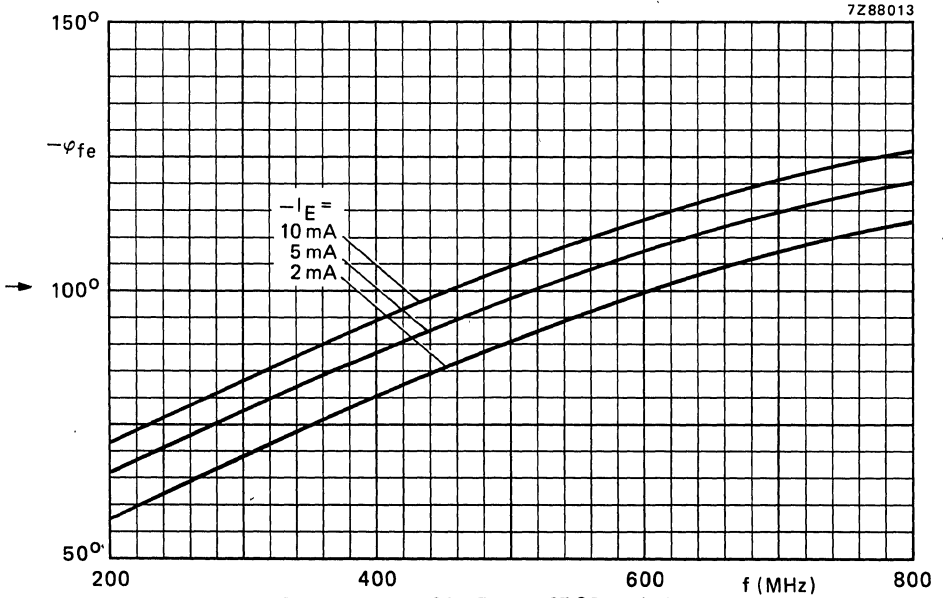


Fig. 11  $V_{CB} = 10$  V;  $T_{amb} = 25$  °C; typical values.

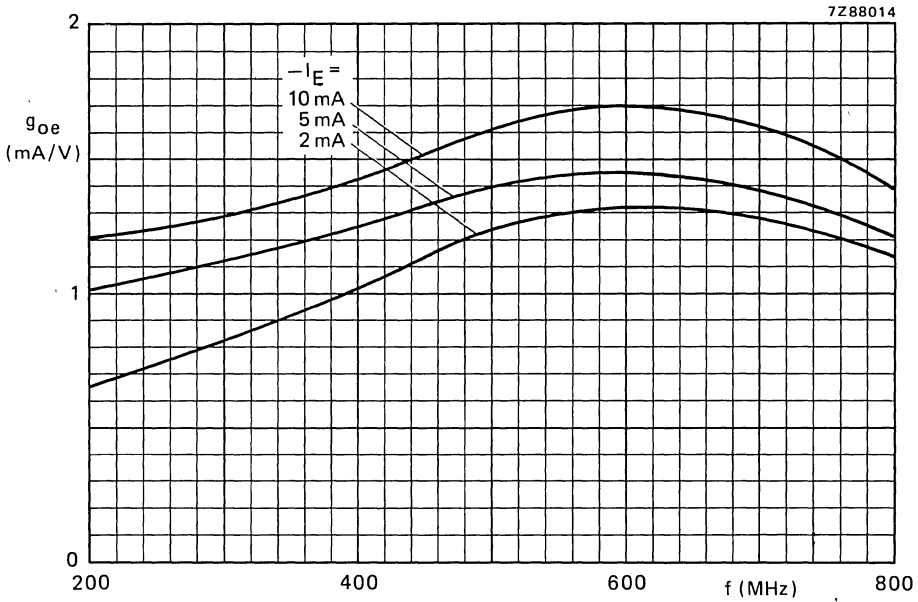


Fig. 12  $V_{CB} = 10 \text{ V}$ ;  $T_{amb} = 25 \text{ }^\circ\text{C}$ ; typical values.

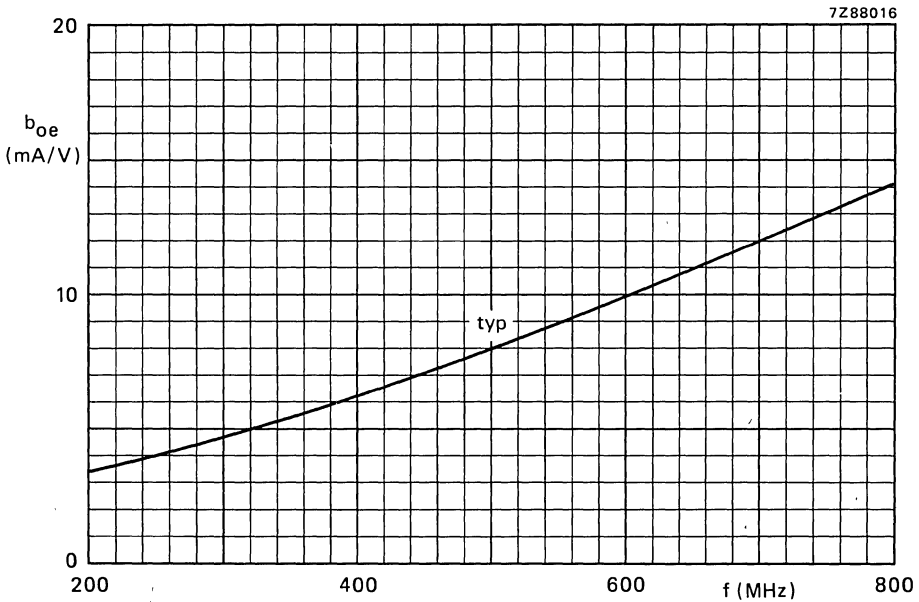


Fig. 13  $V_{CB} = 10 \text{ V}$ ;  $-I_E = 2 \text{ to } 10 \text{ mA}$ ;  $T_{amb} = 25 \text{ }^\circ\text{C}$ .







**RATINGS**

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

Collector-base voltage (open emitter)	$-V_{CB0}$	max.	60 V
Collector-emitter voltage (open base)	PH2907; R $-V_{CEO}$ PH2907A; R $-V_{CEO}$	max.	40 V 60 V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5 V
Collector current (d.c.)	$-I_C$	max.	600 mA
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	625 mW
Storage temperature	$T_{stg}$		$-65$ to $+150\text{ }^\circ\text{C}$
Junction temperature	$T_j$	max.	150 $^\circ\text{C}$

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th\ j-a}$	=	200 K/W
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## CHARACTERISTICS

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

		2N2907; R	2N2907A; R	
Collector cut-off current				
$I_E = 0; -V_{CB} = 50\text{ V}$	$-I_{CBO}$	< 20	10	nA
$I_E = 0; -V_{CB} = 50\text{ V}; T_{amb} = 150\text{ }^{\circ}\text{C}$	$-I_{CBO}$	< 20	10	$\mu\text{A}$
$+V_{BE} = 0,5\text{ V}; -V_{CE} = 30\text{ V}$	$-I_{CEX}$	< 50	50	nA
Base current				
$+V_{BE} = 0,5\text{ V}; -V_{CE} = 30\text{ V}$	$I_{BEX}$	< 50	50	nA
Collector-base breakdown voltage open emitter; $-I_C = 10\text{ }\mu\text{A}$		$-V_{(BR)CBO}$	> 60	60 V
Collector-emitter breakdown voltage* open base; $-I_C = 10\text{ mA}$		$-V_{(BR)CEO}$	> 40	60 V
Emitter-base breakdown voltage open collector; $-I_E = 10\text{ }\mu\text{A}$		$-V_{(BR)EBO}$	> 5	5 V
Saturation voltages*				
$-I_C = 150\text{ mA}; -I_B = 15\text{ mA}$	$-V_{CEsat}$	< 0,4	0,4	V
	$-V_{BEsat}$	< 1,3	1,3	V
$-I_C = 500\text{ mA}; -I_B = 50\text{ mA}$	$-V_{CEsat}$	< 1,6	1,6	V
	$-V_{BEsat}$	< 2,6	2,6	V
D.C. current gain				
$-I_C = 0,1\text{ mA}; -V_{CE} = 10\text{ V}$	$h_{FE}$	> 35	75	
$-I_C = 1\text{ mA}; -V_{CE} = 10\text{ V}$	$h_{FE}$	> 50	100	
$-I_C = 10\text{ mA}; -V_{CE} = 10\text{ V}$	$h_{FE}$	> 75	100	
$-I_C = 150\text{ mA}; -V_{CE} = 10\text{ V}^*$	$h_{FE}$	> 100	100	
	$h_{FE}$	< 300	300	
$-I_C = 500\text{ mA}; -V_{CE} = 10\text{ V}^*$	$h_{FE}$	> 30	50	
Collector capacitance at $f = 100\text{ kHz}$ $I_E = I_C = 0; -V_{CB} = 10\text{ V}$		$C_C$	< 8	pF
Emitter capacitance at $f = 100\text{ kHz}$ $I_C = I_E = 0; -V_{EB} = 2\text{ V}$		$C_E$	< 30	pF
Transition frequency at $f = 100\text{ MHz}$ $-I_C = 50\text{ mA}; -V_{CE} = 20\text{ V}^*$		$f_T$	> 200	MHz

\* Measured under pulse conditions to avoid excessive dissipation:  $t_p \leq 300\text{ }\mu\text{s}; \delta \leq 0,02$ .

Turn-on time (see Fig. 2)

when switched to  $-I_{Con} = 150 \text{ mA}$ ;  $-I_{Bon} = 15 \text{ mA}$

delay time

$$t_d < 10 \text{ ns}$$

rise time

$$t_r < 40 \text{ ns}$$

turn-on time

$$t_{on} < 45 \text{ ns}$$

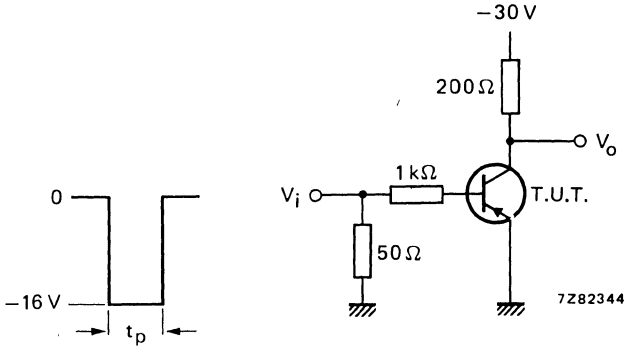


Fig. 2 Input waveform and test circuit for determining delay, rise and turn-on time.

Turn-off time (see Fig. 3)

when switched from  $-I_{Con} = 150 \text{ mA}$ ;  $-I_{Bon} = 15 \text{ mA}$

to cut-off with  $+I_{Boff} = 15 \text{ mA}$

storage time

$$t_s < 80 \text{ ns}$$

fall time

$$t_f < 30 \text{ ns}$$

turn-off time

$$t_{off} < 100 \text{ ns}$$

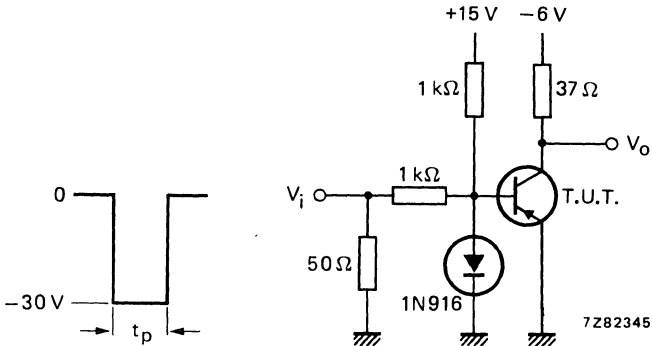


Fig. 3 Input waveform and test circuit for determining storage, fall and turn-off time.

Pulse generator (see Figs 2 and 3)

frequency  $f = 150 \text{ Hz}$

pulse duration  $t_p = 200 \text{ ns}$

rise time  $t_r \leq 2 \text{ ns}$

output impedance  $Z_o = 50 \Omega$

Oscilloscope (see Figs 2 and 3)

rise time  $t_r \leq 5 \text{ ns}$

input impedance  $Z_i \leq 10 \text{ M}\Omega$

## N-P-N SILICON PLANAR TRANSISTORS

N-P-N transistors in TO-18 metal envelopes with the collector connected to the case.

These devices are primarily intended for use in high performance, low-level, low-noise amplifier applications both for direct current and for frequencies of up to 100 MHz.

### QUICK REFERENCE DATA

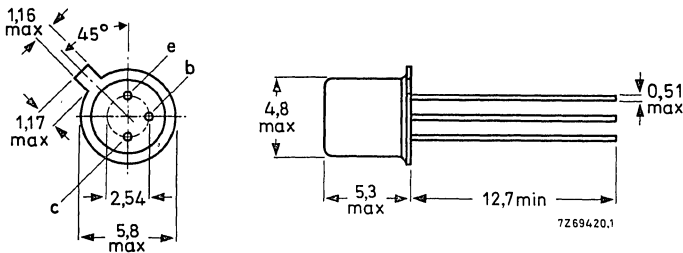
		2N929	2N930
Collector-base voltage (open emitter)	$V_{CB0}$ max	45	45 V
Collector-emitter voltage (open base)	$V_{CEO}$ max	45	45 V
Collector current (peak value)	$I_{CM}$ max	60	60 mA
Total power dissipation up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$ max	300	300 mW
Junction temperature	$T_j$ max	175	175 $^{\circ}\text{C}$
D.C. current gain at $T_j = 25\text{ }^{\circ}\text{C}$ $I_C = 10\text{ }\mu\text{A}; V_{CE} = 5\text{ V}$	$h_{FE}$ >	40	100
	$h_{FE}$ <	120	300
$I_C = 10\text{ mA}; V_{CE} = 5\text{ V}$	$h_{FE}$ >	100	150
	$h_{FE}$ <	350	600
Transition frequency $I_C = 0,5\text{ mA}; V_{CE} = 5\text{ V}$	$f_T$ typ	80	80 MHz
Noise figure at $R_S = 10\text{ k}\Omega$ $I_C = 10\text{ }\mu\text{A}; V_{CE} = 5\text{ V}$ $f = 10\text{ Hz to } 15\text{ kHz}$	F typ	2,5	2 dB
	F <	4	3 dB

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector connected to case



Accessories: 56246 (distance disc).

**RATINGS** Limiting values in accordance with the Absolute Maximum System

Voltages (IEC 134)

Collector-base voltage (open emitter)	$V_{CBO}$	max.	45 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	45 V
Collector-emitter voltage at $V_{EB} = 0$	$V_{CES}$	max.	45 V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	5 V

Currents

Collector current (d.c. or average over any 50 ms period)	$I_C$	max.	30 mA
Collector current (peak value)	$I_{CM}$	max.	60 mA
Emitter current (d.c. or average over any 50 ms period)	$-I_E$	max.	35 mA
Emitter current (peak value)	$-I_{EM}$	max.	70 mA

Power dissipation

Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	300 mW
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Temperatures

Storage temperature	$T_{stg}$	-65 to +175	$^\circ\text{C}$
Junction temperature	$T_j$	max.	175 $^\circ\text{C}$

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th\ j-a}$	=	0.5 $^\circ\text{C}/\text{mW}$
From junction to case	$R_{th\ j-c}$	=	0.25 $^\circ\text{C}/\text{mW}$

**CHARACTERISTICS**

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

Collector cut-off current

$I_E = 0; V_{CB} = 45\text{ V}$	$I_{CBO}$	< 10 nA
$I_B = 0; V_{CE} = 5\text{ V}$	$I_{CEO}$	< 2 nA
$V_{EB} = 0; V_{CB} = 45\text{ V}$	$I_{CES}$	< 10 nA

Emitter cut-off current

$I_C = 0; V_{EB} = 5\text{ V}$	$I_{EBO}$	< 10 nA
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Emitter-base voltage

$-I_E = 0.5\text{ mA}; V_{CB} = 5\text{ V}$	$-V_{EB}$	0.6 to 0.8 V
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Saturation voltages

$I_C = 10\text{ mA}; I_B = 0.5\text{ mA}$	$V_{CEsat}$	< 1 V
	$V_{BEsat}$	0.6 to 1 V

D.C. current gain

		2N929	2N930
$I_C = 10\ \mu\text{A}; V_{CE} = 5\text{ V}$	$h_{FE}$	40 to 120	100 to 300
$I_C = 10\ \mu\text{A}; V_{CE} = 5\text{ V}; T_j = -55^\circ\text{C}$	$h_{FE}$	> 10	> 20
$I_C = 500\ \mu\text{A}; V_{CE} = 5\text{ V}$	$h_{FE}$	> 60	> 150
$I_C = 10\text{ mA}; V_{CE} = 5\text{ V}$	$h_{FE}$	100 to 350	150 to 600

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

$I_E = I_e = 0; V_{CB} = 5\text{ V}$	$C_c$	< 8	< 8 pF
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Transition frequency

$I_C = 0.5\text{ mA}; V_{CE} = 5\text{ V}$	$f_T$	> 50	> 50 MHz
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Cut-off frequency

$I_C = 0.5\text{ mA}; V_{CE} = 5\text{ V}$	$f_{hfe}$	> 200	> 100 kHz
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**CHARACTERISTICS (continued)**

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

Noise figure ( $f = 10\text{ Hz to }15\text{ kHz}$ )

$I_C = 10\text{ }\mu\text{A}; V_{CE} = 5\text{ V}; R_S = 10\text{ k}\Omega$

	2N929	2N930
F	typ. 2.5 < 4	2 dB 3 dB

h parameters at  $f = 1\text{ kHz}$

$I_C = 1\text{ mA}; V_{CE} = 5\text{ V}$

Input impedance

$h_{ie}$	typ. 5.0	10.0 $\text{k}\Omega$
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Reverse voltage transfer

$h_{re}$	typ. 2.5	5.5 $10^{-4}$
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Small signal current gain

$h_{fe}$	typ. 200 60 to 350	350 150 to 600
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Output admittance

$h_{oe}$	typ. 14	25 $\mu\Omega^{-1}$
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## SILICON PLANAR TRANSISTOR



N-P-N double diffused transistor in a TO-39 metal envelope designed for a wide variety of applications including d.c. amplifiers, high-speed switching and high-speed amplifiers.

## QUICK REFERENCE DATA

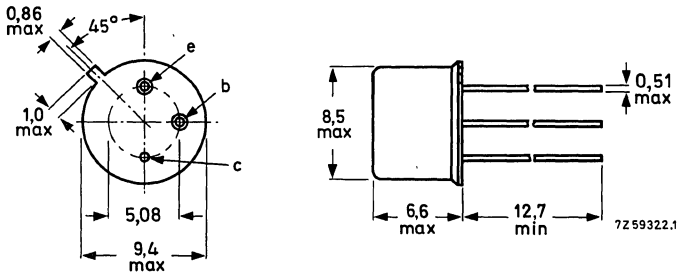
Collector-base voltage (open emitter)	$V_{CBO}$	max.	75 V
Collector-emitter voltage ( $R_{BE} \leq 10 \Omega$ )	$V_{CER}$	max.	50 V
Collector current (peak value)	$I_{CM}$	max.	500 mA
Total power dissipation up to $T_{amb} = 25^\circ\text{C}$	$P_{tot}$	max.	0,8 W
D.C. current gain at $T_j = 25^\circ\text{C}$ $I_C = 150 \text{ mA}; V_{CE} = 10 \text{ V}$	$h_{FE}$		40 to 120
Transition frequency at $f = 20 \text{ MHz}$ $I_C = 50 \text{ mA}; V_{CE} = 10 \text{ V}$	$f_T$	>	60 MHz

## MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).



**RATINGS**

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

Collector-base voltage (open emitter)	$V_{CBO}$	max.	75 V
Collector-emitter voltage ( $R_{BE} \leq 10 \Omega$ )	$V_{CER}$	max.	50 V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	7 V
Collector current (peak value)*	$I_{CM}$	max.	500 mA
Total power dissipation			
up to $T_{amb} = 25 \text{ }^\circ\text{C}$	$P_{tot}$	max.	0,8 W
at $T_{case} = 100 \text{ }^\circ\text{C}$	$P_{tot}$	max.	1,7 W
up to $T_{case} = 25 \text{ }^\circ\text{C}$	$P_{tot}$	max.	3,0 W
Storage temperature	$T_{stg}$		-65 to +200 $^\circ\text{C}$
Junction temperature	$T_j$	max.	200 $^\circ\text{C}$
Lead soldering temperature			
> 1,5 mm from the seating plane; $t_{sld} < 10 \text{ s}$ .	$T_{sld}$	max.	300 $^\circ\text{C}$

**THERMAL RESISTANCE**

From junction to case  $R_{th\ j-c} = 58,3 \text{ K/W}$

\* With the exception of the collector current all other data are Jedec registered.

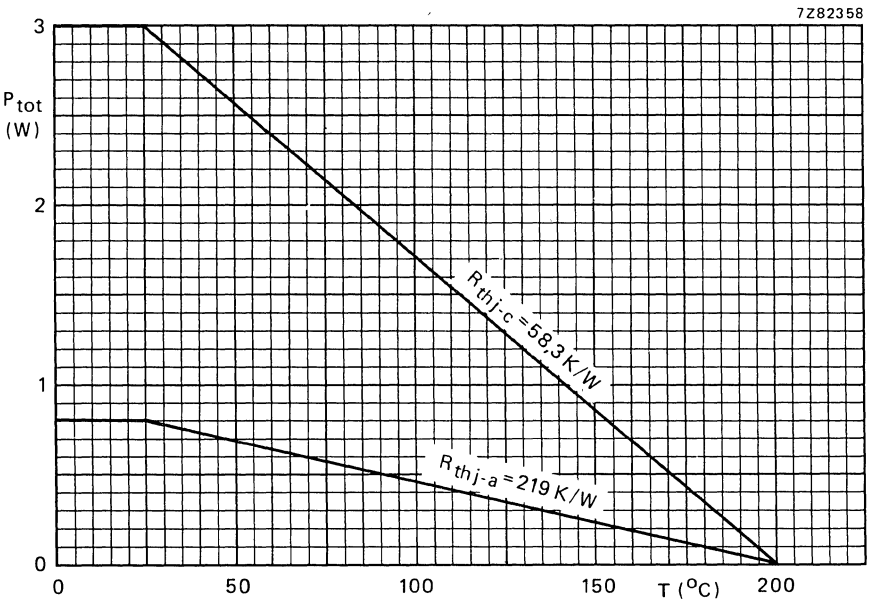


Fig. 2 Maximum permissible total power dissipation as a function of temperature.

## CHARACTERISTICS

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

Collector cut-off current

$I_E = 0; V_{CB} = 60\text{ V}$

$I_{CBO} < 10\text{ nA}$

$I_E = 0; V_{CB} = 60\text{ V}; T_{amb} = 150\text{ }^{\circ}\text{C}$

$I_{CBO} < 10\text{ }\mu\text{A}$

Emitter cut-off current

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

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

Collector-base breakdown voltage

open emitter;  $I_C = 100\text{ }\mu\text{A}$

$V_{(BR)CBO} > 75\text{ V}$

Collector-emitter breakdown voltage\*

$I_C = 100\text{ mA}; R_{BE} \leq 10\text{ }\Omega$

$V_{(BR)CER} > 50\text{ V}$

Emitter-base breakdown voltage

open collector;  $I_E = 100\text{ }\mu\text{A}$

$V_{(BR)EBO} > 7\text{ V}$

Saturation voltages\*

$I_C = 150\text{ mA}; I_B = 15\text{ mA}$

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

$V_{BEsat} < 1,3\text{ V}$

D.C. current gain

$I_C = 0,1\text{ mA}; V_{CE} = 10\text{ V}$

$h_{FE} > 20$

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

$h_{FE} > 35$

$I_C = 10\text{ mA}; V_{CE} = 10\text{ V}; T_{amb} = -55\text{ }^{\circ}\text{C}$

$h_{FE} > 20$

$I_C = 150\text{ mA}; V_{CE} = 10\text{ V}^*$

$h_{FE} > 40\text{ to }120$

$I_C = 500\text{ mA}; V_{CE} = 10\text{ V}^*$

$h_{FE} > 20$

Transition frequency at  $f = 20\text{ MHz}$

$I_C = 50\text{ mA}; V_{CE} = 10\text{ V}$

$f_T > 60\text{ MHz}$

Collector capacitance

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

$C_C < 25\text{ pF}$

Emitter capacitance

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

$C_e < 80\text{ pF}$

Noise figure at  $f = 1\text{ kHz}$

$I_C = 0,3\text{ mA}; V_{CE} = 10\text{ V}; R_S = 510\text{ }\Omega; B = 1\text{ Hz}$

$F < 12\text{ dB}$

h-parameters at  $f = 1\text{ kHz}$

Input impedance

$I_C = 1\text{ mA}; V_{CB} = 5\text{ V}$

$h_{ib} > 24\text{ to }34\text{ }\Omega$

$I_C = 5\text{ mA}; V_{CB} = 10\text{ V}$

$h_{ib} > 4\text{ to }8\text{ }\Omega$

Reverse voltage transfer ratio

$I_C = 1\text{ mA}; V_{CE} = 5\text{ V}$

$h_{rb} < 3 \cdot 10^{-4}$

$I_C = 5\text{ mA}; V_{CE} = 10\text{ V}$

$h_{rb} < 3 \cdot 10^{-4}$

Small-signal current gain

$I_C = 1\text{ mA}; V_{CE} = 5\text{ V}$

$h_{fe} > 30\text{ to }100$

$I_C = 5\text{ mA}; V_{CE} = 10\text{ V}$

$h_{fe} > 35\text{ to }150$

\* Measured under pulse conditions to avoid excessive dissipation:  $t_p = 300\text{ }\mu\text{s}; \delta \leq 0,02$ .

Output admittance

$I_C = 1 \text{ mA}; V_{CE} = 5 \text{ V}$

$I_C = 5 \text{ mA}; V_{CE} = 10 \text{ V}$

Total switching time (see Figs 3 to 6)

$I_{Con} = 50 \text{ mA}; V_{BEon} = -V_{BEoff} = 1 \text{ V}$

$h_{ob} \quad 0,05 \text{ to } 0,5 \mu\text{A/V}$

$h_{ob} \quad 0,05 \text{ to } 0,5 \mu\text{A/V}$

$t_{on} + t_{off} < 30 \text{ ns}$

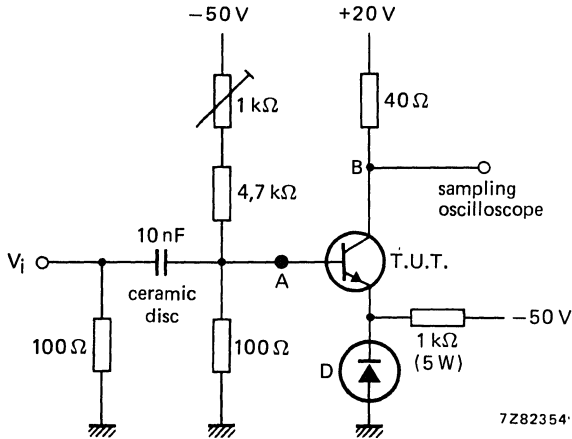


Fig. 3 Turn-on plus turn-off measuring circuit. D = BAW62.

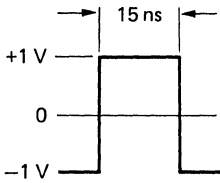


Fig. 4 Waveform at "A".  
Pulse generator:  $t_r; t_f < 1 \text{ ns}$ .

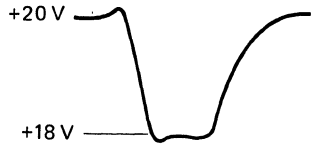


Fig. 5 Waveform at "B".

