Semiconductors

Part 3 April 1980

Small-signal transistors

SEMICONDUCTORS

PART 3 - APRIL 1980

SMALL-SIGNAL TRANSISTORS

DATA HANDBOOK SYSTEM

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

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

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

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

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

ELECTRON TUBES (BLUE SERIES)

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

Part 1	**February 1980**	**T1 02-80** **(ET1a 12-75)**	**Tubes for r.f. heating**
Part 2	**April 1980**	**T2 04-80** **(ET1b 08-77)**	**Transmitting tubes for communications**
Part 2a	**November 1977**	**ET2a 11-77**	**Microwave tubes** Communication magnetrons, magnetrons for microwave heating, klystrons, travelling-wave tubes, diodes, triodes T-R switches
Part 2b	**May 1978**	**ET2b 05-78**	**Microwave semiconductors and components** Gunn, Impatt and noise diodes, mixer and detector diodes, backward diodes, varactor diodes, Gunn oscillators, sub-assemblies, circulators and isolators
Part 3	**January 1975**	**ET3 01-75**	**Special Quality tubes, miscellaneous devices**
Part 4	**March 1975**	**ET4 03-75**	**Receiving tubes**
Part 5a	**October 1979**	**ET5a 10-79**	**Cathode-ray tubes** Instrument tubes, monitor and display tubes, C.R. tubes for special applications
Part 5b	**December 1978**	**ET5b 12-78**	**Camera tubes and accessories, image intensifiers**
Part 6	**January 1977**	**ET6 01-77**	**Products for nuclear technology** Channel electron multipliers, neutron tubes, Geiger-Müller tubes
Part 7a	**March 1977**	**ET7a 03-77**	**Gas-filled tubes** Thyratrons, industrial rectifying tubes, ignitrons, high-voltage rectifying tubes
Part 7b	**May 1979**	**ET7b 05-79**	**Gas-filled tubes** Segment indicator tubes, indicator tubes, switching diodes, dry reed contact units
Part 8	**July 1979**	**ET8 07-79**	**Picture tubes and components** Colour TV picture tubes, black and white TV picture tubes, monitor tubes, components for colour television, components for black and white television.
Part 9	**March 1978**	**ET9 03-78**	**Photomultiplier tubes; phototubes**

SEMICONDUCTORS AND INTEGRATED CIRCUITS (RED SERIES)

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

Part 1a	August 1978	SC1a 08-78	**Rectifier diodes, thyristors, triacs** Rectifier diodes, voltage regulator diodes (> 1,5 W), transient suppressor diodes, rectifier stacks, thyristors, triacs
Part 1	March 1980	S1 03-80 (SC1b 05-77)	**Diodes** Small-signal germanium diodes, small-signal silicon diodes, special diodes, voltage regulator diodes (< 1,5 W), voltage reference diodes, tuner diodes, rectifier diodes
Part 2	June 1979	SC2 06-79	**Low-frequency power transistors**
Part 3	January 1978	SC3 01-78	**High-frequency, switching and field-effect transistors** *
Part 3	April 1980	S3 04-80 (SC2 11-77, partly) (SC3 01-78, partly)	**Small-signal transistors**
Part 4a	December 1978	SC4a 12-78	**Transmitting transistors and modules**
Part 4b	September 1978	SC4b 09-78	**Devices for optoelectronics** Photosensitive diodes and transistors, light-emitting diodes, photocouplers, infrared sensitive devices, photoconductive devices
Part 4c	July 1978	SC4c 07-78	**Discrete semiconductors for hybrid thick and thin-film circuits**
Part 5a	November 1976	SC5a 11-76	**Professional analogue integrated circuits**
Part 5b	March 1977	SC5b 03-77	**Consumer integrated circuits** Radio, audio, television
Part 6	October 1977	SC6 10-77	**Digital integrated circuits** LOCMOS HE4000B family
Part 6b	August 1979	SC6b 08-79	**ICs for digital systems in radio and television receivers**
Signetics integrated circuits			Bipolar and MOS memories 1979 Bipolar and MOS microprocessors 1978 Analogue circuits 1979 Logic - TTL 1978

*Field-effect transistors and wideband transistors will be transferred to S5 and SC3c respectively. The old book SC3 01-78 should be kept until then. The old book SC2 11-77 is now obsolete.

COMPONENTS AND MATERIALS (GREEN SERIES)

Part 1	July 1979	CM1 07-79	**Assemblies for industrial use** PLC modules, high noise immunity logic FZ/30-series, NORbits 60-series, 61-series, 90-series, input devices, hybrid integrated circuits, peripheral devices
Part 2b	February 1978	CM2b 02-78	**Capacitors** Electrolytic and solid capacitors, film capacitors, ceramic capacitors, variable capacitors
Part 3a	September 1978	CM3a 09-78	**FM tuners, television tuners, surface acoustic wave filters**
Part 3b	October 1978	CM3b 10-78	**Loudspeakers**
Part 4a	November 1978	CM4a 11-78	**Soft ferrites** Ferrites for radio, audio and television, beads and chokes, Ferroxcube potcores and square cores, Ferroxcube transformer cores
Part 4b	February 1979	CM4b 02-79	**Piezoelectric ceramics, permanent magnet materials**
Part 6	April 1977	CM6 04-77	**Electric motors and accessories** Small synchronous motors, stepper motors, miniature direct current motors
Part 7	September 1971	CM7 09-71	**Circuit blocks** Circuit blocks 100 kHz-series, circuit blocks 1-series, circuit blocks 10-series, circuit blocks for ferrite core memory drive
Part 7a	January 1979	CM7a 01-79	**Assemblies** Circuit blocks 40-series and CSA70 (L), counter modules 50-series, input/output devices
Part 8	June 1979	CM8 06-79	**Variable mains transformers**
Part 9	August 1979	CM9 08-79	**Piezoelectric quartz devices** Quartz crystal units, temperature compensated crystal oscillators
Part 10	April 1978	CM10 04-78	**Connectors**
Part 11	December 1979	CM11 12-79	**Non-linear resistors** Voltage dependent resistors (VDR), light dependent resistors (LDR), negative temperature coefficient thermistors (NTC), positive temperature coefficient thermistors (PTC)
Part 12	November 1979	CM12 11-79	**Variable resistors and test switches**
Part 13	December 1979	CM13 12-79	**Fixed resistors**

INDEX OF TYPE NUMBERS

Data Handbooks SC1a to SC4c

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

type no.	part	section	type no.	part	section	type no.	part	section
AA119	1	PC	BAV20	1	WD	BB405G	1	T
AAZ13	1	GB	BAV21	1	WD	BBY31	4c	Mm
AAZ15	1	GB	BAV45	1	Sp	BC107	3	Sm
AAZ17	1	GB	BAV70	4c	Mm	BC108	3	Sm
AAZ18	1	GB	BAV99	4c	Mm	BC109	3	Sm
BA182	1	T	BAW56	4c	Mm	BC140	3	Sm
BA220	1	WD	BAW62	1	WD	BC141	3	Sm
BA221	1	WD	BAX12	1	WD	BC146	3	Sm
BA223	1	T	BAX12A	1	WD	BC147	3	Sm
BA243	1	T	BAX13	1	WD	BC148	3	Sm
BA244	1	T	BAX14A	1	WD	BC149	3	Sm
BA280	1	T	BAX16	1	WD	BC157	3	Sm
BA314	1	Vrg	BAX17	1	WD	BC158	3	Sm
BA315	1	Vrg	BAX18A	1	WD	BC159	3	Sm
BA316	1	WD	BB105B	1	T	BC160	3	Sm
BA317	1	WD	BB105G	1	T	BC161	3	Sm
BA318	1	WD	BB106	1	T	BC177	3	Sm
BA379	1	T	BB109G	1	T	BC178	3	Sm
BAS11	1	WD	BB110B	1	T	BC179	3	Sm
BAS16	4c	Mm	BB110G	1	T	BC200	3	Sm
BAT17	4c	Mm	BB119	1	T	BC264A	3	FET
BAT18	4c	Mm	BB204B	1	T	BC264B	3	FET
BAV10	1	WD	BB204G	1	T	BC264C	3	FET
BAV18	1	WD	BB212	1	T	BC264D	3	FET
BAV19	1	WD	BB405B	1	T	BC327	3	Sm

FET = Field-effect transistors
GB = Germanium gold bonded diodes
Mm = Discrete semiconductors for hybrid thick and thin-film circuits
PC = Germanium point contact diodes
Sm = Small-signal transistors
Sp = Special diodes
T = Tuner diodes
Vrg = Voltage regulator diodes
WD = Silicon whiskerless diodes

Mm = Discrete semiconductors for hybrid thick and thin-film circuits
P = Low-frequency power transistors
Sm = Small-signal transistors

FET = Field-effect transistors
P = Low-frequency power transistors
Sm = Small-signal transistors

FET = Field-effect transistors
HFSW = High-frequency and switching transistors
Mm = Discrete semiconductors for hybrid thick and thin-film circuits
P = Low-frequency power transistors
R = Rectifier diodes
Sm = Small-signal transistors
Tra = Transmitting transistors and modules

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

FET = Field-effect transistors
P = Low-frequency power transistors
R = Rectifier diodes
Sm = Small-signal transistors
Th = Thyristors
Tri = Triacs

GB = Germanium gold bonded diodes
I = Infrared devices
LED = Light-emitting diodes
P = Low-frequency power transistors
PC = Germanium point contact diodes
Ph = Photoconductive devices
PhC = Photocouplers
R = Rectifier diodes
Sm = Small-signal transistors
St = Rectifier stacks
TS = Transient suppressor diodes
Vrf = Voltage reference diodes
Vrg = Voltage regulator diodes
WD = Silicon whiskerless diodes

A = Accessories
DH = Diecast heatsinks
FET = Field-effect transistors
HE = Heatsink extrusions
HFSW = High-frequency and switching transistors
I = Infrared devices
P = Low-frequency power transistors
R = Rectifer diodes
Sm = Small-signal transistors
Tra = Transmitting transistors and modules
Vrf = Voltage reference diodes
WD = Silicon whiskerless diodes

A = Accessories
DH = Diecast heatsinks

MAINTENANCE TYPE LIST

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

BD115	BF184	40820
BF167	BF185	40835
BF177	BF327	40838
BF178	BFW45	
BF179	BSW41A	

SELECTION GUIDE

Transistors for audio and general purpose applications

type number	polarity	envelope	RATINGS V_{CEO} V	I_C mA	P_{tot} mW	at T_{amb} °C	CHARACTERISTICS h_{FE} (h_{fe})	at I_C mA	f_T MHz typ.	F dB typ.	remarks
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
BC140	n-p-n	TO-39	40	1000	3700	45 *	40–250	100	> 50	–	
BC141			60								
BC146	n-p-n	SOT-42	20	50	50	45	80–550	0,2	150	2	hearing aids, watches
BC160	p-n-p	TO-39	40	1000	3700	45 *	40–250	100	> 50	–	
BC161			60								
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	p-n-p	TO-92 var.	45	500	800	25	100–600	100	100	–	
BC328			25								
BC337	n-p-n	TO-92 var.	45	500	800	25	100–600	100	200	–	
BC338			25								
BC368	n-p-n	TO-92 var.	20	1000	800	25	85–375	500	60	–	
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	–	
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	
BC548			30				(125–900)				
BC549	n-p-n	TO-92 var.	30	100	500	25	(240–900)	2	300	1,4	
BC550			45								

* T_{case}.

Transistors for audio and general purpose applications

type number	polarity	envelope	RATINGS V_{CEO} V	I_C mA	P_{tot} mW	at T_{amb} °C	CHARACTERISTICS h_{FE} (h_{fe})	at I_C mA	f_T MHz typ.	F dB typ.	remarks
BC556 BC557 BC558	p-n-p	TO-92 var.	65 45 30	100	500	25	(75–500)	2	150	2	
BC559 BC560	p-n-p	TO-92 var.	30 45	100	500	25	(125–500)	2	150	1,2 1	low-noise types
BC635 BC637 BC639	n-p-n	TO-92 var.	45 60 80	1000	1000	25	40–250 40–160 40–160	150	130	–	
BC636 BC638 BC640	p-n-p	TO-92 var.	45 60 80	1000	1000	25	40–250 40–160 40–160	150	50	–	
BCY30A BCY31A BCY32A BCY33A BCY34A	p-n-p	TO-5	64 64 64 32 32	100	600	25	10–35 15–60 20–70 10–35 15–60	20	2	8	
BCY56 BCY57	n-p-n	TO-18	45 20	100	300	25	100–450 200–800	2	85 100	1,5	low-noise types
BCY58 BCY59	n-p-n	TO-18	32 45	200	330	45	(125–700)	2	280	2	switching
BCY70 BCY71 BCY72	p-n-p	TO-18	40 45 25	200	350	25	> 100	10	450	2,0 0,8 2,0	low-noise type
BCY78 BCY79	p-n-p	TO-18	32 45	200	345	45	(125–700)	2	180	2	switching
BCY87 * BCY88 * BCY89 *	n-p-n	TO-71	40	30	150	25	100–450	0,05	> 10	< 3 < 4 < 4	pre-stages of differential amplifiers long-tailed pairs

* Dual transistors for differential amplifiers.

Transistors for audio and general purpose applications

type number	polarity	envelope	RATINGS V_{CEO} V	I_C mA	P_{tot} mW at	T_{amb} °C	CHARACTERISTICS h_{FE} (h_{fe}) at	I_C mA	f_T MHz typ.	F dB typ.	remarks
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		
2N4123 2N4124	n-p-n	TO-92	30 25	200	350	25	(50–200) (120–480)	2	> 250 > 300	6 5	small-signal, low-power

Transistors for h.f. applications

type number	polarity	envelope	RATINGS V_{CEO} V	I_C mA	P_{tot} mW at	T_{amb} °C	CHARACTERISTICS h_{FE} at	I_C mA	C_{re} pF typ.	f_T MHz typ.	F dB typ. at	f MHz	remarks
BF115	n-p-n	TO-72	30	30	145	45	45–165	1	0,65	230	4	100	
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
BF194	n-p-n	SOT-25	20	30	250	25	typ. 115	1	0,95	260	4	100	f.m. tuners and i.f. amp.
BF195	n-p-n	SOT-25	20	30	250	25	typ. 67	1	0,95	200	4	100	f.m. tuners and i.f. amp.
BF196	n-p-n	SOT-25	30	25	250	25	typ. 57	4	0,20	400	3	35	gain-controlled TV i.f. amp.

* I_{CM}.

Transistors for h.f. applications

type number	polarity	envelope	RATINGS: V_{CEO} V	RATINGS: I_C mA	RATINGS: P_{tot} mW	RATINGS: at T_{amb} °C	CHARACTERISTICS: h_{FE}	CHARACTERISTICS: at I_C mA	CHARACTERISTICS: C_{re} pF typ.	CHARACTERISTICS: f_T MHz typ.	CHARACTERISTICS: F dB typ.	CHARACTERISTICS: at f MHz	remarks
BF197	n-p-n	SOT-25	25	25	250	25	> 38	7	0,30	550			output video i.f. amp.
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 BF241	n-p-n	TO-92 var.	40	25	250	25	67–220 36–125	1	0,34	380 350	3,5	0,2	a.m. mixers and i.f. amp. 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 BF337 BF338	n-p-n	TO-39	180 200 225	100	3000	140**	> 20	30	3,5	80			video output stages
BF362 BF363	n-p-n	SOT-37	20	20	120	55	typ. 50	3	0,25	800 > 600	4,5	500	r.f. stage of TV tuner oscillator mixer
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 BF451	p-n-p	TO-92 var.	40	25	250	45	62–200 30–90	1	0,35	325	2	100	mixer stages in a.m. receivers 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_{rb}. ** T_{mb}.

Transistors for h.f. applications

type number	polarity	envelope	RATINGS V_{CEO} V	RATINGS I_C mA	RATINGS P_{tot} mW	RATINGS at T_{amb} °C	CHARACTERISTICS h_{FE} typ.	CHARACTERISTICS at I_C mA	CHARACTERISTICS C_{re} pF typ.	CHARACTERISTICS f_T MHz typ.	CHARACTERISTICS F dB typ.	CHARACTERISTICS at f MHz	remarks
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 BFY51 BFY52	n-p-n	TO-39	35 30 20	1000	5000	50**	112 123 142	150		140 160 185			general purpose industrial and switching applications
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			

Transistors for switching applications

type number	polarity	envelope	RATINGS V_{CEO} V	RATINGS I_C mA	RATINGS P_{tot} mW	RATINGS at T_{amb} °C	CHARACTERISTICS h_{FE}	CHARACTERISTICS at I_C mA	CHARACTERISTICS f_T MHz typ.	CHARACTERISTICS t_{off} ns max.	CHARACTERISTICS at I_C mA	remarks
BC140 BC141	n-p-n	TO-39	40 60	1000	3700	45**	40–250	100	> 50	850	100	
BC160 BC161	p-n-p	TO-39	40 60	1000	3700	45**	40–250	100	> 50	650	100	
BCY58 BCY59	n-p-n	TO-18	32 45	200	330	45	80–1000	10	280	800	10	

* I_{CM}. ** T_{mb}.

Transistors for switching applications

type number	polarity	envelope	RATINGS V_{CEO} V	I_C mA	P_{tot} at mW	T_{amb} °C	CHARACTERISTICS h_{FE} at	I_C mA	f_T MHz typ.	t_{off} at ns max.	I_C mA	remarks
BCY70			40							420	10	
BCY71	p-n-p	TO-18	45	200	350	25	> 100	10	450			BCY71 is low-noise version
BCY72			25							420	10	
BCY78	p-n-p	TO-18	32	200	345	45	80–1000	10	180	800	10	
BCY79			45									
BFT44	p-n-p	TO-39	300	500	5000	50**	50–150	10	70	125	500	
BFT45			250									
BFX34	n-p-n	TO-39	60	2000	5000	25**	40–150	2000	> 70	1200	5000	inverter and switching regulators
BFY50			35				typ. 112		140			
BFY51	n-p-n	TO-39	30	1000	5000	50**	typ. 123	150	160	360	150	
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*									
BSR60			45*									
BSR61	p-n-p	TO-92 var.	60*	1000	800	25	> 2000	500		1500	500	Darlington transistors
BSR62			80*									
BSS38	n-p-n	TO-92 var.	100	100	500	25	> 20	4	> 60	1000	15	driver for numerical indicator tubes
BSS50			45*									
BSS51	n-p-n	TO-39	60*	1000	5000	25**	> 2000	500		1000	500	Darlington transistors
BSS52			80*									
BSS60			45*									
BSS61	p-n-p	TO-39	60*	1000	5000	25**	> 2000	500		1500	500	Darlington transistors
BSS62			80*									
BSS68	p-n-p	TO-92 var.	100	100	500	25	> 30	25	> 50			

*V_{CER}. **T_{case}.

Transistors for switching applications

type number	polarity	envelope	RATINGS V_{CEO} (V_{CER}) V	I_C mA	P_{tot} mW	at T_{amb} °C	CHARACTERISTICS h_{FE}	at I_C mA	f_T MHz typ.	t_{off} ns max.	at I_C mA	remarks
BSV15			40									
BSV16	p-n-p	TO-39	60	1000	5000	25*	40–250	100	> 50	650	100	
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	
BSW68A			150									
BSX19	n-p-n	TO-18	15	500**	360	25	20–60	10	> 400	15	10	high-speed saturated switching and
BSX20							40–120		> 500	18		h.f. amplifier applications
BSX21	n-p-n	TO-18	80	100	300	25	> 20	4	> 60			for switched-mode power supplies
BSX45			40				40–250					
BSX46	n-p-n	TO-39	60	1000	6250	25*	40–250	100	> 50	850	100	
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		
PH2369	n-p-n	TO-92 var.	15	500**	500	25	40–120	10	> 500	18	10	
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	n-p-n	TO-39	30	800	800	25	40–120	150	> 250			
2N2218A			40							285	150	high-speed switching
2N2219	n-p-n	TO-39	30	800	800	25	100–300	150	> 250			
2N2219A			40						> 300	285	150	high-speed switching

* T_{case}. ** I_{CM}.

Transistors for switching applications

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

* I_{CM}.   ** 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/μs	I_P μA max.	I_V μA min.	t_r ns max.	
BRY39P	TO-72	70	175	2,5	20	5	25	80	characteristics measured with R_G = 10 kΩ
BRY56	TO-92 var.	70	175	2,5	20	5	2	80	characteristics measured with R_G = 10 kΩ

Silicon controlled switches

type number	envelope	RATINGS					CHARACTERISTICS				remarks
		V_{CBO} V	I_E mA	I_{ERM} A	P_{tot} mW	at T_{amb} °C	V_{AK} V max.	I_H mA max.	t_{on} μs max.	t_q μs max.	
BR101	TO-72	50	175	2,5	275	25	1,4	1,0	–	–	characteristics measured with R_{KG-K} = 10 kΩ
BRY39S	TO-72	70	175	2,5	275	25	1,4	1,0	1,5	8	characteristics measured with R_{KG-K} = 10 kΩ

Thyristor tetrode

type number	envelope	RATINGS				CHARACTERISTICS at T_j = 25 °C					remarks
		I_T mA	I_{TRM} A	I_{TSM} A	dI_T/dt A/μs	V_{GKT} V min.	I_{GKT} μA min.	V_{GAT} V min.	I_{GAT} μA min.	t_q μs max.	
BRY39T	TO-72	250	2,5	3	20	0,5	1	–1	–100	3	V_{RRMmax} = 70 V

TYPE NUMBER SURVEY

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

type number	polarity	envelope	V_{CEO} V	I_C mA	type number	polarity	envelope	V_{CEO} V	I_C mA
BC107	n-p-n	TO-18	45	100	BC639	n-p-n	TO-92 var.	80	1000
BC108	n-p-n	TO-18	20	100	BC640	p-n-p	TO-92 var.	80	1000
BC109	n-p-n	TO-18	20	100	BCY30A	p-n-p	TO-5	64	100
BC140	n-p-n	TO-39	40	1000	BCY31A	p-n-p	TO-5	64	100
BC141	n-p-n	TO-39	60	1000	BCY32A	p-n-p	TO-5	64	100
BC146	n-p-n	SOT-42	20	50	BCY33A	p-n-p	TO-5	32	100
BC147	n-p-n	SOT-25	45	100	BCY34A	p-n-p	TO-5	32	100
BC148	n-p-n	SOT-25	30	100	BCY56	n-p-n	TO-18	45	100
BC149	n-p-n	SOT-25	30	100	BCY57	n-p-n	TO-18	20	100
BC157	p-n-p	SOT-25	45	100	BCY58	n-p-n	TO-18	32	200
BC158	p-n-p	SOT-25	30	100	BCY59	n-p-n	TO-18	45	200
BC159	p-n-p	SOT-25	30	100	BCY70	p-n-p	TO-18	40	200
BC160	p-n-p	TO-39	40	1000	BCY71	p-n-p	TO-18	45	200
BC161	p-n-p	TO-39	60	1000	BCY72	p-n-p	TO-18	25	200
BC177	p-n-p	TO-18	45	100	BCY78	p-n-p	TO-18	32	200
BC178	p-n-p	TO-18	25	100	BCY79	p-n-p	TO-18	45	200
BC179	p-n-p	TO-18	20	100	BCY87	n-p-n	TO-71	40	30
BC200	p-n-p	SOT-42	20	50	BCY88	n-p-n	TO-71	40	30
BC327	p-n-p	TO-92 var.	45	500	BCY89	n-p-n	TO-71	40	30
BC328	p-n-p	TO-92 var.	25	500	BF115	n-p-n	TO-72	30	30
BC337	n-p-n	TO-92 var.	45	500	BF180	n-p-n	TO-72	20	20
BC338	n-p-n	TO-92 var.	25	500	BF181	n-p-n	TO-72	20	20
BC368	n-p-n	TO-92 var.	20	1000	BF182	n-p-n	TO-72	20	15
BC369	p-n-p	TO-92 var.	20	1000	BF183	n-p-n	TO-72	20	15
BC375	n-p-n	TO-92 var.	20	1000	BF194	n-p-n	SOT-25	20	30
BC376	p-n-p	TO-92 var.	20	1000	BF195	n-p-n	SOT-25	20	30
BC546	n-p-n	TO-92 var.	65	100	BF196	n-p-n	SOT-25	30	25
BC547	n-p-n	TO-92 var.	45	100	BF197	n-p-n	SOT-25	25	25
BC548	n-p-n	TO-92 var.	30	100	BF198	n-p-n	TO-92 var.	30	25
BC549	n-p-n	TO-92 var.	30	100	BF199	n-p-n	TO-92 var.	25	25
BC550	n-p-n	TO-92 var.	45	100	BF200	n-p-n	TO-72	20	20
BC556	p-n-p	TO-92 var.	65	100	BF240	n-p-n	TO-92 var.	40	25
BC557	p-n-p	TO-92 var.	45	100	BF241	n-p-n	TO-92 var.	40	25
BC558	p-n-p	TO-92 var.	30	100	BF324	p-n-p	TO-92 var.	30	25
BC559	p-n-p	TO-92 var.	30	100	BF336	n-p-n	TO-39	180	100
BC560	p-n-p	TO-92 var.	45	100	BF337	n-p-n	TO-39	200	100
BC635	n-p-n	TO-92 var.	45	1000	BF338	n-p-n	TO-39	225	100
BC636	p-n-p	TO-92 var.	45	1000	BF362	n-p-n	SOT-37	20	20
BC637	n-p-n	TO-92 var.	60	1000	BF363	n-p-n	SOT-37	20	20
BC638	p-n-p	TO-92 var.	60	1000	BF422	n-p-n	TO-92 var.	250	50

type number	polarity	envelope	V_{CEO} V	I_C mA	type number	polarity	envelope	V_{CEO} V	I_C mA
BF423	p-n-p	TO-92 var.	250	50	BSS50	n-p-n	TO-39	45**	1000
BF450	p-n-p	TO-92 var.	40	25	BSS51	n-p-n	TO-39	60**	1000
BF451	p-n-p	TO-92 var.	40	25	BSS52	n-p-n	TO-39	80**	1000
BF480	n-p-n	SOT-37	15	20	BSS60	p-n-p	TO-39	45**	1000
BF494	n-p-n	TO-92 var.	20	30	BSS61	p-n-p	TO-39	60**	1000
BF495	n-p-n	TO-92 var.	20	30	BSS62	p-n-p	TO-39	80**	1000
BF496	n-p-n	TO-92 var.	20	20	BSS68	p-n-p	TO-92 var.	100	100
BF926	p-n-p	TO-92 var.	20	25	BSV15	p-n-p	TO-39	40	1000
BF936	p-n-p	TO-92 var.	20	25	BSV16	p-n-p	TO-39	60	1000
BF939	p-n-p	TO-92 var.	25	20	BSV17	p-n-p	TO-39	80	1000
BF967	p-n-p	SOT-37	30	20	BSV64	n-p-n	TO-39	60	2000
BF970	p-n-p	SOT-37	35	30	BSW66A	n-p-n	TO-39	100	1000
BF979	p-n-p	SOT-37	20	30*	BSW67A	n-p-n	TO-39	120	1000
BFR54	n-p-n	TO-92 var.	15	500*	BSW68A	n-p-n	TO-39	150	1000
BFT44	p-n-p	TO-39	300	500	BSX19	n-p-n	TO-18	15	500*
BFT45	p-n-p	TO-39	250	500	BSX20	n-p-n	TO-18	15	500*
BFX29	p-n-p	TO-39	60	600	BSX21	n-p-n	TO-18	80	100
BFX30	p-n-p	TO-39	65	600	BSX45	n-p-n	TO-39	40	1000
BFX34	n-p-n	TO-39	60	2000	BSX46	n-p-n	TO-39	60	1000
BFX84	n-p-n	TO-39	60	1000	BSX47	n-p-n	TO-39	80	1000
BFX85	n-p-n	TO-39	60	1000	BSX59	n-p-n	TO-39	45	1000
BFX86	n-p-n	TO-39	35	1000	BSX60	n-p-n	TO-39	30	1000
BFX87	p-n-p	TO-39	50	600	BSX61	n-p-n	TO-39	45	1000
BFX88	p-n-p	TO-39	40	600	BSY95A	n-p-n	TO-18	15	100
BFY50	n-p-n	TO-39	35	1000	PH2369	n-p-n	TO-92 var.	15	500*
BFY51	n-p-n	TO-39	30	1000	2N929	n-p-n	TO-18	45	30
BFY52	n-p-n	TO-39	20	1000	2N930	n-p-n	TO-18	45	30
BFY55	n-p-n	TO-39	35	1000	2N1613	n-p-n	TO-39	50**	1000*
BR101	p-n-p-n	TO-72	50	175	2N1711	n-p-n	TO-39	50**	1000
BRY39P	p-n-p-n	TO-72	70	175	2N1893	n-p-n	TO-39	80	500
BRY39S	p-n-p-n	TO-72	70	175	2N2218	n-p-n	TO-39	30	800
BRY39T	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*

* I_{CM}.
** V_{CER}.

type number	polarity	envelope	V_{CEO} V	I_C mA
2N2369	n-p-n	TO-18	15	500*
2N2369A	n-p-n	TO-18	15	200
2N2483	n-p-n	TO-18	60	50*
2N2484	n-p-n	TO-18	60	50*
2N2904	p-n-p	TO-39	40	600
2N2904A	p-n-p	TO-39	60	600
2N2905	p-n-p	TO-39	40	600
2N2905A	p-n-p	TO-39	60	600
2N2906	p-n-p	TO-18	40	600
2N2906A	p-n-p	TO-18	60	600
2N2907	p-n-p	TO-18	40	600
2N2907A	p-n-p	TO-18	60	600
2N3019	n-p-n	TO-39	80	1000
2N3020	n-p-n	TO-39	80	1000
2N3053	n-p-n	TO-39	40	700
2N3439	n-p-n	TO-39	350	1000
2N3440	n-p-n	TO-39	250	1000
2N3903	n-p-n	TO-92	40	200
2N3904	n-p-n	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
2N5415	p-n-p	TO-39	200	1000
2N5416	p-n-p	TO-39	300	1000

* I_{CM}.

BS AND CECC
APPROVED TYPES

Products approved to BS9000 and CECC, available on request.

BC107 BC108 BC109	also available to BS9365-F112
BCY30A BCY31A BCY32A BCY33A BCY34A	also available to BS9360-F012
BCY70 BCY71 BCY72	also available to BS9365-F009
BFX29	also available to BS9365-F010
BFX30	also available to BS9365-F011
BFX84 BFX85 BFX86	also available to BS9365-F174
BFY50 BFY51 BFY52	also available to BS9365-F012
BSV15 BSV16 BSV17	also available to BS9360-F013
BSX45 BSX46 BSX47	also available to BS9360-F007
BFX34	also available to CECC 50 004-025
BSV64	also available to CECC 50 004-025

In addition to the above types, approval under BS9300 is also held covering a wide range of British Government (CV) specifications e.g. CV7726 identically equal to BS9300 C726.

Details are available on request.

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

SERIAL NUMBER

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

VERSION LETTER

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

SUFFIX

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

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

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

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

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

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

RATING SYSTEMS

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

DEFINITIONS OF TERMS USED

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

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

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

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

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

Note
Limiting conditions may be either maxima or minima.

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

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

ABSOLUTE MAXIMUM RATING SYSTEM

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

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

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

DESIGN MAXIMUM RATING SYSTEM

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

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

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

DESIGN CENTRE RATING SYSTEM

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

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

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

LETTER SYMBOLS FOR TRANSISTORS AND SIGNAL DIODES

based on IEC Publication 148

LETTER SYMBOLS FOR CURRENTS, VOLTAGES AND POWERS

Basic letters

The basic letters to be used are:

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

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

Subscripts

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

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

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

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

b) instantaneous total values
Example i_B

c) average total values
Example $I_{B(AV)}$

d) peak total values
Example I_{BM}

e) root-mean-square total values
Example $I_{B(RMS)}$

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

a) instantaneous values
Example i_b

b) root-mean-square values
Example $I_{b(rms)}$

c) peak values
Example I_{bm}

d) average values
Example $I_{b(av)}$

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

Additional rules for subscripts

Subscripts for currents

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

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

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

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

Subscripts for voltages

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

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

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

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

Subscripts for supply voltages or supply currents

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

Examples: V_{CC}, I_{EE}

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

Example : V_{CCE}

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

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

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

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

Subscripts for multiple devices

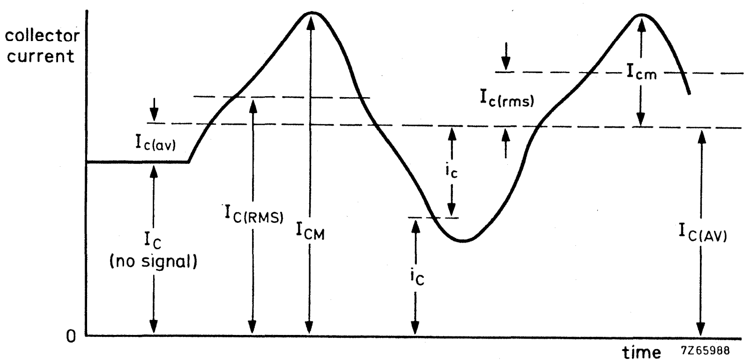
For multiple unit devices, the subscripts are modified by a number preceding the letter subscript; in the case of multiple subscripts, hyphens may be necessary to avoid misunderstanding.

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

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

Application of the rules

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



LETTER SYMBOLS FOR ELECTRICAL PARAMETERS

Definition

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

Basic letters

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

B, b = susceptance; imaginary part of an admittance

C = capacitance

G, g = conductance; real part of an admittance

H, h = hybrid parameter

L = inductance

R, r = resistance; real part of an impedance

X, x = reactance; imaginary part of an impedance

Y, y = admittance;

Z, z = impedance;

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

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

b) all inductances and capacitances.

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

Subscripts

General subscripts

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

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

Examples: Z_S, h_f, h_F

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

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

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

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

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

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

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

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

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

Subscripts for four-pole matrix parameters

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

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

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

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

Distinction between real and imaginary parts

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

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

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

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

SAFE OPERATING AREA CURVES

1. D.C. SOAR

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

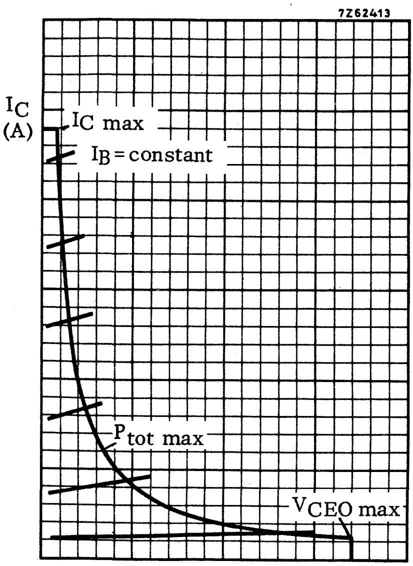


Fig. 1

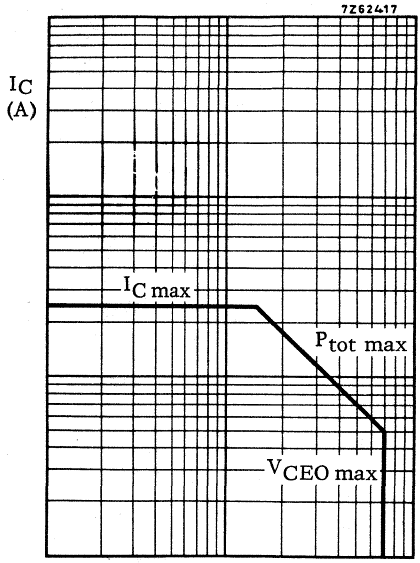


Fig. 2. D.C. SOAR curve

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

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

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

$$T_j - T_{mb} = P_{tot} \cdot R_{th\ j\text{-}mb} \qquad (1)$$

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

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

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

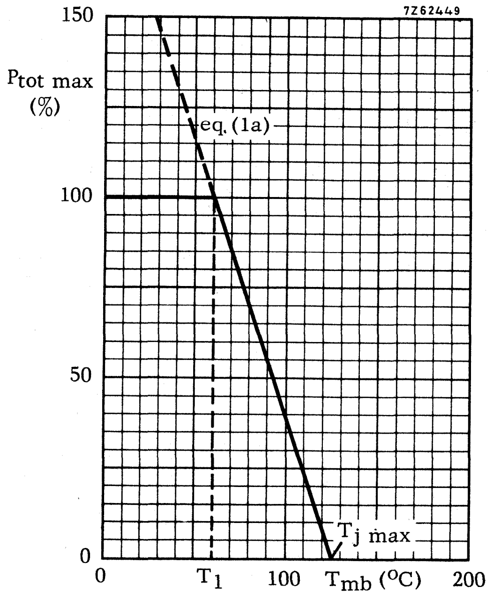


Fig. 3

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

2. Extension of the SOAR for pulse power

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

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

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

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

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

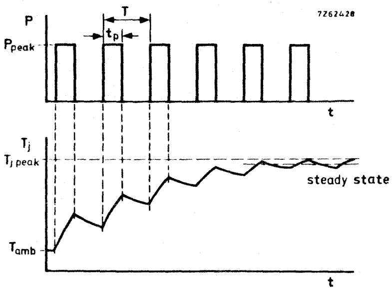


Fig. 4

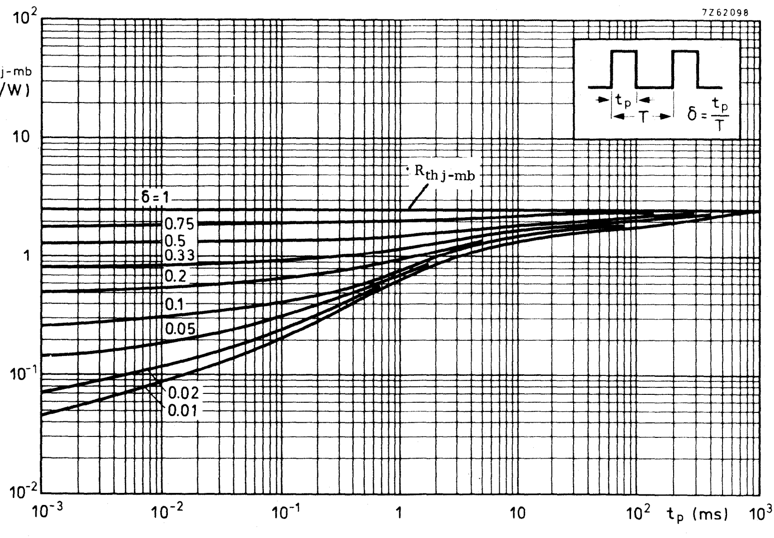


Fig. 5

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

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

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

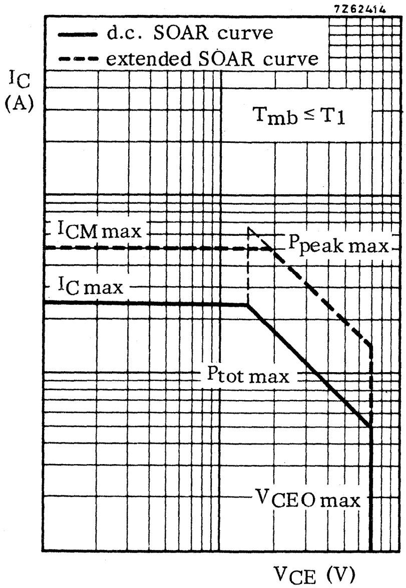


Fig. 6

3. Second Breakdown

3.1 The phenomenon

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

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

3.2 Second breakdown and the d.c. SOAR

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

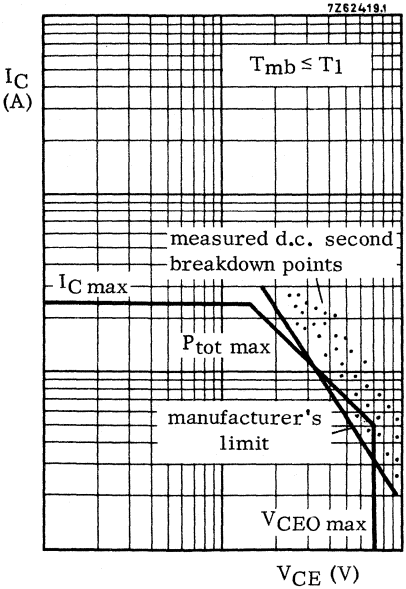


Fig. 7

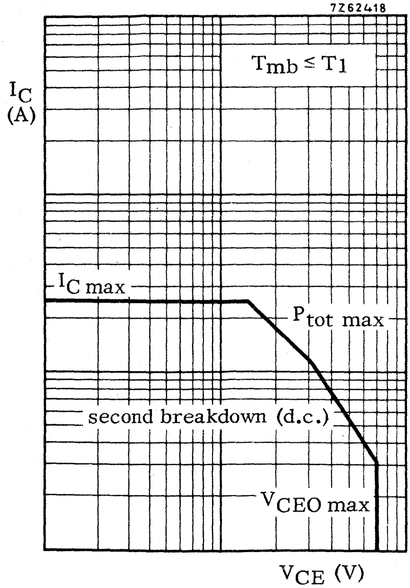


Fig. 8

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

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

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

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

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

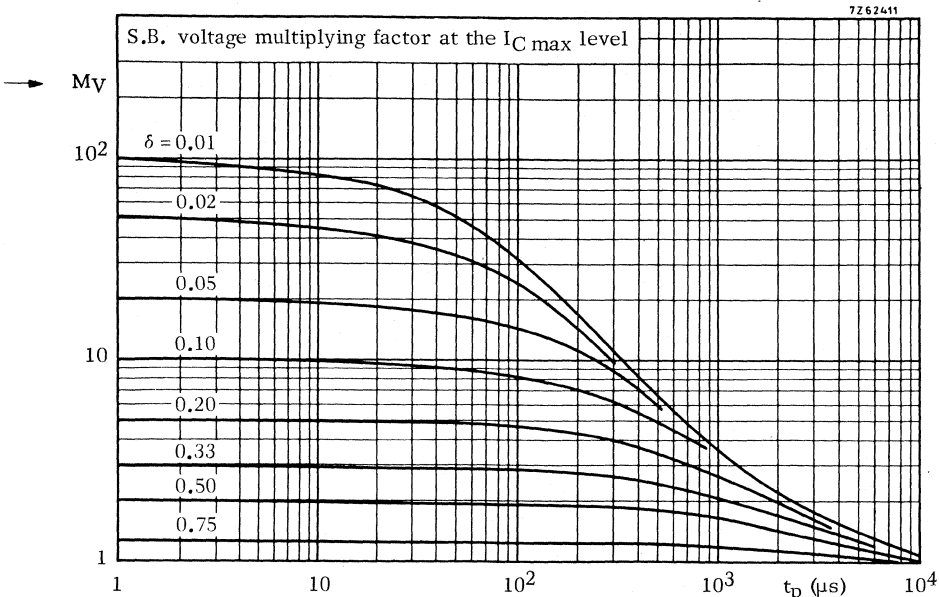

7Z62411
S.B. voltage multiplying factor at the $I_{C\,max}$ level
M_V
$\delta = 0.01$
0.02
0.05
0.10
0.20
0.33
0.50
0.75
10^2
10
1
1
10
10^2
10^3
t_p (μs)
10^4

Fig. 9a

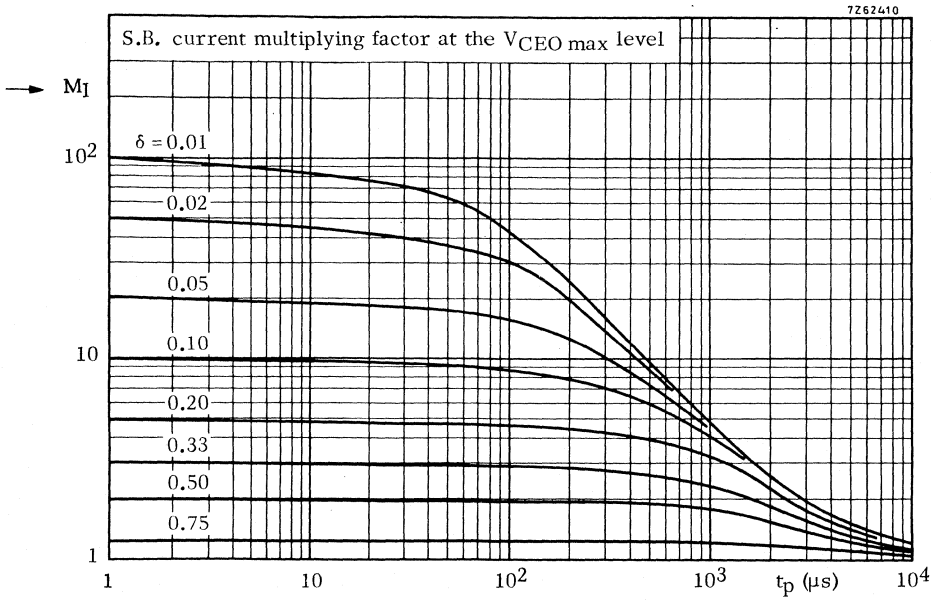

7Z62410
S.B. current multiplying factor at the $V_{CEO\,max}$ level
M_I
$\delta = 0.01$
0.02
0.05
0.10
0.20
0.33
0.50
0.75
10^2
10
1
1
10
10^2
10^3
t_p (μs)
10^4

Fig. 9b

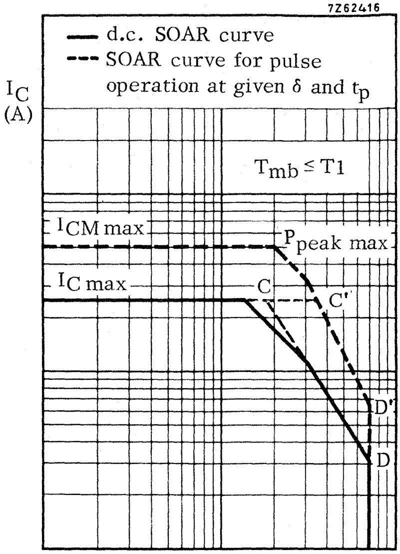


Fig. 10

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

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

4. Example of how to use the published SOAR information

4.1 Statement of the problem

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

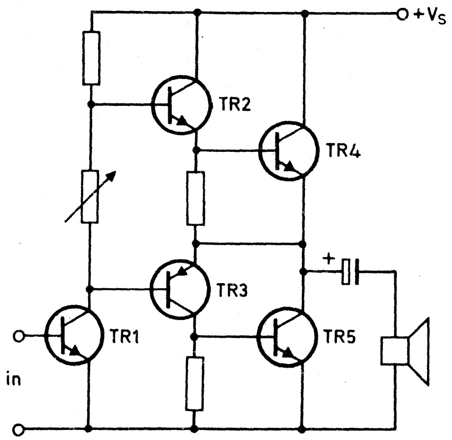


Fig. 11

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

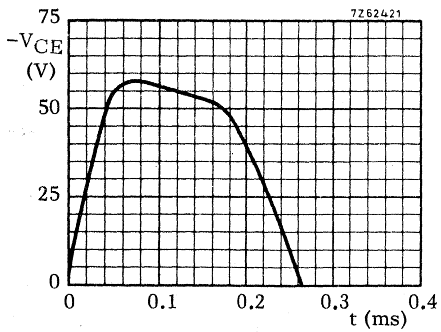


Fig. 12a

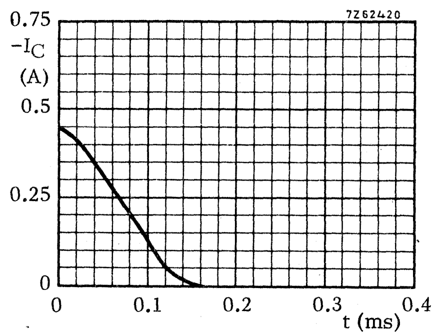


Fig. 12b

4.2 Information obtained from the published data of TR3

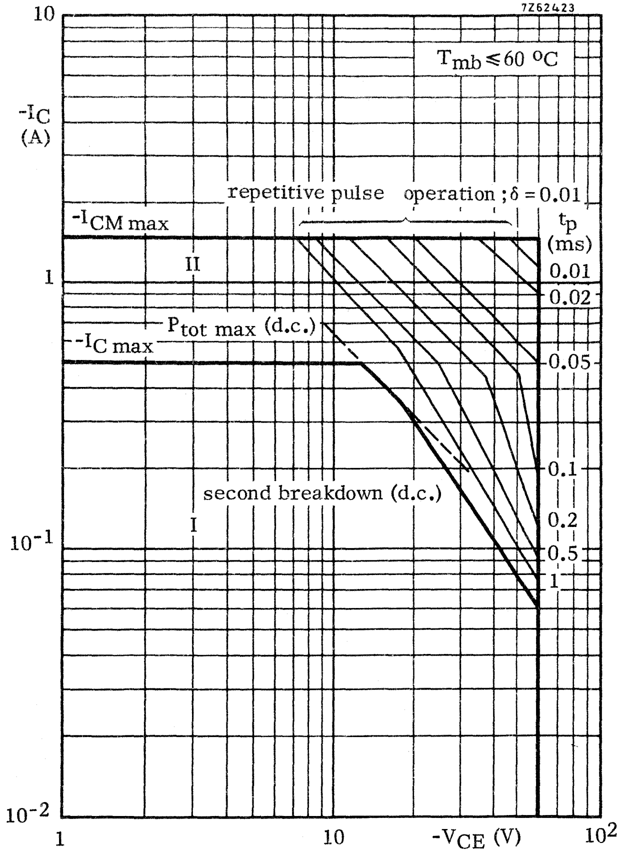
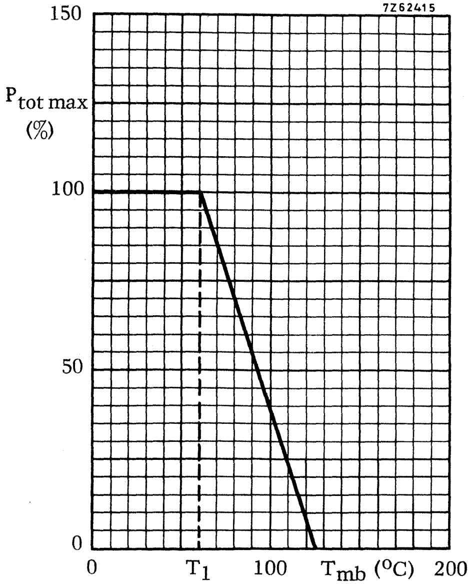


Fig. 13. Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation.



$T_{j\,max}$ = 125 ^oC

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

Fig. 14

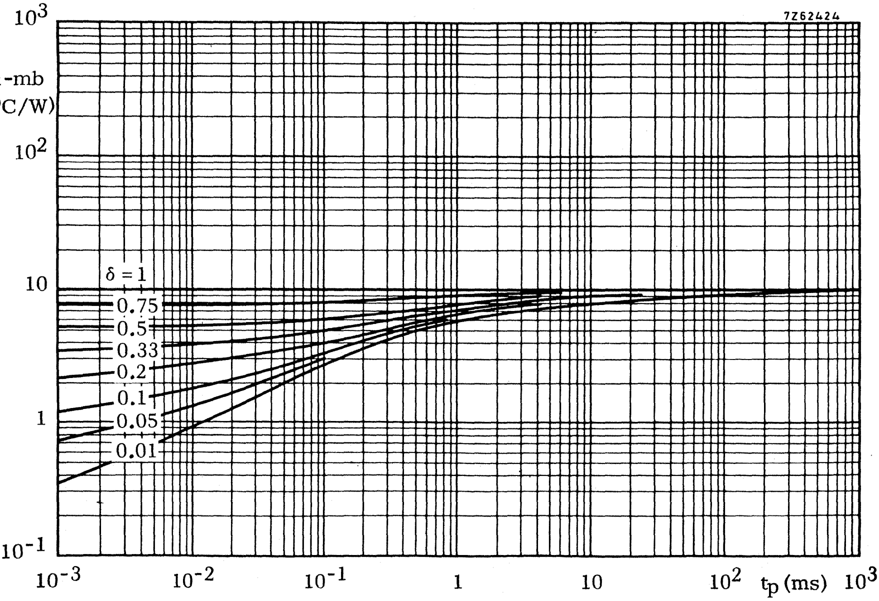


Fig. 15

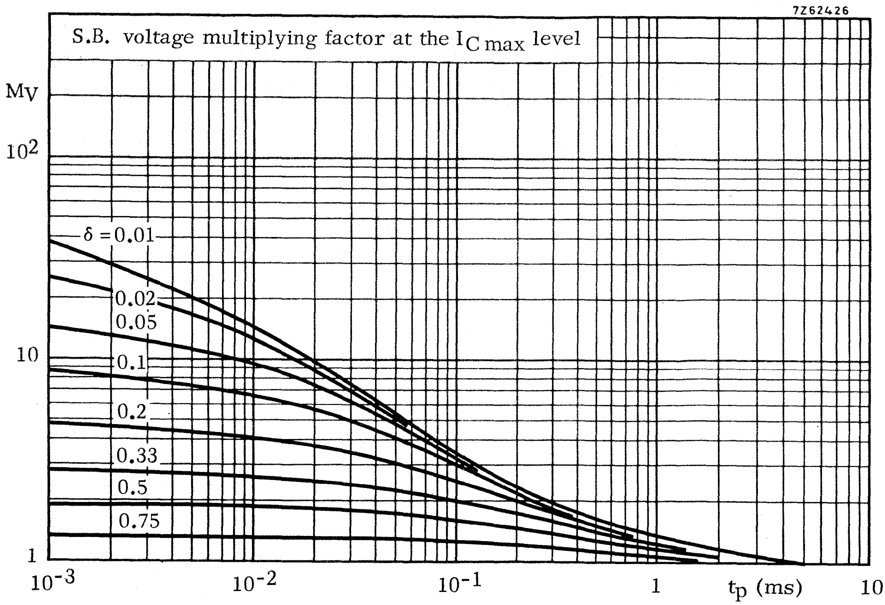

7Z62426
S.B. voltage multiplying factor at the $I_{C\,max}$ level
M_V
10^2
10
1
δ = 0.01
0.02
0.05
0.1
0.2
0.33
0.5
0.75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10

Fig. 16

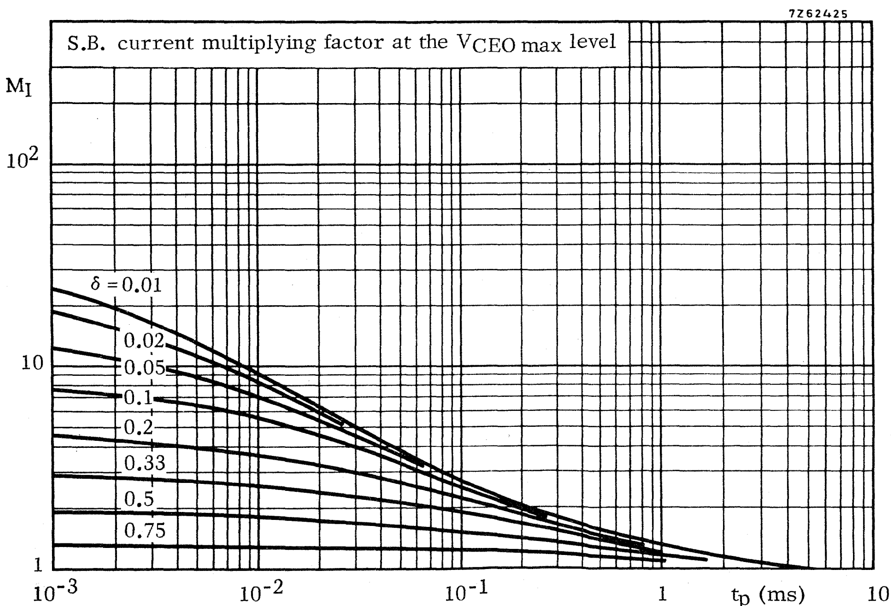

7Z62425
S.B. current multiplying factor at the $V_{CEO\,max}$ level
M_I
10^2
10
1
δ = 0.01
0.02
0.05
0.1
0.2
0.33
0.5
0.75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10

Fig. 17

4.3 Construction of the pulse SOAR of TR3 in this application

4.3.1

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

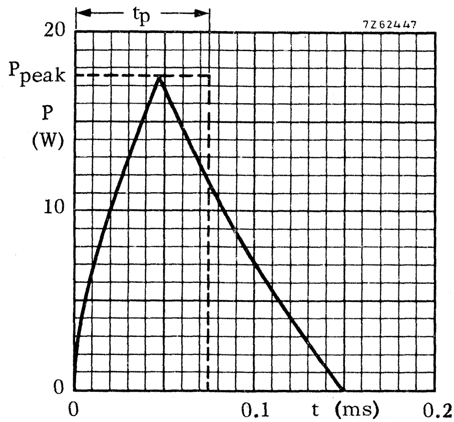


Fig. 18

4.3.2

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

$t_p = 75\ \mu s$

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

$\delta = 0.056$

$P_{peak} = 17.5\ W$

4.3.3

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

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

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

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

4.3.4

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

M_V = 3.6

M_I = 2.8

4.3.5

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

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

  V_A' = 13 V x 0.6 x 3.64 = 28.4 V
- Through point A' construct a line of constant power (45°)

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

4.3.6

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

4.3.7

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

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

P_{peak} = 17.5 W (see 4.3.2)

$Z_{th\ j\text{-}mb}$ = 2.75 °C/W

Therefore:

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

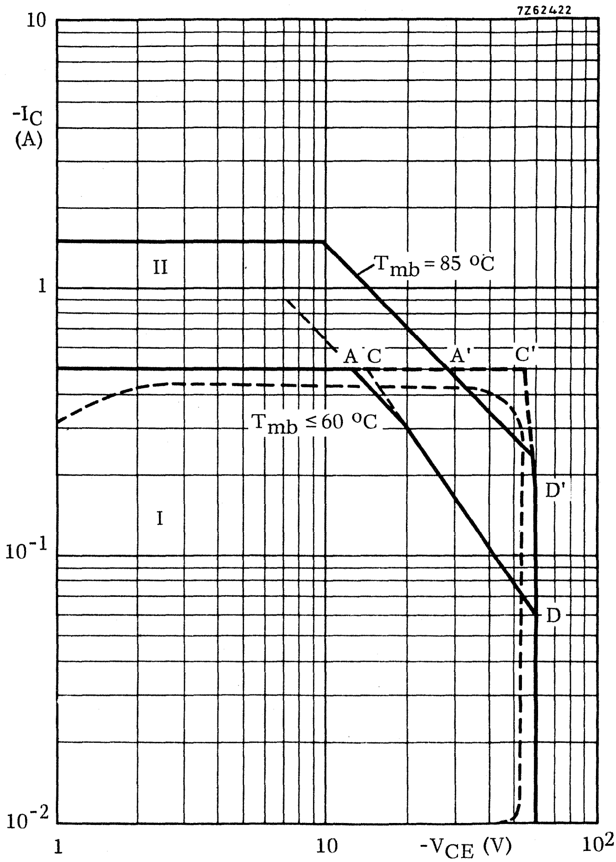


Fig. 19

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

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

4.3.8

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

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

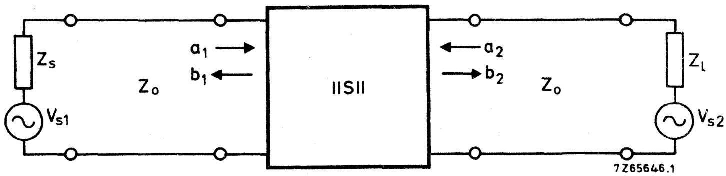
If $T_{mb\ max}$ and P_{peak} are known, the max. allowable $R_{th\ mb\text{-}a}$ may be calculated with

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

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

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.



$$a_1 = \frac{V_{i1}}{\sqrt{Z_o}} \qquad a_2 = \frac{V_{i2}}{\sqrt{Z_o}} \qquad ^{1)}$$

$$b_1 = \frac{V_{r1}}{\sqrt{Z_o}} \qquad b_2 = \frac{V_{r2}}{\sqrt{Z_o}}$$

Z_o = 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.

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 $Z_l = Z_o$ 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 $Z_s = Z_o$ 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 $Z_l = Z_o$ 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 $Z_s = Z_o$ and $V_{s1} = 0$.

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

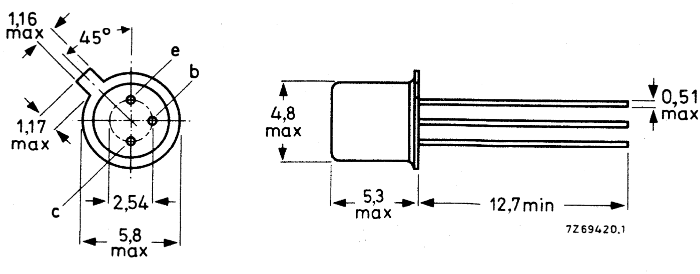
			BC107	BC108	BC109	
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	50	30	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	20	20	V
Collector current (peak value)	I_{CM}	max.	200	200	200	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	300	300	mW
Junction temperature	T_j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

Temperatures

Storage temperature	T_{stg}		−65 to +175	°C
Junction temperature	T_j	max.	175	°C

THERMAL RESISTANCE

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

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

I_E = 0; V_{CB} = 20 V; T_j = 150 °C	I_{CBO}	<	15	µA

Base-emitter voltage[1]

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

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

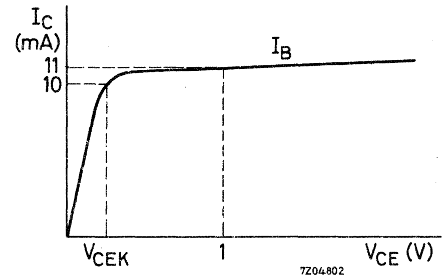
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Saturation voltages [1]

I_C = 10 mA; I_B = 0.5 mA	V_{CEsat}	typ.	90	mV
		<	250	mV
	V_{BEsat}	typ.	700	mV
I_C = 100 mA; I_B = 5 mA	V_{CEsat}	typ.	200	mV
		<	600	mV
	V_{BEsat}	typ.	900	mV

Knee voltage

I_C = 10 mA; I_B = value for which I_C = 11 mA at V_{CE} = 1 V	V_{CEK}	typ.	300	mV
		<	600	mV



Collector capacitance at f = 1 MHz

$I_E = I_e$ = 0; V_{CB} = 10 V	C_c	typ.	2.5	pF
		<	4.5	pF

Emitter capacitance at f = 1 MHz

$I_C = I_c$ = 0; V_{EB} = 0.5 V	C_e	typ.	9	pF

Transition frequency at f = 35 MHz

I_C = 10 mA; V_{CE} = 5 V	f_T	typ.	300	MHz

			BC107	BC108	BC109	
Small signal current gain at f = 1 kHz						
I_C = 2 mA; V_{CE} = 5 V	h_{fe}	>	125	125	240	
		<	500	900	900	
Noise figure at R_S = 2 kΩ; I_C = 200 μA; V_{CE} = 5 V						
f = 30 Hz to 15 kHz	F	typ.			1.4	dB
		<			4	dB
f = 1 kHz; B = 200 Hz	F	typ.	2	2	1.2	dB
		<	10	10	4	dB

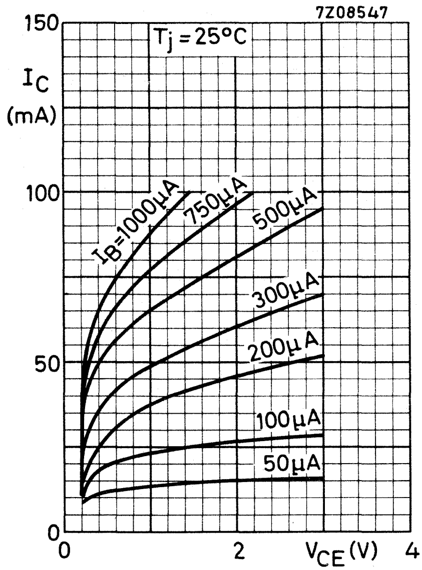
[1] V_{BEsat} decreases by about 1.7 mV/°C with increasing temperature.

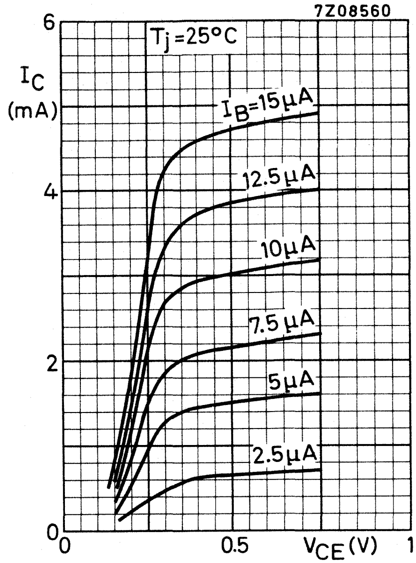
CHARACTERISTICS (continued)

T_j = 25 °C unless otherwise specified

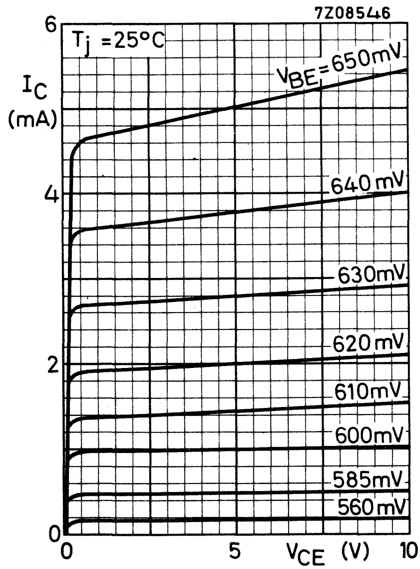
			BC107A BC108A	BC107B BC108B BC109B	BC108C BC109C	
D.C. current gain						
I_C = 10 μA; V_{CE} = 5 V	h_{FE}	>		40	100	
		typ.	90	150	270	
I_C = 2 mA; V_{CE} = 5 V	h_{FE}	>	110	200	420	
		typ.	180	290	520	
		<	220	450	800	
h parameters at f = 1 kHz (common emitter)						
I_C = 2 mA; V_{CE} = 5 V						
Input impedance	h_{ie}	>	1.6	3.2	6	kΩ
		typ.	2.7	4.5	8.7	kΩ
		<	4.5	8.5	15	kΩ
Reverse voltage transfer ratio	h_{re}	typ.	1.5	2	3	10^{-4}
Small signal current gain	h_{fe}	>	125	240	450	
		typ.	220	330	600	
		<	260	500	900	
Output admittance	h_{oe}	typ.	18	30	60	$\mu\Omega^{-1}$
		<	30	60	110	$\mu\Omega^{-1}$

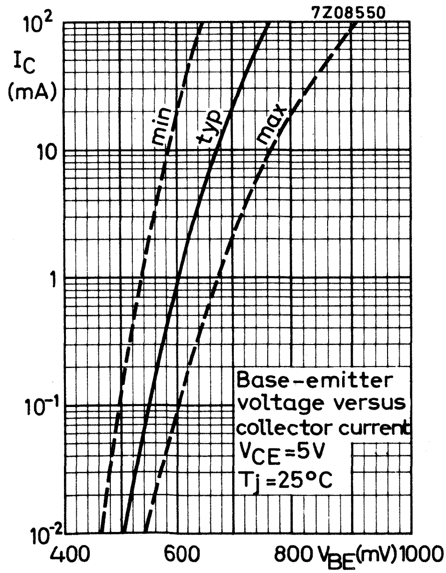
Typical behaviour of collector current versus collector-emitter voltage

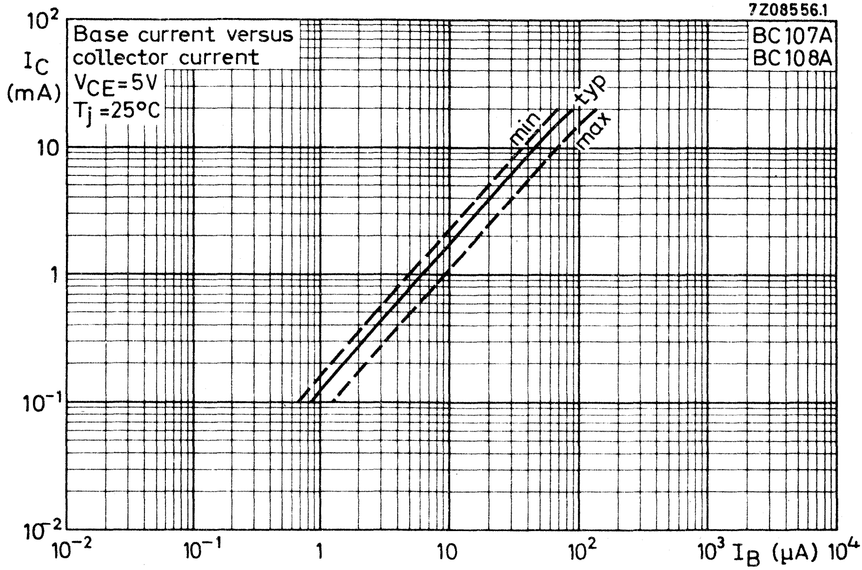


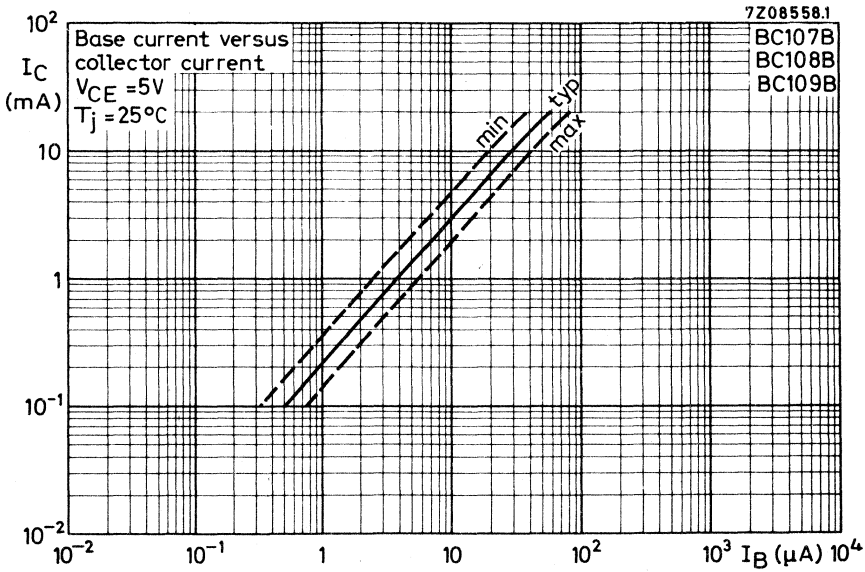


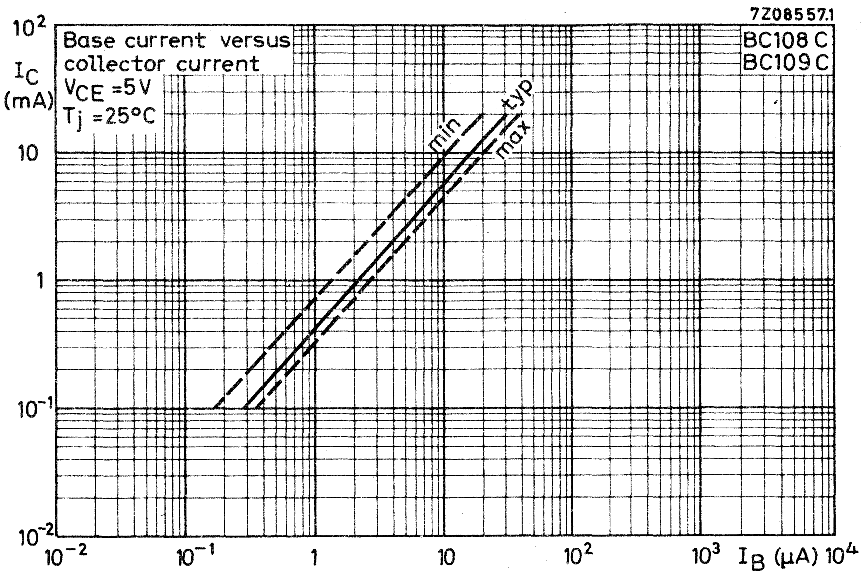
Typical behaviour of collector current versus collector-emitter voltage

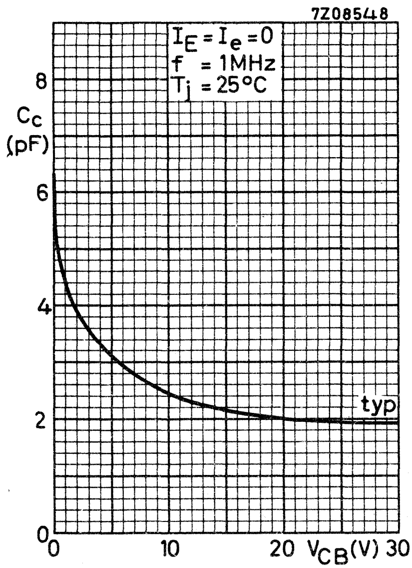


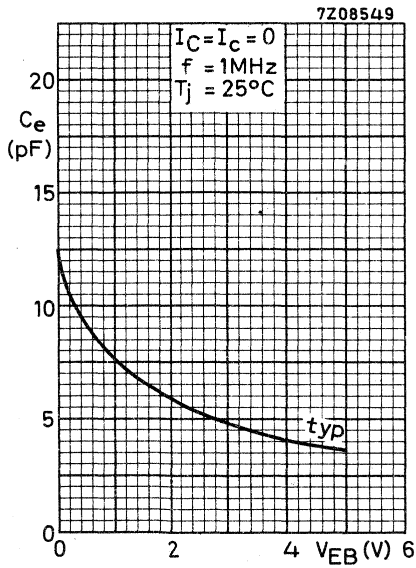


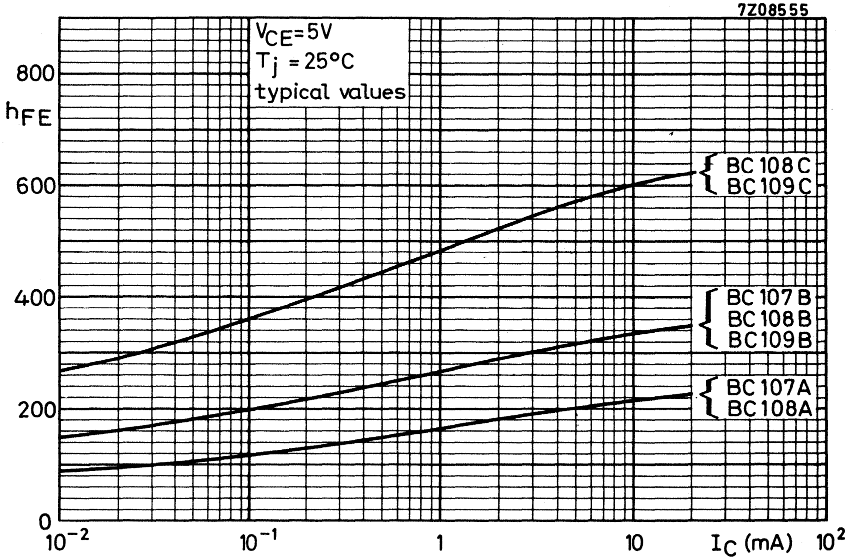

7Z08556.1
Base current versus
collector current
V_{CE} = 5V
T_j = 25°C
BC107A
BC108A
I_C
(mA)
10^2
10
1
10^{-1}
10^{-2}
10^{-2}
10^{-1}
1
10
10^2
10^3
I_B (μA)
10^4
min
typ
max

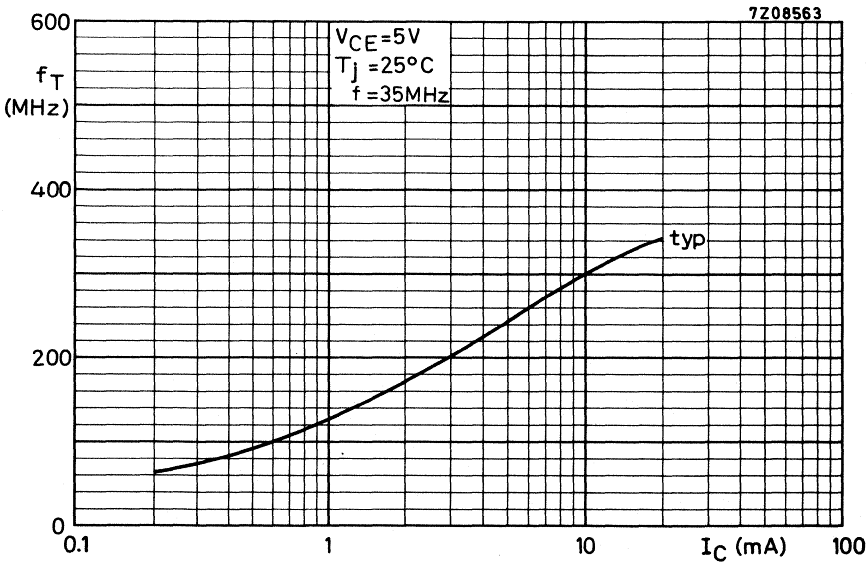

7Z08558.1
Base current versus
collector current
V_{CE} = 5V
T_j = 25°C
BC107B
BC108B
BC109B
I_C
(mA)
10^2
10
1
10^{-1}
10^{-2}
10^{-2}
10^{-1}
1
10
10^2
10^3
I_B (μA)
10^4
min
typ
max


7Z08557.1
Base current versus
collector current
V_{CE} = 5 V
T_j = 25 °C
BC108 C
BC109 C
I_C
(mA)
10^2
10
1
10^{-1}
10^{-2}
min
typ
max
10^{-2}
10^{-1}
1
10
10^2
10^3
I_B (μA)
10^4

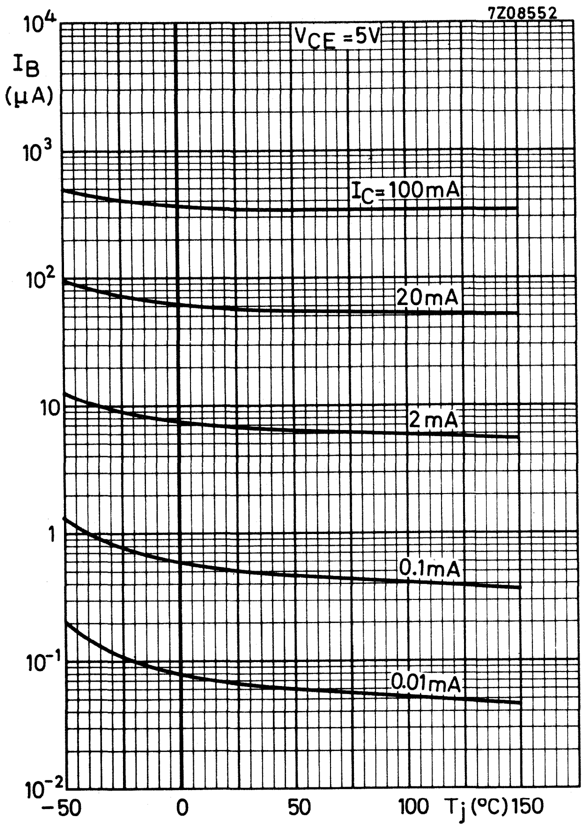

7Z08548
$I_E = I_e = 0$
f = 1 MHz
T_j = 25 °C
C_c
(pF)
8
6
4
2
0
typ
0
10
20
V_{CB} (V)
30

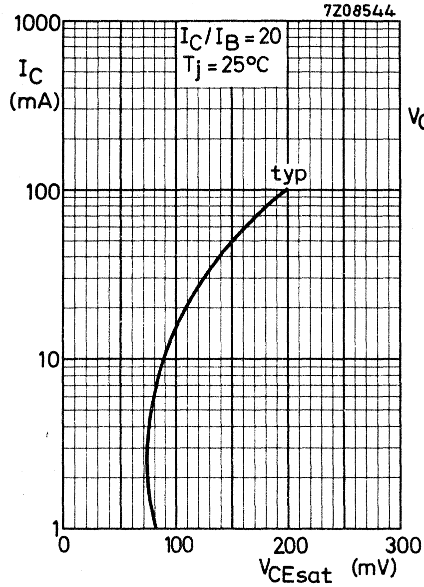

7Z08549
$I_C = I_c = 0$
f = 1 MHz
T_j = 25 °C
C_e
(pF)
20
15
10
5
0
typ
0
2
4
V_{EB} (V)
6

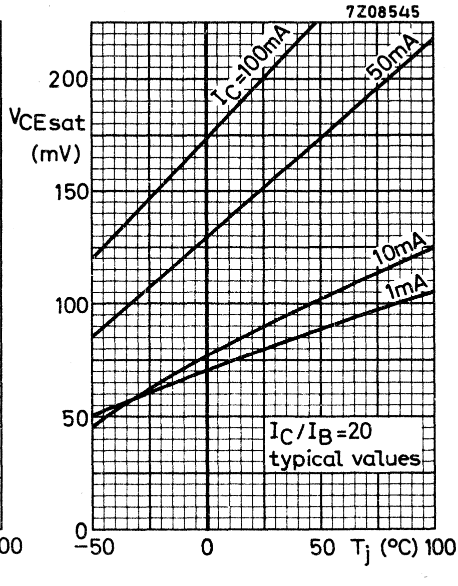

7Z08555
V_{CE}=5V
T_j = 25°C
typical values
800
h_{FE}
600
400
200
0
BC108C
BC109C
BC107B
BC108B
BC109B
BC107A
BC108A
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2

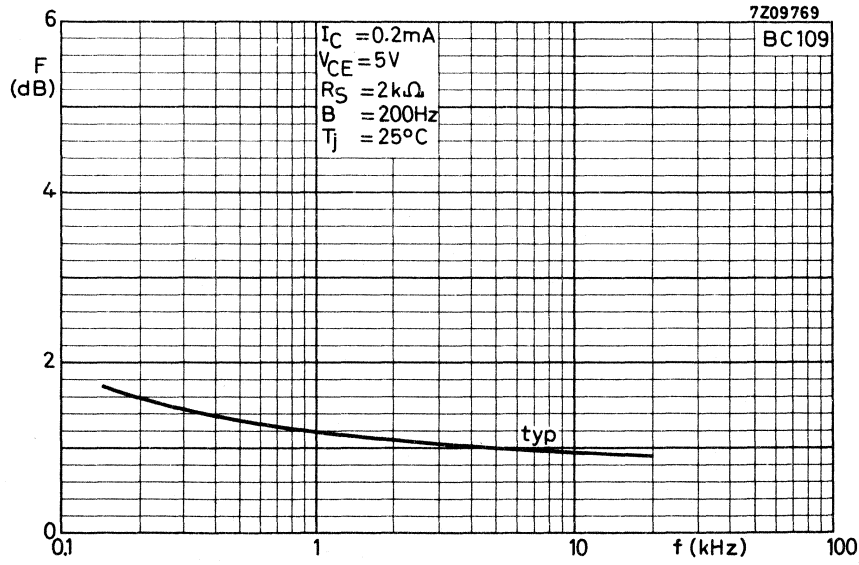

7Z08563
600
f_T
(MHz)
400
200
0
V_{CE}=5V
T_j =25°C
f =35MHz
typ
0.1
1
10
I_C (mA)
100

Typical behaviour of base current
versus junction temperature

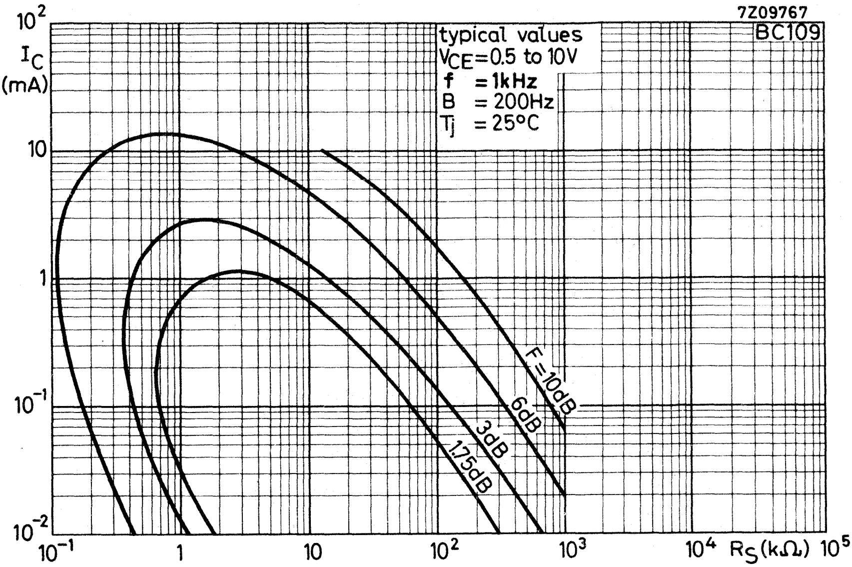


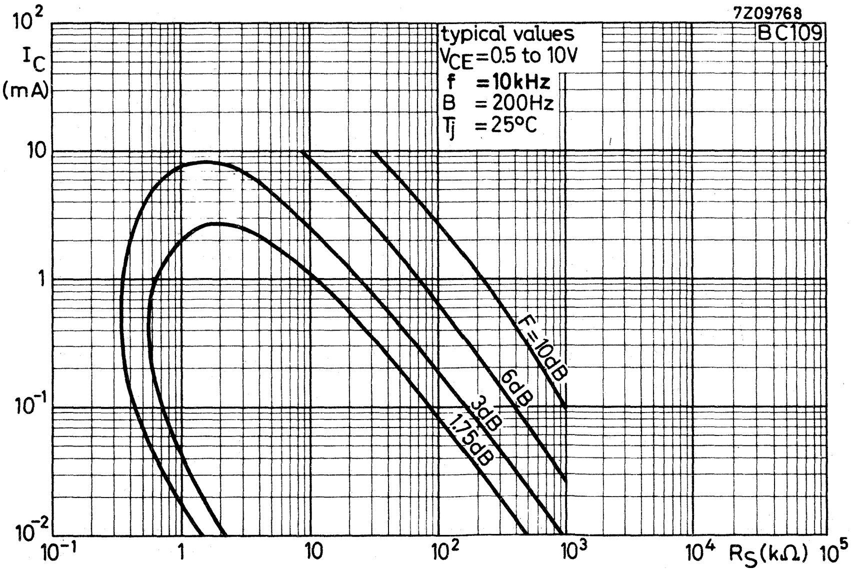

7Z08544
$I_C/I_B = 20$
$T_j = 25°C$
I_C (mA)
1000
100
10
1
typ
0
100
200
300
V_{CEsat} (mV)

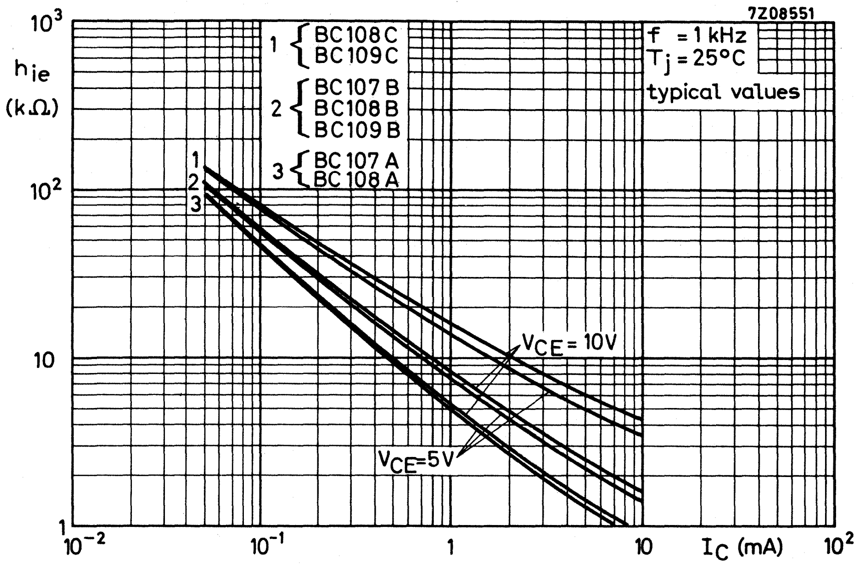

7Z08545
I_C=100mA
50mA
10mA
1mA
V_{CEsat} (mV)
200
150
100
50
0
I_C/I_B=20
typical values
−50
0
50
T_j (°C) 100

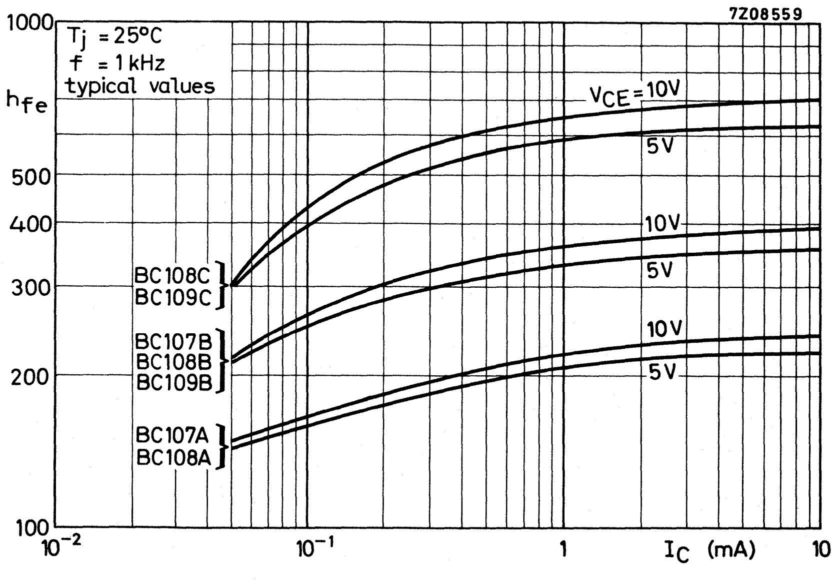

7Z09769
BC109
I_C =0.2mA
V_{CE} = 5V
R_S = 2kΩ
B = 200Hz
T_j = 25°C
F (dB)
6
4
2
0
typ
0.1
1
10
f (kHz)
100

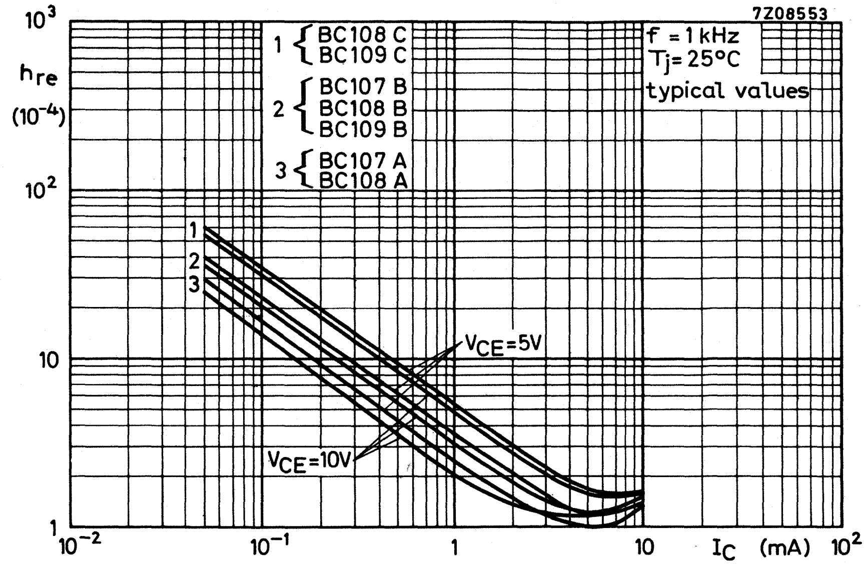
Curves of constant noise figure

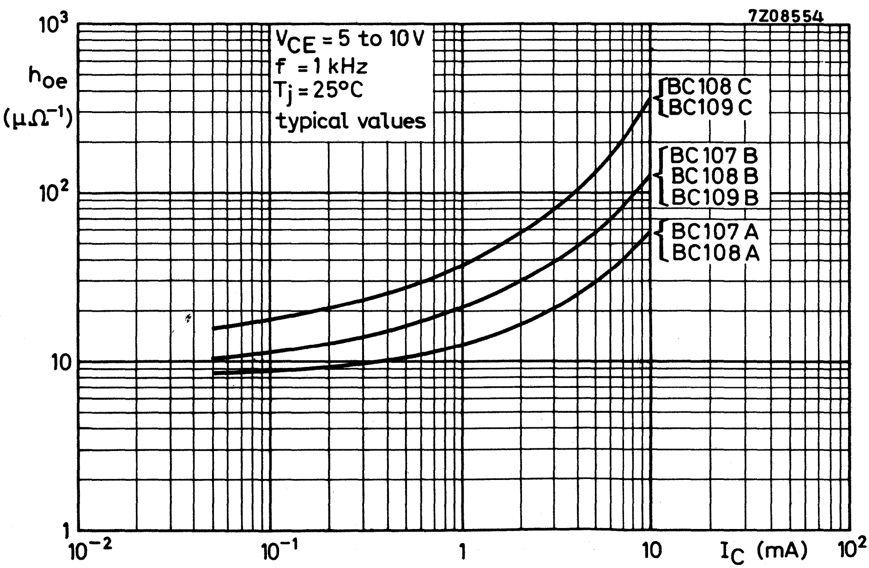


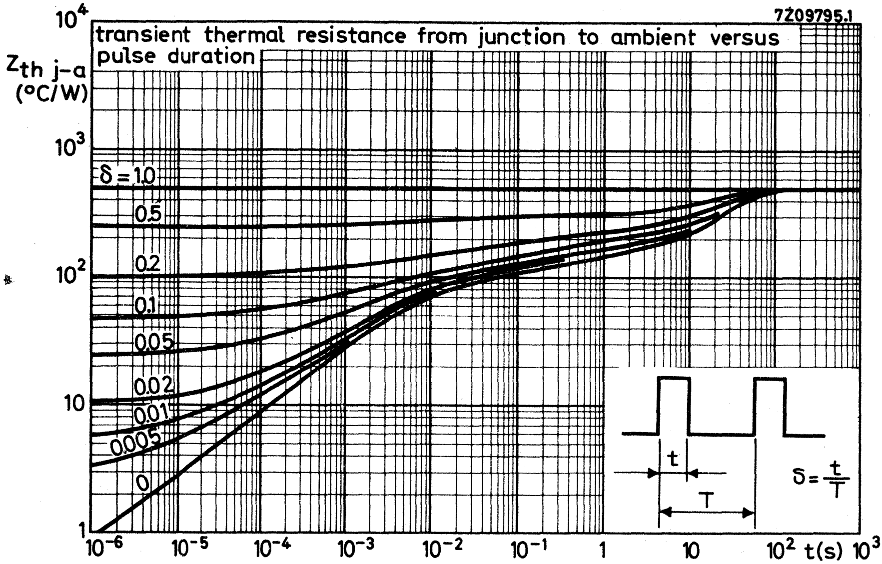



7Z08551
10^3
h_{ie}
(kΩ)
1 { BC108C BC109C
2 { BC107B BC108B BC109B
3 { BC107A BC108A
f = 1 kHz
T_j = 25°C
typical values
10^2
10
1
V_{CE} = 10V
V_{CE}=5V
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2


7Z08559
1000
T_j = 25°C
f = 1 kHz
typical values
h_{fe}
V_{CE} = 10V
5V
500
400
10V
5V
300
BC108C
BC109C
BC107B
BC108B
BC109B
10V
200
5V
BC107A
BC108A
100
10^{-2}
10^{-1}
1
I_C (mA)
10


7Z08553
h_{re} (10^{-4})
1 { BC108 C, BC109 C
2 { BC107 B, BC108 B, BC109 B
3 { BC107 A, BC108 A
f = 1 kHz
T_j = 25°C
typical values
V_{CE}=5V
V_{CE}=10V
I_C (mA)


7Z08554
h_{oe} $(\mu\Omega^{-1})$
V_{CE} = 5 to 10 V
f = 1 kHz
T_j = 25°C
typical values
BC108 C, BC109 C
BC107 B, BC108 B, BC109 B
BC107 A, BC108 A
I_C (mA)


7Z09795.1
transient thermal resistance from junction to ambient versus pulse duration
$Z_{th\ j-a}$ (°C/W)
10^4
10^3
10^2
10
1
δ = 1.0
0.5
0.2
0.1
0.05
0.02
0.01
0.005
0
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t(s)
10^3
t
T
δ = t/T

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in TO-39 metal envelopes for general purpose applications. P-N-P complements are BC160 and BC161.

QUICK REFERENCE DATA

			BC140	BC141	
Collector-emitter voltage (open base)	V_{CEO}	max.	40	60	V
Collector current (d.c.)	I_C	max.	1		A
Total power dissipation up to T_{case} = 45 °C	P_{tot}	max.	3,7		W
Junction temperature	T_j	max.	175		°C
Transition frequency at f = 20 MHz I_C = 50 mA; V_{CE} = 10 V	f_T	>	50		MHz

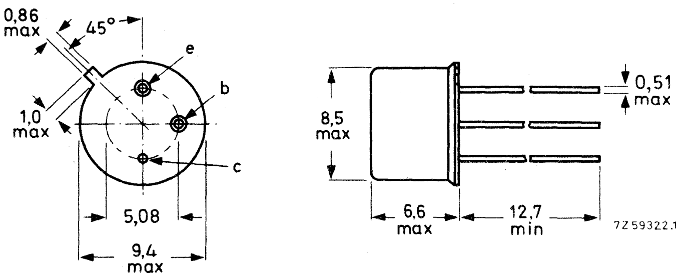
			BC140-6 BC141-6	BC140-10 BC141-10	BC140-16 BC141-16
D.C. current gain I_C = 100 mA; V_{CE} = 1 V	h_{FE}	>	40	63	100
		<	100	160	250

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).

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

			BC 140	BC 141	
Voltages					
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	60	V
Emitter-base voltage (open collector)	V_{EBO}	max.	7	7	V
Currents					
Collector current (d.c.)	I_C	max.	1		A
Base current (d.c.)	I_B	max.	100		mA
Power dissipation					
Total power dissipation up to T_{case} = 45 °C	P_{tot}	max.	3,7		W
Temperatures					
Storage temperature	T_{stg}		−65 to +175		°C
Junction temperature	T_j	max.	175		°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	200	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	35	°C/W

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

Collector cut-off current				
V_{BE} = 0; V_{CE} = 60 V	I_{CES}	typ. <	10 100	nA nA
V_{BE} = 0; V_{CE} = 60 V; T_{amb} = 150 °C	I_{CES}	typ. <	10 100	µA µA
Base-emitter voltage				
I_C = 1 A; V_{CE} = 1 V	V_{BE}	typ. <	1,2 1,8	V V
Saturation voltage				
I_C = 1 A; I_B = 100 mA	V_{CEsat}	typ. <	0,6 1,0	V V
Transition frequency at f = 20 MHz				
I_C = 50 mA; V_{CE} = 10 V	f_T	>	50	MHz
Collector capacitance at f = 1 MHz				
$I_E = I_e$ = 0; V_{CB} = 10 V	C_c	<	25	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c$ = 0; V_{EB} = 0,5 V	C_e	<	80	pF

D.C. current gain

			BC140-6 BC141-6	BC140-10 BC141-10	BC140-16 BC141-16
I_C = 100 µA; V_{CE} = 1 V	h_{FE}	typ.	28	40	90
		>	40	63	100
I_C = 100 mA; V_{CE} = 1 V	h_{FE}	typ.	63	100	160
		<	100	160	250
I_C = 1 A; V_{CE} = 1 V	h_{FE}	typ.	15	20	30

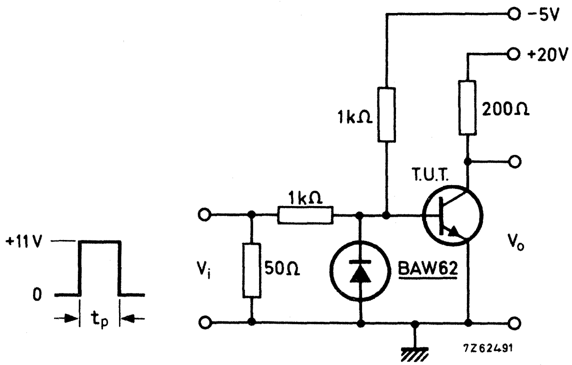
CHARACTERISTICS (continued) $T_{amb} = 25\ ^oC$

Switching times

$I_{Con} = 100$ mA; $I_{Bon} = -I_{Boff} = 5$ mA

Turn-on time	t_{on}	<	250	ns
Turn-off time	t_{off}	<	850	ns

Test circuit:



Pulse generator:

Pulse duration	t_p	= 10 μs
Rise time	t_r	≤ 15 ns
Fall time	t_f	≤ 15 ns
Source impedance	Z_s	= 50 Ω

Oscilloscope

Rise time	t_r	≤ 15 ns
Input impedance	Z_i	≥ 100 kΩ

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.

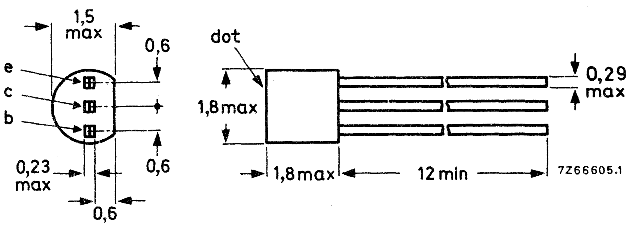
QUICK REFERENCE DATA

			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 °C	P_{tot}	max.	50	50	50	mW
Junction temperature	T_j	max.	125	125	125	°C
D.C. current gain I_C = 0,2 mA; V_{CE} = 0,5 V	h_{FE}	>	80	140	280	
		<	200	350	550	
Noise figure at R_S = 2 kΩ; I_C = 0,2 mA; V_{CE} = 5 V; Bandwidth: f = 30 Hz to 15 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 °C	P_{tot}	max.	50	mW

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

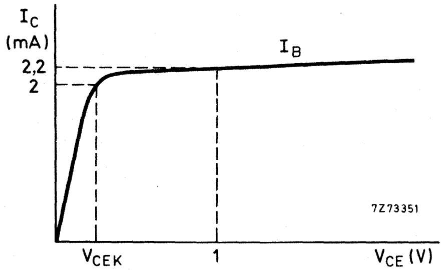
CHARACTERISTICS T_j = 25 °C unless otherwise specified

Base-emitter voltage

I_C = 0,2 mA; V_{CE} = 0,5 V	V_{BE}	typ.	570	mV
I_C = 2 mA; V_{CE} = 1 V	V_{BE}	typ.	630	mV

Knee voltage

I_C = 2 mA; I_B = value for which I_C = 2,2 mA at V_{CE} = 1 V	V_{CEK}	typ.	180	mV



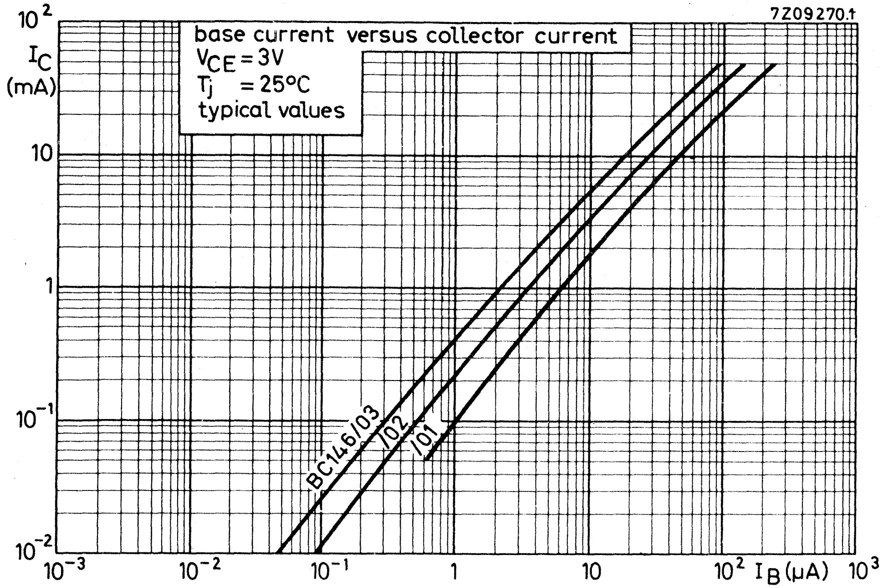
Collector capacitance at f = 1 MHz

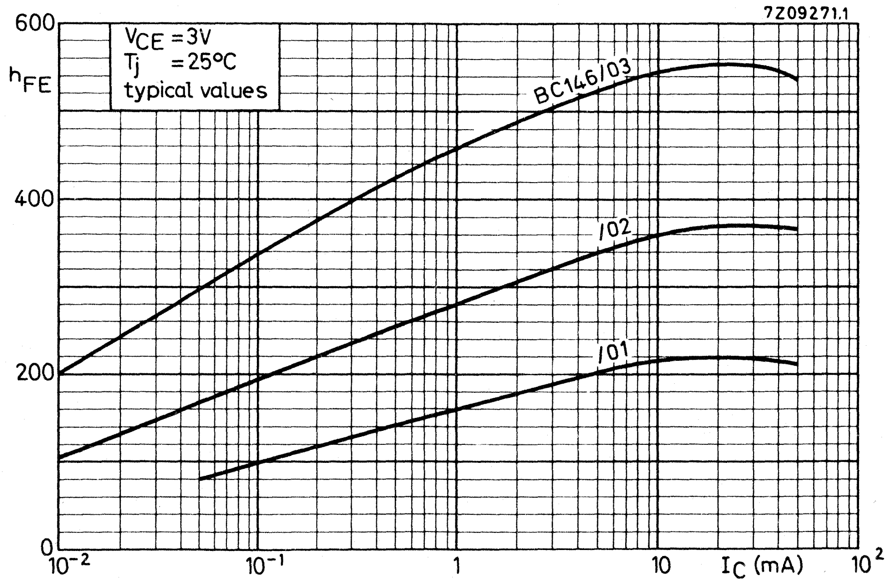
$I_E = I_e$ = 0; V_{CB} = 5 V	C_c	typ.	4	pF

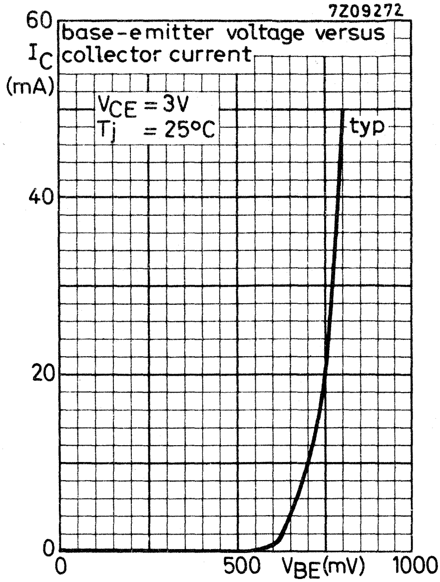
Transition frequency

I_C = 2 mA; V_{CE} = 5 V	f_T	typ.	150	MHz

D.C. current gain	BC146		/01	/02	/03
I_C = 0,2 mA; V_{CE} = 0,5 V	h_{FE}	typ.	115	220	380
			80 to 200	140 to 350	280 to 550
I_C = 2 mA; V_{CE} = 1 V	h_{FE}	>	100	140	280
Noise figure					
I_C = 0,2 mA; V_{CE} = 5 V R_S = 2 kΩ Bandwidth: f = 30 Hz to 15 kHz	F	typ.	2	1,5	2 dB
		<	-	4	- dB
h parameters at f = 1 kHz					
I_C = 0,2 mA; V_{CE} = 0,5 V					
Input impedance	h_{ie}	typ.	20	30	45 kΩ
Reverse voltage transfer ratio	h_{re}	typ.	15	25	40 10^{-4}
Small-signal current gain	h_{fe}	typ.	130	220	380
Output admittance	h_{oe}	typ.	15	20	35 μA/V


7Z09270.1
base current versus collector current
V_{CE} = 3V
T_j = 25°C
typical values
I_C (mA)
10^2
10
1
10^{-1}
10^{-2}
BC146/03
/02
/01
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
I_B (μA)
10^3


7Z09271.1
V_{CE} = 3V
T_j = 25°C
typical values
h_{FE}
600
400
200
0
BC146/03
/02
/01
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2


7Z09272
base-emitter voltage versus collector current
I_C (mA)
60
40
20
0
$V_{CE} = 3V$
$T_j = 25°C$
typ
0
500
V_{BE} (mV)
1000

SILICON PLANAR EPITAXIAL TRANSISTORS

General purpose n-p-n transistors in plastic envelopes with TO-5 compatible pinning.

QUICK REFERENCE DATA

			BC147	BC148	BC149	
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	50	30	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	30	30	V
Collector current (peak value)	I_{CM}	max.	200	200	200	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	350	350	350	mW
Junction temperature	T_j	max.	125	125	125	°C
Small-signal current gain I_C = 2 mA; V_{CE} = 5 V; f = 1 kHz	h_{fe}	>	125	125	240	
		<	500	900	900	
Transition frequency at f = 35 MHz I_C = 10 mA; V_{CE} = 5 V	f_T	typ.	300	300	300	MHz
Noise figure at R_S = 2 kΩ I_C = 200 μA; V_{CE} = 5 V f = 30 Hz to 15 kHz	F	typ.	–	–	1,4	dB
		<	–	–	4,0	dB
f = 1 kHz; B = 200 Hz	F	<	10	10	4,0	dB

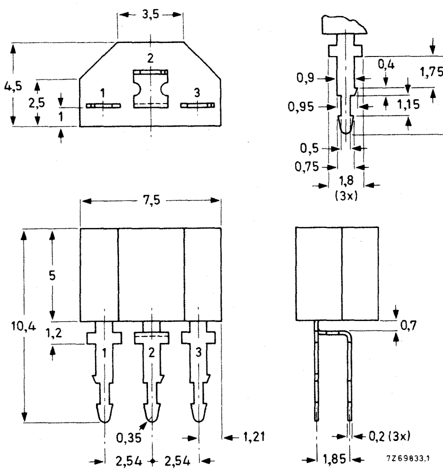
MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT-25.

Connections

1. Emitter
2. Base
3. Collector



FOR NEW DESIGN THE SUCCESSOR TYPES BC547 to 549 ARE RECOMMENDED

MOUNTING INSTRUCTIONS

1. Thickness of printed board: max. 1,1 mm (Fig. 2a)
   Hole diameter 0,77 to 0,83 mm

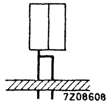


Fig. 2a.

2. Thickness of printed board: max. 1,7 mm (Fig. 2b)
   Hole diameter 1,0 to 1,1 mm
   → (1,0 to 1,3 mm allowable)

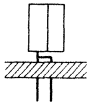
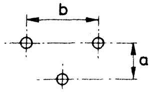


Fig. 2b.



a = 2,49 to 2,59 mm
b = 5,03 to 5,13 mm

Fig. 3 Bore plan.

RATINGS

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

			BC147	BC148	BC149	
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	30	30	V
Emitter-base voltage (open collector)	V_{EBO}	max.	6,0	5,0	5,0	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.	350	mW
Storage temperature	T_{stg}		−65 to + 125	°C
Junction temperature	T_j	max.	125	°C

THERMAL RESISTANCE

→ From junction to ambient in free air	$R_{th\ j-a}$	=	275	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current					
$I_E = 0$; $V_{CB} = 20$ V	BC147/BC149	I_{CBO}	<	15	nA ←
	BC148	I_{CBO}	<	100	nA
$I_E = 0$; $V_{CB} = 20$ V; $T_j = 125$ °C		I_{CBO}	<	5,0	μA
Base-emitter voltage *					
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
Saturation voltages **					
I_C = 10 mA; I_B = 0,5 mA		V_{CEsat}	typ.	90	mV
			<	250	mV
		V_{BEsat}	typ.	700	mV
I_C = 100 mA; I_B = 5 mA		V_{CEsat}	typ.	200	mV
			<	600	mV
		V_{BEsat}	typ.	900	mV
Knee voltage (see Fig. 4)					
I_C = 10 mA; I_B = value for which I_C = 11 mA at V_{CE} = 1 V		V_{CEK}	typ.	300	mV
			<	600	mV

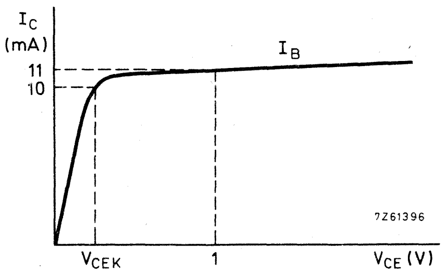


Fig. 4.

Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	typ.	2,5	pF
		<	4,5	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $V_{EB} = 0,5$ V	C_e	typ.	9	pF
Transition frequency at f = 35 MHz				
I_C = 10 mA; $V_{CE} = 5$ V	f_T	typ.	300	MHz

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

			BC147	BC148	BC149	
Small-signal current gain $I_C = 2$ mA; $V_{CE} = 5$ V	h_{fe}	$>$	125	125	240	
		$<$	500	900	900	
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.	–	–	1,4	dB
		$<$	–	–	4,0	dB
f = 1 kHz; B = 200 Hz	F	typ.	2,0	2,0	1,2	dB
		$<$	10	10	4,0	dB
→ D.C. current gain $I_C = 2$ mA; $V_{CE} = 5$ V	h_{FE}	$>$	110	110	200	
		$<$	450	800	800	

			BC147A BC148A	BC147B BC148B BC149B	BC148C BC149C	
D.C. current gain → $I_C = 10\ \mu A$; $V_{CE} = 5$ V	h_{FE}	$>$	–	40	100	
		typ.	90	150	270	
$I_C = 2$ mA; $V_{CE} = 5$ V	h_{FE}	$>$	110	200	420	
		typ.	180	290	520	
		$<$	220	450	800	
h-parameters at f = 1 kHz (common emitter) $I_C = 2$ mA; $V_{CE} = 5$ V Input impedance	h_{ie}	$>$	1,6	3,2	6,0	kΩ
		typ.	2,7	4,5	8,7	kΩ
		$<$	4,5	8,5	15	kΩ
Reverse voltage transfer ratio	h_{re}	typ.	1,5	2,0	3,0	10^{-4}
Small-signal current gain	h_{fe}	$>$	125	240	450	
		typ.	220	330	600	
		$<$	260	500	900	
Output admittance	h_{oe}	typ.	18	30	60	$\mu A/V$
		$<$	30	60	110	$\mu A/V$

SILICON PLANAR EPITAXIAL TRANSISTORS

General purpose p-n-p transistors in plastic envelopes with TO-5 compatible pinning.

QUICK REFERENCE DATA

			BC157	BC158	BC159	
Collector-emitter voltage (+ V_{BE} = 1 V)	$-V_{CEX}$	max.	50	30	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	30	30	V
Collector current (peak value)	$-I_{CM}$	max.	200	200	200	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	350	350	350	mW
Junction temperature	T_j	max.	125	125	125	°C
Small-signal current gain at T_j = 25 °C; $-I_C$ = 2 mA; $-V_{CE}$ = 5 V; f = 1 kHz	h_{fe}	>	75	75	125	
		<	260	500	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 kΩ; $-I_C$ = 200 μA; $-V_{CE}$ = 5 V; f = 30 Hz to 15 kHz	F	typ.	–	–	1,2	dB
		<	–	–	4,0	dB
f = 1 kHz; B = 200 Hz	F	<	10	10	4,0	dB

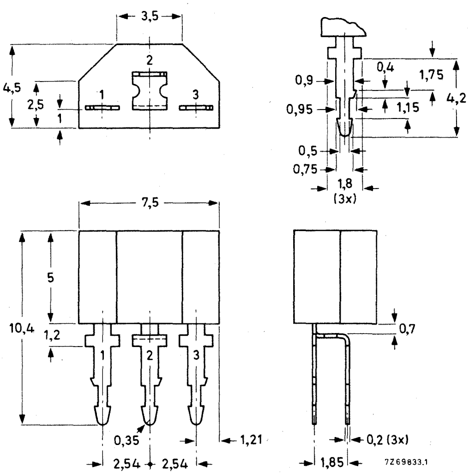
MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT-25.

Connections

1. Emitter
2. Base
3. Collector



FOR NEW DESIGN THE SUCCESSOR TYPES BC557 to 559 ARE RECOMMENDED

MOUNTING INSTRUCTIONS

1. Thickness of printed board: max. 1,1 mm (Fig. 2a)
   Hole diameter 0,77 to 0,83 mm

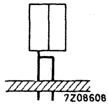


Fig. 2a.

2. Thickness of printed board: max. 1,7 mm (fig. 2b)
   Hole diameter 1,0 to 1,1 mm
   (1,0 to 1,3 mm allowable)

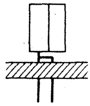
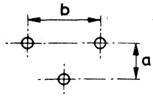


Fig. 2b.



a = 2,49 to 2,59 mm
b = 5,03 to 5,13 mm

Fig. 3 Bore plan.

RATINGS

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

			BC157	BC158	BC159	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	50	30	30	V
Collector-emitter voltage (+ V_{BE} = 1 V)	$-V_{CEX}$	max.	50	30	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	30	30	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5,0	5,0	5,0	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.	350	mW
Storage temperature	T_{stg}		−65 to + 125	°C
Junction temperature	T_j	max.	125	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	275	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current					
$I_E = 0; -V_{CB} = 20$ V	BC157/BC159	$-I_{CBO}$	<	15 nA	←
	BC158	$-I_{CBO}$	<	100 nA	
$I_E = 0; -V_{CB} = 20$ V; $T_j = 125$ °C		$-I_{CBO}$	<	5,0 µA	←
Base-emitter voltage *					
$-I_C = 2$ mA; $-V_{CE} = 5$ V		$-V_{BE}$	typ.	650 mV	
			600 to	750 mV	
Saturation voltages **					
$-I_C = 10$ mA; $-I_B = 0,5$ mA		$-V_{CEsat}$	typ.	75 mV	
			<	300 mV	
		$-V_{BEsat}$	typ.	700 mV	
$-I_C = 100$ mA; $-I_B = 5$ mA		$-V_{CEsat}$	typ.	250 mV	
		$-V_{BEsat}$	typ.	850 mV	
Knee voltage (see Fig. 4)					
$-I_C = 10$ mA; $-I_B$ = value for which $-I_C = 11$ mA at $-V_{CE} = 1$ V		$-V_{CEK}$	typ.	250 mV	
			<	600 mV	

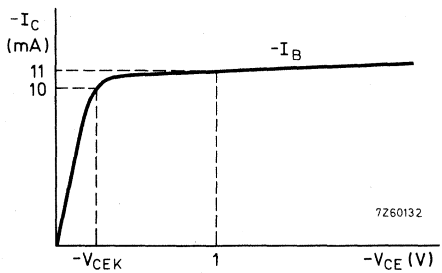


Fig. 4.

Collector capacitance at f = 1 MHz			
$I_E = I_e = 0; -V_{CB} = 10$ V	C_c	typ.	4,5 pF
Transition frequency at f = 35 MHz			
$-I_C = 10$ mA; $-V_{CE} = 5$ V	f_T	typ.	150 MHz

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

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

			BC157	BC158	BC159	
Small-signal current gain						
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{fe}	>	75	75	125	
		<	260	500	500	
Noise figure at R_S = 2 kΩ						
$-I_C$ = 200 μA; $-V_{CE}$ = 5 V						
f = 30 Hz to 15 kHz	F	typ.	–	–	1,2	dB
		<	–	–	4,0	dB
→ f = 1 kHz; B = 200 Hz	F	typ.	–	–	1,0	dB
		<	10	10	4,0	dB
→ D.C. current gain						
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{FE}	typ.	140	210	230	

			BC157	BC158A BC159A	BC158B BC159B
D.C. current gain					
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{FE}	typ.	140	180	290
Small-signal current gain at f = 1 kHz					
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{fe}	>	75	125	240
		<	260	260	500

SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in TO-39 metal envelopes for general purpose applications. N-P-N complements are BC140 and BC141.

QUICK REFERENCE DATA

			BC160	BC161	
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	V
Collector current (d.c.)	$-I_C$	max.	1		A
Total power dissipation up to T_{case} = 45 °C	P_{tot}	max.	3,7		W
Junction temperature	T_j	max.	175		°C
Transition frequency at f = 20 MHz $-I_C$ = 50 mA; $-V_{CE}$ = 10 V	f_T	>	50		MHz

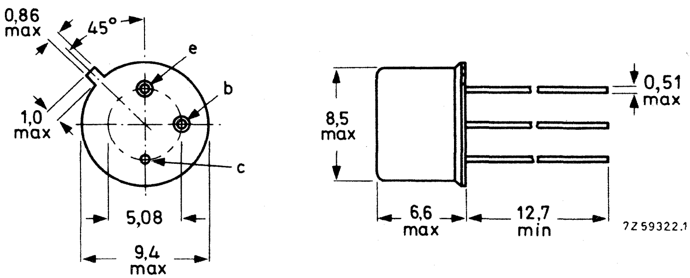
			BC160-6 BC161-6	BC160-10 BC161-10	BC160-16 BC161-16
D.C. current gain $-I_C$ = 100 mA; $-V_{CE}$ = 1 V	h_{FE}	>	40	63	100
		<	100	160	250

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).

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

Voltages

			BC160	BC161	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	40	60	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	V

Currents

Collector current (d.c.)	$-I_C$	max.	1	A
Base current (d.c.)	$-I_B$	max.	100	mA

Power dissipation

Total power dissipation up to T_{case} = 45 °C	P_{tot}	max.	3,7	W

Temperatures

Storage temperature	T_{stg}		−65 to +175	°C
Junction temperature	T_j	max.	175	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	200	°C/W
From junction to case	$R_{th\ j-c}$	=	35	°C/W

CHARACTERISTICS T_{amb} = 25 °C unless otherwise specified

Collector cut-off current				
$V_{BE} = 0$; $-V_{CE} = -V_{CEOmax}$	$-I_{CES}$	typ.	10	nA
		<	100	nA
$V_{BE} = 0$; $-V_{CE} = -V_{CEOmax}$; $T_{amb} = 150$ °C	$-I_{CES}$	typ.	10	μA
		<	100	μA
Base-emitter voltage				
$-I_C = 1$ A; $-V_{CE} = 1$ V	$-V_{BE}$	typ.	1,0	V
		<	1,7	V
Saturation voltage				
$-I_C = 1$ A; $-I_B = 100$ mA	$-V_{CEsat}$	typ.	0,6	V
		<	1,0	V
Transition frequency at f = 20 MHz				
$-I_C = 50$ mA; $-V_{CE} = 10$ V	f_T	>	50	MHz
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $-V_{CB} = 10$ V	C_c	<	30	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $-V_{EB} = 0,5$ V	C_e	<	180	pF

D.C. current gain			BC160-6 BC161-6	BC160-10 BC161-10	BC160-16 BC161-16
$-I_C = 100$ μA ; $-V_{CE} = 1$ V	h_{FE}	typ.	46	80	120
		>	40	63	100
$-I_C = 100$ mA; $-V_{CE} = 1$ V	h_{FE}	typ.	63	100	160
		<	100	160	250
$-I_C = 1$ A ; $-V_{CE} = 1$ V	h_{FE}	typ.	15	20	30

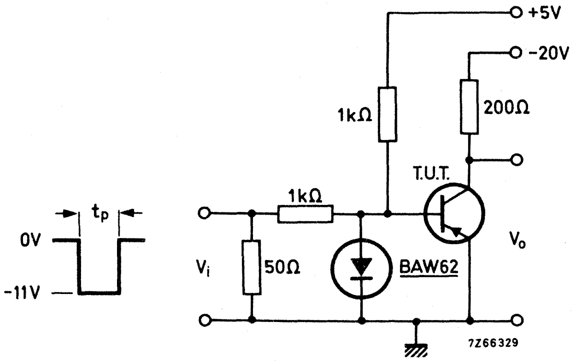
CHARACTERISTICS (continued) T_{amb} = 25 °C

Switching times

$-I_{Con}$ = 100 mA; $-I_{Bon}$ = I_{Boff} = 5 mA

Turn-on time	t_{on}	<	500	ns
Turn-off time	t_{off}	<	650	ns

Test circuit



Pulse generator:

Pulse duration	t_p = 10 μs
Rise time	t_r ≤ 15 ns
Fall time	t_f ≤ 15 ns
Source impedance	Z_s = 50 Ω

Oscilloscope:

Rise time	t_r ≤ 15 ns
Input impedance	Z_i ≥ 100 kΩ

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

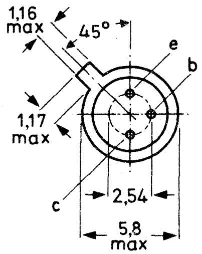
			BC177	BC178	BC179	
Collector-emitter voltage (+ V_{BE} = 1 V)	$-V_{CEX}$	max.	50	30	25	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	25	20	V
Collector current (peak value)	$-I_{CM}$	max.	200	200	200	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	300	300	mW
Junction temperature	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}	>	75	75	125	
		<	260	500	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 kΩ; $-I_C$ = 200 μA; $-V_{CE}$ = 5 V; f = 30 Hz to 15 kHz	F	typ.	–	–	1,2	dB
		<	–	–	4,0	dB
f = 1 kHz; B = 200 Hz	F	<	10	10	4,0	dB

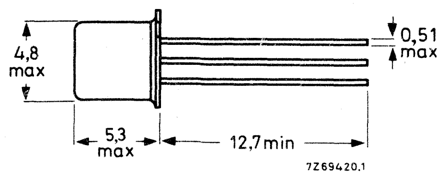
MECHANICAL DATA

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).

Voltages			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

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

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	mW

Temperatures

Storage temperature	T_{stg}		−65 to +175	°C
Junction temperature	T_j	max.	175	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.5	°C/mW
From junction to case	$R_{th\ j\text{-}c}$	=	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 [1]

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

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

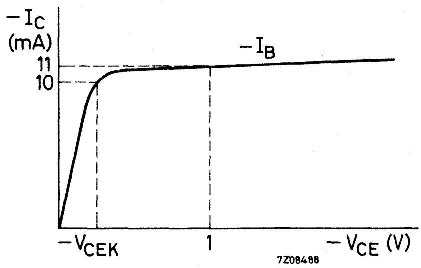
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Saturation voltages

$-I_C$ = 10 mA; $-I_B$ = 0.5 mA	$-V_{CEsat}$	typ.	75	mV
		<	300	mV
	$-V_{BEsat}$	typ.	700	mV
$-I_C$ = 100 mA; $-I_B$ = 5 mA	$-V_{CEsat}$	typ.	250	mV
	$-V_{BEsat}$	typ.	850	mV

Knee voltage

$-I_C$ = 10 mA; $-I_B$ = value for which	$-V_{CEK}$	typ.	250	mV
$-I_C$ = 11 mA at $-V_{CE}$ = 1 V		<	600	mV



Collector capacitance at f = 1 MHz

$I_E = I_e = 0$; $-V_{CB}$ = 10 V — C_c typ. 4.0 pF

Transition frequency at f = 35 MHz

$-I_C$ = 10 mA; $-V_{CE}$ = 5 V — f_T typ. 150 MHz

Small signal current gain at f = 1 kHz

			BC177	BC178	BC179	
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{fe}	>	75	75	125	
		<	260	500	500	

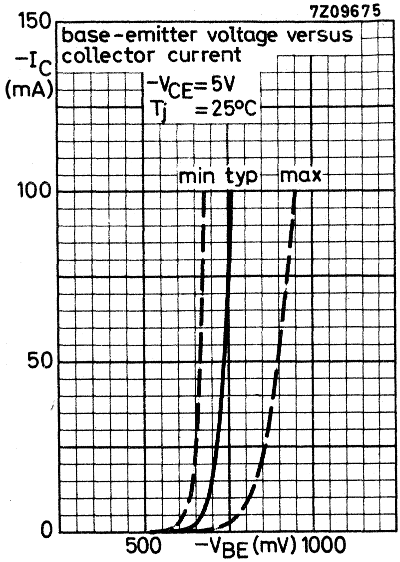
Noise figure at R_S = 2 kΩ

$-I_C$ = 200 μA; $-V_{CE}$ = 5 V

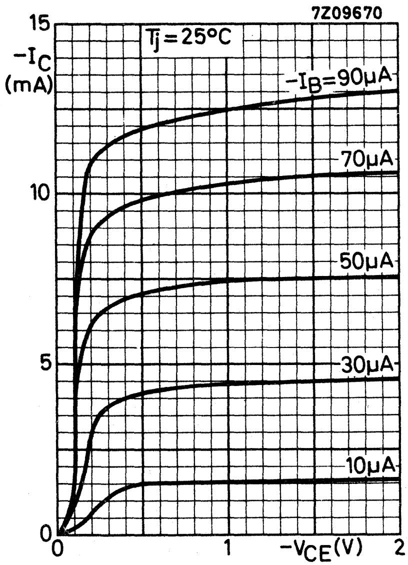
			BC177	BC178	BC179	
f = 30 Hz to 15 kHz	F	typ.			1.2	dB
		<			4	dB
f = 1 kHz; B = 200 Hz	F	typ.	2	2	1	dB
		<	10	10	4	dB

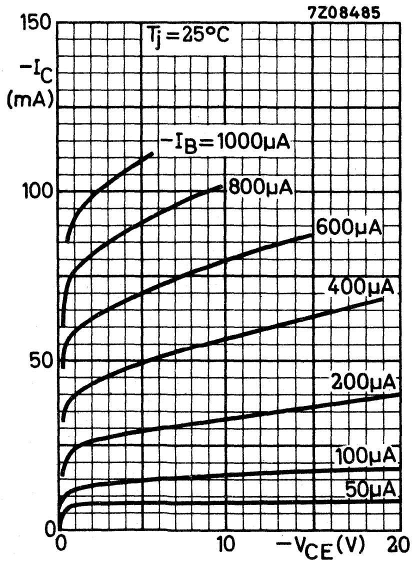
CHARACTERISTICS (continued)

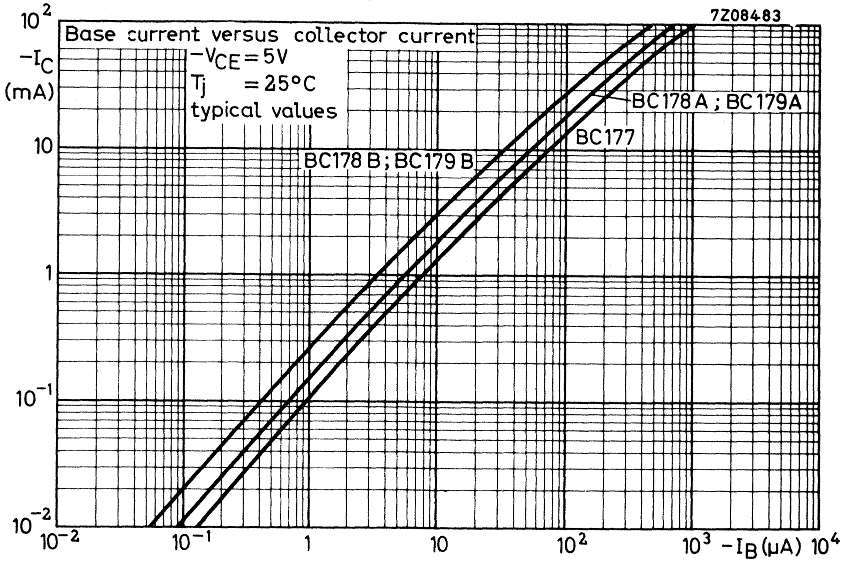
			BC177	BC178A BC179A	BC178B BC179B
D.C. current gain					
$-I_C = 2$ mA; $-V_{CE} = 5$ V	h_{FE}	typ.	140	180	290
Small signal current gain at f = 1 kHz					
$-I_C = 2$ mA; $-V_{CE} = 5$ V	h_{fe}	>	75	125	240
		<	260	260	500

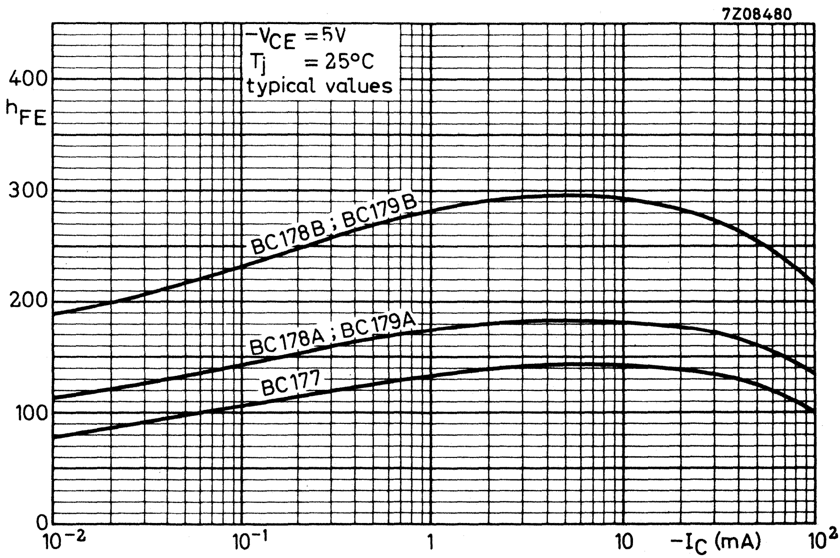


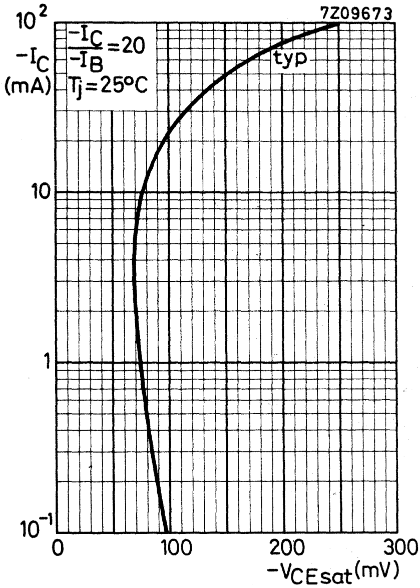
Typical behaviour of collector current versus collector-emitter voltage

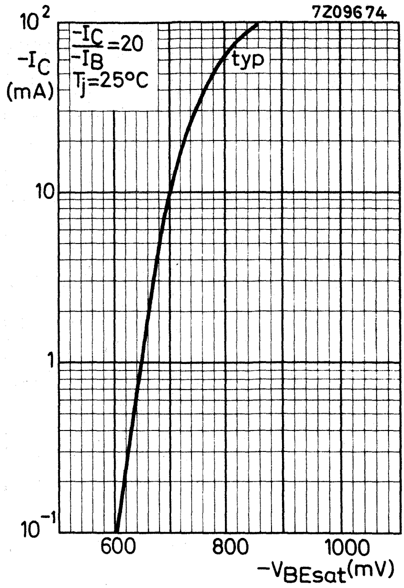


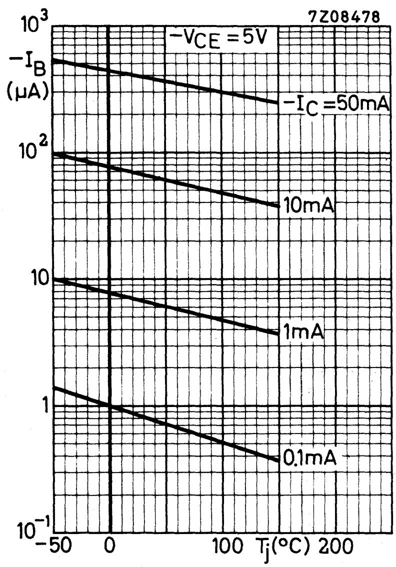



7Z08483
Base current versus collector current
$-V_{CE} = 5V$
$T_j = 25°C$
typical values
$-I_C$ (mA)
10^2
10
1
10^{-1}
10^{-2}
BC178A ; BC179A
BC177
BC178B ; BC179B
10^{-2}
10^{-1}
1
10
10^2
10^3
$-I_B$ (μA)
10^4

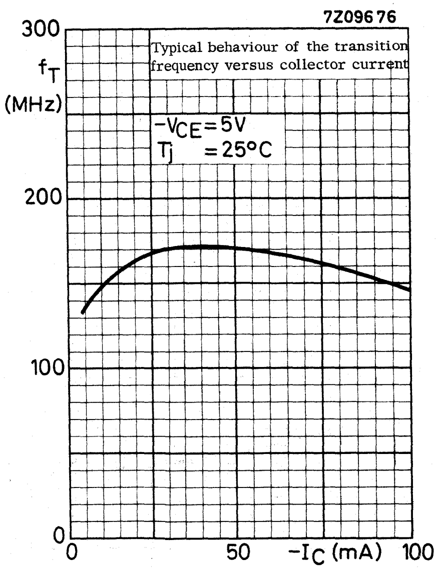

7Z08480
$-V_{CE} = 5V$
$T_j = 25°C$
typical values
h_{FE}
400
300
200
100
0
BC178B ; BC179B
BC178A ; BC179A
BC177
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2

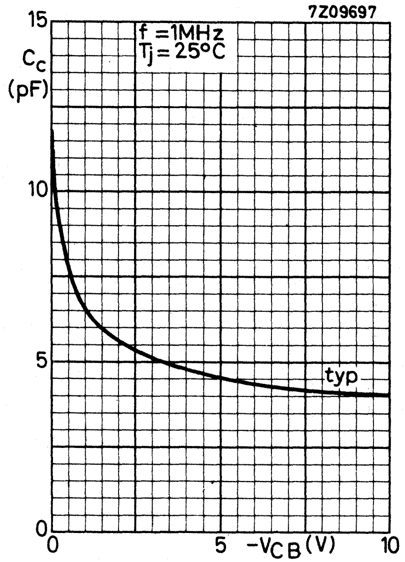


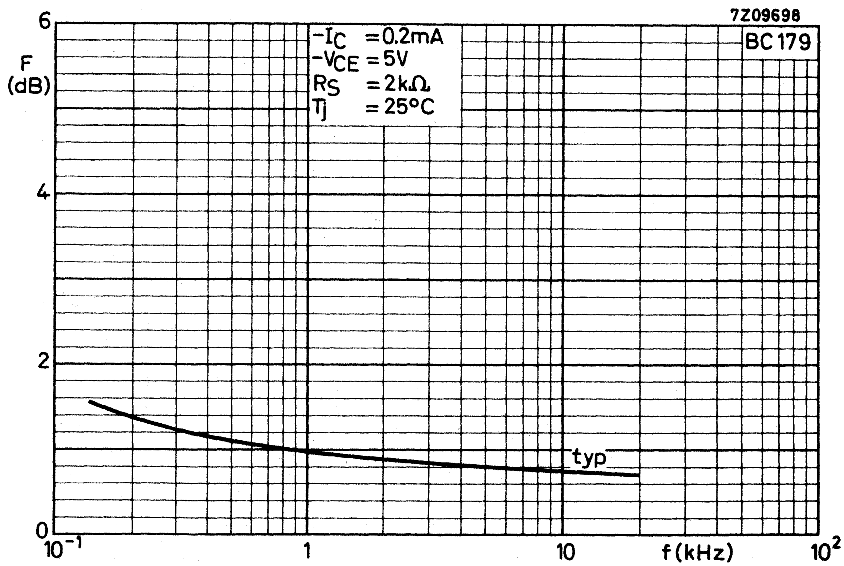




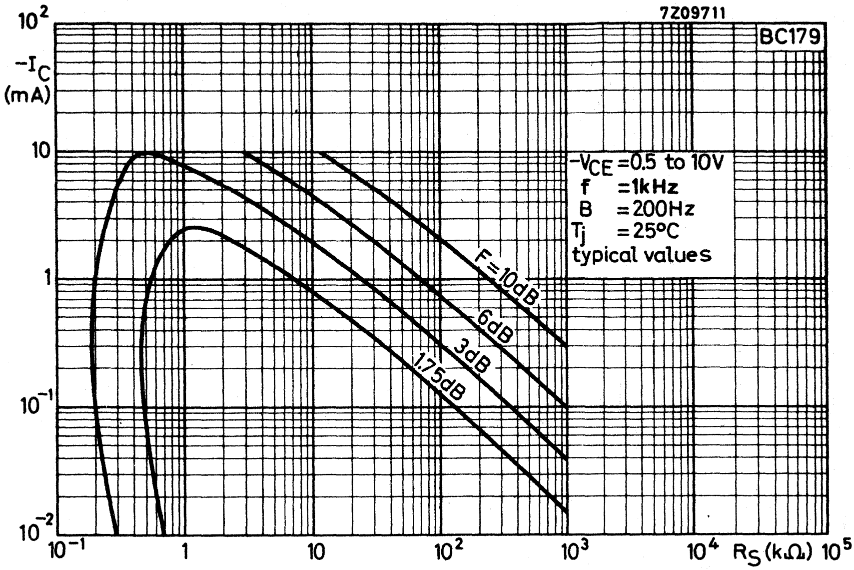
Typical behaviour of base current versus junction temperature

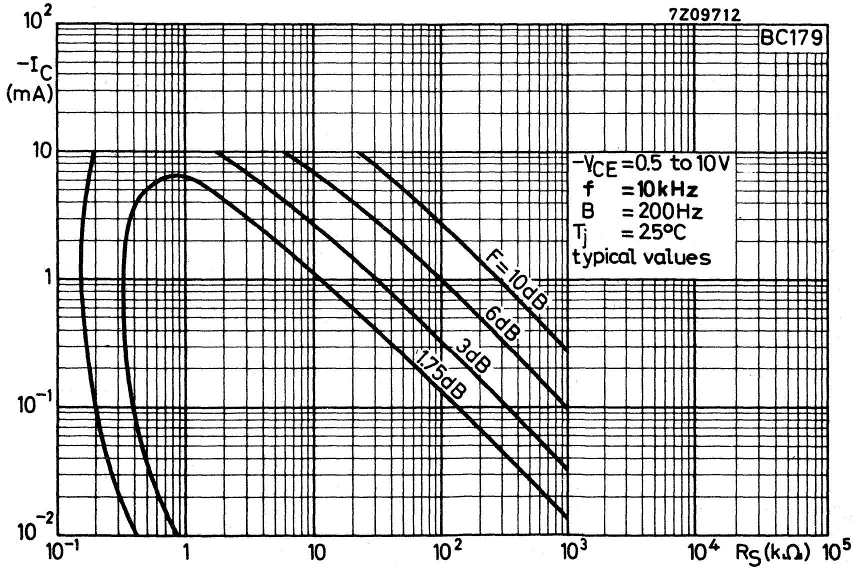


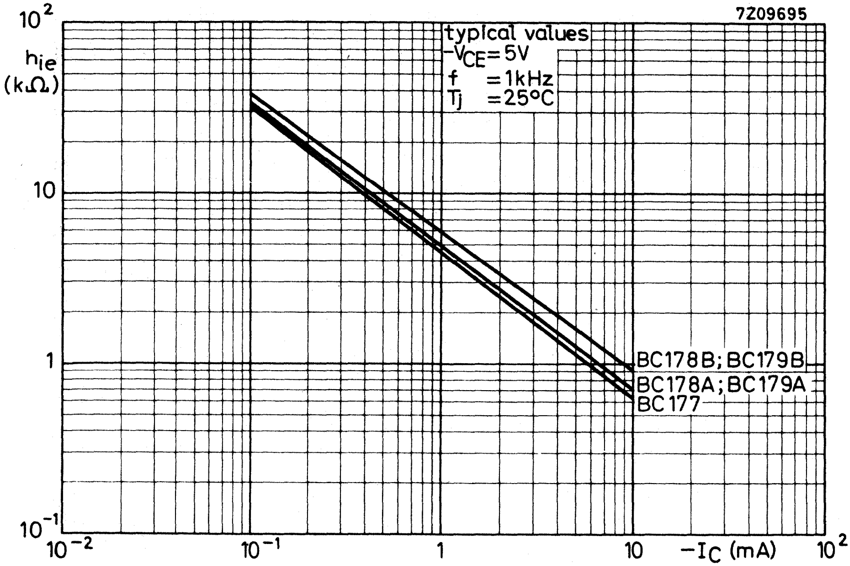

7Z09697
f = 1MHz
Tj = 25°C
Cc
(pF)
15
10
5
0
typ
0
5
-VCB (V)
10

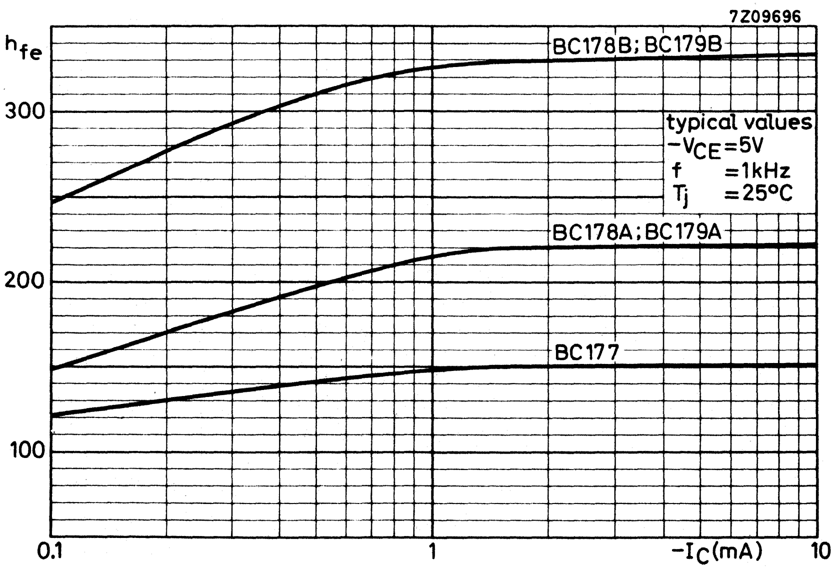

7Z09698
BC179
-IC = 0.2mA
-VCE = 5V
RS = 2kΩ
Tj = 25°C
F
(dB)
6
4
2
0
typ
10^-1
1
10
f (kHz)
10^2

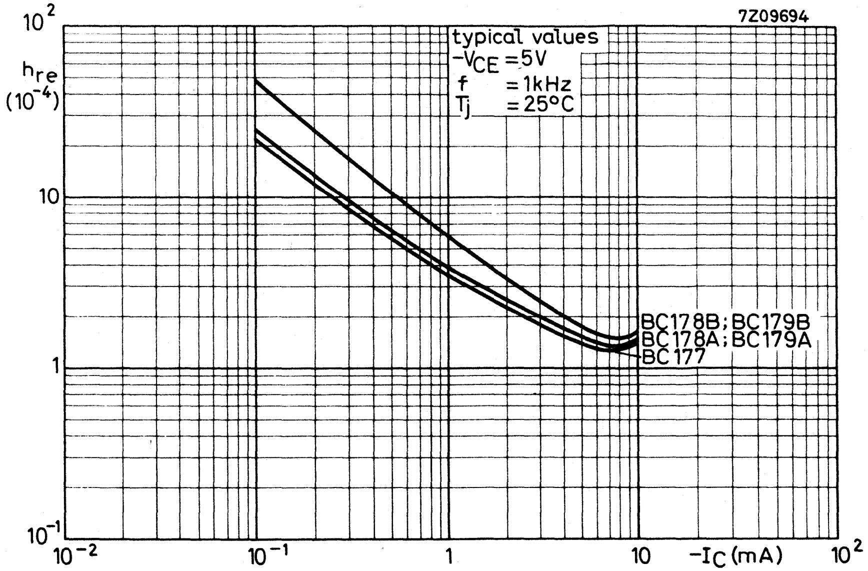
Curves of constant noise figure

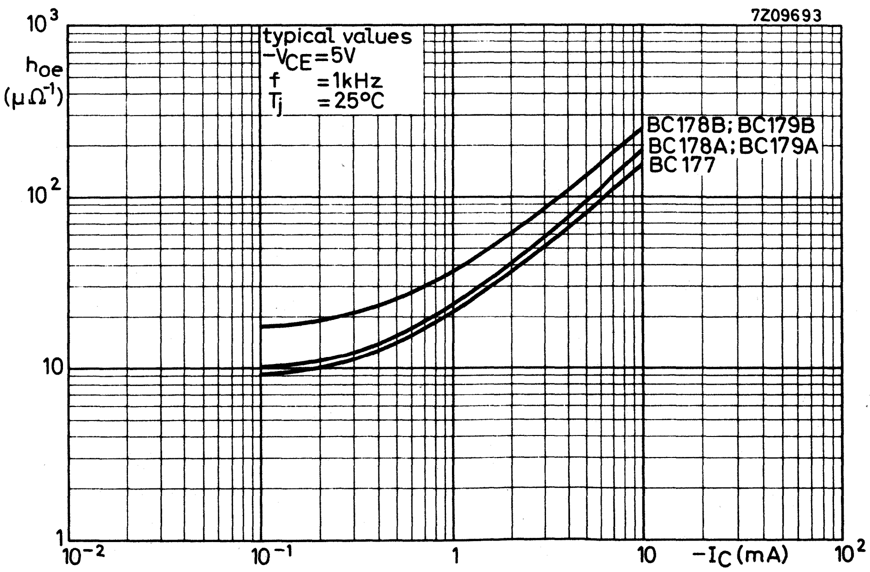


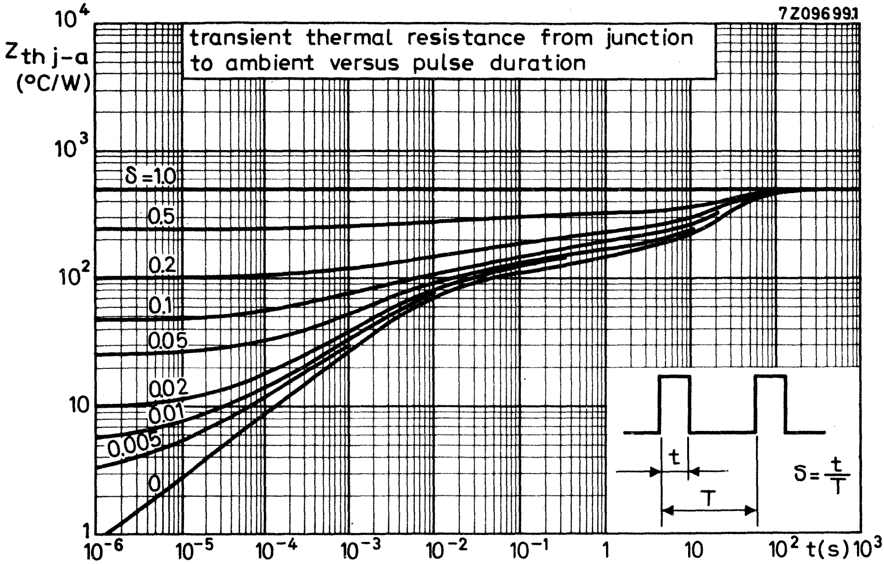



7Z09695
typical values
$-V_{CE} = 5V$
f = 1kHz
T_j = 25°C
h_{ie} (kΩ)
10^2
10
1
10^{-1}
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2
BC178B; BC179B
BC178A; BC179A
BC177


7Z09696
h_{fe}
300
200
100
BC178B; BC179B
typical values
$-V_{CE} = 5V$
f = 1kHz
T_j = 25°C
BC178A; BC179A
BC177
0.1
1
$-I_C$(mA)
10


7Z09694
typical values
$-V_{CE}$ = 5V
f = 1kHz
T_j = 25°C
h_{re} (10^{-4})
10^2
10
1
10^{-1}
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2
BC178B; BC179B
BC178A; BC179A
BC177


7Z09693
typical values
$-V_{CE}$ = 5V
f = 1kHz
T_j = 25°C
h_{oe} ($\mu\Omega^{-1}$)
10^3
10^2
10
1
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2
BC178B; BC179B
BC178A; BC179A
BC177


7Z09699.1
transient thermal resistance from junction to ambient versus pulse duration
$Z_{th\ j-a}$ (°C/W)
10^4
10^3
10^2
10
1
δ = 1.0
0.5
0.2
0.1
0.05
0.02
0.01
0.005
0
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t(s)
10^3
t
T
$\delta = \frac{t}{T}$

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.

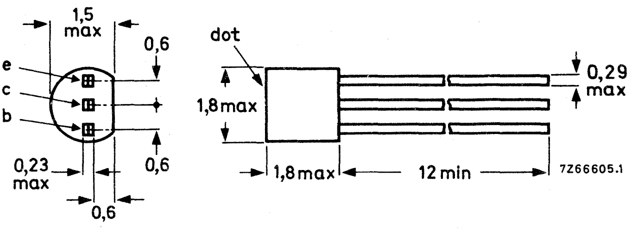
QUICK REFERENCE DATA

			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 ^oC	P_{tot}	max.	50	50	50	mW
Junction temperature	T_j	max.	125	125	125	^oC
D.C. current gain $-I_C$ = 0,2 mA; $-V_{CE}$ = 0,5 V	h_{FE}	$>$	50	85	165	
		$<$	105	200	400	
Noise figure at R_S = 2 kΩ $-I_C$ = 0,2 mA; $-V_{CE}$ = 5 V Bandiwtdh: f = 30 Hz to 15 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:

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 ^oC 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 ^oC.

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 ^oC	P_{tot}	max.	50	mW

Temperatures

Storage temperature	T_{stg}		−65 to +125	^oC
Junction temperature	T_j	max.	125	^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	1,6	$^oC/mW$

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

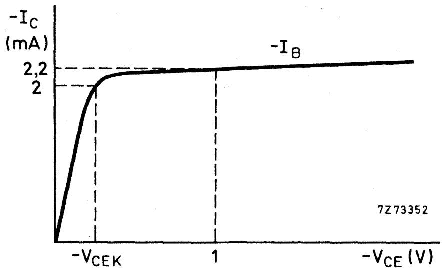
I_E = 0; $-V_{CB}$ = 20 V	$-I_{CBO}$	<	100	nA
I_E = 0; $-V_{CB}$ = 20 V; T_j = 125 °C	$-I_{CBO}$	<	1	μA

Base-emitter voltage

$-I_C$ = 0,2 mA; $-V_{CE}$ = 0,5 V	$-V_{BE}$	typ.	580	mV
$-I_C$ = 2 mA; $-V_{CE}$ = 1 V	$-V_{BE}$	typ.	650	mV

Knee voltage

$-I_C$ = 2 mA; $-I_B$ = value for which
$-I_C$ = 2,2 mA at $-V_{CE}$ = 1 V — $-V_{CEK}$ typ. 200 mV



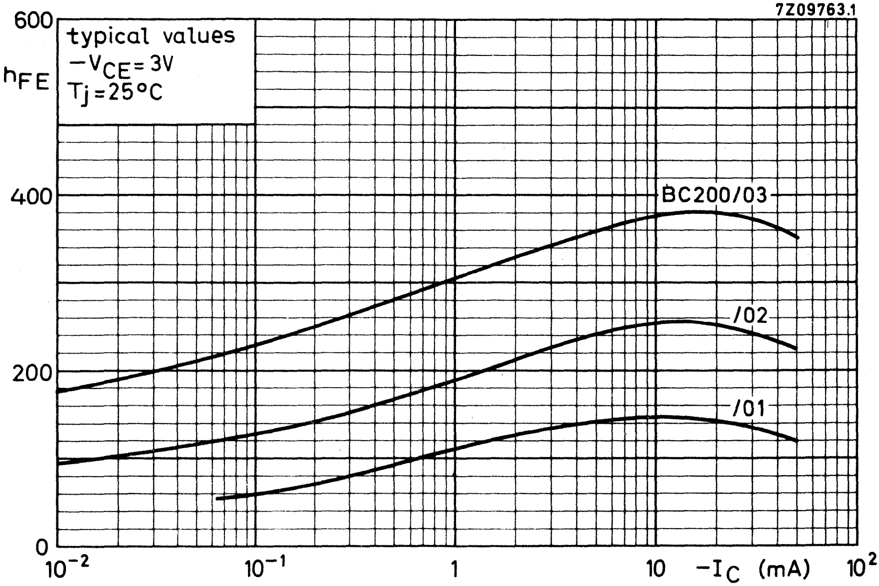
Collector capacitance at f = 1 MHz

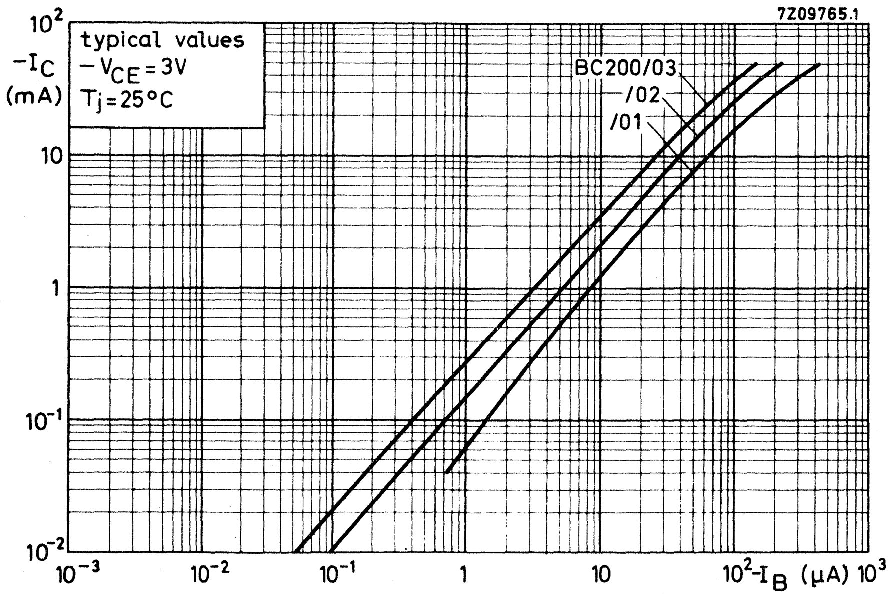
$I_E = I_e$ = 0; $-V_{CB}$ = 5 V	C_c	typ.	5	pF

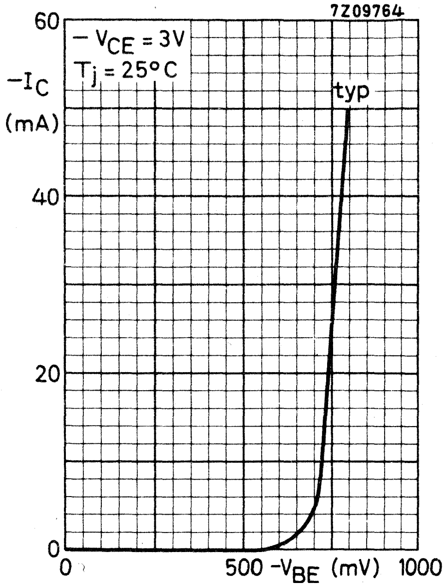
Transition frequency at f = 100 MHz

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

D.C. current gain	BC200	/01	/02	/03	
$-I_C$ = 0,2 mA; $-V_{CE}$ = 0,5 V	h_{FE}	typ. 75	140	250	
		50 to 105	85 to 200	165 to 400	
$-I_C$ = 2 mA; $-V_{CE}$ = 1 V	h_{FE}	> 60	100	175	
h parameters at f = 1 kHz					
$-I_C$ = 0,2 mA; $-V_{CE}$ = 0,5 V					
Input impedance	h_{ie}	typ. 12	15	20	kΩ
Reverse voltage transfer ratio	h_{re}	typ. 13	25	40	10^{-4}
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 mA; $-V_{CE}$ = 5 V; R_S = 2 kΩ					
Bandwidth: f = 30 Hz to 15 kHz	F	typ. 2	1,5	2	dB
		< –	4	–	dB


7Z09763.1
typical values
$-V_{CE} = 3V$
$T_j = 25°C$
h_{FE}
600
400
200
0
BC200/03
/02
/01
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2


7Z09765.1
typical values
$-V_{CE} = 3V$
$T_j = 25°C$
$-I_C$
(mA)
10^2
10
1
10^{-1}
10^{-2}
BC200/03
/02
/01
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
$-I_B$ (μA)
10^3


7Z09764
60
40
20
0
$-V_{CE} = 3V$
$T_j = 25°C$
$-I_C$
(mA)
typ
0
500
$-V_{BE}$ (mV)
1000

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, BC328 are complementary to the BC337 and BC338 respectively.

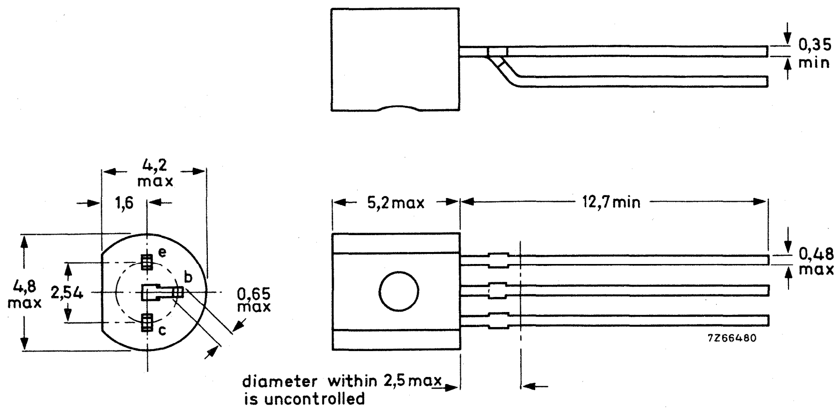
QUICK REFERENCE DATA

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

Voltages

			BC327	BC328	
Collector-emitter voltage (V_{BE} = 0)	$-V_{CES}$	max.	50	30	V
Collector-emitter voltage (open base) $-I_C$ = 10 mA	$-V_{CEO}$	max.	45	25	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	V

Currents

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

Power dissipation

Total power dissipation at T_{amb} = 25 °C	P_{tot}	max.	625	mW
up to T_{amb} = 25 °C	P_{tot}	max.	800	mW [1])

Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0,2	°C/mW
From junction to ambient	$R_{th\ j-a}$	=	0,156	°C/mW [1])

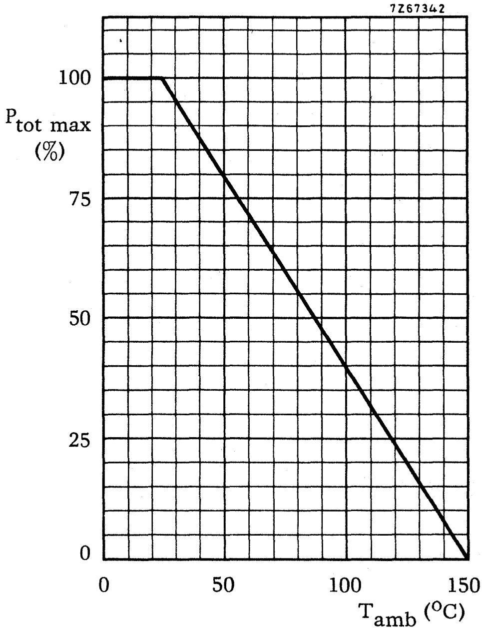
[1]) Transistor mounted on printed circuit board, max. lead length 4 mm, mounting pad for collector lead min. 10 mm x 10 mm.

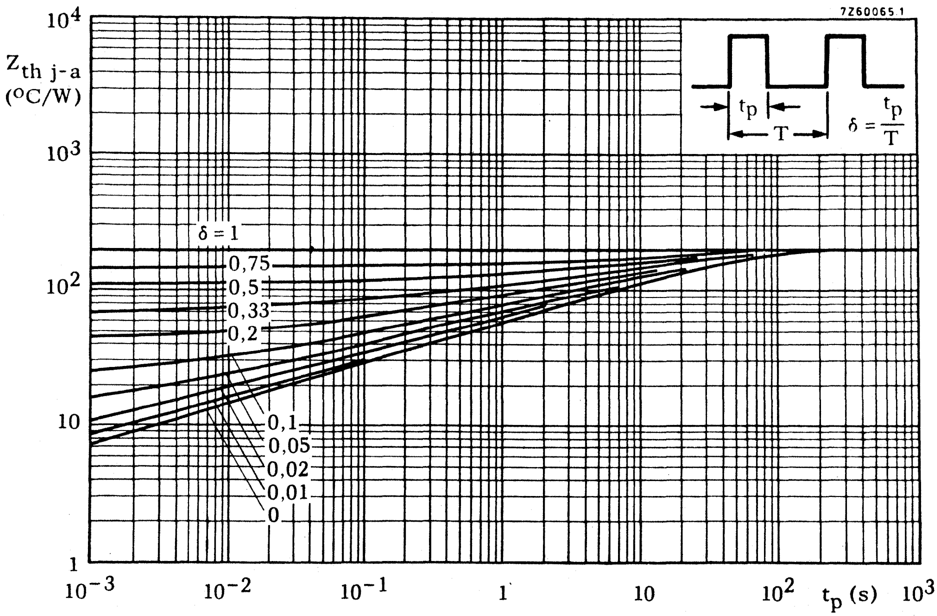
CHARACTERISTICS

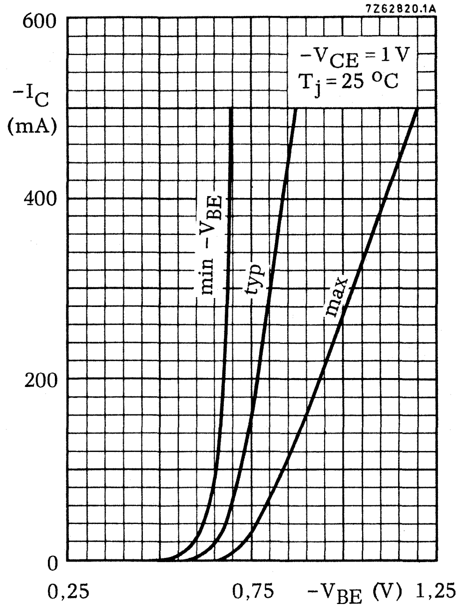
T_j = 25 °C unless otherwise specified

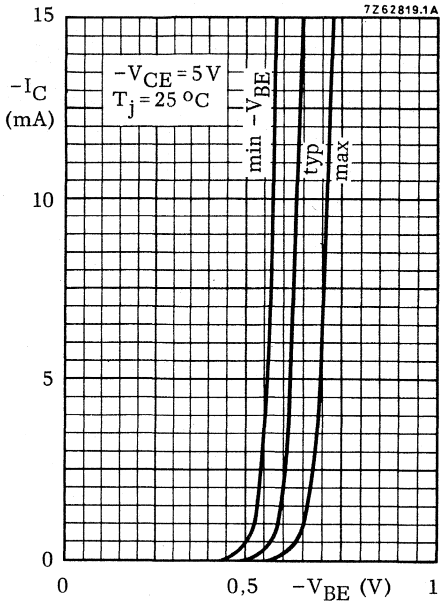
Collector cut-off current				
$I_E = 0; -V_{CB} = 20$ V; T_j = 25 °C	$-I_{CBO}$	<	100	nA
$I_E = 0; -V_{CB} = 20$ V; T_j = 150 °C	$-I_{CBO}$	<	5	μA
Emitter cut-off current				
$I_C = 0; -V_{EB} = 5$ V	$-I_{EBO}$	<	10	μA
Base emitter voltage*				
$-I_C = 500$ mA; $-V_{CE} = 1$ V	$-V_{BE}$	<	1,2	V
Saturation voltage				
$-I_C = 500$ mA; $-I_B = 50$ mA	$-V_{CEsat}$	<	700	mV
D.C. current gain				
$-I_C = 500$ mA; $-V_{CE} = 1$ V	h_{FE}	>	40	
$-I_C = 100$ mA; $-V_{CE} = 1$ V; BC327; BC328	h_{FE}		100 to 600	
BC327-16, BC328-16	h_{FE}		100 to 250	
BC327-25, BC328-25	h_{FE}		160 to 400	
BC327-40, BC328-40	h_{FE}		250 to 600	
Transition frequency at f = 35 MHz				
$-I_C = 10$ mA; $-V_{CE} = 5$ V	f_T	typ	100	MHz
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0; -V_{CB} = 10$ V	C_c	typ	8	pF
D.C. current gain ratio of matched pairs BC327/BC337; BC328/BC338				
$\|I_C\| = 100$ mA; $\|V_{CE}\| = 1$ V	h_{FE1}/h_{FE2}	typ	1,25	
		<	1,40	

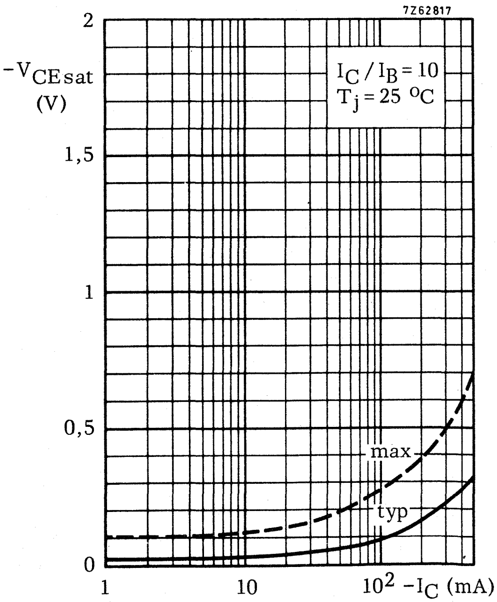
* $-V_{BE}$ decreases by about 2 mV/°C with increasing temperature.

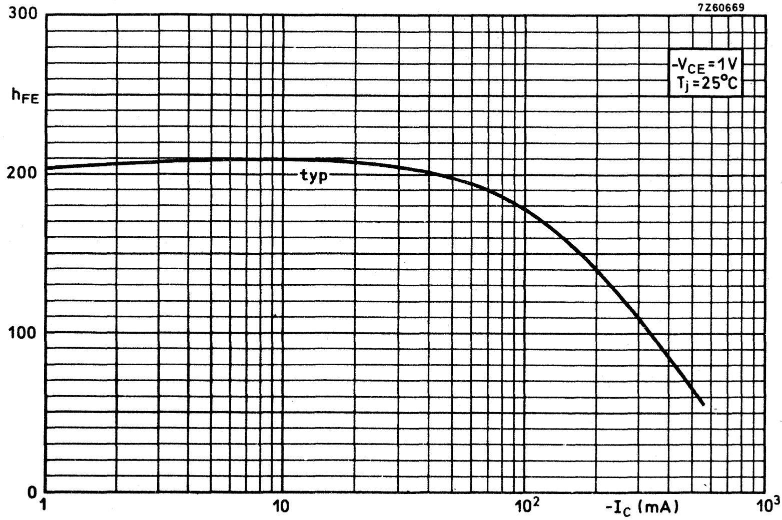

7Z67342
100
$P_{tot\ max}$
(%)
75
50
25
0
0
50
100
150
T_{amb} (°C)

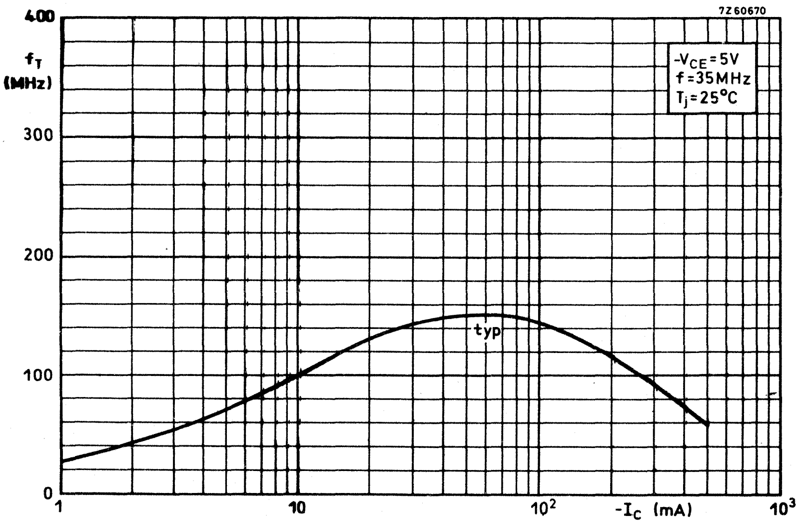

7Z60065.1
10^4
$Z_{th\ j-a}$
(°C/W)
10^3
10^2
10
1
t_p
T
$\delta = \frac{t_p}{T}$
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
0
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (s)
10^3


7Z62820.1A
600
400
200
0
$-I_C$ (mA)
$-V_{CE} = 1$ V
$T_j = 25$ °C
min $-V_{BE}$
typ
max
0,25
0,75
$-V_{BE}$ (V)
1,25


7Z62819.1A
15
10
5
0
$-I_C$ (mA)
$-V_{CE} = 5$ V
$T_j = 25$ °C
min $-V_{BE}$
typ
max
0
0,5
$-V_{BE}$ (V)
1


7Z62817
2
1,5
1
0,5
0
$-V_{CEsat}$ (V)
$I_C / I_B = 10$
$T_j = 25$ °C
max
typ
1
10
10^2
$-I_C$ (mA)


7Z60669
300
h_{FE}
200
100
0
1
10
10^2
$-I_C$ (mA)
10^3
$-V_{CE}$ = 1V
T_j = 25°C
typ


7Z60670
400
f_T
(MHz)
300
200
100
0
1
10
10^2
$-I_C$ (mA)
10^3
$-V_{CE}$ = 5V
f = 35MHz
T_j = 25°C
typ

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, BC338 are complementary to the BC327 and BC328 respectively.

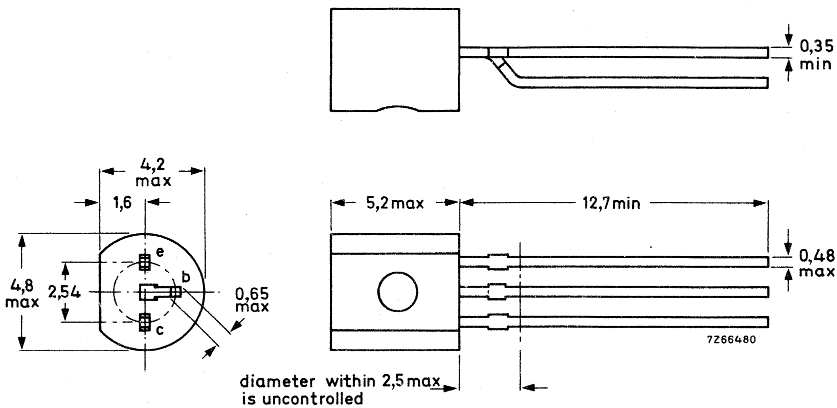
QUICK REFERENCE DATA

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

Voltages

			BC337	BC338	
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	50	30	V
Collector-emitter voltage (open base) I_C = 10 mA	V_{CEO}	max.	45	25	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	V

Currents

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

Power dissipation

Total power dissipation at T_{amb} = 25 °C	P_{tot}	max.	625	mW
up to T_{amb} = 25 °C	P_{tot}	max.	800	mW [1]

Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0,2	°C/mW
From junction to ambient	$R_{th\ j\text{-}a}$	=	0,156	°C/mW [1]

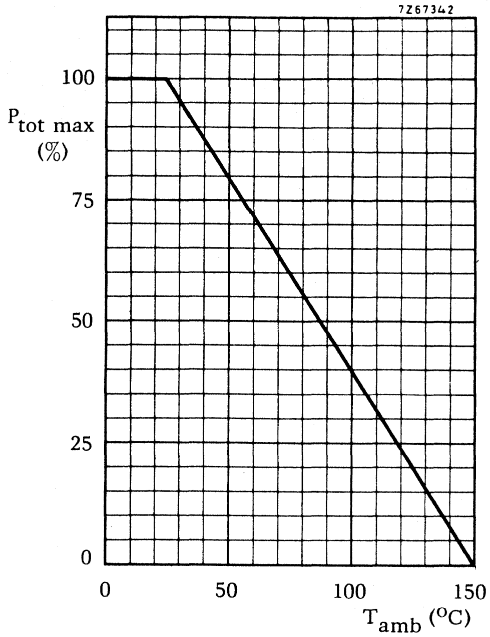
[1] Transistor mounted on printed circuit board, max. lead length 4 mm, mounting pad for collector lead min. 10 mm x 10 mm.

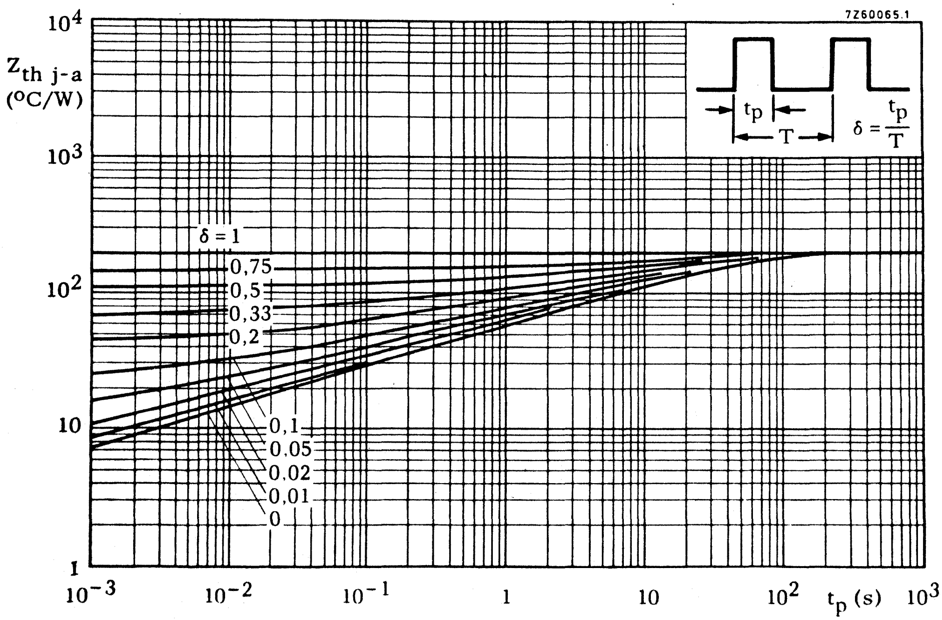
CHARACTERISTICS

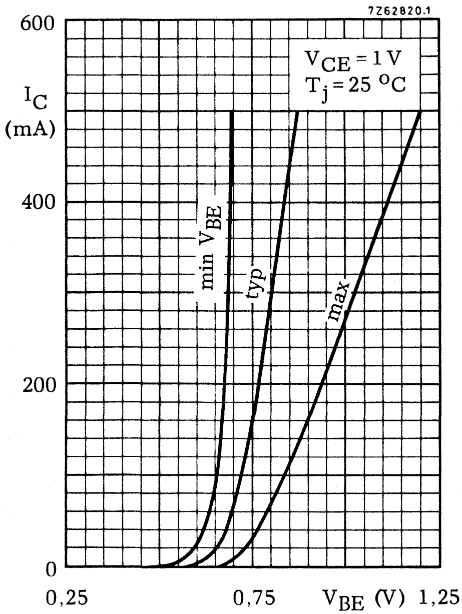
T_j = 25 °C unless otherwise specified

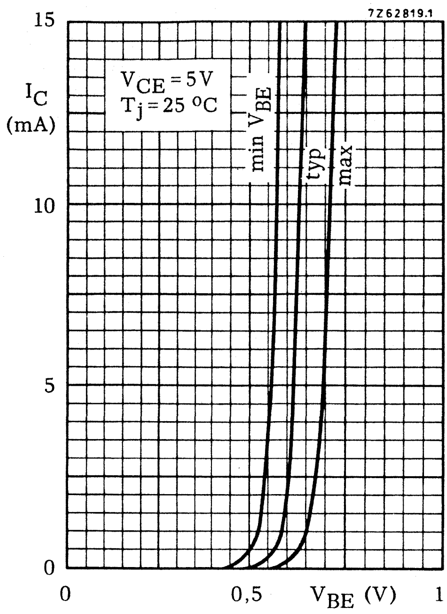
Collector cut-off current			
$I_E = 0$; $V_{CB} = 20$ V; $T_j = 25$ °C	I_{CBO}	<	100 nA
$I_E = 0$; $V_{CB} = 20$ V; $T_j = 150$ °C	I_{CBO}	<	5 µA
Emitter cut-off current			
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10 µA
Base emitter voltage*			
$I_C = 500$ mA; $V_{CE} = 1$ V	V_{BE}	<	1,2 V
Saturation voltage			
$I_C = 500$ mA; $I_B = 50$ mA	V_{CEsat}	<	700 mV
D.C. current gain			
$I_C = 500$ mA; $V_{CE} = 1$ V	h_{FE}	>	40
$I_C = 100$ mA; $V_{CE} = 1$ V; BC337; BC338	h_{FE}		100 to 600
BC337-16, BC338-16	h_{FE}		100 to 250
BC337-25, BC338-25	h_{FE}		160 to 400
BC337-40, BC338-40	h_{FE}		250 to 600
Transition frequency at f = 35 MHz			
$I_C = 10$ mA; $V_{CE} = 5$ V	f_T	typ	200 MHz
Collector capacitance at f = 1 MHz			
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	typ	5 pF
D.C. current gain ratio of matched pairs BC327/BC337; BC328/BC338			
$\|I_C\| = 100$ mA; $\|V_{CE}\| = 1$ V	h_{FE1}/h_{FE2}	typ	1,25
		<	1,40

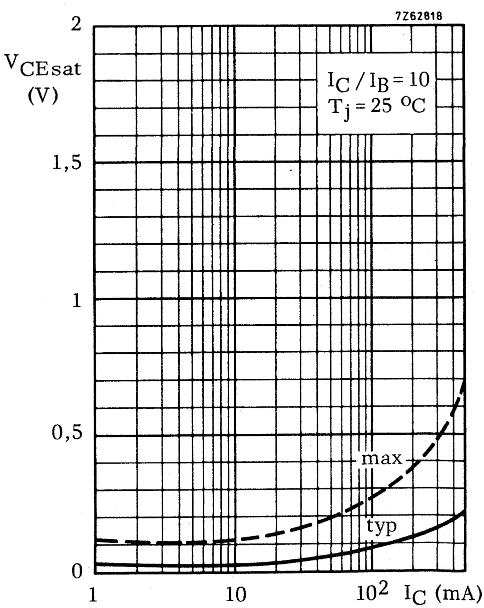
* V_{BE} decreases by about 2 mV/°C with increasing temperature.

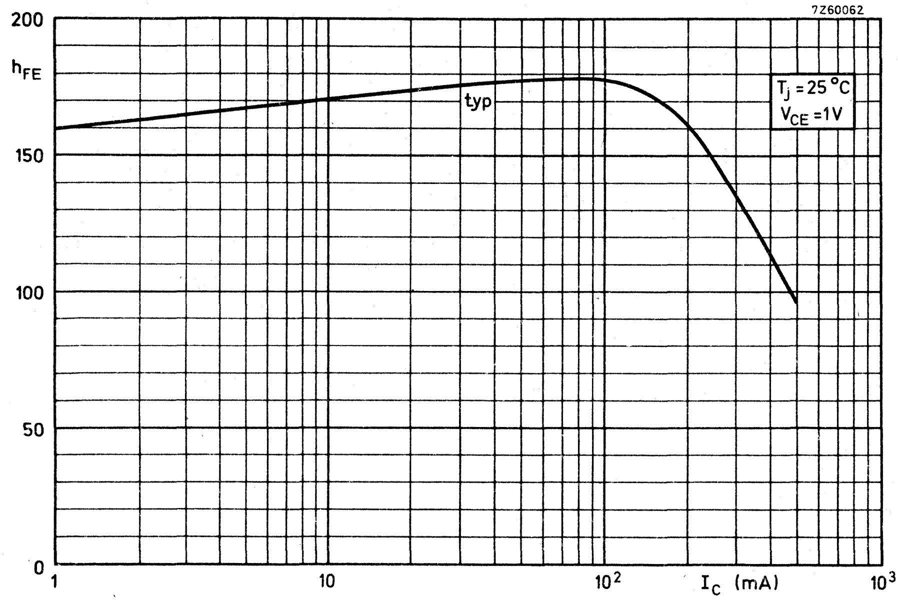

7Z67342
100
$P_{tot\ max}$
(%)
75
50
25
0
0
50
100
150
T_{amb} (^oC)

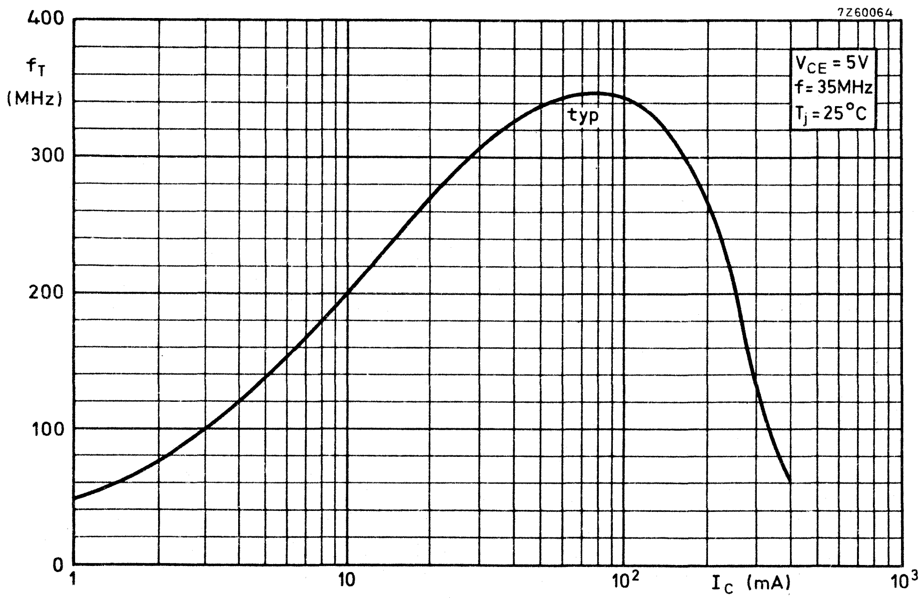

7Z60065.1
10^4
$Z_{th\ j-a}$
($^oC/W$)
10^3
$\delta = 1$
0,75
0,5
0,33
0,2
10^2
0,1
0,05
0,02
0,01
0
10
1
t_p
T
$\delta = \frac{t_p}{T}$
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (s)
10^3


7Z62820.1
600
400
200
0
I_C (mA)
V_{CE} = 1 V
T_j = 25 °C
min V_{BE}
typ
max
0,25
0,75
V_{BE} (V)
1,25


7Z62819.1
15
10
5
0
I_C (mA)
V_{CE} = 5 V
T_j = 25 °C
min V_{BE}
typ
max
0
0,5
V_{BE} (V)
1


7Z62818
2
1,5
1
0,5
0
V_{CEsat} (V)
I_C / I_B = 10
T_j = 25 °C
max
typ
1
10
10^2
I_C (mA)


7Z60062
200
h_{FE}
150
100
50
0
typ
$T_j = 25\,^\circ C$
$V_{CE} = 1V$
1
10
10^2
I_C (mA)
10^3


7Z60064
400
f_T
(MHz)
300
200
100
0
typ
$V_{CE} = 5V$
f = 35MHz
$T_j = 25\,^\circ C$
1
10
10^2
I_C (mA)
10^3

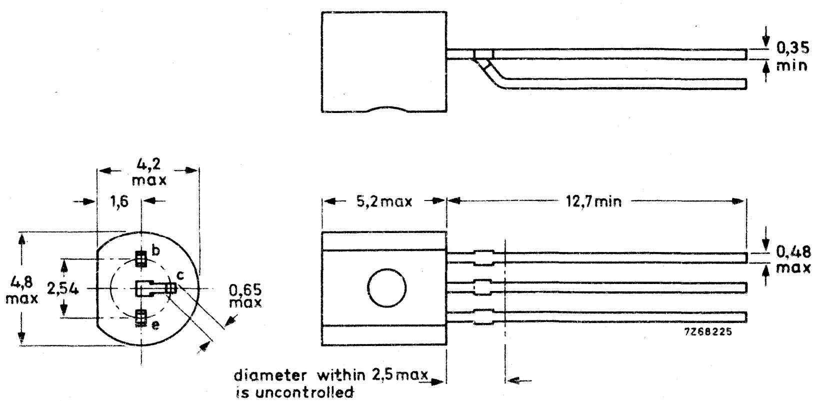
SILICON PLANAR EPITAXIAL TRANSISTOR

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 °C	P_{tot}	max.	1	W
Junction temperature	T_j	max.	150	°C
D.C. current gain I_C = 500 mA; V_{CE} = 1 V	h_{FE}		85 to 375	
Transition frequency I_C = 10 mA; V_{CE} = 5 V	f_T	typ.	60	MHz

MECHANICAL DATA Dimensions in mm

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 °C (in free air)	P_{tot}	max.	0,8	W
up to T_{amb} = 25 °C [1]	P_{tot}	max.	1	W

Temperatures

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

THERMAL RESISTANCE

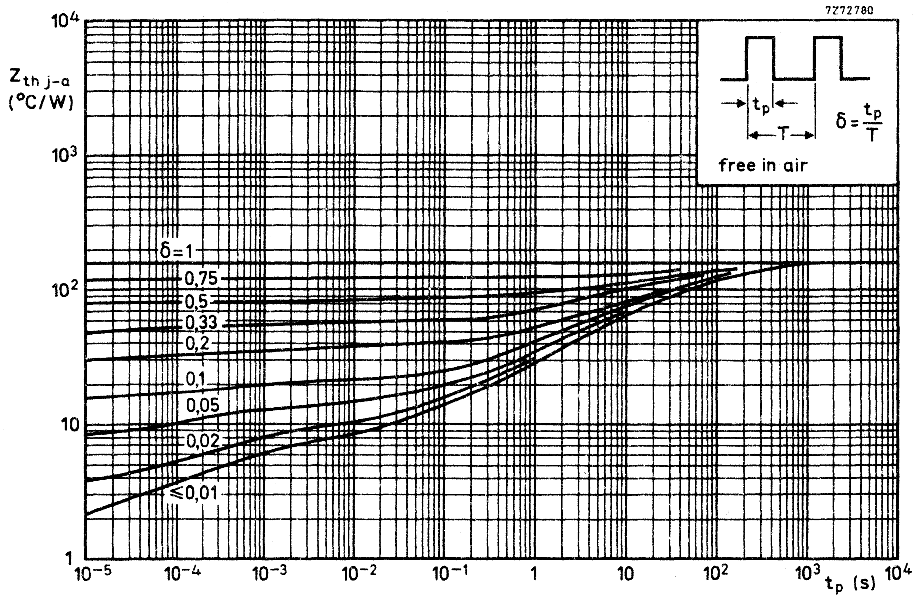
From junction to ambient in free air	$R_{th\ j-a}$	=	156	°C/W
From junction to ambient [1]	$R_{th\ j-a}$	=	125	°C/W
From junction to case	$R_{th\ j-c}$	=	60	°C/W

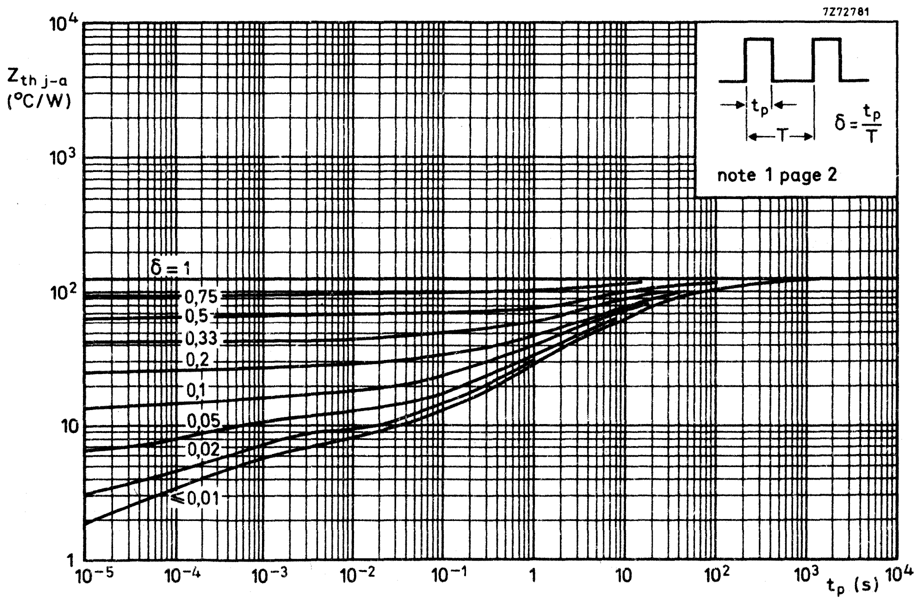
[1] Transistor mounted on printed-circuit board, max. lead length 4 mm, mounting pad for collector lead min. 10 mm x 10 mm.