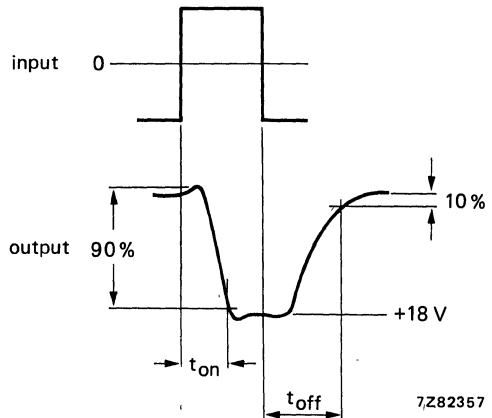


Fig. 6 Turn-on and turn-off time.

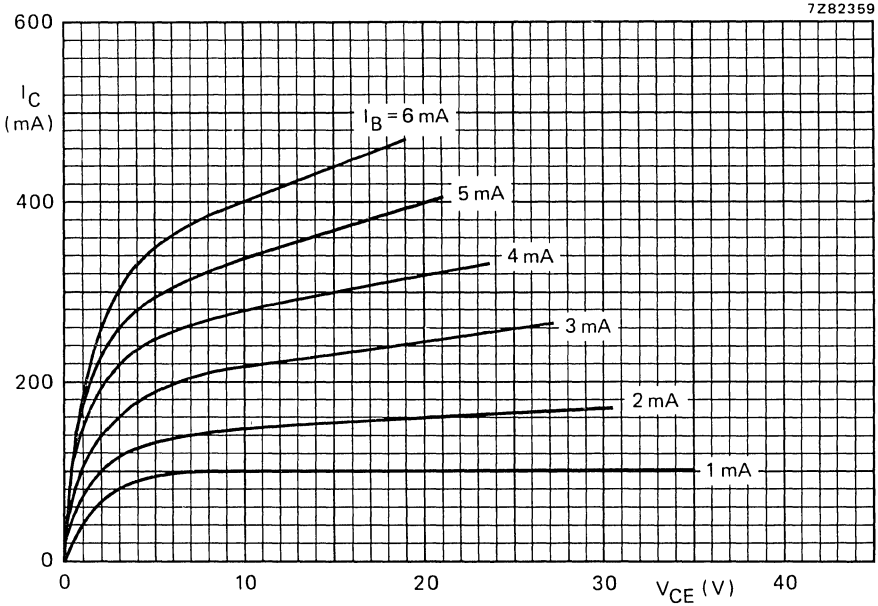


Fig. 7  $T_j = 25^\circ\text{C}$ ; typical values.

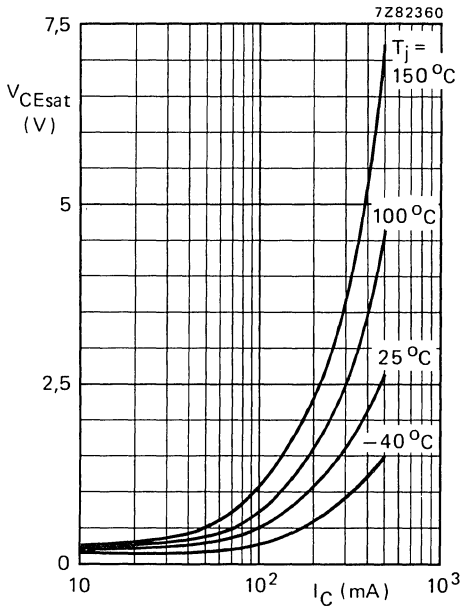


Fig. 8  $I_C/I_B = 10$ ; typical values.

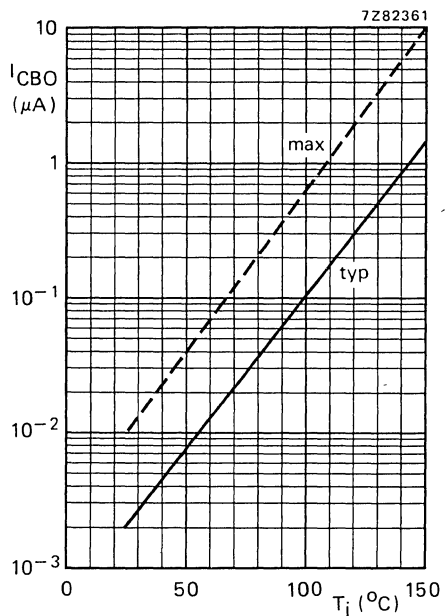


Fig. 9  $V_{CB} = 60$  V.

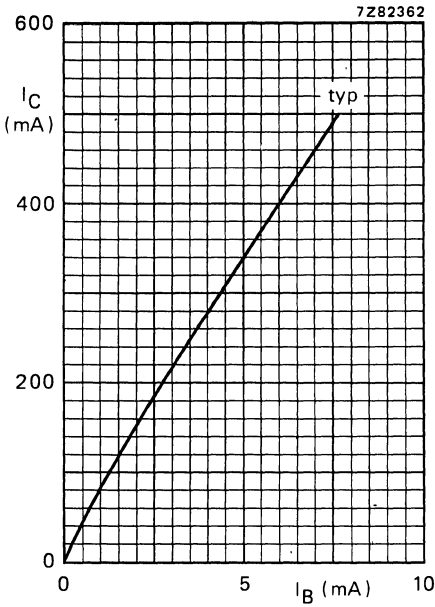


Fig. 10  $V_{CE} = 10\text{ V}$ ;  $T_j = 25\text{ }^\circ\text{C}$ .

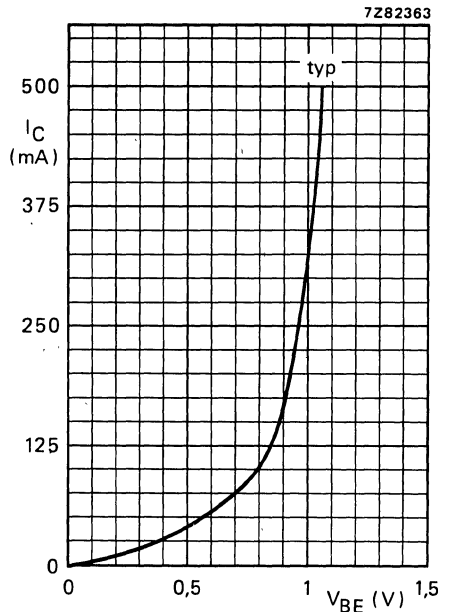


Fig. 11  $V_{CE} = 10\text{ V}$ ;  $T_j = 25\text{ }^\circ\text{C}$ .

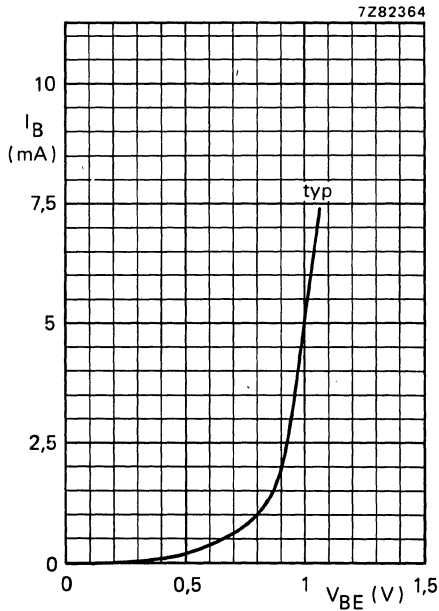


Fig. 12  $V_{CE} = 10\text{ V}$ ;  $T_j = 25\text{ }^\circ\text{C}$ .

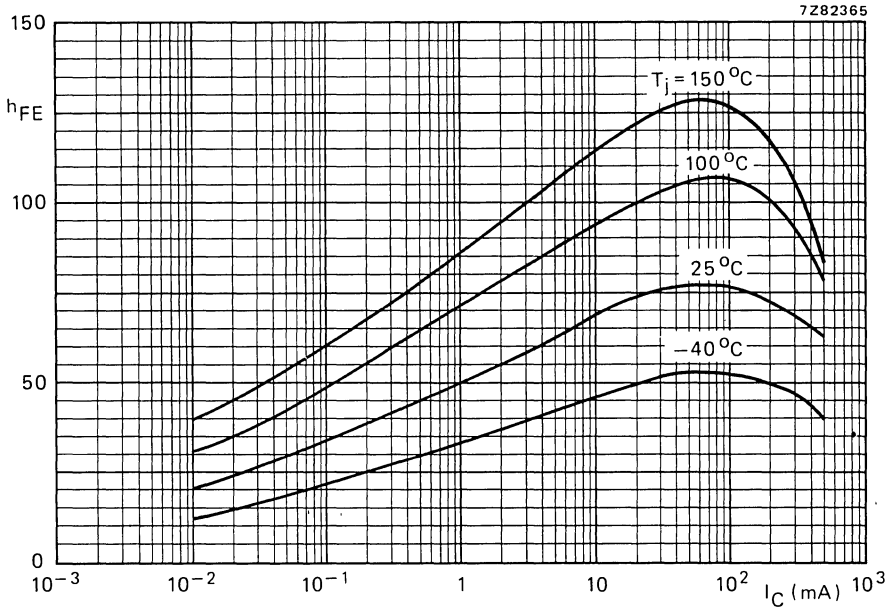


Fig. 13  $V_{CE} = 10$  V; typical values.

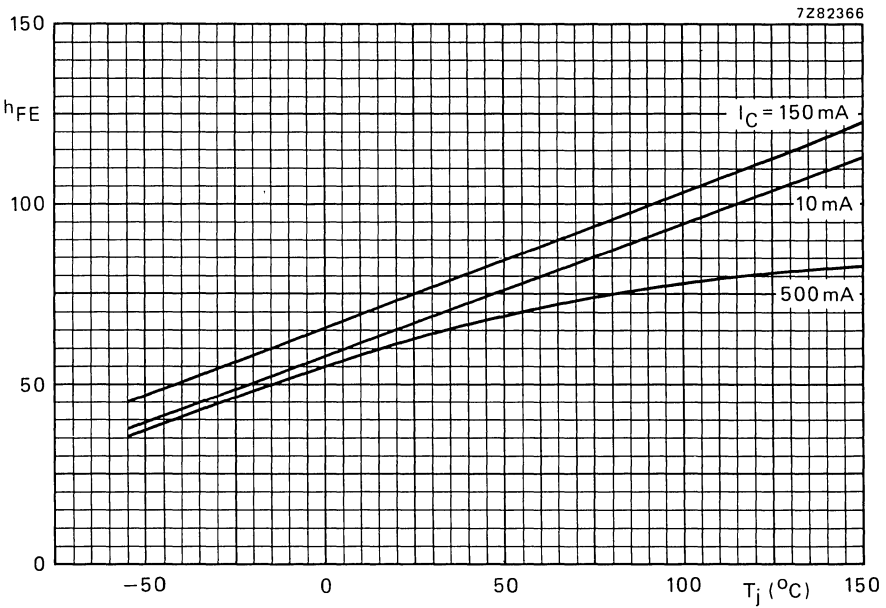


Fig. 14  $V_{CE} = 10$  V; typical values.

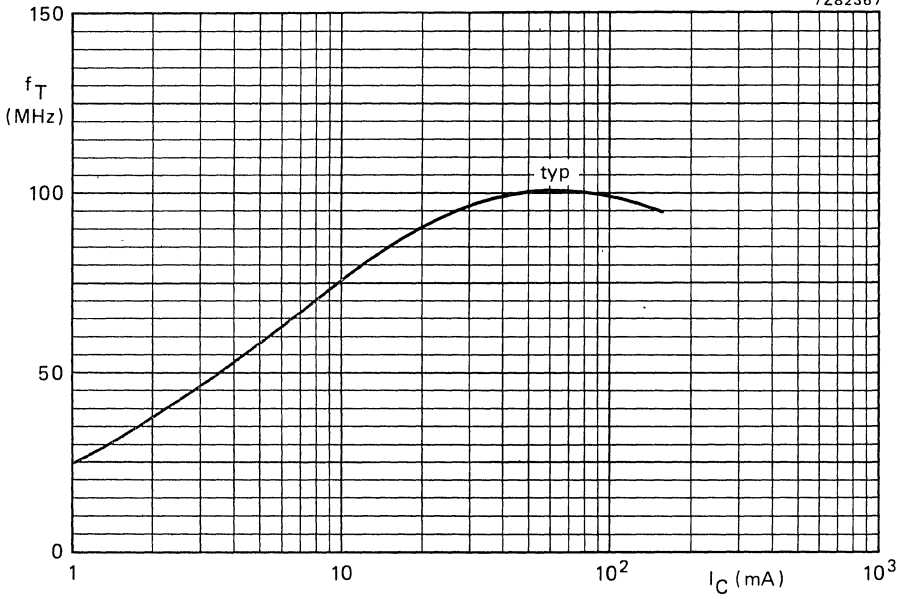


Fig. 15  $V_{CE} = 10 \text{ V}$ ;  $f = 20 \text{ MHz}$ ;  $T_j = 25 \text{ }^\circ\text{C}$ .

## SILICON PLANAR TRANSISTOR



N-P-N double diffused transistor in a TO-39 metal envelope designed for a wide variety of applications such as d.c. and wideband amplifiers.

## QUICK REFERENCE DATA

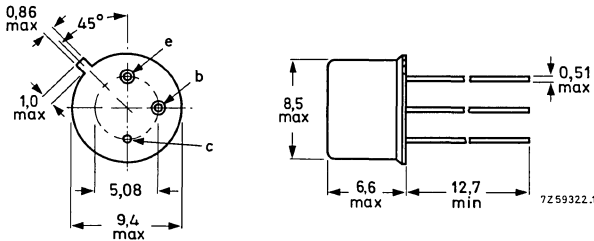
Collector-base voltage (open emitter)	$V_{CBO}$	max.	75 V
Collector-emitter voltage ( $R_{BE} \leq 10 \Omega$ )	$V_{CER}$	max.	50 V
Collector current (peak value)	$I_{CM}$	max.	1,0 A
Total power dissipation up to $T_{amb} = 25 \text{ }^\circ\text{C}$	$P_{tot}$	max.	0,8 W
D.C. current gain	$h_{FE}$		100 to 300
$I_C = 150 \text{ mA}; V_{CE} = 10 \text{ V}$			
Transition frequency at $f = 20 \text{ MHz}$	$f_T$	>	70 MHz
$I_C = 50 \text{ mA}; V_{CE} = 10 \text{ V}$			

## MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).



**RATINGS**

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

Collector-base voltage (open emitter)	$V_{CBO}$	max.	75 V
Collector-emitter voltage ( $R_{BE} \leq 10 \Omega$ )	$V_{CER}$	max.	50 V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	7,0 V
Collector current (peak value)	$I_{CM}$	max.	1,0 A
Total power dissipation			
up to $T_{amb} = 25 \text{ }^\circ\text{C}$	$P_{tot}$	max.	0,8 W
up to $T_{case} = 100 \text{ }^\circ\text{C}$	$P_{tot}$	max.	1,7 W
up to $T_{case} = 25 \text{ }^\circ\text{C}$	$P_{tot}$	max.	3,0 W
Storage temperature	$T_{stg}$		-65 to +200 $^\circ\text{C}$
Junction temperature	$T_j$	max.	200 $^\circ\text{C}$
Lead soldering temperature			
> 1,5 mm from the seating plane; $t_{sld} < 10 \text{ s}$	$T_{sld}$	max.	300 $^\circ\text{C}$

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th \text{ j-a}}$	=	219 K/W
From junction to case	$R_{th \text{ j-c}}$	=	58,3 K/W

## CHARACTERISTICS

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

Collector cut-off current

$$I_E = 0; V_{CB} = 60\text{ V}$$

$$I_{CBO} < 10\text{ nA}$$

$$I_E = 0; V_{CB} = 60\text{ V}; T_{amb} = 150\text{ }^{\circ}\text{C}$$

$$I_{CBO} < 10\text{ }\mu\text{A}$$

Emitter cut-off current

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

$$I_{EBO} < 5\text{ nA}$$

Collector-base breakdown voltage

$$\text{open emitter}; I_C = 100\text{ }\mu\text{A}$$

$$V_{(BR)CBO} > 75\text{ V}$$

Emitter-base breakdown voltage

$$\text{open collector}; I_E = 100\text{ }\mu\text{A}$$

$$V_{(BR)EBO} > 7,0\text{ V}$$

Collector-emitter sustaining voltage \*

$$I_C = 100\text{ mA}; R_{BE} \leq 10\text{ }\Omega$$

$$V_{CERsust} > 50\text{ V}$$

Saturation voltages \*

$$I_C = 150\text{ mA}; I_B = 15\text{ mA}$$

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

$$V_{BEsat} < 1,3\text{ V}$$

D.C. current gain

$$I_C = 10\text{ }\mu\text{A}; V_{CE} = 10\text{ V}$$

$$h_{FE} > 20$$

$$I_C = 0,1\text{ mA}; V_{CE} = 10\text{ V}$$

$$h_{FE} > 35$$

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

$$h_{FE} > 75$$

$$I_C = 10\text{ mA}; V_{CE} = 10\text{ V}; T_{amb} = -55\text{ }^{\circ}\text{C}$$

$$h_{FE} > 35$$

$$I_C = 150\text{ mA}; V_{CE} = 10\text{ V} *$$

$$h_{FE} 100\text{ to }300$$

$$I_C = 500\text{ mA}; V_{CE} = 10\text{ V} *$$

$$h_{FE} > 40$$

Transition frequency at  $f = 20\text{ MHz}$

$$I_C = 50\text{ mA}; V_{CE} = 10\text{ V}$$

$$f_T > 70\text{ MHz}$$

Collector capacitance

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

$$C_c < 25\text{ pF}$$

Emitter capacitance

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

$$C_e < 80\text{ pF}$$

Noise figure at  $f = 1\text{ kHz}$

$$I_C = 300\text{ }\mu\text{A}; V_{CE} = 10\text{ V}; R_S = 510\text{ }\Omega; B = 1\text{ Hz}$$

$$F < 8,0\text{ dB}$$

**h-parameters at  $f = 1\text{ kHz}$**

Input impedance

$$I_C = 1,0\text{ mA}; V_{CB} = 5,0\text{ V}$$

$$h_{ib} 24\text{ to }34\text{ }\Omega$$

$$I_C = 5,0\text{ mA}; V_{CB} = 10\text{ V}$$

$$h_{ib} 4,0\text{ to }8,0\text{ }\Omega$$

Reverse voltage transfer ratio

$$I_C = 1,0\text{ mA}; V_{CB} = 5,0\text{ V}$$

$$h_{rb} < 5,0 \cdot 10^{-4}$$

$$I_C = 5,0\text{ mA}; V_{CB} = 10\text{ V}$$

$$h_{rb} < 5,0 \cdot 10^{-4}$$

Small-signal current gain

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

$$h_{fe} 50\text{ to }200$$

$$I_C = 5,0\text{ mA}; V_{CE} = 10\text{ V}$$

$$h_{fe} 70\text{ to }300$$

\* Measured under pulse conditions to avoid excessive dissipation:  $t_p \leq 300\text{ }\mu\text{s}$ ;  $\delta \leq 0,02$ .

2N1711

Output admittance

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

$I_C = 5,0 \text{ mA}; V_{CE} = 10 \text{ V}$

$h_{ob}$  0,05 to 0,5  $\mu\text{A/V}$

$h_{ob}$  0,05 to 0,5  $\mu\text{A/V}$



## SILICON TRANSISTOR



High voltage n-p-n transistor in a TO-39 metal envelope with the collector connected to the case. It is intended for use in high performance amplifier, oscillator and switching applications.

## QUICK REFERENCE DATA

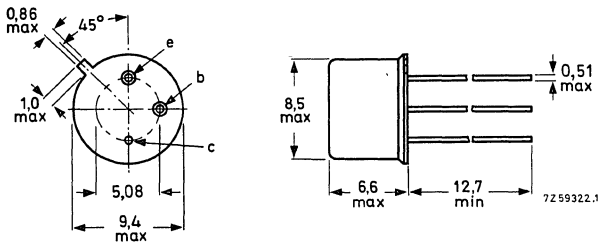
Collector-base voltage (open emitter)	$V_{CBO}$	max.	120 V
Collector-emitter voltage ( $R_{BE} \leq 10 \Omega$ )	$V_{CER}$	max.	100 V
Collector current (d.c.)	$I_C$	max.	500 mA
Total power dissipation up to $T_{case} = 25 \text{ }^\circ\text{C}$	$P_{tot}$	max.	3,0 W
Junction temperature	$T_j$	max.	200 $^\circ\text{C}$
D.C. current gain			
$I_C = 0,1 \text{ mA}; V_{CE} = 10 \text{ V}$	$h_{FE}$	>	20
$I_C = 10 \text{ mA}; V_{CE} = 10 \text{ V}; T = -55 \text{ }^\circ\text{C}$	$h_{FE}$	>	20
$I_C = 10 \text{ mA}; V_{CE} = 10 \text{ V}$	$h_{FE}$	>	35
$I_C = 150 \text{ mA}; V_{CE} = 10 \text{ V}$	$h_{FE}$	40 to	120

## MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).



**CHARACTERISTICS** $T_{amb} = 25\text{ }^{\circ}\text{C}$  unless otherwise specifiedCollector cut-off current

$$I_E = 0; V_{CB} = 90\text{ V} \quad I_{CBO} < 10\text{ nA}$$

$$I_E = 0; V_{CB} = 90\text{ V}; T_{amb} = 150\text{ }^{\circ}\text{C} \quad I_{CBO} < 15\text{ }\mu\text{A}$$

Emitter cut-off current

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

Collector-emitter sustaining voltage <sup>1)</sup>

$$I_C = 100\text{ mA}; R_{BE} \geq 10\text{ }\Omega \quad V_{CER\text{ sust}} > 100\text{ V}$$

$$I_C = 30\text{ mA}; I_B = 0 \quad V_{CEO\text{ sust}} > 80\text{ V}$$

Saturation voltages <sup>1)</sup>

$$I_C = 150\text{ mA}; I_B = 15\text{ mA} \quad V_{CE\text{ sat}} < 5.0\text{ V}$$

$$V_{BE\text{ sat}} < 1.3\text{ V}$$

$$I_C = 50\text{ mA}; I_B = 5\text{ mA} \quad V_{CE\text{ sat}} < 1.2\text{ V}$$

$$V_{BE\text{ sat}} < 0.9\text{ V}$$

Breakdown voltages

$$I_E = 0; I_C = 100\text{ }\mu\text{A} \quad V_{(BR)\text{ CBO}} > 120\text{ V}$$

$$I_C = 0; I_E = 100\text{ }\mu\text{A} \quad V_{(BR)\text{ EBO}} > 7.0\text{ V}$$

D.C. current gain

$$I_C = 0.1\text{ mA}; V_{CE} = 10\text{ V} \quad h_{FE} > 20$$

$$I_C = 10\text{ mA}; V_{CE} = 10\text{ V}; T = -55\text{ }^{\circ}\text{C} \quad h_{FE} > 20$$

$$I_C = 10\text{ mA}; V_{CE} = 10\text{ V} \text{ }^1) \quad h_{FE} > 35$$

$$I_C = 150\text{ mA}; V_{CE} = 10\text{ V} \text{ }^1) \quad h_{FE} \quad 40\text{ to }120$$

<sup>1)</sup> Measured under pulsed conditions to avoid excessive dissipation.  
Pulse duration  $t \leq 300\text{ }\mu\text{s}$ , duty cycle  $\delta < 0.02$

**CHARACTERISTICS** (continued)

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

h parameters at  $f = 1\text{ kHz}$  (common base)

$I_C = 1\text{ mA}; V_{CE} = 5\text{ V}$

Input impedance

$h_{ib} \quad 20\text{ to }30 \quad \Omega$

Reverse voltage transfer ratio

$h_{rb} \quad 1.25 \quad 10^{-4}$

Output conductance

$h_{ob} \quad 0.5 \quad \mu\Omega^{-1}$

$I_C = 5\text{ mA}; V_{CE} = 10\text{ V}$

Input impedance

$h_{ib} \quad 4\text{ to }8 \quad \Omega$

Reverse voltage transfer ratio

$h_{rb} \quad 1.50 \quad 10^{-4}$

Output conductance

$h_{ob} \quad 0.5 \quad \mu\Omega^{-1}$

Small signal current gain (common emitter)

$I_C = 1\text{ mA}; V_{CE} = 5\text{ V}; f = 1\text{ kHz}$

$h_{fe} \quad 30\text{ to }100$

$I_C = 5\text{ mA}; V_{CE} = 10\text{ V}; f = 1\text{ kHz}$

$h_{fe} \quad > 45$

$I_C = 50\text{ mA}; V_{CE} = 10\text{ V}; f = 20\text{ MHz}$

$h_{fe} \quad > 2.5$

Collector capacitance

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

$C_c \quad < 15 \quad \text{pF}$

Emitter capacitance

$I_C = I_c = 0; V_{EB} = 0.5\text{ V}$

$C_e \quad < 85 \quad \text{pF}$

SILICON PLANAR EPITAXIAL TRANSISTORS



N-P-N transistors in a TO-39 metal envelope with the collector connected to the case. They are primarily intended for high speed switching. The 2N2218 is also suitable for d.c. and v.h.f./u.h.f. amplifiers.

QUICK REFERENCE DATA

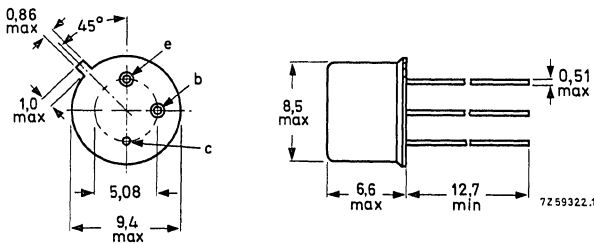
		2N2218	2N2218A	
Collector-base voltage (open emitter)	$V_{CBO}$ max.	60	75	V
Collector-emitter voltage (open base)	$V_{CEO}$ max.	30	40	V
Collector current (d.c.)	$I_C$ max.	800	800	mA
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$ max.	0,8	0,8	W
Junction temperature	$T_j$ max.	175	175	$^\circ\text{C}$
D.C. current gain at $T_j = 25\text{ }^\circ\text{C}$ $I_C = 10\text{ mA}; V_{CE} = 10\text{ V}$	$h_{FE}$	> 35	35	
Transition frequency at $f = 100\text{ MHz}$ $I_C = 20\text{ mA}; V_{CE} = 20\text{ V}$	$f_T$	> 250	250	MHz
Storage time $I_C = 150\text{ mA}; I_B = -I_{BM} = 15\text{ mA}$	$t_s$	< -	225	ns

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).