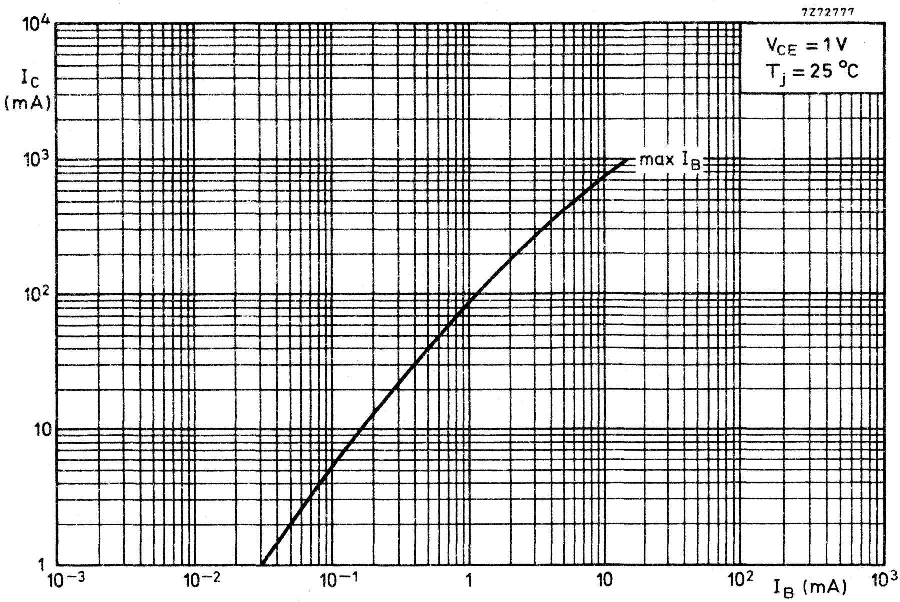
CHARACTERISTICS

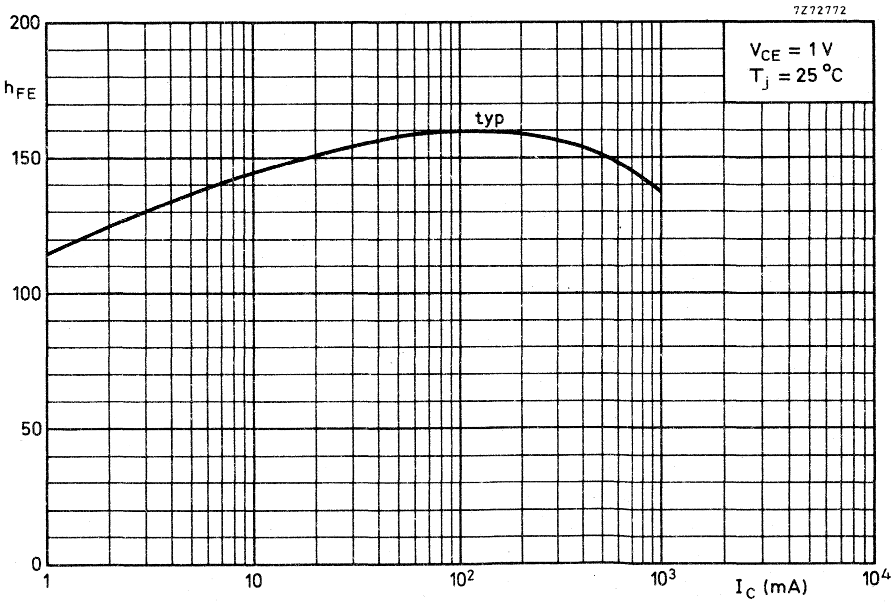
T_j = 25 °C unless otherwise specified

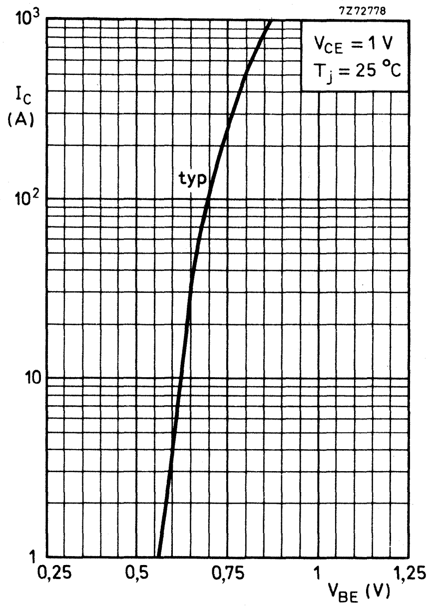
Collector cut-off current				
$I_E = 0$; $V_{CB} = 25$ V	I_{CBO}	<	10	μA
$I_E = 0$; $V_{CB} = 25$ V; $T_j = 150$ °C	I_{CBO}	<	1	mA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10	μA
Base-emitter voltage				
$I_C = 5$ mA; $V_{CE} = 10$ V	V_{BE}	typ.	0,62	V
$I_C = 1$ A; $V_{CE} = 1$ V	V_{BE}	<	1	V
Collector-emitter saturation voltage				
$I_C = 1$ A; $I_B = 100$ mA	V_{CEsat}	<	0,5	V
D.C. current gain				
$I_C = 5$ mA; $V_{CE} = 10$ V	h_{FE}	>	50	
$I_C = 500$ mA; $V_{CE} = 1$ V	h_{FE}		85 to 375	
$I_C = 1$ A; $V_{CE} = 1$ V	h_{FE}	>	60	
Collector capacitance at f = 450 kHz				
$I_E = I_e = 0$; $V_{CB} = 5$ V	C_c	typ.	27	pF
Cut-off frequency				
$I_C = 10$ mA; $V_{CE} = 5$ V	f_{hfe}	typ.	400	kHz
Transition frequency at f = 35 MHz				
$I_C = 10$ mA; $V_{CE} = 5$ V	f_T	typ.	60	MHz
D.C. current gain ratio of matched pair BC368/BC369				
$\|I_C\| = 500$ mA; $\|V_{CE}\| = 1$ V	h_{FE1}/h_{FE2}	<	1,4	

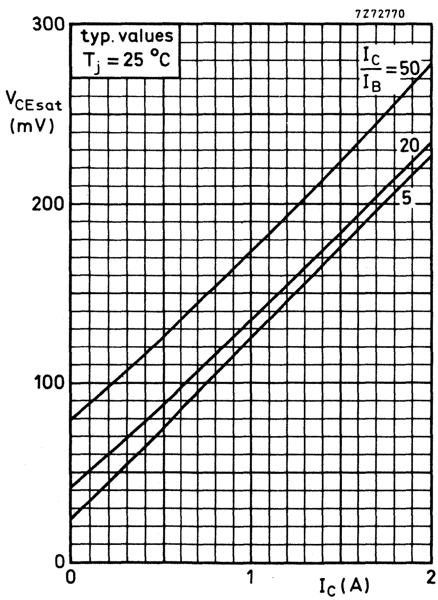

7Z72780
$Z_{th\ j-a}$ (°C/W)
10^4
10^3
10^2
10
1
$\delta = 1$
0,75
0,5
0,33
0,2
0,1
0,05
0,02
≤0,01
t_p
T
$\delta = \frac{t_p}{T}$
free in air
10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 1 10 10^2 10^3 t_p (s) 10^4

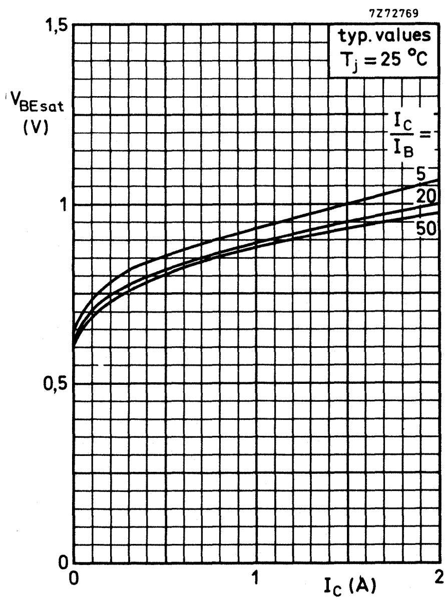

7Z72781
$Z_{th\ j-a}$ (°C/W)
10^4
10^3
10^2
10
1
$\delta = 1$
0,75
0,5
0,33
0,2
0,1
0,05
0,02
≤0,01
t_p
T
$\delta = \frac{t_p}{T}$
note 1 page 2
10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 1 10 10^2 10^3 t_p (s) 10^4

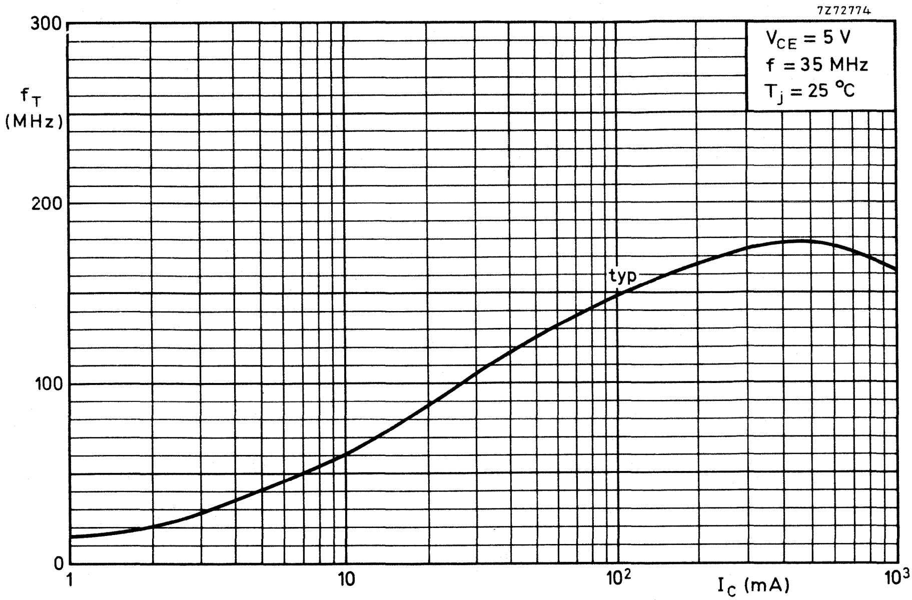

7Z72777
$V_{CE} = 1\ V$
$T_j = 25\ ^oC$
I_C (mA)
10^4
10^3
10^2
10
1
max I_B
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
10^3
I_B (mA)


7Z72772
$V_{CE} = 1\ V$
$T_j = 25\ ^oC$
h_{FE}
200
150
100
50
0
typ
1
10
10^2
10^3
10^4
I_C (mA)


7Z72778
V_{CE} = 1 V
T_j = 25 °C
I_C
(A)
typ
10^3
10^2
10
1
0,25
0,5
0,75
1
1,25
V_{BE} (V)


7Z72770
typ. values
T_j = 25 °C
V_{CEsat}
(mV)
$\frac{I_C}{I_B}$ = 50
20
5
300
200
100
0
0
1
2
I_C (A)


7Z72769
typ. values
T_j = 25 °C
V_{BEsat}
(V)
$\frac{I_C}{I_B}$ =
5
20
50
1,5
1
0,5
0
0
1
2
I_C (A)


7Z72774
V_{CE} = 5 V
f = 35 MHz
T_j = 25 °C
f_T (MHz)
300
200
100
0
1
10
10^2
10^3
I_C (mA)
typ

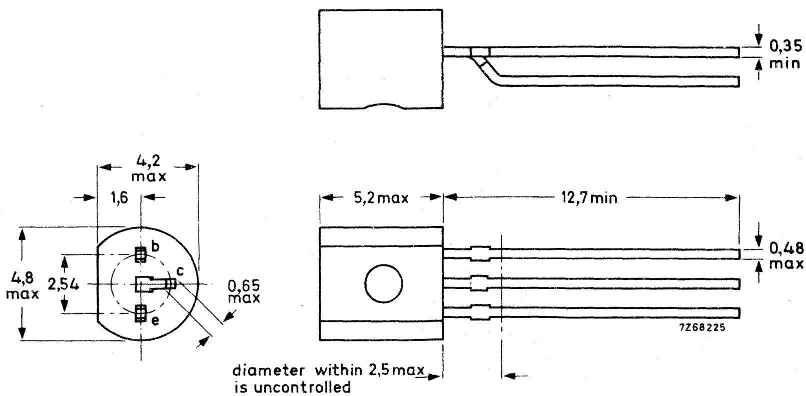
SILICON PLANAR EPITAXIAL TRANSISTOR

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 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 °C	P_{tot}	max.	1	W
Junction temperature	T_j	max.	150	°C
D.C. current gain $-I_C$ = 500 mA; $-V_{CE}$ = 1 V	h_{FE}		85 to 375	
Transition frequency $-I_C$ = 10 mA; $-V_{CE}$ = 5 V	f_T	typ.	60	MHz

MECHANICAL DATA Dimensions in mm

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 °C (in free air)	P_{tot}	max.	0,8	W
up to T_{amb} = 25 °C [1]	P_{tot}	max.	1	W

Temperatures

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

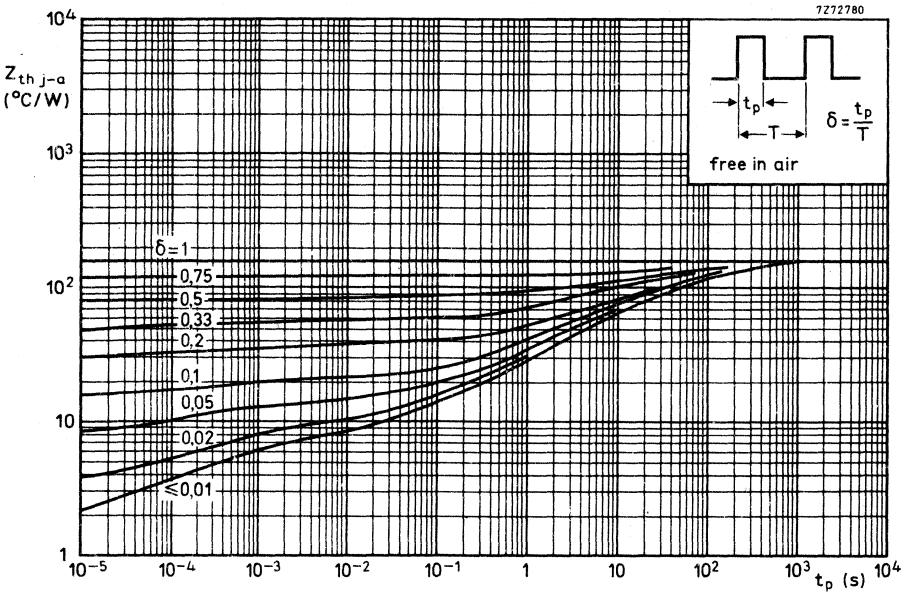
THERMAL RESISTANCE

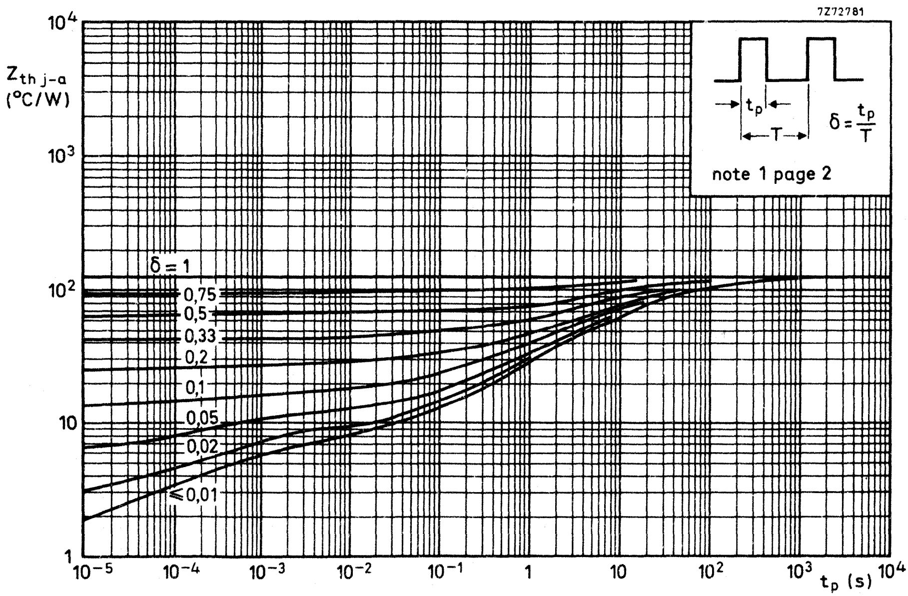
From junction to ambient in free air	$R_{th\ j-a}$	=	156	°C/W
From junction to ambient [1]	$R_{th\ j-a}$	=	125	°C/W
From junction to case	$R_{th\ j-c}$	=	60	°C/W

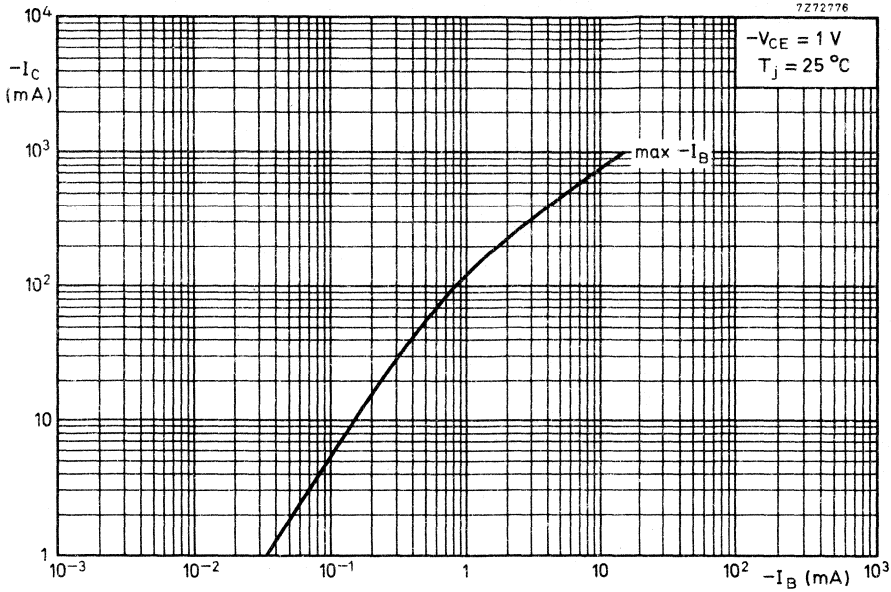
[1]) Transistor mounted on printed-circuit board, max. lead length 4 mm, mounting pad for collector lead min. 10 mm x 10 mm.

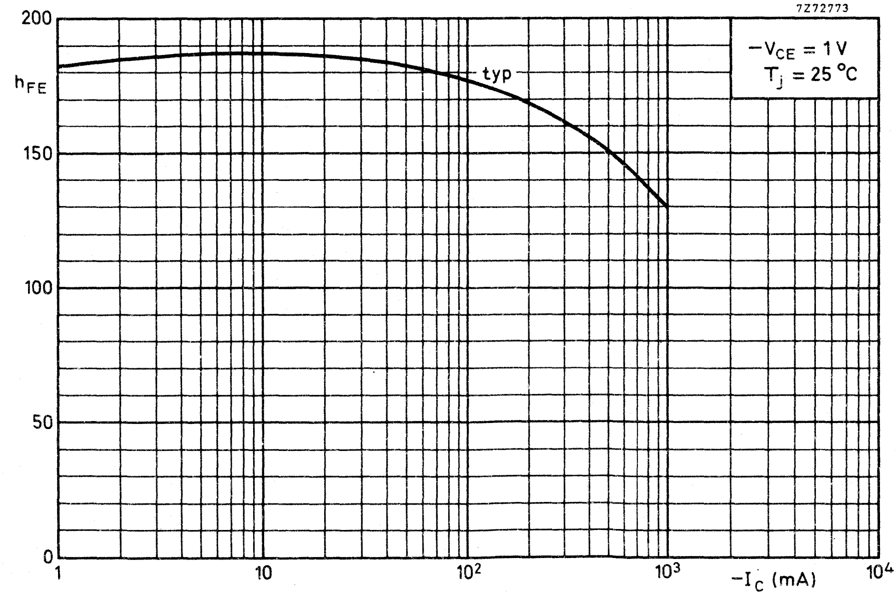
CHARACTERISTICS T_j = 25 °C unless otherwise specified

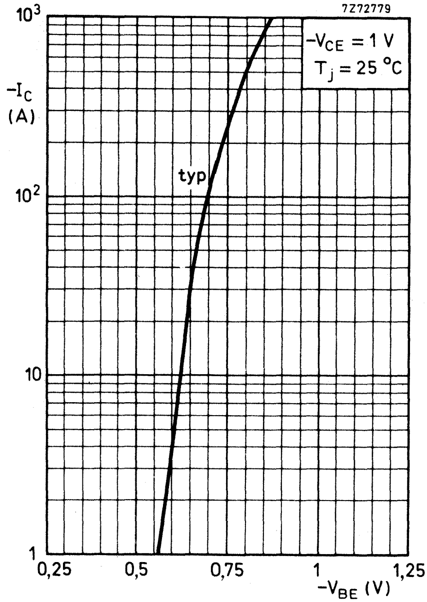
Collector cut-off current				
$I_E = 0$; $-V_{CB} = 25$ V	$-I_{CBO}$	<	10	μA
$I_E = 0$; $-V_{CB} = 25$ V; $T_j = 150$ °C	$-I_{CBO}$	<	1	mA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	10	μA
Base-emitter voltage				
$-I_C = 5$ mA; $-V_{CE} = 10$ V	$-V_{BE}$	typ.	0,62	V
$-I_C = 1$ A; $-V_{CE} = 1$ V	$-V_{BE}$	<	1	V
Collector-emitter saturation voltage				
$-I_C = 1$ A; $-I_B = 100$ mA	$-V_{CEsat}$	<	0,5	V
D.C. current gain				
$-I_C = 5$ mA; $-V_{CE} = 10$ V	h_{FE}	>	50	
$-I_C = 500$ mA; $-V_{CE} = 1$ V	h_{FE}		85 to 375	
$-I_C = 1$ A; $-V_{CE} = 1$ V	h_{FE}	>	60	
Collector capacitance at f = 450 kHz				
$I_E = I_e = 0$; $-V_{CB} = 5$ V	C_c	typ.	45	pF
Cut-off frequency				
$-I_C = 10$ mA: $-V_{CE} = 5$ V	f_{hfe}	typ.	350	kHz
Transition frequency at f = 35 MHz				
$-I_C = 10$ mA; $-V_{CE} = 5$ V	f_T	typ.	60	MHz
D.C. current gain ratio of matched pair BC368/BC369				
$\|I_C\| = 500$ mA; $\|V_{CE}\| = 1$ V	h_{FE1}/h_{FE2}	<	1,4	

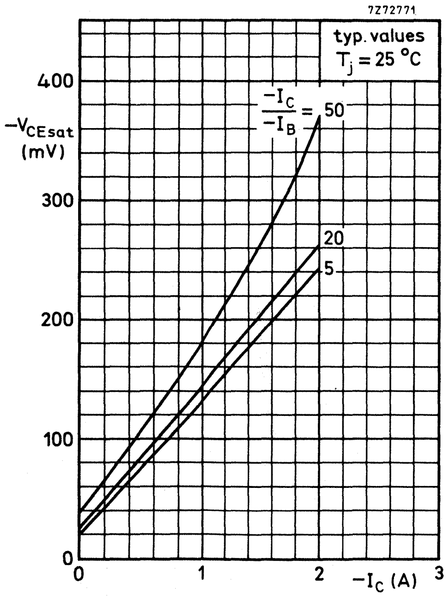

7Z72780
$Z_{th\ j-a}$ (°C/W)
10^4
10^3
10^2
10
1
10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 1 10 10^2 10^3 t_p (s) 10^4
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
≤0,01
t_p
T
$\delta = \frac{t_p}{T}$
free in air

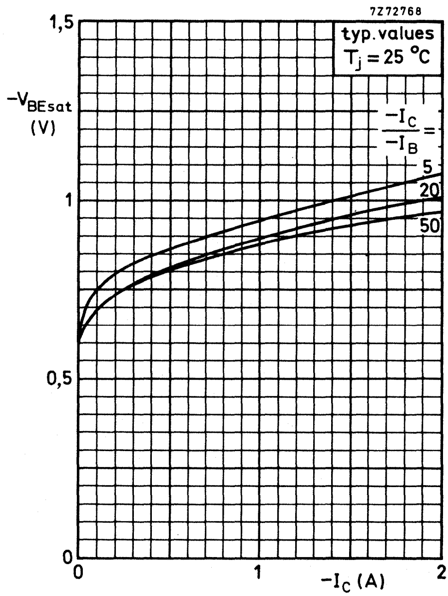

7Z72781
$Z_{th\ j-a}$ (°C/W)
10^4
10^3
10^2
10
1
10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 1 10 10^2 10^3 t_p (s) 10^4
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
≤0,01
t_p
T
$\delta = \frac{t_p}{T}$
note 1 page 2

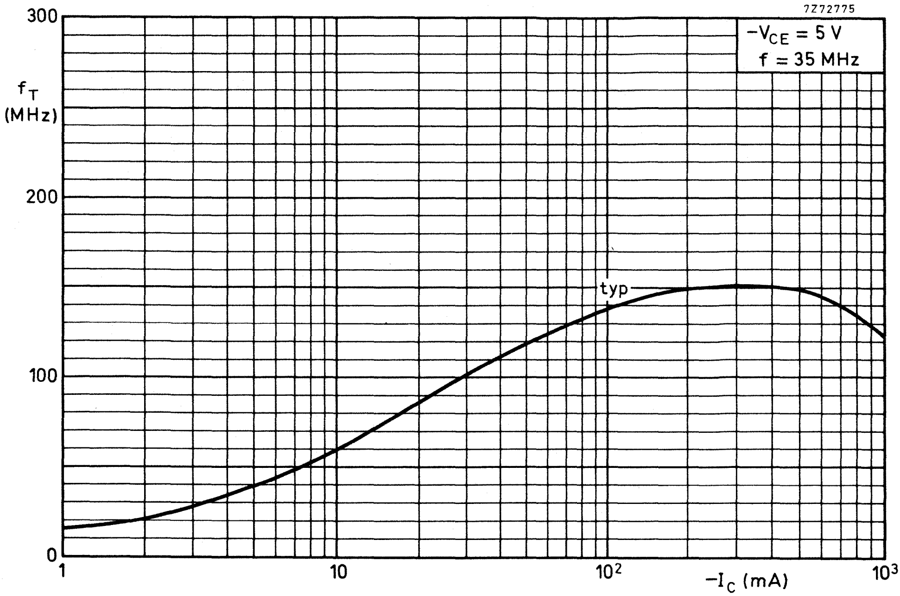

7Z72776
$-I_C$ (mA)
10^4
10^3
10^2
10
1
max $-I_B$
$-V_{CE}$ = 1 V
T_j = 25 °C
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
$-I_B$ (mA)
10^3


7Z72773
h_{FE}
200
150
100
50
0
typ
$-V_{CE}$ = 1 V
T_j = 25 °C
1
10
10^2
10^3
$-I_C$ (mA)
10^4


7Z72779
$-V_{CE} = 1$ V
$T_j = 25$ °C
$-I_C$ (A)
10^3
10^2
10
1
typ
0,25
0,5
0,75
1
1,25
$-V_{BE}$ (V)


7Z72771
typ. values
$T_j = 25$ °C
$-V_{CEsat}$ (mV)
400
300
200
100
0
$\frac{-I_C}{-I_B} =$ 50
20
5
0
1
2
3
$-I_C$ (A)


7Z72768
typ. values
$T_j = 25$ °C
$-V_{BEsat}$ (V)
1,5
1
0,5
0
$\frac{-I_C}{-I_B} =$
5
20
50
0
1
2
$-I_C$ (A)


7Z72775
$-V_{CE}$ = 5 V
f = 35 MHz
f_T
(MHz)
300
200
100
0
1
10
10^2
10^3
$-I_C$ (mA)
typ

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.

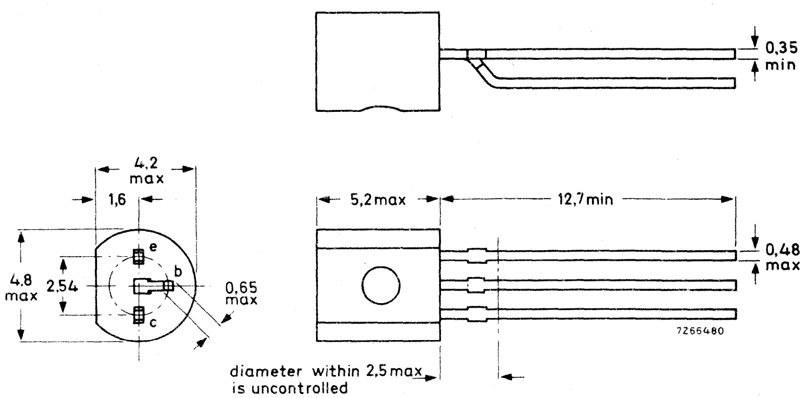
QUICK REFERENCE DATA

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 °C	P_{tot}	max.	800	mW
Junction temperature	T_j	max.	150	°C
D.C. current gain I_C = 150 mA; V_{CE} = 1 V	h_{FE}		60 to 340	
Transition frequency at f = 35 MHz I_C = 150 mA; V_{CE} = 1 V	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 °C (in free air)	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	$R_{th\ j-a}$	=	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 °C unless otherwise specified

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

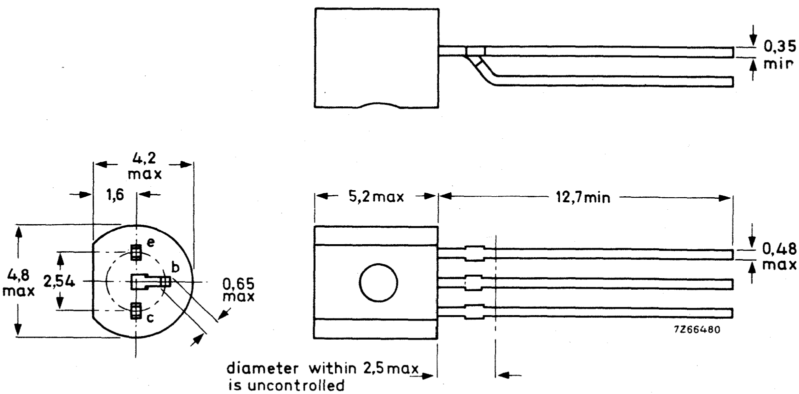
QUICK REFERENCE DATA

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 °C	P_{tot}	max.	800	mW
Junction temperature	T_j	max.	150	°C
D.C. current gain $-I_C$ = 150 mA; $-V_{CE}$ = 1 V	h_{FE}		60 to 340	
Transition frequency at f = 35 MHz $-I_C$ = 150 mA; $-V_{CE}$ = 1 V	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 °C (in free air)	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	$R_{th\ j\text{-}a}$	=	200	K/W
From junction to ambient *	$R_{th\ j\text{-}a}$	=	156	K/W
From junction to case	$R_{th\ j\text{-}c}$		95	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $-V_{CB}$ = 20 V	$-I_{CBO}$	<	100	nA
$I_E = 0$; $-V_{CB}$ = 20 V; T_j = 150 °C	$-I_{CBO}$	<	5	μA
Emitter cut-off current				
$I_C = 0$; $-V_{EB}$ = 5 V	$-I_{EBO}$	<	10	μA
Base-emitter voltage **				
$-I_C$ = 5 mA; $-V_{CE}$ = 10 V	$-V_{BE}$	typ.	650	mV
$-I_C$ = 700 mA; $-V_{CE}$ = 1 V	$-V_{BE}$	<	1000	mV
Collector-emitter saturation voltage				
$-I_C$ = 700 mA; $-I_B$ = 70 mA	$-V_{CEsat}$	typ.	280	mV
		<	500	mV
D.C. current gain				
$-I_C$ = 5 mA; $-V_{CE}$ = 10 V	h_{FE}	>	55	
$-I_C$ = 150 mA; $-V_{CE}$ = 1 V	h_{FE}		60 to 340	
$-I_C$ = 700 mA; $-V_{CE}$ = 1 V	h_{FE}	>	35	
Transition frequency at f = 35 MHz				
$-I_C$ = 150 mA; $-V_{CE}$ = 1 V	f_T	typ.	150	MHz
D.C. current gain ratio of matched pair BC375/BC376				
$\|I_C\|$ = 150 mA; $\|V_{CE}\|$ = 1 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 TRANSISTORS

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

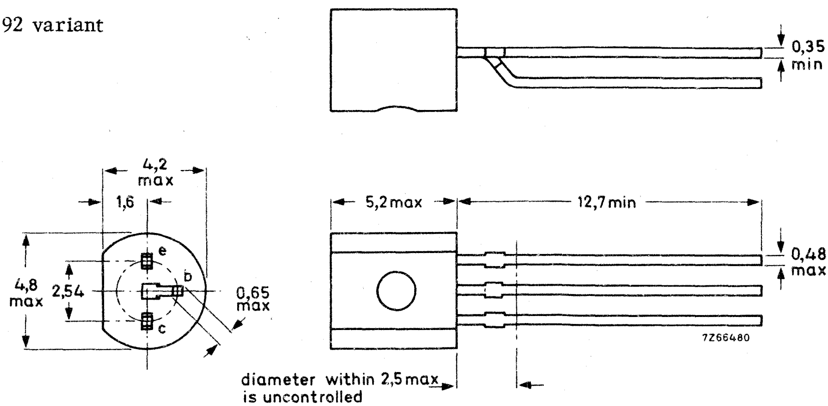
QUICK REFERENCE DATA

			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 °C	P_{tot}	max.	500	500	500	mW
Junction temperature	T_j	max.	150	150	150	°C
Small-signal current gain I_C = 2 mA; V_{CE} = 5 V; f = 1 kHz	h_{fe}	>	125	125	125	
		<	500	900	900	
Transition frequency I_C = 10 mA; V_{CE} = 5 V	f_T	typ.	300	300	300	MHz
Noise figure at R_S = 2 kΩ; I_C = 200 μA; V_{CE} = 5 V; f = 1 kHz; B = 200 Hz	F	typ.	2	2	2	dB

MECHANICAL DATA

Dimensions in mm

TO-92 variant



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

			BC546	BC547	BC548	
Voltage						
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

Current

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 °C	P_{tot}	max.	500	mW

Temperature

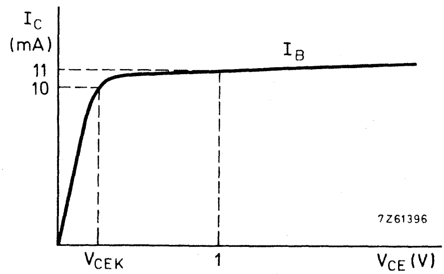
Storage temperature	T_{stg}		−65 to +150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0,25	°C/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0,15	°C/mW

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

Collector cut-off current				
$I_E = 0;\ V_{CB} = 30\ V$	I_{CBO}	<	15	nA
$I_E = 0;\ V_{CB} = 30\ V;\ T_j = 150\ ^oC$	I_{CBO}	<	5	μA
Base-emitter voltage [1]				
$I_C = 2\ mA;\ V_{CE} = 5\ V$	V_{BE}	typ.	660	mV
			580 to 700	mV
$I_C = 10\ mA;\ V_{CE} = 5\ V$	V_{BE}	<	770	mV
Saturation voltage [2]				
$I_C = 10\ mA;\ I_B = 0.5\ mA$	V_{CEsat}	typ.	90	mV
		<	250	mV
	V_{BEsat}	typ.	700	mV
$I_C = 100\ mA;\ I_B = 5\ mA$	V_{CEsat}	typ.	200	mV
		<	600	mV
	V_{BEsat}	typ.	900	mV
Knee voltage				
$I_C = 10\ mA;\ I_B$ = value for which $I_C = 11\ mA$ at $V_{CE} = 1\ V$	V_{CEK}	typ.	300	mV
		<	600	mV



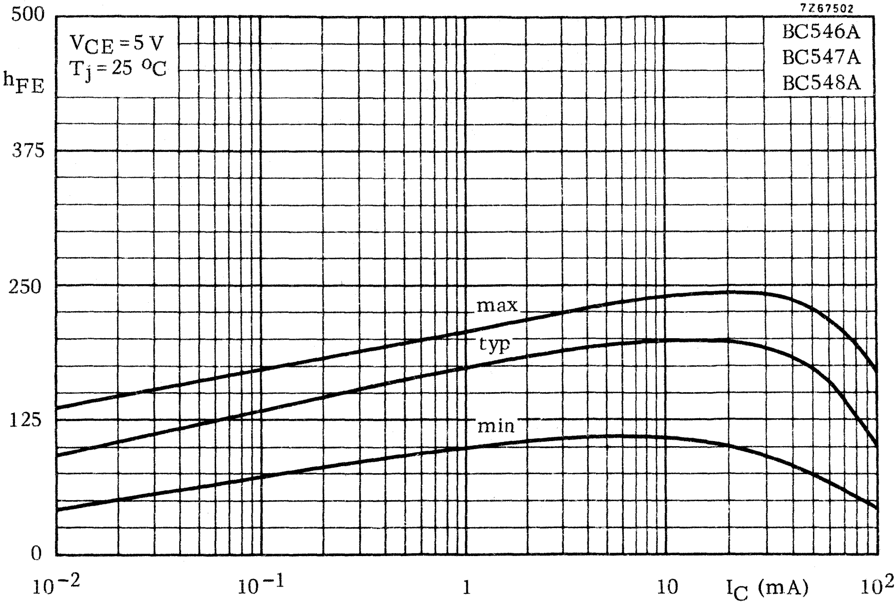
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0;\ V_{CB} = 10\ V$	C_c	typ.	2,5	pF
		<	4,5	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0;\ V_{EB} = 0,5\ V$	C_e	typ.	9	pF
Transition frequency at f = 35 MHz				
$I_C = 10\ mA;\ V_{CE} = 5\ V$	f_T	typ.	300	MHz

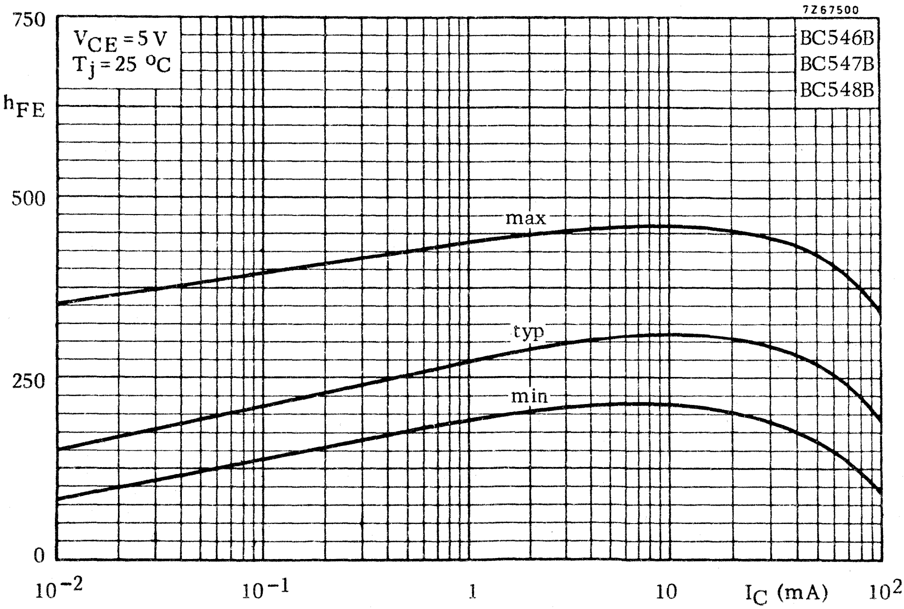
1) V_{BE} decreases by about 2 mV/^oC with increasing temperature.
2) V_{BEsat} decreases by about 1,7 mV/^oC with increasing temperature.

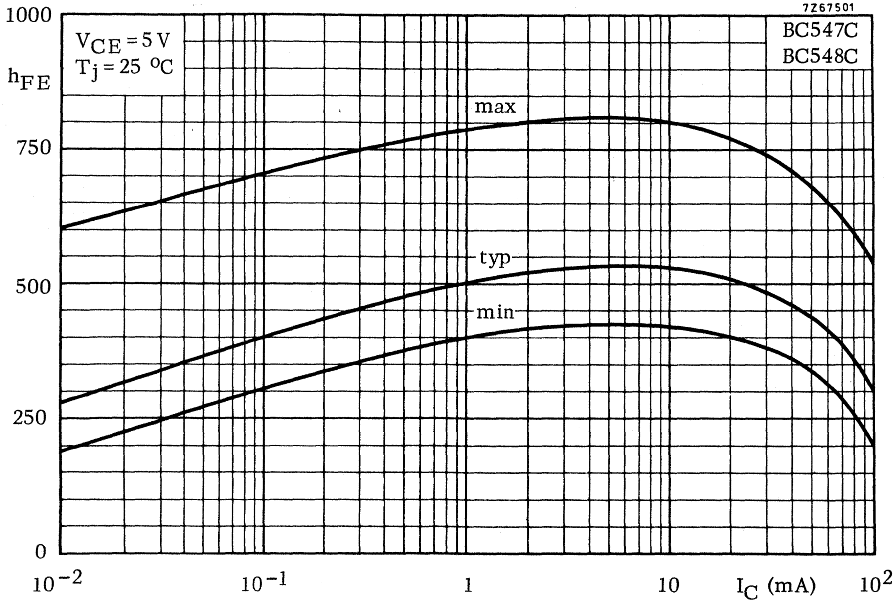
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

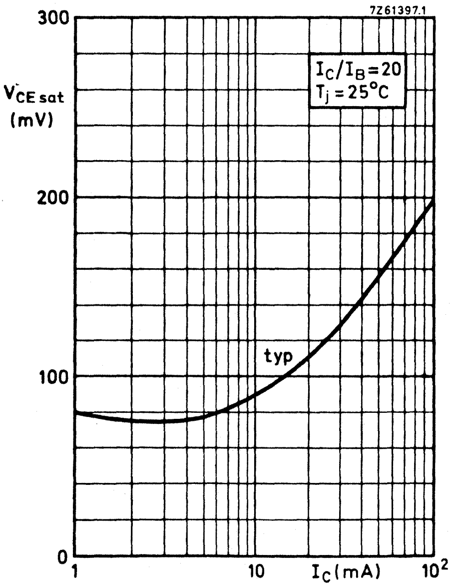
			BC546	BC547	BC548	
Small signal current gain at f = 1 kHz						
I_C = 2 mA; V_{CE} = 5 V	h_{fe}	>	125	125	125	
		<	500	900	900	
Noise figure at R_S = 2 kΩ						
I_C = 200 μA; V_{CE} = 5 V						
f = 1 kHz; B = 200 Hz	F	typ.	2	2	2	dB
		<	10	10	10	dB

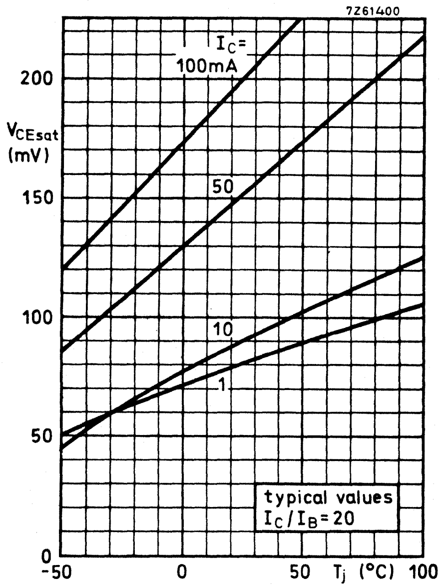
			BC546A BC547A BC548A	BC546B BC547B BC548B	BC547C BC548C	
D.C. current gain						
I_C = 10 μA; V_{CE} = 5 V	h_{FE}	typ.	90	150	270	
		>	110	200	420	
I_C = 2 mA; V_{CE} = 5 V	h_{FE}	typ.	180	290	520	
		<	220	450	800	
h parameters at f = 1 kHz (common emitter)						
I_C = 2 mA; V_{CE} = 5 V						
		>	1,6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

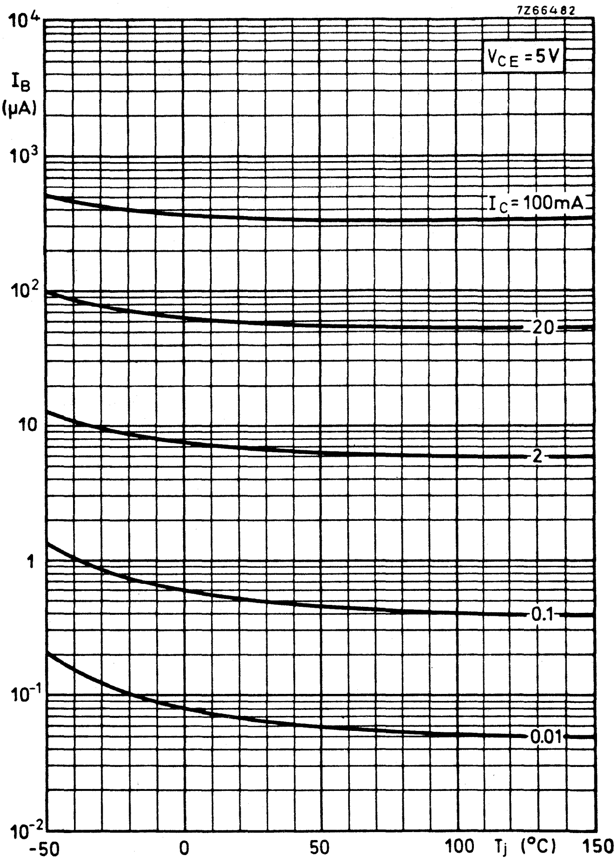

7Z67502
$V_{CE} = 5$ V
$T_j = 25$ °C
h_{FE}
BC546A
BC547A
BC548A
500
375
250
125
0
max
typ
min
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2


7Z67500
$V_{CE} = 5$ V
$T_j = 25$ °C
h_{FE}
BC546B
BC547B
BC548B
750
500
250
0
max
typ
min
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2

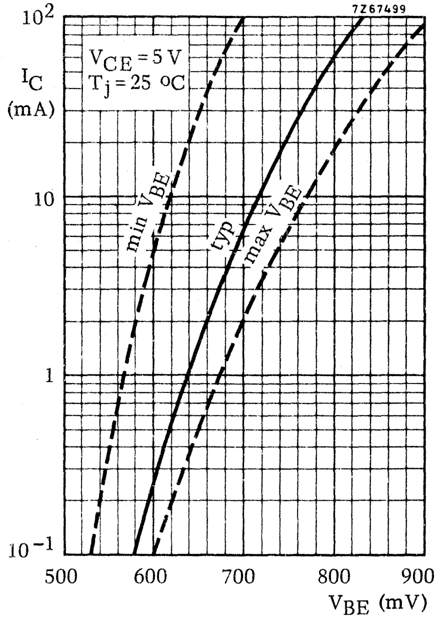

7Z67501
BC547C
BC548C
$V_{CE} = 5$ V
$T_j = 25$ °C
h_{FE}
1000
750
500
250
0
max
typ
min
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2

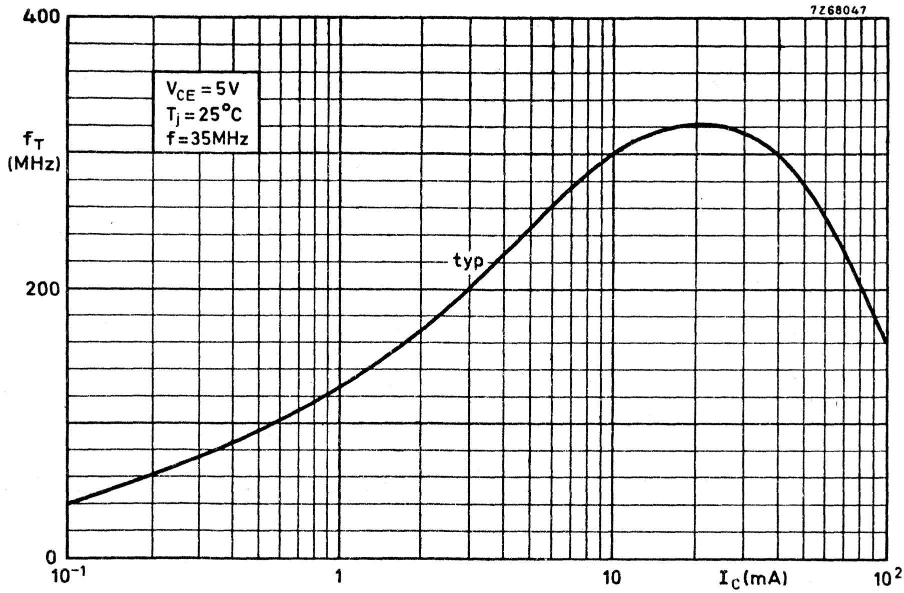

7Z61397.1
$I_C/I_B = 20$
$T_j = 25$°C
V_{CEsat} (mV)
300
200
100
0
typ
1
10
I_C(mA)
10^2

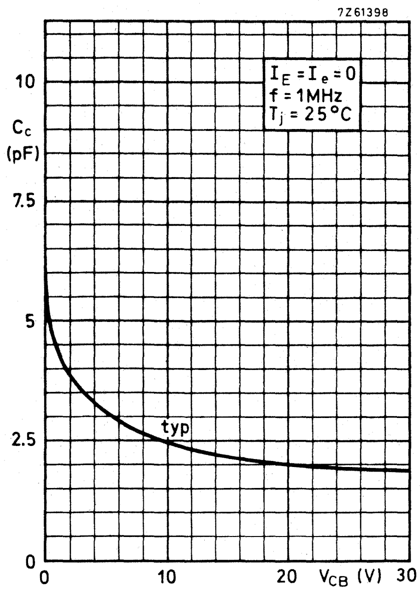

7Z61400
I_C = 100mA
50
10
1
V_{CEsat} (mV)
200
150
100
50
0
typical values
$I_C/I_B = 20$
-50
0
50
T_j (°C)
100

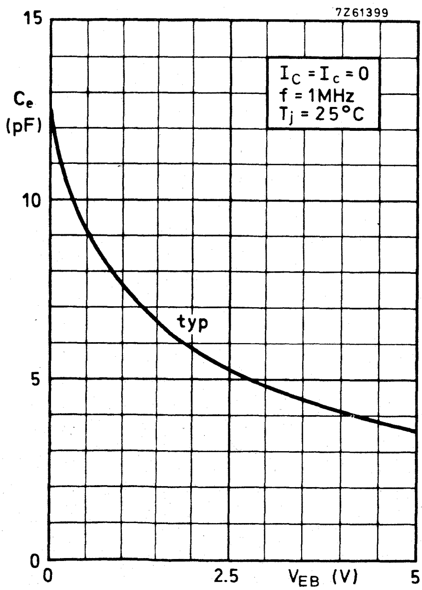


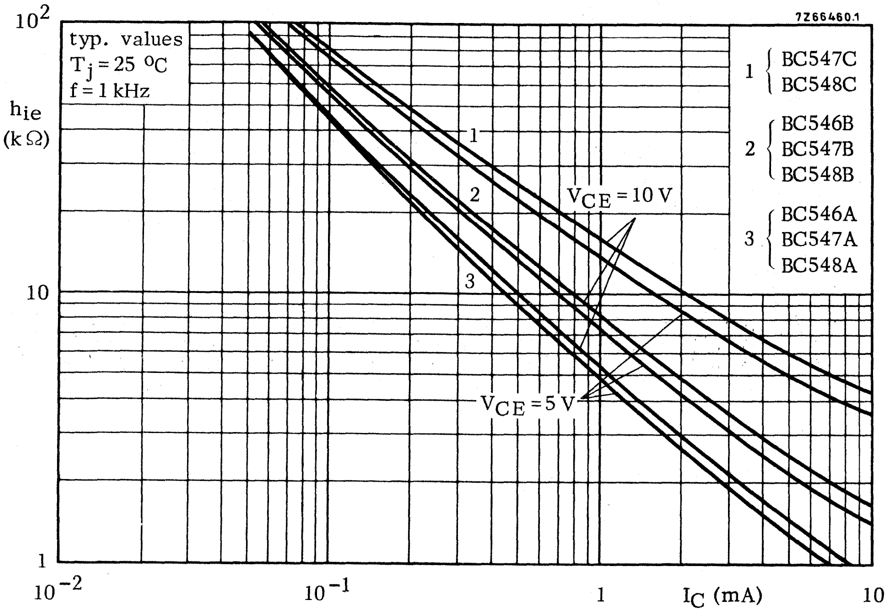
Typical behaviour of base current versus junction temperature

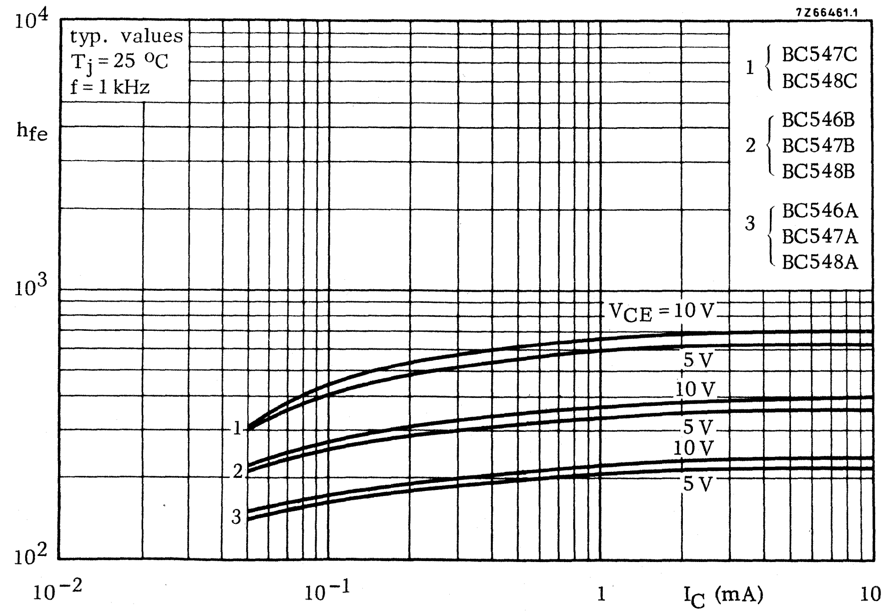

7Z67499
10^2
10
1
10^{-1}
I_C (mA)
$V_{CE} = 5\ V$
$T_j = 25\ ^oC$
min V_{BE}
typ
max V_{BE}
500
600
700
800
900
V_{BE} (mV)

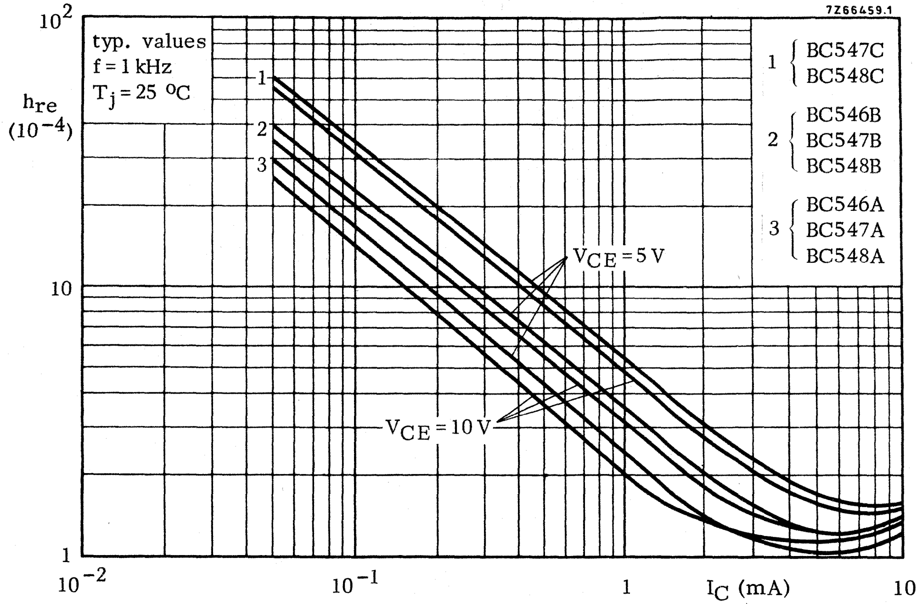

7Z68047
400
200
0
f_T (MHz)
$V_{CE} = 5V$
$T_j = 25°C$
f = 35MHz
typ
10^{-1}
1
10
I_C(mA)
10^2

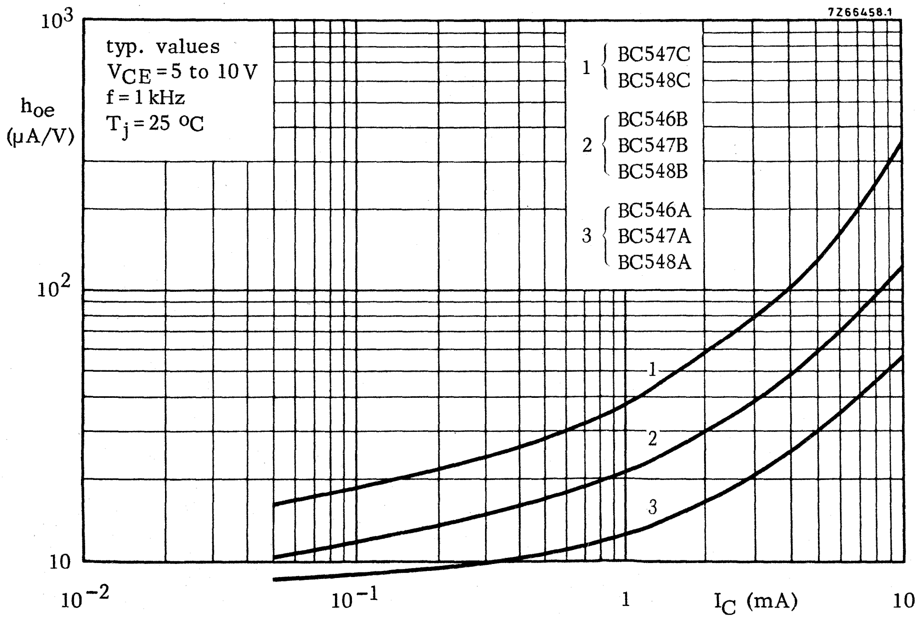

7Z61398
$I_E = I_e = 0$
f = 1MHz
T_j = 25°C
C_c
(pF)
10
7.5
5
2.5
0
typ
0
10
20
V_{CB} (V)
30


7Z61399
$I_C = I_c = 0$
f = 1MHz
T_j = 25°C
C_e
(pF)
15
10
5
0
typ
0
2.5
V_{EB} (V)
5


7Z66460.1
typ. values
Tj = 25 °C
f = 1 kHz
hie
(kΩ)
10^2
10
1
10^-2
10^-1
1
IC (mA)
10
1 { BC547C BC548C
2 { BC546B BC547B BC548B
3 { BC546A BC547A BC548A
1
2
3
VCE = 10 V
VCE = 5 V


7Z66461.1
typ. values
Tj = 25 °C
f = 1 kHz
hfe
10^4
10^3
10^2
10^-2
10^-1
1
IC (mA)
10
1 { BC547C BC548C
2 { BC546B BC547B BC548B
3 { BC546A BC547A BC548A
VCE = 10 V
5 V
10 V
5 V
10 V
5 V
1
2
3


7Z66459.1
typ. values
f = 1 kHz
Tj = 25 °C
hre
(10^-4)
1 BC547C BC548C
2 BC546B BC547B BC548B
3 BC546A BC547A BC548A
VCE = 5 V
VCE = 10 V
1
2
3
10^2
10
1
10^-2
10^-1
1
IC (mA)
10


7Z66458.1
typ. values
VCE = 5 to 10 V
f = 1 kHz
Tj = 25 °C
hoe
(μA/V)
1 BC547C BC548C
2 BC546B BC547B BC548B
3 BC546A BC547A BC548A
1
2
3
10^3
10^2
10
10^-2
10^-1
1
IC (mA)
10

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.

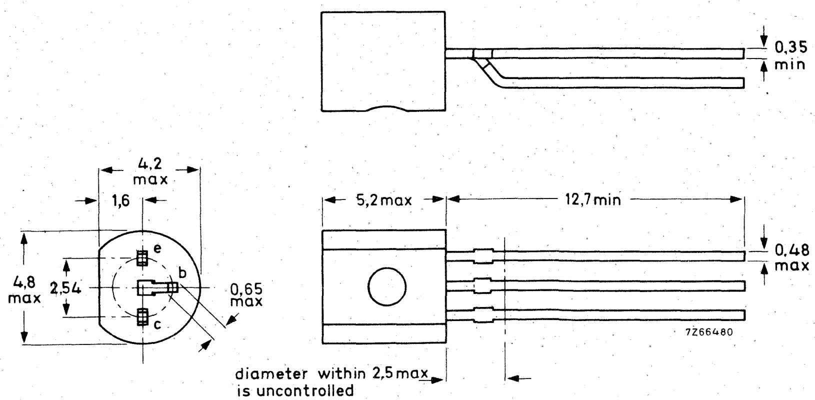
QUICK REFERENCE DATA

			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 °C	P_{tot}	max	500	500	mW
Junction temperature	T_j	max	150	150	°C
Small-signal current gain I_C = 2 mA; V_{CE} = 5 V; f = 1 kHz	h_{fe}	> <	240 900	240 900	
Transition frequency I_C = 10 mA; V_{CE} = 5 V	f_T	typ	300	300	MHz
Noise figure at R_S = 2 kΩ I_C = 200 μA; V_{CE} = 5 V f = 30 Hz to 15 kHz	F	typ <	1,4 4	1,4 3	dB dB
f = 1 kHz; B = 200 Hz	F	typ	1,2	1	dB
f = 10 Hz to 50 Hz (equivalent noise voltage)	V_n	<	–	0,135	μV

MECHANICAL DATA

Dimensions in mm

TO-92 variant



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

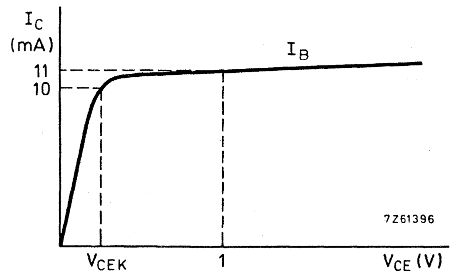
			BC549	BC550	
<u>Voltage</u>					
Collector-base voltage (open emitter)	V_{CBO}	max.	30	50	V
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	30	50	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	45	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	V
<u>Current</u>					
Collector current (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 °C	P_{tot}	max.		500	mW
<u>Temperature</u>					
Storage temperature	T_{stg}			−65 to +150	°C
Junction temperature	T_j	max.		150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0,25	°C/mW
From junction to case	$R_{th\ j-c}$	=	0,15	°C/mW

CHARACTERISTICS Tj = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 30$ V	I_{CBO}	<	15	nA
$I_E = 0$; $V_{CB} = 30$ V; $T_j = 150$ °C	I_{CBO}	<	5	µA
Base emitter voltage				
$I_C = 2$ mA; $V_{CE} = 5$ V	V_{BE}	typ.	660	mV
			580 to 700	mV
$I_C = 10$ mA; $V_{CE} = 5$ V	V_{BE}	<	770	mV
Saturation voltages 2)				
$I_C = 10$ mA; $I_B = 0,5$ mA	V_{CEsat}	typ.	90	mV
		<	250	mV
	V_{BEsat}	typ.	700	mV
$I_C = 100$ mA; $I_B = 5$ mA	V_{CEsat}	typ.	200	mV
		<	600	mV
	V_{BEsat}	typ.	900	mV
Knee voltage				
$I_C = 10$ mA; I_B = value for which $I_C = 11$ mA at $V_{CE} = 1$ V	V_{CEK}	typ.	300	mV
		<	600	mV



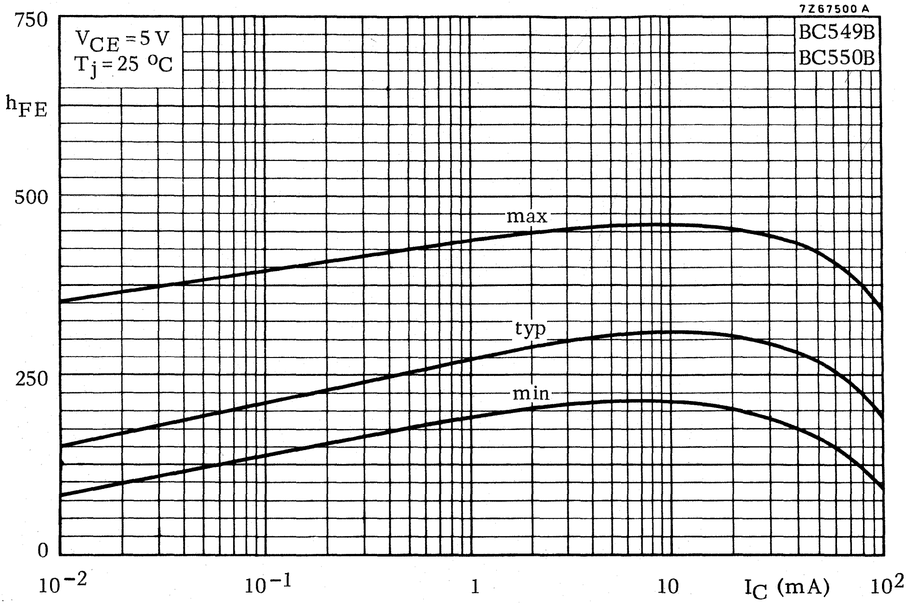
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	typ.	2,5	pF
		<	4,5	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $V_{EB} = 0,5$ V	C_e	typ.	9	pF
Transition frequency at f = 35 MHz				
$I_C = 10$ mA; $V_{CE} = 5$ V	f_T	typ.	300	MHz

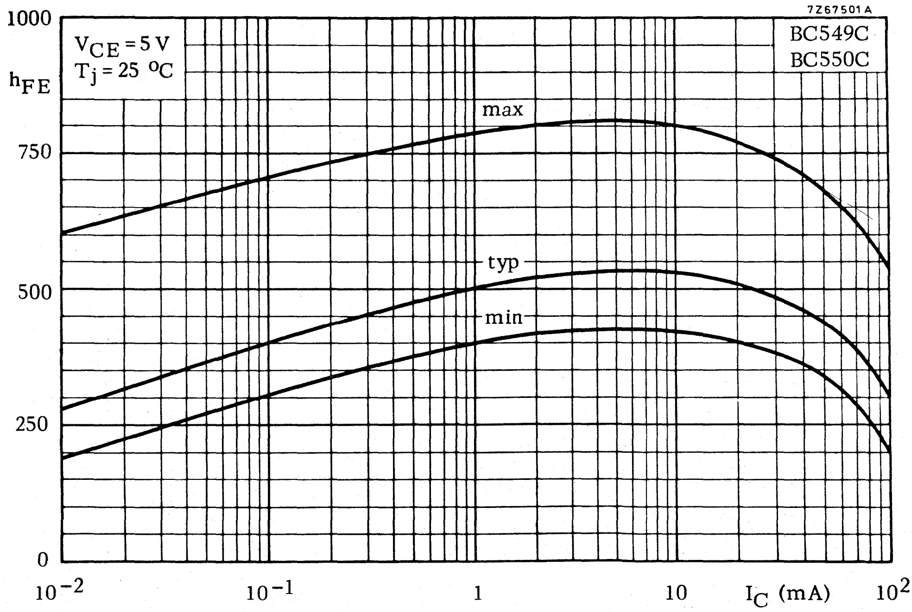
1) V_{BE} decreases by about 2 mV/°C with increasing temperature.
2) V_{BEsat} decreases by about 1,7 mV/°C with increasing temperature.

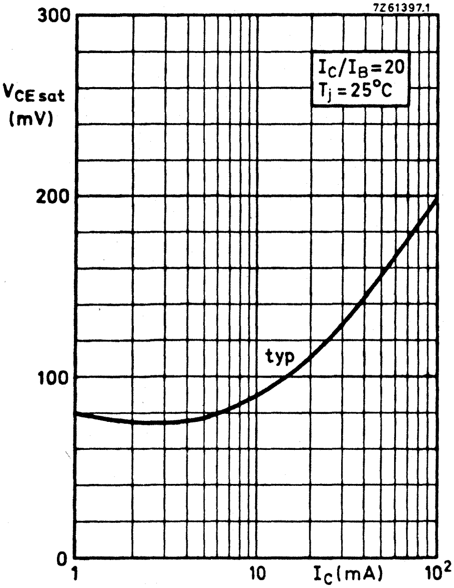
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

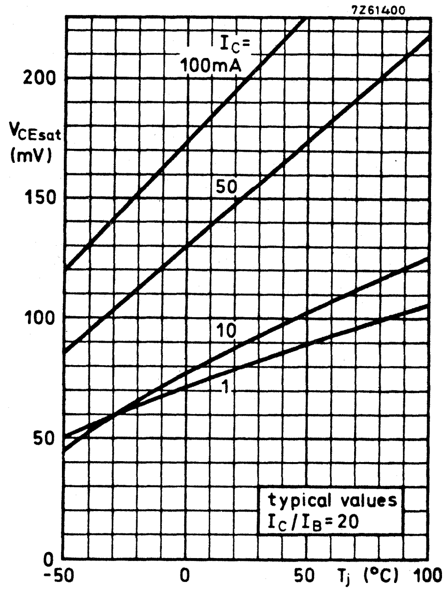
			BC549	BC550	
Small signal current gain at f = 1 kHz					
I_C = 2 mA; V_{CE} = 5 V	h_{fe}	>	240	240	
		<	900	900	
Noise figure at R_S = 2 kΩ					
I_C = 200 μA; V_{CE} = 5 V					
f = 30 Hz to 15 kHz	F	typ.	1,4	1,4	dB
		<	4	3	dB
f = 1 kHz; B = 200 Hz	F	typ.	1,2	1	dB
		<	4	4	dB
Equivalent noise voltage at R_S = 2 kΩ					
I_C = 200 μA; V_{CE} = 5 V					
f = 10 Hz to 50 Hz; T_{amb} = 25 °C	V_n	max.	-	0,135	μV

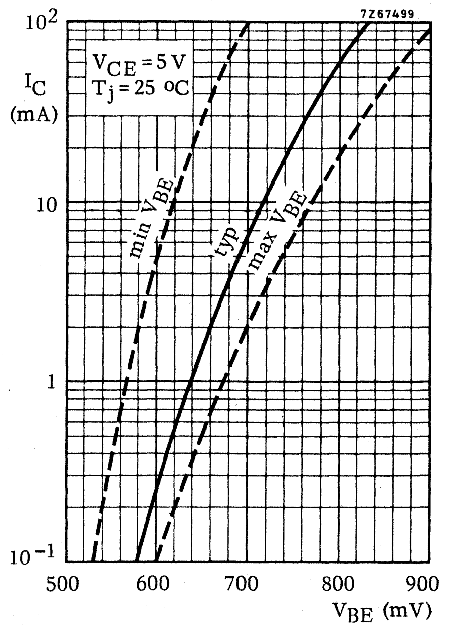
			BC549B BC550B	BC549C BC550C	
D.C. current gain					
I_C = 10 μA; V_{CE} = 5 V	h_{FE}	typ.	150	270	
		>	200	420	
I_C = 2 mA; V_{CE} = 5 V	h_{FE}	typ.	290	520	
		<	450	800	
h parameters at f = 1 kHz (common emitter)					
I_C = 2 mA; V_{CE} = 5 V					
		>	3,2	6	kΩ
Input impedance	h_{ie}	typ.	4,5	8,7	kΩ
		<	8,5	15	kΩ
Reverse voltage transfer ratio	h_{re}	typ.	2	3	10^{-4}
		>	240	450	
Small signal current gain	h_{fe}	typ.	330	600	
		<	500	900	
Output admittance	h_{oe}	typ.	30	60	μA/V
		<	60	110	μA/V

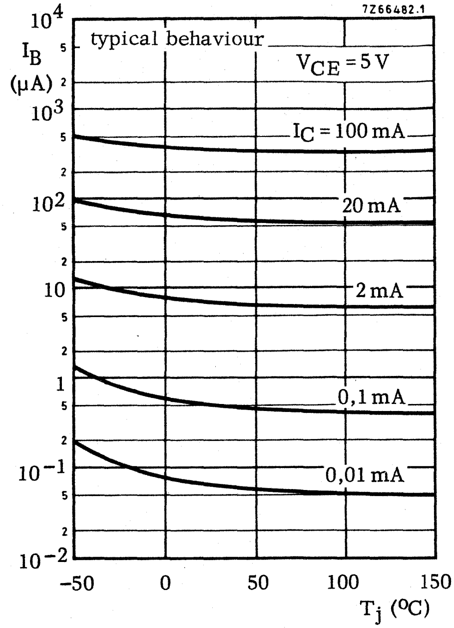

7Z67500 A
V_{CE} = 5 V
T_j = 25 °C
BC549B
BC550B
h_{FE}
750
500
250
0
max
typ
min
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2

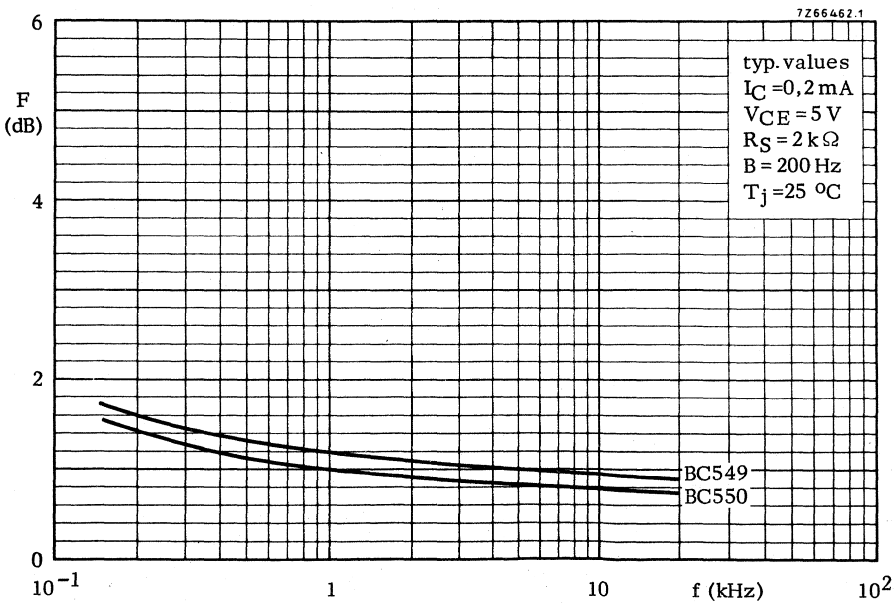

7Z67501 A
V_{CE} = 5 V
T_j = 25 °C
BC549C
BC550C
h_{FE}
1000
750
500
250
0
max
typ
min
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2

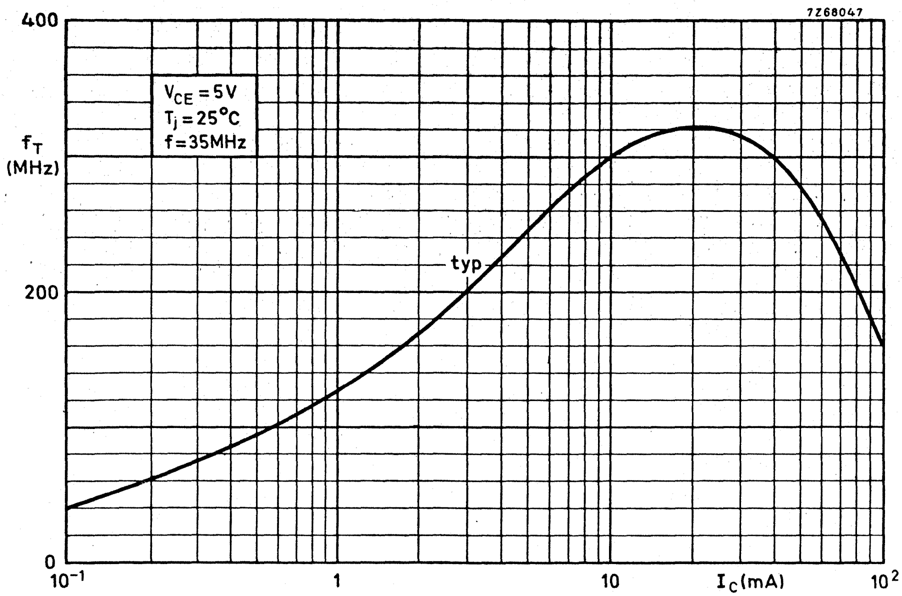

7Z61397.1
300
$V_{CE\,sat}$
(mV)
200
100
0
$I_C/I_B = 20$
$T_j = 25\,^{\circ}C$
typ
1
10
I_C (mA)
10^2

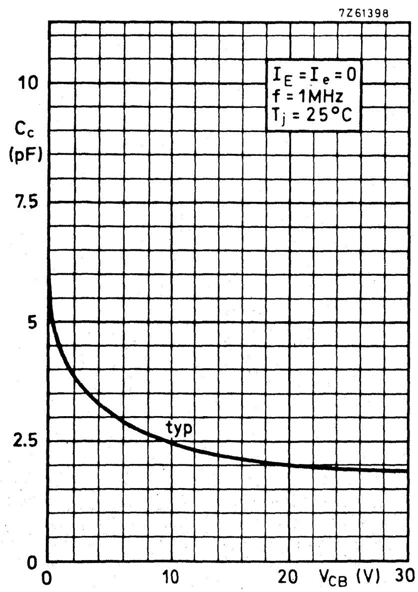

7Z61400
V_{CEsat}
(mV)
200
150
100
50
0
$I_C =$
100mA
50
10
1
typical values
$I_C/I_B = 20$
-50
0
50
T_j (°C)
100

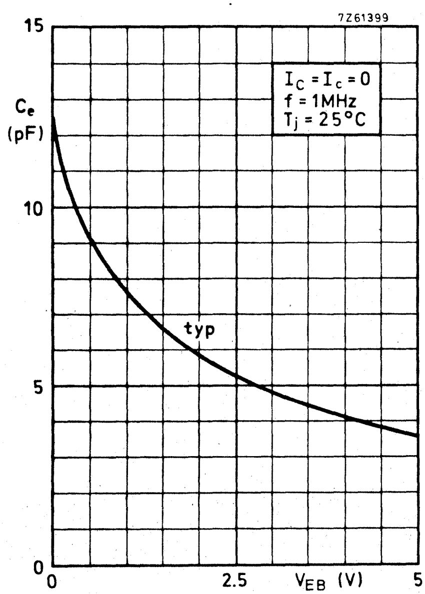

7Z67499
10^2
I_C
(mA)
10
1
10^{-1}
$V_{CE} = 5$ V
$T_j = 25$ °C
min V_{BE}
typ
max V_{BE}
500
600
700
800
900
V_{BE} (mV)

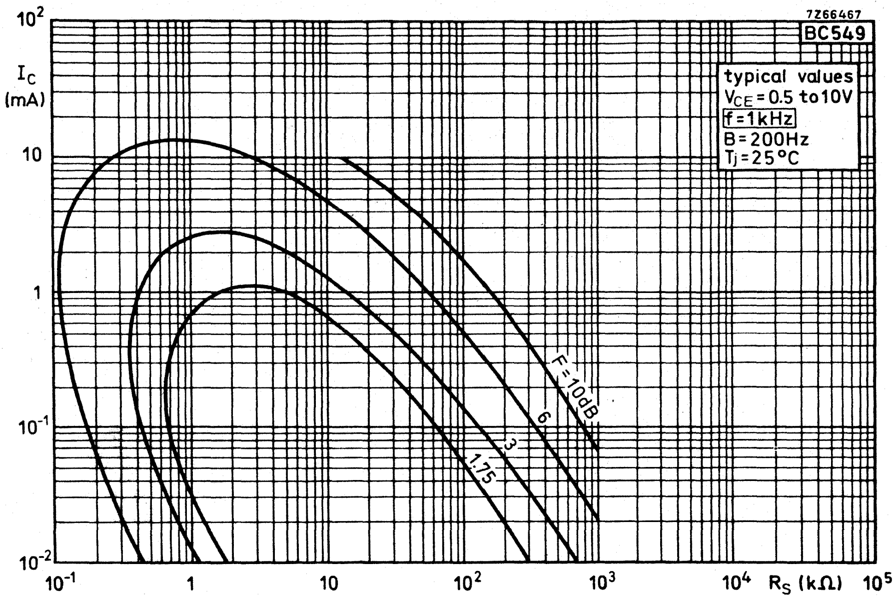

7Z66482.1
typical behaviour
I_B (μA)
$V_{CE} = 5$ V
$I_C = 100$ mA
20 mA
2 mA
0,1 mA
0,01 mA
T_j (°C)


7Z66462.1
F (dB)
typ. values
$I_C = 0,2$ mA
$V_{CE} = 5$ V
$R_S = 2$ kΩ
B = 200 Hz
$T_j = 25$ °C
BC549
BC550
f (kHz)

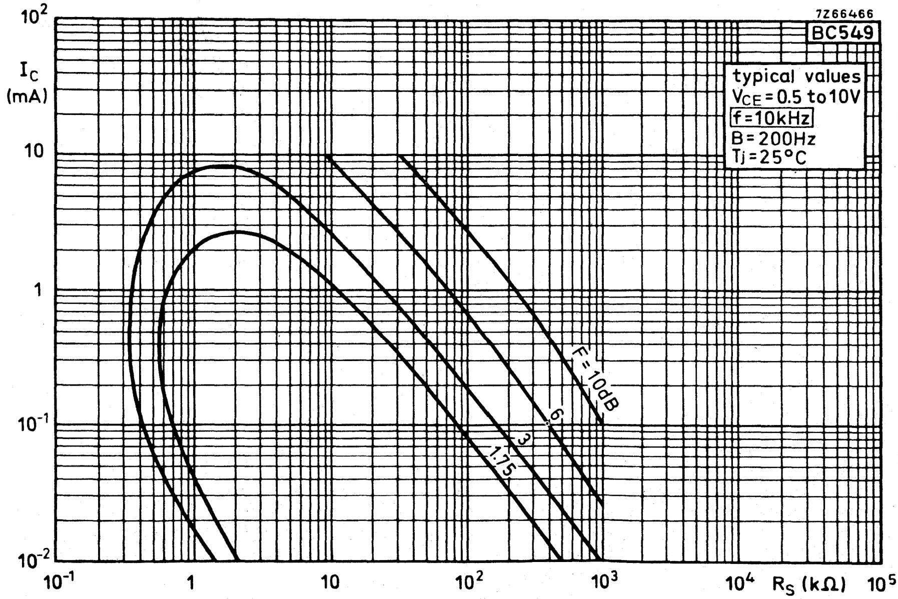

7Z68047
400
200
0
f_T (MHz)
V_{CE} = 5V
T_j = 25°C
f = 35MHz
typ
10^{-1}
1
10
I_C (mA)
10^2


7Z61398
10
7.5
5
2.5
0
C_c (pF)
$I_E = I_e = 0$
f = 1MHz
T_j = 25°C
typ
0
10
20
V_{CB} (V)
30

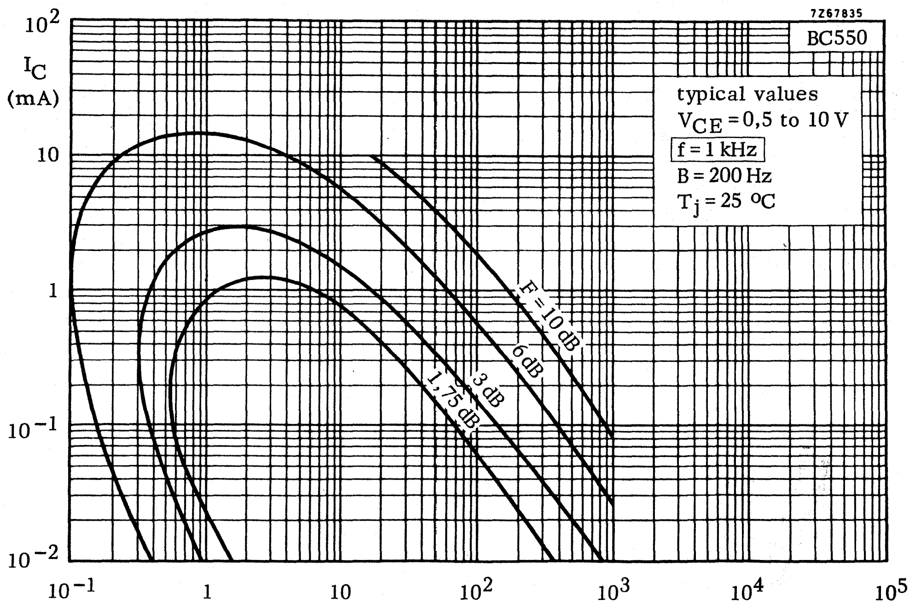

7Z61399
15
10
5
0
C_e (pF)
$I_C = I_c = 0$
f = 1MHz
T_j = 25°C
typ
0
2.5
V_{EB} (V)
5



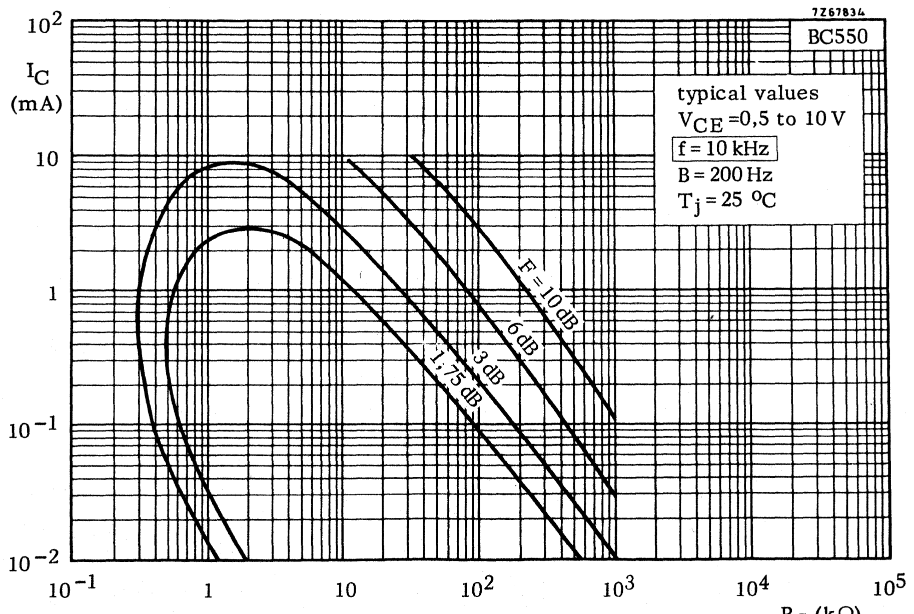
Curves of constant noise figure



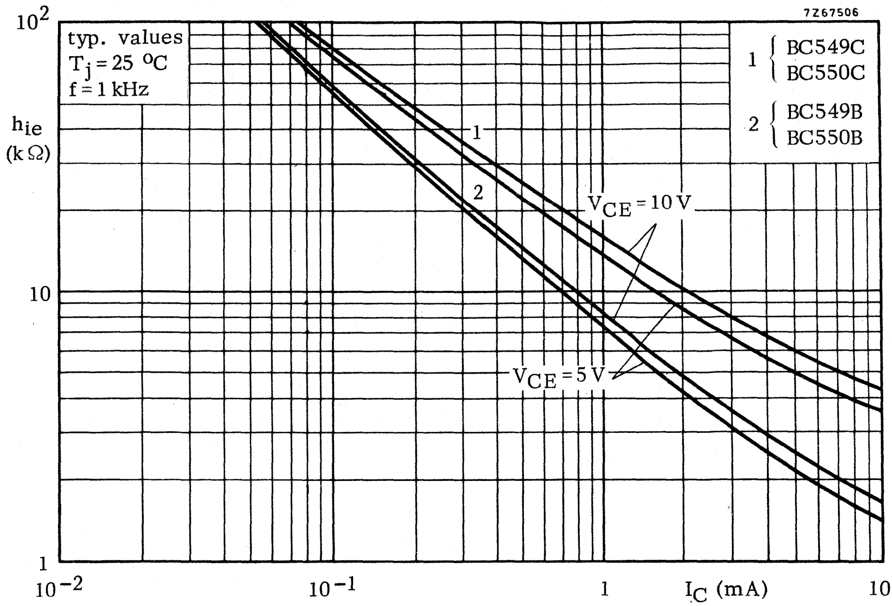
Curves of constant noise figure

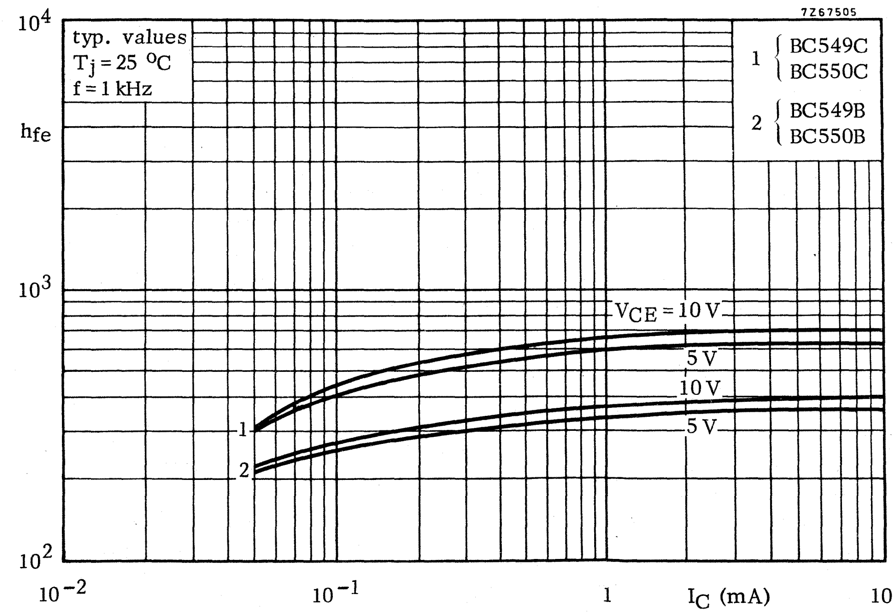


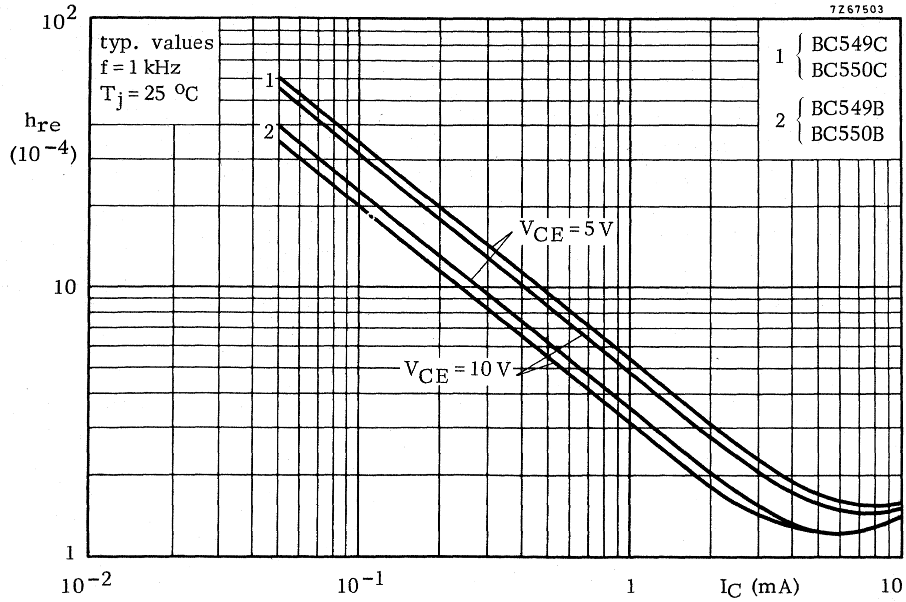
Curves of constant noise figure

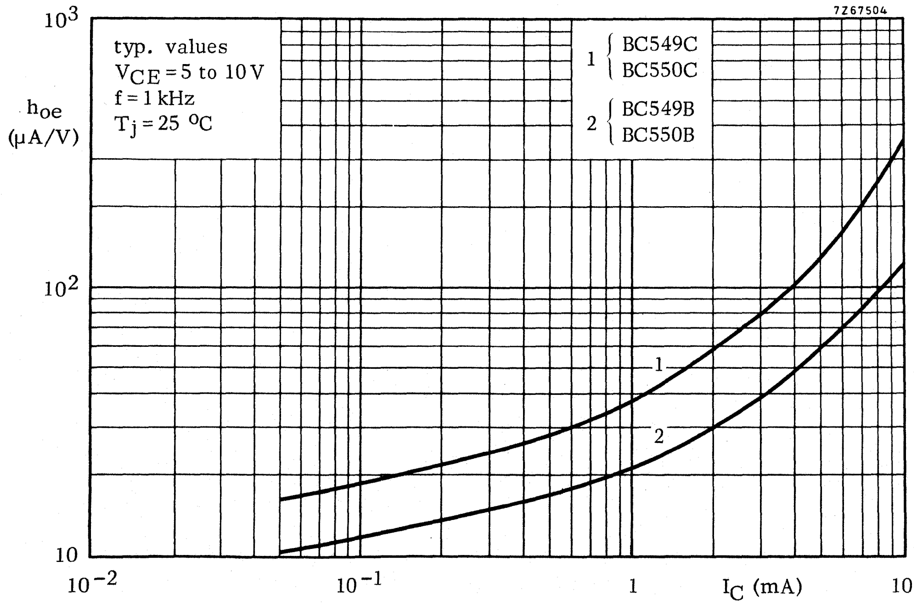


Curves of constant noise figure


7Z67506
typ. values
Tj = 25 °C
f = 1 kHz
1 { BC549C BC550C
2 { BC549B BC550B
hie (kΩ)
10²
10
1
1
2
VCE = 10 V
VCE = 5 V
10⁻²
10⁻¹
1
IC (mA)
10


7Z67505
typ. values
Tj = 25 °C
f = 1 kHz
1 { BC549C BC550C
2 { BC549B BC550B
hfe
10⁴
10³
10²
VCE = 10 V
5 V
10 V
5 V
1
2
10⁻²
10⁻¹
1
IC (mA)
10


7Z67503
typ. values
f = 1 kHz
T_j = 25 °C
h_{re}
(10^{-4})
1 { BC549C BC550C
2 { BC549B BC550B
1
2
V_{CE} = 5 V
V_{CE} = 10 V
10^2
10
1
10^{-2}
10^{-1}
1
I_C (mA)
10


7Z67504
typ. values
V_{CE} = 5 to 10 V
f = 1 kHz
T_j = 25 °C
h_{oe}
(μA/V)
1 { BC549C BC550C
2 { BC549B BC550B
1
2
10^3
10^2
10
10^{-2}
10^{-1}
1
I_C (mA)
10

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.

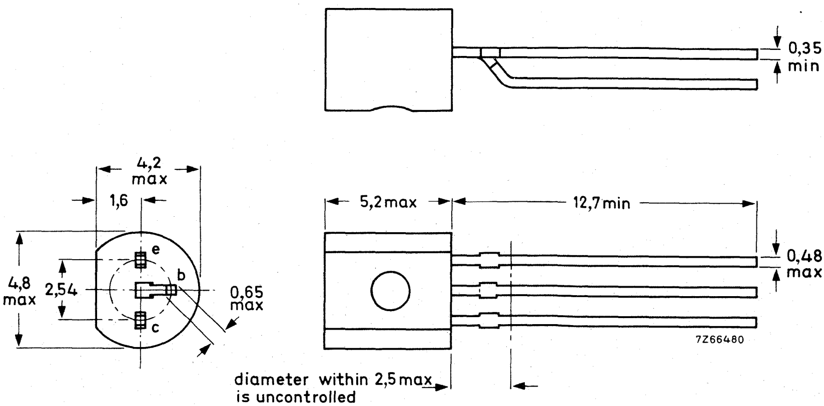
QUICK REFERENCE DATA

			BC556	BC557	BC558	
Collector-emitter voltage (+ V_{BE} = 1 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 °C	P_{tot}	max.		500		mW
Junction temperature	T_j	max.		150		°C
Small-signal current gain $-I_C$ = 2 mA; $-V_{CE}$ = 5 V; f = 1 kHz	h_{fe}			75 to 500		
Transition frequency at f = 35 MHz $-I_C$ = 10 mA; $-V_{CE}$ = 5 V	f_T	typ.		150		MHz
Noise figure at R_S = 2 kΩ $-I_C$ = 200 μA; $-V_{CE}$ = 5 V f = 1 kHz; B = 200 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	$R_{th\ j\text{-}a}$	=	250	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	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	μA

Base-emitter voltage *

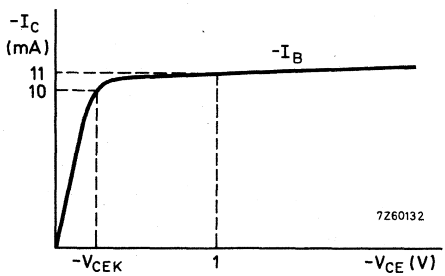
$-I_C = 2$ mA; $-V_{CE} = 5$ V	$-V_{BE}$	typ	650	mV
		600 to	750	mV
$-I_C = 10$ mA; $-V_{CE} = 5$ V	$-V_{BE}$	<	820	mV

Saturation voltages **

$-I_C = 10$ mA; $-I_B = 0,5$ mA	$-V_{CEsat}$	typ	75	mV
		<	300	mV
	$-V_{BEsat}$	typ	700	mV
$-I_C = 100$ mA; $-I_B = 5$ mA	$-V_{CEsat}$	typ	250	mV
		<	650	mV
	$-V_{BEsat}$	typ	850	mV

Knee voltage

$-I_C = 10$ mA; $-I_B$ = value for which $-I_C = 11$ mA at $-V_{CE} = 1$ V	$-V_{CEK}$	typ	250	mV
		<	600	mV



Collector capacitance at f = 1 MHz

$I_E = I_e = 0; -V_{CB} = 10$ V	C_c	typ	4,5	pF

Transition frequency at f = 35 MHz

$-I_C = 10$ mA; $-V_{CE} = 5$ V	f_T	typ	150	MHz

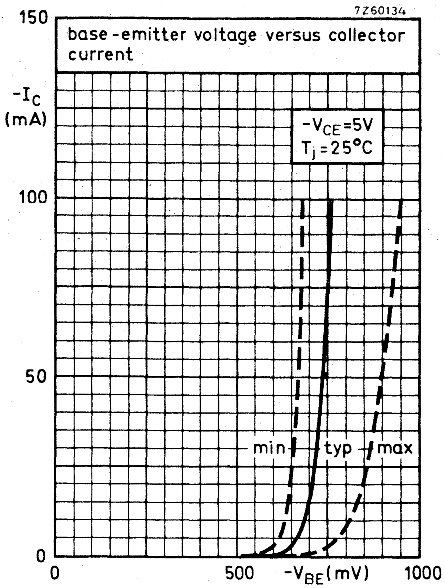
* $-V_{BE}$ decreases by about 2 mV/°C with increasing temperature.
** $-V_{BEsat}$ decreases by about 1,7 mV/°C with increasing temperature.

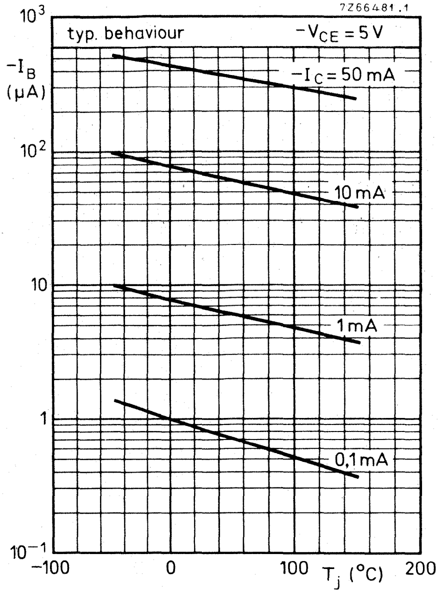
CHARACTERISTICS (continued)

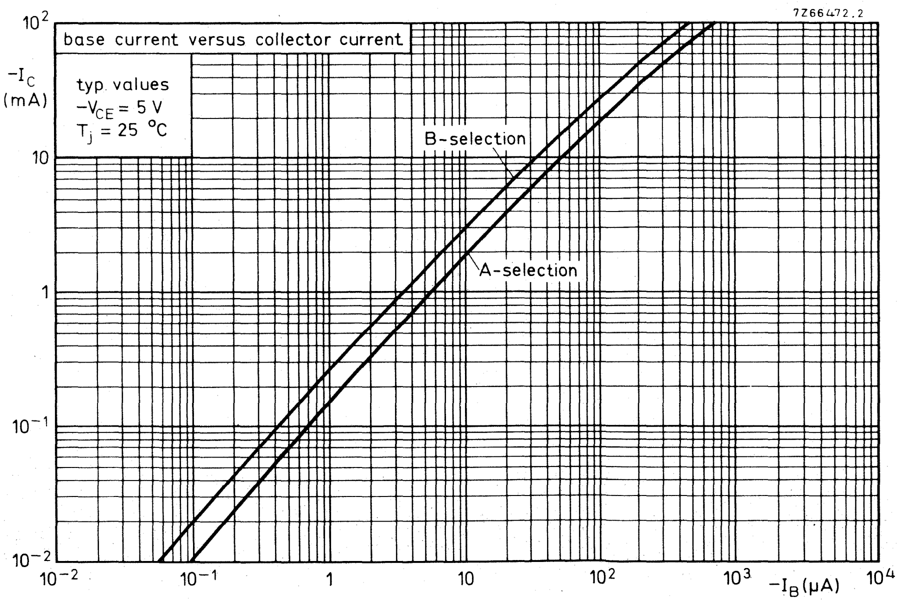
T_j = 25 °C

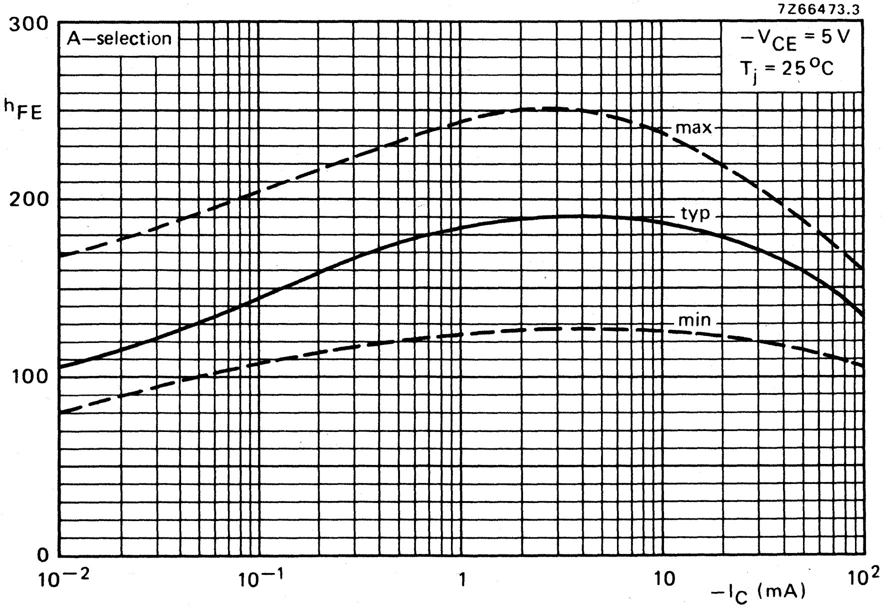
Small-signal current gain at f = 1 kHz					
→ $-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{fe}		75 to 500		
Noise figure at R_S = 2 kΩ; $-I_C$ = 200 μA; $-V_{CE}$ = 5 V; f = 1 kHz; B = 200 Hz	F	typ.	2		dB
		<	10		dB

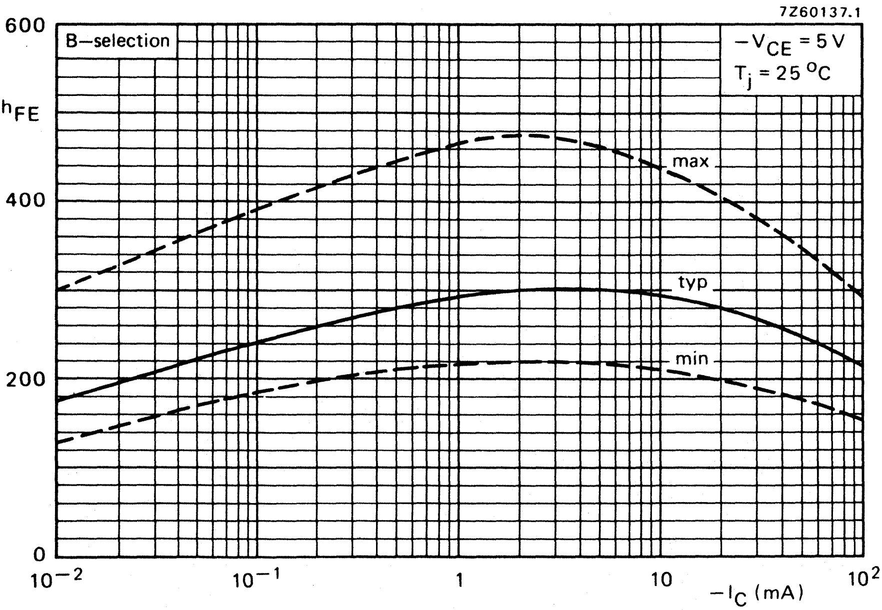
			BC556 BC557 BC558	BC556A BC557A BC558A	BC556B BC557B BC558B
→ D.C. current gain; $-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{FE}	>	75	125	220
		<	475	250	475

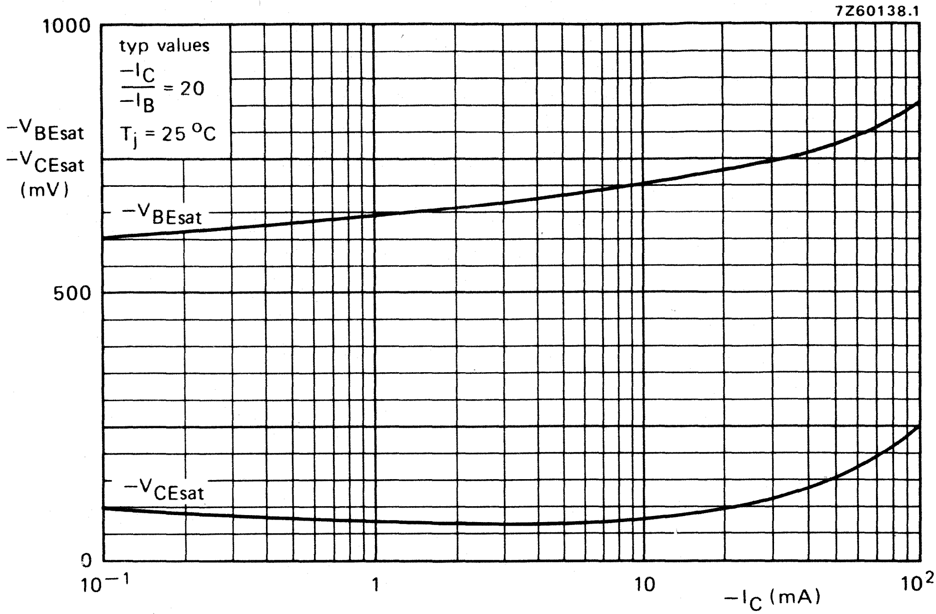

7Z60134
base-emitter voltage versus collector current
$-I_C$ (mA)
$-V_{CE}$=5V
T_j=25°C
min
typ
max
150
100
50
0
0
500
$-V_{BE}$(mV)
1000

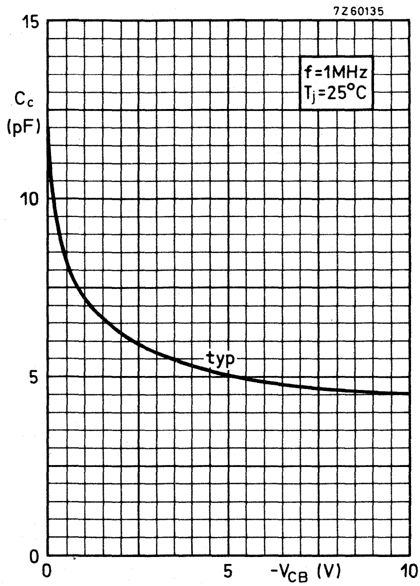

7Z66481.1
typ. behaviour
$-V_{CE}$ = 5 V
$-I_B$ (μA)
$-I_C$ = 50 mA
10 mA
1 mA
0,1 mA
10^3
10^2
10
1
10^{-1}
−100
0
100
T_j (°C)
200

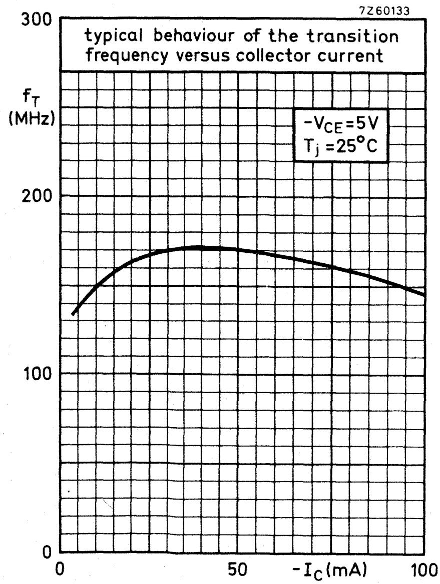

7Z66472.2
base current versus collector current
typ. values
$-V_{CE}$ = 5 V
T_j = 25 °C
$-I_C$ (mA)
B-selection
A-selection
10^2
10
1
10^{-1}
10^{-2}
10^{-2}
10^{-1}
1
10
10^2
10^3
$-I_B$(μA)
10^4

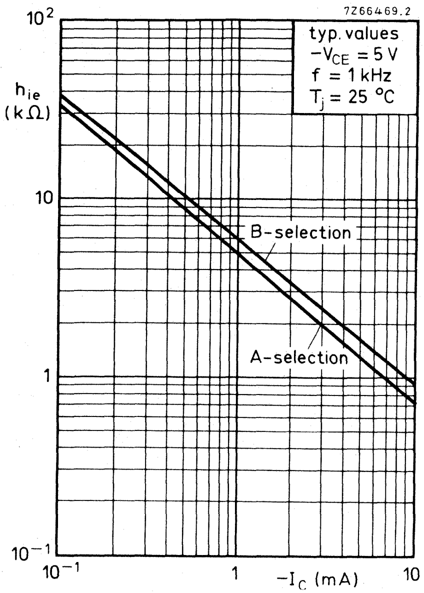

7Z66473.3
A–selection
$-V_{CE}$ = 5 V
T_j = 25 °C
h_{FE}
300
200
100
0
max
typ
min
10^{-2}
10^{-1}
1
10
10^2
$-I_C$ (mA)

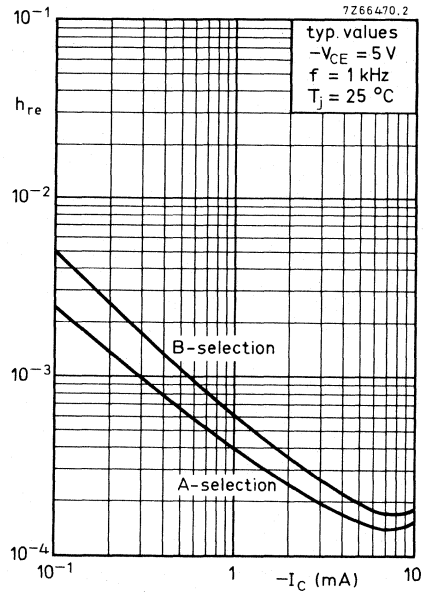

7Z60137.1
B–selection
$-V_{CE}$ = 5 V
T_j = 25 °C
h_{FE}
600
400
200
0
max
typ
min
10^{-2}
10^{-1}
1
10
10^2
$-I_C$ (mA)

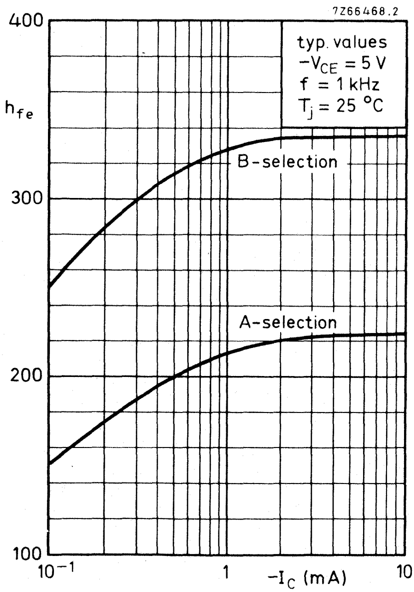

7Z60138.1
1000
typ values
$\frac{-I_C}{-I_B} = 20$
$T_j = 25\ ^oC$
$-V_{BEsat}$
$-V_{CEsat}$
(mV)
$-V_{BEsat}$
500
$-V_{CEsat}$
0
10^{-1}
1
10
$-I_C$ (mA)
10^2

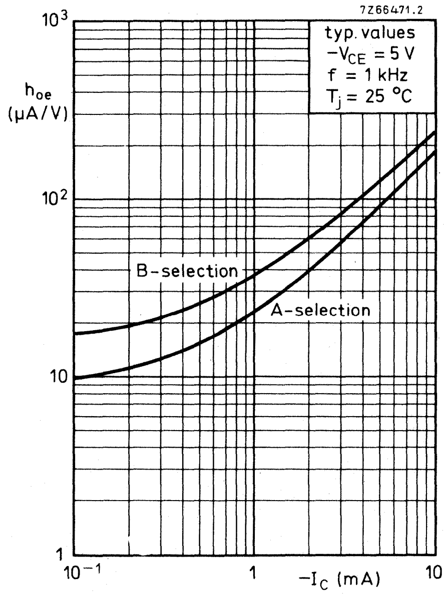

7Z60135
15
C_c
(pF)
f=1MHz
T_j=25°C
10
typ
5
0
0
5
$-V_{CB}$ (V)
10


7Z60133
300
typical behaviour of the transition frequency versus collector current
f_T
(MHz)
$-V_{CE}$=5V
T_j =25°C
200
100
0
0
50
$-I_C$(mA)
100


7Z66469.2
typ. values
$-V_{CE}$ = 5 V
f = 1 kHz
T_j = 25 °C
h_{ie} (kΩ)
B-selection
A-selection
$-I_C$ (mA)


7Z66470.2
typ. values
$-V_{CE}$ = 5 V
f = 1 kHz
T_j = 25 °C
h_{re}
B-selection
A-selection
$-I_C$ (mA)


7Z66468.2
typ. values
$-V_{CE}$ = 5 V
f = 1 kHz
T_j = 25 °C
h_{fe}
B-selection
A-selection
$-I_C$ (mA)


7Z66471.2
typ. values
$-V_{CE}$ = 5 V
f = 1 kHz
T_j = 25 °C
h_{oe} (μA/V)
B-selection
A-selection
$-I_C$ (mA)

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.

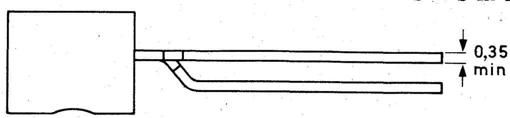
QUICK REFERENCE DATA

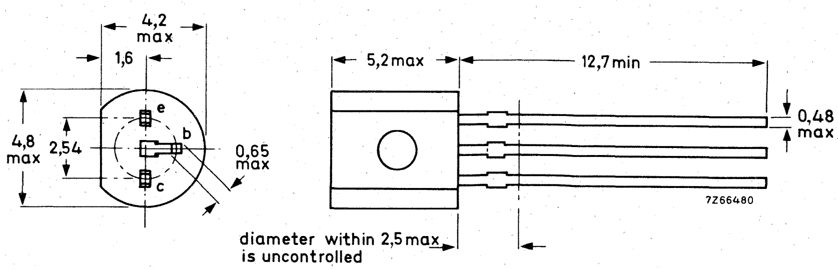
			BC559	BC560	
Collector-emitter voltage ($+V_{BE}$ = 1 V)	$-V_{CEX}$	max.	30	50	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	30	45	V
Collector current (peak value)	$-I_{CM}$	max.	200	200	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500	500	mW
Junction temperature	T_j	max.	150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

MECHANICAL DATA

Dimensions in mm

TO-92 variant





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

			BC559	BC560	
Voltages					
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

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 °C	P_{tot}	max.	500	mW
Temperatures				
Storage temperature	T_{stg}		−65 to +150	°C
Junction temperature	T_j	max.	150	°C

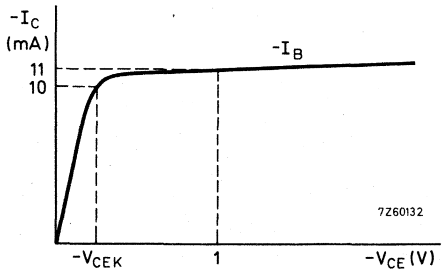
THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0,25	°C/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0,15	°C/mW

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 μA
Base-emitter voltage *			
$-I_C = 2$ mA; $-V_{CE} = 5$ V	$-V_{BE}$	typ	650 mV
		600 to	750 mV
$-I_C = 10$ mA; $-V_{CE} = 5$ V	$-V_{BE}$	<	820 mV
Saturation voltages **			
$-I_C = 10$ mA; $-I_B = 0{,}5$ mA	$-V_{CEsat}$	typ	75 mV
		<	300 mV
	$-V_{BEsat}$	typ	700 mV
$-I_C = 100$ mA; $-I_B = 5$ mA	$-V_{CEsat}$	typ	250 mV
		<	650 mV
	$-V_{BEsat}$	typ	850 mV
Knee voltage			
$-I_C = 10$ mA; $-I_B$ = value for which $-I_C = 11$ mA at $-V_{CE} = 1$ V	$-V_{CEK}$	typ	250 mV
		<	600 mV



Collector capacitance at f = 1 MHz			
$I_E = I_e = 0$; $-V_{CB} = 10$ V	C_c	typ	4,5 pF
Transition frequency at f = 35 MHz			
$-I_C = 10$ mA; $-V_{CE} = 5$ V	f_T	typ	150 MHz

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

CHARACTERISTICS (continued)

T_j = 25 °C unless otherwise specified

Small-signal current gain at f = 1 kHz

$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{fe}		125 to 500

Noise figure at R_S = 2 kΩ

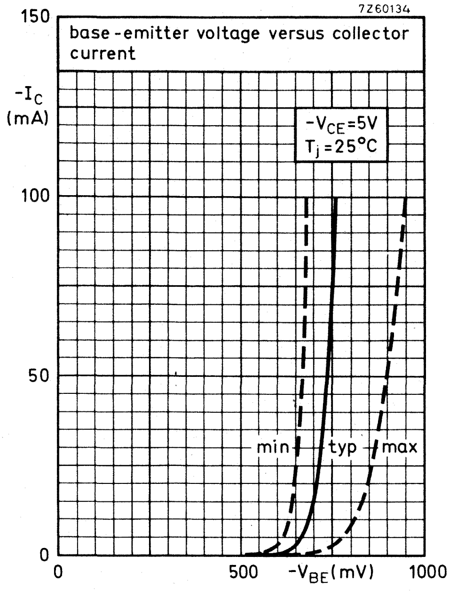
			BC559	BC560	
$-I_C$ = 200 μA; $-V_{CE}$ = 5 V					
f = 30 Hz to 15 kHz	F	typ	1,2	1	dB
		<	4	3	dB
f = 1 kHz; B = 200 Hz	F	typ	1	1	dB
		<	4	4	dB

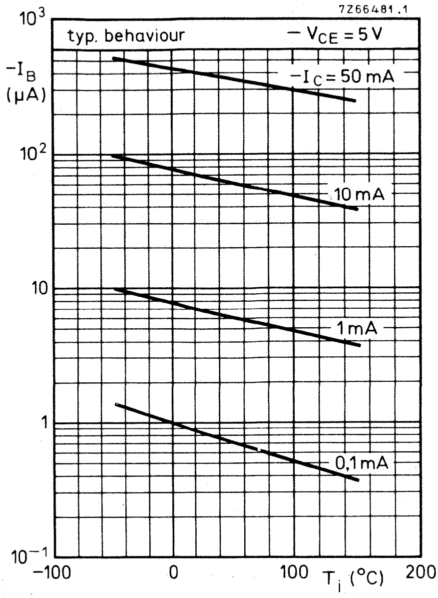
Equivalent noise voltage at R_S = 2 kΩ

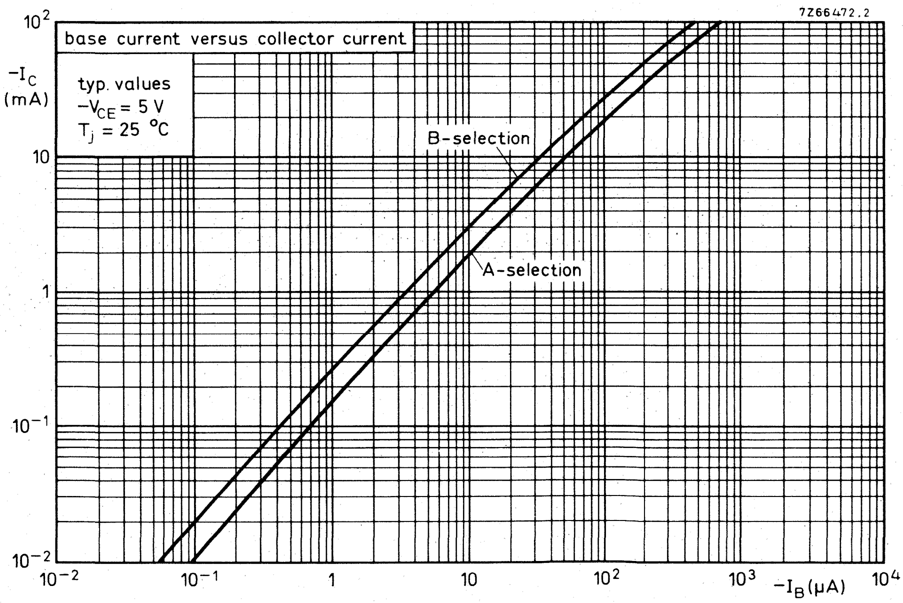
			BC559	BC560	
$-I_C$ = 200 μA; $-V_{CE}$ = 5 V f = 10 Hz to 50 Hz; T_{amb} = 25 °C	V_n	<	–	0,11	μV

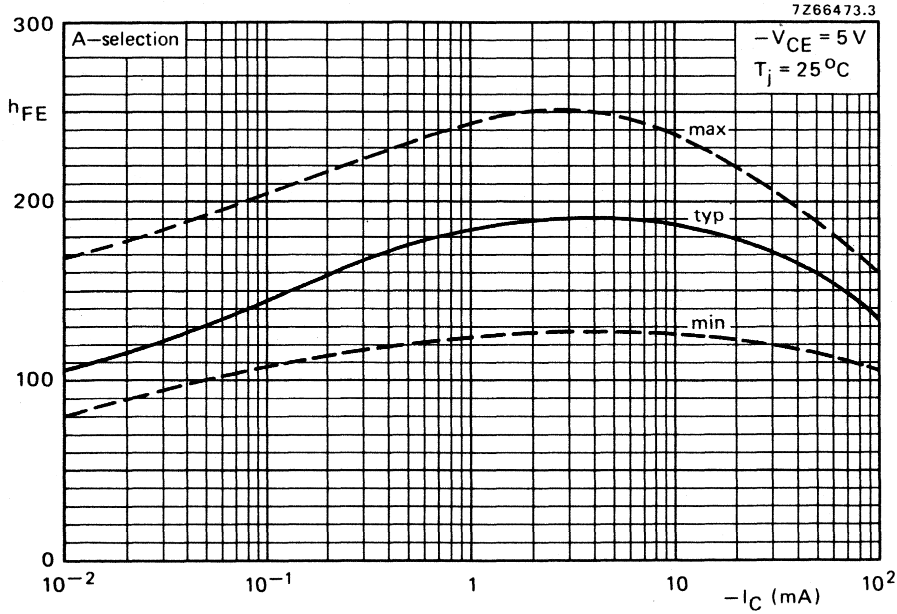
D.C. current gain

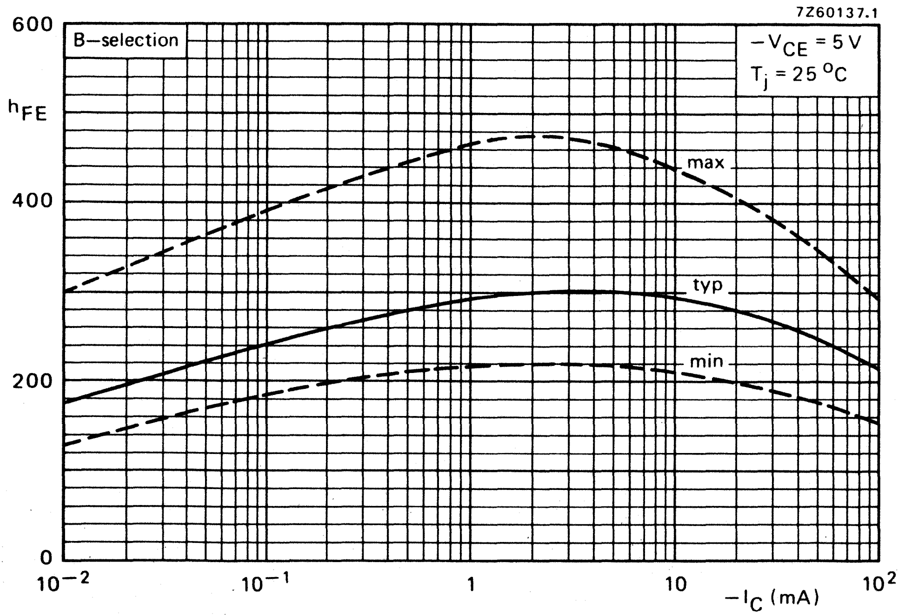
			BC559 BC560	BC559A BC560A	BC559B BC560B
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{FE}	>	125	125	220
		<	475	250	475

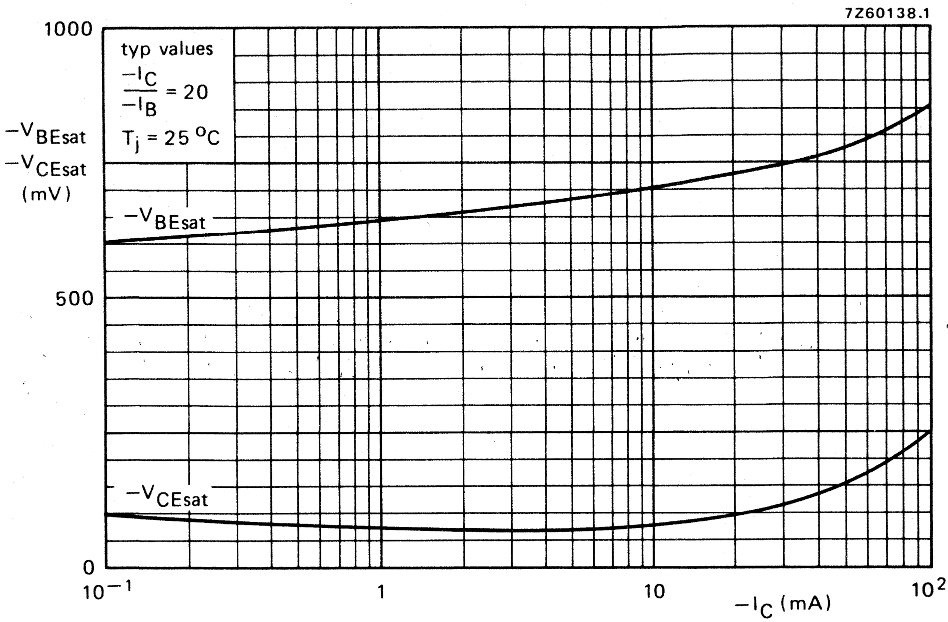

7Z60134
base-emitter voltage versus collector current
$-I_C$ (mA)
$-V_{CE}$=5V
T_j=25°C
min
typ
max
150
100
50
0
0
500
$-V_{BE}$(mV)
1000

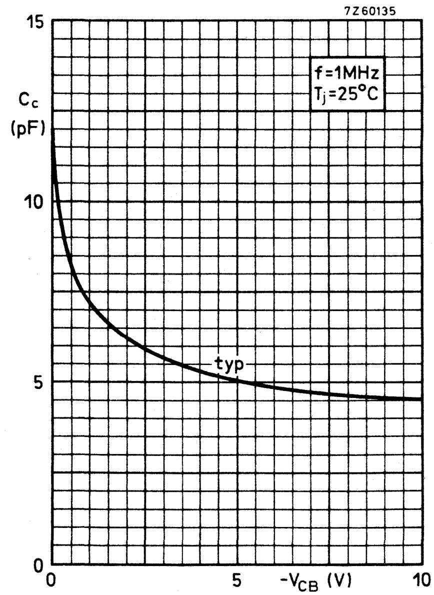

7Z66481.1
typ. behaviour
$-V_{CE}$ = 5 V
$-I_B$ (μA)
$-I_C$ = 50 mA
10 mA
1 mA
0,1 mA
10^3
10^2
10
1
10^{-1}
−100
0
100
T_j (°C)
200

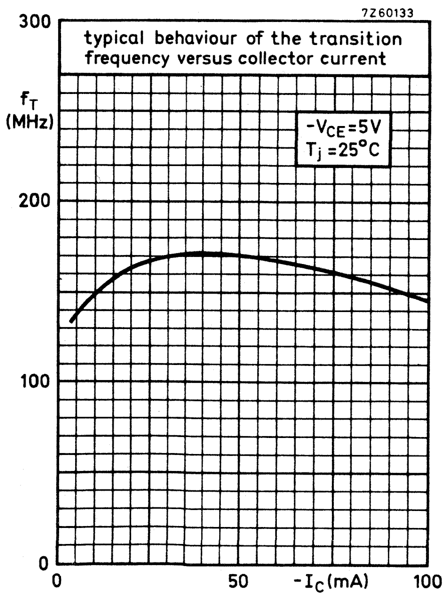

7Z66472.2
base current versus collector current
typ. values
$-V_{CE}$ = 5 V
T_j = 25 °C
$-I_C$ (mA)
B-selection
A-selection
10^2
10
1
10^{-1}
10^{-2}
10^{-2}
10^{-1}
1
10
10^2
10^3
$-I_B$(μA)
10^4

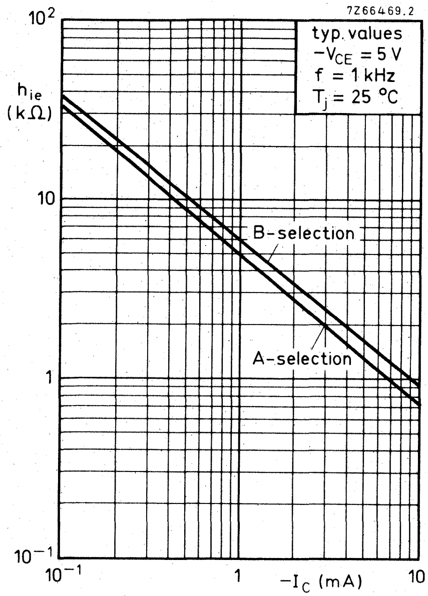

7Z66473.3
A–selection
$-V_{CE} = 5\ V$
$T_j = 25\ ^oC$
h_{FE}
300
200
100
0
max
typ
min
10^{-2}
10^{-1}
1
10
10^2
$-I_C$ (mA)

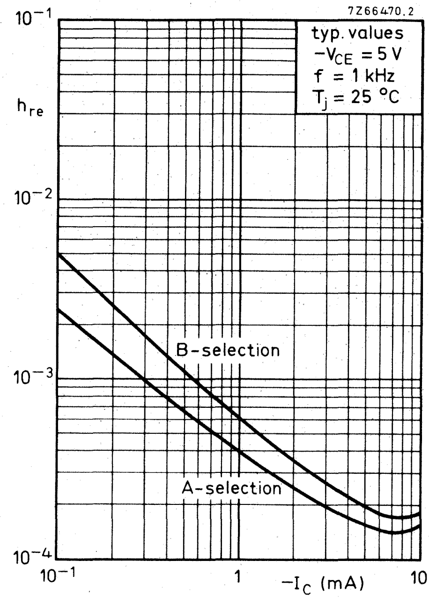

7Z60137.1
B–selection
$-V_{CE} = 5\ V$
$T_j = 25\ ^oC$
h_{FE}
600
400
200
0
max
typ
min
10^{-2}
10^{-1}
1
10
10^2
$-I_C$ (mA)

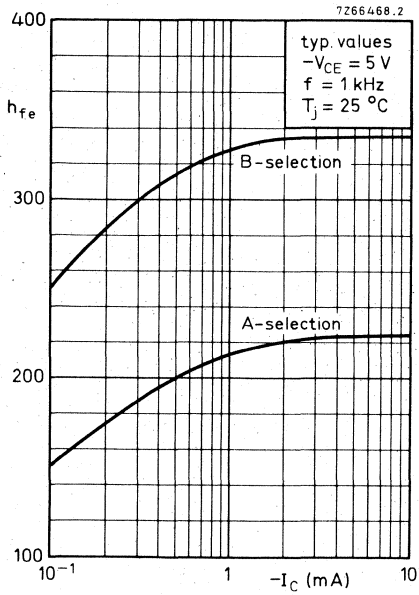

7Z60138.1
typ values
$\frac{-I_C}{-I_B} = 20$
$T_j = 25\ ^oC$
$-V_{BEsat}$
$-V_{CEsat}$
(mV)
1000
500
0
$-V_{BEsat}$
$-V_{CEsat}$
10^{-1}
1
10
10^2
$-I_C$ (mA)

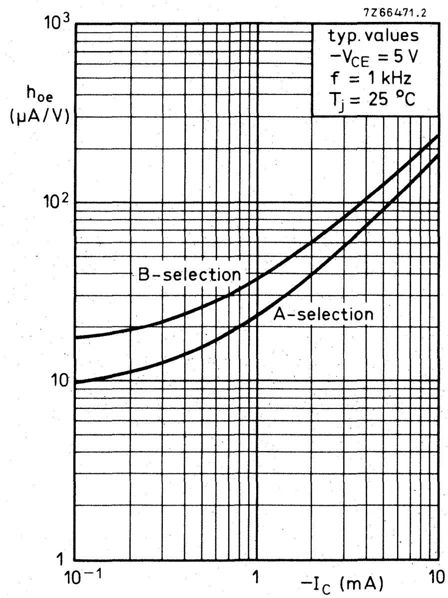

7Z60135
f=1MHz
T_j=25°C
C_c
(pF)
15
10
5
0
typ
0
5
$-V_{CB}$ (V)
10


7Z60133
typical behaviour of the transition frequency versus collector current
f_T
(MHz)
$-V_{CE}$=5V
T_j =25°C
300
200
100
0
0
50
$-I_C$(mA)
100

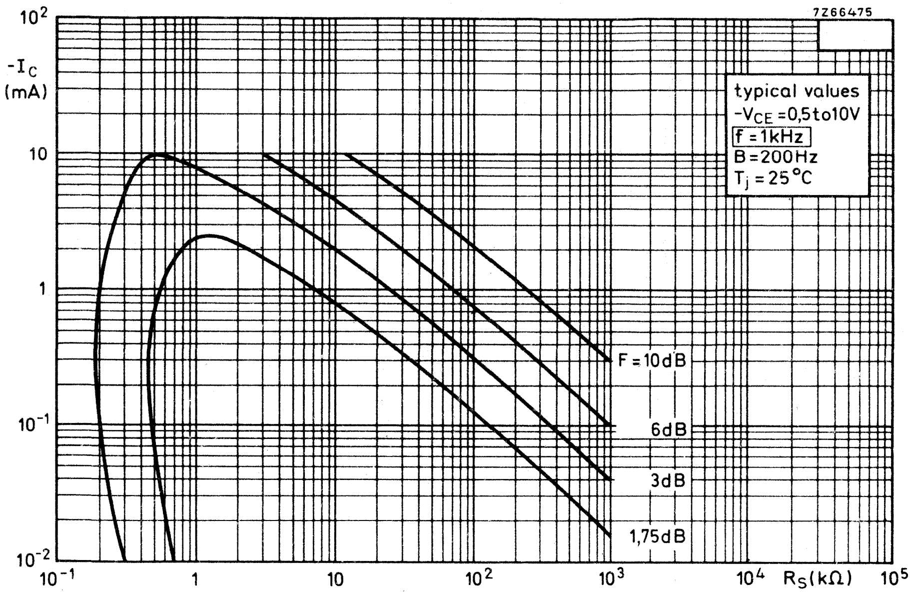

7Z66469.2
typ. values
$-V_{CE}$ = 5 V
f = 1 kHz
T_j = 25 °C
h_{ie}
(kΩ)
10^2
10
1
10^{-1}
B-selection
A-selection
10^{-1}
1
10
$-I_C$ (mA)

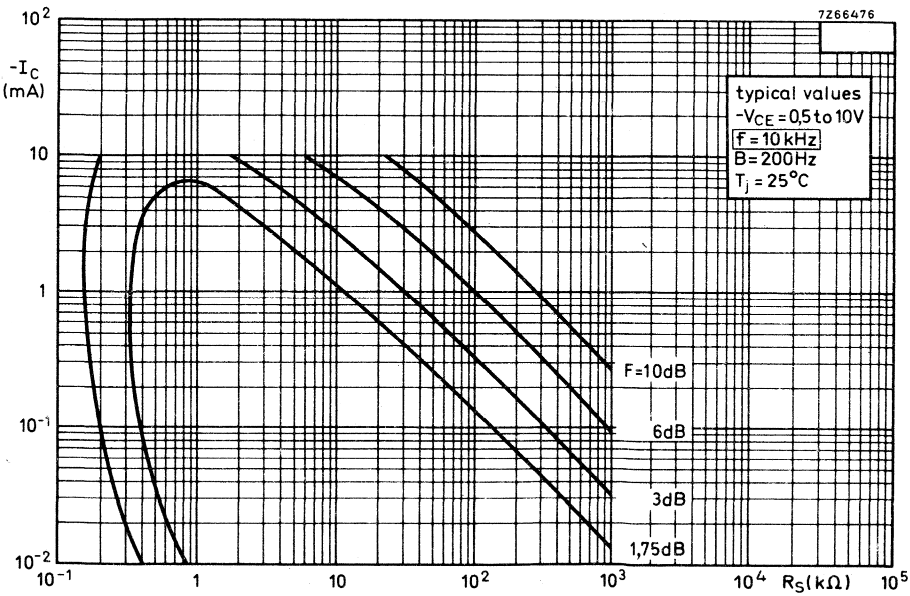

7Z66470.2
typ. values
$-V_{CE}$ = 5 V
f = 1 kHz
T_j = 25 °C
h_{re}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
B-selection
A-selection
10^{-1}
1
10
$-I_C$ (mA)

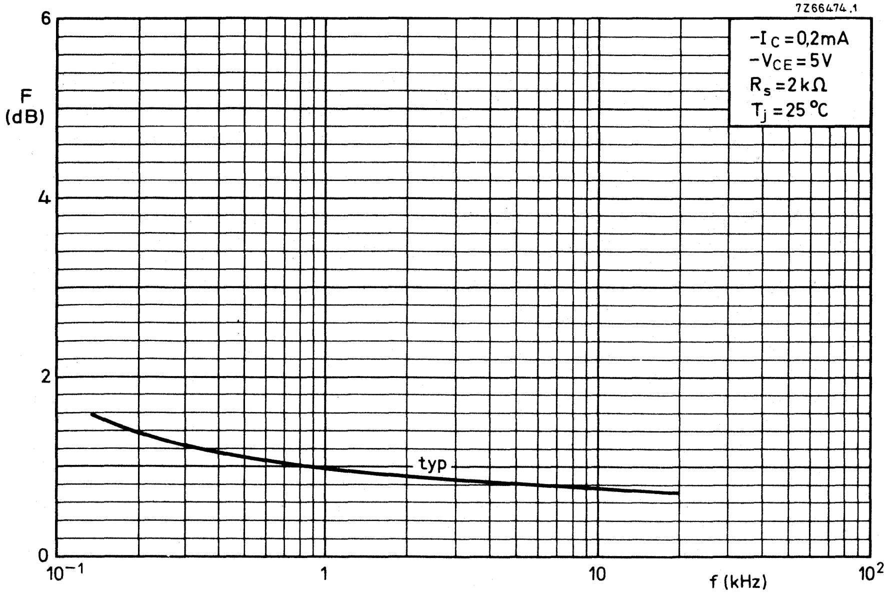

7Z66468.2
typ. values
$-V_{CE}$ = 5 V
f = 1 kHz
T_j = 25 °C
h_{fe}
400
300
200
100
B-selection
A-selection
10^{-1}
1
10
$-I_C$ (mA)


7Z66471.2
typ. values
$-V_{CE}$ = 5 V
f = 1 kHz
T_j = 25 °C
h_{oe}
(μA/V)
10^3
10^2
10
1
B-selection
A-selection
10^{-1}
1
10
$-I_C$ (mA)

curves of constant noise figure






7Z66474.1
F
(dB)
6
4
2
0
$-I_C = 0{,}2mA$
$-V_{CE} = 5V$
$R_s = 2k\Omega$
$T_j = 25\,^{\circ}C$
typ
10^{-1}
1
10
10^2
f (kHz)

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.

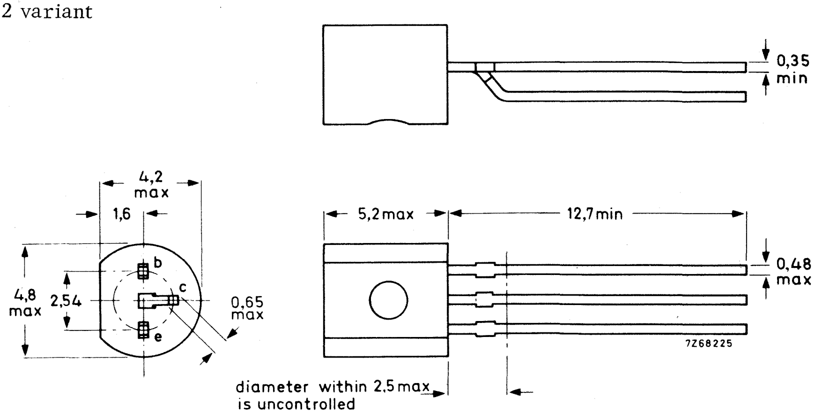
QUICK REFERENCE DATA

			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 kΩ)	V_{CER}	max.	45	60	100	V
Collector-current (peak value)	I_{CM}	max.	1, 5	1, 5	1, 5	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	1	1	1	W
Junction temperature	T_j	max.	150	150	150	°C
D.C. current gain I_C = 150 mA; V_{CE} = 2 V	h_{FE}	>	40	40	40	
		<	250	160	160	
Transition frequency I_C = 10 mA; V_{CE} = 5 V	f_T	typ.	130	130	130	MHz

MECHANICAL DATA

Dimensions in mm

TO-92 variant



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

Voltages			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 kΩ)	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

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 °C	P_{tot}	max.	0,8	W	
up to T_{amb} = 25 °C	P_{tot}	max.	1	W	1)

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

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	156	°C/W	
From junction to ambient	$R_{th\ j-a}$	=	125	°C/W	1)
From junction to case	$R_{th\ j-c}$	=	60	°C/W	

1) 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 °C unless otherwise specified

Collector cut-off current

$I_E = 0$; $V_{CB} = 30$ V	I_{CBO}	<	100	nA
$I_E = 0$; $V_{CB} = 30$ V; $T_j = 150$ °C	I_{CBO}	<	10	μA

Emitter cut-off current

$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10	μA

Base-emitter voltage

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

Saturation voltage

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

D.C. current gain

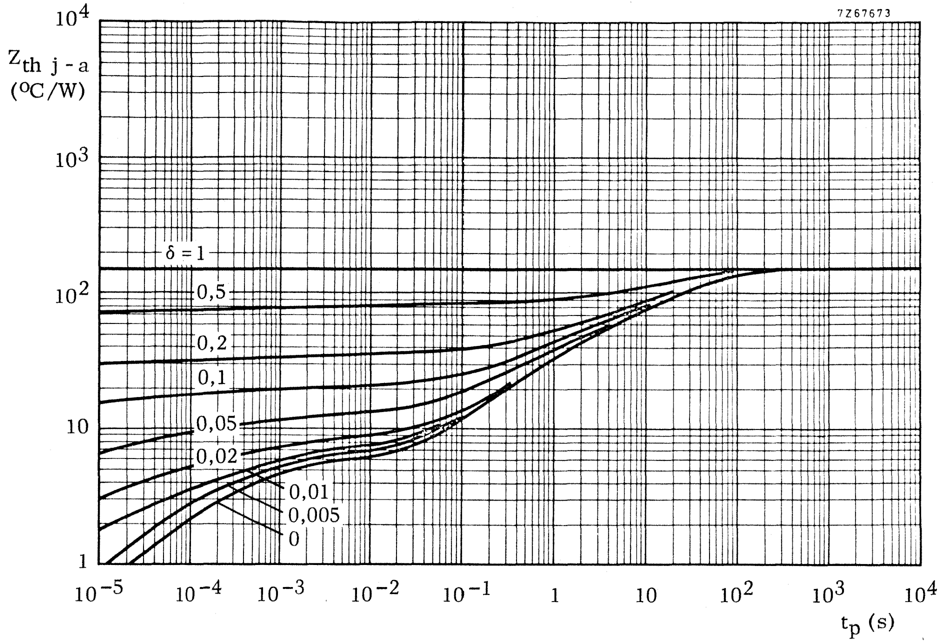
			BC635	BC637	BC639
$I_C = 5$ mA; $V_{CE} = 2$ V	h_{FE}	>	25	25	25
$I_C = 150$ mA; $V_{CE} = 2$ V	h_{FE}	>	40	40	40
		<	250	160	160
$I_C = 500$ mA; $V_{CE} = 2$ V	h_{FE}	>	25	25	25

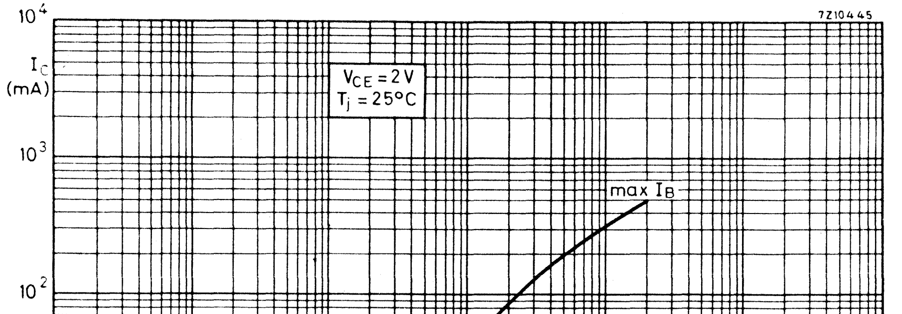
Transition frequency at f = 35 MHz

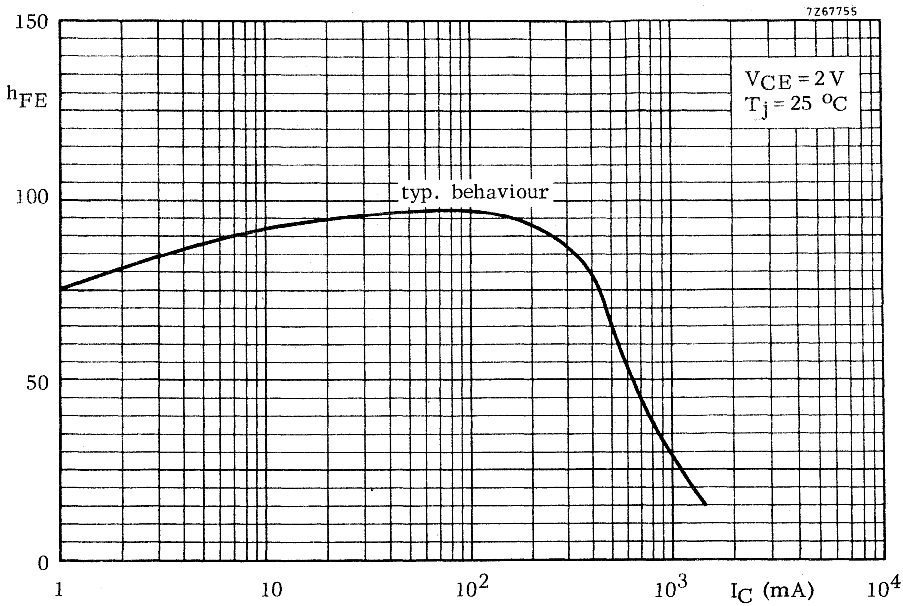
$I_C = 10$ mA; $V_{CE} = 5$ V	f_T	typ.	130	MHz

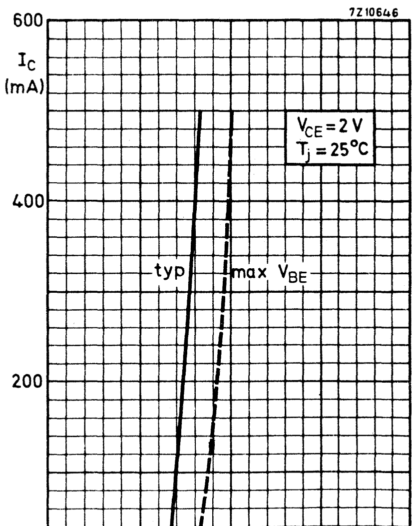
D.C. current gain ratio of matched pairs

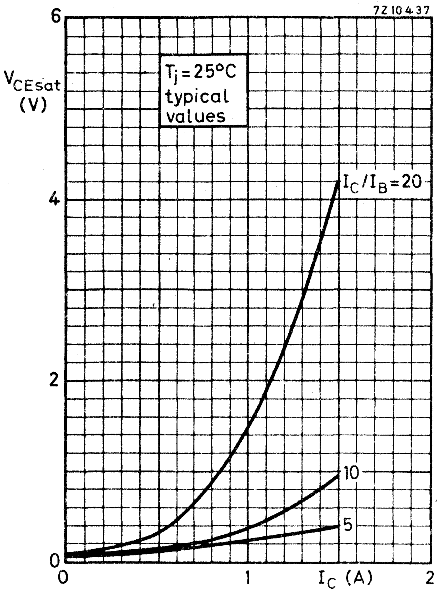
$|I_C| = 150$ mA; $|V_{CE}| = 2$ V
BC635/BC636,
BC637/BC638 and
BC639/BC640 — h_{FE1}/h_{FE2} typ. 1,3; < 1,6

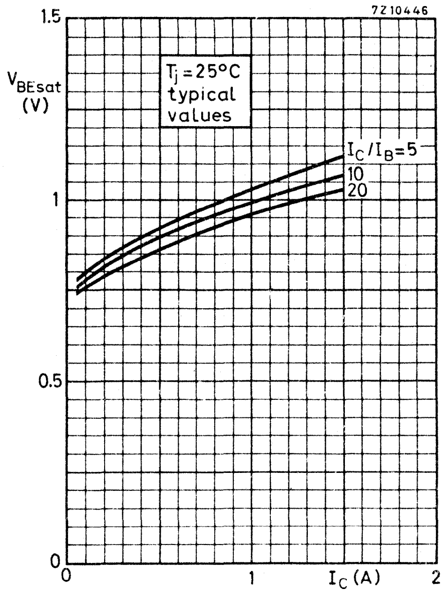

7Z67673
$Z_{th\ j-a}$ (°C/W)
δ = 1
0,5
0,2
0,1
0,05
0,02
0,01
0,005
0
t_p (s)

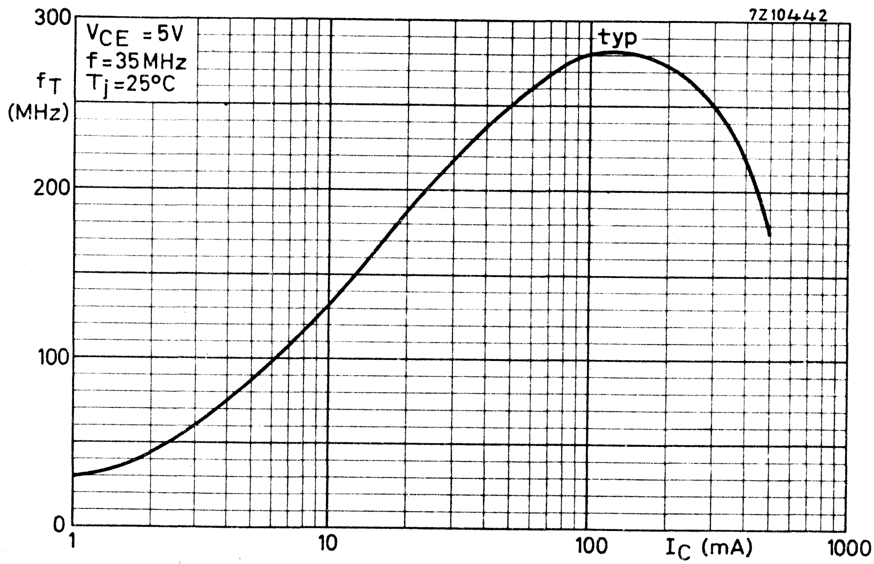

7Z10445
I_C (mA)
V_{CE} = 2 V
T_j = 25 °C
max I_B
I_B (mA)


7Z67755
150
h_{FE}
100
50
0
typ. behaviour
$V_{CE} = 2$ V
$T_j = 25$ °C
1
10
10^2
10^3
I_C (mA)
10^4


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


7Z10437
6
4
2
0
V_CEsat
(V)
Tj = 25°C
typical
values
IC/IB = 20
10
5
0
1
IC (A)
2


7Z10446
1.5
1
0.5
0
V_BEsat
(V)
Tj = 25°C
typical
values
IC/IB = 5
10
20
0
1
IC (A)
2


7Z10442
300
200
100
0
fT
(MHz)
VCE = 5V
f = 35 MHz
Tj = 25°C
typ
1
10
100
IC (mA)
1000

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.

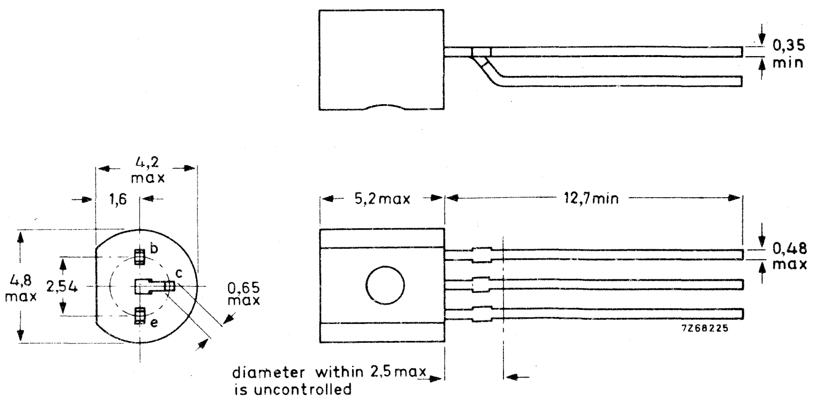
QUICK REFERENCE DATA

			BC636	BC638	BC640	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	$-V_{CER}$	max.	45	60	100	V
Collector-current (peak value)	$-I_{CM}$	max.	1,5	1,5	1,5	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	1	1	1	W
Junction temperature	T_j	max.	150	150	150	°C
D.C. current gain $-I_C$ = 150 mA; $-V_{CE}$ = 2 V	h_{FE}	>	40	40	40	
		<	250	160	160	
Transition frequency $-I_C$ = 10 mA; $-V_{CE}$ = 5 V	f_T	typ.	50	50	50	MHz

MECHANICAL DATA

Dimensions in mm

TO-92 variant



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 kΩ)	$-V_{CER}$	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 °C	P_{tot}	max.	0,8	W
up to T_{amb} = 25 °C	P_{tot}	max.	1	W [1]

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

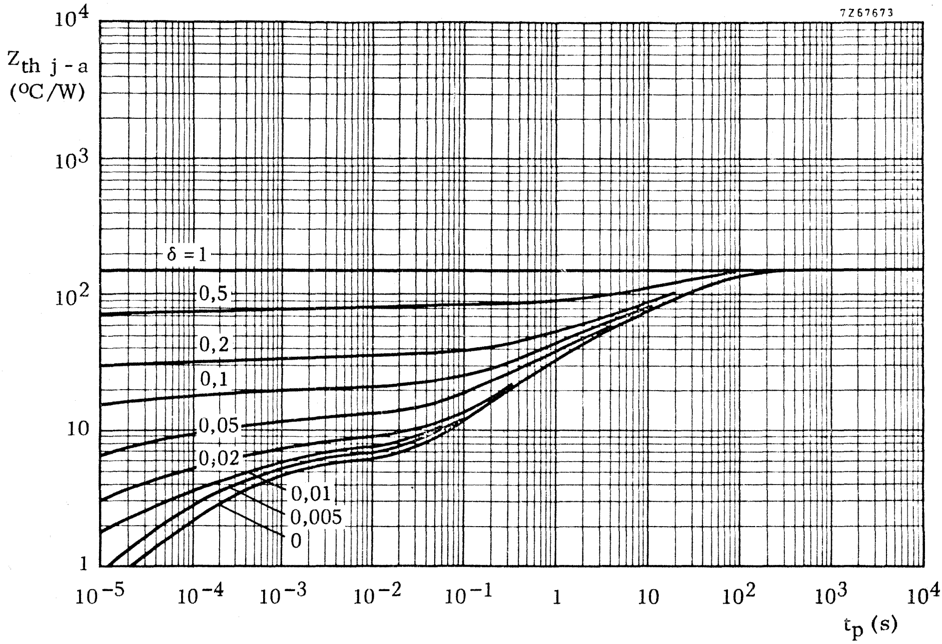
THERMAL RESISTANCE

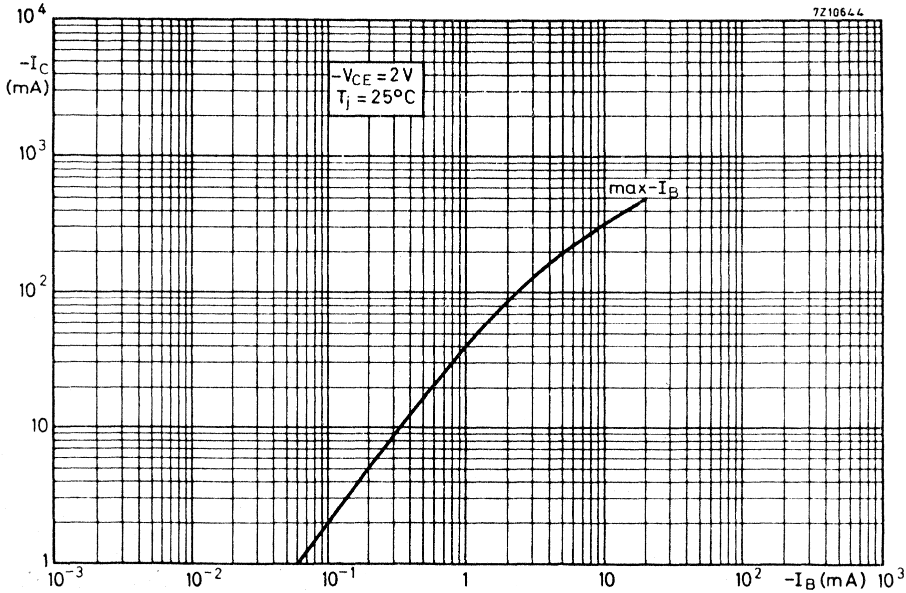
From junction to ambient in free air	$R_{th\ j-a}$	=	156	°C/W
From junction to ambient	$R_{th\ j-a}$	=	125	°C/W [1]
From junction to case	$R_{th\ j-c}$	=	60	°C/W

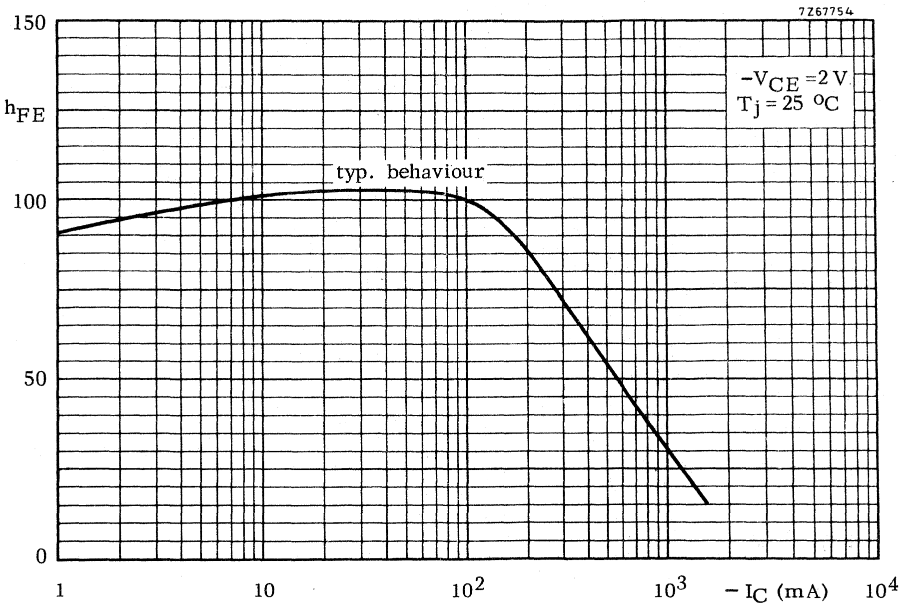
[1]) Transistor mounted on printed circuit board, max. lead length 4 mm, mounting pad for collector lead min. 10 mm x 10 mm.

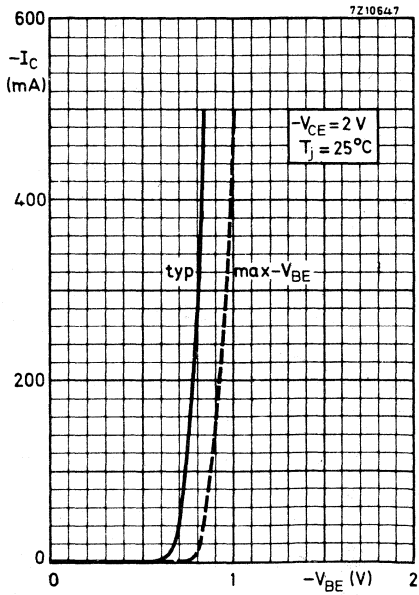
CHARACTERISTICS $T_j = 25\ ^oC$ unless otherwise specified

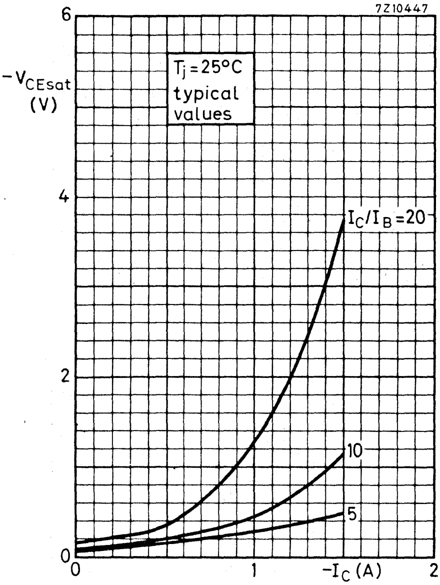
Collector cut-off current						
$I_E = 0;\ -V_{CB} = 30\ V$	$-I_{CBO}$	<		100		nA
$I_E = 0;\ -V_{CB} = 30\ V;\ T_j = 150\ ^oC$	$-I_{CBO}$	<		10		μA
Emitter cut-off current						
$I_C = 0;\ -V_{EB} = 5\ V$	$-I_{EBO}$	<		10		μA
Base-emitter voltage						
$-I_C = 500\ mA;\ -V_{CE} = 2\ V$	$-V_{BE}$	<		1		V
Saturation voltage						
$-I_C = 500\ mA;\ -I_B = 50\ mA$	$-V_{CEsat}$	<		0,5		V
D.C. current gain			BC636	BC638	BC640	
$-I_C = 5\ mA;\ -V_{CE} = 2\ V$	h_{FE}	>	25	25	25	
$-I_C = 150\ mA;\ -V_{CE} = 2\ V$	h_{FE}	>	40	40	40	
		<	250	160	160	
$-I_C = 500\ mA;\ -V_{CE} = 2\ V$	h_{FE}	>	25	25	25	
Transition frequency at f = 35 MHz						
$-I_C = 10\ mA;\ -V_{CE} = 5\ V$	f_T	typ.		50		MHz
D.C. current gain ratio of matched pairs						
$\lvert I_C \rvert = 150\ mA;\ \lvert V_{CE} \rvert = 2\ V$						
BC635/BC636, BC637/BC638 and BC639/BC640	h_{FE1}/h_{FE2}	typ.		1,3		
		<		1,6		

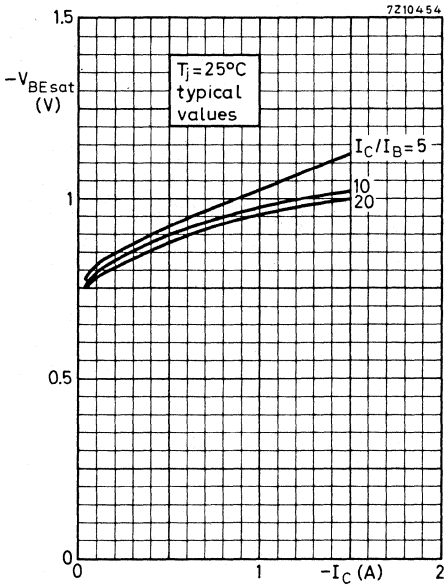

7Z67673
$Z_{th\ j-a}$ (°C/W)
δ = 1
0,5
0,2
0,1
0,05
0,02
0,01
0,005
0
t_p (s)
10^4
10^3
10^2
10
1
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
10^3
10^4

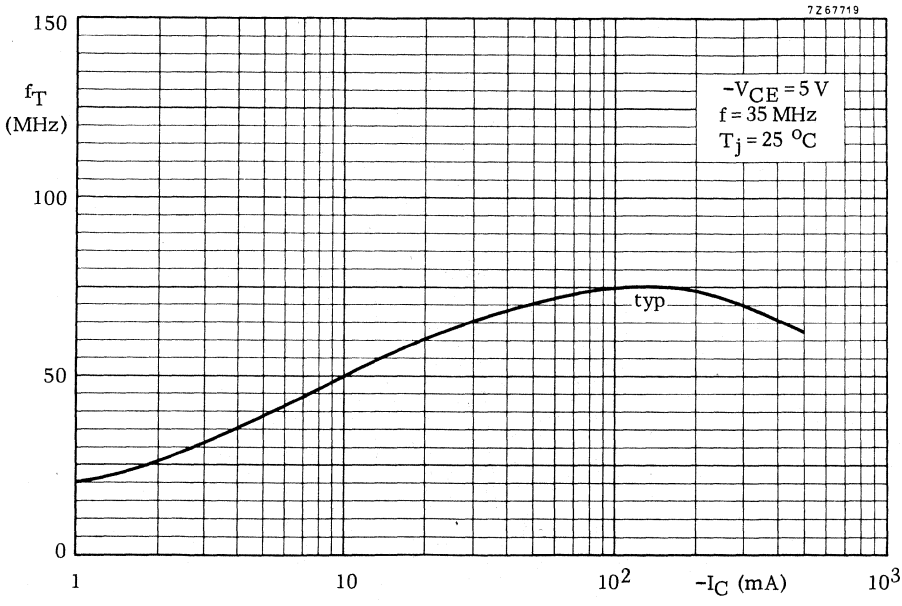

7Z10644
$-I_C$ (mA)
$-V_{CE} = 2$ V
$T_j = 25$°C
max-I_B
$-I_B$ (mA)
10^4
10^3
10^2
10
1
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
10^3


7Z67754
150
100
50
0
h_{FE}
$-V_{CE} = 2$ V
$T_j = 25$ °C
typ. behaviour
1
10
10^2
10^3
$-I_C$ (mA)
10^4


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


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


7Z10454
$-V_{BEsat}$ (V)
$T_j = 25°C$
typical values
$I_C/I_B = 5$
10
20
$-I_C$ (A)
0
0.5
1
1.5
2


7Z67719
f_T (MHz)
$-V_{CE} = 5$ V
f = 35 MHz
$T_j = 25$ °C
typ
$-I_C$ (mA)
0
50
100
150
1
10
10^2
10^3

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.

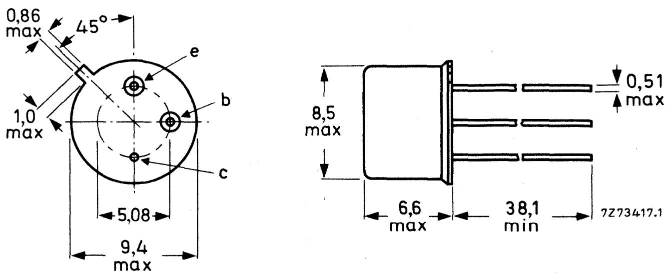
QUICK REFERENCE DATA

			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 °C	P_{tot}	max.	600	600	600	600	600	mW
Small-signal current gain $-I_C$ = 1 mA; $-V_{CE}$ = 6 V; f = 1 kHz	h_{fe}	typ.	25	35	55	25	35	
Transition frequency $-I_C$ = 1 mA; $-V_{CE}$ = 6 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 °C	P_{tot}	max.		600		mW
up to T_{case} = 45 °C	P_{tot}	max.		3		W
Storage temperature	T_{stg}			−65 to + 150		°C
Junction temperature	T_j	max.		150		°C

THERMAL RESISTANCE

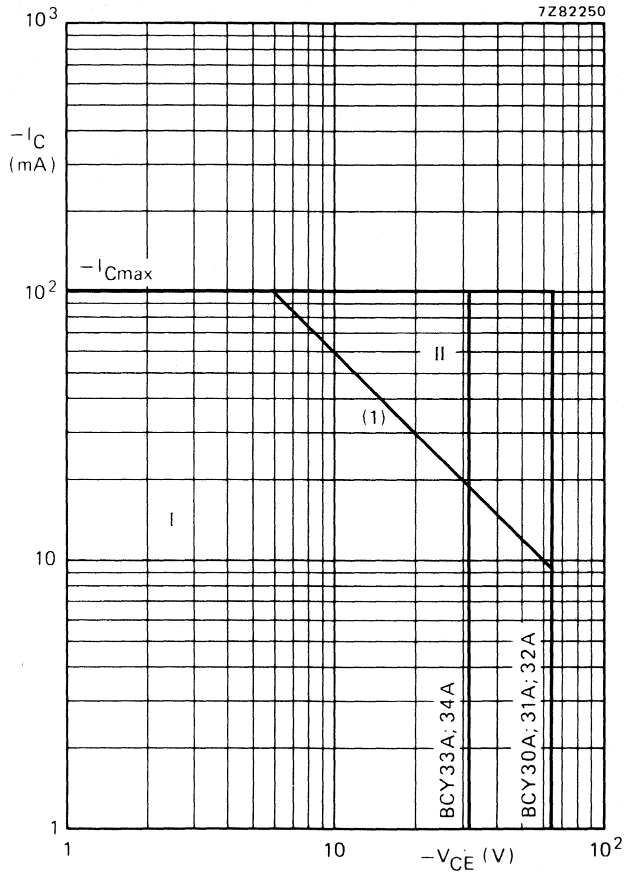
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	200	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	35	K/W

CHARACTERISTICS

T_{amb} = 25 °C

			BCY 30A	BCY 31A	BCY 32A	BCY 33A	BCY 34A	
Collector cut-off current								
$I_E = 0; -V_{CB} = 64$ V	$-I_{CBO}$	<	1,4	1,4	1,4	–	–	μA
$I_E = 0; -V_{CB} = 32$ V	$-I_{CBO}$	<	–	–	–	0,5	0,5	μA
Emitter cut-off current								
$I_C = 0; -V_{EB} = 45$ V	$-I_{EBO}$	<	0,5	0,5	–	–	–	μA
$I_C = 0; -V_{EB} = 32$ V	$-I_{EBO}$	<	–	–	0,5	–	–	μA
$I_C = 0; -V_{EB} = 16$ V	$-I_{EBO}$	<	–	–	–	0,5	0,5	μA
Collector-emitter saturation voltage		typ.	35	35	35	35	35	mV
$-I_C = 250\ \mu A; -I_B = 50\ \mu A$	$-V_{CEsat}$	<	170	170	170	170	170	mV
		typ.	85	60	65	85	60	mV
$-I_C = 20$ mA; $-I_B = 3$ mA	$-V_{CEsat}$	<	550	550	550	550	550	mV
Base-emitter voltage		typ.	0,85	0,80	0,80	0,85	0,80	V
$-I_C = 20$ mA; $-V_{CE} = 4,5$ V	$-V_{BE}$	<	1,45	1,45	1,45	1,45	1,45	V
D.C. current gain		>	10	15	20	10	15	
$-I_C = 20$ mA; $-V_{CE} = 4,5$ V	h_{FE}	typ.	18	28	35	18	28	
		<	35	60	70	35	60	
Small-signal current gain		>	15	25	35	15	25	
$-I_C = 1$ mA; $-V_{CE} = 6$ V; f = 1 kHz	h_{fe}	typ.	25	35	55	25	35	
		<	35	60	80	35	60	
Transition frequency		typ.	2,0	2,0	2,0	2,0	2,0	MHz
$-I_C = 1$ mA; $-V_{CE} = 6$ V	f_T	<	7,0	10	15	7,0	10	MHz
Noise figure at f = 1 kHz		typ.	8	8	8	8	8	dB
$I_E = 500\ \mu A; -V_{CE} = 2$ V; $R_S = 500\ \Omega$	F	<	20	20	20	20	20	dB
Collector capacitance at f = 500 kHz		>	15	15	15	15	15	pF
$I_E = I_e = 0; -V_{CB} = 6$ V	C_c	typ.	20	20	20	20	20	pF
		<	65	65	65	65	65	pF
Emitter resistance *								
$-I_C = 1$ mA; $-V_{CE} = 6$ V	r_e	typ.	25	25	25	25	25	Ω
Base resistance		>	80	100	110	60	50	Ω
$-I_C = 1$ mA; $-V_{CE} = 6$ V; f = 500 kHz	$r_{bb'}$	typ.	160	220	230	190	235	Ω
		<	500	500	500	500	500	Ω
h-parameters (common emitter)								
$-I_C = 1$ mA; $-V_{CE} = 6$ V; f = 1600 Hz								
Input impedance	h_{ie}	typ.	1,1	1,4	1,7	1,1	1,4	kΩ
Reverse voltage transfer ratio	h_{re}	typ.	3,0	6,0	5,0	3,0	6,0	10^{-4}
Output admittance	h_{oe}	typ.	17	25	30	17	25	μA/V

* The value of r_e given here is $\frac{kT}{q} \times \frac{1}{I_E} \approx \frac{25}{I_E}$, where I_E is in mA and T is in K.



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

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

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

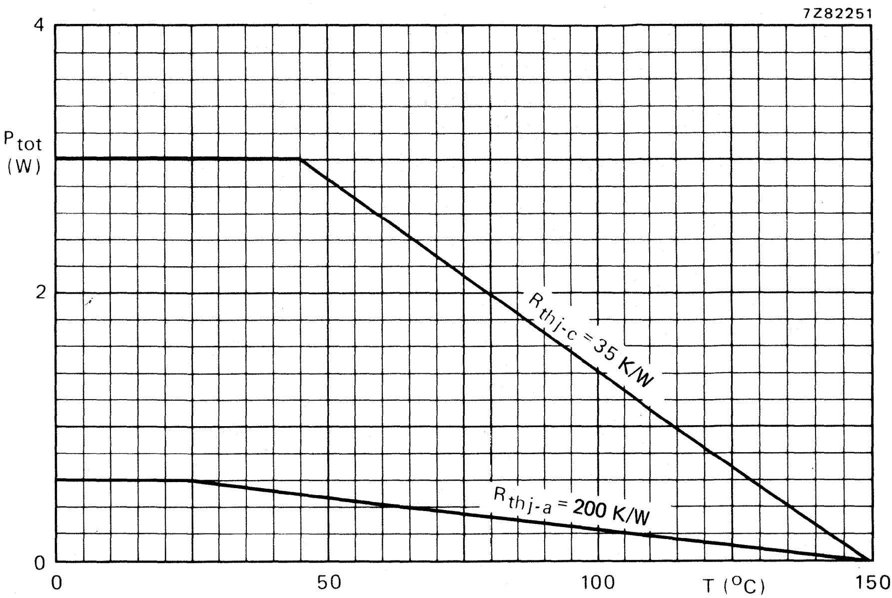

7Z82251
4
2
0
P_{tot} (W)
$R_{th\,j\text{-}c}$ = 35 K/W
$R_{th\,j\text{-}a}$ = 200 K/W
0
50
100
T (°C)
150

Fig. 3.

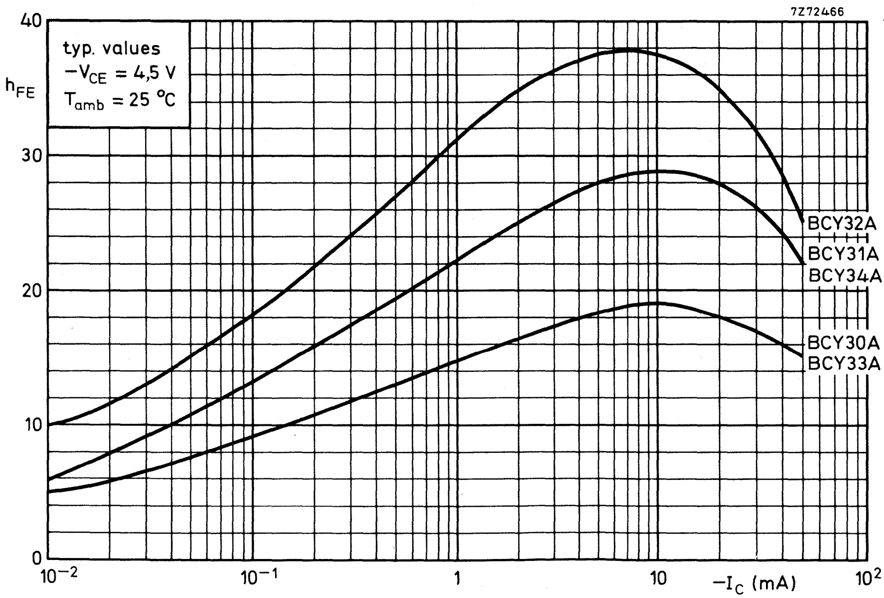

7Z72466
typ. values
$-V_{CE}$ = 4,5 V
T_{amb} = 25 °C
h_{FE}
40
30
20
10
0
BCY32A
BCY31A
BCY34A
BCY30A
BCY33A
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2

Fig. 4.

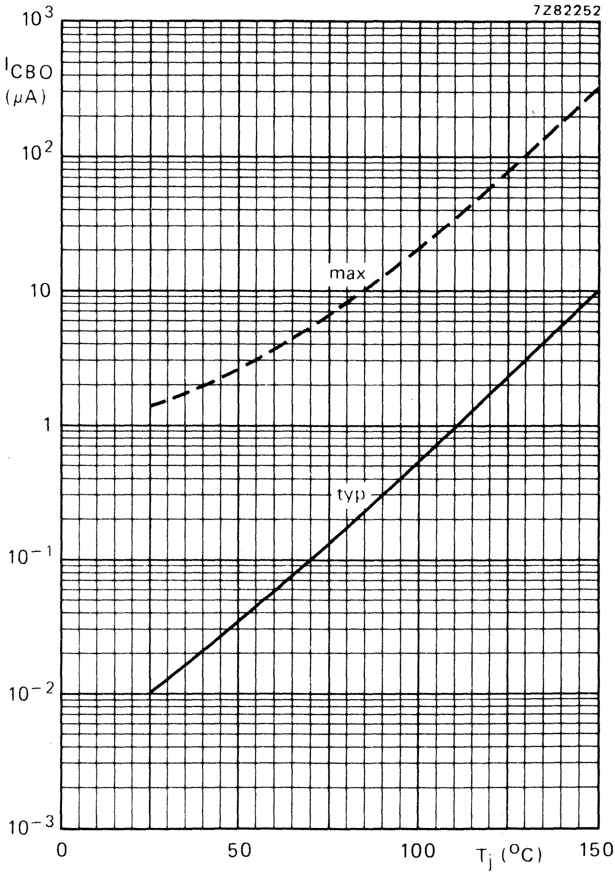


Fig. 5 **BCY30A to BCY32A**; $-V_{CB}$ = 64 V.

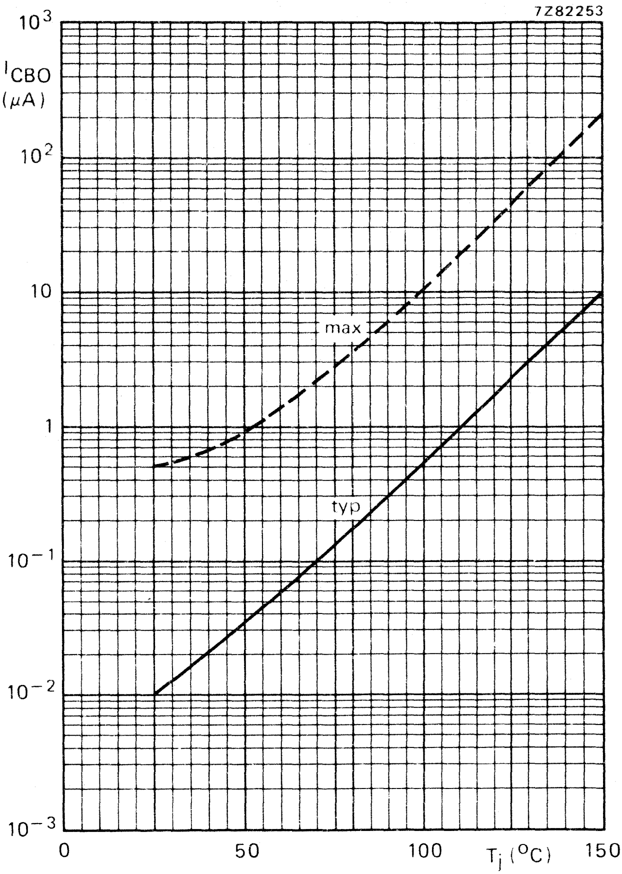


Fig. 6 **BCY33A**; **BCY34A**; $-V_{CB}$ = 32 V.

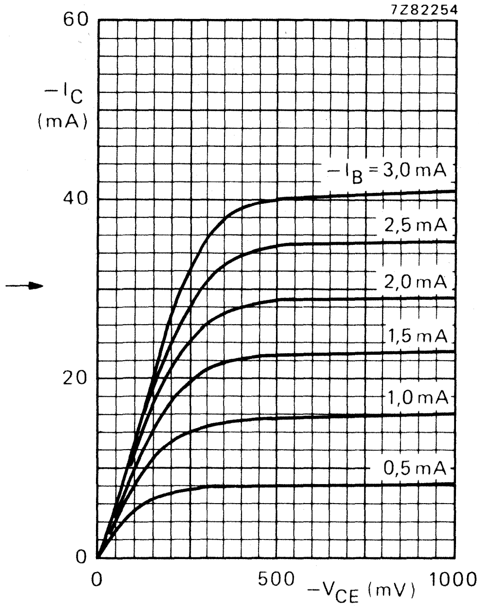


Fig. 7 **BCY30A; BCY33A.**

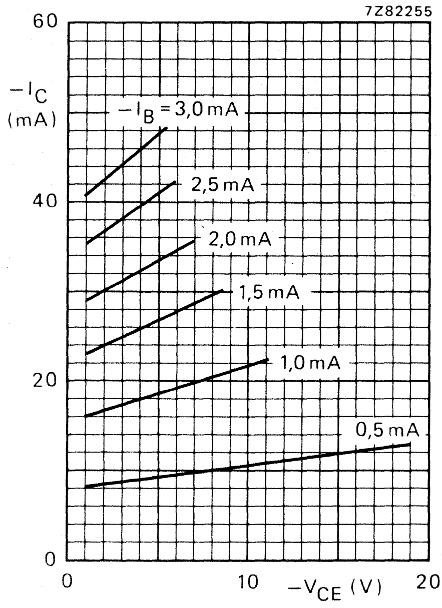


Fig. 8 **BCY30A; BCY33A.**

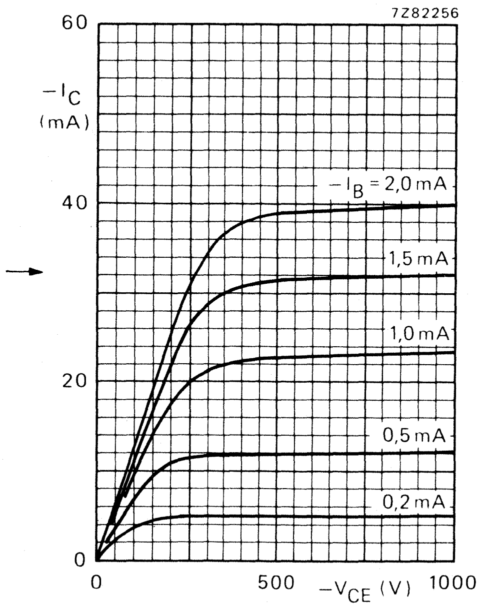


Fig. 9 **BCY31A; BCY34A.**

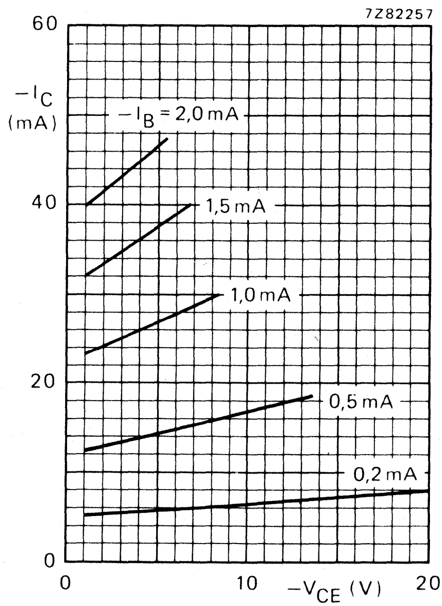


Fig. 10 **BCY31A; BCY34A.**

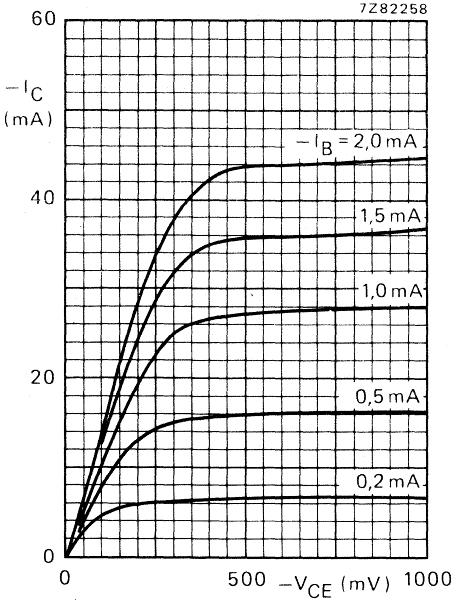


Fig. 11 **BCY32A.**

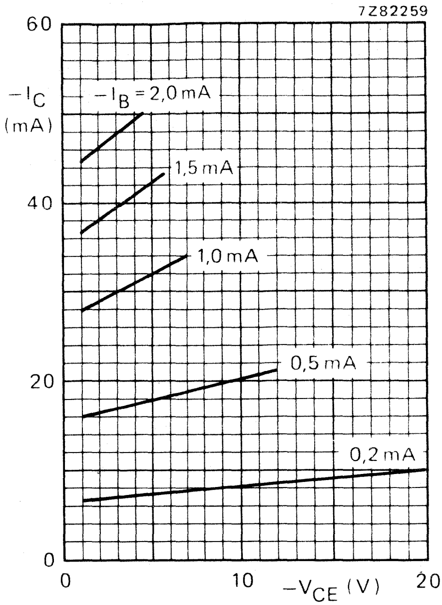


Fig. 12 **BCY32A.**

Measuring conditions for Figs 7 to 12:
Common-emitter; T_{amb} = 25 ^oC; typical values.

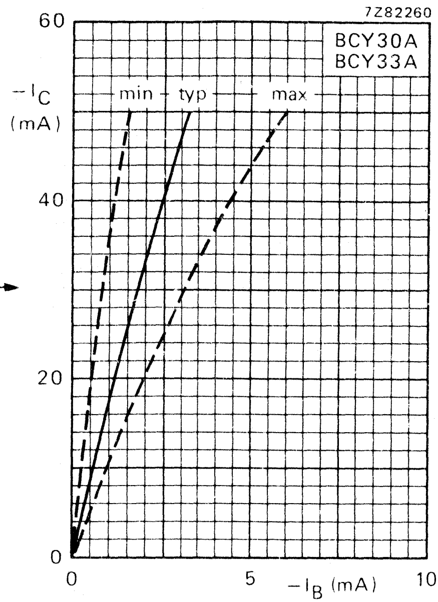


Fig. 13.

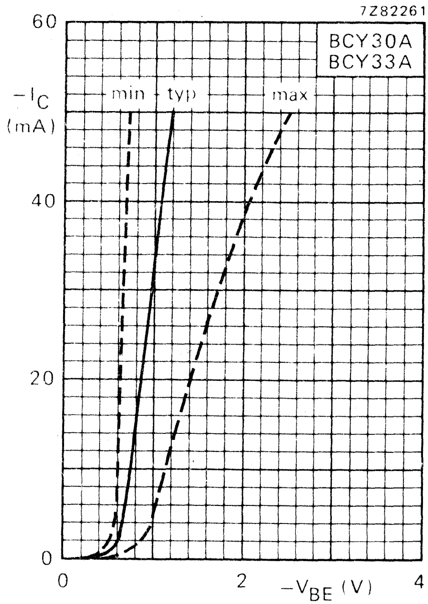


Fig. 14.

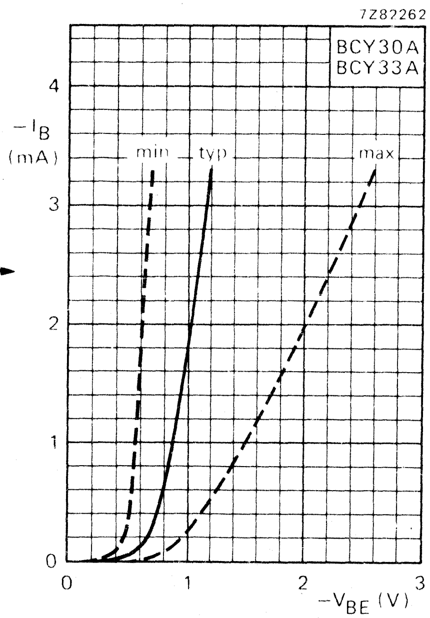


Fig. 15.

Measuring conditions for Figs 13 to 15:
Common-emitter; $-V_{CE}$ = 4,5 V; T_{amb} = 25 °C.

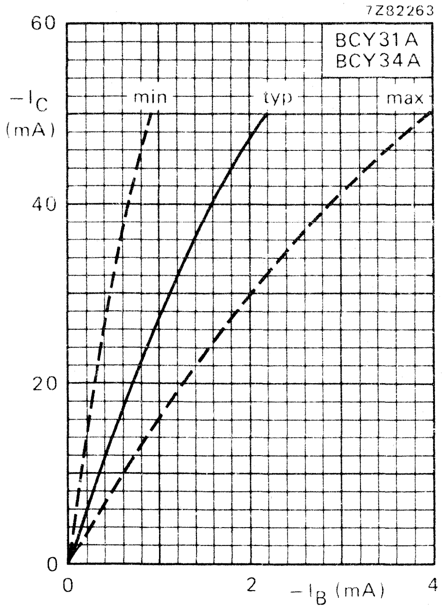


Fig. 16.

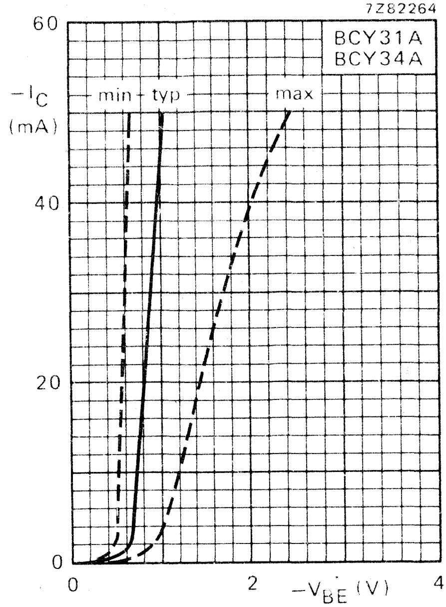


Fig. 17.

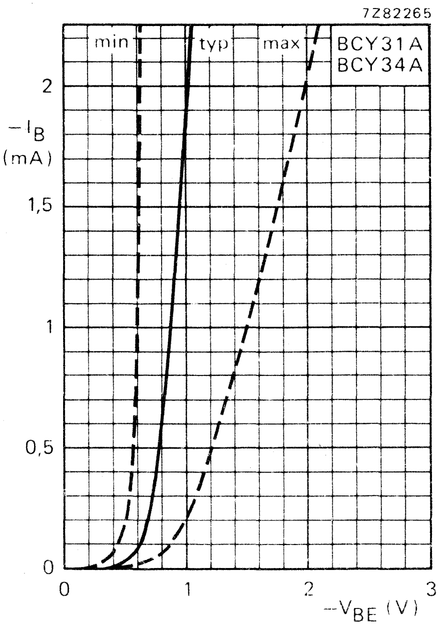


Fig. 18.

Measuring conditions for Figs 16 to 18:

Common-emitter; $-V_{CE}$ = 4,5 V; T_{amb} = 25 °C.

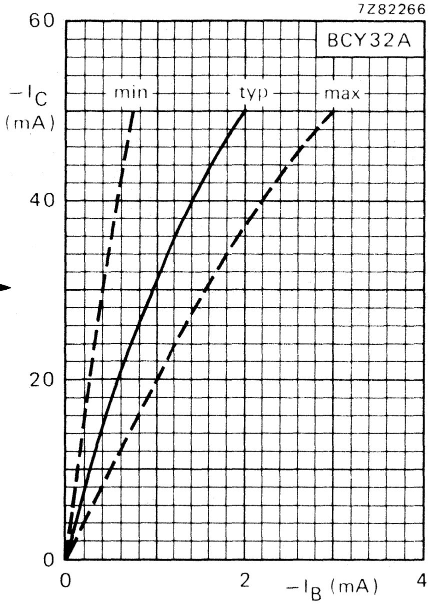


Fig. 19 Common-emitter; $-V_{CE}$ = 4,5 V; T_{amb} = 25 °C.

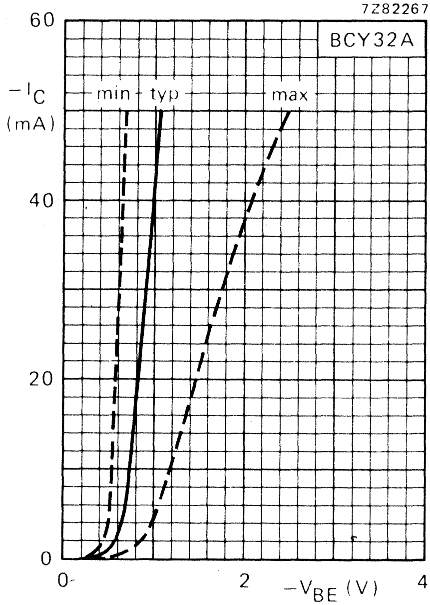


Fig. 20 Common-emitter; $-V_{CE}$ = 4,5 V; T_{amb} = 25 °C.

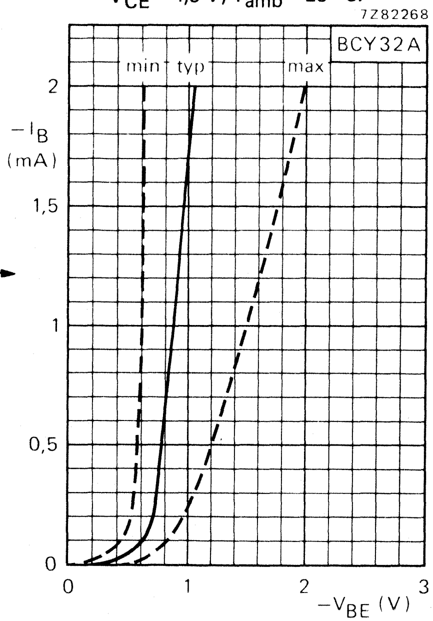


Fig. 21 Common-emitter; $-V_{CE}$ = 4,5 V; T_{amb} = 25 °C.

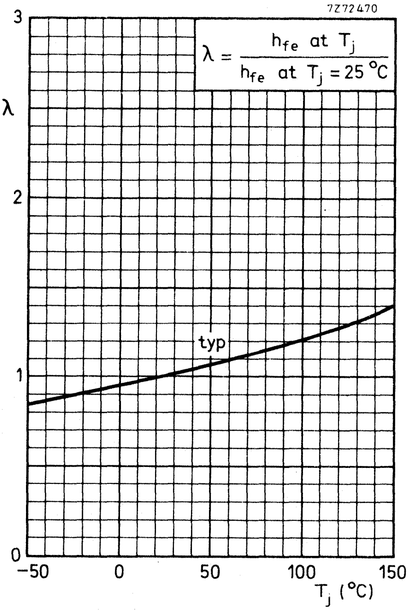


Fig. 22.

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

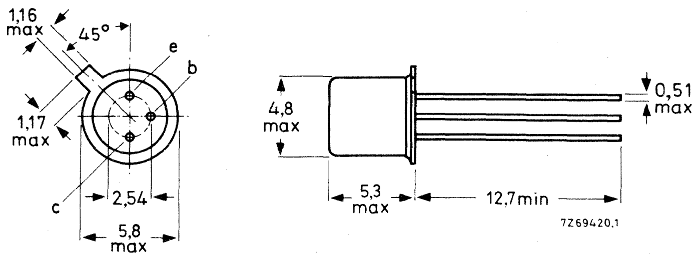
			BCY56	BCY57	
Collector-base voltage (open emitter)	V_{CBO}	max	45	25	V
Collector-emitter voltage (open base)	V_{CEO}	max	45	20	V
Collector current (d.c.)	I_C	max	100	100	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max	300	300	mW
Junction temperature	T_j	max	175	175	°C
D.C. current gain at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

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-18.

Collector connected to case



Accessories: 56246 (distance disc).

RATINGS (Limiting values) [1])

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 °C	P_{tot}	max.	300	mW

Temperatures

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 T_j = 25 °C unless otherwise specified

Collector cut-off current

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

Emitter cut-off current

$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	100	nA

Base-emitter voltage [2])

$I_C = 2$ 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

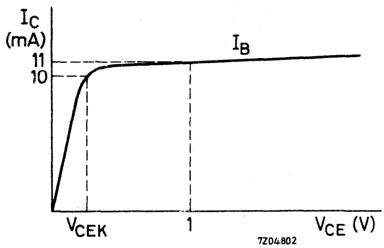
[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

[2]) V_{BE} decreases with about 2 mV/°C at increasing temperature.

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

Knee voltage

I_C = 10 mA; I_B = value for which I_C = 11 mA at V_{CE} = 1 V	V_{CEK}	typ.	300	mV
		<	600	mV



			BCY56	BCY57	
D.C. current gain					
I_C = 10 μA; V_{CE} = 5 V	h_{FE}	>	40	100	
I_C = 2 mA; V_{CE} = 5 V	h_{FE}	typ.	200	400	
			100 to 450	200 to 800	
I_C = 10 mA; V_{CE} = 5 V	h_{FE}	>	100	200	
Transition frequency					
I_C = 0.5 mA; V_{CE} = 5 V	f_T	typ.	85	100	MHz
I_C = 10 mA; V_{CE} = 5 V	f_T	typ.	250	350	MHz
h parameters at f = 1 kHz					
I_C = 2 mA; V_{CE} = 5 V					
Input impedance	h_{ie}	typ.	3.5	7.5	kΩ
Reverse voltage transfer	h_{re}	typ.	1.75	3.5	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	$\mu\Omega^{-1}$
Collector capacitance at f = 1 MHz					
$I_E = I_e$ = 0; V_{CB} = 5 V	C_c	typ.	4.5	4.5	pF
Noise figure					
I_C = 200 μA; V_{CE} = 5 V; R_S = 2 kΩ					
f = 30 Hz to 15.7 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_{CEO}	max.	32	45	V
Collector current (d.c.)	I_C	max.	200	200	mA
Total power dissipation					
up to T_{amb} = 45 °C	P_{tot}	max.	330	330	mW
up to T_{case} = 45 °C	P_{tot}	max.	1000	1000	mW
Junction temperature	T_j	max.	200	200	°C

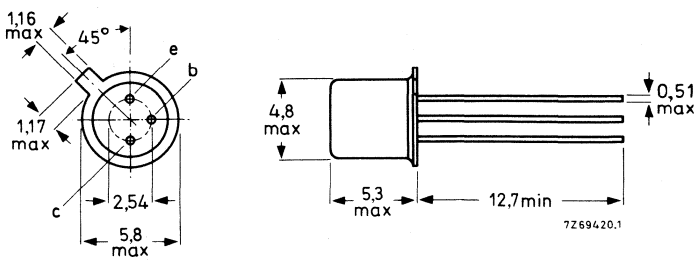
			BCY58–VII BCY59–VII	VIII VIII	IX IX	X X	
Small-signal current gain at T_j = 25 °C I_C = 2 mA; V_{CE} = 5 V; f = 1 kHz	h_{fe}	> <	125 250	175 350	250 500	350 700	
Transition frequency at f = 100 MHz I_C = 10 mA; V_{CE} = 5 V	f_T	typ.		280			MHz
Noise figure at R_S = 2 kΩ I_C = 200 μA; V_{CE} = 5 V f = 1 kHz; B = 200 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)

			BCY58	BCY59	
Voltages					
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** ^{o}C	P_{tot}	max.	1000	mW
Temperatures				
Storage temperature	T_{stg}	− 65 to	+200	^{o}C
Junction temperature	T_j	max.	200	^{o}C

THERMAL RESISTANCE

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

CHARACTERISTICS

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

			BCY58	BCY59	
Collector cut-off currents					
$V_{CE} = 32$ V; $V_{BE} = 0$	I_{CES}	typ.	0.2		nA
		<	10		nA
$V_{CE} = 45$ V; $V_{BE} = 0$	I_{CES}	typ.		0.2	nA
		<		10	nA
$V_{CE} = 32$ V; $V_{BE} = 0$; $T_j = 150\,^{o}C$	I_{CES}	typ.	0.2		µA
		<	10		µA
$V_{CE} = 45$ V; $V_{BE} = 0$; $T_j = 150\,^{o}C$	I_{CES}	typ.		0.2	µA
		<		10	µA
Emitter cut-off current					
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10	10	nA
Collector-emitter breakdown voltage					
$I_B = 0$; $I_C = 2$ mA	$V_{(BR)CEO}$	>	32	45	V
Emitter-base breakdown voltage					
$I_C = 0$; $I_E = 1\ \mu A$	$V_{(BR)EBO}$	>	7	7	V

Base emitter voltage				
$I_C = 10\ \mu A$; $V_{CE} = 5$ V	V_{BE}	typ.	0.5	V
$I_C = 20\ \mu A$; $V_{CE} = V_{CEO\,max}$; $T_j = 100\,^{o}C$	V_{BE}	>	0.2	V
$I_C = 2$ mA; $V_{CE} = 5$ V	V_{BE}	typ.	0.62	V
			0.55 to 0.70	V
$I_C = 10$ mA; $V_{CE} = 1$ V	V_{BE}	typ.	0.70	V
$I_C = 100$ mA; $V_{CE} = 1$ V	V_{BE}	typ.	0.76	V
Saturation voltages				
$I_C = 10$ mA; $I_B = 0.25$ mA	V_{CEsat}	typ.	100	mV
			50 to 350	mV
	V_{BEsat}	typ.	700	mV
			600 to 850	mV
$I_C = 100$ mA; $I_B = 2.5$ mA	V_{CEsat}	typ.	250	mV
			150 to 700	mV
	V_{BEsat}	typ.	875	mV
			750 to 1200	mV

CHARACTERISTICS (continued)

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

Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	typ.	3.0	pF
		<	5.0	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	typ.	10	pF
		<	15	pF
Transition frequency at f = 100 MHz				
$I_C = 10$ mA; $V_{CE} = 5$ V	f_T	>	150	MHz
		typ.	280	MHz
Noise figure at $R_S = 2$ kΩ				
$I_C = 200$ µA; $V_{CE} = 5$ V				
f = 1 kHz; B = 200 Hz	F	typ.	2	dB
		<	6	dB

			BCY58VII BCY59VII	BCY58VIII BCY59VIII	BCY58IX BCY59IX	BCY58X BCY59X	
D. C. current gain							
$I_C = 10$ µA; $V_{CE} = 5$ V	h_{FE}	>	–	20	40	100	
		typ.	20	95	190	300	
$I_C = 2$ mA; $V_{CE} = 5$ V	h_{FE}	>	120	180	250	380	
		typ.	170	250	350	500	
		<	220	310	460	630	
$I_C = 10$ mA; $V_{CE} = 1$ V	h_{FE}	>	80	120	160	240	
		typ.	250	300	390	550	
		<	–	400	630	1000	
$I_C = 100$ mA; $V_{CE} = 1$ V	h_{FE}	>	40	45	60	60	
h parameters at f = 1 kHz							
$I_C = 2$ mA; $V_{CE} = 5$ V							
Input impedance	h_{ie}	>	1.6	2.5	3.2	4.5	kΩ
		typ.	2.7	3.6	4.5	7.5	kΩ
		<	4.5	6.0	8.5	12	kΩ
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	µA/V
		<	30	50	60	100	µA/V

CHARACTERISTICS (continued)

Switching times

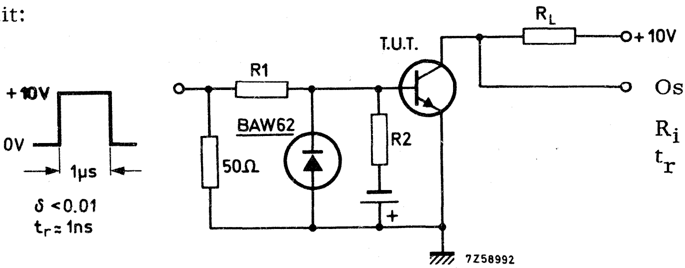
I_C = 10 mA; I_B = 1 mA; $-I_{BM}$ = 1 mA
R1 = 5 kΩ; R2 = 5 kΩ; R_L = 990 Ω
V_{BB} = 3.6 V

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

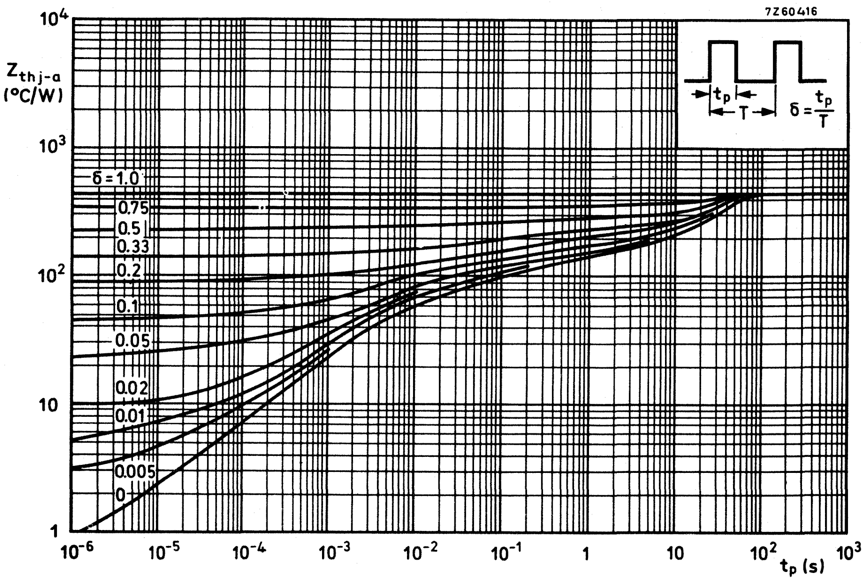
I_C = 100 mA; I_B = 10 mA; $-I_{BM}$ = 10 mA
R1 = 500 Ω; R2 = 700 Ω; R_L = 98 Ω
V_{BB} = 5 V

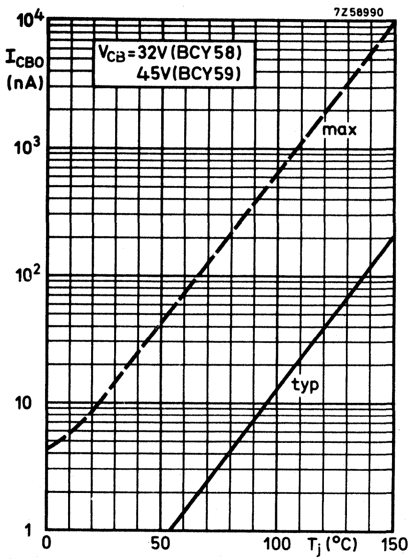
delay time	t_d	typ.	5	ns
rise time	t_r	typ.	50	ns
turn on time	t_{on}	typ.	55	ns
		<	150	ns
storage time	t_s	typ.	250	ns
fall time	t_f	typ.	200	ns
turn off time	t_{off}	typ.	450	ns
		<	800	ns

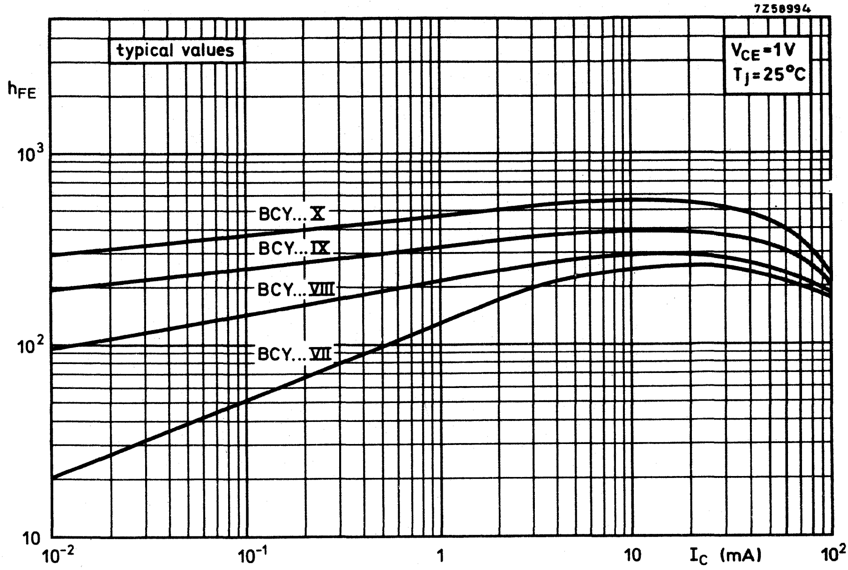
Test circuit:

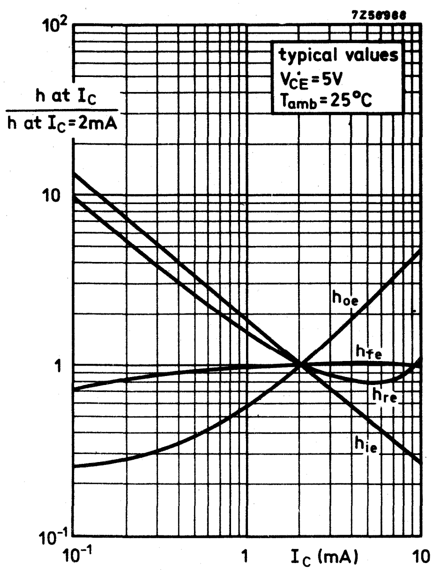


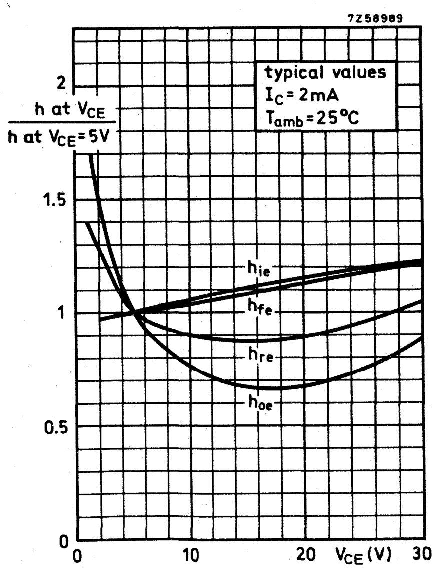
Oscilloscope:
R_i > 100 kΩ
t_r < 15 ns

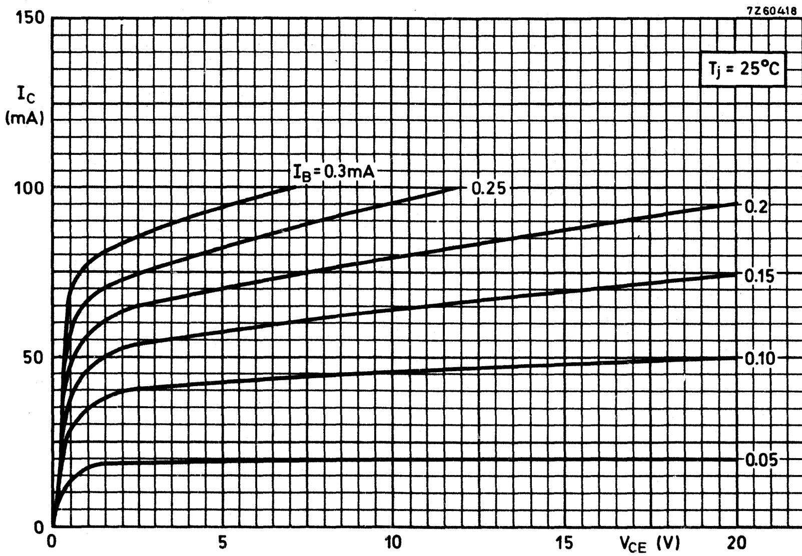

7Z60416
$Z_{th\,j-a}$ (°C/W)
t_p (s)
δ = 1.0
0.75
0.5
0.33
0.2
0.1
0.05
0.02
0.01
0.005
0
$\delta = \frac{t_p}{T}$

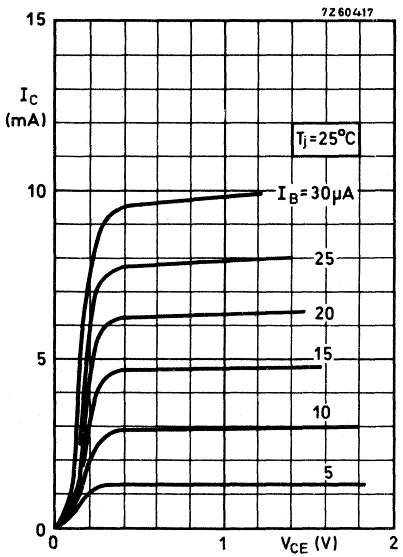

7Z58990
I_{CBO} (nA)
V_{CB} = 32V (BCY58)
45V (BCY59)
max
typ
T_j (°C)

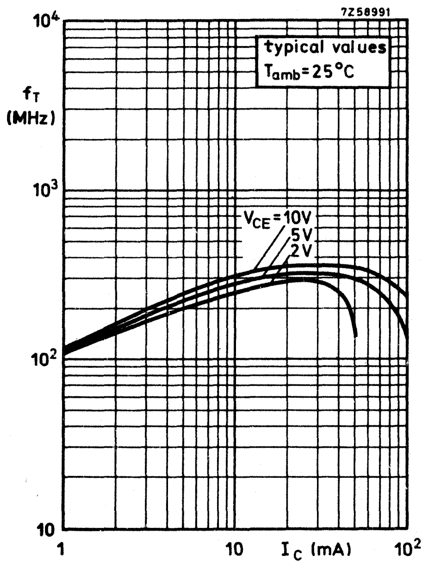

7Z58994
typical values
V_{CE}=1V
T_j=25°C
h_{FE}
10^3
10^2
10
BCY... X
BCY... IX
BCY... VIII
BCY... VII
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2

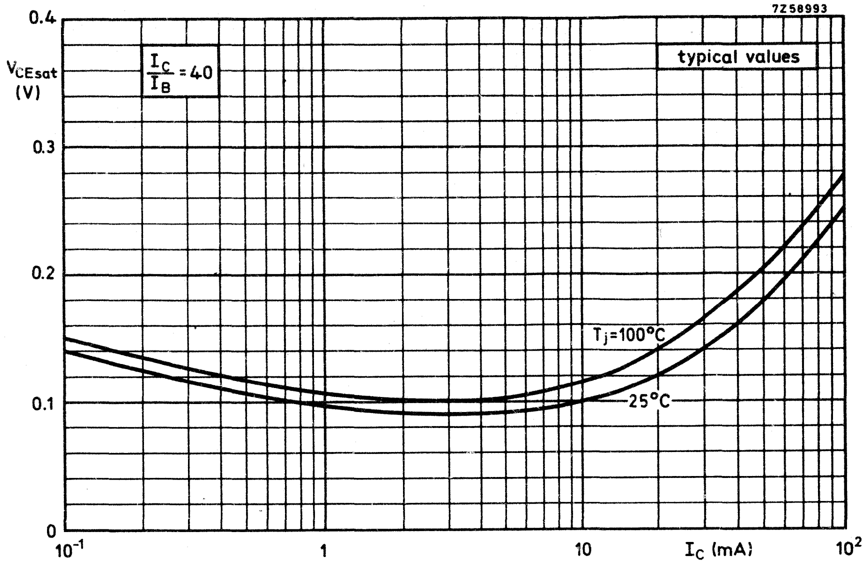

7Z58988
typical values
V_{CE}=5V
T_{amb}=25°C
h at I_C
h at I_C=2mA
10^2
10
1
10^{-1}
h_{oe}
h_{fe}
h_{re}
h_{ie}
10^{-1}
1
I_C (mA)
10

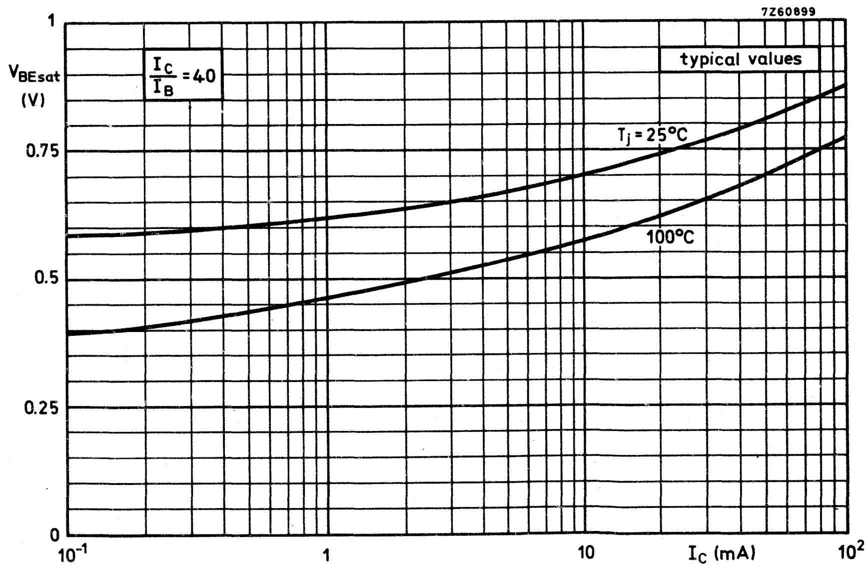

7Z58989
typical values
I_C=2mA
T_{amb}=25°C
h at V_{CE}
h at V_{CE}=5V
2
1.5
1
0.5
0
h_{ie}
h_{fe}
h_{re}
h_{oe}
0
10
20
V_{CE} (V)
30


7Z60418
150
100
50
0
I_C (mA)
$T_j = 25°C$
$I_B = 0.3mA$
0.25
0.2
0.15
0.10
0.05
0
5
10
15
V_{CE} (V)
20


7Z60417
15
10
5
0
I_C (mA)
$T_j = 25°C$
$I_B = 30 \mu A$
25
20
15
10
5
0
1
V_{CE} (V)
2


7Z58991
10^4
10^3
10^2
10
f_T (MHz)
typical values
$T_{amb} = 25°C$
$V_{CE} = 10V$
5V
2V
1
10
I_C (mA)
10^2


7Z58993
0.4
VCEsat
(V)
IC/IB = 40
typical values
0.3
0.2
Tj=100°C
0.1
25°C
0
10-1
1
10
IC (mA)
102


7Z60899
1
VBEsat
(V)
IC/IB = 40
typical values
Tj = 25°C
0.75
100°C
0.5
0.25
0
10-1
1
10
IC (mA)
102

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

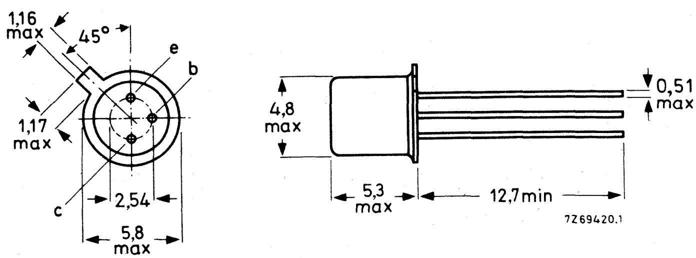
			BCY70	BCY71	BCY72	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	50	45	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	45	25	V
Collector current (peak value)	$-I_{CM}$	max.		200		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.		350		mW
Junction temperature	T_j	max.		200		°C
D.C. current gain $-I_C$ = 10 mA; $-V_{CE}$ = 1 V	h_{FE}	>		100		
Transition frequency at f = 100 MHz $-I_C$ = 10 mA; $-V_{CE}$ = 20 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 °C	P_{tot}	max.		350		mW
Storage temperature	T_{stg}			–65 to + 200		°C
Junction temperature	T_j	max.		200		°C

THERMAL RESISTANCE

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

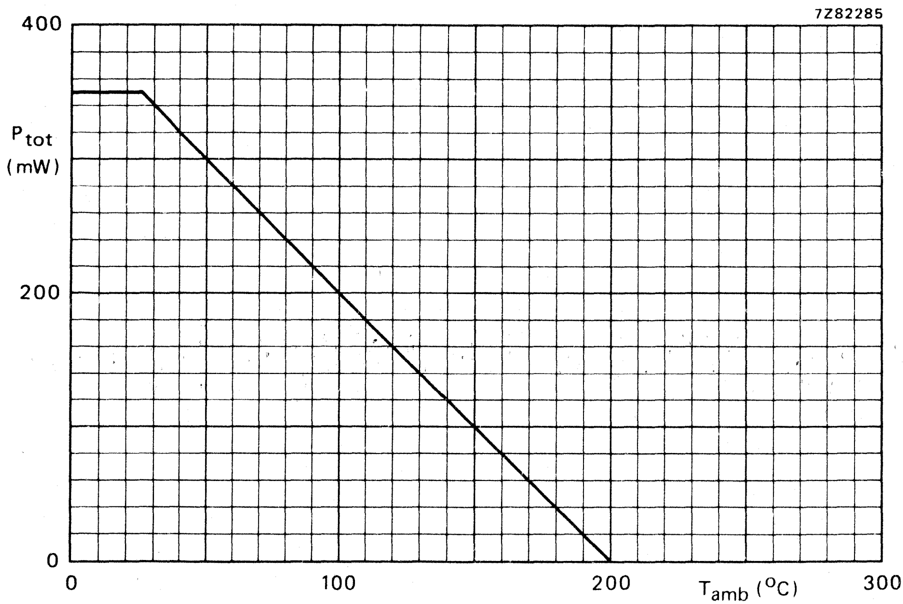


Fig. 2 Maximum permissible power dissipation as a function of ambient temperature.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

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

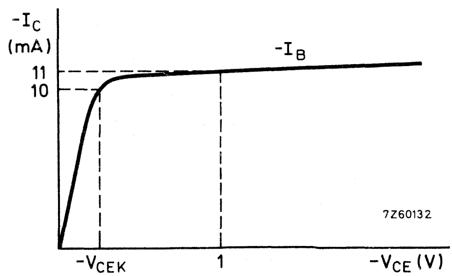


Fig. 3.

D.C. current gain					
$-I_C = 10\ \mu A$; $-V_{CE} = 1,0\ V$		h_{FE}	>	60	
			typ.	245	
$-I_C = 0,1\ mA$; $-V_{CE} = 1,0\ V$		h_{FE}	>	80	
			typ.	270	
$-I_C = 1,0\ mA$; $-V_{CE} = 1,0\ V$		h_{FE}	>	100	
			typ.	300	
$-I_C = 10\ mA$; $-V_{CE} = 1,0\ V$		h_{FE}	>	100	
			typ.	290	
$-I_C = 10\ mA$; $-V_{CE} = 1,0\ V$	**BCY71**	h_{FE}	<	400	
$-I_C = 50\ mA$; $-V_{CE} = 1,0\ V$		h_{FE}	>	45	
			typ.	175	
Collector capacitance at f = 1 MHz					
$I_E = I_e = 0$; $-V_{CB} = 10\ V$		C_c	typ.	4,5	pF
			<	6,0	pF
Emitter capacitance at f = 1 MHz					
$I_C = I_c = 0$; $-V_{EB} = 1,0\ V$		C_e	typ.	6,0	pF
			<	8,0	pF

			BCY70	**BCY71**	**BCY72**	
Transition frequency at $T_{amb} = 25\ ^oC$						
$-I_C = 10\ mA$; $-V_{CE} = 20\ V$; f = 100 MHz	f_T	>	250	250	250	MHz
		typ.	450	450	450	MHz
$-I_C = 100\ \mu A$; $-V_{CE} = 20\ V$; f = 10,7 MHz	f_T	>	–	15	–	MHz
		typ.	–	30	–	MHz
Noise figure						
$-I_C = 100\ \mu A$; $-V_{CE} = 5,0\ V$						
f = 10 Hz to 10 kHz; $R_S = 2,0\ k\Omega$	F	typ.	2,0	0,8	2,0	dB
		<	6,0	2,0	6,0	dB
h-parameters (common emitter)						
$-I_C = 1,0\ mA$; $-V_{CE} = 10\ V$; f = 1 kHz;						
$T_{amb} = 25\ ^oC$		>	–	2,0	–	kΩ
Input impedance	h_{ie}	typ.	–	4,0	–	kΩ
		<	–	12,0	–	kΩ
Reverse voltage transfer ratio	h_{re}	typ.	–	2,1	–	10^{-4}
		<	–	20,0	–	10^{-4}
Small-signal current gain	h_{fe}	>	–	150	–	
		typ.	–	325	–	
		<	–	400	–	
Output admittance	h_{oe}	>	–	10	–	μA/V
		typ.	–	20	–	μA/V
		<	–	60	–	μA/V

Switching times of the **BCY70** and **BCY72**.

$-I_C = 10$ mA; $-I_{Bon} = +I_{Boff} = 1$ mA

delay time	t_d	typ.	23 ns
		<	35 ns
rise time	t_r	typ.	25 ns
		<	35 ns
turn-on time	t_{on}	typ.	48 ns
		<	65 ns
storage time	t_s	typ.	270 ns
		<	350 ns
fall time	t_f	typ.	50 ns
		<	80 ns
turn-off time	t_{off}	typ.	320 ns
		<	420 ns

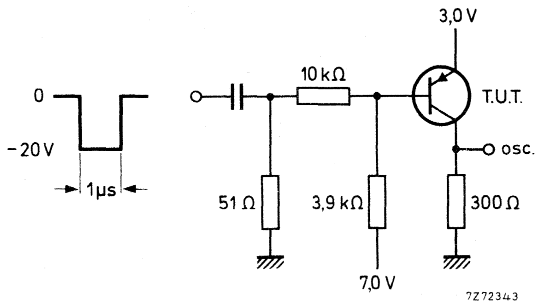


Fig. 4 Test circuit.

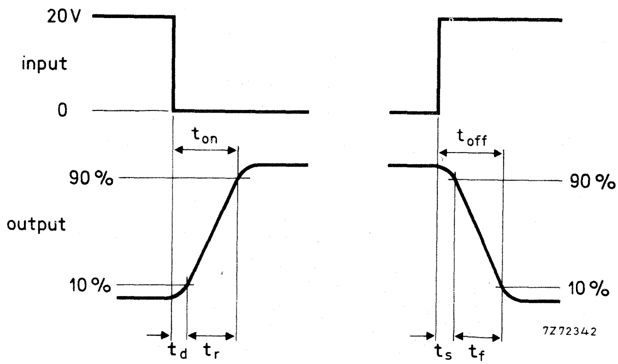


Fig. 5 Switching waveforms.

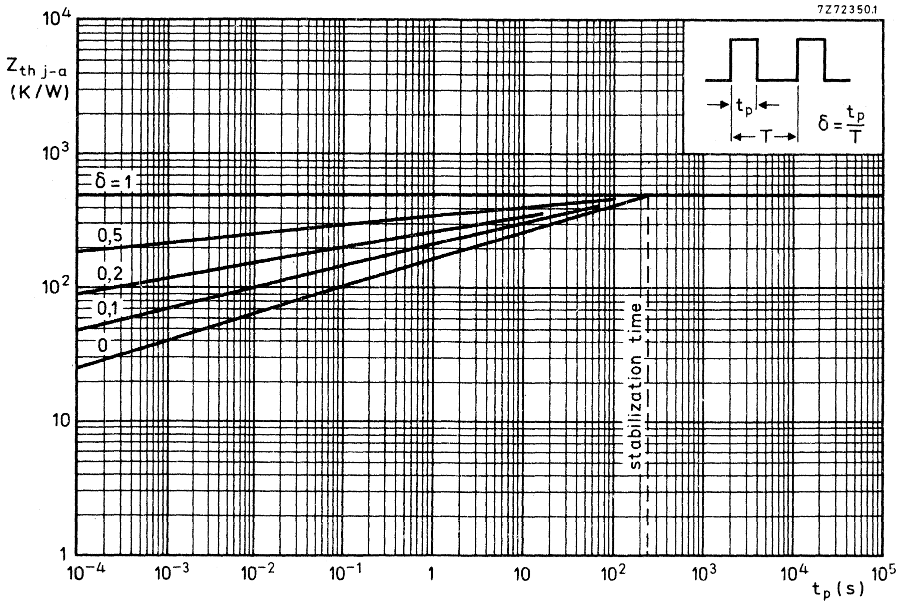

7Z72350.1
$Z_{th\ j-a}$ (K/W)
$\delta = 1$
0,5
0,2
0,1
0
stabilization time
$\delta = \frac{t_p}{T}$
t_p
T
t_p (s)

Fig. 6.

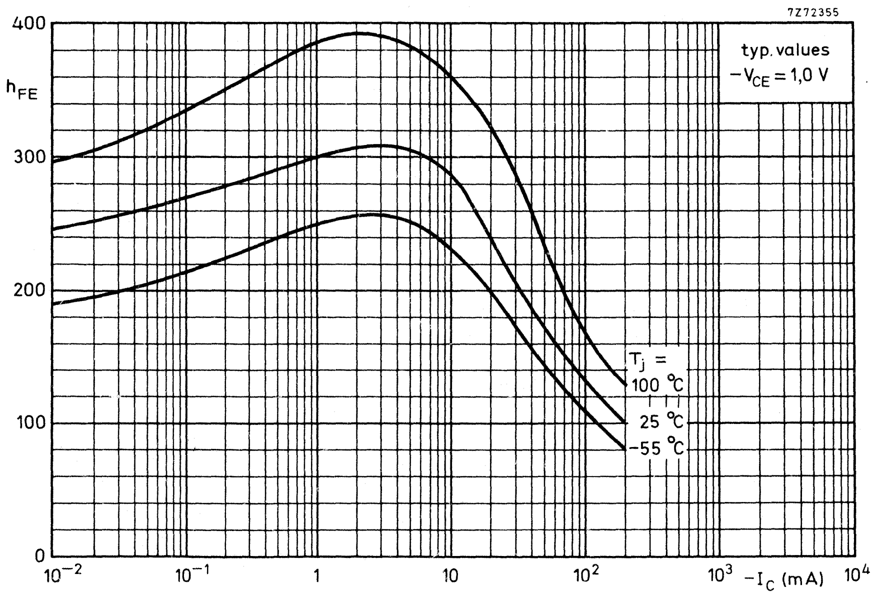

7Z72355
h_{FE}
typ. values
$-V_{CE} = 1,0$ V
T_j =
100 °C
25 °C
−55 °C
$-I_C$ (mA)

Fig. 7.

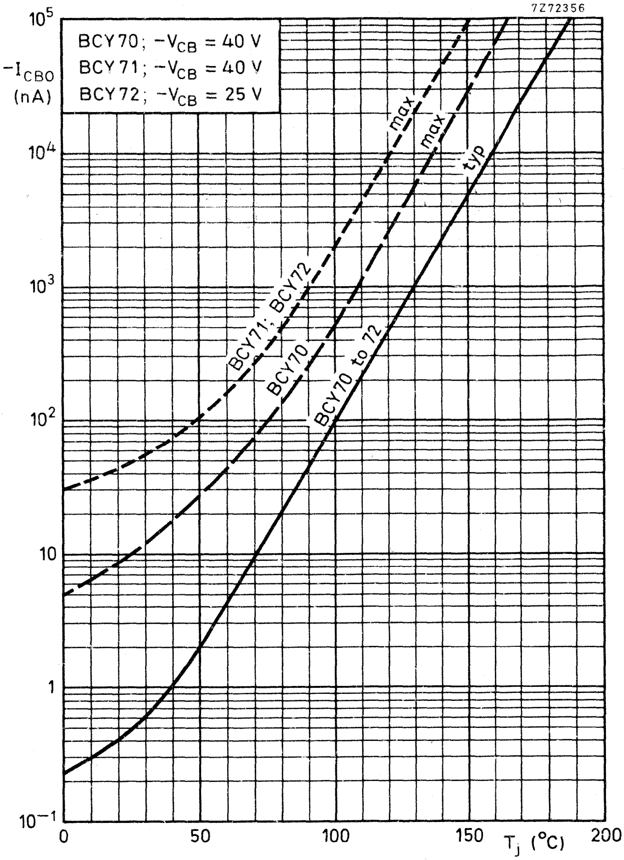

7Z72356
BCY70; $-V_{CB}$ = 40 V
BCY71; $-V_{CB}$ = 40 V
BCY72; $-V_{CB}$ = 25 V
$-I_{CBO}$ (nA)
10^5
10^4
10^3
10^2
10
1
10^{-1}
max
max
typ
BCY71; BCY72
BCY70
BCY70 to 72
0
50
100
150
200
T_j (°C)

Fig. 8.

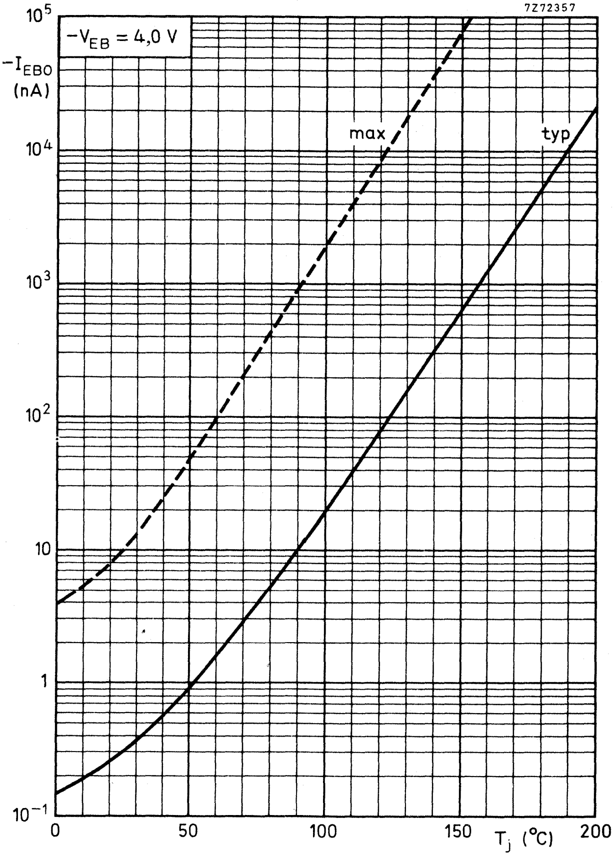

7Z72357
$-V_{EB} = 4{,}0$ V
$-I_{EBO}$ (nA)
10^5
10^4
10^3
10^2
10
1
10^{-1}
max
typ
0
50
100
150
200
T_j (°C)

Fig. 9.

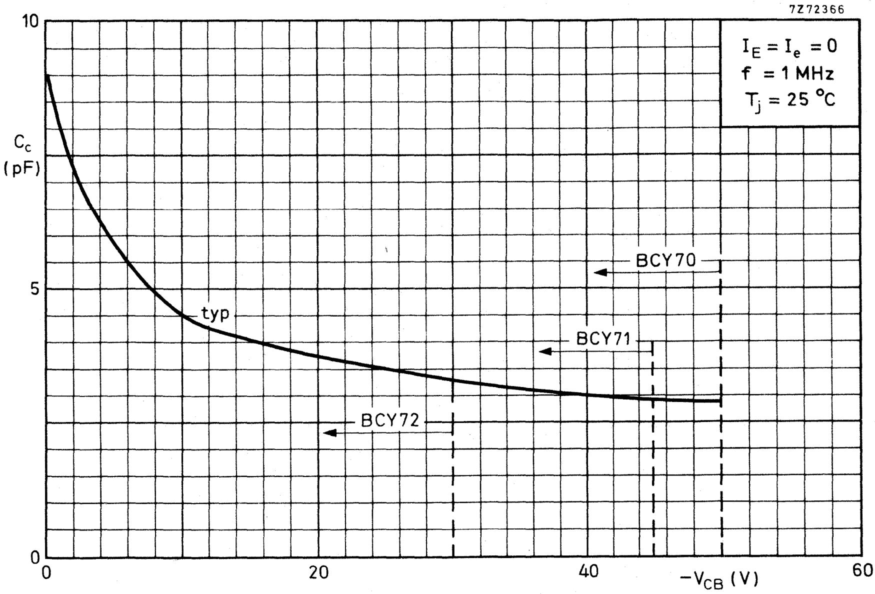

7Z72366
$I_E = I_e = 0$
f = 1 MHz
T_j = 25 °C
C_c (pF)
10
5
0
BCY70
BCY71
BCY72
typ
0
20
40
60
$-V_{CB}$ (V)

Fig. 10.

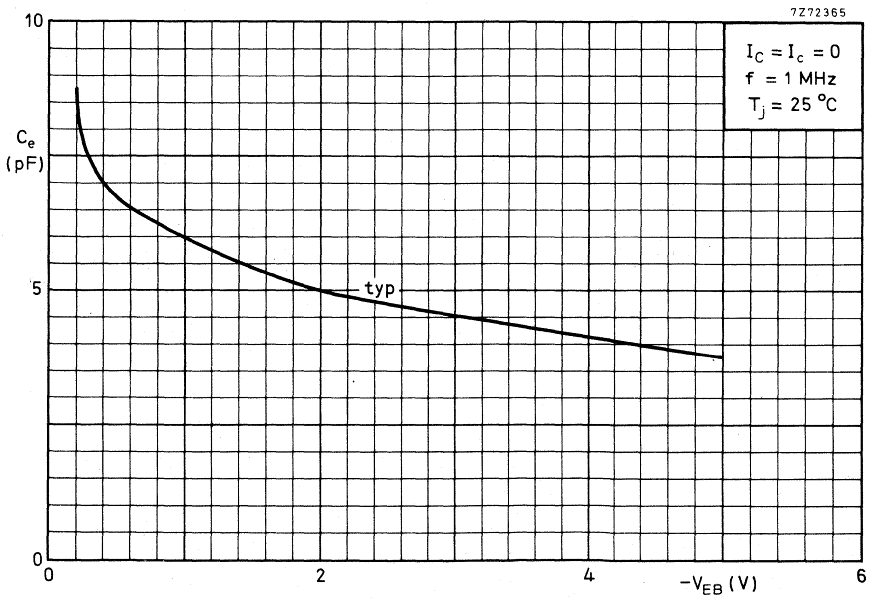

7Z72365
$I_C = I_c = 0$
f = 1 MHz
T_j = 25 °C
C_e (pF)
10
5
0
typ
0
2
4
6
$-V_{EB}$ (V)

Fig. 11.

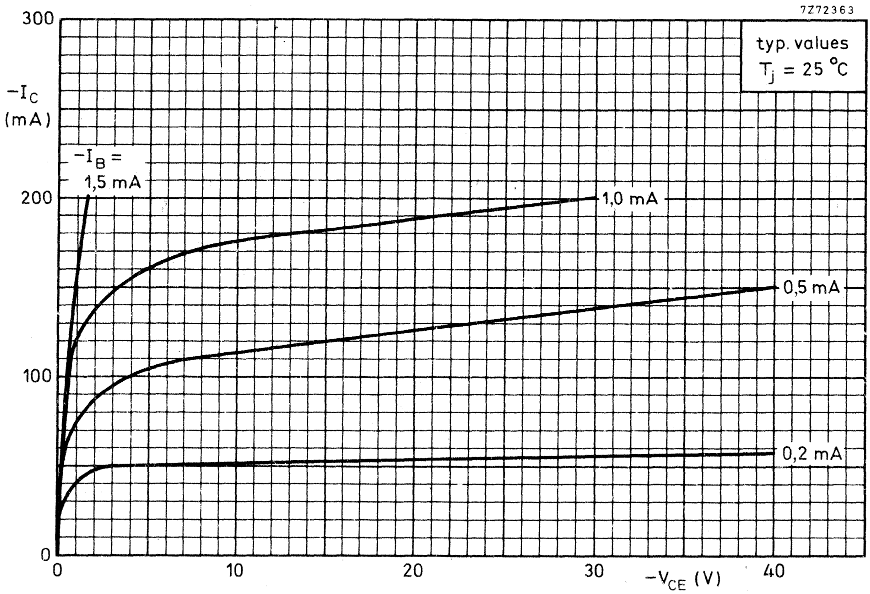

7Z72363
typ. values
T_j = 25 °C
$-I_C$ (mA)
$-I_B$ = 1,5 mA
1,0 mA
0,5 mA
0,2 mA
300
200
100
0
0
10
20
30
40
$-V_{CE}$ (V)

Fig. 12.

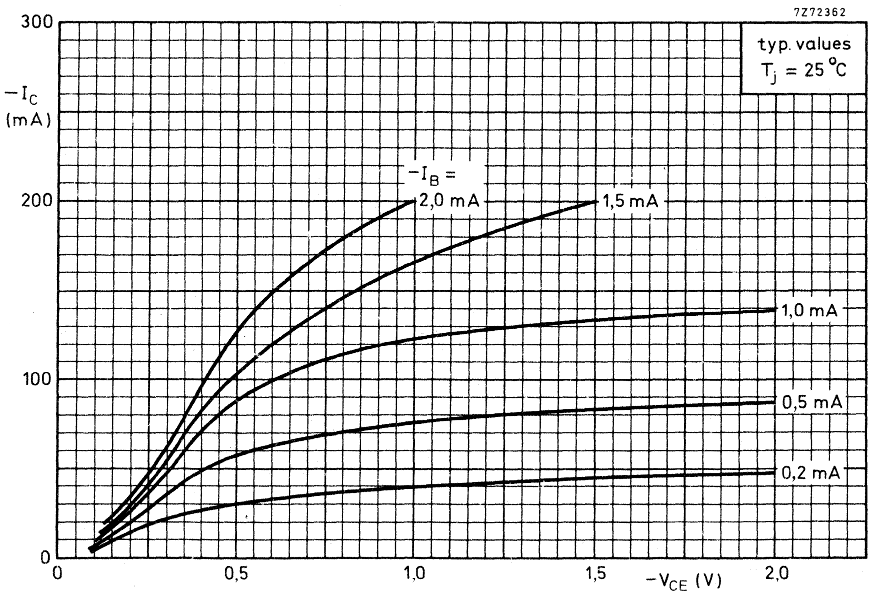

7Z72362
typ. values
T_j = 25 °C
$-I_C$ (mA)
$-I_B$ = 2,0 mA
1,5 mA
1,0 mA
0,5 mA
0,2 mA
300
200
100
0
0
0,5
1,0
1,5
2,0
$-V_{CE}$ (V)

Fig. 13.

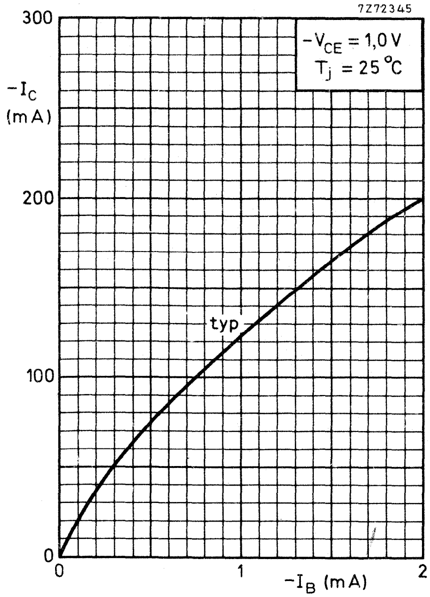


Fig. 14.

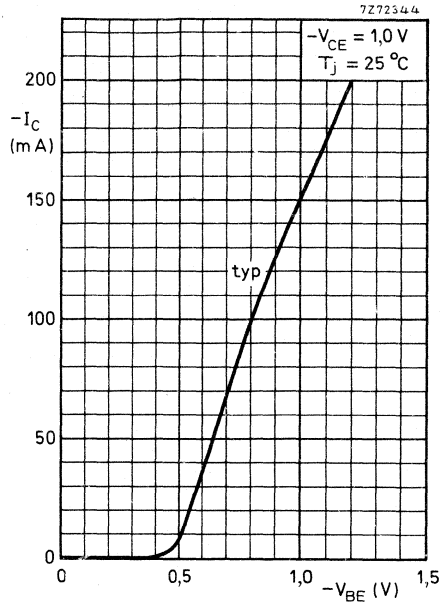


Fig. 15.

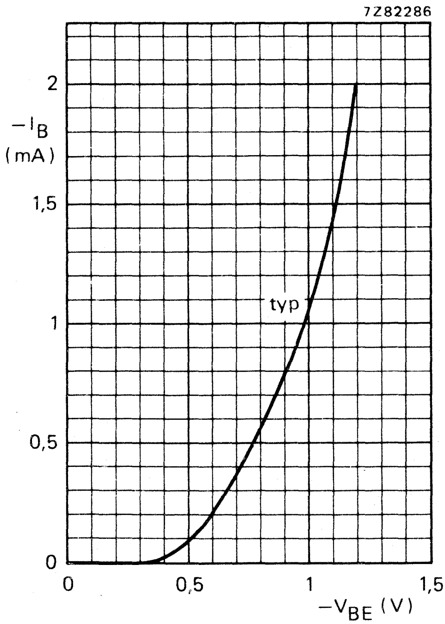


Fig. 16 $-V_{CE}$ = 1,0 V; T_j = 25 °C

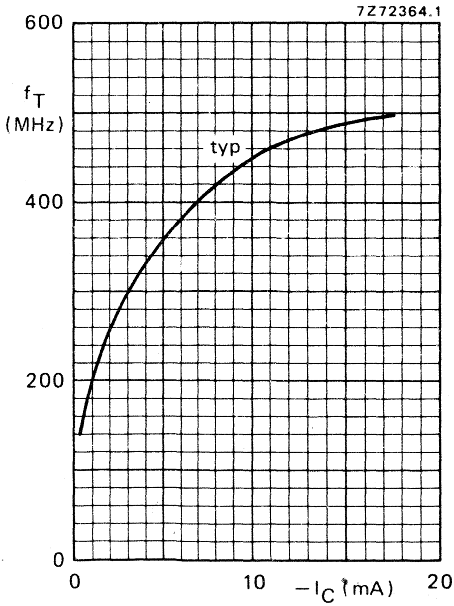


Fig. 17 $-V_{CE}$ = 20 V; f = 100 MHz; T_{amb} = 25 °C.

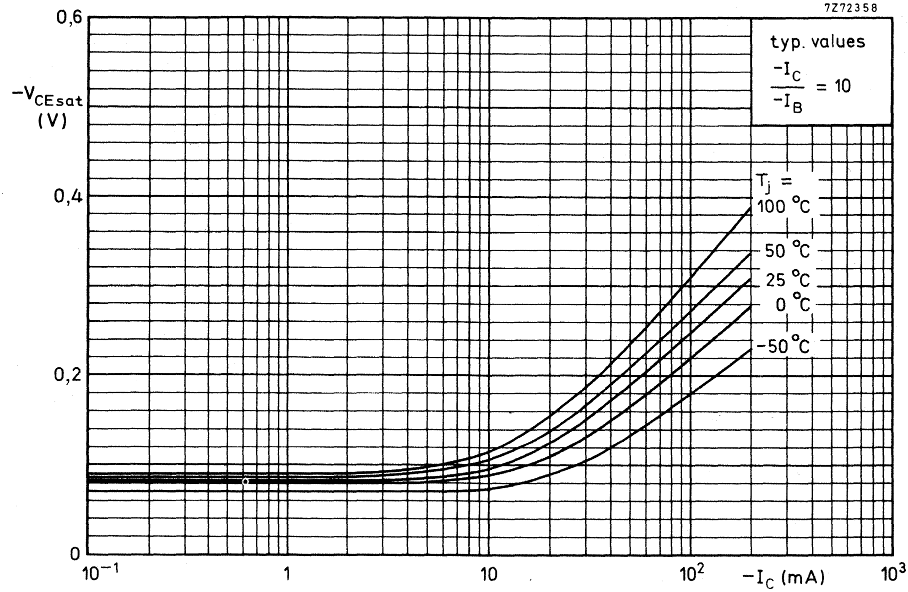

7Z72358
typ. values
$\frac{-I_C}{-I_B} = 10$
$-V_{CEsat}$ (V)
0,6
0,4
0,2
0
T_j =
100 °C
50 °C
25 °C
0 °C
-50 °C
10^{-1}
1
10
10^2
10^3
$-I_C$ (mA)

Fig. 18.

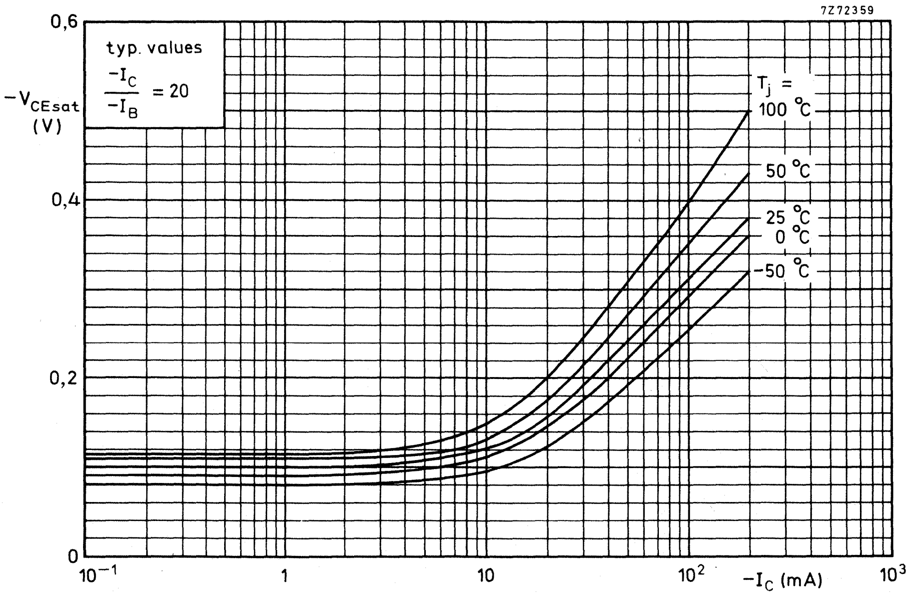

7Z72359
typ. values
$\frac{-I_C}{-I_B} = 20$
$-V_{CEsat}$ (V)
0,6
0,4
0,2
0
T_j =
100 °C
50 °C
25 °C
0 °C
-50 °C
10^{-1}
1
10
10^2
10^3
$-I_C$ (mA)

Fig. 19.

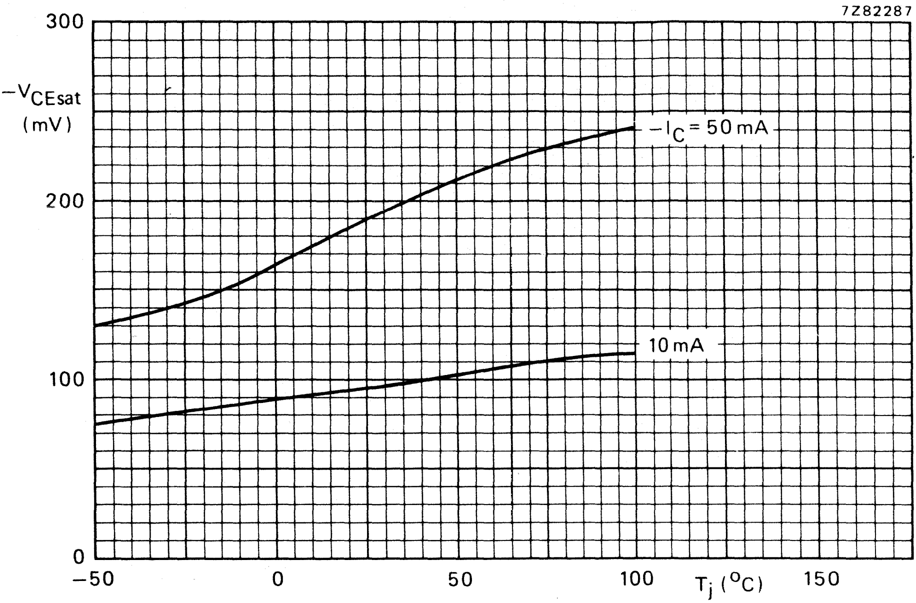


Fig. 20 $-I_C/-I_B = 10$; typical values.

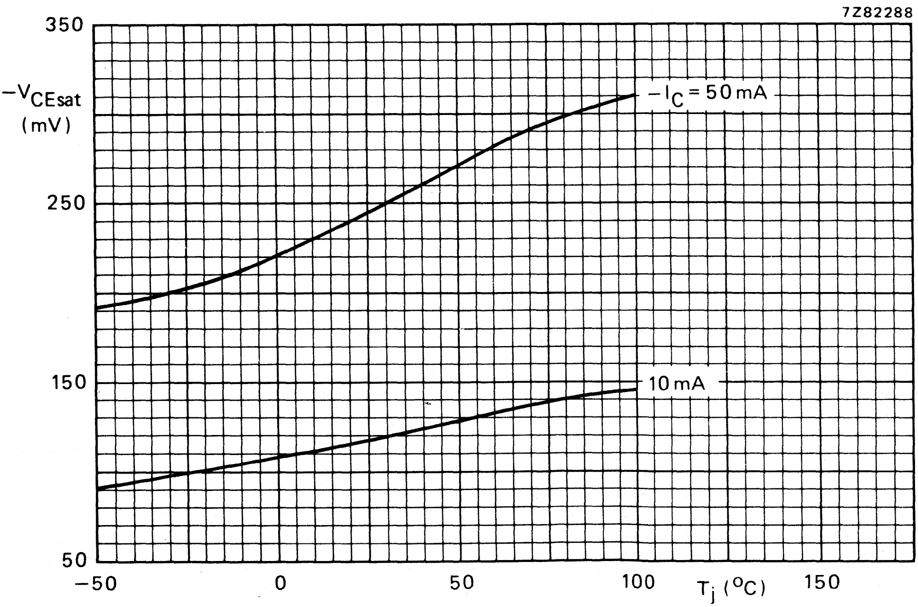


Fig. 21 $-I_C/-I_B = 20$; typical values.

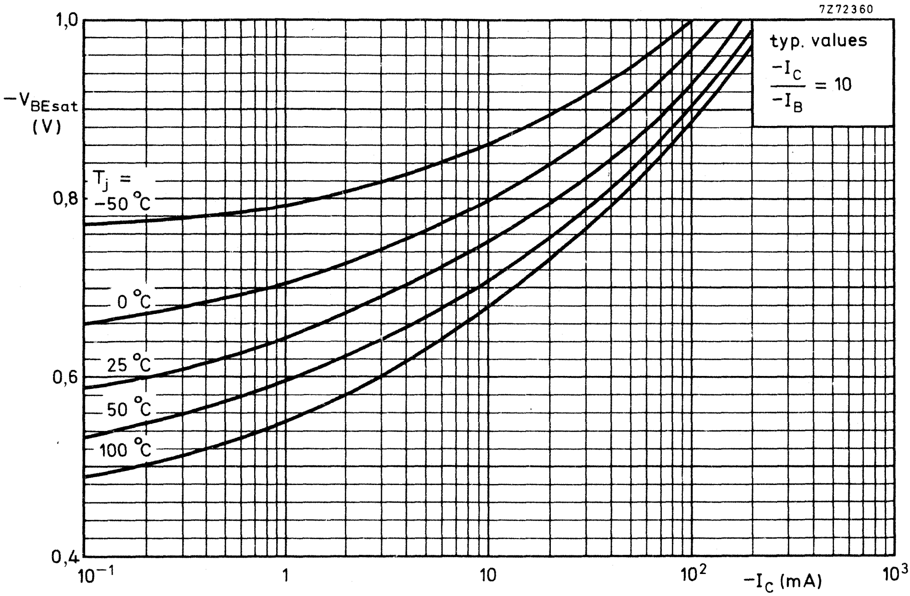

7Z72360
1,0
0,8
0,6
0,4
$-V_{BEsat}$
(V)
T_j =
−50 °C
0 °C
25 °C
50 °C
100 °C
typ. values
$\frac{-I_C}{-I_B}$ = 10
10^{-1}
1
10
10^2
$-I_C$ (mA)
10^3

Fig. 22.

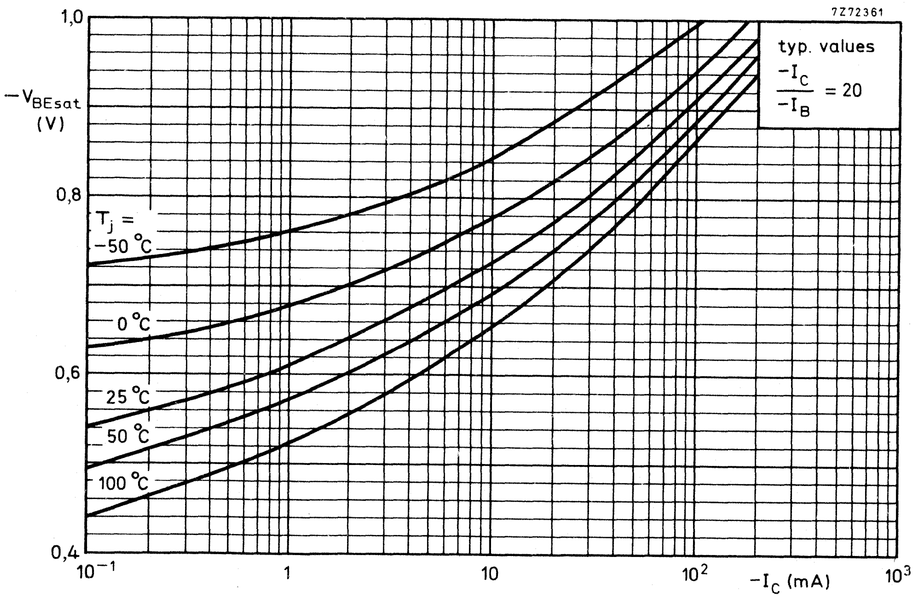

7Z72361
1,0
0,8
0,6
0,4
$-V_{BEsat}$
(V)
T_j =
−50 °C
0 °C
25 °C
50 °C
100 °C
typ. values
$\frac{-I_C}{-I_B}$ = 20
10^{-1}
1
10
10^2
$-I_C$ (mA)
10^3

Fig. 23.

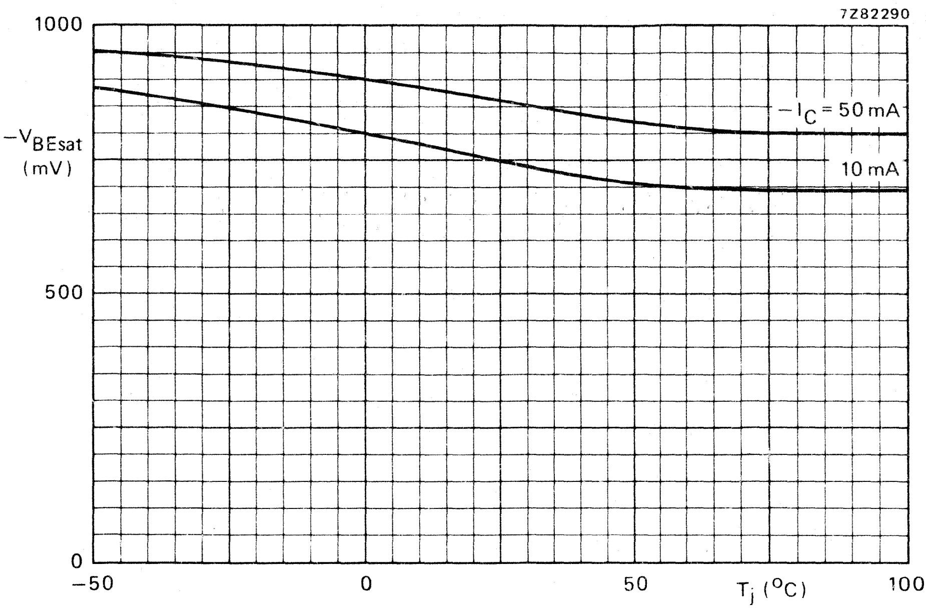


Fig. 24 $-I_C/-I_B = 10$; typical values.

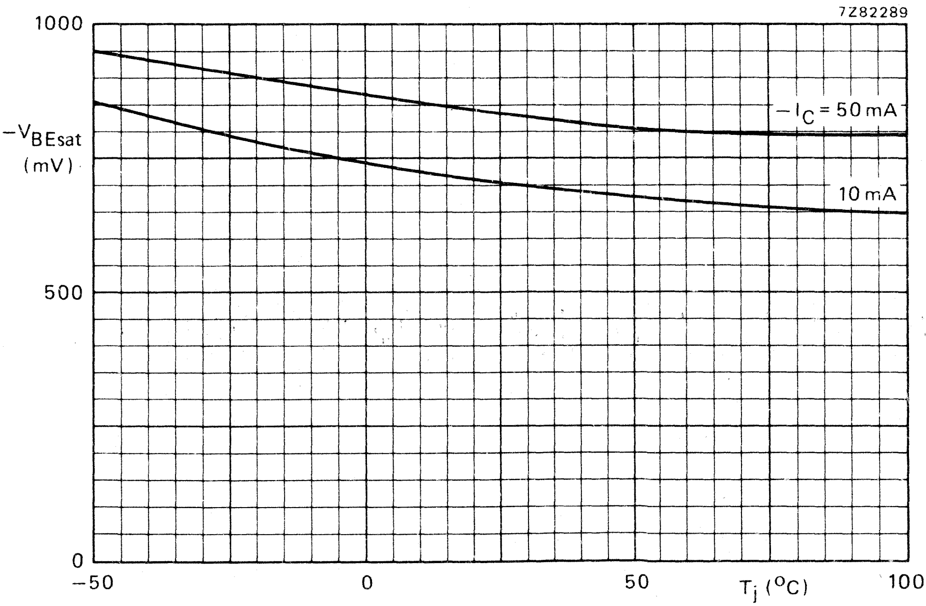


Fig. 25 $-I_C/-I_B = 20$; typical values.

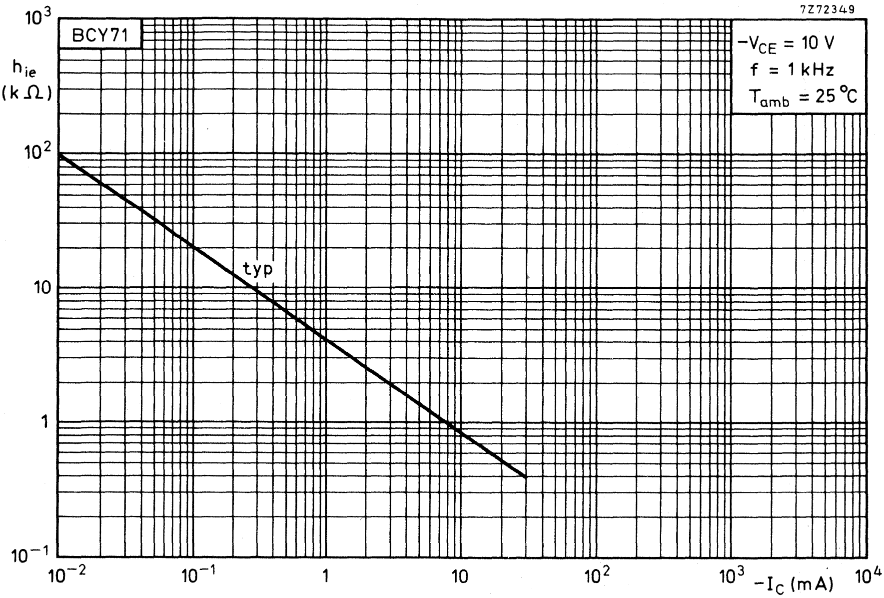

7Z72349
BCY71
h_{ie} (kΩ)
$-V_{CE}$ = 10 V
f = 1 kHz
T_{amb} = 25 °C
typ
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-1}
1
10
10^2
10^3
$-I_C$ (mA)
10^4

Fig. 26.

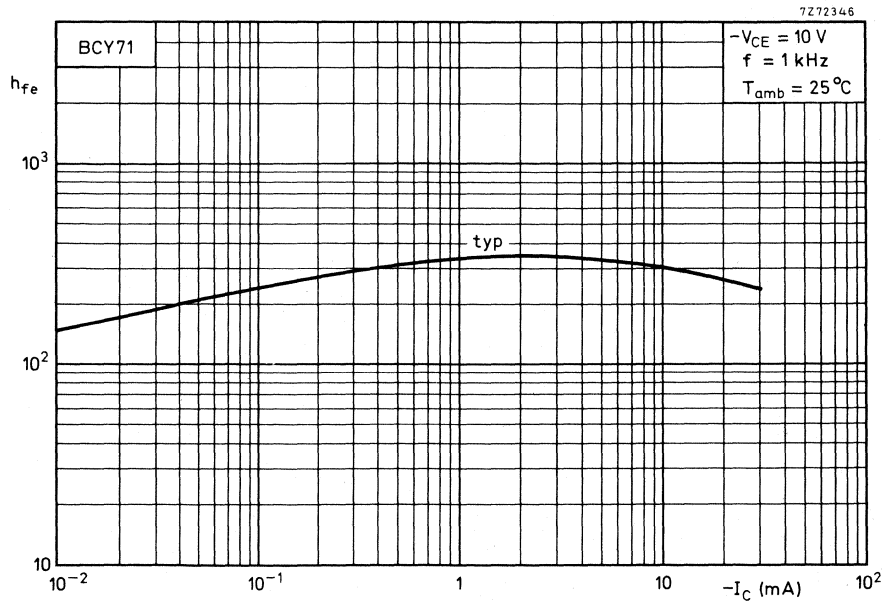

7Z72346
BCY71
h_{fe}
$-V_{CE}$ = 10 V
f = 1 kHz
T_{amb} = 25 °C
typ
10^3
10^2
10
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2

Fig. 27.

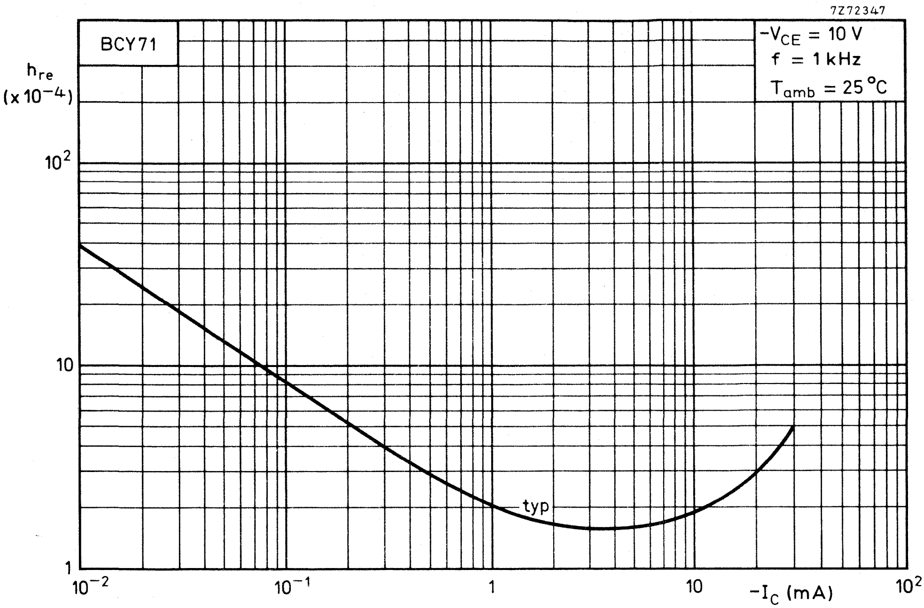

7Z72347
BCY71
h_{re}
$(\times 10^{-4})$
$-V_{CE}$ = 10 V
f = 1 kHz
T_{amb} = 25 °C
typ
10^2
10
1
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2

Fig. 28.

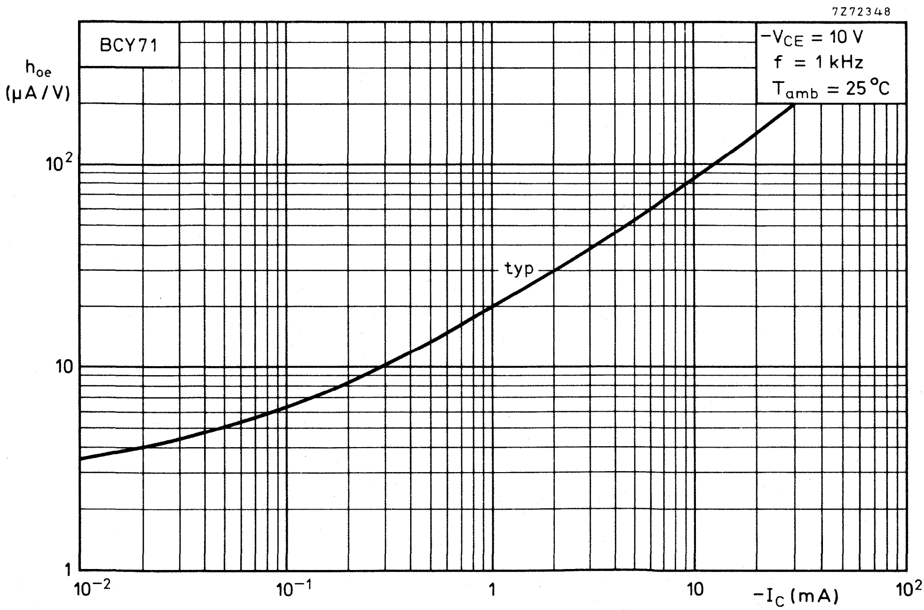

7Z72348
BCY71
h_{oe}
(µA / V)
$-V_{CE}$ = 10 V
f = 1 kHz
T_{amb} = 25 °C
typ
10^2
10
1
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2

Fig. 29.

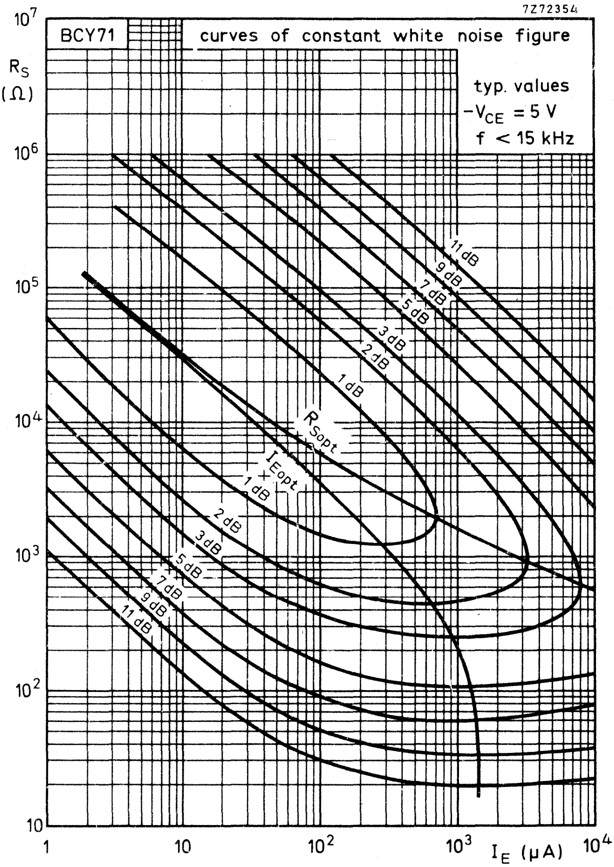


Fig. 30.

See also the graph and text on next page.

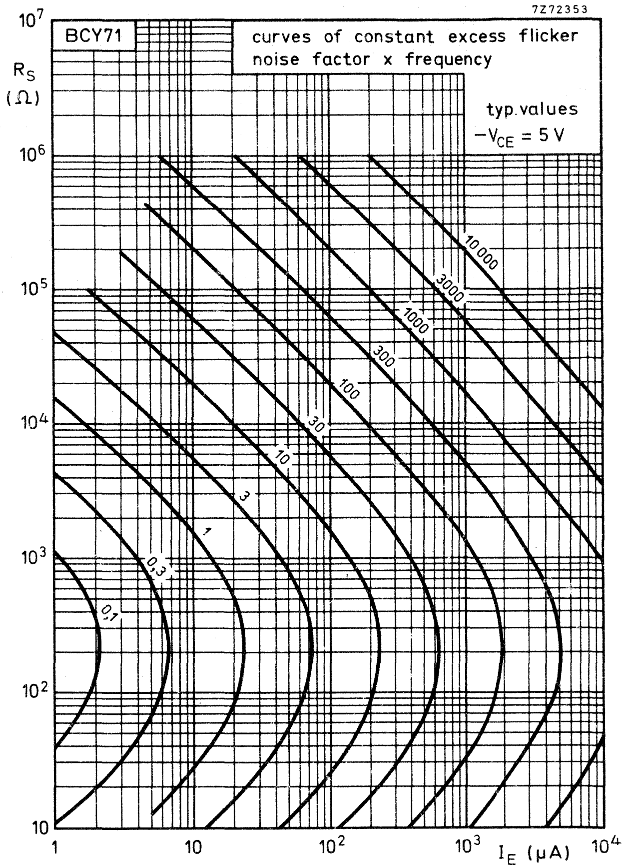


Fig. 31.

Determination of total noise figure

Total noise at f < 15 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 Hz; I_E = 200 μA with a source resistance R_S = 10 kΩ. From the graph on this page it follows that at I_E = 200 μA with R_S = 10 kΩ 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 μA with R_S = 10 kΩ 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.

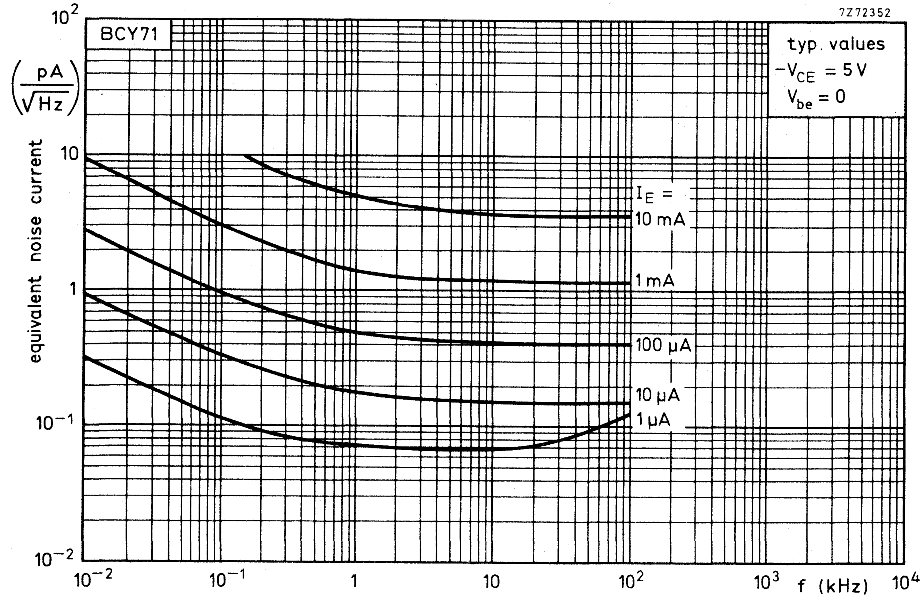

7Z72352
BCY71
typ. values
$-V_{CE} = 5\,V$
$V_{be} = 0$
equivalent noise current
$\left(\frac{pA}{\sqrt{Hz}}\right)$
10^2
10
1
10^{-1}
10^{-2}
I_E =
10 mA
1 mA
100 μA
10 μA
1 μA
10^{-2}
10^{-1}
1
10
10^2
10^3
f (kHz)
10^4

Fig. 32.

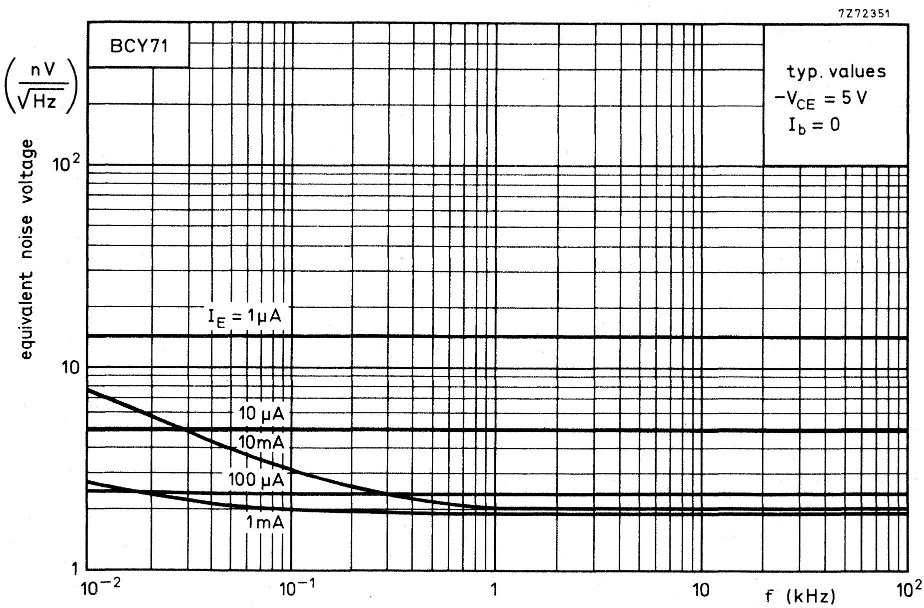

7Z72351
BCY71
typ. values
$-V_{CE} = 5\,V$
$I_b = 0$
equivalent noise voltage
$\left(\frac{nV}{\sqrt{Hz}}\right)$
10^2
10
1
$I_E = 1\,\mu A$
10 μA
10mA
100 μA
1mA
10^{-2}
10^{-1}
1
10
f (kHz)
10^2

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 °C	P_{tot}	max.	345		mW
up to T_{case} = 45 °C	P_{tot}	max.	1000		mW
Junction temperature	T_j	max.	200		°C

			BCY78–VII BCY79–VII	VIII VIII	IX IX	X
Small-signal current gain $-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{fe}	>	125	175	250	350
		<	250	350	500	700

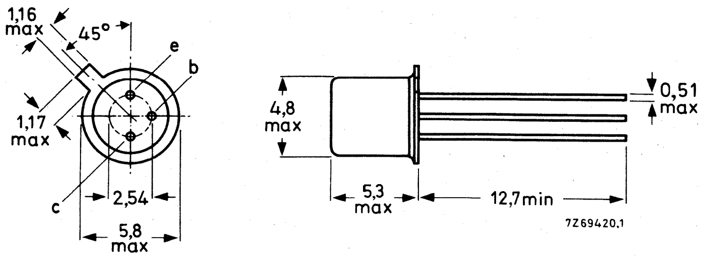
Transition frequency at f = 35 MHz $-I_C$ = 10 mA; $-V_{CE}$ = 5 V	f_T	typ.	180	MHz
Noise figure at R_S = 2 kΩ $-I_C$ = 200 μA; $-V_{CE}$ = 5 V f = 1 kHz; B = 200 Hz	F	typ.	2	dB

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)

			BCY78	BCY79	
Voltages					
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 °C	P_{tot}	max.	345		mW
up to T_{case} = 45 °C	P_{tot}	max.	1000		mW
Temperatures					
Storage temperature	T_{stg}		-65 to 200		°C
Junction temperature	T_j	max.	200		°C

THERMAL RESISTANCE

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

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

			BCY78	BCY79	
<u>Collector cut-off currents</u>					
V_{BE} = 0; $-V_{CE}$ = 25 V	$-I_{CES}$	typ.	2	–	nA
		<	20	–	nA
V_{BE} = 0; $-V_{CE}$ = 35 V	$-I_{CES}$	typ.	–	2	nA
		<	–	20	nA
V_{BE} = 0; $-V_{CE}$ = 25 V; T_{amb} = 150 °C	$-I_{CES}$	<	10	–	μA
V_{BE} = 0; $-V_{CE}$ = 35 V; T_{amb} = 150 °C	$-I_{CES}$	<	–	10	μA
V_{BE} = 0; $-V_{CE}$ = $-V_{CEOmax}$	$-I_{CES}$	<	100	100	nA
$-V_{EB}$ = 0,2 V; $-V_{CE}$ = $-V_{CEOmax}$; T_{amb} = 100 °C	$-I_{CEX}$	<	20	20	μA
<u>Emitter cut-off current</u>					
I_C = 0; $-V_{EB}$ = 4 V	$-I_{EBO}$	<	20	20	nA
<u>Collector-emitter breakdown voltage</u>					
V_{BE} = 0; $-I_C$ = 10 μA	$-V_{(BR)CES}$	>	32	45	V
I_B = 0; $-I_C$ = 2 mA	$-V_{(BR)CEO}$	>	32	45	V

<u>Emitter-base breakdown voltage</u>				
I_C = 0; $-I_E$ = 1 μA	$-V_{(BR)EBO}$	>	5	V
<u>Base-emitter voltage</u>				
$-I_C$ = 10 μA ; $-V_{CE}$ = 5 V	$-V_{BE}$	typ.	550	mV
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	$-V_{BE}$	typ.	650	mV
		600 to	750	mV
$-I_C$ = 10 mA; $-V_{CE}$ = 1 V	$-V_{BE}$	typ.	680	mV
$-I_C$ = 100 mA; $-V_{CE}$ = 1 V	$-V_{BE}$	typ.	750	mV
<u>Saturation voltages</u>				
$-I_C$ = 10 mA; $-I_B$ = 250 μA	$-V_{CEsat}$	typ.	120	mV
		<	250	mV
	$-V_{BEsat}$	typ.	700	mV
		600 to	850	mV
$-I_C$ = 100 mA; $-I_B$ = 2,5 mA	$-V_{CEsat}$	typ.	400	mV
		<	800	mV
	$-V_{BEsat}$	typ.	850	mV
		700 to	1200	mV
<u>Transition frequency</u> at f = 35 MHz				
$-I_C$ = 10 mA; $-V_{CE}$ = 5 V	f_T	typ.	180	MHz

CHARACTERISTICS (continued) T_{amb} = 25 °C unless otherwise specified

Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $-V_{CB}$ = 10 V	C_c	typ.	4,5	pF
		<	7,0	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $-V_{EB}$ = 0,5 V	C_e	typ.	11	pF
		<	15	pF
Noise figure at R_S = 2 kΩ				
$-I_C$ = 200 μA; $-V_{CE}$ = 5 V; f = 1 kHz; B = 200 Hz	F	typ.	2	dB
		<	6	dB

			BCY78-VII BCY79-VII	VIII VIII	IX IX	X	
D.C. current gain							
$-I_C$ = 10 μA ; $-V_{CE}$ = 5 V	h_{FE}	>	–	30	40	100	
		typ.	140	200	270	340	
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{FE}	>	120	180	250	380	
		typ.	170	250	350	500	
		<	220	310	460	630	
$-I_C$ = 10 mA; $-V_{CE}$ = 1 V	h_{FE}	>	80	120	160	240	
		typ.	180	260	360	500	
		<	–	400	630	1000	
$-I_C$ = 100 mA; $-V_{CE}$ = 1 V	h_{FE}	>	40	45	60	60	
h-parameters at f = 1 kHz							
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V							
Input impedance	h_{ie}	typ.	2,7	3,6	4,5	7,5	kΩ
Reverse voltage transfer ratio	h_{re}	typ.	1,5	2	2	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	μA/V
		<	30	50	60	100	μA/V

CHARACTERISTICS (continued)

Switching times

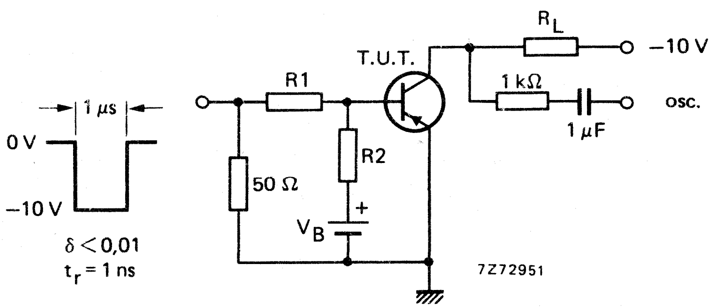
$-I_{Con}$ = 10 mA; $-I_{Bon}$ = I_{Boff} = 1 mA
R1 = R2 = 5 kΩ; R_L = 990 Ω
V_B = 3,6 V

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

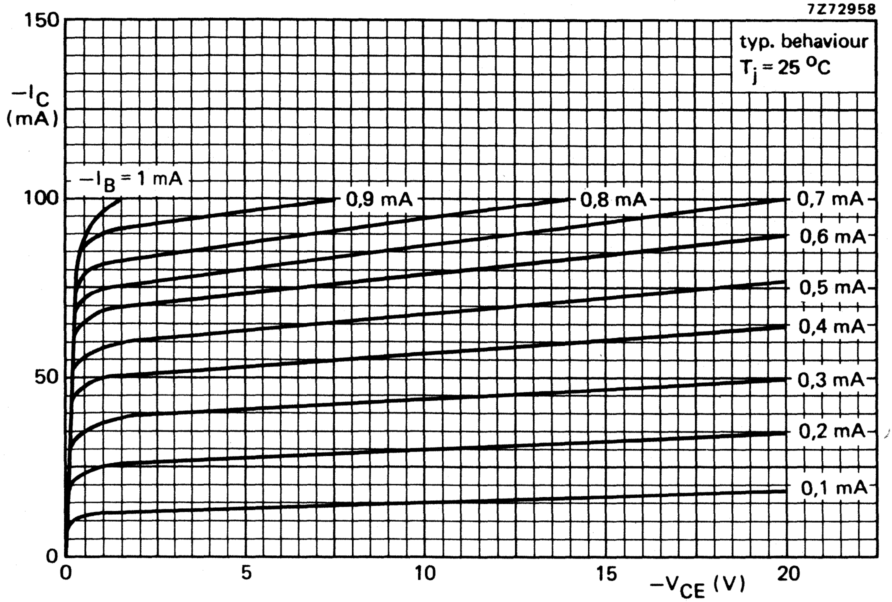
$-I_{Con}$ = 100 mA; $-I_{Bon}$ = I_{Boff} = 10 mA
R1 = 500 Ω; R2 = 700 Ω; R_L = 98 Ω
V_B = 5 V

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

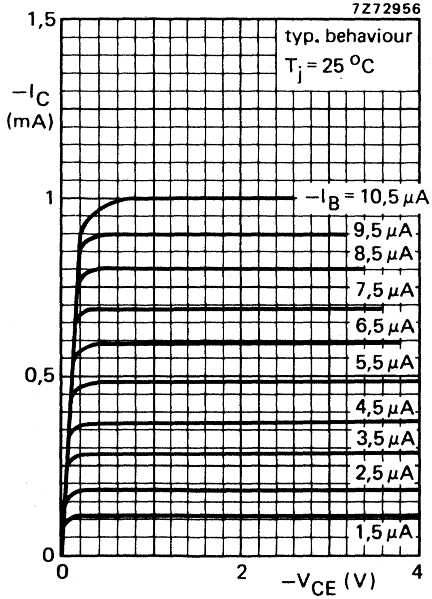
Test circuit:



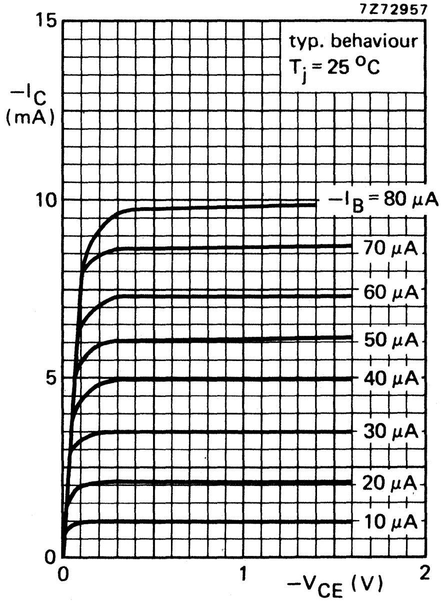
7Z72958

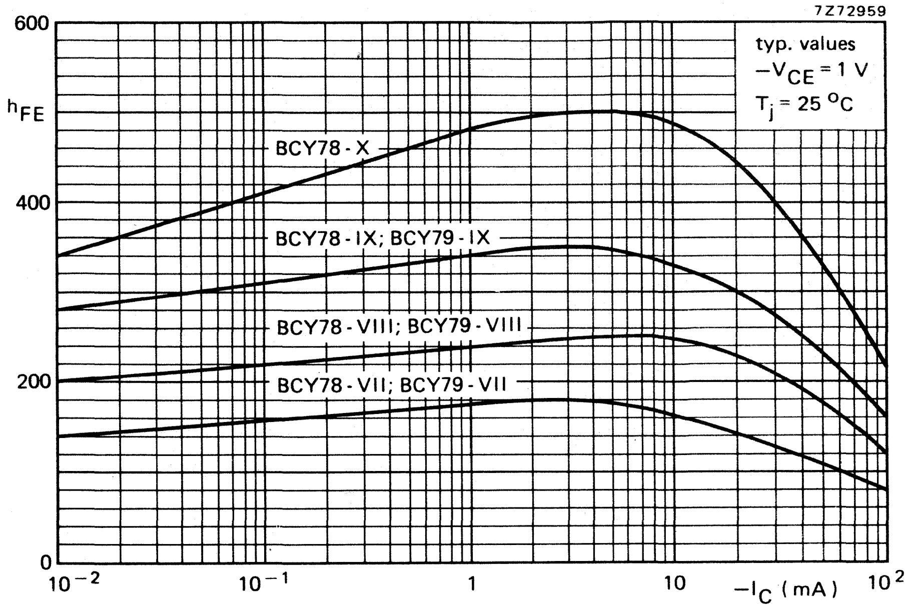


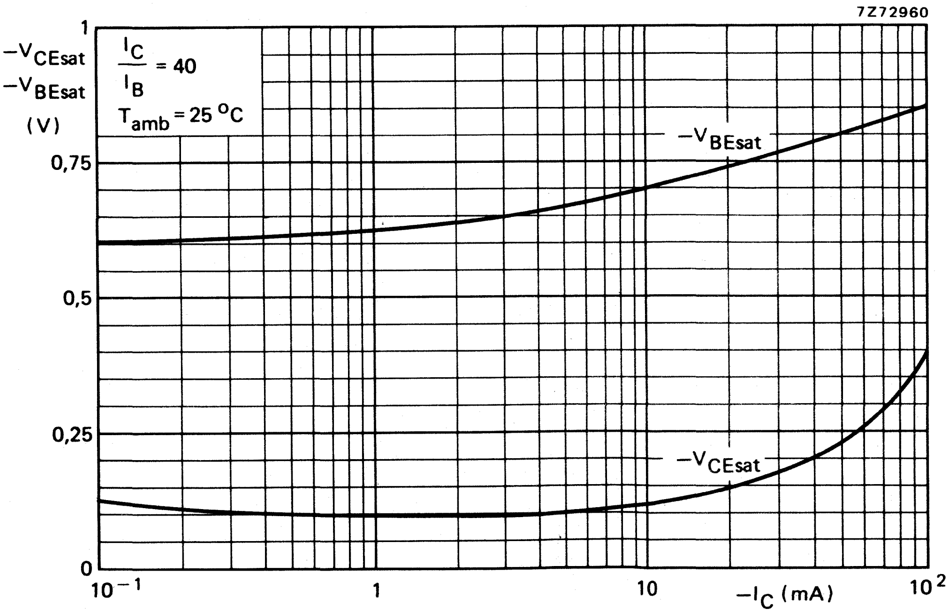
7Z72956

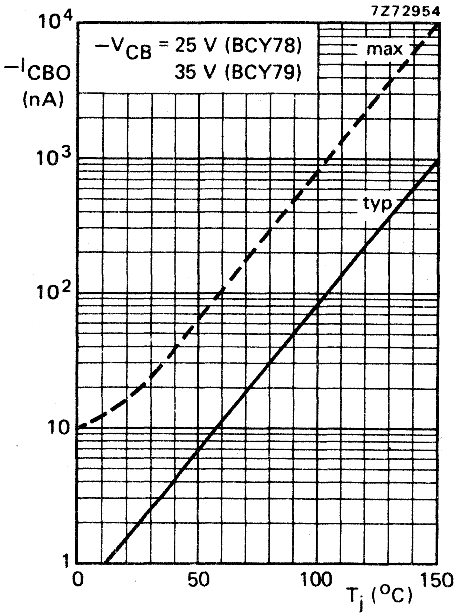


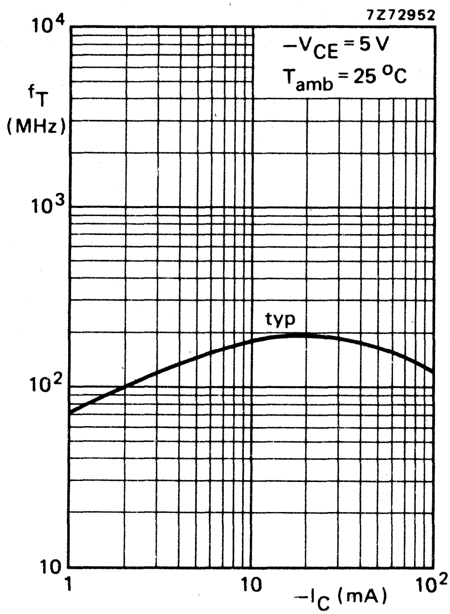
7Z72957

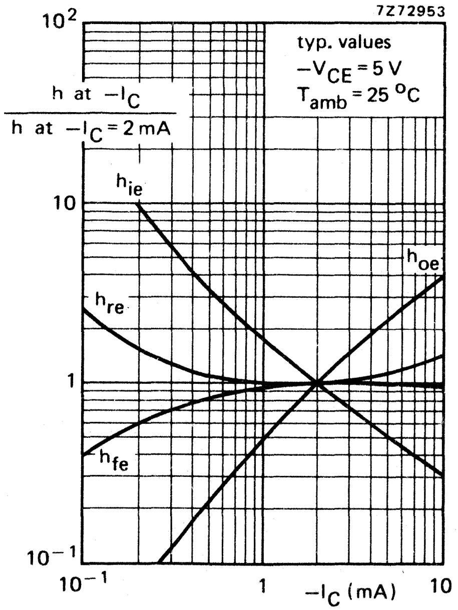


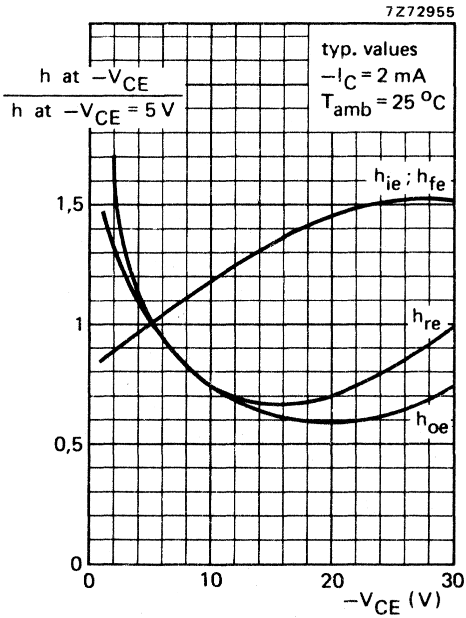

7Z72959
600
400
200
0
h_{FE}
typ. values
$-V_{CE} = 1$ V
$T_j = 25$ °C
BCY78 - X
BCY78 - IX; BCY79 - IX
BCY78 - VIII; BCY79 - VIII
BCY78 - VII; BCY79 - VII
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2


7Z72960
1
$-V_{CEsat}$
$-V_{BEsat}$
(V)
0,75
0,5
0,25
0
$\frac{I_C}{I_B} = 40$
$T_{amb} = 25$ °C
$-V_{BEsat}$
$-V_{CEsat}$
10^{-1}
1
10
$-I_C$ (mA)
10^2


7Z72954
$-V_{CB}$ = 25 V (BCY78)
35 V (BCY79)
$-I_{CBO}$ (nA)
10^4
10^3
10^2
10
1
max
typ
0
50
100
150
T_j (°C)


7Z72952
$-V_{CE}$ = 5 V
T_{amb} = 25 °C
f_T (MHz)
10^4
10^3
10^2
10
typ
1
10
10^2
$-I_C$ (mA)


7Z72953
typ. values
$-V_{CE}$ = 5 V
T_{amb} = 25 °C
$\frac{h \text{ at } -I_C}{h \text{ at } -I_C = 2\text{ mA}}$
10^2
10
1
10^{-1}
h_{ie}
h_{oe}
h_{re}
h_{fe}
10^{-1}
1
10
$-I_C$ (mA)


7Z72955
typ. values
$-I_C$ = 2 mA
T_{amb} = 25 °C
$\frac{h \text{ at } -V_{CE}}{h \text{ at } -V_{CE} = 5\text{ V}}$
1,5
1
0,5
0
h_{ie} ; h_{fe}
h_{re}
h_{oe}
0
10
20
30
$-V_{CE}$ (V)

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 °C	P_{tot}	max	150	mW
Junction temperature	T_j	max	175	°C

Characteristics of the complete device with collector-base voltage of 10 V and sum of emitter currents from 10 to 100 μA.

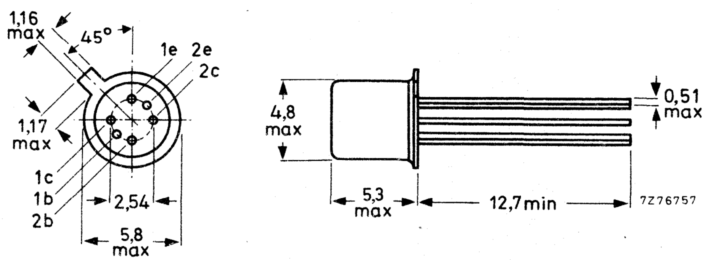
			BCY87	BCY88	BCY89	
Ratio of collector currents at $V_{1B-1E} = V_{2B-2E}$	I_{1C}/I_{2C}		0,9–1,11	0,8–1,25	0,67–1,5	
Base current difference at $V_{1B-1E} = V_{2B-2E}$	$\lvert I_{1B} - I_{2B} \rvert$	<	25	80	300	nA
Equivalent differential voltage change with temperature *	$\left\lvert \frac{\Delta V}{\Delta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

MECHANICAL DATA

Dimensions in mm

TO-71

All leads insulated from the case



* T_{amb} = −20 °C to +90 °C.

RATINGS see page 7

CHARACTERISTICS of the individual transistors

T_{amb} = 25 °C unless otherwise specified

			BCY87	BCY88	BCY89	
Collector cut-off currents						
$I_E = 0$; $V_{CB} = 20$ V; $T_{amb} = 90$ °C	I_{CBO}	<	5	20	–	nA
$I_E = 0$; $V_{CB} = 20$ V	I_{CBO}	<	–	–	10	nA
D.C. current gain						
$I_C = 5$ μA; $V_{CB} = 10$ V	h_{FE}	>	80	–	–	
$I_C = 50$ μA; $V_{CB} = 10$ V	h_{FE}	>	100	100	100	
		<	450	450	450	
$I_C = 500$ μA; $V_{CB} = 10$ V	h_{FE}	>	–	120	–	
		<	–	600	–	
$I_C = 10$ mA; $V_{CB} = 10$ V	h_{FE}	>	–	–	100	
		<	–	–	600	
Transition frequency						
$-I_E = 50$ μA; $V_{CB} = 10$ V	f_T	>	10	10	10	MHz
$-I_E = 500$ μA; $V_{CB} = 10$ V	f_T	>	50	50	50	MHz
Collector capacitance at f = 1 MHz						
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	3.5	3.5	3.5	pF
Noise figures						
$I_C = 50$ μA; $V_{CE} = 5$ V; $R_S = 10$ kΩ Bandwidth 10 Hz to 15 kHz	F	<	3	4	4	dB
1 kHz spot noise figure $I_C = 50$ μA; $V_{CE} = 5$ V; R_S = 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)

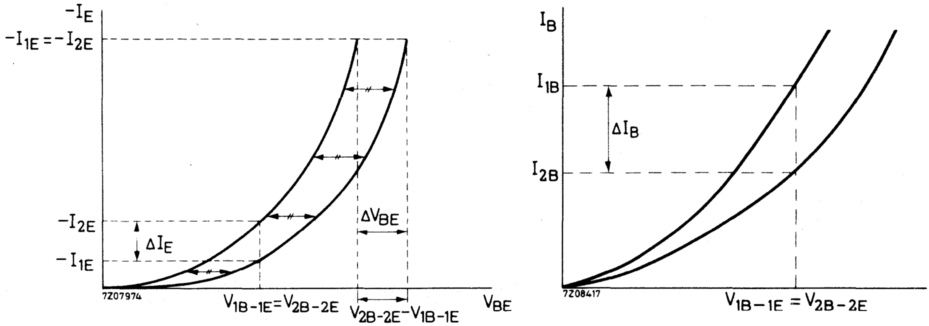
b. Sum of the emitter currents from 10 to 100 μA

$-(I_{1E} + I_{2E}) = 10$ to 100 μA

MATCHING CHARACTERISTICS

		BCY87	BCY88	BCY89	
Ratio of collector currents					
$V_{1B-1E} = V_{2B-2E}$	I_{1C}/I_{2C}	0.9-1.11	0.8-1.25	0.67-1.5	
Difference between base-emitter voltages					
$I_{1C} = I_{2C}$	$\lvert V_{1B-1E} - V_{2B-2E} \rvert$	< 3	6	10	mV
Difference between base currents					
$V_{1B-1E} = V_{2B-2E}$	$\lvert I_{1B} - I_{2B} \rvert$	< 25	80	300	nA
D.C. current gain ratio					
$I_{1C} = I_{2C}$	h_{1FE}/h_{2FE}	0.9-1.11	0.8-1.25	-	

Illustration of matching characteristics:



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

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

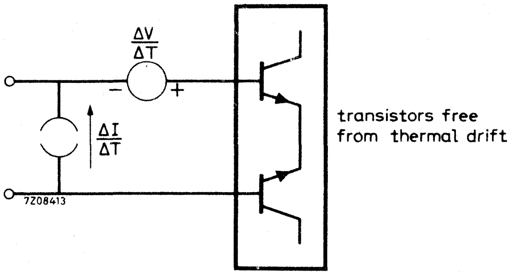
ΔV_{BE} measured at $\dfrac{I_{2E}}{I_{1E}} = 1$

CHARACTERISTICS of the complete device (continued)

Equivalent circuit for drift

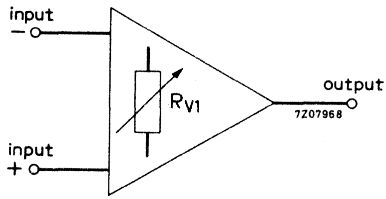
In the equivalent circuit the transistors are considered to be drift free. All temperature coefficients are concentrated in the voltage source $\frac{\Delta V}{\Delta T}$ and in the current source $\frac{\Delta I}{\Delta T}$.

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

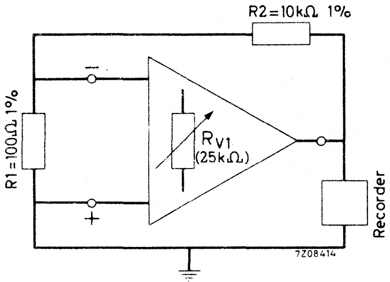
			BCY87	BCY88	BCY89	
T_{amb} = −20 to +90 °C	$\left\|\frac{\Delta V}{\Delta T}\right\|$	typ.	1	2	4	μV/°C
		<	3	6	10	μV/°C

Equivalent differential current change with temperature

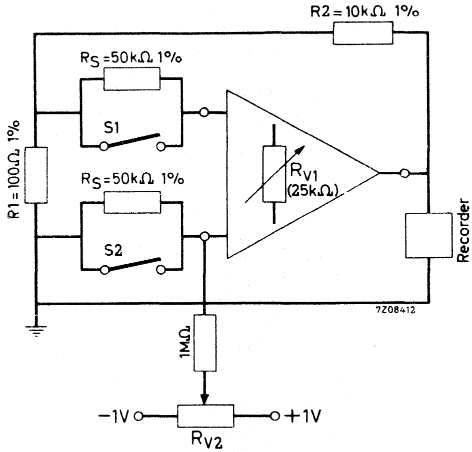
			BCY87	BCY88	BCY89	
T_{amb} = −20 to +90 °C	$\left\|\frac{\Delta I}{\Delta T}\right\|$	<	0.5	2	10	nA/°C

Test methods

$\frac{\Delta V}{\Delta T}$



$\frac{\Delta I}{\Delta T}$



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 °C. When it has stabilized, the output voltage is brought to zero ($|V_{T1}| < 1$ mV)[1]. The amplifier temperature is then adjusted to T_2 between −20 and +90 °C. When it has stabilized the output voltage can be read off.

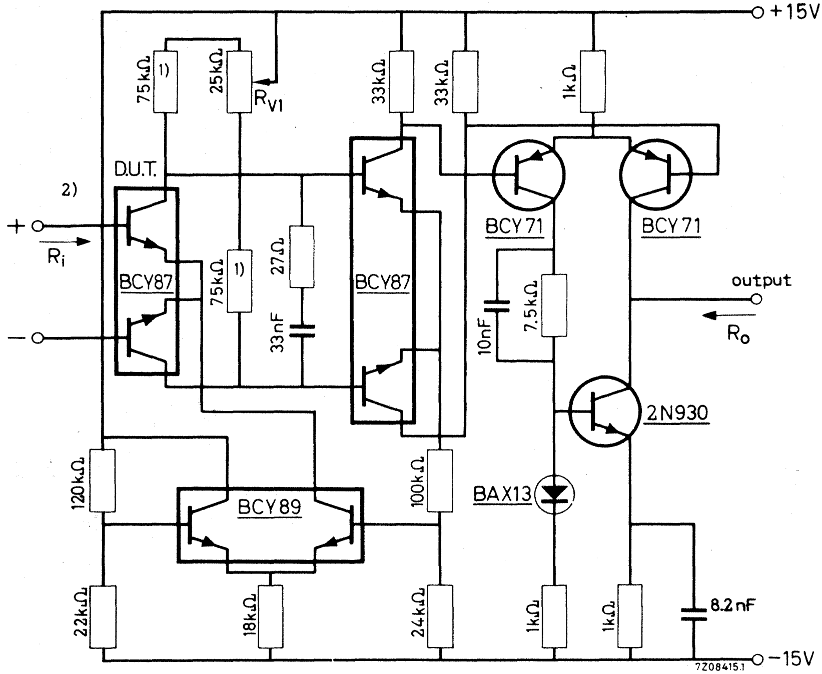
Then: $\frac{\Delta V}{\Delta T} = \frac{V_{T2} - V_{T1}}{T_2 - T_1} \cdot \frac{R1}{R2}$ or $\frac{\Delta I}{\Delta T} = \frac{V_{T2} - V_{T1}}{T_2 - T_1} \cdot \frac{R1}{R2} \cdot \frac{1}{2R_S}$

[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.



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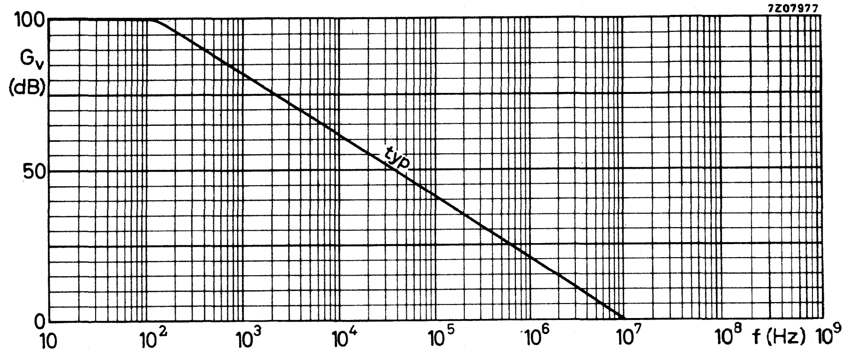
1) Relative temperature coefficient < $10^{-5}/^{o}C$

2) The device at the input is the device under test

Performance of the test amplifier

Open loop voltage gain (Z_L = 10 kΩ)	G_V	typ.	10^5	
Frequency at which G_V = 1	f_1	typ.	10	MHz
Max. common mode input voltage range			±10	V
Max. output current			±2.5	mA
Max. output voltage			±10	V
Input resistance	R_i		100	kΩ
Output resistance	R_o	typ.	20	kΩ
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 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
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	150	mW

Temperatures

Storage temperature	T_{stg}	max.	175	°C
Junction temperature	T_j	max.	175	°C

THERMAL RESISTANCE

From junction to ambient	$R_{th\ j\text{-}a}$	=	1	°C/mW

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.

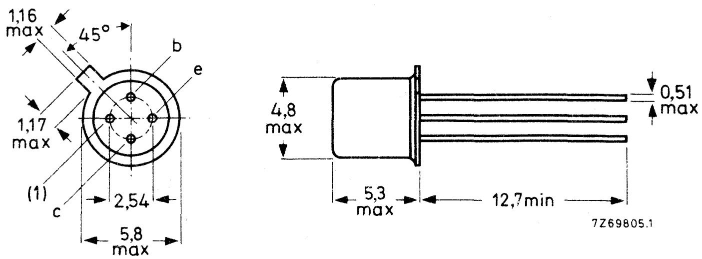
QUICK REFERENCE DATA

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 °C	P_{tot}	max.	145	mW
Junction temperature	T_j	max.	175	°C
Transition frequency I_C = 1 mA; V_{CE} = 10 V	f_T	typ.	230	MHz
Noise figure I_C = 1 mA; V_{CE} = 10 V f = 1 MHz; G_S = 3,3 mA/V	F	typ.	1,2	dB
f = 100 MHz; G_S = 10 mA/V	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) [1])

Voltages

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

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} = 45 °C	P_{tot}	max.	145	mW

Temperatures

Storage temperature	T_{stg}		−65 to +175	°C
Junction temperature	T_j	max.	175	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.9	°C/mW

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

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Emitter-base voltage [1]

$-I_E$ = 1 mA; V_{CB} = 10 V	$-V_{EB}$	0.65 to 0.74	V
$-I_E$ = 20 mA; V_{CB} = 2 V; T_{amb} = 25 °C	$-V_{EB}$	< 1.0	V

Feedback capacitance at f = 0.45 MHz

I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	0.65	pF

D.C. current gain

I_C = 1 mA; V_{CE} = 10 V	h_{FE}	45 to 165	
I_C = 20 mA; V_{CE} = 2 V	h_{FE}	> 40	

Transition frequency

I_C = 1 mA; V_{CE} = 10 V	f_T	typ.	230	MHz

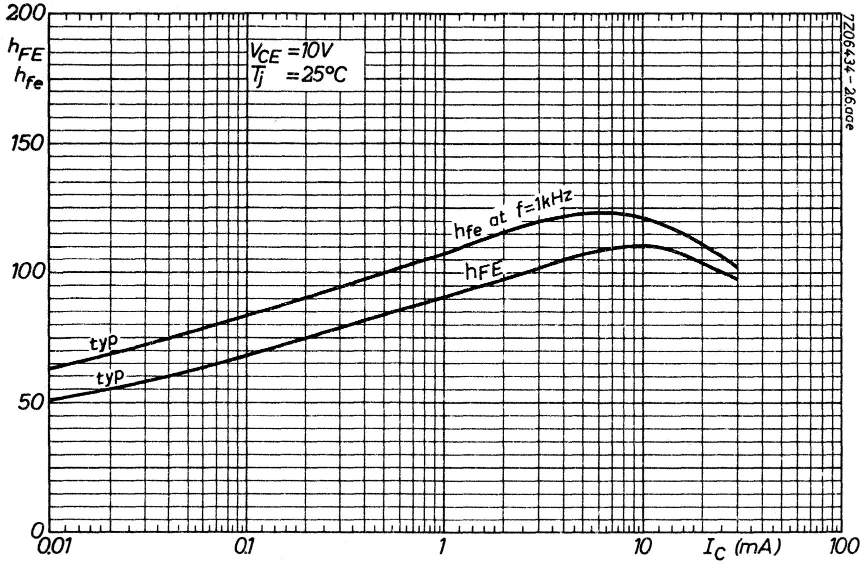
Noise figure at I_C = 1 mA; V_{CE} = 10 V

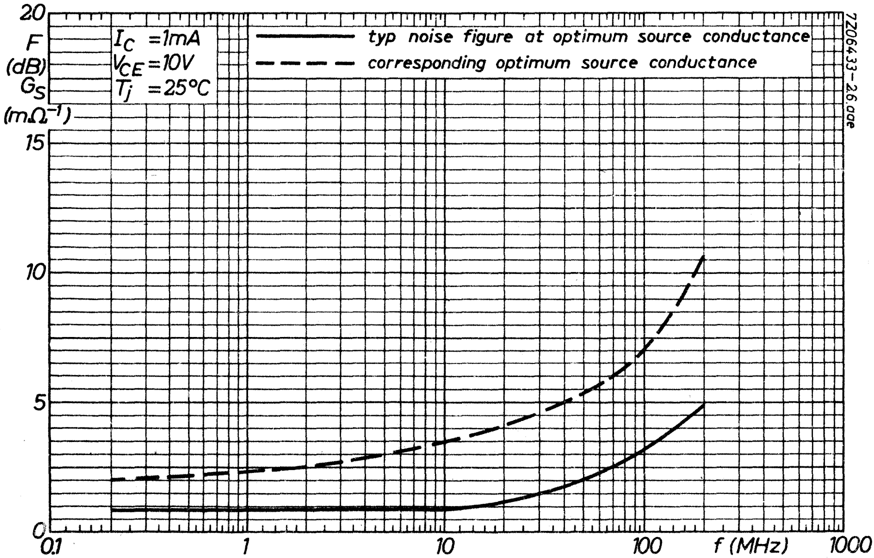
f = 0.2 MHz; G_S = 3.3 mΩ^{-1}	F	typ.	1.5	dB
f = 1 MHz; G_S = 20 mΩ^{-1}	F	typ.	3.5	dB
f = 1 MHz; G_S = 3.3 mΩ^{-1}	F	typ.	1.2	dB
f = 100 MHz; G_S = 10 mΩ^{-1}	F	typ.	4	dB

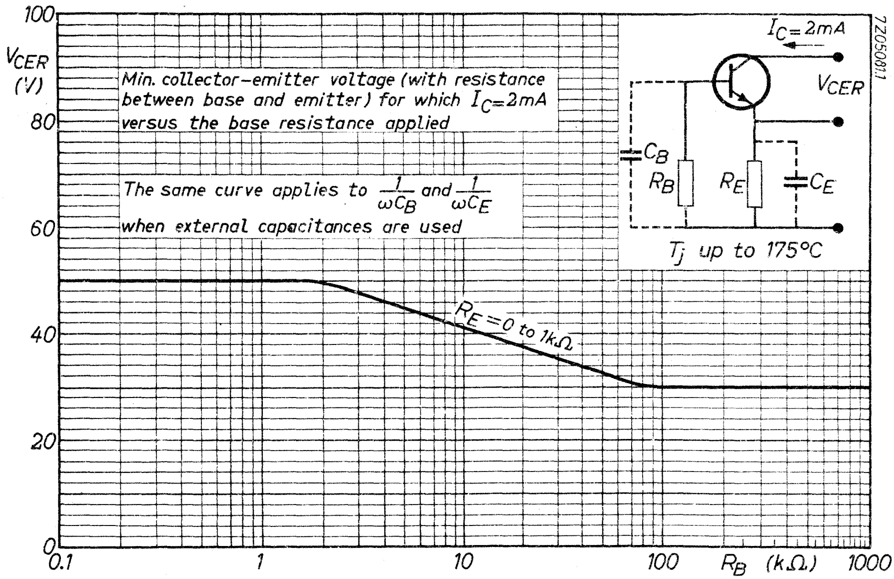
Conversion noise figure at I_C = 1 mA; V_{CE} = 10 V

f = 0.2 MHz; G_S = 1 mΩ^{-1}	F_c	typ.	3.5	dB
f = 1 MHz; G_S = 2 mΩ^{-1}	F_c	typ.	2.5	dB

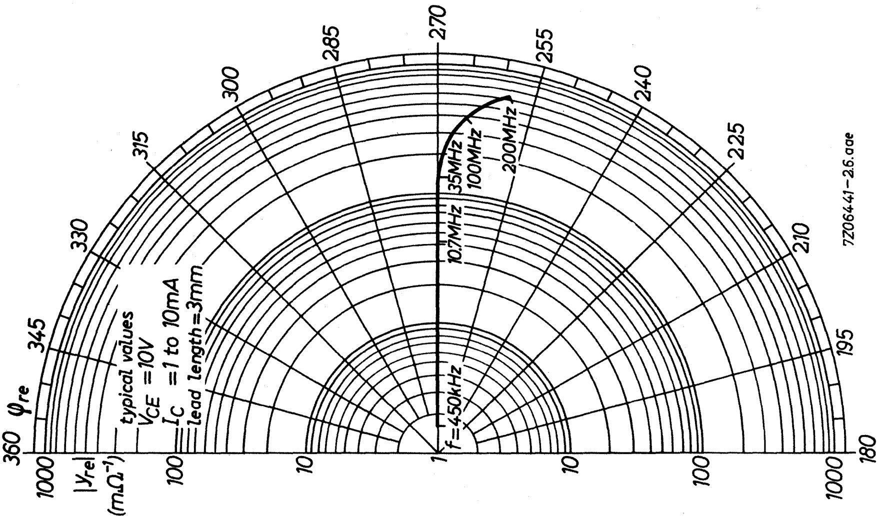
[1] $-V_{EB}$ decreases by about 1.7 mV/°C with increasing temperature.


200
h_{FE}
h_{fe}
150
100
50
0
V_{CE} = 10V
T_j = 25°C
h_{fe} at f=1kHz
h_{FE}
typ
typ
0.01
0.1
1
10
I_C (mA)
100
7Z06434-2.6.aae

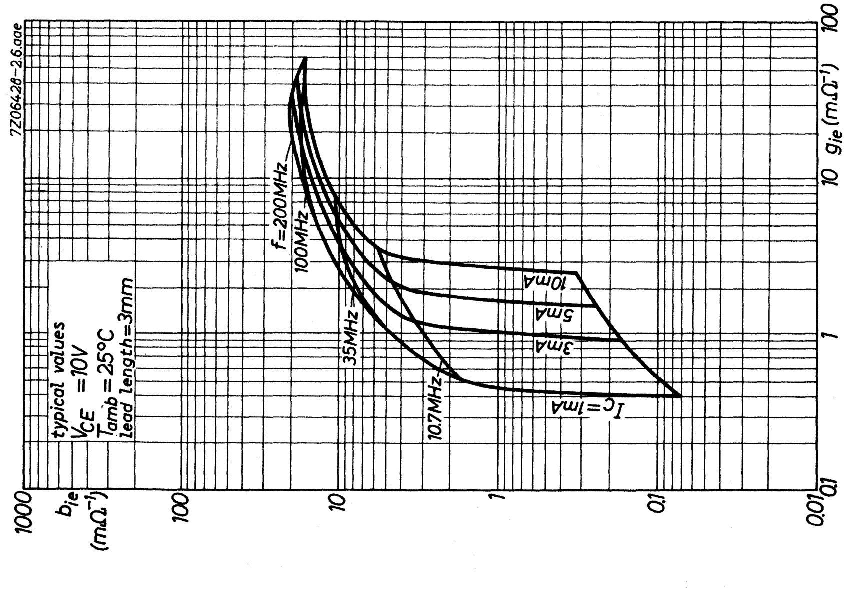

20
F
(dB)
G_S
($m\Omega^{-1}$)
15
10
5
0
I_C = 1mA
V_{CE} = 10V
T_j = 25°C
typ noise figure at optimum source conductance
corresponding optimum source conductance
0.1
1
10
100
f (MHz)
1000
7Z06433-2.6.aae



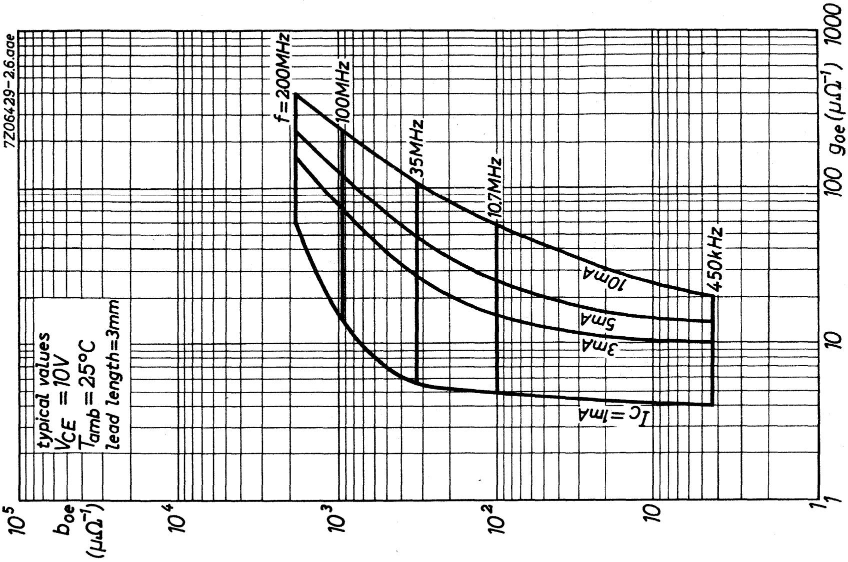
100
80
60
40
20
0
V_{CER} (V)
Min. collector-emitter voltage (with resistance between base and emitter) for which $I_C = 2mA$ versus the base resistance applied
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$ when external capacitances are used
$I_C = 2mA$
V_{CER}
C_B
R_B
R_E
C_E
T_j up to 175°C
7Z05081.1
$R_E = 0$ to $1k\Omega$
0.1
1
10
100
R_B (kΩ)
1000

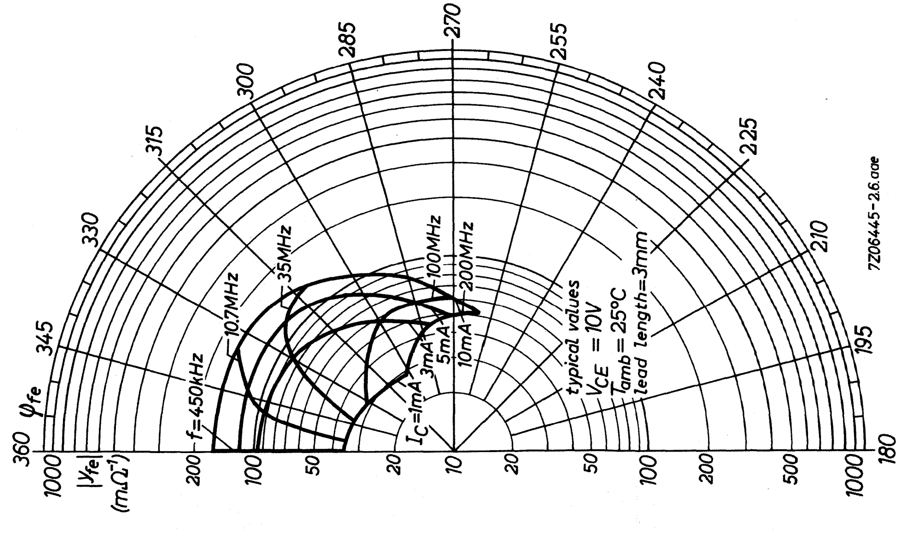


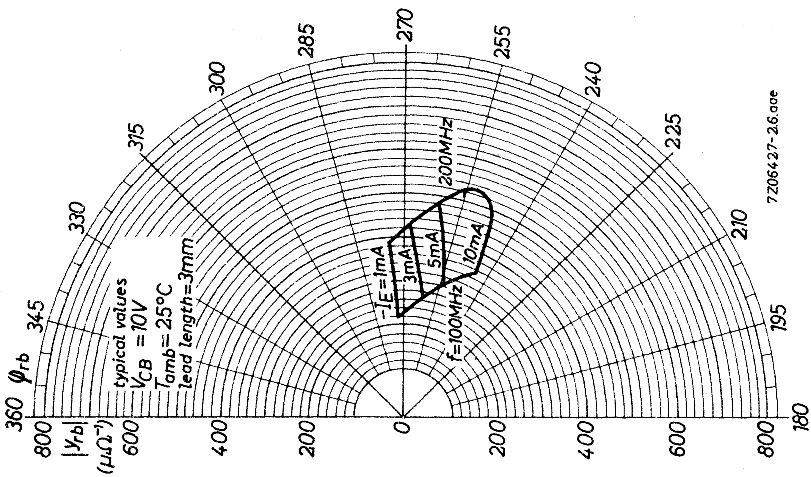
φ_{re}
360
345
330
315
300
285
270
255
240
225
210
195
180
$|y_{re}|$ $(m\Omega^{-1})$
1000
100
10
1
10
100
1000
typical values
V_{CE} = 10V
I_C = 1 to 10mA
lead length = 3mm
f = 450kHz
10.7MHz
35MHz
100MHz
200MHz
7Z06441-2.6.aae



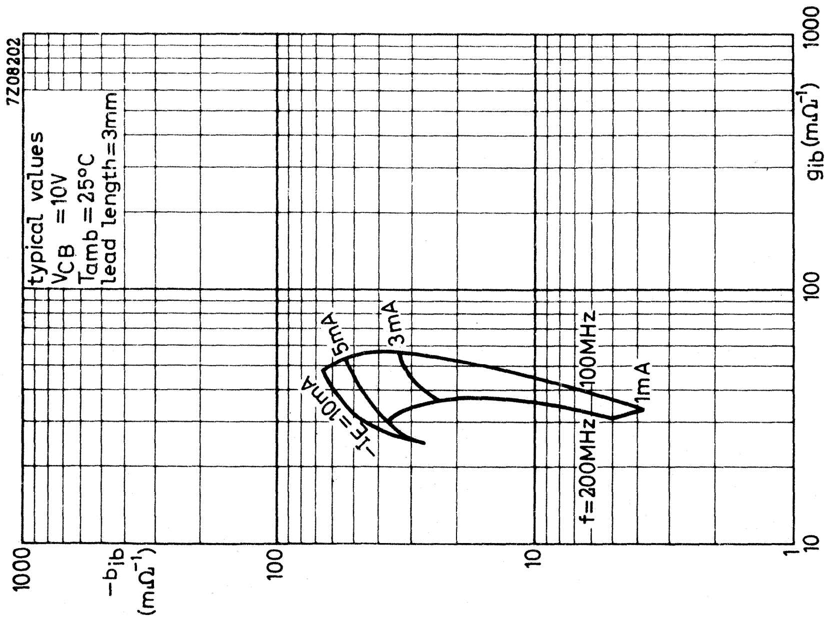
b_{ie} $(m\Omega^{-1})$
1000
100
10
1
0.1
0.01
0.1
1
10
100
g_{ie} $(m\Omega^{-1})$
typical values
V_{CE} = 10V
T_{amb} = 25°C
lead length = 3mm
f = 200MHz
100MHz
35MHz
10.7MHz
I_C = 1mA
3mA
5mA
10mA
7Z06428-2.6.aae


7Z06429-2.6.aae
typical values
V_{CE} = 10V
T_{amb} = 25°C
lead length = 3mm
f=200MHz
100MHz
35MHz
10.7MHz
450kHz
10mA
5mA
3mA
I_C = 1mA
b_{oe} ($\mu\Omega^{-1}$)
10^5
10^4
10^3
10^2
10
1
g_{oe} ($\mu\Omega^{-1}$)
1000
100
10
1

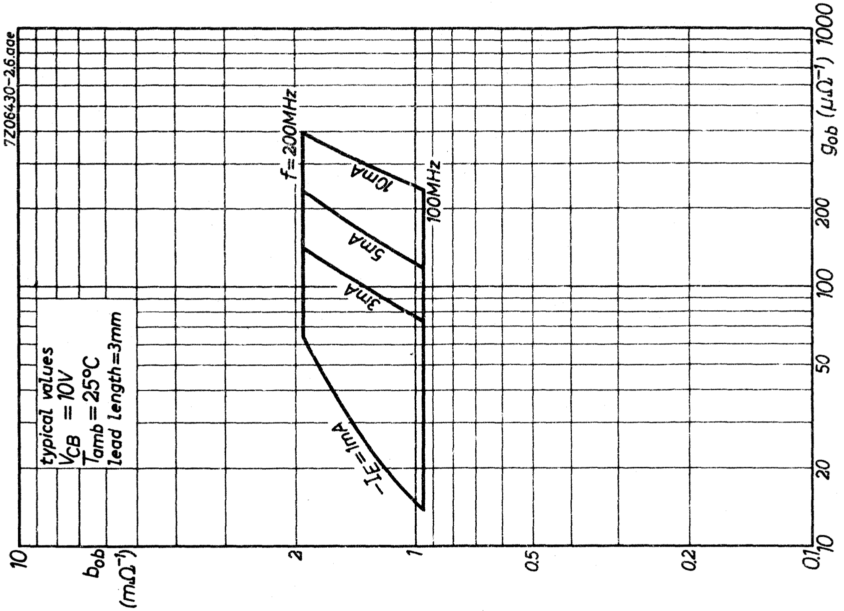

7Z06445-2.6.aae
φ_{fe}
360
345
330
315
300
285
270
255
240
225
210
195
180
$|y_{fe}|$ ($m\Omega^{-1}$)
1000
200
100
50
20
10
20
50
100
200
500
1000
f=450kHz
10.7MHz
35MHz
100MHz
200MHz
I_C=1mA
3mA
5mA
10mA
typical values
V_{CE} = 10V
T_{amb} = 25°C
lead length = 3mm



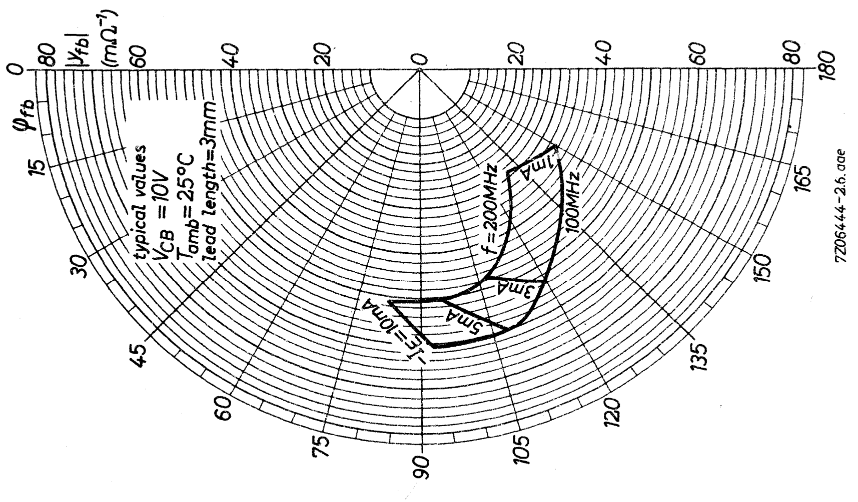
φ_{rb}
360
345
330
315
300
285
270
255
240
225
210
195
180
typical values
V_{CB} = 10V
T_{amb} = 25°C
lead length = 3mm
$|y_{rb}|$
($\mu\Omega^{-1}$)
800
600
400
200
0
200
400
600
800
$-I_E$ = 1mA
3mA
5mA
10mA
200MHz
f = 100MHz
7Z06427-2.6.aae



7Z08202
typical values
V_{CB} = 10V
T_{amb} = 25°C
lead length = 3mm
$-b_{ib}$
($m\Omega^{-1}$)
1000
100
10
1
g_{ib} ($m\Omega^{-1}$)
10
100
1000
$-I_E$ = 10mA
5mA
3mA
1mA
100MHz
f = 200MHz



7Z06430-2.6.aae
typical values
VCB = 10V
Tamb = 25°C
lead length=3mm
f=200MHz
100MHz
10mA
5mA
3mA
-IE=1mA
bob (mΩ-1)
gob (μΩ-1)
10
2
1
0.5
0.2
0.1
20
50
100
200
1000



φfb
|yfb| (mΩ-1)
7Z06444-2.6.aae
typical values
VCB = 10V
Tamb = 25°C
lead length=3mm
f=200MHz
100MHz
1mA
3mA
5mA
-IE=10mA
0
15
30
45
60
75
90
105
120
135
150
165
180
80
60
40
20

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.

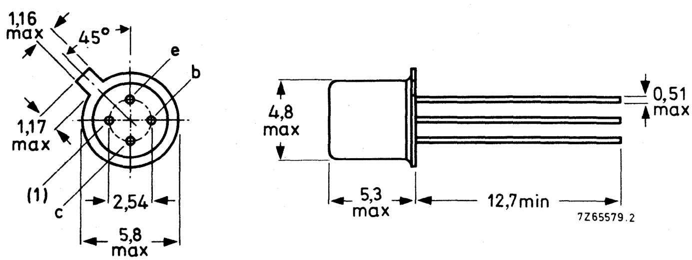
QUICK REFERENCE DATA

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 °C	P_{tot}	max.	150	mW
Junction temperature	T_j	max.	175	°C
Transition frequency I_C = 2 mA; V_{CE} = 10 V	f_T	typ.	675	MHz
Feedback capacitance at f = 10,7 MHz I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	280	fF
Maximum unilateralized power gain $-I_E$ = 2 mA; V_{CB} = 10 V; f = 200 MHz	G_{UM}	typ.	24	dB
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 900 MHz	G_{UM}	typ.	12	dB
Noise figure at optimum source admittance $-I_E$ = 2 mA; V_{CB} = 10 V; f = 200 MHz	F	typ.	2,5	dB
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 800 MHz	F	typ.	5,7	dB

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-72.



(1) = shield lead (connected to case).

Accessories: 56246 (distance disc).

RATINGS (Limiting values) [1]

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 °C	P_{tot}	max.	150	mW

Temperatures

Storage temperature	T_{stg}	−65 to +175		°C
Junction temperature	T_j	max.	175	°C

THERMAL RESISTANCE

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

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

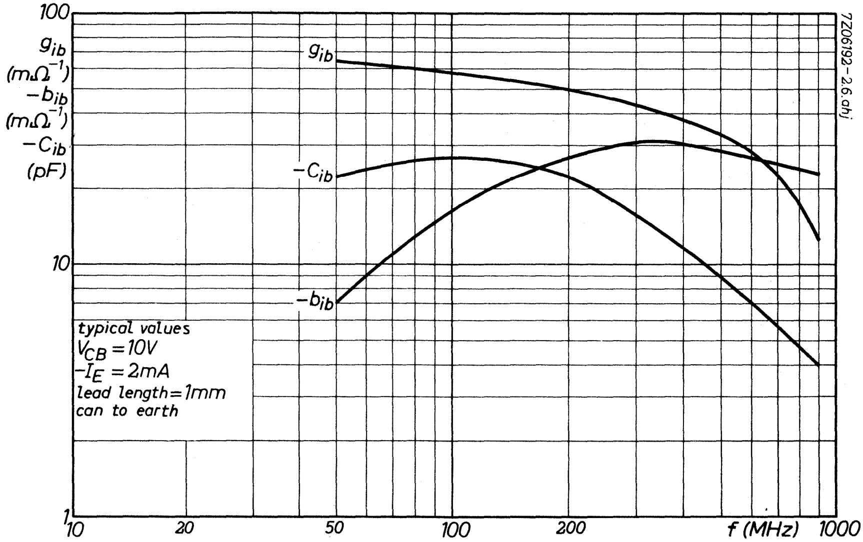
CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

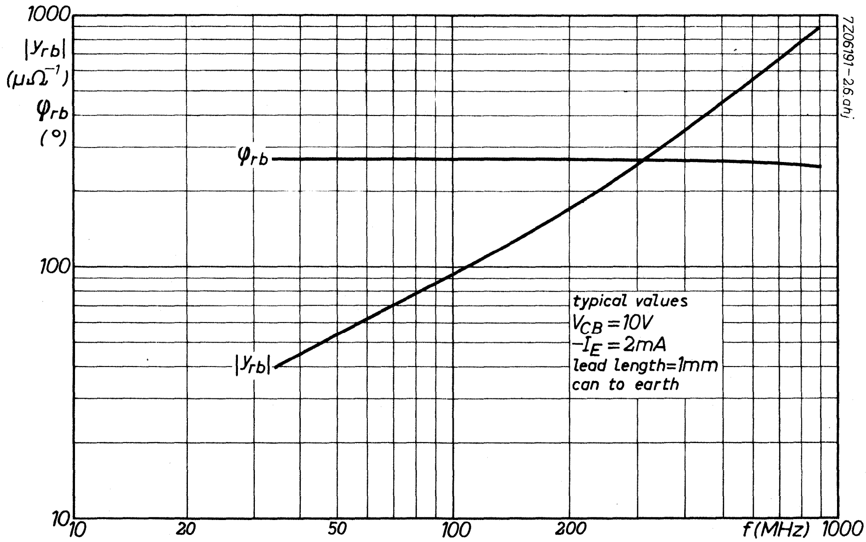
Base current				
$-I_E$ = 2 mA; V_{CB} = 10 V	I_B	typ. <	45 150	μA μA
$-I_E$ = 12 mA; V_{CB} = 7 V	I_B	<	2.2	mA
Emitter-base voltage				
$-I_E$ = 2 mA; V_{CB} = 10 V	$-V_{EB}$	typ.	0.75	V
Feedback capacitance at f = 10.7 MHz				
I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	280	fF [1]
Transition frequency				
I_C = 2 mA; V_{CE} = 10 V	f_T	typ.	675	MHz
Noise figure [2]				
$-I_E$ = 2 mA; V_{CB} = 10 V; G_S = 40 mΩ^{-1}; B_S = 0; f = 200 MHz	F	typ.	4.5	dB
$-I_E$ = 2 mA; V_{CB} = 10 V; G_S = 10 mΩ^{-1}; B_S = 0; f = 800 MHz	F	typ. <	7.0 9.5	dB dB
Maximum unilateralised power gain [2]				
$G_{UM} = \frac{\|y_{fb}\|^2}{4\, g_{ib}\, g_{ob}}$				
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 50 MHz	G_{UM}	>	32	dB
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 200 MHz	G_{UM}	typ.	24	dB
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 500 MHz	G_{UM}	typ.	14	dB
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 900 MHz	G_{UM}	typ.	12	dB
Transducer gain [2]				
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 200 MHz; G_S = 40 mΩ^{-1}; B_S = 0 G_L = 1 mΩ^{-1}; B_L : tuned	G_{tr}	typ.	16.5	dB
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 900 MHz; G_S = 20 mΩ^{-1}; B_S = 0 G_L = 2 mΩ^{-1}; B_L : tuned	G_{tr}	> typ.	7.5 9	dB dB

[1] 1 fF = 1 femtofarad = 10^{-15} F

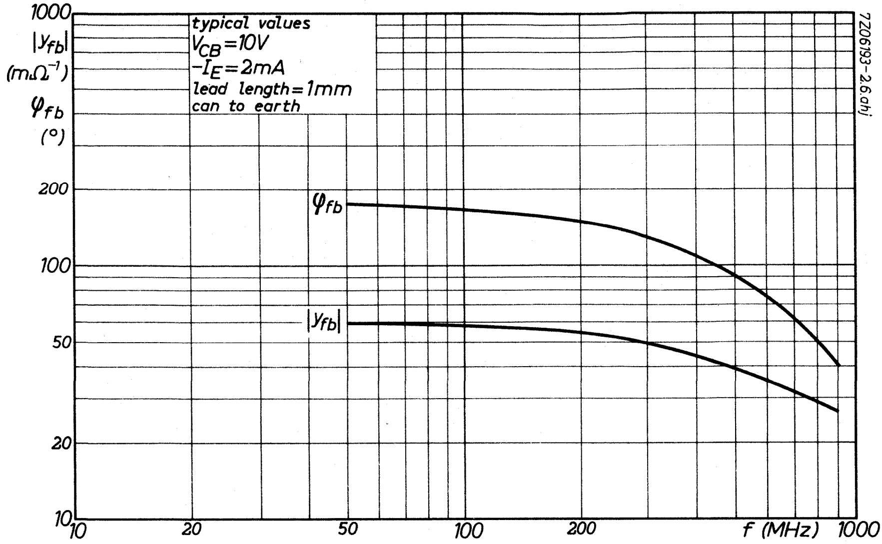
[2] Common base configuration, metal envelope contacted to earth directly, external lead length: 1 mm.

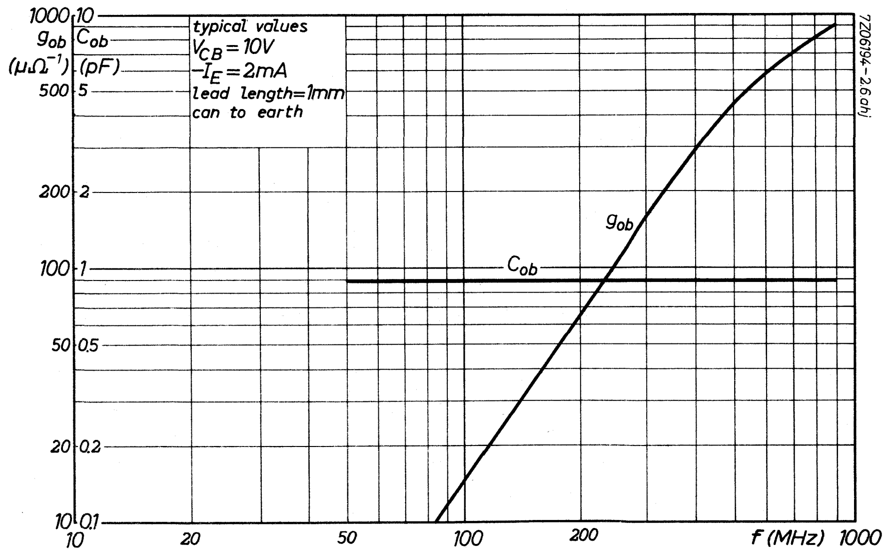


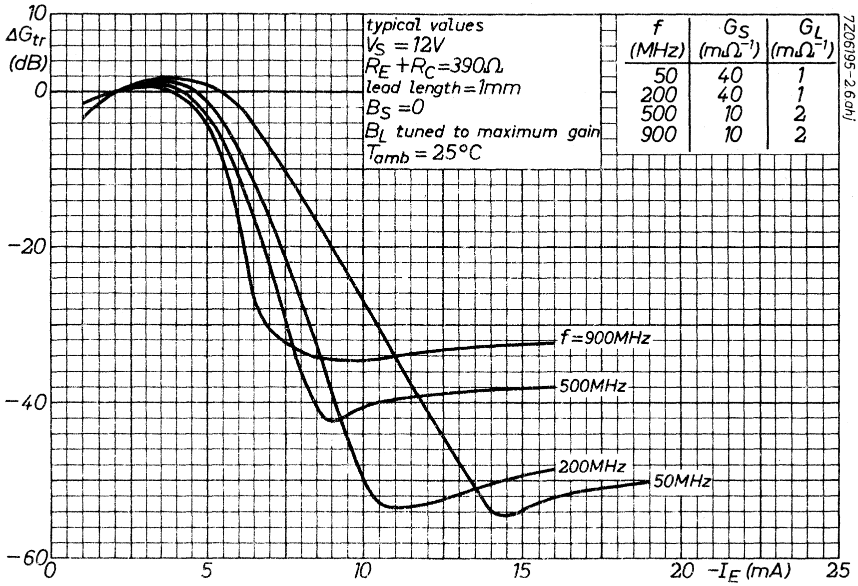
100
g_{ib}
$(m\Omega^{-1})$
$-b_{ib}$
$(m\Omega^{-1})$
$-C_{ib}$
(pF)
10
1
g_{ib}
$-C_{ib}$
$-b_{ib}$
typical values
$V_{CB} = 10V$
$-I_E = 2mA$
lead length=1mm
can to earth
10
20
50
100
200
f (MHz)
1000
7Z06192-2.6.ahj

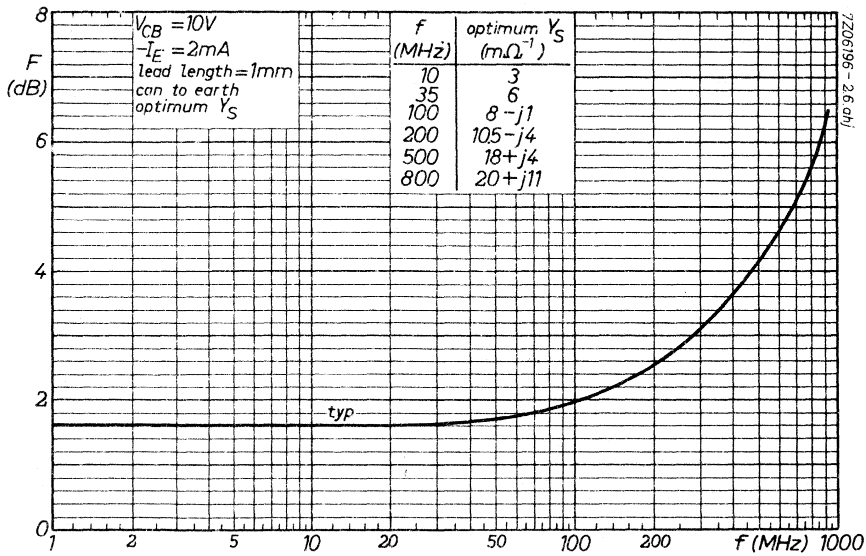


1000
$|y_{rb}|$
$(\mu\Omega^{-1})$
φ_{rb}
(°)
100
10
φ_{rb}
$|y_{rb}|$
typical values
$V_{CB} = 10V$
$-I_E = 2mA$
lead length=1mm
can to earth
10
20
50
100
200
f(MHz)
1000
7Z06191-2.6.ahj


typical values
V_{CB}=10V
$-I_E$=2mA
lead length=1mm
can to earth
$|y_{fb}|$
($m\Omega^{-1}$)
φ_{fb}
(°)
1000
200
100
50
20
10
10
20
50
100
200
f (MHz)
1000
7Z06193-2.6.ahj


typical values
V_{CB}=10V
$-I_E$=2mA
lead length=1mm
can to earth
g_{ob}
($\mu\Omega^{-1}$)
C_{ob}
(pF)
1000
500
200
100
50
20
10
10
5
2
1
0.5
0.2
0.1
10
20
50
100
200
f (MHz)
1000
7Z06194-2.6.ahj


typical values
$V_S = 12V$
$R_E + R_C = 390\Omega$
lead length = 1mm
$B_S = 0$
B_L tuned to maximum gain
$T_{amb} = 25°C$
f (MHz) | G_S ($m\Omega^{-1}$) | G_L ($m\Omega^{-1}$)
50 | 40 | 1
200 | 40 | 1
500 | 10 | 2
900 | 10 | 2
ΔG_{tr} (dB)
10
0
−20
−40
−60
0
5
10
15
20
25
$-I_E$ (mA)
f = 900MHz
500MHz
200MHz
50MHz
7Z06195 - 2.6.ahj


$V_{CB} = 10V$
$-I_E = 2mA$
lead length = 1mm
can to earth
optimum Y_S
f (MHz) | optimum Y_S ($m\Omega^{-1}$)
10 | 3
35 | 6
100 | 8 − j1
200 | 10.5 − j4
500 | 18 + j4
800 | 20 + j11
F (dB)
8
6
4
2
0
1
2
5
10
20
50
100
200
f (MHz)
1000
typ
7Z06196 - 2.6.ahj

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.

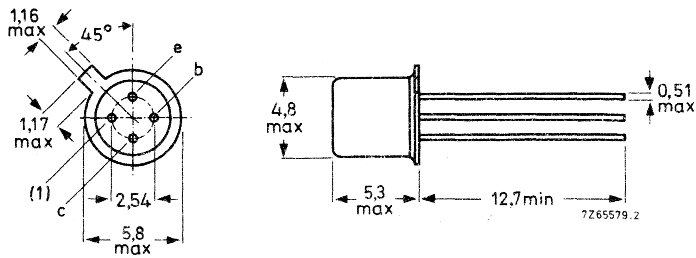
QUICK REFERENCE DATA

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 °C	P_{tot}	max.	150	mW
Junction temperature	T_j	max.	175	°C
Transition frequency I_C = 2 mA; V_{CE} = 10 V	f_T	typ.	600	MHz
Feedback capacitance at f = 10,7 MHz I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	280	fF
Maximum unilateralized power gain $-I_E$ = 2 mA; V_{CB} = 10 V; f = 900 MHz	G_{UM}	typ.	11	dB
Noise figure at optimum source admittance $-I_E$ = 2 mA; V_{CB} = 10 V; f = 900 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) [1])

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 °C	P_{tot}	max.	150	mW

Temperatures

Storage temperature	T_{stg}	−65 to +175		°C
Junction temperature	T_j	max.	175	°C

THERMAL RESISTANCE

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

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

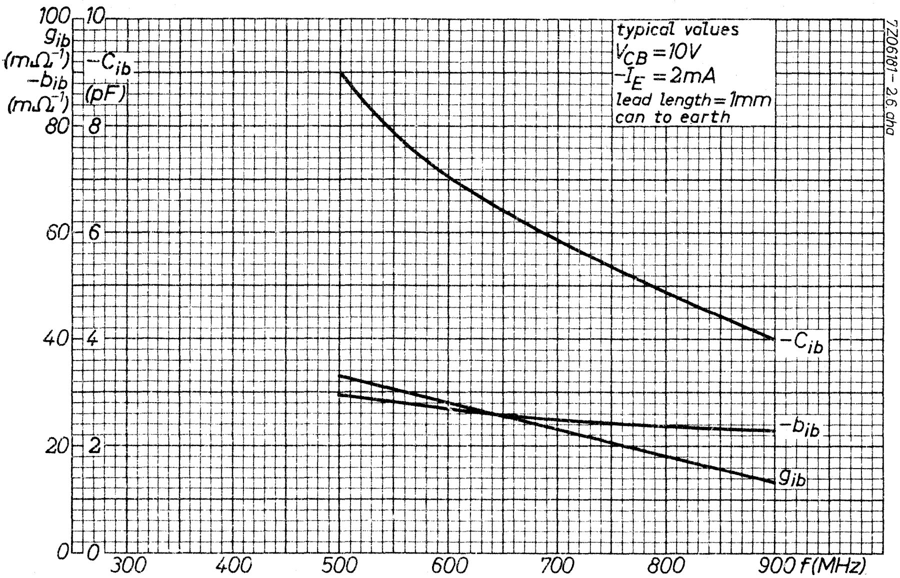
CHARACTERISTICS

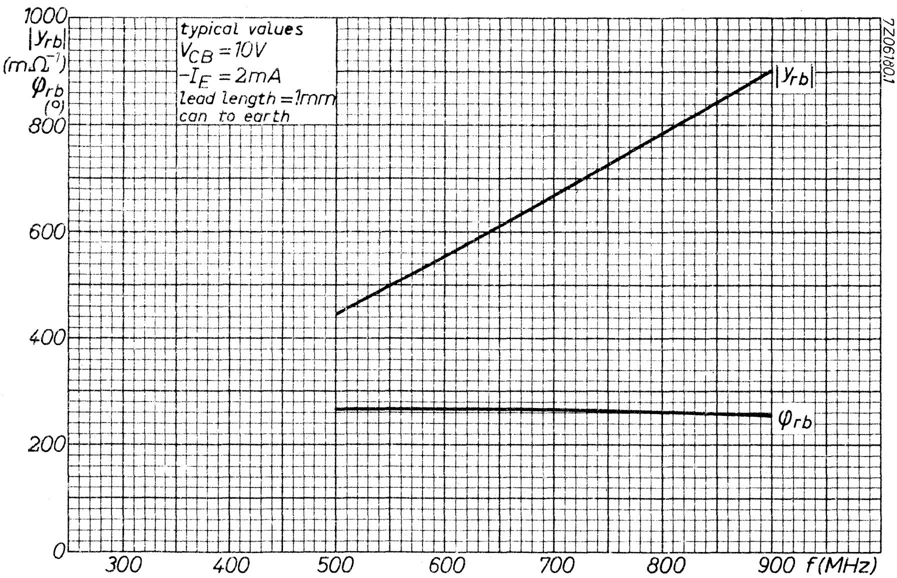
T_{amb} = 25 °C unless otherwise specified

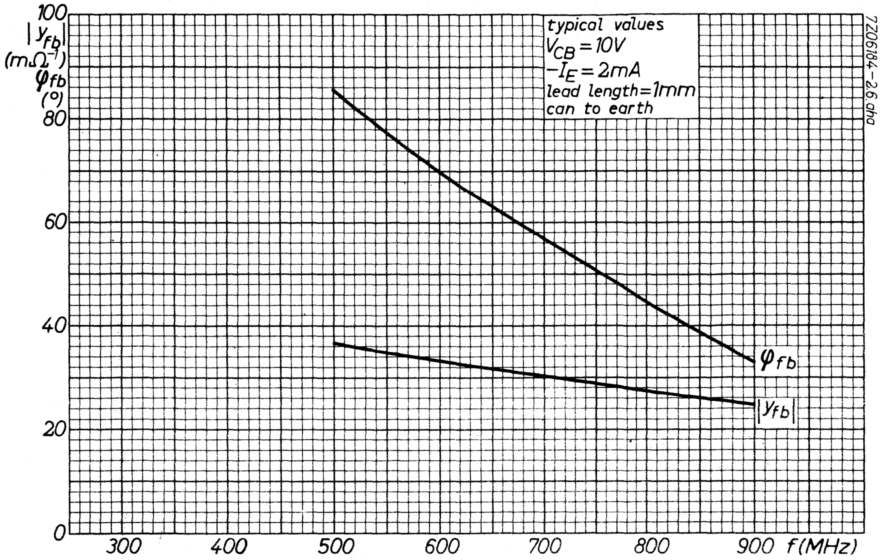
Base current				
$-I_E$ = 2 mA; V_{CB} = 10 V	I_B	typ.	70	μA
		<	150	μA
Emitter-base voltage				
$-I_E$ = 2 mA; V_{CB} = 10 V	$-V_{EB}$	typ.	0.75	V
Feedback capacitance at f = 10.7 MHz				
I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	280	fF [1]
Transition frequency				
I_C = 2 mA; V_{CE} = 10 V	f_T	typ.	600	MHz
y parameters at f = 35 MHz [2]				
$-I_E$ = 2 mA; V_{CB} = 10 V				
Output conductance	g_{ob}	typ.	10	$\mu\Omega^{-1}$
Output capacitance	C_{ob}	typ.	0.9	pF
Maximum unilateralised power gain [2]				
$G_{UM} = \frac{\lvert y_{fb} \rvert^2}{4\, g_{ib}\, g_{ob}}$				
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 500 MHz	G_{UM}	typ.	13.5	dB
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 900 MHz	G_{UM}	typ.	11	dB
Transducer gain [2]				
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 900 MHz;				
$G_S = 20\ m\Omega^{-1}$; $B_S = 0$				
$G_L = 2\ m\Omega^{-1}$; B_L : tuned	G_{tr}	typ.	8	dB

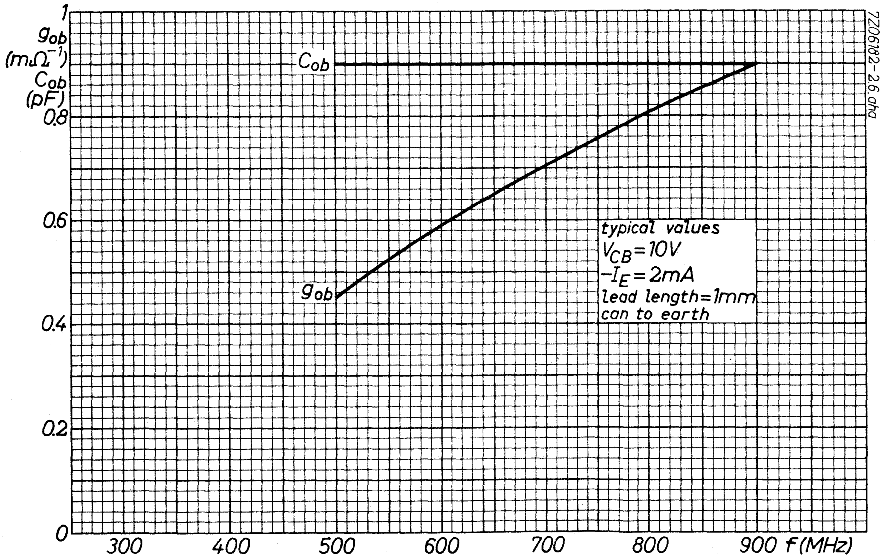
[1]) 1 fF = 1 femtofarad = 10^{-15} F.

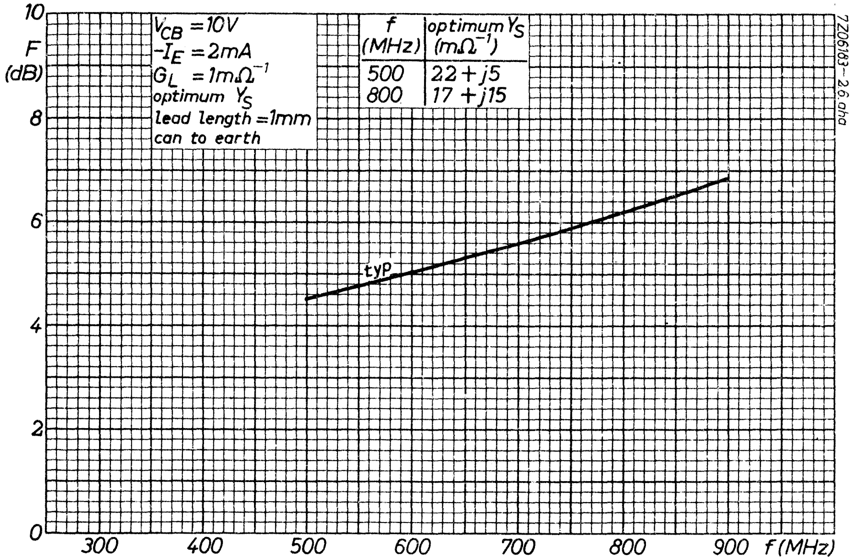
[2]) Common base configuration, metal envelope contacted to earth directly, external lead length: 1 mm.


100
g_{ib}
$(m\Omega^{-1})$
$-b_{ib}$
$(m\Omega^{-1})$
10
$-C_{ib}$
(pF)
80 8
60 6
40 4
20 2
0 0
300
400
500
600
700
800
900 f(MHz)
typical values
$V_{CB} = 10V$
$-I_E = 2mA$
lead length = 1mm
can to earth
7Z06181 - 2.6.cha
$-C_{ib}$
$-b_{ib}$
g_{ib}


1000
$|y_{rb}|$
$(m\Omega^{-1})$
φ_{rb}
(°)
800
600
400
200
0
300
400
500
600
700
800
900 f(MHz)
typical values
$V_{CB} = 10V$
$-I_E = 2mA$
lead length = 1mm
can to earth
7Z06180.1
$|y_{rb}|$
φ_{rb}


100
$|y_{fb}|$
$(m\Omega^{-1})$
φ_{fb}
(°)
80
60
40
20
0
300
400
500
600
700
800
900 f(MHz)
typical values
$V_{CB} = 10V$
$-I_E = 2mA$
lead length=1mm
can to earth
φ_{fb}
$|y_{fb}|$
7Z06184-2.6.aha


1
g_{ob}
$(m\Omega^{-1})$
C_{ob}
(pF)
0.8
0.6
0.4
0.2
0
300
400
500
600
700
800
900 f(MHz)
C_{ob}
g_{ob}
typical values
$V_{CB} = 10V$
$-I_E = 2mA$
lead length=1mm
can to earth
7Z06182-2.6.aha


V_{CB} = 10V
$-I_E$ = 2mA
G_L = 1mΩ^{-1}
optimum Y_S
lead length = 1mm
can to earth
f (MHz) | optimum Y_S (mΩ^{-1})
500 | 22 + j5
800 | 17 + j15
F (dB)
f (MHz)
typ
7Z06183-2.6.aha

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.

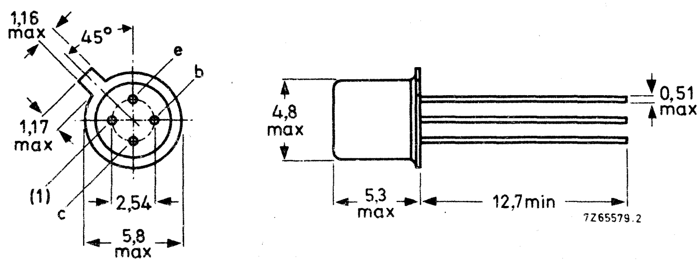
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{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 °C	P_{tot}	max.	150	mW
Junction temperature	T_j	max.	175	°C
Transition frequency I_C = 2 mA; V_{CE} = 10 V	f_T	typ.	650	MHz
Maximum unilateralized power gain $-I_E$ = 2 mA; V_{CB} = 10 V; f = 900 MHz	G_{UM}	typ.	11	dB
Noise figure at optimum source admittance $-I_E$ = 2 mA; V_{CB} = 10 V; f = 800 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) [1])

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 °C	P_{tot}	max.	150	mW

Temperatures

Storage temperature	T_{stg}	-65 to +175		°C
Junction temperature	T_j	max.	175	°C

THERMAL RESISTANCE

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

CHARACTERISTICS T_{amb} = 25 °C unless otherwise specified

Base current

$-I_E$ = 2 mA; V_{CB} = 10 V	I_B	typ.	100	μA
		<	200	μA

Emitter-base voltage [2])

$-I_E$ = 2 mA; V_{CB} = 10 V	$-V_{EB}$	typ.	770	mV

Transition frequency

I_C = 2 mA; V_{CE} = 10 V	f_T	typ.	650	MHz

Feedback capacitance at f = 10.7 MHz

I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	330	fF

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

[2]) $-V_{EB}$ decreases by about 1.6 mV/°C with increasing temperature.

CHARACTERISTICS (continued) T_{amb} = 25 °C unless otherwise specified

Output conductance at f = 35 MHz				
$-I_E$ = 2 mA; V_{CB} = 10 V	g_{ob}	typ.	8	$\mu\Omega^{-1}$
Transducer gain at f = 900 MHz (common base) [1]				
$-I_E$ = 2 mA; V_{CB} = 10 V; G_S = 20 $m\Omega^{-1}$; G_L = 2 $m\Omega^{-1}$	G_{tr}	>	8	dB
		typ.	10	dB
Max. unilateralised power gain $G_{UM} = \frac{\lvert y_{fb}\rvert^2}{4\, g_{ib} g_{ob}}$				
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 500 MHz	G_{UM}	typ.	15	dB
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 900 MHz	G_{UM}	typ.	11	dB
Noise figure at optimum source admittance				
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 200 MHz	F	typ.	3.3	dB
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 800 MHz	F	typ.	7.4	dB

1) 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.

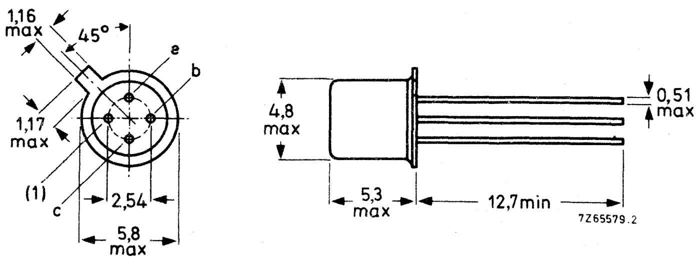
QUICK REFERENCE DATA

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 °C	P_{tot}	max.	150	mW
Junction temperature	T_j	max.	175	°C
Transition frequency I_C = 3 mA; V_{CE} = 10 V	f_T	typ.	800	MHz
Maximum unilateralized power gain $-I_E$ = 3 mA; V_{CB} = 10 V; f = 900 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 °C	P_{tot}	max.	150	mW
Storage temperature	T_{stg}	−65 to + 175		°C
Junction temperature	T_j	max.	175	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	1	K/mW

CHARACTERISTICS

T_{amb} = 25 °C

Base current				
$-I_E$ = 3 mA; V_{CB} = 10 V	I_B	typ.	125	µA
		<	300	µA
Emitter-base voltage *				
$-I_E$ = 3 mA; V_{CB} = 10 V	$-V_{EB}$	typ.	770	mV
Transition frequency				
I_C = 3 mA; V_{CE} = 10 V	f_T	typ.	800	MHz
Feedback capacitance at f = 10,7 MHz				
I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	330	fF
Transducer gain (common base) **				
$-I_E$ = 3 mA; V_{CB} = 10 V				
G_S = 20 mA/V; G_L = 2 mA/V; f = 900 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 mA; V_{CB} = 10 V; f = 500 MHz	G_{UM}	typ.	16	dB
$-I_E$ = 3 mA; V_{CB} = 10 V; f = 900 MHz	G_{UM}	typ.	13	dB

* $-V_{EB}$ decreases by about 1,6 mV/K with increasing temperature.

** Envelope connected to earth directly, lead length = 3 mm.

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a plastic envelope with stiff, self-locking pins suitable for use with standard printed-circuit boards. The BF194 is 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_{CEO}	max.	20	V
Collector current (d.c.)	I_C	max.	30	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	250	mW
Junction temperature	T_j	max.	125	°C
D.C. current gain at T_j = 25 °C I_C = 1 mA; V_{CE} = 10 V	h_{FE}	typ.	115	
Transition frequency I_C = 1 mA; V_{CE} = 10 V	f_T	typ.	260	MHz
Noise figure at f = 100 MHz I_C = 1 mA; V_{CE} = 10 V; G_S = 10 mA/V	F	typ.	4	dB
Conversion noise figure at f = 1 MHz I_C = 1 mA; V_{CE} = 10 V; G_S = 1,2 mA/V	F_c	typ.	2	dB

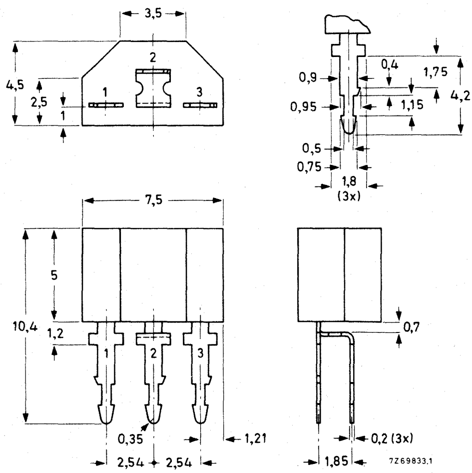
MECHANICAL DATA

Dimensions in mm

SOT-25

Connections

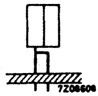
1. Base
2. Emitter
3. Collector



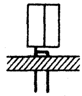
FOR NEW DESIGN THE SUCCESSOR TYPE BF494 IS RECOMMENDED

MOUNTING INSTRUCTIONS

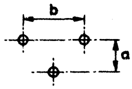
1. Thickness of printed board: max. 1.1 mm
   Hole diameter 0.77 to 0.83 mm



2. Thickness of printed board: max. 1.7 mm
   Hole diameter 1.25 to 1.35 mm



Bore plan



a = 2.49 to 2.59 mm
b = 5.03 to 5.13 mm

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.	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} = 25 °C	P_{tot}	max.	250	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	$R_{th\ j\text{-}a}$	=	0.4	°C/mW

CHARACTERISTICS

$T_j = 25\ ^oC$

Base-emitter voltage [1]				
$I_C = 1$ mA; $V_{CE} = 10$ V	V_{BE}		0.65 to 0.74	V
Base current				
$I_C = 1$ mA; $V_{CE} = 10$ V	I_B	4.5 to	15	μA
		typ.	8.7	μA
Feedback capacitance at f = 0.45 MHz				
$I_C = 1$ mA; $V_{CE} = 10$ V	C_{re}	typ.	0.95	pF
Transition frequency				
$I_C = 1$ mA; $V_{CE} = 10$ V	f_T	typ.	260	MHz
Noise figure				
$I_C = 1$ mA; $V_{CE} = 10$ V				
$G_S = 2\ m\Omega^{-1}$; f = 0.2 MHz	F	typ.	1.5	dB
$G_S = 1.5\ m\Omega^{-1}$; f = 1.0 MHz	F	typ.	1.2	dB
$G_S = 10\ m\Omega^{-1}$; f = 100 MHz	F	typ.	4	dB
Conversion noise figure				
$I_C = 1$ mA; $V_{CE} = 10$ V				
$G_S = 0.6\ m\Omega^{-1}$; f = 0.2 MHz	F_c	typ.	3	dB
$G_S = 1.2\ m\Omega^{-1}$; f = 1.0 MHz	F_c	typ.	2	dB
y parameters at f = 100 MHz (common base)				
$I_C = 1$ mA; $V_{CE} = 10$ V (lead length = 3 mm)				
Input conductance	g_{ib}	typ.	36	$m\Omega^{-1}$
Input susceptance	$-b_{ib}$	typ.	3	$m\Omega^{-1}$
Feedback admittance	$\|y_{rb}\|$	typ.	450	$\mu\Omega^{-1}$
Phase angle of feedback admittance	φ_{rb}	typ.	272^o	
Tranfer admittance	$\|y_{fb}\|$	typ.	33	$m\Omega^{-1}$
Phase angle of transfer admittance	φ_{fb}	typ.	146^o	
Output conductance	g_{ob}	typ.	22	$\mu\Omega^{-1}$
Output susceptance	b_{ob}	typ.	1.1	$m\Omega^{-1}$

y parameters (common emitter)

$I_C = 1$ mA; $V_{CE} = 10$ V (lead length = 3 mm)			f = 10.7 MHz	f = 0.45 MHz	
Input conductance	g_{ie}	<	0.64	0.54	$m\Omega^{-1}$
Output conductance	g_{oe}	<	13.5	11.5	$\mu\Omega^{-1}$

1) V_{BE} decreases by about 1.7 mV/^{o}C with increasing temperature.

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a plastic envelope with stiff self-locking pins suitable for use with standard printed-circuit boards. The BF195 is 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.	20	V
Collector current (d.c.)	I_C	max.	30	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	250	mW
Junction temperature	T_j	max.	125	°C
D.C. current gain at T_j = 25 °C				
I_C = 1 mA; V_{CE} = 10 V	h_{FE}	typ.	67	
Transition frequency				
I_C = 1 mA; V_{CE} = 10 V	f_T	typ.	200	MHz
Noise figure				
I_C = 1 mA; V_{CE} = 10 V				
G_S = 20 mA/V; f = 1 MHz	F	typ.	3,5	dB
G_S = 10 mA/V; f = 100 MHz	F	typ.	4	dB

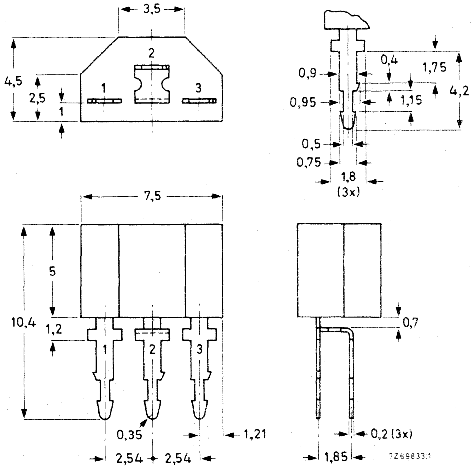
MECHANICAL DATA

Dimensions in mm

SOT-25

Connections

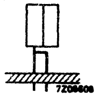
1. Base
2. Emitter
3. Collector



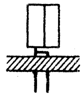
FOR NEW DESIGN THE SUCCESSOR TYPE BF495 IS RECOMMENDED

MOUNTING INSTRUCTIONS

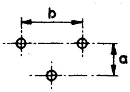
1. Thickness of printed board: max. 1.1 mm
   Hole diameter 0.77 to 0.83 mm



2. Thickness of printed board: max. 1.7 mm
   Hole diameter 1.25 to 1.35 mm



Bore plan



a = 2.49 to 2.59 mm
b = 5.03 to 5.13 mm

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.	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} = 25 °C	P_{tot}	max.	250	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	$R_{th\ j-a}$	=	0.4	°C/mW

CHARACTERISTICS $T_j = 25\ ^oC$

Base-emitter voltage [1]				
$I_C = 1$ mA; $V_{CE} = 10$ V	V_{BE}		0.65 to 0.74	V
Base current				
$I_C = 1$ mA; $V_{CE} = 10$ V	I_B	8 to	28	μA
		typ.	15	μA
Feedback capacitance at f = 0.45 MHz				
$I_C = 1$ mA; $V_{CE} = 10$ V	C_{re}	typ.	0.95	pF
Transition frequency				
$I_C = 1$ mA; $V_{CE} = 10$ V	f_T	typ.	200	MHz
Noise figure				
$I_C = 1$ mA; $V_{CE} = 10$ V				
$G_S = 20\ m\Omega^{-1}$; f = 1 MHz	F	typ.	3.5	dB
$G_S = 10\ m\Omega^{-1}$; f = 100 MHz	F	typ.	4	dB
Conversion noise figure				
$I_C = 1$ mA; $V_{CE} = 10$ V				
$G_S = 1.2\ m\Omega^{-1}$; f = 0.2 MHz	F_c	typ.	4	dB
$G_S = 1.5\ m\Omega^{-1}$; f = 1 MHz	F_c	typ.	2.5	dB
y parameters at f = 100 MHz (common base)				
$I_C = 1$ mA; $V_{CE} = 10$ V (lead length = 3 mm)				
Input conductance	g_{ib}	typ.	38	$m\Omega^{-1}$
Input susceptance	$-b_{ib}$	typ.	1	$m\Omega^{-1}$
Feedback admittance	$\|y_{rb}\|$	typ.	440	$\mu\Omega^{-1}$
Phase angle of feedback admittance	φ_{rb}	typ.	275°	
Transfer admittance	$\|y_{fb}\|$	typ.	34	$m\Omega^{-1}$
Phase angle of transfer admittance	φ_{fb}	typ.	140°	
Output conductance	g_{ob}	typ.	12	$\mu\Omega^{-1}$
Output susceptance	b_{ob}	typ.	1.1	$m\Omega^{-1}$

y parameters (common emitter)

$I_C = 1$ mA; $V_{CE} = 10$ V (lead length = 3 mm)			f = 10.7 MHz	f = 0.45 MHz	
Input conductance	g_{ie}	<	0.96	0.86	$m\Omega^{-1}$
Output conductance	g_{oe}	<	9.5	7.0	$\mu\Omega^{-1}$

[1] V_{BE} decreases by about 1.7 mV/°C with increasing temperature.

SILICON PLANAR TRANSISTOR

N-P-N transistor in a plastic envelope with stiff self-locking pins suitable for use with standard printed-circuit boards. The transistor 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_{CEO}	max.	30	V
Collector current (d.c.)	I_C	max.	25	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	250	mW
Junction temperature	T_j	max.	125	°C
Transition frequency I_C = 4 mA; V_{CE} = 10 V	f_T	typ.	400	MHz
Feedback capacitance at f = 10,7 MHz I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	200	fF
Maximum unilateralized power gain I_C = 4 mA; V_{CE} = 10 V; f = 35 MHz	G_{UM}	typ.	42	dB
I_C = 4 mA; V_{CE} = 10 V; f = 45 MHz	G_{UM}	typ.	39	dB
Gain control range	ΔG_{tr}	typ.	60	dB

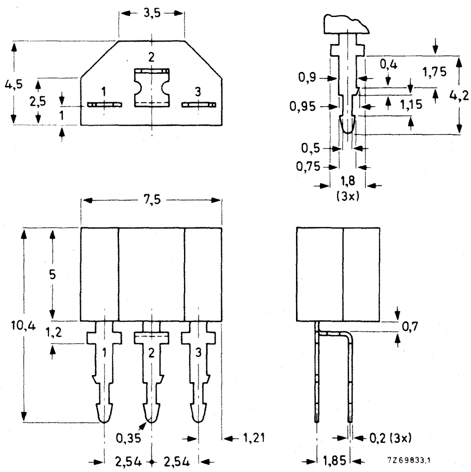
MECHANICAL DATA

Dimensions in mm

SOT-25

Connections

1. Base
2. Emitter
3. Collector



FOR NEW DESIGN THE SUCCESSOR TYPE BF198 IS RECOMMENDED

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a plastic envelope with stiff self-locking pins suitable for use with standard printed-circuit boards. The transistor 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 °C	P_{tot}	max.	250	mW
Junction temperature	T_j	max.	125	°C
Transition frequency I_C = 5 mA; V_{CE} = 10 V	f_T	typ.	550	MHz
Feedback capacitance at f = 10,7 MHz I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	300	fF
Maximum unilateralized power gain I_C = 7 mA; V_{CE} = 10 V; f = 35 MHz	G_{UM}	typ.	43	dB
I_C = 7 mA; V_{CE} = 10 V; f = 45 MHz	G_{UM}	typ.	41	dB
Video detector output voltage	V_O	typ.	7,7	V

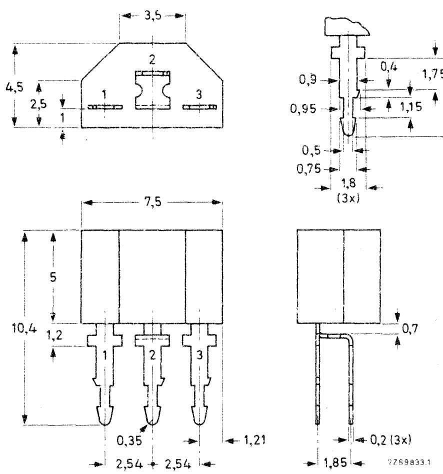
MECHANICAL DATA

Dimensions in mm

SOT-25

Connections

1. Base
2. Emitter
3. Collector



FOR NEW DESIGN THE SUCCESSOR TYPE BF199 IS RECOMMENDED

SILICON PLANAR TRANSISTOR

N-P-N transistor in a plastic TO-92 variant.
The BF 198 has a very low feedback capacitance and is intended for use in the forward gain control stage of the television i.f. amplifier.

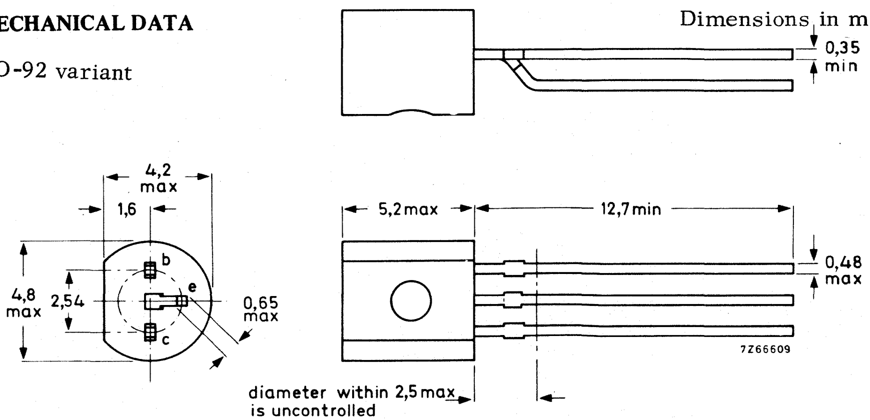
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	V
Collector current (d. c.)	I_C	max.	25	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500	mW
Junction temperature	T_j	max.	150	°C
Transition frequency at f = 100 MHz I_C = 4 mA; V_{CE} = 10 V	f_T	typ.	400	MHz
Feedback capacitance at f = 10.7 MHz I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	200	fF
Max. unilateralized power gain I_C = 4 mA; V_{CE} = 10 V; f = 35 MHz	G_{UM}	typ.	42	dB
f = 45 MHz	G_{UM}	typ.	39	dB
Gain control range	ΔG_{tr}	typ.	60	dB

MECHANICAL DATA

TO-92 variant

Dimensions in mm



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 [1]
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 °C	P_{tot}	max.	500	mW

Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.25	°C/mW

[1]) See also page 6.

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

Base current at about 50 dB gain control				
I_C = 6 mA; V_{CE} = 2 V	I_B	<	270	µA
I_C = 15 mA; V_{CE} = 5 V	I_B	<	1.5	mA
Base current				
I_C = 4 mA; V_{CE} = 10 V	I_B	typ.	60	µA
		<	150	µA
Base-emitter voltage [1]				
I_C = 4 mA; V_{CE} = 10 V	V_{BE}	typ.	760	mV
		<	850	mV
Feedback capacitance at f = 10.7 MHz				
I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	200	fF
Transition frequency at f = 100 MHz				
I_C = 4 mA; V_{CE} = 10 V	f_T	typ.	400	MHz
Noise figure				
I_C = 4 mA; V_{CE} = 10 V; G_S = 10 mA/V; f = 35 MHz; B_S = 0	F	typ.	3	dB

y parameters (common emitter)

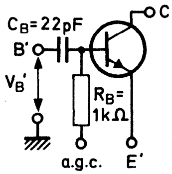
I_C = 4 mA; V_{CE} = 10 V

			f = 35	45	MHz
Input conductance	g_{ie}	typ.	3.2	4.8	mA/V
Input capacitance	C_{ie}	typ.	37	35	pF
Feedback admittance	$\|y_{re}\|$	typ.	47	60	µA/V
Phase angle of feedback admittance	φ_{re}	typ.	268°	268°	
Transfer admittance	$\|y_{fe}\|$	typ.	105	100	mA/V
Phase angle of transfer admittance	φ_{fe}	typ.	340°	340°	
Output conductance	g_{oe}	typ.	50	60	µA/V
Output capacitance	C_{oe}	typ.	1.3	1.3	pF
Maximum unilateralized power gain					
G_{UM} (in dB) = $10 \log \frac{\|y_{fe}\|^2}{4 g_{ie} g_{oe}}$					
I_C = 4 mA; V_{CE} = 10 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.



7Z62020

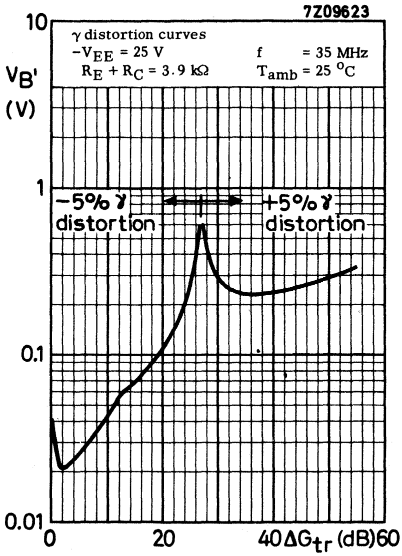
The transistor with these additional components is effectively an "equivalent transistor" for gain control purposes, the signal handling capability of which may be expressed in terms of voltage. (Without these components the varying input admittance means that the signal handling capability can only be expressed in terms of power).

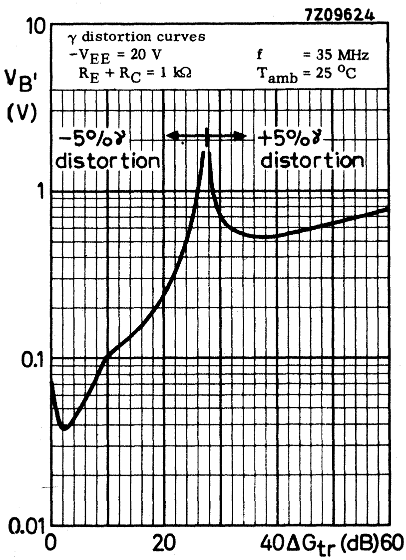
The signal handling capability of the equivalent transistor as a function of ΔG_{tr} (the reduction in transducer gain with gain control) will be found on pages 4 and 5.

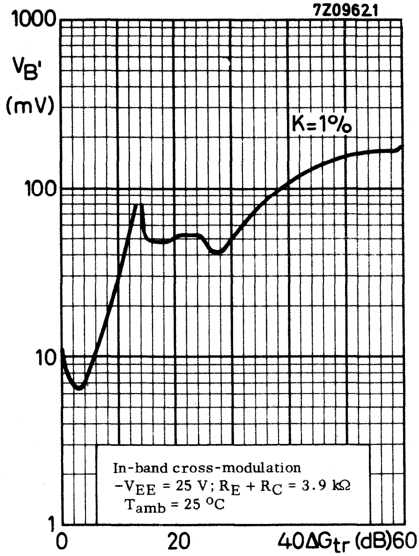
a. Voltage versus ΔG_{tr} curves for a γ distortion of 5% are below.

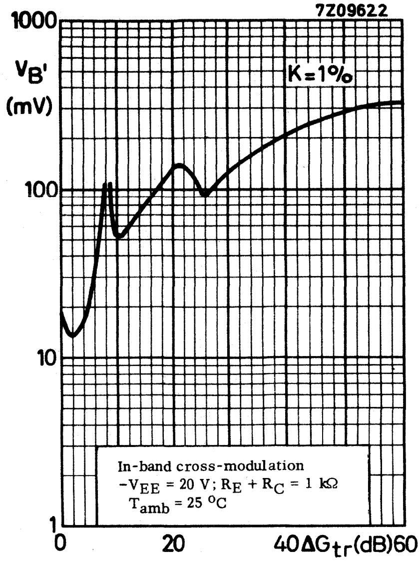
b. Voltage versus ΔG_{tr} curves for an in-band cross modulation factor of 1% are on page 5.

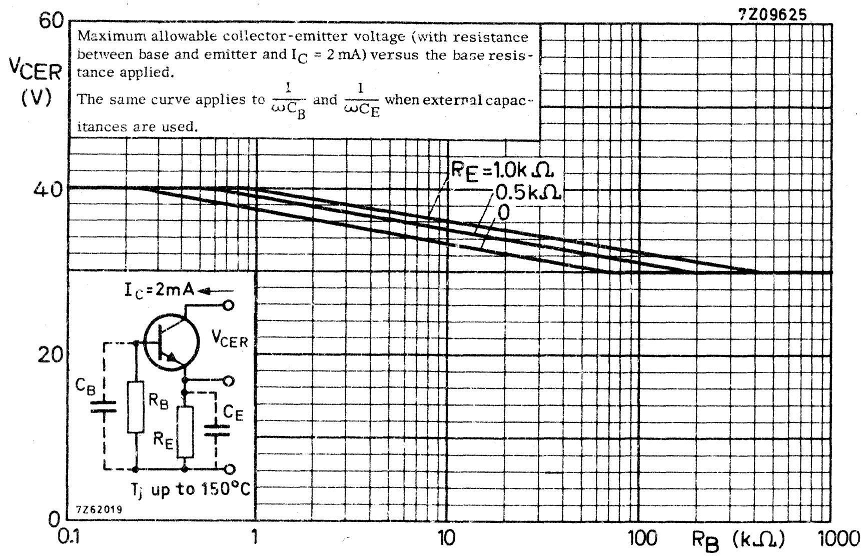
Graphs of the y-parameters are on pages 8 to 11.

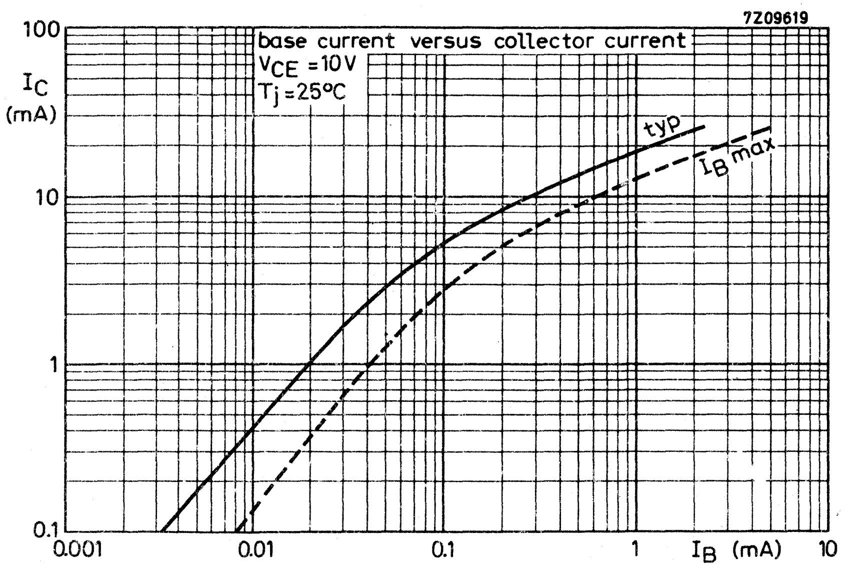


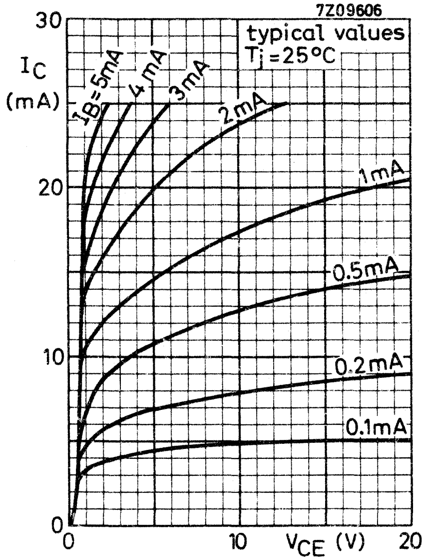


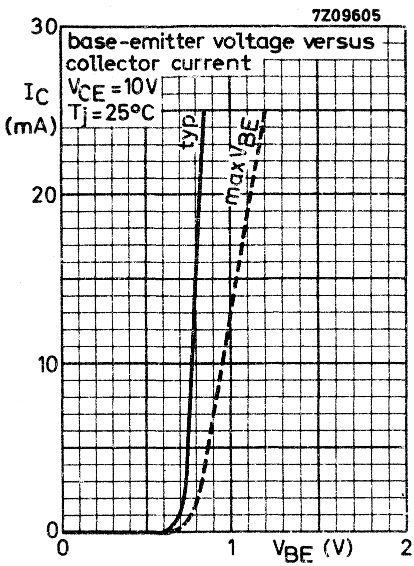

7Z09621
1000
$V_{B'}$
(mV)
K=1%
100
10
1
0
20
40 ΔG_{tr} (dB) 60
In-band cross-modulation
$-V_{EE}$ = 25 V; $R_E + R_C$ = 3.9 kΩ
T_{amb} = 25 °C

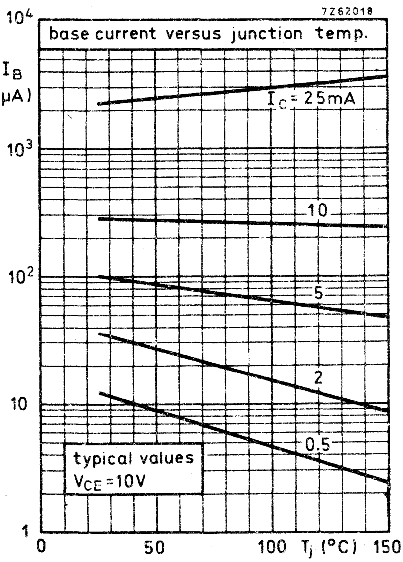

7Z09622
1000
$V_{B'}$
(mV)
K=1%
100
10
1
0
20
40 ΔG_{tr} (dB) 60
In-band cross-modulation
$-V_{EE}$ = 20 V; $R_E + R_C$ = 1 kΩ
T_{amb} = 25 °C

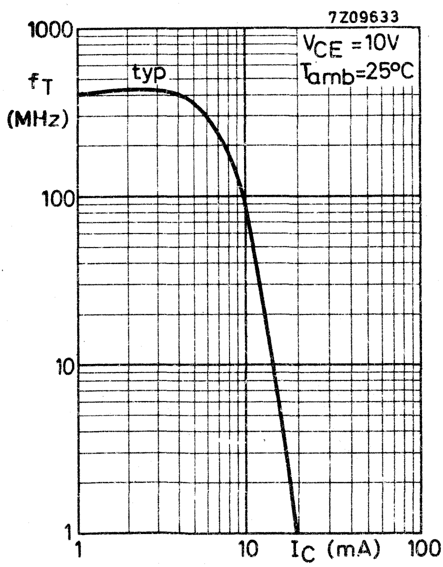

7Z09625
Maximum allowable collector-emitter voltage (with resistance between base and emitter and I_C = 2 mA) versus the base resistance applied.
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$ when external capacitances are used.
V_{CER} (V)
60
40
20
0
R_E = 1.0 kΩ
0.5 kΩ
0
I_C = 2 mA
V_{CER}
C_B
R_B
R_E
C_E
T_j up to 150 °C
7Z62019
0.1
1
10
100
R_B (kΩ)
1000


7Z09619
base current versus collector current
V_{CE} = 10 V
T_j = 25 °C
I_C (mA)
100
10
1
0.1
typ
I_B max
0.001
0.01
0.1
1
I_B (mA)
10

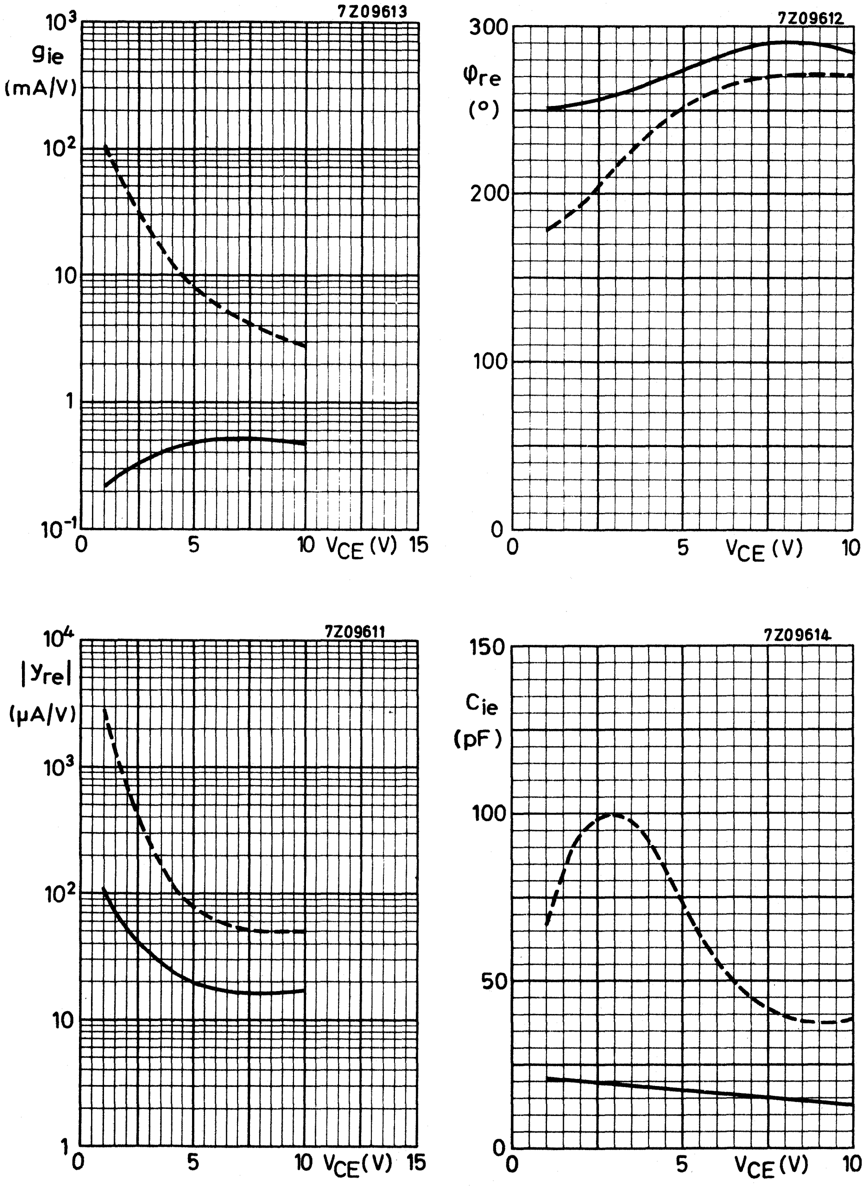

7Z09606
typical values
$T_j = 25°C$
I_C (mA)
I_B=5mA
4 mA
3mA
2mA
1mA
0.5mA
0.2mA
0.1mA
V_{CE} (V)
0
10
20
30


7Z09605
base-emitter voltage versus collector current
V_{CE} = 10V
T_j = 25°C
I_C (mA)
typ
max V_{BE}
V_{BE} (V)
0
1
2
10
20
30


7Z62018
base current versus junction temp.
I_B (μA)
I_C = 25mA
10
5
2
0.5
typical values
V_{CE} = 10V
T_j (°C)
0
50
100
150
1
10
10^2
10^3
10^4

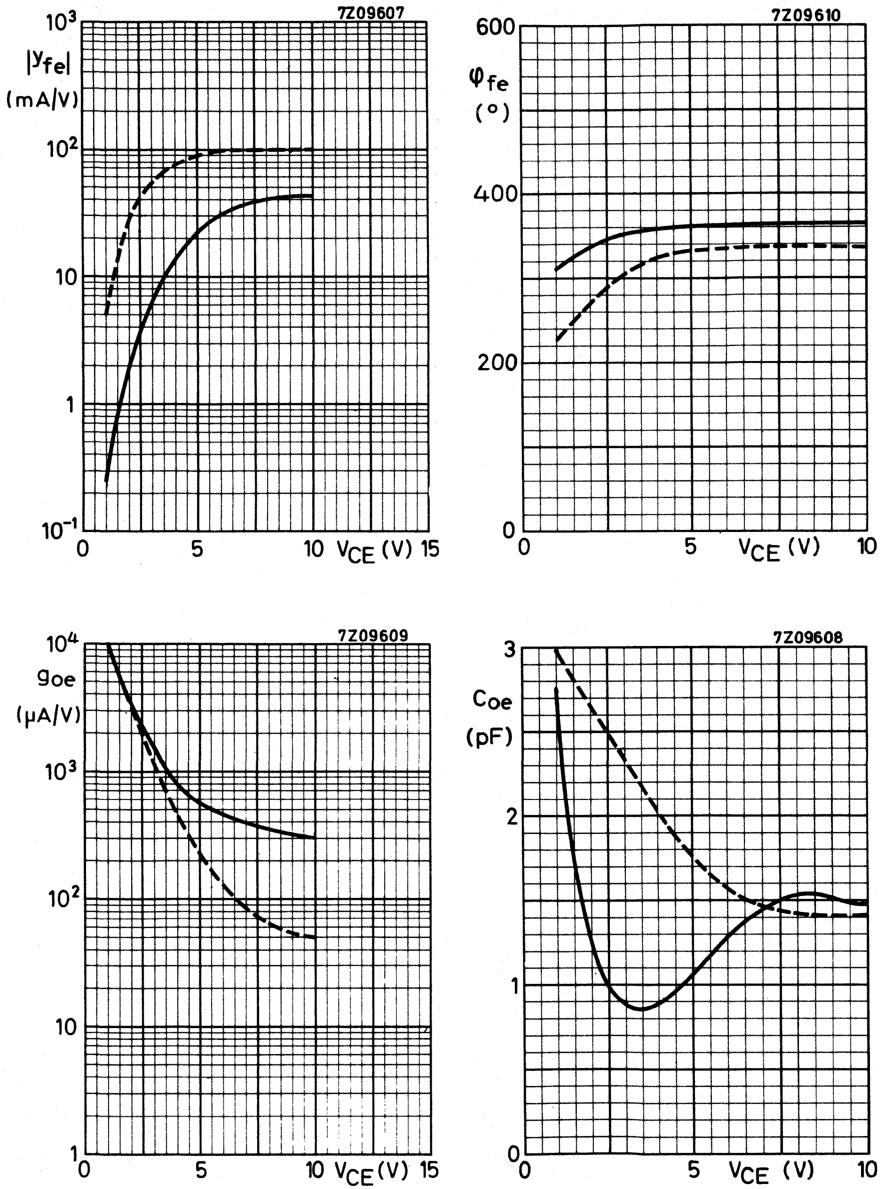

7Z09633
V_{CE} = 10V
T_{amb} = 25°C
f_T (MHz)
typ
I_C (mA)
1
10
100
1000

Voltage control; $-V_{EE}$ = 25 V; $R_E + R_C$ = 3.9 kΩ; f = 35 MHz



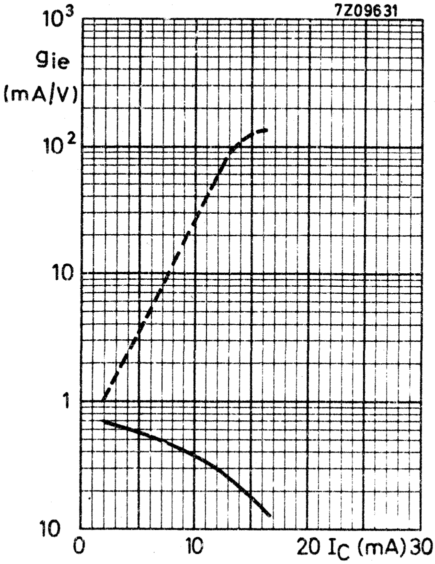
y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on page 4 (dashed curves apply to the transistor only).