# 2N2218

## 2N2218A

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

<u>Voltages</u>		2N2218	2N2218A
Collector-base voltage (open emitter)	$V_{CBO}$	max. 60	75 V
Collector-emitter voltage (open base)	$V_{CEO}$	max. 30	40 <sup>1)</sup> V
Emitter-base voltage (open collector)	$V_{EBO}$	max. 5	6 V

### Current

Collector current (d.c.)	$I_C$	max. 800	mA
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### Power dissipation

Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max. 0.8	W
up to $T_{case} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max. 3	W

### Temperatures

Storage temperature	$T_{stg}$	-65 to +200	$^\circ\text{C}$
Junction temperature	$T_j$	max. 175	$^\circ\text{C}$

### **THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th\ j-a}$	= 190	$^\circ\text{C/W}$
From junction to case	$R_{th\ j-c}$	= 50	$^\circ\text{C/W}$

### **CHARACTERISTICS**

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

<u>Collector-cut-off current</u>		2N2218	2N2218A
$I_E = 0; V_{CB} = 50\text{ V}$	$I_{CBO}$	< 10	- nA
$I_E = 0; V_{CB} = 50\text{ V}; T_{amb} = 150\text{ }^\circ\text{C}$	$I_{CBO}$	< 10	- $\mu\text{A}$
$I_E = 0; V_{CB} = 60\text{ V}$	$I_{CBO}$	< -	10 nA
$I_E = 0; V_{CB} = 60\text{ V}; T_{amb} = 150\text{ }^\circ\text{C}$	$I_{CBO}$	< -	10 $\mu\text{A}$
<u>Emitter cut-off current</u>			
$I_C = 0; V_{EB} = 3\text{ V}$	$I_{EBO}$	< 10	10 nA
<u>Currents at reverse biased emitter junction</u>			
$V_{CE} = 60\text{ V}; -V_{BE} = 3\text{ V}$	$I_{CEX}$	< -	10 nA
	$-I_{BEX}$	< -	20 nA

1) Applicable up to  $I_C = 500\text{ mA}$

**CHARACTERISTICS** (continued)

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

		2N2218	2N2218A
<u>Breakdown voltages</u>			
$I_E = 0; I_C = 10\text{ }\mu\text{A}$	$V_{(BR)CBO} >$	60	75 V
$I_B = 0; I_C = 10\text{ mA}$	$V_{(BR)CEO} >$	30	40 V
$I_C = 0; I_E = 10\text{ }\mu\text{A}$	$V_{(BR)EBO} >$	5	6 V
<u>Saturation voltages</u> <sup>1)</sup>			
$I_C = 150\text{ mA}; I_B = 15\text{ mA}$	$V_{CEsat} <$	0.4	0.3 V
	$V_{BEsat} >$	-	0.6 V
	$V_{BEsat} <$	1.3	1.2 V
$I_C = 500\text{ mA}; I_B = 50\text{ mA}$	$V_{CEsat} <$	1.6	1.0 V
	$V_{BEsat} <$	2.6	2.0 V
<u>D.C. current gain</u>			
$I_C = 0.1\text{ mA}; V_{CE} = 10\text{ V}$	$h_{FE} >$	20	20
$I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$	$h_{FE} >$	25	25
$I_C = 10\text{ mA}; V_{CE} = 10\text{ V}$	$h_{FE} >$	35	35
$I_C = 10\text{ mA}; V_{CE} = 10\text{ V}; T_{amb} = -55\text{ }^\circ\text{C}$	$h_{FE} >$	-	15
$I_C = 150\text{ mA}; V_{CE} = 1\text{ V}$ <sup>1)</sup>	$h_{FE} >$	20	20
$I_C = 150\text{ mA}; V_{CE} = 10\text{ V}$ <sup>1)</sup>	$h_{FE}$	40 to 120	40 to 120
$I_C = 500\text{ mA}; V_{CE} = 10\text{ V}$ <sup>1)</sup>	$h_{FE} >$	20	25
<u>Transition frequency at <math>f = 100\text{ MHz}</math></u>			
$I_C = 20\text{ mA}; V_{CE} = 20\text{ V}$	$f_T >$	250	250 MHz
<u>Collector capacitance at <math>f = 100\text{ kHz}</math></u>			
$I_E = I_e = 0; V_{CB} = 10\text{ V}$	$C_c <$	8	8 pF
<u>Emitter capacitance at <math>f = 100\text{ kHz}</math></u>			
$I_C = I_c = 0; V_{EB} = 0.5\text{ V}$	$C_e <$	-	25 pF
<u>Feedback time constant at <math>f = 31.8\text{ MHz}</math></u>			
$I_C = 20\text{ mA}; V_{CE} = 20\text{ V}$	$r_b C_c <$	-	150 ps

<sup>1)</sup> Pulse duration  $\leq 300\text{ }\mu\text{s}$ ; duty cycle  $\leq 2\%$ .

**2N2218**  
**2N2218A**

**CHARACTERISTICS** (continued)

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

h parameters (common emitter)

$I_C = 1\text{ mA}; V_{CE} = 10\text{ V}; f = 1\text{ kHz}$

2N2218A

Input impedance	$h_{ie}$	1 to 3.5	$k\Omega$
Reverse voltage transfer ratio	$h_{re}$	< 5	$10^{-4}$
Small signal current gain	$h_{fe}$	30 to 150	
Output admittance	$h_{oe}$	3 to 15	$\mu\Omega^{-1}$

$I_C = 10\text{ mA}; V_{CE} = 10\text{ V}; f = 1\text{ kHz}$

Input impedance	$h_{ie}$	0.2 to 1.0	$k\Omega$
Reverse voltage transfer ratio	$h_{re}$	< 2.5	$10^{-4}$
Small signal current gain	$h_{fe}$	50 to 300	
Output admittance	$h_{oe}$	10 to 100	$\mu\Omega^{-1}$

$I_C = 20\text{ mA}; V_{CE} = 20\text{ V}; f = 100\text{ MHz}$

2N2218	2N2218A
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Small signal current gain	$h_{fe}$	> 2.5	2.5
$I_C = 20\text{ mA}; V_{CE} = 20\text{ V}; f = 300\text{ MHz}$			
Real part of input impedance	$\text{Re}(h_{ie})$	< 60	60 $\Omega$

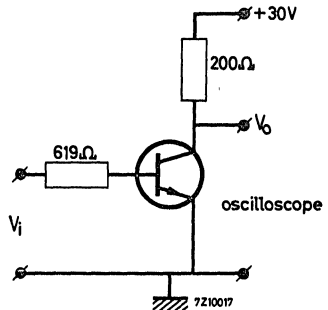
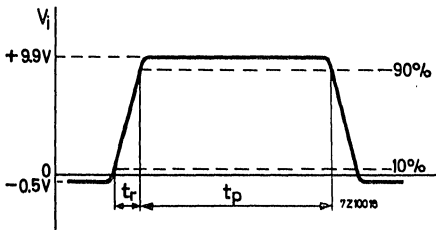
Switching times for 2N2218A

Turn on time when switched from  
 $-V_{BE} = 0.5\text{ V}$  to  $I_C = 150\text{ mA}; I_B = 15\text{ mA}$

Delay time  
Rise time

$t_d < 10\text{ ns}$   
 $t_r < 25\text{ ns}$

Test circuit:



Pulse generator:

pulse duration:  $t_p \leq 200\text{ ns}$   
rise time:  $t_r \leq 2\text{ ns}$

Oscilloscope:

input resistance:  $R_i > 100\text{ k}\Omega$   
input capacitance:  $C_i < 12\text{ pF}$   
rise time:  $t_r < 5\text{ ns}$

Switching times for 2N2218A

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

Turn off time

$I_C = 150\text{ mA}; I_B = -I_{BM} = 15\text{ mA}$

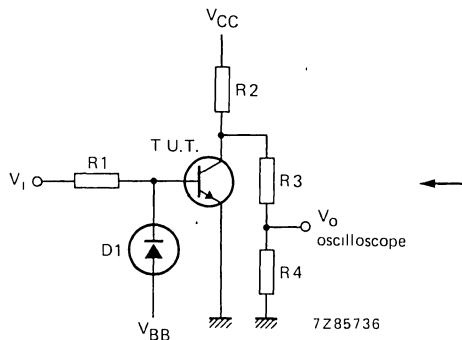
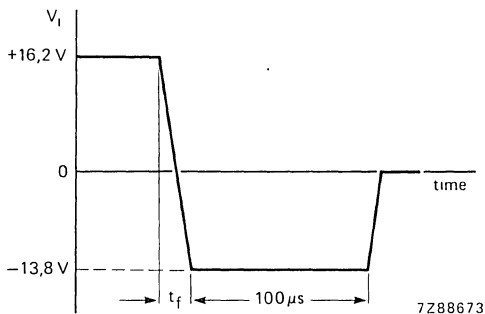
Storage time

$t_s < 225\text{ ns}$

Fall time

$t_f < 60\text{ ns}$

Test circuit:



$V_{CC} = +30\text{ V}; V_{BB} = -3\text{ V}; R1 = 1\text{ k}\Omega; R2 = 200\text{ }\Omega; R3 = 20\text{ k}\Omega; R4 = 50\text{ }\Omega; D1 = 1N916.$

Pulse generator:

fall time  $t_f < 5\text{ ns}$

Oscilloscope:

input impedance  $R_i > 100\text{ k}\Omega$   
input capacitance  $C_i < 12\text{ pF}$   
rise time  $t_r < 5\text{ ns}$



SILICON PLANAR EPITAXIAL TRANSISTORS



N-P-N transistors in a TO-39 metal envelope with the collector connected to the case. They are primarily intended for high speed switching. The 2N2219 is also suitable for d.c. and v.h.f./u.h.f. amplifiers.

QUICK REFERENCE DATA

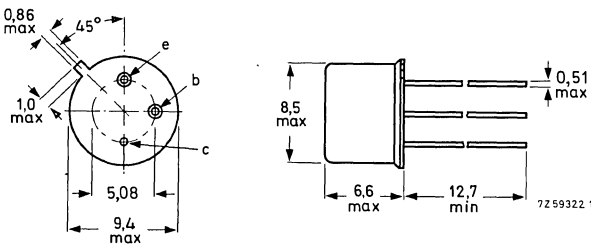
		2N2219	2N2219A	
Collector-base voltage (open emitter)	$V_{CBO}$	max. 60	75	V
Collector-emitter voltage (open base)	$V_{CEO}$	max. 30	40	V
Collector current (d.c.)	$I_C$	max. 800	800	mA
Total power dissipation up to $T_{amb} = 25^\circ\text{C}$	$P_{tot}$	max. 0,8	0,8	W
Junction temperature	$T_j$	max. 175	175	$^\circ\text{C}$
D.C. current gain at $T_j = 25^\circ\text{C}$ $I_C = 10\text{ mA}; V_{CE} = 10\text{ V}$	$h_{FE}$	> 75	75	
Transition frequency at $f = 100\text{ MHz}$ $I_C = 20\text{ mA}; V_{CE} = 20\text{ V}$	$f_T$	> 250	300	MHz
Storage time $I_C = 150\text{ mA}; I_B = -I_{BM} = 15\text{ mA}$	$t_s$	< -	225	ns

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).

# 2N2219

# 2N2219A

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

<u>Voltages</u>		2N2219	2N2219A
Collector-base voltage (open emitter)	$V_{CBO}$	max. 60	75 V
Collector-emitter voltage (open base)	$V_{CEO}$	max. 30	40 <sup>1)</sup> V
Emitter-base voltage (open collector)	$V_{EBO}$	max. 5	6 V

### Current

Collector current (d. c.)	$I_C$	max.	800 mA
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### Power dissipation

Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	0.8 W
up to $T_{case} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	3 W

### Temperatures

Storage temperature	$T_{stg}$	-65 to +200	$^\circ\text{C}$
Junction temperature	$T_J$	max.	175 $^\circ\text{C}$

### **THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th\ j-a}$	=	190 $^\circ\text{C/W}$
From junction to case	$R_{th\ j-c}$	=	50 $^\circ\text{C/W}$

### **CHARACTERISTICS**

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

<u>Collector cut-off current</u>		2N2219	2N2219A
$I_E = 0; V_{CB} = 50\text{ V}$	$I_{CBO}$	< 10	- nA
$I_E = 0; V_{CB} = 50\text{ V}; T_{amb} = 150\text{ }^\circ\text{C}$	$I_{CBO}$	< 10	- $\mu\text{A}$
$I_E = 0; V_{CB} = 60\text{ V}$	$I_{CBO}$	< -	10 nA
$I_E = 0; V_{CB} = 60\text{ V}; T_{amb} = 150\text{ }^\circ\text{C}$	$I_{CBO}$	< -	10 $\mu\text{A}$
<u>Emitter cut-off current</u>			
$I_C = 0; V_{EB} = 3\text{ V}$	$I_{EBO}$	< 10	10 nA
<u>Currents at reverse biased emitter junction</u>			
$V_{CE} = 60\text{ V}; -V_{BE} = 3\text{ V}$	$I_{CEX}$	< -	10 nA
	$-I_{BEX}$	< -	20 nA

1) Applicable up to  $I_C = 500\text{ mA}$

**CHARACTERISTICS** (continued)

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

		2N2219	2N2219A
<u>Breakdown voltages</u>			
$I_E = 0; I_C = 10 \mu\text{A}$	$V_{(BR)CBO} >$	60	75 V
$I_B = 0; I_C = 10 \text{ mA}$	$V_{(BR)CEO} >$	30	40 V
$I_C = 0; I_E = 10 \mu\text{A}$	$V_{(BR)EBO} >$	5	6 V
<u>Saturation voltages</u> <sup>1)</sup>			
$I_C = 150 \text{ mA}; I_B = 15 \text{ mA}$	$V_{CEsat} <$	0.4	0.3 V
	$V_{BEsat} <$	-	0.6 V
$I_C = 500 \text{ mA}; I_B = 50 \text{ mA}$	$V_{CEsat} <$	1.6	1.0 V
	$V_{BEsat} <$	2.6	2.0 V
<u>D. C. current gain</u>			
$I_C = 0.1 \text{ mA}; V_{CE} = 10 \text{ V}$	$h_{FE} >$	35	35
$I_C = 1 \text{ mA}; V_{CE} = 10 \text{ V}$	$h_{FE} >$	50	50
$I_C = 10 \text{ mA}; V_{CE} = 10 \text{ V}$	$h_{FE} >$	75	75
$I_C = 10 \text{ mA}; V_{CE} = 10 \text{ V}; T_{amb} = -55^\circ\text{C}$	$h_{FE} >$	-	35
$I_C = 150 \text{ mA}; V_{CE} = 1 \text{ V}$ <sup>1)</sup>	$h_{FE} >$	50	50
$I_C = 150 \text{ mA}; V_{CE} = 10 \text{ V}$ <sup>1)</sup>	$h_{FE} >$	100 to 300	100 to 300
$I_C = 500 \text{ mA}; V_{CE} = 10 \text{ V}$ <sup>1)</sup>	$h_{FE} >$	30	40
<u>Transition frequency</u> at $f = 100 \text{ MHz}$			
$I_C = 20 \text{ mA}; V_{CE} = 20 \text{ V}$	$f_T >$	250	300 MHz
<u>Collector capacitance</u> at $f = 100 \text{ kHz}$			
$I_E = I_c = 0; V_{CB} = 10 \text{ V}$	$C_c <$	8	8 pF
<u>Emitter capacitance</u> at $f = 100 \text{ kHz}$			
$I_C = I_c = 0; V_{EB} = 0.5 \text{ V}$	$C_e <$	-	25 pF
<u>Feedback time constant</u> at $f = 31.8 \text{ MHz}$			
$I_C = 20 \text{ mA}; V_{CE} = 20 \text{ V}$	$r_b' C_c <$	-	150 ps

<sup>1)</sup> Pulse duration  $\leq 300 \mu\text{s}$ ; duty cycle  $\leq 2\%$ .



# 2N2219

## 2N2219A

### CHARACTERISTICS (continued)

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

ü

#### h parameters (common emitter)

$I_C = 1\text{ mA}; V_{CE} = 10\text{ V}; f = 1\text{ kHz}$

Input impedance

Reverse voltage transfer ratio

Small signal current gain

Output admittance

		2N2219A	
$h_{ie}$	2 to 8	8	$k\Omega$
$h_{re}$	<	8	$10^{-4}$
$h_{fe}$	50 to 300		
$h_{oe}$	5 to 35		$\mu\Omega^{-1}$

$I_C = 10\text{ mA}; V_{CE} = 10\text{ V}; f = 1\text{ kHz}$

Input impedance

Reverse voltage transfer ratio

Small signal current gain

Output admittance

$h_{ie}$	0.25 to 1.25		$k\Omega$
$h_{re}$	<	4	$10^{-4}$
$h_{fe}$	75 to 375		
$h_{oe}$	25 to 200		$\mu\Omega^{-1}$

$I_C = 20\text{ mA}; V_{CE} = 20\text{ V}; f = 100\text{ MHz}$

Small signal current gain

$I_C = 20\text{ mA}; V_{CE} = 20\text{ V}; f = 300\text{ MHz}$

Real part of input impedance

	2N2219	2N2219A
$h_{fe}$	> 2.5	3.0
$Re(h_{ie})$	< 60	60 $\Omega$

#### Noise figure at $f = 1\text{ kHz}$

$I_C = 0.1\text{ mA}; V_{CE} = 10\text{ V}$

$R_G = 1\text{ k}\Omega; B = 1\text{ Hz}$

F	< -	4	dB
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#### Switching times for 2N2219A

Turn on time when switched from

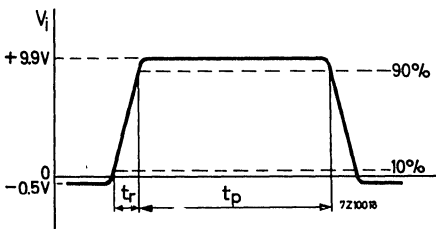
$-V_{BE} = 0.5\text{ V}$  to  $I_C = 150\text{ mA}; I_B = 15\text{ mA}$

Delay time

Rise time

$t_d$	<	10	ns
$t_r$	<	25	ns

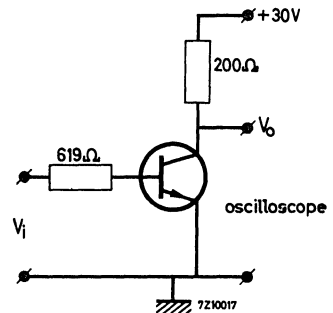
Test circuit:



Pulse generator:

pulse duration  $t_p \leq 200\text{ ns}$

rise time  $t_r \leq 2\text{ ns}$



Oscilloscope:

input resistance  $R_i > 100\text{ k}\Omega$

input capacitance  $C_i < 12\text{ pF}$

rise time  $t_r < 5\text{ ns}$

Switching times for 2N2219A

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

Turn off time

$I_C = 150\text{ mA}; I_B = -I_{BM} = 15\text{ mA}$

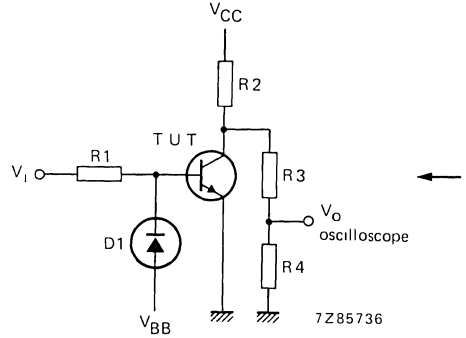
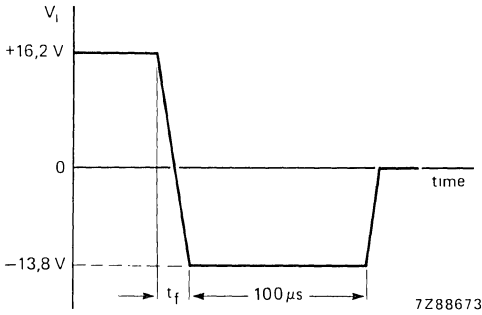
Storage time

$t_s < 225\text{ ns}$

Fall time

$t_f < 60\text{ ns}$

Test circuit:



$V_{CC} = +30\text{ V}; V_{BB} = -3\text{ V}; R1 = 1\text{ k}\Omega; R2 = 200\text{ }\Omega; R3 = 20\text{ k}\Omega; R4 = 50\text{ }\Omega; D1 = 1N916.$

Pulse generator:

fall time  $t_f < 5\text{ ns}$

Oscilloscope:

input impedance  $R_i > 100\text{ k}\Omega$   
input capacitance  $C_i < 12\text{ pF}$   
rise time  $t_r < 5\text{ ns}$



SILICON PLANAR EPITAXIAL TRANSISTORS



N-P-N transistors in a TO-18 metal envelope with the collector connected to the case. They are primarily intended for high speed switching. The 2N2221 is also suitable for d.c. and v.h.f./u.h.f. amplifiers.

QUICK REFERENCE DATA

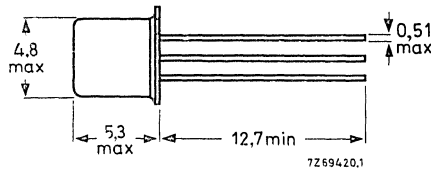
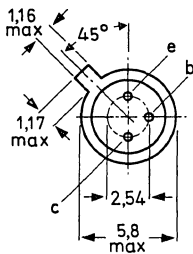
		2N2221	2N2221A	
Collector-base voltage (open emitter)	$V_{CBO}$ max.	60	75	V
Collector-emitter voltage (open base)	$V_{CEO}$ max.	30	40	V
Collector current (d.c.)	$I_C$ max.	800	800	mA
Total power dissipation up to $T_{amb} = 25^\circ\text{C}$	$P_{tot}$ max.	0,5	0,5	W
Junction temperature	$T_j$ max.	200	200	$^\circ\text{C}$
D.C. current gain at $T_j = 25^\circ\text{C}$ $I_C = 10\text{ mA}; V_{CE} = 10\text{ V}$	$h_{FE}$	> 35	35	
Transition frequency at $f = 100\text{ MHz}$ $I_C = 20\text{ mA}; V_{CE} = 20\text{ V}$	$f_T$	> 250	250	MHz
Storage time $I_C = 150\text{ mA}; I_B = -I_{BM} = 15\text{ mA}$	$t_s$	< -	225	ns

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector connected to case



Accessories: 56246 (distance disc).

2N2221  
2N2221A

**RATINGS**

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

		2N2221	2N2221A	
Collector-base voltage (open emitter)	$V_{CBO}$	max. 60	75	V
Collector-emitter voltage (open base)	$V_{CEO}$	max. 30	40*	V
Emitter-base voltage (open collector)	$V_{EBO}$	max. 5	6	V
Collector current (d.c.)	$I_C$	max. 800		mA
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max. 0,5		W
up to $T_{case} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max. 1,2		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 ambient in free air	$R_{th\ j-a}$	=	350	K/W
From junction to case	$R_{th\ j-c}$	=	146	K/W

**CHARACTERISTICS**

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

		2N2221	2N2221A	
Collector cut-off current $I_E = 0; V_{CB} = 50\text{ V}$	$I_{CBO}$	< 10	-	nA
$I_E = 0; V_{CB} = 50\text{ V}; T_{amb} = 150\text{ }^\circ\text{C}$	$I_{CBO}$	< 10	-	$\mu\text{A}$
$I_E = 0; V_{CB} = 60\text{ V}$	$I_{CBO}$	< -	10	nA
$I_E = 0; V_{CB} = 60\text{ V}; T_{amb} = 150\text{ }^\circ\text{C}$	$I_{CBO}$	< -	10	$\mu\text{A}$
Emitter cut-off current $I_C = 0; V_{EB} = 3\text{ V}$	$I_{EBO}$	< 10	10	nA
Currents at reverse biased emitter junction $V_{CE} = 60\text{ V}; -V_{BE} = 3\text{ V}$	$I_{CEX}$	< -	10	nA
	$-I_{BEX}$	< -	20	nA

\* Applicable up to  $I_C = 500\text{ mA}$ .

**CHARACTERISTICS** (continued)

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

<u>Breakdown voltages</u>		2N2221	2N2221A
$I_E = 0; I_C = 10\ \mu\text{A}$	$V_{(BR)CBO}$	> 60	75 V
$I_B = 0; I_C = 10\ \text{mA}$	$V_{(BR)CEO}$	> 30	40 V
$I_C = 0; I_E = 10\ \mu\text{A}$	$V_{(BR)EBO}$	> 5	6 V
<u>Saturation voltages</u> <sup>1)</sup>			
$I_C = 150\ \text{mA}; I_B = 15\ \text{mA}$	$V_{CEsat}$	< 0.4	0.3 V
	$V_{BEsat}$	> -	0.6 V
$I_C = 500\ \text{mA}; I_B = 50\ \text{mA}$	$V_{CEsat}$	< 1.3	1.2 V
	$V_{BEsat}$	< 1.6	1.0 V
	$V_{BEsat}$	< 2.6	2.0 V
<u>D. C. current gain</u>			
$I_C = 0.1\ \text{mA}; V_{CE} = 10\ \text{V}$	$h_{FE}$	> 20	20
$I_C = 1\ \text{mA}; V_{CE} = 10\ \text{V}$	$h_{FE}$	> 25	25
$I_C = 10\ \text{mA}; V_{CE} = 10\ \text{V}$	$h_{FE}$	> 35	35
$I_C = 10\ \text{mA}; V_{CE} = 10\ \text{V}; T_{amb} = -55^\circ\text{C}$	$h_{FE}$	> -	15
$I_C = 150\ \text{mA}; V_{CE} = 1\ \text{V}$ <sup>1)</sup>	$h_{FE}$	> 20	20
$I_C = 150\ \text{mA}; V_{CE} = 10\ \text{V}$ <sup>1)</sup>	$h_{FE}$	40 to 120	40 to 120
$I_C = 500\ \text{mA}; V_{CE} = 10\ \text{V}$ <sup>1)</sup>	$h_{FE}$	> 20	25
<u>Transition frequency at <math>f = 100\ \text{MHz}</math></u>			
$I_C = 20\ \text{mA}; V_{CE} = 20\ \text{V}$	$f_T$	> 250	250 MHz
<u>Collector capacitance at <math>f = 100\ \text{kHz}</math></u>			
$I_E = I_e = 0; V_{CB} = 10\ \text{V}$	$C_c$	< 8	8 pF
<u>Emitter capacitance at <math>f = 100\ \text{kHz}</math></u>			
$I_C = I_c = 0; V_{EB} = 0.5\ \text{V}$	$C_e$	< -	25 pF
<u>Feedback time constant at <math>f = 31.8\ \text{MHz}</math></u>			
$I_C = 20\ \text{mA}; V_{CE} = 20\ \text{V}$	$r_b' C_c$	< -	150 ps

<sup>1)</sup> Pulse duration  $\leq 300\ \mu\text{s}$ ; duty cycle  $\leq 2\%$ .