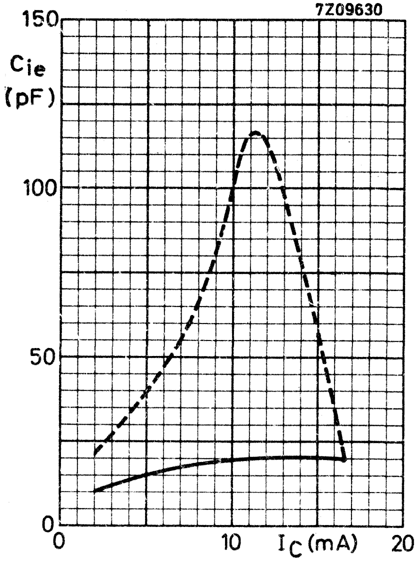
Voltage control; $-V_{EE}$ = 25 V; $R_E + R_C$ = 3.9 kΩ; f = 35 MHz

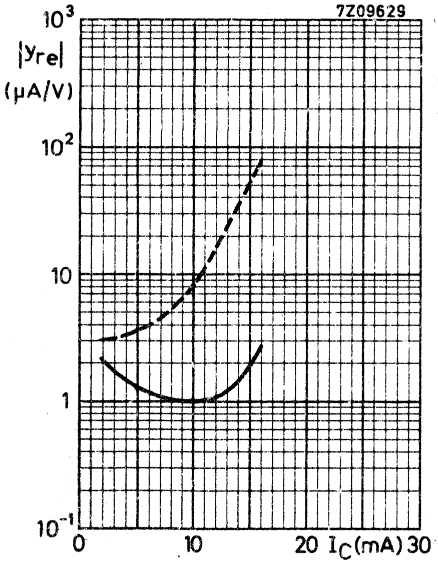


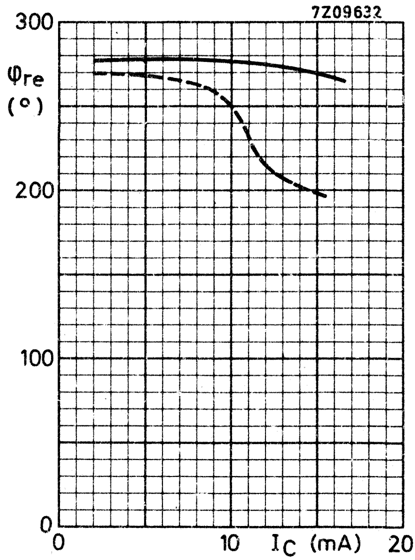
y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on page 4 (dashed curves apply to the transistor only).

Current control; $-V_{EE} = 20$ V; $R_E + R_C = 1$ kΩ; f = 35 MHz



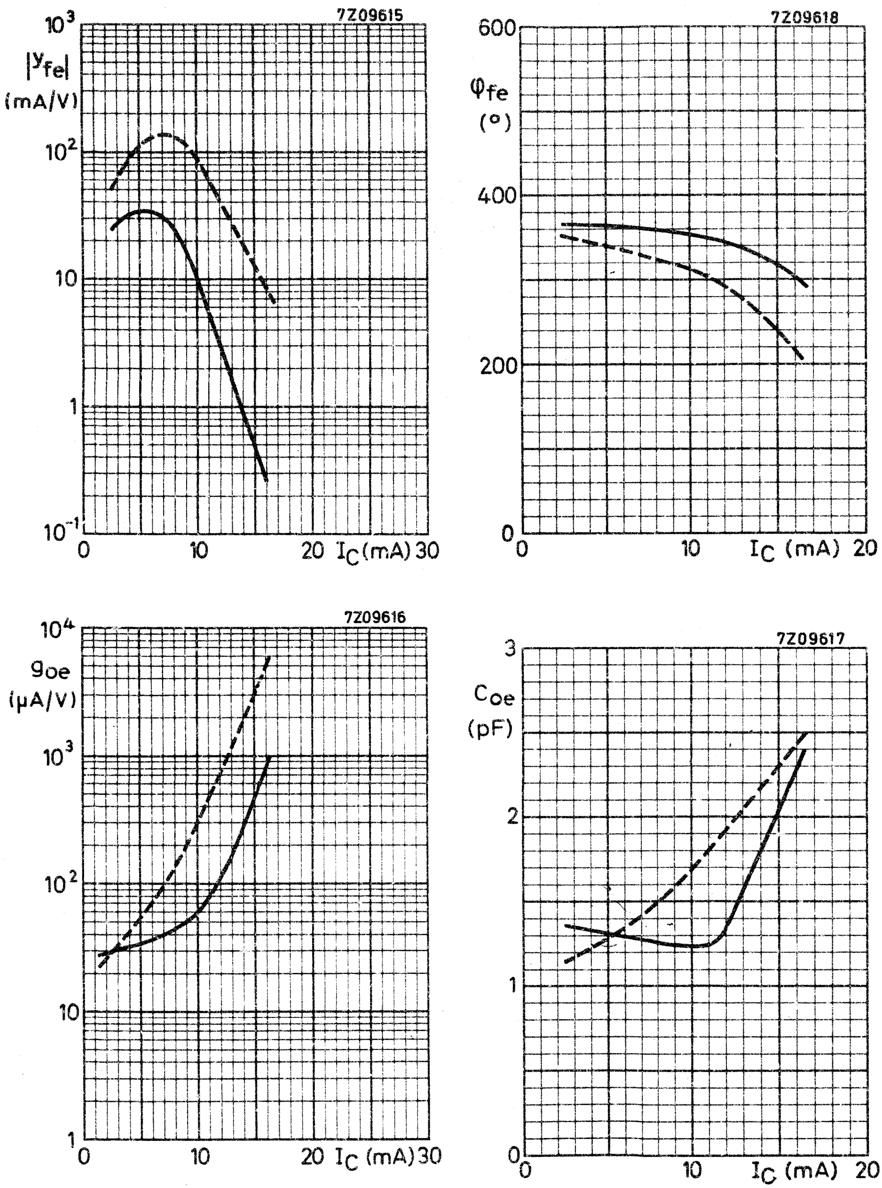






y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on page 4 (dashed curves apply to the transistor only).

Current control; $-V_{EE} = 20$ V; $R_E + R_C = 1$ kΩ; f = 35 MHz



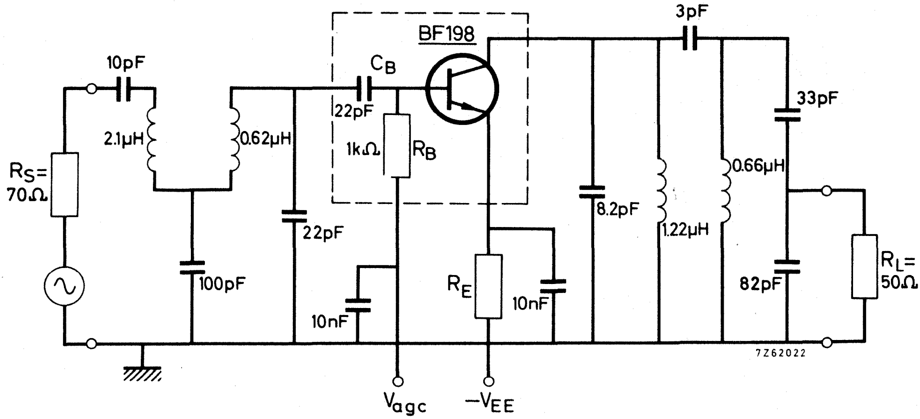
y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on page 4 (dashed curves apply to the transistor only).

APPLICATION INFORMATION

First stage of an i.f. amplifier

Basic circuit with voltage gain control: $R_E + R_C = 3.9\ k\Omega$; $-V_{EE} = 25\ V$

current gain control: $R_E + R_C = 1\ k\Omega$; $-V_{EE} = 20\ V$

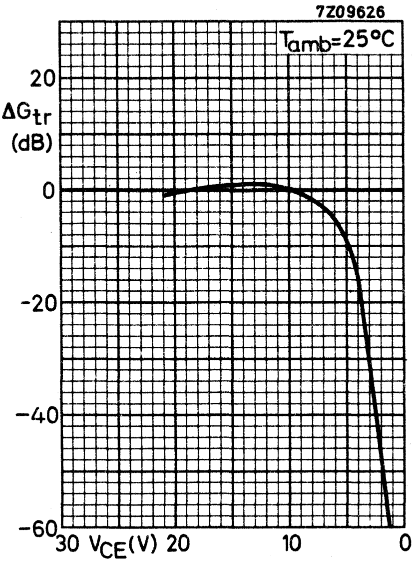


Transducer gain

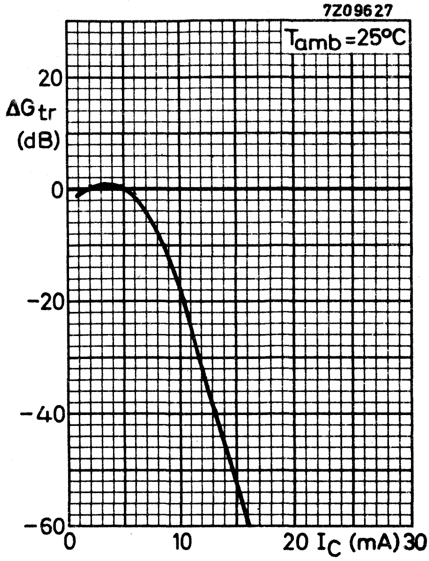
$$G_{tr}\ (\text{in dB}) = 10 \log \frac{\text{output power in load } R_L}{\text{available power from source } R_S}$$

f = 36.4 MHz; I_C = 4 mA; $R_E + R_C$ = 3.9 kΩ; $-V_{EE}$ = 25 V	G_{tr}	typ.	25.5	dB
Gain control range (see also upper graphs next page)	ΔG_{tr}	typ.	60	dB

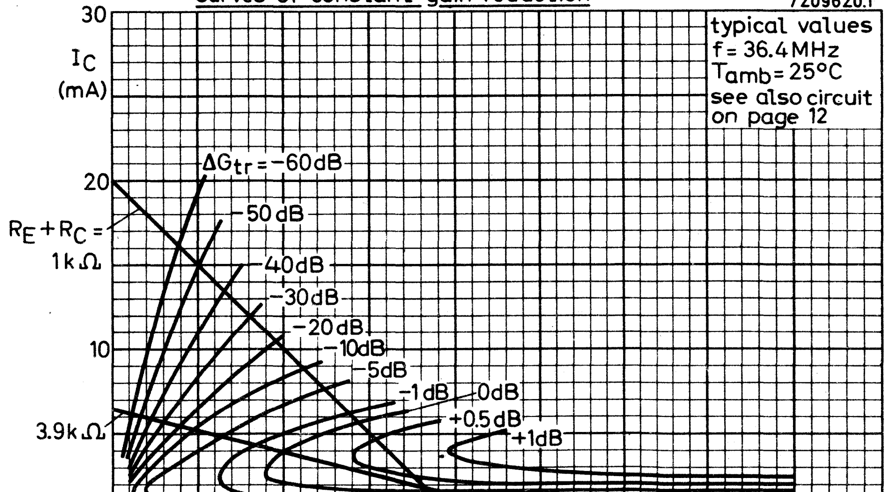
Voltage gain control



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.

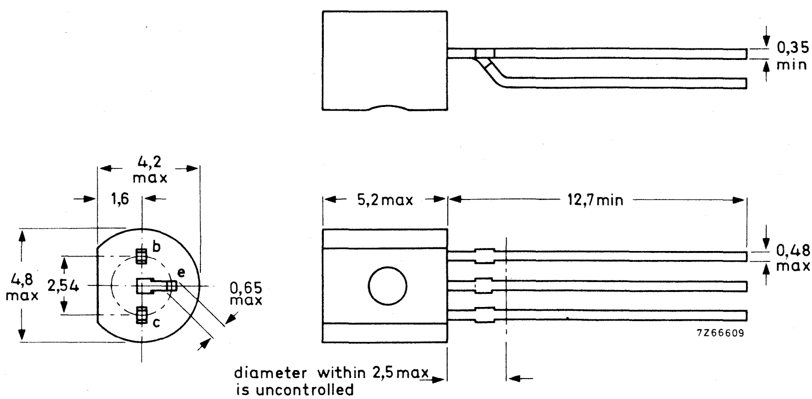
QUICK REFERENCE DATA

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 °C	P_{tot}	max.	500	mW	
Junction temperature	T_j	max.	150	°C	
Transition frequency at f = 100 MHz I_C = 5 mA; V_{CE} = 10 V	f_T	typ.	550	MHz	
Feedback capacitance at f = 10,7 MHz I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	340	fF	←
Maximum unilateral power gain I_C = 7 mA; V_{CE} = 10 V; f = 35 MHz	G_{UM}	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_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	25	V [1]
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 °C	P_{tot}	max.	500	mW
Temperatures				
Storage temperature	T_{stg}		−65 to +150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.25	°C/mW

[1]) See also page 4

CHARACTERISTICS

$T_{amb} = 25\ ^oC$

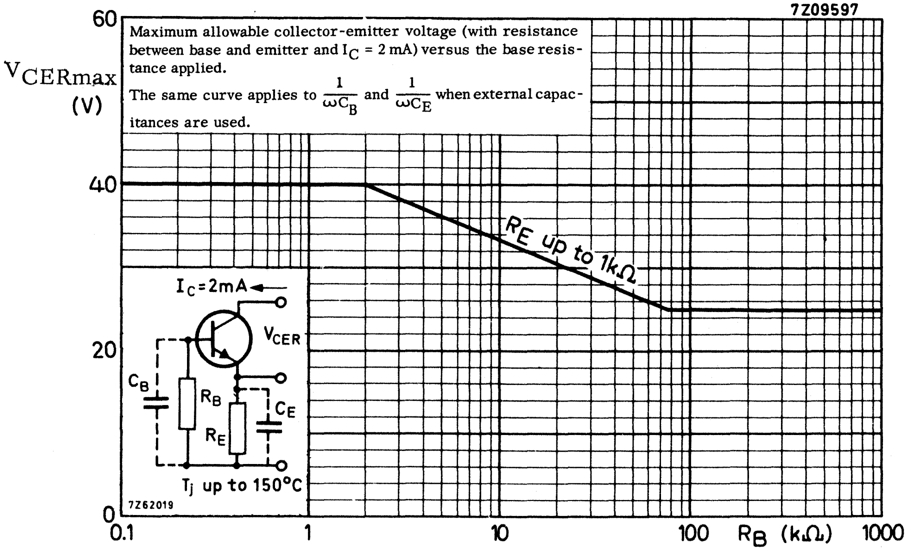
Base current				
$I_C = 7$ mA; $V_{CE} = 10$ V	I_B	typ.	60	μA
		<	185	μA
Base-emitter voltage *				
$I_C = 7$ mA; $V_{CE} = 10$ V	V_{BE}	typ.	775	mV
		<	925	mV
Transition frequency at f = 100 MHz				
$I_C = 5$ mA; $V_{CE} = 10$ V	f_T	typ.	550	MHz
Feedback capacitance at f = 10,7 MHz				
$I_C = 1$ mA; $V_{CE} = 10$ V	C_{re}	typ.	340	fF
y-parameters (common emitter)				
$I_C = 7$ mA; $V_{CE} = 10$ V; f = 35 MHz				
input conductance	g_{ie}	typ.	5,5	mA/V
input capacitance	C_{ie}	typ.	55	pF
feedback admittance	$\lvert y_{re} \rvert$	typ.	75	μA/V
phase angle of feedback admittance	φ_{re}	typ.	268°	
transfer admittance	$\lvert y_{fe} \rvert$	typ.	220	mA/V
phase angle of transfer admittance	φ_{fe}	typ.	338°	
output conductance	g_{oe}	typ.	80	μA/V
output capacitance	C_{oe}	typ.	2,0	pF

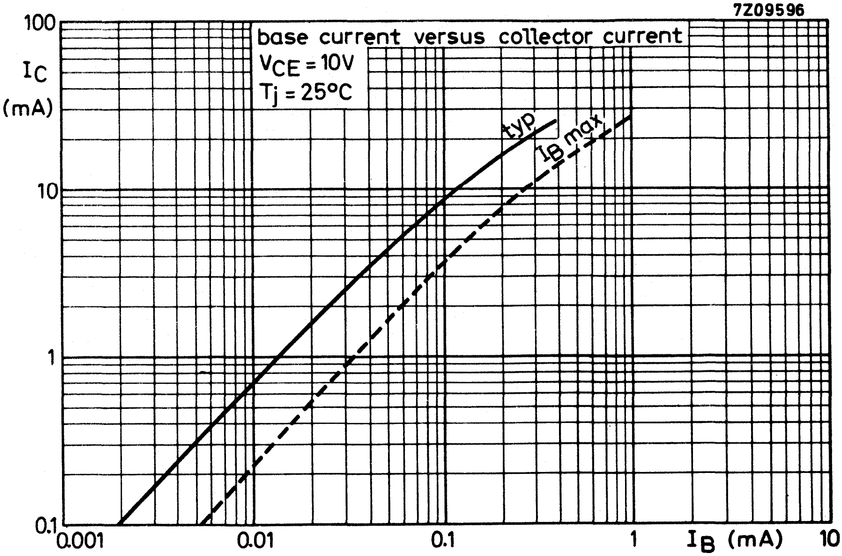
Maximum unilateral power gain

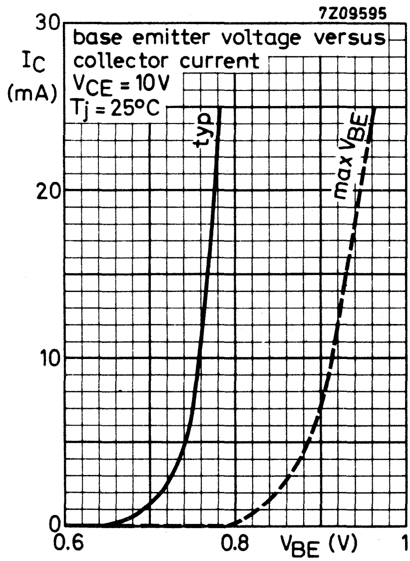
$$G_{UM}\ (\text{in dB}) = 10 \log \frac{\lvert y_{fe} \rvert^2}{4\, g_{ie}\, g_{oe}}$$

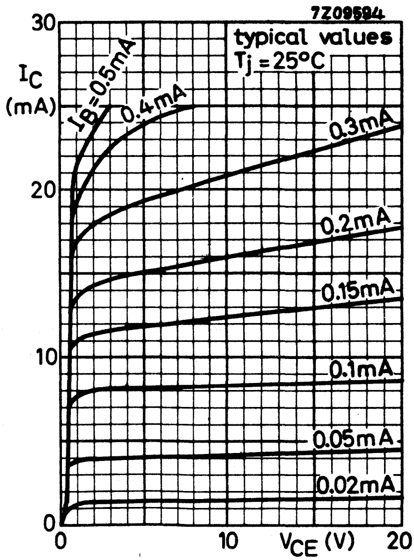
$I_C = 7$ mA; $V_{CE} = 10$ V	G_{UM}	typ.	44,4	dB

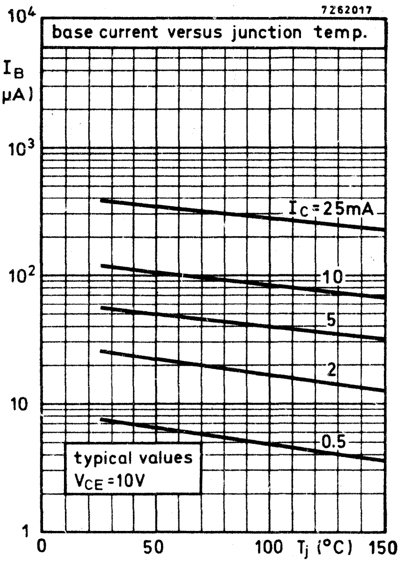
* V_{BE} decreases by about 1,7 mV/K with increasing temperature.

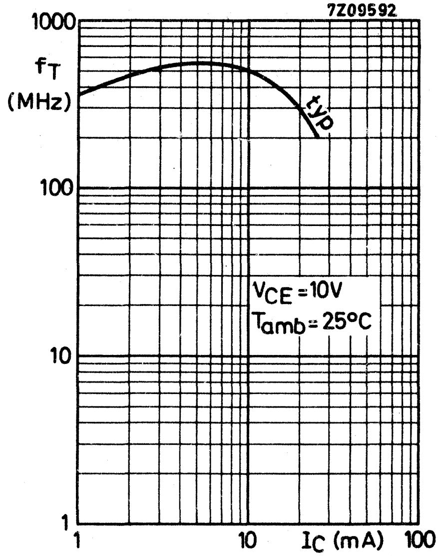

7Z09597
60
40
20
0
VCERmax
(V)
Maximum allowable collector-emitter voltage (with resistance between base and emitter and IC = 2 mA) versus the base resistance applied.
The same curve applies to 1/ωCB and 1/ωCE when external capacitances are used.
RE up to 1kΩ
IC=2mA
VCER
CB
RB
RE
CE
Tj up to 150°C
7Z62019
0.1
1
10
100
RB (kΩ)
1000


7Z09596
base current versus collector current
VCE = 10V
Tj = 25°C
IC (mA)
100
10
1
0.1
0.001
0.01
0.1
1
10
IB (mA)
typ
IB max


7Z09595
base emitter voltage versus collector current
VCE = 10V
Tj = 25°C
IC (mA)
30
20
10
0
0.6
0.8
1
VBE (V)
typ
max VBE

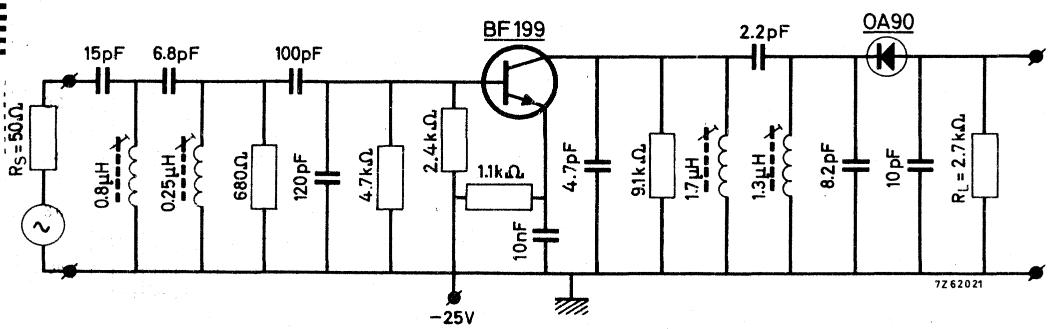

7Z09594
typical values
Tj = 25°C
IC (mA)
30
20
10
0
10
20
VCE (V)
IB = 0.5mA
0.4mA
0.3mA
0.2mA
0.15mA
0.1mA
0.05mA
0.02mA





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 MHz [1])

I_C = 7.2 mA; V_{CE} = 16.6 V	V_O	>	6	V
		typ.	7.7	V

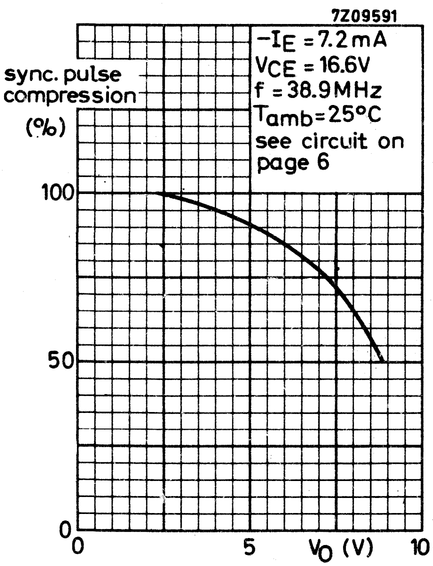
Transducer gain at f = 36.4 MHz

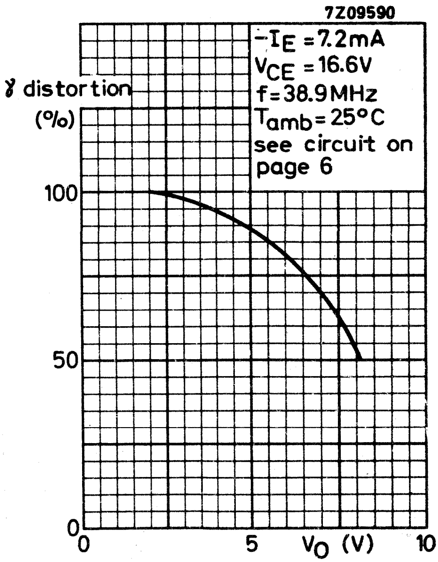
$$G_{tr} \text{ (in dB)} = 10 \log \frac{\text{output power in load } R_L}{\text{available power from source with } R_S}$$

I_C = 7.2 mA; V_{CE} = 16.6 V	G_{tr}	typ.	25.5	dB

Tuning frequency for all tuned circuits is 37 MHz

[1]) The output voltage V_O is difined as the voltage across the 2.7 kΩ 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.

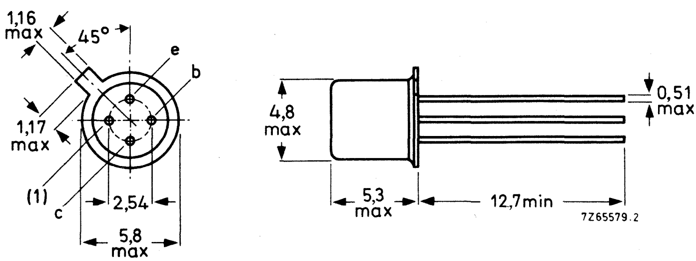
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{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 °C	P_{tot}	max.	150	mW
Junction temperature	T_j	max.	175	°C
Transition frequency				
$-I_E$ = 3 mA; V_{CB} = 10 V	f_T	typ.	650	MHz
Maximum unilateral power gain				
$-I_E$ = 3 mA; V_{CB} = 10 V; f = 50 MHz	G_{UM}	typ.	30	dB
$-I_E$ = 3 mA; V_{CB} = 10 V; f = 200 MHz	G_{UM}	typ.	22	dB
Noise figure at optimum source admittance				
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 100 MHz	F	typ.	2	dB
$-I_E$ = 3 mA; V_{CB} = 10 V; f = 200 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) [1])

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Collector-emitter voltage ($R_{BE} \leq 1$ kΩ)	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 $T_{amb} = 25\ ^oC$	P_{tot}	max.	150	mW

Temperatures

Storage temperature	T_{stg}		−65 to +175	^oC
Junction temperature	T_j	max.	175	^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	1	^oC/mW

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

CHARACTERISTICS $T_{amb} = 25\,^{o}C$ unless otherwise specified

Base current				
$-I_E = 3$ mA; $V_{CB} = 10$ V	I_B	typ.	100	μA
		<	200	μA
$-I_E = 12$ mA; $V_{CB} = 7$ V	I_B	<	2.2	mA
Emitter-base voltage				
$-I_E = 3$ mA; $V_{CB} = 10$ V	$-V_{EB}$	typ.	0.75	V
$-I_E = 12$ mA; $V_{CB} = 7$ V	$-V_{EB}$	<	1.0	V
Transition frequency				
$-I_E = 3$ mA; $V_{CB} = 10$ V	f_T	typ.	650	MHz
Feedback capacitance at f = 10.7 MHz				
$I_C = 1$ mA; $V_{CE} = 10$ V	C_{re}	typ.	280	fF [1]
Noise figure at optimum source admittance				
$-I_E = 3$ mA; $V_{CB} = 10$ V; f = 50 MHz	F	typ.	1.9	dB
f = 200 MHz	F	typ.	2.7	dB
$-I_E = 2$ mA; $V_{CB} = 10$ V; f = 100 MHz	F	typ.	2.0	dB
Maximum unilateralised power gain [2]				
$G_{UM} = \frac{\|y_{fb}\|^2}{4\, g_{ib} g_{ob}}$				
$-I_E = 3$ mA; $V_{CB} = 10$ V; f = 50 MHz	G_{UM}	typ.	30	dB
f = 200 MHz	G_{UM}	typ.	22	dB
$-I_E = 2$ mA; $V_{CB} = 10$ V; f = 100 MHz	G_{UM}	typ.	28	dB

1) 1 fF = 1 femtofarad = 10^{-15} F.

2) Commonbase configuration, metal envelope connected to earth directly, external lead length = 3 mm.

CHARACTERISTICS (continued) T_{amb} = 25 °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	φ_{re}	typ.	270°	
Transfer admittance	$\|y_{fe}\|$	typ.	56	$m\Omega^{-1}$
Phase angle of transfer admittance	φ_{fe}	typ.	340°	
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

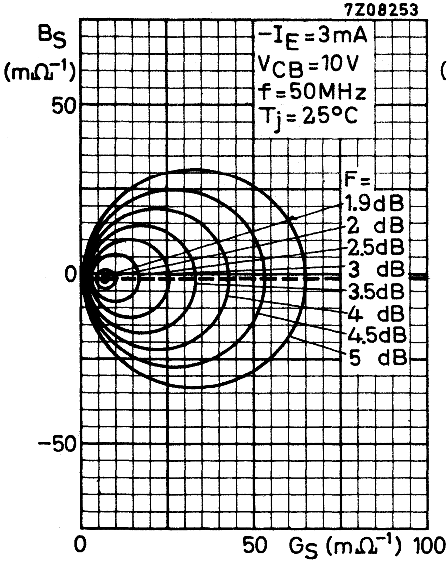
Input conductance	g_{ib}	typ.	85	$m\Omega^{-1}$
Input susceptance	$-b_{ib}$	typ.	15	$m\Omega^{-1}$
Feedback admittance	$\|y_{rb}\|$	typ.	55	$\mu\Omega^{-1}$
Phase angle of feedback admittance	φ_{rb}	typ.	270°	
Transfer admittance	$\|y_{fb}\|$	typ.	85	$m\Omega^{-1}$
Phase angle of transfer admittance	φ_{fb}	typ.	165°	
Output conductance	g_{ob}	typ.	15	$\mu\Omega^{-1}$
Output susceptance	b_{ob}	typ.	280	$\mu\Omega^{-1}$

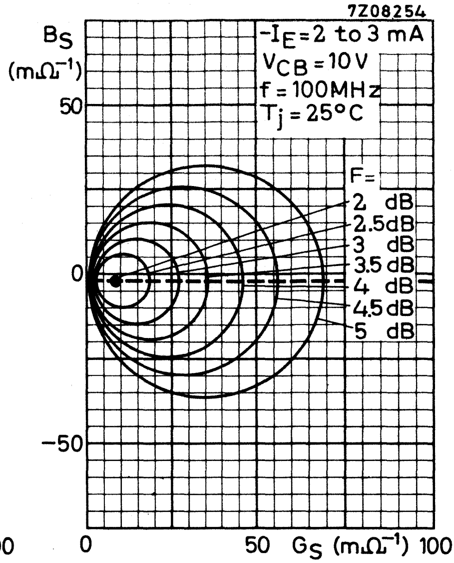
y parameters at f = 200 MHz (common base)

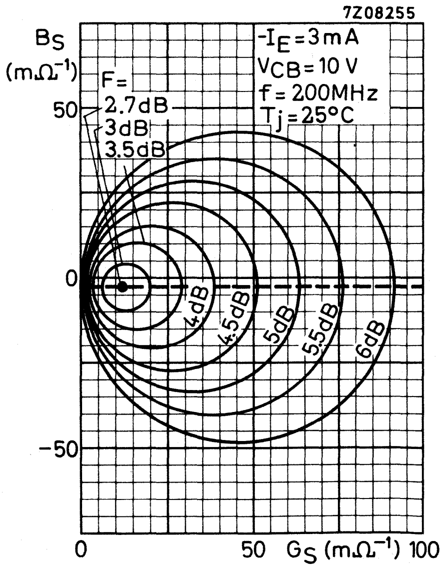
$-I_E$ = 3 mA; V_{CB} = 10 V

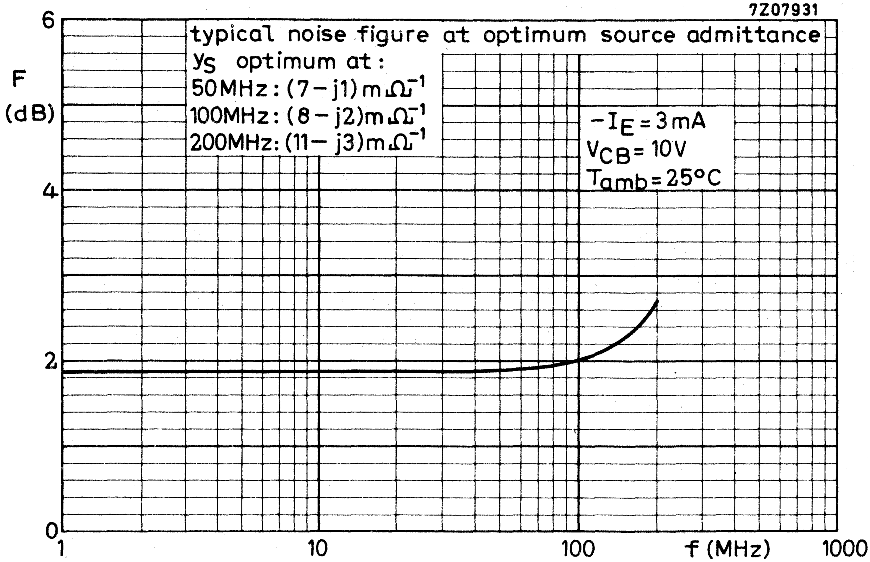
Input conductance	g_{ib}	typ.	62	$m\Omega^{-1}$
Input susceptance	$-b_{ib}$	typ.	38	$m\Omega^{-1}$
Feedback admittance	$\|y_{rb}\|$	typ.	180	$\mu\Omega^{-1}$
Phase angle of feedback admittance	φ_{rb}	typ.	270°	
Transfer admittance	$\|y_{fb}\|$	typ.	70	$m\Omega^{-1}$
Phase angle of transfer admittance	φ_{fb}	typ.	145°	
Output conductance	g_{ob}	typ.	150	$\mu\Omega^{-1}$
Output susceptance	b_{ob}	typ.	1.1	$m\Omega^{-1}$

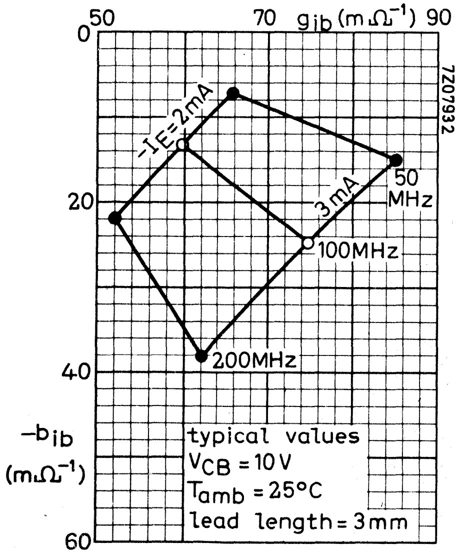
circles of constant noise figure

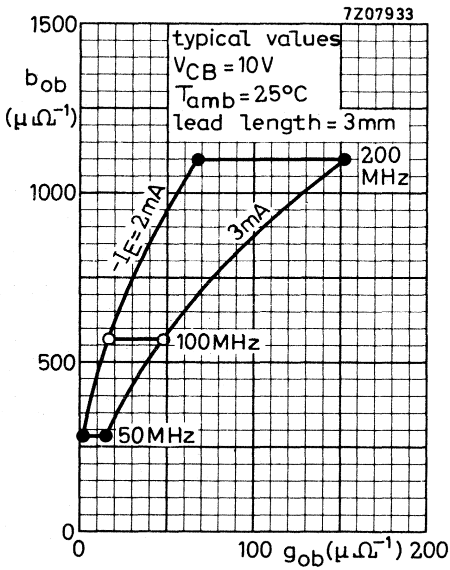


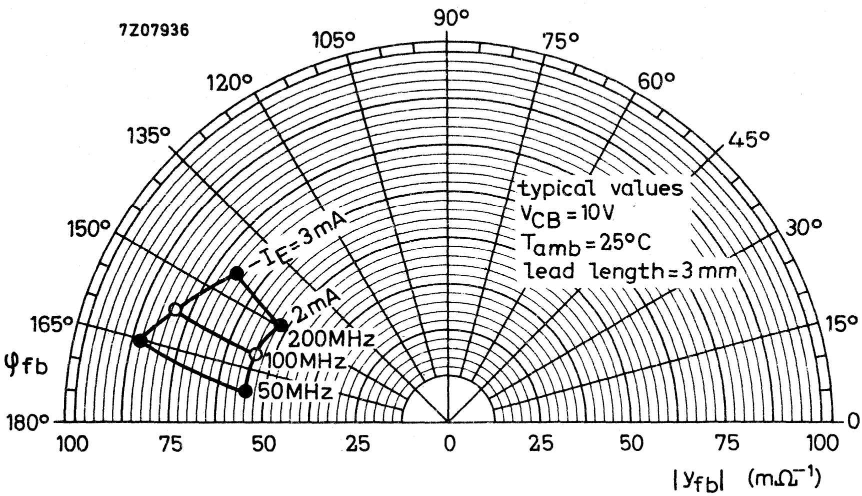


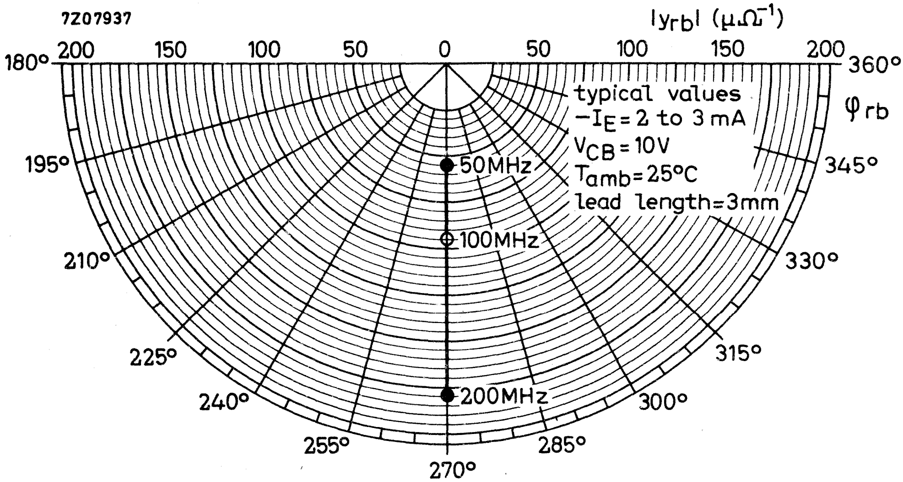


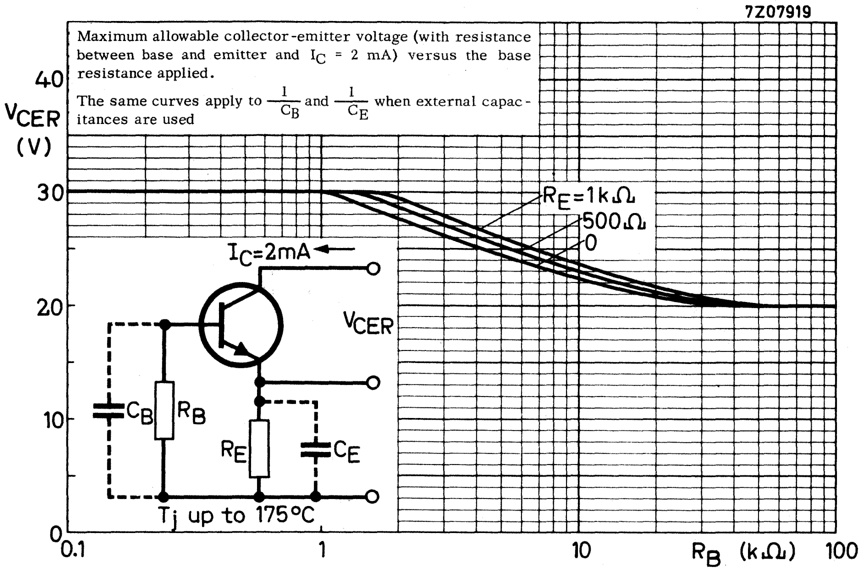

7Z07931
typical noise figure at optimum source admittance
y_S optimum at:
50MHz: (7 − j1) mΩ⁻¹
100MHz: (8 − j2) mΩ⁻¹
200MHz: (11 − j3) mΩ⁻¹
$-I_E$ = 3 mA
V_{CB} = 10 V
T_{amb} = 25°C
F
(dB)
6
4
2
0
1
10
100
f (MHz)
1000


g_{ib} (mΩ⁻¹)
50
70
90
7Z07932
$-I_E$ = 2mA
3mA
50 MHz
100MHz
200MHz
typical values
V_{CB} = 10 V
T_{amb} = 25°C
lead length = 3mm
$-b_{ib}$
(mΩ⁻¹)
0
20
40
60


7Z07933
typical values
V_{CB} = 10 V
T_{amb} = 25°C
lead length = 3mm
b_{ob}
(μΩ⁻¹)
1500
1000
500
0
200 MHz
$-I_E$ = 2mA
3mA
100MHz
50MHz
0
100
g_{ob} (μΩ⁻¹)
200


7Z07936
typical values
V_{CB} = 10V
T_{amb} = 25°C
lead length = 3 mm
$-I_E$ = 3 mA
2 mA
200MHz
100MHz
50MHz
φ_{fb}
$|y_{fb}|$ (mΩ^{-1})
90°
105°
75°
120°
60°
135°
45°
150°
30°
165°
15°
180°
0
100
75
50
25
0
25
50
75
100


7Z07937
$|y_{rb}|$ ($\mu\Omega^{-1}$)
200
150
100
50
0
50
100
150
200
180°
360°
φ_{rb}
typical values
$-I_E$ = 2 to 3 mA
V_{CB} = 10V
T_{amb} = 25°C
lead length = 3mm
50MHz
100MHz
200MHz
195°
345°
210°
330°
225°
315°
240°
300°
255°
285°
270°



Maximum allowable collector-emitter voltage (with resistance between base and emitter and I_C = 2 mA) versus the base resistance applied.

The same curves apply to $\frac{1}{C_B}$ and $\frac{1}{C_E}$ when external capacitances are used

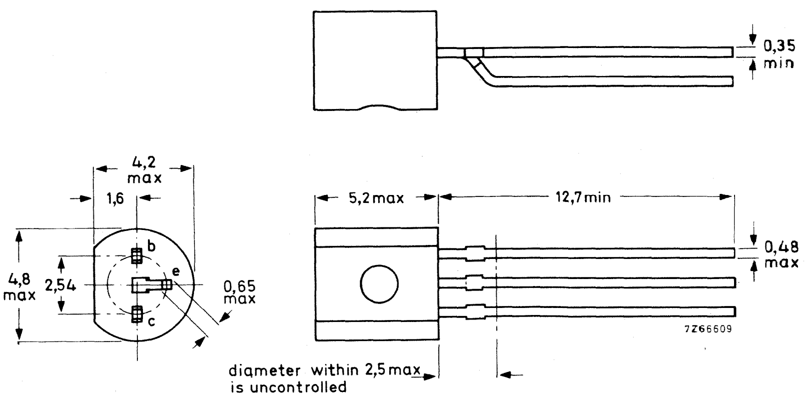
H.F. SILICON PLANAR EPITAXIAL TRANSISTORS

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 °C	P_{tot}	max.	250		mW
Junction temperature	T_j	max.	125		°C
			BF240	BF241	
Base current I_C = 1 mA; V_{CE} = 10 V	I_B		4,5-15	8-28	μA
Transition frequency I_C = 1 mA; V_{CE} = 10 V	f_T	typ.	380	350	MHz
Feedback capacitance at f = 1 MHz I_C = 1 mA; V_{CE} = 10 V	C_{re}	<	0,34		pF
Noise figure I_C = 1 mA; V_{CE} = 10 V R_S = 200 Ω; f = 0,2 MHz	F	<	3,5		dB

MECHANICAL DATA Dimensions in mm

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.	40	V
Emitter-base voltage (open collector)	V_{EBO}	max.	4	V
Current				
Collector current (d.c.)	I_C	max.	25	mA
Power dissipation				
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	250	mW
Temperatures				
Storage temperature	T_{stg}		-55 to +125	°C
Junction temperature	T_j	max.	125	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0,4	°C/mW

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current					
$I_E = 0$; V_{CB} = 20 V	I_{CBO}	<	100		nA
Base-emitter voltage					
I_C = 1 mA; V_{CE} = 10 V	V_{BE}	typ.	700		mV
			650 to 740		mV
			BF240	BF241	
Base current					
I_C = 1 mA; V_{CE} = 10 V	I_B		4,5-15	8-28	μA
Transition frequency at f = 100 MHz					
I_C = 1 mA; V_{CE} = 10 V	f_T	typ.	380	350	MHz
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 Ω; f = 0,2 MHz	F	typ.	1,5	2,0	dB
		<	3,5	3,5	dB

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

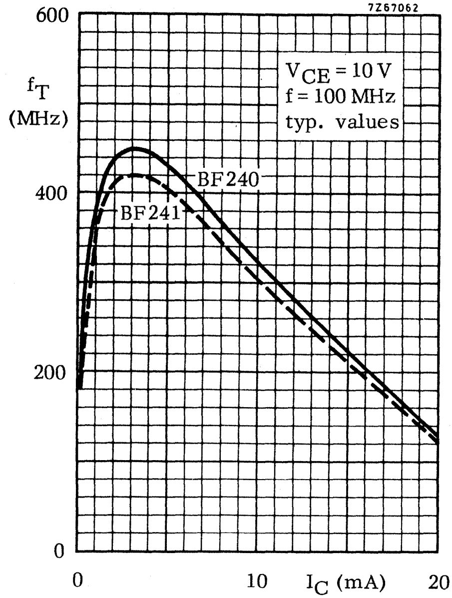
y parameters (common emitter) Lead length = 3 mm

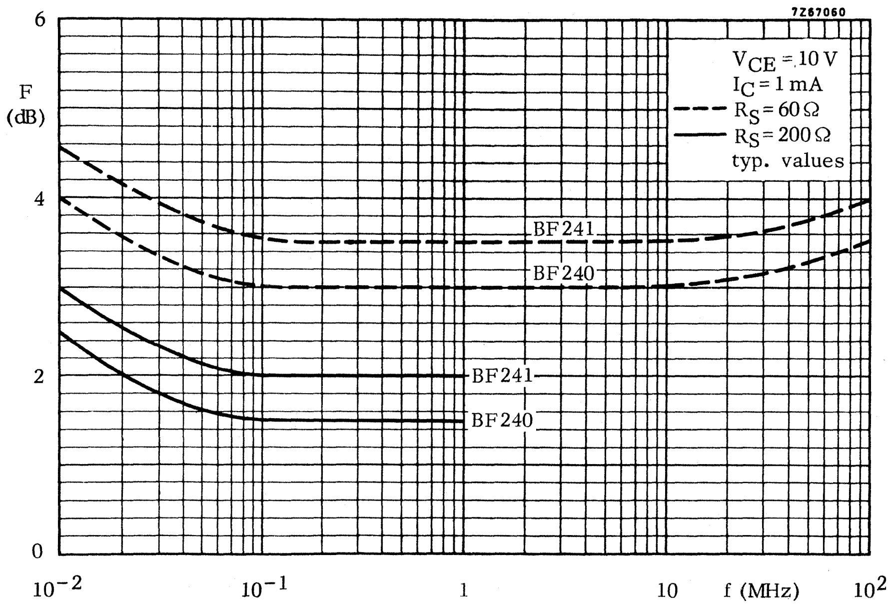
I_C = 1 mA; V_{CE} = 10 V

			BF240		BF241		
	f	=	0,45	10,7	0,45	10,7	MHz
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	φ_{fe}	typ.	0^o	0^o	0^o	0^o	
Output conductance	g_{oe}	<	8,3	10,5	8,3	10,5	µA/V
Output capacitance	C_{oe}	typ.	1	1	1	1	pF
Feedback admittance	$\|y_{re}\|$	typ.	0,75	18	0,75	18	µA/V
Phase angle of feedback admittance	φ_{re}	typ.	270^o	270^o	270^o	270^o	

I_C = 4 mA; V_{CE} = 10 V; f = 35 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	µA/V
Output capacitance	C_{oe}	typ.	1	pF


7Z67062
600
400
200
0
f_T
(MHz)
V_{CE} = 10 V
f = 100 MHz
typ. values
BF240
BF241
0
10
I_C (mA)
20


7Z67060
6
4
2
0
F
(dB)
V_{CE} = 10 V
I_C = 1 mA
R_S = 60 Ω
R_S = 200 Ω
typ. values
BF241
BF240
BF241
BF240
10^{-2}
10^{-1}
1
10
f (MHz)
10^2

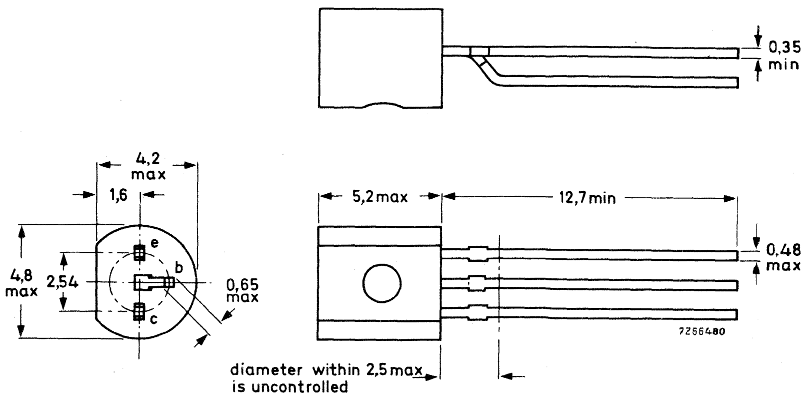
H.F. SILICON PLANAR EPITAXIAL TRANSISTOR

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 °C	P_{tot}	max.	250	mW
Junction temperature	T_j	max.	150	°C
Base current $-I_C$ = 4 mA; $-V_{CE}$ = 10 V	$-I_B$	typ. <	80 160	μA μA
Transition frequency $-I_C$ = 4 mA; $-V_{CE}$ = 10 V	f_T	typ.	450	MHz
Noise figure at f = 100 MHz $-I_C$ = 2 mA; $-V_{CE}$ = 10 V; G_S = 16,7 mA/V	F	typ.	3	dB
Feedback capacitance at f = 1 MHz V_{EB} = 0; $-V_{CB}$ = 10 V	C_{rb}	typ.	0,1	pF

MECHANICAL DATA Dimensions in mm

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

Power dissipation

Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	250	mW

Temperatures

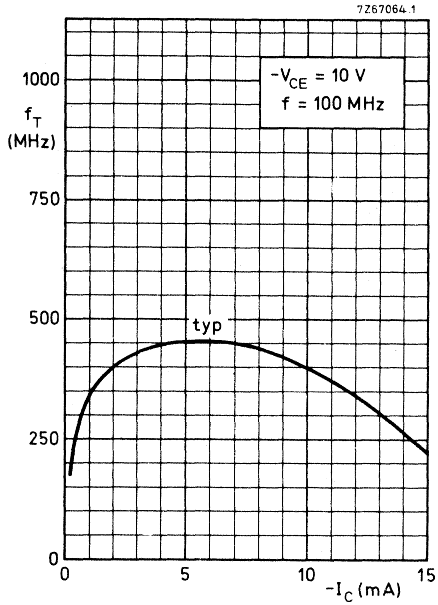
Storage temperature	T_{stg}		−55 to +150	°C
Junction temperature	T_j	max.	150	°C

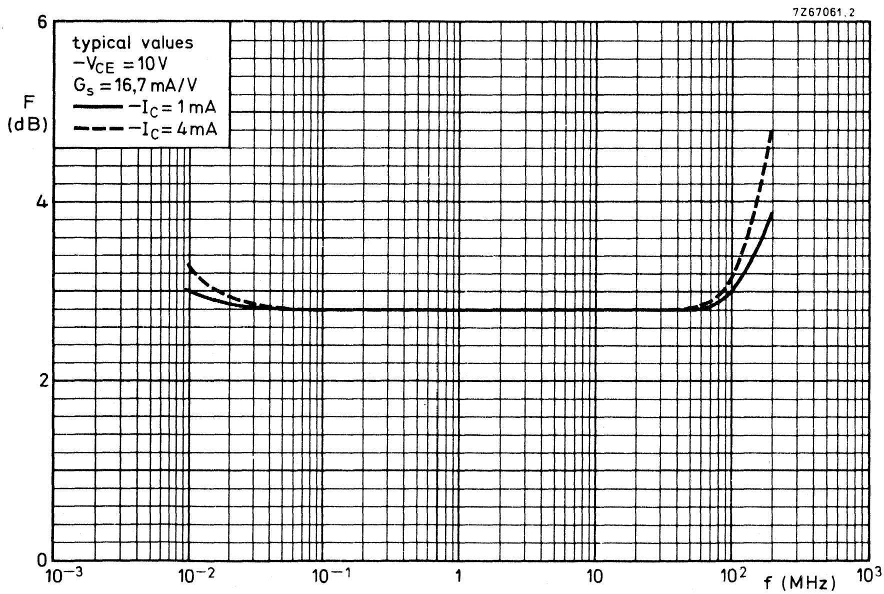
THERMAL RESISTANCE

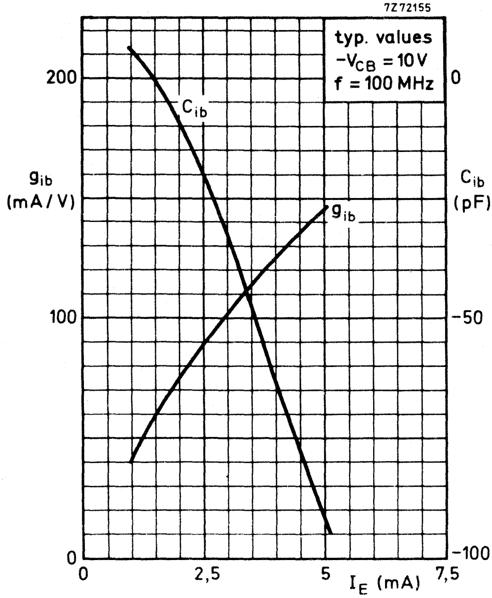
From junction to ambient in free air	$R_{th\ j-a}$	=	0,42	°C/mW

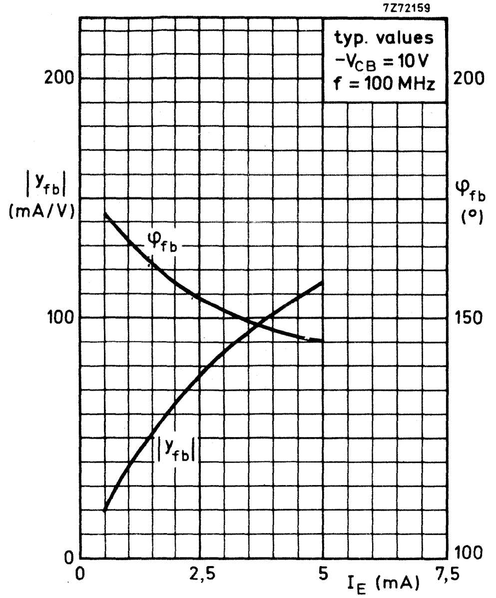
CHARACTERISTICS $T_j = 25\ ^oC$

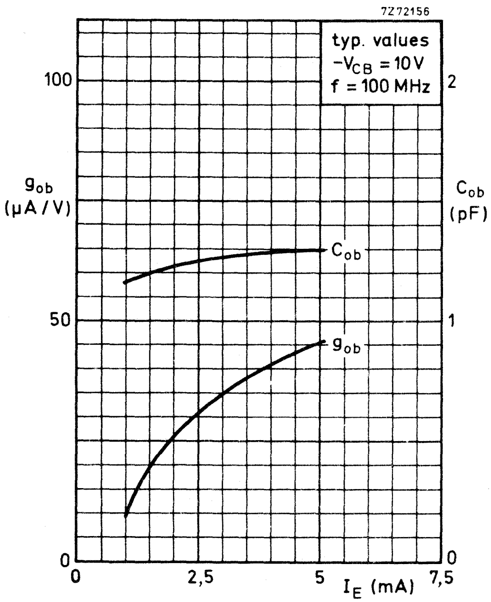
Collector cut-off current				
$I_E = 0; -V_{CB} = 30$ V	$-I_{CBO}$	<	50	nA
Emitter cut-off current				
$I_C = 0; -V_{EB} = 4$ V	$-I_{EBO}$	<	10	μA
Base current				
$-I_C = 4$ mA; $-V_{CE} = 10$ V	$-I_B$	typ.	80	μA
		<	160	μA
$-I_C = 1$ mA; $-V_{CE} = 10$ V	$-I_B$	typ.	22	μA
Base-emitter voltage				
$-I_C = 4$ mA; $-V_{CE} = 10$ V	$-V_{BE}$	typ.	0,76	V
Transition frequency at f = 100 MHz				
$-I_C = 1$ mA; $-V_{CE} = 10$ V	f_T	typ.	350	MHz
$-I_C = 4$ mA; $-V_{CE} = 10$ V	f_T	typ.	450	MHz
$-I_C = 8$ mA; $-V_{CE} = 10$ V	f_T	typ.	440	MHz
Feedback capacitance at f = 1 MHz				
$V_{EB} = 0; -V_{CB} = 10$ V	C_{rb}	typ.	0,1	pF
Noise factor at f = 100 MHz				
$-I_C = 2$ mA; $-V_{CE} = 10$ V; $G_s = 16,7$ mA/V	F	typ.	3	dB
$-I_C = 5$ mA; $-V_{CE} = 10$ V; $G_s = 6,7$ mA/V; $-jB_s = 5$ mA/V	F	typ.	3,5	dB
y-parameters (common base) at f = 100 MHz				
$-I_C = 4$ mA; $-V_{CB} = 10$ 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	φ_{fb}	typ.	147^o	
Output conductance	g_{ob}	typ.	40	μA/V
Output capacitance	C_{ob}	typ.	1,25	pF
Feedback admittance	$\|y_{rb}\|$	typ.	220	μA/V
Phase angle of feedback admittance	$-\varphi_{rb}$	typ.	85^o	

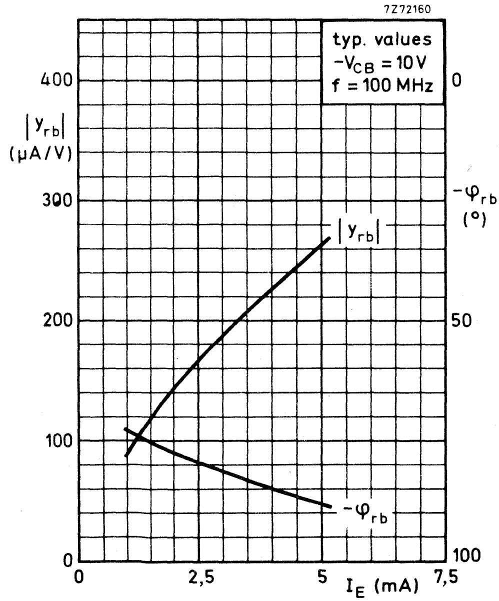

7Z67064.1
$-V_{CE}$ = 10 V
f = 100 MHz
f_T
(MHz)
1000
750
500
250
0
typ
0
5
10
15
$-I_C$ (mA)

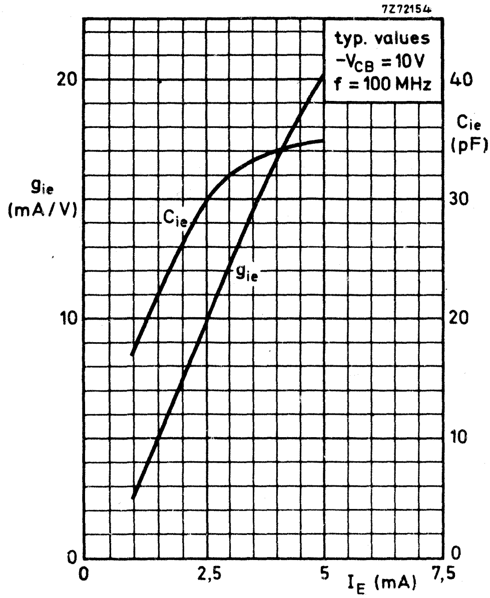

7Z67061.2
typical values
$-V_{CE}$ = 10 V
G_s = 16,7 mA/V
$-I_C$ = 1 mA
$-I_C$ = 4 mA
F
(dB)
6
4
2
0
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
10^3
f (MHz)

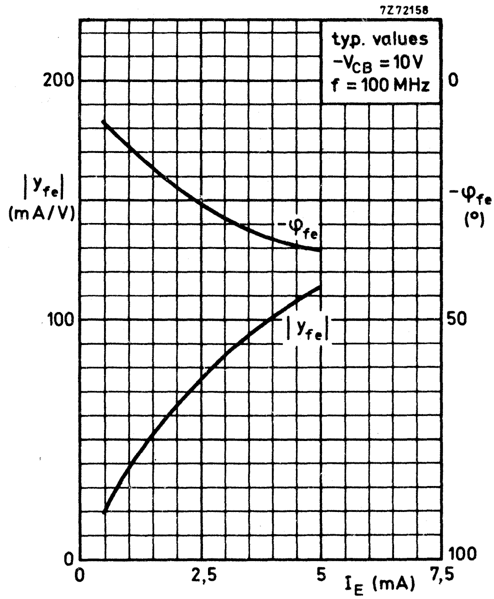

7Z72155
typ. values
$-V_{CB}$ = 10 V
f = 100 MHz
g_{ib} (mA/V)
C_{ib} (pF)
C_{ib}
g_{ib}
I_E (mA)

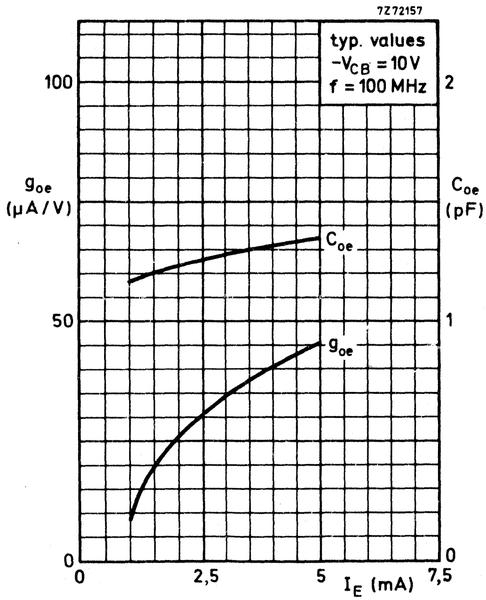

7Z72159
typ. values
$-V_{CB}$ = 10 V
f = 100 MHz
$|y_{fb}|$ (mA/V)
φ_{fb} (°)
φ_{fb}
$|y_{fb}|$
I_E (mA)

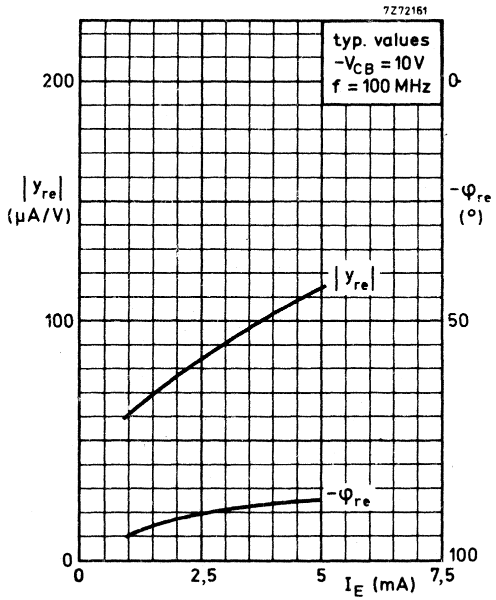

7Z72156
typ. values
$-V_{CB}$ = 10 V
f = 100 MHz
g_{ob} (µA/V)
C_{ob} (pF)
C_{ob}
g_{ob}
I_E (mA)


7Z72160
typ. values
$-V_{CB}$ = 10 V
f = 100 MHz
$|y_{rb}|$ (µA/V)
$-\varphi_{rb}$ (°)
$|y_{rb}|$
$-\varphi_{rb}$
I_E (mA)


7Z72154
typ. values
$-V_{CB}$ = 10 V
f = 100 MHz
g_{ie} (mA/V)
C_{ie} (pF)
C_{ie}
g_{ie}
0
10
20
0
10
20
30
40
0
2,5
5
7,5
I_E (mA)


7Z72158
typ. values
$-V_{CB}$ = 10 V
f = 100 MHz
$|y_{fe}|$ (mA/V)
$-\varphi_{fe}$ (°)
$-\varphi_{fe}$
$|y_{fe}|$
0
100
200
0
50
100
0
2,5
5
7,5
I_E (mA)


7Z72157
typ. values
$-V_{CB}$ = 10 V
f = 100 MHz
g_{oe} (μA/V)
C_{oe} (pF)
C_{oe}
g_{oe}
0
50
100
0
1
2
0
2,5
5
7,5
I_E (mA)


7Z72161
typ. values
$-V_{CB}$ = 10 V
f = 100 MHz
$|y_{re}|$ (μA/V)
$-\varphi_{re}$ (°)
$|y_{re}|$
$-\varphi_{re}$
0
100
200
0
50
100
0
2,5
5
7,5
I_E (mA)

N-P-N SILICON PLANAR TRANSISTORS

for video output stages

N-P-N transistors in TO-39 metal envelopes intended for the video amplifier and the line driver in black-and-white and colour television receivers.

QUICK REFERENCE DATA

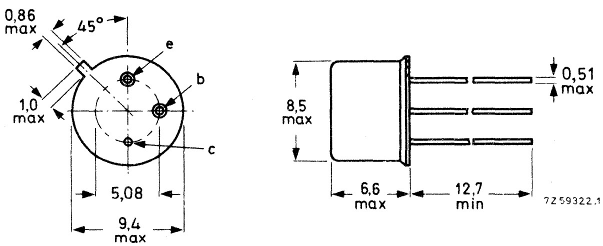
			BF336	BF337	BF338	
Collector-base voltage (open emitter)	V_{CBO}	max.	185	250	300	V
Collector-emitter voltage (open base)	V_{CEO}	max.	180	200	225	V
Collector current (peak value)	I_{CM}	max.		200		mA
Total power dissipation up to T_{mb} = 140 °C	P_{tot}	max.		3,0		W
Junction temperature	T_j	max.		200		°C
D.C. current gain at T_j = 25 °C I_C = 30 mA; V_{CE} = 10 V	h_{FE}	>		20		
Transition frequency I_C = 30 mA; V_{CE} = 20 V	f_T	>		80		MHz
Feedback capacitance at f = 0,5 MHz I_C = 10 mA; V_{CE} = 20 V	C_{re}	<		3,5		pF

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

			BF336	BF337	BF338	
Collector-base voltage (open emitter)	V_{CBO}	max.	185	250	300	V
Collector-emitter voltage ($R_{BE} \leq 1$ kΩ) I_C = 1 mA; up to T_j = 150 °C	V_{CER}	max.	185	250	300	V
Collector-emitter voltage (open base) I_C = 4 mA	V_{CEO}	max.	180	200	225	V
Emitter-base voltage (open collector) I_E = 0.1 mA	V_{EBO}	max.	5	5	5	V

Currents

Collector current (d.c.)	I_C	max.	100	mA
Collector current (peak value)	I_{CM}	max.	200	mA
Base current (peak value)	I_{BM}	max.	20	mA

Power dissipation

Total power dissipation up to T_{mb} = 140 °C	P_{tot}	max.	3.0	W

Temperatures

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

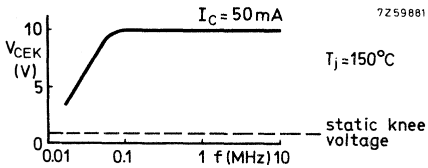
THERMAL RESISTANCE

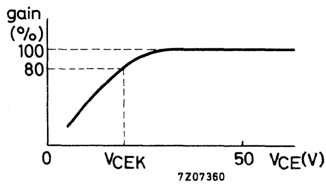
From junction to ambient	$R_{th\ j\text{-}a}$	=	220	°C/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	20	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	25	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

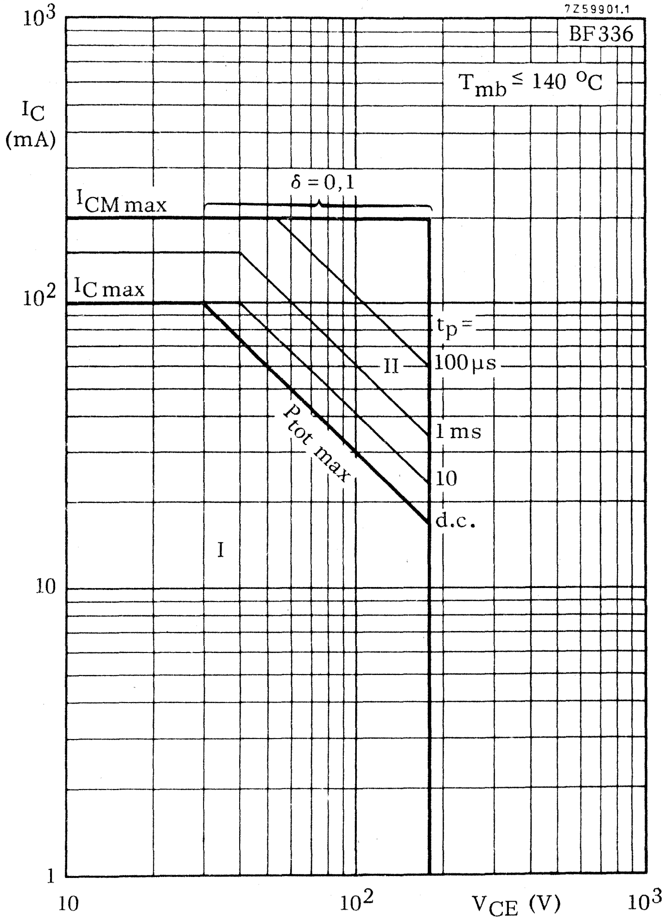
Collector cut-off current at R_{BE} = 1 kΩ				
V_{CE} = 150 V for BF336; V_{CE} = 200 V for BF337; V_{CE} = 250 V for BF338	I_{CER}	typ.	10	nA
		<	100	μA
Base-emitter voltage				
I_C = 30 mA; V_{CE} = 10 V	V_{BE}	typ.	0,7	V
		<	1,2	V
High frequency knee voltage at T_j = 150 °C				
I_C = 50 mA	V_{CEK}	typ.	10	V

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





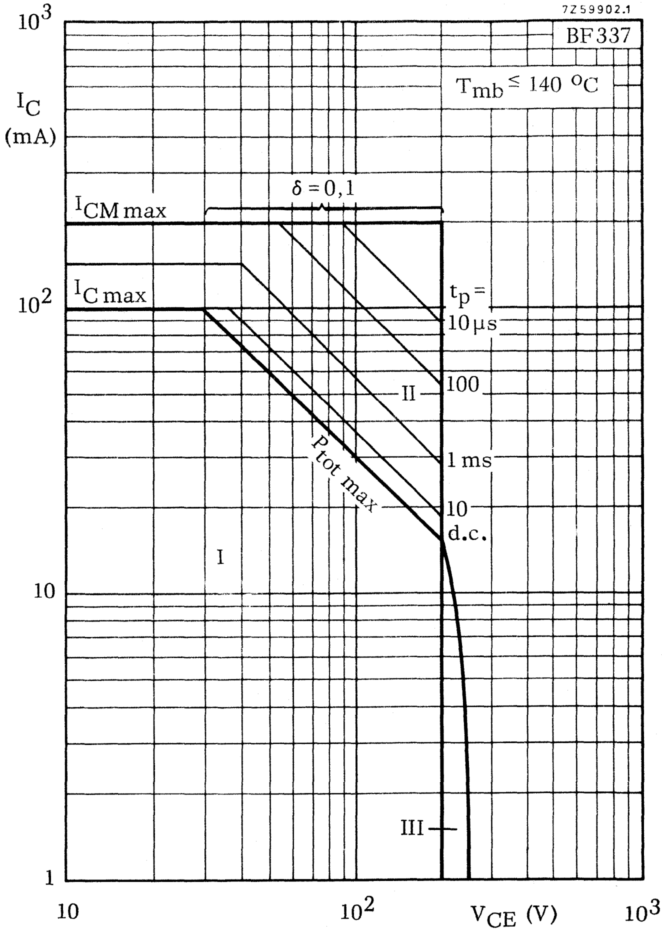
D.C. current gain				
I_C = 30 mA; V_{CE} = 10 V	h_{FE}	>	20	
		typ.	60	
Feedback capacitance at f = 0.5 MHz				
I_C = 10 mA; V_{CE} = 20 V	C_{re}	typ.	3,0	pF
		<	3,5	pF
Feedback time constant at f = 10 MHz				
$-I_E$ = 30 mA; V_{CB} = 20 V	$r_{bb'}C_{b'c}$	typ.	30	ps
		<	100	ps
Transition frequency at f = 100 MHz				
I_C = 30 mA; V_{CE} = 20 V	f_T	>	80	MHz
		typ.	130	MHz



Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

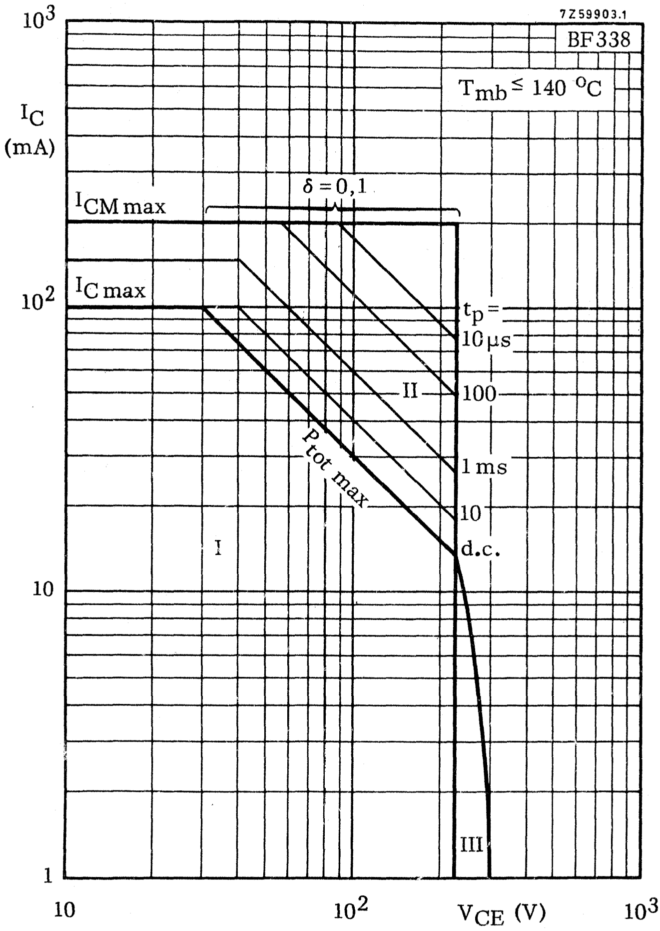


Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

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

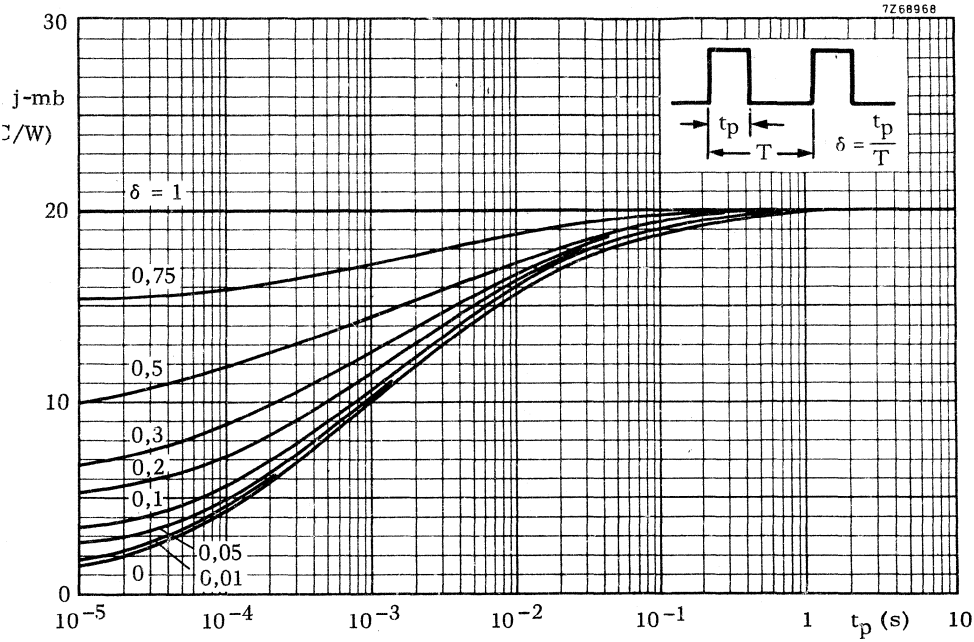


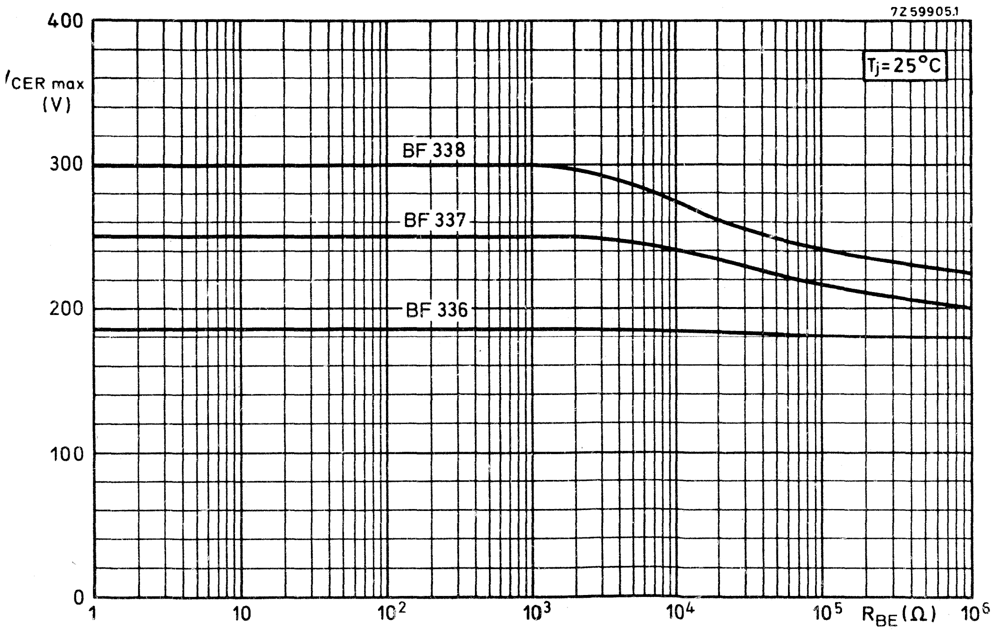
Safe Operating Area with the transistor forward biased

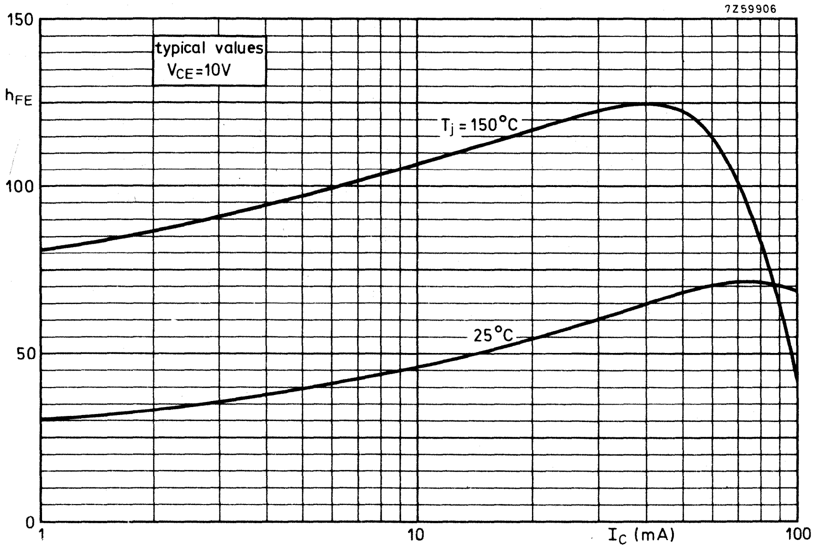
I Region of permissible d.c. operation

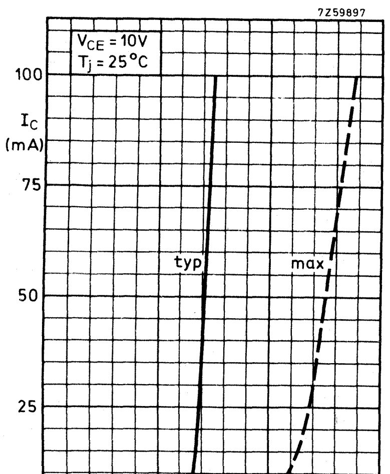
II Permissible extension for repetitive pulse operation

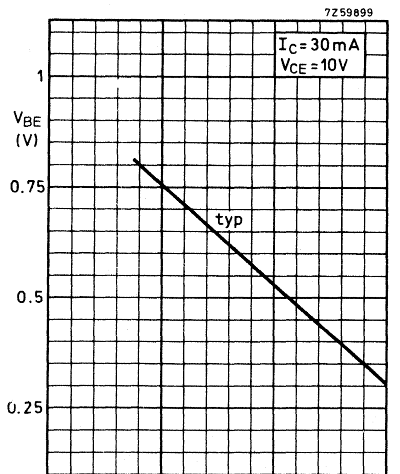
III Repetitive pulse operation in this region is allowable, provided $R_{BE} \leq 1\ k\Omega$

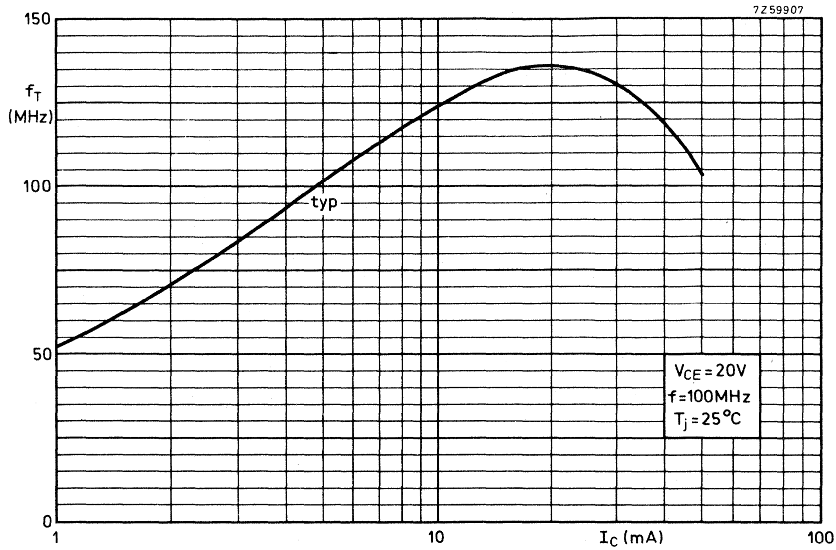

7Z68968
j-mb
C/W)
30
20
10
0
δ = 1
0,75
0,5
0,3
0,2
0,1
0,05
0,01
0
tp
T
δ = tp/T
10−5
10−4
10−3
10−2
10−1
1
tp (s)
10

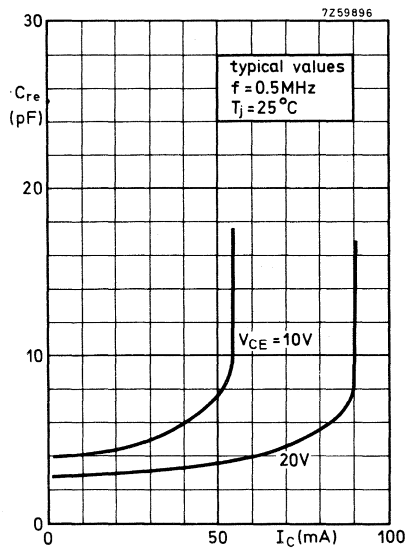

7Z59905.1
VCER max
(V)
400
300
200
100
0
Tj = 25°C
BF 338
BF 337
BF 336
1
10
10²
10³
10⁴
10⁵
RBE (Ω)
10⁶

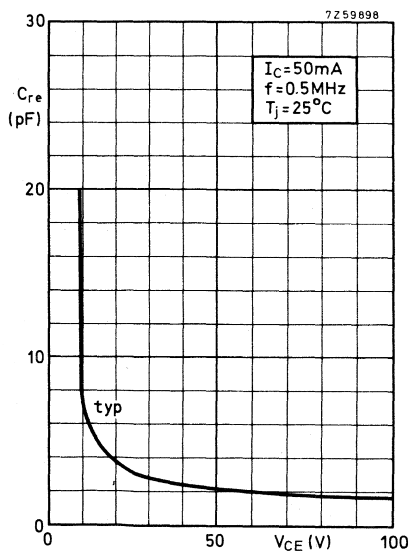

7Z59906
typical values
V_{CE}=10V
h_{FE}
T_j = 150°C
25°C
150
100
50
0
1
10
I_C (mA)
100

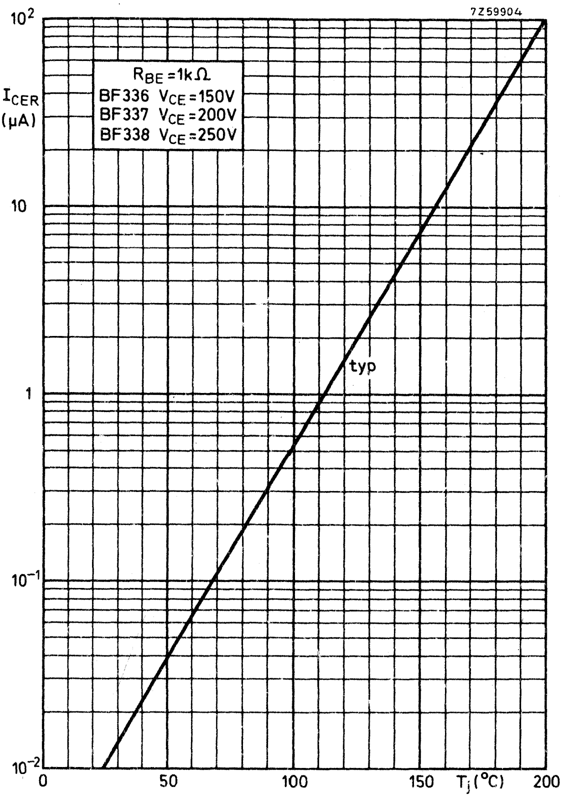

7Z59897
V_{CE} = 10V
T_j = 25°C
I_C
(mA)
100
75
50
25
0
typ
max
0
0.5
1
V_{BE}(V)
1.5


7Z59899
I_C = 30 mA
V_{CE} = 10V
V_{BE}
(V)
1
0.75
0.5
0.25
0
typ
−100
0
100
T_j(°C)
200


7Z59907
150
f_T
(MHz)
100
typ
50
0
1
10
I_C (mA)
100
V_{CE} = 20V
f = 100MHz
T_j = 25 °C


7Z59896
30
C_{re}
(pF)
20
10
0
typical values
f = 0.5MHz
T_j = 25 °C
V_{CE} = 10V
20V
0
50
I_C (mA)
100


7Z59898
30
C_{re}
(pF)
20
10
0
I_C = 50mA
f = 0.5MHz
T_j = 25 °C
typ
0
50
V_{CE} (V)
100


7Z59904
10^2
I_{CER}
(μA)
$R_{BE} = 1k\Omega$
BF336 $V_{CE} = 150V$
BF337 $V_{CE} = 200V$
BF338 $V_{CE} = 250V$
10
1
typ
10^{-1}
10^{-2}
0
50
100
150
T_j (°C)
200

U.H.F. SILICON PLANAR TRANSISTORS

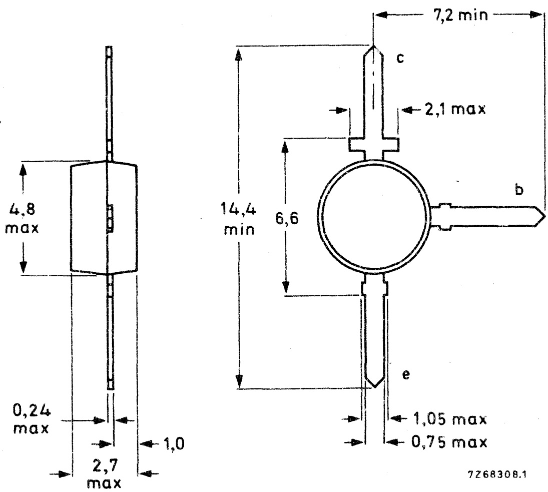
High gain n-p-n transistors in plastic T-package. The BF362 is intended for use in the r.f. stage of television tuners and the BF363 is an oscillator-mixer. The combination of low self-capacitance and low lead inductance due to the T-package makes these devices especially suitable for use in television tuners with diode tuning.

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} = 55 °C		P_{tot}	max.	120	mW
Transition frequency I_C = 3 mA; V_{CE} = 10 V	BF362	f_T	typ.	800	MHz
	BF363	f_T	600 to	820	MHz
Transducer gain at f = 900 MHz $-I_E$ = 3 mA; V_{CC} = 12 V		G_{tr}	>	11	dB
Noise figure at f = 800 MHz $-I_E$ = 3 mA; V_{CC} = 12 V		F	typ.	5	dB
Feedback capacitance at f = 10,7 MHz I_C = 1 mA; V_{CE} = 10 V		C_{re}	typ.	0,25	pF

MECHANICAL DATA Dimensions in mm

SOT 37



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.	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} = 55 °C	P_{tot}	max.	120	mW

Temperature

Junction temperature	T_j	max.	125	°C
Storage temperature	T_{stg}	−55 °C to 125 °C		

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0,58	°C/mW

CHARACTERISTICS T_{amb} = 25 °C unless otherwise specified

Base current

$-I_E$ = 3 mA; V_{CB} = 10 V		I_B	typ.	60	μA
			<	150	μA
$-I_E$ = 12 mA; V_{CB} = 7 V		I_B	typ.	0,3	mA
			<	1,0	mA

Emitter-base voltage

$-I_E$ = 3 mA; V_{CB} = 10 V		$-V_{EB}$	typ.	0,75	V
$-I_E$ = 12 mA; V_{CB} = 7 V		$-V_{EB}$	typ.	0,80	V

Transition frequency at f = 100 MHz

I_C = 3 mA; V_{CE} = 10 V	BF362	f_T	typ.	800	MHz
	BF363	f_T	600 to 820		MHz

Feedback capacitance at f = 10,7 MHz

I_C = 1 mA; V_{CE} = 10 V		C_{re}	typ.	0,25	pF

CHARACTERISTICS (continued) T_{amb} = 25 °C unless otherwise specified

Noise figure

$-I_E$ = 3 mA; V_{CC} = 12 V; f = 800 MHz				
G_S = 27 mA/V; B_S = 9 mA/V; R_C = 390 Ω	F	typ.	5,0	dB
$-I_E$ = 3 mA; V_{CC} = 12 V; f = 500 MHz				
G_S = 32 mA/V; $-B_S$ = 11 mA/V; R_C = 390 Ω	F	typ.	4,5	dB

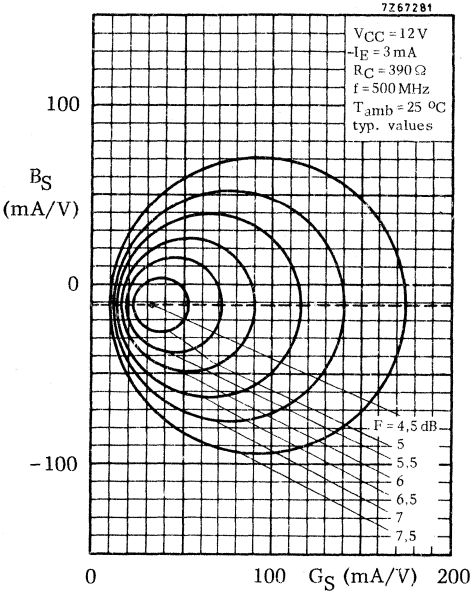
Transducer gain at f = 900 MHz

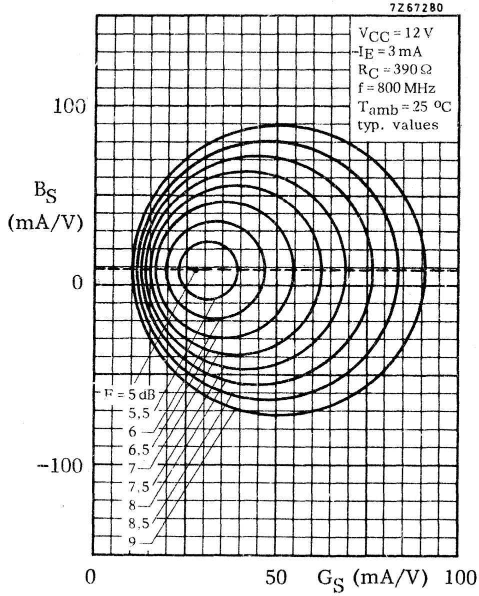
$-I_E$ = 3 mA; V_{CC} = 12 V				
G_S = 20 mA/V; B_S = 0				
G_L = 2 mA/V; B_L tuned; R_C = 390 Ω	G_{tr}	>	11	dB
		typ.	12	dB

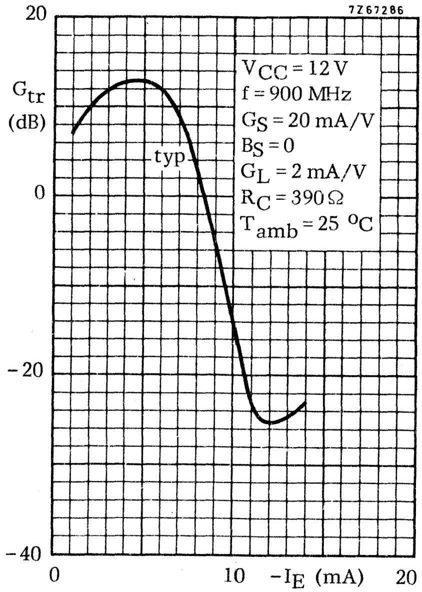
y-parameters (common base)

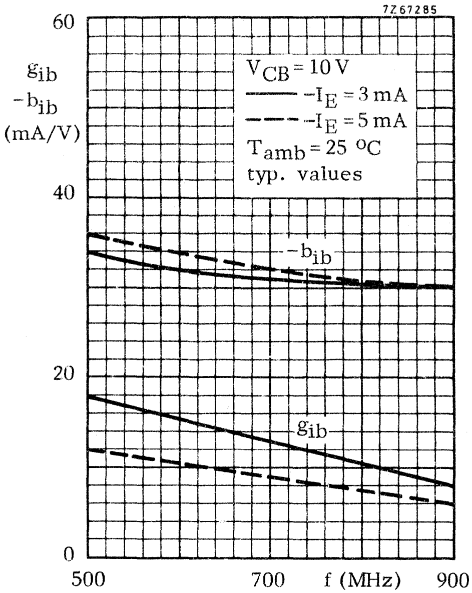
$-I_E$ = 3 mA; V_{CB} = 10 V

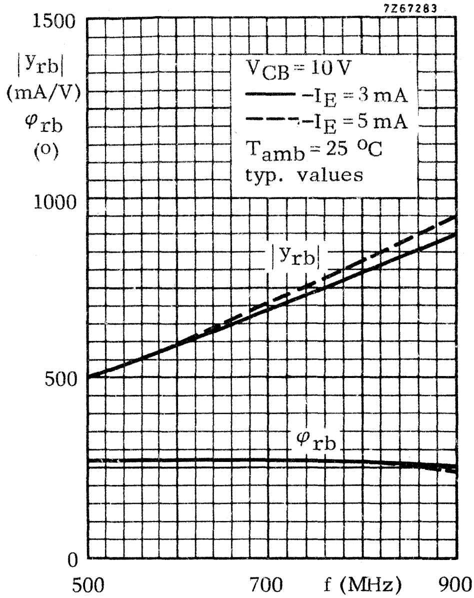
	f	=	500	900	MHz
Input conductance	g_{ib}	typ.	18	8	mA/V
Input susceptance	$-b_{ib}$	typ.	34	30	mA/V
Feedback admittance	$\|y_{rb}\|$	typ.	500	900	μA/V
Phase angle of feedback admittance	φ_{rb}	typ.	270°	250°	
Transfer admittance	$\|y_{fb}\|$	typ.	45	25	mA/V
Phase angle of transfer admittance	φ_{fb}	typ.	80°	40°	
Output conductance	g_{ob}	typ.	0,6	1,9	μA/V ←
Output capacitance	C_{ob}	typ.	0,5	0,6	pF

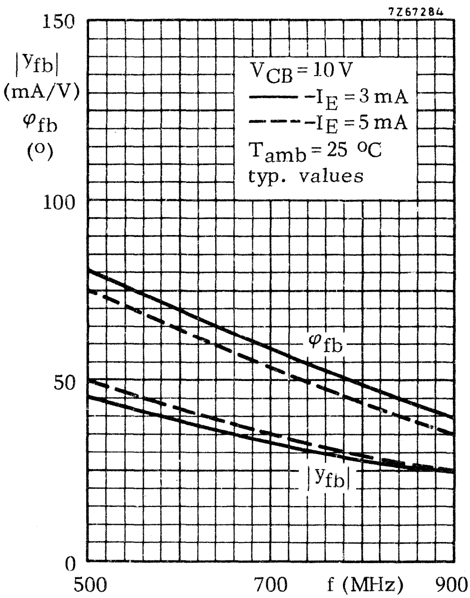

7Z67281
V_{CC} = 12 V
$-I_E$ = 3 mA
R_C = 390 Ω
f = 500 MHz
T_{amb} = 25 °C
typ. values
100
0
−100
B_S
(mA/V)
F = 4,5 dB
5
5,5
6
6,5
7
7,5
0
100
G_S (mA/V)
200

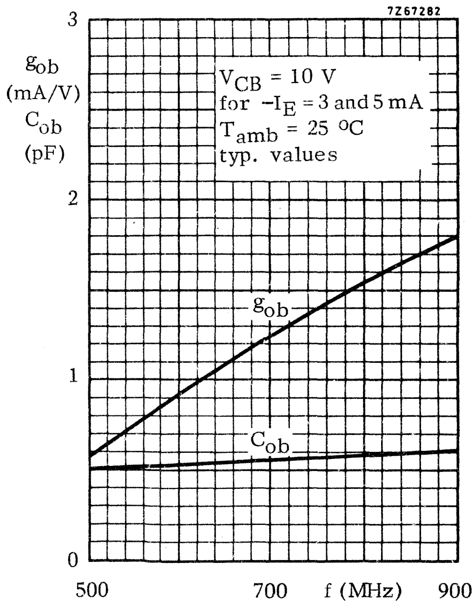

7Z67280
V_{CC} = 12 V
$-I_E$ = 3 mA
R_C = 390 Ω
f = 800 MHz
T_{amb} = 25 °C
typ. values
100
0
−100
B_S
(mA/V)
F = 5 dB
5,5
6
6,5
7
7,5
8
8,5
9
0
50
G_S (mA/V)
100


7Z67286
20
0
−20
−40
G_{tr}
(dB)
typ
V_{CC} = 12 V
f = 900 MHz
G_S = 20 mA/V
B_S = 0
G_L = 2 mA/V
R_C = 390 Ω
T_{amb} = 25 °C
0
10
$-I_E$ (mA)
20


7Z67285
60
40
20
0
g_{ib}
$-b_{ib}$
(mA/V)
$V_{CB} = 10$ V
$-I_E = 3$ mA
$-I_E = 5$ mA
$T_{amb} = 25$ °C
typ. values
$-b_{ib}$
g_{ib}
500
700
f (MHz)
900


7Z67283
1500
1000
500
0
$|y_{rb}|$
(mA/V)
φ_{rb}
(°)
$V_{CB} = 10$ V
$-I_E = 3$ mA
$-I_E = 5$ mA
$T_{amb} = 25$ °C
typ. values
$|y_{rb}|$
φ_{rb}
500
700
f (MHz)
900


7Z67284
150
100
50
0
$|y_{fb}|$
(mA/V)
φ_{fb}
(°)
$V_{CB} = 10$ V
$-I_E = 3$ mA
$-I_E = 5$ mA
$T_{amb} = 25$ °C
typ. values
φ_{fb}
$|y_{fb}|$
500
700
f (MHz)
900


7Z67282
3
2
1
0
g_{ob}
(mA/V)
C_{ob}
(pF)
$V_{CB} = 10$ V
for $-I_E = 3$ and 5 mA
$T_{amb} = 25$ °C
typ. values
g_{ob}
C_{ob}
500
700
f (MHz)
900

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.

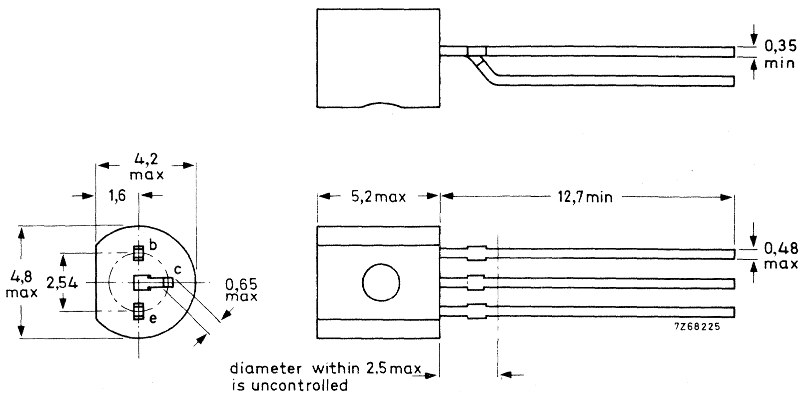
QUICK REFERENCE DATA

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 °C	P_{tot}	max.	830	mW
Junction temperature	T_j	max.	150	°C
D.C. current gain at T_j = 25 °C I_C = 25 mA; V_{CE} = 20 V	h_{FE}	>	50	
Transition frequency $-I_E$ = 10 mA; V_{CB} = 10 V	f_T	>	60	MHz
Feedback capacitance at f = 1 MHz I_E = 0; V_{CB} = 30 V	C_{re}	<	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 °C *	P_{tot}	max.	830	mW
Storage temperature	T_{stg}	−65 to +	150	°C
Junction temperature	T_j	max.	150	°C

→ THERMAL RESISTANCE

From junction to ambient *	$R_{th\ j\text{-}a}$	=	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 °C unless otherwise specified.

Collector cut-off currents			
I_E = 0; V_{CB} = 200 V	I_{CBO}	<	10 nA
R_{BE} = 10 kΩ; V_{CE} = 200 V; T_j = 150 °C	I_{CER}	<	10 μA
Emitter cut-off current			
I_C = 0; V_{EB} = 5 V	I_{EBO}	<	10 μA
D.C. current gain			
I_C = 25 mA; V_{CE} = 20 V	h_{FE}	>	50
High-frequency knee voltage*			
I_C = 25 mA; T_j = 150 °C	V_{CEK}	typ.	20 V
Transition frequency			
$-I_E$ = 10 mA; V_{CB} = 10 V	f_T	>	60 MHz
Feedback capacitance at f = 1 MHz			
I_E = 0; V_{CB} = 30 V	C_{re}	<	1,6 pF
Feedback time constant at f = 10,7 MHz			
$-I_E$ = 30 mA; V_{CB} = 20 V	$r_{bb'}C_{b'c}$	<	70 ps**

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

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

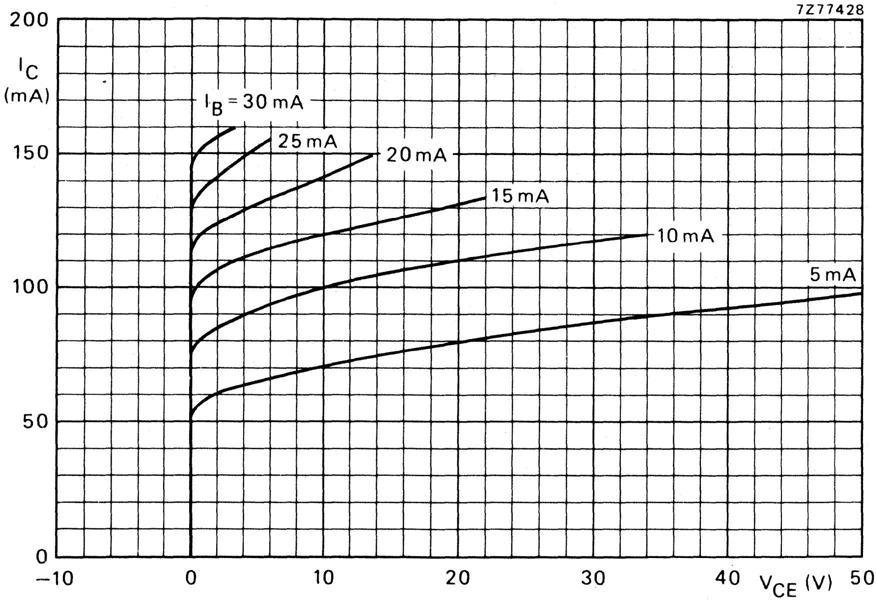


Fig. 2 Typical values at T_j = 25 °C.

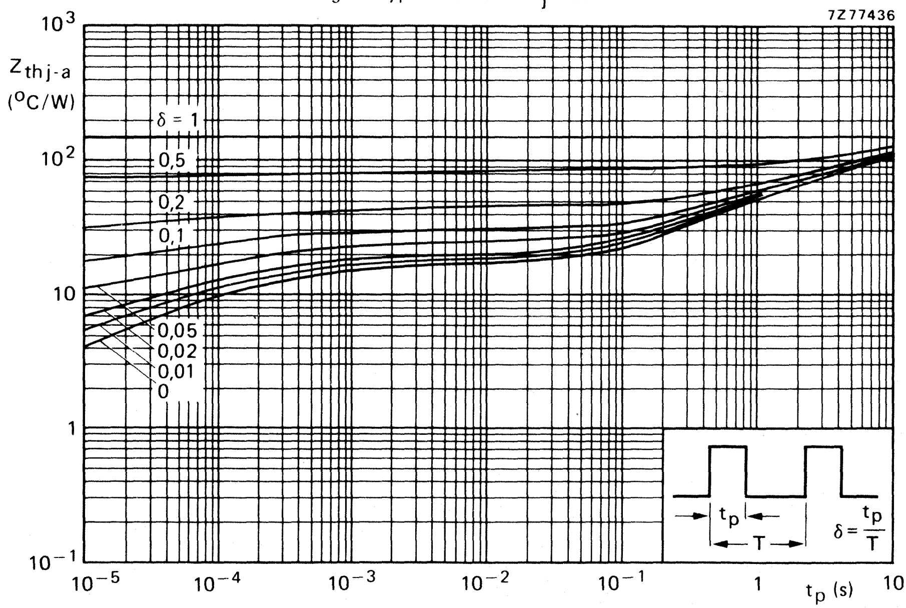


Fig. 3 Thermal impedance from junction to ambient versus pulse duration.
Maximum lead length 3 mm; mounting pad for collector lead minimum 10 mm x 10 mm.

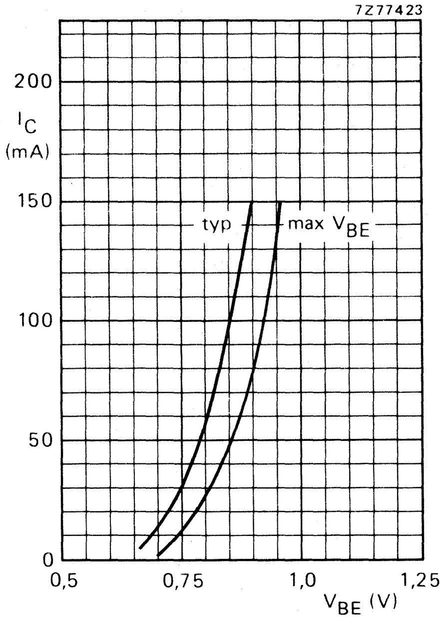


Fig. 4 V_{CB} = 20 V; T_j = 25 °C.

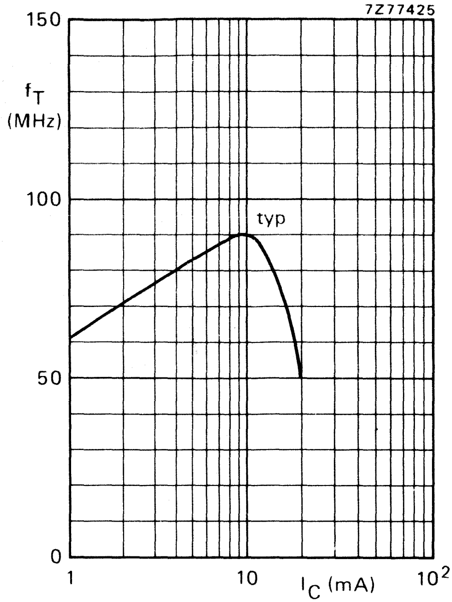


Fig. 5 V_{CE} = 10 V; T_j = 25 °C.

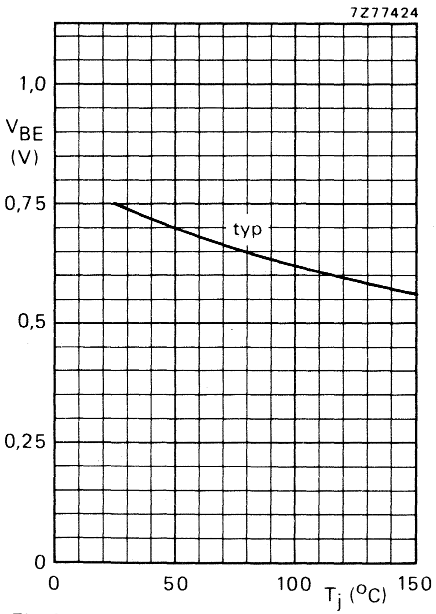


Fig. 6 I_C = 25 mA; V_{CE} = 20 V.

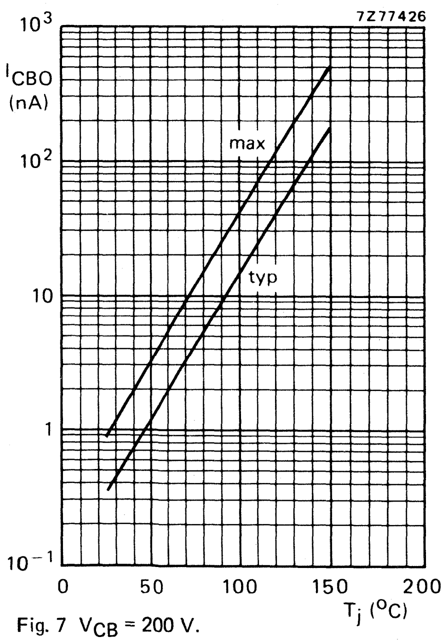


Fig. 7 V_{CB} = 200 V.

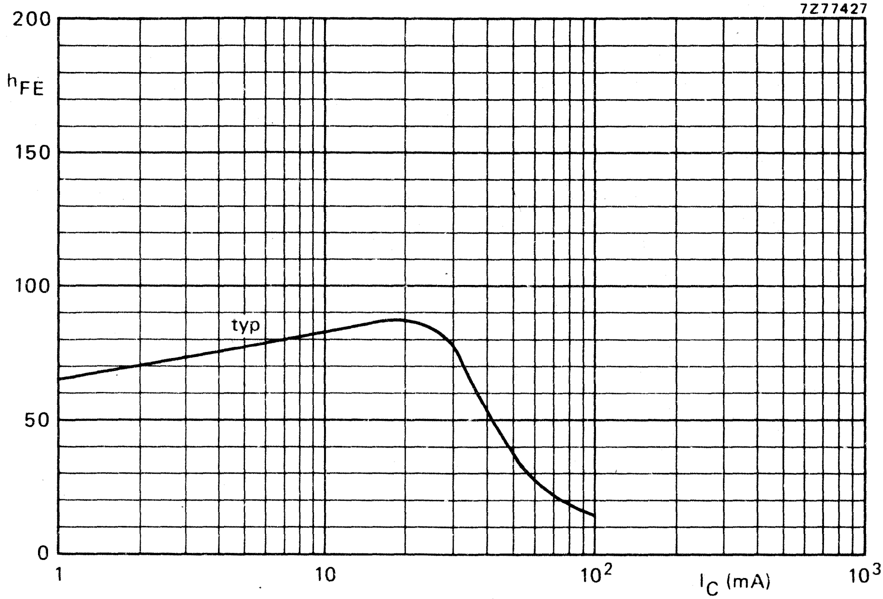


Fig. 8 V_{CE} = 20 V; T_j = 25 °C.

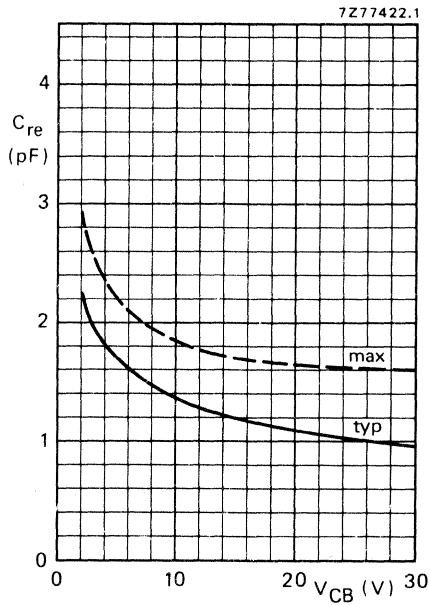


Fig. 9 I_E = 0; f = 1 MHz; T_j = 25 °C.

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.

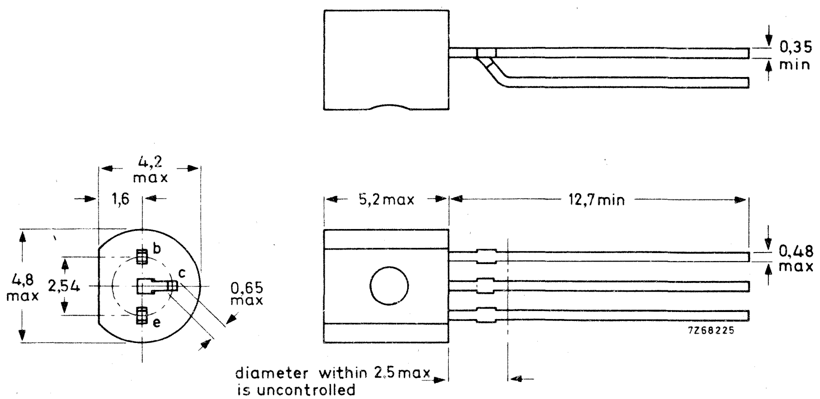
QUICK REFERENCE DATA

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 °C	P_{tot}	max.	830 mW
Junction temperature	T_j	max.	150 °C
D.C. current gain at T_j = 25 °C $-I_C$ = 25 mA; $-V_{CE}$ = 20 V	h_{FE}	>	50
Transition frequency I_E = 10 mA; $-V_{CB}$ = 10 V	f_T	>	60 MHz
Feedback capacitance at f = 1 MHz I_E = 0; $-V_{CB}$ = 30 V	C_{re}	<	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 °C *	P_{tot}	max.	830	mW
Storage temperature	T_{stg}	−65 to + 150		°C
Junction temperature	T_j	max.	150	°C

→ THERMAL RESISTANCE

From junction to ambient *	$R_{th\ j\text{-}a}$	=	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 °C unless otherwise specified

Collector cut-off currents			
$I_E = 0$; $V_{CB} = 200$ V	$-I_{CBO}$	<	10 nA
$R_{BE} = 10$ kΩ; $-V_{CE} = 200$ V; $T_j = 150$ °C	$-I_{CER}$	<	10 μA
Emitter cut-off current			
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	10 μA
D.C. current gain			
$-I_C = 25$ mA; $-V_{CE} = 20$ V	h_{FE}	>	50
High-frequency knee voltage*			
$-I_C = 25$ mA; $T_j = 150$ °C	$-V_{CEK}$	typ.	20 V
Transition frequency			
$I_E = 10$ mA; $-V_{CB} = 10$ V	f_T	>	60 MHz
Feedback capacitance at f = 1 MHz			
$I_E = 0$; $-V_{CB} = 30$ V	C_{re}	<	1,6 pF
Feedback time constant at f = 10,7 MHz			
$I_E = 30$ mA; $-V_{CB} = 20$ V	$r_{bb'}C_{b'c}$	<	70 ps**

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

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

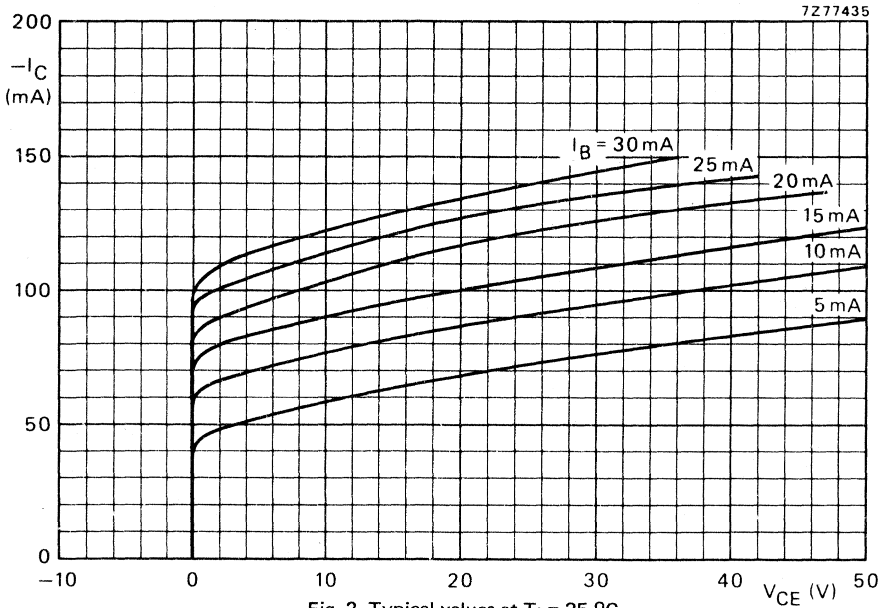


Fig. 2 Typical values at T_j = 25 °C.

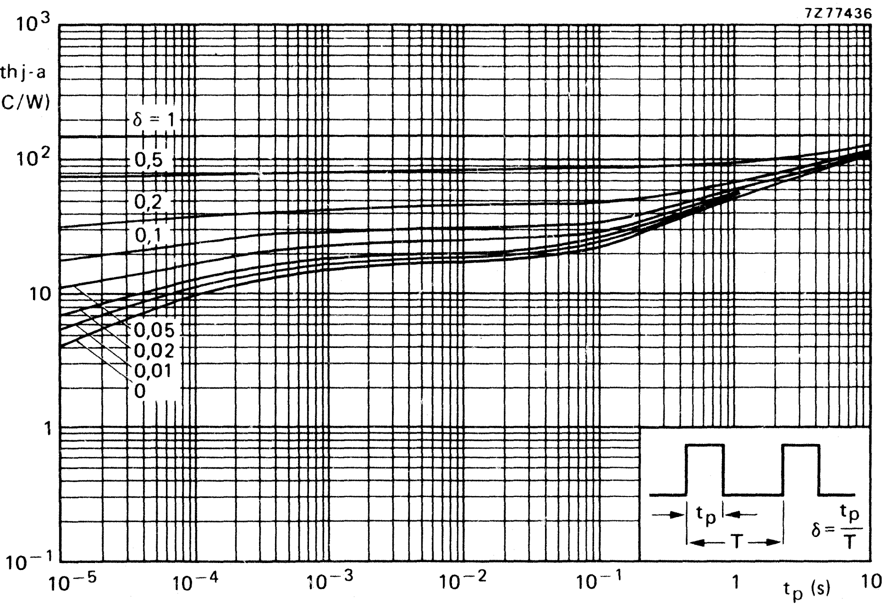


Fig. 3 Thermal impedance from junction to ambient versus pulse duration.
Maximum lead length 3 mm; mounting pad for collector lead minimum 10 mm x 10 mm.

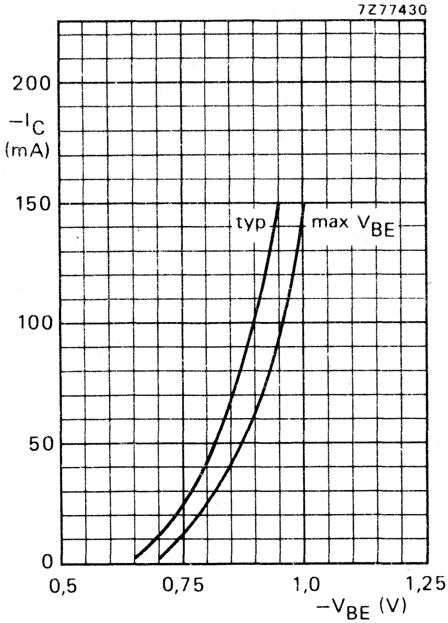


Fig. 4 $-V_{CE}$ = 20 V; T_j = 25 °C.

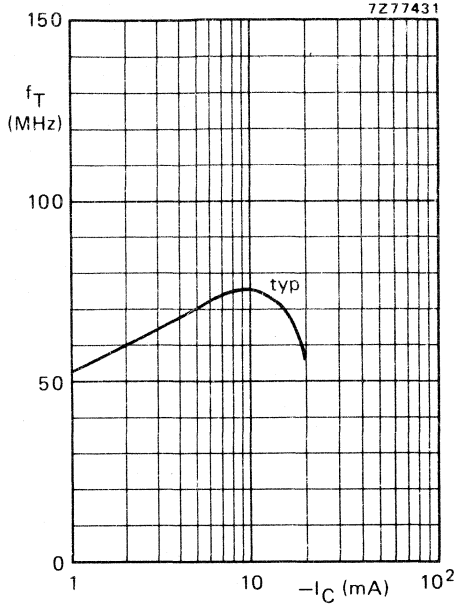


Fig. 5 $-V_{CE}$ = 10 V; T_j = 25 °C.

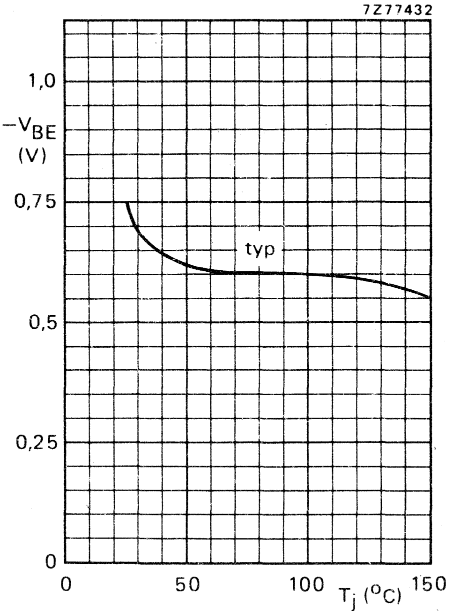


Fig. 6 $-I_C$ = 25 mA; $-V_{CE}$ = 20 V.

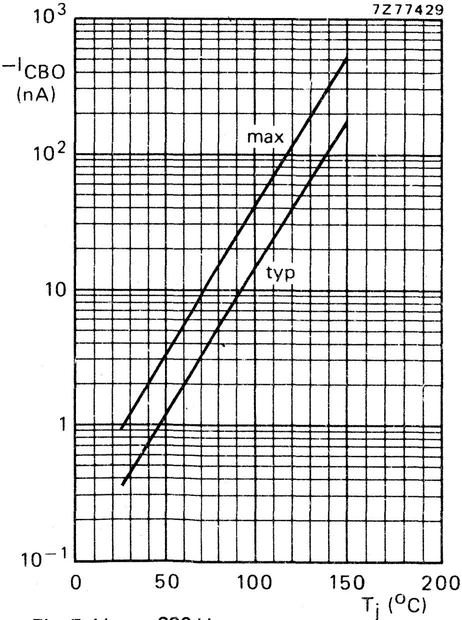


Fig. 7 V_{CB} = 200 V.

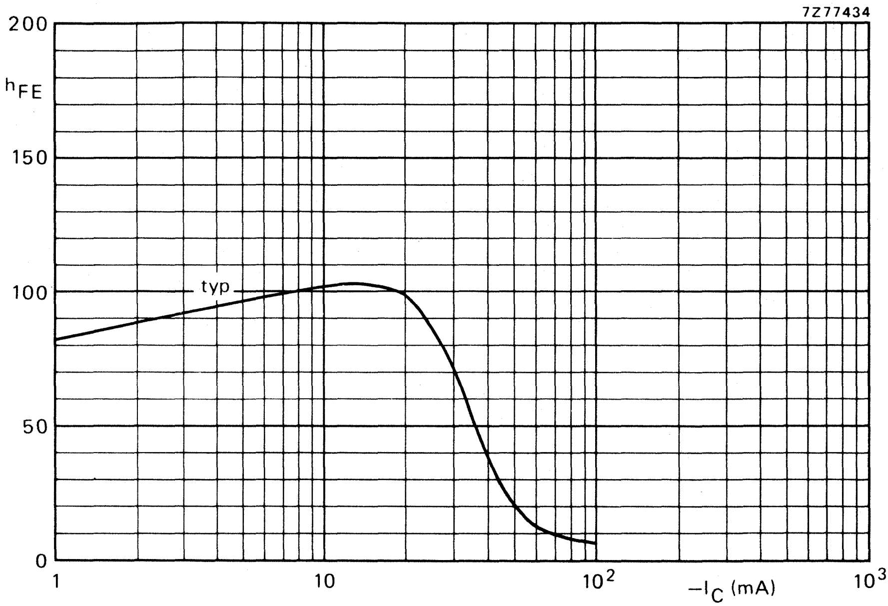


Fig. 8 $-V_{CE}$ = 20 V; T_j = 25 °C.

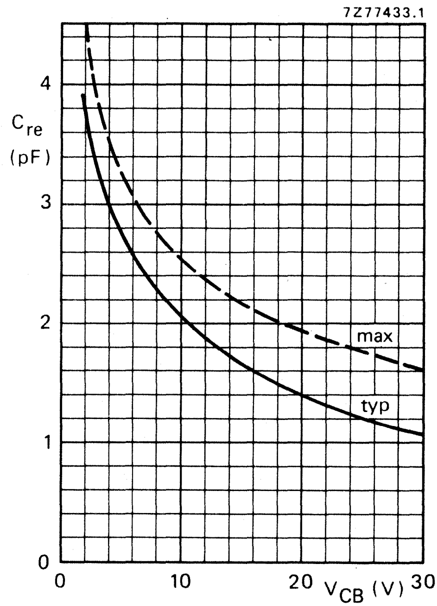


Fig. 9 I_E = 0; f = 1 MHz; T_j = 25 °C.

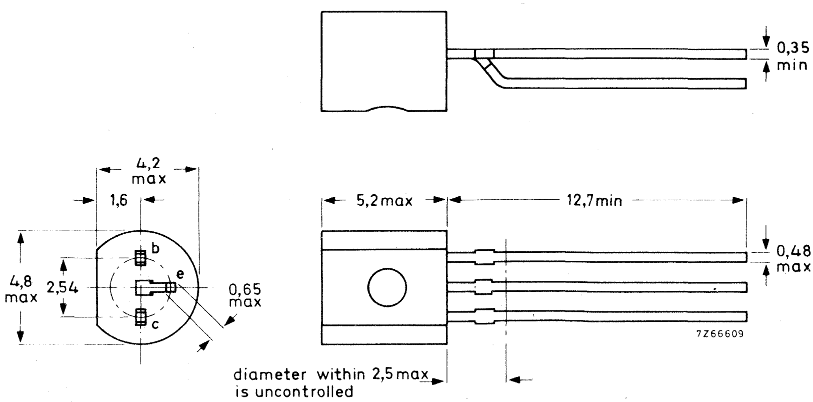
H.F. SILICON PLANAR EPITAXIAL TRANSISTORS

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 °C		P_{tot}	max.	250	mW
Junction temperature		T_j	max.	150	°C
Base current					
$-I_C$ = 1 mA; $-V_{CE}$ = 10 V	BF450:	$-I_B$		5 to 16	μA
	BF451:	$-I_B$		11 to 33	μA
Transition frequency					
$-I_C$ = 1 mA; $-V_{CE}$ = 10 V		f_T	typ.	325	MHz
Noise figure at f = 100 kHz					
$-I_C$ = 1 mA; $-V_{CE}$ = 10 V; R_S = 300 Ω		F	typ.	2	dB

MECHANICAL DATA Dimensions in mm

TO-92 variant



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

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

Power dissipation

Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	250	mW

Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0, 42	°C/mW

CHARACTERISTICS T_j = 25 °C

Collector cut-off current

$I_E = 0$; $-V_{CB} = 30$ V	$-I_{CBO}$	<	50	nA
$I_E = 0$; $-V_{CB} = 40$ V	$-I_{CBO}$	<	10	μA

Emitter cut-off current

$I_C = 0$; $-V_{EB} = 4$ V	$-I_{EBO}$	<	10	μA

Base current

$-I_C = 1$ mA; $-V_{CE} = 10$ V	BF450:	$-I_B$	<	5 to 16	μA
	BF451:	$-I_B$	<	11 to 33	μA

Base-emitter voltage

$-I_C = 1$ mA; $-V_{CE} = 10$ V	$-V_{BE}$	typ.	700	mV

CHARACTERISTICS (continued) $T_j = 25\ ^oC$

Transition frequency at f = 100 MHz

$-I_C = 1$ mA; $-V_{CE} = 10$ V	f_T	typ.	325	MHz

Feedback capacitance at f = 1 MHz

$-I_C = 1$ mA; $-V_{CE} = 10$ V	C_{re}	typ.	0,35	pF

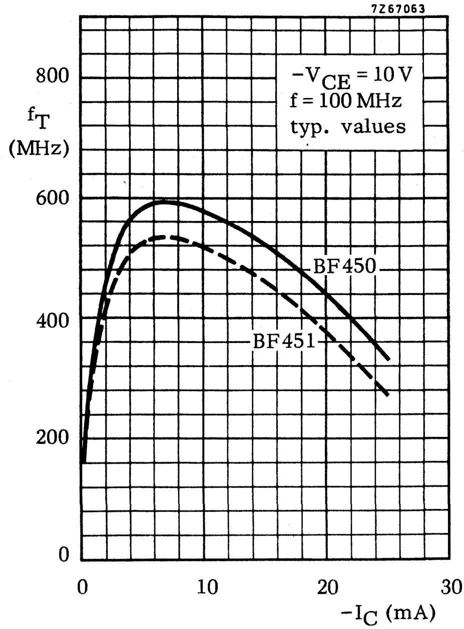
Noise figure at f = 100 kHz

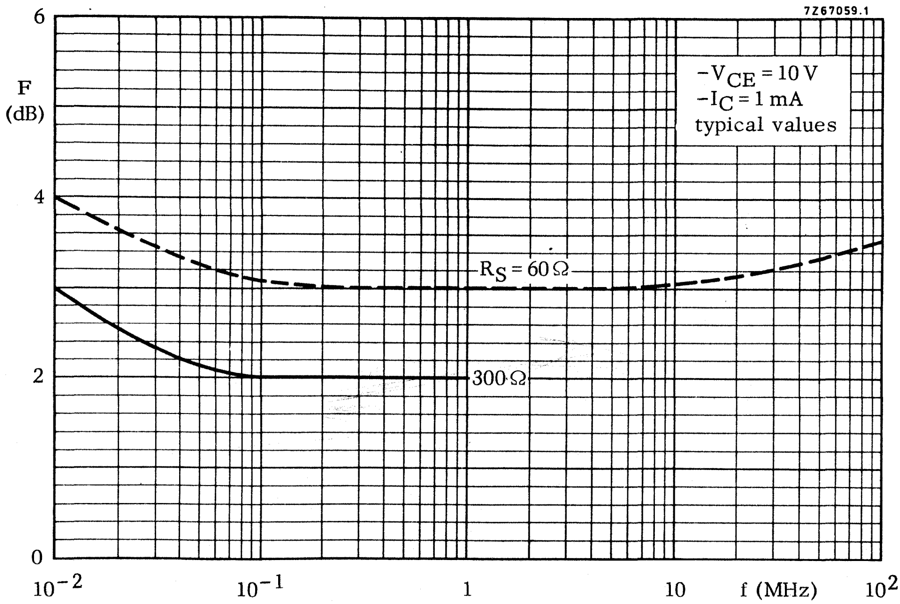
$-I_C = 1$ mA; $-V_{CE} = 10$ V; $R_S = 300\ \Omega$	F	typ.	2	dB

y-parameters (common emitter)

$-I_C = 1$ mA; $-V_{CE} = 10$ 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	φ_{fe}	typ.	0^o	0^o	0^o	0^o	
Output conductance	g_{oe}	typ.	8	10	8	10	µA/V
Output capacitance	C_{oe}	typ.	1	1	1	1	pF
Feedback admittance	$\|y_{re}\|$	typ.	1	24	1	24	µA/V
Phase angle of feedback admittance	φ_{re}	typ.	270^o	270^o	270^o	270^o	


7Z67063
$-V_{CE}$ = 10 V
f = 100 MHz
typ. values
f_T (MHz)
800
600
400
200
0
0
10
20
30
$-I_C$ (mA)
BF450
BF451


7Z67059.1
$-V_{CE}$ = 10 V
$-I_C$ = 1 mA
typical values
F (dB)
6
4
2
0
R_S = 60 Ω
300 Ω
10^{-2}
10^{-1}
1
10
f (MHz)
10^2

SILICON PLANAR TRANSISTOR

N-P-N transistor in a subminiature plastic T-package, primarily intended for application in r.f. stages of television tuners using p-i-n diode attenuators.

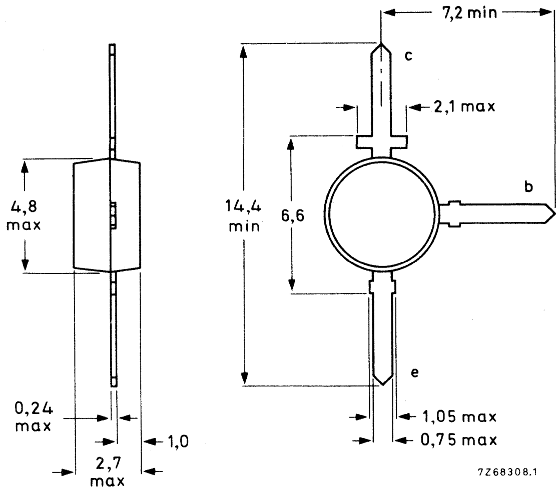
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max	20	V
Collector-emitter voltage (open base)	V_{CEO}	max	15	V
Collector current (d.c.)	I_C	max	20	mA
Total power dissipation up to T_{amb} = 60 °C	P_{tot}	max	200	mW
Junction temperature	T_j	max	150	°C
Transition frequency, $-I_E$ = 10 mA; V_{CB} = 10 V	f_T	typ	2	GHz
Noise figure at optimum source admittance $-I_E$ = 10 mA, V_{CB} = 10 V, f = 800 MHz	F	typ	3,8	dB
Cross-modulation (K = 1%) e.m.f. in 75 Ω	$V_{(int)rms}$	typ	330	mV

MECHANICAL DATA

Dimensions in mm

SOT-37



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 °C	P_{tot}	max	200 mW

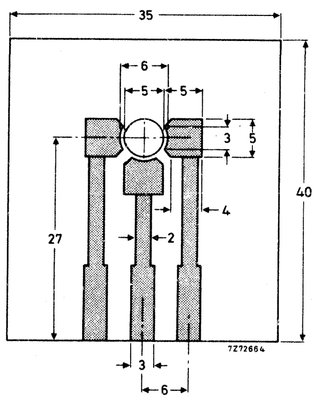
Temperatures

Storage temperature	T_s	−65 to +150	°C
Junction temperature	T_j	max	150 °C

THERMAL RESISTANCE

From junction to ambient
mounted on the printed-circuit board
shown below, which is in free air $R_{th\ j\text{-}a}$ = 0,45 °C/mW

Dimensions in mm



Single-sided 35 μm 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 °C unless otherwise specified

Base current

$-I_E$ = 10 mA; V_{CB} = 10 V	I_B	typ	350 μA
		<	750 μA

Emitter-base voltage

$-I_E$ = 10 mA; V_{CB} = 10 V	$-V_{EB}$	typ	0,8 V

Transition frequency at f = 500 MHz

$-I_E$ = 10 mA; V_{CB} = 10 V	f_T	typ	2 GHz

Noise figure at optimum source admittance (common base)

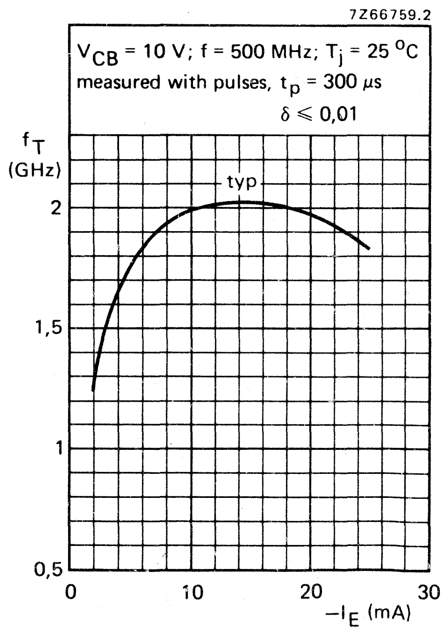
$-I_E$ = 10 mA; V_{CB} = 10 V; f = 800 MHz	F	typ	3,8 dB
$-I_E$ = 10 mA: V_{CB} = 10 V; f = 200 MHz	F	typ	2,9 dB

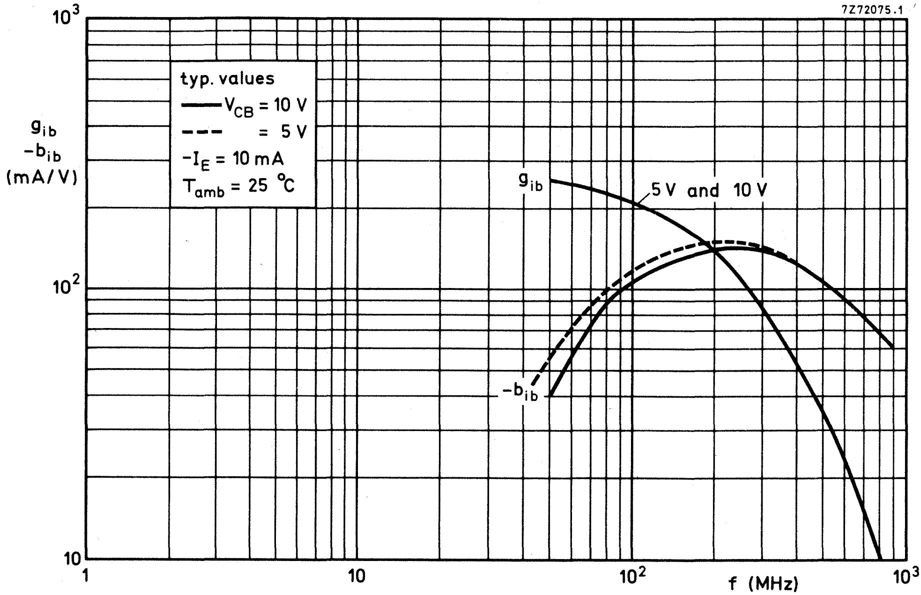
Transducer gain (common base)

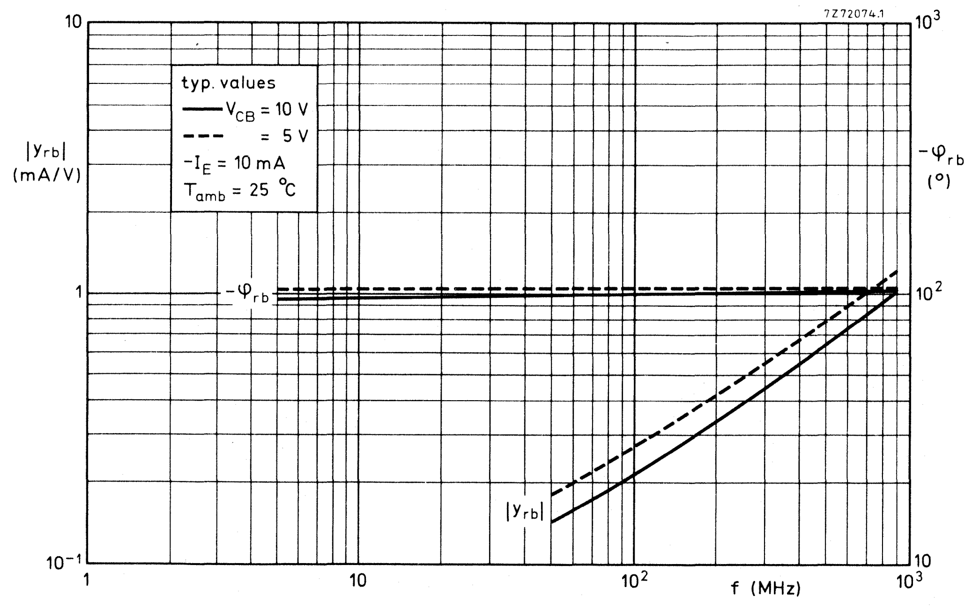
$-I_E$ = 10 mA; V_{CB} = 10 V; f = 900 MHz

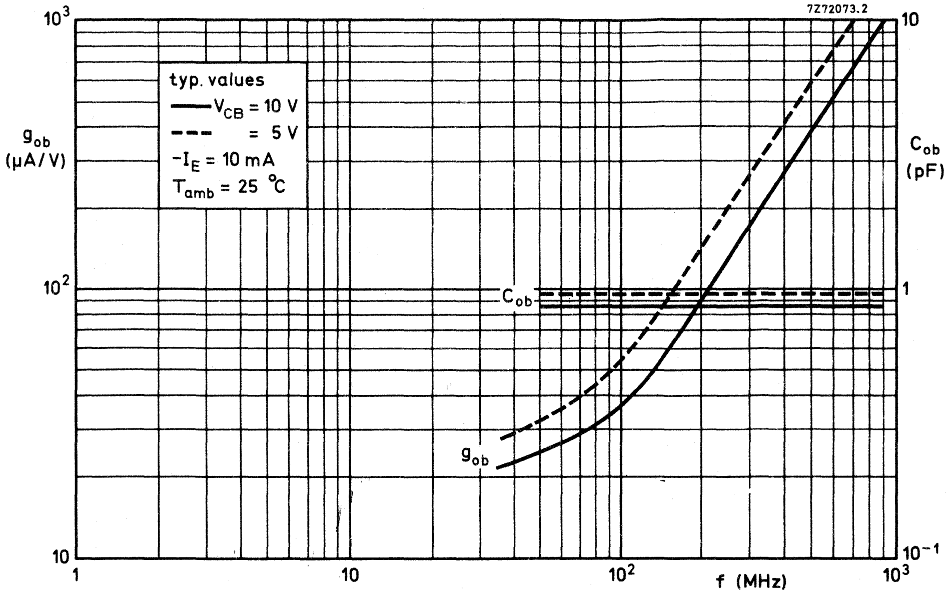
G_s = 20 mA/V; B_s = 0

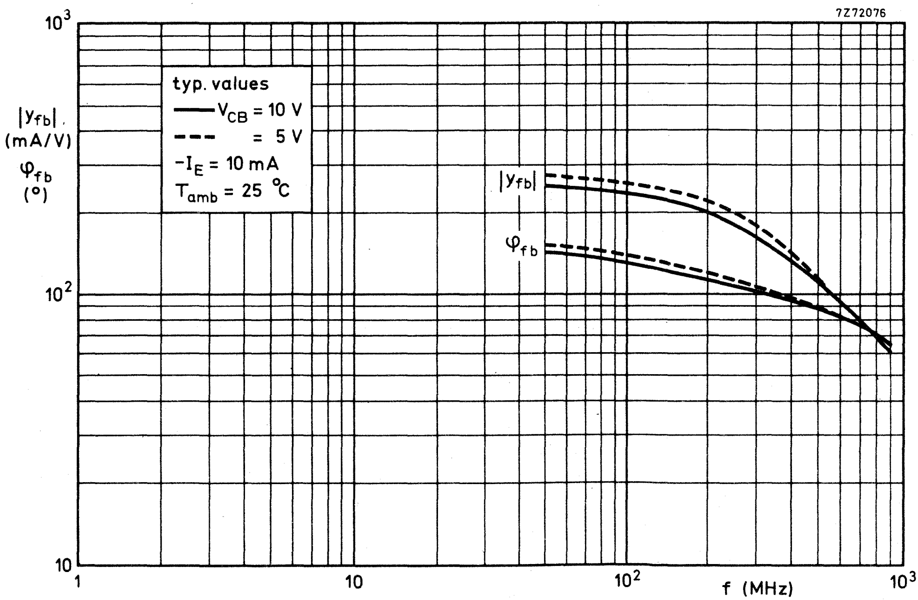
G_ℓ = 2 mA/V; B_ℓ = tuned — G_{tr} typ 15 dB



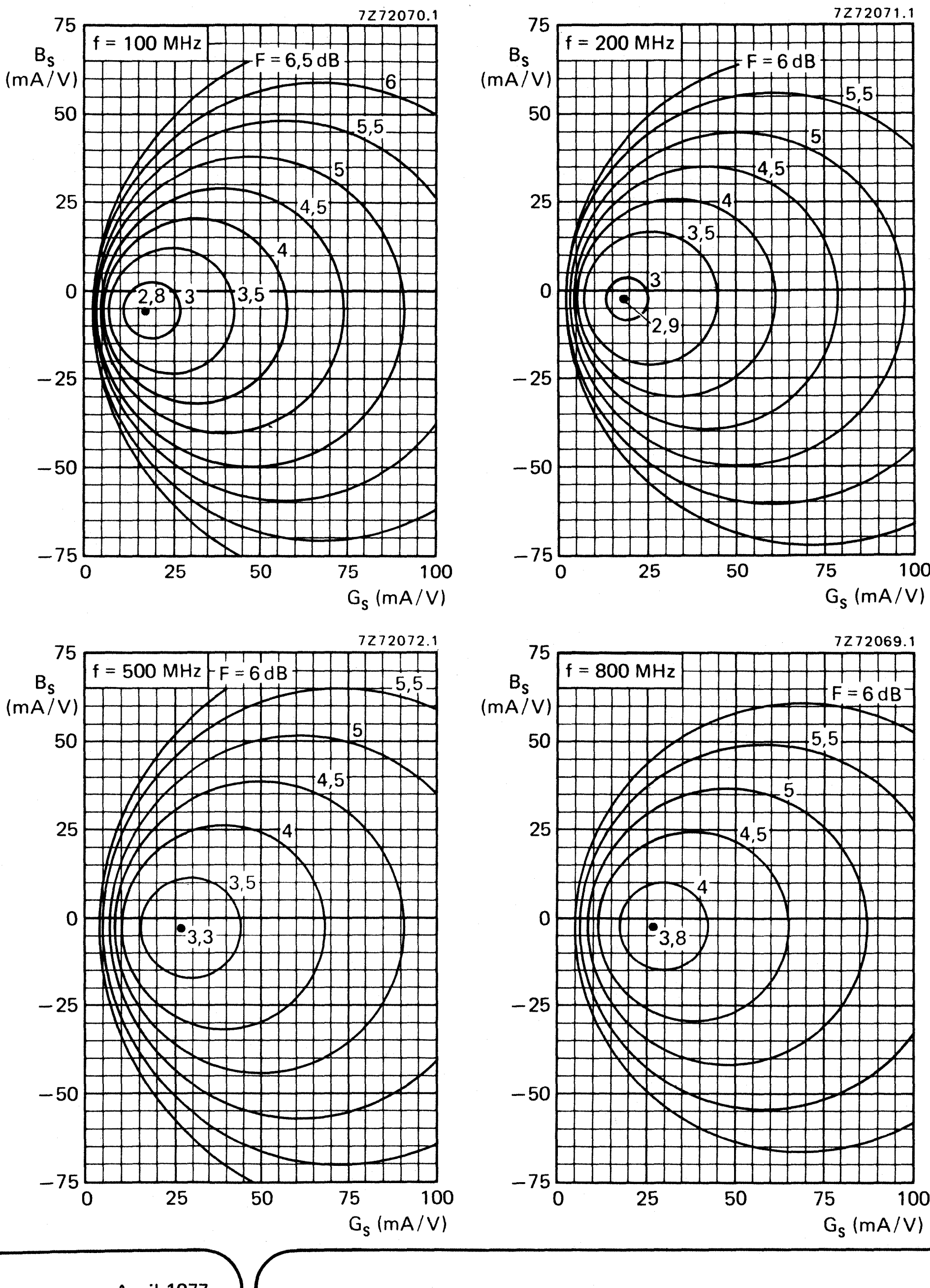

7Z72075.1
typ. values
V_{CB} = 10 V
= 5 V
$-I_E$ = 10 mA
T_{amb} = 25 °C
g_{ib}
$-b_{ib}$
(mA/V)
g_{ib}
5 V and 10 V
$-b_{ib}$
10^3
10^2
10
1
10
10^2
f (MHz)
10^3


7Z72074.1
typ. values
V_{CB} = 10 V
= 5 V
$-I_E$ = 10 mA
T_{amb} = 25 °C
$|y_{rb}|$
(mA/V)
$-\varphi_{rb}$
(°)
$-\varphi_{rb}$
$|y_{rb}|$
10
1
10^{-1}
10^3
10^2
10
1
10
10^2
f (MHz)
10^3


7Z72073.2
typ. values
V_{CB} = 10 V
= 5 V
$-I_E$ = 10 mA
T_{amb} = 25 °C
g_{ob} (μA/V)
C_{ob} (pF)
C_{ob}
g_{ob}
f (MHz)
10^3
10^2
10
1
10
10^2
10^3
10
1
10^{-1}

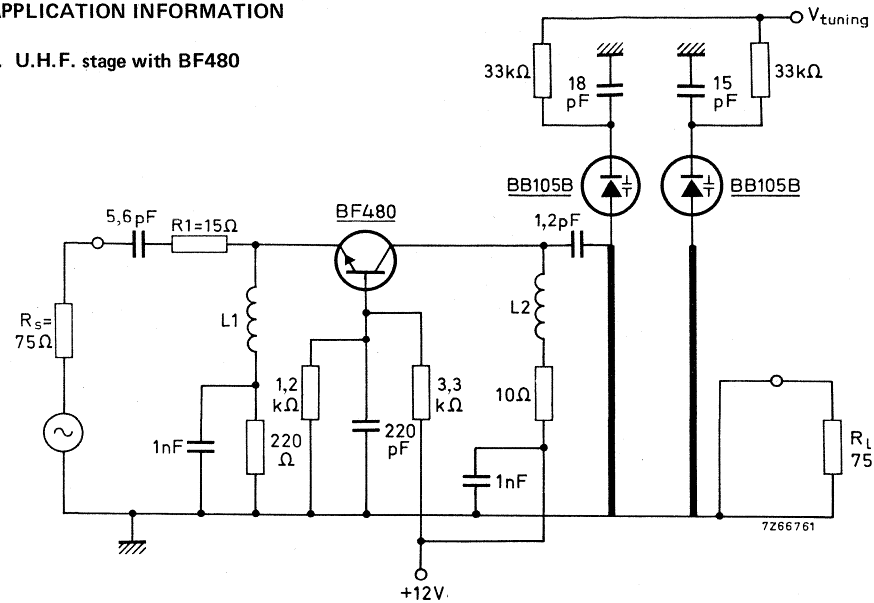

7Z72076
typ. values
V_{CB} = 10 V
= 5 V
$-I_E$ = 10 mA
T_{amb} = 25 °C
$|y_{fb}|$ (mA/V)
φ_{fb} (°)
$|y_{fb}|$
φ_{fb}
f (MHz)
10^3
10^2
10
1
10
10^2
10^3

Conditions for all four graphs: $-I_E$ = 10 mA; V_{CB} = 10 V; T_{amb} = 25 °C



APPLICATION INFORMATION

1. U.H.F. stage with BF480



L_1 = 6 turns, Ø 3 mm
L_2 = 4,5 turns, Ø 3 mm

PERFORMANCE at T_{amb} = 25 °C

Measuring frequency	f_i	=	800	MHz
3 dB bandwidth	B_{3dB}	typ	25	MHz
Emitter current	$-I_E$	typ	10,3	mA
Collector-emitter voltage	V_{CE}	typ	9,7	V
Transducer gain	G_{tr}	typ	10	dB
Noise figure including influence of a. mixer stage with a noise figure of 10 dB b. R_1 = 15 Ω	F	typ	6,5	dB
Voltage standing wave ratio (incl. R_1 = 15 Ω)	VSWR	<	4	
Cross-modulation * Interference voltage for K = 1%	$V_{(int)rms}$	typ	300	mV

* Cross-modulation is defined here as the e.m.f. in 75 Ω of an unwanted signal with 80% modulation depth, giving 0,8% modulation depth on the wanted signal.

SILICON PLANAR EPITAXIAL TRANSISTOR

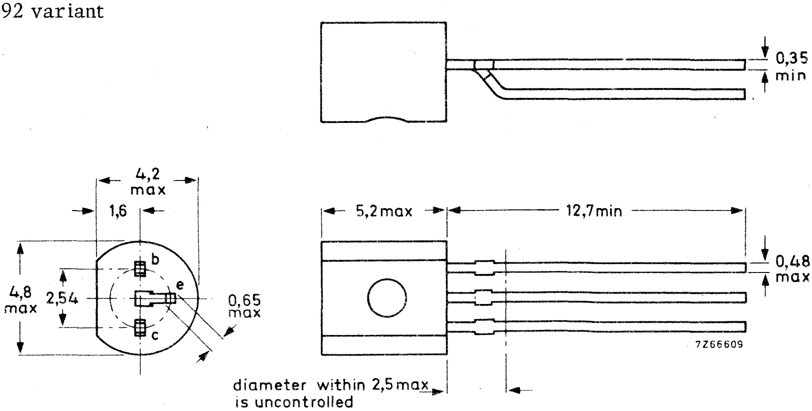
N-P-N transistor in a plastic TO-92 variant intended for h.f. applications in radio and television receivers; it is especially recommended for f.m. tuners, low noise a.m. mixer-oscillators with high source impedance and i.f. amplifiers in a.m./f.m. receivers where a high current gain is of importance.

QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Collector current (d.c.)	I_C	max.	30	mA
Total power dissipation up to T_{amb} = 75 °C	P_{tot}	max.	300	mW
Junction temperature	T_j	max.	150	°C
D.C. current gain at T_j = 25 °C I_C = 1 mA; V_{CE} = 10 V	h_{FE}	typ.	115	
Transition frequency I_C = 1 mA; V_{CE} = 10 V	f_T	typ.	260	MHz
Noise figure at f = 100 MHz I_C = 1 mA; V_{CE} = 10 V; G_S = 10 mA/V	F	typ.	4	dB
Conversion noise figure at f = 1 MHz I_C = 1 mA; V_{CE} = 10 V; G_S = 1,2 mA/V	F_c	typ.	2	dB

MECHANICAL DATA Dimensions in mm

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 °C	P_{tot}	max.	300	mW

Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0,25	°C/mW

CHARACTERISTICS T_j = 25 °C

Base-emitter voltage [2])

I_C = 1 mA; V_{CE} = 10 V	V_{BE}		0,65 to 0,74	V

Base current

I_C = 1 mA; V_{CE} = 10 V	I_B		4,5 to 15	μA
		typ.	8,7	μA

Feedback capacitance at f = 0,45 MHz

I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	0,85	pF

1) V_{BE} decreases by about 1,7 mV/°C with increasing temperature.

CHARACTERISTICS (continued) $T_j = 25\ ^oC$

Transition frequency

$I_C = 1$ mA; $V_{CE} = 10$ V	f_T	typ.	260	MHz

Noise figure

$I_C = 1$ mA; $V_{CE} = 10$ V				
$G_S = 2$ mA/V; f = 0, 2 MHz	F	typ.	1, 5	dB
$G_S = 1, 5$ mA/V; f = 1, 0 MHz	F	typ.	1, 2	dB
$G_S = 10$ mA/V; f = 100 MHz	F	typ.	4	dB

Conversion noise figure

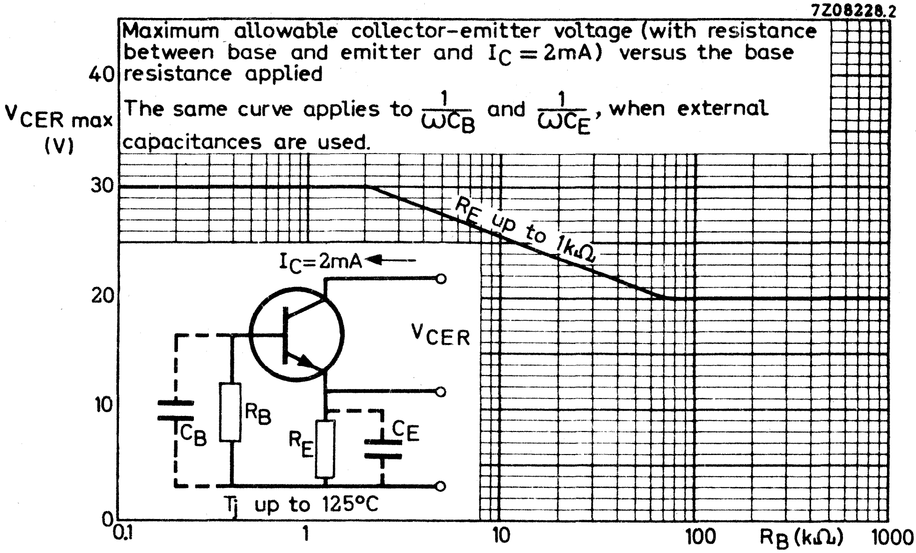
$I_C = 1$ mA; $V_{CE} = 10$ V				
$G_S = 0, 6$ mA/V; f = 0, 2 MHz	F_c	typ.	3	dB
$G_S = 1, 2$ mA/V; f = 1, 0 MHz	F_c	typ.	2	dB

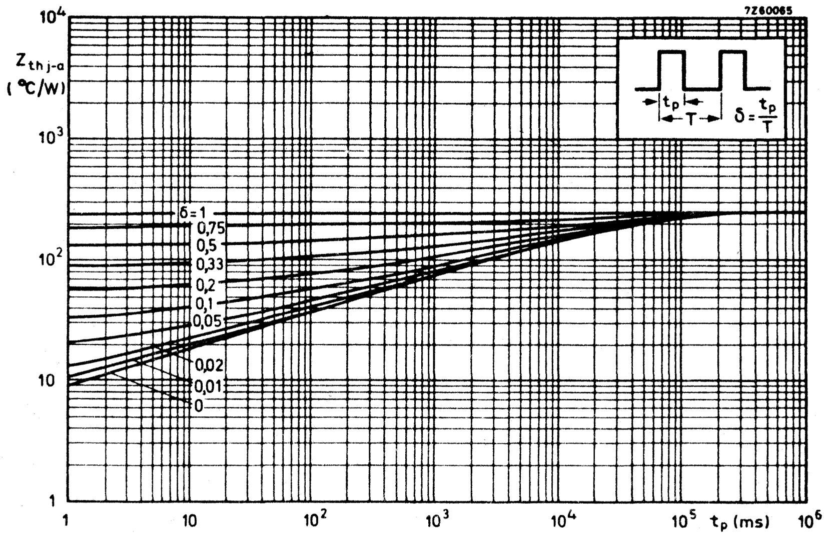
y parameters at f = 100 MHz (common base)

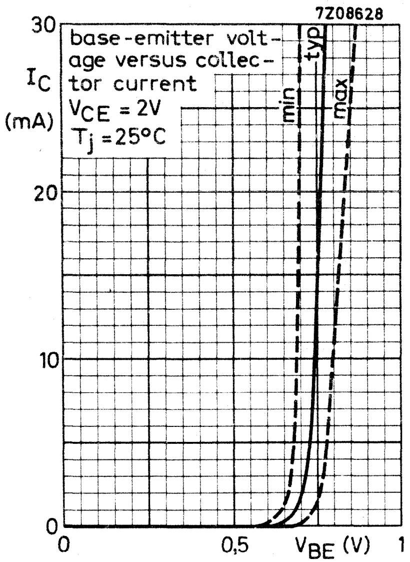
$I_C = 1$ mA; $V_{CE} = 10$ V (lead length = 3 mm)				
Input conductance	g_{ib}	typ.	32	mA/V
Input susceptance	$-b_{ib}$	typ.	3	mA/V
Feedback admittance	$\lvert y_{rb} \rvert$	typ.	500	µA/V
Phase angle of feedback admittance	φ_{rb}	typ.	272^o	
Transfer admittance	$\lvert y_{fb} \rvert$	typ.	33	mA/V
Phase angle of transfer admittance	φ_{fb}	typ.	150^o	
Output conductance	g_{ob}	typ.	22	µA/V
Output susceptance	b_{ob}	typ.	1, 1	mA/V

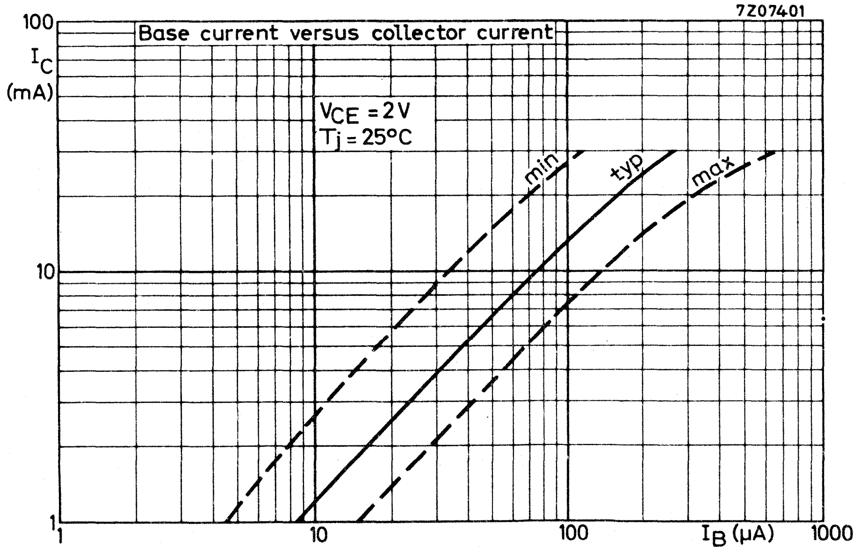
y parameters (common emitter)

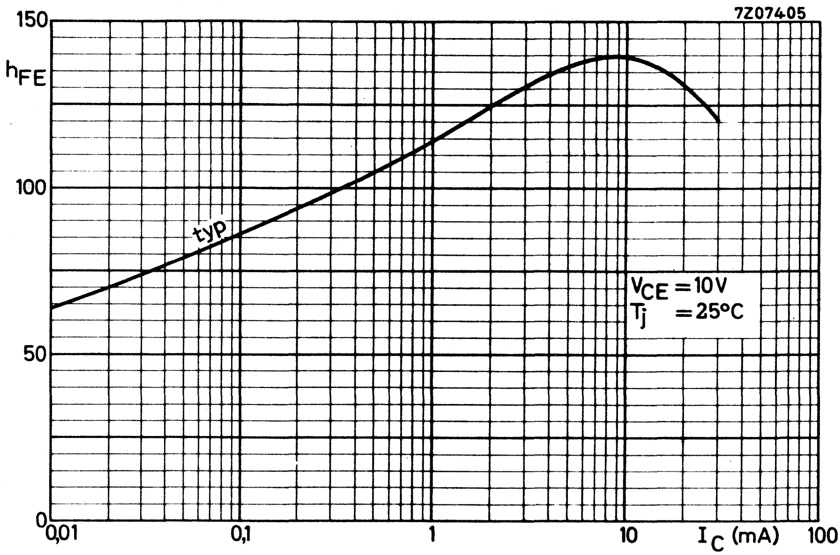
$I_C = 1$ mA; $V_{CE} = 10$ V (lead length = 3 mm)			f = 10, 7 MHz	f = 0, 45 MHz	
Input conductance	g_{ie}	<	0, 64	0, 54	mA/V
Output conductance	g_{oe}	<	13, 5	11, 5	µA/V

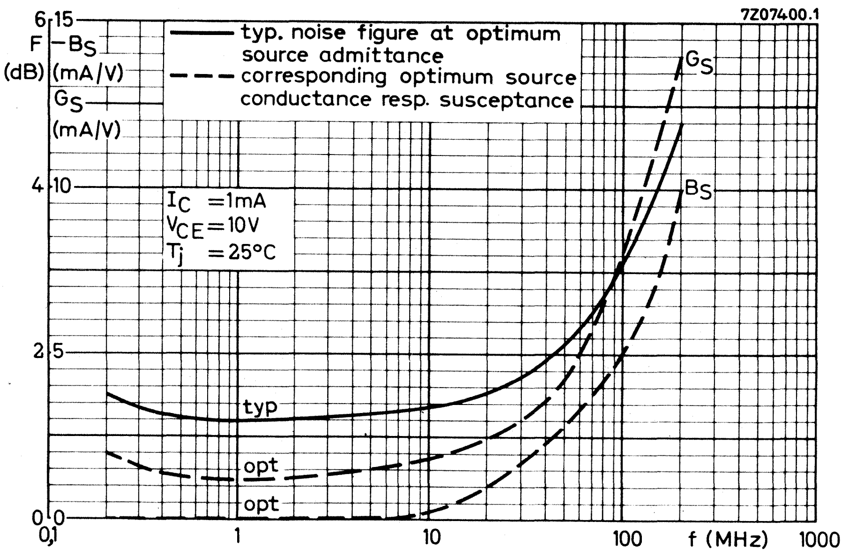

7Z08228.2
Maximum allowable collector-emitter voltage (with resistance between base and emitter and $I_C = 2mA$) versus the base resistance applied
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$, when external capacitances are used.
$V_{CER\ max}$ (V)
40
30
20
10
0
R_E up to 1kΩ
$I_C = 2mA$
V_{CER}
R_B
C_B
R_E
C_E
T_j up to 125°C
0.1
1
10
100
R_B (kΩ)
1000

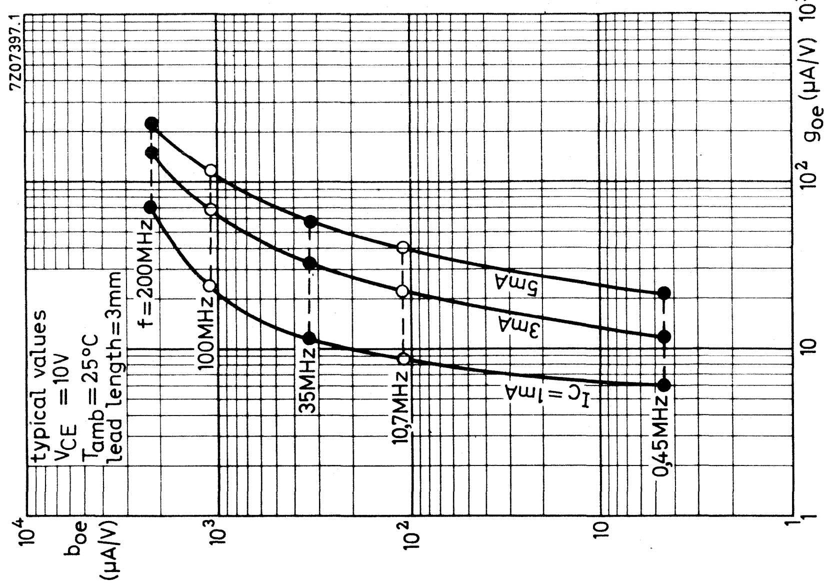

7Z60065
$Z_{th\ j\text{-}a}$ (°C/W)
10^4
10^3
10^2
10
1
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
0
t_p
T
$\delta = \frac{t_p}{T}$
1
10
10^2
10^3
10^4
10^5
t_p (ms)
10^6

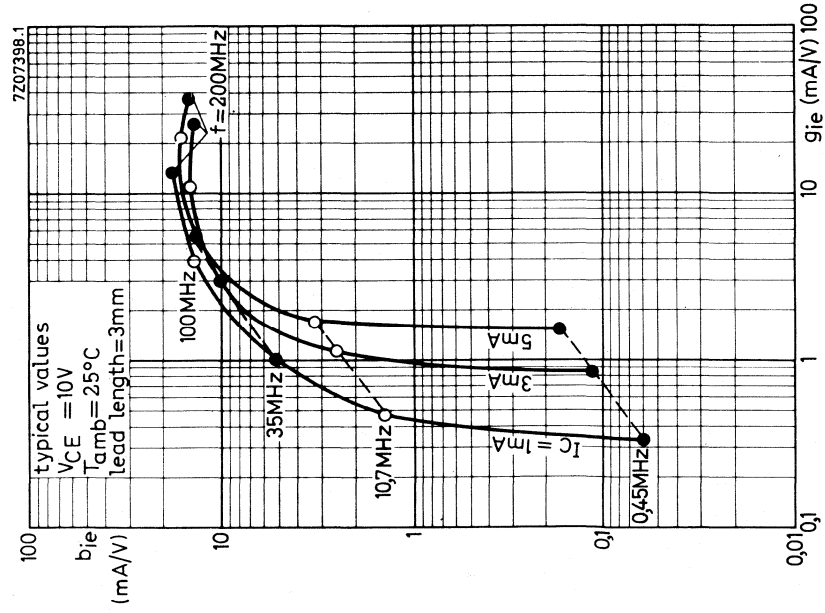

7Z08628
base-emitter voltage versus collector current
V_{CE} = 2V
T_j = 25°C
I_C (mA)
30
20
10
0
0
0,5
V_{BE} (V)
1
min
typ
max

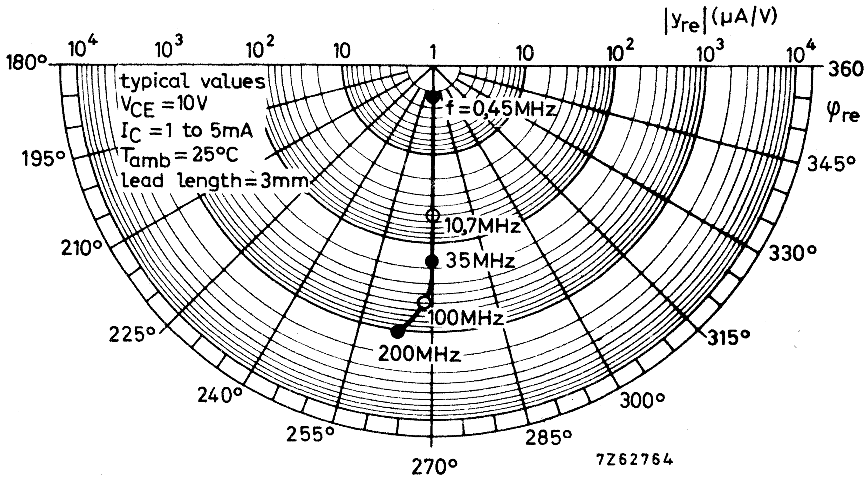

7Z07401
Base current versus collector current
V_{CE} = 2 V
T_j = 25°C
I_C (mA)
100
10
1
1
10
100
I_B (μA)
1000
min
typ
max


7Z07405
150
h_{FE}
100
typ
50
0
V_{CE} = 10 V
T_j = 25 °C
0,01
0,1
1
10
I_C (mA)
100

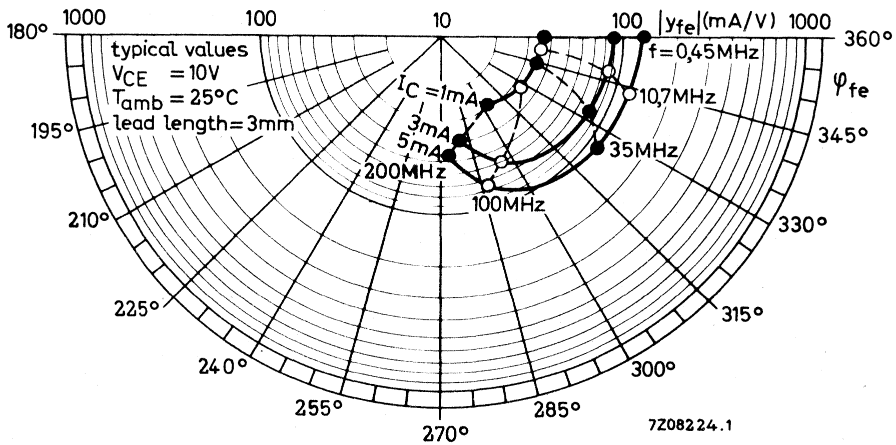

7Z07400.1
6
15
F
(dB)
$-B_S$
(mA/V)
G_S
(mA/V)
typ. noise figure at optimum source admittance
corresponding optimum source conductance resp. susceptance
4
10
I_C = 1 mA
V_{CE} = 10 V
T_j = 25 °C
2
5
typ
opt
opt
0
0
G_S
B_S
0,1
1
10
100
f (MHz)
1000


7Z07397.1
typical values
V_{CE} = 10V
T_{amb} = 25°C
lead length = 3mm
b_{oe} (μA/V)
g_{oe} (μA/V)
f = 200MHz
100MHz
35MHz
10,7MHz
0,45MHz
I_C = 1mA
3mA
5mA


7Z07398.1
typical values
V_{CE} = 10V
T_{amb} = 25°C
lead length = 3mm
b_{ie} (mA/V)
g_{ie} (mA/V)
f = 200MHz
100MHz
35MHz
10,7MHz
0,45MHz
I_C = 1mA
3mA
5mA



|yre| (μA/V)
typical values
VCE = 10V
IC = 1 to 5mA
Tamb = 25°C
lead length = 3mm
f = 0,45MHz
10,7MHz
35MHz
100MHz
200MHz
φre
7Z62764



|yfe| (mA/V)
typical values
VCE = 10V
Tamb = 25°C
lead length = 3mm
IC = 1mA
3mA
5mA
f = 0,45MHz
10,7MHz
35MHz
100MHz
200MHz
φfe
7Z08224.1

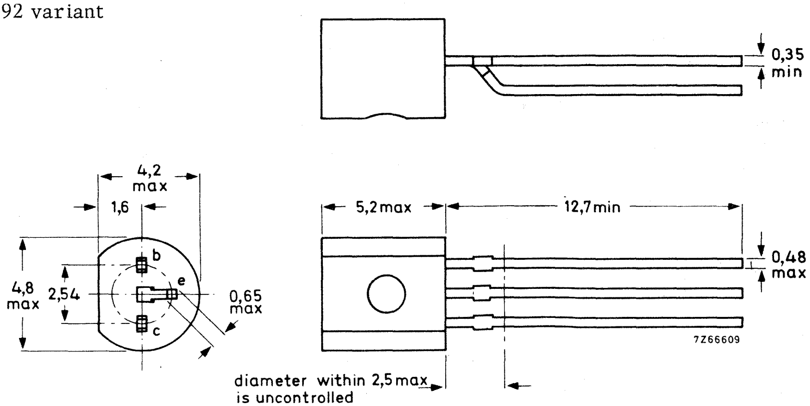
SILICON PLANAR EPITAXIAL TRANSISTOR

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.	20	V
Collector current (d.c.)	I_C	max.	30	mA
Total power dissipation up to T_{amb} = 75 °C	P_{tot}	max.	300	mW
Junction temperature	T_j	max.	150	°C
D.C. current gain at T_j = 25 °C I_C = 1 mA; V_{CE} = 10 V	h_{FE}	typ.	67	
Transition frequency I_C = 1 mA; V_{CE} = 10 V	f_T	typ.	200	MHz
Noise figure I_C = 1 mA; V_{CE} = 10 V G_S = 20 mA/V; f = 1 MHz	F	typ.	3,5	dB
G_S = 10 mA/V; f = 100 MHz	F	typ.	4	dB

MECHANICAL DATA Dimensions in mm

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 °C	P_{tot}	max.	300	mW

Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0,25	°C/mW

CHARACTERISTICS T_j = 25 °C

Base-emitter voltage 2)

I_C = 1 mA; V_{CE} = 10 V	V_{BE}		0,65 to 0,74	V

Base current

I_C = 1 mA; V_{CE} = 10 V	I_B		8 to 28	μA
		typ.	15	μA

Feedback capacitance at f = 0,45 MHz

I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	0,85	pF

1) V_{BE} decreases by about 1,7 mV/°C with increasing temperature.

CHARACTERISTICS (continued) $T_j = 25\ ^oC$

Transition frequency

$I_C = 1$ mA; $V_{CE} = 10$ V	f_T	typ.	200	MHz

Noise figure

$I_C = 1$ mA; $V_{CE} = 10$ V				
$G_S = 20$ mA/V; f = 1 MHz	F	typ.	3,5	dB
$G_S = 10$ mA/V; f = 100 MHz	F	typ.	4	dB

Conversion noise figure

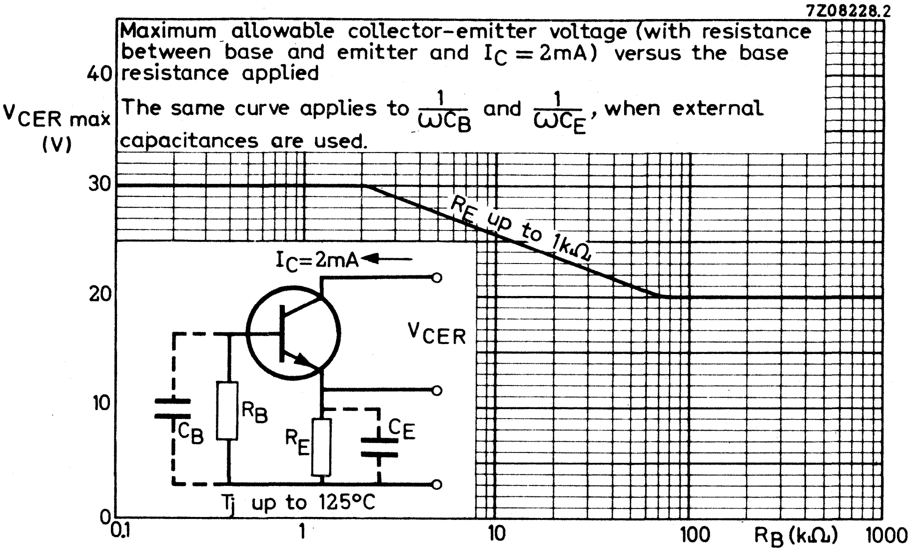
$I_C = 1$ mA; $V_{CE} = 10$ V				
$G_S = 1,2$ mA/V; f = 0,2 MHz	F_c	typ.	4	dB
$G_S = 1,5$ mA/V; f = 1 MHz	F_c	typ.	2,5	dB

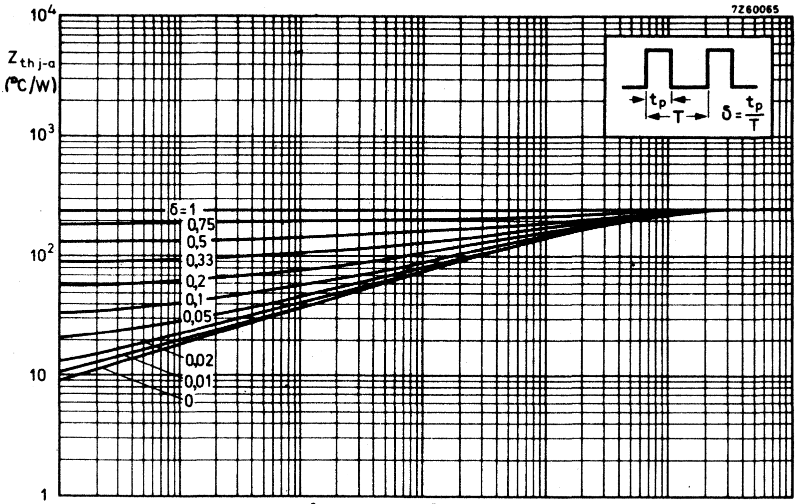
y parameters at f = 100 MHz (common base)

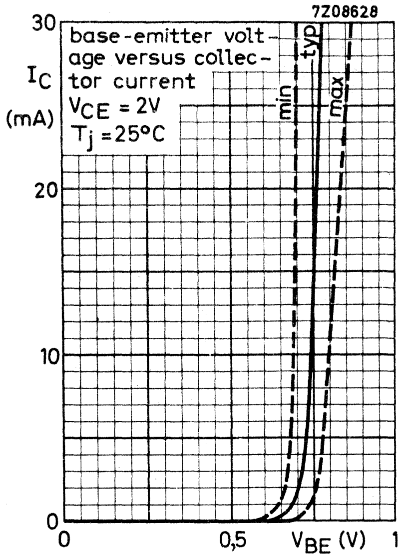
$I_C = 1$ mA; $V_{CE} = 10$ V (lead length = 3 mm)				
Input conductance	g_{ib}	typ.	34	mA/V
Input susceptance	$-b_{ib}$	typ.	1	mA/V
Feedback admittance	$\|y_{rb}\|$	typ.	490	µA/V
Phase angle of feedback admittance	φ_{rb}	typ.	272°	
Transfer admittance	$\|y_{fb}\|$	typ.	34	mA/V
Phase angle of transfer admittance	φ_{fb}	typ.	144°	
Output conductance	g_{ob}	typ.	12	µA/V
Output susceptance	b_{ob}	typ.	1,1	mA/V

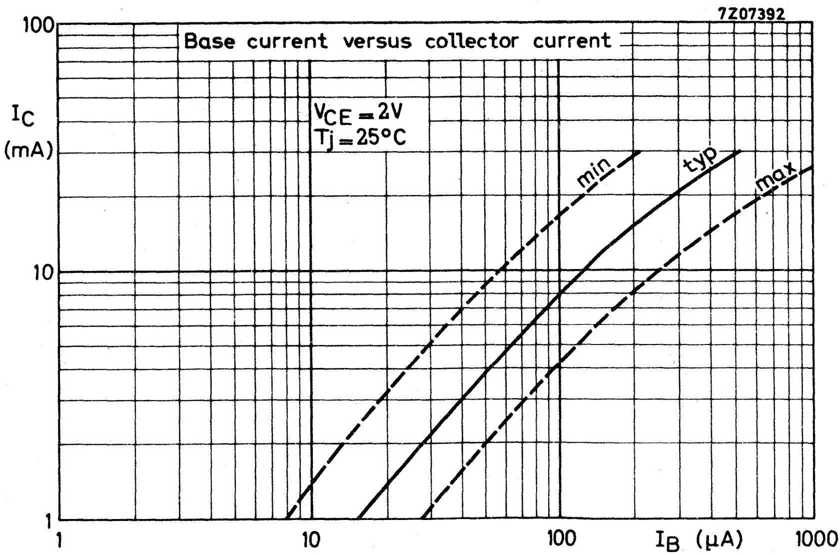
y parameters (common emitter)

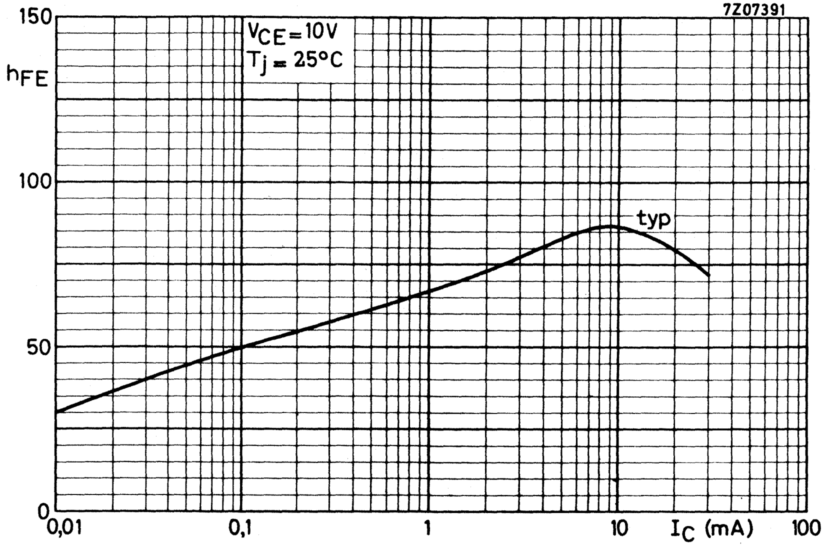
$I_C = 1$ mA; $V_{CE} = 10$ V (lead length = 3 mm)			f = 10,7 MHz	f = 0,45 MHz	
Input conductance	g_{ie}	<	0,96	0,86	mA/V
Output conductance	g_{oe}	<	9,5	7,0	µA/V

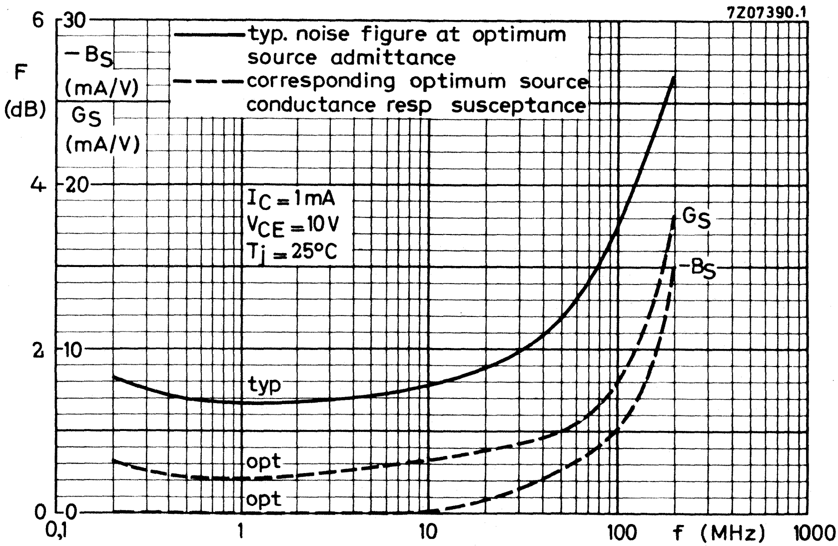

7Z08228.2
Maximum allowable collector-emitter voltage (with resistance between base and emitter and $I_C = 2mA$) versus the base resistance applied
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$, when external capacitances are used.
$V_{CER\,max}$ (V)
R_E up to 1kΩ
I_C=2mA
V_{CER}
R_B
C_B
R_E
C_E
T_j up to 125°C
R_B (kΩ)

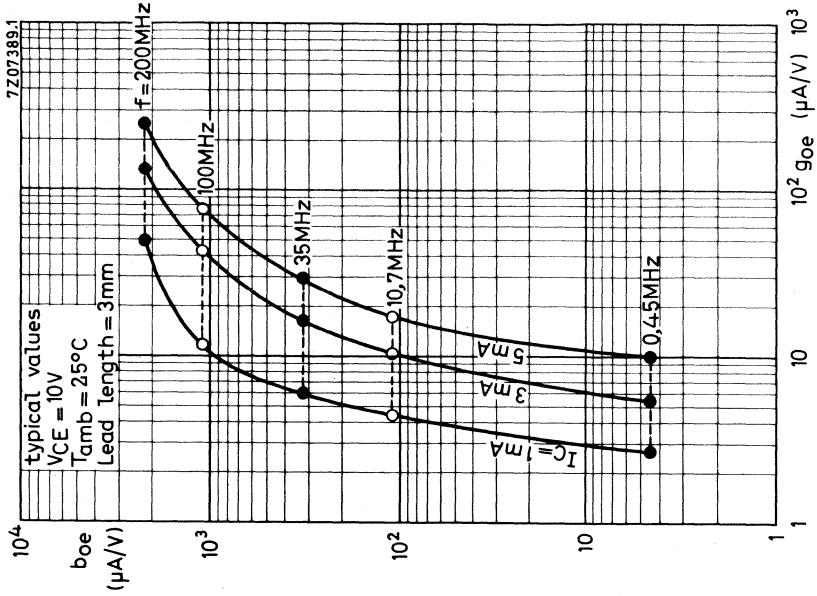

7Z60065
$Z_{th\,j-a}$ (°C/W)
t_p
T
$\delta = \frac{t_p}{T}$
δ=1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
0
t_p (ms)

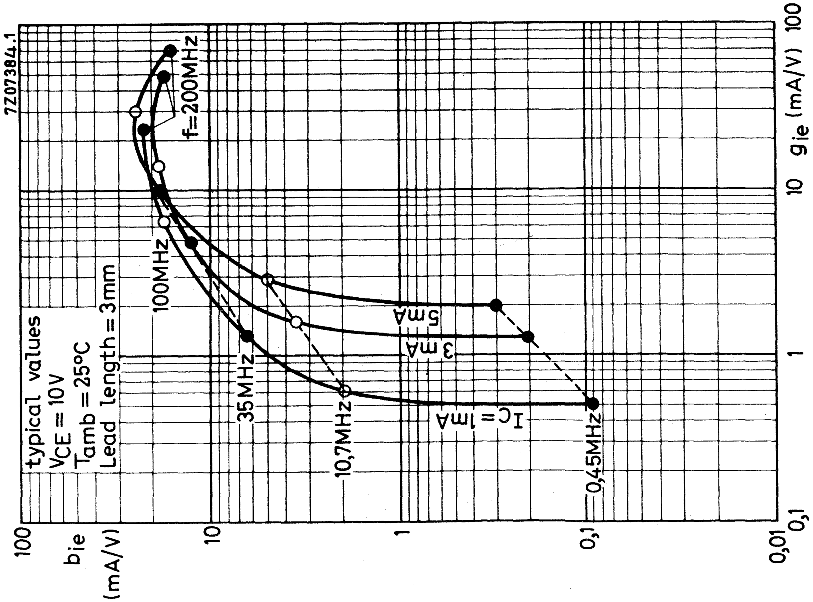

7Z08628
base-emitter voltage versus collector current
V_{CE} = 2V
T_j = 25°C
I_C (mA)
30
20
10
0
min
typ
max
0
0,5
1
V_{BE} (V)

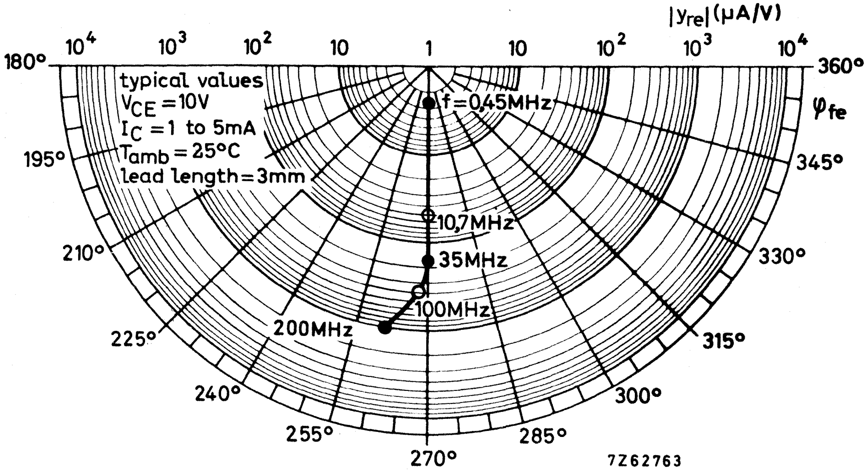

7Z07392
Base current versus collector current
V_{CE} = 2V
T_j = 25°C
I_C (mA)
100
10
1
min
typ
max
1
10
100
1000
I_B (μA)

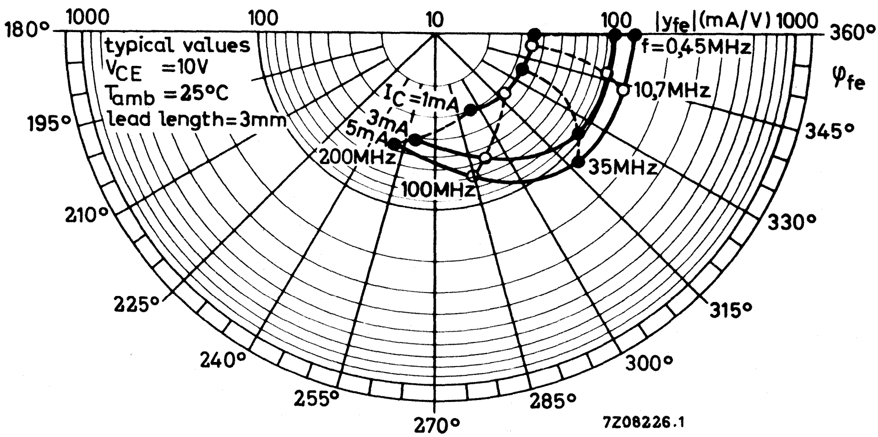

7Z07391
150
100
50
0
h_{FE}
$V_{CE} = 10V$
$T_j = 25°C$
typ
0,01
0,1
1
10
I_C (mA)
100


7Z07390.1
typ. noise figure at optimum source admittance
corresponding optimum source conductance resp susceptance
F (dB)
$-B_S$ (mA/V)
G_S (mA/V)
6
4
2
0
30
20
10
0
$I_C = 1mA$
$V_{CE} = 10V$
$T_j = 25°C$
typ
opt
opt
G_S
$-B_S$
0,1
1
10
100
f (MHz)
1000


7Z07389.1
typical values
V_{CE} = 10V
T_{amb} = 25°C
Lead length = 3mm
f = 200MHz
100MHz
35MHz
10,7MHz
0,45MHz
5 mA
3 mA
I_C = 1mA
b_{oe} (μA/V)
g_{oe} (μA/V)
10^4
10^3
10^2
10
1
10^3


7Z07384.1
typical values
V_{CE} = 10V
T_{amb} = 25°C
Lead length = 3mm
f=200MHz
100MHz
35MHz
10,7MHz
0,45MHz
5 mA
3 mA
I_C = 1mA
b_{ie} (mA/V)
g_{ie} (mA/V)
100
10
1
0,1
0,01
100
10
1
0,1


|yre| (μA/V)
10^4 10^3 10^2 10 1 10 10^2 10^3 10^4
180° 360°
φfe
typical values
VCE = 10V
IC = 1 to 5mA
Tamb = 25°C
lead length = 3mm
f = 0,45MHz
10,7MHz
35MHz
100MHz
200MHz
195° 345°
210° 330°
225° 315°
240° 300°
255° 285°
270°
7Z62763


1000 100 10 100 |yfe| (mA/V) 1000
180° 360°
φfe
typical values
VCE = 10V
Tamb = 25°C
lead length = 3mm
IC = 1mA
3mA
5mA
f = 0,45MHz
10,7MHz
35MHz
100MHz
200MHz
195° 345°
210° 330°
225° 315°
240° 300°
255° 285°
270°
7Z08226.1

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.

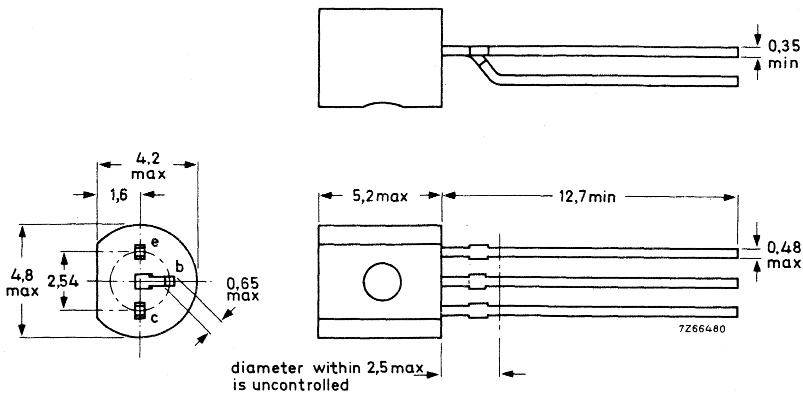
QUICK REFERENCE DATA

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 °C	P_{tot}	max.	300	mW
Junction temperature	T_j	max.	150	°C
Transition frequency $-I_E$ = 2 mA; V_{CB} = 10 V	f_T	typ.	550	MHz
Maximum unilateral power gain $-I_E$ = 3 mA; V_{CB} = 10 V; f = 50 MHz	G_{UM}	typ.	34	dB
$-I_E$ = 3 mA; V_{CB} = 10 V; f = 200 MHz	G_{UM}	typ.	27	dB
Noise figure at optimum source admittance $-I_E$ = 2 mA; V_{CB} = 10 V; f = 100 MHz	F	typ.	2	dB
$-I_E$ = 3 mA; V_{CB} = 10 V; f = 200 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_{CBO}	max.	30 V
Collector-emitter voltage (open base)	V_{CEO}	max.	20 V
Collector-emitter voltage ($R_{BE} \leq 1$ kΩ)	V_{CER}	max.	30 V
Emitter-base voltage (open collector)	V_{EBO}	max.	3 V
Collector current (d.c.)	I_C	max.	20 mA
Collector current (peak value)	I_{CM}	max.	20 mA
Total power dissipation up to T_{amb} = 75 °C	P_{tot}	max.	300 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	$R_{th\ j\text{-}a}$	=	250 K/W

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

Base current			
$-I_E$ = 2 mA; V_{CB} = 10 V	I_B	typ. <	50 μA 150 μA
$-I_E$ = 12 mA; V_{CB} = 7 V	I_B	<	2,2 mA
Emitter-base voltage			
$-I_E$ = 2 mA; V_{CB} = 10 V	$-V_{EB}$	typ.	0,84 V
$-I_E$ = 12 mA; V_{CB} = 7 V	$-V_{EB}$	<	1,0 V
Transition frequency			
$-I_E$ = 2 mA; V_{CB} = 10 V	f_T	typ.	550 MHz
$-I_E$ = 4 mA; V_{CB} = 5 V	f_T	<	530 MHz
Feedback capacitance at f = 10,7 MHz I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ. <	0,8 pF 1,0 pF
Noise figure at optimum source admittance			
$-I_E$ = 3 mA; V_{CB} = 10 V; f = 50 MHz	F	typ.	1,9 dB
$-I_E$ = 3 mA; V_{CB} = 10 V; f = 200 MHz	F	typ.	2,5 dB
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 100 MHz	F	typ.	2,0 dB

Maximum unilateral power gain (common base)

$$G_{UM}\ \text{(in dB)} = 10 \log \frac{|Y_{fb}|^2}{4 g_{ib} g_{ob}}$$

$-I_E$ = 3 mA; V_{CB} = 10 V; f = 50 MHz	G_{UM}	typ.	34 dB
$-I_E$ = 3 mA; V_{CB} = 10 V; f = 200 MHz	G_{UM}	typ.	27 dB
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 100 MHz	G_{UM}	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	φ_{rb}	typ.	280°
Transfer admittance	$\|y_{fb}\|$	typ.	66 mA/V
Phase angle of transfer admittance	φ_{fb}	typ.	155°
Output conductance	g_{ob}	typ.	15 μA/V
Output susceptance	b_{ob}	typ.	660 μA/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 μA/V
Phase angle of feedback admittance	φ_{rb}	typ.	270°
Transfer admittance	$\|y_{fb}\|$	typ.	95 mA/V
Phase angle of transfer admittance	φ_{fb}	typ.	160°
Output conductance	g_{ob}	typ.	10 μA/V
Output susceptance	b_{ob}	typ.	350 μA/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 μA/V
Phase angle of feedback admittance	φ_{rb}	typ.	275°
Transfer admittance	$\|y_{fb}\|$	typ.	85 mA/V
Phase angle of transfer admittance	φ_{fb}	typ.	130°
Output conductance	g_{ob}	typ.	75 μA/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.

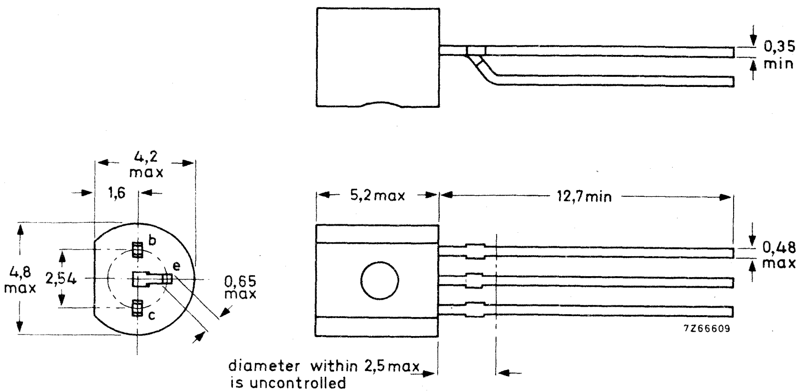
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$-V_{CBO}$	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 °C	P_{tot}	max.	250	mW
Junction temperature	T_j	max.	150	°C
Transition frequency at f = 100 MHz I_E = 1 mA; $-V_{CB}$ = 10 V	f_T	typ.	350	MHz
Noise figure at f = 200 MHz I_E = 1 mA; $-V_{CB}$ = 10 V	F	<	6	dB
Transducer gain (common base) I_E = 3 mA; $-V_{CB}$ = 10 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)	$-V_{CBO}$	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 °C	P_{tot}	max.	250 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	$R_{th\ j\text{-}a}$	=	420 K/W

CHARACTERISTICS

T_{amb} = 25 °C

Collector cut-off current $I_E = 0$; $-V_{CB} = 20$ V	$-I_{CBO}$	<	50 nA
Base current $I_E = 1$ mA; $-V_{CB} = 10$ V	$-I_B$	<	33 μA
Collector-base breakdown voltage open emitter; $-I_C = 10$ μA	$-V_{(BR)CBO}$	>	30 V
Collector-emitter breakdown voltage open base; $-I_C = 2$ mA	$-V_{(BR)CEO}$	>	20 V
Emitter-base breakdown voltage open collector; $-I_E = 10$ μA	$-V_{(BR)EBO}$	>	4 V
Transition frequency at f = 100 MHz $I_E = 1$ mA; $-V_{CB} = 10$ V	f_T	typ.	350 MHz
$I_E = 5$ mA; $-V_{CB} = 10$ V	f_T	typ.	500 MHz
			400 to 700 MHz
Feedback capacitance at f = 1 MHz $I_E = 1$ mA; $-V_{CB} = 10$ V	C_{re}	typ.	0,5 pF
Noise figure at f = 200 MHz $I_E = 1$ mA; $-V_{CB} = 10$ V	F	typ.	5 dB
		<	6 dB
Transducer gain (common base) at f = 200 MHz $I_E = 3$ mA; $-V_{CB} = 10$ V; $R_S = 60\ \Omega$; $R_L = 920\ \Omega$	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.

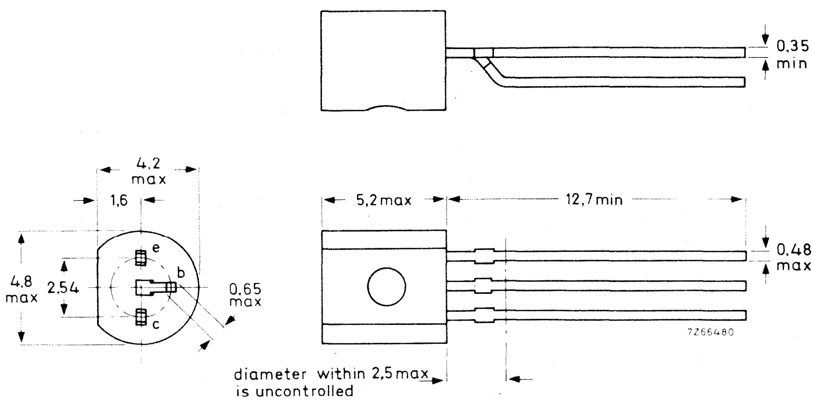
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$-V_{CBO}$	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 °C	P_{tot}	max.	250	mW
Junction temperature	T_j	max.	150	°C
D.C. current gain I_E = 1 mA; $-V_{CB}$ = 10 V	h_{FE}	>	25	
Transition frequency at f = 100 MHz I_E = 1 mA; $-V_{CB}$ = 10 V	f_T	typ.	350	MHz
Noise figure at f = 200 MHz I_E = 1 mA; $-V_{CB}$ = 10 V	F	<	6	dB
Transducer gain (common base) I_E = 3 mA; $-V_{CB}$ = 10 V; f = 200 MHz	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)	$-V_{CBO}$	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 °C	P_{tot}	max.	250	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	$R_{th\ j\text{-}a}$	=	420	K/W

CHARACTERISTICS

T_{amb} = 25 °C

Collector cut-off current $I_E = 0$; $-V_{CB}$ = 20 V	$-I_{CBO}$	<	50	nA
Base current I_E = 1 mA; $-V_{CB}$ = 10 V	$-I_B$	<	38	µA
Collector-base breakdown voltage open emitter; $-I_C$ = 10 µA	$-V_{(BR)CBO}$	>	30	V
Collector-emitter breakdown voltage open base; $-I_C$ = 2 mA	$-V_{(BR)CEO}$	>	20	V
Emitter-base breakdown voltage open collector; $-I_E$ = 10 µA	$-V_{(BR)EBO}$	>	4	V
D.C. current gain I_E = 1 mA; $-V_{CB}$ = 10 V	h_{FE}	>	25	
Transition frequency at f = 100 MHz I_E = 1 mA; $-V_{CB}$ = 10 V	f_T	typ.	350	MHz
Feedback capacitance at f = 1 MHz I_E = 1 mA; $-V_{CB}$ = 10 V	C_{re}	typ.	0,9	pF
Noise figure at f = 200 MHz I_E = 1 mA; $-V_{CB}$ = 10 V; R_S = 50 Ω	F	typ. <	5 6	dB dB
Transducer gain (common base) at f = 200 MHz I_E = 3 mA; $-V_{CB}$ = 10 V; R_S = 60 Ω; R_L = 920 Ω	G_{tr}	> typ.	14 17,5	dB 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.

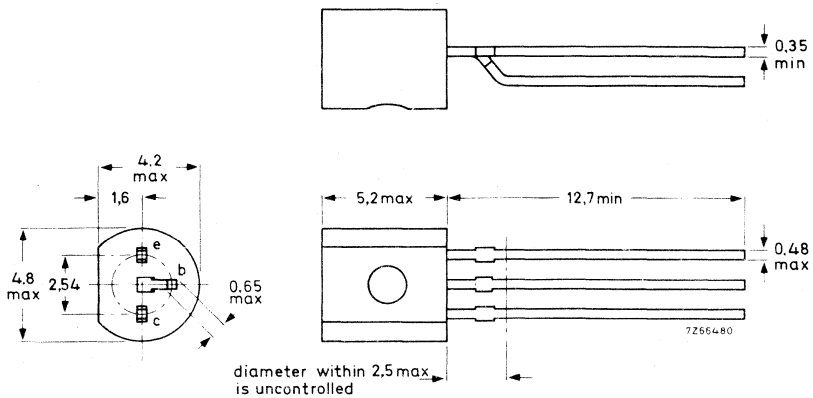
QUICK REFERENCE DATA

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 °C	P_{tot}	max.	225	mW
Junction temperature	T_j	max.	150	°C
Transition frequency at f = 100 MHz I_E = 2 mA; $-V_{CB}$ = 10 V	f_T	typ.	750	MHz
Noise figure at f = 200 MHz I_E = 2 mA; $-V_{CB}$ = 10 V R_S = 60 Ω; R_L = 1 kΩ	F	typ.	2,5	dB
Transducer gain (common base) I_E = 2 mA; $-V_{CB}$ = 10 V; f = 200 MHz R_S = 60 Ω; R_L = 1 kΩ	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 °C	P_{tot}	max.	225 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	$R_{th\ j\text{-}a}$	=	420 K/W

CHARACTERISTICS

T_{amb} = 25 °C

Collector cut-off current			
$I_E = 0$; $-V_{CB}$ = 15 V	$-I_{CBO}$	<	100 nA
Emitter cut-off current			
$I_C = 0$; $-V_{EB}$ = 1 V	$-I_{EBO}$	<	100 nA
Base current			
I_E = 2 mA; $-V_{CB}$ = 10 V	$-I_B$	typ. <	55 μA 125 μA
$-I_C$ = 9 mA; $-V_{CE}$ = 4 V	$-I_B$	<	3,6 mA
Collector-base breakdown voltage			
open emitter; $-I_C$ = 10 μA	$-V_{(BR)CBO}$	>	30 V
Collector-emitter breakdown voltage			
open base; $-I_C$ = 1 mA	$-V_{(BR)CEO}$	>	25 V
Emitter-base breakdown voltage			
open collector; $-I_E$ = 10 μA	$-V_{(BR)EBO}$	>	3 V
Transition frequency at f = 100 MHz			
I_E = 2,0 mA; $-V_{CB}$ = 10 V	f_T	typ.	750 MHz
I_E = 6,5 mA; $-V_{CB}$ = 5,5 V	f_T	<	200 MHz
Feedback capacitance at f = 500 kHz			
$I_E = 0$; $-V_{CB}$ = 10 V	C_{re}	typ.	0,7 pF
$I_E = 0$; $-V_{CB}$ = 10 V	C_{rb}	typ. <	135 fF 160 fF
Noise figure at f = 200 MHz			
I_E = 2 mA; $-V_{CB}$ = 10 V; R_S = 60 Ω; R_L = 1 kΩ	F	typ. <	2,5 dB 4 dB
Transducer gain (common base) at f = 200 MHz			
I_E = 2 mA; $-V_{CB}$ = 10 V; R_S = 60 Ω; R_L = 1 kΩ	G_{tr}	typ.	16 dB

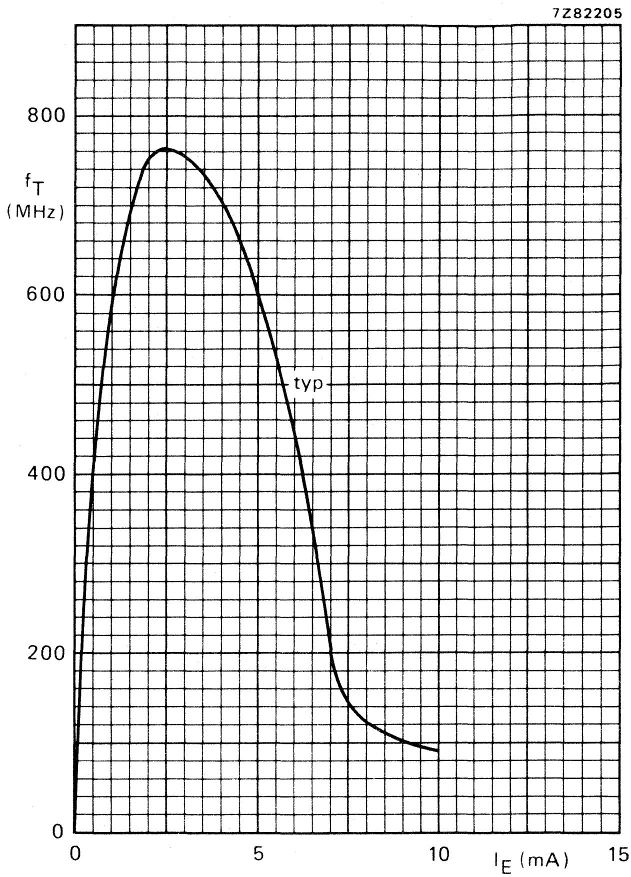


Fig. 2 $-V_{CB}$ = 10 V; f = 100 MHz; T_{amb} = 25 °C.

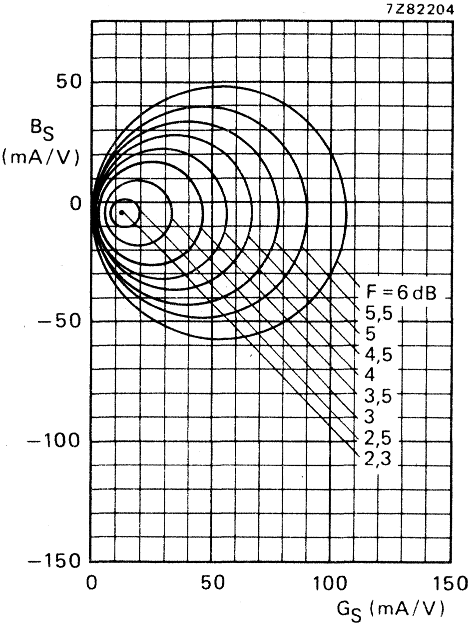


Fig. 3 Circles of constant noise figure.
$-V_{CB}$ = 10 V; I_E = 2 mA; f = 200 MHz;
T_{amb} = 25 °C; typical values.

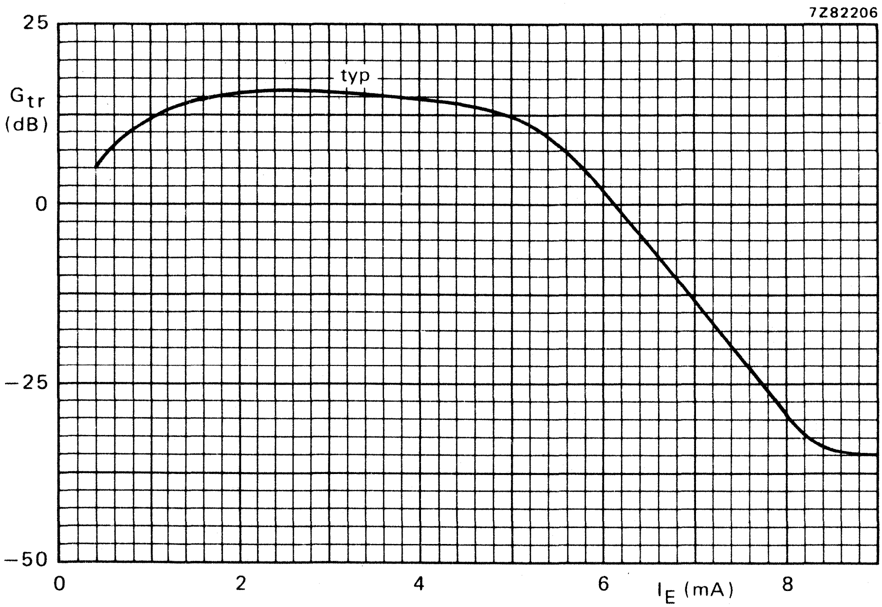


Fig. 4 $-V_{CC}$ = 12 V; R_C = 1 kΩ; R_L = 920 Ω; R_S = 60 Ω; f = 200 MHz; T_{amb} = 25 °C.

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 °C	P_{tot}	max.	160	mW
Junction temperature	T_j	max.	150	°C
Transition frequency at f = 100 MHz I_E = 3 mA; $-V_{CB}$ = 10 V	f_T	typ.	900	MHz
Noise figure (common base) I_E = 3 mA; $-V_{CB}$ = 10 V; f = 800 MHz R_S = 60 Ω; R_L = 500 Ω	F	typ.	4	dB
Transducer gain (common base) I_E = 3 mA; $-V_{CB}$ = 10 V; f = 800 MHz R_S = 60 Ω; R_L = 500 Ω	G_{tr}	typ.	13	dB

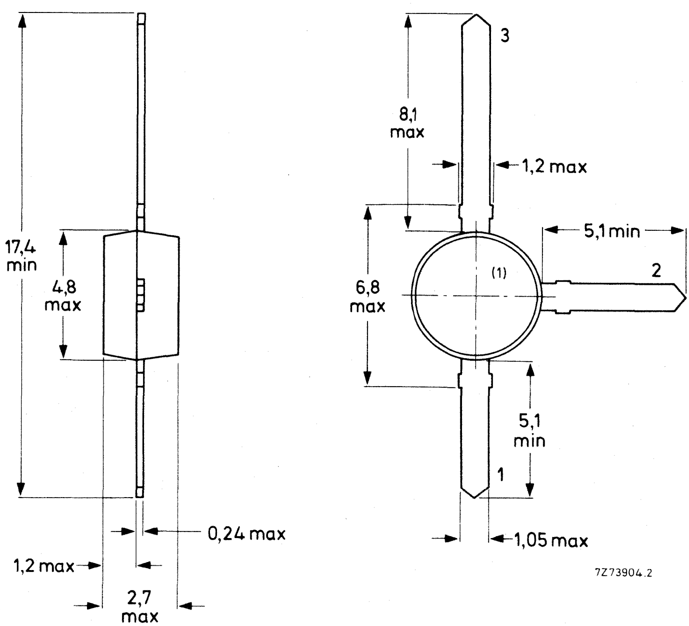
MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT-37.

Connections

1. Emitter
2. Base
3. Collector



(1) = type number marking.

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.	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 °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	$R_{th\ j\text{-}a}$	=	600 K/W

CHARACTERISTICS

T_{amb} = 25 °C

Collector cut-off current $I_E = 0; -V_{CB} = 15$ V	$-I_{CBO}$	<	100 nA
Emitter cut-off current $I_C = 0; -V_{EB} = 1$ V	$-I_{EBO}$	<	100 nA
Collector-base breakdown voltage open emitter; $-I_C = 10\ \mu$A	$-V_{(BR)CBO}$	>	30 V
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
D.C. current gain $I_E = 3$ mA; $-V_{CE} = 10$ V	h_{FE}	> typ.	15 60
$I_E = 7$ mA; $-V_{CE} = 4$ V	h_{FE}	>	10
Transition frequency at f = 100 MHz $I_E = 3$ mA; $-V_{CB} = 10$ V	f_T	typ. 700 to	900 MHz 1100 MHz
$I_E = 7$ mA; $-V_{CB} = 5$ V	f_T	<	200 MHz
Feedback capacitance at f = 500 kHz $I_E = 1$ mA; $-V_{CB} = 10$ V	C_{re}	typ.	0,45 pF
$I_E = 0; -V_{CB} = 10$ V	C_{rb}	typ. <	115 fF 140 fF
Noise figure (common base) $I_E = 3$ mA; $-V_{CB} = 10$ V; f = 800 MHz $R_S = 60\ \Omega$; $R_L = 500\ \Omega$	F	typ. <	4 dB 5 dB
Transducer gain (common base) $I_E = 3$ mA; $-V_{CB} = 10$ V; f = 800 MHz $R_S = 60\ \Omega$; $R_L = 500\ \Omega$	G_{tr}	> typ.	11 dB 13 dB

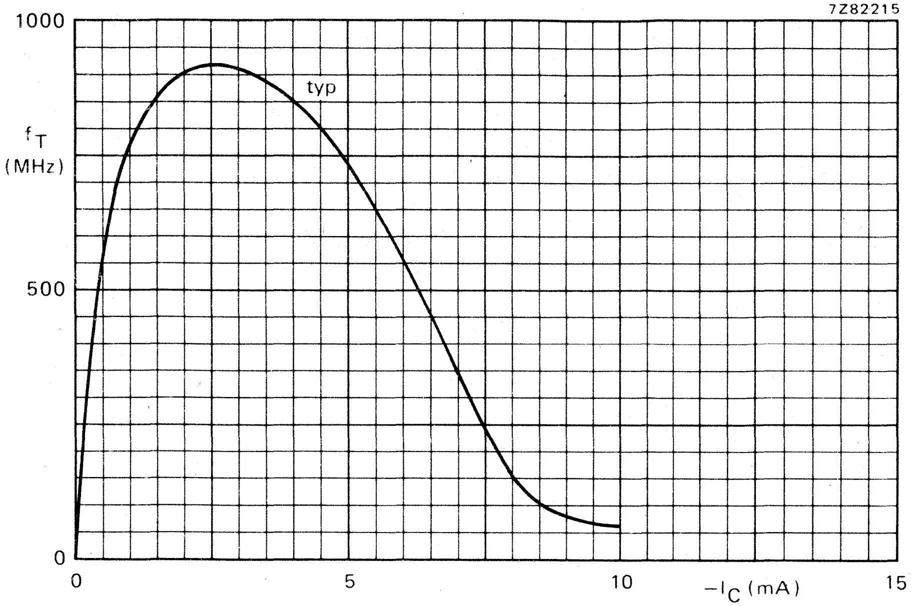


Fig. 2 $-V_{CB}$ = 10 V; f = 100 MHz; T_{amb} = 25 ^oC.

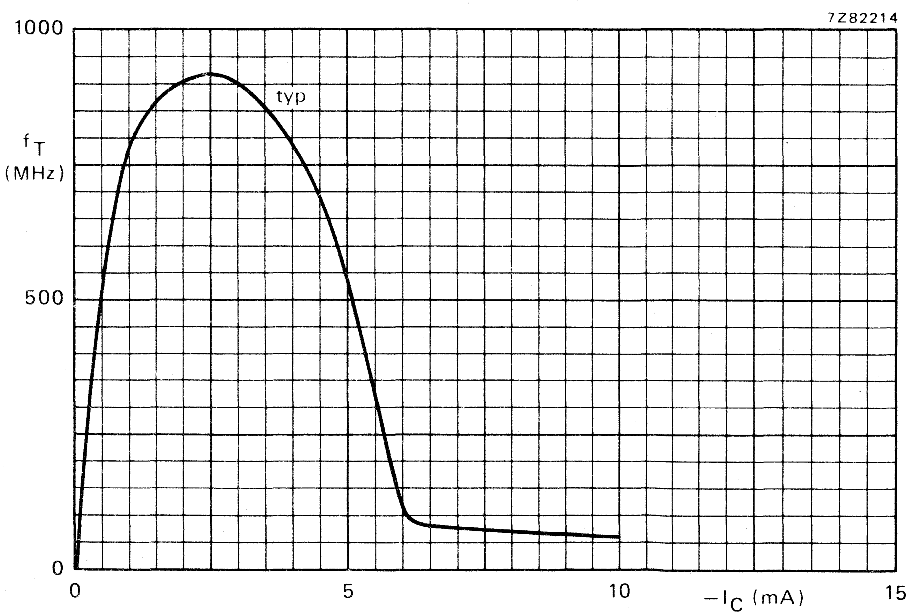


Fig. 3 $-V_{CC}$ = 12 V; R_C = 1 kΩ; f = 100 MHz; T_{amb} = 25 ^oC.

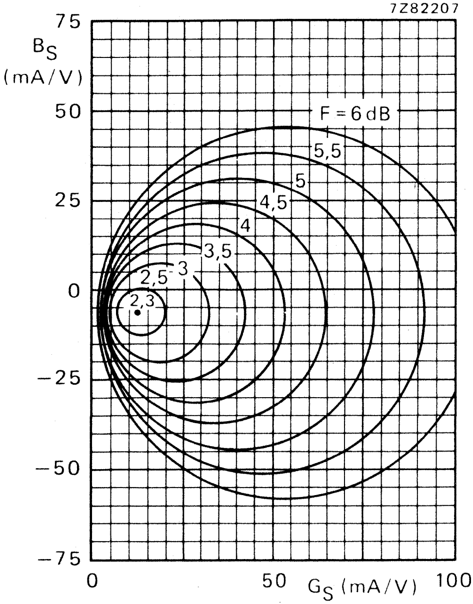


Fig. 4 Circles of constant noise figure.

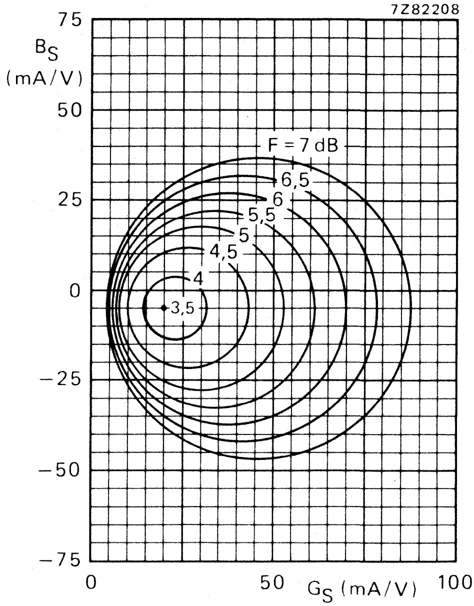
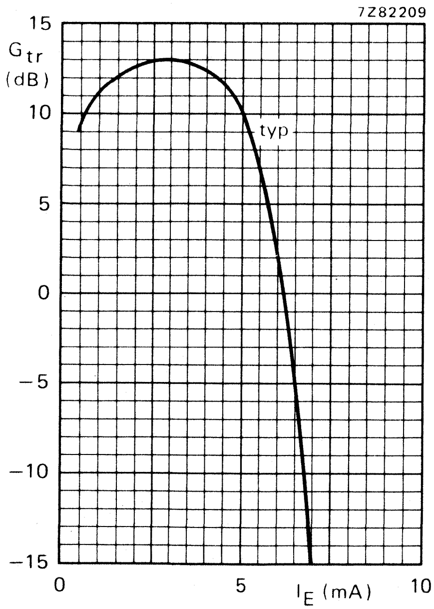


Fig. 5 Circles of constant noise figure.



Measuring conditions:

Fig. 4 $-V_{CB}$ = 10 V; I_E = 3 mA; f = 200 MHz; T_{amb} = 25 ^oC; typical values.

Fig. 5 $-V_{CB}$ = 10 V; I_E = 3 mA; f = 800 MHz; T_{amb} = 25 ^oC; typical values.

Fig. 6 $-V_{CC}$ = 12 V; R_C = 1 kΩ; R_L = 500 Ω; f = 800 MHz; T_{amb} = 25 ^oC.

Conditions for Figs 7 to 10: I_E = 3 mA; $-V_{CB}$ = 10 V; T_{amb} = 25 °C; typical values.

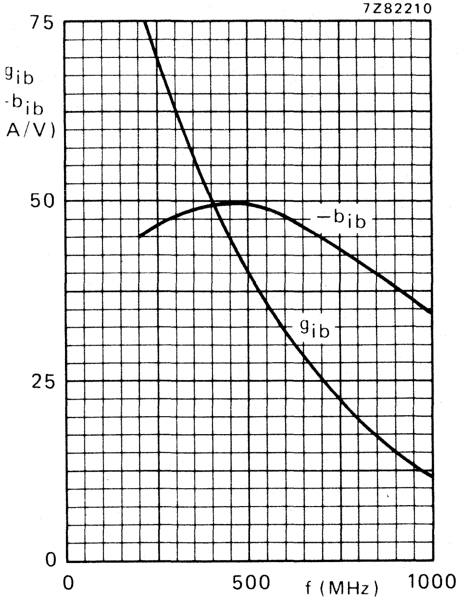


Fig. 7.

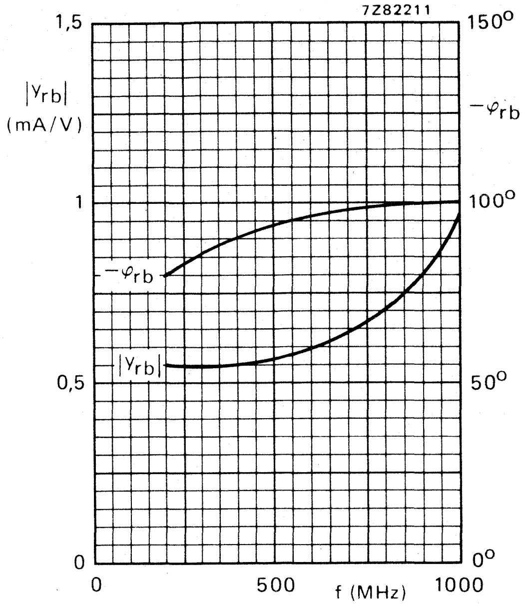


Fig. 8.

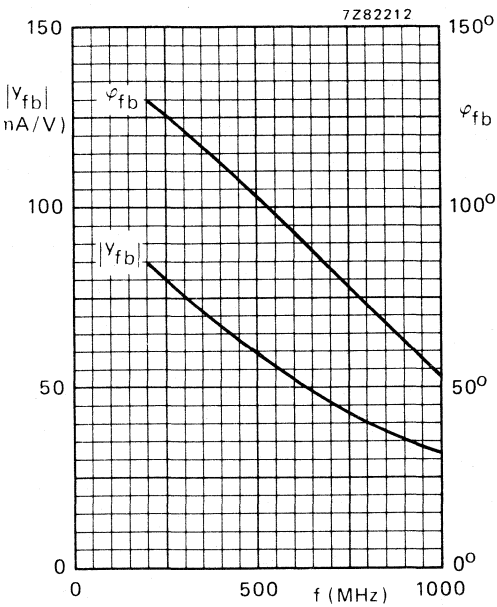


Fig. 9.

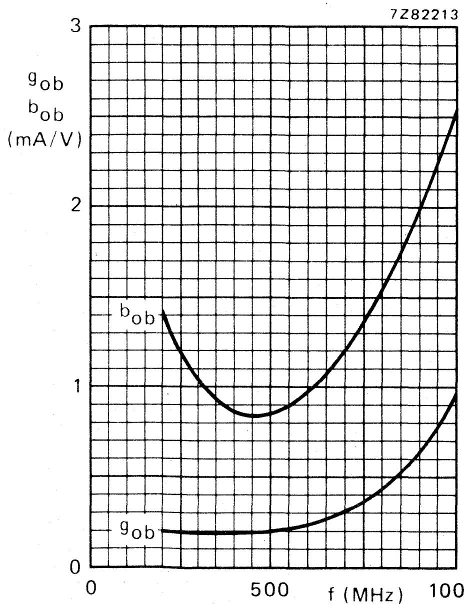


Fig. 10.

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

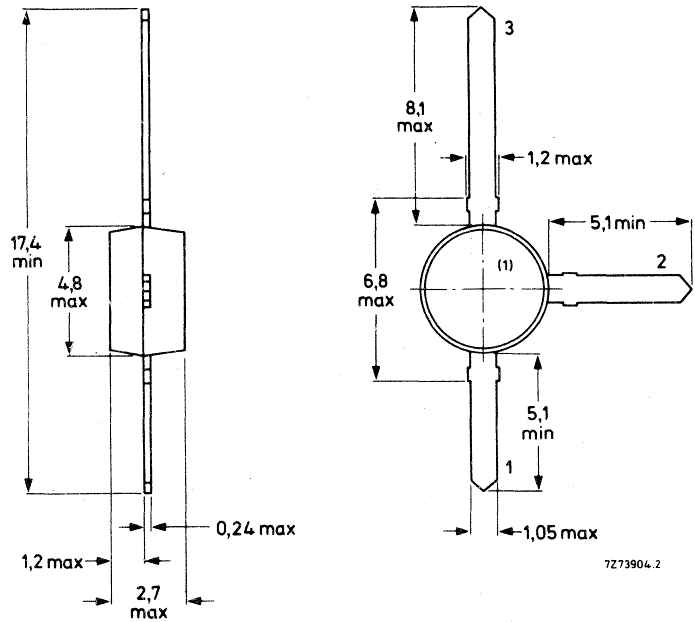
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	40	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	35	V
Collector current (d.c.)	$-I_C$	max.	30	mA
Total power dissipation up to T_{amb} = 55 °C	P_{tot}	max.	160	mW
Junction temperature	T_j	max.	150	°C
Transition frequency at f = 100 MHz I_E = 3 mA; $-V_{CB}$ = 10 V	f_T	typ.	900	MHz

MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT-37.

Connections
1. Emitter
2. Base
3. Collector



(1) = type number marking.

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.	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 °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	$R_{th\ j\text{-}a}$	=	600	K/W

CHARACTERISTICS

T_{amb} = 25 °C

Collector cut-off current				
$I_E = 0$; $-V_{CB} = 20$ V	$-I_{CBO}$	<	100	nA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 1$ V	$-I_{EBO}$	<	100	nA
D.C. current gain				
$-I_C = 3$ mA; $-V_{CB} = 10$ V	h_{FE}	>	25	
		typ.	50	
Transition frequency at f = 100 MHz				
$I_E = 3$ mA; $-V_{CB} = 10$ V	f_T	typ.	900	MHz
			750 to 1060	MHz
$I_E = 7$ mA; $-V_{CB} = 5$ V	f_T	>	400	MHz
		typ.	700	MHz
Feedback capacitance at f = 1 MHz				
$I_E = 0$; $-V_{CB} = 10$ V	C_{rb}	typ.	110	fF
		<	140	fF
$I_E = 1$ mA; $-V_{CB} = 5$ V	C_{re}	typ.	475	fF
Noise figure at $R_S = 60\ \Omega$				
$I_E = 3$ mA; $-V_{CB} = 10$ V; f = 200 MHz	F	typ.	2,6	dB
$I_E = 3$ mA; $-V_{CB} = 10$ V; f = 800 MHz	F	typ.	4,7	dB
		<	6,0	dB
Transducer gain (common base) at f = 800 MHz				
$I_E = 3$ mA; $-V_{CB} = 10$ V; $R_S = 60\ \Omega$; $R_L = 500\ \Omega$	G_{tr}	>	13,0	dB
		typ.	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 °C	P_{tot}	max.	140 mW
Junction temperature	T_j	max.	125 °C
Transition frequency at f = 100 MHz I_E = 10 mA; $-V_{CB}$ = 10 V	f_T	typ.	1350 MHz
Noise figure (common base) I_E = 10 mA; $-V_{CB}$ =10 V; f = 800 MHz R_S = 60 Ω; R_L = 500 Ω	F	typ.	4,5 dB
Transducer gain (common base) I_E = 10 mA; $-V_{CB}$ = 10 V; f = 800 MHz R_S = 60 Ω; R_L = 500 Ω	G_{tr}	typ.	16 dB

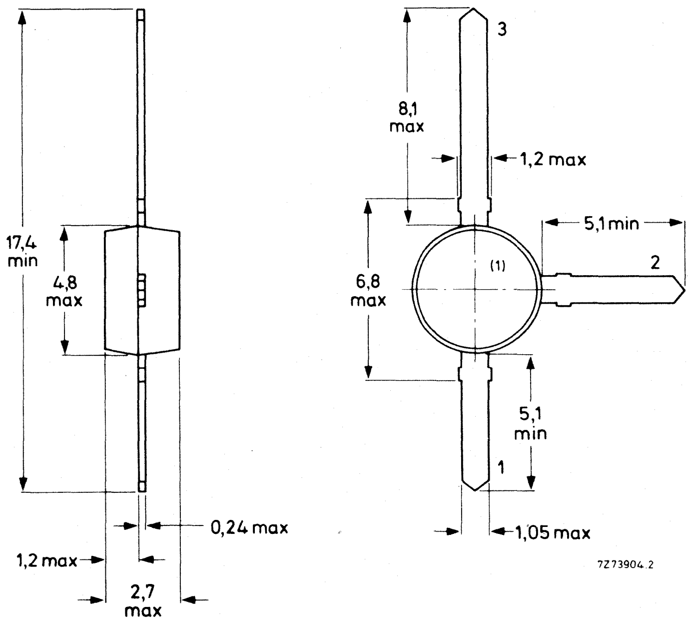
MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT-37.

Connections

1. Emitter
2. Base
3. Collector



(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 °C	P_{tot}	max.	140	mW
Storage temperature	T_{stg}		−55 to +125	°C
Junction temperature	T_j	max.	125	°C

THERMAL RESISTANCE

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

CHARACTERISTICS

T_{amb} = 25 °C

Collector cut-off current $I_E = 0$; $-V_{CB} = 15$ V	$-I_{CBO}$	<	100	nA
Emitter cut-off current $I_C = 0$; $-V_{EB} = 1$ V	$-I_{EBO}$	<	100	nA
Collector-base breakdown voltage open emitter; $-I_C = 10\ \mu A$	$-V_{(BR)CBO}$	>	20	V
Collector-emitter breakdown voltage open base; $-I_C = 1$ mA	$-V_{(BR)CEO}$	>	20	V
Emitter-base breakdown voltage open collector; $-I_E = 10\ \mu A$	$-V_{(BR)EBO}$	>	3	V
D.C. current gain $I_E = 2$ mA; $-V_{CB} = 10$ V	h_{FE}	>	15	
$I_E = 10$ mA; $-V_{CB} = 10$ V	h_{FE}	>	20	
Transition frequency at f = 100 MHz $I_E = 10$ mA; $-V_{CB} = 10$ V	f_T	typ.	1350	MHz
$I_E = 15$ mA; $-V_{CB} = 5$ V	f_T	typ.	1000	MHz
Feedback capacitance at f = 500 kHz $I_E = 0$; $-V_{CB} = 10$ V	C_{re}	typ.	0,65	pF
$I_E = 0$; $-V_{CB} = 10$ V	C_{rb}	typ.	120	fF
Noise figure (common base) $I_E = 10$ mA; $-V_{CB} = 10$ V; f = 800 MHz $R_S = 60\ \Omega$; $R_L = 500\ \Omega$	F	typ. <	4,5 6,0	dB dB
Transducer gain (common base) $I_E = 10$ mA; $-V_{CB} = 10$ V; f = 800 MHz $R_S = 60\ \Omega$; $R_L = 500\ \Omega$	G_{tr}	typ.	16	dB

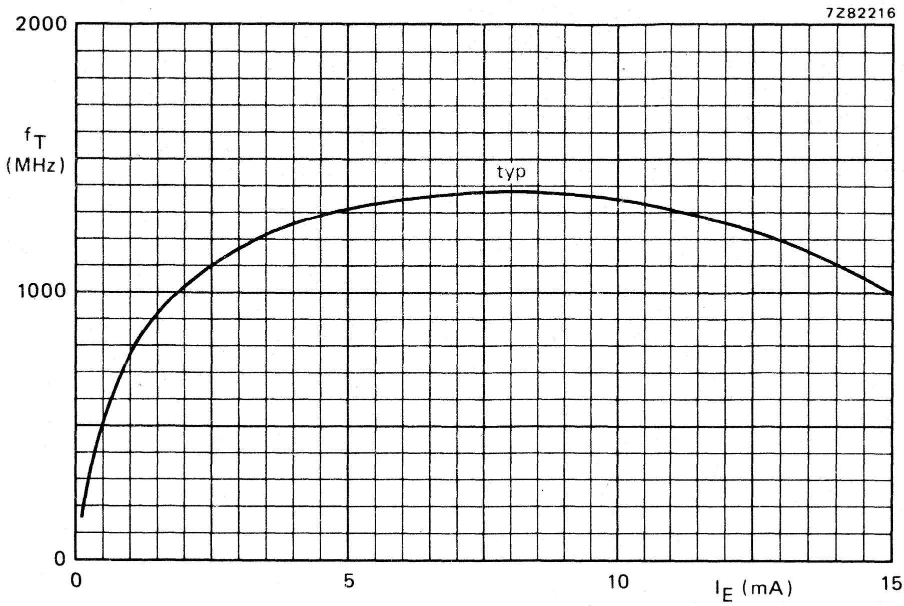


Fig. 2 $-V_{CB}$ = 10 V; T_j = 25 °C.

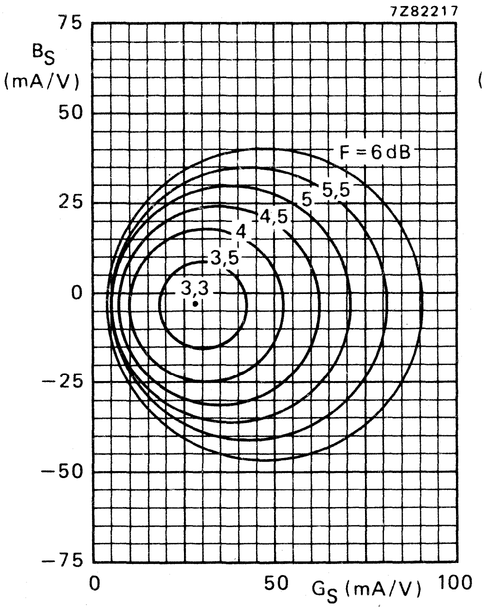


Fig. 3 I_E = 10 mA; $-V_{CB}$ = 10 V; f = 200 MHz; T_{amb} = 25 °C; typical values.

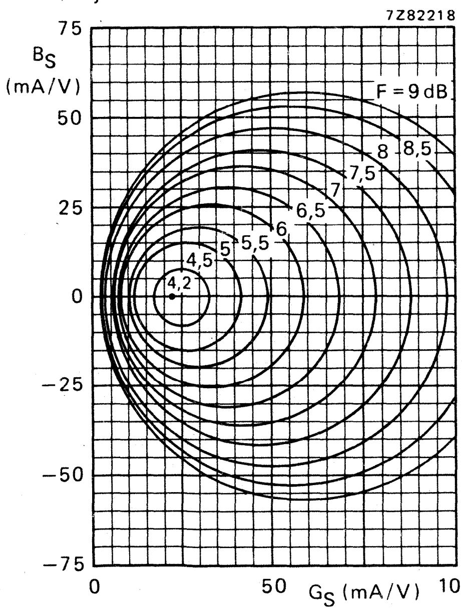


Fig. 4 I_E = 10 mA; $-V_{CB}$ = 10 V; f = 800 MHz; T_{amb} = 25 °C; typical values.

Conditions for Figs 5 to 8: I_E = 10 mA; ——— $-V_{CB}$ = 10 V; - - - - $-V_{CB}$ = 5 V; T_{amb} = 25 °C; typical values.

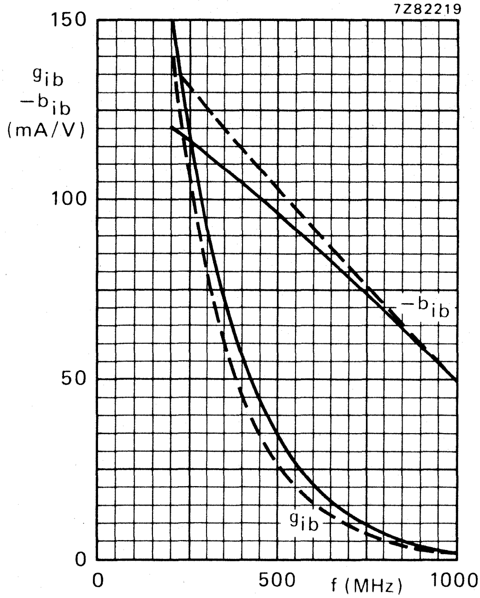


Fig. 5.

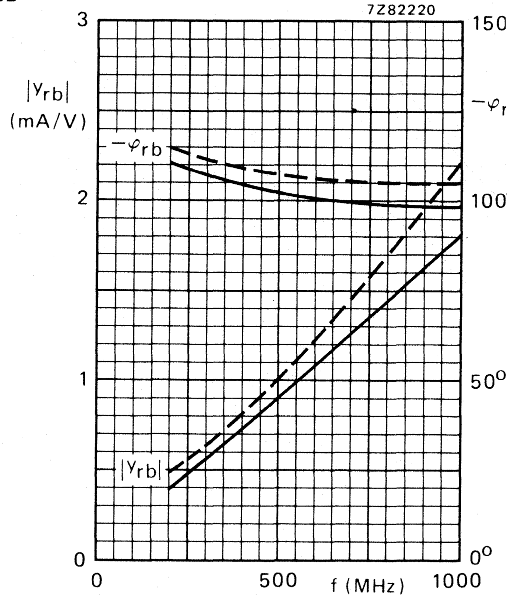


Fig. 6.

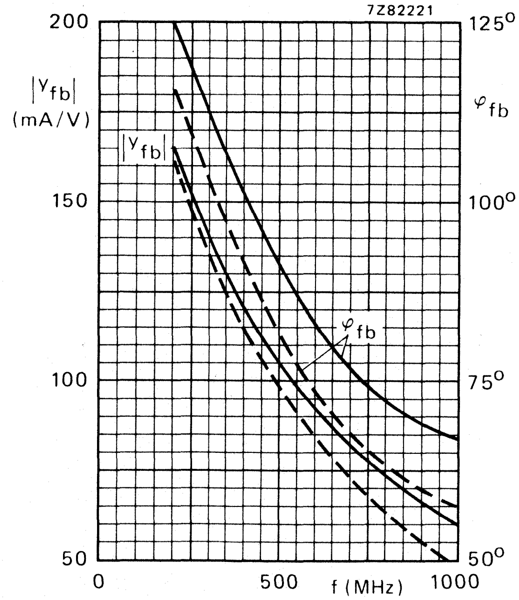


Fig. 7.

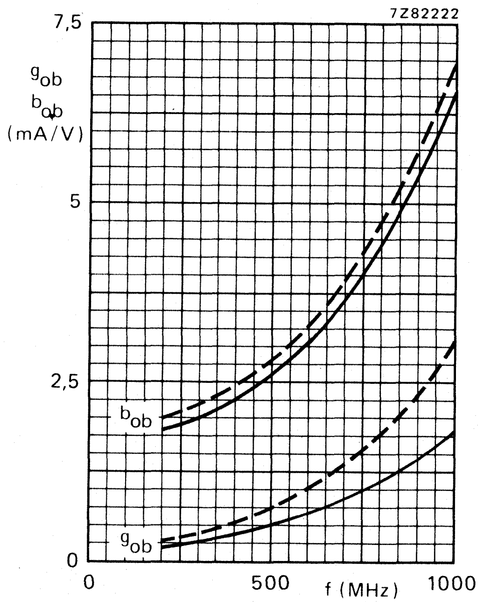


Fig. 8.

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.

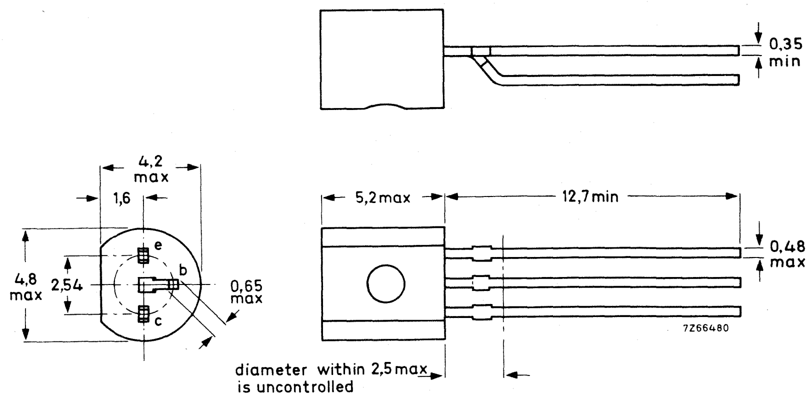
QUICK REFERENCE DATA

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 °C	P_{tot}	max.	500	mW
D.C. current I_C = 10 mA; V_{CE} = 1 V	h_{FE}	>	40	
Transition frequency at f = 100 MHz I_C = 10 mA; V_{CE} = 10 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 μs)	I_{CM}	max.	500	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	$R_{th\ j\text{-}a}$	=	250	K/W

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; V_{CB} = 20 V	I_{CBO}	<	400	nA
$I_E = 0$; V_{CB} = 20 V; T_j = 125 °C	I_{CBO}	<	30	μA
Emitter cut-off current				
$I_C = 0$; V_{EB} = 2 V	I_{EBO}	<	100	nA
Saturation voltage				
I_C = 10 mA; I_B = 1 mA	V_{CEsat}	<	0,25	V
	V_{BEsat}		0,70 to 0,85	V
Knee voltage				
I_C = 45 mA; I_B = value for which I_C = 50 mA at V_{CE} = 2 V	V_{CEK}	<	0,8	V
D.C. current gain				
I_C = 10 mA; V_{CE} = 1 V	h_{FE}	>	40	
Transition frequency at f = 100 MHz				
I_C = 10 mA; V_{CE} = 10 V	f_T	>	500	MHz
		typ.	600	MHz
I_C = 40 mA; V_{CE} = 10 V	f_T	>	490	MHz
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; V_{CB} = 5 V	C_c	<	4	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; V_{EB} = 1 V	C_e	<	4,5	pF

Maximum unilateral power gain (Y_{re} assumed to be zero)

$$G_{UM}\ (\text{in dB}) = 10 \log \frac{|y_{fe}|^2}{4 g_{ie} g_{oe}}$$

I_C = 10 mA; V_{CE} = 10 V; f = 200 MHz	G_{UM}	typ.	10	dB

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.

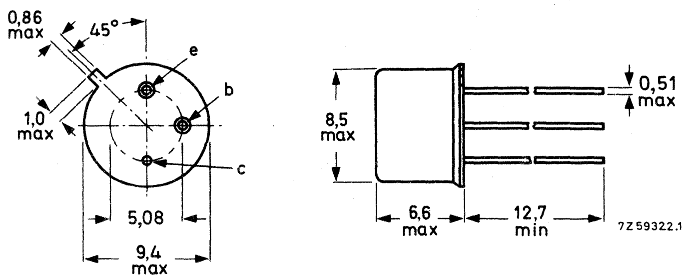
QUICK REFERENCE DATA

			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 °C	P_{tot}	max.	5,0		W
Junction temperature	T_j	max.	200		°C
D.C. current gain $-I_C$ = 10 mA; $-V_{CE}$ = 10 V	h_{FE}		50 to 150		
Transition frequency at f = 35 MHz $-I_C$ = 15 mA; $-V_{CE}$ = 10 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).

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

Voltages

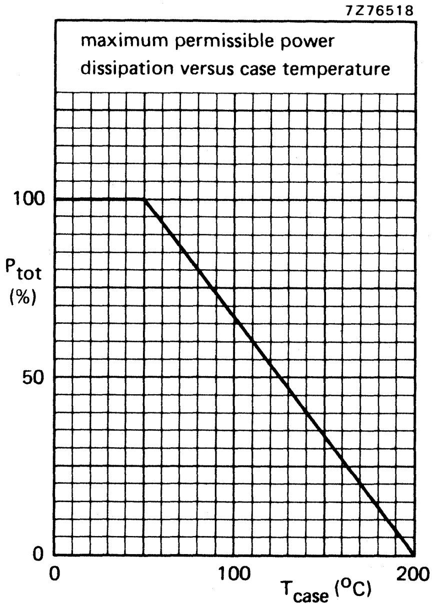
			BFT44	BFT45	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	300	250	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	300	250	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	V

Current

Collector current (d.c.)	$-I_C$	max.	0,5	A

Power dissipation

Total power dissipation up to T_{case} = 50 °C	P_{tot}	max.	5,0	W



Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	200	°C/W
From junction to case	$R_{th\ j-c}$	=	30	°C/W

CHARACTERISTICS — T_j = 25 °C unless otherwise specified

Collector cut-off current

$I_E = 0$; $-V_{CB} = 200$ V	$-I_{CBO}$	<	5	μA
$I_B = 0$; $-V_{CE} = 200$ V; $T_j = 125$ °C	$-I_{CEO}$	<	300	μA

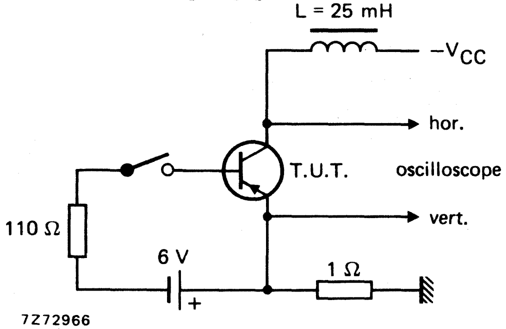
Emitter cut-off current

$I_C = 0$; $-V_{EB} = 3$ V	$-I_{EBO}$	<	5	μA

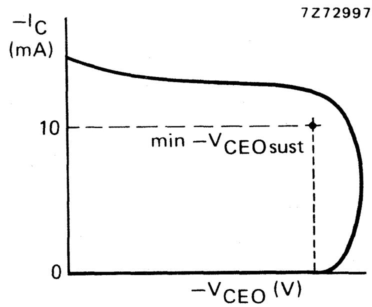
Collector-emitter sustaining voltage

			BFT44	BFT45	
$-I_C$ = 10 mA; $I_B = 0$; L = 25 mH	$-V_{CEOsust}$	>	300	250	V 1)

Test circuit for $V_{CEOsust}$



Oscilloscope display for $V_{CEOsust}$



Saturation voltages

$-I_C$ = 10 mA; $-I_B$ = 1 mA		$-V_{CEsat}$	<	0,5	V
		$-V_{BEsat}$	<	0,8	V
$-I_C$ = 100 mA; $-I_B$ = 10 mA		$-V_{CEsat}$	<	1,4	V
		$-V_{BEsat}$	<	0,9	V
$-I_C$ = 500 mA; $-I_B$ = 100 mA	BFT44	$-V_{CEsat}$	<	5,0	V 2)
	BFT45	$-V_{CEsat}$	<	3,0	V 2)
		$-V_{BEsat}$	<	1,2	V 2)

D.C. current gain

$-I_C$ = 1 mA; $-V_{CE}$ = 10 V	h_{FE}	>	30	
$-I_C$ = 10 mA; $-V_{CE}$ = 10 V	h_{FE}		50 to 150	
$-I_C$ = 100 mA; $-V_{CE}$ = 10 V	h_{FE}	>	50	2)

Collector capacitance at f = 1 MHz

$I_E = I_e = 0$; $-V_{CB}$ = 20 V	C_c	<	15	pF

1) $-V_{CC}$ = 0 to 50 V; f = 400 Hz; δ = 0,5 (see also test circuit).
2) Measured under pulse conditions: t_p = 300 μs; $\delta \leq 0,02$.

CHARACTERISTICS (continued) $T_j = 25\ ^oC$

Transition frequency at f = 35 MHz

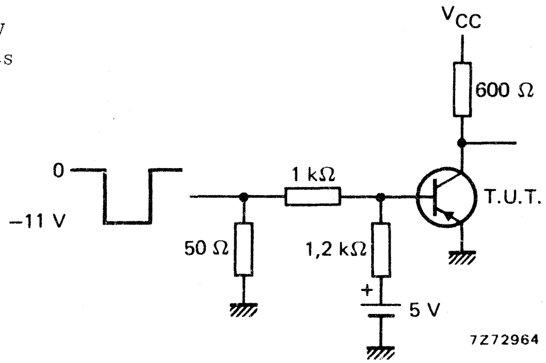
$-I_C$ = 15 mA; $-V_{CE}$ = 10 V	f_T	typ.	70	MHz

Switching times

$-I_{Con}$ = 50 mA; $-I_{Bon} = I_{Boff}$ = 5 mA (test circuit 1)	t_{on}	typ.	125	ns
	t_{off}	typ.	850	ns
$-I_{Con}$ = 500 mA; $-I_{Bon} = I_{Boff}$ = 100 mA (test circuit 2)	t_{on}	typ.	125	ns
	t_{off}	typ.	125	ns

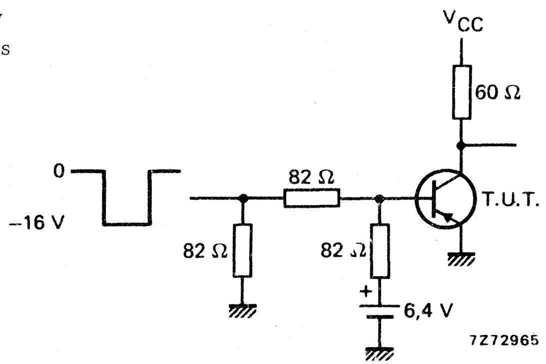
Test circuit 1

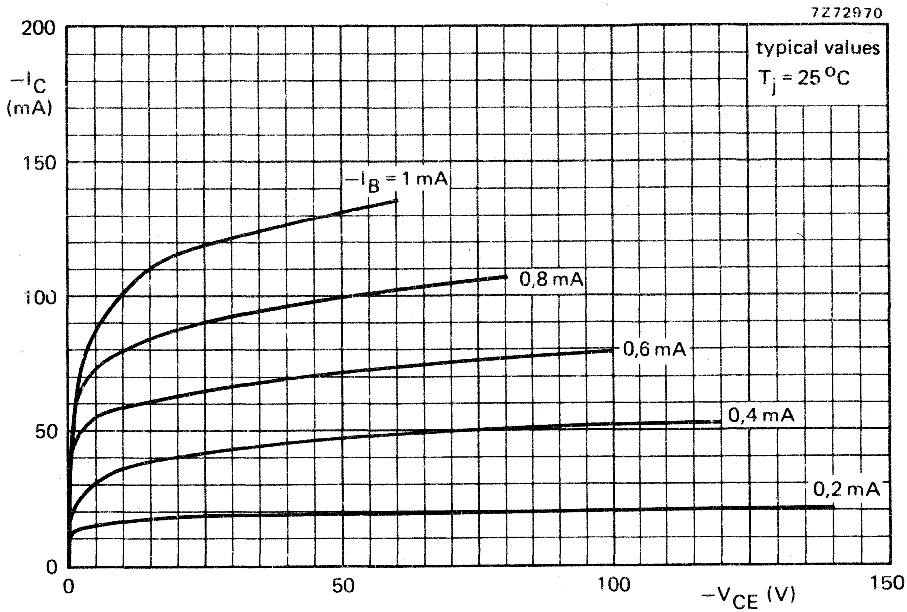
V_{CC} = −31 V
t_p = 10 μs

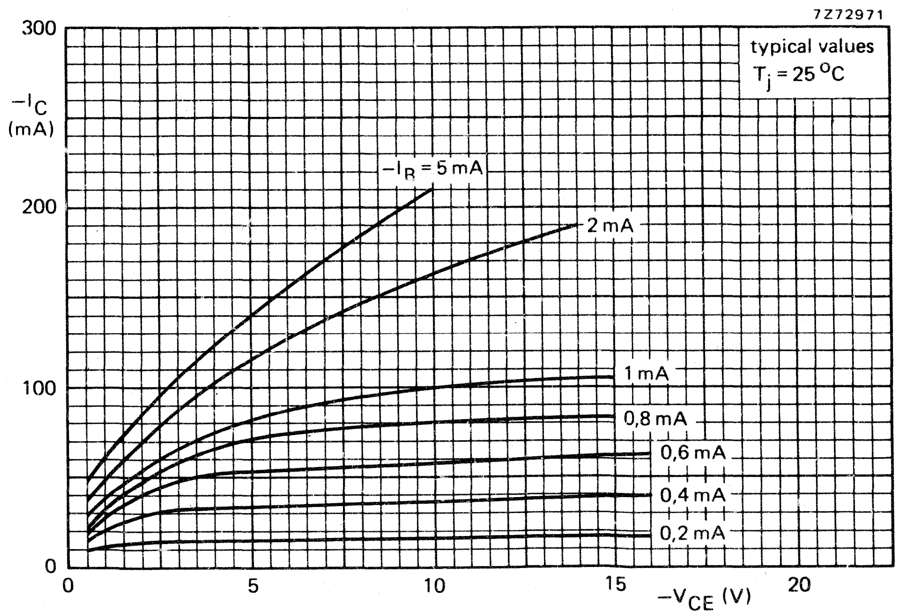


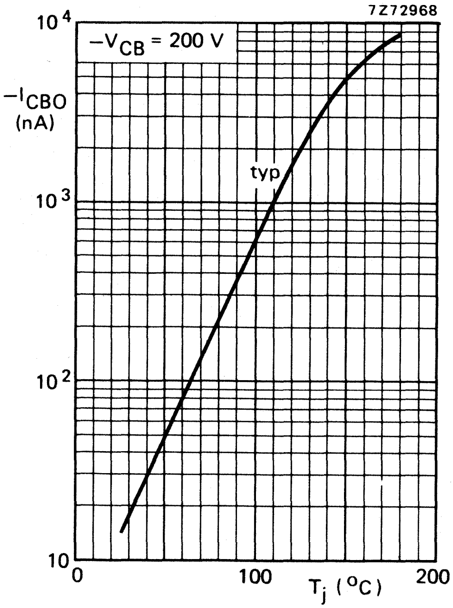
Test circuit 2

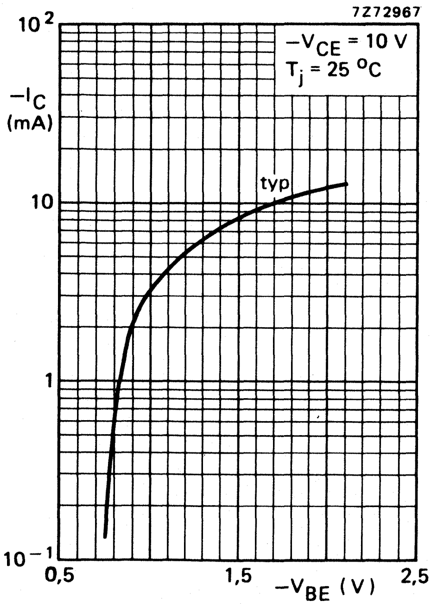
V_{CC} = −31 V
t_p = 10 μs

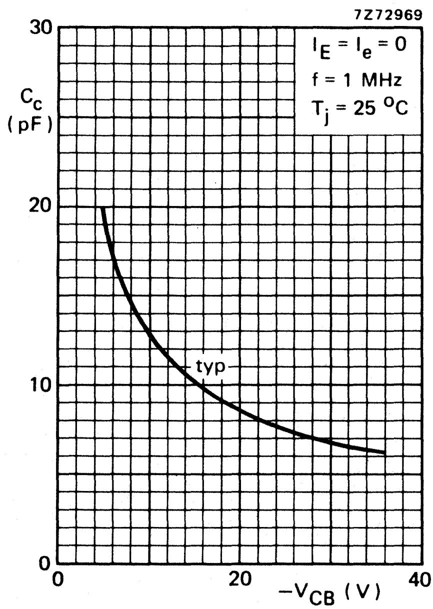


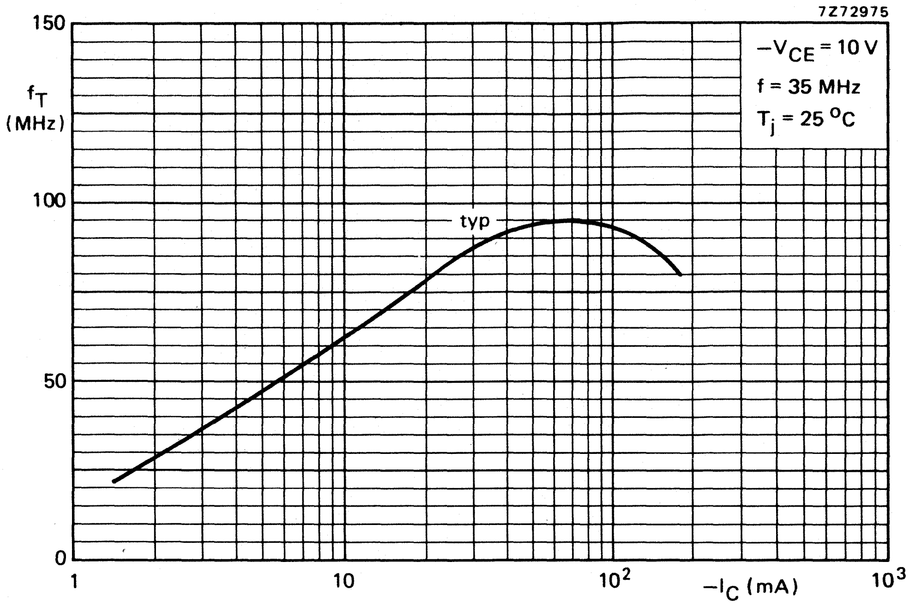

7Z72970
typical values
$T_j = 25\ ^oC$
$-I_C$ (mA)
$-I_B = 1$ mA
0,8 mA
0,6 mA
0,4 mA
0,2 mA
$-V_{CE}$ (V)
200
150
100
50
0
0
50
100
150

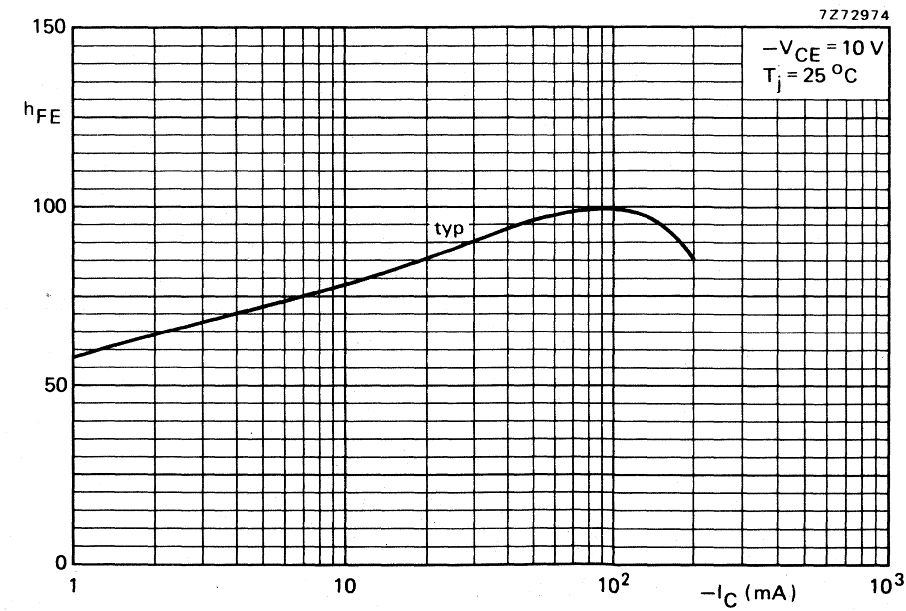

7Z72971
typical values
$T_j = 25\ ^oC$
$-I_C$ (mA)
$-I_B = 5$ mA
2 mA
1 mA
0,8 mA
0,6 mA
0,4 mA
0,2 mA
$-V_{CE}$ (V)
300
200
100
0
0
5
10
15
20

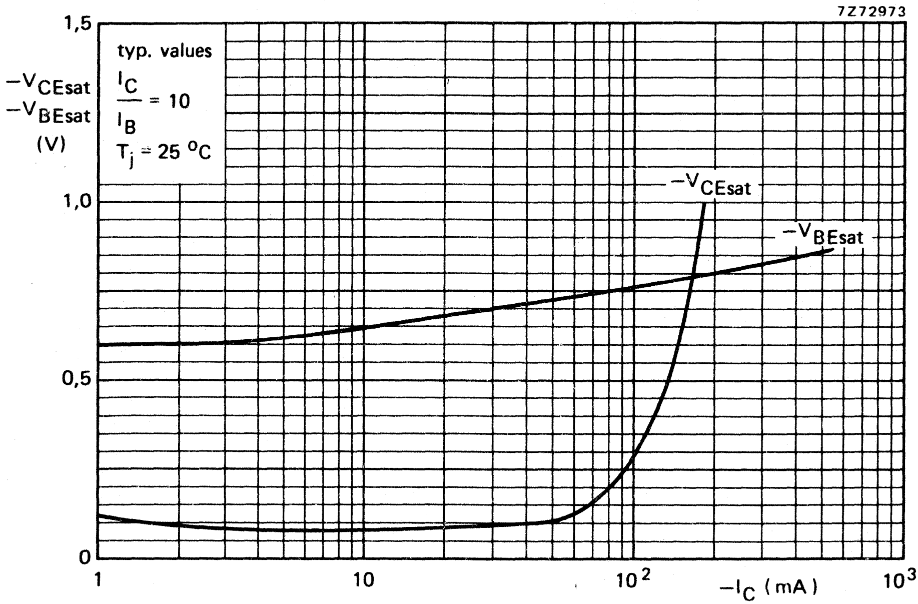

7Z72968
$-V_{CB}$ = 200 V
$-I_{CBO}$ (nA)
typ
10^4
10^3
10^2
10
0
100
200
T_j (°C)

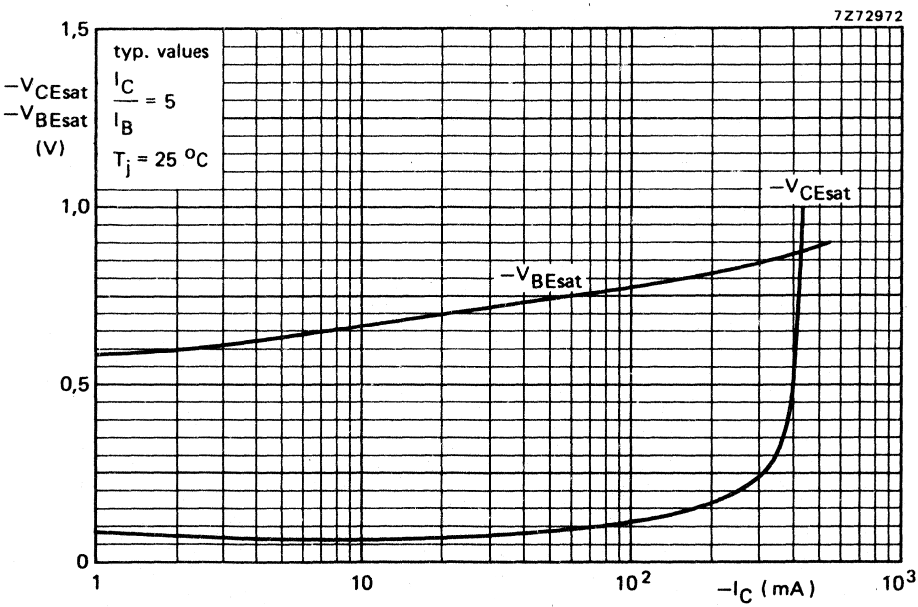

7Z72967
$-V_{CE}$ = 10 V
T_j = 25 °C
$-I_C$ (mA)
typ
10^2
10
1
10^{-1}
0,5
1,5
2,5
$-V_{BE}$ (V)


7Z72969
$I_E = I_e = 0$
f = 1 MHz
T_j = 25 °C
C_c (pF)
typ
30
20
10
0
0
20
40
$-V_{CB}$ (V)


7Z72975
f_T (MHz)
$-V_{CE} = 10$ V
f = 35 MHz
$T_j = 25$ °C
typ
150
100
50
0
1
10
10^2
$-I_C$ (mA)
10^3


7Z72974
h_{FE}
$-V_{CE} = 10$ V
$T_j = 25$ °C
typ
150
100
50
0
1
10
10^2
$-I_C$ (mA)
10^3


7Z72973
1,5
1,0
0,5
0
−V_CEsat
−V_BEsat
(V)
typ. values
I_C / I_B = 10
T_j = 25 °C
−V_CEsat
−V_BEsat
1
10
10^2
10^3
−I_C (mA)


7Z72972
1,5
1,0
0,5
0
−V_CEsat
−V_BEsat
(V)
typ. values
I_C / I_B = 5
T_j = 25 °C
−V_CEsat
−V_BEsat
1
10
10^2
10^3
−I_C (mA)

SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in TO-39 metal envelopes for general industrial applications.

QUICK REFERENCE DATA

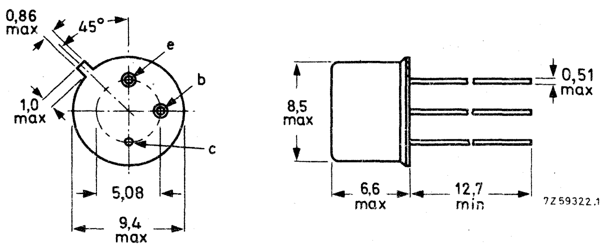
			BFX29	BFX87	BFX88	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	50	40	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	50	40	V
Collector current (peak value)	$-I_{CM}$	max.	600	600	600	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	600	600	600	mW
D.C. current gain $-I_C$ = 10 mA; $-V_{CE}$ = 10 V	h_{FE}	> typ.	50 125	40 125	40 125	
Transition frequency at f = 100 MHz $-I_C$ = 50 mA; $-V_{CE}$ = 10 V	f_T	>	100	100	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 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

Temperature

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

THERMAL CHARACTERISTIC

$R_{th(j-amb)}$	292	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	μA
	$-V_{CB} = 40V$, $I_E = 0$, $T_j = 100^{\circ}C$	BFX87	-	0.03	2.0	μA
	$-V_{CB} = 30V$, $I_E = 0$, $T_j = 100^{\circ}C$	BFX88	-	0.03	2.0	μA
$-I_{EBO}$	Emitter cut-off current					
	$-V_{EB} = 5.0V$, $I_C = 0$	BFX29	-	30	500	nA
	$-V_{EB} = 4.0V$, $I_C = 0$	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					
	$-I_C = 0.1mA$, $-V_{CE} = 10V$	BFX29	20	90	-	
	$-I_C = 1.0mA$, $-V_{CE} = 10V$	BFX29, 87, BFX88	40	105	-	
	$-I_C = 10mA$, $-V_{CE} = 10V$	BFX29	50	125	-	
		BFX87, 88	40	125	-	
	$-I_C = 50mA$, $-V_{CE} = 10V$	BFX29	50	125	-	
	$-I_C = 150mA$, $-V_{CE} = 10V$	BFX29, 87, BFX88	40	90	-	
	$-I_C = 500mA$, $-V_{CE} = 10V$	BFX87, 88	25	40	-	
$-V_{CE(sat)}$	Collector-emitter saturation voltage					
	$-I_C = 150mA$, $-I_B = 15mA$		-	0.15	0.40	V
$-V_{BE(sat)}$	Base-emitter saturation voltage					
	$-I_C = 30mA$, $-I_B = 1.0mA$		-	0.77	0.90	V
	$-I_C = 150mA$, $-I_B = 15mA$		-	1.05	1.30	V
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
f_T	Transition frequency					
	$-I_C = 50mA$, $-V_{CE} = 10V$, $f = 100MHz$, $T_{amb} = 25^{o}C$		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 $-I_C = 10mA$, $-V_{CE} = 10V$, $f = 1.0kHz$, $T_{amb} = 25^oC$

		Min.	Typ.	Max.	
h_{ie}	Input impedance	-	600	-	Ω
h_{re}	Voltage feedback ratio	-	1.50	-	$\times 10^{-4}$
h_{fe}	Forward current transfer ratio	-	155	-	
h_{oe}	Output admittance	-	104	-	μmho

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^oC 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^oC 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

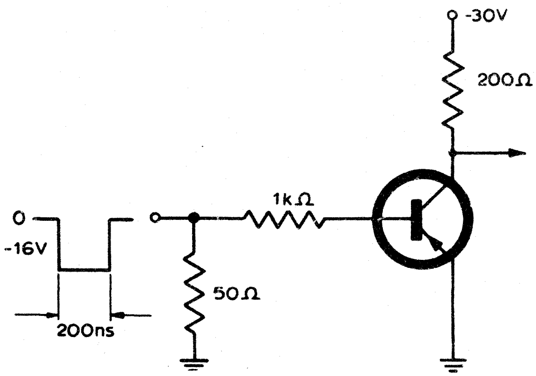


Fig. 1

Saturated turn-off switching time

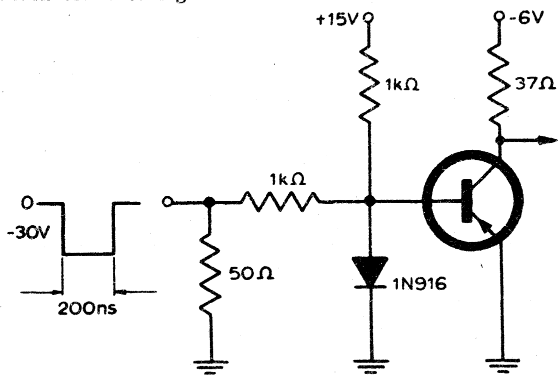
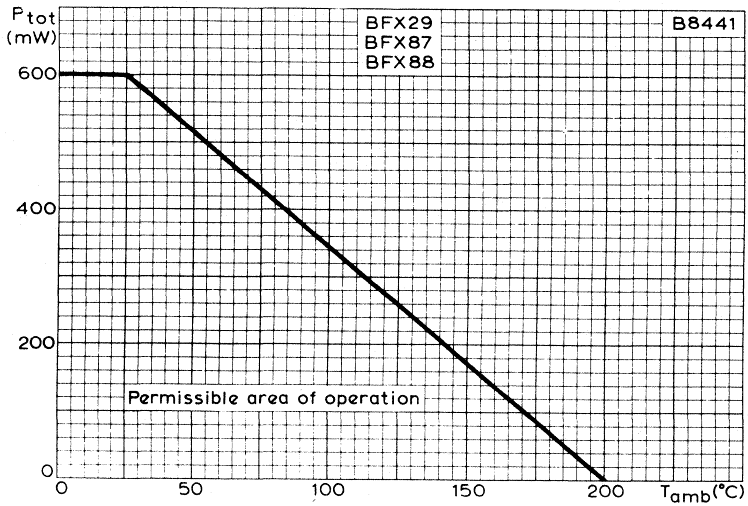
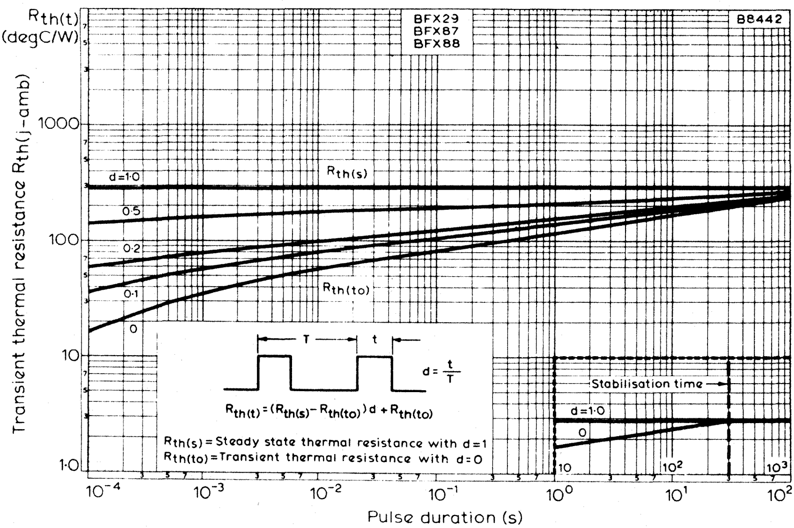


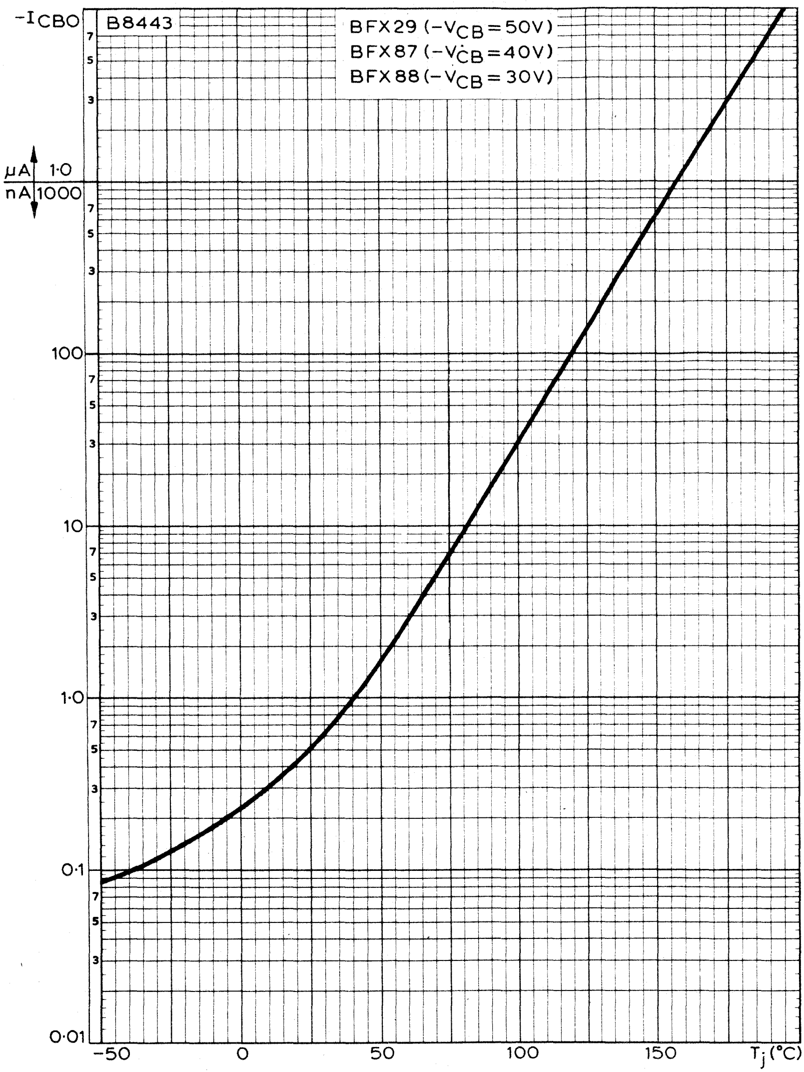
Fig. 2



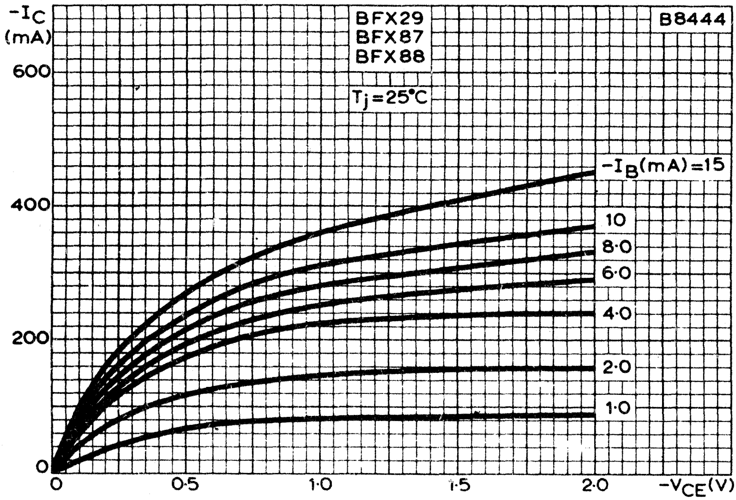
MAXIMUM TOTAL DISSIPATION PLOTTED AGAINST AMBIENT TEMPERATURE

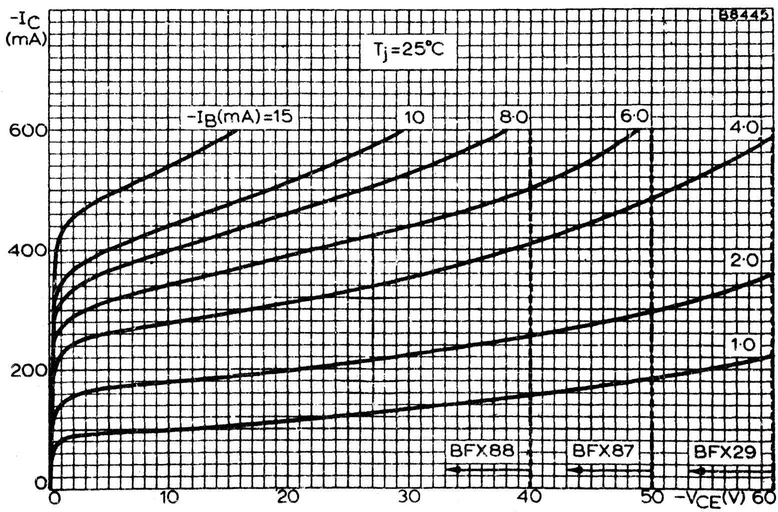


TRANSIENT THERMAL RESISTANCE FOR VARIOUS DUTY FACTORS PLOTTED AGAINST PULSE DURATION

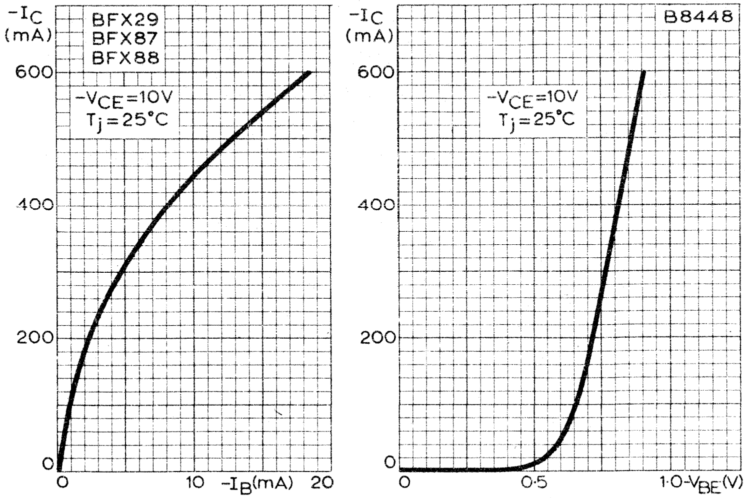


TYPICAL VARIATION OF COLLECTOR CUT-OFF CURRENT
WITH JUNCTION TEMPERATURE

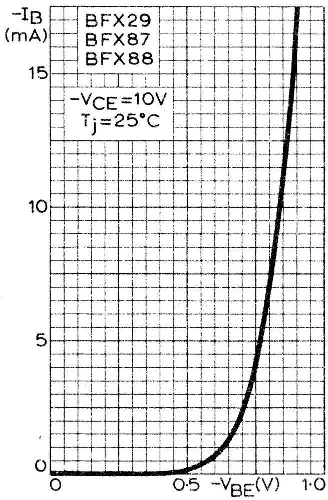




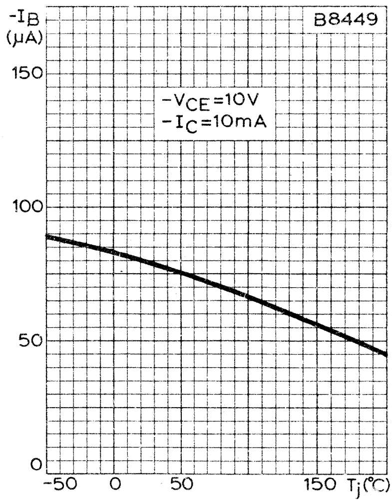
TYPICAL OUTPUT CHARACTERISTICS AT LOW AND HIGH COLLECTOR-EMITTER VOLTAGES



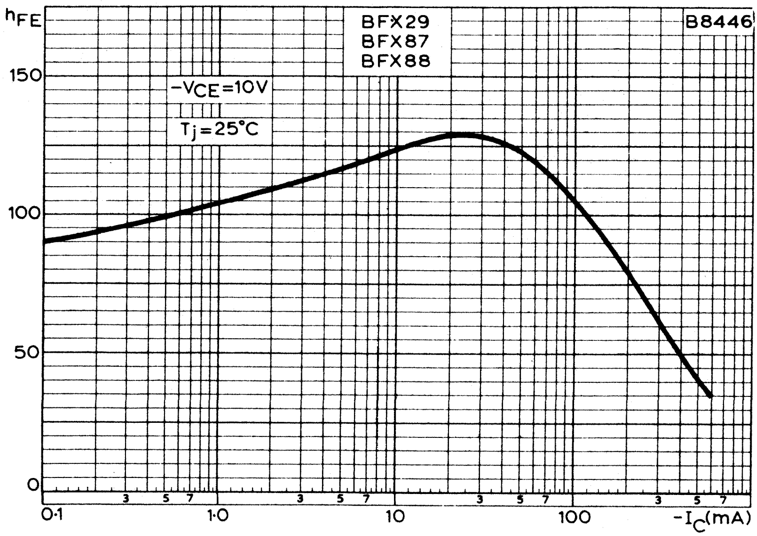
TYPICAL TRANSFER AND MUTUAL CHARACTERISTICS

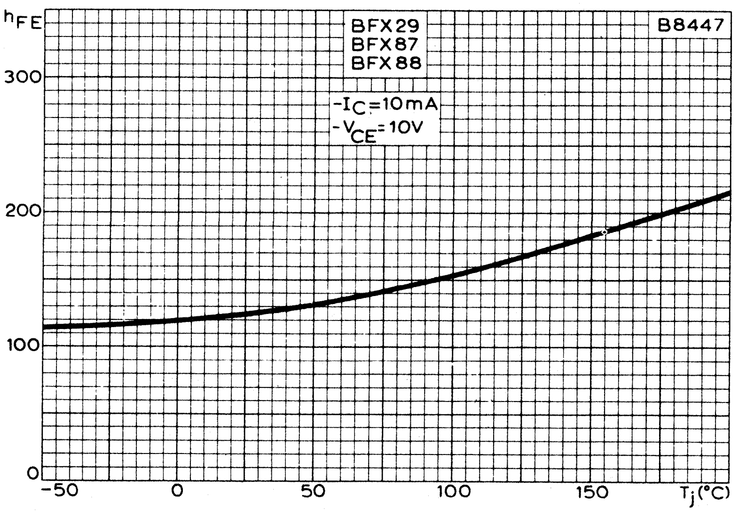


Typical input characteristic

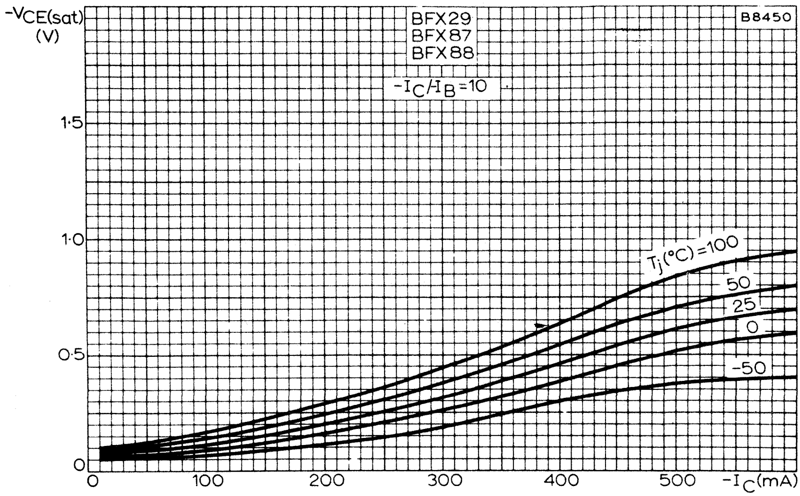


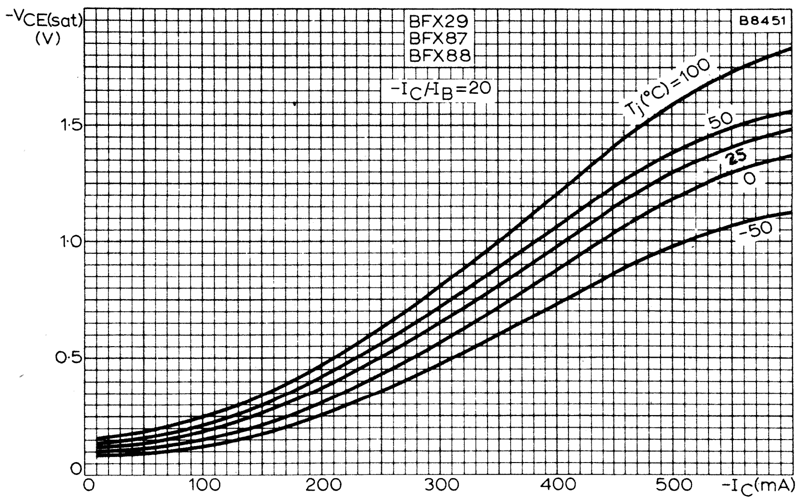
Typical base current versus junction temperature



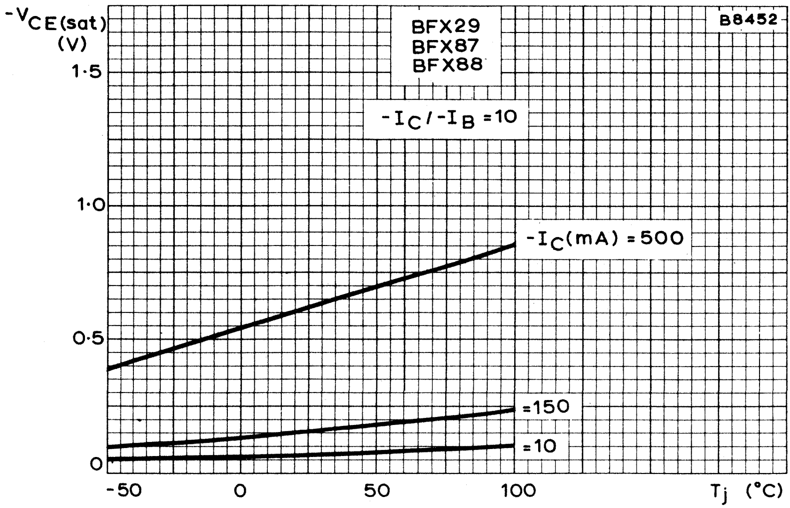


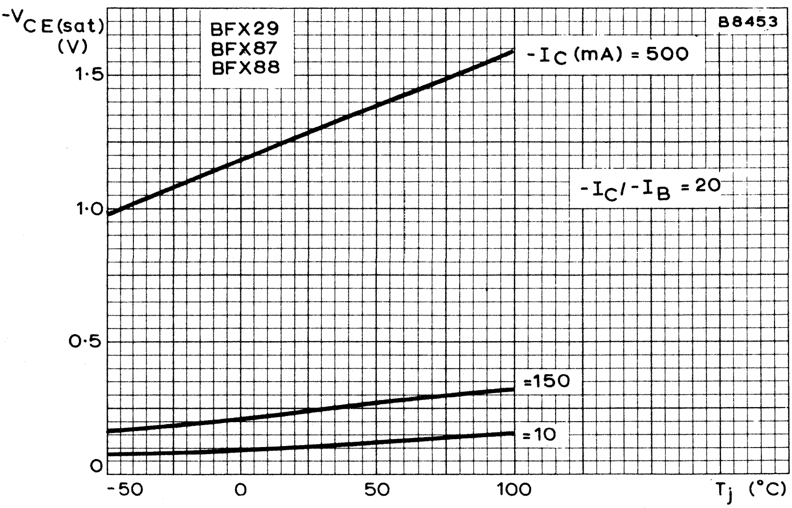
TYPICAL VATIATION OF STATIC FORWARD CURRENT TRANSFER RATIO WITH COLLECTOR CURRENT AND JUNCTION TEMPERATURE



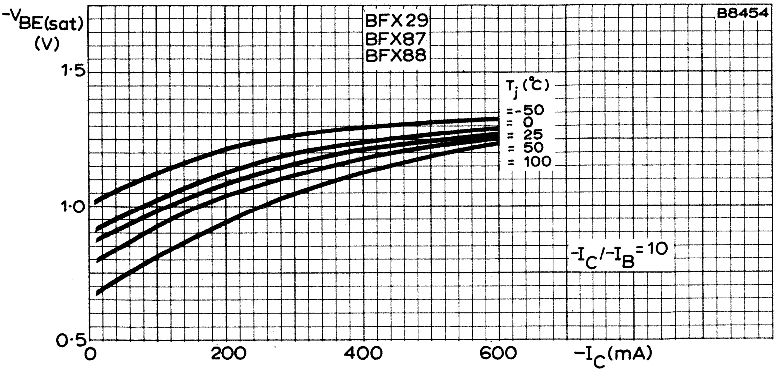


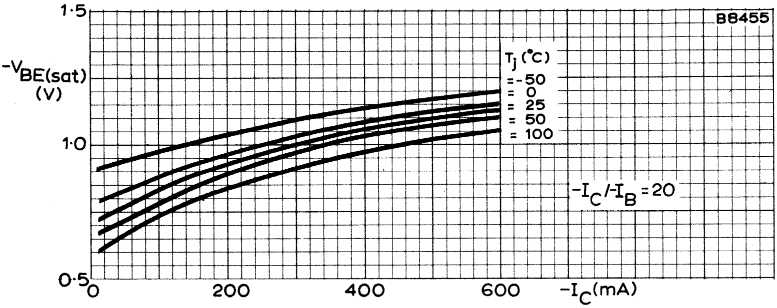
TYPICAL VARIATION OF COLLECTOR-EMITTER SATURATION VOLTAGE WITH COLLECTOR CURRENT

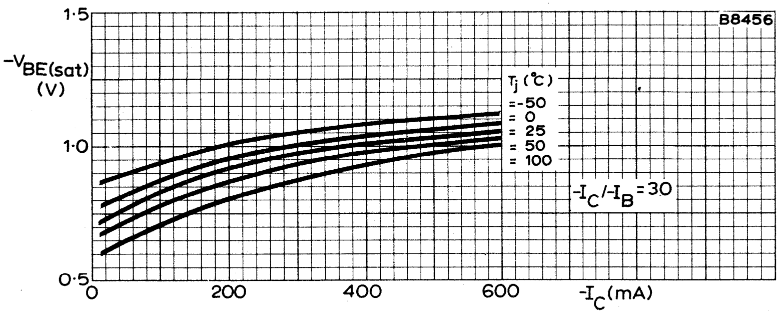




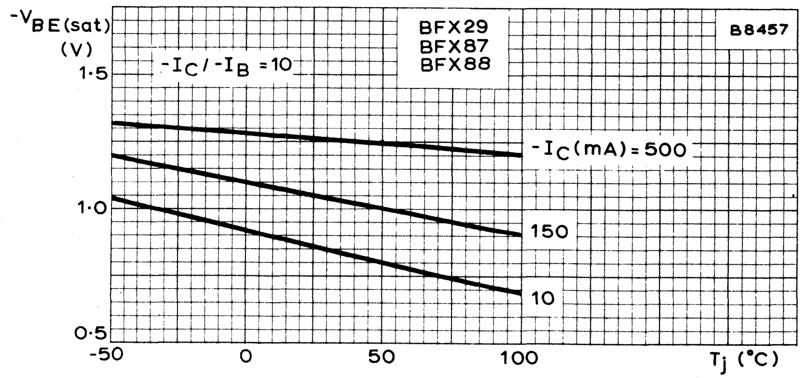
TYPICAL VARIATION OF COLLECTOR-EMITTER SATURATION VOLTAGE WITH JUNCTION TEMPERATURE

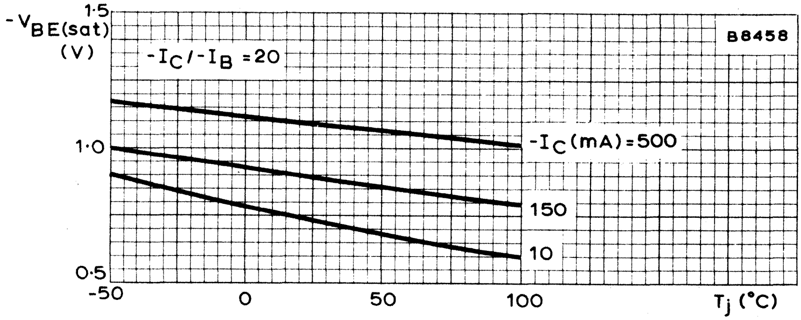


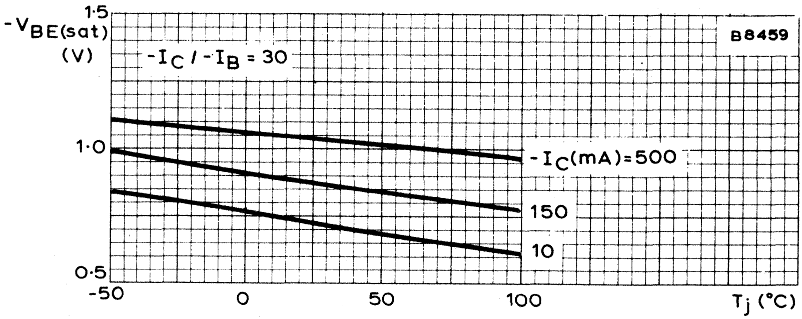




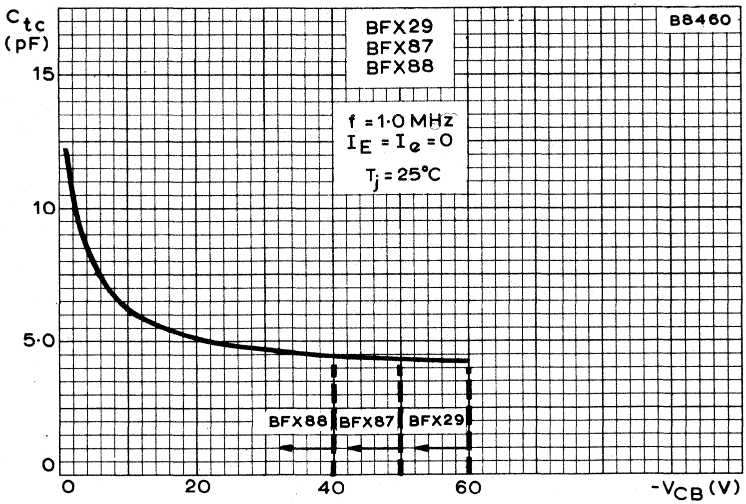
TYPICAL VARIATION OF BASE-EMITTER SATURATION VOLTAGE WITH COLLECTOR CURRENT



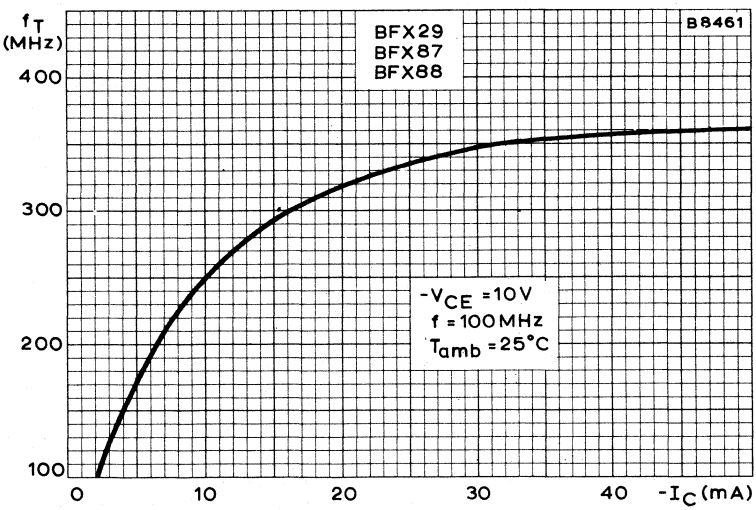




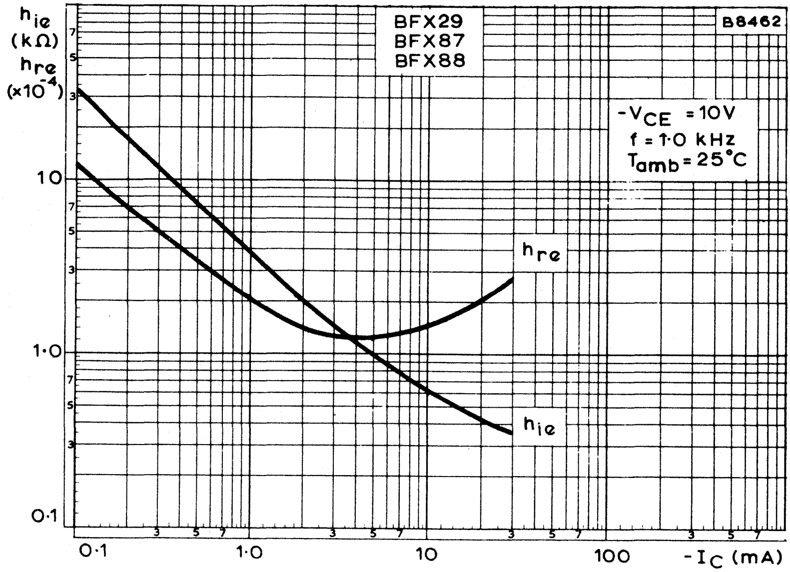
TYPICAL VARIATION OF BASE-EMITTER SATURATION VOLTAGE WITH JUNCTION TEMPERATURE



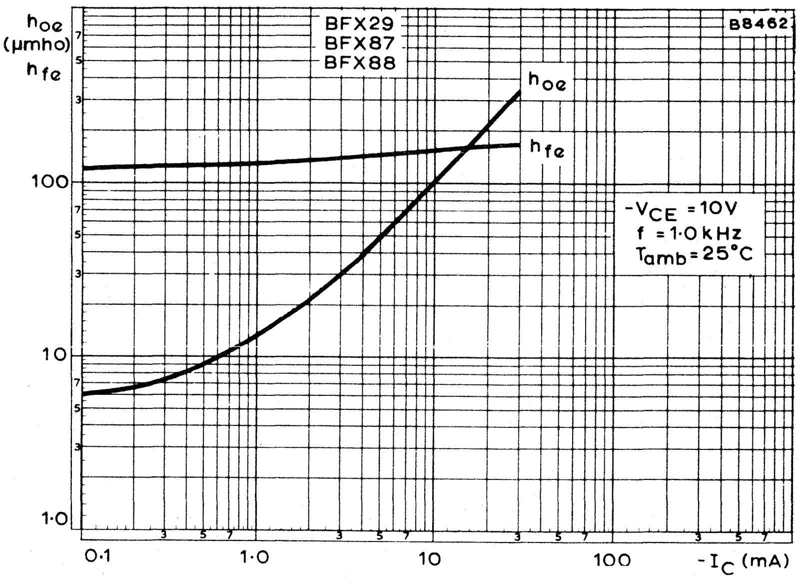
TYPICAL VARIATION OF COLLECTOR CAPACITANCE WITH COLLECTOR-BASE VOLTAGE



TYPICAL VARIATION OF TRANSITION FREQUENCY WITH COLLECTOR CURRENT



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

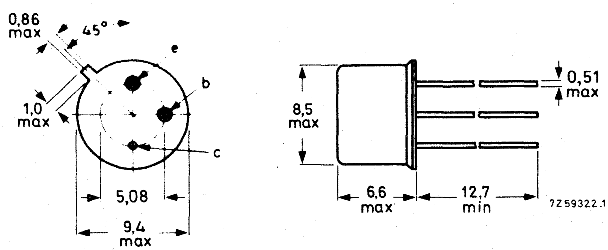
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	65	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	65	V
Collector current (peak value)	$-I_{CM}$	max.	600	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	600	mW
D.C. current gain $-I_C$ = 10 mA; $-V_{CE}$ = 0,4 V	h_{FE}	typ.	90	
			50 to 200	
Storage time $-I_{Con}$ = 100 mA; $-I_{Bon}$ = I_{Boff} = 10 mA	t_s	<	250	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 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. ($T_{amb} \leq 25^oC$)	600	mW

Temperature

T_{stg} min.	-65	^oC
T_{stg} max.	200	^oC
T_j max.	200	^oC

THERMAL CHARACTERISTIC

$R_{th(j-amb)}$	292	degC/W

ELECTRICAL CHARACTERISTICS ($T_j = 25^oC$ unless otherwise stated)

		Min.	Typ.	Max.	
$-I_{CBO}$	Collector cut-off current				
	$-V_{CB} = 65V$, $I_E = 0$	-	1.0	500	nA
	$-V_{CB} = 50V$, $I_E = 0$	-	0.5	50	nA
	$-V_{CB} = 50V$, $I_E = 0$, $T_j = 100^oC$	-	0.03	2.0	μA
$-I_{EBO}$	Emitter cut-off current				
	$-V_{EB} = 5.0V$, $I_C = 0$	-	30	500	nA
	$-V_{EB} = 3.0V$, $I_C = 0$	-	1.0	100	nA
$-V_{BE(sat)}$	Base-emitter saturation voltage				
	$-I_C = 30mA$, $-I_B = 1.0mA$	-	0.77	0.90	V
	$-I_C = 150mA$, $-I_B = 15mA$	-	1.05	1.30	V
h_{FE}	Static forward current transfer ratio				
	$-I_C = 1.0mA$, $-V_{CE} = 0.4V$	40	80	-	
	$-I_C = 10mA$, $-V_{CE} = 0.4V$	50	90	200	
	$-I_C = 50mA$, $-V_{CE} = 0.4V$	20	92	-	
	$-I_C = 150mA$, $-V_{CE} = 0.4V$	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)

$-I_C=100mA,\ -I_{Bon}=I_{Boff}=10mA,\ V_{EE}=10V,\ V_{BEoff}=2.0V$

		Min.	Typ.	Max.	
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

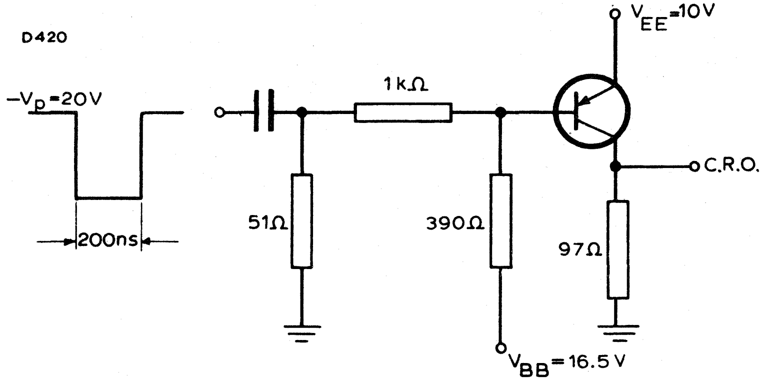
SOLDERING AND WIRING RECOMMENDATIONS

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°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°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

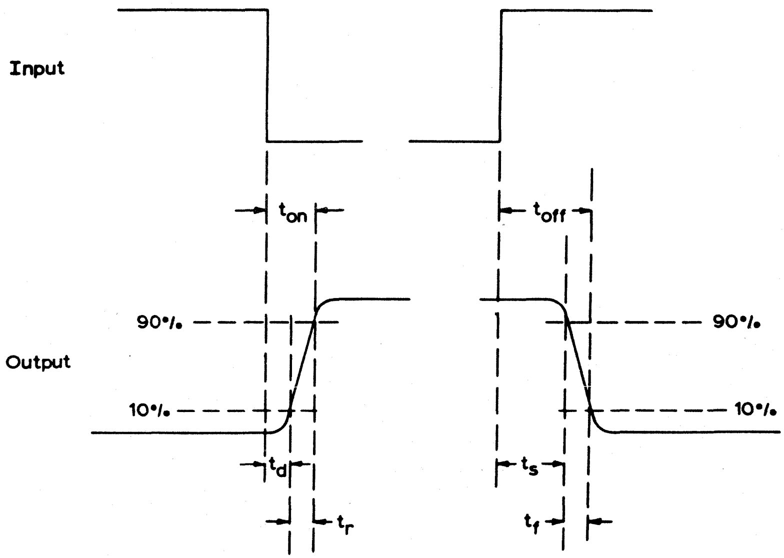
Test circuit

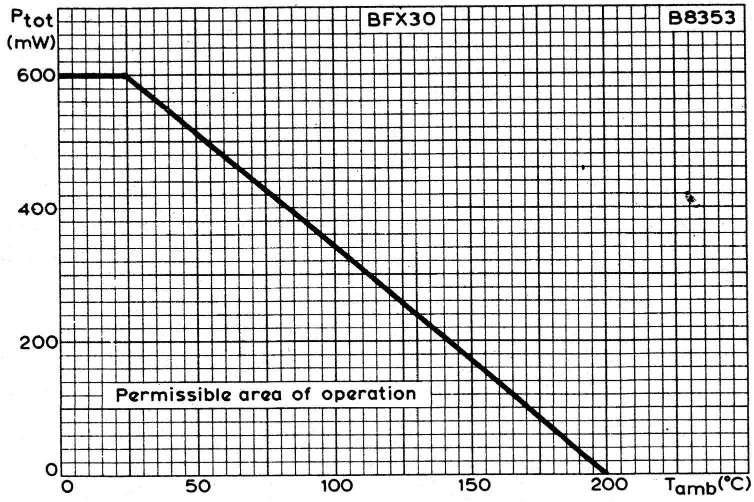


$-I_C = 100mA, -I_{B(on)} = I_{B(off)} = 10mA$

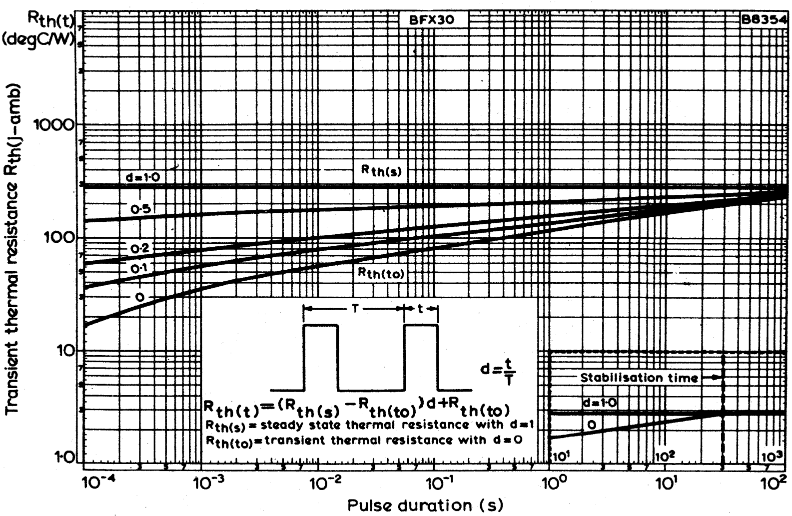
$V_{BE(off)} = 2 \cdot 0V$

Waveforms

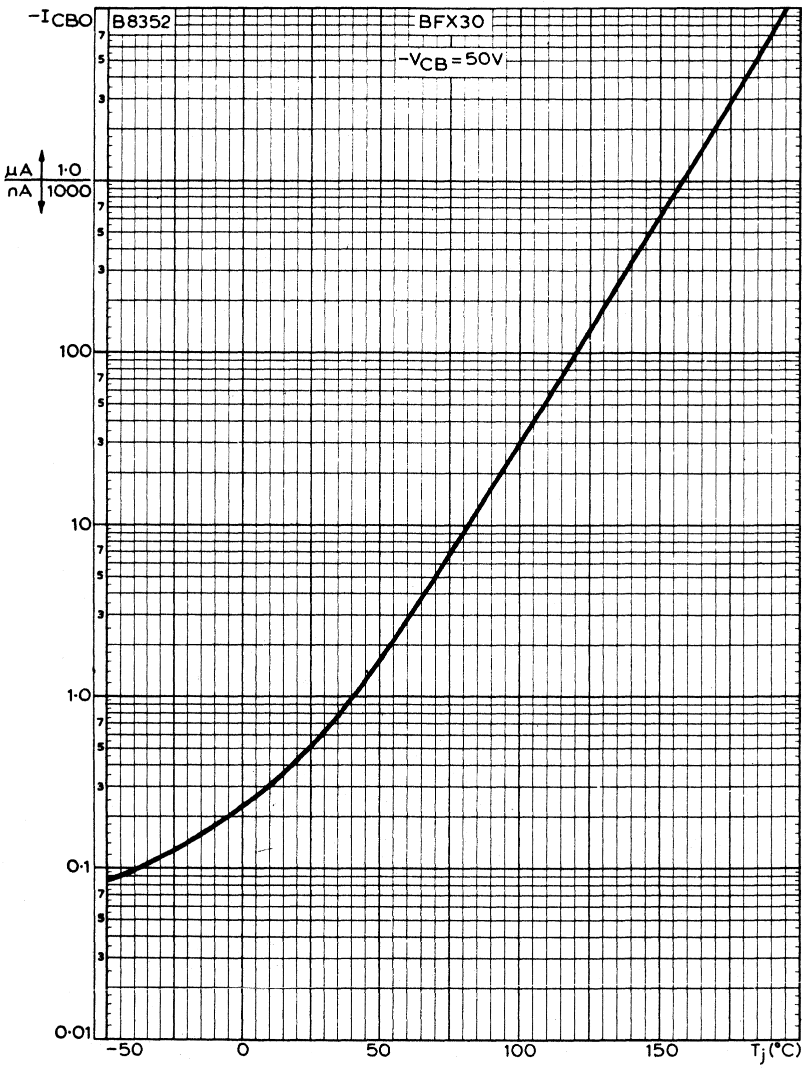




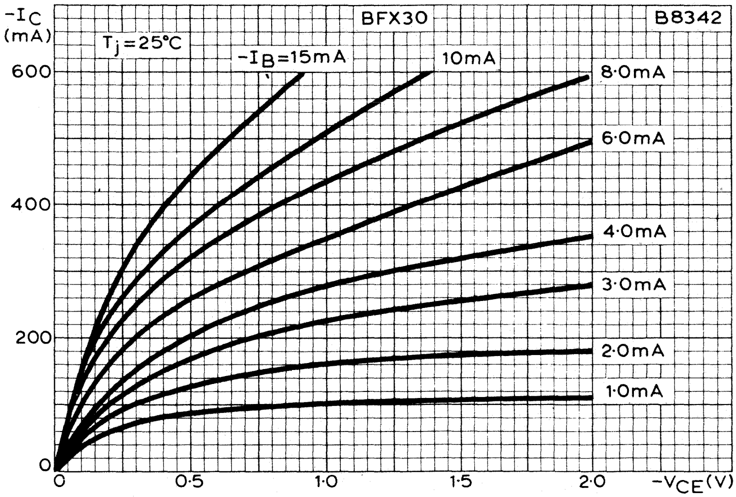
TOTAL DISSIPATION PLOTTED AGAINST AMBIENT TEMPERATURE

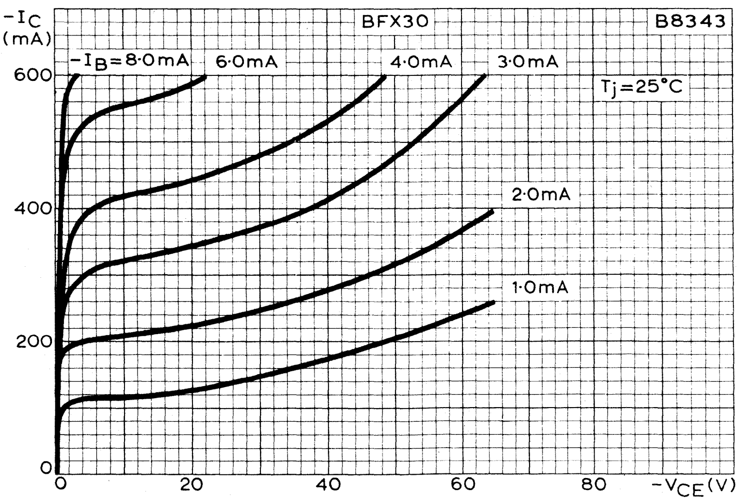


TRANSIENT THERMAL RESISTANCE FOR VARIOUS DUTY FACTORS PLOTTED AGAINST PULSE DURATION

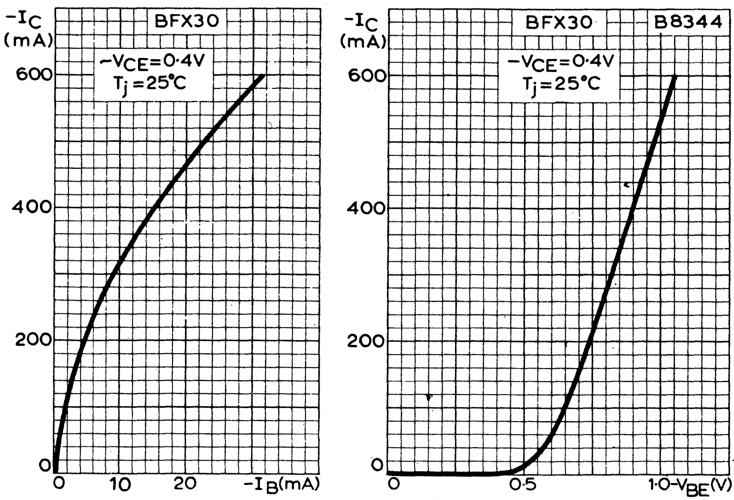


TYPICAL VARIATION OF COLLECTOR CUT-OFF CURRENT
WITH JUNCTION TEMPERATURE

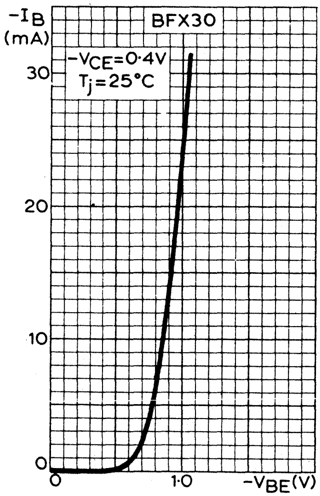




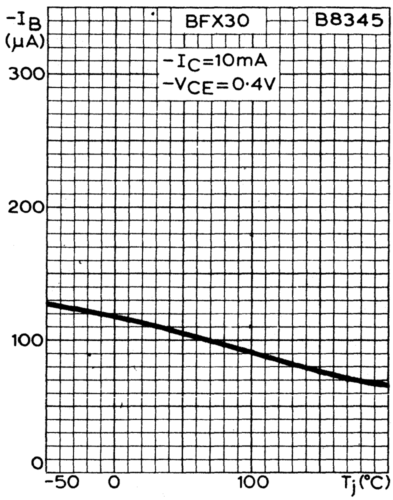
TYPICAL OUTPUT CHARACTERISTICS AT LOW AND HIGH COLLECTOR-EMITTER VOLTAGES



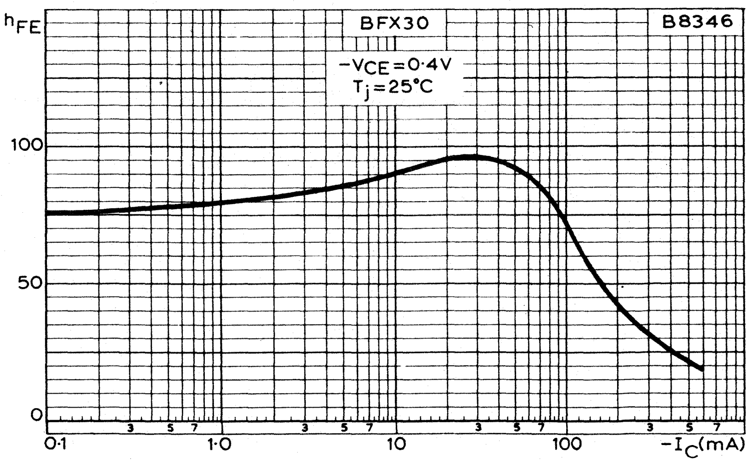
TYPICAL TRANSFER AND MUTUAL CHARACTERISTICS

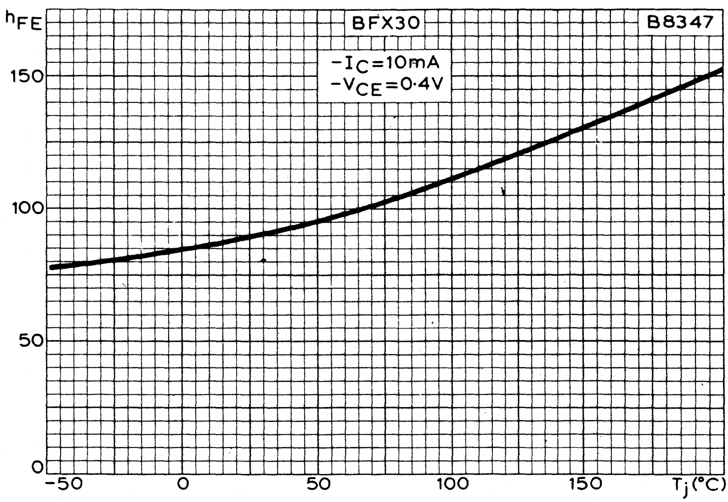


Typical input characteristics

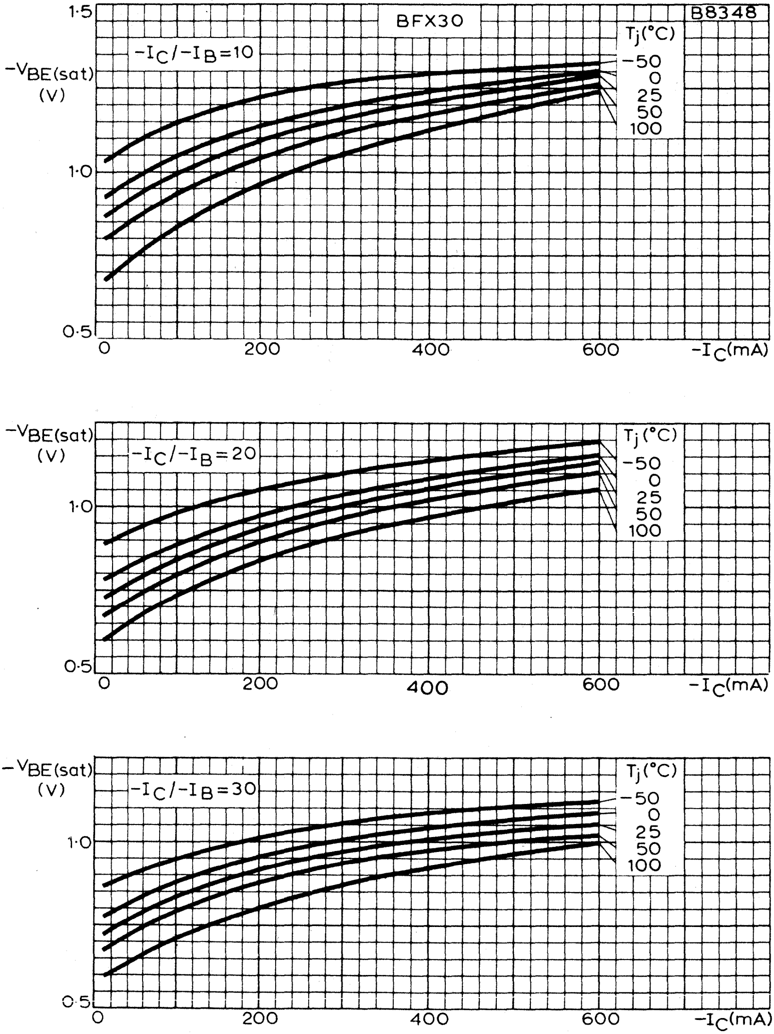


Typical base current versus junction temperature

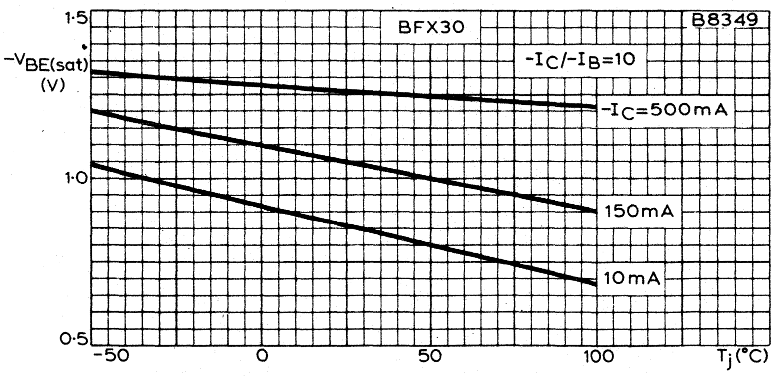


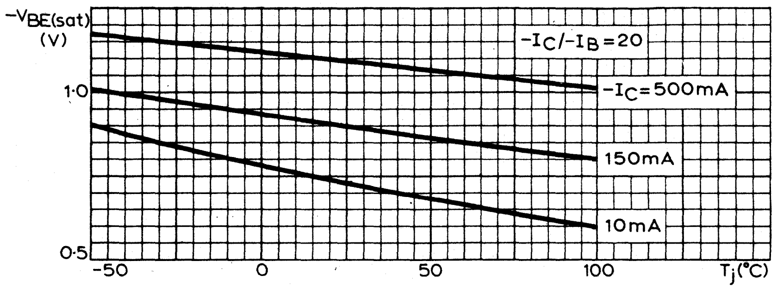


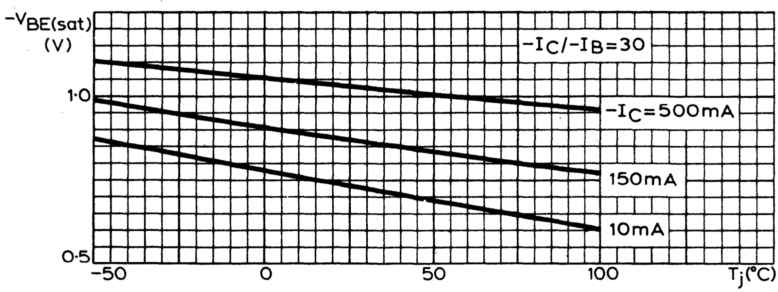
TYPICAL VARIATION OF STATIC FORWARD CURRENT TRANSFER RATIO WITH COLLECTOR CURRENT AND JUNCTION TEMPERATURE



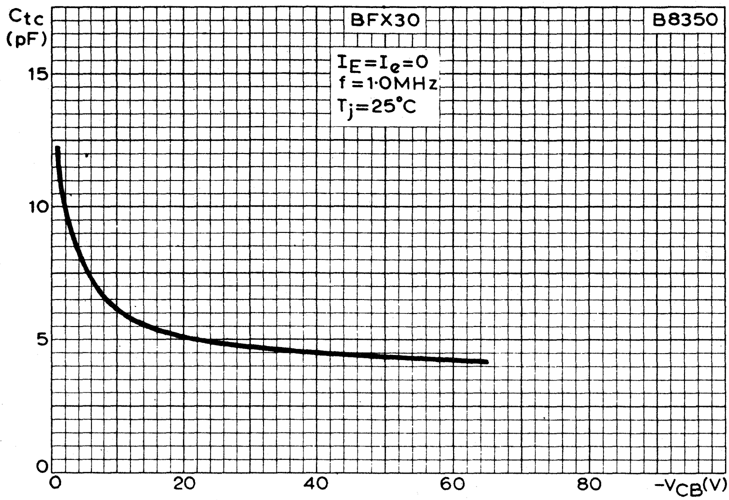
TYPICAL VARIATION OF BASE-EMITTER SATURATION VOLTAGE WITH COLLECTOR CURRENT AND I_C/I_B RATIO



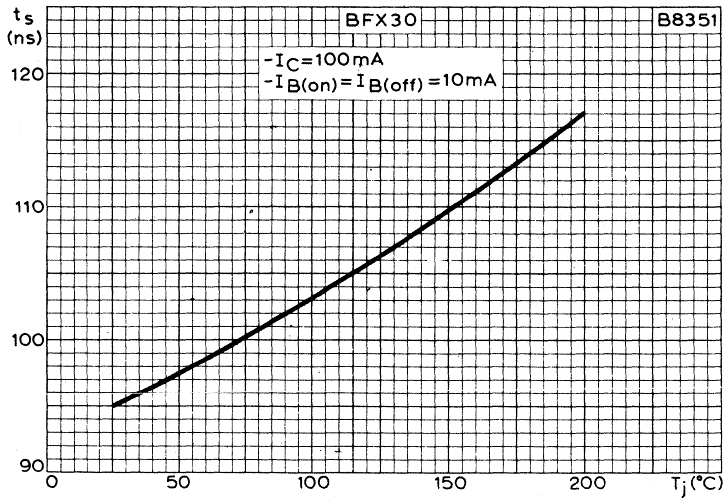




TYPICAL VARIATION OF BASE-EMITTER SATURATION VOLTAGE
WITH JUNCTION TEMPERATURE AND I_C/I_B RATIO



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

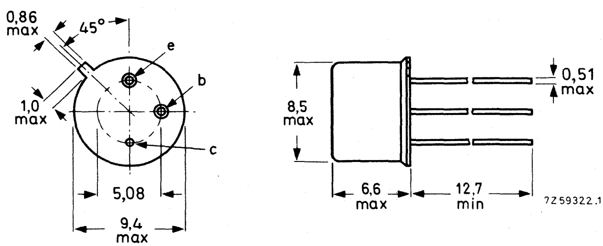
Collector-base voltage (open emitter)	V_{CBO}	max.	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	V
Collector current (peak value)	I_{CM}	max.	5,0	A
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.	5,0	W
Junction temperature	T_j	max.	200	°C
D.C. current gain I_C = 2 A; V_{CE} = 2 V	h_{FE}	40 to 150		
Transition frequency at f = 35 MHz I_C = 0,5 A; V_{CE} = 5 V	f_T	>	70	MHz
Turn-off time when switched from I_C = 5 A; I_B = 0,5 A to cut-off with $-I_{BM}$ = 0,5 A	t_{off}	<	1,2	μs

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).

Products approved to CECC 50 004-025, available on request.

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 °C	P_{tot}	max.	5.0	W
up to T_{amb} = 25 °C	P_{tot}	max.	0.87	W

Temperatures

Storage temperature	T_{stg}		-55 to +200	°C
Junction temperature	T_j	max.	200	°C

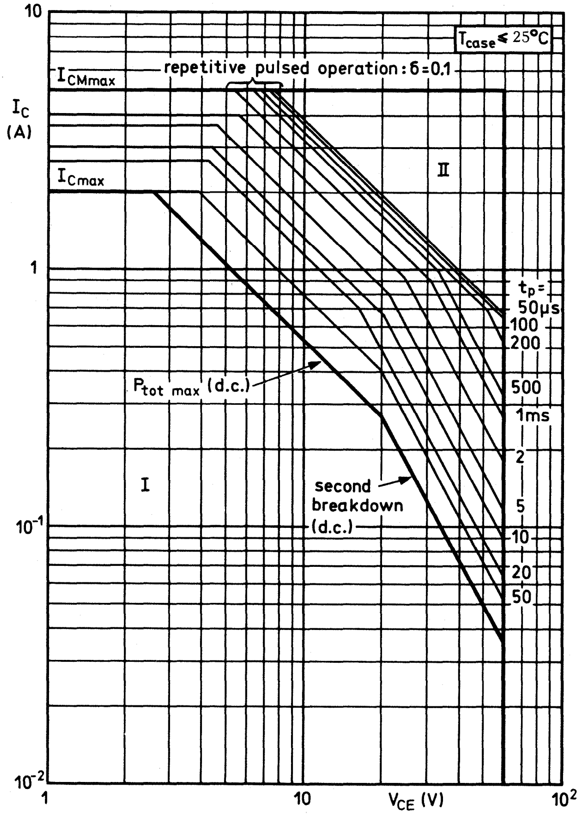
THERMAL RESISTANCE

Frm junction to ambient in free air	$R_{th\ j\text{-}a}$	=	200	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	35	°C/W

CHARACTERISTICS

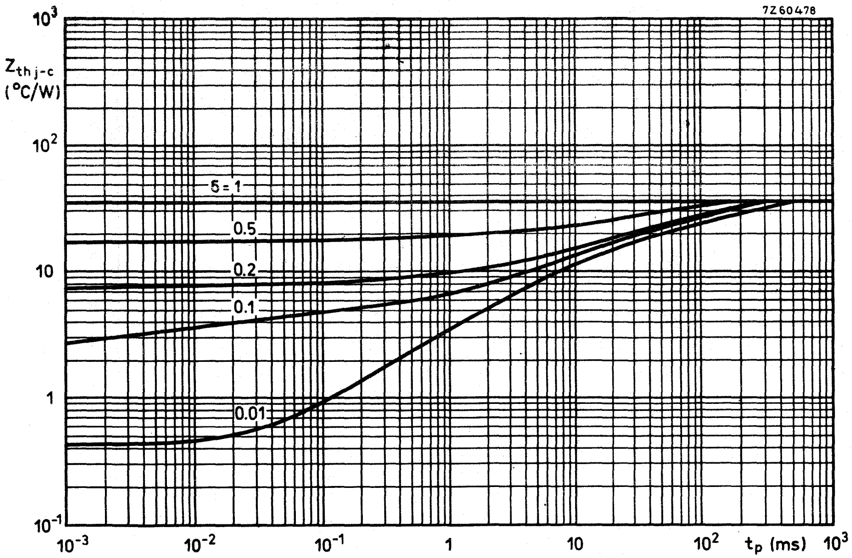
T_j = 25 °C unless otherwise specified

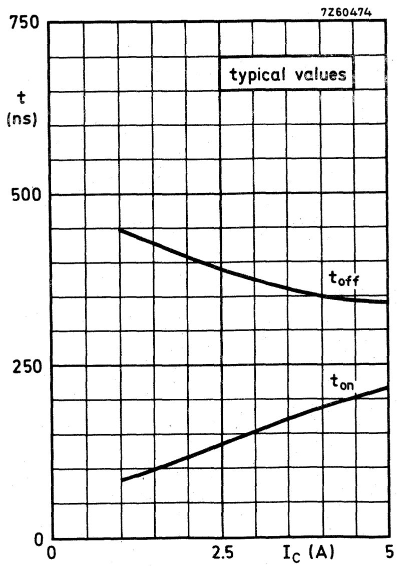
Collector cut-off current				
V_{EB} = 0; V_{CE} = 60 V	I_{CES}	<	10	μA
Emitter cut-off current				
I_C = 0; V_{EB} = 4 V	I_{EBO}	typ.	0.01	μA
		<	10	μA
Saturation voltages				
I_C = 5 A; I_B = 0.5 A	V_{CEsat}	typ.	0.77	V
		<	1.0	V
	V_{BEsat}	typ.	1.43	V
		<	1.8	V
D.C. current gain				
I_C = 1.0 A; V_{CE} = 2.0 V	h_{FE}	typ.	130	
I_C = 1.5 A; V_{CE} = 0.6 V	h_{FE}	typ.	60	
I_C = 2.0 A; V_{CE} = 2.0 V	h_{FE}	typ.	110	
		40 to	150	
Collector capacitance at f = 1 MHz				
I_E = I_e = 0; V_{CB} = 10 V	C_c	typ.	36	pF
		<	100	pF
Emitter-capacitance at f = 1 MHz				
I_C = I_c = 0; V_{EB} = 0.5 V	C_e	typ.	345	pF
Transition frequency at f = 35 MHz				
I_C = 0.5 A; V_{CE} = 5 V	f_T	>	70	MHz
		typ.	100	MHz
Turn on time when switched from				
$-V_{BE}$ = 2.0 V to I_C = 5 A; I_B = 0.5 A with I_{BM} = 0.5 A	t_{on}	typ.	0.2	μs
		<	0.6	μs
Turn off time when switched from				
I_C = 5 A; I_B = 0.5 A to $-V_{BE}$ = 2.0 V with $-I_{BM}$ = 0.5 A	t_{off}	typ.	0.34	μs
		<	1.2	μs

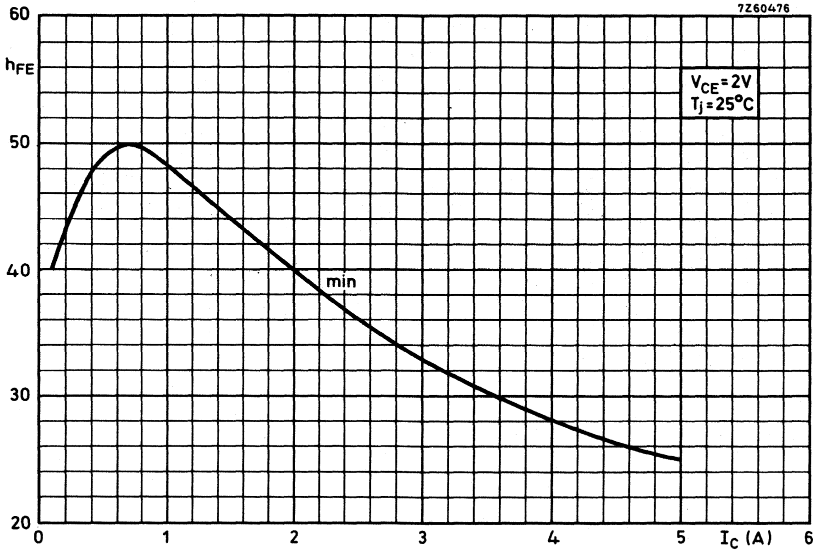


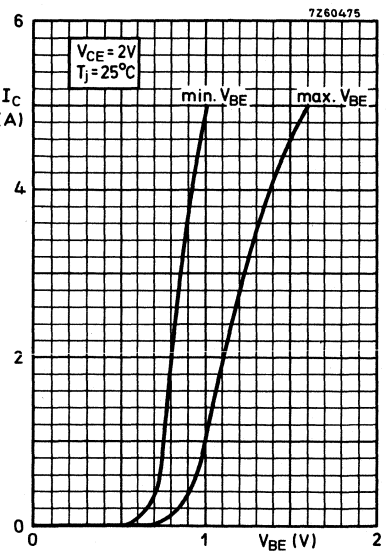
Safe Operation Area with the transistor forward biased

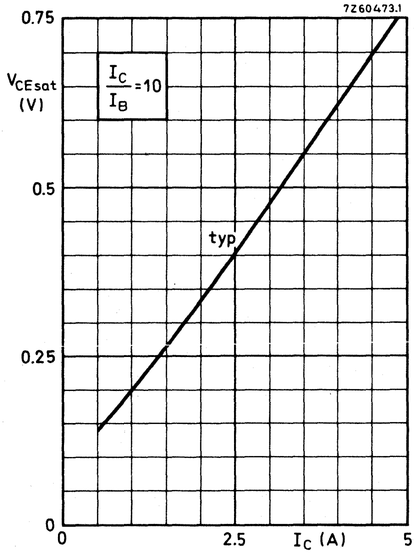
I Region of permissible d. c. operation
II Permissible extension for repetitive pulsed operation


7Z60478
$Z_{th\,j-c}$ (°C/W)
10^3
10^2
10
1
10^{-1}
δ = 1
0.5
0.2
0.1
0.01
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3


7Z60474
typical values
t (ns)
750
500
250
0
t_{off}
t_{on}
0
2.5
I_C (A)
5


7Z60476
60
h_{FE}
50
40
30
20
V_{CE} = 2V
T_j = 25°C
min
0
1
2
3
4
5
I_C (A)
6


7Z60475
6
I_C
(A)
4
2
0
V_{CE} = 2V
T_j = 25°C
min. V_{BE}
max. V_{BE}
0
1
V_{BE} (V)
2


7Z60473.1
0.75
V_{CEsat}
(V)
0.5
0.25
0
$\frac{I_C}{I_B}$ = 10
typ
0
2.5
I_C (A)
5

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in TO-39 metal envelopes for general purpose industrial applications.

QUICK REFERENCE DATA

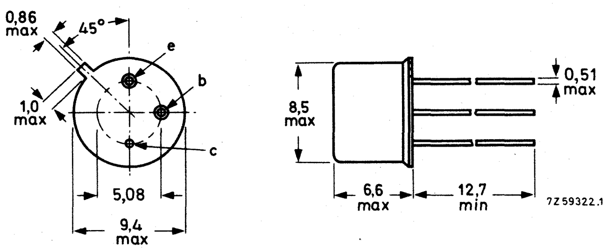
			BFX84	BFX85	BFX86	
Collector-base voltage (open emitter)	V_{CBO}	max.	100	100	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	60	35	V
Collector current (peak value)	I_{CM}	max.	1,0	1,0	1,0	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	800	800	800	mW
Total power dissipation up to T_{case} = 100 °C	P_{tot}	max.	2,86	2,86	2,86	W
D.C. current gain I_C = 150 mA; V_{CE} = 10 V	h_{FE}	>	30	70	70	
		typ.	112	142	142	
Transition frequency at f = 35 MHz I_C = 50 mA; V_{CE} = 10 V; T_{amb} = 25 °C	f_T	>	50	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

	BFX84	BFX85	BFX86	
V_{CBO} max.	100	100	40	V
V_{CE} max. (cut-off, $I_C \leq 1$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. $T_{amb} \leq 25^oC$		800		mW
$T_{case} \leq 25^oC$		5.0		W
$T_{case} > 25, < 100^oC$		2.86		W

Temperature

T_{stg}	-65 to +200	^oC
T_j max.	200	^oC

THERMAL CHARACTERISTICS

$R_{th(j-amb)}$ in free air	220	degC/W
$R_{th(j-case)}$	35	degC/W

BFX84

ELECTRICAL CHARACTERISTICS ($T_j = 25^oC$ unless otherwise stated)

Symbol	Parameter	Min.	Typ.	Max.	Unit
I_{CBO}	Collector cut-off current				
	$V_{CB} = 100V$, $I_E = 0$	-	10	500	nA
	$V_{CB} = 100V$, $I_E = 0$, $T_j = 100^oC$	-	0.5	30	μA
	$V_{CB} = 80V$, $I_E = 0$	-	2.0	50	nA
	$V_{CB} = 80V$, $I_E = 0$, $T_j = 100^oC$	-	0.1	2.5	μA
I_{EBO}	Emitter cut-off current				
	$V_{EB} = 6.0V$, $I_C = 0$	-	10	500	nA
	$V_{EB} = 5.0V$, $I_C = 0$	-	2.0	50	nA
	$V_{EB} = 5.0V$, $I_C = 0$, $T_j = 100^oC$	-	0.1	2.5	μA
h_{FE}	Static forward current transfer ratio				
	$I_C = 10mA$, $V_{CE} = 10V$	20	80	-	
	$I_C = 150mA$, $V_{CE} = 10V$	30	112	-	
	$I_C = 500mA$, $V_{CE} = 10V$	20	70	-	
	$I_C = 1.0A$, $V_{CE} = 10V$	15	35	-	
$V_{CE(sat)}$	Collector-emitter saturation voltage				
	$I_C = 10mA$, $I_B = 1.0mA$	-	0.06	0.15	V
	$I_C = 150mA$, $I_B = 15mA$	-	0.15	0.35	V
	$I_C = 500mA$, $I_B = 50mA$	-	0.35	1.00	V
	$I_C = 1.0A$, $I_B = 100mA$	-	0.66	1.60	V
$V_{BE(sat)}$	Base-emitter saturation voltage				
	$I_C = 10mA$, $I_B = 1.0mA$	-	0.69	1.2	V
	$I_C = 150mA$, $I_B = 15mA$	-	0.92	1.3	V
	$I_C = 500mA$, $I_B = 50mA$	-	1.15	1.5	V
	$I_C = 1.0A$, $I_B = 100mA$	-	1.40	2.0	V
C_{Tc}	Collector capacitance				
	$V_{CB} = 10V$, $I_E = I_e = 0$, f = 1.0MHz	-	7.0	12	pF

BFX84

ELECTRICAL CHARACTERISTICS (contd.)

		Min.	Typ.	Max.	
f_T	Transition frequency $I_C = 50mA$, $V_{CE} = 10V$, $f = 35MHz$, $T_{amb} = 25^oC$	50	140	-	MHz
Saturated switching times $I_C = 150mA$, $I_{B(on)} = -I_{B(off)} = 15mA$, $-V_{EE} = 10V$, $-V_{BE(off)} = 2.0V$					
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}	$I_C = 1.0mA$, $V_{CE} = 5.0V$, $f = 1.0kHz$, $T_{amb} = 25^oC$	10	65	-	
h_{ie}	$I_C = 10mA$, $V_{CE} = 5.0V$, $f = 1.0kHz$, $T_{amb} = 25^oC$	-	250	750	Ω
h_{re}		-	0.85	5.0	$\times 10^{-4}$
h_{fe}		15	80	-	
h_{oe}		-	35	80	μmho

BFX85

ELECTRICAL CHARACTERISTICS ($T_j = 25^oC$ unless otherwise stated)

		Min.	Typ.	Max.	
I_{CBO}	Collector cut-off current				
	$V_{CB} = 100V$, $I_E = 0$	-	10	500	nA
	$V_{CB} = 100V$, $I_E = 0$, $T_j = 100^oC$	-	0.5	30	μA
	$V_{CB} = 80V$, $I_E = 0$	-	2.0	50	nA
	$V_{CB} = 80V$, $I_E = 0$, $T_j = 100^oC$	-	0.1	2.5	μA
I_{EBO}	Emitter cut-off current				
	$V_{EB} = 6.0V$, $I_C = 0$	-	10	500	nA
	$V_{EB} = 5.0V$, $I_C = 0$	-	2.0	50	nA
	$V_{EB} = 5.0V$, $I_C = 0$, $T_j = 100^oC$	-	0.1	2.5	μA
h_{FE}	Static forward current transfer ratio				
	$I_C = 10mA$, $V_{CE} = 10V$	50	90	-	
	$I_C = 150mA$, $V_{CE} = 10V$	70	142	-	
	$I_C = 500mA$, $V_{CE} = 10V$	30	90	-	
	$I_C = 1.0A$, $V_{CE} = 10V$	15	50	-	
$V_{CE(sat)}$	Collector-emitter saturation voltage				
	$I_C = 10mA$, $I_B = 1.0mA$	-	0.06	0.15	V
	$I_C = 150mA$, $I_B = 15mA$	-	0.15	0.35	V
	$I_C = 500mA$, $I_B = 50mA$	-	0.35	1.00	V
	$I_C = 1.0A$, $I_B = 100mA$	-	0.66	1.60	V
$V_{BE(sat)}$	Base-emitter saturation voltage				
	$I_C = 10mA$, $I_B = 1.0mA$	-	0.69	1.2	V
	$I_C = 150mA$, $I_B = 15mA$	-	0.92	1.3	V
	$I_C = 500mA$, $I_B = 50mA$	-	1.15	1.5	V
	$I_C = 1.0A$, $I_B = 100mA$	-	1.40	2.0	V
C_{Tc}	Collector capacitance				
	$V_{CB} = 10V$, $I_E = I_e = 0$, f = 1.0MHz	-	7.0	12	pF

BFX85 / BFX86

ELECTRICAL CHARACTERISTICS (contd.)

		Min.	Typ.	Max.	
f_T	Transition frequency $I_C = 50mA$, $V_{CE} = 10V$, $f = 35MHz$, $T_{amb} = 25^oC$	50	185	-	MHz
Saturated switching times					
$I_C = 150mA$, $I_{B(on)} = -I_{B(off)} = 15mA$, $-V_{EE} = 10V$, $-V_{BE(off)} = 2.0V$					
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}	$I_C = 1.0mA$, $V_{CE} = 5.0V$, $f = 1.0kHz$, $T_{amb} = 25^oC$	20	65	-	
h_{ie}	$I_C = 10mA$, $V_{CE} = 5.0V$, $f = 1.0kHz$, $T_{amb} = 25^oC$	-	250	750	Ω
h_{re}		-	0.85	5.0	$\times 10^{-4}$
h_{fe}		25	80	-	
h_{oe}		-	35	80	µmho

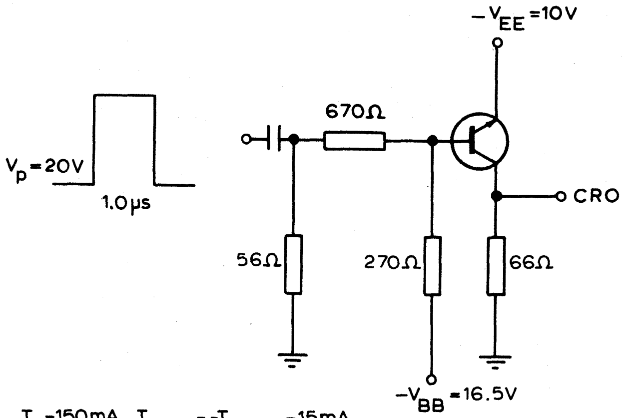
BFX86

ELECTRICAL CHARACTERISTICS ($T_j = 25^oC$ unless otherwise stated)

		Min.	Typ.	Max.	
I_{CBO}	Collector cut-off current				
	$V_{CB}=40V$, $I_E=0$	-	10	500	nA
	$V_{CB}=40V$, $I_E=0$, $T_j=100^oC$	-	0.5	30	μA
	$V_{CB}=30V$, $I_E=0$	-	2.0	50	nA
	$V_{CB}=30V$, $I_E=0$, $T_j=100^oC$	-	0.1	2.5	μA
I_{EBO}	Emitter cut-off current				
	$V_{EB}=6.0V$, $I_C=0$	-	10	500	nA
	$V_{EB}=5.0V$, $I_C=0$	-	2.0	50	nA
	$V_{EB}=5.0V$, $I_C=0$, $T_j=100^oC$	-	0.1	2.5	μA
h_{FE}	Static forward current transfer ratio				
	$I_C=10mA$, $V_{CE}=10V$	50	90	-	
	$I_C=150mA$, $V_{CE}=10V$	70	142	-	
	$I_C=500mA$, $V_{CE}=10V$	30	90	-	
	$I_C=1.0A$, $V_{CE}=10V$	15	50	-	
$V_{CE(sat)}$	Collector-emitter saturation voltage				
	$I_C=10mA$, $I_B=1.0mA$	-	0.06	0.15	V
	$I_C=150mA$, $I_B=15mA$	-	0.15	0.35	V
	$I_C=500mA$, $I_B=50mA$	-	0.35	1.00	V
	$I_C=1.0A$, $I_B=100mA$	-	0.66	1.60	V
$V_{BE(sat)}$	Base-emitter saturation voltage				
	$I_C=10mA$, $I_B=1.0mA$	-	0.69	1.2	V
	$I_C=150mA$, $I_B=15mA$	-	0.92	1.3	V
	$I_C=500mA$, $I_B=50mA$	-	1.15	1.5	V
	$I_C=1.0A$, $I_B=100mA$	-	1.40	2.0	V
C_{Tc}	Collector capacitance				
	$V_{CB}=10V$, $I_E=I_e=0$, f=1.0MHz	-	7.0	12	pF

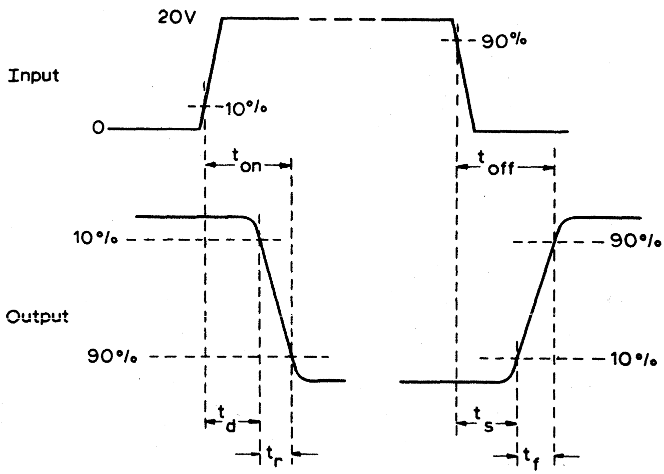
MEASUREMENT OF SATURATED SWITCHING TIMES

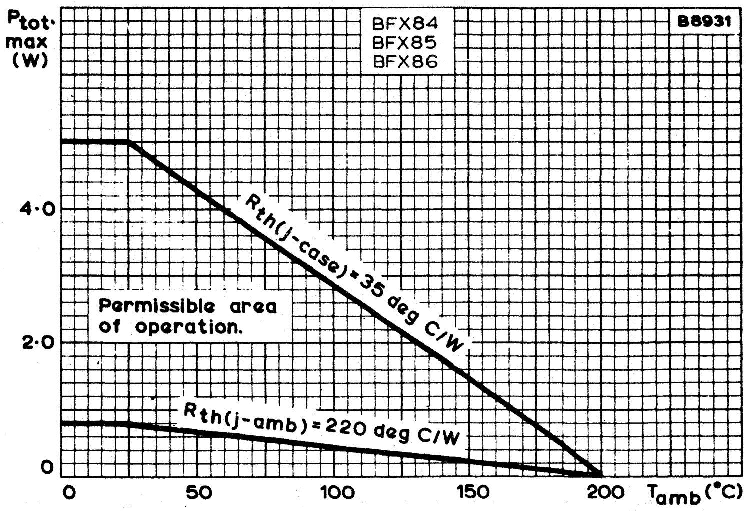
Test circuit



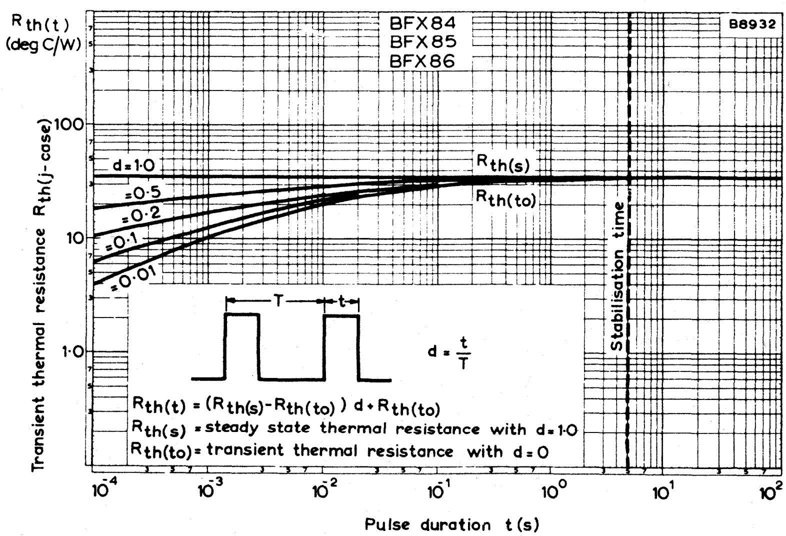
$I_C=150mA$, $I_{B(on)}=-I_{B(off)}=15mA$
$-V_{BE(off)}=2.0V$

Switching waveforms

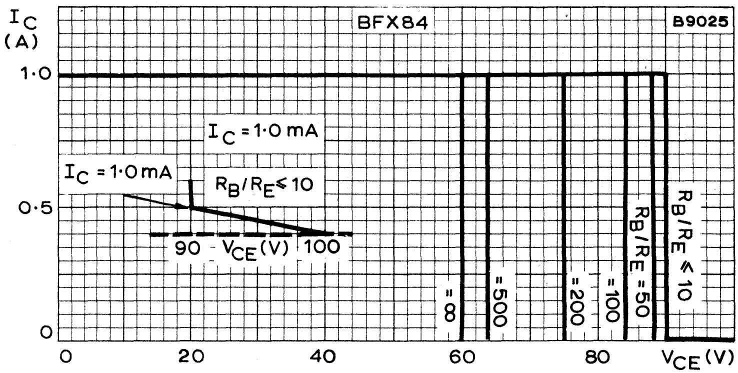


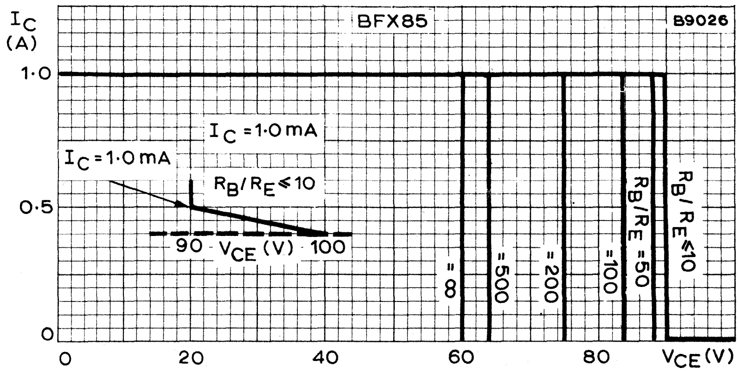


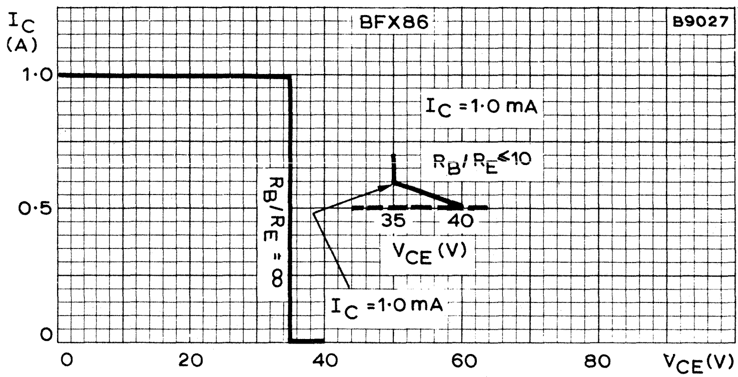
MAXIMUM TOTAL DISSIPATION PLOTTED AGAINST AMBIENT TEMPERATURE



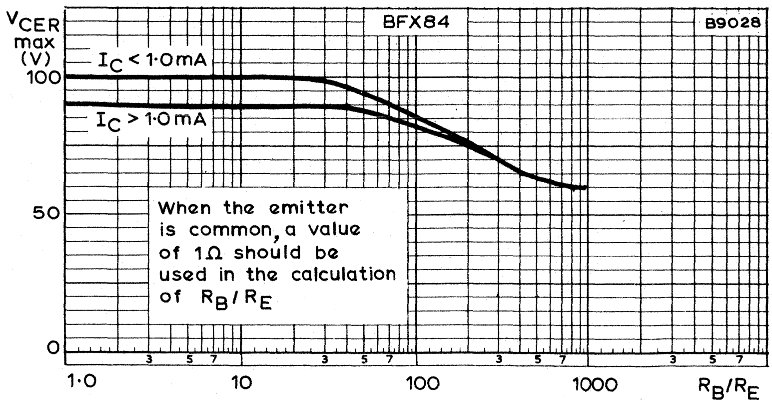
TRANSIENT THERMAL RESISTANCE FOR VARIOUS DUTY FACTORS PLOTTED AGAINST PULSE DURATION

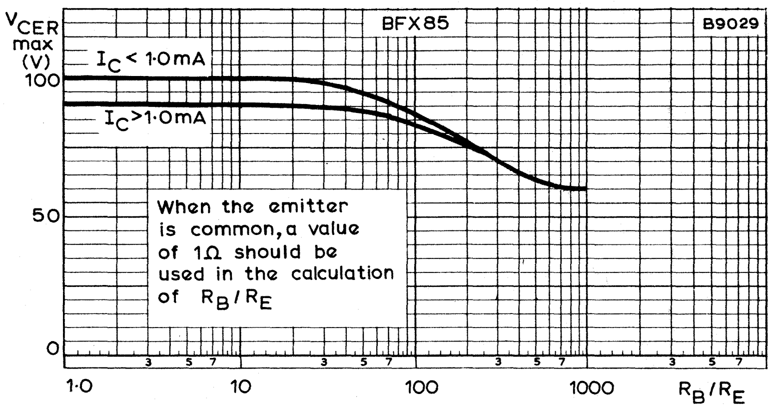


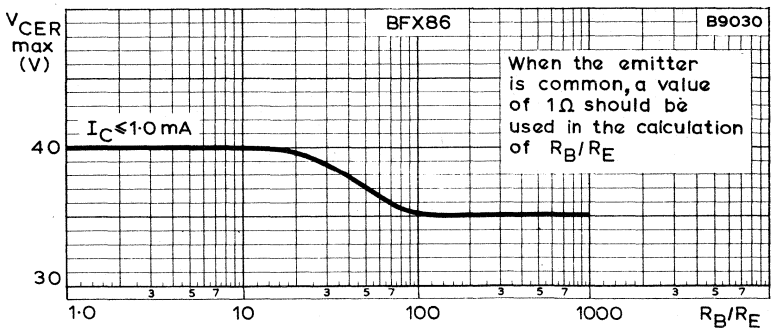




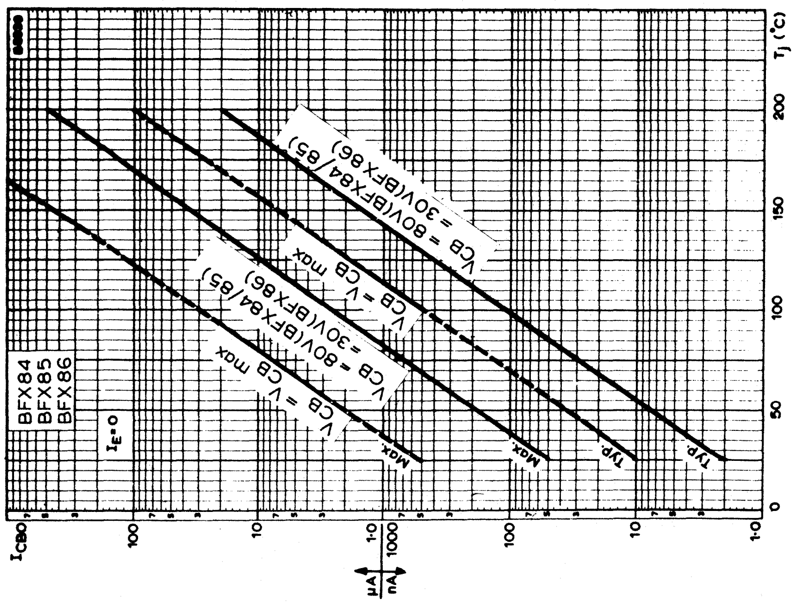
COLLECTOR CURRENT PLOTTED AGAINST MAXIMUM COLLECTOR-EMITTER VOLTAGE WITH R_B/R_E AS PARAMETER

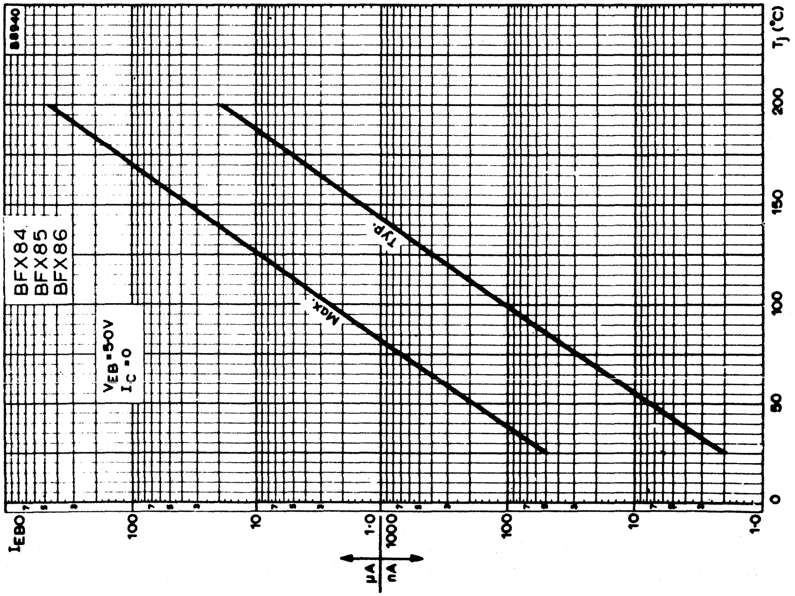




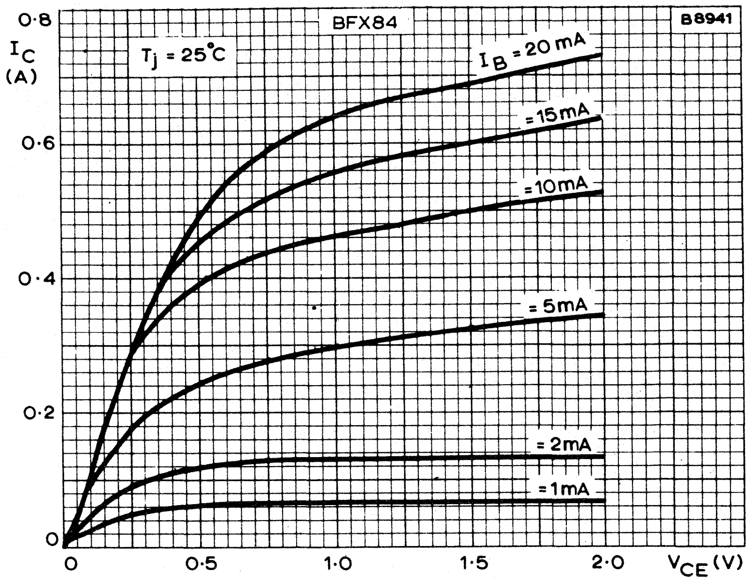


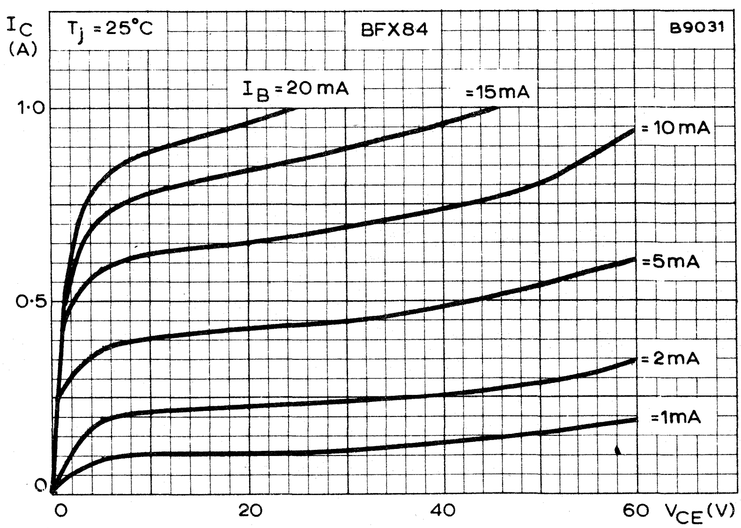
MAXIMUM COLLECTOR-EMITTER VOLTAGE PLOTTED AGAINST R_B/R_E RATIO



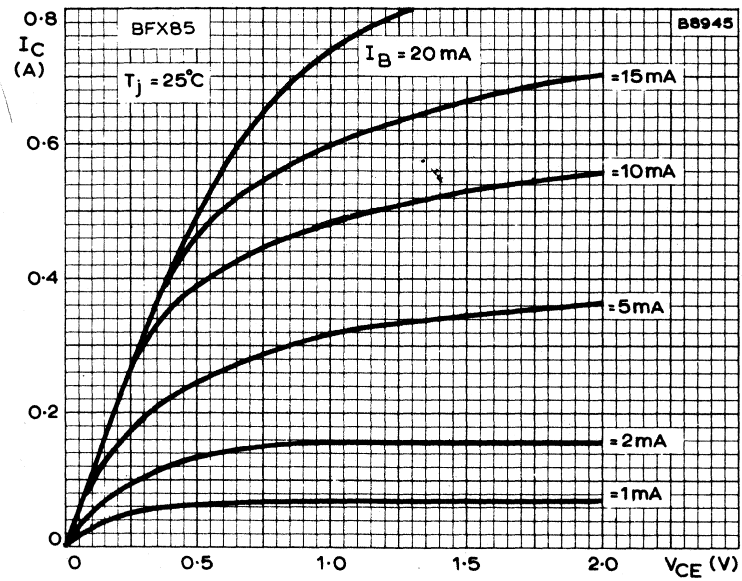


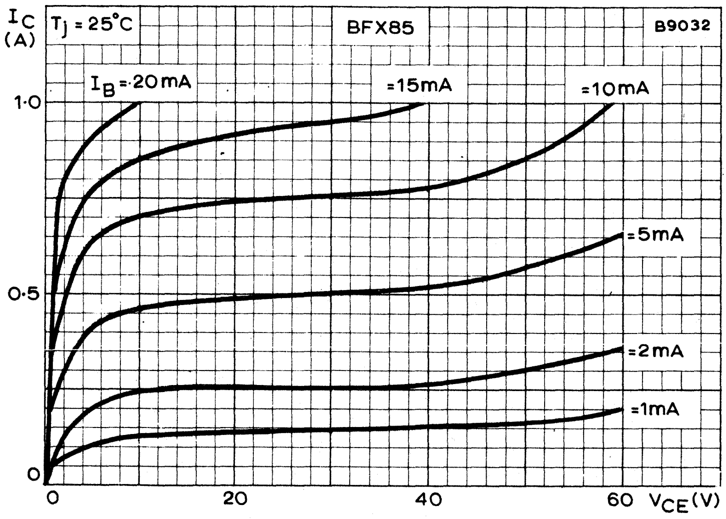
COLLECTOR AND EMITTER CUT-OFF CURRENTS PLOTTED
AGAINST JUNCTION TEMPERATURE



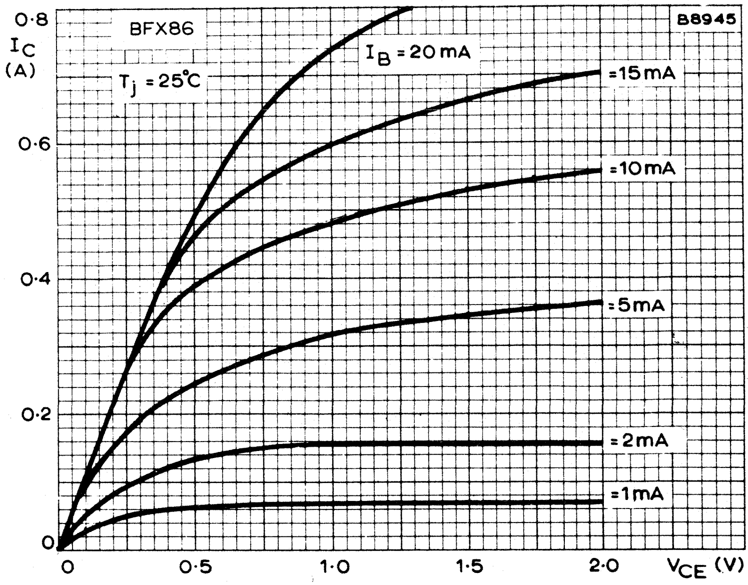


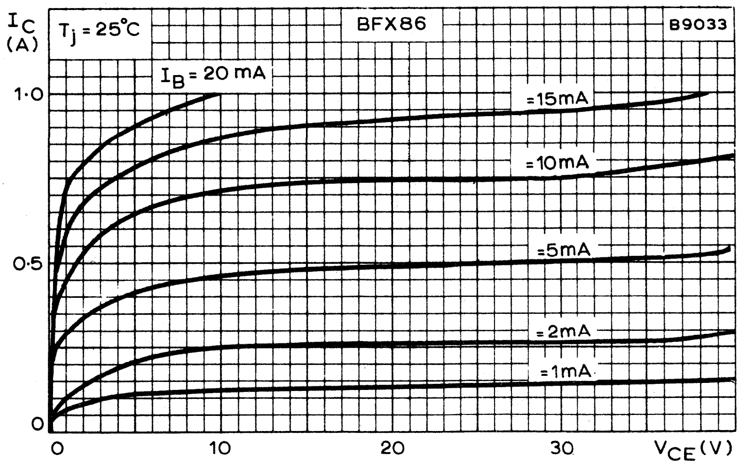
TYPICAL OUTPUT CHARACTERISTICS



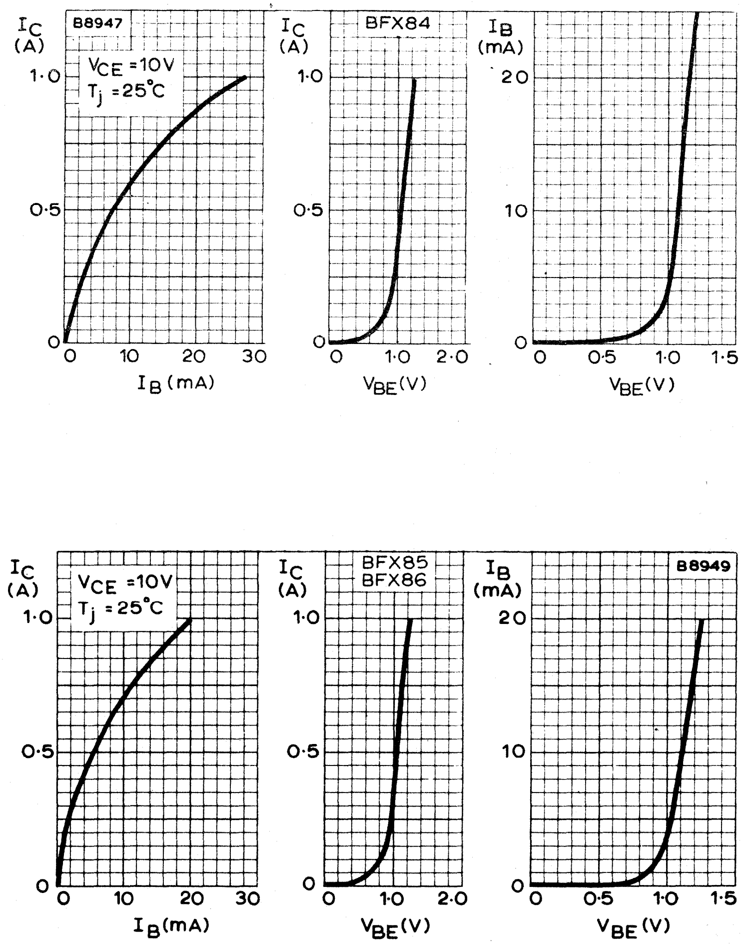


TYPICAL OUTPUT CHARACTERISTICS

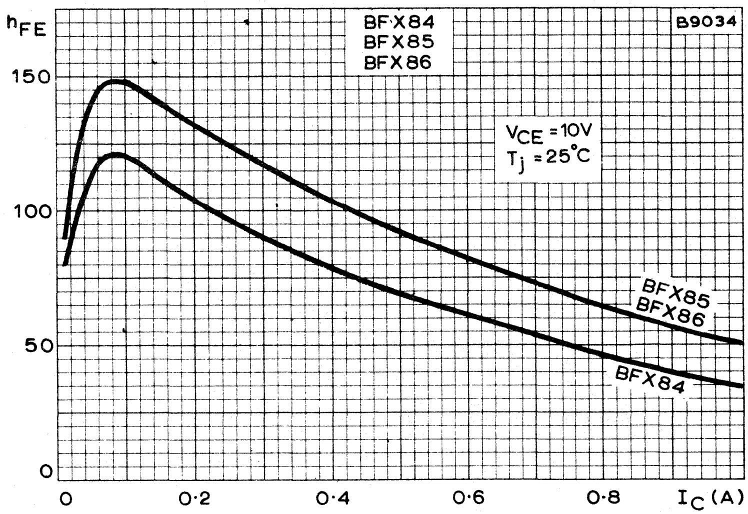


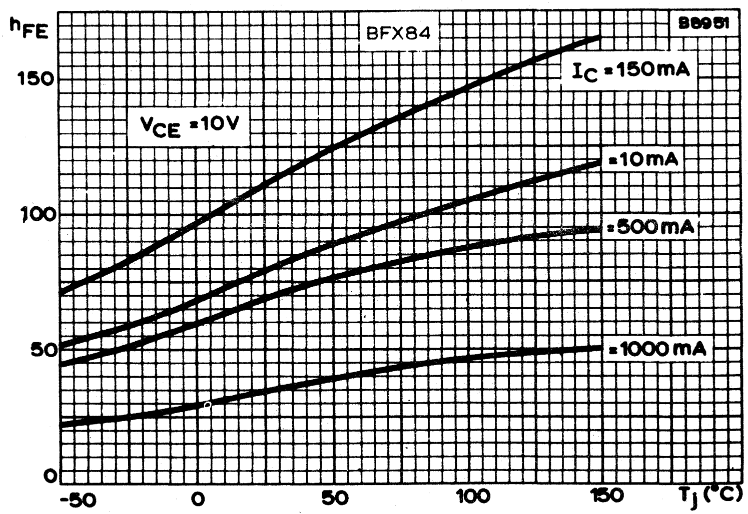


TYPICAL OUTPUT CHARACTERISTICS

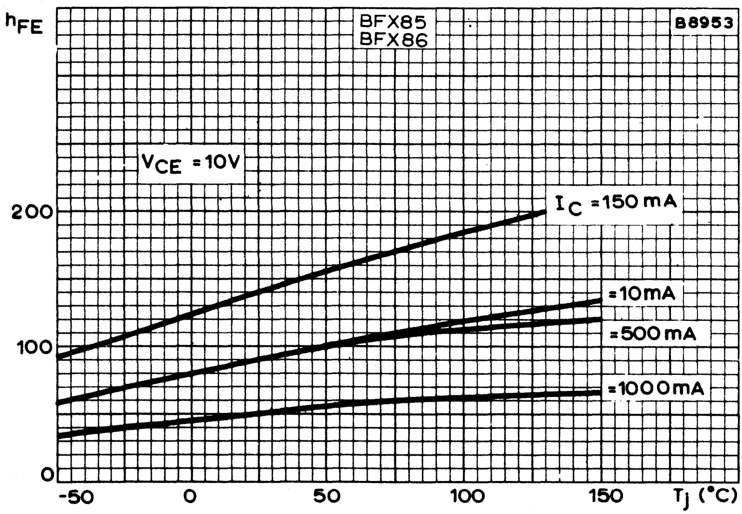


TYPICAL TRANSFER, MUTUAL AND INPUT CHARACTERISTICS

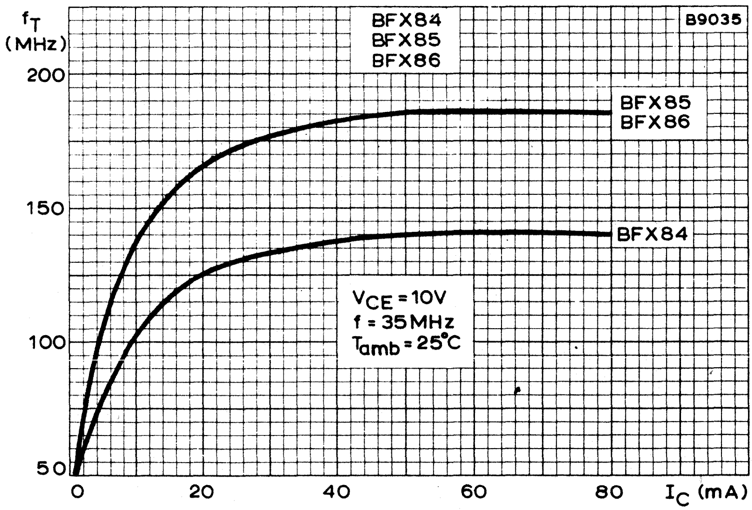




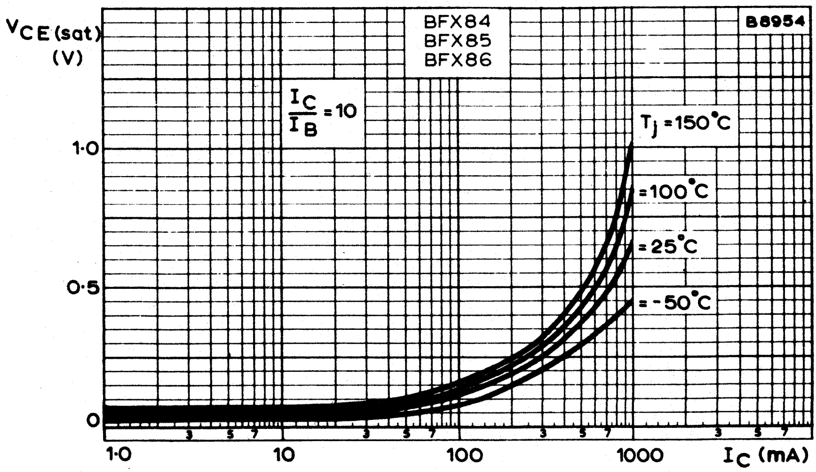
TYPICAL STATIC FORWARD CURRENT TRANSFER RATIO PLOTTED AGAINST COLLECTOR CURRENT AND JUNCTION TEMPERATURE



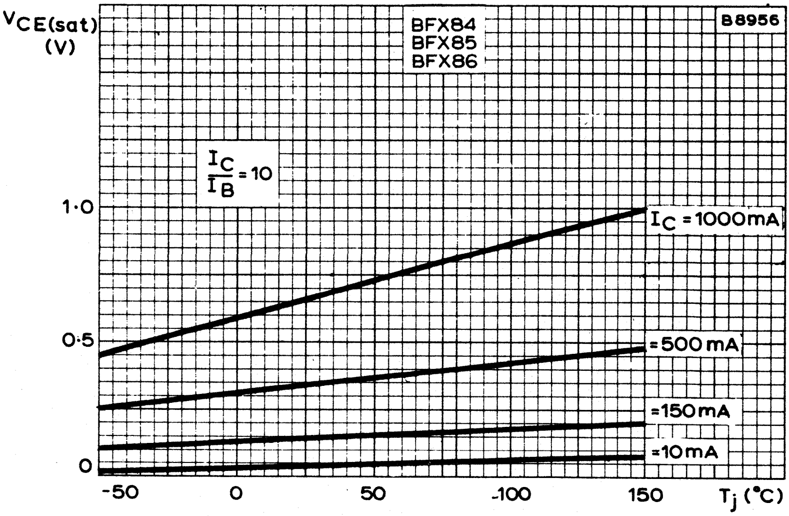
TYPICAL STATIC FORWARD CURRENT TRANSFER RATIO PLOTTED AGAINST JUNCTION TEMPERATURE



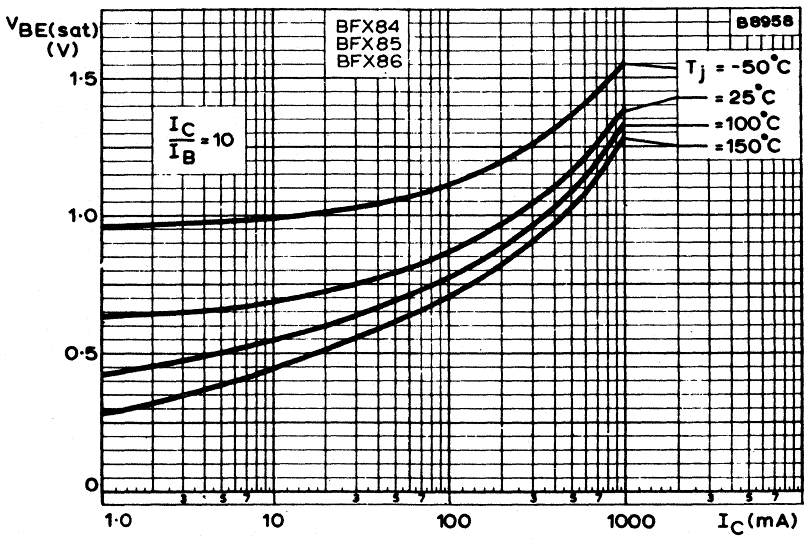
TYPICAL TRANSITION FREQUENCY PLOTTED AGAINST COLLECTOR CURRENT



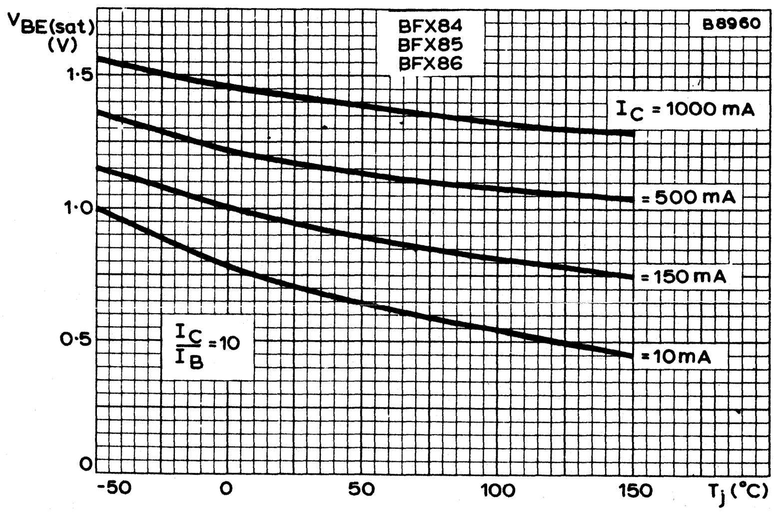
TYPICAL COLLECTOR-EMITTER SATURATION VOLTAGE
PLOTTED AGAINST COLLECTOR CURRENT



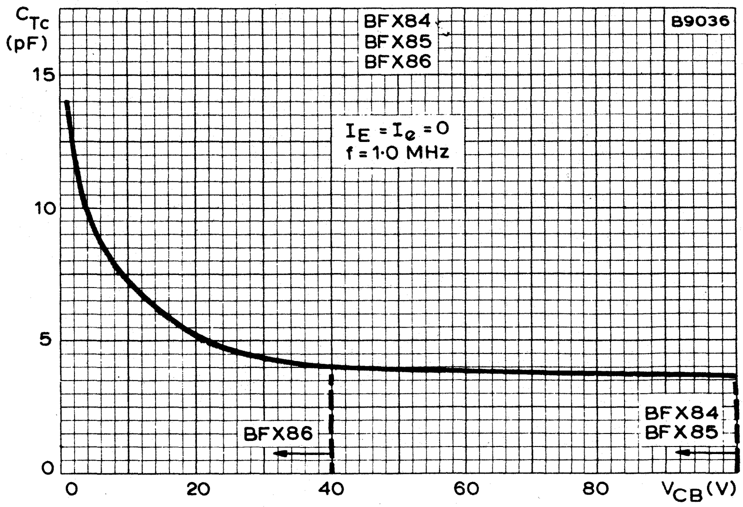
TYPICAL COLLECTOR-EMITTER SATURATION VOLTAGE
PLOTTED AGAINST JUNCTION TEMPERATURE



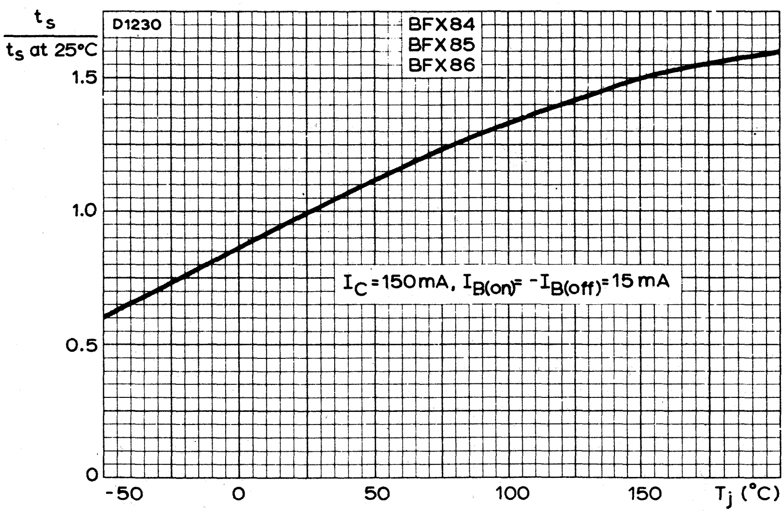
TYPICAL BASE-EMITTER SATURATION VOLTAGE
PLOTTED AGAINST COLLECTOR CURRENT



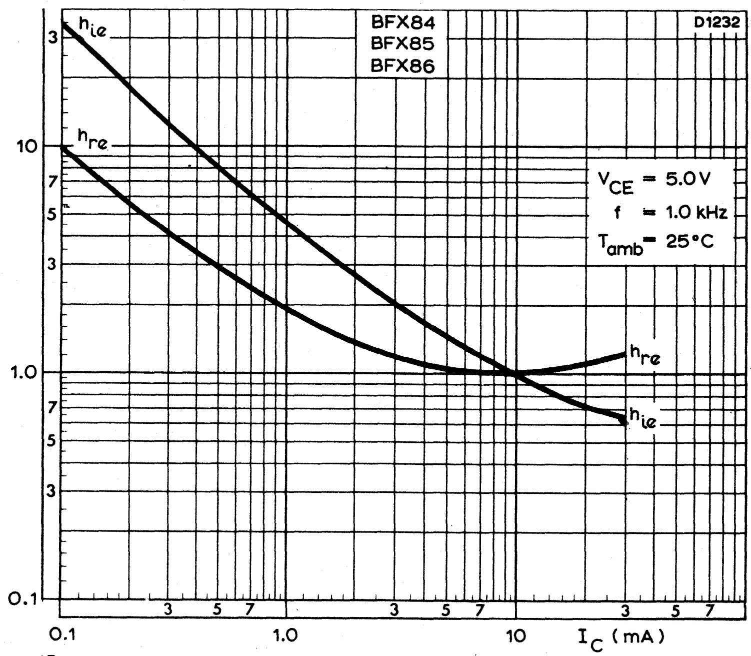
TYPICAL BASE-EMITTER SATURATION VOLTAGE
PLOTTED AGAINST JUNCTION TEMPERATURE

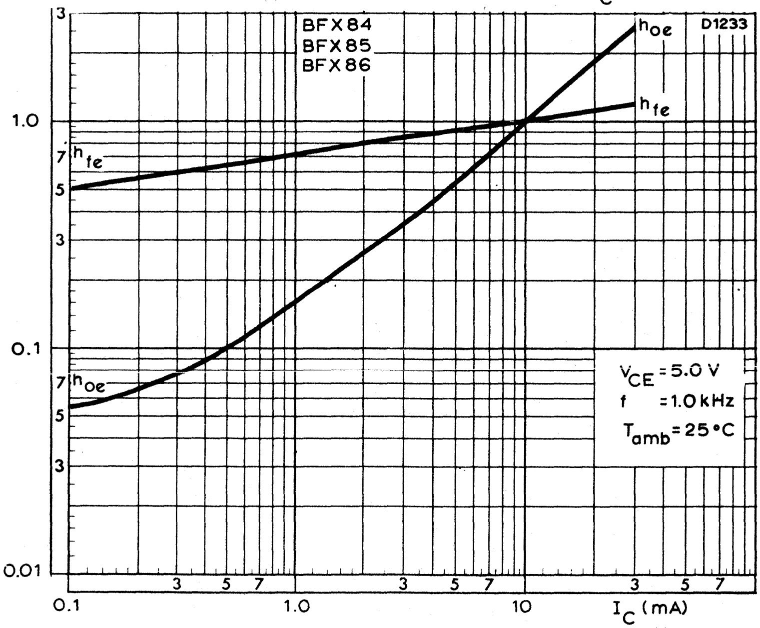


TYPICAL COLLECTOR CAPACITANCE PLOTTED AGAINST COLLECTOR-BASE VOLTAGE



TYPICAL STORAGE TIME NORMALISED AT 25°C





TYPICAL h-PARAMETERS NORMALISED AT I_C = 10mA

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

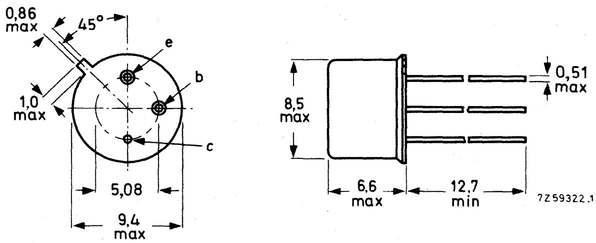
			BFY50	BFY51	BFY52	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	60	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	35	30	20	V
Collector current (peak value)	I_{CM}	max.	1,0	1,0	1,0	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	800	800	800	mW
Total power dissipation up to T_{case} = 100 °C	P_{tot}	max.	2,86	2,86	2,86	W
D.C. current gain I_C = 150 mA; V_{CE} = 10 V	h_{FE}	>	30	40	60	
		typ.	112	123	142	
Transition frequency at f = 35 MHz I_C = 50 mA; V_{CE} = 10 V; T_{amb} = 25 °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, $I_C \leq 1mA$)	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. $T_{amb} \leq 25^{\circ}C$		800		mW
$T_{case} \leq 25^{\circ}C$		5.0		W
$T_{case} > 25, < 100^{\circ}C$		2.86		W

Temperature

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

THERMAL CHARACTERISTICS

$R_{th(j-amb)}$ in free air	220	degC/W
$R_{th(j-case)}$	35	degC/W

BFY50

ELECTRICAL CHARACTERISTICS ($T_j = 25^oC$ unless otherwise stated)

		Min.	Typ.	Max.	
I_{CBO}	Collector cut-off current				
	$V_{CB} = 80V$, $I_E = 0$	-	10	500	nA
	$V_{CB} = 80V$, $I_E = 0$, $T_j = 100^oC$	-	0.5	30	μA
	$V_{CB} = 60V$, $I_E = 0$	-	2.0	50	nA
	$V_{CB} = 60V$, $I_E = 0$, $T_j = 100^oC$	-	0.1	2.5	μA
I_{EBO}	Emitter cut-off current				
	$V_{EB} = 6.0V$, $I_C = 0$	-	10	500	nA
	$V_{EB} = 5.0V$, $I_C = 0$	-	2.0	50	nA
	$V_{EB} = 5.0V$, $I_C = 0$, $T_j = 100^oC$	-	0.1	2.5	μA
h_{FE}	Static forward current transfer ratio				
	$I_C = 10mA$, $V_{CE} = 10V$	20	80	-	
	$I_C = 150mA$, $V_{CE} = 10V$	30	112	-	
	$I_C = 500mA$, $V_{CE} = 10V$	20	70	-	
	$I_C = 1.0A$, $V_{CE} = 10V$	15	35	-	
$V_{CE(sat)}$	Collector-emitter saturation voltage				
	$I_C = 10mA$, $I_B = 1.0mA$	-	0.06	0.10	V
	$I_C = 150mA$, $I_B = 15mA$	-	0.15	0.20	V
	$I_C = 500mA$, $I_B = 50mA$	-	0.35	0.70	V
	$I_C = 1.0A$, $I_B = 100mA$	-	0.66	1.00	V
$V_{BE(sat)}$	Base-emitter saturation voltage				
	$I_C = 10mA$, $I_B = 1.0mA$	-	0.69	1.2	V
	$I_C = 150mA$, $I_B = 15mA$	-	0.92	1.3	V
	$I_C = 500mA$, $I_B = 50mA$	-	1.15	1.5	V
	$I_C = 1.0A$, $I_B = 100mA$	-	1.40	2.0	V
C_{Tc}	Collector capacitance				
	$V_{CB} = 10V$, $I_E = I_e = 0$, f = 1.0MHz	-	7.0	12	pF

BFY50

ELECTRICAL CHARACTERISTICS (contd.)