# 2N2221 2N2221A

## CHARACTERISTICS (continued)

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

### h parameters (common emitter)

$I_C = 1\text{ mA}; V_{CE} = 10\text{ V}; f = 1\text{ kHz}$

Input impedance

Reverse voltage transfer ratio

Small signal current gain

Output admittance

2N2221A	
$h_{ie}$	1 to 3.5 $k\Omega$
$h_{re}$	< 5 $10^{-4}$
$h_{fe}$	30 to 150
$h_{oe}$	3 to 15 $\mu\Omega^{-1}$

$I_C = 10\text{ mA}; V_{CE} = 10\text{ V}; f = 1\text{ kHz}$

Input impedance

Reverse voltage transfer ratio

Small signal current gain

Output admittance

$h_{ie}$	0.2 to 1.0 $k\Omega$
$h_{re}$	< 2.5 $10^{-4}$
$h_{fe}$	50 to 300
$h_{oe}$	10 to 100 $\mu\Omega^{-1}$

$I_C = 20\text{ mA}; V_{CE} = 20\text{ V}; f = 100\text{ MHz}$

Small signal current gain

$I_C = 20\text{ mA}; V_{CE} = 20\text{ V}; f = 300\text{ MHz}$

Real part of input impedance

	2N2221	2N2221A
$h_{fe}$	> 2.5	2.5
Re( $h_{ie}$ )	< 60	60 $\Omega$

### Switching times for 2N2221A

Turn on time when switched from

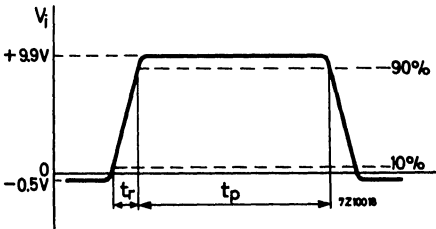
$-V_{BE} = 0.5\text{ V}$  to  $I_C = 150\text{ mA}; I_B = 15\text{ mA}$

Delay time

Rise time

$t_d$	< 10 ns
$t_r$	< 25 ns

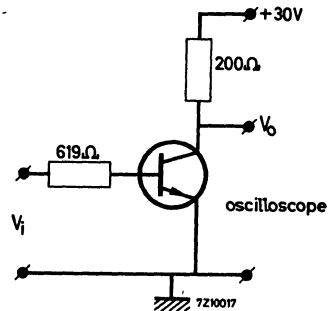
Test circuit:



Pulse generator:

pulse duration  $t_p \leq 200\text{ ns}$

rise time  $t_r \leq 2\text{ ns}$



Oscilloscope:

input resistance  $R_i > 100\text{ k}\Omega$

input capacitance  $C_i < 12\text{ pF}$

rise time  $t_r < 5\text{ ns}$

Switching times for 2N2221A

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

Turn off time

$I_C = 150\text{ mA}; I_B = -I_{BM} = 15\text{ mA}$

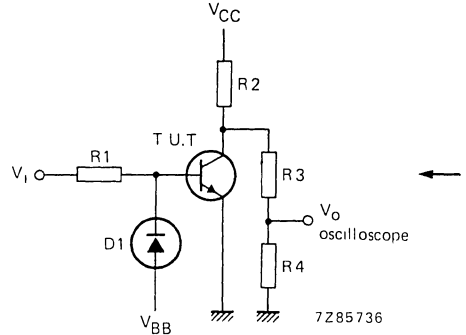
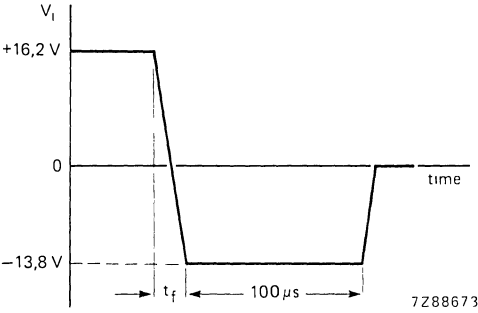
Storage time

$t_s < 225\text{ ns}$

Fall time

$t_f < 60\text{ ns}$

Test circuit:



$V_{CC} = +30\text{ V}; V_{BB} = -3\text{ V}; R_1 = 1\text{ k}\Omega; R_2 = 200\text{ }\Omega; R_3 = 20\text{ k}\Omega; R_4 = 50\text{ }\Omega; D_1 = 1N916.$

Pulse generator:

fall time:  $t_f < 5\text{ ns}$

Oscilloscope:

input impedance  $R_i > 100\text{ k}\Omega$   
 input capacitance  $C_i < 12\text{ pF}$   
 rise time  $t_r < 5\text{ ns}$





SILICON PLANAR EPITAXIAL TRANSISTORS



N-P-N transistors in a TO-18 metal envelope with the collector connected to the case. They are primarily intended for high speed switching. The 2N2222 is also suitable for d.c. and v.h.f./u.h.f. amplifiers.

QUICK REFERENCE DATA

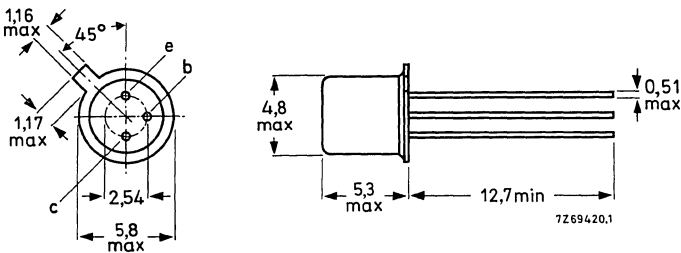
		2N2222	2N2222A	
Collector-base voltage (open emitter)	$V_{CBO}$	max. 60	75	V
Collector-emitter voltage (open base)	$V_{CEO}$	max. 30	40	V
Collector current (d.c.)	$I_C$	max. 800	800	mA
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max. 0,5	0,5	W
Junction temperature	$T_j$	max. 200	200	$^\circ\text{C}$
D.C. current gain at $T_j = 25\text{ }^\circ\text{C}$ $I_C = 10\text{ mA}$ ; $V_{CE} = 10\text{ V}$	$h_{FE}$	> 75	75	
Transition frequency at $f = 100\text{ MHz}$ $I_C = 20\text{ mA}$ ; $V_{CE} = 20\text{ V}$	$f_T$	> 250	300	MHz
Storage time $I_C = 150\text{ mA}$ ; $I_B = -I_{BM} = 15\text{ mA}$	$t_s$	< -	225	ns

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector connected to case



Accessories: 56246 (distance disc).

**RATINGS**

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

		2N2222	2N2222A	
Collector-base voltage (open emitter)	$V_{CBO}$	max. 60	75	V
Collector-emitter voltage (open base)	$V_{CEO}$	max. 30	40*	V
Emitter-base voltage (open collector)	$V_{EBO}$	max. 5	6	V
Collector current (d.c.)	$I_C$	max. 800		mA
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$ up to $T_{case} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max. 0,5		W
	$P_{tot}$	max. 1,2		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 ambient in free air	$R_{th\ j-a}$	=	350	K/W
From junction to case	$R_{th\ j-c}$	=	146	K/W

**CHARACTERISTICS**

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

		2N2222	2N2222A	
Collector cut-off current $I_E = 0; V_{CB} = 50\text{ V}$ $I_E = 0; V_{CB} = 50\text{ V}; T_{amb} = 150\text{ }^\circ\text{C}$ $I_E = 0; V_{CB} = 60\text{ V}$ $I_E = 0; V_{CB} = 60\text{ V}; T_{amb} = 150\text{ }^\circ\text{C}$	$I_{CBO}$	< 10	—	nA
	$I_{CBO}$	< 10	—	$\mu\text{A}$
	$I_{CBO}$	< —	10	nA
	$I_{CBO}$	< —	10	$\mu\text{A}$
	Emitter cut-off current $I_C = 0; V_{EB} = 3\text{ V}$	$I_{EBO}$	< 10	10
Currents at reverse biased emitter junction $V_{CE} = 60\text{ V}; -V_{BE} = 3\text{ V}$	$I_{CEX}$	< —	10	nA
	$-I_{BEX}$	< —	20	nA

\* Applicable up to  $I_C = 500\text{ mA}$ .

**CHARACTERISTICS** (continued)

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

		2N2222	2N2222A
<u>Breakdown voltages</u>			
$I_E = 0; I_C = 10\text{ }\mu\text{A}$	$V_{(BR)CBO} >$	60	75 V
$I_B = 0; I_C = 10\text{ mA}$	$V_{(BR)CEO} >$	30	40 V
$I_C = 0; I_E = 10\text{ }\mu\text{A}$	$V_{(BR)EBO} >$	5	6 V
<u>Saturation voltages</u> <sup>1)</sup>			
$I_C = 150\text{ mA}; I_B = 15\text{ mA}$	$V_{CEsat} <$	0.4	0.3 V
	$V_{BEsat} >$	-	0.6 V
	$V_{BEsat} <$	1.3	1.2 V
$I_C = 500\text{ mA}; I_B = 50\text{ mA}$	$V_{CEsat} <$	1.6	1.0 V
	$V_{BEsat} <$	2.6	2.0 V
<u>D.C. current gain</u>			
$I_C = 0.1\text{ mA}; V_{CE} = 10\text{ V}$	$h_{FE} >$	35	35
$I_C = 1\text{ mA}; V_{CE} = 10\text{ V}$	$h_{FE} >$	50	50
$I_C = 10\text{ mA}; V_{CE} = 10\text{ V}$	$h_{FE} >$	75	75
$I_C = 10\text{ mA}; V_{CE} = 10\text{ V}; T_{amb} = -55\text{ }^\circ\text{C}$	$h_{FE} >$	-	35
$I_C = 150\text{ mA}; V_{CE} = 1\text{ V } \uparrow$	$h_{FE} >$	50	50
$I_C = 150\text{ mA}; V_{CE} = 10\text{ V } \uparrow$	$h_{FE}$	100 to 300	100 to 300
$I_C = 500\text{ mA}; V_{CE} = 10\text{ V } \uparrow$	$h_{FE} >$	30	40
<u>Transition frequency</u> at $f = 100\text{ MHz}$			
$I_C = 20\text{ mA}; V_{CE} = 20\text{ V}$	$f_T >$	250	300 MHz
<u>Collector capacitance</u> at $f = 100\text{ kHz}$			
$I_E = I_e = 0; V_{CB} = 10\text{ V}$	$C_c <$	8	8 pF
<u>Emitter capacitance</u> at $f = 100\text{ kHz}$			
$I_C = I_c = 0; V_{EB} = 0.5\text{ V}$	$C_e <$	-	25 pF
<u>Feedback time constant</u> at $f = 31.8\text{ MHz}$			
$I_C = 20\text{ mA}; V_{CE} = 20\text{ V}$	$r_b' C_c <$	-	150 ps

<sup>1)</sup> Pulse duration  $\leq 300\text{ }\mu\text{s}$ ; duty cycle  $\leq 2\%$ .

# 2N2222

# 2N2222A

## CHARACTERISTICS (continued)

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

### h parameters (common emitter)

$I_C = 1\text{ mA}; V_{CE} = 10\text{ V}; f = 1\text{ kHz}$

Input impedance  
Reverse voltage transfer ratio  
Small signal current  
Output admittance

2N2222A	
$h_{ie}$	2 to 8 $k\Omega$
$h_{re}$	< 8 $10^{-4}$
$h_{fe}$	50 to 300
$h_{oe}$	5 to 35 $\mu\Omega^{-1}$

$I_C = 10\text{ mA}; V_{CE} = 10\text{ V}; f = 1\text{ kHz}$

Input impedance  
Reverse voltage transfer ratio  
Small signal current gain  
Output admittance

$h_{ie}$	0.25 to 1.25 $k\Omega$
$h_{re}$	< 4 $10^{-4}$
$h_{fe}$	75 to 375
$h_{oe}$	25 to 200 $\mu\Omega^{-1}$

$I_C = 20\text{ mA}; V_{CE} = 20\text{ V}; f = 100\text{ MHz}$

Small signal current gain

2N2222	2N2222A
$h_{fe}$	> 2.5
$h_{fe}$	3.0

$I_C = 20\text{ mA}; V_{CE} = 20\text{ V}; f = 300\text{ MHz}$

Real part of input impedance

$\text{Re}(h_{ie})$	< 60	60 $\Omega$
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### Noise figure at $f = 1\text{ kHz}$

$I_C = 0.1\text{ mA}; V_{CE} = 10\text{ V}$   
 $R_G = 1\text{ k}\Omega; B = 1\text{ Hz}$

F	< -	4 dB
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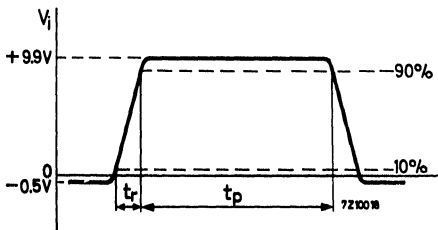
### Switching times for 2N2222A

Turn on time when switched from  
 $-V_{BE} = 0.5\text{ V}$  to  $I_C = 150\text{ mA}; I_B = 15\text{ mA}$

Delay time  
Rise time

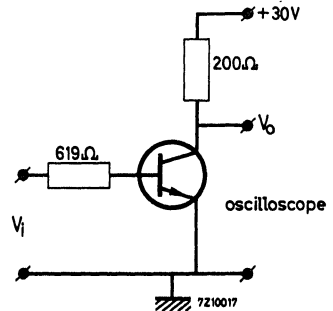
$t_d$	<	10 ns
$t_r$	<	25 ns

Test circuit:



Pulse generator:

pulse duration  $t_p \leq 200\text{ ns}$   
rise time  $t_r \leq 2\text{ ns}$



Oscilloscope:

input resistance  $R_i > 100\text{ k}\Omega$   
input capacitance  $C_i < 12\text{ pF}$   
rise time  $t_r < 5\text{ ns}$

Switching times for 2N2222A

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

Turn off time

$I_C = 150\text{ mA}; I_B = -I_{BM} = 15\text{ mA}$

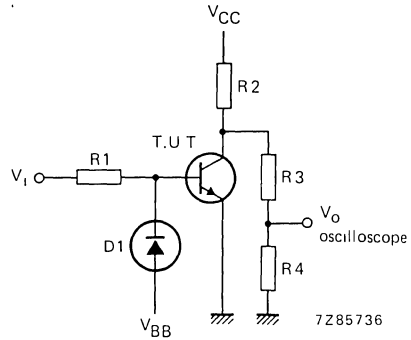
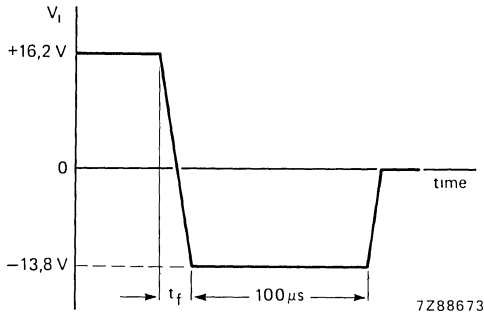
Storage time

$t_s < 225\text{ ns}$

Fall time

$t_f < 60\text{ ns}$

Test circuit:



$V_{CC} = +30\text{ V}; V_{BB} = -3\text{ V}; R_1 = 1\text{ k}\Omega; R_2 = 200\ \Omega; R_3 = 20\text{ k}\Omega; R_4 = 50\ \Omega; D_1 = 1N916.$

Pulse generator:

fall time  $t_f < 5\text{ ns}$

Oscilloscope:

input impedance  $R_i > 100\text{ k}\Omega$   
 input capacitance  $C_i < 12\text{ pF}$   
 rise time  $t_r < 5\text{ ns}$



## SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor intended for large signal h.f. and v.h.f. amplifier applications.

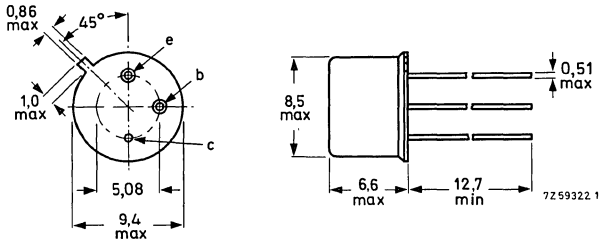
## QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$V_{CBO}$	max.	80 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	35 V
Collector current (d.c.)	$I_C$	max.	1,0 A
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	0,8 W
Junction temperature	$T_j$	max.	200 $^\circ\text{C}$
D.C. current gain $I_C = 150\text{ mA}; V_{CE} = 10\text{ V}$	$h_{FE}$		40 to 120
Transition frequency at $f = 20\text{ MHz}$ $I_C = 50\text{ mA}; V_{CE} = 10\text{ V}$	$f_T$	>	60 MHz

## MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39; collector connected to case.



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).



**RATINGS**

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

Collector-base voltage (open emitter)	$V_{CBO}$	max.	80 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	35 V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	7,0 V
Collector current (d.c.)	$I_C$	max.	1,0 A
Total power dissipation up to $T_{case} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	5,0 W
up to $T_{case} = 100\text{ }^\circ\text{C}$	$P_{tot}$	max.	2,8 W
up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	0,8 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 case	$R_{thj-c}$	=	35 K/W
From junction to ambient in free air	$R_{thj-a}$	=	219 K/W

## CHARACTERISTICS

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

Collector cut-off current

$I_E = 0; V_{CB} = 60\text{ V}$

$I_{CBO} < 10\text{ nA}$

$I_E = 0; V_{CB} = 60\text{ V}; T_{amb} = 150\text{ }^{\circ}\text{C}$

$I_{CBO} < 10\text{ }\mu\text{A}$

Emitter cut-off current

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

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

Collector-emitter sustaining voltage\*

$I_C = 30\text{ mA}; I_B = 0$

$V_{CEO\text{sust}} > 35\text{ V}$

Saturation voltages\*

$I_C = 150\text{ mA}; I_B = 15\text{ mA}$

$V_{CE\text{sat}} < 0,2\text{ V}$

$I_C = 1\text{ A}; I_B = 100\text{ mA}^{**}$

$V_{CE\text{sat}} < 1,0\text{ V}$

$V_{BE\text{sat}} < 1,6\text{ V}$

D.C. current gain\*

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

$h_{FE} > 30$

$I_C = 150\text{ mA}; V_{CE} = 10\text{ V}$

$h_{FE} \quad 40\text{ to }120$

$I_C = 1,0\text{ A}; V_{CE} = 10\text{ V}$

$h_{FE} > 15$

Feedback time constant

$I_C = 10\text{ mA}; V_{CB} = 10\text{ V}; f = 4,0\text{ MHz}$

$r_{bb}, C_{b'c} < 800\text{ ps}$

Collector capacitance at  $f = 500\text{ kHz}$

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

$C_c < 12\text{ pF}$

Emitter capacitance at  $f = 500\text{ kHz}$

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

$C_e < 80\text{ pF}$

Transition frequency at  $f = 20\text{ MHz}$

$I_C = 50\text{ mA}; V_{CE} = 10\text{ V}$

$f_T > 60\text{ MHz}$

\* Measured under pulse conditions to avoid excessive dissipation:  $t_p = 300\text{ }\mu\text{s}; \delta \leq 0,01$ .

\*\* Measured with a lead length of 1 cm.



## SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in a TO-18 metal envelope with the collector connected to the case. The 2N2368 and 2N2369 are primarily intended for use in very high-speed saturated switching and v.h.f. amplification.

### QUICK REFERENCE DATA

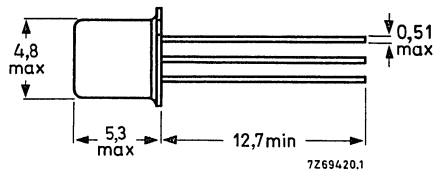
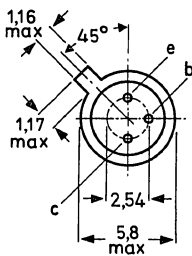
Collector-base voltage (open emitter)		$V_{CBO}$	max.	40 V
Collector-emitter voltage (open base)		$V_{CEO}$	max.	15 V
Collector current (peak value)		$I_{CM}$	max.	500 mA
Total power dissipation up to $T_{amb} = 25\text{ }^{\circ}\text{C}$		$P_{tot}$	max.	360 mW
Junction temperature		$T_j$	max.	200 $^{\circ}\text{C}$
D.C. current gain at $T_j = 25\text{ }^{\circ}\text{C}$		$h_{FE}$	20 to 60	
$I_C = 10\text{ mA}; V_{CE} = 1\text{ V}$	2N2368	$h_{FE}$	40 to 120	
	2N2369			
Transition frequency		$f_T$	>	400 MHz
$I_C = 10\text{ mA}; V_{CE} = 10\text{ V}$	2N2368	$f_T$	>	500 MHz
	2N2369			
Storage time		$t_s$	<	10 ns
$I_C = I_B = -I_{BM} = 10\text{ mA}$	2N2368	$t_s$	<	13 ns
	2N2369			

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector connected to case



Accessories: 56246 (distance disc).

**RATINGS (Limiting values) 1)**

Voltages

Collector-base voltage (open emitter)	$V_{CBO}$	max.	40 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	15 V
Collector-emitter voltage with $V_{BE} = 0$	$V_{CES}$	max.	40 V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	4.5 V

Current

Collector current (peak value; $t = 10 \mu s$ )	$I_{CM}$	max.	500 mA
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Power dissipation

Total power dissipation up to $T_{amb} = 25^\circ C$	$P_{tot}$	max.	360 mW
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Temperatures

Storage temperature	$T_{stg}$	-65 to +200	$^\circ C$
Junction temperature	$T_j$	max.	200 $^\circ C$

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th j-a}$	=	0.48 $^\circ C/mW$
From junction to case	$R_{th j-c}$	=	0.145 $^\circ C/mW$

1) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

**CHARACTERISTICS**

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

Collector cut-off current

$I_E = 0; V_{CB} = 20\text{ V}$	$I_{CBO}$	<	0.4 $\mu\text{A}$
$I_E = 0; V_{CB} = 20\text{ V}; T_j = 150\text{ }^\circ\text{C}$	$I_{CBO}$	<	30 $\mu\text{A}$

Sustaining voltage <sup>1)</sup>

$I_C = 10\text{ mA}; I_B = 0$	$V_{CEOsust}$	>	15 V <sup>1)</sup>
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Saturation voltages

$I_C = 10\text{ mA}; I_B = 1\text{ mA}$	$V_{CEsat}$	<	0.25 V
	$V_{BEsat}$		0.7 to 0.85 V

Collector capacitance at  $f = 140\text{ kHz}$

$I_E = I_e = 0; V_{CB} = 5\text{ V}$	$C_c$	<	4 pF
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D.C. current gain <sup>1)</sup>

		2N2368	2N2369
$I_C = 10\text{ mA}; V_{CE} = 1\text{ V}$	$h_{FE}$	20 to 60	40 to 120
$I_C = 10\text{ mA}; V_{CE} = 1\text{ V}; T_j = -55\text{ }^\circ\text{C}$	$h_{FE}$	> 10	20
$I_C = 100\text{ mA}; V_{CE} = 2\text{ V}$	$h_{FE}$	> 10	20

Transition frequency

$I_C = 10\text{ mA}; V_{CE} = 10\text{ V}$	$f_T$	>	400	500	MHz
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<sup>1)</sup> Measured under pulsed conditions to avoid excessive dissipation  
Pulse duration  $t = 300\text{ }\mu\text{s}$ ; duty cycle  $\delta = 0.01$

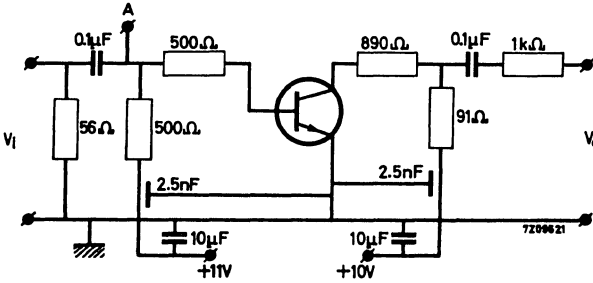
**CHARACTERISTICS (continued)**

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

Storage time

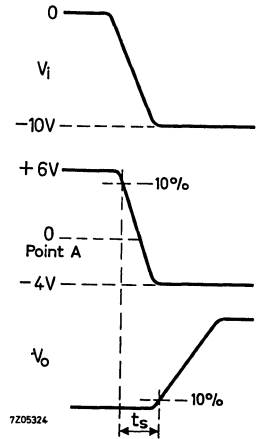
$I_C = I_B = -I_{BM} = 10\text{ mA}$

Test circuit: 1)



2N2368  
2N2369

$t_S < 10\text{ ns}$   
 $t_S < 13\text{ ns}$



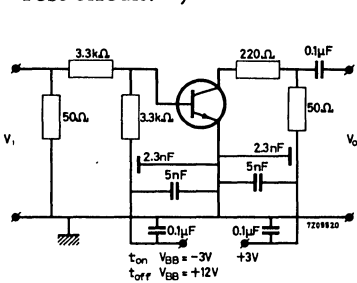
Turn on time

$I_C = 10\text{ mA}; I_B = 3\text{ mA}; -V_{BE} = 1.5\text{ V}$

Turn off time

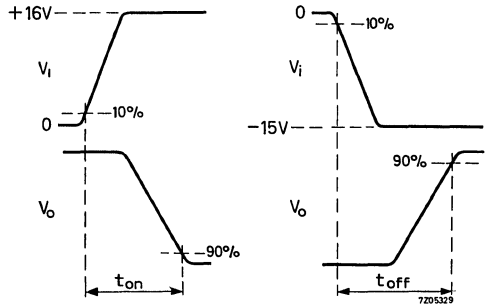
$I_C = 10\text{ mA}; I_B = 3\text{ mA}; -I_{BM} = 1.5\text{ mA}$

Test circuit: 1)



2N2368  
2N2369

$t_{off} < 15\text{ ns}$   
 $t_{off} < 18\text{ ns}$



1) Pulse generator:

Pulse duration  $t \geq 300\text{ ns}$   
Duty cycle  $\delta \leq 0.02$   
Rise time  $t_R \leq 1\text{ ns}$   
Source impedance  $R_S = 50\text{ }\Omega$

Oscilloscope:

Rise time  $t_R \leq 1\text{ ns}$   
Input impedance  $R_i = 50\text{ }\Omega$

## SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a TO-18 metal envelope primarily intended for high-speed saturated switching and high frequency amplifier applications.

## QUICK REFERENCE DATA

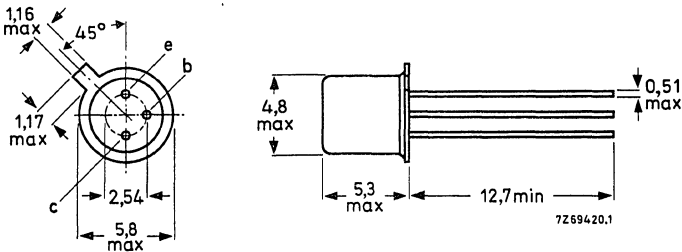
Collector-base voltage (open emitter)	$V_{CB0}$	max.	40 V
Collector-emitter voltage (open base)	$V_{CE0}$	max.	15 V
Collector current (peak value; $t_p = 10 \mu s$ )	$I_{CM}$	max.	500 mA
Total power dissipation up to $T_{amb} = 25 \text{ }^\circ\text{C}$	$P_{tot}$	max.	360 mW
Junction temperature	$T_j$	max.	200 $^\circ\text{C}$
D.C. current gain at $T_j = 25 \text{ }^\circ\text{C}$			
$I_C = 10 \text{ mA}; V_{CE} = 0,35 \text{ V}$	$h_{FE}$	>	40
$I_C = 10 \text{ mA}; V_{CE} = 1,0 \text{ V}$	$h_{FE}$	<	120
Transition frequency at $f = 100 \text{ MHz}$			
$I_C = 10 \text{ mA}; V_{CE} = 10 \text{ V}$	$f_T$	>	500 MHz
Storage time			
$I_{Con} = I_{Bon} = -I_{Boff} = 10 \text{ mA}$	$t_s$	<	13 ns

## MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector connected to case.



Accessories: 56246 (distance disc).