		Min.	Typ.	Max.	
f_T	Transition frequency $I_C = 50mA$, $V_{CE} = 10V$, $f = 35MHz$, $T_{amb} = 25^oC$	60	140	-	MHz
Saturated switching times $I_C = 150mA$, $I_{B(on)} = -I_{B(off)} = 15mA$, $-V_{EE} = 10V$, $-V_{BE(off)} = 2.0V$					
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}	$I_C = 1.0mA$, $V_{CE} = 5.0V$, $f = 1.0kHz$, $T_{amb} = 25^oC$	10	65	-	
h_{ie}	$I_C = 10mA$, $V_{CE} = 5.0V$, $f = 1.0kHz$, $T_{amb} = 25^oC$	-	250	750	Ω
h_{re}		-	0.85	5.0	$\times10^{-4}$
h_{fe}		15	80	-	
h_{oe}		-	35	80	μmho

BFY51

ELECTRICAL CHARACTERISTICS ($T_j = 25^oC$ unless otherwise stated)

		Min.	Typ.	Max.	
I_{CBO}	Collector cut-off current				
	$V_{CB}=60V$, $I_E=0$	-	10	500	nA
	$V_{CB}=60V$, $I_E=0$, $T_j=100^oC$	-	0.5	30	μA
	$V_{CB}=40V$, $I_E=0$	-	2.0	50	nA
	$V_{CB}=40V$, $I_E=0$, $T_j=100^oC$	-	0.1	2.5	μA
I_{EBO}	Emitter cut-off current				
	$V_{EB}=6.0V$, $I_C=0$	-	10	500	nA
	$V_{EB}=5.0V$, $I_C=0$	-	2.0	50	nA
	$V_{EB}=5.0V$, $I_C=0$, $T_j=100^oC$	-	0.1	2.5	μA
h_{FE}	Static forward current transfer ratio				
	$I_C=10mA$, $V_{CE}=10V$	30	85	-	
	$I_C=150mA$, $V_{CE}=10V$	40	123	-	
	$I_C=500mA$, $V_{CE}=10V$	25	79	-	
	$I_C=1.0A$, $V_{CE}=10V$	15	40	-	
$V_{CE(sat)}$	Collector-emitter saturation voltage				
	$I_C=10mA$, $I_B=1.0mA$	-	0.06	0.15	V
	$I_C=150mA$, $I_B=15mA$	-	0.15	0.35	V
	$I_C=500mA$, $I_B=50mA$	-	0.35	1.00	V
	$I_C=1.0A$, $I_B=100mA$	-	0.66	1.60	V
$V_{BE(sat)}$	Base-emitter saturation voltage				
	$I_C=10mA$, $I_B=1.0mA$	-	0.69	1.2	V
	$I_C=150mA$, $I_B=15mA$	-	0.92	1.3	V
	$I_C=500mA$, $I_B=50mA$	-	1.15	1.5	V
	$I_C=1.0A$, $I_B=100mA$	-	1.40	2.0	V
C_{Tc}	Collector capacitance				
	$V_{CB}=10V$, $I_E=I_e=0$, f=1.0MHz	-	7.0	12	pF

BFY51/BFY52

ELECTRICAL CHARACTERISTICS (contd.)

		Min.	Typ.	Max.	
f_T	Transition frequency $I_C = 50mA$, $V_{CE} = 10V$, $f = 35MHz$, $T_{amb} = 25^oC$	50	-	-	MHz

Saturated switching times

$I_C = 150mA$, $I_{B(on)} = -I_{B(off)} = 15mA$,
$-V_{EE} = 10V$, $-V_{BE(off)} = 2.0V$

		Min.	Typ.	Max.	
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

		Min.	Typ.	Max.	
h_{fe}	$I_C = 1.0mA$, $V_{CE} = 5.0V$, $f = 1.0kHz$, $T_{amb} = 25^oC$	20	65	-	
h_{ie}	$I_C = 10mA$, $V_{CE} = 5.0V$, $f = 1.0kHz$, $T_{amb} = 25^oC$	-	250	750	Ω
h_{re}		-	0.85	5.0	$\times 10^{-4}$
h_{fe}		25	80	-	
h_{oe}		-	35	80	μmho

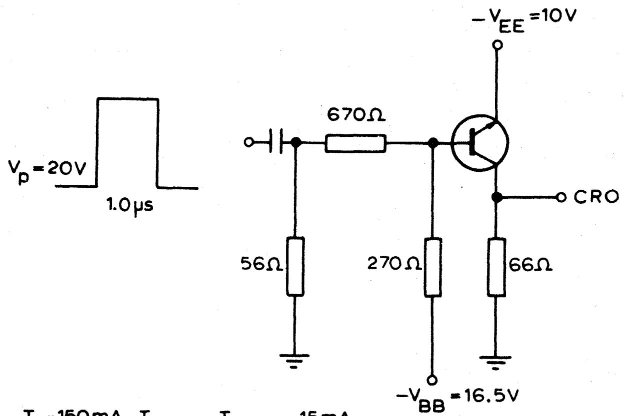
BFY52

ELECTRICAL CHARACTERISTICS ($T_j = 25^oC$ unless otherwise stated)

		Min.	Typ.	Max.	
I_{CBO}	Collector cut-off current				
	$V_{CB} = 40V$, $I_E = 0$	-	10	500	nA
	$V_{CB} = 40V$, $I_E = 0$, $T_j = 100^oC$	-	0.5	30	μA
	$V_{CB} = 30V$, $I_E = 0$	-	2.0	50	nA
	$V_{CB} = 30V$, $I_E = 0$, $T_j = 100^oC$	-	0.1	2.5	μA
I_{EBO}	Emitter cut-off current				
	$V_{EB} = 6.0V$, $I_C = 0$	-	10	500	nA
	$V_{EB} = 5.0V$, $I_C = 0$	-	2.0	50	nA
	$V_{EB} = 5.0V$, $I_C = 0$, $T_j = 100^oC$	-	0.1	2.5	μA
h_{FE}	Static forward current transfer ratio				
	$I_C = 10mA$, $V_{CE} = 10V$	30	90	-	
	$I_C = 150mA$, $V_{CE} = 10V$	60	142	-	
	$I_C = 500mA$, $V_{CE} = 10V$	30	90	-	
	$I_C = 1.0A$, $V_{CE} = 10V$	15	50	-	
$V_{CE(sat)}$	Collector-emitter saturation voltage				
	$I_C = 10mA$, $I_B = 1.0mA$	-	0.06	0.15	V
	$I_C = 150mA$, $I_B = 15mA$	-	0.15	0.35	V
	$I_C = 500mA$, $I_B = 50mA$	-	0.35	1.00	V
	$I_C = 1.0A$, $I_B = 100mA$	-	0.66	1.60	V
$V_{BE(sat)}$	Base-emitter saturation voltage				
	$I_C = 10mA$, $I_B = 1.0mA$	-	0.69	1.2	V
	$I_C = 150mA$, $I_B = 15mA$	-	0.92	1.3	V
	$I_C = 500mA$, $I_B = 50mA$	-	1.15	1.5	V
	$I_C = 1.0A$, $I_B = 100mA$	-	1.40	2.0	V
C_{Tc}	Collector capacitance				
	$V_{CB} = 10V$, $I_E = I_e = 0$, f = 1.0MHz	-	7.0	12	pF

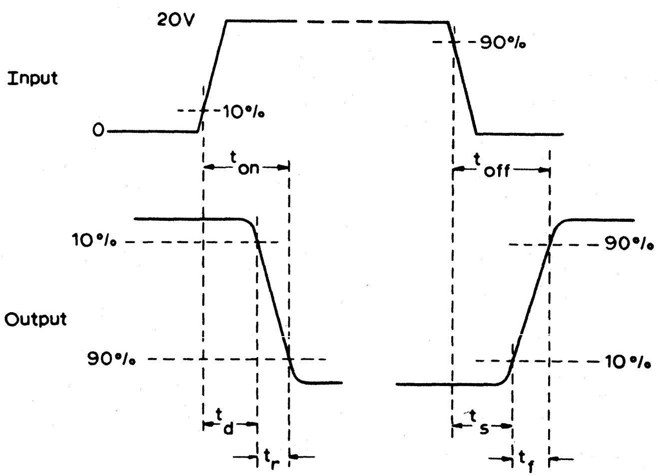
MEASUREMENT OF SATURATED SWITCHING TIMES

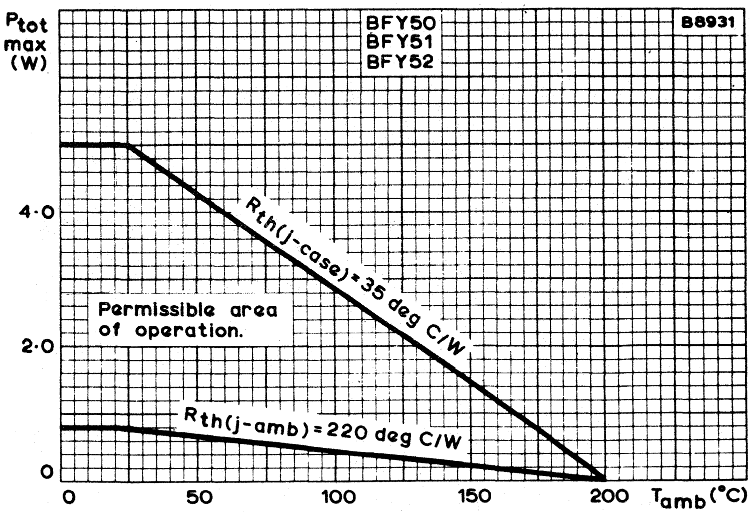
Test circuit



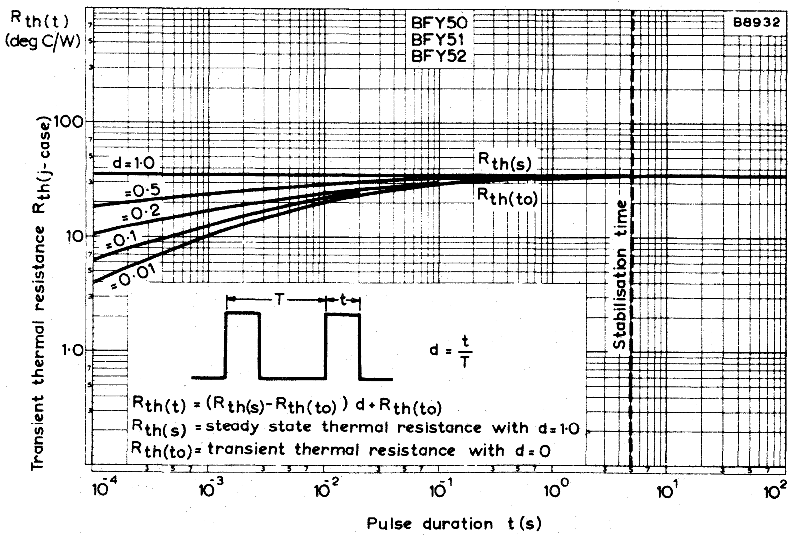
$I_C = 150mA$, $I_{B(on)} = -I_{B(off)} = 15mA$
$-V_{BE(off)} = 2.0V$

Switching waveforms

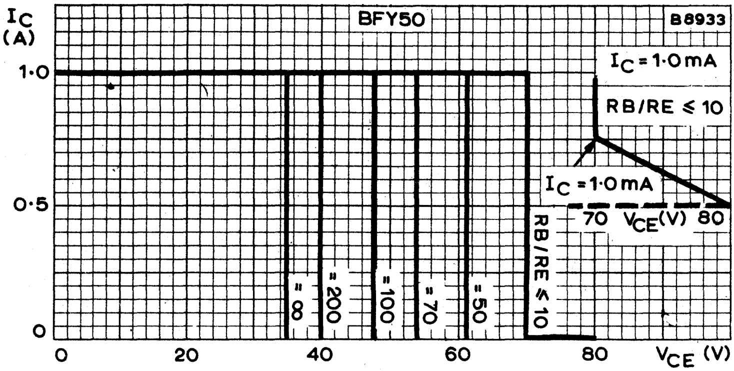


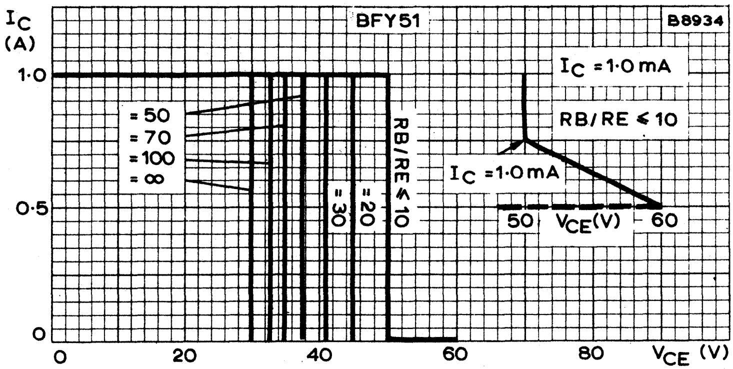


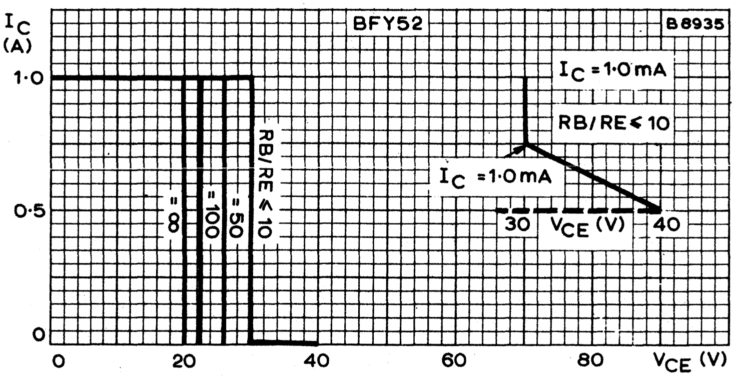
MAXIMUM TOTAL DISSIPATION PLOTTED AGAINST AMBIENT TEMPERATURE



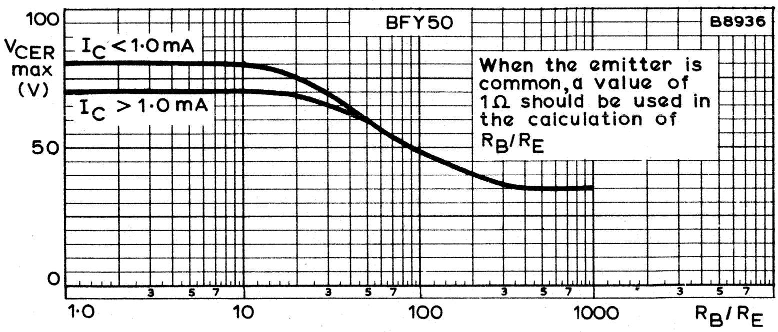
TRANSIENT THERMAL RESISTANCE FOR VARIOUS DUTY FACTORS PLOTTED AGAINST PULSE DURATION

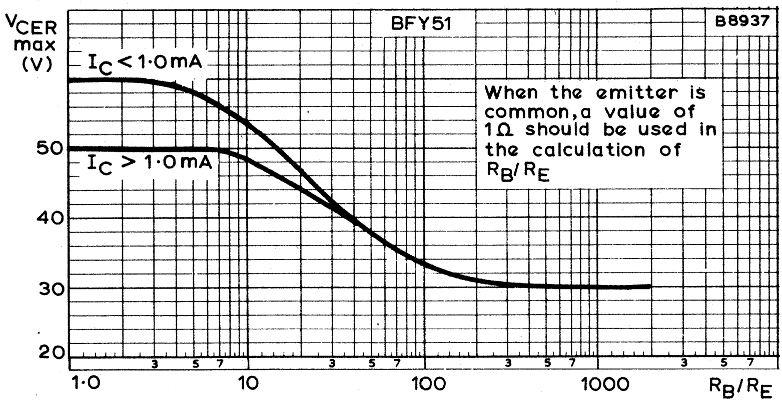


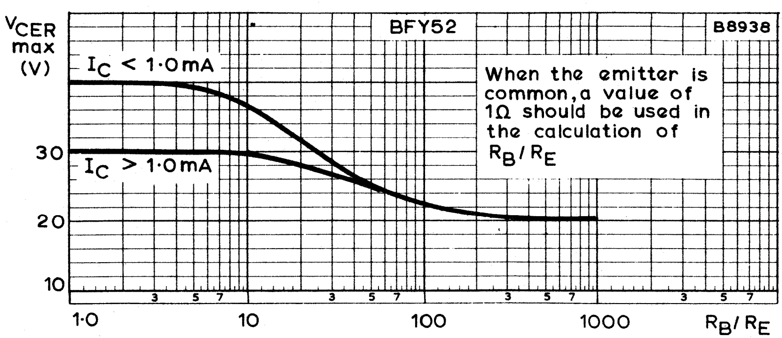




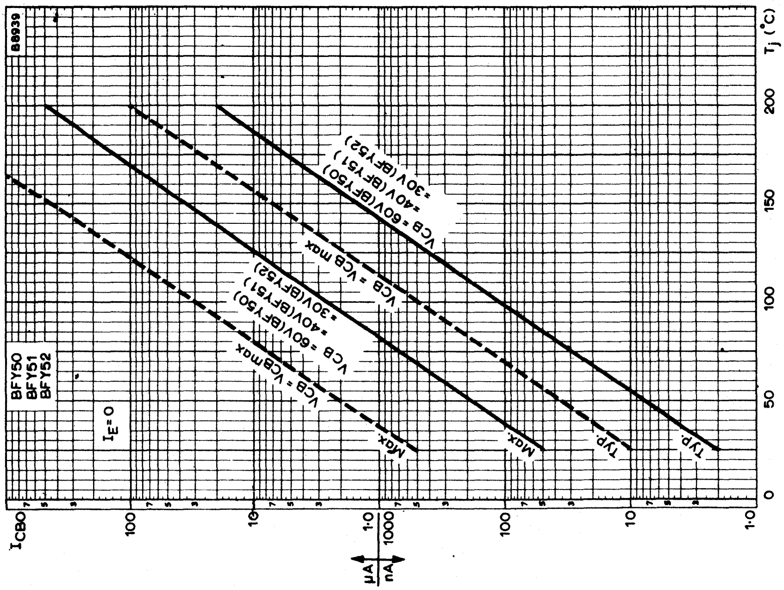
COLLECTOR CURRENT PLOTTED AGAINST MAXIMUM COLLECTOR-EMITTER VOLTAGE WITH R_B/R_E AS PARAMETER

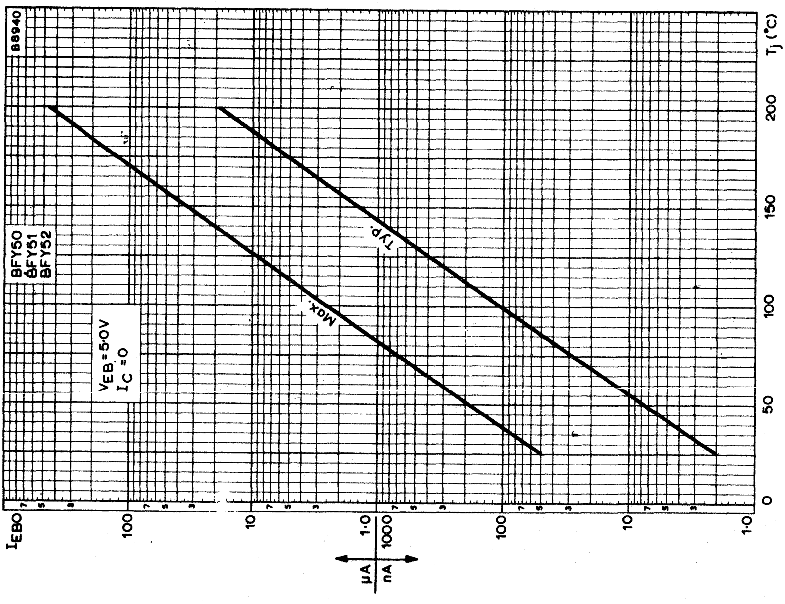




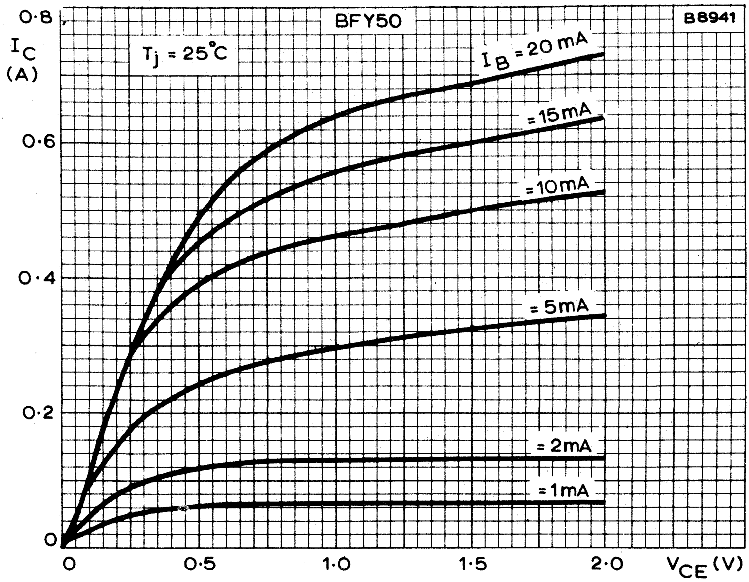


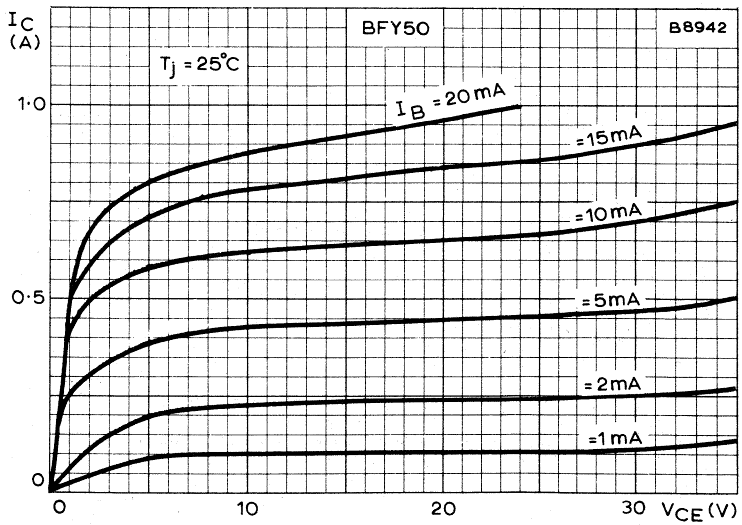
MAXIMUM COLLECTOR-EMITTER VOLTAGE PLOTTED AGAINST R_B/R_E RATIO



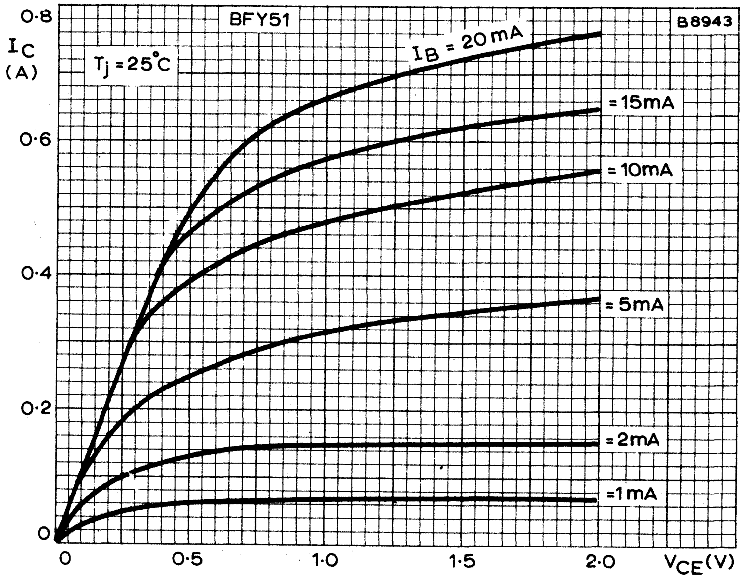


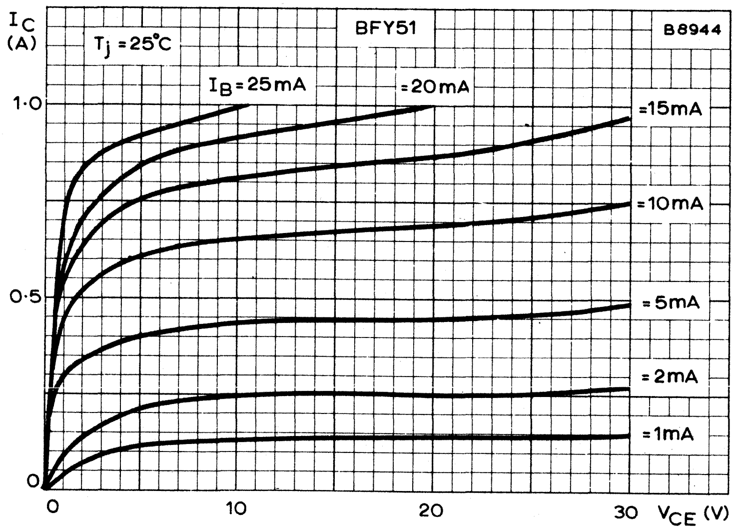
COLLECTOR AND EMITTER CUT-OFF CURRENTS PLOTTED AGAINST JUNCTION TEMPERATURE



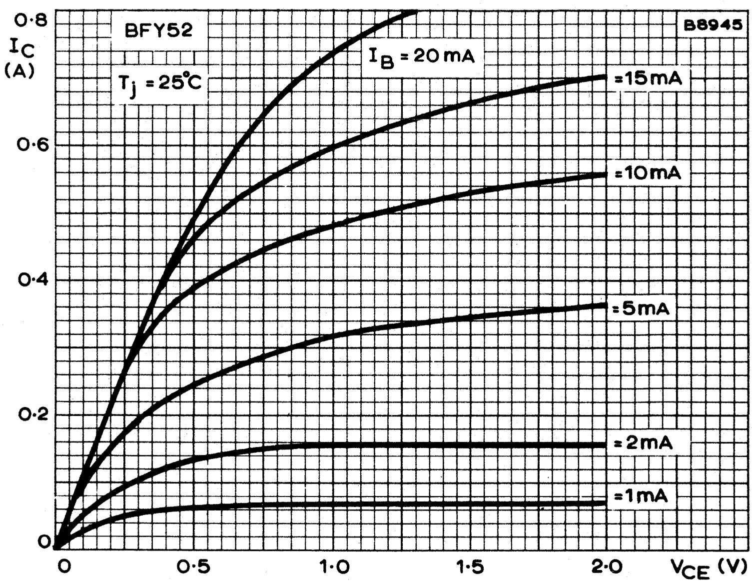


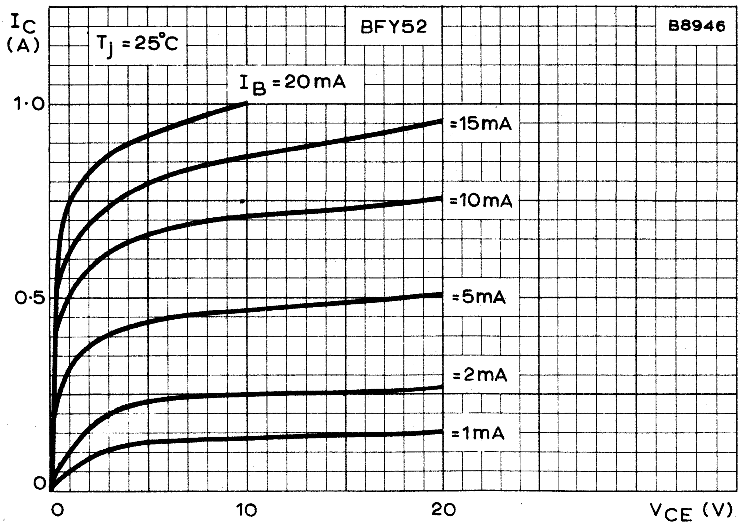
TYPICAL OUTPUT CHARACTERISTICS



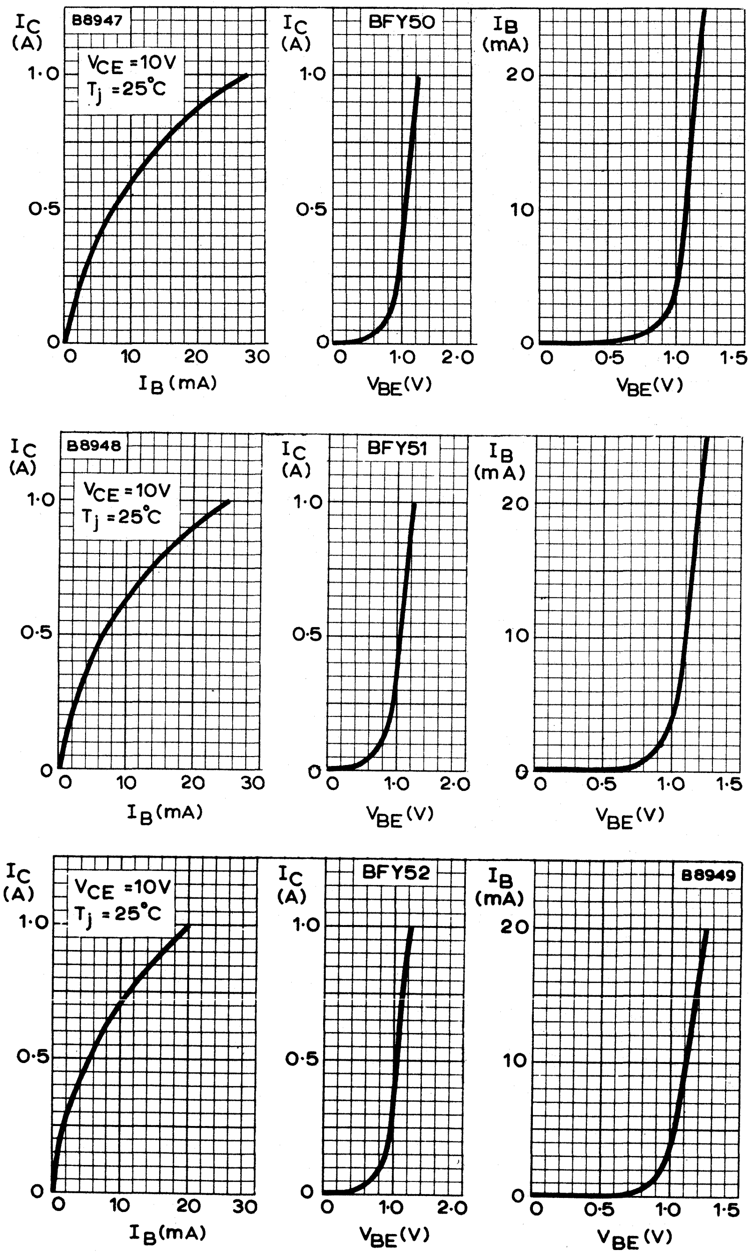


TYPICAL OUTPUT CHARACTERISTICS

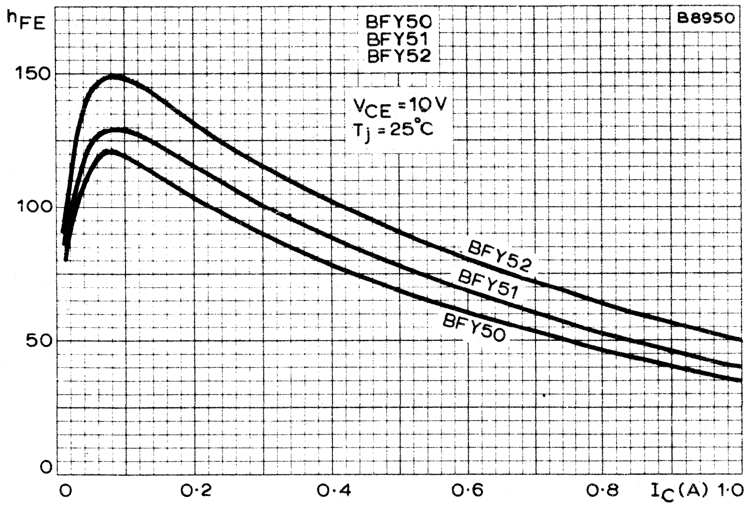


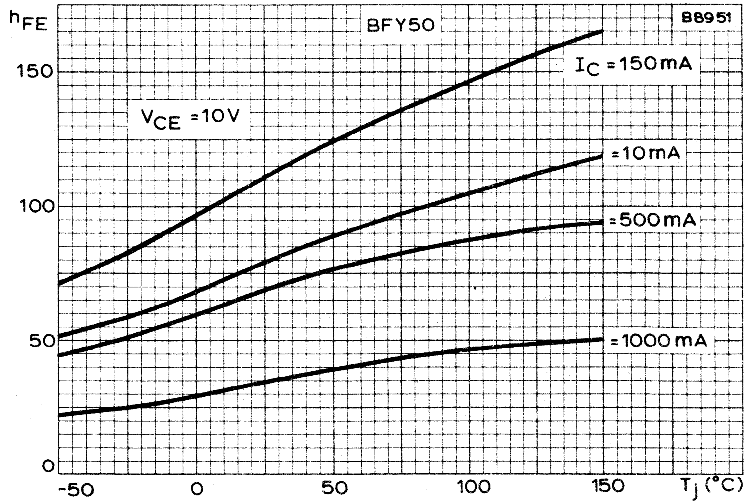


TYPICAL OUTPUT CHARACTERISTICS

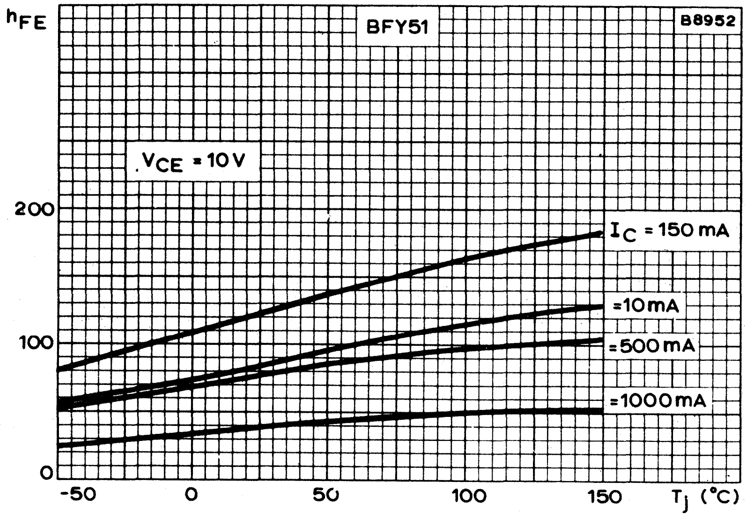


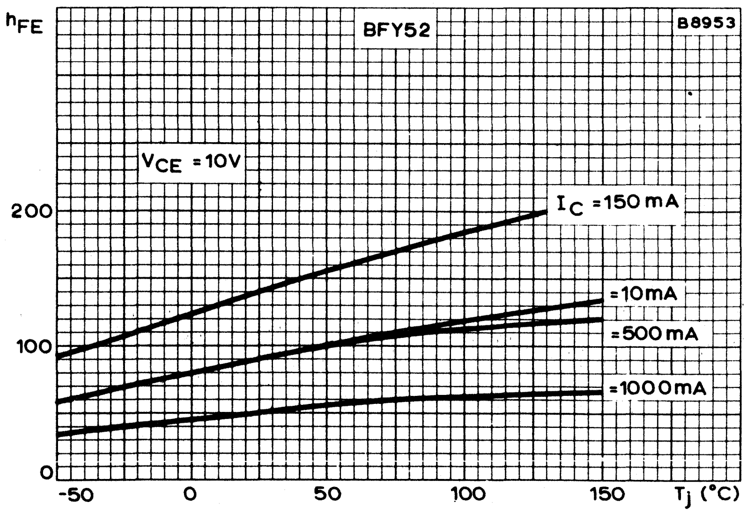
TYPICAL TRANSFER, MUTUAL AND INPUT CHARACTERISTICS



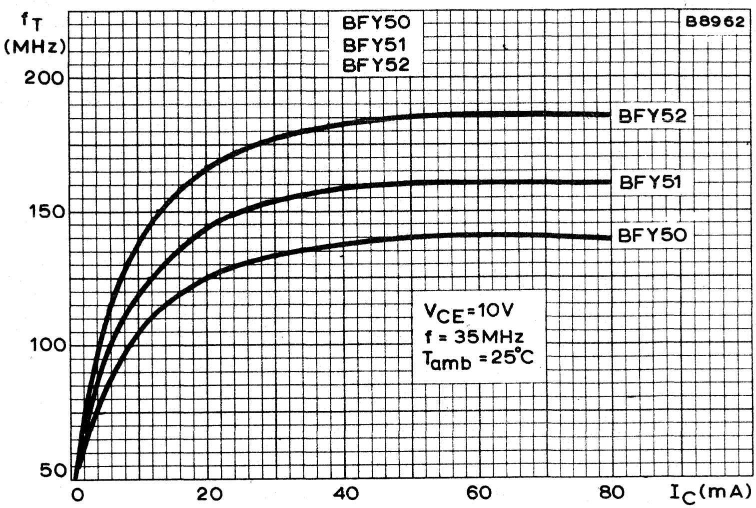


TYPICAL STATIC FORWARD CURRENT TRANSFER RATIO PLOTTED AGAINST COLLECTOR CURRENT AND JUNCTION TEMPERATURE

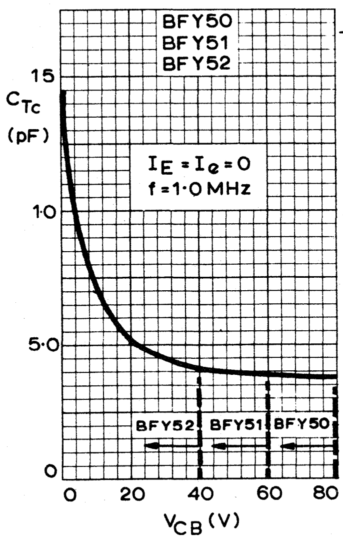




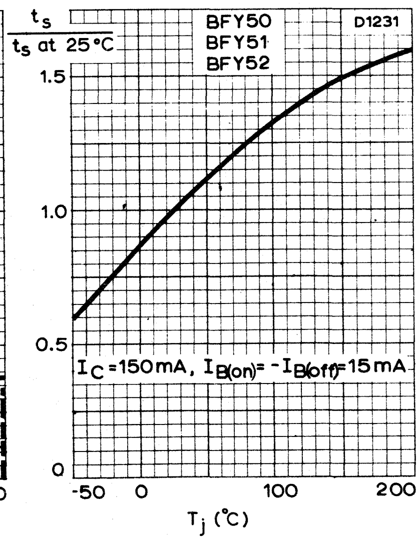
TYPICAL STATIC FORWARD CURRENT TRANSFER RATIO PLOTTED AGAINST JUNCTION TEMPERATURE



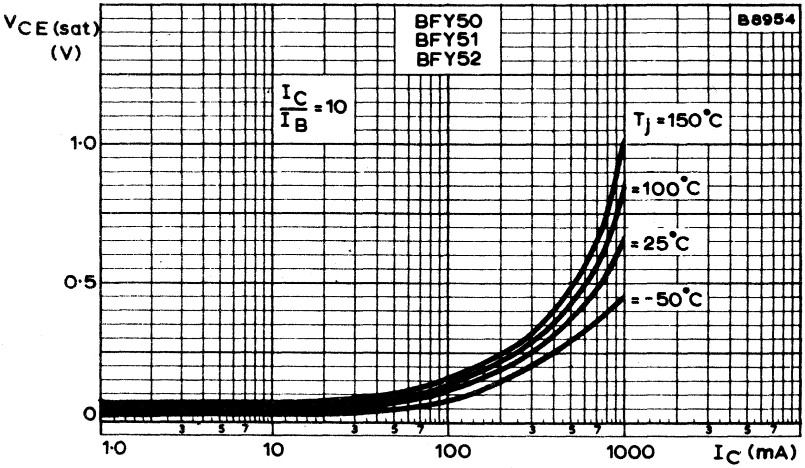
TYPICAL TRANSITION FREQUENCY PLOTTED AGAINST COLLECTOR CURRENT



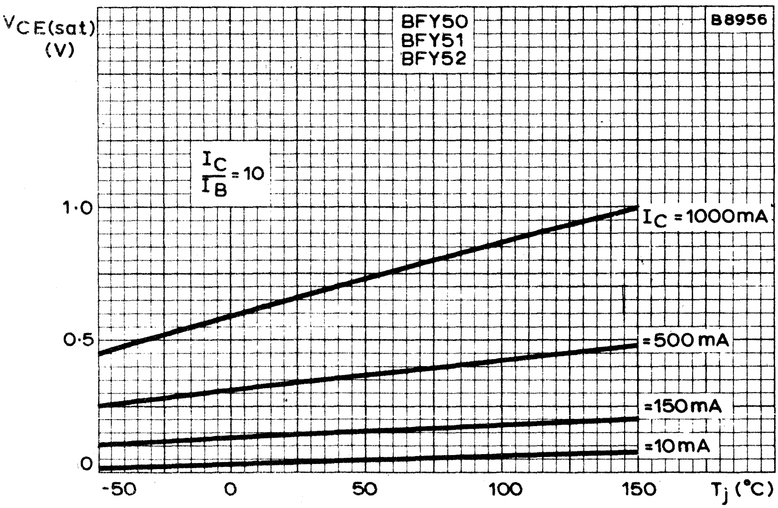
Typical collector capacitance versus collector-base voltage



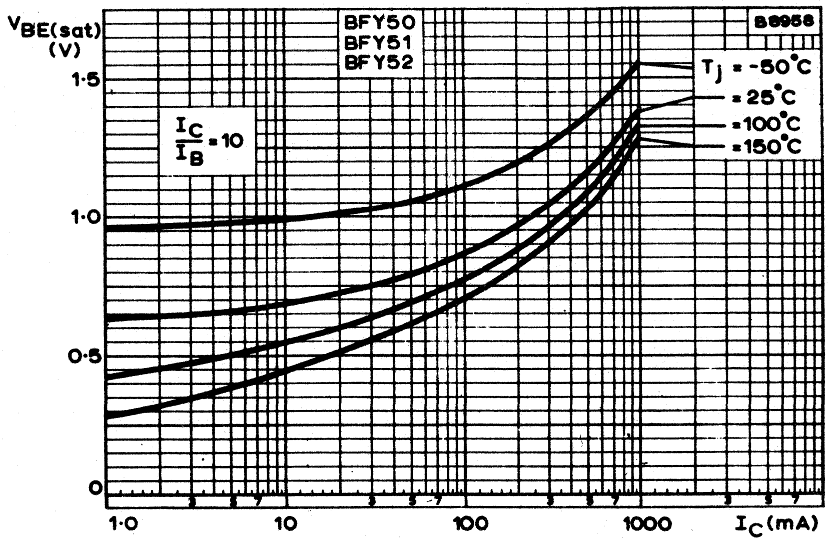
Typical storage time normalised at 25°C



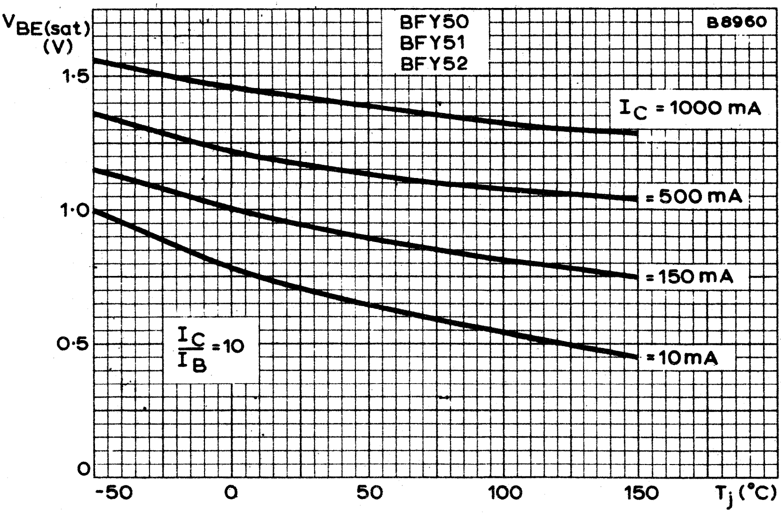
TYPICAL COLLECTOR–EMITTER SATURATION VOLTAGE
PLOTTED AGAINST COLLECTOR CURRENT



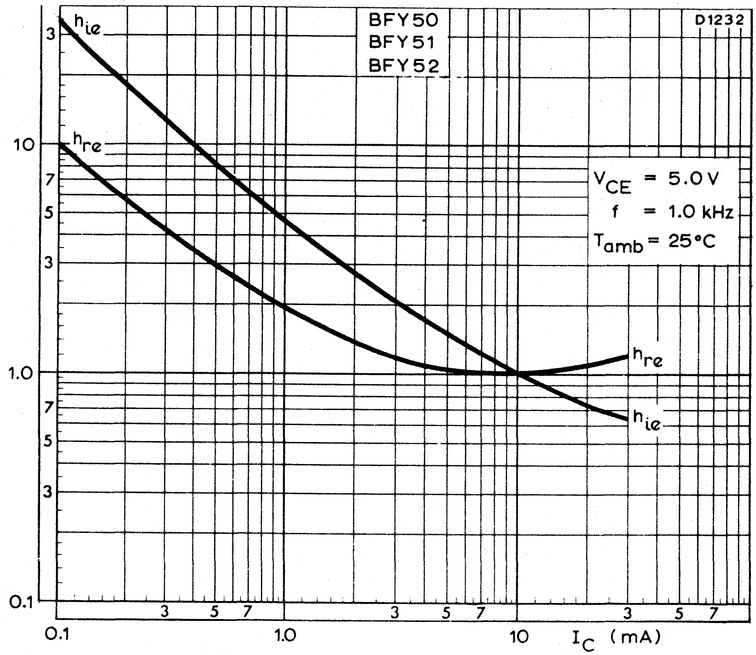
TYPICAL COLLECTOR–EMITTER SATURATION VOLTAGE
PLOTTED AGAINST JUNCTION TEMPERATURE

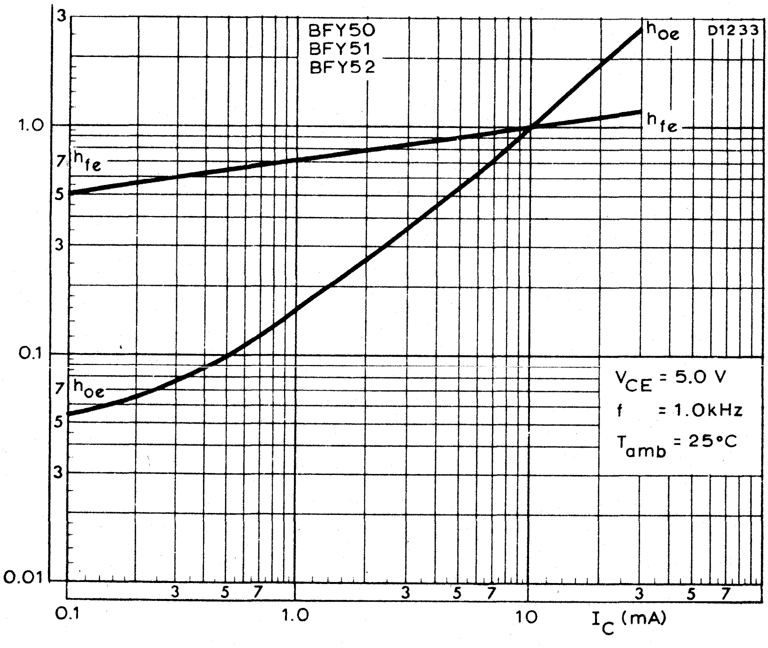


TYPICAL BASE-EMITTER SATURATION VOLTAGE
PLOTTED AGAINST COLLECTOR CURRENT



TYPICAL BASE-EMITTER SATURATION VOLTAGE
PLOTTED AGAINST JUNCTION TEMPERATURE





TYPICAL BASE-EMITTER SATURATION VOLTAGE

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

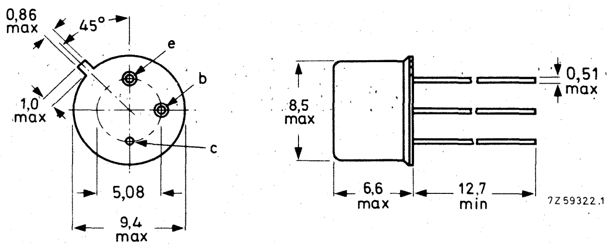
Collector-base voltage (open emitter)	V_{CBO}	max.	80	V
Collector-emitter voltage (open base)	V_{CEO}	max.	35	V
Collector current (d.c.)	I_C	max.	1	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	800	mW
Junction temperature	T_j	max.	200	°C
D.C. current gain at T_j = 25 °C; I_C = 150 mA; V_{CE} = 10 V	h_{FE}	>	40	
Transition frequency; I_C = 50 mA; V_{CE} = 10 V	f_T	>	60	MHz
Collector-emitter saturation voltage; I_C = 1 A; I_B = 100 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) [1]

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 °C	P_{tot}	max.	4	W
Total power dissipation without cooling fin up to T_{amb} = 25 °C	P_{tot}	max.	0.8	W

Temperatures

Storage temperature	T_{stg}		-65 to +200	°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.22	°C/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0.035	°C/mW

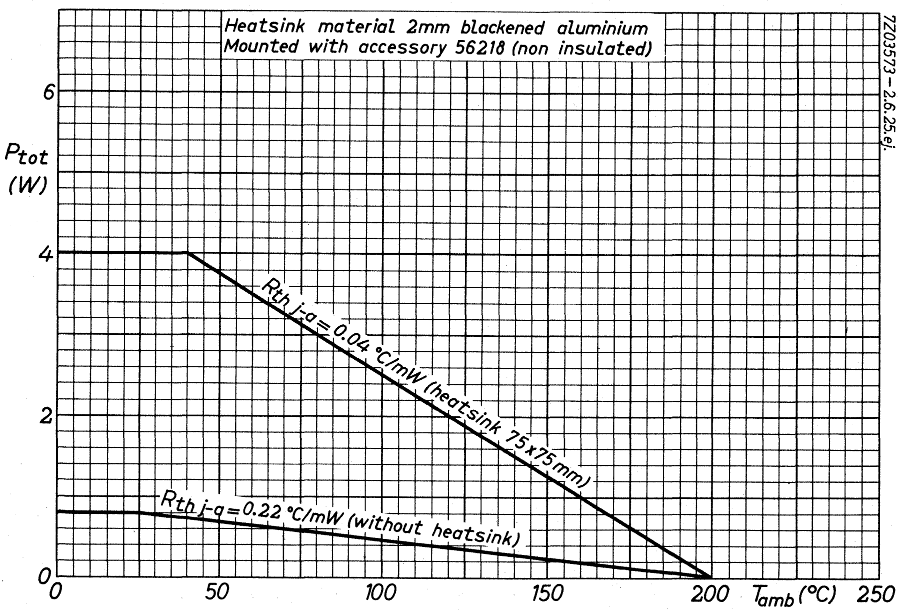
[1] Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

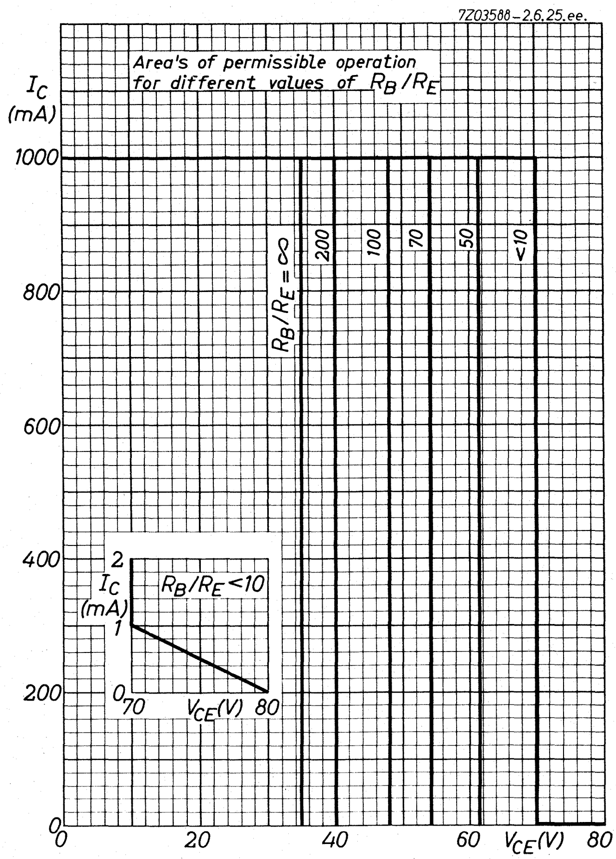
CHARACTERISTICS $T_j = 25\ ^oC$ unless otherwise specified

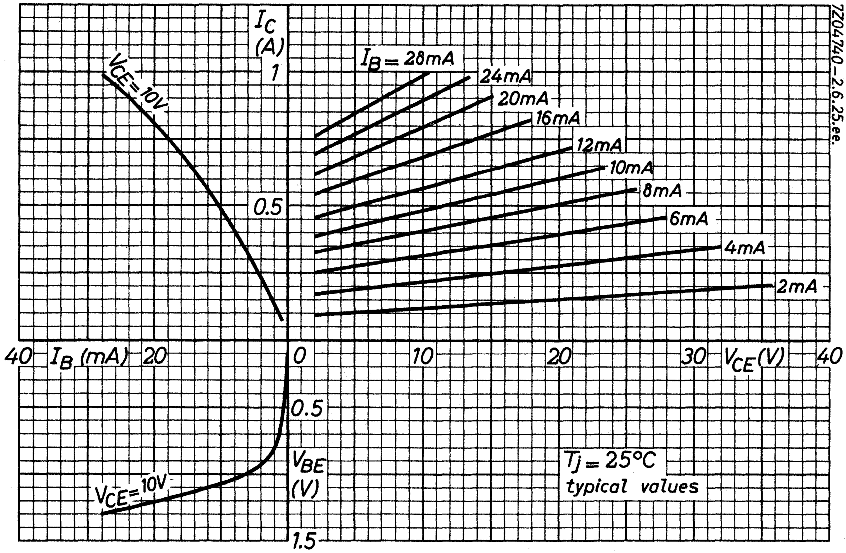
Collector cut-off current				
$I_E = 0$; $V_{CB} = 60$ V	I_{CBO}	<	10	nA
$I_E = 0$; $V_{CB} = 60$ V; $T_j = 150\ ^oC$	I_{CBO}	<	10	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10	nA
Saturation voltages				
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	0.2	V
$I_C = 1$ A; $I_B = 100$ mA [1][2]	V_{CEsat}	<	1.0	V
	V_{BEsat}	<	1.6	V
Sustaining voltage				
$I_C = 30$ mA; $I_B = 0$ [2]	$V_{CEOsust}$	>	35	V
D.C. current gain [2]				
$I_C = 10$ mA; $V_{CE} = 10$ V	h_{FE}	>	30	
$I_C = 150$ mA; $V_{CE} = 10$ V	h_{FE}	40 to 120		
$I_C = 1$ A; $V_{CE} = 10$ V	h_{FE}	>	15	
Feedback time constant				
$I_C = 10$ mA; $V_{CB} = 10$ V; f = 4 MHz	$r_{b'}C_c$	<	800	ps
Collector capacitance at f = 500 kHz				
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	12	pF
Emitter capacitance at f = 500 kHz				
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	<	80	pF
Transition frequency				
$I_C = 50$ mA; $V_{CE} = 10$ V	f_T	>	60	MHz

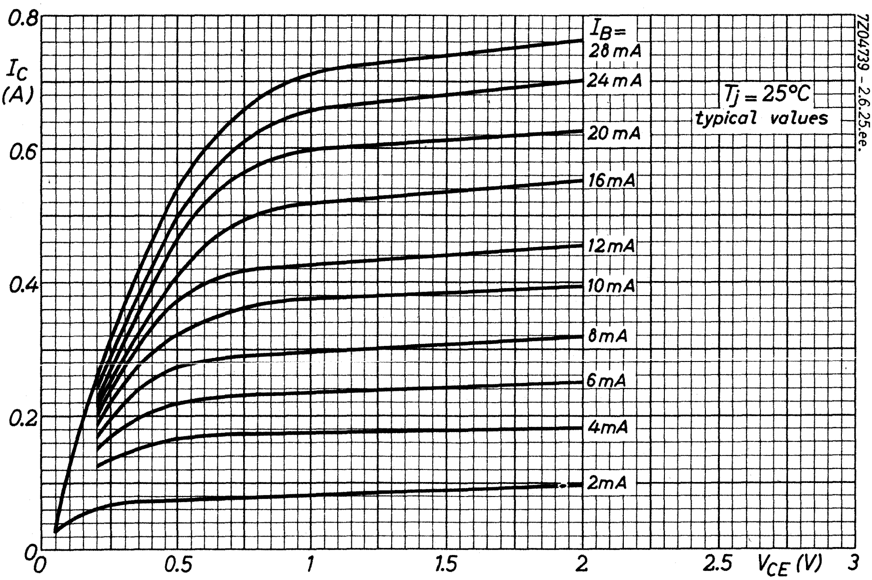
[1]) Measured with a lead length of 1 cm.

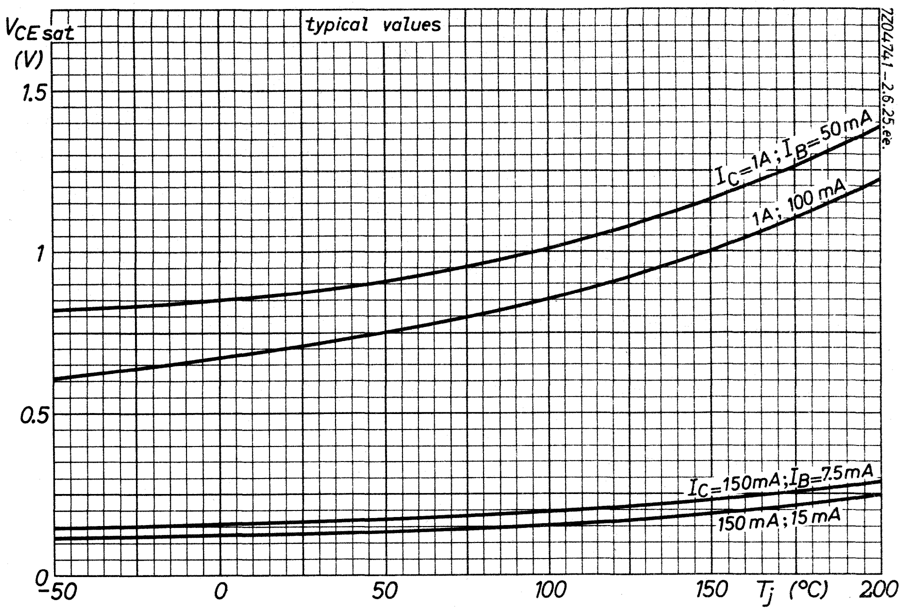
[2]) Measured under pulsed conditions to avoid excessive dissipation.
Pulse duration = 300 μs; duty cycle $\delta < 0.01$

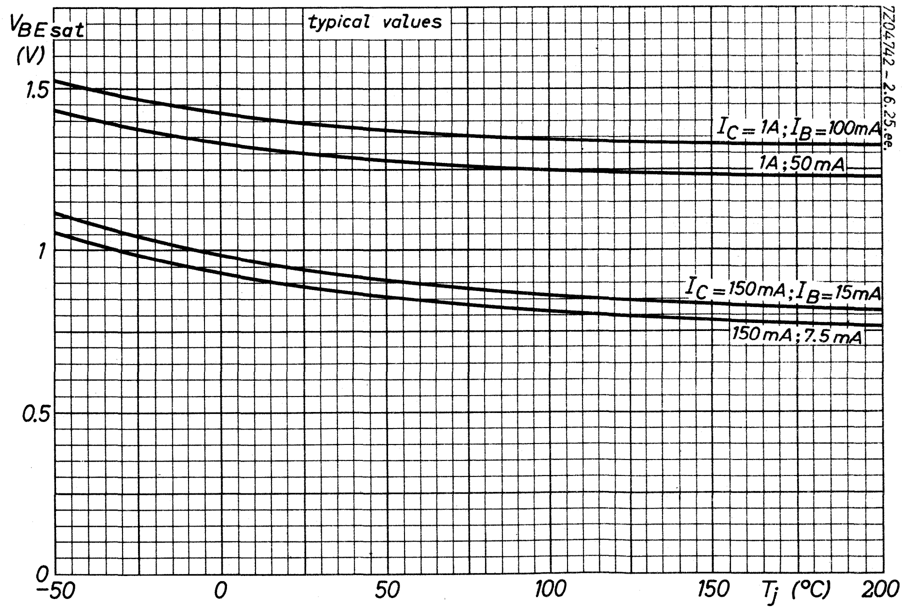

Heatsink material 2mm blackened aluminium
Mounted with accessory 56218 (non insulated)
7Z03573-2.6.25.ej.
Ptot (W)
6
4
2
0
Rth j-a = 0.04 °C/mW (heatsink 75x75mm)
Rth j-a = 0.22 °C/mW (without heatsink)
0
50
100
150
200
Tamb (°C)
250

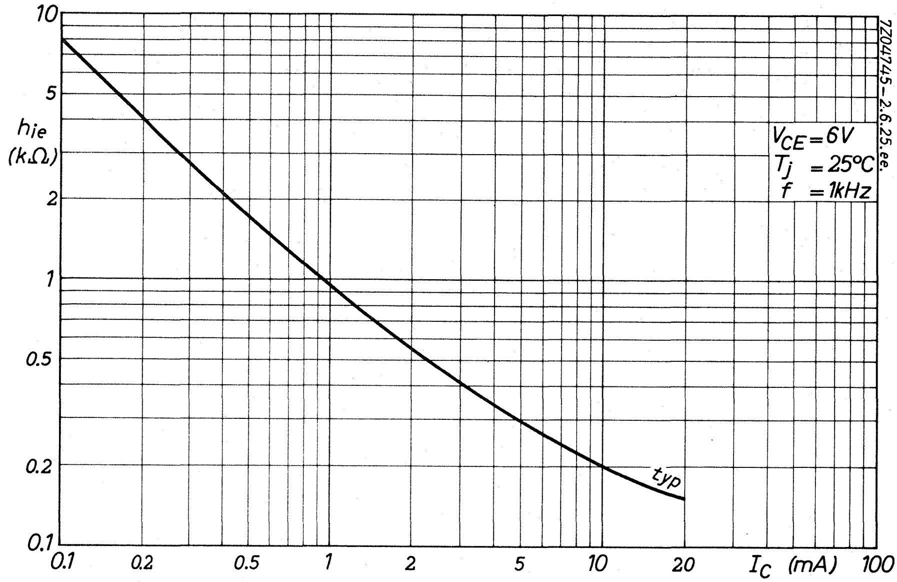

7Z03588-2.6.25.ee.
Area's of permissible operation
for different values of R_B/R_E
I_C (mA)
1000
800
600
400
200
0
$R_B/R_E=\infty$
200
100
70
50
<10
I_C (mA)
2
1
0
R_B/R_E<10
70
V_{CE}(V)
80
0
20
40
60
V_{CE}(V)
80

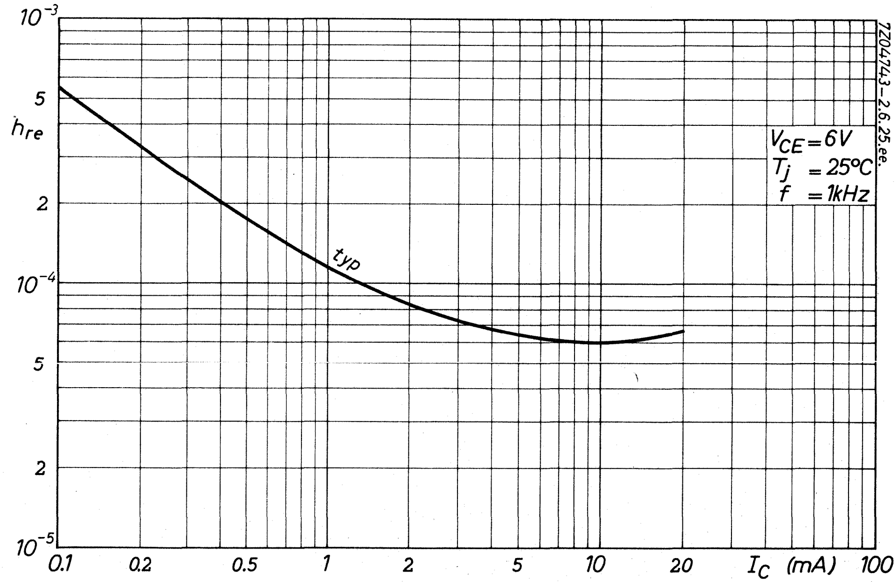

7Z04740 – 2.6.25.ee.
I_C (A)
1
0.5
I_B = 28mA
24mA
20mA
16mA
12mA
10mA
8mA
6mA
4mA
2mA
V_{CE} = 10V
40
I_B (mA)
20
0
10
20
30
V_{CE} (V)
40
0.5
V_{BE} (V)
1.5
V_{CE} = 10V
T_j = 25°C
typical values

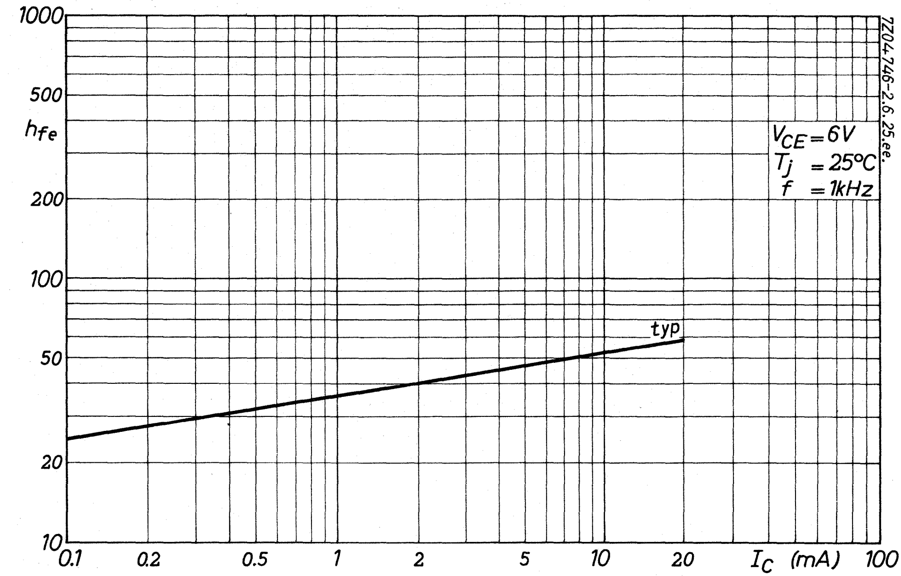

7Z04739 – 2.6.25.ee.
0.8
I_C (A)
0.6
0.4
0.2
0
I_B = 28 mA
24 mA
20 mA
16mA
12mA
10mA
8mA
6mA
4mA
2mA
T_j = 25°C
typical values
0
0.5
1
1.5
2
2.5
V_{CE} (V)
3

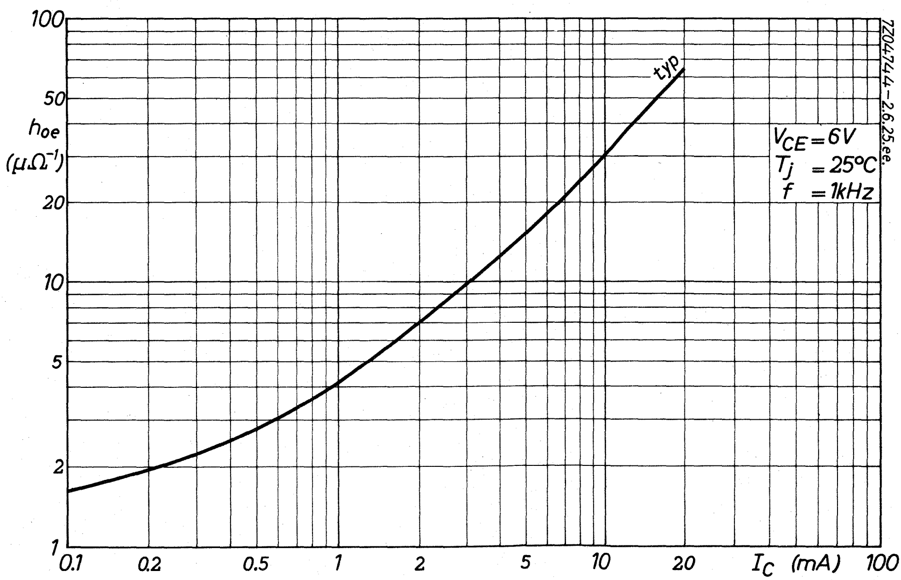

V_CE sat
(V)
typical values
7Z04741 - 2.6.25.ee.
I_C=1A; I_B=50mA
1A; 100 mA
I_C=150mA; I_B=7.5mA
150 mA; 15 mA
1.5
1
0.5
0
-50
0
50
100
150
T_j (°C)
200

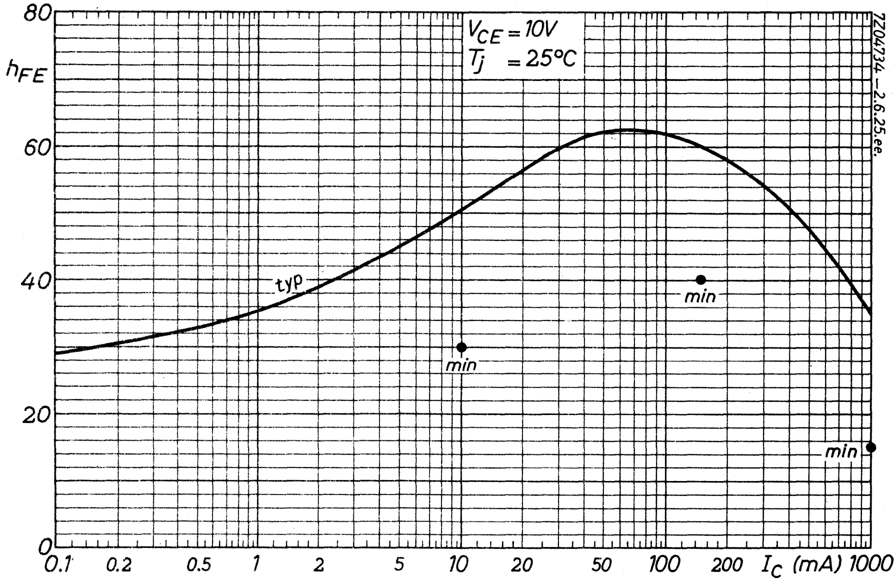

V_BE sat
(V)
typical values
7Z04742 - 2.6.25.ee.
I_C = 1A; I_B=100mA
1A; 50 mA
I_C =150mA; I_B=15mA
150 mA; 7.5 mA
1.5
1
0.5
0
-50
0
50
100
150
T_j (°C)
200

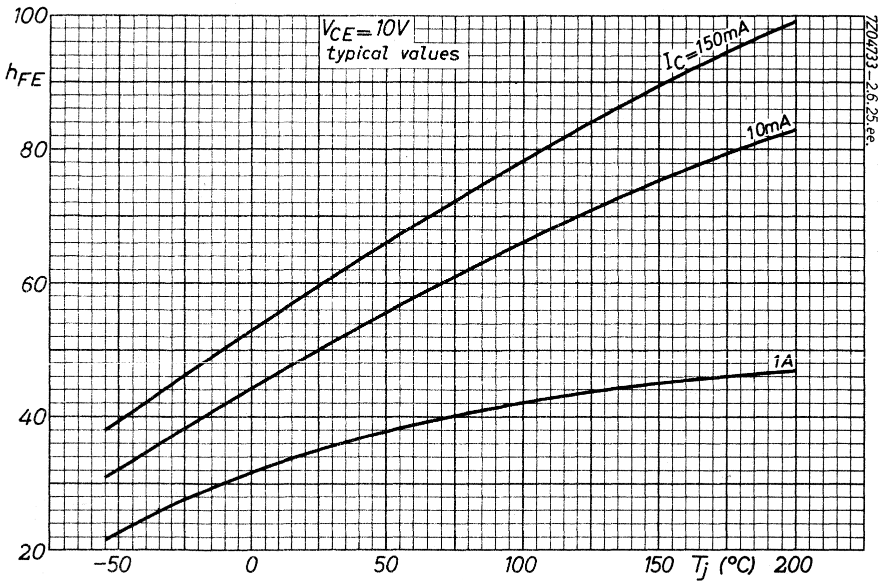

10
5
h_{ie}
(kΩ)
2
1
0.5
0.2
0.1
0.1
0.2
0.5
1
2
5
10
20
I_C (mA)
100
typ
V_{CE} = 6V
T_j = 25°C
f = 1kHz
7Z04745-2.6.25.ee.

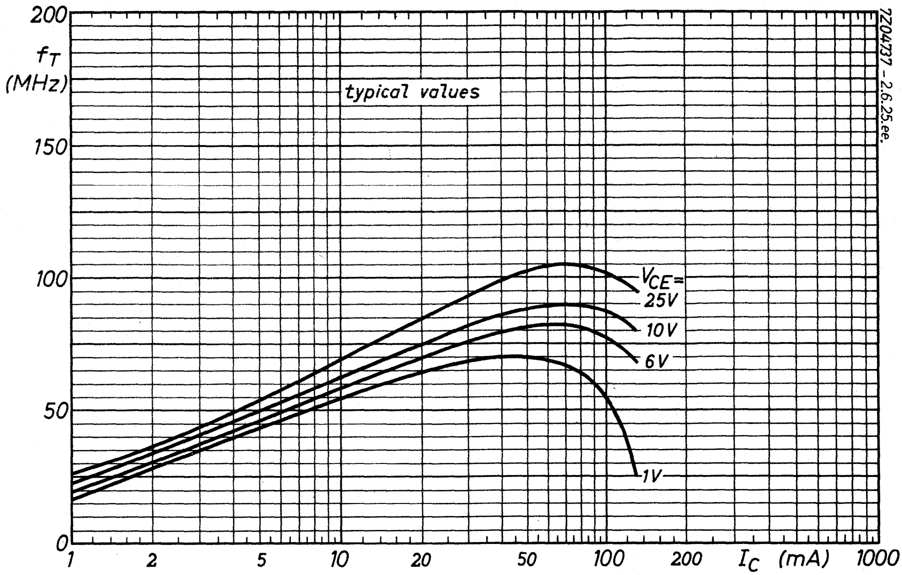

10^{-3}
5
h_{re}
2
10^{-4}
5
2
10^{-5}
0.1
0.2
0.5
1
2
5
10
20
I_C (mA)
100
typ
V_{CE} = 6V
T_j = 25°C
f = 1kHz
7Z04743-2.6.25.ee.

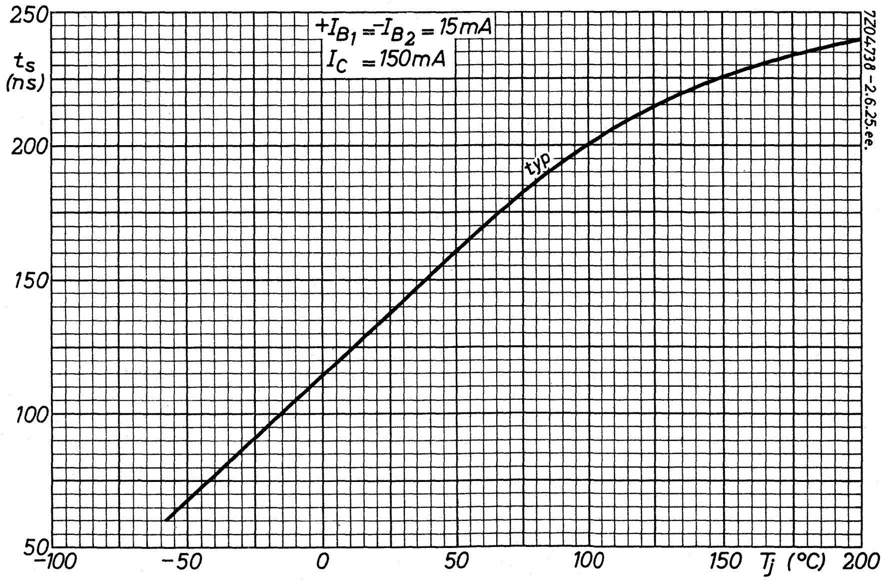

7Z04746-2.6.25.ee.
1000
500
h_{fe}
200
100
50
20
10
V_{CE} = 6V
T_j = 25°C
f = 1kHz
typ
0.1
0.2
0.5
1
2
5
10
20
I_C (mA)
100

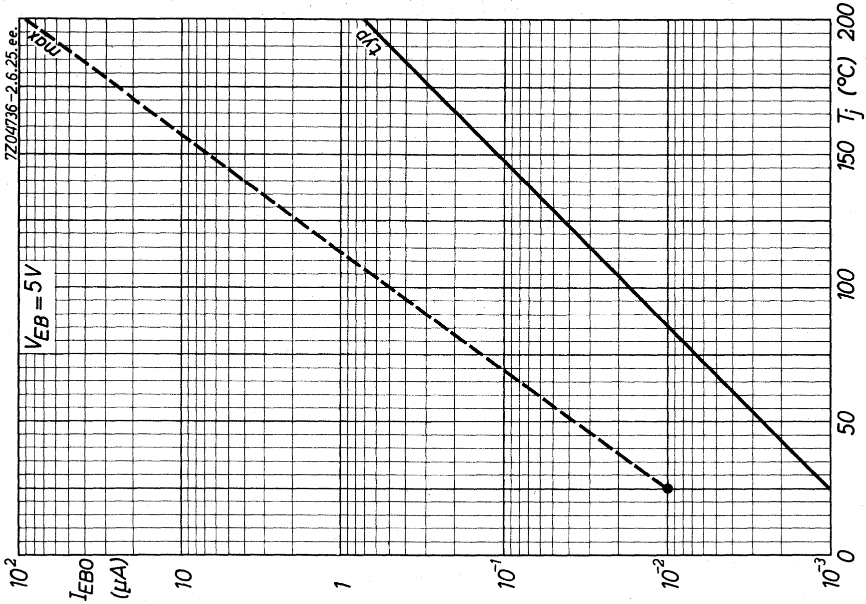

7Z04744-2.6.25.ee.
100
50
h_{oe}
($\mu\Omega^{-1}$)
20
10
5
2
1
V_{CE} = 6V
T_j = 25°C
f = 1kHz
typ
0.1
0.2
0.5
1
2
5
10
20
I_C (mA)
100

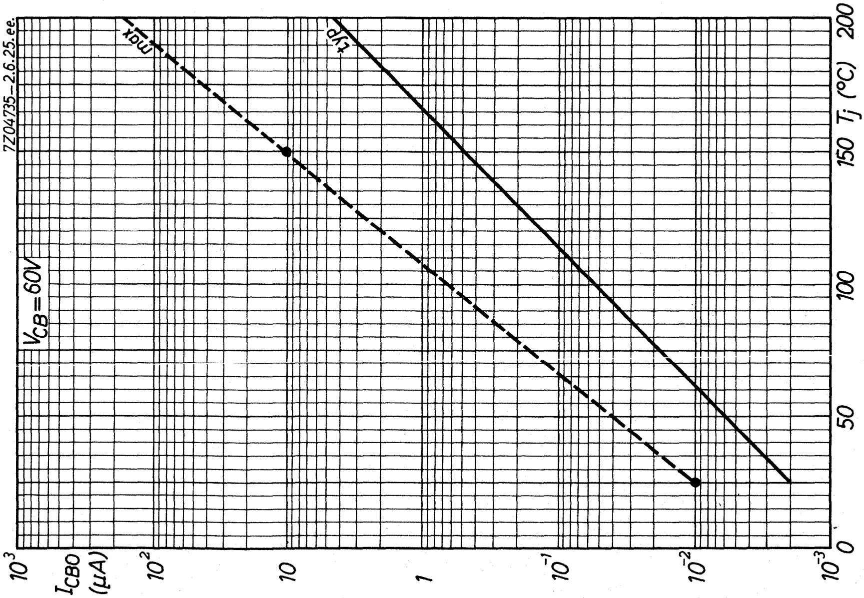

80
60
40
20
0
h_{FE}
$V_{CE} = 10V$
$T_j = 25^{\circ}C$
7Z04734–2.6.25.ee.
typ
min
min
min
0.1
0.2
0.5
1
2
5
10
20
50
100
200
I_C (mA)
1000


100
80
60
40
20
h_{FE}
$V_{CE} = 10V$
typical values
7Z04733–2.6.25.ee.
$I_C = 150mA$
10mA
1A
−50
0
50
100
150
T_j (°C)
200


200
f_T
(MHz)
150
100
50
0
typical values
V_{CE} =
25V
10V
6V
1V
1
2
5
10
20
50
100
200
I_C (mA)
1000
7Z04737 - 2.6.25.ee.


250
t_s
(ns)
200
150
100
50
$+I_{B1} = -I_{B2} = 15mA$
$I_C = 150mA$
typ
-100
-50
0
50
100
150
T_j (°C)
200
7Z04738 - 2.6.25.ee.


7Z04736-2.6.25.ee.
$V_{EB} = 5V$
max
typ
I_{EBO} (μA)
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
T_j (°C)
0
50
100
150
200


7Z04735-2.6.25.ee.
$V_{CB} = 60V$
max
typ
I_{CBO} (μA)
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
T_j (°C)
0
50
100
150
200

SILICON CONTROLLED SWITCH

The BR101 is a planar p-n-p-n 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

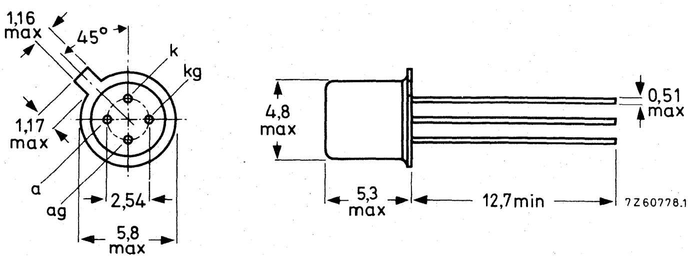
p-n-p transistor				
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	50	V
n-p-n transistor				
Collector-base voltage (open emitter)	V_{CBO}	max.	50	V
Repetitive peak emitter current (peak value)	$-I_{ERM}$	max.	2,5	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	275	mW
Junction temperature	T_j	max.	150	°C
Forward on-state voltage I_A = 50 mA; I_{AG} = 0; $R_{KG\text{-}K}$ = 10 kΩ	V_{AK}	<	1,4	V
Holding current I_{AG} = 10 mA; $-V_{BB}$ = 2 V; $R_{KG\text{-}K}$ = 10 kΩ	I_H	<	1,0	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)

			p-n-p	n-p-n	
Voltages					
Collector-base voltage (open emitter)	V_{CBO}	max.	-50	50	V
Collector-emitter voltage (R_{BE} = 10 kΩ)	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 μs; δ = 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 °C	P_{tot}	max.	275		mW
Temperatures					
Storage temperature	T_{stg}	-65 to +200			°C
Operating junction temperature	T_j	max.	150		°C

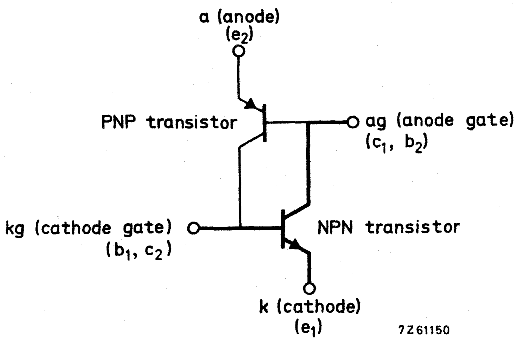
THERMAL RESISTANCE

From junction to ambient	$R_{th\ j-a}$	=	0,45	°C/mW

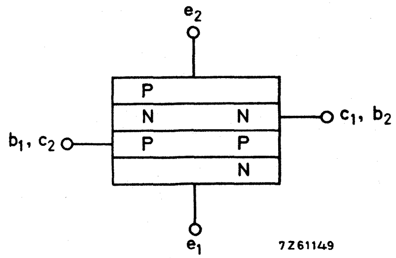
1) Exceeding of this voltage is allowed during the discharge of a capacitor of max. 390 pF, provided the charge does not exceed 50 nC.
2) Provided the I_E rating will not be exceeded.

MEANING OF SYMBOLS , used in the schematic presentation of the S.C.S.

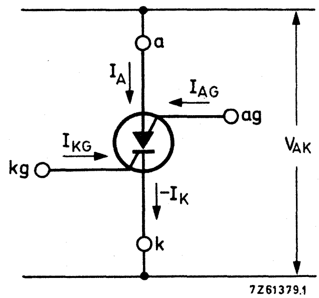
2 transistors equivalent circuit
n-p-n transistor + p-n-p transistor



p-n-p-n S.C.S. equivalent circuit



S.C.S. symbol



CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Individual N-P-N transistor

Collector cut-off current

V_{CE} = 50 V; R_{BE} = 10 kΩ	I_{CER}	<	0,5	µA
V_{CE} = 50 V; R_{BE} = 10 kΩ; T_j = 150 °C	I_{CER}	<	50	µA

Emitter cut-off current

I_C = 0; V_{EB} = 5 V; T_j = 150 °C	I_{EBO}	<	50	µA

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

Individual N-P-N transistor

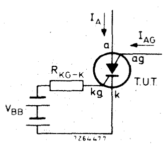
Saturation voltages				
$I_C = 10\ mA$; $I_B = 1\ mA$	V_{CEsat}	<	500	mV
	V_{BEsat}	<	900	mV
D.C. current gain				
$I_C = 10\ mA$; $V_{CE} = 2\ V$	h_{FE}	>	50	
Transition frequency				
$I_C = 10\ mA$; $V_{CE} = 2\ V$	f_T	typ.	300	MHz
Collector capacitance				
$I_E = I_e = 0$; $V_{CB} = 20\ V$	C_c	<	5	pF
Emitter capacitance				
$I_C = I_c = 0$; $V_{EB} = 1\ V$	C_e	<	25	pF

Individual P-N-P transistor

Collector cut-off current				
$I_B = 0$; $-V_{CE} = 50\ V$; $T_j = 150\ ^oC$	$-I_{CEO}$	<	50	µA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 50\ V$; $T_j = 150\ ^oC$	$-I_{EBO}$	<	50	µA
D.C. current gain				
$I_E = 1\ mA$; $V_{CB} = 0$	h_{FE}	0,25 to 2,5		

Combined device

Forward on-state voltage at $R_{KG-K} = 10\ k\Omega$				
$I_A = 50\ mA$; $I_{AG} = 0$	V_{AK}	<	1,4	V
$I_A = 1\ mA$; $I_{AG} = 10\ mA$	V_{AK}	<	1,2	V
Holding current at $R_{KG-K} = 10\ k\Omega$				
$I_{AG} = 10\ mA$; $-V_{BB} = 2\ V$	I_H	<	1,0	mA



PROGRAMMABLE UNIJUNCTION TRANSISTOR

The BRY39P 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

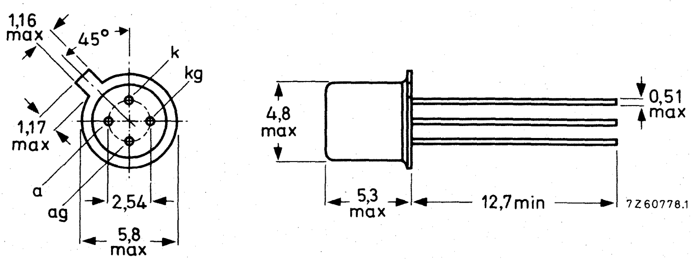
Gate-anode voltage	V_{GA}	max.	70	V
Anode current (d.c.) up to T_{case} = 85 °C	I_A	max.	250	mA
Operating junction temperature	T_j	max.	150	°C
Peak point current V_S = 10 V; R_G = 10 kΩ	I_P	$<$	5	μA
Valley point current V_S = 10 V; R_G = 10 kΩ	I_V	$>$	25	μA

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 °C	I_A	max.	175	mA
Anode current (d.c.) up to T_{case} = 85 °C	I_A	max.	250	mA
Repetitive peak anode current t = 10 μs; δ = 0,01	I_{ARM}	max.	2,5	A
Non-repetitive peak anode current t = 10 μs; T_j = 150 °C	I_{ASM}	max.	3	A
Rate of rise of anode current up to I_A = 2,5 A	$\frac{dI_A}{dt}$	max.	20	A/μs
Storage temperature	T_{stg}	−65 to + 200		°C
Operating junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	450	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	150	K/W

EXPLANATION OF SYMBOLS

For application of the BRY39P 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.

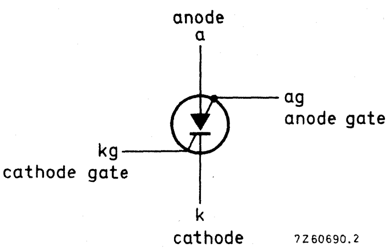


Fig. 2.

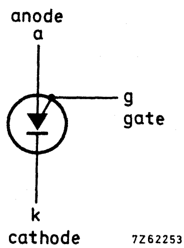


Fig. 3.

CHARACTERISTICS

$T_{amb} = 25\ ^oC$

Peak point current			
$V_S = 10\ V;\ R_G = 10\ k\Omega$	I_P	<	5 μA
$V_S = 10\ V;\ R_G = 1\ M\Omega$	I_P	<	1 μA
Valley point current			
$V_S = 10\ V;\ R_G = 10\ k\Omega$	I_V	>	25 μA ←
$V_S = 10\ V;\ R_G = 1\ M\Omega$	I_V	<	50 μA

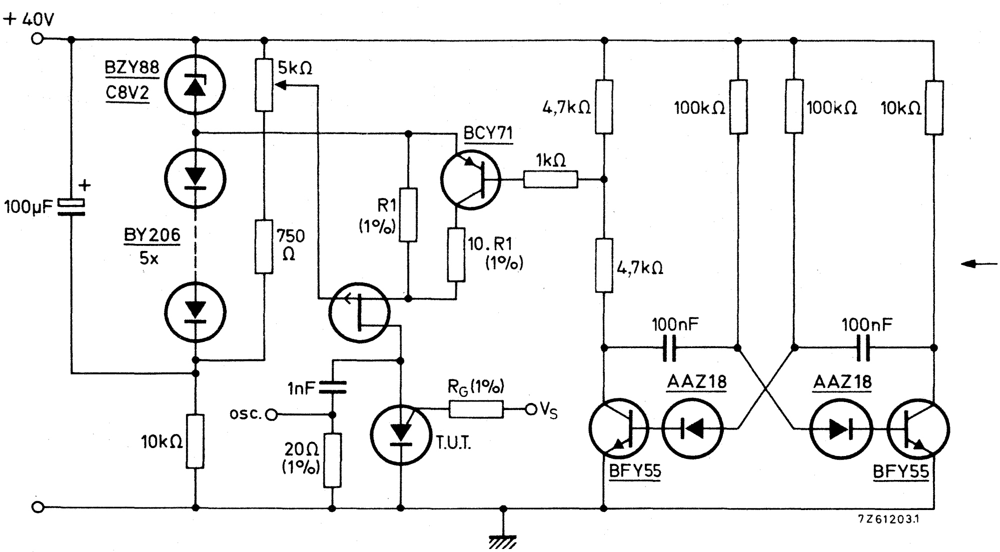


Fig. 4 Practical test circuit:
1. Remove BCY71 during measurement of I_P.
2. Value of R1 depends on the voltage range of voltmeter.

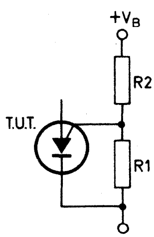


Fig. 5 **BRY39P** with "program" resistors R1 and R2.

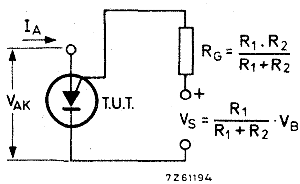


Fig. 6 Equivalent test circuit for characteristics testing.

Gate-anode leakage current (see Fig. 7)
$I_K = 0$; $V_{GA} = 70$ V — I_{GAO} < 10 nA

Gate-cathode leakage current (see Fig. 8)
$V_{AK} = 0$; $V_{GK} = 70$ V — I_{GKS} < 100 nA

Offset voltage (see Figs 9 and 16)
$V_{offset} = V_P - V_S$ ($I_A = 0$)

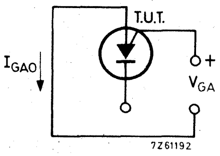


Fig. 7.

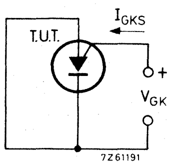


Fig. 8.

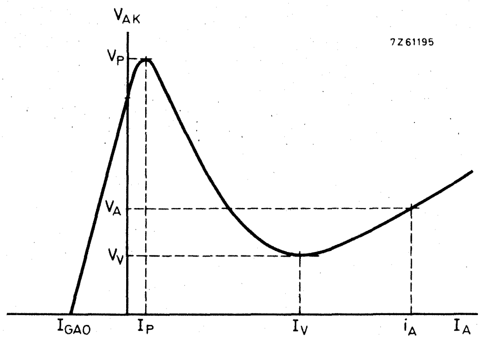


Fig. 9.

Anode voltage
$I_A = 100$ mA — V_A < 1,4 V

Peak output voltage (see Figs 10 and 11)
$V_{AA} = 20$ V; C = 0,2 μF — V_{OM} > 6 V

Rise time (see Figs 10 and 11)
$V_{AA} = 20$ V; C = 10 nF — t_r < 80 ns

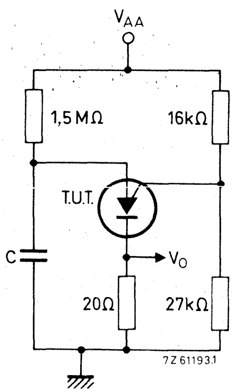


Fig. 10.

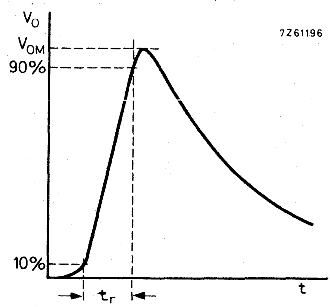


Fig. 11.

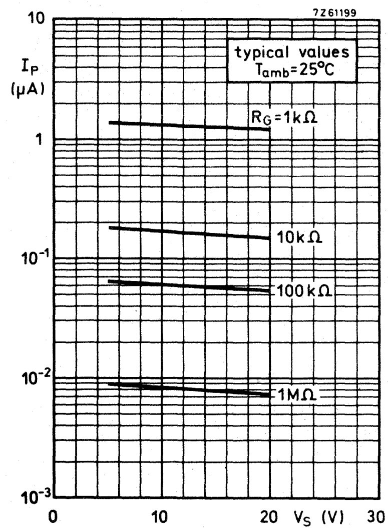


Fig. 12.

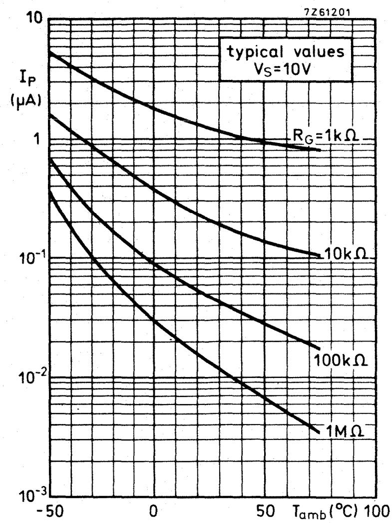


Fig. 13.

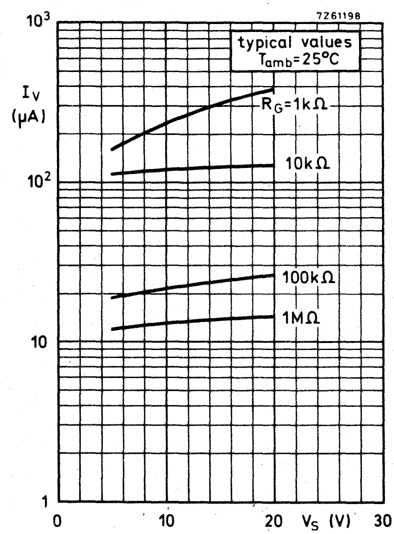


Fig. 14.

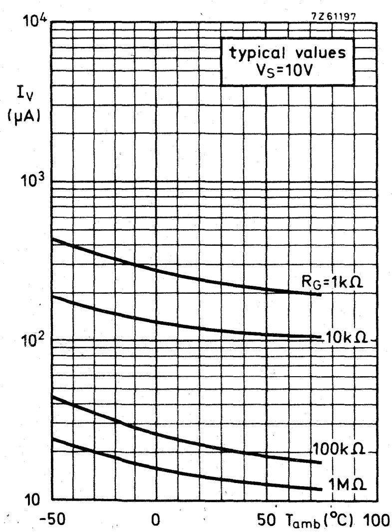


Fig. 15.

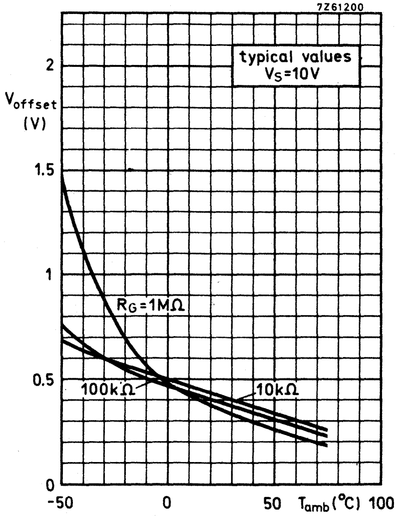

7Z61200
typical values
V_S=10V
V_{offset} (V)
2
1.5
1
0.5
0
R_G=1MΩ
100kΩ
10kΩ
-50
0
50
T_{amb} (°C)
100

Fig. 16.

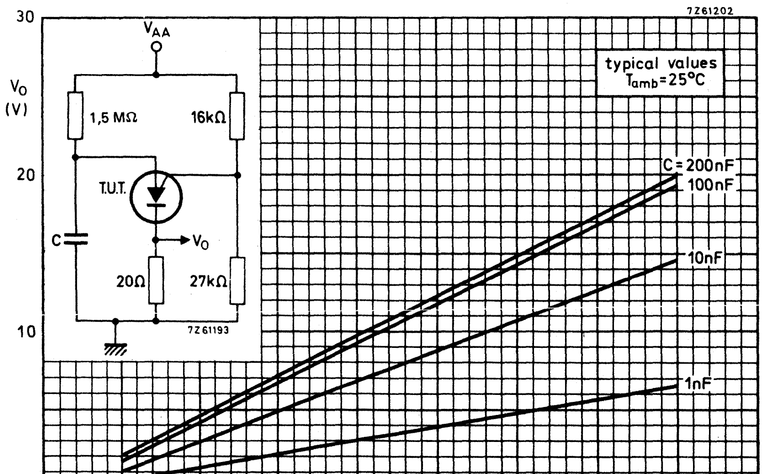

7Z61202
typical values
T_{amb}=25°C
V_O (V)
30
20
10
0
V_{AA}
1,5 MΩ
16kΩ
T.U.T.
C
V_O
20Ω
27kΩ
7Z61193
C=200nF
100nF
10nF
1nF
0
10
20
30
V_{AA} (V)
40

Fig. 17.

SILICON CONTROLLED SWITCH

The BRY39S 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

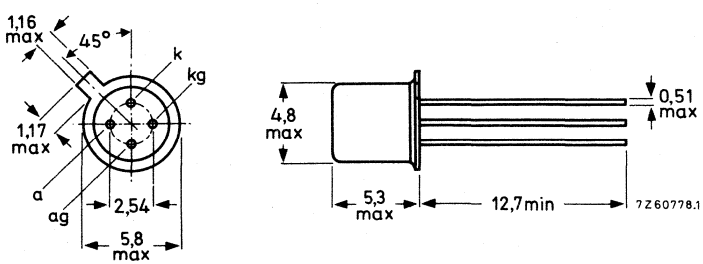
p-n-p transistor				
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	70	V
n-p-n transistor				
Collector-base voltage (open emitter)	V_{CBO}	max.	70	V
Repetitive peak emitter current	$-I_{ERM}$	max.	2,5	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	275	mW
Operating junction temperature	T_j	max.	150	°C
Forward on-state voltage I_A = 50 mA; I_{AG} = 0; R_{KG-K} = 10 kΩ	V_{AK}	$<$	1,4	V
Holding current I_{AG} = 10 mA; $-V_{BB}$ = 2 V; R_{KG-K} = 10 kΩ	I_H	$<$	1,0	mA
Turn-on time	t_{on}	$<$	0,25	μs
Turn-off time	t_q	$<$	5,0	μs

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 kΩ)	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 °C	P_{tot}	max.	275	mW
Storage temperature	T_{stg}		−65 to + 200	°C
Operating junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	450	K/W

* 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 kΩ.

SYMBOLS AND EQUIVALENT CIRCUIT

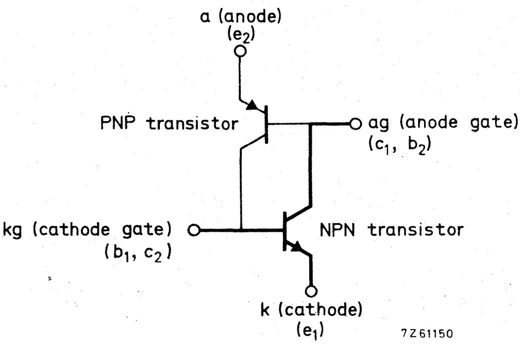


Fig. 2 Two transistor equivalent circuit.

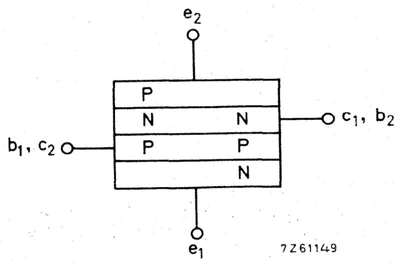


Fig. 3 P-N-P-N silicon controlled switch structure.

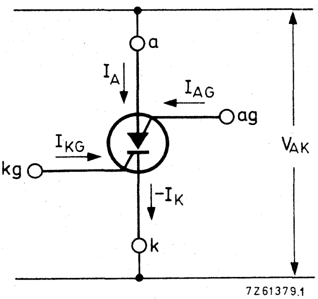


Fig. 4 Silicon controlled switch symbol.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Individual n-p-n transistor

Collector cut-off current			
V_{CE} = 70 V; R_{BE} = 10 kΩ	I_{CER}	<	100 nA
V_{CE} = 70 V; R_{BE} = 10 kΩ; T_j = 150 °C	I_{CER}	<	10 μA
Emitter cut-off current			
I_C = 0; V_{EB} = 5 V; T_j = 150 °C	I_{EBO}	<	10 μA
Saturation voltages			
I_C = 10 mA; I_B = 1 mA	V_{CEsat}	<	500 mV
	V_{BEsat}	<	900 mV
D.C. current gain			
I_C = 10 mA; V_{CE} = 2 V	h_{FE}	>	50
Transition frequency			
I_C = 10 mA; V_{CE} = 2 V	f_T	typ.	300 MHz

Collector capacitance			
$I_E = I_e = 0$; $V_{CB} = 20$ V	C_c	<	5 pF
Emitter capacitance			
$I_C = I_c = 0$; $V_{EB} = 1$ V	C_e	<	25 pF

Individual p-n-p transistor

Collector cut-off current			
$I_B = 0$; $-V_{CE} = 70$ V; $T_j = 150$ °C	$-I_{CEO}$	<	10 μA
Emitter cut-off current			
$I_C = 0$; $-V_{EB} = 70$ V; $T_j = 150$ °C	$-I_{EBO}$	<	10 μA
D.C. current gain			
$I_E = 1$ mA; $V_{CB} = 0$	h_{FE}	0,25 to 2,5	

Combined device

Forward on-state voltage at $R_{KG-K} = 10$ kΩ			
$I_A = 50$ mA; $I_{AG} = 0$	V_{AK}	<	1,4 V
$I_A = 50$ mA; $I_{AG} = 0$; $T_j = -55$ °C	V_{AK}	<	1,9 V
$I_A = 1$ mA; $I_{AG} = 10$ mA	V_{AK}	<	1,2 V
Holding current at $R_{KG-K} = 10$ kΩ (see Fig. 5)			
$I_{AG} = 10$ mA; $-V_{BB} = 2$ V	I_H	<	1,0 mA

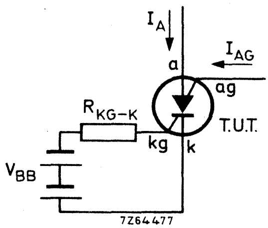


Fig. 5.

Switching times (see Figs 6 to 11)

Turn-on time when switched from

$-V_{KG\text{-}K}$ = 0,5 V to + $V_{KG\text{-}K}$ = 4,5 V

$R_{KG\text{-}K}$ = 1 kΩ	t_{on}	<	0,25 μs
$R_{KG\text{-}K}$ = 10 kΩ	t_{on}	<	1,50 μs

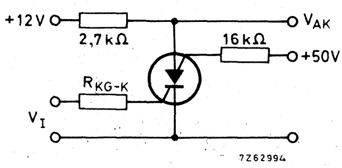


Fig. 6.

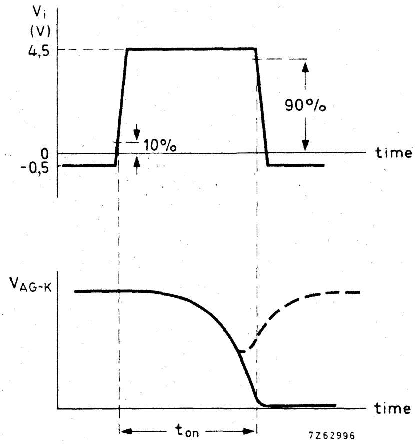


Fig. 7 Pulse duration increased until dashed curve disappears.

Turn-off time (see also Figs 8 and 9)

$R_{KG\text{-}K}$ = 1 kΩ	t_q	<	5 μs
$R_{KG\text{-}K}$ = 10 kΩ	t_q	<	8 μs
$R_{KG\text{-}K}$ = 10 kΩ; T_j = 125 °C	t_q	<	15 μs

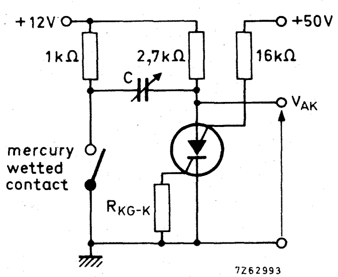


Fig. 8.

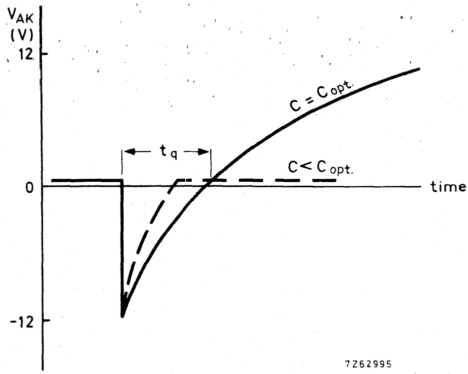


Fig. 9 Capacitance increased until at C = C_{opt} dashed curve disappears.

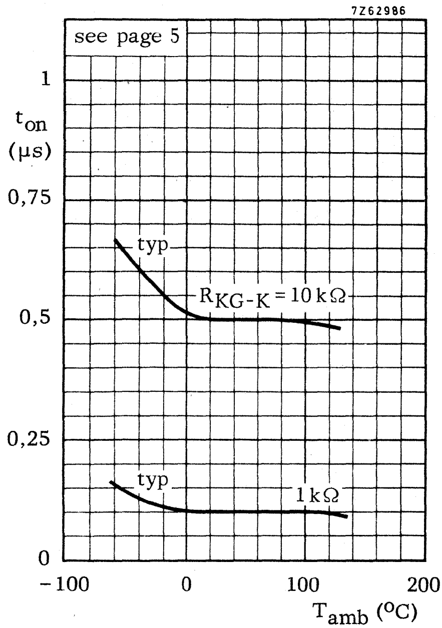


Fig. 10.

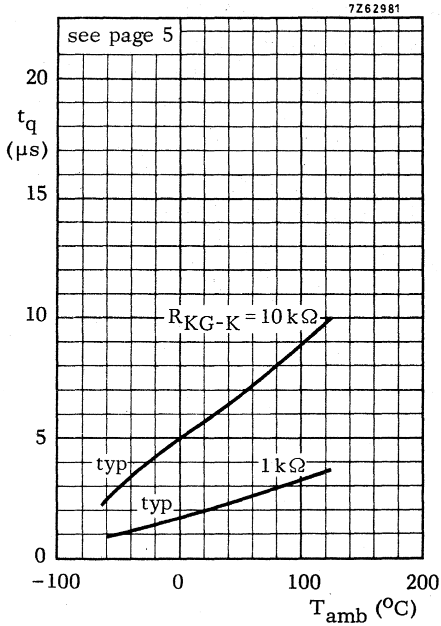


Fig. 11.

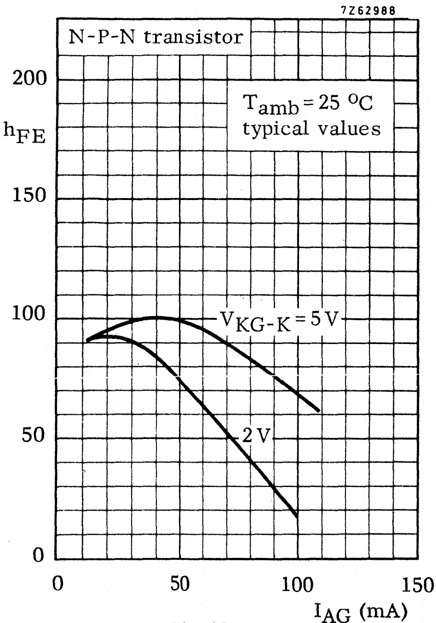


Fig. 12.

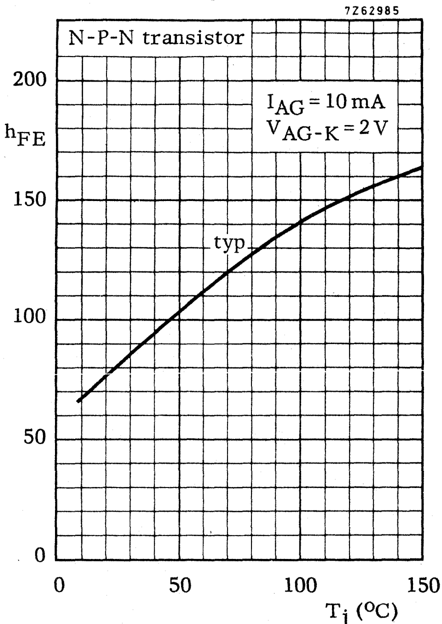


Fig. 13.

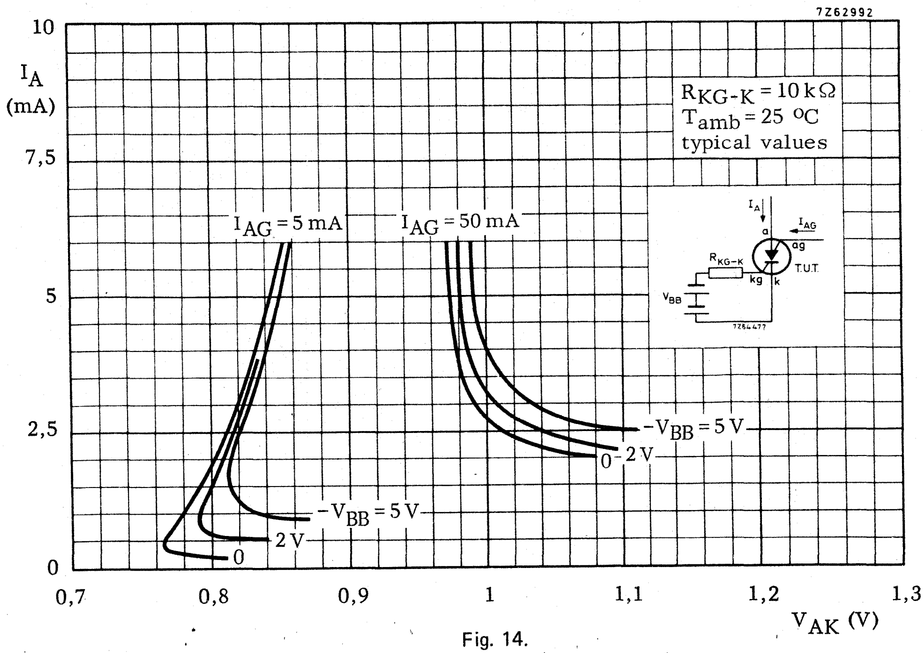

7Z62992
10
I_A
(mA)
7,5
5
2,5
0
0,7
0,8
0,9
1
1,1
1,2
1,3
V_{AK} (V)
R_{KG-K} = 10 kΩ
T_{amb} = 25 °C
typical values
I_{AG} = 5 mA
I_{AG} = 50 mA
$-V_{BB}$ = 5 V
2 V
0
0 2 V
$-V_{BB}$ = 5 V
I_A
I_{AG}
a
ag
R_{KG-K}
T.U.T.
kg
k
V_{BB}
7Z64477

Fig. 14.

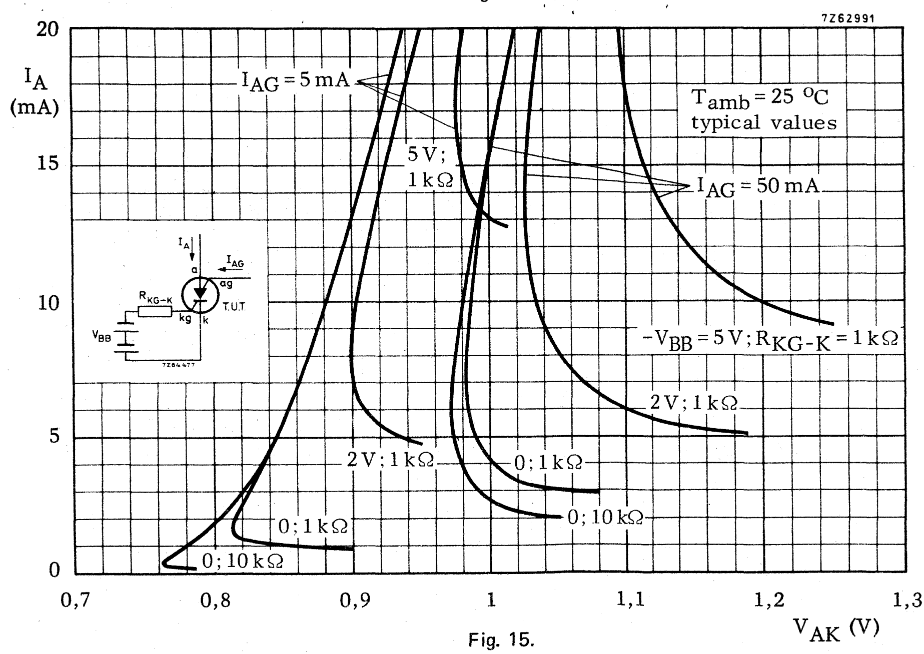

7Z62991
20
I_A
(mA)
15
10
5
0
0,7
0,8
0,9
1
1,1
1,2
1,3
V_{AK} (V)
T_{amb} = 25 °C
typical values
I_{AG} = 5 mA
5 V;
1 kΩ
I_{AG} = 50 mA
$-V_{BB}$ = 5 V; R_{KG-K} = 1 kΩ
2 V; 1 kΩ
2 V; 1 kΩ
0; 1 kΩ
0; 10 kΩ
0; 1 kΩ
0; 10 kΩ
I_A
I_{AG}
a
ag
R_{KG-K}
T.U.T.
kg
k
V_{BB}
7Z64477

Fig. 15.

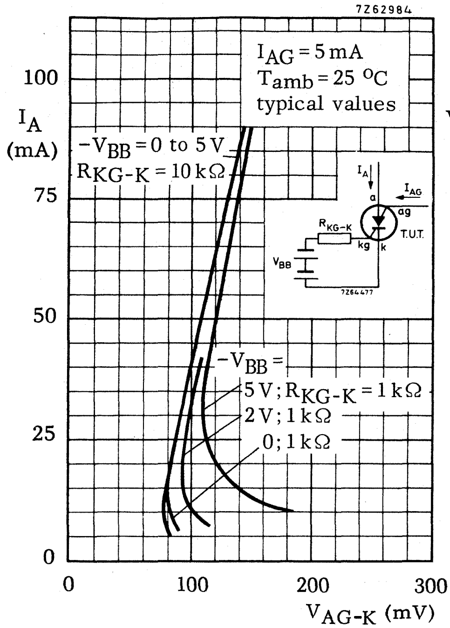


Fig. 16.

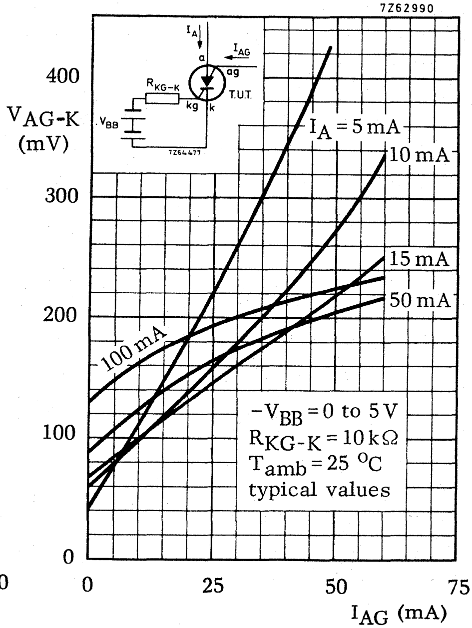


Fig. 17.

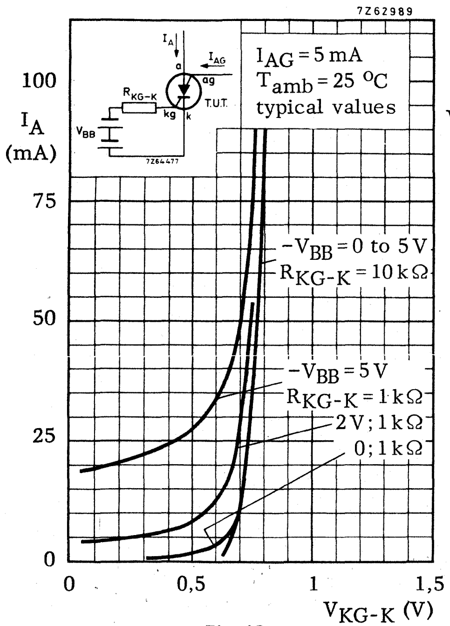


Fig. 18.

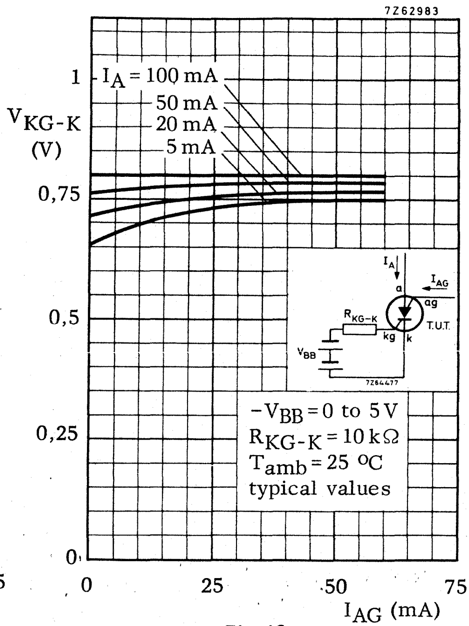


Fig. 19.

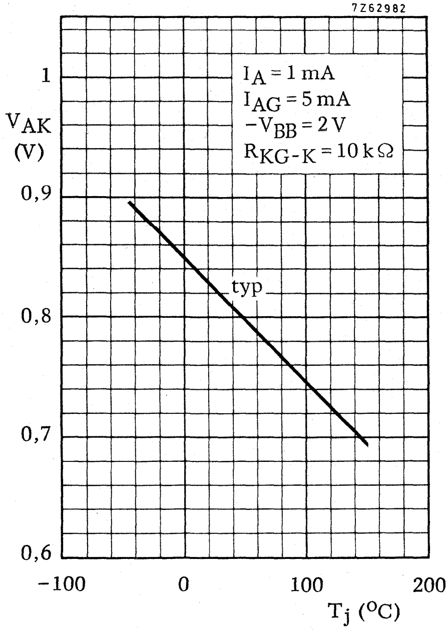


Fig. 20.

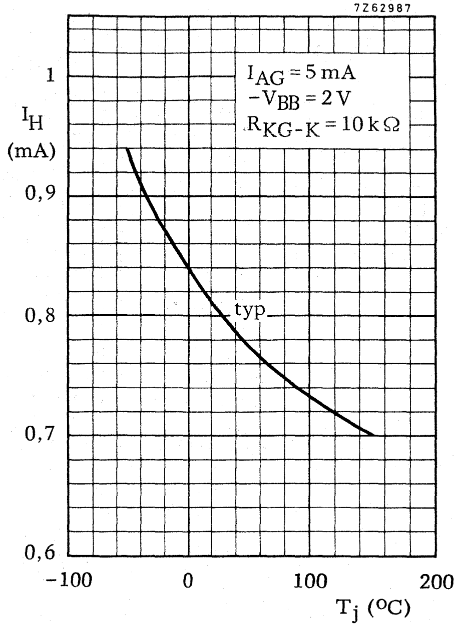


Fig. 21.

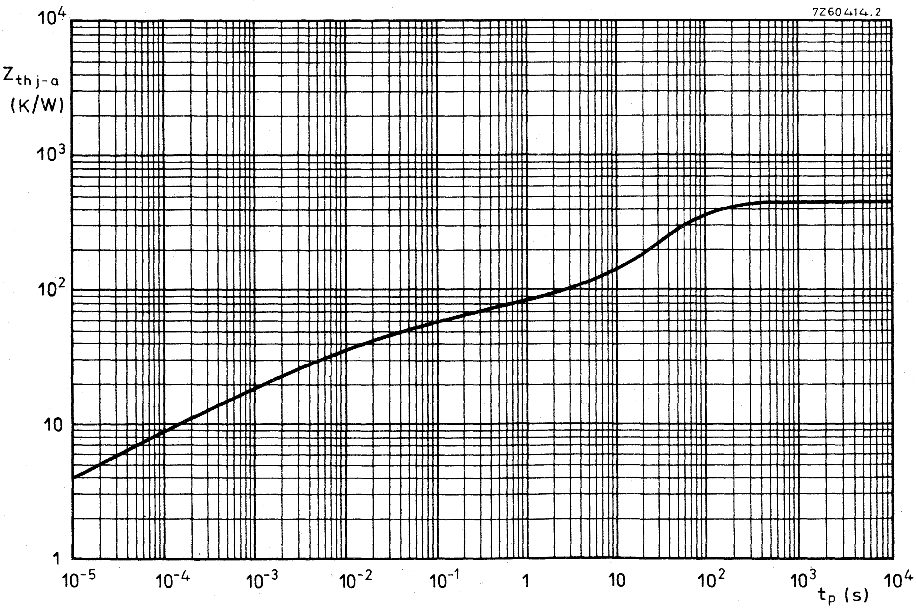


Fig. 22 Thermal impedance from junction to ambient versus pulse duration.

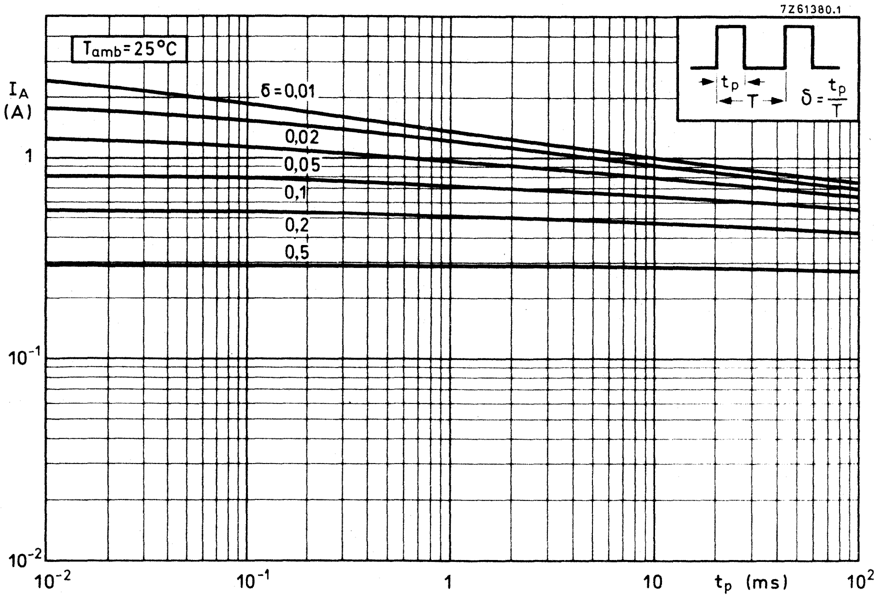

7Z61380.1
T_{amb} = 25 °C
I_A (A)
δ = 0,01
0,02
0,05
0,1
0,2
0,5
t_p (ms)
$\delta = \frac{t_p}{T}$

Fig. 23.

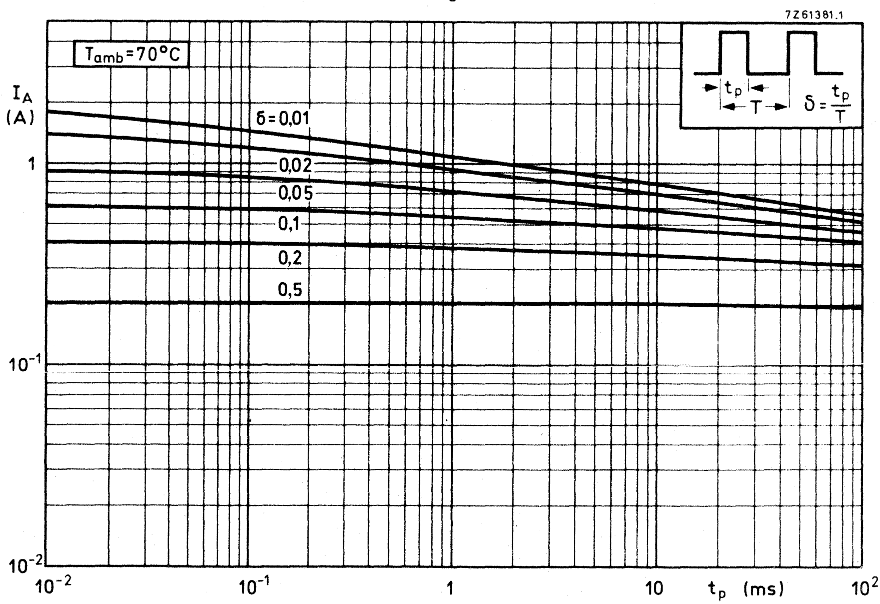

7Z61381.1
T_{amb} = 70 °C
I_A (A)
δ = 0,01
0,02
0,05
0,1
0,2
0,5
t_p (ms)
$\delta = \frac{t_p}{T}$

Fig. 24.

THYRISTOR TETRODE

The BRY39T 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.

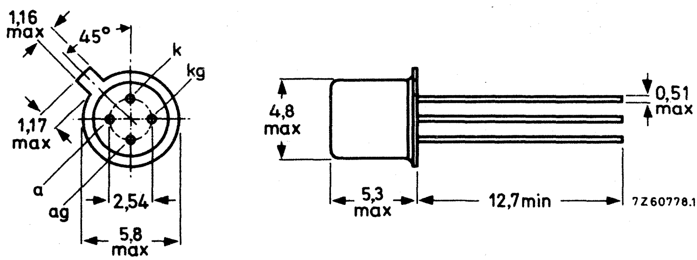
QUICK REFERENCE DATA

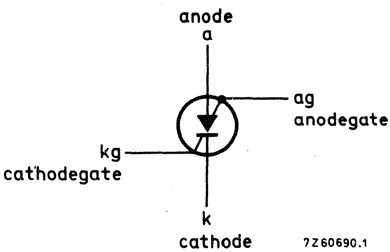
Repetitive peak voltages	$V_{DRM} = V_{RRM}$	max.	70	V
Average on-state current	$I_{T(AV)}$	max.	250	mA
Non-repetitive peak on-state current	I_{TSM}	max.	3	A

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 °C	$I_{T(AV)}$	max.	250	mA
in free air up to T_{amb} = 25 °C	$I_{T(AV)}$	max.	175	mA
Repetitive peak on-state current t = 10 μs; δ = 0.01	I_{TRM}	max.	2,5	A
Non-repetitive peak on-state current t = 10 μs; T_j = 150 °C prior to surge	I_{TSM}	max.	3	A
Rate of rise of on-state current after triggering to I_T = 2.5 A	$\frac{dI_T}{dt}$	max.	20	A/μs

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	°C
Operating junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	450	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	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 ⩽ 10 kΩ is connected between cathode gate and cathode.

CHARACTERISTICS

Anode to cathode

On-state voltage I_T = 100 mA; T_j = 25 °C	V_T	<	1.4	V*
Rate of rise of off-state voltage that will not trigger any device	$\frac{dV_D}{dt}$**			
Reverse current V_R = 70 V; T_j = 25 °C	I_R	typ.	1	nA
		<	100	nA
T_j = 150 °C	I_R	<	2	μA
Off-state current V_D = 70 V; T_j = 25 °C	I_D	typ.	1	nA
		<	100	nA
T_j = 150 °C	I_D	<	2	μA
Holding current R_{GK} = 10 kΩ; R_{GA} = 220 kΩ; T_j = 25 °C	I_H	<	250	μA

Cathode gate to cathode

Voltage that will trigger all devices V_D = 6 V; T_j = 25 °C	V_{GKT}	>	0.5	V
Current that will trigger all devices V_D = 6 V; T_j = 25 °C	I_{GKT}	>	1	μA

Anode gate to anode

Voltage that will trigger all devices V_D = 6 V; T_j = 25 °C	$-V_{GAT}$	>	1	V
Current that will trigger all devices V_D = 6 V; R_{GK} = 10 kΩ; T_j = 25 °C	$-I_{GAT}$	>	100	μA

*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 μA; dI_{GK}/dt = 5 μA/μs; T_j = 25 °C	t_{gt}	<	300	ns
Circuit-commutated turn-off time when switched from I_T = 150 mA to V_R = 15 V; $-dI_T/dt$ = 3 A/μs; dV_D/dt = 70 V/μs; V_D = 15 V	t_q	<	3	μs

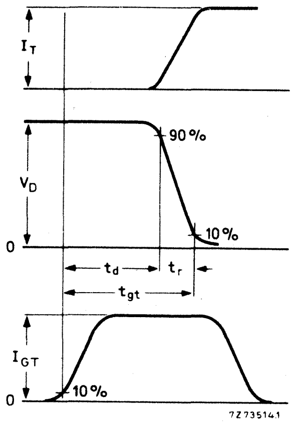


Fig.2 Gate-controlled turn-on time definition.

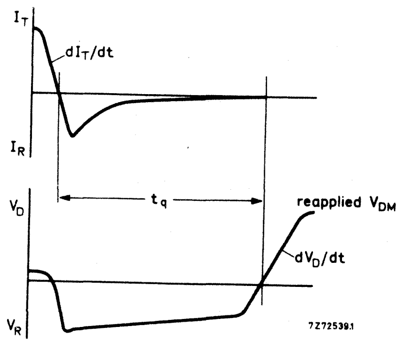


Fig.3 Circuit-commutated turn-off time definition.

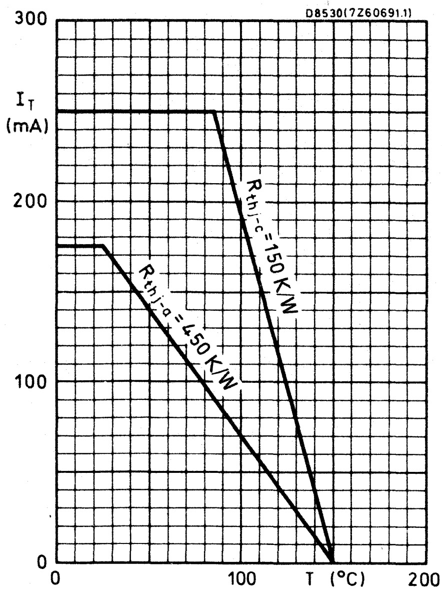


Fig.4

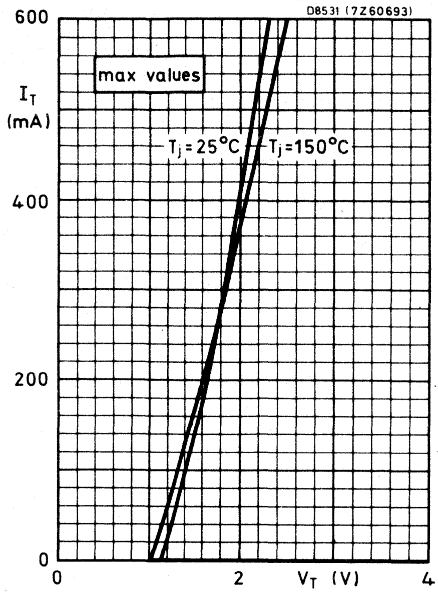


Fig.5

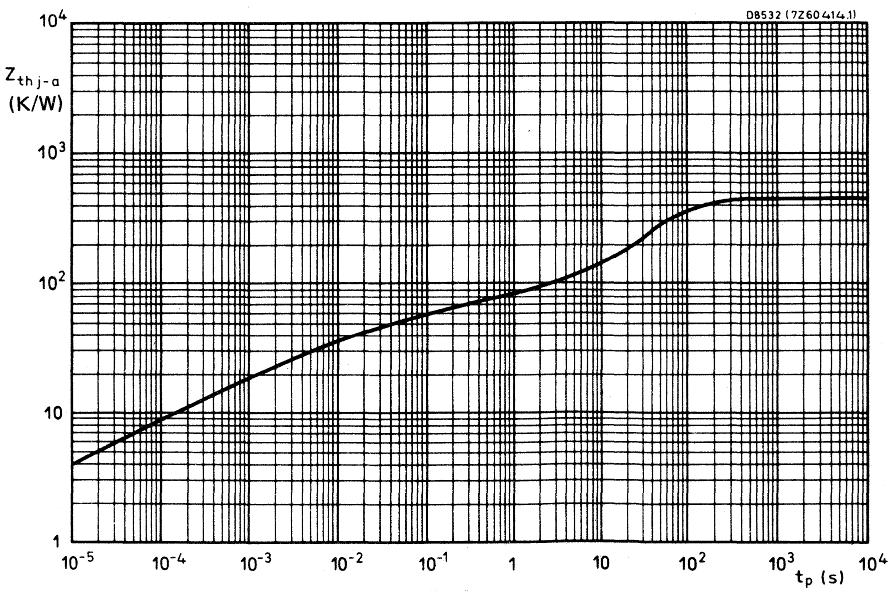


Fig.6

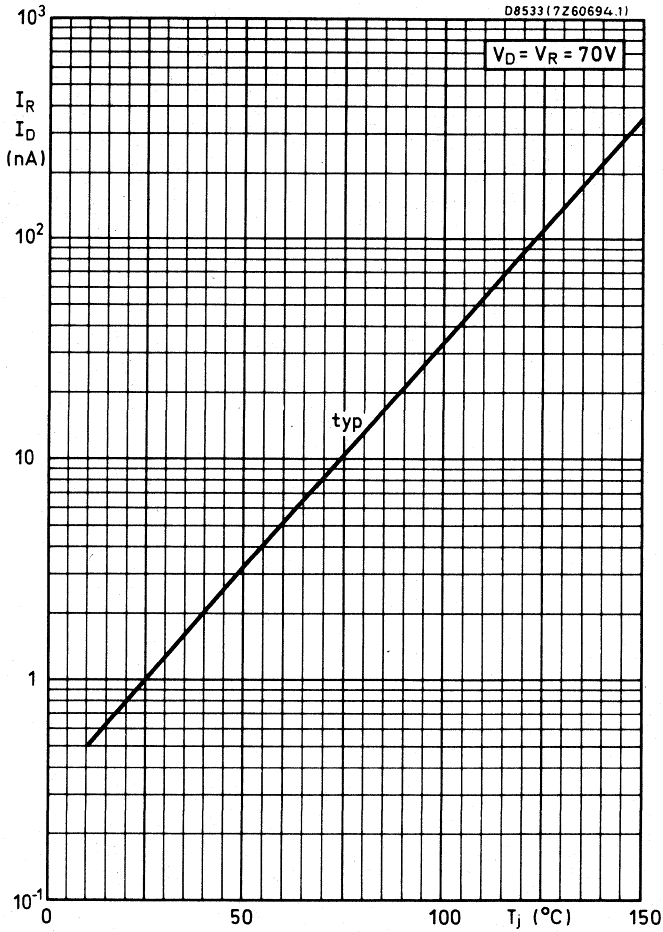

D8533(7Z60694.1)
$V_D = V_R = 70V$
I_R
I_D
(nA)
10^3
10^2
10
1
10^{-1}
typ
0
50
100
T_j (°C)
150

Fig.7

APPLICATION INFORMATION

Sensing network

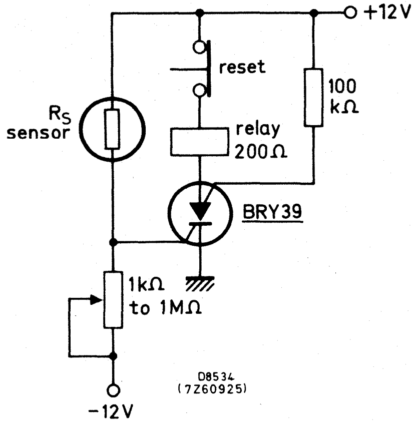


Fig.8

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.

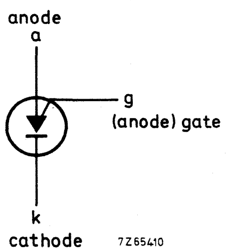
QUICK REFERENCE DATA

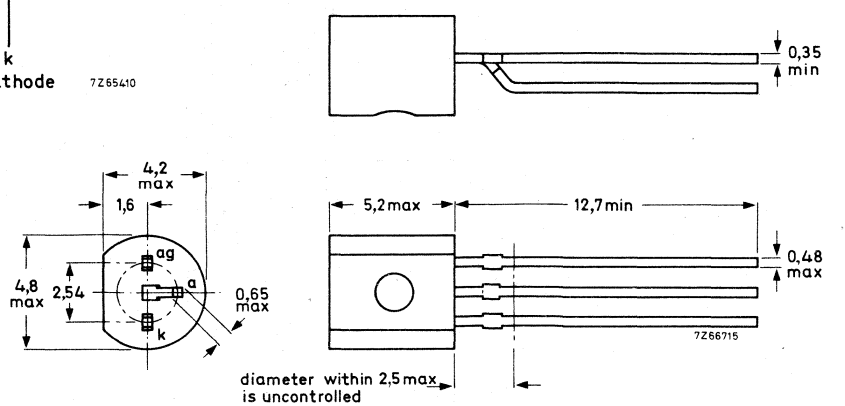
Gate-anode voltage	V_{GA}	max.	70	V
Anode current (average)	$I_{A(AV)}$	max.	175	mA
Total power dissipation up to T_{amb} = 75 ^oC	P_{tot}	max.	300	mW
Junction temperature	T_j	max.	150	^oC
Peak point current V_S = 10 V; R_G = 10 kΩ	I_P	<	5	μA
Valley point current V_S = 10 V; R_G = 10 kΩ	I_V	>	50	μA

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.





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 μs; δ = 0,01	I_{ARM}	max.	2,5	A
Non-repetitive peak anode current t_p = 10 μs	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/μs
Total power dissipation up to T_{amb} = 75 °C	P_{tot}	max.	300	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	$R_{th\ j\text{-}a}$	=	250	K/W

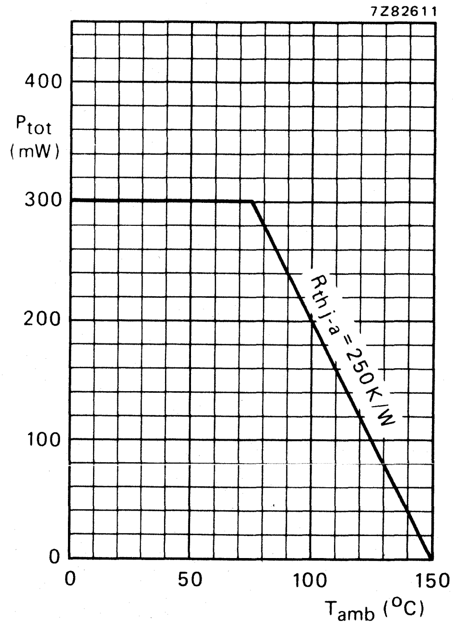


Fig. 2 Maximum permissible power dissipation as a function of ambient temperature.

CHARACTERISTICS

$T_{amb} = 25\ ^oC$

Peak point current (see Fig. 10)			
$V_S = 10$ V; $R_G = 10$ kΩ	I_P	<	5 μA
$V_S = 10$ V; $R_G = 100$ kΩ	I_P	<	2 μA
Valley point current (see Fig. 10)			
$V_S = 10$ V; $R_G = 10$ kΩ	I_V	>	50 μA
$V_S = 10$ V; $R_G = 100$ kΩ	I_V	>	5 μA

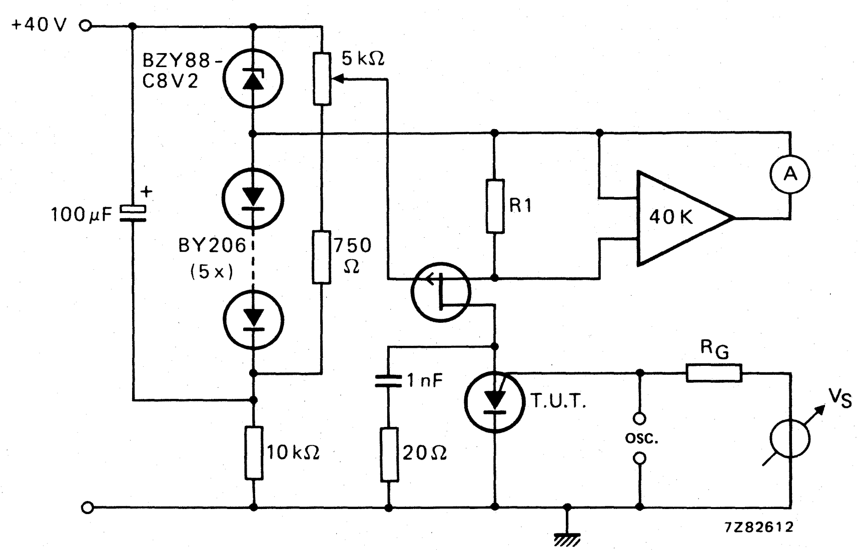


Fig. 3 Measuring circuit for I_P and I_V by means of value of R1. $R1 = \frac{1}{I_A}$ (that is maximum voltage drop over R1 is 1 V). Internal resistance of oscilloscope is 10 MΩ.

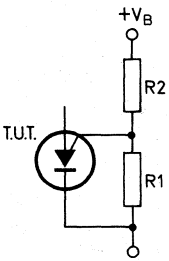


Fig. 4 **BRY56** with "program" resistors R1 and R2.

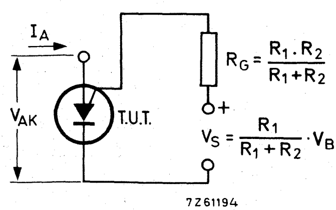


Fig. 5 Equivalent test circuit for characteristics testing.

Gate-anode leakage current (see Fig. 6) $I_K = 0$; $V_{GA} = 70$ V	I_{GAO}	<	10 nA
Gate-cathode leakage current (see Fig. 7) $V_{AK} = 0$; $V_{GK} = 70$ V	I_{GKS}	<	100 nA

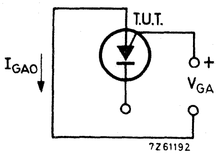


Fig. 6.

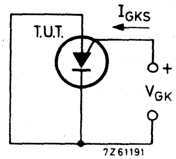


Fig. 7.

Anode-cathode voltage $I_A = 100$ mA	V_{AK}	<	1,4 V
Peak output voltage (see Figs 8 and 9) $V_{AA} = 20$ V; C = 10 nF	V_{OM}	>	6 V
Offset voltage (see Fig. 10) $V_{offset} = V_P - V_S$ ($I_A = 0$)			
Rise time (see Fig. 9) $V_{AA} = 20$ V; C = 10 nF	t_r	<	80 ns

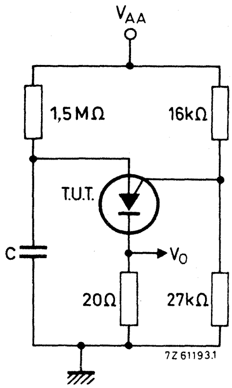


Fig. 8.

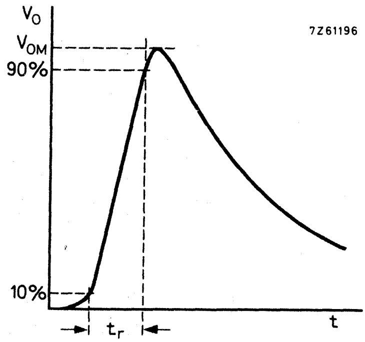


Fig. 9.

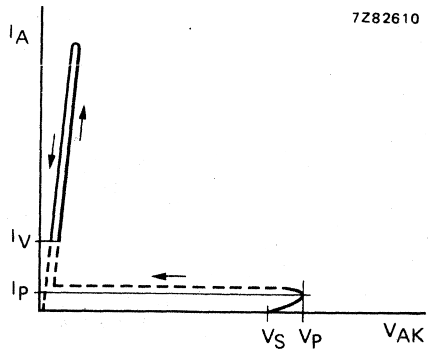


Fig. 10.

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.

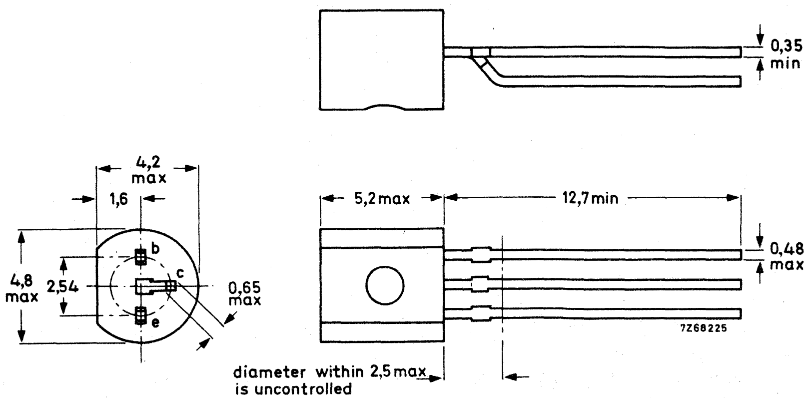
QUICK REFERENCE DATA

			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 °C	P_{tot}	max.		0,8		W
Junction temperature	T_j	max.		150		°C
Collector-emitter saturation voltage I_C = 0,5 A; I_B = 0,5 mA	V_{CEsat}	<		1,3		V
D.C. current gain I_C = 150 mA; V_{CE} = 10 V	h_{FE}	>		1000		
I_C = 500 mA; V_{CE} = 10 V	h_{FE}	>		2000		
Turn-off time when switched from I_{Con} = 500 mA; I_{Bon} = 0,5 mA to cut-off with $-I_{Boff}$ = 0,5 mA	t_{off}	<		1,5		μs

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 °C	P_{tot}	max.		0,8		W
up to T_{amb} = 25 °C *	P_{tot}	max.		1,0		W
Storage temperature	T_{stg}			−65 to + 150		°C
Junction temperature **	T_j	max.		150		°C

THERMAL RESISTANCE **

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	156	K/W

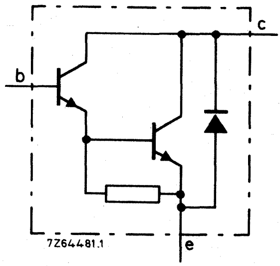


Fig. 2 Circuit diagram.

* 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

$T_j = 25\ ^oC$

Collector cut-off voltage				
$I_E = 0$; $V_{CB} = 45$ V	**BSR50**	I_{CBO}	<	50 nA
$I_E = 0$; $V_{CB} = 60$ V	**BSR51**	I_{CBO}	<	50 nA
$I_E = 0$; $V_{CB} = 80$ V	**BSR52**	I_{CBO}	<	50 nA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 4$ V		I_{EBO}	<	50 nA
Saturation voltages				
$I_C = 0,5$ A; $I_B = 0,5$ mA		V_{CEsat}	<	1,3 V
		V_{BEsat}	<	1,9 V
$I_C = 1,0$ A; $I_B = 1,0$ mA	**BSR51**	V_{CEsat}	<	1,6 V
		V_{BEsat}	<	2,2 V
$I_C = 1,0$ A; $I_B = 4,0$ mA	**BSR50; BSR52**	V_{CEsat}	<	1,6 V
		V_{BEsat}	<	2,2 V
D.C. current gain				
$I_C = 150$ mA; $V_{CE} = 10$ V		h_{FE}	>	1000
$I_C = 500$ mA; $V_{CE} = 10$ V		h_{FE}	>	2000
Small-signal current gain at f = 35 MHz				
$I_C = 500$ mA; $V_{CE} = 5$ V		h_{fe}	typ.	10

Switching times see page 4.

Switching times (see Figs 3 and 4)

I_{Con} = 500 mA; I_{Bon} = $-I_{Boff}$ = 0,5 mA

Turn-on time	t_{on}	typ.	0,4 μs
Turn-off time	t_{off}	<	1,5 μs

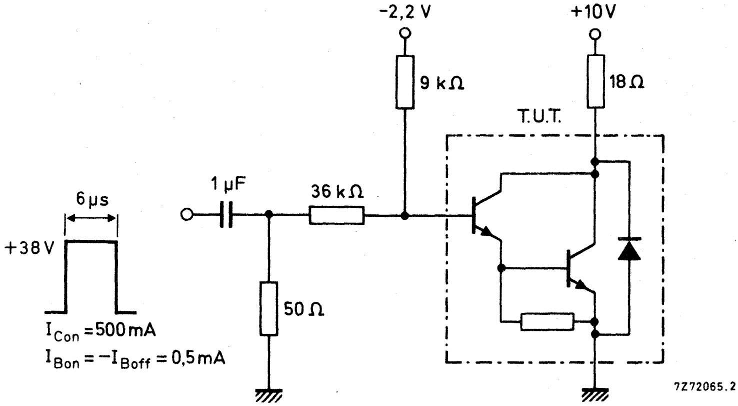


Fig. 3 Test circuit for 500 mA switching.

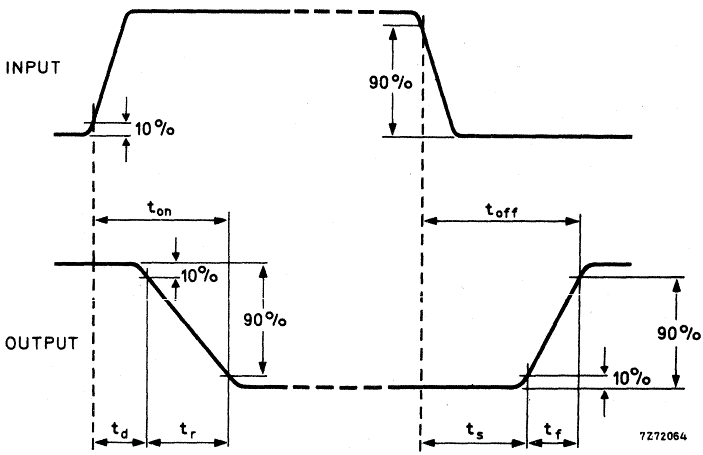


Fig. 4 Switching waveforms.

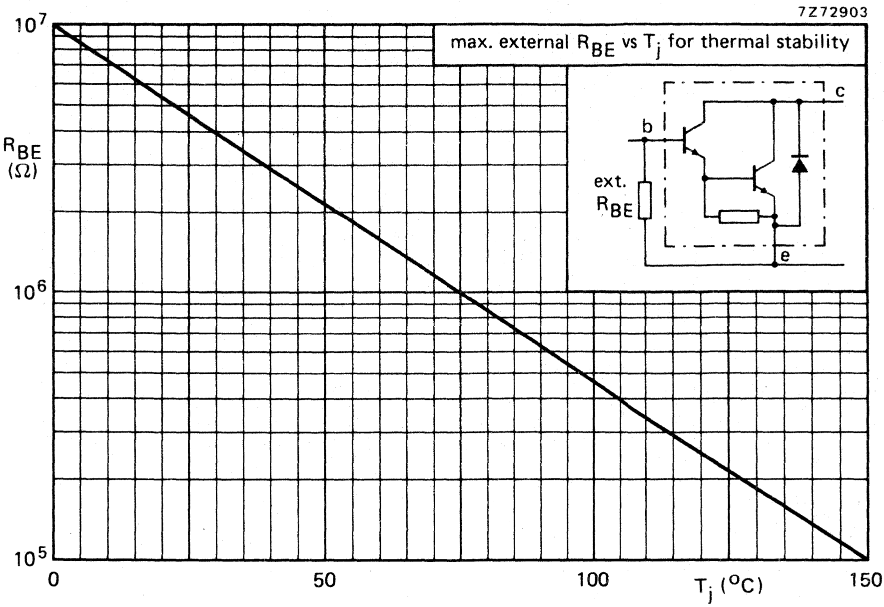


Fig. 5.

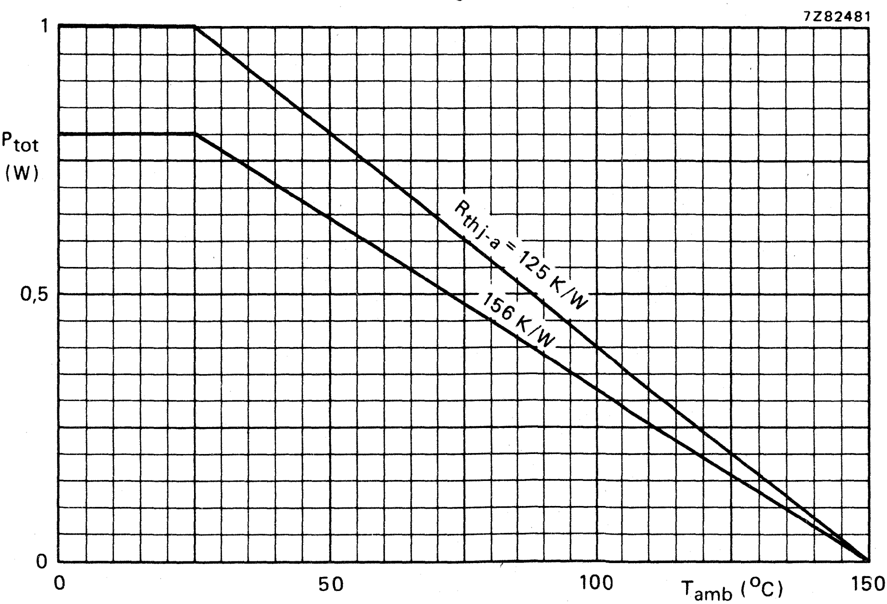


Fig. 6 Maximum permissible power dissipation as a function of ambient temperature.

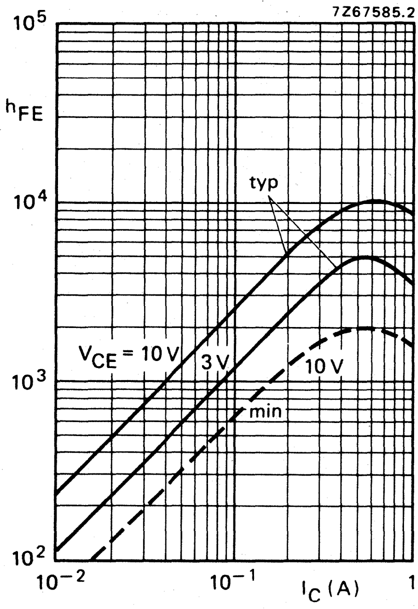


Fig. 7 $T_j = 25$ °C.

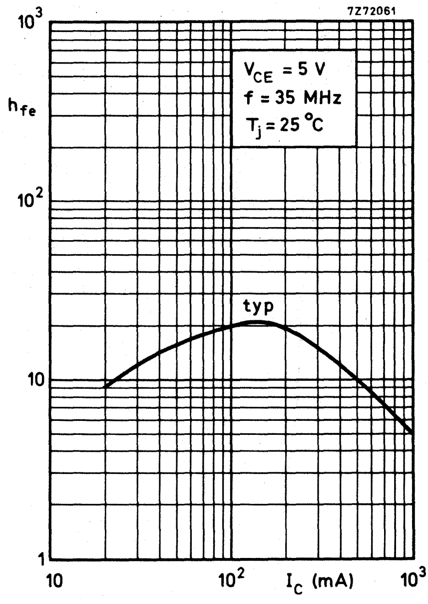


Fig. 8.

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.

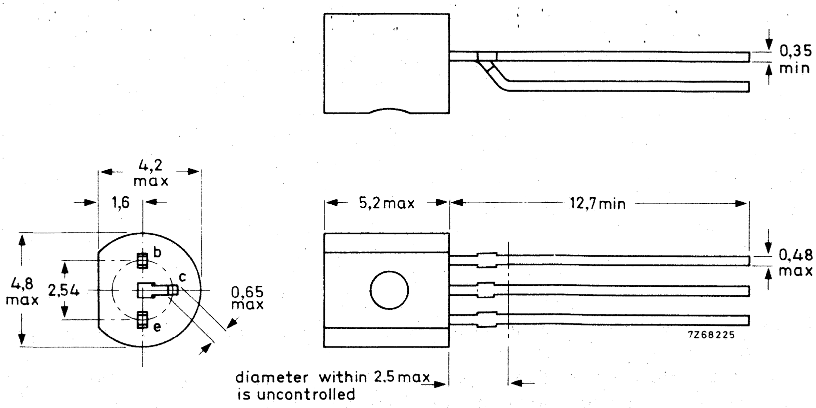
QUICK REFERENCE DATA

			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 °C	P_{tot}	max.	0,8	0,8	0,8	W
Junction temperature	T_j	max.	150	150	150	°C
Collector-emitter saturation voltage $-I_C$ = 0,5 A; $-I_B$ = 0,5 mA	$-V_{CEsat}$	<	1,3	1,3	1,4	V
D.C. current gain $-I_C$ = 150 mA; $-V_{CE}$ = 10 V	h_{FE}	>		1000		
$-I_C$ = 500 mA; $-V_{CE}$ = 10 V	h_{FE}	>		2000		
Turn-off time when switched from $-I_{Con}$ = 500 mA; $-I_{Bon}$ = 0,5 mA to cut-off with + I_{Boff} = 0,5 mA	t_{off}	<		1,5		μs

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 °C	P_{tot}	max.		0,8		W
up to T_{amb} = 25 °C *	P_{tot}	max.		1,0		W
Storage temperature	T_{stg}			−65 to + 150		°C
Junction temperature **	T_j	max.		150		°C

THERMAL RESISTANCE **

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	156	K/W

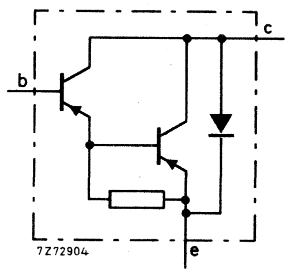


Fig. 2 Circuit diagram.

* 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 °C

Collector cut-off current				
I_E = 0; $-V_{CB}$ = 45 V	BSR60	$-I_{CBO}$	<	50 nA
I_E = 0; $-V_{CB}$ = 60 V	BSR61	$-I_{CBO}$	<	50 nA
I_E = 0; $-V_{CB}$ = 80 V	BSR62	$-I_{CBO}$	<	50 nA
Emitter cut-off current				
I_C = 0; $-V_{EB}$ = 4 V		$-I_{EBO}$	<	50 nA
Saturation voltages				
$-I_C$ = 0,5 A; $-I_B$ = 0,5 mA	BSR60; BSR61	$-V_{CEsat}$	<	1,3 V
		$-V_{BEsat}$	<	1,9 V
$-I_C$ = 0,5 A; $-I_B$ = 0,5 mA	BSR62	$-V_{CEsat}$	<	1,4 V
		$-V_{BEsat}$	<	2,0 V
$-I_C$ = 1,0 A; $-I_B$ = 1,0 mA	BSR61	$-V_{CEsat}$	<	1,6 V
		$-V_{BEsat}$	<	2,2 V
$-I_C$ = 1,0 A; $-I_B$ = 4,0 mA	BSR60	$-V_{CEsat}$	<	1,6 V
		$-V_{BEsat}$	<	2,2 V
$-I_C$ = 1,0 A; $-I_B$ = 4,0 mA	BSR62	$-V_{CEsat}$	<	1,8 V
		$-V_{BEsat}$	<	2,4 V
D.C. current gain				
$-I_C$ = 150 mA; $-V_{CE}$ = 10 V		h_{FE}	>	1000
$-I_C$ = 500 mA; $-V_{CE}$ = 10 V		h_{FE}	>	2000
Small-signal current gain at f = 35 MHz				
$-I_C$ = 500 mA; $-V_{CE}$ = 5 V		h_{fe}	typ.	10

Switching times see page 4.

Switching times (see Figs 3 and 4)
$-I_{Con}$ = 500 mA; $-I_{Bon}$ = + I_{Boff} = 0,5 mA

Turn-on time	t_{on}	<	1,0 μs
Turn-off time	t_{off}	<	1,5 μs

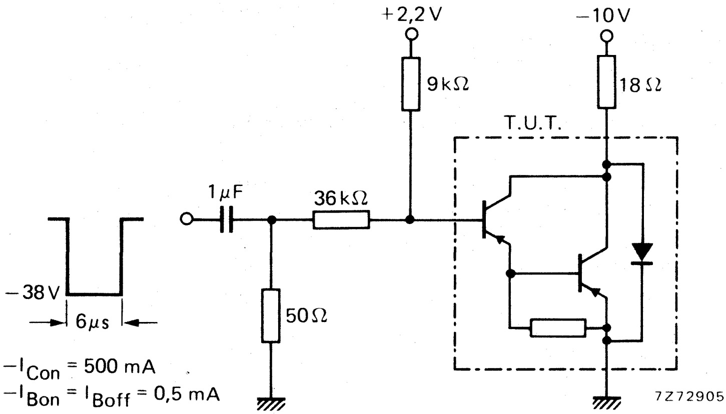


Fig. 3 Test circuit for 500 mA switching.

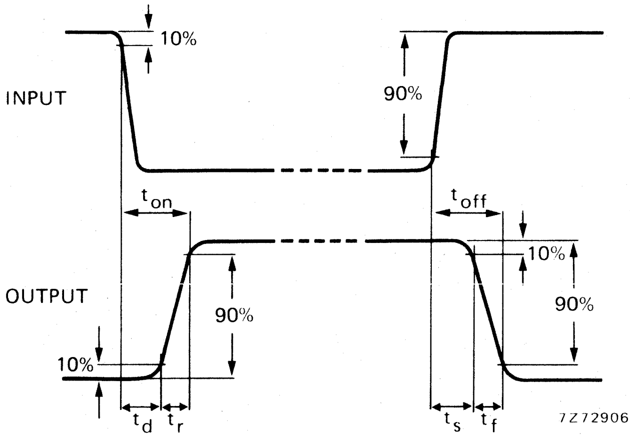


Fig. 4 Switching waveforms.

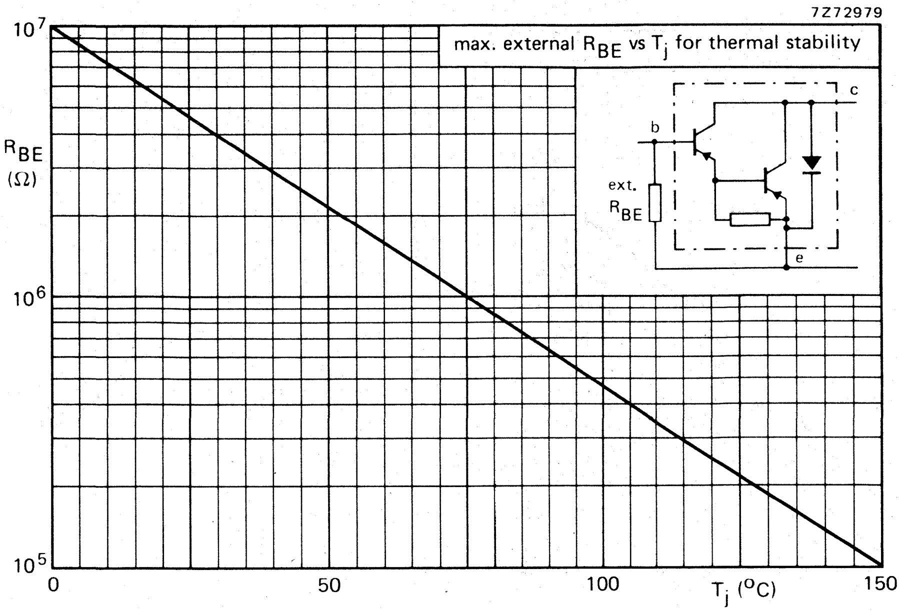


Fig. 5.

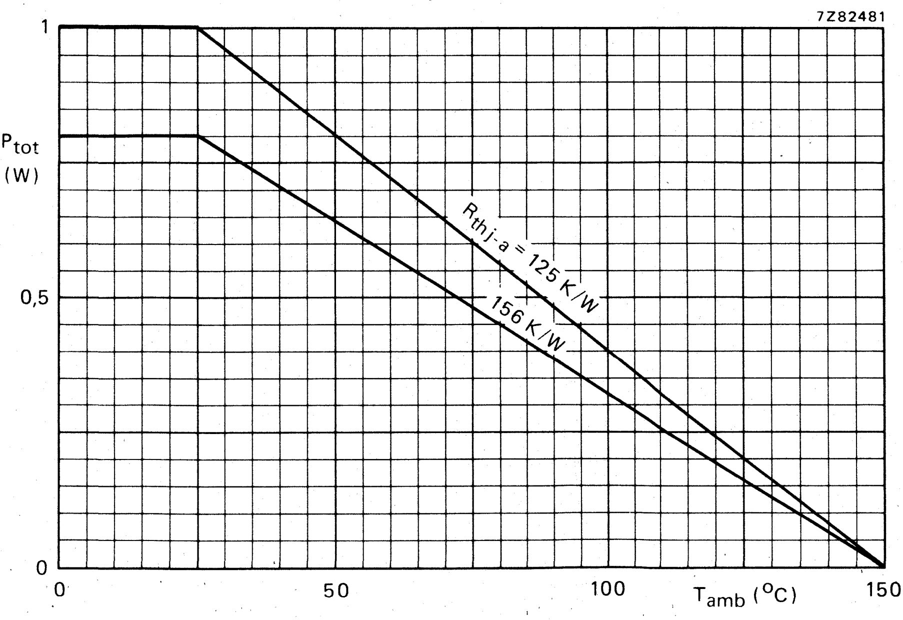


Fig. 6 Maximum permissible power dissipation as a function of ambient temperature.

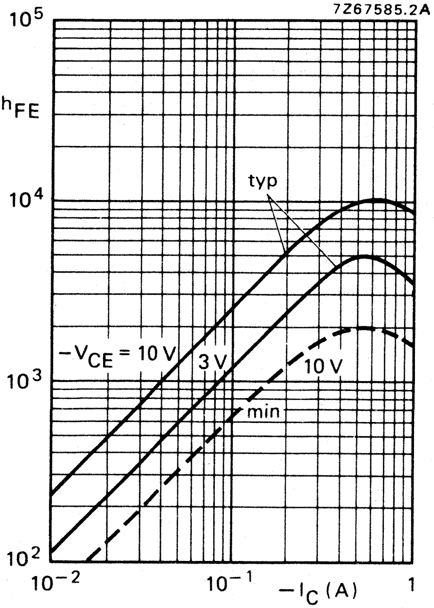


Fig. 7 T_j = 25 °C.

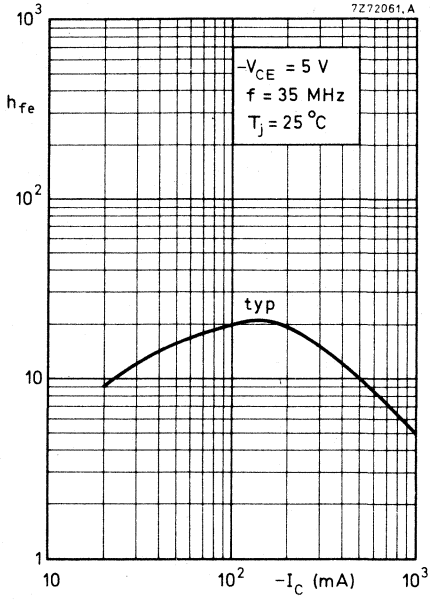


Fig. 8.

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

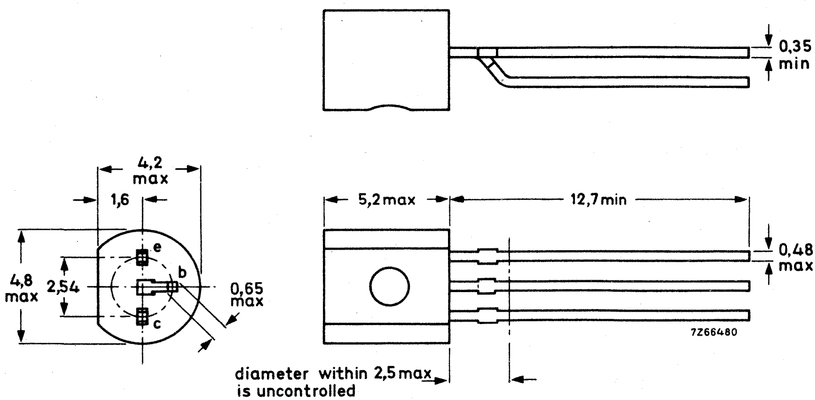
Collector-base voltage (open emitter)	V_{CBO}	max.	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	100	V
Collector current (peak value)	I_{CM}	max.	250	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500	mW
Junction temperature	T_j	max.	150	°C
D.C. current gain I_C = 4 mA; V_{CE} = 1 V	h_{FE}	> typ.	20 80	
Transition frequency at f = 35 MHz I_C = 4 mA; V_{CE} = 10 V	f_T	>	60	MHz
Turn-off time I_{Con} = 15 mA; I_{Bon} = 1 mA; $-I_{Boff}$ = 1 mA	t_{off}	<	1	μs

Note
The BSS38 may be operated in the breakdown region up to V_{CE} = 160 V, provided P_{tot} at T_{amb} = 85 °C does not exceed 100 mW.

MECHANICAL DATA

Dimensions in mm

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 °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	$R_{th\ j\text{-}a}$	=	0,25	°C/mW

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

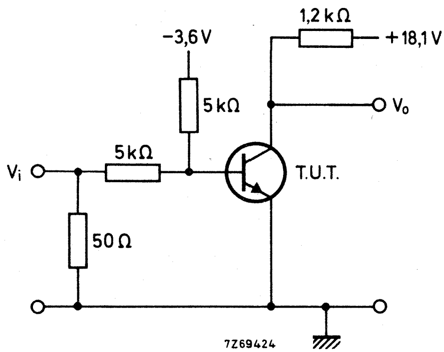
Collector cut-off current				
$I_E = 0$; $V_{CB} = 90$ V	I_{CBO}	<	200	nA
$I_E = 0$; $V_{CB} = 90$ V; $T_j = 150$ °C	I_{CBO}	<	50	μA
$V_{BE} = 0$; $V_{CE} = 80$ V; $T_j = 85$ °C	I_{CES}	<	20	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 4$ V	I_{EBO}	<	200	nA
$I_C = 0$; $V_{EB} = 4$ V; $T_j = 150$ °C	I_{EBO}	<	50	μA
Saturation voltages				
$I_C =$ 4 mA; $I_B = 0,4$ mA	V_{CEsat}	<	0,7	V
	V_{BEsat}	<	1,2	V
$I_C = 50$ mA; $I_B =$ 15 mA	V_{CEsat}	<	3,0	V
D.C. current gain				
$I_C =$ 4 mA; $V_{CE} = 1$ V	h_{FE}	>	20	
		typ.	80	
$I_C = 10$ mA; $V_{CE} = 1$ V	h_{FE}	typ.	80	

* The BSS38 may be operated in the breakdown region up to V_{CE} = 160 V, provided P_{tot} at T_{amb} = 85 °C does not exceed 100 mW.

CHARACTERISTICS (continued)

Transition frequency at f = 35 MHz I_C = 4 mA; V_{CE} = 10 V	f_T	>	60 MHz
Collector capacitance at f = 1 MHz I_E = I_e = 0; V_{CB} = 10 V	C_c	<	4,5 pF
Emitter capacitance at f = 1 MHz I_C = I_c = 0; V_{EB} = 0,5 V	C_e	<	17 pF
Switching time Turn-off time when switched from I_{Con} = 15 mA; I_{Bon} = 1 mA to cut-off with $-I_{Boff}$ = 1 mA	t_{off}	<	1 μs

Test circuit for measuring turn-off time:



Pulse generator:

Input voltage	V_i	= + 10 V
Pulse duration	t_p	= 1 μs
Duty factor	δ	= 0,01
Source impedance	Z_S	= 50 Ω

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

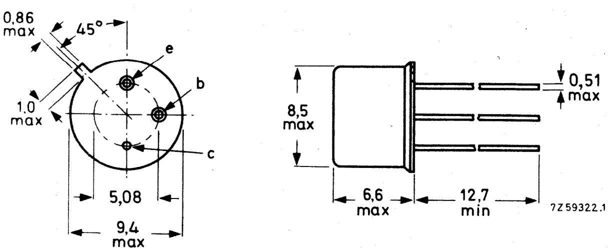
				BSS50	BSS51	BSS52	
Collector-base voltage (open emitter)		V_{CBO}	max.	60	80	100	V
Collector-emitter voltage (see Fig. 4)		V_{CER}	max.	45	60	80	V
Collector current (d.c.)		I_C	max.		1,0		A
Total power dissipation							
up to T_{amb} = 25 °C		P_{tot}	max.		0,8		W
up to T_{case} = 25 °C		P_{tot}	max.		5,0		W
Collector-emitter saturation voltage							
I_C = 1,0 A; I_B = 1,0 mA	**BSS51**	V_{CEsat}	<		1,6		V
I_C = 1,0 A; I_B = 4,0 mA	**BSS50; BSS52**	V_{CEsat}	<		1,6		V
D.C. current gain							
I_C = 500 mA; V_{CE} = 10 V		h_{FE}	>		2000		
Turn-off time when switched from I_{Con} = 500 mA; I_{Bon} = 0,5 mA to cut-off with $-I_{Boff}$ = 0,5 mA		t_{off}	typ.		1,5		μs

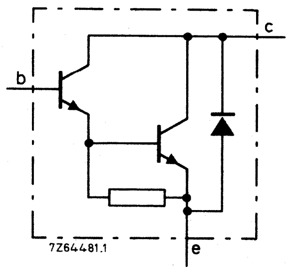
MECHANICAL DATA

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)

			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
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 °C	P_{tot}	max.	0,8	W
up to 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	$R_{th\ j\text{-}a}$	=	220	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	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 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 45$ V	BSS50	I_{CBO}	<	50 nA
$I_E = 0$; $V_{CB} = 60$ V	BSS51	I_{CBO}	<	50 nA
$I_E = 0$; $V_{CB} = 80$ V	BSS52	I_{CBO}	<	50 nA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 4,0$ V		I_{EBO}	<	50 nA
Base-emitter voltage				
$I_C = 150$ mA; $V_{CE} = 10$ V		V_{BE}		1,3 to 1,65 V ←
$I_C = 500$ mA; $V_{CE} = 10$ V		V_{BE}		1,4 to 1,75 V ←
Saturation voltages				
$I_C = 500$ mA; $I_B = 0,5$ mA		V_{CEsat}	<	1,3 V
		V_{BEsat}	<	1,9 V
$I_C = 500$ mA; $I_B = 0,5$ mA; $T_j = 200$ °C		V_{CEsat}	<	1,3 V
$I_C = 1,0$ A; $I_B = 1,0$ mA	BSS51	V_{CEsat}	<	1,6 V
		V_{BEsat}	<	2,2 V
$I_C = 1,0$ A; $I_B = 1,0$ mA; $T_j = 200$ °C	BSS51	V_{CEsat}	<	2,3 V
$I_C = 1,0$ A; $I_B = 4,0$ mA	BSS50; BSS52	V_{CEsat}	<	1,6 V
		V_{BEsat}	<	2,2 V
$I_C = 1,0$ A; $I_B = 4,0$ mA; $T_j = 200$ °C	BSS50; BSS52	V_{CEsat}	<	1,6 V
D.C. current gain				
$I_C = 150$ mA; $V_{CE} = 10$ V		h_{FE}	>	1000
$I_C = 500$ mA; $V_{CE} = 10$ V		h_{FE}	>	2000
Small-signal current gain at f = 35 MHz				
$I_C = 500$ mA; $V_{CE} = 5$ V		h_{fe}	typ.	10 ←

→ **Switching times** (see Figs 2 and 3)

I_{Con} = 500 mA; I_{Bon} = $-I_{Boff}$ = 0,5 mA

Turn-on time	t_{on}	typ.	0,4 μs
Turn-off time	t_{off}	typ.	1,5 μs

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

Turn-on time	t_{on}	typ.	0,4 μs
Turn-off time	t_{off}	typ.	1,5 μs

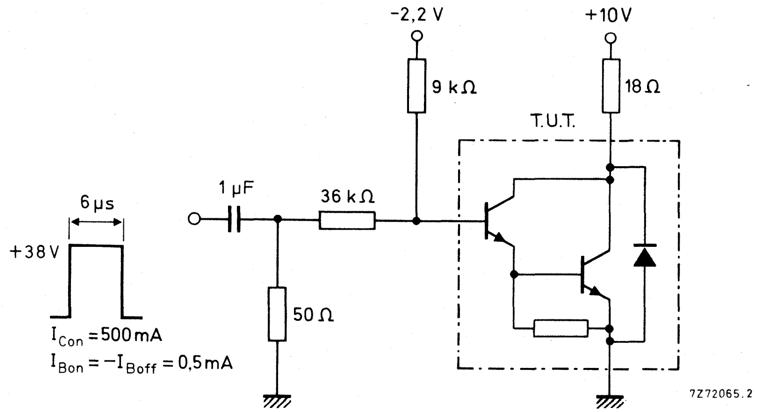


Fig. 2 Test circuit for 500 mA switching.

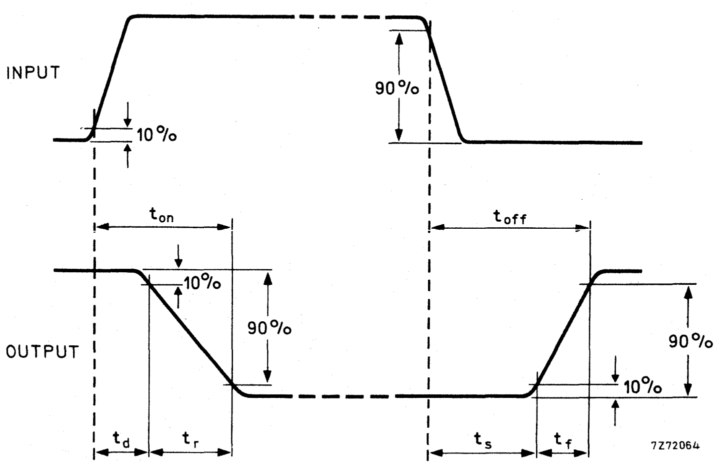


Fig. 3 Switching waveforms.

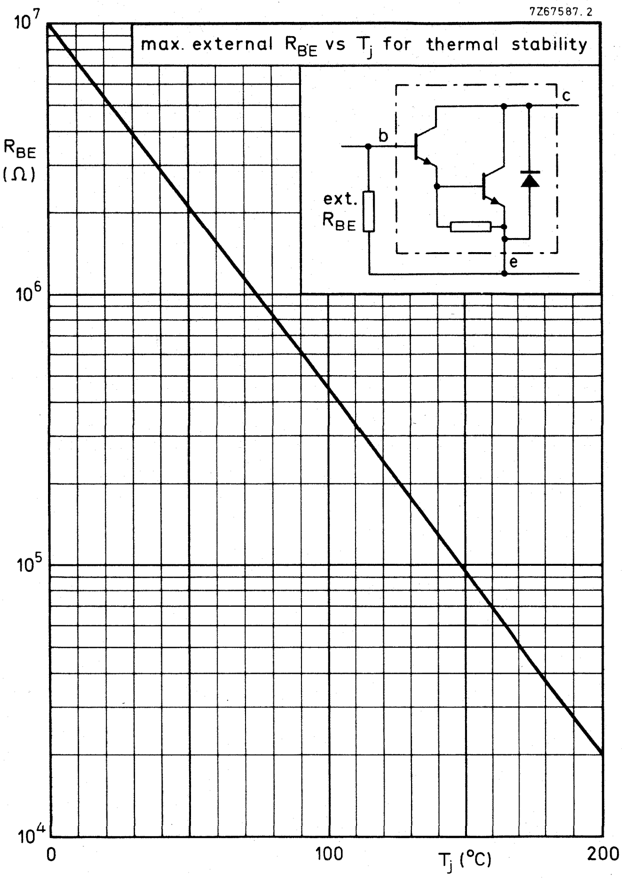

7Z67587.2
max. external R_{BE} vs T_j for thermal stability
R_{BE} (Ω)
10^7
10^6
10^5
10^4
0
100
200
T_j (°C)
c
b
e
ext. R_{BE}

Fig. 4.

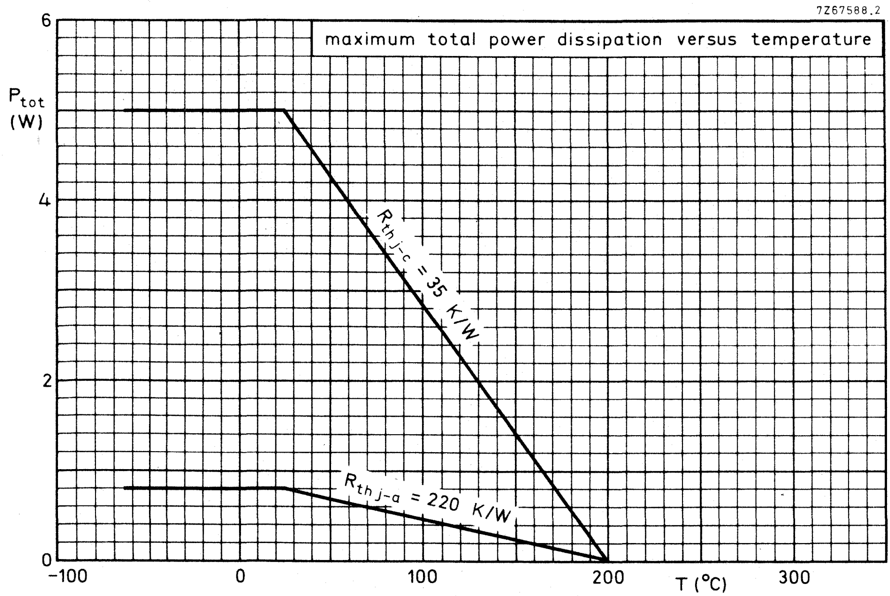

7Z67588.2
maximum total power dissipation versus temperature
P_{tot} (W)
6
4
2
0
$R_{th\ j-c}$ = 35 K/W
$R_{th\ j-a}$ = 220 K/W
−100
0
100
200
300
T (°C)

Fig. 5.

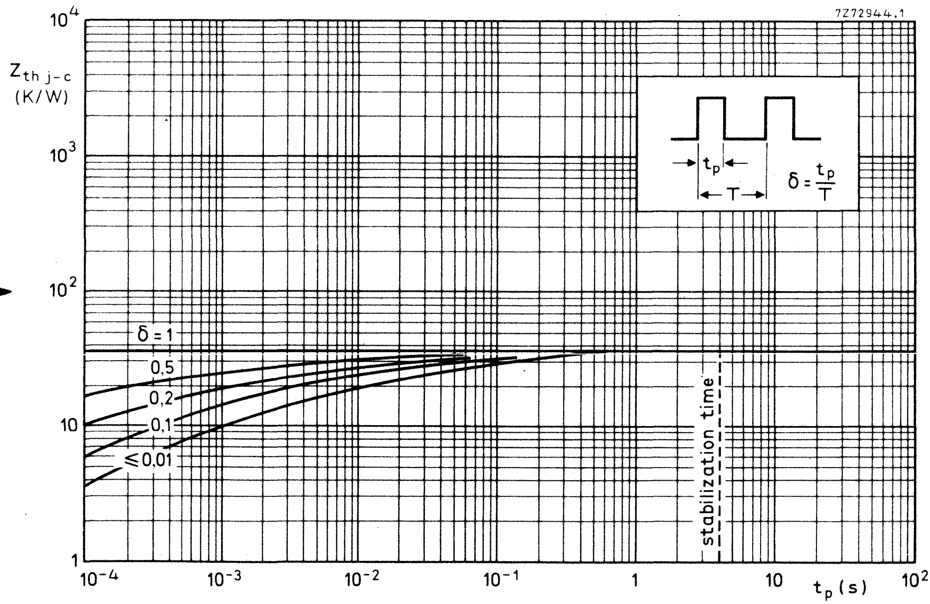

7Z72944.1
$Z_{th\ j-c}$ (K/W)
10^4
10^3
10^2
10
1
δ = 1
0,5
0,2
0,1
≤ 0,01
t_p
T
$\delta = \frac{t_p}{T}$
stabilization time
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (s)

Fig. 6.

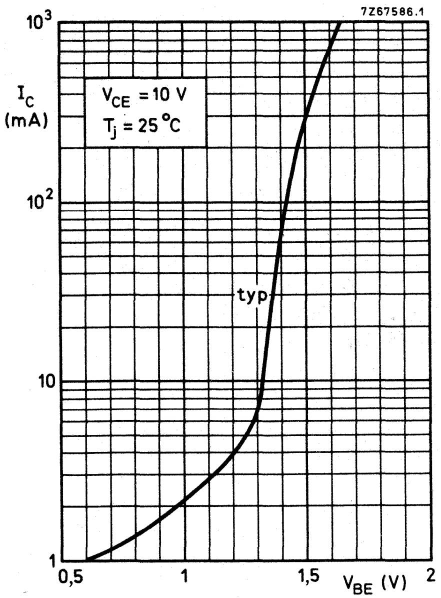


Fig. 7.

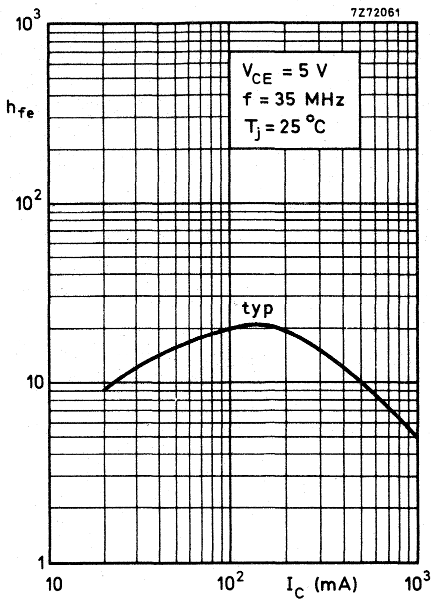


Fig. 8.

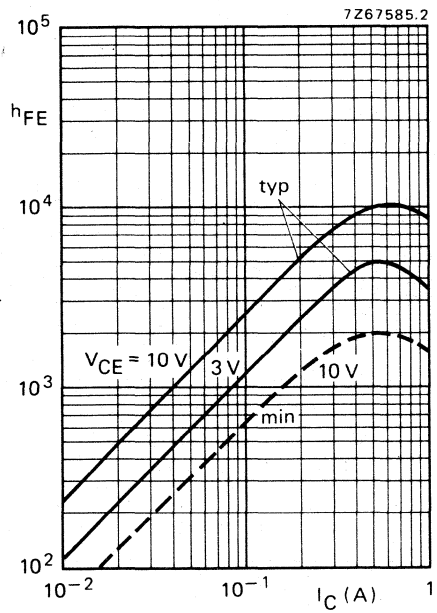


Fig. 9 T_j = 25 °C.

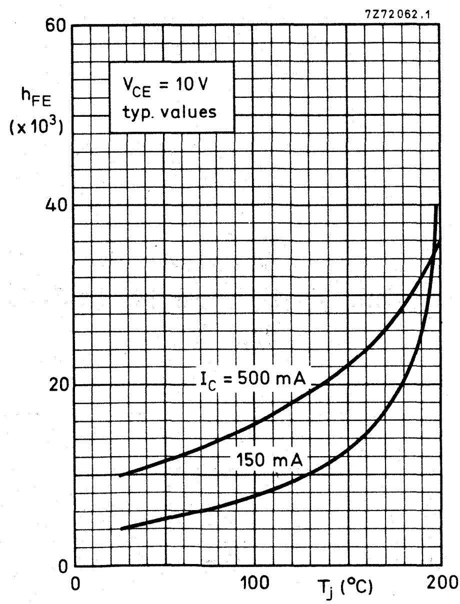


Fig. 10.

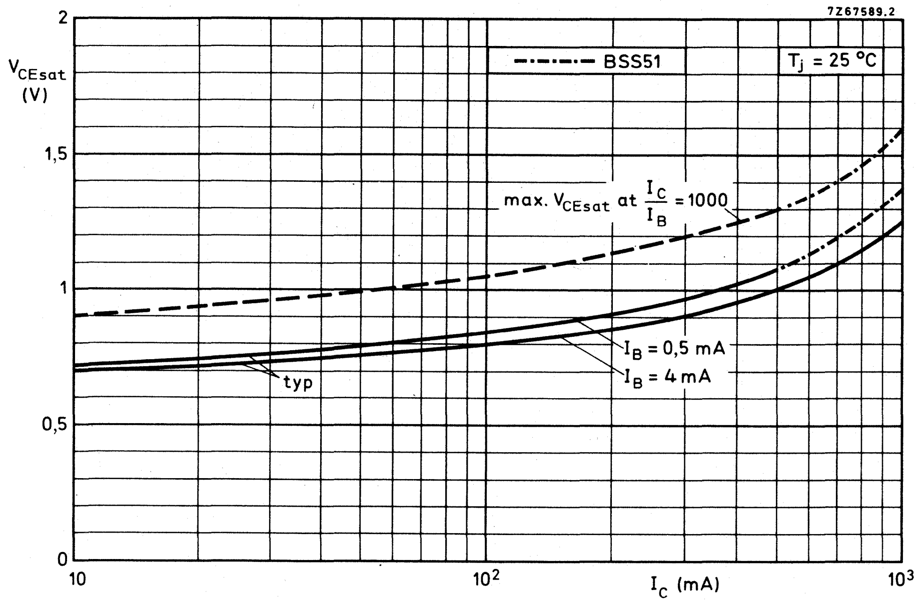

7Z67589.2
BSS51
T_j = 25 °C
V_{CEsat} (V)
2
1,5
1
0,5
0
max. V_{CEsat} at $\frac{I_C}{I_B}$ = 1000
I_B = 0,5 mA
I_B = 4 mA
typ
10
10^2
I_C (mA)
10^3

Fig. 11.

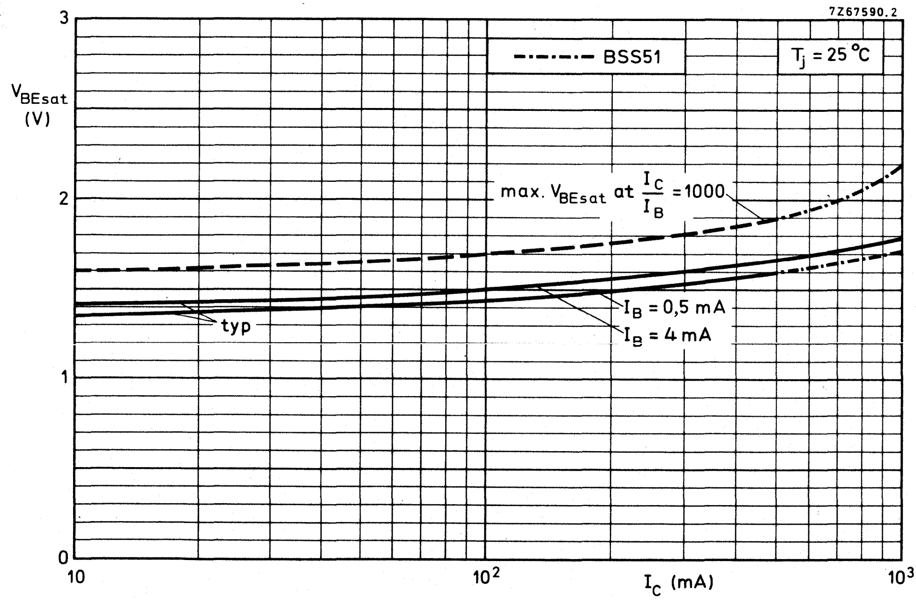

7Z67590.2
BSS51
T_j = 25 °C
V_{BEsat} (V)
3
2
1
0
max. V_{BEsat} at $\frac{I_C}{I_B}$ = 1000
I_B = 0,5 mA
I_B = 4 mA
typ
10
10^2
I_C (mA)
10^3

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

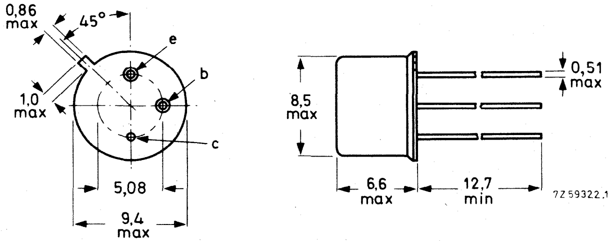
				BSS60	BSS61	BSS62	
Collector-base voltage (open emitter)		$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (see Fig. 4)		$-V_{CER}$	max.	45	60	80	V
Collector current (d.c.)		$-I_C$	max.		1,0		A
Total power dissipation							
up to T_{amb} = 25 °C		P_{tot}	max.		0,8		W
up to T_{case} = 25 °C		P_{tot}	max.		5,0		W
Collector-emitter saturation voltage							
$-I_C$ = 1,0 A; $-I_B$ = 1,0 mA	**BSS61**	$-V_{CEsat}$	$<$		1,6		V
$-I_C$ = 1,0 A; $-I_B$ = 4,0 mA	**BSS60; BSS62**	$-V_{CEsat}$	$<$		1,6		V
D.C. current gain							
$-I_C$ = 500 mA; $-V_{CE}$ = 10 V		h_{FE}	$>$		2000		
Turn-off time when switched from $-I_{Con}$ = 500 mA; $-I_{Bon}$ = 0,5 mA to cut-off with $-I_{Boff}$ = 0,5 mA		t_{off}	typ.		1,5		μs

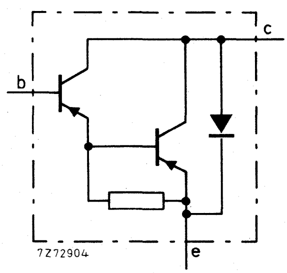
MECHANICAL DATA

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)

			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 °C	P_{tot}	max.	0,8	W
up to 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	$R_{th\ j\text{-}a}$	=	220	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	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 °C unless otherwise specified

Collector cut-off current					
$I_E = 0$; $-V_{CB} = 45$ V	BSS60	$-I_{CBO}$	<	50 nA	
$I_E = 0$; $-V_{CB} = 60$ V	BSS61	$-I_{CBO}$	<	50 nA	
$I_E = 0$; $-V_{CB} = 80$ V	BSS62	$-I_{CBO}$	<	50 nA	
Emitter cut-off current					
$I_C = 0$; $-V_{EB} = 4{,}0$ V		$-I_{EBO}$	<	100 nA	←
Saturation voltages					
$-I_C = 500$ mA; $-I_B = 0{,}5$ mA		$-V_{CEsat}$	<	1,3 V	←
		$-V_{BEsat}$	<	1,9 V	
$-I_C = 500$ mA; $-I_B = 0{,}5$ mA; $T_j = 200$ °C		$-V_{CEsat}$	<	1,3 V	
$-I_C = 1{,}0$ A; $-I_B = 1{,}0$ mA	BSS61	$-V_{CEsat}$	<	1,6 V	
		$-V_{BEsat}$	<	2,2 V	
$-I_C = 1{,}0$ A; $-I_B = 1{,}0$ mA; $T_j = 200$ °C	BSS61	$-V_{CEsat}$	<	1,6 V	
$-I_C = 1{,}0$ A; $-I_B = 4{,}0$ mA	BSS60; BSS62	$-V_{CEsat}$	<	1,6 V	
		$-V_{BEsat}$	<	2,2 V	
$-I_C = 1{,}0$ A; $-I_B = 4{,}0$ mA; $T_j = 200$ °C	BSS60; BSS62	$-V_{CEsat}$	<	1,6 V	
D.C. current gain					
$-I_C = 150$ mA; $-V_{CE} = 10$ V		h_{FE}	>	1000	
$-I_C = 500$ mA; $-V_{CE} = 10$ V		h_{FE}	>	2000	
Small-signal current gain at f = 35 MHz					
$-I_C = 500$ mA; $-V_{CE} = 5$ V		h_{fe}	typ.	10	←

→ **Switching times** (see Figs 2 and 3)

$-I_{Con}$ = 500 mA; $-I_{Bon}$ = I_{Boff} = 0,5 mA

Turn-on time	t_{on}	typ.	0,4 μs
Turn-off time	t_{off}	typ.	1,5 μs

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

Turn-on time	t_{on}	typ.	0,4 μs
Turn-off time	t_{off}	typ.	1,5 μs

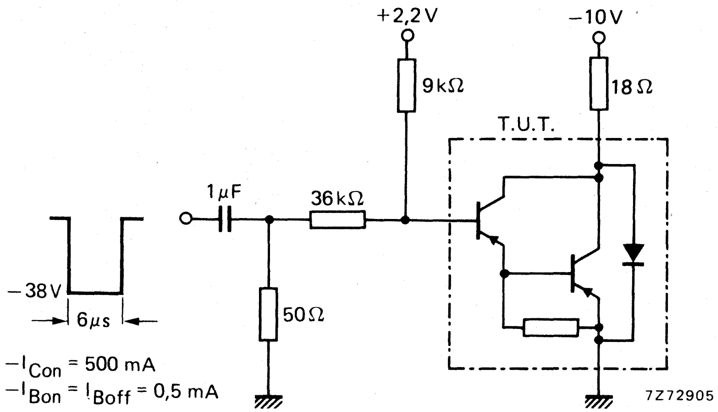


Fig. 2 Test circuit for 500 mA switching.

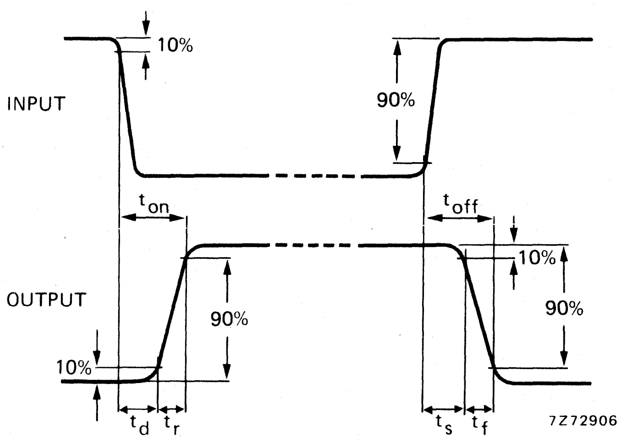


Fig. 3 Switching waveforms.

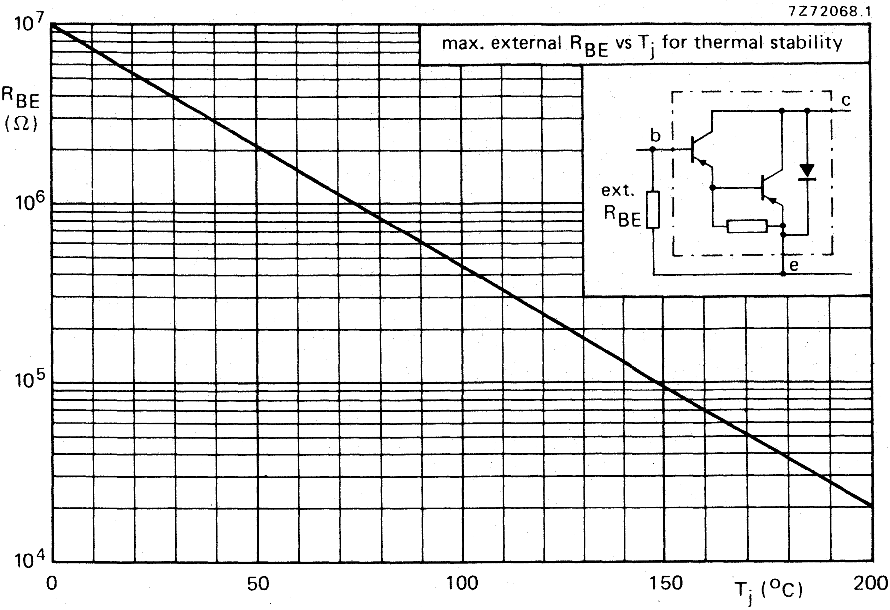

7Z72068.1
max. external R_{BE} vs T_j for thermal stability
R_{BE} (Ω)
10^7
10^6
10^5
10^4
0
50
100
150
200
T_j (°C)
b
c
e
ext. R_{BE}

Fig. 4.

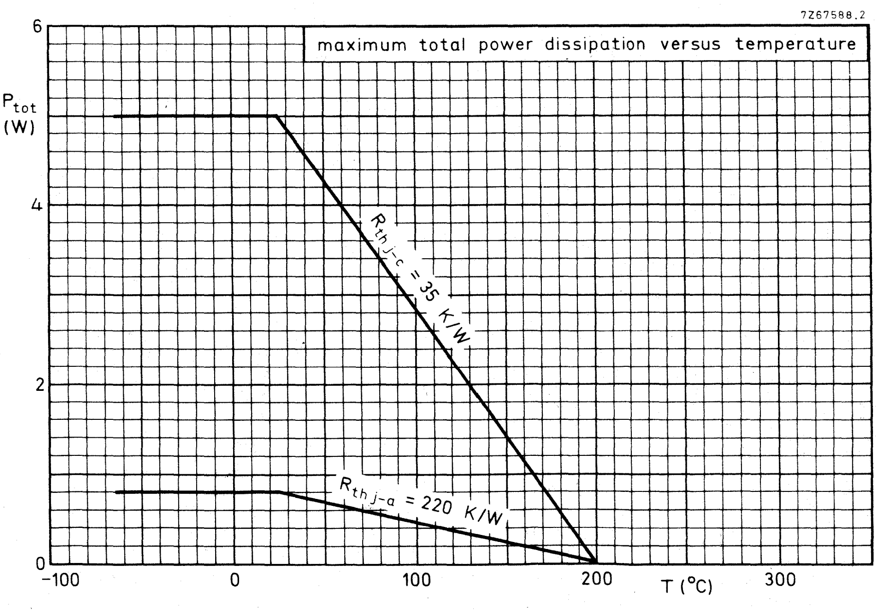

7Z67588.2
maximum total power dissipation versus temperature
P_{tot} (W)
6
4
2
0
−100
0
100
200
300
T (°C)
$R_{th\,j-c}$ = 35 K/W
$R_{th\,j-a}$ = 220 K/W

Fig. 5.

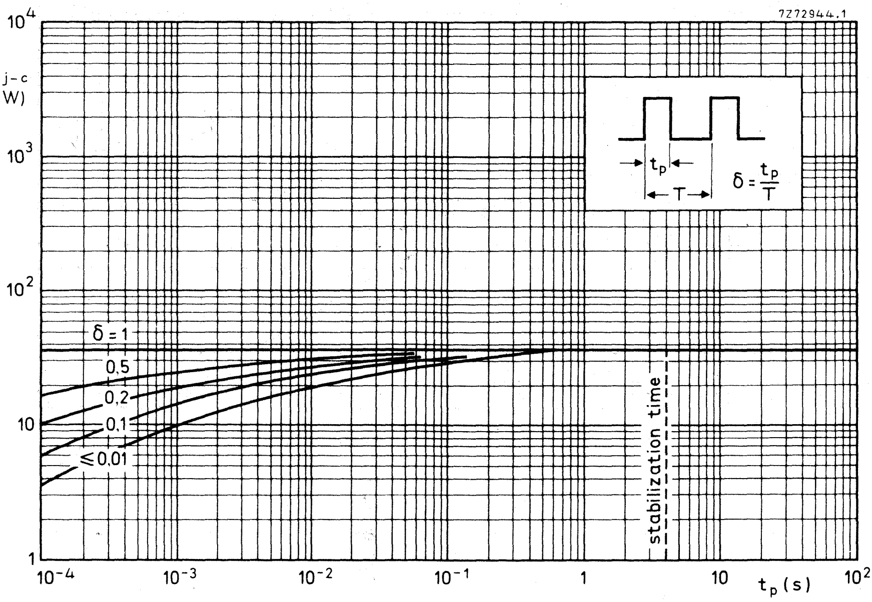


Fig. 6 Thermal impedance as a function of pulse duration.

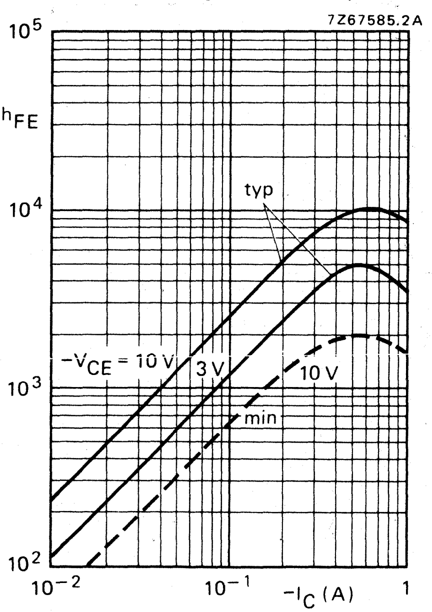


Fig. 7 T_j = 25 °C.

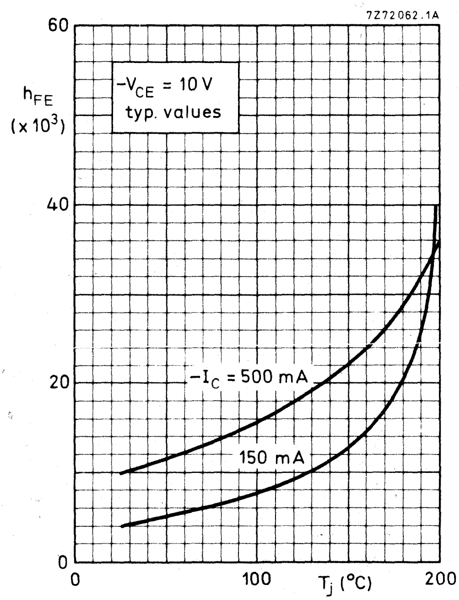


Fig. 8.

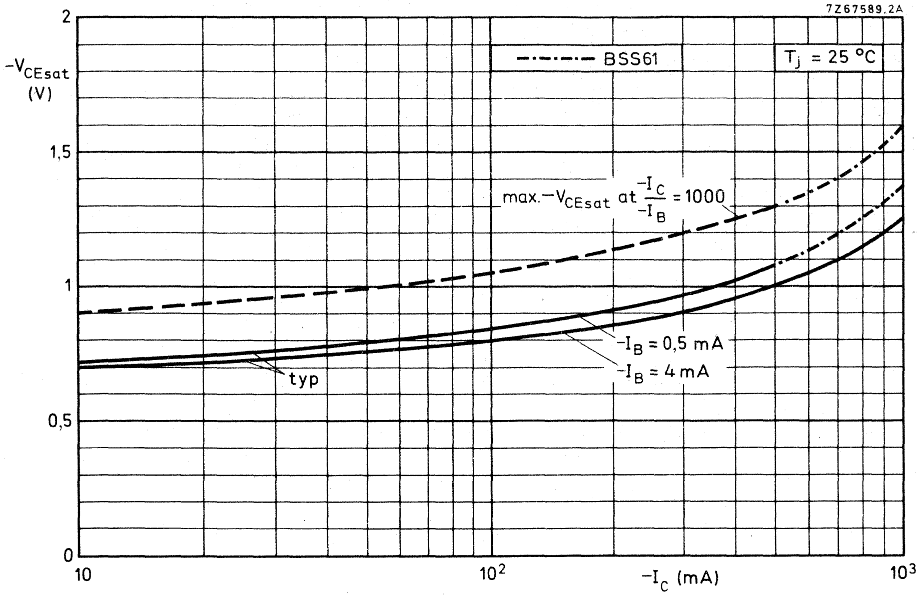

7Z67589.2A
BSS61
T_j = 25 °C
$-V_{CEsat}$ (V)
max. $-V_{CEsat}$ at $\frac{-I_C}{-I_B}$ = 1000
$-I_B$ = 0,5 mA
$-I_B$ = 4 mA
typ
2
1,5
1
0,5
0
10
10^2
10^3
$-I_C$ (mA)

Fig. 9.

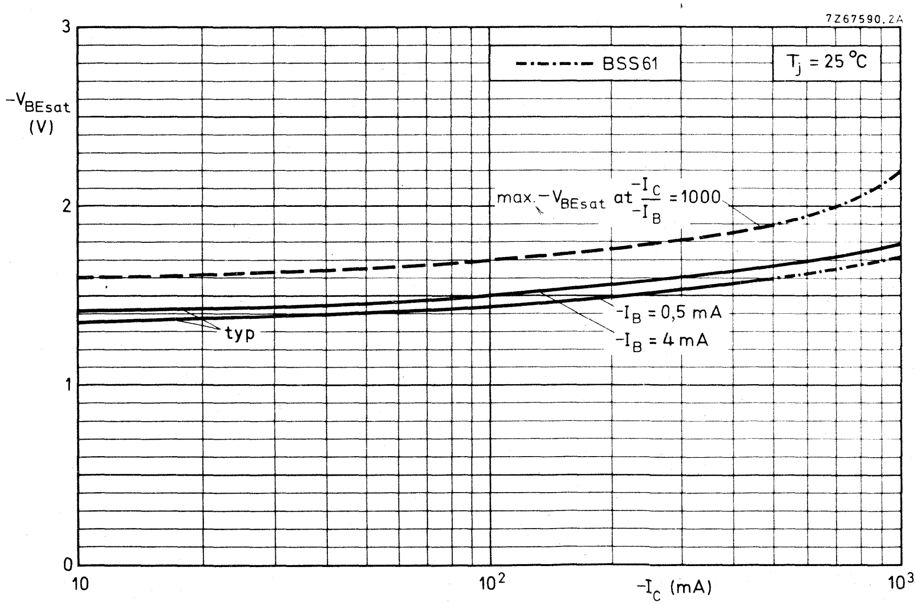

7Z67590.2A
BSS61
T_j = 25 °C
$-V_{BEsat}$ (V)
max. $-V_{BEsat}$ at $\frac{-I_C}{-I_B}$ = 1000
$-I_B$ = 0,5 mA
$-I_B$ = 4 mA
typ
3
2
1
0
10
10^2
10^3
$-I_C$ (mA)

Fig. 10.

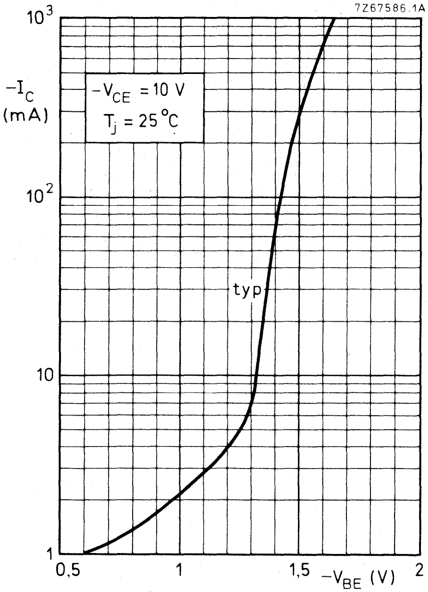

7Z67586.1A
10^3
$-I_C$ (mA)
$-V_{CE}$ = 10 V
T_j = 25 °C
10^2
typ
10
1
0,5
1
1,5
2
$-V_{BE}$ (V)

Fig. 11.

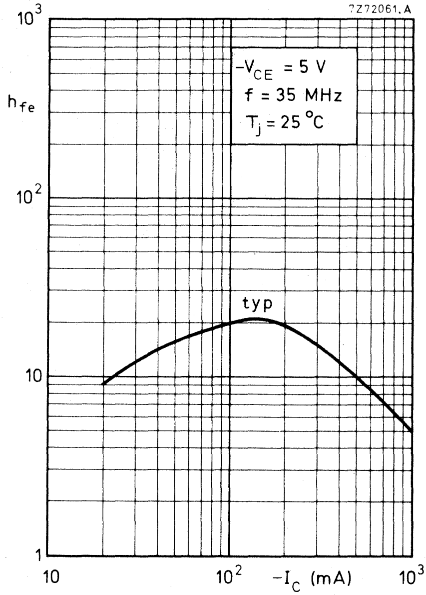

7Z72061.A
10^3
h_{fe}
$-V_{CE}$ = 5 V
f = 35 MHz
T_j = 25 °C
10^2
typ
10
1
10
10^2
$-I_C$ (mA)
10^3

Fig. 12.

HIGH-VOLTAGE P-N-P TRANSISTOR

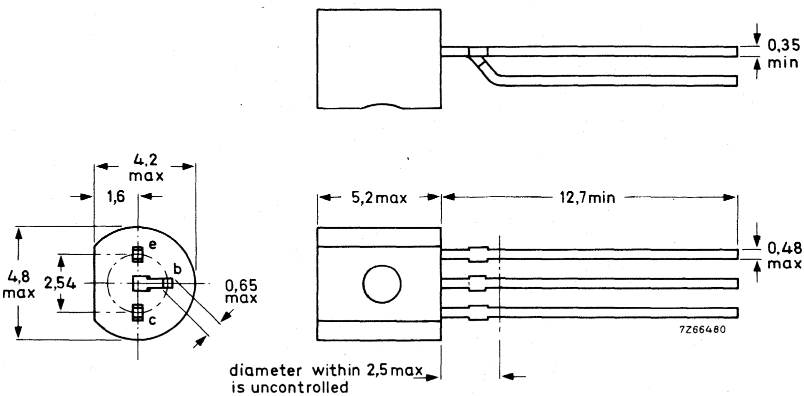
Silicon planar epitaxial transistor in a plastic TO-92 variant.
It is intended for anode switching in dynamically driven numerical indicator tubes and as general purpose switching device.

QUICK REFERENCE DATA				
Collector-emitter voltage (R_{BE} = 10 kΩ)	$-V_{CER}$	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 °C	P_{tot}	max.	500	mW
Junction temperature	T_j	max.	150	°C
D.C. current gain at T_j = 25 °C				
$-I_C$ = 25 mA; $-V_{CE}$ = 5 V	h_{FE}	>	30	
Transition frequency at f = 35 MHz				
$-I_C$ = 25 mA; $-V_{CE}$ = 5 V	f_T	>	50	MHz

MECHANICAL DATA

Dimensions in mm

TO-92 variant



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

Voltages

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	110	V
Collector-emitter voltage (R_{BE} = 10 kΩ)	$-V_{CER}$	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

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500	mW

Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0,25	°C/mW

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

I_E = 0; $-V_{CB}$ = 100 V; T_j = 70 °C	$-I_{CBO}$	<	10	μA

Saturation voltages

$-I_C$ = 25 mA; $-I_B$ = 2,5 mA	$-V_{CEsat}$	<	250	mV
	$-V_{BEsat}$	<	900	mV

D.C. current gain

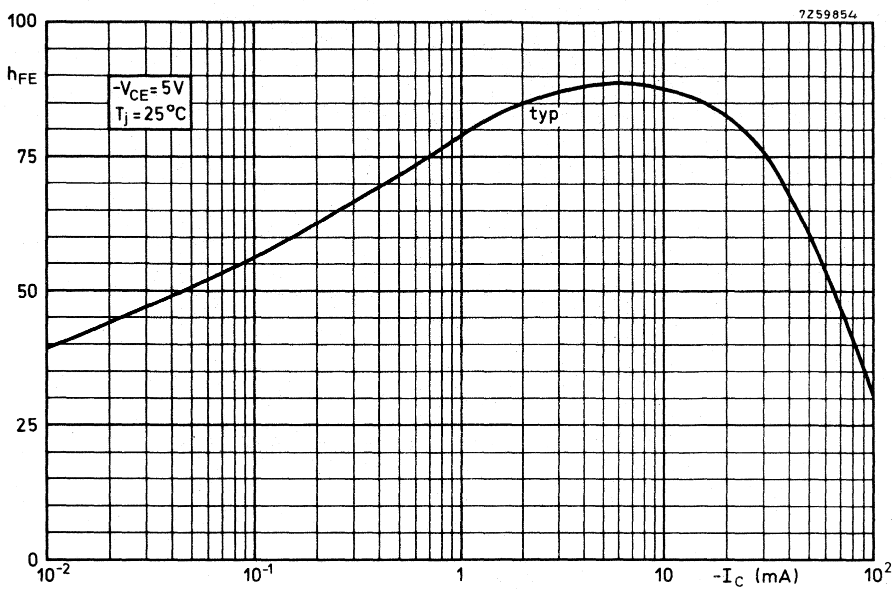
$-I_C$ = 10 mA; $-V_{CE}$ = 5 V	h_{FE}	>	30	
$-I_C$ = 25 mA; $-V_{CE}$ = 5 V	h_{FE}	>	30	

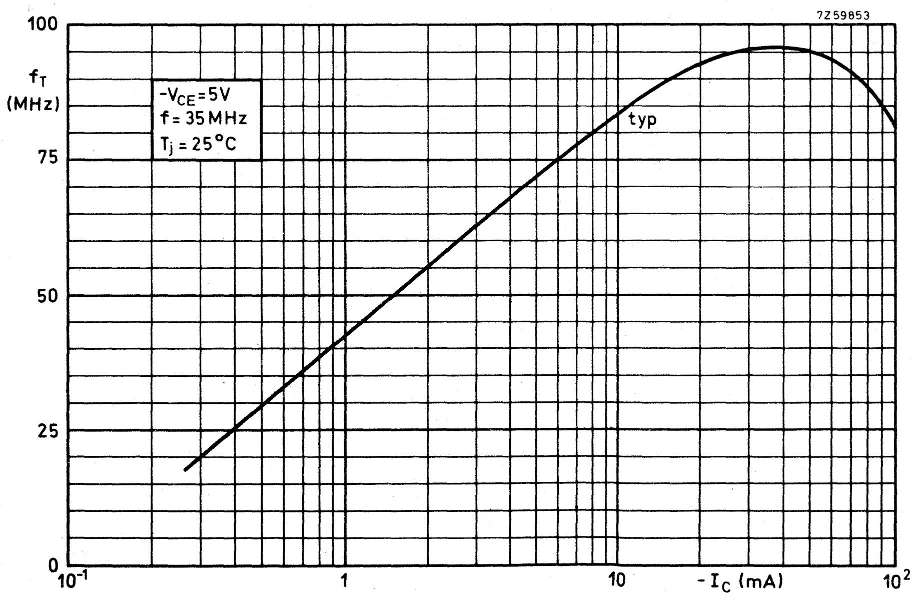
Collector capacitance at f = 1 MHz

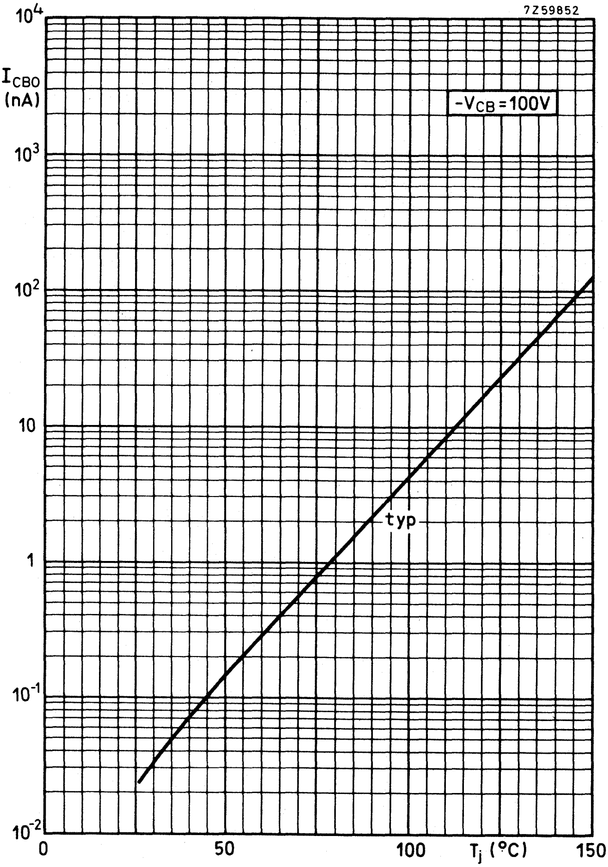
I_E = I_e = 0; $-V_{CB}$ = 10 V	C_c	<	5	pF

Transition frequency at f = 35 MHz

$-I_C$ = 25 mA; $-V_{CE}$ = 5 V	f_T	>	50	MHz


7Z59854
100
h_{FE}
$-V_{CE} = 5V$
$T_j = 25^{\circ}C$
typ
75
50
25
0
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2


7Z59853
100
f_T
(MHz)
$-V_{CE} = 5V$
$f = 35 MHz$
$T_j = 25^{\circ}C$
typ
75
50
25
0
10^{-1}
1
10
$-I_C$ (mA)
10^2


7Z59852
$-I_{CBO}$ (nA)
$-V_{CB} = 100V$
typ
T_j (°C)
10^4
10^3
10^2
10
1
10^{-1}
10^{-2}
0
50
100
150

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 °C	P_{tot}	max.		0,8		W
up to T_{case} = 25 °C	P_{tot}	max.		5,0		W
Junction temperature	T_j	max.		200		°C
Transition frequency at f = 20 MHz						
$-I_C$ = 50 mA; $-V_{CE}$ = 10 V	f_T	>		50		MHz

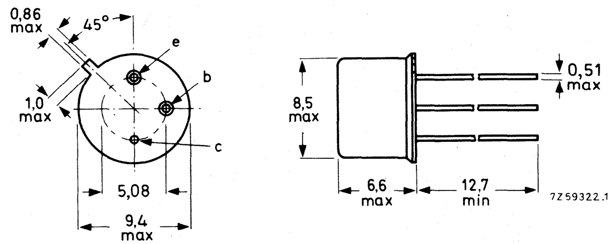
		BSV15–6 BSV16–6 BSV17–6	BSV15–10 BSV16–10 BSV17–10	BSV15–16 BSV16–16
D.C. current gain $-I_C$ = 100 mA; $-V_{CE}$ = 1 V	h_{FE}	40–100	63–160	100–250

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 °C	P_{tot}	max.	0.8	W
up to T_{case} = 25 °C	P_{tot}	max.	5.0	W
up to T_{mb} = 50 °C	P_{tot}	max.	5.0	W
Temperatures				
Storage temperature	T_{stg}		−65 to +200	°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	220	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	35	°C/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	30	°C/W

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

			BSV15	BSV16	BSV17	
Collector cut-off currents						
$V_{BE} = 0$; $-V_{CE} = 40$ V	$-I_{CES}$	<	100	–	–	nA
$V_{BE} = 0$; $-V_{CE} = 40$ V; $T_{amb} = 150$ °C	$-I_{CES}$	<	50	–	–	μA
$V_{BE} = 0$; $-V_{CE} = 60$ V	$-I_{CES}$	<	–	100	–	nA
$V_{BE} = 0$; $-V_{CE} = 60$ V; $T_{amb} = 150$ °C	$-I_{CES}$	<	–	50	–	μA
$V_{BE} = 0$; $-V_{CE} = 80$ V	$-I_{CES}$	<	–	–	100	nA
$V_{BE} = 0$; $-V_{CE} = 80$ V; $T_{amb} = 150$ °C	$-I_{CES}$	<	–	–	50	μA
$-V_{BE} = 0,2$ V; $-V_{CE} = 40$ V; $T_{amb} = 100$ °C	$-I_{CEX}$	<	50	–	–	μA
$-V_{BE} = 0,2$ V; $-V_{CE} = 60$ V; $T_{amb} = 100$ °C	$-I_{CEX}$	<	–	50	–	μA
$-V_{BE} = 0,2$ V; $-V_{CE} = 80$ V; $T_{amb} = 100$ °C	$-I_{CEX}$	<	–	–	50	μA
Emitter cut-off current						
$I_C = 0$; $-V_{EB} = 4$ V	$-I_{EBO}$	<	50	50	50	nA
Breakdown voltages						
$I_B = 0$; $-I_C = 50$ mA; $t_p = 200$ μs; $\delta = 0,01$	$-V_{(BR)CEO}$	>	40	60	80	V
$V_{BE} = 0$; $-I_C = 10$ μA	$-V_{(BR)CES}$	>	40	60	90	V
$I_C = 0$; $-I_E = 10$ μA	$-V_{(BR)EBO}$	>	5	5	5	V

Base-emitter voltage				
$-I_C = 100$ mA; $-V_{CE} = 1$ V	$-V_{BE}$	<	1,0	V
$-I_C = 500$ mA; $-V_{CE} = 1$ V	$-V_{BE}$	typ.	0,85	V
			0,7 to 1,4	V
Saturation voltage				
$-I_C = 500$ mA; $-I_B = 25$ mA	$-V_{CEsat}$	<	1,0	V ←
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $-V_{CB} = 10$ V — BSV15; BSV16	C_c	typ.	20	pF
		<	30	pF
$I_E = I_e = 0$; $-V_{CB} = 10$ V — BSV17	C_c	typ.	15	pF
		<	25	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $-V_{EB} = 0,5$ V	C_e	typ.	180	pF
Transition frequency at f = 20 MHz				
$-I_C = 50$ mA; $-V_{CE} = 10$ V	f_T	>	50	MHz

CHARACTERISTICS (continued) T_{amb} = 25 °C unless otherwise specified

			BSV15-6 BSV16-6 BSV17-6	BSV15-10 BSV16-10 BSV17-10	BSV15-16 BSV16-16
D.C. current gain					
$-I_C$ = 0.1 mA; $-V_{CE}$ = 1 V	h_{FE}	>	15	20	30
		typ.	44	75	120
$-I_C$ = 100 mA; $-V_{CE}$ = 1 V	h_{FE}	typ.	63	100	160
			40 to 100	63 to 160	100 to 250
$-I_C$ = 500 mA; $-V_{CE}$ = 1 V	h_{FE}	>	20	25	35
		typ.	40	55	85

h parameter at f = 1 kHz

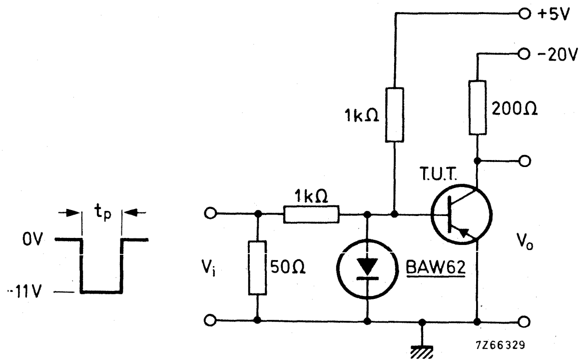
$-I_C$ = 1 mA; $-V_{CE}$ = 5 V

Small signal current gain	h_{fe}	>	20	

Switching times

Turn-on time				
$-I_C$ = 100 mA; $-I_B$ = $+I_{BM}$ = 5 mA	t_{on}	<	500	ns
Turn-off time				
$-I_C$ = 100 mA; $-I_B$ = $+I_{BM}$ = 5 mA				
Storage time	t_s	<	500	ns
Fall time	t_f	<	150	ns

Test circuit:

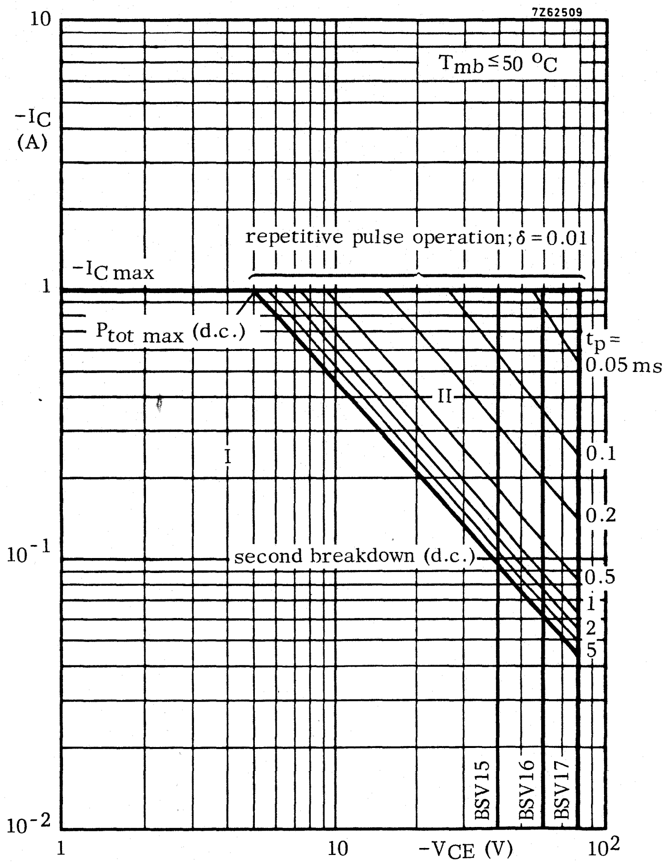


Pulse generator:

Pulse duration	$t_p \geq 10\ \mu s$
Rise time	$t_r \leq 15$ ns
Fall time	$t_f \leq 15$ ns
Source impedance	R_S = 50 Ω

Oscilloscope:

Rise time	≤ 15 ns
Input impedance	≥ 100 kΩ



Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

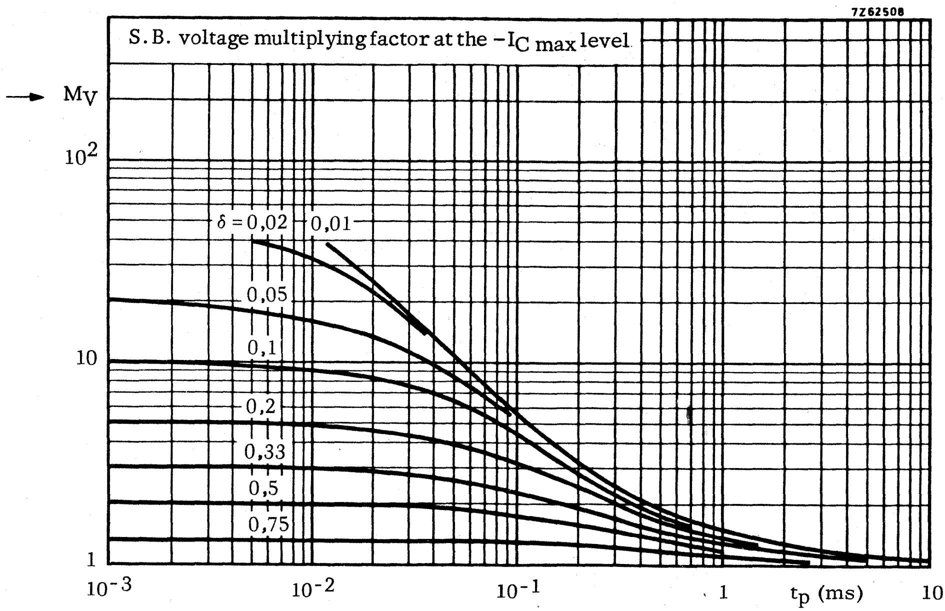

7Z62508
S.B. voltage multiplying factor at the $-I_{C\,max}$ level
M_V
10^2
10
1
δ = 0,02
0,01
0,05
0,1
0,2
0,33
0,5
0,75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10

Fig. 4.

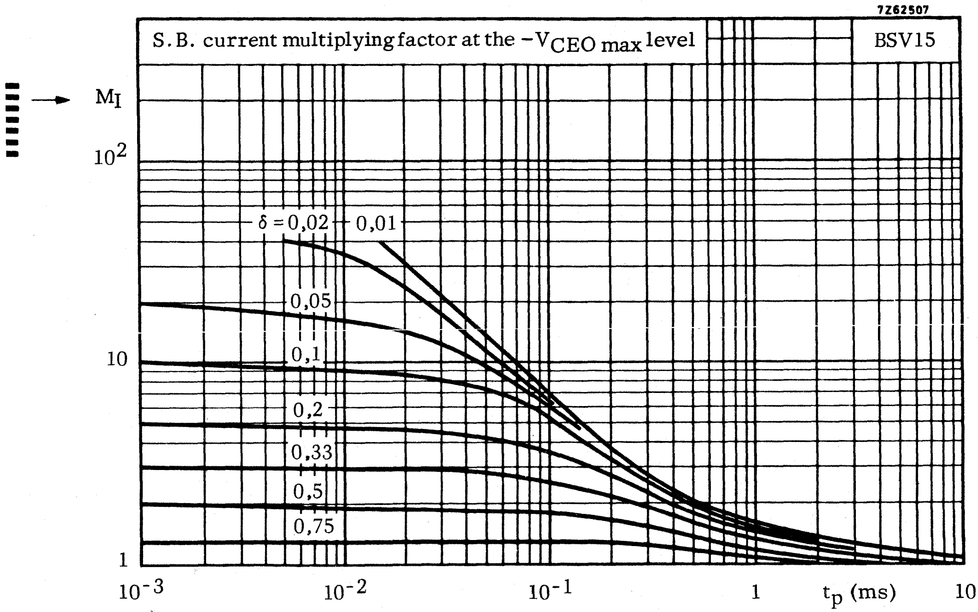

7Z62507
S.B. current multiplying factor at the $-V_{CEO\,max}$ level
BSV15
M_I
10^2
10
1
δ = 0,02
0,01
0,05
0,1
0,2
0,33
0,5
0,75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10

Fig. 5.

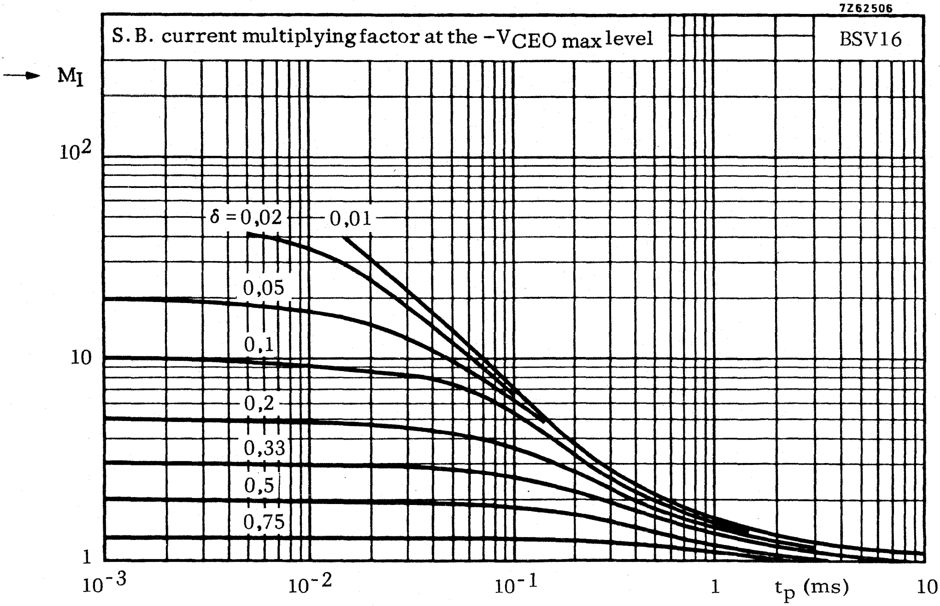

7Z62506
S.B. current multiplying factor at the $-V_{CEO\,max}$ level
BSV16
→ M_I
10^2
10
1
δ = 0,02
0,01
0,05
0,1
0,2
0,33
0,5
0,75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10

Fig. 6.

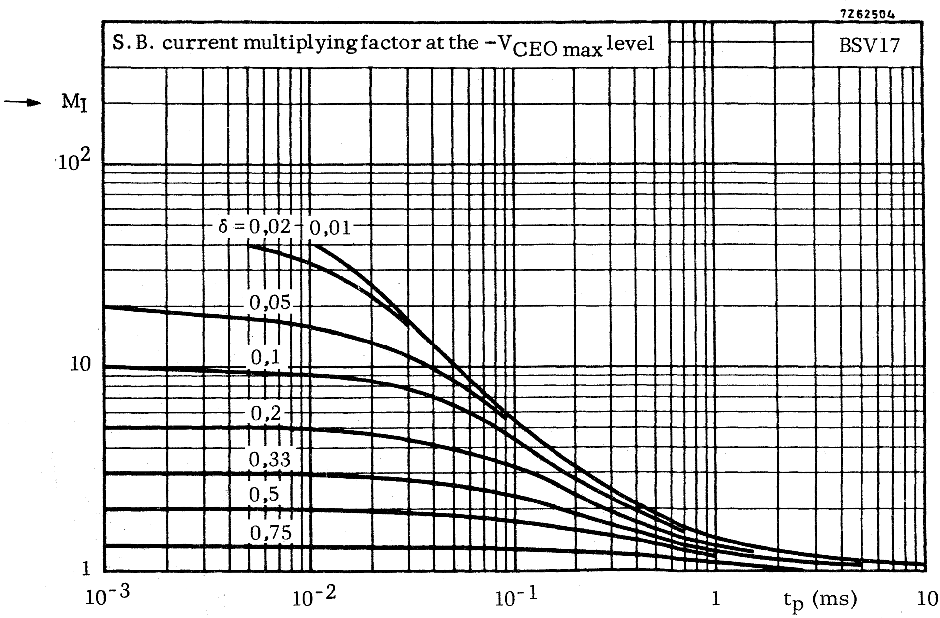
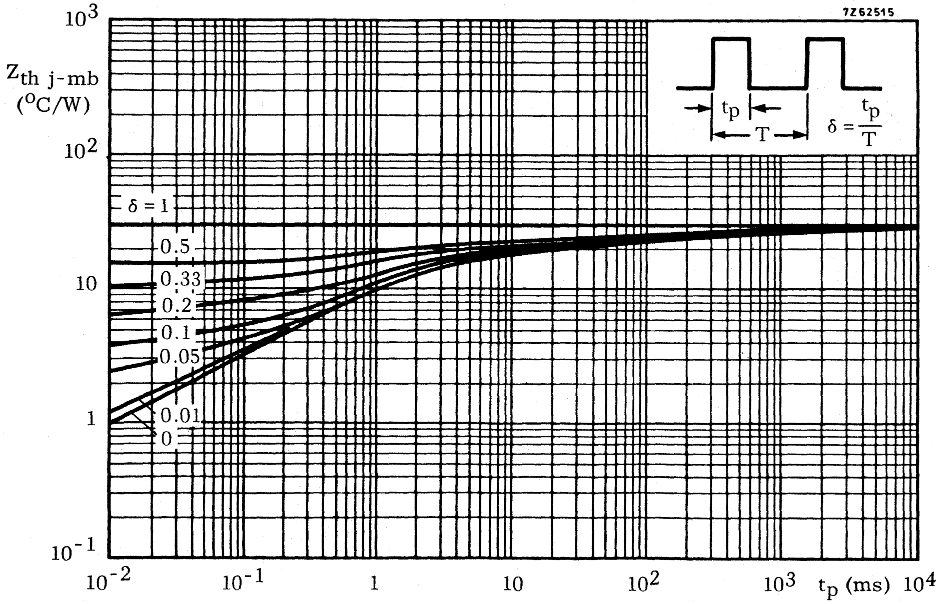
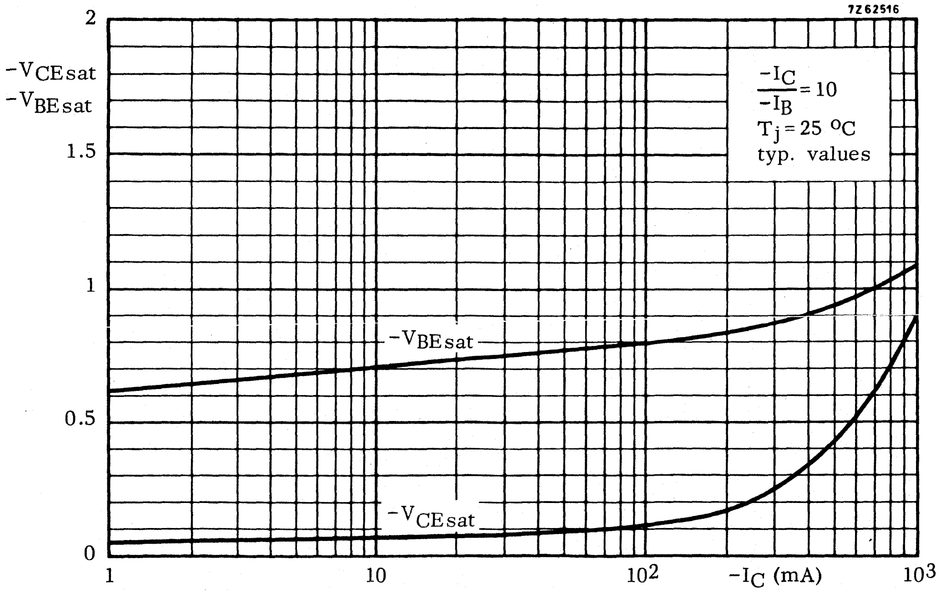
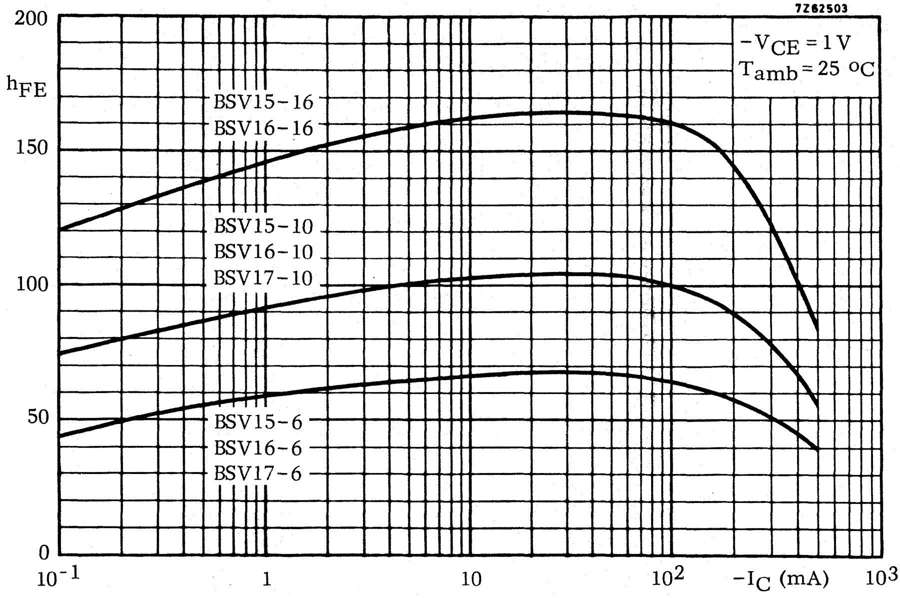
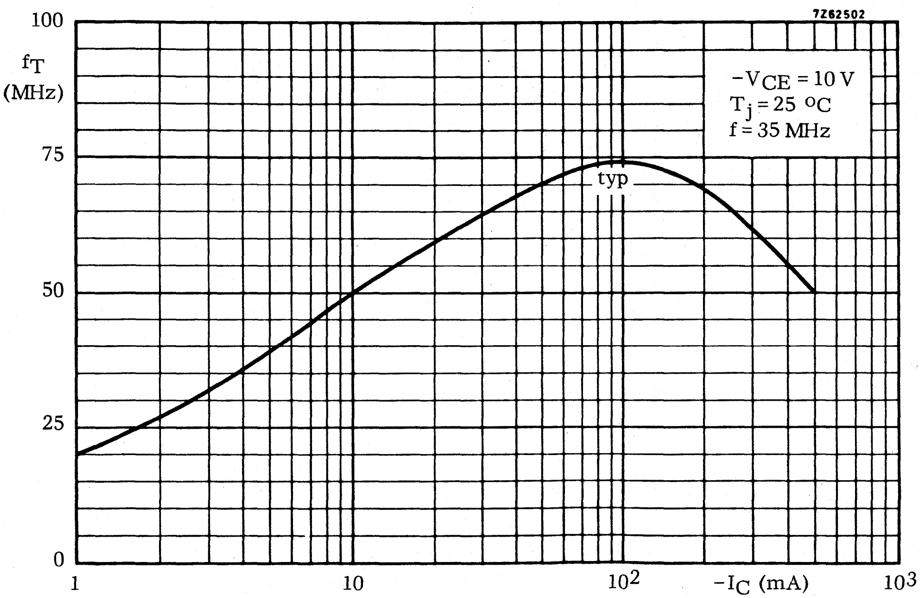

7Z62504
S.B. current multiplying factor at the $-V_{CEO\,max}$ level
BSV17
→ M_I
10^2
10
1
δ = 0,02
0,01
0,05
0,1
0,2
0,33
0,5
0,75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10

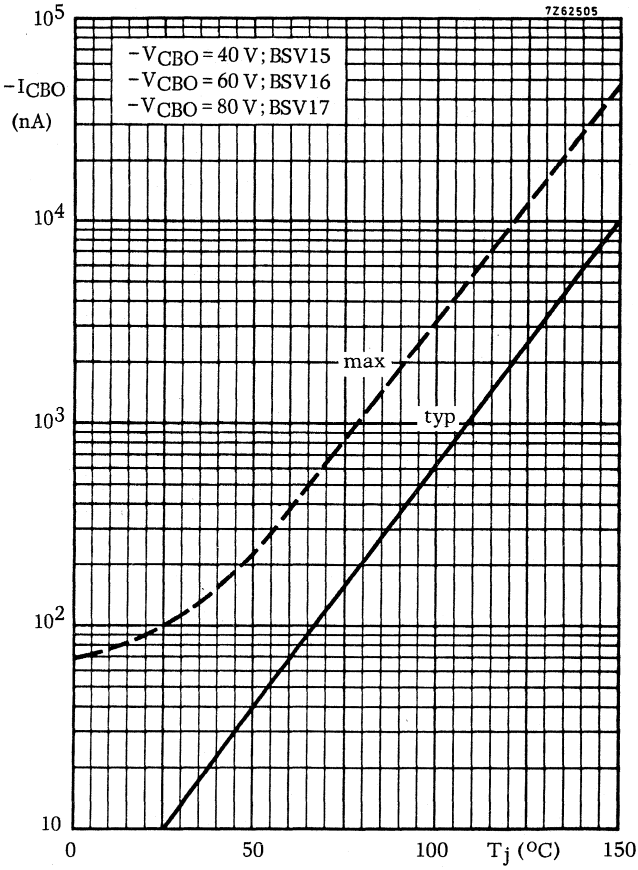
Fig. 7.


7Z62515
$Z_{th\ j\text{-}mb}$ (°C/W)
10^3
10^2
10
1
10^{-1}
δ = 1
0.5
0.33
0.2
0.1
0.05
0.01
0
10^{-2}
10^{-1}
1
10
10^2
10^3
t_p (ms)
10^4
t_p
T
$\delta = \frac{t_p}{T}$


7Z62516
$-V_{CEsat}$
$-V_{BEsat}$
2
1.5
1
0.5
0
$\frac{-I_C}{-I_B} = 10$
$T_j = 25\ ^\circ C$
typ. values
$-V_{BEsat}$
$-V_{CEsat}$
1
10
10^2
$-I_C$ (mA)
10^3


7Z62503
200
hFE
150
100
50
0
BSV15-16
BSV16-16
BSV15-10
BSV16-10
BSV17-10
BSV15-6
BSV16-6
BSV17-6
−VCE = 1 V
Tamb = 25 °C
10-1
1
10
102
−IC (mA)
103


7Z62502
100
fT
(MHz)
75
50
25
0
−VCE = 10 V
Tj = 25 °C
f = 35 MHz
typ
1
10
102
−IC (mA)
103


7Z62505
$-V_{CBO} = 40$ V; BSV15
$-V_{CBO} = 60$ V; BSV16
$-V_{CBO} = 80$ V; BSV17
$-I_{CBO}$ (nA)
10^5
10^4
10^3
10^2
10
max
typ
0
50
100
T_j (°C)
150

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

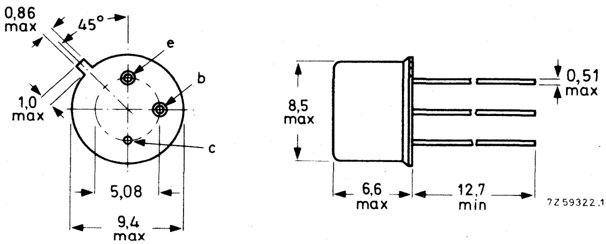
Collector-base voltage (open emitter)	V_{CBO}	max.	100 V
Collector-emitter voltage (open base)	V_{CEO}	max.	60 V
Collector current (peak value)	I_{CM}	max.	5,0 A
Total power dissipation up to T_{case} = 50 °C	P_{tot}	max.	5,0 W
Junction temperature	T_j	max.	175 °C
D.C. current gain I_C = 2 A; V_{CE} = 2 V	h_{FE}	>	40
Transition frequency at f = 35 MHz I_C = 0,5 A; V_{CE} = 5 V	f_T	typ.	100 MHz
Turn-off time when switched from I_{Con} = 5 A; I_{Bon} = 0,5 A to cut-off with $-I_{Boff}$ = 0,5 A	t_{off}	<	1,2 μs

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 50 004-025, available on request.

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 $T_{case} = 50\ ^oC$	P_{tot}	max.	5,0	W

Temperatures

Storage temperature	T_{stg}	−55 to +175		^oC
Junction temperature	T_j	max.	175	^oC

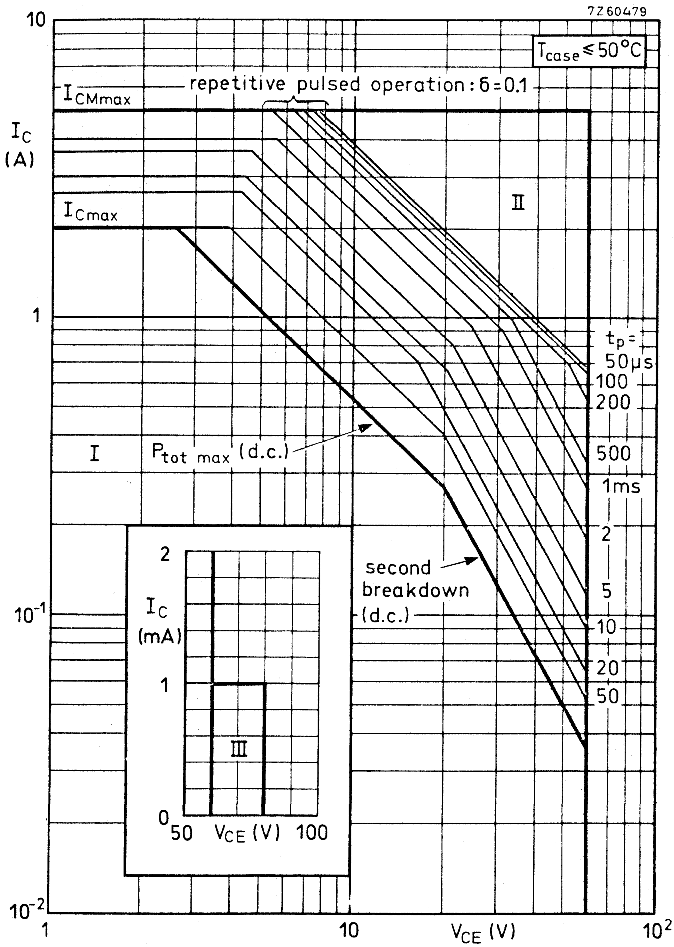
THERMAL RESISTANCE

From junction to case	$R_{th\ j-c}$	=	25	$^oC/W$

CHARACTERISTICS

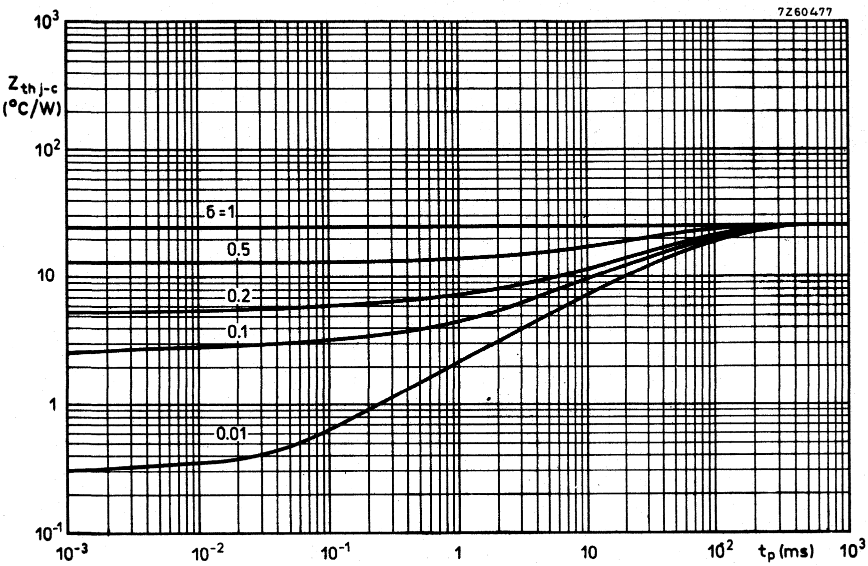
$T_j = 25\ ^oC$

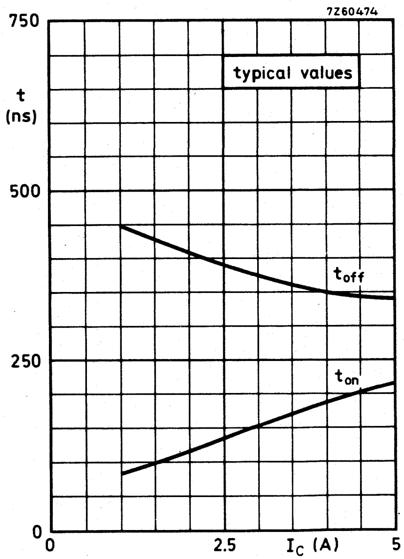
Collector cut-off current			
$I_E = 0$; $V_{CB} = 60$ V	I_{CBO}	<	10 μA
Emitter cut-off current			
$I_C = 0$; $V_{EB} = 4$ V	I_{EBO}	<	10 μA
Saturation voltages			
$I_C = 5$ A; $I_B = 0{,}5$ A	V_{CEsat}	<	1,0 V
	V_{BEsat}	<	1,8 V
D.C. current gain			
$I_C = 2$ A; $V_{CE} = 2$ V	h_{FE}	>	40
Collector capacitance at f = 1 MHz			
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	80 pF
Transition frequency at f = 35 MHz			
$I_C = 0{,}5$ A; $V_{CE} = 5$ V	f_T	typ.	100 MHz
Switching times			
$I_{Con} = 5$ A; $I_{Bon} = -I_{Boff} = 0{,}5$ A			
$-V_{BEoff} = 2$ V			
turn-on time	t_{on}	<	0,6 μs
turn-off time	t_{off}	<	1,2 μs

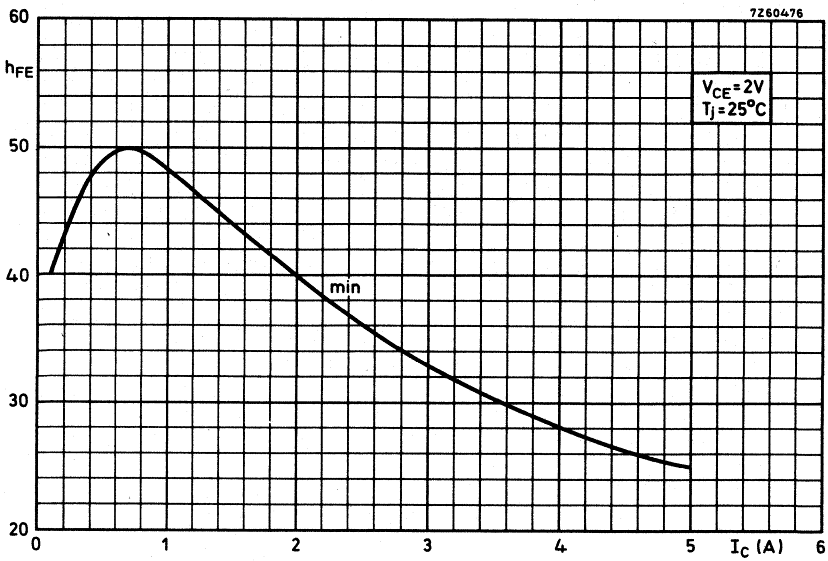


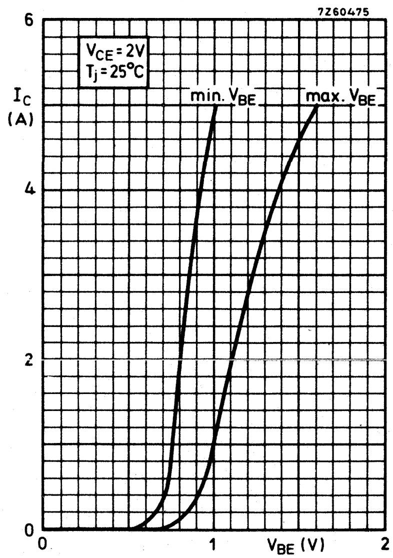
Safe Operating Area

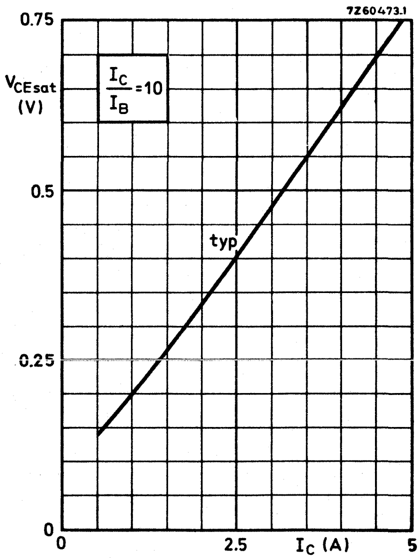
I Region of permissible d.c. operation
II Permissible extension for repetitive pulsed operation
III D.C. operation in this region is allowable, provided $R_{BE} \leq 50\ \Omega$


7Z60477
$Z_{th\,j-c}$ (°C/W)
10^3
10^2
10
1
10^{-1}
δ = 1
0.5
0.2
0.1
0.01
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3


7Z60474
typical values
t (ns)
750
500
250
0
t_{off}
t_{on}
0
2.5
I_C (A)
5


7Z60476
60
h_{FE}
50
40
30
20
V_{CE} = 2V
T_j = 25°C
min
0
1
2
3
4
5
I_C (A)
6


7Z60475
6
4
2
0
I_C
(A)
V_{CE} = 2V
T_j = 25°C
min. V_{BE}
max. V_{BE}
1
V_{BE} (V)
2


7Z60473.1
0.75
0.5
0.25
0
V_{CEsat}
(V)
$\frac{I_C}{I_B}$ = 10
typ
2.5
I_C (A)
5

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors primarily intended for general purpose industrial and switching applications.

QUICK REFERENCE DATA

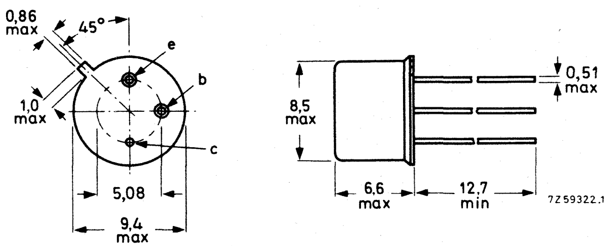
			BSW66A	BSW67A	BSW68A	
Collector-base voltage (open emitter)	V_{CBO}	max.	100	120	150	V
Collector-emitter voltage (open base)	V_{CEO}	max.	100	120	150	V
Collector current (peak value)	I_{CM}	max.		2		A
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.		5,0		W
Collector-emitter saturation voltage I_C = 500 mA; I_B = 50 mA	V_{CEsat}	<		400		mV
D.C. current gain I_C = 10 mA; V_{CE} = 5 V	h_{FE}	>		30		
I_C = 500 mA; V_{CE} = 5 V	h_{FE}	>		30		
Transition frequency at f = 35 MHz I_C = 100 mA; V_{CE} = 20 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						
$T_{amb} = 25\ ^oC$	P_{tot}	max.		0,8		W
$T_{case} = 25\ ^oC$	P_{tot}	max.		5,0		W
Storage temperature	T_{stg}			−65 to + 200		^oC
Junction temperature	T_j	max.		200		^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	220	$^oC/W$
From junction to case	$R_{th\ j\text{-}c}$	=	35	$^oC/W$

CHARACTERISTICS

$T_j = 25\ ^oC$ unless otherwise specified

Collector cut-off current						
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	<		100		μA
$I_E = 0$; $V_{CB} = ½V_{CBOmax}$	I_{CBO}	<		100		nA
$I_E = 0$; $V_{CB} = ½V_{CBOmax}$; $T_j = 150\ ^oC$	I_{CBO}	<		50		μA
Emitter cut-off current						
$I_C = 0$; $V_{EB} = 6$ V	I_{EBO}	<		100		μA
$I_C = 0$; $V_{EB} = 3$ V	I_{EBO}	<		100		nA
			BSW66A	BSW67A	BSW68A	
Collector-emitter breakdown voltage						
$I_B = 0$; $I_C = 10$ 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 mA; V_{CE} = 5 V	h_{FE}	>	30	
		typ.	75	
I_C = 100 mA; V_{CE} = 5 V	h_{FE}	>	40	
		typ.	90	
I_C = 500 mA; V_{CE} = 5 V	h_{FE}	>	30	
		typ.	80	
I_C = 1,0 A; V_{CE} = 5 V	h_{FE}	>	15	
		typ.	20	
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; V_{CB} = 10 V	C_c	<	20	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $V_{EB} = 0$	C_e	<	300	pF
Transition frequency at f = 35 MHz				
I_C = 100 mA; V_{CE} = 20 V	f_T	typ.	130	MHz
Turn-on time (see Fig. 2)				
I_{Con} = 500 mA; I_{Bon} = 50 mA; $-V_{BEoff}$ = 4 V	t_{on}	typ.	0,5	μs
Turn-off time (see Fig. 2)				
I_{Con} = 500 mA; $I_{Bon} = -I_{Boff}$ = 50 mA	t_{off}	typ.	0,9	μs

Pulse generator:
$t_p \geq 5\ \mu s$
$t_r \leq 10$ ns
$t_f \leq 10$ ns

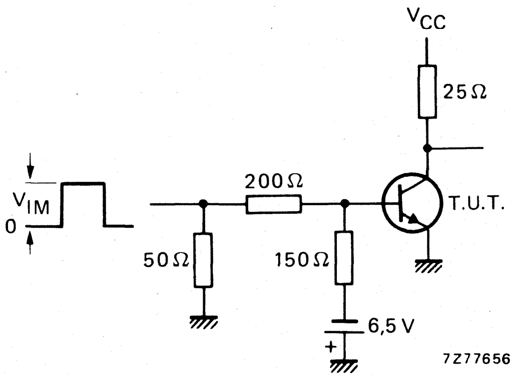


Fig. 2 Test circuit for saturated switching characteristics.
V_{CC} = 13 V; V_{IM} = 21 V.

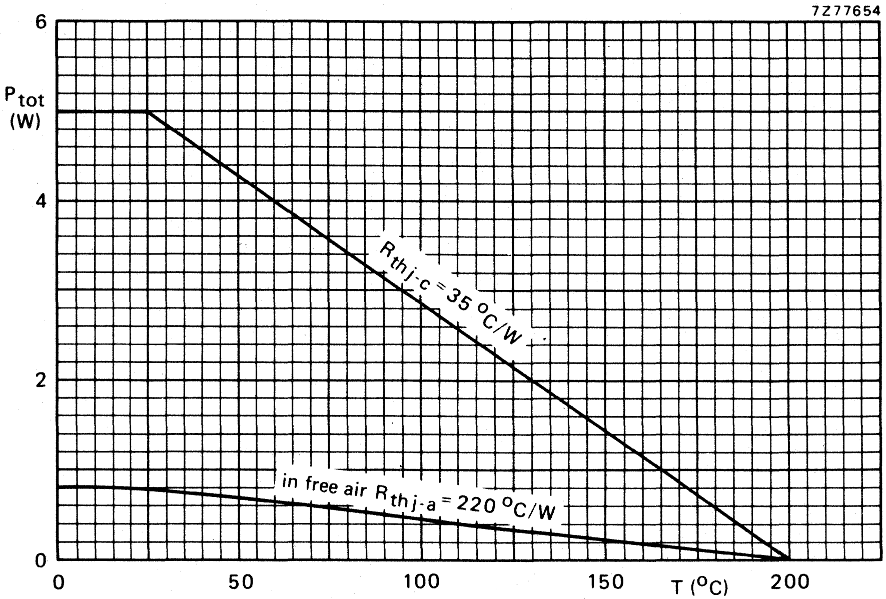


Fig. 3 Maximum permissible power dissipation versus temperature.

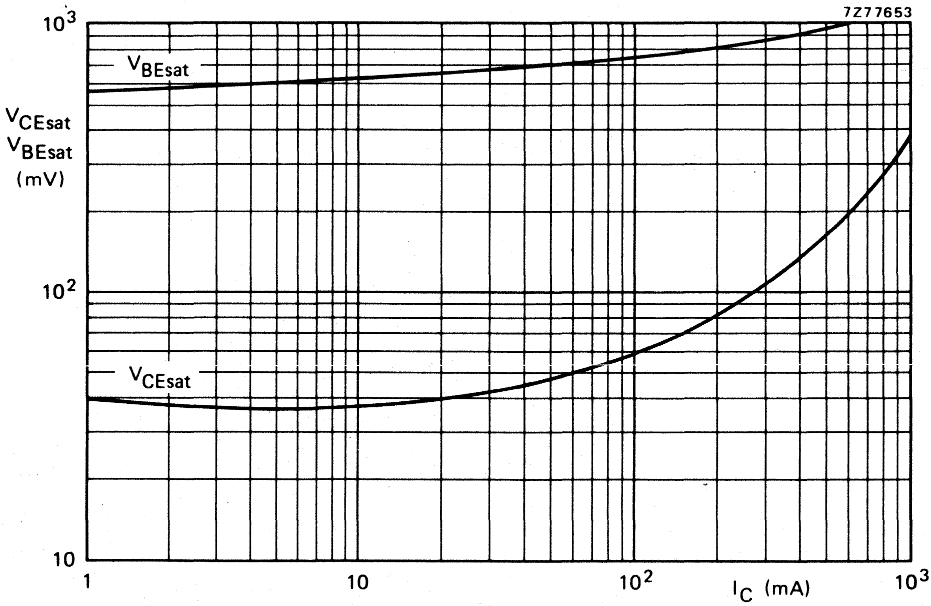


Fig. 4 $I_C/I_B = 10$; $T_j = 25\ ^oC$; typical values.

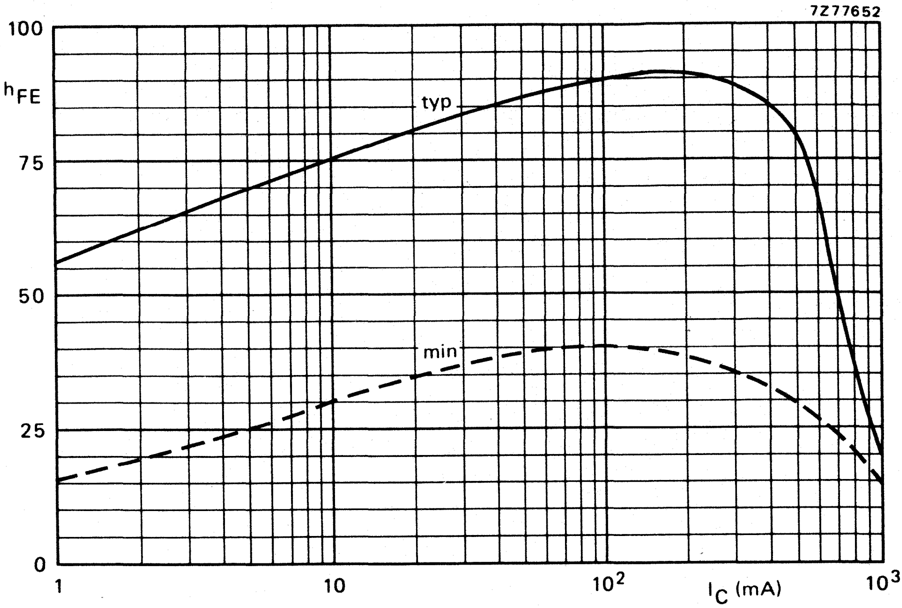


Fig. 5 V_{CE} = 5 V; T_j = 25 ^oC.

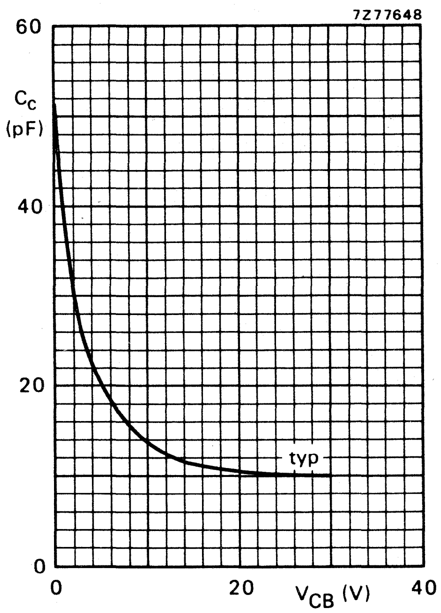


Fig. 6 $I_E = I_e = 0$; T_j = 25 ^oC.

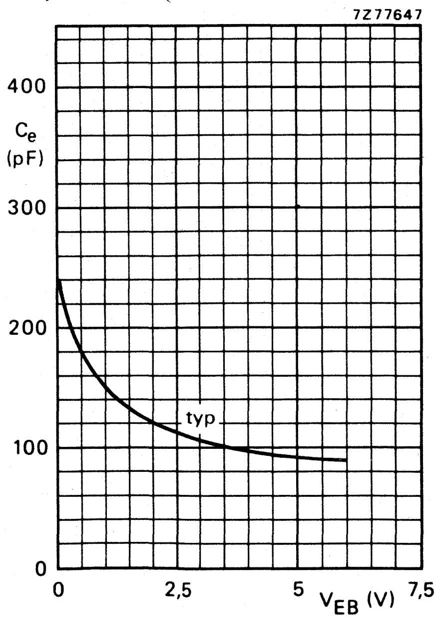


Fig. 7 $I_C = I_c = 0$; T_j = 25 ^oC.

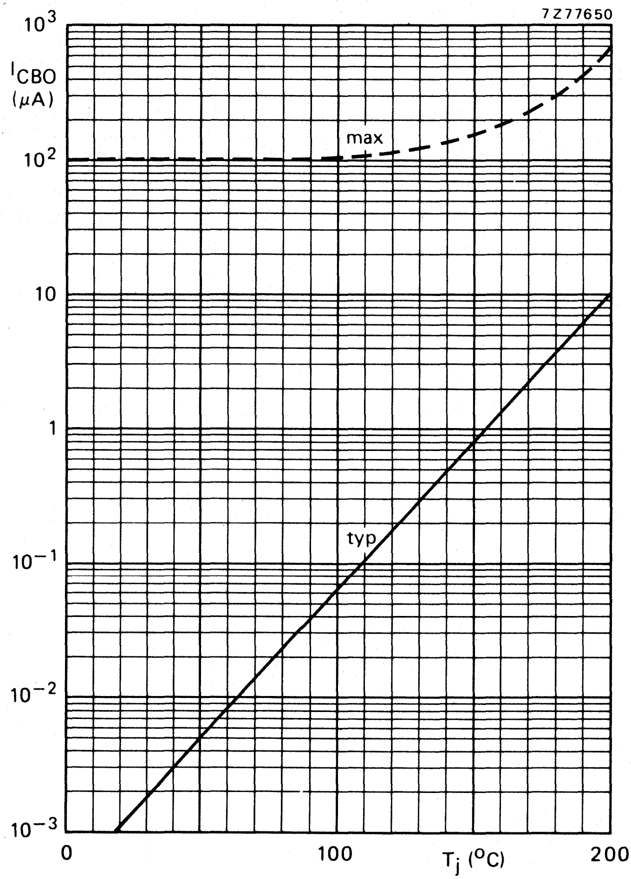


Fig. 8 $V_{CB} = V_{CBOmax}$.

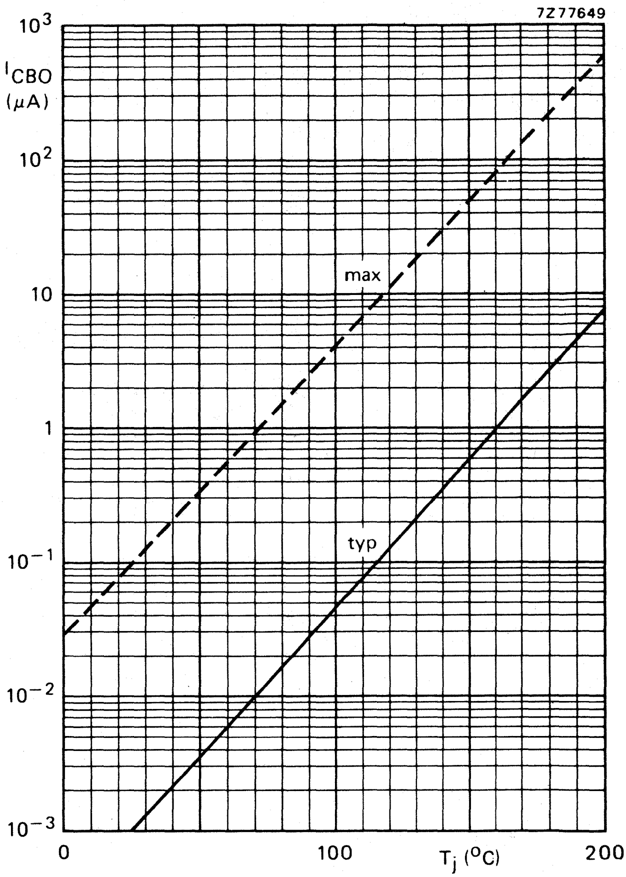


Fig. 9 $V_{CB} = ½V_{CBOmax}$.

APPLICATION INFORMATION

Clamped inductive load turn-off capability

With a base-emitter resistance of ⩾ 330 Ω, i.e. an available reverse base current of ⩽ 2 mA, and the maximum permitted clamping voltage i.e. the rated V_{CEOmax}, 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.

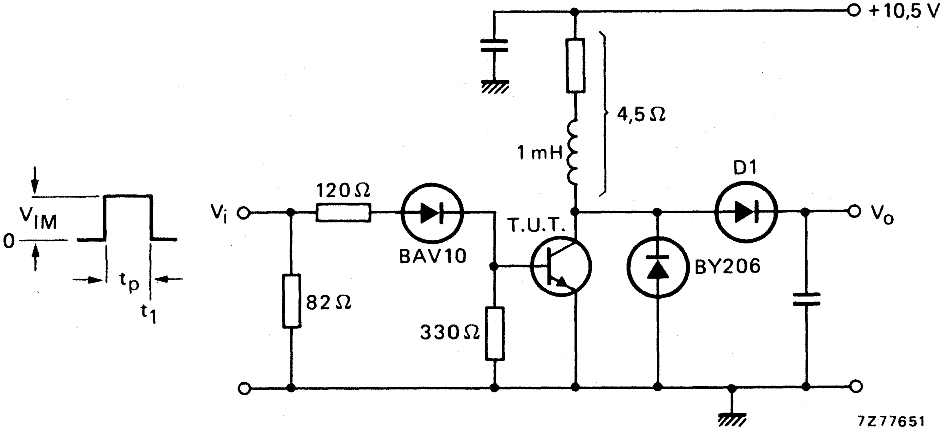


Fig. 10 Test circuit: V_{IM} = 50 V; t_p = 3 ms; δ ⩽ 0,03.
D1 = BY206 or combinations of suitable faster diodes.
V_o Adjusted to make $V_{(CL)}$ equal to rated V_{CEOmax} (see Fig. 11).

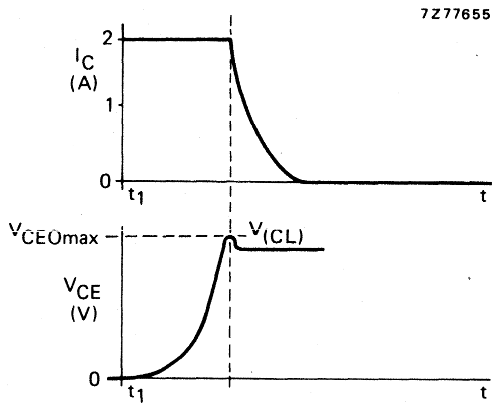


Fig. 11 Waveforms.

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

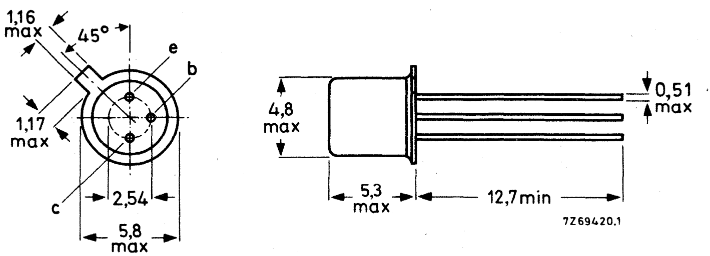
			BSX19	BSX20	
Collector-base voltage (open emitter)	V_{CBO}	max.	40	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	15	V
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	40	40	V
Collector current (peak value)	I_{CM}	max.	500	500	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	360	360	mW
D.C. current gain at T_j = 25 °C					
I_C = 10 mA; V_{CE} = 1 V	h_{FE}		20 to 60	40 to 120	
I_C = 100 mA; V_{CE} = 2 V	h_{FE}	>	10	20	
Transition frequency					
I_C = 10 mA; V_{CE} = 10 V	f_T	>	400	500	MHz
Storage time					
$I_C = I_B = -I_{BM}$ = 10 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) [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

Power dissipation

Total power dissipation up to $T_{amb} = 25\ ^oC$	P_{tot}	max.	360	mW

Temperatures

Storage temperature	T_{stg}	-65 to +200		^oC
Junction temperature	T_j	max.	200	^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.48	$^oC/mW$
From junction to case	$R_{th\ j-c}$	=	0.15	$^oC/mW$

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

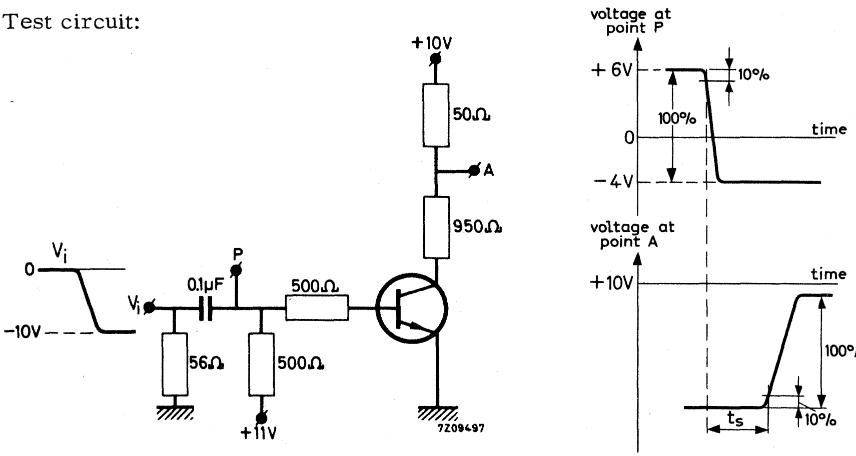
CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 20$ V	I_{CBO}	<	400	nA
$I_E = 0$; $V_{CB} = 20$ V; $T_j = 150$ °C	I_{CBO}	<	30	μA
$V_{BE} = 0$; $V_{CE} = 15$ V; $T_j = 55$ °C	I_{CES}	<	0.40	μA
$V_{BE} = 0$; $V_{CE} = 40$ V	I_{CES}	<	1.0	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 4.5$ V	I_{EBO}	<	10	μA
Currents at reverse biased emitter junction				
$V_{CE} = 15$ V; $-V_{BE} = 3$ V; $T_j = 55$ °C	I_{CEX}	<	0.60	μA
	$-I_{BEX}$	<	0.60	μA
Sustaining voltages				
$I_C = 10$ mA; $I_B = 0$	$V_{CEOsust}$	>	15	V
$I_C = 10$ mA; $R_{BE} = 10\ \Omega$	$V_{CERsust}$	>	20	V
Base-emitter voltage (see also page 8)				
$I_C = 30\ \mu$A; $V_{CE} = 20$ V; $T_j = 100$ °C	V_{BE}	>	0.35	V
Saturation voltages				
$I_C = 10$ mA; BSX19: $I_B = 0.6$ mA; BSX20: $I_B = 0.3$ mA	V_{CEsat}	<	0.3	V
$I_C = 10$ mA; $I_B = 1$ mA	V_{CEsat}	<	0.25	V
	V_{BEsat}		0.70 to 0.85	V
$I_C = 100$ mA; $I_B = 10$ mA	V_{CEsat}	<	0.60	V
	V_{BEsat}	<	1.50	V
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 5$ V	C_c	<	4	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $V_{EB} = 1$ V	C_e	<	4.5	pF

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

		BSX19	BSX20	
D.C. current gain				
I_C = 10 mA; V_{CE} = 1 V	h_{FE}	20 to 60	40 to 120	
I_C = 10 mA; V_{CE} = 1 V; T_j = −55 °C	h_{FE}	> 10	20	
I_C = 100 mA; V_{CE} = 2 V	h_{FE}	> 10	20	
Transition frequency				
I_C = 10 mA; V_{CE} = 10 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 mA	t_s	typ. 5	6	ns
		< 10	13	ns

Test circuit:



Pulse generator:

Rise time	t_r	<	1	ns
Pulse duration	t	>	300	ns
Duty cycle	δ	<	0.02	
Source impedance	R_S	=	50	Ω

Oscilloscope:

Input impedance	R_i	=	50	Ω
Rise time	t_r	<	1	ns

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

Switching times

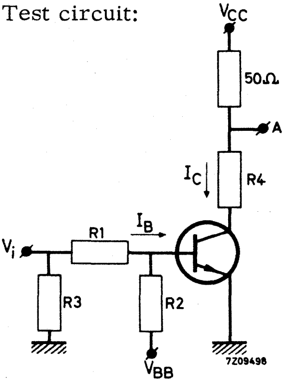
Turn on time (see also pages 14 and 15)

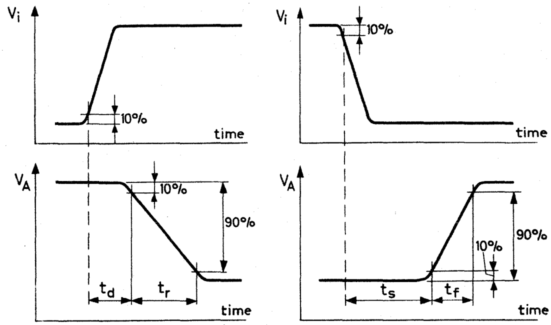
from $-V_{BE} = 1.5$ V to $I_C = 10$ mA; $I_B = 3$ mA		t_{on}	<	12	ns
from $-V_{BE} = 2.25$ V to $I_C = 100$ mA; $I_B = 40$ mA		t_{on}	<	7	ns

Turn off time (see also pages 16 to 19)

from $I_C = 10$ mA; $I_B = 3$ mA	BSX19	t_{off}	<	15	ns
to cut-off with $-I_{BM} = 1.5$ mA	BSX20	t_{off}	<	18	ns
from $I_C = 100$ mA; $I_B = 40$ mA to cut-off	BSX19	t_{off}	<	18	ns
with $-I_{BM} = 20$ mA	BSX20	t_{off}	<	21	ns

Test circuit:





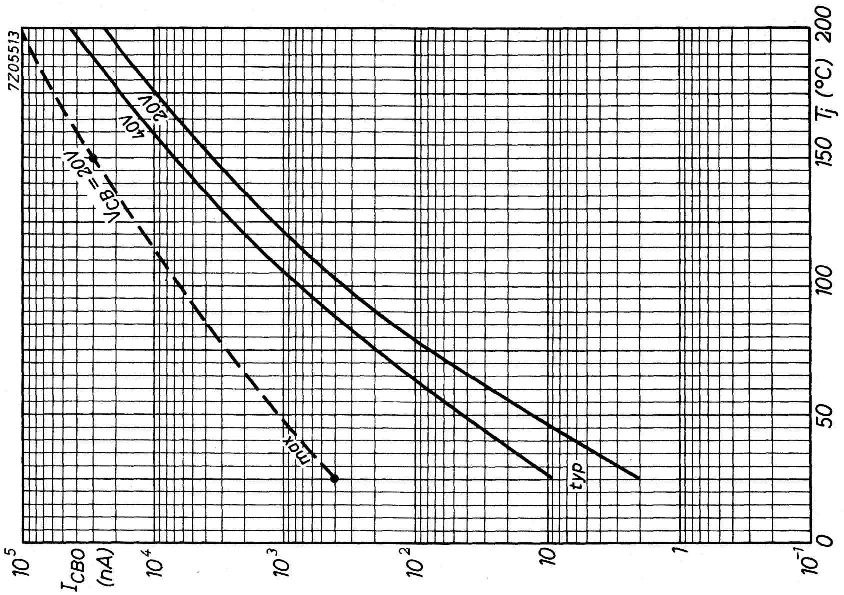
Pulse generator:				
Rise time	t_r	<	1	ns
Pulse duration	t	>	300	ns
Duty cycle	δ	<	0.02	
Source impedance	R_S	=	50	Ω

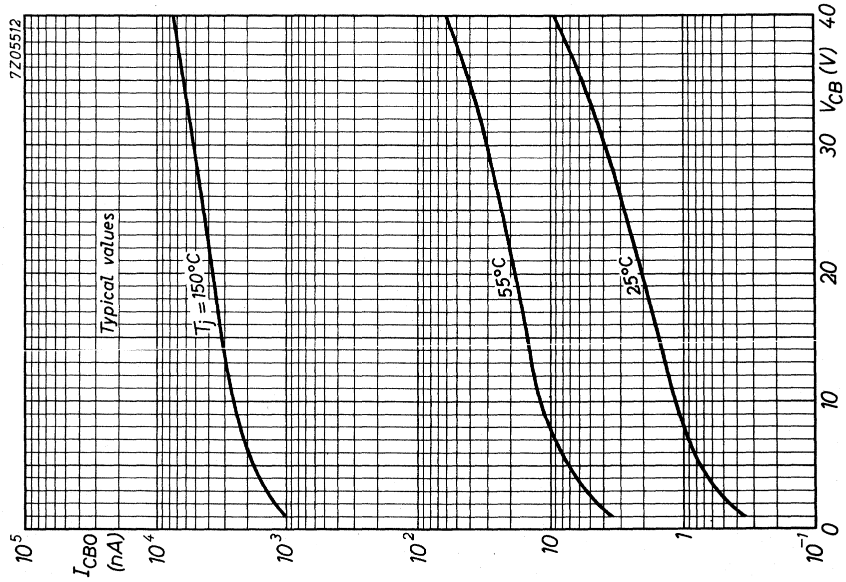
Oscilloscope:				
Input impedance	R_i	=	50	Ω
Rise time	t_r	<	1	ns

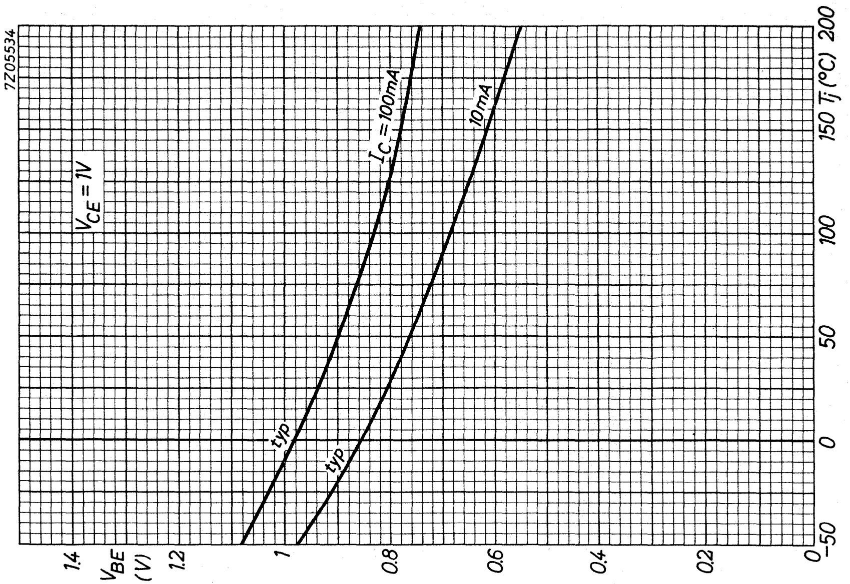
							turn on time			turn off time	
I_C (mA)	I_B (mA)	$-I_{BM}$ (mA)	V_{CC} (V)	R1;R2 (kΩ)	R3 (Ω)	R4 (Ω)	$-V_{BB}$ (V)	$-V_{BE}$ (V)	V_i (V)	V_{BB} (V)	$-V_i$ (V)
10	3	1.5	3	3.3	50	220	3.0	1.5	15	12.0	15
100	40	20	6	0.33	56	0	4.5	2.25	20	15.3	20

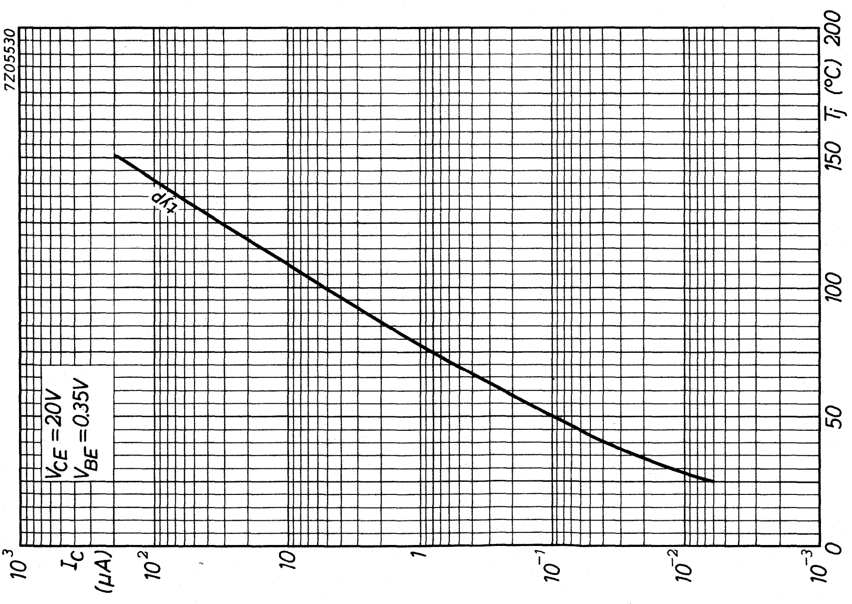
Note

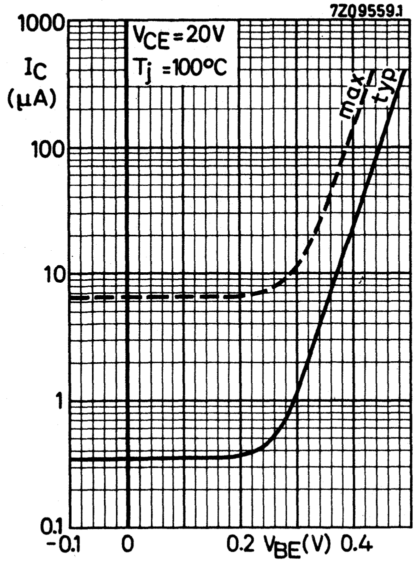
$-I_{BM}$ is the reverse current that can flow during switching off. The indicated $-I_{BM}$ is determined and limited by the applied cut-off voltage and series resistance.

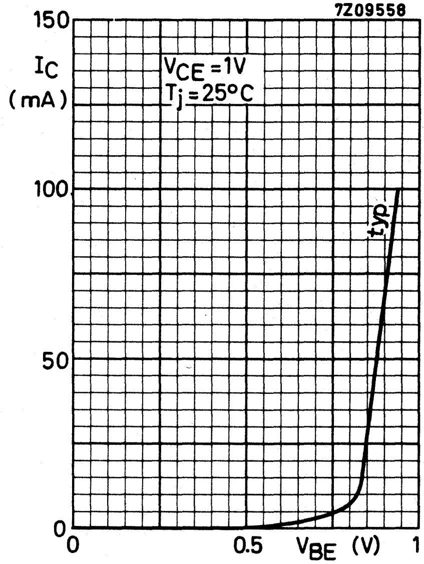

7Z05513
I_{CBO} (nA)
10^5
10^4
10^3
10^2
10
1
10^{-1}
V_{CB} = 20V
40V
20V
max
typ
0
50
100
150
200
T_j (°C)

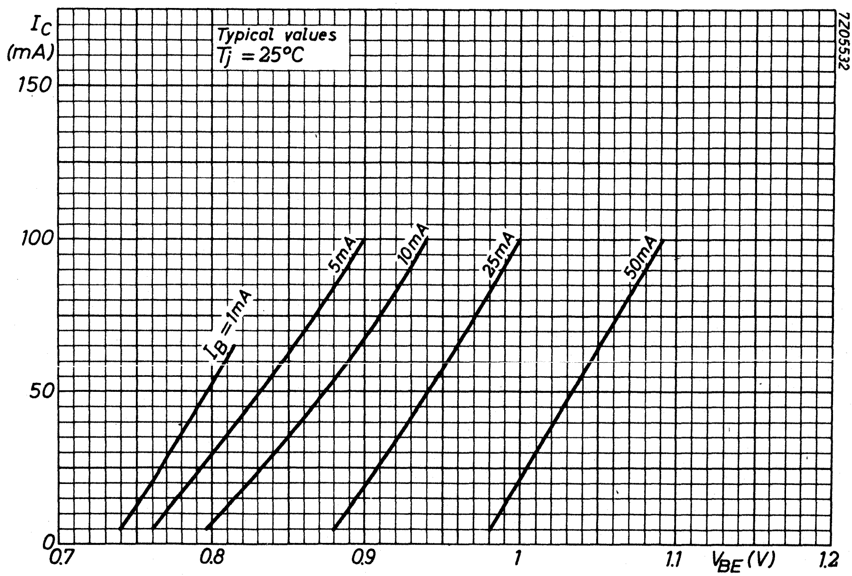

7Z05512
I_{CBO} (nA)
10^5
10^4
10^3
10^2
10
1
10^{-1}
Typical values
T_j = 150°C
55°C
25°C
0
10
20
30
40
V_{CB} (V)

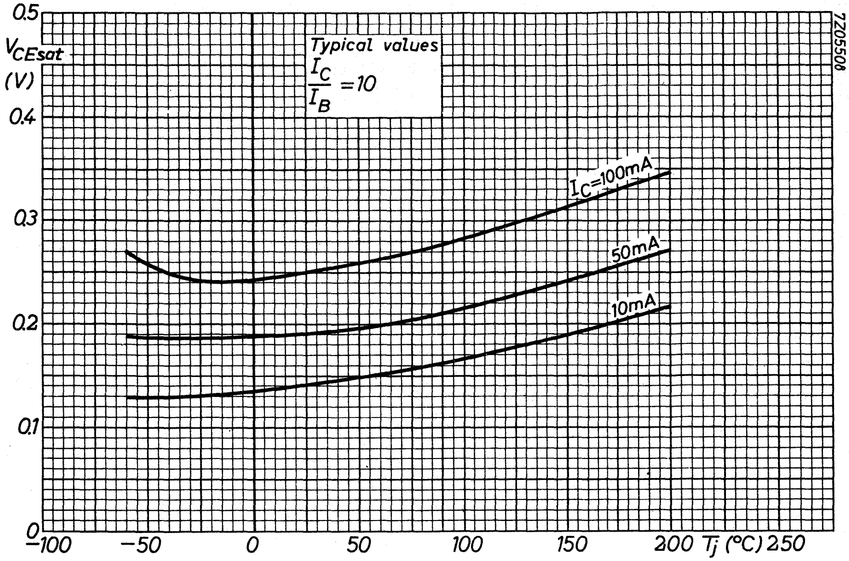

7Z05534
$V_{CE} = 1V$
$I_C = 100mA$
10mA
typ
typ
V_{BE} (V)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
T_j (°C)
−50
0
50
100
150
200

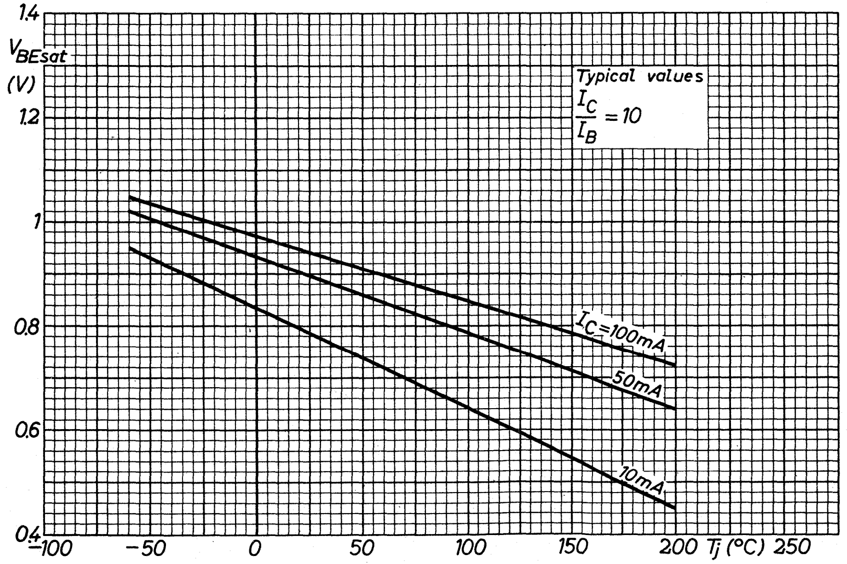

7Z05530
$V_{CE} = 20V$
$V_{BE} = 0.35V$
typ
I_C (μA)
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
T_j (°C)
0
50
100
150
200

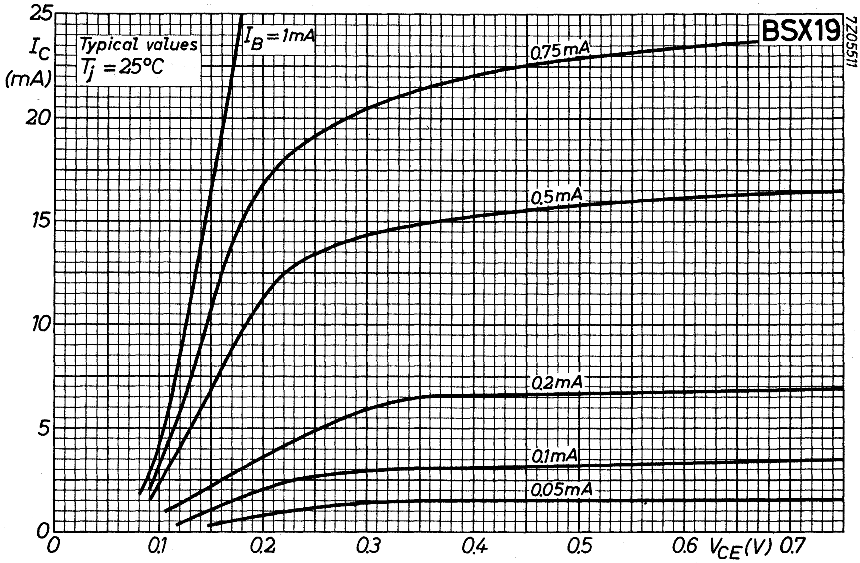

7Z09559.1
1000
I_C
(μA)
100
10
1
0.1
-0.1
0
0.2 V_{BE}(V) 0.4
V_{CE}=20V
T_j =100°C
max
typ

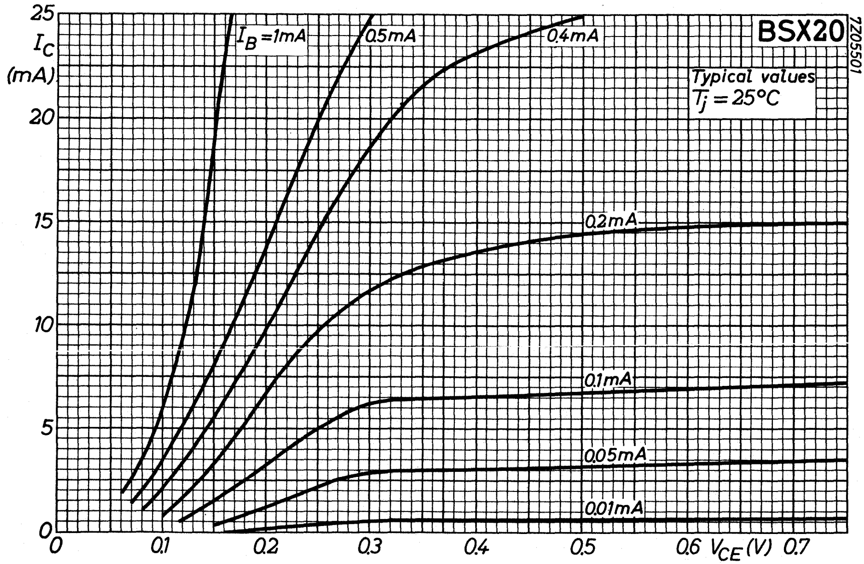

7Z09558
150
I_C
(mA)
100
50
0
0
0.5
V_{BE} (V)
1
V_{CE}=1V
T_j=25°C
typ

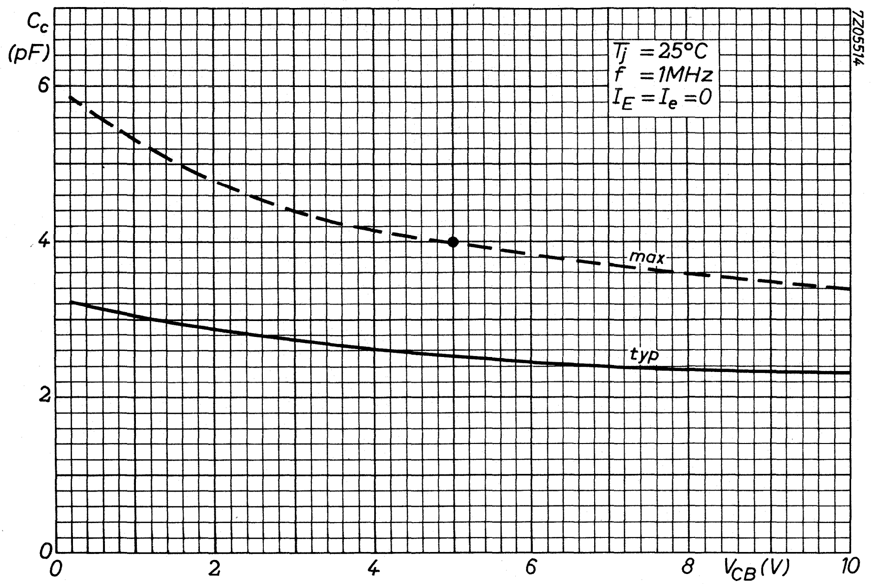

7Z05532
I_C
(mA)
150
100
50
0
0.7
0.8
0.9
1
1.1
V_{BE}(V)
1.2
Typical values
T_j = 25°C
I_B=1mA
5mA
10mA
25mA
50mA

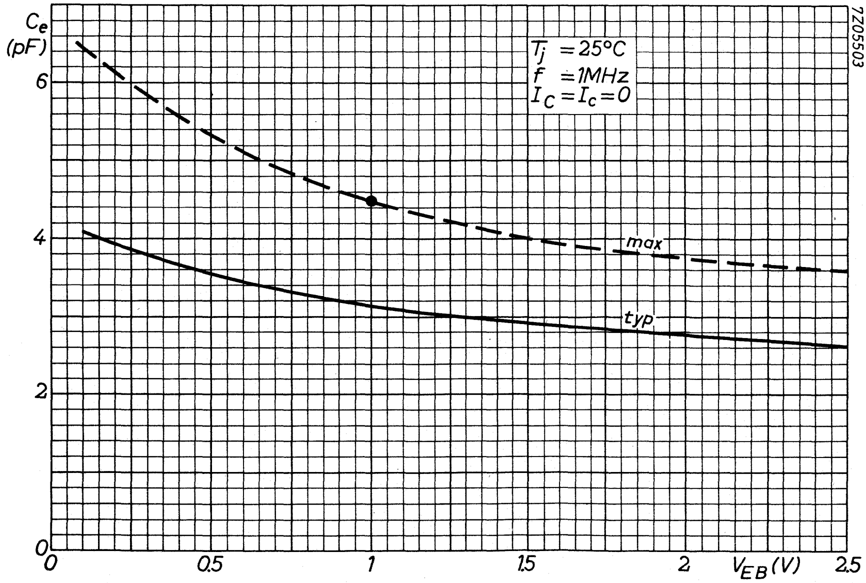

7Z05508
Typical values
$\frac{I_C}{I_B} = 10$
V_{CEsat} (V)
0.5
0.4
0.3
0.2
0.1
0
I_C=100mA
50mA
10mA
−100
−50
0
50
100
150
200
250
T_j (°C)

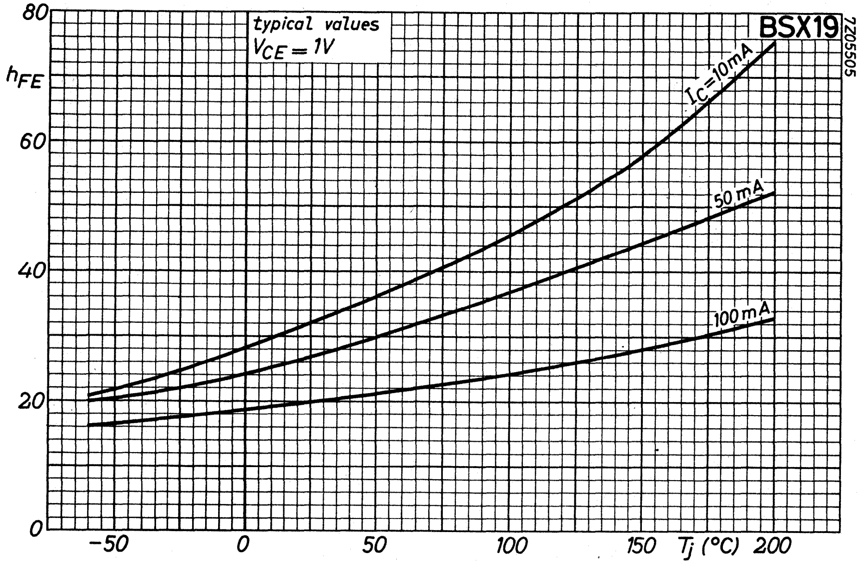

Typical values
$\frac{I_C}{I_B} = 10$
V_{BEsat} (V)
1.4
1.2
1
0.8
0.6
0.4
I_C=100mA
50mA
10mA
−100
−50
0
50
100
150
200
250
T_j (°C)

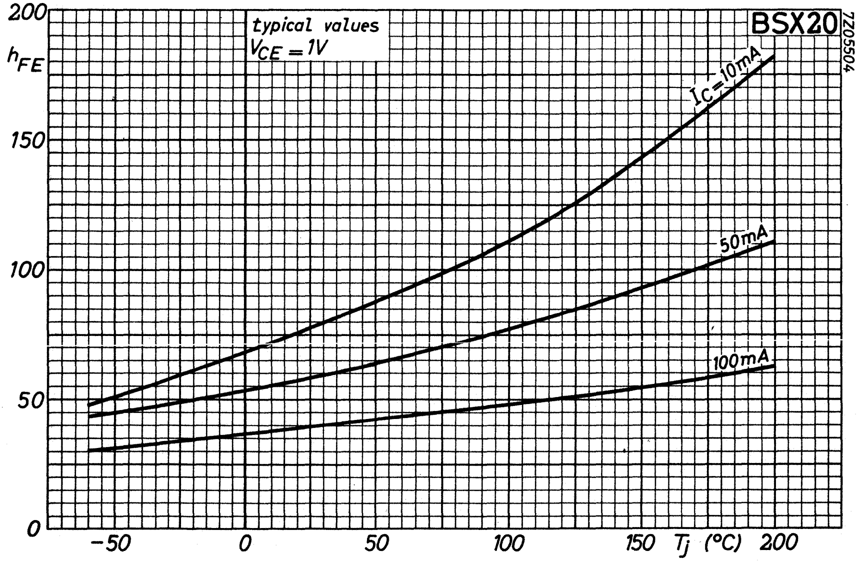

25
I_C
(mA)
20
15
10
5
0
0
0.1
0.2
0.3
0.4
0.5
0.6
V_{CE}(V)
0.7
Typical values
T_j = 25°C
I_B = 1mA
0.75mA
0.5mA
0.2mA
0.1mA
0.05mA
BSX19
7Z05511

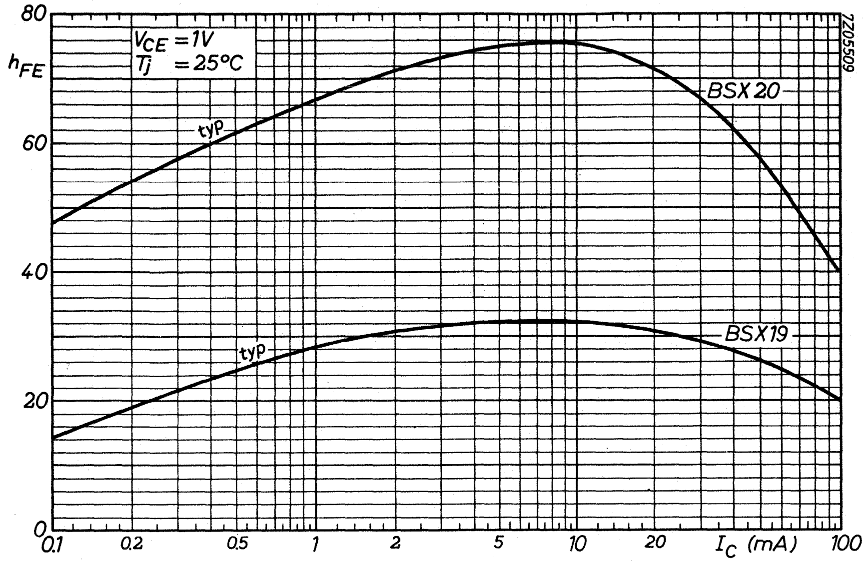

25
I_C
(mA)
20
15
10
5
0
0
0.1
0.2
0.3
0.4
0.5
0.6
V_{CE}(V)
0.7
I_B = 1mA
0.5mA
0.4mA
0.2mA
0.1mA
0.05mA
0.01mA
BSX20
7Z05501
Typical values
T_j = 25°C

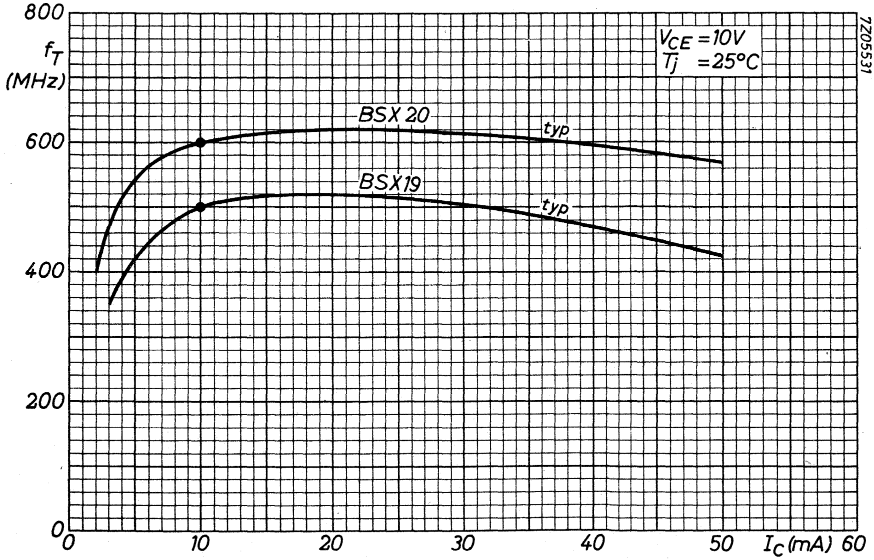

C_c (pF)
T_j = 25°C
f = 1MHz
$I_E = I_e = 0$
max
typ
V_{CB} (V)
7Z05514
0
2
4
6
8
10

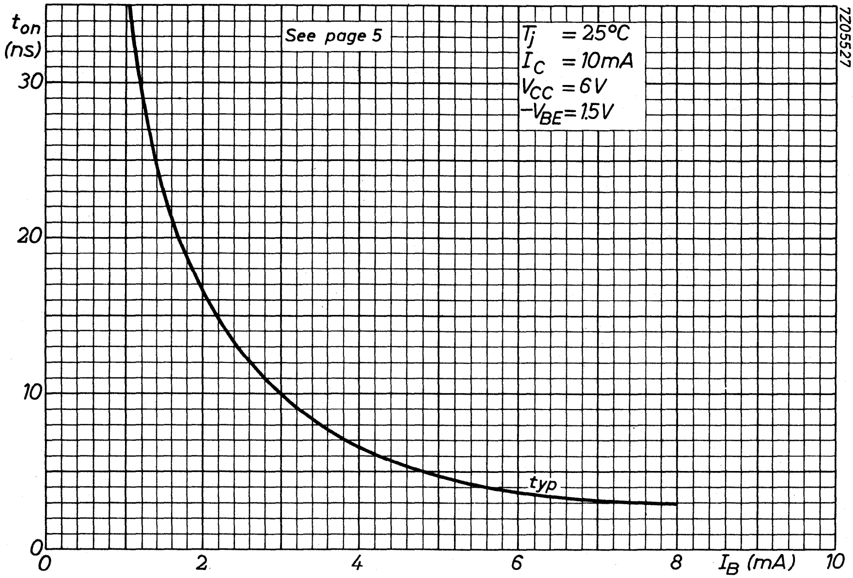

C_e (pF)
T_j = 25°C
f = 1MHz
$I_C = I_c = 0$
max
typ
V_{EB} (V)
7Z05503
0
0.5
1
1.5
2
2.5

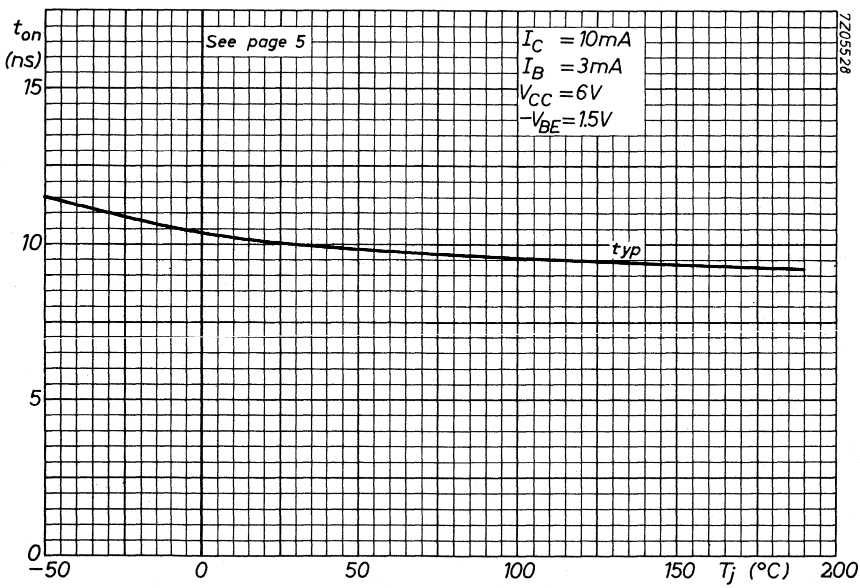

typical values
$V_{CE} = 1V$
BSX19
7Z05505
h_{FE}
80
60
40
20
0
$I_C = 10mA$
50 mA
100 mA
−50
0
50
100
150
T_j (°C)
200

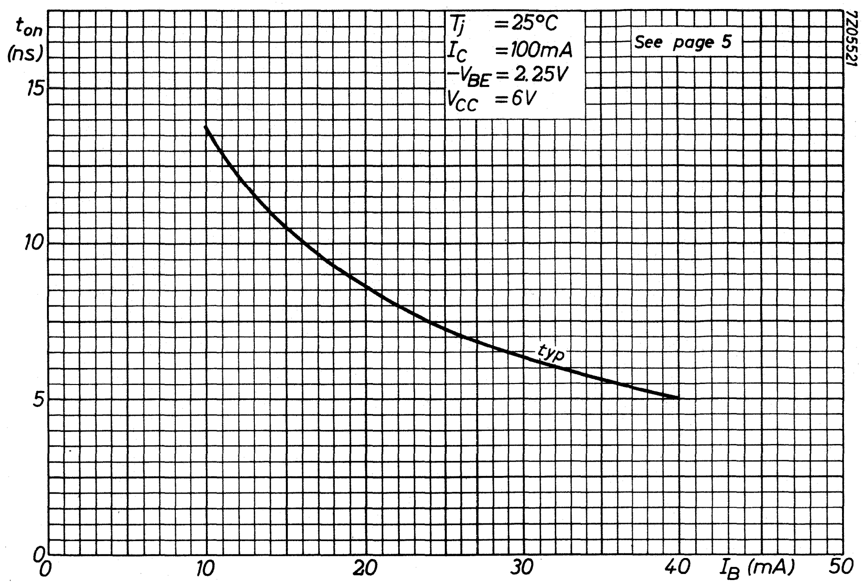

typical values
$V_{CE} = 1V$
BSX20
7Z05504
h_{FE}
200
150
100
50
0
$I_C = 10mA$
50mA
100mA
−50
0
50
100
150
T_j (°C)
200

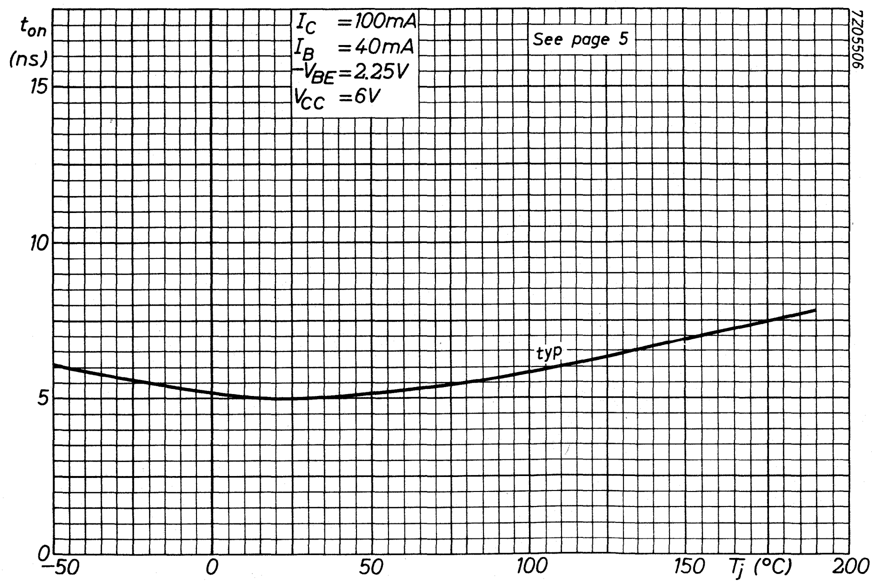

80
hFE
VCE = 1V
Tj = 25°C
7Z05509
typ
BSX 20
60
40
typ
BSX19
20
0
0.1
0.2
0.5
1
2
5
10
20
IC (mA)
100

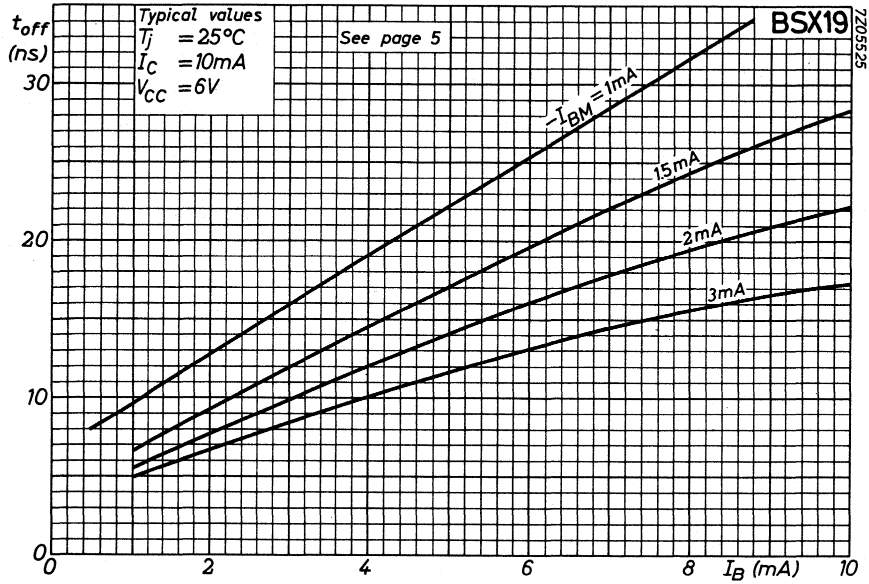

800
fT
(MHz)
VCE = 10V
Tj = 25°C
7Z05531
BSX 20
typ
600
BSX19
typ
400
200
0
0
10
20
30
40
50
IC (mA)
60

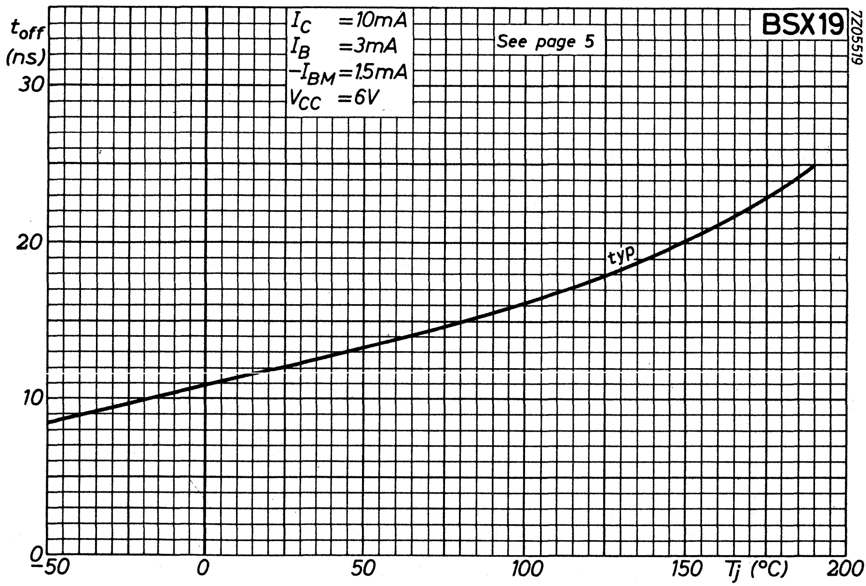

t_{on}
(ns)
30
20
10
0
0
2
4
6
8
10
I_B (mA)
See page 5
T_j = 25°C
I_C = 10mA
V_{CC} = 6V
$-V_{BE}$ = 1.5V
typ
7Z05527

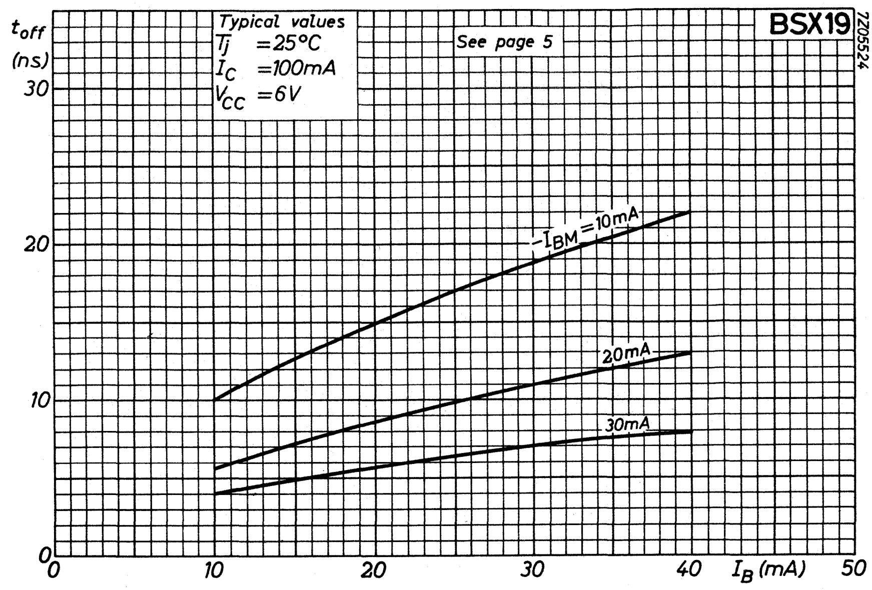

t_{on}
(ns)
15
10
5
0
−50
0
50
100
150
200
T_j (°C)
See page 5
I_C = 10mA
I_B = 3mA
V_{CC} = 6V
$-V_{BE}$ = 1.5V
typ
7Z05528

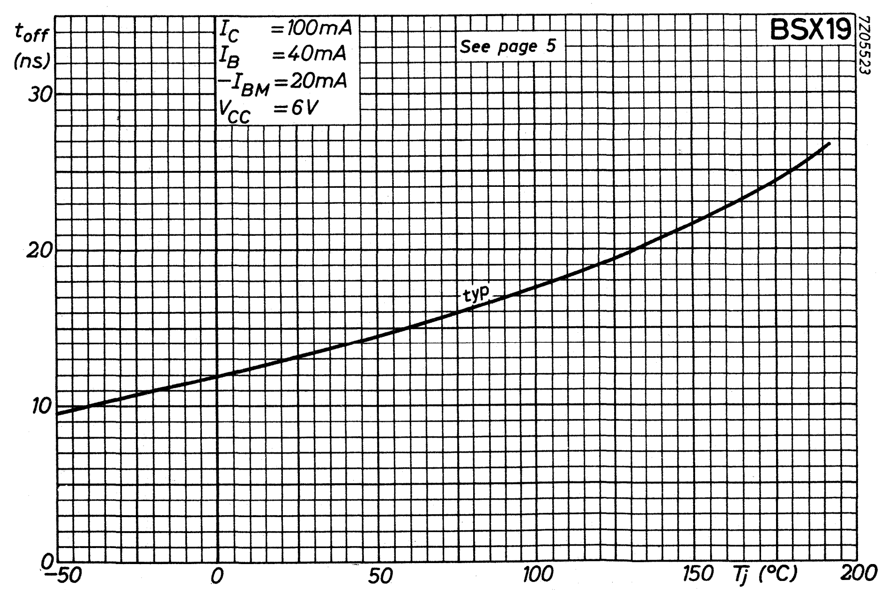

t_{on} (ns)
15
10
5
0
T_j = 25°C
I_C = 100mA
$-V_{BE}$ = 2.25V
V_{CC} = 6V
See page 5
7Z05521
typ
0
10
20
30
40
I_B (mA)
50

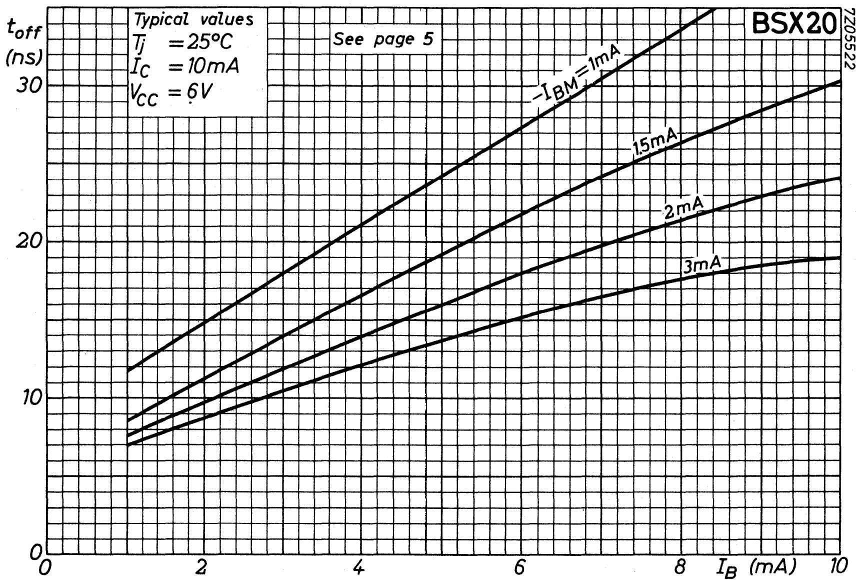

t_{on} (ns)
15
10
5
0
I_C = 100mA
I_B = 40mA
$-V_{BE}$ = 2.25V
V_{CC} = 6V
See page 5
7Z05506
typ
−50
0
50
100
150
T_j (°C)
200

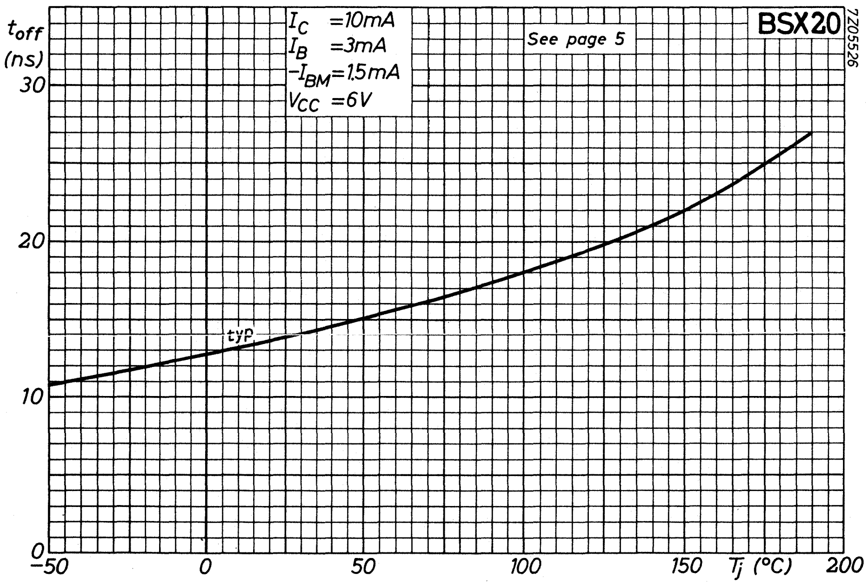

t_{off} (ns)
Typical values
T_j = 25°C
I_C = 10mA
V_{CC} = 6V
See page 5
BSX19
7Z05525
$-I_{BM}$ = 1mA
1.5mA
2mA
3mA
0
10
20
30
2
4
6
8
10
I_B (mA)

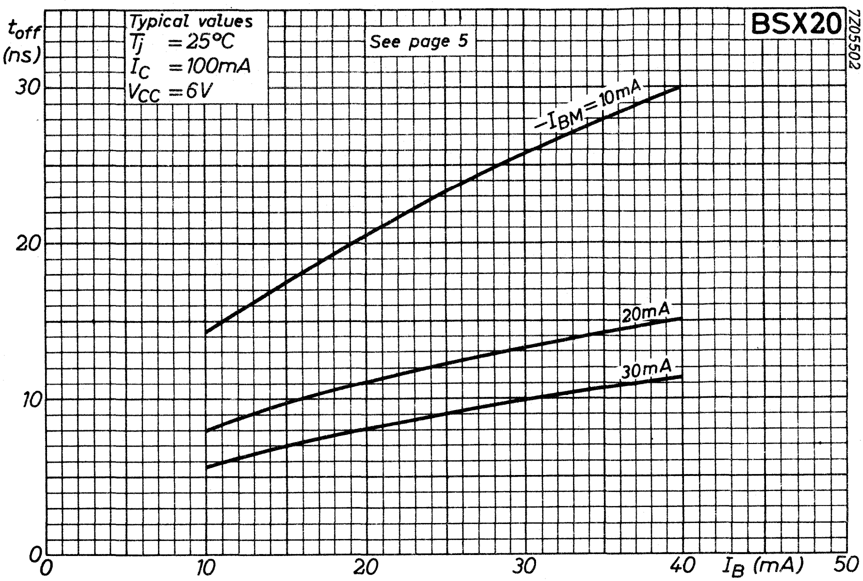

t_{off} (ns)
I_C = 10mA
I_B = 3mA
$-I_{BM}$ = 1.5mA
V_{CC} = 6V
See page 5
BSX19
7Z05519
typ
0
10
20
30
−50
0
50
100
150
200
T_j (°C)

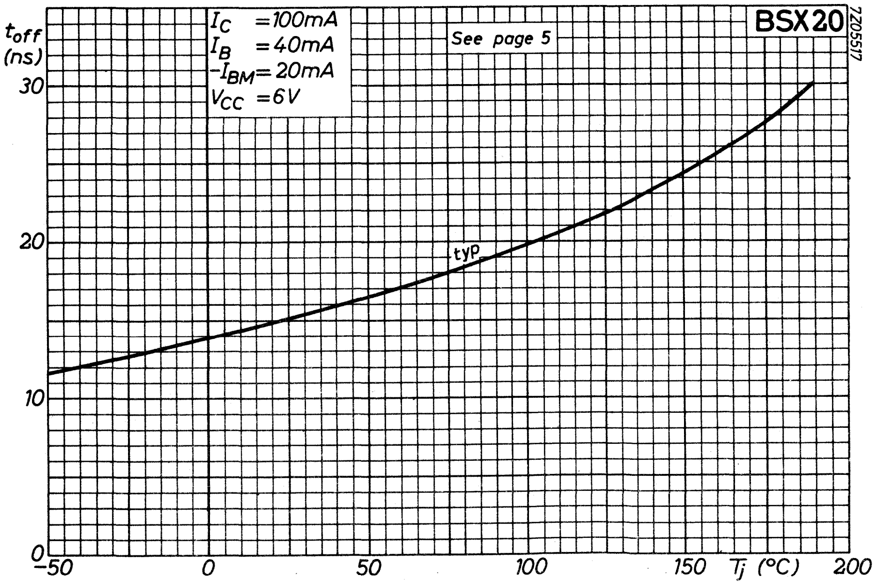

t_off
(ns)
Typical values
Tj = 25°C
IC = 100mA
VCC = 6V
See page 5
BSX19
7Z05524
−IBM = 10mA
20mA
30mA
IB (mA)
0
10
20
30
0
10
20
30
40
50

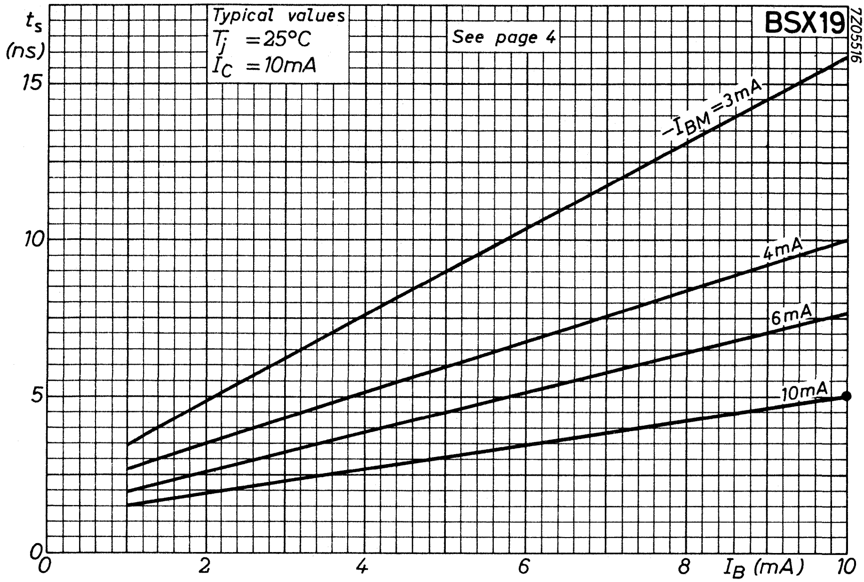

t_off
(ns)
IC = 100mA
IB = 40mA
−IBM = 20mA
VCC = 6V
See page 5
BSX19
7Z05523
typ
Tj (°C)
0
10
20
30
−50
0
50
100
150
200

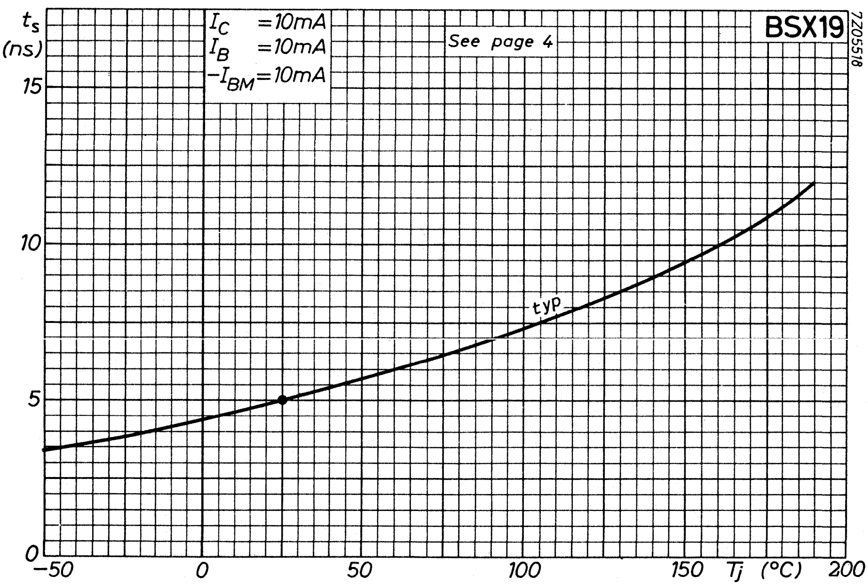

t_{off} (ns)
Typical values
T_j = 25°C
I_C = 10mA
V_{CC} = 6V
See page 5
BSX20
7Z05522
$-I_{BM}$=1mA
1.5mA
2mA
3mA
I_B (mA)
0
10
20
30
0
2
4
6
8
10

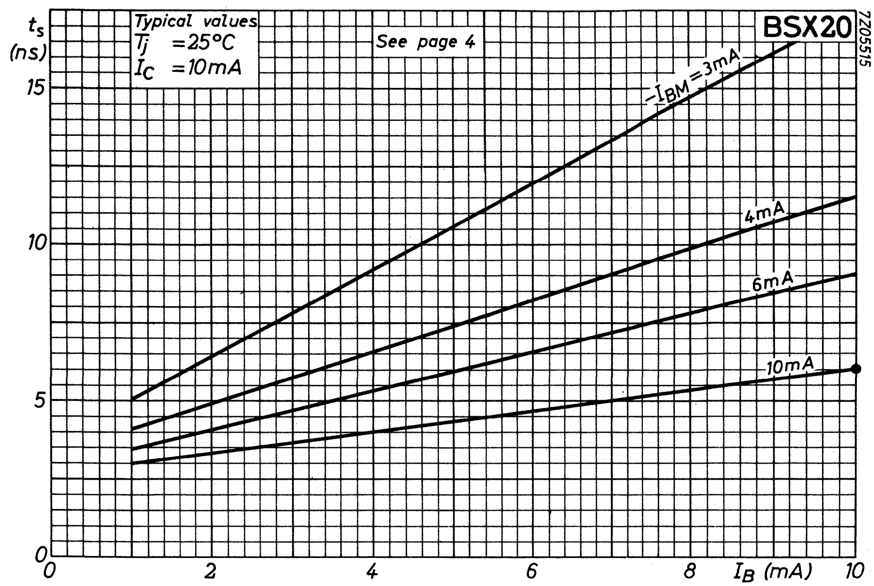

t_{off} (ns)
I_C =10mA
I_B =3mA
$-I_{BM}$=1.5mA
V_{CC} =6V
See page 5
BSX20
7Z05526
typ
T_j (°C)
0
10
20
30
−50
0
50
100
150
200

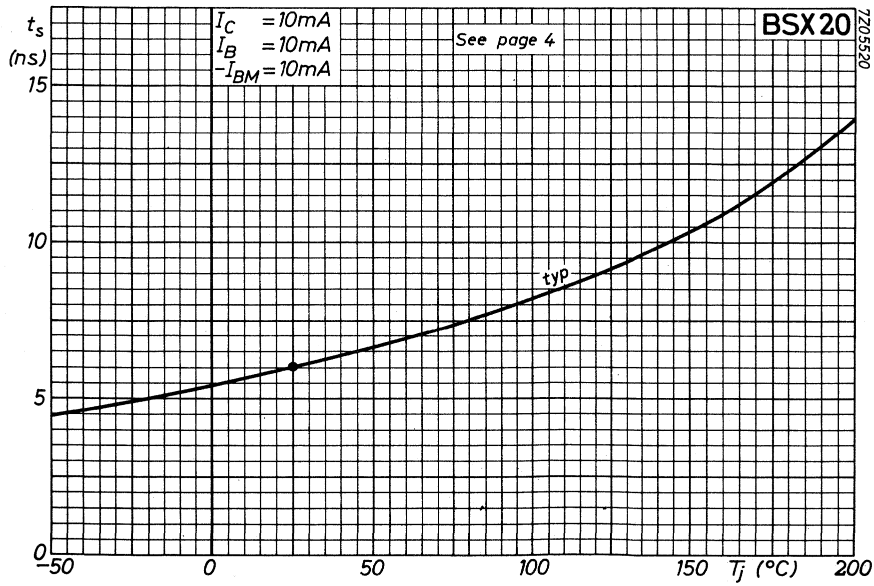

t_{off} (ns)
Typical values
T_j = 25°C
I_C = 100mA
V_{CC} = 6V
See page 5
BSX20
7Z05502
$-I_{BM}$ = 10mA
20mA
30mA
0
10
20
30
40
50
I_B (mA)


t_{off} (ns)
I_C = 100mA
I_B = 40mA
$-I_{BM}$ = 20mA
V_{CC} = 6V
See page 5
BSX20
7Z05517
typ
0
10
20
30
−50
0
50
100
150
200
T_j (°C)


t_s
(ns)
Typical values
T_j = 25°C
I_C = 10mA
See page 4
BSX19
7Z05516
$-I_{BM}$ = 3mA
4mA
6mA
10mA
15
10
5
0
0
2
4
6
8
I_B (mA)
10


t_s
(ns)
I_C = 10mA
I_B = 10mA
$-I_{BM}$ = 10mA
See page 4
BSX19
7Z05518
typ
15
10
5
0
−50
0
50
100
150
T_j (°C)
200


t_s (ns)
Typical values
T_j = 25°C
I_C = 10mA
See page 4
BSX20
7Z05515
$-I_{BM}$ = 3mA
4mA
6mA
10mA
15
10
5
0
0
2
4
6
8
I_B (mA)
10


t_s (ns)
I_C = 10mA
I_B = 10mA
$-I_{BM}$ = 10mA
See page 4
BSX20
7Z05520
typ
15
10
5
0
−50
0
50
100
150
T_j (°C)
200

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a TO-18 metal envelope, primarily intended for use in switched-mode power supplies and for driving numerical indicator tubes.

QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	80	V
Collector current (peak value)	I_{CM}	max.	250	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	mW
Junction temperature	T_j	max.	175	°C
D.C. current gain at T_j = 25 °C; I_C = 4 mA; V_{CE} = 1 V	h_{FE}	>	20	
		typ.	80	
Transition frequency at f = 35 MHz; I_C = 4 mA; V_{CE} = 10 V	f_T	>	60	MHz

NOTE

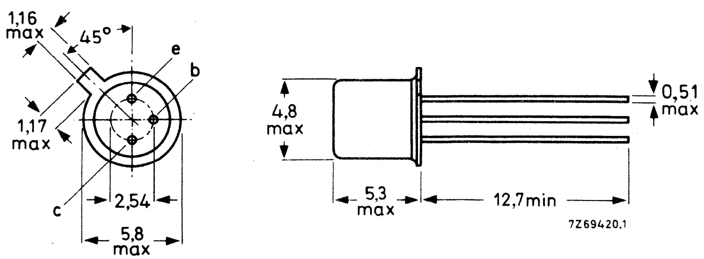
The BSX21 may be operated in the breakdown region up to V_{CE} = 160 V, provided P_{tot} at T_{amb} = 85 °C does not exceed 100 mW.

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				
Collector-base voltage (open emitter) $I_C = 100\ \mu A$	V_{CBO}	max.	120	V [1]
Collector-emitter voltage (open base) $I_C = 4$ mA	V_{CEO}	max.	80	V [1]
Emitter-base boltage (open collector) $I_E = 100\ \mu A$	V_{EBO}	max.	5	V
Currents				
Collector current (d.c. or average over any 20 ms period)	I_C	max.	100	mA
Collector current (peak value)	I_{CM}	max.	250	mA [2]
Emitter current (d.c. or average over any 20 ms period)	$-I_E$	max.	100	mA
Emitter current (peak value)	$-I_{EM}$	max.	250	mA
Power dissipation				
Total power dissipation up to $T_{amb} = 25\ ^oC$	P_{tot}	max.	300	mW
Temperatures				
Storage temperature	T_{stg}		-65 to +175	^oC
Junction temperature	T_j	max.	175	^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.5	$^oC/mW$
From junction to case	$R_{th\ j-c}$	=	0.15	$^oC/mW$

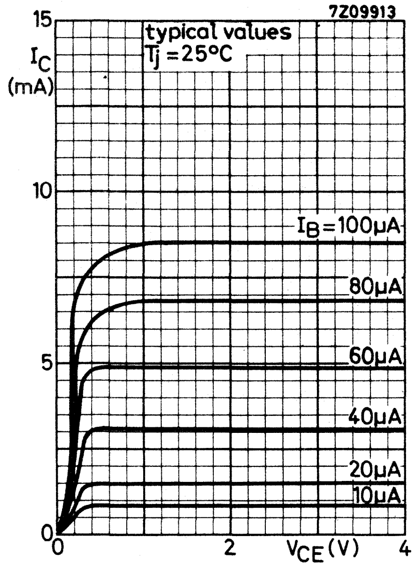
[1]) The BSX21 may be operated in the breakdown region up to $V_{CE} = 160$ V, provided P_{tot} at $T_{amb} = 85\ ^oC$ does not exceed 100 mW.

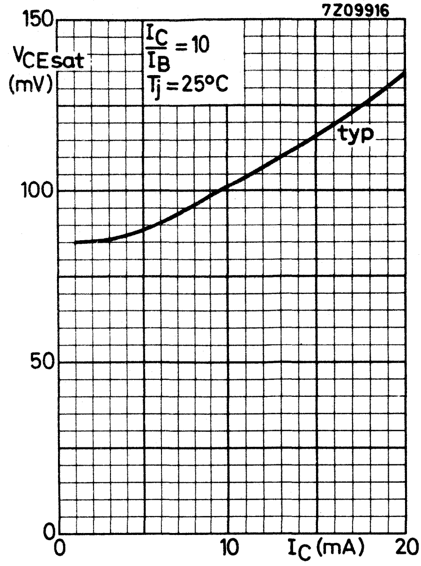
[2]) The transistor can withstand a capacitive load of 500 pF, combined with a collector-base voltage of max. 150 V before switching on.

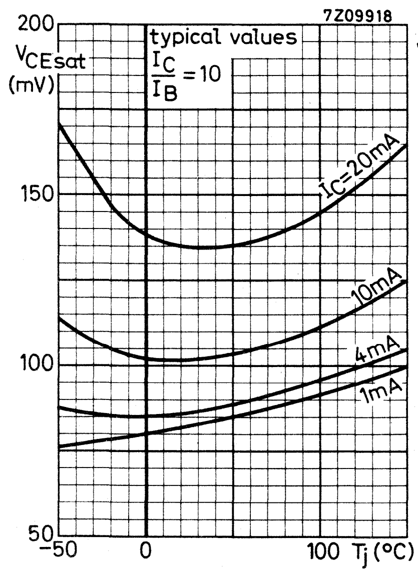
CHARACTERISTICS

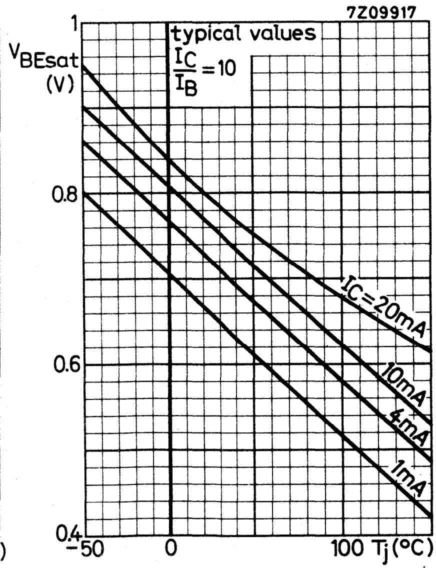
T_j = 25 °C unless otherwise specified

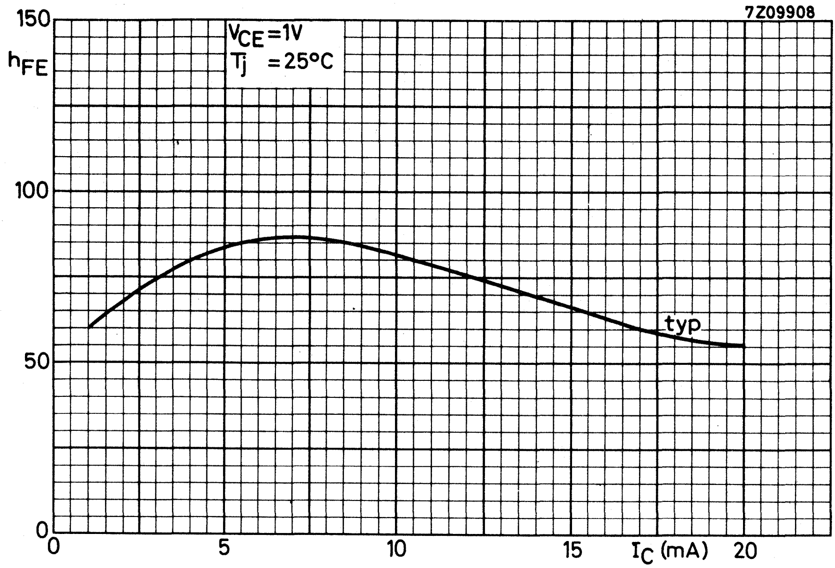
Collector cut-off current				
I_E = 0; V_{CB} = 90 V	I_{CBO}	typ.	1	nA
		<	200	nA
I_E = 0; V_{CB} = 90 V; T_j = 150 °C	I_{CBO}	typ.	0.25	μA
		<	50	μA
V_{BE} = 0; V_{CE} = 80 V; T_j = 85 °C	I_{CES}	typ.	0.01	μA
		<	20	μA
Emitter cut-off current				
I_C = 0; V_{EB} = 4 V	I_{EBO}	typ.	0.5	nA
		<	200	nA
I_C = 0; V_{EB} = 4 V; T_j = 150 °C	I_{EBO}	typ.	0.05	μA
		<	50	μA
Saturation voltages				
I_C = 4 mA; I_B = 400 μA	V_{CEsat}	<	0.7	V
	V_{BEsat}	<	1.2	V
D.C. current gain				
I_C = 1 mA; V_{CE} = 1 V	h_{FE}	typ.	60	
I_C = 4 mA; V_{CE} = 1 V	h_{FE}	>	20	
		typ.	80	
I_C = 10 mA; V_{CE} = 1 V	h_{FE}	typ.	82	
I_C = 20 mA; V_{CE} = 1 V	h_{FE}	typ.	55	
Collector capacitance at f = 1 MHz				
$I_E = I_e$ = 0; V_{CB} = 10 V	C_c	typ.	3.4	pF
		<	4.5	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c$ = 0; V_{EB} = 0.5 V	C_e	typ.	12	pF
		<	17	pF
Transition frequency at f = 35 MHz				
I_C = 4 mA; V_{CE} = 10 V	f_T	>	60	MHz
		typ.	160	MHz

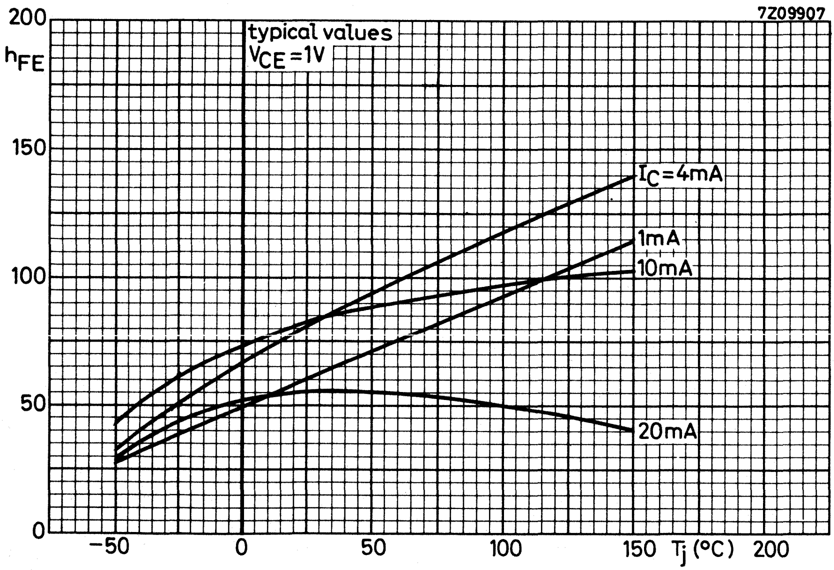

7Z09913
typical values
Tj = 25°C
IC (mA)
IB = 100μA
80μA
60μA
40μA
20μA
10μA
VCE (V)
0
2
4
5
10
15

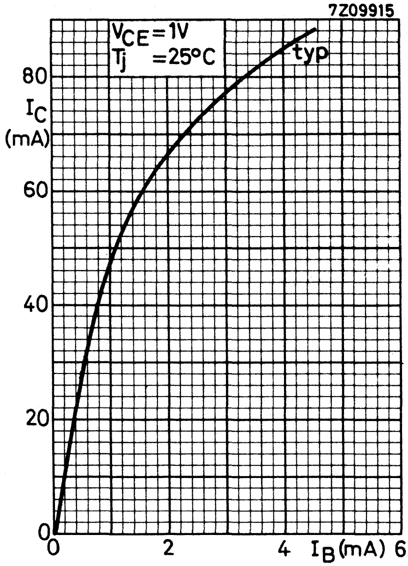

7Z09916
IC/IB = 10
Tj = 25°C
VCEsat (mV)
typ
IC (mA)
0
10
20
50
100
150

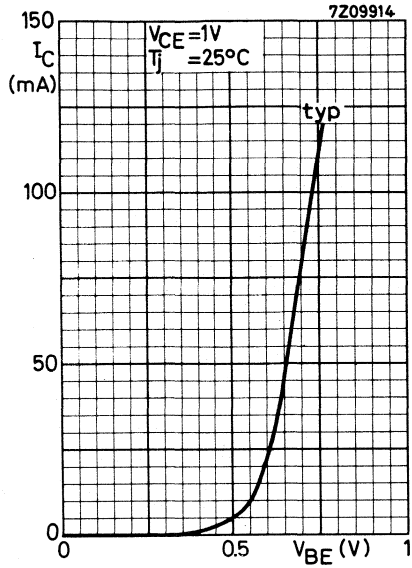

7Z09918
typical values
IC/IB = 10
VCEsat (mV)
IC=20mA
10mA
4mA
1mA
Tj (°C)
−50
0
100
50
150
200

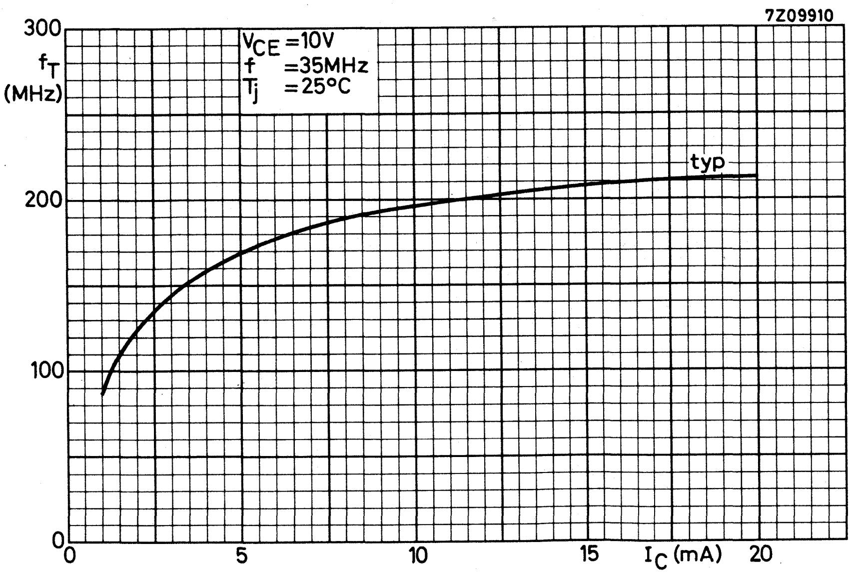

7Z09917
typical values
IC/IB = 10
VBEsat (V)
IC=20mA
10mA
4mA
1mA
Tj (°C)
−50
0
100
0.4
0.6
0.8
1

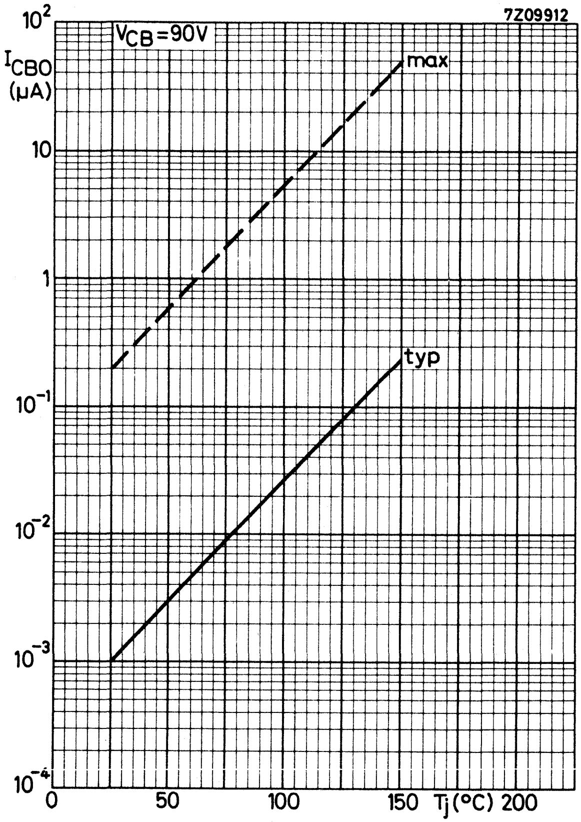

7Z09908
V_{CE} = 1V
T_j = 25°C
h_{FE}
150
100
50
0
typ
0
5
10
15
I_C (mA)
20

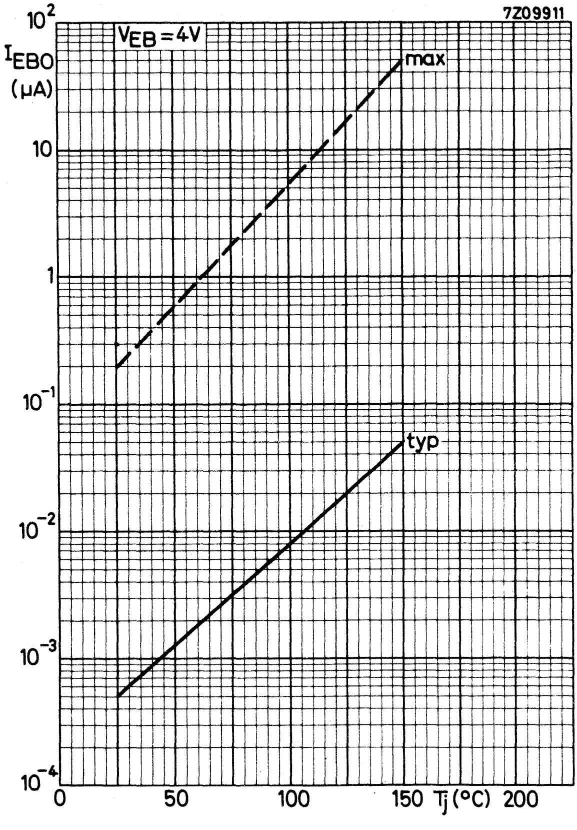

7Z09907
typical values
V_{CE} = 1V
h_{FE}
200
150
100
50
0
I_C = 4mA
1mA
10mA
20mA
−50
0
50
100
150
T_j (°C)
200

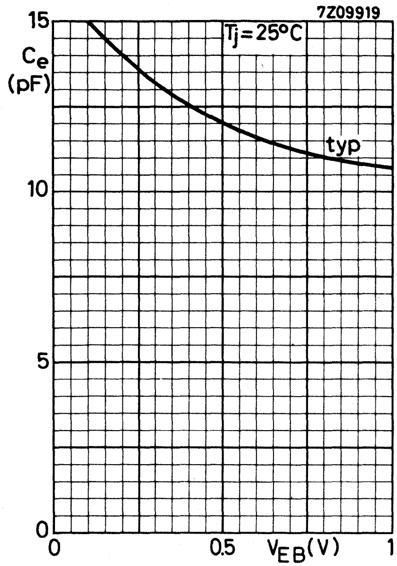

7Z09915
V_{CE} = 1V
T_j = 25°C
typ
I_C (mA)
I_B (mA)
0
20
40
60
80
2
4
6

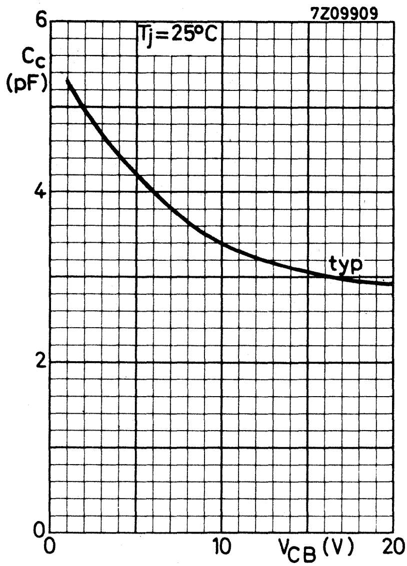

7Z09914
V_{CE} = 1V
T_j = 25°C
typ
I_C (mA)
V_{BE} (V)
0
50
100
150
0.5
1


7Z09910
V_{CE} = 10V
f = 35MHz
T_j = 25°C
typ
f_T (MHz)
I_C (mA)
0
100
200
300
5
10
15
20


7Z09912
$V_{CB} = 90V$
I_{CBO} (μA)
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
max
typ
0
50
100
150
T_j (°C)
200


7Z09911
$V_{EB} = 4V$
I_{EBO} (μA)
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
max
typ
0
50
100
150
T_j (°C)
200


7Z09919
Tj = 25°C
Ce
(pF)
typ
15
10
5
0
0
0.5
VEB (V)
1


7Z09909
Tj = 25°C
Cc
(pF)
typ
6
4
2
0
0
10
VCB (V)
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_{CEO}	max.	40	60	80	V
Collector current (d.c.)	I_C	max.		1		A
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.		6,25		W ←
Junction temperature	T_j	max.		200		°C
Transition frequency at f = 20 MHz I_C = 50 mA; V_{CE} = 10 V	f_T	>		50		MHz

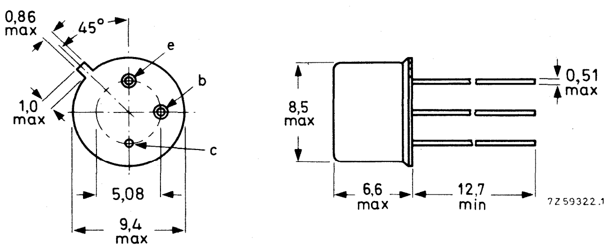
			BSX45–6 BSX46–6 BSX47–6	BSX45–10 BSX46–10 BSX47–10	BSX45–16 BSX46–16
D.C. current gain I_C = 100 mA; V_{CE} = 1 V	h_{FE}	>	40	63	100
		<	100	160	250

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 °C	P_{tot}	max.		6,25		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	$R_{th\ j\text{-}a}$	=	200	K/W
→ From junction to case	$R_{th\ j\text{-}c}$	=	28	K/W

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

			BSX45	BSX46	BSX47	
Collector cut-off currents						
$V_{BE} = 0$; $V_{CE} = 60$ V	I_{CES}	typ.	1	1	–	nA
		<	30	30	–	nA
$V_{BE} = 0$; $V_{CE} = 60$ V; $T_{amb} = 150$ °C	I_{CES}	typ.	1	1	–	μA
		<	10	10	–	μA
$V_{BE} = 0$; $V_{CE} = 80$ V	I_{CES}	<	–	–	30	nA
$V_{BE} = 0$; $V_{CE} = 80$ V; $T_{amb} = 150$ °C	I_{CES}	<	–	–	10	μA
$V_{BE} = 0,2$ V; $V_{CE} = 60$ V; $T_{amb} = 100$ °C	I_{CEX}	<	50	50	–	μA
$V_{BE} = 0,2$ V; $V_{CE} = 80$ V; $T_{amb} = 100$ °C	I_{CEX}	<	–	–	50	μA
Emitter cut-off current						
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10	10	10	nA
Collector-emitter breakdown voltage						
open base; $I_C = 50$ mA	$V_{(BR)CEO}$	>	40	60	80	V
$V_{BE} = 0$; $I_C = 100$ μA	$V_{(BR)CES}$	>	80	100	120	V
Emitter-base breakdown voltage						
open collector; $I_E = 100$ μA	$V_{(BR)EBO}$	>	7	7	7	V
Base-emitter voltage						
$I_C = 100$ mA; $V_{CE} = 1$ V	V_{BE}	<	1	1	1	V
$I_C = 500$ mA; $V_{CE} = 1$ V	V_{BE}	>	0,75	0,75	0,75	V
		<	1,50	1,50	1,50	V
$I_C = 1$ A; $V_{CE} = 1$ V	V_{BE}	typ.	1,30	1,30	1,30	V
		<	2,00	2,00	2,00	V
Saturation voltage						
$I_C = 1000$ mA; $I_B = 100$ mA	V_{CEsat}	typ.	0,7	0,7	–	V
		<	1,0	1,0	–	V
$I_C = 500$ mA; $I_B = 25$ mA	V_{CEsat}	typ.	–	–	0,5	V
		<	–	–	0,9	V
Transition frequency at f = 20 MHz						
$I_C = 50$ mA; $V_{CE} = 10$ V	f_T	>	50	50	50	MHz
Collector capacitance at f = 1 MHz						
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	25	20	15	pF
Emitter capacitance at f = 1 MHz						
$I_C = I_c = 0$; $V_{EB} = 0,5$ V	C_e	<	80	80	80	pF
Noise figure at f = 1 kHz						
$I_C = 100$ μA; $V_{CE} = 10$ V; $R_S = 1$ kΩ; B = 200 Hz	F	typ.	3,5	3,5	3,5	dB

			BSX45–6 BSX46–6 BSX47–6	BSX45–10 BSX46–10 BSX47–10	BSX45–16 BSX46–16	
D.C. current gain						
$I_C = 100\ \mu A$; $V_{CE} = 1$ V	h_{FE}	>	10	15	25	
		typ.	28	40	90	
$I_C = 100$ mA; $V_{CE} = 1$ V	h_{FE}	>	40	63	100	
		typ.	63	100	160	
		<	100	160	250	
$I_C = 500$ mA; $V_{CE} = 1$ V	h_{FE}	>	15	25	35	
		typ.	25	40	60	
$I_C = 1$ A; $V_{CE} = 1$ V	h_{FE}	typ.	15	20	30	
Switching times (see Fig. 2)						
$I_{Con} = 100$ mA; $I_{Bon} = -I_{Boff} = 5$ mA						
Turn-on time	t_{on}	<		200		ns
Turn-off time	t_{off}	<		850		ns

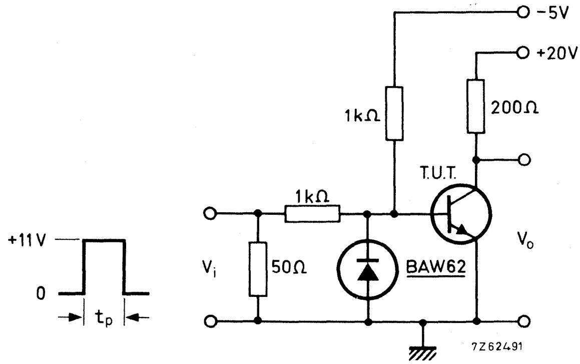


Fig. 2 Switching times test circuit.

Pulse generator:

Pulse duration	t_p	= 10 μs
Rise time	t_r	⩽ 15 ns
Fall time	t_f	⩽ 15 ns
Source impedance	Z_S	= 50 Ω

Oscilloscope:

Rise time	t_r	⩽	15 ns
Input impedance	Z_I	⩾	100 kΩ

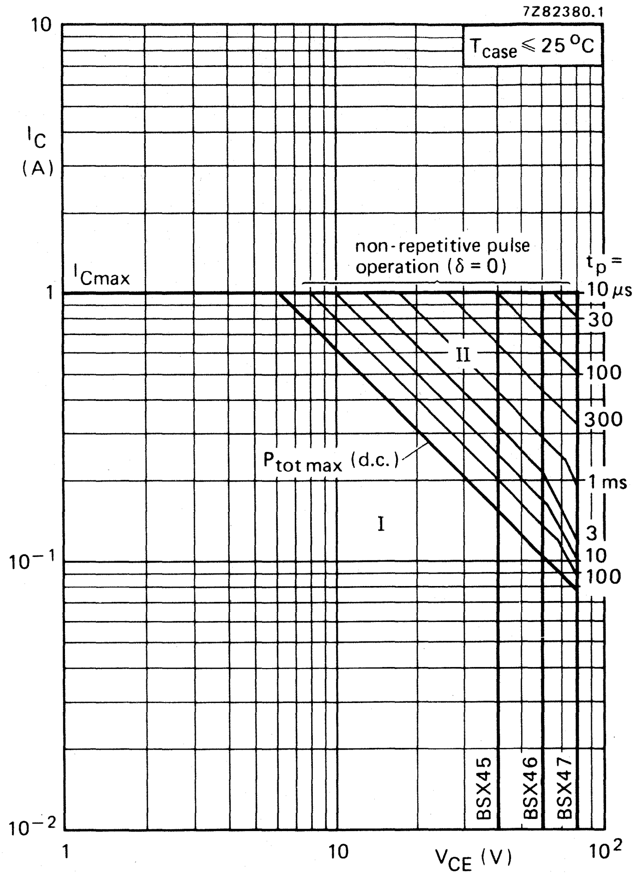


Fig. 3 Safe Operating ARea; $T_{case} \leqslant 25\,^oC$*.

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

* At case temperatures > 25 °C derate constant power portion of boundaries such that:

$P_{(t_p,\,o)} = \frac{200 - T_{case}}{Z_{th\,(t_p,\,o)}}$. (For very short forward mode pulse durations, i.e. $t_p < 3\ \mu s$, assume 3 μs values for Z_{th}.)

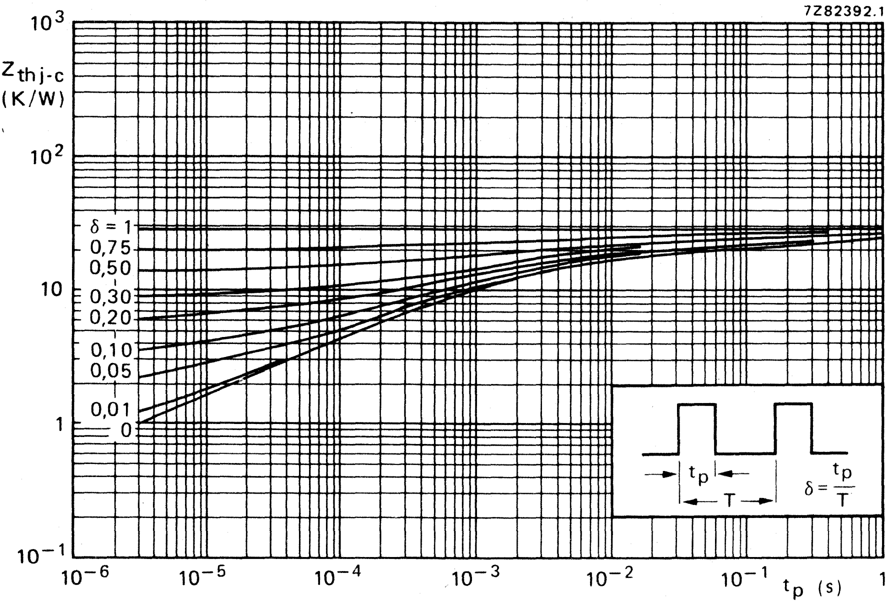


Fig. 4 Thermal impedance versus pulse duration. Stabilization time is 10 s.

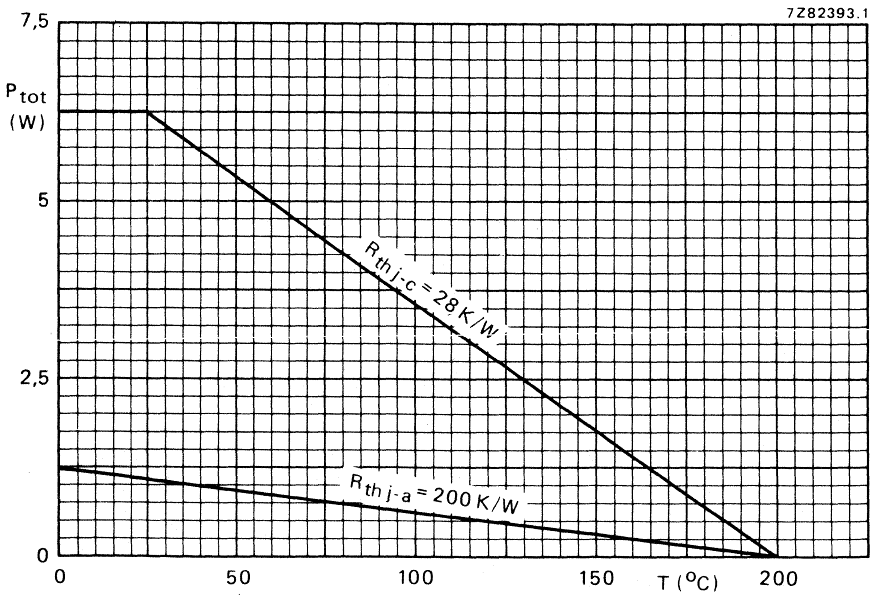


Fig. 5 Maximum permissible power dissipation as a function of temperature.

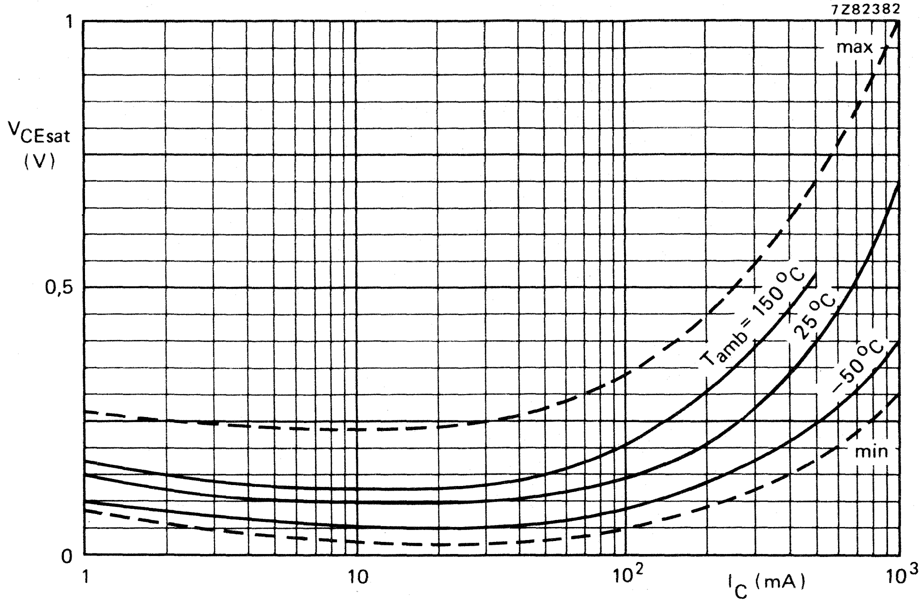


Fig. 6 I_C/I_B = 10; —— typical values; – – – limit values at T_{amb} = 25 °C.

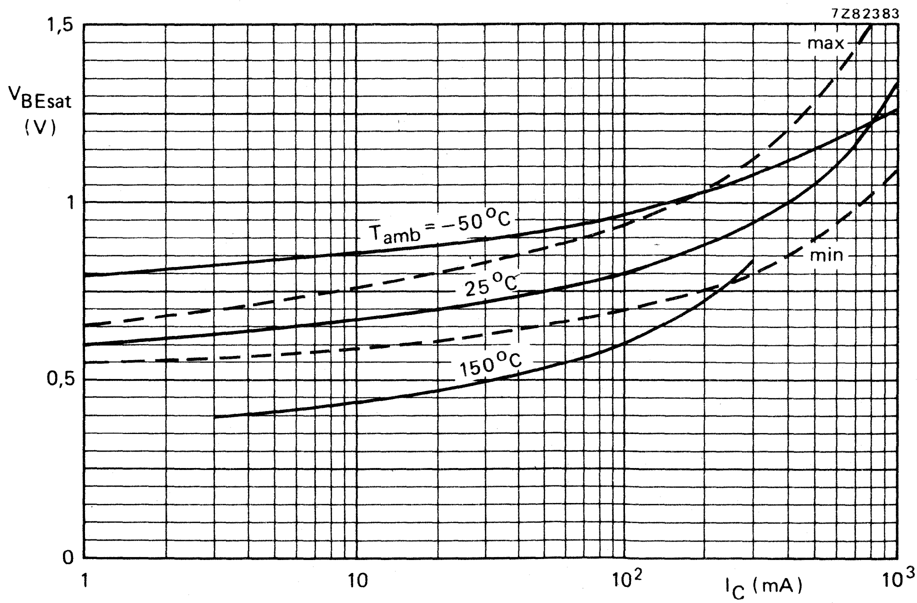


Fig. 7 I_C/I_B = 10; —— typical values; – – – limit values at T_{amb} = 25 °C.

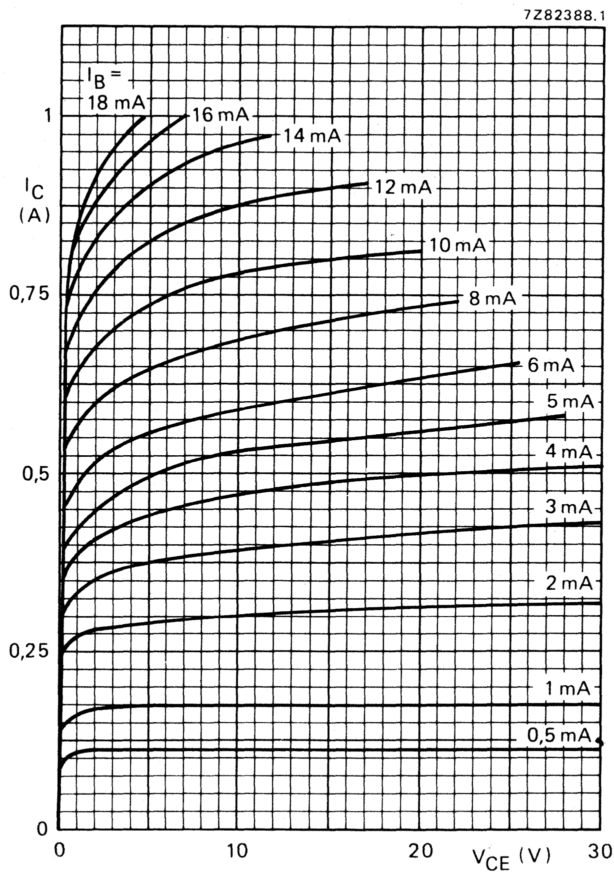


Fig. 8 Typical values; T_j = 25 °C.

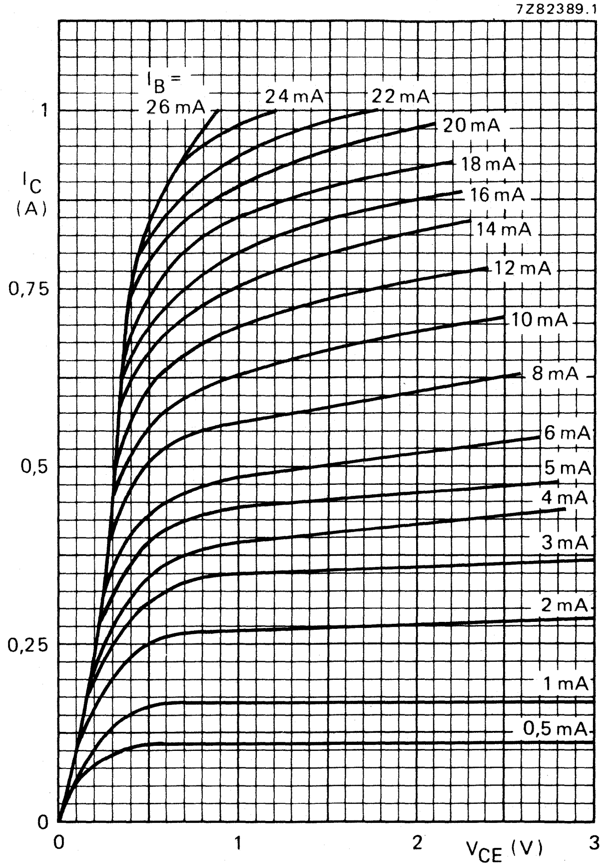


Fig. 9 Typical values; T_j = 25 °C.

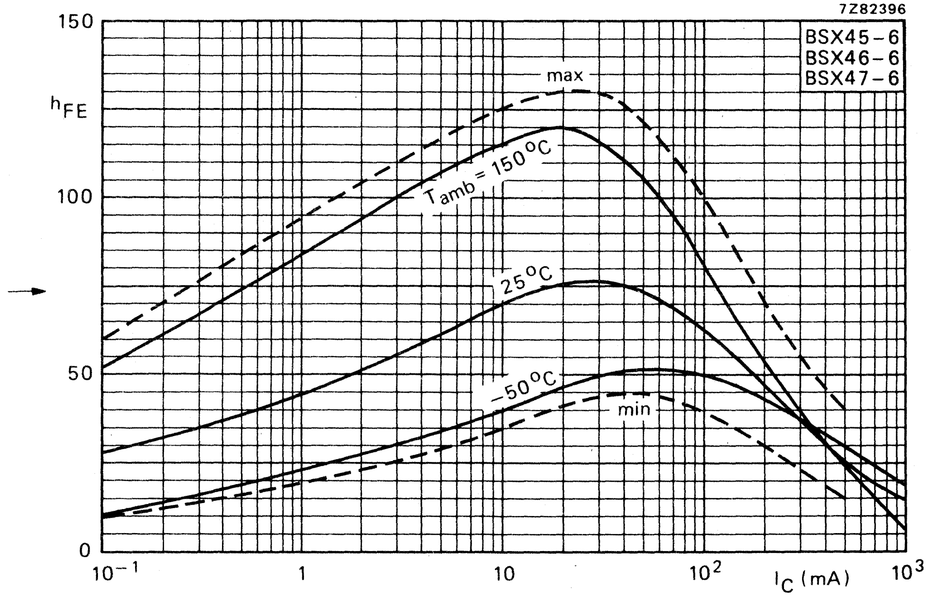


Fig. 10 V_{CE} = 1 V; —— typical values; – – – limit values at T_{amb} = 25 °C.

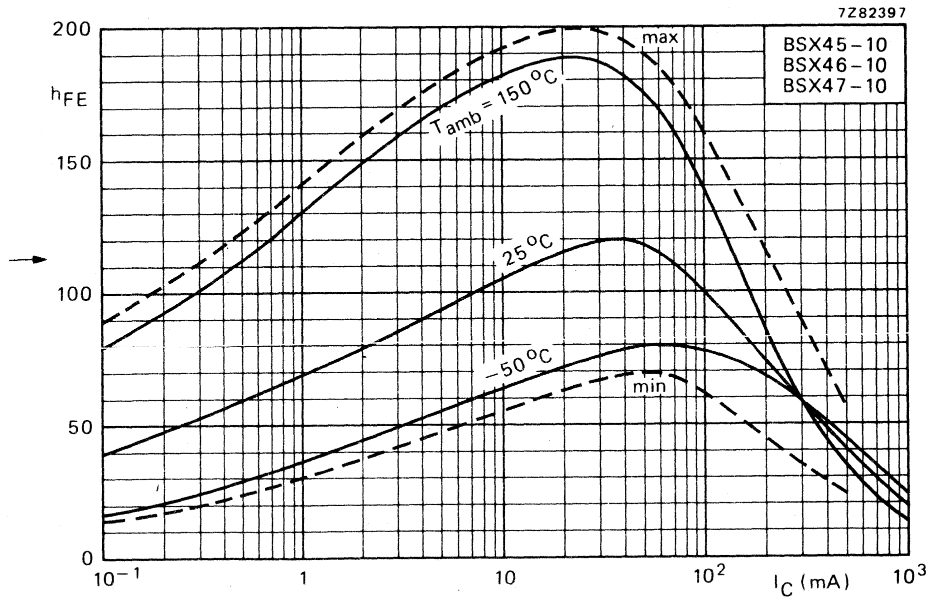


Fig. 11 V_{CE} = 1 V; —— typical values; – – – limit values at T_{amb} = 25 °C.

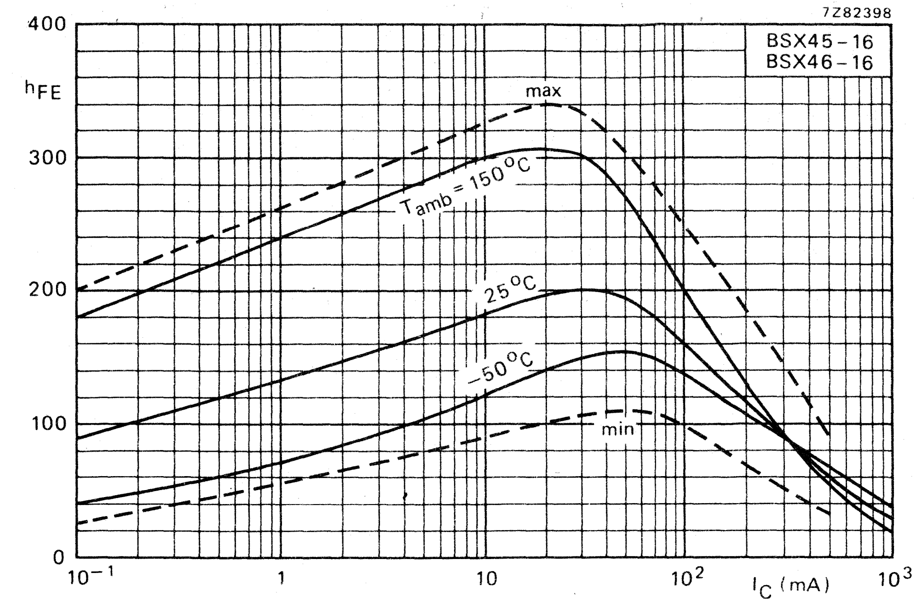


Fig. 12 V_{CE} = 1 V; —— typical values; – – – limit values at T_{amb} = 25 °C.

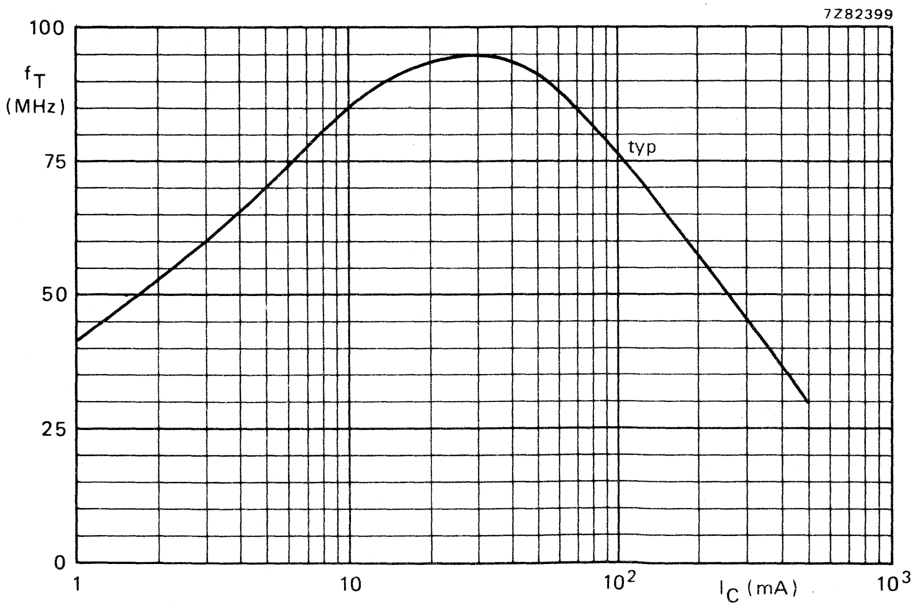


Fig. 13 V_{CE} = 10 V; f = 20 MHz; T_j = 25 °C.