**RATINGS**

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

Collector-base voltage (open emitter)	$V_{CB0}$	max.	40 V
Collector-emitter voltage (open base) $I_C = 0,01$ mA to 10 mA	$V_{CEO}$	max.	15 V
Collector-emitter voltage ( $V_{BE} = 0$ )	$V_{CES}$	max.	40 V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	4,5 V
Collector current (d.c.)	$I_C$	max.	200 mA
Collector current (peak value; $t_p = 10 \mu s$ )	$I_{CM}$	max.	500 mA
Total power dissipation up to $T_{amb} = 25 \text{ }^\circ\text{C}$	$P_{tot}$	max.	360 mW
up to $T_{case} = 25 \text{ }^\circ\text{C}$	$P_{tot}$	max.	1200 mW
up to $T_{case} = 100 \text{ }^\circ\text{C}$	$P_{tot}$	max.	680 mW
Storage temperature	$T_{stg}$		-65 to + 200 $^\circ\text{C}$
Junction temperature	$T_j$	max.	200 $^\circ\text{C}$

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th\ j-a}$	=	486 K/W
From junction to case	$R_{th\ j-c}$	=	146 K/W

## CHARACTERISTICS

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

Collector cut-off current

$V_{BE} = 0; V_{CE} = 20\text{ V}$

$I_{CES} < 0,4\text{ }\mu\text{A}$

$I_E = 0; V_{CB} = 20\text{ V}; T_{amb} = 150\text{ }^{\circ}\text{C}$

$I_{CBO} < 30\text{ }\mu\text{A}$

Base current

$V_{BE} = 0; V_{CE} = 20\text{ V}$

$-I_{BEX} < 0,4\text{ }\mu\text{A}$

Collector-base breakdown voltage

open emitter;  $I_C = 10\text{ }\mu\text{A}$

$V_{(BR)CBO} > 40\text{ V}$

Collector-emitter breakdown voltage

$V_{BE} = 0; I_C = 10\text{ }\mu\text{A}$

$V_{(BR)CES} > 40\text{ V}$

Emitter-base breakdown voltage

open collector;  $I_E = 10\text{ }\mu\text{A}$

$V_{(BR)EBO} > 4,5\text{ V}$

Collector-emitter sustaining voltage\*

open base;  $I_C = 10\text{ mA}$

$V_{CEO\text{sust}} > 15\text{ V}$

Saturation voltages

$I_C = 10\text{ mA}; I_B = 1,0\text{ mA}$

$V_{CE\text{sat}} < 0,20\text{ V}$

$V_{BE\text{sat}} 0,70\text{ to }0,85\text{ V}$

$I_C = 10\text{ mA}; I_B = 1,0\text{ mA}; T_{amb} = 125\text{ }^{\circ}\text{C}$

$V_{CE\text{sat}} < 0,30\text{ V}$

$V_{BE\text{sat}} > 0,59\text{ V}$

$I_C = 10\text{ mA}; I_B = 1,0\text{ mA}; T_{amb} = -55\text{ }^{\circ}\text{C}$

$V_{BE\text{sat}} < 1,02\text{ V}$

$I_C = 30\text{ mA}; I_B = 3,0\text{ mA}$

$V_{CE\text{sat}} < 0,25\text{ V}$

$V_{BE\text{sat}} < 1,15\text{ V}$

$I_C = 100\text{ mA}; I_B = 10\text{ mA}$

$V_{CE\text{sat}} < 0,50\text{ V}$

$V_{BE\text{sat}} < 1,60\text{ V}$

D.C. current gain\*

$I_C = 10\text{ mA}; V_{CE} = 0,35\text{ V}$

$h_{FE} > 40$

$I_C = 10\text{ mA}; V_{CE} = 0,35\text{ V}; T_{amb} = -55\text{ }^{\circ}\text{C}$

$h_{FE} > 20$

$I_C = 10\text{ mA}; V_{CE} = 1,0\text{ V}$

$h_{FE} < 120$

$I_C = 30\text{ mA}; V_{CE} = 0,4\text{ V}$

$h_{FE} > 30$

$I_C = 100\text{ mA}; V_{CE} = 1,0\text{ V}$

$h_{FE} > 20$

Collector capacitance at  $f = 140\text{ kHz}$

$I_E = I_e = 0; V_{CB} = 5,0\text{ V}$

$C_c < 4,0\text{ pF}$

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

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

$f_T > 500\text{ MHz}$

\* Measured under pulse conditions to avoid excessive dissipation:  $t_p = 300\text{ }\mu\text{s}; \delta \leq 0,02$ .

Storage time (see Figs 2 and 3)

$$I_{Con} = I_{Bon} = -I_{Boff} = 10 \text{ mA}$$

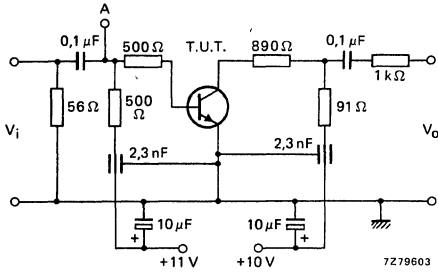


Fig. 2 Storage time test circuit.

$$t_s < 13 \text{ ns}$$

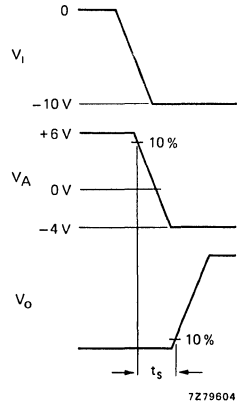


Fig. 3 Waveforms at input, point A and output.

Turn-on time (see Figs 4 and 5)

$$I_{Con} = 10 \text{ mA}; I_{Bon} = 3 \text{ mA}; -V_{BEoff} = 1,5 \text{ V}$$

Turn-off time (see Figs 4 and 5)

$$I_{Con} = 10 \text{ mA}; I_{Bon} = 3 \text{ mA}; -I_{Boff} = 1,5 \text{ mA}$$

$$t_{on} < 12 \text{ ns}$$

$$t_{off} < 18 \text{ ns}$$

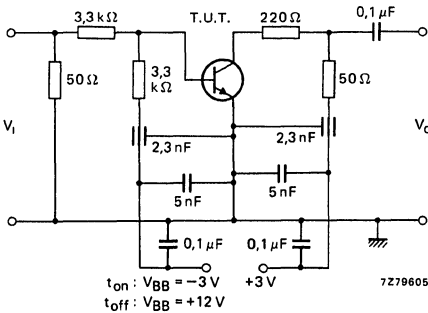


Fig. 4 Turn-on and turn-off test circuit.

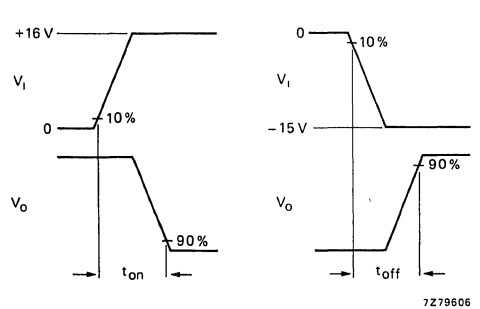


Fig. 5 Input and output waveforms.

Pulse generator:

Rise time	$t_r \leq$	1 ns
Pulse duration	$t_p \geq$	300 ns
Duty factor	$\delta \leq$	0,02
Source impedance	$R_S =$	50 $\Omega$

Oscilloscope:

Rise time	$t_r \leq$	1 ns
Input impedance	$R_i =$	50 $\Omega$

## SILICON PLANAR TRANSISTORS

N-P-N transistors in TO-18 metal envelopes with the collector connected to the case.

These transistors are primarily intended for use in high performance, low-level, low-noise amplifier applications both for direct current and frequencies of up to 100 MHz.

### QUICK REFERENCE DATA

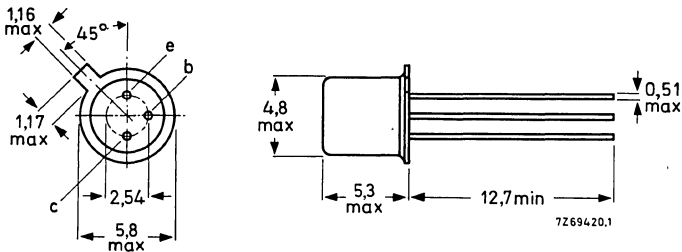
		2N2483	2N2484	
Collector-base voltage (open emitter)	$V_{CBO}$	max 60	60	V
Collector-emitter voltage (open base)	$V_{CEO}$	max 60	60	V
Collector current (peak value)	$I_{CM}$	max 50	50	mA
Total power dissipation up to $T_{amb} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$	max 360	360	mW
Junction temperature	$T_j$	max 200	200	$^{\circ}\text{C}$
D.C. current gain at $T_j = 25\text{ }^{\circ}\text{C}$ $I_C = 10\text{ }\mu\text{A}; V_{CE} = 5\text{ V}$	$h_{FE}$	> 40	100	
	$h_{FE}$	< 120	500	
	$h_{FE}$	> 175	250	
$I_C = 1\text{ mA}; V_{CE} = 5\text{ V}$	$h_{FE}$	> 175	250	
	$h_{FE}$	< 500	800	
Transition frequency $I_C = 0,5\text{ mA}; V_{CE} = 5\text{ V}$	$f_T$	typ 80	80	MHz
	$f_T$	typ 80	80	MHz
Noise figure at $R_S = 10\text{ k}\Omega$ $I_C = 10\text{ }\mu\text{A}; V_{CE} = 5\text{ V}; B = 15,7\text{ kHz}$	F	< 4	3	dB
	F	< 4	3	dB

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector connected to case



Accessories: 56246 (distance disc).

**RATINGS (Limiting values) <sup>1)</sup>**

Voltages

Collector-base voltage (open emitter)	$V_{CBO}$	max.	60	V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	60	V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	6	V

Currents

Collector current (peak value)	$I_{CM}$	max.	50	mA
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Power dissipation

Total power dissipation up to $T_{amb} = 25^{\circ}C$	$P_{tot}$	max.	360	mW
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Temperatures

Storage temperature	$T_{stg}$	-65 to +200	$^{\circ}C$
Junction temperature	$T_j$	max. 200	$^{\circ}C$

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th\ j-a}$	=	0.48	$^{\circ}C/mW$
From junction to case	$R_{th\ j-c}$	=	0.15	$^{\circ}C/mW$

<sup>1)</sup> Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

**CHARACTERISTICS**

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

Collector cut-off current

$I_E = 0; V_{CB} = 45\text{ V}$	$I_{CBO}$	<	10 nA
$I_E = 0; V_{CB} = 45\text{ V}; T_j = 150\text{ }^\circ\text{C}$	$I_{CBO}$	<	10 $\mu\text{A}$

Emitter cut-off current

$I_C = 0; V_{EB} = 5\text{ V}$	$I_{EBO}$	<	10 nA
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Base-emitter voltage

$I_C = 0.1\text{ mA}; V_{CE} = 5\text{ V}$	$V_{BE}$	0.5 to 0.7 V
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Collector-emitter saturation voltage

$I_C = 1\text{ mA}; I_B = 0.1\text{ mA}$	$V_{CEsat}$	<	350 mV
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D.C. current gain

	2N2483	2N2484
$I_C = 1\text{ }\mu\text{A}; V_{CE} = 5\text{ V}$	$h_{FE} >$	30
$I_C = 10\text{ }\mu\text{A}; V_{CE} = 5\text{ V}$	$h_{FE}$	40 to 120
$I_C = 10\text{ }\mu\text{A}; V_{CE} = 5\text{ V}; T_j = 55\text{ }^\circ\text{C}$	$h_{FE} >$	10
$I_C = 100\text{ }\mu\text{A}; V_{CE} = 5\text{ V}$	$h_{FE} >$	75
$I_C = 500\text{ }\mu\text{A}; V_{CE} = 5\text{ V}$	$h_{FE} >$	100
$I_C = 1\text{ mA}; V_{CE} = 5\text{ V}$	$h_{FE} >$	175
$I_C = 10\text{ mA}; V_{CE} = 5\text{ V}^1)$	$h_{FE} <$	500

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

$I_E = I_e = 0; V_{CB} = 5\text{ V}$	$C_c$	<	6	6 pF
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Emitter capacitance at  $f = 1\text{ MHz}$

$I_C = I_c = 0; V_{EB} = 0.5\text{ V}$	$C_e$	<	6	6 pF
--	-------	---	---	------

Transition frequency

$I_C = 50\text{ }\mu\text{A}; V_{CE} = 5\text{ V}$	$f_T$	>	12	15 MHz
$I_C = 500\text{ }\mu\text{A}; V_{CE} = 5\text{ V}$	$f_T$	>	60	60 MHz
		typ.	80	80 MHz

<sup>1)</sup> Measured under pulsed conditions to prevent excessive dissipation.  
Pulse duration  $t < 300\text{ }\mu\text{s}$ ; duty cycle  $\delta < 0.01$

**CHARACTERISTICS (continued)**

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

Noise figure

$I_C = 10\text{ }\mu\text{A}$ ;  $V_{CE} = 5\text{ V}$ ;  $R_S = 10\text{ k}\Omega$

$f = 100\text{ Hz}$ ; bandwidth 20 Hz

$f = 1\text{ kHz}$ ; bandwidth 200 Hz

$f = 10\text{ kHz}$ ; bandwidth 2 kHz

Wide band; bandwidth 15.7 kHz

	2N2483	2N2484
F	< 15	10 dB
F	< 4	3 dB
F	< 3	2 dB
F	< 4	3 dB

h parameters at  $f = 1\text{ kHz}$

$I_C = 1\text{ mA}$ ;  $V_{CE} = 5\text{ V}$

Input impedance

Reverse voltage transfer

Small signal current gain

Output admittance

$h_{ie}$	1.5 to 13	3.5 to 24 $\text{k}\Omega$
$h_{re}$	< 8	8 $10^{-4}$
$h_{fe}$	80 to 450	150 to 900
$h_{oe}$	< 30	40 $\mu\Omega^{-1}$

## SILICON PLANAR EPITAXIAL TRANSISTORS



P-N-P transistors in TO-39 metal envelopes designed primarily for high-speed switching and driver applications for industrial service.

### QUICK REFERENCE DATA

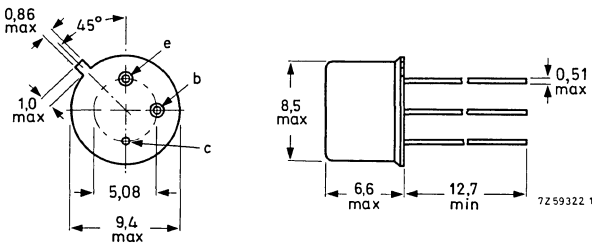
Collector-base voltage (open emitter)		$-V_{CBO}$	max.	60 V
Collector-emitter voltage (open base)	2N2904	$-V_{CEO}$	max.	40 V
	2N2904A	$-V_{CEO}$	max.	60 V
Collector current (d.c.)		$-I_C$	max.	600 mA
Total power dissipation up to $T_{amb} = 25^\circ\text{C}$		$P_{tot}$	max.	0,6 W
Junction temperature		$T_j$	max.	200 $^\circ\text{C}$
D.C. current gain at $T_j = 25^\circ\text{C}$		$h_{FE}$		40 to 120
$-I_C = 150\text{ mA}; -V_{CE} = 10\text{ V}$				
Transition frequency at $f = 100\text{ MHz}$		$f_T$	>	200 MHz
$-I_C = 50\text{ mA}; -V_{CE} = 20\text{ V}; T_j = 25^\circ\text{C}$				
Storage time		$t_s$	<	80 ns
$-I_{Con} = 150\text{ mA}; -I_{Bon} = I_{Boff} = 15\text{ mA}$				

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case.



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).



**RATINGS**

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

Collector-base voltage (open emitter)		$-V_{CBO}$	max.	60 V
Collector-emitter voltage (open base) $-I_C < 100 \text{ mA}$	<b>2N2904</b>	$-V_{CEO}$	max.	40 V
	<b>2N2904A</b>	$-V_{CEO}$	max.	60 V
Emitter-base voltage (open collector)		$-V_{EBO}$	max.	5 V
Collector current (d.c.)		$-I_C$	max.	600 mA
Total power dissipation up to $T_{amb} = 25 \text{ }^\circ\text{C}$		$P_{tot}$	max.	0,6 W
		$P_{tot}$	max.	3,0 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 ambient in free air	$R_{th j-a}$	=	292 K/W
From junction to case	$R_{th j-c}$	=	58 K/W



## CHARACTERISTICS

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

		2N2904	2N2904A
Collector cut-off current			
$I_E = 0; -V_{CB} = 50\text{ V}$	$-I_{CBO}$	< 20	10 nA
$I_E = 0; -V_{CB} = 50\text{ V}; T_{amb} = 150\text{ }^{\circ}\text{C}$	$-I_{CBO}$	< 20	10 $\mu\text{A}$
$+V_{BE} = 0,5\text{ V}; -V_{CE} = 30\text{ V}$	$-I_{CEX}$	< 50	50 nA
Base current			
$+V_{BE} = 0,5\text{ V}; -V_{CE} = 30\text{ V}$	$I_{BEX}$	< 50	50 nA
Collector-base breakdown voltage open emitter; $-I_C = 10\text{ }\mu\text{A}$	$-V_{(BR)CBO}$	> 60	60 V
Collector-emitter breakdown voltage * open base; $-I_C = 10\text{ }\mu\text{A}$	$-V_{(BR)CEO}$	> 40	60 V
Emitter-base breakdown voltage open collector; $-I_E = 10\text{ }\mu\text{A}$	$-V_{(BR)EBO}$	> 5	5 V
Saturation voltages *			
$-I_C = 150\text{ mA}; -I_B = 15\text{ mA}$	$-V_{CEsat}$	< 0,4	0,4 V
	$-V_{BEsat}$	< 1,3	1,3 V
$-I_C = 500\text{ mA}; -I_B = 50\text{ mA}$	$-V_{CEsat}$	< 1,6	1,6 V
	$-V_{BEsat}$	< 2,6	2,6 V
D.C. current gain			
$-I_C = 0,1\text{ mA}; -V_{CE} = 10\text{ V}$	$h_{FE}$	> 20	40
$-I_C = 1\text{ mA}; -V_{CE} = 10\text{ V}$	$h_{FE}$	> 25	40
$-I_C = 10\text{ mA}; -V_{CE} = 10\text{ V}$	$h_{FE}$	> 35	40
$-I_C = 150\text{ mA}; -V_{CE} = 10\text{ V} *$	$h_{FE}$	> 40	40
	$h_{FE}$	< 120	120
$-I_C = 500\text{ mA}; -V_{CE} = 10\text{ V} *$	$h_{FE}$	> 20	40
Collector capacitance at $f = 100\text{ kHz}$ $I_E = I_e = 0; -V_{CB} = 10\text{ V}$	$C_c$	<	8 pF
Emitter capacitance at $f = 100\text{ kHz}$ $I_C = I_c = 0; -V_{EB} = 2\text{ V}$	$C_e$	<	30 pF
Transition frequency at $f = 100\text{ MHz}$ $-I_C = 50\text{ mA}; -V_{CE} = 20\text{ V} *$	$f_T$	>	200 MHz

\* Measured under pulse conditions to avoid excessive dissipation:  $t_p \leq 300\text{ }\mu\text{s}; \delta \leq 0,02$ .

Turn-on time (see Fig. 2)

when switched to  $-I_{Con} = 150 \text{ mA}$ ;  $-I_{Bon} = 15 \text{ mA}$

delay time

rise time

turn-on time

$$t_d < 10 \text{ ns}$$

$$t_r < 40 \text{ ns}$$

$$t_{on} < 45 \text{ ns}$$

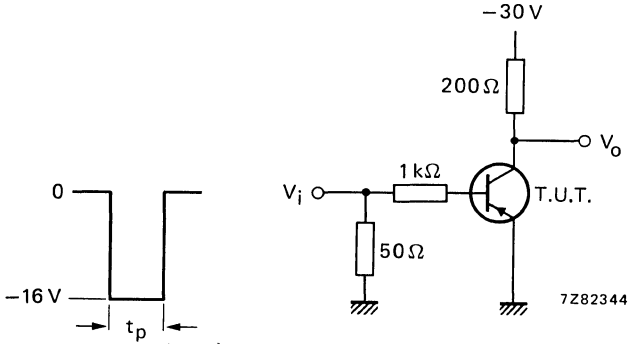


Fig. 2 Input waveform and test circuit for determining delay, rise and turn-on time.

Turn-off time (see Fig. 3)

when switched from  $-I_{Con} = 150 \text{ mA}$ ;  $-I_{Bon} = 15 \text{ mA}$   
to cut-off with  $+I_{Boff} = 15 \text{ mA}$

storage time

fall time

turn-off time

$$t_s < 80 \text{ ns}$$

$$t_f < 30 \text{ ns}$$

$$t_{off} < 100 \text{ ns}$$

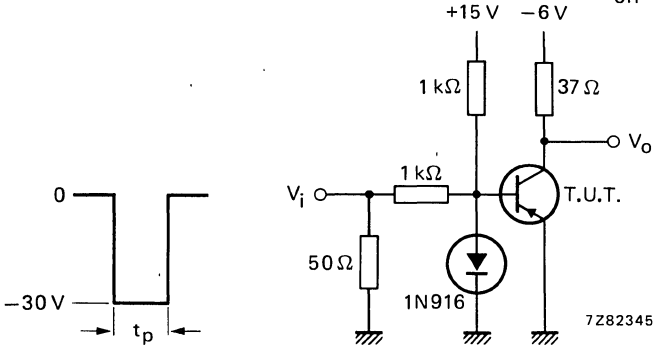


Fig. 3 Input waveform and test circuit for determining storage, fall and turn-off time.

Pulse generator (see Figs 2 and 3)

frequency  $f = 150 \text{ Hz}$

pulse duration  $t_p = 200 \text{ ns}$

rise time  $t_r \leq 2 \text{ ns}$

output impedance  $Z_o = 50 \Omega$

Oscilloscope (see, Figs 2 and 3)

rise time  $t_r \leq 5 \text{ ns}$

input impedance  $Z_i = 10 \text{ M}\Omega$

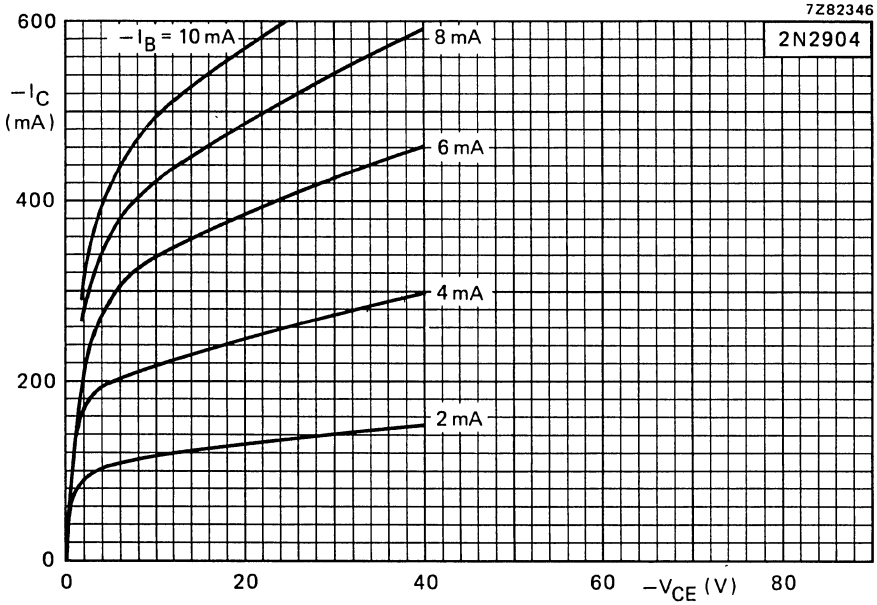


Fig. 4 Typical values;  $T_j = 25^\circ\text{C}$ .

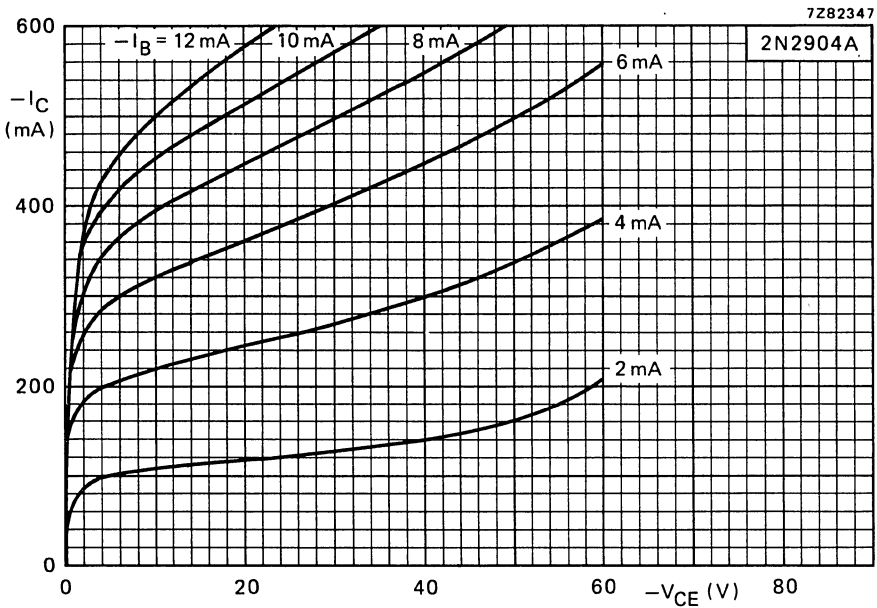


Fig. 5 Typical values;  $T_j = 25^\circ\text{C}$ .

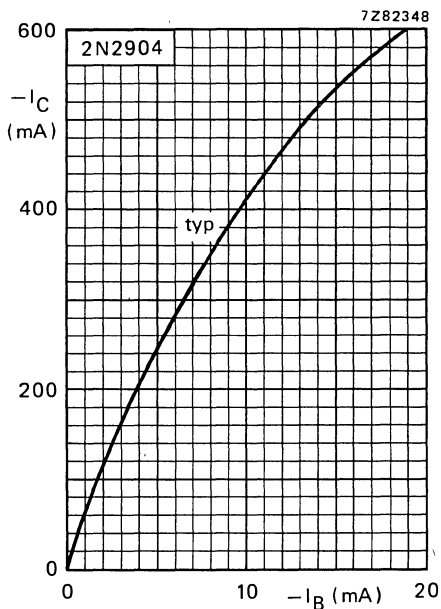


Fig. 6  $-V_{CE} = 5,0$  V;  $T_j = 25$  °C.

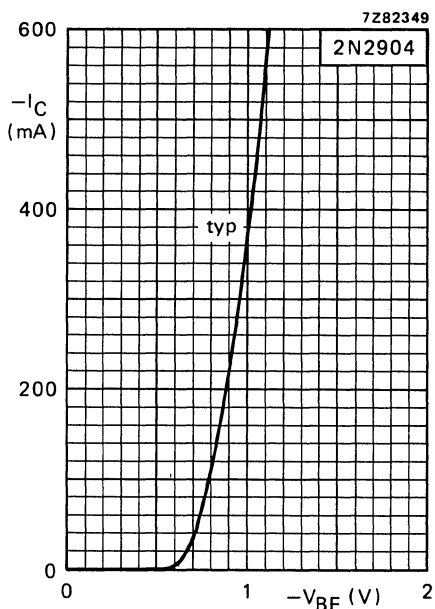


Fig. 7  $-V_{CE} = 5,0$  V;  $T_j = 25$  °C.

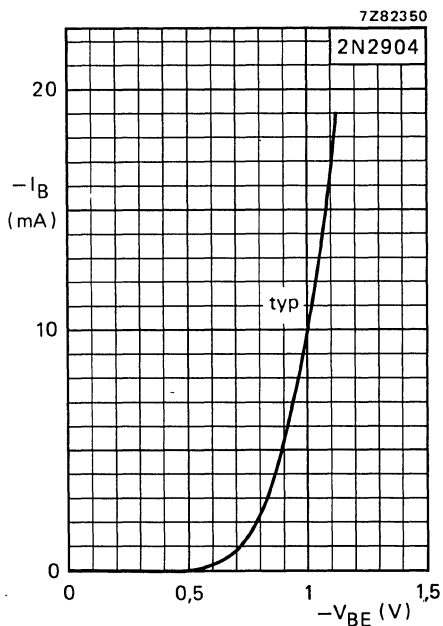


Fig. 8  $-V_{CE} = 5,0$  V;  $T_j = 25$  °C.

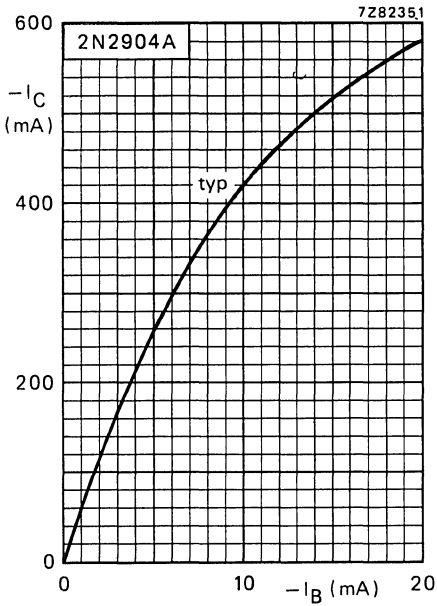


Fig. 9  $-V_{CE} = 5,0$  V;  $T_j = 25$  °C.

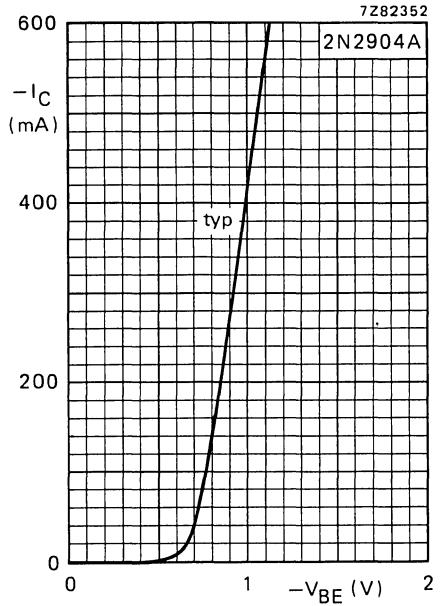


Fig. 10  $-V_{CE} = 5,0$  V;  $T_j = 25$  °C.

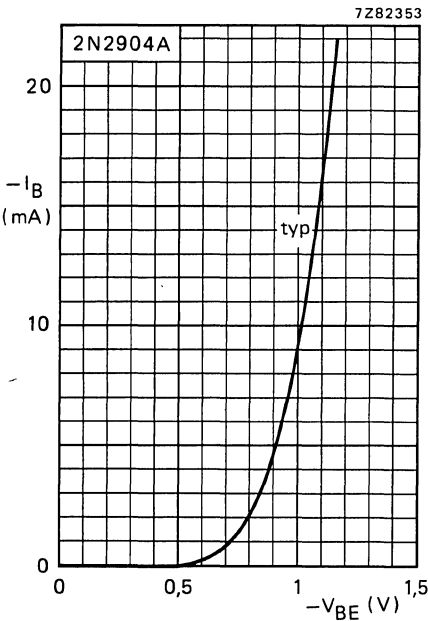


Fig. 11  $-V_{CE} = 5,0$  V;  $T_j = 25$  °C.



## SILICON PLANAR EPITAXIAL TRANSISTORS



P-N-P transistors in TO-39 metal envelopes designed primarily for high-speed switching and driver applications for industrial service.

### QUICK REFERENCE DATA

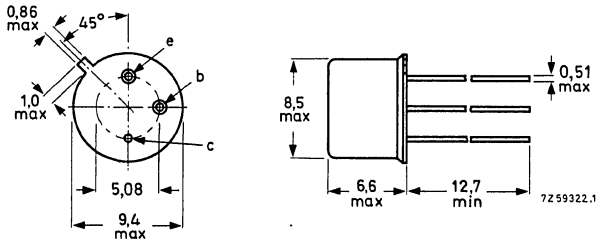
Collector-base voltage (open emitter)		$-V_{CBO}$	max.	60 V
Collector-emitter voltage (open base)	2N2905	$-V_{CEO}$	max.	40 V
	2N2905A	$-V_{CEO}$	max.	60 V
Collector current (d.c.)		$-I_C$	max.	600 mA
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$		$P_{tot}$	max.	0,6 W
Junction temperature		$T_j$	max.	200 $^\circ\text{C}$
D.C. current gain at $T_j = 25\text{ }^\circ\text{C}$		$h_{FE}$		100 to 300
Transition frequency at $f = 100\text{ MHz}$	$-I_C = 150\text{ mA}; -V_{CE} = 10\text{ V}$			
	$-I_C = 50\text{ mA}; -V_{CE} = 20\text{ V}; T_j = 25\text{ }^\circ\text{C}$	$f_T$	>	200 MHz
Storage time	$-I_{Con} = 150\text{ mA}; -I_{Bon} = I_{Boff} = 15\text{ mA}$	$t_s$	<	80 ns

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case.



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).



**RATINGS**

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

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60 V
Collector-emitter voltage (open base) $-I_C < 100 \text{ mA}$	2N2905 $-V_{CEO}$	max.	40 V
	2N2905A $-V_{CEO}$	max.	60 V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5 V
Collector current (d.c.)	$-I_C$	max.	600 mA
Total power dissipation up to $T_{amb} = 25 \text{ }^\circ\text{C}$	$P_{tot}$	max.	0,6 W
	$P_{tot}$	max.	3,0 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 ambient in free air	$R_{th j-a}$	=	292 K/W
From junction to case	$R_{th j-c}$	=	58 K/W

## CHARACTERISTICS

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

		2N2905	2N2905A
Collector cut-off current			
$I_E = 0; -V_{CB} = 50\text{ V}$	$-I_{CBO}$	< 20	10 nA
$I_E = 0; -V_{CB} = 50\text{ V}; T_{amb} = 150\text{ }^{\circ}\text{C}$	$-I_{CBO}$	< 20	10 $\mu\text{A}$
$+V_{BE} = 0,5\text{ V}; -V_{CE} = 30\text{ V}$	$-I_{CEX}$	< 50	50 nA
Base current			
$+V_{BE} = 0,5\text{ V}; -V_{CE} = 30\text{ V}$	$I_{BEX}$	< 50	50 nA
Collector-base breakdown voltage open emitter; $-I_C = 10\text{ }\mu\text{A}$	$-V_{(BR)CBO}$	> 60	60 V
Collector-emitter breakdown voltage* open base; $-I_C = 10\text{ mA}$	$-V_{(BR)CEO}$	> 40	60 V
Emitter-base breakdown voltage open collector; $-I_E = 10\text{ }\mu\text{A}$	$-V_{(BR)EBO}$	> 5	5 V
Saturation voltages*			
$-I_C = 150\text{ mA}; -I_B = 15\text{ mA}$	$-V_{CEsat}$	< 0,4	0,4 V
	$-V_{BEsat}$	< 1,3	1,3 V
$-I_C = 500\text{ mA}; -I_B = 50\text{ mA}$	$-V_{CEsat}$	< 1,6	1,6 V
	$-V_{BEsat}$	< 2,6	2,6 V
D.C. current gain			
$-I_C = 0,1\text{ mA}; -V_{CE} = 10\text{ V}$	$h_{FE}$	> 35	75
$-I_C = 1\text{ mA}; -V_{CE} = 10\text{ V}$	$h_{FE}$	> 50	100
$-I_C = 10\text{ mA}; -V_{CE} = 10\text{ V}$	$h_{FE}$	> 75	100
$-I_C = 150\text{ mA}; -V_{CE} = 10\text{ V}^*$	$h_{FE}$	> 100	100
$-I_C = 500\text{ mA}; -V_{CE} = 10\text{ V}^*$	$h_{FE}$	< 300	300
Collector capacitance at $f = 100\text{ kHz}$ $I_E = I_e = 0; -V_{CB} = 10\text{ V}$	$C_C$	< 8	pF
Emitter capacitance at $f = 100\text{ kHz}$ $I_C = I_c = 0; -V_{EB} = 2\text{ V}$	$C_e$	< 30	pF
Transition frequency at $f = 100\text{ MHz}$ $-I_C = 50\text{ mA}; -V_{CE} = 20\text{ V}^*$	$f_T$	> 200	MHz

\* Measured under pulse conditions to avoid excessive dissipation;  $t_p \leq 300\text{ }\mu\text{s}$ ;  $\delta \leq 0,02$ .

Turn-on time (see Fig. 2)

when switched to  $-I_{Con} = 150 \text{ mA}$ ;  $-I_{Bon} = 15 \text{ mA}$

delay time

$$t_d < 10 \text{ ns}$$

rise time

$$t_r < 40 \text{ ns}$$

turn-on time

$$t_{on} < 45 \text{ ns}$$

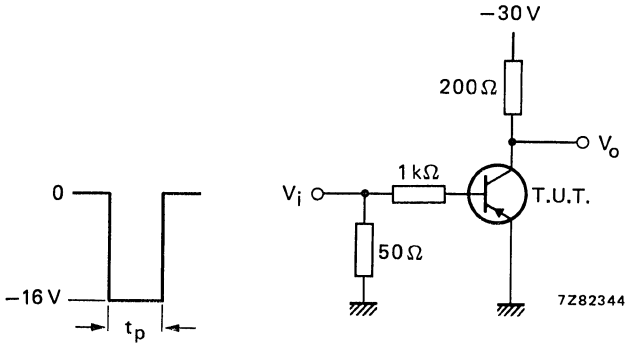


Fig. 2 Input waveform and test circuit for determining delay, rise and turn-on time.

Turn-off time (see Fig. 3)

when switched from  $-I_{Con} = 150 \text{ mA}$ ;  $-I_{Bon} = 15 \text{ mA}$

to cut-off with  $+I_{Boff} = 15 \text{ mA}$

storage time

$$t_s < 80 \text{ ns}$$

fall time

$$t_f < 30 \text{ ns}$$

turn-off time

$$t_{off} < 100 \text{ ns}$$

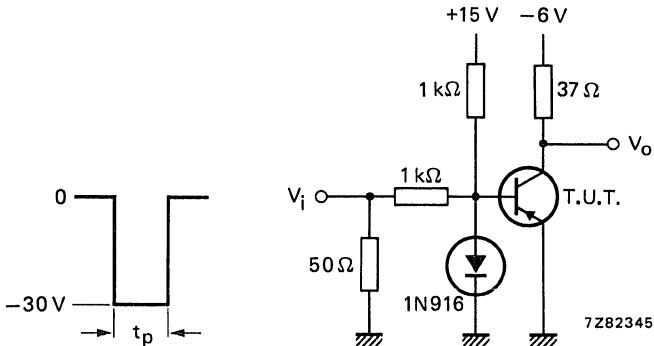


Fig. 3 Input waveform and test circuit for determining storage, fall and turn-off time.

Pulse generator (see Figs 2 and 3)

frequency  $f = 150 \text{ Hz}$

pulse duration  $t_p = 200 \text{ ns}$

rise time  $t_r \leq 2 \text{ ns}$

output impedance  $Z_o = 50 \Omega$

Oscilloscope (see Figs 2 and 3)

rise time  $t_r \leq 5 \text{ ns}$

input impedance  $Z_i = 10 \text{ M}\Omega$

SILICON PLANAR EPITAXIAL TRANSISTORS



P-N-P medium power transistors in TO-18 metal envelopes designed primarily for high-speed switching and driver applications for industrial service.

QUICK REFERENCE DATA

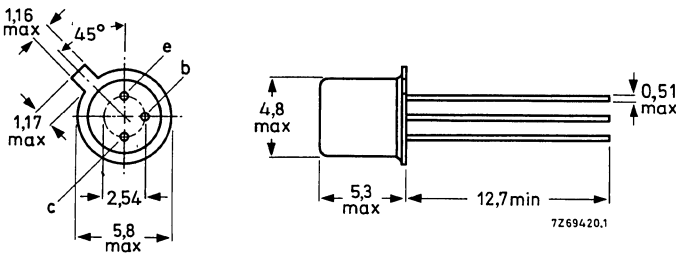
Collector-base voltage (open emitter)		$-V_{CBO}$	max.	60 V
Collector-emitter voltage (open base)	2N2906	$-V_{CEO}$	max.	40 V
	2N2906A	$-V_{CEO}$	max.	60 V
Collector current (d.c.)		$-I_C$	max.	600 mA
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$		$P_{tot}$	max.	0,4 W
Junction temperature		$T_j$	max.	200 $^\circ\text{C}$
D.C. current gain at $T_j = 25\text{ }^\circ\text{C}$		$h_{FE}$		40 to 120
$-I_C = 150\text{ mA}; -V_{CE} = 10\text{ V}$				
Transition frequency at $f = 100\text{ MHz}$		$f_T$	>	200 MHz
$-I_C = 50\text{ mA}; -V_{CE} = 20\text{ V}; T_j = 25\text{ }^\circ\text{C}$				
Storage time		$t_s$	<	80 ns
$-I_{Con} = 150\text{ mA}; -I_{Bon} = I_{Boff} = 15\text{ mA}$				

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector connected to case.



Accessories: 56246 (distance disc).

**RATINGS**

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

Collector-base voltage (open emitter)		$-V_{CB0}$	max.	60 V
Collector-emitter voltage (open base)	<b>2N2906</b>	$-V_{CEO}$	max.	40 V
$-I_C < 100$ mA	<b>2N2906A</b>	$-V_{CEO}$	max.	60 V
Emitter-base voltage (open collector)		$-V_{EBO}$	max.	5 V
Collector current (d.c.)		$-I_C$	max.	600 mA
Total power dissipation		$P_{tot}$	max.	0,4 W
up to $T_{amb} = 25$ °C		$P_{tot}$	max.	1,2 W
up to $T_{case} = 25$ °C		$T_{stg}$	-65 to + 200 °C	
Storage temperature		$T_j$	max.	200 °C
Junction temperature				

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th\ j-a}$	=	438 K/W
From junction to case	$R_{th\ j-c}$	=	146 K/W

## CHARACTERISTICS

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

		2N2906	2N2906A	
Collector cut-off current				
$I_E = 0; -V_{CB} = 50\text{ V}$	$-I_{CBO}$	< 20	10	nA
$I_E = 0; -V_{CB} = 50\text{ V}; T_{amb} = 150\text{ }^{\circ}\text{C}$	$-I_{CBO}$	< 20	10	$\mu\text{A}$
$+V_{BE} = 0,5\text{ V}; -V_{CE} = 30\text{ V}$	$-I_{CEX}$	< 50	50	nA
Base current				
$+V_{BE} = 0,5\text{ V}; -V_{CE} = 30\text{ V}$	$I_{BEX}$	< 50	50	nA
Collector-base breakdown voltage open emitter; $-I_C = 10\text{ }\mu\text{A}$	$-V_{(BR)CBO}$	> 60	60	V
Collector-emitter breakdown voltage* open base; $-I_C = 10\text{ mA}$	$-V_{(BR)CEO}$	> 40	60	V
Emitter-base breakdown voltage open collector; $-I_E = 10\text{ }\mu\text{A}$	$-V_{(BR)EBO}$	> 5	5	V
Saturation voltages*				
$-I_C = 150\text{ mA}; -I_B = 15\text{ mA}$	$-V_{CEsat}$	< 0,4	0,4	V
	$-V_{BEsat}$	< 1,3	1,3	V
$-I_C = 500\text{ mA}; -I_B = 50\text{ mA}$	$-V_{CEsat}$	< 1,6	1,6	V
	$-V_{BEsat}$	< 2,6	2,6	V
D.C. current gain				
$-I_C = 0,1\text{ mA}; -V_{CE} = 10\text{ V}$	$h_{FE}$	> 20	40	
$-I_C = 1\text{ mA}; -V_{CE} = 10\text{ V}$	$h_{FE}$	> 25	40	
$-I_C = 10\text{ mA}; -V_{CE} = 10\text{ V}$	$h_{FE}$	> 35	40	
$-I_C = 150\text{ mA}; -V_{CE} = 10\text{ V}^*$	$h_{FE}$	> 40	40	
		> 120	120	
$-I_C = 500\text{ mA}; -V_{CE} = 10\text{ V}^*$	$h_{FE}$	> 20	40	
Collector capacitance at $f = 100\text{ kHz}$ $I_E = I_e = 0; -V_{CB} = 10\text{ V}$	$C_c$	<	8	pF
Emitter capacitance at $f = 100\text{ kHz}$ $I_C = I_c = 0; -V_{EB} = 2\text{ V}$	$C_e$	<	30	pF
Transition frequency at $f = 100\text{ MHz}$ $-I_C = 50\text{ mA}; -V_{CE} = 20\text{ V}^*$	$f_T$	>	200	MHz

\* Measured under pulse conditions to avoid excessive dissipation:  $t_p \leq 300\text{ }\mu\text{s}; \delta \leq 0,02$ .

Turn-on time (see Fig. 2)

when switched to  $-I_{Con} = 150 \text{ mA}$ ;  $-I_{Bon} = 15 \text{ mA}$

delay time

rise time

turn-on time

$t_d$	<	10 ns
$t_r$	<	40 ns
$t_{on}$	<	45 ns

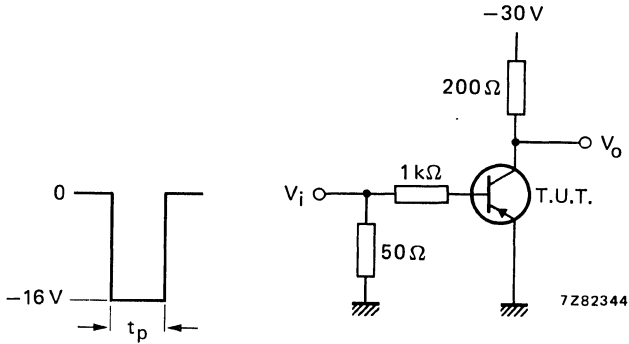


Fig. 2 Input waveform and test circuit for determining delay, rise and turn-on time.

Turn-off time (see Fig. 3)

when switched from  $-I_{Con} = 150 \text{ mA}$ ;  $-I_{Bon} = 15 \text{ mA}$

to cut-off with  $+I_{Boff} = 15 \text{ mA}$

storage time

fall time

turn-off time

$t_s$	<	80 ns
$t_f$	<	30 ns
$t_{off}$	<	100 ns

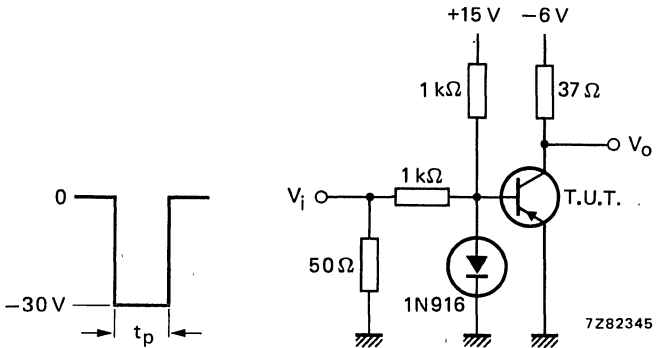


Fig. 3 Input waveform and test circuit for determining storage, fall and turn-off time.

Pulse generator (see Figs 2 and 3)

frequency	$f$	=	150 Hz
pulse duration	$t_p$	=	200 ns
rise time	$t_r$	≤	2 ns
output impedance	$Z_o$	=	50 Ω

Oscilloscope (see Figs 2 and 3)

rise time	$t_r$	≤	5 ns
input impedance	$Z_i$	≤	10 MΩ

SILICON PLANAR EPITAXIAL TRANSISTORS



P-N-P medium power transistors in TO-18 metal envelopes designed primarily for high-speed switching and driver applications for industrial service.

QUICK REFERENCE DATA

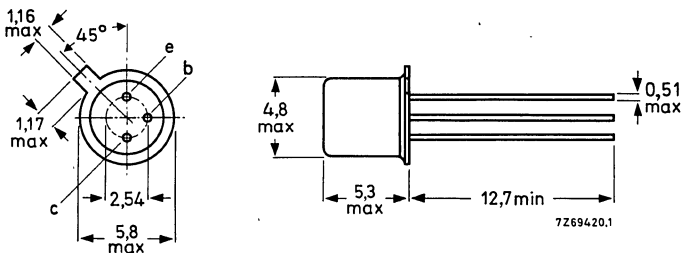
Collector-base voltage (open emitter)		$-V_{CBO}$	max.	60 V
Collector-emitter voltage (open base)	2N2907	$-V_{CEO}$	max.	40 V
	2N2907A	$-V_{CEO}$	max.	60 V
Collector current (d.c.)		$-I_C$	max.	600 mA
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$		$P_{tot}$	max.	0,4 W
Junction temperature		$T_j$	max.	200 $^\circ\text{C}$
D.C. current gain at $T_j = 25\text{ }^\circ\text{C}$		$h_{FE}$		100 to 300
$-I_C = 150\text{ mA}; -V_{CE} = 10\text{ V}$				
Transition frequency at $f = 100\text{ MHz}$		$f_T$	>	200 MHz
$-I_C = 50\text{ mA}; -V_{CE} = 20\text{ V}; T_j = 25\text{ }^\circ\text{C}$				
Storage time		$t_s$	<	80 ns
$-I_{Con} = 150\text{ mA}; -I_{Bon} = I_{Boff} = 15\text{ mA}$				

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector connected to case.



Accessories: 56246 (distance disc).



**RATINGS**

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

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60 V
Collector-emitter voltage (open base) $-I_C < 100 \text{ mA}$	<b>2N2907</b> $-V_{CEO}$	max.	40 V
	<b>2N2907A</b> $-V_{CEO}$	max.	60 V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5 V
Collector current (d.c.)	$-I_C$	max.	600 mA
Total power dissipation up to $T_{amb} = 25 \text{ }^\circ\text{C}$	$P_{tot}$	max.	0,4 W
	$P_{tot}$	max.	1,2 W
up to $T_{case} = 25 \text{ }^\circ\text{C}$			
Storage temperature	$T_{stg}$	-65 to +200	$^\circ\text{C}$
Junction temperature	$T_j$	max.	200 $^\circ\text{C}$

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th j-a}$	=	438 K/W
From junction to case	$R_{th j-c}$	=	146 K/W

## CHARACTERISTICS

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

Collector cut-off current

 $I_E = 0; -V_{CB} = 50\text{ V}$ 

	2N2907	2N2907A
$-I_{CBO}$	< 20	10 nA
$-I_{CBO}$	< 20	10 $\mu\text{A}$
$-I_{CEX}$	< 50	50 nA
$I_{BEX}$	< 50	50 nA
$-V_{(BR)CBO}$	> 60	60 V
$-V_{(BR)CEO}$	> 40	60 V
$-V_{(BR)EBO}$	> 5	5 V
$-V_{CEsat}$	< 0,4	0,4 V
$-V_{BEsat}$	< 1,3	1,3 V
$-V_{CEsat}$	< 1,6	1,6 V
$-V_{BEsat}$	< 2,6	2,6 V
$h_{FE}$	> 35	75
$h_{FE}$	> 50	100
$h_{FE}$	> 75	100
$h_{FE}$	> 100	100
$h_{FE}$	< 300	300
$h_{FE}$	> 30	50
$C_c$	< 8	pF
$C_e$	< 30	pF
$f_T$	> 200	MHz

 $I_E = 0; -V_{CB} = 50\text{ V}; T_{amb} = 150\text{ }^{\circ}\text{C}$  $+V_{BE} = 0,5\text{ V}; -V_{CE} = 30\text{ V}$ 

Base current

 $+V_{BE} = 0,5\text{ V}; -V_{CE} = 30\text{ V}$ 

Collector-base breakdown voltage

open emitter;  $-I_C = 10\text{ }\mu\text{A}$ 

Collector-emitter breakdown voltage \*

open base;  $-I_C = 10\text{ mA}$ 

Emitter-base breakdown voltage

open collector;  $-I_E = 10\text{ }\mu\text{A}$ 

Saturation voltages \*

 $-I_C = 150\text{ mA}; -I_B = 15\text{ mA}$  $-I_C = 500\text{ mA}; -I_B = 50\text{ mA}$ 

D.C. current gain

 $-I_C = 0,1\text{ mA}; -V_{CE} = 10\text{ V}$  $-I_C = 1\text{ mA}; -V_{CE} = 10\text{ V}$  $-I_C = 10\text{ mA}; -V_{CE} = 10\text{ V}$  $-I_C = 150\text{ mA}; -V_{CE} = 10\text{ V} *$  $-I_C = 500\text{ mA}; -V_{CE} = 10\text{ V} *$ Collector capacitance at  $f = 100\text{ kHz}$  $I_E = I_c = 0; -V_{CB} = 10\text{ V}$ Emitter capacitance at  $f = 100\text{ kHz}$  $I_C = I_c = 0; -V_{EB} = 2\text{ V}$ Transition frequency at  $f = 100\text{ MHz}$  $-I_C = 50\text{ mA}; -V_{CE} = 20\text{ V} *$ \* Measured under pulse conditions to avoid excessive dissipation:  $t_p \leq 300\text{ }\mu\text{s}; \delta \leq 0,02$ .

2N2907  
2N2907A

Turn-on time (see Fig. 2)

when switched to  $-I_{Con} = 150 \text{ mA}$ ;  $-I_{Bon} = 15 \text{ mA}$

delay time

rise time

turn-on time

$$t_d < 10 \text{ ns}$$

$$t_r < 40 \text{ ns}$$

$$t_{on} < 45 \text{ ns}$$

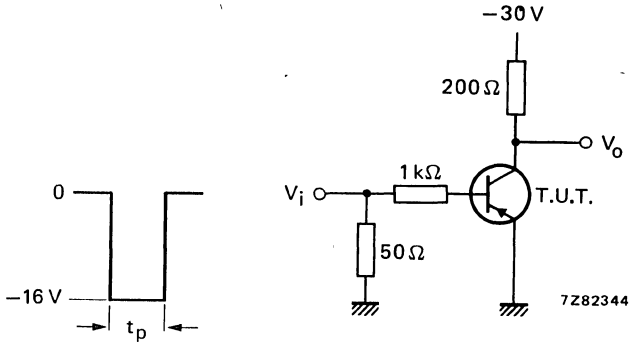


Fig. 2 Input waveform and test circuit for determining delay, rise and turn-on time.

Turn-off time (see Fig. 3)

when switched from  $-I_{Con} = 150 \text{ mA}$ ;  $-I_{Bon} = 15 \text{ mA}$

to cut-off with  $+I_{Boff} = 15 \text{ mA}$

storage time

fall time

turn-off time

$$t_s < 80 \text{ ns}$$

$$t_f < 30 \text{ ns}$$

$$t_{off} < 100 \text{ ns}$$

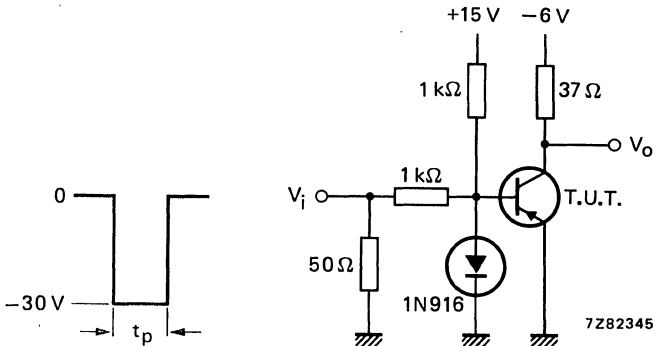


Fig. 3 Input waveform and test circuit for determining storage, fall and turn-off time.

Pulse generator (see Figs 2 and 3)

frequency  $f = 150 \text{ Hz}$

pulse duration  $t_p = 200 \text{ ns}$

rise time  $t_r \leq 2 \text{ ns}$

output impedance  $Z_o = 50 \Omega$

Oscilloscope (see Figs 2 and 3)

rise time  $t_r \leq 5 \text{ ns}$

input impedance  $Z_i \leq 10 \text{ M}\Omega$

SILICON PLANAR EPITAXIAL TRANSISTORS



N-P-N transistors in TO-39 metal envelopes intended for use as amplifiers and in switching circuits.