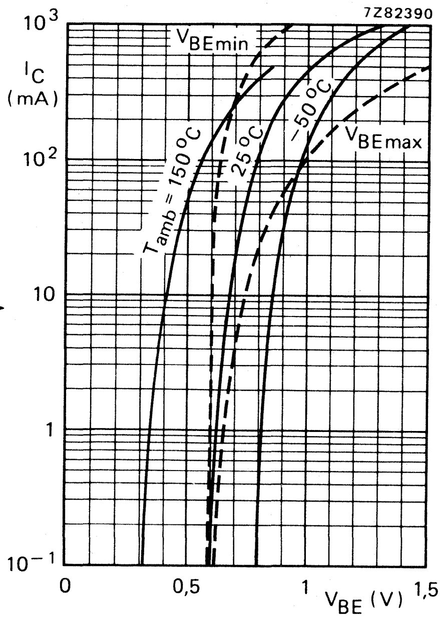


Fig. 14 V_{CE} = 1 V; —— typical values; — — — limit values at T_{amb} = 25 °C.

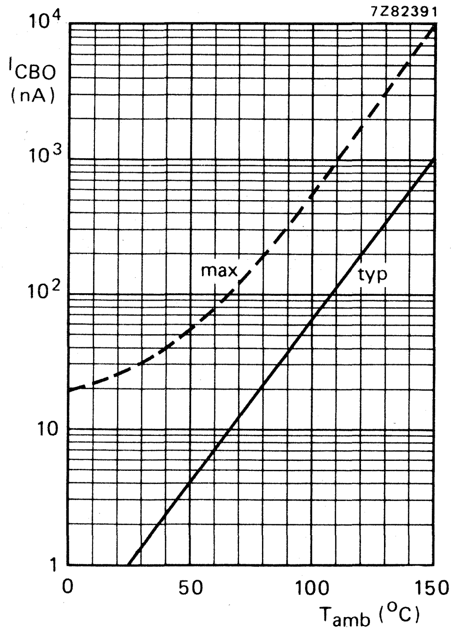


Fig. 15 V_{CBO} = 60 V for **BSX45** and **BSX46**; V_{CBO} = 80 V for **BSX47**.

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

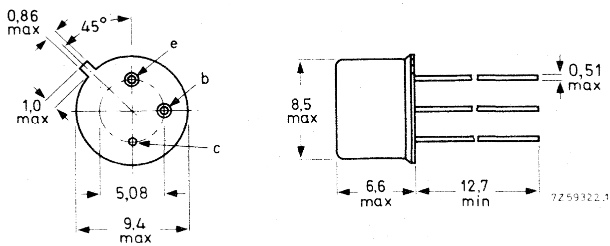
			BSX59	BSX60	BSX61	
Collector-base voltage (open emitter)	V_{CBO}	max.	70	70	70	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	30	45	V
Collector current (peak value)	I_{CM}	max.	1	1	1	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,8	0,8	0,8	W
Junction temperature	T_j	max.	200	200	200	°C
D.C. current gain I_C = 500 mA; V_{CE} = 1 V	h_{FE}	>	30	30	30	
Saturation voltage I_C = 500 mA; I_B = 50 mA	V_{CEsat}	<	0,5	0,5	0,7	V
Transition frequency I_C = 50 mA; V_{CE} = 10 V	f_T	typ.	450	475	475	MHz
Turn-off time I_{Con} = 500 mA; I_{Bon} = $-I_{Boff}$ = 50 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 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 °C	P_{tot}	max.	0.8	W

Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\,j\text{-}a}$	=	220	°C/W
From junction to case	$R_{th\,j\text{-}c}$	=	43	°C/W
From junction to mounting base	$R_{th\,j\text{-}mb}$	=	35	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

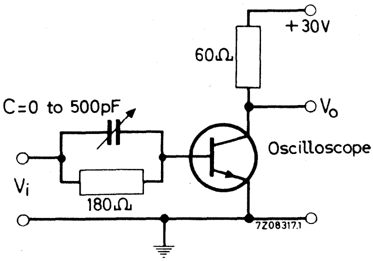
			BSX59	BSX60	BSX61	
Collector cut-off current						
$I_E = 0$; $V_{CB} = 40$ V	I_{CBO}	<	500	500	500	nA
$I_E = 0$; $V_{CB} = 40$ V; $T_j = 150$ °C	I_{CBO}	<	300	300	300	μA
Emitter cut-off current						
$I_C = 0$; $V_{EB} = 4$ V	I_{EBO}	<	300	300	500	nA
$I_C = 0$; $V_{EB} = 4$ V; $T_j = 150$ °C	I_{EBO}	<	50	50	50	μA
Currents at reverse biased emitter junction						
$-V_{BE} = 4$ V; $V_{CE} = 40$ V	$+I_{CEX}$	<	500	500	1000	nA
	$-I_{BEX}$	<	500	500	1000	nA
$-V_{BE} = 4$ V; $V_{CE} = 40$ V; $T_j = 150$ °C	$+I_{CEX}$	<	300	300	500	μA
	$-I_{BEX}$	<	300	300	500	μA
Saturation voltages						
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	0.3	0.3	0.5	V
	V_{BEsat}	<	1.0	1.0	1.0	V
$I_C = 500$ mA; $I_B = 50$ mA	V_{CEsat}	<	0.5	0.5	0.7	V
	V_{BEsat}	>	0.85	0.7	0.7	V
		<	1.2	1.3	1.3	V
$I_C = 1$ A; $I_B = 100$ mA	V_{CEsat}	<	1.0	1.0	1.3	V
	V_{BEsat}	<	1.8	1.8	1.8	V
D.C. current gain						
$I_C = 150$ mA; $V_{CE} = 1$ V	h_{FE}	>	30	30	30	
		typ.	70	90	105	
$I_C = 500$ mA; $V_{CE} = 1$ V	h_{FE}	>	30	30	30	
		<	90	90	90	
$I_C = 1$ A; $V_{CE} = 5$ V	h_{FE}	>	20	25	20	
		typ.	40	50	55	
Transition frequency						
$I_C = 50$ mA; $V_{CE} = 10$ V	f_T	>	250	250	250	MHz
		typ.	450	475	475	MHz
Collector capacitance at f = 1 MHz						
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	typ.	6	6	6	pF
		<	10	10	10	pF
Emitter capacitance at f = 1 MHz						
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	typ.	36	36	36	pF
		<	50	50	50	pF

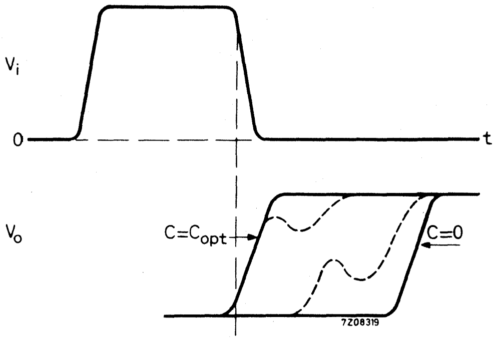
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Recovered charge

I_C = 500 mA; I_B = 50 mA BSX60 Q_s < 5 nC

Test circuit:





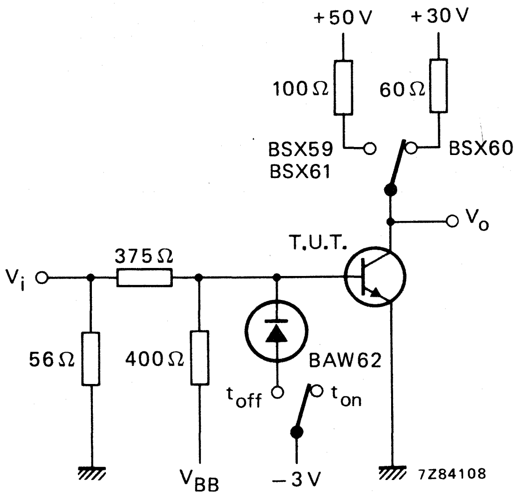
Adjust C from zero to C_{opt}
$Q_s = C_{opt} \cdot V_i$

Pulse generator:

Pulse duration	t_p =	10 μs
Duty cycle	δ =	0.02

Switching times (see also Figs 4, 11 and 12)

			BSX59	BSX60	BSX61	
Turn-on time when switched from $-V_{BE} = 2$ V to $I_{Con} = 500$ mA; $I_{Bon} = 50$ mA	t_{on}	typ.	17	17	18	ns
		<	35	40	50	ns
Turn-off time when switched from $I_{Con} = 500$ mA; $I_{Bon} = 50$ mA to cut-off with $-I_{Boff} = 50$ mA*	t_{off}	typ.	45	58	70	ns
		<	60	70	100	ns



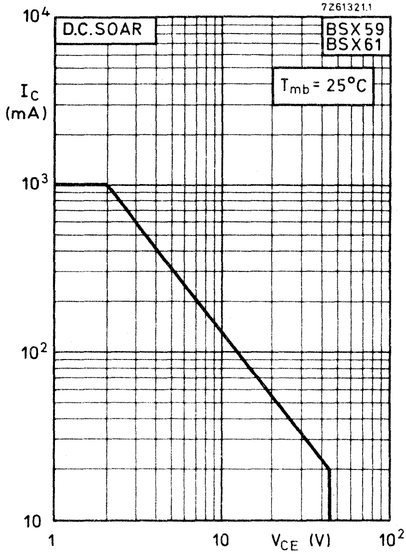
	t_{on}	t_{off}	
$-V_{BB}$	4	16,7	V
V_i	24,75	37,5	V

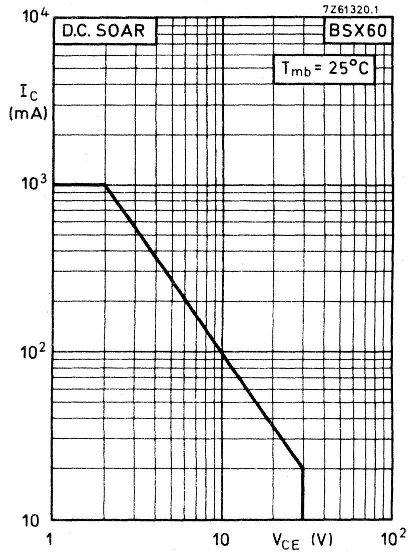
Fig. 4 Switching circuit.

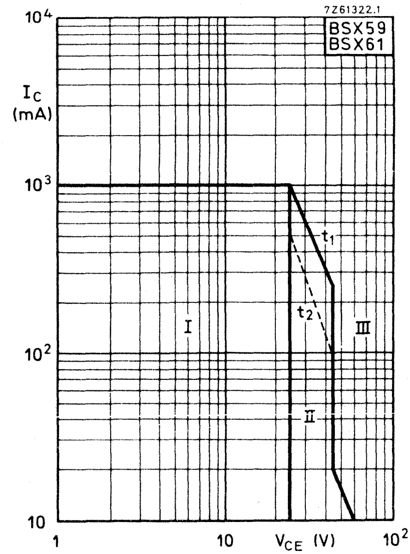
Pulse generator:

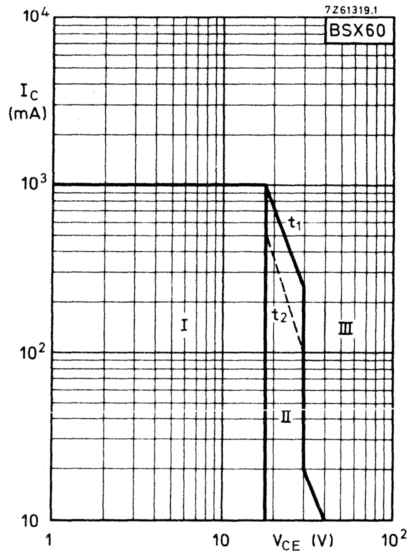
Pulse duration	t_p	≥	500 ns
Rise time	t_r	≤	5 ns
Fall time	t_f	≤	5 ns
Output resistance	R_o	=	50 Ω (during pulse, otherwise infinite)

* $-I_{Boff}$ 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.









I Region of permissible operation during switching off with $-V_{BB}$ = 4 V; R_{BE} = 39 Ω

II Permissible extension for repetitive pulsed operation.

t_1 limits operations with $t_p \leq 0.1$ μs; $\delta = 0.25$

t_2 limits operations with $t_p \leq$ 1 μs; $\delta = 0.25$

III Operation in this area is not allowed.

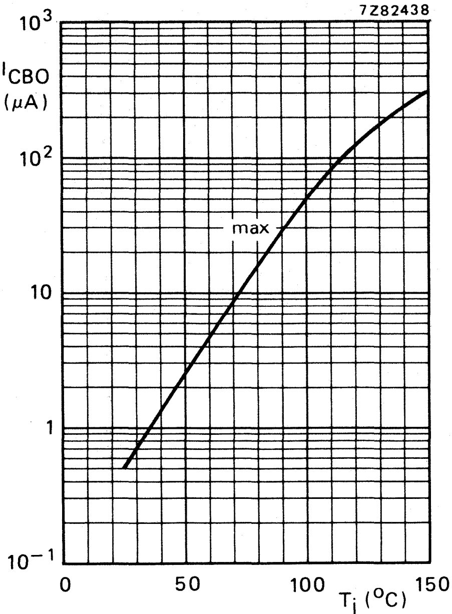


Fig. 9 V_{CB} = 40 V.

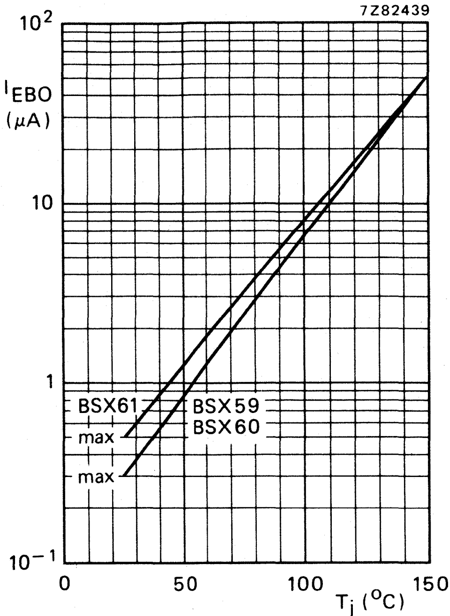


Fig. 10 V_{EB} = 4 V.

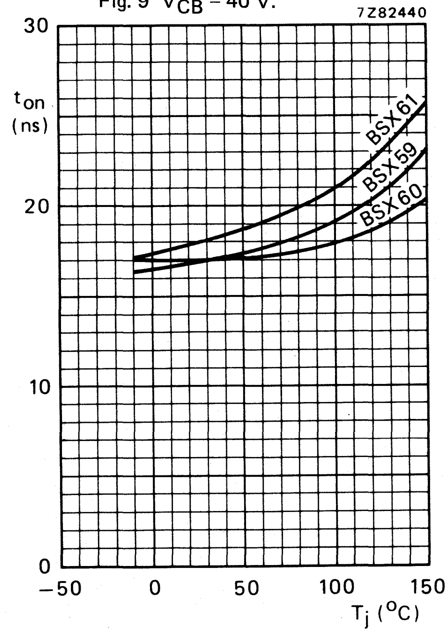


Fig. 11 $-V_{BEoff}$ = 2 V; I_{Con} = 500 mA; I_{Bon} = 50 mA; typ. values. (See also Fig. 4.)

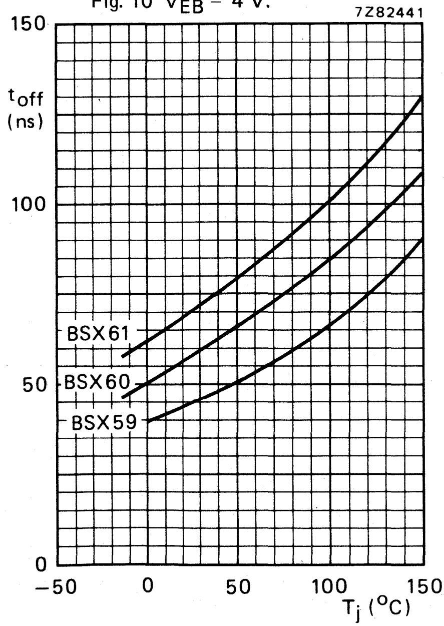


Fig. 12 I_{Con} = 500 mA; I_{Bon} = $-I_{Boff}$ = 50 mA; typical values. (See also Fig. 4.)

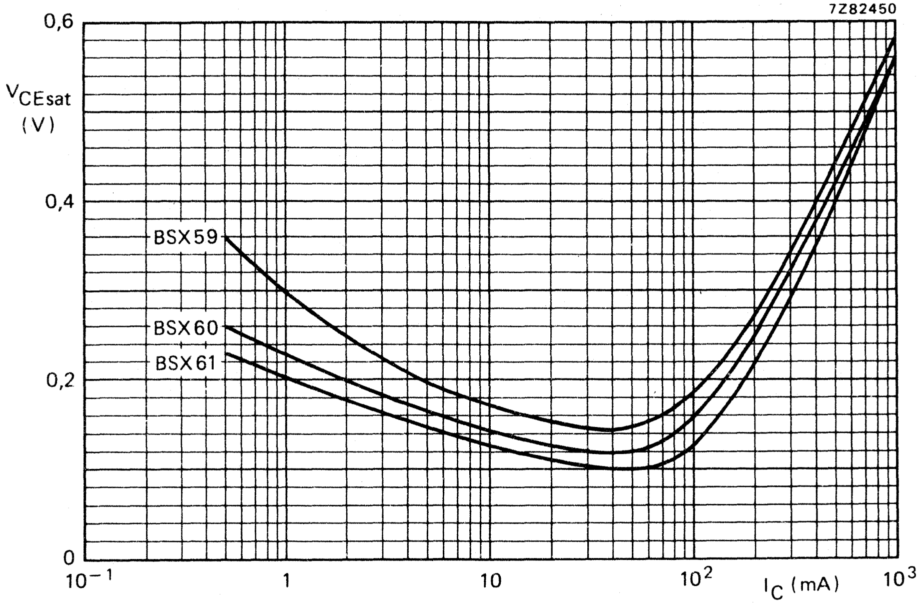


Fig. 13 $I_C/I_B = 10$; $T_j = 25\ ^oC$; typical values.

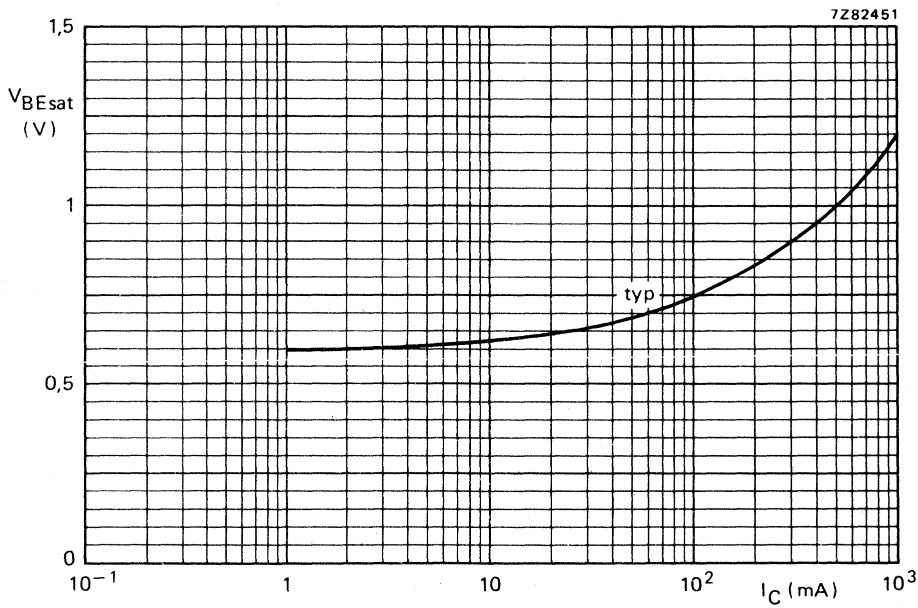


Fig. 14 $I_C/I_B = 10$; $T_j = 25\ ^oC$.

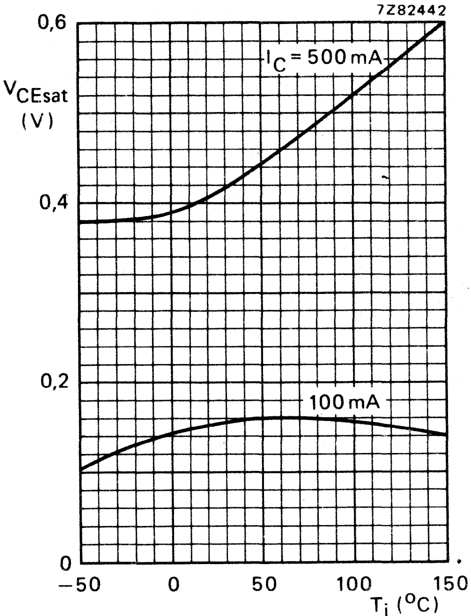


Fig. 15 I_C/I_B = 10; typical values.

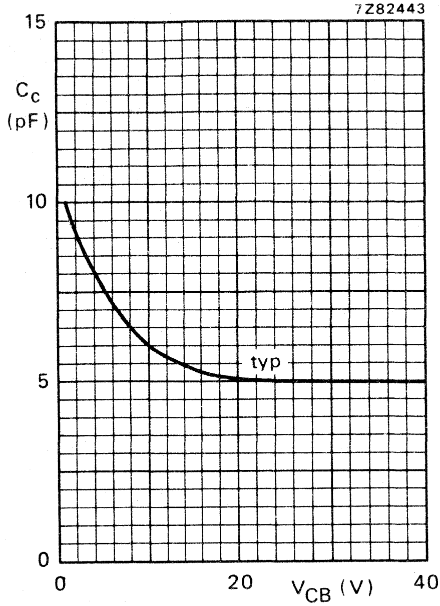


Fig. 16 $I_E = I_e = 0$; f = 1 MHz; T_j = 25 °C.

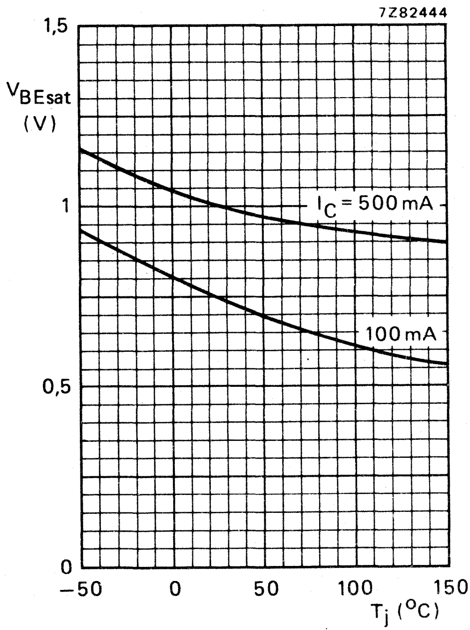


Fig. 17 I_C/I_B = 10; typical values.

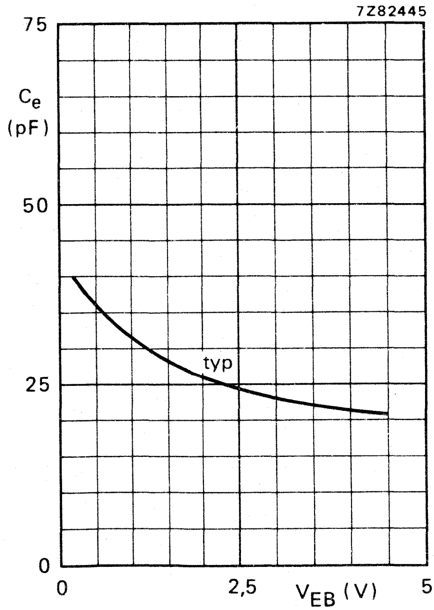


Fig. 18 $I_C = I_c = 0$; f = 1 MHz; T_j = 25 °C.

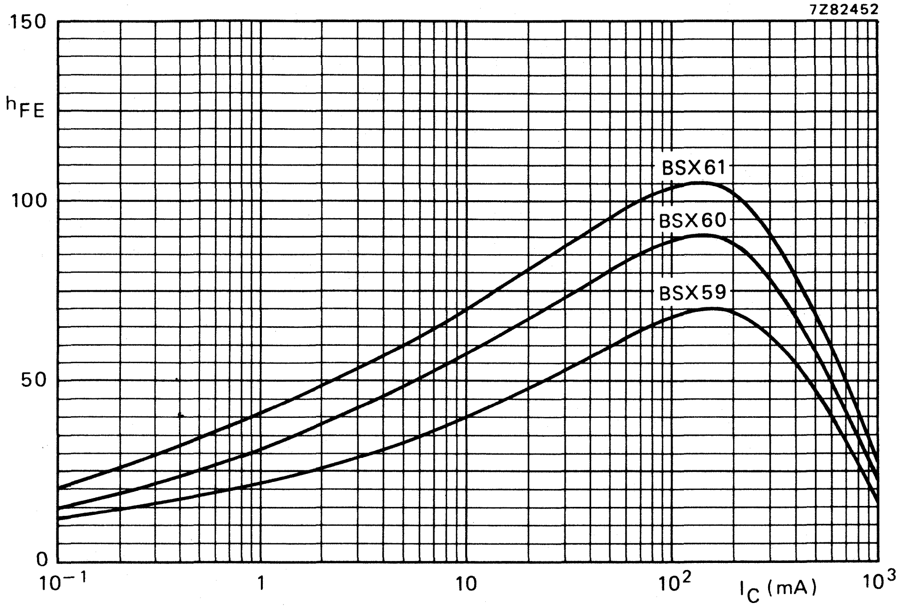


Fig. 19 V_{CE} = 1 V; T_j = 25 °C; typical values.

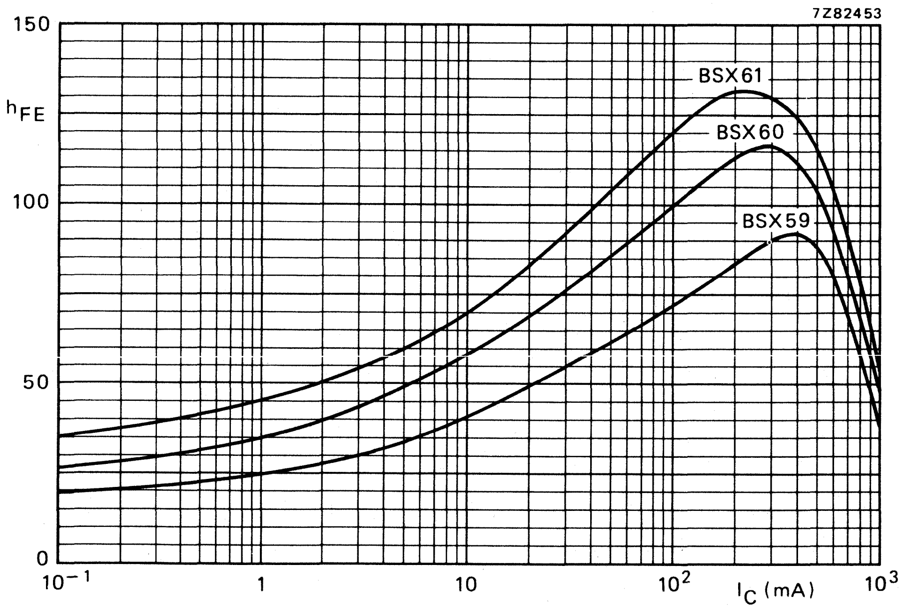


Fig. 20 V_{CE} = 5 V; T_j = 25 °C; typical values.

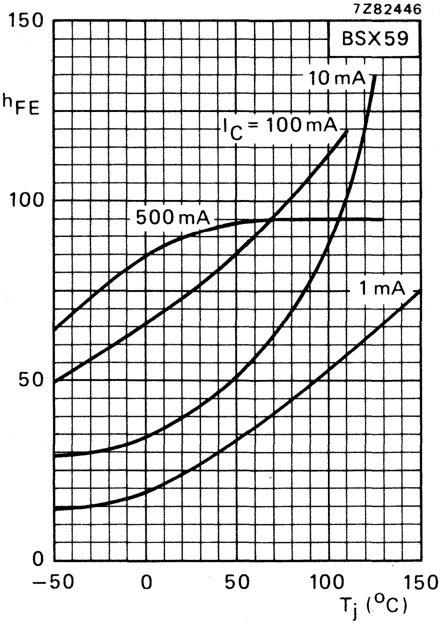


Fig. 21 V_{CE} = 5 V; typical values.

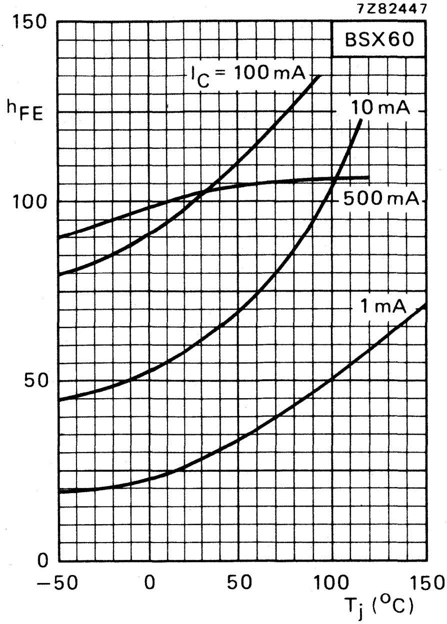


Fig. 22 V_{CE} = 5 V; typical values.

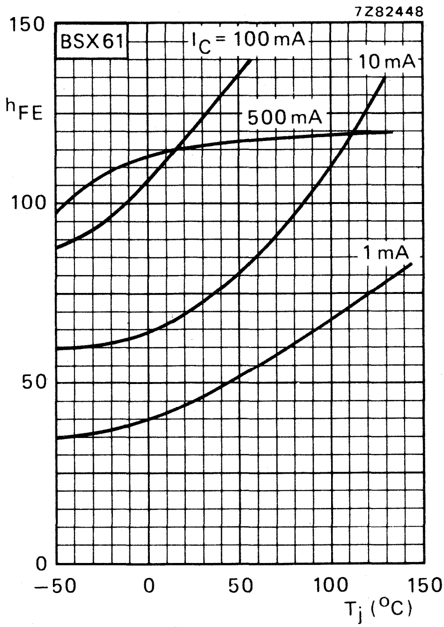


Fig. 23 V_{CE} = 5 V; typical values.

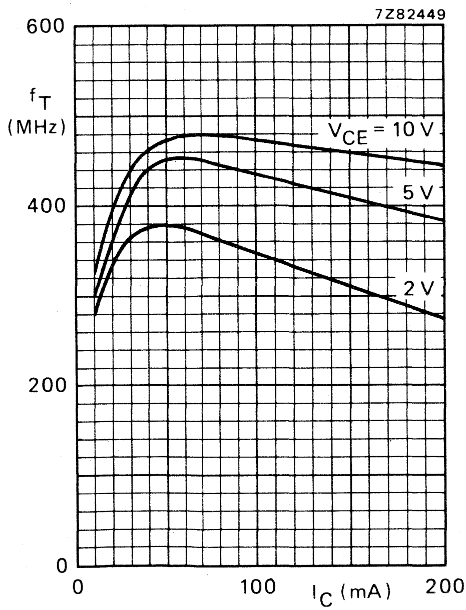


Fig. 24 f = 100 MHz; T_j = 25 °C; typ. values.

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

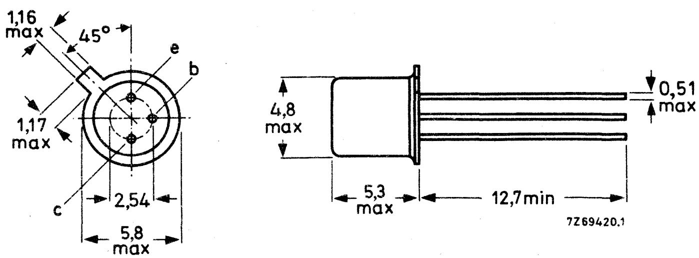
Collector-base voltage (open emitter)	V_{CBO}	max.	20	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Collector current (peak value)	I_{CM}	max.	200	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	mW
D.C. current gain I_C = 10 mA; V_{CE} = 0,35 V	h_{FE}		50 to 200	
Transition frequency at f = 100 MHz I_C = 10 mA; V_{CE} = 9,0 V	f_T	>	200	MHz
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. ($T_{amb} \leq 25^{o}C$)	300	mW

*Averaged over any 20ms period.

Temperature

T_{stg} min.	-65	^{o}C
T_{stg} max.	175	^{o}C
T_j max. (operating)	175	^{o}C

THERMAL CHARACTERISTIC

$R_{th(j-amb)}$	0.5	degC/mW

ELECTRICAL CHARACTERISTICS ($T_{amb} = 25^{o}C$ 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

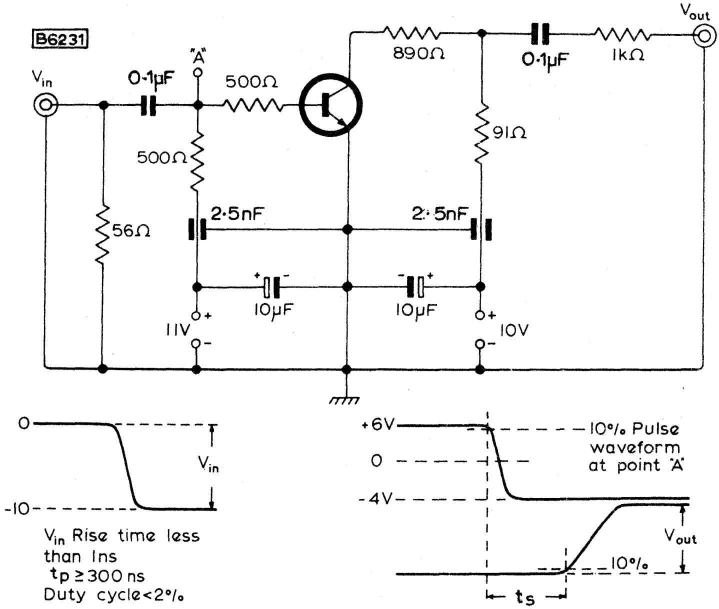
**Pulsed: Pulse width = 300μs, duty cycle < 2%.

		Min.	Max.	
h_{FE}	Common emitter forward current transfer ratio			
	$I_C=1.0mA$, $V_{CE}=0.35V$	30	-	
	$I_C=10mA$, $V_{CE}=0.35V$	50	200	
$V_{CE(sat)}$	Collector-emitter saturation voltage			
	$I_C=10mA$, $I_B=0.2mA$	-	0.35	V
$V_{BE(sat)}$	Base-emitter saturation voltage			
	$I_C=10mA$, $I_B=0.2mA$	0.67	0.87	V
C_{ob}	Collector-base capacitance			
	$V_{CB}=9.0V$, $I_E=0$			
	$f=1.0MHz$	-	6.0	pF
t_s	Storage time			
	$I_C=10mA$	-	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°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°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



V_{in} Rise time less than 1ns
$t_p \geq 300$ ns
Duty cycle<2%

Input and output waveforms

SILICON PLANAR EPITAXIAL SWITCHING TRANSISTOR

N-P-N transistor in a plastic TO-92 variant envelope intended for high-speed switching applications.

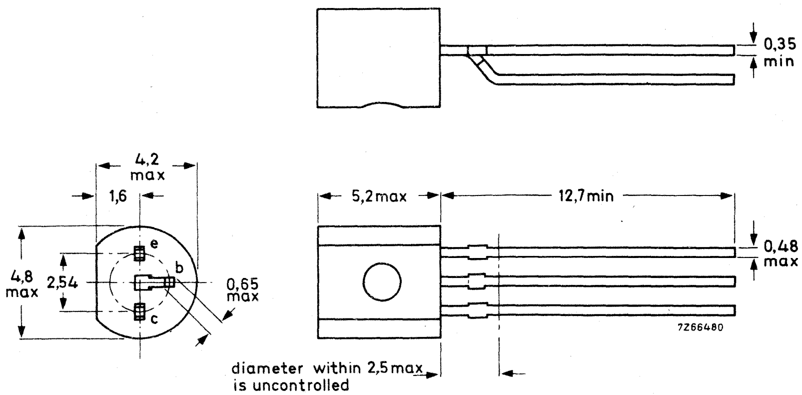
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{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
Collector current (peak value)	I_{CM}	max.	500	mA
Total power dissipation up to $T_{amb} = 25\ ^{o}C$	P_{tot}	max.	500	mW
D.C. current gain				
$I_C = 10$ mA; $V_{CE} = 1$ V	h_{FE}	>	40	
$I_C = 100$ mA; $V_{CE} = 2$ V	h_{FE}	>	20	
Transition frequency at f = 100 MHz				
$I_C = 10$ mA; $V_{CE} = 10$ V	f_T	>	500	MHz
Storage time				
$I_{Con} = I_{Bon} = -I_{Boff} = 10$ 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_{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 μs)	I_{CM}	max.	500	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500	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	$R_{th\ j\text{-}a}$	=	250	K/W

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 20$ V	I_{CBO}	<	400	nA
$I_E = 0$; $V_{CB} = 20$ V; $T_j = 125$ °C	I_{CBO}	<	30	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 2$ V	I_{EBO}	<	100	nA
Saturation voltages				
I_C = 10 mA; I_B = 0,3 mA	V_{CEsat}	<	0,30	V
I_C = 10 mA; I_B = 1 mA	V_{CEsat}	<	0,25	V
	V_{BEsat}		0,70 to 0,85	V
I_C = 100 mA; I_B = 10 mA	V_{CEsat}	<	0,60	V
	V_{BEsat}	<	1,50	V
D.C. current gain				
I_C = 10 mA; V_{CE} = 1 V	h_{FE}		40 to 120	
I_C = 10 mA; V_{CE} = 1 V; T_{amb} = −55 °C	h_{FE}	>	20	
I_C = 100 mA; V_{CE} = 2 V	h_{FE}	>	20	
Transition frequency at f = 100 MHz				
I_C = 10 mA; V_{CE} = 10 V	f_T	>	500	MHz
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 5$ V	C_c	<	4	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $V_{EB} = 1$ V	C_e	<	4,5	pF

Switching times

Storage time (see Fig. 2)				
$I_{Con} = I_{Bon} = -I_{Boff} = 10$ mA	t_s	typ.	6	ns
		<	13	ns

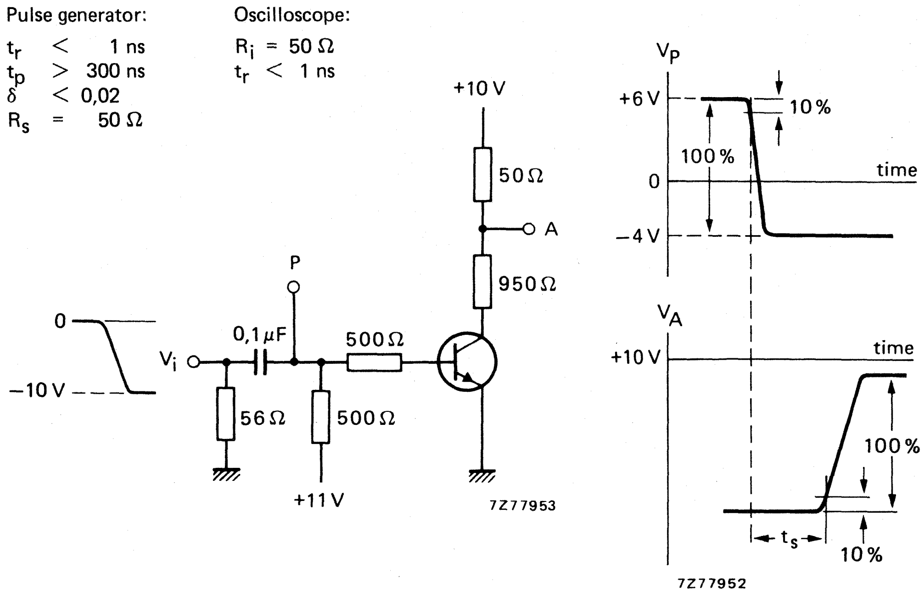


Fig. 2 Test circuit and waveforms.

Turn-on time (see Fig. 3)

from $-V_{BEoff}$ = 1,5 V to I_{Con} = 10 mA; I_{Bon} = 3 mA	t_{on}	<	12	ns
from $-V_{BEoff}$ = 2,25 V to I_{Con} = 100 mA; I_{Bon} = 40 mA	t_{on}	<	7	ns

Turn-off time (see Fig. 3)

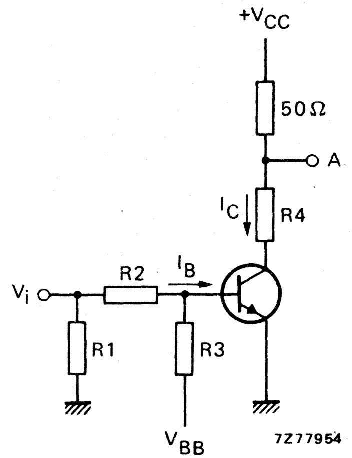
I_{Con} = 10 mA; I_{Bon} = 3 mA; $-I_{Boff}$ = 1,5 mA	t_{off}	<	18	ns
I_{Con} = 100 mA; I_{Bon} = 40 mA; $-I_{Boff}$ = 20 mA	t_{off}	<	21	ns

Pulse generator:

t_r < 1 ns
t_p > 300 ns
δ < 0,02
R_s = 50 Ω

Oscilloscope:

R_i = 50 Ω
t_r < 1 ns



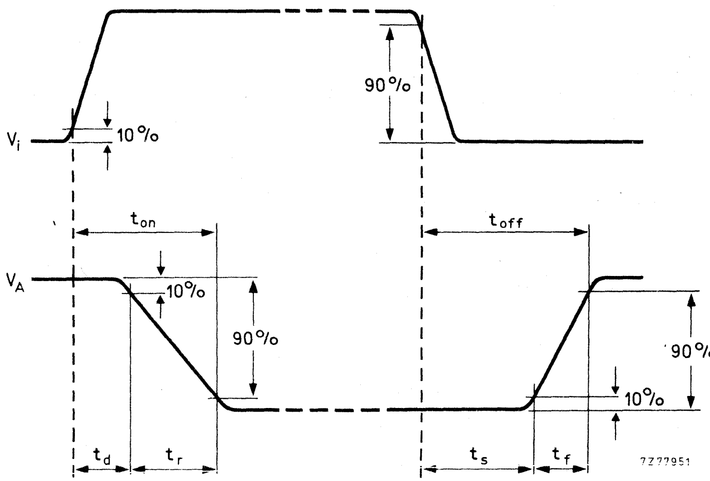


Fig. 3 Test circuit and waveforms.

I_{Con} mA	I_{Bon} mA	I_{Boff} mA	V_{CC} V	R1 Ω	R2; R3 kΩ	R4 Ω	turn-on time V_{BB} V	turn-on time V_{BE} V	turn-on time V_i V	turn-off time V_{BB} V	turn-off time 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

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

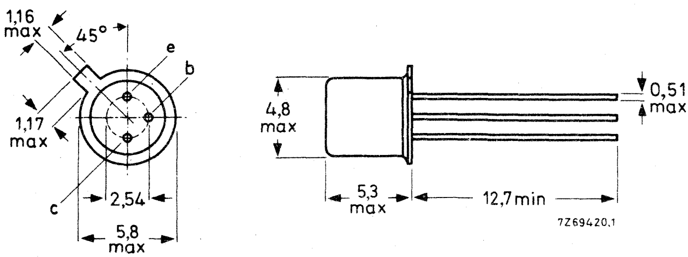
			2N929	2N930	
Collector-base voltage (open emitter)	V_{CBO}	max	45	45	V
Collector-emitter voltage (open base)	V_{CEO}	max	45	45	V
Collector current (peak value)	I_{CM}	max	60	60	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max	300	300	mW
Junction temperature	T_j	max	175	175	°C
D.C. current gain at T_j = 25 °C I_C = 10 μA; V_{CE} = 5 V	h_{FE}	> <	40 120	100 300	
I_C = 10 mA; V_{CE} = 5 V	h_{FE}	> <	100 350	150 600	
Transition frequency I_C = 0,5 mA; V_{CE} = 5 V	f_T	typ	80	80	MHz
Noise figure at R_S = 10 kΩ I_C = 10 μA; V_{CE} = 5 V f = 10 Hz to 15 kHz	F	typ <	2,5 4	2 3	dB 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

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 °C	P_{tot}	max.	300	mW

Temperatures

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	$R_{th\ j-c}$	=	0.25	°C/mW

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

I_E = 0; V_{CB} = 45 V	I_{CBO}	<	10	nA
I_B = 0; V_{CE} = 5 V	I_{CEO}	<	2	nA
V_{EB} = 0; V_{CB} = 45 V	I_{CES}	<	10	nA

Emitter cut-off current

I_C = 0; V_{EB} = 5 V	I_{EBO}	<	10	nA

Emitter-base voltage

$-I_E$ = 0.5 mA; V_{CB} = 5 V	$-V_{EB}$	0.6 to 0.8	V

Saturation voltages

I_C = 10 mA; I_B = 0.5 mA	V_{CEsat}	<	1	V
	V_{BEsat}	0.6 to	1	V

		2N929	2N930	
D.C. current gain				
I_C = 10 μA; V_{CE} = 5 V	h_{FE}	40 to 120	100 to 300	
I_C = 10 μA; V_{CE} = 5 V; T_j = −55 °C	h_{FE}	> 10	> 20	
I_C = 500 μA; V_{CE} = 5 V	h_{FE}	> 60	> 150	
I_C = 10 mA; V_{CE} = 5 V	h_{FE}	100 to 350	150 to 600	
Collector capacitance at f = 1 MHz				
$I_E = I_e$ = 0; V_{CB} = 5 V	C_c	< 8	< 8	pF
Transition frequency				
I_C = 0.5 mA; V_{CE} = 5 V	f_T	> 50	> 50	MHz
Cut-off frequency				
I_C = 0.5 mA; V_{CE} = 5 V	f_{hfe}	> 200	> 100	kHz

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

		2N929	2N930	
Noise figure (f = 10 Hz to 15 kHz)				
I_C = 10 μA; V_{CE} = 5 V; R_S = 10 kΩ	F	typ. 2.5	2	dB
		< 4	3	dB
h parameters at f = 1 kHz				
I_C = 1 mA; V_{CE} = 5 V				
Input impedance	h_{ie}	typ. 5.0	10.0	kΩ
Reverse voltage transfer	h_{re}	typ. 2.5	5.5	10^{-4}
Small signal current gain	h_{fe}	typ. 200	350	
		60 to 350	150 to 600	
Output admittance	h_{oe}	typ. 14	25	$\mu\Omega^{-1}$

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

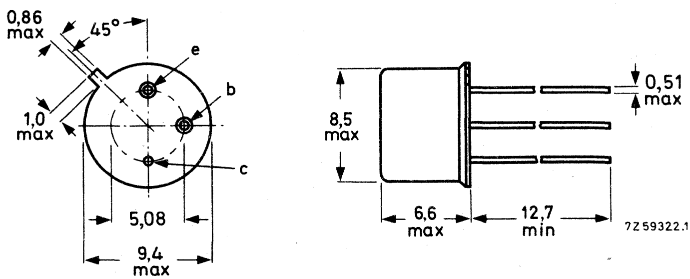
Collector-base voltage (open emitter)	V_{CBO}	max.	75	V
Collector-emitter voltage ($R_{BE} \leq 10\ \Omega$)	V_{CER}	max.	50	V ←
Collector current (peak value)	I_{CM}	max.	500	mA ←
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,8	W
D.C. current gain at T_j = 25 °C I_C = 150 mA; V_{CE} = 10 V	h_{FE}		40 to 120	
Transition frequency at f = 20 MHz I_C = 50 mA; V_{CE} = 10 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 ($R_{BE} \leqslant 10\ \Omega$)	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 °C	P_{tot}	max.	0,8	W
at T_{case} = 100 °C	P_{tot}	max.	1,7	W
up to T_{case} = 25 °C	P_{tot}	max.	3,0	W
Storage temperature	T_{stg}	−65 to + 200		°C
Junction temperature	T_j	max.	200	°C
→ Lead soldering temperature > 1,5 mm from the seating plane; t_{sld} < 10 s.	T_{sld}	max.	300	°C

THERMAL RESISTANCE

From junction to case	$R_{th\ j\text{-}c}$	=	58,3	K/W

* With the exception of the collector current all other data are Jedec registered.

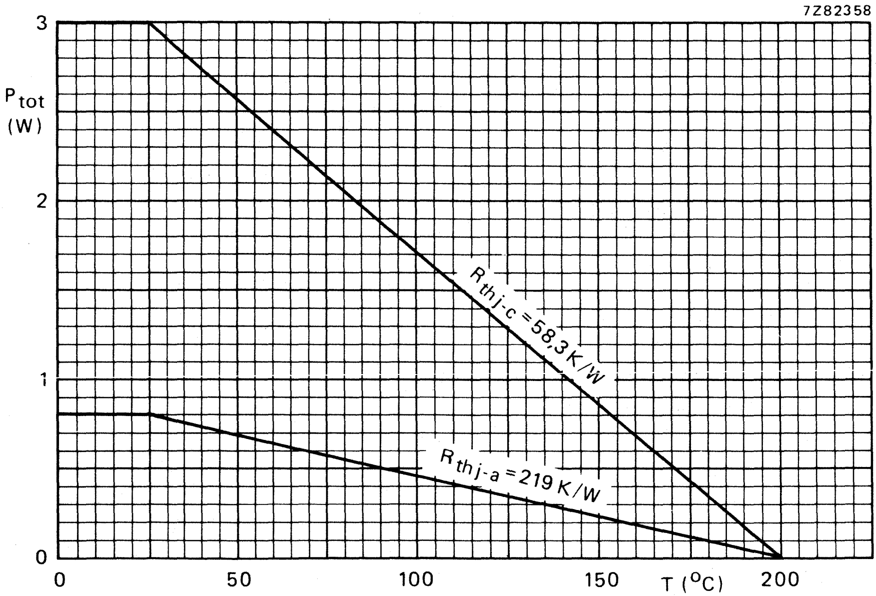


Fig. 2 Maximum permissible total power dissipation as a function of temperature.

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

Collector cut-off current			
$I_E = 0$; $V_{CB} = 60$ V	I_{CBO}	<	10 nA
$I_E = 0$; $V_{CB} = 60$ V; $T_{amb} = 150$ °C	I_{CBO}	<	10 μA
Emitter cut-off current			
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10 nA
Collector-base breakdown voltage			
open emitter; $I_C = 100$ μA	$V_{(BR)CBO}$	>	75 V
Collector-emitter breakdown voltage*			
$I_C = 100$ mA; $R_{BE} \leq 10\ \Omega$	$V_{(BR)CER}$	>	50 V
Emitter-base breakdown voltage			
open collector; $I_E = 100$ μA	$V_{(BR)EBO}$	>	7 V
Saturation voltages*			
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	1,5 V
	V_{BEsat}	<	1,3 V
D.C. current gain			
$I_C = 0,1$ mA; $V_{CE} = 10$ V	h_{FE}	>	20
$I_C = 10$ mA; $V_{CE} = 10$ V*	h_{FE}	>	35
$I_C = 10$ mA; $V_{CE} = 10$ V; $T_{amb} = -55$ °C	h_{FE}	>	20
$I_C = 150$ mA; $V_{CE} = 10$ V*	h_{FE}		40 to 120
$I_C = 500$ mA; $V_{CE} = 10$ V*	h_{FE}	>	20
Transition frequency at f = 20 MHz			
$I_C = 50$ mA; $V_{CE} = 10$ V	f_T	>	60 MHz
Collector capacitance			
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	25 pF
Emitter capacitance			
$I_C = I_c = 0$; $V_{EB} = 0,5$ V	C_e	<	80 pF
Noise figure at f = 1 kHz			
$I_C = 0,3$ mA; $V_{CE} = 10$ V; $R_S = 510\ \Omega$; B = 1 Hz	F	<	12 dB ←

h-parameters at f = 1 kHz ←

Input impedance			
$I_C = 1$ mA; $V_{CB} = 5$ V	h_{ib}		24 to 34 Ω
$I_C = 5$ mA; $V_{CB} = 10$ V	h_{ib}		4 to 8 Ω
Reverse voltage transfer ratio			
$I_C = 1$ mA; $V_{CE} = 5$ V	h_{rb}	<	$3\ 10^{-4}$
$I_C = 5$ mA; $V_{CE} = 10$ V	h_{rb}	<	$3\ 10^{-4}$
Small-signal current gain			
$I_C = 1$ mA; $V_{CE} = 5$ V	h_{fe}		30 to 100
$I_C = 5$ mA; $V_{CE} = 10$ V	h_{fe}		35 to 150

* Measured under pulse conditions to avoid excessive dissipation: $t_p = 300$ μs; $\delta \leq 0,02$.

→ Output admittance		
I_C = 1 mA; V_{CE} = 5 V	h_{ob}	0,05 to 0,5 μA/V
I_C = 5 mA; V_{CE} = 10 V	h_{ob}	0,05 to 0,5 μA/V
→ Total switching time (see Figs 3 to 6)		
I_{Con} = 50 mA; $V_{BEon} = -V_{BEoff}$ = 1 V	$t_{on} + t_{off}$	< 30 ns

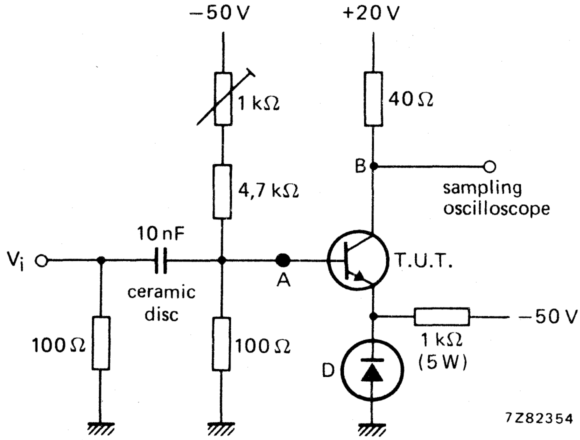


Fig. 3 Turn-on plus turn-off measuring circuit. D = BAW62.

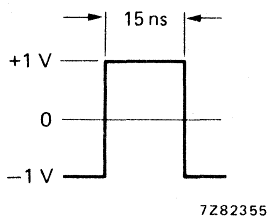


Fig. 4 Waveform at "A".
Pulse generator: t_r; t_f < 1 ns.

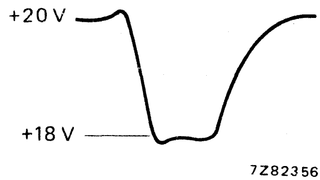


Fig. 5 Waveform at "B".

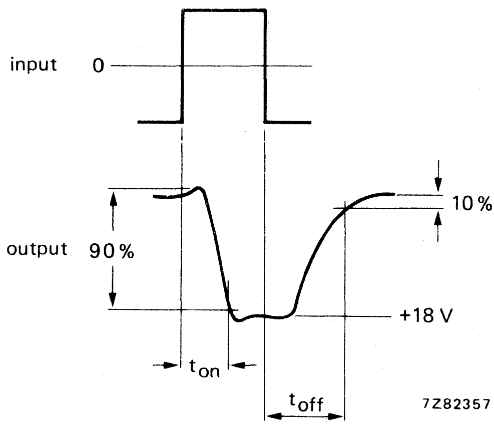


Fig. 6 Turn-on and turn-off time.

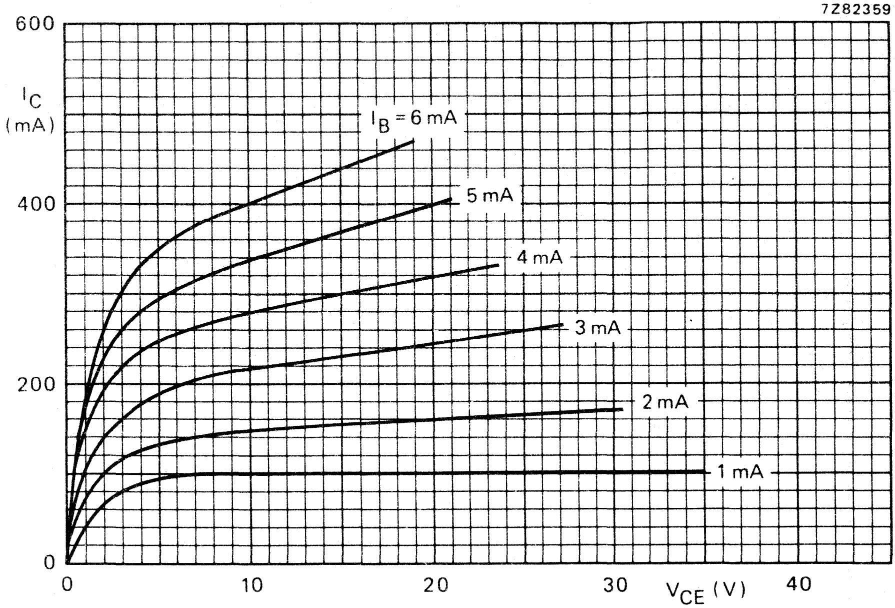


Fig. 7 T_j = 25 °C; typical values.

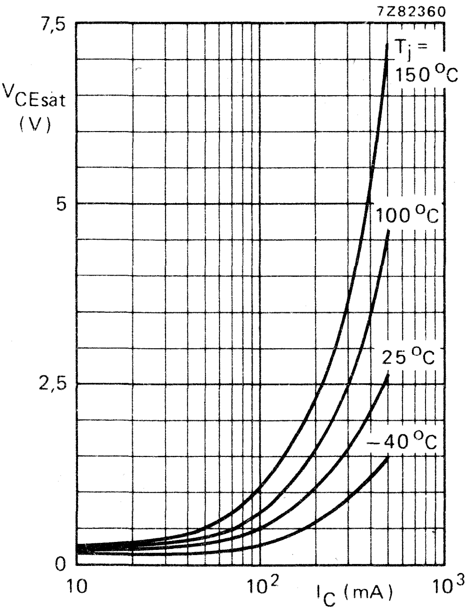


Fig. 8 I_C/I_B = 10; typical values.

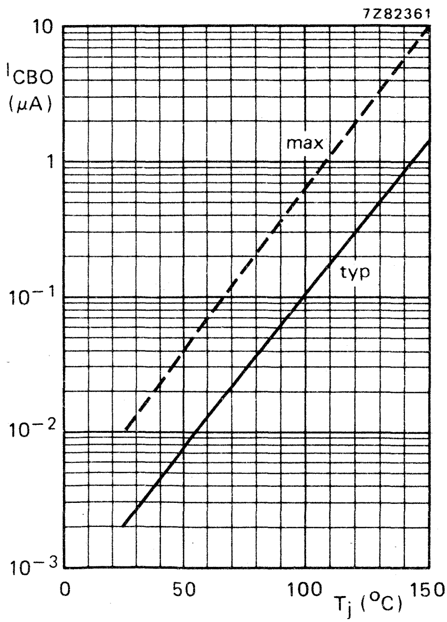


Fig. 9 V_{CB} = 60 V.

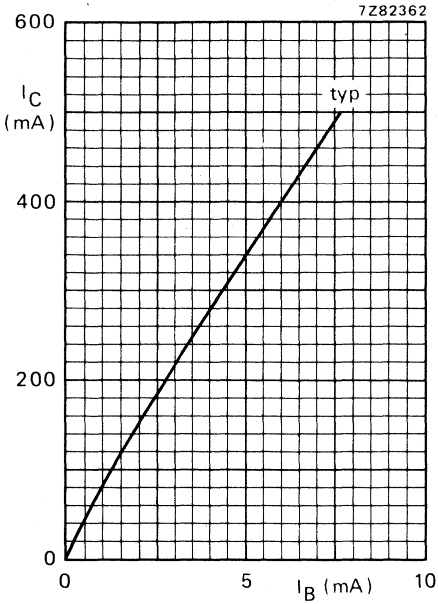


Fig. 10 V_{CE} = 10 V; T_j = 25 °C.

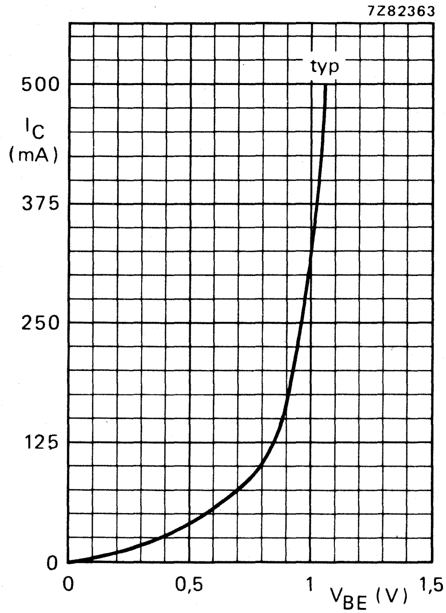


Fig. 11 V_{CE} = 10 V; T_j = 25 °C.

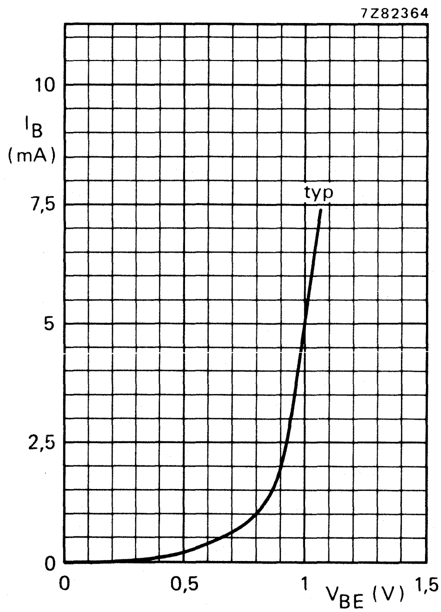


Fig. 12 V_{CE} = 10 V; T_j = 25 °C.

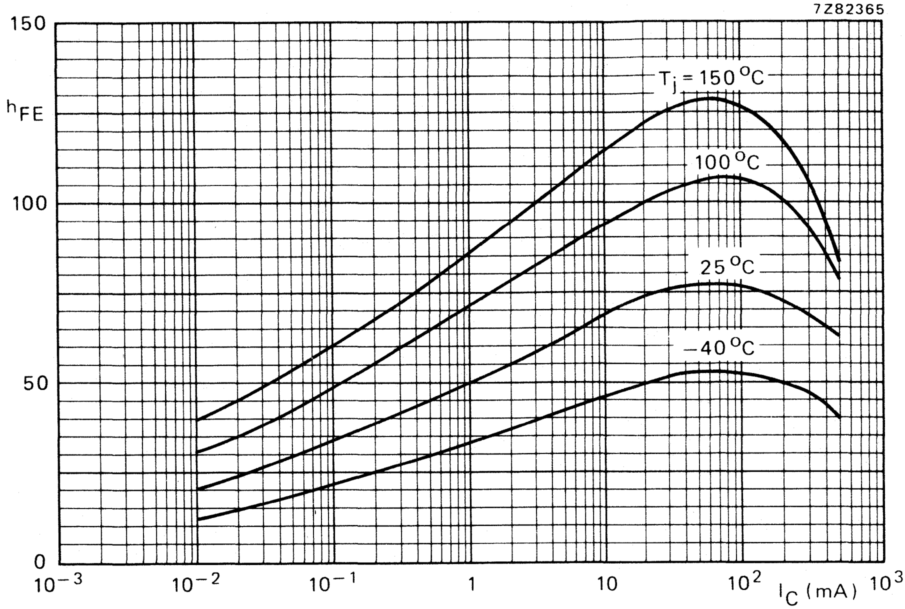


Fig. 13 V_{CE} = 10 V; typical values.

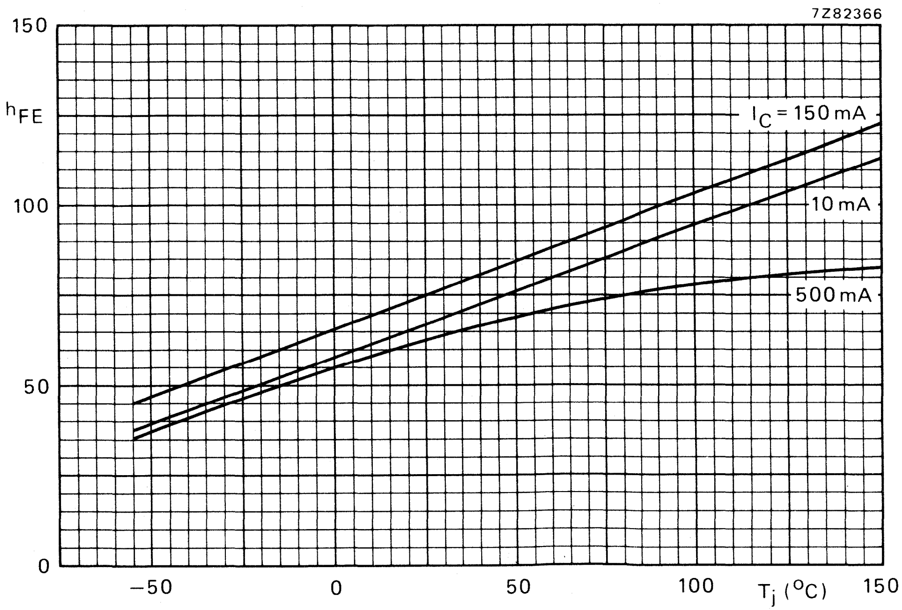


Fig. 14 V_{CE} = 10 V; typical values.

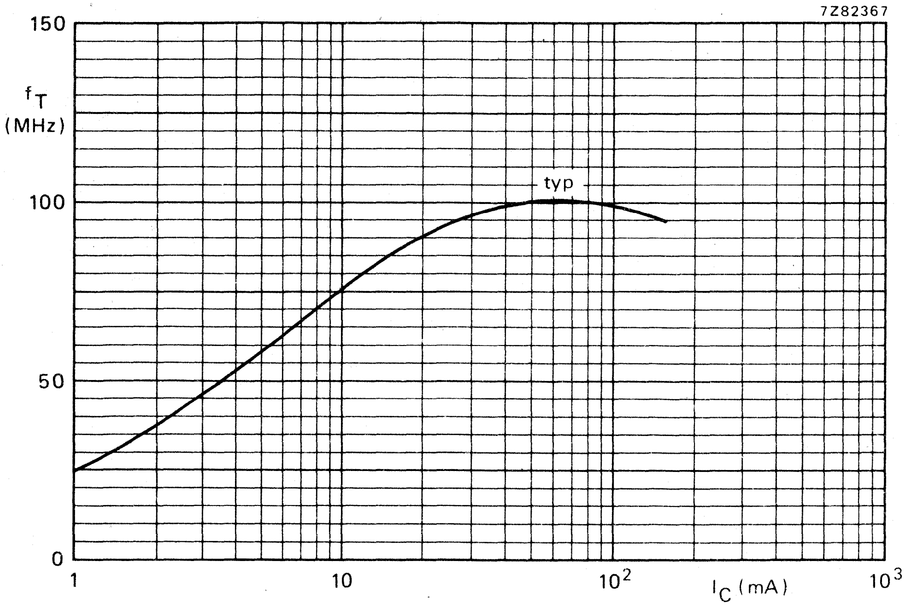


Fig. 15 V_{CE} = 10 V; f = 20 MHz; T_j = 25 °C.

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

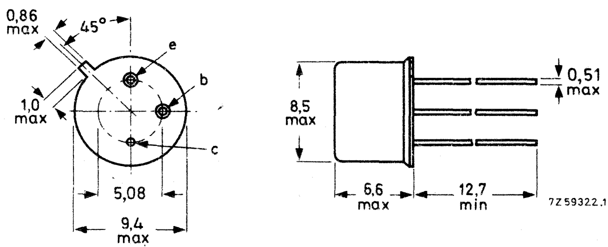
Collector-base voltage (open emitter)	V_{CBO}	max.	75	V
Collector-emitter voltage ($R_{BE} \leq 10\ \Omega$)	V_{CER}	max.	50	V
Collector current (peak value)	I_{CM}	max.	1,0	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,8	W
D.C. current gain I_C = 150 mA; V_{CE} = 10 V	h_{FE}		100 to 300	
Transition frequency at f = 20 MHz I_C = 50 mA; V_{CE} = 10 V	f_T	>	70	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 ($R_{BE} \leqslant 10\ \Omega$)	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 °C	P_{tot}	max.	0,8	W
up to T_{case} = 100 °C	P_{tot}	max.	1,7	W
up to T_{case} = 25 °C	P_{tot}	max.	3,0	W
Storage temperature	T_{stg}	−65 to + 200		°C
Junction temperature	T_j	max.	200	°C
→ Lead soldering temperature				
> 1,5 mm from the seating plane; t_{sld} < 10 s	T_{sld}	max.	300	°C

→ THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	219	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	58,3	K/W

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 60$ V	I_{CBO}	<	10	nA
$I_E = 0$; $V_{CB} = 60$ V; $T_{amb} = 150$ °C	I_{CBO}	<	10	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5{,}0$ V	I_{EBO}	<	5	nA
Collector-base breakdown voltage				
open emitter; $I_C = 100$ μA	$V_{(BR)CBO}$	>	75	V ←
Emitter-base breakdown voltage				
open collector; $I_E = 100$ μA	$V_{(BR)EBO}$	>	7,0	V ←
Collector-emitter sustaining voltage *				
$I_C = 100$ mA; $R_{BE} \leqslant 10\ \Omega$	$V_{CERsust}$	>	50	V
Saturation voltages *				
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	1,5	V
	V_{BEsat}	<	1,3	V
D.C. current gain				
$I_C =$ 10 μA ; $V_{CE} = 10$ V	h_{FE}	>	20	
$I_C =$ 0,1 mA; $V_{CE} = 10$ V	h_{FE}	>	35	
$I_C =$ 10 mA; $V_{CE} = 10$ V *	h_{FE}	>	75	
$I_C =$ 10 mA; $V_{CE} = 10$ V; $T_{amb} = -55$ °C	h_{FE}	>	35	
$I_C = 150$ mA; $V_{CE} = 10$ V *	h_{FE}		100 to 300	
$I_C = 500$ mA; $V_{CE} = 10$ V *	h_{FE}	>	40	
Transition frequency at f = 20 MHz				
$I_C = 50$ mA; $V_{CE} = 10$ V	f_T	>	70	MHz
Collector capacitance				
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	25	pF
Emitter capacitance				
$I_C = I_c = 0$; $V_{EB} = 0{,}5$ V	C_e	<	80	pF
Noise figure at f = 1 kHz				
$I_C = 300$ μA; $V_{CE} = 10$ V; $R_S = 510\ \Omega$; B = 1 Hz	F	<	8,0	dB ←

h-parameters at f = 1 kHz

Input impedance				
$I_C = 1{,}0$ mA; $V_{CB} = 5{,}0$ V	h_{ib}		24 to 34	Ω
$I_C = 5{,}0$ mA; $V_{CB} = 10$ V	h_{ib}		4,0 to 8,0	Ω
Reverse voltage transfer ratio				
$I_C = 1{,}0$ mA; $V_{CB} = 5{,}0$ V	h_{rb}	<	5,0	10^{-4}
$I_C = 5{,}0$ mA; $V_{CB} = 10$ V	h_{rb}	<	5,0	10^{-4}
Small-signal current gain				
$I_C = 1{,}0$ mA; $V_{CE} = 5{,}0$ V	h_{fe}		50 to 200	
$I_C = 5{,}0$ mA; $V_{CE} = 10$ V	h_{fe}		70 to 300	

* Measured under pulse conditions to avoid excessive dissipation: $t_p \leqslant 300$ μs; $\delta \leqslant 0{,}02$.

→ Output admittance

I_C = 1,0 mA; V_{CE} = 5,0 V	h_{ob}	0,05 to 0,5 μA/V
I_C = 5,0 mA; V_{CE} = 10 V	h_{ob}	0,05 to 0,5 μA/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

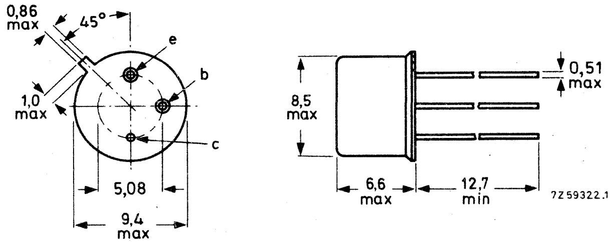
Collector-base voltage (open emitter)	V_{CBO}	max.	120	V
Collector-emitter voltage ($R_{BE} \leqslant 10\ \Omega$)	V_{CER}	max.	100	V
Collector current (d.c.)	I_C	max.	500	mA
Total power dissipation up to $T_{case} = 25\ ^oC$	P_{tot}	max.	3,0	W
Junction temperature	T_j	max.	200	^oC
D.C. current gain				
I_C = 0,1 mA; V_{CE} = 10 V	h_{FE}	>	20	
I_C = 10 mA; V_{CE} = 10 V; T = –55 ^oC	h_{FE}	>	20	
I_C = 10 mA; V_{CE} = 10 V	h_{FE}	>	35	
I_C = 150 mA; V_{CE} = 10 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).

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	80	V
Collector-emitter voltage ($R_{BE} \leq 10\ \Omega$)	V_{CER}	max.	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.	7.0	V

Current

Collector current (d.c.)	I_C	max.	500	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.8	W
up to T_{case} = 100 °C	P_{tot}	max.	1.7	W
up to T_{case} = 25 °C	P_{tot}	max.	3.0	W

Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	219	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	58.3	°C/W

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

CHARACTERISTICS T_{amb} = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 90$ V	I_{CBO}	<	10	nA
$I_E = 0$; $V_{CB} = 90$ V; $T_{amb} = 150$ °C	I_{CBO}	<	15	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10	nA
Collector-emitter sustaining voltage [1]				
$I_C = 100$ mA; $R_{BE} \geq 10\ \Omega$	$V_{CER\ sust}$	>	100	V
$I_C = 30$ mA; $I_B = 0$	$V_{CEO\ sust}$	>	80	V
Saturation voltages [1]				
$I_C = 150$ mA; $I_B = 15$ mA	$V_{CE\ sat}$	<	5.0	V
	$V_{BE\ sat}$	<	1.3	V
$I_C = 50$ mA; $I_B = 5$ mA	$V_{CE\ sat}$	<	1.2	V
	$V_{BE\ sat}$	<	0.9	V
Breakdown voltages				
$I_E = 0$; $I_C = 100$ μA	$V_{(BR)\ CBO}$	>	120	V
$I_C = 0$; $I_E = 100$ μA	$V_{(BR)\ EBO}$	>	7.0	V
D.C. current gain				
$I_C = 0.1$ mA; $V_{CE} = 10$ V	h_{FE}	>	20	
$I_C = 10$ mA; $V_{CE} = 10$ V; $T = -55$ °C	h_{FE}	>	20	
$I_C = 10$ mA; $V_{CE} = 10$ V [1]	h_{FE}	>	35	
$I_C = 150$ mA; $V_{CE} = 10$ V [1]	h_{FE}	40 to	120	

[1] Measured under pulsed conditions to avoid excessive dissipation.
Pulse duration $t \leq 300$ μs, duty cycle $\delta < 0.02$

CHARACTERISTICS (continued) T_{amb} = 25 °C unless otherwise specified

h parameters at f = 1 kHz (common base)

I_C = 1 mA; V_{CE} = 5 V			
Input impedance	h_{ib}	20 to 30	Ω
Reverse voltage transfer ratio	h_{rb}	1.25	10^{-4}
Output conductance	h_{ob}	0.5	$\mu\Omega^{-1}$
I_C = 5 mA; V_{CE} = 10 V			
Input impedance	h_{ib}	4 to 8	Ω
Reverse voltage transfer ratio	h_{rb}	1.50	10^{-4}
Output conductance	h_{ob}	0.5	$\mu\Omega^{-1}$

Small signal current gain (common emitter)

I_C = 1 mA; V_{CE} = 5 V; f = 1 kHz	h_{fe}	30 to 100	
I_C = 5 mA; V_{CE} = 10 V; f = 1 kHz	h_{fe}	> 45	
I_C = 50 mA; V_{CE} = 10 V; f = 20 MHz	h_{fe}	> 2.5	

Collector capacitance

$I_E = I_e$ = 0; V_{CB} = 10 V	C_c	< 15	pF

Emitter capacitance

$I_C = I_c$ = 0; V_{EB} = 0.5 V	C_e	< 85	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

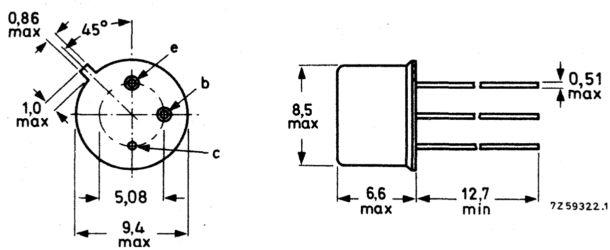
			2N2218	2N2218A	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	75	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	40	V
Collector current (d.c.)	I_C	max.	800	800	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,8	0,8	W
Junction temperature	T_j	max.	175	175	°C
D.C. current gain at T_j = 25 °C; I_C = 10 mA; V_{CE} = 10 V	h_{FE}	>	35	35	
Transition frequency at f = 100 MHz; I_C = 20 mA; V_{CE} = 20 V	f_T	>	250	250	MHz
Storage time; I_C = 150 mA; $I_B = -I_{BM}$ = 15 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).

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

Voltages			2N2218	2N2218A	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	75	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	40[1]	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	6	V

Current				
Collector current (d.c.)	I_C	max.	800	mA
Power dissipation				
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.8	W
up to T_{case} = 25 °C	P_{tot}	max.	3	W
Temperatures				
Storage temperature	T_{stg}		-65 to +200	°C
Junction temperature	T_j	max.	175	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	190	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	50	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

			2N2218	2N2218A	
Collector-cut-off current					
$I_E = 0$; $V_{CB} = 50$ V	I_{CBO}	<	10	–	nA
$I_E = 0$; $V_{CB} = 50$ V; $T_{amb} = 150$ °C	I_{CBO}	<	10	–	μA
$I_E = 0$; $V_{CB} = 60$ V	I_{CBO}	<	–	10	nA
$I_E = 0$; $V_{CB} = 60$ V; $T_{amb} = 150$ °C	I_{CBO}	<	–	10	μA
Emitter cut-off current					
$I_C = 0$; $V_{EB} = 3$ V	I_{EBO}	<	10	10	nA
Currents at reverse biased emitter junction					
$V_{CE} = 60$ V; $-V_{BE} = 3$ V	I_{CEX}	<	–	10	nA
	$-I_{BEX}$	<	–	20	nA

1) Applicable up to I_C = 500 mA

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

			2N2218	2N2218A	
Breakdown voltages					
$I_E = 0$; $I_C = 10\ \mu A$	$V_{(BR)CBO}$	>	60	75	V
$I_B = 0$; $I_C = 10$ mA	$V_{(BR)CEO}$	>	30	40	V
$I_C = 0$; $I_E = 10\ \mu A$	$V_{(BR)EBO}$	>	5	6	V
Saturation voltages [1]					
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	0.4	0.3	V
	V_{BEsat}	>	–	0.6	V
		<	1.3	1.2	V
$I_C = 500$ mA; $I_B = 50$ mA	V_{CEsat}	<	1.6	1.0	V
	V_{BEsat}	<	2.6	2.0	V
D.C. current gain					
$I_C = 0.1$ mA; $V_{CE} = 10$ V	h_{FE}	>	20	20	
$I_C = 1$ mA; $V_{CE} = 10$ V	h_{FE}	>	25	25	
$I_C = 10$ mA; $V_{CE} = 10$ V	h_{FE}	>	35	35	
$I_C = 10$ mA; $V_{CE} = 10$ V; $T_{amb} = -55$ °C	h_{FE}	>	–	15	
$I_C = 150$ mA; $V_{CE} = 1$ V [1]	h_{FE}	>	20	20	
$I_C = 150$ mA; $V_{CE} = 10$ V [1]	h_{FE}		40 to 120	40 to 120	
$I_C = 500$ mA; $V_{CE} = 10$ V [1]	h_{FE}	>	20	25	
Transition frequency at f = 100 MHz					
$I_C = 20$ mA; $V_{CE} = 20$ V	f_T	>	250	250	MHz
Collector capacitance at f = 100 kHz					
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	8	8	pF
Emitter capacitance at f = 100 kHz					
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	<	–	25	pF
Feedback time constant at f = 31.8 MHz					
$I_C = 20$ mA; $V_{CE} = 20$ V	$r_b\ C_c$	<	–	150	ps

[1]) Pulse duration ≤ 300 μs; duty cycle ≤ 2%.

CHARACTERISTICS (continued) $T_j = 25\ ^oC$

h parameters (common emitter)

$I_C = 1$ mA; $V_{CE} = 10$ V; f = 1 kHz

		2N2218A	
Input impedance	h_{ie}	1 to 3.5	kΩ
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	$\mu\Omega^{-1}$

$I_C = 10$ mA; $V_{CE} = 10$ V; f = 1 kHz

Input impedance	h_{ie}	0.2 to 1.0	kΩ
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	$\mu\Omega^{-1}$

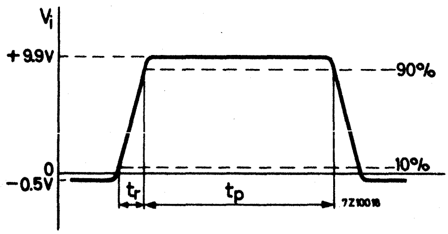
		2N2218	2N2218A	
$I_C = 20$ mA; $V_{CE} = 20$ V; f = 100 MHz				
Small signal current gain	h_{fe}	> 2.5	2.5	
$I_C = 20$ mA; $V_{CE} = 20$ V; f = 300 MHz				
Real part of input impedance	$Re(h_{ie})$	< 60	60	Ω

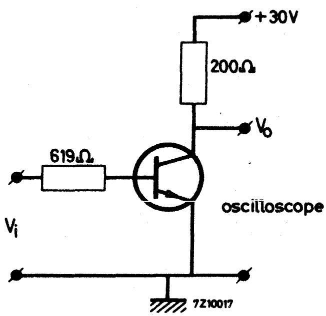
Switching times for 2N2218A

Turn on time when switched from
$-V_{BE} = 0.5$ V to $I_C = 150$ mA; $I_B = 15$ mA

Delay time	t_d	< 10	ns
Rise time	t_r	< 25	ns

Test circuit:





Pulse generator:
pulse duration $t_p \leq 200$ ns
rise time $t_r \leq 2$ ns

Oscilloscope:
input resistance $R_i > 100$ kΩ
input capacitance $C_i < 12$ pF
rise time $t_r < 5$ ns

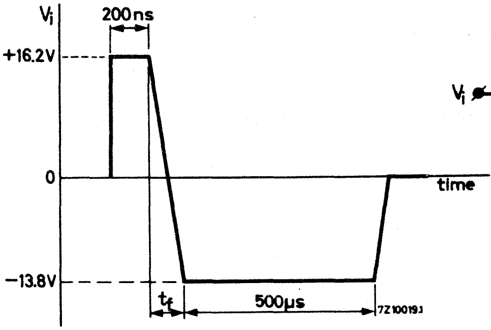
CHARACTERISTICS (continued) $T_j = 25\ ^oC$

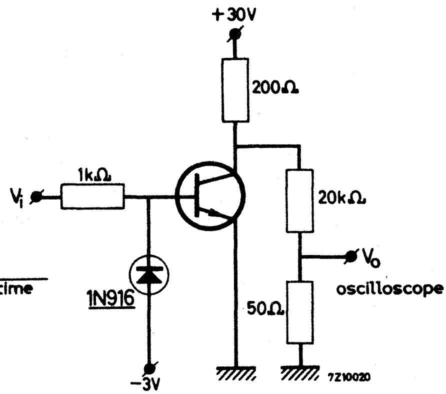
Switching times for 2N2218A

Turn off time
$I_C = 150$ mA; $I_B = -I_{BM} = 15$ mA

Storage time	t_s	<	225	ns
Fall time	t_f	<	60	ns

Test circuit:





Pulse generator:
fall time t_f < 5 ns

Oscilloscope:

input impedance	R_i	>	100 kΩ
input capacitance	C_i	<	12 pF
rise time	t_r	<	5 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

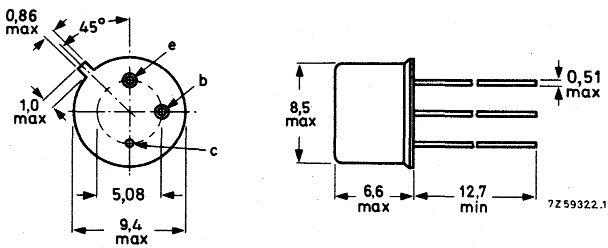
			2N2219	2N2219A	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	75	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	40	V
Collector current (d.c.)	I_C	max.	800	800	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,8	0,8	W
Junction temperature	T_j	max.	175	175	°C
D.C. current gain at T_j = 25 °C I_C = 10 mA; V_{CE} = 10 V	h_{FE}	>	75	75	
Transition frequency at f = 100 MHz I_C = 20 mA; V_{CE} = 20 V	f_T	>	250	300	MHz
Storage time I_C = 150 mA; I_B = $-I_{BM}$ = 15 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).

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

Voltages			2N2219	2N2219A	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	75	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	40 [1]	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	6	V

Current				
Collector current (d.c.)	I_C	max.	800	mA
Power dissipation				
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.8	W
up to T_{case} = 25 °C	P_{tot}	max.	3	W
Temperatures				
Storage temperature	T_{stg}		−65 to +200	°C
Junction temperature	T_j	max.	175	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	190	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	50	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

			2N2219	2N2219A	
Collector cut-off current					
$I_E = 0$; $V_{CB} = 50$ V	I_{CBO}	<	10	−	nA
$I_E = 0$; $V_{CB} = 50$ V; $T_{amb} = 150$ °C	I_{CBO}	<	10	−	μA
$I_E = 0$; $V_{CB} = 60$ V	I_{CBO}	<	−	10	nA
$I_E = 0$; $V_{CB} = 60$ V; $T_{amb} = 150$ °C	I_{CBO}	<	−	10	μA
Emitter cut-off current					
$I_C = 0$; $V_{EB} = 3$ V	I_{EBO}	<	10	10	nA
Currents at reverse biased emitter junction					
$V_{CE} = 60$ V; $-V_{BE} = 3$ V	I_{CEX}	<	−	10	nA
	$-I_{BEX}$	<	−	20	nA

[1]) Applicable up to I_C = 500 mA

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

			2N2219	2N2219A	
Breakdown voltages					
$I_E = 0$; $I_C = 10\ \mu A$	$V_{(BR)CBO}$	>	60	75	V
$I_B = 0$; $I_C = 10$ mA	$V_{(BR)CEO}$	>	30	40	V
$I_C = 0$; $I_E = 10\ \mu A$	$V_{(BR)EBO}$	>	5	6	V
Saturation voltages [1]					
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	0.4	0.3	V
	V_{BEsat}	>	–	0.6	V
		<	1.3	1.2	V
$I_C = 500$ mA; $I_B = 50$ mA	V_{CEsat}	<	1.6	1.0	V
	V_{BEsat}	<	2.6	2.0	V
D.C. current gain					
$I_C = 0.1$ mA; $V_{CE} = 10$ V	h_{FE}	>	35	35	
$I_C = 1$ mA; $V_{CE} = 10$ V	h_{FE}	>	50	50	
$I_C = 10$ mA; $V_{CE} = 10$ V	h_{FE}	>	75	75	
$I_C = 10$ mA; $V_{CE} = 10$ V; $T_{amb} = -55\,^{o}C$	h_{FE}	>	–	35	
$I_C = 150$ mA; $V_{CE} = 1$ V [1]	h_{FE}	>	50	50	
$I_C = 150$ mA; $V_{CE} = 10$ V [1]	h_{FE}		100 to 300	100 to 300	
$I_C = 500$ mA; $V_{CE} = 10$ V [1]	h_{FE}	>	30	40	
Transition frequency at f = 100 MHz					
$I_C = 20$ mA; $V_{CE} = 20$ V	f_T	>	250	300	MHz
Collector capacitance at f = 100 kHz					
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	8	8	pF
Emitter capacitance at f = 100 kHz					
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	<	–	25	pF
Feedback time constant at f = 31.8 MHz					
$I_C = 20$ mA; $V_{CE} = 20$ V	$r_{b'}C_c$	<	–	150	ps

[1]) Pulse duration ≤ 300 μs; duty cycle ≤ 2%.

CHARACTERISTICS (continued) $T_j = 25\ ^oC$ d

h parameters (common emitter)

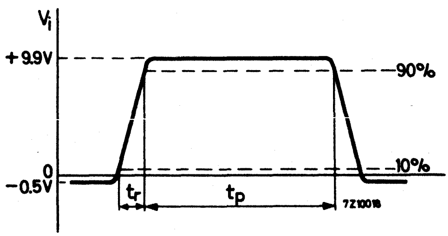
		2N2219	2N2219A	
I_C = 1 mA; V_{CE} = 10 V; f = 1 kHz				
Input impedance	h_{ie}		2 to 8	kΩ
Reverse voltage transfer ratio	h_{re}		< 8	10^{-4}
Small signal current gain	h_{fe}		50 to 300	
Output admittance	h_{oe}		5 to 35	$\mu\Omega^{-1}$
I_C = 10 mA; V_{CE} = 10 V; f = 1 kHz				
Input impedance	h_{ie}		0.25 to 1.25	kΩ
Reverse voltage transfer ratio	h_{re}		< 4	10^{-4}
Small signal current gain	h_{fe}		75 to 375	
Output admittance	h_{oe}		25 to 200	$\mu\Omega^{-1}$
I_C = 20 mA; V_{CE} = 20 V; f = 100 MHz				
Small signal current gain	h_{fe}	> 2.5	3.0	
I_C = 20 mA; V_{CE} = 20 V; f = 300 MHz				
Real part of input impedance	$Re(h_{ie})$	< 60	60	Ω
Noise figure at f = 1 kHz				
I_C = 0.1 mA; V_{CE} = 10 V; R_G = 1 kΩ; B = 1 Hz	F	< –	4	dB

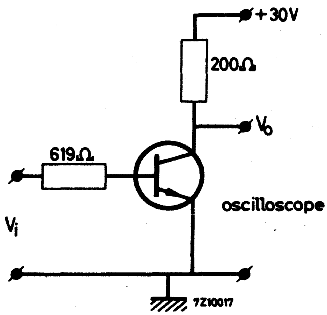
Switching times for 2N2219A

Turn on time when switched from
$-V_{BE}$ = 0.5 V to I_C = 150 mA; I_B = 15mA

Delay time	t_d	<	10	ns
Rise time	t_r	<	25	ns

Test circuit:





Pulse generator:
pulse duration $t_p \leq 200$ ns
rise time $t_r \leq 2$ ns

Oscilloscope:
input resistance R_i > 100 kΩ
input capacitance C_i < 12 pF
rise time t_r < 5 ns

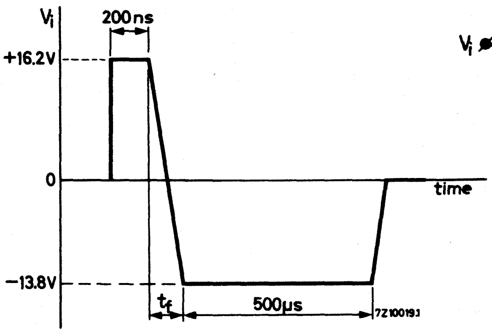
CHARACTERISTICS (continued) $T_j = 25\ ^{\circ}C$

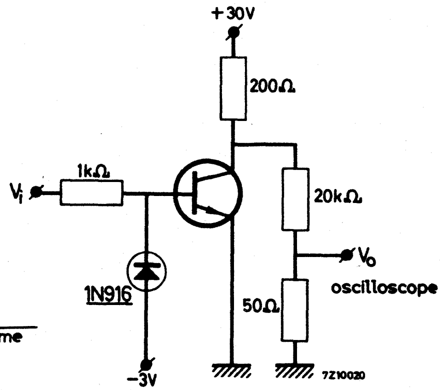
Switching times for 2N2219A

Turn off time
$I_C = 150$ mA; $I_B = -I_{BM} = 15$ mA

Storage time	t_s	<	225	ns
Fall time	t_f	<	60	ns

Test circuit:





Pulse generator:
fall time $t_f < 5$ ns

Oscilloscope:

input impedance	R_i	>	100 kΩ
input capacitance	C_i	<	12 pF
rise time	t_r	<	5 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

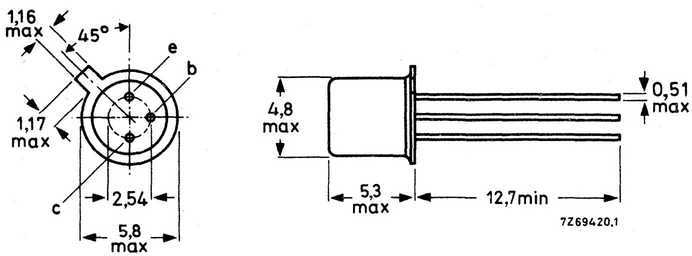
			2N2221	2N2221A	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	75	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	40	V
Collector current (d.c.)	I_C	max.	800	800	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,5	0,5	W
Junction temperature	T_j	max.	200	200	°C
D.C. current gain at T_j = 25 °C I_C = 10 mA; V_{CE} = 10 V	h_{FE}	>	35	35	
Transition frequency at f = 100 MHz I_C = 20 mA; V_{CE} = 20 V	f_T	>	250	250	MHz
Storage time I_C = 150 mA; $I_B = -I_{BM}$ = 15 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)

			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 °C	P_{tot}	max.	0,5	W
up to T_{case} = 25 °C	P_{tot}	max.	1,2	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	$R_{th\ j\text{-}a}$	=	350	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	146	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			2N2221	2N2221A	
Collector cut-off current					
I_E = 0; V_{CB} = 50 V	I_{CBO}	<	10	–	nA
I_E = 0; V_{CB} = 50 V; T_{amb} = 150 °C	I_{CBO}	<	10	–	μA
I_E = 0; V_{CB} = 60 V	I_{CBO}	<	–	10	nA
I_E = 0; V_{CB} = 60 V; T_{amb} = 150 °C	I_{CBO}	<	–	10	μA
Emitter cut-off current					
I_C = 0; V_{EB} = 3 V	I_{EBO}	<	10	10	nA
Currents at reverse biased emitter junction					
V_{CE} = 60 V; $-V_{BE}$ = 3 V	I_{CEX}	<	–	10	nA
	$-I_{BEX}$	<	–	20	nA

* Applicable up to I_C = 500 mA.

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

			2N2221	2N2221A	
Breakdown voltages					
$I_E = 0$; $I_C = 10\ \mu A$	$V_{(BR)CBO}$	>	60	75	V
$I_B = 0$; $I_C = 10$ mA	$V_{(BR)CEO}$	>	30	40	V
$I_C = 0$; $I_E = 10\ \mu A$	$V_{(BR)EBO}$	>	5	6	V
Saturation voltages [1]					
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	0.4	0.3	V
	V_{BEsat}	>	–	0.6	V
		<	1.3	1.2	V
$I_C = 500$ mA; $I_B = 50$ mA	V_{CEsat}	<	1.6	1.0	V
	V_{BEsat}	<	2.6	2.0	V
D.C. current gain					
$I_C = 0.1$ mA; $V_{CE} = 10$ V	h_{FE}	>	20	20	
$I_C = 1$ mA; $V_{CE} = 10$ V	h_{FE}	>	25	25	
$I_C = 10$ mA; $V_{CE} = 10$ V	h_{FE}	>	35	35	
$I_C = 10$ mA; $V_{CE} = 10$ V; $T_{amb} = -55\,^\circ C$	h_{FE}	>	–	15	
$I_C = 150$ mA; $V_{CE} = 1$ V [1]	h_{FE}	>	20	20	
$I_C = 150$ mA; $V_{CE} = 10$ V [1]	h_{FE}		40 to 120	40 to 120	
$I_C = 500$ mA; $V_{CE} = 10$ V [1]	h_{FE}	>	20	25	
Transition frequency at f = 100 MHz					
$I_C = 20$ mA; $V_{CE} = 20$ V	f_T	>	250	250	MHz
Collector capacitance at f = 100 kHz					
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	8	8	pF
Emitter capacitance at f = 100 kHz					
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	<	–	25	pF
Feedback time constant at f = 31.8 MHz					
$I_C = 20$ mA; $V_{CE} = 20$ V	$r_{b'}C_c$	<	–	150	ps

[1] Pulse duration ≤ 300 μs; duty cycle ≤ 2%.

CHARACTERISTICS (continued) T_j = 25 °C

h parameters (common emitter)

I_C = 1 mA; V_{CE} = 10 V; f = 1 kHz

		2N2221A	
Input impedance	h_{ie}	1 to 3.5	kΩ
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 mA; V_{CE} = 10 V; f = 1 kHz

Input impedance	h_{ie}	0.2 to 1.0	kΩ
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	$\mu\Omega^{-1}$

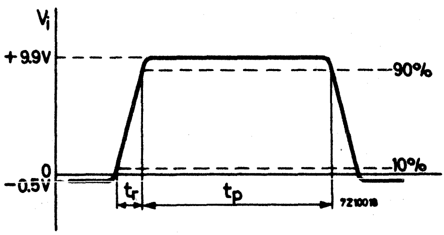
		2N2221	2N2221A	
I_C = 20 mA; V_{CE} = 20 V; f = 100 MHz				
Small signal current gain	h_{fe}	> 2.5	2.5	
I_C = 20 mA; V_{CE} = 20 V; f = 300 MHz				
Real part of input impedance	$Re(h_{ie})$	< 60	60	Ω

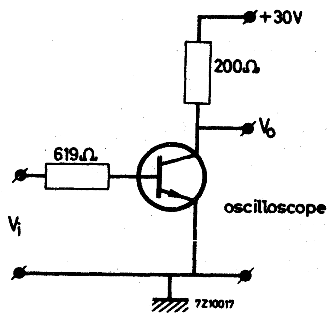
Switching times for 2N2221A

Turn on time when switched from
$-V_{BE}$ = 0.5 V to I_C = 150 mA; I_B = 15 mA

Delay time	t_d	< 10	ns
Rise time	t_r	< 25	ns

Test circuit:





Pulse generator:
pulse duration $t_p \leq$ 200 ns
rise time $t_r \leq$ 2 ns

Oscilloscope:
input resistance R_i > 100 kΩ
input capacitance C_i < 12 pF
rise time t_r < 5 ns

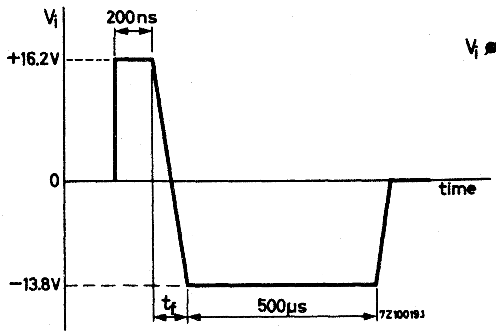
CHARACTERISTICS (continued) $T_j = 25\ ^{o}C$

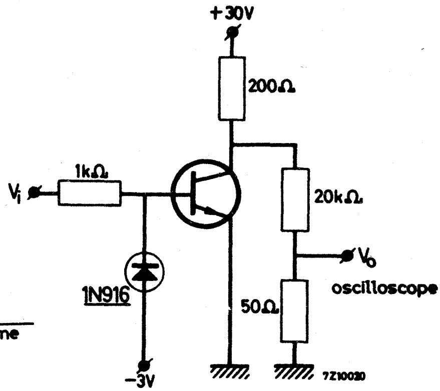
Switching times for 2N2221A

Turn off time
$I_C = 150$ mA; $I_B = -I_{BM} = 15$ mA

Storage time	t_s	< 225	ns
Fall time	t_f	< 60	ns

Test circuit:





Pulse generator:
fall time t_f < 5 ns

Oscilloscope:

input impedance	R_i	> 100 kΩ
input capacitance	C_i	< 12 pF
rise time	t_r	< 5 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

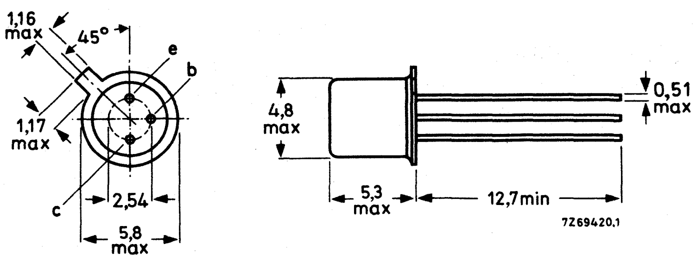
			2N2222	2N2222A	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	75	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	40	V
Collector current (d.c.)	I_C	max.	800	800	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,5	0,5	W
Junction temperature	T_j	max.	200	200	°C
D.C. current gain at T_j = 25 °C; I_C = 10 mA; V_{CE} = 10 V	h_{FE}	>	75	75	
Transition frequency at f = 100 MHz; I_C = 20 mA; V_{CE} = 20 V	f_T	>	250	300	MHz
Storage time; I_C = 150 mA; $I_B = -I_{BM}$ = 15 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 °C	P_{tot}	max.	0,5		W
→ up to T_{case} = 25 °C	P_{tot}	max.	1,2		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	$R_{th\ j\text{-}a}$	=	350	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	146	K/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			2N2222	2N2222A	
Collector cut-off current					
$I_E = 0$; V_{CB} = 50 V	I_{CBO}	<	10	–	nA
$I_E = 0$; V_{CB} = 50 V; T_{amb} = 150 °C	I_{CBO}	<	10	–	μA
$I_E = 0$; V_{CB} = 60 V	I_{CBO}	<	–	10	nA
$I_E = 0$; V_{CB} = 60 V; T_{amb} = 150 °C	I_{CBO}	<	–	10	μA
Emitter cut-off current					
$I_C = 0$; V_{EB} = 3 V	I_{EBO}	<	10	10	nA
Currents at reverse biased emitter junction					
V_{CE} = 60 V; $-V_{BE}$ = 3 V	I_{CEX}	<	–	10	nA
	$-I_{BEX}$	<	–	20	nA

* Applicable up to I_C = 500 mA.

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

			2N2222	2N2222A	
Breakdown voltages					
$I_E = 0$; $I_C = 10\ \mu A$	$V_{(BR)CBO}$	>	60	75	V
$I_B = 0$; $I_C = 10$ mA	$V_{(BR)CEO}$	>	30	40	V
$I_C = 0$; $I_E = 10\ \mu A$	$V_{(BR)EBO}$	>	5	6	V
Saturation voltages [1]					
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	0.4	0.3	V
	V_{BEsat}	>	–	0.6	V
		<	1.3	1.2	V
$I_C = 500$ mA; $I_B = 50$ mA	V_{CEsat}	<	1.6	1.0	V
	V_{BEsat}	<	2.6	2.0	V
D.C. current gain					
$I_C = 0.1$ mA; $V_{CE} = 10$ V	h_{FE}	>	35	35	
$I_C = 1$ mA; $V_{CE} = 10$ V	h_{FE}	>	50	50	
$I_C = 10$ mA; $V_{CE} = 10$ V	h_{FE}	>	75	75	
$I_C = 10$ mA; $V_{CE} = 10$ V; $T_{amb} = -55$ °C	h_{FE}	>	–	35	
$I_C = 150$ mA; $V_{CE} = 1$ V [1]	h_{FE}	>	50	50	
$I_C = 150$ mA; $V_{CE} = 10$ V [1]	h_{FE}		100 to 300	100 to 300	
$I_C = 500$ mA; $V_{CE} = 10$ V [1]	h_{FE}	>	30	40	
Transition frequency at f = 100 MHz					
$I_C = 20$ mA; $V_{CE} = 20$ V	f_T	>	250	300	MHz
Collector capacitance at f = 100 kHz					
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	8	8	pF
Emitter capacitance at f = 100 kHz					
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	<	–	25	pF
Feedback time constant at f = 31.8 MHz					
$I_C = 20$ mA; $V_{CE} = 20$ V	$r_b' C_c$	<	–	150	ps

[1]) Pulse duration ≤ 300 μs; duty cycle ≤ 2%.

CHARACTERISTICS (continued) T_j = 25 °C

h parameters (common emitter)

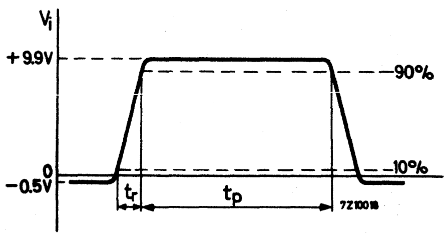
		2N2222	2N2222A	
I_C = 1 mA; V_{CE} = 10 V; f = 1 kHz				
Input impedance	h_{ie}		2 to 8	kΩ
Reverse voltage transfer ratio	h_{re}		< 8	10^{-4}
Small signal current	h_{fe}		50 to 300	
Output admittance	h_{oe}		5 to 35	$\mu\Omega^{-1}$
I_C = 10 mA; V_{CE} = 10 V; f = 1 kHz				
Input impedance	h_{ie}		0.25 to 1.25	kΩ
Reverse voltage transfer ratio	h_{re}		< 4	10^{-4}
Small signal current gain	h_{fe}		75 to 375	
Output admittance	h_{oe}		25 to 200	$\mu\Omega^{-1}$
I_C = 20 mA; V_{CE} = 20 V; f = 100 MHz				
Small signal current gain	h_{fe}	> 2.5	3.0	
I_C = 20 mA; V_{CE} = 20 V; f = 300 MHz				
Real part of input impedance	$Re(h_{ie})$	< 60	60	Ω
Noise figure at f = 1 kHz				
I_C = 0.1 mA; V_{CE} = 10 V R_G = 1 kΩ; B = 1 Hz	F	< –	4	dB

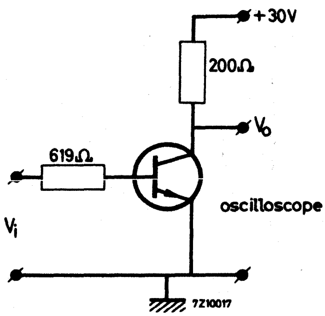
Switching times for 2N2222A

Turn on time when switched from
$-V_{BE}$ = 0.5 V to I_C = 150 mA; I_B = 15 mA

Delay time	t_d	<	10	ns
Rise time	t_r	<	25	ns

Test circuit:





Pulse generator:
pulse duration $t_p \leq$ 200 ns
rise time $t_r \leq$ 2 ns

Oscilloscope:
input resistance R_i > 100 kΩ
input capacitance C_i < 12 pF
rise time t_r < 5 ns

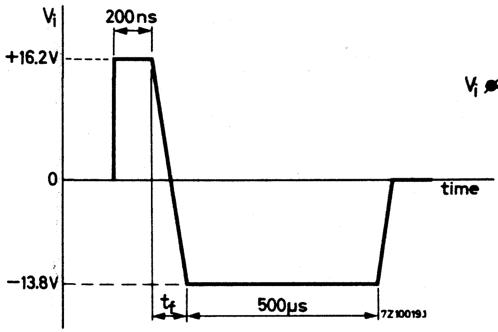
CHARACTERISTICS (continued) T_j = 25 °C

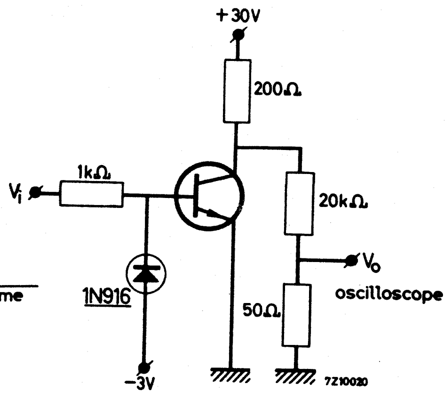
Switching times for 2N2222A

Turn off time
I_C = 150 mA; I_B = $-I_{BM}$ = 15 mA

Storage time	t_s	<	225	ns
Fall time	t_f	<	60	ns

Test circuit:





Pulse generator:
fall time t_f < 5 ns

Oscilloscope:

input impedance	R_i	>	100 kΩ
input capacitance	C_i	<	12 pF
rise time	t_r	<	5 ns

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor intended for large signal h.f. and v.h.f. amplifier applications.

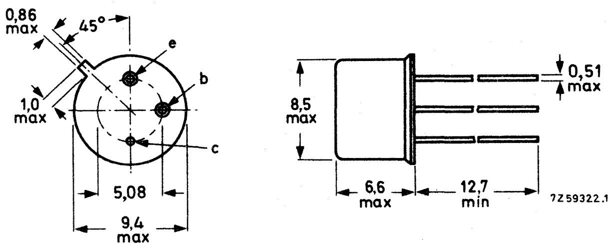
QUICK REFERENCE DATA

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 °C	P_{tot}	max.	0,8 W
Junction temperature	T_j	max.	200 °C
D.C. current gain I_C = 150 mA; V_{CE} = 10 V	h_{FE}		40 to 120
Transition frequency at f = 20 MHz I_C = 50 mA; V_{CE} = 10 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 °C	P_{tot}	max.	5,0	W
up to T_{case} = 100 °C	P_{tot}	max.	2,8	W
up to T_{amb} = 25 °C	P_{tot}	max.	0,8	W
Storage temperature	T_{stg}		−65 to +200	°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

From junction to case	$R_{th\ j\text{-}c}$	=	35	K/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	219	K/W

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

Collector cut-off current			
$I_E = 0$; $V_{CB} = 60$ V	I_{CBO}	<	10 nA
$I_E = 0$; $V_{CB} = 60$ V; $T_{amb} = 150$ °C	I_{CBO}	<	10 μA
Emitter cut-off current			
$I_C = 0$; $V_{EB} = 5{,}0$ V	I_{EBO}	<	10 nA
Collector-emitter sustaining voltage*			
$I_C = 30$ mA; $I_B = 0$	$V_{CEOsust}$	>	35 V
Saturation voltages*			
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	0,2 V
$I_C = 1$ A; $I_B = 100$ mA**	V_{CEsat}	<	1,0 V
	V_{BEsat}	<	1,6 V
D.C. current gain*			
$I_C = 10$ mA; $V_{CE} = 10$ V	h_{FE}	>	30
$I_C = 150$ mA; $V_{CE} = 10$ V	h_{FE}		40 to 120
$I_C = 1{,}0$ A; $V_{CE} = 10$ V	h_{FE}	>	15
Feedback time constant			
$I_C = 10$ mA; $V_{CB} = 10$ V; f = 4,0 MHz	$r_{bb'} C_{b'c}$	<	800 ps
Collector capacitance at f = 500 kHz			
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	12 pF
Emitter capacitance at f = 500 kHz			
$I_C = I_c = 0$; $V_{EB} = 0{,}5$ V	C_e	<	80 pF
Transition frequency at f = 20 MHz			
$I_C = 50$ mA; $V_{CE} = 10$ V	f_T	>	60 MHz

* Measured under pulse conditions to avoid excessive dissipation: $t_p = 300$ μs; $\delta \leqslant 0{,}01$.
** 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

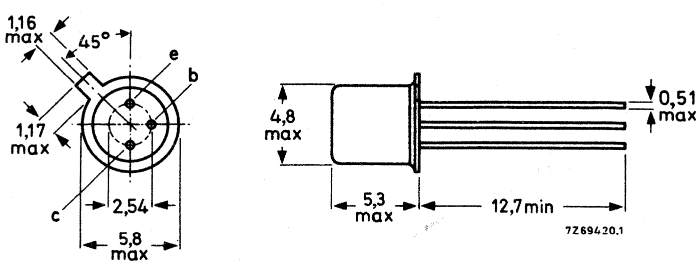
Collector-base voltage (open emitter)		V_{CBO}	max.	40	V
Collector-emitter voltage (open base)		V_{CEO}	max.	15	V
Collector current (peak value)		I_{CM}	max.	500	mA
Total power dissipation up to T_{amb} = 25 °C		P_{tot}	max.	360	mW
Junction temperature		T_j	max.	200	°C
D.C. current gain at T_j = 25 °C; I_C = 10 mA; V_{CE} = 1 V	2N2368	h_{FE}	20 to	60	
	2N2369	h_{FE}	40 to	120	
Transition frequency; I_C = 10 mA; V_{CE} = 10 V	2N2368	f_T	>	400	MHz
	2N2369	f_T	>	500	MHz
Storage time; $I_C = I_B = -I_{BM}$ = 10 mA	2N2368	t_s	<	10	ns
	2N2369	t_s	<	13	ns

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 μs)	I_{CM}	max.	500	mA

Power dissipation

Total power dissipation up to $T_{amb} = 25\,^oC$	P_{tot}	max.	360	mW

Temperatures

Storage temperature	T_{stg}	-65 to +200		^oC
Junction temperature	T_j	max.	200	^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\,j\text{-}a}$	=	0.48	$^oC/mW$
From junction to case	$R_{th\,j\text{-}c}$	=	0.145	$^oC/mW$

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

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 20$ V	I_{CBO}	<	0.4	μA
$I_E = 0$; $V_{CB} = 20$ V; $T_j = 150$ °C	I_{CBO}	<	30	μA
Sustaining voltage [1]				
$I_C = 10$ mA; $I_B = 0$	$V_{CEOsust}$	>	15	V [1]
Saturation voltages				
$I_C = 10$ mA; $I_B = 1$ mA	V_{CEsat}	<	0.25	V
	V_{BEsat}		0.7 to 0.85	V
Collector capacitance at f = 140 kHz				
$I_E = I_e = 0$; $V_{CB} = 5$ V	C_c	<	4	pF

D.C. current gain [1]			2N2368	2N2369	
$I_C = 10$ mA; $V_{CE} = 1$ V	h_{FE}		20 to 60	40 to 120	
$I_C = 10$ mA; $V_{CE} = 1$ V; $T_j = -55$ °C	h_{FE}	>	10	20	
$I_C = 100$ mA; $V_{CE} = 2$ V	h_{FE}	>	10	20	
Transition frequency					
$I_C = 10$ mA; $V_{CE} = 10$ V	f_T	>	400	500	MHz

[1]) Measured under pulsed conditions to avoid excessive dissipation
Pulse duration t = 300 μs; duty cycle $\delta = 0.01$

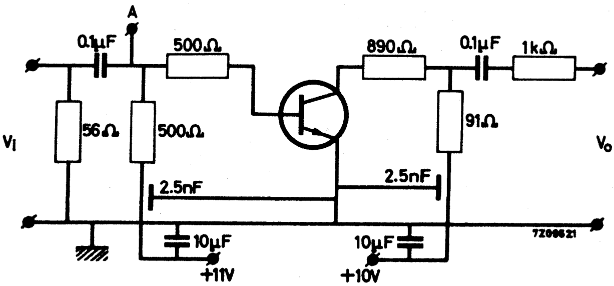
CHARACTERISTICS (continued) $T_j = 25\ ^oC$

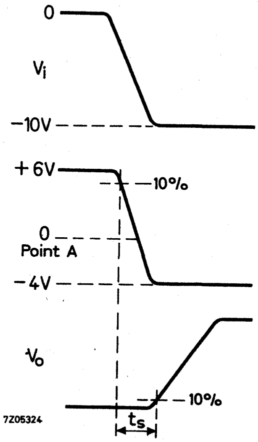
Storage time

$I_C = I_B = -I_{BM} = 10$ mA

2N2368	t_s	<	10	ns
2N2369	t_s	<	13	ns

Test circuit: [1])





Turn on time

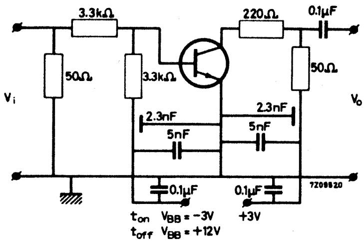
$I_C = 10$ mA; $I_B = 3$ mA; $-V_{BE} = 1.5$ V — t_{on} < 12 ns

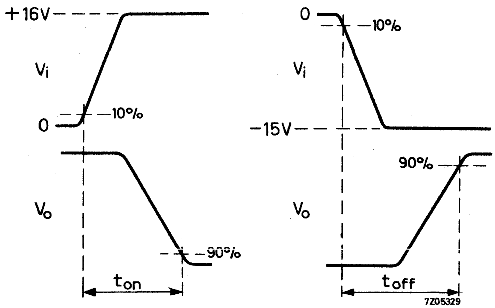
Turn off time

$I_C = 10$ mA; $I_B = 3$ mA; $-I_{BM} = 1.5$ mA

2N2368	t_{off}	<	15	ns
2N2369	t_{off}	<	18	ns

Test circuit: [1])





[1]) Pulse generator:

Pulse duration	t	≥	300	ns
Duty cycle	δ	≤	0.02	
Rise time	t_r	≤	1	ns
Source impedance	R_S	=	50	Ω

Oscilloscope:

Rise time	t_r	≤	1	ns
Input impedance	R_i	=	50	Ω

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

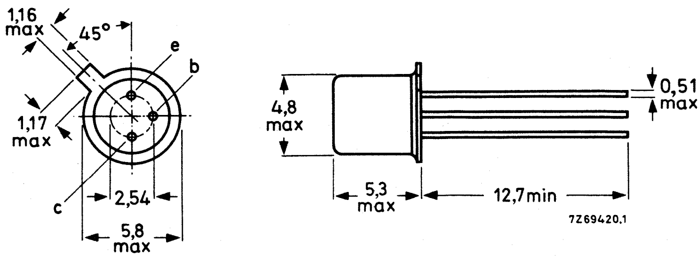
Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Collector current (peak value; t_p = 10 μs)	I_{CM}	max.	500	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	360	mW
Junction temperature	T_j	max.	200	°C
D.C. current gain at T_j = 25 °C				
I_C = 10 mA; V_{CE} = 0,35 V	h_{FE}	$>$	40	
I_C = 10 mA; V_{CE} = 1,0 V	h_{FE}	$<$	120	
Transition frequency at f = 100 MHz				
I_C = 10 mA; V_{CE} = 10 V	f_T	$>$	500	MHz
Storage time				
$I_{Con} = I_{Bon} = -I_{Boff}$ = 10 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_{CBO}	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 μs)	I_{CM}	max.	500	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	360	mW
up to T_{case} = 25 °C	P_{tot}	max.	1200	mW
up to T_{case} = 100 °C	P_{tot}	max.	680	mW
Storage temperature	T_{stg}	−65 to + 200		°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	486	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	146	K/W

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

Collector cut-off current			
V_{BE} = 0; V_{CE} = 20 V	I_{CES}	<	0,4 μA
I_E = 0; V_{CB} = 20 V; T_{amb} = 150 °C	I_{CBO}	<	30 μA
Base current			
V_{BE} = 0; V_{CE} = 20 V	$-I_{BEX}$	<	0,4 μA
Collector-base breakdown voltage			
open emitter; I_C = 10 μA	$V_{(BR)CBO}$	>	40 V
Collector-emitter breakdown voltage			
V_{BE} = 0; I_C = 10 μA	$V_{(BR)CES}$	>	40 V
Emitter-base breakdown voltage			
open collector; I_E = 10 μA	$V_{(BR)EBO}$	>	4,5 V
Collector-emitter sustaining voltage*			
open base; I_C = 10 mA	$V_{CEOsust}$	>	15 V
Saturation voltages			
I_C = 10 mA; I_B = 1,0 mA	V_{CEsat}	<	0,20 V
	V_{BEsat}	0,70 to	0,85 V
I_C = 10 mA; I_B = 1,0 mA; T_{amb} = 125 °C	V_{CEsat}	<	0,30 V
	V_{BEsat}	>	0,59 V
I_C = 10 mA; I_B = 1,0 mA; T_{amb} = −55 °C	V_{BEsat}	<	1,02 V
I_C = 30 mA; I_B = 3,0 mA	V_{CEsat}	<	0,25 V
	V_{BEsat}	<	1,15 V
I_C = 100 mA; I_B = 10 mA	V_{CEsat}	<	0,50 V
	V_{BEsat}	<	1,60 V
D.C. current gain*			
I_C = 10 mA; V_{CE} = 0,35 V	h_{FE}	>	40
I_C = 10 mA; V_{CE} = 0,35 V; T_{amb} = −55 °C	h_{FE}	>	20
I_C = 10 mA; V_{CE} = 1,0 V	h_{FE}	<	120
I_C = 30 mA; V_{CE} = 0,4 V	h_{FE}	>	30
I_C = 100 mA; V_{CE} = 1,0 V	h_{FE}	>	20
Collector capacitance at f = 140 kHz			
I_E = I_e = 0; V_{CB} = 5,0 V	C_c	<	4,0 pF
Transition frequency at f = 100 MHz			
I_C = 10 mA; V_{CE} = 10 V	f_T	>	500 MHz

* Measured under pulse conditions to avoid excessive dissipation: t_p = 300 μs; δ ≤ 0,02.

Storage time (see Figs 2 and 3)
$I_{Con} = I_{Bon} = -I_{Boff} = 10$ mA — t_s < 13 ns

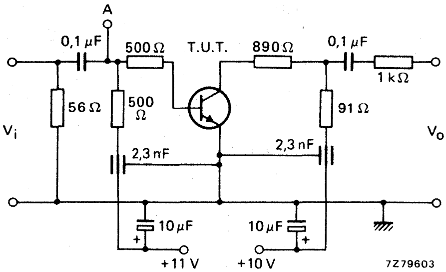


Fig. 2 Storage time test circuit.

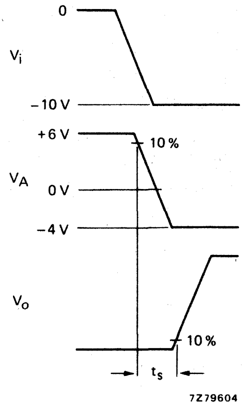


Fig. 3 Waveforms at input, point A and output.

Turn-on time (see Figs 4 and 5)
$I_{Con} = 10$ mA; $I_{Bon} = 3$ mA; $-V_{BEoff} = 1{,}5$ V — t_{on} < 12 ns

Turn-off time (see Figs 4 and 5)
$I_{Con} = 10$ mA; $I_{Bon} = 3$ mA; $-I_{Boff} = 1{,}5$ mA — t_{off} < 18 ns

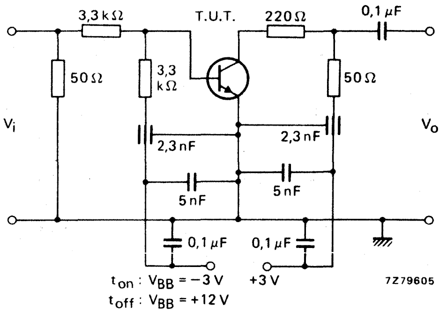


Fig. 4 Turn-on and turn-off test circuit.

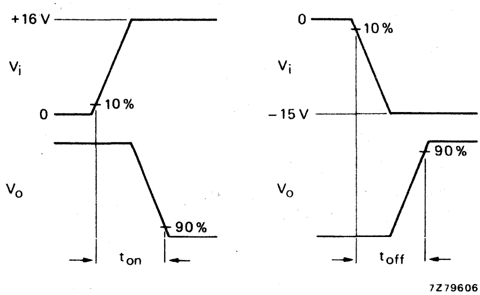


Fig. 5 Input and output waveforms.

Pulse generator:

Rise time	t_r	⩽	1 ns
Pulse duration	t_p	⩾	300 ns
Duty factor	δ	⩽	0,02
Source impedance	R_S	=	50 Ω

Oscilloscope:

Rise time	t_r	⩽	1 ns
Input impedance	R_i	=	50 Ω

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

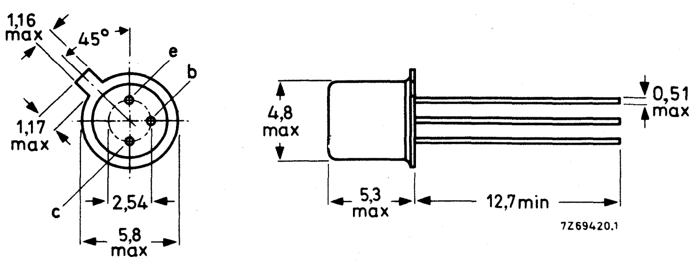
			2N2483	2N2484	
Collector-base voltage (open emitter)	V_{CBO}	max	60	60	V
Collector-emitter voltage (open base)	V_{CEO}	max	60	60	V
Collector current (peak value)	I_{CM}	max	50	50	mA
Total power dissipation up to T_{amb} = 25 ^oC	P_{tot}	max	360	360	mW
Junction temperature	T_j	max	200	200	^oC
D.C. current gain at T_j = 25 ^oC					
I_C = 10 μA; V_{CE} = 5 V	h_{FE}	>	40	100	
		<	120	500	
I_C = 1 mA; V_{CE} = 5 V	h_{FE}	>	175	250	
I_C = 10 mA; V_{CE} = 5 V	h_{FE}	<	500	800	
Transition frequency					
I_C = 0,5 mA; V_{CE} = 5 V	f_T	typ	80	80	MHz
Noise figure at R_S = 10 kΩ					
I_C = 10 μA; V_{CE} = 5 V; B = 15,7 kHz	F	<	4	3	dB

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.	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

Power dissipation

Total power dissipation up to $T_{amb} = 25\,^oC$	P_{tot}	max.	360	mW

Temperatures

Storage temperature	T_{stg}		-65 to +200	^oC
Junction temperature	T_j	max.	200	^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.48	$^oC/mW$
From junction to case	$R_{th\ j\text{-}c}$	=	0.15	$^oC/mW$

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

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current				
I_E = 0; V_{CB} = 45 V	I_{CBO}	<	10	nA
I_E = 0; V_{CB} = 45 V; T_j = 150 °C	I_{CBO}	<	10	μA
Emitter cut-off current				
I_C = 0; V_{EB} = 5 V	I_{EBO}	<	10	nA
Base-emitter voltage				
I_C = 0.1 mA; V_{CE} = 5 V	V_{BE}		0.5 to 0.7	V
Collector-emitter saturation voltage				
I_C = 1 mA; I_B = 0.1 mA	V_{CEsat}	<	350	mV

			2N2483	2N2484	
D.C. current gain					
I_C = 1 μA; V_{CE} = 5 V	h_{FE}	>		30	
I_C = 10 μA; V_{CE} = 5 V	h_{FE}		40 to 120	100 to 500	
I_C = 10 μA; V_{CE} = 5 V; T_j = 55 °C	h_{FE}	>	10	20	
I_C = 100 μA; V_{CE} = 5 V	h_{FE}	>	75	175	
I_C = 500 μA; V_{CE} = 5 V	h_{FE}	>	100	200	
I_C = 1 mA; V_{CE} = 5 V	h_{FE}	>	175	250	
I_C = 10 mA; V_{CE} = 5 V [1]	h_{FE}	<	500	800	
Collector capacitance at f = 1 MHz					
I_E = I_e = 0; V_{CB} = 5 V	C_c	<	6	6	pF
Emitter capacitance at f = 1 MHz					
I_C = I_c = 0; V_{EB} = 0.5 V	C_e	<	6	6	pF
Transition frequency					
I_C = 50 μA; V_{CE} = 5 V	f_T	>	12	15	MHz
I_C = 500 μA; V_{CE} = 5 V	f_T	>	60	60	MHz
		typ.	80	80	MHz

[1]) Measured under pulsed conditions to prevent excessive dissipation. Pulse duration t < 300 μs; duty cycle δ < 0.01

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

			2N2483	2N2484	
Noise figure					
I_C = 10 μA; V_{CE} = 5 V; R_S = 10 kΩ					
f = 100 Hz; bandwidth 20 Hz	F	<	15	10	dB
f = 1 kHz; bandwidth 200 Hz	F	<	4	3	dB
f = 10 kHz; bandwidth 2 kHz	F	<	3	2	dB
Wide band: bandwidth 15.7 kHz	F	<	4	3	dB
h parameters at f = 1 kHz					
I_C = 1 mA; V_{CE} = 5 V					
Input impedance	h_{ie}		1.5 to 13	3.5 to 24	kΩ
Reverse voltage transfer	h_{re}	<	8	8	10^{-4}
Small signal current gain	h_{fe}		80 to 450	150 to 900	
Output admittance	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

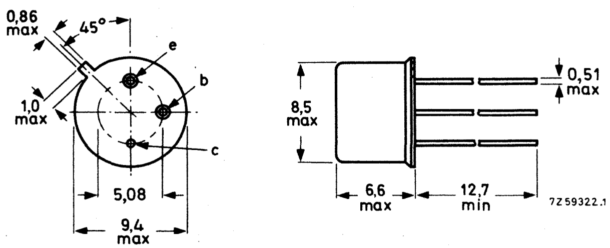
Collector-base voltage (open emitter)		$-V_{CBO}$	max.	60	V
Collector-emitter voltage (open base)	**2N2904**	$-V_{CEO}$	max.	40	V
	2N2904A	$-V_{CEO}$	max.	60	V
Collector current (d.c.)		$-I_C$	max.	600	mA
Total power dissipation up to T_{amb} = 25 °C		P_{tot}	max.	0,6	W
Junction temperature		T_j	max.	200	°C
D.C. current gain at T_j = 25 °C $-I_C$ = 150 mA; $-V_{CE}$ = 10 V		h_{FE}		40 to 120	
Transition frequency at f = 100 MHz $-I_C$ = 50 mA; $-V_{CE}$ = 20 V; T_j = 25 °C		f_T	>	200	MHz
Storage time $-I_{Con}$ = 150 mA; $-I_{Bon}$ = I_{Boff} = 15 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) $-I_C < 100$ mA	2N2904	$-V_{CEO}$	max.	40	V
	2N2904A	$-V_{CEO}$	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 $T_{amb} = 25$ °C		P_{tot}	max.	0,6	W
up to $T_{case} = 25$ °C		P_{tot}	max.	3,0	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	$R_{th\ j\text{-}a}$	=	292	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	58	K/W

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

			2N2904	2N2904A	
Collector cut-off current					
$I_E = 0; -V_{CB} = 50$ V	$-I_{CBO}$	<	20	10	nA
$I_E = 0; -V_{CB} = 50$ V; $T_{amb} = 150$ °C	$-I_{CBO}$	<	20	10	μA
$+V_{BE} = 0,5$ V; $-V_{CE} = 30$ V	$-I_{CEX}$	<	50	50	nA
Base current					
$+V_{BE} = 0,5$ V; $-V_{CE} = 30$ V	I_{BEX}	<	50	50	nA ←
Collector-base breakdown voltage					
open emitter; $-I_C = 10$ μA	$-V_{(BR)CBO}$	>	60	60	V
Collector-emitter breakdown voltage *					
open base; $-I_C = 10$ mA	$-V_{(BR)CEO}$	>	40	60	V
Emitter-base breakdown voltage					
open collector; $-I_E = 10$ μA	$-V_{(BR)EBO}$	>	5	5	V
Saturation voltages *					
$-I_C = 150$ mA; $-I_B = 15$ mA	$-V_{CEsat}$	<	0,4	0,4	V
	$-V_{BEsat}$	<	1,3	1,3	V
$-I_C = 500$ mA; $-I_B = 50$ mA	$-V_{CEsat}$	<	1,6	1,6	V
	$-V_{BEsat}$	<	2,6	2,6	V
D.C. current gain					
$-I_C = 0,1$ mA; $-V_{CE} = 10$ V	h_{FE}	>	20	40	
$-I_C = 1$ mA; $-V_{CE} = 10$ V	h_{FE}	>	25	40	
$-I_C = 10$ mA; $-V_{CE} = 10$ V	h_{FE}	>	35	40	
$-I_C = 150$ mA; $-V_{CE} = 10$ V *	h_{FE}	>	40	40	
		<	120	120	
$-I_C = 500$ mA; $-V_{CE} = 10$ V *	h_{FE}	>	20	40	
Collector capacitance at f = 100 kHz					
$I_E = I_e = 0; -V_{CB} = 10$ V	C_c	<	8		pF
Emitter capacitance at f = 100 kHz					
$I_C = I_c = 0; -V_{EB} = 2$ V	C_e	<	30		pF
Transition frequency at f = 100 MHz					
$-I_C = 50$ mA; $-V_{CE} = 20$ V *	f_T	>	200		MHz

* Measured under pulse conditions to avoid excessive dissipation: $t_p \leqslant 300$ μs; $\delta \leqslant 0,02$.

Turn-off time (see Fig. 2)

when switched to $-I_{Con}$ = 150 mA; $-I_{Bon}$ = 15 mA

delay time	t_d	<	10	ns
rise time	t_r	<	40	ns
turn-on time	t_{on}	<	45	ns

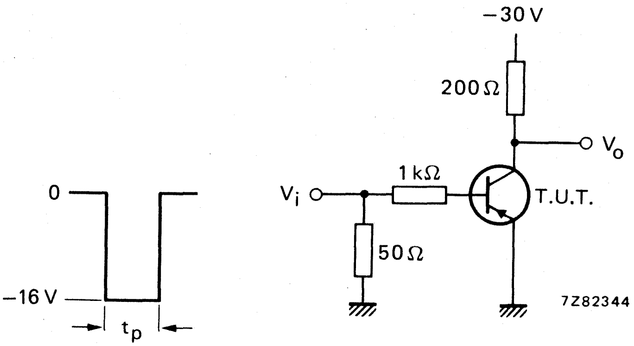


Fig. 2 Input waveform and test circuit for determining delay, rise and turn-on time.

Turn-off time (see Fig. 3)

when switched from $-I_{Con}$ = 150 mA; $-I_{Bon}$ = 15 mA
to cut-off with $+I_{Boff}$ = 15 mA

storage time	t_s	<	80	ns
fall time	t_f	<	30	ns
turn-off time	t_{off}	<	100	ns

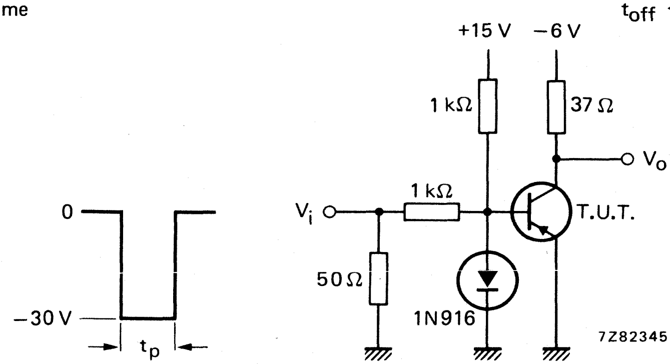


Fig. 3 Input waveform and test circuit for determining storage, fall and turn-off time.

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

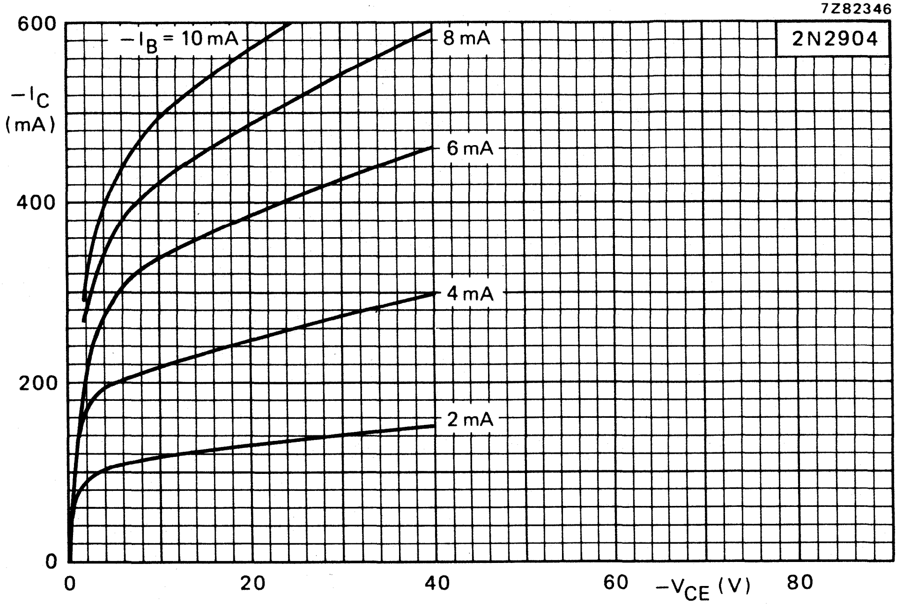


Fig. 4 Typical values; T_j = 25 °C.

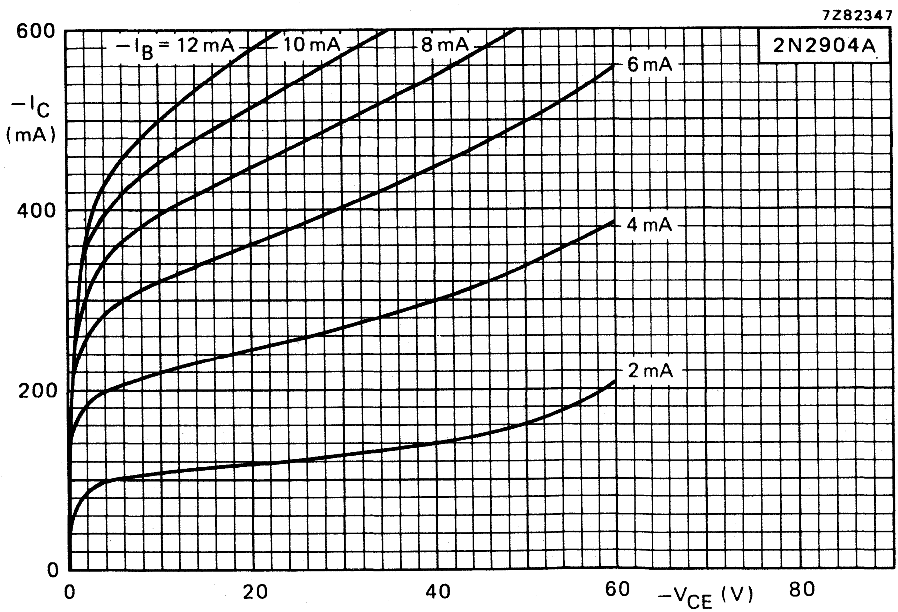


Fig. 5 Typical values; T_j = 25 °C.

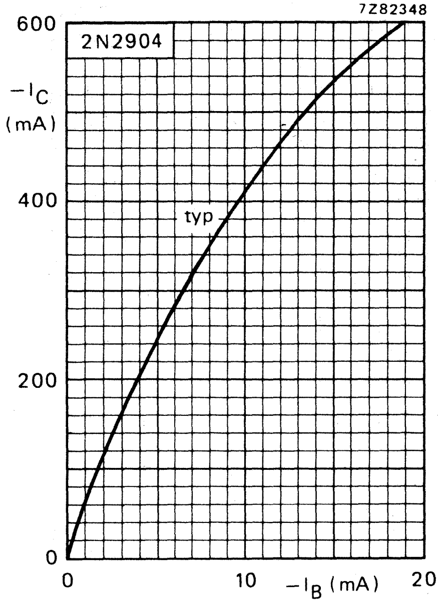


Fig. 6 $-V_{CE}$ = 5,0 V; T_J = 25 °C.

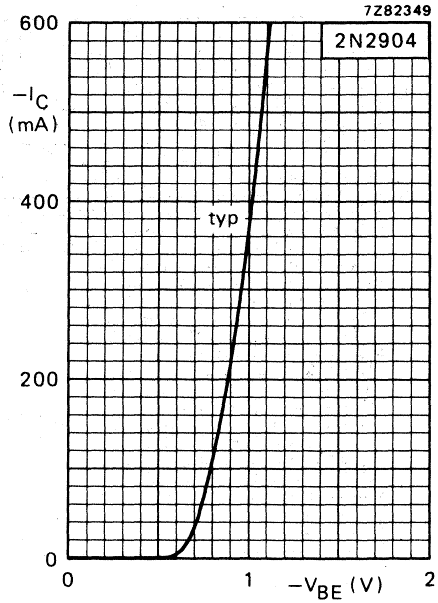


Fig. 7 $-V_{CE}$ = 5,0 V; T_j = 25 °C.

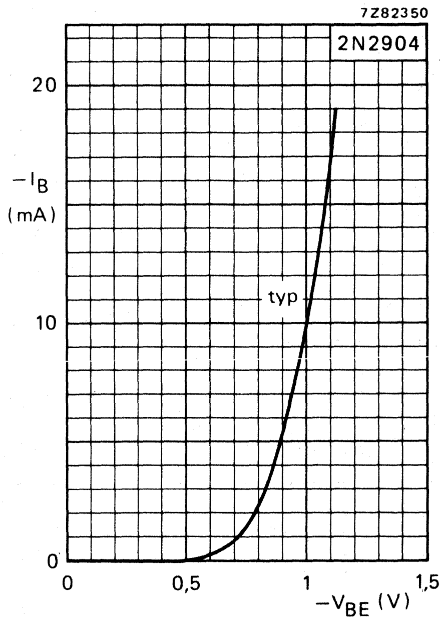


Fig. 8 $-V_{CE}$ = 5,0 V; T_j = 25 °C.

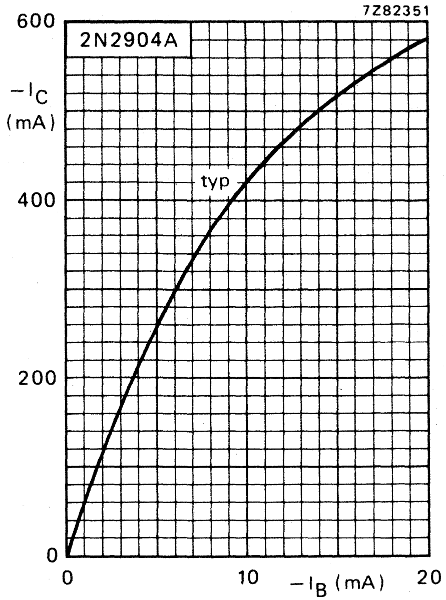


Fig. 9 $-V_{CE}$ = 5,0 V; T_j = 25 °C.

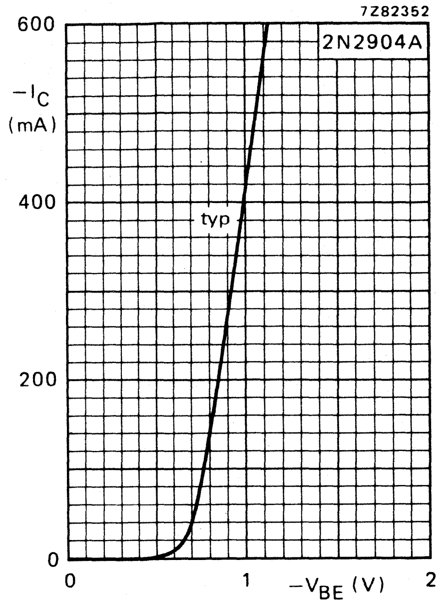


Fig. 10 $-V_{CE}$ = 5,0 V; T_j = 25 °C.

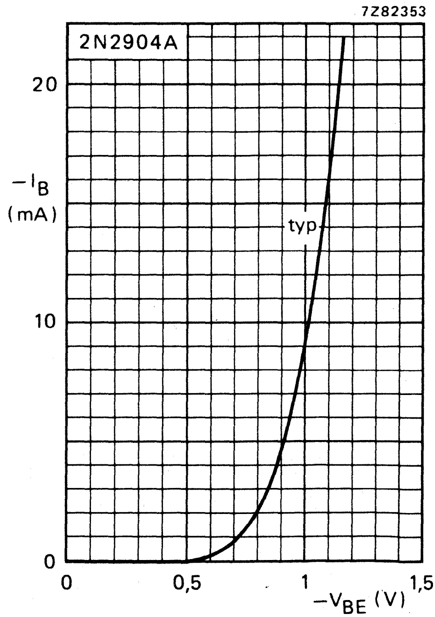


Fig. 11 $-V_{CE}$ = 5,0 V; T_j = 25 °C.

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

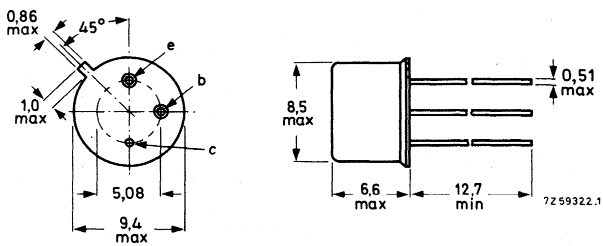
Collector-base voltage (open emitter)		$-V_{CBO}$	max.	60	V
Collector-emitter voltage (open base)	**2N2905**	$-V_{CEO}$	max.	40	V
	2N2905A	$-V_{CEO}$	max.	60	V
Collector current (d.c.)		$-I_C$	max.	600	mA
Total power dissipation up to T_{amb} = 25 °C		P_{tot}	max.	0,6	W
Junction temperature		T_j	max.	200	°C
D.C. current gain at T_j = 25 °C $-I_C$ = 150 mA; $-V_{CE}$ = 10 V		h_{FE}	100 to 300		
Transition frequency at f = 100 MHz $-I_C$ = 50 mA; $-V_{CE}$ = 20 V; T_j = 25 °C		f_T	>	200	MHz
Storage time $-I_{Con}$ = 150 mA; $-I_{Bon}$ = I_{Boff} = 15 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) $-I_C < 100$ 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 $T_{amb} = 25\ ^oC$		P_{tot}	max.	0,6	W
up to $T_{case} = 25\ ^oC$		P_{tot}	max.	3,0	W
Storage temperature		T_{stg}	−65 to + 200		^oC
Junction temperature		T_j	max.	200	^oC

→ THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	292	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	58	K/W

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

			2N2905	2N2905A	
Collector cut-off current					
$I_E = 0; -V_{CB} = 50$ V	$-I_{CBO}$	<	20	10	nA
$I_E = 0; -V_{CB} = 50$ V; $T_{amb} = 150$ °C	$-I_{CBO}$	<	20	10	μA
$+V_{BE} = 0,5$ V; $-V_{CE} = 30$ V	$-I_{CEX}$	<	50	50	nA
Base current					
$+V_{BE} = 0,5$ V; $-V_{CE} = 30$ V	I_{BEX}	<	50	50	nA ←
Collector-base breakdown voltage					
open emitter; $-I_C = 10$ μA	$-V_{(BR)CBO}$	>	60	60	V
Collector-emitter breakdown voltage*					
open base; $-I_C = 10$ mA	$-V_{(BR)CEO}$	>	40	60	V
Emitter-base breakdown voltage					
open collector; $-I_E = 10$ μA	$-V_{(BR)EBO}$	>	5	5	V
Saturation voltages*					
$-I_C = 150$ mA; $-I_B = 15$ mA	$-V_{CEsat}$	<	0,4	0,4	V
	$-V_{BEsat}$	<	1,3	1,3	V
$-I_C = 500$ mA; $-I_B = 50$ mA	$-V_{CEsat}$	<	1,6	1,6	V
	$-V_{BEsat}$	<	2,6	2,6	V
D.C. current gain					
$-I_C = 0,1$ mA; $-V_{CE} = 10$ V	h_{FE}	>	35	75	
$-I_C = 1$ mA; $-V_{CE} = 10$ V	h_{FE}	>	50	100	
$-I_C = 10$ mA; $-V_{CE} = 10$ V	h_{FE}	>	75	100	
$-I_C = 150$ mA; $-V_{CE} = 10$ V*	h_{FE}	>	100	100	
		<	300	300	
$-I_C = 500$ mA; $-V_{CE} = 10$ V*	h_{FE}	>	30	50	
Collector capacitance at f = 100 kHz					
$I_E = I_e = 0; -V_{CB} = 10$ V	C_c	<	8		pF
Emitter capacitance at f = 100 kHz					
$I_C = I_c = 0; -V_{EB} = 2$ V	C_e	<	30		pF
Transition frequency at f = 100 MHz					
$-I_C = 50$ mA; $-V_{CE} = 20$ V*	f_T	>	200		MHz

* Measured under pulse conditions to avoid excessive dissipation; $t_p \leqslant 300$ μs; $\delta \leqslant 0,02$.

Turn-on time (see Fig. 2)
when switched to $-I_{Con}$ = 150 mA; $-I_{Bon}$ = 15 mA

delay time	t_d	<	10 ns
rise time	t_r	<	40 ns
turn-on time	t_{on}	<	45 ns

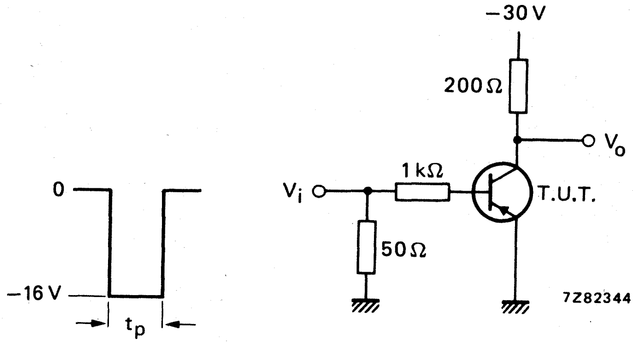


Fig. 2 Input waveform and test circuit for determining delay, rise and turn-on time.

Turn-off time (see Fig. 3)
when switched from $-I_{Con}$ = 150 mA; $-I_{Bon}$ = 15 mA
to cut-off with $+I_{Boff}$ = 15 mA

storage time	t_s	<	80 ns
fall time	t_f	<	30 ns
turn-off time	t_{off}	<	100 ns

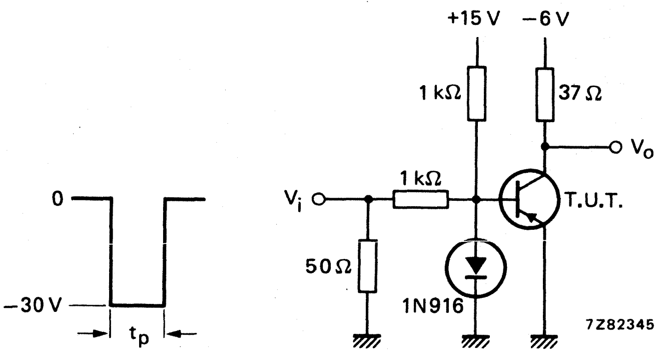


Fig. 3 Input waveform and test circuit for determining storage, fall and turn-off time.

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

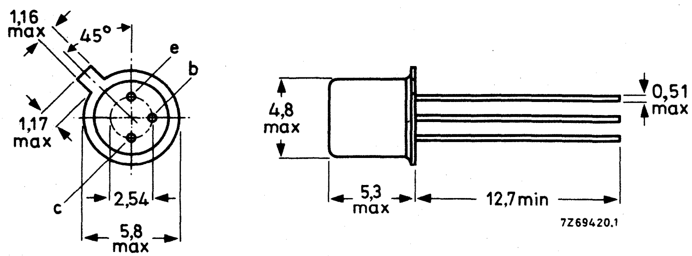
Collector-base voltage (open emitter)		$-V_{CBO}$	max.	60	V
Collector-emitter voltage (open base)	2N2906	$-V_{CEO}$	max.	40	V
	2N2906A	$-V_{CEO}$	max.	60	V
Collector current (d.c.)		$-I_C$	max.	600	mA
Total power dissipation up to T_{amb} = 25 °C		P_{tot}	max.	0,4	W
Junction temperature		T_j	max.	200	°C
D.C. current gain at T_j = 25 °C $-I_C$ = 150 mA; $-V_{CE}$ = 10 V		h_{FE}		40 to 120	
Transition frequency at f = 100 MHz $-I_C$ = 50 mA; $-V_{CE}$ = 20 V; T_j = 25 °C		f_T	>	200	MHz
Storage time $-I_{Con}$ = 150 mA; $-I_{Bon}$ = I_{Boff} = 15 mA		t_s	<	80	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)		$-V_{CBO}$	max.	60	V
Collector-emitter voltage (open base) $-I_C < 100$ mA	**2N2906**	$-V_{CEO}$	max.	40	V
	2N2906A	$-V_{CEO}$	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 $T_{amb} = 25$ °C		P_{tot}	max.	0,4	W
→ up to $T_{case} = 25$ °C		P_{tot}	max.	1,2	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	$R_{th\ j\text{-}a}$	=	438	K/W
→ From junction to case	$R_{th\ j\text{-}c}$	=	146	K/W

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

			2N2906	2N2906A	
Collector cut-off current					
$I_E = 0$; $-V_{CB} = 50$ V	$-I_{CBO}$	<	20	10	nA
$I_E = 0$; $-V_{CB} = 50$ V; $T_{amb} = 150$ °C	$-I_{CBO}$	<	20	10	μA
$+V_{BE} = 0,5$ V; $-V_{CE} = 30$ V	$-I_{CEX}$	<	50	50	nA
Base current					
$+V_{BE} = 0,5$ V; $-V_{CE} = 30$ V	I_{BEX}	<	50	50	nA ←
Collector-base breakdown voltage					
open emitter; $-I_C = 10$ μA	$-V_{(BR)CBO}$	>	60	60	V
Collector-emitter breakdown voltage*					
open base; $-I_C = 10$ mA	$-V_{(BR)CEO}$	>	40	60	V
Emitter-base breakdown voltage					
open collector; $-I_E = 10$ μA	$-V_{(BR)EBO}$	>	5	5	V
Saturation voltages*					
$-I_C = 150$ mA; $-I_B = 15$ mA	$-V_{CEsat}$	<	0,4	0,4	V
	$-V_{BEsat}$	<	1,3	1,3	V
$-I_C = 500$ mA; $-I_B = 50$ mA	$-V_{CEsat}$	<	1,6	1,6	V
	$-V_{BEsat}$	<	2,6	2,6	V
D.C. current gain					
$-I_C = 0,1$ mA; $-V_{CE} = 10$ V	h_{FE}	>	20	40	
$-I_C = 1$ mA; $-V_{CE} = 10$ V	h_{FE}	>	25	40	
$-I_C = 10$ mA; $-V_{CE} = 10$ V	h_{FE}	>	35	40	
$-I_C = 150$ mA; $-V_{CE} = 10$ V*	h_{FE}	>	40	40	
		<	120	120	
$-I_C = 500$ mA; $-V_{CE} = 10$ V*	h_{FE}	>	20	40	
Collector capacitance at f = 100 kHz					
$I_E = I_e = 0$; $-V_{CB} = 10$ V	C_c	<	8		pF
Emitter capacitance at f = 100 kHz					
$I_C = I_c = 0$; $-V_{EB} = 2$ V	C_e	<	30		pF
Transition frequency at f = 100 MHz					
$-I_C = 50$ mA; $-V_{CE} = 20$ V*	f_T	>	200		MHz

* Measured under pulse conditions to avoid excessive dissipation: $t_p \leqslant 300$ μs; $\delta \leqslant 0,02$.

Turn-on time (see Fig. 2)
when switched to $-I_{Con}$ = 150 mA; $-I_{Bon}$ = 15 mA

delay time	t_d	<	10 ns
rise time	t_r	<	40 ns
turn-on time	t_{on}	<	45 ns

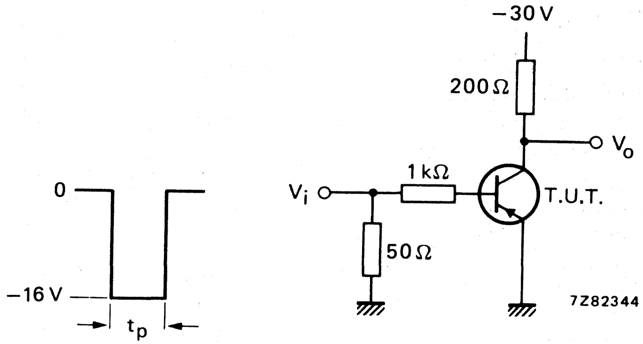


Fig. 2 Input waveform and test circuit for determining delay, rise and turn-on time.

Turn-off time (see Fig. 3)
when switched from $-I_{Con}$ = 150 mA; $-I_{Bon}$ = 15 mA
to cut-off with + I_{Boff} = 15 mA

storage time	t_s	<	80 ns
fall time	t_f	<	30 ns
turn-off time	t_{off}	<	100 ns

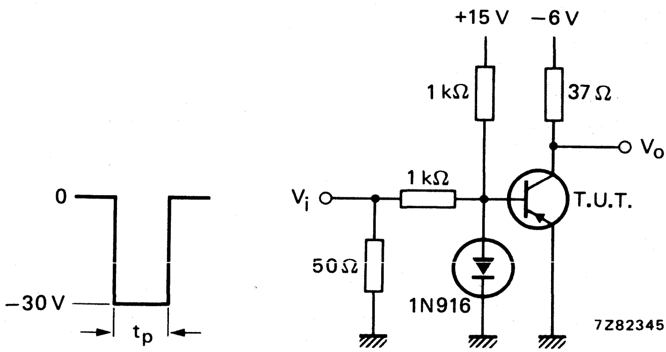


Fig. 3 Input waveform and test circuit for determining storage, fall and turn-off time.

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

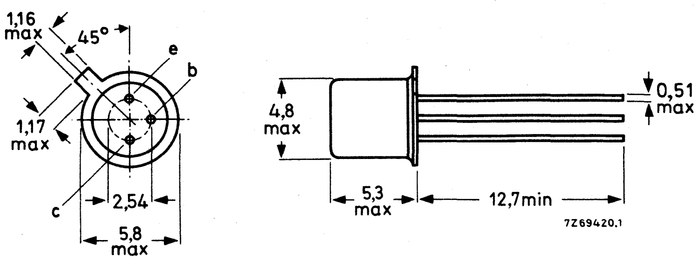
Collector-base voltage (open emitter)		$-V_{CBO}$	max.	60	V
Collector-emitter voltage (open base)	2N2907	$-V_{CEO}$	max.	40	V
	2N2907A	$-V_{CEO}$	max.	60	V
Collector current (d.c.)		$-I_C$	max.	600	mA
Total power dissipation up to T_{amb} = 25 °C		P_{tot}	max.	0,4	W
Junction temperature		T_j	max.	200	°C
D.C. current gain at T_j = 25 °C $-I_C$ = 150 mA; $-V_{CE}$ = 10 V		h_{FE}		100 to 300	
Transition frequency at f = 100 MHz $-I_C$ = 50 mA; $-V_{CE}$ = 20 V; T_j = 25 °C		f_T	>	200	MHz
Storage time $-I_{Con}$ = 150 mA; $-I_{Bon}$ = I_{Boff} = 15 mA		t_s	<	80	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)		$-V_{CBO}$	max.	60	V
Collector-emitter voltage (open base)					
$-I_C < 100$ mA	2N2907	$-V_{CEO}$	max.	40	V
	2N2907A	$-V_{CEO}$	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 °C		P_{tot}	max.	0,4	W
→ up to T_{case} = 25 °C		P_{tot}	max.	1,2	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	$R_{th\ j\text{-}a}$	=	438	K/W
→ From junction to case	$R_{th\ j\text{-}c}$	=	146	K/W

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

			2N2907	2N2907A	
Collector cut-off current					
$I_E = 0; -V_{CB} = 50$ V	$-I_{CBO}$	<	20	10	nA
$I_E = 0; -V_{CB} = 50$ V; $T_{amb} = 150$ °C	$-I_{CBO}$	<	20	10	μA
$+V_{BE} = 0{,}5$ V; $-V_{CE} = 30$ V	$-I_{CEX}$	<	50	50	nA
Base current					
$+V_{BE} = 0{,}5$ V; $-V_{CE} = 30$ V	I_{BEX}	<	50	50	nA ←
Collector-base breakdown voltage					
open emitter; $-I_C = 10$ μA	$-V_{(BR)CBO}$	>	60	60	V
Collector-emitter breakdown voltage *					
open base; $-I_C = 10$ mA	$-V_{(BR)CEO}$	>	40	60	V
Emitter-base breakdown voltage					
open collector; $-I_E = 10$ μA	$-V_{(BR)EBO}$	>	5	5	V
Saturation voltages *					
$-I_C = 150$ mA; $-I_B = 15$ mA	$-V_{CEsat}$	<	0,4	0,4	V
	$-V_{BEsat}$	<	1,3	1,3	V
$-I_C = 500$ mA; $-I_B = 50$ mA	$-V_{CEsat}$	<	1,6	1,6	V
	$-V_{BEsat}$	<	2,6	2,6	V
D.C. current gain					
$-I_C = 0{,}1$ mA; $-V_{CE} = 10$ V	h_{FE}	>	35	75	
$-I_C = 1$ mA; $-V_{CE} = 10$ V	h_{FE}	>	50	100	
$-I_C = 10$ mA; $-V_{CE} = 10$ V	h_{FE}	>	75	100	
$-I_C = 150$ mA; $-V_{CE} = 10$ V *	h_{FE}	>	100	100	
		<	300	300	
$-I_C = 500$ mA; $-V_{CE} = 10$ V *	h_{FE}	>	30	50	
Collector capacitance at f = 100 kHz					
$I_E = I_e = 0; -V_{CB} = 10$ V	C_c	<	8		pF
Emitter capacitance at f = 100 kHz					
$I_C = I_c = 0; -V_{EB} = 2$ V	C_e	<	30		pF
Transition frequency at f = 100 MHz					
$-I_C = 50$ mA; $-V_{CE} = 20$ V *	f_T	<	200		MHz

* Measured under pulse conditions to avoid excessive dissipation: $t_p \leqslant 300$ μs; $\delta \leqslant 0{,}02$.

Turn-on time (see Fig. 2)

when switched to $-I_{Con}$ = 150 mA; $-I_{Bon}$ = 15 mA

delay time	t_d	<	10	ns
rise time	t_r	<	40	ns
turn-on time	t_{on}	<	45	ns

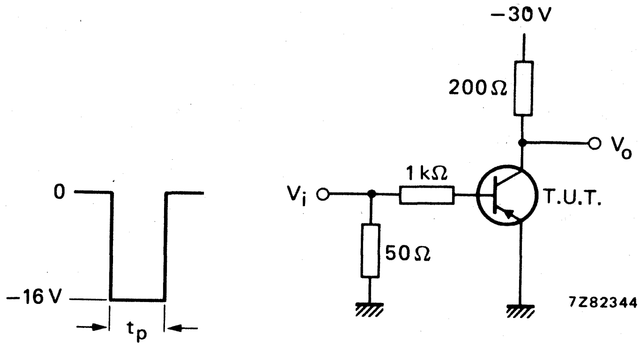


Fig. 2 Input waveform and test circuit for determining delay, rise and turn-on time.

Turn-off time (see Fig. 3)

when switched from $-I_{Con}$ = 150 mA; $-I_{Bon}$ = 15 mA
to cut-off with $+I_{Boff}$ = 15 mA

storage time	t_s	<	80	ns
fall time	t_f	<	30	ns
turn-off time	t_{off}	<	100	ns

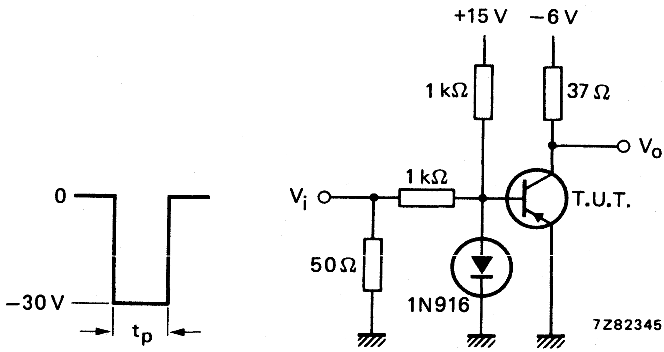


Fig. 3 Input waveform and test circuit for determining storage, fall and turn-off time.

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

N-P-N transistors in TO-39 metal envelopes intended for use as amplifiers and in switching circuits.

QUICK REFERENCE DATA

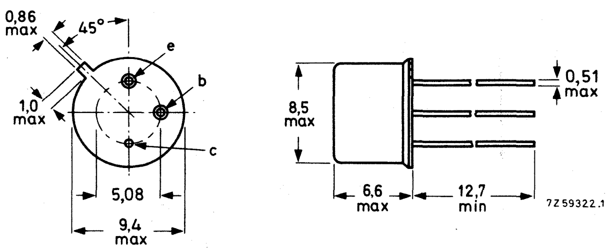
Collector-base voltage (open emitter)	V_{CBO}	max.	140		V
Collector-emitter voltage (open base)	V_{CEO}	max.	80		V
Collector current (d.c.)	I_C	max.	1		A
Total power dissipation					
up to T_{amb} = 25 °C	P_{tot}	max.	0,8		W
up to T_{case} = 25 °C	P_{tot}	max.	5,0		W
Junction temperature	T_j	max.	200		°C
			2N3019	**2N3020**	
D.C. current gain I_C = 150 mA; V_{CE} = 10 V	h_{FE}	>	100	40	
		<	300	120	
Transition frequency at f = 20 MHz I_C = 50 mA; V_{CE} = 10 V	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

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,8	W
up to T_{case} = 25 °C	P_{tot}	max.	5,0	W

Temperatures

Storage temperature	T_{stg}		-65 to +200	°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	218	°C/W
From junction to case	$R_{th\ j-c}$	=	35	°C/W

CHARACTERISTICS T_{amb} = 25 °C unless otherwise specified

Collector cut-off current

$I_E = 0$; $V_{CB} = 90$ V	I_{CBO}	<	10	nA
$I_E = 0$; $V_{CB} = 90$ V; $T_{amb} = 150$ °C	I_{CBO}	<	10	μA

Emitter cut-off current

$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10	nA

Breakdown voltages

$I_E = 0$; $I_C = 100$ μA	$V_{(BR)CBO}$	>	140	V
$I_B = 0$; $I_C = 30$ mA	$V_{(BR)CEO}$	>	80	V [1]
$I_C = 0$; $I_E = 100$ μA	$V_{(BR)EBO}$	>	7	V

Saturation voltages

$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	0,2	V
	V_{BEsat}	<	1,1	V [1]
$I_C = 500$ mA; $I_B = 50$ mA	V_{CEsat}	<	0,5	V [1]

[1]) Measured under pulse conditions: $t_p = 300$ μs; $\delta \leq 0{,}01$.

CHARACTERISTICS (continued) T_{amb} = 25 °C unless otherwise specified

			2N3019	2N3020	
D.C. current gain [1]					
I_C = 0,1 mA; V_{CE} = 10 V	h_{FE}	>	50	30	
		<	–	100	
I_C = 10 mA; V_{CE} = 10 V	h_{FE}	>	90	40	
		<	–	120	
I_C = 150 mA; V_{CE} = 10 V	h_{FE}	>	100	40	
		<	300	120	
I_C = 150 mA; V_{CE} = 10 V; T_{case} = −55 °C	h_{FE}	>	40	–	
I_C = 500 mA; V_{CE} = 10 V	h_{FE}	>	50	30	
		<	–	100	
I_C = 1000 mA; V_{CE} = 10 V	h_{FE}	>	15	15	
Transition frequency at f = 20 MHz					
I_C = 50 mA; V_{CE} = 10 V	f_T	>	100	80	MHz
Collector capacitance at f = 1 MHz					
$I_E = I_e$ = 0; V_{CB} = 10 V	C_c	<	12	12	pF
Emitter capacitance at f = 1 MHz					
$I_C = I_c$ = 0; V_{EB} = 0,5 V	C_e	<	60	60	pF
Feedback time constant at f = 4 MHz					
I_C = 10 mA; V_{CB} = 10 V	$r_{bb'}C_{b'c}$	<	400	400	ps
Small-signal current gain at f = 1 kHz					
I_C = 1,0 mA; V_{CE} = 5 V	h_{fe}	>	80	30	
		<	400	200	
Noise figure at f = 1 kHz					
I_C = 0,1 mA; V_{CE} = 10 V; R_S = 1 kΩ	F	<	4	–	dB

[1]) Measured under pulse conditions: t_p = 300 µs; $\delta \le 0,01$.

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

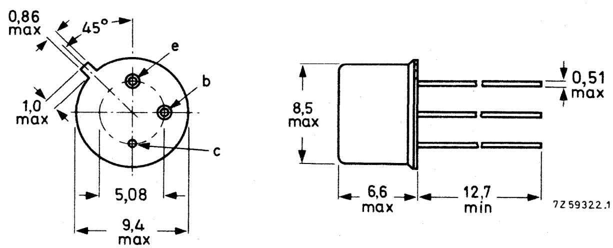
Collector-base voltage (open emitter)	V_{CBO}	max.	60	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	V
Collector current (d.c.)	I_C	max.	700	mA
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.	5,0	W
Junction temperature	T_j	max.	200	°C
D.C. current gain I_C = 150 mA; V_{CE} = 10 V	h_{FE}		50 to 250	
Transition frequency at f = 20 MHz I_C = 50 mA; V_{CE} = 10 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 °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 case	$R_{th\ j\text{-}c}$	=	35	K/W

CHARACTERISTICS

T_{amb} = 25 °C

Collector cut-off current				
V_{CE} = 30 V; $-V_{BE}$ = 1,5 V	I_{CEX}	<	0,25	μA
Emitter cut-off current				
I_C = 0; V_{EB} = 4 V	I_{EBO}	<	0,25	μA
Collector-base breakdown voltage				
open emitter; I_C = 100 μA	$V_{(BR)CBO}$	>	60	V
Collector-emitter breakdown voltage**				
open emitter; I_C = 100 μA	$V_{(BR)CEO}$	>	40	V
I_C = 100 mA; R_{BE} = 10 Ω	$V_{(BR)CER}$	>	50	V
Emitter-base breakdown voltage				
open collector; I_E = 100 μA	$V_{(BR)EBO}$	>	5	V
Base-emitter voltage				
I_C = 150 mA; V_{CE} = 2,5 V	V_{BE}	<	1,7	V
Saturation voltages				
I_C = 150 mA; I_B = 15 mA	V_{CEsat}	<	1,4	V
	V_{BEsat}	<	1,7	V
D.C. current gain				
I_C = 150 mA; V_{CE} = 2,5 V	h_{FE}	>	25	
I_C = 150 mA; V_{CE} = 10 V**	h_{FE}		50 to 250	
Collector capacitance at f = 140 kHz				
I_E = I_e = 0; V_{CB} = 10 V	C_c	<	15	pF
Emitter capacitance at f = 140 kHz				
I_C = I_c = 0; V_{EB} = 0,5 V	C_e	<	80	pF
Transition frequency at f = 20 MHz				
I_C = 50 mA; V_{CE} = 10 V	f_T	>	100	MHz

* For I_C = 0 to 100 mA (pulse conditions): t_p = 300 μs; δ = 0,018, 0 to 700 mA for shorter pulses.

** Measured under pulse conditions to avoid excessive dissipation: t_p = 300 μs; δ = 0,018.

SILICON N-P-N HIGH-VOLTAGE TRANSISTORS

N-P-N high-voltage transistors in TO-39 metal envelopes, designed for general industrial applications and in particular for telephony line switching and video drive circuits.

QUICK REFERENCE DATA

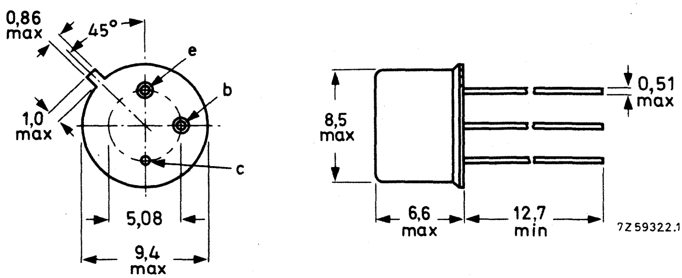
			2N3439	2N3440	
Collector-base voltage (open emitter)	V_{CBO}	max.	450	300	V
Collector-emitter voltage (open base)	V_{CEO}	max.	350	250	V
Collector current (d.c.)	I_C	max.	1		A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	1		W
D.C. current gain I_C = 20 mA; V_{CE} = 10 V	h_{FE}		40 to 160		
Transition frequency at f = 5 MHz I_C = 10 mA; V_{CE} = 10 V	f_T	>	15		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)

			2N3439	2N3440	
Collector-base voltage (open emitter)	V_{CBO}	max.	450	300	V
Collector-emitter voltage (open base)	V_{CEO}	max.	350	250	V
Emitter-base voltage (open collector)	V_{EBO}	max.	7	7	V
Collector current (d.c.)	I_C	max.	1		A
Base current (d.c.)	I_B	max.	0,5		A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	1		W
up to T_{case} = 25 °C	P_{tot}	max.	5		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	$R_{th\ j\text{-}a}$	=	175	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	35	K/W

CHARACTERISTICS

T_{case} = 25 °C

Collector cut-off current					
$I_E = 0$; $V_{CB} = 360$ V	2N3439	I_{CBO}	<	20	μA
$I_E = 0$; $V_{CB} = 250$ V	2N3440	I_{CBO}	<	20	μA
Emitter cut-off current $I_C = 0$; $V_{EB} = 6$ V		I_{EBO}	<	20	μA
Saturation voltages $I_C = 50$ mA; $I_B = 4$ mA		V_{CEsat}	<	0,5	V
		V_{BEsat}	<	1,3	V
D.C. current gain $I_C = 20$ mA; $V_{CE} = 10$ V		h_{FE}		40 to 160	
Collector capacitance at f = 1 MHz $I_E = I_e = 0$; $V_{CB} = 10$ V		C_c	<	10	pF
Emitter capacitance at f = 1 MHz $I_C = I_c = 0$; $V_{EB} = 5$ V		C_e	<	75	pF
Transition frequency at f = 5 MHz $I_C = 10$ mA; $V_{CE} = 10$ V		f_T	>	15	MHz
h-parameters (common emitter) $I_C = 5$ mA; $V_{CE} = 10$ V					
real part of input impedance at f = 1 MHz		$R_e(h_{ie})$	<	300	Ω
small-signal current gain at f = 1 kHz		h_{fe}	>	25	

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in plastic TO-92 envelopes, primarily intended for high-speed, saturated switching applications for industrial service.

QUICK REFERENCE DATA

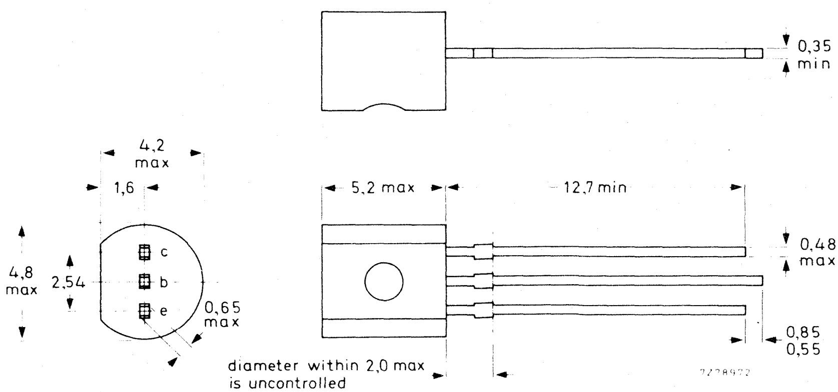
Collector-base voltage (open emitter)	V_{CBO}	max.	60 V
Collector-emitter voltage (open base)	V_{CEO}	max.	40 V
Collector current (d.c.)	I_C	max.	200 mA
Total power dissipation at T_{amb} = 25 °C	P_{tot}	max.	350 mW
Junction temperature	T_j	max.	150 °C

			2N3903	2N3904	
D.C. current gain I_C = 10 mA; V_{CE} = 1 V	h_{FE}	> <	50 150	100 300	
Transition frequency at f = 100 MHz I_C = 10 mA; V_{CE} = 20 V	f_T	>	250	300	MHz
Storage time I_{Con} = 10 mA; I_{Bon} = $-I_{Boff}$ = 1 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 °C	P_{tot}	max.	350 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	$R_{th\ j\text{-}a}$	=	357 K/W

CHARACTERISTICS

T_{amb} = 25 °C

Currents at reverse biased emitter junction			
V_{CE} = 30 V; $-V_{BE}$ = 3 V	I_{CEX}	<	50 nA
	$-I_{BEX}$	<	50 nA
Saturation voltages *			
I_C = 10 mA; I_B = 1 mA	V_{CEsat}	<	200 mV
	V_{BEsat}		650 to 850 mV
I_C = 50 mA; I_B = 5 mA	V_{CEsat}	<	300 mV
	V_{BEsat}	<	950 mV

			2N3903	2N3904
D.C. current gain *				
I_C = 0,1 mA; V_{CE} = 1 V	h_{FE}	>	20	40
I_C = 1 mA; V_{CE} = 1 V	h_{FE}	>	35	70
I_C = 10 mA; V_{CE} = 1 V	h_{FE}	>	50	100
		<	150	300
I_C = 50 mA; V_{CE} = 1 V	h_{FE}	>	30	60
I_C = 100 mA; V_{CE} = 1 V	h_{FE}	>	15	30
Collector capacitance at 100 kHz ⩽ f ⩽ 1 MHz				
$I_E = I_e = 0$; V_{CB} = 5 V	C_c	<	4	4 pF
Emitter capacitance at 100 kHz ⩽ f ⩽ 1 MHz				
$I_C = I_c = 0$; V_{EB} = 0,5 V	C_e	<	8	8 pF
Transition frequency at f = 100 MHz				
I_C = 10 mA; V_{CE} = 20 V	f_T	>	250	300 MHz
Noise figure at R_S = 1 kΩ				
I_C = 100 μA; V_{CE} = 5 V				
f = 10 Hz to 15,7 kHz	F	<	6	5 dB

* Measured under pulse conditions: t_p = 300 μs; δ = 0,02.

h-parameters (common emitter)
I_C = 1 mA; V_{CE} = 10 V; f = 1 kHz

		2N3903	2N3904	
Input impedance	h_{ie}	1 to 8	1 to 10	kΩ
Reverse voltage transfer ratio	h_{re}	0,1 to 5	0,5 to 8	10^{-4}
Small-signal current gain	h_{fe}	50 to 200	100 to 400	
Output admittance	h_{oe}	1 to 40	1 to 40	μA/V

Switching times

Turn-on time (see Figs 2 and 3) when switched from
$-V_{BEoff}$ = 0,5 V to I_{Con} = 10 mA; I_{Bon} = 1 mA

		2N3903	2N3904	
Delay time	t_d	< 35	35	ns
Rise time	t_r	< 35	35	ns

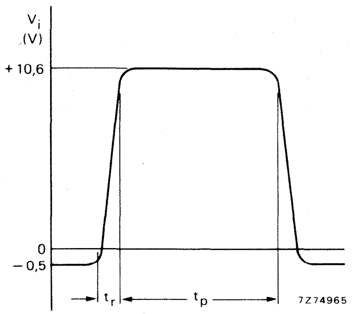


Fig. 2 Input waveform; $t_r < 1$ ns; t_p = 300 ns; δ = 0,02.

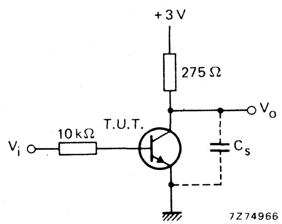


Fig. 3 Delay and rise time test circuit; total shunt capacitance of test jig and connectors $C_s < 4$ pF; scope impedance = 10 MΩ.

Turn-off time (see Figs 4 and 5)
I_{Con} = 10 mA; $I_{Bon} = -I_{Boff}$ = 1 mA

		2N3903	2N3904	
Storage time	t_s	< 175	200	ns
Fall time	t_f	< 50	50	ns

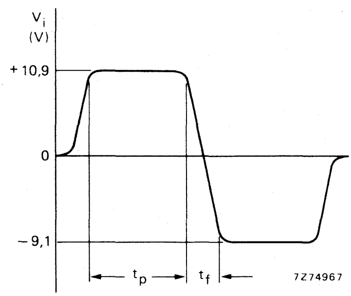


Fig. 4 Input waveform; $t_f < 1$ ns; 10 μs $< t_p <$ 500 μs; δ = 0,02.

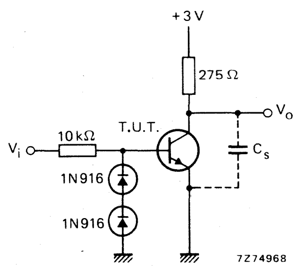


Fig. 5 Storage and fall time test circuit; total shunt capacitance of test jig and connectors $C_s < 4$ pF; scope impedance = 10 MΩ.

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

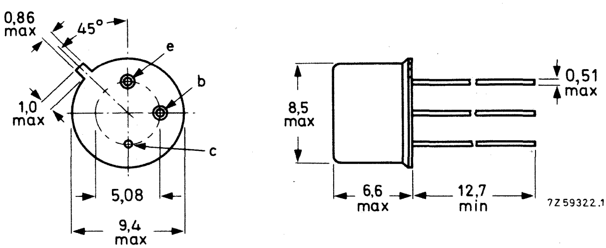
			2N4030 2N4032	2N4031 2N4033	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	V
Collector current (d.c.)	$-I_C$	max.	1		A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,8		W
Junction temperature	T_j	max.	200		°C
			2N4030 2N4031	2N4032 2N4033	
D.C. current gain $-I_C$ = 500 mA; $-V_{CE}$ = 5 V	h_{FE}	>	25	70	
Transition frequency at f = 100 MHz $-I_C$ = 50 mA; $-V_{CE}$ = 10 V	f_T	>	100	150	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)

			2N4030 2N4032	2N4031 2N4033	
Voltages					
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
Power dissipation					
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,8		W
up to T_{case} = 25 °C	P_{tot}	max.	4,0		W
Temperatures					
Storage temperature	T_{stg}		−65 to +200		°C
Junction temperature	T_j	max.	200		°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	218	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	44	°C/W

CHARACTERISTICS T_{amb} = 25 °C unless otherwise specified

			2N4030 2N4032	2N4031 2N4033		
Collector cut-off current						
$I_E = 0$; $-V_{CB} = 50$ V	$-I_{CBO}$	<	50	–	nA	
$I_E = 0$; $-V_{CB} = 60$ V	$-I_{CBO}$	<	–	50	nA	
$I_E = 0$; $-V_{CB} = 50$ V; $T_{amb} = 150$ °C	$-I_{CBO}$	<	50	–	µA	
$I_E = 0$; $-V_{CB} = 60$ V; $T_{amb} = 150$ °C	$-I_{CBO}$	<	–	50	µA	
Emitter cut-off current						
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	10	10	µA	
Breakdown voltages						
$I_E = 0$; $-I_C = 10$ µA	$-V_{(BR)CBO}$	>	60	80	V	
$I_B = 0$; $-I_C = 10$ mA	$-V_{(BR)CEO}$	>	60	80	V	[1]
$I_C = 0$; $-I_E = 10$ µA	$-V_{(BR)EBO}$	>	5	5	V	

[1]) Measured under pulse conditions: t_p = 300 µs; $\delta \leq 0,01$.

CHARACTERISTICS (continued) T_{amb} = 25 °C unless otherwise specified

			2N4030 2N4032	2N4031 2N4033	
Base-emitter voltage					
$-I_C$ = 500 mA; $-V_{CE}$ = 0,5 V	$-V_{BE}$	<	1,1	1,1	V [1]
$-I_C$ = 1000 mA; $-V_{CE}$ = 1,0 V	$-V_{BE}$	<	1,2	-	V [1]
Saturation voltages					
$-I_C$ = 150 mA; $-I_B$ = 15 mA	$-V_{CEsat}$	<	0,15	0,15	V
	$-V_{BEsat}$	<	0,90	0,90	V [1]
$-I_C$ = 500 mA; $-I_B$ = 50 mA	$-V_{CEsat}$	<	0,50	0,50	V
$-I_C$ = 1000 mA; $-I_B$ = 100 mA	$-V_{CEsat}$	<	1,00	-	V

			2N4030 2N4031	2N4032 2N4033
D.C. current gain [1]				
$-I_C$ = 100 μA ; $-V_{CE}$ = 5 V	h_{FE}	>	30	75
$-I_C$ = 100 mA; $-V_{CE}$ = 5 V	h_{FE}	>	40	100
		<	120	300
$-I_C$ = 100 mA; $-V_{CE}$ = 5 V; T_{amb} = −55 °C	h_{FE}	>	15	40
$-I_C$ = 500 mA; $-V_{CE}$ = 5 V	h_{FE}	>	25	70

$-I_C$ = 1000 mA; $-V_{CE}$ = 5 V	2N4030	h_{FE}	>	15
	2N4031	h_{FE}	>	10
	2N4032	h_{FE}	>	40
	2N4033	h_{FE}	>	25

Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $-V_{CB}$ = 10 V	C_c	<	20	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $-V_{EB}$ = 0,5 V	C_e	<	110	pF

			2N4030 2N4031	2N4032 2N4033	
Transition frequency at f = 100 MHz					
$-I_C$ = 50 mA; $-V_{CE}$ = 10 V	f_T	>	100	150	MHz
		<	400	500	MHz

[1] Measured under pulse conditions: t_p = 300 μs; $\delta \leq 0,01$.

CHARACTERISTICS (continued) T_{amb} = 25 °C

Switching times [1])

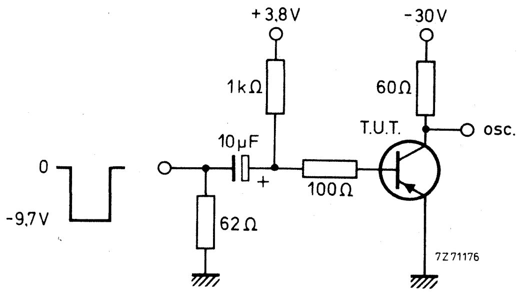
$-I_{Con}$ = 500 mA; $-I_{Bon}$ = 50 mA

Turn-on time	t_{on}	<	100	ns

$-I_{Con}$ = 500 mA; $-I_{Bon}$ = $+I_{Boff}$ = 50 mA

Storage time	t_s	<	350	ns
Fall time	t_f	<	50	ns

Switching circuit:



Pulse generator:

Rise time	t_r <	20 ns
Fall time	t_f <	20 ns
Pulse duration	t_p =	10 μs
Duty factor	δ <	0,02
Source impedance	Z_S =	50 Ω

Oscilloscope:

Rise time	t_r =	10 ns
Input impedance	Z_I >	100 kΩ

[1]) 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.

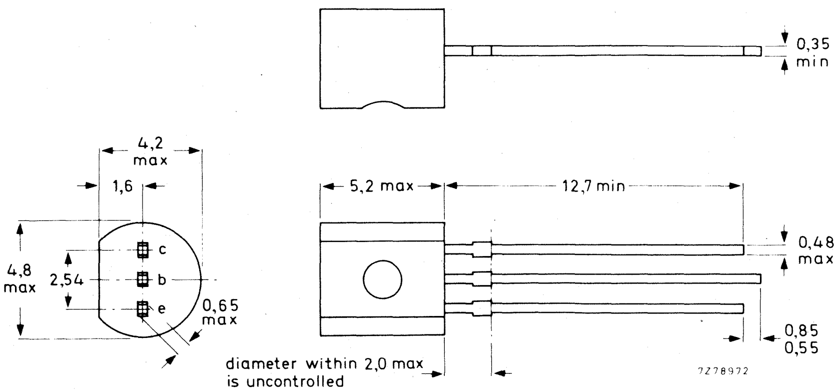
QUICK REFERENCE DATA

			2N4123	2N4124	
Collector-base voltage (open emitter)	V_{CBO}	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 °C	P_{tot}	max.	350	350	mW
Junction temperature	T_j	max.	150	150	°C
Small-signal current gain I_C = 2 mA; V_{CE} = 10 V; f = 1 kHz	h_{fe}	>	50	120	
		<	200	480	
Transition frequency at f = 100 MHz I_C = 10 mA; V_{CE} = 20 V	f_T	>	250	300	MHz
Noise figure at R_S = 1 kΩ I_C = 100 μA; V_{CE} = 5 V f = 10 Hz to 15,7 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 °C	P_{tot}	max.	350		mW
Total power dissipation at T_{case} = 25 °C	P_{tot}	max.	1000		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	$R_{th\ j\text{-}a}$	=	357	K/W
From junction to case	$R_{th\ j\text{-}c}$	=	125	K/W

CHARACTERISTICS

T_{amb} = 25 °C

Collector cut-off current $I_E = 0$; $V_{CB} = 20$ V	I_{CBO}	<	50	nA
Emitter cut-off current $I_C = 0$; $V_{EB} = 3$ V	I_{EBO}	<	50	nA
Saturation voltages * $I_C = 50$ mA; $I_B = 5$ mA	V_{CEsat}	<	300	mV
	V_{BEsat}	<	950	mV

			2N4123	2N4124	
D.C. current gain * I_C = 2 mA; V_{CE} = 1 V	h_{FE}	>	50	120	
		<	150	360	
I_C = 50 mA; V_{CE} = 1 V	h_{FE}	>	25	60	
Collector capacitance at f = 100 kHz $I_E = I_e = 0$; $V_{CB} = 5$ V	C_c	<	4	4	pF
Emitter capacitance at f = 100 kHz $I_C = I_c = 0$; $V_{EB} = 0{,}5$ V	C_e	<	8	8	pF
Transition frequency at f = 100 MHz I_C = 10 mA; V_{CE} = 20 V	f_T	>	250	300	MHz
Noise figure at R_S = 1 kΩ I_C = 100 μA; V_{CE} = 5 V f = 10 Hz to 15,7 kHz	F	<	6	5	dB
Small-signal current gain I_C = 2 mA; V_{CE} = 10 V; f = 1 kHz	h_{fe}	>	50	120	
		<	200	480	

* Measured under pulse conditions: t_p = 300 μs; δ = 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

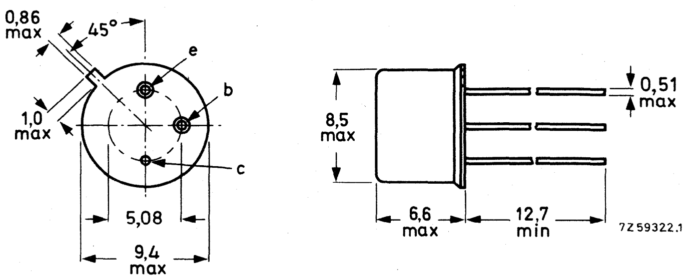
			2N5415	2N5416	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	200	350	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	200	300	V
Collector current (d.c.)	$-I_C$	max.	1	1	A
Total power dissipation up to T_{amb} = 50 °C	P_{tot}	max.	1	1	W
Junction temperature	T_j	max.	200	200	°C
D.C. current gain $-I_C$ = 50 mA; $-V_{CE}$ = 10 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).

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

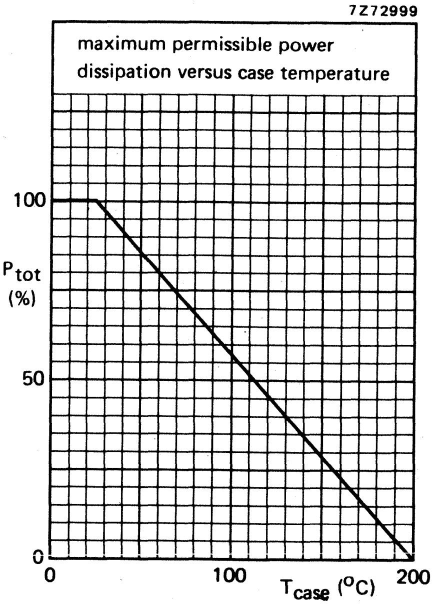
Voltages			2N5415	2N5416	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	200	350	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	200	300	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	4	6	V

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 °C	P_{tot}	max.	10	W
Total power dissipation up to T_{amb} = 50 °C	P_{tot}	max.	1	W



Temperatures

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

THERMAL RESISTANCE

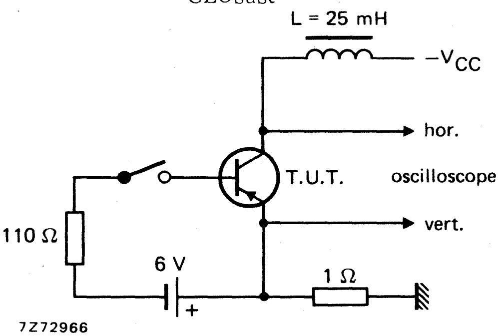
From junction to case	$R_{th\ j-c}$	=	17,5	°C/W
From junction to ambient in free air	$R_{th\ j-a}$	=	150	°C/W

CHARACTERISTICS

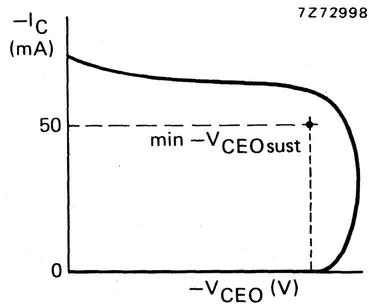
T_{case} = 25 °C

			2N5415	2N5416	
Collector cut-off currents					
$I_E = 0$; $-V_{CB} = 175$ V	$-I_{CBO}$	<	50	–	µA
$I_E = 0$; $-V_{CB} = 280$ V	$-I_{CBO}$	<	–	50	µA
$I_B = 0$; $-V_{CE} = 150$ V	$-I_{CEO}$	<	50	–	µA
$I_B = 0$; $-V_{CE} = 250$ V	$-I_{CEO}$	<	–	50	µA
Emitter cut-off current					
$I_C = 0$; $-V_{EB} = 4$ V	$-I_{EBO}$	<	20	–	µA
$I_C = 0$; $-V_{EB} = 6$ V	$-I_{EBO}$	<	–	20	µA
Sustaining voltage					
$I_B = 0$; $-I_C = 0$ to 50 mA	$-V_{CEOsust}$	>	200	300	V 1)
$R_{BE} = 50\ \Omega$; $-I_C = 50$ mA	$-V_{CERsust}$	>	–	350	V 1)

Test circuit for $V_{CEOsust}$



Oscilloscope display for $V_{CEOsust}$



			2N5415	2N5416	
Saturation voltages					
$-I_C = 50$ mA; $-I_B = 5$ mA	$-V_{CEsat}$	<	2,5	2,0	V
	$-V_{BEsat}$	<	1,5	1,5	V
D.C. current gain					
$-I_C = 50$ mA; $-V_{CE} = 10$ V	h_{FE}	>	30	30	
		<	150	120	
Collector capacitance at f = 1 MHz					
$I_E = I_e = 0$; $-V_{CB} = 10$ V	C_c	<	15		pF
Emitter capacitance at f = 1 MHz					
$I_C = I_c = 0$; $-V_{EB} = -V_{EBOmax}$	C_e	<	75		pF

1) Measured under pulse conditions to avoid excessive dissipation.

CHARACTERISTICS (continued) T_{case} = 25 °C

Transition frequency at f = 5 MHz

$-I_C$ = 10 mA; $-V_{CE}$ = 10 V	f_T	>	15	MHz

h-parameters (common emitter)

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

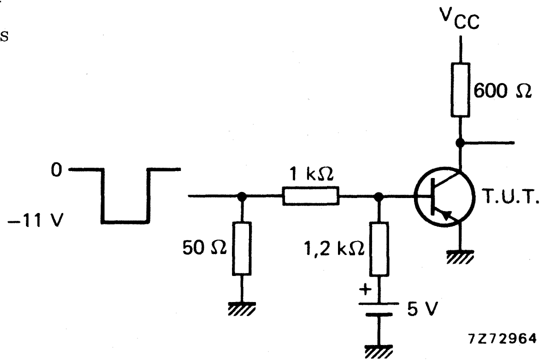
real part of input impedance at f = 1 MHz	$R_e(h_{ie})$	<	300	Ω
small-signal current gain at f = 1 kHz	h_{fe}	>	25	

Switching times

$-I_{Con}$ = 50 mA; $-I_{Bon}$ = I_{Boff} = 5 mA (test circuit 1)	t_{on}	typ.	125	ns
	t_{off}	typ.	850	ns
$-I_{Con}$ = 500 mA; $-I_{Bon}$ = I_{Boff} = 100 mA (test circuit 2)	t_{on}	typ.	125	ns
	t_{off}	typ.	125	ns

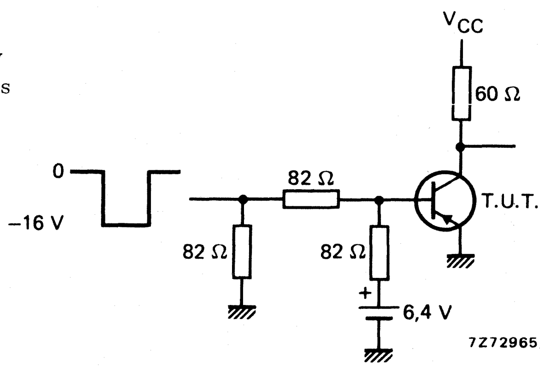
Test circuit 1

V_{CC} = −31 V
t_p = 10 µs



Test circuit 2

V_{CC} = −31 V
t_p = 10 µs



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.

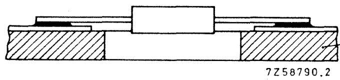


Fig. 1

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.

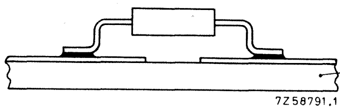


Fig. 2

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.

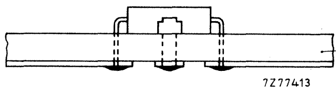


Fig. 3

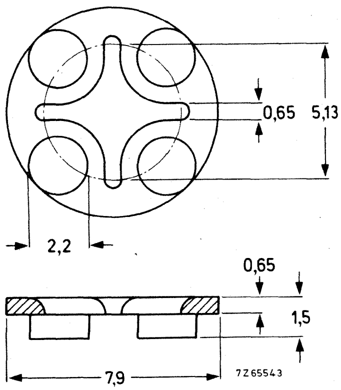
Solder temperature	max.	260 °C
Soldering time	max.	5 s

DISTANCE DISCS

MECHANICAL DATA Dimensions in mm

Fig. 1 **56245** for **TO-5** or **TO-39.**

Insulating material.

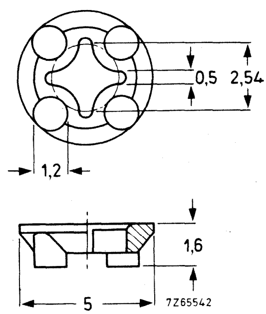


TEMPERATURE

Maximum permissible temperature T max. 100 °C

Fig. 2 **56246** for **TO-18** or **TO-72.**

Insulating material.



TEMPERATURE

Maximum permissible temperature T max. 100 °C

SMALL-SIGNAL TRANSISTORS

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BS AND CECC
APPROVED TYPES

GENERAL

TRANSISTOR DATA

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