QUICK REFERENCE DATA

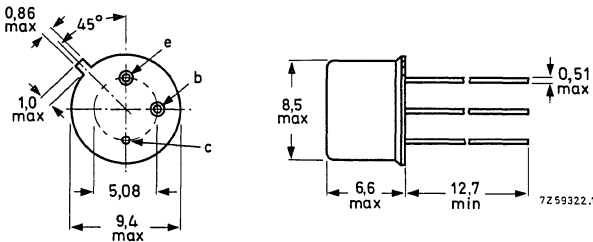
Collector-base voltage (open emitter)	$V_{CB0}$	max.	140	V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	80	V
Collector current (d.c.)	$I_C$	max.	1	A
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$ up to $T_{case} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	0,8	W
	$P_{tot}$	max.	5,0	W
Junction temperature	$T_j$	max.	200	$^\circ\text{C}$
<b>2N3019   2N3020</b>				
D.C. current gain $I_C = 150\text{ mA}; V_{CE} = 10\text{ V}$	$h_{FE}$	>	100	40
	$h_{FE}$	<	300	120
Transition frequency at $f = 20\text{ MHz}$ $I_C = 50\text{ mA}; V_{CE} = 10\text{ V}$	$f_T$	>	100	80
	$f_T$	>	100	80
				MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).

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

Voltages

Collector-base voltage (open emitter)	$V_{CBO}$	max.	140	V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	80	V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	7	V

Current

Collector current (d. c.)	$I_C$	max.	1	A
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Power dissipation

Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	0,8	W
up to $T_{case} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	5,0	W

Temperatures

Storage temperature	$T_{stg}$	-65 to +200	$^\circ\text{C}$
Junction temperature	$T_j$	max.	200 $^\circ\text{C}$

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th\ j-a}$	=	218	$^\circ\text{C/W}$
From junction to case	$R_{th\ j-c}$	=	35	$^\circ\text{C/W}$

**CHARACTERISTICS**

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

Collector cut-off current

$I_E = 0; V_{CB} = 90\text{ V}$	$I_{CBO}$	<	10	nA
$I_E = 0; V_{CB} = 90\text{ V}; T_{amb} = 150\text{ }^\circ\text{C}$	$I_{CBO}$	<	10	$\mu\text{A}$

Emitter cut-off current

$I_C = 0; V_{EB} = 5\text{ V}$	$I_{EBO}$	<	10	nA
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Breakdown voltages

$I_E = 0; I_C = 100\text{ }\mu\text{A}$	$V_{(BR)CBO}$	>	140	V
$I_B = 0; I_C = 30\text{ mA}$	$V_{(BR)CEO}$	>	80	V <sup>1)</sup>
$I_C = 0; I_E = 100\text{ }\mu\text{A}$	$V_{(BR)EBO}$	>	7	V

Saturation voltages

$I_C = 150\text{ mA}; I_B = 15\text{ mA}$	$V_{CEsat}$	<	0,2	V
	$V_{BEsat}$	<	1,1	V <sup>1)</sup>
$I_C = 500\text{ mA}; I_B = 50\text{ mA}$	$V_{CEsat}$	<	0,5	V <sup>1)</sup>

<sup>1)</sup> Measured under pulse conditions :  $t_p = 300\text{ }\mu\text{s}; \delta \leq 0,01$ .

**CHARACTERISTICS (continued)**

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

		2N3019	2N3020	
<u>D. C. current gain <sup>1)</sup></u>				
$I_C = 0,1\text{ mA}; V_{CE} = 10\text{ V}$	$h_{FE} >$	50	30	
	$h_{FE} <$	-	100	
$I_C = 10\text{ mA}; V_{CE} = 10\text{ V}$	$h_{FE} >$	90	40	
	$h_{FE} <$	-	120	
$I_C = 150\text{ mA}; V_{CE} = 10\text{ V}$	$h_{FE} >$	100	40	
	$h_{FE} <$	300	120	
$I_C = 150\text{ mA}; V_{CE} = 10\text{ V}; T_{case} = -55\text{ }^{\circ}\text{C}$	$h_{FE} >$	40	-	
	$h_{FE} <$	-	-	
$I_C = 500\text{ mA}; V_{CE} = 10\text{ V}$	$h_{FE} >$	50	30	
	$h_{FE} <$	-	100	
$I_C = 1000\text{ mA}; V_{CE} = 10\text{ V}$	$h_{FE} >$	15	15	
	$h_{FE} <$	-	-	
<u>Transition frequency at <math>f = 20\text{ MHz}</math></u>				
$I_C = 50\text{ mA}; V_{CE} = 10\text{ V}$	$f_T >$	100	80	MHz
<u>Collector capacitance at <math>f = 1\text{ MHz}</math></u>				
$I_E = I_e = 0; V_{CB} = 10\text{ V}$	$C_c <$	12	12	pF
<u>Emitter capacitance at <math>f = 1\text{ MHz}</math></u>				
$I_C = I_c = 0; V_{EB} = 0,5\text{ V}$	$C_e <$	60	60	pF
<u>Feedback time constant at <math>f = 4\text{ MHz}</math></u>				
$I_C = 10\text{ mA}; V_{CB} = 10\text{ V}$	$r_{bb}'C_{b'c} <$	400	400	ps
<u>Small-signal current gain at <math>f = 1\text{ kHz}</math></u>				
$I_C = 1,0\text{ mA}; V_{CE} = 5\text{ V}$	$h_{fe} >$	80	30	
	$h_{fe} <$	400	200	
<u>Noise figure at <math>f = 1\text{ kHz}</math></u>				
$I_C = 0,1\text{ mA}; V_{CE} = 10\text{ V}; R_S = 1\text{ k}\Omega$	$F <$	4	-	dB

<sup>1)</sup> Measured under pulse conditions:  $t_p = 300\text{ }\mu\text{s}; \delta \leq 0,01$ .



## SILICON PLANAR TRANSISTOR

N-P-N transistor in a TO-39 metal envelope designed for medium speed, saturated and non-saturated switching applications for industrial service.

## QUICK REFERENCE DATA

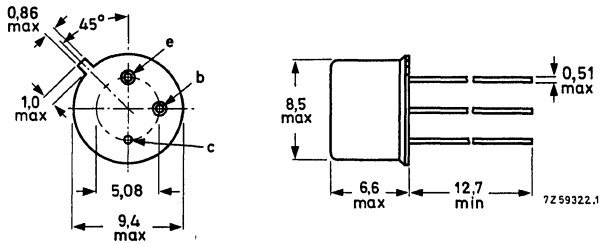
Collector-base voltage (open emitter)	$V_{CBO}$	max.	60 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	40 V
Collector current (d.c.)	$I_C$	max.	700 mA
Total power dissipation up to $T_{case} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	5,0 W
Junction temperature	$T_j$	max.	200 $^\circ\text{C}$
D.C. current gain $I_C = 150\text{ mA}; V_{CE} = 10\text{ V}$	$h_{FE}$		50 to 250
Transition frequency at $f = 20\text{ MHz}$ $I_C = 50\text{ mA}; V_{CE} = 10\text{ V}$	$f_T$	$>$	100 MHz

## MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).



**RATINGS**

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

Collector-base voltage (open emitter)	$V_{CBO}$	max.	60 V
Collector-emitter voltage (open base)*	$V_{CEO}$	max.	40 V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	5 V
Collector current (d.c.)	$I_C$	max.	700 mA
Total power dissipation up to $T_{case} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	5,0 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 case	$R_{th\ j-c}$	=	35 K/W
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**CHARACTERISTICS** $T_{amb} = 25\text{ }^\circ\text{C}$ 

Collector cut-off current

 $V_{CE} = 30\text{ V}; -V_{BE} = 1,5\text{ V}$  $I_{CEX} < 0,25\text{ }\mu\text{A}$ 

Emitter cut-off current

 $I_C = 0; V_{EB} = 4\text{ V}$  $I_{EBO} < 0,25\text{ }\mu\text{A}$ 

Collector-base breakdown voltage

open emitter;  $I_C = 100\text{ }\mu\text{A}$  $V_{(BR)CBO} > 60\text{ V}$ 

Collector-emitter breakdown voltage\*\*

open emitter;  $I_C = 100\text{ }\mu\text{A}$  $V_{(BR)CEO} > 40\text{ V}$  $I_C = 100\text{ mA}; R_{BE} = 10\text{ }\Omega$  $V_{(BR)CER} > 50\text{ V}$ 

Emitter-base breakdown voltage

open collector;  $I_E = 100\text{ }\mu\text{A}$  $V_{(BR)EBO} > 5\text{ V}$ 

Base-emitter voltage

 $I_C = 150\text{ mA}; V_{CE} = 2,5\text{ V}$  $V_{BE} < 1,7\text{ V}$ 

Saturation voltages

 $I_C = 150\text{ mA}; I_B = 15\text{ mA}$  $V_{CEsat} < 1,4\text{ V}$  $V_{BEsat} < 1,7\text{ V}$ 

D.C. current gain

 $I_C = 150\text{ mA}; V_{CE} = 2,5\text{ V}$  $h_{FE} > 25$  $I_C = 150\text{ mA}; V_{CE} = 10\text{ V}^{**}$  $h_{FE} \quad 50\text{ to }250$ Collector capacitance at  $f = 140\text{ kHz}$  $I_E = I_e = 0; V_{CB} = 10\text{ V}$  $C_c < 15\text{ pF}$ Emitter capacitance at  $f = 140\text{ kHz}$  $I_C = I_c = 0; V_{EB} = 0,5\text{ V}$  $C_e < 80\text{ pF}$ Transition frequency at  $f = 20\text{ MHz}$  $I_C = 50\text{ mA}; V_{CE} = 10\text{ V}$  $f_T > 100\text{ MHz}$ \* For  $I_C = 0$  to 100 mA (pulse conditions):  $t_p = 300\text{ }\mu\text{s}$ ;  $\delta = 0,018$ , 0 to 700 mA for shorter pulses.\*\* Measured under pulse conditions to avoid excessive dissipation:  $t_p = 300\text{ }\mu\text{s}$ ;  $\delta = 0,018$ .

## SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in plastic TO-92 envelopes, primarily intended for high-speed, saturated switching applications for industrial service.

P-N-P complements are 2N3905 and 2N3906.

### QUICK REFERENCE DATA

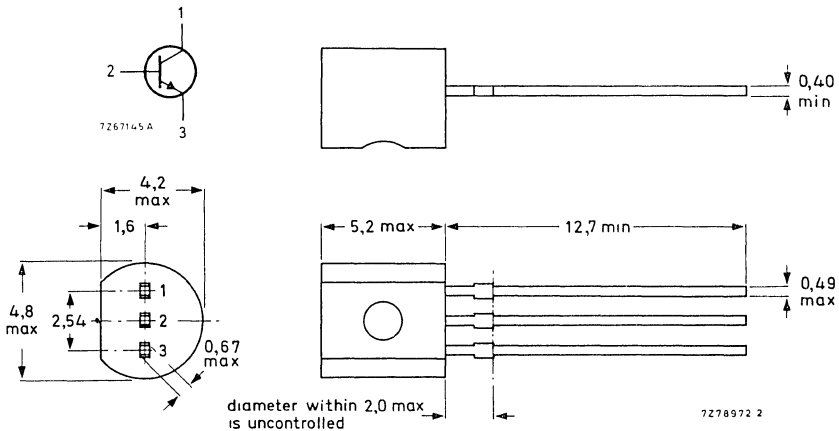
Collector-base voltage (open emitter)	$V_{CBO}$	max.	60 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	40 V
Collector current (d.c.)	$I_C$	max.	200 mA
Total power dissipation at $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	350 mW
Junction temperature	$T_j$	max.	150 $^\circ\text{C}$

		2N3903	2N3904
D.C. current gain $I_C = 10\text{ mA}; V_{CE} = 1\text{ V}$	$h_{FE}$	$> 50$	100
		$< 150$	300
Transition frequency at $f = 100\text{ MHz}$ $I_C = 10\text{ mA}; V_{CE} = 20\text{ V}$	$f_T$	$> 250$	300 MHz
Storage time $I_{Con} = 10\text{ mA}; I_{Bon} = -I_{Boff} = 1\text{ mA}$	$t_s$	$< 175$	200 ns

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92.



**RATINGS**

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

Collector-base voltage (open emitter)	$V_{CBO}$	max.	60 V
Collector-emitter voltage (open base)	$V_{CEO}$	max.	40 V
Emitter-base voltage (open collector)	$V_{EBO}$	max.	6 V
Collector current (d.c.)	$I_C$	max.	200 mA
Total power dissipation at $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	350 mW
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 in free air	$R_{th\ j-a}$	=	357 K/W
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**CHARACTERISTICS**

$T_{amb} = 25\text{ }^\circ\text{C}$

Currents at reverse biased emitter junction

$V_{CE} = 30\text{ V}; -V_{BE} = 3\text{ V}$

$I_{CEX}$	<	50 nA
$-I_{BEX}$	<	50 nA

Saturation voltages \*

$I_C = 10\text{ mA}; I_B = 1\text{ mA}$

$V_{CEsat}$	<	200 mV
$V_{BEsat}$		650 to 850 mV

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

$V_{CEsat}$	<	300 mV
$V_{BEsat}$	<	950 mV

D.C. current gain \*

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

$h_{FE}$	>	20	40
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$I_C = 1\text{ mA}; V_{CE} = 1\text{ V}$

$h_{FE}$	>	35	70
----------	---	----	----

$I_C = 10\text{ mA}; V_{CE} = 1\text{ V}$

$h_{FE}$	>	50	100
	<	150	300

$I_C = 50\text{ mA}; V_{CE} = 1\text{ V}$

$h_{FE}$	>	30	60
----------	---	----	----

$I_C = 100\text{ mA}; V_{CE} = 1\text{ V}$

$h_{FE}$	>	15	30
----------	---	----	----

Collector capacitance at  $100\text{ kHz} \leq f \leq 1\text{ MHz}$

$I_E = I_e = 0; V_{CB} = 5\text{ V}$

$C_c$	<	4	4 pF
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Emitter capacitance at  $100\text{ kHz} \leq f \leq 1\text{ MHz}$

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

$C_e$	<	8	8 pF
-------	---	---	------

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

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

$f_T$	>	250	300 MHz
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Noise figure at  $R_S = 1\text{ k}\Omega$

$I_C = 100\text{ }\mu\text{A}; V_{CE} = 5\text{ V}$

$f = 10\text{ Hz to } 15,7\text{ kHz}$

F	<	6	5 dB
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	2N3903	2N3904
$h_{FE}$	> 20	40
$h_{FE}$	> 35	70
$h_{FE}$	> 50	100
	< 150	300
$h_{FE}$	> 30	60
$h_{FE}$	> 15	30
$C_c$	< 4	4 pF
$C_e$	< 8	8 pF
$f_T$	> 250	300 MHz
F	< 6	5 dB

\* Measured under pulse conditions:  $t_p = 300\text{ }\mu\text{s}; \delta = 0,02$ .

**h-parameters (common emitter)**

$I_C = 1 \text{ mA}; V_{CE} = 10 \text{ V}; f = 1 \text{ kHz}$

Input impedance

Reverse voltage transfer ratio

Small-signal current gain

Output admittance

	2N3903	2N3904
$h_{ie}$	1 to 8	1 to 10 $k\Omega$
$h_{re}$	0,1 to 5	0,5 to 8 $10^{-4}$
$h_{fe}$	50 to 200	100 to 400
$h_{oe}$	1 to 40	1 to 40 $\mu\text{A/V}$

**Switching times**

Turn-on time (see Figs 2 and 3) when switched from

$-V_{BEoff} = 0,5 \text{ V to } I_{Con} = 10 \text{ mA}; I_{Bon} = 1 \text{ mA}$

Delay time

Rise time

$t_d$	< 35	35 ns
$t_r$	< 35	35 ns

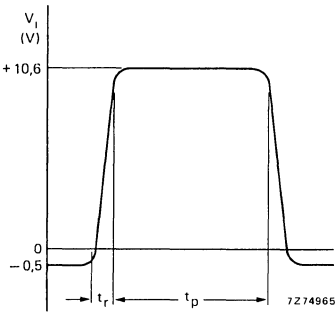


Fig. 2 Input waveform;  $t_r < 1 \text{ ns}; t_p = 300 \text{ ns}; \delta = 0,02$ .

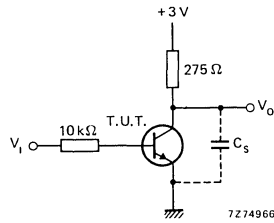


Fig. 3 Delay and rise time test circuit; total shunt capacitance of test jig and connectors  $C_s < 4 \text{ pF}$ ; scope impedance = 10  $M\Omega$ .

**Turn-off time (see Figs 4 and 5)**

$I_{Con} = 10 \text{ mA}; I_{Bon} = -I_{Boff} = 1 \text{ mA}$

Storage time

Fall time

	2N3903	2N3904
$t_s$	< 175	200 ns
$t_f$	< 50	50 ns

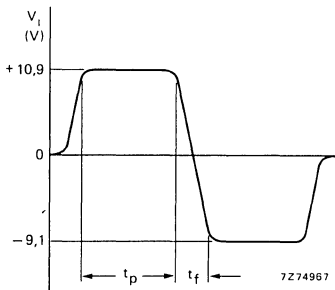


Fig. 4 Input waveform;  $t_f < 1 \text{ ns}; 10 \mu\text{s} < t_p < 500 \mu\text{s}; \delta = 0,02$ .

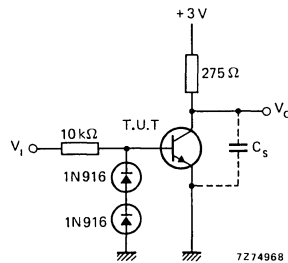


Fig. 5 Storage and fall time test circuit; total shunt capacitance of test jig and connectors  $C_s < 4 \text{ pF}$ ; scope impedance = 10  $M\Omega$ .



## SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in plastic TO-92 envelopes, primarily intended for high-speed, saturated switching applications for industrial service.

N-P-N complements are 2N3903 and 2N3904.

### QUICK REFERENCE DATA

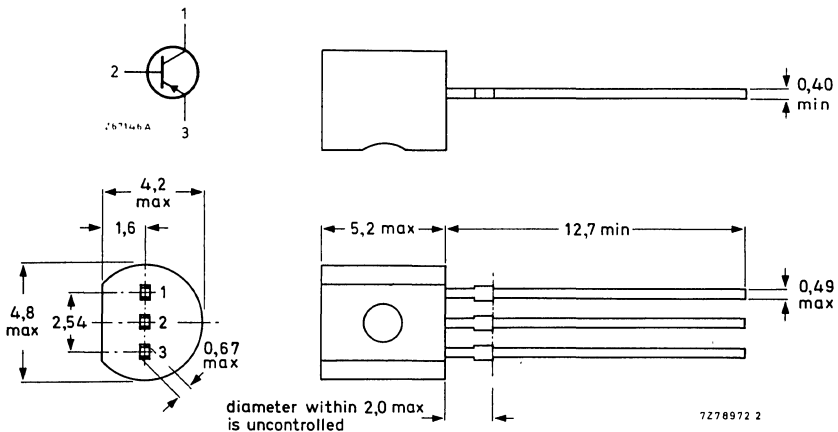
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	40 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40 V
Collector current (d.c.)	$-I_C$	max.	200 mA
Total power dissipation at $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max.	350 mW
Junction temperature	$T_j$	max.	150 $^\circ\text{C}$

		2N3905	2N3906
D.C. current gain $-I_C = 10\text{ mA}; -V_{CE} = 1\text{ V}$	$h_{FE}$	$> 50$	100
		$< 150$	300
Transition frequency at $f = 100\text{ MHz}$ $-I_C = 10\text{ mA}; -V_{CE} = 20\text{ V}$	$f_T$	$> 200$	250 MHz
Storage time $-I_{Con} = 10\text{ mA}; -I_{Bon} = I_{Boff} = 1\text{ mA}$	$t_s$	$< 200$	225 ns

### MÉCHANICAL DATA

Dimensions in' mm

Fig. 1 TO-92.



7278972 2

**RATINGS**

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

Collector-base voltage (open emitter)	$-V_{CB0}$	max.	40 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40 V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5 V
Collector current (d.c.)	$-I_C$	max.	200 mA
Total power dissipation at $T_{amb} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	350 mW
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 in free air	$R_{th\ j-a}$	=	357 K/W
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**CHARACTERISTICS**

$T_{amb} = 25\text{ }^{\circ}\text{C}$

Currents at reverse biased emitter junction

$-V_{CE} = 30\text{ V}; +V_{BE} = 3\text{ V}$	$-I_{CEX}$	<	50 nA
	$+I_{BEX}$	<	50 nA

Saturation voltages \*

$-I_C = 10\text{ mA}; -I_B = 1\text{ mA}$	$-V_{CEsat}$	<	250 mV
	$-V_{BEsat}$		650 to 850 mV
$-I_C = 50\text{ mA}; -I_B = 5\text{ mA}$	$-V_{CEsat}$	<	400 mV
	$-V_{BEsat}$	<	950 mV

D.C. current gain \*

		2N3905	2N3906
$-I_C = 0,1\text{ mA}; V_{CE} = 1\text{ V}$	$h_{FE}$	> 30	60
$-I_C = 1\text{ mA}; V_{CE} = 1\text{ V}$	$h_{FE}$	> 40	80
$-I_C = 10\text{ mA}; V_{CE} = 1\text{ V}$	$h_{FE}$	> 50	100
		< 150	300
$-I_C = 50\text{ mA}; V_{CE} = 1\text{ V}$	$h_{FE}$	> 30	60
$-I_C = 100\text{ mA}; V_{CE} = 1\text{ V}$	$h_{FE}$	> 15	30
Collector capacitance at $100\text{ kHz} \leq f \leq 1\text{ MHz}$ $I_E = I_e = 0; -V_{CB} = 5\text{ V}$	$C_c$	< 4,5	4,5 pF
Emitter capacitance at $100\text{ kHz} \leq f \leq 1\text{ MHz}$ $I_C = I_c = 0; -V_{EB} = 0,5\text{ V}$	$C_e$	< 10	10 pF
Transition frequency at $f = 100\text{ MHz}$ $-I_C = 10\text{ mA}; -V_{CE} = 20\text{ V}$	$f_T$	> 200	250 MHz
Noise figure at $R_S = 1\text{ k}\Omega$ $-I_C = 100\text{ }\mu\text{A}; -V_{CE} = 5\text{ V}$ $f = 10\text{ Hz to }15,7\text{ kHz}$	F	< 5	4 dB

\* Measured under pulse conditions:  $t_p = 300\text{ }\mu\text{s}; \delta = 0,02$ .

**h-parameters (common emitter)**

$-I_C = 1 \text{ mA}; -V_{CE} = 10 \text{ V}; f = 1 \text{ kHz}$

Input impedance

Reverse voltage transfer ratio

Small-signal current gain

Output admittance

	2N3905	2N3906
$h_{ie}$	0,5 to 8	2 to 12 $k\Omega$
$h_{re}$	0,1 to 5	0,1 to 10 $10^{-4}$
$h_{fe}$	50 to 200	100 to 400
$h_{oe}$	1 to 40	3 to 60 $\mu\text{A/V}$

**Switching times**

Turn-on time (see Figs 2 and 3) when switched from

$+V_{BE\text{off}} = 0,5 \text{ V}$  to  $-I_{C\text{on}} = 10 \text{ mA}; -I_{B\text{on}} = 1 \text{ mA}$

Delay time

Rise time

$t_d$	< 35	35 ns
$t_r$	< 35	35 ns

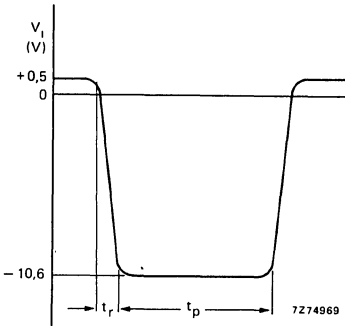


Fig. 2 Input waveform;  $t_r < 1 \text{ ns}; t_p = 300 \text{ ns}; \delta = 0,02$ .

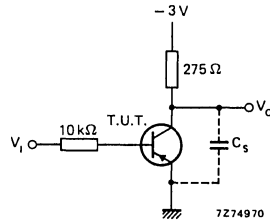


Fig. 3 Delay and rise time test circuit; total shunt capacitance of test jig and connectors  $C_s < 4 \text{ pF}$ ; scope impedance =  $10 \text{ M}\Omega$ .

**Turn-off time (see Figs 4 and 5)**

$-I_{C\text{on}} = 10 \text{ mA}; -I_{B\text{on}} = I_{B\text{off}} = 1 \text{ mA}$

Storage time

Fall time

	2N3905	2N3906
$t_s$	< 200	225 ns
$t_f$	< 60	75 ns

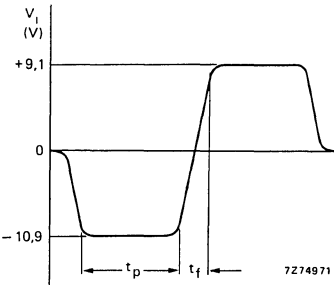


Fig. 4 Input waveform;  $t_f < 1 \text{ ns}; 10 \mu\text{s} < t_p < 500 \mu\text{s}; \delta = 0,02$ .

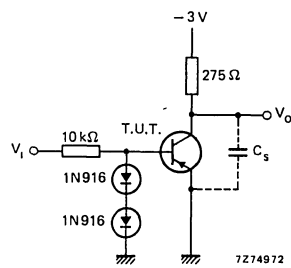


Fig. 5 Storage and fall time test circuit; total shunt capacitance of test jig and connectors  $C_s < 4 \text{ pF}$ ; scope impedance =  $10 \text{ M}\Omega$ .





SILICON PLANAR EPITAXIAL TRANSISTORS



P-N-P transistors in TO-39 metal envelopes primarily intended for large signal, low-noise, low-power audio frequency applications for industrial service.

QUICK REFERENCE DATA

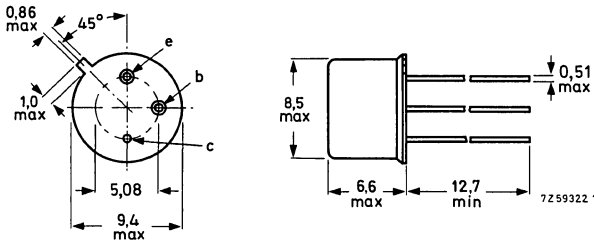
		<b>2N4030</b>	<b>2N4031</b>	
		<b>2N4032</b>	<b>2N4033</b>	
Collector-base voltage (open emitter)	$-V_{CBO}$ max.	60	80	V
Collector-emitter voltage (open base)	$-V_{CEO}$ max.	60	80	V
Collector current (d.c.)	$-I_C$ max.	1		A
Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$ max.	0,8		W
Junction temperature	$T_j$ max.	200		$^\circ\text{C}$
		<b>2N4030</b>	<b>2N4032</b>	
		<b>2N4031</b>	<b>2N4033</b>	
D.C. current gain	$h_{FE} >$	25	70	
$-I_C = 500\text{ mA}; -V_{CE} = 5\text{ V}$				
Transition frequency at $f = 100\text{ MHz}$	$f_T >$	100	150	MHz
$-I_C = 50\text{ mA}; -V_{CE} = 10\text{ V}$				

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).

**2N4030**  
to  
**2N4033**

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

		2N4030	2N4031
		2N4032	2N4033
<u>Voltages</u>			
Collector-base voltage (open emitter)	$-V_{CBO}$	max. 60	80 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max. 60	80 V
Emitter-base voltage (open collector)	$-V_{EBO}$	max. 5	5 V

Current

Collector current (d. c.)	$-I_C$	max. 1	A
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Power dissipation

Total power dissipation up to $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max. 0,8	W
up to $T_{case} = 25\text{ }^\circ\text{C}$	$P_{tot}$	max. 4,0	W

Temperatures

Storage temperature	$T_{stg}$	-65 to +200	$^\circ\text{C}$
Junction temperature	$T_j$	max. 200	$^\circ\text{C}$

**THERMAL RESISTANCE**

From junction to ambient in free air	$R_{th\ j-a}$	= 218	$^\circ\text{C/W}$
From junction to case	$R_{th\ j-c}$	= 44	$^\circ\text{C/W}$

**CHARACTERISTICS**

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

		2N4030	2N4031
		2N4032	2N4033
<u>Collector cut-off current</u>			
$I_E = 0; -V_{CB} = 50\text{ V}$	$-I_{CBO}$	< 50	- nA
$I_E = 0; -V_{CB} = 60\text{ V}$	$-I_{CBO}$	< -	50 nA
$I_E = 0; -V_{CB} = 50\text{ V}; T_{amb} = 150\text{ }^\circ\text{C}$	$-I_{CBO}$	< 50	- $\mu\text{A}$
$I_E = 0; -V_{CB} = 60\text{ V}; T_{amb} = 150\text{ }^\circ\text{C}$	$-I_{CBO}$	< -	50 $\mu\text{A}$
<u>Emitter cut-off current</u>			
$I_C = 0; -V_{EB} = 5\text{ V}$	$-I_{EBO}$	< 10	10 $\mu\text{A}$
<u>Breakdown voltages</u>			
$I_E = 0; -I_C = 10\text{ }\mu\text{A}$	$-V_{(BR)CBO}$	> 60	80 V
$I_B = 0; -I_C = 10\text{ mA}$	$-V_{(BR)CEO}$	> 60	80 V <sup>1)</sup>
$I_C = 0; -I_E = 10\text{ }\mu\text{A}$	$-V_{(BR)EBO}$	> 5	5 V

<sup>1)</sup> Measured under pulse conditions:  $t_p = 300\text{ }\mu\text{s}; \delta \leq 0,01$ .

**CHARACTERISTICS (continued)**

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

		2N4030	2N4031	
		2N4032	2N4033	
<u>Base-emitter voltage</u>				
$-I_C = 500\text{ mA}; -V_{CE} = 0,5\text{ V}$	$-V_{BE}$	< 1,1	1,1	V 1)
$-I_C = 1000\text{ mA}; -V_{CE} = 1,0\text{ V}$	$-V_{BE}$	< 1,2	-	V 1)
<u>Saturation voltages</u>				
$-I_C = 150\text{ mA}; -I_B = 15\text{ mA}$	$-V_{CEsat}$	< 0,15	0,15	V
	$-V_{BEsat}$	< 0,90	0,90	V 1)
$-I_C = 500\text{ mA}; -I_B = 50\text{ mA}$	$-V_{CEsat}$	< 0,50	0,50	V
$-I_C = 1000\text{ mA}; -I_B = 100\text{ mA}$	$-V_{CEsat}$	< 1,00	-	V
<u>D.C. current gain 1)</u>				
$-I_C = 100\text{ }\mu\text{A}; -V_{CE} = 5\text{ V}$	$h_{FE}$	> 30	75	
$-I_C = 100\text{ mA}; -V_{CE} = 5\text{ V}$	$h_{FE}$	> 40	100	
		< 120	300	
$-I_C = 100\text{ mA}; -V_{CE} = 5\text{ V}; T_{amb} = -55\text{ }^{\circ}\text{C}$	$h_{FE}$	> 15	40	
$-I_C = 500\text{ mA}; -V_{CE} = 5\text{ V}$	$h_{FE}$	> 25	70	
$-I_C = 1000\text{ mA}; -V_{CE} = 5\text{ V}$	<u>2N4030</u>	$h_{FE}$	> 15	
	<u>2N4031</u>	$h_{FE}$	> 10	
	<u>2N4032</u>	$h_{FE}$	> 40	
	<u>2N4033</u>	$h_{FE}$	> 25	
<u>Collector capacitance at <math>f = 1\text{ MHz}</math></u>				
$I_E = I_e = 0; -V_{CB} = 10\text{ V}$	$C_c$	< 20		pF
<u>Emitter capacitance at <math>f = 1\text{ MHz}</math></u>				
$I_C = I_c = 0; -V_{EB} = 0,5\text{ V}$	$C_e$	< 110		pF
<u>Transition frequency at <math>f = 100\text{ MHz}</math></u>				
$-I_C = 50\text{ mA}; -V_{CE} = 10\text{ V}$	$f_T$	> 100	150	MHz
		< 400	500	MHz

1) Measured under pulse conditions:  $t_p = 300\text{ }\mu\text{s}; \delta \leq 0,01$ .

**2N4030**  
to  
**2N4033**

**CHARACTERISTICS** (continued)

$T_{amb} = 25\text{ }^{\circ}\text{C}$

Switching times <sup>1)</sup>

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

Turn-on time

$t_{on} < 100\text{ ns}$

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

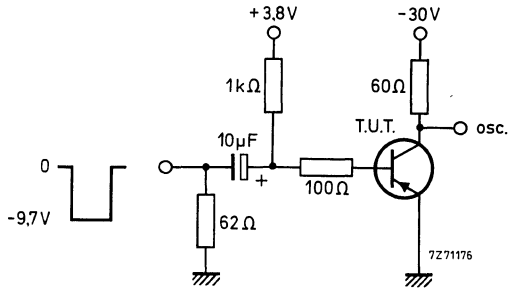
Storage time

$t_s < 350\text{ ns}$

Fall time

$t_f < 50\text{ ns}$

Switching circuit:



Pulse generator:

Rise time  $t_r < 20\text{ ns}$

Fall time  $t_f < 20\text{ ns}$

Pulse duration  $t_p = 10\text{ }\mu\text{s}$

Duty factor  $\delta < 0,02$

Source impedance  $Z_S = 50\text{ }\Omega$

Oscilloscope:

Rise time  $t_r = 10\text{ ns}$

Input impedance  $Z_I > 100\text{ k}\Omega$

<sup>1)</sup> See switching circuit for exact values of  $I_{Con}$ ;  $I_{Bon}$  and  $I_{Boff}$ .

## SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in plastic TO-92 envelopes, primarily intended for low-power, small-signal audio-frequency applications for consumer service.

P-N-P complements are 2N4125 and 2N4126.

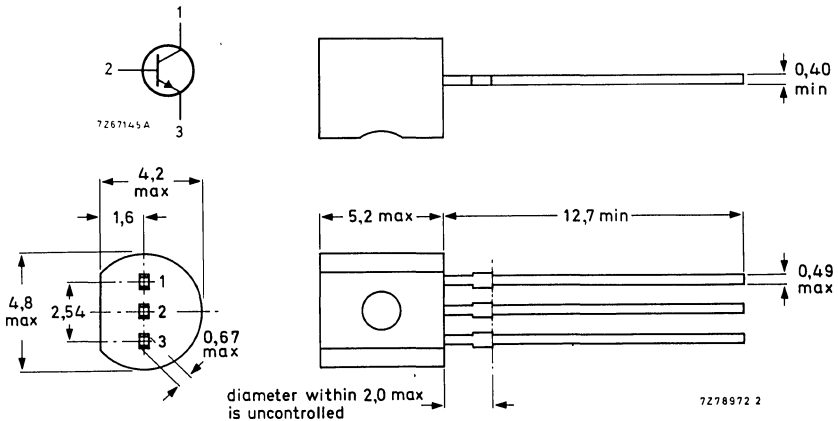
### QUICK REFERENCE DATA

		2N4123	2N4124
Collector-base voltage (open emitter)	$V_{CB0}$ max.	40	30 V
Collector-emitter voltage (open base)	$V_{CEO}$ max.	30	25 V
Collector current (d.c.)	$I_C$ max.	200	200 mA
Total power dissipation at $T_{amb} = 25^\circ\text{C}$	$P_{tot}$ max.	350	350 mW
Junction temperature	$T_j$ max.	150	150 $^\circ\text{C}$
Small-signal current gain $I_C = 2\text{ mA}; V_{CE} = 10\text{ V}; f = 1\text{ kHz}$	$h_{fe} >$	50	120
	$h_{fe} <$	200	480
Transition frequency at $f = 100\text{ MHz}$ $I_C = 10\text{ mA}; V_{CE} = 20\text{ V}$	$f_T >$	250	300 MHz
Noise figure at $R_S = 1\text{ k}\Omega$ $I_C = 100\text{ }\mu\text{A}; V_{CE} = 5\text{ V}$ $f = 10\text{ Hz to }15,7\text{ kHz}$	$F <$	6	5 dB

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92.



**RATINGS**

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

		2N4123	2N4124
Collector-base voltage (open emitter)	$V_{CBO}$ max.	40	30 V
Collector-emitter voltage (open base)	$V_{CEO}$ max.	30	25 V
Emitter-base voltage (open collector)	$V_{EBO}$ max.	5	V
Collector current (d.c.)	$I_C$ max.	200	mA
Total power dissipation at $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$ max.	350	mW
Total power dissipation at $T_{case} = 25\text{ }^\circ\text{C}$	$P_{tot}$ max.	1000	mW
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 in free air	$R_{th\ j-a}$ =	357	K/W
From junction to case	$R_{th\ j-c}$ =	125	K/W

**CHARACTERISTICS**

$T_{amb} = 25\text{ }^\circ\text{C}$

Collector cut-off current

$I_E = 0; V_{CB} = 20\text{ V}$

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

Emitter cut-off current

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

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

Saturation voltages \*

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

$V_{CEsat} < 300\text{ mV}$   
 $V_{BEsat} < 950\text{ mV}$

D.C. current gain \*

$I_C = 2\text{ mA}; V_{CE} = 1\text{ V}$

$h_{FE} > 50$   
 $h_{FE} < 150$

$I_C = 50\text{ mA}; V_{CE} = 1\text{ V}$

$h_{FE} > 25$

Collector capacitance at  $f = 100\text{ kHz}$

$I_E = I_e = 0; V_{CB} = 5\text{ V}$

$C_c < 4\text{ pF}$

Emitter capacitance at  $f = 100\text{ kHz}$

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

$C_e < 8\text{ pF}$

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

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

$f_T > 250$  300 MHz

Noise figure at  $R_S = 1\text{ k}\Omega$

$I_C = 100\text{ }\mu\text{A}; V_{CE} = 5\text{ V}$

$f = 10\text{ Hz to }15,7\text{ kHz}$

$F < 6$  5 dB

Small-signal current gain

$I_C = 2\text{ mA}; V_{CE} = 10\text{ V}; f = 1\text{ kHz}$

$h_{fe} > 50$   
 $h_{fe} < 200$  120 480

\* Measured under pulse conditions:  $t_p = 300\text{ }\mu\text{s}; \delta = 0,02$ .

## SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in plastic TO-92 envelopes, primarily intended for low-power, small-signal audio-frequency applications for consumer service.

N-P-N complements are 2N4123 and 2N4124.

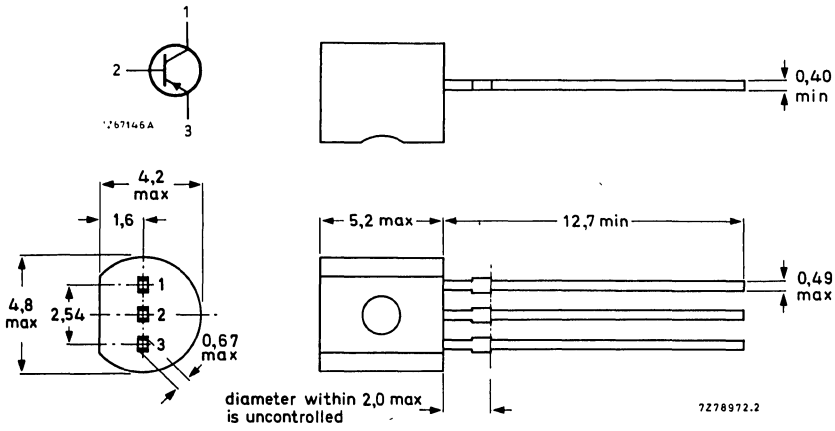
### QUICK REFERENCE DATA

		2N4125	2N4126
Collector-base voltage (open emitter)	$-V_{CBO}$ max.	30	25 V
Collector-emitter voltage (open base)	$-V_{CEO}$ max.	30	25 V
Collector current (d.c.)	$-I_C$ max.	200	200 mA
Total power dissipation at $T_{amb} = 25^\circ\text{C}$	$P_{tot}$ max.	350	350 mW
Junction temperature	$T_j$ max.	150	150 $^\circ\text{C}$
Small-signal current gain $-I_C = 2\text{ mA}; -V_{CE} = 10\text{ V}; f = 1\text{ kHz}$	$h_{fe} >$	50	120
	$h_{fe} <$	200	480
Transition frequency at $f = 100\text{ MHz}$ $-I_C = 10\text{ mA}; -V_{CE} = 20\text{ V}$	$f_T >$	200	250 MHz
Noise figure at $R_G = 1\text{ k}\Omega$ $-I_C = 100\text{ }\mu\text{A}; -V_{CE} = 5\text{ V}$ $f = 10\text{ Hz to }15,7\text{ kHz}$	$F <$	5	4 dB

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92.





2N4125  
2N4126

**RATINGS**

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

		2N4125	2N4126
Collector-base voltage (open emitter)	$-V_{CBO}$ max.	30	25 V
Collector-emitter voltage (open base)	$-V_{CEO}$ max.	30	25 V
Emitter-base voltage (open collector)	$-V_{EBO}$ max.	4 V	
Collector current (d.c.)	$-I_C$ max.	200	mA
Total power dissipation at $T_{amb} = 25\text{ }^\circ\text{C}$	$P_{tot}$ max.	350	mW
Total power dissipation at $T_{case} = 25\text{ }^\circ\text{C}$	$P_{tot}$ max.	1000	mW
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 in free air	$R_{th\ j-a}$ =	357	K/W
From junction to case	$R_{th\ j-c}$ =	125	K/W

**CHARACTERISTICS**

$T_{amb} = 25\text{ }^\circ\text{C}$

Collector cut-off current

$I_E = 0; -V_{CB} = 20\text{ V}$

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

Emitter cut-off current

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

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

Saturation voltages \*

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

$-V_{CEsat} < 400\text{ mV}$   
 $-V_{BEsat} < 950\text{ mV}$

D.C. current gain \*

$-I_C = 2\text{ mA}; -V_{CE} = 1\text{ V}$

$h_{FE} > 50$   
 $h_{FE} < 150$

$-I_C = 50\text{ mA}; -V_{CE} = 1\text{ V}$

$h_{FE} > 25$

Collector capacitance at  $f = 100\text{ kHz}$

$I_E = I_e = 0; -V_{CB} = 5\text{ V}$

$C_c < 4,5$

Emitter capacitance at  $f = 100\text{ kHz}$

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

$C_e < 10$

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

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

$f_T > 200$

Noise figure at  $R_S = 1\text{ k}\Omega$

$-I_C = 100\text{ }\mu\text{A}; -V_{CE} = 5\text{ V}$

$f = 10\text{ Hz to }15,7\text{ kHz}$

$F < 5$

Small-signal current gain

$-I_C = 2\text{ mA}; -V_{CE} = 10\text{ V}; f = 1\text{ kHz}$

$h_{fe} > 50$   
 $h_{fe} < 200$

\* Measured under pulse conditions:  $t_p = 300\text{ }\mu\text{s}; \delta = 0,02$ .

## SILICON P-N-P HIGH-VOLTAGE TRANSISTORS

Transistors in TO-39 metal envelopes with the collector connected to the case. They are intended for high-speed switching and linear amplifier applications in military, industrial and commercial equipment.

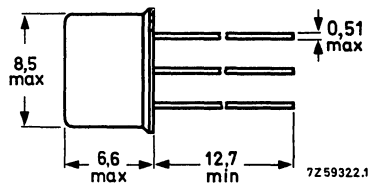
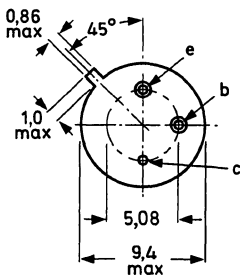
QUICK REFERENCE DATA					
		2N5415		2N5416	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	200	350	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	200	300	V
Collector current (d. c.)	$-I_C$	max.	1	1	A
Total power dissipation up to $T_{amb} = 50\text{ }^\circ\text{C}$	$P_{tot}$	max.	1	1	W
Junction temperature	$T_j$	max.	200	200	$^\circ\text{C}$
D. C. current gain					
$-I_C = 50\text{ mA}; -V_{CE} = 10\text{ V}$	$h_{FE}$	$>$	30	30	
		$<$	150	120	

### MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-39.

Collector connected to case



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories: 56245 (distance disc).

# 2N5415 2N5416

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

## Voltages

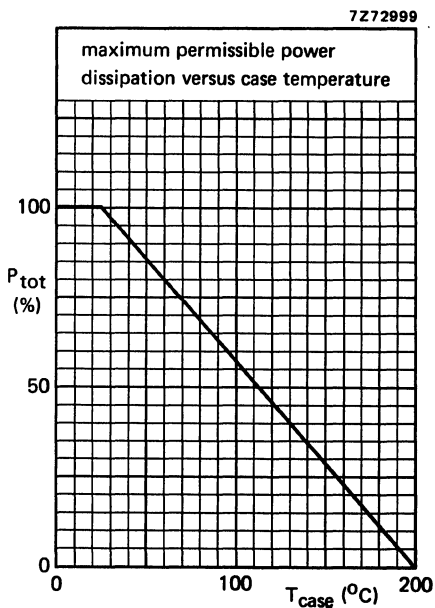
			2N5415	2N5416	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	200	350	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	200	300	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	4	6	V

## Currents

Collector current (d. c.)	$-I_C$	max.	1	A
Base current (d. c.)	$-I_B$	max.	0,5	A

## Power dissipation

Total power dissipation up to $T_{case} = 25\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	10	W
Total power dissipation up to $T_{amb} = 50\text{ }^{\circ}\text{C}$	$P_{tot}$	max.	1	W



## Temperatures

Storage temperature	$T_{stg}$	-65 to +200	$^{\circ}\text{C}$
Junction temperature	$T_j$	max. 200	$^{\circ}\text{C}$

## **THERMAL RESISTANCE**

From junction to case	$R_{th\ j-c}$	= 17,5	$^{\circ}\text{C/W}$
From junction to ambient in free air	$R_{th\ j-a}$	= 150	$^{\circ}\text{C/W}$

**CHARACTERISTICS**

$T_{case} = 25\text{ }^{\circ}\text{C}$

Collector cut-off currents

$I_E = 0; -V_{CB} = 175\text{ V}$

$-I_{CBO} < \begin{array}{|c|c|} \hline 2N5415 & 2N5416 \\ \hline & \end{array} \begin{array}{|c|} \hline - \\ \hline \end{array} \mu\text{A}$

$I_E = 0; -V_{CB} = 280\text{ V}$

$-I_{CBO} < \begin{array}{|c|c|} \hline 2N5415 & 2N5416 \\ \hline & \end{array} \begin{array}{|c|} \hline - \\ \hline \end{array} 50 \mu\text{A}$

$I_B = 0; -V_{CE} = 150\text{ V}$

$-I_{CEO} < \begin{array}{|c|c|} \hline 2N5415 & 2N5416 \\ \hline & \end{array} \begin{array}{|c|} \hline - \\ \hline \end{array} 50 \mu\text{A}$

$I_B = 0; -V_{CE} = 250\text{ V}$

$-I_{CEO} < \begin{array}{|c|c|} \hline 2N5415 & 2N5416 \\ \hline & \end{array} \begin{array}{|c|} \hline - \\ \hline \end{array} 50 \mu\text{A}$

Emitter cut-off current

$I_C = 0; -V_{EB} = 4\text{ V}$

$-I_{EBO} < \begin{array}{|c|c|} \hline 2N5415 & 2N5416 \\ \hline & \end{array} \begin{array}{|c|} \hline - \\ \hline \end{array} 20 \mu\text{A}$

$I_C = 0; -V_{EB} = 6\text{ V}$

$-I_{EBO} < \begin{array}{|c|c|} \hline 2N5415 & 2N5416 \\ \hline & \end{array} \begin{array}{|c|} \hline - \\ \hline \end{array} 20 \mu\text{A}$

Sustaining voltage

$I_B = 0; -I_C = 0 \text{ to } 50\text{ mA}$

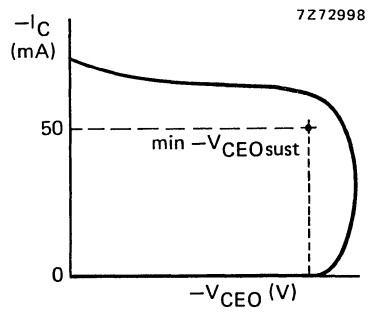
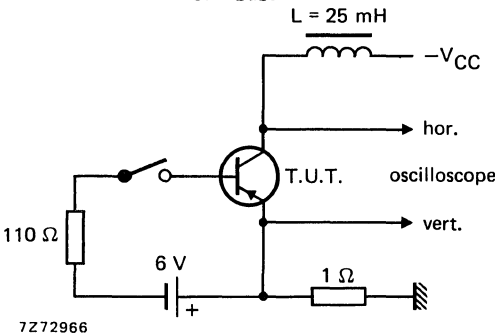
$-V_{CEOsust} > \begin{array}{|c|c|} \hline 2N5415 & 2N5416 \\ \hline & \end{array} \begin{array}{|c|} \hline 200 \\ \hline \end{array} \begin{array}{|c|} \hline 300 \\ \hline \end{array} \text{ V } 1)$

$R_{BE} = 50\text{ }\Omega; -I_C = 50\text{ mA}$

$-V_{CERsust} > \begin{array}{|c|c|} \hline 2N5415 & 2N5416 \\ \hline & \end{array} \begin{array}{|c|} \hline - \\ \hline \end{array} \begin{array}{|c|} \hline 350 \\ \hline \end{array} \text{ V } 1)$

Test circuit for  $V_{CEOsust}$

Oscilloscope display for  $V_{CEOsust}$



Saturation voltages

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

$-V_{CEsat} < \begin{array}{|c|c|} \hline 2N5415 & 2N5416 \\ \hline & \end{array} \begin{array}{|c|} \hline 2,5 \\ \hline \end{array} \begin{array}{|c|} \hline 2,0 \\ \hline \end{array} \text{ V}$   
 $-V_{BEsat} < \begin{array}{|c|c|} \hline 2N5415 & 2N5416 \\ \hline & \end{array} \begin{array}{|c|} \hline 1,5 \\ \hline \end{array} \begin{array}{|c|} \hline 1,5 \\ \hline \end{array} \text{ V}$

D. C. current gain

$-I_C = 50\text{ mA}; -V_{CE} = 10\text{ V}$

$h_{FE} > \begin{array}{|c|c|} \hline 2N5415 & 2N5416 \\ \hline & \end{array} \begin{array}{|c|} \hline 30 \\ \hline \end{array} \begin{array}{|c|} \hline 30 \\ \hline \end{array}$   
 $h_{FE} < \begin{array}{|c|c|} \hline 2N5415 & 2N5416 \\ \hline & \end{array} \begin{array}{|c|} \hline 150 \\ \hline \end{array} \begin{array}{|c|} \hline 120 \\ \hline \end{array}$

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

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

$C_C < \begin{array}{|c|c|} \hline 2N5415 & 2N5416 \\ \hline & \end{array} \begin{array}{|c|} \hline 15 \\ \hline \end{array} \text{ pF}$

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

$I_C = I_c = 0; -V_{EB} = -V_{EBOmax}$

$C_e < \begin{array}{|c|c|} \hline 2N5415 & 2N5416 \\ \hline & \end{array} \begin{array}{|c|} \hline 75 \\ \hline \end{array} \text{ pF}$

1) Measured under pulse conditions to avoid excessive dissipation.

2N5415  
2N5416

**CHARACTERISTICS (continued)**

$T_{\text{case}} = 25\text{ }^{\circ}\text{C}$

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

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

$f_{\text{T}} > 15\text{ MHz}$

**h-parameters (common emitter)**

$-I_{\text{C}} = 5\text{ mA}; -V_{\text{CE}} = 10\text{ V}$

real part of input impedance at  $f = 1\text{ MHz}$

$R_{\text{e}}(h_{\text{ie}}) < 300\text{ }\Omega$

small-signal current gain at  $f = 1\text{ kHz}$

$h_{\text{fe}} > 25$



SOLDERING RECOMMENDATIONS SOT-37  
ACCESSORIES



## SOLDERING RECOMMENDATIONS SOT-37

Transistors in SOT-37 envelopes may be mounted with leads flat (Fig. 1) or bent (Figs 2 and 3). Different soldering procedures apply for the different styles of mounting.

### FLAT-LEAD MOUNTING

#### Soldering by hand

Avoid putting any force on the leads during or just after soldering.

Solder the three leads one at a time, *not* simultaneously.

Proceed from one lead to the adjacent lead, *not* to the opposite one.

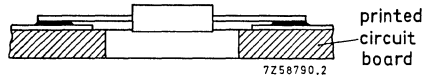


Fig. 1

Solder temperature	max.	300 °C
Soldering time	max.	5 s
Solder-to-case distance	min.	2 mm

### BENT-LEAD MOUNTING

If leads are bent, all three may be soldered simultaneously if desired.

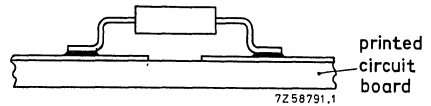


Fig. 2

Solder temperature	max.	300 °C
Soldering time	max.	10 s

### DIP OR WAVE SOLDERING

When dip or wave soldering, the maximum allowable temperature of the solder is 260 °C. This temperature must not be in contact with the joint for more than 5 seconds. The total contact time of successive solder waves must not exceed 5 seconds. The device may be mounted up to the lead projections, but the temperature of the body must not exceed the specified storage maximum.

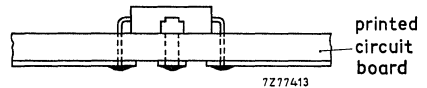


Fig. 3

Solder temperature	max.	260 °C
Soldering time	max.	5 s

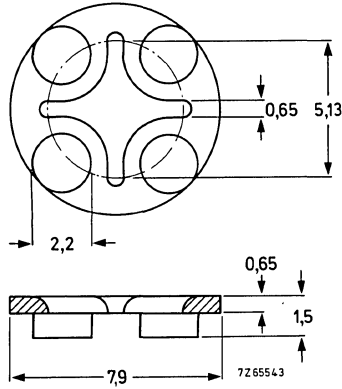
## DISTANCE DISCS

## MECHANICAL DATA

Fig. 1 56245 for TO-5 or TO-39.

Insulating material.

Dimensions in mm



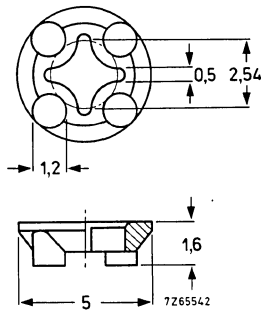
## TEMPERATURE

Maximum permissible temperature

Fig. 2 56246 for TO-18 or TO-72.

Insulating material.

T max. 100 °C



## TEMPERATURE

Maximum permissible temperature

T max. 100 °C



# SMALL-SIGNAL TRANSISTORS



SELECTION GUIDE  
TYPE NUMBER SURVEY

CECC  
APPROVED TYPES

GENERAL

TRANSISTOR DATA

SOLDERING RECOMMENDATIONS SOT-37  
ACCESSORIES

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